

This is the Introduction and General Information sections of the 1996-1999 University of Minnesota Graduate School Catalog

**G r a d u a t e S c h o o l**

<b>2</b>	<b>Introduction</b>
<b>9</b>	<b>General Information</b>
<b>53</b>	<b>Graduate Programs</b>
<b>516</b>	<b>Related Courses</b>
<b>526</b>	<b>Graduate Offerings, Duluth Campus</b>
<b>534</b>	<b>Campus Maps</b>
<b>537</b>	<b>Index</b>
<b>541</b>	<b>Course Designators</b>
<b>Inside back cover</b>	<b>Course Numbers and Symbols</b>

### Graduate School Location

The Graduate School's main administrative offices are on the east bank of the University of Minnesota's Twin Cities campus in Johnston Hall, 101 Pleasant Street S.E., Minneapolis, MN 55455. See campus maps at the end of this bulletin. Johnston Hall is wheelchair accessible.

### Publications

**Graduate School Bulletin**—Prospective and current graduate students are responsible for all information contained in this bulletin that is pertinent to graduate study and their specific field.

The first section, General Information, is the official source of information about Graduate School policies and procedures.

The largest section, Graduate Programs, presents faculty, requirements, and course descriptions for the various programs offering graduate degrees. The short section that follows, Related Courses, features faculty and course descriptions for units offering graduate credits but not graduate degrees. The next section is called Graduate Offerings, Duluth Campus.

At the back are a complete set of Campus Maps, an extensive Index, and an alphabetical list of Course Designators with the programs under which they are found. The inside back cover, Course Numbers and Symbols, explains the numbering system, punctuation, department designators, and symbols used throughout the course descriptions.

The bulletin is available in the Graduate School (309 Johnston Hall) or in the Office of Admissions (240 Williamson Hall), both on the East Bank; in H. D. Smith Bookstore (100 Anderson Hall), West Bank; and in 130 Coffey Hall, St. Paul campus.

**Updates to Bulletin Information**—Changes in Graduate School policies and procedures relating to admission, registration, financial assistance, and commencement are accessible on the Internet at <http://www.grad.umn.edu>.

**Other Publications**—The quarterly *Class Schedule* lists basic costs and regulations. Separate bulletins are printed for University College (formerly Continuing Education and

Extension), the Duluth campus, and other University units. Most may be obtained by visiting the Office of Admissions, 240 Williamson Hall.

### Policies

**Bulletin Use**—The University of Minnesota will change to a semester-based academic calendar beginning academic year 1999-2000. This bulletin is the last quarter-based bulletin that will be produced for the Graduate School. It covers academic years 1996-97, 1997-98, and 1998-99. Information about semester-based academic programs will be provided in the fall of 1998 in semester-transition publications.

The information in this bulletin and other University bulletins, publications, or announcements is subject to change without notice. University offices can provide current information about possible changes.

This publication is available in alternative formats upon request. Please contact the Office of Admissions, University of Minnesota, 240 Williamson Hall, 231 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/625-2008; e-mail [admissions@tc.umn.edu](mailto:admissions@tc.umn.edu)).

This bulletin also is available in electronic format on the Internet and may be accessed via the World Wide Web.

**Equal Opportunity**—The University of Minnesota is committed to the policy that all persons shall have equal access to its programs, facilities, and employment without regard to race, color, creed, religion, national origin, sex, age, marital status, disability, public assistance status, veteran status, or sexual orientation.

In adhering to this policy, the University abides by the Minnesota Human Rights Act, Minnesota Statute Ch. 363; by the Federal Civil Rights Act, 42 U.S.C. 2000e; by the requirements of Title IX of the Education Amendments of 1972; by Sections 503 and 504 of the Rehabilitation Act of 1973; by the Americans With Disabilities Act of 1990; by Executive Order 11246, as amended; by 38 U.S.C. 2012, the Vietnam Era Veterans Readjustment Assistance Act of 1972, as amended; and by other applicable statutes and regulations relating to equality of opportunity.

Inquiries regarding compliance may be directed to Stephanie Lieberman, Director,

Office of Equal Opportunity and Affirmative Action, University of Minnesota, 419 Morrill Hall, 100 Church Street S.E., Minneapolis, MN 55455 (612/624-9547).

The establishment in 1988 of the Office of the Associate Vice President for Academic Affairs with Special Responsibility for Minority Affairs and Diversity has confirmed the University's long-standing commitment to the belief that all students—regardless of their social, racial, or economic backgrounds, their gender, disabilities, or lifestyle—have a right to equity and excellence in education. In conjunction with the faculty and other units of the University administration, this office acts as a catalyst and provides appropriate incentives, programs, and policies to facilitate access and retention among traditionally underrepresented groups. By placing this responsibility within Academic Affairs, the University has uniquely positioned itself in its ability to make excellence and diversity intrinsic components of its institutional makeup.

**Disability Services**—The University's mission is to provide optimal educational opportunities for all students, including for those with disabilities. The University recognizes that students with disabilities sometimes have unique needs that must be met for them to have access to campus programs and facilities. In general, University policy calls for accommodations to be made on an individualized and flexible basis. It is the responsibility of students to seek assistance at the University and to make their needs known.

The first place to seek assistance is at Disability Services (DS). This office promotes program and physical access, which means ensuring the rights of students with disabilities and assisting the University in meeting its obligations under federal and state statutes. DS provides direct assistance such as information, referral, support, and academic accommodations for enrolled and prospective students, as well as consultation to faculty and staff to ensure access to their programs and facilities. The office also assists students with disabilities in obtaining services from other University or community resources and serves as a liaison between the University and the Division of Rehabilitation Services. Campus

accessibility maps also are available from DS; building accessibility information is printed in the *Student-Staff Directory* and the *Class Schedule*. For more information, contact Disability Services, University of Minnesota, 30 Nicholson Hall, 216 Pleasant Street S.E., Minneapolis, MN 55455 (612/626-1333 voice or TTY).

**Access to Student Educational Records**—In accordance with regents' policy on access to student records, information about a student generally may not be released to a third party without the student's permission. (Exceptions under the law include state and federal educational and financial aid institutions.) The policy also permits students to review their educational records and to challenge the contents of those records.

Some student information—name, address, electronic (e-mail) address, telephone number, dates of enrollment and enrollment status (full time, part time, not enrolled, withdrawn and date of withdrawal), college and class, major, adviser, academic awards and honors received, and degrees earned—is considered public or directory information. Students may prevent the release of public information. To do so, they must request suppression from the records office on their campus.

Students have the right to review their educational records. The regents' policy, including a directory of student records, is available for review at 150 Williamson Hall, Minneapolis; at records offices on other campuses of the University; and at <http://www.umn.edu/registrar>. Questions may be directed to the Office of the Registrar, 150 Williamson Hall (612/625-5333).

**Immunization**—Students born after 1956 who take more than one University course are required under Minnesota law to submit a Student Immunization Record form.

The form, which is sent along with the official Graduate School admission letter, should be filled out and returned to Boynton Health Service as soon as possible, but absolutely no later than 45 days after the beginning of the first term of enrollment, in order for students to continue registering for courses at the University. Complete instructions accompany the form.

**Extracurricular Events**—No extracurricular events requiring student participation may be scheduled from the beginning of study day to the end of finals week. Exceptions to this policy may be granted by the Senate Committee on Educational Policy. The Senate advises all faculty that any exemption granted pursuant to this policy shall be honored and that students who are unable to complete course requirements during finals week shall be provided an alternative and timely opportunity to do so.

**Smoke-Free Campus Policy**—Smoking is prohibited in all facilities of the University of Minnesota, Twin Cities campus except for designated private residence hall rooms.

### The Campus and Community

On the Twin Cities campus, Graduate School students enjoy the vast academic and cultural opportunities of a major university and a unique metropolitan area.

**Two Campuses in One**—The Twin Cities campus, the largest and oldest in the University system, is technically two separate campuses: one just east of downtown Minneapolis on the Mississippi River, the other just west of the State Fairgrounds a couple of miles from downtown St. Paul.

The Mississippi River divides the Minneapolis campus into two banks connected by the double-decker Washington Avenue Bridge. The picturesque mall of the main East Bank is bordered by stately traditional buildings—including Johnston Hall, home of the Graduate School. Next door is Northrop Auditorium and its plaza. On the other end of the mall, Coffman Memorial Union offers a good place to relax between classes. Nearby are unique underground facilities and the health sciences complexes.

Just across the river is the West Bank. Newer and smaller, it boasts sleek brick buildings like the main library, the Humphrey Institute of Public Affairs, the Law Center, and the new Ted Mann Concert Hall.

Three miles away is the St. Paul campus, whose animal barns, croplands, flowers, and wooded areas evoke a small college atmosphere.

**Urban Diversity**—The Dinkytown, Stadium Village, Seven Corners, and Cedar-Riverside areas near the Minneapolis campus, and the St. Anthony Park neighborhood alongside the St. Paul campus, all feature shops and restaurants tailored to students' interests and budgets.

Minneapolis (the largest city in Minnesota) and St. Paul (the state capital) are both flourishing centers of commerce and industry, where grandiose historic buildings complement bold new skyscrapers. Focal points of a progressive metropolitan area of 2.3 million people, the two downtowns offer many opportunities for entertainment, research, volunteer or part-time work, internships, and careers.

**Arts and Entertainment**—The Twin Cities are renowned for their innovative and varied cultural attractions, such as the Guthrie Theater, Ordway Music Theater, Orchestra Hall, Science Museum and Omnitheater, and Dudley Riggs' Brave New Workshop. Northrop Auditorium, the campus centerpiece, hosts performances by popular musical and dance artists and outstanding University bands and ensembles. Students can see or star in plays at the Rarig Center and summertime Showboat. Or they can enjoy the Walker Art Center and the Minneapolis Institute of Arts, the Minnesota and Como Zoos, the Mall of America, the Renaissance Festival and Valleyfair, and the Minneapolis Aquatennial and St. Paul Winter Carnival. In 1993, the University Art Museum moved into its new building overlooking the Mississippi River, the Frederick R. Weisman Art Museum, with award-winning design by Frank Gehry.

**Recreation and Sports**—The Rec Sports program, one of the largest of its kind on any campus in the country, offers curling, cycling, racquetball, crew, ballroom dance, juggling, and 100 other teams, clubs, and fitness activities. Big-league sports fans can view Golden Gophers or Vikings football and Twins baseball at the Metrodome. Many women's and men's intercollegiate athletic events also take place right on campus.

Outdoor enthusiasts can explore the Twin Cities' 150 parks and 200 lakes, ideal for picnicking, hiking, biking, swimming, canoeing, sailing, fishing, rollerblading or ice skating, cross-country or downhill skiing, or simply sitting and thinking. The Boundary Waters Canoe Area Wilderness, one of the most unsullied wilderness treasures in the entire nation, is only a few hours drive north.

The warmth of spring, greenery of summer, and bright colors of autumn are followed by at least three months of winter snow, but even then, daytime temperatures generally average an invigorating 10 to 30 degrees above.

## University Counseling and Consulting Services

University Counseling and Consulting Services (UCCS), 109 Eddy Hall on the East Bank and 199 Coffey Hall on the St. Paul campus (612/624-3323 for both), offers counseling for academic, career, personal, or relationship concerns. Besides counseling, UCCS features a variety of services. The Career Development Center and the Learning and Academic Skills Center offer workshops, courses, and materials for career development or academic skills improvement. The Organizational Development Program offers consultation, assessment, team building, conflict mediation, training, and workshops. UCCS's Office of Measurement Services (OMS) scores exams, surveys, and research instruments and provides consultation to University faculty and staff. OMS operates the Minnesota Statewide Testing Program for Minnesota elementary and secondary schools. The Testing Center administers admissions, placement, and national tests. For more information, see <http://www.ucs.umn.edu/uccswww/uccs.html> on the World Wide Web.

## Libraries and Research Opportunities

The University of Minnesota, Twin Cities Libraries, with a collection of more than 5 million catalogued volumes and 46,000 serials, ranks 17th in size among American universities. Included in the system are the *Bio-Medical Library* (health sciences); *St. Paul Central Library* (agriculture, biological

sciences, human ecology); *Walter Library* (engineering, natural sciences, education, psychology); and *Wilson Library* (social sciences, humanities, special collections). Other campus libraries include those for architecture, entomology, forestry, horticulture, journalism, law, mathematics, music, plant pathology, and veterinary medicine. The library system also includes many specialized libraries and archives, such as the Children's Literature Research Collections and the Immigration History Research Center Archives. In addition to strong comprehensive research collections, the system offers a full range of reference and information services, including specialized reference assistance, interlibrary loan service, database literature searching, and library user instruction. MNCAT, the library system's on-line catalog, may be accessed from residence halls, offices, and other locations.

Among the University's many research centers are:

Addiction Studies, Center for  
Aging, Center on  
Agricultural Experiment Station

Alternative Plant and Animal Products, Center for  
Applied Research and Educational Improvement, Center for  
(CAREI)  
Archaeological Studies, Interdisciplinary  
Archaeology Laboratory  
Archaeometry Laboratory  
Army High Performance Computing Research Center  
Austrian Studies, Center for  
Avian Research Center  
Biological Process Technology, Institute for Advanced  
Studies in  
Biomedical Engineering Center  
Biomedical Ethics, Center for  
Biometric Research, Coordinating Centers for (CCBR)  
Building Research Center, Minnesota  
Cedar Creek Natural History Area  
Cereal Rust Laboratory  
Chemical Toxicology Research Center  
Child Welfare, Center for Advanced Studies in  
Clinical Outcomes Research Center (CORC)  
Clinical Research Center  
Cloquet Forestry Center  
Cold Climate Housing Program  
Community and Regional Research, Center for  
Community Integration, Institute on  
Computational Science and Engineering, Laboratory for  
Conflict and Change Center  
Control Science and Dynamical Systems Center  
Cooperative Learning Center  
Corrections Education Research, Center on  
Corrosion Center

CPCRA (Community Program for Clinical Research on AIDS) Statistical Center  
 Criminal Justice Studies, Center for  
 Dairy Foods Research Center  
 Daylighting Center, Regional  
 Death Education and Research, Center for  
 Dental Research Center for Biomaterials and Biomechanics, Minnesota  
 Dental Research Institute  
 Design Center for the American Urban Landscape  
 Early Childhood Research Institute  
 Early Education and Development, Center for  
 Early Modern History, Center for  
 Economic Development Center (Twin Cities)  
 Economic Development (Duluth), Center for  
 Economic Education (Duluth), Center for  
 Economic Education (Twin Cities), Center for  
 Economic Research, Center for  
 Education in Agriculture and Extension, Center for  
 Educational Outcomes, National Center on  
 Entrepreneurial Studies, Carlson Center for  
 Epilepsy Clinical Research Program  
 European Studies, Center for  
 Experiential Education and Service Learning, Center for  
 Feminist Studies, Center for Advanced  
 Geological Survey, Minnesota  
 Geometry Center, The  
 Girls and Women in Sport, Center for Research on  
 Herbarium  
 History of Information Processing, (Charles) Babbage Institute-Center for the  
 Hormel Institute  
 Horticultural Research Center  
 Human Factors Research Laboratory  
 Human Genetics, Institute of  
 Human Resource Development Research Center  
 Imaging Center  
 Immigration History Research Center  
 Immunology, Center for  
 Industrial Relations Center  
 Integrated Natural Resources and Agricultural Management, Center for  
 Interdisciplinary Studies of Writing, Center for  
 Interest Measurement Research, Center for  
 Interfacial Engineering, Center for  
 International Food and Agricultural Policy, Center for  
 International Studies, Royal D. Alworth Jr. Institute for  
 International Studies and Programs, Institute of  
 Interpersonal Relationships, Center for Research on  
 Jewish Studies Center  
 Journalism Center, Minnesota  
 Lake Itasca Forestry and Biological Station  
 Landscape Arboretum, Minnesota  
 Landscape Studies Center  
 Language Acquisition, Center for Advanced Research on (CARLA)  
 Large Lakes Observatory  
 Learning, Perception, and Cognition, Center for Research in  
 Life Course Center  
 Limnological Research Center  
 Long-Term Care Administration, Center for  
 Low-Vision Research, Minnesota Laboratory for  
 Lung Health Study Coordinating Center  
 Magnetic Resonance Research, Center for  
 Management Information Systems Research Center  
 Manufacturing, Design, & Control, Center for Advanced (CAMDAC)  
 Mathematics and Its Applications, Institute for

Medieval Studies, Center for  
 Micromagnetics and Information Technologies Center (MINT)  
 Microtechnology Laboratory (MTL)  
 NanoStructure Laboratory  
 Natural Resource Policy and Management, Center for  
 Natural Resources Research Institute  
 Neurocommunication Research, Edwin Eddy Center for  
 Neuroscientific Databases, Center for  
 North Central Soil Conservation Research Laboratory  
 Nuclear Physics, Williams Laboratory for  
 Occupational Health and Safety, Midwest Center for  
 Pharmaceutical Research in Management and Economics (PRIME) Institute  
 Philosophy of Science, Minnesota Center for  
 Plant Molecular Genetics Institute  
 Political Economy, Center for  
 Polymerization and Polymer Process Engineering Center  
 Population Analysis and Policy, Center for  
 Psychiatry Research  
 Race and Poverty, Institute on  
 Raptor Center, Garrigan  
 Reflective Leadership Center  
 Refugee Studies Center  
 Residential Services and Community Living, Center for  
 Restorative Justice and Mediation, Center for  
 Retail Food Industry Center, The (TRFIC)  
 Rock Magnetism, Institute for  
 Rural Health Research Center  
 Rural Sociology and Community Analysis, Center for  
 St. Anthony Falls Laboratory  
 Sand Plain Research Farm  
 Sea Grant College Program, Minnesota  
 Silha Center  
 Space Grant Consortium, Minnesota  
 Speech, Equality, and Harm, Center for  
 Strategic Management Research Center  
 Supercomputer Institute  
 Superconductivity, Center for Science and Application of  
 Survey Research, Minnesota Center for  
 Sustainable Agriculture, Minnesota Institute for (MISA)  
 Technological Leadership, Center for Development of  
 Theoretical Physics Institute  
 Transportation Studies, Center for  
 Twin and Adoption Research, Minnesota Center for  
 Underground Research Site, Sudan  
 Urban and Regional Affairs, Center for  
 Violence and Abuse, Higher Education Center Against (HECAVA)  
 Vocational Education, Minnesota Research and  
 Development Center for  
 Vocational Education, National Center for Research in  
 Water Resources Research Center  
 Women and Public Policy, Center on  
 Youth Development, Center for

Research support is provided by the Office of the Vice President for Research and Dean of the Graduate School as well as by the public and private sectors. The Graduate School fellowship and research support programs distribute nearly \$7 million annually to students and faculty. The University also ranks among the top research universities receiving federal research money.

## Administration

### University Regents

Thomas R. Reagan, Gilbert, Chair  
H. Bryan Neel III, Rochester, Vice Chair  
Wendell R. Anderson, Wayzata  
Julie A. Bleyhl, Madison  
William E. Hogan II, Minnetonka  
Jean B. Keffeler, Minneapolis  
Hyon T. Kim, St. Anthony  
Warren C. Larson, Bagley  
William R. Peterson, Eagan  
Jessica J. Phillips, Morris  
Stanley D. Sahlstrom, St. Cloud  
Patricia B. Spence, Rice

### University Administrators

Nils Hasselmo, President  
JoAnne G. Jackson, Senior Vice President for Finance and Operations  
Marvin L. Marshak, Senior Vice President for Academic Affairs  
C. Eugene Allen, Provost for Professional Studies  
Frank B. Cerra, Provost for the Academic Health Center  
W. Phillips Shively, Provost for Arts, Sciences, and Engineering  
McKinley Boston, Jr., Vice President for Student Development & Athletics  
Mark L. Brenner, Vice President for Research and Dean of the Graduate School  
Thomas H. Swain, Acting Vice President for Institutional Relations  
Mark B. Rotenberg, General Counsel

### Graduate School Administrators

Mark L. Brenner, Ph.D., Vice President for Research and Dean of the Graduate School  
Frances P. Lawrenz, Ph.D., Assistant Vice President for Research and Associate Dean of the Graduate School  
Charles F. Louis, Ph.D., Assistant Vice President for Research and Associate Dean of the Graduate School  
Stephen C. Hedman, Ph.D., Associate Dean of the Graduate School, Duluth  
George D. Green, Associate Dean of the Graduate School  
Robert K. Leik, Ph.D., Associate Dean of the Graduate School

## Graduate School Executive Committee

Mark L. Brenner, Ph.D., Vice President for Research and Dean of the Graduate School  
Frances P. Lawrenz, Ph.D., Assistant Vice President for Research and Associate Dean of the Graduate School  
Charles F. Louis, Ph.D., Assistant Vice President for Research and Associate Dean of the Graduate School  
George D. Green, Associate Dean of the Graduate School  
Robert K. Leik, Ph.D., Associate Dean of the Graduate School  
Jean B. Regal, Ph.D., Associate Professor, Pharmacology; Chair, Duluth Graduate Faculty Committee  
Sandra O. Archibald, Ph.D., Associate Professor, Public Affairs; Chair, Social Sciences Policy and Review Council  
Nancy J. Ehlike, Ph.D., Associate Professor, Agronomy and Plant Breeding; Chair, Biological Sciences Policy and Review Council  
Charles A. Nelson, Ph.D., Professor, Child Development; Chair, Education and Psychology Policy and Review Council  
Mariah Snyder, Ph.D., Professor, Nursing; Chair, Health Sciences Policy and Review Council  
To be announced; Chair, Language, Literature, and the Arts Policy and Review Council  
To be announced; Chair, Physical Sciences Policy and Review Council  
Wayne L. Gladfelter, Ph.D., Professor, Chemistry; Chair, Graduate School Research Advisory Committee  
John G. Rice, Fil.lic., Professor, Geography; Chair, Graduate School Fellowship Committee  
Four student representatives  
One civil service representative

# General Information

## GENERAL INFORMATION

The central purposes of the Graduate School are the advanced training of men and women in a wide variety of fields and the promotion of research in an atmosphere of freedom of inquiry.

The Graduate School administrative structure includes six policy and review councils, consisting of faculty and students, in the areas of biological sciences; education and psychology; health sciences; language, literature, and the arts; physical sciences; and social sciences. These councils, together with an Executive Committee, are responsible for making general policy for the Graduate School. The Executive Committee is composed of the Graduate School dean; chairpersons of the policy and review councils, the Graduate School Research Advisory Committee, and the Fellowship Committee; and representatives from the Duluth Graduate Faculty Committee, the Graduate School administration and staff, and the Council of Graduate Students.

## Majors and Degrees

### Twin Cities Campus

#### *Major*

Aerospace Engineering  
 Agricultural and Applied Economics  
 Agronomy  
 American Studies  
 Ancient and Medieval  
   Art and Archaeology  
 Animal Sciences  
 Anthropology  
 Arabic  
 Architecture  
 Art  
 Art Education  
 Art History  
 Astrophysics  
 Biochemistry, Molecular  
   Biology and Biophysics  
 Biomedical Engineering  
 Biomedical Science  
 Biophysical Sciences  
   and Medical Physics  
 Biostatistics  
 Biosystems and Agricultural  
   Engineering  
 Business Administration  
 Business Taxation  
 Cellular and Integrative Physiology  
 Chemical Engineering  
 Chemical Physics

#### *Degree*

M.S.Aero.E.,  
 M.Aero.E., Ph.D.  
 M.S., Ph.D.  
 M.S., Ph.D.  
 M.A., Ph.D.  
 M.A., Ph.D.  
 M.S., Ph.D.  
 M.A., Ph.D.  
 M.A.  
 M.Arch.  
 M.F.A.  
 M.A.  
 M.A., Ph.D.  
 M.S., Ph.D.  
 M.S., Ph.D.  
 M.S., Ph.D.  
 M.S., Ph.D.  
 M.S.B.A.E.,  
 M.B.A.E., Ph.D.  
 Ph.D.  
 M.B.T.  
 M.S., Ph.D.  
 M.S.Ch.E.,  
 M.Ch.E., Ph.D.  
 M.S., Ph.D.

Chemistry M.S., Ph.D.  
 Child Psychology M.A., Ph.D.  
 Chinese M.A., Ph.D.  
 Civil Engineering M.S., M.C.E.,  
 Ph.D.  
 M.A., Ph.D.  
 Classics M.A., Ph.D.  
 Clinical Laboratory Science M.S.  
 Communication Disorders M.A., Ph.D.  
 Comparative Literature M.A., Ph.D.  
 Comparative Studies in M.A., Ph.D.  
   Discourse and Society  
 Computer and Information Sciences M.S., M.C.I.S.,  
 Ph.D.  
 Computer Engineering M.S., M.Comp.E.  
 Conservation Biology M.S., Ph.D.  
 Control Science and Ph.D.  
   Dynamical Systems  
 Creative Writing M.F.A.  
 Dentistry M.S.  
 Design, Housing, and Apparel M.A., M.S., Ph.D.  
 East Asian Studies M.A.  
 Ecology M.S., Ph.D.  
 Economics M.A., Ph.D.  
 Education<sup>1</sup> M.A., Ph.D.  
 Educational Administration<sup>1</sup> Ed.D.  
 Educational Policy M.A., Ph.D.  
   and Administration  
 Educational Psychology<sup>1</sup> M.A., Ph.D.  
 Electrical Engineering M.S.E.E.,  
 M.E.E., Ph.D.  
 Elementary Education M.A.  
 English M.A., Ph.D.  
 English as a Second Language M.A.  
 Entomology M.S., Ph.D.  
 Environmental Health M.S., Ph.D.  
 Epidemiology M.S., Ph.D.  
 Experimental Surgery M.S.Exp.Surg.  
 Family Practice and M.S.  
   Community Health  
 Family Social Science M.A., Ph.D.  
 Fisheries M.S., Ph.D.  
 Food Science M.S., Ph.D.  
 Forestry M.S., M.F., Ph.D.  
 French M.A., Ph.D.  
 Geography M.A., Ph.D.  
 Geological Engineering M.S., M.Geo.E.,  
 Ph.D.  
 Geology M.S., Ph.D.  
 Geophysics M.S., Ph.D.  
 German M.A., Ph.D.  
 Germanic Philology M.A., Ph.D.  
 Greek M.A., Ph.D.  
 Health Informatics M.S., Ph.D.  
 Health Services Research M.S.  
   and Policy  
 Health Services Research, Ph.D.  
   Policy and Administration  
 Hispanic and Luso-Brazilian Ph.D.  
   Literatures and Linguistics  
 Hispanic Linguistics M.A.  
 Hispanic Literature M.A.  
 History M.A., Ph.D.  
 History of Medicine and M.A., Ph.D.  
   Biological Sciences  
 History of Science and Technology M.A., Ph.D.  
 Horticulture M.S., Ph.D.  
 Hospital Pharmacy M.S.

Industrial Engineering	M.S.I.E., M.I.E., Ph.D.	Social Work	M.S.W., Ph.D.
Industrial Relations	M.A., Ph.D.	Sociology	M.A., Ph.D.
Interdisciplinary	M.A., M.S., Ph.D.	Soil Science	M.S., Ph.D.
Archaeological Studies		South Asian Languages	M.A., Ph.D.
Italian	M.A.	Speech-Communication	M.A., Ph.D.
Japanese	M.A., Ph.D.	Statistics	M.S., Ph.D.
Kinesiology	M.A., Ph.D.	Surgery	M.S.Surg., Ph.D.Surg.
Landscape Architecture	M.S., M.L.A.	Theatre Arts	M.A., M.F.A., Ph.D.
Latin	M.A., Ph.D.	Therigenology	M.S., Ph.D.
Liberal Studies	M.L.S.	Toxicology	M.S., Ph.D.
Linguistics	M.A., Ph.D.	Veterinary Biology	M.S., Ph.D.
Luso-Brazilian Literature	M.A.	Veterinary Medicine	M.S., Ph.D.
Management of Technology	M.S.MOT.	Veterinary Pathobiology	M.S., Ph.D.
Mass Communication	M.A., Ph.D.	Veterinary Surgery,	M.S., Ph.D.
Materials Science and Engineering	M.S.Mat.S.E., M.Mat.S.E., Ph.D.	Radiology, and Anesthesiology	
Mathematics	M.A., M.S., Ph.D.	Water Resources Science	M.S., Ph.D.
Mathematics Education <sup>1</sup>	M.A.	Wildlife Conservation	M.S., Ph.D.
Mechanical Engineering	M.S.M.E., M.M.E., Ph.D.	Work, Community, and Family Education	Ed.D.
Mechanics	M.S., Ph.D.	Zoology	M.S., Ph.D.
Medicinal Chemistry	M.S., Ph.D.		
Microbial Engineering	M.S.		
Microbiology, Immunology, and Molecular Pathobiology	M.S., Ph.D.	<i>Certificate of Specialist in Education</i>	
Mineral Engineering	M.S., M.Min.E., Ph.D.	Counseling	
Molecular, Cellular, Developmental Biology and Genetics	M.S., Ph.D.	Elementary School Administration	
Music	M.A., M.M., D.M.A., Ph.D.	General Curriculum Supervision	
Music Education	M.A.	General Educational Administration	
Neuroscience	Ph.D.	Mathematics Education	
Nursing	M.S., Ph.D.	School Psychological Services	
Nutrition	M.S., Ph.D.	Secondary School Administration	
Occupational Therapy	M.S.	Special Education	
Oral Biology	M.S., Ph.D.	Special Education Administration	
Otolaryngology	M.S., M.S.Otol., Ph.D.Otol.		
Pharmaceutics	M.S., Ph.D.	<i>Freestanding Minors</i>	
Pharmacology	M.S., Ph.D.	Anatomy	
Philosophy	M.A., Ph.D.	Bioethics	
Physical Therapy	M.S.	Building Science	
Physics	M.S., Ph.D.	Cognitive Science	
Planning	M.Plan.	Composition, Literacy, and Rhetorical Studies	
Plant Biological Sciences	M.S., Ph.D.	Conflict Management	
Plant Breeding	M.S., Ph.D.	Development Studies and Social Change	
Plant Pathology	M.S., Ph.D.	Feminist Studies	
Political Science	M.A., Ph.D.	Gerontology	
Psychology	M.A., Ph.D.	Human Factors/Ergonomics	
Public Affairs	M.A.	International Education	
Recreation, Park, and Leisure Studies	M.A.	Interpersonal Relationships Research	
Rehabilitation Science	M.S., Ph.D.	Law	
Rhetoric and Scientific and Technical Communication	M.A., Ph.D.	Medieval Studies	
Russian Area Studies	M.A.	Microbial Ecology	
Scandinavian Studies	M.A., Ph.D.	Museum Studies	
Science and Technology Policy	M.S.	Political Psychology	
Scientific and Technical Communication	M.S.	Psychoneuroimmunology	
Scientific Computation	M.S., Ph.D.	Public Health	
Social and Administrative Pharmacy	M.S., Ph.D.	Quaternary Paleoeecology	
		Religious Studies	
		Social and Philosophic Studies of Education	
		Studies in Africa and the African Diaspora	
		Studies of Science and Technology	
		Sustainable Agriculture Systems	

<sup>1</sup> Also see *Certificate of Specialist in Education offerings at end of this listing.*

## Duluth Campus

<i>Major</i>	<i>Degree</i>
Applied and Computational Mathematics	M.S.
Art	M.A.
Biology	M.S.
Business Administration	M.B.A.
Chemistry	M.S.
Communication Disorders	M.A.
Computer Science	M.S.
Educational Psychology	M.A.
English	M.A.
Geology	M.S.
Liberal Studies	M.L.S.
Music	M.M.
Physics	M.S.
Social Work	M.S.W.

*Freestanding Minor*  
Linguistics

## Tuition and Fees

Current tuition for the various categories of Graduate School registration and current fees are listed in the quarterly *Class Schedule*. Summer Session tuition and fees are listed in the current *Summer Session Bulletin*.

**Residence**—Because the University is a state institution, Minnesota residents pay lower tuition than nonresidents. To qualify for resident status, students must reside in Minnesota for at least one calendar year before the first day of class attendance. For more information, contact the Resident Classification and Reciprocity Office, University of Minnesota, 240 Williamson Hall, 231 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/625-6330).

**Reciprocity**—For residents of North Dakota, South Dakota, Wisconsin, or Manitoba who qualify for reciprocity privileges, tuition rates are lower than for nonresidents and are, in some cases, comparable to resident rates. For more information, contact the Resident Classification and Reciprocity Office (see above).

**Resident Tuition Benefit**—For information on resident tuition for graduate assistants, fellows, and trainees, see the Assistantships and Fellowships section. For information on the benefit for students of color and disadvantaged students, see the Office of Equal Opportunity in Graduate Studies section.

## Basic Admission Requirements

Any student with a U.S. bachelor's degree or a comparable foreign degree from a recognized college or university may apply to the dean of the Graduate School for admission. Applicants with the necessary background for their chosen major field, an excellent scholastic record from an approved college or university, and appropriate professional qualifications may be admitted for graduate work on recommendation of the graduate faculty in the proposed major field and approval of the Graduate School dean. The Graduate School operational standard for admission is an undergraduate grade point average (GPA) of 3.00. Many programs require a higher GPA. Applicants should consult the program to which they are applying for more specific information about admission standards.

The faculty and staff of the Graduate School encourage applications from persons of color or other groups that have been underrepresented in the student body. The Graduate School is committed to providing equal opportunity to all who seek access to its programs, facilities, and services; establishing fair educational standards and applying them equitably in making decisions about admission and academic standing; and helping to compensate for inequities in society.

For more information on admission requirements and application procedures, contact the proposed major field at the address or phone number listed for each program under Graduate Programs.

## Application Procedure

Requests for application materials should be sent to the director of graduate studies in the individual program (see Graduate Programs for program addresses). Requests should specify the applicant's proposed major field and emphasis, degree objective, and date of entry.

Applicants are encouraged to apply for admission well in advance of the term in which they wish to enter the Graduate School (but no more than one year in advance of the proposed entry date). The Graduate School application,

complete with all required materials, must be submitted by the following deadlines:

*Fall quarter*—July 15

*Winter quarter*—October 25

*Spring quarter*—December 15

*Summer session, first term*—April 15

*Summer session, second term*—May 15

Deadlines that fall on a holiday or weekend will be extended through the next regular workday.

*Many major fields have established deadlines earlier than those listed above and also require additional application and supporting materials. It is the applicant's responsibility to obtain information about those deadlines and requirements from the program description in this bulletin and from the director of graduate studies for the proposed major.*

*Note:* More detailed and up-to-date information regarding the application fee, transcripts, and test data is included in the instructions accompanying the Graduate School Application for Admission form.

**Transcripts**—Official transcripts of previous academic study must be submitted.

Experience at the University of Minnesota has been that often during the course of the program of study a student has need of a complete set of official credentials covering previous college and university training. Applicants are urged to request two sets of official credentials when preparing their application for admission—one to be submitted for permanent filing in the Graduate School and the other for personal use.

**International Applicants**—All international applicants are required to submit complete credentials. Details on the types of transcripts required are given in the Graduate School Application for Admission instructions.

**Test Data**—One or more of the following tests may be required as part of the application process (in addition, consult the individual program requirements under Graduate Programs):

*Graduate Management Admission Test (GMAT)*—Please see the Business Administration program description under Graduate Programs. For information on registering for the GMAT, write to the

Educational Testing Service, CN 6108, Princeton, NJ 08541.

*Graduate Record Examination (GRE)*—Most major fields request the GRE. It would be wise, therefore, for applicants to complete this test either in the senior year of undergraduate work or before filing an application for admission.

The Graduate School requires GRE General Test results from all applicants who submit undergraduate narrative transcripts or transcripts containing “pass-no credit (P-N),” “credit,” or other ungraded notations for a substantial number of courses taken during the junior and senior years or whose transcripts do not show a substantial number of letter grades during those years.

For information about the test, contact the Educational Testing Service, CN 6000, Princeton, NJ 08541. Official scores must be sent to the Graduate School office from the testing service.

In 1999, the paper and pencil, three-part format of the GRE General Test (Verbal, Quantitative, and Analytical) will be replaced by a computer-adaptive General Test with five components. These components will include a college-level mathematical reasoning test and a writing test, as well as revised versions of the current Verbal, Quantitative, and Analytical measures. The General Test will be available in two packages: 1) Verbal, Analytical, Writing, and Quantitative Reasoning, and 2) Verbal, Analytical, Writing, and Mathematical Reasoning. Applicants should contact their proposed major program directly to determine which package their program requires.

*Test of English as a Foreign Language (TOEFL) and Michigan English Language Assessment Battery (MELAB)*—The operational standard for admission to the Graduate School is a TOEFL score of 550 or a MELAB score of 80; individual programs may require a higher score. One of these tests is required of all international applicants whose native language is not English, except those who will have completed 24 quarter credits/16 semester credits (within the past 24 months) in residence as a full-time student at a recognized institution of higher learning in the United States before entering the University of

Minnesota. These transfer students, however, may be asked to take locally administered English tests after arrival on campus.

**Foreign Medical Graduate Examination in the Medical Sciences (FMGEMS)**—Applicants seeking admission to graduate study in clinical medical fields whose medical degrees or qualifications were conferred by medical schools outside the United States, Puerto Rico, or Canada must submit certification by the Educational Commission for Foreign Medical Graduates or evidence of a full and unrestricted license to practice medicine issued by a state or other territory under United States jurisdiction that is authorized to license physicians. For more information on certification and the FMGEMS, write directly to the Educational Commission for Foreign Medical Graduates, 3624 Market Street, Philadelphia, PA 19104, U.S.A. or phone 215/386-5900.

**Additional Information**—The Graduate School and individual programs within it reserve the right to request additional information for any case in which it is believed necessary.

### Special Applicant Categories

**University of Minnesota Undergraduates**—University of Minnesota students who have no more than nine quarter credits or two courses to complete for their bachelor's degree (including both distribution and total credit requirements), if they are admitted, may register in the Graduate School to begin a graduate program while simultaneously completing their baccalaureate work.

**Professional Development**—Applicants who wish to enroll in a field in the Graduate School but are not interested in a graduate degree may apply for admission for "professional development coursework." Applicants for professional development courses must complete the usual application materials and meet existing deadlines and admission standards. Because some major fields restrict admission to those planning on pursuing an advanced degree, applicants are advised to consult with the director of graduate studies in

their proposed major field before completing application materials.

**Visiting Graduate Students**—Students who have registered within the previous 24 months in a graduate degree program at another recognized U.S. graduate school and wish to enroll for a summer session or single quarter in the University of Minnesota Graduate School to earn credits to apply toward their degree program may be admitted as visiting graduate students. Applicants must meet the current University of Minnesota entrance standards. They are required to ask the dean of their graduate school to complete the Visiting Student Application (G.S. Form 57) and return it to the Graduate School, University of Minnesota, 309 Johnston Hall, 101 Pleasant Street S.E., Minneapolis, MN 55455. Submission of the application fee and a photocopy of the bachelor's degree transcript is required.

Under no circumstances will students be permitted to register for more than one quarter or summer session as visiting students. Persons originally registering under this status who wish to apply for regular admission must follow the application procedures outlined above.

**Academic Staff**—Members of the University of Minnesota staff holding academic appointments above the rank of instructor or research fellow are normally not permitted to complete a graduate degree at the University. Those who wish to register for courses and transfer them elsewhere may apply for admission for "professional development coursework."

**Committee on Institutional Cooperation Traveling Scholar Program**—The University of Minnesota is a participant in the Traveling Scholar Program for graduate students enrolled in CIC (Committee on Institutional Cooperation) institutions. The 14 participating universities are the members of the "Big Ten," the University of Chicago, the University of Illinois at Chicago, and the University of Wisconsin (Milwaukee).

The program enables doctoral students at any CIC university to take advantage of

educational opportunities—specialized courses, unique library collections, unusual laboratories—at any other CIC university without change in registration or increase in fees. Students may take advantage of these educational opportunities for three quarters or two semesters.

Graduate students interested in graduate course offerings not available at the University of Minnesota should confer first with their major department and major adviser concerning which of the cooperating institutions to select for program enrichment and diversification. Information on procedures for participation in the Traveling Scholar Program is available in the Graduate School Admissions Office, 309 Johnston Hall, or by calling 612/625-9364.

## Assistantships and Fellowships

**Resolution of the Council of Graduate Schools in the United States**—Acceptance of an offer of financial aid (such as a graduate scholarship, fellowship, traineeship, or assistantship) for the next academic year by an enrolled or prospective graduate student completes an agreement that both student and graduate school expect to honor. When a student accepts an offer before April 15 and subsequently desires to withdraw, the student may submit a written resignation for the appointment at any time through April 15. However, an acceptance given or left in force after April 15 commits the student not to accept another offer without first obtaining a written release from the institution to which a commitment was made. Similarly, an offer made by an institution after April 15 is conditional on presentation by the student of a written release from any previously accepted offer. It is further agreed by the institutions and organizations subscribing to this resolution that a copy of the resolution should accompany every scholarship, fellowship, traineeship, and assistantship offer.

**Graduate Assistantships**—Graduate assistantships are academic appointments that are reserved for graduate and professional students. Appointments to teaching assistant,

research assistant, or administrative fellow positions are offered through various departments. A teaching assistant helps in teaching students in a specified course or courses under the general supervision of the academic staff and may be assigned primary responsibility for an entire course. A research assistant carries out activities connected with research studies that are assigned by the supporting department or principal research investigator. An administrative fellow performs duties of a specialized nature connected with academic administration.

*To be eligible to hold one of these appointments, a student must have been admitted to the Graduate School or a professional school and be registered in the Graduate School or professional school each quarter of the appointment; this applies to appointments of any percentage or any number of hours. For more specific information, refer to the Handbook for Graduate Assistants.*

**Benefits**—All graduate assistants holding appointments as teaching assistants, research assistants, and administrative fellows may become eligible for the following benefits:

**Tuition Benefits**—Upon reaching minimum qualification for eligibility (refer to the *Handbook for Graduate Assistants*), students receive a tuition benefit equal to twice the percentage of time worked. For example, a 40 percent appointment includes an 80 percent tuition benefit, which applies only to tuition costs (including the base registration fee). The maximum benefit is 100 percent and applies to a maximum of 12 credits each academic quarter. The tuition benefit does not cover course or student services fees.

**Resident Rate Privilege**—Upon reaching minimum qualification for eligibility (refer to the *Handbook for Graduate Assistants*), students receive a resident rate break, which is credited on the fee statement before the tuition benefit. This privilege applies concurrently to members of the immediate family (spouse or domestic partner, children, and parents).

**Extended Resident Rate Privilege**—When a graduate assistant has completed three qualifying quarters of assistantship (two summer terms count as one quarter), the

resident rate break continues for the number of quarters the appointments were held, up to a maximum of six quarters. This privilege applies also to the student's immediate family. *Note:* For the student and family, this privilege does not extend beyond three years from the termination of the last or most recent qualifying appointment.

Each department sets its own financial aid application deadline. Unless otherwise noted, students should apply by January 15 for appointments for the ensuing academic year; applications received after January 15 are considered for available vacancies.

Graduate assistants are compensated according to a pay range established each year by the University's central administration and approved by the Board of Regents. The current pay range for graduate assistants is available from the department or the Graduate Assistant Office. Graduate students may not hold appointments for which there is no monetary compensation, nor are they allowed to hold appointments for which they receive only course credit or resident tuition rates.

Further information may be obtained from either the head of the department offering the appointment or from the Graduate Assistant Office, which distributes *The Handbook for Graduate Assistants* and the *Grapevine*, a quarterly newsletter for graduate assistants. Copies of the handbook and more information about the assistantship program at the University may be obtained from the Graduate Assistant Office, University of Minnesota, 200 Donhowe Building (first floor for walk-in assistance), 319 15th Avenue S.E., Minneapolis, MN 55455 (612/624-7070; fax 612/625-9801; e-mail [gaoinfo@tc.umn.edu](mailto:gaoinfo@tc.umn.edu)).

**Graduate Assistant Healthcare Plan**—University-subsidized health insurance through Medica is available to most Graduate School or professional school students who hold an appointment as a teaching assistant, research assistant, or administrative fellow (some other fellows and trainees enrolled in the Graduate School are also eligible). For these students, the University pays 50 to 100 percent of the insurance premium during the academic year (fall, winter, and spring quarters), the

percentage depending on the level of appointment. *To receive this coverage, eligible students must apply for it by the end of the second week of classes.* An eligible student's spouse and children may also be enrolled (at the student's expense) in a separate Medica plan. To apply, and for further information, contact the Graduate Assistant Insurance Office, N-323 Boynton Health Service, 410 Church Street S.E., Minneapolis, MN 55455 (612/625-6936).

**General College Assistantships**—Graduate students are eligible to apply for teaching assistantships in the General College in mathematics, natural sciences, social sciences, writing, oral communication, and the humanities. The General College program consists of developmental and general education courses that enable underprepared students to later transfer to degree-granting colleges. Approximately 35 percent of the students in the college are from Asian/Pacific-American, African-American, Native American, and Hispanic ethnic groups.

All graduate teaching assistantships for General College are posted for at least five days in the Graduate Assistant Office, University of Minnesota, 1313 5th Street S.E., Suite 317, Minneapolis, MN 55414 (612/627-1075). Notices of vacancies in General College may also be sent to related academic departments in other University colleges.

**Graduate Fellowships**—Graduate fellowships, awards based on academic merit, are available to new and currently enrolled graduate students. The Graduate School Fellowship Office, 321 Johnston Hall, administers several fellowship programs, described in detail below; a number of individual academic departments also administer field-specific fellowships. Entering students should contact their prospective graduate program. Currently enrolled students should consult the Fellowship Office and their graduate program office for current information on fellowship opportunities. The Fellowship Office also processes applications for several international competitions, such as Fulbright Grants for graduate study abroad.

**Resident Benefit for Graduate Fellows and Trainees**—Graduate students who hold fellowships or traineeships are eligible for resident tuition rates, provided the award is administered by the University and the stipend is at least equal to a 25-percent-time graduate assistantship. This eligibility also extends to members of the immediate family (i.e., parent, spouse, child, or ward). Any changes to this policy will appear in the quarterly *Class Schedule*.

**Fellowships Awarded and Administered Through the Graduate School Fellowship Office**—Awards listed below are subject to change in amounts or cancellation, depending on availability of funds. The following policies govern all awards administered by the Graduate School Fellowship Office:

**Supplementation**—Recipients of any full-support Graduate School awards may concurrently hold an assistantship or other position at 25 percent time or less without reduction in the fellowship stipend. Recipients of full-support awards may not hold other fellowships, scholarships, grants, or similar awards that duplicate the benefits of the fellowship; they may, however, receive additional partial stipends (not administered by the Graduate School) not to exceed the value of a 25-percent-time assistantship. No part of any full Graduate School fellowship may be used to supplement other full support awards.

**Terms of Award**—Graduate School awards may not be renewed, used for summer study (unless specifically designated), or deferred for use in another academic year.

## For New Graduate Students

**GRADUATE SCHOOL FELLOWSHIPS**—Intended for recruiting outstanding new students to the University's graduate programs, these fellowships provide approximately \$12,000 for the academic year plus tuition for up to 12 credits per quarter. Prospective students must be nominated by their chosen major field in early February through procedures announced by the Graduate School during fall quarter. Applicants should contact the director of graduate studies in their major field in advance.

**NORWEGIAN NATIONAL TORSKE KLUBBEN FELLOWSHIP**—See Endowed Fellowships below.

**FELLOWSHIPS AVAILABLE FOR STUDENTS OF COLOR AND DISADVANTAGED STUDENTS**—Because eligibility varies depending on the fellowship, students should contact the appropriate program office to see if they are eligible. Information can also be obtained from the Office of Equal Opportunity in Graduate Studies, 303 Johnston Hall (612/625-6858; e-mail gsoeo@tc.umn.edu).

**Educational Opportunity Fellowship**—Students planning to enter the Graduate School for the first time in the fall quarter are eligible for these one-year fellowships, which provide a stipend of approximately \$11,800 plus tuition and health insurance (fees not included) for the academic year. Departmental support following the fellowship year is included. All applicants must be nominated by the graduate program they plan to enter. About 10 fellowships are awarded by the Graduate School each year.

**Other Available Fellowships**—The availability of other fellowships for graduate students of color changes yearly. They include the Ford Foundation Predoctoral and Dissertation Fellowships for Minorities, the National Science Foundation Minority Graduate Fellowship, the GEM Master's Fellowship, the GEM Ph.D. Engineering and Natural Science Fellowship, the MacArthur Scholars Fellowship, the National Physical Science Consortium Fellowships for Minorities and Women in the Physical Sciences, and others. Contact the Office of Equal Opportunity in Graduate Studies, 303 Johnston Hall, for information. In addition, students of color should check all regular sources of support described in this bulletin.

## For Currently Enrolled Graduate Students

**GRADUATE SCHOOL DOCTORAL DISSERTATION FELLOWSHIPS**—Available to Ph.D. candidates who have completed all degree requirements except the dissertation. The fellowship provides approximately \$12,000 for the academic year plus tuition for thesis credits. Candidates must be nominated by their graduate program through procedures announced by the Graduate School during fall quarter.

**GRADUATE SCHOOL DOCTORAL DISSERTATION SPECIAL GRANTS**—For dissertation research expenses for students who have passed preliminary written and oral examinations by the end of the quarter in which they apply. Deadlines: May and December. Up to \$1,500.

**ENDOWED FELLOWSHIPS**—Not all fellowships listed below are offered every year. Stipends are approximate and may vary from year to year. Deadlines for application are generally in early March unless otherwise indicated. Contact the Graduate School Fellowship Office for current information and application procedures.

**Alexander P. Anderson and Lydia Anderson Fellowship**—For students who have completed either a bachelor's or master's degree at the University of Minnesota in the plant and animal sciences, e.g., agronomy, ecology, forestry, genetics, horticulture, plant breeding, plant pathology, and zoology. May be used for study or research in summer or during the academic year. Up to \$3,000.

**Charles J. Brand Fellowship**—Offered to graduate students doing study or research in the botanical sciences. About \$9,000 plus tuition.

**Carolyn M. Crosby Fellowship**—Available to graduate students or, in rare instances, undergraduates engaged in field-based botanical investigation. May be used for independent field research or study at Lake Itasca Forestry and Biological Station or other similar facility. Up to \$3,000.

## GENERAL INFORMATION

**Norman Johnston DeWitt Fellowship**—For an advanced graduate student in the humanities. About \$9,000 plus tuition.

**Louise T. Dosdall Fellowship in Science**—For women graduate students in any field of the natural and physical sciences who show exceptional promise for a successful career in research. About \$9,000 plus tuition.

**Grants for Research Abroad**—Available to graduate students who are U.S. citizens or permanent residents for research abroad. Preference to doctoral students for dissertation research. Supported in part by private foundations. Up to \$4,000.

**Stanwood Johnston Memorial Fellowship**—For promising graduate students in geology, geophysics, physics, chemistry, biochemistry, or microbiology. About \$9,000 plus tuition.

**Harold Leonard Memorial Fellowship in Film Study**—Open to graduate students proposing a year of well-defined research or study in film history, criticism, theory, or aesthetics. About \$9,000 plus tuition.

**Harold Leonard Memorial Film Study Grants**—For graduate or undergraduate students in good standing at the University of Minnesota for specific research expenses in film history, criticism, or aesthetics. Up to \$3,000.

**Eva O. Miller Fellowship**—For graduate students in the broad areas of psychology or statistics and measurement who are engaged in research. Projects may include, but are not limited to, the study of individual differences and cognitive aspects of measurement. About \$9,000 plus tuition.

**Norwegian National Torske Klubben Fellowship**—Available to Norwegian nationals, both new and continuing students, for one year of graduate study at the University of Minnesota. Approximately \$7,500 for the academic year supplemented by a tuition scholarship.

**Shevlin Fellowship**—For graduate students in the biological and agricultural sciences, basic physical and medical sciences, and liberal arts. Relevant graduate programs may nominate one student. About \$9,000 plus tuition.

**William W. Stout Fellowship**—Open to graduate students in the humanities or social sciences who are in the intermediate years of the Ph.D. Relevant graduate programs in which the Ph.D. is offered as a major may nominate one student. About \$9,000 plus tuition.

**Torske Klubben Fellowship to Norway**—For a University of Minnesota graduate student for up to nine months of study or research in Norway. Up to \$7,500 for the year.

**Thomas F. Wallace Fellowship**—Open to graduate students in the humanities or social sciences who are in the intermediate years of the Ph.D. Relevant graduate programs in which the Ph.D. is offered as a major may nominate one student. About \$9,000 plus tuition.

**Woman's Club of Minneapolis Fellowship**—Available to a graduate student with high scholarship and leadership qualifications. Must be U.S. citizen. Special consideration given to candidates who are planning to remain in the metropolitan area. \$2,200.

**Fellowships and Scholarships Awarded and Administered Through Academic Departments**—*See the end of this General Information section for a listing by department.*

## Office of Equal Opportunity in Graduate Studies

This office (303 Johnston Hall; 612/625-6858; e-mail [gsoeo@tc.umn.edu](mailto:gsoeo@tc.umn.edu)) provides prospective students of color and disadvantaged students with information on graduate education. It assists students with the admissions process and identifies financial aid sources. The office also administers fellowships and initiatives that focus on retention and graduation.

**Resident Tuition Benefit**—In keeping with the University's goal to increase the diversity of its student body, nonresident graduate students of color and disadvantaged students are eligible for resident tuition rates. To be eligible, a student of color must have an undergraduate GPA of 3.00 or above, be a member of an ethnic minority group, and be a U.S. citizen or permanent resident. To be eligible under disadvantaged status, a student must fall within the federally set poverty guidelines. When admitted to the Graduate School, eligible students should submit a letter requesting resident rates, along with a copy of their undergraduate transcript, to the Office of Equal Opportunity in Graduate Studies.

## Orientation to the Twin Cities Campus

Designed to ease graduate students' transition to the University, Graduate Student Orientation (GSO) provides information about University policies and services in an atmosphere in which graduate students can meet each other. GSO also conducts writing and library research workshops in the fall. All incoming graduate students (except those with foreign addresses) are mailed a brochure outlining GSO's schedule; F1 and J1 visa students receive information from International Student and Scholar Services, 612/626-7100. For more information and additional copies of

the brochure, contact the program coordinator, Graduate Student Orientation, New Student Programs Office, University of Minnesota, 324 Coffman Memorial Union, 300 Washington Avenue S.E., Minneapolis, MN 55455 (612/624-0666).

In addition to this University-wide orientation service, many graduate programs offer orientation information specifically for graduate students in their respective fields. For more information, students should contact the director of graduate studies in their major field.

## Council of Graduate Students

The Council of Graduate Students (COGS) is the official governing body representing graduate students at the University. COGS provides opportunities for graduate students to participate actively in University and Graduate School administrative and policy decisions. Graduate students in each degree-granting program are entitled to elect one representative to serve on COGS, which also recruits student representatives for the Graduate School Policy and Review Councils, the University Senate, and many College of Liberal Arts and University-wide committees. In addition, COGS assists in providing ombudsman services for graduate students and disseminates information, primarily through the *Gradletter* and through general meetings held twice per quarter. Information on University governance and grievance procedures is available from the COGS office.

Students may contact COGS at University of Minnesota, 405 Johnston Hall, 101 Pleasant Street S.E., Minneapolis, MN 55455 (612/626-1612; e-mail [cogs@tc.umn.edu](mailto:cogs@tc.umn.edu)).

## Preparing Future Faculty

Preparing Future Faculty (PFF), formerly the Teaching Opportunity Program for Doctoral Students (TOPDS), welcomes graduate and postdoctoral participants from all disciplines. PFF helps participants acquire information about the teaching and learning process and the role of faculty at a variety of higher education institutions; gain a realistic perspective on the

skills required for success as a faculty member; examine their fit with a teaching career in higher education; work with a faculty mentor in a teaching opportunity at the University of Minnesota-Twin Cities or at a regional college or university; demonstrate, document, and reflect upon their teaching skills; and market themselves for faculty or other professional positions.

To receive a letter of recognition and certificate of program participation from the Graduate School, participants must complete Grad 8100—Teaching in Higher Education and Grad 8150—Practicum for Instructors in Higher Education. Grad 8200—Presentation and Verbal Interaction Skills for the Future Professoriate is an optional course. Some graduate programs may have additional requirements for doctoral students participating in PFF. Other courses for credit in higher education teaching may be recognized by PFF as substitutes for Grad 8100 or Grad 8150. Completion of an enrollment interview before the beginning of the term is required for admittance to the program.

PFF is a program of the Graduate School, funded by the Bush Foundation and administered through the Teaching Enrichment Programs of the Office of Human Resources. The PFF office is located in the University Technology Center, Suite 228, 1313 5th Street S.E., Minneapolis, MN 55414. For information on program enrollment, contact the PFF program assistant at 612/627-4040 or [pff@tc.umn.edu](mailto:pff@tc.umn.edu), or visit <http://www.umn.edu/ohr/pff/pff.html>.

## Registration

The Graduate School operates on a quarter system, with registration ordinarily beginning about six weeks before the opening of the term. Courses are also offered in a variety of fields during two summer terms of five weeks each (two terms per summer session).

New graduate students must receive notification of admission from the Graduate School before attempting to register. New graduate students may register any time during the registration period (see below). Previously registered graduate students must follow the registration queue published in the quarterly *Class Schedule*.

## GENERAL INFORMATION

Postdoctoral scholars who wish to register in the Graduate School should contact the Graduate School, 316 Johnston Hall.

**Registration Deadlines**—All graduate students must register before the start of classes to avoid a late registration fee. Friday of the second week of the quarter is the last day to register during fall, winter, and spring quarters. Exceptions to these deadlines will be considered only by written request to the Graduate School; such requests are not routinely granted. For University calendar and registration information and the University-wide policy governing cancel/adds, refer to the quarterly *Class Schedule*. For information about summer terms, including registration deadlines, refer to the *Summer Session Bulletin*.

**Registration Requirements**—Registration requirements for the various graduate degrees are specified in the subsections on degree requirements in this bulletin. Most graduate students are enrolled full time every quarter. In addition, the following requirements apply as appropriate.

1. To maintain their active status, *graduate students must at minimum register once every year*. Those who do not register in the Graduate School at least once per year are considered to have withdrawn; their Graduate School records are deactivated. Deactivated students may not register for courses, take examinations, submit degree program or thesis proposal forms, file for graduation, or otherwise participate in the University community as Graduate School students. Those who wish to resume graduate work must request readmission to the Graduate School (see Readmission and Other Changes below) *and, if readmitted, must register in the Graduate School for the quarter of readmission* to regain their active status. See Registration Deadlines above.

Graduate students who *have* registered within the past year need not register for the sole purpose of taking final written or oral examinations for the master's degree or specialist certificate, or preliminary written, preliminary oral, or final oral examinations for the doctorate.

2. Graduate students holding appointments as teaching assistants, research assistants, or administrative fellows must be registered each quarter of their appointment; this applies to appointments of any percentage or any number of hours. See Graduate Assistantships under Assistantships and Fellowships above for more information.

3. Each individual enrolled in a clinical residency or post-M.D. graduate training program sponsored by the University of Minnesota and directed by a clinical department of the Medical School is required to register either as a medical fellow in the Graduate School or as a medical fellow specialist in the Medical School.

4. Students receiving other types of financial aid from the University or from other agencies, international students with certain types of visas, and students who wish to use various University services and facilities may have specific registration requirements; these students are responsible for obtaining information about such requirements from the appropriate offices.

**Varieties of Registration**—There are two kinds of registration.

1. *Registration for Coursework*—Graduate students may register for no more than 18 credits during any single fall, winter, or spring quarter. The maximum registration permitted during a single summer term is 11 credits.

2. *Thesis Credit Registration*—Students completing a Plan A master's thesis or a professional master's degree in engineering, design project track, are required to enroll for a minimum of 16 master's thesis credits (8777) before receiving the degree. Students completing a doctoral degree are required to enroll for a minimum of 36 doctoral thesis credits (8888) before the final oral examination can be scheduled.

Some students who were first registered in the Graduate School before fall quarter 1983 may have their thesis credit requirement reduced or eliminated. Contact the Graduate School, 316 Johnston Hall, for more information.

**Changes in Registration**—During fall, winter, and spring quarters, Friday of the second week of the quarter is the last day to add a course or

change sections of a course, change grading option (including to or from auditor status), or cancel a course without a “W” (indicating withdrawal) appearing on the student’s transcript.

Students may *cancel* courses through Friday of the sixth week of the quarter; canceling courses after the sixth week requires the signature of both the adviser and the instructor, as well as Graduate School approval. For University calendar and registration information and the University-wide policy governing cancel/adds, refer to the quarterly *Class Schedule*. For information about summer terms, including registration deadlines, refer to the *Summer Session Bulletin*.

Students are not permitted to change their registration after the last day of instruction of a quarter and are not permitted to register for previous quarters.

**Registration Holds**—Students who maintain active registration are reminded by the Graduate School to file official degree program and thesis proposal forms at times defined by the faculty of their major field (e.g., after a certain number of credits or quarters of registration). Those who fail to do so may have holds placed on their registration by the director of graduate studies. Registration holds may also be placed on students who fail to meet the standards for academic achievement and degree progress defined by their major field.

Registration holds can also be placed by other University units, such as the University Libraries and Student Accounts Receivable. Students must contact the specific unit for instructions on how to clear such holds.

To register for a particular quarter, students must clear any outstanding registration holds before the end of the regular registration period for that quarter. After this period, even when holds are cleared, requests to register are not routinely granted.

## Readmission and Other Changes

Requests for readmission, change of major or degree objective, or change of campus within the Graduate School should be made on the Change of Status/Readmission Request form (G.S. Form 72), available from the Graduate School Admissions Office, 309 Johnston Hall. Payment of a \$40 fee must accompany the form.

**Readmission**—To maintain their active status, *graduate students must at minimum register once every year*. Previously registered students who do not register in the Graduate School of the University of Minnesota at least once per year will be considered to have withdrawn and must apply for readmission in order to resume graduate work.

**Change of Major or Degree Objective**—Students currently enrolled in the Graduate School who intend to change either their major or their degree objective from that originally approved by the Graduate School should request a change of status. Students who have already been awarded a degree in the Graduate School must request a change of status if they wish to pursue another degree.

**Change of Campus**—Students currently enrolled in the Graduate School on one campus who wish to complete their studies on another campus should request a change of status. Graduate study is currently available on the Twin Cities campus and on the Duluth campus.

## Grading System

The Graduate School uses two grading systems: A-B-C-D-F and S-N. Students have the option of choosing the system under which they will be graded, except in courses in which grading has been restricted to one system with approval of the Graduate School. Only 5xxx and 8xxx courses with grades of A, B, C, and S may be applied to a Graduate School degree program. Students pursuing a Plan A master’s degree or a doctoral degree are required to register for thesis credits (8777 and 8888 respectively); these registrations are not graded and therefore cannot be used to meet course credit

requirements. At least two-thirds of the total number of course credits included on any degree program must be taken under the A-F system. Individual major fields have the option of specifying more stringent requirements regarding the application of S-N courses to a degree program.

Students must declare their choice of grading system as part of their initial registration. Any changes in grading option must be made as an official registration change no later than Friday of the second week of the quarter during the academic year (refer to the *Summer Session Bulletin* for summer term deadlines for changing the grading option).

For information about courses in which grading is restricted, students should consult the department offering the course (see also Minimum Grade Requirements under Master's Degree or under Doctor of Philosophy Degree below).

**Incomplete Grades**—The symbol “I” may be assigned by an instructor to indicate “incomplete,” in accordance with provisions announced in class at the beginning of the quarter, when in the instructor’s opinion there is a reasonable expectation that the student can successfully complete the work of the course. An “I” remains on the transcript until the instructor replaces it with a final A-F or S-N grade. Course instructors may, at their discretion, establish a time limit for the removal of incomplete grades. The maximum number of credits of incompletes allowable at any given time is established by each major field for its graduate students. Students should refer to the Graduate School’s Web site (<http://www.grad.umn.edu>) for further information.

**Retaking Courses**—The Graduate School discourages the retaking of courses to improve grades. If a course is retaken, all registrations and grades for the course remain on the student’s transcript and are calculated into the cumulative GPA.

**Grade Changes**—To preserve the integrity of the graduate transcript as an accurate record of a student’s academic progress, the Graduate School does not approve requests to change final grades assigned to students in prior quarters.

## Credit Hour Definition

The credit hour, as defined by the University of Minnesota Senate, is equivalent to three hours of work by the student per week. “Work” includes time spent in class, in the laboratory, and in outside preparation. Independent study courses, workshops, clinics, and practicums are also assigned credit on this basis. One quarter credit, then, involves three hours of student work per week for ten weeks, or thirty hours total.

## Student Transcripts and Other Records

The Office of the Registrar of the University maintains and releases the *official* University of Minnesota student transcript. Requests may be submitted in person or in writing, accompanied by the appropriate fee, to the Transcript and Certification Service, University of Minnesota, 150 Williamson Hall, 231 Pillsbury Drive S.E., Minneapolis, MN 55455 (call 612/625-5333 for current fee). Fax requests, which must be paid by credit card, may be sent to either 612/625-4351 (Minneapolis campus) or 612/624-4943 (St. Paul campus).

An *unofficial* copy of the transcript may be obtained at no charge by presenting a picture ID at 150 Williamson Hall or 202 Fraser Hall (East Bank campus) or at 130 Coffey Hall (St. Paul campus), with a limit of one per day.

The Graduate School also maintains records of students who have been admitted and enrolled. In accordance with regents’ policy on access to student records, students are permitted to review their educational records and to challenge the contents of those records. For information, students should contact the Graduate School, 316 Johnston Hall.

## Satisfactory Progress Toward the Degree

In addition to fulfilling the Graduate School requirements described in this bulletin, students should consult their major program’s graduate studies handbook for program-specific criteria for satisfactory progress toward their degree.

## Termination of Graduate Student Status

When performance is unsatisfactory in terms of grades or normal progress toward the student's degree objective, graduate student status may be terminated. All guidelines stated in this bulletin are minimal requirements, and each program is free to set more specific terms by which progress is measured for purposes of continuation. Students are encouraged to check with the director of graduate studies in their major field for complete information about academic performance and degree progress standards and the procedures used to monitor these standards.

Students who do not register in the Graduate School at least once per year are considered to have withdrawn; their Graduate School records are deactivated (see Registration Requirements above).

## Master's Degree

The master's degree is awarded in recognition of academic accomplishment as demonstrated by a coherent program of coursework, passing of the required examinations, and the preparation of a thesis or projects.

**Two Plans for the Master's Degree**—The Graduate School offers the master's degree under two plans: Plan A, requiring a thesis, and Plan B, which substitutes additional coursework and special projects for the thesis. For plans offered in each major, consult the Graduate Programs section of this bulletin.

**Registration Requirement for the Master's Degree**—Master's degree students are required by the Graduate School to complete at least 60 percent of the coursework for their official degree programs (excluding thesis credits) as registered University of Minnesota Graduate School students; individual major fields may require a higher percentage. With the approval of the adviser, the director of graduate studies in the major (and the director of graduate studies in the minor, if the courses are for a designated minor), and the Graduate School, transfer coursework may make up the remaining 40 percent (maximum) of the degree coursework (see Transfer of Credits below).

Master's Plan A students are required to enroll for a minimum of 16 thesis credits (8777) before receiving the degree.

**Double Counting**—Students may have a maximum of 9 credits in common between two Plan A master's degrees or a maximum of 12 credits between two Plan B master's degrees or between a Plan A and Plan B master's degree.

### Transfer of Credits for the Master's Degree

—Unless otherwise specified under a student's major in Graduate Programs, the following rules apply to transfer of credits.

Master's degree students are required by the Graduate School to complete at least 60 percent of the coursework for their official degree programs (excluding thesis credits) as registered University of Minnesota Graduate School students. With the approval of the adviser, the director of graduate studies in the major (and the director of graduate studies in the minor, if the courses are for a designated minor), and the Graduate School, the transfer of up to 40 percent of the degree program coursework from any combination of the following is permitted:

1. Other recognized graduate schools;
2. Adult Special, Summer Session, and Continuing Education and Extension (renamed University College) registrations at the University of Minnesota.

In all cases, official transcripts of the work must be attached to the degree program form, unless they have already been included in the student's Graduate School file.

Individual graduate programs have the option of specifying a lower percentage of coursework for transfer.

The work to be transferred must be graduate level (postbaccalaureate), must have been taken for graduate credit, and must have been taught by faculty members authorized to teach graduate courses. Credits transferred from other institutions must in addition have been taken as an enrolled, graduate-degree-seeking student and must appear on official graduate school transcripts of the institutions. University of Minnesota courses taken in Continuing Education and Extension (renamed University College) must bear the special CEE or UC transcript entry verifying that they were completed for graduate credit.

In the case of a transfer from a non-U.S. institution, the credits must have been earned in a program judged by the Graduate School to be comparable to a graduate degree program in a graduate school of a regionally accredited institution in the United States.

*Regarding the transfer of coursework from either a U.S. or non-U.S. institution, if conditions are placed on a student's admission to exclude certain coursework from transfer to a Graduate School degree program, that coursework may not be transferred regardless of the level of the coursework or the status of the school or college in which it was earned.*

The transfer of credits is accomplished by the inclusion of the courses on the proposed degree program. Credits that are not accepted as part of a student's degree program cannot be transferred to the Graduate School transcript.

*Courses completed through independent (correspondence) study, completed through extension or special categories at other institutions, or taken before the awarding of a baccalaureate degree cannot be transferred.*

**CEE/UC Tuition Differential**—For all coursework taken fall 1980 or later in Continuing Education and Extension (renamed University College) and then transferred to a graduate degree program, students will be billed by University College for the difference between the CEE or UC rate and the Graduate School rate in effect at the time the credits were taken.

**Time Limit for Earning the Master's Degree**—All requirements for the master's degree must be completed and the degree awarded within seven years. The seven-year period begins with the earliest work included on the official degree program, including any transfer work. The graduate faculty in a specific program may set more stringent time requirements.

Students who are unable to complete the degree within the seven-year limit may petition the Graduate School for an extension of up to one additional year. *Extensions beyond one year are considered only in the most extraordinary circumstances.* Contact the Graduate School, 316 Johnston Hall,

concerning information to be included in such a petition. To ensure timely consideration, petitions should be filed early in the quarter in which the time limit expires.

If a petition is approved, the student is notified of the expectations for progress and completion of the degree. If the petition is denied, the student is terminated from the graduate program.

Students who have been terminated under such circumstances may apply for readmission to the Graduate School; *readmission under these circumstances is not assured, however.* The faculty in the major field and the Graduate School would set any readmission conditions on the student's resumption of work toward the degree, such as registering for additional coursework, retaking written examinations, completing the degree within a specified time period, or other appropriate terms.

**Official Program for the Degree**—By the time students have completed 15 credits, and ordinarily not later than the third quarter of registration (the second year for the longer programs), they must file with the Graduate School an official program for the degree. The degree program form is available from the Graduate School, 316 Johnston Hall. Students list all coursework, completed and proposed, that will be offered in fulfillment of degree requirements, including transfer work (see Transfer of Credits above). If a foreign language is required for the degree, it also is specified on the degree program form. If the degree is being completed under Plan A, students include the proposed thesis title. *The members of a student's final examining committee (who are the thesis reviewers for Plan A) are appointed by the dean of the Graduate School on recommendation of the faculty in the major field at the time the student's official degree program is approved.*

The minimum credit requirements for the program are specified under the Plan A and Plan B sections below.

A degree program approved by the Graduate School must be on file before reviewers report, examination, or graduation forms can be released to the student.

**Official Program for the Degree in the Clinical Medical Fields**—Students are expected to file an official program for the degree, including the proposed thesis title, before the end of the second year of registration. Approval by the faculty in the major field and by the Graduate School indicates a student's admission to candidacy for the degree. Students should include on the official program forms only the minimum number of credits actually required for the award of the degree, rather than the full complement of credits taken during the course of the residency program.

**Changes in the Approved Program**—Once approved, the degree program must be fulfilled in every detail to meet graduation requirements. Changes in the program that are found necessary or desirable should be requested by completing a Graduate School petition form.

**Minimum Grade Requirements**—*The Graduate School requires a minimum GPA of 2.80 (on a 4.00 scale) for courses included on any official master's degree program. Courses with grades of A, B, C, and S may be included in the official degree program, but grades of S are not calculated in the GPA. Students pursuing a Plan A master's degree are required to register for thesis credits (8777); these registrations are not graded and therefore cannot be used to meet course credit requirements. At least two-thirds of the course credits included on any degree program must be taken A-F.*

Individual major fields have the option of setting higher grade requirements and specifying more stringent requirements regarding the application of S-N courses to a degree program; students should be familiar with any special requirements in their major field.

**Language Requirement**—See Graduate Programs to determine the language requirement, if any, for a specific major field. The Graduate School monitors the fulfillment of language study when a major field requires a language. Information on how to demonstrate proficiency, and on the conditions under which proficiency will be recorded on the official transcript, is available from the Graduate School, 316 Johnston Hall.

**Use of Human or Animal Subjects in Research**—All research on the Twin Cities, Duluth, Morris, and Crookston campuses that involves the use of human or animal subjects must be reviewed and approved before initiation by the Institutional Review Board: Human Subjects Committee (IRB) or the Institutional Animal Care and Use Committee (IACUC). This policy, approved by the University Senate and Board of Regents, applies to funded and nonfunded faculty, staff, and student research. All research, including Plan B projects, theses, and dissertations, that involves human or animal subjects must be approved by the appropriate committee to ensure that the rights and welfare of the subjects are protected. For more information, contact the Research Subjects Protection Office, University of Minnesota, Box 820 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (612/626-5654; fax 612/626-6061).

**Clearance for Graduation**—Degrees are awarded at the end of each month. To qualify for graduation for a particular month, students must submit the Application for Degree form on or before the first workday of that month and must complete the final examination and all other requirements (including submission of all necessary forms) by the last workday of that month.

**Commencement Ceremony**—Two Graduate School commencement ceremonies are held each year—in *late spring* (for January through June graduates) and in *late fall* (for July through December graduates). Graduates are encouraged, but not required, to attend. To make sure their names appear in the program distributed at the commencement ceremony, students must submit the commencement attendance form, signed by their adviser and director of graduate studies, by the deadline specified in the Graduate School section of the *Class Schedule*.

**Further Information**—Students who have questions about the master's degree after reading this entire section (including the following on Plan A and Plan B) may contact the Graduate School by e-mail (gsmast@tc.umn.edu). *Note:* Some commonly used forms are available on the Graduate School Web site.

## Plan A: Master's Degree with Thesis

**Minimum Credit Requirements**—Students must complete an approved program of coursework consisting of a minimum of 20 quarter credits in the major field and a minimum of 8 quarter credits in one or more related fields outside the major. All credits included in the official degree program must be in graduate-level courses. A minimum GPA of 2.80 must be maintained for all courses included on the program. Students are also required to register for a minimum of 16 master's thesis credits (8777); these registrations are not graded and therefore cannot be used to meet course credit requirements.

Students who wish to complete a designated minor (which is certified on the transcript—unlike the related fields option, which is not) must complete 9 or more quarter credits in a single field. A designated minor must be approved by the director of graduate studies in the minor field.

For majors in clinical branches, the minor or related fields must be in nonclinical fields that will serve as a basis for the proposed clinical specialization. This fundamental work should be taken early in the program. Familiarity with those phases of the nonclinical disciplines essential to proficiency in the major specialty is required.

**Thesis Credits**—Students must enroll for a minimum of 16 master's thesis credits (8777) before receiving the degree. Students cannot include thesis credits in the total program credits when determining maximum transfer allowed (see Transfer of Credits above). They also cannot transfer thesis credits from other graduate institutions, double-count thesis credits between two master's degrees, or use thesis credits to meet the minimum major and related field coursework requirements for the degree.

Some students who were first registered in the Graduate School before fall quarter 1983 may have their thesis credit requirement reduced or eliminated. Contact the Graduate School, 316 Johnston Hall, for more information.

## Master's Thesis

Students must demonstrate familiarity with the tools of research or scholarship in their major field, the ability to work independently, and the ability to present the results of their investigation effectively, by completing a master's thesis.

**Thesis Title**—The thesis title is submitted for approval as part of the information provided on the student's official degree program form. Subsequent changes *in the wording of the thesis title only* may be made without special approval. However, once the student registers the thesis title with the Graduate School (see Registration of the Thesis Title below), changes to the title should not be made.

**Language of the Thesis**—Theses must normally be written in English or in the language of instruction. *If a thesis is to be written in a foreign language, including a language of instruction other than English, a letter should be attached to the degree program form when it is submitted to the Graduate School.* This letter should confirm that the recommended thesis reviewers (including the outside reviewer) are qualified to read, comprehend, and criticize a thesis in the foreign language.

**Published Work Included in or in Lieu of the Thesis**—The thesis may include materials that students have published while University of Minnesota graduate students, provided the research was carried out under the direction of the graduate faculty and approved by the adviser for incorporation into the thesis. Such publication is welcomed as the best demonstration of quality in a student's research, and the Graduate School encourages the practice. The adviser should notify the Graduate School in writing of the intention to publish part of the thesis material, but the Graduate School's approval is not required.

In cases where the thesis research is to be presented to the examining committee in the form of one or more articles that have been published, or are in a form suitable for publication, the student should contact the Graduate School, 316 Johnston Hall, for information on accommodating such a presentation to the required thesis format.

**Registration of the Thesis Title**—When the draft of the thesis is ready to be distributed to the thesis reviewers, the student must register the *title* with the Graduate School, 316 Johnston Hall, by submitting a copy of the thesis title page as it will appear in the final document. Upon submission of the thesis title page, the Graduate School confirms that the degree program has been approved by the Graduate School and that the student has maintained active status (see Registration Requirements under Registration above). If so, the student is provided with the thesis reviewers report form and the other forms and information necessary to graduate.

**Thesis Reviewers**—The thesis is read by the entire examining committee, which is appointed by the dean of the Graduate School on recommendation of the faculty in the major field at the time the student's official degree program is approved. This examining committee consists of at least three members: two representatives from the major field and one from the minor or a related field.

*To permit faculty to allocate sufficient time to read the thesis and decide whether it is ready for defense, students must notify their adviser and other members of the final oral committee at least two weeks in advance that the thesis will be delivered on a particular date. All members of the examining committee must then have at least two weeks to read the thesis after it has been delivered.* These are minimum standards; individual programs may establish other standards for their students.

The entire committee must be unanimous in certifying that the thesis is ready for defense, as indicated by their signatures on the thesis reviewers report form. When the signed form is returned to the Graduate School, 316 Johnston Hall, the student is provided with the final examination report form.

**Final Examinations**—Candidates for the master's degree, Plan A, must pass a final oral examination; a final written examination may also be required at the discretion of the graduate faculty in the major field. If both a written and an oral examination are specified, the written examination must precede the oral examination. The final examinations cover the major field and the minor or related fields, and

may include any work fundamental to these fields. The final oral for the master's degree is conducted as a closed examination, attended by only the student and the examining committee.

Final examinations are coordinated by the chair of the student's examining committee. All committee members must be present at the examination; *the absence of any member results in an invalid examination.* The results of the examinations are reported to the Graduate School on the final examination report form. *A majority vote of the committee, all members present and voting, is required to pass the examination.* A student who fails the examination may be terminated from the graduate program or may be allowed, on unanimous recommendation of the examining committee, to retake the examination, *providing the reexamination is conducted by the original examining committee.*

**Changes in the Examining Committee**—Substitutions on the examining committee may be necessitated by such circumstances as a faculty member's temporary absence on leave from the University. The adviser or the director of graduate studies must request the Graduate School's approval of such substitutions well in advance of the examination. *Substitutions for an oral examination that are necessitated by emergency situations must also be approved in advance. In such cases, the adviser should consult with the Graduate School staff by telephone before the start of the examination.*

**Preparation and Submission of the Thesis**—Two copies of the thesis must be submitted to the Graduate School. *The student's adviser(s) must sign both copies of the thesis to confirm that they are complete and satisfactory in all respects and that all revisions required by the final examining committee have been made.* Instructions for the preparation of the thesis, including format specifications and adviser's signature requirements, should be obtained from the Graduate School, 316 Johnston Hall.

Plan B:  
Master's Degree Without Thesis

**Minimum Credit Requirements**—Students must complete an approved program of coursework consisting of a minimum of 20 quarter credits in the major field and a minimum of 8 quarter credits in one or more related fields outside the major. The balance of the credits to be completed to meet the 44-credit minimum requirement for the degree is chosen by agreement between the adviser and the student, subject to whatever restrictions the graduate faculty in the major field may place on that choice. All credits included in the official degree program must be in graduate-level courses. A minimum GPA of 2.80 must be maintained for all courses included on the program.

Students who wish to complete a designated minor (which is certified on the transcript—unlike the related fields option, which is not) must complete 9 or more quarter credits in a single field. A designated minor must be approved by the director of graduate studies in the minor field.

**Plan B Project(s)**—Students must demonstrate familiarity with the tools of research or scholarship in their major field, the ability to work independently, and the ability to present the results of their investigation effectively, by completing at least one Plan B project. The graduate faculty in each major field may require as many as three such projects.

The Plan B project(s) should involve a combined total of approximately 120 hours (the equivalent of three full-time weeks) of work. The graduate faculty in each major field specifies both the nature and extent of the options available to satisfy this requirement, and whether the requirement is to be satisfied in conjunction with or independent of the courses in the student's program.

**Final Examinations**—The Graduate School requires a final examination for Plan B candidates; this may be written, oral, or both, at the discretion of the graduate faculty in the major field. The final examinations cover the major field and the minor or related fields, and may include any work fundamental to these fields. Students should make the Plan B project(s) available to the examining committee

for its review well in advance of the final examination. If a final oral is held, it is conducted as a closed examination, attended by only the student and the examining committee. All committee members must be present at the oral examination; *the absence of any member results in an invalid examination.*

A committee of at least three examiners is appointed by the dean of the Graduate School upon recommendation of the faculty in the major field at the time the official degree program is approved. This committee consists of two representatives from the major field and one from the minor or a related field. The examination is coordinated by the chair of the student's examining committee. The results of the examination are reported on a form the student must obtain from the Graduate School, 316 Johnston Hall, before the examination is held. To obtain this form, the student must have on file a degree program approved by the Graduate School and must have maintained active status (see Registration Requirements under Registration above). *A majority vote of the committee, all members present and voting, is required to pass the examination. A student who fails the examination may be terminated from the graduate program or may be allowed, on unanimous recommendation of the examining committee, to retake the examination, providing the reexamination is conducted by the original examining committee.*

**Changes in the Examining Committee**—Substitutions on the examining committee may be necessitated by such circumstances as a faculty member's temporary absence on leave from the University. The adviser or the director of graduate studies must request the Graduate School's approval of such substitutions well in advance of the examination. *Substitutions for an oral examination that are necessitated by emergency situations must also be approved in advance. In such cases, the adviser should consult with the Graduate School staff by telephone before the start of the examination.*

## Master of Architecture

See Architecture under Graduate Programs for requirements.

## Master of Business Taxation

See Business Administration under Graduate Programs for requirements.

## Professional Master's Degree in Engineering

A number of engineering departments offer programs, with emphasis on design methods, leading to a designated professional master of engineering degree. The design emphasis of the program is on applications rather than on development of engineering methods or material behavior, and on application of knowledge and methods of the physical and social sciences as well as of engineering. The programs are designed primarily for students who have already earned a bachelor's degree in a related engineering field. Students normally are expected to be recent graduates of bachelor of science in engineering programs accredited by the Engineers' Council for Professional Development (ECPD). Full-time students should be able to complete a program in one calendar year. The professional master's degree in engineering is considered a terminal degree. Students should also note that only under exceptional circumstances will the Graduate School and the participating programs permit students to transfer from this program to an M.S. program.

**Fields in Which the Program is Offered**—Refer to the appropriate engineering department sections under Graduate Programs for information about the fields in which the professional master of engineering program is offered.

Regular Graduate School application procedures should be followed. Applicants should designate the master of engineering as their degree objective, to distinguish it from the master of science degree also available in the engineering fields.

**Two Tracks for the Professional Master's Degree in Engineering**—The Graduate School offers the professional master's degree in engineering under two tracks, depending on the major field: a design project track and a coursework only track.

*Design Project Track*—This track requires 20 quarter credits in the major field, a minimum of 8 credits in one or more related fields outside the

major, and a design project measured as a minimum of 16 credits. Students who wish to complete a designated minor must complete 9 or more quarter credits in a single field. The design project stresses problem solving based on engineering design criteria extant in industry. Performance of professional caliber is expected which can be subjected to the scrutiny and critique of senior design engineers in industry as well as engineering faculty members.

*Coursework Only Track*—This track requires a minimum of 44 quarter credits distributed to include 20 credits in the major field, a minimum of 8 credits in one or more related fields outside the major, and the remaining credits to be determined by the student and adviser subject to whatever guidelines the graduate faculty in the major field may place on such elective choices. Students who wish to complete a designated minor must complete 9 or more quarter credits in a single field. No projects or papers specific to this track are required.

**Final Examinations for the Two Tracks**—The design project track requires a final oral examination focused on the design project itself and involving a three-person faculty committee. For the coursework-only track, students should confer with their director of graduate studies about the final examination.

## Master of Fine Arts

**Prerequisites**—Admission to master of fine arts programs is limited to students with the bachelor's degree or its equivalent from an accredited university or college who demonstrate exceptional promise as creative artists in one or more of the subfields in their major area. For a list of the subfields, see Art and Theatre Arts under Graduate Programs.

**Course Requirements**—For specific program requirements, see Art, Creative Writing (see English), and Theatre Arts under Graduate Programs. *Note:* Creative project and final examination requirements for Creative Writing differ from the following. Contact the Department of English for details.

A degree program approved by the Graduate School must be on file before exhibit report, examination, or graduation forms can be released to the student.

**Creative Project**—Students must complete a creative project (production or exhibition) accompanied by a supporting paper that deals with the project’s planning or execution. Those pursuing a master of fine arts in art must obtain an Exhibit Report form and an Examination Report form from the Department of Art. After securing the appropriate signatures on these forms, return them immediately to 316 Johnston Hall.

**Final Examinations**—The Graduate School requires a final examination for the master of fine arts degree; this may be written, oral, or both, at the discretion of the graduate faculty in the major field. The final examinations cover the major field and the minor or related fields, and may include any work fundamental to these fields. If a final oral is held, it is conducted as a closed examination, attended by only the student and the examining committee. All committee members must be present at the oral examination; *the absence of any member results in an invalid examination.*

Except as noted in this section, requirements for the master of fine arts degree are comparable to those described under Plan B: Master’s Degree Without Thesis above.

## Master of Forestry

See Forestry under Graduate Programs for requirements.

## Master of Landscape Architecture

See Landscape Architecture under Graduate Programs for requirements.

## Master of Music

See Music under Graduate Programs for requirements.

## Master of Planning

See Public Affairs under Graduate Programs for requirements.

## Master of Science (Designated) in Clinical Medicine

See Master’s Degree above for requirements.

## Master of Social Work

See Social Work under Graduate Programs for requirements.

## Specialist Certificate in Education

The Graduate School offers two-year specialist programs in several education fields (see Curriculum and Instruction, Education, Educational Administration under Educational Policy and Administration, and Educational Psychology under Graduate Programs for specific fields and program descriptions). The specialist certificate requires completion of a minimum of 90 credits.

**Transfer of Credits**—With the approval of the adviser, the director of graduate studies in the major, and the Graduate School, the transfer of up to 50 percent of the degree program coursework from any combination of the following is permitted:

1. Other recognized graduate schools;
2. Adult Special, Summer Session, and Continuing Education and Extension (renamed University College) registrations at the University of Minnesota.

Individual graduate programs have the option of specifying a lower percentage of coursework for transfer.

The work to be transferred must be graduate level (postbaccalaureate), must have been taken for graduate credit, and must have been taught by faculty members authorized to teach graduate courses. Credits transferred from other institutions must in addition have been taken as an enrolled, graduate-degree-seeking student and must appear on official graduate school transcripts of the institutions. University of Minnesota courses taken in Continuing Education and Extension (renamed University College) must bear the special CEE or UC transcript entry verifying that they were completed for graduate credit.

In the case of a transfer from a non-U.S. institution, the credits must have been earned in a program judged by the Graduate School to be comparable to a graduate degree program in a graduate school of a regionally accredited institution in the United States.

*Regarding the transfer of coursework from either a U.S. or non-U.S. institution, if conditions are placed on a student's admission to exclude certain coursework from transfer to a Graduate School degree program, that coursework may not be transferred regardless of the level of the coursework or the status of the school or college in which it was earned.*

The transfer of credits is accomplished by the inclusion of the courses on the proposed degree program. Credits that are not accepted as part of a student's degree program cannot be transferred to the Graduate School transcript.

*Courses completed through independent (correspondence) study, completed through extension or special categories at other institutions, or taken before the awarding of a baccalaureate degree cannot be transferred.*

**Degree Requirements**—Students pursuing the specialist certificate ordinarily complete the requirements for the master's degree with a major in the field of the specialty as the first year of the program. All first-year students must meet regular admission, candidacy, and examination requirements for the master of arts degree and should specify as their degree objective the master's degree on the application form. A decision regarding continuation beyond the master's degree in a specialist program will depend on an evaluation of performance in meeting the master's requirements.

#### **Time Limit for Earning the Specialist**

**Certificate**—The specialist certificate can be completed in 2 years but must be completed and awarded in 12 years. The 12-year period begins with the earliest work included on the program, including any transfer work. Graduate credits earned before the 12-year span are evaluated by the graduate faculty in the area of specialization and may be recommended to the Graduate School for acceptance on a full or partial basis. Students who expect to exceed the 12-year limit may petition the Graduate School for an extension of time; contact 316 Johnston Hall for more information.

**Final Examinations**—The Graduate School requires a final examination for specialist certificate candidates; this may be written, oral, or both, at the discretion of the graduate faculty in the major field. A committee of at least four examiners is appointed by the dean of the Graduate School upon recommendation of the faculty in the major field at the time the official degree program is approved. This committee must include two members from the student's major field and two members from outside the major field.

The examination is coordinated by the chair of the student's examining committee. The results of the examination are reported on a form the student must obtain from the Graduate School, 316 Johnston Hall, before the examination is held. *A majority vote of the committee, all members present and voting, is required to pass the examination. A student who fails the examination may be terminated from the graduate program or may be allowed, on unanimous recommendation of the examining committee, to retake the examination, providing the reexamination is conducted by the original examining committee.*

Except as noted in this section, the requirements and procedures for completing the specialist certificate are comparable to those described under Plan B: Master's Degree Without Thesis above.

A degree program approved by the Graduate School must be on file before examination or graduation forms can be released to the student.

## Doctor of Philosophy Degree

The doctor of philosophy degree is awarded chiefly in recognition of high attainment and ability in a special subject field as demonstrated by passing the required examinations covering both a candidate's general and special subject fields, and by preparing and successfully defending a thesis that is based on original research and that makes a significant contribution to knowledge in the student's field.

**Registration Requirement for the Doctoral Degree**—Doctoral students are generally required to register for major field and minor or

supporting program coursework. Students should consult their graduate program to determine whether coursework completed while pursuing a University of Minnesota master's degree may be used to meet their doctoral coursework requirement.

Doctoral students are required to enroll for a minimum of 36 thesis credits (8888) while writing the doctoral thesis. Students may not register for thesis credits until the quarter *after* they have passed their preliminary oral examination.

Some students who were first registered in the Graduate School before fall quarter 1983, or who filed a doctoral degree program with the Graduate School before fall quarter 1991, may have their thesis credit requirement reduced or eliminated. Contact the Graduate School, 316 Johnston Hall, for more information.

#### **Doctoral Pre-Thesis Credits (8666)**—

Doctoral pre-thesis credits (8666) are available for doctoral students who have not yet passed their preliminary oral examination but who need to be registered in the Graduate School to meet requirements of agencies or departments outside the Graduate School (e.g., loan agencies). Doctoral pre-thesis credits are not graded. *Note: Registration for doctoral pre-thesis credits cannot be used to meet any Graduate School degree requirements.*

#### **Transfer of Credits for the Doctoral Degree**—

Students may request from the Graduate School the transfer of the following types of course credits by including the courses on the proposed degree program. In all cases, official transcripts of the graded work must be attached to the degree program form, unless they have already been included in the student's Graduate School file. Transfer of graduate credit is not allowed for courses completed through independent (correspondence) study, completed through extension or special categories at other institutions, or taken before the awarding of a baccalaureate degree.

*From Adult Special or Summer Session*—Students admitted to and registered in the Graduate School may transfer to their doctoral programs the graduate-level credits earned in their *first academic quarter as adult special*

*students* (or in their first summer session, including both summer terms if registered in the same calendar year) at the University of Minnesota. Such work must be graduate level and must be offered by members of the faculty approved to teach graduate courses, and students must complete the work required of graduate students in the courses.

*From Continuing Education and Extension (CEE)/University College (UC)*—A maximum of 12 credits of graduate-level work completed in Continuing Education and Extension (renamed University College) may be transferred to the doctoral program. This applies only to credits earned in CEE or UC at the University of Minnesota; extension credits earned at other institutions may not be transferred. University of Minnesota extension courses must bear the special CEE or UC transcript entry showing they were completed for graduate credit.

*CEE/UC Tuition Differential*—For all coursework taken fall 1980 or later in Continuing Education and Extension (renamed University College) and then transferred to a graduate degree program, students will be billed by University College for the difference between the CEE or UC rate and the Graduate School rate in effect at the time the credits were taken.

*From Other Graduate Institutions*—Graduate credits earned at other recognized graduate institutions may be applied to doctoral degrees if the coursework was taken as an enrolled, graduate-degree-seeking student and the credits appear on official graduate school transcripts.

In the case of a transfer from a non-U.S. institution, the credits must have been earned in a program judged by the Graduate School to be comparable to a graduate degree program of a regionally accredited institution in the United States.

*In the case of a transfer from either a U.S. or non-U.S. institution, if conditions are placed on a student's admission to exclude certain coursework from transfer to a Graduate School degree program, that coursework may not be transferred regardless of the level of the coursework or the status of the school or college in which it was earned.*

*Transfer of graduate credit is not allowed for courses completed through independent (correspondence) study, completed through extension or special categories at other institutions, or taken before the awarding of a baccalaureate degree.*

**Time Limit for Earning the Doctoral Degree—**All requirements for the doctoral degree must be completed and the degree awarded within five calendar years after passing the preliminary oral examination (see Preliminary Written and Oral Examinations below).

Students who are unable to complete the degree within the five-year limit may petition the Graduate School for an extension of up to one additional year. *Extensions beyond one year are considered only in the most extraordinary circumstances.* Contact the Graduate School, 316 Johnston Hall, concerning information to be included in such a petition. To ensure timely consideration, petitions should be filed no later than early in the quarter in which the time limit expires.

If a petition is approved, the student is notified of the expectations for progress and completion of the degree. If the petition is denied, the student is terminated from doctoral candidacy and from the graduate program.

Students who have been terminated under such circumstances may apply for readmission to the Graduate School; *readmission under these circumstances is not assured, however.* The faculty in the major field and the Graduate School would set any readmission conditions on the student's resumption of work toward the degree, such as registering for additional coursework, retaking written examinations, filing a revised thesis proposal, completing the degree within a specified time period, or other appropriate terms.

**Official Program for the Degree—**Students are expected to file an official program for the degree during their second year of study; the specific quarter depends upon individual major field requirements. *Students should submit their completed degree program forms to the Graduate School at least two quarters before the term in which they plan to take the preliminary oral examination.* The degree program form is available from the Graduate School, 316 Johnston Hall. The form should list all coursework, completed and proposed, that

will be offered in fulfillment of degree requirements in the major field and in the minor field or supporting program, including any transfer work (see Transfer of Credits above). If the student's major field requires proficiency in one or more foreign languages, these should be specified as well. *The members of a student's preliminary oral examining committee are appointed by the dean of the Graduate School on recommendation of the faculty in the major field at the time the student's official degree program is approved.*

A degree program approved by the Graduate School must be on file before the student is permitted to schedule the preliminary oral examination.

**Changes in the Approved Program—**Once approved, the program must be fulfilled in every detail to meet graduation requirements. Changes in the program that are found necessary or desirable should be requested by completing a Graduate School petition form.

**Minimum Grade Requirements—**The Graduate School does not define a minimum GPA for courses included on an official doctoral degree program, although individual programs are free to do so as part of their effort to monitor their students' academic achievement and degree progress. Courses with grades of A, B, C, and S may be included in the official degree program, but grades of S are not calculated in the GPA. Students pursuing a doctoral degree are required to register for doctoral thesis credits (8888); these registrations are not graded and therefore cannot be used to meet course credit requirements. *At least two-thirds of the total number of course credits included on any degree program must be taken A-F.* Individual major fields have the option of specifying more stringent requirements concerning the application of S-N courses to a degree program.

**Major Field Credits—**The Graduate School does not specify a minimum number of credits in the major field for the doctoral degree. Depending on previous preparation and the nature of the research undertaken, the number of credits required for individual students, even within the same major field, may vary considerably.

**Minor Field or Supporting Program**

**Work**—For the doctoral degree, at least 18 quarter credits must be offered in the minor field or supporting program. With a traditional minor, this work is in a single field related to the major; *the minor field must be declared before the student passes the preliminary oral examination*. If the student is offering a supporting program, it must be composed of a coherent pattern of courses, possibly embracing several disciplines. Both the minor and supporting program options may require students to take written preliminary examinations in the fields included, but students electing the supporting program option are not expected to have competency in each of the fields comparable to that of a person with a traditional minor.

*For majors in clinical branches, the minor field or supporting program must be in nonclinical fields that will serve as a basis for the proposed clinical specialization. This fundamental work should be concentrated in the first part of the program. Familiarity with those phases of the nonclinical disciplines essential to proficiency in the major specialty is required.*

**Language Requirement**—See Graduate Programs to determine the language requirement, if any, for a specific major field. The Graduate School monitors the fulfillment of language study when a major field requires a language. Information on how to demonstrate proficiency, and on the conditions under which proficiency will be recorded on the official transcript, is available from the Graduate School, 316 Johnston Hall.

**Official Doctoral Candidacy**—Doctoral candidacy is established when a student passes the preliminary oral examination (including “pass with reservations”).

**Further Information**—Students who have questions about the doctoral degree after reading this entire section (including the following on examinations and the thesis) may contact the Graduate School by e-mail (gsdoc@tc.umn.edu). *Note:* Some commonly used forms are available on the Graduate School Web site.

**Preliminary Written and Oral Examinations**

**Preliminary Written Examination**—All doctoral students are required to pass a written examination in the major field. This examination covers all work completed in the major field and may include any work fundamental to this field. The results of the examination are reported on the preliminary written examination report form, signed by the student’s adviser and the director of graduate studies in the major field. It is the student’s responsibility to ensure that this form is received by the Graduate School, 316 Johnston Hall, before scheduling the preliminary oral examination.

**Preliminary Oral Examination**—Students take the preliminary oral examination after completing a substantial part of the coursework and passing the preliminary written examination, but before writing the dissertation.

**Preliminary Oral Examining Committee**—The examination is administered by the committee appointed by the dean of the Graduate School on recommendation of the faculty in the major field at the time the student’s official doctoral degree program is approved. The examining committee includes a minimum of five members: three (including the student’s adviser) from the major field and two from the minor field or supporting program.

All assigned members must be present at the preliminary oral examination; *the absence of any member results in an invalid examination*.

**Changes in the Preliminary Oral Examining Committee**—Substitutions on the examining committee may be necessitated by such circumstances as a faculty member’s temporary absence on leave from the University. The adviser or the director of graduate studies must request the Graduate School’s approval of such substitutions well in advance of the examination. *Substitutions necessitated by emergency situations must also be approved in advance. In such cases, the adviser should consult with the Graduate School staff by telephone before the start of the examination.*

### **Scheduling the Preliminary Oral**

**Examination**—It is the responsibility of the student to schedule the preliminary oral with the examiners and with the Graduate School, 316 Johnston Hall, *at least one week in advance*. In certain of the health science fields, however, the faculty requires 30 days' notice of the date of the preliminary oral.

Preliminary oral examinations should not be scheduled from the beginning of the second term of summer session to the opening of the fall quarter, unless the members of the assigned committee can be assembled without substitution.

Before the oral examination can be scheduled, a degree program form approved by the Graduate School must be on file, along with a written examination report form indicating that the student has passed the preliminary written examination. The Graduate School must also confirm that the student has maintained active status (see Registration Requirements under Registration above).

If these documents are on file and the student has active status, the Graduate School issues the preliminary oral examination report form and instructions for conducting the preliminary oral examination to the chair of the examining committee. A copy of the student's degree program form is also sent to both the chair of the examining committee and the student; this may be useful to the committee in reviewing the student's preparation and in confirming the completion of degree requirements, including coursework and any language requirements. The preliminary oral examination may be authorized in spite of deficiencies in these requirements, unless more stringent standards have been established by the major field. All requirements must be completed before the final oral examination may be scheduled.

**Preliminary Oral Examination Content and Outcome**—All doctoral students are required to pass an oral examination in the major field. The preliminary oral examination covers the major field, the minor field or supporting program, and any work fundamental to these areas, including possible plans for thesis research. Unlike the final oral examination, *the preliminary oral is conducted as a closed*

*examination, attended by only the student and the examining committee.*

Immediately before the preliminary oral examination, the committee chair stipulates the objectives of the examination and, in consultation with other members of the examining committee, determines how the examination is to be conducted. Immediately after the examination, the candidate is excused from the room and a written secret ballot is taken before discussing the examination. Following the discussion, a second and final vote is taken, and the participants sign in the appropriate place on the report form, which is to be returned to the Graduate School, 316 Johnston Hall, *no later than the first workday after the examination.*

The outcome of the examination, with all committee members present and voting, is recorded in one of three ways: pass, pass with reservations, or fail. The voting proportions necessary for these decisions are as follows: if the committee consists of five members, a favorable verdict for passing consists of either a unanimous vote or a vote of 4-1; if the committee consists of six members, a unanimous vote or a vote of 5-1 or 4-2 is needed; and if there are seven members, a unanimous vote or a vote of 6-1 or 5-2 is needed. Candidates who do not earn committee votes in these proportions *fail* the examination. If, to achieve the *minimum* number of votes to reach a verdict of pass, any vote of pass with reservations is included, then the outcome will be recorded as a *pass with reservations*. A vote to pass the student with reservations still constitutes a passing vote.

**Pass With Reservations**—If the student passes the examination with reservations, the student is informed immediately, but the committee is permitted one week in which to convey its reservations to the student *in writing*, informing the student of the steps that must be taken to remove them. *A copy of this letter must be sent to the Graduate School and should accompany the signed oral examination report form.* When the student has satisfied the committee's reservations, a second letter informing the student and the Graduate School that the reservations have been removed and that the student may proceed toward the degree is also

required. Both letters should be written by the committee chair. *The final oral examination may not be scheduled until the Graduate School has received a copy of the letter indicating that the reservations have been removed.*

If the committee members disagree as to whether the reservations have been satisfactorily removed, the committee chair asks for another vote, the results of which are subject to the same voting proportions as the initial vote. If the student is unable to satisfy the committee's reservations, his or her doctoral candidacy and graduate student status may be terminated.

**Failure of the Preliminary Oral Examination**—Students who fail the examination may be excluded from candidacy for the degree or may be allowed, on unanimous recommendation of the examining committee, to retake the examination, *providing the reexamination is conducted by the original preliminary oral examining committee.*

In no case may the reexamination take place before at least one full academic quarter (10 weeks) has passed. No more than one reexamination is allowed.

**Recess of a Preliminary Oral Examination**—If the preliminary oral examining committee recesses without having determined whether a student has passed the examination, the chair of the committee must send a letter to the dean of the Graduate School explaining the reasons for the recess and noting the date on which the examining committee will reconvene. If the recess will be longer than one week, the examination report form must be returned to the Graduate School, 316 Johnston Hall, and the student must reschedule the examination with the Graduate School one week in advance. A new examination report form will be mailed to the chair of the committee one week before the date on which the committee will reconvene. *The reconvened committee must be composed of the same members as the original preliminary oral examining committee.*

## Ph.D. Thesis

The thesis must demonstrate the student's originality and ability for independent investigation, and the results of the research must constitute a contribution to knowledge. The thesis must exhibit the student's mastery of the literature of the subject and familiarity with the sources. The subject matter must be presented with a satisfactory degree of literary skill.

**Thesis Proposal**—At the time of submission of the doctoral program, or not later than the first quarter after passing the preliminary oral examination, students must file the thesis proposal form with the Graduate School, 316 Johnston Hall. The form must include the proposed thesis title and a thesis proposal, about 250 words in length, describing the research to be undertaken and the methods to be employed in carrying it out.

*The thesis reviewers and other members of the final oral examining committee are appointed by the dean of the Graduate School upon recommendation of the faculty in the major field at the time the student's thesis proposal is approved.*

A thesis proposal approved by the Graduate School must be on file before the reviewers report form can be issued to the student.

**Changes in the Thesis Title or the Thesis Proposal**—Changes in the *wording* of the thesis title may be made without special approval, but changes should not be made after the thesis title is registered (see Registration of the Thesis Title and Delivery of the Thesis to Thesis Reviewers below). If substantive changes are made in the nature of the thesis research itself, the student must submit a revised thesis proposal immediately.

**Language of the Thesis**—Theses must normally be written in English or in the language of instruction. *If a thesis is to be written in a foreign language, including a language of instruction other than English, a letter should be attached to the thesis proposal form when it is submitted to the Graduate School.* This letter should confirm that the recommended thesis reviewers (including the outside reviewer) are qualified to read, comprehend, and criticize a thesis in the foreign language.

**Use of Human or Animal Subjects in Research**—All research on the Twin Cities, Duluth, Morris, and Crookston campuses that involves the use of human or animal subjects must be reviewed and approved before initiation by the Institutional Review Board: Human Subjects Committee (IRB) or the Institutional Animal Care and Use Committee (IACUC). This policy, approved by the University Senate and Board of Regents, applies to funded and nonfunded faculty, staff, and student research. All research, including Plan B projects, theses, and dissertations, that involves human or animal subjects must be approved by the appropriate committee to ensure that the rights and welfare of the subjects are protected. For more information, contact the Research Subjects Protection Office, University of Minnesota, Box 820 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (612/626-5654; fax 612/626-6061).

**Published Work Included in or in Lieu of the Thesis**—The thesis may include materials that students have published while University of Minnesota graduate students, provided the research was carried out under the direction of the graduate faculty and approved by the adviser for incorporation into the thesis. Such publication is welcomed as the best demonstration of quality in a student's research, and the Graduate School encourages the practice. The adviser should notify the Graduate School in writing of the intention to publish part of the thesis material, but the Graduate School's approval is not required.

In cases where the thesis research is to be presented to the examining committee in the form of one or more articles that have been published, or are in a form suitable for publication, the student should contact the Graduate School, 316 Johnston Hall, for information on accommodating such a presentation to the required thesis format.

**Registration of the Thesis Title**—Students must register the thesis title with the Graduate School, 316 Johnston Hall, by submitting a copy of the *thesis title page* as it will appear in the final document. Upon submission of the thesis title, the Graduate School provides the student with the thesis reviewers report form

and the other forms necessary to graduate, on condition that the student has on file a thesis proposal approved by the Graduate School and has maintained active status (see Registration Requirements under Registration above).

**Thesis Reviewers**—*All members of the final oral examining committee read the thesis, although only those designated as thesis reviewers sign the report form certifying that the thesis is ready for defense.*

The designated thesis reviewers consist of the adviser, representing the major field, and at least two other members of the final oral examining committee, including at least one representative from the major field and one representative from the minor or supporting program. Part of this group of reviewers should come from outside of the graduate program's thesis advisory committee, if the program uses such a committee.

Certification of the thesis as ready for defense is a necessary step toward the final oral examination, but in no way diminishes the significance of that examination.

**Delivery of the Thesis to Thesis Reviewers**—At the time the candidate submits a draft of the thesis to the thesis reviewers, copies must also be provided to all other members of the final oral examining committee. The thesis abstract must be included with the thesis when it is distributed to the committee. The abstract must be signed by the adviser before it is submitted to the Graduate School, which forwards it to University Microfilms.

*To permit faculty to allocate sufficient time to read the thesis and decide whether it is ready for defense, students must notify their adviser and other members of the final oral committee at least two weeks in advance that the thesis will be delivered on a particular date. All members of the examining committee must then have at least two weeks to read the thesis after it has been delivered.*

When signing the thesis reviewers report form, the reviewers have three options: the thesis is acceptable for defense as presented; the thesis is acceptable for defense with minor revisions; or the thesis requires major revisions and is not acceptable for defense as presented.

The reviewers must be unanimous in certifying that the thesis is ready for defense, whether as presented or with minor revisions. If this is the case, and all other requirements have been met (see Final Oral Examination below), the Graduate School authorizes the final oral examination. In any instance where revisions are required, the committee must inform the student in writing of the revisions required, and all questions concerning such revisions must be resolved before the final copies of the thesis are submitted and the degree is conferred. *It is the adviser's responsibility to ensure that revisions required by the reviewers are satisfactorily made* (see Preparation of the Copies of the Thesis below).

### Final Oral Examination

All doctoral students are required to successfully defend their theses in a final oral examination within five calendar years after passing the preliminary oral examination. To be eligible for the final oral examination, a student must have completed all work on the official doctoral degree program form, including the language requirement, if any; must have passed both the written and oral preliminary examinations; must have maintained active status; and must have satisfied the thesis credit requirement. In addition, the thesis must have been certified by the readers as ready for defense.

**Scheduling the Final Oral with the Graduate School**—*The student must schedule the examination at least one week in advance with both the committee and the Graduate School (see Clearance for Graduation below). In certain of the health science fields, however, the faculty requires 30 days' notice of the date of the final oral.*

When the examination is scheduled, the student's Graduate School file is checked to determine if the student can be cleared to take the examination as stipulated above. If so, the report form for the final oral examination will be forwarded to the chair of the examining committee. If difficulties are apparent, the Graduate School staff will contact the adviser and the student immediately.

*A minimum of ten weeks must intervene between the preliminary oral and the final oral*

*examinations. Also, the final oral should not be scheduled from the beginning of the second summer term to the opening of the fall quarter unless the committee members can be assembled without substitution.*

**Final Oral Examining Committee**—The committee must consist minimally of five members: three (including the student's adviser) from the major field and two from the minor field or supporting program. At least two of the faculty from the minor field or supporting program should represent a graduate program and budgetary unit other than that of the student's major.

Although the student's adviser serves as a member of the final oral examining committee, another member of the committee is designated as the chair and functions in this capacity at the final oral examination. The chair must be a full member of the graduate faculty and may be from either the major field or the minor field or supporting program. *The chair and other members of the final oral examining committee are appointed by the dean of the Graduate School upon recommendation of the faculty in the major field at the time the student's thesis proposal is approved.*

All committee members must be present at the examination; *the absence of any member results in an invalid examination.*

**Changes in the Final Oral Examining Committee**—Substitutions on the examining committee may be necessitated by such circumstances as a faculty member's temporary absence on leave from the University. The adviser or the director of graduate studies must request the Graduate School's approval of such substitutions well in advance of the examination. *Substitutions necessitated by emergency situations must also be approved in advance. In such cases, the committee chair should consult with the Graduate School staff by telephone before the start of the examination.*

**Form of the Final Oral Examination**—The final oral examination consists of a seminar in which the candidate presents the thesis and to which the scholarly community is invited. The seminar may take place only after the thesis has been judged ready for defense. The

examination is limited to the candidate's thesis subject and relevant areas. It will not exceed three hours. A closed meeting between the candidate and the appointed examining committee immediately follows the thesis presentation. The candidate is then excused and the vote taken on whether the candidate passed the examination.

**Reporting the Results of the Final Oral Examination**—Upon completion of the examination, a formal vote of the committee is taken. To be recommended for the award of the doctoral degree, candidates must receive a vote with no more than one dissenting member of the total examining committee. If the student has clearly *passed* or clearly *failed* the examination and all members have signed the final examination report form, the report form must be returned to the Graduate School *no later than the first workday following the examination*.

The adviser should be responsible for ensuring the inclusion of appropriate modifications and required revisions, if any, in the final thesis. The final oral examination report form should not be signed and submitted to the Graduate School until all reservations have been satisfied. *If the form will be held for more than one week, a letter must be sent to the Graduate School stating that the form is being held pending required revisions.*

Once the final report form has been returned to the Graduate School indicating that the student has either passed or failed the final oral examination, a hold is placed on the student's records to prevent further registration in the Graduate School. If the adviser indicates that the student needs additional time to make minor revisions to the thesis before it is submitted to the Graduate School, the student is permitted to register for one additional quarter. Once the thesis has been submitted, no further registration in the Graduate School is permitted unless the student has been admitted to professional development status or to another major field.

**Recess of a Final Oral Examination**—On rare occasions, the examining committee may conclude that the final oral examination should be recessed, to be reconvened at a later date. Guidelines for such circumstances are sent to

the chair of each examining committee along with the final oral examination report form.

The Graduate School need not be notified until after the fact of informal recesses of up to a week. In the case of a longer recess, the committee must inform the student *in writing* of the reasons for recessing the examination, including any deficiencies noted in the student's thesis or defense, and must indicate when they expect to reconvene and resume the examination. A copy of this letter must be sent to the Graduate School, along with the unsigned final examination report form. When the student and the committee are ready to reconvene the examination, it should be scheduled in the normal way with the Graduate School. A new examination report form will be mailed to the chair of the committee one week before the date on which the committee will reconvene. *The reconvened committee must be composed of the same members as the original final oral examining committee.*

### Preparation and Submission of the Copies of the Thesis

Two copies of the thesis must be submitted to the Graduate School. *The student's adviser(s) must sign both copies of the thesis to confirm that they are complete and satisfactory in all respects and that all revisions required by the final examining committee have been made.*

Instructions for the preparation of the thesis, including format specifications and adviser's signature requirements, should be obtained from the Graduate School, 316 Johnston Hall.

### Clearance for Graduation

Degrees are awarded at the end of each month. To qualify for graduation for a particular month, a student must submit the Application for Degree form on or before the first workday of that month and must complete the examination and all other requirements (including necessary forms and fees) by the last workday of that month.

### Commencement Ceremony

Two Graduate School commencement ceremonies are held each year—in *late spring* (for January through June graduates) and in *late fall* (for July through December

graduates). Graduates are encouraged, but not required, to attend. To make sure their names appear in the program distributed at the commencement ceremony, students must submit the commencement attendance form by the deadline specified in the Graduate School section of the *Class Schedule*.

### Pursuit of a Second Ph.D. Degree

Students are not permitted to earn two Ph.D. degrees at the same time in two fields using the same program of study and thesis. Although students are generally discouraged from doing so, special circumstances may warrant taking a second Ph.D. degree at a later date, but only when a completely separate program and thesis are involved.

## Doctor of Education

The University of Minnesota awards the doctor of education (Ed.D.), its highest professional degree in the fields of work, community, and family education and educational administration in recognition of satisfactory academic preparation and demonstrated competence for professional activity in those fields.

Standards and procedures for admission, and expectations for scholastic performance, are comparable to those for the Ph.D. A major part of the program must be conducted in full-time residence, including at least one continuous academic year at advanced stages of the program. Rules and procedures governing examinations, candidacy, time limits, appointment of committees, and the thesis for the Ph.D. apply in general to the Ed.D.

**Program for the Degree**—The Ed.D. program requires the completion of a major, a minor or a supporting program consisting of at least 18 course credits, and a collateral field of study. A foreign language is not required. A significant proportion of the graduate coursework, usually at least one-fifth of the total program, should be completed in fields other than education.

A supervised internship or clinical experience is an integral part of the program and must be completed by each candidate.

**Project**—Candidates for the Ed.D. must complete an extended essay that demonstrates the ability to carry out an independent and meaningful study of a problem relevant to the field.

**Examinations**—Satisfactory performance on both a written comprehensive examination conducted by the major field and a preliminary oral examination conducted by a committee of graduate faculty members is required to establish candidacy for the degree. The preliminary oral examination committee is appointed by the dean of the Graduate School upon recommendation of the faculty in the major field at the time the degree program is filed. These examinations assess students' scholarly mastery of the subject matter of their major field and their general readiness and qualifications to pursue the Ed.D.

The final examination committee is appointed by the dean of the Graduate School upon recommendation of the faculty in the major field at the time the thesis/project proposal is filed. It consists of three project reviewers and two others who are qualified to assess the student's professional competency. In the final examination, students are expected to defend the essay and their general qualifications for the degree.

For detailed requirements, see Doctor of Philosophy Degree above.

## Doctor of Musical Arts

The program for the professional doctor of musical arts (D.M.A.) degree has a performance-teaching orientation. Emphases are offered in piano, organ, voice, violin, viola, cello, clarinet, woodwinds, trumpet, trombone, guitar, accompanying/coaching, and orchestral conducting. Standards and procedures for admission, and expectations for scholastic performance, are comparable to those for the Ph.D. Details concerning major and minor requirements, recitals, and supporting papers for the D.M.A. are included in the Music section under Graduate Programs. Rules and procedures governing examinations, candidacy, time limits, and appointment of committees for the Ph.D. apply in general to the D.M.A.; in place of the thesis, a project document or paper is required.

## Doctor of Philosophy (Designated) in Clinical Medicine

In the clinical fields, the Ph.D. is always a degree with designation. See Doctor of Philosophy Degree above and individual clinical medicine fields under Graduate Programs for requirements.

## Other Financial Assistance

**Student Employment**—The University's Student Employment Center (part of the Office of Human Resources) offers graduate students a wide range of non-academic employment opportunities both on campus and throughout the Twin Cities area. All jobs are posted outside the Student Employment Center, 120 Fraser Hall, 106 Pleasant Street S.E., Minneapolis, MN 55455 (612/624-8070). On-campus jobs are also posted at 130 Coffey Hall, St. Paul campus. Contact the Student Employment Center for further information, including registration requirements for graduate student eligibility.

In addition to University (on-campus) employment, the Center offers programs for off-campus employment: the Job Location and Development (JLD) Program helps locate career-related opportunities with private and public employers in the Twin Cities; Community Service Programs helps arrange employment on and off campus with nonprofit organizations and agencies.

Students who prefer more flexibility may apply for short-term, on-campus temporary positions through the Student Temporary Service (STS). STS also offers free microcomputer training and temporary job placement through the Microcomputer Training Program. Training is provided on Macintosh and IBM microcomputers. Once qualified, students are placed in temporary, on-campus microcomputer-related jobs at competitive wages.

**Office of Scholarships and Financial Aid (OSFA)**—To apply for financial aid, graduate students must complete the Free Application for Federal Student Aid (FAFSA), available from the financial aid office each year.

Graduate students will be considered for the following programs, according to their degree program, student status, and other qualifying criteria: Ford Federal Direct Subsidized and Unsubsidized Loans; Federal Perkins Loans; Student Educational Loan Fund (SELF); University Trust Fund Loan (UTFL); University of Minnesota scholarships and fellowships; regular student employment and work-study programs; Health and Human Services Health Care Professions Grants (may be discontinued after 1997-98); Minnesota Medical Foundation Scholarship; Minnesota Tuition Offset for Health Professions; Nursing Grant Program for Persons of Color; Peters Pharmacy Scholarship; University of Minnesota Medical School Scholarships; Health Professions Student Loan (HPSL); Loans for Disadvantaged Students (LDS) for health professions; Nursing Student Loan (NSL); Primary Care Loan (PCL) for medical students; and private loans. International graduate students must contact International Student and Scholar Services for financial aid opportunities (see below).

Most awards are based on financial need and full-time enrollment status. Aid from the UTFL, Perkins, and work-study programs is awarded as applications become complete and until all funds have been spent. Students who submit their FAFSAs early to the federal processor receive first priority consideration for limited funds. Prospective students may apply before admission to the University.

For detailed information, students should pick up the most recent edition of the *Scholarships and Financial Aid Handbook*, a comprehensive guide to the financial aid process at the University of Minnesota. The handbook is accompanied by the FAFSA, which must be completed for aid consideration. Students may write to the Office of Scholarships and Financial Aid at either University of Minnesota, 210 Fraser Hall, 106 Pleasant Street S.E., Minneapolis, MN 55455, or University of Minnesota, 130 Coffey Hall, 1420 Eckles Avenue, St. Paul, MN 55108, or call 612/624-1665 or, July-September, 1-800-400-UofM(8636); the fax number is 612/624-9584 and the e-mail address is [osfa@tc.umn.edu](mailto:osfa@tc.umn.edu). To receive accommodations when in Fraser Hall or information in an

alternative format, call the disability services liaison for financial aid at 612/625-9578; TTY telephone is 612/626-0701.

**International Students and Scholars—**Counseling, advising, and educational services are provided for students and scholars from other countries by International Student and Scholar Services (ISSS). Staff members offer counseling and advising services regarding visa requirements and other immigration issues; social, personal, and financial matters; international and intercultural educational opportunities; academic issues; and English language requirements.

International students new to the University of Minnesota are required to participate in ISSS's Pre-Registration Program, which introduces students to academic, social, and practical matters relevant to their study in the United States. In addition, ISSS coordinates many cross-cultural programs for students, faculty, staff, and the community. All admitted international students and scholars are mailed materials pertaining to pre-arrival, arrival, and transition to the University system. Prospective student inquiries may be addressed to International Student and Scholar Services, University of Minnesota, 149 Nicholson Hall, 216 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/626-7100).

**Army and Air Force ROTC—**Students in the Graduate School may pursue a two-year Army or Air Force ROTC program. To be eligible, applicants must have six quarters of academic work remaining after successful completion of a required six-week paid ROTC basic summer camp. Transportation, meals, lodging, and a salary are furnished during the summer encampment. All ROTC textbooks and uniforms are loaned to the student without cost, and all cadets receive a tax-free stipend of \$150 per month during the school year. Students successfully completing the program are commissioned as second lieutenants in the Army or Air Force. For more information, see the University's *Army-Navy-Air Force ROTC Bulletin* or call the Army ROTC (612/624-7300) or the Air Force ROTC (612/624-2884).

**Fellowships and Scholarships Awarded and Administered Through Academic Departments—**Further information on eligibility and application procedures for the following fellowships and scholarships is available from academic departments unless otherwise indicated. Awards are subject to change or cancellation depending on availability of funds.

*AGRICULTURAL ENGINEERING*

**Alton Levorson Award—**For an agricultural engineering graduate student who demonstrates excellence in academics and research. Variable amount.

*AGRONOMY AND PLANT GENETICS*

**H. K. Hayes Memorial Scholarship—**For a current graduate student in the Department of Agronomy and Plant Genetics who is outstanding in scholarship, research, and leadership in department and student activities. \$1,000.

**J. W. Lambert Memorial Fellowship—**For graduate students entering the Department of Agronomy and Plant Genetics with exceptional academic records and/or experience. \$3,000 plus a half-time assistantship first year; \$1,000 plus a half-time assistantship subsequent years.

**Pioneer Hi-Bred Graduate Fellowship—**For outstanding graduate students in applied plant breeding. Variable amount, consisting of augmentation to a half-time assistantship.

*AMERICAN STUDIES*

**American Studies Fellowship—**To support three first-year graduate students. A stipend and quarter-time assistantship about equal to first-year Graduate School Fellowship stipend.

*APPLIED ECONOMICS*

**The Center for International Food and Agricultural Policy Graduate Study Fellowships—**To attract high-quality Ph.D. students to the program and to strengthen opportunities for international experience within the graduate curricula. Up to \$2,000 plus a regular 12-month, half-time research assistantship each year for up to 45 months of study; up to \$2,000 travel grant in the final year of the student's program.

*ARCHITECTURE*

All scholarships/fellowships are for graduate and undergraduate students already in the architecture program and are given at the discretion of the department, unless otherwise noted.

**AIA (American Institute of Architects) Foundation Scholarships—**Stipends awarded to architecture students on the basis of financial need and academic achievement. Nominations are made by CALA to the AIA Foundation.

**AIA Henry Adams Medal and Certificate—**Awarded to the two graduating architecture students highest in academic rank.

**AIA Minneapolis Chapter—**Two stipends for third-year architecture students who do not qualify for other awards.

**AIA Minority-Disadvantaged Scholarship Program—**Awarded to architecture students based upon need and background. Nominations are made by CALA to the AIA.

**Alpha Rho Chi Medal**—Given to a graduating architecture student for leadership and service by the national architecture fraternity.

**Thomas Ellerbe Fellowship**—Stipend awarded to architecture students in their final year by the Minnesota Architectural Foundation based on academic record, portfolio, and recommendations.

**Stanley and Doris Moe Scholarship**—Offered to outstanding architecture applicants at the time of their admission.

**SPQR Travel Award**—Stipend awarded to architecture students for participating in the Study Abroad Program based on need and academic rank.

**Stretch/Morrill Memorial Award**—Thesis award for graduating architecture students nominated by faculty.

In addition, several corporations and firms sponsor other annual scholarships and architectural design competitions (with financial awards) as part of design studios. Recent sponsors have included Pella Products, and the Minnesota Prestress Association. For graduate students, there are many teaching and research assistantships available as well as a limited number of tuition scholarships.

*ART (Twin Cities Campus)*

**Dayton-Hudson Internships in the Arts**—To enhance graduate student involvement and visibility in the local arts community and to assist arts organizations with their missions. \$6,000 for each year of the three-year program.

**Studio Arts Endowed Scholarships**—To assist graduate students in their individual visual research. \$500-\$3,500.

*ART (Duluth Campus)*

**Alice Tweed Tuohy Foundation Scholarship**—For graduate or undergraduate art students to help defray tuition expenses. Variable amount.

*ART HISTORY*

**Elizabeth Roe Fellowship**—For art history graduate students. \$500 to \$3,000.

**Pioneer Fellowship**—For Art History Graduate Students \$500 to \$3,000.

*BIOCHEMISTRY*

**Chemical Bases of Cell and Molecular Biology Training Grant**—To train doctoral students in biochemistry, chemistry, genetics and cell biology, and microbiology, in a chemically based approach to cellular and molecular biology. U.S. citizenship required. \$8,800 plus tuition, health insurance, and certain fees. This amount is supplemented to bring the stipend to that received by other graduate students in the program.

**Arnold H. Johnson Doctoral Fellowship**—To train pre-doctoral students in biochemistry with faculty in the College of Biological Sciences. U.S. citizenship required. Apply through the Biochemistry Department, College of Biological Sciences. \$8,250.

*BIOLOGICAL SCIENCES*

**Bell Delta Waterfowl Fellowship**—For graduate students in ecology, evolution, behavior, and biology who are studying North American waterfowl at the Delta Waterfowl Research Station in Manitoba. Apply through Bell Museum of Natural History. Variable amounts.

**Dayton Natural History Fund**—To encourage field research in field biology by graduate students without geographic restrictions. Apply through Bell Museum of Natural History. Variable amounts, usually \$100 to \$2,000.

**Itasca Research Stipends**—To encourage research at Lake Itasca Forestry and Biological Station by qualified graduate students from any area relating to field biology. Apply through the Itasca Biology Program. Variable amounts.

**Florence Rothman Fellowship**—For first- or second-year graduate students in ecology or associated with Bell Museum faculty to support exploratory field studies. Students should apply through the Department of Ecology, Evolution, and Behavior. At least \$500.

**Sigerfoos Fellowship**—For short-term zoological study by graduate students at another institution or research area. Preference for study of marine or tropical zoology. Apply through the director of graduate studies in zoology.

**James W. Wilkie Fund for Natural History**—For field studies in natural history by graduate students in any aspect of field biology. Apply through Bell Museum of Natural History. Variable amounts, usually \$100 to \$2,000.

*BIostatISTICS*

**National Research Service Award Traineeships**—For graduate students in biostatistics. U.S. citizenship or permanent residency required. Salary (usually \$10,008) plus tuition and insurance premium waivers.

**U.S. Public Health Service Traineeships in Public Health**—For graduate students in biostatistics. U.S. citizenship or permanent residency required. Variable amounts.

*BUSINESS ADMINISTRATION*

**Accounting Department Scholarships**—Awarded to MBA and Ph.D. accounting students on the basis of merit. Variable amount. Further information is available from the Carlson School Accounting Department.

**American Production and Inventory Control Society**—For Carlson School of Management graduate and undergraduate students interested in a career in operations and materials management. Variable amount.

**R. Glen Berryman Scholarship Fund**—Awarded to Carlson School accounting students based on merit. Variable amount.

**Carlson Companies Scholarship**—For Carlson Companies employees or children or grandchildren of employees enrolled as graduates or undergraduates in the Carlson School. Variable amount.

**Carlson School Dissertation Fellowships**—Awarded to dissertation-stage Ph.D. students on the basis of merit. Variable amount.

**Carlson School Ph.D. Fellowships**—Awarded to first-year Ph.D. students on the basis of merit. Variable amount.

**Carlson Student Aid Fund**—For graduate and undergraduate students enrolled in the Carlson School. Variable amount.

**Richard Ellis Dupuy, Jr. Fellowship in Strategic Management**—Awarded to Ph.D. students in the department of Strategic Management and Organization on the basis of merit. Variable Amount.

## GENERAL INFORMATION

**Elwell Foundation**—Awarded to several Ph.D. students in finance. Variable amount.

**Richard K. Gaumnitz Scholarship**—In honor of Professor Gaumnitz for Carlson School students in the department of strategic management. Variable amount.

**Frederick Grose Scholarship**—Awarded to a Carlson School undergraduate or graduate student in accounting.

**Ernest Heilman Award**—An Outstanding Teacher Award for a Ph.D. student in accounting.

**Herrick Scholarship**—For Carlson School Ph.D. students in finance; based on financial need and merit. Variable amount.

**Honeywell Scholarship**—Awarded to an outstanding graduate student in accounting. Variable amount.

**Robert Lieberman Memorial Award**—For one or two Carlson School Ph.D. student(s) in marketing; based on excellence in teaching. Variable amount.

**Carl Nelson Doctoral Award**—Awarded to a Ph.D. student in accounting.

**Jay Phillips Endowed Scholarship**—For Carlson School graduate students based on need and merit. Variable amount.

**Charles R. Purdy Scholarship**—Awarded to a Carlson School Ph.D. student in accounting.

**George Russell International Fund**—For students and faculty of the Carlson School to defray costs of international research and study. Variable amount.

**C. E. Tranter Scholarship**—Awarded to outstanding graduate and undergraduate students in accounting.

**Naren Udayagiri Fellowship in Management**—Awarded to Ph.D. students in the Department of Strategic Management and Organization based on merit. Variable amount.

**Roland S. Vaile Fellowship in Business**—Awarded to a graduate student interested primarily in marketing. Variable amount.

### *CELLULAR AND INTEGRATIVE PHYSIOLOGY*

**Bacaner Research Awards**—For doctoral students in cell biology and neuroanatomy, biochemistry, laboratory medicine and pathology, microbiology, pharmacology, and physiology. Students are selected by their departmental faculty on the basis of research conducted for the Ph.D. degree. Limited to students who have completed or will complete all requirements for the Ph.D. degree by no later than December of the year awarded. \$500.

**Irwin J. Fox Award**—To recognize outstanding academic achievement by a doctoral student in cellular and integrative physiology. \$1,000.

**Allan Hemingway Endowed Scholarship**—For a doctoral candidate in cellular and integrative physiology who has demonstrated outstanding merit, academic potential, and financial need. \$1,500.

**Lifson-Johnson Award**—For a doctoral student in cellular and integrative physiology, to recognize outstanding teaching or research in the area of physiological transport systems. \$1,000.

### *CHEMICAL ENGINEERING AND MATERIALS SCIENCE*

All chemical engineering and materials science graduate students who submit applications for graduate assistantships or Graduate School Fellowships are considered for departmental fellowships. The criterion for selection is academic excellence. In recent years, departmental fellowship funds have come from the following sources:

#### **Air Products and Chemicals**

#### **Chevron**

#### **Dow Chemical Company Foundation**

#### **Eastman Kodak**

#### **Exxon Education Foundation**

#### **Fridley Foundation**

#### **Minnesota Mining and Manufacturing Company (3M)**

#### **Mobil**

#### **Pillsbury Company**

#### **Proctor and Gamble**

#### **Shell Companies Foundation**

#### **Union Carbide**

#### **Upjohn Company**

### *CHEMISTRY*

The Department of Chemistry awards fellowships for outstanding graduate students each year. Several fellowships for partial summer support are sponsored by a number of corporations.

### *CHEMISTRY/CHEMICAL PHYSICS*

Same as Chemistry.

### *CHILD PSYCHOLOGY*

**Center for Research in Learning, Perception, and Cognition**—To prepare doctoral students in learning, perception, cognition, and related areas for research careers in cognitive science. Must be U.S. citizen, national, or permanent resident. \$10,800 (12 months) plus tuition and fees.

**Institute of Child Development**—To prepare continuing doctoral students in child psychology for research careers. Must be U.S. citizen, national, or permanent resident. \$7,506 (9 months) plus tuition and fees.

### *CIVIL ENGINEERING*

**Sommerfeld Fellowships**—For outstanding graduate students in any branch of civil engineering. \$10,200 plus tuition and health coverage.

### *CLASSICAL AND NEAR EASTERN STUDIES*

**John C. Hutchinson Fellowship**—To support promising classics students in the study of Greek and Latin language and literature at an advanced level. \$1,000 to \$4,000.

### *COMMUNICATION DISORDERS (Twin Cities Campus)*

#### **Center for Research in Learning, Perception, and Cognition**

—To prepare doctoral students with interests in perception, learning, and cognition for research careers in cognitive science. U.S. citizenship required. \$10,008 plus tuition, fees, and insurance.

**Robert G. Robinson Scholarship in Audiology**—For students in audiology. Recipients must be nonsmoking U.S. citizens. Variable amount.

**Veteran's Administration Traineeships in Speech-Language Pathology and Audiology**—For master's and doctoral students in speech-language pathology and audiology. U.S. citizenship required. \$4,000.

*COMMUNICATION DISORDERS (Duluth Campus)*

**Eddy Foundation Scholarships**—For students in communication disorders at University of Minnesota-Duluth. Preference to Duluth area residents. \$400 per quarter.

**Robert F. Pierce Scholarship for Academic Excellence**—For top applicant to the communication disorders graduate program on the Duluth campus. Awarded annually. \$10,000 paid in \$5,000 installments.

#### *COUNSELING*

**Counseling Internship and Associate Staff Positions**—For doctoral students in psychology and education to provide experience and training in college student counseling. Apply through University Counseling and Consulting Services.

#### *CREATIVE WRITING*

See *ENGLISH* below.

#### *CURRICULUM AND INSTRUCTION*

(Reading/Language Arts Education)

**Guy Bond Research Assistantship**—To support a new doctoral student in reading education. \$12,000 plus tuition for the first two years; departmental teaching assistantship for third year.

**Reading/Language Arts Education Dissertation Fellowship**—To support preparation of a publishable paper. \$1,000.

**Robert Schreiner Reading Fellowship**—To support preparation of a publishable paper. \$1,000.

**Frances Triggs Reading/Language Arts Memorial Fellowship**—To assist a doctoral candidate in the completion of the dissertation. \$2,500.

#### *ECONOMICS*

**Harold Hardy Fellowship**—Thesis support for doctoral students.

**Heller Fellowship in Public Policy**—For thesis research support in public policy economics.

#### *EDUCATION*

See also *CURRICULUM AND INSTRUCTION* above.

**Ruth Eckert Scholarship**—For women doctoral students who have completed the preliminary examination for the Ph.D. Recommendations from the student's major adviser and one other faculty member are required. Variable amount not to exceed \$1,000.

**Education and Human Development Alumni Society Advanced Study Scholarship**—For graduate students with outstanding academic performance and whose faculty recommendations show the students' potential to make significant contributions to the field. \$500, subject to availability of funds.

**Education and Human Development Alumni Society Larry Wilson Scholarship**—For degree-seeking students who have career objectives related to non-school-based education. Recipients will be selected based on leadership potential and a strong academic record. \$500, subject to availability of funds.

**Education and Human Development Student Community Service Award**—For students who have performed outstanding volunteer service for nonprofit organizations and groups external to the University. \$500.

**Epsilon Chapter of Pi Lambda Theta Dissertation Research Grant**—For graduate students who have completed the preliminary exam for the doctorate in education. \$500, subject to availability of funds.

**Home Economists in Business**—For graduate student majoring in home economics education with career goals oriented toward working in a business setting. Applicants must be members of the Minnesota Home Economics Association. \$800.

**Minnesota Home Economics Association**—For students in home economics, preferably members of the Minnesota Home Economics Association. \$500.

**Minnesota Recreation and Park Foundation Scholarship**—For students in recreation, park, and leisure studies. Awards are based on scholarship, volunteer work, and extracurricular activities.

**J. Anna Norris Award**—For graduate or postbaccalaureate women students in a program likely to lead to a career in college teaching or adult education in physical education and/or sport. Variable from \$100 to \$500 per quarter.

**Omicron Nu Research Fellowship**—Awarded to graduate students at the doctoral level in family education within the Department of Work, Community, and Family Education. \$2,250.

**Jason David Schleien Memorial Scholarship Fund**—For students in therapeutic recreation, adapted physical education, special education, or areas related to serving students with disabilities. \$100 to \$1,000.

**Twin City Home Economists in Homemaking**—Awarded to a graduate student in home economics education or other home economics field. \$1,200.

#### *ENGLISH*

**Edelstein-Keller Teaching/Writing Fellowships**—For outstanding writers entering or enrolled in the M.F.A. program in creative writing. Up to three appointments combining fellowship support with some work for a total stipend of about \$9,000.

**Frederick Klaeber Fellowship in Medieval Studies**—For doctoral students in medieval English language and literature, especially those concentrating in Anglo-Saxon. \$9,000 plus tuition for the year of tenure; a teaching assistantship plus tuition for two more years.

**Martin Ruud Memorial Fellowship**—Given in alternate years. For doctoral students in English during their first three years of coursework. \$9,000 plus tuition for the first year; a teaching assistantship plus tuition for the second and third years.

#### *ENTOMOLOGY*

**Dr. Alexander A. Granovsky Pest Management Scholarship**—To recognize an entomology student for outstanding professional interests and studies related to pest management, with particular focus on urban pest management. Must be a student member of the Entomological Society of America and have at least one popular or scientific publication related to arthropods published or in press. \$1,000.

## GENERAL INFORMATION

### ENVIRONMENTAL HEALTH

**National Institute for Occupational Safety and Health**—For graduate students specializing in industrial hygiene, occupational health nursing, and injury prevention. U.S. citizenship or permanent residency required. Up to \$8,500 plus tuition and fees; partial awards also offered.

**U.S. Public Health Service Traineeships in Public Health**—For graduate students in environmental health. U.S. citizenship or permanent residency required. Stipend plus tuition and fees; partial awards also offered.

**Richard G. Bond Memorial Scholarship**—For full-time environmental health student with preference to student with experience in environmental health or related field. Full tuition for up to four quarters.

### EPIDEMIOLOGY

**Behavioral Aspects of Cardiovascular Diseases Fellowship**—For pre- and postdoctoral scholars preparing for research careers. \$8,800 to \$32,300, plus tuition, fees, and travel (according to level of training and experience).

**Cancer Epidemiology Fellowship**—Pre- and postdoctoral cancer research training program in the epidemiology of cancer. Stipend, tuition, fees, and travel (stipend according to level of training and experience).

**Cardiovascular Epidemiology and Prevention Fellowship**—Pre- and postdoctoral research training in the epidemiology and prevention of cardiovascular disease. Stipends according to level of training and experience.

### FAMILY SOCIAL SCIENCE

**Mary Ellen McFarland Assistantship**—For a currently enrolled graduate student in family social science to work on a research or teaching project. One award.

### FISHERIES AND WILDLIFE

**John Dobie Fellowship in Fisheries**—To encourage graduate students in fisheries who are interested in careers in fisheries research and management, particularly in Minnesota; must have ranked in upper third of college graduating class. Variable amount.

**Gordon Guillion Scholarship**—Awarded to a student in Wildlife Conservation who demonstrates an interest in subject areas that reflect Gordon Guillion's dedication to the study of the beneficial relationship between forest management and the proliferation of diverse wildlife species. \$1,000.

### FORESTRY

**Leiton E. Nelson Scholarship**—For a graduate student in forest resources or forest products. Offered alternate years. \$1,500.

**Potlatch Fellowship in Forestry**—For a graduate student in forest resources. \$10,000.

### FRENCH

**Marguerite Guinotte Memorial Scholarship**—For needy and promising graduate students or advanced undergraduates in French language and literature to study in or travel to a French-speaking country. \$350 to \$500.

**Elizabeth Folsom Rathert Graduate Fellowship in French**—For graduate students in French literature to become more proficient in foreign languages. Recipient teaches in fall quarter and receives fellowship in winter and spring. Must be U.S. citizen with limited experience living in French-speaking cultures. Offered every year. \$9,000 plus tuition.

**Travel or Special Project Grant**—For current graduate students in French and Italian seeking support for a trip (e.g., to present a conference paper or to conduct research) or for a special project related to the student's academic work. \$300 to \$400.

**Université Paul Valéry Exchange**—For advanced graduate students in French to spend one year teaching English at the Université Paul Valéry in Montpellier.

**Université Paul Valéry**—For graduate students in French to spend one quarter as a teaching assistant at the Université Paul Valéry through the University of Minnesota Global Campus program.

### GEOGRAPHY

**John R. Borchert/CURA Fellowship**—For geography graduate students in their second or later year of graduate study who propose to carry out a research project consistent with the mission of CURA (Center for Urban and Regional Affairs). Equivalent to 50%-time assistantship for 9 months plus tuition.

**Darrell Haug Davis Memorial Fellowship**—For doctoral students in geography who are in their third, fourth, or fifth year of study. \$9,500 plus tuition.

### GEOLOGY AND GEOPHYSICS

**Richard Clarence Dennis Fellowship**—For graduate students in geology and geophysics with strong academic records. Up to \$10,000/year.

**William Harvey Emmons Fund**—In part for graduate students in geology and geophysics who have strong academic records and financial need. Up to \$5,000.

**Francis A. Gibson Fellowship**—For graduate students in geology and geophysics with preference for those studying hydrogeology or energy. Up to \$6,000.

**Samuel S. Goldich Award**—To support graduate students in geology and geophysics conducting research in geochemistry of the Precambrian. Variable amount.

**John W. Gruner Fellowship**—For outstanding graduate students in geology and geophysics. Up to \$6,000.

**Harold M. Mooney Fellowship**—In part for meritorious graduate students in geophysics. Variable amount.

### GERMAN

**Humboldt University Exchange**—For graduate students in German with teaching experience who are native speakers of English to spend one quarter teaching English at Humboldt University in East Berlin.

**Elizabeth Folsom Rathert Graduate Fellowship in German**—For graduate students in German. Must have been U.S. citizen at least ten years before fellowship term. For students with limited experience in German-speaking culture. Offered every year. At least \$5,000.

### GERONTOLOGY

**Center on Aging**—To support graduate research on aging. Contact Center on Aging. Variable amount, between \$500 and \$1,500.

### HEALTH INFORMATICS

**NLM Traineeships in Medical Informatics**—For doctoral students or postdoctorates in health informatics or related computer-oriented fields. Must demonstrate computer expertise and knowledge of health sciences. U.S. citizenship or permanent residency required. NIH stipends.

## HEALTH SERVICES RESEARCH

**Health Services Research Traineeship**—For entering doctoral students who show interest in the organizing and delivery of cost-effective health services and policy issues. U.S. citizenship required. \$10,000 plus tuition.

## HISTORY

**Class of 1889 Memorial Prize Fund**—Annual awards for the best essay in history with both undergraduates and first-year graduate students eligible. Variable amount.

**Dissertation Research Fellowships**—For students who have passed their preliminary examinations. One-quarter fellowships to further dissertation research and writing. Two awarded annually. Each fellowship is named for one of the donors whose gifts support the awards (William Stearns Davis, Samuel Deinard, the Lothrop Memorial Fund, Harriet Rislove Schoonover, Albert Beebe White, and John B. and Theta Wolf).

**History Department Summer Grants for Language or Special Training**—For graduate students in history. Variable amount.

## INDUSTRIAL RELATIONS

**Randy A. Bray Scholarship**—For a promising new master's degree student. Variable amount.

**Chevron Scholarship**—For a promising new master's degree student. Variable amount.

**Chrysler Corporation Fund Scholarship**—For an outstanding master's degree student. Variable amount.

**Citicorp Scholarship**—For a promising new master's degree student. Variable amount.

**Exxon Scholarship**—For an outstanding master's degree student. Variable amount.

**General Mills Scholarship**—For a promising new master's degree student. Variable amount.

**Herbert G. Heneman, Jr. Scholarship**—For a promising new graduate student. Variable amount.

**I.R. Council on Graduate Opportunities for Advanced Level Studies (G.O.A.L.S.) Graduate Fellowships**—For a minority student. \$7,800 per academic year plus tuition and fees. Renewable for second year if progress is satisfactory.

**Pfizer Scholarship**—For a master's degree student. Variable amount.

**Pillsbury Scholarship**—For a promising new master's degree student. Variable amount.

**Twin City Personnel Association Scholarship**—For a second-year master's degree student who is a Minnesota resident and intends to pursue a personnel career in the Twin Cities. Variable amount.

**Union Carbide Scholarship**—For an outstanding master's degree student with at least one full academic year of study remaining. Variable amount.

**Weyerhaeuser Company**—For an outstanding master's degree student. Variable amount.

## INTEREST MEASUREMENT

**E. K. Strong, Jr., Memorial Fellowship**—For doctoral candidates in psychology, child development, or educational psychology for interest measurement research. Contact Center for Interest Measurement Research. Up to \$1,000.

## INTERNATIONAL STUDIES

(Foreign Language and Area Studies [FLAS] Fellowships)

**International Studies**—Competitive fellowships for graduate students in fields other than foreign languages and literatures to study an eligible foreign language. Applicants must have research interests with an international focus and be a U.S. citizen or resident alien. Fellowships are for summer or academic year and include stipend and tuition. For applications and information contact FLAS Coordinator, Institute of International Studies, 214 Social Sciences. Application deadline is mid-February.

**Western European Studies**—Competitive fellowships for graduate students in fields other than foreign languages and literatures to study an eligible foreign language. Applicants must have research interests with a Western European focus and be a U.S. citizen or resident alien. Fellowships are for summer or academic year and include stipend and tuition. For applications and information contact FLAS Coordinator, Center for European Studies, 309 Social Sciences. Application deadline is mid-February.

## ITALIAN

See *FRENCH* above.

## LANDSCAPE ARCHITECTURE

**Edmund J. Phelps Memorial Fellowship**—To recruit outstanding students from allied disciplines. \$4,500.

## MASS COMMUNICATION

**Ralph D. Casey Dissertation Award**—For doctoral candidates embarking on dissertation research who have proposed outstanding, meritorious dissertation research projects. \$2,000.

**Herbert Berridge Elliston Fellowship**—For worthy and needy seniors or graduate students in mass communication. Variable amount.

**Arle and Billy Haerberle Memorial Scholarship**—A merit scholarship for graduate students based on academic excellence. Variable amount.

**Hubbard/KSTP Broadcast Scholarship**—For currently enrolled graduate students in broadcast journalism who show professional promise and academic achievement. Variable amount.

**Silha Center Research Fellowship in Ethics and Law**—For graduate students in mass communication who have demonstrated interest and ability in mass communication ethics or law. Variable amount.

## MATHEMATICS

**Lando Fund**—For doctoral students in mathematics for summer support. \$2,400.

**NSF Research Funds**—For doctoral students in mathematics for summer support. \$2,400.

**Ella Thorpe Fund**—For doctoral students in mathematics for summer support. \$2,400.

## MECHANICAL ENGINEERING

**McDonnell Douglas Fellowship**—For outstanding graduate students in mechanical engineering.

**Murphy/Robertson Fellowship**—To support outstanding graduate students in study of power and propulsion.

**Chester E. Dekko Fellowship**—To recognize outstanding graduate students in mechanical engineering.

## GENERAL INFORMATION

### *MEDICAL SCHOOL, CLINICAL SCIENCES*

A medical student or physician seeking information on post-M.D. graduate training programs (residencies), fellowships, or advanced degree programs in any of the clinical fields should contact the director of graduate studies or the department office in the clinical science of interest.

### *MICROBIOLOGY, IMMUNOLOGY, AND MOLECULAR PATHOBIOLOGY*

**National Institutes of Health National Research Service Awards**—For doctoral students receiving research training in biotechnology, cancer biology, immunology, and molecular pathogenesis of infectious diseases. \$10,008 plus tuition, fees, and health insurance.

**Dennis W. Watson Fellowship**—Awarded annually to an outstanding doctoral student in honor of Regents' Professor Emeritus and former Department of Microbiology head Dennis W. Watson. \$13,500 fellowship plus \$500 cash award.

### *MOLECULAR, CELLULAR, DEVELOPMENTAL BIOLOGY AND GENETICS*

**Program Fellowships**—For outstanding new doctoral students in Molecular, Cellular, Developmental Biology and Genetics. \$1,200 per month plus tuition and health insurance.

### *MUSIC*

**School of Music Scholarship**—For graduate students in all areas of music. Performance awards require audition. Up to \$4,500.

### *NEUROSCIENCE*

**Predocctoral Traineeships**—To provide interdisciplinary training for doctoral students. Must be U.S. citizen or permanent resident.

### *NURSING*

**Edna and Myron Allen Nursing Scholarship**—For a qualified enrolled undergraduate or graduate nursing student intending to work with underserved populations.

**Marion Borgenson Nursing Scholarship**—For a qualified enrolled undergraduate or graduate nursing student.

**Ruth Thomas Brisker Nursing Scholarship**—Provides a minimum of one quarter tuition for a qualified enrolled undergraduate or graduate nursing student.

**Clifton J. Brisco Nursing Scholarship**—For qualified enrolled undergraduate or graduate nursing student.

**Margaret Caldwell Memorial Nursing Scholarship**—For qualified enrolled undergraduate or graduate nursing student. Must have scholastic record, ability, personal attributes, professional promise. Financial need.

**Grace B. Dayton Nursing Scholarship**—For enrolled undergraduate or graduate nursing student with demonstrated ability.

**Beatrice Lofgren Delue Scholarship in Nursing**—For a Minnesota resident. Must have a minimum GPA of 3.00 and demonstrated financial need.

**Agnes Dempster Nursing Scholarship**—Applicant must have completed a minimum of 12 graduate credits and have a minimum 3.50 GPA. Minimum award of \$1,000. Random drawing by Foundation's board member.

**Kathleen Dineen Scholarship in Nurse-Midwifery**—For a qualified enrolled graduate nurse-midwifery student. Must have minimum 3.50 GPA, financial need, two letters of reference, and personal statement.

**Suzanne J. Doehring Memorial Scholarship in Nursing**—For qualified enrolled undergraduate or graduate nursing student with demonstrated ability.

**Katherine Densford Drees Nursing Scholarship**—Minimum \$100 awards for students with superior scholastic achievement/promise/aptitude. Financial need.

**Eisenmenger Scholarship in Nursing**—For qualified enrolled undergraduate or graduate nursing student. Financial need.

**Ardu Kluth Hopkins Nursing Scholarship**—Annual award of up to one-half tuition and fees. Career goal of public school nurse.

**Florence Julian Memorial Nursing Scholarship**—Enrolled graduate student with demonstrated interest or aptitude in area of management.

**James Lillehei Scholarship in Cardiac Nursing Research**—Enrolled graduate student with demonstrated interest in conducting research relating to care of patients and families with cardiac conditions. Financial need.

**Minority Nursing Scholarship Fund**—Financial assistance for minority or non-traditional enrolled nursing student.

**Nursing Alumni Scholarship**—For an enrolled undergraduate or graduate nursing student. Alumni selects annually.

**Alice and Gale W. Perry Nursing Scholarship Fund**—For qualified enrolled undergraduate or graduate nursing student.

**Eloise Reichert**—For currently enrolled graduate nursing student in public health.

**Jennie Siebold Memorial**—For qualified enrolled undergraduate or graduate nursing student.

**Mary Hensler Spurzem Nursing Scholarship**—For qualified enrolled undergraduate or graduate nursing student. Financial need.

**Marion Vannier Nursing Scholarship**—For students who show academic promise and are in financial need.

### *PHARMACOLOGY*

**National Research Service Award**—For doctoral students in pharmacology and toxicology. \$13,000 plus tuition, fees, and health insurance.

### *PHARMACY*

**American Foundation for Pharmaceutical Education Graduate Fellowships**—For U.S. citizens. \$6,000 to \$10,000.

**S. W. Melendy Fellowships**—For graduate students engaged in programs offered through the College of Pharmacy. *Summer Fellowships*: Average \$600 to \$800; *Academic Year Fellowships*: \$10,000. Departments determine number and amount of individual student awards.

**William and Mildred Peters Graduate Fellowship**—For students currently registered in the four graduate programs or the post-Pharm.D. resident and fellowship program within the College of Pharmacy. Eligibility established and determined by department in which program is located. Variable amounts.

**Ted Rowell Fellowship**—For graduate students engaged in basic science programs offered through the College of Pharmacy. \$3,000 to \$6,000. Preference to Minnesota residents who are U.S. citizens.

**3M Fellowship**—For first year students in the pharmaceuticals graduate program. Supported by 3M Pharmaceuticals. \$18,000 total; the department determines the number and amount of awards.

#### *PHYSICS AND ASTRONOMY*

In addition to the awards listed below, other fellowships from the University and the Institute of Technology are available to physics and astronomy students.

**Phyllis St. Cyr Freier Fellowships**—In honor of Professor Freier and the centennial of physics at the University of Minnesota. \$9,600.

#### *PLANT BIOLOGY*

**USDA National Needs Fellowship in Plant Biotechnology**—To support doctoral students in plant biotechnology, which has been identified as an area of national need for trained scientists. Students in plant molecular biology, biochemistry, physiology, cell biology, and genetics are eligible to apply. \$17,000 plus tuition and travel funds.

#### *PLANT PATHOLOGY*

**Fred I. Froshiser Scholarship**—For graduate students in plant pathology who have demonstrated outstanding abilities in scholarship, research, and all aspects of graduate study, based on at least one year of a proven performance record in graduate school. Variable amounts.

**M. F. Kernkamp Fellowship**—For graduate students in plant pathology who are outstanding in scholarship, research, and all aspects of graduate study including participation in department activities. Variable amounts.

#### *POLITICAL SCIENCE*

**Harold W. Chase Memorial Award**—For doctoral students with distinguished records in public law. Up to \$1,000.

**Asher N. Christensen Memorial Award**—For doctoral students in political science for study abroad or research in American government and politics.

**Hubert H. Humphrey Fellowship**—For doctoral students with distinguished records in political science. Up to \$8,500.

**Clara H. Ueland Memorial Fellowship**—For female doctoral students with distinguished record in political science. Up to \$8,500.

**Vernie Wolfsberg Fellowship**—For female doctoral students with distinguished record in political science. Up to \$8,500.

#### *PSYCHOLOGY*

**Center for Research in Learning, Perception, and Cognition**—To prepare doctoral students in related areas for research careers in cognitive science. Apply through Center for Research in Learning, Perception, and Cognition. \$10,008 plus tuition and fees.

**University Counseling and Consulting Services**—To provide APA-approved predoctoral internships for clinical and counseling psychology students. Internship is a 12-month, full-time position for \$13,500 plus health insurance. Apply through Training Program Director, University Counseling and Consulting Services. Typical deadline is November 30 for the following year.

**Veterans Administration**—For doctoral students in counseling and clinical psychology to pursue APA-approved internship experience. U.S. citizenship required. Apply through Training Director, Psychology Service, Veterans Administration Medical Center, Minneapolis. \$17,000 for 1,900 hours.

#### *PUBLIC AFFAIRS*

**Cram-Dalton International Women's Rights Scholarship**—For an entering graduate student who has shown an interest in international women's rights. International students are encouraged to apply. Variable amount.

**Gerald W. Heaney Fellowship or Scholarship**—Award made on basis of academic merit. Applicants should be from Duluth, the Duluth area, or northeast Minnesota. Variable amounts.

**Hubert H. Humphrey Fellowships and Scholarships in Public Affairs**—For outstanding graduate students preparing for careers in public service. Up to \$10,000 plus tuition first year; with satisfactory performance, up to \$4,200 plus tuition second year.

**Minority and Disadvantaged Student Awards**—For graduate students preparing for careers in public affairs; awards based on need. Variable amounts.

**Joseph Robbie Fellowship or Scholarship in Metropolitan Government and Planning**—Award made on basis of academic merit. Applicants must be planning to enter career in metropolitan or regional government or planning. Variable amounts.

**Woodrow Wilson Minority Access Program Fellowships**—For minority students entering graduate school in public affairs or planning. Must have completed one of the Wilson Junior Year Summer Institutes Programs.

#### *PUBLIC HEALTH*

Federally funded traineeships are available in some major areas. Research assistant, teaching assistant, and postdoctoral fellowship positions are available dependent on student's area of interest. See specific listings in this section for biostatistics, environmental health, epidemiology, health services research and policy and health services research, policy and administration.

#### *RHETORIC*

**Rhetoric and Scientific and Technical Communication Scholarship**—National awards of \$2,000 through the Society for Technical Communication.

**Scientific and Technical Communication Fellowship**—To encourage MSSTC candidates to pursue qualitative and quantitative research and theory building in STC and to encourage MSSTC candidates to teach STC at the postsecondary level. \$300 to \$1,500.

#### *SOCIAL WORK*

A small number of training fellowships from federally funded grants, paid field placements from local agencies, and assistantships, including the Morris Hursh Graduate Assistant Endowment, are directly available from the School of Social Work. Number of awards and amounts vary from year to year.

**Rose E. Snyder Memorial Scholarship**—Provides annual funding for tuition for M.S.W. students.

## GENERAL INFORMATION

### *SOCIAL WORK (Duluth Campus)*

**Will Dodge Memorial Fund**—For graduate students in social work to support field placements or projects that involve grass-roots community organizing. Must register for 7 credits per quarter during the next academic year. About \$500.

### *SOCIOLOGY*

**Bright Research Award**—Given annually to graduate student(s) for whom the award will make possible a significant improvement in the progress of research toward the Ph.D. Up to \$3,000.

**Don Martindale Award for Scholarship**—Given annually to a current Ph.D. student who has shown exceptional accomplishment and progress toward the degree as well as toward contributing to the profession. \$1,000.

### *SPEECH-COMMUNICATION*

**Frizelle-Reid Memorial Award**—For doctoral candidates in speech-communication for expenses associated with the completion of their programs. Based on academic excellence and quality of proposal. About \$600.

**Arl and Billie Haerberle Fellowship and Awards**—The fellowship is for a first-year graduate student specializing in the use of electronic media in communication. Based on academic excellence. \$10,000 plus tuition. The awards are for undergraduate and graduate students and are based on academic excellence and demonstrated interest in the study of electronic media. Amounts vary from \$200 to \$2,000.

**Marguerite Garden Jones Award**—For graduate or undergraduate students based on excellence in pursuing study and application of coursework in speech-communication. About \$2,000.

**Stuart A. Lindman Award**—For graduate or undergraduate students who intend to pursue a career in electronic media. Based on academic excellence and real-life application of coursework in speech-communication. About \$500.

### *STATISTICS*

**Statistics Alumni Fellowship Fund**—For second- or third-year full-time graduate student in statistics. Amount variable depending on funds, approximately commensurate with research assistantship.

### *THEATRE ARTS*

**Ken Bryant Directing Scholarship**—For a graduate student who has expressed an interest in directing. About \$1,000.

**Oscar W. Firkins Scholarship**—For currently enrolled graduate students in theatre arts. Award based on service, potential in theatre, and need. About \$1,500.

**Kenneth L. Graham Graduate Theatre Fellowship**—For an outstanding graduate theatre major in residence. About \$1,500.

**Haerberle Scholarships**—For graduate students in theatre arts. Selection is made on basis of outstanding artistic and/or scholarly potential or achievement. About \$3,000.

**Paul Joncas Technical Theatre Scholarship**—For a currently enrolled student, junior through graduate, to benefit technical theatre students attending the annual USITT Conference. About \$500.

**Elsie Kelley Lindquist Scholarship**—For an outstanding undergraduate or graduate theatre major in residence. Award based on service, potential in theatre, and need. About \$1,000.

**Dorothy Lamberton Fellowship**—For a first-year MFA Acting student with outstanding potential. About \$1,000.

**Dorothy Magnus Scholarship Fund**—For deserving graduate students at the discretion of members of the Theatre Arts Department. About \$1,400.

**Robert Moulton Scholarship 50**—Funded by alumni and patrons for outstanding theatre students with financial need. Variable amount.

**Frank M. Rarig, Sr., Graduate Fellowship in Oral Interpretation**—For a currently enrolled, worthy graduate student with a major interest in oral interpretation. About \$1,250.

**Scott-Norcostco Theatre Fund**—For a currently enrolled student, junior through graduate, in technical theatre. About \$750.

**Frank and Josinette Whiting Scholarship**—For an outstanding undergraduate or graduate major in residence. Award based on service, potential in theatre, and need. About \$1,800.

**August Wilson Fellowship in Dramaturgy and Literary Criticism**—For an African-American graduate student in the area of literary criticism and dramaturgy. Support is for up to three years of graduate study leading to the M.A. or Ph.D. with internships in dramaturgy at the Penumbra and Guthrie Theatres. About \$10,000 per year in fellowship and/or assistantship support.

### *VETERINARY BIOLOGY AND VETERINARY PATHOBIOLOGY*

**Alvin F. Weber Scholarship**—For graduate students accepted to, or currently enrolled in, the combined Ph.D./D.V.M. program. \$11,150.

### *OTHER FELLOWSHIPS*

**Foreign Language and Area Studies Fellowships**—See European Studies above.

## Visiting Faculty and Scholars

**Honorary Fellow**—A professor or eminent scholar from another U.S. institution who is not a degree candidate at the University of Minnesota and seeks temporarily the privileges of using library or research facilities or attending seminars at the University, may be named an honorary fellow, without stipend, upon recommendation of the appropriate department head and approval of the Graduate School dean. (Note that for a professor or scholar from an international institution, the host department appoints the individual to a specific payroll appointment class, with or without salary depending upon arrangements agreed to between the department and the foreign scholar.)

**Postdoctoral Associate**—A postdoctoral fellow who does not hold a payroll class appointment (either with or without salary) may be named a postdoctoral associate by the Graduate School for up to one year upon recommendation of the host department.

**Visiting Scholar**—A regular faculty member of a Minnesota public or private college who is not studying for an advanced degree at the University of Minnesota and seeks temporary library privileges, can be named a visiting scholar, without stipend, by the Graduate School upon request of the host department. The request must include a letter from the college's academic dean or vice president verifying the visitor's faculty status and field of specialization.

## Student Grievance Procedures

**Academic Grievances**—An all-University Student Academic Grievance Policy exists to resolve “complaints brought by students regarding the University’s provision of education and academic services affecting their role as students.” Copies of the policy and information about its implementation are available from the Grievance Office, 419 Walter Library, Twin Cities campus (612/624-1030).

**Sexual Harassment**—Policies and procedures pertaining to sexual harassment are contained in the University Senate’s policy statement of May 17, 1984. As the introduction to the statement notes, sexual harassment undermines the mission of the University and jeopardizes the careers of students, faculty, and staff. The statement defines sexual harassment in this manner:

“Unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature constitute sexual harassment when (1) submission to such conduct is made either explicitly or implicitly a term or condition of an individual’s employment or academic advancement, (2) submission to or rejection of such conduct by an individual is used as the basis for employment decisions or academic decisions affecting such individual, or (3) such conduct

has the purpose or effect of unreasonably interfering with an individual’s work or academic performance or creating an intimidating, hostile, or offensive working or academic environment.”

Individuals seeking information and guidance in matters involving sexual harassment should contact the sexual harassment officer, 419 Morrill Hall. All inquiries will be held in strictest confidence.

## Housing

Students interested in living in a residence hall on campus or in off-campus housing in Minneapolis or St. Paul should contact Housing & Residential Life, Comstock Hall-East, 210 Delaware Street S.E., Minneapolis, MN 55455 (612/624-2994; fax 612/624-6987; e-mail housing@tc.umn.edu). Centennial and Middlebrook Halls offer residential living space that is predominantly for graduate/professional school students. Listings of apartments, duplexes, houses, sleeping rooms, shared units, and sublets are also maintained. Information on temporary housing, living costs, transportation, and day-care centers in the Twin Cities area is also available. A comprehensive booklet, *The Housing Resource Guide*, may be purchased for \$2.00.

For information on University family housing, contact Commonwealth Terrace Cooperative, 1250 Fifield Avenue, St. Paul, MN 55108 (612/646-7526) or Como Student Community, 1024 27th Avenue S.E., Minneapolis, MN 55414 (612/378-2434).

## Placement

Graduate students seeking placement in college, university, or other positions may obtain aid and counsel from advisers and departments, from the deans of various colleges of the University, and through Student & Professional Services. This last office receives reports of vacancies for college teaching positions in all fields as well as for positions in counseling, administration, adult education, student personnel work, and research. Noneducation graduate students seeking college teaching positions are eligible to establish credential files. The address of Student &

## GENERAL INFORMATION

Professional Services is University of Minnesota, 110 Wulling Hall, 86 Pleasant Street S.E., Minneapolis, MN 55455 (612/625-6501).

The following offices offer placement services to graduate students seeking employment in fields other than teaching.

*College of Agricultural, Food, and Environmental Sciences*  
Career Services

University of Minnesota  
120 Biosystems and Agricultural Engineering  
1390 Eckles Avenue  
St. Paul, MN 55108  
612/624-2710; fax: 612/625-1260  
e-mail: jmunder@tc.umn.edu

*College of Biological Sciences*

Career Information Center  
Kathie Peterson, Career Information Adviser  
University of Minnesota  
217 Snyder Hall  
1475 Gortner Avenue  
St. Paul, MN 55108  
612/624-9270; fax: 612/624-2785

*School of Dentistry*

Minnesota Dental Placement Service  
University of Minnesota  
15-106 Moos Health Sciences Tower  
515 Delaware Street S.E.  
Minneapolis, MN 55455  
612/626-0171; fax: 612/626-2654  
e-mail: m-lach@tc.umn.edu

*University of Minnesota, Duluth*

Career Services  
University of Minnesota  
21 Campus Center  
10 University Drive  
Duluth, MN 55812  
218/726-7985; fax: 218/726-6394  
e-mail: carserv@ub.d.umn.edu

*College of Human Ecology*

Career Services and Development  
Jeanne Exline, Director  
University of Minnesota  
68 McNeal Hall  
1985 Buford Avenue  
St. Paul, MN 55108  
612/624-6762; fax: 612/625-7234  
e-mail: exline@che1.che.umn.edu

*College of Liberal Arts*

Career Services  
University of Minnesota  
220 Johnston Hall  
101 Pleasant Street S.E.  
Minneapolis, MN 55455  
612/624-7577; fax: 612/624-6839

*Curtis L. Carlson School of Management*

Career Services Center  
University of Minnesota  
190 Hubert H. Humphrey Center  
271 19th Avenue South  
Minneapolis, MN 55455  
612/624-0011; fax: 612/626-1822  
e-mail: csc@csom.umn.edu

*College of Natural Resources*

Career Opportunities Coordinator's Office  
University of Minnesota  
135 Natural Resources Administration Building  
2003 Upper Buford Circle  
St. Paul, MN 55108  
612/624-6247; fax: 612/624-8701  
e-mail: psplett@forestry.umn.edu

*Hubert H. Humphrey Institute of Public Affairs*

Office of Career Services  
Lynne Schuman, Director  
University of Minnesota  
225 Hubert H. Humphrey Center  
301 19th Avenue South  
Minneapolis, MN 55455  
612/625-2847; fax: 612/625-6351  
e-mail: lschuman@hhh.umn.edu

*School of Public Health*

Career Center  
University of Minnesota  
D-305 Mayo Memorial Building  
420 Delaware Street S.E.  
Minneapolis, MN 55455  
612/624-6915; fax: 612/626-6931  
e-mail: sph-uofm@greg2.sph.umn.edu

*Institute of Technology*

Career Services  
University of Minnesota  
50 Lind Hall  
207 Church Street S.E.  
Minneapolis, MN 55455  
612/624-4090; fax: 612/626-0261  
e-mail: itcs@tc.umn.edu

# **G r a d u a t e P r o g r a m s**

**This is the Aerospace Engineering and Mechanics to Comparative Literature program and course sections of the 1996-1999 University of Minnesota Graduate School Catalog**

*For an explanation of the numbering system, punctuation, department prefixes, and symbols used throughout the course descriptions in this section, see the last page of this bulletin.*

## **Aerospace Engineering and Mechanics (AEM)**

*Regents' Professor:* Daniel D. Joseph; James B. Serrin (*emeritus*; mechanics)

*Professor:* William L. Garrard, *head*; Theodore A. Wilson, *associate head*; Roger E. A. Arndt (aerospace engineering); Gordon S. Beavers; Roger L. Fosdick; Chih-Chun Hsiao (*emeritus*); Richard D. James; Thomas S. Lundgren; Mitchell B. Lusk (mechanics); Tayfun E. Tezduyar; Andrew Vano; William H. Warner (*emeritus*)

*Associate Professor:* Ellen K. Longmire, *director of graduate studies*; Amy E. Alving; Gary J. Balas; Graham V. Candler; Perry H. Leo; Thomas W. Shield; Lev Truskinovsky; Yiyuan Zhao

*Adjunct Associate Professor:* Dale F. Enns

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Aerospace Engineering: M.S.Aero.E. (Plan A and Plan B), M.Aero.E. (Coursework Only and Design Project), and Ph.D.; Mechanics: M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—The department offers graduate study in two major fields, mechanics and aerospace engineering. The graduate programs emphasize engineering sciences that are basic to these fields: fluid mechanics, dynamical systems and controls, and continuum and solid mechanics. Theoretical, analytical, experimental, and computational aspects of these fields are covered by the courses and research opportunities offered by the department.

**Prerequisites for Admission**—A four-year B.S. degree in an engineering, basic science, or mathematics program is required. Admission depends primarily on the applicant's undergraduate record and letters of recommendation.

**Special Application Requirements**—Graduate Record Examination scores are not required but are strongly recommended for students applying for graduate fellowships. In all cases, these test scores are taken into account if they are provided.

Students are admitted fall quarter only. Only under unusual circumstances are students allowed to begin their studies at another time during the academic year.

**Master of Science Degree Requirements**—For the M.S. degrees, see the General Information section of this bulletin. At least one sequence of 8xxx courses is required.

**Master of Aerospace Engineering Degree Requirements**—See Professional Master's Degree in Engineering in the General Information section of this bulletin.

**Doctoral Degree Requirements**—The Ph.D. program in the two major fields, mechanics and aerospace engineering, requires about two years of coursework, but the heart of the Ph.D. program is the thesis research. A Ph.D. program must contain a minimum of 64 credits of approved courses and six quarters of colloquium attendance. The first year of the Ph.D. program is similar to the master's program and most Ph.D. students receive the master's degree. By the end of the first year, the student has chosen an adviser. The second year is devoted to more advanced courses and beginning research. Subsequent years include some coursework with increased focus on research. The time required to complete a research project varies, but most students finish the Ph.D. about four years after their bachelor's degree.

**Language Requirements**—None, for either major. Some doctoral candidates, however, may find that reading proficiency in one or more languages is essential.

**For Further Information and Applications**—Contact the Chair, Graduate Admissions Committee, Department of Aerospace Engineering and Mechanics, University of Minnesota, 107 Akerman Hall, 110 Union Street S.E., Minneapolis, MN 55455 (612/625-8000; fax 612/626-1558; e-mail dept@aem.umn.edu; <http://www.aem.umn.edu>).

*Note*—The courses listed below are appropriate for majors in both aerospace engineering and mechanics.

**AEM 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**AEM 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**AEM 8888. Thesis Credits: Doctoral.** (36 cr required)

**AEM 5200. Kinematics and Dynamics of Fluid Flow.** (4 cr; prereq IT or grad student, 3036, ¶Math 3331 or Math 3252) Longmire  
Stress and strain rate descriptions, fluid statics, use of differential and finite control volume analysis with continuity, momentum, energy equations, Bernoulli and Euler equations, introduction to Navier-Stokes equations, vorticity, potential flow.

**AEM 5202. Viscous Flow.** (4 cr; prereq 5200, IT or grad student) Alving, Beavers, Wilson  
Incompressible viscous flow using Navier-Stokes equations. Dimensional analysis; one-dimensional exact solutions; pipe flow; laminar and turbulent boundary layers, wakes, and jets; momentum integral; pressure gradients and separation; introduction to turbulence; Reynolds stresses.

**AEM 5204. Shock Waves and Compressible Fluid Flow.** (4 cr; prereq 5200, IT or grad student) Beavers  
Basic concepts of thermodynamics. One-dimensional steady isentropic flow. Laval nozzle. Normal and oblique shock waves and reflections. Prandtl-Meyer flow. Supersonic thin airfoil theory.

**AEM 5205. Aerospace Propulsion.** (4 cr; prereq 5204, ME 3301, upper div IT student) Beavers  
Fundamentals; performance parameters; thermodynamic cycles; performance analysis of flight propulsion systems: turbojets, turbofans, ramjets, rockets, propellers.

**AEM 5206. Aerodynamics of Lifting Surfaces.** (4 cr; prereq 5200, CSci 3101 or CSci 3104) Candler  
Pressure distributions, forces, and moments on airfoils and wings of finite span. Analysis of potential flow by thin airfoil theory, lifting line theory, and panel methods. Viscous effects and their relation to design variables.

**AEM 5240. Rarefied Gas Dynamics.** (4 cr; prereq IT or grad student, 5204 or Δ) Longmire  
Relationship between continuum and molecular models for gas flow. Free molecule flows. Lift, drag, and energy transfer in free molecule flows. Slip flow and temperature jump.

**AEM 5243. Advanced Aerodynamics.** (4 cr; prereq IT or grad student, 5206)  
Interaction between pressure distribution and boundary-layer growth on airfoils of arbitrary shape. Inviscid flow past non-planar wings of specified planform.

**AEM 5244. Hypersonic Aerodynamics.** (4 cr; prereq IT or grad student, 5204) Candler  
Importance and properties of hypersonic flow. Hypersonic shock and expansion-wave relations. Local surface inclination methods. Approximate and exact methods for hypersonic inviscid flowfields. Viscous flow: boundary layers, aerodynamic heating, hypersonic viscous interactions, computational methods. Hypersonic propulsion and vehicle design.

**AEM 5250. Computational Fluid Mechanics.** (4 cr; prereq IT or grad student, FORTRAN, 5200 or Δ) Tezduyar

Finite element method; fundamentals of spatial discretization and numerical time-integration. Introduction to engineering and scientific computing environment and large-scale computing.

**AEM 5300. Flight Mechanics.** (4 cr; prereq 3005 or 5206, IT or grad student) Enns, Garrard  
Standard atmosphere, analysis of power required, the classical performance data, maximum and minimum speed, maximum rate of climb, angle of climb and glide, absolute ceiling, service ceiling of propeller and jet-propelled aircraft. Static longitudinal stability, wing contribution, tail contribution, fuselage contribution and the neutral point. Power effect and longitudinal control. Formal aerospace vehicle design and wind tunnel projects.

**AEM 5319. Dynamics and Control of Aerospace Vehicles.** (4 cr; prereq 3401, 5300 or #, IT or grad student) Enns, Garrard  
Reference frames, kinematics, and equations of motion. Forces and moments, trim, linearization, and dynamic response characteristics for aircraft and spacecraft. Handling qualities. Aircraft stability derivatives, phugoid, short period, spiral, roll subsidence, dutch roll modes, approximations, and transfer functions.

**AEM 5321. Automatic Control.** (4 cr; prereq 3401 or equiv) Balas, Garrard  
Basic theory of linear, single-input, single-output feedback control systems. Analysis and design using root locus, Nyquist Bode techniques. Introduction to state-space formulation. Applications to automatic flight control and mechanical systems.

**AEM 5329. Fundamentals of Aerospace Vehicle Design.** (4 cr; prereq 5300 or #, AEM sr) Vano  
Design process and requirements, mission analysis, tradeoffs, vehicle component sizing, weight estimates, performance, propulsion systems, weight and balance, stability and control, cost, ground and flight testing, compliance and certification. Students prepare conceptual design of aerospace vehicle and written and oral reports.

**AEM 5330, 5331. Design of Aerospace Elements and Systems.** (4 cr per qtr; prereq sr aerospace major or Δ) Vano  
Group and individual design projects.

**AEM 5359. Deceleration of Aerospace Craft.** (4 cr; prereq 3036, 5200, IT student) Garrard  
Parachutes and other aerodynamic decelerators. Types, characteristics and applications, drag coefficients and steady descent, stability, deployment and opening forces, apparent mass effects, trajectory analysis, stress analysis, engineering properties of textile materials. Individual design projects.

**AEM 5370. Aerodynamics of V/STOL Flight.** (4 cr; prereq 5206) Zhao  
Aerodynamic characteristics of the classical rotor. Combinations of rotor-wing and direct thrust-wing configurations are analyzed for high speed V/STOL aircraft. Jet flap, boundary layer control, and ground effect machines.

**AEM 5410. Introduction to Astrodynamics.**

(4 cr; prereq 3036)

Fundamental concepts of the two-body problem. Celestial coordinates, orbital elements. Orbit maneuvers and introduction to the three-body problem.

**AEM 5438. Intermediate Dynamics.**

(4 cr; prereq 3036) Enns, Garrard

Three-dimensional Newtonian mechanics, kinematics of rigid bodies, dynamics of rigid bodies, analytical mechanics, generalized coordinates, holonomic constraints, Lagrange equations and applications, multidegree-of-freedom dynamical systems.

**AEM 5440. Dynamics of Systems and****Structures.**

(4 cr; prereq 5438, IT or grad IT student) Balas  
Application of Lagrangian methods to multidegree-of-freedom systems; vibrations of strings, rods, shafts, and beams; frequency and time domain analysis of multidegree-of-freedom mechanical systems; finite elements in structural dynamics.

**AEM 5515. Aerospace Structures I.**

(4 cr; prereq 3016, IT student) Leo, Shield  
Elastic analysis of components important to aerospace structures. Finite element methods. Elastic limit and post-elastic behavior of trusses. Matrix methods for isotropic metals and composite materials in plane stress. Design and analysis of thin-walled and semi-monocoque structural members in bending and torsion. Energy and Castigliano methods for statically indeterminate structures.

**AEM 5516. Aerospace Structures II.**

(4 cr; prereq IT student, 5515 or  $\Delta$ ) Shield  
Use of prepared computer programs for microcomputers and mainframe computers to solve moderately sized problems of analysis and design of trusses, plane frames, torsion, plane stress, and combination structures; elastic and inelastic analysis; use of symmetry and superposition to extend power of prepared programs; basis of finite element methods used.

**AEM 5518. Mechanics of Composite**

**Materials.** (4 cr; prereq 3016) Leo  
Analysis, design, and applications of laminated and chopped fiber-reinforced composites. Micro- and macro-mechanical analysis of elastic constants, failure and environmental degradation.

**AEM 5580. Mechanics of Solids.**

(4 cr; prereq Math 3251, IT or grad student) Fosdick, James, Truskinovsky  
Nonlinear continuum mechanics and thermodynamics in one dimension. Kinematics; mass, momentum, energy, and entropy; balance equations and jump conditions. Linear and nonlinear elastic constitutive equations. Applications drawn from wave propagation, stability, fracture mechanics, plasticity and viscoelasticity.

**AEM 5581. Thermodynamics of Solids.**

(4 cr; prereq Math 3251, IT or grad student) Truskinovsky  
Energy, power, heating, entropy, and stability; their use in formulating nonlinear constitutive equations and designing experiments. Analysis of shear-induced phase transitions and other instabilities. Topics may include shock waves, solid state engines, and other devices.

**AEM 5630. Aeromechanics Laboratory I:**

**Fluid Mechanics.** (4 cr; prereq 3016, 3036, 5200, upper div IT student) Alving, Longmire  
Experimental methods and design in fluid mechanics. Wind tunnel and water channel experiments involving flow visualization, pressure, velocity, and force measurement techniques. Computerized data acquisition dimensional analysis, error analysis, and data reduction methods. Oral and written reports.

**AEM 5631. Aeromechanics Laboratory II:**

**Solids and Structures.** (4 cr; prereq 3016, 3036, 5200, upper div IT student) James, Leo, Shield  
Experimental determination of stresses, strains, and displacements that occur in solids and structures. Error analysis, computerized data acquisition and analysis, strain gauges, photo-elasticity, material behavior, stress concentrations, and composite materials. Written reports.

**AEM 5632. Aeromechanics Laboratory III:**

**Dynamics and Control.** (4 cr; prereq 3016, 3036, 5200, upper div IT student) Balas, Garrard  
Experimental determination of dynamic response of systems and design and implementation of feedback controllers. Actuators and sensors for dynamic systems, digital signal processing, fast Fourier transforms. Written and oral reports.

**AEM 5650. Aeroelasticity I.**

(4 cr; prereq 5206)  
Static aeroelastic phenomena, torsional divergence of a lifting surface, control surfaces reversal and elastic efficiency. Effects of elastic deformations on stability, aeroelastic twisting of propeller blades and rotary wings, theory of lifting surface flutter, problems of gust response and buffeting, scaling of aeroelastic force models.

**AEM 5687. Introduction to Acoustics and**

**Environmental Noise.** (4 cr; prereq Math 3261, Phys 1253, IT or grad student) Wilson  
Derivation of the wave equation, plane wave solution, transmission and reflection at boundaries, resonators and mufflers, three-dimensional wave propagation, properties of environmental noise sources, hearing and perception of sound, acoustical properties of rooms, lab experience in sound and noise measurements, noise control techniques.

**AEM 5800, 5801, 5802. Problems in Mechanics and Materials.**(1-4 cr per qtr; prereq  $\Delta$ )

Topics of current interest. Individual projects.

**AEM 5810, 5811, 5812. Problems in Fluid**

**Mechanics.** (1-4 cr per qtr; prereq  $\Delta$ )  
Topics of current interest. Individual projects.

**AEM 8001, 8002, 8003. Seminar: Aerospace Engineering and Mechanics.**

(1 cr per qtr; prereq consent of director of graduate studies; S-N only)  
Short project based on colloquium series required for credit.

**AEM 8201-8202-8203. Fluid Mechanics I-III.**

(4 cr per qtr; prereq undergrad fluid mechanics and vector analysis; 8203 offered alt yrs) Alving, Lundgren  
 Mathematical and physical principles governing the motion of fluids; kinematic, dynamic, and thermodynamic properties of fluids. Stress and deformation. Equations of motion. Analysis of rotational and irrotational inviscid incompressible flow. Two-dimensional and three-dimensional potential flow. Application to jets and lifting airfoils of infinite and finite span. Analysis of incompressible viscous flow. Creeping flows. Boundary layer flow. Analysis of compressible flow and shock waves. Method of characteristics for one-dimensional unsteady flow and for two-dimensional steady flow.

**AEM 8209. Rotating Fluids.** (3 cr; prereq background in fluid mechanics especially boundary layer theory; offered when feasible) Lundgren

**AEM 8216-8217. Theory of Turbulence I-II.** (3 cr per qtr; prereq 8202; offered alt yrs) Lundgren  
 8216: Analysis of turbulent flows. Reynolds equations, mixing length theory, classical boundary layer, pipe and wake flows, more general models. 8217: Theories of homogeneous turbulence.

**AEM 8219. Computers in the Laboratory.** (4 cr; offered alt yrs) Longmire  
 Overview of computer organization, including external communications and A/D, D/A conversion. Measurement techniques, such as pressure measurements, hot-wire and laser Doppler anemometry. Signal processing and uncertainty, computer control of experiments.

**AEM 8220. Rheological Fluid Mechanics I.** (3 cr; prereq 8201 or 8510 or #; offered alt yrs) Joseph  
 Methods of solution for flows of simple fluids with general constitutive equations. Topics from viscometric flow, extensional flow, perturbations of the rest state with steady and unsteady flow, secondary flow.

**AEM 8221. Rheological Fluid Mechanics II.** (3 cr; prereq 8220 or #; offered alt yrs) Joseph  
 Structure theories of constitutive relations. Suspension rheology. Anisotropic fluids.

**AEM 8232. Physical Gas Dynamics.** (3 cr; prereq undergrad fluid mechanics, compressible flow, thermodynamics) Longmire  
 Molecular and chemical effects in gas flows. Use of collision theory to determine mean free path, velocity distributions. Statistical mechanics. Partition function. Maxwellian and Boltzmann distributions. Nonequilibrium flows. Applications in rarefied and hypersonic flows.

**AEM 8240. Perturbation Methods in Fluid Mechanics.** (3 cr; prereq 8202 or #; offered alt yrs) Joseph, Lundgren  
 Method of matched asymptotic expansions presented through simple examples and applied to viscous flows at high and low Reynolds numbers, lifting wings, hypersonic flow, acoustics, and other problems in fluid mechanics.

**AEM 8250. Computational Aerodynamics.**

(4 cr; prereq FORTRAN)  
 Navier-Stokes equations and different levels of approximations. Finite difference approximations; accuracy, consistency, conservation form, and stability. Solution of Burger's equation; project: shock generation. Solution of Euler's equations; project: flow inside shock tube. Subsonic potential flow and transonic flow around airfoil. Multigrid techniques and grid generation.

**AEM 8251. Finite Volume Methods in Computational Fluid Dynamics.** (4 cr; prereq grad-level numerical analysis course or #)  
 Developing methods for solving compressible Navier-Stokes equations. High-resolution upwind shock-capturing schemes. Explicit and implicit formulations. Treating boundary conditions. Recent developments and other advanced topics.

**AEM 8260. Nonlinear Waves in Mechanics.** (3 cr; prereq 8201 or 8510 or #; offered alt yrs) Lundgren  
 Theory of kinematic, hyperbolic, and dispersive waves, with application to traffic flow, gas dynamics, elastodynamics, and water waves.

**AEM 8410. Advanced Dynamics.** (4 cr; prereq 5438 or #)  
 Lagrange's equations; ignorable coordinates and momentum integrals; Routh's procedure; impulsive motion; constraints and Lagrange multipliers; calculus of variations and Hamilton's principle of stationary action; linearization; classical vibration theory; gyroscopic, circulatory, and non-stationary linear systems.

**AEM 8411. Linear Systems.** (4 cr; prereq 5438, # or 8410)  
 Linearization of equations of motion; Jordan form; singular value decomposition; numerical methods; solution procedures; matrix methods; qualitative properties; stability; observability and controllability; frequency domain methods.

**AEM 8412. Nonlinear Systems.** (4 cr; prereq 8411 or #)  
 Introduction to nonlinear dynamical systems. Method of averaging and its applications. Center manifold and normal form theories. Codimension one bifurcation analysis. Introduction to chaotic phenomena.

**AEM 8413. Advanced Nonlinear Systems.** (3 cr; prereq 8411, 8412 or #)  
 Dynamical systems with emphasis on higher dimensional (more than three) systems and global and chaotic phenomena. Bifurcation analysis with codimension greater than one, Melnikov method, and Silnikov phenomena. Concepts of symmetry. Application to problems modeled by partial differential equations.

**AEM 8420. Trajectory Optimization Techniques.** (4 cr; prereq 5321 or #) Zhao  
 Review of parameter optimization problems. Topics in calculus of variations. Necessary conditions of nonlinear optimal control problems. Classification of trajectory optimization algorithms. Steady-state aircraft flight. Minimum-time climb aircraft trajectory. Aero-assisted orbital transfer trajectories. Optimal space trajectories.

**AEM 8421. Modern Control Theory for Aerospace Systems.** (4 cr; prereq 5321, 8410 or #) Balas, Zhao

State space theory for multiple-input-multiple-output (MIMO) aerospace systems. Singular value decomposition (SVD) technique and its applications to performance and robustness. Linear quadratic gaussian (LQG) and eigenstructure assignment design methodologies. Topics in  $H_\infty$ . Examples of aerospace systems and synthesis.

**AEM 8422. Robust Multivariable Control Design.** (3 cr; prereq 8410, 8421 or similar courses in mech eng or elec eng) Balas

Emphasizes application to aerospace systems. Role of model uncertainty/modeling errors in design process. Control analysis and synthesis, including  $H_2$  and  $H_\infty$  optimal control design and structural singular value ( $\mu$ ).

**AEM 8425. Advanced Topics in Aerospace Guidance and Control.** (3 cr [may be repeated for cr]; prereq 8410, 8421 or #; offered when feasible)

**AEM 8501, 8502, 8503. Research Seminar in the Mechanics of Materials.** (2-4 cr) Fosdick, James, Leo, Truskinovsky  
Developing research programs from the macroscopic point of view. Topics drawn from current research and student interests.

**AEM 8510. Continuum Mechanics I.** (4 cr; prereq  $\Delta$ ) Fosdick

Concepts that are common to all continuous media. Elements of tensor analysis. Motion, deformation, and vorticity. Material derivatives. Mass and the continuity equation. Balance of linear and angular momentum. Stress and its geometric characterization. Need for constitutive equations.

**AEM 8511, 8512. Continuum Mechanics II, III.** (4 cr per qtr; prereq 8510 or #; 8512 offered alt yrs) Fosdick, James

Balance of energy. Principle of frame indifference. Constitutive equations of mechanics and characterization of solid and fluid type behavior including materials with memory. Principle of fading memory. Position of classical and approximate constitutive theories. Variational principles; virtual work and fundamental applications. Thermodynamics; entropy, Clausius-Duhem inequality. Solution of special problems.

**AEM 8522. Theory of Plasticity.** (4 cr; prereq 5580 or 8510 or #; offered alt yrs) Shield  
General theory of plane plastic strain for a rigid, perfectly plastic material. Applications to incipient plastic flow, steady flow, and pseudosteady flow. General theory of work hardening and perfectly plastic materials. Drucker postulates. Uniqueness and existence. Minimum principles and limit analysis. Applications.

**AEM 8540. Theory of Viscoelasticity.** (4 cr; prereq 5580 or 8510 or #; offered alt yrs) Fosdick, James  
Principles of physics and mechanics of viscoelastic media. General balance of a physical law and field equations. General constitutive behavior of materials, methods of obtaining constitutive equations. General viscoelastic behavior and nonlinear large deformations. Microstructural consideration of viscoelastic systems.

**AEM 8570. Fracture Mechanics.** (4 cr; prereq  $\Delta$ ; offered alt yrs) Truskinovsky  
Theories of mechanical breakdown. Kinetic rate theories and instability considerations. Formation of equilibrium cracks and circular crack propagation under pulses. Statistical aspects of strength and fracture of micromolecular systems. Time and temperature dependency in fracture problems and instability of compressed material systems.

**AEM 8585. Advanced Topics in Continuum Mechanics.** (3 cr; prereq 8510, 8511, 8512 or #) Fosdick, James

Finite elasticity theory; theoretical study of exact solutions and experimental significance of selected problems, inequalities and work theorems, plane problems, iterative solutions and second-order effects, small deformations superposed on large, and relationship to stability. Singular surfaces and waves. Viscometric flows of non-Newtonian fluids; viscometric functions. Solution of special problems that illustrate the normal stress effect. Selected experimental results. Possible additional topics: Cosserat materials, multipolar continuum mechanics, modern theories of plasticity, mixtures, hypoelasticity, elastic dielectric and electrified materials.

**AEM 8589. Mechanics of Crystalline Solids.** (4 cr; prereq 8510 or #) James

Molecular theory of crystals and origins of stress in crystals. Relation between atomic and macroscopic motion and constitutive equations for crystals; phase transformations and analysis of microstructure; effects of shear stress, pressure, temperature, electromagnetic fields, and composition on transformation temperatures and microstructure; surface energy in solids.

**AEM 8594. Elastostatics I.** (4 cr; prereq 5580 or 8510 or #, 8511 recommended; offered alt yrs) Fosdick, James, Leo  
Principles and field equations of elasticity. Fundamental boundary value problems. Topics selected from energy theorems, St. Venant beam theory, plane problems, three-dimensional stress function methods, fundamental solutions.

**AEM 8595. Elastostatics II.** (3 cr; prereq 8594; offered alt yrs) Fosdick, James, Leo  
(Continuation of 8594) Contact stress; finite deformations; other special topics.

**AEM 8596. Elastodynamics.** (4 cr; prereq 5580 or 8510 or #; offered alt yrs) Fosdick, James  
Waves and vibrations in rods, beams, and plates. Dispersion. Volume and surface waves; reflection. Energy theorems. Vibrations of bounded media and relation to technical theories. Elements of nonlinear waves, inelastic waves, stability of motion of elastic systems.

**AEM 8601. Finite Element Methods in**

**Computational Mechanics.** (4 cr; prereq IT grad student or  $\Delta$ ) Tezduyar

Fundamental concepts and techniques of finite element analysis. Variational equations and Galerkin's method; weak formulations for problems with nonsymmetric differential operators; Petrov-Galerkin methods; examples from solid and fluid mechanics; properties of standard finite element families, implementation.

**AEM 8602. Finite Element Methods in**

**Computational Fluid Dynamics.** (4 cr; prereq 8601) Tezduyar

Finite element methods for time-dependent problems; stability, convergence, and accuracy concepts. Analysis and applications of Petrov-Galerkin formulations for convection-diffusion equations. Incompressible Navier-Stokes equations; vorticity-stream function formulation and velocity-pressure formulation. Hyperbolic systems, compressible Euler equations.

**AEM 8800, 8801, 8802. Selected Topics in**

**Mechanics and Materials.** (1-4 cr per qtr; prereq  $\Delta$ ) Fosdick, James, Leo, Shield, Truskinovsky  
Topics of current interest. Individual student projects completed under guidance of faculty sponsor.

**AEM 8810, 8811, 8812. Selected Topics in**

**Fluid Mechanics.** (1-4 cr per qtr; prereq  $\Delta$ ) Alving, Beavers, Candler, Joseph, Longmire, Lundgren, Tezduyar, Wilson  
Topics of current interest. Individual student projects completed under guidance of faculty sponsor.

**AEM 8820, 8821, 8822. Selected Topics in**

**Dynamical Systems and Controls.** (1-4 cr per qtr; prereq  $\Delta$ ) Balas, Enns, Garrard, Zhao  
Topics of current interest. Individual student projects completed under guidance of faculty sponsor.

**AEM 8880. Plan B Project.** (1-4 cr [max 4 cr]; prereq grad major in aerospace engineering or mechanics,  $\Delta$ )

Satisfies project requirement for Plan B master's degree. May appear on M.S. program but does not count toward 20-credit minimum in the major field. Topic arranged by student and adviser; written report required.

*Associate Professor:* Sandra O. Archibald; Buddy G. Crewdson; Jeremiah E. Fruin; William F. Lazarus; Kent D. Olson; Philip G. Pardey; Stanley C. Stevens; Steven J. Taff; Yacov Tsur

*Assistant Professor:* Brian L. Buhr; Jay S. Coggins; Frances R. Homans; Donald J. Liu; Rodney B. Smith; Thomas Stinson

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Graduate study requires an operational knowledge of economic theory and modern methods of quantitative analysis as well as practical application in specialized fields of inquiry, including agricultural policy, consumption economics, development economics and trade, natural resource and environmental economics, prices and marketing, production economics, and regional economics and public services.

**Prerequisites for Admission**—A grade point average of 3.00 for the undergraduate program and for graduate-level work is the minimum standard for admission. Applicants with at most a bachelor's degree are, except in a few special cases, considered only for admission to the M.S. program. The following coursework is considered the minimum preparation for admission to the M.S. program: intermediate-level micro and macroeconomic theory, elementary statistics, calculus, and linear algebra. Applicants to the Ph.D. program should also have completed courses in micro and macroeconomic theory at the master's level. Students lacking background in economics or quantitative methods may be required to complete deficiencies before being accepted into the program.

**Special Application Requirements**—Graduate Record Examination scores are required for all students. A minimum TOEFL score of 550 is required for applicants whose native language is not English, including those with other academic study in the United States. Applicants should provide evidence of superior scholarship, professional experience, and general aptitude for graduate study. Students are admitted any quarter but should keep in mind that most assistantships are allocated by the end of February for the following fall quarter.

## Agricultural and Applied Economics (ApEc)

*Regents' Professor:* Vernon W. Ruttan

*Professor:* James P. Houck, *head*; Robert P. King, *director of graduate studies*; Jeffrey D. Apland; Dale C. Dahl; Reynold P. Dahl (*emeritus*); K. William Easter; Vernon R. Eidman; Earl I. Fuller (*emeritus*); William C. Gartner; Hans M. Gregersen; Jerome W. Hammond; Beth W. Honadle; Jean D. Kinsey; Richard A. Levins; Wilbur R. Maki (*emeritus*); Michael V. Martin; George W. Morse; Claudia A. Parliament; Glenn D. Pederson; Willis L. Peterson; Philip M. Raup (*emeritus*); Terry L. Roe; C. Ford Runge; G. E. Schuh; Benjamin H. Senauer; Wesley B. Sundquist (*emeritus*); Delane E. Welsch

## GRADUATE PROGRAMS

Applicants seeking fellowships should submit all application materials by December 15.

**Master's Degree Requirements**—All M.S. students are required to complete graduate-level courses in micro- and macro-economic theory and statistics, or to have completed equivalent courses. Under Plan A, the thesis counts for 16 of 44 credits. Under Plan B, the project counts for 6 to 9 of 44 credits.

A minimum GPA of 3.00 in the graduate program is required for graduation. A final oral examination is required.

**Doctoral Degree Requirements**—Students follow a study program in the major that includes micro and macroeconomic theory, quantitative techniques, and three fields of specialization selected from those listed under Curriculum above. One of these fields can be replaced by a minor in another graduate program, such as economics, public health, or statistics, or sustainable agriculture systems (a free-standing graduate minor).

Preliminary written examinations cover economic theory and fields in agricultural and applied economics. Oral examinations are required for approval of the dissertation proposal and for its defense.

**Language Requirement**—None.

**Minor Requirements for Students Majoring in Other Fields**—Master's students must take Econ 5151 and Econ 5152 (or approved substitute), plus three applied economics courses at the 5xxx or 8xxx level, for a total of 15 credits. Students must also take two graduate-level quantitative courses. Specific courses are approved by the director of graduate studies in the Department of Applied Economics. All courses must be taken for a letter grade (A-F) and completed with a GPA of 3.00 or better.

Doctoral students must complete 20 credits of coursework in economics or applied economics at the 5xxx or 8xxx level with a minimum of 12 credits in applied economics. Courses for the minor are approved by the director of graduate studies in the Department of Applied Economics. All courses must be taken for a letter grade (A-F) and completed with a GPA of 3.00 or better.

**For Further Information and Applications**—Contact the Department of Applied Economics, University of Minnesota, 231 Classroom Office

Building, 1994 Buford Avenue, St. Paul, MN 55108 (612/625-2758; e-mail dgs@dept.agecon.umn.edu).

**ApEc 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**ApEc 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**ApEc 8888. Thesis Credits: Doctoral.** (36 cr required)

**ApEc 5020. Applied Linear Programming.** (4 cr; prereq 3002 or Econ 3101 or #) Apland Application of linear programming to economic problems of the firm. Resource allocation, product mix, investment and distribution decisions in context of cost minimization and profit maximization.

**ApEc 5030. Methods of Economic Data Analysis.** (4 cr; prereq Stat 5021 or equiv; familiarity with matrix algebra recommended) Emphasizes practical aspects. Econometric methods and models commonly used in applied economics; economic and statistical theory underlying these methods. Primarily for M.S. students.

**ApEc 5400. Intermediate Market and Price Analysis.** (4 cr; prereq 3003 or Econ 3101 or #) Hammond Development of analytical models and their application in various market situations. Unique market institutions developed in response to marketing problems and policies.

**ApEc 5440. Cooperatives and Agribusiness Organization.** (4 cr; prereq 3002 or Econ 3101 or #) Parliament Economic problems and issues facing agricultural cooperatives, including changing market organization, financing, taxation, antitrust regulations, and others.

**ApEc 5480. Futures Markets and Prices.** (4 cr; prereq 3002 or Econ 3101 or #) Liu Economics of futures trading; basis and theoretical price relationships in storable and nonstorable commodities; hedging and commercial use of futures markets, with illustrations; arbitrage; options on agricultural futures; financial futures; speculation; futures market performances and regulation.

**ApEc 5500. Financial Markets and Agricultural Credit Institutions.** (4 cr; prereq 3500 or BFin 3000 or grad student or #) Pederson Analysis of financial institutions and financial markets. Managerial policy issues confronting managers of financial intermediaries with particular reference to those operating in an agricultural setting. Current problems confronting financial intermediaries.

**ApEc 5550. Food Marketing Economics.** (4 cr; prereq 3001 or Econ 3101 or #) Senauer Economics of food marketing in the United States. Food consumption trends; consumer food behavior; food expenditure and consumption data; consumer survey methodology; food distribution and retailing system; food policy issues related to food marketing. Individual and group projects required.

**ApEc 5580. Household Economics: Time, Labor, and Human Capital Around the Globe.**

(3 cr; prereq 3002 or Econ 3101 or #) Kinsey  
Investment in household formation, children, education, health, labor force participation, and non-market work analyzed in context of household economics and national productivity. Effects of economic variables on investment decisions and returns.

**ApEc 5600. Land and Water Economics.** (3 cr; prereq 3002 or Econ 3101 or #) Taff

Land and water as public resources and as factors of production; economic analysis of policies that influence asset use; sale and rental markets; valuation of rights to land and water; taxation and regulation as instruments for influencing private management decisions; comparative land and water legal and market settings.

**ApEc 5620. Regional Economic Analysis.** (3 cr; prereq 3006 or Econ 3102 or #) Morse

Analysis of regional economies; alternative theories of firm location (neo-classical, profit cycle, competitive advantage, cumulative causation); labor markets and migration; alternative development approaches and public incentives; emphasis on medium-sized metro areas, rural areas, and value-added industries.

**ApEc 5630. Regional Development Systems.** (3 cr; prereq 3006 or Econ 3102 or #) Morse

Regional systems analysis (economic base, input-output, and computable general equilibrium); application of impact models to development problems; theoretical foundations of models; basic skills in developing and interpreting regional input-output analyses with real-world data and problems.

**ApEc 5637. Law and Agricultural Policy.** (3 cr; prereq ApEc grad student) Chen

Economic regulation of agriculture. Industrial organization and market structure in agribusiness, public lands and water law, agricultural cooperatives, farm labor, farm finance, crop insurance and disaster assistance, agricultural biotechnology, food and drug law, price and income regulation, and international agricultural markets.

**ApEc 5640. Financing State and Local Governments.** (4 cr; prereq 3002 or Econ 3101 or #) Honadle

Problems and issues in financing state and local public services in the United States, state and local revenue systems, debt and expenditures. Intergovernmental fiscal relations. Budget analysis.

**ApEc 5650. Economics of Natural Resource and Environmental Policy.** (4 cr; prereq 3002 or 3610 or Econ 3101 or #) Easter

Application of economic analysis, including project evaluation, to current natural resource and environmental issues. Emphasis on conservation and resource scarcity, environmental quality, and resource use issues and their implications for public policy.

**ApEc 5660. Economics of Public Services.**

(3 cr; prereq 3002 or Econ 3101 or #) Honadle  
Issues of finance and supply and demand for public services; pricing, producing, and financing public goods; bureaucratic decision making; implementing policies.

**ApEc 5710. U.S. Agriculture: Farm, Food, and Environmental Policy.** (3 cr; prereq ApEc 3002 or Econ 3101, ApEc 3006 or Econ 3102, ApEc 3007 or Econ 3102 or #) Runge

Development of U.S. agriculture and U.S. agricultural and trade policy; agricultural input and commodity markets; design and economic effects of U.S. agricultural policy; determinants of U.S. agricultural and trade policies.

**ApEc 5720. Economics of World Agriculture.** (3 cr; prereq ApEc 3002 or Econ 3101, ApEc 3006 or Econ 3102 or #) Ruttan

Theories of agricultural development, comparative agricultural organization and structure, technical and institutional change in agricultural development, national development policies, bilateral and multilateral assistance, international policy conflicts.

**ApEc 5750. Agricultural Trade and Commercial Policies.** (3 cr; prereq 3002 or Econ 3101 or #) Houck

Trade policies and practices of export and import nations; commodity agreements; agricultural trade policies of common market areas; negotiations and potential trade developments.

**ApEc 5790. World Food Problems.** (3 cr, \$Agro 5200, \$CAPS 5280, \$FScN 5643; prereq sr or grad student) Peterson

A multidisciplinary examination of social, economic, and technical problems of feeding the world's growing population. Principles sought from economic, plant, animal, and food sciences for their application to food problems.

**ApEc 5860. Economics of Agricultural Production.** (3 cr; prereq 3002 or Econ 3101 or #) Coggins

Production economics applied to agriculture, profitable combination of production factors; comparative advantage and location of production.

**ApEc 5890. Independent Study: Advanced Topics in Farm Management.** (1-6 cr; prereq #) Eidman, Olson

Special topics or individual work arranged on subjects suited to needs of particular groups of students.

**ApEc 5990. Special Topics and Independent Study in Applied Economics.** (Cr ar; prereq #)

Special classes, independent study, and supervised reading and research on subjects and problems not covered in regularly offered courses.

**ApEc 8100. Graduate Seminar.** (2 cr; prereq 2 qtrs regis in agric and applied econ MS prog, exam committee selected, #) Levins

Writing, critiquing, and oral presentation skills for master's students. Oral presentation of research proposal for thesis or Plan B paper critiqued by peers and committee members.

## GRADUATE PROGRAMS

**ApEc 8110. Master's Paper: Plan B Project.** (1-9 cr per qtr [max 9 cr]; prereq #; S-N only)

**ApEc 8200. Advanced Topics in Agricultural and Applied Economics.** (1-9 cr [may be repeated for cr]; may be used to develop PhD thesis proposal on S-N only)  
Special seminars or individual work on subject suited to needs of students.

**ApEc 8210. Applied Econometrics.** (3 cr; prereq Econ 8201 or Econ 5261, Econ 8202 or Econ 5262)  
Tsur  
Basic skills for using econometrics in actual practice. Choosing functional forms and selecting variables; collinearity and outliers; limited dependent variable models in a single- and simultaneous-equation context. Emphasis on application to real-world data.

**ApEc 8220. Applied Mathematical Programming.** (3 cr; prereq Econ 5151 or MS-level operations research or #) Aplan  
Applications of mathematical programming to economic problems of the firm, sector, and economy. Classes of optimization problems include linear and nonlinear programming, integer, multiple objective, and stochastic programming. Use of economic concepts to build and interpret models.

**ApEc 8231. Agricultural Prices.** (3 cr; prereq Econ 5151, Econ 5152 or equiv) Smith  
Nature of demand for farm products; supply considerations; price formation and markets; price variation and instability; dynamic analysis; methodological considerations.

**ApEc 8245. Agricultural Marketing Economics.** (3 cr; prereq Econ 5151, Econ 5152 or #) Liu  
Time, space, and form dimensions of markets studied for cases of static and stochastic environments. Emphasis on use of current conceptual constructs. Implications of markets for contingent claims, incomplete information, and rent seeking on welfare.

**ApEc 8264. Resource Economics.** (3 cr; prereq Econ 5151, Econ 5152 or #) Homans  
Economic analysis of resource use and management. Capital theory and dynamic resource allocation; applications to renewable and nonrenewable resources; empirical studies and policy issues.

**ApEc 8270. Applied Welfare Economics and Public Policy.** (3 cr; prereq calculus, intermediate economic theory) Runge  
Basic concepts underlying measurement of welfare change, problems of market failure and externalities, social welfare functions, and distribution within and across generations. Application of concepts, based on case studies of the environment, returns to research, technical change, and agricultural policy.

**ApEc 8278. Agricultural and Economic Development.** (3 cr; prereq Econ 8101 or #) Roe  
Theories of socioeconomic growth; models of economic growth; consumption, production, and supply relations in agricultural development; agricultural development policy.

**ApEc 8287. Production and Supply.** (3 cr; prereq 5860 or equiv, Stat 5302 or equiv) Peterson  
Functional forms and specification of production functions; measurement problems; specification bias; dummy variables; evaluating marginal products and returns to scale; supply estimation; distributed lags; demand for factors of production; project evaluation; technical change; returns to research; human capital.

**ApEc 8288. Dynamic Production Economics.** (3 cr; prereq Econ 5151, Econ 5152 or #) King  
Analysis of firm-level production economics problems in dynamic setting. Alternative theories of the firm and techniques of analysis evaluated.

**ApEc 8345. Seminar: Agricultural Marketing.** (3 cr; offered when demand warrants) Hammond, Roe

**ApEc 8364. Seminar: Resource Economics and Policy.** (3 cr; offered when demand warrants) Easter, Homans

**ApEc 8366. Seminar: Applied Regional Economics.** (3 cr; offered when demand warrants) Morse

**ApEc 8370. Seminar: Agricultural and Trade Policy in Developed Countries.** (3 cr; prereq 8270 or #) Runge  
Agriculture in developed countries and the world economy; goals, principles, instruments of agricultural and trade policy intervention; implementation and problems of agricultural and trade policies in developed countries; political economy of agricultural policy decision making.

**ApEc 8378. Seminar: Agricultural Development.** (1 or 3 cr; offered when demand warrants) Roe, Ruttan

**ApEc 8382. Seminar: Production Economics.** (3 cr; offered when demand warrants) King

**ApEc 8590. Economics of Food and Consumer Policy.** (3 cr; prereq 8270 or equiv, Econ 5113 or Econ 5151 or equiv) Kinsey  
Economic analysis of issues and impact of public policies relating to food pricing and distribution, product quality and information, food safety and liability; international comparisons of food and agricultural policy and its impact on consumers' welfare.

**ApEc 8591. Consumption Economics.** (3 cr; prereq microeconomic theory at the 5xxx level at least, basic regression analysis) Senauer  
Analytical and empirical treatment of consumer behavior. Modern adaptations of theory to explain household economics, Lancaster models, consumer demand, and expenditure models and estimations.

## Agricultural Engineering

See Biosystems and Agricultural Engineering.

## Agronomy (Agro)

*Regents' Professor:* Ronald L. Phillips

*Professor:* R. Kent Crookston, *head*; Steve R. Simmons, *director of graduate studies*; Orvin C. Burnside; Robert H. Busch; Vernon B. Cardwell; Burle G. Gengenbach; Leland L. Hardman; Dale R. Hicks; Robert J. Jones; Hans-Joachim G. Jung; William E. Lueschen; Neal P. Martin; Ervin A. Oelke; James H. Orf; Donald C. Rasmusson; Craig C. Sheaffer; David A. Somers; Deon D. Stuthman; Carroll P. Vance; Donald L. Wyse

*Adjunct Professor:* Howard W. Rines

*Associate Professor:* Roger L. Becker; Beverly R. Durgan; Nancy J. Ehlke; Jeffrey L. Gunsolus; John V. Wiersma

*Adjunct Associate Professor:* John W. Gronwald

*Assistant Professor:* Gregg A. Johnson; Nicholas R. Jordan; Paul M. Porter

*Adjunct Assistant Professor:* Frank Forcella; Mark E. Westgate

*Other:* Helene Murray

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Training is provided in basic and applied aspects of management, physiology, production, and weed control of field crops, with emphasis on sustaining the environment and profitable practices. The program is closely aligned with the interdepartmental programs of plant breeding and plant biological sciences. Prospective students should consult other sections of this bulletin which describe these programs. The Department of Agronomy and Plant Genetics can supply information about all three programs on request.

**Prerequisites for Admission**—Applicants should have university-level training in agronomy, biology, chemistry, and mathematics. Applicants must have a background in biochemistry and biometrics, or must acquire this background as part of the degree program.

**Special Application Requirements**—Three letters of recommendation, a statement by the applicant outlining career objectives and experience, and Graduate Record Examination scores are required. Students may enter the program at any time, but most assistantships begin in the summer or fall, and applications are usually acted on by mid-February.

**Master's Degree Requirements**—Most programs are Plan A. Students plan their course program and thesis research in consultation with their adviser and a department advisory committee. A final oral examination which includes a department seminar covering the thesis research or Plan B project is required.

**Doctoral Degree Requirements**—Course programs normally range from 60 to 75 quarter credits, depending on previous preparation. Students plan their course program and thesis research in consultation with their adviser and a department advisory committee. The final oral examination includes a department seminar covering the thesis research.

**Minor Requirements for Students Majoring in Other Fields**—Ph.D. minors must complete a minimum of 20 credits in agronomy including 8020.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Department of Agronomy and Plant Genetics, University of Minnesota, 411 Borlaug Hall, 1991 Buford Circle, St. Paul, MN 55108 (612/625-7773).

**Agro 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**Agro 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**Agro 8888. Thesis Credits: Doctoral.** (36 cr required)

**Agro 5001f,w,s,su. Problems in Agronomy for Advanced Students.** (1-5 cr; prereq 20 cr agro, #) Independent research or study in agronomy. For advanced students who wish to pursue aspects of agronomy in greater depth than that offered in formal courses or who wish to investigate areas not presently offered in courses.

**Agro 5020w. Introduction to Plant Breeding.** (4 cr; prereq GCB 3022 or Hort 3003 or equiv) Orf Applying genetic principles to improve crop plants. Includes self-pollinated, cross-pollinated, and asexually propagated crops. Lecture.

**Agro 5030f. Weed Control.** (5 cr; prereq 3020, Soil 3125 or #; PBio 3131 recommended) Wyse Survey of the magnitude of the weed problem. Regulatory aspects of weed control and herbicide usage. Principles and methods of weed control. Lecture and discussion.

**Agro 5050f. Management Technologies for Crop Production in Minnesota.** (4 cr; prereq agro course) Hardman, Sheaffer

Solutions to crop production problems. Quality, productivity, and profitability. Principles needed for decisions. Corn/soybean, small grains, and forage crops. Lecture and discussion.

**Agro 5070. Agroecology.** (3 cr; prereq 3010, 3 cr agronomic sciences or #) Jordan

Design, management, and evaluation of and structure-function relationships in agricultural ecosystems. Examines proposition that many current problems of agriculture can effectively be addressed by ecological analysis of agricultural systems. Case studies, discussion, experiential learning, field trips.

**Agro 5095. History of U.S. Agriculture.** (3 cr; prereq 2 courses in physical and biol sci, 2 courses in history and soc sci or #) Tjossem

Social, scientific, and political development of U.S. agriculture, focusing on issues of food supply and consumption and interaction with nature/soil, water, "pests," and fellow humans (cooperation, competition, surpluses, subsidies, etc.); basis for contemporary sustainable agriculture.

**Agro 5120s. Growth and Development of Field Crops.** (4 cr; prereq 1007 or Biol 1009, Chem 1002, Chem 1051 or equiv) Cardwell

Principles and mechanisms that affect crop productivity. Physiological and morphological basis of growth and development; effects of physical and biological environmental factors. Lecture and lab.

**Agro 5130f. Harvest, Storage, and Utilization of Field Crops.** (4 cr; prereq 1007 or Biol 1009, Chem 1002, Chem 1051 or equiv)

Crop quality traits associated with utilization: their influence on harvesting, processing, and storage. Principles and technology used in crop storage to minimize damage from fungi and insects and maximize crop quality. Lecture, lab, and discussion.

**Agro 5200f. World Food Problems.** (3 cr, §AgEc 5790, §CAPS 5280, §FScN 5643; prereq sr or grad student) Hardman

Multidisciplinary examination of social, economic, and technical problems of feeding the world's growing population. Principles sought from social, economic, plant, animal, and food sciences for their application to food problems.

**Agro 5310su.f. Orientation to Field Crop Breeding.** (1 cr; prereq 5020 or #) Stuthman

Field study of plant breeding programs and techniques.

**Agro 5320. Orientation to Agronomy and Soils Field Research.** (1 cr; S-N only) Cardwell

Field survey and discussion of research techniques in crop physiology, crop and soil management, and weed science programs.

**Agro 5330w. Plant Biotechniques.** (2 cr; prereq 3xxx genetics and biochem courses)

Molecular and traditional biotechniques discussed by postdoctoral research associates to give broader understanding of molecular and quantitative techniques in agricultural research.

**Agro 5999. Special Workshop in Agronomy.** (1-4 cr; prereq #)

Offered off campus. Consult the *Class Schedule* or department for current topics.

**Agro 8000f. Supervised Teaching Experience.**

(2 cr, §Hort 8000, §Soil 8000; prereq #) Simmons  
Classroom or extension teaching experience in one of the following departments: Agronomy and Plant Genetics, Horticultural Science, or Soil, Water, and Climate. Participation in teaching topic discussions to strengthen skills and develop personal teaching philosophy.

**Agro 8010f,w,s,su. Research in Agronomy.** (Cr ar; prereq #)

Problems in physiology and production of crop plants.

**Agro 8020f,w. Seminar: Agronomy.** (1 cr)

Reviews and discussions of important agronomic literature.

**Agro 8050f. Physiology of Field Crops.** (3 cr; prereq 5120, PIPh 5131 or #; offered alt yrs) Jones

Physiology of crop productivity with emphasis on improving yield or quality. Assimilation and partitioning of nitrogen and carbon, transpiration, water stress, temperature stress, and vernalization.

**Agro 8080f. Current Topics in Agronomy.** (2 cr; prereq 5040, 8050, #; offered alt yrs)

Current developments in agronomy and crop physiology.

**Agro 8200f. Plant Breeding Principles and Methods I.** (3 cr; prereq 5020, Stat 5301 or equiv) Rasmusson

Principles and current methods involved in breeding, emphasizing self-pollinated crops. Parent selection, modifications of traditional breeding procedures, priority setting and allocation of resources, breeding for special traits.

**Agro 8210s. Plant Breeding Principles and Methods II.** (3 cr; prereq 8200, Stat 5301, GCB 5042)

Principles and methods of breeding, emphasizing cross-pollinated crops. Population concepts, constructing source populations, recurrent selection techniques, varietal development, and new approaches.

**Agro 8220f. Application of Quantitative Genetics to Plant Breeding.** (3 cr; prereq 8210, 8260, GCB 5042 or #) Ehlke

Covariance of relative concepts in cross- and self-pollinated crops. Use of quantitative genetics in decision making in plant breeding. Genotype/environment interaction in relation to stability parameter estimation and interpretation. Selection index theory and application.

**Agro 8230f. Cytogenetics.** (4 cr; prereq GCB 5034 or #; 3 lect and 2 lab hrs per wk) Phillips

Genetic principles in relation to the eukaryotic chromosome. Molecular cytogenetics of chromosome structure, replication, pairing, and crossing over. Behavior of deficiencies, duplications, inversions, interchanges. Aneuploidy, autopolyploidy, allopolyploidy, and uses of cytogenetic stocks in molecular and classical genetics and plant breeding.

**Agro 8240w. Cellular and Molecular Genetics of Plant Improvement.** (3 cr; prereq GCB 5034)

Gengenbach, Somers

Principles of genetic modification of higher plants by application of cellular and molecular biotechnology approaches, including tissue culture mutant selection and characterization, somaclonal variation, protoplast fusion, gene tagging and isolation, gene and genome transfer, and organelle genetics.

**Agro 8250s. Advanced Plant Genetics.** (2 cr;

prereq 8240 or GCB 8131) Gengenbach, Somers  
Current literature in cellular and molecular plant genetics, including gene transfer concepts and applications, analysis of gene structure and function in transgenic plants, molecular genetics of transposable elements and organelle genomes, and applications of new plant biotechnologies.

**Agro 8270f,w. Seminar: Plant Breeding.** (1 cr)**Agro 8280s. Current Topics in Plant Breeding.** (2 cr; prereq 8210 or #) Stuthman**Agro 8330f,w,s,su. Research in Plant Genetics.** (Cr ar)**Agro 8340f,w,s,su. Directed Studies for**

**Thesis Research.** (Cr ar; prereq PhD student in agro or in plant breeding or #; S-N only)

For planning and implementation of thesis research, before passing preliminary oral examination.

**AnPI 5060s. Integrated Management of Cropping Systems.** (4 cr; Agro 3020 or Hort 3002, Soil 3125 or #) Simmons

Case study/simulation and discussions considering integrated production management of selected agronomic and horticultural cropping systems in Minnesota. Problem analysis, principle application, and decision making involving integration of disciplines.

**American Studies (AmSt)***FACULTY*

*Professor:* David Roediger, *chair*; Roland A. Delattre; Elaine T. May; David W. Noble; Gayle Graham Yates

*Associate Professor:* Riv-Ellen Prell, *director of graduate studies*; Lary L. May; Carol A. Miller

*Assistant Professor:* Leola A. Johnson

*AFFILIATED FACULTY*

*Professor:* Ronald R. Aminzade (sociology); Ayers L. Bagley (educational policy and administration); Kent R. Bales (English); Terence W. Ball (political science); Hyman Berman (history); David O. Born (health ecology); Kinley J. Brauer (history); Roger D. Clemence (architecture); Hazel Dicken-Garcia (journalism); Mary G. Dietz (political science); Sara M. Evans (history); James Farr (political science); Philip G. Furia (English); Philip J. Gersmehl (geography); Edward M. Griffin (English); John R. Howe, Jr. (history); Karen N. Hoyle (Children's Literature Research Collections); Sally G. Kohlstedt (history of science and technology); Barbara Laslett

(sociology); Richard D. Leppert (cultural studies and comparative literature); Alex J. Lubet (music); Marion Lundy-Dobbert (educational policy and administration); Karal Ann Marling (art history); Ronald C. McCurdy (music); Toni A. H. McNaron (English); Russell R. Menard (history); Paul L. Murphy (history); Paula Rabinowitz (English); Martin Roth (English); Harvey B. Sarles (cultural studies and comparative literature); Ellen J. Stekert (English); Roger H. Stuewer (physics; history of science and technology); Rudolph J. Vecoli (history); Jean W. Ward (journalism); Jack D. Zipes (German)

*Associate Professor:* W. John Archer (cultural studies and comparative literature); Rose M. Brewer (Afro-American and African studies); Maria Damon (English); John M. Dolan (philosophy); Arthur I. Geffen (English); George D. Green (history); Mary Jo Kane (kinesiology and leisure studies); March L. Krotec (kinesiology and leisure studies); Judith A. Martin (geography); Roger P. Miller (geography); Gail K. Noble (General College); Joanna O'Connell (Spanish and Portuguese); Nancy L. Roberts (journalism); Guillermo Rojas (Chicano studies); Steven Ruggles (history); Thomas M. Scanlan (rhetoric); Robert B. Silberman (art history); Allan H. Spear (history); Dennis N. Valdes (Chicano studies); John S. Wright (English; Afro-American and African studies); Jacquelyn N. Zita (women's studies)

*Assistant Professor:* Angela D. Dillard (history); Josephine D. Lee (English); Lisa A. Norling (history); Jean O'Brien-Kehoe (history); Jennifer L. Pierce (sociology)

*Other:* William C. Beyer (coordinator, College of Liberal Arts Student Academic Support Services); Harry C. Boyte (senior fellow, Humphrey Institute of Public Affairs); Colleen J. Sheehy (program director, Frederick R. Weisman Art Museum)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) under special circumstances as part of the Ph.D. program, and Ph.D.

**Curriculum**—American Studies is an interdisciplinary, interdepartmental degree program. The graduate faculty of the program consists of core faculty members and graduate faculty members from participating departments.

**Prerequisites for Admission**—An undergraduate major in a field related to American Studies or other preparation acceptable to the Admissions Committee for American Studies is required.

**Special Application Requirements**—The following should be sent to the program office: a special application form available through the program office, a personal statement, three letters of recommendation, a writing sample,

## GRADUATE PROGRAMS

scores from the General (Aptitude) Test of the Graduate Record Examination, and transcripts of all college work. Applications must be submitted by December 15. Entry is only in fall quarter.

**Master's Degree Requirements**—The master's degree is offered under Plan A and Plan B. A minimum of 13 courses is required, distributed as follows: introductory seminars 8201, 8202, and 8203; 1 two-quarter sequence from the American Studies specialty seminars or approved from another department; 2 comparative culture courses covering international or non-U.S. subjects; 2 courses in cultural pluralism within the American experience; and 4 other adviser-approved courses. A final oral examination is required for both plans.

**Doctoral Degree Requirements**—A minimum of 20 courses is required, distributed between the major field of American Studies and one or more fields of concentration that demonstrate programmatic coherence. Courses are distributed as follows: introductory seminars 8201, 8202, and 8203; dissertation seminars 8801, 8802; practicum in American Studies 8401; 2 two-quarter series from the American Studies specialty seminars or other approved two-quarter graduate seminars; 2 comparative culture courses covering international or non-U.S. subjects; 2 courses in cultural pluralism within the American experience; and 6 adviser-approved courses. Preliminary written and oral examinations covering coursework, and a dissertation and final oral defense of it, are required.

**Language Requirements**—For both the M.A. and the Ph.D. degrees, reading knowledge of one foreign language is required.

**Minor Requirements for Students Majoring in Other Fields**—Students are expected to choose courses consistent with or complementary to their major. Students should complete six courses in American Studies, one of which must be 8201, 8202, or 8203.

**For Further Information and Applications**—Contact the Program in American Studies, University of Minnesota, 104 Scott Hall, 72 Pleasant Street S.E., Minneapolis, MN 55455 (612/624-4190).

**AmSt 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**AmSt 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**AmSt 8888. Thesis Credits: Doctoral.** (36 cr required)

**AmSt 5101. Religion in American Culture.** (4 cr, §RelS 5101) Delattre  
Not a survey, but a representative profile of religion in American, past and present, organized each quarter around a theme or problem.

**AmSt 5920. Topics in American Studies.** (1-4 cr per qtr [max 12 cr])  
Topics specified in *Class Schedule*.

**AmSt 8201. Historical and Theoretical Foundations of American Studies.** (4 cr; prereq admission to AmSt grad program)  
Exposition of American studies as a field of inquiry, including its history, major theoretical frameworks, and interdisciplinary methodologies.

**AmSt 8202. Theory, Current Research, and Practice in American Studies.** (4 cr; prereq admission to AmSt grad program)  
Review of contemporary interdisciplinary scholarship in the field.

**AmSt 8203. American Studies Methodology.** (4 cr; prereq admission to AmSt grad program)  
Application of American Studies methods to various types of cultural materials.

**AmSt 8219, 8220. American Cultural Regions.** (4 cr per qtr [max 12 for 8220]; prereq # or Δ for 8219; 8219 or # or Δ for 8220)  
Regional, ethno-cultural investigation of United States, including national and regional cultures. Interdisciplinary use of historical, geographic, literary, and artistic approaches to describe and analyze regional character and to define and defend regional boundaries. 8219: Research strategies. 8220: Topical development.

**AmSt 8229, 8230. The United States in International Perspective.** (4 cr per qtr [max 12 cr for 8230], §Hist 8229-8230; prereq # or Δ for 8229, 8229 or # or Δ for 8230)  
Relationship between American culture and role of United States in world; how United States has been imagined, defined, responded to by other cultures; historical, cultural, economic, political factors. 8229: Research strategies. 8230: Topical development.

**AmSt 8239, 8240. Gender, Race, Class, Ethnicity, and Sexuality in America.** (4 cr per qtr [max 12 cr for 8240], §Hist 8239-8240; prereq # or Δ for 8239, 8239 or # or Δ for 8240)  
Social, psychological, historical, and artistic modes of self-expression and intellectual analysis of people in the United States identified as female and male or as members of racial, ethnic, or national-origin groups. 8239: Research strategies. 8240: Topical development.

**AmSt 8249, 8250. Material Culture and/or Popular Culture.** (4 cr per qtr [max 12 cr for 8250], §Hist 8249-8250; prereq # or Δ for 8249, 8249 or # or Δ for 8250)  
Patterns of American building, artifacts, customs; human-made plans and procedures for use of space and conduct of daily life in physical and social environments. 8249: Research strategies. 8250: Topical development.

**AmSt 8259, 8260. Literature, History, and Culture.** (4 cr per qtr [max 12 cr for 8260]; prereq # or  $\Delta$  for 8259, 8259 or # or  $\Delta$  for 8260)

Interdisciplinary study of connections between literary expression and history, particularly as they articulate themes in American culture. 8259: Research strategies. 8260: Topical development.

**AmSt 8269, 8270. Politics, Economics, and/or the Law.** (4 cr per qtr [max 12 cr for 8270]; prereq # or  $\Delta$  for 8269, 8269 or # or  $\Delta$  for 8270)

Interdisciplinary investigation of underlying ideas of politics, economics, and the law in American culture. Draws upon research by historians, literary critics, political scientists, economists, and sociologists. 8269: Research strategies. 8270: Topical development.

**AmSt 8289, 8290. Religion, Ethics, and Public Life in America.** (4 cr per qtr [max 12 cr for 8290]; prereq # or  $\Delta$  for 8289, 8289 or # or  $\Delta$  for 8290)

Forms, practices, and history of religious life and institutions in the United States. 8289: Research strategies. 8290: Topical development.

**AmSt 8401. Practicum in American Studies.** (4 cr; prereq #)

Application of American studies expertise, either inside or outside the classroom.

**AmSt 8801-8802. Dissertation Seminar.** (4 cr per qtr; prereq # or  $\Delta$ )

Intended for doctoral students beginning work on dissertations in American studies.

**AmSt 8970. Readings in American Civilization.** (Cr ar)

Independent study of interdisciplinary aspects of American civilization under guidance of members of various departments.

## Anatomy (CBN)

*Professor:* David W. Hamilton, *head, director of graduate studies;* G. Eric Bauer; Robert P. Elde; Stanley L. Erlandsen; Glenn J. Giesler; Ryoko Kuriyama; Paul C. Letourneau; Richard W. Linck; Steven C. McLoon; Jonathan A. Parsons; Arlen R. Severson<sup>1</sup>; Virginia S. Seybold; Robert L. Sorenson

*Associate Professor:* Stephen W. Downing<sup>1</sup>; Lillian A. Repesh<sup>1</sup>; Donald W. Robertson

**Course of Study**—Minor in anatomy, applicable to M.S programs only.

**Curriculum**—Major research interests in the department focus on the cell biology of reproduction, development, transplantation, and endocrinology in mammals, as well as on the neurobiology of peptidergic pathways and the basic mechanisms of pain, cancer, and diabetes. Students thus have a broad range of

opportunities for research at the cellular level using biochemical, electron microscopical, and cell physiological techniques.

**Prerequisites for Admission**—Nine credits of general biology, and at least one course each in chemistry and physics are required. Advanced mathematics (calculus) is recommended.

**Special Application Requirements**—Individuals interested in the M.S. program should consult the director of graduate studies before applying. Graduate Record Examination scores (General Test and Subject Test in biology) are required.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—Required coursework for the minor in anatomy includes two of the four introductory courses in anatomy (5100-5101, 5103, 5104, and 5111) and at least 6 credits of advanced courses.

**For Further Information and Applications**—Contact the Department of Cell Biology and Neuroanatomy, University of Minnesota, 4-135 Jackson Hall, 321 Church Street S.E., Minneapolis, MN 55455 (612/624-1123).

**CBN 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**CBN 5058. Anatomy of the Extremities.** (6 cr; prereq 1004, registration in occupational therapy or physical therapy)

Lecture and lab dissection of bones, muscles, joints, nerves, vessels, connective tissue, and selected internal organs. Histology, embryology, and surface anatomy. Correlation to clinical conditions.

**CBN 5100-5101†. Human Gross Anatomy A-B.** (8 cr for 5100, 4 cr for 5101, §5107 and §5108 for 5100, §5109 for 5101; prereq regis med fr or grad student with #) Parsons, staff  
Lectures and dissections of the human body.

**CBN 5103. Human Histology.** (3-8 cr [7 cr for med/dent fr]; prereq regis med/dent fr, Anat grad student or grad student with #) Letourneau, staff  
Microscopic structure, cytochemical and functional aspects of cells, tissues, and organs.

**CBN 5104. Biochemistry, Molecular and Cellular Biology.** (1 cr; prereq regis med fr, ¶MdBc 5100)

Integrated introduction to biochemistry, molecular biology, genetics, cell biology, and developmental biology.

**CBN 5110. Neuroscience for Dental Students.** (1.5 cr, ¶Phs1 5100; prereq regis dentistry fr, #) Elde, staff  
Introduction to structure and function of central nervous system. Correlation between morphology and physiology emphasized.

<sup>1</sup> University of Minnesota, Duluth

**CBN 5111. Human Neuroscience A.** (3-4 cr [3 cr for med students]; prereq regis med fr or grad student or #; 5111-Phsl 5112†) Ebner, staff  
Structure and function of the nervous system including the organs of special sense.

**CBN 5190. Advanced Anatomy.** (1-10 cr; prereq regis med, #)  
Teaching methods, supervision of student's original research or combination of both.

**CBN 5304. Head and Neck Anatomy for Medical/Dental Residents.** (5 cr; prereq participation in a residency program in the medical or dental schools) Robertson, staff  
Detailed consideration of head and neck anatomy from the gross morphological, functional, developmental, and radiographic aspects, with emphasis on areas of interest by specialty. Lab participation required.

**CBN 8135. Biological Electron Microscopy: Technics.** (1-5 cr; prereq #; offered alt yrs) Erlandsen  
Introduction to principles and technics of electron microscopy. Lab emphasis on acquisition of skills in tissue preparation, photography, use of electron microscope and ancillary equipment.

**CBN 8136. Biological Electron Microscopy: Technics.** (1-5 cr; prereq #; offered alt yrs) Erlandsen  
Specialized ultrastructural technics and their application to biologic problems. Lab emphasis on high resolution microscopy and use of scanning electron microscope.

**CBN 8137. Biological Electron Microscopy: Interpretation.** (1-5 cr; prereq 5103, 8135-8136, #; hrs ar; offered alt yrs) Erlandsen  
Structure and function of cell organelles. Individual projects using advanced technics for both transmission and scanning electron microscopy.

**CBN 8148. Advanced Cell Biology I.** (4 cr, §GCB 8148; prereq Biol 5004 or #)  
Eucaryotic systems with emphasis on structure, function, and chemistry of cell organelles; specialized cells. Membranes and secretion, including membrane methodologies, structure, function, synthesis, and turnover; cell surfaces, protein synthesis, glycosylation, membrane fusion, lysosomes, endocytosis, role of peroxisomes, and detoxification by endoplasmic reticulum.

**CBN 8149. Advanced Cell Biology II.** (4 cr, §GCB 5049, §GCB 8149; prereq Biol 5003, Biol 5004)  
Eucaryotic systems with emphasis on structure, function, and chemistry of cell organelles; specialized cells. Motility and cell nucleus, including roles of microtubules and microfilaments in cell locomotion, shape changes, cytokinesis, ciliary beating, and organelle redistribution; cell cycle, chromosomal structure, replication, mitosis; compartmentalization and autonomy of mitochondria and chloroplasts.

**CBN 8153, 8154, 8155, 8156. Advanced Anatomy.** (1-6 cr per qtr; prereq #)  
Cytochemistry, embryology, gross anatomy, hematology, histology, neurology, or experimental morphology.

**CBN 8166. Seminar: Pancreatic Islet Biology.** (3 cr; prereq #; offered alt yrs) Bauer, staff  
Structure, development, physiology, and cell biology of pancreatic islets of Langerhans. Primary sources: original publications supplemented by recent reviews.

**CBN 8200. Research.** (1-10 cr [max 20 cr]; prereq #)  
Faculty-directed research in cell and developmental biology and neuroscience.

**CBN 8205, 8206, 8207. Seminar: Cell Biology and Neuroanatomy.** (1 cr per qtr; prereq #) Hamilton  
Reviews of current literature and discussion of research work being carried on in the department.

**CBN 8210. Developmental Neurobiology.** (3 cr; prereq 5111, Phsl 5112 or #; offered alt yrs) McLoon  
Nervous system development. General mechanisms and experimental approaches.

**CBN 8215. Molecular and Cellular Basis of Development.** (3 cr; prereq Biol 5003, Biol 5004) Yost  
Molecular and cellular mechanisms of animal development; lectures, readings, and discussions of primary research literature; focus on historical concepts and principles of developmental biology and modern experimental analysis of these principles.

**CBN 8221. Neurobiology of Pain and Analgesia.** (3 cr; prereq #; offered in alt sequence with 8222 and 8223) Giesler, Seybold  
Neural systems underlying pain perception, production of analgesia. Series of weekly lectures coordinated with student presentations on relevant topics.

**CBN 8222. Central Regulation of Autonomic Function.** (3 cr; prereq #; offered in alt sequence with 8221 and 8223) Elde, Seybold  
Morphology and physiology of autonomic ganglia and enteric nervous system, discussions of neuronal circuitry underlying central regulation of the adrenal medulla, cardiovascular system, respiratory system, and pelvic viscera. Weekly lectures and presentations of student papers.

**CBN 8223. Neurobiology of Endocrine Regulation.** (3 cr; prereq #; offered in alt sequence with 8221 and 8222) Elde, Seybold  
Neural systems involved in regulating endocrine function. Lectures and student-led discussions on the hypothalamic-pituitary-target organ axes.

**CBN 8301s. Molecular Biology of the Cytoskeleton.** (2 cr; prereq #; S-N only) Linck  
Seminar with lecture and discussion and visiting speakers.

## Ancient and Medieval Art and Archaeology

See Classical and Near Eastern Studies.

## Animal Sciences (AnSc)

*Professor:* Donald E. Otterby, *head*; Bernard J. Conlin; Craig N. Coon; Bo G. Crabo; Brian A. Crooker; William R. Dayton; Gary E. Duke; Mohamed E. El-Halawani; Richard J. Epley; Douglas N. Foster; Esther M. Gallant; Leslie B. Hansen; Alan G. Hunter; Dennis G. Johnson; Shirley D. Johnston; Benjamin S. Leung; James G. Linn; Charles F. Louis; George D. Marx; Sally L. Noll; Scott M. O'Grady; James E. Pettigrew; Jeffrey K. Reneau; William D. Schmid; Lawrence B. Schook; Anthony J. Seykora; Marshall D. Stern; Paul E. Waibel; Jonathan E. Wheaton

*Adjunct Professor:* Hans-Joachim G. Jung

*Associate Professor:* Marcia R. Hathaway, *director of graduate studies*; Hugh Chester-Jones; Lee J. Johnston; Mathur S. Kannan; William G. Olson; John W. Osborn; Gerald C. Shurson; Michael E. White

*Assistant Professor:* Mitchell S. Abrahamsen; Alfredo DiCostanzo; John B. Hall; William A. Head, Jr.; Hugh C. Hensleigh; Vijay M. Kumar; Brent W. Woodward

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Students emphasize one of the animal sciences subdisciplines such as genetics, growth biology, nutrition, physiology, or production systems. They have the option of taking a management component in conjunction with the subdisciplines. Technical training involves both animal and laboratory experience.

**Prerequisites for Admission**—A bachelor's degree in agriculture or a biological field with training in chemistry, physics, and mathematics is required.

**Special Application Requirements**—A complete set of transcripts in addition to that required by the Graduate School, three letters of recommendation evaluating the applicant's potential, and a statement of career goals are required. The minimum GPA generally required for admission is 3.00 for the M.S. and 3.20 for the Ph.D. Graduate Record Examination scores are required. Applicants are admitted every quarter.

**Master's Degree Requirements**—For Plan A, the minimum number of course credits required (excluding thesis credits) is 20 credits in the major and 8 credits in one or more related fields outside the major. For Plan B, the minimum is 20 credits in the major and 8 credits in one or more related fields, with the adviser and the student choosing

the balance of credits for meeting the 44-credit minimum for the degree. Students must complete basic courses in the chosen subdiscipline. The final examination for the M.S. degree is oral.

**Doctoral Degree Requirements**—Students must complete basic courses in the chosen subdiscipline. No minimum number of credits for the major is specified.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—Requirements are designed to fit the student's needs. Doctoral students must complete a minimum of 18 credits in areas not closely related to the major; no more than 3 of these credits may be in research or special problems.

**For Further Information and Applications**—Contact the Department of Animal Science, University of Minnesota, 122 Peters Hall, 1404 Gortner Avenue, St. Paul, MN 55108 (612/624-3491; fax 612/625-5789; e-mail smith072@tc.umn.edu; <http://www.animal.agri.umn.edu>).

**AnSc 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**AnSc 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**AnSc 8888. Thesis Credits: Doctoral.** (36 cr required)

**AnSc 5231s. Dairy Cattle Breeding.** (4 cr; prereq 3220 or #) Hansen  
Application of quantitative genetic principles to the breeding of dairy cattle. Emphasis on evaluation of males, females, and systems of breeding. Rates of genetic improvement with and without artificial insemination.

**AnSc 5322f. Physiology of Reproduction.** (5 cr; prereq 6 cr systemic physiology or #) Crabo  
Principles of reproductive physiology with emphasis on endocrinological aspects.

**AnSc 5327w. General Endocrine Physiology.** (3 cr; prereq 3301 or #) Wheaton  
Biological effects, biochemistry, methods of assay, and regulatory aspects of hormones.

**AnSc 5328s. General Endocrine Physiology Laboratory.** (2 cr; prereq 5327 or #) Wheaton  
Demonstration of concepts in endocrinology using basic experimental approaches.

**AnSc 5330s. Current Topics in Endocrinology.**

(1 cr; prereq 3301, Biol 5001) Wheaton  
Discussion of current developments in endocrinology, including introductory and review material, methodology, applicability of results to basic and applied research, and impact on existing endocrine principles.

**AnSc 5401f. Swine Nutrition and Feeding.**

(4 cr; prereq 3401) Shurson  
Nutrient requirements of swine, nutrition interrelationships, nutritive value of feed ingredients, formulation of diets for optimum biological performance, nutritional management of all phases of pork production, quality control of on-farm feed manufacturing and feeding systems.

**AnSc 5403w. Ruminant Nutrition.**

(4 cr; prereq 1401 or 3401) Crooker, Otterby, Stern  
Nutrient requirements of ruminants (beef and dairy cattle, sheep); nutrient content of feedstuffs, primarily forages; protein and nonprotein nitrogen use; energy use; nutritional disorders, formulation of adequate rations.

**AnSc 5405w. Poultry Nutrition.**

(3 cr; prereq 3401) Waibel  
Nutrition and feeding of chickens and turkeys emphasizing nutrition concepts and feeding programs using least cost methods.

**AnSc 5601s. Swine Production.**

(4 cr; prereq 3401; 3220 recommended) Shurson  
Integration of economics, environment and facilities, nutrition, health, reproduction, genetics, management, and current industry issues in a systems approach to understanding pork production and solving pork production management problems.

**AnSc 5602w. Sheep Production.**

(3 cr; prereq 3401 or #; 3220, 5403 recommended) Christians, Head, Wolfe  
Status and characteristics of the sheep industry; application of principles of animal breeding, nutrition, physiology, and economics to sheep flock management. Sheep production systems, including breeding programs, selection of breeds and breeding animals, feeding, health programs, dairy sheep, marketing, and budgets.

**AnSc 5603s. Beef Cattle Production.**

(4 cr; prereq 1401 or 3401; 3220, 5403 recommended) DiCostanzo, Woodward  
Status and characteristics of the beef cattle industry; application of principles of animal breeding, nutrition, physiology, and economics to management of beef cattle breeding herds. Ration formulation, management, and marketing of feedlot cattle.

**AnSc 5604s. Dairy Farm Management.**

(4 cr, \$5614; prereq 5403 or #; 3220 recommended) Reneau  
Application of the principles of animal breeding, nutrition, physiology, and economics to the planning and management of the dairy farm; genetic influences, housing requirements, health programs for large herds, feed budgets, and record analysis.

**AnSc 5605f. Poultry Production.** (4 cr; prereq 1401 or 3401; 5405 recommended) Coon, El-Halawani, Noll, Waibel

Physiology, genetics, diseases, and nutrition of poultry examined in relation to current management practices for production of eggs, broilers, and turkeys. Technical and practical phases of production and marketing and their underlying principles. Visits to commercial production units.

**AnSc 5609w. Principles of Farm Animal Environment.**

(4 cr; prereq jr, 3301 or #) El-Halawani  
Processes involved in the adjustment of animals to ambient environments, with applications to farm animal management.

**AnSc 5710f,w,s,su. Special Problems.**

(Cr ar; open to students who have completed pertinent prereqs; prereq #)  
Research in an area of animal science under supervision of a staff member. Written report of research is required.

**AnSc 5715f,w,s,su. Tutorial.**

(Cr ar; prereq #)  
Informally structured course to encourage study in depth of a specific discipline in animal science. Pertinent readings, centered around fundamental propositions; preparation of written essays of high quality. Available in cryobiology, cytogenetics, genetics, nutrition, and physiology.

**AnSc 5999. Special Workshop in Animal Science.**

(1-4 cr; prereq #)  
Offered off campus. Consult the *Class Schedule* or department for current topics.

**AnSc 8210w. Genetic Improvement of Animals.**

(4 cr; prereq #) Seykora  
Application of population genetics to livestock breeding; selection index theory and practice; basis of relationship and covariances among relatives; selection based on multiple sources of information.

**AnSc 8230s. Linear Model Methods.**

(2-4 cr; prereq Stat 5021; GCB 5033, Math 3142 recommended) Hansen  
Techniques and statistical tools for analysis of data. Matrix manipulations, least-squares procedures, correction for environmental factors, estimation of components of variance, and standard errors of estimates.

**AnSc 8325w. Physiology of Fertilization and Gestation.**

(4 cr; prereq 5322 or #; offered alt yrs) Hunter  
Physiological events occurring during gametogenesis; capacitation and fertilization; the period of the embryo; the period of the fetus; and parturition.

**AnSc 8326s. Immunoreproduction.**

(4 cr; prereq 5322 or #; offered alt yrs) Hunter  
Blood groups and polymorphic proteins affecting reproduction; immunoglobulin formation; antigens of semen, ova and genital secretions; immunopathology; maternal-fetal incompatibility, and antibodies to hormones.

**AnSc 8332s. Preservation of Spermatozoa and Embryo.**

(5 cr; prereq 5322, 3 cr upper div biochemistry, #) Crabo  
Chemical, physical, and physicochemical properties of gametes, reproductive secretions. Preservation of gametes using cryogenic techniques.

**AnSc 8335. Molecular Biology Techniques in Animal Science.** (4 cr; prereq Biol 5001, Biol 5003 or equiv or #) Foster

Basic theory and current methodologies of molecular biology and recombinant DNA technology. Lab work includes DNA and RNA hybridization, gene transfer, and polymerase chain reaction techniques. Primarily for students with limited exposure to molecular biology.

**AnSc 8420f. Animal Bioenergetics and Nutritional Physiology.** (3 cr; prereq #; BioC 5002 recommended; offered alt yrs) Crooker

Integrated systems approach to nutritional physiology and energy metabolism of animals. Application of classical techniques of calorimetry and comparative slaughter, development of systems for expressing energy content of feeds, and techniques for measuring whole body and organ metabolism of specific nutrients in vivo.

**AnSc 8421s.\* Protein and Amino Acid Nutrition.** (3 cr; prereq BioC 5002 or equiv or #, BioC 5743 recommended; offered alt yrs) Coon  
Role; sources, how determined; measurements of protein quality; fat and use of ingested protein and amino acids and interrelationships with other nutrients.

**AnSc 8440w.\* Ruminant Nutrition.** (4 cr; prereq BioC 5002 or #; MicB 5321 recommended; offered alt yrs) Stern, staff

Development, physiology, and function of the rumen; role of rumen microflora in digestion and synthesis and factors influencing these phenomena.

**AnSc 8441w. Research Techniques in Ruminant Nutrition.** (4 cr; prereq 8440 or #; MicB 5321 recommended; offered alt yrs) Stern  
Techniques for measuring rumen fermentation and digestion in the gastrointestinal tract, including batch culture fermentation, in situ digestion, continuous culture fermentation, ruminal and intestinal cannulation, and blood sampling techniques.

**AnSc 8740w. Concepts and Developments in Ruminant Nutrition.** (2 cr; prereq #) Stern  
Review and critical evaluation of recent research reports of relevance to ruminant nutrition.

**AnSc 8742s. Concepts and Developments in Swine Nutrition.** (2 cr; prereq #; offered alt yrs) Pettigrew  
Review and evaluation of scientific literature pertinent to swine nutrition.

**AnSc 8743. Concepts and Developments in Nutritional Physiology.** (2 cr; prereq #) Crooker  
Review and critical evaluation of scientific literature.

**AnSc 8810.\* Research in Animal Science.** (Cr ar; prereq #)  
Research including experimental studies in disciplines associated with animal production and research, with emphasis on interdisciplinary studies embracing environmental and managerial considerations.

**AnSc 8820.\* Research in Animal Genetics.**

(Cr ar; prereq #)  
Research in quantitative genetics, cytogenetics, molecular genetics, and other areas related to animal breeding.

**AnSc 8830.\* Research in Animal Physiology.**

(Cr ar; prereq #)  
Individual research under faculty direction. Topic to be determined by consultation—may be a specialized aspect of a thesis problem or an independent problem of mutual interest to graduate student and adviser.

**AnSc 8840.\* Research in Animal Nutrition.**

(Cr ar; prereq #)  
Research in selected areas of animal nutrition. Research topics and animal species determined by consultation.

## Anthropology (Anth)

*Professor:* Luther P. Gerlach; Guy E. Gibbon; Stephen F. Gudeman; Glenn L. Hendricks; John M. Ingham; Marion L. Lundy-Dobbert; Frank C. Miller; Eugene Ogan (*emeritus*); William L. Rowe (*emeritus*); Peter S. Wells

*Associate Professor:* Gloria Goodwin Raheja, *chair*; David M. Lipset, *director of graduate studies*; Timothy Dunnigan; Mischa Penn; Riv-Ellen Prell; Janet D. Spector

*Assistant Professor:* Kathleen Barlow; Lisette E. Josephides; Joy McCorriston

*Other:* John M. Weeks

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) and Ph.D. Admission to the Ph.D. is conditional pending the results of a qualifying examination at the end of the first year of study.

**Curriculum**—The department offers M.A. and Ph.D. degrees in the subfields of sociocultural anthropology and archaeology. Strong supporting programs in related fields are available. A special M.A. track in public archaeology is offered.

**Prerequisites for Admission**—None. Any necessary background work may be completed after admission.

**Special Application Requirements**—Three letters of recommendation on a form furnished by the department and scores from the General (Aptitude) Test of the Graduate Record Examination should be sent to the director of graduate studies. Admission is usually in fall quarter; the deadline for all materials is January 15.

**Master's Degree Requirements**—For the M.A. degree, 8001, 8002, 8003 or 8004, a course in the method of one subfield, and a graduate-level statistics course are required. The rest of each student's program is individually designed with the provision that one-half of degree courses must be at the 8xxx level. A final oral examination is required of all students.

The Plan A master's degree requires a minimum of 20 course credits in anthropology, a minimum of 9 credits for a designated minor (certified on transcript) or a minimum of 8 credits in one or more related fields (not certified on transcript), and 16 thesis credits, for a minimum total of 44 credits.

The Plan B master's requires a minimum of 20 course credits in anthropology, a minimum of 8 credits in one or more related fields, and one to three Plan B projects (number is determined in consultation with student's advisory committee), for a minimum total of 44 credits.

**Doctoral Degree Requirements**—Course requirements are the same as for the master's degree, with additional courses and seminars selected in consultation with the student's advisory committee. No minimum credit requirement for the major has been established. Minor or supporting fields should comprise 18-24 credits. In practice, the normative minimum total is 60 credits.

**Language Requirements**—For the M.A. degree, none. For the Ph.D. degree, students must demonstrate a basic reading knowledge of one language other than English for which there is an anthropological literature or a long-standing literate tradition (e.g., Chinese, Hindi).

**Minor Requirements for Students Majoring in Other Fields**—The minor program is individually designed by each student.

**For Further Information and Applications**—Contact the Department of Anthropology, University of Minnesota, 215 Ford Hall, 224 Church Street S.E., Minneapolis, MN 55455 (612/625-3400; fax 612/625-3095).

**Anth 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**Anth 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**Anth 8888. Thesis Credits: Doctoral.** (36 cr required)

**Anth 5102. Principles of Cultural**

**Anthropology.** (4 cr, §1102; prereq jr or #) Penn Introduction to elements of cultural anthropology. Range and variability of human behavior. Principles of cultural dynamics.

**Anth 5104. History of Anthropology.** (4 cr; prereq 1102, 15 cr in 3xxx- and 5xxx Anth courses) Penn Principal themes in 19th- and 20th-century anthropological thought: diffusionism, autonomy of culture, evolutionism, and emerging methodological viewpoints such as functionalism, structuralism, cultural materialism, and interpretivism. Whether or not anthropological theory has a logic.

**Anth 5112. Gender and Kinship.** (4 cr; prereq 1102 or 5102, 3201 or #) Gudeman, Raheja Gender, sexuality, marriage, and kinship in cross-cultural perspective; role of kinship studies in anthropological theory, including contemporary feminist critiques.

**Anth 5114. Structural Anthropology.** (4 cr; prereq 1102 or 5102, 3201 or #) Gudeman, Penn Assumptions, methods, and problems of structural and semiotic anthropology; theory and analysis of kinship, myth, and social organization.

**Anth 5115. Economic Anthropology.** (4 cr; prereq 1102 or 5102, 3201 or #) Gudeman Systems of production and distribution, especially in nonindustrial societies; history, comparison, and critique of major theories in the field; development of anthropological approach to facts and processes of economy in the United States and other societies.

**Anth 5116. Ecological Anthropology.** (4 cr, §3116; prereq 1102) How humans interact with biophysical environment through nature. Cross-cultural comparative study of ways of making a living, e.g., foraging, herding, farming, industry; correlates environment with technology, economy, social and political organization, religion. Resource controversies and global environmental change.

**Anth 5118. Political Anthropology.** (4 cr; prereq 1102 or 5102 or #) Lipset Anthropological approaches to politics: the structural-functionalists, Manchester School, and others. Key political concepts: authority, legitimacy, power, ideology, order and conflict. Focus on how symbols and rituals shape political process. Symbolic dimensions of ethnic and class consciousness.

**Anth 5121. Anthropology of Law.** (4 cr; prereq 1102 or 5102—waived for majors in political science and law) Lipset Theory and method of various legal systems. Cultural background of law and relation of law to society. Functions and evolution of law in cultures ranging from small-scale to complex.

**Anth 5131. Anthropology of Religion.** (4 cr; prereq 1102 or 5102 or #) Lipset, Penn, Prell Comparative study of beliefs, myths, and rituals in folk and indigenous religions. Analysis of how religion and social relations are integrated.

**Anth 5132. Symbolic Anthropology.** (4 cr; prereq 1102 or 5102 or #) Ingham, Lipset  
Introduction to semiotic or symbolic interpretation of cultures in anthropology. General problems in theory and method, structure and motivation of cultural symbolism in particular societies.

**Anth 5141. Psychological Anthropology.** (4 cr; prereq 1102 or 5102 or #—waived for majors in public health, nursing, psychology, sociology, and social work) Ingham  
Self, emotion, cognitive processes, and child development in cross-cultural perspectives.

**Anth 5145. Anthropology and Education.** (4 cr; prereq 1102 or 5102 or #) Barlow, Lundy-Dobbert  
Cross-cultural perspectives in examining educational patterns, implicit and explicit cultural assumptions underlying them. Methods and approaches to cross-cultural studies in education.

**Anth 5151. Cultural Change and Development.** (4 cr; prereq 1102 or 5102 or #) Miller  
Processes of cultural change: invention, innovation, diffusion, and acculturation. Theories of modernization, dependency, and world systems. Roles of anthropologists in development programs.

**Anth 5152. Anthropology of Social Movements.** (4 cr) Gerlach  
Cross-cultural study of nature, process, and function of social, political, and religious movements of change. Examination of theories and case studies including Christianity, Islam, Asia, Africa, the United States.

**Anth 5153. Urban Anthropology.** (4 cr; prereq 1102 or 5102 or #)  
Structure and process in non-Western urban centers; role of rural migrants, relationship of urbanism to political and economic development, role of voluntary associations, adjustment of kinship groups to urban life.

**Anth 5154. Anthropology of Colonialism.** (4 cr; prereq 1102 or 5102 or #) Raheja  
Social, structural, symbolic, and psychological aspects of the societies of colonizers and colonized; emphasis on South Asia, Oceania, and Puerto Rico.

**Anth 5157. The Political Discourse of Social Change.** (4 cr) Josephides  
Tension between tradition and innovation of ideas, techniques, and material development in contexts of rapid social change, especially when local cultures come into contact with outside, politically more forceful ones. Tradition as an already politicized discourse.

**Anth 5161. Cultural Semantics.** (4 cr; prereq #) Dunnigan  
Language-based approaches to study of cultures.

**Anth 5176. Environmental Archaeology.** (4 cr; prereq 1101, 3111 or #) Spector  
Archaeological and natural scientific approaches to studying past human society: human impact on and use of environment, reconstructing past environmental conditions. Field and lab techniques in association with archaeological research problems.

**Anth 5191. Folklore, Power, and Cultural Description.** (4 cr; prereq 1102 or 5102 or #) Raheja  
Song, oral poetry, story, and other performed speech genres as sites of cultural contestation, in arenas of gender, class, and colonial relations. Politics of expressive forms in contemporary and colonial societies; implications for practice of ethnography.

**Anth 5201. Contemporary Perspectives in Anthropology.** (4 cr; prereq 1102; required for sr cultural anth majors)  
Contemporary theoretical perspectives in cultural anthropology and their historical background. Modernism, reconceptualization resulting from postmodern and feminist critiques of fieldwork and ethnographic writing, and application of these to contemporary American cultural diversity.

**Anth 5258. Anthropological Analysis of American Culture.** (4 cr; prereq 1102 or 5102 or #) Ingham  
Anthropological perspectives on contemporary American culture and society with emphasis on values, family organization, socialization and kinship, education, community integration.

**Anth 5301. Advanced Method and Theory in Archaeology.** (4 cr; prereq 3111 or #; recommended for anth majors specializing in archaeology) McCorriston  
Contemporary theoretical and methodological issues and approaches in archaeology. Projects incorporating theories and methods, including simple computer analysis.

**Anth 5305. Studies in Ethnographic Classics.** (4 cr) Penn  
Intensive studies of notable theoretical and ethnographic works in the past and recent history of anthropology. Topics and works selected yearly.

**Anth 5325. Gender and Power in South Asia.** (4 cr; prereq 1102, 3261 or 5102 or #) Raheja  
Multiple perspectives on gender, power, kinship, and sexuality in South Asian society; theoretical issues this multiplicity poses for ethnographic writing. Textual traditions, folklore, ritual and exchange, politics of everyday life, colonialism, and post-colonialism.

**Anth 5331. Culture Theory: An Introduction.** (4 cr; prereq jr or sr or grad student or #) Penn  
Selected issues in the development of culture theory, e.g., do cultural phenomena have an independent reality, or are they a derived aspect of social systems?

**Anth 5392. Philosophical Anthropology.** (4 cr; prereq 1102 or 5102) Penn  
Survey of traditional problems associated with certain major and broad ranging views on human nature and culture. Variations on these views; specific arguments of relativists, phenomenologists, behaviorists, and others. Recent ethnographic theory.

**Anth 5461. North American Indian Architecture.** (4 cr, §Arch 5461)  
Historic and contemporary principles and theories. Culture, technology, environment, art, and craft of North American Indians in their architecture and settlements.

**Anth 5520. Current Issues in Archaeology.** (4 cr; prereq 3111 or #)  
Discussion/review/analysis of specific theoretical and/or methodological issues in archaeology.

**Anth 5524. Archaeological Research Design.** (4 cr; prereq #)  
Recommended for undergraduate anthropology majors specializing in archaeology who select senior project option.

**Anth 5592. History of Archaeology.** (4 cr; prereq 12 cr in 3xxx- or 5xxx Anth courses) Gibbon, McCorriston  
Survey course emphasizing development of major concepts and research goals.

**Anth 5910, 5920. Topics in Anthropology.** (Cr ar)  
Special courses in all branches of anthropology. Topic, prerequisites, and instructor specified in the *Class Schedule*.

**Anth 5960. Senior Seminar.** (4 cr; prereq sr major)  
Research seminar. Topics vary according to staff and student interests.

**Anth 5970. Directed Readings.** (2-4 cr; prereq #, Δ, CLA approval)  
Qualified students may register for work on tutorial basis.

**Anth 8001, 8002. Foundations of Social and Cultural Anthropology I, II.** (3 cr per qtr; prereq anth grad student or #)  
Classical and contemporary foundations.

**Anth 8003. Foundations of Social and Cultural Anthropology III.** (3 cr; prereq anth grad student or #)  
Theoretical foundations in contemporary perspective.

**Anth 8004. Foundations of Anthropological Archaeology.** (3 cr; prereq anth grad student or #)  
Theoretical foundations in contemporary perspective.

**Anth 8111. Pedagogy.** (3 cr; prereq anth grad student) Barlow  
Ways of teaching anthropology to undergraduates. Understanding learning goals and processes; developing discipline-specific skills, teaching materials, a syllabus, written assignments, discussion groups, tests, and a grading system.

**Anth 8124. Problems in Archaeology.** (3 cr)  
Gibbon, McCorriston,

**Anth 8125. Problems in Linguistic Anthropology.** (3 cr) Dunnigan

**Anth 8201. Method and Theory in Archaeology.** (3 cr) Gibbon, McCorriston, Spector

**Anth 8202. Research Methods in Social and Cultural Anthropology.** (3 cr; prereq grad major in anth or #)

**Anth 8211. Advanced Field Techniques in Archaeology.** (3 cr) Gibbon, McCorriston

**Anth 8320. Seminar: Social Anthropology.** (3 cr)

**Anth 8330. Seminar: Economic Anthropology.** (3 cr) Gudeman

**Anth 8340. Seminar: Political Anthropology.** (3 cr) Lipset

**Anth 8350. Seminar: Culture and Personality.** (3 cr) Ingham

**Anth 8370. Seminar: Symbolism.** (3 cr) Ingham

**Anth 8390. Seminar: Philosophical Anthropology.** (3 cr) Penn

**Anth 8420. Seminar: Cultural Change.** (3 cr)  
Gerlach, Miller, Dunnigan

**Anth 8460. Seminar: Anthropology of Gender.** (3 cr) Barlow, Lipset, Raheja

**Anth 8510. Seminar: Archaeology.** (3 cr)  
Gibbon, McCorriston

**Anth 8810. Seminar: Special Topics.** (Cr ar)

**Anth 8950. Directed Studies.** (Cr ar; prereq #)

## Arabic (Arab)<sup>1</sup>

*Professor:* Caesar E. Farah

*Assistant Professor:* Teirab AshShareef, *director of graduate studies;* Charles Ben Pike

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—M.A. (Plan B only).

**Curriculum**—The program focuses on the Arabic language and the literature and culture of the Arab world.

**Prerequisites for Admission**—Two years of Arabic (Arab 3103 or equivalent) is required, and a minimum of 16 credits in Arabic literature or culture, 12 credits of which must be at the upper division level.

**Special Application Requirements**—A short statement of purpose (in Arabic) and three letters of recommendation are required. Students are admitted fall, winter, and spring quarters.

**Master's Degree Requirements**—The minimum requirement is 44 credits in addition to one Plan B research paper (nine courses plus 8 credits for the research paper). The coursework must include 28 credits (seven courses) in Arabic literature or culture, including Arab 5001 (4 credits), and two 8xxx seminars (8 credits). The coursework must also include 8 credits

<sup>1</sup> No new students will be accepted for the Arabic major during 1996-99.

(2 courses) in related fields outside Arabic depending on the student's academic goals and subject to the approval of the director of graduate studies. The final examination is an oral defense of the research paper.

**Language Requirements**—Three years of Arabic (Arab 5103 or equivalent) is required. A reading knowledge of one classical or one modern language appropriate to the student's academic goals and approved by the director of graduate studies is also required.

**For Further Information and Applications**—Contact the Arabic Program, Department of Afro-American and African Studies, University of Minnesota, 808 Social Sciences Building, 267 19th Avenue South, Minneapolis, MN 55455 (612/624-9847).

**Arab 5001. Introduction to Research in Arabic Studies.** (4 cr) AshShareef, Farah, Youssif  
Survey of most important research bibliographies in Arabic and Islamic studies. Bibliographic references in English and possibly in Arabic if sufficient interest.

**Arab 5036. The Religion of Islam.** (4 cr, §3036, §MELC 3036, §RelS 3036, §RelS 5036) Farah  
Evolution of Islam in historical context. Institutions that made for diversity and continuity: traditions, law, and observances of the faith; sectarian movements; philosophical and theological trends; modern developments (reformist, revolutionary, and militant).

**Arab 5101, 5102, 5103. Advanced Arabic.**  
(5 cr per qtr; prereq 3101 or # for 5101, 3102 or # for 5102, 3103 or # for 5103) AshShareef  
Reading, writing, listening, and speaking. Journals, compositions, and two oral presentations.

**Arab 5501. Modern Arabic Poetry.** (4 cr) AshShareef  
The free verse movement and its radical departure from traditional ode form. Major trends: post-romantic, social-realist, symbolist, resistance, prose poem. Emphasis on leading poets: al-Mala'ika, al-Sayyab, al-Bayati, Adunis, Hawi, al-Khal, Abd-al-Sabur, al-Fayturi, Darwish, Sayigh, Jabra, and al-Maghut. Theoretical and critical essays. All readings in English.

**Arab 5502. The Arabic Novel.** (4 cr) AshShareef  
The novel as a new genre in modern Arabic literature. Its relation to narrative genres in Arabic literary tradition, both written and oral. Trends: realist, psychological, existentialist, feminist, post-modernist/fantastic/experimentalist. Emphasis on major novelists: Mahfouz, Ghanem, Salih, Jabra, Kanafani, El Saadawi, al-Shaykh, Munif, Habibi, al-Qa'id, al-Ghitany, and Khoury. Novels discussed in cultural and historical context. Theoretical and critical essays. All readings in English.

**Arab 5503. Arabic Drama.** (4 cr) AshShareef  
Drama as a new genre in modern Arabic literature under influence of European drama. Relation with traditional dramatic forms in Arabic literature and culture. Trends: "Theater of the Mind," social realist, existentialist, absurdist, experimentalist, epic, and verse drama. Emphasis on major playwrights: al-Hakim, Abd-al-Sabur, Diyab, Salem, Faraj, Idris, al-Maghut, al-'Ani, Wannus, and al-Madani. Plays discussed in cultural and historical context. Theoretical and critical essays. All readings in English.

**Arab 5505. Survey: The Middle East.** (4 cr, §3505, §Hist 3505, §MELC 3505) Farah  
Cultures, religions, and scholarly achievements from pre-Islamic times to present.

**Arab 5523. The Middle East in World Affairs: The 19th Century.** (4 cr, §MELC 5523) Farah  
Structure of society; cultural and political impact of the West; revivalist and nationalist trends; reformist and separatist movements.

**Arab 5545. Islamic Mysticism.** (4 cr, §3545, §Hum 3545, §Hum 5545) AshShareef, Farah  
Rise of Sufism, from asceticism to theosophical mysticism; leading historical personalities, their beliefs and teachings; relationship to Orthodox Islam and non-Muslim mystical movements; concepts and organizations; place of Sufism in modern religious trends.

**Arab 5546. Theological and Mystical Doctrines of Islam.** (4 cr, §MELC 5546, §RelS 5546) AshShareef, Farah  
Classical works of scholastics, mystics, jurists, and philosophers; their writings on principal Islamic religious beliefs and institutions. Content analysis, beginning with Qur'an and traditions.

**Arab 5730. Proseminar in Middle East History: 16th to 19th Century.** (4 cr, §Hist 5730) Farah  
Topics, which vary quarterly, on Mamluk, Safavid-Qajar, and Ottoman era concerning relations with each other and outside world, including political, diplomatic, and ideological orientations and conflicts; cultural and social trends; commerce; transformations due to Western impact, to secularization, and to modernization and colonial encroachments that shaped new ideological trends and gave rise to nationalisms and Islamic activism.

**Arab 5900. Topics: Readings in Arabic Texts.** (4 cr per qtr [max 12 cr]; prereq 5103 or #) AshShareef, Farah, Youssif  
Reading and discussion of selected classical works in Arabic.

**Arab 5910. Topics in Arabic Studies.** (4 cr)  
Topics specified in *Class Schedule*.

**Arab 5970. Directed Readings.** (Cr ar; prereq #, Δ, CLA approval) AshShareef, Farah, Youssif  
Special problems for advanced students. Reading and periodic consultations.

**Arab 5990. Honors Course: Research.** (Cr ar; prereq 5970 or #) AshShareef, Farah, Youssif  
Individual studies for honors work at advanced level.

**Arab 8801. Seminar: Modern Arabic**

**Literature.** (4 cr; prereq 5103 or #) AshShareef  
In-depth study of single author (e.g., Mahfouz, Adunis, al-Hakim) or single theme (e.g., modern Arabic critical theory, Arabic modernism, free verse movement). Topic specified in *Class Schedule*. Readings in Arabic and English.

**Arab 8802. Seminar: Orientalism.** (4 cr)

AshShareef  
Orientalist discourse on Islam and Arabs. Orientalist texts. Theoretical and critical essays.

See South Asian and Middle Eastern Studies and Studies in Africa and the African Diaspora (in the Graduate Programs section) and Jewish Studies (in the Related Courses section).

**Architecture (Arch)**

*Professor:* Garth C. Rockcastle, *head*; Julia W. Robinson, *director of graduate studies*; Roger D. Clemence; Dennis Grebner; Lance LaVine; Roger B. Martin; William R. Morrish; Leon Satkowski; James E. Stageberg

*Adjunct Professor:* Dale Mulfinger; John G. Rauma; Milo H. Thompson; Duane E. Thorbeck

*Associate Professor:* Lee B. Anderson; Gunter Dittmar; Robert D. Sykes; J. Stephen Weeks

*Adjunct Associate Professor:* Bruno M. Franck; Thomas A. Meyer; Lee Tollefson

*Assistant Professor:* Mary M. Guzowski; Cynthia Jara; Andrzej Piotrowski; Katherine M. Solomonson

*Adjunct Assistant Professor:* Ralph K. Nelson; Bruce A. Parker; Lars H. Peterssen; Timothy G. Quigley; Todd J. Rhoades; Jeff Scherer; Julie V. Snow

*Lecturer:* William A. Blanski; Timothy J. Fuller; Vincent James; Gary L. Johnson; Janis LaDouceur; Robert C. Mack; Mark Searls; Mark S. Wentzell

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered—M.Arch.**

**Curriculum—**The three-year professional curriculum accredited by the National Architectural Accreditation Board (NAAB) consists of a minimum of 131 graduate credits, including the thesis. Because the admitted student will already have a broad educational background and will have completed fundamental courses, the program focus is on professional and disciplinary coursework, including required and elective lecture, seminar, and design studio courses. For most students, the first-year integrated curriculum is followed by two years of less-structured coursework that culminates in a thesis.

**Prerequisites for Admission—**Applicants to the M.Arch. program must hold a baccalaureate degree and must have completed the equivalent of at least a year of preparatory work, including coursework in calculus, physics, architectural history, drawing, and architectural design.

Students are expected to have basic computer skills before beginning the M.Arch. program, including familiarity with either Macintosh or Windows operating systems, word processing, basic drawing or painting programs, and use of e-mail. Intermediate classes in computer methods in architecture (Arch 5371, 5372, 5373) are part of degree requirements during the first year; advanced classes (Arch 5374, 5375) are required during the second year.

In exceptional circumstances, students who have a nonprofessional baccalaureate degree in architecture and have completed the equivalent of the first year of the M.Arch. program requirements may qualify for advanced placement in the program. Depending on their academic record, their previous coursework, and their portfolio review, these students could complete the M.Arch. degree in a minimum of two years.

A small number of students who hold a Bachelor of Architecture professional degree (B.Arch.) are admitted each year to pursue a second professional degree. Admission is based on the quality of the previous academic work and the quality of the portfolio. Depending on their background, these students could complete the M.Arch. degree in a minimum of four quarters.

For more complete information, please see the *College of Architecture and Landscape Architecture Bulletin* and contact the Department of Architecture.

**Special Application Requirements—**

Admission to the M.Arch. program is highly competitive. In addition to meeting Graduate School application requirements, students applying to the program must demonstrate design talent in a portfolio and must submit all of the following: a one-page statement of interest, transcripts of all coursework, three faculty recommendations, a recent paper written in English, and Graduate Record Examination scores. The portfolio should be a notebook no larger than 10" x 12" (other portfolio formats will be rejected). International students must submit scores from the Test of

English as a Foreign Language (TOEFL) or the Michigan English Language Assessment Battery (MELAB). Priority for admission and financial aid is given to students who apply by January 10.

**Degree Requirements**—The three-year, 131-credit M.Arch. program is a Plan A program consisting of required and elective courses distributed as follows: 8 each in design studio and technology; 2 each in history, theory, and professional practice; 5 one-credit courses in computer-aided design; and 1 each in urban design and visual communication; and 16 thesis credits.

Students who hold a B.Arch. degree (i.e., those who seek a post-professional degree) must take a minimum of 44 graduate credits in an individually developed program of study. Students may choose either Plan A or Plan B: the 44 credits include 16 thesis credits for Plan A and two or three major papers for Plan B.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—Students who want to minor in architecture should contact the director of graduate studies.

**For Further Information and Applications**—Contact the Department of Architecture, University of Minnesota, 110 Architecture Building, 89 Church Street S.E., Minneapolis, MN 55455 (612/624-7866; fax 612/624-5743; e-mail drasi001@tc.umn.edu).

*Note*—See also the program in Landscape Architecture.

**Arch 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

## Design

**Arch 5241. Principles of Design Programming.** (4 cr, §5292, §5391; prereq 5111 or 8253, Arch or grad Arch major; A-F only)  
Concepts and techniques of architectural programming, including space and activity analysis, site selection, precedent study, code review, appropriate technology identification, hypothesis formulation and evaluation. Emphasizes conceptual development, research, and analytic drawing.

**Arch 5250. Topics in Architecture Design.** (1-6 cr; prereq 5283 or grad Arch major)

**Arch 8250. Topics in Design.** (2-4 cr; prereq 1st-yr design or 8101 or #; A-F only)

**Arch 8251, 8252, 8253.\* Graduate Architectural Design I.** (6 cr per qtr; prereq Arch grad student; A-F only)  
Problems involving design as a creative inquiry; individual and collaborative effort.

**Arch 8254, 8255, 8256.\* Graduate Architectural Design II.** (6 cr per qtr; prereq Arch grad student; A-F only)  
Comprehensive architectural problems; in-depth exploration of fundamental architectural issues; individual and collaborative effort.

**Arch 8257, 8258. Graduate Architectural Design III.** (6 cr per qtr; prereq Arch grad student)  
Case studies in architecture exploring societal issues in architecture and/or urban design; project resolution emphasized; individual and collaborative effort.

## Representation and Communication

**Arch 5309. Representation in Architecture.** (4 cr, §LA 5309; prereq 3311 or LA 3311, Arch or Land Arch professional candidate) Piotrowski  
Historical and theoretical study of representation and its depiction in architecture and landscape architecture. Media, conventions, and techniques used to visualize or reproduce architecture and how they affect production of ideas.

**Arch 5313. Visual Communication Techniques in Architecture.** (4 cr, §3033; prereq 3311 or #) Grebner  
Professional delineation, exploration and use of variety of presentation and study techniques, methods/media investigation, modern techniques. Intended primarily for more advanced students in architectural design.

**Arch 5321. Architecture in Watercolor.** (4 cr, §3110; prereq Arch/BED major, 3311 or #)  
Watercolor as representation and communication in design process. Foundation principles, techniques, medium, tools, and materials. Color relationships, mixing, composition, and applications to design.

**Arch 5350. Topics in Architectural Representation.** (Cr ar; prereq Arch or grad Arch major or #; A-F only)  
Theory and practice of visual representation.

**Arch 5371, 5372, 5373. Intermediate Computer Methods in Architecture.** (1 cr per qtr; prereq grad Arch major, ¶8251 or ¶8252 or ¶8253, basic computer graphics course)  
Drawing and painting, 3-D modeling, image and video editing, desktop publishing.

**Arch 5374, 5375. Advanced Computer Methods in Architecture.** (1 cr; prereq grad Arch major, 5371, 5372, 5373, ¶8254 or ¶8255)  
CAD, 3-D modeling, and rendering.

**Arch 5381. Introduction to Computer Aids for Architectural Design.** (4 cr; prereq Arch/BED or Land Arch major) Anderson, staff  
Document design, 2-D drawing, 3-D modeling, animation, printing, and plotting. Electronic networking and communication.

**Arch 5382. Computer Aids for Architectural Design.** (4 cr; prereq Arch/BED or Land Arch major) Anderson, staff  
Database management, spreadsheet analysis, land-use analysis, 2-D/3-D CAD, image manipulation, project management.

**Arch 5383. Advanced CAD Visualization for Architecture.** (4 cr; prereq Arch/BED or Land Arch major) Anderson, staff  
Solid modeling, photo-realistic imaging, animation, video editing and recording.

**Arch 8350. Advanced Topics in Representation.** (2-4 cr; prereq 1st-yr design or 8101 or #)  
Theory and practice of visual representation in architecture.

## History

**Arch 5410. Topics in Architectural History.** (Cr ar; prereq #)  
Advanced study. Readings, research, seminar reports.

**Arch 5417. Asian Architecture.** (4 cr, §5057; prereq Arch major or #; A-F only)  
Topics from history of architecture and urban design in West, South, and East Asia.

**Arch 5422. Early Medieval Architecture.** (4 cr, §5052; prereq 3411 or Arch major or #; 3 lect, 1 seminar hrs per wk; A-F only)  
History of the development of architecture and urban design during early Christian, Byzantine, Islamic, Carolingian, and Romanesque periods in the Near East and Western Europe until 1150 A.D.

**Arch 5423. Gothic Architecture.** (4 cr, §5053; prereq 3411 or Arch major or #; 3 lect, 1 seminar hrs per wk; A-F only)  
History of development of architecture and urban design in Western Europe from 1150 until 1400 A.D.

**Arch 5424. Renaissance Architecture in Italy.** (4 cr, §5054; prereq 3411, Arch major or #; 3 lect, 1 seminar hrs per wk; A-F only) Satkowski  
History of architecture and urban design in Italy, 1400-1600 A.D. Emphasis on major figures (Brunelleschi, Alberti, Bramante, Palladio) and evolution of major cities (Rome, Florence, Venice).

**Arch 5425. Baroque Architecture in Italy.** (4 cr, §5064; prereq Arch major or #; 3 lect, 1 seminar hrs per wk) Satkowski  
Architecture and urban design in Italy, 1600-1750 A.D. Emphasis on major figures (Bernini, Borromini, Cortona, Guarini) and evolution of major cities (Rome, Turin).

**Arch 5426. Architecture and Nature, 1500-1750.** (4 cr; prereq 3411, 3412 or #) Satkowski  
History of interaction between architecture and nature in Italy, England, and France in 16th and 17th centuries. Major monuments and their relationship to theories of architecture and gardening; urban and rural life.

**Arch 5431. Eighteenth-Century Architecture and the Enlightenment.** (4 cr, §5055; prereq 3412 or Arch major or #; 2 lect hrs per wk; A-F only) Solomonson  
Architecture, urban planning, and garden design in Europe, 1700-1850.

**Arch 5432. Modern Architecture.** (4 cr, §5056; prereq 3412 or Arch major or #; 3 lect, 1 seminar hrs per wk; A-F only) Solomonson  
Architecture and urban design from early 19th-century sources in Europe and America to World War II.

**Arch 5433. American Architecture and Urbanism to 1870.** (4 cr; prereq 3412 or #) Solomonson  
American vernacular landscape and architect-designed structures and spaces, from colonization through Civil War. Topics range from colonial architecture in Southwest and New England to development of an expression of national identity, from Southern plantations and Midwestern farms to architecture of industrial city.

**Arch 5434. Contemporary Architecture.** (4 cr, §5061; prereq Arch major or #; 3 lect, 1 seminar hrs per wk) Solomonson  
Developments, theories, movements, and trends in architecture and urban design from World War II to the present.

**Arch 5439. History in Architectural Theory.** (4 cr, §5067; prereq 3412 or #) Satkowski, Solomonson  
From antiquity to 20th century.

**Arch 8410. Topics in History.** (2-4 cr; prereq 1st-yr design or 8101 or #; A-F only)

## Theory and Criticism

**Arch 5401. Principles of Design Theory.** (4 cr; prereq grad Arch or #; A-F only) Jara  
Principles of design and their instrumentation. How and why architecture theory is generated. Types and significance of formal analysis. Theoretical positions and modes of criticism.

**Arch 5450. Topics in Architectural Theory.** (Cr ar; prereq Arch or grad Arch major or #; A-F only)  
Topics in theory and criticism.

**Arch 5451. Architecture: Theory and Philosophy.** (4 cr; prereq BArch major or MArch major or #; A-F only) Dittmar  
Architecture as a discipline: its nature, role, purpose, and meaning within a general philosophical and theoretical framework. Paradigms through which architecture defines itself and derives its mode of operation.

**Arch 5452. Architecture: Thought and Design Process.** (4 cr; prereq BArch major or MArch major or #; offered when feasible; A-F only) Dittmar

**Arch 5453. Architecture: Form, Order, and Meaning.** (4 cr; prereq BArch major or MArch major or #; A-F only) Dittmar  
Fundamental, constituent elements of architectural form and order; inherent tectonic, phenomenal, experiential, and symbolic characteristics of these elements and their potential and implications for creation and structure of meaningful, human place(s).

**Arch 5454. Semiotics and Deconstruction in Architecture.** (4 cr; prereq 5401, grad Arch major or #; A-F only) Rockcastle

Expressive and cultural dimensions of architecture, especially as they relate to linguistic analogies, knowledge production, and contemporary philosophy, including broad critical perspective of architectural discussion and argumentation which addresses current aspects of the debates.

**Arch 5455. Typology and Architecture: Theories of Analysis and Synthesis.** (4 cr; prereq 5401, grad Arch major or #; A-F only) Rockcastle  
Theoretical traditions and development of the use of typology in architecture. Historical works of Laugier, Quatremère de Quincy, Viollet-Le-duc, Ledoux, Durand, Camillo Sitte, and Le Corbusier. Recent developments and theoretical positions of the “neorationalist” and “contextual” arguments for contemporary applications of idea of type.

**Arch 5458. Architecture and Culture.** (4 cr; prereq 3412, Arch major or #) Robinson  
Architecture as a cultural medium; relation between architecture, people, and culture; physiological and symbolic messages; relation between research findings and design and between vernacular and high-style architecture; reception theory in architecture; cultural critique and cultural change; implications for architectural practice.

**Arch 5461. North American Indian Architecture.** (4 cr, §Anth 5461)  
Historic and contemporary principles and theories. Culture, technology, environment, art, and craft of North American Indians in their architecture and settlements.

**Arch 8450. Topics in Theory.** (2-4 cr; prereq 8101 or 8401 or #; A-F only)

**Technology**

**Arch 5511. Construction Materials in Architecture.** (4 cr, §3061; prereq grad Arch major or #; A-F only)  
Study and analysis of building materials, assemblies, and operations affecting construction of building designs. Considerations of materials performance, durability, workmanship, and compatibility in detailing of masonry, wood, and metal framing designs. Examination of building partner relationships and their implications for materials, elements, components, and assembly selections.

**Arch 5512. Historic Building Conservation.** (4 cr, §5142; prereq Arch major or #; 2 lect, 2 lab hrs per wk) Mack  
Historic building systems and materials and methods for their conservation; introduction to use of contemporary systems in historic buildings.

**Arch 5521. Building Methods in Architecture.** (4 cr, §3062; prereq BArch or BED or MArch student or #; A-F only) Weeks  
Analysis of architectural materials, building products, and construction operations related to structural and enclosure systems in design and detailing of noncombustible and fire-resistive constructions. Emphasizes concrete systems and structural steel frames and composite structures. Application of legal constraints and regulations, cost controls, and life safety factors in preparation of construction documents, specifications, and drawings.

**Arch 5522. Techniques and Form.** (4 cr per qtr, §5116; prereq 5511, 5571, grad Arch major or #; A-F only) Rauma  
Form as interface between programmatic requirements for environmental change and physical means available to the architect: social and cultural paradigms and physical environment; search for organizational principles of architectural form; geometrical order, properties of materials, distribution of forces, construction techniques, accommodation of building infrastructure.

**Arch 5523. Light Frame Buildings: Design for Energy Efficiency, Health, and Durability.** (4 cr; prereq 5521, 5541, grad Arch major or #) Weeks  
Design principles and construction methods for resolution of problems of comfort, energy efficiency, and durability. Problems integrating building systems and envelope assemblies with design solutions for moisture, infiltration, indoor air quality, and material degradations.

**Arch 5525. Design in Masonry.** (4 cr; prereq grad Arch major, 5521, 8253 or #)  
Design principles, construction methods, and document production for masonry structures.

**Arch 5531. Lighting and Acoustic Design.** (4 cr, §3065; prereq BArch or BED or MArch student or #)  
Principles of daylighting, electric lighting, and acoustic design in architecture. Relation between luminous and acoustic environments, human comfort, and architectural experience. Analytic methods, design process, and modeling of daylighting.

**Arch 5539. Daylighting and Architectural Design.** (4 cr, §3065, §5959; prereq 5551, grad Arch major or #; A-F only) Guzowski  
Principles, strategies, energy and environmental issues, psychology of light and color, and integration of electric lighting. Design projects investigate qualitative and quantitative issues through drawing, physical models, and photometric analyses.

**Arch 5541. Thermal Design in Architecture.** (4 cr, §3064; prereq BArch or BED or MArch student or #)  
Thermal and climatic issues in design of small and midsize buildings. Built and mechanical means to modify climate. Evaluation of design techniques in terms of potential impacts on energy use, environment, and architectural meaning.

**Arch 5542. Building Energy Systems.** (4 cr, §5966; prereq 5541, grad Arch major or #; A-F only)  
Through case studies, conceptual understanding of functions of building mechanical systems and their integration with other building components. Residential and commercial HVAC systems, alternative energy sources, energy efficiency, and structural implications of mechanical systems, indoor air quality, and environmental control strategies.

**Arch 5543. Climate and Architecture.** (4 cr, §5957; prereq 5541, grad Arch major or #; A-F only)  
Role of climate in architectural design and theory. Environmental and energy implications at site, building, and component scales. Design projects explore graphic analysis, physical modeling, and quantitative assessment.

## GRADUATE PROGRAMS

### **Arch 5550. Topics in Architecture Technology.**

(Cr ar; prereq Arch or grad Arch major or #)  
Construction, environmental management, energy performance, lighting, or materials.

**Arch 8550. Topics in Technology.** (2-4 cr;  
prereq 5535, 5541, 5551 or 8101 or #)

### **Structures**

**Arch 5572. Theory and Design of Architectural Structures: Space, Span, Order.** (4 cr; prereq 5511, 5521, BArch major or MArch major or #)

Principles and concepts of historic and modern architectural structures; interrelated nature of design and structure. Structural elements, systems, materials, and technical principles. Lectures, construction exercises, graphical analyses, and lab modeling.

**Arch 5573. Architectural Structures I: Wood and Steel Construction.** (4 cr; prereq BArch major or MArch major or #)

Principles of structural behavior, analysis, and design in wood and steel materials and systems. Emphasizes whole building design and individual structural elements. Conceptual design strategies: example studies; estimating loads; wall, beam, and column design; connection design; performance problems. Case studies, exercises, design problems, physical models, computer and quantitative analysis.

**Arch 5574. Architectural Structures II: Concrete and Masonry Construction.** (4 cr; prereq BArch major or MArch major or #)

Principles of structural behavior, analysis, and design in reinforced concrete framing systems and structural masonry constructions. Emphasizes whole building design and individual structural elements. Conceptual design strategies: properties of materials; estimating loads; footing, wall, beam, slab, and column design; connection design; performance problems. Case studies, exercises, design problems, physical models, computer and quantitative analysis.

### **Practice**

**Arch 5411. Historic Preservation Process.** (4 cr, \$5141; prereq Arch major or #; 4 lect hrs per wk) Mack  
Philosophy and theory of historic preservation, historic origins, descriptive analysis of buildings, building documentation, technology of building conservation, historical archaeology, economic considerations, preservation law, guidelines for preservation, neighborhood conservation, international preservation, and case studies of representative preservation projects.

**Arch 5413. Historic Building Research and Documentation.** (4 cr, \$5143; prereq Arch major or #; 2 lect, 2 lab hrs per wk) Mack  
Philosophy, theory, and methods of historic building research, descriptive analysis of buildings, building documentation, historical archaeology, and architectural taxonomy.

### **Arch 5621. Professional Practice in**

**Architecture.** (4 cr, \$5126; prereq Arch or grad Arch major or #) Scherer

Legal, ethical, business, and practical requirements to practice architecture. Contemporary and historical models of contract formation, business principles, accounting, project management, and design services marketing.

### **Arch 5631. Legal Contracts in Architecture I.**

(4 cr, \$5127; prereq 3093 or #; A-F only)

Legal subject matter relevant to work of architects and design professionals.

### **Arch 5650. Topics in Architectural Practice.**

(Cr ar; prereq Arch major, 5621 or #)

Topics in architectural practices, methods of design production, marketing, operation, and relationships between clients, architects, and society.

### **Arch 8650. Topics in Architectural Practice.**

(2-4 cr; prereq 1st-yr design or 8101 or #; A-F only)

### **Urban Design**

#### **Arch 5711. Design Principles of the Urban**

**Landscape.** (4 cr, \$5137; prereq Arch/BED major or #) Morrish, staff

Art and design of making city, neighborhood, and development plans. Public policies, planning tools and process, and physical models for design professionals and private and civic institutions to shape physical environment.

**Arch 5724. The Meanings of Place.** (4 cr; prereq #; A-F only) Clemence

Analyzing meanings and messages of surroundings. What present-day environments reveal about the past; links between sense of place and feelings of well-being. Twin Cities central districts and selected neighborhoods and other settings within and outside Minnesota.

**Arch 5750. Topics in Urban Design.** (Cr ar; prereq 5711, grad Arch major for #; A-F only)

Theory and practice of urban design.

**Arch 8750. Topics in Urban Design.** (2-4 cr; prereq 1st-yr design or 8101 or #)

### **General**

**Arch 8101. Seminar: Subjects and Methods in Architecture.** (2 cr)

### **Art (ArtS)**

*Professor:* Wayne E. Potratz (sculpture), *chair*; Curtis C. Hoard (ceramics), *director of graduate studies*; Karl Bethke (printmaking); Diane Katsiaficas (drawing and painting); Clarence E. Morgan (drawing and painting); Mark Pharis (ceramics); Thomas A. Rose (sculpture)

*Associate Professor:* Guy A. Baldwin (sculpture); Thomas R. Cowette (drawing and painting); David L. Feinberg (drawing and painting); Lynn A. Gray (drawing and painting); Gary L. Hallman (photography); James V. Henkel (photography); Jerald Krepps (printmaking and papermaking); Thomas J. Lane

(ceramics and neon); Susan M. Lucey (sculpture); Joyce Lyon (drawing and painting); William N. Roode (drawing and painting)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—M.F.A. (Plan B).

**Curriculum**—The master of fine arts program places major emphasis on studio work of high quality. The program normally takes three years to complete. Most students concentrate in one area of study, but may take courses in studio areas outside the major concentration. The following areas of concentration are available: ceramics; drawing and painting; photography; printmaking; and sculpture.

**Prerequisites for Admission**—A bachelor of fine arts or its equivalent, or an undergraduate major in studio arts, is required.

**Special Application Requirements**—All applications for the M.F.A. are reviewed once a year for fall quarter entry. Applicants must submit from 10 to 20 color slides of work completed in their chosen medium to the director of graduate studies in art. Printmaking applicants must submit a minimum of 4 original prints in addition to slides. Photography applicants may submit a minimum of 10 finished prints. Three letters of recommendation are required from all applicants.

Completed Graduate School applications (including official transcripts) must reach the Graduate School by January 5. Slides, letters of recommendation, the statement of purpose, along with a second set of transcripts and other supporting materials, must reach the director of graduate studies in the Department of Art also by January 5.

**Degree Requirements**—Students must complete a minimum of 75 graduate credits, at least 45 of which must be earned at the University of Minnesota. Additional credits may be required by the graduate faculty. Upon completing the required credits, students must present an acceptable thesis exhibition accompanied by a supporting paper. The related fields requirement may be satisfied by completing either (a) 15 credits in art history or (b) 8 credits in art history plus 8 credits in another field outside of studio arts. The individual program, although designed by the

student, must be approved by the adviser and director of graduate studies. Final oral examinations are taken after the thesis exhibition and the supporting paper are completed.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—A minor in art consists of a minimum of 16 credits for the M.A. degree, chosen in consultation with the director of graduate studies, and a minimum of 18 credits for the Ph.D. degree, as approved by the director of graduate studies. The minor must include ArtS 8400.

**For Further Information and Applications**—Contact the Department of Art, University of Minnesota, 208 Art Building, 216 21st Avenue South, Minneapolis, MN 55455 (612/625-8096 or 612/625-1848; fax 625-7881; <http://artdept.umn.edu>).

## Drawing and Painting

**ArtS 5110. Drawing.** (4 cr per qtr [max 16 cr]; prereq 12 cr of 3110 or #) Cowette, Feinberg, Gray, Katsiaficas, Lyon, Morgan, Roode  
Drawing in all mediums from life.

**ArtS 5120. Painting.** (4 cr per qtr [max 16 cr]; prereq 12 cr of 3120 or #) Cowette, Feinberg, Katsiaficas, Lyon, Morgan, Roode  
Various media. Individual problems.

**ArtS 5123. Dimensional Painting.** (4 cr; prereq 3123 or #) Feinberg  
Two-dimensional concepts combined with three-dimensional form.

**ArtS 5141. Interpreting the Present.** (4 cr; prereq 3141 or #; offered alt yrs) Feinberg  
Advanced drawing focuses on search for personal visual form and content as inspired by specific sites. Field visits to area locations to stimulate development of new marks and symbols to interpret responses into visual language of drawing.

**ArtS 5160. Drawing and Electronic Media.** (4 cr per qtr [max 16 cr]; prereq 12 cr of 3160) Katsiaficas  
Expands traditional drawing methods and materials with use of electronic technology. Access to computers, scanner, and color copier to aid in image making.

**ArtS 8110. Drawing.** (4 cr per qtr [max 12 cr]) Cowette, Feinberg, Gray, Katsiaficas, Lyon, Morgan, Roode

**ArtS 8120. Painting.** (4 cr per qtr [max 24 cr]) Cowette, Feinberg, Katsiaficas, Lyon, Morgan, Roode

## Sculpture

**ArtS 5310. Sculpture: Direct Metal.** (4 cr per qtr [max 16 cr]; prereq 3301) Baldwin  
Advanced work in welding and brazing; metal construction.

**ArtS 5320. Sculpture: Spatial Projects and Problems.** (4 cr per qtr [max 16 cr]; prereq 3302) Rose  
Physical relationships between objects, elements, and materials and how these can be manipulated to affect space.

**ArtS 5330. Sculpture: Cast Metal.** (4 cr per qtr [max 16 cr]; prereq 3303) Potratz  
Lost-wax and sand casting in bronze, aluminum, iron.

**ArtS 5331. Primitive and Low-Tech Approaches to Metal Casting.** (4 cr; prereq 3331 or #) Potratz  
Metal casting of sculpture using techniques and materials derived from Meso-American, African, Indian, Chinese, and Japanese sources. Design and construction of primitive molds, tools, and furnaces.

**ArtS 5340. Sculpture: Wood and Stone.** (4 cr per qtr [max 16 cr]; prereq 3304) Lucey  
Examination of possibilities of wood and stone with emphasis on construction, assemblage, and arrangement.

**ArtS 5350. Sculpture: Kinetics.** (4 cr per qtr [max 16 cr]; prereq 3305) Baldwin  
Constructions, kinetics, electronics.

**ArtS 5370. Sculpture: Modeling and Casting.** (4 cr [max 16 cr]; prereq 3307) Baldwin, Potratz, Rose  
Modeling with clay and other materials from human figure and other subjects; moldmaking with plaster and rubber; casting in plaster and other materials.

**ArtS 8310. Sculpture: Direct Metal.** (4 cr per qtr [max 12 cr]) Baldwin

**ArtS 8320. Sculpture: Spatial Projects and Problems.** (4 cr per qtr [max 12 cr]) Rose

**ArtS 8340. Sculpture: Wood and Stone.** (4 cr per qtr [max 12 cr]) Lucey

**ArtS 8350. Sculpture: Kinetics.** (4 cr per qtr [max 12 cr]) Baldwin

**ArtS 8370. Sculpture: Modeling and Casting.** (4 cr [max 12 cr]; prereq #) Potratz

## Printmaking

**ArtS 5510. Printmaking: Intaglio.** (4 cr per qtr [max 16 cr]; prereq 12 cr of 3510 or #) Bethke, Krepps  
Color processes, intaglio, and combined techniques.

**ArtS 5520. Printmaking: Lithography.** (4 cr per qtr [max 16 cr]; prereq 12 cr of 3520 or #) Krepps  
Specialized work in color printing and planographic techniques.

**ArtS 5530. Printmaking: Relief.** (4 cr per qtr [max 16 cr]; prereq 12 cr of 3530 or #) Bethke  
Relief processes. Letter press and combined techniques.

**ArtS 5540. Printmaking: Screen.** (4 cr per qtr [max 16 cr]; prereq 12 cr of 3540 or #) Bethke  
Screen processes and combined techniques.

**ArtS 5550. Printmaking: Expanded Approaches/Monoprints.** (4 cr per qtr [max 16 cr]; prereq 12 cr of 3550 or #) Krepps  
Advanced, contemporary approach to printmaking that investigates variations of, departures from, and alternatives to traditional print processes and results. Focuses on immediacy and flexibility of monoprint in conjunction with handmade paper and other print processes.

**ArtS 8510. Printmaking.** (4 cr per qtr [max 36 cr]) Bethke, Krepps

## Photography

**ArtS 5710. Photography.** (4 cr per qtr [max 16 cr]; prereq 12 cr of 3710 or #) Hallman, Henkel  
Continued individual work in photographic controls, processes; related photosensitive media.

**ArtS 8710. Photography.** (4 cr per qtr [max 24 cr]) Hallman, Henkel

## Ceramics

**ArtS 5810. Ceramics.** (4 cr per qtr [max 16 cr]; prereq 12 cr of 3810 or #) Hoard, Lane, Pharis  
Aesthetic awareness and development; techniques and materials.

**ArtS 5811. Mold-Made Ceramics.** (4 cr; prereq 3811 or #) Lane  
Advanced mold-forming ceramics. Plaster mold-making techniques. Conceptual and aesthetic issues applied to making of ceramic objects.

**ArtS 5821. Ceramic Materials Analysis.** (4 cr; prereq 1811, 1812, 8 cr of 3810) Pharis  
Glaze analysis and calculation; glaze types, formulation, materials. Procedures for investigation of unidentified ceramic materials.

**ArtS 8810. Ceramics.** (4 cr per qtr [max 24 cr]) Hoard, Lane, Pharis

## Advanced Entrance Courses

The following are courses in which students from one area of concentration bring skills and insights into another area for application to new materials, processes, and approaches.

**All courses:** (4 cr per qtr [max 16 cr per area]; prereq #, Δ)

**ArtS 5190. Drawing and Painting**

**ArtS 5390. Sculpture**

**ArtS 5590. Printmaking**

**ArtS 5790. Photography**

**ArtS 5890. Ceramics and Glass**

## General Courses

**ArtS 5360. Performance Art.** (4 cr per qtr [max 16 cr]; prereq 3306) Lucey  
Development of individual performance artworks and research on pioneers of this art form.

**ArtS 5430. Paper: Pulp to Plastic Expression.** (4 cr per qtr [max 16 cr]; prereq 12 cr of 3430 or #) Krepps  
Creative and traditional approaches to papermaking.

**ArtS 5830. Glass: Neon.** (4 cr per qtr [max 16 cr]; prereq 12 cr of 3830) Lane  
Advanced conceptual and aesthetic applications of neon tube manipulation; applications to other media.

**ArtS 5970. Directed Studies.** (1-5 cr [max 12 cr]; prereq 24 cr studio arts, #, Δ, CLA approval)

**ArtS 8410. Post Studio.** (4 cr; prereq ArtS grad student, 16 8xxx cr or #)  
Conceptual concern and aesthetic awareness across media boundaries. Critical and theoretical inquiry into individual graduate projects from diverse media areas. Readings, projects, and topics depend on instructor and student interests.

## Seminars

**ArtS 5401. Art from the Source.** (4 cr; prereq 8 cr ArtS; offered alt yrs) Feinberg  
Field trips to current area exhibitions and artists' studios as basis for discussion and hands-on visual projects. Exposure to diversity of artistic interpretations; investigation of origins of differences in perception.

**ArtS 8100. Twentieth-Century Art Theories in Painting.** (2 cr; required of painting majors)

**ArtS 8300. Twentieth-Century Art Theories in Sculpture.** (2 cr per qtr [6 cr required]; MFA candidate in studio arts or #)

**ArtS 8400. Concepts in Contemporary Art.** (required) (4 cr; prereq ArtS grad student or #)

**ArtS 8402. Presentation and Instruction.** (4 cr; prereq MFA candidate or #)  
Workshop on presenting workshops, lectures, instructional activities, and professional discourse.

## Art Education

See Curriculum and Instruction.

## Art History (Arth)

*Professor:* Frederick M. Asher, *chair*; Frederick A. Cooper; Karal Ann Marling; Sheila J. McNally; Robert J. Poor; Leon G. Satkowski (architecture); Gabriel P. Weisberg

*Associate Professor:* Catherine E. B. Asher, *director of graduate studies*; W. John Archer (humanities); Timothy T. Blade (design, housing, and apparel); Robert B. Silberman; John W. Steyaert; Michael W. Stoughton

*Assistant Professor:* Katherine M. Solomonson (architecture)

*Other:* Lyndel I. King (director, Weisman Art Museum); Patricia McDonnell (associate curator, Weisman Art Museum)

*Adjunct Faculty:* Robert D. Jacobsen (Minneapolis Institute of Arts); Bruce L. Jenkins (Walker Art Center); Evan M. Maurer (Minneapolis Institute of Arts)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan B only) and Ph.D.

**Curriculum**—Areas of specialization (all of the following pertain to the M.A.; those with an asterisk also pertain to the Ph.D.): \*American art, architecture, and popular culture; Baroque art; \*East Asian art and Bronze Age archaeology; \*film and photography studies; Greek and Roman art and archaeology; \*Islamic art and architecture; Italian Renaissance and mannerist art; Late Gothic and northern Renaissance art; \*nineteenth- and twentieth-century art; \*South Asian art and architecture.

**Prerequisites for Admission**—For the M.A. program, a bachelor's degree is required, preferably in art history or a closely related field. Ability and scholarly promise must be demonstrated by a past record of academic excellence. For the Ph.D. program, an M.A. degree in art history or in a field closely related to the chosen area of specialization is required, as well as coursework or other experience indicating substantial background in art historical methods and knowledge.

**Special Application Requirements**—For the M.A. program: results from the Graduate Record Examination (GRE) General Test, at least one substantial research paper in art history, and three letters of recommendation from persons well acquainted with the applicant's research and writing skills. In addition, M.A. applicants must provide a detailed statement describing previous experience and academic training as related to the projected course of study and academic goals. For the Ph.D. program: results from the GRE General Test, an M.A. thesis or a minimum of two substantial M.A. papers in art history, and three letters of recommendation from persons well acquainted with the applicant's research and writing skills. In addition, Ph.D. applicants must provide a statement describing previous experience and academic training as related to the projected course of study and academic goals. Ph.D. candidates are urged to contact the director of graduate studies before application.

Applications for the Ph.D. program (if not previously enrolled in the department) and M.A. program are reviewed in January for admission in the fall quarter only. For both of these, the application form, statement of purpose, official transcripts, and official GRE scores must reach the Graduate School by early in January (contact the Department of Art History for the precise date); duplicates of these materials, as well as the three letters of recommendation and research paper(s), must reach the department by the same deadline. Internal Ph.D. applicants should contact the department for details and deadlines. All applications for financial aid (M.A. and Ph.D.) are due on the same date in early January as the applications for admission.

**Master's Degree Requirements**—A minimum of 44 course credits (about eleven courses) is required, including at least four 8xxx seminars in art history. A minimum of 28 course credits must be art historical in content and drawn from courses in at least three of the following areas: ancient, medieval, renaissance/baroque, modern, East Asian, South Asian, and Islamic. Of these, three courses must be in an area of primary concentration, two courses in an area of secondary concentration, and one course in a third area. Students focusing on western art must take at least one course in Asian/Islamic art, while students focusing on Asian/Islamic art must take at least one course in western art. In addition, students must take 8 credits in courses not art historical in content. Two Plan B papers are required, the first of which should be completed by the end of the first year of full-time study. The final M.A. examination is written during the sixth quarter of full-time work.

**Doctoral Degree Requirements**—The Ph.D. program is designed by the student in consultation with the faculty adviser and other faculty members in or outside the department in related areas of interest. Coursework, including credits accepted from the M.A. degree, should total no fewer than 70 credits. Of these, at least 24 credits must be in an area of primary concentration and 12 credits in an area of secondary concentration; a minimum of 18 credits must be in courses not art historical in content. In addition, 36 doctoral thesis credits are required.

**Language Requirements**—For the M.A. degree, students must attain reading proficiency in a second language directly related to their course of

study by no later than the third quarter of residence. For the Ph.D., reading proficiency of two second languages directly related to their course of study is required. Students should contact the director of graduate studies for details.

**Minor Requirements for Students Majoring in Other Fields**—For an M.A. degree, a minimum of 16 graduate credits in art history is required for a designated minor. For a Ph.D. degree, the Graduate School requirement of a minimum of 18 graduate credits in art history is necessary for a designated minor.

**For Further Information and Applications**—Contact the Department of Art History, University of Minnesota, 107 Jones Hall, 27 Pleasant Street S.E., Minneapolis, MN 55455 (612/624-0847 or 612/624-4500; fax 612/626-8679; e-mail [arthist@tc.umn.edu](mailto:arthist@tc.umn.edu); <http://www.umn.edu/arthist>).

**Arth 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**Arth 8888. Thesis Credits: Doctoral.** (36 cr required)

**Arth 5055. Eighteenth-Century Architecture and the Enlightenment.** (4 cr, §Arch 5055; prereq Arch 1021 or #) Satkowski, Solomonson  
Architecture, urban planning, and garden design in Europe, 1770-1850.

**Arth 5102. Classical Greek Art.** (5 cr, §Clas 5102) McNally  
Architecture, sculpture, and painting in Greece from Persian Wars to conquests of Alexander.

**Arth 5104. Roman Architecture.** (5 cr, §Clas 5104; prereq jr or sr or #) Cooper, McNally  
Buildings in Rome and the empire from the 5th century B.C. to the 4th century A.D. Major archaeological sites.

**Arth 5105. Roman Painting and Mosaics.** (5 cr, §Clas 5105; prereq jr or sr or #) McNally  
Roman painting and mosaics, specific problems; sites such as Pompeii and Antioch.

**Arth 5106. Greek Painting.** (5 cr, §Clas 5106; prereq jr or sr or #; offered every 3rd yr) McNally  
Research and analysis in classical art as applied to study of vases; original objects and sources.

**Arth 5107. Roman Sculpture.** (4 cr, §Clas 5107; prereq jr or sr or #) Cooper, McNally  
Sculpture from Rome and its provinces from the 1st century B.C. to the 4th century A.D.; the role of sculpture in Roman politics and religion.

**Arth 5108. Greek Architecture.** (4 cr, §Clas 5108; prereq jr or sr or #) Cooper, McNally  
Archaic and classical examples of religious and secular architecture; their setting in major archaeological sites.

**Arth 5111. Bronze Age Art and Architecture in Greece: Ca. 3000-1100 B.C.** (4 cr, §Clas 5111; prereq one ancient art or archaeology course) Cooper Artistic and architectural forms in the Neolithic period in the Aegean area and the Cycladic, Minoan, and Mycenaean cultures.

**Arth 5113. Archaic and Classical Greek Art and Archaeology.** (4 cr, §Clas 5113; prereq jr or sr or #) McNally Greek architecture, sculpture, and painting from 9th through 5th centuries B.C. Material remains of Greek culture; archaeological problems such as identifying and dating buildings; analysis of methods and techniques.

**Arth 5120. Field Research in Archaeology.** (3-6 cr, §Clas 5120; prereq #) Cooper Field excavation, survey, and research in archaeological sites in Mediterranean area. Techniques of excavation and exploration; interpretation of archaeological materials.

**Arth 5234. Gothic Sculpture of the Cathedral Age.** (5 cr; prereq 3009 or grad student or #) Steyaert Sculpture in France and Germany from 1150 to 1350. Emphasis on stylistic evolution.

**Arth 5324. Fifteenth-Century Painting in Northern Europe.** (5 cr; prereq 3009 or 3011 or grad student or #) Steyaert Painting in the Netherlands, France, and Germany during the late Gothic period and its influences.

**Arth 5346. Baroque Art in Italy and Spain.** (5 cr; prereq 3011 or grad student or #; offered alt yrs) Stoughton Italian sculpture, painting, and architecture and Spanish painting of the 17th century.

**Arth 5347. Baroque Art in France and the Lowlands.** (5 cr; prereq 3011 or grad student or #; offered alt yrs) Stoughton French architecture, painting, and sculpture; Flemish and Dutch painting of the 17th century. Major artists: Rembrandt, Rubens, Poussin.

**Arth 5357. Eighteenth-Century Art in France.** (4 cr, §3303; prereq 3011 or grad student or #; offered alt yrs) Stoughton Rococo and neoclassical painting, sculpture, and architecture in France.

**Arth 5358. Eighteenth-Century Art in Italy, Germany, Austria.** (4 cr; prereq 3011 or grad student or #) Stoughton Italian painting, sculpture, and architecture; German and Austrian architecture.

**Arth 5422. History of 19th-Century Graphic Arts.** (5 cr, §3422; prereq one 3xxx art history course or grad student or #; offered alt yrs) Weisberg History and theory of creation and evolution of lithography, social caricature (e.g., Daumier, Gavarni), revival of etching at mid-century, and emergence of color lithography at turn of century (e.g., Toulouse-Lautrec, Vuillard, Bonnard). Major artistic figures and revolutionary nature of new media. Local print collections used.

**Arth 5423. Gothic Architecture.** (4 cr, §5053, §Arch 5053, §Arch 5423; prereq Arch major or Arch 3411 or #) Steyaert History of development of architecture and urban design in Western Europe from 1150 to 1400 A.D.

**Arth 5425. Baroque Architecture in Italy.** (4 cr, §5064, §Arch 5064, §Arch 5425; prereq Arch major or Arch 3411 or #) Stoughton Architecture and urban design in Italy from 1600 to 1750 A.D. Emphasis on major figures (Bernini, Borromini, Cortona, Guarini) and evolution of major cities (Rome, Turin).

**Arth 5431. Age of Revolution: French Painting From 1789 to 1848.** (5 cr; prereq one 3xxx art history course or grad student or #) Weisberg Major styles and movements in France and their leading exponents: neoclassicism—David; romanticism—Corot and Delacroix; early landscape painting—the Barbizon group.

**Arth 5432. Realism to Impressionism: French Painting From 1848 to 1886.** (5 cr; prereq one 3xxx art history course or grad student or #) Weisberg Major movement of French painting from realism of Courbet through end of impressionism. Roots of popular imagery, critical study of realism, and radical innovations of impressionism.

**Arth 5433. The Advent of Modernism: Later 19th-Century French Painting From 1886 to 1905.** (5 cr; prereq one 3xxx art history course or grad student or #) Weisberg, staff Major styles and movements: post-impressionism, symbolism, fin de siècle, jungendstil.

**Arth 5434. Contemporary Architecture.** (4 cr) Solomonson Developments, theories, movements, and trends in architecture and urban design from World War II to present.

**Arth 5435 (formerly 5056). Modern Architecture.** (4 cr, §Arch 5432; prereq Arch 1021 or 3411 or #) Solomonson Architecture and urban design from early 19th-century sources in Europe and America to World War II.

**Arth 5454. Art Nouveau.** (5 cr; prereq one 3xxx art history course or grad student or #) Weisberg History and evolution of art nouveau movement in France, England, Belgium, Germany, Austria, Scotland, and the United States. Innovations in architecture, graphics, and decorative arts; continental variants of style (e.g., Liberty Style). Major promoters (e.g., S. Bing) and pioneers of modern design (e.g., William Morris).

**Arth 5463. Early 20th-Century Painting.** (5 cr; prereq one modern art course or #) Weisberg, staff Fauvism, cubism, surrealism, dadaism, and early abstraction.

**Arth 5535. Art in the United States.** (5 cr; prereq 4 cr art history or #; offered alt yrs) Marling Painting and sculpture in the United States. Selected key works and artists from early settlement to the early 20th century.

## GRADUATE PROGRAMS

**ArTh 5546. American Architecture From 1860 to 1914.** (5 cr; prereq sr or grad student or #; offered alt yrs) Archer, Marling  
American developments and European influences from Civil War to about 1914. New materials and structural methods. Emphasis on Hunt, Richardson, McKim, Mead and White, Sullivan, early Wright, others.

**ArTh 5725. Ceramics of East Asia.** (5 cr; offered alt yrs) Poor  
Ceramic art in East Asia: China, Korea, and Japan, from Neolithic times to the present.

**ArTh 5765. Early Chinese Art.** (5 cr; offered alt yrs) Poor  
Development of ancient ceramics and ritual bronzes, early Buddhist sculpture, and early Chinese painting.

**ArTh 5766. Chinese Painting.** (5 cr; offered alt yrs) Poor  
Survey of major works from the 4th to the 17th centuries. Development of the landscape tradition and the literary genre of later Chinese painting.

**ArTh 5767. Japanese Painting.** (4 cr; offered alt yrs) Poor  
Japanese pictorial arts from earliest to modern times; works that best exemplify development of indigenous traditions.

**ArTh 5769. Connoisseurship in Oriental Art.** (5 cr; prereq jr or sr or #; offered alt yrs) Poor  
Examination of Oriental art objects in local collections.

**ArTh 5775. Early Indian Art.** (5 cr; prereq 4 cr art history or #; offered alt yrs) F Asher  
Sculpture and architecture of India from the Indus Valley civilization through the Kushana period.

**ArTh 5776. Art of India: 300 to 1200.** (5 cr; prereq 4 cr art history or #; offered alt yrs) F Asher  
Sculpture, architecture, and painting. Focus on Buddhist and Hindu monuments throughout South Asian subcontinent; earliest Islamic monuments of India.

**ArTh 5777. Painting of India.** (5 cr; prereq 4 cr art history or #; offered alt yrs) C Asher  
Entire history of Indian painting beginning with the early tradition of mural painting but concentrating primarily on miniature painting from the 12th century onward.

**ArTh 5781. Age of Empire: The Mughals, Ottomans, Safavids.** (4 cr; offered alt yrs) C Asher  
Development of art and architecture in three contemporary Islamic empires: the Mughals of India, Safavids of Iran, and Ottomans of Turkey.

**ArTh 5783. Art of Islamic India.** (4 cr; offered alt yrs) C Asher  
Development of art and architecture in Indian subcontinent during period of Islamic domination into colonial period.

**ArTh 5785. Art of Islamic Iran.** (4 cr; offered alt yrs) C Asher  
Development of art and architecture in Iranian-dominated eastern Islamic realm (Iran, the former southern Soviet Union, and Afghanistan) from inception of Islam to present.

**ArTh 5787. Art of the Western Islamic World.** (4 cr; offered alt yrs) C Asher  
Development of art and architecture in western Islamic world from inception of Islam to present.

**ArTh 5895. Methods of Research in Art History.** (4 cr, \$8801; prereq sr art history major, #; offered alt yrs)  
For highly qualified undergraduate majors intending to pursue professional training and for incoming master's majors.

**ArTh 5925. History of Photography as Art.** (4 cr; prereq 3012 or #; offered alt yrs) Silberman  
Origins and development of photography with attention to both technology and cultural impact. Investigation of major aesthetic achievements in photography from beginnings to present.

**ArTh 5940. Topics: Art of the Film.** (4 cr; prereq 3921-3922 or #; offered alt yrs) Silberman  
Film and society. Topics include sex and violence in the cinema, race and ethnicity in the cinema; films of the 30s, 50s, or 60s.

**ArTh 5950, 5960. Topics in Art History.** (2-5 cr per qtr; prereq jr or sr or #)  
Topics specified in the *Class Schedule*.

**ArTh 5970. Directed Readings.** (1-5 cr; prereq sr, #, Δ, CLA approval)

**ArTh 5990. Directed Research.** (1-5 cr; prereq sr, #, Δ, CLA approval)

**ArTh 8190. Seminar: Problems in Ancient Art.** (4 cr, \$Clas 8190; prereq #) Cooper, McNally  
Selected topics in ancient art.

**ArTh 8200. Seminar: Problems in Medieval Sculpture.** (4 cr; prereq #) Steyaert

**ArTh 8230. Seminar: Problems in Medieval Art.** (4 cr; prereq 9 cr art history or #) Steyaert

**ArTh 8340. Seminar: Problems in Baroque Art.** (4 cr; prereq #) Stoughton

**ArTh 8400. Seminar: 19th-Century Art.** (4 cr; prereq #) Weisberg

**ArTh 8440. Seminar: 20th-Century Art.** (4 cr; prereq #)

**ArTh 8520. Seminar: American Art.** (4 cr; prereq #) Marling

**ArTh 8720. Seminar: Asian Art.** (4 cr; prereq #) Poor

**ArTh 8770. Seminar: Art of India.** (4 cr; prereq #) C Asher, F Asher

**ArTh 8910. Seminar: Problems in Classical Archaeology.** (4 cr [may be repeated for cr], \$Clas 8910; prereq #) Cooper, McNally

**Arth 8940. Seminar: Film History and Theory.**

(4 cr per qtr [max 8 cr]; prereq #) Silberman  
Selected problems, including study of specific periods, genres, and directors. Topics such as concept of national cinema, nature of film spectatorship, representation of women in film, and changing role of film after development of television. Topic varies quarterly.

**Arth 8950. Seminar: Issues in the History of Art.** (4 cr; prereq #)

Theoretical or topical issues; topic varies.

**Arth 8970. Directed Studies.** (1-5 cr; prereq #)**Arth 8975. Directed Museum Studies.** (1-3 cr; prereq #)

Projects in museum studies based on the literature, practice, or internship.

**Astrophysics (Ast)**

*Professor:* Thomas W. Jones, *chair*; Kris D. Davidson; John M. Dickey; Robert D. Gehrz; Roberta M. Humphreys; Terry J. Jones; Paul J. Kellogg; Leonard V. Kuhi; Robert L. Lysak; Keith A. Olive; Robert O. Pepin; Lawrence Rudnick; C. J. Waddington; Paul R. Woodward

*Associate Professor:* Evan D. Skillman, *director of graduate studies*

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—The program offers emphases in observational, theoretical, and computational astronomy and astrophysics and in instrument development. Current research emphasizes the properties and dynamics of normal and active galaxies, quasars, stellar evolution, interaction of stars with their environments, the interstellar medium, astrophysical magnetohydrodynamics, and galactic and cosmological structure. Observational research includes ultraviolet, optical, infrared, and radio astronomy. Extensive research programs in space physics and the elementary particle-cosmology interface are also carried out in the School of Physics and Astronomy.

**Facilities**—The University operates a 60-inch telescope on Mt. Lemmon, near Tucson, Arizona, which is well equipped for both optical and infrared observations. A 30-inch telescope with a CCD camera and infrared instruments is maintained at the O'Brien Observatory about 40 miles from the Twin Cities campus. Both telescopes are fully computer controlled and can

be operated remotely. Plans are under development for a major (3.5 meter) observatory. Excellent shop facilities support our instrument development for the telescopes at O'Brien and Mt. Lemmon, for the University of Wyoming's infrared telescope, and for major national observatories such as the NASA Infrared Telescope Facility (IRTF) in Hawaii.

The Automated Plate Scanner (APS) is a high-speed, high-precision measuring engine. It is unique in its ability to scan two photographic plates simultaneously. The APS is currently used to digitize the famous Palomar Sky Survey to produce a massive database of stars and galaxies. The associated computer reduction system can analyze 100,000 images per hour.

Another image-processing system is coupled to the departmental SUN and SGI network for the reduction and analysis of optical, infrared, single-dish radio, and Very Large Array (VLA) radio interferometry data. The department is connected through an ethernet backbone to clusters of supercomputers and super-workstations at the University's Supercomputer Institute and the Laboratory for Computational Science and Engineering. These facilities are available to faculty and students for their research.

In addition, members of the department regularly use such national facilities as the Kitt Peak National Observatory; Cerro Tololo Inter-American Observatory in Chile; National Radio Astronomy Observatory's single-dish facilities in Green Bank and Kitt Peak and its VLA; Arecibo Radio Observatory; the International Ultraviolet Explorer satellite; the Hubble Space Telescope; and the IRTF in Hawaii.

**Prerequisites for Admission**—For major work, an undergraduate degree in astronomy or physics or the equivalent. Contact the director of graduate studies for exceptions.

**Special Application Requirements**—A statement of career goals, scores from the Graduate Record Examination General (Aptitude) Test and Subject (Advanced) Test in physics, and three letters of recommendation are required. Applications for financial aid are due January 15. Applications are accepted for entry in fall quarter only.

**Master's Degree Requirements**—Two quarters of the classical physics sequence Phys 5051-5052-5053 and three 5xxx astronomy courses are

required. Additional requirements depend on whether the student chooses the thesis (Plan A) or non-thesis (Plan B) option. Completion of the degree normally takes two years. An oral examination is required.

**Doctoral Degree Requirements**—Five 5xxx astronomy courses are required along with Phys 5051-5052-5053. Competence in quantum physics at the level of Phys 5101-5102 is expected. A comprehensive written examination in astrophysics is taken during spring of the second year. A research project that must be completed before fall quarter of the third year serves as a focus for the preliminary oral examination.

**Language Requirement**—None.

**Minor Requirements for Students Majoring in Other Fields**—Ast 3051 or the equivalent, differential and integral calculus, and one year of college physics are prerequisites for admission to the minor.

**For Further Information and Applications**—

Contact the Department of Astronomy, University of Minnesota, 356 Tate Lab of Physics, 116 Church Street S.E., Minneapolis, MN 55455 (612/624-0211; fax 612/626-2029; e-mail grad-req@astro.spa.umn.edu; <http://ast1.spa.umn.edu>).

**Ast 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**Ast 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**Ast 8888. Thesis Credits: Doctoral.** (36 cr required)

**Ast 5061. Computational Methods in the Physical Sciences I.** (4 cr, §Phys 5061; prereq CLA jr or sr or IT upper div student or grad student or #; 2 lect, 6 lab hrs per wk)

Introduction to solution of problems in physical sciences with computer programs. Selected numerical methods and general spirit of mapping problems onto computational algorithms. Arranged lab at scientific computer workstation.

**Ast 5062. Computational Methods in the Physical Sciences II.** (4 cr, §Phys 5062; prereq CLA jr or sr or IT upper div student or grad student, Phys/Ast 5061 or #; 2 lect, 6 lab hrs per wk)

Introduction to advanced techniques in computer simulation through examples from classical statistical mechanics, classical electrodynamics, and fluid dynamics. Computer experiments using SUN systems and their graphics capabilities.

**Ast 5161.\* Astrophysics of Diffuse Matter.**

(4 cr; prereq 3051, Phys 5024 or #; offered alt yrs) Physical processes in diffuse matter: gas dynamics, MHD, excitation processes and equilibria in atoms and molecules. Emission and absorption by gas and dust. Dynamical processes in interstellar space, HII regions and molecular clouds.

**Ast 5162.\* Stars and Stellar Evolution.** (4 cr; prereq 3051, Phys 3513 or 3501 or #)

Stars and stellar evolution. Stellar atmospheres, structure and evolution of single stars. White dwarfs, neutron stars, black holes, novae and supernovae. Formation of stars.

**Ast 5163.\* Galactic Astronomy and the Interstellar Medium.** (4 cr; prereq 3051 or #; offered alt yrs)

Structure, kinematics, and evolution of Milky Way galaxy and its constituents, stars, star clusters, and interstellar medium. Observed properties of the galaxy.

**Ast 5164.\* Extragalactic Astronomy.** (4 cr; prereq 5163 or #; offered alt yrs)

Structure and evolution of external galaxies. Classification, stellar and gaseous contents, kinematics and dynamics, extragalactic distance scale, clusters, galactic nuclei and associated activity.

**Ast 5165.\* Cosmology.** (4 cr; prereq Phys 3513 or #; offered alt yrs)

Large-scale structure and history of universe. Newtonian and relativistic world models, Big Bang model, microwave background, physics of early universe; cosmological tests, measurement of Hubble constant and deceleration parameter, galaxy formation.

**Ast 5201. Methods of Experimental Astrophysics.** (4 cr; prereq 3051, Phys 3513; offered alt yrs)

Introduction to contemporary techniques and instrumentation in astronomy. Astronomical observations including data acquisition and instrument control at O'Brien Observatory and data reduction and image processing using department computing facilities.

**Ast 5321.\* Radiation Processes in Astrophysics.** (4 cr; prereq Phys 5024, 5102 or #; offered alt yrs)

Physics of radiation by atoms and molecules. Radiation by energetic charged particles and plasma emission processes. Emission and absorption by solid particles. Transfer of continuum radiation and formation of spectral lines. Application to various astrophysical environments.

**Ast 5362.\* Stellar Astrophysics.** (4 cr; prereq 5321 or #; offered alt yrs)

Theory of stellar structure and evolution. Basic physics and equations of stellar structure. Application to stellar interiors and atmospheres. Nucleosynthesis.

**Ast 5421.\* High Energy Astrophysics.** (4 cr; prereq 3051, Phys 5024, 5101 or #; offered alt yrs)

Energetic phenomena in the universe. Supernovae, pulsars, radio and X-ray stars. Radio galaxies and quasars. Acceleration of high energy particles. Observational basis and current theoretical understanding.

**Ast 5990. Directed Research.** (3 cr minimum; prereq #, Δ)  
Independent research in observational and/or theoretical astrophysics under the direction of a faculty member. Intended for senior astrophysics majors.

**Ast 8200.\* Seminar.** (1-3 cr)

**Ast 8481,8482,8483.\* Topics in Astrophysics.** (3 cr per qtr; prereq #)  
Advanced discussions of important topics of current research interest. Recent topics include stellar spectroscopy, astrophysical fluid dynamics, signal processing, galactic dynamics, and modern instrumentation.

**Ast 8990.\* Research in Astronomy and Astrophysics.** (Cr ar; prereq #)

### Other Courses of Interest

**Phys 5051-5052-5053.\* Classical Physics**

**Phys 5151-5152-5153.\* Quantum Mechanics**

**Phys 5162.\* Introduction to Plasma Physics**

**Phys 5301.\* Introduction to Nuclear Physics**

**Phys 5371.\* Introduction to Elementary Particle Physics**

**Phys 5401.\* Introduction to Contemporary Problems in Cosmic Ray and Space Physics**

**Phys 8081-8082.\* General Relativity**

**Phys 8161.\* Atomic and Molecular Structure**

**Phys 8163-8164.\* Plasma Physics**

**Phys 8400.\* Seminar: Space Physics**

**Phys 8411.\* Cosmic Ray and Space Physics**

**Phys 8421. Solar and Magnetospheric Physics**

## Biochemistry, Molecular Biology and Biophysics

*Professor:* David A. Bernlohr, *interim head*, Department of Biochemistry<sup>1</sup>; John D. Lipscomb, *interim head*, Department of Biochemistry<sup>2</sup>; Lester R. Drewes, *head*, Department of Biochemistry and Molecular Biology<sup>3</sup>, and *associate director of graduate studies*; John S. Anderson, *co-director of graduate studies* (biochemistry<sup>1</sup>); Brian G. Van Ness, *co-director of graduate studies* (biochemistry<sup>2</sup>); Norma M. Allewell (biochemistry<sup>1</sup>); Paul M. Anderson (biochemistry<sup>3</sup>); Ian M. Armitage (biochemistry<sup>2</sup>); Leonard J. Banaszak (biochemistry<sup>2</sup>); Victor A. Bloomfield (biochemistry<sup>1</sup>); James W. Bodley (biochemistry<sup>2</sup>); Bianca M. Conti-Fine (biochemistry<sup>1</sup>); Anath Das (biochemistry<sup>1</sup>); Mary E. Dempsey (biochemistry<sup>2</sup>); Joseph DiSalvo (medicine<sup>3</sup>); Edward H. Egelman (cell biology and neuroanatomy); Michael C. Flickinger (biochemistry<sup>1</sup>); James A. Fuchs (biochemistry<sup>1</sup>); Nelson D. Goldberg (biochemistry<sup>2</sup>); Gary R. Gray (chemistry); Harry P.C. Hogenkamp (biochemistry<sup>2</sup>); Alan B. Hooper (genetics and cell

biology); James B. Howard (biochemistry<sup>2</sup>); James F. Koerner (biochemistry<sup>2</sup>); David C. LaPorte (biochemistry<sup>2</sup>); Dennis M. Livingston (biochemistry<sup>2</sup>); Charles F. Louis (vet pathobiology); Rex E. Lovrien (biochemistry<sup>1</sup>); Matthew F. Mescher (laboratory medicine and pathology); Gary L. Nelsestuen (biochemistry<sup>1</sup>); Theodore R. Oegema (orthopaedic surgery); Douglas H. Ohlendorf (biochemistry<sup>2</sup>); Harry T. Orr (laboratory medicine and pathology); Joseph R. Prohaska (biochemistry<sup>2</sup>); Michael A. Raftery (biochemistry<sup>1</sup>); Palmer Rogers (microbiology); Janet L. Schottel (biochemistry<sup>1</sup>); David D. Thomas (biochemistry<sup>2</sup>); Howard C. Towle (biochemistry<sup>2</sup>); Kamil Ugurbil (radiology); Lawrence P. Wackett (biochemistry<sup>1</sup>); Clare K. Woodward (biochemistry<sup>1</sup>)

*Associate Professor:* Kenneth W. Adolph (biochemistry<sup>2</sup>); Bridgette A. Barry (biochemistry<sup>1</sup>); Robert J. Brooker (genetics and cell biology); David J. Eide (biochemistry<sup>3</sup>); Thomas E. Huntley (biochemistry<sup>3</sup>); Kevin H. Mayo (biochemistry<sup>2</sup>); Robert J. Roon (biochemistry<sup>2</sup>); Wilmar L. Salo (biochemistry<sup>2</sup>); Michel M. Sanders (biochemistry<sup>2</sup>)

*Assistant Professor:* Vivian J. Bardwell (biochemistry<sup>2</sup>); Benjamin L. Clarke (biochemistry<sup>3</sup>); Stephen C. Ekker (biochemistry<sup>2</sup>); Gregg B. Fields (laboratory medicine and pathology); Alex J. Lange (biochemistry<sup>2</sup>); Kathryn E. McLane (chemistry<sup>3</sup>); Karin Musier-Forsyth (chemistry); Ann E. Rougvie (genetics and cell biology); Paul G. Siliciano (biochemistry<sup>2</sup>); Jeffrey A. Simon (biochemistry<sup>2</sup>); David A. Zarkower (biochemistry<sup>2</sup>)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Ph.D. and M.S. (Plan A only). All newly admitted students must qualify for admission to the Ph.D. program.

**Curriculum**—Biochemistry, molecular biology and biophysics is a joint graduate program offered by the two Departments of Biochemistry in the College of Biological Sciences and the Medical School. Training is offered in three designated areas: biochemistry, molecular biology, and molecular biophysics. Students may select a concentration in one area and take courses from other areas to fulfill a minor or supporting program. Graduate training in biochemistry, molecular biology and biophysics at the University of Minnesota, Duluth, is described in the *Duluth Bulletin*.<sup>4</sup>

<sup>1</sup> College of Biological Sciences, St. Paul campus

<sup>2</sup> Medical School, Minneapolis campus

<sup>3</sup> University of Minnesota, Duluth

<sup>4</sup> For information on the master's and doctoral degree programs offered in conjunction with the University of Minnesota, Duluth, please contact the associate director of graduate studies, Department of Biochemistry and Molecular Biology, University of Minnesota, 251 School of Medicine, 10 University Drive, Duluth, MN 55812 (218/726-7922).

**Prerequisites for Admission**—The graduate program in biochemistry, molecular biology and biophysics is flexible enough to accommodate students with a wide variety of educational backgrounds. The program encourages application from students with undergraduate or master's degrees in the biological, chemical, or physical sciences. Recommended academic preparation includes one year each of calculus, organic chemistry, and physics and a background in basic biology, including biochemistry and genetics. Coursework in physical chemistry is recommended for graduate-level biochemistry courses. For students of demonstrated ability, background deficiencies can be made up during the first year of graduate study.

**Special Application Requirements**—Applicants must submit three letters of recommendation from persons familiar with their academic and research capabilities. A statement of interests and goals, a complete set of transcripts, and official scores from the General Test of the Graduate Record Examination (GRE) are required. The GRE Subject Test in biochemistry, cell and molecular biology, biology, or chemistry is strongly recommended, but not required. The recommended date for receipt of completed applications is January 15. Completed files are reviewed between January and March. Graduate studies typically begin fall term. Information about an early start program involving participation in laboratory research beginning on August 1 may be obtained from the director of graduate studies.

**Master's Degree Requirements**—Students must satisfactorily complete one year of graduate biochemistry (8001-8002-8003), one laboratory rotation, and two special topics biochemistry courses and must participate in seminars, for a minimum total of 25 credits. A thesis based on original laboratory research and an oral examination also are required.

**Doctoral Degree Requirements**—Students must satisfactorily complete one year of graduate biochemistry (8001-8002-8003), two laboratory rotations, and two advanced topics courses in their area of concentration and must participate in seminars. One written and two oral examinations are required. A thesis based on extensive original laboratory research is the primary requirement. For more information, contact the director of graduate studies.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—For the M.S. degree, a minimum total of 10 credits of graduate-level courses in biochemistry, with at least 5 of these credits in 8xxx courses, is required. For the Ph.D. degree, a minimum total of 18 credits of graduate-level courses in biochemistry, with at least 10 of these credits in 8xxx courses, is required. Students planning a minor program should consult with the director of graduate studies in biochemistry.

**For Further Information and Applications**—Contact the Department of Biochemistry (Medical School), University of Minnesota, 4-225 Millard Hall, 435 Delaware Street S.E., Minneapolis, MN 55455 (612/625-6100; fax 612/625-2163), or Department of Biochemistry (Biological Sciences), 140 Gortner Lab, University of Minnesota, 1479 Gortner Avenue, St. Paul, MN 55108 (612/624-7755; fax 612/625-5780). Information may also be requested through e-mail (bmbbgp@brain.biochem.umn.edu).

**BioC 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**BioC 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**BioC 8888. Thesis Credits: Doctoral.** (36 cr required)

*The courses directly below have both biochemistry designators, BioC and MdBc. Courses with only the BioC or MdBc designator follow this listing.*

## **Biochemistry (BioC and MdBc)**

(College of Biological Sciences and Medical School)

**BioC and MdBc 5525s. Physical Biochemistry: Solution Structure and Interactions of Biological Macromolecules.** (4 cr, §Chem 5525; prereq BioC 5331 or equiv, 2 qtrs physical chemistry) Allewell, Bloomfield Physical chemistry of equilibrium, transport and scattering phenomena in solution, with application to proteins and nucleic acids. Intermolecular forces, macromolecular dynamics, conformational transitions, binding thermodynamics, and methods for determining biopolymer size and shape, including sedimentation, diffusion, viscosity, electrophoresis, and scattering.

**BioC and MdBc 5526w. Physical Biochemistry: Spectroscopic Methods I.** (4 cr, §Chem 5526; prereq 2 qtrs physical chem) Armitage, Mayo Lectures on fundamental spectroscopic principles emphasizing development of magnetic resonance theory used in study of biological macromolecules.

**BioC and MdBc 5527f. Physical Biochemistry: Spectroscopic Methods II.** (4 cr, §Chem 5527; prereq 2 qtrs physical chem, BioC/MdBc 5526) Barry, Thomas  
Applications of optical and magnetic resonance techniques to study of structure and dynamics in proteins, lipids, nucleic acids, and synthetic analogs.

**BioC and MdBc 5528w. Physical Biochemistry: Enzyme Kinetics.** (4 cr, §Chem 5528; prereq 2 qtrs physical chem, BioC 5331 or BioC/MdBc 8001 or equiv) Lipscomb

Theory and application of steady-state and transient kinetics for study of enzymes, enzyme systems, and cellular regulation.

**BioC and MdBc 5529s. Protein Structure and Folding.** (4 cr, §Chem 5529; prereq BioC 5331 or equiv, 1 qtr physical chem or #) Banaszak, Woodward  
Advanced course on protein structure, stability, folding, and molecular modeling. Results from X-ray crystallography, solution thermodynamics, NMR, computer graphics, and protein engineering.

**BioC and MdBc 8001f. Advanced Biochemistry I: Protein Structure and Function.** (4-5 cr, §BioC/MdBc 5751; prereq # or 3 qtrs organic chem, 2 qtrs physical chem, 1 qtr biochem) Ohlendorf, Wackett  
Primary, secondary, tertiary, and quaternary structure of proteins. Methods to determine structure. Protein folding, forces stabilizing macromolecular structure; examples related to protein engineering and design. Interaction of proteins with ligands: structural change and reaction energetics. Dynamic properties of proteins and enzymes; enzyme substrate complexes and mechanism of enzyme catalysis.

**BioC and MdBc 8002w. Advanced Biochemistry II: Molecular Biology.** (4-5 cr, §BioC/MdBc 5753; prereq BioC/MdBc 8001 or #) Das, Siliciano  
Structure and stability of nucleic acids; organization of prokaryotic and eukaryotic genomes. Chromosome mechanics, including DNA replication, recombination, and transposable elements. Mechanism and regulation of gene expression, including transcription, processing, and translation in both prokaryotic and eukaryotic organisms.

**BioC and MdBc 8003s. Advanced Biochemistry III: Regulation of Metabolism and Biological Processes.** (4-5 cr, §BioC/MdBc 5752; prereq BioC/MdBc 8002 or #) Bernlohr, LaPorte  
Membrane structure and function; strategies for metabolic control. Important control points in key metabolic pathways. Transmembrane signaling and second messengers; their role in regulation. Coordination of genetic and enzymatic controls. Regulation of cell division, regulation of development, and integration of regulatory systems such as nerve transmission, muscle contraction, and vision.

**BioC and MdBc 8094. Research and Literature Reports.** (1 cr)  
Current developments in biochemistry.

**BioC and MdBc 8206f. Cell Signaling and Metabolic Regulation.** (3 cr, §MdBc 8206; prereq BioC/MdBc 8001-8002-8003 or equiv) Raftery, staff  
Mechanisms of regulation of signal receptors and second messengers, including cyclic nucleotides, calcium, and phosphoinositol derivatives; polypeptide and catecholamine hormone-mediated processes; molecular basis of neurotransmitter signaling and ion-channels.

**BioC and MdBc 8213f. Advanced Molecular Biology I.** (4 cr, §GCB 8213; prereq BioC/MdBc 8002 or GCB 8132 or #) Bodley, Ekker, LaPorte, Siliciano, Towle, Zarkower

Lectures, readings, and discussions. Topics include DNA replication, recombination and gene conversion, regulation of gene expression in procaryotes, regulation of gene expression in eucaryotes, chromatin structure and transcription, organellar gene expression.

**BioC and MdBc 8214w. Advanced Molecular Biology II.** (4 cr, §GCB 8214; prereq BioC/MdBc 8002 or GCB 8132 or #) Bardwell, Das, Mauro  
Lectures, readings, and discussions. Topics include RNA splicing, RNA stability, initiation and control of translation, animal viruses, gene families, transposable elements, somatic recombination, yeast molecular biology, oncogenes.

**BioC and MdBc 8230w. Membrane Biochemistry.** (3 cr; prereq BioC/MdBc 8001 or #) Thomas, staff  
Lectures and readings on molecular structure, dynamics, and function of cell membranes. Fundamental principles and current research topics, with emphasis on systems and methods under investigation at University of Minnesota.

**BioC and MdBc 8290f,w,s,su. Current Research Techniques.** (1-3 cr; prereq grad major in biochemistry)  
Research projects in biochemistry, each to be carried out in the research laboratory of an individual staff member. Satisfies all or part of the laboratory requirements for the Ph.D. degree.

## Biochemistry (BioC)

(College of Biological Sciences)

**BioC 5025f,w,s. Laboratory in Biochemistry.** (2 cr; prereq 3021 or ¶3021 or 5331 or ¶5331 or Biol 5001 or ¶Biol 5001) Barry, Conti-Fine, Fuchs, Lovrien  
Discussions of techniques and problem-solving approaches illustrated with laboratory experiments and demonstrations.

**BioC 5301w. Ecological Biochemistry.** (3 cr; prereq 3021 or 5331 or #) Wackett  
Biochemistry of environmental processes. Biochemistry of organismal interactions, biological responses to environmental stress, gene transfer in environment, and effects and fate of environmental toxins.

**BioC 5331f. Structure, Catalysis, and Metabolism in Biological Systems.** (4 cr, §3021, §Biol 5001; prereq 2 qtrs organic chem, Biol 1009 or Biol 1202 or #) Allewell, Flickinger, Nelsestuen  
Structure and function of biological molecules. Protein structure, catalysis, and intermediary metabolism. Enzyme kinetics, thermodynamics, and role of cofactors in catalysis.

**BioC 5332w. Energy and Signal Transduction in Biological Systems.** (4 cr; prereq 5331 or #)

Barry, Bernlohr

Biological membrane structure and membrane-associated proteins. Transport, oxidation/reduction, photosynthesis, electron transfer mechanisms, membrane receptors, signal transduction, and specific regulatory systems.

**BioC 5333s. Molecular Mechanism of Gene Action.** (4 cr; prereq 5332 or #) Das, Fuchs, Schottel, Simon

Structure and function of nucleic acids and regulatory process involved in gene expression from biochemical point of view.

**BioC 5352s. Applied Microbial Biochemistry.**

(4 cr, §MicB 5352; prereq 3021 or 5331 or MicB 5321, intro microbiology course or #) Flickinger  
Biochemistry of microorganisms and enzymes of industrial interest. Heterologous peptide overproduction by microorganisms and yeasts; polymer, antibiotic, organic acid, and amino acid production; genetics of industrially useful microorganisms; biological systems useful for biotransformation and environmental remediation; introduction to fermentation technology.

**BioC 5401f. Metabolism and Its Regulation.**

(3 cr; prereq 3021 or 5331) Nelsestuen  
Underlying principles determining metabolism of common and unusual compounds in plants, animals, and microbes. Regulation of carbon and energy flow in whole organisms.

**BioC 5418s. Topics in Molecular Immunology.** (4 cr; prereq MicB 5218) Conti-Fine

Molecular interactions occurring among proteins and peptides involved in immune recognition.

**BioC 5950. Special Topics.** (1-5 cr; prereq #, Δ)**BioC 5970. Directed Studies.** (Cr ar; prereq #, Δ)

Individual study of selected topics; selected readings and use of scientific literature.

**BioC 5990. Directed Research.** (Cr ar; prereq #, Δ)

Laboratory or field investigation of selected areas of research.

**Biochemistry (MdBc)**

(Medical School)

**MdBc 5053f,w,s,u. Problems in Biochemistry.**

(Cr and hrs ar [may be repeated 1 or more qtrs for cr]; prereq Δ; grad majors must regis S-N)

**MdBc 5100f.<sup>1</sup> Biochemistry, Molecular and Cellular Biology.** (9 cr; prereq regis med fr, ¶|CBN 5104) Livingston, staff

Integrated introduction to biochemistry, molecular biology, genetics, cell biology, and developmental biology.

**MdBc 5101w. Human Nutrition.** (1 cr; prereq

5100, regis med fr or grad student) Towle  
Principles of nutrition as foundation for understanding clinical nutrition.

**MdBc 5201f. Biochemistry for Dental Students.** (4 cr; prereq regis dental fr or grad student) Lange, Room

Chemical properties, biosynthesis, catabolism, structure, and function of biomolecules. Fundamentals of molecular biology and metabolic regulation.

**MdBc 5202w. Biochemistry for Dental Students.** (3 cr; prereq regis dental fr or grad student) Adolph, Oegema, Room

Introduction to physiological chemistry emphasizing biological processes that occur in human tissues and fluid compartments.

**MdBc 5300f. Biochemistry.** (4 cr; prereq organic chem or #; recommended for med tech majors) Bardwell, Room

Survey of chemical properties, biosynthesis, catabolism, and structural interaction of biomolecules. Metabolic regulation and molecular biology.

**MdBc 5301w. Biochemistry.** (3 cr; prereq 5300 or #; recommended for med tech majors) Adolph, Oegema, Room

Survey of physiological biochemistry emphasizing human processes.

**MdBc 5444s. Muscle Contraction.** (3 cr; prereq undergrad courses in biochemistry or physiology or #) Thomas, staff

Introduction to physiology, biochemical regulation, and physical chemistry of muscle contraction.

**MdBc 5460-5461. Cellular and Molecular Neuroscience.** (3 cr per qtr; for 5460: §GCB 5460, §NSc 5460, §Phcl 5460, §Phsl 5460, §VB 5460; for 5461: §GCB 5461, §NSc 5461, §Phcl 5461, §Phsl 5461, §VB 5461; prereq biochem)

Gene structure and regulation, cloning and molecular strategies for studying gene function, ion channels and membrane excitability, synaptic transmission, receptor structure and function, signal transduction.

**MdBc 5531f. Macromolecular Crystallography: Fundamentals.** (1 cr; prereq 1 qtr organic chem, biochem or ¶|biochem, 2 qtrs calculus, college physics) Ohlendorf

Basics of macromolecular crystallography as required for protein structure determination and engineering. Properties of X-rays, crystal growth and handling, space groups and symmetry, data collection and reduction, structure factors.

**MdBc 5532w. Macromolecular Crystallography: Techniques.** (1 cr; prereq 5531) Ohlendorf

Techniques for determining structure of macromolecule from its diffraction. Properties of Patterson function, heavy atoms techniques, molecular replacement, phase determination, generation and interpretation of electron density maps and refinement.

**MdBc 5533s. Macromolecular Crystallography: Applications.** (1 cr; prereq 5532) Ohlendorf

Practical use of current software in macromolecular crystallography. Density modification, molecular dynamics refinement, computer graphics, modeling, computational aspects.

<sup>1</sup> Offered on the Medical School calendar, which is different from the regular University calendar. Fall classes may start as much as one month ahead of other courses.

## Bioethics

*Professor:* Muriel J. Bebeau (preventive sciences—dentistry); Norman O. Dahl (philosophy); Jasper S. Hopkins (philosophy); Rosalie A. Kane (public health); H. E. Mason (philosophy); David J. Mayo (philosophy); Muriel B. Ryden (nursing); Naomi B. Scheman (philosophy)

*Associate Professor:* Mila A. Aroskar (health management and policy), *director of graduate studies;* Ronald E. Cranford (neurology); Patricia Crisham (nursing); John M. Dolan (philosophy); John M. Eyler (history of medicine); Steven H. Miles (medicine); Michael D. Root (philosophy); Susan M. Wolf (law)

*Assistant Professor:* Kathy Faber-Langendoen (medicine)

**Course of Study**—Minor in bioethics, applicable to master's (M.A. and M.S.) and doctoral programs.

**Curriculum**—A structured graduate minor in bioethics is offered in conjunction with the Center for Biomedical Ethics in cooperation with the Department of Philosophy. While recognizing that philosophy is the focal discipline for the field of bioethics, the program offers varied opportunities for multidisciplinary study, including coursework in history and philosophy of medicine, health law and public policy, healthcare economics, professional ethics, medical humanities, and moral development. In addition to a sequence of required courses in ethical theory and bioethics, the program consists of approximately 50 additional courses offered by a wide variety of departments within the University from which students make a selection in consultation with the director of graduate studies for bioethics.

**Prerequisites for Admission**—Admission to the bioethics graduate minor is contingent upon prior admission to a master's or doctoral degree-granting program within the Graduate School. Students are encouraged to have some previous exposure to philosophy or biomedicine or both. Graduate students in philosophy are expected to have successfully completed at least one graduate course in ethical theory.

**Special Application Requirements**—Contact the director of graduate studies in bioethics for an "Intent to Enroll" form, which students are encouraged to submit by the end of winter quarter the year before initiating coursework in the minor. Later submissions are considered as space permits. Fifteen students can be accepted per year. Although some priority is given to

doctoral students, students familiar with philosophy, biomedicine, or both are admitted to the minor program on a first-come, first-served basis. Enrollment is contingent upon approval by the director of graduate studies for bioethics.

**Minor Requirements**—Students are encouraged to attend monthly seminars sponsored by the Center for Biomedical Ethics, preferably during the year the student is completing coursework for the minor.

*Master's students* are required at a minimum to complete 10 graduate-level quarter credits in ethical theory and bioethics.

*Doctoral students* are required at a minimum to complete 18 graduate-level quarter credits in ethical theory and bioethics.

If mastery of the field of bioethics is desired, the student should consider coursework in addition to the minimum requirements for the minor program. Students also have the option of the related field(s) at the master's level or the supporting program at the doctoral level in the programs described further in this bulletin.

**Language Requirement**—None specific to the minor program.

**For Further Information and Applications**—Contact the Graduate Minor in Bioethics, Center for Biomedical Ethics, University of Minnesota, University Office Plaza, 2221 University Avenue S.E., Suite 110, Minneapolis, MN 55455 (612/626-9756; fax 612/626-9786).

## Biological Sciences

The biological sciences at the University of Minnesota offer both traditional and custom-designed interdisciplinary graduate programs that allow students to obtain the combination of advisers and courses needed to support their research and career interests. A high degree of interdisciplinary cooperation allows graduate students access to state-of-the-art equipment, facilities, and the expertise of more than 1,000 members of the graduate faculties in biological sciences across the Twin Cities and Duluth campuses.

Graduate programs in the biological sciences are found in many colleges and departments. Most programs offer master's degrees under Plan A (involving a thesis) and Plan B (coursework only), and doctoral degrees, although some programs do not accept master's students (see

<sup>1</sup> University of Minnesota, Duluth

## GRADUATE PROGRAMS

listing of majors and degrees in the General Information section). All graduate programs follow general Graduate School requirements, but many programs have additional requirements unique to their own program. Brief information about each program's curriculum, prerequisites for admission, special application requirements, degree requirements for the master's and doctoral degrees, and language requirements is listed under the appropriate graduate program heading.

Detailed and up-to-date information about a particular program can be obtained by writing to or calling the director of graduate studies of that program. Students who are undecided about a graduate field of study, or have general questions about the biological sciences, may contact the Coordinator for Life Sciences, College of Biological Sciences, University of Minnesota, 124 Snyder Hall, 1475 Gortner Avenue, St. Paul, MN 55108 (612/624-4240), or the Graduate School, Biological Sciences Graduate Programs, University of Minnesota, 306 Johnston Hall, 101 Pleasant Street S.E., Minneapolis, MN 55455 (612/625-9364).

The table on the following page illustrates the inter-relatedness of major fields of study in the biological sciences at the University of Minnesota. The table shows that training and research opportunities in any particular discipline of the biological sciences are available to graduate students in a number of different programs. Undecided students, or students contemplating entering graduate school in a specific biological discipline, may find more than one program that offers graduate training and research in their chosen field of study. The table is divided into three parts: Basic Biological Sciences, Agricultural Sciences, and Natural Resource Sciences. Use the following codes to identify the graduate programs offering training in each discipline:

### Graduate Programs and Codes:

Agro ..... Agronomy  
 AnSc ..... Animal Sciences<sup>1</sup>  
 BMBB ..... Biochemistry, Molecular Biology and Biophysics<sup>2</sup>  
 BMSc ..... Biomedical Science<sup>1</sup>  
 CBio ..... Conservation Biology<sup>1</sup>  
 DU ..... Duluth Campus: Biology<sup>3</sup>  
 EEB ..... Ecology  
 Ent ..... Entomology  
 FW ..... Fisheries<sup>4</sup>  
 FSsN ..... Food Science<sup>5</sup>  
 Fors ..... Forestry<sup>6</sup>  
 Hort ..... Horticulture

LA ..... Landscape Architecture<sup>7</sup>  
 MCDDBG .. Molecular, Cellular, Developmental Biology and Genetics<sup>8</sup>  
 MedC ..... Medicinal Chemistry  
 MicE ..... Microbial Engineering<sup>1</sup>  
 MIMP ..... Microbiology, Immunology, and Molecular Pathobiology<sup>9</sup>  
 NSc ..... Neuroscience<sup>1</sup>  
 Nutr ..... Nutrition<sup>1,5</sup>  
 PBio ..... Plant Biological Sciences  
 Phcl ..... Pharmacology  
 Phm ..... Pharmaceutics  
 Phsl ..... Cellular and Integrative Physiology  
 PIBr ..... Plant Breeding<sup>1,10</sup>  
 PIPa ..... Plant Pathology<sup>11</sup>  
 Soil ..... Soil Science  
 Txcl ..... Toxicology<sup>1</sup>  
 VB ..... Veterinary Biology<sup>12</sup>  
 VP ..... Veterinary Pathobiology<sup>12</sup>  
 WC ..... Wildlife Conservation<sup>1</sup>  
 Zool ..... Zoology<sup>1</sup>

### Free-Standing Minors:

MiEc ..... Microbial Ecology—applicable to master's (M.S. only) and doctoral programs.  
 PNI ..... Psychoneuroimmunology—applicable to doctoral programs only.  
 QP ..... Quaternary Paleoecology—applicable to master's (M.A. and M.S.) and doctoral programs.  
 SAgr ..... Sustainable Agriculture Systems—applicable to master's (M.A. and M.S.) and doctoral programs.

- <sup>1</sup> A nondepartmental, interdisciplinary program.
- <sup>2</sup> The graduate program in biochemistry, molecular biology and biophysics is jointly administered through the Department of Biochemistry in the College of Biological Sciences (BioC) and the Medical School (MdBc).
- <sup>3</sup> Refer to Graduate Offerings, Duluth Campus, at the end of this bulletin for more specific information about the opportunities for research and training on that campus.
- <sup>4</sup> The graduate programs in fisheries and in wildlife conservation are administered in the Department of Fisheries and Wildlife.
- <sup>5</sup> The graduate program in food science is administered in the Department of Food Science and Nutrition. The graduate program in nutrition is an intercollegiate program also administered in the Department of Food Science and Nutrition.
- <sup>6</sup> The graduate program in forestry is administered in the Department of Forest Products and the Department of Forest Resources.
- <sup>7</sup> The master of landscape architecture (M.L.A.) is offered by this program.
- <sup>8</sup> An interdisciplinary program with most coursework offered through the Department of Genetics and Cell Biology.
- <sup>9</sup> The graduate program in microbiology, immunology, and molecular pathobiology is administered through the Department of Microbiology.
- <sup>10</sup> The graduate program in plant breeding is administered in the Department of Agronomy and Plant Genetics and the Department of Horticultural Science.
- <sup>11</sup> The graduate program in plant pathology also offers the Ph.D. degree with a concentration in mycology.
- <sup>12</sup> The graduate programs in veterinary biology and veterinary pathobiology are administered in the Department of Veterinary Pathobiology.

**Fields of Study Graduate Programs Offering Training in This Area**

**Basic Biological Sciences**

Animal and Human Anatomy .....	DU, MCDBG, NSc, Phsl, VB, Zool
Biochemistry/Chemistry .....	AnSc, BMBB, BMSc, Ent, Fors, FScN, FW, Hort, MCDBG, MedC, MIMP, MicE, NSc, Nutr, PBio, Phcl, Phm, Phsl, PIBr, PIPa, PNI, Soil, Txcl, VB, VP, Zool
Biomedical Sciences .....	BMSc (as part of the M.D./Ph.D. program in the Medical School)
Biotechnology .....	AnSc, BMBB, Ent, FScN, Hort, MedC, MIMP, MicE, NSc, Nutr, PBio, Phm, Phsl, PIBr, PIPa, SAg, Soil, Txcl, VB, VP, Zool
Cell/Developmental Biology .....	AnSc, BMBB, BMSc, DU, Ent, Fors, Hort, MCDBG, MIMP, NSc, PBio, Phsl, PIPa, Txcl, VB, VP, Zool
Ecology/Environmental Biology .....	CBio, DU, EEB, Ent, Fors, FW, Hort, LA, MiEc, NSc, PBio, QP, Soil, SAg, WC, Zool
Entomology .....	CBio, DU, EEB, Ent, NSc, PIPa, Zool
Evolutionary/Systematic Biology .....	CBio, EEB, Ent, Fors, FW, Hort, MCDBG, MIMP, PBio, PIPa, QP, SAg, Zool
Genetics .....	AnSc, BioC, BMSc, CBio, EEB, Ent, Fors, Hort, MCDBG, MIMP, MicE, NSc, PBio, Phsl, PIBr, PIPa, VB, VP, WC, Zool
Immunology .....	AnSc, BMBB, BMSc, MIMP, PNI, VP
Microbiology .....	BMSc, FScN, MIMP, MicE, MiEc, PIPa, Soil, VP
Molecular Biology .....	The techniques of molecular biology are used in nearly all fields, but are important components of biological research in the following programs: AnSc, BMBB, BMSc, DU, Ent, Fors, Hort, MCDBG, MedC, MIMP, MicE, MiEc, NSc, Nutr, PBio, Phcl, Phsl, PIBr, PIPa, PNI, VB, VP
Neurobiology .....	AnSc, BMSc, DU, Ent, FW, MCDBG, NSc, Phcl, Phsl, PNI, VB
Nutrition .....	AnSc, FScN, Nutr
Parasitology .....	Ent, VP
Pharmacokinetics/Drug Delivery .....	Phcl, Phm, Txcl, VB
Pharmacology .....	BMSc, NSc, Phcl, Phsl, VB
Physiology, Animal and Plant .....	Agro, AnSc, DU, Ent, Fors, Hort, MCDBG, MIMP, NSc, Nutr, PBio, Phcl, Phsl, PIBr, PIPa, Txcl, VB, VP, WC, Zool
Plant Biology .....	Agro, BioC, CBio, DU, EEB, Fors, Hort, PBio, PIBr, PIPa, QP, Soil, WC
Plant Pathology .....	PIPa, SAg
Toxicology .....	BMSc, CBio, FW, MedC, Phcl, Phm, SAg, Txcl, VB
Virology .....	BMSc, Hort, MIMP, PIPa
Zoology .....	CBio, DU, EEB, Zool

**Agricultural Sciences**

Agronomy and Plant Breeding .....	Agro, Hort, PIBr, SAg, Soil
Animal Sciences .....	AnSc, VB, VP, WC, Zool
Food Sciences/Nutrition .....	AnSc, FScN, MIMP, Nutr
Horticulture .....	Hort, LA, PBio, PIBr
Landscape Architecture .....	LA
Soil Science .....	Agro, Fors, Hort, PIPa, SAg, Soil
Veterinary Sciences .....	NSc, VB, VP

**Natural Resource Sciences**

Conservation .....	CBio, DU, EEB, Fors, FW, LA, SAg, Soil, WC
Environmental Sciences .....	See Ecology/Environmental Biology above
Fish/Wildlife .....	AnSc, CBio, DU, EEB, FW, WC
Forestry .....	CBio, Fors, Soil
Limnology .....	DU, EEB, Fors

**Biomedical Engineering (BMEn)**

*Professor:* Matthew V. Tirrell (chemical engineering and materials science), *director of graduate studies;* Robert J. Bache (medicine); David G. Benditt (medicine); Perry L. Blackshear, Jr. (*emeritus:* mechanical engineering); William R. Brody (radiology); Henry Buchwald (surgery); Dennis D. Caywood (small animal clinical sciences); Frank B. Cerra (surgery); Jay N. Cohn (medicine); Max Donath (mechanical engineering); Arthur G. Erdman (mechanical engineering); Stanley M. Finkelstein (laboratory

medicine and pathology); John E. Foker (surgery); Leo T. Furcht (laboratory medicine and pathology); James R. Gage (orthopaedic surgery); Robert P. Hebbel (medicine); Russell K. Hobbie (physics); Mostafa Kaveh (electrical engineering); Tarald O. Kvalseth (mechanical engineering); David G. Levitt (physiology); Jack L. Lewis (orthopaedic surgery); Rex E. Lovrien (biochemistry); James B. McCarthy (laboratory medicine and pathology); Wilmer G. Miller (chemistry); David A. Nelson (otolaryngology); Suhas V. Patankar (mechanical engineering); Dennis L. Polla (electrical engineering); Richard E. Poppele (physiology); Gundu H. R. Rao (laboratory medicine and pathology); Donald R. Riley (mechanical engineering); John F. Soechting

## GRADUATE PROGRAMS

(physiology); Ephraim M. Sparrow (mechanical engineering); Ahmed H. Tewfik (electrical engineering); Neal F. Viemeister (psychology)

*Associate Professor:* Jerome H. Abrams (surgery); Michael G. Garwood (radiology); James E. Holte (electrical engineering); Wei-Shou Hu (chemical engineering and materials science); Robert P. Patterson (physical medicine and rehabilitation); Clark M. Smith II (pediatrics)

*Assistant Professor:* Joan E. Bechtold (orthopaedic surgery); John C. Bischof (mechanical engineering); Gregg B. Fields (laboratory medicine and pathology); William B. Gleason (laboratory medicine and pathology); Bruce E. Hammer (radiology); Linda K. Hansen (laboratory medicine and pathology); Xiaoping Hu (radiology); Allison Hubel (laboratory medicine and pathology); Paul A. Iazzo (anesthesiology); Daniel L. Mooradian (laboratory medicine and pathology); Lisa M. Schutte (orthopaedic surgery); Robert T. Tranquillo (chemical engineering and materials science); Jay Zhang (medicine)

*Clinical Instructor:* Carl S. Smith (surgery)

*Other:* Arthur J. Coury (vice president in biomaterials and pharmaceutical research, Focal Interventional Therapeutics); Prakash Keshaviah (corporate research fellow, Baxter Clinical Laboratories)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Biomedical engineering is an interdisciplinary program designed to provide familiarity with the interactions among the engineering, biological, and medical sciences. Thesis research topics might include the following areas of biomedical engineering research: blood fluid mechanics; hemodynamics of cardiovascular function, structure, and instrumentation; design of artificial internal organs; biomaterials and biointerfacial science; tissue engineering; biomedical imaging; organ preservation; chemotaxis; modeling of lung dynamics and study of pathological pulmonary conditions; bone and joint mechanics and design of bone and joint prostheses; microbial population dynamics; membranes and mass transfer; development of instrumentation and control devices to correct neurological defects; human factors engineering; health effects of design of tools and workplace; application of computer science to a wide variety of problems in physiological simulation, diagnosis, and medical data recording. Further information on current research areas is available from the director of graduate studies.

**Prerequisites for Admission**—A baccalaureate degree in engineering or in a physical or biological science is required. Successful applicants without an engineering degree are required to complete appropriate coursework to provide preparation for graduate-level engineering courses before being admitted as a candidate for the degree. In most cases, this coursework is not considered part of the degree program.

**Special Application Requirements**—Three letters of recommendation are required. In evaluating applications, consideration is given to whether or not an appropriate focus exists within the program to match the candidate's interests. The Graduate Record Examination is required of all students. For international students requiring the Test of English as a Foreign Language (TOEFL), the minimum score is 575.

**Master's Degree Requirements**—For the M.S. degree, students are required to complete 53 credits, including 3 credits of graduate seminars and a 12-credit minor program in a *traditional engineering field* (approved by that department). Plan B students are required to complete an internship and Plan B paper. Plan A students are required to complete a research thesis. A final oral examination is required for the M.S. degree.

**Doctoral Degree Requirements**—Ph.D. programs are planned with the aid of an adviser and a committee selected jointly by the candidate and the director of graduate studies from the above list of department faculty and approved by the Biomedical Engineering Graduate Program Review Committee. The committee decides on the suitability of the program and thesis topic and is responsible for the appointment of examination committees, subject to Graduate School approval.

The major program provides students with comprehensive training in both the engineering and life sciences aspects of at least one area of biomedical engineering. Students normally complete a broad but cohesive program consisting of coursework from a variety of departments. Students are required to take six credits of graduate seminar. In addition, students are required to complete a *minor program in a traditional engineering field*. That engineering department must approve the minor program.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**

—For the M.S. degree, students are required to complete 12 credits in two departments other than that of their major. For the Ph.D. degree, 18 credits outside the major are required. For both degrees, courses are approved by the director of graduate studies based on consultation with the student. Students must also register for three quarters of an approved biomedical engineering seminar series.

**For Further Information and Applications**

—Contact the Biomedical Engineering Program, University of Minnesota, Box 107 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (mailing address) (612/626-3446; e-mail [bmengp@tc.umn.edu](mailto:bmengp@tc.umn.edu)). Program office is located at 2-639 Malcolm Moos Tower, 515 Delaware Street S.E., Minneapolis campus.

**BME 8666. Doctoral Pre-Thesis Credits.**

(max 18 cr per qtr; doctoral student who has not passed oral prelims)

**BME 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**BME 8888. Thesis Credits: Doctoral.** (36 cr required)

**BME 5001. Biomaterials I.** (3-4 cr, §MatS 5481, §MatS 5482; prereq IT upper div or grad student or med student or #)  
Physical and chemical aspects of biomaterials.

**BME 5002. Biomaterials II.** (3 cr, §MatS 5483; prereq IT upper div or grad student or med student or #)  
Biological aspects of biomaterials.

**BME 5003. Tissue Engineering.** (4 cr, §ChEn 5757; prereq IT upper div or grad student or med student or #) Hansen, Hubel  
Engineering of matrix from synthetic and natural polymers; cell matrix interactions; case studies of engineered tissues, e.g., skin, vessel, cartilage; regulatory and manufacturing issues associated with development of engineered tissues.

**BME 5701. Biomedical Applications of Heat Transfer in Humans.** (4-5 cr; prereq Phsl 3053, Phsl 3056, Phsl 5441) Iazzo, Sparrow  
Overview of physiology underlying thermoregulation in humans, clinical applications of heat transfer in humans, and framework for a design project.

**BME 5950. Bioelectric Measurements.** (3 cr; prereq Phsl 5441, calculus, college physics)  
Electrodes, instrumentation, and processing requirements for endogenously generated electric potentials and electrical impedance of tissue. Electrode characteristics, signal processing, and interpretation of physiological events by ECG, EEG, EMG, and EOG. Measurement of respiration, blood flow and volume, and other physiological events by electrical impedance.

**BME 5951. Bioelectric Stimulation.** (3 cr; prereq Phsl 5441, engineering-level calculus and physics)  
Theory and application of electrical stimulation in areas of therapeutic and functional neuromuscular stimulation and pain control, cardiac pacing, and defibrillation, tissue healing, and electrotherapy. Efficiency, safety, and environmental electrical fields.

**BME 8002. Internship in Biomedical Engineering.** (3 cr; prereq BME grad major or Δ)  
Supervised lab experience unrelated to student's normal employment. Report required.

**BME 8100-8200-8300. Biomedical Engineering Seminar.** (1 cr per qtr)  
Lectures, demonstrations, and individual research that introduces graduate students and faculty to techniques and goals of biomedical engineering and surgery.

**BME 8400. Biomedical Engineering Graduate Student Seminar.** (1 cr per qtr [max 3 cr]; prereq BME grad major or #) Mooradian  
Student presentations of current thesis research or other areas of biomedical engineering.

**BME 8702. Advanced Topics in Biomaterials.** (2 cr; prereq 5001, 5002, 5003 or #)  
Surgical implantation of materials, hybrid artificial organs, inflammation and infection caused by implants; collagen and biopolymers; biocompatibility; blood-surface interactions; biodegradation; mineralization; antimicrobial treatments; drug delivery; wound healing; Society of Biomaterials conference report.

**BME 8770. Plan B Project.** (4 cr, no cr toward PhD; prereq #)  
May be taken to satisfy Plan B master's project requirement. May appear on master's program, but does not count toward 20-credit minimum in major. Project topic arranged between student and instructor. Written report required.

**BME 8970. Independent Study.** (1-4 cr; prereq #)  
Topic determined by interests of student in consultation with instructor; requires approval by consenting faculty member and director of graduate studies.

**BME 8990. Directed Research.** (1-4 cr; prereq #)  
Content determined by interests of student in consultation with instructor.

**Biomedical Science (BMSc)**

*Regents' Professor:* Alfred Michael (pediatrics); James G. White (laboratory medicine and pathology)

*Professor:* Theodore R. Oegema (orthopaedic surgery; biochemistry), *director of graduate studies:* Norma M. Allewell (biochemistry); Dwight L. Anderson (microbiology); Robert J. Bache (medicine); Leonard J. Banaszak (biochemistry); James W. Bodley (biochemistry); Frank B. Cerra (surgery); P. Patrick Cleary (microbiology); Bianca M. Conti-Fine (biochemistry); David L. Dunn (surgery); Martin Dworkin (microbiology); Timothy J. Ebner

(neurosurgery); Edward H. Egelman (cell biology and neuroanatomy); Robert P. Elde (cell biology and neuroanatomy); Esam E. El-Fakahany (psychiatry); Stanley L. Erlandsen (cell biology and neuroanatomy); David P. Fan (genetics and cell biology); Anthony J. Faras (microbiology); Stanley M. Finkelstein (laboratory medicine and pathology); Leo T. Furcht (laboratory medicine and pathology); Apostolos P. Georgopoulos (physiology); Glenn J. Giesler (cell biology and neuroanatomy); Gordon D. Ginder (medicine); Gary R. Gray (chemistry); Ashley T. Haase (microbiology); Perry B. Hackett (genetics and cell biology); David W. Hamilton (cell biology and neuroanatomy); Janet W. Heasman (cell biology and neuroanatomy); Robert K. Herman (genetics and cell biology); Jordan L. Holtzman (medicine); Margaret K. Hostetter (pediatrics); Thomas H. Hostetter (medicine); James B. Howard (biochemistry); Harry S. Jacob (medicine); Ronald R. W. Jemmerson (microbiology); Marc K. Jenkins (microbiology); Ross G. Johnson (genetics and cell biology); Russell C. Johnson (microbiology); M. Colin Jordan (medicine); James F. Koerner (biochemistry); Ryoko Kuriyama (cell biology and neuroanatomy); David C. LaPorte (biochemistry); Alice A. Larson (veterinary pathobiology); Tucker W. LeBien (laboratory medicine and pathology); Hon Cheung Lee (physiology); Paul C. Letourneau (cell biology and neuroanatomy); Jack L. Lewis (orthopaedic surgery); Richard W. Linck (cell biology and neuroanatomy); John D. Lipscomb (biochemistry); Horace H. Loh (pharmacology); Charles F. Louis (veterinary pathobiology); Walter C. Low (neurosurgery); James B. McCarthy (laboratory medicine and pathology); Steven C. McLoon (cell biology and neuroanatomy); Matthew F. Mescher (laboratory medicine and pathology); Eric A. Newman (physiology); Jack H. Oppenheimer (medicine); Harry T. Orr (laboratory medicine and pathology); Peter G. W. Plagemann (microbiology); Richard E. Poppele (physiology); R. Paul Robertson (medicine); Irwin Rubenstein (genetics and cell biology); Michel M. Sanders (biochemistry); Patrick Schlievert (microbiology); Virginia S. Seybold (cell biology and neuroanatomy); Norman E. Sladek (pharmacology); John F. Soechting (physiology); Chang W. Song (therapeutic radiology); Robert L. Sorenson (cell biology and neuroanatomy); Sheldon B. Sparber (pharmacology); David D. Thomas (biochemistry); Matthew V. Tirrell (chemical engineering and materials science); Howard C. Towle (biochemistry); Kamil Ugurbil (biochemistry); Daniel Vallera (laboratory medicine and pathology); Brian G. Van Ness (biochemistry); Ben G. Zimmerman (pharmacology)

*Adjunct Professor:* Stephen J. Riederer (Mayo Clinic/diagnostic radiology)

*Associate Professor:* Bruce R. Blazar (pediatrics); Aristidis S. Charonis (laboratory medicine and pathology); Kathleen F. Conklin (microbiology); Costantino Iadecola (neurology); David H. Ingbar (medicine); Victoria Iwanij (genetics and cell biology); R. Scott McIvor (laboratory medicine and pathology); Amy P. Skubitz (laboratory medicine and pathology); Peter Southern (microbiology); Effie C. Tsilibary (laboratory medicine and pathology); Susan M. Wick (plant biology)

*Assistant Professor:* Linda M. Boland (physiology); Christopher M. Gomez (neurology); Kristin A. Hogquist (laboratory medicine and pathology); Louise M. Nutter (pharmacology); José V. Pardo (psychiatry); Mary E. Porter (cell biology and neuroanatomy); Sundaram Ramakrishnan (pharmacology); Paul G. Siliciano (biochemistry); Stanley A. Thayer (pharmacology); H. Joseph Yost (cell biology and neuroanatomy)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered—Ph.D.**

**Curriculum—**In consultation with their faculty advisers and the Committee on Graduate Studies, students custom-design interdisciplinary programs at the interfaces of biology, medicine, engineering, and physical sciences.

**Prerequisites for Admission—**Admission is limited to students who have been accepted by the Medical School's M.D./Ph.D. program.

**Language Requirements—**None.

**For Further Information and Applications—**Contact the director of the M.D./Ph.D. Program, Medical School, University of Minnesota, Box 293 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (mailing address) (612/625-3680; fax 612/626-6800; e-mail [mdphd@lenti.med.umn.edu](mailto:mdphd@lenti.med.umn.edu)).

**BMSc 8666. Doctoral Pre-Thesis Credits.**

(max 18 cr per qtr; doctoral student who has not passed oral prelims)

**BMSc 8888. Thesis Credits: Doctoral.** (36 cr required)

**BMSc 8990. Research: Biomedical Science.** (Cr ar; prereq enrollment in MD/PhD program)

## Biophysical Sciences and Medical Physics (BPhy)

*Professor:* Dean E. Abrahamson (public affairs); Eugene Ackerman (*emeritus*: laboratory medicine and pathology); Dwight L. Anderson (oral sciences); Victor A. Bloomfield (biochemistry/biological sciences); Bianca M. Conti-Fine (biochemistry/biological sciences); William H. Douglas (operative dentistry); Stanley M. Finkelstein (laboratory medicine and pathology); John E. Foker (surgery); Russell K. Hobbie (physics); Faiz M. Khan (therapeutic radiology); Christopher C. Kuni (radiology); Rex E. Lovrien (biochemistry/biological sciences); Scott M. O'Grady (veterinary biology); Richard Poppele (physiology); Andreas Rosenberg (laboratory medicine and pathology); Chang W. Song (therapeutic radiology); David D. Thomas (biochemistry/medical school); Fatih

M. Uckun (therapeutic radiology); Kamil Ugurbil (radiology); Warren J. Warwick (pediatrics); Clare K. Woodward (biochemistry/biological sciences)

*Associate Professor:* E. Russell Ritenour (radiology), *director of graduate studies*; Michael G. Garwood (radiology); Bruce J. Gerbi (therapeutic radiology); Xiaoping Hu (radiology); Stephen C. Strother (radiology)

*Assistant Professor:* Vincent A. Barnett (physiology); F. Christopher Deibel, Jr. (therapeutic radiology); Ralph DeLong (operative dentistry); Richard A. Geise (radiology); Bruce E. Hammer (radiology); Bruce E. Hasselquist (radiology); Patrick Higgins (therapeutic radiology); Kelly Rehm (radiology); Beth A. Schueler (radiology); Arthur E. Stillman (radiology)

*Research Associate:* Jeih-San Liow (radiology)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Degree programs include concentration in one or more of the four areas: experimental biophysics, applied biophysics, theoretical biophysics, and medical biophysics. A list of more than 50 courses offered by a variety of departments and accepted for credit in the biophysical sciences major is available on request from the director of graduate studies. Other pertinent courses may also be used as part of the program.

**Prerequisites for Admission**—All students should have some familiarity with physical chemistry, intermediate physics, intermediate mathematics, biostatistics, computer programming, biology, physiology, and biochemistry. This may be demonstrated by coursework completed at the undergraduate level or as part of the graduate program; by reading or practical experience; or by informal competency examinations.

**Special Application Requirements**—Three letters of recommendation and scores from the General Test of the Graduate Record Examination are required. Applicants are considered for admission in all quarters.

**Master's Degree Requirements**—Three core courses—Phys 5551, 5552, and 5553—are normally required. A special three-person committee, chaired by the adviser, is responsible for assuring that the student's

program includes broad training in the biophysical sciences. This committee is usually recommended to the Graduate School to administer the oral examination. A final oral examination is required.

**Doctoral Degree Requirements**—The core curriculum consists of Phys 5551, 5552, and 5553. A significant portion of the coursework should be relevant to the area of thesis research. Programs should also include an area of specialization outside the thesis area. Students are required to take a written preliminary examination at the end of one year of postbaccalaureate study, or as soon as possible after completing Phys 5551, 5552, and 5553. This examination is prepared by a committee and is given at the start of the fall quarter. A special committee is recommended to the Graduate School to administer the Ph.D. oral preliminary examination, which should be taken by October of the third year of full-time registration or its equivalent. The oral examining committee is also expected to review the student's course program.

**Language Requirements**—For the M.S. degree, none. For the Ph.D. degree, candidates must demonstrate competence in reading scientific literature in at least one foreign language. International students may submit evidence of competence in their native language if significant, relevant publications exist in that language. All other students must meet Graduate School requirements for the language selected.

**Minor Requirements for Students Majoring in Other Fields**—Programs are arranged on an individual basis and must consist of courses that represent broad coverage of the biophysical sciences. Eight-credit minors are not acceptable.

**For Further Information and Applications**—Contact the Biophysical Sciences and Medical Physics Program, Department of Radiology, University of Minnesota, Box 292 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (mailing address) (612/626-6638).

*Note*—The following courses are offered in biophysical sciences. Those numbered 5170 through 5174 are taught concurrently with courses in radiology and/or in therapeutic radiology that bear the same course numbers.

## GRADUATE PROGRAMS

**BPhy 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**BPhy 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**BPhy 8888. Thesis Credits: Doctoral.** (36 cr required)

**BPhy 5138. Seminar: Biophysical Sciences.** (Cr ar)

**BPhy 5155, 5156, 5157. Biophysics.** (3 cr per qtr; prereq basic preparation in biological sciences, physical sciences, mathematics, #) Schmitt  
Selected topics in theoretical, experimental, and technical areas of biophysical science where quantitative methods of the physical sciences are especially applicable. *5155:* Basic principles of biophysical analysis and experimentation. Biostatistics; structure of biological systems, especially as revealed by electronic, optical, and ionizing radiation imaging techniques; hypermicroscopy, birefringence, colloidal and micellar systems. *5156:* Biophysical function; dynamics of biophysical systems, excitatory state in nerve and muscle, contractility, secretion, synthesis, sensory and motor transducers. *5157:* Organization of biological systems for communication and control; stability of feedback and feed-ahead systems; biocommunication theory, computer aspects of living systems, biomimetics.

**BPhy 5170. Basic Radiological Physics.** (3 cr, §Rad 5170, §TRad 5170; prereq #) Khan  
Theoretical and experimental aspects of radiological physics. Physical properties of various ionizing radiations; interactions of ionizing radiations with matter; methods of radiation dose measurement.

**BPhy 5171. Physics of Nuclear Medicine.** (3 cr, §Rad 5171, §TRad 5171; prereq 5170, #) Geise, Hasselquist, Ritenour  
Theoretical and experimental applications of radionuclides in medicine and biology. Imaging devices and techniques; dynamic tracer analysis; internal emitter dosimetry. Radioimmunoassay and statistics of counting.

**BPhy 5172. Radiation Biology.** (3 cr, §Rad 5172, §TRad 5172; prereq 5170, #) Song  
Effects of ionizing radiation on cells, tissues, and organisms; biochemical and physiological bases of radiation effects; biological rationale for radiation therapy practices.

**BPhy 5173. Physics of Radiation Therapy.** (3 cr, §Rad 5173, §TRad 5173; prereq 5170 or #) Khan  
High energy and teletherapy machines. Measurements of radiation quality, output, and depth dose distributions for clinical use. Calculation of treatment parameters. Beam modification and shaping. Treatment planning for fixed field and rotational therapy. Physics of intracavitary and interstitial therapy. Computer applications in treatment planning. Principles and criteria for radiation protection.

**BPhy 5174. Physics of Diagnostic Radiology.** (3 cr, §Rad 5174, §TRad 5174; prereq 5170 or #) Ritenour  
Physics of diagnostic imaging; includes CAT scanning and ultrasound. X-ray production, image receptors, radiation exposure and protection. Special imaging modes including computerized tomographic scanning and electron radiography.

**BPhy 5181. Physics of Nuclear Medicine Laboratory.** (1 cr; prereq 5171 or #) Hasselquist  
Supplements 5171. Basic counting devices, gamma counters, gamma cameras, quality control techniques, hot lab techniques, and radiation safety.

**BPhy 5184. Diagnostic Radiological Physics Laboratory.** (2 cr; prereq 5174 or #) Geise  
Introduction to techniques of performance testing and calibration of radiological imaging equipment and related radiation safety survey methods.

**BPhy 8147. Physics of Magnetic Resonance Imaging.** (3 cr; prereq 5174 or #) Hammer, Hu  
NMR physics, spatial selection and encoding, imaging hardware and system engineering. Imaging sequences and associated contrast. Advanced topics, including more recent development in MRI.

**BPhy 8204. Research in Biophysics and Radiation Biology.** (Cr ar)

**BPhy 8221, 8222, 8223. Research in Biophysics.** (Cr ar)

See also Phys 5551, 5552, 5553.

## Biophysics

See Biochemistry, Molecular Biology and Biophysics.

## Biostatistics (PubH)<sup>1</sup>

*Professor:* Thomas A. Louis, *head*; Anne I. Goldman, *director of graduate studies*; James R. Boen; Kathryn M. Chaloner; John E. Connett; David R. Jacobs; Marcus O. Kjelsberg; Chap T. Le; James D. Neaton; Vernon E. Weckwerth

*Associate Professor:* Bradley P. Carlin; Patricia M. Grambsch; Kathleen M. Keenan; J. William Thomas

*Assistant Professor:* Aparna B. Anderson; Lance A. Waller

*Senior Research Associate:* Dorothee P. Aepli; James S. Hodges; John P. Matts

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered—M.S. (Plan A and Plan B) and Ph.D.**

**Curriculum—**The field of biostatistics combines statistics, computing, and biomedical science to further research in human health. Biostatisticians design, direct, and analyze clinical trials; plan and carry out health surveys; develop new statistical

<sup>1</sup> A master of public health degree (M.P.H.) with an emphasis in biostatistics is offered by the School of Public Health. Consult the School of Public Health Bulletin for more information.

methods; and analyze data from observational studies, laboratory experiments, follow-up studies, and surveys. The program is designed to develop methodologically sound and applications-oriented biostatisticians. The research program couples collaboration on projects in human health with development of biostatistical methods to meet the challenges of these applications.

**Prerequisites for Admission**—For the M.S., program-specific admission requirements are as follows: mathematics through multivariable calculus (four quarters or three semesters) and linear algebra (one quarter or semester); at least one (quarter or semester) course in applied statistics; and at least one (quarter or semester) course in computer programming using a standard procedural language, such as FORTRAN or C. For the Ph.D., direct admission of non-University of Minnesota applicants is rare but possible with the following requirements: fulfillment of all M.S. admission prerequisites, an M.S. in statistics or biostatistics from a strong program, real analysis, mathematical statistics, and inference equivalent to the first-year biostatistics M.S. sequence.

Admission preference is given to those with a demonstrated background and interest in health sciences and public health. Applicants should have an overall grade point average of 3.10 or above on a 4.00 point scale with a 3.40 or above in quantitative courses for the M.S., and an average of 3.70 or above in mathematics/statistics courses for the Ph.D. The Graduate Record Examination (GRE) is required, with expected scores in the verbal area of at least 450 for the M.S. and 550 for the Ph.D., and in the quantitative and analytical areas of 550 in each for the M.S. and 650 in each for the Ph.D. If the applicant's native language is not English, the Test of English as a Foreign Language (TOEFL) is required. A score of 600 or better on the TOEFL may replace the minimum verbal GRE requirement. Three letters of recommendation are also required from all applicants.

**Special Application Requirements**—Fall quarter entry is recommended.

**Master's Degree Requirements**—Biostatistical inference, theory of statistics, clinical trials, statistical computing, analysis of categorical data, survival analysis, statistics, biostatistics, and health sciences electives. The master's degree usually requires two years of full-time study.

**Doctoral Degree Requirements**—The doctoral program is open to students who have completed the requirements for the M.S., have shown proficiency in statistics and computing, and have adequate background in mathematics and health sciences. The Ph.D. degree usually requires one or two years of coursework beyond the M.S., plus the dissertation. Additional course topics for the Ph.D. include general linear models, analysis of longitudinal data, sequential analysis, advanced survival analysis, bioassay and screening, Bayes and empirical Bayes methods, spatial biostatistics, and modern nonparametric methods. Consult the director of graduate studies for more details.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Student Services Center, School of Public Health, University of Minnesota, Box 819 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (612/626-3500 or 1/800/774-8636; fax 612/626-6931; e-mail sph-uofm@greg2.sph.umn.edu; http://www.sph.umn.edu).

*Note*—Biostatistics courses are listed and described in the Public Health section of this bulletin. See PubH 5404 to 5470 and 8420 to 8450.

**PubH 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**PubH 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**PubH 8888. Thesis Credits: Doctoral.** (36 cr required)

## Biosystems and Agricultural Engineering

*Professor:* R. Vance Morey, *head*; Kevin A. Janni, *director of graduate studies*; Frederick G. Bergsrud; Theodore P. Labuza; John L. Nieber

*Associate Professor:* Mrinal Bhattacharya; James J. Boedicker; Jonathan Chaplin; Charles J. Clanton; Philip R. Goodrich; Larry D. Jacobson; John M. Shutske; William F. Wilcke; Bruce N. Wilson

*Assistant Professor:* Rongsheng R. Ruan; Anu Subramanian

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S.B.A.E. (Plan A and Plan B); M.B.A.E.; and Ph.D.

**Curriculum**—Areas of emphasis include bioprocessing; food engineering; livestock environment; water quality, surface and subsurface flow, contaminant transport; waste management and resource utilization; terramechanics; safety; and grain quality. With approval from the department faculty, supporting courses in other fields of engineering and the physical, biological, or agricultural sciences may be included in the major.

**Prerequisites for Admission**—A B.S. degree in biological, agricultural, or related field of engineering, or equivalent coursework in mathematics, physics, engineering science, and engineering design, is required. A strong academic record is also required.

**Special Application Requirements**—Graduate Record Examination scores, while not required, are encouraged. Students are admitted each quarter.

**Master's Degree Requirements**—The M.S.B.A.E. degree is normally taken under Plan A, but may be completed under Plan B with approval from the department faculty. The M.B.A.E. program is recommended for those desiring design-oriented study beyond the B.S. degree. See Professional Master's Degree in Engineering in the General Information section of the bulletin for a program description. The final examination for both master's degrees is oral.

**Doctoral Degree Requirements**—Coursework for the major should provide in-depth knowledge in a specific area. It may include closely related topics, and should provide adequate background for the thesis investigation. A minimum of 16 credits in mathematics, statistics, and numerical analysis, including two or more mathematics courses, is required. The student may use these credits as a supporting program or may choose a designated minor in a single, related field.

**Enrichment Program**—In lieu of a language requirement for the Ph.D., the department requires completion of an enrichment program, consisting of 2 or more credits of nontechnical courses in a single area. Possible areas include (a) communication, educational methods, (b) foreign language and culture, (c) sociology, psychology, humanities, or (d) some other field related to the candidate's career objectives and approved by the department faculty.

**Language Requirements**—For the master's degree, none. For the Ph.D. degree, see above under Enrichment Program.

**For Further Information and Applications**—Contact the Director of Graduate Studies, Department of Agricultural Engineering, University of Minnesota, 1390 Eckles Avenue, St. Paul, MN 55108 (612/625-7733; fax 612/624-3005).

**BAE 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**BAE 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**BAE 8888. Thesis Credits: Doctoral.** (36 cr required)

## Biosystems and Agricultural Engineering (BAE)

*Courses That Carry Graduate Credit for Majors or Minors*

**BAE 5070. Instrumentation and Control for Biological Systems.** (4 cr; prereq EE 1400, EE 3009, ME 3900 or Stat 3091, forest products major or upper div IT or grad student; 3 lect, 2 lab hrs per wk) Chaplin  
Measurement of motion, force, pressure, flow, temperature, size, shape, color, texture, rheology, moisture, water mobility, fat, and pH. Linking physical and biological control systems.

**BAE 5072. Finite Element Method: Fundamentals and Applications.** (4 cr; prereq Math 3261, upper div IT or grad IT major; 4 lect hrs per wk) Bhattacharya

Basic theory and principles of implementation of the finite element method for a number of fundamental engineering areas. Applications in heat transfer, fluid mechanics, solid mechanics, radial and axisymmetric field problems, and time-dependent field problems.

**BAE 5074. Microcomputer Interfacing.** (4 cr; prereq CSci 3101, CSci 3102 or CSci 3113, EE 1400, EE 3009, upper div IT or grad IT major; 2 lect, 4 lab hrs per wk) Goodrich

Introduction to digital components, integrated circuits, and microcomputers. Interfacing of microcomputers for data acquisition and control.

**BAE 5140. Thermal Processes for Food.** (4 cr; prereq ChEn 5103 or ME 5342, upper div IT or grad IT major; 3 lect, 3 lab hrs per wk) Bhattacharya  
Engineering principles of thermal processing of food, pasteurization, microwave heating, heat exchange, evaporation, refrigeration, and freezing. Process design and evaluation.

**BAE 5191-5192. Special Problems in Biosystems and Agricultural Engineering.** (1-5 cr per qtr; prereq #)

Individual study project in agricultural engineering at advanced level. Application of engineering principles to a specific problem.

**BAE 5350. Agricultural Machinery and Terramechanics.** (4 cr; prereq AEM 3016, AEM 3036, upper div IT or grad IT major; 3 lect, 3 lab hrs per wk) Chaplin

Engineering principles governing performance of agricultural machinery. Soil-machine interaction (traction and tillage), off-road vehicle dynamics, operator-machine interaction, drive-line design, power unit selection, and duty cycle analysis.

**BAE 5540. Watershed Engineering.** (4 cr; prereq 3052 or ¶13052 or CE 3300, CE 3400, upper div IT or grad IT major; 3 lect, 3 lab hrs per wk) Wilson

Applying engineering principles to management of surface runoff and soil water in agricultural, range, and urban lands. Designing facilities to control surface runoff to mitigate problems of flooding and degradation of surface water quality.

**BAE 5550. Water Management Engineering.** (4 cr; prereq 3052 or CE 3300, CE 3400, upper div IT or grad IT major; 3 lect, 3 lab hrs per wk) Nieber

Applying engineering principles to management of water for production and environmental protection in agricultural systems. Designing facilities to irrigate and drain croplands and enhance water quality.

**BAE 5560. Mechanics of Flow in the Unsaturated Zone.** (4 cr; prereq Soil 5232, Math 3261 or #, upper div IT or grad IT or grad COAFES major; 3 lect hrs per wk) Nieber

Fluid retention and transmission properties of unsaturated porous media. Equations of mass conservation and Darcy's law for unsaturated porous media. Simultaneous flow of immiscible fluids. Analytical, finite difference and finite element solutions to governing equations.

**BAE 5745. Ventilating Systems for Indoor Air Quality.** (4 cr; prereq ME 3301, AEM 3200 or CE 3400, upper div IT or grad IT major; 4 lect hrs per wk) Janni

Impact of indoor air quality on humans, animals, and plants. Contaminant sources. Ventilating processes, systems, control strategies, and equipment for indoor air quality control. Case studies from residential, commercial, and agricultural systems.

**BAE 5751. Biochemical Engineering I.** (3 cr, §ChEn 5751; prereq BAE major or chem eng major or grad or #; 3 lect hrs per wk) Srienc

Applications of material and energy balances and of concepts from thermodynamics, kinetics, and transport phenomena to cellular and enzyme systems.

**BAE 5910. Agricultural Waste Management Engineering.** (4 cr; prereq 3052, upper div IT or grad IT major; 3 lect, 3 lab hrs per wk) Clanton

Sources and characteristics of agricultural wastes, including livestock, food processing, and domestic wastes. Physical, biological, chemical, rheological, and microbiological properties. Effects on environment. Collection, storage and treatment (aerobic and anaerobic), and use/disposal. Land application of livestock and food processing wastes, municipal effluents, and sludges. On-site sewage treatment.

**BAE 8000. Supervised Teaching Experience.** (2 cr, §Agro 8000, §Hort 8000, §Soil 8000; prereq #) Janni

Classroom or extension teaching experience in one of the following departments: Biosystems and Agricultural Engineering, Agronomy and Plant Genetics, Horticultural Science, or Soil, Water, and Climate. Students strengthen skills and develop personal teaching philosophy.

**BAE 8100. Seminar.** (1 cr; prereq #, grad IT major) Janni

Reports on current topics and department research.

**BAE 8190, 8191. Advanced Problems and Research.** (2-6 cr per qtr; prereq 5191, 5192, Δ) Research problems in agricultural engineering.

**BAE 8500. Hydrologic Modeling—Small Watersheds.** (4 cr; prereq CE 5405, grad IT major; 3 lect, 1 rec hrs per wk; offered alt yrs) Wilson

Study and representation of hydrologic processes by mathematical models; infiltration, overland flow, return flow, evapotranspiration, channel flow, and storage. Time-flow relationships. Linear and nonlinear methods. Frequency relationships. Emphasis on parametric methods.

**BAE 8700. Coupled Moisture, Heat, and Chemical Transfer in Porous Media.** (4 cr; prereq knowledge of differential equations, numerical solutions methods, a computer programming language; offered alt yrs)

Mathematical study of coupled transfer of moisture, heat, and chemical mass in porous media with emphasis on freezing processes. Numerical solution of governing equations with emphasis on applications.

**Agricultural Engineering Technology (AgET)**

*Courses That Carry Graduate Credit for Nonengineering Students Only*

**AgET 5027. Appropriate Technology for International Development.** (4 cr; prereq basic understanding of math, chem, physics; 3 lect, 3 lab hrs per wk) Goodrich

Definitions, history, successes, and failures of appropriate technology. Social and technical appropriateness. Water supply, treatment, storage, and conveyance. Water pumps, sanitation. Power: pedal, wind, water, solar, rice-hull furnace, methane, Stirling-cycle engine. Building materials. Agricultural machinery and storage. Transfer and adoption of technology.

**AgET 5091. Special Problems in Agricultural Engineering.** (2-5 cr; prereq #)

Individual study project in agricultural engineering at advanced level. Application of engineering principles to a specific problem.

**AgET 5200. Health and Safety Issues in Agricultural Work Environments.** (3 cr; 3 lect/ rec hrs per wk)

Hazards and control strategies for at-risk populations working in agricultural production and processing.

**AgET 5410. Hydrology and Water Quality.**

(5 cr; prereq Math 1111, Phys 1041, Chem 1052; 3 lect, 3 lab, 1 rec hrs per wk) Wilson  
Hydrologic cycle: precipitation, infiltration, evaporation, surface and subsurface run-off, ground water recharge. Flow in streams and in aquifers, flow measurement; soil erosion, sediment transport and deposition; chemical pollution of surface water and groundwater.

**AgET 5999. Special Workshop in Biosystems and Agricultural Engineering.** (1-4 cr; prereq #)

Offered off campus. Consult *Class Schedule* or department for current topics.

**Building Science (Bldg)**

*Professor:* James L. Bowyer (forest products); Thomas H. Kuehn (mechanical engineering); Lance LaVine (architecture); James W. Ramsey (mechanical engineering)

*Associate Professor:* Kevin A. Janni (bioystems and agricultural engineering); Elmer L. Schmidt (forest products); Becky L. Yust (design, housing, and apparel)

*Research Fellow:* Mary Vogel (landscape architecture)

*Other:* David T. Grimsrud (program director, Minnesota Building Research Center), *director of graduate studies*

**Course of Study**—Minor in building science, applicable to master's (M.A. and M.S.) and doctoral programs.

**Curriculum**—A graduate minor in building science is offered in conjunction with the Minnesota Building Research Center. The minor offers varied opportunities for multidisciplinary study, including relevant coursework in agricultural engineering, architecture, civil engineering, computer science, electrical engineering, forest products, housing, landscape architecture, mechanical engineering, public affairs, and public health.

In addition to a required seminar in building science, the program consists of courses offered by a wide variety of departments within the University from which students make a selection in consultation with the director of graduate studies in building science.

**Prerequisites for Admission**—Admission to the building science graduate minor is contingent upon prior admission to a master's or doctoral degree-granting program within the Graduate School.

**Special Application Requirements**—Contact the director of graduate studies in building science for an Intent to Enroll form, which students are encouraged to submit by April 1 in the academic year before beginning coursework in the minor. Later submissions are considered as space permits. A maximum of 15 students are accepted each year. Enrollment is contingent upon approval by the director of graduate studies in building science.

**Minor Requirements**—The required seminar must be taken before the elective courses.

*Master's students* are required to complete at least 12 graduate credits outside their major, which include 3 credits for Seminar: Building Science and 9 credits for elective courses.

*Doctoral students* are required to complete at least 21 graduate credits outside their major, which include 3 credits for Seminar: Building Science and 18 credits for elective courses from two departments.

**Language Requirements**—None specific to the minor program.

**For Further Information and Applications**—Contact the Graduate Minor in Building Science, Minnesota Building Research Center, University of Minnesota, 1425 University Avenue S.E., Room 220, Minneapolis, MN 55455 (612/626-7419).

**Bldg 8000. Topics in Building Science.**

(3 cr; prereq admission to bldg sci minor or #)  
Major topics and research methods used in different disciplines to investigate research questions about buildings.

**Arch 5381. Computer-Aided Architectural Design****Arch 5539. Daylighting and Architectural Design****CE 5301. Foundation Engineering****CE 8605. The Finite Element Method in Civil Engineering****CE 8606. Advanced Topics in Finite Element Analysis****CSci 5121. Algorithms and Data Structures II**

**CSci 5280. Computer-Aided Design I****CSci 5511. Artificial Intelligence I****EE 5255. Digital Control Systems****ForP 5303. Wood Deterioration****ForP 5355. Mechanics and Structural Design With Wood Products****LA 5228. Seminar: Topics in Campus Planning****ME 5342. Heat Transfer****ME 5603. Thermal Environmental Engineering****ME 5604. Heating and Cooling Loads in Buildings****ME 5605. Refrigeration and Air Conditioning Systems****ME 5712. Solar Energy Utilization****PA 5711. Energy Policy I****PA 5721. Environmental Policy I****PubH 5181. Air Pollution****Business Administration**

*Professor:* Paul E. Johnson, *director of graduate studies, Ph.D. program;* Carl R. Adams; Gordon J. Alexander; Beth E. Allen; Amin H. Amershi; John C. Anderson; Richard D. Arvey; Rajiv D. Banker; Frederick J. Beier; Lawrence M. Benveniste; R. Glen Berryman (*emeritus*); Mario F. Bognanno; Norman E. Bowie; John H. Boyd; Philip Bromiley; Richard N. Cardozo; Balaji S. Chakravarthy; Norman L. Chervany; Terry L. Childers; Larry L. Cummings; Gordon B. Davis; John W. Dickhaut; Michael U. Dothan; W. Bruce Erickson; John A. Fossum; Joseph Galaskiewicz; Donald V. Harper; Arthur V. Hill; Thomas R. Hoffmann; Michael J. Houston; Ravi K. Jagannathan; Deborah Roedder John; George John; James S. Jordan; Edward J. Joyce; Chandra S. Kanodia; John H. Kareken; Stefanie A. Lenway; Stephen F. LeRoy; Barbara J. Loken; Salvatore T. March; Alfred A. Marcus; Christopher J. Nachtsheim; Timothy J. Nantell; Mary Lippitt Nichols; Kenneth J. Roering; William Rudelius; Roger G. Schroeder; James G. Scoville; Allan D. Shocker; Andrew H. Van de Ven; Orville C. Walker, Jr.; James C. Wetherbe; Andrew F. Whitman; Mahmood A. Zaidi

*Associate Professor:* Dennis A. Ahlburg; Stuart Albert; Ross E. Azevedo; John M. Bryson; Chun Chang; Shawn P. Curley; Gordon L. Duke; Gordon C. Everest; James M. Gahlon; Robert A. Hansen; Robert J. Kauffman; Murugappa Krishnan; Ian H. Maitland; John J. Mauriel; Thomas P. Murtha; J. David Naumann; Akshay R. Rao; Judy D. Rayburn; Peter Rosko; Robert Ruekert; David E. Runkle; Shaker B. Srinivasan; Michael J. Stutzer; Michael R. Taaffe  
*Assistant Professor:* Erhard Bruderer; Gary W. Carter; Dale L. Goodhue; Ellie G. Harris; Christina M. L. Kelton;

Abbas A. Kurawarwala; Arijit Mukherji; Diane L. Rülke; P. Jane Saly; Linda G. Schneider-Stone; Priti P. Shah; Kingshuk K. Sinha; Akbar Zaheer; Srilata Zaheer

*Other:* Donald R. Bell, *assistant dean;* Frederick R. Jacobs, *director of graduate studies, business taxation;* Paul G. Gutterman; Howard Strauss; Terry L. Tranter

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered<sup>1</sup>**—M.B.T. (Plan B only) and Ph.D.

**Master of Business Taxation (M.B.T.)**

**Curriculum**—This degree program is designed to help students acquire a conceptual understanding of taxation and to develop technical competence in the practical application of the rules of taxation in business and personal decision making. The program is offered only in the evening through the Carlson School of Management and University College (formerly Continuing Education and Extension). It is designed to accommodate the nontraditional student who is employed during the day and enrolled in the program on a part-time basis during the evening. Students enrolled part time can expect to complete the program in approximately two to three years. Students enrolled full-time can complete the program in a shorter period.

**Special Application Requirements**—Results of the Graduate Management Admissions Test (GMAT) or the Law School Admission Test (LSAT) are required. Applicants are considered for admission for fall, winter, spring, and first summer term.

**Degree Requirements**—Students are required to have gained, through coursework, a common body of knowledge in the various areas of business. When the appropriate coursework is lacking, students must make up the deficiencies. These courses may be taken after admission.

Students must complete 47 credits, including 16 credits in business, economics, and accounting; 15 credits in tax methods and periods, tax research, tax procedure, and

<sup>1</sup> As of July 1, 1996, the M.B.A. program is offered through the Carlson School of Management (CSOM), rather than through the Graduate School. All queries regarding the M.B.A. should be directed to CSOM.

corporate tax; and 16 credits of elective tax courses. Students must maintain a 3.00 grade point average.

#### **For Further Information and Applications—**

Contact the Master of Business Taxation Degree Program, Department of Accounting, University of Minnesota, 645 Management & Economics, 271 19th Avenue South, Minneapolis, MN 55455 (612/624-7511; fax 612/626-7795; e-mail [mcooper@csom.umn.edu](mailto:mcooper@csom.umn.edu); <http://www.cee.umn.edu/mbt>).

### **Doctor of Philosophy**

**Curriculum—**The doctoral program in business administration offers advanced graduate education for students seeking academic positions at leading universities and research-oriented positions in business and government. The study program is designed for individuals who have the intellectual capacity for advanced study, enjoy independent research and analytical thinking, and wish to master a discipline within business administration and contribute to its future development. The following areas of specialization are offered: accounting, finance, information and decision sciences, marketing and logistics management, operations and management science, and strategic management and organization.

**Special Application Requirements—**Scores from the Graduate Management Admission Test (GMAT) taken within the last five years are required unless the applicant has already taken the Graduate Record Examination (GRE), in which case GRE scores may substitute for GMAT scores.

**Degree Requirements—**The program includes a field of specialization within the Carlson School of Management, research methodology, supporting fields of study, preliminary written and oral examinations, and a doctoral dissertation. If a student does not have a bachelor's or master's degree in business administration, certain basic courses may also be required. Three to four years of full-time study are usually required to complete the Ph.D.

**Minor Requirements for Students Majoring in Other Fields—**For a Ph.D. minor in business administration, students must complete a

cohesive program of 24 credits of graduate work in the field, developed in consultation with an adviser who is a full member of the graduate faculty in business administration.

#### **For Further Information and Applications—**

Contact the Ph.D. program, Carlson School of Management, University of Minnesota, 295 Humphrey Center, 271 19th Avenue South, Minneapolis, MN 55455 (612/624-0875; fax 612/626-7785).

**BA 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**BA 8888. Thesis Credits: Doctoral.** (36 cr required)

### **Accounting (Acct)**

#### **Acct 5101. Corporate Financial Reporting.**

(4 cr; prereq 1050 or MBA 8030, MBA student or Sch Mgmt approval)

Preparation and interpretation of corporate financial reports. Income determinations, revenue recognition, income tax allocation, inventories, fixed assets, long-term debt, and leases.

#### **Acct 5102. Advanced Financial Reporting I.**

(4 cr; prereq 3101 or 5101, mgmt or grad mgmt student or Sch Mgmt approval)

Relationship between complex events such as defined benefit pension plans, leases, and intercorporate investments and their reflection in financial statements. Introduction to business combinations and consolidated financial reporting.

#### **Acct 5125. Auditing Principles and**

**Procedures.** (4 cr; prereq 3101 or 5101, accounting major or Sch Mgmt approval)

The auditor's role and function. Includes audit standards, ethics, procedures, legal responsibilities.

#### **Acct 5126. Internal Auditing.** (4 cr; prereq 3201

or 5201, 5102, accounting major or Sch Mgmt approval) Financial and operational auditing. Standards. Management of the function.

#### **Acct 5135. Income Tax Accounting.** (4 cr; prereq

1025 or 1050, accounting major or Sch Mgmt approval) Introduction to principles of federal income taxation of various taxpaying entities.

#### **Acct 5160. Financial Statement Analysis.**

(4 cr; prereq 1050 or MBA 8030, accounting major or Sch Mgmt approval)

Interpretation and analysis of financial statements and schedules for investors and other users.

#### **Acct 5180. Advanced Accounting II.** (4 cr; prereq

5102, mgmt or MBA student or Sch Mgmt approval) Consolidated financial reporting with focus on international business organizations. Introduction to reporting issues in governmental and not-for-profit entities.

**Acct 5230. Corporate Taxation.** (4 cr; prereq 5135 or equiv, MBT program approval) Jacobs  
Tax consequences of formation, operation, and liquidation of a business corporation.

**Acct 5236. Taxation II.** (4 cr; prereq 5135, accounting major or Sch Mgmt approval)  
Income taxation of corporations. Partnerships. Tax research.

**Acct 5310. International Accounting.** (4 cr; prereq 3001, Sch Mgmt approval)  
Macroeconomic concepts of international economics; survey of accounting policies and approaches among nations.

**Acct 5340. Partnership Taxation.** (4 cr; prereq 5135 or equiv, MBT program approval)  
Tax consequences of formation, operation, and dissolution of a partnership.

**Acct 5390. Current Topics in Taxation.** (Cr ar; prereq 5135 or equiv, MBT program approval)  
Current tax legislation problems. Topics vary quarterly.

**Acct 8100. Tax Accounting Methods and Periods.** (4 cr; prereq 5135 or equiv, MBT program approval) Carter  
Rules affecting timing of income and deductions for tax purposes. Cash and accrual accounting methods examined overall and with respect to individual items of income and deductions. Rules for changing accounting methods and accounting periods.

**Acct 8150. Financial Accounting Issues.** (4 cr; prereq 1050, 3001, MBT program approval) Tranter  
Accounting principles and practices underlying preparation of financial statements and additional disclosures. Includes recent pronouncements on financial accounting.

**Acct 8220. Tax Research and Communication.** (3 cr; prereq 5135 or equiv, MBT program approval) Gutterman  
In-depth treatment of tax research methodology including tax questions, locating potential authority, assessing potential authority, and communicating research results.

**Acct 8225. Tax Procedure and Practice.** (4 cr; prereq 5135 or equiv, MBT program approval) Gutterman  
Procedure dealing with the IRS including sources of IRS policy; processing returns; auditing returns; rulings and determination letters; closing agreements; assessments and collections.

**Acct 8230. Taxation of Corporations I.** (4 cr; prereq 5135 or equiv, MBT program approval) Jacobs  
Federal income taxation of corporations and shareholders. Organization of a corporation; establishment of its capital structure; determination of its tax liability; dividends and other nonliquidating distributions, stock redemptions, and liquidations.

**Acct 8330. Taxation of Corporations II.** (4 cr; prereq 8230 or equiv, MBT program approval)  
Corporate readjustments related to multiple corporations and consolidated returns.

**Acct 8340. Taxation of Partners and Partnerships.** (4 cr; prereq 5135 or equiv, MBT program approval)  
Reviews tax consequences associated with formation, operation, and dissolution of a partnership.

**Acct 8350. Taxation of Estates, Gifts, and Trusts.** (4 cr; 5135 or equiv, MBT program approval)  
Taxation of transfers under federal estate and gift tax laws. Includes property owned by the decedent; retained life estates; transfers taking effect at death; revocable transfers; joint interest; powers of appointment; valuation problems; expenses, debts, and taxes; charitable requests; marital deduction; taxable inter vivos gifts, gift splitting and credits.

**Acct 8356. Taxation of Deferred Compensation and Fringe Benefits.** (4 cr; prereq 8230 or equiv, MBT program approval)  
Federal income taxation of corporate deferred compensation and fringe benefits with emphasis on pension plans, profit sharing plans, stock options plans, individual retirement accounts, annuities and insurance, medical related compensation benefits, and reporting requirements.

**Acct 8360. State and Local Taxation.** (4 cr; prereq 5135 or equiv, MBT program approval)  
Minnesota individual and corporate income, property, sales, and excise taxes. Tax problems of businesses with multistate operations.

**Acct 8380. Tax Aspects of International Business.** (4 cr; prereq 8230 or equiv, MBT program approval)  
Multinational business operations and transactions involving foreign income. Tax consequences of transactions with foreign organizations and by related foreign companies.

**Acct 8390. Current Topics in Taxation.** (Cr ar; prereq 5135 or equiv, MBT program approval)  
Current tax legislation and problems. Topics may vary quarterly.

**Acct 8805. Seminar I.** (4 cr; prereq PhD student or Grad Sch Mgmt approval)  
Economics modeling applied to accounting issues.

**Acct 8810. Seminar II.** (4 cr; prereq PhD student or Grad Sch Mgmt approval)  
Empirical financial accounting research.

**Acct 8820. Seminar III.** (4 cr; prereq PhD student or Grad Sch Mgmt approval)  
Behavioral accounting research.

**Acct 8990. Readings in Accounting.** (Cr ar; prereq #, Grad Sch Mgmt approval)  
Readings not available in regular courses.

**Acct 8995. Research in Accounting.** (Cr ar; prereq PhD student, Grad Sch Mgmt approval)

## Business, Government, and Society (BGS)

**BGS 8017. Organizational Politics and Management.** (4 cr; prereq grad mgmt student or Grad Sch Mgmt approval)

Political aspects of managing a large corporation. Political considerations examined both in terms of the political process within an organization and in terms of the organization's political relationships with other institutions.

**BGS 8019. Topics in Business, Government, and Society.** (4 cr; prereq grad mgmt student)

Selected topics and problems of current interest and of a varied nature considered in depth. Class discussion and course projects. Content varies quarterly depending on the instructor.

## Business Law (BLaw)

**BLaw 8158. Introduction to Law, the Law of Contracts and Sales Contracts.** (4 cr, §3058; prereq Econ 1002, grad mgmt student or Grad Sch Mgmt approval)

Origin of law, its place in and effect upon society; history and development of law; system of courts, legal procedure. Extensive study of the law of contracts as the basic law affecting business transactions; law affecting sales of goods contracts.

**BLaw 8278. Agency, Partnerships, Corporations, and Commercial Paper.** (4 cr, §3078; prereq 8158, grad mgmt student or Grad Sch Mgmt approval; offered when feasible)

**BLaw 8288. Law of Personal Property, Real Property, Wills and Estates.** (4 cr, §3088; prereq 8158, grad mgmt student or Grad Sch Mgmt approval; offered when feasible)

## Entrepreneurship (Entr)

**Entr 8082. Entrepreneurship.** (4 cr, §Mgmt 8082, §Mktg 8082; prereq MBA core courses) Cardozo  
Analysis of entrepreneurial activities, including identifying opportunities, creating value, developing business concept and plan, attracting resources, building an organization, handling risks, managing growth, coping with failure, restructuring and redirecting an organization. Role of entrepreneurship in organization, economy, society. Integrates concepts and materials from all business functions. Extensive use of case studies.

## Finance (BFin)

**BFin 8100. Cases in Financial Management.** (4 cr; prereq MBA 8040 or #, grad mgmt student or Grad Sch Mgmt approval)

Introduction to corporate project analysis and financial planning and to corporate financial decision making. Cases used to illustrate what modern finance theory implies for evaluation of operating, e.g., marketing, production, strategic, and capital structure decisions. Intended primarily for students not specializing in finance.

**BFin 8150. Theory of Finance.** (4 cr; prereq MBA 8040 or #, grad mgmt/IR student or Grad Sch Mgmt approval)

Rigorous introduction to modern theory of finance. Discussion of, inter alia, capital budgeting, capital structure, dividend policy, asset pricing, application of option pricing to corporate finance, and efficiency of financial markets.

**BFin 8200. Financial Markets and Interest Rates.** (4 cr; prereq MBA 8040 or #, grad mgmt student or Grad Sch Mgmt approval)

Survey of financial markets of modern economies and introduction to theory of how interest rates in the various markets are related. Discussion of, inter alia, interest rate term structure, relationship between interest rate and exchange rate, inflation and interest rates, and use of financial futures.

**BFin 8300. Investments and Portfolio Management.** (4 cr; prereq 8150 or #, grad mgmt student or Grad Sch Mgmt approval)

Introduction to investment decision-making procedures and environment for individuals and institutions. Analytical methods for evaluating securities and how these methods relate to modern portfolio theory. Focus on common stocks.

**BFin 8400. International Financial Management.** (4 cr; prereq 8150 or #, grad mgmt student or Grad Sch Mgmt approval)

Implications of modern finance theory for multinational corporation. Discussion, for background, of alternative exchange rate regimes and risks each regime imposes on the multinational and how different international risks influence basic corporate financial decisions.

**BFin 8601. Corporate Investment and Financial Strategy.** (4 cr; prereq 8150 or #, grad mgmt student or Grad Sch Mgmt approval)

In-depth theoretical analysis of long-term financial decisions, using case studies. Discussion of, inter alia, Modigliani-Miller results for capital structure and dividend policy, and use of capital asset pricing models in capital budgeting.

**BFin 8602. Financial Management of Financial Institutions.** (4 cr; prereq 8150 or #, grad mgmt student or Grad Sch Mgmt approval; Econ 3101 or Econ 3105 recommended)

Introduction to decision making in commercial banks and other depository institutions, with emphasis on lending and funding decisions. Interest rate risk and, inter alia, influence of technological change on banking business.

**BFin 8603. Futures Markets.** (4 cr; prereq 8150 or #, grad mgmt student or Grad Sch Mgmt approval)

Markets and uses for financial futures and options on these futures. Rational pricing of these instruments and their application by financial and portfolio managers.

**BFin 8604. Options Markets.** (4 cr; prereq 8150 or #, grad mgmt student or Grad Sch Mgmt approval)

Basic features and uses of options. Stock, stock index, bond, currency, and futures options. Use of options in management of portfolio risk, interest rate risk, and foreign currency risk.

**BFin 8606. Investment Banking.** (4 cr, §8605; prereq 8150 or #, grad mgmt student or Grad Sch Mgmt approval)

How investment bankers serve corporate clients (and themselves), optimal contracts, pricing of new issues, mergers and acquisitions, and legal framework of investment banking.

**BFin 8801. Introduction to Finance.** (4 cr; prereq Math 1261 or equiv, Math 3251 or equiv or ¶Math 3251, Math 3261 or equiv or ¶Math 3261, Econ 8101 or ¶Econ 8101 or #, PhD student) Expected utility theory, measures of risk, portfolio choice, aggregation and separation, linear pricing models.

**BFin 8810. Corporate Finance.** (4 cr, §8821; prereq 8801, PhD student) Separation and unanimity, investment strategies, valuation of corporate liabilities, financing strategies, dividend policy.

**BFin 8811. Mathematical Methods in Finance.** (4 cr, §8802; prereq 8801, Stat 5121 or equiv or #, PhD student)

Discrete theory: information structures, Radner equilibria, spanning. Continuous theory: information structures, Ito calculus, integral representation of martingales, Radner equilibria, arbitrage pricing.

**BFin 8812. Econometric Methods in Finance.** (4 cr, §8831; prereq 8801, Stat 5121-5122 or Stat 5131-5132 or #, PhD student) Econometric tests of linear pricing models, tests of market efficiency, event studies.

**BFin 8813. Theory of Financial Contracts.** (4 cr; prereq 8801, PhD student)

Risk sharing contracts, incentive contracts, agency, signaling, self-selection, incentive compatibility, financial intermediation.

**BFin 8814. Advanced Theory of Capital Markets.** (4 cr, §8803; prereq 8801, 8811, Econ 8102 or equiv or #, PhD student)

Intertemporal portfolio choice, intertemporal general equilibrium models, options, futures, theory of the term structure, rational expectations.

**BFin 8850. Independent Study in Finance.**

(Cr or [may be repeated for cr]; prereq #, grad mgmt student, Grad Sch Mgmt approval) Problems or developments of special interest in finance.

**BFin 8900. Directed Research in Finance.** (Cr or [may be repeated for cr, max 24 cr]; prereq PhD finance student, completion of required coursework for PhD)

Individualized directed research. Project approved and advised by faculty member.

## Information and Decision Sciences (IDSc)

**IDSc 5410. Decision Support and Expert Systems.** (4 cr; prereq 3030 or MBA 8025 or MBA 8225 or equiv or #)

Overview of technical and organizational aspects of decision support systems (DSS), including individual and group DSS, expert systems, and executive information systems. Management of DSS within end-use computing environments. Conceptual foundations of DSS, DSS software reviews, and case examples.

**IDSc 5998. Special Research Topics.** (4 cr; prereq Δ; offered when feasible)

**IDSc 8110. Individual Productivity With Information Technology.** (4 cr, §8103) Davis, Naumann

Analysis design, development, and use of information technology and systems in support of productivity by a knowledge worker or work group. Information resources for individual knowledge worker tasks and activities. Analyzing individual information requirements and defining an appropriate information technology infrastructure. Defining data needs plus access and retention of records, text, and multimedia data. Tailoring and extending capabilities and utility of common tools and software packages. Applying application development tools to specify, design, and implement individual information system applications. Defining work-group information access and connectivity needs. Differentiating role of knowledge worker in building and maintaining individual systems from role of IS specialist in departmental and corporate application development and maintenance.

**IDSc 8120. Organizational Productivity With Information Technology.** (4 cr, §8102)

Conceptual foundations and trends in hardware, software, databases, and telecommunications. Program architecture, information architectures, systems development, programming languages and tools, operations, re-engineering, data management, systems planning, IT industry, data security, disaster recovery, and legal issues in management of computing. Conceptual foundations, alternative corporate approaches, and case examples. Perspectives of information systems manager and user manager.

**IDSc 8130. Information Systems Analysis, Design, and Development.** (4 cr, §8103; prereq 8110 or #) March

Development of large-scale applications systems, including abstraction, design, and construction. Theoretical and methodological perspectives. Basic systems concepts; information requirements determination; data flow, data structure, behavior, and object-oriented modeling; relational database concepts. Use of CASE tools in storing and analyzing data flow diagrams.

### **IDSc 8140. Managing Information Services.**

(4 cr, \$8101; prereq 8120, 8130 or #) Chervany, Wanninger

Issues, strategies, and tactics for managing delivery of information technology and related services to organizations. Major topics in the managing of information systems at corporate and business-unit level. Case examples, role-playing, and outside speakers. Alternative corporate approaches. Students prepare briefing reports on corporate MIS approaches.

### **IDSc 8430. Advanced Database Design and Administration.**

(4 cr; prereq grad mgmt student, 8130 or equiv or #) Everest

Perspective of data administrator serving users of information and DBMS. Role, organization, functions, and tools of data administration. Data planning and information architectures. Advanced logical database design. Advanced database manipulation with high-level and natural languages. Object-oriented DBMS and support for graphics and CAD/CAM applications. Data security, maintaining database integrity, and managing data in a shared, networking, or distributed environment. Strategies for using advanced DBMS tools in systems development and operations.

### **IDSc 8440. Advanced Information Systems Development.**

(4 cr; prereq 8130 or equiv or #) March

Emerging technologies affecting information systems development process and information systems. Computer-aided software engineering tools, distributed systems, and electronic data interchange. Field study of new technology or new technique required.

### **IDSc 8450. Telecommunications.**

(4 cr; prereq MBA 8225 or equiv or #) Naumann

Introduction to concepts and terminology of electronic communications. Data communications hardware, software, and facilities. Public and private, local and wide area networks. Communications industry, telecommunications regulations, standards, and standards development process. Data communications systems, including network planning, implementation and maintenance, systems development in telecommunications environment, and planning and management of telecommunications systems in organizations.

### **IDSc 8500. Conceptual and Research Introduction to Information and Decision Sciences.**

(4 cr; prereq PhD student or #) Davis, staff Relationships to underlying disciplines. Major research streams. Seminal articles, survey literature, and major researchers. Framework for organizing knowledge about information and decision sciences.

### **IDSc 8502. Organization Theory and Research in the Information and Decision Sciences.**

(4 cr; prereq PhD student or #) Goodhue Review of organization theory and research from economics, organization studies, and sociology relevant to study of information and decision sciences.

### **IDSc 8503. Cognitive Science Research and Theory in the Information and Decision Sciences.**

(4 cr; prereq PhD student or #) Johnson Empirically based concepts of knowledge and reason. Mental representation and conceptual systems that guide problem solving and decision making. Computational metaphor of mind drawn from psychology, computer science, linguistics, anthropology, and philosophy. Implications for understanding of knowledge work.

### **IDSc 8599. Seminar in Information and Decision Sciences Topics.**

(4 cr [may be repeated for cr]; prereq PhD student or #)

Topic selected from new areas of research, research methods, and significant issues.

### **IDSc 8601. System Development Seminar.**

(4 cr; prereq PhD student or #; offered alt yrs) March

Concepts and practice in information systems development; process and data analysis; development life cycle research issues; research methods, emphasizing modeling and simulation.

### **IDSc 8702. Behavioral Decision Theory.**

(4 cr; prereq PhD student or #; offered alt yrs) Curley

Choice and related judgments from behavioral perspective. Models of choice, including decisions under certainty and uncertainty. Processes involved in deriving major underlying judgments, including likelihood, covariation, and causation. Judgment learning and effectiveness of training. Metachoice: selecting among choice strategies.

### **IDSc 8710. Heuristic Decision Making.**

(4 cr; prereq PhD student or #) Johnson

Cognitive basis for human decision making; theory and methodology for study of the knowledge individuals use to meet demands of tasks in work settings and everyday life.

### **IDSc 8990. Readings in Information and Decision Sciences.**

(Cr ar; prereq PhD student, #)

### **IDSc 8995. Graduate Research in Information and Decision Sciences.**

(Cr ar; prereq PhD student, #)

## **Insurance (Ins)**

### **Ins 5100. Risk Management and Insurance.**

(4 cr; prereq grad mgmt student or Grad Sch Mgmt approval)

Recognizing and evaluating the property, liability, and personal risks facing businesses, nonprofit organizations, government units, individuals, or families. Tools of risk management—retention, loss control, and insurance—and conditions under which they should be used. Selecting and dealing with an insurer. Public policy issues—government regulation, social insurance, health insurance and pension legislation, and automobile insurance problems.

**Ins 5230. Life Contingencies I.** (4 cr, §Math 5057; prereq Math 1211, Math 1221, Math 1231 or Math 1131 or #)

Calculation of net premiums, gross premiums, reserves, and nonforfeiture values for major life insurance contracts. Impact of assumed mortality, interest, and expense assumptions on these items.

**Ins 5231. Life Contingencies II.** (4 cr, §Math 5058; prereq 5230 or #)

Advanced topics such as compound interest and annuities certain, the measurement of mortality, life insurance and annuity premiums and reserves. Multilife functions. Population problems and multiple-decrement theory.

## Logistics Management (LM)

**LM 5010. Topics in Logistics Management.** (4 cr; prereq 3000 or 5030 or 5020, #, mgmt or grad mgmt student, Sch Mgmt approval) Beier, Harper  
Specialized topics in field of logistics; topics change quarterly.

**LM 5020. Advanced Logistics Management.** (4 cr; prereq 3000 or 5030 or equiv, mgmt or grad mgmt student, Sch Mgmt approval) Beier, Harper  
Management of flow of physical products (supply and distribution) of an organization. Transportation alternatives, customer service, inventory management, location decisions, warehousing, logistics information systems, international logistics, and logistics system design. Primarily case problems. Includes simulation exercise.

**LM 5030. Principles of Transportation.** (4 cr; prereq Econ 1101 or equiv, mgmt or grad mgmt student, Sch Mgmt approval) Beier, Harper  
Organizational, economic, and service aspects of U.S. transportation system, including rail, highway, water, pipeline, and air transportation. Decision making in transportation companies. Government promotional and regulatory policy.

**LM 8030. Seminar in Logistics Management.** (4 cr; prereq 3000 or 3010 or 5030; offered when feasible)

**LM 8990. Readings in Logistics Management.** (Cr ar; prereq consent of adviser, #, Grad Sch Mgmt approval)

**LM 8995. Graduate Research in Logistics Management.** (Cr ar; prereq Grad Sch Mgmt approval)

## Management (Mgmt)

**Mgmt 5101. Advanced Topics in Management.** (Cr ar [may be repeated for cr]; prereq sr or grad student, #)  
Specialized topics; content varies quarterly.

**Mgmt 5175. Strategic Forecasting for Managers.** (4 cr; prereq 3001 or MBA student or #)  
Methods of economic, social, and technological forecasting and applications to problems of managerial decision making and planning.

**Mgmt 8004. Advanced Topics in Management.** (4 cr [may be repeated for cr]; prereq 3001 or 8001 or MBA 8010, grad mgmt student or Grad Sch Mgmt approval)  
Topics of special interest; content varies quarterly.

**Mgmt 8006. Psychology in Management.** (4 cr, §3002; prereq grad mgmt student or Grad Sch Mgmt approval)  
Development and application of behavioral principles, methods, and skills fundamental to managerial competence in preventing and solving problems within and between individuals and groups and that aid in effective use of human resources. Various lab procedures used to study these concepts, methods, and skills and furnish practice in applying them to management problems.

**Mgmt 8012. Organizational Behavior and Management Analysis.** (4 cr; prereq grad mgmt student or Grad Sch Mgmt approval)  
Concepts, theories, and empirical research relevant to diagnosis, prediction, and control of human behavior in complex organizations. Models and techniques for analyzing group processes, leadership styles, and organizational structure, change, and environment. Students prepare papers based on their own research or on secondary analysis of existing literature.

**Mgmt 8021. Organization Design and Development.** (4 cr; prereq grad mgmt student or Grad Sch Mgmt approval)  
Design and implementation of organizational change. An information processing point of view used to examine design of communication, decision making, and task systems. Theories and techniques of change at both the organization-wide and individual levels. Emphasis on developing skills for managing change and conflict.

**Mgmt 8031. Industry and Competitive Analysis.** (4 cr; prereq MBA 8060)  
Formulating competitive strategies at business unit level. Students acquire skills necessary to analyze an industry and competition within it.

**Mgmt 8032. International and Cooperative Strategies.** (4 cr; prereq MBA 8060)  
International corporate strategies and cooperative strategies between organizations, such as licensing, franchising, joint ventures, and other strategic alliances.

**Mgmt 8033. Managing the Strategy Process.** (4 cr; prereq MBA 8060)  
Process through which strategy is formed and implemented in large diversified organizations. Structuring the organization, strategic planning and control systems, incentives systems, strategic human resource management, and top management style.

**Mgmt 8050. The Management of Innovation and Change.** (4 cr, §5050; prereq grad mgmt student or Grad Sch Mgmt approval)  
Application of theories and research on development and implementation of new organizational programs, products, and technologies, and which paths lead to success, which to failure. Builds diagnostic skills and principles for managing organizational innovation and change.

**Mgmt 8082. Entrepreneurship.** (4 cr, §Entr 8082, §Mktg 8082; prereq MBA core courses) Cardozo Analysis of entrepreneurial activities, including identifying opportunities, creating value, developing business concept and plan, attracting resources, building an organization, handling risks, managing growth, coping with failure, restructuring and redirecting an organization. Role of entrepreneurship in organization, economy, society. Integrates concepts and materials from all business functions. Extensive use of case studies.

**Mgmt 8101. Seminar in Strategic Management.** (4 cr; prereq PhD student or Grad Sch Mgmt approval) Research and theory on strategic management, including policy formulation and implementation, long-range corporate planning, internal organizational design, administrative behavior, management of external environment, interactions between business, government, and society, and interorganizational relations.

**Mgmt 8102. History of Management Thought.** (4 cr; prereq PhD student or #, Grad Sch Mgmt approval) History and philosophy of management thought as it emerged from economics, sociology, psychology, industrial engineering, and management perspectives.

**Mgmt 8201. Foundations of Business-Government-Society.** (4 cr; prereq PhD student or #, Grad Sch Mgmt approval) Original works in political philosophy, legal philosophy, social theory, and economics. Understanding of history of thought in this area, critical awareness of competing contemporary approaches to public policy decisions.

**Mgmt 8202. Seminar in International Management.** (4 cr; prereq PhD student or Grad Sch Mgmt approval) Substantive strategic and organizational challenges posed to firms by global market integration; links to economics, political science, and macro- and micro-organization theory.

**Mgmt 8203. Research Topics and Methods in Business-Government-Society.** (4 cr [may be repeated for cr]; prereq PhD student or Grad Sch Mgmt approval) Helps students understand current research area, identify research topics, formulate researchable problems, and choose appropriate methods. Critique of methods used in outstanding current research required.

**Mgmt 8301. Seminar in Organization Behavior.** (4 cr; prereq PhD student or Grad Sch Mgmt approval; offered alt yrs) Major theories and current research on individual and group processes in organizations from a micro perspective.

**Mgmt 8302. Seminar in Organization Theory.** (4 cr; prereq PhD student or Grad Sch Mgmt approval; offered alt yrs) Major theories and current research on organizational and interorganizational topics from a macro perspective.

**Mgmt 8303. Organizational Research Seminar.** (4 cr; prereq PhD student, #) Advanced topics and research problems related to specific organizational issues. Development of focused research problems, theory building, hypotheses formulation, research design, and observation.

**Mgmt 8401. Seminar in Strategy Formulation.** (4 cr; prereq PhD student or Grad Sch Mgmt approval) Theories and current research on processes by which organizations develop goals, objectives, strategic policies, long-range plans, and programs. Theories and research across functions of marketing, finance, accounting, operations research, and other disciplines.

**Mgmt 8402. Seminar in Strategy Implementation.** (4 cr; prereq PhD student or #, Grad Sch Mgmt approval) Process through which strategy is formed/implemented in multibusiness firms. Introduces important theoretical and empirical literature on how senior managers can effectively establish premises that guide subordinate managers in making/implementing strategic decisions.

**Mgmt 8403. Strategic Management Research Seminar.** (4 cr [may be repeated for cr]; prereq PhD student or Grad Sch Mgmt approval) Special, advanced theories and research in strategic management. Helps students formulate strategic problems, create theories and hypotheses, design research, collect and analyze data, and critique current theories and methods used to examine strategic managerial problems.

**Mgmt 8990. Readings in Management Theory and Administration.** (Cr ar; prereq 2nd-yr grad student, requisite intro courses, adviser consent, #, Grad Sch Mgmt approval) Intensive research in a particular subject; preparation of a major term paper normally required.

**Mgmt 8995. Graduate Research in Management Theory and Administration.** (Cr ar; prereq 2nd-yr grad student, requisite intro courses, adviser consent, #, Grad Sch Mgmt approval) Special research projects on a specific problem completed in cooperation with a business firm.

## Marketing (Mktg)

**Mktg 8051. Marketing Research.** (4 cr; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad Sch Mgmt approval) Childers, D John, Stone  
Methods for collecting and analyzing data to solve marketing problems. Survey research techniques. Research design, secondary and primary data collection, sample design, and data analysis. Application of these techniques to marketing problems.

**Mktg 8053. Marketing Research: Advanced Topics and Fieldwork.** (4 cr; prereq 8051, grad mgmt student or Grad Sch Mgmt approval) Childers  
Application of marketing research in a study with an actual client. Advanced topics such as single source data and computer-assisted interviewing. Advanced techniques for sampling and data analysis.

**Mktg 8055. Consumer Behavior.** (4 cr; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad Sch Mgmt approval) Loken, Rao  
Applications of behavioral sciences to understanding customer behavior in the marketplace. Perception, learning, persuasion, motivation, personality, decision-making strategies, and family, social, and cultural influences. Managerial implications and applications.

**Mktg 8060. Distribution Systems.** (4 cr; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad Sch Mgmt approval) Beier, G John, Walker  
Analysis of interrelationships between marketing institutions and their formation into channels of distribution. Interorganizational problems, including design and management of distribution channels.

**Mktg 8072. International Marketing.** (4 cr; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad Sch Mgmt approval)  
Managing international marketing function. Identifying marketing-based international business opportunities; constructing and evaluating culturally adjusted marketing strategies.

**Mktg 8074. Product Policy.** (4 cr, §8084; prereq MBA 8045 or equiv or  $\Delta$ , grad mgmt student or Grad Sch Mgmt approval) Ruekert, Shocker  
New product development process. Modification of existing product lines and managing product portfolio.

**Mktg 8075. Pricing Strategy.** (4 cr; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad School Mgmt approval) Rao  
Analysis of cost, customer, and competition issues in formulation of pricing strategy. Pricing new and existing products, product lines, and services through channels of distribution for industrial and consumer markets.

**Mktg 8076. Sales Management.** (4 cr; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad Sch Mgmt approval) Rao, Walker  
Management of personal selling function of promotional mix. Problems of performance evaluation, sales force selection, compensation, and territorial design.

**Mktg 8078. Marketing Communications.** (4 cr; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad Sch Mgmt approval) Ritson  
Managing communication aspect of marketing strategy. Advertising and sales promotion. Setting advertising objectives and budgets, media selection, creative strategy, and sales promotion techniques.

**Mktg 8080. Business-to-Business Marketing.** (4 cr; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad Sch Mgmt approval) G John  
Marketing issues facing firms that buy/sell products and services to other firms. Combining tools and analytic techniques. Buying behavior of organizational clients, trade marketing programs, vertical integration, and alliances between firms.

**Mktg 8082. Entrepreneurship.** (4 cr, §Entr 8082, §Mgmt 8082; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad School Mgmt approval) Cardozo  
Analysis of entrepreneurial activities, including identifying opportunities, creating value, developing business concept and plan, attracting resources, building an organization, handling risks, managing growth, coping with failure, restructuring and redirecting an organization. Role of entrepreneurship in organization, economy, society.

**Mktg 8088. Strategic Marketing.** (4 cr; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad Sch Mgmt approval) G John, Roering, Ruekert  
Determination of product-markets where organization should compete; sustainable competitive advantage to be developed. Matching marketing strategy with environment. Coordination between marketing and other business functions. Organization of marketing function and management of marketing process.

**Mktg 8090. Marketing Topics.** (4 cr [may be repeated for cr]; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad Sch Mgmt approval)  
Selected topics and problems of current interest and of a varied nature considered in depth. Class discussion and course projects. Content varies quarterly.

**Mktg 8800. Seminar: Marketing Theory.** (4 cr; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad Sch Mgmt approval) Rao, Ruekert

**Mktg 8810. Seminar: Consumer Behavior.** (4 cr; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad Sch Mgmt approval) Loken

**Mktg 8830. Seminar: Inter-Organizational Relations.** (4 cr; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad School Mgmt approval) G John

**Mktg 8840. Seminar: Theory and Methods of Measurement.** (4 cr; prereq MBA 8045 or MBA 8210 or equiv or  $\Delta$ , grad mgmt student or Grad School Mgmt approval) Childers

## GRADUATE PROGRAMS

**Mktg 8850. Seminar: Design and Implementation of Marketing Strategies.** (4 cr; prereq MBA 8045 or MBA 8210 or equiv or Δ, grad mgmt student or Grad School Mgmt approval) Ruekert

**Mktg 8890. Seminar: Marketing Topics.** (4 cr [may be repeated for cr]; prereq MBA 8045 or MBA 8210 or equiv or Δ, grad mgmt student or Grad School Mgmt approval)

**Mktg 8990. Readings in Marketing.** (Cr ar [may be repeated for cr]; prereq MBA 8045 or MBA 8210 or equiv or Δ, consent of adviser, #, grad mgmt student or Grad Sch Mgmt approval)  
Readings useful to student's individual program and objectives that are not available in regular course offerings.

**Mktg 8995. Graduate Research in Marketing.** (Cr ar [may be repeated for cr]; prereq MBA 8045 or MBA 8210 or equiv or Δ, consent of adviser, #, grad mgmt student or Grad Sch Mgmt approval)  
Individual research on an approved topic appropriate to the student's program and objectives.

### Master of Business Administration (MBA)

*Graduate School students who wish to take MBA courses must contact CSOM.*

**MBA 5100. Management Topics.** (Cr ar; prereq #)

**MBA 8005. Computer Access and Programming for Business Analysis.** (1 cr; prereq MBA student; evening program)  
Computer access and use information necessary for MBA courses. Introduction to computer terminology and computing at Minnesota, plus programming in BASIC.

**MBA 8010. Management and Organization Behavior.** (4 cr; prereq MBA student; evening program)  
The process of planning, organizing, directing, and controlling. Theories of organization performance, structure, and design. Interpersonal and leadership skills. Emphasis on applications of theory to business situations faced by the practicing manager and on development of interpersonal skills. Case studies and in-class simulations used.

**MBA 8015. Human Resources Management.** (4 cr; prereq MBA student; evening program)  
Systematic approach to major phases of human resource management in organizations, including knowledge bases and theories; problems; constraints; opportunities; program controls, evaluations, and costs; and results of effective and efficient human resource management. Point of view is that of the generalist, not that of the specialist personnel or industrial relations professional.

**MBA 8020. Business Statistics: Data Sources, Presentation, and Analysis.** (4 cr; prereq MBA student; evening program)  
Descriptive and inferential statistics for managerial problem solving. Analysis of primary and secondary data; regression analysis; use of statistical packages.

**MBA 8025. Decision Sciences and Information Systems.** (4 cr; prereq MBA student; evening program)

Systems analysis, probability and decision analysis applied to managerial problems under conditions of uncertainty. Formulation and interpretation of mathematical models. Role of information systems in decision making. Principles of implementation of decision science models and information systems.

**MBA 8030. Financial Accounting.** (4 cr; prereq MBA student; evening program)  
Understanding, interpreting, and analyzing financial statements of business enterprises.

**MBA 8035. Managerial Accounting.** (4 cr; prereq MBA student; evening program)  
Use of accounting data in management decisions; accounting systems to generate accounting data, including study of planning and control; transfer pricing, performance evaluation, cost behavior, cost allocation, and standard costs.

**MBA 8040. Financial Management.** (4 cr; prereq MBA student; evening program)  
Analytical introduction to the theory and practice of finance. Application of basic financial concepts of risk, return, and valuation to decisions that a person engaged in a small business or a corporate financial officer must make about sources and uses of funds during conditions of changing financial markets.

**MBA 8050. Operations Management.** (4 cr; prereq MBA student; evening program)  
Operations function in different types of organizations and relations of operations to business decisions. Operations strategy, process management, Just-In-Time, scheduling, inventory control, and quality improvement.

**MBA 8055. Business, Government, and Macroeconomics.** (4 cr; prereq MBA student; evening program)  
Roles of government and business in society; alternative systems of economic and political values; social, political, economic, and cultural conflicts affecting the business sector.

**MBA 8060. Strategy and Policy.** (4 cr; prereq MBA student; evening program)  
Emphasis on development of skills necessary for effective oral presentation, written presentation, and oral attack and defense of alternative positions. Focuses on strategy, planning, and control systems. Topics include problem location or identification and determination of priorities, problem analysis, development of alternative solutions, choice among alternatives, and implementation.

**MBA 8070. Problem Formulation and Decision Making.** (5 cr; prereq MBA student; evening program)  
Formulation and analysis of managerial problems in unstructured situations.

**MBA 8110. Behavioral Science for Business.**

(4 cr; prereq MBA student)

Basic knowledge from various disciplines about human, collective, and institutional behavior, and methods for learning this knowledge. Fundamental behavioral science theories and evidence; ability to diagnose situations and critique applications presented in subsequent courses.

**MBA 8120. Data Analysis and Statistics for Managers.**

(4 cr; prereq MBA student)

Application of exploratory data analysis, basic inferential procedures, statistical process control, and regression analysis; methods selected for relevance to managerial decision making and problem solving. Improvement of “statistical thinking” abilities.

**MBA 8130. Financial Accounting.**

(3 cr; prereq MBA student) Hughes, Rayburn

Basic principles of financial accounting underlying construction, interpretation, and use of corporate financial reports.

**MBA 8140. Managerial Economics.**

(4 cr; prereq MBA student) Leroy, McCabe

How markets work, how positive economic rents (profits) are made, and how strategic behavior affects profits. Market micro-structure, industrial structure, uncertainty, and incentives and firm governance.

**MBA 8210. Marketing Management.**

(4 cr; prereq MBA student) D John, Roering, Walker  
Managing the marketing function; understanding foundational marketing concepts, marketing strategy and planning. Diagnosis of marketing problems and opportunities at operational and strategic levels. Part of integrated functional core.

**MBA 8215. Human Resource Management.**

(2 cr; prereq MBA student) Arvey, Noe

Theory, research, and practice of managing human resources. Acquiring, developing, and compensating employees, designing work, assessing outcomes. Influence of business strategy, legislation, labor markets, and unions. Part of integrated functional core.

**MBA 8220. Operations Management.**

(4 cr; prereq MBA student)

Management of operations function in manufacturing and service organizations. Managerial perspective; impact of operations decisions related to cost, quality, flexibility, and service. Part of integrated functional core.

**MBA 8225. Integrated Information Management.**

(2 cr; prereq MBA student) Chervany, Davis

Managing information resources and providing support services for users. Information resources include internally and externally developed information and associated hardware and software technology, personnel and users, and operational and management systems. Part of integrated functional core.

**MBA 8230. Financial Management.**

(4 cr; prereq MBA student) Gahlon, Nantell

Tools and concepts of financial management and their use by financial and non-financial managers to measure creation of value within organizations. Valuation of businesses and business opportunities; identification of financial requirements and financing sources. Part of integrated functional core.

**MBA 8235. Managerial Accounting.**

(3 cr; prereq MBA student) Joyce, Kanodia

Cost systems as potential sources of sustainable competitive advantage. Designing cost systems to provide manager with accurate, relevant, and timely information. Part of integrated functional core.

**MBA 8300. Strategic Management.**

(4 cr; prereq MBA student) Balakrishnan, Bromiley

Introduction to concepts and techniques of strategic analysis and management used to create and implement a coherent concept of overall corporate direction. Strategy formulation and implementation at business unit and corporate levels. Takes international orientation.

**MBA 8305. The International Environment of Business.**

(2 cr; prereq MBA student) Jacque, Lenway

Dynamics of international business environment (institutions, markets, and sociocultural systems) and its impact on competitiveness of firms. Roles of and relationships with governments and sociopolitical systems, trade theories and policies, international monetary and financial systems.

**MBA 8315. The Ethical Environment of Business.**

(2 cr; prereq MBA student) Bowie, Maitland

Relationship of ethical management and the law. Implications for corporate profitability. Managing to maximize profits of shareholders vs. managing to harmonize interests of various stakeholders. Workplace safety, product liability, the environment, regulation, and fiduciary obligations to shareholders.

**MBA 8325. Organizations and the Management of Change.**

(2 cr; prereq MBA student) Sutcliffe, Van de Ven

Structure and functioning of complex organizations and of organizational change processes. Development of managerial ability to effectively influence organizational situations.

**MBA 8335. Managing for Quality and Continuous Improvement.**

(2 cr; prereq MBA student)

Theory and practice of quality management and continuous improvement. Incorporation of issues of quality improvement in business strategy, customer requirements, organizational design, process and product design and control, and management of products and services in the field.

**MBA 8500. Field Consulting Project.**

(6 cr; prereq MBA student; offered in day MBA program only)

Interdisciplinary team approach to formulation and execution of a study of an actual business problem. Teams work on problems currently faced by business, nonprofit, and government organizations in the Twin Cities metropolitan area.

**MBA 8600. Top Management Perspectives.**

(2 cr; prereq MBA student)

Brings students face-to-face with leading executives and entrepreneurs from throughout the nation. Values, attitudes, and skills for leadership. How personal characteristics and beliefs of leaders shape situations.

**Operations and Management Science (OMS)****OMS 5155. Methods for Quality and Productivity Improvement.**

(4 cr, §DSci 5055; prereq 1020 or MBA 8020 or #, mgmt or grad mgmt student)

Statistical methods for on-line and off-line quality control. Quality management philosophy, Pareto analysis, control charts, experimental design, and sampling inspection. Applications to administrative, service, and production operations.

**OMS 5170. Simulation Modeling.**

(4 cr; prereq MBA student, Grad Sch Mgmt approval)

Survey of probabilistic modeling, with emphasis on computer simulation of complex systems. Event-scheduling simulation models, process-interaction simulations using high-level simulation language, structural and quantitative simulation modeling, overview of simulation methodological issues, animation. Use of computers and various languages to carry out actual simulation studies. Business applications.

**OMS 5180. Reliability Design and Analysis.**

(4 cr; prereq MBA student, Grad Sch Mgmt approval)

Fundamental aspects of reliability theory and practice. Designing reliability into products or systems via probabilistic modeling and analysis, and development of cost-efficient, life-testing procedures for analysis of lifetime data.

**OMS 5850. Topics in Operations and Management Science.**

(4 cr; prereq 1020, 3000 or #, MBA student, Grad Sch Mgmt approval)

Topics may vary quarterly.

**OMS 8041. Project Management.**

(4 cr, §OM 8041; prereq 3000 or MBA 8050 or #, grad mgmt student or Grad Sch Mgmt approval)

Planning and executing projects; product and system development. Creating development strategy and project plans, tools, and methods for effective cross-functional integration such as QFD and DFM. Project scheduling techniques such as PERT/CPM, effective prototyping, organizing and leading project teams. Examples from manufacturing, software, and service industries.

**OMS 8051. Management of Service Operations.**

(4 cr; prereq 3000 or MBA 8050 or #, grad mgmt student or Grad Sch Mgmt approval)

Decision making for producing services and improving service firm productivity and quality. Service output measurement, defining customer contact, service classification, designing service delivery systems, capacity management in service firms, service automation, and service quality improvement. Lectures and case studies.

**OMS 8056. Production and Inventory Management.**

(4 cr, §OM 8056; prereq 3000 or MBA 8050 or #, grad mgmt student or Grad Sch Mgmt approval)

Inventory planning, production planning, Materials Requirement Planning (MRP), Just-In-Time concepts, finite loading systems, distribution systems, forecasting, master scheduling, capacity management, production activity control, and purchasing. Taught from planning and control systems viewpoint with managerial orientation.

**OMS 8057. Process, Technology, and Innovation in the Operations Function.**

(4 cr, §OM 8057; prereq 3000 or MBA 8050 or #, grad mgmt student or Grad Sch Mgmt approval)

Comparison of different operations process types; fundamental management problems in each type, including importance of process technology choice, innovation, and future technological advances. Case studies used in conjunction with lectures.

**OMS 8058. Operations Strategy.**

(4 cr, §OM 8058; prereq 3000 or MBA 8050 or #, grad mgmt student or Grad Sch Mgmt approval)

Integrated view of operations function within an organization, with focus on decision making and policy from chief operations manager perspective. Structural and infrastructure decisions. Managing operations for competitive advantage. Cases and lectures.

**OMS 8059. Quality Management.**

(4 cr, §OM 8059; prereq 3000 or MBA 8050 or #, grad mgmt student or Grad Sch Mgmt approval)

Managing quality improvement within service and manufacturing organizations, including establishing culture and strategy for quality, quality costs, process analysis, statistical process control, customer/supplier management, quality control, and organization for quality. Taught from managerial perspective. Lectures, demonstrations, and cases.

**OMS 8650. Regression Analysis.**

(4 cr, §DSci 8650; prereq MBA 8020 or equiv or #)

Regression and correlation models, inferences in simple and multiple regression, multicollinearity, indicator variables, variable selection techniques, assumption violation treatment, applications to management problems, introduction to logistic regression and other advanced topics.

**OMS 8651. Experimental Design.**

(4 cr, §DSci 8651; prereq 8650 or #)

Variance analysis for one-way, two-way, and multi-way data. Basic statistical design concepts and result analysis. Randomized block, latin square, cross-over, factorial designs, confounding; estimation and effect comparison; response surfaces; applications to management.

**OMS 8660. Linear Programming.**

(4 cr; prereq 5160 or equiv or #)

Revised simplex, primal-dual, and large-scale methods, including decomposition and partitioning and methods for bounded variables.

**OMS 8662. Combinatorial Optimization.** (4 cr; prereq 8660 or #; offered alt yrs)  
Solution techniques for class of optimization problems characterized by an optimal solution drawn from a finite or countably infinite set of feasible solutions. Such problems can be formulated in general as integer programs. Specialized solution techniques, such as for network flow, matching, and matroid problems, and more general solution techniques, such as cutting plane methods and enumeration methods (e.g., dynamic programming and branch-and-bound). Theory of NP-Completeness as classification scheme for computational complexity of such problems.

**OMS 8670. Stochastic Modeling and Analysis.** (4 cr, §DSci 8670; prereq Stat 5122 or #; offered alt yrs)  
Probabilistic modeling of dynamic process, including Markov chains; Poisson, renewal, and continuous-time Markov processes; queuing models. Statistical estimation of selected models; applications to managerial problems, such as brand shift, industrial migration, manufacturing, and computer/communications networks.

**OMS 8671. Simulation Analysis.** (4 cr, §DSci 8671; offered alt yrs)  
Treatment of underlying probabilistic and statistical aspects of computer simulation. Random number generators, variate and process generation, statistical analysis of simulation output, ranking and selection of simulation models, and variance reduction techniques.

**OMS 8680. Queueing Theory: A Computational Approach.** (4 cr; prereq 8670; offered alt yrs)  
Theory of Stochastic Service Systems (theory of queues) from an algorithmic point of view. Prepares students to model and analyze complex stochastic service systems via classical methods and algorithmic methods and approximations.

**OMS 8710. Research in Operations Strategy.** (4 cr; prereq PhD student or #; offered alt yrs)  
Operations performance, competitive advantage, focused factory, product and process innovation, operations strategy implementation. Research results and methods.

**OMS 8720. Management of Technological Operations.** (4 cr; prereq PhD student or #; offered alt yrs)  
Theories and models used to address problems of managing technological operations and operations in manufacturing and service firms. Technology strategy, economic/organizational perspectives on technology, productivity analysis, technology evaluation, project selection and evaluation, learning, etc.

**OMS 8730. Research On Scheduling.** (4 cr; prereq 5160, PhD student or #; offered alt yrs)  
Literature and research methods in aggregate planning, scheduling, routing, sequencing, and dispatching in manufacturing and service industries. Advanced research papers and methods discussed.

**OMS 8735. Operations Forecasting and Inventory Research.** (4 cr; prereq PhD student or #; offered alt yrs)  
Research on forecasting, inventory control, Materials Requirement Planning (MRP), Just-In-Time manufacturing, and related subjects. Research studies and methods discussed.

**OMS 8745. Research On Quality Management.** (4 cr; prereq PhD student or #; offered alt yrs)  
Examination of research literature, methods, and results. Research on quality strategy, economics of quality, statistical process control, vendor management, statistical process control, off-line quality, and quality practice.

**OMS 8799. Seminar: Operations and Management Science.** (4 cr)  
Examination of current literature and research methods. Topics vary according to faculty and student interest.

**OMS 8850. Topics in Operations and Management Science.** (4 cr, §OM 8850; prereq MBA 8050, MBA 8020 or #, grad mgmt student or Grad Sch Mgmt approval)  
Seminar providing broad range of state-of-the-art topics.

**OMS 8990. Readings in Operations and Management Science.** (Cr ar, §OM 8990; prereq #, Grad Sch Mgmt approval)

**OMS 8995. Graduate Research in Operations and Management Science.** (Cr ar; prereq #, Grad Sch Mgmt approval)

## Business Taxation

See Business Administration.

## Cell and Developmental Biology

See Molecular, Cellular, Developmental Biology and Genetics.

## Cellular and Integrative Physiology (Phsl)

*Professor:* Robert F. Miller, *head*; Peter B. Bitterman; Dwight A. Burkhardt; Frank B. Cerra; Joseph DiSalvo<sup>1</sup>; Timothy J. Ebner; John E. Foker; Esther M. Gallant; Robert P. Heibel; Lois J. Heller<sup>1</sup>; Thomas H. Hostetter; Hon Cheung Lee; Arthur S. Leon; David G. Levitt; Walter C. Low; Eric A. Newman; Scott M. O'Grady; Richard E. Poppele; Richard L. Purple

*Associate Professor:* Stephen A. Katz, *director of graduate studies*; Edwin W. Haller<sup>1</sup>, *associate director of graduate studies*; W. Dale Branton; Janet M. Dubinsky; William C. Engeland; Jurgen Fohlmeister; Costantino Iadecola; Paul A. Ialzo; David H. Ingbar; David Mohrman<sup>1</sup>; John W. Osborn; Winfried A. Raabe; Edward K. Stauffer<sup>1</sup>; O. Douglas Wangensteen; Lorentz E. Wittmers, Jr.<sup>1</sup>

<sup>1</sup> University of Minnesota, Duluth

*Assistant Professor:* Vincent A. Barnett; Linda M. Boland; LaDora V. Thompson

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Physiology is the application of mathematics, physics, and chemistry to the study of structure and function in living systems. This interdisciplinary program emphasizes a quantitative approach to understanding normal and abnormal functions of cells, organs, and organ systems in humans and other animals. Twin Cities faculty members are from the Department of Physiology, other basic science departments in the Medical School and College of Veterinary Medicine, and clinical departments in the Medical School. Duluth faculty members are from the Department of Medical and Molecular Physiology of the Duluth School of Medicine. Research possibilities for students range from molecular to organ system studies, with opportunities for learning and applying modern techniques of organ, cell, and molecular physiology.

The Ph.D. program typically requires four to five years. In the first two years, students take core courses that provide a broad background in molecular, cell, and organ physiology. Supporting work may be from any of several disciplines, including but not limited to, biochemistry, cell and molecular biology, computer science, engineering, mathematics, and physics. Individualized programs are structured so each student can build a core of commonly required knowledge as well as strengths for particular areas of research. By the start of the second year, students must choose an adviser and begin laboratory work. A preliminary written examination is taken after the end of the first year. A preliminary oral thesis proposal is prepared after the second year when coursework has been completed and a plan for thesis research has been formulated. Specialty areas of this program include membrane and epithelial transport, ion channels, signal transduction, contractile processes, renal and cardiovascular integration, and neurophysiology, with emphasis on motor systems, vision, and computational neuroscience.

**Prerequisites for Admission**—For the major, an undergraduate degree with at least one year (three quarters or two semesters) of calculus, one year of physics, one year of biology, and two years of chemistry. For the minor, a background in mathematics, physics, chemistry, and biology acceptable to the graduate faculty.

**Special Application Requirements**—For the Ph.D., applicants must take either the General Test of the Graduate Record Examination or the Medical College Admission Test. For all applicants, three letters of recommendation must be submitted. Admission is generally in fall quarter.

**Master's Degree Requirements**—A one-year core academic program is offered in cellular and human physiology. Programs are thereafter individualized to meet the needs of each student.

**Doctoral Degree Requirements**—The two-year core sequence consists of courses in cell and molecular biology, cell physiology, medical physiology, and medical neuroscience. Substitution or waiver of these requirements is possible upon petition to and concurrence by the graduate program executive committee. Supporting work is individualized to meet the needs of each student.

**Language Requirements**—None, although all students are expected to gain a solid background in the use of computers and in a computer language.

**For Further Information and Applications**—Contact the Department of Physiology, University of Minnesota, 6-255 Millard Hall, 435 Delaware Street S.E., Minneapolis, MN 55455 (612/625-5902). Additional information concerning the master's program is available by contacting the Associate Director of Graduate Studies, Department of Medical and Molecular Physiology, School of Medicine, University of Minnesota, 10 University Drive, Duluth, MN 55812 (218/726-8551).

**Phsl 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**Phsl 8888. Thesis Credits: Doctoral.** (36 cr required)

**Phsl 5100w. Systems Physiology.** (5 cr; prereq biochem, human anatomy; primarily for dental, pharmacy, med tech, nurse anesthetist students; not recommended for students who have taken 3051 or 3052 or 3053 or 3055 or 3056 or 5440 or 5441) Katz, staff Cell, general, endocrine, cardiovascular, respiratory, gastrointestinal, energy metabolism, and renal physiology.

**Phsl 5101s. Neuroscience for Dental**

**Students.** (1.5 cr; prereq biochem and human anatomy courses, ¶|CBN 5110 [1.5 cr] required; 3 lect and 3 lab hrs per wk)

Basic principles of nervous function examined through study of neuroanatomy and neurophysiology.

**Phsl 5110-5111. Human Physiology.** (3 cr for 5110, 4 cr for 5111; primarily for 1st-yr med students and grad students) Wangenstein, staff

**Phsl 5112. Human Neuroscience B.** (3 cr; prereq 1st-yr med or grad student; Anat 5111-Phsl 5112†) Eber, staff

**Phsl 5130-5131†. Intermediate Systems**

**Physiology.** (4 cr for 5130, 5 cr for 5131; prereq phsl grad student or #, physics, calculus, cell biol) Wangenstein, staff

Survey of systems physiology. Lectures and labs same as *Phsl 5110-5111*. Weekly discussion sessions.

**Phsl 5150. Introduction to Neuroscience.** (3 cr, §Biol 5150, §NSc 5150; prereq 3055-3056 or Biol 3011 or equiv, BioC 3021 or equiv or #)

Survey from invertebrates to humans. Ion channels and membrane currents, neurotransmitters and signal transduction, neuroanatomy, sensory and motor systems, learning and memory, emotion, disease states, neural networks, and development.

**Phsl 5201. Computational Neuroscience I:**

**Membranes and Channels.** (5 cr; prereq 5112 or equiv; 3 lect, 4 lab hrs per wk) Fohlmeister

Comprehensive examination of membrane and ion channels using UNIX work stations to simulate their properties. Includes Hodgkin-Huxley model, non-linear dynamic systems, voltage and ligand gated ion channels, and impulse propagation.

**Phsl 5202. Computational Neuroscience II:**

**Cells and Circuits.** (5 cr; prereq understanding of UNIX, 5201 or equiv) Miller, staff

Comprehensive investigation of computational properties of single neurons and locally connected cell networks. Linear cable theory, compartmental modeling of single neuron properties, spatio-temporal interactions between synaptic inputs in neuronal dendritic trees, computational properties of passive and active dendritic spines and spine clusters, quantitative interpretation of whole-cell voltage-clamp data, and dynamics of locally connected cell networks.

**Phsl 5203. Computational Neuroscience III:**

**Neural Systems and Information Processing.** (5 cr; prereq 5202) Soechting

Quantitative examination of information processing by networks of neurons based on experimental data and theoretical models. Neural codes, neural network models and information processing, neural control systems, and computational maps.

**Phsl 5440f-5441w. Quantitative Physiology.**

(3 cr; prereq 1 yr each of college chem, physics, math through integral calculus) Levitt, staff

Diffusion, surface tension, and mechanics of respiration, circulation, digestion, and locomotion. Chemical aspects of blood, respiration, renal function, nutrition, and metabolism. Endocrine, sensory, neuromuscular, and central neural functioning.

**Phsl 5444s. Muscle Contraction.** (3 cr, §MdBc 5444; prereq undergrad biochem or physiology courses, #)

Introduction to physiology, biochemical regulation, and physical chemistry of muscle contraction.

**Phsl 5460-5461. Cellular and Molecular**

**Neuroscience.** (3 cr per qtr; for 5460: §GCB 5460, §MdBc 5460, §NSc 5460, §Phcl 5460, §VPB 5460; for 5461: §GCB 5461, §MdBc 5461, §NSc 5461, §Phcl 5461, §VPB 5461; prereq biochem)

Gene structure and regulation, cloning and molecular strategies for studying gene function, ion channels and membrane excitability, synaptic transmission, receptor structure and function, and signal transduction.

**Phsl 8113f,w,s,su. Problems in Physiology.**

(Cr and hrs ar; prereq #)

Topics assigned for readings or lab study; conferences.

**Phsl 8202.\* Readings in Physiology.** (Cr and hrs ar)

Topics selected for each student; written reviews prepared and discussed.

**Phsl 8203.\* Research in Physiology.** (Cr and hrs ar)

**Phsl 8211.<sup>1</sup> Selected Topics in Heart and**

**Circulation.** (2-4 cr; prereq 5130-5131 or equiv or #) Heller, Mohrman, staff

One or more seminars in advanced physiology of heart and circulation.

**Phsl 8300. Cellular and Molecular**

**Physiology.** (4 cr; prereq GCB 5035, GCB 8148, GCB 8149 or equiv or #) Branton, Lee, Levitt, Miller, Newman, O'Grady

Contemporary concepts and developments in mechanisms of signal transduction, ion channel, and transport processes. Cellular and molecular approaches. Lectures, readings, and discussion.

**Phsl 8316. Current Topics in Cellular and Molecular Physiology.** (1 cr; prereq #)

Topics vary quarterly.

For additional graduate course listings, please consult the *Duluth Bulletin*.

<sup>1</sup> Students should consult the department for offerings during any specific quarter.

## Chemical Engineering and Materials Science and Engineering

### CHEMICAL ENGINEERING

*Regents' Professor:* Rutherford Aris; L. Edward Scriven

*Professor:* Matthew V. Tirrell, *head*; Lanny D. Schmidt, *director of graduate studies*; Frank S. Bates; Robert W. Carr, Jr.; Barry C. Carter; James R. Chelikowsky; Edward L. Cussler; John S. Dahler; H. Ted Davis; D. Fennell Evans; Michael C. Flickinger (biochemistry); Arnold G. Fredrickson; Christie J. Geankoplis; William W. Gerberich; Wayne L. Gladfelter (chemistry); Wei-Shou Hu; Timothy P. Lodge (chemistry); Christopher W. Macosko; Wilmer G. Miller (chemistry); David A. Shores; William H. Smyrl; Tayfun E. Tezduyar (aerospace engineering and mechanics); Michael D. Ward; John H. Weaver

*Associate Professor:* Jeffrey J. Derby; Lorraine F. Francis; Alon V. McCormick; Christopher J. Palmstrom; John M. Sivertsen; Friedrich Srien; Robert T. Tranquillo

*Assistant Professor:* Prodromos Daoutidis; C. Daniel Frisbie; J. Ilja Siepmann (chemistry); Renata M. M. Wentzcovitch

### MATERIALS SCIENCE AND ENGINEERING

*Regents' Professor:* Rutherford Aris; L. Edward Scriven

*Professor:* William W. Gerberich, *associate head*; Michael D. Ward; *director of graduate studies*; Frank S. Bates; Robert W. Carr, Jr.; Barry C. Carter; James R. Chelikowsky; Philip I. Cohen (electrical engineering); Edward L. Cussler; E. Dan Dahlberg (physics); John S. Dahler; H. Ted Davis; D. Fennell Evans; Arnold G. Fredrickson; Wayne L. Gladfelter (chemistry); Allen M. Goldman (physics); J. Woods Halley (physics); Shun-ichiro Karato (geology and geophysics); David L. Kohlstedt (geology and geophysics); Timothy P. Lodge (chemistry); Christopher W. Macosko; Wilmer G. Miller (chemistry); Marshall I. Nathan (electrical engineering); Emil Pfender (mechanical engineering); Dennis L. Polla (electrical engineering); Hermann Schmalzried; Lanny D. Schmidt; David A. Shores; William H. Smyrl; James H. Stout (geology and geophysics); Tayfun E. Tezduyar (aerospace engineering and mechanics); Matthew V. Tirrell; John H. Weaver

*Adjunct Professor:* Daniel M. Kroll (medicinal chemistry)

*Associate Professor:* Jeffrey J. Derby; Alfonso Franciosi; Lorraine F. Francis; Alon V. McCormick; Christopher J. Palmstrom; John M. Sivertsen; Robert T. Tranquillo

*Assistant Professor:* Prodromos Daoutidis; C. Daniel Frisbie; J. Ilja Siepmann (chemistry); Renata M. M. Wentzcovitch

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Chemical Engineering: M.Ch.E., M.S.Ch.E. (Plan A only), and Ph.D.; Materials Science and Engineering: M.Mat.S.E., M.S.Mat.S.E. (Plan A only), and Ph.D.

**Curriculum**—Emphases are available in colloids, interfaces, microelectronic materials, ceramics, polymers, molecular materials, nanostructures and nanocomposites, organic solid state chemistry, catalysis, surface chemistry and physics, chemical kinetics, molecular theory of rate processes, thermodynamics, chemical reactor analysis, control and optimization, fluid and interfacial mechanics, crystal growth, bioengineering, molecular interfaces, interface chemistry and physics, physical and chemical metallurgy, metal physics, electronic properties of materials, electronic structure theory, superconductivity, electrochemistry, corrosion, rheology, structure-property relationships, electron microscopy, scanning tunneling microscopy, and atomic force microscopy.

**Prerequisites for Admission**—A bachelor's degree in chemical engineering, materials science, metallurgy, polymer engineering, chemistry, physics, or electrical engineering is required. Applicants may be accepted without this prerequisite, but may be required to complete additional preparatory studies prescribed by their adviser or the director of graduate studies after admission.

**Special Application Requirements**—Three letters of recommendation are required. Graduate Record Examination scores are required for students with degrees in other disciplines and are strongly recommended for all applicants. Deadline for application is February 1; late applications are considered if space is available.

**Master's Degree Requirements**—For the M.S.Ch.E. and M.S.Mat.S.E. degrees, see the General Information section of this bulletin. For the M.Ch.E. and M.Mat.S.E. degrees, 28 credits, of which 20 must be in the major field, plus a work-related project, are required. A final oral examination is required for all master's degrees.

**Doctoral Degree Requirements**—The Ph.D. program requires 45 credits in the major (including up to 9 seminar credits) and 21 to 23

credits in the minor or supporting program. If a minor is chosen instead of a supporting program, the field is generally mathematics, physics, chemistry, or electrical engineering.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Department of Chemical Engineering and Materials Science, University of Minnesota, 151 Amundson Hall, 421 Washington Avenue S.E., Minneapolis, MN 55455 (612/625-0382).

**ChEn 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**ChEn 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**ChEn 8888. Thesis Credits: Doctoral.** (36 cr required)

**MatS 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**MatS 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**MatS 8888. Thesis Credits: Doctoral.** (36 cr required)

## Chemical Engineering (ChEn)

**ChEn 5001. Computational Methods in Chemical Engineering and Materials Science.** (4 cr; §MatS 5001; prereq ChEn or MatS major; 3 lect, 1 computer lab hrs per wk)

Introduction to analysis of representative chemical engineering problems by computer and mathematical methods.

**ChEn 5101. Principles of Chemical Engineering I.** (4 cr; prereq 5001 or ¶5001, IT student; 3 lect, 2 rec hrs per wk)  
Energy and material balances applied to chemical engineering systems.

**ChEn 5102. Principles of Chemical Engineering II.** (4 cr; prereq 5001, 5101; 3 lect, 2 rec hrs per wk)  
Fluid dynamics and its application to chemical engineering unit operations.

**ChEn 5103. Principles of Chemical Engineering III.** (4 cr; prereq 5102, upper div ChEn or MatS major; 3 lect, 2 rec hrs per wk)  
Heat and mass transfer and their application to chemical engineering unit operations.

**ChEn 5104. Unit Operations and Separation Processes.** (4 cr; prereq 5101, upper div ChEn or MatS major; 3 lect, 2 rec hrs per wk)  
Absorption, extraction, distillation, stagewise and continuous separations.

**ChEn 5201. Thermodynamics and Materials States.** (4 cr; prereq 5001, 5101, Chem 5534, upper div ChEn or MatS major; 3 lect, 2 rec hrs per wk)  
Principles of thermodynamics applied to closed and open systems and to equilibrium states of homogeneous and heterogeneous substances, gases, liquids, and solids.

**ChEn 5202. Chemical Engineering Thermodynamics and Kinetics.** (4 cr; prereq 5201, upper div ChEn or MatS major; 3 lect, 2 rec hrs per wk)  
Chemical equilibrium and chemical kinetics applied to chemical engineering systems.

**ChEn 5301. Chemical Reactor Analysis.** (4 cr; prereq 5202, upper div ChEn or MatS major; 3 lect, 2 rec hrs per wk)  
Principles of reactor design for homogeneous and heterogeneous reactions. Analysis of reactors from a kinetic and thermodynamic point of view.

**ChEn 5302. Applied Reactor Analysis.** (4 cr; prereq 5301 or equiv)  
Treatment of practical chemical reaction systems and the reactors for them. Catalysis and its role in chemical industry. Analysis of functioning chemical reaction systems such as ammonia synthesis, polymerization reactors, combustion, sulfur dioxide removal systems.

**ChEn 5401. Chemical Engineering Laboratory.** (2 cr; prereq 5102, ¶5103, upper div ChEn or MatS major; 4 lab, 1 conf hrs per wk)  
Applications of unit operations; principles of fluid flow, heat and mass transfer; experiments with reports.

**ChEn 5402. Chemical Engineering Laboratory.** (4 cr; prereq 5103, upper div ChEn or MatS major; 4 lab, 1 lect, 1 conf hrs per wk)  
Continuation of 5401.

**ChEn 5501. Process Evaluation and Design.** (4 cr; prereq 4th yr or #, upper div ChEn or MatS major; 3 lect, 3 design lab hrs per wk)  
Dynamics of chemical engineering industries, economics of process evaluation, bases for cost estimations. Plant designs prepared and compared with actual installation. Special applications of unit operations, reaction kinetics, and thermodynamics.

**ChEn 5502. Process Evaluation and Design.** (4 cr; prereq 5501 or #, upper div ChEn or MatS major; 3 lect, 2 lab hrs per wk)  
Computer-aided design of unit operations, chemical reactors and integrated plants; operability characteristics of chemical processes; design for optimum operability (safety, reliability, control).

**ChEn 5601. Process Control.** (4 cr; prereq 4th yr or #, upper div ChEn or MatS major; 3 lect, 2 rec hrs per wk)  
Elementary theory of control and its application to chemical processes. Synthesis of feedback control loops for linear systems.

**ChEn 5603. Process Control.** (3 cr; prereq 5601 or #; 3 lect hrs per wk)  
Advanced topics in chemical process control; synthesis.

**ChEn 5604. Process Control Laboratory.** (2 cr; prereq 5601)

Experiments that illustrate and apply control theory. Measurement techniques, calibration, tuning of controls, characterization of sensors and control circuits.

**ChEn 5640. Polymerization Reactor**

**Engineering.** (4 cr [available to grads for 3 cr]; prereq chemical engineering reactor design course or #; 3 lect hrs, 1 lab hr ar per wk)

Introduction to analysis and design of polymerization reactors. Topics include mathematical modeling techniques, chain-growth and step-growth polymerization, copolymerization, molecular weight distributions, composition and sequence distributions. Emphasis on application of results.

**ChEn 5751. Chemical Engineering in Biotechnology and Environment.** (3 cr; prereq ChEng sr or grad student or #; 3 lect hrs per wk)

Chemical engineering principles applied to biological systems and to analysis and design of complex cellular and enzyme processes, such as production of proteins, synthesis of antibodies, and degradation of toxic compounds.

**ChEn 5753. Biochemical Engineering III.** (3 cr; prereq Biol 5001, ChEng sr or grad student or #; 3 lect hrs per wk)

Description and analysis of methods for separation of biochemical products of cellular and enzyme activity; applications to process synthesis.

**ChEn 5754. Food Processing Technology.**

(4 cr; prereq 5103 or #; 3 lect hrs per wk)

Heat transfer in food processing; protein processing; financial evaluation of projects; case studies; discussions of marketing, government regulation, nutrition.

**ChEn 5756. Biochemical Engineering**

**Laboratory.** (2 cr; prereq 5751 or 5752; 4 lab hrs per wk)

Microbial growth, biochemical product formation, isolation, purification, and medium sterilization.

**ChEn 5757. Principles of Artificial Internal Organ Design.** (3 cr; prereq #; 3 lect hrs per wk)

Survey of artificial internal organs important in the maintenance of homeostasis; emphasis on general principles and particular problems of design including blood compatibility, access, and alternative approaches to replacing natural organ function.

**ChEn 5761. Science and Technology of Porous Media.** (3 cr; 3 lect hrs per wk)

Fundamentals of porous media structures and of flow, transport, and deformation in them. Relations of macroscopic properties and behavior to underlying microscopic structures and mechanisms. Examples from nature and technology, with reference to in situ processing and enhanced recovery.

**ChEn 5771. Colloids and Dispersions.** (3 cr; prereq physical chem; 3 lect hrs per wk)

Preparation, stability, and coagulation kinetics of colloidal solutions. DLVO theory, electrokinetic phenomena, and properties of micelles and other microstructures.

**ChEn 5774. Interfacial Phenomena of**

**Liquids.** (3 cr; prereq physical chem, 5012 or equiv)

Surface tension, surface geometry and capillarity, thin-films and disjoining pressure, contact angle; capillarity-driven and surface tension gradient-driven flows; wetting, spreading, dewetting, retraction; surfactant effects; fluid displacement, detergency, flotation, dynamic wetting, entrainment, adhesion. Examples from science and technology.

**ChEn 5780. Principles of Mass Transfer in Engineering and Biological Engineering.** (3 cr; prereq upper div engineering or science student; 3 lect hrs per wk)

Mass transfer in gases, liquids, biological and macromolecular solutions, gels, solids, membranes, capillaries, and porous solids. Interaction between mass transfer and chemical reaction. Applications in biological, environmental, mineral, chemical engineering systems.

**ChEn 5810. Processing of Electronic Materials.**

(3 cr; prereq MatS 5011 or #; 3 lect hrs per wk)

Materials science and chemical engineering aspects of processing of materials for microelectronic devices (e.g., semiconductor memories and microprocessors) and optical devices (e.g., semiconductor lasers and optical waveguides).

**ChEn 5902, 5903, 5904, 5905. Special Problems.** (Cr ar)

Investigations in chemical engineering. Library or lab research.

**ChEn 8004, 8005. Physical Rate Processes.**

(3 cr per qtr; prereq 5103, #)

Heat and mass transfer. Mechanisms of heat and mass transport. Derivations of equations of change for energy and individual chemical species. Application to selected problems in unsteady state heat and mass transport, forced and free convection, coupled transport, and conic diffusion.

**ChEn 8101. Intermediate Fluid Mechanics.**

(3 cr; prereq 5103, #)

Derivation of equations of change; analysis of statics, kinematics, and dynamics of viscous fluids; survey of rectilinear, boundary-layer, creeping, inviscid, irrotational, and other flow approximations; representative problems with emphasis on chemical engineering applications.

**ChEn 8102. Problems in Fluid Mechanics.**

(3 cr; prereq 8101)

Application of principles to prototypal cases of flow and transfer. Problem solving and critical analysis of literature of physicochemical fluid mechanics.

**ChEn 8104. Interfaces and Interfacial Phenomena.** (3 cr; prereq 8101; offered alt yrs)

Theory of boundary conditions. Equilibrium and dynamics of fluid interfaces. Analysis of surface tension-driven motions and other interfacial phenomena.

**ChEn 8105. Principles and Applications of Rheology.** (3 cr; prereq 8101, 8103; offered alt yrs)

Deformation and flow of non-Newtonian and viscoelastic fluids, plastic materials, and perfectly elastic solids. Phenomenological and molecular interpretation of rheology of elastomers, polymer melts and polymer solutions, application of rheology to polymer processing.

**ChEn 8201-8202-8203. Advanced Mathematics for Chemical Engineers.** (3 cr per qtr; prereq #)

Elements and applications of linear algebra. Intermediate level treatment of linear ordinary and partial differential equations. Eigenvalue problems and generation of finite Fourier transforms of general type. Elementary functional analysis. First order partial differential equations and sometime perturbation methods.

**ChEn 8301-8302. Physical and Chemical Thermodynamics.** (3 cr per qtr; prereq 5202 or #)

Principles of thermodynamics and applications to phase equilibria and chemical equilibria, especially in flow systems, with examples drawn from applied chemistry, chemical engineering, and materials science.

**ChEn 8401. Chemical Reaction Kinetics—Kinetics of Homogeneous Reactions.** (3 cr; prereq #)

Description and characterization of reacting systems. Theory of elementary reactions. Energy transfer and relaxation in gases. Methods of elucidating the reactions of highly reactive transient intermediates.

**ChEn 8402. Chemical Reaction Kinetics—Surface Chemistry.** (3 cr; prereq #)

Atomistics of adsorption and reaction on solid surfaces. Discussion of modern techniques for characterization of surfaces such as AES, LEED, UPS, XPS, SEM, and TEM. Principles of heterogeneous catalysis and survey of important existing and developing catalytic processes.

**ChEn 8403. Chemical Reaction Kinetics—Advanced Topics.** (3 cr; prereq #)

**ChEn 8408. Nuclear Magnetic Resonance Principles for Chemical Engineering and Materials Science.** (3 cr)

Techniques and examples of nuclear magnetic resonance. NMR physics: classical, quantum, density matrix formalism, equations of change. Theory of NMR parameters: chemical shift, various relaxation rates, quadrupole coupling constant, dipole coupling constant, J-coupling. Diffusion and imaging techniques. Applications in chemical engineering and materials science.

**ChEn 8500. Intermediate Chemical Reactor Analysis.** (3 cr)

Survey of the analysis of chemical reactions and reactors. Steady state design and optimality. Transient behavior and stability problems.

**ChEn 8601-8602-8603. Molecular Theory of Equilibrium and Nonequilibrium Processes.** (3 cr per qtr)

Theory and interpretation in terms of molecular scale processes of (a) structure and thermodynamic properties of homogeneous and inhomogeneous systems at equilibrium (8601-8602) and (b) transport phenomena and theory of irreversible processes (8602-8603). Major emphasis on fluids.

**ChEn 8701. Analysis of Chemical Engineering Problems.** (3 cr; prereq 8203)

Critical analysis of current chemical engineering literature.

**ChEn 8702. Advanced Topics in Chemical Engineering.** (1-3 cr per qtr)

**ChEn 8703. Process Control.** (3 cr; prereq 5601 or #; 3 lect hrs per wk)

Advanced topics in chemical process control; synthesis of control structures; multivariable control schemes; optimal control and estimation; computer-aided real-time process control.

**ChEn 8774. Interfacial Phenomena of Liquids.** (3 cr; prereq physical chem, 8101 or equiv) Scriven

Surface tension, surface geometry and capillarity, thin-films and disjoining pressure, contact angle; capillarity-driven and surface tension gradient-driven flows; wetting, spreading, dewetting, retraction; surfactant effects; fluid displacement, detergency, flotation, dynamic wetting, entrainment, and adhesion. Examples from science and technology.

**ChEn 8801, 8802, 8803. Seminar.** (1 cr per qtr)

Presentation and discussion of papers concerning the newer developments in chemical engineering.

**ChEn 8810. Processing of Electronic Materials.** (3 cr; prereq MatS 5011 or #; 3 lect hrs per wk)

Materials science and chemical engineering aspects of processing of materials for microelectronic devices (semiconductor memories, microprocessors) and optical devices (semiconductor lasers, optical wave guides).

**ChEn 8850. General Survey of Chemical Engineering.** (1 cr)

Independent reading under staff guidance.

**ChEn 8901, 8902, 8903. Research in Chemical Engineering.** (Cr ar)

Heat and mass transfer, fluid dynamics, chemical kinetics, chemical reactor theory, thermodynamics, process control, bioengineering, applied mathematics.

**Materials Science and Engineering (MatS)**

**MatS 5011. Introduction to the Science of Materials.** (4 cr; prereq upper div ChEn or MatS major; 3 lect and 2 rec hrs per wk)

Introduction to materials. Metals, polymers, ceramics, glasses, composites, electronic and magnetic materials.

**MatS 5012. Introduction to Dislocations and Physical Metallurgy.** (4 cr; prereq upper div IT standing, 5011 or #; 3 lect, 1 rec hrs per wk)

Basis of work hardening, solid solution strengthening, precipitation hardening and heat treatment of alloys.

**MatS 5013. Introduction to Electrical and Magnetic Properties of Materials.** (4 cr; prereq upper div IT standing, 5011 or #; 3 lect, 1 rec hrs per wk)

Introduction to quantum mechanics and semi-quantitative theories of electrical and magnetic properties of solids.

**MatS 5101. Thermodynamics of Solids.** (4 cr; prereq Chem 5534 or #; 3 lect, 1 rec hrs per wk)  
Fundamental concepts, 1st and 2nd laws, free energy, equilibrium constant, fugacity and activity relationships, solution models, order-disorder.

**MatS 5102. Diffusion and Solid State Kinetics.** (4 cr; prereq 5101 or #, upper div IT standing; 3 lect, 1 rec hr per wk)  
Kinetics: quantitative relationship between rate of reaction and reactant concentration. Diffusion: interstitial and substitution diffusion, steady-state and transient systems.

**MatS 5112. Ceramics.** (4 cr; prereq 5102 or #; 3 lect, 1 rec hrs per wk)  
Introduction to ceramics, including glasses. Crystalline and non-crystalline structures; phase relations; ternary phase diagrams; mechanical, thermal, electrical, magnetic, and optical properties of ceramics.

**MatS 5200. Optical and Electron Microscopy of Solids.** (4 cr; prereq upper div IT standing, 3400 or #; 2 lect, 3 lab hrs per wk)  
Practical experience in materials and techniques of evaluation. Investigation of microstructure using optical metallography. Use of transmission electron microscopy, scanning electron microscopy, and elemental microanalysis for metallurgical systems.

**MatS 5202. X-Ray Structural Analysis.** (4 cr; prereq upper div IT standing; 1 lect, 1 rec, 5 lab hrs per wk)  
Geometry of crystals; properties and diffraction of X-rays; single crystal Laue methods and powder techniques; crystal structure determination; structure of polycrystals; single crystal orientation; crystal texture; precision lattice parameter measurements; chemical analysis; stress measurements; radiography.

**MatS 5304. Failure Analysis.** (4 cr; prereq 3400, 5013, 5411 or #; 2 lect, 4 lab hrs per wk)  
Embrittlement, wear, corrosion, integrated circuit breakdown, vibration, and fatigue. Analysis of failure using metallographic, electron microscopy, and microanalytic techniques.

**MatS 5411. Materials Design.** (4 cr; prereq sr MatS major; 3 lect, 1 rec hrs per wk)  
Mechanical and thermal processing with applications to forging, extrusion, rolling; advanced topics on heat treatment of steel, titanium and aluminum alloys, and materials for microelectronic applications. Materials selection based on cost and design function.

**MatS 5450. Corrosion and Electrochemistry of Corrosion.** (4 cr; prereq IT upper div, 5101 or #; 3 lect, 2 lab hrs per wk)  
Electrochemical thermodynamics, Butler-Volmer equation, electrochemical kinetics, theory of corrosion, passivation, inhibition, forms of corrosion, environmental degradation of mechanical properties, cathodic and anodic protection.

**MatS 5455. Electrochemical Engineering.** (4 cr; prereq upper div IT, grad student or #; 4 lect hrs per wk)  
Fundamentals of electrochemical engineering. Topics include electrokinetics, thermodynamics of cells, batteries, fuel cells, electrosynthesis, and modern sensors.

**MatS 5460. Oxidation of Metals.** (4 cr; prereq 5102, upper div IT standing; 3 lect, 1 rec hrs per wk)  
Theory of high temperature oxidation of metals and alloys; oxidation in complex environments; practical applications and design criteria.

**MatS 5470. Corrosion and Electrochemistry of Homogeneous and Heterogeneous Surfaces.** (4 cr; prereq 5450 or 5460 or #; 3 lect, 1 rec hrs per wk)  
Transport and kinetic phenomena in corrosion processes. Wagner-Traud coupling of oxidation and reduction reactions on homogeneous and heterogeneous surfaces. Principles of current, potential, and concentration distribution modeling in general and localized corrosion.

**MatS 5481-5482-5483. Special Problems in Physical Metallurgy and Materials Science.** (Cr and hrs ar; prereq sr)  
Library or lab studies of scientific or engineering problems in physical metallurgy and materials science.

**MatS 5610. Polymer Chemistry I.** (4 cr; prereq upper div IT student, ChEn 3301 or ChEn 3331 or #; 3 lect, 3 lab hrs per wk)  
Polymer synthesis and physical chemistry: polymerization kinetics and reactors, molecular weight distribution, network formation, macromolecules in solution and their characterization, glassy and crystalline state, rubber elasticity, flow and viscoelasticity, environmental degradation.

**MatS 5613. Polymer Laboratory.** (2 cr; prereq 5610 or 5630 or ¶5630 or Chem 8611)  
Synthesis and characterization of molecular structure and properties of several polymers. Experiments include free radical copolymerization, copolymer ratio by IR, molecular size by SEC, crosslinking polymerization, solubility, swelling, crystallization kinetics, thermal transitions by DSC, viscoelasticity, rubber elasticity, tensile properties.

**MatS 5620. Processing of Polymers and Their Composites.** (4 cr [3 cr w/o lab by dept permission]; prereq heat transfer, fluid mechanics or #; 3 lect, 1 lab-rec hrs per wk)  
Polymer processing principles and applications: rheology of long chain molecules, flow in simple geometries, die design, mixing, thermal properties, heat transfer and phase change; thermoplastic operations—extrusion, forming, and molding; thermoset operations—fiber and particulate reinforced composite molding, pultrusion, and filament winding.

**MatS 5630. Polymer Physical Properties.** (4 cr; prereq 3400 or 5011, MatS/Chem 5610 or #; 3 lect, 1 open lab hrs per wk)  
Polymer structure-property relations: structure and morphology of the crystalline and amorphous state. Crystallization kinetics, vitrification and the glass transition, mechanical properties, failure, permeability, optical and electrical properties, polymer composites, effect of processing on properties.

**MatS 5820. Thin Films and Interfaces of Microelectronic Materials.** (3 cr; prereq 5013 or #; 3 lect hrs per wk)

Oxidation of Si; formation of interfaces, silicides, and multilayers; interface growth and morphology; thermodynamic and kinetic parameters of evolving interfaces; distribution of reaction products; fabrication of diffusion barriers; epitaxial overlayers; electrical and analytical techniques for characterization.

**MatS 8110. Fundamentals of Materials Science.** (3 cr)

Chemical bonding; perfect and imperfect crystals; defects; thermodynamics and kinetics; phase diagrams and phase transformation; diffusion; electronic structure of solids and electrical properties; semiconductor statistics.

**MatS 8112. Solid State Reactions.** (3 cr; prereq #)

The kinetics of phase transformations and processes such as oxidation and epitaxial layer formation are considered in the framework of modern concepts of nucleation and growth theory such as the theory of spinodal decomposition.

**MatS 8114. Symmetry and Scattering in Soft Materials.** (3 cr; 3 lect hrs per wk)

Theory and concepts of symmetry and structure in polymers and organic crystals. Role of symmetry in X-ray and neutron scattering. Point group and space group symmetries. Molecular origins for ordering in solids.

**MatS 8210. Structure-Property Relationships: Mechanical and Microelectronic.** (3 cr; prereq #)

Geometry and properties of metal crystals; electrical and thermal conductivity; Hall effect; optical properties; elastic and plastic behavior of metals; principles of microelectronic materials and devices.

**MatS 8213, 8214. Electronic Properties of Materials.** (3 cr per qtr; prereq #)

Basic physical theory of bonding in metals, alloys, and semiconductors. Crystal structures related to fundamental parameters. Band theory using free electron, tight binding, APW, KKR, pseudopotential, and other techniques. Experimental techniques for measuring electronic properties, including photoemission, Auger spectroscopy, and optical spectroscopy. Transport properties, microelectronic materials, metal-semiconductor interface phenomena, and other topics.

**MatS 8311. Theories of Mechanical Behavior of Solids.** (3 cr)

The theoretical analysis of the mechanical behavior of solids. Included are theories of work-hardening, recovery, creep, fatigue, and fracture. Fracture mechanics theories examined in lab exercises associated with compliance, strain-energy release rate, and J-integral techniques.

**MatS 8401. Transformations in Alloys and Origins of Microstructure.** (3 cr; prereq #)

Factors governing polycrystalline microstructures, including topology of two-dimensional and three-dimensional cellular arrays, nature of grain boundaries and interfaces, recovery, recrystallization and grain growth, allotropic transformation, eutectoid decomposition, martensitic transformations, precipitation reactions.

**MatS 8460. Oxidation of Metals.** (4 cr; prereq 5102 or #; 3 lect, 1 rec hrs per wk)

Theory of high temperature oxidation of metals and alloys; oxidation in complex environments; practical applications and design criteria.

**MatS 8470-8471-8472. Seminar: Materials Science and Engineering.** (Cr ar)**MatS 8480-8481-8482. Selected Topics in Materials Science and Engineering.** (Cr ar)**MatS 8520. Electron Diffraction and Electron Microscopy.** (3 cr)

Scattering of electrons by solids, mass thickness, and diffraction contrast. Kinematic theory of diffraction and image interpretation. Chemical and structural analysis by electron diffraction. X-ray energy microanalysis and secondary electron topography. Instruction in use of the TEM and SEM. Five lab exercises.

**MatS 8521. Topics in Electron Microscopy.** (3 cr)

(Continuation of 8520) Research projects using either scanning or transmission electron microscopy. Lectures on specimen preparation techniques, and special applications of the microscope.

**MatS 8522. Advanced X-Ray Diffraction of Metals.** (3 cr; prereq 5403 or #)

Reciprocal lattice, structure factor, Fourier analysis, diffuse and low angle scattering.

**Chemical Physics (ChPh)**

*Professor:* Norma M. Allewell (biochemistry); Paul F. Barbara (chemistry); Victor A. Bloomfield (biochemistry); Charles E. Campbell (physics and astronomy); James R. Chelikowsky (chemical engineering and materials science); John S. Dahler (chemistry); H. Ted Davis (chemical engineering and materials science); W. Ronald Gentry (chemistry); Clayton F. Giese (physics and astronomy); Allen M. Goldman (physics and astronomy); J. Woods Halley (physics and astronomy); Cheng-Cher Huang (physics and astronomy); Sanford Lipsky (chemistry); Wilmer G. Miller (chemistry); Albert J. Moscovitz (chemistry); Lanny D. Schmidt (chemical engineering and materials science); David D. Thomas (biochemistry); Donald G. Truhlar (chemistry); John H. Weaver (chemical engineering and materials science); Walter Weyhmann (physics and astronomy)

*Associate Professor:* Doreen G. Leopold (chemistry), *director of graduate studies*; Christopher J. Cramer (chemistry); Kenneth R. Leopold (chemistry); Jeffrey T. Roberts (chemistry)

*Assistant Professor:* David M. Ferguson (medicinal chemistry); Karin Musier-Forsyth (chemistry); J. Ilja Siepmann (chemistry)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A) and Ph.D.

**Curriculum**—Focus is on areas where the techniques of chemistry and physics are brought together for the study of atoms and molecules, their interactions in gases, liquids, and solids, and the detailed structure and dynamics of material changes. Areas of research and specialization include spectroscopy, optical properties, laser applications, molecular collisions, chemical dynamics, quantum mechanics, statistical mechanics, thermodynamics, low-temperature behavior, polymers or macromolecules, surface science, biochemistry, computational chemistry, and biochemical and heterogeneous catalysis.

**Prerequisites for Admission**—Applicants should have adequate preparation in mathematics, physics, and chemistry. For financial support, applicants should apply either to the Department of Chemistry or the Department of Physics. Applicants not requiring financial support have their academic qualifications reviewed by the director of graduate studies in chemical physics.

**Special Application Requirements**—Three letters of recommendation are required.

**Master's Degree Requirements**—At least 8 credits of coursework must be in chemistry and must include statistical or chemical thermodynamics or both; at least 8 credits must be in appropriate physics courses; and at least 8 credits must be in quantum mechanics, which may be taken in either the chemistry or physics department.

**Doctoral Degree Requirements**—A proficiency examination in physical chemistry is required. Programs ordinarily include at least 36 graduate credits, which include coursework in chemistry and/or physics with options for coursework in quantum mechanics, thermodynamics, statistical physics, and/or chemical dynamics. There is no minor or supporting field requirement. A graduate student handbook that provides complete requirements is available from the address below.

**Language Requirement**—None.

**For Further Information and Applications**—Contact the Chemical Physics Program, Department of Chemistry, University of

Minnesota, 137 Smith Hall, 207 Pleasant Street S.E., Minneapolis, MN 55455 (612/626-7444; fax 612/626-7541; e-mail inquiry@chemsun.chem.umn.edu).

**ChPh 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**ChPh 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**ChPh 8888. Thesis Credits: Doctoral.** (36 cr required)

**ChPh 8101. Chemical Physics Seminar.** (1 cr; prereq ChPh grad student)  
Seminar by student on his or her research.

## Chemistry (Chem)

*Professor:* W. Ronald Gentry, *chair*; Wilmer G. Miller, *vice chair*; John E. Ellis, *director of graduate studies*; Norma M. Allewell; George Barany; Paul F. Barbara; Victor A. Bloomfield; J. Doyle Britton; Peter W. Carr; John S. Dahler; H. Ted Davis; John F. Evans; Wayne L. Gladfelter; Gary R. Gray; Thomas R. Hoye; John D. Lipscomb; Sanford Lipsky; Hung-wen Liu; Timothy P. Lodge; Kent R. Mann; Larry L. Miller; Albert J. Moscovitz; Wayland E. Noland; Louis H. Pignolet; Lawrence Que; Michael A. Raftery; Marian Stankovich; Harold S. Swofford, Jr.; Donald G. Truhlar

*Associate Professor:* Frank S. Bates; Christopher J. Cramer; Steven R. Kass; Doreen G. Leopold; Kenneth R. Leopold; Jeffrey T. Roberts; William B. Tolman; Michael D. Ward

*Assistant Professor:* Mark D. Distefano; Craig J. Forsyth; Eric J. Munson; Karin Musier-Forsyth; George A. O'Doherty; J. Ilja Siepmann; Andreas Stein; Li Sun

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.<sup>1</sup>

**Curriculum**—Graduate work in the Department of Chemistry is organized into six specialty areas: analytical chemistry, biological chemistry, inorganic chemistry, materials chemistry, organic chemistry, and physical chemistry. Interdisciplinary work is also an option.

**Prerequisites for Admission**—Applicants must offer the substantial equivalent of the courses in analytical, inorganic, organic, and physical

<sup>1</sup> For information on the doctoral degree program offered in conjunction with the University of Minnesota, Duluth, please contact the director of graduate studies on the Twin Cities campus, or the program director or Graduate School office on the Duluth campus.

chemistry required of undergraduate majors in the Minnesota chemistry curriculum. They must also have at least one year of college physics plus college mathematics through calculus.

**Special Application Requirements**—Three letters of recommendation are required for all applications. Scores from General (Aptitude) and Subject (Advanced) Tests of the Graduate Record Examination (GRE) are required for fellowship consideration and are strongly recommended for all other applicants. International applicants are expected to provide scores of at least 580 on the Test of English as a Foreign Language (TOEFL), as well as GRE scores.

**Proficiency Examination**—Students working toward the M.S. or Ph.D. in chemistry are required to take a set of four proficiency examinations, one each in analytical, inorganic, organic, and physical chemistry. These examinations are taken on entrance; the results are used for guidance. Ph.D. students are expected to satisfy the proficiency requirements in all four fields during their first academic year in residence. M.S. students are expected to pass the proficiency examination in their specialty area during their first academic year in residence.

**General Degree Requirements**—A list of required and recommended courses, including courses from outside the field of chemistry, can be obtained from the director of graduate studies. Procedures are available for satisfying course requirements through special examination rather than course registration.

**Master's Degree Requirements**—One to three 4-credit project papers are required for Plan B. A final oral examination is required for both Plan A and Plan B.

**Doctoral Degree Requirements**—Ph.D. candidates must complete 36 credits of work in approved graduate courses (30 credits for students in organic chemistry). Analytical, biological, inorganic, materials, and organic chemistry specialty areas require a written research dossier. For students specializing in physical chemistry, this examination consists of two papers. A student needs to pass the written preliminary examination in only one of the five specialty areas. When the written examination has been passed, the student may proceed to the preliminary oral examination.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Assistant to the Director of Graduate Studies, Department of Chemistry, University of Minnesota, 137 Smith Hall, 207 Pleasant Street S.E., Minneapolis, MN 55455 (612/626-7444 or 1-800-777-2431; fax 612/626-7541).

**Chem 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**Chem 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**Chem 8888. Thesis Credits: Doctoral.** (36 cr required)

**Chem 5122. Advanced Analytical Chemistry.** (4 cr; prereq 1 yr organic chem, thermodynamics course)  
Equilibria in aqueous and nonaqueous systems.

**Chem 5126. Modern Analytical Chemistry.** (4 cr; prereq 3332 and 3335, IT chemical engineering major or  $\Delta$ ; 2 lect hrs, two 3-hr labs per wk)  
Strategies and techniques for solving modern analytical problems. The use of modern instruments in analysis.

**Chem 5127. Analog Instrumentation.** (5 cr; prereq Phys 1253, Math 1262 or equiv or #, chem major or grad student)  
Basic principles of electronic design and circuitry, servo systems, operational amplifiers, feedback control, oscillators, digital gates, converters for signal processing and control of measurement systems.

**Chem 5128. The Small Computer in the Chemical Laboratory.** (5 cr; prereq 5127 or #; 3 lect hrs, two 4-hr labs per wk)  
Applications of the lab computer to control of chemical instrumentation and acquisition of data. Hardware (interfacing) and software (assembly language programming) aspects of automating the chemical experiment.

**Chem 5130. Analytical Chemistry.** (3 cr; prereq 1 yr organic chem with lab, CLA or IT chem major; 3 lect, 1 rec hrs per wk)  
Methods and concepts of measurement by chemical and instrumental analysis, including titrimetry, quantitative spectrophotometric analysis, chromatographic separations, and equilibrium and rate methods of analysis emphasizing applications to organic and biochemical systems.

**Chem 5131. Analytical Chemistry Laboratory.** (2 cr; prereq 5130 or ¶5130; two 4-hr labs per wk)  
High-precision methods, acidimetry and complexometry, single- and multi-component analysis by spectrophotometry, analysis of mixtures by ion exchange and gas chromatography, enzymatic and rate methods of analysis.

**Chem 5133. Chemical Instrumentation and Analysis Lecture.** (3 cr; prereq 5130, 5131, 5534, 5535 or #)

Methodology and practices for solving analytical problems. Application of modern instrumental techniques to analysis.

**Chem 5139. Chromatography and Separation Science.** (4 cr; prereq 5133, 5140 or equiv or #, chem major or grad student)

Fundamental and practical aspects of gas liquid chromatography, modern liquid chromatography, electrophoresis, and other techniques used for analyses and separations.

**Chem 5140. Chemical Instrumentation and Analysis Laboratory.** (3 cr; prereq 5133, chem major)

Instrumental techniques including spectroscopic methods of analysis, electrochemical methods of analysis, and analyses based on separation. Emphasis on use of computers in data collection and reduction.

**Chem 5301. Spectral Methods of Organic Qualitative Analysis.** (4 cr, §8302; prereq 3303 or 3333 or equiv; 3 lect, 1 conf hrs per wk)

Practical application of nuclear magnetic resonance, mass, ultraviolet infrared spectral analysis to solution of organic problems.

**Chem 5331, 5332. Advanced Organic Chemistry I, II.** (4 cr per qtr, §8331, §8332; prereq 3303, #)

Depending on year and instructor, emphasizes heterocyclic chemistry, natural products chemistry, organic electrochemistry, synthetic applications of organometallic chemistry, solid-state chemistry, polymer chemistry and/or stereochemistry.

**Chem 5344. Heterocyclic Compounds.** (3 cr; prereq 3303 or 3333 or equiv; offered alt yrs)

Typical classes of heterocyclic compounds, their chemical and physical properties and uses, synthesis.

**Chem 5520-5521. Elementary Physical Chemistry.** (3 cr per qtr; prereq 1 yr college chem, Phys 1291 or ¶Phys 1291 or Phys 1106, Math 3211) Brief general survey. *5520*: Thermodynamics and applications to chemistry. *5521*: Elementary statistical mechanics, kinetics, and structure.

**Chem 5525. Physical Biochemistry: Solution Structure and Interactions of Biological Macromolecules.** (4 cr, §BioC 5525, §MdBc 5525; prereq 2 qtrs physical chem, Biol 5001 or equiv)

Physical chemistry of equilibrium, transport, and scattering phenomena in solution, with application to proteins and nucleic acids. Intermolecular forces, macromolecules dynamics, conformational transitions, binding thermodynamics, methods for determining biopolymer size and shape, including sedimentation, diffusion, viscosity, electrophoresis, and scattering.

**Chem 5526. Physical Biochemistry: Spectroscopic Methods I.** (4 cr, §BioC 5526, §MdBc 5526; prereq 2 qtrs physical chem)

Lectures on fundamental spectroscopic principles with emphasis on development of magnetic resonance theory used in study of biological macromolecules.

**Chem 5527. Physical Biochemistry: Spectroscopic Methods II.** (4 cr, §BioC 5527, §MdBc 5527; prereq 2 qtrs physical chem, BioC/Chem/MdBc 5526 or #)

Application of optical and magnetic resonance techniques to study of structure and dynamics in proteins, lipids, nucleic acids, and synthetic analogs.

**Chem 5528. Physical Biochemistry: Enzyme Kinetics.** (4 cr, §BioC/MdBc 5528; prereq 2 qtrs physical chem, BioC/MdBc 5751; BioC 5002 or equiv recommended)

Theory and application of steady-state and transient kinetics to study of enzymes, enzyme systems, and cellular regulation.

**Chem 5529. Protein Structure and Folding.** (4 cr, §BioC/MdBc 5529; prereq Biol 5001 or equiv, 1 qtr physical chem or #)

Advanced course on protein structure, stability, folding, and molecular modeling. Results from X-ray crystallography, solution thermodynamics, NMR, computer graphics, and protein engineering.

**Chem 5533. Quantum Chemistry.** (4 cr; prereq 1 yr college chem, Phys 1291 or ¶Phys 1291 or 1106 with #, Math 3211)

Principles of quantum mechanics with applications to atomic and molecular structure and to spectroscopy.

**Chem 5534. Chemical Thermodynamics.** (4 cr; prereq 1T upper div or CLA chem major or Δ, Phys 1291 or ¶Phys 1291 or 1106 with #, Math 3211)

Principles of thermodynamics with applications to chemical systems.

**Chem 5535. Statistical Mechanics and Reaction Kinetics.** (4 cr; prereq 5534)

(Continuation of 5534) Developing statistical thermodynamics and the kinetic theory of gases with applications to reaction rate theory. Phenomenological kinetics and experimental methods.

**Chem 5538. Physical Chemistry Laboratory.** (1 cr; prereq 5535 or ¶5535; not open to chem majors) Experiments in thermodynamics and reaction kinetics.

**Chem 5540. Physical Chemistry Laboratory.** (3 cr; prereq chem major, 5533, 5535 or ¶5535; 1 lect, 8 lab hrs per wk)

Experiments illustrating principles and methods of thermodynamics, reaction kinetics, and quantum mechanics.

**Chem 5610. Polymer Science.** (4 cr, §MatS 5610; prereq physical chem or MatS 5011 or #; 3 lect hrs, one 3-hr lab per wk)

Polymer synthesis and physical chemistry: polymerization kinetics and reactors, molecular weight distribution, network formation, macromolecules in solution and their characterization, the glassy and crystalline state, rubber elasticity, flow and viscoelasticity, environmental degradation.

**Chem 5732. Transition Metal Inorganic Chemistry.** (3 cr; prereq 5533 or ¶5533 or 5534 or ¶5534, chem or chem eng major)

Transition metal compounds where d electrons are important. Organometallic, bioinorganic, and metal cluster chemistry.

**Chem 5740. Inorganic Chemistry Laboratory.** (3 cr; prereq chem major, 5731, 5732 or ¶5732; 1 lect, 8 lab hrs per wk)

Experiments in inorganic and organometallic chemistry illustrating synthetic and spectroscopic techniques.

**Chem 5803. The Chemistry of Industry.** (4 cr; prereq chem sr or grad student or #)

Basic industry and polymer chemistry, and technology on which industry is based. Relationship of basic properties to industrial utility. Emphasis on economics, social problems, and industrial environment.

**Chem 5991, 5992, 5993. Selected Topics in Chemistry.** (Cr ar; prereq sr, Δ)

Topics of current interest in chemistry. Consult department for details of offerings for any particular quarter.

**Chem 8001. Applied Chemical Thermodynamics.** (4 cr; prereq chem grad student or #; 3 lect hrs per wk)

Systems in gas and solution phase, inorganic, organic, and biochemical reactions. Chemically important consequences of first and second laws. Heat reaction, entropy of reaction, and heat capacity changes from chemical measurement. Fluid, solid state equilibria, electrochemical equilibria, and surface processes. Phenomenological interpretation of phase diagrams in solid state chemistry and polymer mixtures.

**Chem 8002. Mechanisms of Chemical Reactions.** (4 cr; prereq chem grad student or #; 3 lect hrs per wk)

Reaction mechanisms and methods of study. Mechanistic concepts in chemistry. Topics include gas phase reactions to mechanisms, "electron pushing" mechanisms in organic reactions, mechanism of enzymatic reactions. Kinetic schemes and other strategies to investigate mechanisms.

**Chem 8003. Computational Chemistry.** (4 cr; prereq chem grad student or #; 3 lect hrs per wk)

Modern theoretical methods used in study of molecular structure, bonding, and reactivity. Concepts and practical applications. *Ab initio* and semi-empirical calculations of molecular electronic structure. Theoretical determination of molecular structure and spectra; relationship to experimental techniques. Molecular mechanics. Structure determination of large systems. Study of molecular properties and reactivity by theoretical methods. Computational tools for theoretical determination and lab for hands-on experience. Critical assessment of reliability of methods and theoretical work in literature.

**Chem 8104. Spectroscopic Methods of Analysis.** (4 cr; prereq 5133 or equiv or #) Systematic treatment of modern optical methods of analysis.

**Chem 8133. Modern Electroanalytical Techniques, Principles, and Practices.** (3 cr; prereq 5122)

Polarography, galvanostatic and potentiostatic methodology, coulometry, linear scan and cyclic voltammetry, pulse methods, and OTTLE applications.

**Chem 8134. Bioanalytical Chemistry.** (3 cr; prereq 5133 or equiv, BioC 5001 or equiv) Theory and practical aspects of analytical methods used in determination and characterization of biologically important materials. Enzymatic and kinetic methods in study of amino acids, proteins, carbohydrates, lipids, and nucleic acids.

**Chem 8135. Mass Spectrometry.** (3 cr; prereq #) Introduction to physical and chemical aspects of mass spectrometric analysis.

**Chem 8136. Surface and Thin Film Analysis.** (3 cr; prereq #) Survey of modern ultrahigh vacuum techniques appropriate to analysis of surface and thin film structure.

**Chem 8190. Seminar: Modern Problems in Chemical Instrumentation and Analysis.** (1 cr [may be repeated for cr]; prereq chem grad student or #)

**Chem 8191. Seminar Presentation: Modern Problems in Chemical Instrumentation and Analysis.** (1 cr; prereq chem grad student, #)

**Chem 8211. Introduction to Materials Chemistry.** (3 cr; prereq 3301, 5501 or 5534 or #) Gladfelder

Structure of and molecular routes to solids, including CVD and sol-gel processing; self-assembly of organic arrays and properties of organic crystals; basic properties of polymers, including important polymer synthetic methods.

**Chem 8290. Seminar: Materials Chemistry.** (1 cr; prereq chem grad student or #)

**Chem 8291. Seminar Presentation: Materials Chemistry.** (1 cr; prereq chem grad student, #)

**Chem 8302. Interpretation of Organic Spectra.** (4 cr; prereq 1 yr undergrad organic chem or #) Practical application of nuclear magnetic resonance, mass, ultraviolet, and infrared spectral analyses to the solution of organic structural problems.

**Chem 8311. Organic Synthesis I.** (4 cr; prereq 3303 or equiv or #) Core course; fundamental concepts, reactions, reagents, structural and stereochemical issues, and mechanistic skills necessary for understanding organic chemistry.

**Chem 8312. Organic Synthesis II.** (4 cr; prereq 8311 or #) Topics such as complex carbon skeleton synthesis, asymmetric synthesis, and/or modern studies in organic chemistry.

**Chem 8321. Physical Organic Chemistry I.**

(4 cr; prereq 8002 or #)

Core course. Fundamental concepts, mechanistic tools, and methods for the understanding and critical analysis of detailed mechanistic studies in organic chemistry.

**Chem 8322. Physical Organic Chemistry II.**

(4 cr; prereq 8321 or #)

Topics such as reactive intermediates, gas-phase chemistry, photochemistry, and/or strained-ring chemistry.

**Chem 8331. Advanced Organic Chemistry I.**

(4 cr, §5331; prereq 3303 or #)

Topics such as heterocyclic chemistry, natural products chemistry, organic electrochemistry, synthetic applications of organometallic chemistry, solid-state chemistry, polymer chemistry, and/or stereochemistry.

**Chem 8332. Advanced Organic Chemistry II.**

(4 cr, §5332; prereq chem grad student, 3303 or #)

Topics, which vary by instructor and year, include heterocyclic, natural products, solid-state, and polymer chemistry; organic electrochemistry; stereochemistry; and synthetic applications of organometallic chemistry.

**Chem 8390. Seminar: Organic Chemistry.**

(1 cr; prereq chem grad student or #)

**Chem 8391. Seminar Presentation: Organic Chemistry.** (1 cr; prereq chem grad student, #)**Chem 8401. Bioorganic Chemistry I.** (4 cr; prereq 3303 or equiv)

Chemistry of amino acids, peptides, and proteins; peptide structure determination, synthesis, and reactivity; biological applications of synthetic peptides.

**Chem 8402. Bioorganic Chemistry II.** (4 cr; prereq 3303 or equiv)

Chemistry of lipids and carbohydrates: structure, nomenclature, characterization by NMR spectroscopy, synthesis, and reactivity.

**Chem 8403. Bioorganic Chemistry III.** (4 cr; prereq 3303 or equiv)

Chemistry of nucleic acids: structure and reactivity, interactions with small molecules and proteins, chemical oligonucleotide synthesis, ribozymes, overview of techniques used in nucleic acid research.

**Chem 8404. Bioorganic Chemistry IV.** (4 cr; prereq 3303 or equiv)

Enzymecatalyzed reactions: group transfers, eliminations, isomerizations, rearrangements, oxidation-reduction reactions, chemical mechanisms in enzymatic systems.

**Chem 8521. Methods of Theoretical Chemistry.** (4 cr; prereq undergrad physical chem)

Basic theoretical techniques of physical chemistry, application to selected chemical problems.

**Chem 8531-8532-8533. Introductory Quantum Mechanics and Spectroscopy.** (4 cr per qtr; prereq 8521 or equiv)

Wave mechanics, soluble problems, approximate methods, chemical applications, structure of molecules, group theory, elementary treatment of scattering, atomic and molecular spectroscopy.

**Chem 8535. Molecular Quantum Mechanics.** (4 cr; prereq 8531)

Application of quantum mechanics to molecular problems including topics such as Born-Oppenheimer approximation, symmetry of electronic and vibrational wave functions, molecular orbital theory, and rotational and vibrational eigenstates and spectra.

**Chem 8545. Reaction Dynamics.** (4 cr; prereq undergrad physical chem)

Reaction dynamics from microscopic viewpoint with an emphasis on modern experimental methods and interpretation of scattering data.

**Chem 8547. Elements of Statistical Mechanics.** (4 cr; prereq undergrad physical chem)

Principles of equilibrium statistical mechanics, ensemble theory, partition functions; application to simple systems such as ideal gases and crystals, and simple lattice statistics.

**Chem 8548. Advanced Statistical Mechanics.** (4 cr; prereq 8547)

More advanced topics in statistical mechanics, such as nonideal gases and solutions, distribution functions, and nonequilibrium statistical mechanics.

**Chem 8560. Seminar: Biological Systems.**

(1 cr; chem grad student or #)

**Chem 8561. Seminar Presentation: Biological Systems.** (1 cr; prereq chem grad student, #)**Chem 8590. Seminar: Physical Chemistry.**

(1 cr; prereq chem or chem phys grad student; S-N only)

**Chem 8591. Seminar Presentation: Physical Chemistry.** (1 cr; prereq chem or chem phys grad student or #)**Chem 8611. Introduction to Polymer Properties.** (3 cr, prereq 5534 or #)

Molecular weight distribution, formation of network polymers, statistical thermodynamics of polymer solutions, polymers characterization by viscosity, light scattering, sedimentation methods, viscoelastic behavior of polymers.

**Chem 8612. Advanced Topics in Polymer Science.** (3 cr; prereq 8611 or #; offered alt yrs)

For graduate students in chemistry, chemical engineering, and materials science, and others interested in modern statistical theories of equilibrium and nonequilibrium polymer systems.

**Chem 8751. Physical Inorganic Chemistry I.** (4 cr, §5751; prereq chem grad student or #)

Physical methods and concepts applied to inorganic and organometallic systems, including NMR, IR, UV-VIS, ESR, Mossbauer and mass spectroscopy, magnetic measurements, X-ray crystallography.

**Chem 8756. X-Ray Crystallography.** (4 cr, §5756; prereq chem grad student or #)  
Determination of crystal structures by X-ray diffraction of single crystals. Data collection, structure solving and refining for inorganic and organic molecules of 100 or fewer atoms.

**Chem 8761. Organometallic Chemistry.** (4 cr, §5761; prereq chem grad student or #)  
Syntheses, reactions, structures, and other important properties of main group and transition metal organometallic compounds; treatment in terms of modern electronic and structural theory; emphasis on their use as stoichiometric and homogeneous catalytic reagents in organic and inorganic systems.

**Chem 8762. Chemistry of the Elements.** (4 cr, §5762; prereq chem grad student or #)  
Survey of synthesis, structure, physical properties, and chemical reactivity of the elements. Topics equally divided between transition and nontransition elements.

**Chem 8765. Bioinorganic Chemistry.** (4 cr, §5765; prereq chem grad student or #)  
Survey of role of metal ions in biology with emphasis on structure, function, and spectroscopy of metalloproteins and their synthetic analogs.

**Chem 8766. Solid State Chemistry.** (4 cr; prereq chem grad student or #)  
Synthetic methods, structures of crystalline solids, and bonding in solids. Solid state phase diagrams and kinetics of solid state reactions. Classes of solids include molecular, ionic, metallic, and semiconducting compounds.

**Chem 8790. Seminar: Modern Problems in Inorganic Chemistry.** (1 cr; prereq chem grad student or #)

**Chem 8791. Seminar Presentation: Modern Problems in Inorganic Chemistry.** (1 cr; prereq chem grad student, #)

**Chem 8881, 8882, 8883. M.S. Plan B Project I, II, III.** (4, 1-4, 1-4 cr; prereq grad major in chem or chem physics, Δ)  
Satisfies project requirement for Plan B master's degree. May appear on M.S. degree program, but does not count toward 20-credit minimum in major field. Topic arranged by student and adviser; written report required. 8881 required; 8882 and 8883 optional.

**Chem 8990. Research in Chemistry.** (Cr ar; prereq chem grad student or Δ)

**Chem 8991. Special Topics in Chemistry.** (Cr ar; prereq Δ)

**Chem 8992. Special Topics in Chemistry.** (Cr ar; prereq #)

**Chem 8993. Special Topics in Chemistry.** (Cr ar; prereq Δ)

**Chem 8994, 8995, 8996. Special Topics in Chemistry.** (Cr ar; prereq Δ)

**Chem 8997, 8998. Special Topics in Chemistry.** (Cr ar; prereq chem grad student or Δ)

## Child Psychology (CPsy)<sup>1</sup>

*Professor:* Richard A. Weinberg, *director*; Charles A. Nelson, *director of graduate studies*; Geraldine K. Brookins; William R. Charlesworth (*emeritus*); W. Andrew Collins; Byron R. Egeland; Norman Garmezy (*emeritus*); Harold D. Grotevant; Megan R. Gunnar; Willard W. Hartup; Susan C. Hupp; Gloria R. Leon; Michael P. Maratsos; Ann S. Masten; Shirley G. Moore (*emeritus*); Anne C. Petersen (on leave); Anne D. Pick; Herbert L. Pick, Jr.; L. Alan Sroufe; Mildred C. Templin (*emeritus*); James E. Turnure; Albert Yonas

*Associate Professor:* Patricia J. Bauer; Sandra L. Christenson; Scott R. McConnell; Charles N. Oberg; Maria D. Sera; Elsa G. Shapiro; Paulus W. van den Broek; Carolyn L. Williams

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Ph.D. and M.A. (Plan A and Plan B). Students are admitted only for the Ph.D.; the M.A. is a necessary part of the Ph.D. program.

**Curriculum**—Emphases include developmental aspects of cognition, genetics-ethology, language, learning, cognitive neuroscience, perception, personality, social psychology, child clinical, and school psychology.

**Prerequisites for Admission**—At least 12 quarter credits in psychology and one course in statistics are required.

**Special Application Requirements**—New students are normally admitted in fall quarter. Application deadline is January 15 of the preceding year. A department application, a statement of goals and interests, three letters of recommendation, and scores from the General (Aptitude) Test of the Graduate Record Examination are also required. A résumé is also recommended.

**Master's Degree Requirements**—Courses in history, current issues, and research methods of child psychology and in advanced statistics are required. Other courses, including those for a minor or supporting field, are selected in consultation with the adviser. The individual examining committee determines whether the final examination is written, oral, or both.

<sup>1</sup> See the College of Education and Human Development Bulletin for information on the master of education (M.Ed.) program in early childhood education.

**Doctoral Degree Requirements**—Courses in history, current issues, and research methods in child psychology, statistical analysis, and research are required. Other courses are selected in consultation with the adviser.

Completion of a supporting program, rather than a minor, is required. Non-coursework requirements include successful completion of a predoctoral research paper, a teaching apprenticeship, preliminary written and oral examinations, and a dissertation.

**Language Requirement**—None.

**Minor Requirements for Student Majoring in Other Fields**—For the doctoral degree, at least 12 of the minimum 18 credits must be at the 8xxx level.

**For Further Information and Applications**—

Contact the Child Psychology Program, University of Minnesota, 156 Child Development Building, 51 East River Road, Minneapolis, MN 55455 (612/624-2576; fax 612/624-6373).

**CPsy 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**CPsy 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**CPsy 8888. Thesis Credits: Doctoral.** (36 cr required)

**CPsy 5302. Infancy.** (4 cr; prereq 1301 or #) Nelson, Yonas

Perceptual, motor, emotional, social, and cognitive development during first two years of life; developing infant in its social and physical environment.

**CPsy 5303. Adolescent Psychology.** (4 cr, §3303; prereq 5 cr introductory psychology) Egeland, Masten

Physical, cognitive, and social development during adolescence.

**CPsy 5305. Multidisciplinary Perspectives On Aging.** (4 cr, §AdEd 5440, §HSU 5009, §Nurs 5780, §PA 5414, §Phar 5009, §PubH 5520, §PubH 5737, §SW 5024, §Soc 5960)

Multidisciplinary introduction to aging and the aging process.

**CPsy 5310. Topics in Child Psychology.**

(1-4 cr; prereq 1301)

Selected topics in general content area.

**CPsy 5311. Introduction to Developmental Psychopathology.** (4 cr, §3311; prereq 1301 or equiv, 3308 or Psy 1005) Egeland, Masten, Sroufe  
Theories and research strategies to investigate origins and course of disordered behavior in childhood and adulthood, including description, etiology, development.

**CPsy 5313. Psychology of Atypical Children.** (4 cr, §3313; prereq 1301 or equiv)

Problems of research, assessment, and behavior associated with atypicality; evaluation of research in areas of major concern for sensory, language, intellectual, and physical deviation.

**CPsy 5315. Introduction to Mental Retardation.** (4 cr, §EPsy 5620; prereq 1301 or equiv) Turnure

Psychological and educational problems related to the mentally retarded.

**CPsy 5319. Introduction to Clinical Child Psychology.** (4 cr; prereq 12 cr child psych or educ psych or psych or sociology) Masten

Survey of assessment and intervention procedures of child clinical psychology in clinical and community settings. Primarily for students not majoring in clinical psychology.

**CPsy 5322. Motor Development.** (3 cr, §Kin 5132; prereq 3132 or #) Wade

Motor skill development from birth to physical maturity.

**CPsy 5329. Genetics, Ethology, and Development.** (4 cr; prereq 1301 or equiv) Maratsos

Survey of evolutionary theory, behavioral genetics applied to understanding of development of human behavior; formation of species-typical adaptive behavior and individual differences in infancy, childhood, and adolescence.

**CPsy 5330. Directed Experiences With Children.** (4 cr; prereq 1301, #)

Intellectual and/or social development of children as individuals or members of peer groups. Experiences offered in case study, social behavior, and cognitive stimulation of children.

**CPsy 5331. Processes of Social Development.** (4 cr, §3331; prereq 1301 or equiv) Collins, Hartup

Processes of individual change from infancy through adolescence and development of capacities for and influences of social relations; research, methodology, and theoretical perspectives.

**CPsy 5332. Cross-Cultural Child Development.** (4 cr; prereq 4 cr child psych)

Interdisciplinary, cross-cultural survey of theories and research on similarities and differences in cognitive, perceptual, socioemotional, and personality development; emphasis on child-caretaker relations and Asian and Hispanic cultures.

**CPsy 5334. Children and Youth in Society.**

(4 cr; prereq 4 cr child psych)

Child development principles relative to social policy decision making; application of theories and findings to such issues as media influences, mainstreaming, day care, child abuse, effects of peers.

**CPsy 5336. Development and Interpersonal****Relations.** (4 cr, §5339; prereq 1301 or equiv, 3331 or 5331, 3308 or Psy 1005) Collins, Hartup

Processes and functions of interactions with parents and peers; analysis of theory and research on developmental changes and influences.

**CPsy 5341. Perceptual Development.** (4 cr;

prereq 1301 or #, 3308 or Psy 1005) H Pick, Yonas

Perceptual learning and the development of sensory and perceptual processes.

**CPsy 5343. Cognitive Development.** (4 cr;

prereq 3343, 3308 or Psy 1005) Bauer, A Pick, H Pick, Sera

Cognitive processes; relevant theory, research literature, and methodology.

**CPsy 5345. Language Development.** (4 cr;

prereq 1301 or #, 3308 or Psy 1005) Maratsos

Structure and function of language; factors influencing development; methodological problems, language scales, theories.

**CPsy 5353. Development During the School Years.** (4 cr; prereq 4 cr psych)

Principles of psychological development, emphasizing ages 5-18. Theory and research from developmental psychology relevant to individual growth and achievement; issues in applying developmental perspective to topics in child and adolescent development (e.g., fostering learning, risk for school failure, behavior and emotional problems, diversity).

**CPsy 5970. Directed Study in Child****Psychology.** (Cr ar; prereq #)

Independent reading.

**CPsy 5990. Directed Research in Child****Psychology.** (Cr ar; prereq #)

Individual empirical investigation.

**CPsy 8301. Developmental Psychology:****Biological Processes.** (4 cr; prereq doctoral student or #) Nelson

Biobehavioral development, including embryology and prenatal development; molecular/behavioral genetics and ethology; developmental neurobiology; physical growth/motor development; sensory development.

**CPsy 8302. Developmental Psychology:****Cognitive Processes.** (4 cr; prereq doctoral student or #) Sera, Yonas

Perceptual, cognitive, and language development. Conceptual framework for understanding research issues in these areas.

**CPsy 8303. Developmental Psychology:****Social and Emotional Processes.** (4 cr; prereq doctoral student or #)

Normative issues and individual differences in social development from infancy through adolescence, with special reference to developmental psychopathology. Life span considerations.

**CPsy 8304. Research Methods in Child Psychology.** (3 cr) A Pick

Review of principal research methods and designs in child psychology, including issues of scientific integrity.

**CPsy 8310. Seminar: History of Child****Development.** (1 cr) Hartup, Weinberg

Problems and issues in professional child psychology for first-year graduate students.

**CPsy 8320. Seminar: Current Issues in Teaching Developmental Psychology.** (1 cr)

Charlesworth, Collins

Problems and issues in professional child psychology for advanced graduate students.

**CPsy 8330. Directed Field Experiences.** (1-6 cr; prereq #; S-N only)

Intellectual and/or social development of children as individuals or members of groups; may include interactions with children in natural settings, or research on applied topics or with atypical populations.

**CPsy 8360. Seminar: Developmental Psychology.** (3 cr per section)

Intensive study in the following topics. *Section 1:* Ethology of child behavior. *Section 2:* Language development. *Section 3:* Perceptual development. *Section 4:* Social development. *Section 5:* Cognitive development. *Section 6:* Developmental neuropsychobiology. *Section 7:* Applied child development.

**CPsy 8606. New Approaches to Psychopathology in Children and****Adolescents.** (3 cr, §EPsy 8853) Egeland, Masten

Alternative formulation of childhood disorders, emphasizing competency training rather than medical nosology.

**CPsy 8970. Independent Study.** (Cr ar)

Independent reading.

**CPsy 8980. Research Seminar.** (1-3 cr; S-N only)

Participation in organized research group in developmental psychology.

**CPsy 8990. Research Problems.** (Cr ar)

Individual empirical investigation.

**Chinese**

See East Asian Languages, Literatures, and Linguistics.

## Civil Engineering (CE)

*Professor:* Steven L. Crouch, *head*; Heinz G. Stefan, *director of graduate studies*; Roger E. A. Arndt; Patrick Brezonik; Andrew Drescher; Charles Fairhurst; Cesar Farell; Efi Foufoula-Georgiou; Theodore V. Galambos; John S. Gulliver; Malcolm T. Hepworth; Walter J. Maier; Panos G. Michalopoulos; John L. Nieber; Gary Parker; Kenneth J. Reid; Michael J. Semmens; Charles C. S. Song; Yorgos J. Stephanedes; Otto D. L. Strack

*Adjunct Professor:* Peter A. Cundall

*Associate Professor:* Randal J. Barnes; Gary A. Davis; Emmanuel M. Detournay; Daryl F. Dwyer; Catherine E. French; Gerald W. Johnson; Joseph F. Labuz; David E. Newcomb; Arturo E. Schult; Karl A. Smith; Mark B. Snyder; Henryk K. Stolarski; Vaughan R. Voller

*Assistant Professor:* Jerome F. Hajjar; Carol Kittredge Shield

*Adjunct Assistant Professor:* Paul D. Capel

*Research Associate:* Eil Kwon; Victor Sapozhnikov

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B), M.C.E. (Coursework Only and Design Project), and Ph.D.

**Curriculum**—Please refer to the General Information section of this bulletin for information about Plans A and B of the master of science (M.S.) degree.

The professional master's degree (M.C.E.) is intended for engineering graduates interested in design, planning, or operation rather than in research. It is offered under both the design project track and the coursework only track. The coursework only track requires 44 course credits, of which 12 should be from a set of core courses in one of the subdisciplines. All subdisciplines of civil engineering (e.g., environmental and water resources engineering, structures, transportation, geotechnical engineering) are available for the M.S. and M.C.E. programs.

Emphases in the Ph.D. program are structural design and analysis; construction materials engineering; water resources engineering (including fluid mechanics, hydrology, and water resources management); environmental engineering (including water and wastewater process engineering, environmental chemistry, and environmental microbiology); transportation engineering (including traffic and pavement engineering);

and geotechnical engineering. Students are expected to concentrate the major part of their coursework and research in one of these areas.

**Prerequisites for Admission**—For the master's and doctoral programs, the normal requirement for admission is an adequate academic record in a civil engineering undergraduate program accredited by the Accreditation Board for Engineering and Technology (ABET). Some areas of civil engineering are so broad that students with other undergraduate preparation may be considered for admission. For example, in environmental engineering, students with an undergraduate concentration in chemistry, chemical engineering, physics, or certain of the biological sciences may be admitted. In transportation, applicants with an undergraduate concentration in electrical engineering, computer science, mathematics, or physics may be admitted. Applicants who lack civil engineering training are often required to complete one or more appropriate courses from the undergraduate civil engineering program. Graduate degree credit is not awarded for such preparatory work. For the M.C.E. program, an ABET-accredited bachelor's degree in engineering is required.

**Special Application Requirements**—

Applicants should submit to the director of graduate studies three letters of recommendation, either from professors qualified to estimate their class rank and evaluate their ability to complete a program of graduate study, or from engineering professionals who can assess their professional potential. These letters may also be used in applying for financial aid. Applicants for admission should also submit a résumé of their academic history and professional experience and a statement of purpose, including the proposed area of emphasis within civil engineering. Applicants for the M.S. or Ph.D. are required to submit results of the General Test of the Graduate Record Examination (GRE). International applicants are also required to submit a score of 550 or better on the TOEFL (Test of English as a Foreign Language). Students are admitted each quarter, but applicants are strongly encouraged to begin fall quarter and to submit their applications in December before the year their studies are expected to begin.

**Professional Registration**—Applicants who have as their goal a professional career as a civil, structural, or geological engineer need to obtain registration as a professional engineer. Admission to the registration examination is, in most states, restricted to graduates of an ABET-accredited curriculum for the bachelor's degree in engineering. Students who lack this preparation should seriously consider obtaining the training before entering a graduate program. For a student with an undergraduate background in mathematics, for example, this can normally be accomplished in four or five quarters. Prospective students may receive counseling on the need for professional registration in light of their career objectives from the director of graduate studies.

**Degree Requirements**—For M.C.E. degree requirements, see Professional Master's Degree in Engineering in the General Information section of this bulletin. All students should also consult the *Department of Civil Engineering General Information Bulletin for Graduate Students* for more information.

The final examination for the M.S. and M.C.E. degrees is oral.

For M.S. and Ph.D. requirements, see the General Information section of this bulletin. Certain graduate-level civil engineering courses are acceptable for graduate credit only as part of a minor or supporting program for students majoring in a field other than civil engineering. Consult the director of graduate studies for further information.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Department of Civil Engineering, University of Minnesota, 122 Civil Engineering Building, 500 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/625-5522; fax 612/626-7750; e-mail cive@tc.umn.edu; http://www.cme.umn.edu).

**CE 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**CE 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**CE 8888. Thesis Credits: Doctoral.** (36 cr required)

## General

**CE 5002. Engineering Economics.** (2 cr; prereq jr, IT student or adult spec or grad student)  
Time value of money; compound amount factors; present worth of uniform and single payments; cost-benefit analysis; net present worth analysis; internal rate of return.

**CE 5021. Computer Applications in Civil Engineering II.** (4 cr; prereq 3020, Math 3221 or Math 3212 or #)

Introduction to three methods (finite differences, finite elements, and boundary elements) for solution of problems in hydrology, structural engineering, geomechanics, transportation, and environmental engineering that reduce to partial differential equations. Each method illustrated in context of one or more practical problems.

**CE 5055. Engineering Geostatistics.** (4 cr, §GeoE 5555; prereq Stat 3091 or #, sr or grad in CE or GeoE or MinE or Geo) Barnes

Problem solving and decision making in civil and geological engineering using applied statistics. Emphasis on spatially correlated data, e.g., geologic site characterization, spatial sampling in environmental engineering, optimal sample design for groundwater contamination assessment.

**CE 5097-5098-5099. Advanced Design, Analysis, Research or Tutorial in Civil Engineering.** (Cr ar [may be repeated for cr]; prereq approval of adviser)

Planning, design, or analysis of complex civil engineering systems. Individual lab research problems, literature studies, and reports supervised by staff. Studies may be conducted in any discipline within civil engineering and hydraulics, including, but not limited to, land development, materials, environmental engineering, soil and rock mechanics, structures, and transportation.

**CE 5700. Systems Analysis for Civil Engineers.** (4 cr, §GeoE 5700; prereq IT or grad student)

Introduction to systems analysis and decision making; expert systems; operations research techniques, modeling, and simulation. Applications in civil engineering and related areas.

**CE 5703. Project Management.** (4 cr; prereq sr, IT major)

Practical approach to construction project management including project planning, budgeting, scheduling, staffing, task and cost control, and communicating with, motivating, and managing team members.

**CE 8022. Numerical Methods for Free and Moving Boundary Problems.** (4 cr; prereq 8605 or #)

Voller  
Examples of free and moving boundary problems: metal solidification, filling, polymer molding, flow in porous media, ground freezing. Solutions of free and moving boundary problems: analytical, fixed finite difference, fixed finite element, front tracking schemes, general deforming finite element methods.

**CE 8097-8098-8099.\* Civil Engineering****Research.** (1-5 cr per qtr; prereq #)

Original work in concrete, structural steel, soils, hydraulics, hydrology, and municipal, environmental, or transportation problems. Investigations, reports, tests, designs.

**CE 8970. Directed Research: Doctoral.** (Cr ar; prereq PhD student, #)**Surveying and Land Use Planning****CE 5102. Site and Route Engineering.** (4 cr; prereq 3100, IT or grad student)

Site and route design fundamentals and problems based on spatial data obtained through photogrammetric mapping. Problems in geometric design; grades, horizontal and vertical curves; fitting of design to topography; earthwork, area and volumes; drainage. Construction control and layout.

**Transportation****CE 5200. Geometric Design of Highways.**

(4 cr; prereq 3200 or #, IT student or grad)

Forecast of traffic volume demand; impact of vehicle type on geometric design; vertical and horizontal alignment; intersection design; highway capacity.

**CE 5201. Highway Traffic Characteristics and Operations.** (4 cr; prereq 3200, IT or grad student) Davis

Characteristics and measurements of volume, speed, density, and travel time; characteristics of vehicles and road users; parking characteristics and design of facilities; applications of signs, signals, and markings in traffic control.

**CE 5210. Introduction to Transportation Systems Analysis.** (4 cr; prereq #; offered alt yrs) Stephanedes

Techniques of analysis and planning for transportation services; demand-supply interactions; evaluating transportation alternatives; travel demand forecasting; integrated modal systems; citizen participation in decision making; proposal writing.

**CE 8200. Theory of Traffic Flow.** (4 cr; prereq #) Michalopoulos

Definitions and measurements of basic flow parameters. Macroscopic and microscopic traffic flow models, dynamic models, shock waves, flow speed and travel time distributions, gap availability and acceptance, simulation of traffic flow, traffic control theory and applications, queuing theory and applications.

**CE 8201. Urban Traffic Operations.** (4 cr; prereq #) Michalopoulos

Capacity analysis techniques for urban streets, optimal traffic signal control, real time control, signal hardware and detectors, operational techniques for optimizing traffic flow, use of computer programs in traffic engineering practice, air and noise pollution, street and intersection design.

**CE 8210. Modeling Consumer Choices in****Transportation.** (4 cr; prereq Stat 3091 or #; offered alt yrs) Davis

Overview of existing models derived from theories of individual choice behavior; properties of statistical estimators, model specification, and sources of model error; applications in urban and rural transportation; transportation-energy interactions; transportation as related to social services, recreation, and other human activities.

**CE 8212. Automatic Incident Detection.** (4 cr; prereq Math 3211 or #; offered alt yrs) Stephanedes  
Algorithms for detection of incidents. Pattern recognition, time-series, filters, dynamic models, neural networks. Detection and false alarm rates. Performance curves. Implementation with real traffic data.**CE 8214. Transportation Systems Dynamics and Control.** (4 cr; prereq Math 3211 or #; offered alt yrs) Stephanedes

Nonlinear differential equations describing demand, service, economics, and energy consumption of transportation systems. Optimal control policies to improve typical performance indices such as transit service frequency and energy consumption by all transportation modes. Second order linear approximation. Stability analysis and controllability. System synthesis and simulation.

**CE 8215. Stochastic Models of Traffic Flow and Travel Demand.** (4 cr; prereq 8200 or 8210 or #) Davis

Random variables and estimation; time-series models, linear systems and Kalman filtering; discrete-time Markov processes and dynamic models of traveler choice; continuous-time Markov processes and traffic flow.

**Water Resources Engineering and Fluid Mechanics****CE 5401. Water Resources Engineering.** (4 cr; prereq 3400 or #, IT or grad student)

Introduction to water resources engineering including flow in conduits, pumps, open channels, and culverts; introduction to flow measurements, hydraulic structures, and systems approach to water resources engineering.

**CE 5402. Computational Hydraulics.** (4 cr; prereq 5401, CSci 3101 or #, IT or grad student) Parker  
Computer applications and numerical methods in hydraulic engineering. Computational analysis of water surface profiles in open channel and river flow; bridge waterways; culverts, pipe system; flow in sewer systems; reservoir routing. Numerical interpolation and integration.**CE 5403. Hydraulic Structures.** (4 cr; prereq 5401 or #, IT or grad student; offered alt yrs) Stefan  
Hydraulic design procedures for such structures as culverts, dams, spillways, outlet works; river control works; drop structures, water intakes, bridge crossings, pipeline crossings.

**CE 5405. Hydrology and Hydrologic Design.**

(4 cr; prereq 5401 or #, IT or grad student) Fofoula-Georgiou

Hydrologic cycle, precipitation, evaporation, infiltration, runoff analysis, flood routing, statistical procedures in hydrology, urban hydrology, introduction to mathematical models of medium and large watersheds, application of hydrology to design of outlet works and flow control structures.

**CE 5410. Open Channel Hydraulics.**

(4 cr; prereq 3400, 5401 or #, IT or grad student) Arndt, Song  
Mechanics of flow in open channels including gradually varied, spatially varied, and rapidly varied flow; unsteady flow (waves and surges); and flow in alluvial channels.

**CE 5425. Groundwater Mechanics.**

(4 cr; prereq 3400 or #, IT or grad student) Strack  
Basic equations. Horizontal confined, unconfined, and interface flow. Flow from rivers and lakes toward wells. Systems of interconnected aquifers. Leaky flow. Modeling of aquifers by use of boundary integral equation techniques. Non-steady flow. Application of finite element methods. Explicit finite difference methods.

**CE 5426. Computer Modeling of**

**Groundwater Flow.** (4 cr; prereq IT or grad student, 5425 or #) Strack

Principles of analytic element method. Mathematical and computer modeling of single- and multi-aquifer systems. Modeling of aquifers by use of boundary integral equation techniques. Theory and application of contaminant transport models, including capture zone analysis.

**CE 5435. Intermediate Fluid Mechanics With Applications.**

(4 cr; prereq 3400, IT or grad student)  
Basic laws and equations of mass, energy, and momentum transport in fluid flow; exact and approximate solutions; viscous flow; irrotational flow; similitude and inspectional analysis. Application to engineering problems.

**CE 8401. Introduction to Environmental Boundary Layer Theory.**

(4 cr; prereq 5435 or #) Parker  
Laminar and turbulent boundary layers and their interaction with potential flow. Application to engineering problems.

**CE 8402. Introduction to the Theory and Measurement of Turbulent Flows.**

(4 cr; prereq 8401 or #) Farell  
Free-turbulence shear flows, dimensional analysis; statistical description of turbulence; random data analysis, measurement in transient flows.

**CE 8407. Stochastic Hydrology.**

(4 cr; prereq Stat 5021 or #) Fofoula-Georgiou  
Analysis and synthesis of hydrologic series and systems; derived distributions; flood frequency analysis; hydrologic time series; correlation and spectral analysis; reservoir range analysis; linear analysis; linear estimation; geostatistics; sampling networks; and real-time hydrologic forecasting.

**CE 8408. Special Topics in Hydrology.**

(4 cr; prereq 8407) Fofoula-Georgiou  
Dynamical systems theory, systems approach in hydrology, state-space representation of hydrologic systems, optimal control and estimation, Kalman filtering; scaling processes in hydrology, multiresolution and space-scale analysis.

**CE 8413.\* Mechanics of Sediment Transport.**

(3 cr; prereq 5410 or #) Parker  
Theories of sediment transport. Transport processes and types of movement. Interrelationship of sediment transport, channel geometry, and channel stability in alluvial streams. Applications to river regulation, artificial channels, local scour, deposition in reservoirs, beach processes, other areas.

**CE 8415. Hydropower Development.**

(3 cr; prereq 5405) Arndt, Gulliver  
Stream flow and water power estimates. Storage problems. Analysis, design, and selection of water power structures and equipment. Types and purposes of dams. Turbine analysis. Transmission lines. Cost and value of water power. Typical problems, inspection trips.

**CE 8418. Computational Hydrodynamics I.**

(4 cr; prereq 5401 or #) Song  
Theory and applications of finite difference methods to solving unsteady one-dimensional flow problems.

**CE 8419. Computational Hydrodynamics II.**

(4 cr; prereq 8418 or #) Song  
Computer simulation of 1-, 2-, and 3-dimensional flows of incompressible and weakly compressible fluids with and without free-surface. Basic principles of governing equations, finite difference, and other numerical schemes, and their application to hydraulic and water resources engineering problems.

**CE 8425. Advanced Groundwater Mechanics I.**

(4 cr; prereq 5425 or #) Strack  
Solute transport. Shallow flow in leaky aquifers. Complex variable methods in groundwater flow. Analytic element-method: potentials for line sinks, line doublets, line dipoles, area sinks, and special analytic elements. Singular Cauchy integrals. Analytic elements in domains with closed boundaries.

**CE 8426. Advanced Groundwater Mechanics II.**

(4 cr; prereq 5425 or #) Strack  
Applying complex variable methods, including conformal mapping, in groundwater mechanics. Solving problems with free boundaries using hodograph method. Drains in aquifers with free boundary; superposition of solutions with drains. Singular Cauchy integrals. Boundary elements.

**CE 8435. Special Topics in Hydrodynamic Theory.**

(3 cr; prereq #)  
Linearized theory, wave motion, cavity and separated flow, and other topics to meet special requirements of students.

**CE 8440. Flow Effects On Structures.** (4 cr; prereq 5435 or #) Farell  
Flow around bluff bodies. Hydroelastic (aeroelastic) phenomena; vortex-induced vibrations, lock in, galloping, flutter. Vibrations induced by oscillating flows and turbulence. Analytical and experimental modeling. Wind loads on buildings, forces on hydraulic structures, and propulsion devices. Wave forces on submerged structures, piles, walls, floating bodies.

## Environmental Engineering

**CE 5500. Analysis and Design of Water Supply Systems.** (4 cr; prereq 3400 or #, IT or grad student) Reid, Semmens  
Planning and engineering design considerations in developing water supply systems for urban centers. Supply quality, storage, treatment, distribution, and cost analysis.

**CE 5501. Analysis and Design of Wastewater Systems.** (4 cr; prereq Chem 1005, 3400 or #, IT or grad student) Dwyer, Maier  
Planning and engineering design considerations in developing wastewater disposal systems for urban centers. Volumes and quality of waste streams, treatment and ultimate disposal of domestic and industrial wastewaters, storm water run-off. Environmental effects, cost, and political aspects of ultimate disposal.

**CE 5504. Mass Transport with Environmental Applications.** (4 cr; prereq 3400, IT upper div or grad student) Gulliver  
Reactor design for water and wastewater treatment and pollutant transport in the environment.

**CE 5505. Water Quality Engineering.** (4 cr; prereq 5506 or #) Brezonik  
Chemical, physical, and biological properties of natural waters; water quality criteria, standards, and legislation; mathematical modeling to predict fate/effects of oxygen-demanding pollutants, nutrients, and refractory organic contaminants on receiving waters.

**CE 5506. Environmental Water Chemistry.** (4 cr; prereq Chem 1052 or #, IT or grad student) Brezonik, Capel  
Composition of natural waters and wastewater; chemical processes affecting distribution of chemical species, including pollutants, in water; methods to evaluate fate of organic pollutants.

**CE 5507. Environmental Engineering Laboratory.** (4 cr; prereq 5506, 5500 or 5501 or #; 3 lect, 3 lab hrs per wk) Brezonik  
Methods of sampling natural water and wastewater; techniques for the chemical, biological, and physical characterization of samples, including nutrients, indicator organisms, BOD, major and minor ions, natural synthetic organic matter.

**CE 5510. Solid and Hazardous Waste Management.** (4 cr) Hepworth  
Analysis and design of engineered systems for collection, transportation, processing, and disposal of solid and hazardous waste materials. Waste characteristics affecting management options, discussion of relevant regulatory legislation.

**CE 5512. Solid and Hazardous Waste Processing I.** (4 cr; prereq 5510 or IT upper div or grad student or #; 4 lect hrs per wk) Hepworth  
Application of physical and chemical principles to unit operations and processes for recovering and recycling solid wastes. Remediation and pollution prevention methodologies on solid and hazardous wastes from manufacturing industries, municipal waste treatment plants, electric power utilities, and the mining industry. Student presentations and reports.

**CE 5513. Solid and Hazardous Waste Processing II.** (4 cr; prereq 5512 or #; 4 lect hrs per wk) Hepworth  
Continuation of CE 5512. Pyro-processing and high-temperature systems; thermal incineration principles; encapsulation of radioactive waste; developing technologies in high-temperature treatment of hazardous wastes.

**CE 5515. Water and Wastewater Microbiology.** (4 cr; prereq Chem 1052 or #, IT or grad student) Dwyer  
Role of microbes in environmental degradation and pollution control. Organism growth and selection in wastewater treatment systems. Pathogens in water supplies and receiving waters. Microbial indicators of water quality.

**CE 5540. Analysis of Groundwater-Soil Pollution Abatement Technology.** (4 cr; prereq IT major or grad student, 5401, 5501 or #) Maier  
Fate of chemicals in groundwater and soils analyzed and modeled. Combined effects of chemical-biological transformation, transport, dispersion, and accumulation. Models for studying in situ clean-up of groundwater and aquifers and for simulating time-dependent changes in pollutant concentration.

**CE 5580. Introduction to Environmental Law for Engineers.** (4 cr; understanding of pollution control technology recommended; 4 lect hrs per wk) Braaten  
Environmental regulatory law relevant to civil and environmental engineering; specific provisions of federal statutory and regulatory laws such as NEPA, CWA, RCRA, CAA, and CERCLA.

**CE 8500.\* Physical and Chemical Processes for Water and Wastewater Treatment.** (3 cr; prereq 5500, 5501 or #) Semmens  
Theoretical principles underlying physical and chemical processes for water and wastewater treatment including sedimentation, flotation, adsorption, precipitation, and disinfection.

**CE 8501.\* Physical and Chemical Processes for Water and Wastewater Treatment—Part II.** (3 cr; prereq 5500, 5501, 5506 or #) Semmens  
Theoretical principles, design considerations, and performance of processes not covered in CE 8500. Coagulation flocculation, filtration, membrane processes, gas transfer, sludge dewatering, mixing, and other processes commonly used in water pollution control.

**CE 8502.\* Biological and Chemical Processes for Wastewater Treatment.** (3 cr; prereq 5501 or #) Maier

Theoretical principles underlying chemical and biological wastewater treatment processes including aerobic and anaerobic biological processes for carbon and nitrogen removal, aeration, and chemical processes for phosphorus and nitrogen removal.

**CE 8505.\* Aquatic Chemistry for Environmental Engineers.** (4 cr; prereq Chem 5506 or #) Brezonik

Application of principles of physical chemistry to quantification of chemical processes in aquatic systems. Natural waters as equilibrium and dynamic systems. Ionic equilibria; protolysis, complexation, solubility, and redox equilibria. Precipitation and mineral dissolution kinetics. Aqueous metal species in electrolyte solutions.

**CE 8507s. Environmental Processing of Organic Chemicals.** (3 cr; prereq grad student, 5506 or #; offered alt yrs)

Occurrence, composition, and reactions of organic matter in surface- and groundwaters. Physical-chemical properties of organic contaminants; solubility; activity of organic chemicals in water. Processes controlling organic contaminant fate in natural waters. Environmental processing of organic chemicals in atmosphere, hydrosphere, sediments, and groundwaters case studies.

**CE 8508. Groundwater Microbiology.** (4 cr; prereq #) Dwyer

Subsurface microbial ecology; biogeochemical cycling; metabolic classification of subsurface bacteria; modeling bacterial transport; diagnosis of microbial induced fouling (MIF) events; bioremediation of contaminated aquifers; kinetic analyses of biodegradation for pollutants in subsurface samples.

**CE 8509. Environmental Microbiology.** (4 cr; prereq #) Dwyer

Molecular biology techniques used in environmental microbiology; measuring microbial biomass; analyzing microbial activities important for bioremediation; constructing and using genetically engineered microorganisms in environmental engineering.

**CE 8540. Interfacial Mass Transfer With Environmental Applications.** (4 cr; prereq 5504 or #) Gulliver

Interfacial mass transfer in turbulent flows. Applications to air-water transfer in rivers, lakes, and oceans; to sediment-water mass transfer; and to pollution abatement technology.

**CE 8550. Analysis and Modeling of Aquatic Environments.** (4 cr; prereq #) Stefan

Introduction to hydrologic transport and water quality simulation in natural water systems. Mixed cell models, advection, turbulent diffusion and dispersion in one- and two-dimensional systems. Chemical and biological kinetics in water quality models. Applications to temperature, dissolved oxygen, primary productivity, and other water quality management problems in rivers, lakes, and reservoirs. Deterministic versus stochastic models. Water quality dynamics.

**CE 8551. Seminar: Models of Aquatic Environments.** (1-5 cr; prereq 8550) Stefan  
Case studies of specific aquatic stream and lake systems.

**Structural Engineering, Soil and Rock Mechanics, Construction Materials**

**CE 5300. Critical State Soil Mechanics.** (4 cr; prereq 3300, IT upper div or grad student) Drescher  
Strength of granular soils. Volume changes under shear (dilatancy, contractancy), liquefaction. Cyclic loading. Strength of cohesive soils. Normal consolidation. Overconsolidation. Critical state concept.

**CE 5301. Foundation Engineering.** (4 cr; prereq 3300, 3301, IT upper div or grad student)  
Settlement analysis; retaining walls and earth pressure theories; stability of slopes; bearing capacity of shallow foundations; deep foundations.

**CE 5302. Applied Rock Mechanics.** (4 cr, §GeoE 5302; prereq 3300 or #, IT upper div or grad student) Detournay  
Site investigation; rock mass classifications; in situ stress; behavior of intact rock; shear strength of joints; rock mass behavior; stereographic projections; kinematic analysis of rock slopes; foundations on rock.

**CE 5304. Design of Highway and Airport Pavements.** (4 cr; prereq 3300, 5603, IT or grad student) Newcomb, Snyder  
Theories of pavement design, flexible and rigid; equivalent wheel loads. Strength tests and frost action. Design procedures for flexible and rigid pavements.

**CE 5305. Design of Underground Excavations in Rock.** (4 cr, §GeoE 5218; prereq IT or grad IT major, GeoE 5302 or #) Fairhurst  
Stresses and deformations around underground excavations in rock; design of linings and support systems; excavation by boring, drilling, and blasting; tunneling under adverse conditions; materials handling and tunnel ventilation.

**CE 5600. Linear Structural Systems.** (4 cr; prereq AEM 1015, 3016, IT or grad student)  
Analysis of determinate and indeterminate linear structural systems; analysis of trusses and frames by virtual work, moment distribution, energy methods, and slope-deflection equations. Influence lines. Approximate methods of analysis. Design considerations.

**CE 5601. Matrix Analysis of Structures.** (4 cr; prereq 5600, IT or grad student) Stolarski  
Analysis of linear structural systems by matrix methods; stiffness and flexibility methods of analysis. Introduction to computerized structural analysis of trusses and frames.

**CE 5602. Topics in Structural Mechanics.** (4 cr; prereq 5600, AEM 3036, IT upper div or grad student) Shield  
Introduction to theory of elasticity; theory of vibration for single-degree-of-freedom structures; energy methods of approximate structural analysis; torsion of beams; numerical calculation of buckling loads of bars and plates.

**CE 5603. Introduction to Construction**

**Materials.** (4 cr; prereq IT upper div student, AEM 3016; 3 lab hrs per wk)

Basic concepts of behavior mechanisms of materials. Characteristics of materials such as concretes, metals, and woods.

**CE 5610. Design of Metal Structures:**

**Introduction.** (4 cr; prereq 5600, 5603 or ¶5603, upper div IT or grad student)

Loads on civil structures, load factor and working stress philosophies of design. Design of tension, compression, and flexural members and their connections. Codes, properties of structural metals.

**CE 5611. Design of Reinforced Concrete**

**Structures.** (4 cr; prereq 5600, 5603 or ¶5603, upper div IT or grad student)

Principles of strength and serviceability in reinforced concrete structural design. Strength analysis, design of beams, joists, one-way slabs for flexure and shear. Anchorage development, splicing of reinforcement. Stresses at service, deflections, cracking, long-term effects. Introduction to design of columns; continuity; simple footings.

**CE 5612. Design of Metal Structures:**

**Intermediate.** (4 cr; prereq 5610, IT or grad student) Galambos, Hajjar

Design of complete metal structures; plate girder bridges, industrial buildings, multistory structural frames.

**CE 5613. Intermediate Reinforced Concrete**

**Design.** (4 cr; prereq 5611, IT or grad student) French, Schultz

Eccentrically loaded columns. Shear friction; design of brackets. Deep beam design. Continuous beams and frames. Combined and continuous footings. Retaining walls. Combination of shear and torsion. Two-way slabs.

**CE 5615. Prestressed Concrete.** (4 cr; prereq

5611; 5613 recommended, IT or grad student; offered alt yrs) French, Schultz

Types and properties of high-strength concretes and steels for prestressed concretes. Design of pretensioned and posttensioned members. Posttensioning systems. Precast, prestressed building systems, floors, roofs, bridges. Continuity in precast, prestressed systems. Design of connections.

**CE 5617. Design of Masonry Structures.** (4 cr;

prereq 5600 or #, IT or grad student; offered alt yrs) Schultz

Masonry materials and their production; mortars and grouts; design of nonreinforced and reinforced masonry structural systems; walls; columns; lintels; arches. Codes and specification, testing and inspection.

**CE 5701. Bituminous Materials I.** (4 cr; prereq

5603, IT upper div or grad student; 3 lect, 3 lab hrs per wk) Newcomb

Physical and chemical properties and characteristics of bituminous binders and aggregates. Properties and design of bituminous mixtures and surface treatments.

**CE 5702. Components, Properties, and**

**Design of Portland Cement Concrete.** (4 cr; prereq 5603, IT upper div or grad student; 3 lect, 3 lab hrs per wk) Snyder

Physical and chemical properties and characteristics of portland cement, aggregates, and admixtures. Properties and design of concrete mixtures.

**CE 8302. Soil/Rock Plasticity and Limit**

**Analysis.** (4 cr, §GeoE 8302; prereq 3300; offered alt yrs) Drescher

Plasticity of soils and rocks. Hardening and perfectly plastic models. Yield conditions, flow rules. Theorems of limit analysis. Static solutions, method of characteristics. Kinematic solutions, hodograph, energy balance. Applications to soil/rock engineering problems.

**CE 8320. Thermoporelasticity.** (4 cr, §GeoE

8320; prereq AEM 5580 or #) Detournay  
Micro-mechanical description of porous media. Thermodynamics foundations. Linear theory of thermoporelasticity; constitutive, transport, and balance laws; field equations. Determination of material constants. Singular solutions. Methods of solution: integral transform, method of singularities, finite and boundary element method. Geomechanics applications.

**CE 8321. Mechanics of Granular Media.** (4 cr;

prereq 5301 or 5302 or #; offered alt yrs) Drescher  
Advanced constitutive models for granular media; simple hardening and double hardening plastic models. Bifurcation analysis; localized and diffuse bifurcation. Experimental methods for validation of constitutive models.

**CE 8322. Storage and Flow of Granular**

**Materials.** (4 cr; prereq 5301 or 5302 or #; offered alt yrs) Drescher

Plasticity of granular media; static and dynamic method of slices; storage and flow of granular materials in bins and hoppers; stress concentrations, rarefaction waves, arching, piping.

**CE 8360. Engineering Model Fitting.** (4 cr; prereq

civil or geo or mineral engr grad student or #) Barnes  
Parameter estimating and inverse modeling in civil, geological, and mineral engineering. Formulating engineering model fitting problems, comparing and selecting various fit criteria, selecting and implementing solution algorithms on computer, analyzing and interpreting results, and designing future measurement plans.

**CE 8605. The Finite Element Method in Civil**

**Engineering.** (4 cr; prereq 5601 or #) Stolarski  
Theoretical foundations for formulation of finite element representation in structural analysis. Methods for the construction of element and system stiffness matrices. Applications to static problems of linear elastic structures and solids. Some applications to soil and fluid mechanics.

**CE 8606. Advanced Topics in Finite Element Analysis.** (4 cr; prereq 8605 or #; offered alt yrs) Stolarski

Large strains and work conjugate stresses; equilibrium and principle of virtual work for nonlinear problems; nonlinear elasticity and plasticity; finite element discretization and discrete nonlinear equations; linearization and solution algorithms for nonlinear problems; structural stability.

**CE 8608. Advanced Analysis and Design of Structures.** (4 cr; prereq 5601, 5612 or equiv or #; offered alt yrs) Hajjar

Advanced theory and computational techniques for analyzing and designing complex structural systems. Using comprehensive geometric and material nonlinear analysis for designing steel and composite structures.

**CE 8609. Principles of Structural Stability.**

(4 cr; prereq #; offered alt yrs) Galambos, Stolarski  
Classification of discrete and continuous conservative and nonconservative systems; buckling analysis of structural members, frameworks, plates, etc., by classical and numerical methods.

**CE 8610. Shell Structures.** (4 cr; prereq #; offered alt yrs) Shield, Stolarski

Static analysis of thin elastic shells based on Love's postulates; membrane and bending resistance; approximate analytical solutions; higher order theories; design considerations.

**CE 8611. Plate Structures.** (4 cr; prereq #; offered alt yrs) Shield, Stolarski

Analysis and design of flat plate structures based on the small-deflection elastic Kirchhoff-Love theory. Classical and numerical design methods. Skew and orthotropic plate structures. Large-deflection theory.

**CE 8612. Plastic Design of Steel Structures.**

(4 cr; prereq 5610 or #; offered alt yrs) Galambos, Hajjar  
Plastic analysis and design of structures with applications to grillages, continuous beams, portal and gable frames, collapse mechanisms, minimum weight design, plastic deformations.

**CE 8616. Nonlinear Structural Systems.** (4 cr; prereq 5610 or #; offered alt yrs) Galambos, Shield

Modern analysis of structural members and systems taking into account geometrical and material sources of nonlinearity. Second-order analysis of simple structures. Inelastic buckling. Emphasis on design considerations.

**CE 8618. Reliability in Structural Engineering.** (4 cr; prereq 5612, 5613 or equiv)

Galambos, Stolarski  
Structural design standards and methods, uncertainties in structural design, basic probabilities concepts and statistical distributions, resistance and load statistics, first- and second-order reliability methods, systems reliability, development of probability-based design codes.

**CE 8620. Structural Dynamics I.** (4 cr; prereq AEM 3036 or #) French, Galambos, Hajjar, Shield, Stolarski

Response of lumped parameter systems to dynamic loading; formulation and solution of problems of one or more degrees of freedom for discrete systems, modal analysis, numerical integration, and transform techniques. Response of continuous systems.

**CE 8621. Structural Dynamics II.** (4 cr; prereq 8620 or #) French, Schultz

Introduction to earthquake engineering; response spectra; energy absorption capacity of structures; estimation of damping; aseismic design; seismic codes; soil-structure interaction. Wind effects on structures. Blast resistant design. Approximate design methods.

**CE 8625. Behavior of Reinforced Concrete Structures.** (4 cr; prereq 5611, 5613, 5615) French, Schultz

Advanced topics in behavior of reinforced concrete structures, relationship with element design. Code requirements, reasons behind theoretical and experimental studies for understanding structural behavior and applications to design.

**CE 8626. Behavior of Reinforced Concrete Structures II.** (4 cr; prereq 8625 or #) French, Schultz

Limit analysis and failure mechanisms for reinforced concrete structures; response and behavior under cyclic, blast, and impact loading; membrane effects; design code requirements.

**CE 8697-8698-8699. Seminar: Structures.** (1 cr per qtr)

Syllabus varies according to interests of instructor and student; in recent years the following topics have been offered: theory of elasticity, optimization and reliability, wave propagation, soil dynamics, structural lab, wind forces on structures, design in prestressed concrete, modern construction practices.

## Classical and Near Eastern Studies

*Regents' Professor:* Rutherford Aris

*Professor:* Elizabeth S. Belfiore; Thomas S. Clayton; Frederick Cooper; Gerald M. Erickson (*emeritus*); Jackson Hershbell; Thomas Kelly; Eva Keuls; Sheila McNally; Robert P. Sonkowsky; Theofanis Stavrou; Peter S. Wells

*Adjunct Professor:* William D. E. Coulson

*Associate Professor:* Nita Krevans, *director of graduate studies*; Oliver P. Nicholson; Jonathan S. Paradise; Sandra L. Peterson; Philip H. Sellow; George A. Sheets

*Assistant Professor:* André P. M. H. Lardinois

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Classics<sup>1</sup>, Greek, Latin, and Ancient and Medieval Art and Archaeology: M.A. (Plan B and, in exceptional cases only, Plan A) and Ph.D.

**Curriculum**—In addition to Classical Greek and Latin literary studies, flexible degree programs under the Greek and Latin rubrics permit minors or supporting programs in other disciplinary areas such as archaeology, linguistics, modern Greek and Hellenic studies, Medieval and Renaissance Latin, myth and folklore, oral performance, philosophy, and religious studies. The art and archaeology degree includes a variety of programs ranging broadly over ancient and medieval periods, with flexible emphases on languages and textual studies. While full faculty participation from a wide variety of fields provides differing coursework, all students take a common core of courses to promote optimum collegiality and intellectual exchange. Related special facilities include Interdisciplinary Archaeological Studies, the Center for Medieval Studies, and the Center for Modern Greek Studies.

**Prerequisites for Admission**—Prerequisites for unqualified admission to majors in Classics, Greek, and Latin include sufficient knowledge to begin graduate reading courses in at least one of the two Classical languages and at least intermediate ability in the other. For a major in Ancient and Medieval Art and Archaeology, a background in archaeology, art history, and history sufficient for beginning graduate-level studies, and evidence of language acquisition ability, are required for unqualified admission. Ability, motivation, imagination, and creativity are important criteria. Some course prerequisites can be made up on provisional admission.

Applications from students with undergraduate majors in such fields as the following are welcomed: English, history, Greek and Latin, Near Eastern languages, philosophy, comparative literature, anthropology, theatre, religious studies, art history, political science, the modern languages, and linguistics.

<sup>1</sup> For degree purposes, “Classics” indicates a program in which courses in Greek and Latin are combined to form a major. This use of the term should not be confused with the course designation “Classics (Clas),” which indicates courses that do not require knowledge of Greek or Latin.

**Special Application Requirements**—

Applicants must send the following directly to the Department of Classical and Near Eastern Studies: results of the Graduate Record Examination; three letters of recommendation from persons well acquainted with their academic work and professional experience; and a two-page statement describing their previous experience and academic training as related to the intended course of study and professional goals. Students may be admitted in any academic term, but financial assistance is normally available only to applicants admitted in the fall quarter (deadline: January 15).

**Master’s Degree Requirements**—There are four degree programs:

*M.A. in Greek:* Advanced courses and seminars in Greek literature and supporting work in related fields such as Latin, Modern Greek, myth, Near Eastern language, and religion are required. The total minimum course credit requirement for Plan A is 57 credits (not including 16 thesis credits) and for Plan B is 63 credits.

*M.A. in Latin:* Advanced courses and seminars in Latin literature and supporting work in related fields such as Greek, English, and Medieval and Renaissance Latin are required. The total minimum course credit requirement for Plan A is 57 credits (not including 16 thesis credits) and for Plan B is 63 credits.

*M.A. in Classics:* This program requires nearly equal emphasis on courses and seminars in Greek and Latin, as well as in related fields. The total minimum course credit requirement for Plan A is 61 credits (not including 16 thesis credits) and for Plan B is 67 credits.

*M.A. in Ancient and Medieval Art and Archaeology:* This program includes not only core courses and seminars in the Department of Classical and Near Eastern Studies, but also work in related fields in the Department or other departments. It is offered in cooperation with the Department of Art History, Interdisciplinary Archaeological Studies, and the Center for Medieval Studies. The total minimum course credit requirement for Plan A is 49 credits (not including 16 thesis credits) and for Plan B is 55 credits.

The final examinations for all master’s degrees are both written and oral. Consult the department’s *Graduate Student Handbook* for details.

**Doctoral Degree Requirements**—Although the M.A. degree is not a prerequisite for admission to the Ph.D. program, doctoral students must complete departmental M.A. course requirements or their equivalent and incorporate them into their Ph.D. programs. In the Classics, Greek, and Latin programs, additional work leads to specialized study and research in Greek and Latin literature, a special (elective) author or genre, and a special (elective) topic or subdiscipline. In the Ancient and Medieval Art and Archaeology program, the four foci are art and archaeology, an ancient textual component, a complementary area (e.g., ancient and medieval history, geology, anthropology), and a special (elective) topic. The Ph.D. program normally averages 90-100 credits.

**Minor Requirements for Students Majoring in Other Fields**—For master's students, the minimum credit requirement is 13 credits for a minor in Greek, Latin, or Ancient and Medieval Art and Archaeology, and 17 credits for a minor in Classics. For doctoral students, the minimum credit requirement is 25-33 credits.

**Modern Language Requirements**—For the M.A. degree, reading knowledge of one modern foreign language appropriate to the student's program is required (normally German or French). For the Ph.D. degree, reading knowledge of German and one other modern foreign language appropriate to the program (normally French) is required.

**For Further Information and Applications**—Contact the Department of Classical and Near Eastern Studies, University of Minnesota, 330 Folwell Hall, 9 Pleasant Street S.E., Minneapolis, MN 55455 (612/625-5353; fax 612/624-4894; e-mail cnes@tc.umn.edu).

**Clas 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**Clas 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**Clas 8888. Thesis Credits: Doctoral.** (36 cr required)

**Grk 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**Grk 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**Grk 8888. Thesis Credits: Doctoral.** (36 cr required)

**Lat 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**Lat 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**Lat 8888. Thesis Credits: Doctoral.** (36 cr required)

## ***Classical Languages, Literatures, and Cultures***

### **Greek (Grk)**

**Grk 5012. Prose Composition.** (4 cr; prereq 3106 or Δ)

**Grk 5032. Textual Criticism.** (4 cr)  
Theory and practice. Basic tools for analyzing a textual apparatus with some independence; constructing a critical edition of Greek or Latin literary text.

**Grk 5121. Biblical and Patristic Greek.** (4 cr; prereq 3106 or 3120 or Δ) Sellw  
The Septuagint, Philo, Josephus, New Testament, Apostolic Fathers, and other patristic literature. Reading and discussion of selected texts in the major genres to the fifth century A.D.

**Grk 5310, 5320, 5330, 5340, 5350, 5360, 5370, 5380, 5390. Greek Literature.** (4 cr per qtr [max 12 cr in each course])  
One or more appropriate authors studied in a given course. Authors vary from term to term and from year to year. *5310*: oratory. *5320*: tragedy. *5330*: comedy. *5340*: history. *5350*: philosophy. *5360*: religious texts. *5370*: epic. *5380*: lyric. *5390*: romance.

**Grk 5715. Introduction to Classical Philology.** (4 cr, §Lat 5715) Sheets  
Historical grammar of Greek and Latin from their Indo-European origin to Classical norms.

**Grk 5716. History of Greek.** (4 cr; prereq Grk/Lat 5715 or equiv, 2 yrs Greek) Sheets  
Reading and analysis of documents illustrating the evolution of the Greek language from Mycenaean to modern times.

**Grk 5718. Greek Dialects.** (4 cr; prereq 3 yrs Greek or #) Sheets  
Nature and extent of dialectal variation within ancient Greek through reading and analysis of inscriptions and earlier Greek literature.

**Grk 5970. Directed Study.** (1-5 cr; prereq #, Δ, CLA approval)

**Grk 5980. Directed Teaching.** (Cr ar; prereq #, Δ, CLA approval)

**Grk 5990. Directed Research.** (Cr ar; prereq #, Δ, CLA approval)

## GRADUATE PROGRAMS

**Grk 8120. Greek Text Course.** (4 cr; prereq 3052 or Δ; restricted to students in depts other than Classical and Nr East Sts)  
Students attend 3xxx Greek courses if they meet the prerequisites for these courses. Supplementary work at the discretion of the instructor.

**Grk 8264. Survey of Greek Literature: Archaic.** (4 cr)

**Grk 8265. Survey of Greek Literature: Literature of the Fifth Century.** (4 cr)

**Grk 8266. Survey of Greek Literature: Literature of the Fourth and Third Centuries.** (4 cr)

**Grk 8510. Seminar: Philosophy.** (4 cr; offered when feasible) Hershbell

**Grk 8910. Seminar.** (4 cr)  
Seminars on various topics or authors, such as Greek lyric poetry, Greek tragedy, Greek rhetoric, Greek comedy, Homer, Pindar, and Euripides.

### Latin (Lat)

**Lat 5012. Prose Composition.** (4 cr; prereq 3106 or Δ)

**Lat 5032. Textual Criticism.** (4 cr)  
Theory and practice. Basic tools for analyzing a textual apparatus with some independence; constructing a critical edition of Greek or Latin literary text.

**Lat 5310, 5320, 5330, 5340, 5350, 5360, 5370, 5380, 5390. Latin Literature.** (4 cr per qtr [max 12 cr in each course])

One or more appropriate authors studied in each course. Authors vary from term to term and from year to year. 5310: history. 5320: epistles and essays. 5330: oratory. 5340: epic and pastoral. 5350: lyric and elegiac poetry. 5360: drama. 5370: satire. 5380: law. 5390: religious texts.

**Lat 5410. Latin Literature of Late Antiquity.**

(4 cr [max 12 cr]) Nicholson, Sonkowsky  
Pagan and Christian Latin literature from 3rd to 8th centuries.

**Lat 5420. Medieval Latin.** (4 cr [max 12 cr])  
Nicholson, Sonkowsky  
Literature from 6th to 15th centuries. Authors and genres vary.

**Lat 5430 (formerly 5236). Renaissance Latin.** (4 cr [max 12 cr]) Nicholson, Sonkowsky  
Literature after 14th century.

**Lat 5621. Latin Paleography.** (4 cr; prereq 3 cr 3xxx-5xxx Latin or #) Aris  
Analysis of various hands used in manuscripts of Latin authors with attention to date and provenance; transmission of ancient Latin literature.

**Lat 5715. Introduction to Classical Philology.** (4 cr, §Grk 5715) Sheets  
Historical grammar of Greek and Latin from their Indo-European origin to Classical norms.

**Lat 5717. History of Latin.** (4 cr; prereq Grk/Lat 5715 or equiv or #, 2 yrs Latin) Sheets  
Reading and analysis of documents illustrating the evolution of the Latin language from its origins to late antiquity.

**Lat 5735. Italic Dialects.** (4 cr; prereq Grk/Lat 5715 or #; offered when feasible) Sheets

**Lat 5970. Directed Study.** (1-5 cr; prereq #, Δ, CLA approval)

**Lat 5980. Directed Instruction.** (Cr ar; prereq #, Δ, CLA approval)

**Lat 5990. Directed Research.** (Cr ar; prereq #, Δ, CLA approval)

**Lat 8120. Latin Text Course.** (4 cr; prereq 3052 or Δ; restricted to students in depts other than Classical and Nr East Sts)

Students attend 3xxx Latin courses if they meet the prerequisites for these courses. Supplementary work at the discretion of the instructor.

**Lat 8150. Medieval Latin Texts.** (4 cr; prereq #; offered when feasible) Nicholson, Sonkowsky

**Lat 8160. Renaissance Latin Texts.** (4 cr; prereq #; offered when feasible) Nicholson, Sonkowsky

**Lat 8264. Graduate Survey: Literature of the Republic.** (4 cr)

**Lat 8265. Graduate Survey: Literature of the Augustan Age.** (4 cr)

**Lat 8266. Graduate Survey: Literature of the Empire.** (4 cr)

**Lat 8267. Graduate Survey: Latin Literature of Late Antiquity.** (4 cr; prereq #)

Wide range of Latin authors of pagan and Christian prose and poetry, from revival of Latin literature under last pagan emperors to dawn of Middle Ages.

**Lat 8910. Seminar.** (4 cr)  
Various topics or authors such as Roman drama, Cicero, Lucretius, odes and epodes of Horace, Ovid, and Juvenal.

### Classics (Clas)

*Courses for Which Knowledge of Latin or Greek Is Not Required*

#### Classical Humanities

**Clas 5001. Greek, Roman Lyric Poetry in Translation.** (4 cr, §3001; prereq 2 courses in Engl lit beyond Engl 1002 or in foreign lit or Δ; offered when feasible)

**Clas 5007. The Pastoral Tradition.** (4 cr; prereq 2 lit courses or #) Krevans  
Origins and development of pastoral poetry and prose. Readings in English translation from Greek and Latin pastoral poets, and vernacular imitations of the Middle Ages and Renaissance. Nature of allegory, "debate poems," *pastourelle*, pastoral genre.

**Clas 5011su. The World of Greece.** (4 cr, §3011)  
Survey of Greek civilization from Homer to Alexander. Way of life as seen in art, history, literature, and philosophy. Special attention to golden age in fifth century B.C. and to expansion of Greek presence under Alexander.

**Clas 5012su. The World of Rome.** (4 cr, §3012)  
Survey of Roman civilization from origins to Constantine. Way of life as seen in art, history, literature, and philosophy. Special attention to Etruscans and golden age under Augustus.

**Clas 5013. Roman Law and Society.** (4 cr) Sheets  
Roman law as a social institution; basic concepts of persons, property, obligations in historical and social perspective.

**Clas 5071. Greek and Hellenistic Religions.** (4 cr, §3071, §3071H, §RelA 3071, §RelA 3071H, §RelA 5071) Sellw  
Ancient Greek religion from Bronze Age to Hellenistic times. Sources include literature, art, and archaeology. Prehistoric religion; Homer and Olympian deities; music, dance, and procession as ritual performance; prayer and sacrifice; temple architecture and sanctuaries; oracles; beliefs about death and afterlife; mystery cults; philosophical religion; criticism of traditional myths; ruler cult; and Near Eastern salvation religions.

**Clas 5072. The New Testament.** (4 cr, §3072, §3072H, §RelA 3072, §RelA 5072, §RelS 3072, §RelS 5072) Sellw  
Early Jesus movement in its social and historical setting; origins in Judaism; traditions about Jesus; Paul, his controversies and interpreters; questions of authority, religious practice, and structure in early communities; apocryphal literature and emergence of a scriptural canon. Contemporary methods of New Testament study. Ancient sources studied as evidence for constructing critical history; appreciating their narrative structures and other literary techniques.

**Clas 5073. Roman Religion and Early Christianity.** (4 cr, §3073, §3073H, §RelA 3073, §RelA 5073, §RelS 3073, §RelS 5073) Nicholson, Sellw  
The Etruscans. Republican religion. Appeal of non-Roman cults. Ruler worship. Christians in Asia Minor, Egypt, and the West. Popular piety, Christian and non-Christian. Rabbinic Judaism. Varieties of Christianity in 2nd and 3rd centuries. Influence of Greco-Roman culture upon emerging church. Constantine and Julian. Meets with 3073; students do additional work for graduate credit.

**Clas 5080. New Testament Proseminar.** (4 cr per qtr [max 12 cr]; prereq 3072 or 5072 or #) Sellw  
Selected topics in study of the New Testament and related ancient literatures. Topics announced in the *Class Schedule*.

**Clas 5081. Classical Epic in Translation.** (4 cr, §3081)  
Homer's *Iliad* and *Odyssey*, Virgil's *Aeneid*; cultural context of epic, the heroic character, epic formulas, and poetic techniques.

**Clas 5082. Greek Tragedy in Translation.** (4 cr, §3082)  
Origin of European drama as distinct literary form; characteristics of Greek tragedy; ancient theatres and theatrical conventions. Selected tragedies. Problems posed in relation to cultural patterns of the time.

**Clas 5085. Greek Philosophy: The Pre-Socratics to Plato.** (4 cr; prereq jr) Hershbell  
Fragments of the pre-Socratics and Sophists and selected dialogues of Plato.

**Clas 5090. Topics in Greek Philosophy.** (4 cr; prereq #)  
Selected topics in ancient Greek philosophy to be announced in the *Class Schedule*.

**Clas 5145. Greek and Roman Mythology II.** (4 cr, §3145; prereq 1042 or #)  
Methodologies for the interpretation of myth, such as those of Müller, Jung, and Levi-Strauss, examined on the basis of Classical mythology; successive reinterpretations and applications of selected myths in literature, art, music, and modern sociological disciplines. Independent reading and research assignments completed in consultation with instructor. Meets with 3145; students do additional work for graduate credit.

**Clas 5794. Proseminar: Introduction to Classical and Near Eastern Studies.** (1 cr; prereq grad major or #)  
Introduction to core research materials in classical studies and reference tools that give access to them. Organization of library collections and services.

**Clas 5950. Cultural Aspects of Classical Antiquity.** (4 cr)  
Art, archaeology, and social history of Greco-Roman antiquity.

**Clas 5970. Directed Study.** (1-5 cr; prereq #, Δ, CLA approval)

**Clas 5980. Directed Instruction.** (Cr ar; prereq #, Δ, CLA approval)

**Spch 5611. Classical Rhetoric.** (4 cr; prereq Spch 1101 or 1101H) Scott

## Art and Archaeology

**Clas 5089. Introduction to Biblical Archaeology.** (4 cr, §RelS 5089; offered when feasible) Sellw

**Clas 5102. Classical Greek Art.** (5 cr, §Arth 5102) McNally  
Architecture, sculpture, and painting in Greece from Persian Wars to conquests of Alexander.

**Clas 5104. Roman Architecture.** (5 cr, §Arth 5104; prereq jr or #) Cooper, McNally  
Buildings in Rome and the empire from the 5th century B.C. to the 4th century A.D. Major archaeological sites.

**Clas 5105. Roman Painting and Mosaics.** (5 cr, §Arth 5105; prereq jr or #) McNally  
Specific problems; sites such as Pompeii and Antioch.

**Clas 5106. Greek Painting.** (5 cr, §Arth 5106; prereq jr or #)  
Research and analysis in Classical art as applied to the study of vases, original objects, and sources.

**Clas 5107. Roman Sculpture.** (4 cr, §Arth 5107; prereq jr or #) McNally  
Sculpture of Rome and its provinces from the 1st century B.C. to the 4th century A.D.; role of sculpture in Roman politics and religion.

**Clas 5108. Greek Architecture.** (4 cr, §Arth 5108; prereq jr or #) Cooper  
Archaic and Classical examples of religious and secular architecture, their setting in major archaeological sites.

**Clas 5111. Bronze Age Art and Architecture in Greece, CA. 3000-1100 B.C.** (4 cr, §Arth 5111; prereq one ancient art or archaeology course) Cooper  
Artistic and architectural forms in the Neolithic period in the Aegean area and the Cycladic, Minoan, and Mycenaean cultures.

**Clas 5113. Archaic Greek Art.** (4 cr, §Arth 5113; prereq jr or #) McNally  
Architecture, sculpture, and painting from 9th century B.C. through 480 B.C. Material remains of Greek culture; scholarly problems such as identifying and dating buildings; analysis of methods and techniques.

**Clas 5120. Field Research in Archaeology.** (3-6 cr; prereq #; offered when feasible)

**Clas 5122. Greek Art, Architecture, and Archaeology.** (4 cr, §3122) McNally  
Survey of Greek art from earliest times to 31 B.C. Main trends and concepts in architecture, sculpture, and painting; the art in its social, literary, and historical context.

**Clas 5340. Practicum in Archaeological Field Techniques.** (4 cr, §3340, §CICv 3340; prereq major in Grk or Lat or Clas or Hebr or ANE Studies or CICv or #, ancient art or archaeology course) Cooper  
Introduction to methods of excavation on classical sites. Meets at selected Minnesota site for day-long sessions for half of quarter. Arranged according to procedures in field: handling instruments, setting up field notebooks, preparing trenches, excavating, and recording and analyzing strata and artifacts.

**Clas 8114. Seminar: The Topography of Athens.** (4 cr, §Arth 8114; prereq #)

**Clas 8190. Seminar: Problems in Ancient Art.** (4 cr [may be repeated for cr], §Arth 8190; prereq #)

**Clas 8910. Seminar: Problems in Classical Archaeology.** (4 cr [may be repeated for cr], §Arth 8910; prereq #)

## Modern Greek

### Modern Greek (MdGk)

**MdGk 5970. Directed Study.** (1-5 cr; prereq #, Δ, CLA approval)

**MdGk 5980. Directed Teaching.** (Cr ar; prereq #, Δ, CLA approval)

**MdGk 5990. Directed Research.** (Cr ar; prereq #, Δ, CLA approval)

## Near Eastern Studies

### Akkadian (Akka)

**Akka 5011-5012-5013. Elementary Akkadian.** (4 cr per qtr; prereq advanced undergrad with permission or grad student; offered alt yrs)  
Introduction to cuneiform script. Outline of Akkadian grammar, written drills, selected readings from historical annals, law collections, religion and epic literature.

### Ancient Near Eastern (ANE)

**ANE 5501, 5502. Ancient Israel.** (4 cr per qtr, §3501, 3502; prereq grad student or #; knowledge of Hebrew not required)  
History of Israel and development of its religion, from earliest times through intertestamental period. *5501*: Formation of Hebrew people; patriarchal period; development of Israelite religious and legal institutions; conquest of Canaan; development of monarchy and United Kingdom. *5502*: Divided kingdom; classical prophecy, destruction, exile, and restoration.

**ANE 5505. Ancient Israel: The Hellenistic Period.** (4 cr, §3505; prereq grad student or #; knowledge of Hebrew not required)  
Period of Ezra and Nehemiah, Samaritans; apocalyptic and other eschatological types; Maccabean period; Sadducees, Pharisees, Zealots, Christians, Qumran, wisdom literature; Philo; Josephus; Jewish rights in Roman Empire. Emphasis on evaluation of sources for historical reliability.

**ANE 5711. Northwest Semitic Inscriptions.** (4 cr; prereq Hebr 3013 or #; offered when feasible)

**ANE 5970. Directed Studies.** (1-4 cr; prereq #)

### Aramaic (Arm)

**Arm 5011, 5012, 5013. Aramaic.** (4 cr per qtr; for students preparing for biblical studies, ancient history majors, and students specializing in Semitic languages; recommended for students of Talmud; prereq 1 yr Hebrew or Arabic or #; offered alt yrs)  
*5011*: Biblical Aramaic—fundamentals of grammar and fluency in reading of biblical and ancient Aramaic. *5012*: Syriac—grammar, fluency of reading Syriac texts. *5013*: Aramaic inscriptions—study of epigraphy, morphology, and syntax of old Aramaic inscriptions from the 9th to 5th centuries B.C.

### Coptic (Copt)

**Copt 5011-5012. Elementary Coptic.** (4 cr per qtr; prereq some knowledge of another ancient language, preferably Greek) Sellew  
*5011*: Introduction to Coptic grammar and vocabulary (Sahidic dialect). *5012*: Further instruction in grammar, introduction to other dialects; first reading of texts.

**Copt 5300. Readings in Coptic.** (4 cr [may be repeated twice for cr]; prereq 5012 or equiv) Sellwe Advanced reading in variety of Coptic literature, such as Nag Hammadi treatises, Hermetic writings, and Egyptian monastic texts. Authors vary each year.

## Hebrew (Hebr)

**Hebr 5200. Problems in Biblical Studies.** (4 cr per qtr; for majors and others adequately prepared to read the Bible in Hebrew; prereq 3202 or #; offered when feasible)

**Hebr 5970. Directed Readings.** (Cr ar; prereq 3013, #, Δ, CLA approval)  
Special problems for advanced students.

## Sumerian (Sum)

**Sum 5011-5012. Elementary Sumerian.** (4 cr per qtr; prereq advanced undergrad with 2 yrs other foreign language or grad student; offered alt yrs) Introduction to Sumerian writing and grammar. Readings from classical Sumerian literary and historical texts.

## Classical and Indo-Iranian Linguistics

**Grk 5715, 5716, 5718; Lat 5715, 5717, 5733, 5735** (For course descriptions see Greek and Latin under Classical Languages, Literatures, and Cultures above.)

See South Asian and Middle Eastern Languages and Cultures for descriptions of the following courses:

**SALC 5090. Instruction in South Asian Languages Skt 5131-5132-5133. Beginning Sanskrit Skt 5201-5202-5203. Intermediate Sanskrit**

*Representative courses of interest offered by Classical and Near Eastern Studies faculty through other departments:* Hist 5061, 5062, 5063 (Ancient Greece); Hist 5276, 5756-5757 (Modern Greece); Phil 5005.

## Classics

See Classical and Near Eastern Studies.

## Clinical Laboratory Science (CLS)

*Professor:* Fred S. Apple; Ellis S. Benson (*emeritus*); Richard D. Brunning; Jaroslav Cervenka; Paul P. Cleary; Agustin P. Dalmasso; Gary M. Dunny; John H. Eckfeldt; J. Roger Edson; Stanley L. Erlandsen; Patricia Ferrieri; Alexandra H. Filipovich; Russell C. Johnson; Karen Karni; John H. Kersey; Tucker W. LeBien; J. Jeffrey McCullough; Harry T. Orr; Herbert F. Polesky; Andreas Rosenberg; Daniel A. Vallera; Carol L. Wells

*Associate Professor:* Helen M. Hallgren, *director of graduate studies*; Robert J. Boudreau; Ronald R. W. Jemerson; Karen G. Lofsness; R. Scott McIvor; Miriam Segall; Amy P. Skubitz; William R. Swaim; Michael Y. Tsai; Michael J. Wilson

*Assistant Professor:* Ronald C. McGlennen; Angela Mortari

*Senior Research Associate:* Robert D. Nelson

*Research Associate:* Connie J. Gebhart

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—M.S. (Plan A only).

**Curriculum**—Graduate work in clinical laboratory science offers students with basic science or medical technology backgrounds the opportunity to gain competence in a specialized area of laboratory medicine. It provides training in the research, supervisory, and teaching aspects of the field. Students pursue investigative work in one of six specialty areas: chemistry, genetics, hematology, immunohematology, immunology, and microbiology.

**Prerequisites for Admission**—A bachelor's degree in a basic science or in medical technology, including standard college courses in organic/inorganic chemistry, biochemistry, quantitative analysis, physics, and mathematics, is required. Previous laboratory experience is desirable.

**Special Application Requirements**—Applicants must forward to the Department of Laboratory Medicine and Pathology three letters of recommendation, an autobiographical outline that includes a statement of career goals, and scores from the General Test of the Graduate Record Examination. A minimum score of 550 on the Test of English as a Foreign Language (TOEFL) is required for applicants whose native language is not English. Students may be admitted any quarter.

**Degree Requirements**—Students are encouraged to file their program after completing 9 to 15 graduate credits. At least 25 credits are required in the specialty area; at least 9 credits are required in a single supporting program, or 8 credits in related fields outside the major. Students must pass a final oral examination for defense of the thesis.

**Language Requirement**—None.

**For Further Information and Applications—**

Contact the Clinical Laboratory Science Program, Department of Laboratory Medicine and Pathology, University of Minnesota Medical School, Box 609 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (612/625-9171).

**CLS 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**CLS 5064s. Introduction to Clinical Immunohematology.** (3 cr; prereq #) Hallgren  
Fundamental principles of blood grouping, antibody identification, compatibility testing, serology, and immunology. Lecture.

**CLS 5065s. Introduction to Clinical Immunohematology: Laboratory.** (2 cr; prereq #) Hallgren

Exercises illustrating basic techniques in blood grouping, antibody identification, compatibility testing, and detection of antibodies by serological and immunological methods.

**CLS 5077f. Hematology I: Basic Techniques.** (3 cr, §MedT 5077; prereq Δ) Lofsness  
Theory and application of basic principles and techniques in clinical hematology. Lecture and lab.

**CLS 5078w. Hematology II: Hemostasis/Instrumentation.** (3 cr, §MedT 5078; prereq 5077 or MedT 5077, Δ)  
Theory and application of basic principles and techniques. Lecture and lab.

**CLS 5103f. Principles of Diagnostic Microbiology.** (5 cr, §MedT 5102; prereq MdBc 3103, 5232 or #) Wells

**CLS 5120. Seminar: Clinical Laboratory Science.** (1 cr [may be repeated for cr]; prereq #)  
Review and discussion of current literature; presentation and discussion of research carried on in department.

**CLS 5125. Practicum Teaching.** (1-3 cr; prereq #)  
Supervised experience in teaching, development of skills in effective use of instructional materials, tests, and measurements.

**CLS 5135. Advanced Clinical Microbiology.** (1-5 cr, §MedT 5135; prereq #) Wells  
Observation, study, and practice in special problems, advanced techniques, and methodology in clinical microbiology.

**CLS 5140. Techniques for Teaching.** (3 cr, §MedT 5140) Karni  
Development of objectives, classroom activities, and evaluation criteria for medical technology education.

**CLS 5155. Advanced Clinical Hematology.** (5 cr [may be repeated for cr], §MedT 5155; prereq #) Lofsness  
Observation, study, and practice in special problems, advanced techniques, and methodology in clinical hematology.

**CLS 5165. Advanced Clinical Immunohematology.** (5 cr [may be repeated for cr], §MedT 5165; prereq #) Hallgren  
Observation, study, and practice in special problems, advanced techniques, and methodology in clinical immunohematology.

**CLS 5175. Advanced Clinical Chemistry.** (5 cr [may be repeated for cr], §MedT 5175; prereq #) Tsai  
Observation, study, and practice in special problems, advanced techniques, and methodology in clinical chemistry.

**CLS 5196s. Computer Methodology in the Delivery of Healthcare I: Physiological Monitoring and Testing.** (3 cr, §Hlnf 5433; prereq Hlnf 5432 or #) Finkelstein  
Role of the computer in monitoring and testing patients; hardware and software requirements for processing clinically significant signals; comparison and evaluation of currently available systems.

**CLS 5197f. Computer Methodology in the Delivery of Healthcare II: Introduction to Medical Decision-Making Techniques.** (3 cr, §Hlnf 5434; prereq Hlnf 5432, PubH 5452 or #) Connelly  
Introduction to biometrical concepts and techniques used to support the medical decision-making process, including test efficacy, decision analysis, Bayes theorem, and multivariate analysis. Current studies of the medical problem-solving process, and computer-based medical decision support systems.

**CLS 5198w. Computer Methodology in the Delivery of Healthcare III: Operations Research and Control Systems for Hospitals.** (3 cr, §Hlnf 5435; prereq Hlnf 5432 or #) Potthoff  
Health information systems for inpatient, outpatient, and research use, including status of current systems, costs and benefits, and legal/ethical considerations. System 2000 and other database management systems for clinical research used for class problems.

**CLS 5272f. Immunohematology I: Immunology and Hematology in Immunohematology.** (3 cr) Polesky  
Immunology and HLA; principles of inheritance and molecular genetics; review hematopoiesis; structure, function, and disorders of red and white blood cells and platelets.

**CLS 5273w. Immunohematology II: Blood Group Systems.** (3 cr) Polesky  
Biochemistry, genetics, antigens, antibodies, serology, and clinical significance of blood group systems. Neutrophil and platelet antigens and antibodies. Parentage testing.

**CLS 5274s. Immunohematology III: Transfusion Medicine.** (3 cr) Polesky  
Donor selection, collection, processing; apheresis; component preparation; indications for use of blood components; transfusion in selected clinical conditions; transplantation and transfusion; hemolytic disease of the newborn and Rh immune globulin; transfusion reactions; transfusion transmitted viruses.

**CLS 5280f, 5281w, 5282s. Advanced Immunohematology Practicum I, II, III.** (2 cr per qtr; prereq #)

Component preparation; collection and processing blood from donors; testing for transfusion transmitted viruses; HLA methods; parentage testing; advanced serological techniques and problem solving. Educational methods; exposure to management in blood center and transfusion service.

**CLS 5310. Clinical Chemistry I: Lecture.** (2 cr, §MedT 5310; prereq Chem 3301, Chem 3302, Chem 3305, Chem 3306, MdBc 5300, MdBc 5301) Tsai  
Renal structure, renal function, and analysis of urine and body fluids; renal role in homeostasis and chemical methods to evaluate renal function; quality assurance, quality control, reference ranges, and method evaluation.

**CLS 5311. Clinical Chemistry I: Laboratory Applications.** (2 cr, §MedT 5311; prereq Chem 3301, Chem 3302, Chem 3305, Chem 3306, MdBc 5300, MdBc 5301)  
Analyzing urine and body fluids using physical, chemical, and microscopic examination; developing lab skills in performing renal function tests (e.g., creatinine, urea) and using instrumentation (e.g., spectrophotometers).

**CLS 5320. Clinical Chemistry II.** (2 cr, §MedT 5320; prereq Chem 3301, Chem 3302, Chem 3305, Chem 3306, MdBc 5300, MdBc 5301) Tsai  
Lectures on electrolytes, acid-base balance, enzyme kinetics, liver function, digestive tract and carbohydrates; emphasizes methods of measurement and physiologic relevance.

**CLS 5321. Clinical Chemistry II: Laboratory Applications.** (2 cr, §MedT 5321; prereq Chem 3301, Chem 3302, Chem 3305, Chem 3306, MdBc 5300, MdBc 5301)  
Methods for analyzing electrolytes, osmolarity, blood gases, enzymes, liver and digestive function tests. Develop lab skills and use of instruments; emphasizes quality control and technique.

**CLS 5330. Clinical Chemistry III.** (2 cr, §MedT 5330; prereq Chem 3301, Chem 3302, Chem 3305, Chem 3306, MdBc 5300, MdBc 5301) Tsai  
Lectures on proteins, lipids, endocrinology, therapeutic drug monitoring, and toxicology; emphasizes methods of measurement and physiologic relevance.

**CLS 5331. Clinical Chemistry III: Laboratory Applications.** (2 cr, §MedT 5331; prereq Chem 3301, Chem 3302, Chem 3305, Chem 3306, MdBc 5300, MdBc 5301)  
Methods for analyzing proteins, hormones, lipids, and drugs; techniques include electrophoresis, nephelometry, radioimmunoassay, thin layer chromatography, and gas chromatography.

**CLS 5346f. Computer Applications in Healthcare.** (4 cr, §HInf 5430; prereq health professional or student in healthcare discipline) Finkelstein  
Current applications of computers and associated provider roles in healthcare areas in hospitals and communities.

**CLS 5765f. Hematology.** (4 cr; prereq #) Lofsness  
Blood and blood forming organs; blood and bone marrow from the standpoint of diagnosis and prognosis.

**CLS 5768f,w,s,su. Advanced Hematology.** (Cr ar; prereq #) Brunning

**CLS 8176. Advanced Topics in Clinical Chemistry.** (3 cr; prereq #; offered when feasible) Tsai  
Use of statistics, predictive value of tests, new concepts in methodology and automation, principles and advantages of kinetic and equilibrium assays.

**CLS 8236f,w,s,su. Research On Clinical Laboratory Problems.** (1-10 cr)

**CLS 8240. Educational Administration in Medical Technology.** (3 cr; prereq #) Karni  
Responsibilities of administration to students, faculty, and educational community. Topics include curriculum planning, accreditation, staffing, student selection, finances. Sample administrative problems and decisions used as practice vehicles.

## Cognitive Science (CgSc)

*Professor:* Paul W. Fox (psychology); Jeanette K. Gundel (linguistics); Keith Gunderson (philosophy); Paul Johnson (information and decision sciences); Michael B. Kac (linguistics); Daniel J. Kersten (psychology); Gordon E. Legge (psychology); Charles A. Nelson (child development); J. Bruce Overmier (psychology); Herbert L. Pick, Jr. (child development); C. Wade Savage (philosophy); Gerald M. Siegel (communication disorders); James R. Slagle (computer science); Joseph P. Stemberger (linguistics); Albert Yonas (child development)

*Associate Professor:* Charles R. Fletcher (psychology), *director of graduate studies;* Patricia J. Bauer (child development); Maria L. Gini (computer science); David S. Knopman (neurology); Mary Jo Nissen (psychology); Maria D. Sera (child development); Paulus W. van den Broek (educational psychology)

**Course of Study**—Minor in cognitive science, applicable to master's (M.A. and M.S.) and doctoral programs.

**Curriculum**—Cognitive science is a field of inquiry at the interface of cognitive psychology, computer science, linguistics, neuroscience, and philosophy. Cognitive science is concerned with the acquisition, representation, and use of knowledge by humans and machines. The curriculum provides students with a broad foundation in psychological, philosophical, and computational approaches to the study of cognition.

**Prerequisites for Admission**—Admission to the cognitive science graduate minor is

contingent upon prior admission to a master's or doctoral degree-granting program within the Graduate School. Admission to the minor program is limited and only by permission of the director of graduate studies in cognitive science. Applications for admission to the minor are due November 1; students are admitted effective winter quarter.

**Minor Requirements**—Students seeking to complete the cognitive science minor at either the M.A./M.S. or Ph.D. level are required to take those of the following core courses that are outside their major department: CgSci 8000, CSci 5511, and Psy 5015. In addition, CgSci 8001 (a three-quarter proseminar) is required for the Ph.D. minor. The minor program at the M.A./M.S. level requires a minimum of 12 graduate-level quarter credits; the minor at the Ph.D. level requires 21 credits. Additional credits beyond the required courses must be taken in courses selected from the list of elective courses. Credits from courses in the student's major department, however, do not count toward the minor.

**Language Requirement**—None specific to the minor program.

**For Further Information and Applications**—Contact Professor Charles R. Fletcher, Center for Research in Learning, Perception, and Cognition, University of Minnesota, 205 Elliott Hall, 75 East River Road, Minneapolis, MN 55455 (612/625-6096 or 612/625-9092).

### Core Courses

**CgSc 8000. Philosophy of Cognitive Science.** (4 cr; prereq #) Savage  
Philosophical framework for analyzing cognitive sciences. Recent developments in metaphysics and epistemology. Nature of scientific theories, methodologies of cognitive sciences, relations among cognitive sciences, relation of cognitive science to epistemology and various philosophical problems.

**CgSc 8001. Proseminar in Cognitive Science.** (1 cr per qtr for 3 qtrs; prereq admission to cog sci grad minor) Fletcher  
Survey of major topics in cognitive science, including theoretical assumptions, methods, and samples of current research.

**CgSc 8360. Seminar: Topics in Cognitive Science.** (1-4 cr; prereq admission to cog sci grad minor or #)  
Lectures and in-depth discussion.

**CSci 5511. Artificial Intelligence I.** (4 cr; prereq 3322 or #; informal lab)

**Psy 5015. Cognitive Processes.** (4 cr; prereq 3011 or 3051 or 5014 except for honors sequence students and grads)

### Elective Courses—Cognition

**Anth 5114. Structural Anthropology**

**Anth 5132. Symbolic Anthropology**

**CPsy 5343. Cognitive Development**

**Psy 5014. Psychology of Human Learning and Memory**

**Psy 8970. Seminar: Special Areas of Psychology and Related Sciences**

*(Some of these seminars are acceptable for the minor, including the Seminar in Computer Models of Cognitive Processes and the Seminar in Cognitive Neuropsychology. Students should consult with the director of graduate studies in cognitive science to determine whether a particular seminar is acceptable.)*

### Elective Courses—Philosophy

**Phil 5615. Minds, Bodies, and Machines**

**Phil 8180. Seminar: Philosophy of Language**

### Elective Courses—Perception

**CPsy 5341. Perceptual Development**

**Psy 5031. Perception**

### Elective Courses—Language

**Anth 5161. Cultural Semantics**

**CPsy 5345. Language Development**

**Ling 5001. Introduction to Linguistics**

**Ling 8820. Topics in Language and Cognition**

**Psy 5054. Psychology of Language**

**Psy 8056. Seminar: Psychology of Language**

### Elective Courses—Applications

**CSci 5512. Artificial Intelligence II**

*(Some of these seminars are acceptable for the minor. Students should consult with the director of graduate studies in cognitive science to determine whether a particular seminar is acceptable.)*

**Psy 5051. Psychology of Human-Machine Interaction**

**Psy 8201. Social Cognition**

## Communication Disorders (CDIs)

*Professor:* Charles E. Speaks, *chair*; Joe E. Reichle, *director of graduate studies*; Patricia A. Broen; Robert H. Brookshire; Julia M. Davis; Samuel K. Haroldson; Robert H. Margolis; Karlind T. Moller; David A. Nelson; Gerald M. Siegel; Clark D. Starr; Joseph P. Stemberger; Dianne J. Van Tasell

*Associate Professor:* Arlene E. Carney; Robert S. Schlauch; Jennifer A. Windsor

*Adjunct Associate Professor:* David A. Preves

*Assistant Professor:* Timothy N. Doyle; Nancy P. Solomon

*Visiting Assistant Professor:* Leslie E. Glaze

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) and Ph.D.

**Curriculum**—Emphases in the master's program are speech-language pathology and audiology. Emphases in the doctoral program are speech-language pathology, speech science, audiology, and hearing science.

**Prerequisites for Admission**—There are no specific academic prerequisites. Prospective students generally have completed an undergraduate degree or coursework in the field, but individuals from other academic areas are welcome. Students entering the M.A. program with minimal background in communication disorders should expect their program to extend beyond the usual two years.

**Special Application Requirements**—Three letters of recommendation evaluating the applicant's scholarship (at least two from professorial-rank faculty), a complete set of transcripts (in addition to that required by the Graduate School), and Graduate Record Examination scores are required. Deadline for application to the master's program is February 1; late applications are considered only if space is available. Master's students ordinarily begin graduate study during fall or summer terms.

**Master's Degree Requirements**—Students who complete the master's degree with emphasis in speech-language pathology or audiology are eligible for clinical certification by the American Speech-Language-Hearing

Association. A complete list of degree program requirements may be obtained from the director of graduate studies. An oral final examination is required for Plan A and Plan B students.

**Doctoral Degree Requirements**—Programs are designed by the student and the adviser to develop skills in research and scholarship. Required courses are EPsy 8260, 8261, and 8262.

**Language Requirement**—None.

**For Further Information and Applications**—Contact the Department of Communication Disorders, University of Minnesota, 115 Shevlin Hall, 164 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/624-3322; fax 612/624-7586).

**CDIs 8666. Doctoral Pre-Thesis Credits.** (max 18 cr per qtr; doctoral student who has not passed oral prelims)

**CDIs 8777. Thesis Credits: Master's.** (16 cr required; Plan A only)

**CDIs 8888. Thesis Credits: Doctoral.** (36 cr required)

**CDIs 5101. Communication Problems of Children.** (3 cr; prereq non-speech and hearing science major; offered alt yrs) S Doyle, staff  
Problems of children with impaired communication due to delayed language development, hearing loss, articulation disorders, voice disorders, stuttering, cleft palate (oral-facial anomalies), and neuromuscular disorders. Emphasis on providing information about these disorders and their effects on speech and language development.

**CDIs 5102. Communication Problems Associated With Aging.** (3 cr; prereq non-speech and hearing science major; offered alt yrs) Starr  
Speech, hearing, and language problems associated with aging: their characteristics, etiology, and management; implications for families, associates, and caregivers.

**CDIs 5103. Communication Disorders and Cultural Diversity.** (4 cr) Siegel  
Children in public schools are increasingly from diverse cultural backgrounds. Influence of culture on communication disorders; role of speech-language clinician in serving diverse populations.

**CDIs 5301. Introduction to Acoustics.** (5 cr) Speaks  
Elements of acoustics necessary to understand quantitative aspects of speech and hearing science, speech-language pathology, and audiology. Nature of sound, sound transmission, units of measurement, acoustic characteristics of speech, and elementary electronics.

**CDIs 5302. Anatomy and Physiology of the Speech and Hearing Mechanisms.** (5 cr)

Solomon

Gross anatomy, physiology, and function of structures related to phonation, articulation, and audition.

**CDIs 5303. Phonetics Laboratory.** (2 cr) Broen

Phonetic analysis of speech, the IPA classification system and articulatory correlates of English phonemes. Lab transcription of isolated sounds, words, and connected speech.

**CDIs 5304. Speech Science.** (4 cr; prereq 5301, 5302, 5303 or #) Speaks

Acoustic characteristics of speech. Consideration of theories of speech production and speech perception, and critical review of classical and current research in production and perception. Introduction to techniques for analysis and synthesis of speech.

**CDIs 5305. Language Acquisition.** (4 cr)

Windsor

Theory and experimental research dealing with language development.

**CDIs 5306. Hearing Science.** (4 cr; prereq 5301, 5302 or #) Schlauch

Fundamental concepts in normal audition.

Psychoacoustic methods; sensitivity and acuity; loudness, pitch, timbre, distortion, aural harmonics; masking, adaptation; the auditory reflex; binaural phenomena, localization.

**CDIs 5502. Stuttering.** (4 cr) Haroldson

Description, nature, and treatment of stuttering in children and adults. Students are involved at various levels in therapeutic and research activities.

**CDIs 5504. Normal and Disordered Child Phonology.** (4 cr; prereq 5302, 5303 or #) Broen

Theory and research relating to normal and disordered phonological development. Emphasis on assessment and treatment of phonological disorders.

**CDIs 5507. Cleft Palate, Oral-Facial Anomalies and Speech.** (4 cr; prereq 5304, 5504 or #) Starr, Moller

Relationships between oral-facial structures and speech. Emphasis on speech problems associated with dental and palatal anomalies and on their clinical management. Observations of clinical activities.

**CDIs 5508. Voice Disorders.** (4 cr; prereq 5304 or #) Starr, Haroldson

Physical and physiological bases of normal voice production reviewed. Voice disorders (pitch, loudness, quality); their symptomatology, etiology, and clinical management. Laryngectomy and other organic disorders emphasized.

**CDIs 5509. Motor Speech Disorders.** (4 cr; prereq 5304 or ¶5304) Solomon

Nature, assessment, and treatment of motor speech disorders in adult and pediatric populations.

**CDIs 5606. Language Assessment, Intervention: Early Stages.** (4 cr; prereq 5305 or #) Reichle

Analysis of communication disorders in preschool-age children. Emphasis on assessment and management of language disorders observed in children with developmental disabilities as well as intellectually normal children.

**CDIs 5607. Language Assessment, Intervention: Later Stages.** (4 cr; prereq 5305 or #) Windsor

Analysis of language disorders in school-age children. Emphasis on assessment and intervention.

**CDIs 5608. Language Assessment, Intervention: Adults.** (4 cr; prereq 5302 or #) Brookshire

Analysis of language disorders in adolescent and adult populations. Emphasis on assessment and intervention strategies applicable to aphasia and other neurogenic disorders.

**CDIs 5611. Augmentative Systems of Communication.** (4 cr) Reichle

Review of equipment and instructional procedures used to establish communication board and signing skills in severely handicapped populations.

**CDIs 5701. Hearing Loss and Audiometry.**

(5 cr; prereq 5301, 5302 or #) Carney, Schlauch  
Basic orientation to audiology. Overview of hearing disorders: audiometric and medical correlates, medical and surgical management, effects on communication and psychosocial adjustment. Introduction to basic audiometry: pure-tone audiometry, speech audiometry, screening, acoustic immittance. Lab participation required.

**CDIs 5702. Advanced Audiometry.** (5 cr; prereq 5701 or #) Schlauch

Advanced audiometric procedures, including speech discrimination testing, pediatric testing, detection and evaluation of pseudohypacusis. Behavioral diagnostic procedures for determining site of lesion, along with auditory pathologies that these procedures are designed to detect. Lab participation required.

**CDIs 5703. Communication Problems of the Hearing-Impaired.** (5 cr; prereq 5701 or #) Carney

Effects of hearing loss on development of language, perception and production of speech, and psychosocial adjustment. Techniques for habilitation and rehabilitation of hearing-impaired children and adults, including use of amplification, speechreading, and auditory training. Basic instruction in finger spelling and elements of manual communication.

**CDIs 5705. Objective Measures of Auditory Function.** (3 cr; prereq 5701 or #; offered alt yrs)

Margolis

Advanced techniques for clinical physiological evaluation of the auditory system. Major emphasis on acoustic immittance and auditory evoked potentials, with some discussion of electronystagmography, galvanic skin response, and electrocardiac response. Lab participation required.

**CDIs 5706. Hearing Aids.** (4 cr; prereq 5701 or #)

Van Tasell  
Electroacoustic characteristics of personal hearing aids and group amplification systems. Acoustical principles of earmold design and modification. Methods for selecting amplification for hearing-impaired children and adults.

**CDIs 5707. Audiology in Educational Settings.** (3 cr; prereq 5703 or #; offered alt yrs) Carlstrom

Audiological services for hearing-impaired school children. Selection and maintenance of group amplification equipment. Acoustical evaluation of classrooms. Legal educational rights of hearing-impaired children. In-service training of other professionals who work with hearing-impaired school children.

**CDIs 5900. Topics in Communication Disorders.** (1-4 cr)

**CDIs 5970. Directed Studies.** (Cr ar [may be repeated for cr]; prereq #)  
Directed readings and preparation of reports on selected topics.

**CDIs 8305. Laboratory Instrumentation.** (2 or 4 cr; prereq 5301 or #) Schlauch, Speaks, Van Tasell  
Two-credit course includes basic theoretical and practical information; 4-credit course also includes application of basic principles to the calibration and evaluation of audiometric equipment. M.A. students in speech pathology must enroll for 2 credits; in audiology, for 4 credits. Doctoral students from any department may enroll for either 2 or 4 credits. Lab participation required.

**CDIs 8502. Seminar: Stuttering.** (3 cr; prereq 5502 or #) Siegel  
Theoretical explanations of stuttering; research data and methodologies subserving the respective theories. Students independently design and, when feasible, execute research studies that derive from, and are consistent with, a particular theory of stuttering.

**CDIs 8504. Seminar: Normal and Disordered Child Phonology.** (3 cr; prereq 5504 or #) Broen  
Advanced study and independent research.

**CDIs 8507. Seminar: Cleft Palate.** (3 cr; prereq 5507 or #) Starr, Moller  
Research on communication problems of persons with cleft palates.

**CDIs 8508. Seminar: Voice.** (3 cr; prereq 5508 or #) Starr  
Advanced study and independent research.

**CDIs 8520, 8521. Clinical Education in Speech-Language Pathology.** (1-6 cr [may be repeated for cr]; prereq grad major in comm dis)

**CDIs 8590. Seminar: Current Issues in Speech-Language Pathology.** (3 cr) Solomon, Stemberger, staff  
Significant problem areas in speech-language pathology; relation to other rehabilitation programs and personnel. Class projects involving in-depth exploration of a specific problem.

**CDIs 8605, 8606, 8607. Seminar: Language Disorders.** (3 cr per qtr; prereq 5305 or #) Broen, Reichle, Siegel, Windsor  
Advanced study and independent research.

**CDIs 8608. Seminar: Aphasia.** (3 cr; prereq 5608 or #) Brookshire  
Review of principal theoretical instruments for evaluation and methods of clinical management of acquired aphasia and related disorders. Independent investigation of parameters determinative of aphasic behavior.

**CDIs 8715, 8716, 8717, 8718. Seminar: Hearing.** (3 cr per qtr) Carney, Schlauch, Van Tasell  
Major experimental research in psychophysiological and psychoacoustical nature of hearing. Critical analysis of theory, experimental method, and treatment of data.

**CDIs 8720, 8721. Clinical Education in Audiology.** (1-6 cr [may be repeated for cr]; prereq grad major in comm dis)

**CDIs 8990. Research.** (Cr ar [may be repeated for cr])  
Open to graduate students doing research.

## Comparative Literature (CLit)

*Professor:* Tom C. Conley (French and Italian); Peter E. Firchow (English); Harvey B. Sarles (cultural studies and comparative literature); Jochen Schulte-Sasse (cultural studies and comparative literature; German); Nicholas Spadaccini (Spanish and Portuguese); Anthony N. Zahareas (Spanish and Portuguese); Jack D. Zipes (German)

*Associate Professor:* Maria M. Brewer (French and Italian); John W. Mowitz (cultural studies and comparative literature)

*Assistant Professor:* Prabhakara Jha (cultural studies and comparative literature)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan B only) and Ph.D.

## GRADUATE PROGRAMS

### This is the Comparative Literature (cont.) through Educational Psychology program and course sections of the 1996-1999 University of Minnesota Graduate School Catalog

**Curriculum**—A major portion of coursework for degrees in comparative literature is offered by the literature and language departments. Approval may also be given, however, to take graduate courses in such areas as anthropology, art, architecture, history, music, philosophy, and sociology. In all cases, students should consult with an adviser concerning course selections.

**Prerequisites for Admission**—Although most students in the program have undergraduate majors in language or literature, applicants with other undergraduate backgrounds are considered.

#### **Special Application Requirements**—

Applicants must submit scores from the Graduate Record Examination. The deadline for applying for admission and for financial aid is January 15. Admission is only for the following fall quarter.

#### **Degree and Language Requirements**—

Consult the director of graduate studies for degree and language requirements.

#### **For Further Information and Applications**—

Contact the Department of Cultural Studies and Comparative Literature, University of Minnesota, 350 Folwell Hall, 9 Pleasant Street S.E., Minneapolis, MN 55455 (612/624-8099; fax 612/626-0228; <http://www.grad.umn.edu/grad/dept/complit.html>).

CLit 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

CLit 8888. Thesis Credits: Doctoral. (36 cr required)

CLit 5147. Teaching As Dialogue. (4 cr) Sarles  
Nature of teaching and of the teacher. Teaching authority; dynamics of Socratic dialogue and relation of teacher to students, to oneself, in present, toward students' futures.

CLit 5165. Perspectives in Human Behavior. (4 cr) Sarles

Comparative basis for studying different disciplines, especially in behavioral sciences. Uses in-depth interviews of disciplinary practitioners to demonstrate nature of similarities, differences, and complementarities: integration and coherence vs. independence of disciplinary unities.

CLit 5221. Basic Concepts of Cinema. (4 cr) Mowitz

Tools and knowledge necessary to situate film in historical context, define major parameters of film theory, and introduce basic concepts of film analysis. Comparative study of French, English, and American theories.

CLit 5555. Introduction to Semiotics. (4 cr; offered when feasible) Sarles

CLit 5701. The Concept of Modernity. (4 cr; prereq reading knowledge of German or French or Spanish or #: offered alt yrs)  
Concept of modernity as it unfolds in 19th century in works of Poe, Baudelaire, Nietzsche, Dostoevsky, and others and as reflected by contemporary theorists of language and literature.

CLit 5711. Sociocriticism. (4 cr; prereq 3xxx lit course or #) Jha  
Introduction to sociological theories of literary discourse. Theoreticians such as Goldmann, Foucault, Bakhtin; application of theory to practice in readings of specific texts.

CLit 5910. Topics in Comparative Literature. (3-6 cr; prereq reading knowledge of French or German or Spanish or #)  
Topics vary and include: English and American literature in China; John Donne's Renaissance background; Joyce, Proust, and Mann; literature and ideas; medieval Latin literary texts; myth and ritual: the past redefined; the romantic novel; translation: theory and practice; the vanguard in Paris, 1900-1930.

CLit 5970. Directed Reading in Comparative Literature. (1-4 cr; prereq #, Δ, CLA approval)

CLit 8001-8002-8003†. Seminar in Comparative Literature. (4 cr per qtr) Jha, Schulte-Sasse  
Guided research in selected areas with attention to methods applicable in the study of comparative literature.

CLit 8125. On Discourse and Language. (4 cr) Sarles  
Language as rhetorical, discursive, and dynamic phenomenon. What is a rhetorical grammar? What is relation of language to human nature and question of nature in general sense? How language relates to human body, tone-of-voice phenomena.

CLit 8910-8920-8930. Advanced Comparative Literature Seminar. (4 cr; prereq 8001, 8002, 8003 or #)  
Advanced seminar emphasizing the practical applications of specific methodologies and theories to a determined area. Topics vary.

CLit 8962. Modernism and Feminism. (4 cr)  
Different paths that recognizable modernist and feminist discourses take in common project of negating and rewriting the past. Implications of these discourses' (at times explosive) confrontation for understanding of fictional as well as theoretical texts.

CLit 8970. Directed Reading in Comparative Literature. (1-4 cr; prereq grad student in comparative literature, Δ)

## Comparative Studies in Discourse and Society (CSDS)

*Professor:* Jackson P. Hershbell (Classical and Near Eastern studies); Richard D. Leppert (cultural studies and comparative literature); Helen E. Longino (women's studies); Paula Rabinowitz (English); Jochen (Schulte-Sasse) (cultural studies and comparative literature; German); Hernán Vidal (Spanish and Portuguese) Jack D. Zipes (German)

*Associate Professor:* John Archer (cultural studies and comparative literature), *director of graduate studies;* Rita Copeland (English); Maria Damon (English); William W. Malandra (Classical and Near Eastern studies); Ellen Messer-Davidow (English); Roger P. Miller (geography); John W. Mowitz (cultural studies and comparative literature; English); Gianna Pomata (history); Gary C. Thomas (cultural studies and comparative literature); Jacquelyn N. Zita (women's studies)

*Assistant Professor:* Lisette E. Josephides (anthropology); Katherine M. Solomonson (architecture)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan B only) and Ph.D. Only students intending to pursue a Ph.D. in CSDS are admitted for either degree; the M.A. is a necessary step for the Ph.D.

**Curriculum**—The curriculum emphasizes small seminars and directed research. The core requirement is a three-quarter research seminar, a practicum that develops critical and analytic skills and introduces current theoretical perspectives with the study of historic problems. The majority of courses are offered on a nonrecurring basis and are closely related to current faculty research. For listings, students should consult the quarterly *Class Schedule* and fliers available in the department office. In all cases, students should consult their advisers and the director of graduate studies concerning course selections.

**Prerequisites for Admission**—Applicants to the master's program are required to have a bachelor of arts degree in a humanities or social science discipline or other relevant field. Applicants to the doctoral program must have a master of arts degree or demonstrate evidence of adequate background and competence. Because the program involves broad, often interdisciplinary, courses of study and a variety of emphases, the graduate admissions committee carefully reviews each applicant's background in terms of analytical skills,

knowledge of subject matter, experience, language preparation, and especially, congruity with faculty interests and expertise.

**Special Application Requirements**—Scores from the General (Aptitude) Test of the Graduate Record Examination are required. The deadline for financial aid application is January 15 preceding the academic year for which aid is sought. Applications for admission are considered only at the January 15 deadline, except in certain cases for students already enrolled in a graduate degree program at the University of Minnesota. Consult the director of graduate studies for application requirements.

**Master's Degree Requirements**—The master's degree requires 44 quarter credits. All master's students are required to take the three-quarter research seminar. The remaining credits are divided between seminars in the program and electives in other departments, chosen in consultation with the adviser and the director of graduate studies. Written and oral final examinations are required.

**Doctoral Degree Requirements**—The doctoral degree requires an additional 36 credits beyond the master's degree. All doctoral students are required to take the three-quarter research seminar. The remaining credits are divided between seminars in the program and electives in other departments, chosen in consultation with the adviser and the director of graduate studies.

**Language Requirements**—Students must obtain a reading knowledge of one language other than English for the master's degree and of two languages other than English for the doctoral degree, appropriate to individual research interests.

**Minor Requirements for Students Majoring in Other Fields**—Minor field requirements are 16 credits for the master's program and 20 credits for the doctoral program. All minors must include at least two courses from the three-quarter research seminar sequence.

**For Further Information and Applications**—Contact the Comparative Studies in Discourse and Society Program, University of Minnesota, 350 Folwell Hall, 9 Pleasant Street S.E., Minneapolis, MN 55455 (612/625-5358; e-mail [csds@tc.umn.edu](mailto:csds@tc.umn.edu); <http://www.grad.umn.edu/grad/dept/csds.html>).

## GRADUATE PROGRAMS

CSDS 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

CSDS 8888. Thesis Credits: Doctoral. (36 cr required)

CSDS 5711. Interpretation of Myth. (4 cr, §Hum 5711, §ReIS 5111; prereq jr or sr or grad student)  
Structure and function of myths. Myth as social charter, ideological system, literary form. Readings in classic theories of myth and primary sources from India, Iran, Mesopotamia, Greece, Africa, North and South America.

CSDS 5910. Topics in Comparative Studies in Discourse and Society. (4 cr; prereq jr or sr or grad student)

Themes in comparative, sociohistorical analysis of discursive practices. Individually or team taught. Topics vary quarterly.

CSDS 5970. Directed Studies. (Cr ar; prereq grad student, #)

Guided individual reading or study.

CSDS 8001, 8002, 8003. Basic Research Seminar in Comparative Studies in Discourse and Society. (4 cr per qtr; prereq grad student, Δ)  
Year-long practicum focusing on such issues as interrelations of center and periphery in production and reception of discourse; role of discourse in struggles over social boundaries; power and formation of cultural constituencies. Theoretical readings and case studies.

CSDS 8404. International Hierarchy. (3 cr, §Pol 8404; prereq pol sci or CSDS grad student or #) Duvall  
Asymmetric structures and processes of international relations; systematic conditions and implications of informal empire and structures of dependency and hegemony.

CSDS 8910. Advanced Topics in the Comparative Study of Discourse and Society. (4 cr; prereq grad student)

Themes in comparative, sociohistorical analysis of discursive practices. Individually or team taught. Topics vary quarterly.

CSDS 8970. Directed Studies. (Cr ar; prereq grad student, #)

Guided individual reading or study.

Other courses eligible for CSDS credit that are offered by the Department of Cultural Studies and Comparative Literature and are listed in the Related Courses section of this bulletin.

CSCL 5102. Cultural Politics

CSCL 5154. Theoretical Constructions of Space

CSCL 5178. The Political Discourse of Change

CSCL 5256. Suburbia

CSCL 5301. Society, Ideology, and the Production of Art

CSCL 5302. Aesthetics, Ideology, Valuation of Art

CSCL 5398. Phenomenology and Ethnography

CSCL 5751. Basic Concepts of Cinema

CSCL 5910. Topics in Cultural Studies and Comparative Literature

## Composition, Literacy, and Rhetorical Studies

*Professor:* Christopher M. Anson (English); Richard W. Beach (curriculum and instruction); Lillian S. Bridwell-Bowles (English); Karlyn K. Campbell (speech-communication); Andrew D. Cohen (linguistics); Terence G. Collins (General College); Alan G. Gross (rhetoric); Michael Hancher (English); Dale L. Lange (curriculum and instruction); Mary M. Lay (rhetoric); Earl E. McDowell (rhetoric); Donald J. Ross, Jr. (English); Robert L. Scott (speech-communication); Elaine E. Tarone (linguistics); Barbara M. Taylor (curriculum and instruction); Paulus W. van den Broek (educational psychology); Billie J. Wahlstrom (rhetoric)

*Associate Professor:* Robert L. Brown, Jr. (English), *director of graduate studies*; Lisa Albrecht (General College); Rita Copeland (English); Ann H. Duin (rhetoric); Amy L. Sheldon (speech-communication); Geoffrey M. Sirc (General College); Diane J. Tedick (curriculum and instruction); Constance L. Walker (curriculum and instruction); Arthur E. Walzer (rhetoric)

*Assistant Professor:* Laura J. Gurak (rhetoric)

**Course of Study**—Minor in composition, literacy, and rhetorical studies, applicable to doctoral programs.

**Curriculum**—Students develop a program of study in consultation with their major adviser (preferably one of the faculty above), the director of graduate studies in their major, and the director of graduate studies in composition, literacy, and rhetorical studies (CLRS).

**Prerequisites for Admission**—Admission to the CLRS graduate minor is contingent upon prior admission to a doctoral degree-granting program within the Graduate School.

**Special Application Requirements**—

Admission is competitive and restricted to a number that will allow for a quality experience. Entrance to the minor is granted only by permission of the director of graduate studies in CLRS and the faculty selection committee. Application materials include a completed application form, statement of goals, teaching

portfolio, curriculum vitae, and two letters of recommendation addressing the teaching component. The deadline for all application materials is March 15 for the following fall quarter. Applications received after that date are considered as space allows.

**Minor Requirements**—The minor requires a minimum of 20 credits (five or six courses). Only one course can be from the student's home department; of the remaining courses at least one course should come from each of the following four categories: seminar in a theoretical topic, seminar or course in pedagogical theory and practice, seminar or course in research methods and practices, and a capstone writing seminar.

**Language Requirement**—None specific to the minor program.

**For Further Information and Applications**—Contact the Center for Interdisciplinary Studies of Writing, University of Minnesota, 227 Lind Hall, 207 Church Street S.E., Minneapolis, MN 55455 (612/626-7579; fax 612/626-7580; e-mail [micha013@tc.umn.edu](mailto:micha013@tc.umn.edu); <http://cisw.cla.umn.edu/gradstu/compminor>).

## Computer and Information Sciences (CSci)

*Professor:* Ahmed Sameh, *head*; Frederic N. Bailey; Gordon B. Davis; David H. Du; Ding-Zhu Du; David W. Fox; Laël C. Gatewood; Paul E. Johnson; Michael B. Kac; Richard Y. Kain; Daniel J. Kersten; Larry L. Kinney; K. S. P. Kumar; Vipin Kumar; E. Bruce Lee; Arthur L. Norberg; Linda R. Petzold; Marian B. Pour-El; J. Ben Rosen (*emeritus*); Youcef Saad; Eugene B. Shragowitz; James R. Slagle; Marvin L. Stein; Wei-Tek Tsai; Hans F. Weinberger; Paul R. Woodward; Pen-Chung Yew

*Associate Professor:* Daniel L. Boley; John V. Carlis; Vladimir Cherkassky; Krzysztof S. Frankowski; Maria Gini; Larry G. Hutchinson; Ravi Janardan; David J. Lilja; J. David Naumann; Matthew T. O'Keefe; Nikolaos P. Papanikolopoulos; Haesun Park; John T. Riedl; Shashi Shekhar; Gerald E. Sobelman; Jaideep Srivastava; Anand R. Tripathi

*Assistant Professor:* Shantanu Dutt; Joseph A. Konstan; Gyungho Lee; Zhiyuan Li; Bamshad Mobasher; Shang-Hua Teng; Bapiraju Vinnakota

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B), M.C.I.S., and Ph.D.

**Curriculum**—The faculty of the Department of Computer Science conducts research in a broad spectrum of the computer sciences and interdisciplinary fields. Graduate students may pursue research and study with faculty on topics such as theory of computation and algorithms, numerical algorithms and software for supercomputer and parallel machines, languages and compilers, systems, artificial intelligence, computer and system design, computer-aided design, software engineering, and history of computing. In addition, students may choose a course of study that combines a portion of one of these major areas with an entirely different field.

Graduate students have access to today's most powerful supercomputers through the Minnesota Supercomputer Center. In addition, Computer and Information Services provides an integrated computing environment ranging from microcomputers to workstations to large mainframe computing equipment. The Department of Computer Science also provides computing facilities through its various laboratories, such as the Instructional Laboratory, the Software Engineering Laboratory, the Artificial Intelligence Laboratory, the High Performance and Computing Laboratory, and the Distributed Systems Laboratory.

**Prerequisites for Admission**—A degree in any major with a substantial background in mathematics and basic core computer science is required; a computer science major is preferred. Applicants with an inadequate background must remove any deficiencies before beginning their degree program.

**Special Application Requirements**—Three letters of recommendation are required. Scores from the General (Aptitude) Test of the Graduate Record Examination (GRE) are required from M.S. and Ph.D. program applicants. The Subject Test is optional, although highly recommended, especially for those seeking financial assistance. If taken, it should be in the undergraduate major field or, if it is not offered in that field, in computer science, mathematics, or engineering. The department accepts new master's and Ph.D. students for fall admission only. The application deadline is May 31. Students seeking financial aid must apply by January 2.

Before applying, M.C.I.S. students must have the equivalent of six months full-time computer-related industrial experience in the United States.

### Master of Science (M.S.) Degree

**Requirements**—All courses taken from the Department of Computer Science must be taken A-F, unless they are offered S-N only. Courses in other departments may be taken S-N. The total number of credits taken S-N cannot exceed one third of the total credits in your program. In addition to general Graduate School requirements, all M.S. students must demonstrate competence in the basic material through a final oral examination.

### Master of Computer and Information Sciences (M.C.I.S.) Degree Requirements

—This program is designed for the working professional. Students must complete a minimum of 44 quarter credits in graduate courses with a minimum of 28 credits in the major. All courses taken from the Department of Computer Science must be taken A-F, unless they are offered S-N only. Courses in other departments may be taken S-N. The total number of credits taken S-N cannot exceed one third of the total credits in your program.

**Doctoral Degree Requirements**—Doctoral students must take the written preliminary examination as outlined in the departmental student handbook. All courses taken from the Department of Computer Science must be taken A-F, unless they are offered S-N only. Courses in other departments may be taken S-N. The total number of credits taken S-N cannot exceed one third of the total credits in your program.

**Language Requirements**—None.

### For Further Information and Applications

—Contact the Department of Computer Science, University of Minnesota, 4-192 Electrical Engineering/Computer Science Building, 200 Union Street S.E., Minneapolis, MN 55455 (612/625-4002; fax 612/625-0572; e-mail [dgs@cs.umn.edu](mailto:dgs@cs.umn.edu); <http://www.cs.umn.edu>).

CSci 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

CSci 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

CSci 8888. Thesis Credits: Doctoral. (36 cr required)

CSci 5090. History of Computing. (4 cr, §HSci 5321)

Developments in the last century; evolution of hardware and software, growth of the industry and its relation to other business areas, and changing relationships resulting from new data-gathering and analysis techniques.

CSci 5101. Introduction to the Organization of Computer Systems. (4 cr, §3107, §3327; prereq non-CSci major, 3121 or 3316 or #)

Organization of hardware and software systems that support computer programming and program execution. Symbolic assembly language to study mapping of application programs and data into underlying hardware. Ideas illustrated in assembly language (currently Motorola 680x0).

CSci 5102. Introduction to Systems Programming. (4 cr; prereq 3327, 5101 or #; no grad cr for CSci majors; informal lab)

User-level programming view of operating system functions; introduction to UNIX systems programming; use of system calls, relationships between C library functions and systems calls, file systems, process management functions, input-output, signal handling, use of pipes and sockets, and shell programming.

CSci 5103. Introduction to Operating Systems. (4 cr, §5502; prereq 3322, 5102, 5201 or #; informal lab)

Conceptual foundations used in operating system design and implementation; relationship between operating system structure and underlying machine architecture; UNIX implementation mechanisms used as example.

CSci 5104. System Simulation: Languages and Techniques. (4 cr; prereq 3327 or 5101, Stat 3091 or #; informal lab; offered alt yrs)

Methodologies relevant to system modeling and simulation. Application of stochastic process, Markov chains, and queuing theory to developing system models and designing simulation experiments. Data collection and statistical analysis of output. Fundamentals of discrete event-based simulations using digital computers. Simulation languages, both process- and event-oriented, including SIMULA and SIMPAS. Applications of these techniques to job shops, operations research, and modeling of computer and communications systems.

CSci 5106. Structure of Higher Level Languages. (4 cr; prereq 3317, 3321, 3327 or #; no grad cr for CSci majors)

Motivation, syntax and semantics, imperative languages (e.g., Ada, C), type system, control structures, procedures, activation record model, exception handlers; encapsulation, parameterization; functional languages (e.g., Lisp, Scheme, ML, FP); object-oriented languages (e.g., Smalltalk, C++, CLOS); trends (e.g., concurrent model).

CSci 5107. Computer Graphics I. (4 cr; prereq 3322, 3327 or #)

Extensive programming; theoretical underpinnings of computer graphics. General graphics issues, user interface issues, 2D graphics, and introduction to 3D graphics, including 3D pipeline, shading and hidden surface removal, and ray tracing.

CSci 5110. User Interface Design, Implementation, and Evaluation. (4 cr; prereq 3322, 3327 or #; informal lab)

Designing, programming, and evaluating interactive applications, with focus on task-centered approaches to user interface design. Designing, prototyping, evaluating, and implementing an application interface. Interface evaluation techniques, including user testing and non-user walk-through and heuristic techniques.

CSci 5111. GUI Toolkits and Their Implementation. (4 cr; prereq 5107 or 5110 or #; informal lab)

Structure and design of user interface toolkits and frameworks. Window system protocols, toolkit design, event processing, data management and constraints, geometry management, resource management, and other features of advanced interface development toolkits. Students implement a toolkit extension or widget.

CSci 5113. Introduction to Object-Oriented Programming Using C++. (4 cr, §3121, §3321, §3322; prereq C language programming equiv to 3113; no grad cr for CSci majors)

Object-oriented programming; inheritance, including polymorphism and multiple inheritance; container classes and iterators; operator overloading, user-defined implicit conversions, constructors, destructors, and templates.

CSci 5117. Computer Graphics II. (4 cr; prereq 5107 or #; informal lab)

Spline curves and surfaces and other advanced modeling techniques, solid modeling, color theory, advanced shading algorithms, advanced ray tracing, radiosity, introduction to scientific visualization.

CSci 5121. Algorithms and Data Structures II. (4 cr, §3322; prereq 3311, non-CSci major; 3322 recommended for CSci majors)

Fundamental paradigms for algorithm design with supporting data structures. Complexity, correctness analysis, and lower bound theory. Implementation of selected algorithms and data structures using C++ language.

CSci 5151. Introduction to Parallel Computing. (4 cr; prereq 3121 or 3322 or #)

Programming techniques, algorithms, data structures. Evaluation of algorithm quality. Effectiveness and scalability. Basic concepts and algorithms for parallel computation.

CSci 5161. Introduction to Compilers. (4 cr, §5504; prereq 5106 or #; informal lab)

Techniques for implementing programming languages; compiler front end, recognizing syntactic structures, generating internal representations; symbol table manipulation and type checking.

CSci 5180. Software Engineering I. (4 cr; prereq 5106 or #; informal lab)

Software life cycle, requirement acquisition, specification, design, coding and testing. Criteria for requirement acquisition, object-oriented analysis and modeling, structures analysis, process description. Techniques for specification verification and validation, completeness and consistency, and multilevel checking. Formal analysis of semi-formal specifications. Object-oriented design techniques and patterns. Current software development and application environments. Software prototyping, maintenance, and application issues. Group project to develop application from user requirement.

CSci 5181. Software Engineering II. (5 cr; prereq 5180; scheduled lab)

Requirements analysis. Project planning and management. Design reviews, software testing, validation strategies. Maintenance. Student groups specify, design, implement, and test partial software systems. Emphasis on application of general software development methods and principles from 5180.

CSci 5199f,w,s. Problems in Languages and Systems. (1-4 cr [may be repeated for cr]; prereq #) Special courses or individual study arranged with faculty member.

CSci 5201. Computer Architecture. (4 cr; prereq 3327 or #; no grad cr for CSci majors; informal lab)

Elementary computer architecture, gates and digital logic, register transfers and micro-operations, processor studies of existing systems.

CSci 5205. Parallel Computer Architecture. (4 cr; prereq 5201 or #; offered alt yrs)

Parallel computer system analysis and design; organizational dependence on computations to be performed; primary components of parallel architectures (processors, control units, memories, interconnection networks); implemented paradigm of pipelined and vector processors, array processors, and multiprocessors.

CSci 5211. Data Communications and Computer Networks. (4 cr; prereq 5102 or #; informal lab)

Network classification and services. Hardware components: multiplexors, concentrators, communications media. Network protocols and architectures. Research areas.

CSci 5212. Network Programming. (2 cr; prereq 5102, ¶5211 or #; no grad cr for CSci majors)

Network and distributed programming concepts using C++ and UNIX, including TCP/IP, sockets, and RPC applications.

CSci 5221. Advanced Computer Networks and Their Applications. (4 cr; prereq 5211 or #)

Design, maintenance, and use of high-speed networks and their impact on society. Emphasizes new emergent protocols, such as FDDI-11, Frame-Relay, ATM. Characteristics of hardware, protocols, and applications such as high performance distributed computing and multimedia.

CSci 5222. Network Operations and Administration. (4 cr; prereq 5211 or #; no grad cr for CSci majors)

Plan, configure, install, diagnose, performance tune, operate, and manage computer networks. Internetworking devices and protocols. Hands-on experience with network components.

CSci 5280. Computer-Aided Design I. (4 cr; prereq 3311 or #; informal lab)

CAD for digital systems with emphasis on VLSI. Hardware description languages: synthesis, simulation, test generation.

CSci 5281. Computer-Aided Design of VLSI. (4 cr; prereq 3311 or #; informal lab)

CAD for digital systems with emphasis on VLSI. Physical design: partitioning, placement and routing, design rule checks, electrical rule checks. Inherent complexity of algorithms. Analysis of best known algorithms.

CSci 5299f,w,s. Problems in Machine Design. (1-4 cr [may be repeated for cr]; prereq #)

Special courses or individual study arranged with faculty member.

CSci 5301. Numerical Computation. (4 cr; prereq Math 3261, knowledge of a programming language or #; no grad cr for CSci majors; informal lab)

Floating point arithmetic and rounding errors. Iterative methods. Numerical solution of nonlinear equations. Newton's method. Direct methods for linear systems of equations. Gaussian elimination. Factorization methods. Interpolation and approximation. Numerical integration and differentiation. Introduction to numerical solution of ordinary differential equations.

CSci 5302. Analysis of Numerical Algorithms. (4 cr; prereq 5301 or #)

Norms, condition numbers, and error analysis. Convergence rates for iterative methods. Numerical approximation methods. Least squares. Fast Fourier transform. Spline interpolation. Gaussian quadratures. Computation of eigenvalues and eigenvectors. Stability and error analysis of methods for ordinary differential equations.

CSci 5304. Computational Aspects of Matrix Theory. (4 cr; prereq 5302 or #; informal lab)

Direct and iterative solution of large linear systems. Decomposition methods. Computation of eigenvalues and eigenvectors. Singular value decomposition. Linpack and other software packages. Methods for sparse and large structured matrices.

CSci 5305. Numerical Methods for Ordinary Differential Equations. (4 cr; prereq 5302 or #; informal lab)

Initial value problem. Convergence and stability. Efficient implementation. Error estimation and step size control. Comparison of recent software packages. Two-point boundary value problems. Collocation and finite element methods.

CSci 5306. Numerical Methods for Partial Differential Equations. (4 cr; prereq 5302, differential equations or advanced calculus)

Fundamentals of partial differential equations (PDEs). Finite difference and finite element discretization methods. Numerical treatment of parabolic, hyperbolic, and elliptic problems. Convergence, stability, and consistency. Iterative methods. Programming techniques and use of FORTRAN packages.

CSci 5320. Introduction to Linear Programming. (4 cr, \$5001; prereq 5301 or #; informal lab)

Basic solutions to linear systems; inequalities; convex polyhedral sets; linear programming formulation and optimality conditions; theoretical and computational aspects of simplex algorithm; postoptimal analysis; duality. Revised simplex and numerically stable methods, upper-bounded problems; commercially available LP systems; methods for large, sparse systems. Interior methods for LP.

CSci 5399f,w,s. Problems in Numerical Analysis. (1-4 cr [may be repeated for cr]; prereq #) Special courses or individual study arranged with faculty member.

CSci 5400. Introduction to Automata Theory. (4 cr; prereq 3311 or #; no grad cr for CSci majors)

Turing machines, computable functions, unsolvability of the halting problem, recursive functions. Finite state models: equivalence, minimization, properties, decision questions, characterizations. Regular expressions. Survey of other automata.

CSci 5421. Introduction to Algorithm Design. (4 cr, \$8401; prereq 3322 or 5121 or #)

Divide-and-conquer, dynamic programming, the greedy method, matroids, backtracking and branch-and-bound, basic graph algorithms, techniques for geometric problems, and string matching.

CSci 5422. Advanced Data Structures. (4 cr, \$5122; prereq 3322 or 5121 or #)

Techniques for representing and manipulating data efficiently and for analyzing performance of these methods. Priority queues, balanced search trees, multidimensional searching structures, amortized complexity and its applications to data structure design, persistent data structures, and data structures for secondary storage.

CSci 5442. Introduction to Computational Geometry. (4 cr; prereq 5421 or #)

Techniques for design and analysis of geometric algorithms. Geometric problems that occur naturally in applications such as computer graphics, solid modeling, CSD, robotics, manufacturing, vision. Pure and applied aspects of geometric computation.

CSci 5499f,w,s. Problems in Computational Theory or Logic. (1-4 cr [may be repeated for cr]; prereq #)

Special courses or individual study arranged with faculty member.

CSci 5511. Artificial Intelligence I. (4 cr; prereq 3322 or #; informal lab)

Introduction to ideas, issues, and applications of artificial intelligence. Knowledge representation, problem solving, search, inference techniques, theorem proving. Expert systems. Artificial intelligence programming languages.

CSci 5512. Artificial Intelligence II. (4 cr; prereq 5511 or #; informal lab)

Techniques of artificial intelligence to solve complex problems. Natural language processing and speech recognition. Machine perception and integrated robots. Planning. Machine learning. Expert systems.

CSci 5521. Pattern Recognition. (4 cr; prereq 5301, Stat 3091 or #; informal lab)

Definition of problems of pattern recognition, feature selection, measurement techniques, etc. Classification methods; statistical decision theory, nonstatistical techniques. Automatic feature selection. Syntactic pattern recognition. The relationship between mathematical pattern recognition and artificial intelligence. Applications.

CSci 5531. Artificial Intelligence Programming Techniques. (4 cr; prereq 5511 or #; informal lab; offered alt yrs)

Languages and programming techniques for problems in artificial intelligence. Lisp and Prolog. Production system and frame-based languages. High level tools. Implementation of knowledge representation structures and inference operations. Applications in expert systems.

CSci 5551. Introduction to Intelligent Robotic Systems. (4 cr; prereq 5511 or #)

Fundamentals of robot manipulator operations. Sensing techniques and their basic principles. Real-time programming issues as applied to control of robots. Robot programming and planning.

CSci 5561. Computer Vision. (4 cr; prereq 5511 or #)

Representational and computational tools. Matching. Edge detection. Shape from shading, motion, stereo. Texture. Object recognition. Introduction to applications.

CSci 5571. Expert Systems. (4 cr; prereq 5511 or #)

Aspects of artificial intelligence representations and inferencing mechanisms as applied to expert systems. Students develop small expert system.

CSci 5599. Problems: Artificial Intelligence. (1-4 cr [may be repeated for cr]; prereq #)

Special courses or individual study arranged with faculty member.

CSci 5702. The Principles of Database Systems. (4 cr; prereq 3322 or #; informal lab)

Fundamental concepts. Conceptual data organization. Data models. Data manipulation languages. Database design. Security and integrity. Performance evaluation. Query optimization. Distributed database systems.

CSci 5703. Database System Design. (4 cr; prereq 5702 or #; informal lab)

Application of database concepts in design and development of database systems and applications. Design of current commercial as well as research-oriented database systems. Techniques of using database systems for applications.

CSci 5705. Object-Oriented Databases. (4 cr; prereq 5702 or #)

Applications and motivation; extended relational, object-relational, and object-oriented data models; object identifier, types, and constructors; versions and schema evolution; query language (e.g., recursion, path expressions); object indices, buffer management, and other implementation issues; triggers, rules, complex objects, and case studies.

CSci 5799. Problems: Information Science.

(1-4 cr per qtr [may be repeated for cr]; prereq #)  
Special courses or individual study arranged with faculty member.

CSci 5863. Computer Systems Performance Analysis. (4 cr, §EE 5863; prereq grad IT major, 5201 or EE 5858 or #; offered alt yrs)

Tools and techniques for measuring and analyzing computer hardware, software, and system performance. Benchmark programs, measurement tools, performance metrics. Presenting data, summarizing measured data, comparing system performance. Deterministic and probabilistic simulation techniques, random number generation and testing. Bottleneck analysis.

CSci 8101. Advanced Operating Systems. (3 cr; prereq 5103, 5211 or #)

Multiprocessor and distributed system architectures. Interprocess communication models and primitives. Information protection: access control list and capability-based systems. Secure communication protocols. Dynamic linking and sharing. Naming, synchronization, and mutual exclusion in distributed systems. Recovery principles. Network file systems.

CSci 8102. Operating Systems Theory. (3 cr; prereq 5103, 5104 or #)

Computer system modeling and performance evaluation. Queuing network models and analysis methods. Multiprocessor and distributed system control algorithms: synchronization, mutual exclusion protocols, resource management, deadlocks, scheduling, load balancing. Security models; security problems in distributed systems.

CSci 8103. Distributed and Parallel Programming. (3 cr; prereq 5103, 8101 or #)

Concurrent programming constructs. Formal models of concurrent systems. Problem mapping to distributed and parallel architectures. Synchronous algorithms. Termination detection problem. Distributed and parallel algorithms for graph problems. Common knowledge in distributed systems. Reliable communication and consensus protocols.

CSci 8110. Human-Computer Interaction and User Interface Technology. (3 cr; prereq 5110 or 5111 or #)

Research issues in HCI, UI toolkits and frameworks, and other areas of UI technology. HCI research techniques, model-based UI development, gesture-based interfaces, interface development by demonstration, constraint-based programming, event processing models, innovative UI systems, and UI technology and HCI issues in multimedia systems.

## GRADUATE PROGRAMS

CSci 8161. Advanced Compiler Techniques. (3 cr, \$5505; prereq 5102, 5201, grad IT major or #) Back end compiler techniques for generating efficient uniprocessor machine code; effect of modern architecture features on code generation; basic block and global dataflow analysis; machine independent optimizations; register allocation; instruction scheduling for efficient instruction pipeline and superscalar and VLIW operations; data locality enhancement; interprocedural analysis.

CSci 8163. Compiler Techniques for Parallel Architectures. (3 cr; prereq 8161, grad IT major or #) Compiler techniques for generating efficient parallel machine code; effect of modern parallel architecture features on code generation; parallelism extraction by data dependence analysis and data flow analysis; data locality enhancement and memory latency hiding; static and dynamic scheduling of parallel tasks; program transformations; interprocedural analysis.

CSci 8180. Advanced Software Engineering. (3 cr; prereq 5180 or #) Selected research topics, including software development and maintenance techniques for real-time, safety-critical applications; object-oriented analysis and design techniques; reengineering legacy code; automated requirement acquisition; multimedia applications; software fault-tolerant techniques; software testing.

CSci 8203. Advanced Computer Architecture. (3 cr, \$5205, \$EE 8362; prereq 5201 or #) High-speed uniprocessor design; Amdahl's Law; static (VLIW) and dynamic (scoreboarding, Tomasulo's algorithm, multithreading) instruction scheduling techniques; multiple instruction issue (superscalar) architecture; pipelining and pipeline design; vector units, interrupts, and interrupt handling; branch handling strategies; performance evaluation and benchmarking.

CSci 8205. Parallel Computer Organization. (3 cr, \$EE 8363; prereq 5201 or #) Parallel computer organization and architecture; shared and distributed memory architectures; synchronization techniques; static and dynamic scheduling; hardware/software interaction in parallel systems; parallel system software and compilers; example parallel machines and performance evaluation.

CSci 8221. Special Research Topics in Computer Networking. (3 cr; prereq 5211 or #) Topics in high-speed networking, including ATM, HIPPI, Fibre Channel, and optical networks; protocol design, routing and flow control for high-speed networks; management and security issues.

CSci 8305. Computational Methods for Differential-Algebraic Equations. (3 cr; prereq 5305 or #) Numerical methods for differential-algebraic equations (DAEs). Solvability, index, order and stability for numerical methods, software, delays, boundary value problems, and applications.

CSci 8314. Iterative Methods for Linear Systems. (3 cr; prereq 5304; offered alt yrs) Iterative methods for large sparse matrices, matrices too big to keep in memory. Jacobi, Gauss-Siedel, relaxation methods. Chebyshev acceleration. Conjugate gradient method: basic theory, convergence. Connection with Lanczos tridiagonalization. Extensions to non-symmetric matrices. Preconditioning techniques. Supercomputer implementation.

CSci 8320. Numerical Solution of Linear Least Squares Problems. (3 cr; prereq 5304 or #; offered alt yrs) Linear least squares. Post decomposition. Weighting and constrained least squares. Modified least squares. Signal and image processing applications.

CSci 8350. Advanced Parallel Numerical Methods. (3 cr, \$5307, \$8307; prereq 5301, 5151 or #) Parallel solution of dense and banded linear systems; eigenvalue techniques for tridiagonal and dense matrices; Cuppen's and Jacobi's methods; FFT and fast Poisson solvers; basic iterative methods (e.g., over-relaxation, alternating direction implicit, multigrid); domain decomposition techniques.

CSci 8360. Numerical Linear Algebra in Dynamical Systems. (3 cr; prereq 5304 or #) Computational methods in linear algebra; matrix decomposition for linear equations, least squares, eigenvalue and generalized eigenvalue problems, conditioning and stability; state space methods in dynamical systems; controllability, poles, zeroes, Lyapunov and Riccati equations; norms of dynamical systems and model reduction.

CSci 8403-8404. Theory of Computation. (3 cr per qtr; prereq 5400 or equiv or #; offered alt yrs) Models of computation. Computability and unsolvability. Computational complexity. Speed-up theorems. Hierarchy theorems. Intractable problems (e.g., NP-complete, PSPACE-complete, provably intractable). Relativized problems. Advanced topics.

CSci 8421. Advanced Algorithm Design. (3 cr, \$8402; prereq 5421 or #) Linear programming; advanced graph and geometric, approximation, on-line, and randomized algorithms.

CSci 8521. Neurocomputing and Neural Networks. (3 cr; prereq 5511) Learning laws, associative networks, mapping networks, backpropagation, overfitting and generalization, complexity of learning, self-organizing maps; current topics such as optimization via boltzman networks, spatio-temporal networks, physiological networks, efficient implementations on parallel computers.

CSci 8551. Artificial Intelligence Techniques in Robotics. (3 cr; prereq 5512 or #; informal lab) Representation of physical world and reasoning over world models. Complex modeling, representation of physical properties, uncertainty. Qualitative and quantitative reasoning techniques. Use of knowledge bases, reasoning about space, reasoning with geometry, reasoning with time. Program synthesis, plan formation, error recovery.

CSci 8561. Readings in Computational Vision. (3 cr; prereq 5561 or #; offered alt yrs)  
Classic papers and recent results relating to computational models of vision and other perceptual systems.

CSci 8571. Readings in Expert Systems. (3 cr; prereq 5571 or #; offered alt yrs)  
Classic papers and recent results relating to expert systems and computational models of expert problem solving.

CSci 8581. Readings in Parallel Symbolic Computing. (3 cr; prereq 5512 or #; offered alt yrs)  
Exploiting parallelism in symbolic applications with special emphasis on problems related to artificial intelligence. Parallel search, parallel execution of expert systems. Parallel algorithms for natural language, vision, neural networks.

CSci 8701. Overview of Database Research. (3 cr; prereq 5703 or #)  
Methodologies, relational implementation techniques, active databases, storage systems, benchmarking, distributed and parallel databases, new data models, prototype systems, vision and future directions.

CSci 8703. Distributed and Parallel Databases. (3 cr; prereq 5703 or #)  
Distributed DBMS architecture, including client-server, distributed DB design, distributed query optimization and processing; distributed transaction management (concurrency control and recovery); federated/multibases definition and issues; database machines (concepts, successes, and failures); parallel databases.

CSci 8705. Scientific Databases and Applications. (3 cr; prereq 5702 or #)  
Scientific applications and data management; image data and operations; databases and data blades; database research issues and survey from an application domain such as geographical information systems, environmental studies, molecular biology, or neuroscience.

CSci 8760. Plan B Project. (3 cr [may be taken once to satisfy Plan B master's requirement, may appear on master's program, but may not be applied toward 20 cr minimum in major field]; prereq CSci MS student, #; S-N only)  
Project topic(s) arranged between student and adviser. Written report(s).

*Note*—All of the following seminars may be presented as either lectures or as individually assigned readings in the current literature. The amount of credit earned is arranged with the faculty member. Seminars may be repeated for credit when topics change.

CSci 8199. Seminar: Languages and Systems. (1-3 cr; prereq #)

CSci 8299. Seminar: Machine Design. (1-3 cr; prereq #)

CSci 8399. Seminar: Numerical Analysis. (1-3 cr; prereq #)

CSci 8499. Seminar: Computational Theory and Logic. (1-3 cr; prereq #)

CSci 8599. Seminar: Artificial Intelligence. (1-3 cr; prereq #)

CSci 8799. Seminar: Information Science. (1-3 cr; prereq #)

## Other Acceptable Courses

In addition to the courses offered by the Department of Computer Science that are listed above, the following courses, taught by members of the graduate faculty in computer science, may be applied to the major.

EE 5852-5853. Computer Organization and Design I-II

Math 5162-5163-5164. Mathematical Logic

Math 8140-8141-8142. Applied Logic

Math 8181-8182-8183. Formal Languages and Automata

Math 8190-8191-8192. Topics in Logic

Psy 5036. Vision: Computational Theory to Neural Systems

## Computer Engineering

*Professor:* David H.-C. Du; Larry L. Kinney; Vipin Kumar; Ahmed Sameh; Eugene B. Shragowitz; Wei-tek Tsai; Pen-Chung Yew

*Associate Professor:* David J. Lilja, *director of graduate studies;* Vladimir Cherkassky; Matthew T. O'Keefe; Gerald E. Sobelman; Shashi Shekhar; Jaideep Srivastava

*Assistant Professor:* Zhiyuan Li; Lori Lucke; Bapiraju Vinnakota

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and M.Comp.E. (coursework only).

**Curriculum**—Computer engineering is an interdisciplinary graduate program offered jointly by the Department of Electrical Engineering and the Department of Computer Science. Students in this program develop a broad understanding of both hardware and software design issues. The M.S. degree is a traditional research-oriented graduate degree that prepares graduates to work in industry or to continue with their graduate studies in either electrical engineering or computer and information sciences. The M.Comp.E. degree is a coursework-only professional engineering degree tailored primarily for working professionals.

## GRADUATE PROGRAMS

Access to a wide variety of computational and laboratory equipment is provided through the Departments of Electrical Engineering and Computer Science. Students can focus their studies in several different areas, including computer architecture and system design, compilers, computer-aided design, databases, networks, operating systems, parallel computing, software engineering, and VLSI design and testing.

**Prerequisites for Admission**—Graduate study in computer engineering is open to students with an undergraduate degree in computer engineering, electrical engineering, computer science, or a closely related field, such as mathematics or physics. In some instances, additional preparatory work may be required after admission.

**Special Application Requirements**—All applicants are required to submit three letters of recommendation. Scores from the Graduate Record Examination General Test are required of all students seeking financial aid. Applicants whose native language is not English must also submit TOEFL scores.

**Degree Requirements**—In addition to the Graduate School requirements, all graduate programs in computer engineering require a core program of courses in system software, computer architecture and networking, VLSI and digital design, and data structures and algorithms, with a minimum of 6 credits from electrical engineering and 6 credits from computer and information sciences. The comprehensive final exam for the M.S. degree is oral; no final exam is required for the M.Comp.E. degree.

**Minor Requirements for Students Majoring in Other Fields**—There is no designated minor available in computer engineering.

**Language Requirement**—None.

**For Further Information and Applications**—Contact the Graduate Program in Computer Engineering, University of Minnesota, 4-178 Electrical Engineering/Computer Science Building, 200 Union Street S.E., Minneapolis, MN 55455 (612/625-3300; fax 612/625-4583; e-mail gradinfo@compengr.umn.edu).

CmpE 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

The following courses can be applied to the major field credit requirements:

CSci 5103. Introduction to Operating Systems  
CSci 5104. System Simulation: Languages and Techniques

CSci 5106. Structure of Higher Level Languages  
CSci 5151. Introduction to Parallel Computing

CSci 5161. Introduction to Compilers

CSci 5180-5181. Software Engineering I-II

CSci 5201/EE 5858. Computer Architecture

CSci 5211. Data Communications and Computer Networks

CSci 5280. Computer-Aided Design I

CSci 5281. Computer-Aided Design of VLSI

CSci 5421. Introduction to Algorithm Design

CSci 5422. Advanced Data Structures

CSci 5702. The Principles of Database Systems

CSci 5703. Database System Design

CSci 5705. Object-Oriented Databases

CSci/EE 5863. Computer Systems Performance Analysis

CSci 8101. Advanced Operating Systems

CSci 8102. Operating Systems Theory

CSci 8103. Distributed and Parallel Programming

CSci 8161. Advanced Compiler Techniques

CSci 8163. Compiler Techniques for Parallel Architectures

CSci 8180. Advanced Software Engineering

CSci 8203/EE 8362. Advanced Computer Architecture

CSci 8205. Parallel Computer Organization or EE 8363. Parallel Processing I

CSci 8221. Special Research Topics in Computer Networking

CSci 8421. Advanced Algorithm Design

CSci 8521. Neurocomputing and Neural Networks or EE 8359. Computing with Neural Networks

CSci 8701. Overview of Database Research

CSci 8703. Distributed and Parallel Databases

CSci 8705. Scientific Databases and Applications

EE 5571-5572-5573. VLSI Design I-II-III

EE 5574-5575. Computer-Aided VLSI Design Laboratory

EE 5576. VLSI Modeling and Processing

- EE 5851. Applied Switching Theory
- EE 5852-5853. Computer Organization and Design I-II
- EE 5854. Advanced Computer Networks
- EE 5860. Microcomputer Architecture
- EE 5874. Simulation and Test in Digital Design
- EE 8352. Fault Diagnosis and Reliable Design
- EE 8353. Sequential Circuit Theory
- EE 8364. Parallel Processing II
- EE 8370. Design of Intelligent Systems

## Conflict Management

*Professor:* Mario F. Bognanno (industrial relations); Eugene Borgida (psychology); Paul V. Ellefson (forest resources)

*Assistant Professor:* Mark S. Umbreit (social work)

**Course of Study**—Minor in conflict management, applicable to master’s (M.A. and M.S.) and doctoral programs.

**Curriculum**—Conflict management is a recently recognized and rapidly advancing area of inquiry that is concerned with the study of the origin, process, and management of conflict interactions among individuals, groups, organizations, and systems, and the impact of these interactions. It is an interdisciplinary effort with roots in economics, family studies, industrial relations, law, political science, primary communication, psychology, public policy, social work, and other departments.

**Prerequisites for Admission**—Admission to the graduate minor in conflict management is contingent upon prior admission to a master’s or doctoral degree-granting program within the Graduate School.

**Special Application Requirements**—None.

**Minor Requirements**—The minimum number of graduate-level quarter credits for the minor at the master’s level is 11 and at the doctoral level is 21. The program for an individual student is developed in consultation between the student, the major adviser, and the director of graduate studies in conflict management. A sequence of three required core courses in conflict management theory and practice is chosen, one each from the following pairs: SW 5026 or Spch 5407; IR 5002 or PA 5114; and IR 8027 or Law 5833.

**Language Requirements**—None specific to the minor program.

**For Further Information and Applications**—Contact the Director of Graduate Studies, Graduate Minor in Conflict Management, Conflict and Change Center, University of Minnesota, Humphrey Center, 301 19th Avenue South, Minneapolis, MN 55455 (612/625-0362; fax 612/625-3513; e-mail [conflmin@tc.umn.edu](mailto:conflmin@tc.umn.edu)).

### Core Courses

- IR 5002. Systems of Conflict and Dispute Resolution (Azevedo)
- IR 8027. Dispute Resolution Practices: Mediation, Fact Finding, and Arbitration
- Law 5833. Alternative Dispute Resolution (see Law School Bulletin for complete description)
- PA 5114. Conflict Management: Theory and Practice (Fiutak)
- PA 5966. Application of Mediation Methods (Fiutak)
- Spch 5451. Intercultural Communication (Albert)
- SW 5026. Mediation and Conflict Resolution

### Elective Courses

*The following is an illustrative, not exhaustive, list of potential elective courses. With the permission of the director of graduate studies, students may elect courses other than those listed below in fulfillment of the degree requirements. (See the Law School Bulletin for complete descriptions of the Law courses listed below.)*

- Anth 5116. Ecological Anthropology (Gerlach)
- Anth 5152. Anthropology of Social Movements (Gerlach)
- Econ 5107H. Honors Course: Game Theory and Its Applications (McLennan)
- Econ 8117, 8118. Noncooperative Game Theory (McLennan)
- EPsy 5154. Organizational Development and Change (Johnson)
- EPsy 8150. Psychology of Conflict Resolution (Johnson)
- IR 8004. Design and Management of Organizations for a Changing World
- IR 8007. Collective Bargaining: Private and Public Sectors
- IR 8017. Labor Movements in a Changing World (Budd)

## GRADUATE PROGRAMS

IR 8024. Organization Design and Change (Wang)  
IR 8032. Comparative and International Labor Movements (Scoville)  
IR 8037. Labor-Management Negotiations (Budd)  
Jour 8651. Seminar: Mass Media and Social Change  
Law 5820. Labor Arbitration (Cooper)  
Mgmt 8050. Innovation and Change (Van de Ven)  
Psy 5702. Individual Behavior in Organizations (Kanfer)  
Soc 5211. Social Processes in Small Group Settings (Leik)  
Soc 5311. Sociology of Conflict (Cooperman)  
Soc 5411. Formal Organizations  
Spch 5452. Intercultural Interaction: Theory and Application (Albert)  
Spch 8421. Seminar: Communication and Negotiation  
Spch 8451. Face to Face Intercultural Communication (Albert)  
Spch 8452. Facilitating Intercultural Communication (Albert)  
SW 8350. Planned Social Change (Umbreit)

## Conservation Biology (CBio)

*Regents' Professor:* Margaret B. Davis (ecology, evolution, and behavior)

*Professor:* Donald B. Siniff (ecology, evolution, and behavior), *director of graduate studies;* Dean E. Abrahamson (public affairs); Franklin H. Barnwell (ecology, evolution, and behavior); Marvin E. Bauer (forest resources); Elmer C. Birney (Bell Museum of Natural History; ecology, evolution, and behavior); Charles R. Blinn (forest resources); Kenneth N. Brooks (forest resources); Dwight A. Brown (geography); Vernon B. Cardwell (agronomy and plant genetics); Kendall W. Corbin (Bell Museum of Natural History; ecology, evolution, and behavior); William P. Cunningham (genetics and cell biology); James W. Curtsinger (ecology, evolution, and behavior); Edward J. Cushing (ecology, evolution, and behavior); Gary E. Duke (veterinary biology); Paul V. Ellefson (forest resources); Luther P. Gerlach (anthropology); Hans M. Gregersen (forest resources); Robert T. Holt (political science); Anne R. Kapuscinski (fisheries and wildlife); D. Frank McKinney (Bell Museum of Natural History; ecology, evolution, and behavior); L. David Mech (fisheries and wildlife); Patrice A. Morrow (ecology, evolution, and behavior); Richard E. Phillips (ecology, evolution, and behavior); Philip J. Regal (ecology, evolution, and behavior); Peter B. Reich (forest resources); Anthony M. Starfield (ecology, evolution, and behavior); John R. Tester (ecology, evolution, and behavior)

*Adjunct Professor:* A. Richard Weisbrod (fisheries and wildlife)

*Associate Professor:* Donald N. Alstad (ecology, evolution, and behavior); Dorothy H. Anderson (forest resources); David A. Andow (entomology); Francesca J. Cuthbert (fisheries and wildlife); David L. Garshelis (fisheries and wildlife); Ralph W. Holzenthal (entomology); Peter A. Jordan (fisheries and wildlife); Linda L. Kinkel (plant pathology); James R. Kitts (fisheries and wildlife); Gerald J. Niemi (Natural Resources Research Institute<sup>1</sup>); James A. Perry (forest resources); Patrick T. Redig (veterinary biology); Ruth G. Shaw (ecology, evolution, and behavior); J. L. David Smith (fisheries and wildlife); Roderick H. Squires (geography); Robert W. Sterner (ecology, evolution, and behavior); Robert M. Zink (Bell Museum of Natural History)

*Adjunct Associate Professor:* David E. Andersen (fisheries and wildlife); Kenneth L. Cole (forest resources); Frederick J. Jannett, Jr. (fisheries and wildlife); Ronald L. Tilson (fisheries and wildlife); Bruce C. Vondracek (fisheries and wildlife)

*Assistant Professor:* David N. Bengston (forest resources); Glenn R. Furnier (forest resources); Susan M. Galatowitsch (horticulture); Barbara J. Kanninen (public affairs); Shahid Naem (ecology, evolution, and behavior)

*Research Associate:* Allen L. Lundgren (forest resources)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—The conservation biology program has two complementary aims leading to a unique interdisciplinary program. The program provides students with sound graduate training in the biological sciences relevant to the conservation of plants, animals, and ecosystems globally. Students study the social, political, and economic sciences that relate to both the recognition and solution of conservation problems. The overall objective of the program is to prepare students to develop solutions or approaches to these problems that are scientifically and environmentally sound and likely to be acted upon or implemented by existing social and political structures.

**Prerequisites for Admission**—A B.S. degree in biology or a closely related field is preferred. Applicants with a baccalaureate degree in another field are accepted, but may be required to make up selected courses in biology. In

<sup>1</sup> University of Minnesota, Duluth

general, Ph.D. applicants holding a baccalaureate degree are expected first to complete a master's degree.

**Special Application Requirements**—A statement of career goals and three letters of recommendation evaluating the applicant's potential for graduate study are required. The Graduate Record Examination General Test is required. The deadline for application is January 7; earlier application is encouraged for individuals seeking financial aid. Typically students are admitted only in fall quarter.

**Master's Degree Requirements**—All master's students must complete a minimum of 44 credits in the biological and social aspects of conservation biology. For Plan A students, 16 of these credits are thesis credits; Plan B students take 16 credits that include credits arranged for Plan B papers.

**Doctoral Degree Requirements**—Students complete a total of 68 graduate credit hours. Ph.D. candidates take the core courses and are expected to show competency in both the biological and social sciences. With their advisory committee, students develop a program that emphasizes the ecological and social aspects of conservation biology. Dissertation research may require proficiency in supporting areas (e.g., statistics, computing, communications).

**Language Requirements**—None.

**For Further Information, Applications, and a List of Courses**—Contact the Director of Graduate Studies, Conservation Biology Program, Department of Ecology, Evolution, and Behavior, University of Minnesota, 100 Ecology Building, 1987 Upper Buford Circle, St. Paul, MN 55108 (612/625-5732; e-mail [siniff@ecology.umn.edu](mailto:siniff@ecology.umn.edu)).

CBio 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

CBio 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

CBio 8888. Thesis Credits: Doctoral. (36 cr required)

CBio 8001. Conservation Biology Seminar. (1 cr)

Presentations by students, faculty, and visiting specialists.

## Control Science and Dynamical Systems (CSDy)

*Regents' Professor:* Daniel D. Joseph (aerospace engineering and mechanics)

*Professor:* Tryphon T. Georgiou (electrical engineering), *co-director:* Donald G. Aronson (mathematics); Fredric N. Bailey (electrical engineering); Max Donath (mechanical engineering); David P. Fan (genetics and cell biology); William Garrard (aerospace engineering); Mostafa Kaveh (electrical engineering); John C. Kieffer (electrical engineering); Larry L. Kinney (electrical engineering); K. S. P. Kumar (electrical engineering); E. Bruce Lee (electrical engineering); Walter Littman (mathematics); Richard P. McGehee (mathematics); Katsuhiko Ogata (mechanical engineering); Linda R. Petzold (computer science); George R. Sell (mathematics); Yasutaka Sibuya (mathematics); Marian Stachowicz (electrical and computer engineering); Marvin L. Stein (computer science); Kim A. Stelson (mechanical engineering); Allen R. Tannenbaum (electrical engineering); Ahmed H. Tewfik (electrical engineering)

*Associate Professor:* Gary J. Balas (aerospace engineering and mechanics), *co-director and director of graduate studies:* Daniel Boley (computer science); Maria Gini (computer science); Nikolaos P. Papanikolopoulos (computer science); Yiyuan Zhao (aerospace engineering and mechanics)

*Adjunct Associate Professor:* Dale F. Enns (aerospace engineering and mechanics)

*Assistant Professor:* Prodrimos Daoutidis (chemical engineering and materials science); Andrew R. Teel (electrical engineering)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—Ph.D.

**Curriculum**—Student programs must emphasize modeling—mathematical and physical analyses of control and/or dynamical systems, with some computational or numerical expertise—and two areas selected from the following three: control theory for deterministic processes; stability theory and general analysis of dynamical systems; stochastic processes and information theory.

**Prerequisites for Admission**—Applicants must have completed a master's degree in one of the related fields of engineering, computer science, mathematics, statistics, or physics. Master's degrees with an emphasis in control science and/or dynamical systems can be earned in any of these programs at Minnesota. An applicant with a master's degree in another area whose scientific, mathematical, and/or engineering

<sup>1</sup> University of Minnesota, Duluth

background is adequate to pursue the program also is considered. A high level of proficiency in mathematics is necessary to successfully complete the Ph.D. program. Applicants are strongly encouraged to obtain a faculty adviser before formally applying to the program.

**Special Application Requirements**—Three letters of recommendation evaluating the applicant's scholarship and a complete set of transcripts are required. At least one letter of recommendation must be from a faculty member familiar with the applicant's previous graduate work. Because faculty are drawn from a number of disciplines and students' programs can reflect a variety of emphases, it is important for applicants to clearly specify career goals and program emphasis desired in their application materials. Submission of Graduate Record Examination scores is strongly encouraged.

**Doctoral Degree Requirements**—Programs are designed by the student and the adviser. Coursework is normally selected from those courses in science, mathematics, engineering, and related fields that are relevant to the field of control science and dynamical systems. The written preliminary examination covers three of the four areas of emphasis (see Curriculum above). Normally students can prepare for this examination by completing three 8xxx or suitably advanced courses in three of the four areas. In addition, students normally take substantial coursework in advanced mathematics.

**Language Requirements**—For emphases other than mathematics, one foreign language. For the emphasis in mathematics, a second foreign language or a special project.

**For Further Information and Applications**—Contact the Control Science and Dynamical Systems Center, University of Minnesota, 107 Akerman Hall, 110 Union Street S.E., Minneapolis, MN 55455 (612/625-3364; e-mail csdy@aem.umn.edu).

CSDy 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

CSDy 8888. Thesis Credits: Doctoral. (36 cr required)

CSDy 8899. Seminar in Control and Dynamical Systems. (1-3 cr [may be repeated for cr]; prereq #: S-N only)

Current research, advanced topics. Arranged with instructor.

## Creative Writing

See English.

## Curriculum and Instruction

*Professor:* Barbara M. Taylor, *chair*; Richard W. Beach; Thomas R. Berger; Carol A. Carrier; John J. Cogan; William E. Gardner; Michael F. Graves; Harlan S. Hansen; Ilene B. Harris; Roger T. Johnson; Richard Kimpston (*emeritus*); Judith Lambrecht; Dale L. Lange; Frances P. Lawrenz; Darrell R. Lewis; John C. Manning; Dianne L. Monson; Thomas R. Post; S. Jay Samuels; James E. Stochl; Ruth G. Thomas

*Associate Professor:* Margaret K. DiBlasio, *director of graduate studies*; Eugene M. Anderson; Patricia G. Avery; J. Michael Bennett; Fred N. Finley; Kerry J. Freedman; Patricia A. Heller; Simon R. Hooper; Helen L. Jorstad; Jean A. King; Laura C. Koch; Robert E. Orton; R. Michael Paige; Rosemarie J. Park; Diane J. Tedick; Constance L. Walker

*Assistant Professor:* Felipe Golez; Margaret Y. Phinney; Susan M. Watts

*Lecturer:* Sandra J. Balli; L. Joanne Buggey; Melodee Landis

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan B only) in education (emphasis in curriculum and instruction), art education, elementary education, and mathematics education; Ph.D. in education (emphasis in curriculum and instruction); and Certificate of Specialist in Education.

**Curriculum**—Majors for the master's degree in art education, education, elementary education, and mathematics education are administered by the Department of Curriculum and Instruction, under the direction of a single director of graduate studies. The education major with emphasis in curriculum and instruction is divided into the following concentration areas: curriculum studies; English education; instructional systems; reading education; science education; second languages and cultures education; and social studies education.

For the Ph.D. degree in education with emphasis in curriculum and instruction, concentrations include art education, communications education (children's literature, English education, language arts, and reading), curriculum and instruction (curriculum studies, early childhood education, instructional

systems), elementary education, mathematics education, science education, second languages education, and social science education.

The specialist certificate is offered in curriculum supervision and mathematics education.

**Prerequisites for Admission**—Prerequisites vary among areas of emphasis or concentration. Generally a bachelor's degree with licensure fulfills the requirement. For some areas, however, there is no equivalent undergraduate program. In that case, 15 to 20 credits of work at the undergraduate level determined acceptable by advisers and the director of graduate studies are adequate. Some areas require a minimum of one year of teaching experience.

**Special Application Requirements**—Scores from the Graduate Record Examination are required. Master's and doctoral applications are reviewed by the department on specific dates in the fall, winter, and spring quarters.

**Master's Degree Requirements**—Students must complete requirements in the areas common to all emphasis areas, in behavioral and humanistic studies, in multicultural education, and in preparation for research. A final oral examination is required.

**Doctoral Degree Requirements**—Requirements include core courses and coursework in the concentration. Students must show competency in methodology; social, historical, and philosophical foundations; and psychological foundations.

**Specialist Certificate Requirements**—Students complete coursework in an area of emphasis and related studies. An internship, a project, and final examination are required.

**Language Requirements**—For the master's degree and specialist certificate, none. For the doctoral degree, some concentrations require at least one foreign language.

**Minor Requirements for Students Majoring in Other Fields**—Requirements are designed according to individual student needs.

**For Further Information and Applications**—Contact the Department of Curriculum and Instruction, University of Minnesota, 125 Peik Hall, 159 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/625-2545).

Educ 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Educ 8888. Thesis Credits: Doctoral. (36 cr required for PhD)  
Section 1. Curriculum and Instruction

## Curriculum and Instruction (CI)

CI 5008. Theory and Practice of Teaching Art in Elementary Schools. (2-4 cr, §ArEd 5308)  
Art concepts, skills, and processes appropriate for elementary school, methods of art instruction, and children's production of and responses to art.

CI 5045. Advanced Contemporary Crafts. (4 cr, §ArEd 5020; prereq 3045 or ArEd 3020 or #)  
In-depth experiences in craft techniques, including ceramics, fibers, jewelry, and metal design, with emphasis on design analysis, understanding of materials, and mastery of processes.

CI 5049. Art Media Techniques. (3-6 cr [max 12 cr], §ArEd 5001)  
Lectures, demonstrations, and critique sessions on creative processes; handling specific media. Topic varies.

CI 5052. Introduction to Art Therapy. (3 cr, §ArEd 5201)  
History, current conceptions, and practices.

CI 5055. Multicultural Art Education. (4 cr, §ArEd 5316; offered when feasible)

CI 5058. Issues in Art Education. (1-12 cr, §ArEd 3800)  
Issues and trends, current practices, and recent research.

CI 5065. Improving Art Programs in the Schools. (4 cr, §ArEd 5386; prereq tchg exper or #)  
Critical examination of current art programs.

CI 5069. Curriculum Innovations in Art Education. (4 cr, §ArEd 5302)  
Study and analysis of innovations, evaluation of materials for teaching units and projects.

CI 5070. History of American Art Education. (3 cr, §ArEd 5310; offered alt yrs)  
Development of art as subject matter in curriculum; relation to traditions in art and in schooling; comparison of change within social, political, and economic contexts.

CI 5074. Visual Culture, Education, and Global Development. (4 cr, §ArEd 5318; offered when feasible)

CI 5078. Application of Aesthetic Theory in Education. (3 cr, §ArEd 5389; offered alt yrs)  
Contemporary theories of art; their psychological and philosophical foundations. Open to teachers, supervisors, and administrators concerned with art in general education at all levels.

CI 5080. Internship in Art Education. (2-9 cr, §ArEd 5600; prereq #)  
Professional assignment for degree candidates under joint supervision of departments and cooperating agency.

## GRADUATE PROGRAMS

CI 5085. Practicum in Art Education. (2-9 cr, §ArEd 5605; prereq #)  
Independent project under direction; gathering data, developing proposals, experimenting with evaluating innovative practices.

CI 5086. Student Teaching in Art Education. (3 or 6 or 12 cr, §ArEd 3600; prereq 5150, 5110 or Elem 3101 or SeEd 3150)  
Observation of, participation in, and supervisory experiences with various types and levels of art classes.

CI 5101. Workshop: Programs and Procedures of Curriculum Development in Elementary Schools. (1-3 cr, §Elem 5101; prereq elem school tchg exper, #; S-N only)  
Leadership in procedures; operational processes; major considerations in planning and organizing; interpersonal relationships, and evaluation of improvement programs.

CI 5110. Introduction to Elementary School Teaching. (3 cr, §Elem 3101, §Elem 5000; prereq ¶5183, elem educ major or CLA music educ major or □) Curriculum, organization, instruction, management, and professional decision making.

CI 5113. Classroom Management in the Elementary School. (4 cr, §Elem 5145, §SeEd 5145; prereq tchg or admin exper or #)  
For teachers, administrators, and support staff. Management of student behavior, instruction as it relates to student behavior, and teacher organizational tasks in the classroom.

CI 5130. Introduction to Curriculum Studies. (4 cr, §CISy 5600)  
Definitions of curriculum; historical and current issues; curriculum principles and theories; alternative models and methods of design and evaluation.

CI 5133. Curriculum Planning and Design. (4 cr, §CISy 5605)  
Theoretical and practical bases of interdisciplinary curriculum design; models for developing interdisciplinary approaches to curriculum design and implementation; evaluating interdisciplinary curricula.

CI 5136. History of Curriculum in the United States. (4 cr, §CISy 5607)  
Survey of formation of public school subjects and curriculum theory in United States from their European roots and early development in 19th century to contemporary issues of reform discussed in relation to the past. Social, political, and economic implications of curriculum history.

CI 5137. The Multicultural Gender-Fair Curriculum. (4 cr, §Elem 5225, §SeEd 5225)  
Planning for development and implementation of multicultural and gender-fair perspective in elementary and secondary classrooms. Individual teacher goals, professional issues, and resources and teaching strategies for successfully exploring new perspectives.

CI 5138. Multicultural and Moral Perspectives on Classroom Instruction. (4 cr; prereq MEd or grad student or #)  
Factors leading to effective communication in ethnically diverse classrooms, preschool through adult. Communication techniques and classroom structures that have cultural and moral implications.

CI 5145. Curriculum Topics. (1-4 cr [max 6 cr], §CISy 5100; offered when feasible)

CI 5149. America's Schools in the 20th Century. (3 cr, §CISy 5370, §EdPA 5370; prereq educ or grad student or #)  
Analysis and interpretation of events and issues that shaped America's schools in 20th century; current education reform proposals and their antecedents.

CI 5150. Secondary School Teaching. (3 cr, §SeEd 5250; prereq educ or CLA music educ student or #, ¶5185 or regis in approved program area practicum)  
Curricular, instructional, managerial, leadership, and professional functions.

CI 5152. Innovation and the Instructional Process. (3 cr, §CISy 5100; prereq MEd or grad student or #)  
Information, concepts, and interpretive frameworks for comprehending, analyzing, and evaluating innovations and the process that brings them about. Developing and consuming instructional innovations.

CI 5153. Thematic Instruction for Middle Grades. (2 cr, §AdEd 5191, §Educ 5191, §Elem 5191, §SeEd 5291)  
Logical and contextual relationships among mathematics, science, and social studies as taught in middle grades.

CI 5155. Classroom Instruction and Assessment. (4 cr, §CISy 5902; prereq MEd or grad student)  
Identifying goals, selecting instructional strategies, and developing assessment procedures for contemporary K-12 students. Incorporates issues related to multicultural education and reflective teaching.

CI 5156. Techniques of Instruction. (3 cr, §SeEd 5132)  
Cross-departmental course for developing individual competencies, applying current psychological research to classroom instruction, and defining objectives in terms of achievable student competencies.

CI 5160. Supervision of Elementary, Secondary, and Postsecondary Instruction. (3 cr, §CISy 5800; prereq 5130 or CISy 5600)  
Achievement of appropriate teaching expectations focusing on problems of personnel responsible for their improvement.

CI 5162. Peer Coaching for Teachers. (1-3 cr, §CISy 5801; prereq grad or MEd student)  
Teachers coaching teachers: acquiring concepts, skills, and dispositions for observing classroom instruction and providing feedback.

- CI 5170. Classroom Management in the Secondary Schools. (3 cr, §Elem 5145, §SeEd 5145) For teachers, administrators, and support staff working in secondary school programs: focus on management of student behavior, instruction as it relates to student behavior, and teacher organizational tasks in the classroom.
- CI 5172. Teaching Students With Learning Difficulties. (3 cr, §Elem 5107) Diagnosis of pupil difficulty; development and prevention; tests as aids to teaching; following up a testing program; socioemotional problems associated with learning difficulties.
- CI 5178. Project in Teacher Leadership. (1-9 cr, §5188, §EdPA 5178; prereq grad student or #) Create and present project for instigating and/or promoting change within education.
- CI 5180. Clinical Experience in Elementary School Teaching. (6-12 cr, §Elem 5212) Supervised classroom teaching.
- CI 5183. Applying Instructional Methods in the Elementary School. (2 cr per qtr [max 4 cr], §Elem 5211) Supervised experience in elementary school classrooms.
- CI 5184. Pre-Fall Student Teaching in Elementary Schools. (3 cr, §Elem 3610; prereq 9 cr methods, Δ) Observing and teaching beginning fall semester in public schools until University classes begin.
- CI 5185. Orientation in the Secondary Schools. (0-2 cr, §SeEd 5251; prereq ¶15150) Supervised observation in classroom and related school activities.
- CI 5186. School-Related Projects in Curriculum and Instruction. (1-12 cr [max 12 cr], §5090, §5480, §5583, §5669, §5764; prereq MEd student in CI or #) Individual or group work on curricular, instructional, or evaluation problems and projects applicable to school situations.
- CI 5187. Practicum: Improvement of Teaching in Elementary or Pre-Kindergarten Schools. (3 cr, §Elem 5602; prereq MEd student in elem educ or in early childhood educ) Elementary school classroom teaching project for improving specific teaching skills; planned by student and approved and directed by student's adviser as part of M.Ed. program.
- CI 5190. Directed Individual Study in Curriculum and Instruction. (1-6 cr [max 6 cr], §CISy 5509; prereq #) Producing and evaluating curricular materials; review and analysis of literature concerning issues or problems; assessing curriculum processes.
- CI 5195. Directed Study in Elementary and Secondary Education. (Cr ar [max 6 cr], §SeEd 5351; prereq educ or grad student; S-N optional) Individual or group work on curricular, instructional, or evaluation problems.
- CI 5250. Current Trends in Early Childhood Education. (4 cr, §Elem 5377; prereq tchg exper in kindergarten or primary or #) Continuing needs of children in our changing culture; current practices and recent research; curriculum assessment techniques and evaluation of education materials.
- CI 5252. Contemporary Programs for Young Children. (3 cr, §Elem 5378; prereq MEd student in early childhood educ) Growth and development of preschool children in light of need for curriculum intervention programs; current trends, program evaluation, and recent research.
- CI 5253. Cognitive and Creative Learning in Early Childhood Education. (3 cr, §Elem 3379, §Elem 5379; prereq CPsy 1301 or CPsy 5301) Development approach to planning cognitive, language, and creative curriculum.
- CI 5280. Student Teaching in the Kindergarten. (3-6 cr, §3280; prereq 5250, 6 cr elem student teaching or current elem license) Five half-days each week in supervised teaching and observation in public or private kindergartens.
- CI 5281. Student Teaching in the Nursery School. (3-6 cr, §Elem 3604; prereq approval of major adviser and director of student tchg) Supervised teaching.
- CI 5300. Technology for Teaching and Learning. (2 cr) Using technology for accessing and creating educational materials. Using diverse educational technologies for communicating with other users, accessing and sorting electronic databases, creating multimedia documents, and publishing on the Internet.
- CI 5310. Microcomputer Uses in the Elementary Classroom. (3 cr, §CISy 5206, §Elem 5140) Using microcomputers to enhance instruction across curriculum.
- CI 5331. Instructional Systems: Trends and Issues. (1-3 cr [max 9 cr]; offered when feasible)
- CI 5335. Introduction to Instructional Systems and Technology. (4 cr, §CISy 5151) Historical foundations, contemporary issues, and research base of instructional systems.
- CI 5337. Principles and Procedures in Designing Instruction. (4 cr, §CISy 5209) Major models of instructional development; generic components; design models; review of instructional design and learning environments.
- CI 5351. Topics: Computer-Based Tools for Teachers. (1-4 cr, §CISy 5208) Use of technology for material generation, record keeping, and classroom management tasks in K-12 classrooms.

## GRADUATE PROGRAMS

CI 5355. Introductory Educational Technology Methods. (4 cr, §CISy 5080)  
Techniques for evaluating and selecting hardware and software to meet instructional needs. Strategies and techniques for integrating educational technology to meet curricular goals and objectives.

CI 5356. Advanced Education Technology Methods. (1-6 cr [no more than 3 cr may be applied to IS concentration within the educ MA and PhD programs], §CISy 5090; prereq 5355 or 5360 or CISy 5003 or CISy 5080 or #)  
Selecting hardware and software, integrating technology into a variety of curricular areas. Developing and implementing plans for integrating technology into classroom instruction.

CI 5360. Teaching via the Internet. (4 cr)  
Using the Internet to access and publish educational materials. Creating multimedia documents and publishing on the World Wide Web.

CI 5362. Introduction to Computer-Based Instructional Design. (4 cr; A-F only)  
Mathematics or science background not required.

CI 5363. Computer-Based Instruction: Introduction to Design. (3 cr, §CISy 5205; prereq 5362 or CISy 5006 or #)  
Computer uses in education and training; models for designing computer-based instruction with emphasis on interface design.

CI 5364. Computer-Based Instruction: Design and Development. (4 cr, §CISy 5212; prereq 5362 or CISy 5205 or #; offered when feasible)

CI 5367. Interactive Multimedia Instruction. (4 cr, §CISy 5207; prereq 5337 or 5363 or #)  
Multimedia technologies; design and development of interactive instruction.

CI 5390. Directed Individual Study in Curriculum and Instruction. (1-6 cr [max 6 cr], §CISy 5509; prereq #)  
Production and evaluation of curricular materials; review and analysis of literature concerning issues or problems; assessment of curriculum processes.

CI 5400. Survey of Children's Literature. (3 cr, §Elem 5210; prereq educ student or #)  
Techniques of and materials for teaching with children's literature in elementary schools.

CI 5401. Literature for the Elementary School. (4 cr, §Elem 5300)  
Evaluate survey of books for children; research related to children's reading interests; selection of literature.

CI 5402. Survey of Special Collections in Children's Literature. (3 cr, §Elem 5305; prereq 5401 or #)  
Content and accessibility of collections that relate the creation of books; emphasis on possibilities and methods for interpreting content of collections to children.

CI 5403. Creative Writing for and by Children. (1-3 cr [max 6 cr], §Elem 5318; prereq 3400 or 3420 or Elem 3300 or Elem 3316 or elem tchg exper or #)  
Literature and writing in elementary school for experienced teachers, graduate students, and college instructors; emphasis on aspects of writing and illustrating children's literature and on children's own writing.

CI 5410. Teaching Reading in the Elementary School. (3 cr, §Elem 5331; prereq 9 cr educ)  
Elementary school reading programs from perspectives of historical change, language research, and sociocultural demographics.

CI 5411. Reading Difficulties: Assessment and Instruction. (4 cr, §Elem 5334; prereq 5410 or 5450)  
Causes, prevention, and correction; remedial practices useful to the classroom teacher, school counselor, and reading specialist.

CI 5413. Teaching Students With Reading Difficulties. (4 cr, §Elem 5336; prereq 5172 or 5411 or Elem 5334 or Elem 5107, #)  
Assessment and tutoring of individual children who have difficulty in school learning.

CI 5414. Literacy Development in the Primary Grades. (4 cr, §Elem 5337; prereq 3410 or elem teacher or #)  
Theory and practice of integrating teaching of reading, literature, writing, and language.

CI 5415. Literacy Development in the Intermediate Grades. (4 cr, §Elem 5338; prereq 3410 or elem teacher or #)  
Theory and practice of integrating teaching of reading, literature, writing, and language.

CI 5416. Workshop: Curriculum Implementation in Elementary School Reading. (1-9 cr [max 9 cr], §Elem 5339; prereq elem tchg exper or #; offered when feasible)

CI 5418. Whole Language in the Elementary School. (4 cr; prereq educ or grad student)  
Philosophy and practice of whole language teaching. Meaning-based integration of reading/writing; learner support; noncompetitive environments; locus of control; performance-based assessment, including miscue analysis; theoretical, social, and political implications.

CI 5420. Teaching Writing in the Elementary School. (4 cr, §Elem 5315; prereq postbac or MEd or grad student)  
Theory and research on writing process, applications to developing an elementary school writing curriculum.

CI 5425. Teaching Language Arts in the Elementary School. (3 cr, §Elem 5316; prereq 3420 or elem tchg exper)  
Improvement of instruction, study of trends in English education.

CI 5440. Teaching Literature in Secondary Schools. (4 cr, §SeEd 5321)  
Current theory and methods of instruction; research and response to literature and reading; adolescent literature; growth assessment; curriculum design and evaluation.

CI 5441. Literature for Adolescents. (3 cr, §SeEd 5320)  
Reading and analysis of fiction and nonfiction; methods for critically assessing quality and appeal. Appropriate for secondary English and social studies teachers and librarians.

CI 5450. Teaching Reading in Content Areas. (4 cr, §SeEd 5344)  
Methods of accommodating to student abilities and facilitating reading in regular content classes.

CI 5451. Secondary Remedial Reading Instruction. (4 cr, §SeEd 5175; prereq 5410 or 5450)  
Principles and techniques for developing and conducting programs for secondary students seriously deficient in reading skills; methods for assessing these students' proficiency and progress.

CI 5460. Teaching Writing in Secondary School and College. (4 cr, §SeEd 5322)  
Historical and contemporary context; analysis of composing processes; prewriting and revision; audience analysis; comprehension and coherence; selected problems in diagnosing and evaluating writing.

CI 5461. Diagnosing and Assessing Writing in Secondary Schools. (3 cr, §SeEd 5323; prereq educ jr or sr or grad student)  
Application of theory and research on composition instruction to analysis of diagnosis of writing samples; evaluation of writing using written or conference feedback; large group writing assessment using different rating scales; development of assignments and curriculum materials for writing instruction.

CI 5470. Classroom Research in Literary Education. (3 cr, §SeEd 5176)  
Review and analysis of current studies; design and analyses for school-based research.

CI 5472. Teaching Film, Television, and Media Studies. (3 cr, §SeEd 5326)  
Current theory and methods of teaching critical response to film, television, and media; techniques of film/video production, genres, history; methods for analyzing cultural roles in media; integration and use of short films and videos with English and social studies instruction.

CI 5473. Language, Culture, and Education. (4 cr, §SeEd 5404, §Spch 5404)  
Psychological and social-psychological perspectives for study of language-communication; dimensions of language variation (dialects, codes, registers); implications for program development and instructional practices.

CI 5485. Directed Experiences in Teaching English. (6-12 cr, §SeEd 3621; prereq 5475 or SeEd 5350)

CI 5491. Current Developments in English Education. (1-6 cr [max 12 cr], §SeEd 5350; offered when feasible)

CI 5500. Teaching Science in the Elementary School. (3 cr, §Elem 5346; prereq postbac in elem educ or #; offered when feasible)

CI 5501. Workshop: Elementary School Science Education. (1-8 cr [max 16 cr], §Elem 5347)  
Issues, materials, and instructional techniques. Topic varies.

CI 5504. Materials and Resources for Elementary School Science. (4 cr; prereq elem tchg exper)  
Using educational materials and media common to the teaching of modern elementary school science.

CI 5506. Teaching Health in the Elementary Schools. (1 cr, §Elem 5213; prereq elem postbac student or #)  
Techniques of and materials for teaching health at elementary level.

CI 5530. Science Education for the Middle School. (4 cr, §SeEd 5700; prereq science educ postbac student or #)  
Planning science education.

CI 5531. Teaching Secondary School Science: A Constructivist Approach. (4 cr, §SeEd 5702; prereq 5530, 5580 or SeEd 5700, SeEd 5701, ¶CI 5581 or ¶SeEd 5703, postbac science educ student or #)  
Science teaching methods.

CI 5532. Current Developments in Secondary School Science Teaching. (4 cr, §SeEd 5390; prereq MED or grad student or #)  
Curricula, methods, materials of instruction, evaluation.

CI 5533. Studies in Science Education. (4 cr, §SeEd 5397; prereq MED or grad student or #)  
Improvement of science teaching through application of research findings.

CI 5534. Foundations of Science Education. (4 cr, §SeEd 5706; prereq MED or grad student)  
Analyzes present practice in light of historical and philosophical foundations of science education.

CI 5535. Advanced Methods of Secondary Science Teaching and Assessment. (4 cr; prereq MED or grad student or #)

CI 5537. Workshop: Science Education. (1-8 cr [max 16 cr], §SeEd 5394)  
For middle and high school and college science teachers. Issues, materials, and instructional techniques. Topic varies.

CI 5572. Seminar: Reflecting On Clinical Experience in Science Teaching. (3 cr, §SeEd 5705; prereq 5331 or SeEd 5702, SeEd 5703 or #, ¶CI 5582)  
Reflections and issues.

CI 5580. Applying Science Methods in Middle and Secondary Schools. (1-4 cr [max 10 cr], §SeEd 5701, §SeEd 5703; prereq ¶15530 or ¶15531, postbac science educ student or #)  
Practicum in conducting, analyzing, and reflecting on science teaching.

CI 5582. Clinical Experience in Science Teaching. (6 or 12 cr, §SeEd 5704; prereq 5531, 5581, ¶15572 or SeEd 5702, SeEd 5703, ¶155705, #)  
Supervised clinical experiences in secondary school science teaching.

## GRADUATE PROGRAMS

CI 5619. Teaching Second Languages and Cultures in Elementary Schools. (4 cr, §Elem 5319) Methods and materials; developing oral and written communication; consideration of alternatives in program format; preparation of materials; global awareness and cross-cultural experience; assessing children's language; children's literature, games, songs, developing units and lessons.

CI 5620. Second Languages and Young Children: Like Child's Play. (4 cr, §Elem 5321) Current approaches to teaching second languages to young children; how young children acquire language; effects of bilingualism on child development; rationales, advantages, and pedagogical theories of program models, from full immersion to programs that emphasize cultural understanding.

CI 5631. Second Language Curriculum. (3 cr per qtr [total 9 cr], §SeEd 5801; prereq postbac student) Course spans one academic year; component of teacher education program. Nature of school and second language curriculum; variety of curricular orientations and their implications for instruction and evaluation.

CI 5632. Second Language Instruction. (3 cr per qtr [total 9 cr], §SeEd 5802; prereq postbac student) Course spans one academic year; component of teacher education program. Developing skills for selecting, organizing, and providing effective second language learning opportunities through observation, practice, and reflection.

CI 5633. Second Language Research. (2 cr per qtr [max 6 cr], §SeEd 5803; prereq graduate of SLC postbac licensure, 6 cr after licensure) Classroom-based examination of teaching and student learning over academic year.

CI 5642. Assessment of Learners With Limited English Proficiency. (4 cr, §SeEd 5218) Social, political, and educational context of assessing students with limited English proficiency; evaluation vs. research and implications for bilingual schooling, curriculum development, and materials selection; methods for assessing language proficiency and academic achievement.

CI 5645. Schooling Outcomes for a Multiethnic Society. (4 cr, §SeEd 5221) Analysis of schooling experiences for students of African-American, Hispanic, Asian, and American Indian backgrounds. Changing perspectives concerning ethnic student achievement, research on factors influencing school achievement, and prospects for change.

CI 5650. Second Language and Cultures Education: Introduction and Overview. (4 cr, §SeEd 5186) Curricula and instruction in various settings: elementary, secondary, open, free, suburban, and center city schools; bilingual programs, colleges, community colleges, universities, and adult programs including teacher preparation.

CI 5652. Teaching Culture: Theory and Application. (4 cr, §SeEd 5122; prereq postbac or grad student) Analysis of concept; related factors and materials for classroom use; culture shock; empathy; culture conflict, awareness, learning.

CI 5656. Reading and Writing in a Second Language. (4 cr, §SeEd 5219) Reading comprehension and composing processes in a second language; relationship between first and second language comprehension and composing processes, between reading and writing, and between culture and reading comprehension and writing; politics of literacy; assessment of second language literacy.

CI 5657. Speaking and Listening in a Second Language. (4 cr, §SeEd 5219) Theories and methods of teaching language as communication in oral and aural modes; planning student interaction; classroom organization for learning and acquisition. Students complete reflective analyses of lessons.

CI 5658. Second Language Testing, Assessment, and Evaluation. (4 cr, §SeEd 5382) Language proficiency assessment, English as a second language, bilingual education; oral interviews; testing communicative abilities; standardized language measures; building test items; evaluating programs; aptitude and attitude measurement.

CI 5660. Special Topics in the Teaching of Second Languages and Cultures. (1-10 cr [max 10 cr], §SeEd 5191) Related specifically to the needs of the in-service teacher; topics, location, and duration is highly flexible.

CI 5662. Critical Issues in Second Language Curriculum. (4 cr, §SeEd 5189) Development of competencies in curriculum and materials construction; application to lessons, units, modules, courses, levels of instruction in ongoing programs of second language acquisition in schools.

CI 5680. Practicum: Teaching Second Languages and Cultures in Elementary Schools. (3 cr, §Elem 5320; prereq 5619 or Elem 5319, ¶CI 5619 or ¶Elem 5319, #: S-N only) Minimum of three hours weekly of supervised teaching and observation in elementary schools.

CI 5684. Clinical Experiences in Second Languages. (6 cr per qtr [max 12 or 18 cr]; prereq initial licensure/MED student) Component of second languages teacher education program. Teaching and learning experiences in elementary and secondary second language.

CI 5690. Directed Study in Second Languages and Cultures. (Cr ar [max 6 cr], §SeEd 5351; prereq educ or grad student; S-N optional) Individual or group work on curricular, instructional, or evaluation problems.

CI 5700. Teaching Social Studies in the Elementary School. (3 cr, §Elem 5361; prereq 5110 or Elem 3101 or equiv, postbac student)

Content and organization of social studies programs; programs of understanding, improving the learning situation, and effective use of materials.

CI 5730. Social Studies for the In-Service Elementary/Middle School Teacher. (4 cr, §Elem 5361; elem tchg exper or #)

Content and organization of social studies programs; programs of understanding, improving the learning situation, and effective use of materials.

CI 5740. Introduction to Social Studies Education. (4 cr, §SeEd 5152; prereq postbac student)

Analysis of teaching strategies and contemporary curriculum materials in the social studies; techniques of instruction useful in inquiry; strategies of analysis; classroom behavior and evaluation; required of all M.A., M.Ed., and Ph.D. candidates.

CI 5741. Advanced Methods for Teaching the Social Studies. (4 cr, §SeEd 5150; prereq postbac student)

Advanced methods for social studies teachers; prerequisite to other graduate-level courses in social studies education.

CI 5742. The Social Sciences and the Social Studies. (3 cr per qtr [max 6 cr], §SeEd 5153; prereq postbac student)

Issues, materials, and instructional techniques.

CI 5743. Seminar: Reflecting on the Clinical Experience in Social Studies Education. (3 cr; prereq social studies tchg major or #)

Reflecting on student teaching experience, developing a professional identity, and refining teaching skills.

CI 5746. Teaching About the Newspaper in the Classroom. (1-3 cr [max 4 cr], §Elem 5227, §SeEd 5227)

Institution of the newspaper; articulation of series of useful instructional strategies, curriculum development techniques, and teaching materials.

CI 5747. Global and Environmental Education: Content and Practice. (4 cr; offered alt yrs)

To help classroom teachers, curriculum specialists, and administrators assess current issues, instructional methods, and materials.

CI 5760. Social Studies for the Inservice Middle/Secondary School Teacher. (4 cr, §SeEd 5152; prereq secondary tchg licensure or #)

Provides broader understanding of each of the social sciences; central concepts and generalizations, methods of inquiry, pedagogical techniques, and resources.

CI 5780. Practicum: Secondary Social Studies Education. (1-7 cr [max 7 cr], §SeEd 3152; prereq educ student, Δ for postbac students)

Pre-student-teaching experience for developing teacher competencies; supervised observation and participation in classroom and related school activities.

CI 5782. Student Teaching in Secondary Social Studies. (3-15 cr [max 15 cr], §SeEd 3641; prereq postbac MEd student)

CI 5821. Teaching Mathematics in the Elementary School. (3 cr, §Elem 3391; prereq 5110 or Elem 3100, Elem 3101, Math 1005, Math 1006)

Principles of learning pertinent to modern program of mathematics in primary and elementary grades; objectives, content, philosophy, instructional materials, and methods of instruction and evaluation.

CI 8075. Seminar: Art Education. (1 cr, §ArEd 8306)

Reports, evaluation of problems, recent literature.

CI 8079. Research in Art Education. (3 cr, §ArEd 8300)

Research techniques.

CI 8099. Problems: Art Education. (Cr ar, §ArEd 8900; prereq #)

Independent projects under staff guidance may include advanced studio practice or technical problems requiring experimental or library research.

CI 8130. Curriculum and Instruction Core: Critical Examination of Curricular Contexts. (3 cr, §CISy 8100; prereq PhD student or #)

Impact of aesthetic, historical, social, political, and cultural forces on current curriculum contexts. Seminar.

CI 8131. Curriculum and Instruction Core: Teaching Theory and Research. (3 cr, §CISy 8102; prereq PhD student or #)

Overview of research on teaching: historical perspective, modern empirical procedures and findings, and implications of research for practice and for future investigation.

CI 8132. Curriculum and Instruction Core: Research Methods in Curriculum and Instruction. (3 cr, §CISy 8103; prereq PhD student or #: A-F only)

Purposes, approaches, and assumptions related to methods of educational research, such as descriptive, correlational, case-study, experimental, ethnographic, and developmental. Seminar.

CI 8133. Seminar in Teaching in Colleges of Education. (3 cr, §CISy 8201; prereq doctoral student or #, ¶8134)

Goals, instructional strategies, and evaluation procedures.

CI 8134. Practicum in Teaching in Colleges of Education. (1 cr, §CISy 8202; prereq 8133 or CISy 8201, doctoral student or #)

Supervised teaching in education course at University of Minnesota or at another college or university.

CI 8135. Interdisciplinary Curriculum Issues. (1-4 cr, §CISy 8416)

Disciplinary and interdisciplinary learning in various settings, educational implications for conceptual relationships between professional disciplines, and relationships between curriculum and knowledge.

## GRADUATE PROGRAMS

CI 8136. Curriculum Reform and Social Change. (4 cr, §CISy 8600; prereq 5100 or 5130 or CISy 5600 or Elem 5100 or #)

Connections between social change and educational reform movements; relationship of curriculum to school, society, and culture; methods and purposes of reform; and issues of implementation in various institutional and cultural settings with diverse populations.

CI 8140. Curriculum Implementation and Leadership. (4 cr, §CISy 8610)

Enactment of curriculum in various institutional and cultural settings; methods and processes of implementation; several types of curriculum packages and various populations; leadership strategies for curriculum specialists.

CI 8147. The Domain of Curriculum Theory and Research: Alternative Paradigms and Research Methods. (4 cr, §CISy 8620)

Assessment of inquiry traditions, research methods, and exemplar studies in empirical-analytic, deliberative, and reconceptualist traditions of curriculum. Includes survey of quantitative and qualitative research methods and other inquiry as applied to curriculum questions.

CI 8160-8161. Planning a Research Experience. (3, 3 cr; prereq 8132, concurrent regis in 1 cr independent study course with faculty in area of specialization)

Research questions, literature reviews, methodology, data collection devices, data collection, and how these interact to produce successful research.

CI 8190. Problems: Improvement of Instruction. (Cr ar, §Elem 8991; prereq #)

For students qualified to make intensive studies of problems related to school supervision.

CI 8198. Problems: Teacher Education. (3-9 cr; prereq #)

Research in supervision, organization, and administration; lab experiences at elementary and secondary levels.

CI 8199.\* Problems: Curriculum Studies. (3-9 cr, §CISy 8501; prereq PhD student)

Individual empirical investigation.

CI 8290. Problems: Teaching Kindergarten. (3 cr, §Elem 8976; prereq #)

Opportunity for in-depth study or research related to self-selected interest areas in kindergarten education.

CI 8361. Advanced Courseware and Design: Issues. (4 cr, §CISy 8411; prereq 5364 or CISy 5212 or #; offered when feasible)

CI 8390.\* Problems: Instructional Systems. (Cr ar, §CISy 8501; prereq #)

Individual empirical investigation.

CI 8391. Instructional Systems Seminar. (2 cr [max 6 cr], §CISy 8416; prereq #; offered alt yrs)

Problems and issues in instructional theory and research.

CI 8400. Special Topics in Children's and Young Adult Literature. (1-9 cr [max 9 cr], §Elem 8300)  
Study of original manuscripts and artwork for children's books; research in children's response to literature.

CI 8412. Research in Reading. (4 cr, §Elem 8332; prereq #)

Critical analysis of methodology and findings of research; appraising research methods, population limitations, and educational implications.

CI 8413. Special Topics in Reading Research and Instruction. (1-9 cr [max 9 cr], §SeEd 8333; prereq #)

Problems of research at all levels; topics vary according to offering; presentation of proposed designs and current studies.

CI 8420. Research in Composition. (4 cr, §Elem 8316; prereq 5425 or 5460 or Elem 5316, #)

Review of research on writing processes of kindergarten-college students and factors influencing those processes.

CI 8471. Special Topics in Literacy. (1-9 cr [max 9 cr], §SeEd 8899; prereq #)

Selected topics with implications for curriculum development and change.

CI 8492. Readings in English Education and Reading. (1-3 cr, §SeEd 8895)

Readings in secondary school English curriculum and instruction.

CI 8493. Problems: Teaching English and Reading. (Cr ar, §Elem 8916, §Elem 8931, §SeEd 8896)  
For those qualified to undertake individual research.

CI 8500. Research Foundations of Science Education. (4 cr [max 16 cr], §Elem 8346, §SeEd 8887)

Critical review and analysis of classical research studies; criteria for appraising research findings; educational implications.

CI 8570. Advanced Topics in Science Education. (4 cr [max 16 cr], §SeEd 8899)

Critical review and analysis of research in selected topics with implications for change in curriculum and instructional practices. Topics vary.

CI 8590. Problems: Science Education. (Cr ar, §SeEd 8871; prereq #; offered when feasible)

CI 8630. Research in Second Languages and Cultures Education. (4 cr, §SeEd 8188)

Identification and retrieval of information; preparation of research proposals, papers, and theses; examination of empirical research models; discussion of needed research; designing an individual study.

CI 8631-8632-8633. Research Seminar: Second Languages and Cultures Education. (3 cr per qtr [max 9 cr], §SeEd 8387; prereq 8630 or SeEd 8188)

Three-quarter seminar. Students select a problem; design an appropriate study; collect and analyze data; summarize results; prepare and submit a manuscript designed for publication; cooperate in critical review of projects.

CI 8650. Seminar: Special Topics in Second Languages and Cultures Research. (1-4 cr)

CI 8694. Problems: Second Languages and Cultures Education. (Cr ar [max 8 cr], §SeEd 8894)  
Individual research.

CI 8698. Readings in Second Languages and Cultures Education. (1-4 cr, §SeEd 8898)  
Readings in development, research, curriculum, instruction, evaluation, culture, teacher education as needed by student.

CI 8740. Seminar: Trends and Issues in Social Studies Education. (3 cr, §Elem 8363, §SeEd 8364; prereq doctoral student or #)  
Historical and contemporary trends and issues in K-12 social studies education.

CI 8742. Seminar: Research in Social Studies Education. (3 cr, §Elem 8362, §SeEd 8362; prereq doctoral student or #; offered when feasible)

CI 8750. Problems: Social Studies Education. (3-9 cr [max 9 cr], §Elem 8961, §SeEd 8801; prereq 5741, 5740 or SeEd 5150, SeEd 5152, SeEd 5156, SeEd 8104 or #)  
Individual research.

## Mathematics Education (MthE)

MthE 5020. Teaching Mathematics: Algebraic Structures. (3 cr, §5082; prereq 5010, 5610, math ed student or #)  
Pedagogy, content, and instructional strategies for teaching algebra. Content and issues relevant to algebra curriculum. Instructional materials and appropriate technology.

MthE 5040. Teaching Mathematics: Advanced Topics. (3 cr; prereq math ed or grad student or #)  
Pedagogy, content, and instructional strategies for teaching trigonometry, analysis, calculus, probability, statistics, discrete mathematics. Content and issues relevant to advanced mathematics curriculum. Instructional materials and appropriate technology.

MthE 5081. Teaching Arithmetic in the Secondary School. (3 cr; prereq math educ major or minor, Math 5081 or ¶15081 or #)  
Survey of concepts, principles, and processes of secondary school pre-algebra curriculum; learning difficulties, teaching strategies and alternatives; mathematical foundations of pre-algebra topics.

MthE 5082. Teaching Algebra in the Secondary School. (3 cr, §5020; prereq math educ major or minor, Math 5082 or ¶15082 or #)  
Survey of concepts, principles, and processes of secondary school curriculum; learning difficulties, teaching strategies and alternatives; mathematical foundations of algebra topics.

MthE 5083. Teaching Geometry in the Secondary School. (3 cr; prereq math educ major or minor, Math 5083 or ¶15083 or #)  
Survey of concepts, principles, and processes of secondary school geometry curriculum; learning difficulties, teaching strategies and alternatives; mathematical foundations of geometry topics.

MthE 5101. Workshop: Elementary School Mathematics. (1-12 cr [max 12 cr]; not open to majors in math educ)  
Modern trends, methods, and materials used to convey mathematical ideas.

MthE 5102. Workshop: Mathematics Education. (1-12 cr [max 12 cr])  
Issues, materials, and instructional techniques focusing on a single current topic of particular relevance to secondary school and college mathematics teachers.

MthE 5150. Topics in Recreational Mathematics. (3 cr; prereq educ or grad student or #)  
Survey including magic squares; palindromes, repunits, repdigits from number theory; geometric dissections, topological recreations, cryptarithms; uses as problem-solving modes in mathematics classrooms.

MthE 5151. Calculator Use in the Elementary and Middle School. (1-3 cr [max 3 cr]; prereq educ or grad student or #)  
Structure and function of hand-held calculators. Materials and instructional techniques for integrating calculators into daily lessons; evaluating commercial materials; research on use of calculators in instructional settings.

MthE 5152. Geometry in the Elementary Grades. (1-3 cr [max 3 cr]; prereq educ or grad student or #)  
Geometric content and pedagogy for grades K-8. Levels of geometric thought, formation of spatial abilities; early childhood concepts from topology, transformational geometry, Euclidean geometry, and applications; dimensional models, construction, planal tessellations.

MthE 5153. Geometry in the Intermediate Grades. (1-3 cr [3 max cr]; prereq educ or grad student or #)  
Instructional approaches and physical materials relating to teaching of informal and intuitive geometric concepts in intermediate and middle school grades. Fundamental concepts of measurements and geometric relationships in 1, 2, and 3 dimensions, measurement systems, estimation, geometric figures and their properties, transformations and symmetry, congruence and similarity.

MthE 5155. Rational Number Concepts and Proportionality. (1-3 [max 3 cr]; prereq educ or grad student or #)  
Relationship between role of rational number concepts and developing proportional reasoning skills. Psychological, instructional, and pedagogical issues.

MthE 5157. Probability and Statistics in the Elementary School. (1-3 cr [max 3 cr]; prereq educ or grad student or #)  
Principles for systematic observation; techniques for collecting, organizing, representing, and interpreting data.

MthE 5160. Developing Leadership in School Mathematics. (1-3 cr [max 3 cr]; prereq educ or grad student or #)  
Current developments in psychology and pedagogy of mathematics education as they relate to evolving nature of mathematics education objectives. Emerging role of technology in mathematics curriculum. Effective techniques for developing supervisory abilities.

## GRADUATE PROGRAMS

MthE 5170. Teaching Problem Solving, Reasoning, and Proof. (4 cr; prereq math ed or grad student or #)

Fundamental concepts and principles. Emphasis on activities and applications for junior and senior high classes. Pedagogical experiences to prepare teachers.

MthE 5171. Teaching Probability and Statistics. (3 cr, \$SeEd 5274; prereq postbac educ student or #; at least 1 math course in probability or statistics or combinatorics recommended)

Fundamental concepts and principles. Emphasis on activities and applications for junior and senior high classes. Pedagogical experiences to prepare teachers to integrate quantitative literacy in classrooms.

MthE 5172. Historical Topics in the Mathematics Classroom. (3 cr; prereq math ed or grad student or #)

History of school mathematics content and methodology. Cross-cultural contributions in development of mathematical ideas; development of lessons, activities, and materials for school use.

MthE 5312. Teaching and Supervision of Mathematics in the Secondary School. (4 cr; prereq mathematics tchg exper or #)

Methods, materials, and curriculum development; principles of learning; review of research; preparation and evaluation of tests, units, and materials of instruction.

MthE 5313. Teaching and Supervision of Mathematics in the Middle School. (4 cr; prereq elem or secondary licensure)

Mathematics objectives, concepts and principles, skills and processes; instructional alternatives, including calculators and microcomputers; applying mathematics to individual differences; evaluation techniques for improving instruction and learning.

MthE 5332. Current Trends and Issues in School Mathematics. (4 cr; prereq 5312 or #)

Recent developments in mathematics curriculum and instructional alternatives, issues in teaching and learning; providing for special student needs; program planning and evaluation.

MthE 5355. Mathematics for Diverse Learners. (4 cr; prereq CI 5821 or #)

Units of instruction emphasizing mathematical concepts essential for vocational competence; experimental materials and methods designed to improve performance of low achievers.

MthE 5366. Technology-Assisted Mathematics Instruction. (4 cr; prereq CI 5362 or CIsy 5006 or equiv, math ed or grad student or #)

Technology, including computers, programmable and graphing calculators, and video as instructional tools in mathematics; design and evaluation of technology-based mathematics lessons; effect of technology on mathematics curriculum; managing technology in the classroom.

MthE 5610. Clinical Experiences in Teaching Arithmetic. (2 cr; prereq 5600, ¶15010, math educ student or #)

Observing and participating in arithmetic classes. Supervised microteaching and peer teaching. Developing observational, classroom management, and communication skills.

MthE 5620. Clinical Experiences in Teaching Algebra. (2 cr; prereq 5610, ¶15020, math educ student or #)

Observing and participating in algebra classes. Supervised microteaching and peer teaching. Developing observational, classroom management, and communication skills.

MthE 5630. Clinical Experiences in Teaching Geometry. (2 cr; 5620, ¶15030, math educ student or #)

Observing and participating in geometry classrooms. Supervised microteaching and peer teaching. Developing observational, classroom management, and communication skills.

MthE 5640. Half-Day Student Teaching in Mathematics. (6 cr; prereq ¶15540, math educ student, enrollment in math educ initial licensure/MEd program)

Student teaching in secondary school mathematics classes.

MthE 5650. Full-Day Student Teaching in Mathematics. (12 cr; prereq 5540, 5640, math educ postbac student or #)

Student teaching in secondary mathematics classes.

MthE 5680. Practicum in Mathematics Education. (3-9 cr [max 9 cr]; prereq #)

Supervised experience in teaching or related work in school.

MthE 8500. Theory and Classical Research in Mathematics Education. (3 cr; prereq 5311 or 5312 or #)

Critical review of research and relevant theoretical formulations; criteria for appraising research methods, educational implications.

MthE 8570. Research in Mathematics Education. (4 cr; prereq 8500 or #; offered when feasible)

MthE 8590. Seminar: Mathematics Education. (Cr ar [max 8 cr]; prereq #)

Problems of mathematics instruction at levels of kindergarten through junior college; opportunity to develop proposals and design models for empirical research.

MthE 8680. Internship: Mathematics Education. (Cr ar)

Participation in supervision, instruction, curriculum development, or research to gain in-service experience in a leadership role; includes a seminar; related project; required for the specialist certificate in mathematics education.

MthE 8980. Problems: Mathematics Education. (Cr ar; prereq 8500 or 8570)

Surveying the most recent literature, designing and preparing research reports on special problems.

## Dentistry

*Regents' Professor:* Robert J. Gorlin (*emeritus*)

*Professor:* Robert A. Vickers, *director of graduate studies*; Dwight L. Anderson; M. Bashar Bakdash; Muriel J. Bebeau; David O. Born; Jaroslav Cervenka; Anthony J. DiAngelis; William H. Douglas; Mohamed E. N. ElDeeb; Richard P. Elzay; James R. Friction; Mark C. Herzberg; Myer S. Leonard; William F. Liljemark; Leslie V. Martens; Karlind T. Moller; Bruce L. Pihlstrom; Charles F. Schachtele; Erwin M. Schaffer (*emeritus*); Eric L. Schiffman; Burton L. Shapiro; T. Michael Speidel; Michael J. Till; Larry F. Wolff

*Clinical Professor:* Richard R. Bevis; Gerald D. Cavanaugh; Frank W. Worms

*Associate Professor:* Gary C. Anderson; James L. Baker; John P. Conry; Ralph DeLong; Mahmoud E. ElDeeb; Kenneth M. Hargreaves; James E. Hinrichs; James R. Holtan; Ramesh K. Kuba; Thomas D. Larson; Kathleen J. Newell; Paul S. Olin; Maria R. Pintado; Nelson L. Rhodus; John K. Schulte; Stephen K. Shuman; James Q. Swift; Omar A. Zidan

*Assistant Professor:* Pamela R. Erickson; Bryan S. Michalowicz

*Clinical Assistant Professor:* Daniel E. Gatto

*Clinical Dental Specialist:* Chester J. Schultz, Jr.

*Research Associate:* John O. C. Look

*Senior Psychologist:* Kate M. Hathaway

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—M.S. (Plan A only).

**Curriculum**—Advanced educational programs for the M.S. degree (and for clinical specialties) in the School of Dentistry include endodontics, oral pathology, oral and maxillofacial surgery, orthodontics, pediatric dentistry, periodontics, prosthodontics, and general practice residencies and programs. Other clinical and postdoctoral programs include temporomandibular disorders and craniofacial pain, operative dentistry, caries research, oral and maxillofacial radiology, geriatric dentistry, primary dental care, and the Dentist Scientist Award.

The Dentist Scientist Award (DSA), which is supported by a grant from the National Institutes of Health, provides for Ph.D. training in basic sciences and advanced education in a clinical specialty of dentistry. Individual awards are competitive. Information regarding the DSA may be obtained from the principal investigator, Dr. Mark Herzberg, or the director of graduate studies.

**Clinical Instruments**—The School of Dentistry Dental Clinics maintain a centralized instrument usage and sterilization system that provides clinical instrumentation and related services for graduate students. Usage fees, where applicable, are listed in the quarterly *Class Schedule*.

**Prerequisites for Admission**—A D.D.S. degree (or its foreign equivalent) from an accredited school of dentistry, with a B average or better or with academic standing in the top fourth of the applicant's graduating class is required.

**Master's Degree Requirements**—Programs are designed by the individual areas of specialization in the major subject within the Graduate School's minimum credit and distribution requirements. Students may elect to take a minor or related fields in nonclinical fields in consultation with their adviser. A final oral examination is required.

**Language Requirements**—Proficiency in a language in addition to English is required for individuals specializing in oral pathology.

**Minor Requirements for Students Majoring in Other Fields**—Graduate study related to dentistry and leading to the M.S. and Ph.D. degrees may also be pursued through majors in such allied sciences as anatomy, biochemistry, microbiology, oral biology, pathobiology, pharmacology, and physiology. A Ph.D. program in one of the above fields with a minor in dentistry is offered to qualified dental graduates.

**For Further Information and Applications**—Contact the Director of Graduate Studies or the main office, School of Dentistry, University of Minnesota, 15-238 Moos Health Sciences Tower, 515 Delaware Street S.E., Minneapolis, MN 55455 (612/625-9982).

Dent 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

### Dentistry (Dent)

Dent 5945. Geriatric Hospital Dentistry. (Cr ar [may be repeated for cr; 4 cr required]) Shuman Rotations at University of Minnesota Hospital Dental Clinic and/or Minneapolis V.A. Medical Center Dental Clinic. Management of elderly patients in acute care settings. Dental management of patients compromised by medical therapies such as radiation treatment or chemotherapy, as well as those with acute illnesses.

## GRADUATE PROGRAMS

Dent 5950, 5951, 5952, 5953. Advanced General Dentistry Seminar I, II, III, IV. (Cr ar) Martens  
Clinical seminars with emphasis on treatment planning, case presentation, techniques and materials, comprehensive oral healthcare and maintenance, and issues in practice management. Correlated with concurrent clinical experiences.

Dent 5960, 5961, 5962, 5963, 5964, 5965, 5966, 5967. Advanced General Dentistry Clinic I, II, III, IV, V, VI, VII, VIII. (Cr ar) Martens  
Comprehensive oral healthcare delivered in variety of settings, emphasizing complex restorative care, coordinating care with dental and medical specialists, special needs patients, and advanced techniques.

Dent 5970, 5971, 5972, 5973. General Practice Seminar I, II, III, IV. (Cr ar) Martens  
A sequence of lectures, discussions, and seminars on topics related to current dental practice. Correlated with clinical experiences.

Dent 5974, 5975, 5976, 5977. General Practice Clinical Administration I, II, III, IV. (Cr ar) Martens  
Field experience in hospital dental clinic administration for residents.

Dent 5980, 5981, 5982, 5983, 5984, 5985, 5986, 5987. General Practice Clinic I, II, III, IV, V, VI, VII, VIII. (Cr ar) Martens  
A series of planned experiences in the clinical disciplines of dentistry, with emphasis on patient care.

Dent 5989. Advanced Clinical Geriatric Dentistry. (Cr ar) Shuman  
Practical clinical experience in examination, diagnosis, treatment planning, and treatment of older adult patients in the dental clinic at the Amherst H. Wilder Senior Health Center.

Dent 5990. Field Experience: Administration in a Multidisciplinary Health Center. (Cr ar) Shuman  
Administrative and management concerns related to development of dental service in multidisciplinary care facility for older adults. Field placement at the Amherst H. Wilder Senior Health Clinic and affiliated residences.

Dent 5992-5993-5994. Oral Health Services for Older Adults. (Cr ar) Shuman  
A series of seminars for graduate students on broad variety of topics related to aging, oral health of older adults, and delivery of oral health services to older adults. Students present articles, complex clinical cases, and ongoing research projects for group discussion.

Dent 5955, 5956, 5957, 5958. Advanced General Dentistry Clinical Administration I, II, III, IV. (Cr ar) Martens  
Field experience in community dental clinic practice and administration.

Dent 5996. Psychological Issues in Medical and Dental Patient Management. (2 cr; prereq #: offered alt yrs) Hathaway  
Psychological issues interfacing with medical and dental evaluation and treatment, psychopathology, stress, and illness.

Dent 8126. Teaching and Evaluation in Dentistry I. (3 cr; prereq #: offered alt yrs) Born  
Application of educational and psychological principles to professional dental education. Theoretical principles of behavioral and cognitive psychology applied to topics appropriate to dental education. Students apply these principles to concrete instructional situations in their own areas of interest and become familiar with instructional practice in both traditional and new instructional settings.

Dent 8127. Teaching and Evaluation in Dentistry II. (3 cr; prereq 8126; offered alt yrs) Born  
Application of evaluation and measurement theory to higher education, specifically dental education. Objectives for teaching and evaluation, construction of tests and measurement instruments, analysis of tests, interpretation of test results, principles of marking.

Dent 8400. Craniomandibular Disorders: Selected Topics. (3 cr) Schulte  
Seminar on current issues in diagnosis and treatment of craniomandibular disorders.

Dent 8440. TMJ and Craniofacial Pain: Advanced Theory and Principles. (3 cr; prereq #) Friction, staff  
Nature and pathophysiology of disorders causing chronic pain in TMJ and craniofacial regions; advanced principles and theory on assessment, diagnosis, and interdisciplinary management.

Dent 8441. Seminars in TMJ and Craniofacial Pain. (1 cr; prereq #) Friction, staff  
Advanced topics on theories and application of recently developed techniques of data collection, diagnostic strategies, and management for TMJ and craniofacial pain.

Dent 8442. Advanced Clinical TMJ and Craniofacial Pain. (1-4 cr; prereq #) Friction, staff  
Interdisciplinary study of patients with TMJ and craniofacial pain using techniques of assessment currently being researched; background and clinical knowledge of patient synthesized with respect to current literature on management; management program is developed, discussed with faculty, and implemented; effects of treatment and compliance reviewed at each follow-up appointment.

Dent 8443. Current Literature in TMJ and Craniofacial Pain. (1 cr; prereq #) Friction, staff  
Review of current literature in TMJ and craniofacial pain and how it relates to past literature, theories on pain, and philosophies of management.

## Endodontics (Endo)

Endo 5300f, 5301w, 5302s, 5303su, 5304f, 5305w, 5306s. Advanced Clinical Endodontics. (Cr ar) M E EIDeeb  
Diagnosis and treatment of clinical cases. Students are assigned complex cases and explore new and unique techniques.

Endo 5310f, 5311w, 5312s, 5313su, 5314f, 5315w, 5316s. Endodontic Emergency Problems. (1 cr per qtr) M E EIDeeb  
Each student is assigned a one-week period (8 hours per day) and is responsible for all emergencies in the Endodontic Clinic during this time.

Endo 5330f, 5331w, 5332s, 5333su, 5334f, 5335w, 5336s. Review of Cases. (1 cr per qtr) M E ElDeeb  
Students present cases for review by endodontic faculty and other graduate students.

Endo 8004su. Research in Endodontics. (Cr ar) M E ElDeeb

Organized literature review in area of specific interest of student, selection of thesis project, and completion of research and thesis.

Endo 8310f, 8311w, 8312s, 8313su, 8314f, 8315w, 8316s. Seminar: Endodontics. (2 cr per qtr) M E ElDeeb

Review of current literature, research, and clinical cases. Sessions assigned to student.

Endo 8320f, 8321w, 8322s. Advanced Endodontic Lectures. (1 cr per qtr) M E ElDeeb  
Pulpal and periapical pathology, diagnosis, and treatment planning in endodontics.

Endo 8335. Endodontic-Periodontic Seminar. (1 cr) M E ElDeeb  
Discussions of endodontic-periodontic problems for all graduate dental students.

## Oral Biology (OBio)

See the separate major heading Oral Biology later in this bulletin.

## Oral and Maxillofacial Surgery (OSur)

OSur 5257. Ambulatory General Anesthesia. (1 cr) Swift  
A clinical rotation involving experience in outpatient management and using intravenous sedation and general anesthesia.

OSur 5276. Medicine for the Oral Surgeon. (2 cr; prereq participation in oral surgery residency program) Swift  
Six-week rotation at Mt. Sinai Hospital on medical service under direction of University's Internal Medicine Department. Rotation involves workup and admission and daily management of patients on medical service.

OSur 5277. Physical Diagnosis for Oral Surgery Residents. (1 cr; prereq participation in oral surgery residency program) Swift  
Six-week didactic course coupled with evaluation of patients at University Hospital under direction of Department of Medicine and its faculty.

OSur 8250. Advanced Oral and Maxillofacial Surgery. (Cr ar) Swift  
Assigned clinics in the University of Minnesota Hospital and Clinic, Veterans Administration Medical Center, Hennepin County Medical Center, and School of Dentistry.

OSur 8251. Seminar: Oral Surgery. (1 cr) Swift  
Oral surgical subjects.

OSur 8253. Problems in Oral and Maxillofacial Surgery. (Cr ar) Swift  
Current literature review; experience in surgical techniques.

OSur 8254. Topics. (1 cr) Swift  
Surgical orthodontic techniques and seminar.

OSur 8255. General Surgery. (Cr ar)  
Clinical rotation on general surgical service at the University of Minnesota Hospital and Clinic. Seminars, clinics, and operating room experience.

## Oral Pathology (OPat)

OPat 5017. Oral Pathology Clinic. (Cr ar) Vickers  
Resident participates in management of Oral Pathology Clinic patients at the School of Dentistry and serves as oral pathology consultant with designated staff in school's screening facilities.

OPat 8004. Histopathology. (2 cr) Vickers  
Weekly presentation of currently encountered diagnostic material. Evaluation and interpretation by trainees of individual and representative material. Additional diagnostic information, such as clinical and radiologic information, is collated as an introduction to the individual problem of diagnosis when possible. Cases chosen in advance and made available for individual study.

OPat 8006. Current Literature Review. (1 cr) Gorlin, Vickers  
Seminars on a variety of research problems, topics, and areas of special interest between graduate students and oral pathology faculty. Students expected to determine both subjects for discussion and nature of discussions.

OPat 8007. Special Oral Pathology. (2 cr) Gorlin, Vickers  
Review of the clinical, radiographic, and treatment aspects of oral disease and oral manifestations of systemic disease. For residents and graduate students in disciplines other than oral pathology.

OPat 8011. Surgical Oral Pathology. (Cr ar) Vickers  
Residents and graduate students participate as staff assistants in diagnosis of oral diseases. Histopathologic, frozen section, clinical, cytologic, cytogenetic, microbiologic, hematologic, radiologic, and other diagnostic means are used.

OPat 8300f. Human Development Genetics I. (2 cr; prereq GCB 3022, BioC 5970, Path 5101 or #)  
Genetic and genetic-environmental interactions in development of normal and abnormal human traits. Genetic control of prenatal and postnatal differentiation at the cellular tissue level. Morphological and functional (behavioral) human traits, especially those affecting the face and oral structures.

## Oral Radiology (ORad)

ORad 8300. Advanced Oral Roentgenographic Interpretation. (2 cr; prereq #) Kuba  
Theory, principles, and practice of roentgenographic interpretation of intraoral and extraoral roentgenograms. Normal roentgenographic anatomy and roentgenographic evidence of the presence of pathology and anomalies integrated with relevant anatomical, pathological, clinical, and statistical data in establishing differential, provisional and final diagnoses, prognoses, treatment plans, and treatment.

## GRADUATE PROGRAMS

### Orthodontics (Otho)

Otho 5001, 5002, 5003, 5004. Clinical Orthodontics. (Cr ar) Speidel, staff  
Students assigned patients for complete management of orthodontic and orthodontically related occlusal problems under direct staff supervision.

Otho 8001. Research in Orthodontics. (Cr ar) Speidel, Viazis, staff

Otho 8200, 8201, 8202, 8203. Growth and Development. (Cr ar) Speidel, staff  
Head growth, development, osteology, and myology. Both normal and abnormal morphology and function, with emphasis on cephalometric methods.

Otho 8204, 8205, 8206, 8207. Orthodontic Diagnosis and Treatment Planning. (Cr ar) Speidel, staff  
Etiology, treatment, and prognosis of clinical orthodontic patients.

Otho 8208, 8209, 8210, 8211. Orthodontic Seminar. (Cr ar) Speidel, staff  
Current literature, research, implications.

Otho 8217w, 8218s, 8219su. Topics in Orthodontics. (Cr ar) Speidel, staff

### Pediatric Dentistry (Pedo)

Pedo 5414. Advanced Clinical Pedodontics. (Cr ar)  
Assignment of patients for treatment of difficult or unusual pedodontic problems under direct faculty supervision.

Pedo 8001. Research in Pediatric Dentistry. (Cr ar)

Pedo 8290, 8291. Hospital Pedodontics I, II. (Cr ar)  
Faculty-supervised diagnosis and treatment of pedodontic problems at Hennepin County Medical Center. Participation on a rotation basis in seminars in pediatrics and anesthesia. Preoperative and postoperative seminar discussion and evaluation of treatment plans.

Pedo 8292. Pedodontic Literature. (Cr ar)  
In-depth literature review and seminar discussion of specific pedodontic topics.

Pedo 8293. Advanced Pedodontic Techniques. (Cr ar)  
Description of and exercises in advanced pedodontic skills and techniques.

Pedo 8294. Pedodontic Diagnosis and Treatment Planning. (Cr ar)  
Systematic approach to diagnosis of and treatment planning for various pedodontic problems.

Pedo 8295. Independent Pedodontic Study. (Cr ar)  
Preparation of a position paper on assigned topic, including review of pertinent literature.

Pedo 8298. Interdisciplinary Care of the Cleft Palate Patient. (1 cr)  
Comprehensive surgical, dental, and speech and hearing evaluation and management of patients with cleft lip and palate.

### Periodontics (Pero)

Pero 5123. Periodontal Practice Management. (1 cr; prereq Dent grad student)  
Seminar on practice styles, referral patterns, third-party carriers, and management of employees.

Pero 5222f. Dentistry and Systemic Healthcare. (1 cr; prereq Dent grad student) Hinrichs, Rhodes  
Seminar for improving dentist's knowledge about treating medically compromised patients. Cardiac murmurs, coagulation, diabetes mellitus, organ transplants, hypertension, radiation and chemotherapy for oncology patients, and control of transmittable diseases.

Pero 5321. Periodontics/Orthodontics. (1 cr; prereq Dent grad student)  
Combined therapeutic effect of periodontics and orthodontics to treat malocclusions that exhibit periodontitis.

Pero 8000f,w,s,su. Advanced Clinical Periodontology. (Cr ar) Hinrichs, Michalowicz, Pihlstrom, Schaffer, Wolff  
Clinical training in examination, diagnosis, treatment planning, and various phases of prevention and treatment of patients with periodontal disease.

Pero 8200f,w,s,su. Clinical Seminars in Periodontology. (Cr ar) Hinrichs, Michalowicz  
Clinical cases are discussed from a diagnostic, treatment planning, and therapeutic viewpoint.

Pero 8220f. Topics in Conscious Sedation. (2 cr; prereq Dent grad student) Hinrichs  
Seminar for evaluating current literature. Patient selection and evaluation; approaches in oral, inhalation, and intravenous sedation; and management of medical emergencies for dental patients.

Pero 8250su. Supporting Structures of the Teeth. (Cr ar) Schaffer  
Gingival tissues, cementum, periodontal ligament, and alveolar bone discussed from a histological, physiological, and pathological point of view.

Pero 8300f,w,s,su. Seminar: Periodontology. (Cr ar) Bakdash, Hinrichs, Michalowicz, Pihlstrom, Schaffer, Wolff  
Discussion of assigned weekly literature reviews. Preparation of assigned formal literature reviews.

Pero 8305s. Periodontic-Prosthodontic Seminar. (1 cr; offered alt yrs) Hinrichs  
Discussions of periodontal-prosthodontic problems for all graduate dental students.

Pero 8335. Dental Implantology: A Multidisciplinary Offering. (2 cr; prereq Dent grad student; offered alt yrs) Hinrichs, Michalowicz  
Theories and techniques associated with implants in managing partially or completely edentulous patients; contributions from periodontology, prosthodontics, and oral-maxillofacial surgery.

Pero 8400w,s. Anatomy of Normal and Observed Periodontium. (2 cr; prereq Dent grad student; offered alt yrs) Schaffer  
Discussions on histopathological alterations and regenerative potential of periodontium.

Pero 8450. Bacteriology and Immunology of Periodontal Diseases. (1 cr; prereq Dent grad student; offered alt yrs) Wolff  
Discussions of etiology of periodontal diseases from a genetic, bacterial, and immunological perspective.

## Prosthodontics (Pros)

Pros 5010. Graduate Prosthodontics Seminar. (2 cr per qtr [max 12 cr]; prereq Pros grad student)  
Various topics discussed during first two years of program.

Pros 8003. Advanced Technical Restorative Dentistry. (Cr ar [may be repeated for cr]) Goodkind  
Clinical and technological theories and practices interrelated in an effort to solve more complex problems in restorative therapy.

Pros 8005. Advanced Clinical Prosthodontics I. (Cr ar [may be repeated for cr]) Goodkind  
Practical clinical experience in examination, diagnosis, treatment planning, and various phases of treatment of patients with restorative dental problems. New and/or unfamiliar concepts and techniques emphasized.

Pros 8025. Seminar: Applied Biomaterials I. (Cr ar; prereq #) Holtan  
Principles that govern manipulation of materials used in restorative dental practice. Physical properties and dimensional changes emphasized.

Pros 8032. Principles of Maxillofacial Care. (Cr ar [may be repeated for cr]; prereq #) Schreiner  
Treatment biomechanics and technical procedures associated with fabrication, fitting, and servicing of various types of oral and facial restorations.

Pros 8034. Advanced Clinical Maxillofacial Prosthetics. (Cr ar [may be repeated for cr]; prereq 8030, 8032, #) Schreiner  
Factors involved in diagnosis and organization of a treatment plan for maxillofacial patient and practical experience in associated clinical and lab procedures.

## Design, Housing, and Apparel

*Regents' Professor:* Joanne B. Eicher

*Professor:* William J. Angell; Marian-Ortolf Bagley (*emeritus*); Timothy T. Blade; Marilyn R. DeLong; Denise A. Guerin; Earl W. Morris (*emeritus*)

*Associate Professor:* Becky L. Yust, *head*; Edward G. Goetz, *director of graduate studies*; Homa Amir-Fazli; Margaret K. DiBlasio; Ann M. Erickson; Evelyn M. Franklin (*emeritus*); Kim K. P. Johnson; Wanda W. Olson; Gloria M. Williams

*Assistant Professor:* Sherri Gahring; Delores A. Ginthner; Karen L. LaBat; Barbara E. Martinson

*Other:* Suzanne J. Baizerman; David T. Grimsrud; Brad Hokanson

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B), M.S. (Plan A and Plan B), and Ph.D.

**Curriculum**—Emphases are in apparel, design communication, interior design, and housing. Concentrated study in apparel includes the history, design, and aesthetics of clothing; museology; textile and apparel product analysis; and the social science aspects of textiles and apparel. Focus in design communication is on the design process and involves concentrations in design practice; color theory and technology; and the history of design and of the decorative arts. Concentrations in interior design focus on the application of the design elements to interior environments and includes aesthetics, energy consumption, and health and safety issues. Study in housing prepares students for careers in state and federal agencies, non-profit community organizations, and housing management and regulation. Concentrations include the analysis of designed environments and technology; policy and community development; and housing for special populations.

*Note*—In 1992, department course numbers were changed. The designators Dsgn, Hsg, and TexC were changed to DHA effective winter quarter 1994. Please contact the department for further information.

**Prerequisites for Admission**—Individuals must have adequate undergraduate education in the area of emphasis and background in the basic disciplines of art, social science, physical science, and biological science appropriate to the area of emphasis. Specific requirements may be obtained by contacting the director of graduate studies.

**Special Application Requirements**—Consult the director of graduate studies; scores from the Graduate Record Examination are required. Students are admitted each quarter.

**Degree Requirements**—For the master's degree, the minimum course credit requirement is 28 for Plan A and 40 for Plan B. For the Ph.D., the minimum course credit requirement is 57 credits.

Consult the director of graduate studies for further information. A final oral examination is required.

**Language Requirements**—Determined by the graduate faculty in the area of emphasis or the adviser in consultation with the student.

**For Further Information and Applications**—Contact the Director of Graduate Studies, Design, Housing, and Apparel, University of Minnesota, 240 McNeal Hall, 1985 Buford Avenue, St. Paul, MN 55108 (612/626-1219; fax 612/624-2750; e-mail dhagradingo@che2.che.umn.edu).

DHA 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

DHA 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

DHA 8888. Thesis Credits: Doctoral. (36 cr required)

### Design, Housing, and Apparel (DHA)

DHA 5101. Introduction to Design, Housing, and Apparel Research. (4 cr; prereq grad student or #) Goetz

DHA 5103. Field Study: National/International. (1-15 cr; prereq #)

DHA 5105. History of Visual Communication. (4 cr; prereq art history course) Martinson  
Technological, cultural, and aesthetic influences on graphic design.

DHA 5107. History of Decorative Arts: Textiles. (3 cr, \$Dsgn 5107, \$Dsgn 5507; prereq Arch 3411, Arch 3412 or ArH 1002 or #) Erickson  
Textiles from early civilization to 20th century. Design, materials, and techniques.

DHA 5109. History of Decorative Arts: Ceramics, Metal, and Glass. (3 cr, \$Dsgn 5109, \$Dsgn 5509; prereq Arch 3411, Arch 3412 or ArH 1002 or #) Blade  
Ceramics, metal, and glass from selected historical periods in a global context.

DHA 5112. History of European Furniture and Interiors. (3 cr, \$Dsgn 5112, \$Dsgn 5512; prereq Arch 3411, Arch 3412 or #) Erickson  
Furniture and interiors from ancient civilization through the 19th century.

DHA 5114. History of American Furniture and Interiors. (3 cr, \$Dsgn 5114, \$Dsgn 5514; prereq 5112 or Dsgn 5112 or #) Blade  
Styles of American interiors and furnishings from the 17th to the 20th century.

DHA 5115. Twentieth-Century Interiors and Furnishings. (3 cr, \$Dsgn 5115, \$Dsgn 5515; prereq 5114 or #) Erickson  
In-depth study from Victorian time to present.

DHA 5118. History of Costume: 19th and 20th Centuries. (4 cr, \$Dsgn 5118, \$Dsgn 5518; prereq 3117 or 3517 or #) DeLong  
Emphasis on American costume. Study of historic costumes from the Goldstein Gallery's costume collection.

DHA 5170. Special Topics in Design, Housing, and Apparel. (1-4 cr)  
In-depth investigation of single topic, announced in advance.

DHA 5180. Directed Study in Design, Housing, and Apparel. (1-4 cr per qtr [max 8], \$5280, \$5380, \$5480, \$5680; prereq #)  
Independent study under tutorial guidance.

DHA 5211. Issues and Trends in Textiles and Apparel. (3 cr, \$TexC 5211) Williams  
Needs of textile consumer; protection from deception and hazard; analysis of federal, state, and local legislation; voluntary standards; change mechanisms; business practices; and professional ethics.

DHA 5212. Clothing and Human Behavior. (4 cr, \$TexC 5212; prereq jr or sr or #) Eicher  
Clothing in relation to individual and group behavior patterns; personal and social meaning attributed to dress; conventions and standards influencing clothing choice and use.

DHA 5216. Textile and Apparel Consumer. (4 cr, \$TexC 5216, \$TexC 5662; prereq 3216 or 3621, AgEc 1101 or Econ 1101 or #) Williams  
Textile and clothing problems; effects of psychological dispositions, socioeconomic conditions, technology, and public/private policies.

DHA 5217. International Trade in Textiles and Apparel. (4 cr, \$TexC 5217, \$TexC 5685; prereq #) Williams  
Comparison of production, distribution, and consumption in United States and Europe. Effects of world trade on supply and distribution.

DHA 5218. Pattern Development III. (4 cr, \$TexC 3221; prereq 3218 or TexC 3218) LaBat  
Advanced problems in pattern manipulation and grading.

DHA 5231. Clothing Design Studio IV. (4 cr, \$Dsgn 5231, \$Dsgn 5541; prereq 3232, 5218, Dsgn 3232, Dsgn 5218) Amir-Fazli  
Advanced problems in draping and sketching. Pencil, crayon, and watercolor techniques. Studies and reports. Undergrads develop their senior line.

DHA 5232. Clothing Design Studio V. (4 cr, \$Dsgn 5232, \$Dsgn 5544; prereq 5231 or Dsgn 5231) Amir-Fazli  
Clothing design for mass production, including costing and lay-out.

DHA 5234. Clothing Design for Special Needs. (4 cr, \$Dsgn 5234; prereq 5231 or 5541, TexC 3216 or TexC 3621; offered alt yrs) Amir-Fazli, DeLong  
Experimental design concepts as they relate to special market segments: physical limitations, safety protection, energy consumption. Emphasizes integration of human needs, fabric character, and garment structure.

DHA 5241. Retail Promotion. (4 cr, \$TexC 3646, \$TexC 5241; prereq 1211 or TexC 1211, Mktg 3000) Johnson

Marketing communication theory, concepts, and research with in-depth treatment of elements of retail promotion mix: advertising, sales promotions, point-of-purchase communication, direct marketing.

DHA 5242. Managerial Decision Making. (4 cr, \$TexC 5242; prereq 3646 or 5241; offered alt yrs) Johnson

Decision making in retail situations, including merchandise planning and management of sales and human resources.

DHA 5254. Performance Evaluation: Fabrics and Garments. (5 cr, \$TexC 5254, \$TexC 5627; prereq 3216 or TexC 3216; offered alt yrs) LaBat  
Testing procedures, standards, and specifications used in designing and purchasing fabrics and garments. Application of test results to design and specification of garments.

DHA 5266. Ethnic Dress. (3 cr, \$TexC 5266, \$TexC 5668; prereq 3212 or 3661, Anth 1102, Soc 1001 or #: offered alt yrs) Eicher  
Sociocultural analysis of ethnic dress (apparel, accessories, and body modification) emphasizing cultural patterns of technology, aesthetics, ritual, morality, and symbolism. External and internal influences encouraging change.

DHA 5289. Problems in Design: Costume. (3-4 cr per qtr [max 12 cr], \$Dsgn 5289; prereq dsgn or hsg or apparel major)  
Independent study under tutorial guidance.

DHA 5323. Design Process: Drawing III. (4 cr; prereq 3323 or 3523 or #) Martinson  
Application of design principles to advanced drawing problems.

DHA 5325. Design Process: Two-Dimensional Design III. (4 cr; prereq 3325 or grad student; A-F only) Martinson  
Students complete design projects and examine design and visual perception research literature.

DHA 5328. Color and Design. (4 cr, \$Dsgn 5328, \$Dsgn 5528; prereq 1328 or 1528 or #) Martinson  
Color concepts and their application to design.

DHA 5331. Surface Fabric Design III. (4 cr, \$Dsgn 5331, \$Dsgn 5531; prereq 3331 or 3531, pass portfolio review, dsgn or hsg or apparel major)  
Designing in one special surface textile technique. Studio problems. Readings.

DHA 5332. Fiber Structure: Weaving II. (4 cr, \$5532; prereq 3332 or 3532; University College only)  
Advanced loom weaving; pattern weaves and color.

DHA 5334. Computer Applications to Design Problems II. (4 cr; prereq 3334 or #)  
Solving design problems primarily using Macintosh computers. Using software to combine images and print and explore color and desktop publishing.

DHA 5337. Fiber Structure Design: Quilting. (4 cr, \$5537; prereq pass design comm portfolio review; University College only)  
Applying color and design principles using patchwork and quilting techniques.

DHA 5350. Advanced Typographic Design. (4 cr; prereq 3350, 3351 or #)  
Layout, design, letterforms, and typefaces.

DHA 5384. Interactive Media. (4 cr; prereq 5334 or #)  
Solving design problems involving interactive media and computer programs. Using software to create interactive presentations primarily using Macintosh computers. Hypermedia, scripting, video and sound editing, animation, and digital output.

DHA 5461. Housing Management. (5 cr, \$Hsg 5461, \$Hsg 5861; prereq 1101, 3463 or #)  
Management of multiunit housing. Historical perspectives, current status of housing, management approaches, psychosocial impact of housing and community design, specific residential populations. Students conduct post-occupancy evaluation of housing complex.

DHA 5463. Housing Policy. (3 cr, \$Hsg 5463, \$Hsg 5863, \$PA 5611; prereq grad student or adult spec or 3463 or 3863) Goetz  
Role of American national, state, and local government in financing, control, taxation, and construction of housing.

DHA 5465. Housing in World Perspective I. (4 cr, \$Hsg 5465, \$Hsg 5865; prereq 3463 or 3863 or #)  
Social analysis of housing around world; emphasizes population, environment, and social organization of nations as contexts for national policy and for housing choices of households.

DHA 5467. Housing and the Social Environment. (4 cr, \$Hsg 5467, \$Hsg 5867; prereq 1101, 3463 or 5863 or #) Yust  
Housing choices of households; emphasis on special needs of the elderly, the disabled, minorities, large families, and female-headed households.

DHA 5481. Designed Environments for Aging. (4 cr, \$Hsg 5481, \$Hsg 5881; prereq 3463 or 3863 or Dsgn 1555 or Dsgn 1642 or #; offered alt yrs)  
Design of environments with potential to compensate for deficits in physical and mental functioning. Older adults and barrier-free, flexible, and responsive physical environments.

DHA 5482. The Family and Energy Issues. (3 cr, \$Hsg 5482, \$Hsg 5801; prereq 1400 or 1851, 1401 or 1801 or #; offered alt yrs) Yust  
Analysis of family behavior as it relates to energy use, impact of scarcity on quality of family functioning, family energy issues in future.

## GRADUATE PROGRAMS

DHA 5483. Housing Discrimination. (4 cr; prereq 3463 or #: A-F only; offered alt yrs) Goetz  
Causes, effects, and patterns of housing segregation and discrimination; public policies aimed at addressing problems.

DHA 5485. Homelessness. (5 cr, §Hsg 5485; offered alt yrs) Goetz  
Causes of homelessness in contemporary times; subpopulations among the homeless; public policies aimed at addressing the problem.

DHA 5612. Interior Design Research. (2 cr, §Dsgn 5575, §Dsgn 5612; prereq 3553 or 3643 or #) Guerin  
Examination and development of studies.

DHA 5634. Interior Design Codes and Environmental Issues. (3 cr; A-F only; offered alt yrs)  
Impact of environmental issues, legislation, and social awareness on designing for life safety, health, diverse populations, and earth's resources.

DHA 5644. Interior Design Studio IV. (6 cr, §5553; prereq 3643 or 3553, Δ; offered alt yrs)  
Solving design problems using an interdisciplinary team approach.

DHA 5645. Interior Design Studio V. (4 cr, §Dsgn 5552, §Dsgn 5645; prereq DHA 3216 or TexC 3621, DHA 3631 or Dsgn 3557, DHA 3633 or Dsgn 3548, DHA 3643 or Dsgn 3553, #) Erickson, Guerin  
Advanced problems related to residential spaces.

DHA 5646. Interior Design Studio VI. (4 cr, §Dsgn 5554, §Dsgn 5646; prereq DHA 3216 or TexC 3621, DHA 3631 or Dsgn 3557, DHA 3633 or Dsgn 3548, DHA 3643 or Dsgn 3553, #) Ginthner  
Advanced problems related to nonresidential spaces.

DHA 5647. Interior Design Thesis. (6 cr, §Dsgn 5555, §Dsgn 5647; prereq 5575 or 5612, 5552 or 5645, 5554 or 5646)  
Comprehensive independent project generated from research conducted in Dsgn 5612.

DHA 8101. Philosophy of Design and Human Interaction. (3 cr; prereq DHA grad student or #)  
Philosophical questions that arise when integrating content areas of design, housing, and apparel. Builds on interdisciplinary approaches to problem analysis of designed environment.

DHA 8102. Theoretical Orientations in Design, Housing, and Apparel. (4 cr; prereq 5101 or equiv, 8101 or #: offered alt yrs) Williams  
Development and current status of theoretical and practical knowledge. Intra- and interdisciplinary relations to philosophical perspectives and needs of practitioners in everyday settings.

DHA 8103. Advanced Research Methods in Design, Housing, and Apparel. (4 cr; prereq stats course)  
Developing skills in analysis and interpretation of data, application of theories in research, and reporting of results; using statistical packages.

DHA 8110. Design Education. (3 cr)  
Educational processes and methods, including studios, in design disciplines. Learning styles, criticism, evaluation, and curriculum development.

DHA 8111. Literature of Design. (3 cr) Guerin, Martinson  
Seminar focusing on visualization, creativity, and design method literature and student-generated issues.

DHA 8170. Special Topics in Design, Housing, and Apparel. (1-4 cr per qtr)  
In-depth investigation of specific topic, announced in advance.

DHA 8180. Directed Study in Design, Housing, and Apparel. (1-4 cr per qtr [max 8 cr]; prereq #)  
Independent study under tutorial guidance.

DHA 8181. Integrative Seminar. (1 cr)  
Ideas, issues, and trends in design, housing, and apparel.

DHA 8190. Readings in Design, Housing, and Apparel. (1-4 cr per qtr [max 8 cr]; prereq #)  
Independent study and review of books and periodicals useful for individual programs but not available in other courses.

DHA 8262. Literature of Dress I. (3 cr, §TexC 8662; offered alt yrs) Eicher, Johnson  
Orientation to classic historical readings; basis for key ideas.

DHA 8263. Literature of Dress II. (3 cr, §TexC 8663; offered alt yrs) Williams  
Orientation to contemporary readings; basis for key ideas.

DHA 8264. Innovation Theory and Analysis. (3 cr; prereq #: offered alt yrs) DeLong  
Theories and factors influencing adoption and diffusion of design products, including fashion. Methodologies used in analysis of the diffusion process.

DHA 8266. Aesthetic Concepts Related to Apparel Design. (3 cr, §TexC 8666; prereq 3217 or #: offered alt yrs) DeLong  
Comprehensive survey and application of theory to the analysis of clothing design. Development of a methodology for visual perceptual evaluation.

DHA 8268. Methodological Orientations in Clothing and Human Behavior. (4 cr, §TexC 8668; prereq 8267, HEEd 8300, HEEd 8305 or equiv or #: offered alt yrs) Williams  
Alternative methodological perspectives interrelated with theoretical streams in clothing and human behavior; orientation to knowledge use and evaluation in practical settings.

DHA 8323. Design Process: Drawing. (4 cr, §Dsgn 8523; prereq #) Martinson  
Drawing media as applied to design problems.

DHA 8325. Design Process: Two-Dimensional Design. (4 cr, §Dsgn 8525; prereq #) Martinson  
Experiments with principles of two-dimensional design; emphasis on alternative solutions to design problems.

DHA 8328. Design Process: Color. (1-4 cr, \$Dsgn 8528; prereq #: A-F only) Martinson  
Color concepts and their application to design.

DHA 8467. Housing Theory. (3 cr; prereq 5101, 5467 or #; offered alt yrs) Yust  
Theories applied to study of housing behavior of households.

DHA 8671. Interior Design Criticism and Theory. (3 cr; A-F only)  
Design theories examined to establish framework for criticism. Field investigation in Twin Cities to develop critical inquiry methods.

DHA 8676. Environmental Studies in Interior Design. (4 cr, \$Dsgn 8556; prereq 6 cr interior design or #)  
Human needs as related to interior design.

## Human Ecology (HE)

HE 5003. Field Experience. (1-5 cr per qtr [max 15 cr]; prereq #) Yust  
Directed preprofessional work experience in home economics position in business or industry, government, or other appropriate organization.

HE 5130. Independent Study in Home Economics. (1-5 cr [max 16 cr]; prereq #) Yust

## Development Studies and Social Change (DSSC)

*Regents' Professor:* Vernon W. Ruttan (agricultural and applied economics)

*Professor:* Raymond D. Duvall (political science), *director of graduate studies*; Ronald R. Aminzade (sociology); Vernon B. Cardwell (agronomy and plant genetics); William P. Cunningham (genetics and cell biology); Allen F. Isaacman (history); Robert T. Kudrle (public affairs); Philip W. Porter (geography); David R. Roediger (history); Eric S. Sheppard (geography); Anthony M. Starfield (ecology, evolution, and behavior)

*Associate Professor:* Jean Allman (history); Lisa J. Disch (political science); Susan N. G. Geiger (women's studies); Amy K. Kaminsky (women's studies); Anne R. D. Kapuscinski (fisheries and wildlife); Daniel R. Kelliher (political science); John W. Mowitz (cultural studies and comparative literature); August H. Nimtz, Jr. (political science); Joanna O'Connell (Spanish and Portuguese); Abdi I. Samatar (geography); Kathryn A. Sikkink (political science); Ann B. Waltner (history); John S. Wright (Afro-American and African studies)

*Assistant Professor:* Ragui Assaad (public affairs); Jeffrey P. Broadbent (sociology); Leola A. Johnson (American studies); Lisette E. Josephides (anthropology); Deborah Levison (public affairs); Jennifer L. Pierce (sociology); Charles Ben Pike (Afro-American and African studies)

**Course of Study**—Minor in development studies and social change, applicable to doctoral programs only.

**Curriculum**—A structured interdisciplinary graduate minor in development studies and social change is offered in conjunction with the MacArthur Interdisciplinary Program on Peace and International Cooperation. The minor program focuses on three major areas: 1) the relationships between macroscopic processes of political, economic, and social change, and the microscopic conditions of lived experience in the developing world; 2) specifically interdisciplinary perspectives (encompassing the social sciences, the biological sciences, and the humanities) on this general thematic concern; and 3) preparation of doctoral students for field research in the developing world.

**Prerequisites for Admission**—Admission to the graduate minor in development studies and social change is contingent upon prior admission to a doctoral degree-granting program within the Graduate School and upon affiliation with the MacArthur Program.

**Special Application Requirements**—Students enrolled in a doctoral degree-granting program may apply for the minor at any time during the academic year; acceptance will take effect the following term.

**Minor Requirements**—A sequence of three core seminars in development studies and social change (totaling ten credits) is required. In addition, students take two or three courses (totaling eight credits) chosen from an approved list, from across the Graduate School curriculum, which are relevant to the field of development studies and social change.

**Language Requirements**—None specific to the minor program.

**For Further Information and Applications**—Contact the MacArthur Interdisciplinary Program on Peace and International Cooperation, University of Minnesota, 260 Social Sciences Building, 267 19th Avenue South, Minneapolis, MN 55455 (612/624-0832; fax 612/626-2242; e-mail macarth@tc.umn.edu).

DSSC 8110s. Approaches to Knowledge and Truth: Defining Ways of Knowing in Development Studies and Social Change. (3 cr; prereq DSSC minor student or #)  
Approaches as practiced by physical, biological, and social scientists and scholars in the humanities. "Ways of knowing" as practiced in different cultures or by different groups within cultures. Team taught by faculty from biological and social sciences and the humanities.

DSSC 8210-8211-8212. Field Research Methodology in Development Studies and Social Change. (1 cr per qtr; prereq DSSC minor student or #)

Identification of potential funding sources for field research and the writing of grant proposals. Preparing for and conducting field research. Students take this course during the year before undertaking field research, typically the third year of graduate study.

DSSC 8310F, 8311w. Topics in Development Studies and Social Change. (2 cr per qtr; prereq DSSC minor student or #)

Offered in conjunction with MacArthur Program on Peace and International Cooperation workshop series.

## East Asian Languages, Literatures, and Linguistics

*Professor:* Yu-shih Chen (Chinese); Chun-Jo Liu (*emeritus*: Chinese); Richard B. Mather (*emeritus*: Chinese); Stephen S. Wang (Chinese)

*Associate Professor:* Polly E. Szatrowski (Japanese), Ann B. Waltner (Chinese; history)

*Assistant Professor:* Sarah Jane Pradt (Japanese)

*Lecturer:* Hong Li (Chinese)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Chinese: M.A. (Plan A and Plan B) and Ph.D. Japanese: M.A. (Plan A and Plan B) and Ph.D. See also East Asian Studies following this listing.

**Curriculum**—*Chinese:* Two areas of concentration are available—literature and linguistics. Programs may include courses from both of these areas, but must minimally fulfill the core requirements for one of them, as determined in consultation with the student's adviser. Areas of subspecialty in the literature concentration include medieval, early modern, and 20th century. Areas of subspecialty in Chinese linguistics include aspects of synchronic and diachronic studies of Chinese.

*Japanese:* Two areas of concentration are available—literature and linguistics. Programs may include courses from both of these areas, but must minimally fulfill the core requirements for one of them, as determined in consultation with the student's adviser. Areas of subspecialty in the literature concentration include medieval, Tokugawa, modern and contemporary, modern drama, and modern

literary theory and criticism. Areas of subspecialty in the linguistics concentration include aspects of the phonology, syntax, semantics, discourse structure, pragmatics, and history of Japanese.

**Prerequisites for Admission**—Normally, an undergraduate major in Chinese or Japanese is the prerequisite for graduate studies. Students from other academic areas may be admitted with the provision that prerequisite coursework be made up after admission.

**Special Application Requirements**—Three letters of recommendation and a statement of purpose should be submitted to the department. Graduate Record Examination General Test scores (verbal and quantitative sections) are required; a minimum score of 550 on the Test of English as a Foreign Language (TOEFL) is required for applicants whose native language is not English. Students normally are admitted in fall quarter of each academic year. To be considered for financial aid, completed applications must be received by the first week of January.

**Master's Degree Requirements**—A complete list of degree requirements may be obtained from the director of graduate studies. A final oral examination is required.

**Doctoral Degree Requirements**—Programs are designed by the student and the adviser, with approval from the director of graduate studies, to provide a coherent course of study in an area of concentration. A complete list of requirements may be obtained from the director of graduate studies.

**Language Requirements**—For the M.A., students are expected to have research competence in Chinese or Japanese. For the Ph.D., students are also required to complete, or demonstrate by examination an ability equivalent to, two years of Chinese or Japanese language study (whichever language is not the chosen area of concentration); they must also demonstrate a reading knowledge in one of the following: French, German, or Russian (which may be fulfilled by passing the Graduation Reading Proficiency Test offered by the relevant language program at the University of Minnesota).

**Minor Requirements for Students Majoring in Other Fields**—A description of minor requirements in Chinese or Japanese is available from the director of graduate studies.

**For Further Information and Applications**—Contact the Department of East Asian Languages, Literatures, and Linguistics, University of Minnesota, 192 Klæber Court, 320 16th Avenue S.E., Minneapolis, MN 55455 (612/624-3331).

Chn 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Chn 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Chn 8888. Thesis Credits: Doctoral. (36 cr required)

Jpn 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Jpn 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Jpn 8888. Thesis Credits: Doctoral. (36 cr required)

## Chinese (Chn)

Chn 5041-5042-5043. Third-Year Modern Chinese. (4 cr per qtr, §3041, §3042, §3043; prereq 3023 for 5041, 3031 for 5042, 3042 for 5043)  
*5041*: Reading and analysis of 20th century texts. *5042-5043*: Reading and analysis of vernacular texts.

Chn 5051, 5052. Advanced Chinese Conversation and Composition. (4 cr per qtr, §3051, §3052; prereq 3023 or #)  
To perfect conversation and pronunciation; to advance competence in grammar by exercises in composition and translation from English into Chinese. Additional work beyond that required for 3051, 3052.

Chn 5101. Contemporary Chinese Writing. (4 cr; prereq 3041)  
Reading, translation, and discussion of representative works of Chinese authors since 1976.

Chn 5102. Readings in Modern Chinese Fiction. (4 cr; prereq 3041)  
Reading and analysis of selected short fiction from 1918 to the present day.

Chn 5103. Pre-Modern Prose. (4 cr; prereq 3031, 3041)  
Reading of representative Chinese texts of pre-modern periods.

Chn 5105. Readings in Chinese Vernacular Fiction. (4 cr; prereq 3041)  
Selections from great works of traditional fiction including short stories and novels such as *Journey to the West* and *Dream of the Red Chamber*.

Chn 5165. History of Chinese Literature. (4 cr; prereq 3033, 3043)  
Survey of major Chinese literary movements from emergence of early Confucian canon to May 4th movement in 1919.

Chn 5251. Structure of Standard Chinese. (4 cr; prereq 1013)  
Introduction to phonological and syntactic structures of modern standard Chinese.

Chn 5252. History of the Chinese Language. (4 cr; prereq 3031, Ling 3601 recommended)  
Survey using both traditional native philological sources as well as modern dialectal evidences.

Chn 5451, 5452. Studies in Chinese Linguistics. (4 cr per qtr; prereq jr or #)  
Topic for each quarter chosen in advance, in consideration of students' interests, from the following: syntax of modern standard Chinese, Chinese dialectology, Chinese historical phonology, grammar of classical Chinese.

Chn 5460. Topics in Chinese Literature. (4 cr per qtr [max 12 cr])  
Reading and discussion of selected texts from all periods of Chinese civilization and from all genres—poetic, expository, narrative, or dramatic. Topics announced in advance.

Chn 5704. Early Chinese Poetry. (4 cr; prereq 5165 or #)  
Reading and analysis of selected major poets and poetic forms from first anthologies through twelfth century.

Chn 5705. Chinese Fiction in the Ming and Qing. (4 cr; prereq 3033, 3043)  
Contextual readings of traditional fiction, including short stories and novels such as *Journey to the West* and *Dream of the Red Chamber*.

Chn 5706. Chinese Philosophical/Historical Texts. (4 cr; prereq 3033, 3043)  
Major texts in Chinese philosophy and historical tradition; Confucian/Buddhist/Taoist and other canonical writings; selections from Dynastic histories.

Chn 5970. Directed Studies. (1-4 cr; prereq #, Δ, CLA approval)  
Guided individual reading for study.

Chn 8650. Seminar: Chinese Linguistics. (4 cr; prereq 5451 or 5452)

Chn 8660. Seminar: Vernacular Chinese Literature. (4 cr; prereq 5472, 5990 or #)  
Consult Class Schedule for topics to be discussed during any given year.

## Japanese (Jpn)

Jpn 5042. Classical Japanese. (5 cr; prereq 3033)  
Masterpieces of Japanese literature in classical language grammatical construction.

Jpn 5051-5052-5053. Advanced Japanese Conversation and Composition. (4 cr per qtr, §3051-3052-3053; prereq 3033 or #)  
Verbal expression, oral and written; grammar review; idioms and nuances; short compositions, correspondence.

Jpn 5061f-5062w-5063s. Social Science Readings. (4 cr; prereq 3053, 5051, 5052, 5053 or #)  
Advanced Japanese reading, discussion, and writing on topics related to newspaper/magazine articles and social science texts.

Jpn 5071f-5072w-5073s. Communication for Japan-Oriented Careers. (4 cr; prereq 3053, 5051, 5052, 5053 or #)  
Effective communication using spoken Japanese in contexts likely to be encountered by a career-oriented professional in Japan.

Jpn 5166. Literature by 20th-Century Japanese Women. (4 cr; prereq 3033 for Japanese majors, previous work in lit and feminist theory or #)  
Analysis of fiction and nonfiction writings by 20th-century Japanese women.

Jpn 5251. History of Japanese Language. (4 cr; prereq 3033, 5451 or #)  
Development of Japanese grammar from classical to modern language.

Jpn 5361, 5362. Readings in Modern Japanese Literature I. (4 cr per qtr; prereq 3031)  
Works of traditionalist and aestheticist authors of 19th- and 20th-century Japan.

Jpn 5451. Structure of Japanese—Syntax/Semantics. (4 cr; prereq 3023, Ling 3001 or #)  
Structure and meaning of Japanese sentence patterns.

Jpn 5452. Structure of Japanese—Phonology/Morphology. (4 cr; prereq 3023, Ling 3001 or #)  
Generative and nongenerative approaches to Japanese sound and word structure.

Jpn 5453. Structure of Japanese Discourse/Conversational Analysis. (4 cr; prereq 3023, Ling 3001 or #)  
Emergence of grammar in discourse; discourse/conversational structural units, patterns, genre, strategies, style, and sociolinguistic variables.

Jpn 5460. Topics in Japanese Literature. (4 cr; prereq 3033)  
Topics in context of culture and intellectual history.

Jpn 5650. Proseminar: Japanese Linguistics. (4 cr [max 12 cr]; prereq 5451 or #)  
Selected topics from the syntax, pragmatics, and lexicon of Japanese and/or comparative English/Japanese, with attention to contributions from Eastern and Western linguistic traditions.

Jpn 5970. Directed Studies in Japanese. (1-15 cr; prereq #, Δ, CLA approval)  
Individual study of selected texts with guidance of faculty member.

Jpn 8650. Seminar: Japanese Linguistics. (4 cr; prereq 5451, 5452 or #)  
Research in a selected topic from the syntax, pragmatics, lexicon, or history of Japanese language; emphasis on gathering and analysis of primary data.

Jpn 8960. Seminar in Japanese Literature (Classical). (4 cr; prereq Δ)  
Intensive study of particular authors or works within the total range of the classical Japanese written literary tradition.

## East Asian Studies

*Professor:* Edward L. Farmer (history), *director of graduate studies;* Mei-ling Hsu (geography); Chin-Chuan Lee (journalism and mass communication); Byron K. Marshall (history); Robert J. Poor (art history)

*Associate Professor:* Alan L. Kagan (music); Daniel Kelliher (political science); Ann B. Waltner (history)

*Assistant Professor:* Jeffrey P. Broadbent (sociology)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—East Asian Studies: M.A. (Plan A and Plan B). See also East Asian Languages, Literatures, and Linguistics.

**Curriculum**—The East Asian Studies master's program is interdisciplinary, and the student may formulate an individualized program concentration.

**Prerequisites for Admission**—Ideally, an applicant's background should include undergraduate study in fields related to East Asia or East Asian languages. Students from other academic areas may be admitted, however, with the provision that prerequisite coursework be made up after admission.

**Special Application Requirements**—Three letters of recommendation and statement of purpose should be submitted to the department. Graduate Record Examination General Test scores are required. Students are admitted each quarter.

**Master's Degree Requirements**—A complete list of degree requirements and applicable courses may be obtained from the director of graduate studies. Coursework pertaining to East Asia taken outside of East Asian studies may be applied toward the degree. A final oral examination is required.

**Language Requirements**—Three years of training in Chinese or Japanese (or an equivalent or greater competency) is required.

**Minor Requirements for Students Majoring in Other Fields**—A description of minor requirements in East Asian studies is available from the director of graduate studies.

**For Further Information and Applications**—Contact East Asian Studies, Area Studies Programs, University of Minnesota, 214 Social Sciences Building, 267 19th Avenue South, Minneapolis, MN 55455 (612/624-8543).

EAS 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

### Area Studies (Area)

Area 5910. Topics in East Asian Studies. (2-4 cr)

Area 5970. Directed Studies. (1-15 cr per qtr; prereq #, Δ, □)  
Tutorial for qualified seniors and graduate students.

Area 5990. Directed Research. (1-15 cr per qtr; prereq #, Δ, □)  
Tutorial for qualified seniors and graduate students.

### East Asian Studies (EAS)

EAS 8061. Scope and Methods of East Asian Studies. (4 cr)  
Introduction to subfields, problems, and methodologies involved in study of East Asia as a world area.

### Ecology (EEB)

*Regents' Professor:* Margaret B. Davis; Eville Gorham; Herbert E. Wright, Jr. (*emeritus*)

*Professor:* Patrice A. Morrow, *head*; Edward J. Cushing, *director of graduate studies*; Franklin H. Barnwell; Elmer C. Birney; Patrick L. Brezonik; Yosef Cohen; Kendall W. Corbin; James W. Curtsinger; David F. Grigal; Kerry R. Kelts; Scott M. Lanyon; D. Frank McKinney; Donald C. McNaught; L. David Mech; Robert O. Megard; Jean-Alex E. Molina; Craig Packer; Richard E. Phillips; Anne E. Pusey; Philip J. Regal; Peter B. Reich; Michael J. Sadowsky; William D. Schmid; Michael J. Simmons; Donald B. Siniiff; Anthony M. Starfield; John R. Tester; G. David Tilman; Melbourne C. Whiteside<sup>1</sup>

*Associate Professor:* Donald N. Alstad; David A. Andow; John H. Beatty; Glenn R. Furnier; Linda L. Kinkel; Ruth G. Shaw; Peter W. Sorensen; Robert W. Sterner; Robert M. Zink

*Assistant Professor:* Georgiana May; Shahid Naeem

*Adjunct Assistant Professor:* Johannes M. H. Knops; John Pastor<sup>1</sup>

*Research Associate:* Karen S. Oberhauser

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Activity centers on the biology of organisms: how they interact in social groups, populations, and communities, and how those interactions have influenced the distribution of organisms in space and time. The program provides broad training across the general areas of ecology, evolution, and animal behavior, with opportunities for more specialized courses and research in behavior, evolution, population genetics, population ecology, community ecology, ecosystem ecology, and paleoecology. Opportunities exist for field research in various parts of the world as well as in local habitats. Seminars and tutorials constitute an important part of all student programs.

**Prerequisites for Admission**—Incoming graduate students are ordinarily expected to have completed coursework in inorganic chemistry, organic chemistry, and general physics; one year of college calculus; and at least one course each in animal biology, plant biology, genetics, biochemistry, and physiology. Proficiency in a foreign language is recommended. Deficiencies must be made up early in the graduate program.

**Special Application Requirements**—Students are admitted only in fall quarter. Deadline for application is January 7; earlier application is encouraged for individuals seeking financial aid. Three letters of recommendation evaluating the applicant's scholarship are required, plus Graduate Record Examination scores (including the Subject Test). Successful applicants are encouraged to participate in the Lake Itasca Biology Session during the summer before their first quarter in residence.

**Master's Degree Requirements**—Plan A requires a minimum of 20 course credits in the major, a minimum of 8 course credits in one or more related fields outside the major, and 16 thesis credits. Plan B requires the same minimum course credits as for Plan A for the major and related field(s), plus 16 additional course credits and one to three research papers, which may be written in conjunction with

<sup>1</sup> University of Minnesota, Duluth

graduate courses. Significant field experience and competence in statistics, to include hypothesis testing, regression, and correlation, are required. Degree programs are planned by the student and an advisory committee of three faculty to meet the student's interests and needs. The final examination is oral.

**Doctoral Degree Requirements**—Students are expected to acquire knowledge in four areas—behavior, evolution, population and community ecology, and ecosystem ecology—through courses, seminars, and directed study. No minimum number of credits is required for the major, but at least 18 course credits are required for either a minor in another field or a supporting program in several relevant fields. Significant field experience, proficiency in using computers in research, and competence in statistics, including experimental design, are required. Degree programs are planned by the student and an advisory committee of three to five faculty.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—For master's students, a minimum of 9 credits is required for a minor in ecology; for doctoral students, a minimum of 18 credits, distributed among several of the four areas listed under Doctoral Degree Requirements, is required.

**For Further Information and Applications**—Contact the Department of Ecology, Evolution, and Behavior, University of Minnesota, 100 Ecology Building, 1987 Upper Buford Circle, St. Paul, MN 55108 (612/625-5700; fax 612/624-6777; e-mail [talston@biosci.cbs.umn.edu](mailto:talston@biosci.cbs.umn.edu); [http://biosci.cbs.umn.edu/eeb/ecol\\_grad](http://biosci.cbs.umn.edu/eeb/ecol_grad)).

EEB 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

EEB 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

EEB 8888. Thesis Credits: Doctoral. (36 cr required)

### Community Ecology and Paleoecology

EEB 5002. Ecology of Minnesota. (3 cr; prereq college-level biology course or #) Tester  
Analysis of physical environment and of past and present ecosystems in Minnesota; influence of human activities on these ecosystems; future ecology of the state.

EEB 5004. Earth System: Geosphere/Biosphere Interactions. (4 cr, §Geo 5631; prereq Geo 3202, 3301 or #) Davis, Kelts  
Interdisciplinary study of mechanisms, feedbacks, and dynamics that force global change on various time scales, using paleorecord to illustrate processes.

EEB 5008. Quaternary Ecology. (4 cr; prereq Biol 5041 or Biol 5841 or #) Cushing, Davis  
Impact of changes in physical and biological environment during Quaternary period on plants and animals. Evolutionary rates, geographical distributions, community composition, and fluctuations in population sizes. Prehistoric human culture and ecosystem-level changes recorded in sedimentary sequences. Recent climatic changes. Principles of analysis, methods of investigation, and interpretation.

EEB 5014. Ecology of Vegetation. (5 cr; prereq Biol 5041 or Biol 5841, 1 qtr statistics or #) Cushing  
Methods of describing, sampling, and classifying vegetation; spatial and temporal variation of vegetation on landscapes; theory of structure and dynamics of plant communities. Field trips to examine local vegetation types; analysis of quantitative data.

EEB 5016. Ecological Plant Geography. (5 cr; prereq Biol 5041 or Biol 5841, PBio 3201 or #) Cushing  
Vegetation regions of the world in general and North America in detail; ecological principles of plant distribution; interpretation of regional and temporal patterns in the distribution of vegetation and taxonomic groups. Field trips to floristic regions of Minnesota.

EEB 8410. Community Ecology Seminar. (1 cr; prereq #)  
Reading and discussion of recent literature on community ecology.

### Population and Evolutionary Biology

EEB 5034. Population Genetics. (3 cr; prereq basic genetics, 1 qtr calculus, familiarity with computer programming) Curtsinger  
Introduction to genetic basis of evolutionary change, including basic population genetics theory, techniques for Monte Carlo simulation of genetic evolution, and important papers in literature of experimental population genetics.

EEB 5042. Quantitative Genetics. (4 cr; prereq Biol 5003 or GCB 3022, course in statistics or #) Shaw  
Genetic basis of variation in traits that are continuous, rather than discrete, in distribution and that are influenced by numerous genes, as well as environment. Assessing genetic variance and heritability of traits in populations. Predicting response to selection.

EEB 5044. Evolution. (4 cr; prereq Biol 1106 or Biol 3011, Biol 1103 or Biol 3012) Regal  
Evidence for and causes of biological evolution.

EEB 5051. Analysis of Populations. (4 cr; prereq Biol 5041 or Biol 5841 or #; offered alt yrs) Siniff  
Factors in regulation, growth, and general dynamics of populations. Data needed to describe populations, population growth, population models, and regulatory mechanisms.

**EEB 5052. Theoretical Population Ecology.** (5 cr; prereq Biol 5041 or Biol 5841 or #; offered alt yrs) Tilman

Models of growth and regulation of single populations; models of interactions between populations, including competition, predation, mutualism; assumptions and rationales of models and their predictions for dynamics, stability, and diversity of communities.

**EEB 5064. The Process of Evolution.** (4 cr; prereq Biol 5041 or Biol 5841 or #) Alstad  
Introduction to mechanistic bases of evolution, including causes and consequences of natural selection, stochastic consequences of Mendelian segregation, and their combined influences on structure of natural and captive populations. Includes lab exercises based on "Populus" computer simulation software.

**EEB 8400. Population Biology Seminar.** (1 cr; prereq #)  
Reading and discussion of recent literature on biology of plant and animal populations.

**EEB 8430. Evolutionary Genetics Seminar.** (3 cr; prereq 5063 or GCB 5033 or #; offered alt yrs) Curtsinger  
Reading and discussion of recent literature in evolutionary biology that has genetic component.

## Organismal Biology and Physiological Ecology

**EEB 5122. Plant/Animal Interactions.** (4 cr; prereq Biol 1106 or Biol 3011, Biol 1103 or Biol 3012, 10 cr biological sciences or #) Morrow  
Herbivory, pollination, seed dispersal. Implications of interaction for plants and animals at organismal, population, and community levels. Coevolution.

**EEB 5129. Mammalogy.** (5 cr, \$FW 5129; prereq Biol 1106 or Biol 3011 or #) Birney  
Recent families and orders of mammals of the world and of genera and species of mammals of North America, with emphasis on morphology, evolution, and zoogeographic history.

**EEB 5134. Introduction to Ornithology.** (5 cr; prereq Biol 1106 or Biol 3011) Zink  
Lab and field course in structure, classification, distribution, migration, habits, habitats, and identification of birds. Weekend trips scheduled.

**EEB 5136. Ichthyology.** (4 cr; prereq 15 cr incl Biol 1106 or Biol 3011)  
Biology of fishes including development, systematics, anatomy, physiology, and ecology.

**EEB 5156. Comparative Animal Physiology.** (3 cr; prereq Biol 1106 or Biol 1806 or Biol 3011, Chem 3302 or #) Schmid  
The environment imposes passive stresses upon organisms—not equilibrium; various physiological adaptations allow maintenance of homeostasis. Introduction to the passive organism; environmental stresses and biological mechanisms by which they are counteracted.

**EEB 5157. Animal Physiology Laboratory.** (3 cr; prereq 5156 or 5323 or AnSc 3301 or Biol 3011 or Biol 3111 or Ent 5030 or FW 5459 or GCB 5114 or ¶5156 or ¶5323 or ¶AnSc 3301 or ¶Biol 3011 or ¶Biol 3111 or ¶Ent 5030 or ¶FW 5459 or ¶GCB 5114 or #) Phillips, Schmid

Basic physiological processes in animals; using computerized equipment and techniques to record and analyze bioelectric events, transduction of force and displacement into electrical signals, respirometry, spectrophotometry. Independent or team research projects.

**EEB 8162w. Winter Ecology.** (2 cr; prereq #; offered alt yrs) Schmid  
Seminar on characteristics of subnivean environment and adaptations by plants and animals to winter environments. Includes weekend fieldwork.

## Behavior

**EEB 5321. Evolution of Social Behavior.** (4 cr; prereq Biol 1106 or Biol 3011 or #) McKinney  
Introduction to current theories and concepts relating to mating systems, spacing systems, and cooperative behavior in animals.

**EEB 5323. Mechanisms of Behavior.** (3 cr; prereq 3111 or Biol 3011 or #; offered alt yrs) Phillips  
Neural and hormonal mechanisms that mediate adaptive behavior in invertebrate and vertebrate animals, using series of well-studied examples to illustrate general principles.

**EEB 5324. Evolution of Primate Social Behavior.** (3 cr; prereq 3111 or #) Pusey  
Ecological factors that influence variation in demography, social structure, and social behavior of non-human primates. Application of current evolutionary theory (e.g., kin selection, reciprocity) to understanding of social behavior.

**EEB 5325. Behavioral Ecology.** (4 cr; prereq 3111 or 5321 or Biol 5041 or Biol 5841 or #; offered alt yrs) Packer  
Evolutionary principles applied to study of aggressive competition, mating systems, cooperation, and parental investment. Optimization models used to examine foraging strategies, predator/prey interactions and territoriality. Evolution of sex, sexual selection, and dispersal.

**EEB 8061. Social Systems.** (3 cr; prereq 5321 or equiv, #; offered when feasible) McKinney

**EEB 8510. Behavioral Biology Seminar.** (1 cr; prereq #)  
Critical reading and discussion of recent literature in behavioral biology.

## Limnology and Ecosystem Ecology

**EEB 5601. Limnology.** (4 cr, \$Geo 5601; prereq Chem 1005 or #) Megard, Sterner  
Description and analysis of events in lakes, reservoirs, and ponds, beginning with their origins and progressing through their physics, chemistry, and biology. Interrelationships of these parameters, and effects of civilization on lakes.

## GRADUATE PROGRAMS

EEB 5607. Ecology of Animal Plankton. (5 cr; prereq 5601, Biol 5041 or Biol 5841 or #; offered when feasible) McNaught

EEB 5608. Ecosystems: Form and Function. (4 cr; prereq 5601 or Biol 5041 or Biol 5841 or equiv, advanced course in writing such as Comp 3015 or Comp 3027 or Comp 3033 or Comp 3085 or Rhet 3562) Gorham  
Nature and development of terrestrial, wetland, and aquatic ecosystems. Analysis of energy flow and element cycling in relation to environmental controls, self-regulation, natural and human disturbances.

EEB 5621. Limnology Laboratory. (2 cr, \$Geol 5621; prereq 5601 or Geol 5601 or #) Megard  
Principal techniques for obtaining information about environmental conditions in lakes and streams. Procedures for measuring abundance and population dynamics of aquatic organisms, especially plankton. Field instruments, sampling devices, chemical analyses, microscopy, and analysis of data. One Saturday field trip.

EEB 5652. Community and Ecosystem Processes. (4 cr; prereq 2 qtrs calculus, Biol 3041 or Biol 5041 or equiv, additional ecology course in populations or communities or ecosystems or #) Sterner  
Empirical and theoretical studies at interface between community and ecosystem studies. Species-based approaches focusing on population dynamics combined with energy- and material-flux-based approaches.

EEB 8602. Advanced Limnology. (3 cr, \$Geol 8602; prereq 5601 or Geol 5601 or equiv)  
Selected problems in limnology using current and classical literature. Term paper required.

### Courses Offered at Lake Itasca Forestry and Biological Station

*(In addition to courses listed below, Itasca offers special topic courses for 1 to 5 weeks during the summer. For information on these courses, contact the Itasca Biology Program through the Ecology and Behavioral Biology Department office.)*

EEB 5814su. Plant Community Ecology. (5 cr; prereq ecol course, Δ; limited to 20 students; offered annually)  
Communities represented in Itasca Park and vicinity, with emphasis on vegetation. Patterns of distribution of communities, interaction with environment, dynamic relationships. Methods of community description and analysis.

EEB 5817su. Vertebrate Ecology. (5 cr; prereq ecol course, Δ; limited to 20 students)  
Field studies on vertebrate populations and their relationships to local environments; habitat analysis and ecological research methods. Students work as team investigating factors influencing distribution and abundance of selected vertebrates in various habitats. Research-oriented course supplemented with lectures and field trips.

EEB 5834su. Field Ornithology. (5 cr; prereq general biol course including study of zoology, Δ; limited to 15 students)

Emphasis on breeding season, biology, and behavioral ecology of birds in Itasca State Park region. Field trips to variety of habitats to learn bird identification and to observe and practice techniques for conducting field studies. Lab sessions investigate family distinctions and species identification. Individual field projects.

EEB 5839su. Field Studies in Mammalogy. (5 cr; prereq college-level biol course including study of animals or #, Δ)  
Techniques used in study of small mammals. Lectures and field projects emphasizing identification, distributions, community interactions, copysiology, and population ecology.

EEB 5852. Ecological Genetics. (5 cr; prereq college-level course in general biol or genetics or #)  
Basic population and quantitative genetics; variation in natural populations; electrophoretic analysis of field samples; reconstructing phylogeny; genetic studies of population structure; introduction to mitochondrial DNA analysis.

### Directed Studies

EEB 5965. Decision Analysis. (4 cr; prereq conservation biol grad student or #) Starfield  
Use of decision analysis techniques and modeling to clarify issues in conservation biology; active-learning class.

EEB 5970. Directed Studies. (Cr ar; prereq #, Δ)

EEB 5990. Directed Research. (Cr ar; prereq #, Δ)  
Lab or field investigation of selected areas of research.

EEB 8390. Graduate Seminar. (Cr ar; prereq #)

EEB 8391. Advanced Work in Ecology and Behavioral Biology. (Cr ar; prereq #)  
Individual work in some special aspect of the area.

EEB 8990. Graduate Research. (Cr ar; prereq #)

*See the Related Courses section for descriptions of the following courses:*

Biol 5816. Field Biology Photography

Biol 5841. Ecology

Biol 5890. Research Problems at Itasca

### Economics (Econ)

*Regents' Professor:* John S. Chipman; Vernon W. Ruttan

*Professor:* Craig E. Swan, *chair*; Edward Foster, *director of graduate studies*; S. Rao Aiyagari; Beth E. Allen; Varadarajan V. Chari; Roger D. Feldman; John F. Geweke; Edward J. Green; James P. Houck; Leonid Hurwicz (*emeritus*); James S. Jordan; John H. Kareken; Michael P. Keane; Timothy J. Kehoe; Stephen F. LeRoy; Herbert D. Mohring (*emeritus*); Edward C. Prescott; Marcel K. Richter; G. Edward Schuh

*Associate Professor:* George D. Green; Thomas J. Holmes; Nobuhiro Kiyotaki; Andrew McLennan; Richard Rogerson; Jan Werner

*Assistant Professor:* Gautam Gowrisankaran; Yuichi Kitamura; Ellen McGrattan; Antonio Merlo; Lee E. Ohanian; James A. Schmitz; Warren E. Weber

*Other:* Harold L. Cole; Jose-Victor Rios-Rull; David E. Runkle; Simran Sahi

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Ph.D. and M.A. (Plan A and Plan B). Students are admitted only for the Ph.D.; the M.A. is an optional part of the Ph.D. program.

**Curriculum**—The department offers degree work in the following fields: economic theory; econometrics; economic development; financial economics; game theory; industrial organization; international economics; labor economics; mathematical economics; monetary economics; public economics.

**Prerequisites for Admission**—The general requirement is the capability to pursue Ph.D.-level work. Normally the student should have an undergraduate record from a recognized college that includes coursework in economic theory and mathematics (multivariate calculus and linear algebra).

**Special Application Requirements**—Scores from the Graduate Record Examination (GRE) and letters of recommendation must be submitted. Applicants desiring financial assistance should submit their applications, including a record of GRE scores and three letters of recommendation, to the director of graduate studies no later than December 15. Students are admitted in fall quarter only.

**Master's Degree Requirements**—For Plan A, a minimum of 28 course credits (not including thesis credits) is required. For Plan B, a minimum of 44 course credits overall is required, with 20 of these credits in economics and at least 8 credits in one or more related fields (or 9 credits in a single field for a minor).

**Doctoral Degree Requirements**—The program does not specify a minimum number of courses required for the major, but a minimum of 18 credits outside the major is required; these may include economics courses not included in the major.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—Master's students minoring in

economics must take a minimum of 9 credits. Doctoral students minoring in economics must take six 8xxx courses and pass preliminary written examinations. All courses must be approved by the director of graduate studies in economics.

**For Further Information and Applications**—Contact the Director of Graduate Studies, Department of Economics, University of Minnesota, 1035 Management & Economics, 271 19th Avenue South, Minneapolis, MN 55455 (612/625-6833; fax 612/624-0209; e-mail econodgs@atlas.socsci.umn.edu; <http://www.econ.umn.edu/~econodgs>).

Econ 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Econ 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Econ 8888. Thesis Credits: Doctoral. (36 cr required)

## General

Econ 5021. Economics, Ethics, and Economic Philosophy. (3-5 cr; prereq 1001, 1002 or equiv) Literature and the issues it raises; relation of ethics to economic organization, practice, and policy. Different economic philosophies; elements involved in formulation of an economic philosophy.

Econ 5041 (formerly 5421). The Prospective World Economy. (4 cr; prereq 3101 or 3105 or #; offered when feasible)

Econ 5960. Topics in Economics. (4 cr per qtr; prereq 3101, 3102, 3103 or equiv) Topics specified in *Class Schedule*.

Econ 5970. Readings in Economics. (Cr ar; prereq consent of adviser, #, Δ, CLA approval; offered when feasible)

Econ 8990. Individual Graduate Research. (Cr ar)

## Theory

Econ 5107H. Honors Course: Game Theory and Its Applications. (4 cr for grad students; prereq 3101, 3102, 3103 or equiv, Math 1251-1252, Math 1261 or equiv)

Introduction to games; normal and extensive form; wars of attrition; games of timing; bargaining applications in industrial organization, macroeconomics, and international economics.

Econ 5113. Introduction to Mathematical Economics. (4 cr; prereq 3101, 3102, 3103 or equiv, Math 1251-1252, Math 1261, Math 3251 or equiv) Development in mathematical terms of selected models of economic behavior. Topics selected to illustrate advantages of a mathematical formulation.

## GRADUATE PROGRAMS

Econ 5151. Elements of Economic Analysis: Firm and Household. (3 cr; prereq 3101 or equiv, 1 qtr linear algebra, 1 qtr calculus, grad student or #) Decision making by households and by firms under conditions of monopoly, competition, and monopolistic competition.

Econ 5152. Elements of Economic Analysis: Income and Employment. (3 cr; prereq 3101, 3102 or equiv, 1 qtr linear algebra, 1 qtr calculus, grad student or #) Determinants of national income, employment, and price level; aggregate consumption, investment and asset holding.

Econ 8001-8002-8003. Microeconomic Analysis. (4 cr per qtr; prereq 3101 or 5151 or equiv, 1 qtr multivariable calculus, 1 qtr linear algebra) Theories of consumer demand, producer supply, and market equilibrium; general equilibrium and welfare. 8003 may include topics such as externalities, economics of information and uncertainty, and game theory.

Econ 8101-8102-8103. Microeconomic Theory. (4 cr per qtr; prereq 3101 or 5151, Math 3142, Math 3211 or equiv) Decision problems faced by the household and firm; theories of choice under conditions of certainty and uncertainty. Partial equilibrium analysis of competition and monopoly. General equilibrium analysis. Welfare economics: economic efficiency of alternative market structures; social welfare functions. Dynamics: stability of markets, introduction to capital theory.

Econ 8104-8105-8106. Macroeconomic Theory. (4 cr per qtr; prereq 3102, Math 3142, Math 3211 or equiv) 8104: Dynamic general equilibrium models: solving for paths of interest rates, consumption, investment, and prices. 8105-8106: General equilibrium models with uncertainty, search, matching, indivisibilities, private information, etc. Implications of theory for measurement and data reporting. Overlapping generations and dynasty models with money and government. Variational and recursive methods.

Econ 8111-8112-8113. Introduction to Mathematical Economics. (3 cr per qtr; prereq ¶8101, Math 3142, Math 3211 or equiv, ¶Math 5612 or equiv for 8111; Math 5243 recommended) Use of mathematical models in economic theory; the more standard techniques developed in 8111 and 8112; 8113 may include special topics.

Econ 8117, 8118. Noncooperative Game Theory. (3 cr; prereq Math 5614 or equiv or #) Solution concepts for noncooperative games in normal form, including Nash and perfect equilibrium and stable sets of equilibria. Extensive form games of perfect and incomplete information, sequential equilibrium, and consequences of stability for extensive form. Applications including bargaining and auctions.

Econ 8119. Cooperative Game Theory. (3 cr; prereq 8101-8102-8103, Math 5614 or equiv or #) Allen Basics of cooperative game theory, emphasizing concepts used in economics. Games with and without transferable utility; the core, the value, and other solution concepts. Recent results, including potentials, reduced games, consistency, and noncooperative implementation of cooperative solution concepts.

Econ 8181-8182-8183. Advanced Topics in Microeconomics. (3 cr per qtr; prereq 8103; offered when feasible)

Econ 8184-8186. Advanced Topics in Macroeconomics. (3 cr per qtr; offered when feasible)

Econ 8192. Workshop in Mathematical Economics. (Cr ar) Written and oral presentations by Ph.D. students engaged in or planning to engage in thesis research in mathematical economics.

## Econometrics

Econ 5211. Principles of Econometrics. (4 cr, §3231, §5231; prereq 1101, 1102 or equiv, Stat 3011-3012 or equiv, 1 qtr calculus, familiarity with computers) Data analysis and quantitative methods in economics. Violation of classical regression model assumptions and consideration of modified estimation procedures that retain desirable properties; multiequation models. Computer applications and interpretation of empirical results.

Econ 5261f-5262w-5263s. Introduction to Econometrics. (5 cr per qtr; prereq 3101 or equiv, Math 1251-1252, Math 1261 or equiv, Stat 5121-5122 or Stat 5131-5132-5133 or #) Review of basic linear regression model and its variants; panel data, censored and truncated regression, discrete choice models, time series and simultaneous equation models.

Econ 8201f-8202w-8203s. Econometric Analysis. (4 cr per qtr; prereq 3101 or equiv, Math 1251-1252, Math 1261 or equiv, Stat 5121-5122 or Stat 5131-5132-5133 or #) Basic linear regression model and its variants; panel data, censored and truncated regression, discrete choice models; time series and simultaneous equation models.

Econ 8204f-8205w-8206s. Applied Econometrics. (3 cr per qtr; prereq ¶8101, ¶8104, Math 3252 or equiv, Math 5242 or equiv, ¶Stat 5131 or #) Application in research, including classical and Bayesian approaches; formulation, comparison, and use of models and hypotheses; inference and prediction in structural models; simulation methods.

Econ 8211-8212-8213. Econometrics. (3 cr per qtr; prereq 5151, 5152, Math 5243 or equiv, Stat 5133 or Stat 5122 or #) 8211: Linear regression. General linear hypotheses. Gauss Markov Theorem, generalized least squares and their applications. Decision-theoretic choice among estimators. 8212: Simultaneous equations models; identification and estimation. Asymptotic distribution theory. 8213: Asymptotic distribution theory for nonlinear models. Applications, including multivariate time series models and/or limited dependent variables models.

Econ 8281-8282. Advanced Topics in Econometrics. (3 cr per qtr; offered when feasible)

## Development

Econ 5301. Economic Development. (4 cr, \$5331; not open to economics majors; prereq 1101, 1102 or equiv) Problems of economic growth in low income countries. Theory of aggregate and per capita income growth. Role of population growth, productivity increases and capital formation. Allocation of resources between consumption and investment and among sectors. International assistance and trade.

Econ 5307. Comparative Economic Systems. (4 cr; not open to econ majors; prereq 1101, 1102 or equiv) Functions of economic systems; market economy vs. centrally planned economy. Post-socialist transitions in Eastern Europe and reforms in China. Initial conditions and strategy for reforms; results of reforms in terms of key economic indicators.

Econ 5311. Economy of Latin America. (4 cr, \$5341; not open to econ majors; prereq 1101, 1102 or equiv) Economic evolution in Latin America since 1950. Trade liberalization, poverty, inflation, and development strategies in selected countries. Theory and applications of important issues.

Econ 5312. Technology and Development. (4 cr; prereq 3101, 3102 or equiv or #) Economics of research development; technical change and productivity growth; impact of technology on institutions; science and technology policy.

Econ 5313. The Russian Economy. (4 cr; prereq 3101, 3102 or equiv) Soviet economic system and its development from 1917 to 1980s. Soviet Union collapse in 1991. Recent economic reforms adopted by Russia and other republics of the former Soviet Union.

Econ 5315. The Japanese Economy. (4 cr, \$3315; prereq 3101 or equiv; offered when feasible)

Econ 5331. Economic Development. (4 cr, \$5301; prereq 3101, 3102 or equiv) Problems of economic growth in low income countries. Theory of aggregate and per capita income growth. Role of population growth, productivity increases, and capital formation. Allocation of resources between consumption and investment and between sectors. International assistance and trade.

Econ 5337. Comparative Economic Systems. (4 cr, \$5307; prereq 3101, 3102 or equiv) Functions of economic systems; market economy vs. centrally planned economy. Post-socialist transitions in Eastern Europe and reforms in China. Initial conditions and strategy for reforms; results of reforms in terms of key economic indicators.

Econ 5341. Economy of Latin America. (4 cr, \$5311; prereq 3101, 3102 or #) Economic evolution in Latin America since 1950. Trade liberalization, poverty, inflation, and development strategies in selected countries. Theory and applications of important issues.

Econ 8311. Economic Growth and Development Theory. (3 cr; prereq 8103, 8105) Methods of analyzing dynamical systems; applying methods to new models of growth and development; deriving and evaluating models' quantitative implications in light of growth and development in a number of countries.

Econ 8312. Technology and Development. (3 cr; prereq 8103, 8105; offered when feasible)

## International Economics

Econ 5401. International Economics. (4 cr, \$5429, \$5431, \$5432; not open to econ majors; prereq 1101, 1102 or equiv) Explanation of trade patterns. Commercial policy, protection, factor mobility. Balance of payments, exchange rate determination, international monetary system.

Econ 5421. Economic Integration in the Americas. (4 cr; prereq 3101, 3102, 3103 or equiv or #) Kehoe  
Analysis of economic relationships among countries in Western Hemisphere. Modeling impact of the North American Free Trade Agreement and similar regional trade accords. Prospects for further integration.

Econ 5431. International Trade. (4 cr, \$5401, \$5429; prereq 3101, 3102, 3103 or equiv) Theories of trade and explanation of trade patterns. Trade restrictions and commercial policy. International factor movements. Economic growth and trade.

Econ 5431H. Honors Course: International Trade. (4 cr for grad students, \$5401; prereq 3101, 3102, 3103 or equiv, 1 qtr calculus; B avg recommended) For description, see Econ 5431.

Econ 5432. International Finance. (4 cr, \$5401; prereq 3101, 3102, 3103 or equiv; 5431 or equiv recommended) Balance of payments, foreign exchange market, exchange rate determination. International monetary system.

Econ 8401-8402-8403. International Trade and Payments Theory. (3 cr per qtr; prereq 8102, 8104) 8401: Impact of trade on factor rentals. Stolper-Samuelson, Rybczynski, and factor price equalization theorems. Heckscher-Ohlin theorem. Derivation of offer curves and general international equilibrium. Transfer problem. 8402: Tariffs, quotas, and other barriers to trade; gains from trade; trading blocs; increasing returns; growth. 8403: International business cycles; exchange rates; capital movements; international liquidity.

Econ 8483. Advanced Topics in International Trade Theory. (3 cr; prereq 8101, 8102, 8403 or equiv or #; offered when feasible)

Econ 8491-8492. Workshop in Trade and Development. (Cr ar)  
Written and oral presentations by Ph.D. students engaged in or planning to engage in thesis research in trade and development.

## GRADUATE PROGRAMS

### Labor

Econ 5531. Labor Economics. (4 cr, \$3501; prereq 3101, 3102 or equiv)

Role of labor in economy: labor as a factor of production; population and the labor force; economics of labor markets; labor market institutions; theories of wages and employment; unions and collective bargaining; public policy.

Econ 8501-8502. Wages and Employment. (3 cr per qtr; prereq 8101, 8104)

Economic analysis of labor markets and their operation under conditions of both individual and collective bargaining. Implications of labor market operations for resource allocation, wage and price stability, income and employment growth. Wage structures and wage levels. Wage and employment theories and practices. Economic impacts of unions.

Econ 8583. Advanced Topics in Labor Economics. (3 cr; offered when feasible)

### Industrial Organization

Econ 5611. Resource and Environmental Economics. (4 cr; prereq 3101 or equiv, 1 qtr calculus) Exhaustible resources and theory of optimal depletion. Renewable resources and theory of optimal use. Does resource scarcity limit growth? Natural resources and natural environments. Environmental pollution and economic efficiency.

Econ 5611H. Honors Course: Resource and Environmental Economics. (5 cr; prereq 3101 or equiv, 1 qtr calculus)

Exhaustible resources and theory of optimal depletion. Renewable resources and theory of optimal use. Does resource scarcity limit growth? Natural resources and natural environments. Environmental pollution and economic efficiency.

Econ 5621. Urban Economics. (4 cr; prereq 3101 or equiv)

Location of economic activity and of cities; central place theory; site rents and form of city; urban economic base and economic policy; urban problems and economic policies: transportation, poverty and segregation, housing, public finance.

Econ 5623. Housing Markets and Public Policy. (4 cr; prereq 1101, 1102 or equiv)

Analysis of housing markets. Market failures, externalities and the case for government intervention. Relative efficiency of particular forms of intervention.

Econ 5631. Industrial Organization and Antitrust Policy. (4 cr, \$3601; prereq 3103, 3103 or equiv)

Economic aspects of antitrust and related policies. Relations between market structure and economic efficiency and welfare. Economic origins of monopoly and other restraints on competition. Purposes and effects of antitrust and related legislation.

Econ 5631H. Honors Course: Industrial Organization and Antitrust Policy. (4 cr for grad students; prereq 3101, 3103 or equiv, 1 qtr calculus; B avg recommended)

For description, see 5631.

Econ 8601-8602-8603. Industrial Organization and Government Regulation. (3 cr per qtr; prereq 8101)

Behavior of businesses and industries: productivity, firm size distributions, exit-entry dynamics, etc. Theories of the firm, industry structure and performance, invention and innovation, and technology adoption. Positive and normative theories of regulation.

Econ 8683. Advanced Topics in Industrial Organization. (3 cr; offered when feasible)

### Money and Financial Economics

Econ 5701. Money, Banking, and Monetary Policy. (4 cr, \$3701, \$5761; not open to econ majors; prereq 1001, 1002 or equiv or #)

Economic role of financial institutions, with emphasis on commercial banks, money supply, and monetary policy.

Econ 5721. Money and Banking. (4 cr, \$5701; prereq 3101, 3102 or equiv; offered when feasible)

Econ 5721H. Honors Course: Money and Banking. (4 cr for grad students; prereq 3101, 3102 or equiv, 1 qtr calculus; B average recommended) For description, see 5721.

Econ 5731. Macroeconomic Policy. (4 cr; prereq 3101, 3102 or equiv)

Monetary vs. fiscal policy debate in context of underlying macroeconomic theory controversy. Comparison of Keynesian, Monetarist, and Classical theories; rational expectations; policy ineffectiveness; time inconsistency; rules vs. discretion; budget deficits; unemployment and inflation.

Econ 5731H. Honors Course: Macroeconomic Policy. (4 cr for grad students; prereq 3101, 3102 or equiv, 1 qtr calculus; B average recommended) For description, see 5731.

Econ 5733. Intertemporal Economics and Money. (4 cr; prereq 3101, 3103 or equiv, Math 1251-1252, Math 1261 or equiv)

Real intertemporal economics: overlapping-generations models of interest rates; applications of social security and deficit finance. Representative agent model, Ricardian Equivalence, introduction to neo-classical growth model.

Econ 5741. Business Cycles. (4 cr; prereq 3101, 3102, Stat 3011 or equiv)

Models of economic growth are developed and matched to U.S. data; review of business cycle facts; growth model is used to examine impact of changes in important growth factors, including public finance and technology and for business fluctuations.

Econ 5741H. Honors Course: Business Cycles. (4 cr for grad students; prereq 3101, 3102, Stat 3011 or equiv, 1 qtr calculus; B avg recommended)

For description, see 5741.

Econ 5752H. Honors Course: Financial Economics II. (4 cr for grad students, \$3752; prereq 3751; B avg recommended)

Efficiency of financial markets. Theoretical concepts and empirical evidence.

Econ 8701-8702-8703. Monetary Economics. (3 cr per qtr; prereq 8102, 8105)  
Economic role of principal financial institutions. Determinants of value of money. Principal problems of monetary policy.

Econ 8704-8705-8706. Financial Economics. (3 cr per qtr; prereq 8102, 8105)  
Role of financial institutions in efficient allocation of risk; multiperiod and continuous-time securities markets; theory of firm under uncertainty; financial intermediation; derivation of empirical asset-pricing relationships; tests concerning alternative market structures.

Econ 8781-8782. Advanced Topics in Monetary Economics. (3 cr per qtr; offered when feasible)

Econ 8793. Workshop in Macroeconomics. (Cr ar)  
Written and oral presentations by Ph.D. students engaged in or planning to engage in thesis research in macroeconomics.

## Public Finance

Econ 5821. Introduction to Public Economics. (4 cr, \$3801; prereq 3101, 3103 or equiv)  
Tax and expenditure policies, primarily at federal level. Impact of tax structure on distribution of income. Evaluation of public programs. Optimal mix of public and private sector output.

Econ 5831. Cost-Benefit Analysis. (4 cr; prereq 3101, 3103 or equiv)  
Principles for evaluation of benefits and costs of public projects or programs. Issues connected with definition and measurement of benefits and costs. Rate of return and rate of discount. Market imperfections, risk, and uncertainty.

Econ 5831H. Honors Course: Cost-Benefit Analysis. (4 cr for grad students; prereq 3101, 3103 or equiv, 1 qtr calculus; B avg recommended)  
For description, see 5831.

Econ 8801-8802-8803. Public Economics. (3 cr per qtr; prereq 8102, 8105)  
Theories of public choice and role of government in economy. Economic effects of taxes, public debt, and public expenditure. Current problems in economics of public sector, including local public economics.

Econ 8882-8883. Advanced Topics in Public Finance. (3 cr per qtr; offered when feasible)

## Education<sup>1</sup>

**Degrees Offered**—M.A., Ph.D., and Certificate of Specialist in Education.

**Curriculum**—The broad goal of graduate programs with a major in education is to develop, validate, and disseminate knowledge on educational theory and practice to improve the quality of education at all levels. The master's degree is offered with emphases in curriculum and instruction and in work, community, and family education. The doctoral degree is offered with emphases in curriculum and instruction (see Curriculum and Instruction for description); recreation, park, and leisure studies (see Kinesiology and Leisure Studies for description); and work, community, and family education (see Work, Community, and Family Education for description). The specialist certificate is offered with emphases in general curriculum supervision and mathematics education.

Please note that the Ph.D. thesis credit course entry for education is divided as follows into sections corresponding to the various emphases:

Educ 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Educ 8888. Thesis Credits: Doctoral. (36 cr required for Ph.D.)

- Section 1. Curriculum and Instruction
- Section 2. Work, Community, and Family Education
- Section 3. Recreation, Park, and Leisure Studies

*Note*—For other education-related degrees, see also Child Psychology; Curriculum and Instruction; Educational Policy and Administration; Educational Psychology; Kinesiology and Leisure Studies; and Work, Community, and Family Education.

## Educational Administration

See Educational Policy and Administration.

<sup>1</sup> *Advanced work leading to the professional degree of master of education (M.Ed.) is offered by the College of Education and Human Development in adult education; agricultural education; art education; business and marketing education; community education administration; curriculum and instructional systems; early childhood education; elementary education; family education; industrial education; mathematics education; music education; physical education; developmental/adapted physical education; recreation, park, and leisure studies; special education; work, community, and family education; and several secondary academic fields. Interested persons should consult the College of Education and Human Development Bulletin.*

## Educational Policy and Administration (EdPA)

*Professor:* Ayers Bagley, *director of graduate studies*; William M. Ammentorp<sup>1</sup>; Robert H. Bruininks<sup>1</sup>; John J. Cogan<sup>1</sup>; George H. Copa<sup>2</sup>; Glenn L. Hendricks; Vernon L. Hendrix<sup>1</sup>; Stephen A. Hoenack; Clifford P. Hooker<sup>1</sup> (*emeritus*); Dale L. Lange<sup>1</sup>; Darrell R. Lewis<sup>1</sup>; Karen Seashore Louis<sup>1</sup>; Marion Lundy-Dobbert; Tim L. Mazzoni<sup>1</sup>; Josef A. Mestenhauer<sup>1</sup>; Charles E. Moore<sup>1</sup>; Van D. Mueller<sup>1</sup>; Neal C. Nickerson<sup>1</sup>; James R. Rest; Charles H. Sederberg<sup>1</sup>; Robert D. Tennyson; Joyce Ann Walker<sup>2</sup>; Richard F. Weatherman<sup>1</sup>; W. Keith Wharton<sup>1</sup>; Kathleen M. Zurcher

*Associate Professor:* Gary F. Alkire<sup>1</sup>; Melissa S. Anderson; Arthur M. Harkins; Jean A. King<sup>1</sup>; Elaine L. Leach<sup>1</sup>; Theodore Lewis<sup>1</sup>; John M. McLaughlin<sup>1</sup>; Robert E. Orton; R. Michael Paige<sup>1</sup>; Thomas D. Peacock<sup>1,3</sup>; Barbara Pillingier<sup>1</sup>; Byron J. Schneider<sup>1</sup>; James R. Stone III<sup>1</sup>; Caroline S. Turner<sup>1</sup>

*Assistant Professor:* Jennifer York-Barr<sup>1</sup>

*Senior Fellow:* Richard B. Heydinger<sup>1</sup>; Dean Honetschlager<sup>1</sup>; Josie R. Johnson<sup>1</sup>

*Research Associate:* Darwin D. Hendel

*Lecturer:* Neil E. Christenson<sup>1</sup>; Timothy J. Delmont<sup>1</sup>; David R. Johnson<sup>1</sup>; Clark M. Kirkpatrick<sup>1</sup>; Gerald G. Mansergh<sup>2</sup>; Judee G. McMullen<sup>1</sup>; Bruce H. Miles<sup>2</sup>; Thomas F. Morgan<sup>1</sup>; Joseph H. Nathan<sup>1</sup>; Benjamin Ramirez-Shkwegnaabi<sup>2</sup>; Terry H. Schultz<sup>1</sup>; Barbara J. S. Shin<sup>1</sup>; Kyla L. Wahlstrom<sup>1</sup>

*Adjunct Lecturer:* Michael J. Lovett<sup>1</sup>

*Other:* Carol M. Boyer<sup>1</sup>; Gerald A. McIntosh<sup>1</sup>; David Murphy

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) in educational policy and administration; Ed.D. in educational administration; Ph.D. in educational policy and administration; Certificate of Specialist in Education in educational administration (admissions to the Certificate of Specialist program are on hold for 1996-99).

**Curriculum**—The Department of Educational Policy and Administration has recently reorganized to provide a more integrated and focused program for graduate studies. A single M.A. and Ph.D. degree program is offered with concentrations in educational administration, higher education, comparative and international

development education, and policy and evaluation studies. The department cooperates with other departments within the College of Education and Human Development and the University to offer individualized concentrations in areas such as youth policy and special education policy.

The master's degree ordinarily serves as a first step for students beginning graduate study in the field. The Ph.D. program emphasizes intensive and individualized study in one of the concentrations described above, and is especially appropriate for those who plan to pursue research, teaching, or leadership careers in the field of educational policy and administration. The Ed.D. program is particularly suitable for individuals interested in leadership careers in the operation of K-12 or two-year postsecondary institutions.

Free-standing minors are available in international education and in social and philosophical studies of education. See separate sections for each.

**Prerequisites for Admission**—Applicants must have completed appropriate undergraduate and graduate study. In some cases, where previous coursework or degrees are marginally related, otherwise qualified applicants will be asked to complete additional background courses after admission. Applications for doctoral studies are encouraged from individuals who may have completed master's programs in areas such as curriculum studies, public affairs, sociology, psychology, economics, political science, international relations, management science, measurement and statistics, and educational psychology. Opportunities are designed for mature/employed students as well as for those who wish to pursue graduate studies full time.

**Special Application Requirements**—Scores from the Graduate Record Examination (GRE), General Test only, are required from all applicants. Applicants must also submit a department application that includes a statement on background, interests, and goals, and two personal references.

**Master's Degree Requirements**—There is considerable flexibility in designing programs to meet individual circumstances, depending on the student's emphasis and career interests. A typical program includes 21 to 24 credits in the

<sup>1</sup> Also holds graduate faculty appointment in educational administration

<sup>2</sup> Advising role restricted to students pursuing the Ed.D. or Certificate of Specialist degree

<sup>3</sup> University of Minnesota, Duluth

area of emphasis, 8 to 10 credits in a related field, 6 to 9 credits in related methodology preparation, and 9 to 12 credits in electives or an optional internship. The final requirements for the Plan B program, which is recommended for most students, are an oral examination and a research paper. More specific information and sample course plans for each separate degree program are available from the department.

**Doctor of Education Degree Requirements—**

The doctorate of education consists of a major of at least 21 credits in the core curriculum, 12 credits in a research methodology sequence, 0 to 9 credits in an internship or clinical experience (depending on the previous professional experience of the applicant), and 12 to 21 credits in specializations (e.g., seminars, leadership courses, technical courses). Twenty-four credits are taken in supporting areas; typically at least 15 of these are taken from outside the College of Education and Human Development in areas that are appropriate for the study of administration. The preliminary written and oral examination requirements vary depending on the Ed.D. program. The final project is a research project that should contribute to the improvement of practice. Several specialized cohort programs are available or are under development; Ed.D. degrees are offered in leadership in two-year institutions, metropolitan school administration, and international education leadership.

**Doctor of Philosophy Degree**

**Requirements—**Students must take 18 credits in the department core curriculum. The various emphases also have common core requirements that range from 15 to 18 credits. A minimum of 18 credits is required in a research sequence that includes quantitative and qualitative methods. At least 18 credits are required in a minor or supporting program. All Ph.D. students take a preliminary written examination that covers the department core courses and the student’s area of emphasis, and an oral examination. The final dissertation is a research project that should contribute to the theory of educational policy or administration.

**Language Requirements—**None.

**For Further Information and Applications—**

Contact the Department of Educational Policy

and Administration, University of Minnesota, 330 Wulling Hall, 86 Pleasant Street S.E., Minneapolis, MN 55455 (612/624-1006; fax 612/624-3377).

EdAd 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

EdAd 8888. Thesis Credits: Doctoral. (36 cr required; EdD only)

EdPA 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

EdPA 8777. Thesis Credits: Master’s. (16 cr required; Plan A only)

EdPA 8888. Thesis Credits: Doctoral. (36 cr required; PhD only)

EdPA 5090. School and Society. (3 cr, \$3090, \$SPFE 5090; prereq foundations of educ student or sr or postbac student in educ or CLA music ed major or tchg major or □; cannot apply to tchr educ prog if taken correspondence; A-F only) Bagley, Harkins, King, Lange, Lewis, Lundy-Dobbert, Mueller  
Readings in social science and philosophy relevant to thinking about role of school in a changing American society.

EdPA 5099. Directed Study. (Cr ar [max 9 cr]; prereq #)  
Individual or group work on topics or problems in social and philosophical foundations of education.

EdPA 5101. Historical Foundations of Modern Education. (4 cr, \$3101, \$Hum 3101/5101) Bagley  
Analysis and interpretation of important elements in modern education derived from the Greeks, Romans, Middle Ages, Renaissance, Reformation, Enlightenment, and Industrial Revolution. Background course for all other courses in history and philosophy of education.

EdPA 5102. Education Imagery in Europe and America. (3 cr) Bagley  
Images and ideas of education expressed in the visual arts of Western civilization (antiquity to 20th century) in relation to concurrent educational thought and practice; symbolism, myth, propaganda, didacticism, genre, caricature.

EdPA 5103. Supervision and Administration of Special Education. (3 cr, \$EPsy 5660; prereq #)  
D Johnson  
Procedures in establishing and improving educational programs for exceptional children.

EdPA 5104. Interagency Cooperation for At-Risk Populations. (3 cr, \$EPsy 5714, \$VoEd/WCFE 5806)

Overview of interagency planning issues and practices for educational and human service organizations. Transition of students from school to work and community living; infant and preschool services; use of locally based planning teams to achieve enhanced service coordination.

## GRADUATE PROGRAMS

EdPA 5120. History of Childhood Education. (3 cr, §3120, §SPFE 5120) Bagley  
Childhood education in Western civilization; emphasis on images, symbols, ideas important to educational theory and practice in home and school.

EdPA 5125. Youth in Modern Society. (4 cr, §Soc 5952) Schneider  
Youth in advanced societies and as a social entity; functions and roles in industrial society, family, education, politics and government, economy and work, welfare and religion; organizations, social movements, and subcultures; empirical research and cross-cultural perspectives.

EdPA 5128. Workshop: Educational Administration. (1-6 cr)  
Lab approach provides opportunities for experienced administrators to concentrate on common administrative and supervisory problems.

EdPA 5130. Leadership Development Seminar. (3 cr; prereq advanced application, College of EHD approval) Nickerson  
Assessment and development of skills required of the educator in areas of planning, decision making, and human relations; introduction to contemporary issues in educational administration.

EdPA 5131. Comparative Education. (4 cr) Cogan  
European, Asian, and American systems and philosophies of education; possibilities of international education.

EdPA 5139. Laboratory in Decision Making. (3 cr; prereq advanced application) Nickerson  
Contribution of recent research and theory to effective administration; analysis of administrative behavior in realistic settings and relations of administration to human behavior.

EdPA 5141. Critical Issues in Contemporary Education. (3 cr) King, York-Barr  
Introduces graduate students to ideas involved in current theory and practice.

EdPA 5142. Racial and Ethnic Diversity in Higher Education. (3 cr; A-F only) Turner  
Review of research. Theoretical frameworks, methodological perspectives, and research strategies used to study students, staff, and faculty; historical perspectives.

EdPA 5155. History of Western Educational Thought. (4 cr, §3155, §Hum 3155/5155) Bagley  
Major educational classics of Western civilization: Plato, Aristotle, Cicero, Quintilian, Montaigne, Milton, Locke, Rousseau, and others.

EdPA 5156. History of Ideas in American Education. (3 cr) Bagley  
Readings in American political, economic, and social development related to education; reference to the emerging system of public education. Recommended as background for EdPA 5170, but not a prerequisite.

EdPA 5167. The American Middle School. (3 cr) Nickerson  
Sources of the movement; purposes, functions, and limitations; fundamental problems, types, and curricular implications of reorganization.

EdPA 5169. Ethnic Groups and Communities: Perspectives on Families, Children, and Youth. (3 cr) Lundy-Dobbert  
Roles of young people in widely varied North American communities. Comparative aspects of youth commitment to society, economic value of youth, youth-adult conflict, and youth roles in the family. Well-defined analyses of contextual roles. Complexity of policy for appropriate educational and community development.

EdPA 5170. American Pragmatism and Education. (3 cr)  
Analysis and interpretation of the educational philosophy of pragmatism (experimentalism); readings from Dewey, Kilpatrick, Bode, Counts, Childs, and others.

EdPA 5171. Anthropology and Education. (4 cr, §Anth 5145) Lundy-Dobbert  
Cross-cultural perspectives in examining educational patterns, the implicit and explicit cultural assumptions underlying them; methods and approaches to cross-cultural studies in education.

EdPA 5173. Case Studies for Policy Research. (3 cr; prereq educ or grad student or #; A-F only) Turner  
Using qualitative case study research method and applying it to educational practice. Emphasis on designing studies that employ open-ended interviewing as primary data collection technique. Class project.

EdPA 5174. Ethnographic Research Methods. (4 cr; prereq 5171 or Anth 5144 or Anth 5145) Lundy-Dobbert  
Practice in aspects of field methodology below the level of full field study; detailed reading; analysis of studies in anthropology and education for methodological content.

EdPA 5176. Ethnographic Research Skills Laboratory. (2 cr; prereq ¶5174; S-N only) Lundy-Dobbert  
Introduction to processes of creating evaluative design; supervised practice in data analysis, use of theory, proposal writing, reporting.

EdPA 5178. Project in Teacher Leadership. (1-9 cr, §CI 5178; prereq grad student or #)  
Create and present project for instigating or promoting change within education.

EdPA 5180, 5181. Seminar: Administration of Special Education. (3 cr per qtr, §EPsy 8760, 8761; prereq 5103 or EPsy 5660 or #) Weatherman  
Problems of administration and organization of special education programs.

EdPA 5182. Comparative Philosophies of Education. (3 cr) Orton  
Examination of competing philosophies of education.

EdPA 5190. Sociology of Education. (4 cr, §Soc 5953) Louis  
Advanced studies in social aspects of education including schooling as a socialization process, the social structure of education, the role of school in social change.

EdPA 5201. Formal Organizations in Education. (3 cr) Anderson, Louis, Turner  
Introduction to classical and current theories of organizational behavior and administration in education. Leadership and control, communication, conflict, effects of educational environments, organizational design and change, and organizational effectiveness.

EdPA 5202. Politics of Education. (3 cr) Mazzoni  
Social science findings, concepts, and methods used to consider political context of educational administration; emphasis on creation of public school policy by local and state governments; role of administrators.

EdPA 5204. Financing Elementary and Secondary Schools. (3 cr) Mueller, Sederberg  
Value assumptions and educational finance policy, economic factors, sources and characteristics of educational revenue, state and local distribution systems, federal support, urban/rural variations, institutional financing alternatives.

EdPA 5209. Education in Future Social Systems. (3 cr) Harkins  
Interdisciplinary inquiry into problems of social specialization and generalization; projections and analysis of long-range (30 years or more) social and technological trends related to education.

EdPA 5210. Social Forecasting and Educational Futures. (3 cr) Harkins  
Application of social sciences in their academic and applied dimensions to formal education, including social-scientific and systems orientation toward communities; emphasis on short-range social and educational planning, near-present to a few years hence.

EdPA 5211. Social Design and Educational Futures. (3 cr) Harkins  
Medium-range interdisciplinary approach to community design and analysis emphasizing formal education systems in community context; focus upon new neighborhoods, towns, experimental cities, and subcultural enclaves in rural and urban settings emphasizing time periods from several years to three decades hence.

EdPA 5212. School Budgeting. (3 cr) Sederberg  
Concepts and skills involved in preparing financial budgets for public schools; competency in translating educational programs into budgetary systems, anticipating revenue receipts, planning expenditures, and techniques for preparing a balanced budget.

EdPA 5214. School Management Information Systems. (3 cr) Hendrix, Sederberg  
Basic techniques required to generate, maintain, and make accessible computer-based management information system in education.

EdPA 5215. The Principalship. (3 cr) Alkire, Nickerson  
Role of the principal: qualifications, duties, and problems.

EdPA 5216. Recent Research in Elementary School Administration. (3 cr; prereq 5215) Alkire  
Pertinent research literature.

EdPA 5221. Introduction to Policy Research. (3 cr; A-F or S-N for grad students, A-F for others)  
Anderson, Mazzoni, Mueller  
Political, philosophical, environmental, and methodological issues that accompany policy research in education; applicability of quantitative and qualitative methods.

EdPA 5224. Legal Implications of Acts by School Boards, Administrators, and Teachers. (3 cr; A-F only) Hooker  
Constitutional, statutory, and common law bases of school administration; principles growing out of fundamental legal procedures.

EdPA 5225. Educational Policy and the Law. (3 cr; A-F only)  
Analysis of court decisions, statutes, and administrative regulations related to equality of educational opportunity and equal protection under the law.

EdPA 5227. Public School Personnel Programs. (3 cr) Alkire  
Selection, assignment, evaluation, and development of school personnel; salary and conditions of service; policies of administrative, instructional, and noninstructional personnel.

EdPA 5240. Seminar: Clinical Experiences in Educational Administration. (1-9 cr, \$8240; S-N only)  
For educational administration majors engaged in clinical experiences.

EdPA 5245. Ethics, Morality, and Values in Education. (3 cr) Orton  
Application to key issues of professional practice.

EdPA 5250. American Higher Education. (4 cr) Anderson, Lewis  
American higher and postsecondary education in historical and contemporary perspective; special emphasis on societal and political demands on higher education system; consequent changes in various forms and functions.

EdPA 5260. Introduction to Educational Planning. (3 cr)  
Principles, tools, and emerging issues in higher and elementary/secondary education settings, including decision-making models, strategic planning, forecasting, program planning, and short-range planning.

EdPA 5265. Administering the High School Program. (3 cr) Nickerson  
Principal as instructional leader; practices and procedures used in building master schedule; analysis and evaluation of school program and services.

EdPA 5267. Small Group Dynamics and Shared Decision Making. (3 cr, \$EPsy 5155; EPsy 5150 recommended)  
Theory and research in group dynamics; application to practical situations. Setting clear and operational group goals, communicating, leadership, power and influence, group decision making, controversy and group problem solving, and conflict resolution.

EdPA 5272. Problems: Educational Policy and Administration. (1-3 cr per qtr, \$8272)  
For students in educational policy and administration who are qualified to carry out intensive studies of a school system.

EdPA 5274. Two-Year Postsecondary Institutions. (3 cr, \$VoEd/WCFE 5274) Turner  
Present status, development, functions, organization, curriculum, and trends in postsecondary but nonbaccalaureate institutions.

## GRADUATE PROGRAMS

EdPA 5280. Introduction to the Economics of Education. (4 cr) Lewis

Economic impact of education on educational markets, prices and production relationships, distribution of income, and investment and cost-benefit analysis in education.

EdPA 5281. Cost and Economic Analysis in Educational Evaluation. (3 cr; S-N only) Lewis  
Use and application of cost-effectiveness, cost-benefit, cost-utility, and cost-feasibility in evaluating educational problems and programs.

EdPA 5285. Principles and Methods of Evaluation. (3 cr, §EPsy 5240) King  
Introduction to program evaluation; theory; practical examples; purposes, role, program descriptions, and evaluation strategies.

EdPA 5292. The Law and Postsecondary Educational Institutions. (3 cr; A-F only)  
Analysis of court opinions and Federal regulations affecting postsecondary educational institutions.

EdPA 5420. Leadership and Administration of Student Affairs. (3 cr, §EPsy 5420)  
Scope, administration, coordination, and evaluation of programs in college and university student affairs.

EdPA 5540. Seminar: The College Student. (3 cr, §EPsy 5451; prereq 6 cr psychology or educational psychology) Hendel  
Psychology and sociology of college students; research on diversity of populations, vocational development, student society, culture, mental health, underachievement, dropouts, values and attitudes; relevant research methods.

EdPA 5601. International Education: Topics in Classroom Practices and Procedures. (1-12 cr [max 12 cr], §AdEd 5601; prereq tchg licensure, #; A-F only) Cogan, Mestenhauer, Paige  
Educational practices in a designated country, region, or cultural group; impact of social and cultural features; organization, school structures, classroom practices, and delivery of educational services; potential for implementation in the United States.

EdPA 5603. International Education and Development. (4 cr, §AdEd 5603; A-F only) Cogan, Mestenhauer, Paige  
Contemporary theories relating formal and nonformal education to national development in social, cultural, political, and economic sectors; alternative conceptualizations and theoretical perspectives on education and development.

EdPA 5605. Research Topics: International Development Education. (4 cr, §AdEd 5605; A-F only) Cogan, Mestenhauer, Paige  
Empirical research conducted in developing societies relating formal and nonformal education to national development in social, cultural, political, and economic sectors.

EdPA 5607. Applied International Development Education. (4 cr, §AdEd 5607; A-F only)  
Educational innovations designed to promote national development in selected developing nations; educational case studies in the context of such objectives; conceptualizations of the role of education in development and outcomes.

EdPA 5609. Critical Issues in International Education and Educational Exchanges. (4 cr; prereq #) Mestenhauer  
Comprehensive, multidimensional approach to policy and practices of U.S. and other universities in international education and its components. Conceptual development; interdisciplinarity; integration of learning and production; application to programs, global careers, and curriculum.

EdPA 5701. Theories of International Development. (4 cr; prereq international relations major or #)  
Interdisciplinary approaches to understanding contemporary development theory and practice. Selected theoretical framework and case studies illustrating complexities of development planning and implementation.

EdPA 5716. Collaboration for Inclusive School Communities. (3 cr, §EPsy 5607; A-F only) York-Barr  
Implications of and rationale and strategies for including students with unique needs (e.g., disabilities) in general education classroom settings. Importance of creating a sense of community among students and adults in today's heterogeneous classrooms and schools.

EdPA 5931. Minnesota Studies in International Development (MSID) Seminar. (4 cr; prereq international relations major or #)  
Intercultural living and learning, and undertaking research activities in developing nations, in preparation for internships in overseas development agencies.

EdPA 8170. Seminar: Research Methods in Anthropology and Education. (1-3 cr [max 9 cr]; prereq 5174 or 5175 or Anth 8152 or #) Lundy-Dobbert  
Anthropological research below dissertation level including designing and carrying out a research project related to education, schools, or socialization; emphasizes relevant theory, reliability and validity, research ethics, and reporting.

EdPA 8172. Classic Readings in Anthropology and Education. (3 cr; prereq 5171 or anth grad student)  
History and philosophy; current impact of different schools of thought from 1898 to present.

EdPA 8175. General Systems Thinking for Analyzing Education. (4 cr, §5175) Lundy-Dobbert  
Historical and contemporary systems philosophy, thinking, and analysis. Developing concepts and skills for coping with evolutionary and chaotic environments. Modeling and simulating learning systems in rapidly changing national and international contexts.

EdPA 8220. Quantitative Foundations for Management Methods. (3 cr)  
Quantitative techniques for research and analysis of policy, program, and management problems, and decision situations in administration of educational organizations; includes computer usage.

EdPA 8225. Evaluation Theory and Models: Qualitative and Quantitative Alternatives. (3 cr; prereq 5285 or EPsy 5240 or equiv or #) King  
Models and theoretical frameworks developed by program evaluation professionals since 1960s.

EdPA 8228. Problems: Higher Education. (Cr ar; prereq #)  
Selected topics on college programs, instruction, organization, and administration.

EdPA 8229!. Seminar: Higher Education. (1-4 cr; prereq #)  
Intensive study of selected topics.

EdPA 8230. Seminar: Dissertation Research in Higher Education. (1 cr per quarter; S-N only)  
Anderson, Lewis, Louis, Turner  
Two-quarter seminar for candidates designing or conducting studies. Selecting a problem; designing an appropriate study; collecting, analyzing, and summarizing data and preparing a written account; critical review of candidates' individual projects.

EdPA 8238. Seminar: Theory and Research. (3 cr; prereq educational administration or educational policy major or #) Ammentorp, Hendrix, Mazzoni, Mueller  
Research design involving thesis or field project; interrelatedness of conceptual framework formulation and the analytical process; clinical and research problems.

EdPA 8241. Seminar: Internship in Educational Administration. (0-9 cr; S-N only) Sederberg  
For interns in elementary, secondary, general, and postsecondary administration.

EdPA 8248. Seminar: Metropolitan School Governance. (3 cr; prereq 5202)  
Impact of metropolitanization on policy issues confronting public schools in core cities; strategies proposed for restructuring educational governance emphasizing Twin Cities metropolitan area.

EdPA 8250. The Higher Education Institution: Organization and Environment. (3 cr; prereq 5201, 5250) Turner  
Colleges and universities as complex organizations. Emphasis on effects of social, economic, political, and demographic environment on structures and processes; reciprocal effects of colleges and universities on their environments.

EdPA 8252. Instruction and Learning in Higher Education. (3 cr; prereq 5250)  
Teaching-learning relationship; study and appraisal of methods employed to encourage, guide, and appraise students' learning.

EdPA 8255. Leadership and Administration in Higher Education. (3 cr; prereq 5201, 5250) Anderson  
Higher education governance, administration, and leadership from theoretical and applied perspectives; decision-making structures and processes, and planning.

EdPA 8257. Financing Higher Education. (3 cr) Ammentorp  
Financing postsecondary systems at national and state levels; financing postsecondary students; budgeting and financial analysis in postsecondary institutions; cost-effectiveness analysis.

EdPA 8258. Federal and State Higher Education Policy. (3 cr; prereq 5250) Anderson  
Issues in developing and implementing federal and state higher education policy; finance and financial aid.

EdPA 8261. Problems: Social and Philosophical Foundations of Education. (Cr ar, \$SPFE 8241; prereq #)  
For graduate students interested in research and original work in these areas.

EdPA 8268. Seminar: Social and Educational Futures. (1-6 cr [max 6 cr]; prereq 5209 or 5210 or 5211 or #) Harkins  
Review and critique of outstanding theoretical contributions of leading social and educational futurists to delineate areas for additional inquiry and research.

EdPA 8270. Problems: Elementary School Administration. (Cr ar; prereq #)

EdPA 8271. Problems: Secondary School Administration. (Cr ar; prereq #)

EdPA 8273. Field Study. (0-10 cr; prereq #)  
Required for specialist in education certificate. The 10 credits are based on a written report covering an approved field study. Students may register for the general planning and organization of their study without credit.

EdPA 8340. Simulation in Educational Design. (3 cr, \$EdAd 8340; prereq 8220: S-N only) Ammentorp  
Policy systems as feedback control structures; reduction of policy problems to causal structures translated into mathematical models; general principles of system structure and response used to interpret behavior of typical policy systems in education.

EdPA 8341. Simulation Analysis of Educational Policy Systems. (3 cr, \$EdAd 8341; prereq 8340; S-N only) Ammentorp  
Techniques of computer simulation applied to study of policy impact and management structures in education; simulation analysis of specific education policies and techniques applicable to problems of personal interest.

EdPA 8603. Seminar: International Development Education. (3 cr; prereq 5603) Cogan, Mestenhauer, Paige  
Key theoretical issues; formal and nonformal education.

EdPA 8605. Problems: International Education Research. (3-6 cr; prereq 5605) Cogan, Mestenhauer, Paige  
Examination of comparative research studies, emphasizing development education.

## Educational Psychology (EPsy)

*Professor:* Susan C. Hupp, *chair*; William M. Bart; Jerome Beker; Robert H. Bruininks; Mark L. Davison; Stanley L. Deno; Byron Egeland; David L. Giese; L. Sunny Hansen; Vernon L. Hendrix; Thomas J. Hummel; David W. Johnson; Paul E. Johnson; Roger T. Johnson; Frances P. Lawrenz; Rodney G. Loper; Geoffrey R. Maruyama; Patricia R. McCarthy Veach; Scott R. McConnell; Jack C. Merwin (*emeritus*); Joe E. Reichle; James R. Rest; John E. Rynders; S. Jay Samuels; Stuart J. Schleien; Thomas M. Skovholt; Robert D. Tennyson; James S. Terwilliger; James E. Turnure; Paul W. van den Broek; Richard F. Weatherman; Richard A. Weinberg;

Wayne W. Welch (*emeritus*); Frank B. Wilderson, Jr.; Frank Henderson Wood (*emeritus*); James E. Ysseldyke

*Associate Professor:* Marie Knowlton, *director of graduate studies*; Sandra L. Christenson; Ernest C. Davenport; Lynne K. Edwards; V. Lois Erickson; Christine A. Espin; Joan B. Garfield; Jean A. King; Donald G. MacEachern; Mary A. McEvoy; John L. Romano; Susan Rose; John M. Taborn

*Assistant Professor:* Annie Baldwin; Carol A. Davis; Lynn Friedman; Darcia F. Narvaez; Jennifer York-Barr

*Lecturer:* Brian H. Abery; Ann M. Casey; David R. Johnson; Douglas B. Marston; Ronald P. Matross; Kevin S. McGrew; Robert J. Murphy; Steven L. Robinson; Richard J. Spicuzza; Joyce D. Weinsheimer

*Other:* Sue A. Kroeger; Kevin J. Nutter; Kay A. Thomas

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B), Ph.D., and Certificate of Specialist in Education.

**Curriculum**—Program areas are counseling and student personnel psychology (CSPP); school psychology; special education; and psychological foundations of education (including evaluation, computer applications, statistics, and research design, as well as learning, cognition, human relations, measurement, social psychology, and educational technology).

**Prerequisites for Admission**—There are no special prerequisites for admission at the M.A. level in any of the four program areas, or at the Ph.D. level in school psychology or psychological foundations of education.

Applicants to the CSPP doctoral program should hold either a bachelor's or master's degree with a major in psychology, education, counseling, or a related field. CSPP applicants interested in earning the specialist certificate should hold an M.A. degree; if not, they should apply to both the M.A. and specialist certificate programs.

**Special Application Requirements**—Applicants must submit a department application (*with clear indication of the desired program area*), a statement of goals and interests, three letters of recommendation, and a Graduate School application accompanied by official transcripts from all colleges and universities attended. These test scores are required: the CSPP, psychological foundations of education, and special education programs require the Graduate Record Examination (GRE); the school psychology program requires the GRE and later an interview for those who make the initial cut.

Applications to CSPP, school psychology, and special education are accepted for fall admission only; the deadline is January 15. Applications to psychological foundations are accepted throughout the year.

**Master's Degree Requirements**—Programs must include a minimum of four core courses (one in each of the following content areas): statistics, measurement or evaluation, human learning or cognition, and personality or social psychology. The final examination in CSPP is a written comprehensive exam. The other final examinations are oral.

**Doctoral Degree Requirements**—Programs must include a minimum of twelve core courses: three in statistics; two in human learning or cognition; at least one in each of the following areas—measurement, evaluation, personality, social psychology, and critical issues in educational psychology; plus two more. Students should check with their specific program area concerning additional course requirements, written general preliminary examination requirements, and thesis procedures.

**Specialist Certificate Requirements**—Programs must include a minimum of six core courses, one in each of the following areas—statistics, measurement or evaluation, human learning or cognition, personality or social psychology—plus two more. The final examination is oral. For general requirements, see Specialist in Education in the General Information section of this bulletin. These specialist certificate programs are available:

*Counseling*—This program provides advanced training in one or more specialized areas related to the field of counseling. Applicants should have a broad background in the social and behavioral sciences. The program allows for in-depth study related to the work of the counselor. It is expected that the student will have completed coursework or can demonstrate competency in specified areas, with specialization in one or two.

*School Psychology*—Across two years, the student completes requirements for the M.A. degree, including coursework in educational psychology, psychology, child psychology, diagnostic and remedial procedures, and special education. Specialist certificate students complete an internship during the third year, doctoral students during the fifth year.

*Special Education*—This program is for students preparing for administrative, supervisory, and consultative positions in special education. Flexibility allows concentration in a particular field (e.g., education of persons who are learning disabled, mentally disabled, or deaf/hard of hearing). Generally students are expected to develop competencies in several areas of special education. Applicants should have basic preparation and experience in at least one special education area as well as licensure for public school work.

**Minor Requirements for Students Majoring in Other Fields**—A minor in educational psychology for doctoral students consists of 21 quarter credits, 12 of which must be at the 8xxx level. The minor must include either (a) 21 credits in psychological foundations or (b) 12 credits in psychological foundations plus 9 credits in the applied areas CSPP, school psychology, special education, 6 of which must be the same area. A minor in educational psychology for master's students consists of 9 quarter credits.

**Language Requirements**—None.

**For Further Information and Applications**—For general assistance and information, contact the Director of Graduate Studies Assistant, Department of Educational Psychology, University of Minnesota, 202 Burton Hall, 178 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/624-1698; fax 612/624-8241; e-mail warho004@tc.umn.edu). For specific program materials, contact the program areas as follows: Counseling and Student Personnel Psychology (CSPP), University of Minnesota, 129 Burton Hall, 178 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/624-6827; fax 612/625-4063); School Psychology, University of Minnesota, 344 Elliott Hall, 75 E. River Road, Minneapolis, MN 55455 (612/624-4156; fax 612/624-0879); Special Education, University of Minnesota, 227 Burton Hall, 178 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/624-2342; fax 612/626-9627); Psychological Foundations of Education, University of Minnesota, 206 Burton Hall, 178 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/624-6083; fax 612/624-8241; e-mail kwalter@tc.umn.edu).

EPsy 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

EPsy 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

EPsy 8888. Thesis Credits: Doctoral. (36 cr required)

EPsy 5110. Intelligence. (3 cr) Bart  
Theories of intelligence, including contemporary theories; its development; implications for educational practices and psychological inquiry.

EPsy 5112. Knowing, Learning, and Thinking. (4 cr) Samuels  
Principles of human information processing; issues in memory and thought; discussion of mental operations in comprehension and understanding; analysis of intellectual structures supporting problem solving in applied settings.

EPsy 5113. Introduction to Instructional Psychology and Technology. (3 cr) R Tennyson  
Theory, research, and practice. Contemporary issues in advanced learning technologies, including instructional design, open/distance learning, virtual environments, instructional interfaces, feedback strategies for technology-based learning, multimedia/interactive media, adaptive learning, and courseware authoring.

EPsy 5114. Psychology of Student Learning. (3 cr) Samuels, van den Broek  
Survey of psychological methods and principles; models of the learner; topics in development, creativity, intelligence, and motivation; implications for teaching and curriculum design in preschool, elementary, and secondary education; professional training with children and adolescents as clients.

EPsy 5115. Psychology of Adult Learning. (4 cr) R Tennyson  
Survey of psychological methods and principles in human learning; models of adult learner, topics in motivation, creativity, achievement, intelligence; implications for teaching and curriculum design in higher education, continuing education, and professional training.

EPsy 5116. Behavior Analysis in Education. (4 cr) Davis, Deno, McEvoy  
Practical applications of reinforcement theory; behavior analysis, precision teaching, programmed instruction.

EPsy 5117. Problem Solving and Decision Making. (4 cr) Bart  
Strategies, rules, methods, and other cognitive components involved in problem solving and decision making; implications for practices in education and other applied domains.

EPsy 5119. Learning and Cognitive Foundations of Education. (4 cr; prereq College of EHD student or CLA music educ major or Δ; 1 psychology course recommended) Bart, Samuels  
Principles of development, learning, cognition, individual differences, classroom management, instructional delivery, and related topics, and their applicability to instruction and organization of curricular materials.

EPsy 5125. Psychology of Building Character, Values, and Behavior. (3 cr) Samuels  
New approaches to motivating and creating desirable values and behavior. Strengths and weaknesses of traditional and new approaches.

## GRADUATE PROGRAMS

EPsy 5130. Personality and Social Development. (3 cr; prereq 5 cr intro psychology) Major concepts and research findings in adjustment and development, with special emphasis on educational implications.

EPsy 5135. Human Relations Workshop. (6 cr; meets human relations req for tchr licensure renewal; S-N only) Puncocar  
Experientially based course addressing issues of prejudice and discrimination in terms of history, power, and social perception. Skills in cooperative learning, multicultural education, group dynamics, prejudice reduction, and conflict resolution.

EPsy 5139. Building a Learning Community. (4 cr, §3139; prereq College of EHD student or CLA music major or Δ, at least 1 psychology course) Narvaez  
Major theories of and research on schooling as it relates to human relations, small groups, face-to-face relations, and individual personality and social development.

EPsy 5150. Social Psychology of Education. (3 cr) D Johnson  
Theory and research; major theorists; using knowledge in applied settings. Social perception, interdependence, interaction, and influence; conflict resolution.

EPsy 5151. Structuring Learning: Social Psychological Approaches. (3 cr) D Johnson  
Understanding cooperation, how it works, the teacher's role, and research validating its use; using cooperative learning in instructional situations.

EPsy 5154. Organizational Development and Change. (3 cr, §8151; 5150 or equiv recommended; offered alt yrs) D Johnson  
Theory and research. Organizational and social psychological theory and research applied to practical situations. Diagnosis and intervention skills.

EPsy 5155. Small Group Dynamics and Shared Decision Making. (3 cr, §EdPA 5267; 5150 or equiv recommended; offered alt yrs) D Johnson  
Theory, research, and practical applications. Setting clear and operational group goals, communication, leadership, power and influence, group decision making, controversy and group problem solving, and conflict resolution.

EPsy 5200. Special Topics: Psychological Foundations. (1-6 cr)  
Analysis of psychological and methodological concepts relevant to current educational practice.

EPsy 5217. Proseminar in Educational Psychology. (1-3 cr [max 3 cr])  
Examination of types of research.

EPsy 5220. Educational Measurement in the Classroom. (4 cr) Terwilliger  
Principles and methods for construction, evaluation, and improvement of classroom measures; techniques for describing results statistically; use of measurement in evaluating instruction and student performance; assignment of grades.

EPsy 5221. Basic Principles of Measurement. (3 cr; prereq 5260 or 8260 or PsyF 5110 or 8110) Davenport, Terwilliger  
Fundamental concepts, principles, and methods in educational and psychological measurement; educationally useful properties of tests; types and uses of derived scores; factors influencing reliability and validity.

EPsy 5222. Modern Measurement Theory and Practice. (3 cr; prereq 5221, 8260, 8261 or equiv; offered alt yrs) Davison  
Introduction to modern measurement practices, such as item banking and test scoring equipment; modern measurement theories of test items analysis, reliability, and validity.

EPsy 5229. Classroom Assessment Methods. (2 cr; concurrent practice tchg or similar field exper recommended)  
Concepts and techniques for effective diagnosis of learning problems and assessment of educational outcomes. Emphasis on constructing teacher-made assessment devices that are efficient, technically sound, and directly relevant to classroom decision making.

EPsy 5240. Principles and Methods of Evaluation. (3 cr, §EdPA 5285, §PsyF 5125) Garfield, King, Lawrenz  
Introductory course in program evaluation; theory; practical examples; purpose, roles, program descriptions, and evaluation strategies.

EPsy 5243. Practicum: Survey and Observational Research Methods. (3 cr; prereq 5220 or 5221 or equiv; offered alt yrs) Garfield  
Planning, development, implementation, analysis, and reporting of survey and observational methods including questionnaires, interviews, and various observational techniques.

EPsy 5246. Evaluation Colloquium. (1 cr [max 6 cr]; S-N only; offered when feasible) King

EPsy 5260. Introductory Statistical Methods. (4 cr)  
Techniques for organizing and presenting data; descriptive indices of central tendency, variability and bivariate correlation/regression; procedures for making inferences concerning means and proportions.

EPsy 5261. Applied Matrix and Vector Concepts. (1 cr; S-N only)  
Introduction to concepts and operations; applications in multiple regression, factor analysis of variance.

EPsy 5262. Statistical Computing Using Minitab. (2 cr; prereq 5260 or equiv; S-N only; offered alt yrs)  
Practical experience using time-sharing computer language MINITAB; applications of introductory statistical methods and concepts to data files.

EPsy 5263. Statistics for Preprofessional Students. (4 cr)  
Descriptive statistics for continuous variables, simple regression and correlation, inferences on means, introduction to analysis of variance and multiple regression, contingency tables, computer analysis techniques.

EPsy 5280. Computer Programming: PASCAL. (3 cr; prereq sr; offered when feasible)

EPsy 5281. Introduction to Statistical Computing. (1 cr; S-N only)  
Computing resources at the University; SPSS and MINITAB on MS DOS (Windows), VAX, and Macintosh; spreadsheets, editors, word processing, e-mail, and compilers. Data analysis applications.

EPsy 5400. Workshop: Counseling Psychology. (1-6 cr [max 12 cr])  
For all counselors, teachers, and administrators; aspects of intervention theory in relation to psychological principles; counseling, career development, assessment, psychological education, and consultation.

EPsy 5401. Counseling Procedures. (3 cr)  
For persons whose professional work includes counseling and interviewing; not for licensure as school counselor. Emphasis on counseling relationship and principles of interviewing; case studies, role playing, and demonstration.

EPsy 5417. Clinical Use of Tests in Psychological Services. (3 cr; prereq 5221 or equiv, 5260 or equiv, CSPP major) Hummel  
Statistical methods related to test interpretation; critical review and selection of standardized tests.

EPsy 5420. Leadership and Administration of Student Affairs. (3 cr, §5420)  
Scope, administration, coordination, and evaluation of programs in college and university student affairs.

EPsy 5430. Foundations of Career Development. (3 cr) Hansen  
Introduction: theory, research, practice; examination of concepts of work, work values, career and career education; application of theory and research to career guidance practice in educational, industrial, and community agency settings.

EPsy 5431. Career Development: Theory and Counseling Applications. (3 cr; prereq CSPP student) Hansen  
Provides students in counseling and allied fields with background; emphasis on counseling skills; topics include work and other life values, counseling process, planning and decision making, information and employment trends, sex equity in career options, needs of specific groups.

EPsy 5432. Career Development Programs and Organizational Change. (3 cr; prereq 5430 or 5431 or equiv or #) Hansen  
Provides knowledge and skills to create and implement programs for a variety of populations and settings; life-roles concept integrated with systematic model of program development. Emphasizes new patterns of work and career, organizational change and interventions, and diversity issues in career development.

EPsy 5433. Developmental Career Counseling of Women. (3 cr) Hansen  
Counseling skills and interventions to facilitate career development of girls and women at different life stages; sex role system, female socialization and stereotyping; facts, myths, and trends regarding women's changing roles in technological society; issues of sexism in strategies and programs.

EPsy 5434. Counseling Adults in Transition. (3 cr) Romano  
Psychological, physical, and social dimensions of transitions in adulthood, e.g., family and personal relationships, career. Adult development theory, stress and coping, and helping skills and strategies.

EPsy 5451. Seminar: The College Student. (3 cr, §EdPA 5540; prereq 6 cr psychology or educ psychology)  
Psychology and sociology of college students; research concerning diversity of populations, vocational development of students, student society, culture, mental health, underachievement, dropouts, values and attitudes; relevant research methods.

EPsy 5461. Cross-Cultural Counseling. (3 cr) Thomas  
Effect of cross-cultural and cross-national differences in counseling process.

EPsy 5531. Career Skills. (2 cr; prereq CSPP student or #) Hansen  
Applied course is part of career counseling sequence and is coordinated with career development theories and field placement. Applications of theories from 5431 and practice through case studies, role plays, simulations, and assessments.

EPsy 5600. Childhood Language Development: Classroom Implications. (3 cr, §PsyS 5100) Turnure  
Recent trends and findings in study of language acquisition and communication; classroom implications, including education of exceptional children.

EPsy 5601. Education of Exceptional Children. (4 cr)  
Introduction to field of special education for classroom teachers and other school personnel.

EPsy 5602. Computer Technology in Special Education. (3 cr) Rose  
Application of computer technology to special education in light of learning theory, principles of effective instruction, and the instructional needs of special education populations.

EPsy 5604. Transition From School to Work and Community Living for Persons With Special Needs. (4 cr)  
Organization and design of training programs to promote independent living and vocational and community adjustment for persons with disabilities and for other at-risk populations; curriculum materials, methods, and organizational strategies for adolescent and adult learners, families, and community service providers.

EPsy 5605. Law and the Handicapped: Implications for Education. (2-4 cr, §EdPA 5223)  
Analysis of recent litigation and legislation; emphasis on implementation of right to education, right to treatment, labeling, due process, and related issues.

EPsy 5607. Collaboration for Inclusive School Communities. (3 cr, §EdPA 5716)  
Implications of and rationale and strategies for including students with unique needs (e.g., disabilities) in general education classroom settings. Importance of creating sense of community among students and adults in today's heterogeneous classrooms and schools.

## GRADUATE PROGRAMS

EPsy 5608. Parent and Professional Planning for Handicapped Students. (3 cr)  
Study and demonstration of constructive approaches to cooperative planning and implementation of education programs by parents, teachers, and persons involved with children who have special needs.

EPsy 5609. Family-Professional Planning for Persons With Severe Handicaps. (3 cr)  
Interdisciplinary course on needs of families who have children with severe handicaps, emphasizing life-cycle needs, service issues, programs of support from infancy through adulthood, services from different agencies, disciplines, professional requirements, and responsibilities in serving families.

EPsy 5612. Education of Learning-Disabled Children. (3 cr) Deno, Espin  
Analysis of considerations in design and conduct of services for learning-disabled children; approaches to education of such children.

EPsy 5615. Educational Interventions for Learning Disabilities. (3 cr; prereq 5612) Deno, Espin  
Planning, implementing, and evaluating academic programs for students with disabilities in written and spoken language, quantitative concepts, and cognitive skills required for learning.

EPsy 5620. Introduction to Mental Retardation. (4 cr, \$CPsy 5315; prereq 5601 or PsyS 5101 or #) Turnure  
Issues relating to educational practices; community planning; educational philosophy, administration and organization, and programming.

EPsy 5621. Methods and Materials for Students With Mild to Moderate Mental Retardation. (4 cr, \$PsyS 5121; prereq 5601 or PsyS 5101 or equiv) Rynders  
Curriculum content, materials and methods of instruction for students with mental retardation; preparation of instructional instruments leading to both individual and group teaching expertise.

EPsy 5622. Programs and Curricula for Learners With Moderate to Severe Disabilities. (4 cr) Hupp  
Elementary and secondary school program design and curricula. Preparing children and youth for integrated, normalized community environments in domestic living, leisure, and vocational domains. Developmentally appropriate programming. Structured observation of learners with severe disabilities.

EPsy 5624. Biomedical and Physical Aspects of Developmental Disabilities. (3 cr, \$PsyS 5124)  
Selected information in genetics; anatomy, physiology, and kinesiology; central and peripheral nervous system; prenatal, perinatal, and postnatal development; physically disabling conditions; and management and educational procedures.

EPsy 5625. Education of Infants and Preschool Children With Developmental Disabilities. (3 cr, \$PsyS 5125; prereq 5601 or 5620 or PsyS 5101 or PsyS 5120 or #) McEvoy, Rynders  
Issues, problems, and practical applications in designing strong programs for young children with all types of disabilities.

EPsy 5626. Instruction for Learners With Moderate to Severe Disabilities. (4 cr; prereq 56116, 5622) Hupp  
Data-based strategies for school and nonschool instruction: basic measurement principles; assessment, design, implementation, and instruction evaluation; concept and task analysis; natural and instructional cues, corrections, and consequences.

EPsy 5635. Education of Students With Physical Disabilities. (4 cr; prereq 5601 or PsyS 5101 or #)  
Characteristics and abilities; methods and materials for training; observation of teaching situations involving these groups; personal consultation in addition to class hours.

EPsy 5636. Education of Multihandicapped Learners With Sensory Impairments. (3 cr; prereq 5601) Hupp  
Characteristics of learners with visual and auditory impairments; design of instructional programs to remediate or circumvent disabilities, including use of prosthetic devices; related areas of performance affected by sensory impairments.

EPsy 5640. Psychological, Social, and Educational Aspects of Deafness. (3 cr, \$PsyS 5140) Rose  
Historical and current societal perceptions of deaf individuals; analysis of effects and patterns of hearing loss on children and adults; intelligence, personal and social adjustment, effect of psychological processes on acquisition of language, speech, and speechreading skills.

EPsy 5641. Models of Service Delivery to Students With Hearing Loss. (3 cr, \$PsyS 5141; prereq 5644 or #) Rose  
Programmatic systems of support for infants, children, and youth who are deaf or hard of hearing; educational delivery system models, curriculum and material adaptation, and consultation skills.

EPsy 5642. Classroom Communication Through ASL. (2 cr [max 6 cr]; prereq educ or grad student, fingerspelling skills, conversational sign skills, #)  
ASL form and function. Emphasis on vocabulary production, phrase structure rules, classifiers, and other grammatical features needed by professionals working with children who are deaf.

EPsy 5643. Language for Deaf/Hard-of-Hearing Children. (4 cr, \$PsyS 5143; prereq 5640 or PsyS 5140) Rose  
Functional language development in communicatively disabled persons; overview of language curricula and programming strategies, pertinent research and models of instruction for use in educational environment.

EPsy 5644. Language Programming for Children With Hearing Loss. (3 cr, \$PsyS 5144; prereq 5643 or #) Rose  
Programs and practices focusing on development of language in deaf and hard-of-hearing infants, children, and youth; comparative study of language development among deaf, hard-of-hearing, and hearing persons.

EPsy 5646. Reading and Instructional Practices With Students Who Are Deaf or Hard-of-Hearing. (4 cr; prereq 5643 or #) Rose  
Knowledge and skills required to assess, plan, and implement instruction for individuals with hearing loss. Emphasis on theoretical and programmatic issues in acquisition of reading and writing skills, curricular adaptations, and effective instructional approaches.

EPsy 5647. Aural and Speech Programming for Children With Hearing Loss. (4 cr, \$PsyS 5147) Rose  
Fundamentals of speech and hearing mechanisms; survey of instructional practices and technology-based assistive devices to develop auditory and speech skills. Strategies to adapt classroom environments.

EPsy 5648. Modes of Communication for Persons With Disabilities. (3 cr, \$PsyS 5148) Rose  
Theoretical and applied study of selection and application of alternative communication modalities; assessment and development of modes including gestures, speech reading, cued speech, sign language, form boards, and technology-based systems.

EPsy 5651. Managing Problem Behavior in the Classroom. (3 cr)  
Typical patterns of problem behavior in classroom settings; relationships to teacher mental health; simulation of methods for prevention and management.

EPsy 5656. Educational Needs of Students With Emotional Disturbances or Behavioral Disorders. (3 cr) Davis, Wilderson  
Preparation for specialists: educational characteristics, educational interventions, teaching of social behavior, legal and ethical issues.

EPsy 5657. Educational Interventions for Students With Emotional Disturbances or Behavioral Disorders. (3 cr; prereq 5656) Davis, Wilderson  
Preparation for specialists: assessment and planning procedures, interagency cooperation, career preparation and transition for EBD students.

EPsy 5660. Supervision and Administration of Special Education. (3 cr, \$EdPA 5103)  
Procedures in establishing and improving educational programs for exceptional children.

EPsy 5670. Introduction to Education of Children With Visual Disabilities. (3 cr, \$PsyS 5170) Knowlton  
Educational programs, services, and resources for blind and partially seeing children; historical background; philosophy; sociological and psychological problems.

EPsy 5671. Literary Braille. (3 cr; prereq 5670 or PsyS 5170) Knowlton  
Mastery of literary Braille code: analysis of specialized equipment with emphasis on use of Braille writers, slates, and computers for Grade 2 Braille transcription.

EPsy 5672. Advanced Braille. (3 cr; prereq 5671 or PsyS 5171) Knowlton  
Mastery of Nemeth Code of mathematics, introduction to foreign languages, computer notation, and consideration of Braille textbook formats and techniques; consideration of music Braille.

EPsy 5673. Methods of Teaching Children With Visual Disabilities. (4 cr, \$PsyS 5173; prereq 5670 or PsyS 5170) Knowlton  
Principles of preparation, selection, and effective use of instructional materials and adaptive devices; adaptation of school environment; use of family, school, and community resources.

EPsy 5674. Orientation and Mobility Techniques for Students With Visual Disabilities. (3 cr, \$PsyS 5174)  
Introduction to basic techniques to gain skills in pre-cane techniques, orientation to learning environment, construction of mobility maps; consideration of cane, guide dog, and telescopic aids to mobility.

EPsy 5675. Structure and Function of the Eye: Educational Implications. (3 cr) Knowlton  
Ophthalmological and educational considerations of anatomy and physiology of the eye and visual tract, visual screening and visual efficiency.

EPsy 5676. Educational Management of Children With Visual Disabilities. (3 cr; prereq 5675 or #) Knowlton  
Advanced course evaluating and managing cognitive, psychosocial, and physical needs of students; consideration of parent, teacher, and student counseling.

EPsy 5680. Education of the Disadvantaged. (3 cr; prereq 12 cr psychology or educ psychology or sociology) Taborn  
Educational needs of children handicapped by behavior related to deficiencies of physical and/or cultural environment; adaptations of educational programs.

EPsy 5681. Methods and Materials for Infants and Preschool Children With Developmental Disabilities. (4 cr, \$PsyS 8181; prereq 12 cr educ or #) McEvoy, Rynders  
Methods, materials, conceptual models for maximizing educational development of young children with all types of disabilities.

EPsy 5700. Assessment and Decision Making in Special Education. (3 cr) Deno  
For teachers and other educational personnel. Identifying needs of handicapped students; planning, monitoring, evaluating instructional programs; practice in use of standardized devices and development of clinical measures for handicapped students.

EPsy 5701. Practicum: Special Education. (Cr ar; prereq #)  
Observation of teaching practices or related work in schools or other agencies serving exceptional children.

EPsy 5702. Workshop: Special Education. (Cr ar; prereq #)  
Lab approach. Provides opportunities for school personnel to study specific problems related to special education.

EPsy 5704. Workshop: Interventions and Practices in Educational and Human Service Programs. (Cr ar; S-N only)  
Concepts, issues, and practices; development of educational and psychological support services in school and human service settings. For practicing professionals.

## GRADUATE PROGRAMS

EPsy 5710. Contemporary Services for Persons With Developmental Disabilities. (3 cr) York-Barr  
Survey of characteristics and service needs of persons with developmental disabilities using multidisciplinary approaches. Changing concepts, models of services, issues related to promoting self-determination, independence, productivity, and integration into the community.

EPsy 5714. Interagency Cooperation for At-Risk Populations. (3 cr, §EdPA 5104, §VoEd/WCFE 5806)  
Overview of interagency planning issues and practices for educational and human service organizations. Transition of students from school to work and community living; infant and preschool services; use of locally based planning teams to achieve enhanced service coordination.

EPsy 5751. Student Teaching: Deaf, Hard-of-Hearing. (Cr ar; prereq #) Rose  
Supervised experience in teaching or related work in schools or other agencies serving children with hearing impairments.

EPsy 5752. Student Teaching: Learning Disabled. (Cr ar; prereq #) Deno, Espin  
Supervised experience in teaching or related work in schools or other agencies serving children with learning disabilities.

EPsy 5753. Student Teaching: Early Childhood Special Education. (Cr ar; prereq #) McEvoy  
Supervised experience in teaching or related work in schools or other agencies serving children in early childhood special education.

EPsy 5754. Student Teaching: Emotional/Behavioral Disorders. (Cr ar; prereq #) Davis, Wilderson  
Supervised experience in teaching or related work in schools or other agencies serving children with emotional/behavioral disorders.

EPsy 5755. Student Teaching: Mild to Moderate Intellectual Disabilities. (Cr ar; prereq #) Rynders, Turnure  
Supervised experience in teaching or related work in schools or other agencies serving children with mild to moderate intellectual disabilities.

EPsy 5756. Student Teaching: Moderate to Severe Disabilities. (Cr ar; prereq #) Hupp  
Supervised experience in teaching or related work in schools or other agencies serving children with moderate to severe disabilities.

EPsy 5757. Student Teaching: Physical and Health-Related Disabilities. (Cr ar; prereq #)  
Supervised experience in teaching or related work in schools or other agencies serving children with physical and health-related disabilities.

EPsy 5758. Student Teaching: Visual Impairments. (Cr ar; prereq #) Knowlton  
Supervised experience in teaching or related work in schools or other agencies serving children with visual impairments.

EPsy 5849. Assessment of the Preschool Child. (3 cr; prereq statistics or measurement or grad course in assessment) Christenson, McConnell  
Review of assessment of children ages 0-5 from developmental perspective; overview of normal and abnormal development; issues and techniques in cognitive, social, and emotional assessment; early education programs.

EPsy 5850. Creating Family-School-Community Partnerships for Educational Success. (4 cr) Christenson  
Theoretical and empirical bases; essential partnership variables; partnership models, programs, and strategies for K-12.

EPsy 5900. Independent Study. (Cr ar [max 12 cr]; prereq #)  
Independent study in areas of special interest to students.

EPsy 8111. Knowledge and Skill. (3 cr; offered when feasible) Bart

EPsy 8115. Psychology of Instruction. (3 cr; prereq course in learning and/or instructional psychology) R Nyson  
Identification and analysis of issues in development of instructional theory; review and analysis of research in teaching-learning processes in instruction; practice in design, development, evaluation of instructional techniques and technologies.

EPsy 8129. Research Problems: Learning and Cognition. (Cr ar; prereq #)  
Formulation of research designs.

EPsy 8130. Personality Development and Socialization. (4 cr, §5130; prereq 1 grad course in personality or child psychology) McCarthy Veach  
Major research strategies; emphasis on educational and developmental influences on personality.

EPsy 8131. Development of Moral-Political Judgment and Programs in Value Education. (2-4 cr; prereq #: ¶8149 recommended; offered when feasible) Narvaez

EPsy 8149. Research Problems: Personality. (Cr ar [max 9 cr]; prereq #)  
Formulation of research topics and designs.

EPsy 8150. Psychology of Conflict Resolution. (3 cr) D Johnson  
Theory and research; practical applications. Nature of conflict, history of theorizing about conflict, strategies for resolving conflicts, distributive and integrative negotiations, third-party interventions.

EPsy 8153. Social and Psychological Influences on Individual Behaviors. (3 cr; prereq intro course in social psychology or #) Maruyama  
Social and situational influences on individual behavior, focusing on effects of norms, peers, and others; situational characteristics affecting evaluation by self or others.

EPsy 8169. Research Problems: Social Psychology. (Cr ar; prereq #)  
Formulation of research topics and designs.

EPsy 8210. Methods in Educational Research. (3 cr; prereq spring qtr PhD students only) Hummel  
Methods and techniques employed in investigation and reporting of educational problems. Suggested for all candidates for graduate degrees.

EPsy 8220. Advanced Theory of Measurement. (3 cr; prereq 5221, 8261, PsyF 5121, PsyF 8111 or #; offered alt yrs) Davison  
Principles underlying construction and use of psychological and educational measuring instruments, limitations of tests for purposes of measurement and evaluation. Students may register concurrently or subsequently for 8239 for individual extensions and applications.

EPsy 8221. Theory of Psychological Scaling. (3 cr; prereq 5221, 8261 or PsyF 5121, 8111 or #; offered alt yrs) Davison  
Principles and theories underlying unidimensional scaling of properties of psychological behaviors, with minor attention to multidimensional scaling and mapping. Students may register concurrently or subsequently for 8239 for individual extensions and applications.

EPsy 8239. Problems: Measurement. (1-3 cr [max 9 cr])  
Intensive study and individual research.

EPsy 8245. Seminar: Special Topics in Educational Evaluation. (3 cr; prereq 5240 or PsyF 5125 or #; offered when feasible) King

EPsy 8247. Internship: Evaluation. (3 cr [max 12 cr]; prereq #) King  
Practical experience on an evaluation project. Student is given specified responsibilities under the supervision of an evaluator.

EPsy 8259. Problems: Evaluation. (Cr ar; prereq 5243 or 8245 or PsyF 5621 or 8525) King  
Designing, implementing, analyzing strategies. Students work on their own problems, on evaluation problems of schools in area, or on problems associated with national curriculum projects.

EPsy 8260, 8261, 8262. Statistical Methods. (3 cr per qtr; prereq 5260 or PsyF 5110 or Psy 3801 or equiv for 8260, 8260 for 8261, 8261 for 8262) Edwards, Hummel, MacEachern  
Foundations of statistical theory; practice in applying theories in solution of educational and psychological problems.

EPsy 8263. Design and Analysis of Experiments. (3 cr; prereq 8262 or PsyF 8112 or #) Edwards  
Functional approach to principles of efficient design of experiments and other types of observational programs; improved sampling techniques; methods of analyzing observational results.

EPsy 8264. Multiple Regression Analysis. (3 cr; prereq 5261 and 8261 or ¶5261 or PsyF 5111, PsyF 8111 or #) Davenport, Terwilliger  
Techniques appropriate to analysis of data in education and behavioral sciences including polynomial regression, stepwise solutions, and analysis of variance; experience with computer applications.

EPsy 8265. Factor Analysis. (3 cr; prereq 5261, 8261 or ¶5261 or PsyF 5111, 8111 or #) Davenport, Terwilliger  
Techniques appropriate to analysis of data in education and behavioral sciences including component, common factor, and image analysis; approaches to factor extraction, rotation, and factor score estimation; experience with computer applications.

EPsy 8266. Analysis of Results From Nonexperimental Research. (4 cr; prereq 8261 or PsyF 8511 or equiv or #) Maruyama  
Examination of quantitative techniques for drawing causal inferences, including path analysis, panel analysis, multitrait, multimethod analysis, structural equation approaches, and applications in social psychology of education.

EPsy 8279. Problems: Statistics for Students in Education and Psychology. (Cr ar)  
Recent developments in statistical science; application to educational and psychological problems.

EPsy 8280. Statistical Computing Using SPSSX. (3 cr; prereq 8261 or equiv)  
In-depth understanding of statistical package, SPSSX, on micro and mainframe; interpretation of results; attention to large-scale problems.

EPsy 8402. Individual Counseling: Theory and Procedures. (3 cr; prereq EPsy MA or PhD student with CSPP subprog or #) Romano  
Theories of individual counseling and psychotherapy and their application.

EPsy 8403. Social/Cultural Contexts of Counseling: Theory and Procedures. (3 cr; prereq EPsy MA or PhD student with CSPP subprog or #) Hansen  
Multicultural populations within United States, with focus on race, ethnicity, gender, and class. Systems interventions and social change. Students examine own biases as well as counseling and human development models and procedures for diverse groups.

EPsy 8404. Group Counseling: Theory and Procedures. (3 cr; prereq EPsy MA or PhD student with CSPP subprog or #) Romano  
Theories and procedures of group process; ethical issues in group counseling.

EPsy 8410. Seminar: Advanced Counseling Research. (4 cr; prereq EPsy PhD student with CSPP subprog or #)  
Analysis and integration of counseling research.

EPsy 8411. Seminar: Advanced Counseling Theory. (4 cr; prereq EPsy PhD student with CSPP subprog or #) Hummel  
Comparative analysis of major models of counseling and psychotherapy.

EPsy 8412. Seminar: Counseling Ethics and Professional Development. (4 cr; prereq EPsy PhD student with CSPP subprog or #) Skovholt  
Ethical and professional development of counseling psychologists.

EPsy 8413. Personality Assessment of Adults. (3 cr; prereq CSPP or counseling psychology doctoral student; offered alt yrs) Skovholt  
Developing expertise in psychological assessment used in counseling clients in colleges and universities, agencies, and similar settings. Structured interviews, objective testing with MMPI, and using DSM3R criteria. Combining this data into written assessment report.

EPsy 8431. Master's Seminar: CSPP. (Cr ar [max 6 cr]; prereq MA student, #) Hummel  
Discussion of significant issues in the field.

## GRADUATE PROGRAMS

EPsy 8435. Integrative Seminar: School Counseling. (3 cr [max 9 cr]; prereq CSPP student in school counselor licensure prog; not open to sr or MEd students, offered alt yrs, A-F only) Professional and ethical issues, problems, and programs related to students in practicum or internship settings.

EPsy 8450. Psychological Aspects of Counseling Supervision. (3 cr, \$PsyS 8150; prereq CSPP doctoral student or #) McCarthy Veach Consideration of theories; review of relevant research; demonstration and in-class practice of supervision skills.

EPsy 8501. Counseling Pre-Practicum. (3 cr; A-F only) McCarthy Veach Demonstration and in-class practice of individual helping skills.

EPsy 8502-8503-8504†. Counseling Practicum I, II, III. (4 cr each; prereq CSPP MA student or #; A-F only) McCarthy Veach, Romano, Skovholt Supervised practice in counseling with individuals and groups; emphasis on systematic evaluation of progress through direct observations, video and audio tapes.

EPsy 8505. Field Placement in Counseling and Student Personnel Psychology. (1-3 cr [max 9 cr]; prereq CSPP MA student or #) Supervised involvement of beginning M.A. students in appropriate agencies.

EPsy 8508. Group Counseling Skills. (2 cr; prereq CSPP grad student, 8404 or #; S-N only) Romano Observation, practice, and processing of group counseling skills and techniques.

EPsy 8509. Supervision Practicum. (2 cr; prereq 8450, CSPP doctoral student or #; A-F only) McCarthy Veach, Romano, Skovholt Supervised practice in development, management, and supervision of counseling practicum.

EPsy 8510. Internship: CSPP. (1-6 cr [max 9 cr for MA and specialist students, 18 cr for PhD students]) McCarthy Veach Supervised employment at department-approved sites.

EPsy 8513-8514-8515†. Counseling Practicum: University Counseling Services. (4 cr per qtr [max 9 cr]; prereq #; S-N only) Levin, Loper Supervised experience in counseling at college and adult levels; 3 consecutive quarters beginning fall.

EPsy 8520. Counseling Practicum: Advanced. (1-3 cr [max 9 cr]; prereq CSPP doctoral student; S-N only) Levin, Skovholt Opportunity to continue development of counseling skills. Each student assigned to senior staff member for supervision.

EPsy 8521. Practicum in Student Personnel Work. (1-3 cr [max 9 cr]; prereq 5420, 5451, 8404, 8504 or #) Supervised practice in college student personnel work in settings selected to match student interest.

EPsy 8612. Current Issues in Learning Disabilities. (4 cr; offered alt yrs) Deno, Espin Survey, analysis, application of relevant theories and research to current issues in the field; development of skill in scholarly inquiry, writing, and debate.

EPsy 8620. Psychological Theory and Research in Mental Retardation. (4 cr, \$PsyS 8120; offered alt yrs) Turnure Review of research and theories in context of relevant developmental theories; important contributions in primary sources concerning principles of cognitive development and applied problems.

EPsy 8621. Functional Analysis of Behavior and Cognition in Persons With Mental Retardation. (4 cr, \$PsyS 8121; prereq 8620 or PsyS 8120 or #; offered alt yrs) Turnure Empirical approach to study of development in persons with mental retardation, emphasizing psychological research; procedures for deriving appropriate field applications; generating and implementing researchable questions.

EPsy 8652. Research in Education of Disturbed Children. (3 cr; prereq #; offered alt yrs) Wilderson Review; critical analysis of specific designs and procedures; critique of current status of research.

EPsy 8677. Seminar: Issues and Research in Visual Impairment. (3 cr [max 9 cr]; prereq 5675, NSc 5031 or Psy 5031 or equiv) Knowlton Research findings from diverse disciplines on impact of visual impairment on social, cognitive, language, and motor development.

EPsy 8702. Seminar: Special Education. (Cr ar; prereq #) Special topics and schedules announced by department.

EPsy 8706. Single Case Designs for Intervention Research. (3 cr) Deno Design and analysis of single case experiments to examine effects of interventions on individual behavior in school, home, and community environments.

EPsy 8760, 8761. Seminar: Administration of Special Education. (3 cr per qtr, \$EdPA 5180, \$EdPA 5181; prereq 5660 or PsyS 5160, EdAd 5103 or #) Weatherman Problems of administration and organization of special education programs.

EPsy 8770. Intervention Strategies for Persons With Developmental Disabilities: Interdisciplinary Perspectives. (3 cr; prereq admission to educ to human servs grad prog or #) Bruininks, McConnell Introduction to principles and procedures.

EPsy 8810. Assessment Approaches in School Psychology I. (3 cr) Christenson, McConnell, Ysseldyke Theories of and models, strategies, and techniques for psychoeducational assessment of child and adolescent within home, school, and community. Conceptual and empirical foundations of eco-behavioral assessment approach in schools; efficient data gathering regarding child's cognitive-intellectual functioning, social-emotional functioning, and educational progress. Interpreting child-oriented assessment data in relation to child's social milieu (home, school, peer environments).

EPsy 8811. Assessment Approaches in School Psychology II. (3 cr)  
 Assessment and decision-making issues, especially for determining eligibility for special education services and developing appropriate interventions for students with disabilities; current practice in assessing students with disabilities; psychometric and legal perspectives on bias in assessment; and introduction to administration of scoring and interpretation of individualized assessment instruments.

EPsy 8812. Assessment Approaches in School Psychology III. (3 cr)  
 Final preparation for school practicum: students recommend comprehensive evaluation and suggest goals for future intervention. Factors affecting reliability of educational diagnosis and evidence for differential diagnosis; guidelines for planning interventions in schools; making placement decisions in special education; and introduction to multidisciplinary team (MDT) process.

EPsy 8813. Assessment Practicum in School Psychology. (2 cr; prereq ¶8810, ¶8811, ¶8812, school psychology student or #) Christenson, McConnell, Ysseldyke  
 Administering assessment devices and communicating results in written and oral forms. Students practice content from 8810, 8811, and 8812 in assigned schools. Guided practice and supervision.

Epsy 8815. Program Development and Systems Consultation. (3 cr; prereq EPsy major) McConnell  
 Theory underlying psychological interventions and analysis of interventions used in schools. Principles and models of consultation, process and content of intervention planning and program development, and analysis of primary and secondary prevention programs to promote competence of children and youth.

EPsy 8816. Instructional Intervention and Consultation. (3 cr; prereq EPsy major; A-F only) Casey, Christenson  
 Theoretical considerations and training in use of functional techniques and appropriate preventive and remedial procedures. Emphasis on psychological implications of individual and classroom instructional practice and consultation skills with school personnel to address academic/instructional concerns.

EPsy 8817. Social-Emotional Intervention and Consultation. (3 cr; prereq EPsy major; A-F only) Christenson  
 Analysis of school-based interventions for psychological problems and childhood disorders. Addresses social-emotional concerns through a systems/ecological service delivery model and consultation with school personnel, family, and community professionals.

EPsy 8818. Intervention Practicum in School Psychology. (1 cr; prereq ¶8815, ¶8816, ¶8817, school psychology student or #) Casey, Christenson, McConnell  
 Observation of school psychologists in collaboration with educators and parents in intervention-related activities. Students design, implement, and evaluate effectiveness of an intervention with individual and/or groups of students under supervision of practicing school psychologists.

EPsy 8820. Seminar: Research in School Psychology. (1 cr [max 6 cr]; S-N only) McConnell, Ysseldyke  
 Seminar for doctoral candidates planning dissertation research in school psychology.

EPsy 8821. Seminar: School Psychology. (Cr ar) Casey, Christenson, Spicuzza, Ysseldyke  
 Intensive study of significant topics from behavioral sciences as they apply to contemporary educational problems.

EPsy 8831!. Practicum: School Psychological Services. (1-5 cr; prereq EPsy major with school psychology subprog or #) Casey  
 Typical functions of school psychologists; assessment procedures, case studies, consultation with parents, school personnel, and community agencies. Field experience under supervision, participation in seminar required.

EPsy 8832!. Clinical Practice in School Psychology. (1-5 cr; prereq 8810) Casey  
 Supervised diagnosis and treatment of children referred to psychoeducational settings; training in broad range of approaches to problems of adjustment in school-age children, their families, schools, and community settings.

EPsy 8840!. Internship: School Psychological Services. (1-15 cr; prereq EPsy major with school psychology subprog or #; S-N only) Casey, Christenson  
 Advanced field experience for doctoral candidates in school psychology.

EPsy 8841. Internship: Instruction and Supervision in School Psychology. (3 cr; prereq EPsy major with school psychology subprog or #) Christenson, McConnell, Spicuzza, Ysseldyke  
 Experience and tutorial for doctoral candidates preparing to train school psychologists in higher education settings.

EPsy 8853. New Approaches to Psychopathology in Children and Adolescents. (3 cr; §CPsy 8606) Egeland  
 Alternative formulation of childhood disorders, emphasizing competency training rather than medical nosology.

EPsy 8900. Research Problems. (Cr ar; prereq # except for sect 3)  
 Research methodology and techniques; examination of literature; participation in formulating and executing research proposal.

EPsy 8905. Landmark Issues and Great Controversies in Educational Psychology. (3 cr; prereq 1st-yr EPsy doctoral student or #) Samuels  
 Overview of intellectual history of educational psychology highlighting philosophical underpinnings, conceptual and theoretical milestones, major debates, and roots of critical issues.

EPsy 8910. Directed Study. (Cr ar; prereq # except for sect 3)  
 Reading and analysis of research on selected problems.

This is the Electrical Engineering through history of Medicine and Biological Sciences program and course sections of the 1996-1999 University of Minnesota Graduate School Catalog

## Electrical Engineering (EE)

*Professor:* Mostafa Kaveh, *head*; Larry L. Kinney, *associate head*; Vernon D. Albertson; Fredric N. Bailey; Steven K. Case; Keith S. Champlin; Stephen Y. Chou; Philip I. Cohen; David H. Du; Tryphon T. Georgiou; Anand Gopinath; Jack H. Judy; Richard Y. Kain; John C. Kieffer; K. S. P. Kumar; E. Bruce Lee; James R. Leger; Ned Mohan; Marshall I. Nathan; Hendrik J. Oskam (*emeritus*); Keshab K. Parhi; Robert P. Patterson; William T. Peria; Dennis L. Polla; Mahmoud Riaz; William P. Robbins; P. Paul Ruden; James R. Slagle; Marian Stachowicz<sup>1</sup>; Allen R. Tannenbaum; Ahmed H. Tewfik; Bruce F. Wollenberg; Pen-Chung Yew

*Adjunct Professor:* Gregory T. Cibuzar; Barry K. Gilbert; David Lamb; David S. Lo; Andrzej Peczalcki; Frank G. Soltis; Frederick M. Waltz

*Associate Professor:* Kevin M. Buckley, *director of graduate studies*; Stephen A. Campbell; Vladimir S. Cherkassky; Douglas W. Ernie; Ramesh Harjani; Ted K. Higman; James E. Holte; Vipin Kumar; Thomas S. Lee; David J. Lilja; Jay Moon; Matthew T. O'Keefe; Nikolaos P. Papanikolopoulos; Gerald E. Sobelman; Jian-Gang Zhu

*Assistant Professor:* Philip Cheung<sup>1</sup>; Shantanu Dutt; Gyungho Lee; Lori E. Lucke; Laurie B. Nelson; Andrew R. Teel; Bapiraju Vinnakota; Michael E. Zervakis<sup>1</sup>

*Other:* William C. Black, Jr.

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S.E.E. (Plan A and Plan B), M.E.E. (Coursework Only and Design Project), and Ph.D.

**Curriculum**—Emphases in the major include solid state and physical electronics, sensors, micromechanics, nanoelectronics, quantum electronics, plasma physics, automatic controls, power systems, power electronics, communication systems and theory, optics, lasers, fiber optics, magnetic devices and systems, VLSI engineering, signal and image processing, computer vision, analog and mixed signal circuits, low-power electronics, microwave devices, and computer and systems engineering. Interdisciplinary work is also available in bioelectrical sciences, bioengineering, control sciences, and computer sciences.

**Prerequisites for Admission**—Graduate work is open to students who have shown exceptional scholarship and ability in an accredited undergraduate curriculum in

electrical engineering or physics. Consideration is given to students who have completed another curriculum in engineering, science, or mathematics which includes sufficient preparation to pursue a graduate program in electrical engineering. In some instances, additional preparatory studies may be required after admission. Students whose training is in engineering technology will not be considered for admission.

**Special Application Requirements**—Scores from the Graduate Record Examination (General Test only) are required of all students desiring financial aid. International students desiring financial aid. International students applying from within the country should furnish letters attesting to their ability to understand technical instruction in English from United States faculty members. Students submitting transcripts from non-American institutions should furnish letters of recommendation that verify their academic standing in a specific way (e.g., class rank). Entry other than in fall quarter is not recommended. Applicants for fall quarter admission interested in financial aid should file a completed admission application with the Graduate School by December 15 for admission the following September and should send a copy of their application materials directly to the department.

**Master's Degree Requirements**—The minimum credit requirements established by the Graduate School are used by the electrical engineering program; however, colloquium credits cannot be applied toward the degree, and the number of seminar and special investigations credits that can be applied is limited (see the program's graduate student handbook for details).

For the M.S.E.E. degree, part-time students are encouraged to choose the Plan B program, whereas full-time students may choose either Plan A or Plan B. For the M.E.E. degree, see Professional Master's Degree in Engineering in the General Information section of this bulletin. The M.E.E. degree is offered under both the design project and coursework-only tracks. The final examination for the M.S.E.E. degree is oral, but no final oral examination is required for the M.E.E. degree taken under the coursework-only track.

<sup>1</sup> University of Minnesota, Duluth

All master's students must maintain a 3.00 GPA or be denied further registration; consult the program's graduate student handbook for details. All coursework on the program must be taken under A-F grading (unless that option is not available for a particular course).

**Doctoral Degree Requirements**—The preliminary written examination is conducted by the department twice each year. Students who enter the program with the M.S. degree in electrical engineering must pass the examination during their first academic year in residence. All other students must pass the examination before the end of their second academic year in residence. The department requires that each Ph.D. program include a minimum of 60 credits, of which at least 9 credits must be in advanced graduate courses (8xxx), and that all coursework in the degree program be taken under A-F grading (unless that option is not available for a particular course); consult the department for details. Each Ph.D. student must satisfactorily complete the department's program in oral paper presentation before the thesis proposal will be approved. All Ph.D. students must maintain a 3.30 GPA to register; see the program's graduate student handbook for details.

**Minor Requirements for Students Majoring in Other Fields**—Credits presented to satisfy the minor requirement in electrical engineering must be from classroom and laboratory courses graded on an A-F scale. In particular, colloquia, seminar, and special investigations credits do not count toward meeting the minor requirements.

**Language Requirement**—None.

**For Further Information and Applications**—Contact the Director of Graduate Studies, Department of Electrical Engineering, University of Minnesota, 4-178 Electrical Engineering/Computer Science Building, 200 Union Street S.E., Minneapolis, MN 55455 (612/625-3564; fax 612/625-4583; e-mail graduate\_studies@ee.umn.edu).

EE 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

EE 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

EE 8888. Thesis Credits: Doctoral. (36 cr required)

### Courses Acceptable Only for Satisfaction of Minor Requirements

EE 5002. Digital Signal Processing. (3 cr; prereq upper div EE major or grad IT major, 3012 or #) Buckley, Lucke, Moon, Tewfik  
General concepts of signal processing; discrete-time systems and digital filters.

EE 5003. Digital Signal Processing Laboratory. (1 cr; prereq upper div EE major, 3402 or ¶3402, 5002 or #) Buckley, Lucke, Moon, Tewfik  
Computer experiments in digital signal processing and digital filter design.

EE 5053. Design of Digital Circuits. (3 cr; prereq upper div EE major or grad IT major, 3062 or #) Champlin  
Design of modern digital integrated circuits at subsystem level. Nonlinear device models, use to predict system performance. Comparison of performance and topology of various logic families including TTL, MOS, CMOS, PL, and ECL.

EE 5055. Instrumentation and Control Electronics. (4 cr; prereq upper div EE major or grad IT major, 3012 or ¶3012, 3062 or #) Champlin, Robbins  
Characteristics of operational amplifiers; applications of operational amplifiers including A-D and D-A converters; compensation of operational amplifiers; power amplifiers; semiconductor controlled rectifiers, applications; linear and switching voltage regulators.

EE 5056. Electronics Circuits Laboratory. (1 cr; prereq IT student or grad IT major, 3402 or ¶3402, ¶5055) Champlin, Robbins

EE 5090. Digital Circuit Design Laboratory. (1 cr; prereq 3402 or ¶3402, ¶5053) Champlin

EE 5151. Materials and Devices I. (4 cr; prereq IT student or grad IT major, 3062, 3111, Phys 3501 or #) Nathan, Robbins  
Fundamental electronic properties of materials, with emphasis on semiconductors. Carrier transport and statistics. Diodes, BJTs, LASERS.

EE 5161. Materials and Devices II. (4 cr; prereq 5151 or #) Nathan, Ruden  
Introduction to fundamental physical properties of device structures and dielectrics. Metal semiconductor contacts, MOS structures, fiber optics, superconductors.

EE 5162. Solid-State Transducers. (3 cr; prereq IT student or grad IT major, 3060, 3111, Phys 3501 or #) Polla  
Design and operation of solid state devices used for transducing physical and chemical signals.

EE 5202. Analog Communication. (3 cr; prereq upper div EE major or grad IT major, 3012, Stat 3091 or #) Nelson, Tewfik  
Selected topics in analog communication systems: amplitude and frequency modulation. Spectral analysis and effect of noise in modulation systems. Detection.

EE 5203. Digital Communication. (3 cr; prereq upper div EE major or grad IT major, 3012, 5202, Stat 3091 or #) Kaveh, Moon, Nelson

Selected topics in pulse and digital communication systems: pulse modulation systems, pulse-code modulation. Data-transmission systems including phase-shift keying and frequency-shift keying. Effect of noise. Coding.

EE 5240. Analog Communications Laboratory. (1 cr; prereq 3402 or ¶3402, ¶5202) Nelson, Tewfik

EE 5241. Digital Communications Laboratory. (1 cr; prereq 3402 or ¶3402, ¶5203) Kaveh, Moon, Nelson

EE 5253. Linear Control Systems. (3 cr; prereq upper div EE major or grad IT major, 3012 or #) Bailey, Teel

Modeling, characteristics, and performance of feedback control systems. Stability, root-locus, and frequency-response methods. Compensator design.

EE 5255. Digital Control Systems. (3 cr; prereq upper div EE major or grad IT major, 3351, 3352 or equiv, 5002 or ¶5002 or #) Bailey, Georgiou, Tannenbaum

Time- and frequency-domain analysis of discrete-time and digital control systems. Data conversion and interfacing. Digital computers as control system components. Software and hardware considerations in digital control system design.

EE 5290. Digital Control Systems Laboratory. (1 cr; prereq 3402 or ¶3402, ¶5255) Bailey, Georgiou, Tannenbaum

EE 5291. Linear Control Systems Laboratory. (1 cr; prereq 3402 or ¶3402, ¶5253) Bailey, Teel

EE 5300. Electromechanics. (4 cr; prereq upper div EE major or grad IT major, 3011, 3110) Mohan, Riaz

Principles of electromechanical energy conversion with applications to actuators, transducers, and rotating machines. Performance characteristics derived from analytical models of AC and DC machines.

EE 5310. Electric Power Systems. (4 cr; prereq IT student or grad IT major, 3402 or ¶3402, 5300 or #) Albertson

Introduction to power system engineering. Modeling of power-system components: transformers, synchronous generators, transmission lines, cables, and circuit breakers. Describing equations for power networks. Solution techniques for load-flow and fault studies. Power system relaying.

EE 5315. Electromechanics in Robotics. (3 cr; prereq upper div EE major, 3012, 5300 or #) Mohan  
Modeling of mechanical system elements. Sensors and encoders for speed and position control. Mathematical modeling and control of DC-, “brushless” DC-, induction-, and stepper-motors in incremental motion systems. Torsional resonances and optimum design in high performance systems. Design examples.

EE 5322. Electromechanical Processes and Devices. (4 cr; prereq IT student or grad IT major, 3402 or ¶3402, 5300 or #) Mohan  
Principles of electromechanical energy conversion. Modeling of rotating machines. Computer-aided steady-state analysis of DC and AC machines. Special purpose devices: single-phase machines, linear machines, stepper motors. Solid-state motor control.

EE 5355. Microprocessor Interfacing and System Design. (4 cr; prereq upper div EE major or grad IT major, 3351, 3352, 3402 or ¶3402 or #) Lilja  
Microprocessor interfacing. Memory design. Exception handling. Parallel and serial input/output: techniques and devices. Bus arbitration control and multimaster systems. Direct memory access. Designing dynamic RAM memory systems. Memory management. Integral lab.

EE 5358. Digital Design With Programmable Logic. (4 cr; prereq 3351, 3352, upper div EE major or grad IT major or adult spec) Kinney  
Focuses on designing viable projects using Mentor Graphics ECAD tools and Xilinx field programmable gate arrays.

EE 5470. Directed Study. (Cr or [may be repeated for cr]; prereq Δ)  
Studies of approved topics, theoretical or experimental in nature.

### Courses Acceptable for Satisfaction of Either Major or Minor Requirements

EE 5505. Analog Integrated Circuit Design. (3 cr; prereq grad student or #) Harjani  
Review of MOS fabrication technology and device-level models. Basic equations and higher-order effects. Noise. Basic CMOS building blocks: current mirrors, differential pairs, transconductance amplifiers, etc. Unbuffered operational amplifiers; single-stage, Miller-compensated and folded-cascode. Output stages and comparators.

EE 5506. Analog Circuits for Signal Processing. (3 cr; prereq 5505, grad student or #) Harjani  
Review of filter types and Laplace and Fourier transforms; time and frequency-domain concepts; approximation methods (Butterworth, Chebyshev, etc.); frequency transformations. Ideal and non-ideal operational amplifiers. Switched-capacitor filters: biquads and higher-order filters. Switched-capacitor gain stages, rectifiers, and oscillators.

EE 5511. Digital Filtering and Signal Processing. (3 cr; prereq grad IT major, 5002 or #) Parhi  
Review of theory of linear shift-invariant, discrete-time systems (z-transform, discrete-time Fourier transform, sampling, discrete Fourier transform); interpolation and decimation; fast Fourier transform and fast convolution; finite-impulse-response filter design approaches and techniques; infinite-impulse-response filter design approaches and techniques; quantization.

EE 5512. Adaptive Digital Filter Theory. (3 cr; prereq grad IT major, 5511, 5702 or #) Buckley  
Review of partial characterization of discrete-time random processes, correlation matrix eigenstructure; autoregressive modeling; FIR Wiener filter theory; linear prediction; least squares; LMS algorithm (transient and steady state behavior); RLS algorithm; lattice structure.

EE 5513. Multiscale and Multirate Signal Processing. (3 cr; prereq 5511, 5702, grad IT major or #) Tewfik

Discrete time linear systems, sampling of continuous and discrete time signals; multirate discrete time systems; bases and frames; continuous wavelet transforms; scaling equations; discrete wavelet transforms; applications in signal and image processing.

EE 5514. Real-time Digital Signal Processing Lab. (3 cr; prereq 3352, 5511, EE sr or grad IT major or adult spec or #) Buckley

Real-time computation of digital signal processing functions, including filtering, sample-rate change, and differential pulse code modulation; implementation of a current digital signal processing chip; chip architecture, assembly language and arithmetic; real-time processing issues, including data quantization, limiting and scaling, processor limitations, and I/O handling.

EE 5515. Fast Fourier Transform and Convolution Algorithms. (3 cr; prereq 5002 or #) Sobelman

Theory and implementation of fast algorithms for Discrete Fourier Transform and convolution, including both one-dimensional and multidimensional cases.

EE 5560. Biomedical Instrumentation. (4 cr; prereq #) Holte

Biological signal sources. Electrodes, microelectrodes, other transducers. Characteristics of amplifiers for biomedical applications. Noise in biological signals. Filtering, recording, and display. Protection of patients from electrical hazards. Experiments in neural and muscle stimulation, EKG and EMG recording, neuron simulation, filtering and low-noise amplifiers.

EE 5561. Magnetism: Physics, Geophysics, and Engineering. (3 cr, §Geo 5561, §Phys 5545; prereq Phys 1253, IT major or grad IT major or IT adult spec)

Elementary statistical mechanics, rock magnetism, and micromagnetic modeling; applications of magnetism in geophysics, biomagnetism, magnetic sensors and recording.

EE 5571. VLSI Design I. (3 cr; prereq EE or CSci or Phys grad student or #) Lucke, Sobelman

CMOS switch model, stick diagrams, restoring logic, and steering circuits. Process flows, layout design rules, and latch-up avoidance. Parasitic resistance and capacitance, delay models, design optimization, and worst-case design. Dynamic circuit techniques, including precharging, Domino CMOS, multiple-phase clocking, charge sharing, clock generation, and synchronization failure. Subsystem design, including multiplexers, registers, decoders, PLAs, finite state machines, adders, and function units.

EE 5572. VLSI Design II. (3 cr; prereq 5571 or #) Vinnakota

Design methodologies, switch-level simulation, symbolic layout, and compaction. CMOS fault models, scan design, signature analysis, and built-in test. Computational unit design, including arithmetic-logic units, counters, fast multipliers, and barrel shifters. Memory architectures, RAM and ROM cells, sense amplifiers, content-addressable memory, and hardware stack. VLSI system case studies.

EE 5573. VLSI Design III. (3 cr; prereq 5572 or #) Sobelman

Register files, busing structures, pipelining, and fine-grained parallelism. Control structures based on random logic, PLAs and ROMs. Multilevel control schemes and microsequencer design. RISC architectures, including overlapped register windows, delayed branching, pipeline interlocks, and hardware-software trade-offs. Memory management units and cache memory design. VLSI system case studies.

EE 5574-5575†. Computer-Aided VLSI Design Laboratory. (3 cr per qtr; prereq IT sr or IT adult spec or grad IT major, # and 5571 or ¶5571 for 5574, 5574 and 5572 or ¶5572 for 5575) Lucke, Sobelman

Creative use of design aids in parameter extraction, schematic capture, chip layout, channel-routing, maze-routing, multilevel simulation, and artwork verification. Complete design of integrated circuits in MOS and bipolar technologies. Designs evaluated by computer simulation.

EE 5576. VLSI Modeling and Processing. (3 cr; prereq 5572 or #) Parhi

Advanced modeling and processing; arithmetic considerations. Algorithmically specialized processors: locality, pipelining, and interconnection patterns. Special algorithms for signal processing, finite element problems, and tree search (optimization).

EE 5604. Introduction to Microwave Engineering. (3 cr; prereq EE sr or grad IT major, 3111 or equiv) Champlin

Review of Maxwell's equations, wave equation, transmission lines. Circuit theory of waveguiding systems. Transmission lines and lumped elements, conventional and planar structures. Impedance transformation and matching. Passive devices. Resonators. Filters.

EE 5605. Microwave Devices and Circuit Applications. (3 cr; prereq 3111, 5604 or equiv or #) Champlin, Gopinath

Two-terminal devices, including varactors, p-i-n diodes, step-recovery diodes, Gunn devices and Impatt diodes for device physics and circuit applications as detectors, mixers, frequency converters, amplifiers, and oscillators. Three-terminal devices, including FETs and Heterostructure Bipolar Transistors, device physics and circuit applications in amplifiers, oscillators, mixers, and frequency converters.

## GRADUATE PROGRAMS

EE 5606. Antenna Theory and Design. (3 cr; prereq 3111 or #) Champlin  
Fundamentals of antenna design for transmission and reception at radio and microwave frequencies. Antenna analysis techniques. Antenna applications including linear, loop, microstrip, aperture, and traveling wave antennas; broadband antennas and antenna arrays.

EE 5625. Fourier Optics. (4 cr; prereq 3011, 3111 or #) Leger

Fourier analysis of optical systems and images with applications to spatial filtering, optical information processing, and holography, Fresnel and Fraunhofer diffraction. Current topics such as speckle interferometry, hybrid (optical-digital) information processing systems, and computer-generated holograms.

EE 5630. Contemporary Optics. (4 cr; prereq 3111 or Phys 5024 or #) Leger

Fundamentals of lasers, including propagation of Gaussian beams, optical resonators, theory of laser oscillation, electro-optic and acousto-optic modulation, and nonlinear optics.

EE 5631. Photonic Devices. (3 cr; prereq EE sr or grad IT major, 5630 or 5661) Higman, Ruden  
Optical properties of semiconductors, light-emitting diodes, lasers, and photodetectors.

EE 5634. Physical Optics: Applications and Techniques. (3 cr; prereq 5625 or #) Leger  
Applications of interference, diffraction, and polarization in optical systems. Diffractive optical elements and microlenses. Volume diffraction in color and reflection holograms. Interferometry in astronomy and spectroscopy. Optical pattern recognition and optical computing.

EE 5635. Optical System Design. (3 cr; prereq IT sr or grad IT major) Nussbaum  
Elementary or paraxial optics. Non-paraxial, exact ray tracing. Energy considerations in instrument design. Fourier optics and image quality. Design examples: telescopes, microscopes, diffraction-limited lenses, projectors, and scientific instruments.

EE 5636. Optical Fiber Communication. (3 cr; prereq 3011, 3111 or #) Gopinath  
Components and systems aspects of optical fiber communication. Modes of optical fibers. Signal degradation and dispersion. Optical sources and detectors. Digital and analog transmission systems. Direct detection and coherent detection.

EE 5637. Physical Optics Laboratory. (3 cr; prereq 5625 or #) Leger  
Fundamental optical techniques, diffraction, optical pattern recognition, spatial and temporal coherence, speckle; interferometry, coherent and incoherent imaging, coherent image processing, and fiber optics. Also includes lab experiments at local industries.

EE 5650. Physical Methods in Solid State Materials I. (3 cr; prereq EE sr or adult spec or grad student, 3111) Cohen

Basic concepts in classical and statistical mechanics relevant to properties of solid state materials. Hamiltonian dynamics, statistical ensembles, phase space, partition function, classical and quantum statistics, relation between statistical mechanics and thermodynamics, Boltzmann transport theory.

EE 5651. Physical Methods in Solid State Materials II. (3 cr; prereq 5650 or #) Cohen  
Application of quantum theory to solid state materials. Schrödinger's equation, one-dimensional problems, angular momentum, central forces, scattering, spin, atomic and chemical structure. Crystal structure in solids, lattice vibrations and phonons, energy bands.

EE 5652. Physical Methods in Solid State Materials III. (3 cr; prereq 5651 or #) Nathan, Ruden  
Physical properties of solid state materials. Properties of insulators and doped semiconductors, transport and scattering in semiconductors, Hall and thermal effects, quasi-Fermi levels, generation and recombination. Conduction in metals, superconductivity. Magnetic properties of materials. Amorphous materials.

EE 5661. Semiconductor Properties and Devices I. (3 cr; prereq EE sr or adult spec or grad student, 5650, 3111 or #) Chou, Nathan  
Principles and properties of semiconductor devices. Semiconductor materials, statistics, and transport. Aspects of transport in p-n junctions, heterojunctions.

EE 5662. Semiconductor Properties and Devices II. (3 cr; prereq EE sr or adult spec or grad student, 5661) Chou, Nathan, Ruden  
Principles and properties of semiconductor devices. Charge control in different FETs, transport, modeling. Bipolar transistor models (Ebers-Moll, Gummel-Poon), heterostructure bipolar transistors. Special devices.

EE 5666-5667. Magnetic Properties of Materials and Applications. (3 cr per qtr; prereq #) Judy  
5666: Magnetic measurement techniques, physical principles of magnetism, and properties of magnetic materials with applications. 5667: Physical principles of crystalline and induced magnetic anisotropy, magnetostriction, magnetic domains and the magnetization process, fine particles and thin films and magnetization dynamics.

EE 5669. Magnetic Recording. (3 cr; prereq #) Judy, Zhu  
Review of fundamental magnetic concepts relevant to magnetic recording. Introduction to basic models of longitudinal and perpendicular magnetic recording and reproduction processes. Comparison of design, fabrication, and performance of conventional and thin film heads, tapes, disks, and recording systems.

EE 5670. Basic Microelectronics. (3 cr; 5670-5672†; prereq EE sr or adult spec or grad student) Campbell

Experimental and theoretical studies of the basic physical processes used in microelectronic device fabrication. Transistor and integrated-circuit layout, fabrication, and evaluation.

EE 5672. Basic Microelectronics Laboratory. (1 cr; prereq IT sr or adult spec or grad student, 5670 or ¶5670) Campbell

Students fabricate a polysilicon gate, single-layer metal, NMOS chip, performing about 80 percent of processing, including photolithography, diffusion, oxidation, and etching. In-process measurement results compared with final electrical test results. Simple circuits used to estimate technology performance.

EE 5673. Advanced Microelectronics. (3 cr; prereq IT sr or adult spec or grad IT student, 5670, 5672 or ¶5672) Campbell

Integration of unit processes into a fabrication technology; physics and chemistry of advanced techniques such as molecular beam epitaxy, electron beam lithography, and reactive ion etching.

EE 5680. Principles of Thin Film Technology. (4 cr; prereq IT sr or grad IT major) Judy

Introduction to principles of fabrication, characterization, and processing of thin films for engineering applications. High-vacuum systems, thin film deposition techniques, energetics and kinetics of thin film formation, and electrical, dielectric, magnetic, optical, and piezoelectric properties of thin films. Lab.

EE 5700. Information Theory and Coding. (3 cr; prereq Stat 3091 or #, IT sr or EE adult spec or grad student) Kieffer, Nelson

Discrete information sources and channels, source encoding, the binary channel and Shannon's second theorem. Block codes for the binary channel.

EE 5702. Stochastic Processes and Optimum Filtering. (3 cr; prereq Stat 3091, grad standing or #) Kieffer

Stochastic processes, linear system response to stochastic inputs. Gaussian process, Markov process. Linear filtering, maximum-likelihood estimate, stochastic control.

EE 5704. Digital Communication. (3 cr; prereq 5203, Stat 3091, upper div EE major or grad IT major or #) Moon

Theory and techniques: channel capacity, modulation and detection, data transmission over channels with large intersymbol interference, optimal and suboptimal sequence detection, equalization, error correction coding, and trellis-coded modulation.

EE 5712. Kalman Filtering and Applications. (3 cr; prereq grad student, 5702, Stat 3091 or #) Bailey, E B Lee

Mathematical description of random signals; response of linear systems to random inputs. Discrete Kalman filter; applications. Continuous Kalman filter; smoothing; nonlinear extensions.

EE 5750. Topics in Linear Systems. (3 cr; prereq grad student, Math 5242 or #) E B Lee, Tannenbaum  
State variable and input/output models of linear systems. Controllability, observability, stability, minimality, and structure. State variable feedback and observers.

EE 5751. Linear Optimal Control. (3 cr; prereq grad IT major, 5750, Math 5243 or ¶Math 5243 or #) Georgiou, E B Lee

Time- and frequency-domain models of multiple-input-multiple-output systems. Linear-quadratic and linear-quadratic-Gaussian problems. Properties of linear-quadratic and linear-quadratic-Gaussian regulators. Output feedback and separation theorem.

EE 5752. Computer-Aided Design of Control Systems. (3 cr; prereq grad IT major, 5751 or #) Tannenbaum, Teel

Development of control system design problem. Frequency response techniques in design of single-input-single-output and multiple-input-multiple-output control systems. Robust control concepts. Computer-aided design tools, application in design of single-input-single-output and multiple-input-multiple-output control systems with robust performance.

EE 5760. Biological System Modeling and Analysis. (4 cr; prereq #) Holte

Purposes of biological system modeling; advantages, limitations, and special problems. Models of nerve excitation and propagation. Biological control systems: respiratory system, cardiovascular system. Sensory organs and various theories of perception. Limbs and locomotion.

EE 5802. Electric Power System Analysis. (3 cr; prereq 3010, 5300, 5310, IT sr or grad IT major or IT adult spec or #) Wollenberg

Formulating equations for describing electric power networks. Advanced computer methods for large-scale electric power systems. Application to power-flow, faulted system calculations, and stability studies.

EE 5803-5804. Power Generation, Operation, and Control. (3 cr per qtr; prereq grad IT major, 5802 or #) Wollenberg

Economic dispatch of generation units, transmission system loss models, unit scheduling via dynamic programming and Lagrange relaxation algorithms, fuel and hydro scheduling via linear programming and transportation algorithms, energy production costing algorithms, evaluation of energy transactions between suppliers, energy management systems, real time control of generating units, system security evaluation, state estimation techniques, optimal power flow algorithms.

EE 5805. Electric Power System Engineering. (3 cr; prereq 3010, 5300, 5310, IT sr or grad IT major or IT adult spec or #) Wollenberg

Control of large power systems. Power system overvoltages and transients caused by faults, switching surges, and lightning. AC and DC electric power transmission and distribution; overhead and underground. Environmental impact of electrical energy systems. Current research topics.

## GRADUATE PROGRAMS

EE 5807. Power System Protection. (3 cr; prereq 3010, 5300, 5310, IT sr or grad IT major or IT adult spec or #) Wollenberg

Fundamentals of fault condition calculations, modern power system circuit breakers and interrupt devices. Sensing transducers for input to protection relays, differential principle, time-overcurrent protection; directional and distance sensing, backup protection. System grounding principles, generator protection, and transformer, reactor, and shunt capacitor protection. Bus and line protection.

EE 5814. Switched Mode Power Electronics I. (3 cr; prereq IT sr or IT adult spec or grad IT major, 3061, 3402 or #) Mohan

Overview of power capabilities and switching speeds of power semiconductor devices. Generic converter topologies and regulation techniques. Application and design of generic circuits such as switching power supplies, inverter devices for motors, battery chargers, uninterruptible power supplies, wind/photovoltaic inverters.

EE 5815. Switched Mode Power Electronics II. (3 cr; prereq IT sr or IT adult spec or grad IT major, 5814 or #) Champlin, Robbins

Limitations and methods of increasing power capabilities of switching devices. Device physics, switching characteristics, gate/base drives, stress reduction and loss considerations in using devices such as BJTs, MOSFETs, Gate-Turn-Off Thyristors. Future developments. Passive components and circuit layout in switched mode power electronics.

EE 5816. Switched Mode Power Electronics Laboratory. (2 cr; prereq IT sr or IT adult spec or grad IT major, ¶5815 or #) Mohan

Switching characteristics of power semiconductor devices. Gate/base drives and snubbers. DC to DC converter circuits. Design and control of a switching power supply. Drives for DC-, induction-, "brushless" DC-, and stepper-motors. Battery chargers and uninterruptible power supplies. Other residential and industrial applications.

EE 5820. Electromechanical System Dynamics. (3 cr; prereq #) Riaz

Electromechanical transducers and rotating machines with emphasis on their dynamic performance in systems. State models of machines. Computer-aided analysis of typical transient operations. Small-signal analysis. Transient stability of power systems. Electromechanical components in control systems. Engineering applications.

EE 5825. Finite-Element Methods in Electrical Engineering. (3 cr; prereq #, grad IT major or EE sr) Riaz  
Finite-element methods for solving electromagnetic field problems. Electric circuit approach to finite-element analysis. Engineering applications selected from two-dimensional problems in electrostatics, magnetostatics, and electric conduction. Computer implementation.

EE 5851. Applied Switching Theory. (3 cr; prereq 3351, 3352 or #) Vinnakota

Review of traditional logic design methods; algorithmic state machine method; synthesis of sequential synchronous and asynchronous machines; synthesis by programmable devices; linear sequential circuits; Von Neumann architectures; register transfer language; hardware description in RTL.

EE 5852-5853. Computer Organization and Design I-II. (3 cr per qtr; prereq 3351, 3352, ¶5851) Cherkassky, Dutt, O'Keefe

Digital computer organization; register-level simulation; control unit design; microprogramming; memory organization. Input-output techniques; arithmetic unit design; features of larger computers.

EE 5854. Advanced Computer Networks. (3 cr; prereq grad IT major or EE adult spec student, CSci 5211 or #) Cherkassky

International Standards Organization (ISO) network architecture; topology analysis; data communication; satellite and packet radio networks; distributed systems and case studies.

EE 5858. Computer Architecture. (3 cr; prereq IT sr or adult spec or IT grad student, 5853 or #) Kain, G H Lee

Conventional and unconventional uniprocessor system design options. Impact of software on system architecture. Instruction set selection and architectural consequences. Memory systems, including segmentation, paging, and cache memories. Control unit design. Object manipulation structures. Examples from current and historically important designs.

EE 5860. Microcomputer Architecture. (4 cr; prereq grad IT major, 5355 or #) O'Keefe

Advanced microprocessor organization, 16- and 32-bit microprocessors, microprocessor bus structures, exception processing, interrupts, and virtual memory. Coprocessor organizations and multiprocessor systems. Design for testability. Integral lab.

EE 5863. Computer Systems Performance Analysis. (4 cr; prereq 5858, grad IT major or #) Lijia

Tools and techniques for measuring and analyzing computer hardware, software, and system performance; benchmark programs, measurement tools, performance metrics; presenting data, summarizing measured data, comparing system performance; deterministic and probabilistic simulation techniques, random number generation and testing; bottleneck analysis.

EE 5865. Coding Techniques and Applications. (3 cr; prereq grad IT major or #) Kinney

Linear error detecting/correcting codes, application to computers, polynomial description of codes, cyclic codes, encoder and decoder circuits, application to magnetic tapes, random test vector generation for self-test, signature analysis for data compression.

EE 5874. Simulation and Test in Digital Design. (3 cr; prereq 5851, CSci 3113 or equiv, IT sr or grad IT major or IT adult spec) Vinnakota  
Theory and practice of simulation and test generation algorithms in digital design.

EE 5952. Special Topics in Electrical Engineering. (1-3 cr; prereq grad IT major or adult spec or #)

Topics vary according to needs and staff.

- EE 8060. Advanced Bipolar Transistor Theory. (3 cr; prereq 5660 or 5661 or #) Chou Recent developments in device modeling with emphasis on bipolar junction transistors. High-level effects in base and collector regions and their interrelationship.
- EE 8090. Electronics Seminar. (Cr or [may be repeated for cr]; prereq #)  
Current literature; individual assignments.
- EE 8110-8111. Plasma Physics. (3 cr per qtr; prereq 5652 or equiv, #) Ernie  
Plasma theory; electron and ion orbits, self-consistent solutions, Maxwell-Boltzmann transport equation, introduction to magnetohydrodynamics. Collision phenomena: introduction to the theory of collision, basic collision processes, methods of measurement. Topics: theory of breakdown of gases, types of discharges, emission of radiation by free electrons in a plasma.
- EE 8140. Seminar: Plasma Physics. (Cr or [may be repeated for cr]; prereq #)  
Current literature; individual assignments.
- EE 8143. Seminar: Modern Optics. (Cr or [may be repeated for cr]; prereq #)  
Current literature; individual assignments.
- EE 8153-8154. Properties of Semiconductors. (3 cr per qtr; prereq #) Chou, Nathan, Ruden  
Application of modern solid-state theory to study of specific semiconductor materials. Influence of band structure and scattering mechanisms upon the electrical, optical, thermal, and thermoelectric properties. Plasma effects in semiconductors at low and high frequency. Mathematical treatments of generation-recombination kinetics, carrier injection, drift and diffusion. Use of semiconductor properties in devices, especially devices of current importance.
- EE 8160. Quantum Electronics. (3 cr; prereq 5630, #) Gopinath  
Properties of quantum systems: energy levels of atoms, molecules, and magnetic ions in crystals. Interaction of radiation with matter. Stimulated emission. Ammonia masers. Paramagnetic resonance. Three-level solid-state microwave masers, cavity and traveling wave. Noise properties. Optical masers: resonator properties and pumping methods. Solid-state spectroscopy. Gas optical masers.
- EE 8164. Quantum Electronics II (Guided Wave Optics). (3 cr; prereq 5630, grad IT major or #) Gopinath  
Planar optical wave guides and optical fibers, ray and wave analysis. Nonlinearities, nonlinear devices, modulators, switches, solitons, optical fiber amplifiers, and active planar amplifiers.
- EE 8185. Low Power Analog Circuit Design. (3 cr; prereq grad IT major, 5505, 5506 or #) Harjani  
Advanced techniques for designing CMOS analog integrated circuits. Emphasis on low power and low voltage design techniques. Weak inversion models, advanced opamp topologies, low power comparator design, low power data converters.
- EE 8190. Seminar: Quantum Electronics. (Cr or [may be repeated for cr]; prereq #)  
Current literature; individual assignments.
- EE 8191. Seminar: Surface Physics. (Cr or [may be repeated for cr]; prereq #)  
Current literature; individual assignments.
- EE 8192. Seminar: Magnetics. (Cr or [may be repeated for cr]; prereq #)  
Current literature; individual assignments.
- EE 8203-8204. Signal Detection and Estimation Theory With Applications. (3 cr per qtr; prereq 5702 or #) Kaveh, Nelson  
Risk theory approach to detection and estimation, random process representation, signal parameter estimation. Waveform estimation; detection of phase, frequency, and delay in signals. Applications to communications and radar-sonar signal design and processing.
- EE 8205. Image Processing and Applications. (3 cr; prereq grad student, 5002, 5700 or #) Tannenbaum, Tewfik  
Two-dimensional digital filtering and transforms, application to image enhancement, restoration, compression and segmentation.
- EE 8207. VLSI Digital Signal Processing Architectures. (3 cr; prereq grad IT major, 5571 or #) Lucke, Parhi  
Characteristics of DSP computations; iteration bound; high-level transformations such as unfolding, pipelining and retiming; implementation of computer arithmetic structures; carry-save arithmetic; canonic signed digit number systems; high-level synthesis of bit-serial systems; synthesis of dedicated DSP architectures.
- EE 8211. Coding Theory. (3 cr; prereq 5700 or #) Sobelman  
Error correcting codes; cyclic codes, finite fields, and BCH codes; majority logic decoding; burst error correction, convolutional codes.
- EE 8220. Topics in Statistical Theory of Communication. (3 cr [may be repeated for cr with #]; prereq 5700, 5702 or #)  
Selected special topics associated with recent advances in statistical communication theory.
- EE 8240. Seminar: Communication. (Cr or [may be repeated for cr]; prereq #)  
Current literature; individual assignments.
- EE 8250-8251-8252. Advanced Control Topics. (3 cr per qtr; prereq #) E B Lee, Tannenbaum, Teel  
Adaptive and learning systems, discrete systems, invariance, optimum control of deterministic and stochastic processes, modeling of physical systems, and stability of dynamical systems.
- EE 8257, 8258. Advanced Systems Theory I, II. (3 cr per qtr; prereq grad IT major, #) Georgiou  
Generalized linear systems: applications, structural properties, computational approaches, classification, functorial behavior, and synthesis.

## GRADUATE PROGRAMS

EE 8260. Topics in Nonlinear Systems. (3 cr; prereq #)

Current topics in stability analysis of nonlinear systems, design of controllers for nonlinear systems, discrete-time and stochastic nonlinear systems.

EE 8290. Seminar: Control Theory. (Cr ar [may be repeated for cr]; prereq #)

Current literature; individual assignments.

EE 8291. Seminar: System Theory. (Cr ar [may be repeated for cr]; prereq #)

Current literature; individual assignments.

EE 8305. Sparse Matrix Methods in Power System Analysis. (3 cr; prereq 5802, grad IT major or #) Wollenberg

Solving sets of equations that involve large sparse matrices. Sparse matrix storage, ordering schemes, application to power flow, short circuit calculation, optimal power flow, and state estimation.

EE 8340. Seminar: Electric Power. (Cr ar [may be repeated for cr]; prereq grad IT major or #)

Current literature, individual assignments in the areas of power systems and electromechanics.

EE 8341. Seminar: Energy Conversion. (Cr ar [may be repeated for cr]; prereq grad IT major or #)

Physical processes involved in converting nonelectrical energy to electrical energy and devices that exploit these processes.

EE 8342. Power Electronics: Utility Applications. (3 cr; prereq 5814, grad IT major or #) Mohan

Impact of power electronics loads on power quality. Passive and active filters. Active input current wave shaping. HVDC transmission. Static VAR control, energy storage systems. Interconnecting photovoltaic and wind generators. Static phase shifters and circuit breakers for flexible AC transmission (FACTS).

EE 8352. Fault Diagnosis and Reliable Design. (3 cr; prereq #) Kinney

Generation of fault tests for combinational and sequential machines; experiments on sequential machines; simulation techniques; redundancy techniques; linear sequential circuits and codes; current topics.

EE 8353. Sequential Circuit Theory. (3 cr; prereq #) Kinney

Analysis and synthesis of asynchronous sequential circuits; algebra of partitions; simplification of incompletely specified sequential machines; state assignments; current topics.

EE 8359. Computing With Neural Networks. (3 cr; prereq EE or Math or CSci grad student or #)

Cherkassky

Neural networks as computation model. Relationship to AI, statistics, and algorithmic computing. Neural network models and learning rules. Applications to associative recognition/retrieval, optimization, expert systems. Software/hardware implementations and scaling issues.

EE 8362. Advanced Computer Architecture.

(3 cr; prereq grad IT major, 8355, 8356 or #) G H Lee  
High-speed uniprocessor design. Amdahl's Law. Static (VLIW) and dynamic (scoreboarding, Tomasulo's algorithm, multithreading) instruction scheduling techniques, multiple instruction issue (superscalar). Pipelining and pipeline design, vector units, interrupts and interrupt handling. Branch handling strategies. Performance evaluation and benchmarking.

EE 8363-8364. Parallel Processing I, II. (3 cr per qtr; prereq grad IT major, 5858 or #) Dutt, G H Lee  
Parallel computer organization and architecture; shared and distributed memory architectures; synchronization techniques; static and dynamic scheduling; hardware/software interaction in parallel systems; parallel system software and compilers; example parallel machines and performance evaluation; I/O, networks, and secure computer design.

EE 8370. Design of Intelligent Systems. (3 cr) Cherkassky

Basic elements and application areas of artificial intelligence (AI) related to design and implementation of expert systems (ES). Knowledge representation, reasoning under uncertainty, ES and their environment, planning, natural language processing (NLP), intelligent computer-aided instruction (ICAI), and AI tools (software and hardware).

EE 8390. Computer Systems Seminar. (Cr ar [may be repeated for cr]; prereq grad IT major or #)

Current literature; individual assignments.

EE 8450. Special Investigations. (1-4 cr [may be repeated for cr]; prereq #)

Studies of approved topics, theoretical or experimental in nature.

EE 8451. Advanced Topics in Electrical Engineering. (Cr ar [may be repeated for cr]; prereq #)

Topics vary according to needs and available staff.

EE 8460-8461. Plan B Project. (4 cr per qtr [no cr toward PhD]; may be taken to satisfy requirement for Plan B master's degree, may appear on master's program but may not be applied toward 20-cr minimum in major field; prereq EE grad student)  
Project topic(s) arranged between student and adviser. Written report(s).

EE 8490-8491-8492. Graduate Seminar. (1 cr per qtr [may be repeated for cr]; prereq grad student or staff)

Recent developments in electrical engineering and related disciplines.

## Elementary Education

See Curriculum and Instruction.

## English

*Professor:* Shirley N. Garner, *chair*; Madelon Sprengnether<sup>2</sup>, *director, creative writing program*; Kent Bales; Michael Dennis Browne<sup>2</sup>; Thomas S. Clayton; Geneviève J. Escure; Peter E. Firchow; Philip G. Furia; Edward M. Griffin; Patricia Hampf<sup>2</sup>; Michael Hancher; Gordon D. Hirsch; Karen N. Hoyle; Klaus P. Jankofsky<sup>1</sup>; Richard J. Kelly; Calvin B. Kendall; Toni A. H. McNaron; Valerie J. Miner<sup>2</sup>; Marcia Pankake; Paula Rabinowitz; Peter J. Reed; Donald Ross, Jr.; Marty Roth; Robert Solotaroff; Ellen J. Stekert; David J. Wallace; Joel C. Weinsheimer

*Associate Professor:* Rita Copeland, *director of graduate studies*; Christopher Anson; Lillian Bridwell-Bowles; Robert L. Brown, Jr.; Maria Damon; Andrew Elfenbein; Maria J. Fitzgerald<sup>2</sup>; Arthur I. Geffen; David B. Haley; Archibald I. Leyasmeyer; Ellen Messer-Davidow; John W. Mowitz; Angelita D. Reyes; Charles J. Sugnet<sup>2</sup>; John A. Watkins; John S. Wright

*Assistant Professor:* Josephine D. Lee; David B. Luke

*Lecturer:* Marisha Chamberlain<sup>2</sup>; Kathleen Coskran<sup>3</sup>; Samuel R. Delany<sup>2</sup>; John Engman<sup>3</sup>; Katharine V. Green<sup>2</sup>; Janet Holmes<sup>2</sup>; James Moore<sup>2</sup>; David A. Mura<sup>3</sup>; Sheila M. O'Connor<sup>2</sup>; Aless D. Pate<sup>2</sup>; Julie Schumacher<sup>2</sup>; Susan Welch<sup>2</sup>

*Other:* Stephanie C. Van D'Elden;

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan B only), M.F.A., and Ph.D.

**Curriculum**—Course requirements for the Ph.D. program are broadly defined, allowing the student to shape a personal program of study. The English program encourages and supports interdisciplinary work. Three emphases are available in the master's program: language and literature; literary genre; and English language and linguistics. The M.F.A. program requires coursework in English and writing and emphasizes intensive work on a creative project. The M.A. programs in literary genre and the M.F.A. program in creative writing may be completed through University College (formerly Continuing Education and Extension), which schedules mainly late afternoon and evening classes.

**Admission to the Program**—Holders of a bachelor's degree may apply either to the master's program or to the doctoral program. An M.A. degree, but not an M.F.A. degree, can be gained en route to the Ph.D. degree. Admission to the master's program ordinarily is restricted to those having immediate career objectives for which an M.A. in English is important. However, M.A. candidates who wish to continue their studies may apply for admission to the Ph.D. program.

**Prerequisites for Admission**—A minimum of 16 credits in English, 12 of which must be at the upper division level, is required. The courses should be widely distributed.

**Special Application Requirements**—Three letters of recommendation; scores from the General Test of the Graduate Record Examination; a short essay explaining scholarly, professional, and personal goals and reason for choosing the University of Minnesota; and a writing sample, such as a course paper, are required. Applications to the M.F.A. in creative writing are reviewed by the writing faculty; these applications should include a substantial portfolio of writing in place of the usual writing sample. Candidates for all degrees are admitted fall quarter only; all materials must be received by December 20.

**Master's Degree Requirements**—The minimum requirement is 44 credits (normally 11 courses).

For the *master's degree with an emphasis on language and literature—the degree program with an historical emphasis*—coursework must include at least 36 credits (nine courses) in English, of which 8 credits (two courses) are at the 8xxx level, including 4 credits (one course) at the seminar level; 8 credits (two courses) in related fields outside of English; and three Plan B papers.

For the *master's degree with an emphasis on literary genre—the degree program with a literary problems or theoretical emphasis*—coursework must include Engl 8012; 4 credits (one course) in English language or English linguistics; 16 credits (four courses) in literary genres, such as poetry, the novel, drama, literary theory, and nonfictional prose (three of the four courses to be devoted to the same genre); 8 credits (two courses) in related fields outside

<sup>1</sup> University of Minnesota, Duluth

<sup>2</sup> Also holds graduate faculty appointment in creative writing.

<sup>3</sup> Advising role restricted to students pursuing the M.F.A. in creative writing.

of English; three elective courses in English or related fields; and three Plan B papers.

For the *master's degree with an emphasis on English language and linguistics*, coursework must include at least 44 credits (eleven courses), of which at least 24 credits (six courses) are in English (specifically including Engl 5815, Engl 5851, and Engl 5843) and at least 8 credits (two courses) are in related fields outside of English; and three Plan B papers.

The written examination for the master's program (all emphases except English language and linguistics) is administered twice a year, in the fall and the spring. The written examination for the emphasis in English language and linguistics is administered separately.

**Master of Fine Arts Degree Requirements—**The minimum requirement is 68 credits, which includes 16 creative project credits.

Coursework must include 4 credits (one course) in a multi-genre writing seminar, preferably taken during the first quarter of study; 20 credits (five courses) in writing, including one seminar and one course outside the primary genre; 20 credits (five courses) in language and literature; 8 credits (two courses) in related fields outside of English, including one in a related artistic field; 16 creative project credits, including 8 credits in a manuscript preparation workshop and 8 credits of creative project registration; and an M.F.A. essay based on a list of twenty books chosen biannually by the creative writing faculty. The M.F.A. essay is administered once yearly at the beginning of spring quarter.

**Doctoral Degree Requirements—**The following courses are required: Engl 8011 and 8012, preferably during the first year of doctoral study; four courses, distributed among broad areas; four additional English courses in a focused area of emphasis; and two extra-departmental courses related to the area of emphasis. Students are encouraged to enroll in additional courses as appropriate.

All doctoral students must take a preliminary written examination and a preliminary oral examination; both are based on a reading list of approximately 50 to 75 works defining a research program that the student constructs in consultation with his or her examining committee. A dissertation and a final oral examination in defense of the dissertation complete the program.

**Language Requirements—**For the master's program, a reading knowledge of one classical or modern language approved by the director of graduate studies is required. For the doctorate, a reading knowledge of two languages, classical or modern, approved by the director of graduate studies, is required. The master of fine arts degree does not have a language requirement.

**Minor Requirements for Students Majoring in Other Fields—**A minimum of 16 undergraduate credits in English literature is a prerequisite for undertaking a minor in English.

For a master's program minor, a minimum of 16 graduate credits in English is required. For a doctoral program minor, a minimum of 20 graduate credits in English is required. Students should consult the director of graduate studies for advice in selecting courses.

**For Further Information and Applications—**Contact the Director of Graduate Studies, Department of English, University of Minnesota, 209 Lind Hall, 207 Church Street S.E., Minneapolis, MN 55455 (612/625-3882; <http://english.cla.umn.edu>).

Engl 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Engl 8888. Thesis Credits: Doctoral. (36 cr required)

## English (Engl)

*Recent course offerings typically include many specialized courses under the "seminar," "topics," and "studies" numbers. For a current listing of these courses, contact the director of graduate studies.*

Engl 5131. Renaissance Poetry. (4 cr; offered alt yrs) Watkins  
Historical and intellectual background; poetic theory; major figures, including Wyatt, Sidney, Spenser, Donne, Herbert, and Jonson.

Engl 5133. Nineteenth-Century British Poetry. (4 cr; offered alt yrs) Elfenbein  
Historical and intellectual background; poetic theory; major figures, including Wordsworth, Coleridge, Keats, R. Browning, E. B. Browning, Tennyson, and Arnold.

Engl 5151. Eighteenth-Century English Novel. (4 cr) Weinsheimer  
Novels by such authors as Defoe, Richardson, Fielding, Smollett, Sterne, and Austen.

- Engl 5152. Nineteenth-Century English Novel. (4 cr) Hirsch  
Novels by such authors as Scott, Dickens, the Brontës, Thackeray, Eliot, and Hardy.
- Engl 5153. Twentieth-Century English Novel. (4 cr) Reed  
Novels by such modern authors as Conrad, Ford, Joyce, Woolf, Lawrence, Forster, Cary, and Waugh.
- Engl 5171. English Drama to the Time of Shakespeare. (4 cr; prereq 3241 or 3242, grad student or Engl undergrad major or Δ; offered alt yrs)  
Mystery plays, moralities, interludes, academic and court plays; plays of Kyd, Marlowe, Lyly, Greene, and Peele.
- Engl 5173. Restoration and 18th-Century Drama. (4 cr; prereq 3241 or 3242) Haley  
The heroic play, tragedy, comedy of manners, and sentimental comedy.
- Engl 5174. Modern Drama, 1880-1920. (4 cr; offered alt yrs) Lee, Leyasmeyer  
Beginnings of modern realism, naturalism, and expressionism in English and Continental drama.
- Engl 5175. Modern Drama Since 1920. (4 cr; offered alt yrs) Lee, Leyasmeyer  
Survey of chief dramatists, English, American, and Continental.
- Engl 5211. Old English (Anglo-Saxon). (5 cr) Kendall  
Introductory study of the language to A.D. 1150. Selected readings in prose and poetry. Some attention to the culture of the Anglo-Saxons.
- Engl 5212. Readings in Old English Prose and Verse. (4 cr; prereq 5211)  
Critical reading of texts, introduction to versification.
- Engl 5213. *Beowulf*. (4 cr) Kendall  
Introduction to the Old English poem, with reading of considerable portions of text.
- Engl 5215. Major Types of Middle English Literature. (4 cr) Copeland, Wallace  
Readings in Middle English, in romance, lyric, allegory, and devotional prose.
- Engl 5221. Chaucer. (5 cr; prereq grad student or Engl undergrad major or Δ) Wallace  
Reading of Chaucer's works and introduction to Chaucer's language. Prerequisite for all courses in Middle English literature (5215-5222).
- Engl 5261. Milton. (4 cr) McNaron  
*Paradise Lost*, *Samson Agonistes*, minor poems, *Areopagitica*, and often, though not always, *Paradise Regained*.
- Engl 5363, 5364. James Joyce. (4 cr per qtr)  
5363: Life and early works, particularly *Dubliners*, *A Portrait of the Artist as a Young Man*, and the first four episodes of *Ulysses*. 5364: *Ulysses* and *Finnegans Wake*.
- Engl 5414. Contemporary American Literature. (4 cr)  
Important authors, intellectual currents, movements, conventions, genres, and themes since 1940.
- Engl 5431, 5432, 5433. American Poetry. (4 cr per qtr) Bales, Damon, Furia, Geffen, Griffin  
5431: Beginnings to 1890—Typical authors: Taylor, Poe, Whitman, Bryant, Dickinson. 5432: 1890-1940—Frost, Stevens, Pound, Moore, Hughes, Williams, Stein. 5433: Since 1940—Lowell, Ginsberg, Plath, Rich, Kaufmann, Baraka, Brooks.
- Engl 5451, 5452. American Novel. (4 cr; prereq grad student or Engl undergrad major or Δ) Bales, Geffen, Griffin, Ross, Roth  
Typical authors: Hawthorne, Melville, Stowe, Twain, James, Dreiser, Cather, Hemingway, Fitzgerald, Faulkner.
- Engl 5471. American Drama. (4 cr; prereq grad student or Engl undergrad major or Δ) Geffen  
From 1914 to present. Typical playwrights: O'Neill, Rice, Hellman, Wilder, Miller, Williams, Odets, Wilson.
- Engl 5481, 5482, 5483. Folklore. (4 cr per qtr; prereq 5481 or 5482 for 5483) Stekert  
5481: Folklore genres such as proverbs, oral prose narratives (tales and legends), foodways, and games. Outline of the history of folklore. 5482: Manner in which folklore is transmitted and changed with concentration on how folklore functions in literature, the mass media, and everyday activity. Emphasis on folk customs, festivals, heroes, humor, and medicine. 5483: Training in collection of folklore materials.
- Engl 5486-5487. Introduction to Anglo- and African-American Folksong. (4 cr per qtr; prereq 5486 or # for 5487, grad student or Engl undergrad major or Δ; offered alt yrs) Stekert  
5486: Introduction to Anglo- and Afro-American folksong: basic elements of the folksong with emphasis on how folksongs change over time and space; concentration on such genres as ballads, blues, broadsides, lyric, and sentimental and topical songs. 5487: Development of Anglo- and Afro-American folksong: how these two streams of American folksong influenced one another as well as the "folksong revival."
- Engl 5593. The Afro-American Novel. (4 cr, §Afro 5593; offered alt yrs) Wright  
Contextual readings of 19th- and 20th-century black novelists such as Charles Chesnut, James Weldon Johnson, Zora Neale Hurston, Richard Wright, Chester Himes, Ann Petry, James Baldwin, John Williams, Toni Morrison, and Ishmael Reed.
- Engl 5597. The Harlem Renaissance. (4 cr, §Afro 5597; offered alt yrs) Wright  
Multidisciplinary review of Harlem Renaissance of Jazz Age: literature, popular culture, visual arts, political journalism, and black and white figures such as Jean Toomer, Claude McKay, Langston Hughes, Bessie Smith, DuBose Heyward, Carl Van Vechten, Eugene O'Neill, and Marcus Garvey.

## GRADUATE PROGRAMS

Engl 5620. British and American Women Writers. (4 cr per qtr; prereq grad student or Engl undergrad major or Δ; offered alt yrs) Garner, McNaron, Rabinowitz, Sprengnether  
Readings of one or more women writers, perhaps working at various times within various forms. Writers specified in the *Class Schedule*.

Engl 5651. Techniques of Poetry. (4 cr)  
Analysis of poetry. Form and sound; meter, stanza, euphony, free verse.

Engl 5671. Theory of the Novel. (4 cr) Firchow, Rabinowitz  
Readings in theoretical criticism of the novel with application to selected British and American fiction.

Engl 5711. Classics of Literary Criticism. (4 cr, §3711, §CIV 3711, §CIV 5711) Copeland, Hancher  
Principles of criticism as expressed and used in selected major works in classic critical tradition by such writers as Plato, Aristotle, Horace, Longinus, Sidney, Dryden, Johnson, Hume, Coleridge, and Eliot.

Engl 5714. Modern and Contemporary Critical Theory. (4 cr) Mowitt  
Readings in modern and postmodern literary criticism, with attention to contemporary movements, theory, and practice.

Engl 5811. Celtic World. (4 cr; offered alt yrs)  
Survey of history, folklore, and literature of the six Celtic countries: Brittany, Cornwall, Ireland, Isle of Man, Scotland, and Wales.

Engl 5815. History of the English Language. (4 cr)  
The development of the English language from Old to Early Modern English: phonology, morphology, and syntax.

Engl 5831. Development of American English. (4 cr; offered alt yrs)  
History of the English language in the United States; significant regional variation.

Engl 5843. American Social Dialects. (4 cr) Escure  
Methods for and results of investigating social and class variation in American English; emphasis on urban dialects.

Engl 5851. Structure of Modern English. (4 cr, §3851) Anson, Bridwell-Bowles, Brown, Escure  
Survey of modern English grammar dealing with English phonology, syntax, and semantics; variations and change in English.

Engl 5852-5853-5854. Modern Irish Language. (5 cr per qtr; prereq grad student or Engl undergrad major or Δ for 5852) Stenson  
Grammatical structures of modern Irish dialect of Connemara, Co. Galway; development of skills in both oral and written language: vocabulary, manipulation of grammatical structures, speaking, listening, reading and writing practice; modern Gaelic culture.

Engl 5862. World Englishes. (4 cr) Escure  
Development, significance, and linguistic characteristics of varieties of English spoken in non-western countries (Caribbean, Central America, Africa, Asia). Pidgins, creoles, and local standards included with reference to issues of cultural identity and language nativization.

Engl 5910. Topics in English and North American Literature. (4 cr)  
Topics specified in *Class Schedule*.

Engl 5920. Topics in Anglophone Literature. (4 cr)  
Topics specified in *Class Schedule*.

Engl 5940. Figures in English and North American Literature. (4 cr)  
Figures specified in *Class Schedule*.

Engl 5950. Figures in Anglophone Literature. (4 cr)  
Figures specified in *Class Schedule*.

Engl 8011. Introduction to Advanced Literary Study. (4 cr)  
Ends and methods of literary research, including professional literary criticism, analytical bibliography, and textual criticism, with attention to basic reference works, critical and scholarly journals, bibliographies of broad and narrow literary subjects, and forms of presenting results of critical and scholarly investigation.

Engl 8012. Problems in Literary History and Theory. (4 cr) Bales, Messer-Davidow, Mowitt, Rabinowitz, Weinsheimer  
Approaches to practical and theoretical problems of literary history and genre.

Engl 8050. Studies in Special Subjects. (2-4 cr [max 12 cr])  
Topics specified in *Class Schedule*.

Engl 8111 through 8119. Proseminars. (4 cr each)  
Wide reading in the literature of a given period or subject designed to prepare graduate students for work in other graduate courses or seminars. Attention to relevant scholarship or criticism.

*Engl 8111. Proseminar in Medieval Studies (Copeland)*

*Engl 8115. Proseminar in the English Romantic Movement (Elfenbein)*

*Engl 8116. Proseminar in Victorian Studies (Hirsch)*

*Engl 8117. Proseminar in Early American Literature (Griffin)*

*Engl 8118. Proseminar in 19th-Century American Literature (Bales, Ross)*

*Engl 8119. Proseminar in 20th-Century British and American Literature (Solotaroff)*

Engl 8210 through 8810. Seminars. (4 cr each)  
Descriptive title specified in the *Class Schedule*.

*Engl 8210. Medieval Studies (Copeland, Kendall, Wallace)*

*Engl 8220. Chaucer (Wallace)*

*Engl 8230. Renaissance Studies (Watkins)*

*Engl 8240. Shakespeare (Clayton, Garner)*

*Engl 8250. Seventeenth-Century Studies (Haley)*

*Engl 8310. Studies in the English Romantic Movement (Elfenbein, Luke)*

*Engl 8330. Victorian Studies (Hancher, Hirsch)*

*Engl 8480. Studies in Folklore (Stekert)*

*Engl 8510. Studies in Early American Literature (Griffin)*

*Engl 8530. Studies in 19th-Century American Literature (Ross, Roth)*

*Engl 8590. Studies in Afro-American Literature (Wright)*

*Engl 8610. Studies in 20th-Century British and American Literature (Furia, McNaron, Solotaroff)*

*Engl 8650. Studies in Poetry (Damon, Furia)*

*Engl 8670. Studies in Prose Fiction (Solotaroff)*

*Engl 8690. Studies in Drama (Lee)*

*Engl 8710. Studies in Criticism (Hancher, Messer-Davidow, Rabinowitz, Weinsheimer)*

*Engl 8720. Studies in Feminist Criticism (Rabinowitz, Sprenghether)*

*Engl 8810. Studies in the English Language (Anson, Bridwell-Bowles, Brown, Escure)*

*Engl 8970. Independent Reading (1-15 cr; prereq #, Δ)*

## English Creative and Professional Writing (EngW)

EngW 5101, 5102, 5103. Advanced Fiction Writing. (4 cr per qtr; prereq Δ) Fitzgerald, Miner  
Advanced workshop for students with considerable experience in writing fiction.

EngW 5105, 5106, 5107. Advanced Poetry Writing. (4 cr per qtr; prereq Δ) Browne  
Advanced workshop for students with considerable experience in writing poetry. Opportunity for students to open their work to new possibilities and to read widely in contemporary poetry and poetics.

EngW 5110. Topics in Advanced Fiction Writing. (4 cr; prereq Δ) Fitzgerald, Miner  
Workshops by Edelstein-Keller visiting writers. See the *Class Schedule* for particular topics.

EngW 5120. Topics in Advanced Poetry Writing. (4 cr; prereq Δ) Hampl, Browne  
Special workshops by Edelstein-Keller visiting writers. See the *Class Schedule* for particular topics.

EngW 5130. Topics in Advanced Creative Writing. (4 cr; prereq Engl grad student or Δ)  
Workshop in areas other than fiction, poetry, and nonfiction.

EngW 5201, 5202. Memoir Writing. (4 cr per qtr; prereq Δ) Hampl  
Autobiographical prose writing. Students read numerous memoirs, consider aspects of memory and imagination and the memoir genre, and write their own autobiographical pieces.

EngW 5204, 5205. Advanced Playwriting. (4 cr per qtr; prereq Δ)  
Advanced workshop for students with creative writing experience and interest in writing for stage or screen. Step-by-step creation of short script; field trips to local productions.

EngW 5210. Topics in Advanced Literary Nonfiction. (4 cr; prereq Δ) Sprenghether, Sugnet  
Special topics in essay writing, such as arts reviewing, writing about public affairs, and writing in personal voice. See the *Class Schedule* for particular topics.

EngW 5310, 5320. Reading as Writers. (4 cr per qtr; prereq Δ for 5310, Engl grad student or Δ for 5320) Fitzgerald, Miner, Sprenghether, Sugnet  
Special topics. Open to graduate and advanced undergraduate students in literature, as well as to creative writing students. See the *Class Schedule* for particular topics.

EngW 5401. Introduction to Professional Editing. (4 cr) Marquit, Ready  
Beginning editing, from substantive editing to nature of editor-writer relationship: manuscript reading, author queries, rewrite and style, some discussion of copy editing. Editing awareness and skills developed by working on varied writing samples.

EngW 5402. Advanced Editing. (4 cr; prereq EngW 5401, #, Δ) Marquit  
For students with advanced editing competence to further advance their skills. Workshop/seminar: editing long text and fiction, children's literature, translations, and indexes.

EngW 5501. Minnesota Writing Project Institute. (4 cr; prereq writing teacher [K-college] eligible for grad cr through University College; requires nomination and competitive selection by board of Minnesota Writing Project)  
Summer workshop in which participants reflect on own writing processes as they produce essays and examine current pedagogical theory and practice through readings and demonstrations.

EngW 5502. Minnesota Writing Project Open Institute. (3 cr; prereq writing teacher [K-college] eligible for grad cr through University College)  
Summer workshop in which participants reflect on own writing processes as they produce essays and examine current pedagogical theory and practice through readings and demonstrations.

EngW 5570. Minnesota Writing Project: Directed Studies. (1-4 cr)  
Workshops in which writing teachers investigate current theories of writing and writing pedagogy.

EngW 5970. Directed Study in Writing. (1-4 cr; prereq #, Δ, □)  
Projects in writing poetry, fiction, drama, and nonfiction, or study of ways to improve writing.

EngW 8101. Reading Across Genres. (4 cr; prereq creative writing MFA student, Δ)  
Contemporary writing in fiction, poetry, and creative nonfiction. Primarily a reading course rather than a writing workshop.

EngW 8110. Seminar: Writing of Fiction. (4 cr; prereq Δ)  
Writing of fiction with focus on full-length book, e.g., a novel or collection of short stories. Some common assignments, but each student works on individual project.

EngW 8120. Seminar: Writing of Poetry. (4 cr; prereq Δ)  
Writing of poetry with focus on the exploration and practice of various styles. Some common assignments, but each student works on individual project.

EngW 8130. Seminar: Writing of Literary Nonfiction. (4 cr; prereq Δ)  
Advanced workshop in areas that do not fit into fiction or poetry categories exclusively. Complements EngW 8110 and EngW 8120.

EngW 8140. Fiction: Manuscript Preparation. (4-8 cr; prereq 8110, creative writing MFA student, #)  
For students working on their creative project.

EngW 8150. Poetry: Manuscript Preparation. (4-8 cr; prereq 8120, creative writing MFA student, #)  
For students working on their creative project.

EngW 8160. Literary Nonfiction: Manuscript Preparation. (4-8 cr; prereq 8130, creative writing MFA student, #)  
For students working on their creative project.

EngW 8990. Creative Project Credits: MFA. (1-16 cr; prereq 8140 or 8150 or 8160, creative writing MFA student, #)  
For students working on their creative project.

## English as a Second Language

*Professor:* Elaine E. Tarone, *director of graduate studies*; Andrew D. Cohen; Jeanette Gundel

*Associate Professor:* Bruce T. Downing; Amy L. Sheldon; Nancy Stenson

*Adjunct Assistant Professor:* Micheline Chalhouh-Deville

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—M.A. (Plan A and Plan B).

**Curriculum**—The program offers a master's degree for those wishing to teach English as a second or foreign language to adults at the college or university level. The major emphasis is on preparation in applied linguistics. Elective coursework allows students to specialize in a variety of areas, including second-language acquisition, English for special purposes, computer-assisted instruction, and materials development.

**Prerequisites for Admission**—A bachelor's degree in the liberal arts or sciences with a strong academic record is required.

**Special Application Requirements**—Scores from the General (Aptitude) Test of the Graduate Record Examination, three letters of reference, and a statement of the applicant's research interests in the field are required. Non-native speakers of English must submit scores (minimum 550) from the Test of English as a Foreign Language (TOEFL). Students may begin the program fall quarter or first summer session. Applications for both admission dates are due on March 15. Applications for financial aid must be submitted by January 15.

**Master's Degree Requirements**—The requirement is 34 credits in applied coursework (TESL 5721, 5722, Ling 5001, 5002, 5301, 5701, 5741, 5742) and 8-12 additional credits of elective coursework. See the English as a Second Language Program brochure for details. A final oral examination is required.

**Language Requirement**—Proficiency, demonstrated by examination or coursework, in one language not native to the student is required upon completion of the program.

**Minor Requirements for Students Majoring in Other Fields**—TESL 5721, Ling 5001, 5301, 5741, and 5742 are required. Prospective minors must be approved by the program to be granted the status of minor. A minimum grade point average of 3.20 is required for approval.

**For Further Information and Applications**—Contact the Program in English as a Second Language, University of Minnesota, 192 Klaeber Court, 320 16th Avenue S.E., Minneapolis, MN 55455 (612/624-3331; fax 612/625-2312).

ESL 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

## Teaching English as a Second Language (TESL)

TESL 5721. English as a Second Language: Methods. (4 cr; prereq Ling 3001 or Ling 5001 or #) Teaching methods.

TESL 5722. English as a Second Language: Practicum. (4 cr; prereq ESL major or minor, 5721, #; S-N only)

Observation of and practice in teaching English as a second language.

TESL 5723. English as a Second Language: Materials. (3 cr; prereq 5721, 5722, #; offered alt yrs) Evaluation and preparation of teaching materials.

TESL 5910. Seminar in Teaching English as a Second Language. (4 cr; prereq #)  
Topics specified in *Class Schedule*.

TESL 5970. Directed Studies. (1-5 cr per qtr; prereq ESL major, #)

TESL 8751. English for Special Purposes. (4 cr; prereq 5741, 5742 or #)  
Critical review of the literature. Investigation of types of English used in fields such as engineering, nursing, and business.

### Program Requirements

Ling 5001. Introduction to Linguistics (Gundel)

Ling 5002. Linguistic Analysis (Gundel, Kac, Stenson)

Ling 5301. Phonetics (Stemberger)

Ling 5701. Introduction to Second-Language Acquisition (Cohen, Tarone)

Ling 5741-5742. Linguistic Description of Modern English (Downing, Gundel, Tarone)

TESL 5721. English as a Second Language: Methods (Cohen, Tarone)

TESL 5722. English as a Second Language: Practicum (Cohen, Tarone)

### Suggested Electives

Structure of a foreign language (not English)—See language department listings.

CI 5362. Introduction to Computer-Based Instructional Design

CI 5656. Reading and Writing in a Second Language

CI 5657. Speaking and Listening in a Second Language

CI 5658. Second Language Testing, Assessment, and Evaluation

CI 5662. Critical Issues in Second Language Curriculum

EPsy 5150. Social Psychology of Education (D Johnson)

LgTT 5101. Technology in the Language Classroom (Stenson)

Ling 5201. Introduction to Syntax (Downing, Gundel, Kac)

Ling 5302. Introduction to Phonology (Stemberger)

Ling 5702. Second-Language Acquisition (Cohen, Tarone)

Ling 8731. Research Methods in Language Acquisition (Cohen, Tarone)

Psy 5054. Psychology of Language (Fletcher)

Spch 5411. Small Group Communication Theory (Hewes, Poole)

Spch 5451. Intercultural Communication

TESL 5723. English as a Second Language: Materials (Tarone)

TESL 8751. English for Special Purposes (Tarone)

## Entomology (Ent)

*Professor:* Mark E. Ascerno, *head*; Ann M. Fallon; Timothy J. Kurtji; Roger D. Moon; Edward B. Radcliffe; David W. Ragsdale; David D. Walgenbach

*Adjunct Professor:* William E. Miller

*Associate Professor:* Ralph W. Holzenthal, *director of graduate studies*; David A. Andow; William D. Hutchison; Karen A. Mesce; Kenneth R. Ostlie

*Adjunct Associate Professor:* Susan Palchick-Silver

*Assistant Professor:* Vera A. Krischik; Marla Spivak; Susan J. Weller

*Adjunct Assistant Professor:* Steven A. Katovich

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—This program is administered in the Department of Entomology. Fundamental research areas such as ecology, molecular genetics, microbiology, physiology, and systematics are available, as well as specialized or applied areas such as apiculture, biological control, economic entomology, host-plant resistance, integrated pest management, and insects related to forests, livestock and humans, plant diseases, and urban areas.

**Prerequisites for Admission**—A bachelor's degree with a major in a biological science is a prerequisite. Preference is given to students with a broad background in the basic sciences.

**Special Application Requirements**—Three letters of recommendation are required from persons well acquainted with the student's academic record. Graduate Record Examination scores are recommended, but not required. Students are admitted each quarter.

**Degree Requirements**—Requirements for the master's and doctoral degrees beyond the Graduate School's requirements include a core curriculum of fundamental entomology courses and two credits of Graduate Seminar.

Additional requirements are flexible and are determined by the student in consultation with the adviser and other members of the student's advisory committee. Master's Plan A is recommended for all master's students contemplating a career in entomological research. Written and oral preliminary examinations and final oral examinations are required for all degrees.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—Requirements are flexible and are determined by the student in consultation with the director of graduate studies in entomology.

**For Further Information and Applications**—Contact the Department of Entomology, University of Minnesota, 219 Hodson Hall, 1980 Folwell Avenue, St. Paul, MN 55108 (612/624-3636; fax 612/625-5299; e-mail entodept@tc.umn.edu).

Ent 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Ent 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Ent 8888. Thesis Credits: Doctoral. (36 cr required)

Ent 5010f. Insect Morphology. (5 cr; prereq 3005 or #; offered alt yrs) Weller  
Comparative study of insect structure within evolutionary and phylogenetic perspective.

Ent 5020f. Insect Taxonomy. (5 cr; prereq 3005 or equiv) Holzenthal  
Identification of families of adult insects; evolution and classification of insects; techniques of collecting and curating insects; principles of phylogeny reconstruction.

Ent 5030w. Insect Physiology. (3 cr; prereq 5010, 1 biochem course or #) Kurtti, Mesce  
Essential processes of insects. Includes nerve and muscle mechanisms, energy metabolism, respiration, nutrition and digestion, excretion, regulation and interactions of processes, sensory mechanisms and behavior; reproductive behavior, embryology, and postembryonic development of insects.

Ent 5040f. Insect Ecology. (4 cr; prereq Biol 5041 or EBB 5122 or #; offered alt yrs) Andow  
Synthetic analysis of causes of insect diversity and of fluctuations in insect abundance. Focus on abiotic, biotic, and evolutionary mechanisms influencing insect populations and communities.

Ent 5210w. Insect Pest Management. (4 cr; prereq 1005 or #) Radcliffe  
Prevention or suppression of injurious insects by comprehensive and coordinated integration of multiple control tactics, e.g., chemical, biological, cultural. Strategies to optimize dynamic integration of control methodologies in context of their economic, environmental, and social consequences.

Ent 5215s. Insects in Relation to Plant Diseases. (3 cr; prereq ent course, plant pathology course or #; offered alt yrs) Ragsdale  
Insect transmission and dissemination of plant pathogens; development of plant-insect relationships; habits of principal insect vectors.

Ent 5250s. Forest and Shade Tree Entomology. (4 cr; prereq any 2 courses among the forestry, zoological, botanical, biological and/or agricultural sciences) Ascerno  
Lectures and lab concerning ecology and population management of forest and shade tree insects, with emphasis on tree factors and integrated control.

Ent 5275f. Medical Entomology. (3 cr; prereq 3005 recommended; offered alt yrs) Fallon, Kurtti, Moon  
Biology of arthropod vectors of human disease. Disease transmission and host, vector, and pathogen interactions.

Ent 5280w. Livestock Entomology. (4 cr) Moon  
Biology and management of insects, mites, and ticks that affect domestic livestock and pets.

Ent 5310w. Sampling Biological Populations. (4 cr; prereq Stat 5021 or equiv; offered alt yrs) Moon  
Design of sampling plans for study of field and lab populations of living organisms. Sampling distributions and techniques for detecting and coping with aggregation. Randomization, required sample size, and optimal resource allocation within alternative sampling designs.

Ent 5320f. Ecology of Agriculture. (4 cr; prereq 3xxx biol or environmental studies course or equiv or #; offered alt yrs) Andow  
Ecological perspective on post-industrial agriculture; origins of agriculture, social functions, and ecology of contemporary and extinct agricultural systems. Soils, plant development, pest ecology, forage quality, animal production, and food quality as an interactive network.

Ent 5350f. Insect Pathology. (3 cr; prereq 5030; offered alt yrs) Kurtti  
Survey of major pathogenic microorganisms that cause diseases in insects; routes of infection of insects; lab propagation of disease agents; factors in application of disease to control of pest insects with safety considerations.

Ent 5360. Aquatic Insects. (3 cr; prereq 3005 or equiv or #; offered alt yrs and Itasca summer session I) Holzenthal  
Taxonomy and natural history of aquatic insects, including their importance in aquatic ecology, resource management, recreation, and conservation. Family-level identification. Field trips to local aquatic habitats. Collection required.

Ent 5370s. Principles of Systematics. (3 cr; prereq #; offered alt yrs) Holzenthal, Zink  
Theoretical and practical procedures of systematics, including phylogeny reconstruction, classification, systematic literature, nomenclature, and presentation of systematic research results.

Ent 5380. LepidopteroLOGY. (2 cr [3 cr with term paper]; prereq ent course or #; 1 ecology and 1 genetics course recommended) Miller  
Processes and phenomena such as polymorphism, mimicry, and individual quality well demonstrated by this order.

Ent 5480w. Invertebrate Neurobiology. (2 cr) Mesce  
Principles and concepts underlying cellular bases of behavior and “systems” neuroscience. Particular invertebrate preparations discussed.

Ent 5900f,s. Basic Entomology. (Cr ar; prereq #)  
Opportunity to make up certain deficiencies in biological background.

Ent 5910f,w,s. Special Problems in Entomology. (Cr ar; prereq #)  
Individual field, lab, or library studies in various aspects of entomology.

Ent 5920. Special Lectures in Entomology. (Cr ar)  
Lectures and/or labs in special fields of entomological research given by a visiting scholar or regular staff member.

Ent 5999. Special Workshop in Entomology. (1-4 cr; prereq #)  
Offered off campus. Topics specified in *Class Schedule*.

Ent 8040f. Advanced Insect Genetics. (3 cr; prereq basic course in genetics, 5030 or #; offered alt yrs) Fallon  
Survey of molecular genetic techniques and their applications, with emphasis on insect species other than *Drosophila*. Application of genetic techniques to physiological processes.

Ent 8050f. Toxicology. (3 cr; prereq 15 cr incl 1005 or equiv or #, inorganic and organic chemistry; offered alt yrs) Fallon  
Chemistry, physiological action, toxicology of insecticides.

Ent 8200. Colloquium in Social Insects. (1-3 cr; prereq 3020 or 3200) Spivak  
Discussion of current research on bees, wasps, ants, and termites. Student critiques and research reports.

Ent 8210. Colloquium in Insect Evolution. (1-3 cr; prereq 5370 or #)  
Research issues in systematics and evolution. Among topics are comparative biology, biogeography, and molecular evolution. Students may re-enroll as topics alternate. Students critique papers from primary literature.

Ent 8240f,w,s. Colloquium in Insect Ecology. (1-2 cr; prereq 5040 or #) Andow  
Advanced topics.

Ent 8300f,w,s. Graduate Seminar. (1 cr; prereq #) Ragsdale  
Oral and written reports on and discussion by students of selected topics from current literature in entomology.

Ent 8500f,w,s. Research in Entomology. (Cr ar; prereq #)

## Environmental Health (PubH)<sup>1</sup>

*Professor:* Jack S. Mandel, *head*; Donald E. Barber; Sagar M. Goyal; Jordan L. Holtzman; Irving J. Pflug; R. Ashley Robinson; Ken Sexton; Sheldon B. Sparber; Donald Vesley; James H. Vincent; W. Dixon Ward (*emeritus*)

*Adjunct Professor:* Paul W. Willard

*Associate Professor:* Deborah L. Swackhamer, *director of graduate studies*; Susan G. Gerberich; Ian A. Greaves; Rita B. Messing

*Clinical Associate Professor:* Alan P. Bender

*Assistant Professor:* Lisa M. Brosseau; Rebecca A. Johnson; George Maldonado; Patricia McGovern; Gurumurthy Ramachandran; Fay M. Thompson; Elizabeth V. Wattenberg

*Adjunct Assistant Professor:* Jeffrey H. Mandel; Marian C. Marbury; David L. Parker

*Instructor:* Debra K. Olson

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Emphases include environmental epidemiology, environmental chemistry, environmental toxicology, industrial hygiene, environmental policy, environmental microbiology, occupational epidemiology, occupational health nursing, occupational injury, epidemiology and control, and occupational medicine.

<sup>1</sup> A master of public health degree (M.P.H.) with an emphasis in environmental health is offered by the School of Public Health. Consult the School of Public Health Bulletin for more information.

**Prerequisites for Admission**—A bachelor's degree, including coursework in biological, chemical, or physical sciences or engineering, is required. Prerequisites depend on requirements of specialty area within the degree program.

**Special Application Requirements**—Graduate Record Examination scores, a letter describing the applicant's professional objectives, and three letters of recommendation are required.

**Master's Degree Requirements**—The program requires a selection of specialty area. Most specialty tracks require two years to complete. Students are required to complete PubH 5156, 5158, 5159, 5250, and 5261 or 5267. Other core courses from the area of emphasis in the major are also required and are expected to include courses in biostatistics and epidemiology. An oral final examination is required.

**Doctoral Degree Requirements**—Candidacy for the Ph.D. program requires completion of the master's degree (or the equivalent) in environmental health.

**Language Requirements**—For the master's degree, none. For the doctoral degree, reading ability in a foreign language or additional coursework is required at the discretion of the adviser.

**For Further Information and Applications**—Contact the Student Services Center, School of Public Health, University of Minnesota, Box 819 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (612/626-3500 or 1/800/774-8636; fax 612/626-6931; e-mail sph-uofm@greg2.sph.umn.edu; <http://www.sph.umn.edu>).

PubH 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

PubH 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

PubH 8888. Thesis Credits: Doctoral. (36 cr required)

*Note*—Courses in environmental health are listed and described under Public Health later in this bulletin. See PubH 5150 to 5281 and 8150 to 8272.

## Epidemiology (PubH)<sup>1</sup>

*Professor:* Russell V. Luepker, *head*; Henry Blackburn; Richard S. Crow; Aaron R. Folsom; Laël Gatewood; Richard H. Grimm; John H. Himes; David R. Jacobs, Jr.; Robert W. Jeffery; Robert L. Kane; Harry A. Lando; Arthur S. Leon; Jack Mandel; David M. Murray; Cheryl L. Perry; Phyllis L. Pirie; R. Ashley Robinson; Leslie L. Robison; David G. Thawley; Alexander C. Wagenaar

*Adjunct Professor:* Michael T. Osterholm

*Associate Professor:* John R. Finnegan, Jr., *director of graduate studies*; Patricia J. Elmer; Jean L. Forster; Lawrence H. Kushi; Alan R. Lifson; Leslie L. Lytle; Paul G. McGovern; Joseph P. Neglia; Thomas A. Sellers; Eyal Shahar; Carolyn L. Williams

*Adjunct Associate Professor:* Alan P. Bender

*Assistant Professor:* Kristin E. Anderson; Donna K. Arnett; Simone A. French; Myron D. Gross; Wendy L. Hellerstedt; Rhonda J. Jones-Webb; Philip W. Lowry; George Maldonado; Dianne Neumark-Sztainer; Pamela Schreiner; Xiao Ou Shu; Seth L. Welles; Mark Wolfson; Wei Zheng

*Adjunct Assistant Professor:* Sally A. Bushhouse; Richard N. Danila

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—The division offers basic and advanced instruction for students planning teaching, research, or administrative careers in epidemiology. Courses are also available to students from other public health and health-related programs.

Students may select areas of concentration appropriate to their academic interests and career objectives, including the epidemiology of cancer, epidemiology of infectious diseases, epidemiology of cardiovascular diseases, nutritional epidemiology, and behavioral epidemiology. In addition to the required public health courses, students may select courses from a wide range of areas such as anthropology, biochemistry, computer science (public health), genetics, microbiology, pathology, physiology, and sociology. A detailed description of the course of study and a more comprehensive list of elective courses may be obtained by writing to the director of graduate studies.

<sup>1</sup> A master of public health degree (M.P.H.) with an emphasis in epidemiology is offered by the School of Public Health. Consult the School of Public Health Bulletin for more information.

**Prerequisites for Admission**—For the master's program, a strong undergraduate background in biological and physical sciences and high scholastic achievement are desirable.

For the doctoral program, applicants must have received a master's degree. Applicants who have not yet completed a master's degree in epidemiology or a related field are usually admitted, initially, to the master's program in epidemiology, where they must demonstrate their research capability. Because positions in the program are relatively limited, selection of students is competitive with respect to academic background and experience presented.

**Special Application Requirements**—The following materials are required by the department: an acceptable score on the Graduate Record Examination (test results should be forwarded to the department); a minimum of three recommendations (form and separate letter) from faculty or work supervisors with knowledge of the applicant's scholastic and professional capabilities and potential; and a statement of goals and objectives (letter of intent) for seeking a career in epidemiology.

In addition to the above materials, applicants for the Ph.D. program must submit a separate essay demonstrating evidence of their capability in or potential for original research.

M.S. and Ph.D. students should begin their studies in the fall quarter. Applications must be completed by January 15 of the same year.

**Master's Degree Requirements**—The M.S. degree program prepares students for careers in teaching, research and program development, administration and evaluation in health agencies, medical institutions, regulatory agencies, and industry. The two-year program includes advanced coursework in the basic medical sciences. Students who have a graduate degree in a health-related field or a professional degree such as an M.D., D.D.S., or D.V.M. may complete the program in one year. Students usually complete the curriculum under Plan B. A complete list of degree program requirements may be obtained from the director of graduate studies. Students take an oral final examination.

**Doctoral Degree Requirements**—The doctoral program helps students develop proficiency in epidemiologic investigations as a preparation for careers in service, research, or teaching in health agencies and institutions. The program includes advanced coursework, with electives chosen according to the individual's background, interests, and needs. Students participate in ongoing field research designed to provide increasingly complex experiences commensurate with their development. The thesis should be based on an original field investigation of acceptable complexity and sophistication.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—For the master's degree, a minimum of 9 credits selected by the minor adviser on the basis of the student's major field of study is required. For the doctoral degree, a minimum of 20 credits selected by the minor adviser on the basis of the student's major field of study is required.

**For Further Information and Applications**—Contact the Student Services Center, School of Public Health, University of Minnesota, Box 819 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (612/626-3500 or 1/800/774-8636; fax 612/626-6931; e-mail sph-uofm@greg2.sph.umn.edu; <http://www.sph.umn.edu>).

PubH 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

PubH 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

PubH 8888. Thesis Credits: Doctoral. (36 cr required)

*Note*—Courses in epidemiology are listed and described in the Public Health section of this bulletin. See PubH 5330 to 5399 and 8330 to 8389.

## Experimental Surgery

See Surgery.

## Family Education

See Work, Community, and Family Education.

## Family Practice and Community Health (FPCH)

*Professor:* Edward W. Ciriacy, *head*; Carole J. Bland; Joseph M. Keenan; John T. Kelly; Roger S. Mazze; Vernon E. Weckwerth

*Associate Professor:* Donald S. Asp, *director of graduate studies*; Edmond J. Coleman; Dwenda K. Gjerdingen; Harold R. Ireton; Richard L. Reed; B. R. Simon Rosser; Sharon B. Satterfield

*Assistant Professor:* Donald R. Houge; Leon J. Nesvacil; James J. Pattee; Harold C. Seim

*Lecturer:* Faruk Abuzzahab

*Other:* Michael E. Metz

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—M.S. (Plan B only).

**Curriculum**—Studies focus on the discipline of family medicine and on academic skills.

**Prerequisites for Admission**—Applicants must have completed an M.D. or D.O. degree.

**Special Application Requirements**—Applicants must meet with a department adviser to obtain a letter of endorsement, which must be submitted with the formal application. Students are admitted each quarter.

**Master's Degree Requirements**—A minimum of 20 credits from the major field is required. Nonclinical courses must make up a minimum of 50% of the credits in the major. If the total number of credits presented in the major is 30 or fewer, however, a minimum of 16 credits must be in nonclinical courses. For the minor, at least 9 credits are required. Courses may be taken from more than one department if they are relevant to the major and form a coherent sequence related to the minor. All courses included in the minor must be nonclinical, and must be taken on the A-F grading system. In lieu of choosing a minor, students may elect to present at least 8 credits in a number of related nonclinical fields outside the major. A final oral examination is required.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Department of Family Practice and Community Health, 6-240 Phillips-Wangensteen Building (Box 381 Mayo), University of Minnesota, 516 Delaware Street S.E., Minneapolis, MN 55455 (612/624-2622).

*Note*—The courses listed below are described in the broadest outline to convey the character of the work. Coursework in fields related to family practice and community health is also available in other departments of the University.

FPCH 5251. Cross-Cultural Medicine and International Health. (Cr ar; prereq family practice residency or #) Patten, staff

Concepts of illness and healing within different cultural contexts; efficacy of systems of healing other than biomedicine; interaction of cultural and biological factors in disease and illness; population-based health, illness, disease.

FPCH 5345-5346. Analysis of Instruction and Educational Evaluation. (3 cr per qtr; prereq #) 5345: Curriculum design: from identifying course goals to building course goals to building course, teacher, or learner evaluations. 5346: Acquiring effective teaching strategies, including lecture, demonstration, small-group discussion, clinical teaching, and computer-assisted instruction.

FPCH 5504. Medical Ethics. (2 cr) Daly  
Reading and discussion of major ethical issues relevant to the practice of medicine. Critical review of case studies to gain experience in solving medical ethics problems.

FPCH 5555. Sexual Counseling for Family Physicians. (2 cr; prereq medical school completion) Coleman, staff  
Assessment of and therapy for sexual dysfunction problems that arise in clinical practice of primary care physicians.

FPCH 5563. Clinical Neuropsychopharmacology. (2 cr; prereq FPCH residency) Abuzzahab  
Identification, diagnosis, treatment, and follow-up of major psychiatric disorders. Emphasis on the neuro-psychopharmacological approach, identification of psychoactive drugs, contraindications, side effects, and long-term management of patients.

FPCH 5564. Family Practice Seminar. (1-3 cr)  
Knowledge, skills, and attitudes in biomedical and behavioral sciences that form foundation for academic discipline of family medicine; medical decision making, common problems and procedures, family theory and assessment, clinical pharmacy, and human sexuality.

FPCH 5570. Practicum in Counseling. (1 cr; prereq completion of 1st-yr residency) Kelly  
Basic techniques of short-term counseling. Lectures, classroom exercises, and actual counseling contact.

FPCH 5582. Practice Management Workshop. (2 cr; prereq completion of 1st-yr residency or #) Ciriacy, staff

Practical counsel and information on day-to-day management of medical clinics including economic and legal aspects; community and hospital relations; human relations; types of practice opportunities. Two-day workshop with department faculty and community specialists on concepts relevant to effective management of a family practice clinic.

FPCH 5583. Personal and Financial Planning. (2 cr) Seim

Personal and financial planning. Includes an overview of life insurance, equity investments, and real estate. Pros and cons of these methods of personal investments, sources of information about them, and their history.

FPCH 5596. Introduction to Intercultural/International Medicine. (4.5 cr; prereq 3rd- or 4th-yr med student or FPCH resident; apply at least 3 months ahead)

Didactic and field experience program during four-week period. Combines clinical activity and involvement in ongoing field-based research. Conducted in conjunction with Indian Health Services.

FPCH 5598. Introduction to Physician's Role in Nursing Homes. (2 cr) Ciriacy, staff  
Roles of nursing home staff. Helps medical fellows become comfortable in nursing homes.

FPCH 5650, 5651, 5652. Principles of Geriatrics. (1 cr per qtr; prereq candidate for or recipient of grad degree in hlth sci) Boul  
Geriatric approach to medicine, common geriatric syndromes, diseases of later life. Instructors include rotating clinical faculty, geriatric fellows, and guest lecturers. Held at local nursing homes.

FPCH 5653. Future Health Interventions for Older Populations. (2 cr; prereq hlth sci grad student or hlth sci grad degree)

Successful and promising interventions designed by managed care organizations, including outcome data.

FPCH 5843. Disease Prevention and Health Promotion: An Appraisal of Goals and Techniques in Family Practice. (2 cr; prereq MD)  
Role of family physician in development, operation, and research of office-based prevention/promotion activities. Presentation and discussions with leaders in this field.

FPCH 5903. Community Health. (Cr ar; prereq #) Lindblom, Staff

Practical experience in delivery of healthcare in urban or rural communities.

FPCH 5904. Community Health. (2 cr; prereq 2nd- or 3rd-yr residency or #)

Introduction to concepts of community health. In-depth look at community health activities in Minnesota. Tools and techniques for the study of contemporary health problems in the state. Strategies to meet community health needs.

FPCH 5950. Clinical Issues in Human Sexuality. (3 cr; prereq enrollment in health sciences grad programs in CSPP, Psych, PubH, SW or FSoS or #) Coleman  
Clinical issues, assessment techniques, and treatment techniques pertaining to common sexual problems.

FPCH 5952-5953-5954. Practicum in Sexual Counseling. (3-6 cr per qtr; prereq #; offered when feasible) Coleman

FPCH 5955. Directed Study. (1-15 cr; prereq #; qualified students may register with # for work on a tutorial basis) Kelly

FPCH 5956. Human Sexuality Throughout the Life Cycle for the Primary Care Physician. (3 cr; prereq college-level human sexuality intro course, #; offered alt years) Metz

Developmental aspects of sexuality throughout the life cycle examined from such theories as psychodynamics and social role theory, with emphasis on significance of psychosocial aspects of sexuality for the primary care physician.

FPCH 5957. Female Sexuality. (3 cr; offered alt yrs) Satterfield

Lectures and discussions on basic aspects of the female experience of sexuality.

FPCH 5958. Small Group Process. (3 cr; prereq #) Coleman

Group dynamics; various schools of group process and therapy active today. Experiential and cognitive methods used.

FPCH 5960. Basic Research Methods Seminar and Practicum. (4 cr) Kelly

Basic inquiry skills. Topics suitable for the advancement of family practice research.

FPCH 5962. Clinical Hypnosis Workshop. (1-2 cr per workshop; prereq #) Houge

New departures and/or new applications from the behavioral science area of clinical practice. Lectures, workshops, and conferences.

FPCH 5967. Introduction to Health Data Systems. (Cr ar; prereq completion of 1st-yr residency or #)

Machine-readable databases and decision support systems relevant to community health.

FPCH 5972, 5973, 5974. Research Methods in Family Medicine I, II, III. (2 cr per qtr; prereq FPCH grad student or #)

Research design and methodology, biostatistics, epidemiology, and demography. Steps necessary to formulate a question, determine its significance, develop an appropriate methodology, implement and complete a study, analyze data, and report findings in peer-reviewed literature.

FPCH 8201. Clinical Family Medicine. (Cr ar) Ciriacy, staff

Supervised care for patients of all ages on a continuous, primary, preventive, and general diagnostic basis. Diagnosis, methods of treatment, and problem-solving devices for the benefit of the patient and family are emphasized with particular emphasis on health hazard appraisal. New and refined methods of recording, documentation, and retrieval of clinical data.

FPCH 8202. Families in Loss, Grief: Recovery Resources. (2 cr; prereq #) Seim

FPCH 8204. Seminar: Quantitative Strategies in Healthcare Practice and Research. (2 cr; prereq #) Weckwerth

Review of elementary statistical methods for both description and inference. Use of workbooks to identify and sharpen skills. Application of elementary decision making with emphasis on sensitivity/specificity and decision errors. Elementary literature critiques. Students make presentation and write paper, based on one or more journal articles, explaining an application to patient care of a strategy.

## GRADUATE PROGRAMS

FPCH 8205. Medical Records Systems. (2 cr)  
Ciriacy

Introduction to the problem-oriented medical record. Emphasis on forms analysis, tabulation systems, and the use of a structured medical record in health services research.

FPCH 8206. Seminar: Psychology in Medicine. (2 cr; offered when feasible) Ireton

FPCH 8207. Seminar: Common Diseases Seen in Family Practice. (1 cr) Ciriacy, staff

FPCH 8208. Family Medicine Conferences. (1 cr) Ciriacy, staff  
Problem cases from the Family Practice Service. Diagnosis, treatment, and consideration of relevant current literature.

FPCH 8209. Family Medicine X-Ray Conference. (1 cr) Ciriacy, staff

FPCH 8210. Family Medicine Grand Rounds. (1 cr) Asp, staff  
Monthly conference with each institution presenting topics.

FPCH 8211. Practice Management. (2 cr)  
Lindblom  
Establishment of practice, allocation of income, and professional relations.

FPCH 8212. Clinical Psychiatry Rounds. (1 cr; prereq 1st-yr FPCH resident) Kelly  
Medical fellows meet with a teaching psychiatrist to review cases, preferably from among patients. Topics of high clinical relevance presented and discussed.

FPCH 8215. Seminar: Psychosomatic Medicine. (2 cr; prereq completion of 1st-yr residency or #) Kelly  
Concept of multicausality of disease including biologic, psychologic, and social factors that may predispose, precipitate, or aggravate disease. Theoretical models of psychosomatic disease and concept of "symptom choice" by patients. Methods of recognition, quantification, and treatment including pharmacal therapy and psychotherapy.

FPCH 8216. Pediatric Psychology. (2 cr; prereq completion of 1st-yr residency or #; offered when feasible) Ireton

FPCH 8217. Seminar in Counseling. (2 cr; prereq 5567, 8215 or #) Kelly  
Skills and strategies for performing short-term supportive counseling in family practice setting. Patient selection. Skills applicable to beginning, middle, and end of counseling. Strategies for working with patients presenting different types of problems seen by the family physician.

FPCH 8223. Introduction to Gerontology and Geriatric Medicine. (2 cr; prereq completion of 1st-yr residency or #) Reed  
Introduction to human aging: social, biological, and psychological aspects. Programs and policies dealing with aging. Developmental and holistic approaches to the aging process and healthcare.

FPCH 8224. Community Mental Health Seminar. (1 cr; required for 3rd-yr residents; prereq completion of 2nd-yr residency) Kelly  
Background material in a given area of community mental health followed by a community experience in that particular area and sharing of experiences with other residents at the training center. Split-time experience for the resident during which experience in medical sociology is made available.

FPCH 8225. Medical Sociology. (3 cr; offered when feasible)

FPCH 8226. Medical Sociology Seminar. (2 cr; prereq physician or sociology grad student; offered when feasible)

FPCH 8228. Seminar: Interdisciplinary Health. (2 cr; prereq #) Kelly

FPCH 8240. Community Resources. (2 cr) Kelly  
Discussions with representatives of selected community agencies.

FPCH 8242. Economics of Healthcare Delivery Systems. (3 cr; offered when feasible)

FPCH 8243. Family Medicine in the Rural Area. (Cr ar; prereq #) Lindblom  
Problems specific to rural areas such as physician distribution, use of allied health personnel, initial emergency treatment, referral patterns.

FPCH 8250. Quantitative Strategies in Healthcare Practice and Research II. (2 cr [1 addtl cr available]; prereq 8204) Weckwerth  
Presumptive review of elementary descriptive and inferential quantitative methods; models for decision making; evaluation; logic tree; critique of literature. Major output: designing in-practice study of test, treatment, service, or method of choice to show outcome effect on patients.

FPCH 8582. Practice Management II. (2 cr; prereq 3rd-yr residency, 5581; offered when feasible) Lindblom

FPCH 8253. Research Problems. (Cr ar; prereq #) Kelly  
Under supervision of faculty member.

## Family Social Science (FSoS)

*Professor:* M. Janice Hogan, *head*; Kathryn D. Rettig, *director of graduate studies*; Jean Bauer; Pauline Boss; Thomas Brothen; Daniel F. Detzner; William J. Doherty; M. Geraldine Gage (*emeritus*); Harold D. Grotevant; Mary E. Heltsley; James W. Maddock; David H. Olson; Paul C. Rosenblatt; Shirley Zimmerman

*Associate Professor:* Bonnie S. Braun; Rose M. Brewer; Sharon M. Danes; Ann W. Garwick; Joan M. Patterson; Beatrice E. Robinson; Marlene S. Stum

*Other:* Philip L. Colgan; William J. Goodman

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) and Ph.D.

**Curriculum**—Family social science is a multidisciplinary program that offers an integrated program of study in the areas of family relationships, family therapy, and family policy, economics, and resource management. The program uses the knowledge of various social sciences to study the family as a system and its interaction with other social systems. The goals of graduate training include emphasizing theory, research, and application (e.g., family life education, marriage and family therapy, family policy). Marriage and family therapy is not available at the master's level.

**Prerequisites for Admission**—Minimum requirements for admission to the master's program include two family courses; at least one course in economics, political science, government, or public policy; one course in sociology, anthropology, or human geography; one psychology course; and one statistics course. Minimum requirements for admission to the doctoral program include all the requirements for admission to the master's program plus two additional social or behavioral science courses and two additional statistics and/or research methods courses.

It is recommended that students have one research methods course, one course in calculus, experience working with families through paid employment or volunteer work, and evidence of interest in research and in the development of research competence, particularly for students applying for the Ph.D. program.

Students may apply for admission to the Ph.D. program after completing either a bachelor's degree or a master's degree.

**Special Application Requirements**—Consult the *Family Social Science Graduate Handbook* or the director of graduate studies. The application deadline is December 15 for admission fall quarter of the following year.

**Degree Requirements**—Consult the *Family Social Science Graduate Handbook* or the director of graduate studies.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Department of Family Social Science,

University of Minnesota, 290 McNeal Hall, 1985 Buford Avenue, St. Paul, MN 55108 (612/625-3116 or 612/625-1900; fax 612/625-4227).

FSoS 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

FSoS 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

FSoS 8888. Thesis Credits: Doctoral. (36 cr required)

FSoS 5001. Human Sexual Behavior. (5 cr; prereq 90 cr, 3600 or grad student in social or behavioral or educational or health science or human service program or #) Maddock  
Multidisciplinary approach to sexual development through individual/family life cycles, emphasizing scientific knowledge to promote sexual health through individual, family, and community services; ethics and values issues.

FSoS 5025. Parenting. (4 cr; prereq 5200 or 5202)  
Parenting methods and child development from infancy through adolescence. Students identify differing parenting techniques, develop their own parenting approach, and conduct parenting classes.

FSoS 5200. Family Systems. (5 cr; prereq intro course in psych and soc) Doherty, Olson  
Advanced survey of current developments emphasizing families as complex systems of interpersonal relationships that also interact with larger social systems.

FSoS 5202. Family Psychology: The Study of Close Relationship Processes. (4 cr; prereq 3600 for FSoS majors, Psy 3204 for psych majors and others) Boss, Grotevant  
Processes of interaction and communication within families of origin, families of choice, and other close relationships. Consideration of multidisciplinary research and theory taken from psychology, sociology, and family therapy. Marriage, divorce, friendship, partnership, and being single discussed in light of theories of attraction, love, intimacy, and sexuality. Issues of fairness, altruism, equity, power, violence, and communication as central to relationship formation and dissolution. Focuses on dynamic processes of family and couple relationships within diverse social contexts.

FSoS 5205. Introduction to Family Research Methods. (4 cr; prereq 3260, 5200) Rosenblatt  
Logic and philosophy of scientific method. Family research questions and objectives, standards for evaluating family research, techniques of data gathering (qualitative and quantitative methods), analysis, reporting, and writing.

FSoS 5210. The Family in World Perspective. (4 cr; prereq 3600 or 5200, intro cultural anth course or #) Rosenblatt  
Comparison of kinship, marriage, family organization, the family life cycle and modes of family functioning across cultures; relationship to economic, political, religious, and other institutions, with emphasis on adaptations of the family to urbanization and industrialization.

## GRADUATE PROGRAMS

FSoS 5218. Family Financial Management. (4 cr; prereq 3260 or equiv) Hogan, Rettig  
Analysis of family financial management principles. Financial planning of savings, investments; credit, mortgages; taxation; life, disability, health, property insurances; public, private pension; estate planning.

FSoS 5220. Family Economics. (4 cr; prereq 3260 or #) Rettig  
Variations in family income, saving, spending, and decision making related to socioeconomic factors. Conceptual development and research on economic problems of families.

FSoS 5230. Independent Study in Family Social Science. (1-5 cr [max 16 cr])  
Independent reading or research under faculty supervision.

FSoS 5240. Special Topics in Family Social Science. (2-6 cr per qtr [max 16 cr]; prereq determined by instructor, specific for each topic)  
Review of research and discussion. See the *Class Schedule* for topics.

FSoS 5241. Legal-Economic Controversies in Family Life. (4 cr; prereq 3260 or 3600 or 5200 or #) Rettig  
Interdisciplinary seminar on legal-economic controversies across family life span for diverse family forms. Alternative family definitions and living arrangements; premarital and marital contracts; alternative means of parenting; income, support, and debt issues; property transfer at death and divorce; decision making for health and long-term care.

FSoS 5251. Aging Families. (4 cr; prereq 3600 or 5200 or SW 5024 or #) Detzner  
Aging families as complex developing systems interacting with changing social structure. Marital relationships, role changes, and family care-giving issues.

FSoS 5252. Aging, Family, and Society. (4 cr; prereq 3600 or 5210 or SW 5024 or #) Detzner  
Elderly populations from diverse cultures examined within context of individual life history, family systems, and social structure.

FSoS 5253. Humanities, Aging, and Family Living. (4 cr; prereq 3600 or 5200 or SW 5024 or #)  
Aging and family living from literature and film perspectives.

FSoS 5255. Approaches to Family Policy. (4 cr; prereq 3260 or 3600, SW 3202 or #) Zimmerman  
Interrelationship between families and social policy in welfare, housing, healthcare, family law, education, and social services.

FSoS 5256. Family Policy: An International Perspective. (4 cr; prereq 5210 or 5252 or 5255 or #) Zimmerman  
Comparison of different countries' policy choices and actions in areas directly affecting families: health, education, social services, income maintenance, employment and the work force, taxation; values and traditions such policies represent.

FSoS 5260. Dynamics of Family Decision Making. (4 cr; prereq 3260 or #) Rettig  
Conceptual models of decision making and resource management. Review and critique of current research and literature.

FSoS 5500. Racial and Ethnic Diversity in Families. (4 cr; prereq 3600) Goodman, Rosenblatt  
Overview of family issues of various American racial and ethnic populations. Study of research and case studies; individual projects to develop and enrich understanding of cultural diversity.

FSoS 8203. Family Stress, Coping, and Adaptation. (4 cr; offered alt yrs) Boss  
Theories related to family development, structure, and behavior in response to social and psychological stress. Normal and dysfunctional family behavior. Emphasis on research and intervention for family stress or crisis.

FSoS 8205. Qualitative Family Research. (3 cr; prereq 8255) Rosenblatt  
Intensive examination of role of qualitative methods in social sciences. Data collection techniques; participant observation; informant interviewing; document analysis; sampling; field relations and rapport; ethical issues; reliability and validity of qualitative data; role of theory in field studies. Students conduct qualitative study.

FSoS 8214. Theories of Marital and Family Therapy. (4 cr; prereq 8255) Boss, Doherty  
Comprehensive review and critique of major theories of marital and family therapy with emphasis on clinical integration of these models.

FSoS 8215. Clinical Issues in Marital and Family Therapy. (4 cr; prereq 8214; offered alt yrs) Boss, Doherty, Maddock  
Issues such as divorce, sexual dysfunction, enrichment, and chemical dependence, using research and theory to determine clinical strategies.

FSoS 8216. Marital and Family Assessment. (4 cr; offered alt yrs) Olson  
Overview and experience administering and interpreting a variety of marital and family assessment tools.

FSoS 8217. Clinical Interventions for Sexual Problems. (3 cr; prereq human service or health science grad student, 5001 or #; offered alt yrs) Maddock  
Rationales for sexual healthcare in clinical settings and methods of intervention into sex-related problems of various populations, with focus on assessment, behavioral change techniques, and specialized therapy approaches.

FSoS 8221. Internship in Teaching College-Level Family Courses I. (4 cr; prereq 12 cr FSoS; offered alt yrs) Detzner, Maddock, Rettig  
Theoretical course on learning styles, teaching techniques, curriculum development, and family life education. Students develop philosophy of teaching/ learning inclusive of race, class, and gender differences. Practical teaching issues analyzed: course content, objectives, syllabi development, formal/informal teaching techniques, and student evaluation.

**FSoS 8222. Internship in Teaching College-Level Family Courses II.** (2 cr; prereq 8221, #) Detzner, Maddock, Rettig  
Practice-teaching course. Students assist in planning 3xxx course, participate in its teaching, and construct method for evaluation of student performance.

**FSoS 8223. Internship in Teaching College-Level Family Courses III.** (2 cr; prereq 8222, #) Detzner, Maddock, Rettig  
Students plan, teach, and evaluate student performance in 1xxx course under supervision and mentoring of faculty. Videotaped self-assessment of teaching.

**FSoS 8230. Directed Study in Family Social Science.** (1-7 cr; prereq #)

**FSoS 8231. Seminar in Gender Roles.** (3 cr; offered alt yrs) Doherty, Hogan  
Discussion and research on selected problems in area of gender roles, similarities, and differences; review of scholarly literature.

**FSoS 8242. Value Theories and Research in Family Social Science.** (4 cr; prereq 5200, 5260 or equiv or #: offered alt yrs) Rettig  
Review and critique of theories and research on values and valuing processes in families.

**FSoS 8251. Problems: Family Social Science.** (1-5 cr; prereq #)

**FSoS 8255. Conceptual Frameworks in the Family.** (4 cr; prereq 5200 or equiv, #) Boss, Doherty  
Required of all first-year graduate students in family social science. Overview and theoretical orientation to family field.

**FSoS 8256. General Systems Theory and Family Systems.** (4 cr; prereq 8255, FSoS grad student or #: offered alt yrs) Maddock  
Theoretical concepts and principles of systems/ ecosystems and their application to family theory, research, and practice.

**FSoS 8257. Family Theory Development.** (3 cr; prereq 8255; offered alt yrs) Olson  
Meta-analysis, inductive and deductive approaches, and qualitative and quantitative approaches to developing family theory.

**FSoS 8258. Family Research from Economic Perspectives.** (4 cr; prereq soc sci theories grad course, research methods course; offered alt yrs) Rettig  
Review and critique of family research.

**FSoS 8260. Family Decision Making.** (4 cr; prereq 5260 or #: offered when feasible) Hogan, Rettig

**FSoS 8261. Process Seminar for Family.** (2 cr; prereq #)  
Required of all first-year family social science students (orientation to graduate program); not open to other students.

**FSoS 8266. Family Research Methodology.** (4 cr; prereq 8255; offered alt yrs) Olson  
Various research approaches, research design, and instrument development used to study the family. Students design and conduct pilot research projects. (First of two courses.)

**FSoS 8270. Practicum in Family Research.** (1-5 cr; prereq #)  
Supervised family research.

**FSoS 8317-8318. Family of Origin: I, II.** (2 cr per qtr; prereq family therapy intern) AAMFT-approved clinical faculty  
In-depth study of each intern's family of origin in process setting of fellow interns and clinical family therapy supervisor.

**FSoS 8319. Ethical and Legal Issues in Marital and Family Therapy.** (4 cr; prereq 8214, 8215 or #: offered alt yrs) Boss, Doherty, Maddock  
Major issues—ranging from general social issues (e.g., feminism), to legal concerns (e.g., reporting laws), to specific client situations (e.g., sexual exploitation by therapists)—explored from a systemic perspective.

**FSoS 8500. Clinical Consultation with Couples and Families.** (3 cr; prereq 8214, official acceptance into AAMFT-accredited training program or #)  
Students become part of supervised consultation team working with community clinicians and their clients.

**FSoS 8501. Family Therapy Practicum.** (4 cr; prereq 8255, official acceptance into AAMFT-accredited training program, #) Boss, Doherty, Goodman, Maddock, Olson  
Clinical experiences in preparation for internship; focus on integrating theory with skills in presence of families.

**FSoS 8551. Internship in Marital and Family Therapy.** (1-7 cr; prereq 8214, 8215, #) Boss, Doherty, Maddock  
Participation in actual marital and family therapy clinical practice in approved community setting with on-site supervision (one to one) plus on-campus supervision (group setting with fellow interns).

## Feminist Studies

*Professor:* Helen E. Longino (women's studies), *director of graduate studies;* Terence Ball (political science); Karlyn K. Campbell (speech-communication); Mary Dietz (political science); Sara Evans (history); Patricia Faunce (women's studies; psychology); Mary L. Fellows (law); Shirley Garner (English); Barbara A. Hanawalt (history); Ruth-Ellen Joeres (German); Indira Y. Junghare (South and Southwest Asian studies); Amy Katz Kaminsky (women's studies); Sally G. Kohlstedt (history of science and technology); Barbara Laslett (sociology); Elaine Tyler May (American studies); M. J. Maynes (history); Toni McNaron (English; women's studies); Valerie J. Miner (English); Jeylan Mortimer (sociology); Susan J. Noakes (French and Italian); Jean Quam (social work); Paula Rabinowitz (American Studies); Martin Roth (English); Naomi Scheman

## GRADUATE PROGRAMS

(philosophy; women's studies); Madelon Sprengnether (English); Billie J. Wahlstrom (rhetoric)

*Associate Professor:* Lisa Albrecht (General College); Jean M. Allman (history); Ronald Aminzade (sociology); Walter O. Bocking (Medical School); Maria Minich Brewer (French and Italian); Rose M. Brewer (women's studies; Afro-American and African studies); Lillian S. Bridwell-Bowles (English); Maria Damon (English); Lisa J. Disch (political science); Lois Erickson (educational psychology); Susan Geiger (women's studies); Jane F. Gilgun (social work); Linda Jones (social work); Mary Jo Kane (kinesiology and leisure studies); Sally J. Kenney (Humphrey Institute of Public Affairs); Helen Q. Kivnick (social work); Mary M. Lay (rhetoric); Richard W. McCormick (German); Ellen R. Messer-Davidow (English); Carol A. Miller (American studies); Joanna O'Connell (Spanish and Portuguese); Gianna Pomata (history); Riv-Ellen Prell (American studies); Gloria Goodwin Raheja (anthropology); Angelita D. Reyes (women's studies); Julia Robinson (architecture); Hanna Schissler (German; history); Amy Sheldon (linguistics); Eileen B. Sivert (French and Italian); Janet Spector (anthropology); Constance Sullivan (Spanish and Portuguese); Caroline Turner (educational policy and administration); Ann B. Waltner (history); Oliver J. Williams (social work); Gayle Graham Yates (American studies); Jacquelyn Zita (women's studies)

*Assistant Professor:* Lisette E. Josephides (anthropology); Josephine D. Lee (English); Lisa A. Norling (history); Jean M. O'Brien-Kehoe (history); Jennifer L. Pierce (sociology)

*Lecturer:* Doris G. Marquit (women's studies)

**Course of Study**—Minor in feminist studies, applicable to master's (M.A. and M.S.) and doctoral programs.

**Curriculum**—A structured interdisciplinary graduate minor in feminist studies is offered in conjunction with the Center for Advanced Feminist Studies (CAFS). The program focuses on the acquisition of skills and competencies in four general areas: interdisciplinary knowledge of women and gender; feminist theories and methods; competency in feminist research in a specific field; feminist practice through teaching or internships.

**Prerequisites for Admission**—Admission to the CAFS graduate minor is contingent upon prior admission to a master's or doctoral degree-granting program within the Graduate School.

**Special Application Requirements**—Completion of application form, due February 1 for consideration for acceptance into the minor program in the following academic year. Applications received after February 1 are considered as space allows. It is anticipated that no more than fifteen students will be admitted

into this minor each year. CAFS does not require an undergraduate major or minor in Women's Studies as a prerequisite for admission to the minor program. However, applicants are expected to show general knowledge of feminist scholarship as evidenced, for example, in some combination of previous coursework, research, writing, or organizational experience.

**Minor Requirements**—A sequence of two core seminars in feminist theory and methods is required of all students in the program. In addition, M.A. students must take two electives, for a total of 16 credits, for a minor. Doctoral students take one additional seminar, in feminist research and writing, and two electives, for a total of 20 credits for a minor.

**Language Requirements**—None specific to the minor program.

**For Further Information and Applications**—Contact the Center for Advanced Feminist Studies, University of Minnesota, 496 Ford Hall, 224 Church Street S.E., Minneapolis, MN 55455 (612/624-6310; fax 612/624-3753; e-mail [cafs@tc.umn.edu](mailto:cafs@tc.umn.edu)).

### Women's Studies (WoSt)

WoSt 5100, 5200, 5300, 5400, 5500, 5600.  
Topics in Women's Studies. (4 cr per qtr [max 12 cr])  
Topics specified in the *Class Schedule*.

WoSt 5101. History of Western Feminism. (4 cr; prereq 1001, 1002; offered alt yrs)  
Feminist thought and movements; feminist politics since 1790, especially in the United States and Great Britain; other international references.

WoSt 5102. Current Feminist Scholarship. (4 cr; prereq 1001, 1002 or grad student or #; offered alt yrs)  
Current scholarship dealing with feminist ideas and issues.

WoSt 5103. Feminist Pedagogies. (4 cr; prereq 8 cr WoSt or #) Albrecht, Geiger, McNaron, Scheman, Zita  
Theory and practice of feminist teaching and learning as system or systems of inquiry, emphasizing challenges raised by diversity of women's experiences and perspectives.

WoSt 5106. The Cultural Construction of Sex, Gender, and Sexuality. (4 cr; prereq Center for Advanced Feminist Studies student or undergrad with 12 cr WoSt or #) Messer-Davidow, Zita  
Euro-American concepts of sex, gender, and sexuality in representative texts and images from 17th century to present. Critical and source materials from literary and cultural studies, history, biology, anthropology, psychology, and sociology.

WoSt 5201. *The Older Woman: A Feminist Perspective*. (4 cr; prereq 12 cr WoSt or substantial work in social sciences or psychology) Quam  
Changing roles of older women in our society. Societal, health, economic, familial, emotional, sexual, and political concerns unique to older women.

WoSt 5202. *Feminist Therapies*. (4 cr) Faunce  
Exploration of sexism in theoretical views of women and in therapy; alternative views and therapeutic approaches for women.

WoSt 5203. *Women, Feminism, and Power*. (4 cr; prereq 12 cr WoSt or #) Faunce  
Feminist conceptualizations of power, including personal power, empowerment, spirituality, networking, civil disobedience, holism, and utopias.

WoSt 5206. *Women and Madness: Representations, Differences, Resistances*. (4 cr, §CSCL 5910[sec 2]; prereq jr) Joeres  
Prescriptive application of label "madness" to women since 19th century. Readings in literature, case studies, and critical and theoretical texts.

WoSt 5301H. *Women's Autobiographical Narratives*. (4 cr)

WoSt 5305. *Women and Representation in Europe*. (4 cr; prereq 12 cr literature or feminist theory; offered alt yrs) Kaminsky  
Ways in which women and gender are represented in various cultural discourses, including fiction, drama, poetry, painting, music, medicine, and science in Europe.

WoSt 5308H. *Women Writers of Africa and Latin America*. (4 cr, §5308; prereq 8 cr WoSt or Latin Amer St or African St or #) Kaminsky  
Novels, short stories, poetry, and/or drama by contemporary African and Latin American women in context of gender analysis and history of colonialism.

WoSt 5401. *Women, Colonialism, and Underdevelopment*. (4 cr) Geiger  
Impact of colonial domination and economic underdevelopment on lives of women in Third World, strategies used by women to resist, survive, and overcome oppressive conditions.

WoSt 5402. *Women and Contemporary American Spirituality*. (4 cr; prereq 8 cr WoSt or grad student or #) Yates  
Present-day American women's spiritual consciousness and participation in religious institutions and religious movements. New forms of women's spiritual/religious knowledge and beliefs; quests for and expressions of them; their history and sources.

WoSt 5501. *Women and the Law*. (4 cr) Balos, Fellows  
The legal system as it relates to women. Areas of criminal law, welfare law, employment law, corporate law, alternative delivery systems for legal service, and legal education.

WoSt 5502. *Women and Public Policy*. (4 cr; prereq 1001, 1002 or #) Jones, Kenney  
Survey of social problems and public policy issues of special significance to women in United States. Macro-political, social, and economic forces shaping women's experiences as policy makers, administrators, citizens, and clients.

WoSt 5601. *Gender and Class*. (4 cr; prereq grad student or 12 cr WoSt incl 1001 or 1002 for undergrad, #) Laslett, Maynes  
Interactions between gender roles and social class in historical and comparative perspective; introduction to concepts and methods of gender and class analysis, women's work and economic systems, domestic work, social reproduction, feminism, socialism.

WoSt 5602. *Working Class Women's Lives*. (4 cr, §5304; prereq 12 cr WoSt or #; offered alt yrs) McNaron, Rabinowitz  
Social, historical, economic, and ideological influences/effects of women's participation in wage labor. Multidisciplinary study of impact of class, race, ethnicity, and gender on employment issues; protective legislation, job segregation, comparable worth, trade unions; women's experiences in workplace, child-rearing, and family life.

WoSt 5970. *Directed Study*. (1-5 cr per qtr [max 12 cr]; prereq #, Δ, CLA approval)

WoSt 8101. *Intellectual History of Feminism*. (4 cr; prereq #) Evans, Waltner  
Survey of Western feminist thought from Enlightenment to 1980; emphasis on United States.

WoSt 8102. *Feminist Literary Criticism*. (4 cr; prereq #) Kaminsky  
Key concepts and approaches in current feminist literary theory and criticism: survey of topics and international perspectives.

WoSt 8103. *Feminist Theories in the Social Sciences*. (4 cr) Geiger  
Recent disciplinary and interdisciplinary feminist theories in social sciences: major developments and issues; perspectives from disciplines; national and international conceptual frameworks.

WoSt 8510. *Feminist Theory and Method*. (4 cr; prereq #) Dietz, Kaminsky, Longino, Maynes, Rabinowitz  
Multidisciplinary methods, feminist theories; frameworks for feminist work; differences between feminist and traditional research; development of skills for challenging assumptions in methods and theories that define traditional fields.

WoSt 8511. *Feminist Theory and Method*. (4 cr; prereq 5810, #) Disch, Kaminsky, Longino, Messer-Davidow, Pierce  
Continuation of 8510.

WoSt 8610. *Topics in Feminist Studies*. (4 cr; prereq 8 cr grad-level WoSt or substantial work in topic area or #)  
Selected topics in interdisciplinary feminist research and scholarship.

WoSt 8710. Feminist Research and Writing. (4 cr per qtr [max 8 cr]; prereq 8511, passed prelims in degree-granting program, #) Geiger, Kaminsky, Spector

Examine and compare feminist research methods and evaluate feminist writing. Students research and write complete text or portion of extended project (e.g., thesis or dissertation proposal, chapter, article).

WoSt 8970. Directed Study. (1-8 cr; prereq completion of courses approved by faculty supervisor and director of graduate studies)

Allows students to register for independent readings with appropriate program faculty.

## Fisheries (FW)

*Professor:* Ira R. Adelman, *head, director of graduate studies*; Yosef Cohen; Anne Kapuscinski; Daniel A. Panshin; George R. Spangler

*Associate Professor:* Raymond M. Newman; Peter W. Sorensen; Bruce C. Vondracek

*Adjunct Associate Professor:* Gerald T. Ankley; Clayton J. Edwards

*Adjunct Assistant Professor:* Charles S. Anderson; Ned H. Euliss, Jr.; Cecil A. Jennings; Donald L. Pereira

*Research Associate:* Carl Richards<sup>1</sup>

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—This program is administered within the Department of Fisheries and Wildlife. Areas of emphasis include fish ecology, physiology, behavior, and genetics; fish population dynamics; computer modeling; stream ecology; aquaculture; and fishery management.

**Prerequisites for Admission**—Prospective students are expected to have a basic background in the biological sciences. Some experience in fisheries or aquatic science is desirable, but not required. A strong background in physical sciences, chemistry, mathematics, statistics, and computer use is recommended. For admission to the Ph.D., a master's degree is recommended.

**Special Application Requirements**—Three letters of recommendation from persons able to evaluate the applicant's academic and professional experience and results from the Graduate Record Examination (GRE) General

Test are required. When registering for the GRE, prospective students should list the fishery sciences major field code (0106).

Applications are accepted at any time.

However, because the faculty reviews most applications in late January for admission the following fall, applications should be sent before January 1.

**Master's Degree Requirements**—Plan A is recommended, although Plan B may be pursued with the consent of the advisory committee. For Plan A, the minimum coursework requirement is 20 credits in the major and 8 credits in a related field; for Plan B, the minimum is 44 credits. The Plan A thesis should be on a subject within the areas of emphasis. Coursework requirements are flexible, but typically include courses in fisheries, limnology or aquatic biology, statistics and biometrics, computer science, and related subjects. Programs may include a traditional minor or coursework in a related field. An oral preliminary examination is required as well as a final seminar and oral defense of the thesis or Plan B papers.

**Doctoral Degree Requirements**—The doctoral program includes a major research effort in the areas of emphasis, resulting in a written dissertation. It also includes advanced coursework in fisheries, limnology or aquatic ecology, and related subjects. Students must present a public lecture describing the thesis findings.

**Language Requirements**—No foreign language is required for either the master's or doctoral degree, except when the advisory committee determines that a foreign language is needed to support the student's research objectives.

**For Further Information and Applications**—Contact Karen Kanda, College of Natural Resources, University of Minnesota, 115 Green Hall, 1530 N. Cleveland Avenue, St. Paul, MN 55108 (612/624-2748; e-mail [kkanda@forestry.umn.edu](mailto:kkanda@forestry.umn.edu); <http://www.fw.umn.edu>).

FW 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

FW 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

FW 8888. Thesis Credits: Doctoral. (36 cr required)

<sup>1</sup> University of Minnesota, Duluth

FW 5279. Special Lectures in Fisheries. (Cr ar; offered when feasible)

FW 5455. Aquaculture. (3 cr; prereq Biol 1009, 1103, 1106 or equiv, Chem 1001-1002 or Chem 1004-1005 or equiv or #; offered alt yrs) Kapuscinski  
 Role of aquaculture in resource management and world food production; institutional and economic considerations; principles of husbandry of aquatic organisms; interactions between fish metabolism and water quality; nutrition and energetics; fish health and genetics.

FW 5459. Fish Physiology. (4 cr; prereq EEB 5136 or EEB 5156 or AnSc 3301 or #) Sorensen  
 Relationships among fish physiology, fish behavior, and the aquatic environment. Ionic and osmotic balance, gas exchange, locomotion, orientation and migration, reproduction, endocrinology, growth, and stress.

FW 5460. Pollution Impacts on Aquatic Systems. (2 cr; prereq Biol 5041, EEB 5601, Chem 1004, Chem 1005, Chem 3301, Chem 3305 or #; offered alt yrs)  
 Pollution assessment approaches, biological effects, fate and flow of contaminants in aquatic systems, and major types of pollutants.

FW 5461. The Behavior of Fishes. (3 cr; prereq 5459 or EEB 3111 or #; offered alt yrs) Sorensen  
 Organismal and sub-organismal perspectives of fish behavior. Feeding behavior and optimal foraging theory; learning and intelligence; genetic, neural, and endocrine bases of behavior; communication; orientation and navigation; schooling and shoaling; reproduction; and application of understanding of behavior to harvest, management, and conservation.

FW 5565. Fisheries and Wildlife Ecology and Management: Field Trip. (1 cr)  
 Ten-day field trip to Wyoming and points en route during spring break. Includes big game, waterfowl, and endangered species.

FW 5600. Fisheries and Wildlife Techniques. (4 cr; prereq Biol 5041 or EEB 3001 or #; offered at Itasca)  
 Introduction to field techniques and skills; planning and implementing field projects; data collection and analysis using microcomputers; written reports and field journal.

FW 5601. Fisheries Population Analysis. (4 cr; prereq NRES 1020 or computer competency, Stat 3011, Stat 3012 or Stat 5021, 1 qtr intro calculus)  
 Theory and methods for estimating vital statistics of fish populations. Students use microcomputers and statistical software to describe and model attributes of fish populations in case studies drawn from literature of marine freshwater fisheries management.

FW 5604. Fisheries Ecology and Management. (3 cr; prereq EEB 5601 or equiv or #, NRES 1020 or computer competency)  
 Emphasizes managed species and systems; applied aquatic and fish ecology related to fisheries; role of planning in fisheries management; applying management tools and assessing their effectiveness.

FW 5620. Geographical Information Systems (GIS) for Fisheries, Wildlife, and Biological Conservation. (4 cr; prereq Biol 5041) Cohen  
 Hands-on experience with GIS as tool for understanding, analysis, and management of ecological systems. ARC/INFO as applied to problems in fisheries, wildlife, and biological conservation.

FW 5701f, 5702w. Senior Project. (1, 2 cr; prereq FW sr or grad student or #) Cooper  
 Problem-solving training. Management problem identification and analysis design, information and data gathering and analysis, and oral and written problem reporting. Problem selection influenced by guest speakers, resource agency contacts, and group discussions; topic is contemporary fisheries and wildlife management issue.

FW 8100. Seminar. (Cr ar)  
 Lectures by and discussions with faculty members, visiting scholars, and graduate students on current topics.

FW 8200. Seminar. (Cr ar)  
 Oral and written reports and discussion by students on selected topics from current literature in fisheries biology and management. Lectures by and discussions with faculty members and visiting specialists.

FW 8364.\* Research in Fisheries Biology. (Cr ar; prereq fisheries grad student)

FW 8448. Fishery Science. (4 cr; prereq fisheries grad student or #; offered alt yrs) Spangler  
 Applications of ecological theory to the study and manipulation of fish populations; dynamics of growth, mortality, and yield of fish stocks; simulation applied to management problems.

FW 8452. Conservation Biology: Genetic and Demographic Issues. (3 cr; prereq #) Kapuscinski, Smith  
 Seminar on current conservation biology issues; genetic, demographic, and environmental analysis and management of populations; ecosystem conservation; case studies of species conservation strategies.

FW 8459. Stream and River Ecology. (4 cr; prereq EEB 5601 or equiv or #; offered alt yrs) Newman  
 Introduction to structure and dynamics of running waters from an ecosystem perspective. Historical perspective, basic hydrology and fluvial geomorphology, terrestrial-aquatic interactions, detrital dynamics, metabolism, drift, trophic relations, biotic and abiotic interactions, ecosystem experiments and natural alterations, stability and succession, and ecosystem dynamics in a watershed perspective. One field trip.

FW 8460. Fish Habitats and Restoration. (3 cr; prereq Biol 5041 or equiv, grad student or #; offered alt yrs) Vondracek  
 Mechanisms underlying physiology and behavior that shape fish community structure in specific north temperate habitats; current techniques and planning procedures for restoration of lakes and streams.

FW 8579. Ecosystem Analysis and Simulations: A Numerical Approach. (5 cr; prereq 1 qtr calculus, 1 qtr statistics, some exposure to computers; offered alt yrs) Cohen  
Systems analysis methods (e.g., state-space models, transfer functions) and numerical simulations in ecology and fisheries/wildlife management. Presentation of data in time and frequency domains; interpretation of results.

NRES 5575. Wetlands Conservation

*See Ecology for other relevant courses.*

## Food Science (FScN)

*Professor:* Francis F. Busta, *head*; Gary A. Reineccius, *director of graduate studies*; Paul B. Addis; Linda J. Brady; William M. Breene (*emeritus*); Agnes S. Csallany; Eugenia A. Davis; Richard J. Epley; R. Gary Fulcher; Joan Gordon (*emeritus*); Theodore P. Labuza, Larry L. McKay; Howard A. Morris (*emeritus*); Irving J. Pflug; Joanne L. Slavin; David E. Smith; Sita R. Tatini; Joseph J. Warthesen; Edmund A. Zottola

*Associate Professor:* Elaine H. Asp; Craig A. Hassel; H. William Schafer; Zata M. Vickers

*Assistant Professor:* Eric D. Bastian; Mrinal Bhattacharya; Joellen M. Feirtag; Daniel J. O'Sullivan; Rongsheng R. Ruan

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Students may emphasize the chemistry, engineering, microbiology, nutrition, or technology of food products.

**Prerequisites for Admission**—Superior applicants with an undergraduate major in any physical or biological science usually have completed the necessary prerequisites. The minimum requirements are general chemistry, organic chemistry with laboratory, physics with laboratory, and calculus. If preparation appears inadequate, certain additional courses may be required after admission.

**Special Application Requirements**—Submission of scores from the General (Aptitude) Test of the Graduate Record Examination is required. Submission of three letters of reference is also required whether or not the prospective student is applying for financial assistance. Students are admitted each quarter.

**Master's Degree Requirements**—Coursework in each of five program areas is required so that students develop a depth and breadth of knowledge in the field. The five program areas and the appropriate courses (equivalents may be substituted) are: (1) Chemistry—minimum of 5 credits from among FScN 5110, 5312, 5314, 8311, 8312, 8315, 8403; (2)

Engineering—a minimum of 5 credits from among FScN 5135, 5555, 8322, AgEn 5140; (3) Technology—a minimum of 4 credits from among FScN 5512, 5522, 5523, 5530, 5540, 5550, 5562; (4) Microbiology—a minimum of 5 credits from among FScN 5120, 5122, 5123, 5320, 8322, 8323, 8324; and (5) Consumer Issues—a minimum of 3 credits from among FScN 5360, 5390, 5404, 5474, 5524, 5643. In addition, 1 credit of FScN 8205 is required. Familiarity with nutrition, as demonstrated through completion of a course equivalent to FScN 1612, as a minimum, is required.

Master of science candidates may exceed the 40 percent limit on transfer of Continuing Education and Extension/University College credits customarily permitted in the Graduate School. Students wishing to do so must consult the director of graduate studies for further instructions.

The minor may be chosen from a variety of fields including biochemistry, business administration, chemistry, chemical engineering, economics, industrial engineering, marketing, microbiology, nutrition, physiology, public health, and technical communication. A final oral examination is required; a final written examination may be required at the discretion of the graduate faculty.

**Doctoral Degree Requirements**—No specific coursework for the major is designated, but students must take an entrance examination to suggest courses that will assure a broad food science background. Courses beyond these are determined by the student and adviser, with approval by the graduate studies committee. Students usually take the basic courses required for the M.S. degree (Plan A), along with courses in the thesis area. To insure approval of the program, students should consult with the adviser and director of graduate studies. The minor may be chosen from among the fields suggested for the master's degree minor.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—For the master's degree, a minimum of 11 credits selected from two of the five program areas. For the doctoral degree, a minimum of 20 credits from three of the five program areas. These courses should be chosen in consultation with the director of graduate studies.

**For Further Information and Applications**—Contact the Graduate Program in Food Science, University of Minnesota, 225 Food Science and Nutrition, 1334 Eckles Avenue, St. Paul, MN 55108 (612/624-1290).

FScN 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

FScN 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

FScN 8888. Thesis Credits: Doctoral. (36 cr required)

FScN 5110. Food Chemistry. (4 cr; prereq 3102, BioC 3031 or Biol 5001) Csallany  
Chemical structures and functional properties of food components in relation to their roles as parts of complex biochemical systems and as modified by environmental and processing factors.

FScN 5111. Independent Study in Food Science and Nutrition. (1-5 cr [may be repeated for cr]; prereq Δ)

Individual lab or library research in some area related to food science or nutrition.

FScN 5120. Food Microbiology. (5 cr; prereq 1102, 3112, VPB 3103 or MicB 5105 or #) Tatini  
Relationship of environment to occurrence, growth, and survival of microorganisms in foods; methods of evaluation, mechanisms to control, genera and species of importance, control of foodborne pathogens and toxins. Enumeration, isolation, and identification of microbes in foods.

FScN 5122. Control Systems in Food Microbiology. (2 cr; prereq 5120) Zottola  
Control and destruction of microorganisms in foods; hazard analysis; critical control points; chemical, physical, and microbiological considerations in cleaning and sanitizing food contact surfaces and equipment; microbiological criteria for raw and processed foods; sampling methodologies.

FScN 5123. Food Fermentations and Biotechnology. (3 cr; prereq 5120) McKay  
Food fermentation processes; characteristics of microorganisms involved in food fermentations and production of food ingredients; composition and factors influencing activity of starter cultures; microbiology of natural and controlled fermentations; properties of lactic bacteriophages and methods of control during dairy fermentations.

FScN 5135. Food Engineering Unit Operations. (5 cr; prereq 3136, Phys 1042) Bhattacharya  
Principles and food system applications of the following unit operations: fluid flow, heat transfer, drying, evaporation, contact equilibrium (distillation, extraction, crystallization, and membrane processes), and mechanical separation (filtration, centrifugation, sedimentation, and sieving).

FScN 5312. Instrumental Analysis of Foods. (3 cr; prereq 3112, 5110) Reineccius  
Application of instrumental methods of analysis to the examination of food products.

FScN 5314. Physicochemistry of Foods. (4 cr; prereq 5110; offered alt yrs)  
Characterization of crystalline systems, gels, emulsions, and foams; functionality of food macromolecules in these systems.

FScN 5316. Quantitative Light Microscopy in Agriculture and Food Research. (4 cr; prereq Biol 1009 or Chem 1052; offered alt yrs) Fulcher  
Introduction to light microscopy and its variants. Description and applications of quantitative instruments for characterizing cell, tissue, and other raw or processed materials. Digital image analysis, scanning microspectrophotometry, and laser scanning microscopy.

FScN 5360. Sensory Evaluation of Food Quality. (4 cr; prereq 3102, Stat 3012 or Stat 5021; offered alt yrs) Vickers  
Fundamentals of sensory perception. Test designs and methods used in studying the sensory quality of foods.

FScN 5380. Food Packaging. (3 cr; prereq 1102, 3102, Phys 1042; offered alt yrs) Willson  
Basics of packaging materials; principles of packaging development and product protection as applied to foods.

FScN 5390. Introduction to Food Law. (4 cr; prereq 1102 or #; offered alt yrs) Labuza  
Analysis of federal and state legal requirements and case law history affecting production, processing, packaging, marketing, and distribution of food and food products.

FScN 5401. Special Topics in Food Science and Nutrition. (1-4 cr; prereq varies with topic)  
In-depth investigation of topic not covered by other courses; topics specified in *Class Schedule*.

FScN 5404. Current Issues in Food and Nutrition. (2-4 cr; prereq 15 cr food science and nutrition or #)  
Evaluation of popular and scientific literature as it deals with nutrition, food additives, food safety, food fads, health foods, environmental contamination, the consumer movement, naturally occurring food toxicants, processed foods, synthetic foods, organically grown foods.

FScN 5474. Food Marketing Economics. (3-4 cr, \$AgEc 5550; prereq AgEc 3101 or #) Asp, Senauer  
Economics of food marketing in United States. Food consumption trends; consumer food behavior; food expenditure and consumption data; consumer survey methodology; food distribution and retailing system; food policy issues related to food marketing. Individual and group projects required.

## GRADUATE PROGRAMS

FScN 5512. Meat Technology. (4 cr; prereq 5110; offered alt yrs) Addis  
Industrial processing of meat, fish, and poultry products, including protein functionality, thermal processing, curing, smoking, and deterioration during storage. Use of preblending and least-cost analysis in product development and formulation.

FScN 5522. Technology of Fluid and Concentrated Milk Products. (4 cr; prereq 3136, 5110; offered alt yrs) Smith  
Application of scientific principles to problems involved in processing fluid and dehydrated milk systems and their control. Demonstration of basic processing operations including heating, cooling, homogenization, evaporation, drying, crystallization, and freezing.

FScN 5523. Technology of Fermented Dairy Products. (4 cr; prereq 5110, 5123; offered alt yrs) Bastian  
Integration of chemical, microbiological, and physical principles involved in manufacturing and storing cheeses and fermented milks.

FScN 5524. Sensory Evaluation of Dairy Products. (1 cr; prereq 3102) Smith  
Lab and commercial procedures for evaluating the sensory properties and market quality of dairy products. Cause and identification of common defects in flavor, physical properties, and appearance.

FScN 5540. Fats and Oils Chemistry and Technology. (4 cr; prereq 5110; offered alt yrs) Csallany  
Nature of fats and oils, their structure, composition, chemical and physical properties; raw materials for fat and oil products; extraction, refining, hydrogenization, and other industrial manipulations; handling, storage, analysis, and grading of raw materials and finished products.

FScN 5550. Grains: Introduction to Cereal Chemistry and Technology. (4 cr; prereq Biol 1009 or Chem 1052; offered alt yrs) Fulcher  
Origins, structure, biochemistry, and cellular properties of major cereal grains as they relate to primary processing (milling) and secondary processing (production of cereal products). Relation between structure and functionality as determinants of quality in grains and grain products. Quality evaluation technologies.

FScN 5555. Freezing and Dehydration of Foods. (5 cr; prereq 1102, 5135; offered alt yrs) Labuza  
Principles involved in the processing, handling, and storage of frozen, dry, and intermediate moisture foods, with emphasis on the physicochemical properties of water in foods.

FScN 5560. Introduction to New Product Development. (3 cr; prereq 8 crs food science; offered alt yrs) Fulcher  
Principles, from identification and testing of new product concepts through prototype testing, to basic process design using an interactive format and industrial examples. Statistical and chemical control of new processes and methods for evaluating consumer acceptance.

FScN 5562. Flavor Technology. (4 cr; prereq 1102, 5110; offered alt yrs) Reineccius  
Flavor and off-flavor development in foods. Industrial production of food flavorings and their proper application to food systems.

FScN 5614. Nutrition Education. (3 cr; prereq 3610)  
Application of educational principles, models, and theories to development, delivery, and evaluation of nutrition lessons, curricula, and communications.

FScN 5620. Nutrition and Metabolism. (5 cr; prereq 3612 or #, Biol 5001) Brady  
Physiological function and metabolic fate of carbohydrates, lipids, and proteins and their involvement in fulfilling energy needs for maintenance, growth, and work. Physiological function of vitamins and minerals.

FScN 5623. Vitamin and Mineral Biochemistry. (4 cr; prereq 3612, Biol 5001, Phsl 3051) Gallaher  
Nutritional/biochemical and physiological function of essential vitamins and minerals in humans and experimental animal models.

FScN 5624. Human Protein and Energy Utilization. (4 cr; prereq 5622) Kurzer  
Regulation of human protein and energy use, interactions, adaptations; critical evaluations of methods for determining requirements; technical and ethical problems in human experimentation and determination of recommended levels of intake.

FScN 5643. World Food Problems. (3 cr, \$AgEc 5790, \$Agro 5200, \$CAPS 5280; prereq sr or grad student; limited enrollment)  
Multidisciplinary approach to social, economic, and technical problems of feeding the world's growing population. Principles from social and economic sciences and from plant, animal, and food sciences for application to world food problems.

FScN 5999. Special Workshop in Food Science and Nutrition. (1-4 cr; prereq #)  
Offered off campus. Topics specified in *Class Schedule*.

FScN 8101. Research Seminar. (1 cr; prereq #; S-N only)  
Seminar discussion with faculty member(s) of research progress within the group, or review and discussion of current research literature related to food science and nutrition.

FScN 8205. General Seminar. (1 cr; prereq #; S-N only)  
Presentation of topics related to food science and nutrition by staff members, graduate students, and outside speakers.

FScN 8311. Flavor Chemistry. (3 cr; prereq 5312 or #; offered alt yrs) Reineccius  
Chemistry of food flavor including biogenesis of flavor, production during processing, deterioration during storage, potentiation, duplication as an art and science, and use in food industry.

FScN 8312. Reaction Kinetics of Food Deterioration. (3 cr; prereq Chem 5520 or #; offered alt yrs) Labuza

Review of the basis for application of chemical kinetic theory to deteriorative reactions occurring in the processing and storage of foods. Specific systems studied include hydrolytic reactions, vitamin deterioration, lipid oxidation, non-enzymatic browning, frozen reactions and moisture changes. Application of these kinetics to the study of accelerated shelf life testing of foods and choice of food packaging material based on legal requirements of nutritional labeling and open dating.

FScN 8315. Food Proteins. (3 cr; prereq 5110, 5312 or #; offered alt yrs)

Principles of isolating, handling, and processing of proteins from conventional and new protein sources. Relationship of structural, functional, and interactive properties of proteins to developing and/or maintaining nutritional and aesthetic properties of products.

FScN 8323. Microbial Starter Cultures. (3 cr; prereq 5123, Biol 5001 or #; offered alt yrs) McKay

Microbiology of food starter cultures; selection, identification, and composition of starters; nutrition and metabolism, strain association and compatibility, cause and control of culture related defects; genetics, preservation, and mass production; bacteriophage in cheesemaking.

FScN 8324. Microbial Toxins and Toxic Microorganisms in Foods. (4 cr; prereq 5120 or #; offered alt yrs) Tatini

Incidence and reasons for presence of various microbial toxins and toxic microorganisms in foods. Nature of toxins and mechanisms of toxicity. Biological, serological, and biochemical methods for detecting toxins. Means for control of these toxins in foods for prevention of food-borne public health hazards.

FScN 8401. Independent Study: Food Science. (1-5 cr; prereq Δ)

Independent study and written reports.

FScN 8403. Advanced Topics in Food Science. (1-4 cr; prereq #)

Review of recent research in food science or presentation of special topics course.

Nutr 8745. Seminar. (1 cr [may be repeated for cr]; prereq #)

Nutr 8990. Graduate Research. (2-5 cr; prereq #)

## Forestry

*Professor:* Alfred D. Sullivan, *dean*; Kenneth N. Brooks, *director of graduate studies*; Joseph G. Massey, *head, forest products*; Alan R. Ek, *head, forest resources*; Neil A. Anderson; Marvin E. Bauer; Melvin J. Baughman; Robert A. Blanchette; Charles R. Blinn; James L. Bowyer; Thomas E. Burk; Edward J. Cushing; Paul V. Ellefson; Roland O. Gertjeansen; Hans M. Gregersen; David F. Grigal; Wesley P. Hackett; Leo H. McAvoy, Jr.; Carl A. Mohn; John L. Nieber; James A. Perry; Peter B. Reich; Dietmar W. Rose; C. Ford Runge; Elmer L. Schmidt; Edward I. Sucoff

*Associate Professor:* Dorothy H. Anderson; Glenn R. Furnier; Howard M. Hoganson; Patrick H. Huelman; Gary R. Johnson; Shri Ramaswamy; Simo Sarkanen; J. L. David Smith; Ulrike Tschirner

*Assistant Professor:* Paul V. Bolstad; Stephan P. Carlson; Timothy D. Larson; Steven B. Laursen; Mutombo Muvundamina; Harlan D. Petersen; Klaus Y. Puettmann

*Other:* David N. Bengston; Erwin R. Berglund; Stephen M. Bratkovich; Kenneth L. Cole; Karlyn Eckman; Daniel L. Erkkila; Lee E. Frelich; Thomas A. Greene; Robert G. Haight; Mark H. Hansen; George H. Honadle; Glenn T. Howe; Judson G. Isebrands; Rolfe A. Leary; David W. Lime; David C. Lothner; Allen L. Lundgren; Thomas J. Nichols; Jacek Oleksyn; Michael E. Ostry; Michael J. Phillips; Don E. Riemenschneider; Thomas L. Schmidt; Robert T. Seavey; Elon S. Verry; Xiwei Yin; Zhi Xu

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B), M.F., and Ph.D.

**Curriculum**—Students normally emphasize one of the following subfields: the chemistry of lignocellulosic materials; paper and fiber products recycling; deterioration of wood; wood mechanics; structural design with wood; wood moisture interaction and drying; processing and performance of wood composites; economics of manufacturing systems; technology and processing of solid wood products; design and production of housing components; energy-efficient building construction; ecology and silviculture; ecophysiology; economics in forest and related natural resource management; genetics and tree improvement; geographic information systems; hydrology and water quality; watershed management; survey, measurement, and modeling; policy and administration; tree physiology and tissue culture; recreation land management; remote sensing; and urban forestry. Faculty in forestry also offer courses in natural resources and environmental studies (NRES) listed after the forest products and forest resources courses below.

**Prerequisites for Admission**—Prerequisites vary by subfield. Most admitted students have earned degrees in forestry or forest products. Applicants with exceptional academic records but no forestry background are eligible; if admitted, they may complete the necessary

prerequisites for advanced courses during the early stages of their graduate program. Applicants for the doctoral program should demonstrate a capacity for advanced study and independent research.

### **Special Application Requirements—**

Applications are processed on a continual basis, and students are admitted each quarter. Graduate Record Examination scores are required. Letters of recommendation are optional but highly recommended. Applicants for the doctoral program should supply the names and addresses of three people who can provide evaluations of their capacity for advanced study and independent research.

**Master's Degree Requirements—**M.S. (Plan B) students, in consultation with faculty, design a program that develops competence in one or more subfields. M.S. (Plan A) students usually design a program to support their specific thesis project. Master's degree students are required to present a seminar on the thesis, Plan B project, or a topic selected in consultation with the graduate adviser. Specific requirements vary by subfield; prospective students should contact the director of graduate studies and/or a prospective faculty adviser for specific information. Students in the M.F. program are required to complete basic science courses and introductory forestry courses if not included in their undergraduate program. The minimum number of course credits for both Plan A and Plan B is that set by the Graduate School.

The final examination is oral.

**Doctoral Degree Requirements—**The program ensures that students gain the necessary competence in the subfield for independent research. Programs normally vary from 60 to 90 credits, not including thesis credits. Course selection and thesis proposals are developed by each student in consultation with the faculty adviser for review and approval by the forestry graduate study committee.

**Language Requirements—**None.

**Minor Requirements for Students Majoring in Other Fields—**Students who wish to minor in forestry should contact the director of graduate studies. The selection of courses for an acceptable minor is influenced by the

student's background and educational objective. Minor field competence is evaluated in the oral examination.

### **For Further Information and Applications—**

Contact the Forestry Graduate Program, College of Natural Resources, University of Minnesota, 115 Green Hall, 1530 Cleveland Avenue North, St. Paul, MN 55108 (612/624-2748; fax 612/625-5212; e-mail [kkanda@forestry.umn.edu](mailto:kkanda@forestry.umn.edu)).

Fors 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Fors 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Fors 8888. Thesis Credits: Doctoral. (36 cr required)

### **Forest Products (ForP)**

ForP 5300. \* Wood-Fluid Relations. (3 cr; prereq 1301 or #) Larson

Moisture in wood and its relationship to density and specific gravity, shrinking and swelling, electrical properties, strength properties, thermoconductivity, absorption isotherms, dimensional stabilization, permeability and diffusion.

ForP 5301. Mechanical Properties. (3 cr; prereq 1301 or #) Larson

Basic mechanics and strength of materials as applied to wood products.

ForP 5302. Wood Chemistry I. (3 cr; prereq Chem 3302) Sarkanen

Molecular structure of wood cell wall. Structures, properties, and reactions of monosaccharides and derivatives; oligosaccharides. Structure, properties, and biogenesis of cellulose; cellulose derivatives; comparison with starch.

ForP 5303. Wood Deterioration. (4 cr; prereq 1301 or #) Schmidt

Deterioration of wood and wood products by bacteria, fungi, insects, marine organisms, fire, and weathering; methods of preservation and preservatives used. Lecture and lab.

ForP 5304. \* Wood Drying and Preservation Processes. (4 cr; prereq 5300, 5303 or #) Petersen

Materials, equipment, processes, and technical considerations involved in industrial drying and preservative treatment of wood products. Lectures, lab exercises, and plant tours.

ForP 5305. Pulp and Paper Technology. (2 cr; prereq 5300 or #) Tschirner

Pulping processes; fiber refining and processing; manufacture of paper; fiber and paper properties; recycling of paper; water requirements and effluent treatment. Lecture and lab.

ForP 5306. Analysis of Production Systems. (3 cr; prereq 1301 or #; 3300 recommended) Bowyer  
Engineering and economic analysis of manufacturing and distribution systems for wood-based products. Material balances, equipment selection, economic analysis, and presentation techniques.

ForP 5307. Wood-Base Panel Technology. (4 cr; prereq 5300, 5301 or #) Gertjeansen  
Design, manufacture, properties, and applications of structural and nonstructural wood-base panels. Adhesives and their application in the panel industry. Lecture and lab.

ForP 5308. Wood Machining. (3 cr; prereq 1301, 1303) Bowyer  
Wood machining technologies and methods; development and application of wood processing systems. Lectures, discussions, demonstrations, and company visits.

ForP 5310. Pulp and Paper Process Laboratory. (3 cr; prereq 5305 or #) Gertjeansen, Muvundamina  
Chemical and mechanical pulping, pulp preparation, secondary fiber, wet end additives. Lab problems and exercises supplemented by lectures.

ForP 5311. Pulp and Paper Process Engineering Calculations I. (4 cr; AgET 3030 or CSci 3101, ChEn 5011, CE 3400, ME 3301 recommended)  
Physical and chemical process engineering calculations; steady and unsteady state material and energy balances applied to pulping and papermaking processes; flowsheet and system calculations; computer-aided material and energy balances.

ForP 5312. Pulp and Paper Process Engineering Calculations II. (4 cr; prereq 5311 or ChEn 5101, ¶IME 3301; AgET 3030 or CSci 3101, ChEn 5011, CE 3400 recommended)  
Physical and chemical process engineering calculations; steady and unsteady state material and energy balances applied to pulping and papermaking processes; flowsheet and system calculations; computer-aided material and energy balances.

ForP 5313. Pulp and Paper Process Operations I. (4 cr; prereq 5305, 5312, 5353, CE 3400, ME 3301, ChEn 5102 or ME 5342 or #) Ramaswamy  
Application of principles of momentum, heat, and mass transfer to unit operations in pulp and paper industry: fluid transport, filtration, sheet forming, sedimentation, drainage, pressing, heat exchange, evaporation, washing, bleaching, humidification and drying, and chemical and energy recovery. Computer simulation of multiple-stage systems.

ForP 5314. Pulp and Paper Process Operations II: Paper Machine Operations, Finishing and Converting. (3 cr; prereq 5305, 5310, 5311, 5312, 5315, 5321, 5359, CE 3400, ME 3301, ME 5342) Ramaswamy  
Theory and practice of design and operation of paper machines and associated finishing and converting equipment.

ForP 5315. Paper Engineering Laboratory. (2 cr; prereq 5305, 5310 or ¶5310, 5312 or #; 5306 recommended) Ramaswamy  
Experiments that illustrate and apply the principles of momentum, heat, and mass transfer. Operation and performance optimization of pilot-plant paper machine. Process engineering studies of industrial production systems.

ForP 5316. Coated Product Development. (2 cr; prereq 5359) Tschirner  
Coating process and products (primarily paper) associated with process components of coating; theory, techniques, and procedures for formulating and applying coatings; properties of coated products and their uses.

ForP 5318. Pulp and Paper Process Dynamics and Control. (3 cr; prereq 5305, 5310, 5311, 5312, 5315, CE 3400, ME 3301, ¶IME 5342 or #) Ramaswamy  
Theory and practice of process control in pulp and paper industry; sensors, control equipment and algorithms, final control elements; applications to industrial pulp and paper manufacturing and quality control; applications of SPC and SQC; available hardware and software.

ForP 5320. Biological and Environmental Science of Pulp and Paper. (3 cr; prereq jr or sr or grad student in ForP) Schmidt  
Environmental impacts related to biology and chemistry of pulp and paper processes; treatment of process effluents and discharges; governmental regulations and industry compliance; theory, design, and operation of equipment for treatment or prevention of environmental effects; biochemistry of pulp and paper aquatic systems; advances in biological pulping and papermaking.

ForP 5321. Material Science of Paper: Paper and Fiber Physics and Properties. (4 cr; prereq 5305, 5310, 5311, 5312, 5315, CE 3400, ¶Chem 5520, ME 3301, ME 5342 or #) Muvundamina  
Advances in understanding response of fibers subjected to various operations of papermaking processes: mechanisms acting in stock preparation, refining, wet-end operations, web consolidation, and drying; analysis of corresponding influences on fiber, pulp suspension, and paper properties; challenges placed on end products by changing raw materials and requirements, including introduction of recycled pulp in paper products.

ForP 5350. Woody Tissue Microtechnique. (2 cr; offered when feasible)

ForP 5353. Wood Chemistry II. (3 cr; prereq 5302) Sarkanen  
Composition, distribution, and structures of hemicelluloses and their interactions with cellulose; biosynthesis, structure, and analytical degradation of lignin; delignification of wood; pulp bleaching chemistry; lignin biodegradation.

ForP 5355.\* Mechanics and Structural Design With Wood Products. (4 cr; prereq 5301) Larson  
Mechanical behavior of lumber, plywood, and particleboard applied to structural considerations in building construction. Lecture and lab.

## GRADUATE PROGRAMS

ForP 5359. Surface and Colloid Chemistry of Papermaking. (3 cr; prereq 5361 or #, Chem 3302, Chem 5520) Muvundamina

Principles of surface and colloid chemistry applied to basic problems in pulp and paper manufacturing operations and product uses.

ForP 5361. Adhesion and Adhesives. (3 cr; prereq Chem 3302, Chem 5520) Sarkanen

Scope and utility of adhesive applications; fundamental nature of adhesion; ideal adhesive joint; conformations of linear polymers; statistical thermodynamics and polymer adsorption onto adherend surface; adhesives in common use; mechanical properties of adhesive joints.

ForP 5405. Paper in Today's World. (3 cr, §5305) Gertjeansen

Primarily to enable elementary and secondary school teachers to prepare unit on pulp and paper for elementary through senior high school science classes. Lectures, labs, and demonstrations on pulp and paper manufacturing, properties and characteristics of paper, uses for paper, recycling with pulp, and paper equipment, including a pilot plant paper machine. Written report required for graduate credit.

ForP 8300.\* Research Problems. (Cr ar)

ForP 8301.\* Research Problems. (Cr ar)

ForP 8303. Advanced Topics in Panel Products Technology. (2 cr; prereq 5307) Gertjeansen

Advanced treatment of selected topics in panel products technology: particle and fiber processing; additives; the press cycle; design of panels for specific end uses. Lectures and lab.

ForP 8304. Advanced Topics in Wood Drying. (3 cr; prereq 5304)

Rheological behavior of first-dried solid wood; significance of creep to stress-strain pattern, shrinkage and degrade development in lumber drying; interpretation and evaluation of schedules, processes, primary and auxiliary equipment used in commercial drying processes; energy considerations in drying processes.

ForP 8306. Seminar: Forest Products. (2 cr) Assigned topics, papers, and oral presentations.

ForP 8307. Advances and Methods in Forest Products Pathology and Preservation. (3 cr; prereq 5303, 5304 or #) Schmidt

Principles in wood protection and methods of evaluating preservatives with emphasis on international developments.

### Forest Resources (FR)

FR 5100. Silviculture. (4 cr; prereq for FR majors: Itasca Session, 1100, 3104; for nonmajors: 3104 or equiv, #) Puettmann

Introduction to silvics, forest regeneration and site preparation techniques, intermediate silvicultural practices, silvicultural systems.

FR 5101. Field Silviculture. (4 cr; prereq 5100, Δ; offered at Cloquet) Nichols

Regeneration surveys, plantation inspection, site preparation and reforestation prescription. Practice in marking for thinning and determining effect on stands. Compartment examination and prescription. Written and oral reports.

FR 5102. Forest Wildlife Habitat Management. (1 cr; prereq 5100, FW 3052, ¶5101; offered at Cloquet) Jordon

Forest vegetation management techniques for developing and maintaining wildlife habitat; vegetation dynamics, habitat requirements, and silvicultural techniques.

FR 5104. Forest Ecology. (4 cr; prereq 8 cr biol, 4 cr chem) Sucoff

Ecological concepts and principles as basis for conservation and management of forest ecosystems.

FR 5107. Forest Ecology Laboratory. (1 cr, §5160; prereq ¶5104)

Field trips to introduce forest stands, communities, and ecosystems.

FR 5108. Physiological Ecology: Organisms to Ecosystems. (3 cr; prereq 5103 or 5104 or Biol 5041 or Hort 5041) Reich

Interaction between plants and their environment, focusing on mechanisms affecting whole plant, community, and ecosystem processes. Variation in resource availability and stress in diverse ecosystems: causes and consequences and relationships to plant establishment, growth, and survival. Links between organismal, community, successional, and ecosystem processes.

FR 5114. Forest Hydrology. (4 cr; prereq 3103, Biol 1009, Chem 1052, Geo 1001, Math 1142, Phys 1001 or #) Brooks

Introduction to the hydrologic cycle and hydrologic processes. Effects of forest management activities on water yield, storm flow, and water quality.

FR 5115. Forest Hydrology, Field Applications. (2 cr; prereq 5114 or #) Brooks  
Use of hydrologic instrumentation needed to measure precipitation, streamflow, infiltration capacity, soil moisture, air temperature, evaporation, and selected water quality constituents. Collection and interpretation of hydrologic information needed to evaluate forest-use impacts on water quantity and quality.

FR 5120. Tree Physiology. (3 cr; prereq Chem 1001 or Chem 1004, 10 cr biol) Sucoff

Genetic variation in forest trees, its underlying causes, and its use in forestry. Tree growth, nutrition, and water relations. Environmental and internal regulation of growth. Plant biochemistry and photo-chemistry. Physiology related to silviculturally and ecologically significant phenomena.

FR 5126. Silviculture: Soil-Site Relationships. (2 cr; prereq 1122, 5100, Δ; offered at Cloquet) Grigal  
Field examination of forest soils and their relationship to site productivity and forest management.

FR 5130. Geographic Information Systems in Natural Resource Analysis. (2 cr; prereq sr or grad student or #) Bolstad  
Introduction to application of Geographic Information Systems to natural resource and regional planning studies; theory and technical points, emphasizing applications; hands-on microcomputer experience; performance of case study, including map digitizing, data processing, and generation of map products.

FR 5131. Geographic Information Systems Lab. (1 cr; prereq ¶5130)

FR 5142. Tropical Forest Ecology. (3-4 cr; prereq 1 ecology course at 3xxx or higher) Reich  
Ecological principles related to form, function, and development of wet and dry tropical forests, at organismal, community, and ecosystem scales. Succession, productivity, biodiversity, sustainability, agroforestry, and management alternatives. Natural distribution of forest types; causes, consequences, and extent of deforestation.

FR 5146. Dynamics of Global Change: Plant Ecology. (3-4 cr; prereq plant ecology or plant physiology course at 3xxx or higher) Reich  
Implications of global change upon wild and cultivated vegetation, including forests, grasslands, and agricultural ecosystems. Responses at ecosystem, community, organismal, and physiological scales. Potential climate change; elevated atmospheric concentrations of carbon dioxide, ozone, and other trace gasses; acid deposition; and other pollutants.

FR 5152.\* Forest Genetics. (3 cr; prereq Biol 1103, Stat 3011) Mohn  
Genetic variation of forest-tree species and underlying principles; application of plant breeding principles to forestry.

FR 5153.\* Advanced Forest Hydrology. (4 cr; prereq 3220, 5114 or #) Brooks  
Current hydrologic problems associated with management of forested watersheds. Analytical methods to evaluate vegetation management effects on quantity and quality of runoff.

FR 5160. Practicum in Forest Biology and Measurements. (3 cr; prereq grad student, #; offered at Itasca) Sucoff  
Plant identification, plant dynamics, land survey, tree measurement.

FR 5200. Aerial Photo Interpretation. (3 cr) Bauer  
Types, characteristics, procurement, preparation, viewing, and interpretation of color, black-and-white, and color infrared aerial photographs; basic aerial photography; introduction to mapping; applications to resource surveys.

FR 5202. Remote Sensing: Field Applications. (2 cr; prereq 5200, 5212; offered at Cloquet) Bauer  
For inventorying, mapping, and monitoring forest and natural resources.

FR 5215. Forest Fire Ecology and Management. (2 cr; prereq 1100, Itasca Session, 3103, 5100 or #) Cole  
Effects and control of fire on wild landscapes, especially forests and grasslands; fire effects on vegetation, fire history studies, fire behavior, fuel load modeling, and fire policy in land management agencies.

FR 5218. Assessment and Modeling of Forests. (3 cr; prereq Itasca Session, Math 1142 or Math 1211, NRES 5210, Stat 3011 or Stat 5121) Burk  
Measurement and sampling methods for forest vegetation, tree and stand growth modeling, and landscape processes, characterization, and modeling.

FR 5221. Plant Molecular Evolution. (3 cr, \$Bot 5221; prereq Biol 5003 or GCB 3022 or GCB 5022) Furnier  
Experimental molecular techniques applicable to evolutionary studies; molecular methods of quantifying genetic diversity; statistical methods for phylogenetic reconstruction; application of RFLPs to study of chromosomal and morphological evolution; evolution of organellar genomes and multigene families; role of transposable elements in plant evolution; DNA sequence evolution; molecular aspects of development relating to plant evolution.

FR 5222. Forest Resources Inventory. (2 cr; prereq 5212; offered at Cloquet) Ek  
Field application of sampling methods for estimating natural resources characteristics for inventory, appraisal, and monitoring purposes.

FR 5225. Directed Study Experience. (1-5 cr; prereq jr or sr or grad student, #)  
Opportunity to pursue experiences not available under independent study or extra credit registration. In consultation with adviser for project, student develops prospectus and completes progress and final reports on project.

FR 5226. Forest Economics and Planning. (5 cr; prereq Ag Econ 1101 or Econ 1101 or #) Gregersen, Rose  
Conduct and interpretation of economic analysis, forest planning concepts, principles, and techniques of forest regulation.

FR 5228. Advanced Topics in Resource Assessment and Modeling. (4 cr; prereq 5218 or equiv, NRES 5210 or equiv, Stat 5021 or equiv) Burk  
Recently developed mathematics, computer science, and statistics methodologies applied to problems of resource functioning, management, and use.

## GRADUATE PROGRAMS

FR 5231. Range Management. (3 cr; prereq Biol 1103 or #) Brooks

Important range plants; range livestock; range management methods and improvements; public grazing land administration; relationship of livestock grazing to wildlife, forest, watershed, and recreation management on public and private range lands.

FR 5236. Forest Recreation Planning. (1 cr; prereq 5232, Δ; offered at Cloquet) D Anderson  
Recreation area and site planning, examples and managerial concerns. Fieldwork and presentation.

FR 5240. Natural Resource Policy and Administration. (3 cr; prereq AgEc 1101 or Econ 1101, AgEc 1102 or Econ 1102, Pol 1001, Rhet 1151) Ellefson

Basic concepts of political and administrative processes important to development of natural resource policies and programs. Focus on policy processes, agenda setting, political decision rules, strategies for achieving agreement, participants in policy development, public means of implementing policies, and case examples.

FR 5248. Harvesting and Engineering. (3 cr; prereq 3300 or CE 3100, Δ; offered at Cloquet)  
Introduction to harvesting systems, relationship to forest management, and the preparation and administration of timber sales. Location, construction, and maintenance of forest roads.

FR 5250. Role of Renewable Natural Resources in Developing Countries. (2 cr) Gregersen, Rose

International perspective on important resource issues, including integration of natural resource, social, and economic considerations. Overviews on important issues and case studies. Term paper and/or other requirements.

FR 5257.\* Recreation Land Policy. (3 cr; prereq 5232 or #; offered alt yrs) D Anderson, Lime  
Policy issues affecting the use and management of lands devoted entirely or in part to recreational objectives.

FR 5259.\* Analysis of Outdoor Recreation Behavior. (3 cr; prereq 5232, RRM major or grad student or #; offered alt yrs) D Anderson, Lime  
Development of environmental framework for understanding recreation behavior; contributions of several disciplines; current cultural trends; management implications.

FR 5262. Remote Sensing of Natural Resources. (4 cr)  
Basics, interpretation, measurement, and mapping from aerial photography; introduction to digital remote sensing and image analysis.

FR 5264. Quantitative Techniques in Forest Management. (3 cr; prereq 5212, 5226 or #) Rose  
Forestry applications of quantitative techniques in allocation and other decision-making problems. Mathematical programming, simulation.

FR 5270. Forest Management and Planning. (3 cr; prereq 5218, ApEc 1101 or Econ 1101, ApEc 1102 or Econ 1102, ¶INRES 5260) Rose

Role of models in resource decisions at stand and forest-wide levels; regulation principles and techniques; management scheduling approaches; principles of economic trade-off and impact analysis.

FR 5403.\* Fundamentals of Natural Resource Education. (1-3 cr; prereq elem school tchrs or #) Ek, Johnson, Vogt

The forest community, tools used by forester, and effective forest management practices. Forestry-related indoor and outdoor activities for classroom use.

FR 5412. Advanced Remote Sensing. (4 cr; prereq 5262 or #) Bauer

Theoretical basis and practical applications of quantitative remote sensing, including spectral-biophysical relationships, radiation measurements, and spectral pattern recognition. Lectures, problems, and case studies with digital image analysis system.

FR 5500. Urban Forest Management. (4 cr) Johnson

Terminology and principles of urban tree inventory, forest care, and health evaluation; management case studies; sociology of urban forestry and best management practices.

FR 5703. Colloquium in Forest Biology. (1-4 cr; prereq varies with topic) Furnier, staff  
Specialized topics in forest biology and silviculture.

FR 5704. Colloquium in Natural Resources. (1-4 cr; prereq varies with topic) Brooks, Gregersen, staff

FR 8100.\* Research Problems: Silviculture. (Cr ar) Puettmann

FR 8101.\* Research Problems: Forest-Tree Physiology. (Cr ar) Sucoff

FR 8102.\* Research Problems: Forest-Tree Genetics. (Cr ar) Furnier, Mohn

FR 8103.\* Research Problems: Forest Hydrology. (Cr ar) Brooks, Perry

FR 8104. Research Problems: Forest Ecology. (1-8 cr) Grigal, Reich, Sucoff

FR 8105. Advanced Field Silviculture. (3 cr; prereq 5101, #)  
Selected current problems and research in silviculture. Plant-soil relationships with particular reference to forest soils. Methods of forest soil investigations in the field and lab.

FR 8107. Seminar: Forest Resources. (1 cr)  
Assigned topics, problem analyses, and research reports.

FR 8112. Research Problems: Physiological Ecology. (1-8 cr) Reich, Sucoff  
Interaction between plants and their environment, focusing on mechanisms that affect whole plant, community, and ecosystem processes. Causes and consequences of variation in resource availability and stress in diverse ecosystems; relationships of resource availability and stress to plant establishment, growth, and survival; linkages between organismal, community, successional, and ecosystem processes.

FR 8200.\* Research Problems: Forest Management. (Cr ar) Blinn, Hoganson, Rose

FR 8201.\* Research Problems: Forest Economics. (Cr ar) Ellefson, Gregersen, Hoganson, Rose

FR 8202.\* Research Problems: Forest Measurements. (Cr ar) Burk, Ek, Rose

FR 8203.\* Research Problems: Forest Recreation. (Cr ar) D Anderson, Lime

FR 8204.\* Research Problems: Forest Policy. (Cr ar) Baughman, Ellefson, Gregersen

FR 8205.\* Research Problems: Remote Sensing. (Cr ar) Bauer, Bolstad

FR 8207. Economic Analysis of Forestry Projects. (3 cr; prereq #) Gregersen  
Public and private forestry projects; analysis of commercial profitability and application of benefit-cost analysis; preparation of feasibility studies; case studies.

FR 8301. Teaching Practicum. (2-4 cr; prereq adviser permission, #) Furnier, staff  
Students develop and teach undergraduate colloquium, recitation or lab section, or extension workshop on natural resources topic. Instructor advises on development and execution of course.

## Natural Resources and Environmental Studies (NRES)

NRES 5020. Plant Resource Management and the Environment. (4 cr; prereq soph, Biol 1009, ¶13020) Puettmann  
World vegetation management practices, extent, and implications. Forest management, agriculture, and agroforestry; historical, current, and prospective practices and environmental and societal implications.

NRES 5100. Problem Solving in Natural Resources and Environmental Studies. (5 cr; prereq 12 cr in concentration for NRES majors, FR 5232 and FR 5233 for rec resource mgmt majors, Rhet 3562, Stat 3012) D Anderson, Bolstad  
Solving real-world natural resources and/or environmental problem. Discussions and assignments reflect diverse aspects of problem. Oral and written presentations. Team participation.

NRES 5101. Integrated Natural Resource Planning. (5 cr; prereq 5210 or FR 5212, FR 5226, FR 5240, rec resource mgmt course, ecol course, hydrology course or #) Rose, staff  
Application of skills from previous courses. Information and models for assessing impacts of natural resource management and trade-offs among alternative management approaches.

NRES 5210. Survey, Measurement, and Modeling Methods for Natural Resources I. (4 cr; prereq AgEt 3030 or CSci 3101 or CSci 3102 or CSci 3113 or GC 1571, Math 1142 or Math 1251, Stat 3011 or Stat 5021) Ek

Introduction to survey design, measurement concepts, and modeling methods useful in study of natural resources and environmental issues. Emphasis on data collection and analysis.

NRES 5220. Survey, Measurement, and Modeling Methods for Natural Resources II. (4 cr; prereq 5210 or FR 5212 or equiv; offered alt yrs) Burk, Ek

Advanced survey design, measurement concepts, and modeling methods for study of natural resources and environmental problems.

NRES 5225. Directed Study Experience. (1-5 cr; prereq jr or sr or grad student, #)

Opportunity to pursue experiences not available under independent study or extra credit registration. In consultation with adviser for project, student develops prospectus and completes progress and final reports on project.

NRES 5575. Wetlands Conservation. (4 cr; prereq EEB 3001 or EEB 3101, Biol 5041 or #: ¶13575, plus one more hr per wk) Cooper  
Freshwater wetland classification, biota, current/historic status, value, and conservation strategies and ecological principles used in wetland management.

NRES 5600. Principles of Waste Management. (4 cr; prereq Biol 1009 or Chem 1051, Stat 3011 or #) Cooper, Holbach  
Understanding issues, problems, and solutions in remedying waste stream generated by current society. Waste stream dynamics, MSW and yard waste composting, WTE incineration operation, ash disposal, recycling, landfill requirements, and direct land disposal requirements, regulatory trends, and case studies.

## French and Italian

*Professor:* Maria F. Paganini, *chair*; Ronald F. Akehurst; Tom C. Conley; Susan J. Noakes; Joseph L. Waldauer

*Associate Professor:* Mária M. Brewer, *director of graduate studies*; Betsy K. Barnes; Daniel Brewer; Ronald L. Martinez; Judith Preckshot; Peter H. Robinson; Eileen B. Sivert

*Assistant Professor:* Susanna Ferlito; Catherine Liu

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—French: M.A. (Plan A and Plan B) and Ph.D.; Italian: M.A. (Plan A and Plan B).

**Curriculum**—Majors in French and Italian are offered.

**Prerequisites for Admission**—For major work, 50 upper division quarter credits or the equivalent in the major field (French or Italian), at least 20 credits of which are in literature, are required. Students in the program ordinarily find it necessary to supplement their undergraduate work with a considerable amount of independent reading.

**Special Application Requirements**—New students may enter in any quarter or summer term.

**Master's Degree Requirements**—Before registering for their first quarter of graduate work, students must consult the director of graduate studies. Students also should familiarize themselves with the special requirements of the department. The minimum coursework requirement is 28 credits for Plan A and 44 credits for Plan B. A final written examination (given during the third week of fall and spring quarters) and a final oral examination are required. See the department's general information bulletin for details.

**Doctoral Degree Requirements**—Before registering for their first quarter of graduate work, students must consult the director of graduate studies. Students entering with an M.A. degree from another institution may be required to take a qualifying examination before the end of the seventh week of their second quarter. Immediately after passing the M.A. or qualifying examination, students design their programs in consultation with their advisory committees. The minimum coursework requirement is 60 credits in the major. Four topics or fields of inquiry are chosen. See the department's general information bulletin for details.

**Language Requirement**—See the department's information bulletin. Master's students must demonstrate proficiency in one language other than French or English. Doctoral students must demonstrate this proficiency at a level higher than for master's students and suitable for use in research. Doctoral students intending to specialize in the Middle Ages, Renaissance, or Early Modern Period (to roughly 1666) must also demonstrate knowledge of Latin.

**For Further Information and Applications**—A department general information bulletin and a projection of graduate-level courses to be offered is available from the Department of French and Italian, University of Minnesota, 260 Folwell Hall, 9 Pleasant Street S.E., Minneapolis, MN 55455 (612/624-4308).

Fren 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Fren 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Fren 8888. Thesis Credits: Doctoral. (36 cr required)

Ital 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

### French (Fren)

Fren 5017. Composition et Stylistique. (4 cr; prereq 3017 or #)

Translation, imitation, and composition of fiction and nonfiction, prose and poetry, using both English and French texts.

Fren 5105. Topics in Criticism. (4 cr; prereq 3209 or above, undergrad French lit major or MA student) Introduction to current issues in critical theory.

Fren 5207. Old French. (4 cr; prereq 3209 or above) Akehurst  
Preparation for reading medieval French texts in the original.

Fren 5219. Humanism and Italianism in the Literature of the 16th Century. (4 cr, \$Frit 5219, \$Ital 5219; prereq 3209 or above)

Aspects of Italian civilization from Dante to Machiavelli that led to the Renaissance. Focus on French and Italian literary texts. Taught in English; knowledge of Italian not required.

Fren 5289. Topics in African Literature. (4 cr; prereq 3209 or above) Preckshot  
Francophone African and Afro-Caribbean literature in its historical, cultural, or ideological contexts.

Fren 5311. Renaissance Poetry Before the Pléiade. (4 cr; prereq 3209 or above) Conley  
The *grands rhétoriciens*, Lemaire, Marot, Saint-Gelays, Louise Labé, and others; includes study of elegy, emblem, *blason*, and *art poétique*.

- Fren 5312. *Pléiade and Baroque*. (4 cr; prereq 3209 or above) Conley  
Ronsard, Du Bellay, and other poets of the *Pléiade* and the first baroque poets, including Sponde, Du Bartas, Desportes, Chassignet.
- Fren 5331. *French Poetry From D'aubigné to La Fontaine*. (4 cr; prereq 3209 or above) Conley  
Movement from baroque to classicism studied in the great verse creations of the 17th century.
- Fren 5354. *Drama of the 18th Century*. (4 cr; prereq 3209 or above) Waldauer  
Tragedy, drama, comedy (emphasis on comedy).
- Fren 5355. *Novel of the 18th Century*. (4 cr; prereq 3209 or above) Waldauer  
Emphasis on novels of Marivaux, Diderot, and Laclos.
- Fren 5368. *Short Stories of the 19th Century*. (4 cr; prereq 3209 or above) Sivert  
From Charles Nodier to Villiers de l'Isle-Adam. (See 5467 for Flaubert).
- Fren 5380. *The French Novel in the 20th Century*. (4 cr; prereq 3209 or above) M Brewer, Paganini  
Includes prose texts. Novel, essay, short story, philosophical récit, autobiography.
- Fren 5415. *Rabelais*. (4 cr; prereq 3209 or above) Conley  
*Gargantua and Pantagruel* in original text.
- Fren 5457. *Rousseau*. (4 cr; prereq 3209 or above) Waldauer
- Fren 5459. *Diderot*. (4 cr; prereq 3209 or above) D Brewer, Waldauer
- Fren 5461. *Baudelaire*. (4 cr; prereq 3209 or above) Robinson
- Fren 5465. *Stendhal*. (4 cr; prereq 3209 or above) Sivert, Waldauer
- Fren 5466. *Balzac*. (4 cr; prereq 3209 or above) Sivert
- Fren 5467. *Flaubert*. (4 cr; prereq 3209 or above) Paganini, Sivert
- Fren 5471. *Mallarmé*. (4 cr; prereq 3209 or above) Robinson
- Fren 5475. *Zola and the Naturalistic Novel*. (4 cr; prereq 3209 or above) Sivert
- Fren 5486. *Proust*. (4 cr; prereq 3209 or above) Paganini
- Fren 5505. *Topics in Culture*. (4 cr; prereq 3201 or above, knowledge of French)  
Comprehensive seminar on contemporary continental theories of discourse and culture. Conceptions of language, ideology, and culture as symbolic systems.
- Fren 5701. *Structure of French: Phonology*. (4 cr; prereq 3014 or 3016 or #) Barnes  
Advanced study of sound system of contemporary French.
- Fren 5702. *Structure of French: Morphology and Syntax I*. (4 cr; prereq 3016; 5701, Ling 3001 or Ling 5001 recommended) Barnes  
Linguistic study of word forms of contemporary French (derivational and inflectional morphology); introduction to French syntax (linguistic study of grammar).
- Fren 5703. *Structure of French: Syntax II*. (4 cr; prereq 5702 or #)  
Linguistic study of selected aspects of contemporary French syntax, such as pronouns, relative clauses, interrogatives, reflexive verbs. Some attention to syntactic features of spoken French.
- Fren 5710. *Topics in French Sociolinguistics*. (4 cr; prereq 3016)  
Socioculturally appropriate uses of the language and regional and contextual language variation.
- Fren 5800. *CIEE Contemporary Film Programs in Paris*. (1-45 cr [undergrad], 1-15 cr [grad]; prereq 1105 or #)  
Semester or year of study in film criticism and/or history with French faculty. Structural analysis, modern institutions and media, study/criticism of European and American film. Remedial courses in French available. Advanced students also may take courses at Paris universities.
- Fren 5900. *Topics in French Literature*. (3-5 cr per qtr [max 15 cr]; prereq 3209 or above)
- Fren 5920. *Topics in Early French Prose (800-1600)*. (3-5 cr per qtr; prereq 3219 or above)
- Fren 5930. *Topics in Medieval-17th Century Poetry*. (3-5 cr per qtr; prereq 3219 or above)
- Fren 5940. *Topics in Early Modern French Prose (1600-1900)*. (3-5 cr per qtr; prereq 3219 or above)
- Fren 5950. *Topics in Modern French Poetry (19th and 20th Centuries)*. (3-5 cr per qtr; prereq 3219 or above)
- Fren 5960. *Topics in Modern French Prose (1850-present)*. (3-5 cr per qtr; prereq 3219 or above)
- Fren 5980. *Topics in French Theatre*. (3-5 cr per qtr; prereq 3219 or above)
- Fren 5999. *Foreign Language Teaching: Theory and Practice*. (4 cr; prereq grad student or #) Barnes  
Theoretical and practical aspects of French-language learning and teaching.
- Fren 8010. *Seminar in Poetry*. (3-5 cr per qtr [max 15 cr]) Preckshot
- Fren 8030. *Seminar in Drama*. (3-5 cr per qtr [max 15 cr]) M Brewer, Sivert
- Fren 8050. *Seminar in Fiction*. (3-5 cr per qtr [max 15 cr]) M Brewer, Paganini
- Fren 8070. *Seminar in Poetic Theory*. (3-5 cr per qtr [max 15 cr]) Robinson
- Fren 8090. *Seminar in Filmic Analysis*. (3-5 cr per qtr [max 15 cr]) Conley

## GRADUATE PROGRAMS

Fren 8110. Seminar in Problems of Medieval Writing. (3-5 cr per qtr [max 15 cr]) Akehurst, Noakes

Fren 8120. Seminar in Problems of 16th-Century Writing. (3-5 cr per qtr [max 15 cr]) Conley, Noakes

Fren 8130. Seminar in Problems of 17th-Century Writing. (3-5 cr per qtr [max 15 cr]) D Brewer, Liu

Fren 8150. Seminar in Problems of 18th-Century Writing. (3-5 cr per qtr [max 15 cr]) D Brewer, Waldauer

Fren 8170. Seminar in Problems of 19th-Century Writing. (3-5 cr per qtr [max 15 cr]) Sivert

Fren 8190. Seminar in Problems of 20th-Century Writing. (3-5 cr per qtr [max 15 cr]) M Brewer, Paganini

Fren 8310. Seminar in Criticism and Literary Theory. (3-5 cr per qtr [max 15 cr])

Fren 8501. Methodology and Bibliography. (4 cr)

Fren 8701. History of the French Language. (4 cr) Akehurst

Fren 8704. Old Provençal. (4 cr) Akehurst  
Language and literature of the troubadours.

Fren 8970. Directed Readings for Graduate Students. (1-5 cr)

Fren 8980. Directed Teaching. (1-5 cr)

Fren 8990. Ph.D. Topics. (1-7 cr per qtr; prereq PhD student in French)  
For students who have completed major portion of coursework and are preparing Ph.D. exam topics. Does not fulfill degree requirements.

### Italian (Ital)

Ital 5042. Intensive Reading of Modern Italian Narrative Literature. (4 cr; prereq 3015 or 3041 or #)  
Twentieth-century authors analyzed from linguistic and literary points of view to achieve high level of reading competency and understanding of contemporary Italian literary scene. Taught in Italian.

Ital 5219. Humanism and Italianism in the Literature of the 16th Century. (4 cr, \$Fren 5219, \$FrIt 5219; prereq 3209 or above)  
Taught in English; knowledge of French and Italian not required. Aspects of Italian civilization from Dante to Machiavelli that led to the Renaissance. Focus on French and Italian literary texts.

Ital 5321. Renaissance Epic. (4 cr; prereq 3015) Martinez  
Pulci, Boiardo, Ariosto, Tasso, Folengo. Chivalric epic in Florence and Ferrara in contexts of humanism, rise of nation-state, and questions of gender. Comparative reading in other European epic traditions. English and Italian sections.

Ital 5328. Italian Renaissance Authors. (4 cr; prereq 3015) Martinez  
Bembo, Poliziano, Machiavelli, Gaspara Stampa, Castiglione, and others. Male and female authors subject to system of court patronage and currents of humanism and anti-humanism. Taught in Italian.

Ital 5331. Modern Poetry. (5 cr; prereq 3015)  
Crepuscular and hermetic poets from Gozzano to Ungaretti, Montale, Saba, and Quasimodo.

Ital 5337. Manzoni and the 19th-Century Novel. (4 cr; prereq 3015 or #) Ferlito  
*I promessi sposi*; novels by Verga, Deledda, D'Annunzio, and others. Textual analysis; evolution of modern novel.

Ital 5385. Twentieth-Century Narrative. (4 cr; prereq 3015 or #) Ferlito  
Evolution and analysis of modern novel and novella. Authors include Svevo, Vittorini, Calvino, and others. Taught in Italian.

Ital 5401-5402-5403. Dante. (4 cr per qtr; prereq 3015) Martinez  
*Divina Commedia* and minor works. Historical approach to most important literary work in Italian. Study of cosmology, scriptural exegesis, Italian history and Roman authors (Virgil, Ovid, Boethius) on Middle Ages, and revolution due to reintroduction of Aristotle, while following Dante's pilgrim through otherworld. English and Italian sections.

Ital 5411. Petrarch and Petrarchism. (4 cr; prereq 3015) Martinez  
Life and works of most influential writer of early modern Europe. *Rime sparse* and *Secretum*. Petrarch as founder of humanism and Italian lyric tradition from Troubadors to Dante. Comparative readings in subsequent Petrarchist movements in Europe. English, and Italian sections.

Ital 5418. Boccaccio and the Novella. (4 cr; prereq 3015) Martinez  
*Decameron* and Boccaccio's minor works; story collections in Middle Ages and Early Renaissance, from *Novellino* to *Bandello*. English and Italian sections.

Ital 5609. Dante (in English). (4 cr) Martinez

Ital 5900. Topics in Italian Literature. (4 cr; prereq 3209 or above)

Ital 8970. Directed Readings for Graduate Students. (1-5 cr)

### French and Italian (FrIt)

FrIt 5531. Baroque Literature in France and Italy. (4 cr; prereq at least one 3xxx or 5xxx course in literature of France or Italy)  
Taught in English. Spread of the Baroque in literature through Europe. Movement from Italy, changing but rooted in particular view of the world.

## Genetics

See Molecular, Cellular, Developmental Biology and Genetics.

## Geography (Geog)

*Professor:* Helga Leitner, *director of graduate studies*; John S. Adams; Ward J. Barrett; Dwight A. Brown; Philip J. Gersmehl; John F. Hart; Mei-Ling Hsu; Fred E. Lukermann (*emeritus*); Philip W. Porter; John G. Rice; Joseph E. Schwartzberg; Earl P. Scott; Eric S. Sheppard; Richard H. Skaggs; Graham A. Tobin<sup>1</sup>

*Associate Professor:* Lawrence M. Knopp, Jr.<sup>1</sup>; Judith A. Martin; Robert B. McMaster; Roger P. Miller; Abdi I. Samatar; Roderick H. Squires; Connie H. Weil

*Assistant Professor:* William J. Craig (Center for Urban and Regional Affairs); Katherine Klink; Howard D. Veregin

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) and Ph.D.

**Curriculum**—This geography program covers six broad clusters: cultural and historical geography and the history and philosophy of the discipline; physical geography and environmental systems; urban and economic geography; cartography and geographic information systems; regional geography; and social and political economy of development. Students work with their advisers to design individual programs suited to their educational and professional goals.

**Prerequisites for Admission**—Prospective students should have completed the equivalent of introductory courses in physical and human geography and at least seven upper division courses in systematic and regional geography. Students who were not undergraduate geography majors are encouraged to apply but may be required to make up deficiencies.

**Special Application Requirements**—Three letters of recommendation must be sent directly to the department. Tardy letters delay processing of the application. Scores from the General (Aptitude) Test of the Graduate Record Examination (GRE) that are less than five years old are required of students with baccalaureate degrees from U.S. institutions. Graduate study in the program begins in the fall quarter. The

application deadline is January 1; all applications are evaluated once each year in early February.

**Master Degree Requirements**—The minimum number of course credits is 28 credits for Plan A (excluding thesis credits) and 44 credits for Plan B. All students must take three of the seven proseminars (8001-8007) during the course of their graduate program. The final examination for both plans is oral. In unusual circumstances the graduate faculty may substitute a written examination for the Plan B oral examination. For further information about master's degree requirements, contact the director of graduate studies.

**Doctoral Degree Requirements**—Information on selecting an adviser and constructing a doctoral program can be obtained by requesting a copy of "The Graduate Program in Geography at the University of Minnesota" from the director of graduate studies. All students must take three of the seven proseminars (8001-8007) during the course of their graduate program.

**Language Requirements**—M.A. and Ph.D. students are expected to acquire competence in the research tools appropriate to their endeavors as graduate students and to their future professional work. Often these are foreign languages and/or quantitative or experimental skills. The language and technique requirement is set by the advising committee, which is also responsible for certifying that the requirement has been met before the M.A. final examination is scheduled.

**Minor Requirements for Students Majoring in Other Fields**—A minor program must be developed in consultation with an appropriate faculty adviser. Consult the director of graduate studies about selecting an adviser.

**For Further Information and Applications**—Contact the Department of Geography, University of Minnesota, 414 Social Sciences Building, 267 19th Avenue South, Minneapolis, MN 55455 (612/625-6080; fax 612/624-1044; e-mail willi046@tc.umn.edu; <http://www.geog.umn.edu>).

Geog 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Geog 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Geog 8888. Thesis Credits: Doctoral. (36 cr required)

<sup>1</sup> University of Minnesota, Duluth

### Regional Studies

Geog 5101. Historical Geography of North America. (4 cr) Lukermann

Sequential analysis of settlement and economy in changing environment and resource pattern of North America in the period of frontier interaction, 1500-1900.

Geog 5111. Selected Regions of the Eastern United States. (4 cr; offered alt yrs) Hart

Intensive geographical analysis of selected regions east of the Great Plains. Regions selected vary yearly.

Geog 5131. Colonial Mexico and the Caribbean. (4 cr) Barrett

Exploration, discovery, livelihood, and circulation to about 1800.

Geog 5132. South America. (4 cr; offered alt yrs) Weil  
Regional survey of physical resources, population, agriculture, manufacturing, and transportation in South America.

Geog 5142. Geography of East Africa. (4 cr, \$Afro 5142; offered alt yrs) Porter, Samatar  
Physical and human geography of Kenya, Tanzania, and Uganda with emphasis on environment as resource, historical geography of colonial and postcolonial eras, geographical organization of human activity, and regional contrasts.

Geog 5143. Geography of West Africa. (4 cr, \$Afro 5143) Scott

Regional study of West Africa from Senegal to Cameroon: social geography of resource use, population, settlement, economic development, and international relations.

Geog 5145. Development in Africa. (4 cr, \$Afro 5145, \$IntR 5145) Samatar, Scott

Economic, political and social development in Africa, from independence to present. Recording colonial landscapes, bases for North-South relations, big power interventions, and participation in the world economy.

Geog 5171. Western Europe. (4 cr; offered when feasible) Leitner, Rice

Geog 5173. Norden. (4 cr; offered alt yrs) Rice  
Physical and human geography of Sweden, Finland, Denmark, Norway, and Iceland; emphasis on population change and settlement patterns.

Geog 5176. Scandinavia in the 19th and 20th Centuries. (4 cr, \$Hist 3273; offered alt yrs) Metcalf, Rice  
Team-taught, interdisciplinary examination of social and economic transformation of Scandinavia, 1800 to present; from agrarian periphery to European integration; impact of demographic, economic, and social change; social democracy and politics of consensus.

Geog 5177. Scandinavia in the Early Modern Period. (4 cr, \$Hist 3272; offered alt yrs) Metcalf, Rice

Team-taught, interdisciplinary examination of social and economic transformation of Scandinavia, 1500-1800; centralization of state power and the Reformation; struggle for commercial and political control of Baltic; absolutism in the North; political and agrarian reforms.

Geog 5178. Scandinavia in the Middle Ages. (4 cr, \$Scan 5118; offered alt yrs) Rice, Metcalf  
Team-taught interdisciplinary examination of economic, political, and social history of Scandinavia, from late Viking period until circa 1500. Agrarian and urban societies; peasant and elite perspectives; growth of economic, political, religious and social institutions.

Geog 5181. Russia and Environs. (4 cr) Adams  
Physical and human geography of republics of former USSR. Imprint of central planning and state socialism on regional economies, city systems, and internal structures of cities. Economic and cultural linkages among regions and republics. Conflicts rooted in religion, ethnicity, and tradition. Contacts with neighboring states and regions. Physical environmental problems.

Geog 5211. East Asia: Regional Analysis. (4 cr, \$3211) Hsu

Regional aspects of East Asian life. The effects, within a traditional context, of population growth and modern technology on the transformation of society and reorganization of space.

Geog 5212. South Asia. (4 cr, \$3212) Schwartzberg

Physical and human geography of India, Pakistan, Bangladesh, Sri Lanka, Afghanistan, and the Himalayan kingdoms; geographic aspects of social structure, population pressure, economic development, and international relations.

Geog 5215. China. (4 cr, \$3215; prereq social science course) Hsu

Socioeconomic geography of China. Environment as resource, population dynamics, economic development, and social change. Geographic organization of human activities, regional contracts, foreign trade, and international relations.

### Topical Studies

Geog 5361. The Geography of Land Ownership. (4 cr; prereq #) Squires

Evolution and spread of land ownership in United States. Public records associated with land ownership.

Geog 5371. North American Cities. (4 cr; prereq 1301 or 1501 or 1970 or 3371 or 3973 or 5001 or #) Adams

Emergence of towns and cities in North America; urban economy and its locational requirements, past and present; central place theory; comparisons of city systems in capitalist, socialist, and developing areas; structure and change of land used inside urban areas.

Geog 5372. Metro Analysis I: Population and Housing. (4 cr) Adams

Metro housing stocks, supply of housing services; demand for housing; population and households; housing price structure, changes, intraurban migration; spatial submarkets and housing in metro areas. Emphasis on linking theory, method, and case studies.

Geog 5373. Metropolitan Analysis II: Land Use and Transportation. (4 cr) Adams  
Metropolitan economic structure, change, and measurement methods; transportation and urban land use and land use conflict; competition for local property tax base; industrial and commercial land blight and real estate redevelopment.

Geog 5385. Political Economy of Development. (4 cr; prereq sr or grad student or #) Samatar  
Nature and scope of the modern world system (capitalism) and its impact on regional development processes; roles of the state and international financial institutions.

Geog 5393. Look of the Land. (4 cr; offered alt yrs) Hart  
Major components of landscape; emphasis on interaction between structures created by people and distinctive rural landscapes in North America, northwestern Europe.

Geog 5411. Medical Geography. (4 cr; offered alt yrs) Weil  
Concepts and methods, including distribution and diffusion of disease; impact of environmental, population, and social change on health; distribution, accessibility, and use of health practitioners and facilities.

Geog 5423. Climate Models and Modeling. (4 cr; prereq 3421 or #) Klink, Skaggs  
Survey of development of and research with one-, two-, and three-dimensional climate models. Overview of environmental processes and their numerical representation in models; evaluation of model sensitivity and accuracy; coupling between atmosphere, biosphere, hydrosphere, and cryosphere; assessment of model predictions for climate change.

Geog 5426. Climate Variations. (4 cr; prereq 3421, Soil 3421 or #)  
Theories of climate fluctuation and change at decadal to centuries time scales; analysis of temporal and spatial patterns in climate fluctuations, especially during periods of instrumental records.

Geog 5441. Quaternary Landscape Evolution. (4 cr; prereq 1401 or #) Brown  
Roles of geomorphic history, climate change, soil development, and vegetation change in evolution of landscape patterns during Quaternary, with emphasis on North America.

Geog 5444. Water Resources, Individuals, and Institutions. (4 cr, \$WRes 5101) Brown  
Control of water resources by natural system functions, user actions, and social and political institutions. How these controls vary in space and time, complexities of each, and feedbacks among them.

Geog 5601. Introduction to Land Use Planning. (4 cr) Lukermann  
Context of planning within changing geographic patterns of land use. Nature of land use plans; purpose and process of land use planning.

Geog 5605, 5606. Geographical Perspectives on Urban Planning I, II. (4 cr; offered alt yrs) Leitner, Miller

Comparative examination of planning concepts and practices in reshaping geography of 19th- and 20th-century cities in Europe, North America, and selected Third World countries. History and ideologies of planning. Planning as response to economic, political, and social change and problems. Interest groups and power relations in planning process. Planning and geography of livable city. *5605*: systematic critical overview of historical evolution of planning; *5606*: case studies.

## Technical Studies

Geog 5511. Cartographic Analysis. (4 cr; prereq 3511 or basic statistics course; offered alt yrs) Brown, Hsu, McMaster, Porter

Methods of data compilation; quantitative analysis of maps, map types, graphic correlation, composite mapping; area sampling, classification, and other generalization problems.

Geog 5512. Cartography: Topics. (4 cr; prereq 3511 or #; offered alt yrs) Brown, Hsu, McMaster, Porter, Veregin

Selected topics: the system of cartographic communication, map design, map reading, map analysis, history of cartography.

Geog 5522. Computer Cartography: Principles and Design Concepts. (4 cr; prereq 3511 or #) Hsu  
Elements and principles of cartographic design; applications to different map themes; using microcomputer with package software to explore message-focused map design.

Geog 5523. Elements of Digital Cartography. (4 cr; prereq 3511, 3531 or 5522, 1 programming language or #) McMaster, Veregin  
Fundamental issues. UNIX operating system and programming on workstations. FORTRAN programming and SUNPHIGS. Vector encoding and error. Generalization models and techniques. Geographical data structures. Computational geometry. Cartometric analysis. Computer-generated cartographic symbolization.

Geog 5530. Cartography Internship. (2-5 cr per qtr [max 10 cr, incl combined cr at 3xxx and 5xxx levels]; prereq #) Hsu, McMaster  
Internship with institution, government agency, or private company arranged through and supervised by department.

Geog 5531. Advanced Quantitative Methods in Geography. (4 cr; prereq basic statistics course; offered alt yrs) Klink, McMaster, Sheppard, Skaggs  
Topics include multivariate methods, regionalization, spatial autocorrelation, spatial pattern analysis.

Geog 5562. Introduction to Geographic Information Systems. (4 cr, \$LA 5562; prereq jr or sr in geog or LA or grad student or #) Brown, McMaster, Veregin  
Geographic information systems structure; theory and applications for geographic research, location and resource analysis, and regional planning; location principles, data structure, and variable attributes.

## GRADUATE PROGRAMS

Geog 5563. Advanced Geographic Information Systems. (4 cr; prereq 5562 or LA 5562 or #) McMaster, Veregin

Concepts and theories. Sources of geographical data including image processing. Geographic data structures, including hierarchical, relational, quadtree, and raster methods. Techniques of spatial analysis. Error modeling in geographic databases. Spatial interpolation and classification. Visualization of GIS processes and spatial modeling.

Geog 5564. Urban Geographic Information Systems and Analysis. (4 cr, \$PA 5664; prereq 5562, PA 5601 or #)

Geog 5565. Geographical Analysis of Environmental Systems and Global Change. (4 cr; prereq FR 5130, Geog 5562, LA 5562, sr or grad or #) Applications of geographic information systems and other spatial analysis tools to analysis of environmental systems patterns, dynamics, and interactions. Global-to-landscape databases developed for analysis of atmospheric, hydrospheric, geomorphic, pedologic, biologic, and human land-use systems.

Geog 5701. Field Research. (4 cr; prereq 12 cr geog, #) Field investigation in physical, cultural, and economic geography; techniques of analysis and presentation; reconstruction of environments.

Geog 5710. Field Internship. (Cr ar, \$IntR 5701; prereq IntR 5930) Requirements and credits vary with nature of internship. Those for MSID normally carry eight credits per quarter for up to two quarters. All internships are conducted off campus and require contract with department supervisor specifying work to be accomplished and means of reporting achievement.

### History and Philosophy of Geography

Geog 5001. Modes of Geographic Inquiry. (4 cr) Sheppard

Different ways of knowing the world and their application to explaining and interpreting geography since 1960. Empirical approaches and geographical hypothesis; structural approaches and socio-spatial systems; interpretive approaches and meaning of geographical phenomena. Application to city systems; integration and diffusion.

Geog 5775. Geographical Education. (4 cr; prereq three geog courses, background in social studies or history of educ or #) Teaching geography in middle school and above; pedagogical use of geographical themes; methods for effective teaching of multiple cognitive domains (facts, theories, analytical skills, and evaluations); designing audio-visual aids, independent projects, simulations, etc., to meet national standards in geography.

Geog 5801. Development of Geographic Thought. (4 cr, \$3801; prereq sr or grad student, three geog courses) Lukermann  
Concepts and methods of geography; differing schools of geographic thought as expressed in contemporary geographic literature.

Geog 5808. Regional Analysis of North America. (4 cr; prereq #) Gersmehl  
Regions: what they are, where they come from, how we delimit them, how people perceive them, how they interact with other places, and how they change through time. Attendance at selected lectures and slide presentations in Geog 3101 required.

Geog 5856. The Meanings of Place. (4 cr, \$Arch 5956; prereq #) Martin  
Analysis of messages and meanings of our surroundings. Twin Cities central districts and neighborhoods, and selected settings elsewhere. Direct experience.

### Directed Studies

Geog 5900. Topics in Geography. (4 cr; prereq sr or grad student, Δ)  
Course on special topics and regions offered by visiting professors in their research fields.

Geog 8001. Proseminar: Geography and Cultural Ecology. (3 cr; prereq #)  
Interconnectedness of people and environment: human ecology, behavioral geography, cultural ecology, behavioral environment, perception of environment, ethnogeography, energetics, and natural hazards research. Efforts to connect this theme to physical geography, study of spatial organization, geo-political economy, and regional geography.

Geog 8002. Proseminar: The Economy, the State, and Spatial Development. (3 cr; prereq #)  
Conceptual literature in economic, political, and urban geography; theoretical foundations for examining interrelationship between political and economic processes and spatial organization of society; survey of empirical research documenting nature and extent of interrelationship at different spatial scales.

Geog 8003. Proseminar: Historical Geography. (3 cr; prereq #)  
Development, traditions, and major problems and approaches in current research.

Geog 8004. Proseminar: Physical Geography. (3 cr, \$8401; prereq #) Brown, Gersmehl, Klink, Skaggs  
Historical development of research in physical geography, current research trends, and transfer of current research to undergraduate education.

Geog 8005. Proseminar: Population Geography. (3 cr; prereq #)  
Approaches taken by geographers and social scientists to better understand current population issues and problems.

Geog 8006. Proseminar: Research Methods in Geography. (3 cr; prereq #)  
Research design, strategies, and methods of data collection, analysis, and representation.

Geog 8007. Proseminar: Theories of Development and Change. (3 cr; prereq #) Capitalism and underdevelopment; populist vs. Marxist debates; grassroots movements and development; gender, development, and democracy; nongovernmental organizations in the democratic transition; new paradigms of development.

Geog 8010. Seminar: Theoretical Geography. (3 cr; prereq #; offered when feasible)

Geog 8020. Seminar: Economic Geography. (3 cr; prereq #; offered alt yrs)

Geog 8120. Seminar: Historical Geography. (1-3 cr; prereq #)

Geog 8125. Seminar: Public Land History. (3 cr; prereq) Squires  
Guide to published and unpublished materials describing land ownership in the United States.

Geog 8140. Seminar: Africa. (3 cr; prereq #) Porter, Samatar, Scott

Geog 8210. Seminar: South Asia. (1-3 cr; prereq #) Schwartzberg

Geog 8300. Geographical Writing. (3 cr; prereq #) Hart  
Analysis of the organization and presentation of geographic research. Critiques of selected examples of geographical writing.

Geog 8301. Geographical Education. (3 cr; prereq #) Gersmehl  
Guided study of the process of teaching geography at the college level.

Geog 8302. Research Development. (1-3 cr; prereq #) Guided study of research proposal process: topic choice, statement of problems, research design, identification of funding sources, and proposal writing.

Geog 8320. Considering Space, Place, and Human Activity. (3 cr; prereq #) Martin  
Aspects of place analysis/place description from variety of analytical and perceptual perspectives.

Geog 8330. Seminar: Rural Geography. (3 cr; prereq #) Hart

Geog 8335. Agrarian Change in the Third World. (4 cr) Samatar  
Nature of agricultural development in Third World capitalist economies. Assessment of transformation of peasant agriculture into predominantly commodity-producing system.

Geog 8344-8345†. Seminar: Public Land Policy. (3 cr per qtr; prereq #) Squires  
Policies of federal and state governments in acquiring and using land.

Geog 8350. Seminar: World Population Problems. (3 cr; prereq #; offered alt yrs) Hsu, Rice

Geog 8380. Seminar: Medical Geography. (3 cr; prereq 5411 or #)

Geog 8400. Seminar: Physical Geography. (3 cr; prereq #) Brown, Gersmehl, Klink, Skaggs

Geog 8420. Seminar: Climatology. (3 cr; prereq #; offered alt yrs) Klink, Skaggs  
Detailed study of selected topics. Topics vary yearly; examples include modeling, climatic variability, predictability, severe local storms, drought, and energy balance.

Geog 8510. Seminar: Cartography. (1-3 cr; prereq #; offered when feasible) Hsu, McMaster, Porter

Geog 8800. Seminar: Development of Geographic Thought. (3 cr; prereq #) Lukermann

Geog 8970. Directed Readings. (1-5 cr)

Geog 8980. Topics in Geography. (1-3 cr; prereq #)

Geog 8990. Research Problems in Geography. (Cr ar)

## Geological Engineering (GeoE)

*Professor:* Steven L. Crouch, *head*; Andrew Drescher; Charles Fairhurst; Efi Foufoula-Georgiou; Theodore V. Galambos; Gary Parker; Otto D. L. Strack

*Adjunct Professor:* Peter A. Cundall

*Associate Professor:* Randal J. Barnes; Gary A. Davis; Emmanuel M. Detournay; Catherine E. French; Joseph F. Labuz; David E. Newcomb; Karl A. Smith; Mark B. Snyder; Henryk K. Stolarski; Vaughan R. Voller

*Assistant Professor:* Jerome F. Hajjar; Carol Kittredge  
Shield

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B), M.Geo.E., and Ph.D.

**Curriculum**—The graduate program in geological engineering is administered in the Department of Civil Engineering and is closely allied with civil engineering. The master of geological engineering (M.Geo.E.) program is designed for engineering graduates who are particularly interested in planning, design, operation, and management in geotechnical areas, or for graduate students with experience in engineering geology and other geotechnical areas who wish to study current developments and design procedures.

**Prerequisites for Admission**—In general, adequate preparation in undergraduate subjects and in the sciences fundamental to geological engineering is required. A bachelor's degree from an engineering program accredited by the Accreditation Board for Engineering and

Technology (ABET) is required for admission to the M.Geol.E. program. Applicants to this professional program who have B.S. degrees in other fields (geology, physics, chemistry) are required to make up deficiencies in the basic engineering curriculum after admission.

**Special Application Requirements**—None.

**Degree Requirements**—For M.S. and Ph.D. degree requirements, see the General Information section of this bulletin. M.Geol.E. students should consult the General Information section under Professional Master's Degree in Engineering. All students should also consult the Department of Civil Engineering *General Information Bulletin for Graduate Students* for more information.

The final examination for the M.S. and M.Geol.E. degrees is oral.

**Language Requirements**—None.

**For Further Information and Applications**—

Contact the Geological Engineering Program, University of Minnesota, Civil Engineering Building, 500 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/625-5522; fax 612/626-7750; e-mail [cive@tc.umn.edu](mailto:cive@tc.umn.edu); <http://www.cme.umn.edu>).

GeoE 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

GeoE 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

GeoE 8888. Thesis Credits: Doctoral. (36 cr required)

GeoE 5218. Design of Underground Excavations in Rock. (4 cr, §CE 5305; prereq 5302 or #, IT student or grad IT major) Fairhurst Stresses and deformations around underground excavations in rock; design of linings and support systems; excavation by boring, drilling, and blasting; tunneling under adverse conditions; materials handling and tunnel ventilation.

GeoE 5260. Drilling, Blasting, and Comminution. (4 cr; prereq CE 3300 or #, IT student) Fairhurst Rock excavation and size reduction by drilling, blasting, and comminution; basic mechanics of fracture; bit penetration into rock; breakage and selection functions in comminution. Properties of explosive; strain wave transmission, reflection, and refraction in drilling and blasting; design of blasting rounds; controlled blasting; ground and air vibrations. Tunnel boring machines; types of crushing and grinding equipment and their selection.

GeoE 5262. Geo-Engineering Analysis. (4 cr; prereq sr or #, IT student or grad IT major) Barnes Comprehensive analysis of a geological engineering or rock mechanics problem. Involves integration of concepts of rock and soil mechanics, geology and geophysics, mineral engineering, and economics in a specific problem chosen by the student and staff. Preparation of a professional report.

GeoE 5302. Applied Rock Mechanics. (4 cr, §CE 5302; prereq CE 3300 or #, IT upper div or grad student) Detournay, Labuz Site investigation; rock mass classifications; in situ stress; behavior of intact rock; shear strength of joints; rock mass behavior; stereographic projections; kinematic analysis of rock slopes; foundations on rock.

GeoE 5437. Computer Applications in Geological Engineering. (4 cr; prereq CE 3020, Math 3221 or equiv or #) Barnes, Voller Methods (finite differences, finite elements, boundary elements) for solution of problems in hydrology, structural engineering, geomechanics, and environmental engineering that reduce to partial differential equations. Each method illustrated in context of one or more practical problems.

GeoE 5555. Engineering Geostatistics. (4 cr; prereq Stat 3091 or #, IT upper div or grad student) Barnes Problem solving and decision making in geological engineering using tools of applied statistics. Emphasis on spatially correlated data, e.g., geologic site characterization, rock mass parameter estimation, ore body modeling, optimal sample design for groundwater contamination assessment.

GeoE 5660-5661-5662. Special Geological-Engineering Problems. (Cr and hrs ar; prereq IT sr or #) Literature survey, research work, or design study in geological-engineering problems.

GeoE 5700. Systems Analysis for Geological Engineering. (4 cr; prereq IT upper div or grad student) Introduction to systems analysis and decision making; expert systems; operations research techniques, modeling and simulation. Applications in geological engineering and related fields.

GeoE 8302. Soil/Rock Plasticity and Limit Analysis. (4 cr, §CE 8302; prereq 3300) Drescher Plasticity of soils and rocks. Hardening and prescher plastic models. Yield conditions, flow rules. Theorems of limit analysis. Static solutions, method of characteristics. Kinematic solutions, hodograph, energy balance. Applications to soil/rock engineering problems.

GeoE 8320. Thermoporoelasticity. (4 cr, §CE 8320; prereq AEM 5580 or #) Detournay Micro-mechanical description of porous media. Thermodynamics foundations. Linear theory of thermoporoelasticity; constitutive, transport, and balance laws; field equations. Determination of material constants. Singular solutions. Methods of solution: integral transform, method of singularities, finite and boundary element method. Geomechanics applications.

GeoE 8336. Boundary Element Methods I. (4 cr; prereq AEM 3016 or #) Crouch  
Boundary element methods for elastostatics: stress discontinuity, displacement discontinuity, and direct boundary integral methods. Derivation of basic mathematical solutions from theory of elasticity. Applications of boundary element methods in geomechanics.

GeoE 8350. Advanced Rock Mechanics I. (4 cr; prereq 5302) Labuz  
Implementation of rock mechanics techniques in civil and mining engineering practice, involving lab and field techniques for specification of rock material and rock mass properties, stress determination in rock, rock support, reinforcement and improvement, and methods of measuring response of rock to excavation-induced loads.

GeoE 8352. Modeling Geomechanical Processes. (4 cr; prereq geo eng grad major or #) Detournay  
Data-limited nature of problems in geomechanics; dimensional analysis; regimes of solution; similarity solutions; elements of fracture mechanics, elastoplasticity, poroelasticity; geomechanical applications to stability of underground excavations (borehole, tunnel), fluid flow in fracture, tool-rock interaction (cutting, indentation), hydraulic fracturing (initiation, propagation).

GeoE 8360. Engineering Model Fitting. (4 cr; prereq civil or mineral or geo eng grad student or #; offered alt yrs) Barnes  
Parameter estimation and inverse modeling in civil, geological, and mineral engineering. Formulation of engineering model fitting problems, comparison and selection of various fit criteria, selection and implementation of solution algorithms on computer, analysis and interpretation of results, and design of future measurement plans.

GeoE 8601, 8602, 8603. Seminar: Geological-Engineering. (Cr ar; prereq #)

GeoE 8612, 8613, 8614. Geological-Engineering Research Problems. (Cr ar; prereq #)

## Geology and Geophysics (Geo)

*Regents' Professor:* Herbert E. Wright, Jr. (*emeritus*)

*Professor:* William Seyfried, Jr., *head*; E. Calvin Alexander, Jr.; Subir K. Banerjee; Roger LeB. Hooke; Peter J. Hudleston; Thomas C. Johnson<sup>1</sup>; Shun-ichiro Karato; Kerry R. Kelts; David L. Kohlstedt; Ronald L. Morton<sup>1</sup>; V. Rama Murthy; Robert O. Pepin; Hans-Olaf Pfannkuch; Robert E. Sloan; David L. Southwick; James H. Stout; Paul W. Weiblen; David Yuen

*Adjunct Professor:* Wayne C. Shanks III

*Associate Professor:* Christian P. Teyssier, *director of graduate studies*; R. Lawrence Edwards; Emi Ito; Karen L. Kleinspehn; Bruce Moskowitz; Christopher Paola

*Assistant Professor:* Mark A. Person

*Other:* Michael E. Berndt; Val W. Chandler; Daniel R. Engstrom; Paul H. Glaser; Neal R. Iverson; Robert G. Johnson; Glenn B. Morey; Linda C. K. Shane

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Geology: M.S. (Plan A, Plan B, and coursework-only option with emphasis in hydrogeology and environmental geoscience) and Ph.D.; Geophysics: M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—The geology major includes the areas of Quaternary studies, structural geology, stratigraphy, paleontology, crystallography, mineralogy, economic geology, experimental and theoretical petrology, isotopic and aqueous geochemistry, experimental geochemistry, geomorphology, glaciology, groundwater geology, limnology, and sedimentology. The geophysics major includes the areas of applied and theoretical geophysics, paleomagnetism and rock magnetism, and mineral and rock physics. Courses in the minor and supporting fields are normally taken from outside the department, although they may be taken from within in special cases. Students may accommodate other areas of interest such as earth resources, engineering geology, environmental geology, materials science, soil science, and paleoecology by choosing a minor or supporting field from outside the department.

**Prerequisites for Admission**—A bachelor's degree in geology or geophysics; at least one year of study in calculus, chemistry, and physics; and a full-time geological field course of at least five weeks' duration are required. Applicants with degrees in other fields or with limited background deficiencies are also considered. In general, an outstanding academic record is expected.

**Special Application Requirements**—Graduate Record Examination scores are required for admission and financial aid consideration; three letters of recommendation are required for financial aid and are optional but recommended for admission consideration. Applications for admission are considered at any time, although applications for financial aid should be submitted by January 15 to ensure consideration. Studies may begin in any quarter or summer session, although fall quarter is preferable.

**General Degree Requirements**—For both the master's and doctoral degrees, certain advanced courses must be completed either before entrance

<sup>1</sup> University of Minnesota, Duluth

or during the first year of graduate work. These courses include two quarters of mathematics or one quarter each of mathematics and statistics (in addition to the prerequisites for admission) and two quarters of 5xxx or 8xxx analytical science, with courses selected from a list available from the director of graduate studies. These courses may form part of a supporting field or minor if taken after admission.

**Master's Degree Requirement**—For Plan A, the minimum course credit requirement is 20 credits in the major (excluding thesis credits) and 8 credits in the supporting program. For Plan B, the minimum course credit requirement is 44 credits, which includes 20 credits in the major and 8 credits in the supporting program. For the course-work only option, the minimum course credit requirement is 44 credits, which includes 24 credits in the major and 8 credits in the supporting program (or 9 credits in a designated minor).

**Doctoral Degree Requirements**—The minimum course credit requirement for the doctoral program is 37 credits in the major (excluding thesis credits).

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—Established on an individual basis with approval by the Graduate Studies Committee.

**For Further Information and Applications**—Contact the Department of Geology and Geophysics, University of Minnesota, 106 Pillsbury Hall, 310 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/624-1333; fax 612/625-3819; e-mail [umn\\_geo@darcy.geo.umn.edu](mailto:umn_geo@darcy.geo.umn.edu); <http://www.geo.umn.edu>).

Geo 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Geo 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Geo 8888. Thesis Credits: Doctoral. (36 cr required)

## General Geology

Geo 5004. Mineralogy. (4 cr, \$3401; prereq Chem 1051, Math 1252 or #; not open to geol or geophys or geo or min engr majors)  
Introduction to crystallography, crystal chemistry, and crystal physics. Physical and chemical properties, crystal structures and chemical equilibria of major mineral groups. Lab includes crystallographic and polarizing microscopes. X-ray diffraction exercises, hand specimen mineral identification.

Geo 5010. Field Workshop. (2 cr; prereq geol or geophys or geo eng major or #)  
Geologic or geophysical field study.

Geo 5020. Laboratory Workshop. (2 cr; prereq geol or geophys or geo eng major or #)  
Geologic or geophysical lab study.

Geo 5030. Modeling Workshop. (2 cr; prereq geol or geophys or geo eng major or #)  
Modeling of geologic or geophysical systems.

Geo 5051. Physical Geology for Teachers. (4 cr, \$1001; prereq educ degree, 1 term college chem or physics; no grad cr for geol or geophys majors)  
Introduction to scientific methods and the nature of Earth. Survey of main features of the physical world and of processes that have evoked them.

Geo 5052. Historical Geology for Teachers. (4 cr, \$1002; prereq educ degree, 1001 or 5051 or #; no grad credit for geol or geophys majors) Sloan  
Introduction to origin of Earth, physical evolution of its crust through geological time, and biological changes that occurred during its history. Lab, fieldwork, and seminar.

Geo 5054. Introduction to the Mesozoic for Teachers. (4 cr, \$1003; prereq educ degree) Kirkby  
Introduction to dinosaurs and Mesozoic Era; concepts of plate tectonics, evolution, extinction, and global change; students design course modules for elementary or secondary schools.

Geo 5061. Earth System Science from the Perspective of Minnesota Geology for Teachers. (4 cr, \$1031; prereq educ major or educ degree or #) Weiblen  
Basic principles of geology used to explore dynamic interactions of the solid Earth, hydrosphere, biosphere, and atmosphere; increasing significance of human activity in geological processes; pedagogic approaches to Earth System Science, field trips, and lab exercises.

Geo 5101f. Geochronology and Stratigraphy. (4 cr; prereq 3301)  
Methods for measuring geologic time and dating rocks; correlation and other stratigraphic techniques.

Geo 5108. Advanced Environmental Geology. (4 cr; prereq geol core curriculum through 5201 for majors or #) Pfannkuch  
Human impact on the geological environment and effect of geology/geologic processes on human life from point of view of ecosystems and biogeochemical cycles. Geologic limits to resources and carrying capacity of Earth. Land use planning, environmental impact assessment, ecogeologic world models. Field project.

Geo 5111su. Advanced Field Geology. (4 cr; prereq 3111, #)  
Geologic mapping; igneous, metamorphic, and sedimentary rocks; structures and surficial features; problem solving. Paper required.

Geo 5112su. Field Hydrogeology. (4 cr; prereq 5641, #) Alexander, Person, Pfannkuch  
 Aquifer, vadoze zone, and surface water hydrology field techniques; shallow soil boring and sampling; well installation; single and multiple well aquifer testing; ground water sampling for chemical analysis; weather data collection, hydrogeologic mapping, and water balance calculation.

Geo 5121f. History of the Earth. (3 cr; prereq geol major or #) Sloan  
 Analysis of interrelationships between plate tectonics, atmospheric composition, sea level, stratigraphic record, and organism evolution. Causes of mass extinctions and adaptive radiations.

Geo 5151. Introduction to Paleontology. (5 cr; prereq 1002 or #) Sloan  
 Morphology, classification, and ecology of major fossil groups.

Geo 5154. Vertebrate Paleontology I. (5 cr; prereq 5151 or EEB 5114) Sloan  
 Morphology, evolution, and stratigraphic distribution of fossil fish, amphibians, reptiles, and birds.

Geo 5155. Vertebrate Paleontology II. (5 cr; prereq 5154 or EEB 5114) Sloan  
 Morphology, evolution, and stratigraphic distribution of fossil mammals.

Geo 5201. Structural Geology. (4 cr; prereq 3402, 5101 or #) Teyssier  
 Concepts related to deformation of Earth's crust; processes associated with deformation, faulting, folding, and fabric development; labs, recitations, and field trips.

Geo 5202. Tectonic Styles. (3 cr; prereq 5201 or #; offered alt yrs) Hudleston  
 Origin and nature of major types of disturbances affecting the continental crust, including analysis of the form and development of individual structural components.

Geo 5203. Geotectonics. (3 cr; prereq 5201 or #; offered alt yrs) Kleinspehn, Teyssier  
 Problems associated with global tectonics; structure and evolution of Earth's crust and lithosphere; active compressional, extensional, and wrench tectonic regimes, with numerous examples from various parts of world; interpretation of older tectonic systems.

Geo 5251. Geomorphology. (4 cr [5 cr with term project]; prereq 1001, Math 1031 or #; 3 lect, 2 lab hrs per wk, lab often used for field trips) Hooke  
 Origin, development, and continuing evolution of landforms in various environments. Environmental implications emphasized. Weathering, slope and shore processes, fluvial erosion and deposition, wind action, tectonics, and impact phenomena.

Geo 5252. Regional Geomorphology. (3 cr [may be repeated for cr if different regions studied]; prereq 5201 or #; 1-wk field trip; offered alt yrs) Hooke  
 Geology of particular region of country, emphasizing geomorphology. One-week field trip late in quarter.

Geo 5255. Glaciology. (4 cr [5 cr with term project]; prereq Math 3261 or #; offered alt yrs) Hooke  
 Theory of glacier flow. Internal structures and temperature distribution in glaciers and ice sheets. Reading assignments and problems.

Geo 5261. Glacial Geology. (4 cr [5 cr with field trips]; prereq 1002 or #)  
 Formation and characteristics of modern glaciers; erosional and depositional features of Pleistocene glaciers; history of Quaternary environmental changes in glaciated and non-glaciated areas. Field trips.

Geo 5311. Geochemical Processes. (4 cr; prereq 3301, Chem 5520 or #) Ito, Seyfried  
 Processes pertinent to the distribution and control (structural, thermodynamic and kinetic) of chemical species in Earth and hydrosphere.

Geo 5313. Aqueous Geochemistry. (4 cr; prereq 5311, Chem 5520 or #) Seyfried  
 General principles of solution chemistry with application to geology including solution-mineral equilibria, redox processes in natural waters, and geochemistry of hydrothermal fluids.

Geo 5321. Isotope Geology. (4 cr; prereq 3301 or #) Edwards, Ito  
 Introduction to theory and uses of radioactive, radiogenic, and stable isotopes in geology. Radioactive dating, geothermometry, and tracer techniques in geologic processes.

Geo 5405. Optical Mineralogy. (2 cr; prereq 3401) Weiblen  
 Optical properties of minerals; symmetry and crystal optics; identification of minerals using polarizing microscope.

Geo 5452. Igneous and Metamorphic Petrology. (5 cr; prereq 3402, Chem 5520, Math 3261 or #) Stout  
 Theoretical course that develops basic thermodynamic tools and chemographic analysis for the interpretation of chemical processes in igneous and metamorphic rocks. Lab, field trip, problem sets, and term paper.

Geo 5454. Electron Microprobe Theory and Practice. (2-4 cr; prereq 3401, 1 yr chem and physics or #) McSwiggen  
 Introduction to characterizing solid materials with electron beam instrumentation, including reduction of X-ray data to chemical compositions.

Geo 5601. Limnology. (4 cr §EEB 5601; prereq Chem 1052)  
 Events occurring in lakes, reservoirs, and ponds; their origins, physics, chemistry, and biology. Interrelationships of these parameters and effects of civilization on lakes.

Geo 5603. Geological Limnology. (4 cr; prereq 5601 or EEB 5601)  
 Tectonic and climatic setting of lakes; physical, chemical, and biological processes of sedimentation in lakes.

## GRADUATE PROGRAMS

Geo 5613. Karst Hydrogeology and Tracer Applications. (4 cr; prereq 5641, #; offered alt yrs) Alexander

Physical and chemical principles and processes operating in karst hydrogeology and use of natural and synthetic chemical and isotopic labels or tracers to determine source, age, and mixing parameters of water in various natural reservoirs.

Geo 5621. Limnology Laboratory. (2 cr, \$EEB 5621; prereq 5601 or EEB 5601 or #) Megard  
Lab to accompany Geo 5601 (EEB 5601). Techniques for obtaining information about conditions in lakes and streams. Procedures for measuring abundance and population dynamics of aquatic organisms, with emphasis on plankton. Field instruments, sampling devices, chemical analyses, microscopy, and analysis of data. One Saturday field trip.

Geo 5631. Earth System: Geosphere/Biosphere Interactions. (4 cr, \$EEB 5004; prereq 3202, 3301 or #) Interdisciplinary study of mechanisms, feedbacks, and dynamics that force global change on various time scales, using paleorecord to illustrate processes.

Geo 5641. General and Physical Hydrogeology. (4 cr; prereq 1001, Chem 1052, Math 1252, Phys 1105, core curriculum through 3402 for geol majors or #) Pfannkuch

Introduction to theory of groundwater geology, hydrologic cycle, watershed hydrology, Darcy's law, governing equations of groundwater motion, flow net analysis, analog models, and groundwater resource evaluation and development.

Geo 5642. Quantitative Hydrogeology. (4 cr; prereq 1001, Chem 1052, Math 1252, Phys 1105, core curriculum through 3402 for geol majors or #) Person  
Applied analysis of steady and transient equations of groundwater motion and chemical transport using analytical and numerical methods. Numerical flow net analysis, well hydraulics, salt-water intrusion problems, and unsaturated flow.

Geo 5643. Chemical Hydrogeology. (4 cr; prereq 1001, Chem 1052, Math 1252, Phys 1105, core curriculum through 3402 for geol majors or #) Alexander  
Introduction to chemistry of natural waters, acid-base and redox reactions, carbonate equilibria, contaminant hydrology, isotope hydrology, and chemical modeling.

Geo 5651. Sedimentology. (4 cr; prereq 3402, IT upper div major in geol, geophys, geo engr, mineral engr or CLA jr or sr geol major or #; no grad cr for geol or geophys majors) Paola  
Interpretation of origin of sedimentary rocks through application of basic physical and chemical principles, understanding of modern depositional environments, and petrographic microscopy.

Geo 5653. Stratigraphy and Basin Analysis. (4-6 cr [6 cr with lab]; prereq 5651 or #; offered alt yrs) Kleinspehn

Modern techniques and principles of stratigraphic analysis of sedimentary basins in various tectonic settings. Seismic stratigraphy, correlation techniques, paleocurrent analysis, computer basin modeling, and geochronology of sedimentary basins.

Geo 5654. Marine and Lacustrine Sedimentary Environments. (4 cr; prereq 5651 or #; offered alt yrs) Kleinspehn

Principles of facies analysis of modern and ancient marine depositional systems, including deltas, fan deltas, barrier islands, beaches, storms, and turbidity currents in lakes and marine settings. Interpretations of marine tidal systems, carbonate platforms, reefs, continental shelves, and abyssal-plain processes.

Geo 5655. Continental Sedimentary Environments. (4 cr; prereq 5651 or #; offered alt yrs) Kleinspehn

Principles of facies analysis of modern and ancient non-marine depositional systems.

Geo 5656. Depositional Mechanics. (3-4 cr; prereq 5651, Math 3261 or #; offered alt yrs) Paola  
Elementary mechanics of sediment transport applied to quantitative interpretation of sedimentary rocks.

Geo 5701. Scientific Visualization. (4 cr; prereq CSci 3101, CSci 3102 or CSci 3113 or #)  
Practical application to data evaluation from such fields as geology, geophysics, engineering, and medicine.

Geo 5980. Seminar: Current Topics in Geology and Geophysics. (1-6 cr; prereq #)

Geo 8097. Seminar: Current Topics in Geology and Geophysics. (1-6 cr; prereq #)

Geo 8098. Seminar: Current Topics in Geology and Geophysics. (1-6 cr; prereq #)

Geo 8099. Research in Geology and Geophysics. (1-6 cr; prereq #)

Geo 8202. Advanced Structural Geology. (3 cr; prereq 5201; offered alt yrs) Hudleston  
Detailed study of structural geometry of folded rocks; origin of foliation and lineation; multiple deformation; advanced structural methods. Extensive reading in journal literature. Lab research on selected topics. Field trips.

Geo 8203. Geotectonics. (3 cr, \$5203; prereq 5201 or #; offered alt yrs) Kleinspehn, Teysier  
Problems associated with global tectonics; structure and evolution of Earth's crust and lithosphere; active compressional, extensional, and wrench tectonic regimes, with numerous examples from various parts of world; interpretation of older tectonic systems.

Geo 8262. Quaternary Paleocology and Climate. (4 cr; prereq 5261 or #) Kelts, Wright  
Principles of stratigraphic pollen analysis. Pleistocene and Holocene vegetation and climatic history as interpreted from pollen diagrams from different parts of the world. Paleoclimatic interpretation of ocean-sediment cores.

Geo 8351. Geochemical Modeling of Aqueous Systems. (3 cr; prereq 5313 or #)  
Using mass transfer reaction path models to assess chemical evolution of natural fluids, hydrothermal alteration processes, and formation of hydrothermal ore deposits.

Geo 8453. Phase Equilibrium in Mineral Systems. (3 cr; prereq 5452, Chem 5520, Math 3261; offered yrly when demand warrants) Stout Principles of homogeneous and heterogeneous equilibria and their application to problems in petrology. Emphasis on derivations from first principles and formulation of algebraic and graphical methods essential to multicomponent systems.

Geo 8454. Igneous Petrology. (3 cr; prereq 5452; offered yrly when demand warrants) Weiblen Igneous rocks and processes including igneous textures and associations, and appropriate phase equilibria to relate current theory and observation to the broad problems of petrogenesis. Term paper required.

Geo 8455. Metamorphic Petrology. (3 cr; prereq 8453; offered yrly when demand warrants) Stout Metamorphic processes; theory and observation are related to current problems. Fundamental concepts and techniques are related to progressive development of mineral assemblages. Term paper required.

Geo 8602. Advanced Limnology. (3 cr, \$EEB 8602; prereq 5601 or EEB 5601, #) Detailed study of selected problems in limnology using current and classical literature. Term paper required.

Geo 8612. Analytical Geohydrology. (3 cr [4 cr with term paper]; prereq Math 3261, CE 3400 or #; offered alt yrs) Pfannkuch Microphysics of flow through porous media; geological factors in aquifer performance; equations for groundwater flow; analysis of pumping tests; potential theory in groundwater flow; computer and analog models of aquifers; groundwater basin analysis.

Geo 8617. Transport Phenomena in Natural Porous Media. (2-3 cr; prereq CE 3400 or Chem 5520 or equiv or #: 2 lect hrs per wk, term paper) Pfannkuch Microscopic flow parameters, momentum, mass and energy transport through porous media, rate processes, coupled processes and nonequilibrium thermodynamics, geologic controls of natural flow systems in porous media and aquifers.

Geo 8618. Finite Element Methods in Subsurface Flow and Transport Problems. (4 cr; prereq #) Person Derivation of shape functions, formulation of strong and weak variation form of transport equations, assembly of local and global stiffness matrices and load vectors, solution procedures, stability analysis, and post-processing. Students develop 1- and 2-dimensional models of diffusion and advection-dispersion equations applied in sensitivity studies.

Geo 8620. Geofluids Seminar: Fluid Flow and Geologic Processes Within the Earth's Crust. (2 cr; prereq #) Person Chemical-rock interactions in mid-ocean ridge systems, metal ore genesis, remagnetization of sediments by hydrothermal fluids, fate of pollutants, ice flow in glaciers, magma melt migration, mantle convection. Lab, field, and computational methods used to study fluid transport processes and rock-water interactions within Earth's crust.

## Geophysics

Geo 5505. Solid-Earth Geophysics I. (4 cr; prereq 3201, Phys 1253) Basic elasticity, basic seismology, and physical structure of Earth's crust and deep interior.

Geo 5506. Solid-Earth Geophysics II. (4 cr; prereq 3201, Phys 1253) Earth's gravity fields, mantle viscosity, paleomagnetism, seismic tomography, and basic mantle convection and thermal history.

Geo 5507. Solid-Earth Geophysics III. (4 cr; prereq 3201, Phys 1253) Mechanical properties and transport processes in Earth materials and their importance to geophysical phenomena.

Geo 5508. Mineral and Rock Rheology. (4 cr; prereq 3201, Phys 1253) Karato Elastic, anelastic, and viscous deformation of minerals and rocks. Materials science fundamentals and geological/geophysical applications.

Geo 5515. Principles of Geophysical Exploration. (4 cr; prereq Phys 1253) Seismic exploration (reflection and refraction), potential techniques (gravity and magnetics), and electrical techniques of geophysical exploration.

Geo 5522. Time-Series Analysis of Geological and Geophysical Phenomena. (4 cr; prereq Math 3221 or #) Yuen Analysis of both linear and nonlinear phenomena. Examples from ice age cycles, earthquakes, climatic fluctuations, volcanic eruptions, atmospheric phenomena, thermal convection, and other time-dependent natural phenomena. Modern concepts of nonlinear dynamics and complexity theory applied to geological phenomena.

Geo 5535. Geological Thermomechanical Modeling. (4 cr; prereq Math 3261 or #; offered alt yrs) Yuen Heat and mass transfer processes in Earth's crust and mantle. Quantitative study of thermomechanical phenomena. Emphasis on analytical and modern numerical techniques.

Geo 5541. Geomagnetism. (4 cr; prereq 3201, Math 1251, Phys 1251 or #; offered alt yrs) Banerjee Present geomagnetic field at Earth's surface and core-mantle boundary, secular variation, paleointensity variation, geomagnetic field reversal, models for field transition.

Geo 5543. Paleomagnetism. (4 cr; prereq 3201, Math 1251, Phys 1251 or #; offered alt yrs) Moskowit Physical and chemical basis of paleomagnetism. Origin of natural remanent magnetization and its stability, mineralogy of magnetic minerals, paleomagnetic measurement techniques, statistics of paleomagnetic data, magnetic polarity stratigraphy, apparent polar wander, environmental magnetism.

Geo 5561. Magnetism: Physics, Geophysics, and Engineering. (3 cr, \$EE 5561, \$Phys 5561; prereq Phys 1251) Moskowit Elementary statistical mechanics, rock magnetism, and micromagnetic modeling; applications of magnetism in geophysics; biomagnetism; magnetic sensors; and recording.

Geo 8522. Time-Series Analysis of Geological and Geophysical Phenomena. (3 cr; prereq Math 3221 or #) Yuen

Time-series analysis of linear and nonlinear phenomena. Examples from ice age cycles, earthquakes, climatic fluctuations, volcanic eruptions, atmospheric phenomena, thermal convection, and other time-dependent natural phenomena. Modern concepts of nonlinear dynamics and complexity theory applied to geological phenomena.

Geo 8543. Principles of Rock Magnetism. (3 cr; prereq 5541 or #) Banerjee  
Remanent magnetizations, their classification and origins. Primary versus secondary magnetizations. Separation of multicomponent magnetizations. Paleointensities from rocks and meteorites.

Geo 8571. Advanced Geodynamics. (3 cr; prereq Math 3261 or #; offered alt yrs) Yuen  
Theory of mantle convection, thermal history of Earth, viscoelastic processes in Earth, postglacial rebound, and mantle rheology.

## Geophysics

See Geology and Geophysics.

## German

*Professor:* Jack D. Zipes, *chair*; James A. Parente, Jr., *director of graduate studies*; Evelyn S. Firchow; Frank D. Hirschbach (*emeritus*); Ruth-Ellen B. Joeres; Anatoly Liberman; Jochen Schulte-Sasse; Wolfgang F. Taraba (*emeritus*); Gerhard H. Weiss

*Associate Professor:* Leonard L. Duroche; G. Lee Fullerton; Richard W. McCormick; Hanna Schissler; Arlene A. Teraoka; Ray M. Wakefield

*Assistant Professor:* Gary C. Thomas; Stephanie C. Van D'Elden

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan B only) and Ph.D.

**Curriculum**—Coursework and theses may emphasize German literature, philologically oriented aspects of the language, or a combination of the two.

**Prerequisites for Admission**—For major work, a minimum of 36 upper division quarter credits or equivalent in German, of which a minimum of 20 credits must be in German literature courses, is required. Candidates whose preparatory work evidences gaps that can be remedied may be asked to complete supplemental work before admission.

**Special Application Requirements**—The following must be forwarded directly to the

department: three letters of recommendation, a complete set of transcripts (in addition to transcripts sent to the Graduate School), a copy of one or more papers representative of current level of scholarly development, and a statement of professional goals describing the applicant's intellectual development and plans for the future. For master's program applicants, and for all students wishing to be considered for fellowships, the General (Aptitude) Test of the Graduate Record Examination (GRE) is required; the GRE is optional for those applicants whose native language is not English and who are required to take the Test of English as a Foreign Language (TOEFL). For the doctoral program, applicants must have a master's degree from an accredited institution or present other evidence of adequate background and competence.

Prospective students should contact the department for further information. Students generally are admitted in the fall quarter only. All financial aid application materials for the Graduate School Fellowship, departmental fellowships, and teaching assistantships must be received by January 15.

**Master's Degree Requirements**—Students must complete Ger 8001-8002-8003 or equivalent; four literature courses selected from four of the following periods: 1) Middle Ages, 2) Renaissance to Baroque, 3) 18th century, 4) 19th century, 5) 20th century; two courses in philology; and two or more courses outside the German program for a minimum of 44 credits. Consult the current *Graduate Study in German* brochure for more details. Students must demonstrate proficiency in German at the ACTFL Advanced Plus level and submit one research paper of high quality. The final examination is oral, involving not only the areas included in coursework but also the Plan B paper and the minor or related field.

**Doctoral Degree Requirements**—A minimum of seven courses (28 credits) beyond the M.A. level is required, including one philology course and 8801. In addition, five courses (totaling at least 18 credits) outside the department are required for a minor or supporting program. For the written preliminary examination, the candidate submits a bibliography of her/his research area from which three department examiners develop a set of questions. The candidate selects one question and has one week to write a 20- to 25-page paper. The oral

preliminary examination includes general questions on German literature, philology, and the minor or supporting program. Consult the current *Graduate Study in German* brochure for more details.

**Language Requirements**—For the M.A. degree, proficiency in German is the only requirement, but students are strongly urged to learn a third language. For the Ph.D. degree, students must demonstrate a high degree of competence in one language, or reading proficiency in two languages, other than German and English.

**Minor Requirements for Students Majoring in Other Fields**—The approval of the director of graduate studies is a prerequisite for minor work in the field. A minimum of 12 credits in German literature courses is required for an M.A. minor in German, and a minimum of 24 credits in graduate German courses (12 credits beyond the M.A.), which must include 4 credits in philology, is required for a Ph.D. minor.

**For Further Information and Applications**—Contact the Department of German, Scandinavian, and Dutch, University of Minnesota, 205 Folwell Hall, 9 Pleasant Street S.E., Minneapolis, MN 55455 (612/625-2080; fax 612/624-8297; <http://macro.micro.umn.edu/german>).

*Note*—Because not all courses listed below are offered every year, see current *Graduate Study in German* brochure for course selection in a given year.

Ger 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Ger 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Ger 8888. Thesis Credits: Doctoral. (36 cr required)

## German (Ger)

### *German Language, Literature, and Culture Studies*

Ger 5011. Advanced Composition and Conversation. (4 cr; prereq 3013 or equiv)

Ger 5016. Advanced Translation: Theory and Practice. (4 cr; prereq 3016 or #)

Readings and discussion of translation theory, related issues in stylistics, philosophy of language; examination of sample translations; student production of translations, with methodological commentary.

Ger 5101, 5102. The Analysis of German. (4 cr per qtr; prereq 1105, Ling 3001/5001 or #)

5101: Phonology and morphology of modern German. 5102: Syntax of modern German.

Ger 5103. The Teaching of Germanic Languages. (4 cr)

Second language acquisition theory, methods, testing, and technology with respect to modern Germanic languages.

Ger 5331. Cultural Analysis. (4 cr; prereq 1 qtr German civilization and culture or equiv)

Techniques of cultural analysis (contrastive, anthropological, traditional) through the examination of literary texts, newspapers, language usage, etc.; "cultural myths" and forms of humor.

Ger 5490. Topics in German Literature. (4 cr per qtr [max 8 cr]; prereq 3104, 3105, jr or sr or grad student)

Topic, specified in *Class Schedule*, focuses on specific author, group of authors, genre, period, or subject matter.

Ger 5510. Topics in Contemporary German Culture. (4 cr [may be repeated for max 8 cr]; prereq 3513 or equiv)

Ger 5621. German Cinema From Caligari to Hitler. (4 cr; prereq 3xxx film studies course or #; may be applied toward German major or minor if part of reading done in German)

German cinema from its beginnings, through its golden age in 1920s, to end of Weimar Republic in 1933; includes Expressionism and New Objectivity; leading directors: Rye, Wiene, Lubitsch, Murnau, Lang, Pabst.

Ger 5622. Nazi and Postwar German Cinema. (4 cr; prereq 3xxx film studies course or #; may be applied toward German major or minor if part of reading done in German)

German cinema, 1933-1962: Nazi cinema, including Riefenstahl, Harlan, Sirk; continuities (e.g., Harlan) and discontinuities (e.g., Staudte's work in East and West Germany) in postwar cinema.

Ger 5623. New German Cinema. (4 cr; 3xxx film studies course or #; may be applied toward German major or minor if part of reading done in German)

West German cinema, 1962 to present: from early acclaim in mid-1960s (Schlöndorff, Kluge) to attainment of international stature by mid-1970s (Herzog, Fassbinder, Wenders, von Trotta); feminist and avant-garde films; crisis of 1980s.

Ger 5624. GDR Cinema. (4 cr; prereq 3xxx film studies course or #; may be applied toward German major or minor if part of reading done in German)

History of East German cinema, from Staudte's work in 1940s, through "socialist realism" in 1950s, to development of more critical and sophisticated cinema of 1970s and 1980s (Wolf, Beyer, others).

Ger 5630. Topics in German Cinema. (4 cr [max 8 cr]; prereq 3xxx film studies course or #; may be applied toward German major or minor if part of reading done in German)

Topic may focus on specific directors, formal or political characteristics, film production or reception, or other film-theoretical issues (e.g., "Politics of Melodrama in Sirk and Fassbinder").

Ger 5711, 5712. History of German Language. (4 cr)

Internal and external history. Changes in sounds, grammar, and vocabulary of German and its dialects as manifested in texts from 750 A.D. to present.

## GRADUATE PROGRAMS

- Ger 5721-5722. Middle High German Language. (4 cr)  
Fluent reading of normalized texts. Reading and analysis of non-normalized texts. Formal description of phonology, morphology, syntax.
- Ger 5731-5732. Old High German. (4 cr)  
Reading and analysis of texts. Formal description of phonology, morphology, and syntax.
- Ger 5734. Old Saxon. (4 cr)  
Reading and analysis of texts. Formal description of phonology, morphology, syntax.
- Ger 5740. Readings in Philology. (4 cr per qtr [max 12 cr])  
Reading of new and/or old research on some single topic in structure of historical and/or contemporary German languages.
- Ger 5771. Early New High German. (4 cr)  
Reading and analysis of texts. Formal description of phonology, morphology, syntax.
- Ger 5781, 5782. Varieties of Modern German. (4 cr per qtr; prereq 5101, 5102 or #)  
5781: Regional varieties. 5782: Social varieties. Lexical, syntactic, and phonological variation examined using contemporary methods of dialectology and sociolinguistics.
- Ger 5970. Directed Studies. (1-5 cr; prereq #, Δ, □)
- Ger 8001-8002-8003. Basic Seminar in German Literature. (4 cr per qtr; prereq grad major in German or #)  
Guided research in selected areas; methods and theory applicable in study of German literature. Introduction to bibliography and research skills. Oral reports and seminar papers.
- Ger 8202. Nibelungenlied. (4 cr; prereq 5721 or 5722 or #)
8203. Middle High German Courtly Lyric. (4 cr; prereq 5721 or 5722 or #)
- Ger 8204. Walther von der Vogelweide. (4 cr; prereq 5721 or 5722 or #)
8205. Middle High German Courtly Epic. (4 cr; prereq 5721 or 5722 or #)
- Ger 8206. Topics in Middle High German Literature. (4 cr; prereq 5721 or 5722 or #)
- Ger 8210. Topics in 16th- and 17th-Century German Literature. (4 cr per qtr [max 12 cr])
- Ger 8211. Literature From 1500 to 1600. (4 cr)
- Ger 8212. German Literature of the 17th Century. (4 cr)
- Ger 8219. Literature of the 19th Century. (4 cr)  
Literature, literary movements and influences represented in drama, lyric, and shorter prose forms.
- Ger 8220. Topics in 18th-Century German Literature. (4 cr per qtr [max 12 cr])
- Ger 8221, 8222. Romanticism. (4 cr per qtr)
- Ger 8230. Lyric Poetry. (4 cr per qtr [max 12 cr])  
Literary periods or movements, thematic and genre issues, historical and cultural contexts.
- Ger 8235, 8236. Eighteenth Century: From Aufklärung Through Sturm Und Drang. (4 cr per qtr)
- Ger 8241. Expressionism in German Literature. (4 cr)
- Ger 8261, 8262. German Literature Since World War II. (4 cr per qtr)
- Ger 8301. The 19th-Century Novel. (4 cr)
- Ger 8307. The German Novelle: From Goethe to Kafka. (4 cr)
- Ger 8311. The 20th-Century Novel. (4 cr)
- Ger 8324, 8325, 8326. German Drama From Naturalism to the Present. (4 cr per qtr)  
8324: From 1880 to 1910. 8325: From 1910 to 1930. 8326: From 1930 to present.
- Ger 8330. Topics in 19th-Century German Literature. (4 cr per qtr [max 12 cr])  
An issue or movement in 19th-century German literature, using a variety of critical approaches.
- Ger 8331. The 18th-Century Novel. (4 cr)  
Selected readings, theoretical writings on the novel; several contemporaneous non-German novels by English writers.
- Ger 8340. Topics in 20th-Century German Literature. (4 cr per qtr [max 12 cr])
- Ger 8351. Romantheorie. (4 cr)  
Analysis of 20th-century criticism of the genre *Roman*.
- Ger 8407. Goethe. (4 cr)
- Ger 8421. Heinrich Von Kleist. (4 cr)
- Ger 8431. Heine. (4 cr)
- Ger 8451. Friedrich Nietzsche. (4 cr per qtr)
- Ger 8801. Dissertation Seminar. (4 cr)  
For doctoral students beginning to establish topics and doing research for dissertations in German literature.
- Ger 8810. The German Woman as Writer. (4 cr per qtr [max 8 cr])  
German women writers from 18th to 20th century, using methods of feminist critical analysis.
- Ger 8820. Advanced Theoretical Seminar. (4 cr per qtr [max 12 cr]; prereq 8003 or #)  
Issues in contemporary critical thought.

### *Philology*

- Ger 8701. Philological Proseminar: Bibliography. (4 cr)
8713. Contemporary German. (4 cr; prereq 8712)  
Varieties and analysis in an historical framework.
- Ger 8740. Readings in Philology. (4 cr per qtr [max 12 cr])

Ger 8741, 8742, 8743. Gothic and Methods of Comparative Germanic Linguistics. (4 cr per qtr; prereq #)

Ger 8751-8752. Manuscript Readings and Text Reconstruction. (4 cr per qtr; 8751: prereq #; 8752: prereq 8751 or #)  
8751: Manuscript readings. 8752: Medieval text editing.

Ger 8761, 8762, 8763. Philological Seminar. (4 cr per qtr; prereq #)

### *Literature and Philology*

Ger 8990. Reading and Research. (Cr or [3-6 cr]; prereq #; may be taken on tutorial basis with #)

### Dutch (Dtch)

Dtch 5490. Topics in Dutch Literature. (4 cr per qtr [max 8 cr]; prereq reading knowledge of Dutch, jr or sr or grad student)

Topic on specific author, group of authors, genre, period, or subject matter. Topic listed in *Class Schedule*.

Dtch 5742. Middle Dutch. (4 cr)

Study of oldest recorded poetry and prose; linguistic and literary aspects; older Dutch dialects; relations between Middle Dutch and Middle High German.

Dtch 5743. Early Modern Dutch. (4 cr; prereq 5742 or #)

Study of 16th and 17th century Dutch poetry and prose; linguistic and literary aspects in context of Dutch "Golden Age." Development toward modern standard Dutch.

Dtch 5970. Directed Studies. (1-5 cr; prereq #, Δ, □)

## Germanic Philology

*Professor:* Evelyn S. Firchow (German, Scandinavian, and Dutch); Nils Hasselmo (German, Scandinavian, and Dutch); Calvin B. Kendall (English); Anatoly Liberman (German, Scandinavian, and Dutch); James A. Parente (German, Scandinavian, and Dutch); Robert Sonkowsky (Classical and Near Eastern Studies); David J. Wallace (English)

*Associate Professor:* Rita Copeland (English); Kaaren Grimstad (German, Scandinavian, and Dutch); Nita Krevans (Classical and Near Eastern Studies); Ray M. Wakefield (German, Scandinavian, and Dutch)

*Other:* Stephanie C. Van D'Elden (associate director, Independent Study), *director of graduate studies*

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) and Ph.D.

**Curriculum**—Emphases are medieval literature and the history and structure of the Germanic languages.

**Prerequisites for Admission**—None.

**Special Application Requirements**—Three letters of recommendation and a satisfactory score on the General (Aptitude) Test of the Graduate Record Examination (GRE) are required. Because Germanic philology is not listed in the GRE department codes, applicants should use the department code for Scandinavian when taking the test. GRE results should be forwarded to the Department of German, Scandinavian, and Dutch.

**Master's Degree Requirements**—Nine quarter courses are required. See the program publication for details. The final examinations consist of a three-hour written and a one-hour oral examination.

**Doctoral Degree Requirements**—A total of 25 to 30 quarter courses (including work completed for the M.A. degree) are recommended. A Ph.D. qualifying examination, which is substantially the same as the written M.A. examination in Germanic philology, is administered to students who have earned their M.A. degree at another institution. This examination must be taken within one year of entering the Ph.D. program. See the program publication for details.

**Language Requirements**—For the M.A. degree, students must demonstrate competence in English and Medieval Latin. For the Ph.D. degree, students must demonstrate competence in English, German, Medieval Latin, and two additional languages chosen in consultation with the adviser.

**Minor Requirements for Students Majoring in Other Fields**—For a master's degree minor, three philological courses are required. All courses must be selected with the help of a philology adviser from the committee. For a doctoral degree minor, three additional philological courses are required.

**For Further Information and Applications**—Contact the Germanic Philology Program, Center for Medieval Studies, University of Minnesota, 304 Walter Library, 117 Pleasant Street S.E., Minneapolis, MN 55455 (612/626-0805).

GPhI 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

GPhI 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

GPhI 8888. Thesis Credits: Doctoral. (36 cr required)

## Gerontology (Gero)

*Professor:* Nancy N. Eustis (public affairs), *director of graduate studies*; Dennis A. Ahlburg (industrial relations); David O. Born (health ecology; dentistry); Pauline G. Boss (family social science); James C. Cloyd (pharmacy practice); Daniel F. Detzner (family social science); Maurice W. Dysken (psychiatry); Judith M. Garrard (public health); Robert L. Kane (public health); Rosalie A. Kane (health services research and policy, public health); Joseph M. Keenan (family practice and community health); Frank M. Lassman (*emeritus*: otolaryngology; communication disorders; physical medicine and rehabilitation); Matthew K. McGue (psychology); Donald G. McTavish (sociology); Susan S. Meyers (rural sociology); Jeylan T. Mortimer (sociology); Jean K. Quam (social work); Muriel B. Ryden (nursing); Mariah Snyder (nursing); Michael Wade (kinesiology and leisure studies); Jonathan D. Wirschafter (ophthalmology); Shirley L. Zimmerman (family social science)

*Associate Professor:* Charles E. Boulton (family practice and community health); Margaret J. Bull (nursing); Sara S. DeHart (nursing); Richard P. DiFabio (physical medicine and rehabilitation); Corinne T. Ellingham (physical medicine and rehabilitation); Bernadine M. Feldman (nursing); Cynthia R. Gross (pharmacy practice); David R. Guay (pharmacy practice); Peter A. Hancock (kinesiology and leisure studies); Lois J. Heller<sup>1</sup> (physiology); Robert E. Kennedy (sociology); Helen Q. Kivnick (social work); March L. Krotee (kinesiology and leisure studies); Tom Alan Larson (pharmacy practice); Steven H. Miles (medicine); Mary E. O'Connell (pharmacy practice); Richard L. Reed (family practice and community health); Robert C. Serfass (kinesiology and leisure studies); Stephen K. Shuman (dentistry); Marlene S. Stum (family social science); Oliver J. Williams (social work); Robert E. Yahnke (General College)

*Assistant Professor:* Leslie A. Grant (public health); Kenneth W. Hepburn (family practice and community health); Merrie J. Kaas (nursing); Kathleen Krichbaum (nursing); James T. Pacala (family practice and community health); James R. Reinardy (social work); Carla E. S. Tabourne (kinesiology and leisure studies); La Dora V. Thompson (physical medicine and rehabilitation); Paul D. Thuras (psychiatry)

*Adjunct Assistant Professor:* Barton W. Galle, Jr. (continuing medical education)

*Clinical Assistant Professor:* Susan L. Cooper (pharmacy practice); Patrick W. Irvine (medicine)

*Senior Fellow:* Sharon K. Patten (public affairs)

*Other:* Christine A. Heine (nursing); Alice J. Stark (public health)

**Course of Study**—Minor in gerontology, applicable to master's (M.A. and M.S.) and doctoral programs.

**Curriculum**—The graduate minor program in gerontology provides a multidisciplinary foundation in gerontology and a concentration in one of the following four tracks within gerontology: clinical care; social and behavioral sciences; policy, administration, and ethics; and arts and humanities. The program of courses is developed in consultation between the student and the director of graduate studies of the Center on Aging.

**Prerequisites for Admission**—Admission to the gerontology graduate minor is contingent upon prior admission to a master's or doctoral degree-granting program within the Graduate School and preparation of a minor program of coursework approved by the director of graduate studies in gerontology. Informal discussion of potential programs can be arranged with the director of graduate studies at any time.

**Minor Requirements**—At the master's level, the minor program requires a minimum of 9 graduate-level quarter credits that include the Multidisciplinary Perspectives on Aging course (4 credits). In addition, students select at least 5 credits in designated courses within one of the four tracks.

The doctoral program requires a minimum of 18 graduate-level quarter credits. For a doctoral program, students select one of the four tracks in which to take 12 credits of designated fundamental courses and at least 6 credits of designated supplemental courses.

If mastery of the field of gerontology is desired, it is suggested that the student consider additional coursework beyond the required minimums for the master's or doctoral programs. Students also have the option of a related area in gerontology at the master's level or a supporting program in gerontology for the doctoral programs that are described further in this bulletin.

**Language Requirements**—None specific to the minor program. See requirements of the major department.

**Application Procedures**—Contact the director of graduate studies of the Center on Aging.

<sup>1</sup> University of Minnesota, Duluth

**For Further Information and Applications—** Contact the Graduate Minor Program in Gerontology, Center on Aging, University of Minnesota, Box 197 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (612/624-3904; fax 612/624-8448).

Courses sponsored directly by the minor program and the Center on Aging are identified below. In addition, designated courses are listed under each of the four tracks.

Gero 8100. Research in Gerontology. (3 cr; prereq #)

Current multidisciplinary theoretical and research literature on age-related issues. Topics specified in *Class Schedule*. Project that includes analysis and interpretation of age-related data.

AdEd 5440; CPsy 5305; Nurs 5780; PubH 5737; Soc 5960 (sec 1); SW 5024. Multidisciplinary Perspectives on Aging. (4 cr)  
Multidisciplinary introduction to aging and aging process. Biological, social, and psychological aspects of aging; theories of aging; physiology of aging; death and bereavement; issues and problems of older adults in America; human services and delivery systems such as social services, health, nutrition, long-term care, and education; public policy and legislation; advocates; retirement; lifelong learning; and humanities and aging.

FPCH 5653. Future Health Interventions for Older Populations. (2 cr; prereq hlth sci grad student or hlth sci grad degree)

Successful and promising interventions designed by managed care organizations, including outcome data.

SAPh 5007. Biology of Aging. (2 cr)

Biological theories of aging; organ systems; cardiovascular and renal systems; reproductive and endocrine systems; immunity, hearing, visual, and dental changes in older individuals; and issues of health and disease.

## Designated Courses

Clinical Care

FPCH 5650, 5651, 5652. Principles of Geriatrics  
FPCH 5653. Future Health Interventions for Older Populations

Nurs 5609. Special Educational Experiences in Nursing  
Nurs 5642. Behavioral Problems in Persons with Dementia  
Nurs 5943. Care of the Elderly II: Psychosocial Concepts  
Nurs 8020. Evaluating Quality of Healthcare in Communities

PMed 5817w. Special Topics in Physical Therapy:  
The Biology of Aging

SAPh 5870. Geriatric Assessment

Social and Behavioral Sciences

DHA 5481. Designed Environments for Aging  
FSoS 5251. Aging Families  
FSoS 5252. Aging, Family, and Society  
Psy 5138. Psychology of Aging

Rec 5240. Recreation and Aging

Soc 5956. Sociology of Death

SW 5212. Social Work With Older Adults

WoSt 5201. The Older Women: A Feminist Perspective

Policy, Administration, and Ethics

ApEc 8270. Applied Welfare Economics and Public Policy

FPCH 5653. Future Health Interventions for Older Populations

Nurs 5609. Special Educational Experiences in Nursing

Nurs 5660. Basic Management in Long-Term Care Facilities

PA 5413. Seminar: Aging and Disability Policy

PA 5415. Economic and Demographic Aspects of Aging

PubH 5749. Long-Term Care Administration

PubH 5750. Long-Term Care Industry

PubH 8803. Long-Term Care: Principles and Policies

Arts and Humanities

Engl 5910. Topics in English and North American Literature

FSoS 5251. Aging Families

FSoS 5252. Aging, Family, and Society

FSoS 5253. Humanities, Aging, and Family Living

Nurs 5609. Special Educational Experiences in Nursing

Soc 5956. Sociology of Death

SW 5211. Advanced Theories of Human Growth and Change

WoSt 5201. The Older Woman: A Feminist Perspective

## Greek

See Classical and Near Eastern Studies.

## Health Informatics (HInf)

*Professor:* Laël C. Gatewood, *director, health computer sciences;* Stanley M. Finkelstein, *director of graduate studies;* Donald P. Connelly; Sheila A. Corcoran-Perry; David P. Fan; Ilene B. Harris; Paul E. Johnson; George G. Klee; Donald G. McQuarrie; Robert P. Patterson; Stuart M. Speedie; George L. Wilcox

*Associate Professor:* Christopher G. Chute; Lynda B. Ellis; Stephen C. Strother

*Assistant Professor:* Steven D. Hillson; Sandra J. Potthoff

*Research Associate:* Denton R. Peterson; Ernest F. Retzel; Bruce H. Sielaff

*Other:* David A. Garloff; Brian J. Westrich

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered—**M.S (Plan A and Plan B) and Ph.D.

**Curriculum—**The graduate programs in health informatics train students to apply the methodologies and use of computers, statistics,

and information sciences to information management for the health sciences. These programs offer instruction in health services computing, clinical decision making, health systems analysis, simulation, and consulting. Training is provided for health professionals seeking a master's degree to validate competencies in information management, for information technologists obtaining a master's degree to emphasize health applications, and for graduate students undertaking doctoral studies to develop new methodologies and to evaluate applications of clinical information systems. Further information on current research areas is available from the director of graduate studies.

**Prerequisites for Admission**—A baccalaureate degree in one of the social, biological, mathematical, or physical sciences is required. Before admission to the program, a student must complete at least two courses in the biological or life sciences, one year of calculus, linear algebra, and experience or coursework in at least one higher-level computer programming language. At least one course in biology or life science, the calculus, and the programming prerequisite are required before applying for admission to the program. A course in differential equations is required for doctoral studies.

**Special Application Requirements**—The Graduate Record Examination or similar professional examination (e.g., MCAT) is required. Three letters of recommendation and a statement of purpose must be submitted with the application. Fall quarter entry is recommended.

**Master's Degree Requirements**—Both plans require seven core courses in health informatics (24 credits), a sequence in statistics or biostatistics (10-12 credits), and registration in the Health Informatics Seminar (3 credits) for the first year of study. For most students, the program takes two academic years. It is concluded with an oral examination. For the Plan B master's degree, an additional 20 credits is required. Of these, 10 credits come from a technical area and 10 credits from the health sciences. The research-oriented Plan A master's degree is available to advanced applicants, such

as those with a doctoral or professional degree in a health sciences discipline. In addition to the required courses, the Plan A requires 8 credits in related fields. Programs are planned with the aid of a faculty adviser. A student handbook containing sample programs and other information is available upon request from the director of graduate studies.

**Doctoral Degree Requirements**—For the Ph.D. degree, students should fulfill the master's basic requirements (37 credits). Also, 18 additional credits in health informatics and a minimum of 18 credits in a minor or supporting program are required. At least 24 of the total credits must be in 8xxx courses in the area of concentration. Preliminary written and oral examinations are required for admission to candidacy. A final oral examination is required upon completion of the dissertation.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—Programs are arranged on an individual basis upon consultation with the director of graduate studies, who also approves the final program. Programs consist of 9 or more quarter credits in health informatics for the master's program (Plan A or B) and 18 or more quarter credits for the doctoral program.

**For Further Information and Applications**—Contact the Director of Graduate Studies in Health Informatics, Division of Health Computer Sciences, University of Minnesota, Box 511 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (mailing address) (612/625-8440; fax 612/625-7166; e-mail doreen@umnhcs.labmed.umn.edu).

HIInf 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

HIInf 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

HIInf 8888. Thesis Credits: Doctoral. (36 cr required)

HIInf 5430. Health Informatics I: Concepts and Elements. (4 cr; prereq elem algebra, programming, stats or #) Gatewood History and challenges of health informatics; computerized patient records; clinical information systems; basics of information, computation, and communication; data management in health settings.

Hlnf 5431. Health Informatics II: Methods and Systems. (4 cr; prereq 5430, elem algebra, programming, stats or #) Finkelstein  
Clinical decision analysis and support systems; clinical monitoring; signal processing; image analysis; modeling and simulation; computational biology; informatics support for basic research.

Hlnf 5432. Health Informatics III: Organizational Context. (4 cr; prereq 5430, 5431, elem algebra, programming, stats or #) Gatewood  
Structures of healthcare delivery systems; clinical information exchange; databases supporting clinical and research efforts; evaluation methodologies; managing information technology as strategic resource for healthcare organizations.

Hlnf 5433. Computer Methodology in the Delivery of Healthcare I: Physiological Monitoring and Testing. (3 cr; prereq 5432 or #) Finkelstein  
Role of computer in monitoring and testing patients; hardware and software requirements for processing clinically significant signals; comparison and evaluation of currently available systems.

Hlnf 5434. Computer Methodology in the Delivery of Healthcare II: Introduction to Medical Decision-Making Techniques. (3 cr; prereq 5432 or PubH 5452 or #) Connelly, Speedie  
Introduction to biometrical concepts and techniques used to support medical decision-making process, including test efficacy measures, decision analysis, Bayes' Theorem, expert systems, decision support systems, and multivariate analysis.

Hlnf 5435. Computer Methodology in the Delivery of Healthcare III: Systems Analysis and Operations Research Methods for Health Services. (3 cr, \$PubH 5760; prereq PubH 5404 or #) Potthoff  
Models for queuing, inventory, networks, linear programming, and scheduling.

Hlnf 5436. Seminar: Health Informatics. (1-3 cr) Ellis  
Presentation and discussion of research problems and current literature.

Hlnf 5446. Professional Studies in Health Informatics. (1 cr per qtr [3 qtr sequence required]; prereq Hlnf major, 5432, PubH 5454 or #) Gatewood  
Health informatics as a profession, including discipline, responsibilities, resources, and job opportunities. Directed experiences in consulting, teaching, writing, conducting research, and managing facilities.

Hlnf 5470. Topics in Health Informatics. (Cr ar; prereq #)  
Selected readings and/or projects.

Hlnf 8405, 8406, 8407. Advanced Topics in Health Informatics I, II, III. (3 cr per qtr; prereq 5432, 5435, PubH 5452 or #; offered alt yrs) Finkelstein  
Computer systems design for health sciences, small computer concepts and use, computers for clinical services, computer-aided medical decision making, biomedical image processing, and pattern recognition. All topics use techniques and incorporate actual examples or case studies from the health sciences.

Hlnf 8415. Mathematical Modeling in the Health Sciences I: Deterministic Models. (3 cr; prereq Math 3221, programming or #; offered alt yrs) Altmann  
Mathematical and computer development of deterministic models for processes in epidemiology, demography, healthcare, and biochemistry. Matrix and differential equation formulations. Analysis and biological interpretation of long-term behavior, stability, and equilibrium. Computer modeling packages.

Hlnf 8416. Mathematical Modeling in the Health Sciences II: Stochastic Models. (3 cr; prereq 8415, Math 3221, PubH 5450 or #; offered alt yrs) Altmann  
Development and analysis of stochastic models for biomedical sciences. Sources of randomness and error. Semi-Markov chains for state transitions. Probability distributions, transition times, equilibria. Spatial models of disease spread and neuronal activity. Deterministic versus stochastic models.

Hlnf 8417. Mathematical Modeling in the Health Sciences III: Stochastic Simulation. (3 cr; prereq 8416, Math 3221, PubH 5450, PubH 5452, programming or #; offered alt yrs) Altmann  
Construction and use of software for simulation of stochastic models in health sciences. Discrete event scheduling. Methods of random variate generation and variance reduction. Design and analysis of simulation experiments. Sensitivity analysis and response surfaces.

Hlnf 8449. Advanced Readings in Health Informatics. (1-3 cr; prereq 5432, PubH 5434, #)  
Discussion of methodology and results.

Hlnf 8450. Research in Health Informatics. (Cr ar; prereq #)

## Health Services Research and Policy (PubH)

*Professor:* Bryan E. Dowd, *director of graduate studies;* Jon B. Christianson; Roger D. Feldman; Judith M. Garrard; Robert L. Kane; Rosalie Ann Kane; John E. Kralewski; Theodor J. Litman; Nicole Lurie; Willard G. Manning; Ira S. Moscovice

*Associate Professor:* Thomas Choi; John A. Nyman

*Assistant Professor:* Kathleen Call

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—M.S. (Plan A and Plan B).

**Curriculum**—The objective of the program is to train health services researchers and health policy analysts to carry out studies using appropriate theoretical and empirical techniques, formulate health policy options, work effectively in the political arena to shape policies, and evaluate policy initiatives once implemented. The degree can serve as a terminal degree or as the first step toward the Ph.D. in health services research, policy and administration. Two options are available. Plan A is primarily for students with a professional degree in medicine, dentistry, nursing, or pharmacy. Plan B is for students without a health professional background. Students electing Plan B substitute additional coursework and special projects, including a summer internship in a public or private health services agency/organization, for the thesis. Both options are two-year programs.

In the first year of the program, students receive an overview of the health services research field and are introduced to the social and health sciences paradigms employed most frequently in health services research: economics, sociology, and epidemiology. Students also complete coursework in theoretical statistics and regression analysis. The second year focuses on research design and advanced analytic techniques in coursework on research methods, surveys and sampling, measurement, and evaluation research. In the health policy sequence, analytic methods are applied to current problems. Students may choose electives from other divisions within the School of Public Health or from other departments within the University.

**Prerequisites for Admission**—Applicants who have not completed coursework in calculus, statistics, and microeconomics, but are otherwise qualified for admission, will be required to take relevant summer session courses either at the University or at another accredited institution before beginning the program.

**Special Application Requirements**—Above average performance in the Graduate Record Examination is required for admission. A statement of purpose and three letters of reference are also required. Students are admitted in fall quarter only. The program is full time.

**Master's Degree Requirements**—Plan A students are required to take a minimum of 48 course credits (as well as 16 thesis credits). Plan B students are required to take a minimum of 55 credits.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—A minimum of 18 credits is required for the minor.

**For Further Information and Applications**—Contact the Student Services Center, School of Public Health, University of Minnesota, Box 819 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (612/626-3500 or 1/800/774-8636; fax 612/626-6931; e-mail sph-uofm@greg2.sph.umn.edu; <http://www.sph.umn.edu>).

PubH 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

*Note*—Courses in health services research and policy are listed and described under Public Health in this bulletin. See PubH 5330, 5790, 5852, 5862, 5863, 5868, 5870, 5893, 5894, 8801, 8810-8811-8812, 8813, 8830, 8831, and 8832. See also Stat 5121, 5122, and 5302 under Statistics.

## Health Services Research, Policy and Administration (PubH)

*Professor:* Willard G. Manning, *director of graduate studies*; Mario F. Bognanno; Jon B. Christianson; Bright M. Dornblaser; Bryan E. Dowd; Roger Feldman; Judith M. Garrard; Robert L. Kane; Rosalie A. Kane; John Kralewski; Theodor J. Litman; Nicole Lurie; A. Marshall McBean; Ira Moscovice; Vernon E. Weckwerth

*Associate Professor:* Thomas Choi; Michael D. Finch; George O. Johnson; John A. Nyman; Michael D. Resnick

*Adjunct Associate Professor:* N. Tor Dahl; Richard J. Oszustowicz

*Assistant Professor:* Kathleen T. Call; Robert A. Connor; Leslie A. Grant; Sandra J. Pothoff

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—Ph.D.

**Curriculum**—The doctoral studies program offers advanced graduate education for students seeking teaching and research positions related

to health services in academic institutions, government, or the private sector. Students acquire an understanding of the influence of economic, social, and political forces on health and healthcare, including the cost of healthcare, with emphasis on the factors affecting the public and private financing of health services; the problems of access to health services among different population subgroups and the attendant issues of equity and social justice in the allocation of healthcare resources; the nature and evolution of government involvement in healthcare and its consequences; and the legislative process and role of interest groups in the formulation of health policy.

**Prerequisites for Admission**—Applicants who have not completed coursework in calculus, statistics, and microeconomics, but are otherwise qualified for admission, will be required to take relevant summer session courses either at the University or at another accredited institution before beginning the program.

**Special Application Requirements**—Above average performance on the Graduate Record Examination is required for admission. A statement indicating reasons for seeking the Ph.D., plus three letters of reference attesting to the applicant's academic ability and potential for a career in teaching and research, are required. Students are admitted in fall quarter only. The program is full time.

**Doctoral Degree Requirements**—The minimum credit requirement for the Ph.D. is 54 course credits in the major, 18 credits for a supporting program or minor, and 36 thesis credits.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—A minimum of 18 credits is required for the minor.

**For Further Information and Applications**—Contact the Student Services Center, School of Public Health, University of Minnesota, Box 819 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (612/626-3500 or 1/800/774-8636; fax 612/626-6931; e-mail sph-uofm@greg2.sph.umn.edu; http://www.sph.umn.edu).

PubH 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

PubH 8888. Thesis Credits: Doctoral. (36 cr required)

*Note*—Courses in health services research, policy and administration are listed and described under Public Health in this bulletin. See PubH 5868, 5893, 8750 to 8796, and 8801-8833.

## Hispanic and Luso-Brazilian Literatures and Linguistics

*Professor:* Rene Jara; Louise Mirrer; Antonio Ramos-Gascón; Nicholas Spadaccini; Hernan Vidal; Anthony N. Zahareas

*Associate Professor:* Amy K. Kaminsky; Carol A. Klee; Francisco A. Ocampo; Joanna O'Connell; Constance A. Sullivan

*Assistant Professor:* Fernando E. Arenas

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B): Hispanic Literature, Luso-Brazilian Literature, Hispanic Linguistics; Ph.D.: Hispanic and Luso-Brazilian Literatures and Linguistics.

**Curriculum**—Emphases available for the Ph.D. are Spanish literature, Spanish-American literature, Lusophone literatures, and Hispanic linguistics.

**Prerequisites for Admission**—Prospective students generally have completed an undergraduate degree or substantial coursework in the field, although individuals with other backgrounds may be admitted. The Graduate Studies Committee may require completion of background coursework, without graduate degree credit, for admitted students with insufficient preparation.

**Special Application Requirements**—Three letters of recommendation from previously attended institutions evaluating the applicant's scholarship, a sample of a writing project, and a complete set of transcripts in addition to that required by the Graduate School should be sent to the director of graduate studies. The Graduate Record Examination is strongly recommended, and is required for fellowship candidates. The deadline for application for admission and financial aid is January 15 for fall quarter entry.

**Master's Degree Requirements**—The minimum coursework requirement for Plans A and B is 44 credits. For more specific information about program requirements, consult the department's *Graduate Handbook*.

Both written and oral final examinations are required for all M.A. degrees.

**Doctoral Degree Requirements**—A minimum of 17 courses in the major beyond the bachelor's degree is required. Students who hold an M.A. degree or who wish to bypass the M.A. program must pass a Ph.D. qualifying examination by the second quarter after beginning work toward the doctorate. For further information consult the department's *Graduate Handbook*.

**Language Requirements**—For the doctoral degree, students must have proficiency in the minor language (i.e., Portuguese for those emphasizing one of the Hispanic components, Spanish for those emphasizing the Luso-Brazilian component). Proficiency is usually demonstrated by use of the minor language in written and oral forms (see the department's *Graduate Handbook*).

**For Further Information and Applications**—Contact the Department of Spanish and Portuguese, University of Minnesota, 34 Folwell Hall, 9 Pleasant Street S.E., Minneapolis, MN 55455 (612/625-5858; fax 612/625-3549). Students are issued the department's *Graduate Handbook* on admission.

Port 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Span 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Span 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Span 8888. Thesis Credits: Doctoral. (36 cr required)

## Portuguese (Port)

Port 5523. Nationalism in Brazilian Literature. (4 cr; prereq three 3xxx Portuguese courses or  $\Delta$ )  
Major literary works—poetry, novel, essay, or drama—and literary trends from Colonial period and/or 19th century as expressions of nativist/nationalistic project in Brazil.

Port 5524. Brazilian Literature and Modernization. (4 cr; prereq three 3xxx Portuguese courses or  $\Delta$ )  
Major literary works—poetry, novel, essay, memoirs, or drama—and literary trends from 20th century as expressions of modernization process of Brazilian society.

Port 5910. Topics in Luso-Brazilian Cultures. (4 cr; prereq Span 3104 or SpPt 3104 or  $\Delta$ )  
Important cultural manifestations in Portuguese-speaking world: e.g., literature, music, film, oral traditions, TV. Topics specified in *Class Schedule*.

Port 5920. Figures in Luso-Brazilian Literature. (4 cr; prereq Span 3104 or SpPt 3104 or  $\Delta$ )  
One Portuguese, Brazilian, or other major Lusophone writer or group of writers whose work has had impact on thought, literature, or social problems. Figures specified in *Class Schedule*.

Port 5970. Directed Readings. (1-5 cr per qtr [max 15 cr]; prereq # and  $\Delta$ , CLA approval)  
Luso-Brazilian studies, especially in areas not previously covered. Students must submit reading plans for particular topics, figures, periods, or issues. For M.A. and Ph.D. candidates.

Port 5990. Directed Research. (1-5 cr; prereq #,  $\Delta$ , CLA approval)

Port 8101. Literary Criticism and Research Methods. (4 cr)

Port 8920. Seminar: Luso-Brazilian Literature. (4 cr)  
Advanced level study of problems in Luso-Brazilian language, literature, and cultural history. Topics specified in *Class Schedule*.

## Spanish (Span)

*Linguistics, Philology, History of the Language, and Research Methods*

Span 5015. Methods of Translation. (4 cr; prereq 10 cr from 3001-3005 series or #)  
Meaning, use, and theories of translation. Techniques and problems of translation from Spanish and Portuguese to English and vice versa. Translation patterns, use of special vocabularies, and other adjuncts needed to understand both languages. Practical vocabulary and usage for various fields of work.

Span 5701, 5702. History of Ibero-Romance. (4 cr per qtr; prereq 3701 or 3702 or #)  
Comparative study of origins and development of Ibero-Romance languages; evolution of Catalan, Portuguese, and Spanish compared and contrasted. Methods in reading and analysis of non-literary and literary medieval texts.

Span 5711. The Structure of Modern Spanish: Phonology. (4 cr; prereq 3701, Ling 5302 or #)  
Formulation and evaluation of phonological descriptions of Spanish. Approaches to problems in Spanish phonology within metrical, autosegmental, and lexical phonological theories. Useful for students who plan to teach Spanish and for those whose primary language is Spanish.

Span 5713. The Structure of Modern Spanish: Syntax. (4 cr; prereq 3702, Ling 5302 or #) Introduction to linguistic types that appear across languages, such as grammatical relations, word order, transitivity, causative constructions, relative clauses, and how these are present in syntax of Spanish. Useful for students who plan to teach Spanish and for those whose primary language is Spanish.

Span 5714. The Structure of Modern Spanish: Semantics. (4 cr; prereq 5713 or #) Relationship between syntax and semantics. Application of structural semantics to the Spanish language, including concepts of semantic and lexical fields. Examines cultural patterns in Hispanic world as reflected in semantic structures. Theories of meaning; euphemisms; taboos; semantics and social class. Semantic approaches to literary analysis.

Span 5715. The Structure of Modern Spanish: Pragmatics. (4 cr; prereq 5713 or #) Introduction to concepts used in current literature in Spanish pragmatics.

Span 5732. Spanish Dialectology: Regional and Social Dialects of Modern Spanish America. (4 cr; prereq #) Major dialect areas in modern Hispanic America. Form, speech, and language as they relate to the old political and religious divisions of Hispanic America and to the new national boundaries.

Span 5985. The Study of Spanish in the United States: Theory and Field Methods. (4 cr; prereq 3701) Sociolinguistic theory and field methods related to study of Spanish in United States; field experience in Hispanic community of St. Paul.

Span 5991. The Acquisition of Spanish as a First and Second Language. (4 cr; prereq 3702 or #) Examination of studies on acquisition of Spanish as a first and second language; second language acquisition in both formal and informal environments.

Span 8730. Seminar in Spanish and Portuguese Syntax. (4 cr; prereq 5713 or #) Research and critical examination of readings in specific topic of Hispanic syntax.

Span 8750. Seminar in Spanish and Portuguese Pragmatics. (4 cr; prereq 5715 or #) Research and critical examination of readings in specific topic of Hispanic pragmatics.

Span 8780. Seminar in Hispanic Sociolinguistics. (4 cr; prereq 5985 or #) Current topics.

### *Peninsular Literature*

Span 5106. The Literature of the Reconquest and Feudal Spain. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese) Major literary works and genres of medieval Spain—from the primitive lyric to *La Celestina*—examined against background of social and historical transformations of Spanish Middle Ages.

Span 5107. The Literature of the Spanish Empire and Its Decline. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese) Major Renaissance and baroque works of 16th and 17th centuries—poetry, nonfiction prose, novel, drama—examined against background of establishment of Spanish Empire, internal economic crisis, and ideological apparatus developed by the modern state.

Span 5108. The Spain of Cervantes' *Don Quixote*: History and Fiction. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese) Historical function of literary techniques, narrative perspectives, and ironic discourse of Cervantes' major work during the period of imperial decadence. Tradition of Erasmusian folly, madness as anachronism and social satire.

Span 5109. The Literature of Bourgeois Order: Enlightenment, Romanticism, and Positivism. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese) Major literary works—poetry, essay, novel, and drama—and literary movements of 18th and 19th centuries examined as aesthetic expressions of the long process of consolidation of the bourgeois social order in Spain.

Span 5111. The Literature of the Spanish Crisis of the 20th Century. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese) Major literary works and aesthetic trends of contemporary Spain examined within context of the social, political, and intellectual crisis, from the Spanish-American War of 1898 to the post-Franco period.

Span 5221. Spanish Literature of the 17th Century: The Drama. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese or Δ) Representative playwrights: Lope, Alarcón, Tirso, Calderón. Dramatic forms, especially comedia, tragedy, and auto sacramental. Approaches to golden age comedia. Themes of honor, purity of blood, country vs. city, free will, others, viewed against background of literary, cultural, and social history.

Span 5234. Feminism and Literature in Spain. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese or Δ) Spanish feminism in thought and practice; literature, cultural discourse, and literary theory.

Span 5272. Hispanic Modernism. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese or Δ) Critical review of artistic and literary production in Hispanic cultures from middle of 19th century to avant-garde. Modernity and modernization in Hispanic world. Spanish generation of 1898. Castilian, Catalan, and Latin-American practices along interdisciplinary and comparative lines.

## GRADUATE PROGRAMS

Span 8100. Research in Sociohistorical Approaches to Spanish Literature. (4 cr)  
Sociohistorical functions of Spanish literary texts and major theories concerning literary production.

Span 8200. Spanish Literary Texts: Theories of Formal Structures. (4 cr)  
Research in approaches to and methods of literary analysis of the discourse.

Span 8202. Orality and Literacy in Medieval Spain. (4 cr; offered when feasible)

Span 8252. Spanish Literature: 19th Century. (4 cr; offered when feasible)

Span 8271. Spanish Theatre in the 20th Century. (4 cr; offered when feasible)

Span 8300. The Construction of Spanish Literary History. (4 cr)

Critical purview of how canon of Spanish literary history has been established during last 100 years. Sociocultural and sociopolitical theories that underlie constitution of literary history as an academic and historiographic discipline. Literature from Spain or literature in Spanish. Hegemonic literature as national literature in Spain.

Span 8533. The Baroque in European Literature: Spain. (4 cr)

Third quarter of interdepartmental sequence of literature in translation. The baroque movement in Spain. Characteristics in common with the baroque movement in Italy, France, and Germany.

### *Spanish-American Literature*

Span 5525. Caribbean Literature: An Integral Approach. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese or Δ)

Review of the literature of the Caribbean area; common generic traits and preoccupations. Conceptualization of the region as a totality; themes, similar lines of development, generic tendencies, periods of development and crisis.

Span 5526. Creole Consciousness and Mercantilist Culture. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese or Δ)  
Texts written between 1492 and 1780, sociohistorical context. Generic variants and the approach to changing reality in which they are inscribed.

Span 5527. National Literary Consciousness and Free Trade. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese or Δ)  
Literary movements as part of the process of formation of nation-states: the incorporation of Latin America in the international capitalist system as producer of foodstuffs and raw materials and importer of manufactured goods (1780-1900).

Span 5528. Popular Literary Consciousness, 1900-1950. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese or Δ)

Spanish-American literature between the eve and aftermath of the two world wars. Impact of modernization, industrialization, and nationalistic and populist thought on emergence of distinctive writing, thematic trends, and literary genre conventions.

Span 5529. National Affirmation and Transnationalization. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese or Δ)  
Literary trends of the period (1950 to present) as a reaction to internal social demands for development of independent national cultures and conflicting influence of international economic system.

Span 5531. Hispanic Literatures of the United States. (4 cr; prereq three 3xxx or 5xxx Spanish or Portuguese lit courses or Δ; offered when feasible)

Span 5532. Literature and National Disintegration. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese or Δ)  
Literary reaction to contemporary structural changes in world economic system (1970 to present). Effects on literature as institution. Texts related to revolutionary trends and social movements (feminism, Theology of Liberation, defense of human rights).

Span 5533. Latin-American Cultural Discourse. (4 cr; prereq three 3xxx or 5xxx lit courses in Spanish or Portuguese or Δ)  
Contemporary discourses that attempt global explanations of development of Latin-American culture and civilization: liberal diffusionism, Dependency Theory, geopolitics, Doctrine of National Security, Theology of Liberation, human rights movement.

Span 8940. Advanced Research in Spanish-American Literary Historiography. (4 cr)  
Sources and procedures that have given rise to institutionalizations of Spanish-American literary history. Evaluation and review of epistemological principles and assumptions in theory of literary criticism and histories of literature.

Span 8960. Advanced Research in Social Approaches to Spanish-American Literary Texts. (4 cr)  
Function of Spanish-American literature in society according to various theories of social structures: Marxist, Weberian, Frankfurt School, Dependency Theory, Simmelian sociology.

Span 8980. Advanced Research in Semiotic/Structural Analysis of Spanish-American Literary Texts. (4 cr)  
Challenging Spanish-American literary texts as semiotic processes, both to illuminate their structural machinery of meaning and to open their semiotic projection to the symbolic activity pervading Spanish-American cultural and social environment.

Span 8990. Advanced Comparative Research of Caribbean Genres. (4 cr)  
Major literary works and genres of Caribbean literature studied against the background of the sociohistorical vicissitudes of the process leading to the formation and consolidation of the national states.

### *Topics, Seminars, and Directed Study*

Span 5800. Spanish Culture and Society in 20th-Century Spain. (4.5 cr)  
Major sociocultural changes in Spanish society from humanities and social sciences perspectives; emphasizes current situation and developments leading into 21st century. Literature, history, politics, geography and regional diversity, art, music, and cinema.

Span 5910. Topics in Spanish Peninsular Literature. (4 cr; prereq Span 3104 or Δ)  
Major issues or approaches of Spanish literature examined through important groups, movements, trends, methods, genres. Topics may include: conversos; “mysticism”; poesia tradicional; “essay” and Enlightenment; novela realista; avant-garde. Topics specified in *Class Schedule*.

Span 5920. Topics in Spanish-American Literature. (4 cr; prereq Span 3104 or SpPt 3104 or Δ)  
Spanish-American literature examined through important groups, movements, trends, methods, genres. Topics specified in *Class Schedule*.

Span 5930. Topics in Ibero-Romance Linguistics. (4 cr per qtr [max 12 cr]; prereq 10 cr from Span 3001-3005 series or #)  
Topics specified in *Class Schedule*. For list of sample topics, consult the department. Problems in Hispanic linguistics, including aspects of Luso-Brazilian language. A variety of linguistic approaches and methods.

Span 5950. Figures in Spanish-American Literature. (4 cr; prereq Span 3104 or Δ)  
One Spanish-American writer or group of writers whose work has had impact on thought, literature, or social problems.

Span 5970. Directed Readings. (1-5 cr per qtr [max 15 cr]; prereq #, Δ, CLA approval)  
To fill gaps in students' preparation, especially when certain courses have not been offered. Students must submit reading plans for particular topics, figures, periods, or issues. Readings in Spanish and/or Spanish-American areas. For master's and Ph.D. candidates.

Span 5990. Directed Research. (1-5 cr ar; prereq #, Δ, CLA approval)

Span 8900.\* Spanish Seminar. (4 cr)  
Special projects relying heavily on advanced research in Spanish problems. Limited to small group of students. Investigation of assigned fields, analysis of problems, appraisal of principles. For list of sample seminars, consult the department.

Span 8920. Seminar: Migration, Transnationalization, and Hispanic Literature. (4 cr)

Development of growing corpus of literature that, while Hispanic in character, has no specific Hispanic national or regional origins but instead issues out of cultural context created by displaced Spanish American populations, particularly in the United States.

Span 8950.\* Seminar: Spanish-American Literature. (4 cr)

Special projects of advanced research in Latin-American problems. Investigation of assigned areas, analysis of problems, appraisal of principles. Limited to small group of students. For list of sample topics, consult the department.

Span 8970. Directed Readings in Romance Languages. (Cr ar; prereq Δ)

Studies in authors and topics not offered in other courses. Weekly meetings based on student's research and analysis. Students and instructor agree on plan of reading or particular topics, figures, issues, etc. Readings in Spanish or Spanish-American areas. Primarily for Ph.D. candidates.

### Spanish-Portuguese (SpPt)

SpPt 5930. Selected Topics in the Hispanic Cultural Discourses. (4 cr; prereq reading knowledge of Spanish and Portuguese)  
Cultural discourses of Portuguese-speaking and Spanish-speaking worlds. Common background and differences among Iberian and/or Latin American intellectual production. Taught in Portuguese.

SpPt 5999. The Teaching of College-Level Spanish and Portuguese: Theory and Practice. (4 cr)  
For new teaching assistants in Department of Spanish and Portuguese.

SpPt 8911. Seminar: Feminist Perspectives on Hispanic and Luso-Brazilian Cultural Discourses. (4 cr)  
Feminist theoretical issues and critical practice, application to Hispanic and Luso-Brazilian literary and cultural discourse; relationship of feminist criticism to other theoretical models and methodologies.

SpPt 8920. Cross-Cultural Issues in Hispanic and Luso-Brazilian Literatures. (4 cr; prereq #)  
Comparative study of literary production in historical periods when economic, social, political, and ideological bonds among Hispanic and Lusophone countries are intensified.

### History (Hist)

*Professor:* Kinley J. Brauer, *chair*; Josef L. Altholz; Bernard S. Bachrach; Paul W. Bamford (*emeritus*); Hyman Berman; Clarke A. Chambers (*emeritus*); John K. Evans; Sara M. Evans; Caesar E. Farah (Afro-American and African studies); Edward L. Farmer; David F. Good; Barbara A. Hanawalt; John R. Howe; Allen F. Isaacman;

Thomas Kelly; Sally G. Kohlstedt (history of science and technology); David Kopf; Edwin T. Layton (history of science and technology); Stanford E. Lehmborg; Byron K. Marshall; Elaine Tyler May (American studies); Mary Jo Maynes; Robert E. McCaa; Russell R. Menard; Michael F. Metcalf; John K. Munholland; Paul L. Murphy; David W. Noble; Thomas S. Noonan; Carla R. Phillips; William D. Phillips, Jr.; Kathryn L. Reyerson; David Roediger; Richard L. Rudolph; Joel B. Samaha; Stuart B. Schwartz; Theofanis G. Stavrou; Romeyn Taylor (*emeritus*); John A. Thayer; James D. Tracy; Carol L. Urness (James Ford Bell Library); Rudolph J. Vecoli; William E. Wright (*emeritus*)

*Associate Professor:* George D. Green, *director of graduate studies*; Jean M. Allman; John M. Eyler (history of medicine); Susan N. G. Geiger (women's studies); Andrea Hinding (Humanities/Social Sciences Libraries); David O. Kieft; Lary L. May (American studies); Gianna Pomata; Steven Ruggles; Allan H. Spear; Dennis Valdes; Ann B. Waltner

*Assistant Professor:* Victoria Coifman (Afro-American studies); Lisa A. Norling; Jean M. O'Brien-Kehoe

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) and Ph.D.

**Curriculum**—Areas of concentration include Africa; Asia; England; Ancient, Medieval, Early Modern, and Modern Europe; Early Modern World; Latin America; and the United States and its colonial background. Scholarly resources include the Center for Austrian Studies, the Center for Advanced Feminist Studies, the Center for Medieval Studies, the Immigration History Research Center, Modern Greek Studies, the Center for Early Modern History, and the Social Welfare History Archives.

**Prerequisites for Admission**—Applicants for the master's degree normally should have completed general undergraduate survey courses in two or three broad areas of history, two years of advanced undergraduate work in two areas of history, and training in a foreign language. Some prerequisites may be made up after admission. In some circumstances, students without undergraduate history majors may be admitted to the M.A. program. Applicants for the Ph.D. program normally should have completed a master's degree, but highly qualified applicants may apply directly for admission to the Ph.D. program without having completed an M.A. degree.

**Special Application Requirements**—The following are required by the department: a statement of background and purpose, three letters of recommendation, a statement of specific areas and subfields of interest, and scores from the General (Aptitude) Test of the Graduate Record Examination or the Miller Analogies Test. Deadline for financial aid applications is the last week in December. Forms and instructions should be requested from the department.

**Master's Degree Requirements**—Plan A requires a thesis, plus a minimum of nine courses in history (including thesis credits for the equivalent of four of these) and two courses in other fields. Plan B requires a minimum of seven courses in history, two in outside fields, and two more in either history or outside fields. For detailed requirements see the department publication *Graduate Study in History*. A final oral examination is required for all master's programs.

**Doctoral Degree Requirements**—Students must complete advanced research seminars and prepare for preliminary examinations in areas of concentration. Students are expected to complete twelve courses in history and five in outside fields. Detailed requirements are outlined in the department publication *Graduate Study in History*.

**Language Requirements**—A reading knowledge of one foreign language is required before admission to the master's examination, and of two foreign languages before admission to the preliminary examinations for the Ph.D. degree. Some areas of concentration may require additional foreign languages. In some cases, competence in quantitative methods may replace one of the foreign languages. See *Graduate Study in History* for details.

**Minor Requirements for Students Majoring in Other Fields**—For the master's degree, Plan A (a Plan B minor is not available), a minimum of three related courses in history are required. For the Ph.D. degree, at least six courses in history, including proseminar or seminar work, and a written and oral examination, are required.

**For Further Information and Applications—**  
Contact the Department of History, University of Minnesota, 633 Social Sciences Building, 267 19th Avenue South, Minneapolis, MN 55455 (612/624-2800).

Hist 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Hist 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Hist 8888. Thesis Credits: Doctoral. (36 cr required)

## Methodology and Comparative History

Hist 5011, 5012. Quantitative Methods in Historical Research. (4 cr per qtr; prereq #) McCaa, Menard, Ruggles

Introduction to quantitative approaches to analysis of historical problems. Data collection, questions of measurement, analytical techniques, and rudimentary statistics as they apply to historical research.

Relationship of quantitative inferences to nonquantitative procedures.

Hist 5429. Slavery in the Americas. (4 cr; offered alt yrs) Isaacman, Menard, Schwartz, Spear  
Comparative history of slavery, concentrating on slave regimes in the United States, Latin America, and Caribbean. Emphasis on slavery as both an economic and social system.

Hist 5630. Comparative Early Modern History. (4 cr; prereq #)

Critical examination of literature comparing history of different regions of world in Early Modern era, ca. 1450-1750.

Hist 5797. Methods of Population History. (4 cr; prereq #; offered alt yrs) McCaa, Ruggles  
Study and analysis of past population and its relation to other historical developments. Birth, marriage and the family, household structure, diseases, death, impact of industrialization and urbanization in various areas and times.

Hist 5920. Topics in Comparative Women's History. (4 cr; prereq #) S Evans, Maynes, Norling, Waltner  
Cross-cultural and thematic explorations in the history of women, including women, markets, and agriculture; women in colonialism; women and class formation; women and religion; prostitution; the medical construction of gender; women's narratives as historical sources.

Hist 5930. Topics in Comparative Third World History. (4 cr; prereq #) Isaacman, Kopf, Schwartz  
Recurring themes in third world history. Topics vary quarterly.

Hist 5970. Directed Study. (1-15 cr; prereq #, Δ, CLA approval)  
Qualified senior and graduate students may register for work on a tutorial basis.

Hist 5990. Directed Research. (1-15 cr; prereq #, Δ, CLA approval)  
Qualified senior and graduate students may register for work on a tutorial basis.

Hist 8011. Social History as Social Science. (4 cr; prereq #; offered when feasible) Pomata

Hist 8015. Scope and Methods of Historical Studies. (4 cr; prereq #)  
Development of historical studies over time (especially in 19th and 20th centuries); methodologies currently shaping historical research; theoretical developments within the discipline during 19th and 20th centuries.

Hist 8630. Seminar in Early Modern History. (4 cr; prereq grad in history, #; 5630 recommended)

Hist 8640. World History. (4 cr; prereq #)  
Critical examination of historical literature on theoretical approaches to and teaching of world history.

Hist 8942. Mass Media and Popular Culture in the 18th and 19th Centuries. (4 cr; prereq #)  
Follows Hist 5942. Students write research paper on an historical aspect of popular culture or on a topic in which popular culture is an inherent component.

Hist 8970. Directed Study. (1-15 cr; prereq #)  
Work on a tutorial basis.

Hist 8990. Directed Research. (1-15 cr; prereq #)  
Work on a tutorial basis.

## Africa and African Peoples

Hist 5436. Social History of African Women: 1850 to Present. (4 cr; prereq # for undergrads) Geiger  
Recent scholarship in African women's social history, undertaken from various perspectives and employing, as well as testing, differing frameworks of historical analysis for African continent.

Hist 5446. Problems in West African History. (4 cr)  
Advanced seminar focusing on specific historical debates and methodological problems. Topics such as slavery and the state, Islam and trade, colonial encounter, gender and social change, resistance, nationalism.

Hist 5931. History of Africa: Social Groupings, Conflicts. (4 cr; prereq #; offered alt yrs) Isaacman  
Rise of social differentiations in precolonial and contemporary African societies and how this process affects state formation and development.

Hist 5932. African Historiography. (4 cr; prereq #) Isaacman  
Written sources of African history from antiquity to the present. Emphasis on critique of content and writing.

## GRADUATE PROGRAMS

Hist 5939. Methodology for the Study of African History. (4 cr; prereq #: offered alt yrs) Isaacman

The process of historical reconstruction in nonliterate societies; collection and interpretation of oral traditions.

Hist 8944, 8945. African History. (3 cr per qtr; prereq #: offered when feasible) Isaacman

### Ancient

Hist 5061. History of Greece: To 600 B.C. (4 cr) Kelly

Political, economic, and social developments from first appearance of Greeks to ca. 600 B.C.

Hist 5062. History of Greece: 600-400 B.C. (4 cr) Kelly

Birth and development of democracy in Athens and militarism in Sparta; birth and development of philosophical and historical thought; development of Athenian Empire; Peloponnesian War between Athens and Sparta.

Hist 5063. History of Greece: 400-200 B.C. (4 cr) Kelly

Spartan, Theban, and Macedonian hegemony; Alexander the Great and the Hellenistic monarchies to 200 B.C.

Hist 5071, 5072, 5073, 5074. History of Rome. (4 cr per qtr) J Evans  
5071: To 133 B.C. 5072: 133 B.C. to 31 B.C. 5073: 31 B.C. to A.D. 180. 5074: A.D. 180 to A.D. 395.

Hist 5561-5562†. Ancient Greek History. (4 cr per qtr; prereq #: offered when feasible) Kelly

Hist 5571-5572-5573. Roman History. (4 cr per qtr; prereq #: offered when feasible) J Evans

### East Asia

Hist 5461. Ancient China. (4 cr)  
Origins of Chinese civilization, classical philosophies, and Han empire (to 220 A.D.).

Hist 5462. Buddhist China. (4 cr; offered alt yrs)  
Disintegration of Han empire; aristocratic society; barbarian invasions; spread of Buddhism and reintegration of empire in T'ang period (220-906 A.D.).

Hist 5464. Early Modern China: 1350-1750. (4 cr, §3464) Farmer, Waltner  
Ming and early Ch'ing empires; expulsion of Mongols and centralization of imperial power; high point of Confucian bureaucratic rule, commercial development, philosophical innovation, popular fiction, Manchu conquest, and early Western contacts.

Hist 5465. China's Response to the West: 1750-1911. (4 cr, §3465) Farmer, Waltner  
Eighteenth-century demographic crisis; growth of Western trade, Opium Wars, and peasant rebellion; early reform efforts, cultural conflicts with West, imperialism in China, and first phase of Chinese revolution.

Hist 5467. The Nationalist Revolution in China: 1900 to Present. (4-5 cr; prereq # for 5-cr regis) Farmer

Failure of early republic, warlordism, new culture movement, and development of Chinese nationalism. Rise of Nationalist Party and intervention of Soviet Union, Japan, and United States. Taiwan and Republic of China.

Hist 5468. People's Republic of China: The Communist Revolution, 1900 to Present. (4 cr, §3468; prereq 3468) Farmer

Introduction of Marxism to China, rise of Communist Party and development of rural guerrilla movement. Career of Mao Tse-tung and developments in the People's Republic: The Great Leap, Cultural Revolution, Gang of Four.

Hist 5473. Family, School, and Work in Modern Japanese History. (4 cr) Marshall  
Impact of industrialization on family life, economic role of women, educational opportunities and curriculum, the work ethic and Japanese employment system in 19th and 20th centuries.

**Hist 5510. Topics in East Asian History.** (4 cr per qtr [may be repeated for cr]; prereq #: offered when feasible) Farmer, Marshall, Taylor

Hist 5511. Social and Intellectual Change in Late Chou and Han China. (4 cr; prereq #: offered alt yrs)

Axial Age transcendence of primordial myths in cultural crisis of late Chou and early Han: major schools of philosophy and statecraft; establishment of literati as social elite.

Hist 5515. Local Institutions in Modern China. (4 cr; prereq #: offered alt yrs) Farmer  
Marketing system, village, and clan and family structure in rural China; local control devices, religious practices, and status of women.

Hist 5517. Chinese Intellectual History: 20th Century. (4 cr; prereq #: offered alt yrs) Farmer  
Cultural change and intellectual currents leading up to May 4th Movement of 1919. Major disputes and problems growing out of that period.

Hist 5518. Chinese Intellectual History: Mao Tse-tung and Marxism. (4 cr; prereq #: offered alt yrs) Farmer

Introduction of Marxism into China; thought and writings of Mao Tse-tung, questions of cultural identity and values in People's Republic of China.

Hist 5519. Topics in Chinese History. (4 cr; prereq #: offered alt yrs) Farmer  
Readings and discussions of topics in recent Chinese history.

Hist 5521. Introductory Proseminar on the Meiji Revolution in Japan. (4 cr; prereq #: offered alt yrs) Marshall  
Readings in English on the reforms from 1868 to 1912 and their economic, social, political, and cultural consequences.

Hist 5522. Current Issues in Japanese History. (4 cr; prereq #; offered alt yrs) Marshall  
Readings in English on current interpretations and topics in Japanese history.

Hist 8465, 8466. Research in Late Imperial China: Yuan, Ming, and Qing. (3 cr per qtr; prereq reading knowledge of Chinese, #; offered when feasible) Farmer, Waltner

Hist 8960. Topics in Chinese History. (4 cr; prereq good reading knowledge of modern Chinese) Farmer, Waltner  
Seminar examines particular aspect of Chinese history, using materials primarily in Chinese. Topics vary.

## Near East

Hist 5730. Proseminar in Middle East History, 16th to 19th Century. (4 cr per qtr [max 12 cr]) Farah

Topics, which vary quarterly, on Mamluk, Safavid-Qajar, and Ottoman era concerning relations with each other and outside world, to include political, diplomatic, and ideological orientations and conflicts; cultural and social trends; commerce; transformations due to Western impact, to secularization, and to modernization and colonial encroachments, which shaped new ideological trends and gave rise to nationalisms and Islamic activism.

## Medieval Europe

Hist 5100. Selected Topics in Medieval Europe. (4 cr per qtr; prereq #; offered when feasible) Bachrach, Hanawalt, W Phillips, Reyerson

Hist 5115. Medieval Latin Historians. (4 cr; prereq good reading knowledge of Latin) Bachrach  
Writing of history in Western Europe during Middle Ages. Focus on idea of history, philosophy of various historians, techniques of research by medieval historians and chroniclers, history as literature, and value of medieval histories to modern research scholars. Original Latin texts only.

Hist 5118. Scandinavia in the Middle Ages. (4 cr, §Scan 5118, §Geog 5178) Metcalf, Rice  
Team-taught interdisciplinary examination of economic, political, and social history of Scandinavia from late Viking period until circa 1500. Agrarian and urban societies; peasant and elite perspectives; growth of economic, political, religious, and social institutions.

Hist 5134. Russia Before the Mongol Conquest. (4 cr; offered alt yrs) Noonan  
Origins and development of the Kievan state, 850-1240.

Hist 5611, 5612, 5613. Medieval History. (4 cr per qtr; prereq 1 yr of medieval history or equiv, reading knowledge of French or German, #) Bachrach, Hanawalt, W Phillips, Reyerson

Hist 5616. Proseminar: Medieval Spain. (4 cr; prereq #)  
Review of secondary literature of history of medieval Spain from Visigothic period to Renaissance. Emphasis on later Middle Ages.

Hist 5620. Selected Topics in Medieval History. (4 cr; prereq 1 yr medieval hist or equiv, reading knowledge of appropriate foreign language[s], #)  
Topics in European and/or Mediterranean history from fall of Roman Empire through end of Middle Ages.

Hist 5634. Proseminar: Medieval Russian History. (4 cr per qtr; prereq #; offered when feasible) Noonan

Hist 5641, 5642, 5643. Proseminar: Medieval English History. (4 cr per qtr; prereq 1 yr medieval hist, reading knowledge of French or German, #) Hanawalt  
Major historiographical issues; types of primary source evidence.

Hist 8111-8112-8113†. Medieval History. (3 cr per qtr; prereq #; offered when feasible) Bachrach, Hanawalt, W Phillips, Reyerson

Hist 8141-8142†. Medieval French History. (3 cr per qtr; prereq #; offered when feasible) Bachrach, Reyerson

## Early Modern Europe

Hist 5135. From Khan to Tsar: Russia, 1240-1530. (4 cr; offered alt yrs) Noonan  
Mongol rule of Russia, rise of Lithuania, emergence of Muscovy.

Hist 5136. From Ivan the Terrible to Peter the Great: Russia, 1530-1700. (4 cr; offered alt yrs) Noonan  
Reign of Ivan the Terrible, time of troubles, great Cossack revolt in Ukraine, 17th-century Muscovy, enserfment of peasantry.

Hist 5200. Topics in European History. (4 cr)  
Detailed treatment of selected historical themes. Topics vary quarterly.

Hist 5211. France in the Old Regime. (4 cr; offered when feasible)

Hist 5617. Spain, the Early Modern Period, 1450-1750. (4 cr; prereq #; offered when feasible) C Phillips

Hist 5618. Spanish Paleography: Deciphering Handwriting of the 15th-18th Centuries. (2-4 cr; prereq reading knowledge of Spanish)  
Practical training in reading handwritten Spanish documents; essential for research in early modern Spain or colonial Spanish America.

Hist 5631. Early Modern History. (4 cr; prereq #, reading knowledge of at least 1 foreign language)  
Review of secondary literature on processes of global integration ca. 1450-1700 and on comparative study of different regions.

Hist 5635. Early Modern Russian History. (4 cr; prereq #)

Hist 5640. Topics in Early Modern Europe. (4 cr)

## GRADUATE PROGRAMS

Hist 5650. Early Modern Europe, 1450-1650. (4 cr [max 12 cr]; prereq #)

Readings in economic, intellectual, political, and religious history. Students choose one of the following to emphasize: France, Germany, Italy, the Low Countries, or Spain. Countries may vary with instructor.

Hist 5651-5652-5653. English History: Tudor and Stuart Periods. (4 cr per qtr; prereq #) Lehmborg  
Critical study of principal writings about English history. 5651: 1485 to 1558. 5652: 1558 to 1625. 5653: 1625 to 1689.

Hist 5715. Readings on European Women's History: 1450-1750. (4 cr per qtr; prereq #) Pomata  
Survey of recent literature on social history of European women and introduction to bibliographical and archival resources.

Hist 5961-5962. Expansion of Europe. (4 cr per qtr; prereq #)

Hist 8150. Seminar in English History. (3 cr [may be repeated for cr]; prereq #; offered when feasible) Altholz, Hanawalt, Lehmborg

Hist 8715. Research on European Women's History: 1450-1750. (4 cr; prereq 5715, one European language, #) Pomata  
Follows Hist 5715. Research project based on primary sources identified in Hist 5715.

### Modern Europe

Hist 5200. Topics in European History. (4 cr)  
Detailed treatment of selected historical themes. Topics vary quarterly.

Hist 5212. French Revolution and Napoleon. (4 cr; offered when feasible)

Hist 5231. Modern France From 1848 to de Gaulle. (4-5 cr) Munholland  
Survey of French society and political life from revolution of 1848 to contemporary France. Foreign language component (French) available for an extra credit.

Hist 5249. The History of Poland in the 19th and 20th Centuries. (4 cr)

Hist 5265. Modern Russia: The 19th Century. (4 cr; offered alt yrs) Stavrou  
Political, cultural, and social developments from Alexander I to the 1905 revolution. The revolutionary movement and consequences of the emancipation of the serfs; Russian industrialization.

Hist 5266. Modern Russia: The 20th Century. (4 cr; offered alt yrs) Stavrou  
Fall of the Russian monarchy, revolutions, and Soviet regime.

Hist 5276. Intellectual and Cultural History of Modern Greece. (4 cr; offered alt yrs) Stavrou  
Literary and cultural contributions of modern Greece in national and European contexts.

Hist 5284. Diplomatic History of Europe: 1848-1900. (4 cr; offered when feasible) Kieft

Hist 5285. Diplomatic History of Europe: 1900-1945. (4 cr; offered when feasible) Kieft

Hist 5286. Diplomatic History of Europe: 1945 to Present. (4 cr; offered when feasible) Kieft

Hist 5294. Social History of Russia and Eastern Europe. (4 cr) Rudolph  
Lives of peasants and workers, nobles, and merchants. Family, marriage, sexuality; culture and tradition; work; social movements (revolutionary, women's, nationalist); socialist societies and economies; post-community society. Through 19th century.

Hist 5671-5672-5673†. Modern England: 1783 to Present. (4 cr per qtr; prereq #; offered alt yrs) Altholz

Hist 5720. Introductory Proseminar in Contemporary Europe. (4 cr per qtr; prereq #)  
Selected topics to introduce problems of interpretation and analysis in contemporary European history from late 19th century to Cold War period.

Hist 5721-5722†. Europe in the 20th Century. (4 cr per qtr; prereq #; offered alt yrs) Munholland  
5721: Background and impact of World War I. 5722: Interwar years and World War II.

Hist 5735. Readings on European Women's History: 1750-Present. (4 cr per qtr; prereq #) Maynes  
Reading and discussion.

Hist 5744. Topics in Modern German History. (4 cr; prereq #; offered alt yrs) Kieft, Maynes  
Selected readings and discussions on topics such as the reform era, social crisis of Vörmärz, 1848 revolution, unification, imperial economic development, World War I, growth of German socialism, intellectual history of Weimar, Nazi state.

Hist 5756-5757†. Modern Greek Studies. (4 cr per qtr; prereq #; offered alt yrs) Stavrou  
Evolution of modern Greece from middle of 18th century to present. 5756: Political, cultural, and socioeconomic factors that contributed to Greek nationalism and establishment of independent Greece. 5757: Political and cultural developments in 20th century.

Hist 5761. Russian History. (4 cr; prereq reading knowledge of Russian or German or French or #; offered alt yrs) Stavrou

Hist 5764, 5765, 5766. New Interpretations and Approaches in Russian History. (4 cr; prereq #)  
Interpretations, methods, and approaches that have revolutionized Russian history since late 1980s. 5764: Medieval and Early Modern periods. 5765: From Peter the Great to present. 5766: Students write substantive essay.

Hist 5777, 5778. Austrian and Habsburg History. (4 cr per qtr; prereq #; offered alt yrs) Good, Rudolph, Wright

5777: Habsburg Central Europe to 1918. 5778: Modern Austria in context of Central and Eastern Europe after 1918.

Hist 5784-5785. Diplomatic History of 19th- and 20th-Century Europe. (4 cr per qtr; prereq #; offered when feasible) Kieft

Hist 5791, 5792. Social History of Modern Europe Since 1750. (4 cr per qtr; prereq #; offered when feasible) Rudolph

Hist 5793, 5794. Readings in European Economic History: 1750 to Present. (4 cr per qtr; prereq #)

5793: Europe's rise in world economy, England's industrial revolution; uneven spread of development within Europe. 5794: Late-nineteenth-century capitalism and imperialism, interwar economic instability, post-World War II economic miracle in western Europe, continuity and change in eastern Europe.

Hist 8150. Seminar in English History. (3 cr [may be repeated for cr]; prereq #; offered when feasible) Altholz, Hanawalt, Lehmborg

Hist 8223. Recent European History. (3 cr; prereq #) Munholland

Hist 8260. Research in Modern European History. (4 cr; prereq #)

Hist 8735. Research on European Women's History: 1750 to Present. (4 cr; prereq 5735, one European language, #) Maynes

Follows 5735. Research project based on primary sources identified in 5735.

## Latin America

Hist 5420. Topics in Latin American History. (4 cr per qtr; prereq #) McCaa, C Phillips, Schwartz, Valdes  
Detailed treatment of historical themes common to entire Latin American area. Topics vary quarterly.

Hist 5901, 5902. Latin American History. (4 cr per qtr; prereq reading knowledge of Spanish, #) McCaa, Schwartz, Valdes  
Designed for beginning graduate students as an introduction to major historical writings on various Latin American themes.

Hist 8401-8403. Latin American History. (3 cr per qtr; prereq #; offered when feasible) McCaa, Schwartz

## United States

Hist 5331, 5332. American Constitutional History. (4 cr per qtr; offered alt yrs) Murphy  
Origins and development of constitutional government in America with emphasis on role of constitutional politics in evolution of public policy. 5331: English and colonial background through reconstruction. 5332: Constitution and the rule of law in modern America.

Hist 5334. American Legal History. (4 cr) Murphy

History of American law from English antecedents, American reception, Americanization, and development of American legal institutions and legal culture through the rise and decline of legal realism.

Hist 5349. Social Welfare in America. (4 cr) Chambers

Advanced survey of social services, public policies, and profession of social work—colonial era to present. Issues include dependency, deviancy, crime, social security, public health, social reform, functions of public and voluntary institutions (charities, settlements).

Hist 5379. Problems in Colonial American History. (4 cr; prereq 3801 or #) Howe, Menard, Norling, O'Brien-Kehoe  
Specific problems in colonial history with emphasis on intellectual and cultural history.

Hist 5381su. Minnesota History Workshop. (5 cr)

Survey of Minnesota history with emphasis on local resources for constructing such accounts, and appropriate methodologies. Themes vary yearly.

Hist 5801-5802†. Seventeenth- and Eighteenth-Century American History. (4 cr per qtr; prereq #; offered alt yrs) Menard, O'Brien-Kehoe

Hist 5807. Research in U.S. Political History. (4 cr; prereq 5805 or 5806 or #; offered when feasible) Howe

Hist 5816. The Beginnings of American Politics. (4 cr; prereq #; offered alt yrs) Howe  
Development of American political institutions, behavior, and culture from colonial beginnings through American Revolution and ratification of federal constitution. Emphasis on connections between politics, society, and American culture.

Hist 5817. Proseminar: 19th-Century U.S. Political History. (4 cr; prereq #; offered alt yrs) Howe

Intensive readings course surveying history and historiography of 19th-century American politics. Emphasis on social analysis of politics. 5817: 1789-1850s.

Hist 5821-5822. American History in the 20th Century. (4 cr per qtr; prereq #) Berman, Chambers, Spear

Hist 5831-5832†. American Political and Constitutional History. (4 cr per qtr; prereq #; offered alt yrs) Murphy

Reading and research proseminar exploring various dimensions of constitutional politics in American experience. 5831: Late 18th and 19th century. 5832: 20th century.

Hist 5841, 5842. American Economic History. (4 cr per qtr; prereq #) Green

Hist 5844, 5845. American Labor History. (4 cr per qtr; prereq #) Berman  
Readings in classics of American labor history. Research methods and materials in labor history.

Hist 5857-5858. Social History of American Women. (4 cr per qtr; prereq #) S Evans, Norling  
Survey of historical literature, conceptual frameworks, and methodological problems in history of American women from 1600 to present.

Hist 5861-5862. History of American Immigration. (4 cr per qtr; prereq #; offered alt yrs) Vecoli  
Readings in the historiography of immigration and ethnic groups.

Hist 5871-5872. Intellectual History of the United States in the 19th and 20th Centuries. (4 cr per qtr; prereq #) Noble  
Writings of current scholars of American culture that express paradigmatic conflicts in study of ideas and values.

Hist 5881, 5882. American Foreign Relations. (4 cr per qtr; prereq #; offered alt yrs) Brauer  
Intensive readings in the historiography of American foreign relations with emphasis on American imperialism, domestic sources of foreign policy, and international political, economic, and cultural relations. 5881: To 1900. 5882: Since 1900.

Hist 5890. Topics in American Indian Social History. (4 cr per qtr [max 12 cr]; prereq #) O'Brien-Kehoe  
Social history of American Indian groups, focusing on historical demography, gender roles, interracial relationships, urbanization, and internal differences within Indian communities.

Hist 5910. Topics in American History. (4 cr; prereq #)  
Cultural, social, economic, and political concerns in the United States and its constituent elements.

Hist 5957. Law, Society, and American Criminal Justice. (4 cr; prereq #) Samaha  
Readings in societal, legal, and ideological development of modern American criminal justice, focusing on influences of ideology, politics, culture, social science on law and criminal justice.

Hist 8239-8240. Gender, Race, Class, and/or Ethnicity in America. (4 cr per qtr [max 12 cr for 8240], \$AmSt 8239, \$AmSt 8240; prereq # or Δ for 8239, 8239 or # or Δ for 8240) E May  
Social, psychological, historical, and artistic modes of self-expression and intellectual analysis of people in the United States identified as female and male or as members of racial, ethnic, or national-origin groups. 8239: Research strategies. 8240: Topical development.

Hist 8347. Social History of American Women. (4 cr; prereq 5857-5858, #; offered when feasible) S Evans, Norling

Hist 8381. History of American Foreign Relations. (3 cr; prereq 5881, 5882, #; offered when feasible) Brauer

## History of Medicine and Biological Sciences (HMed)

*Professor:* Leonard G. Wilson, *head and director of graduate studies*

*Associate Professor:* John H. Beatty; John M. Eyler

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—M.A. (Plan A only) and Ph.D.

**Curriculum**—Candidates for the master's degree take 21 credits in the history of medicine and 8 credits in history. Doctoral students complete approximately 54 credits in the history of medicine, history of science, history, and science.

**Prerequisites for Admission**—Applicants for the master's degree should already possess either the M.D. degree, or a Ph.D. or master's degree in a medical or biological science. Applicants for the Ph.D. degree should either possess the M.S. degree, or have extensive training in the biological sciences basic to medicine or in public health.

**Special Application Requirements**—Three letters of recommendation from former teachers and scores from the General (Aptitude) and Subject (Advanced) Tests of the Graduate Record Examination are required of all applicants. New students are admitted quarterly.

**Master's Degree Requirements**—The program is intended to be completed within four to six academic quarters of full-time study, or an equivalent period of part-time study. Each candidate will be required to submit a 40- to 50-page thesis on a subject in the history of medicine based on historical research in primary sources with proper citation of the sources used.

**Doctoral Degree Requirements**—Survey courses in the history of medicine and history of science are required. Other courses are chosen on the advice of the director of graduate studies. Students are required to take their minor or supporting field in history, unless they already possess extensive training in history.

**Language Requirements**—Master's students must demonstrate competence in one foreign

language, preferably French or German. Doctoral students must demonstrate competence in two foreign languages, preferably French and German. Doctoral students must pass the examination in one foreign language before the end of their first academic year and in the second language before the end of their second academic year. For students interested in a historical period before 1800, Latin is a third required foreign language.

**Minor Requirements for Students Majoring in Other Fields**—Master's degree students with a minor in history of medicine and history of the biological sciences must complete the sequence of survey courses in the history of medicine (5400, 5401, 5402) and the seminar (5410-5411-5412). Ph.D. students with a minor in history of medicine and history of the biological sciences must complete the same course requirements as for the M.A. minor and take written and oral examinations.

**For Further Information and Applications**—Write to the Department of History of Medicine, University of Minnesota, Box 506 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (mailing address) (612/624-4416).

HMed 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

HMed 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

HMed 8888. Thesis Credits: Doctoral. (36 cr required)

HMed 5002. Public Health Issues in Historical Perspective. (4 cr, \$PubH 5002) Eyler  
Introduction to the evolution of major recurring problems and issues in public health including environment and health, food customs and nutrition, control of alcohol and drugs, venereal diseases and public policy, human resources regulation, and relationship of science to promotion of health.

HMed 5035. The Germ Theory and the Medical Profession. (4 cr, \$Hist 5035) Eyler  
Formulation of the germ theory of disease and consequences for medical procedures (therapeutics, surgery, management of hospitals), public health programs, and structure and prestige of the medical profession.

HMed 5045. Medical Profession in America. (4 cr, \$Hist 5045) Eyler  
Historical analysis of the American medical profession in the 19th and 20th centuries; role of institutions, influence of social and moral values, and consequences of specialization and scientific innovation.

HMed 5102. Medicine and Society in the Enlightenment. (4 cr, \$Hist 5702; prereq #) Eyler  
Seminar dealing with the interrelations of medicine and society from the late 17th to the early 19th centuries. Emphasis on methods and materials used by medical historians. Readings and research.

HMed 5120-5130. Historical Topics: Medicine and the Modern State. (4 cr per qtr [sequence may be repeated for max 16 cr], \$Hist 5940-5950; prereq #) Eyler  
Topics vary yearly. Emphasis on mid-18th century to the present.

HMed 5400. Early History of Medicine to 1650. (4 cr; offered alt yrs) Wilson  
Paleopathology, primitive medicine, medicine in ancient Egypt and Mesopotamia, Greek medicine in classical times and under Roman Empire, transmission of Greek medicine through the Arabs to the Latin West, medieval medicine, Andreas Vesalius and the revival of anatomy, William Harvey and the discovery of circulation of the blood.

HMed 5401. Medicine During the Scientific Revolution: 1650-1850. (4 cr; offered alt yrs) Wilson  
Thomas Sydenham and the concept of distinct diseases, new chemical and mechanical theories of medicine, rise of medical teaching, pathological anatomy and definition of new diseases, impact of chemistry and physics on medicine in early 19th century, cell theory, discovery of anesthesia.

HMed 5402. Medicine Since 1850. (4 cr; offered alt yrs) Wilson  
Controversy over spontaneous generation and germ theory of disease, development of antiseptic surgery, the public health movement, revolution in basic medical sciences, reform of medical education and growth of medical specialties, changing relationship of medicine to society.

HMed 5410f-5411w-5412st. Seminar: Emergence of Modern Medicine, 1750-1900. (3 cr per qtr; prereq 3001, 3002, 3003, Hist 3031, Hist 3032, Hist 3033 or 5400, 5401, 5402) Wilson

HMed 8630, 8631, 8632f,w,s. Directed Study. (3 cr per qtr [max 15 cr]; prereq #)  
Work on a tutorial basis.

This is the History of Science and Technology through Philosophy program and course sections of the 1996-1999 University of Minnesota Graduate School Catalog

## History of Science and Technology (HSci)

*Professor:* Alan E. Shapiro, *director*; Arthur L. Norberg, *director of graduate studies*; Ronald N. Giere; Sally Gregory Kohlstedt; Edwin T. Layton; Robert W. Seidel; Roger H. Stuewer

*Associate Professor:* John Beatty; John M. Eyler

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) and Ph.D.

**Curriculum**—The program emphasizes conceptual developments within science and technology, as well as interactions between science, technology, and society.

**Prerequisites for Admission**—The prerequisite is a bachelor's degree with a minimum grade average of B. Students should be capable of interdisciplinary study. Depending on background and career objectives, additional preparatory studies may be necessary in either the science-technology area or in the humanities and social sciences.

**Special Application Requirements**—Three letters of recommendation are required.

**Master's Degree Requirements**—Programs vary with the student's needs and background, but typically include at least six foundation courses from at least three of the following "areas": history of physics, history of biology, history of technology, and social and institutional history of science and technology. An oral final examination is required.

**Doctoral Degree Requirements**—The Ph.D. program is intended for those planning professional careers in teaching, research, or other activities requiring a high degree of scholarly competence. Individual curricula vary, but a typical program includes at least six "area" courses (see Master's Degree Requirements). Ph.D. candidates must also take at least three courses in ancient to early modern history of science or technology, and at least three courses in modern to contemporary history of science or technology.

**Language Requirements**—Candidates for the M.A. degree must demonstrate reading proficiency in one foreign language, normally

French or German. Candidates for the Ph.D. degree must demonstrate reading proficiency in two foreign languages, normally French and German.

**Minor Requirements for Students Majoring in Other Fields**—Requirements are arranged on an individual basis. See also the description of the freestanding minor program in studies of science and technology.

**For Further Information and Applications**—Including the publication *A Guide to Graduate Study in the History of Science and Technology*, which supplies more detailed information about requirements, contact the Program in History of Science and Technology, University of Minnesota, 342e Tate Laboratory of Physics, 116 Church Street S.E., Minneapolis, MN 55455 (612/624-7069).

HSci 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

HSci 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

HSci 8888. Thesis Credits: Doctoral. (36 cr required)

HSci 5011. Theories of Color: Newton to Helmholtz. (4 cr; offered when feasible) Shapiro

HSci 5050. Special Topics in History of Science. (4 cr; prereq #)

Contact faculty member or program office for information on specific topics.

HSci 5060. Special Topics in History of Technology. (4 cr; prereq #)

Contact faculty member or program office for information on specific topics.

HSci 5111. Physical Sciences in Antiquity. (4 cr; offered when feasible) Shapiro

HSci 5113. Natural Philosophy in the Scientific Revolution. (4 cr) Shapiro  
Emergence of modern science in 17th century. Development of scientific method (nature of scientific explanation, experiment, quantitative approach) and new conceptual basis for physical world (space, matter, force). Bacon, Galileo, Descartes, Boyle, and Newton, among others.

HSci 5201, 5202. History of Biology. (4 cr per qtr, §3201, §3202) Beatty  
Scientific, philosophical, and social factors in development of biology; changing styles of biological reasoning and changing relationships between biological and physical sciences. 5201: Biology from antiquity through early modern period. 5202: Biology in 19th and 20th centuries.

HSci 5242. The Darwinian Revolution. (4 cr; prereq Biol 1009 or 1101 or #) Beatty  
Pre-Darwinian conceptions of nature; development and reception of Darwin's theory of evolution by natural selection; broader context of Darwinian Revolution, including religious thought, political theory, and views about proper scientific methodology.

HSci 5321. History of Computing. (4 cr, §3321) Norberg  
History of computing developments in the last century with equal attention to factors affecting evolution of hardware and software, growth of the industry and its relation to other business areas, and changing relationships resulting from new data gathering and use of machinery.

HSci 5331. Technology and American Culture. (4 cr, §3331) Norberg  
Historical survey of development of American technology in its cultural and intellectual context, from colonial period to present. Transfer of technology to America; establishment of infrastructure promoting economic growth; relationship among government, corporate, and academic influences; social response to technological developments.

HSci 5332. Science and American Culture. (4 cr, §3332) Kohlstedt  
Historical survey of development of American science. Transfer of science to America; development of indigenous traditions for pursuit of science; establishment of infrastructure for education and research; response of public to scientific development; relationship among government, corporate, and academic scientists.

HSci 5401. Engineering Ethics in Historical Perspective. (4 cr, §3401)  
Historical survey of engineering ethics in America. Successful and unsuccessful strategies for dealing with ethical issues compared primarily by using recent case studies, such as the space shuttle Challenger.

HSci 5511. History of Scientific Methodology. (4 cr; offered when feasible) Beatty

HSci 5825. The Nuclear Age. (4 cr)  
Origin, development, and social impact of nuclear physics from beginning of 20th century through post-World War II era. Experimental discoveries; theoretical models of nucleus; refugees from Nazism and Fascism; construction and use of atomic bomb; Oppenheimer and McCarthyism.

HSci 5924. History of 19th-Century Physics. (4 cr, §Phys 5924; prereq general physics or #) Stuewer  
Conceptual developments in physics (Young, Fresnel, Oersted, Ampère, Faraday, MacCullagh, Maxwell, Hertz, Lorentz, Lavoisier, Rumford, Dalton, Mayer, Joule, Helmholtz, Carnot, Clausius, Kelvin, Boltzmann, Mach, others). Relationships of these developments to social, philosophical, and theological influences.

HSci 5925. History of 20th-Century Physics. (4 cr, §Phys 5925; prereq general physics or #) Stuewer  
Conceptual developments in relativity (Michelson, Lorentz, Poincaré, Einstein, others), quantum mechanics (Planck, Einstein, Rutherford, Bohr, Sommerfeld, Ehrenfest, Pauli, Millikan, Compton, Heisenberg, de Broglie, Schrödinger, Born, others), and nuclear physics (Chadwick, Gamow, Fermi, others). Relationships of these developments to social, philosophical, and theological influences.

HSci 5935. History of Nuclear Physics. (4 cr; prereq general physics or #; offered when feasible) Stuewer

HSci 5970. Directed Studies. (1-15 cr; prereq #)

HSci 5990. Directed Research. (1-15 cr; prereq #)

HSci 8111. Historiography of Science and Technology. (4 cr; prereq HSci grad student or #)  
Analysis of scholarship in history of science and technology. Major approaches and controversies.

HSci 8121. Foundations for Research in Ancient Science. (4 cr; prereq HSci grad major or minor or #)  
Development of natural and mathematical science in ancient Near East and Classical Greece.

HSci 8122. Foundations for Research in the Scientific Revolution. (4 cr; prereq HSci grad major or minor or #)  
Copernican revolution; mechanical philosophy; development of experimental science; Newtonian synthesis.

HSci 8420. Social and Cultural Studies of Science. (4 cr, §CSDS 8910, §SST 8420)  
Seminar focuses on theoretical and methodological differences among practitioners of social and cultural studies of science; selected responses from historians and philosophers of science.

HSci 8900. Seminar: History of Early Physical Sciences. (4 cr; prereq #) Shapiro

HSci 8910. Seminar: History of Modern Physical Sciences. (4 cr; prereq #) Stuewer

HSci 8920. Seminar: History of Biological Sciences. (4 cr; prereq #) Beatty

HSci 8930. Seminar: History of Technology. (4 cr; prereq #) Layton, Norberg

HSci 8940. Seminar: History of Science and Technology in America. (4 cr; prereq #) Kohlstedt, Norberg, Seidel

HSci 8941. Women in Science: Historical Perspectives. (4 cr) Kohlstedt  
Analysis of women's roles in development of science and technology; emphasis on their initiative, their participation in scientific institutions, and attitudes toward women as scientists within scientific inquiry.

HSci 8950. Seminar: Science and Technology in Cultural Settings. (4 cr; prereq HSci grad student or #)

HSci 8970. Directed Studies. (1-5 cr per qtr [max 15 cr]; prereq #)

HSci 8990. Directed Research. (1-5 cr per qtr [max 15 cr]; prereq #)

## Horticulture (Hort)

*Professor:* Gary M. Gardner, *head*; James J. Luby, *director of graduate studies*; Peter D. Ascher; Mark L. Brenner; John V. Carter; David W. Davis (*emeritus*); Wesley P. Hackett; Florian I. Lauer (*emeritus*); Pen (Paul) H. Li; Albert H. Markhart III; Joan Nassauer; Harold M. Pellett; David G. Pitt; Carl J. Rosen; Joseph R. Sowokinos; Bert T. Swanson (*emeritus*); Donald B. White; David K. Wildung

*Associate Professor:* Deborah L. Brown; John E. Erwin; Vincent A. Fritz; Anne M. Hanchek; Emily E. Hoover; Peter J. Olin; Alan G. Smith; Mark S. Strefeler

*Assistant Professor:* Susan M. Galatowitsch; Mary H. Meyer; Cindy B. Tong

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Students normally emphasize either a subdiscipline of horticulture (floriculture, fruits, nursery management, potatoes, turf, or vegetables); a biological discipline related to horticulture (genetics, plant breeding, plant physiology, landscape ecology, or restoration ecology); or landscape horticulture. The Department of Horticultural Science administers this program, which is closely aligned with the interdepartmental programs of plant breeding and plant biological sciences (see the appropriate headings in this bulletin). All three majors are offered in the Department of Horticultural Science.

**Prerequisites for Admission**—Applicants are expected to have successfully completed college-level courses in horticulture, biology, chemistry, physics, and mathematics.

**Special Application Requirements**—Three letters of recommendation submitted on the department's form from persons familiar with the applicant's scholarship potential, a statement of background and career goals, a listing of completed prerequisite courses submitted on the department's form, scores from the General Test of the Graduate Record Examination, and a complete set of transcripts

in addition to that required by the Graduate School are required. Students may enter the program any quarter. Because fellowship nominations and departmental research assistant awards are made in early February, students with outstanding academic records should apply by December 15 preceding the year they wish to enter.

**Master's Degree Requirements**—The minimum coursework requirement is 28 credits for Plan A (plus 16 thesis credits) and 44 credits for Plan B. A complete statement of degree program requirements may be obtained from the director of graduate studies. There are few specific course requirements, because each program is planned to meet the individual interests and needs of the student. Students are required to present a research planning seminar (8066) and a final seminar (8042). The final examination is oral.

**Doctoral Degree Requirements**—Programs are flexible, tailored to the student's background and professional interests. With approval from the advisory committee, courses in related fields may be used as part of the major work. One quarter of teaching in conjunction with a supervised teaching course (8000) is required of all students. Students are expected to participate in and present at least one seminar (8042) and one research planning discussion (8066) and to earn 2 credits in such discussion courses as 8060, 8062, 8063, and 8065.

**Minor Requirements for Students Majoring in Other Fields**—Nine credits are required for a master's minor in horticulture; 18 credits for a doctoral minor.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Department of Horticultural Science, University of Minnesota, 305 Alderman Hall, 1970 Folwell Avenue, St. Paul, MN 55108 (612/624-4242; fax 612/624-4941; e-mail [kuype001@tc.umn.edu](mailto:kuype001@tc.umn.edu); <http://www.soils.umn.edu:8003>).

Hort 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Hort 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Hort 8888. Thesis Credits: Doctoral. (36 cr required)

**Hort 5001f. Harvest to Market of Horticultural Crops.** (3 cr; prereq PBio 3131) Li, Tong  
Physiological processes of horticultural crops after harvest as related to maturity, time to harvest, quality, ripening, senescence, handling, storage, and marketing. Interdisciplinary approaches to problem solving and decision making in postharvest management.

**Hort 5015s. Restoration and Reclamation Ecology.** (4 cr; prereq 1 plant biol or botany course, 1 ecol course) Galatowitsch  
Ecological and physiological concepts as basis for revegetation of grasslands, wetlands, forests, and other landscapes. Methods for plant materials selection, stand establishment, evaluating revegetation success. Overview of federally and state-administered restoration and reclamation programs. Weekend and evening trips to examine several restoration and reclamation sites in Minnesota.

**Hort 5020. Topics in Plant Science for Teachers.** (1-4 cr; prereq 1 plant science or educ course; not for credit in Hort grad program; University College only)  
Intensive workshop on inquiry-based science instruction for elementary and secondary school educators; skills and activities for teaching plant science. Managing classroom/schoolyard plant growth.

**Hort 5026f. Landscape Management.** (4 cr; prereq completion of business enrichment requirements and 75 percent of cr requirement in landscape, nursery, turf sequence) Pedersen  
Integrates environmental horticulture industry disciplines and commodities; superimposes appropriate business management principles. Scientific methods and technical applications incorporated through problem solving and case studies.

**Hort 5030. Landscape Design of Residential and Small Commercial Sites.** (3 cr, §3030; prereq 1021, 1022, LA 1301 or #)  
Fundamentals of landscape design theory, including organization of space, complementary shapes and forms, site analysis, and relationship of structure, texture, and seasonal interest in the landscape; further study of plans and environmental requirements as they influence design.

**Hort 5031f. Temperate Fruit Production.** (4 cr; prereq 3001; PBio 3131 recommended; offered odd yrs) Hoover  
Principles of fruit production, emphasizing temperate fruit crops. Integrated management of fruit cropping systems, including site selection, cultural and management practices, taxonomic classifications, physiological and environmental control of plant development. Intensive use of writing.

**Hort 5034s. Commercial Vegetable Agriculture.** (5 cr; prereq 3002 or Agro 1010, Soil 3125)  
Crop cultural and product handling and use systems in various world regions. History and evolution of species and product development. Seed and stand establishment; propagation; pest management. Applied physiology and genetics of fruit, bulb, tuber initiation; sink development, maturation, and quality. Lectures, labs, and field trips.

**Hort 5040w. Advanced Plant Growth Regulation.** (4 cr; prereq sr with 15 cr plant sciences incl 3 cr plant physiology; offered even yrs)  
Principles of plant growth and development in relation to optimizing cropping efficiency and product quality. Emphasis on physiological and morphogenetic basis of horticultural practices. Exercises in use of principles and scientific literature to solve horticultural problems.

**Hort 5041. Landscape Design and Implementation.** (4 cr, §3040; prereq 3030 or 5030)  
Builds on techniques in Hort 5030. Architectural and graphic techniques and design concepts in relation to horticultural plant performance and maintenance. Implementation of students' designs encompasses grading, site manipulation, and plant installation.

**Hort 5042f.\* Turfgrass Science.** (5 cr; prereq 3001, 3072, PIPa 3002) White  
For advanced students in turf with career objectives in professional turf management. All phases of the turf industry considered. Emphasis on the ecology, physiology, and theory of turf population dynamics and on specialized management situations such as golf course, commercial sod production, and fine turf athletic settings.

**Hort 5046f. Nursery Management I.** (4 cr, 5046-5047-5048†; prereq 1021, 1036) Swanson  
Introduction, history, organization, and scope of the nursery industry. General nursery business administration, production schedules and cultural management for seedbeds and field grown stock. Lab includes field trips and greenhouse and field training in nursery operations. Field trips.

**Hort 5047w. Nursery Scheduling and Enterprise Development.** (2 cr, 5046-5047-5048†; prereq 5046) Swanson  
Development of specific crop schedules, using current technical and economic data for efficient production. Development of total nursery enterprise designed for workable and profitable business establishment.

**Hort 5048s. Nursery Management and Production II.** (4 cr, 5046-5047-5048†; prereq 5047) Swanson  
Pest management and governmental regulations concerning the nursery industry. Container growing operations and marketing of all products. Specific topic research and nursery operation development by the student. Lab includes field trips and greenhouse and field training in nursery operations. Field trips required.

**Hort 5054s. Commercial Floricultural Production Practices.** (4 cr; prereq 1036, 3002, PBio 3131) Erwin  
Principles of commercial bedding plant production systems. Emphasis on major bedding plant crops and their cultural practices. Lectures, labs, field trips.

## GRADUATE PROGRAMS

Hort 5055f. Commercial Floriculture Production Systems. (5 cr; prereq 1036, 3002, PBio 3131 or #) Strefeler

Problem-solving and management practices in floricultural crop production. Cultural practices, diagnosis of problems, interpretation of soil/leaf analyses, scheduling crop production and mechanization, and computerization of greenhouse operations. Lectures, labs, field trips.

Hort 5091.\* Directed Studies. (2-6 cr; prereq 8 cr upper div hort course, Δ)

Written or oral report based on library, lab, or field research.

Hort 5999. Special Workshop in Horticulture. (1-4 cr; prereq #)

Offered in locations off the Twin Cities campus. Consult *Class Schedule* or department for current topics.

Hort 8000. Supervised Teaching Experience in Horticulture. (2 cr, \$Agro 8000, \$Soil 8000; prereq #) Hoover

Students are provided classroom or extension teaching experience in Departments of Agronomy and Plant Genetics or Horticultural Science or Soil, Water, and Climate and participate in teaching topic discussions to strengthen skills and develop personal teaching philosophy.

Hort 8007f,w,s. Extension Horticulture Practicum. (1-5 cr; prereq 12 grad cr)

Selected activities that may include development of an extension fact sheet, assistance in Horticulture Clinic, or preparation of a workshop or short course.

Hort 8022w. Breeding Asexually Propagated Crops. (3 cr; prereq Agro 5020; offered alt yrs)

Methods applied to improving asexually propagated plants. Apomixis, polyploidy, chimeras, mutations, and interspecific hybridization.

Hort 8023f.\* Evolution of Crop Plants. (4 cr; prereq 13 grad-level credits) Ascher

Origin, distribution, and evolution of cultivated plants; implication of evolutionary processes on crop breeding for needs of people today.

Hort 8041w. Discussions in Administrative Organization. (1 cr) Gardner

Organization and administration in agricultural experiment stations; project development and research outlines.

Hort 8042f,w,s.\* Horticultural Seminar. (1 cr)

Reports and discussions of problems and investigational work.

Hort 8045w.\* Plant Response to Environmental Stress. (3 cr; prereq 3 cr 5xxx biochem, 3 cr 5xxx plant physiology; offered alt yrs) Carter

Examined from molecular to organismal levels.

Hort 8051f,w,s,su.\* Advanced Problems in Horticultural Crop Breeding. (3-9 cr; prereq #)

Written report based on library, lab, or field research.

Hort 8052f,w,s.\* Advanced Problems in Physiology of Horticultural Crops. (3-9 cr; prereq #)

Written report based on library, lab, or field research.

Hort 8060f,w,s. Discussions in Potato Research. (1 cr)

Covers all aspects of potato genetics, breeding, and physiology. Emphasis on current research and literature.

Hort 8062f,w,s.\* Discussions in Plant Hardiness. (1 cr; prereq #) Li, Carter

Broad subject area of plant hardiness. Temperature and drought stress.

Hort 8063f.\* Seminar: Discussions in

Horticultural Plant Breeding. (1 cr; prereq #) Luby

The application of plant breeding theory and techniques to selected horticultural crops. Structured to encourage student leadership and direction.

Hort 8065w,s.\* Discussions in Postharvest Physiology. (1 cr; prereq #) Li, Tong

Physical requirements and physiological basis of storage techniques used in maintaining quality in horticultural products. Topics include historical evolution of postharvest physiology, biochemical and physical changes occurring during storage and senescence of horticultural products.

Hort 8066. Discussions in Horticulture Research. (1 cr) Smith

Emphasis on research being conducted by graduate students in the department.

Hort 8090. Graduate Horticultural Research. (1-18 cr; prereq Δ)

Directed studies.

### *Other Courses of Interest*

Agro 5020. Introduction to Plant Breeding

Agro 8200. Plant Breeding Principles and Methods I

Agro 8210. Plant Breeding Principles and Methods II

PBio 5183. Water, Minerals, and Translocation

## Hospital Pharmacy

*Professor:* Daniel Canafax; James C. Cloyd; Charles E. Halstenson; John C. Rotschafer; Darwin E. Zaske

*Associate Professor:* Ronald S. Hadsall, *director of graduate studies*; Paul W. Abramowitz; Robert J. Cipolle; Courtney V. Fletcher; Nina M. Graves; David R. Guay; Henry Mann; Mary E. O'Connell; Linda M. Strand

*Assistant Professor:* Charles E. Daniels; Ricci M. Giese; Thomas S. Rector

*Clinical Assistant Professor:* Christine M. Jolowsky; Bruce E. Scott

*Adjunct Instructor:* Delores M. Ryan

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered—M.S. (Plan A and Plan B).**

**Curriculum**—The program is designed for qualified pharmacists who wish to prepare for careers in pharmacy management, practice, and drug therapy research in organized healthcare settings. Research focuses on the delivery of pharmacy services and the use of therapeutic agents in humans.

**Prerequisites for Admission**—A degree from a college of pharmacy and an exceptional scholastic record are required. Evidence of personal capability and fitness for work in the healthcare field is essential.

**Special Application Requirements**—Submission of a résumé and special supplemental application form plus completion of a personal interview are required.

**Degree Requirements**—For Plan A, a minimum of 20 quarter credits in the major field, a minimum of 8 quarter credits in one or more related fields outside the major, and 16 thesis credits. Students are encouraged to select a minor. The final examination is oral.

For Plan B, a minimum of 44 credits of coursework in computer science, healthcare delivery, hospital administration, hospital pharmacy administration, management seminar, research, statistics, and other subjects. One Plan B project and two Plan B papers are required. Minor fields vary. The final examination is oral.

**Language Requirements**—None.

**For Further Information and Applications**—Contact Graduate Studies in Hospital Pharmacy, University of Minnesota, 7-115 Weaver-Densford Hall, 308 Harvard Street S.E., Minneapolis, MN 55455 (612/624-2973; fax 612/625-9931).

SAPh 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

## Social and Administrative Pharmacy (SAPh)

SAPh 8100. Seminar. (1 cr per qtr)

SAPh 8200. Research Problems. (Cr ar)

SAPh 8210, 8220. Experimental Pharmacotherapeutics I, II. (3 cr per qtr; offered alt yrs) Canafax, O'Connell

Theory of advanced methodologies, applications, and evaluation techniques used to determine safety, efficacy, and toxicity of drug therapies. 8210: Advanced theory: approaches, problems, and applications in pharmacotherapeutic problem solving. 8220: Advanced techniques: therapeutic end points and newly developing methodologies.

SAPh 8301. Clinical Therapeutics. (3 cr per qtr; offered alt yrs)

Clinical lectures on diagnosis and treatment of common diseases.

SAPh 8400. Special Clinical Problems. (Cr ar) Medication errors, drug distribution systems, patterns of drug use, cost-benefit analysis of prescribed medication according to diagnosis, age, dosage form, effectiveness, side effects, incidence of adverse effects, or drug use and misuse.

SAPh 8700. Hospital Administration. (2 cr; offered alt yrs) Abramowitz  
History, classification, organization, and functions of hospital departments in relation to the pharmacy service.

SAPh 8701. Hospital Pharmacy Administration I. (3 cr; offered alt yrs)

SAPh 8702. Hospital Pharmacy Survey. (1 cr; prereq 8701; offered alt yrs) Broekemeier

SAPh 8703. Hospital Pharmacy Administration II. (3 cr; offered alt yrs) Continuation of 8701.

## Human Factors/Ergonomics (HumF)

*Professor:* Michael Wade (kinesiology), *director of graduate studies;* Arthur G. Erdman (mechanical engineering); Laël C. Gatewood (laboratory medicine and pathology); Denise Guerin (design, housing, and apparel); Tarald O. Kvalseth (mechanical engineering); Gordon E. Legge (psychology); Donald Vesley (environmental and occupational health)

*Associate Professor:* Peter Hancock (kinesiology); Ruth Kanfer (psychology); Don R. Riley (mechanical engineering)

*Assistant Professor:* Joseph A. Konstan (computer science); Karen LaBat (design, housing, and apparel); Shashi Shekhar (computer science)

*Senior Research Fellow:* John C. Carmody (Minnesota Building Research Center)

**Course of Study**—Minor in human factors/ergonomics, applicable to doctoral programs only.

**Curriculum**—Human factors/ergonomics, an interdisciplinary area of study, focuses on the interaction between people and technology. It emphasizes a bio-behavioral approach to human performance in the context of the human-machine interactions. Human factors/ergonomics has its roots in psychology, kinesiology, cognitive science, engineering, operations research, and physiology. More recently, computer science and software engineering have become significant elements in human factors/ergonomics.

**Prerequisites for Admission**—Admission to the human factors/ergonomics graduate minor is contingent upon prior admission to a doctoral degree-granting program within the Graduate School. Admission to the minor is limited and only by permission of the director of graduate studies in the human factors/ergonomics minor.

**Minor Requirements**—The minimum number of graduate credits for the minor is 21.

Individual student programs are developed in consultation with the major adviser and the director of graduate studies in the minor. Students with sufficient background or previous course experience equivalent to one or more courses within the curriculum may apply for waiver of the appropriate requirements and replace waived courses with additional electives. The core of the minor curriculum consists of three required courses: a lecture course on the foundations of human factors/ergonomics (Kin 5xxx), a proseminar in human factors/ergonomics (HumF 8xxx), and a seminar in application of human factors/ergonomics (HumF 8xxx). Students select their remaining courses from a list of electives.

**Language Requirements**—None specific to the minor program.

**For Further Information and Applications**—Contact the Doctoral Minor Program in Human Factors/Ergonomics, Human Factors Research Laboratory, School of Kinesiology and Leisure Studies, College of Education and Human Development, University of Minnesota, 141 Mariucci Arena, 1901 Fourth Street S.E., Minneapolis, MN 55455 (612/625-5300).

Kin 5001. Foundations of Human Factors/Ergonomics. (4 cr; prereq admission to HumF minor or #; 3 lect, 1 rec-lab hrs per wk)

Historical, conceptual, empirical, methodological, and practical foundations; interrelationships and interdependence between human performance and design factors in performance environment.

HumF 8001. Proseminar in Human Factors/Ergonomics. (1 cr per qtr [3 cr required for HumF minor]; prereq admission to HumF minor) Survey of major topics, including theoretical influences, methods, and samples of current research.

HumF 8002. Topics in Human Factors. (2-4 cr [3 or 4 cr requires participation in supervised research project]; prereq admission to HumF minor or #) Lectures and in-depth discussion.

## Immunology

See Microbiology, Immunology, and Molecular Pathobiology.

## Industrial Engineering

See Mechanical Engineering.

## Industrial Relations (IR)

*Professor:* James G. Scoville, *director of graduate studies;* Dennis A. Ahlburg; Richard D. Arvey; Avner Ben-Ner; Hyman Berman; Mario F. Bognanno; Richard J. Butler; John P. Campbell; Rene V. Dawis; Marvin D. Dunnette; John A. Fossum; Morris M. Kleiner; Jeylan T. Mortimer; John Remington; Paul R. Sackett; George Seltzer (*emeritus*); Andrew F. Whitman; Mahmood A. Zaidi

*Associate Professor:* Ross E. Azevedo; Michael P. Keane; Brian P. McCall

*Assistant Professor:* John W. Budd; Yijiang Wang

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) and Ph.D.

**Curriculum**—Subfields are collective bargaining; compensation and reward theory and administration; economics of human resources; organization theory and administration; and staffing, training, and development.

**Prerequisites for Admission**—Entering students are expected to have completed, or to complete during their first quarter, introductory courses in micro- and macroeconomics, and psychology.

**Special Application Requirements**—Three letters of recommendation evaluating the applicant's scholarship, a complete set of transcripts (in addition to that required by the Graduate School), and Graduate Record Examination scores are required. Applicants whose native language is not English are required to score at least 550 on the Test of English as a Foreign Language (TOEFL).

Entry in both the day and evening M.A. programs is in fall or spring quarter only. *Priority* application deadline is December 15 for fall quarter. Applications received after this deadline are considered on a space-available basis. Entry in the Ph.D. program is usually in the fall; application deadlines are those established by the Graduate School. The financial aid application deadline is December 15.

**Master's Degree Requirements**—The M.A. degree is offered in day and evening programs. For Plan A, a minimum of twelve courses (48 credits), 16 thesis credits, and a thesis are required. Major coursework includes 8001, 8002, 8011, one course from at least three areas in industrial relations, and three additional industrial relations courses. The related field must consist of a minimum of two courses in an approved field or fields of study related to industrial relations. Commonly selected fields are business administration, economics, psychology, sociology, or statistics. The twelfth course may be in industrial relations or a related field.

For Plan B a minimum of sixteen courses (64 credits) and three Plan B papers are required. Major coursework includes 8001, 8002, 8003, 8004, 8005, 8006, 8007, 8011, 8012, and four additional industrial relations courses. A minimum of 12 graduate credits must be earned in related fields, at least 8 credits of which are usually in a single field. Commonly selected fields are business administration, economics, psychology, sociology, or statistics. A Plan B paper must be written in conjunction with 8011 and 8012. The third paper can be written in conjunction with any other course appearing on the approved program.

Students with limited or no business administration background may take a core of specified M.B.A. courses consisting of a minimum of 12 credits.

A final oral examination is required under both plans after all coursework and Plan B papers are accepted or the thesis draft approved by the adviser.

**Doctoral Degree Requirements**—In addition to coursework and study in industrial relations, students are expected to have a solid preparation in one or more of the six designated related social or behavioral science disciplines (anthropology, economics, history, political science, psychology, sociology). Students must successfully complete examinations in research methodology and two of the five industrial relations subfields.

Ph.D. programs should be composed of a major and a research program. The research program must include a minimum of 24 credits in research methods and techniques.

The graduate faculty in industrial relations may require higher performance standards than those specified in the General Information section of this bulletin.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—Industrial relations may be selected as a minor or as part of a supporting program for the Ph.D. by students majoring in education, hospital and healthcare administration, or the social and behavioral sciences. The minor must consist of at least 28 credits, including five courses in at least four subfields, plus a Ph.D. seminar. Industrial relations can also be offered as a related field in business administration. Students must complete a minimum of 28 credits. For specific minor and related field requirements, consult the director of graduate studies.

**For Further Information and Applications**—Contact the Industrial Relations Center, University of Minnesota, 537 Management and Economics Building, 271 19th Avenue South, Minneapolis, MN 55455 (612/624-5810; fax 612/624-8360; e-mail [efrench@csom.umn.edu](mailto:efrench@csom.umn.edu)).

IR 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

IR 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

IR 8888. Thesis Credits: Doctoral. (36 cr required)

IR 5000. Topics in Personnel and Industrial Relations. (1-8 cr)  
Selected topics of current relevance to human resource management.

IR 5002. Systems of Conflict and Dispute Resolution. (4 cr) Azevedo  
Introduction to theoretical and practical treatment of conflict settlement in interpersonal, work-related, community, business, and international settings. Lectures, discussions, observations of actual dispute resolution sessions, and lab exercises with students participating in dispute resolution simulations applied to real world conflicts.

IR 5006. Labor Policy. (3 cr, \$PA 5430) Budd, Kleiner  
Analysis of public policies regarding employment, unions, and labor markets. Public programs affecting wages, unemployment, training, worker mobility, security, and quality of work life. Policy implications of the changing nature of work.

IR 5990. Independent Study in Personnel and Industrial Relations. (1-8 cr; prereq Sch Mgmt or Grad Sch Mgmt approval)  
Individual readings or research topics in human resource management.

## GRADUATE PROGRAMS

IR 8000. Graduate Topics in Industrial Relations. (Cr ar; prereq 8002, IR MA student or Sch Mgmt approval)  
Selected topics.

IR 8001. Introduction to Quantitative Methods and Techniques for Industrial Relations. (4 cr; prereq IR grad student or Δ) Ahlburg, Budd, Keane, McCall, Wang  
Industrial relations problems. Application of descriptive and inferential statistics, including probability, hypothesis testing, confidence intervals, analysis of variance, and bivariate linear regression and correlation. Introduction to computer software and hardware for problem solutions and exercises.

IR 8002. An Introduction to Industrial Relations. (4 cr, \$3002; prereq Econ 1101, Econ 1102, Psy 1001, IR MA student or Δ) Azevedo, Fossum, Scoville, staff  
Labor markets, human resource management, federal-state employment policy, resolution of industrial conflict. Valuing, employing, developing, motivating, and maintaining human resources in an industrial society.

IR 8003. Staffing, Training and Development. (4 cr; prereq 8002 or #, IR grad major or Δ; IR grad major must register A-F) Arvey, Sackett, Wanberg  
Introduction to staffing processes (recruitment, selection, promotion, demotion, transfer, dismissal, layoff, retirement), training development theory and techniques as mechanisms for influencing individual and organizational outcomes, such as performance, satisfaction, and climate.

IR 8004. Design and Management of Organizations for a Changing World. (4 cr; prereq 8002 or #, IR grad major or Δ; IR grad major must register A-F) Arvey, Ben-Ner, Wang  
Introduction to micro through macro organizational issues at individual, dyadic, group, organizational, and environmental levels; their implications for organizational design, control, coordination, and development.

IR 8005. Compensation and Reward Theory and Programs. (4 cr; prereq 8002 or #, IR grad major or Δ; IR grad major must register A-F) Azevedo, Butler, Fossum  
Introduction to compensation and reward programs in employing organizations. Concepts, models, and theories of organizational and employee behavior in design and implementation of pay programs. Job evaluation, salary surveys, pay structures, salary increase programs, variable compensation, benefit programs, executive compensation, skill-based pay, and laws and regulations.

IR 8006. Introduction to Labor Market Analysis. (4 cr; prereq 8002 or #, IR grad major or Δ; IR grad major must register A-F) Ahlburg, Azevedo, Bognanno, Budd, Keane, McCall, Zaidi  
Labor supply and demand analysis, its international dimensions; determination of wages, employment and unemployment; accumulation of human capital and investment in education and training; government regulation in areas of discrimination and workplace safety; role of unions in wage determination.

IR 8007. Collective Bargaining: Private and Public Sectors. (4 cr; prereq 8002 or #, IR grad major or Δ; IR grad major must register A-F) Bognanno, Budd, Remington  
Introduction. Evolution of U.S. trade unions and public policy, bargaining environment and structure, goals and negotiations, contract administration and results. International comparisons, labor-management cooperation, and newly emerging issues.

IR 8011. Intermediate Quantitative Methods and Techniques for Industrial Relations. (4 cr; prereq 8001, IR grad student or Δ) Ahlburg, Budd, Keane, McCall  
Theory and applications of alternative quantitative methods and techniques in formulation and analysis of various industrial relations problems and practices. Cases, problem sets, and computer exercises.

IR 8012. Industrial Relations Systems. (4 cr; prereq completion of the core course sequence in IR or #, IR grad major or Δ; IR grad major must register A-F) Arvey, Fossum, Sackett, Scoville, Seltzer  
Integration of industrial relations subfields. Application of elements of industrial relations to human resource management issues in public and private sectors. Course project involves evaluation of industrial relations practices in chosen organization.

IR 8013. Staffing and Selection: Strategic and Operational Concerns. (4 cr; prereq 8003 or #, IR grad major or Δ; IR grad major must register A-F) Arvey, Sackett, Wanberg  
Theory and practice related to staffing decisions (recruitment, selection, promotion, demotion, transfer, dismissal, layoff, retirement) in organizations. Legal environment in which staffing decisions are made. Staffing from strategic and operational perspectives.

IR 8014. Organizational Structure and Environmental Systems. (4 cr; prereq 8004 or #, IR grad major or Δ; IR grad major must register A-F) Arvey, Ben-Ner, Wang  
Impact of environmental systems on organization design and dynamics of organizational redesign. Employing organizations in terms of general and specific environmental conditions: technological, legal, political, economic, demographic, ecological, and cultural.

IR 8015. Compensation Theory and Applications. (4 cr; prereq 8005 or #, IR grad major or Δ; IR grad major must register A-F) Azevedo, Fossum  
Effects of economy and demography of employees on employers and pay programs; effects of changes in hiring, development, and use of employees on design of pay program components. Cost-benefit analysis of compensation program components on organizational outcomes. Integration of compensation programs in human resource management.

IR 8016. Human Resource Planning. (4 cr, §8036; prereq 8006 or #, IR grad major or Δ; IR grad major must register A-F) Azevedo, Zaidi  
 Theoretical and empirical models of planning for human resource use. Micro-economic analysis; Delphi processes; Markov, Career-Path, and Transition models; and programming approaches. Focus on quantitative analysis of movement of workers through organization.

IR 8017. Labor Movements in a Changing World. (4 cr; prereq 8007 or #, IR grad major or Δ; IR grad major must register A-F) Bognanno, Budd, Remington  
 Labor movement philosophies. Critical evaluation of labor movement growth and adjustment to environmental change. Domestic and international perspectives of labor movement innovations.

IR 8022. International Human Resource Management. (4 cr; prereq 8002 or MBA 8015 or # or Δ; IR grad major must register A-F) Bognanno, Scoville, Zaidi  
 Introduction. Legal, institutional, and market aspects of work arrangement, and their impact on multinational and transnational corporations operating in foreign countries.

IR 8023. Employee Training: Creating a Learning Organization. (4 cr; prereq 8003 or #, IR grad major or Δ; IR grad major must register A-F) Arvey, Sackett, Wanberg  
 Theory, research, and practice related to design and implementation of employee training programs. Instructional design, training techniques, transfer of training, and program evaluation and costing. Role of employees, unions, and firm policies and practices in training process.

IR 8024. Organization Design and Change. (4 cr; prereq 8004 or #, IR grad major or Δ; IR grad major must register A-F) Arvey, Ben-Ner, Wang  
 Principles of organizational and task design in relation to internal organizational operations. Resource dependency, power, conflict, and political behavior in organizations. Information structures, centralization, and decentralization.

IR 8025. Employer-Sponsored Employment Benefits Programs. (4 cr; prereq 8005 or #, IR grad major or Δ; IR grad major must register A-F) Azevedo, Butler  
 Design and administration of nonmandatory compensation benefit programs: health insurance and wellness programs; pensions, salary reduction, and deferred compensation programs; pay for time not worked; other insurance plans. Analysis of risks related to work force demography and employee behaviors. Compliance with legal requirements. Cafeteria benefit plans.

IR 8026. Human Resources and Firm Performance. (4 cr, §8046; prereq 8006 or #, IR grad major or Δ; IR grad major must register A-F) Kleiner  
 Role that human resource policies and practices play in firm productivity, profitability, and market value.

IR 8027. Dispute Resolution Practices: Mediation, Fact Finding, and Arbitration. (4 cr; prereq 8007 or #, IR grad major or Δ; IR grad major must register A-F) Bognanno, Budd, Remington  
 Private and public sector impasse/dispute resolution for contract negotiation and administration. Methods and practices used in grievance resolution, mediation, fact finding, and arbitration. Newly emerging approaches.

IR 8032. Comparative and International Labor Movements. (4 cr; prereq 8002 or #, IR grad major or Δ; IR grad major must register A-F) Scoville  
 Emergence, evolution, structures, functions, and challenges ahead of labor movement in developed countries. Industrial relations systems in comparative perspective. International labor organizations. Prospects and problems of labor in developing countries.

IR 8033. Employee Development: Creating a Competitive Advantage. (4 cr; prereq 8003 or #, IR grad major or Δ; IR grad major must register A-F)  
 Theory, research, and practice. Career development and planning, employee and management development techniques, and organizational and employee concerns related to mobility, job stress, balancing work and family, obsolescence and plateauing, and cross-cultural assignments.

IR 8034. Motivation and Work Behavior in Contemporary Organizations. (4 cr, §8035; prereq 8004 or #, IR grad major or Δ; IR grad major must register A-F)  
 Major topics of microlevel organizational behavior with more intensity and depth than typically found in survey course. Accountability, organization citizenship behaviors, forms of organizational attachment, motivation and issues of equity and justice.

IR 8037. Labor-Management Negotiations. (4 cr; prereq 8007 or #, IR grad major or Δ; IR grad major must register A-F) Bognanno, Budd  
 Analysis of the nature of negotiations with applications to private and public sector collective bargaining. Nature of conflict and dilemma between competition and cooperation. Determinants of bargaining strategies, tactics, outcomes, and impasses. Newly emerging issues.

IR 8042. Human Resource Information Systems. (4 cr; prereq IR core or #, IR grad major or Δ; IR grad major must register A-F)  
 Analysis of use of human resource information systems as related to industrial relations. Hardware and database fundamentals, software applications, security issues, vendor evaluation, system and software development and design issues, and strategies for gaining user acceptance.

IR 8045. Public Policy and Employee Benefits. (4 cr; prereq 8005 or #, IR grad major or Δ; IR grad major must register A-F) Butler  
 Survey of federally and state-mandated employee benefits: workers compensation, unemployment insurance, and social security. Tax issues related to benefits. Impacts of legally mandated benefits on employers and employees. International and comparative issues in legally mandated benefits. Coordination of benefits for expatriate employees.

IR 8106. Topics in Micro Labor Market Analysis. (4 cr; prereq 8006 or #, IR PhD major or Δ; IR grad major must register A-F) Ahlburg, Bognanno, Keane, McCall, Zaidi  
May include micro aspects of unemployment, implicit-contracts and efficiency wages, investment in human capital, occupational choice, job search, job matching and turnover, migration, labor force participation, and government program evaluation.

IR 8116. Topics in Macro Labor Market Analysis. (4 cr; prereq 8006 or #, IR PhD major or Δ) Ahlburg, Keane, Zaidi  
May include theories of unemployment based on sectoral shocks, theories of wage rigidity, efficiency wage theories, interindustry wage structure, role of labor market in resource allocation, and effects of government intervention in labor market.

IR 8800. Advanced Quantitative Research Methods. (4 cr; prereq IR core or #, IR PhD major or Δ; IR grad major must register A-F) Ahlburg, Budd, Keane, McCall  
General linear model and its assumptions and violations; simultaneous equations; pooling cross-section and time series; limited and qualitative dependent variable models; sample selection models; hazard models. Emphasis on application to industrial relations and management.

IR 8801. Seminar: Industrial Relations Research Methodology. (4 cr; prereq IR PhD major or Δ) Ahlburg, Bognanno, Keane, McCall, Sackett  
Research methodology appropriate to study of industrial relations; application in research projects.

IR 8802. Seminar: Industrial Relations Systems. (4 cr; prereq IR core or #, IR PhD major or Δ) Scoville, Zaidi  
Industrial relations thought and research. Investigating, integrating, and synthesizing more traditional related disciplines, theories, and research into interdisciplinary body of knowledge concerned with human resource problems and employment relationships.

IR 8803. Seminar: Staffing, Training, and Development. (4 cr; prereq 8003 or #, IR PhD major or Δ) Arvey, Sackett  
Staffing and training concepts, problems, and research.

IR 8804. Seminar: Organization Theory. (4 cr; prereq 8004 or #, IR PhD major or Δ) Arvey, Ben-Ner, Wang  
Organization theories, application in industrial relations research and practice.

IR 8805. Seminar: Compensation and Reward. (4 cr; prereq 8005 or #, IR PhD major or Δ) Azevedo, Fossum  
Issues of employee compensation and reward; analysis of relevant theoretical models; formulation of research into compensation and reward issues.

IR 8806. Seminar: Analysis of Current Labor Market Theory and Empirical Research. (4 cr; prereq 8006 or #, IR PhD major or Δ) Ahlburg, Bognanno, Keane, McCall, Zaidi  
Functions and operations of labor markets, theory, and research.

IR 8807. Seminar: Collective Bargaining and Labor Relations. (4 cr; prereq 8007 or #, IR PhD major or Δ) Bognanno, Budd  
Analysis of contemporary theoretical and empirical research.

IR 8990. Independent Study in Industrial Relations. (Cr ar; prereq #; IR grad major must register A-F only)  
Individual readings and/or research projects especially useful to student's objectives and program.

## Interdisciplinary Archaeological Studies (InAr)

*Regents' Professor:* George R. Rapp, Jr.<sup>1</sup> (Archaeometry Laboratory), *associate director of graduate studies;* Rutherford Aris (chemical engineering and materials science)

*Professor:* Guy E. Gibbon (anthropology), *director of graduate studies;* Frederick M. Asher (art history); Arthur C. Aufderheide<sup>1</sup> (laboratory medicine and pathology); Subir K. Banerjee (geology and geophysics); Frederick A. Cooper (Classical and Near Eastern studies); Edward J. Cushing (ecology, evolution, and behavior); Stephen Gudeman (anthropology); Jackson P. Hershbell (Classical and Near Eastern studies); Calvin B. Kendall (English); Eva C. Keuls (Classical and Near Eastern studies); Sheila J. McNally (Classical and Near Eastern studies); Michael F. Metcalf (history); Thomas S. Noonan (history); Robert J. Poor (art history); Timothy G. Roufs<sup>1</sup> (sociology-anthropology); William B. Schwabacher (chemistry); Alan E. Shapiro (history of science); Theofanis G. Stavrou (history); Ellen J. Stekert (English); Peter S. Wells (anthropology)

*Adjunct Professor:* Orrin C. Shane

*Associate Professor:* Gerald W. Johnson (civil engineering); William W. Malandra (Classical and Near Eastern studies); Howard D. Mooers<sup>1</sup> (geology); Jonathan Paradise (Classical and Near Eastern studies); Daniel D. Reisman (Classical and Near Eastern studies); Philip H. Sellev (Classical and Near Eastern studies); Janet D. Spector (anthropology)

*Adjunct Associate Professor:* Scott F. Anfinson; Clark A. Dobbs; Dale R. Henning; Gordon R. Peters<sup>1</sup>; Nancy C. Wilkie

*Assistant Professor:* Catherine E. B. Asher (art history); Eve B. Cole<sup>1</sup> (philosophy); Oliver P. Nicholson (Classical and Near Eastern studies)

*Adjunct Assistant Professor:* Susan C. Mulholland<sup>1</sup> (Archaeometry Laboratory)

*Lecturer:* Bettina Arnold (anthropology); John R. Bower<sup>1</sup> (sociology-anthropology); William K. Miller<sup>1</sup> (Archaeometry Laboratory)

*Other:* John M. Weeks (University Libraries)

<sup>1</sup> University of Minnesota, Duluth

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. and M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—The program in interdisciplinary archaeological studies offers opportunities to create individualized degree programs in which a focus in archaeology is integrated with aspects of one or more other fields. Students define their own interests and, in consultation with their adviser, design a program suited to their individual needs. The potential combination of fields integrated with archaeology is limited only by faculty expertise and interest. Graduate work toward the master's degrees can be pursued on the Twin Cities campus or Duluth campus or both. The focus of coursework for the Ph.D. is on the Twin Cities campus.

**Prerequisites for Admission**—Applicants must demonstrate a commitment to a course of interdisciplinary studies not available in traditional department settings.

**Special Application Requirements**—Graduate Record Examination scores are required. The program normally begins in fall quarter, but enrollment beginning in winter or spring quarter is possible in special circumstances. The application deadline for consideration for Graduate School fellowships is December 15.

**Degree Requirements**—The program does not offer set tracks of study. However, students at the master's level are expected to take a series of three core seminars, which include combinations of method and theory in archaeology, archaeologic science, and an interdisciplinary topics seminar. New doctoral-level students are expected to take an interdisciplinary topics seminar and core seminars they have not taken earlier in one form or another. Except for these basic requirements, each student creates her/his own interdisciplinary program in consultation with program advisers. All programs of study are subject to review by the program steering committee. The final examination for both master's degrees is oral.

**Language Requirements**—All students are expected to acquire competence in the research tools necessary for their graduate and future professional work. Often these are foreign

languages and/or quantitative or experimental skills. The language and/or technique requirement is set by the student's advising committee.

**For Further Information and Applications**—Contact Interdisciplinary Archaeological Studies, University of Minnesota, 215 Ford Hall, 224 Church Street S.E., Minneapolis, MN 55455 (612/625-1062).

InAr 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

InAr 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

InAr 8888. Thesis Credits: Doctoral. (36 cr required)

InAr 5100. Topics in Interdisciplinary Archaeological Studies. (4 cr; prereq enrollment in program or #)

InAr 8001. Method and Theory in Archaeology. (4 cr, §AnSt 8001; prereq grad major or #)  
Survey and evaluation of archaeological approaches to the nonliterary, material evidence for past human activities and societies.

InAr 8002. Advanced Theory in Archaeology. (4 cr, §AnSt 8002; prereq grad major or #)  
Theoretical foundations in contemporary perspective.

InAr 8100. Interdisciplinary Seminar. (4 cr, §AnSt 8100; prereq grad major or #), visitors  
Review and evaluation of approaches to interdisciplinary research; themes vary; leadership and research shared by staff, visitors, and students.

InAr 8200. Directed Readings. (Cr ar, §AnSt 8200; prereq Δ)  
Independent reading under supervision of program staff members.

InAr 8300. Directed Research. (Cr ar, §AnSt 8300; prereq Δ)  
Independent work under supervision of program staff members. Projects include, but are not restricted to, research involved in master's and Ph.D. programs.

## International Education

*Professor:* Ayers Bagley; William M. Bart; John J. Cogan; L. Sunny Hansen; Frances Lawrenz; Gary N. McLean; Josef A. Mestenhauer; Dianne L. Monson; Edgar A. Persons; S. Jay Samuels; Robert D. Tennyson

*Associate Professor:* R. Michael Paige, *director of graduate studies;* Patricia Avery; James M. Brown; V. Lois Erickson; Kerry J. Freedman; March L. Krotee; Robert E. Orton; Jane E. Plihal

*Other:* Kay A. Thomas

**Course of Study**—Minor in international education, applicable to master's (M.A. only) and doctoral programs.

**Curriculum**—The freestanding, interdisciplinary graduate minor in international education is for students enrolled in any M.A. or Ph.D. degree program who wish to enter careers in research, consulting, administration, and teaching in an international context. The minor offers a coordinated set of courses from the Departments of Curriculum and Instruction, Educational Policy and Administration, Educational Psychology, and Work, Community, and Family Education; the School of Kinesiology and Leisure Studies; and the Institute of Child Development.

**Prerequisites for Admission**—Admission to the international education minor is contingent upon prior admission to the Graduate School and to an M.A. or Ph.D. program at the University of Minnesota. Admission to the minor program is limited and only by permission of the International Education Committee and the director of graduate studies. Students interested in this option are welcome to consult with the director of graduate studies.

**Minor Requirements**—The minimum number of graduate-level quarter credits for the minor is 10 credits at the master's level and 18 credits at the doctoral level. A student's program is developed in consultation with the major adviser, the director of graduate studies of the home department, and the director of graduate studies for international education. Three course areas are addressed in the minor: foundations and critical issues; research (doctoral only); and area-specific coursework. It is understood that some courses may not have specific international content but nevertheless produce competencies and skills deemed essential to students intending to work in an international context. The minor is not available to students completing a Graduate School degree in educational policy and administration with a concentration in comparative and international development education.

**Language Requirements**—None specific to the minor program.

**For Further Information and Applications**—Contact the Director of Graduate Studies, International Education Minor, Comparative and International Development Education, Educational Policy and Administration,

University of Minnesota, 330 Wulling Hall, 86 Pleasant Street S.E., Minneapolis, MN 55455 (612/626-7456 or 612/624-1006; e-mail r-paig@tc.umn.edu).

### Core Courses

*Foundations and Critical Issues (one required for M.A., both required for Ph.D.)*

EdPA 5131. Comparative Education. (4 cr) Cogan

EdPA 5609. Critical Issues in International Education and Educational Exchanges. (4 cr) Mestenhauer

*Research (none required for M.A., one required for Ph.D.)*

AgEd 5023. Methods for Change in Developing Countries. (3 cr) Persons

AgET 5027. Appropriate Technology for International Development. (4 cr) Goodrich

EdPA 5605. Research Topics: International Development Education. (4 cr) Paige

EdPA 5607. Applied International Development Education. (4 cr) Paige

### Area-Specific Coursework

CI 5055. Multicultural Art Education. (4 cr) Freedman

CI 5400. Survey of Children's Literature. (3 cr) Monson

CI 5652. Teaching Culture: Theory and Application. (4 cr) Paige

CI 5747. Global and Environmental Education: Content and Practice. (4 cr) Avery, Cogan

EdPA 5120. History of Childhood Education. (3 cr) Bagley

EdPA 5182. Comparative Philosophies of Education. (3 cr) Orton

EdPA 5603. International Education and Development. (4 cr) Paige

EdPA 5605. Research Topics: International Development Education. (4 cr) Paige

EdPA 5607. Applied International Development Education. (4 cr) Paige

EPsy 5110. Intelligence. (3 cr) Bart

EPsy 5112. Knowing, Learning, and Thinking. (4 cr) Samuels

EPsy 5113. Introduction to Instructional Psychology and Technology. (3 cr) Tennyson

EPsy 5119. Learning and Cognitive Foundations of Education. (4 cr) Samuels

EPsy 5401. Counseling Procedures. (3 cr) Erickson

EPsy 5430. Foundations of Career Development. (3 cr) Hansen

EPsy 5461. Cross-Cultural Counseling. (3 cr) Thomas

EPsy 8403. Social/Cultural Contexts of Counseling: Theory and Procedures. (3 cr) Hansen

FE 5321. International Perspectives in Family Education. (3 cr) Plihal

Kin 5371. Sociology of Sport. (4 cr) Krotee

Kin 8607. Comparative Physical Education and Sport. (4 cr) Krotee

WCFE 5808. Diversity Issues and Practices. (3 cr) Brown

WCFE 8150. Comparative Systems in Education for Work, Community, and Family. (3 cr) Copa, Lewis

## Interpersonal Relationships Research (IReI)

*Professor:* W. Andrew Collins (child development, director of graduate studies); Ellen Berscheid (psychology); Larry L. Cummings (management); Harold D. Grotevant (family social science); Willard W. Hartup (child development); Dean Hewes (speech-communication); Robert Leik (sociology); James Maddock (family social science); Geoffrey Maruyama (educational psychology); David Olson (family social science); A. Marilyn Sime (nursing); Mark L. Snyder (psychology); Alan Sroufe (child development)

*Associate Professor:* Patricia Tomlinson (nursing)

*Assistant Professor:* Patricia Frazier (psychology); Becky L. Omdahl (speech-communication)

**Course of Study**—Minor in interpersonal relationships research, applicable to doctoral programs only.

**Curriculum**—Interpersonal relationships research is an interdisciplinary field concerned with behavioral interaction patterns between two persons and the impact of these interactions. Its roots lie in psychology, sociology, family studies, communication, and nursing. The curriculum provides students with broad theoretical and methodological foundations for research on interpersonal relationships.

**Prerequisites for Admission**—Admission to the interpersonal relationships research graduate minor is contingent upon prior admission to the Graduate School and to a doctoral program in a degree-granting

department. Admission to the minor program is limited and only by permission of the director of graduate studies in interpersonal relationships research.

**Minor Requirements**—Students seeking to complete the interpersonal relationships research minor at the Ph.D. level are required to take the following core courses: Psy 5204, IReI 8001 (a three-quarter proseminar), and IReI 8010. The minor requires a minimum of 21 credits. Additional credits beyond the required courses must be selected from a designated course list that includes approximately 40 courses offered by many disciplines. Credits from courses in the student's major department, however, do not count toward the minor.

**Language Requirements**—None specific to the minor program.

**For Further Information and Applications**—Contact the Doctoral Minor Program in Interpersonal Relationships Research, Institute of Child Development, University of Minnesota, 104 Child Development, 51 East River Road, Minneapolis, MN 55455 (612/624-2396; fax 612/624-6373; e-mail mcdon007@tc.umn.edu).

IReI 8001. Proseminar in Interpersonal Relationships Research. (1 cr per qtr [max 3 cr]; prereq admission to IReI minor) Survey of major topics, including theoretical assumptions, methods, and samples of current research.

IReI 8010. Seminar: Statistical and Methodological Issues in Research on Dyadic Relationships. (3 cr; prereq admission to IReI minor, #) Survey of topics in design and analysis of research on behavior in two-person interactions.

IReI 8360. Seminar: Topics in Interpersonal Relationships Research. (1-4 cr; prereq admission to the IReI minor or #)

## Italian

See French and Italian.

## Japanese

See East Asian Languages, Literatures, and Linguistics.

## Journalism

See Mass Communication.

## Kinesiology and Leisure Studies

### Kinesiology

*Professor:* Michael G. Wade, *director*; Fred S. Apple (laboratory medicine and pathology); Richard S. Crow (epidemiology); Richard P. DiFabio (physical medicine and rehabilitation); Arthur G. Erdman (mechanical engineering); David W. Johnson (educational psychology); Roger T. Johnson (curriculum and instruction); Arthur S. Leon; Herbert L. Pick (child development); Lela J. Stoner; Albert Yonas (child development)

*Associate Professor:* Allen W. Burton, *director of graduate studies*; Bruce D. Anderson; Peter A. Hancock; Mary Jo Kane; March L. Krotee; Robert C. Serfass; Diane M. Wiese-Bjornstal

*Adjunct Associate Professor:* Virgil G. Mathiowetz

*Lecturer:* Nancy L. Greer; James V. Mastro

*Research Associate:* Thomas W. Kernozek; Stirling P. Stackhouse; Ava J. Walker

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) and Ph.D.

**Curriculum**—Emphases in the master's and doctoral programs are biodynamics (exercise physiology and biomechanics), motor behavior (motor development, motor learning/control, human factors, adapted physical education), and psychological and sociocultural dimensions of sport.

**Prerequisites for Admission**—Although prospective students generally have an undergraduate degree in the field, others with a baccalaureate degree may be admitted who have related preparation and a significant background and interest in the scientific study of physical activity. Admitted students may be required to complete background preparation.

**Special Application Requirements**—A completed kinesiology application form, scores from the Graduate Record Examination General Test (verbal and quantitative) or Miller Analogies Test, three letters of recommendation evaluating the applicant's scholarship, and submission of a scholarly paper are required.

**Master's Degree Requirements**—Course requirements include Kin 5980, 8980, 8981 (Plan B only), EPsy 5260, and evidence of

effective professional communication. For Plan A the minimum course credit requirement is 28 credits (excluding 16 thesis credits); for Plan B it is 44 credits. The final examination is oral for both Plan A and Plan B students.

**Doctoral Degree Requirements**—Programs are individually designed with one area of emphasis in association with a minor or supporting field of study. Preliminary written and oral examinations are based on Kin 5170, Kin 5980, and program coursework. Other coursework requirements for all Ph.D. students include a minimum of nine credits in statistics and six credits of graduate seminar.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the School of Kinesiology and Leisure Studies, University of Minnesota, 111 Cooke Hall, 1900 University Avenue S.E., Minneapolis, MN 55455 (612/624-5017).

Kin 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Kin 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Kin 8888. Thesis Credits: Doctoral. (36 cr required)

*Note*—Kinesiology course listings immediately follow the recreation, park, and leisure studies program description below.

### Recreation, Park, and Leisure Studies

*Professor:* Leo H. McAvoy<sup>1</sup>; John E. Rynders (educational psychology); Stuart J. Schleien<sup>1</sup>; Michael G. Wade

*Associate Professor:* Bruce D. Anderson<sup>1</sup>; Mary Jo Kane<sup>1</sup>; John H. Schultz<sup>1</sup>; Carla E. S. Tabourne; Diane M. Wiese-Bjornstal

*Assistant Professor:* Dorothy H. Anderson (forest resources); Stephan P. Carlson (4-H youth development)

*Research Associate:* David W. Lime (forest resources)

*Other:* Linda A. Heyne

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B); and Ph.D. in education (emphasis in recreation, park, and leisure studies).

<sup>1</sup> Also holds graduate faculty appointment in education.

**Curriculum**—Emphases in the master’s program are parks and recreation administration, therapeutic recreation, outdoor education/recreation, and sport management. The doctoral degree with the major in education offers preparation for an academic career in the emphases above. For a general description of the major in education, see the Education section of this bulletin.

**Prerequisites for Admission**—Although prospective students generally have an undergraduate degree in the field, others with related backgrounds may be admitted. Admitted students may be required to complete appropriate undergraduate and graduate courses.

**Special Application Requirements**—A completed RPLS application form and scores from either the Miller Analogies Test or the Graduate Record Examination (verbal and quantitative) are required. Students are admitted each quarter.

**Master’s Degree Requirements**—Requirements include 5980, 8980, and 8981 (Plan B only). For Plan A the minimum course credit requirement is 28 credits (excluding 16 thesis credits); for Plan B it is 44 credits. A final oral examination is required for both plans.

**Doctoral Degree Requirements**—The program consists of the following: a common core of at least 18 credits in the historical, scientific, and philosophical foundations of recreation, park, and leisure studies and of higher education; an emphasis area of at least 32 credits; thesis development of at least 52 credits (including 36 thesis credits); and a supporting program or minor of at least 21 credits. Three Ph.D. seminar courses must be included in these degree requirements. Foundation requirements are examined in association with the written preliminary examination.

**Language Requirement**—None.

**For Further Information and Applications**—Contact the School of Kinesiology and Leisure Studies, University of Minnesota, 111 Cooke Hall, 1900 University Avenue S.E., Minneapolis, MN 55455 (612/624-5017).

Rec 8777. Thesis Credits: Master’s. (16 cr required; Plan A only)

Educ 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Educ 8888. Thesis Credits: Doctoral. (36 cr required)  
Section 3. Recreation, Park, and Leisure Studies

*Note*—Recreation, park, and leisure studies course listings immediately follow the kinesiology course listings below.

### Kinesiology (Kin)

Kin 5100. Developmental/Adapted Physical Education. (3 cr; PEL) Burton, Mastro  
Physical education for students with disabilities, emphasizing administration, curriculum, assessment, history, legal mandates, and resources.

Kin 5101. Physical Activities for Persons With Disabilities. (3 cr; PEL) Burton  
Adaptation of physical activities for persons with disabilities, emphasizing application of current movement science research.

Kin 5102. Practicum: Developmental/Adapted Physical Education. (1-6 cr [max 6 cr]; prereq 5100; S-N only; PEL) Burton  
Observation of and participation in physical education instruction for students with disabilities; includes seminar component for discussion of current issues in development/adapted physical education and exchange of ideas and problems.

Kin 5106. Adapted Aquatics. (2 cr; prereq current American Red Cross Water Safety Instructor certification or equiv YMCA certification to receive Adapted Aquatic Instructor certification or no prereq if no certification desired)  
Approaches to teaching aquatics, aquatic programming options, accommodations, and adaptations for persons with disabilities; organization and administration, resources, assessments, and individualized education plans.

Kin 5111. Sport Facilities. (3 cr, §Rec 5111; prereq kin or rec major or #) Anderson  
Planning of areas and facilities for athletics, physical education, and sport; emphasizing current trends and problems.

Kin 5120. Advanced Biomechanics. (4 cr; prereq biomechanics, 3111 or #; PEL)  
Principles of mechanics applied to human movement and analysis of motor skills; application to individual projects.

Kin 5121. Contributions of Basic Science to Kinesiology. (3 cr) Hancock  
Recent research in related physical sciences; applications in selected areas.

Kin 5122. Applied Exercise Physiology. (3 cr; prereq 3386 or equiv or #; PEL) Serfass  
Application of concepts in human physiology to exercise physiology, sports training, and physical activities, with particular reference to respiratory and cardiovascular systems.

## GRADUATE PROGRAMS

Kin 5124. Human Factors Physiology. (3 cr)

Hancock

Concepts, problems, and issues associated with ergonomic applications to design and operation of human work space. Ergonomic tools and methodologies, hands-on experience in criticism and redesign of existing systems, and principles for design of more efficient future systems.

Kin 5126. Advanced Psychological and Sociological Dimensions of Physical Activity.

(3 cr; prereq kin major or #; PEL) Krotee, Wiese-Bjornstal  
Advanced insight into substance, nature, and significance of these dimensions of physical activity; focus on current research, issues, and trends as well as potential practical contributions.

Kin 5127. Observation and Analysis of

Teaching Physical Activity. (3 cr; prereq PEL or sr kin major or MA or MEd student or #)

Developing skills in using observation and supervision tools to analyze teaching/coaching of physical activity.

Kin 5132. Motor Development. (3 cr, §CPsy

5322; prereq 3132 or #; A-F only; PEL) Wade  
Developmental aspects of movement skill learning across life span, emphasizing processes underlying skill changes.

Kin 5135. Motor Learning and Human

Performance. (3 cr; prereq 3135 or #; A-F only; PEL) Hancock

Theories of movement skill learning, coordination, and control, with applications to human performance.

Kin 5136. Psychology of Coaching. (3 cr)

Wiese-Bjornstal

Psychological aspects of coaching, including leadership and communication skills, motivation, and mental skills training for performance enhancement.

Kin 5140. Biomechanics of Sport Safety. (3 cr;

prereq undergrad kin major) Stoner

Forces and torques developed in sports activities; tolerances of the human body; techniques for preventing injury; design of protective equipment.

Kin 5141. Nutrition for Exercise and Physical

Performance. (3 cr; prereq 3115 or FScN 1612 or equiv) Leon, Serfass

Application of basic nutritional principles to active populations; current issues related to dietary modifications for possible improvement of physical performance; strategies for educating clientele about nutrition and physical performance.

Kin 5151. Curriculum Implementation. (3 cr;

prereq admission to initial licensure or MEd PE prog or #; PEL)

For initial licensure students and those without previous teaching experience; objectives, organization, task analysis, teaching styles, and assessment.

Kin 5152. Curriculum Development. (3 cr; prereq

admission to initial licensure or MEd PE prog or #; PEL)

Trends, issues, and problems at selected levels of interest: elementary, secondary, junior college; for beginning and experienced teachers.

Kin 5163. Developmental Motor Assessment.

(3 cr; PEL) Burton

In-depth view of concepts, problems, and issues in assessment of motor functioning of children who may be handicapped or nonhandicapped, including critical survey of existing assessment tools and experience in developing specific assessment tool.

Kin 5170. Foundations of Kinesiology. (3 cr;

prereq grad student or MEd student) Wade

Establishment of guidelines for individual and group professional action; examination of pertinent social forces, educational philosophies, and general ethics.

Kin 5328. Proseminar: International and

Comparative Sport and Physical Education.

(4 cr; prereq 3131 or #) Krotee

Secondary literature detailing and interpreting development and cultural integration of sport and physical education in global marketplace.

Kin 5371. Sociology of Sport. (4 cr, §Soc 5371;

prereq kin major or #) Krotee

Sport within and among societies and nations; social organizations: socioeconomic development, contemporary structure, personnel, fans; relationship to other institutions: economy, education, family, government, religion; social differentiation: status, ethnicity, gender, age; careers; ethical and social problems: honesty and violence.

Kin 5375. Competitive Sport for Children and

Youth. (3 cr) Wiese-Bjornstal

Cognitive, behavioral, and biological factors affecting competitive sport participants from early childhood through high school. Emphasis on translating sport science research into practical applications for youth sport coaches, teachers, and administrators.

Kin 5380. Computer Applications in

Kinesiology. (3 cr; prereq kin major or #)

Potential uses of computers in testing and research; introduction to hardware selection, interfacing of computers and data acquisition devices, and management of data for analysis and presentation.

Kin 5385. Exercise for Special Populations.

(3 cr; prereq undergrad physiology or biol; PEL) Leon

Problems associated with exercise for persons with conditions or diseases such as arthritis, cancer, diabetes, mental disorders, obesity, old age, or paralysis. Recommended exercise prescriptions and potential benefits for special populations.

Kin 5387. Detection and Prevention of

Coronary Heart Disease. (4 cr; prereq 3386 or

equiv or #) Leon, Serfass

Introduction to causes, detection, and prevention of major cardiovascular disease emphasizing risk factor identification and modification, role of exercise in prevention, and measurement and interpretation of exercise electrocardiograms.

Kin 5388. Exercise Testing, Conditioning, and Cardiac Rehabilitation. (4 cr; prereq 3386 or equiv, 5387 or #; A-F only for day-school students) Leon, Serfass  
Administration and interpretation of exercise tests, cardiopulmonary resuscitation, and exercise prescription; survey of exercise programs for apparently healthy adults and CHD patients; familiarization with principles for establishment of intervention and rehabilitative programs.

Kin 5389. Practical Experience in Graded Exercise Testing, Prescription, and Direction. (3-6 cr [max 6 cr]; prereq 5388 or #) Serfass  
Supervised on-site training in testing, prescription, and direction of programs for adults.

Kin 5455. Recreational Sports. (3 cr, §Rec 5455; prereq kin or rec major or #) Anderson  
Programming and participation; in-depth view of foundations, programs, and operational considerations.

Kin 5460. Foundations of Sport Management. (3 cr, §Rec 5460; prereq kin or rec major or #) Anderson, Kane  
Principles of sport management and fitness, including theories and techniques in marketing, administration, and management of sport enterprises. Organizational theory and policy, with practical examples of sport management skills and strategies.

Kin 5510. Women in Sport and Leisure. (3 cr, §Rec 5510) Kane  
Historical, cultural, philosophical, and sociopsychological factors that have shaped the growth and development of women's involvement in sport and leisure; obstacles to fuller involvement.

Kin 5521. Pedagogy I: Elementary Physical Education. (6 cr; prereq initial licensure or MEd student; PEL)  
Class planning, structuring, communicating, and managing; evaluating role of K-6 physical educator in diverse settings.

Kin 5522. Pedagogy II: Secondary Physical Education. (6 cr; prereq initial licensure or MEd student; PEL) Spletzer  
Class planning, structuring, communicating, and managing; evaluating role of grade 6-12 physical educator in diverse settings.

Kin 5530. Biological and Physical Foundations of Education. (2 cr; prereq student in foundations of educ or educ tchr licensure program; PEL) Burton  
Overview of biological and physical development from birth through adulthood and relationship of this development to education.

Kin 5540. Technology in Sport and Physical Education. (3 cr; prereq kin major or #)  
Current technology for developing materials for physical education and sports science; software and video reviewed and evaluated.

Kin 5561-5562-5563. Clinical Experience I-II-III: Physical Education. (6,6,9 cr; prereq admission to initial licensure or MEd PE prog or #, 5521, 5522; 5561 is S-N only; PEL) Spletzer  
5561: supervised observation and teaching in school physical education; 5562 and 5563: supervised teaching only.

Kin 5620. Advanced Athletic Training. (3 cr; prereq 3114, CBN 1027, kin major or #; PEL) Broxterman, Mays  
Overview of problems (recognition, evaluation, assessment techniques) related to athletic injuries. Clinical instruction in advanced athletic training techniques and implementation.

Kin 5720. Topics in Kinesiology. (1-12 cr [max 12 cr]; prereq #)  
Current issues related to kinesiology and applied activities.

Kin 5740. Workshop: Coaching of Individual, Dual, or Team Sports. (1-12 cr [max 12 cr]; PEL)  
Instruction at advanced level, including analyses of skills, game strategies, specific techniques of coaching, and methods of training and conditioning.

Kin 5860. Legal Aspects of Sport and Physical Activity. (4 cr, §Rec 5860; prereq 3143 or 5460 or Rec 3550, kin or rec major or #)  
Survey of legal considerations involved in sport and physical activity programs in schools, colleges, and the private sector.

Kin 5980. Research Methodology. (3 cr, §Rec 5980; prereq kin or MEd student or #; PEL)  
Methods and design for research in kinesiology, and leisure studies.

Kin 5983. Readings: Kinesiology. (Cr ar [max 9 cr]; prereq educ or grad student, #)  
Independent study under tutorial guidance.

Kin 5985. Applications of Research. (3 cr; prereq educ or grad student; PEL) Stoner  
Strategies and techniques for applying and interpreting research related to physical education in public school setting.

Kin 8126. Seminar: Psychological and Sociological Dimensions of Physical Activity. (3 cr; prereq 5126 or #) Krotee, Wiese-Bjornstal  
Analysis of current literature, theoretical constructs, research methodology and design relative to these dimensions of physical activity; focus primarily on student-selected problems.

Kin 8128. Psychology of Sport. (3 cr; prereq 5126 or equiv or #) Wiese-Bjornstal  
Emergence of field of sport psychology, current research methodologies, and advanced theory and research.

Kin 8132. Seminar: Motor Development. (4 cr; prereq 5132 or equiv, stat course or #) Burton, Wade  
Review and critique of contemporary research literature focusing on motor skill development from before birth to adolescence, emphasizing interaction between physical constraints, environmental constraints, and coordination and control of movement.

## GRADUATE PROGRAMS

Kin 8135. Seminar: Motor Learning and Human Performance. (3-9 cr [max 9 cr], \$8330; prereq 5130 or 5135 or #; offered alt yrs) Hancock, Wade

Advanced reading and discussion of research on specialized topics in the field.

Kin 8320. Seminar: Biomechanics. (3-9 cr; prereq 5120)

Application of one or more techniques of analysis to an individually selected problem.

Kin 8381. Exercise Physiology: Research Techniques. (3 cr; prereq 5980 or #) Serfass  
Demonstration and student participation in lab procedures involving assessment of exercise parameters.

Kin 8382. Biomechanics: Research Techniques. (3 cr; prereq 5120 or #)

Lab course: developing expertise in techniques used for biomechanical research in human motion.

Kin 8607. Comparative Physical Education and Sport. (4 cr; prereq Educ 5603 or #) Krotee  
Comparative analysis of selected physical education and sport delivery systems and structures. Physical education and sport policies, practices, systems, and management of prominent sporting countries and of lesser developed nations. Sociocultural impact and issues concerning conduct of sport.

Kin 8980. Graduate Research Seminar. (1-9 cr; prereq #; S-N only) Burton, Hancock, Krotee, Leon, Serfass, Wade, Wiese-Bjornstal  
Reporting and discussion of student and faculty research activity. Required of all M.A. and Ph.D. candidates.

Kin 8981. Research Problems. (Cr ar; prereq 8980 or #; S-N only)  
Individual problems.

### Recreation, Park, and Leisure Studies (Rec)

Rec 5100. Foundations of Recreation. (3 cr; prereq MEEd or grad student or #) Kane, Schultz  
Investigation of the historical, sociological, and educational bases of the recreative use of leisure in contemporary society.

Rec 5111. Sport Facilities. (3 cr, \$Kin 5111; prereq kin or rec major or #) Anderson  
Planning areas and facilities for athletics, physical education, and sport; emphasizing current trends and problems.

Rec 5160. Recreation Land Policy. (3 cr; prereq 1520 or 5100 or #) McAvoyn  
Environmental considerations in relation to recreation and leisure services.

Rec 5190. Commercial Recreation. (3 cr; prereq 3550 or #) Schultz  
Survey of the scope and development of profit-making recreation agencies, facilities, and services.

Rec 5210. Introduction to Therapeutic Recreation. (3 cr; prereq 1520 or ¶15100, rec major or #) Tabourne

Range of approaches and settings in which services are delivered to meet physical, emotional, cognitive, and social needs of persons with disabilities and other special populations.

Rec 5220. Therapeutic Recreation Services. (5 cr; prereq 5210 or #, rec major) Tabourne

In-depth analyses and application of techniques for comprehensive program design, best practices and protocols, and outcomes of participant, client, patient, and program management.

Rec 5230. Recreation and Persons With Developmental Disabilities. (4 cr; prereq 5210 or #) Schleien

Issues relating to leisure services for persons with developmental disabilities; approaches to programming in the institution and in the community.

Rec 5235. Leisure and Mental Health. (4 cr; prereq 5210, Psy 3604 or Psy 5604 or #) Tabourne

Role of leisure in preserving mental health and in intervening or reducing effects of mental illness; techniques of program design and assessment of benefits.

Rec 5240. Recreation and Aging. (4 cr; prereq 3540 or 5100 or #) Tabourne

Issues surrounding aging; theories supporting program design and delivery; procedures for therapy, leisure education, and counseling; and techniques for selecting choices of activities for leisure participation in home, community, outpatient, and clinical settings.

Rec 5250. Financing Leisure Services. (3 cr; prereq 3550 or #)

Methods and techniques of financing operations and capital improvements in public park and recreation agencies and non-public community leisure services; examination of sources of revenue, budgeting procedures.

Rec 5255. Leisure Education for Special Populations. (3 cr; prereq 5220 or #) Tabourne  
Instruction, counseling, and other methods of education for awareness of leisure, self-in-leisure, leisure-related problem solving and decision making, and access to leisure services.

Rec 5270. Community Leisure Services and Persons With Disabilities. (4 cr; prereq 1520, rec major or #) Schleien  
Concepts and techniques of normalization; least restrictive environment strategies to include recreation service delivery in community settings for persons with disabilities.

Rec 5288. Grant Writing in Human Services. (4 cr) Schleien

Identify, develop, and procure financial assistance for programs in human services, including education, recreation, and social programs. Strategies for preparing competitive proposals for grant support through federal agencies, private foundations, and corporations.

Rec 5299. Assessment and Evaluation in Leisure Services. (4 cr; prereq 1520 or #) Schleien  
In-depth study and application of approaches to assessment and program evaluation in human services; introduction to research methods.

Rec 5300. Adventure Education. (3 cr; prereq sr, 1520 or 5100 or #) McAvoy  
Classroom and fieldwork activities dealing with rationale and methods for experiential education and adventure programs; analysis and experience in adventure activities (initiative games, climbing walls, outdoor adventure trips) focusing on communication, trust, team building, self-discovery, risk taking, leadership development.

Rec 5310. Programming Outdoor and Environmental Education. (4 cr) McAvoy  
Methods and materials for developing and conducting outdoor education, environmental education, and interpretation programs; emphasis on development of practical skills.

Rec 5350. Wilderness Outdoor Recreation Programming. (4 cr; prereq 3150) McAvoy  
Exploration of leisure and educational resources of wilderness and management of wilderness-based outdoor recreation and outdoor education programs.

Rec 5455. Recreational Sports. (3 cr, \$Kin 5455; prereq kin or rec major or #) B Anderson  
In-depth analysis of processes and benefits of recreational sports programming and participation.

Rec 5460. Foundations of Sport Management. (3 cr, \$Kin 5460; prereq kin or rec major or #) B Anderson, Kane  
Principles of sport management and fitness areas, including theories and techniques related to marketing, administration, and management of sport enterprises. Organizational theory and policy, with practical examples of sport management skills and strategies.

Rec 5510. Women in Sport and Leisure. (3 cr, \$Kin 5510) Kane  
Historical, cultural, philosophical, and sociopsychological factors that have shaped the growth and development of women's involvement in sport and leisure; obstacles to fuller involvement.

Rec 5630. Practicum: Therapeutic Recreation. (3-9 cr; prereq recreation MEd or grad student; S-N only) Schleien, Tabourne  
Supervised field-based experience in program operation; administrative and supervisory duties.

Rec 5640. Practicum: Leisure Services. (3-9 cr; prereq recreation MEd or grad student; S-N only) McAvoy, Schultz  
Supervised experiences in program operation; administrative and supervisory duties.

Rec 5695. Practicum: Sport Management. (3-9 cr; prereq recreation MEd or grad student or sport mgmt major, #) Anderson, Kane  
Theory and application of principles in developing and managing sport programs, including supervised experiences in program operation.

Rec 5750. Legal Issues in Leisure Services. (4 cr; prereq 3550 or #)  
Basic legal considerations in delivery of leisure services in public and private sectors.

Rec 5860. Legal Aspects of Sport and Physical Activity. (4 cr, \$Kin 5860; prereq 3550 or 5460 or Kin 3143, kin or rec major or #)  
Survey of legal considerations involved in sport and physical activity programs in schools, colleges, and the private sector.

Rec 5900. Workshop: Contemporary Issues in Leisure Services. (1-12 cr [max 12 cr])  
Contemporary issues emphasizing administrative and supervisory functions for recreation and allied professionals; individual offerings focus on special issues and/or professional groups.

Rec 5980. Introduction to Research. (3 cr, \$Kin 5980; prereq MEd or grad student or #) Kane  
Basic techniques; emphasis on social research methodology; survey of present status of recreation and park research.

Rec 5981. Problems. (Cr ar; prereq MEd or grad student or #)  
Independent study in recreation, park, and leisure services under faculty supervision.

Rec 5983. Readings: Recreation. (1-3 cr; prereq MEd or grad student or #)  
Independent study under tutorial guidance.

Rec 8310. Seminar: Recreation and Park Administration. (1-9 cr; prereq #)  
Critical study and special problems in recreation, park, and leisure studies.

Rec 8320. Seminar: Theoretical Perspectives of Leisure Behavior. (3 cr; prereq 5100 or #) Kane  
Analysis, synthesis, and evaluation of major theoretical paradigms of leisure from social and behavioral sciences in general and leisure science in particular. Examination and development of strategies for application of these theories and research findings.

Rec 8370. Seminar: Administrative Problems in Therapeutic Recreation. (3 cr; prereq 5220 or #) Schleien, Tabourne  
Examination of organizational patterns, legal aspects, interdepartmental relationships; discussion and case study approach.

Rec 8380. Seminar: Administrative Problems in Recreation and Parks. (3 cr; prereq 3550 or equiv) Schultz  
Investigation of legal, financial, personnel, public relations, political, and philosophical problems in management of federal, state, and local government agencies; discussion and case study approach.

Rec 8980. Seminar: Research Problems. (1-3 cr per qtr [max 3 cr]; prereq 5980 or #; S-N only)  
Designing, reporting on individual problems. Required of all M.A. and Ph.D. candidates.

Rec 8981. Research Problems. (Cr ar; prereq 8980 or #; S-N only)  
Individual problems.

## Landscape Architecture (LA)

*Professor:* Joan Nassauer, *head*; Roger B. Martin, *director of graduate studies*; Roger D. Clemence; John F. Hart; William R. Morrish; David G. Pitt

*Associate Professor:* Lance M. Neckar; Peter J. Olin; Robert D. Sykes

*Assistant Professor:* Susan M. Galatowitsch; John A. Koepke

*Adjunct Assistant Professor:* Deborah Karasov

*Lecturer:* Robert J. Gunderson; Barbara Lukermann

*Research Associate:* David W. Lime

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.L.A. and M.S. (Plan A only).

**Curriculum**—The M.L.A. prepares students to practice as registered landscape architects. It is a professional degree in an accredited program. Students without previous design experience can expect to take three years to complete the degree; students with advanced standing can expect to take two years.

The M.S. degree program is research-oriented and allows students to focus on specialized areas of landscape architecture. It is a 44-credit program for students with a clear research focus and takes about two years to complete. Students specialize within areas of faculty expertise, which include art and landscape architecture, landscape ecology, landscape architectural history, landscape architectural theory, rural and suburban landscape planning, landscape reclamation, waterway planning and design, landscape perception studies, and transportation design. Prospective students may request a summary of faculty research for a comprehensive description of potential specializations.

**Prerequisites for Admission**—M.L.A. program applicants must have completed a baccalaureate degree. M.S. program applicants must have completed a baccalaureate degree in landscape architecture or a related discipline. All applicants will also be asked to explain the relationship of their previous academic work and work experience to their proposed graduate study.

**Special Application Requirements**—M.L.A. program applicants must apply by January 15 for

entry the following fall. The department requires the following materials: a letter of intent, which includes whether or not the applicant is interested in financial aid; three letters of reference; a photocopy of official transcripts; and examples of creative work. Applicants with degrees in related design professions such as architecture or planning should clearly indicate in their letter of intent an interest in being evaluated for advanced standing in design. The Graduate Record Examination (GRE) is not required for entry but can be helpful to applicants applying for fellowships.

M.S. program applicants must apply by January 15 for entry the following fall. The department requires the following materials: GRE scores; a statement of intent outlining research objectives that also includes whether or not the applicant is interested in financial aid; and examples of previous research and/or design work related substantively or methodologically to the applicant's proposed research, or examples of academic or professional work that includes 10 to 30 pages of writings, published or unpublished. Successful applicants will have secured the participation of a faculty adviser before completing their applications.

**Degree Requirements**—M.L.A. students without previous design experience must take 129 credits of coursework, of which 121 are graduate credits. Students with advanced standing in other design disciplines normally must take 90 graduate credits. The core curriculum for both is 54 credits of studio, with one studio required each quarter. Students also take four technology courses, two landscape architectural history courses, and courses in planting design, geographic information systems, ecology, professional practice, and graphics. A total of 16 credits in seminars and in advanced coursework in other disciplines is also required, as is LA 8200 and a research colloquium series.

Applicants who have completed an accredited, professional bachelor's degree in landscape architecture may complete the M.L.A. degree with 44 graduate credits, including 18 credits of landscape architecture studio courses, the 5 credit research methods course (8200), 1 credit of the research survey course (8820), and 8 credits of coursework outside the department. Up to 12 credits earned as part of the M.L.A. may be applied to the M.S.

The M.S. requires 44 graduate credits, which includes a minimum of 7 credits in landscape architecture, 16 credits for a Plan A thesis, and a minimum of 8 credits in an area of focus outside of landscape architecture. M.S. students are also required to take a 5-credit course on research issues and methods and a colloquium series.

**Language Requirement—None.**

**For Further Information and Applications—**

Contact the Department of Landscape Architecture, University of Minnesota, 125 Architecture Building, 89 Church Street S.E., Minneapolis, MN 55108 (612/625-6860; fax 612/625-7525).

LA 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

LA 5131. Directed Studies in Landscape Architecture History and Theory. (1-6 cr; prereq LA student or  $\Delta$ : A-F only)  
Advanced independent studies.

LA 5133. Directed Studies in Landscape Architecture Technology. (1-6 cr; prereq LA student,  $\Delta$ : A-F only)  
Advanced independent studies.

LA 5134. Directed Studies in Emerging Areas of Landscape Architecture. (1-6 cr; prereq LA student,  $\Delta$ : A-F only)  
Advanced independent studies in areas of student's choice.

LA 5140. Interdisciplinary Studies in Landscape Architecture. (2-6 cr per qtr [max 18 cr]; prereq #: A-F only)  
Research, planning, and/or design project. Topics may include energy efficient design, historic preservation, downtown revitalization, agricultural land use, computerized land-use planning, housing.

LA 5200. Directed Studies in Landscape Architecture Design. (1-6 cr, \$5132; prereq #: A-F only)  
Advanced independent studies.

LA 5201. Field Techniques for Landscape Analysis. (3 cr; prereq LA grad student or BED student or  $\Delta$ : A-F only)  
Vegetation, soil, and landform description. Applying techniques to agricultural, urban, and natural landscapes. Includes one-week session at Lake Itasca Forestry and Biological Station before fall term and weekly field trips during fall term.

LA 5202. Landscape Ecology. (3 cr; prereq ecology course or #: A-F only)  
Relationships among spatial patterns, temporal patterns, and ecological processes in landscapes. Factors affecting landscape pattern, measurement of landscape pattern, material transport through landscapes, effects of landscape pattern on population dynamics, and landscape planning.

LA 5211. Making Landscape Space. (6 cr, \$3081; prereq BED or BLA student or  $\Delta$ : A-F only)  
Design exploration using three-dimensional models to make outdoor space for human habitation and use, with landforms, structures, and plants. Development of form vocabulary to provide spatial order. Use of metaphorical thinking to imbue designed space with meaning.

LA 5212. Ecological Informants of Design. (6 cr, \$3082; prereq 5211; A-F only)  
Draws on landscape ecology, aesthetics, and design arts to help students select and analyze ecological phenomena that influence function and human experience of landscape and to use fundamental aesthetic principles to portray those phenomena in design.

LA 5213. Making Landscape Types. (6 cr, \$3083; prereq 5211; A-F only)  
Theory, precedents, and practice in making fundamental space types in professional landscape architecture. Order, form, and meaning in designing discrete landscape types and types in combination.

LA 5221. Planted Form. (5 cr; prereq 5211, 5213; A-F only)  
Lectures, presentations, field trips, readings, and projects exploring design principles related to using plants in the landscape. Explores cultural and ecological principles through design projects of various scales.

LA 5228. Seminar: Topics in Campus Planning. (4 cr; prereq 3093 or #: A-F only)  
Lectures, discussion, presentations, field trips, readings, and paper. Contemporary and historic issues in campus planning, use of energy-efficient buildings, efficient land use, and site planning.

LA 5431. History of Landscape Architecture: Individual Influences. (4 cr, \$5265; prereq 3413; A-F only) Neckar  
Lectures, presentations, field trips, readings, papers, and/or projects. Assessment of influences of individuals on formation of the profession, 1800-present.

LA 5562. Introduction to Geographic Information Systems. (4 cr; prereq jr or sr or grad major in Geog or LA or #: A-F only) Nassauer  
Theory and applications for landscape location and resource analysis and regional planning. Location principles, data structure, variable attributes.

LA 5571. Landscape Construction: Landform Systems. (4 cr, \$3065; prereq 5211 or #: A-F only)  
Theory and professional applications of landform systems for design. Landform typology, representation methods, manipulation techniques, use of survey data, and earthwork construction issues. Landscape integrity assurance and economic performance.

LA 5572. Landscape Construction: Spatial Performance. (4 cr, \$5063; prereq 5211 or #: A-F only) Sykes  
Theory and application of appropriate standards, proportions, and dimensions for spatial performance in landscape architecture; spatial accommodation of people and automobiles in landscape applications; land use and development controls.

## GRADUATE PROGRAMS

LA 5621. Professional Practice. (4 cr, §5226; prereq terminal yr of study; A-F only)  
Office and project management analyzed using case studies. Organizational behavior, marketing, sales, strategic planning, financial and cost accounting, insurance, legal issues and contracts.

LA 5810. Visions of Paradise: Garden Design and the Good Life. (4-6 cr; prereq LA or Arch or BED student or #; A-F only)  
Theoretical inquiry and studio exploration into the art of garden design as a lamp to illuminate ideals for living. Aristotelian and Objectivist thought on art and happiness as a whole good life provide the foundation for exploration and artistic expression.

LA 5911!. Urban Design Journal. (4.5 cr; prereq admittance to Denmark International Study program; given in Denmark)  
Methods and theories in urban design and human behavior. Students develop journal as tool for experiencing, analyzing, and recording the urban landscape, its fabric, spatial elements, and individual components, and for analyzing design solutions.

LA 5912!. Landscape Architecture Studio. (9 cr; prereq admittance to Denmark International Study program; given in Denmark)  
Individual and small-group projects focusing on urban issues; design process in Danish conditions; solutions based on knowledge of Danish problems in landscape and urban design and an understanding of how these problems are solved within Danish and European context.

LA 5913!. Landscape Architecture, Architecture, and Planning. (4.5 cr; prereq admittance to Denmark International Study program; given in Denmark)  
Methods and theories in urban design and human behavior. Students develop urban design journal as tool for experiencing, analyzing, and recording the urban landscape, its fabric, spatial elements, and individual components, and for analyzing design solutions.

LA 8110. Graduate Landscape Planning and Design. (6 cr; prereq 5101, 5103, 5015 or 5107, grad student; A-F only)  
Studio experience in comprehensive landscape planning, or design project in area of student's choice.

LA 8111. Directed Studio in Landscape Architecture. (6 cr; prereq 8222, grad student; A-F only)  
Studio experience in comprehensive project execution in landscape planning, or design in area of instructor's specialty.

LA 8200. Landscape Architectural Research Issues and Methods. (5 cr, §8281, §8282; prereq LA student or #; A-F only)  
Alternative methodological approaches to landscape architectural research and their appropriateness to contemporary research topics.

LA 8221. Design of Landscapes for Dwelling. (6 cr, §3091; prereq 5213, 5572, LA student or Δ; A-F only)  
Design studio. Theory and applications of the meaning of home, dwelling, and associated human behavior issues related to professional design of residential landscape architecture. Studies range from individual home landscapes to neighborhoods as dwelling places.

LA 8222. The Landscape Architectural Design of Community Places. (6 cr, §3092; prereq 8221, LA student or #; A-F only)  
Design studio. Public places as settings for the gathering of people. Historical precedent used as idea resource for designing streets and outdoor public gathering spaces in context of mixed-use urban and suburban settings.

LA 8223. Regional Landscape Design. (6 cr, §5107; prereq 5562 or FR 5130 or Geog 5562 or PA 5562, 8222, LA student or Δ; A-F only)  
Design exploration of landscape ecology, landscape perception, and public policy as informants of design decision making in regional landscapes at or exceeding a township level. Geographic information systems used as design tools.

LA 8231. Urban Landscape Design. (6 cr, §5103; prereq LA student or #; A-F only)  
Advanced design studio exploring urban and landscape design principles through analysis of case studies and development of strategies from landscape systems within the urban environment.

LA 8232. Design of Recreational Landscapes. (6 cr, §5105; prereq 8223; 2 lect, 10 lab hrs per wk; A-F only)  
Design studio. Analysis, development, and presentation of designs for diverse recreational landscapes.

LA 8233. Special Problems: Design Proposal. (2 cr, §5109; prereq 8223 or 8231; A-F only)  
Individual research resulting in proposal for capstone project to be developed in LA 8234.

LA 8234. Advanced Landscape Planning and Design. (6 cr, §5110, §8110; prereq LA grad student in terminal qtr of study; A-F only)  
Advanced studies in area of student's choice.

LA 8500. Landscape Architecture Research Project. (1-6 cr; prereq 8283 or #; A-F only)

LA 8573. Landscape Construction: Structural Systems. (4 cr, §3067; prereq 5123, LA student or #; A-F only)

Lectures, projects, and exercises on professional design of pavements, enclosures, and decks. Theory and principles of structural design, properties and use of materials, construction communication. Landscape integrity and economic viability as performance issues.

LA 8574. Landscape Construction: Mechanical Systems. (4 cr, §3069; prereq 8221, LA student or #; A-F only)

Lectures, projects, and exercises on landscape architectural applications of storm water management, urban utilities, irrigation, and electrical and lighting systems and techniques. Systems planning and design; historical precedents; professional design communication; landscape construction, integrity, and performance issues.

LA 8600. Landscape Architecture Education. (1-4 cr; prereq MLA candidate or #; A-F only)

Planning and execution of undergraduate landscape architecture course under direct supervision of a course instructor.

LA 8801. Concepts of Landscape Evaluation. (4 cr, §8330; prereq LA student or #; A-F only) Nassauer

Philosophical basis for wide-ranging approaches to evaluating qualitative aspects of landscape. Emphasis on aesthetic factors and integration of landscape evaluation into regional design decision making.

LA 8802. Perception Manipulation in Design of Exterior Space. (4 cr, §8320; prereq LA or Arch grad student or #; A-F only) Martin

Historic and modern design devices that alter sense of spatial control and arrangement to create illusionary situations in exterior environment. Readings, lectures, and research projects inform and test principles of perception distortion in exterior space.

LA 8803. The Sublime, the Beautiful, and the Picturesque: Theory and Practice. (4 cr, §8370; prereq LA or Arch grad student or 3411 or 5431; A-F only) Neckar

Reading, discussion, and research paper on 18th- and early 19th-century theoretical bases for landscape design. Analysis of executed designs, theoretical relationships to current design issues.

LA 8804. Landscape Ecology and Design. (4 cr, §8390; A-F only) Nassauer

Readings, discussion, and field investigations to establish a landscape ecological basis for designing ecosystems as part of human settlement. Design and planning implications of scientific conclusions and theory; meaningful techniques for creating high-functioning ecosystems in inhabited landscapes.

LA 8820. Survey of Landscape Architecture Research. (1-3 cr, §8284; prereq LA student; S-N only) Nassauer

Critical review of invited lectures and discussion on current topics.

## Latin

See Classical and Near Eastern Studies.

## Law

*Professor:* Daniel A. Farber, *director of graduate studies*; Carl A. Auerbach; Stephen F. Befort; Karen B. Brown; David Bryden; Laura Cooper; John J. Cound; Barry C. Feld; Mary L. Fellows; Richard S. Frase; Philip P. Frickey; Daniel J. Gifford; Joan S. Howland; Robert E. Hudec; William D. Kilbourn, Jr.; K. Bart Koeppen; Victor H. Kramer; Maury S. Landsman; Robert J. Levy; Donald G. Marshall; John H. Matheson; C. Robert Morris; Fred L. Morrison; Steve H. Nickles; Roger C. Park; John A. Powell; M. Kathleen Price; Stephen B. Scallen; Ferdinand P. Schoettle, Jr.; Suzanna Sherry; Robert A. Stein; Michael Tonry; Gerald Torres; Thomas L. Waterbury; David Weissbrodt; Judith T. Younger

*Associate Professor:* Edward S. Adams; Karen C. Burke; Ann M. Burkhardt; Jim C. Chen; Carol L. Chomsky; Tahirih V. Lee; Michael S. Paulsen; Susan M. Wolf

*Clinical Professor:* Beverly Balos; Kathryn J. Sedo; Stephen M. Simon; Carl M. Warren

*Research Associate:* Keith Bellairs

**Course of Study**—Minor in law, applicable to master's (M.A. and M.S.) and doctoral programs.

**For Further Information and Applications**—Contact Meredith M. McQuaid, Assistant Dean of Students and Director of International and Graduate Programs, Law School, University of Minnesota, 285 Law Building, 229 19th Avenue South, Minneapolis, MN 55455 (612/625-3025; fax 612/626-1874).

## Liberal Studies (LS)

*Professor:* Ronald R. Aminzade (sociology); Frederick M. Asher (art history); Kent Bales (English); Terence W. Ball (political science); Subir Banerjee (geology and geophysics); Darrell R. Lewis (educational policy and administration); Paul T. Magee (genetics and cell biology); Toni A. H. McNaron (English); David W. Noble (American studies); Robert J. Poor (art history); Dwight H. Purdy (English<sup>1</sup>); Harvey B. Sarles (cultural studies and comparative literature); Naomi B. Scheman (philosophy)

*Associate Professor:* William E. Mishler (German, Scandinavian, and Dutch), *director of graduate studies*; Catherine E. B. Asher (art history); Kevin Dooley (mechanical engineering); Roger S. Jones (physics and astronomy); Nita Krevans (Classical and Near Eastern studies); Judith A. Martin (Center for Urban and Regional Affairs); Carol A. Miller (American studies); David V. Taylor (General College)

*Adjunct Associate Professor:* Nicholas Hayes

*Assistant Professor:* C. Victor Fung (General College)

*Lecturer:* Carol M. Bly (English); Stephen L. Daniel (University College); Sarah M. Dennison (University College); Donna Mae J. Gustafson (University College); John

<sup>1</sup> University of Minnesota, Morris

Haaland (University College); Alan R. Kahn<sup>2</sup> (University College); Judith Katz (University College); Roseann Lloyd (University College); Katherine Kolb Reeve (French and Italian); David A. Shupe (University College)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

### Degree Offered—M.L.S.

**Curriculum**—The graduate major in liberal studies offers an interdisciplinary curriculum that includes four M.L.S. seminars, six elective courses, and a final project course. Although courses for the M.L.S. are scheduled mainly late afternoons and evenings, most graduate-level courses offered during the day are also open to M.L.S. students. Careful selection of courses, with the help of the student's graduate faculty adviser, is crucial to insuring a coherently interdisciplinary program of study.

**Prerequisites for Admission**—In addition to a bachelor's degree, students must indicate an ability to succeed in graduate study.

**Special Application Requirements**—A statement of purpose, letters of support, an undergraduate transcript, and examples of written work should accompany the application. Graduate Record Examination scores may also be submitted, but are not required.

**Master's Degree Requirements**—The minimum requirement is 44 credits (normally 11 courses).

**Language Requirements**—None.

### For Further Information and Applications—

Contact University College, University of Minnesota, 306 Westbrook Hall, 77 Pleasant Street S.E., Minneapolis, Minnesota 55455 (612/625-3898; fax 612/625-2568; e-mail jlundbla@mail.cee.tc.umn.edu).

LS 5100. Topics in Liberal Studies. (4 cr per qtr)

LS 5101. Goethe: Transcendental Approach to Nature. (4 cr)

Goethe's critique of Newton: its historical context and issues raised. Important phase in historical debate concerning relationship of human beings to nature.

LS 5610. Environmental Ethics, Politics, and Public Policy. (4 cr, SPol 5610: University College only)  
Moral obligations, meaning of "freedom," responsibilities of freedom, and legitimate limits on freedom to speak and act; who and what deserves protection.

LS 5910. Lively Imagination: Ethics and Aspects of Moral Thinking. (4 cr, SEngl 5910: University College only)

Considers first-rate stories and essays; effects of telling, hearing, and interpreting stories; empathy with respect to stories and stage development theory. Involves creative writing.

LS 5970. Directed Studies. (1-4 cr per qtr [max 15 cr]; prereq #, Δ)

Tutorial for qualified graduate students. Guided individual reading or study.

LS 5990. Directed Research. (1-4 cr per qtr [max 15 cr]; prereq #, Δ)

Tutorial for qualified graduate students.

LS 8000. Introduction to Graduate Liberal Studies. (4 cr; prereq MLS student or Δ)

Topic varies.

LS 8001. Final Project for Graduate Liberal Studies. (4 cr; prereq MLS student)

## Linguistics (Ling)

*Professor:* Jeanette K. Gundel, *director of graduate studies*; Patricia A. Broen; Andrew D. Cohen; Michael B. Kac; Michael P. Maratsos; Gerald A. Sanders (*emeritus*); Joseph P. Stemberger; Elaine E. Tarone

*Associate Professor:* Betsy K. Barnes; Bruce T. Downing; Charles R. Fletcher; G. Lee Fullerton; Larry G. Hutchinson; Carol A. Klee; Amy L. Sheldon; Nancy J. Stenson; Polly E. Szatrowski

*Assistant Professor:* Michael Hegarty; Maria D. Sera

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) and Ph.D.

**Curriculum**—Areas of specialization include language acquisition (first and second), language processing, core linguistics (phonology, syntax, semantics/pragmatics), and the interface of two or more of these areas.

**Prerequisites for Admission**—There are no specific prerequisites for admission. Students admitted normally have a broad undergraduate background that includes some linguistics courses.

### Special Application Requirements—

Applicants must submit a completed application, scores from the Graduate Record Examination, three letters of recommendation, and a supplementary questionnaire detailing background, interests, and accomplishments.

<sup>2</sup> University of Minnesota, Duluth

Applicants wishing to be considered for financial support should apply no later than January 7 of the preceding academic year. Entry is usually in fall quarter but may be permitted in other quarters in exceptional cases.

**Degree Program Prerequisites**—Consult with the director of graduate studies.

**Master's Degree Requirements**—Twenty-five credits in the major field, including coursework in phonetics, phonology, syntax, semantics, and field methods. Other coursework is selected in consultation with the student's adviser.

**Doctoral Degree Requirements**—Same as for the master's degree plus an individualized plan of study (including 8xxx courses) to be determined in consultation with the student's committee. All Ph.D. students must pass preliminary written examinations in phonology, syntax, and their primary and secondary areas of concentration. Papers judged to be of publishable quality by the student's committee can be substituted for examination questions in any of these areas.

**Language Requirements**—For the M.A. degree, knowledge of one language not native to the student. For the Ph.D. degree, knowledge of two languages not native to the student. Mechanisms for demonstrating knowledge are described in the program's *Information for Graduate Students*.

**Minor Requirements for Students Majoring in Other Fields**—For the master's degree, 5001, 5201, and 5302, or their equivalents, are required. For the doctoral degree, six courses approved by the director of graduate studies, including those required for the master's minor, are required.

**For Further Information and Applications**—Contact the Program in Linguistics, Institute of Linguistics and Asian and Slavic Languages and Literatures, University of Minnesota, 190 Klæber Court, 320 16th Avenue S.E., Minneapolis, MN 55455 (612/624-3331).

Ling 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Ling 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Ling 8888. Thesis Credits: Doctoral. (36 cr required)

Ling 5001. Introduction to Linguistics. (5 cr, \$3001; prereq grad standing or #) Phonetics, phonology, morphology, syntax, semantics, and historical-comparative linguistics; language learning and psychology of language; linguistic universals; language in society.

Ling 5002. Linguistic Analysis. (4 cr, \$5201, \$5302; especially recommended for nonmajors; prereq 3001 or 5001 or #) Gundel, Kac, Stenson  
Techniques for analyzing phonological, morphological, and syntactic data from a wide variety of languages; discovering, stating, and justifying generalizations; comparison of diverse languages.

Ling 5201-5202. Introduction to Syntax. (4 cr per qtr; prereq 3001 or 5001 or #) Gundel, Hutchinson, Kac

5201: Principles of grammar construction and evaluation; examination of syntactic phenomena in a variety of languages. 5202: Survey of modern syntactic theory.

Ling 5211. Semantics. (4 cr; prereq 5011, 5202 or #) Gundel, Hutchinson, Kac

Linguistic analysis and explanation of synonymy, analyticity, presupposition, and other meaning phenomena in natural language; comparison of alternative theories of meaning.

Ling 5212. Linguistic Pragmatics. (4 cr; prereq 5002, 5201 or #) Gundel

Analysis and description of linguistic phenomena in relation to beliefs and intentions of language users; speech act theory, conversational implicature, shared knowledge and presupposition, topic-comment structure, discourse coherence.

Ling 5301. Phonetics. (5 cr, \$3301, \$5003; prereq 3001 or 5001 or ¶5001 or #) Stemberger

Production, acoustics, and perception of speech sounds; practice in production and transcription.

Ling 5302-5303. Introduction to Phonology.

(4 cr per qtr; prereq 3301 or 5301 or #) Stemberger  
5302: Formulation and evaluation of phonological descriptions; phonological processes in a variety of languages. 5303: Current approaches to phonological theory; metrical, autosegmental, and lexical phonology.

Ling 5401-5402. Computational Linguistics.

(4 cr per qtr; prereq 3001 or 5001 or #: some programming experience helpful)  
Methods and issues in computer understanding of natural language. LISP and Prolog programming languages, with emphasis on their linguistic applications. Lab projects.

Ling 5503. Introduction to Applied Linguistics. (4 cr; prereq 3001 or 3005 or 5001 or #) Cohen, Downing, Stenson, Tarone

Role of linguistics in neighboring disciplines; applications to practical fields such as lexicography, orthography, translation, language planning, reading, English and foreign language teaching, bilingual education, education of the deaf and correction of language disorders; computer applications; forensic applications.

## GRADUATE PROGRAMS

Ling 5601. Introduction to Historical Linguistics. (4 cr; prereq 5001 or #)  
Historical change in phonology, syntax, semantics, and the lexicon; factors underlying language change; linguistic reconstruction; genetic relationship among languages.

Ling 5602. Phonological Change and Reconstruction. (4 cr; prereq 3601 or 5601, 5302 or #)  
Change in phonological systems; factors underlying phonological change; internal and comparative reconstruction in phonology.

Ling 5691. History of Linguistics. (4 cr; prereq 3601 or 5601, 5202, 5303 or #)  
Examination of various objectives and methods of linguistic analysis from antiquity to the present.

Ling 5701. Introduction to Second-Language Acquisition. (4 cr; prereq 5002 or 5201, 5302, 5003 or 5301 or #) Cohen, Sheldon, Tarone  
Overview of second-language acquisition and processing; implications for second-language teaching.

Ling 5702. Second-Language Acquisition. (4 cr; prereq 5701 or #) Cohen, Sheldon, Tarone  
Empirical and theoretical studies of second-language acquisition and processing.

Ling 5711-5712. Field Methods in Linguistics. (4 cr per qtr; prereq #) Hutchinson, Stenson  
Techniques for obtaining and analyzing linguistic data from unfamiliar languages through direct interaction with a native speaker.

Ling 5720. Topics in Second-Language Acquisition. (3-4 cr [may be repeated for cr]; prereq 3001/5001 or #)  
Topics specified in *Class Schedule*.

Ling 5732. A Contrastive Approach to Modern English. (4 cr; prereq 3001 or 5001 or #; does not fulfill degree requirements for majors in Ling or ESL)  
Grammatical structures of standard English and contrastive analysis of these structures with those of another language. Implications for learning English as a second language.

Ling 5741-5742. Linguistic Description of Modern English. (4 cr per qtr; prereq 3001 or 5001 or #) Downing, Gundel  
Word and sentence structure of present-day English.

Ling 5751. Conversation Analysis. (4 cr, \$Spch 5461; prereq 3001 or 5001, Spch 3401 or #)  
Discourse processes involved in dyadic and multiparty conversation. Applying concepts through analysis of conversations.

Ling 5752. Field Research in Spoken Language. (4 cr, \$Spch 5462; prereq 5751 or Spch 5461 or #)  
Transcribing, coding, and analyzing spoken and recorded conversations.

Ling 5910. Seminar in Linguistics. (4 cr; prereq #)

Ling 5970. Directed Studies. (1-5 cr per qtr; prereq linguistics or ESL major, #, Δ, CLA approval)

Ling 8200. Topics in Syntax and Semantics. (4 cr [may be repeated for cr as topics change]; prereq 5206 or #) Gundel, Hutchinson, Kac

Ling 8210. Seminar in Syntax. (4 cr; prereq 5206, 5211 or #) Gundel, Hutchinson, Kac, Stenson

Ling 8211. Formal Semantics of Natural Language. (4 cr; prereq 5011 or Phil 5201 or #) Hutchinson, Kac  
Truth-conditional model-theoretic semantics applied to treatment of opacity, intensionality, quantification, and related phenomena in natural language.

Ling 8220. Seminar in Semantics. (4 cr; prereq 5211 or #) Gundel, Hutchinson, Kac

Ling 8300. Topics in Phonology. (4 cr [may be repeated for cr as topics change]; prereq 5304 or #) Stemberger

Ling 8310. Seminar in Phonology. (4 cr; prereq 5304, 5602 or #) Stemberger

Ling 8500. Seminar: Topics in Linguistics. (4 cr [may be repeated for cr as topics change]; prereq #)

Ling 8600. Topics in Historical Linguistics. (4 cr [may be repeated for cr as topics change]; prereq 5603 or #)

Ling 8731. Research Methods in Language Acquisition. (4 cr; prereq 5702 or 5805 or CDis 5305 or CPsy 5345 or #) Cohen, Sheldon, Tarone  
Critical review of research methods and design in the study of first- and second-language acquisition.

Ling 8820. Topics in Language and Cognition. (4 cr; prereq 5001 or #) Gundel, Stemberger  
Language-related issues in cognitive science from linguistic perspective.

Ling 8900. Independent Study. (1-5 cr per qtr; prereq linguistics major, #)  
Related courses in other departments may be elected as part of a linguistics major with the approval of the director of graduate studies.

## Luso-Brazilian Literature

See Hispanic and Luso-Brazilian Literatures and Linguistics.

## Management of Technology (MOT)

*Regents' Professor:* Vernon W. Ruttan (applied economics)

*Professor:* Yechiel Shulman (mechanical engineering), *director*, Center for the Development of Technological Leadership, and *co-director of graduate studies*; Mary Nichols (strategic management and organization), *co-director of graduate studies*; Carl R. Adams (information and decision sciences); Sandra O. Archibald (public affairs); Avram Bar-Cohen (mechanical engineering); Norman E. Bowie (philosophy); Norman L. Chervany (information and decision sciences); W. Bruce Erickson (strategic management and organization); Arthur V. Hill (operations and management sciences); Ettore F. Infante (mathematics); George John (marketing and logistics management); Edward J. Joyce (accounting); Timothy J. Nantell (finance); Dennis L. Polla (electrical engineering); Subbiah Ramalingam (mechanical engineering); Donald R. Riley (mechanical engineering); Kenneth Roering (marketing and logistics management); Aaron Shenhar (mechanical engineering); Andrew Van de Ven (strategic management and organization)

*Associate Professor:* Srinivasan Balakrishnan (strategic management and organization); Kevin J. Dooley (mechanical engineering); Karl Smith (civil and mineral engineering)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—M.S.MOT. (Plan B).

**Curriculum**—The management of technology program is an intensive, two-year practitioner-oriented program for experienced engineers and scientists who have achieved springboard positions in their organizations and want to manage technological activities. Students enter the program in the fall and advance as a cohort, taking a prescribed sequence of courses together, including a capstone project. Classes are held for a full day each week, on alternate Fridays and Saturdays, allowing students to carry on their full-time employment responsibilities while participating in the program. In addition to regular classes, the program includes three three-day domestic and one ten-day international residencies. Tuition and fees, books, supplies, weekly lunches, parking, a variety of services, and off-campus accommodations for all residencies are included in an annual comprehensive fee. For current program costs, contact the management of technology graduate program. To maintain

the atmosphere of teamwork in small groups and close contact among students, faculty, and invited lecturers, admission to the program is limited.

**Prerequisites for Admission**—A bachelor's degree in engineering or in a natural science discipline from an accredited program is required. Applicants should also have completed coursework (or can show proficiency) in economics, mathematical modeling, statistics, and computer literacy.

**Special Application Requirements**—A minimum of five years of professional experience in the applicant's technical field is required (in exceptional circumstances, promising candidates with less experience may be considered). Applicants are required to submit three letters of recommendation, a résumé, a statement of purpose, and Graduate Record Examination or Graduate Management Admission Test scores (if the applicant already holds a master's or Ph.D. degree, this test requirement is waived). The professional track record of the applicant weighs heavily in the admissions process. A personal interview with the director of graduate studies is required. Admission is in fall quarter only.

**Degree Requirements**—In addition to course requirements, students must successfully complete an oral examination and a written report on the capstone project.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Management of Technology Graduate Program, Center for the Development of Technological Leadership, University of Minnesota, 107 Lind Hall, 207 Church Street S.E., Minneapolis, MN 55455 (612/624-5747; fax 612/624-7510; e-mail MOT@cdtl.umn.edu).

MOT 8111. Marketing Management in Technology-Based Organizations. (4 cr, SMBA 8045; prereq MOT student) Roering  
Emphasizes marketing of industrial products. Overall consideration of marketing strategy. Issues of product strategy, including pricing, promotion, product mix, and sales and distribution decisions.

## GRADUATE PROGRAMS

**MOT 8112. Management Accounting.** (4 cr, \$MBA 8035; prereq MOT student) Joyce  
Introduction to methods for estimating and analyzing product costs and using cost information for product mix and pricing decisions. Cases from manufacturing firms used for understanding principles of activity-based costing. Uses of cost data in managerial decision making, budgeting and control, and financial statement analysis.

**MOT 8113. Manufacturing for Competitive Advantage.** (4 cr, \$MBA 8050, \$OMS 5100; prereq MOT student) Hill  
Overview of manufacturing functions and impact of manufacturing on competitiveness of firm. Strategic framework used to describe key relationships between operations and other functions in value chain (e.g., design, marketing, distribution) and to show how decisions within operations can be integrated to achieve strategic objectives. Product/process design, production, work force issues, and role of technology.

**MOT 8121I. Managing in a Technical Environment.** (4 cr; prereq MOT student) Erickson  
General management principles, with applications to management of professional, research and development, and technical personnel. Discussion, readings, cases, and projects.

**MOT 8122. Financial Management for Technology-Based Organizations.** (5 cr, \$MBA 8040; prereq MOT student) Nantell  
Development of concept of creating value with the organization. Use of financial methods most important to managers of technology-based organizations, including capital budgeting, projection of financial needs, and management of working capital.

**MOT 8131. Problem Formulation and Managerial Decision Making.** (2 cr, \$MBA 8070; prereq MOT student) Adams  
Basic characteristics of managerial decision making and concept of bounded rationality. General approach to definition of unstructured problems frequently encountered by higher-level management. Specific methods for problem expansion based on different lines of reasoning, such as cause-effect and systems thinking.

**MOT 8132. Quality Control and Management.** (4 cr, \$IEOR 5030; prereq MOT student) Dooley  
Concepts, methodologies, and techniques used to continuously improve quality and productivity of products and services. Managerial and technical aspects. Evolution of quality function, definitions of quality, conceptual contributions to quality management, quality as an operational strategy, statistical process control, fault diagnosis, design of experiments, reliability, and quality in product development process.

**MOT 8133I. Communications in a Technical Environment.** (4 cr; prereq MOT student)  
Oral and written communications. Introductory and specialized workshops. Memo writing, presentation skills, visual aid design and integration.

**MOT 8134. Support and Control of Manufacturing Processes.** (4 cr; prereq MOT student) Ramalingam

Overview of mechanical, microelectronic, and process industries with emphasis on discrete product and continuous flow manufacturing. Product realization process, product information content and its significance to design and manufacturing. Current design and manufacturing practices. Impact of information technology on automation of design and manufacture. Concurrent engineering and emphasis on quality and reduced cycle time, integration of design and manufacturing. Tools for computer-aided design and manufacture and standardization.

**MOT 8212. Managing Functional and External Interfaces in New Product Development.** (4 cr; prereq MOT student) John  
Need for and problems of organizational integration in development of product policy and execution of new product development process. Necessary organizational interactions among marketing, R & D, and operations in design and delivery of products.

**MOT 8213. Business, Government, and Macroeconomics.** (4 cr, \$MBA 8055; prereq MOT student) Erickson  
Business-government relations, especially as they affect scientific and technical issues, global competitiveness, and macroeconomic policies while they influence firms' domestic and international strategies and operations. Effects of legal and economic forces on management of firms, especially on their technical strategies.

**MOT 8214. Understanding and Forecasting Technology Development.** (4 cr; prereq MOT student) Van Wyk  
Introduction to methods of technology assessment and forecasting, and their application to study of history of technology and industry. Technological developments and their economic, social, and industrial impacts.

**MOT 8221. Project Management and Leadership.** (4 cr, \$OMS 8041; prereq MOT student) Shenhar, Smith  
Principles and methods for planning and controlling a project, including development of a project plan, resource planning and scheduling (PERT/CPM), project monitoring, and termination. Students develop skills for managing interdisciplinary project teams.

**MOT 8222. Technology Competitiveness and Development.** (2 cr, \$Econ 5312; prereq MOT student) Ruttan  
Technical change and economic growth, sources of productivity change, economics of research and development, science and technology policy.

**MOT 8223. Organizational Communication.** (3 cr, \$Spch 5441; prereq MOT student)  
Organizations as open systems, cultures, and politicized environments. Identification and management of problems developing from integration of organization and communication. Ethics and strategies in corporate communications.

MOT 8224!. Pivotal Technologies for the 1990s. (4 cr, §ME 8701; prereq MOT student) Bar-Cohen

Guest experts present state-of-the-art in pivotal technologies and principal barriers to their commercialization. In workshops, students work in groups to develop and present concepts for applying these technologies to an industrial setting.

MOT 8231. Managing Information Resources in a Technology-Based Organization. (3 cr, §IDSc 8101; prereq MOT student) Chervany  
Selection of information technologies; discussion of such issues as power and politics of information systems, trade-offs between centralization of computing (for global coordination) and decentralization (for local autonomy and innovation), role of information technology infrastructures, and information systems as competitive weapons.

MOT 8232. Managing Innovation in a Technological Environment. (4 cr; prereq MOT student) Shenhar, van de Ven  
Inputs, processes, and outputs of innovation ventures as they develop from concept to implementation. Developing a "road map" to guide innovation managers. Conditions that facilitate and inhibit innovation, typical patterns of innovation development, and adoption of innovations developed elsewhere.

MOT 8233. Strategic Technology Management. (4 cr; prereq MOT student) Chakravarthy  
Technology from general manager's standpoint, as key strategic resource for building competitive advantage of a firm. Important links between technology and strategic planning. Technology and global competition; creating, acquiring, and leveraging technology competence.

MOT 8234!. Project. (4 cr; prereq MOT student) Shulman  
Practicum carried out in cooperation with each student's home organization. Background research and full development, analysis, and proposed resolution of significant issue, applying concepts and methods learned in program. Faculty adviser provides support and evaluation.

MOT 8241!. Fundamentals of Simulation Modeling. (1 cr, §IEOR 5445, §OMS 8671; prereq MOT student)  
Computer simulation and hands-on work in building models using high-level simulation software.

MOT 8900. Conflict Management. (1 cr; prereq MOT student) Fiutak  
Theory and methods for applying conflict management techniques in organizations. Cooperative and competitive models of conflict, basics of bargaining, conflict strategies, communication styles, listening skills, dispute resolution, third-party mediation, and use of computers for conflict mediation.

MOT 8910. Corporate Responsibility. (2 cr; prereq MOT student) Bowie  
Principles of stakeholder management. Ethical framework for responsible management of investors, employees, customers, suppliers, and external community. Moral leadership, trust in organizations, and quality control. New metaphors and techniques for managing socially responsible firm.

## Mass Communication

*Professor:* Hazel F. Dicken-Garcia; Ronald J. Faber; Irving E. Fang; Donald M. Gillmor; Chin Chuan Lee; Daniel B. Wackman; William D. Wells

*Associate Professor:* Albert R. Tims, Jr., *director of graduate studies*; William A. Babcock; Tsan-Kuo Chang; Kenneth O. Doyle, Jr.; Kathleen A. Hansen; Nancy L. Roberts; Dona B. Schwartz

*Assistant Professor:* Michael S. Griffin

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A only) and Ph.D.

**Curriculum**—A general mass communication M.A. is offered that emphasizes the theoretical study of mass communication and analysis of media systems. It is intended for those who wish to pursue teaching and research careers and/or a Ph.D. Individuals who have extensive professional experience in mass communication or a B.A. degree in journalism and are interested in graduate work are encouraged to enter the M.A. program.

The doctoral program offers training for academic careers primarily in communication instruction, research, or policy. Areas of specialization include communication law and regulation, media ethics, international mass communication, history of mass communication, and mass media structures, processes, and effects.

Special facilities include the Minnesota Journalism Center for Professional Studies, the Silha Center for the Study of Media Ethics and Law, the China Times Center, the Eric Sevareid Library, and the SJMC Research Division.

**Prerequisites for Admission**—The minimum requirement for admission is the B.A. or equivalent.

**Special Application Requirements**—In addition to Graduate School requirements, a department application, letters of

recommendation, academic work samples, and scores from the General (Aptitude) Test of the Graduate Record Examination (GRE) are required. For students whose native language is not English, scores are required from the Test of English as a Foreign Language (TOEFL), but not from the GRE. Admission is in fall quarter; the application deadline is December 15.

**Master's Degree Requirements**—A minimum of 36 credits plus a thesis are required. Coursework must include 16 credits in required core courses, 8-12 credits in other journalism and mass communication seminars or courses, and 8-12 credits in other departments, in addition to the thesis. Students must also register for 16 master's thesis credits (Jour 8777). A final oral examination is required. All graduate coursework must be taken A-F.

**Doctoral Degree Requirements**—In consultation with an adviser, students select a dissertation field and supporting coursework. Areas of specialization may be tailored to suit students' interests, including communication law and regulation, media ethics, international mass communication, history of mass communication, and mass media structures, processes, and effects. Students complete a minimum of 88 credits, including 16 credits in required core courses, and 32 credits in departments outside of the school. Doctoral students must also register for 36 doctoral thesis credits (Jour 8888). All graduate coursework must be taken A-F. The written and oral preliminary examinations cover the proseminars and methodology courses, dissertation area, and supporting coursework.

**Language Requirements**—For the master's program, foreign language study is recommended for students in international mass communication. Doctoral students pursuing international study are expected to have high language proficiency, or obtain it, in the appropriate area. Doctoral students in other areas are encouraged to consult advisers regarding the appropriateness of language study for their chosen specialization.

**Minor Requirements for Students Majoring in Other Fields**—Minor programs are planned in consultation with the director of graduate studies or another member of the graduate

faculty in mass communication. A master's minor consists of a minimum of 12 credits in a coherent area, with at least 8 credits at the 8xxx level. A doctoral minor consists of a minimum of 18 credits in a coherent disciplinary area. Students completing a doctoral minor in mass communication are required to take a preliminary written examination covering their coursework.

**For Further Information and Applications**—Contact the Graduate Studies Center, School of Journalism and Mass Communication, University of Minnesota, 15 Murphy Hall, 206 Church Street S.E., Minneapolis, MN 55455 (612/625-4054; fax 612/626-8251; e-mail sjmgrad@tc.umn.edu).

Jour 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Jour 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Jour 8888. Thesis Credits: Doctoral. (36 cr required)

### Journalism and Mass Communication (Jour)

Jour 5251.\* Psychology of Advertising. (4 cr; prereq jour major or minor, 3004, Psy 1001, Δ) Faber Psychological principles, research techniques, and applications in advertising and selling. Consumer attitudes and behavior. Psychological mechanisms upon which effectiveness of advertisements and commercials depends.

Jour 5274.\* Advertising in Society. (4 cr; prereq jour major or minor, 3004, Δ) Wackman Advertising as an institution. Social and economic criticism. Ethics. Regulation and self-regulation.

Jour 5316.\* Theories of Visual Communication. (4 cr; prereq jour major or minor, 3004, 3006 or #, Δ) Schwartz Perspectives on study and analysis of visual communication; contributions from sociology, anthropology, psychology, and history. Message structure, systems of production, and use of visual media.

Jour 5501.\* Communication and Public Opinion I. (4 cr; prereq jour major or minor, 3004, Δ) Doyle, Lee Theories of communication process and of persuasion and attitude change. Functions of interpersonal and mediated communication in diffusion of information and in opinion formation.

**Jour 5531.\* Communication and Public Opinion II.** (4 cr; prereq jour major, 3004, 5501 or Soc 5355, Δ) Chang, Doyle

Advanced study of theories and research findings on opinion formation, persuasion, and diffusion of information. Social science contributions to studies of the process and effects of mass communication.

**Jour 5541.\* Mass Communication and Public Health.** (3 cr, §PubH 5394; prereq public hlth or epidemiology grad or jour grad student or #, social or behavioral science courses) Finnegan

Role, function, and effects of mass media on public health; planned and unplanned effects; review and analysis of literature to understand how theories, models, and assumptions of mass communication research relate to public health.

**Jour 5601.\* History of Journalism.** (4 cr; prereq jour major or minor, 3004, Δ) Dicken-Garcia, Roberts  
Development of American newspapers and periodicals, from beginnings in Europe to present day; rise of radio and television; relation of communications developments to political, economic, and social trends.

**Jour 5606.\* Literary Aspects of Journalism.** (4 cr; prereq jour major or minor, 3004, #, Δ) Roberts  
Literary aspects of journalism as exemplified in and influenced by works of English and American writers, past and present. Lectures, discussions, weekly papers.

**Jour 5611.\* Development of American Broadcasting.** (4 cr; prereq jour major or minor, 3004, Δ) Fang

Historical and economic development of radio and television in the United States; government regulation, industry self-regulation, forms of social control, contemporary broadcasting issues; the journalist as broadcaster.

**Jour 5615.\* History of Visual Communication in the Mass Media.** (4 cr; prereq jour major or minor, 3004, Δ) Griffin

Social history of photography, film, and video. Informational, documentary, propaganda, and entertainment functions of visual communication. Rise and influence of visual media industries and public image making.

**Jour 5721.\* Mass Media and U.S. Society.** (4 cr; prereq jour major or minor, 3004, Comp 3027 or #, Δ) Hansen

Economic, political, and social determinants of character and content of mass communication in United States. Structure and functioning of mass media. Problems, prospects, and criticism. Professionalism, technology, and reform.

**Jour 5725.\* The Management of Media Organizations.** (4 cr; prereq jour major or minor, 3004, Δ)

Media organizations as businesses; economics of mass media; markets, finances, organizational structure, and management practices of principal media industries; issues in media management.

**Jour 5726.\* Case Studies in Modern Media Management.** (4 cr; prereq for jour student: jour major or minor status, 3004, Δ; prereq for others: #, Δ; 5725 recommended)

How media managers make decisions dealing with money, marketing, product, personnel, and production information. Interaction between quality, price, service, and the limits of technology.

**Jour 5731H.\* Honors Course:**

Communications Problems and Issues. (4 cr; prereq jour major or minor, 3004, sr, #, Δ, honors div regis) Hansen, Roberts, Wells

Individual project and topical seminar of major problems and issues of communication.

**Jour 5741. Minorities and Mass Media.** (4 cr, §Afro 5910; prereq jour major or minor, 3004, Δ)  
Relationships between mass media and communities of color in United States. Issues of content and control.

**Jour 5771. Media Ethics: Principles and Practice.** (4 cr; prereq jour major or minor, 3004, #, Δ) Babcock

What it means to act ethically; tools to identify and analyze ethical issues; ethical norms of print and broadcast journalism, photojournalism, public relations, and advertising.

**Jour 5777.\* Contemporary Problems in Freedom of Speech and Press.** (4 cr; prereq jour major or minor, 3004, Δ) Gillmor

Legal and constitutional derivation of freedom of speech and press with emphasis on case law, judicial theories, doctrines, tests and values. Symbolic, commercial, compelled speech, speech plus, petition and assembly, leading press cases, legal research techniques.

**Jour 5801.\* International Communication.** (4 cr; prereq jour major or minor, 3004, Δ) Chang, Lee  
Structures, processes, and consequences of international mass communication. Problems in the free flow of information. Roles of international organizations. Mass communication in social, political, economic development; implications for conflict resolution.

**Jour 5825.\* World Communication Systems.** (4 cr; prereq jour major or minor, 3004, Δ) Chang  
Mass media systems of the world, described and analyzed regionally and nationally, with special reference to historical roots, social, economic, and cultural context, contemporary conditions and prospects, and the relevance of journalism and mass communication to international affairs.

**Jour 5970.\* Advanced Projects in Journalism.** (1-4 cr per qtr [max 8 cr]; prereq jour major or minor, 3004, B avg, #, Δ, □)

Independent study; projects.

**Jour 5970H.\* Honors Course: Advanced Projects in Journalism.** (1-4 cr per qtr [max 8 cr]; prereq jour major or minor, 3004, B avg, #, Δ, □, honors div regis)

Independent study; projects.

## GRADUATE PROGRAMS

Jour 5990.\* Special Topics in Mass Communication. (1-4 cr per qtr [max 8 cr]; prereq jour major or minor, 3004, #, Δ)  
Topics announced in *Class Schedule*.

Jour 8010-8020.\* Studies in Mass Communication. (4 cr per qtr) Chang, Dicken-Garcia, Faber, Griffin  
*8010*: Historical development of mass communication studies in social sciences, humanities, and legal areas; survey of research literature using individualistic and structural approaches to mass communication. *8020*: Survey of literature on history of mass communication; cultural and humanistic approaches to study of mass communication; legal/ethical issues in mass communication.

Jour 8501.\* Seminar: The Process of Quantitative Mass Communication Research. (4 cr; prereq 12 cr soc sci, statistics course or ¶) Doyle, Wackman  
Survey of quantitative research methods. Relationship between theory and research, concept explication, measurement, instrumentation, and design issues. Methods such as social surveys, content analysis, and experimentation.

Jour 8502.\* Seminar: Mass Communication Research Design. (4 cr; prereq 8501, statistics course or ¶) Doyle, Faber  
Application of social research methods to theoretical issues and problems in mass communication studies. Advanced issues in theory testing, problem definition, sampling and design considerations. Students design projects and gather data.

Jour 8503.\* Seminar: Mass Communication Research Analysis. (4 cr; prereq 8502, statistics course or ¶) Doyle  
Quantitative analysis of mass communication research. Analysis strategies, application of multivariate models, and reporting of research findings. Students analyze data from projects conducted in Jour 8502.

Jour 8513.\* Seminar: Ethnographic Methods in Mass Communication Research. (4 cr; prereq proseminars or #, Δ) Schwartz  
Theoretical foundations in anthropology and sociology; field projects.

Jour 8560.\* Seminar: History of Mass Communication. (4 cr; prereq 5601, #, Δ) Dicken-Garcia  
Research methods; development of a research project.

Jour 8580.\* Seminar: Problems in International Communication Research. (4 cr; prereq 5801 or 5825 or #, Δ) Chang  
Research strategies and designs relating to telecommunications and mass communication, with emphasis on comparative and cross-cultural analysis and Third World developmental concerns.

Jour 8620.\* Seminar: Advertising Research. (4 cr; prereq 5251 or #, Δ) Faber  
Advertising as persuasive communication. Current research findings and theory related to advertising decision-making process. Measurement issues in advertising and market research.

Jour 8630.\* Seminar: Visual Communication Research. (4 cr; prereq 5316, proseminars or #, Δ) Griffin  
Research in visual communication. Theoretical approaches, analysis of research methods, development of research designs and projects.

Jour 8640.\* Seminar: Broadcast News. (4 cr; prereq 5442 or #) Fang  
Major issues in broadcast journalism; confrontations between federal government and network news departments; historical studies of broadcast news.

Jour 8650.\* Seminar: Mass Communication Theory. (4 cr; prereq proseminars, #, Δ) Lee, Tims  
Research paradigms, concepts, and findings that offer promise for development of a general theory of mass communication.

Jour 8651.\* Seminar: Mass Media and Social Change. (4 cr; prereq statistics course, #, Δ)  
Research designs; procedures for quantitative studies of media control, content, audiences, and effects; structural models for mass media research; relationships between research and decision making.

Jour 8660.\* Seminar: History of Mass Communication. (4 cr; prereq 5601, #, Δ) Roberts  
Research in history and development of U.S. mass media.

Jour 8661.\* Seminar: History of Mass Communication. (4 cr; prereq 5601, #, Δ) Dicken-Garcia, Roberts  
Theories and models in historical literature; major research paper.

Jour 8662.\* Seminar: Literary Aspects of Journalism. (4 cr; prereq 5606, #, Δ) Roberts  
Research in literary aspects of journalism exemplified in careers and works of English and American writers.

Jour 8670.\* Communication Agencies as Social Institutions. (4 cr per qtr; prereq 5721 or equiv or #, Δ) Babcock  
Influence and effects of mass communication, internal dynamics of media organizations, criticism and modes of reform. Theoretical frameworks for analysis.

Jour 8671.\* Seminar: Communication Ethics—Public/Civic Journalism. (4 cr; prereq grad student, Δ) Babcock  
Historical underpinnings, philosophical debate, theoretical dynamics, legal concerns, and ethical implications.

Jour 8673.\* Seminar: Media Management. (4 cr; prereq #, Δ; 5725 or 5726 recommended) Management issues in media organizations; relation to dynamics of organization structure, employees, markets, and economics/finances.

Jour 8675. Seminar: Issues in Information Access and Communication. (4 cr; prereq 5731 or equiv or #, Δ; offered alt yrs) Hansen Information access issues as they relate to mass communication concerns. Societal, industry, technological, and policy aspects and developments that affect information access, particularly through mass media.

Jour 8678.\* Government and Mass Communication: Constitutional Law. (4 cr; prereq 5777 or #, Δ) Gillmor Problems of constitutional and tort law affecting press and theories that underlie them.

Jour 8679.\* Seminar: Research Methods in Media Ethics and Law. (4 cr; prereq Δ) Babcock Focuses on research at intersection of the first amendment and media ethics.

Jour 8681, 8682.\* Seminar: International Mass Communication. (4 cr per qtr; prereq 5801 or 5825 or #, Δ) Lee Main problems and currents of international mass communication. Focus on concepts, research, and policy relevant to global development, including issues of freedom and constraint, media technology, and role of journalism in world affairs.

Jour 8970.\* Advanced Projects in Mass Communication. (1-4 cr per qtr [max 8 cr]; prereq grad major or minor in mass communication, #, Δ) Individual research.

Jour 8990.\* Special Problems in Mass Communication. (4 cr per qtr; prereq #, Δ) Special topics for seminars.

## Professional (Skills) Courses

While open to graduate students, these courses typically are not included in a mass communication master's or doctoral degree program.

Jour 5131.\* Interpretive Reporting. (4 cr; prereq jour major, 3004, 3121 or 3173 or 5155, Δ, pass 40 wpm keyboarding test with 6 or fewer errors) Advanced problems in reporting about government, politics, social problems, and the arts.

Jour 5155.\* Advanced Reporting Methods. (4 cr; prereq jour major, 3004, C or higher in 3101, pass 40 wpm keyboarding test with 6 or fewer errors, Δ) Investigative techniques for mass media, including quantitative research methods, use of records and documents, analysis of statistics, advanced interviewing, and methods for adverse conditions.

Jour 5159. Case Studies in Public Relations. (4 cr; prereq jour major, 3004, 3159, Δ) Tims Case study approach to application of public relations principles to solution of problems in business, government, education, and community. For sharpening perceptions, insights, and judgments in examining practical and ethical questions.

Jour 5171.\* Arts Reviewing and Reporting. (4 cr; prereq for jour students: jour major status, 3004, C or higher in 3101, pass 40 wpm keyboarding test with 6 or fewer errors, Δ; prereq for nonmajors: #, Δ) Covering the arts and entertainment beat, both as a reviewer and a reporter. Assignments follow Twin Cities arts and entertainment season, including its controversies. Weekly writing assignments, readings, field trips, guest lectures from artists and arts journalists.

Jour 5174.\* Magazine Editing and Production. (4 cr; prereq jour major, 3004, 3155 or 3173 or 3321 or 5302 or prof exper, #, Δ) Roberts Writing, editing, illustration, design, layout, photocomposition of a single-issue magazine.

Jour 5261.\* Advertising: Media Analysis. (4 cr; prereq jour major, 3004, 3201 or #, Δ) Tims Print and electronic media, their role in advertising; selection and scheduling; rate structures and policies; evaluation and use of media and market measurements and data.

Jour 5263.\* Advertising Campaign Planning. (4 cr; prereq jour major, 3004, 5261, Mktg 3000 or #, Δ) Faber, Wells Development of campaign strategy and tactics. Emphasis on planning and decision-making skills needed to design effective advertising campaigns.

Jour 5321. Publication Graphics. (4 cr; prereq jour major, 3004, 3321, Δ) Role of design process in production of magazines, brochures, and newsletters. Computer as design tool; preparing electronic documents for printing process.

Jour 5441.\* Electronic Newsgathering. (4 cr; prereq jour major, 3004, 3451, Δ; lect, lab, news production hrs) Modern television news reporting. Demonstrations and field exercises in planning, lighting, shooting, editing, and scripting typical broadcast news assignments.

Jour 5442.\* Advanced Television News. (4 cr; prereq jour major, 3004, 3451, pass 40 wpm keyboarding test with 6 or fewer errors, Δ; lect, lab, news production hrs) Fang Preparation and delivery of television newscasts. Current problems of the industry. Legal and ethical considerations. Social impact of electronic journalism.

## Materials Science and Engineering

See Chemical Engineering.

## Mathematics (Math)

*Professor:* Naresh Jain, *head*; Donald W. Kahn, *director of graduate studies*; Alfred Aeppli; Stephen B. Agard; Greg W. Anderson; Donald G. Aronson; John Baxter; Thomas Berger; John A. Eagon; Paul H. Edelman; Eugene B. Fabes; Mark Feshbach; Avner Friedman; Bert Fristedt; Paul B. Garrett; J. Gil de Lamadrid; Jay Goldman; Lawrence F. Gray; Leon W. Green; Robert D. Gulliver II; Morton Harris; Dennis Hejhal; Ettore F. Infante; Max A. Jodeit, Jr.; Harvey Keynes; Nicolai V. Krylov; Walter Littman; Mitchell B. Luskin; Gennady Lyubeznik; Albert Marden; Charles McCarthy; Richard McGehee; William Messing; Norman G. Meyers; Willard Miller, Jr.; Richard Moeckel; Wei-Ming Ni; Johannes C. C. Nitsche; Peter J. Olver; Marian B. Pour-El; Karel Prikry; Edgar Reich; Peter A. Rejto; Joel Roberts; Mikhail Safonov; Fadi Santosa; David Sattinger; George R. Sell; Yasutaka Sibuya; Steven I. Sperber; Dennis W. Stanton; Marvin L. Stein; David A. Storvick; Vladimir Sverak; Peter J. Webb; Hans F. Weinberger; Dennis E. White

*Associate Professor:* Scot Adams; Bennett Chow; Bernardo Cockburn; Jack F. Conn; David Frank; E. Gebhard Fuhrken; Lisl N. Gaal; Hillel Gershenson; Laurence Harper; John S. Lowengrub; Chester L. Miracle; Wayne Richter

*Adjunct Associate Professor:* Blaise Morton

*Assistant Professor:* Satyanad Kichenassamy; Nai-Chung Leung; Victor Reiner; John M. Sullivan

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B), M.S. (Plan A and Plan B), and Ph.D.

**Curriculum**—Special areas of research include ordinary and partial differential equations; probability; real, complex, harmonic, functional and numerical analysis; differential and algebraic geometry; topology; number theory, algebra, and group theory; logic; combinatorics; mathematical physics and industrial mathematics. The M.S. Plan A includes a program with emphasis in industrial and applied mathematics. The M.S. Plan B includes a program with emphasis in mathematics education.

See also Control Science and Dynamical Systems, and Fluid Mechanics in this bulletin for Ph.D. programs that rely heavily on mathematics.

**Prerequisites for Admission**—A solid background in undergraduate-level mathematics is expected. For students whose goal is the Ph.D. degree, their background should include full-year courses in analysis, abstract algebra, and topology (roughly equivalent to Math 5612-5613-5614, 5282-5283-5284, and 5341-5342 and 5343).

Entering students are ordinarily admitted to the master's degree program. Transfer to the Ph.D. program is made when the Ph.D. preliminary written examination is passed (and does not require earning a master's degree).

**Special Application Requirements**—All applicants are expected to submit three letters of recommendation, a score from the Graduate Record Examination Subject (Advanced) Test in mathematics, and a supplementary application form available from the mathematics department. Applicants desiring financial assistance should submit their applications, including the departmental form, GRE scores, and letters of recommendation, to the director of graduate studies no later than January 15 to be considered for a fellowship, and no later than February 15 to be considered for a teaching assistantship. Students normally are admitted fall quarter only.

**Master's Degree Requirements**—There are two options: Plan A and Plan B. Under Plan A, students must write a thesis and complete a minimum of 28 credits of graduate-level coursework. Plan B allows more breadth; students must complete at least 48 credits of graduate-level coursework, of which 50 percent could be in areas outside of mathematics. A final oral examination is required.

For more information, see the *Graduate Studies in Mathematics* publication.

**Doctoral Degree Requirements**—The Ph.D. preliminary written examinations, given twice each year, cover real analysis, complex analysis, algebra, and manifolds and topology. Students are required to pass the examination by the end of their second year. After passing the written examination and completing the coursework for the program, students may take the preliminary oral examination for the Ph.D. degree. This examination is given at the convenience of students and faculty, and tests the thesis area and the minor or supporting program. Students are required to pass this examination by the end of their fourth year.

If a supporting program is chosen, it may consist partly or entirely of mathematics courses.

For more information, see the publication *Graduate Studies in Mathematics*.

**Language Requirements**—For the master’s degree—none. For the doctoral degree, two foreign languages are required from among the following: French, German, Russian, and Italian.

**Minor Requirements for Students Majoring in Other Fields**—For the master’s degree minor, a three-quarter 8xxx or 5xxx sequence is required. For the Ph.D. minor in mathematics, coursework must include 1) a three-quarter 8xxx sequence or a three-quarter 5xxx sequence that has two quarters of 5xxx coursework as prerequisites, or one of the following sequences: 5282-5283-5284, 5341-5342-5343, 5571-5572-5573 or 5612-5613-5614; and 2) any three-quarter 8xxx or 5xxx sequence or any two two-quarter 8xxx or 5xxx sequences.

**For Further Information and Applications**—Contact the School of Mathematics, University of Minnesota, 127 Vincent Hall, 206 Church Street S.E., Minneapolis, MN 55455 (612/625-1306; fax 612/626-2017; e-mail gradprog@math.umn.edu).

*Note*—Certain 5xxx courses are acceptable only for satisfaction of the minor requirements in mathematics and may not be counted toward the total credits required for a master’s or doctoral program in mathematics. Such courses are designated by the phrase “no grad cr for math majors.”

Because topics courses are offered only when feasible, primarily to serve the needs of Ph.D. candidates, all advanced students are urged to request useful topics by February 1 before the academic year containing the desired courses.

“Offered alternate years,” for the mathematics course listing only, means offered regularly, but not annually, and not necessarily every other year.

Math 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Math 8777. Thesis Credits: Master’s. (16 cr required; Plan A only)

Math 8888. Thesis Credits: Doctoral. (36 cr required)

Math 5005, 5006, 5007. The Diversity of Mathematics. (4 cr; prereq elem educ major, 1005-1006 or equiv, 10 more cr college-level math; no grad cr for math majors)

Mathematics enrichment topics for elementary school instructors. *5005*: number theory, including prime numbers and congruences, and fractions and decimals. *5006*: polyhedra, regular and semi-regular map coloring, graph theory and applications. *5007*: analysis of two-person mathematical games.

Math 5056. Theory of Interest. (4 cr; prereq 1252 or equiv)

Application of compound interest formulas to determine present value, payment schedules, and effective interest and discount rates for installment loans, annuities, sinking funds, bonds, and other securities, including differing payment periods and interest conversion periods.

Math 5057-5058-5059. Actuarial Mathematics I-II-III. (4 cr per qtr; prereq 5056, 1 qtr 5xxx probability or statistics; carries grad cr for actuary math majors only)

Survival function; actuarial notation; actuarial present values for life insurance and life annuities. Equivalence principle; net premiums and reserves; multiple life functions and multiple decrement models; valuation of pensions. Further topics at instructor’s discretion.

Math 5081. Fundamental Topics in Analysis. (4 cr; prereq ¶3531H or 3211 or equiv; no grad cr for math majors)

Primarily for prospective secondary teachers. To develop analytic abilities and to broaden perspective on and enhance interest in mathematics. May include real number systems, theory of sets, continuous functions, and properties of limits.

Math 5082. Fundamentals of Algebra. (4 cr; prereq 3511H or 3212 or 3142 or 3221 or equiv; no grad cr for math majors)

Primarily for prospective secondary teachers. Number theory, including fundamental theorem of arithmetic and congruences; at least one general algebraic structure—group ring, or field; equivalence relations; possibly other topics. Proofs by mathematical induction and by contradiction.

Math 5083. Fundamentals of Geometry. (4 cr; prereq 3142, 3211 or 3211, 3221 or 3212 or 3511H or equiv; no grad cr for math majors)

Primarily for prospective secondary teachers. One non-Euclidean geometry, including attention to the axiomatic approach; topics involving three or more dimensions; some use of transformations; possibly other topics. Proofs by contradiction.

Math 5151. Elementary Set Theory. (4 cr; prereq one 32xx Math course or equiv or #)

Basic properties of operations on sets, cardinal numbers, simply ordered sets, well-ordered sets, ordinal numbers, axiom of choice, axiomatics.

## GRADUATE PROGRAMS

Math 5152. Elementary Mathematical Logic. (4 cr; prereq one 32xx Math course or equiv or #) Grammar and semantics of first and second order languages; relational structures; a deductive system for first order logic; completeness theorem; axiomatics of formal theories.

Math 5162-5163-5164. Mathematical Logic. (4 cr per qtr; prereq 1 yr calculus or equiv or Phil 5202 or #)

*5162*: Theory of computability: notion of algorithm, Turing machines, primitive recursive functions, recursive functions, Kleene Normal form, Recursion Theorem. *5163*: Probability and truth in formal systems: propositional and predicate logic, models of axiom systems, Gödel Completeness Theorem, nonstandard analysis. *5164*: Gödel Incompleteness Theorem: decidable and undecidable theories, models of arithmetic.

Math 5209. Theory of Numbers. (4 cr; prereq one 32xx Math course or equiv or #; no grad cr for math majors)

Rigorous introduction to elementary theory of numbers developed up to classical results about congruences to a prime modulus (e.g., Fermat's Theorem). Another advanced topic such as continued fractions, Gaussian integers, or quadratic reciprocity usually covered.

Math 5232-5233. Computer-Oriented Linear Algebra. (4 cr per qtr, \$5242-5243, \$5247, \$5284; prereq 1261, 3261 or 3142 or equiv or #; no grad cr for math majors)

Linear transformations on finite dimensional vector spaces. Linear dependence, matrix algebra, inner products, orthogonality, matrix inversion presented from algorithmic viewpoint, with students constructing and running illustrative computer programs. Eigenvalues and eigenvectors, Jordan canonical form, polar representation of linear transformations, determinants.

Math 5242-5243. Linear Algebra With Applications. (4 cr per qtr, \$5232-5233, \$5247, \$5284; prereq 1261, 3261 or 3142 or equiv or #; no grad cr for math majors)

Systems of linear equations, finite dimensional linear spaces, bases, linear transformations, matrices, determinants, eigenvalues, reduction to canonical forms, quadratic and bilinear forms, applications.

Math 5245-5246-5247. Introduction to Modern Algebra I-II-III. (4 cr per qtr, \$5282 for 5245, \$5283 for 5246, \$5284 for 5247; prereq three 32xx Math courses or equiv or #; no grad cr for math majors)

Basic algebra at more concrete level than 5282-5283-5284. Group theory, including normal subgroups, homomorphism, theories of Lagrange and Cayley. Ring theory, including ideals, integral domains, Euclidean rings, polynomial rings; fields. Linear algebra, including an abstract approach to vector spaces; linear transformations and their structure.

Math 5282-5283-5284. Fundamental Structures of Algebra. (4 cr per qtr; prereq one soph-level sequence or #, some previous abstract math recommended)

Theory course, principally for students planning mathematics graduate work. Group theory: normal subgroups, homomorphisms, automorphisms, and the theorems of Lagrange, Cayley, and Sylow. Ring theory: rings, ideals, integral domains, Euclidean rings, polynomial rings, fields. Linear algebra—abstract approach to vector spaces, linear transformations, and the theory of canonical forms including the Jordan and rational canonical forms.

Math 5331-5332-5333. Geometry I-II-III. (4 cr per qtr, \$3161 for 5331, \$5083 for 5332; prereq 1261 or equiv; no grad cr for math majors)

Advanced Euclidean geometry; axiomatic and analytic hyperbolic geometry; projective geometry; symmetry and geometrical transformations and their connections to linear algebra, group theory, and complex arithmetic; finite geometries, convex geometrical figures.

Math 5341-5342. Introduction to Topology. (4 cr per qtr; prereq one soph-level sequence or #, some previous abstract math recommended)

Set theory: axiom of choice, Zorn's lemma. Metric spaces: completeness, compactness, continuity. Basic point set topology: countability and separation axioms, Urysohn's lemma, compactness, connectedness, product spaces.

Math 5343. Introduction to Algebraic Topology. (4 cr; prereq 5342)

Classification of two-manifolds, fundamental group, homology theory.

Math 5375-5376-5377. Differential Geometry. (4 cr per qtr; prereq 3252 or equiv or # for 5375; 5375, 3261 or 3142 or equiv for 5376-5377)

Plane and space curves. Frenet formulas, elementary theory of surfaces. Differential forms. Advanced theory of surfaces, integral geometry, Riemannian geometry.

Math 5381-5382. Introduction to Basic Algebraic Geometry. (4 cr per qtr; prereq multivariable calculus, 3521H-3531H or 3551H-3552H, #) Geometry of polynomials defining curves and surfaces. Uses computer algorithms and packages for manipulating polynomials.

Math 5404. Variational Problems. (4 cr; prereq 3252, 3261 or equiv or #; offered when feasible)

Math 5428. Mathematical Models in Economics and the Social, Actuarial, and Management Sciences. (4 cr; prereq 3261 or equiv or #; no grad cr for math majors)

Mathematical models and associated mathematical techniques for describing behavior of and for optimizing various systems. How to find a model for a given situation.

Math 5447-5448-5449. Mathematical Thermodynamics. (4 cr per qtr; primarily for math majors interested in applications, for engineers, for scientists; prereq 5567, 5568 or 5607 or 5613 or #; offered when feasible)

Math 5457-5458-5459. Methods of Applied Mathematics. (4 cr per qtr; prereq 3252, 3261 or equiv; 3262 recommended)

Modern analytic tools used in applications of mathematics; emphasis on technique. Linear algebra, ordinary and partial differential equations, calculus of variations, Fourier series, complex variables, optimization, numerical methods.

Math 5463-5464-5465. The Mathematics of Industrial Problems. (4 cr per qtr; prereq 2 yrs calculus including ¶13262 or equiv, familiarity with FORTRAN, Pascal or C, #)

Industrial problems such as crystal precipitation, air quality modeling, color film developing, laser semiconductors. Theoretical foundations and computational methods involving ordinary and partial differential equations, calculus of variations, and numerical analysis.

Math 5473-5474-5475. Analysis of Numerical Methods. (4 cr per qtr; prereq 3252, 3261 or equiv; some computer skills recommended)

Interpolation and approximation by polynomials. Solution of linear and nonlinear systems of equations. Methods for eigenvalue problems. Numerical integration. Numerical solution of ordinary differential equations. Selected topics if time permits.

Math 5477-5478-5479. Applied Numerical Analysis of Partial Differential Equations. (4 cr per qtr; prereq 5242 or equiv, 5608 or equiv, 5513 or equiv, computer skills or #)

Numerical methods for the partial differential equations of linear and nonlinear elasticity, compressible and incompressible fluid flow, multiphase flow, heat transfer, and other selected systems of partial differential equations.

Math 5512-5513. Differential Equations With Applications I-II. (4 cr per qtr; prereq 3261 or equiv or #; 3262 recommended; no grad cr for math majors)

5512: Applications, review of special techniques, and numerical approximation for first-order equations. Euler and Runge-Kutta methods with error analysis. Applications and power series solutions for second-order equations. 5513: Applications and Laplace transforms for second-order linear equations. First-order linear systems with elementary linear algebra. Phase-plane analysis with applications. Boundary value problems and an introduction to partial differential equations.

Math 5514. Integral Equations. (4 cr; prereq 3261 or 5512 or equiv or #; no grad cr for math majors)

Integral equations; Fredholm formula, Neumann series, Laplace transforms, successive approximations, and numerical methods. Relation of integral equations to systems of linear algebraic equations and to differential equations.

Math 5521-5522-5523. Introduction to Ordinary Differential Equations. (4 cr per qtr; prereq one soph-level sequence or #; abstract math recommended)

5521: Existence and uniqueness theorems; successive approximations; differential inequalities; linear systems; fundamental matrix solutions; linear systems with constant coefficients; variation of parameters. 5522: Phase plane analysis; Poincaré-Bendixson theory; linear and nonlinear oscillations; stability theory; asymptotic behavior of solutions; control theory. 5523: Power series solutions, majorant method; regular and irregular singular points; error estimates, perturbation methods.

Math 5531-5532-5533. Dynamical Systems and Chaos. (4 cr per qtr; prereq multivariable calculus, linear algebra)

Introduction to dynamical systems theory, emphasizing iteration of mappings of line, circle, and plane. Fixed points, periodic points, stability, bifurcations, invariant Cantor sets, rotation number, Smale horseshoe, fractal dimension, Julia sets, Mandelbrot sets, nonlinear oscillations, computer experiments.

Math 5567. Fourier Series and Boundary Value Problems. (4 cr; prereq 3261 or equiv or #; 3262 recommended; no grad cr for math majors)

Partial differential equations of theoretical physics. Fourier series, proof of convergence, orthogonal systems. Sturm-Liouville systems, solution of boundary value problems by separation of variables, applications.

Math 5568. Elementary Theory of Complex Variables. (4 cr, §3541, §5572; prereq 3252 or equiv) Derivative and integral of a function of a complex variable. Cauchy's integral theorem and formula, residues. Application to evaluation of integrals, conformal mapping.

Math 5569. Operational Mathematics. (4 cr, §5573; prereq 5568)

Laplace transforms, Fourier transforms, inversion theorems; applications to differential equations.

Math 5571-5572-5573. Elementary Partial Differential Equations. (4 cr per qtr, §5568 for 5572 and for 5573; prereq 5613 or ¶5608)

Partial differential equations of theoretical physics, one-dimensional wave equation, characteristics, classification of second-order equations, heat and Laplace equations, uniqueness, maximum principle, orthogonal systems, Fourier series, separation of variables. Complex numbers, derivatives and integrals of analytic functions, elementary functions and their geometry, Cauchy's integral theorem and formula, Laurent expansions, evaluation of contour integrals by residues. Fourier and Laplace transforms and their inversion, method of residues, applications to ordinary and partial differential equations, applications to heat, wave, and Laplace equations.

## GRADUATE PROGRAMS

Math 5606-5607-5608. Advanced Calculus: A Rigorous Approach. (4 cr, \$5612 for 5606, \$5613 for 5607, \$5614 for 5608; prereq 3252 or equiv, ¶13262; no grad cr for math majors)

Basic analysis course at a more concrete level than 5612-5613-5614. Foundations of analysis: completeness of the line, limits, convergence, continuity, integration. Analysis on the line and in Euclidean space. Other topics chosen by instructor.

Math 5612-5613-5614. Introduction to Analysis. (4 cr per qtr; principally for non-math grad students and math undergrads planning grad work; prereq 3252 or equiv, ¶13262)

Theory of real numbers; elements of point set theory; limits; differentiation; multivariable analysis.

Math 5679. Probability. (4 cr, \$5681, \$Stat 5131; prereq 3252 or equiv; not recommended for those going on in probability or statistics; no grad cr for math majors) Probability spaces, expectation; conditional probability and expectation, probability distributions and densities, repeated trials and independence.

Math 5681-5682-5683. Probability and Stochastic Processes. (4 cr per qtr, \$5679 and \$Stat 5131 for 5681; prereq 3252 or equiv; ¶13262 recommended)

Logical development and various applications of probability. Probability spaces, random variables and their distributions and expected values, law of large numbers and central limit theorem, generating functions. Topics from many random walks and Markov chains, branching processes. Poisson point processes, martingales, stationary sequences, second-order processes, stochastic differential equations.

Math 5701. Enumerative Combinatorics. (4 cr; prereq 3251 or equiv; 3xxx linear algebra recommended) Basic enumeration. Sets, permutations, distributions, partitions, generating functions (exponential and ordinary), recurrence relations, methods of inclusion-exclusion, and Polyá theory.

Math 5702. Graph Theory and Optimization. (4 cr; prereq 3251 or equiv; 3xxx linear algebra recommended)

Basic concepts in graph theory. Connectedness, Hamiltonian and Eulerian paths, trees, colorings, and matchings. Topics in optimization: networks, flows, spanning trees, and graph algorithms. Definitions and examples of designs, Latin squares, and codes.

Math 5703. Constructive Combinatorics. (4 cr; prereq 5701, knowledge of a computer language) Algorithmic and bijective approaches to permutations, subsets, trees, tableaux, partitions, ranking and unranking algorithms. Connections with generating functions. Lagrange inversion formula.

Math 5900. Tutorial Course in Advanced Mathematics. (Cr ar; prereq #)

Qualified students whose needs are not met by courses offered may make arrangements to study the content of other graduate courses regularly offered by the department.

Math 8000!. Preparation for Teaching College Mathematics. (2 cr; prereq math PhD student beyond 1st yr in good standing, #)

Teaching/learning, incorporating new approaches in teaching, issues in math education, components and expectations of being a college math professor.

Math 8140-8141-8142. Applied Logic. (3 cr per qtr; prereq #)

8140: Theory of computability: Turing machines, partial recursive functions, recursive functions, primitive recursive functions, Kleene Normal Form, Smm-theorem, recursion theorem, reducibilities and degrees of unsolvability; complexity of computation-polynomial time, nondeterministic polynomial time, and polynomial space computabilities,  $OP=NP$  problem.

8141: Propositional and predicate logic with selected applications to computer science (e.g., program verification, machine proving, database theory).

8142: Selected topics.

Math 8150-8151-8152. Axiomatic Set Theory. (3 cr per qtr; prereq 5162-5163-5164 or #: offered alt yrs)

Axiomatic development of set theory, set theory as a foundation for mathematics. Consistency and independence of the axiom of choice, the continuum hypothesis and other questions, theory of types, theory of categories and other alternative systems.

Math 8166-8167-8168. Recursion Theory. (3 cr per qtr; prereq 5162-5163-5164 or #: offered alt yrs)

Detailed analysis of the concept of computability—including a discussion of the various equivalent definitions of this concept; primitive, general, and partial recursive functions—the enumeration theorem and the recursion theorem: recursive and recursively enumerable sets (including the priority method); relation between recursively enumerable sets and formal theories, creative and effectively inseparable theories; arithmetical and analytic hierarchies—including a discussion of constructive ordinals; higher order computability.

Math 8172-8173-8174. Model Theory. (3 cr per qtr; prereq 5164 or #: offered alt yrs)

Study of the interrelationship between formal languages (first order, as well as higher order, infinitary, etc.) and model structures based on the notion of satisfaction (two-valued, as well as other, e.g., Boolean valued); basic theorems (e.g., Lowenheim-Skolem theorems, compactness theorems); characterization of classes (e.g., EC, PC); preservation of properties under algebraic constructions; ultraproducts; special kinds of structures (e.g., homogeneous, saturated); applications to classical branches of mathematics.

Math 8181-8182-8183. Formal Languages and Automata. (3 cr per qtr; prereq 5162, ¶15163, ¶15164; offered when feasible)

Math 8190-8191-8192. Topics in Logic. (1-3 cr per qtr; prereq 5164 or #)

Math 8200-8201-8202. General Algebra. (3 cr per qtr; prereq 5284 or #)  
 8200: Sets with compositions. Groups and semigroups with operators. Homomorphism theorems. Jordan-Hölder theorem. Abelian groups. Finitely generated groups. Rings, modules, and fields. Ideals and quotients. Commutative rings, especially polynomial and power series algebras. Unique factorization. Prime fields, finite fields. Finite field extensions. 8201: Vector spaces and modules. Duality, space of linear maps. Multilinear algebra; tensor products; special algebras. Application to algebraic field extensions; Galois theory. Transcendental field extensions. Valuations. 8202: Simple and semisimple rings. Chain conditions on rings and modules. Wedderburn theory. Representations of finite groups.

Math 8203-8204-8205. Algebraic Geometry. (3 cr per qtr; prereq 8202, #; offered alt yrs)  
 Basic concepts of algebraic geometry: properties of curves, surfaces, varieties, schemes, morphisms, and cohomology of coherent sheaves.

Math 8206-8207-8208. Algebraic Number Theory. (3 cr per qtr; prereq 5342, 8202 or #; offered alt yrs)  
 Local and global fields, decomposition of primes, generalized L-functions, local and global class field theory.

Math 8209-8210. Homological Algebra. (3 cr per qtr; prereq 8202 or #; offered when feasible)

Math 8211-8212. Commutative Algebra. (3 cr per qtr; prereq 8202 or #; offered when feasible)

Math 8245-8246-8247. Group Theory. (3 cr per qtr; prereq 8202 or #)  
 Sylow theorems, p-groups, nilpotent groups, solvable groups, the Jordan-Holder theorem for groups with operators, automorphism groups, permutation groups, representation theory for finite groups, finite simple groups, free groups, free products.

Math 8250-8251-8252. Topics in Group Theory. (1-3 cr per qtr; prereq #)

Math 8263-8264-8265. Topics in Algebraic Geometry. (1-3 cr per qtr; prereq #)

Math 8266-8267-8268. Topics in Number Theory. (1-3 cr per qtr; prereq #)

Math 8270-8271-8272. Lie Groups and Lie Algebras. (3 cr per qtr; prereq 8202 or #)  
 Groups of matrices, topological groups, local groups, Lie algebras and Lie groups. Structure theorems, classification of semisimple Lie algebras. Topics in homogeneous spaces and representations.

Math 8290-8291-8292. Topics in Algebra. (1-3 cr per qtr; prereq 8202 or #)  
 Topics vary depending on instructor and demand. Consult the instructor about topics to be covered during a particular quarter.

Math 8300-8301-8302. Manifolds/Topology. (3 cr per qtr; prereq 5282-5283, 5341 or #)  
 Covering spaces and the fundamental group; homology and cohomology of topological spaces, invariance of domain, degree of a mapping; smooth manifolds, Sard's Theorem, differential forms, tensor fields, integration on manifolds; metric geometry, curvature, Gauss-Bonnet Theorem.

Math 8306-8307-8308. Algebraic Topology. (3 cr per qtr; prereq 5342 or #; offered alt yrs)  
 Axiomatic homology theory; various homology and cohomology theories; introduction to homotopy theory.

Math 8330-8331-8332. Differential Topology. (3 cr per qtr; prereq 5342 or #; offered alt yrs)  
 General introduction to algebraic topology, as far as is needed for development of special tools of differential topology. Theory and applications of differentiable sheaves.

Math 8342-8343-8344. Topological Dynamics. (3 cr per qtr; prereq 5341 or #; offered when feasible)

Math 8360-8361-8362. Topics in Topology. (1-3 cr per qtr; prereq 8308 or #)

Math 8365-8366-8367. Riemannian Geometry. (3 cr per qtr; prereq 5377 or #)  
 Differentiable manifolds. Riemannian metric. Exterior differential calculus. Methods of global differential geometry. Differential equations of mathematical physics. Tensor algebra.

Math 8370-8371-8372. Topics in Geometry. (1-3 cr; prereq #)

Math 8380-8381-8382. Topics in Advanced Differential Geometry. (1-3 cr per qtr; prereq #)

Math 8406-8407-8408. Advanced Methods of Applied Mathematics. (3 cr per qtr; prereq 5459 or equiv or #)  
 Fundamental linear problems; linear transformations and quadratic forms, orthogonal series, linear integral equations, calculus of variations, eigenvalue problems and expansions, singular eigenvalue problems and expansions.

Math 8430-8431-8432. Mathematical Theory of Fluid Dynamics. (3 cr per qtr; prereq 5573, 5602 or #)  
 Equations of continuity and motion. Kinematics, Bernoulli's theorem, stream function and velocity potential. Applications of conformal mapping. Foundations of thermodynamics. One-dimensional flow. Plane flow of gas, characteristic method, hodograph method. Singular surfaces, shock waves and shock layers. Viscous flow, Navier-Stokes equations, exact solutions; uniqueness, stability, and existence theorems.

Math 8441. Variational Methods in Eigenvalue Problems. (3 cr; prereq 5573 or #)  
 Minimum, maximum-minimum, and minimum-maximum characteristics of eigenvalues and eigenvectors ("natural frequencies" and "normal modes") of various differential operators occurring in mathematical physics. Methods yielding upper and lower bounds for eigenvalues. Approximation of eigenvectors.

## GRADUATE PROGRAMS

Math 8445-8446-8447. Numerical Analysis of Ordinary and Partial Differential Equations. (1-3 cr per qtr; prereq 5567, 5571 or equiv, 5513 or equiv)

Finite element and finite difference methods for elliptic boundary value problems (e.g., Laplace's equation) and solution of the resulting linear systems by Gaussian elimination, SOR, conjugate gradients. Numerical methods for parabolic equations (e.g., heat equation) and hyperbolic equations (e.g., wave equation). Methods for the system of linear elasticity, Navier-Stokes equation, and systems of nonlinear conservation laws.

Math 8450-8451-8452. Topics in Numerical Analysis. (1-3 cr per qtr; prereq #)

Math 8460-8461-8462. Mathematical Problems in Theoretical Physics. (3 cr per qtr; prereq #)  
Topics vary yearly.

Math 8470-8471-8472. Topics in the Mathematical Theory of Continuum Mechanics. (1-3 cr; prereq 5573 or #)  
Topics vary yearly.

Math 8480-8481-8482. Selected Topics of Celestial Mechanics. (1-3 cr per qtr; prereq #)

Math 8500-8501-8502. Theory of Ordinary Differential Equations. (3 cr per qtr; prereq 5614 or equiv, 5521 or #)

Existence and uniqueness theorems, linear and nonlinear differential equations, singular points and series solutions, eigenvalue problems, oscillation and comparison theorems, stability of solutions, periodic solutions, Poincaré-Bendixson theory, equations of Duffing and van der Pol.

Math 8540. Topics in Differential and Difference Equations. (1-3 cr; prereq #)

Math 8550-8551-8552. Theory of Partial Differential Equations. (3 cr per qtr; prereq 5614 or equiv, 5521 or #)

Derivation of special equations. First-order equations. Classification. Cauchy-Kowalewski theorem. Hyperbolic equations; general theory of characteristics, first-order systems, energy method, special topics. Elliptic equations; maximum principle and applications, general theory of the Laplace equation, potential theory, boundary value problems. High order parabolic equations.

Math 8560-8561-8562. Calculus of Variations and Minimal Surfaces. (3 cr per qtr; prereq 5614 or equiv, 5521 or #; offered when feasible)

Math 8570-8571-8572. Infinite Dimensional Dynamical Systems. (3 cr per qtr; prereq 5614 or equiv, 5521 or #)

Existence, uniqueness, and continuity theorems for differential-delay equations and nonlinear parabolic partial differential equations. Concepts from dynamical systems, including stability, dichotomies, and finite dimensional structures. Existence and approximation of invariant manifolds. Bifurcation theories in infinite dimensions.

Math 8580-8581. Mathematical Modeling of Industrial Problems. (4 cr; prereq 5521-5522-5523, 5571-5572-5573 or 5463-5464-5465, some computer exper)

Case studies of problems that arise in industry. Methods for and experience in setting up mathematical models of "raw" problems; analysis of models. Projects based on team approach.

Math 8590-8591-8592. Topics in Partial Differential Equations. (1-3 cr per qtr; prereq 8609, 8552 or #)

Math 8600-8601-8602. Real Analysis. (3 cr per qtr; prereq 5614 or equiv or 8702 or #)

Review of fundamental concepts of analysis, elementary set theory. Measures and measure spaces, measurable functions, Borel and Lebesgue measure. Integration, fundamental convergence theorems, Radon-Nikodym theorem, Fubini's theorem. Differentiation of functions of a single variable; arc length. Metric, linear, and Banach spaces; Lp spaces, representation of linear functionals; C(X) spaces, Riesz representation theorem, Stone-Weierstrass theorem, Hilbert space, compact operators.

Math 8620-8621-8622. Theory of Singular Integrals. (3 cr; prereq 8602 or equiv or #)

Differentiation of multiple integrals, maximal functions, covering theorems; BMO; singular integrals, scalar and vector-valued; Littlewood-Paley theory, multilinear singular integrals operators; Stein's work on differentiation through surface averages, dimensional invariance of maximal constants for  $p > 1$ ; multiplier theory, relation to differentiation theory; restrictions of Fourier transforms; Hp theory.

Math 8640-8641-8642. Topics in Real Analysis. (1-3 cr per qtr; prereq 8602 or #)

Math 8650-8651-8652. Theory of Probability. (3 cr per qtr; prereq 8602 or #)

Topics in modern probability theory, including recent advances in limit theorems and introduction to stochastic processes.

Math 8653-8654. Introduction to Stochastic Processes. (3 cr; prereq 8650 or 8656 or 8600, 5681-5682 or #)

Weak convergence of measures, Kolmogorov's consistency theorem, Brownian motion, Poisson process, conditioning, martingales, Markov processes, stationary processes, stochastic integration, stochastic control and filtering. Emphasis on parts of theory most useful to applied fields.

Math 8656-8657-8658. Measure Theory and Probability. (3 cr per qtr; prereq 5614 or #)

Measure and measure spaces, measurable functions, integration, fundamental convergence theorems, Radon-Nikodym theorem, Fubini theorem, Kolmogorov consistency theorem. Random variables, distribution functions, characteristic functions, expectation, conditional expectation, martingales, sums of independent random variables, limit theorems including rates of convergence and the Berry Esseen theorem.

Math 8668-8669-8670. Introduction to Combinatorial Theory. (3 cr per qtr; prereq #) 8668: Basic enumeration, including sets and multisets, permutation statistics, inclusion-exclusion, permutations with restricted position, Ferrers diagrams, integer and set partitions, unimodal sequences, involutions, and Polya theory. 8669: Partially ordered sets, including lattices, distributive and semimodular lattices, chains, incidence and Mobius algebras, Mobius inversion, Zeta polynomials, Eulerian and binomial posets, generating functions, P-partitions, and Sperner theorems. 8670: Further topics in enumeration, including symmetric functions, Schensted correspondence, and standard tableaux; non-enumerative combinatorics, including graph theory and coloring, matching theory, connectivity, flows in networks, codes, and extremal set theory.

Math 8672, 8673, 8674. Topics in Combinatorial Theory. (1-3 cr per qtr; prereq #) Combinatorial geometry, matroids, enumeration, ordered sets and Mobius inversion. Graph theory, coloring problems, matching theory, design, large sets, statistical physics, finite geometry, linear programming and algorithms.

Math 8690-8691-8692. Topics in the Theory of Probability. (1-3 cr per qtr; prereq 8652 or #)

Math 8700-8701-8702. Complex Analysis. (3 cr per qtr; prereq 5614 or equiv or 5573 or #) Review of fundamental concepts of analysis, real and complex numbers, analytic functions and conformal mapping. Cauchy's theorem and related concepts, sequences of analytic functions. Taylor and Laurent series, infinite products; residue calculus; the argument principle. Analytic continuation, algebraic functions.

Math 8790-8791-8792. Topics in the Theory of Analytic Functions. (1-3 cr per qtr; prereq 8702 or #)

Math 8800-8801-8802. Functional Analysis. (3 cr per qtr; prereq 8602 or #) Basic properties of topological, locally convex and Banach spaces: theorems of Hahn-Banach, Krein-Milman, Mazur, Banach-Steinhaus, Eberlein; also open mapping, closed graph, uniform boundedness, Riesz convexity theorems; resolvents, spectra, spectral theorem in Hilbert space, integration of vector-valued functions.

Math 8990-8991-8992. Reading and Research. (Cr ar)

## Mathematics Education

See Curriculum and Instruction.

## M.D./Ph.D.

A central theme of the M.D./Ph.D. program, a dual-degree program in the School of Medicine and the Graduate School, is the interface between basic biomedical science and clinical practice, and the constant interplay between them. The training

period, which is typically about seven years, combines coursework, fundamental biomedical research, and clinical training culminating in a dissertation, a Ph.D. degree, and an M.D. degree. Students selected for the program receive a yearly stipend approximately equal to or greater than that received by predoctoral trainees supported by the National Institutes of Health (NIH) and also have their tuition paid. This support extends throughout the training period. The program at the University of Minnesota has been awarded a Medical Scientist Training Program grant by NIH.

**Curriculum**—The M.D./Ph.D. training period is divided into three phases: 1) two years of basic biomedical sciences coursework. During this period students select an area of basic biomedical science, choose a research adviser to supervise their thesis research, and begin their research; 2) approximately three years of coursework and research leading to the Ph.D. thesis. This research can be done in *any* graduate program approved by the Graduate School and the M.D./Ph.D. advisory committee, but most likely would be in anatomy, cell and developmental biology, biochemistry, genetics, microbiology, neuroscience, pathobiology, pharmacology, physiology, biomedical engineering, or biomedical science; and 3) approximately one year of clinical rotations.

Research projects take place in the laboratories of carefully selected, outstanding faculty who act as preceptors in the program. Research projects for the Ph.D. portion of the program have recently been carried out in the following areas: animal virology, biochemistry, cell biology, developmental biology, immunobiology, mechanism of pathogenicity, neurobiology, physical biochemistry, and plant biology.

**Prerequisites for Admission**—Applicants must have had excellent grades as undergraduates, outstanding scores on the MCAT examination or Graduate Record Examination, and strong letters of recommendation. Applicants must also have taken part in some research as undergraduates and have at least one letter of reference from a research adviser.

It is also possible for students in their first year of Medical School or Graduate School to transfer to the M.D./Ph.D. program; essentially the same prerequisites apply.

**Special Application Requirements—**

Applications must be submitted to the Medical School through the American Medical College Application Service and to the Graduate School through the M.D./Ph.D. program. An M.D./Ph.D. selection committee reviews the applications and makes a recommendation to the Graduate School and to the Medical School admissions committees. Once accepted, students are admitted by the Graduate School to any participating graduate program of their choice. The deadline for application to the combined M.D./Ph.D. program is December 15.

**For Further Information and Applications—**

Contact the M.D./Ph.D. Program, Medical School, University of Minnesota, Box 293 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (mailing address) (612/625-3680; fax 612/626-6800; e-mail [mdphd@lenti.med.umn.edu](mailto:mdphd@lenti.med.umn.edu)).

## Mechanical Engineering and Industrial Engineering

*Regents' Professor:* Richard J. Goldstein, *head*; Ernst R. G. Eckert (*emeritus*); Benjamin Y. H. Liu

*Professor:* Thomas H. Kuehn, *director of graduate studies*; Sant Ram Arora; Avram Bar-Cohen; Perry L. Blackshear (*emeritus*); Max Donath; Arthur G. Erdman; Edward A. Fletcher; Darrell A. Frohrib; Steven L. Girshick; Joachim V. R. Heberlein; Warren E. Ibele; David B. Kittelson; Francis A. Kulacki; Tarald O. Kvalseth; Jack L. Lewis; Virgil A. Marple; Peter H. McMurry; Katsuhiko Ogata; Suhas V. Patankar; Emil Pfender; David Y. H. Pui; Subbiah Ramalingam; James W. Ramsey; Donald R. Riley; Yechiel Shulman; Terrence W. Simon; Ephraim M. Sparrow; Patrick J. Starr; Kim A. Stelson; Kumar K. Tamma

*Associate Professor:* Thomas R. Chase; Jane H. Davidson; Kevin J. Dooley; William K. Durfee; David L. Hofeldt; Barney E. Klamecki; Charles J. Scott; Paul J. Strykowski

*Assistant Professor:* Saifallah Benjaafar; John C. Bischof; Uwe R. Kortshagen; Susan C. Mantell

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered—**Mechanical Engineering: M.S.M.E. (Plan A and Plan B), M.M.E., and Ph.D.; Industrial Engineering: M.S.I.E. (Plan A and Plan B), M.I.E., and Ph.D.

**Curriculum—**Coursework and research for all graduate degrees are offered in bioengineering;

biomechanics; combustion; computer-aided design; computer-aided manufacturing; computer graphics; control systems; design; energy conservation; environmental control; environmental engineering; fluid mechanics; heat and mass transfer; history of science and technology; human factors engineering; industrial engineering; innovative methodologies; integration of structural and environmental systems; lubrication; manufacturing engineering; particle technology; plasma chemistry; plasma heat transfer; power, propulsion, and applied thermodynamics; socioeconomic systems; solar energy; solar processing and thermochemistry; statistics; structures; systems dynamics; technology assessment; thermal energy storage; thermal environmental engineering; thermodynamics; transportation; tribology; vibration; and interdisciplinary finite element methodology. Additional instructional and research programs can be formulated.

**Prerequisites for Admission—**An undergraduate degree in engineering or in a closely related scientific field such as physics, chemistry, or mathematics, is required. Unusually well-qualified students may be admitted directly to the Ph.D. program with a baccalaureate degree.

**Special Application Requirements—**Graduate Record Examination General Test scores are required for admission and also are used in evaluating requests for financial aid. For the Ph.D. program, three letters of recommendation from senior faculty members at the previous educational institution are required, including one from the master's degree adviser. Students are admitted in the fall and spring quarters only.

**Master's Degree Requirements—**For the M.S.M.E. and M.S.I.E. degrees, students are required to complete two credits of graduate seminars. The final examination is oral. For Plan B students, the number of Plan B papers required is from one to three, depending on their length, and is determined in consultation with the adviser. The papers may derive from any of the courses offered for majors in the graduate program or may address topics chosen by a graduate faculty member and the student. For the M.M.E. and M.I.E. degrees, see

Professional Master's Degree in Engineering in the General Information section of this bulletin.

**Doctoral Degree Requirements**—Students are required to complete three credits of graduate seminars.

**Language Requirements**—None.

**For Further Information and Applications**—

Contact the Mechanical Engineering and Industrial Engineering Graduate Programs, University of Minnesota, 121 Mechanical Engineering, 111 Church Street S.E., Minneapolis, MN 55455 (612/625-2009; fax 612/624-2010; e-mail gradinfo@me.umn.edu).

IEOR 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

IEOR 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

IEOR 8888. Thesis Credits: Doctoral. (36 cr required)

ME 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

ME 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

ME 8888. Thesis Credits: Doctoral. (36 cr required)

## Mechanical Engineering (ME)

### Graduate Credit Courses for Nonmajors

ME 5190. Advanced Engineering Problems. (2-4 cr; prereq #, Δ)

Special investigations in various fields of mechanical engineering and related areas including independent study project.

ME 5254. Design Morphology With Applications. (4 cr; prereq upper div ME major, 1025, 3201, 3205, 3303, 5342 or #; 2 lab hrs per wk) Detailed study of design problem formulation and structure of the open-ended solution process based on design morphology. Case studies and student projects.

ME 5260. Engineering Materials and Processing. (4 cr; prereq upper div ME student, 3020, AEM 3016, Chem 1052, MatS 3400, Phys 1253; 3 lect, 1 rec hrs per wk, safety glasses required) Introduction to materials and processing including physical and metallurgical properties, consolidation, etc. Material processing including machining, welding, and deformation processes.

ME 5342. Heat Transfer. (4 cr; prereq 3301, CE 3400 or AEM 3200, upper div IT or grad student or forest products student; 4 lect hrs per wk)

Steady and unsteady conduction of heat. Convection heat transfer in boundary layer and duct flows; forced and free convection; condensation and boiling; heat exchanges. Heat transfer by thermal radiation; radiative properties of black bodies and real surfaces.

### Advanced Courses in Mechanical Engineering

Design and Controls

ME 5203. Advanced Analysis and Synthesis of Mechanism Systems. (3-4 cr; prereq 3203 or equiv, IT or grad student; computer programming desirable)

Analytical methods of kinematic, dynamic, and kinetoelastodynamic analysis and synthesis of mechanisms. Computerized design for function, path, and motion generation based on Burmeister theory.

ME 5205. Creativity in Engineering Design. (3-4 cr [1 cr term paper option]; prereq 3203, 3205, 3303, 5342 or equiv, IT or grad student; 3 lect hrs per wk)

Role of creative action at various stages in morphology of the design process. Creative decision making in developing design criteria, alternative solutions, and their evaluation.

ME 5207. Experimental Stress Analysis. (4 cr; prereq AEM 3016, IT upper div or grad student; 3 lect, 3 lab hrs per wk)

Experimental application and theoretical evaluation of methods of stress analysis. Strain gages, surface coatings, photoelasticity techniques. Design of transducing systems using strain.

ME 5209. Friction and Lubrication. (3-4 cr [1 cr term paper option]; prereq CE 3400, AEM 3200 or equiv, IT or grad student; 3 lect hrs per wk)

Solid friction mechanism and boundary lubrication. Hydrodynamic and hydrostatic lubrication theory applied to bearing design. Introduction to gas bearings.

ME 5220. Computer-Aided Design. (4 cr; prereq 3020, IT or grad student, 3rd-yr ME courses, FORTRAN programming; 3 lect, 1 rec hrs per wk)

Application of computer-aided design techniques to engineering design. Engineering design projects/case studies using computer implementation of selected numerical techniques, design optimization, and computer graphical presentation of results.

ME 5225. Finite Elements in Mechanical Design. (4 cr; prereq 3205, 5342, programming, IT or grad student)

Introduction to fundamentals of finite element analysis, oriented to mechanical engineering design applications. Extensive examples from industry; student projects involve actual set-up and solution of descriptive problems using industry-accepted analysis codes and interactive graphics for model generation.

ME 5226. Finite Element Methods in Mechanical Engineering I. (4 cr; prereq Math 3221, AEM 3016, FORTRAN programming, IT upper div or grad student)

Introduction to computational methods, direct stiffness approach, elasticity, and energy methods. Interpolation, development of simple finite elements, assembling, and solution methods. Programming considerations and design application.

ME 5227. Finite Element Methods in Mechanical Engineering II. (4 cr; prereq 5226 or #, programming, IT upper div or grad student)

Fundamental concepts of FEM; variational and weighted residual methods; interpolation functions; linear/higher-order elements; methodology and formulation for one-end two-dimensional problems in structural mechanics and heat transfer; axi-symmetric problems; solution schemes for linear/nonlinear static/steady-state models; computer implementation.

ME 5244. Vibration Engineering. (4 cr; prereq 3201 or equiv, IT or grad student; 4 lect hrs per wk)

Applications of theory of vibration to design and optimization of isolators, detuning mechanisms, viscoelastic suspensions and structures.

ME 5255. Engineering Design Project. (4 cr [may be repeated for cr]; prereq 5254, ME upper div; 1 lect, 2 lab hrs per wk)

Participation in solution of systems design problems with well-developed criteria, order-of-magnitude evaluation of alternatives, and generation of preliminary design.

ME 5271. Robotics. (3-5 cr [2 cr lab option]; prereq IT or grad student, 5283 or equiv)

Analysis and design of computer control of multidegree-of-freedom mechanical systems. Robotics, multijointed manipulator kinematics, dynamics, control and integration with sensors. Position, velocity, path, force control. Lab projects.

ME 5272. Non-Contact Sensing. (3-5 cr [2 cr lab option]; prereq IT or grad student, 5271 or equiv)

Optical- and acoustic-based sensing for inspection and closed loop control. Integration with robots. Mathematics of image processing as used in sensors for inspection, part classification, tracking, and ranging. Lab projects.

ME 5275. Computer Controlled Experimentation. (4 cr; prereq 5283 or equiv; 3 lect, 2 lab-rec hrs per wk)

A/D and D/A conversion, Sampling Theorem, DFT and FFT, analog and digital filter design, simulation, real time micro- and mini-computer control.

ME 5283. Industrial Instrumentation and Automatic Control. (4 cr; prereq 3201 or equiv, IT or grad student; 2 lect, 2 lab hrs per wk)

Basic theory of linear feedback control systems. Transfer function representation of electromechanical, pneumatic, and hydraulic components. Industrial automatic controllers. Root-locus and frequency-response methods of analysis and design.

ME 5284. Control Systems. (4 cr; prereq 5283 or equiv, IT or grad student; 4 lect hrs per wk)

State-space analysis of discrete-time and continuous-time control systems. Z-transform method, Liapunov stability analysis. Controllability and observability. Introduction to optimal control and adaptive control.

ME 5285. Control Systems Laboratory. (2 cr; prereq IT major, 5283 or equiv)

Experiments that illustrate and apply control theory to mechanical engineering systems. Measurement techniques, calibration, timing of controls, characterization of sensors and control circuits.

ME 5288. Modeling and Simulation of Dynamic Systems. (4 cr; prereq 5283 or equiv, IT or grad student; 3 lect, 1 lab-rec hrs per wk)

Generalized approach to developing models for describing complex dynamic interactions between mechanical, electrical, fluid, and thermal systems. Analog and digital simulation. Applications to electromechanical devices, transducers, hydraulic power, and thermofluid systems.

ME 8203. Advanced Planar Linkage Synthesis. (3 cr; prereq 5203)

Burmester Theory: review, special cases, alternate formulations; dimensional synthesis of complex linkages; solution rectification; application of graph theory to mechanism synthesis; optimization as linkage synthesis technique.

ME 8226. Finite Element Methods for Nonlinear/Linear Transient/Dynamic Problems. (4 cr; prereq 5227, programming course or #)

Concepts and techniques of Finite Element Methods; introduction to nonlinear/linear and transient/dynamic problems in engineering; formulations for conduction/convection/radiation, phase change and convective diffusion models; structural dynamics and wave propagation; stability, convergence, and accuracy for algorithms in structural dynamics and computational heat transfer.

ME 8227. The Finite Element Method in Metal-Forming Processes. (4 cr; prereq 5227, AEM 8511, AEM 8522, programming course or #) Finite Element Method (FEM) fundamentals; material and geometric nonlinearities; FEM for inelastic small and finite deformation problems; constitutive equations for finite deformation inelasticity; adaptive and deforming FEM techniques; applications to metal-forming operations (e.g., extrusion, rolling, casting).

ME 8250-8251-8252. New Product Design and Development. (4 cr per qtr; prereq 5254 or equiv; offered jointly with Carlson School of Management)

Conception, design, and development of new product for client company by team of IT and CSOM graduate students and faculty coaches and client personnel, resulting in one or more working physical prototypes of new product and a comprehensive business plan detailing how product will be marketed and produced over its life cycle.

ME 8280. Multivariable Control Systems I. (4 cr; prereq 5283 or equiv)  
 Integrated state space and frequency domain description of linear multivariable feedback control systems based on models of physical process; realizations and structures of multi-input, multi-output linear systems; multivariable system analysis, stability, controllability, observability, poles, zeros, and modal properties; Eigenstructure assignment; multivariable Nyquist criterion in singular value-based robustness test; impact of unstable poles, nonminimum phase zeros and time delays; extensive computer-aided homework.

ME 8281. Multivariable Control Systems II. (4 cr; prereq 8280)  
 Unified computer-aided design of multivariable feedback control systems using time and frequency domain concepts; loop-shaping concepts via singular value plots; performance and robustness trade-offs; derivation of LQR and its properties in frequency domain; Kalman filter and its properties in time and frequency domain; linear quadratic gaussian compensator with loop-transfer recovery; recent methods in compensator design; extensive computer-aided homework.

Production Engineering

ME 5262. Material Working and Fabrication Processes. (4 cr; prereq 5260, IT or grad student; 3 lect, 1 rec hrs per wk)  
 Theory and application of joining techniques, welding, brazing, and adhesive bonding. Metal forming operations, rolling, swaging, drawing, and similar operations. Inspection and test methods to control and evaluate fabrication processes including X-ray, magnetic, metallographic, and chemical methods.

ME 5268. Properties and Fabrication of Plastics. (4 cr; prereq 5260, IT or grad student; 3 lect, 1 lab-rec per wk)  
 Materials, equipment, and processes for fabrication of plastics. Principles of products and tool design. Hydraulic and temperature circuit control for equipment.

ME 5270. Materials—Design Requirements. (4 cr; prereq 5260, IT or grad student; 3 lect, 1 rec hrs per wk)  
 Fundamental properties of engineering materials including fabrication, treatment, physical and corrosive properties. Failure mechanism, cost and value analysis as related to material selection and specification.

Thermodynamics and Heat Transfer

ME 5343. Introduction to Thermal Design. (4 cr; prereq 5342, 5254 or equiv, upper div IT or grad student)  
 Elements of thermal design. Development of design philosophy and governing relations for thermal configurations, including barriers and enclosures; longitudinal, radial and pin-fins; longitudinal fin arrays. Case studies from diverse thermal application areas, e.g., furnaces and ovens, HVAC systems, solar energy use, and electronic equipment.

ME 5344. Thermodynamics of Fluid Flow. (4 cr, SAEM 5201; prereq CE 3400 or AEM 3200, IT or grad student; 4 lect hrs per wk)  
 Compressible flow of gases in engineering systems such as nozzles, ducts, combustion chambers, ramjets, pipe lines. Isentropic flow in variable area passages. One-dimensional discontinuities. Flow with wall friction, heat transfer, and mass transfer.

ME 5345. Heat Transfer in Electronic Equipment. (4 cr; prereq IT or grad student, 5342; 3 lect, 1 rec hrs per wk)  
 Development and application of analytical models of thermal phenomena in electronic equipment. Thermal characteristics and thermal failure modes of microelectronic components. Packaging configurations used for various microelectronic applications.

ME 5346. Intermediate Heat Transfer. (4 cr; prereq 5342, upper div IT or grad student; 4 lect hrs per wk)  
 Heat transfer fundamentals related to applications. Conduction across thermal contacts, through composite materials, and in unsteady state. Convection in complex fluid flows. Simple turbulence models. Phase change processes (boiling, condensation, melting, freezing). Radiation between surfaces and through participating media. Mass transfer fundamentals and applications; analogy between heat and mass transfer.

ME 5351. Computational Heat Transfer. (4 cr; prereq 5342, IT or grad student)  
 Numerical solution of heat conduction and duct flows. Use of computer program to solve complex problems involving steady and unsteady conduction, fully developed flow and heat transfer in ducts, and other special applications. Case studies illustrate design optimization.

ME 8310. Advanced Thermodynamics. (3 cr; prereq 3303)  
 Critical examination of thermodynamic principles, equations of state for liquids, gases, and mixtures. Interpretation of thermodynamic functions and applications to processes, reactions, and equilibrium states.

ME 8311. Statistical and Nonequilibrium Thermodynamics. (3 cr; prereq 8310)  
 Elements of statistical thermodynamics. Equilibrium considerations, equations of state, heat capacities. Transport property predictions, thermal conductivity, viscosity, diffusion. Irreversible effects, metastability, mechanism of two-phase equilibrium. Nonequilibrium effects.

ME 8326. Boiling Heat Transfer and Multiphase Flow. (3 cr; prereq 5342 or #)  
 Phenomena pertaining to boiling heat transfer and multiphase flow; superheat, nucleation, bubble dynamics, interfacial phenomena, boiling crisis, film boiling; flow patterns in two-component two-phase flows, two-phase critical and supercritical flows.

ME 8330. Conduction. (3 cr; prereq 5342)  
 Steady and unsteady heat conduction with and without heat sources. Change of phase. Classical and approximate solutions.

ME 8331. Convection. (3 cr; prereq 5342)  
 Fundamentals and applications of heat transfer in presence of fluid motion. Heat transfer in fluids flowing around bodies and in tubes and ducts. Externally driven flows (forced convection) and buoyancy-induced flows (natural convection). Laminar and turbulent flow regimes. Application to heat exchange devices with complex geometries. Convection mass transfer and vapor-liquid phase change.

ME 8332. Radiation. (3 cr; prereq 5342)  
 Heat radiation of black bodies and nonblack bodies. Radiation between surfaces and through participating media.

ME 8334. Turbulent Convection. (3 cr; prereq 8331)  
 Heat and mass transfer in turbulent flows; turbulent transport, turbulence modeling, high speed flows, viscous dissipation, variable property effects, transpiration, and film cooling.

ME 8351. Computation of Fluid Flow and Heat Transfer. (3 cr; prereq 5342)  
 Finite-difference methods of solving equations of motions and energy. Mathematical models for turbulence, radiation, and combustion; their computing implications. Application of prediction procedures to practical situations.

ME 8352. Advanced Computation of Fluid Flow and Heat Transfer. (3 cr; prereq 8351 or #; 3 lect, 1 rec hrs per wk)  
 Use of computer program to solve complex problems involving fluid flow, heat transfer, and chemical reaction. Advanced models for turbulence and chemical reaction. The finite-element method and other methods of fluid flow computation.

ME 8360. Introduction to Plasma Technology. (3 cr; prereq 5342 or #)  
 Atomic theory; kinetic gas theory, fundamentals of gaseous electronics; thermal excitation and ionization; nonequilibrium and equilibrium plasmas; local thermodynamic equilibrium (LTE); introduction to irreversible thermodynamics of a fully ionized plasma; plasma equations; thermodynamic functions; collisions cross sections.

ME 8361. Introduction to Plasma Technology. (3 cr; prereq 8360 or #)  
 The plasma state; plasmas generation; glow discharges; arcs; rf-discharges sparks and pulsed discharges; shock waves. Plasma diagnostics; potential probes; magnetic probes; plasma spectroscopy; microwave diagnostics; short-time and high-speed photography; enthalpy probes; laser methods; interferometry.

ME 8362. Introduction to Plasma Technology. (3 cr; prereq 8360, 8361 or #)  
 Plasma heat transfer; transport equations; transport properties; heat transfer with and without current flow; electric and magnetic field effects. Plasma applications; arc furnaces; extractive metallurgy; plasma synthesis; plasma welding, spraying, and cutting; MHD power generation; nonthermal plasma processing; thermonuclear fusion.

ME 8370. Experimental Methods in Heat Transfer. (3 cr; 3 lect hrs per wk)  
 Planning experiments: uncertainty, qualification, visualization, analogies; temperature, pressure, heat flux and flow measurements; signal processing and analysis.

ME 8372. Optical Diagnostics of Flow Systems. (3 cr; prereq IT grad student)  
 Experimental techniques for measuring velocity, temperature, chemical composition, and particulates in high-temperature flows; basic principles of optics and spectroscopy, instrumentation; laser Doppler anemometry; use of emission and absorption; laser-induced fluorescence; light scattering techniques.

ME 8379. Thermal Sciences Graduate Seminar. (1 cr)  
 Students attend tutorial on preparing and presenting a seminar, deliver a one-hour lecture, and attend nine student seminars.

Power, Propulsion, and Applied Thermodynamics  
 ME 5442. Vapor Cycle Power Systems. (4-5 cr [1 cr term paper option]; prereq 3303, IT or grad student; 4 lect hrs per wk)  
 Vapor cycle analysis, regeneration, reheat, compound cycle modifications, combined gas turbine-vapor cycle systems, binary systems. Combustion problems, solar, nuclear, and unusual energy sources for space power systems. Variety of configurations evaluated using steam cycle computer code.

ME 5443. Turbomachinery. (4-5 cr [1-2 cr term paper option]; prereq 3301 or equiv, IT or grad student; 3 lect hrs per wk)  
 Thermodynamic analysis of energy transfer between fluid and rotor; dimensional analysis; principles of axial, mixed, and radial flow pumps, fans, compressors, and turbines; cascade performance; computer flow simulations; applications to propulsion systems and power plants.

ME 5446. An Introduction to Combustion. (4 cr; prereq 5342 or equiv, IT or grad student; 4 lect hrs per wk)  
 Flame propagation, quenching and ignition in a gaseous mixture; combustion of solid and liquid particles, and gaseous jets. Applications to selected propulsion systems.

ME 5455. Rocket Propulsion. (3-5 cr [1-2 cr term paper option]; prereq 3303, IT or grad student; 3 lect hrs per wk)  
 Mode of operation and performance limitations of chemical rockets with liquid, and solid, thermal and electromagnetic propellant acceleration and the thermodynamics of the propulsion process.

ME 5460. Internal Combustion Engines. (4 cr; prereq 3301, IT or grad student; 4 lect hrs per wk)  
 Principles of power production, fuel consumption, and emissions of gasoline and diesel engines; fuel-air cycle analysis, combustion flames, knock phenomena, air flow and volumetric efficiency, mixture requirements, ignition requirements and performance.

ME 5461. Advanced Internal Combustion Engines. (4-5 cr [1 cr term paper option]; prereq 5460, IT or grad student; 4 lect hrs per wk)

Traditional and alternate fuels; engine lubrication and friction; engine emissions and measurement techniques; turbocharging; heat transfer and cooling; computer-based cycle modeling.

ME 5462. Gas Turbines. (4 cr; prereq 3301, IT or grad student; 4 lect hrs per wk)

Gas turbine cycles, regeneration, reheat, and intercooling. Axial and radial flow compressors and turbines; burner types and combustion efficiency; emissions and noise. Matching of compressor and turbine. Turbojet, fanjet, and turboprop engine performance.

ME 5480. Biological Fluid Flow. (3-4 cr [1 cr term paper option]; prereq IT or grad student, CE 3400, AEM 3200 or equiv; 3 lect hrs per wk)

Introduction to rheology and fluid dynamics of biological fluids. Blood flow, biological pumping, self-propelled particles, unusual viscoelastic behavior of biological fluids, and other fluid motions.

ME 8443. Applied Thermodynamics I. (3 cr; prereq 3303 or equiv)

Practical problems involving use of classical thermodynamics and thermochemistry. Equilibrium composition and flame temperature calculations. Chemical potential, fuel cells, and batteries. Efficient use of fuel, with emphasis on application of second law of thermodynamics.

ME 8444. Applied Thermodynamics II. (3 cr; prereq 8443 or equiv)

Application of statistical thermodynamics to calculation of thermodynamic properties, equilibrium constants, and energetics and kinetics of chemical reactions, with emphasis on application to combustion phenomena and exhaust product composition.

ME 8445. Advanced Combustion. (4 cr; prereq 8443, 8444 or #: 5446 recommended)

Conservation equations of reacting flows; asymptotic methods in combustion; spray combustion; combustion instabilities; turbulent combustion; solid combustion; fire dynamics; combustion modeling.

#### Environmental Engineering

ME 5603. Thermal Environmental Engineering. (4 cr; prereq 3303, 5342 or equiv; 4 lect hrs per wk)

Thermodynamic properties of moist air; H-W diagram for moist air; solar radiation; heat and water vapor transmission in structures; effects of thermal environments upon people, processes, and materials; thermal loads, thermal environmental control systems.

ME 5604. Heating and Cooling Loads in Buildings. (4 cr; prereq 5603; 4 lect hrs per wk)

Transient heat transfer through structures; lighting and other internal gains; ventilation; winter and summer design loads; seasonal energy estimation methods; computer simulation programs; codes and standards.

ME 5605. Refrigeration and Air Conditioning Systems. (4 cr; prereq 3303, IT or grad student; 4 lect hrs per wk)

Vapor compression and absorption refrigeration systems; heat pumps; heat exchangers; piping and duct layout and sizing; operation and control of building air conditioning systems.

ME 5609. Air Pollution. (4 cr; prereq 3303 or #, IT or grad student; 4 lect hrs per wk)

Air pollution sources, atmospheric transport, transformations and fate. Air pollution meteorology, dispersion, and models. Basic chemistry of secondary pollutant formation, aerosol growth, air pollutant-visibility relationships. Standards and regulations.

ME 5610. Air Pollution Control. (4 cr; prereq 3303, IT or grad student; 4 lect hrs per wk)

Control devices and techniques for gases and particulate emissions from stationary and mobile sources. Cyclones, electrostatic precipitators, bag houses, wet and dry scrubbers, combustion modification, and alternate fuels.

ME 5613. Principles of Particle Technology. (4 cr; prereq 3303, IT or grad student; 4 lect hrs per wk)

Definition, theory, and measurement of particle properties; particle statistics; fluid dynamics; optical, electrical, and thermal behavior of particles.

ME 5614. Principles of Particle Technology. (4 cr; prereq 5613, IT or grad student; 4 lect hrs per wk)

Gas cleaning, particle transport, comminution, classification, surface properties, packed beds, powder behavior, and miscellaneous topics.

ME 5616. Aerosol Measurement. (2 cr; prereq 5613, 5614 or #, IT or grad student; 3 lect-lab hrs per wk)

Principles of aerosol measurement. Modern aerosol instrumentation. Optical techniques, inertial collectors, electrical mobility techniques, Beta attenuation and piezoelectric mass sensing techniques, condensation nuclei counters and diffusion batteries.

ME 5617. Advanced Aerosol Measurement. (4 cr; \$5616; prereq 5613 or #, IT or grad student)

Principles and techniques of airborne particle measurement. Modern aerosol instrumentation: inertial collectors, optical particle counters, differential mobility particle sizer, condensation nucleus counters, aerodynamic particle sizer. Aerosol generation and instrument calibration. Aerosol measurement in clean room and source emission measurement. Data analysis and interpretation.

ME 5620. Clean Room Technology and Particle Monitoring. (4 cr; prereq IT or grad student, 3303 or #; 3 lect, 2 lab hrs per wk)

Fundamentals of clean room technology for microelectronics manufacturing; particle mechanics and filtration; filter performance and testing; airborne and liquid-borne particulate contaminants; optical particle counters, condensation nucleus counter, wafer surface scanner; clean room design and operation; exhaust ventilation; high purity gas and water supply systems.

## GRADUATE PROGRAMS

ME 8613. Fundamentals of Aerosol Behavior. (4 cr; prereq 5613, 5614 or #; 4 lect hrs per wk)  
Kinetic theory applications to aerosol systems, including free molecules and transition regime treatments of transport phenomena; analytical and numerical solutions to aerosol dynamics problems; homogeneous nucleation theory; light scattering and absorption.

### General

ME 5712. Solar Energy Utilization. (4 cr; prereq 3303, 5342 or equiv, IT or grad student; 4 lect hrs per wk)  
History and potential of solar energy; clear and cloudy sky solar radiation availability on surfaces of various orientations; flat plate and concentrating solar collectors; solar thermal storage; solar heating and cooling systems; computer simulation codes; power generation.

ME 5990. Topics in Mechanical Engineering. (4 cr [may be repeated for cr]; prereq submission of approved dept permission form, #, IT upper div or grad student)

Current topics; may vary quarterly.

ME 8701, 8702. Design Studies in Engineering I, II. (3 cr per qtr; prereq grad student or  $\Delta$ )  
Interdisciplinary design exercises, primarily in mechanical and electrical engineering. Student teams create engineering design for selected problems. Written reports and oral presentations. Case study lectures on methodology.

ME 8770-8771-8772. Mechanical Engineering Research. (Cr ar; prereq  $\Delta$ )

ME 8773-8774-8775. Graduate Seminar. (1 cr per qtr; for grads and staff)  
Recent developments in industrial engineering and operations research.

ME 8800. Modern Developments in Mechanical Engineering. (1 cr per qtr)  
Seminars on special topics in engineering science of importance to mechanical engineers. Invited scholars deliver a five-lecture series on each topic; two to five topics examined each quarter.

## Industrial Engineering (IEOR)

### Graduate Credit Courses for Nonmajors

The following courses may be taken for graduate credit by students majoring in fields other than industrial engineering upon the approval of the student's adviser and the mechanical engineering graduate committee.

IEOR 5010. Introduction to Work Analysis. (4 cr; prereq 3000, IT or grad student; 3 lect, 1 rec hrs per wk)

Fundamentals of methods engineering, work measurement, and plant layout. Charting techniques, process charts, predetermined time systems, work sampling, time study, master standard data, cross charting, line balancing.

IEOR 5020. Engineering Cost Accounting, Analysis, and Control. (4-5 cr; prereq IT or grad student; 3000 and ME 3900 recommended; 3 lect, 1 rec hrs per wk)

Basic accounting concepts, financial statements, analysis and control of current assets such as cash, receivables, and inventory, income-tax planning, cost analysis, standard costs for product costing, time value of money, qualification of risk and uncertainty, utility theory, cost of capital and capital structure, capital budgeting under capital rationing, management decisions, and investment decisions.

IEOR 5030. Quality Control and Reliability. (4 cr; prereq Math 1231, ME 3900, IT or grad student; 3000 recommended; 3 lect, 1 rec hrs per wk)  
History of quality control, quality policies and objectives, economics of quality, design for system effectiveness, reliability and maintainability, statistical aids to reliability, quality specifications, inspection, acceptance sampling, vendor relations, process control, motivation for quality, quality assurance, and quality control engineering.

IEOR 5040. Introduction to Operations Research. (4 cr; prereq Math 1231, IT or grad student; 3000 recommended; 3 lect, 1 rec hrs per wk)  
Linear programming, algebra and geometry of linear models, simplex method, sensitivity testing, and duality, network models, network algorithms, and dynamic models.

IEOR 5180, 5181. Applied Industrial Engineering. (3-5 cr per qtr [1-2 cr term paper option]; prereq 3000, 5010, 5020, 5030, 5040,  $\Delta$ )  
Industrial engineering surveys and programs, case problems, studies in local plants.

### Advanced Courses in Industrial Engineering

IEOR 5050. Engineering Economic Analysis. (4 cr; prereq 3000 or #, IT or grad student; 3 lect, 1 rec hrs per wk)

Fundamental principles and techniques of economic analysis of engineering projects including economic measures of effectiveness, time value of money, cost estimation, depreciation, taxes, break-even, replacement and investment analysis.

IEOR 5070. Introduction to Human Factors Engineering. (4 cr; prereq #, IT or grad student or public health major; 3 lect, 1 rec-lab hrs per wk)  
Analysis and design of operations, machines, equipment, work stations, and work environments relative to capabilities, limitations, and needs of the human operator. Topics include human-machine systems, displays, controls, human-machine interface layout, work station design, anthropometry, work physiology and biomechanics, illumination, noise, toxicology, climate.

IEOR 5071. Human Factors in System Design. (4 cr; prereq 5070 or 5010, IT or grad student; 1 lect-rec, 3 fieldwork hrs per wk)  
Application of theory and principles from 5070 and 5010 to analysis and design of real industrial work settings in local industry.

IEOR 5221. Industrial Plants. (3-5 cr; prereq 5010, IT or grad student; 3 lect, 1 rec hrs per wk)  
Layout of production and service facilities in manufacturing operations, analysis of materials flow, development of materials handling systems, and industrial packaging techniques.

IEOR 5311. Management for Engineers. (4-5 cr; prereq 3000, IT or grad student; 4 lect hrs per wk)  
Historical development of management concepts. Organizational systems and authority relationships. Planning, communication, and management responsibility.

IEOR 5321. Industrial Safety. (4 cr; prereq, IT or grad student; 3000 recommended; 4 lect hrs per wk)  
Definition and philosophy of safety, safety training, safety requirements for production processes, equipment and plants, industry standards, safety devices, and product safety.

IEOR 5351. Analysis of Production Processes. (4 cr; prereq 5020, background in all industrial engineering areas [3000, 5010, 5030, 5040 recommended], IT or grad student)  
Case course of problems in production engineering and production management. Analysis of production problems from selected industries. Development of ability to recognize and diagnose industrial problems.

IEOR 5361. Inventory and Production Control. (4 cr; prereq 3000, 5040, ME 3900, IT or grad student; 3 lect, 1 rec hrs per wk)  
Forecasting techniques and analysis of inventory systems, aggregate planning, capacity decision, scheduling techniques, line balancing, use of linear programming and dynamic programming models in design, operation, and control of production and distribution systems.

IEOR 5441. Operations Research II. (4 cr; prereq 5040, IT or grad student; 3 lect, 1 rec hrs per wk)  
Dynamic programming, integer programming, nonlinear and probabilistic models.

IEOR 5442. Operations Research III. (4 cr; prereq 5441, IT or grad student; 3 lect, 1 rec hrs per wk)  
Optimization in probability models, Markov chains, queuing theory, and simulation.

IEOR 5445. Topics in Management Science. (3-5 cr [1-2 cr term paper option]; 5010, 5020, 5030, 5040, IT or grad student; 3 lect hrs per wk)  
Specialized topics in management science. Analytical tools for decision making and management of the production function. Emphasis on topics appearing in current literature. Topics vary quarterly.

IEOR 5446. Topics in Industrial Engineering. (4 cr [may be repeated for cr]; prereq IT or grad student; 5010, 5020, 5030, 5040 recommended; 4 lect hrs per wk)  
Current topics; may vary quarterly.

IEOR 5550. Design and Analysis of Experiments I. (4 cr; prereq ME 3900, IT or grad student; 3 lect, 1 rec hrs per wk)

One-factor experiments, analysis of variance, estimation and comparison of effect, orthogonal contrasts, fixed, random, and mixed models, incomplete block designs.

IEOR 5703. Engineering Project Management. (4 cr, \$CE 5703; prereq IT sr or grad student)  
Broad practical understanding of project management, including project planning, scheduling, budgeting, staffing, task and cost control, and how to communicate with, motivate, and manage team members.

IEOR 8110-8111-8112. Advanced Industrial Engineering. (3 cr per qtr; prereq #)  
Manufacturing policy; production engineering, plant operation, engineering economy, and industrial development.

IEOR 8310-8311. Production Engineering Problems. (3-5 cr per qtr; prereq #)  
Application of industrial engineering principles to solution of manufacturing problems in local plants.

IEOR 8410-8411-8412. Industrial Engineering Research. (3-5 cr per qtr; prereq #)  
Research studies in selected areas of industrial engineering, production, and management; work of thesis quality but lesser scope.

IEOR 8430. Nonlinear Programming. (3 cr; prereq 5040 or #; offered when feasible)

IEOR 8773-8774-8775. Graduate Seminar. (1 cr per qtr; S-N only)  
Presentation and discussion of recent developments in industrial engineering and operations research.

## Mechanics

See Aerospace Engineering and Mechanics.

## Medical Physics

See Biophysical Sciences and Medical Physics.

## Medicinal Chemistry (MedC)

*Professor:* Rodney L. Johnson, *interim head*; Patrick E. Hanna, *director of graduate studies*; Yusuf J. Abul-Hajj; Herbert T. Nagasawa; Philip S. Portoghese; Wayne T. Shier; Marilyn K. Speedie; Robert Vince

*Associate Professor:* Simon M. N. Efange; Rory P. Remmel; David H. Sherman

*Assistant Professor:* David M. Ferguson; William B. Gleason; Deborah A. Kallick; Carston R. Wagner

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Ph.D. and, under special circumstances, M.S. (Plan A only).

**Curriculum**—The program emphasizes the application of chemical principles to research on the action of drugs on biological systems. Areas of research include drug design and synthesis; chemical aspects of drug metabolism; chemical mechanisms of drug toxicity and carcinogenicity; computer-assisted drug design; pharmaceutical cell systems; delivery systems for gene therapy; nuclear magnetic resonance spectroscopic analysis of drug-protein interactions; design of catalytic antibodies; and development of radiopharmaceuticals.

**Prerequisites for Admission**—Applicants should have a B.S. or M.S. degree in an appropriate related science field such as pharmacy, chemistry, or biology. All applicants should have completed undergraduate chemistry through elementary organic chemistry. Undergraduate coursework in biochemistry and biology is desirable but not required.

**Special Application Requirements**—Scores from the General (Aptitude) Test of the Graduate Record Examination and at least three letters of recommendation from college-level faculty are required. Students usually are admitted fall quarter only. Admissions are generally for the Ph.D. program only.

**Master's Degree Requirements**—Courses and credits are arranged on an individual basis. A final oral examination is required.

**Doctoral Degree Requirements**—All students must complete a core curriculum composed of advanced courses in organic chemistry (11 credits), biochemistry (12 credits), and medicinal chemistry (8-12 credits). Pharmacology coursework is also required of most students.

Ph.D. students must participate in the department seminar program, successfully complete a cumulative examination requirement, and prepare an original research proposal.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—Requirements include an introductory course (5600), advanced medicinal chemistry courses (8xxx level).

**For Further Information and Applications**—Contact the Department of Medicinal Chemistry, College of Pharmacy, University of Minnesota, 8-101 Weaver-Densford Hall, 308 Harvard Street S.E., Minneapolis, MN 55455 (612/624-9919; fax 612/624-2974).

MedC 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

MedC 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

MedC 8888. Thesis Credits: Doctoral. (36 cr required)

MedC 5185. Principles of Bio-molecular Simulation. (4 cr; prereq ¶15151 or Chem 5521 or #) Molecular simulation for students in medicinal chemistry, pharmaceuticals, biochemistry, and chemical physics.

MedC 5200. The New Drug Development Process. (1 cr)  
New drug development process in U.S. pharmaceutical industry.

MedC 5495f. Vistas in Medicinal Chemistry Research. (1 cr)  
Selected topics of contemporary interest in pharmaceutical sciences.

MedC 5600f. General Principles of Medicinal Chemistry. (4 cr; prereq Phcl 1009, BioC 5001)  
Hanna, Johnson, staff  
General principles of drug design and molecular basis of recognition of receptor sites.

MedC 8100.\* Medicinal Chemistry Seminar. (Cr ar; required of all majors in medicinal chemistry)  
Vince

MedC 8114f. Natural Toxins. (2 cr, \$Phcg 8114; prereq #: offered when feasible) Shier

MedC 8116f. Steroid Drugs. (2 cr, \$Phcg 8116; prereq #: offered when feasible) Abul-Hajj

MedC 8500w. Design of Chemotherapeutic Agents. (3 cr; prereq MedC 5600 or #: offered alt yrs)  
Vince

Modern aspects of drug design, with emphasis on chemotherapeutic agents. Strategies for enzyme inhibition and metabolic blocks in development of anticancer, antimicrobial, and antiviral agents.

MedC 8600w. Chemical Aspects of Drug Metabolism and Bioactivation. (3 cr; prereq 5600 or #: offered alt yrs) Hanna, staff  
Chemical aspects of drug metabolism and toxicity. Mechanisms of biotransformations of drugs and other xenobiotics.

MedC 8700s. Advanced Concepts in Drug Design. (2 cr; prereq MedC 5600 or #: offered alt yrs)  
Wagner, staff  
Current approaches to rational design of drugs.

MedC 8760. Design of Peptidomimetics. (2 cr; prereq 5600 or #; offered alt yrs) Johnson  
Current approaches to designing peptidomimetics of biologically active peptides. Rationale behind structures used in designing peptidomimetics and synthetic routes used in synthesizing them.

MedC 8800. Medicinal Chemistry Laboratory Techniques. (Cr ar; prereq Chem 3303 or #)

MedC 8900. Research in Medicinal Chemistry. (Cr ar; prereq Chem 3303 or #)  
Study and experimental investigation of topics in the area of natural products and synthetic organic medicinal agents.

## Medieval Studies (MeSt)

*Regents' Professor:* Rutherford Aris (chemical engineering and materials science)

*Professor:* Barbara A. Hanawalt (history), *director of graduate studies;* F. R. P. Akehurst (French and Italian); Bernard S. Bachrach (history); Caesar E. Farah (history); Evelyn S. Firchow (German, Scandinavian, and Dutch); Donna G. Cardamone Jackson (music); Klaus P. Jankofsky (English<sup>1</sup>); Calvin B. Kendall (English); Anatoly Liberman (German, Scandinavian, and Dutch); Louise Mirrer (Spanish and Portuguese); Susan J. Noakes (French and Italian); Thomas S. Noonan (history); James A. Parente, Jr. (German, Scandinavian, and Dutch); William D. Phillips, Jr. (history); Kathryn L. Reyerson (history); Robert P. Sonkowsky (Classical and Near Eastern studies); David J. Wallace (English); Anthony N. Zahareas (Spanish and Portuguese)

*Associate Professor:* Rita Copeland (English); G. Lee Fullerton (German, Scandinavian, and Dutch); Kaaren E. Grimstad (German, Scandinavian, and Dutch); Michal A. Kobialka (theatre arts and dance); Nita Krevans (Classical and Near Eastern studies); Ronald L. Martinez (French and Italian); Oliver P. Nicholson (Classical and Near Eastern studies); John W. Steyaert (art history); Ray M. Wakefield (German, Scandinavian, and Dutch); John A. Watkins (English)

*Adjunct Assistant Professor:* Stephanie C. Van D'Elden (English)

**Course of Study**—Minor in medieval studies, applicable to master's (M.A. and M.F.A.) and doctoral programs.

**Curriculum**—The medieval studies minor offers a structured interdisciplinary program that provides graduate students with an opportunity to take courses with faculty who participate in the Center for Medieval Studies. The program focuses on acquisition of Latin, paleography, and other skills, as well as encourages a broad knowledge of various disciplines within medieval studies.

**Prerequisites for Admission**—Admission to a medieval studies graduate minor is contingent upon prior admission to a master's or doctoral degree-granting program in the Graduate School.

**Minor Requirements**—The master's minor requires a total of 9 credits: two courses in medieval studies outside the student's major department, including a Latin course (Latin 34xx taken as 8120, or any Latin course at the 5xxx level or above), and either one MeSt core course (5610, 8110, 8120, or 8130) or one MeSt colloquium course (8010, 8020, or 8030). The doctoral minor requires 18 credits: courses in medieval studies outside the student's major department, including an additional Latin course at the 5xxx level or above.

**Language Requirements**—Latin.

**For Further Information**—Contact the Center for Medieval Studies, University of Minnesota, 304 Walter Library, 117 Pleasant Street S.E., Minneapolis, MN 55455 (612/626-0805; fax 612/626-7735; e-mail [cmедst@tc.umn.edu](mailto:cmедst@tc.umn.edu)).

MeSt 5610. Topics in Medieval Studies. (2-5 cr; prereq one-yr work on Middle Ages, reading knowledge of appropriate language[s])  
From fall of Rome through end of Middle Ages (ca. 500 B.C. to ca. 1500 A.D.). Current topics specified in *Class Schedule*.

MeSt 8010, 8020, 8030. Medieval Studies Colloquium. (1 cr per qtr; prereq #)  
Lectures by and discussions with faculty and visiting speakers.

MeSt 8110, 8120, 8130. Seminar in Medieval Studies. (1-5 cr per qtr; prereq #; offered when feasible)

## Microbial Ecology

*Regents' Professor:* Eville Gorham (ecology, evolution, and behavior)

*Professor:* Michael J. Sadowsky (microbiology; soil, water, and climate), *director of graduate studies;* Martin Dworkin (microbiology); Arnold Fredrickson (chemical engineering); Greg Germaine (dentistry); Richard Hanson (microbiology); Timothy J. Kurti (entomology); David McLaughlin (plant biology); Robert Megard (ecology, evolution, and behavior); Jean-Alex Molina (soil, water, and climate); Philip Regal (ecology, evolution, and behavior); Palmer Rogers (microbiology); G. David Tilman (ecology, evolution, and behavior); Lawrence P. Wackett (biochemistry; Biological Process Technology Institute)

<sup>1</sup> University of Minnesota, Duluth

*Associate Professor:* Randall Hicks<sup>1</sup> (biology); Linda L. Kinkel (plant pathology)

**Course of Study**—Minor in microbial ecology, applicable to master's (M.S. only) and doctoral programs.

**Curriculum**—Microbial ecology is an area of interdisciplinary research concerned with the relationships of microorganisms to their natural environment. The microbial ecology program offers a core curriculum of coursework in microbiology, microbial physiology, microbial genetics, microbial ecology, and theoretical ecology as well as additional courses and opportunities to interact with others interested in microbial ecology. The microbial ecology seminar series allows students and faculty to hear and interact with microbial ecologists from other universities. The curriculum encourages interdisciplinary interaction, communication, and synthesis.

**Prerequisites for Admission**—To be admitted to the microbial ecology graduate minor, a student must be admitted to a master's or doctoral degree-granting program within the Graduate School, should have broad training in the biological sciences, and must be accepted by the director of graduate studies of the microbial ecology minor program. All students are expected to have had the equivalent of introductory microbiology (MicB 5105) and general ecology, but may fulfill deficiencies in these areas by taking these courses while in the program.

**Special Application Requirements**—Consult the director of graduate studies. Students are admitted each quarter.

**Minor Requirements**—For master's students, 12 credits are required, all of which must be from outside the student's major department. These 12 credits must include at least one laboratory course in microbiology (e.g., MicB 5322) and one ecology (EBB) course from the list below; the remaining courses, which are to be chosen with the guidance and approval of the director of graduate studies, can come from any of the other courses listed below. For doctoral students, a total of 24 credits are required, 17 credits of which must come from five required core courses (listed below). Contact the director of graduate studies for

potential alternatives to these required courses. The remaining credits must come from at least two courses chosen from the additional courses listed below, but may not be in the student's major area.

**Language Requirements**—None specific to the minor program.

**For Further Information and Applications**—Contact Dr. Michael Sadowsky, Microbial Ecology Minor Program, University of Minnesota, 246 Borlaug Hall, 1991 Upper Buford Circle, St. Paul, MN 55108 (612/624-2706; e-mail [sadowsky@soils.umn.edu](mailto:sadowsky@soils.umn.edu)).

### Core Courses

EEB 5052. Theoretical Population Ecology  
MicB 5105. Biology of Microorganisms  
MicB 5321. Physiology of Bacteria  
MicB 5611. Microbial Ecology  
MicB 8112. Microbial Genetics

### Additional Courses

BioC 5301. Ecological Biochemistry  
CE 5515. Water and Wastewater Microbiology  
CE 8505. Aquatic Chemistry for Environmental Engineers  
EEB 5601. Limnology  
EEB 5608. Ecosystems: Form and Function  
EEB 8602. Advanced Limnology  
MicB 5322. Microbial Diversity and Physiology Laboratory  
PBio 5103. Algae, Fungi, and Bryophytes  
PIPa 5206. Biology of Fungi  
PIPa 5211 (formerly 8111). Fungal Genetics  
PIPa 5500. Epidemiology and Ecology of Plant Disease  
Soil 5515. Soil Development, Classification, and Geography

<sup>1</sup> University of Minnesota, Duluth

## Microbial Engineering (Mice)

*Professor:* Peter W. Carr (chemistry); Gary M. Dunny (microbiology); Anthony J. Faras (microbiology; Institute of Human Genetics); Michael C. Flickinger (biochemistry; Biological Process Technology Institute); James A. Fuchs (biochemistry); Richard S. Hanson (microbiology); Alan B. Hooper (genetics and cell biology); Wei-Shou Hu (chemical engineering and materials science); Theodore P. Labuza (food science and nutrition); Larry L. McKay (food science and nutrition); Palmer Rogers (microbiology); Michael J. Sadowsky (soil, water, and climate; microbiology); Janet L. Schottel (biochemistry); W. Thomas Shier (medicinal chemistry); David A. Somers (agronomy and plant genetics); Lawrence P. Wackett (biochemistry; Biological Process Technology Institute); James F. Zissler (microbiology)

*Associate Professor:* Friedrich Srienc (chemical engineering and materials science; Biological Process Technology Institute), *director of graduate studies*; Robert J. Brooker (genetics and cell biology; Biological Process Technology Institute); Lynda B. Ellis (laboratory medicine and pathology; Institute of Human Genetics); R. Scott McIvor (laboratory medicine and pathology; Institute of Human Genetics); Bernard C. Reilly (microbiology; oral sciences); David H. Sherman (microbiology; Biological Process Technology Institute); Peter J. Southern (microbiology); Robert T. Tranquillo (chemical engineering and materials science)

*Assistant Professor:* Daniel J. O'Sullivan (food science and nutrition); C. Rick Wagner (medicinal chemistry)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—M.S. (Plan A and Plan B)

**Curriculum**—Microbial engineering is an interdisciplinary program that combines an understanding of basic principles in microbiology, molecular biology, chemical engineering, and related sciences with development of technical knowledge and know-how in industrial microbiology. In addition to the major coursework, Plan B students participate in preceptorships at local private company research laboratories. Plan A students conduct research and write a thesis guided by a faculty member. Supporting courses may be chosen from specific fields including biochemistry, food science, genetics and cell biology, or pharmacognosy.

**Prerequisites for Admission**—A baccalaureate degree in biological sciences, biochemistry, chemistry, or chemical engineering is preferred. Undergraduate coursework should include one year each of

calculus, organic chemistry, physics, microbiology, and basic chemical engineering, as well as a background in basic biology, physical chemistry, biochemistry, and genetics. Deficiencies may be made up during the first year of graduate studies.

**Special Application Requirements**—Three letters of recommendation, scores from the General Test of the Graduate Record Examination, the TOEFL score for international applicants, transcripts, and an autobiographical statement including occupational goals must be submitted to the director of graduate studies. Applications are accepted at any time, but the majority of students are accepted for fall quarter. To receive full consideration for financial aid, students must apply for fall quarter admission by February 1.

**Degree Requirements**—The two-year program is planned by the student and adviser. Coursework is required in a specialized program of microbiology, molecular biology, immunobiology, and chemical engineering. In addition, students are required to present two seminars and assist with instructing one course in advanced microbiology, molecular biology, or biochemical engineering. At the end of the first year, Plan B students participate in an eight- to twelve-week industrial research preceptorship, which may form the basis of a Plan B paper. Plan A students complete a research thesis during the second year. Supporting coursework may be chosen from specified fields including biochemistry, food science, genetics and cell biology, or pharmacognosy. Proficiency in computer programming and one computer language must be demonstrated. A Plan B paper or Plan A research thesis and a final oral examination are required. For Plan A the minimum number of course credits required is 31-32 (plus 16 thesis credits); for Plan B the minimum number is 35-36 (plus 2-4 research credits).

**Language Requirements**—None.

**For Further Information and Applications**—Contact the M.S. Program in Microbial Engineering, Biological Process Technology Institute, University of Minnesota, 1479 Gortner Avenue, Suite 240, St. Paul, MN 55108 (612/625-0212; fax 612/625-1700; e-mail [bpti@biosci.cbs.umn.edu](mailto:bpti@biosci.cbs.umn.edu)).

MicE 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

MicE 5309. Biocatalysis and Biodegradation. (4 cr, \$BioC 5309; prereq chem through organic chem, microbiol or adv chem, knowledge of word proc, e-mail, WWW access; access to college-level sci library recommended)

Novel method for obtaining information on biocatalytic and/or biodegradation reactions and pathways. Students verify and update existing Web pages in this database and develop Web pages for metabolic pathways for degradation of environmental pollutants.

MicE 5990. Teaching Practicum. (0-1 cr)  
To satisfy teaching assistant requirement for microbial engineering M.S. degree.

MicE 8950. Special Topics. (1-4 cr)  
Topics in biological processing.

MicE 8990. Biotechnology Seminar. (1 cr)  
Student presentations of thesis research; required for M.S. degree.

**Note**—The following courses are selected for major and minor programs; other courses are also available. Descriptions of all courses can be found in the course listings of the respective departments.

Biol 5003. Genetics. (4 cr, \$GCB 3022, \$GCB 5022, prereq 5001 or BioC 3021 or BioC 5331)

ChEn 5001. Computational Methods in Chemical Engineering and Materials Science. (4 cr, \$MatS 5001; prereq chem engr or mat sci major)

ChEn 5101-5102-5103. Principles of Chemical Engineering I-II-III. (4 cr per qtr; prereq 5001 or ¶5001, IT student)

ChEn 5104. Unit Operations and Separation Processes. (4 cr; prereq 5101, upper div ChEn or MatS major)

ChEn 5301. Chemical Reactor Analysis. (4 cr; prereq 5202, upper div ChEn or MatS major)

ChEn 5751. Chemical Engineering in Biotechnology and Environment. (3 cr; prereq ChEn sr or grad student or #)

ChEn 5753. Biochemical Engineering III. (3 cr; prereq Biol 5001, ChEn grad student or sr or #)

ChEn 5756. Biochemical Engineering Laboratory. (2 cr; prereq 5751 or 5752)

ChEn 5780. Principles of Mass Transfer in Engineering and Biological Engineering. (3 cr; prereq upper div engr or science student)

FScN 5120. Food Microbiology. (5 cr; prereq 1102, 3112, VPB 3103 or MicB 5105 or #)

FScN 5123. Food Fermentations and Biotechnology. (3 cr; prereq 5120)

FScN 5555. Freezing and Dehydration of Foods. (5 cr; prereq 1102, 5135; offered alt yrs)

FScN 8323. Microbial Starter Cultures. (3 cr; prereq 5123, Biol 5001 or #; offered alt yrs)

MicB 5218. Immunology. (3 cr; prereq Biol 5001)

MicB 5232. Medical Microbiology. (3 cr; prereq 5105 or 3103 or 8110 or Biol 5013, 5216 or 5218)

MicB 5234. Immunology and Medical Microbiology Laboratory. (3 cr; prereq 5218 or ¶5218, 5232 or ¶5232)

MicB 5321. Physiology of Bacteria. (3 cr; prereq 3103 or 5105 or Biol 5103 or VPB 3013, Biol 5001, 10 cr organic chem, 3 cr genetics)

MicB 5322. Microbial Diversity and Physiology Laboratory. (3 cr; prereq 5321 or ¶5321 or equiv)

MicB 5352s. Applied Microbial Biochemistry. (4 cr, \$BioC 5352; prereq 5321 or BioC 3021 or BioC 5331, intro micro course or #)

MicB 5424. Biology of Viruses. (3 cr; prereq 5105 or Biol 5004 or Biol 5013, Biol 5003)

MicB 5425s. Virology and Microbial Genetics Laboratory. (3 cr, \$Biol 5125; prereq 5424 or ¶5424, BioC 3021 or BioC 5331 or Biol 5001, Biol 5003 or GCB 3022 or GCB 5022)

MicB 8110. Structure, Function, and Metabolism of Bacteria. (3 cr; prereq beginning microbiology, organic chemistry, biochemistry, general biology or #)

MicB 8112. Microbial Genetics. (3 cr; prereq grad major in micro or #)

MicB 8125. Microbial Ecology. (3 cr; prereq coursework in micro, biochem or #)

MIMP 8216. Frontiers of Immunology I: Molecular Immunology. (3 cr, \$MicB 8216, \$Path 8216; prereq MicB 5218)

MIMP 8217w. Frontiers of Immunology II: Cellular Immunology. (3 cr, \$MicB 8217, \$Path 8217; prereq Biol 5001 or equiv or #)

MIMP 8218s. Frontiers of Immunology III: Clinical Immunology. (4 cr, \$MicB 8218, \$Path 8218; prereq 8216, 8217)

## Microbiology, Immunology, and Molecular Pathobiology

*Regents' Professor:* Alfred Michael

*Professor:* Khalil Ahmed; Dwight L. Anderson; Fred S. Apple; P. Patrick Cleary; Agustin P. Dalmasso; Gary M. Dunny; Martin Dworkin; Anthony J. Faras; Michael C. Flickinger; Leo T. Furcht; Gregory R. Germaine; Ashley T. Haase; Richard Hanson; Robert P. Hebbel; Alan B. Hooper; Margaret K. Hostetter; Harry S. Jacob; Russell C. Johnson; M. Colin Jordan; John Kersey; Tucker W. LeBien; Walter C. Low; Paul T. Magee; James B. McCarthy; Larry L. McKay; Matthew F. Mescher; Theodore R. Oegema, Jr.; Harry T. Orr; Peter G. W.

Plagemann; Gundu Rao; Palmer Rogers; Andreas Rosenberg; Michael J. Sadowsky; Patrick Schlievert; Lawrence B. Schook; Janet Schottel; Burton L. Shapiro; Daniel Vallera; Brian G. Van Ness; Gregory M. Vercellotti; Lawrence P. Wackett; Lee W. Wattenberg

*Associate Professor:* Marc K. Jenkins, *director of graduate studies;* Peter B. Bitterman; Bruce R. Blazar; Aristidis S. Charonis; Kathleen F. Conklin; Lynda B. Ellis; Alejo Erice; Vincent F. Garry; Dale S. Gregerson; Betsy A. Hirsch; Ronald R. W. Jemmerson; R. Scott McIvor; Robert D. Nelson; Stewart Scherer; Leslie A. Schiff; Yoji Shimizu; Amy P. Skubitz; Keith M. Skubitz; Peter Southern; Michael Y. Tsai; Effie C. Tsilibary; Carol L. Wells

*Assistant Professor:* Vivian J. Bardwell; Timothy W. Behrens; Frederick T. Boyd; Rod M. Feddersen; Gregg B. Fields; William B. Gleason; Kristin A. Hogquist; Stephen C. Jameson; Vivek Kapur; Bruce R. Lester; Ambika Mathur; Daniel L. Mooradian; Daniel L. Mueller; Christopher A. Pennell; David H. Sherman; Catherine M. Verfaillie; Carston Wagner

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A only) and Ph.D.

**Curriculum**—The microbiology, immunology, and molecular pathobiology program was formed by the merger of the microbiology and pathobiology graduate programs. Students in the program complete a Ph.D. with specialization in one of three tracks (microbiology, immunology, or molecular pathobiology), but receive broad training in the other tracks as well. The program offers exceptional research opportunities for graduate training in the fields of genetic engineering of microorganisms, biotechnology, microbial pathogenesis, environmental microbiology, lymphocyte activation and development, autoimmunity, superantigens, cancer biology, vascular biology and inflammation, and the molecular genetics of disease. In their first year, students take courses and do laboratory rotations before identifying an adviser. Students also have weekly opportunities to participate in the program's research seminar, journal clubs, and student research seminars. Students gain valuable teaching experience by assisting in laboratory courses for one or two quarters.

**Prerequisites for Admission**—College coursework, including a year of general chemistry; organic chemistry; physics; calculus; and one academic year or the equivalent of

courses in the biological sciences supplemented by courses in biochemistry and genetics. A course in microbiology, immunology, or histology is highly recommended but not required.

**Special Application Requirements**—The following must be submitted to the program: three letters of recommendation; scores from the General (Aptitude) Test of the Graduate Record Examination; and a brief description of reasons for seeking an advanced degree, areas of research interest and reasons for these interests, and career objectives. A minimum TOEFL score of 600 is required of applicants whose native language is not English. Applicants are encouraged to apply for fall quarter admission only, because the core curriculum begins in fall. Applications should be submitted by January 1; those received after that date are considered only if space in the desired program is available.

**Master's Degree Requirements**—The final examination for the master's degree is a closed oral examination and covers all areas of microbiology as well as the student's thesis research.

**Doctoral Degree Requirements**—Students choose a track early in the first year and complete the curriculum for that track. Four major field courses are required for each track. Eighteen additional credits make up the supporting program. Students complete a written preliminary examination at the end of the first year and an oral preliminary examination early in the third year. The oral preliminary examination consists of the oral defense of a written research proposition covering the student's proposed thesis research as well as general questions in the areas of microbiology, immunology, and pathobiology.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—Contact the program office for information about the required minor curriculum.

**For Further Information and Applications**—Contact the Microbiology, Immunology, and Molecular Pathobiology Program, University of Minnesota, Box 196 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (mailing address) (612/624-5947; fax 612/626-0623; e-mail [mimp@lenti.med.umn.edu](mailto:mimp@lenti.med.umn.edu)).

MIMP 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

MIMP 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

MIMP 8888. Thesis Credits: Doctoral. (36 cr required)

### Microbiology (MicB)

MicB 5105f, w, s.<sup>1</sup> Biology of Microorganisms. (5 cr, §3103, §Biol 5013, §VPB 3103; prereq 5 cr biol sci, BioC 3021 or BioC 5331 or Biol 5001 or #) Dunny, Hanson, Sherman  
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Molecular structure in relation to bacterial function. Laboratory.

MicB 5201f. Microbiology for Dental Students. (8 cr) Anderson, Liljemark, Reilly  
Nature and diversity of microorganisms; bacterial anatomy; nutrition and growth; variation and genetic exchange; fundamentals of immunology; pathogenic bacteria, fungi, and viruses; principles of sterilization and disinfection; chemotherapy; development and ecology of the oral flora; microbiology of dental caries and periodontal disease.

MicB 5205w. Microbiology for Medical Students. (5 cr; prereq regis med fr or #) Schlievert, staff  
Basic medical aspects of immunology, parasitology, mycology, medical bacteriology, and virology with emphasis on pathogenesis. Principles and techniques enabling diagnosis, treatment (especially chemotherapy), and prevention of infectious disease.

MicB 5206s. Microbiology for Medical Students. (5 cr; prereq regis med fr or #)  
(Continuation of MicB 5205) Lecture and lab.

MicB 5218w. Immunology. (3 cr; prereq BioC 3021 or BioC 5331 or Biol 5001) Gray  
Cellular, protein, and genetic bases of humoral immunity; methods for measuring antibodies and antigens. T lymphocytes: interaction of T helper cells with B lymphocytes and other T cells in cell-mediated immunity. Clinical immunology: immunodeficiency, allergy, auto-immunity, transplantation.

MicB 5232w. Medical Microbiology. (3 cr; not open to med students; prereq 5105 or 3103 or 8110 or Biol 5013, 5216 or 5218) Cleary  
Pathogenic bacteria and fungi; mechanisms of pathogenicity and virulence; properties of microorganisms and their animal hosts that influence the outcome of host-parasite relations analyzed from genetic and metabolic view.

MicB 5234w.1 Immunology and Medical Microbiology Laboratory. (3 cr; prereq 5218 or ¶15218, 5232 or ¶15232) Cleary, Gray  
Principles that determine outcome of host-parasite interactions. Methods basic to host defense and immunology, including immunochemical and microbiological methods for diagnosing infectious disease.

MicB 5235f. Microorganisms and Disease. (3 cr, §5233; prereq 10 cr chemistry, 5 cr biological sciences or #; not open to microbiology majors) Johnson  
Lectures on nature of microorganisms, immunology, medical bacteriology, virology, mycology, and principles of disease control.

MicB 5321f. Physiology of Bacteria. (3 cr; prereq 3103 or 5105 or Biol 5013 or VPB 3103, Biol 5001, 10 cr organic chem, 3 cr genetics) Rogers  
Chemical and physical organization of bacteria as related to function; growth; energy metabolism including oxidations and fermentations; nutritional requirements; antimicrobial agents; autotrophic mechanisms; microbial differentiation.

MicB 5322f. Microbial Diversity and Physiology Laboratory. (3 cr; prereq 5321 or ¶15321 or equiv) Dworkin, Rogers  
Isolation from natural sources; physiology and metabolism of wide variety of microorganisms, such as *Clostridium*, yeast, *Caulobacter*, myxobacteria, *Leptospira*, photosynthetic bacteria, *Bdellovibrio*, luminescent bacteria, and others. Lab only.

MicB 5352s. Applied Microbial Biochemistry. (4 cr, §BioC 5352; prereq 5321 or BioC 3021 or BioC 5331, intro micro course or #) Flickinger  
Biochemistry of microorganisms and enzymes of industrial interest. Heterologous peptide overproduction by microorganisms and yeasts; polymer, antibiotic, organic acid, and amino acid production; genetics of industrially useful microorganisms; biological systems useful for biotransformations and environmental mediation; introduction to fermentation technology.

MicB 5424s. Biology of Viruses. (3 cr; prereq 5105 or Biol 5004 or Biol 5013, Biol 5003) Plagemann  
Structure, composition, and properties of bacterial, plant, and animal viruses; their interaction with cells and effects on host cell metabolism; biochemistry of viral replication; techniques used in study of viruses and viral infections; viral tumorigenesis.

MicB 5425s. Virology and Microbial Genetics Laboratory. (3 cr, §Biol 5125; prereq 5424 or ¶15424, BioC 3021 or BioC 5331 or Biol 5001, Biol 5003 or GCB 3022 or GCB 5022) Plagemann, Schiff, Southern  
Modern techniques: animal cell culture, virus infectivity titrations, analysis of viral nucleic acids and proteins by radiolabeling, gel electrophoresis and blot hybridizations, cell transformation by tumor viruses and DNA, analysis and mapping of mutants in microorganisms.

<sup>1</sup> Microscope required. Students may obtain use of microscope by purchasing a \$6 microscope card from the bursar.

MicB 5611s. Microbial Ecology. (3 cr, §Soil 5605; prereq 3103 or 5105 or Biol 5013 or Soil 5610 or #) Sadowsky

Interrelationship of microorganisms with terrestrial, aquatic, and organismal environments; survey of bacterial, fungal, and algal components of ecosystems; evolution and structure of microbial communities; population interactions within ecosystems; quantitative and habitat ecology; biogeochemical cycling; and biotechnological approaches to study of microbial ecology.

MicB 8110f. Structure, Function, and Metabolism of Bacteria. (3 cr; prereq beginning micro, biochem, organic chem, general biol or #) Dworkin, Rogers

Physiology of eubacteria and archaeobacteria with emphasis on their organismic diversity. Structure, motility, chemotaxis, metabolism, phototrophy, growth, transport, and molecular evolution. Lectures and discussion.

MicB 8112w. Microbial Genetics. (3 cr; prereq grad major in micro or #) Dunny, Scherer  
Lecture and discussion in molecular genetics.

MicB 8125w. Microbial Ecology. (3 cr; prereq coursework in micro, biochem or #) Sadowsky  
Relationship between microorganisms and their interactions with the living and non-living components of their environments.

MicB 8231s. Advanced Topics in Microbial Pathogenesis. (3 cr; prereq micro grad student or #)  
Contemporary approaches and insights into complex interactions of microorganisms with their hosts that result in disease.

MicB 8421s. Eukaryotic Molecular Virology and Tumor Biology. (3 cr; prereq coursework in biochem, cell biol, micro or #) Conklin, Schiff  
Analysis of virus-host interaction at molecular level. Replication strategies of RNA, DNA, and retroviruses; oncogenic mechanisms of tumor viruses. Use of viruses to understand basic cellular and molecular processes. Lectures, analysis of primary literature, and student-led discussions.

MicB 8910f,w,s. Seminar. (1 cr; prereq #)

## Microbiology, Immunology, and Molecular Pathobiology (MIMP)

MIMP 5992f,w,s,su. Practicum: Teaching. (1 cr, §MicB 5992; prereq MIMP grad major or #)  
Supervised experience in lab instruction: development of skills in effective use of instructional materials, tests and measurement.

MIMP 8216f. Frontiers of Immunology I: Molecular Immunology. (3 cr, §MicB 8216, §Path 8216; prereq MicB 5218) Jemmerson, Pennell  
Molecular basis of immunological recognition: B and T cells; immunoglobulin and T-cell receptor genes and mechanisms of expression; antigen processing and presentation; signal transduction in lymphokines; MHC gene products; structure and function; costimulatory and adhesion molecules.

MIMP 8217w. Frontiers of Immunology II: Cellular Immunology. (3 cr, §MicB 8217, §Path 8217; prereq Biol 5001 or equiv or #) Jenkins  
Overview of B-cell/T-cell interactions, major histocompatibility complex, cell surface markers, B-cell development and responses, negative regulatory mechanisms, T-cell responses, PMNs, and macrophages.

MIMP 8218s. Frontiers of Immunology III: Clinical Immunology. (4 cr, §MicB 8218, §Path 8218; prereq 8216, 8217; offered alt yrs) Gray, Mueller  
Antibody-mediated hypersensitivity, cellular hypersensitivity, autoimmunity, transplantation, tumor immunology, immunocytology, immune deficiencies.

MIMP 8990f,w,s,su. Research in Microbiology, Immunology, and Molecular Pathobiology. (Cr ar; prereq grad major in microbiology or pathology or MIMP or #)  
Graduate students with requisite preliminary training may elect research project outside their thesis work.

## Pathobiology (Path)

Path 5109. Seminar: Selected Topics in Pathobiology. (1 cr; prereq #; intended for Path grad students; A-F for students presenting seminars, S-N for all others)  
Current thesis topics and other aspects of pathobiology.

Path 5110. Seminar: Pathology. (1 cr; prereq #)  
Department research seminar series.

Path 8108f-8109w-8110st. Pathobiology I-II-III. (3 cr; prereq MdBc 5100, 5101 [or ¶MdBc 5100, 5101], CBN 5103, 5104 [or ¶CBN 5103, 5104] or #) McCarthy (8108), Orr (8109), LeBien (8110), staff  
In-depth examination of cell injury and death, cell adhesion/growth, cell cycle and aging, platelets and coagulation, immunology/immunopathology, carcinogenesis, molecular genetics and inborn errors of metabolism, inflammation and mechanisms of pathogenesis, cell biology, and biochemistry.

Path 8122w. Basic Science of Cancer. (1 cr; prereq MdBc 5100 or equiv) Wattenberg  
Causes of cancer and mechanisms by which neoplasia is produced.

Path 8130. Cell Biology of the Extracellular Matrix. (3 cr; prereq MdBc 5100-5101 or equiv, 8108-8109-8110 or #; offered alt yrs) McCarthy  
Classification of extracellular matrices and structural nature of components within them; cell adhesion and spreading on extracellular matrix; extracellular matrix in certain normal and pathologic conditions.

Path 8135w. Biochemical Aspects of Normal and Abnormal Cell Growth. (3 cr; prereq #) Ahmed  
Current studies on biochemical mechanisms in model systems relating to gene action, cell cycle, physiological, and pathological cell growth.

Path 8201. Research. (Cr and hrs ar; grads with necessary preliminary training may elect research, either as majors or minors in pathobiology) McCarthy, staff

Path 8263. Pathophysiology of Environmental Disease. (3 cr; prereq PubH 8261 or #) Garry  
General mechanisms of environmentally induced tissue injury; compensatory mechanisms and repair processes; acute and chronic pathophysiology; tissue specificity of toxic agents; mutagenesis; teratogenesis.

Path 8300. Current Topics in Medical Genetics. (2 cr; prereq # or Δ) Hirsch, Orr  
Current developments in medical genetics and concepts of pathogenesis of genetic diseases.

Path 8335. Mammalian Gene Transfer and Expression. (3 cr; prereq #) Mclvor  
Techniques, concepts, and application of gene transfer to mammalian physiology, pathology, and genetics; gene regulation, gene mapping, genetically engineered biologicals, transgenic animals, prospects for human gene therapy.

## Mineral Engineering<sup>1</sup>

*Professor:* Steven L. Crouch, *head*; Patrick L. Brezonik; Andrew Drescher; Charles Fairhurst; Efi Foufoula-Georgiou; Malcolm T. Hepworth; Kenneth J. Reid; Michael J. Semmens

*Adjunct Professor:* Peter A. Cundall

*Associate Professor:* Emmanuel M. Detournay; Catherine E. French; Joseph F. Labuz; Karl A. Smith; Vaughan R. Voller

*Assistant Professor:* Randal J. Barnes; David E. Newcomb

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B), M.Min.E., and Ph.D.

**Curriculum**—The program is administered in the Department of Civil Engineering. The master of mineral engineering degree (M.Min.E.) is designed for engineering graduates who are interested in design, operations, or management.

**Prerequisites for Admission**—Adequate preparation in undergraduate subjects and in the sciences fundamental to mineral engineering is required. A bachelor's degree in mineral engineering is required for the M.Min.E. program. Applicants to these programs who have B.S. degrees in other fields (e.g., geology, physics, chemistry) are required to make up deficiencies in the basic engineering curriculum.

**Special Application Requirements**—None.

**Degree Requirements**—For the M.Min.E. degree, see Professional Master's Degree in Engineering in the General Information section of this bulletin. All students should consult the department publication *General Information Bulletin for Graduate Students* for further information.

The final examination for all master's degrees is oral.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Department of Civil Engineering, University of Minnesota, 122 Civil Engineering Building, 500 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/625-5522).

## Molecular Biology

See Biochemistry, Molecular Biology and Biophysics.

See Molecular, Cellular, Developmental Biology and Genetics.

## Molecular, Cellular, Developmental Biology and Genetics

*Regents' Professor:* James G. White (laboratory medicine and pathology)

*Professor:* Steven C. McLoon (cell biology and neuroanatomy), *director of graduate studies*; Dwight L. Anderson (microbiology); G. Eric Bauer (cell biology and neuroanatomy); Robert M. Brambl (plant biology); Jaroslav Cervenka (oral sciences); Bianca M. Conti-Fine (biochemistry); William L. Cunningham (genetics and cell biology); James W. Curtsinger (ecology, evolution, and behavior); Edward H. Egelman (cell biology and neuroanatomy); Robert P. Elde (cell biology and neuroanatomy); Stanley L. Erlandsen (cell biology and neuroanatomy); David P. Fan (genetics and cell biology); Anthony J. Faras (microbiology); James A. Fuchs (biochemistry); Leo T. Furcht (laboratory medicine and pathology); Burle G. Gengenbach (agronomy and plant genetics); Gordon D. Ginder (medicine); Perry B. Hackett (genetics and cell biology); David W. Hamilton (cell biology and neuroanatomy); Janet H. Heasman (cell biology and neuroanatomy); Robert K. Herman (genetics and cell biology); William S. Herman (genetics and cell biology); Mark C. Herzberg (preventive sciences); Alan B. Hooper (genetics and cell biology); Ross G. Johnson (genetics and cell biology); Richard A. King (medicine); William Krivit (pediatrics); Ryoko Kuriyama (cell biology and neuroanatomy); Hon Cheung Lee (physiology); Paul A. Lefebvre (genetics and cell biology); Paul C. Letourneau (cell biology and neuroanatomy); Richard W. Linck (cell

<sup>1</sup> No new students are being accepted for the mineral engineering major. See programs in civil engineering and geological engineering.

biology and neuroanatomy); Dennis M. Livingston (biochemistry); Charles F. Louis (veterinary pathobiology); Paul T. Magee (genetics and cell biology); James B. McCarthy (laboratory medicine and pathology); Matthew K. McGue (psychology); Larry L. McKay (food science and nutrition); Robert G. McKinnell (genetics and cell biology); David J. McLaughlin (plant biology); Matthew F. Mescher (laboratory medicine and pathology); Jack H. Oppenheimer (medicine); Harry T. Orr (laboratory medicine and pathology); Ronald L. Phillips (agronomy and plant genetics); R. Paul Robertson (medicine); Irwin Rubenstein (plant biology); Walter Sauerbier (microbiology); Lawrence B. Schook (veterinary medicine); Janet L. Schottel (biochemistry); Burton L. Shapiro (dentistry); W. Thomas Shier (medicinal chemistry); Carolyn D. Silflow (genetics and cell biology; plant biology); Michael J. Simmons (genetics and cell biology); Akhouri Sinha (genetics and cell biology); D. Peter Snustad (genetics and cell biology); David A. Somers (agronomy and plant genetics); Robert L. Sorenson (cell biology and neuroanatomy); Clifford J. Steer (medicine); Howard C. Towle (biochemistry); Brian G. Van Ness (biochemistry); Patricia R. M. Veach (educational psychology); Susan M. Wick (plant biology); Clare K. Woodward (biochemistry); Christopher C. Wylie (pediatrics)

*Adjunct Professor:* Howard W. Rines (agronomy and plant genetics)

*Associate Professor:* Judith G. Berman (plant biology); Susan A. Berry (pediatrics); Martin Blumenfeld (genetics and cell biology); Robert J. Brooker (Biological Process Technology Institute; genetics and cell biology); Aristidis S. Charonis (laboratory medicine and pathology); Kathleen F. Conklin (microbiology); J. Stephen Gantt (plant biology); Stuart F. Goldstein (genetics and cell biology); Dale S. Gregerson (ophthalmology); Thomas S. Hays (genetics and cell biology); Betsy A. Hirsch (laboratory medicine and pathology); Maria Hordinsky (dermatology); Victoria Iwanij (genetics and cell biology); David C. LaPorte (biochemistry); Patrick W. Mantyh (psychiatry); Ambika Mathur (oral sciences); R. Scott McIvor (Institute of Human Genetics); Neil E. Olszewski (plant biology); Mary E. M. Pierpont (pediatrics); Mary E. Porter (cell biology and neuroanatomy); Bernard E. Reilly (oral sciences); Sarah J. Schwarzenberg (pediatrics); Thomas A. Sellers (epidemiology); Jocelyn E. Shaw (genetics and cell biology); Yoji Shimizu (laboratory medicine and pathology); Robert T. Tranquillo (chemical engineering and materials science); Effie C. Tsilibary (laboratory medicine and pathology); Chester B. Whitley (pediatrics)

*Assistant Professor:* Linda M. Boland (physiology); Frederick T. Boyd (laboratory medicine and pathology); Linda Hammer Burns (obstetrics and gynecology); Stephen C. Ekker (biochemistry); Kristin A. Hogquist (laboratory medicine and pathology); Stephen C. Jameson (laboratory medicine and pathology); Brett K. Levay-Young (surgery); M. David Marks (genetics and cell biology); Georgiana May (plant biology); Sue V. Petzel (obstetrics and gynecology); Laura P. W. Ranum

(neurology); Kenneth P. Roberts (urologic surgery); Ann E. Rougvie (genetics and cell biology); Raymond E. Sicard (surgery); Jeffrey A. Simon (biochemistry); Amy P. N. Skubitz (laboratory medicine and pathology); H. Joseph Yost (cell biology and neuroanatomy)

*Other:* Mary J. Ahrens; Shari R. Baldinger; Bonnie A. Hatten; Beth A. Henderson-Conrad; Bonnie S. LeRoy; Carol J. Ludowese; Vickie L. Matthias Hagan; Karol R. Rubin; Trine L. Shimota; Alysia B. Spear; Catherine M. Walsh Vockley

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—The program provides students with scientific training in the basic life sciences, with emphasis on the molecular basis of genetics, development, and cell biology. Areas of specialization in the program are cell biology, developmental biology, genetics, and human genetics. Special institutes in human genetics, plant molecular genetics, and biological process technology provide opportunities for graduate study, as does a specialty in genetic counseling.

**Prerequisites for Admission**—The program is sufficiently flexible to accommodate students with a wide range of backgrounds. Students with bachelor's degrees in any of the biological, chemical, or physical sciences are encouraged to apply. Recommended academic preparation includes one year each of calculus, organic chemistry, and physics, and background in basic biology including biochemistry and genetics. Research experience is highly desirable. For students of demonstrated ability, background deficiencies can be made up during the first year of graduate study. Exceptional international applicants with TOEFL scores of 650 or better will be considered.

**Special Application Requirements**—Applicants are required to submit three letters of recommendation from persons familiar with their academic and research capabilities; scores from the General (Aptitude) Test and the Subject (Advanced) Test (in biology; chemistry; or biochemistry, cell and molecular biology) of the Graduate Record Examination; and a statement of interests, goals, and research experience. Recommended date for receipt of

completed applications is January 15. Graduate studies typically begin in summer session or fall term.

**Master's Degree Requirements**—The average length of time required to obtain a master's degree is two years. Students are admitted to the M.S. program only under exceptional circumstances (e.g., if, for personal reasons, they can be in the area for only two years) or if they are accepted into the genetic counseling specialization; in both cases, applicants must also be competitive for admission at the Ph.D. level.

**Doctoral Degree Requirements**—The Ph.D. program is designed by the student and the adviser to meet individual interests and goals. Advanced courses in genetics, molecular biology, cell biology, and biochemistry are required, in addition to special courses, topical seminar courses, laboratory research rotations, thesis research, department seminars, and journal clubs.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—Proposed minor courses typically include the genetics core series (GCB 8131 and 8132) and advanced cell biology courses (GCB 8148 and 8149) as appropriate to the student's field of specialization.

**For Further Information and Applications**—Inquiries about admission and financial support should be directed to the Director of Graduate Admissions, Molecular, Cellular, Developmental Biology and Genetics, University of Minnesota, 250 Biological Sciences Center, 1445 Gortner Avenue, St. Paul, MN 55108 (612/624-7470; fax 612/625-5754; e-mail [mcdbg@molbio.cbs.umn.edu](mailto:mcdbg@molbio.cbs.umn.edu)). Inquiries about graduate program activities, courses, and research opportunities should be directed to the Director of Graduate Studies at the same address and phone number.

MCDG 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

MCDG 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

MCDG 8888. Thesis Credits: Doctoral. (36 cr required)

## Molecular, Cellular, Developmental Biology and Genetics (MCDG)

MCDG 8920. Special Topics. (1-5 cr; prereq MCDG grad or  $\Delta$ ; S-N only)  
Participation in organized symposia and short courses.

MCDG 8950. Teaching Practicum. (1 cr; prereq MCDG grad or  $\Delta$ ; S-N only)  
Supervised experience in classroom, laboratory, and/or recitation instruction; development of skills in effective use of instructional materials, tests, and measurement.

MCDG 8970. Directed Studies. (Cr ar; prereq MCDG grad or  $\Delta$ )  
Content determined by student's interests, in consultation with instructor; opportunity for independent, non-lab study.

MCDG 8990. Research. (Cr ar; prereq MCDG grad or  $\Delta$ ; S-N only)  
Research determined by student's interests, in consultation with faculty mentor.

## Genetics and Cell Biology (GCB)

GCB 5015s. Histology: Cell and Tissue Organization. (5 cr; prereq Biol 5004 or #) Cunningham  
Structure and function of vertebrate tissues and organs. Lectures combine electron microscopy, light microscopy, physiology, and cell biology of higher animals. Labs concentrate on light microscopy of mammalian tissues.

GCB 5024s. The Genetics of Development. (4 cr; prereq Biol 5003 or #) R Herman, Shaw  
Introduction to current concepts of and experimental approaches to the genetic basis of morphogenesis and metazoan development. Emphasis on organisms amenable to genetic analysis, including some prokaryotes and single-cell eucaryotes, a nematode and *Drosophila*.

GCB 5030s. Laboratory: Genetics. (2 cr; prereq 3022 or 5022 or BioC 5333 or Biol 5003)  
Investigative approaches to analysis of genetic problems. Focus on a given organism or related group of organisms may differ quarterly.

GCB 5034w. Intermediate Molecular Genetics. (4 cr; prereq Biol 5003, 5004, advanced bioscience undergrad or non-bioscience grad student) Shaw  
Molecular genetics of prokaryotes and eucaryotes, concentrating on characterization and regulation of gene expression; techniques used to study gene expression.

GCB 5035f. Intermediate Cell Biology. (4 cr; prereq Biol 5004 or #) Iwanij  
Selected scientific papers illustrating new concepts and experimental approaches to basic questions of cell organization and function. Membranes, secretion, endocytosis, the cytoskeleton, and the nucleus.

GCB 5061s. Developmental Biology. (4 cr; prereq Biol 3011 or Biol 3111, Biol 5004)  
Animal embryology; morphogenesis and cellular differentiation with emphasis on vertebrates and pattern formation. Control mechanisms of development.

## MOLECULAR, CELLULAR, DEVELOPMENTAL BIOLOGY AND GENETICS

GCB 5073s. Advanced Human Genetics. (4 cr; prereq 5034 or #) King  
Application of molecular, biochemical, chromosomal, and population genetics to human variation and disease. Abnormal chromosome number and structure; abnormal enzyme, structural protein, receptor and transport; analysis of inheritance patterns; behavioral genetics; and genetic basis of common disease.

GCB 5114f. General Physiology. (3 cr; prereq Biol 3011 or Biol 3111, Biol 5001 or BioC 3021 or BioC 5331, Phys 1109 or Phys 1253 or Phys 1295) Goldstein  
Quantitative approach to the study of cell function with emphasis on application of physical and chemical principles. Transport, electrical activity of cell membranes, cell contractility.

GCB 5134s. Endocrinology. (4 cr; prereq Biol 3011 or Biol 3111, Biol 5001 or BioC 3021 or BioC 5331 or #) W Herman  
Survey of structure and function of invertebrate and vertebrate endocrine systems.

GCB 5605f. Cell Biology Laboratory. (2 cr; prereq Biol 5004 or #5004 or #)  
Experimental approaches to cell structure, function, and replication, including microscopy, autoradiography, cell fractionation, and molecular and chemical analyses.

GCB 8131w. Advanced Genetics I. (4 cr; prereq 3022 or Biol 5003, Biol 5001 or BioC 5751 or #) R Herman, Simon  
Comparative organization of genetic material in prokaryotic and eukaryotic organisms. Mutation, complementation, and recombination as operational criteria for genetic analysis.

GCB 8132f. Advanced Genetics II. (4 cr) Hackett  
Action of the gene in molecular, cellular, and organismal development. Mechanisms of information transfer and regulation of these processes in various biological systems; emphasis on examining original research.

GCB 8148w. Advanced Cell Biology I. (4 cr, §CBN 8148; prereq Biol 5004 or #) Brooker  
Eucaryotic systems with emphasis on structure, function, and chemistry of cell organelles; also selected specialized cells. Membranes and secretion, including membrane methodologies, structure, function, synthesis, and turnover; cell surfaces, protein synthesis, glycosylation, membrane fusion, lysosomes, endocytosis, role of peroxisomes, and detoxification by endoplasmic reticulum.

GCB 8149s. Advanced Cell Biology II. (4 cr, §CBN 8149; prereq Biol 5003, Biol 5004) Hays  
Eucaryotic systems with emphasis on structure, function, and chemistry of cell organelles; also selected specialized cells. Motility and cell nucleus. Roles of microtubules and microfilaments in cell locomotion, shape changes, cytokinesis, ciliary beating, and organelle redistribution; cell cycle, chromosomal structure, replication and mitosis; compartmentalization and autonomy of mitochondria and chloroplasts.

GCB 8213f. Advanced Molecular Biology I. (4 cr, §BioC 8213, §MdBc 8213; prereq BioC/MdBc 8002 or GCB 8132 or #)  
Lectures, readings, and discussions. DNA replication, recombination and gene conversion, regulation of gene expression in prokaryotes, regulation of gene expression in eucaryotes, chromatin structure and transcription, organellar gene expression.

GCB 8214w. Advanced Molecular Biology II. (4 cr, §BioC 8214, §MdBc 8214; prereq BioC/MdBc 8002 or GCB 8132 or #)  
Lectures, readings, and discussions. RNA splicing, RNA stability, initiation and control of translation, animal viruses, gene families, transposable elements, somatic recombination, yeast molecular biology, oncogenes.

GCB 8900f,w,s. Seminar. (1 cr [may be repeated for cr]; S-N only)

GCB 8910f,w,s. Journal Clubs. (1 cr; prereq Δ; S-N only)  
Critical evaluation of selected current literature.

GCB 8912s. Genetic Counseling in Practice. (4 cr; prereq admission to genetic counseling emphasis within genetics master's program or #) LeRoy  
Practical genetic counseling, communicating genetics and medical information to the family. Helping families with decision making.

GCB 8913f. Psychosocial Issues in Genetic Counseling. (3 cr; prereq admission to genetic counseling emphasis within genetics master's program or #) LeRoy  
Interviewing skills, supportive counseling, case study analysis.

GCB 8914w. Ethical and Legal Issues in Genetic Counseling. (3 cr; prereq admission to genetic counseling emphasis within genetics master's program or #) LeRoy  
Professional ethics and concerns with new technologies.

### Cell Biology and Neuroanatomy (CBN)

CBN 5103. Human Histology. (3-8 cr [7 cr for med/dent fr]; prereq regis med/dent fr, Anat grad student or grad student with #)  
Microscopic structure, cytochemical and functional aspects of cells, tissues, and organs.

CBN 8135. Biological Electron Microscopy: Technics. (1-5 cr; prereq #; offered alt yrs) Erlandsen  
Introduction to principles and technics of electron microscopy. Laboratory emphasis on acquisition of skills in tissue preparation, photography, use of electron microscope and ancillary equipment.

CBN 8136. Biological Electron Microscopy: Specialized ultrastructural technics and their application to biologic problems. Laboratory emphasis on high resolution microscopy and use of scanning electron microscope.

CBN 8137. Biological Electron Microscopy: Interpretation. (1-5 cr; prereq 5103, 8135-8136, #; hrs ar; offered alt yrs) Erlandsen

Structure and function of cell organelles. Individual projects using advanced techniques for both transmission and scanning electron microscopy.

CBN 8166. Seminar: Pancreatic Islet Biology. (3 cr; prereq #: offered alt yrs) Bauer, staff  
Structure, development, physiology, and cell biology of pancreatic islets of Langerhans. Primary sources: original publications supplemented by recent reviews.

CBN 8210. Developmental Neurobiology. (3 cr; prereq 5111, Pshl 5112 or #) McLoon  
Nervous system development. General mechanisms and experimental approaches.

### *Other Courses of Interest*

Agro 8230. Cytogenetics

BioC 5025. Laboratory in Biochemistry

BioC 5529. Protein Structure and Folding

BioC 8206. Cell Signaling and Metabolic Regulation

BioC 8230. Membrane Biochemistry

Biol 5003. Genetics

Biol 5004. Cell Biology

Biol 5125. Recombinant DNA Laboratory

Biol 5951. Social Uses of Biology

CBN 8215. Molecular and Cellular Basis of Development

CBN 8223. Neurobiology of Endocrine Regulation

CBN 8301. Molecular Biology of the Cytoskeleton

EEB 5044. Evolution

MicB 5218. Immunology

MicB 5321. Physiology of Bacteria

MicB 5424. Biology of Viruses

MicB 8112. Microbial Genetics

MicB 8125. Microbial Ecology

MicB 8231. Advanced Topics in Microbial Pathogenesis

MicB 8421. Eukaryotic Molecular Virology and Tumor Biology

MIMP 8216, 8217, 8218. Frontiers of Immunology

NSc 5460. Cellular and Molecular Neuroscience

NSc 8210. Developmental Neurobiology

OPat 8012. Human and Medical Cytogenetics

OPat 8300. Human Development Genetics I

Path 8108. Pathobiology I

Path 8109. Pathobiology II

Path 8110. Pathobiology III

Path 8130. Cell Biology of the Extracellular Matrix

Path 8335. Mammalian Gene Transfer and Expression

PBio 5109. Molecular Genetics and Biochemistry of Yeasts and Filamentous Fungi

PBio 5141. Plant Cell Biology

PBio 5184. Plant Growth and Development

PBio 5221. Plant Molecular Evolution

PBio 8287. Plant Molecular Biology

## Molecular Pathobiology

See Microbiology, Immunology, and Molecular Pathobiology.

## Museum Studies (MSt)

*Professor:* Elmer C. Birney (Bell Museum of Natural History); Joanne B. Eicher (design, housing, and apparel); Robert J. Poor (art history); Janet D. Spector (anthropology); Peter S. Wells (ancient studies); Gayle Graham Yates (American studies)

*Associate Professor:* Suzanne J. Baizerman (design, housing, and apparel); Margaret K. DiBlasio (curriculum and instruction); Kerry J. Freedman (curriculum and instruction)

*Adjunct Associate Professor:* Gordon R. Murdock (Bell Museum of Natural History), *director of graduate studies*

*Assistant Professor:* Lyndel I. King (University Art Museum); David J. Rhees (history of science and technology)

*Adjunct Assistant Professor:* Robert Jacobsen (art history)

**Course of Study**—Minor in museum studies, applicable to master's (M.A. and M.S.) and doctoral programs.

**Curriculum**—The museum studies minor offers a structured graduate curriculum for students interested in museums. It provides students from a variety of disciplines with an introduction to the issues involved in museum practices (e.g., educational, curatorial, administrative, and conservation). The curriculum can include seminars, directed readings, and internships.

**Prerequisites for Admission**—Admission to the museum studies graduate minor is contingent upon prior admission to a master's or doctoral degree-granting program within the Graduate School. It is anticipated that no more than 15 students will be admitted to this minor each year.

**Minor Requirements**—Master's students must take a total of 9 credits for the minor, doctoral students a total of 18 credits; for both master's and doctoral students, 4 of these required credits are for the introduction to museum studies core seminar.

**Language Requirements**—None specific to the minor program.

**For Further Information, Applications, and List of Courses**—Contact the Museum Studies Minor, University of Minnesota, 300 Bell Museum, 10 Church Street S.E., Minneapolis, MN 55455 (612/624-4112).

MSt 8010. Museum History and Philosophy. (4 cr; prereq #)  
Historical and philosophical roots of museum development from Renaissance to modern-day museums and historical societies.

MSt 8012. Museum Practices: Curatorial and Education Departments in Museums. (3 cr; prereq 8010 or #; offered alt yrs)  
Practical aspects of museum work. Responsibilities and issues. Larger context of the museum in which these departments operate.

MSt 8013. Museum Practices: Technical and Administrative Departments. (3 cr; prereq 8010 or #; offered alt yrs)  
Practical aspects of work of technical and administrative departments in contemporary museums: standards, practices, and larger museum context in which these departments function. Collections management, security, funding, boards, public relations, installation, budgeting.

MSt 8016. Internship. (1-6 cr per qtr; prereq 8010, permission of MSt director of graduate studies after agreement between student and internship supervisor)

## Music

*Regents' Professor:* Dominic Argento

*Professor:* Everett L. Sutton, *director*; John E. Anderson; Lydia Artymiw; David B. Baldwin; Alexander Braginsky; Margo Garrett; Paul A. Haack; James A. Hepokoski; Donna Cardamone Jackson; Craig J. Kirchoff; Thomas S. Lancaster; Richard Leppert; Alex Lubet; Glenda Maurice; Ronald C. McCurdy; Sally O'Reilly; Tanya Remenikova; Judith L. Zaimont

*Associate Professor:* David A. Grayson, *director of graduate studies*; Thomas J. Ashworth; Dean W. Billmeyer; Michael Cherlin; David A. Damschroder; Jean Del Santo; Charles E. Furman; Alan L. Kagan; Young-Nam Kim; Korey B. Konkol; Claire W. McCoy; Duncan R. McNab; Stephen W. Schultz; Rebecca P. Shockley; D. Clifton Ware, Jr.; Lawrence Weller

*Assistant Professor:* Eric A. Becher; Mark P. Bjork; Fernando A. Meza; Paul M. A. Shaw

*Affiliated Faculty:* Kendall A. Betts<sup>1</sup>; Julia Bogorad<sup>2</sup>; Gary A. Bordner<sup>2</sup>; Christopher Brown<sup>2</sup>; James L. Clute<sup>1</sup>; Richard Dirlam; David W. Eagle; Elaine K. Eagle; Jorja Fleezanis<sup>1</sup>; Kathryn Greenbank<sup>2</sup>; David B. Kamminga<sup>1</sup>; Barbara G. Kierig; Adam Kuenzel<sup>1</sup>; Rosalind L. Laskin; Manuel Laureano<sup>1</sup>; James P. McGuire; Frances G. Miller; John W. Miller, Jr.<sup>1</sup>; Timothy Paradise<sup>2</sup>; Basil Reeve<sup>1</sup>; Kathy S. Romey; Ross Tolbert<sup>1</sup>; Charles Ullery<sup>2</sup>; Jeffrey W. Van; Herbert E. Winslow<sup>2</sup>

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Music: M.A. (Plan A and Plan B), M.A. (Plan B only), M.M., D.M.A., and Ph.D.; Music Education: M.A. (Plan B only).

**Curriculum**—For the *master of arts (M.A.) degree (Plan A and Plan B) in music* (Graduate School application code 0580), emphases are offered in musicology and ethnomusicology. For the *master of arts (M.A.) degree (Plan B only) in music* (Graduate School application code 0580), emphases are offered in theory and composition. For the *master of arts (M.A.) degree (Plan B only) in music education* (Graduate School application code 0584), emphases are offered in music education and music therapy. For the *master of music (M.M.) degree*, emphases are offered in piano, harpsichord, organ, voice, violin, viola, cello, double bass, flute, oboe, clarinet, saxophone, bassoon, French horn, trumpet, trombone, euphonium, tuba, percussion, harp, guitar, piano pedagogy, accompanying and coaching, orchestral conducting, wind ensemble and band conducting, choral conducting, and church music (choral and organ concentrations). For the *doctor of musical arts (D.M.A.) degree*, emphases are offered in piano, organ, voice, violin, viola, cello, clarinet, woodwinds, trumpet, trombone, guitar, accompanying and coaching, and orchestral conducting. For the *doctor of philosophy (Ph.D.) degree*, emphases are offered in musicology, ethnomusicology, theory, composition, and music education/music therapy.

**Prerequisites for Admission**—Applicants to the M.A., M.M., Ph.D., and D.M.A. programs must hold a bachelor's degree or its equivalent with a major emphasis in one of the following areas of music: musicology and/or ethnomusicology, theory and/or composition, performance, or music education and/or music therapy.

<sup>1</sup> Minnesota Orchestra

<sup>2</sup> St. Paul Chamber Orchestra

**Special Application Requirements**—Three letters of recommendation. In addition, applicants to emphases in musicology/ethnomusicology, theory, or composition must submit scores for the Graduate Record Examination (GRE) General Test and music Subject Test. For music education and music therapy, only the GRE General Test scores are required. Applicants whose primary language is not English must score a minimum of 500 on the TOEFL test for admission and 550 for exemption from further English study (ESL).

The various degree programs also require the following additional application materials:

Degree Objective	Additional Materials
Theory (M.A., Ph.D.)	Original papers (tonal and post-tonal analysis)
Composition (M.A., Ph.D.)	Original scores
Musicology/Ethnomusicology (M.A., Ph.D.)	Original paper(s)
Music Education/ Music Therapy (M.A.)	None
Music Education/ Music Therapy (Ph.D.)	Original paper(s)
Accompanying/Coaching (M.M., D.M.A.)	Audition/Repertoire list
Choral Conducting (M.M.)	Audition/Interview
Church Music (M.M.)	Audition/Interview
Orchestral Conducting (M.M., D.M.A.)	Audition/Interview
Wind Ensemble/ Band Conducting (M.M.)	Audition/Interview
Piano Pedagogy (M.M.)	Audition/Interview
Performance (M.M., D.M.A.)	Audition/Repertoire list

For the M.M. and D.M.A. programs in performance, applicants living more than 200 miles from Minneapolis may submit a tape in lieu of a live audition. In the case of admission based on a taped recording, the appropriate level of study, including the possibility of remedial work, is determined by a live audition before registration. For the M.M. and D.M.A. in accompanying and coaching, a preliminary (audio) tape screening is required. For the M.M. and D.M.A. in orchestral conducting and the M.M. in wind ensemble/band conducting, a preliminary tape screening is required in both audio and video formats.

Although students may be admitted any quarter, opportunities for financial assistance are maximized by applying before January 15 for

fall admission. Applicants to the musicology/ethnomusicology, theory, and composition emphases maximize their chances for admission by completing their applications before March 1 for fall admission.

**Diagnostic Tests**—Music Theory and Music History Placement Tests are administered to all entering students. All graduate students in music must demonstrate proficiency in the material found in the undergraduate music theory and ear training sequences, including the form and structure of tonal music and twentieth-century music theory and ear training. Similarly, they must demonstrate proficiency in music history from the Middle Ages to the present. Students in musicology and ethnomusicology degree programs must take an additional discipline-specific diagnostic examination at the onset of their study; during the first year, a piano proficiency test is administered for the musicology specialization and a transcription test for ethnomusicology. An audition is required for registration in all applied music courses.

**Degree Requirements**—Program descriptions may be obtained from the School of Music graduate studies office.

**Language Requirements**—For the M.M. degree and for the M.A. and Ph.D. degrees in music education, none. For the M.A. degree in music, a reading knowledge of French, German, or Italian is required. For the Ph.D. degree and the D.M.A. degrees in accompanying/coaching and orchestral conducting, two languages chosen from French, German, or Italian are required (German is required of theory and orchestral conducting majors). Substitution may be made with the approval of the relevant division when a different language is needed for an individual research project. For the Ph.D. degrees in theory and composition, one language may be replaced by a special research technique or collateral field of knowledge. For D.M.A. degree programs other than those named above, language requirements are at the discretion of the adviser according to the nature of the degree plan.

**For Further Information and Applications**—Contact the School of Music, University of Minnesota, 100B Ferguson Hall, 2106 4th Street South, Minneapolis, MN 55455 (612/624-0071; fax 612/626-2200; e-mail mus-adm@tc.umn.edu).

## Music Applied (MusA)

Graduate courses in applied music are classified according to seven modes: elective, principal, major, secondary required, secondary elective, principal beyond requirement, and major beyond requirement. Students may not register for a course in applied music until they have passed the required applied entrance audition. The audition committee determines the mode(s) for which a student may register. Students should consult the School of Music, 100 Ferguson Hall, regarding the audition as well as the mode and level of music appropriate for fulfilling specific requirements for their degree programs. All scholarship students and all M.M. students enrolled in principal- or major-level lessons are required to register concurrently for a large ensemble. This requirement does not pertain to keyboard or guitar majors.

Applied music courses in the various modes offered at the graduate level are listed below. Credits and prerequisites for all MusA courses are:

MusA 5101 to 5123  
(2 cr; prereq audition, Δ)

MusA 8201 to 8223; 8401 to 8723  
(2 or 4 cr [max 12 cr]; prereq music major, Δ)

MusA 8301 to 8324  
(2 or 4 cr [max 16 cr for MM; max 48 cr for DMA]; prereq audition, Δ)

Mus 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Mus 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Mus 8888. Thesis Credits: Doctoral. (36 cr required for PhD, 6 cr required for DMA)

Mus 8999. Recital Credits: Doctoral. (6 cr [max 12 cr per qtr]; prereq DMA student)

Registration for recital credits coincides with performance of DMA recital, for total of 30 credits (5 recitals).

## Music (Mus)

### Vocal/Choral/Opera Studies

(See also Music Applied section above and *Ensembles*)

Mus 5150. Body Awareness in Activity: The Alexander Technique for Musicians. (2 cr; University College only)

Introduction to Alexander Technique with specific applications to music performance. Emphasis on body/mind awareness to promote technical ease and freedom.

Mus 5270. Stage Movement and Acting for Singers. (2 cr; prereq audition, #)  
Basic techniques; application to various forms of music theatre.

Mus 5370. Vocal Pedagogy Practicum. (1 cr per qtr [max 3 cr]; prereq sr or grad student, #) Ware  
Application of principles and techniques for group or individual adult instruction at beginning, intermediate, and advanced levels. Observation of faculty while teaching students.

Instrument	Elective	Principal	Major	Secondary Required	Secondary Elective	Principal Beyond Requirement	Major Beyond Requirement
Piano	5101	8201	8301	8401	8501	8601	8701
Harpsichord	5102	8202	8302	8402	8502	8602	8702
Organ	5103	8203	8303	8403	8503	8603	8703
Voice	5104	8204	8304	8404	8504	8604	8704
Violin	5105	8205	8305	8405	8505	8605	8705
Viola	5106	8206	8306	8406	8506	8606	8706
Cello	5107	8207	8307	8407	8507	8607	8707
Double Bass	5108	8208	8308	8408	8508	8608	8708
Flute	5109	8209	8309	8409	8509	8609	8709
Oboe	5111	8211	8311	8411	8511	8611	8711
Clarinet	5112	8212	8312	8412	8512	8612	8712
Saxophone	5113	8213	8313	8413	8513	8613	8713
Bassoon	5114	8214	8314	8414	8514	8614	8714
French Horn	5115	8215	8315	8415	8515	8615	8715
Trumpet	5116	8216	8316	8416	8516	8616	8716
Trombone	5117	8217	8317	8417	8517	8617	8717
Baritone	5118	8218	8318	8418	8518	8618	8718
Tuba	5119	8219	8319	8419	8519	8619	8719
Percussion	5121	8221	8321	8421	8521	8621	8721
Harp	5122	8222	8322	8422	8522	8622	8722
Guitar	5123	8223	8323	8423	8523	8623	8723
Accompanying/Coaching			8324				

## GRADUATE PROGRAMS

Mus 5371f, 5372w, 5373s. Diction for Singers. (2 cr per qtr; prereq 12 cr of 1204 or #) Principles and techniques of singing in English, Italian, German, and French. International Phonetic Association alphabet used. 5371: English and Italian. 5372: German. 5373: French.

Mus 5374. Text and Language: A Singer's Tools for Interpretation. (2 cr; prereq #) Maurice Specific meanings, properties, and inflections of words as used by singers for artistic interpretation; role of musical setting in defining meaning. Performance required.

Mus 5375. The Vocal Mechanism. (2-3 cr; prereq sr or grad student, #) Ware Mental and physical preparations for singing. Voice production basics of singing and speaking: respiration, phonation, registration, resonance, articulation. Anatomy and physiology of vocal mechanism. Efficient, healthy voice methods and techniques. Optional 1 credit research project.

Mus 5376. Vocal Performance. (2-3 cr; prereq sr or grad student, #) Ware Analysis and interpretation of art songs. Performance skills, styles, methods, and techniques; recital programming; career opportunities; pedagogical application of subject matter to art song performance. Optional 1 credit research project.

Mus 5377. Vocal Pedagogy. (2-3 cr; prereq sr or grad student, 5375, #) Ware Historical survey of voice pedagogues and comparative teaching methodology. Learning theory; general teaching methods and techniques; teaching child, adolescent, and aging voice; teaching pedagogy classes, individuals, and group voice. Optional 1 credit research project.

Mus 5378. Vocal Conference/Workshop. (1-2 cr; prereq sr or grad student, #) Ware Specific theme for each conference or workshop. Anatomy and physiology of vocal mechanism; scientific research and applications; vocal methods and techniques; voice use and care.

Mus 5383. Choral Conducting Technique. (2 cr; prereq #) Lancaster Techniques, rehearsal procedure. Shorter works from various eras.

Mus 5384, 5385. Choral Conducting. (4 cr per qtr; prereq #; offered alt yrs) Lancaster Techniques, rehearsal procedure. 5384: Music before 1750. 5385: Music after 1750.

Mus 5741, 5742. Vocal Literature. (4 cr per qtr; prereq 12 cr in 1104 or 1204 or 1304 or #; offered alt yrs) Vocal literature of major and minor composers from 16th century to present; structure, style, and performance practice.

Mus 8399f,w,s. Performance: Choral Conducting. (4 cr; prereq 5384, 5385, #) Lancaster Preparation and performance of a choral conducting recital, with supporting paper.

Mus 8537. Score Study (Choral). (4 cr; prereq grad student, #) Lancaster Analysis of various choral scores ranging from Renaissance era through 20th century. Reading of choral and choral/orchestral scores at piano, including scores employing C clefs and transposing instruments.

Mus 8754. Choral Literature: Renaissance Through Baroque Eras. (4 cr; prereq grad student, #) Lancaster Sacred and secular choral works of Renaissance and baroque eras.

Mus 8755. Choral Literature: Classical Era Through the 20th Century. (4 cr; prereq grad student, #) Lancaster Sacred and secular choral works of classical era through 20th century.

### Keyboard Studies

(See also Music Applied section above and *Ensembles and Jazz Studies*)

Mus 5150. Body Awareness in Activity: The Alexander Technique for Musicians. (2 cr; University College only) See Vocal/Choral/Opera Studies for description.

Mus 5310. Piano Pedagogy Practicum. (1 cr per qtr [max 3 cr]; prereq ¶|5351-5352-5353 or ¶|5354-5355-5356 or #) Shockley Application of principles and techniques for group or individual instruction at elementary, early intermediate, and late intermediate levels in directed teaching setting.

Mus 5351f-5352w-5353s. Piano Pedagogy. (2 cr per qtr; prereq 12 cr in MusA 1201 or MusA 1301 or #; offered alt yrs) Shockley Demonstration and discussion of teaching techniques, methods, and materials for group and individual instruction at elementary, early intermediate, and late intermediate levels.

Mus 5354f-5355w-5356s. Advanced Piano Pedagogy. (2 cr per qtr; prereq grad piano major or 5353 or #; offered alt yrs) Shockley Demonstration and discussion of teaching techniques, methods, and materials for group and individual instruction at intermediate and early advanced levels.

Mus 5411. Instrumental Accompanying Skills and Repertoire. (2 cr; prereq accompanying major) Garrett Performance class in accompanying skills particular to orchestral reductions and "non-sonata" instrumental accompanying. Repertoire to include, but not be limited to, classical and romantic string concerti and "encore" pieces.

Mus 5421, 5422, 5423. Vocal Accompanying Skills and Repertoire. (2 cr per qtr; prereq French and German and Italian diction, accompanying or graduate vocal major) Garrett Performance class (*Lieder, mélodie*, opera) with emphasis on coaching techniques and performance skills of pianists and singers.

Mus 5521f-5522w-5523s. Advanced Keyboard Skills. (2 cr per qtr; prereq 3532, sr or grad student or #) Billmeyer  
Students develop fluency of application of theoretical skills: diatonic and chromatic harmonic vocabulary of tonal music, transposition, modulation, improvisation, harmonization, figured bass realization and accompaniment, and reading music in C clefs and open score.

Mus 5744f, 5745w, 5746s. Piano Literature. (2 cr per qtr; prereq 12 cr of MusA 1201 or 1301 or #; offered alt yrs) McNab  
Literature for piano from late Baroque period to mid-20th century.

Mus 5747, 5748, 5749. Organ Literature. (2 cr per qtr; prereq 3606, 3532 or #) Billmeyer  
Organ literature from 14th century to present. Influence of organ design from various periods and national schools on literature, performance.

Mus 8401, 8402, 8403. Sonata Seminar. (2 cr per qtr; prereq accompanying major; strings and winds by audition, #) Garrett  
Performance class in standard Baroque, Classical, and Romantic sonatas for piano and violin, cello, viola, flute, clarinet, or oboe.

Mus 8421, 8422, 8423. Advanced Vocal Accompanying Skills and Repertoire. (2 cr per qtr; prereq French and German and Italian diction, accompanying major or DMA vocal major; MM vocal major by audition only) Garrett  
Advanced performance class (*Lieder, mélodie*, opera) with emphasis on coaching techniques and performance skills of pianists and singers.

## Instrumental Studies

(See also Music Applied section above and *Ensembles*)

Mus 5016. Trumpet Pedagogy. (2 cr; prereq 12 cr lower div trumpet lessons) Baldwin  
Principles. Discussion of literature, history, method, and current teaching aids.

Mus 5150. Body Awareness in Activity: The Alexander Technique for Musicians. (2 cr; University College only)  
See Vocal/Choral/Opera Studies for description.

Mus 5321-5322-5323. Suzuki Violin Pedagogy. (2 cr per qtr; prereq undergrad or grad string major with violin as principal performing instrument or #) Bjork  
Intensive examination of philosophy and teaching techniques of Japanese pedagogue Shinichi Suzuki and their application in Western culture. Discussion, playing experience, and observation of children's lessons in MacPhail Center Suzuki Program.

Mus 5324-5325-5326. Advanced Suzuki Violin Pedagogy. (2 cr per qtr; prereq 5323 or equiv, audition; offered when feasible) Bjork

Mus 5350. Orchestral Repertoire. (1 cr)  
Performance problems in standard orchestral repertoire: style and interpretation.

Mus 5361f-5362w. Violin Pedagogy I. (2 cr per qtr; prereq 12 cr in 1205 or 1206 or 1305 or 1306 or #)  
Private teaching of violin students at beginning, intermediate, and advanced levels. Discussion and demonstrations of pedagogical techniques.

Mus 5364, 5365. Cello Pedagogy. (2 cr; prereq 12 cr applied cello or MuEd 3501 or #; offered when feasible) Remenikova

Mus 5366. Guitar Pedagogy. (2 cr; prereq guitar principal or major or #) Van  
Teaching techniques, including historical survey of methods and etudes from late 18th century to present; variety of content and approach.

Mus 5391. History and Acoustics of Single Reed Instruments. (2 cr; prereq upper div standing in major instrument or #) Anderson  
Clarinet and saxophone history and literature, mechanical design and development, acoustics, modern schools of performance.

Mus 5392, 5393. Woodwind Literature and Pedagogy I and II. (3 cr per qtr; prereq upper div standing in major instrument or grad student or #) Anderson  
5392: Major teaching methods for the five woodwind instruments, including solos and ensembles used primarily for pedagogical reasons. 5393: Major solo and chamber literature for the five woodwind instruments.

Mus 5731-5732-5733. Percussion Literature I-II-III. (2 cr per qtr; prereq upper div undergrad or grad perc major or #) Meza  
Study, analysis, and performance. 5731: Orchestral/band repertoire for snare drum and percussion accessories; solo literature for percussion instruments. 5732: Orchestral/band repertoire for mallet instruments; literature for percussion ensemble. 5733: Orchestral/band repertoire for timpani; chamber music for mixed ensembles of percussion and non-percussion instruments.

Mus 5971. Music Transcription for Winds. (2 cr; prereq 3532) Baldwin  
Transcription of three works with score and parts copied in ink. Principles of music manuscript and examination of examples of transcription.

Mus 8371, 8372, 8373. Wind Ensemble/Band Conducting I, II, III. (4 cr per qtr; prereq wind conducting major or #) Kirchhoff  
Practical conducting experience. 8371: Wind band repertory of the 18th, 19th, and 20th centuries emphasizing stylistic and period practices; techniques of score study, analysis, and interpretation. 8372: *Harmoniemusik* tradition and music for small wind ensembles; rehearsal techniques and strategies. 8373: Music since 1960; contemporary notation systems; rehearsal techniques and strategies.

## GRADUATE PROGRAMS

Mus 8379. Performance and Document: Wind Ensemble/Band Conducting. (4 cr; prereq 8373, #) Kirchhoff

Preparing and performing a full wind ensemble/band conducting program with supporting document.

Mus 8380. Orchestral Conducting. (4-5 cr; prereq #; required for orchestral conducting majors) Orchestral conducting techniques, including work with diverse orchestral, operatic, choral, and dance repertoires of differing styles and periods; 17th century to present.

Mus 8389. Performance and Document: Orchestral Conducting. (4 cr; prereq 12 cr 8380, #) Preparing and performing a full orchestral conducting program with supporting document.

### Jazz Studies

(See also *Ensembles*)

Mus 5300. Jazz Rhythm Section Techniques. (1 cr per qtr; prereq jazz studies major or #) McCurdy Study and function of instruments in jazz rhythm section. Bass line construction, voicings for piano and guitar, style patterns for percussion.

Mus 5301, 5302, 5303. Advanced Jazz Class Piano. (2 cr per qtr; prereq keyboard major, #) Hamilton Jazz harmony and keyboard techniques for the advanced pianist with extensive knowledge of keyboard theory; reading chord progressions, realizing chord symbols, formula voicings, expanded harmonies, aural development, jazz style “comping” and improvisation techniques.

Mus 5331. Jazz Improvisation IV. (2 cr; prereq 3331, 3332, 3333 or audition) McCurdy Analysis of and improvisation on advanced tunes from post-bop literature (ballads, Latin, swing, rock); application of harmony beyond seventh chords, quartal harmonies; development of knowledge of American standards.

Mus 5332. Jazz Improvisation V. (2 cr; prereq 5331 or audition) McCurdy Analysis of and improvisation on advanced tunes from post-bop literature; application of advanced harmony; development of ability to execute in faster tempos; transposition and transcriptions.

Mus 5333. Jazz Improvisation VI. (2 cr; prereq 3331, 3332, 3333 or audition) McCurdy Analysis of and improvisation on advanced tunes from post-bop literature; application of advanced harmony; development of ability to execute 5/4, 7/4, and other multimetered tunes, ballads, and transcribed solos.

Mus 5336. Jazz Arranging I. (2 cr; prereq 3532 or #) McCurdy Beginning techniques for arranging for chamber jazz ensemble; vocal and instrumental.

Mus 5337. Jazz Arranging II. (2 cr; prereq 3532, 5336 or #) McCurdy Intermediate and advanced techniques for arranging for chamber jazz ensemble; vocal and instrumental.

Mus 5341. Jazz Pedagogy. (2 cr; prereq 3532) McCurdy Published and unpublished jazz improvisation methods and materials. Rehearsal techniques for big band, combo, and vocal jazz ensemble.

Mus 5342. Jazz Theory. (2 cr; prereq 3532 or #) McCurdy Beginning techniques for basic chord construction, extended chords, and nomenclature in jazz idiom.

### Ensembles

Mus 5290. Jazz Singers. (1 cr per qtr; prereq #) McCurdy Sight reading, study, and performance of representative vocal jazz literature.

Mus 5330. Concerto Grosso Ensemble. (1 cr; prereq #) Kim Study and performance of string orchestra and small chamber orchestra literature.

Mus 5340f,w,s. Jazz Ensemble. (1 cr per qtr [max 6 cr]; prereq audition, #) McCurdy A 20-member performing organization covering significant jazz compositions and arrangements written specifically for this medium.

Mus 5360. Woodwind Ensemble. (1 cr per qtr; prereq audition) Anderson Practice and performance of chamber music for combinations of woodwind instruments in small groups (3 or more players) and in large homogenous instrumental choirs.

Mus 5380. Brass Choir. (1 cr per qtr; prereq #) Baldwin Practice and performance of representative brass ensemble literature from antiphonal music of Giovanni Gabrieli to works of 20th century.

Mus 5390. Percussion Ensemble. (1 cr; prereq #) Practice and performance of standard and contemporary compositions for percussion ensembles in various combinations.

Mus 5410f,w,s. University Wind Bands. (1 cr per qtr; prereq audition, #) Wind ensemble and symphony bands perform standard and contemporary literature; concerts and tour appearances. Players from all colleges may participate.

Mus 5420f,w,s. Orchestra. (1 cr per qtr; prereq audition, #) Symphony orchestra performs standard repertory and major works with chorus; concerts and tour appearances. Players from all colleges may participate.

Mus 5430f,w,s. Chorus. (1 cr per qtr; prereq audition, #) Sec. 1—Women’s Chorus: Performance of concert music for women’s voices, 16th-20th centuries. Sec. 2—Men’s Chorus: Performance of concert music for men’s voices, 16th-20th centuries. Sec. 3—Concert Choir: Performance of concert music for mixed ensemble, 16th-20th centuries. Sec. 4—Choral Union: Large oratorio chorus that performs major works for chorus with orchestra. Sec. 5—Conducting Class Ensemble: Participation in laboratory ensemble for choral conducting class.

Mus 5440f,w,s. Ensemble. (1 cr per qtr; prereq #) Performance of chamber music: duos (sonatas), trios, quartets, quintets, and other ensemble combinations for instruments and/or voices.

Mus 5460f,w,s. New Music Ensemble. (1 cr per qtr; prereq #)

Practice and performance of recent music for various combinations of vocal and instrumental ensembles.

Mus 5470f,w,s. Opera Workshop and Ensemble. (1 cr per qtr; prereq ability to sing arias satisfactorily by audition, #) Sutton

Preparation and performance of operatic arias, choruses, and scenes. Participation in fully staged or workshop productions of music-theatre repertoire.

Mus 5480. Opera Theatre. (2 cr; prereq advanced ability to sing arias satisfactorily by audition, #) Sutton  
Preparation and performance of fully-staged operatic production. Major involvement in singing, acting, and technical aspects of opera.

Mus 5490f,w,s. Chamber Singers. (1 cr per qtr; prereq audition, #) Lancaster  
Mixed chorus of 24 voices. Performances each quarter.

### Topics and Directed Studies

Mus 5950. Topics in Music. (1-5 cr [exact cr and prereq designated for each offering])  
For topics, see current *Class Schedule*.

Mus 5970. Directed Studies. (1-5 cr; prereq #, Δ, CLA approval)  
Guided individual reading or study.

Mus 8950. Topics in Music. (1-5 cr)  
For topics, see current *Class Schedule*.

Mus 8990. Special Problems. (2-12 cr; prereq Δ)

### Music Theory and Composition

Mus 5529. Twentieth-Century Music Theory and Analysis. (4 cr; prereq ¶|3512 or equiv exam, grad student or #) Cherlin  
Introduction; for graduate student music majors.

Mus 5532. Analysis of 20th-Century Music. (3 cr; prereq 3532)

Mus 5533. Music Since 1945. (4 cr; prereq 3532 or #)  
Procedures and techniques of music composed since 1945.

Mus 5541f. Counterpoint. (4 cr; prereq 3531, 3511 or equiv) Lubet  
Practice writing in polyphonic styles of Renaissance and Baroque.

Mus 5550. Composition. (2 cr per qtr [max 12 cr]; prereq 3532 or equiv, 3553 or grad student, #) Argento, Lubet, Zaimont  
Original work in various forms.

Mus 5561f-5562w-5563s. Orchestration. (2 cr per qtr; prereq 3532) Argento, Zaimont  
Scoring instruments for ensemble combinations and full orchestra.

Mus 5571. Schenkerian Analysis for Performers. (4 cr; prereq 3531; offered alt yrs) Damschroder  
Theory and analysis of tonal music using principles developed by Heinrich Schenker. Basic concepts and notation, and their application to excerpts and short pieces from 18th and 19th centuries.

Mus 5572. Chromaticism in Late-Tonal Music. (4 cr; prereq 3534; offered alt yrs) Damschroder  
Exploration of late-tonal chromatic practice through analysis of selected repertory, completion of written exercises (figured bass, harmonization of melodies, model composition), ear training, and keyboard drill.

Mus 5791. Electronic Music: History, Literature, Principles. (4 cr)  
History of technological developments that made electronic music possible; composers and compositions that reflect maturation of craft and connection with prevailing aesthetic values; equipment, principles, and techniques used in production.

Mus 5793. Analog Synthesis and Recording Techniques. (2 cr; prereq 5791 or ¶|5791)  
Studio work with stereo and quadraphonic tape recorders and selected microphones directed toward development of recording skills (e.g., splicing, dubbing, preparation of tape loops, and synchronization of recording on discrete channels); exploration of analog synthesis equipment and its compositional possibilities and techniques.

Mus 5795. Digital Music Synthesis and Processing Techniques. (2 cr; prereq 5793)  
Studio work with digital synthesizers and processors, recording equipment, and computers (using variety of software) to develop skills in using digital equipment for composition, teaching, and performance.

Mus 5797. Music and Text: Seminar on the Interrelations of Text and Music. (4 cr; prereq 3531, 3532) Cherlin  
Interrelations of poetic imagery, form, metrics, and sonic characteristics with aspects of musical form, including repertory from 18th through 20th centuries.

Mus 8540. Electronic Composition. (3 cr per qtr [max 12 cr]; prereq composition major, 5550 or 8550, 5795 or equiv or #)  
Music composition including use of computers and MIDI equipment.

Mus 8550. Composition. (3 cr per qtr [max 18 cr]; prereq completion of undergrad major sequence in music theory and composition, #) Argento, Lubet, Zaimont

Mus 8555. Music Theory Pedagogy. (4 cr; prereq undergrad degree in music or #) Lubet  
Comparative study of different approaches to teaching music theory; available literature (harmony, ear-training/sightsinging, counterpoint, composition, orchestration, form and analysis texts and anthologies); specific pedagogical problems.

Mus 8560. Readings in Music Theory. (4 cr; prereq #)  
Seminars on major theoretical text or group of interrelated texts.

Mus 8565. Text Setting. (4 cr; prereq major in composition or choral conducting or voice or accompanying or music educ, #) Zaimont  
Text setting techniques for many mediums (from jingle to art song to choral settings) through analysis of repertoire and original compositions. Emphasizes sense and sound features of language in general, nature of specific text, and special considerations in writing for voice.

Mus 8570. Seminar in Composition. (2 cr; prereq grad student, #)  
Aesthetic and technological influences on compositional attitudes and techniques; career concerns.

Mus 8571. Composers' Laboratory I. (2 cr; prereq 8570) Zaimont  
Current compositional styles focusing on works by class members. Project involving composing to specification for possible radio/TV/theatre/dance/film use.

Mus 8572. Composers' Laboratory II. (2 cr; prereq 8570, 8571) Zaimont  
Analytical/critical project based on research into current factors influencing criticism in arts/music journalism. Current compositional styles focusing on works by class members.

Mus 8575. Women Composers. (4 cr; prereq #) Zaimont  
Contributions by women composers to development of European-American art music, primarily from the 17th through 20th centuries. Historical and current issues affecting women's access to professional music sphere. Music analysis, listening list, research and performance components.

Mus 8580. Topics in Tonal Analysis. (4 cr; prereq #)  
Seminars on major composition or group of interrelated compositions from tonal period.

Mus 8581-8582. Schenkerian Theory and Analysis I-II. (4 cr per qtr; prereq 3534 or #) Damschroder  
Critical reading of major treatises by Heinrich Schenker, including *Harmony*, *Counterpoint*, and *Free Composition*. Application of his method to representative repertoire from 18th and 19th centuries. Contrapuntal writing modeled after presentation in *Counterpoint*.

Mus 8590. Topics in 20th-Century Analysis. (4 cr; prereq #)  
Seminars on major composition or group of interrelated compositions from 20th century.

Mus 8863. Seminar: Theories and Concepts in Post-Tonal Music. (4 cr; prereq completion of 3-yr undergrad theory program or equiv) Cherlin  
Discussion of post-tonal music theories (as conceived by composers and theorists) and views of such music for which theories have not been articulated, using appropriate writings and scores.

## **Musicology and Ethnomusicology**

Mus 5182. Baroque Performance Practice. (4 cr; prereq sr or grad student, 3606, 3532 or #)  
Ornamentation, phrasing, articulation, and improvisation in music of period 1550-1759. Instruction books of period; analysis of performance of baroque music in baroque style.

Mus 5644. Studies in 20th-Century American Music. (4 cr; prereq 3606, 5532 or #) Hepokoski  
Competing concepts of musical style and purpose in 20th-century America: stylistic and cultural bases of both "art" and "popular" music and their (often uneasy) interrelationships. Typical areas include Ives, Copeland, 1920s jazz, Broadway, and popular song.

Mus 5645. Eighteenth-Century European Music. (4 cr; prereq 3606 or equiv [12 undergrad cr in mus hist], 3534 or equiv, # for undergrads)  
Survey of vocal and instrumental genres (opera and church, orchestral, chamber, and keyboard music) as they developed from High Baroque through Classical era.

Mus 5646. Nineteenth-Century European Music. (4 cr; prereq 3606 or equiv [12 undergrad cr in mus hist], 3534 or equiv, # for undergrads) Grayson, Hepokoski  
Survey of major composers, issues, and problems in history of 19th-century European music: transformations of sonata and symphony, "absolute" and "program" music, opera and "music drama," aesthetic conceptions of music, structural and harmonic innovations.

Mus 5647. Twentieth-Century European/American Music. (4 cr; 3606 or equiv, 12 undergrad cr in mus hist, 5532 or equiv, # for undergrads) Jackson  
Survey of major composers, issues, and problems in history of 20th-century European/American music: principal trends and artistic movements, new musical aesthetics, transformations of 19th-century genres, new methods of organization.

Mus 5666. Stravinsky. (4 cr; prereq 12 cr music history, 5532) Jackson  
Changing styles and aesthetic principles of Stravinsky as seen in representative compositions and writings on music; contributions to artistic life in Europe and America (particularly ballet).

Mus 5757, 5758. History of the Symphony. (4 cr per qtr; prereq 3606, 3532; offered when feasible)

Mus 5804. Folk and Traditional Music: Cross-Cultural Survey. (4 cr; offered when feasible) Kagan

Mus 5810. Asian Music in Performance. (2 cr; prereq #) Kagan  
Development of vocal and/or instrumental skills through applied training and lecture demonstrations.

Mus 5811. Traditional Indian Music: The Sacred and the Profane. (4 cr) Kagan  
Vedic chant and regional folk music. Musical analysis and associations with belief systems, social institutions, history and aesthetic expression. Music theory of India, notational systems, tonal and rhythmic materials and classifications, musical forms and performance practices.

Mus 5841. Resources for Music Research. (2 cr; prereq 3606 or #) Probst  
Introduction to use of basic bibliographies and indexes, reference works, periodicals and historical editions; techniques for preparing an annotated bibliography.

Mus 5863. Musical Instruments of the World. (4 cr; offered when feasible) Kagan

Mus 5864. American Fiddle Traditions. (4 cr; prereq #) Kagan  
Repertoire and performance practice of American fiddle music; rural and urban contexts; social, stylistic, and regional history. Training in performance is optional.

Mus 8631f. Music in Medieval Europe. (4 cr; prereq 3606; offered alt yrs) Jackson  
Medieval styles from 9th through 13th centuries: chant and liturgy, lyric song forms, polyphonic genres. Analysis and criticism, performance traditions in sociocultural contexts.

Mus 8632w. Music of the Ars Nova and Early Renaissance. (4 cr; prereq 3606; offered alt yrs) Jackson  
History of music from Machaut through Josquin: secular song, mass and motet. Analysis and criticism, performance traditions in sociocultural contexts.

Mus 8661. Seminar: Editing Lasso's Music for Performance. (4 cr; prereq undergrad degree in music) Jackson  
Preparation of scores from primary sources of vocal and instrumental music (partbooks and tablatures); performance traditions in sociocultural contexts.

Mus 8840. Seminar in Musicology. (4 cr)  
Topics differ with each offering; readings, research strategies, and methods.

Mus 8843. Current Issues in Historical-Critical Practice. (4 cr; prereq grad student in music or #) Hepokoski  
Key issues, controversies, and problems in the humanities; their implications for advanced work in musicology.

Mus 8844f. Seminar: Advanced Research in Historical Musicology. (4 cr; prereq undergrad degree in music) Jackson  
Reference and research materials, including computer applications and databases. Historical methods and historiography. Research strategies, documentation, and writing (criticism and narrative).

Mus 8845w. Advanced Research in Current Musicology. (4 cr; prereq undergrad degree in music) Hepokoski  
Readings and topics in recent scholarly and analytical work.

Mus 8847. Seminar: Notation of Polyphonic Music. (4 cr; prereq undergrad degree in music; offered alt yrs) Jackson  
White mensural notation of 15th and 16th centuries. Transcribing and editing for historically informed performance from primary sources.

Mus 8864. Research in Ethnomusicology. (4 cr; prereq 5861 or #) Kagan  
Methods and techniques of fieldwork, eliciting and collecting. Practicum in field research with Minnesota ethnic and Indian music. Theories of transcription and actual transcription of materials collected. Description of musical compositions and analyses. Advanced readings in ethnomusicology.

## Music Education (MuEd)

MuEd 5111. Research in Music Education: Bibliography. (3 cr) Schultz  
Sources, materials, and techniques.

MuEd 5112. Research in Music Education: Techniques. (3 cr) Furman, Haack  
Methods and techniques employed in investigating and reporting of music education problems; review of significant research and proposal development.

MuEd 5115. Research in Music Education: Measurement. (3 cr) McCoy  
Measurement and assessment in music education; survey of testing materials and methods of assessment.

MuEd 5211. Philosophical Foundations of Music Education. (3 cr; offered alt yrs) Haack  
Analysis and interpretation of philosophies in music and education as applied to teaching of music.

MuEd 5214. Psychological Foundations of Music Education. (3 cr; offered alt yrs) Furman  
Analysis and interpretation of psychologies of music and education as applied to teaching of music.

MuEd 5217. Historical Foundations of Music Education. (3 cr; offered alt yrs) Furman  
Analysis and interpretation of important elements in modern music teaching derived from the past.

MuEd 5313. Influence of Music on Youth Behavior. (3 cr) Haack  
How music functions to influence human behavior; effects of commercial styles on children and youth. Particularly appropriate for teachers and parents.

MuEd 5606. Movement-Based Methods for Music Education. (3 cr) McCoy  
Participation in movement activities; Dalcroze philosophy and techniques; applications of movement to music education; examination of research.

MuEd 5611. Teaching Music With Related Arts. (3 cr) Haack  
Techniques and materials for teaching music in cultural context, including other art forms.

MuEd 5612. Multicultural Music for Teachers. (3 cr) Haack  
For teachers of all subject areas. Educational uses of music from various cultures, including American subcultures, across the curriculum; music and sociocultural values; cross-cultural uses and functions of music; materials development for classroom use.

## GRADUATE PROGRAMS

MuEd 5613. Teaching Music Literature. (3 cr; offered alt yrs) Haack  
Principles, methods, and materials for teaching music literature, history, appreciation, uses, and functions in grades K-12.

MuEd 5621. Supervision and Administration of School Music. (3 cr; offered alt yrs)  
Analysis and evaluation of instructional, supervisory, and administrative techniques; readings, new trends.

MuEd 5633. Techniques and Materials: Choral Ensembles. (3 cr) McCoy  
Empirical research and literature on voice development in individual, class, and choral work; instructional techniques for choral music classes; choral repertoire for varied ensembles.

MuEd 5647. Teaching the Percussion Instruments. (3 cr; offered alt yrs) Schultz  
Practical performance, demonstrations, and discussion of research in performance techniques. Contemporary approaches for teaching in schools.

MuEd 5655. New Dimensions in Music Education. (3 cr) Haack  
Analysis of recent curricular trends and current issues.

MuEd 5666. Microcomputers in the Music Classroom. (3 cr) Schultz  
Using the microcomputer to enhance instruction; materials for theory, ear training, composition, electronic music; developing a database for music libraries, instrument inventories, budgets.

MuEd 5667. Computer-Based Music Instruction. (3 cr) Schultz  
Design, development, and implementation of computer applications for the music classroom, emphasizing HyperCard environment with interactive audio, video, and MIDI.

MuEd 5668. Computerized Music Notation. (3 cr) Schultz  
Fundamentals of music notation and printing using Macintosh computer, MIDI keyboards, and Finale software. Preparation of instrumental and vocal scores, part extraction, and page layout.

MuEd 5669. Conducting the Musical Show. (3 cr) Schultz  
Rehearsal techniques, coordination of singing actors and instrumental accompaniment, conducting of pit orchestra; lab performance and listening activities focus on traditions and trends in musical theatre.

MuEd 5750. Topics in Music Education. (1-6 cr [max 12 cr])  
Selected topics in music education. Each offering focuses on a single topic.

MuEd 5802. Psychology of Music II. (4 cr; prereq 3801) Haack  
Elements of music and their psychological effects; music ability and its measurement; research methods applied in psychology of music studies.

MuEd 5804. Music in Therapy. (3 cr; grad student in mus educ or mus therapy or #) Furman  
Principles and methods related to public school, hospital, and other community mental health and education settings; observation and laboratory sessions.

MuEd 5821. History of Music Therapy. (3 cr; offered when feasible) Furman

MuEd 5831. Music for Exceptional Children. (3 cr; offered alt yrs) Furman  
Trends; methods and materials for a functional program of singing, playing, rhythm, listening, and creative activities for mentally and physically handicapped and gifted pupils.

MuEd 5970. Independent Study. (1-4 cr; prereq music educ/therapy or grad student, #, Δ)  
Independent study project organized by the student in consultation with the appropriate instructor.

MuEd 8281. Music Education Seminar: Philosophical Issues. (3 cr; prereq MA in music or music educ or #) Haack  
Survey and analysis of issues in philosophical foundations of music education.

MuEd 8282. Music Education Seminar: Historical Issues. (3 cr; prereq MA in music or music educ or #) Schultz  
Survey and analysis of issues in historical foundations of music education.

MuEd 8283. Music Education Seminar: Psychological Issues. (3 cr; prereq MA in music or music educ or #) Furman  
Survey and analysis of issues in psychological foundations of music education.

MuEd 8700. Seminar: Advanced Topics in Music Education/Therapy. (1-4 cr; prereq #)  
Issues and problems in music education/therapy theory, research, and practice.

MuEd 8880. Master's Research Project. (1-8 cr; prereq 5112 or #)  
Individual Plan B projects.

MuEd 8990. Research Problems. (1-12 cr; prereq knowledge of elementary statistics, Δ)  
Individual projects.

## Music Education

See Music.

## Neuroscience (NSc)

*Professor:* Timothy J. Ebner (neurosurgery), *director of graduate studies;* Alvin J. Beitz (veterinary biology); Gary Birnbaum (neurology); Dwight A. Burkhardt (psychology); Marilyn E. Carroll (psychiatry); Bianca Conti-Fine (biochemistry); Robert P. Elde (cell biology and neuroanatomy); Esam E. El-Fakahany (psychiatry); Apostolos P. Georgopoulos (physiology); Glenn J. Giesler, Jr. (cell biology and neuroanatomy); Boyd K.

Hartman (psychiatry); William G. Iacono (psychology); William R. Kennedy (neurology); Daniel J. Kersten (psychology); James F. Koerner (biochemistry); Alice A. Larson (veterinary biology); Gordon E. Legge (psychology); Paul C. Letourneau (cell biology and neuroanatomy); Allen S. Levine (food science and nutrition); Horace H. Loh (pharmacology); Charles F. Louis (veterinary biology); Walter C. Low (neurosurgery); Steven C. McLoon (cell biology and neuroanatomy); Robert F. Miller (physiology); Charles A. Nelson (child development); Eric A. Newman (physiology); Jack H. Oppenheimer (medicine); Harry T. Orr (laboratory medicine and pathology); J. Bruce Overmier (psychology); Richard E. Poppele (physiology); Richard L. Purple (physiology); David A. Rottenberg (neurology); Peter A. Santi (otolaryngology); Ronald J. Sawchuk (pharmaceutics); Virginia S. Seybold (cell biology and neuroanatomy); Burt Sharp (medicine); John F. Soechting (physiology); Sheldon B. Sparber (pharmacology); David D. Thomas (biochemistry); Kamil Ugurbil (biochemistry); Neal F. Viemeister (psychology); George L. Wilcox (pharmacology)

*Associate Professor:* John H. Anderson (otolaryngology); W. Dale Branton (physiology); David R. Brown (veterinary biology); Howard B. Clark (laboratory medicine and pathology); Janet M. Dubinsky (physiology); S. Mbuja Ngale Efange (radiology); William C. Engeland (surgery); Martha Flanders (physiology); Jergen F. Fohlmeister (physiology); Kenneth M. Hargreaves (restorative sciences); Christopher N. Honda (cell biology and neuroanatomy); Karen K. Hsiao (neurology); Costantino Iadecola (neurology); Eric Javel (otolaryngology); Keith C. Kajander (oral biology); Ping-Yee Law (pharmacology); Patrick W. Mantyh (psychiatry); Linda K. McLoon (ophthalmology); Karen A. Mesce (entomology); John W. Osborn (animal science); Winfried A. Raabe (neurology); Peter W. Sorensen (fisheries and wildlife); Stanley A. Thayer (pharmacology)

*Assistant Professor:* James Ashe (neurology); Linda M. Boland (physiology); Patricia L. Faris (psychiatry); William H. Frey II (psychiatry); Christopher M. Gomez (neurology); Jon Gottesman (physiology); Jose V. Pardo (psychiatry); Laura P. W. Ranum (neurology); Margaret E. Ross (neurology); Donald A. Simone (psychiatry); Richard L. Sutton (neurosurgery); Martin W. Wessendorf (cell biology and neuroanatomy)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

### **Degree Offered—Ph.D.**

**Curriculum—**Neuroscience is a relatively new field of scientific inquiry. The objects of this inquiry—the brain and nervous systems—are sufficiently complex and unique among biological systems as to require analytical approaches that cross the traditional boundaries of anatomy, behavioral biology, biochemistry, cell biology, genetics, pharmacology, physiology, and

psychology. In some instances, neuroscientific inquiry also encompasses the disciplines of computer science, information processing, engineering, physics, and mathematics.

The neuroscience curriculum for the Ph.D. begins in the summer session with the intensive laboratory course in cellular and molecular neurobiology (5550), held at the Lake Itasca Biological Station at the headwaters of the Mississippi River in northern Minnesota. The core curriculum continues through the academic year at the Twin Cities campus with a series of seven courses: NSc 5460, NSc 5461, NSc 5480, NSc 5660, NSc 8210, CBN 5111, and Phsl 5112. While taking these courses, students explore research opportunities in the laboratories of the faculty and thereby select a thesis adviser. Elective courses and a minor or supporting program are selected through consultation between the student and the adviser. Students with sufficient background and previous course experience may apply for waiver of appropriate requirements. Because thesis research is expected to include statistical analysis of data, a course in statistics (such as Stat 5021) is required. Proficiency in at least one computer programming language is highly recommended.

**Prerequisites for Admission—**Applicants to the Ph.D. program must have a bachelor's degree or its foreign equivalent from a recognized college or university.

Undergraduate coursework should include instruction in several of the following disciplines: mathematics, physics, chemistry, biology, psychology, and neuroscience.

**Special Application Requirements—**Applicants are required to take the Graduate Record Examination General Test. The Subject Test appropriate to their field of emphasis is optional.

**Degree Requirements—**The written preliminary examination is administered to students before the start of the second year. Upon completion of most of the elective and minor courses, students take the preliminary oral examination. The final oral examination is a defense of the research presented in the thesis.

**Language Requirements—**None, although a reading knowledge of a foreign language relevant to the student's major field of interest is highly recommended.

**Minor Requirements for Students Majoring in Other Fields**—The program for an individual student is developed by consultation between the student and the director of graduate studies for neuroscience. Students must take NSc 5460, NSc 5461, NSc 5660, CBN 5111, Phsl 5112, and elective courses in one area, for a minimum total of 18 credits (including the core courses).

**For Further Information and Applications**—Contact the Neuroscience Program, University of Minnesota, 421 Lions Research Building, 2001 6th Street S.E., Minneapolis, MN 55455 (612/626-9206; e-mail neurosci@tc.umn.edu).

NSc 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

NSc 8888. Thesis Credits: Doctoral. (36 cr required)

### Required Courses

NSc 5460-5461. Cellular and Molecular Neuroscience. (3 cr per qtr; for 5460: \$GCB 5460, \$MdBc 5460, \$Phcl 5460, \$Phsl 5460, \$VPB 5460; for 5461: \$GCB 5461, \$MdBc 5461, \$Phcl 5461, \$Phsl 5461, \$VPB 5461; prereq biochem) Boland, staff  
Gene structure and regulation, cloning and molecular strategies for studying gene function, ion channels and membrane excitability, synaptic transmission, receptor structure and function, and signal transduction.

NSc 5480. Invertebrate Neurobiology. (2 cr, \$Ent 5480) Mesce  
Cellular bases of invertebrate behavior. Functional organization of nervous systems common to invertebrates and vertebrates. Sensory, motor, and central integrative systems, neuromodulation, learning, and neurogenetics.

NSc 5550. Itasca Cell and Molecular Neurobiology Laboratory. (6 cr; prereq NSc grad student or Δ) Poppele  
Intensive laboratory introduction to cellular and molecular aspects of research techniques in contemporary neurobiology; held at Itasca Biological Station. Electrophysiological investigations of neuronal properties, neuropharmacological assays of transmitter action, and immunohistochemical studies in experimental preparations.

NSc 5660s. Behavioral Neuroscience. (4 cr; prereq NSc major or minor or #) Georgopoulos  
Introduction to animal behavior from neuroscience perspective. Neural mechanisms for orientation and migration, rhythms, sleep, reproduction, motivated behaviors, perception, learning and memory, communication, and behavioral disorders.

NSc 8210s. Developmental Neurobiology. (3 cr, \$CBN 8210; prereq CBN 5111, Phsl 5112 or #) Letourneau, McLoon  
Nervous system development. General mechanism and experimental approaches.

NSc 8333. Lab Neuroscience. (Cr ar; prereq NSc grad student or Δ)

CBN 5111. Human Neuroscience A. (4 cr; prereq regis med fr or grad student, #; CBN 5111-Phsl 5112t) Giesler  
Structure and function of nervous system, including organs of special sense.

Phsl 5112. Human Neuroscience B. (3 cr; prereq regis med fr or grad student; CBN 5111-Phsl 5112t) Giesler

### Elective Courses

NSc 5031. Perception. (4 cr, \$Psy 5031; prereq Psy 3051 or Psy 3031 or #) Legge  
Data and principles of visual perception: color vision, pattern vision, object recognition, abnormal vision, and physiological optics.

NSc 5034. Psychobiology of Vision. (4 cr, \$Psy 5034; prereq Psy 3031 [except for grads] or #) Burkhardt  
Analysis of properties and biological bases of sensory perception in humans and animals. Color vision, visual sensitivity and adaptation, and nerve cell circuits of eye and brain.

NSc 5037. Psychology of Hearing. (4 cr, \$Psy 5037; prereq 3031 or #)  
Biological and physical aspects of hearing; auditory psychophysics; theories and models of hearing; perception of complex sounds, including music and speech; clinical and other applications.

NSc 5100. Introductory Neurobiology Laboratory at Itasca. (3 cr; prereq upper div student in biological or physical sciences, intro biol and chem, #)  
Concepts in cellular neurosciences in laboratory environment. Basis of membrane properties, including ionic and molecular mechanisms of resting, action, and synaptic potentials. State-of-the-art equipment and contemporary techniques used to examine experimental evidence.

NSc 5102. Veterinary Neurobiology. (3 cr, \$VB 5102; prereq #) Fletcher  
Structural and functional organization of central nervous system of domestic animals.

NSc 5150. Introduction to Neuroscience. (3 cr, \$GCB 5150, \$Phsl 5150; prereq Biol 3011 or equiv or Phsl 3055-3056, BioC 3021 or equiv or #)  
Survey of field from invertebrates to human. Ion channels and membrane currents, neurotransmitters and signal transduction, neuroanatomy, sensory and motor systems, learning and memory, emotion, disease states, neural networks, and development.

NSc 5201. Computational Neuroscience I: Membranes and Channels. (5 cr, \$Phsl 5201; prereq Phsl 5112 or equiv) Fohlmeister  
Comprehensive examination of membrane and ion channels using UNIX work stations to simulate their properties. Hodgkin-Huxley model, nonlinear dynamic systems, voltage and ligand gated ion channels, impulse propagation.

**NSc 5202. Computational Neuroscience II: Cells and Circuits.** (5 cr; prereq understanding of UNIX, Phsl 5201 or equiv) Miller

Comprehensive investigation of computational properties of single neurons and locally connected cell networks. Linear cable theory; compartmental modeling of single neuron properties; spatio-temporal interactions between synaptic inputs and neuronal dendritic trees; computational properties of passive and active dendritic spines and spine clusters; quantitative interpretation of whole-cell voltage-clamp data; and dynamics of locally connected cell networks.

**NSc 5203. Computational Neuroscience III: Neural Systems and Information Processing.** (5 cr, \$Phsl 5203; prereq 5202 or equiv) Poppele, Soechting

Quantitative examination of information processing by networks of neurons based on experimental data and theoretical models. Neural codes, neural network models and information processing, neural control systems, computational maps.

**NSc 5400. Veterinary Pharmacology.** (3 cr, \$VB 5400; prereq VB 5310 or equiv or #) Larson

General principles of drug action, disposition, and use, focusing on drug action in central and peripheral nervous systems. Pharmacology of autonomic drugs, local anesthetics, parenteral general anesthetics, tranquilizing agents, analeptics, anticonvulsants, and neuromuscular blockers.

**NSc 5444. Muscle Contraction.** (3 cr, \$MdBc 5444, \$Phsl 5444, \$VB 5444; prereq undergrad biochem or physiology courses or #) Louis, Poppele, Thomas

Introduction to physiology, biochemical regulation, and physical chemistry of muscle contraction.

**NSc 5462. Neuroscience Principles of Drug Abuse.** (2 cr; prereq #: offered alt yrs) Law, Wilcox  
Current research on drugs of abuse: their mechanisms of action, characteristics shared by various agents, and cellular and neural systems affected by them.

**NSc 8026. Neuro-Immune Interactions.** (3 cr, \$PNI 8026, \$Psy 8026, \$VMic 8026; prereq 5111 or equiv, MicB 5218 or equiv) Sharp

Regulatory systems (neuroendocrine, cytokine, and autonomic nervous systems) linking brain and immune systems in a brain-immune axis. Functional effects of bidirectional brain-immune regulation.

**NSc 8031. Seminar: Visual Perception.** (3 cr, \$Psy 8031; prereq Psy 5031 or #) Legge  
Physiological, psychophysical, and cognitive determinants of visual perception.

**NSc 8124. Recent Advances in Chemoreception Science.** (1 cr; prereq #) Sorensen

Interdisciplinary and comparative seminar. Receptor function, signal transduction, coding, central pathways, animal behavior, and psychophysics.

**NSc 8207. Seminar: Psychopharmacology.** (3 cr on completion of 3 qtrs, \$Phcl 8207; prereq #) Sparber

Topics on behavioral aspects of drug action.

**NSc 8216. Selected Topics: Neurophysiology.** (Cr ar, \$Phsl 8216; prereq CBN 5111, Phsl 5112 or equiv or #)

Advanced seminar.

**NSc 8217. Selected Topics: Systems and Computational Neuroscience.** (2 cr; prereq CBN 5111, Phsl 5112 or equiv or #) Poppele, Soechting, staff  
Advanced seminar.

**NSc 8221. Neurobiology of Pain and Analgesia.** (3 cr, \$CBN 8221; prereq #: offered in alt sequence with 8222 and 8223) Giesler

Neural systems underlying pain perception, production of analgesia.

**NSc 8222. Central Regulation of Autonomic Function.** (3 cr, \$CBN 8222; prereq #: offered in alt sequence with 8221 and 8223) Engeland, Osborn  
Morphology and physiology of autonomic ganglia and enteric nervous system, neuronal circuitry underlying central regulation of pupil, exocrine glands, cardiovascular system, respiratory system, and pelvic viscera.

**NSc 8247. Physiology of Hearing.** (3 cr, \$Otol 8247; prereq #) Javel

Structure and function of mammalian auditory systems. Cochlear anatomy; basilar membrane mechanics, cochlear potentials, and the anatomy and neurophysiology of auditor nerve and nuclei.

**NSc 8248. Readings in Auditory Physiology.** (1-3 cr, \$Otol 8248; prereq #) Santi

Current research on biophysics and physiology of auditory system; topics selected for each student. Preparation and discussion of written reviews.

**NSc 8324. Readings in Neurobiology.** (1 cr per qtr, \$NSu 8324; prereq Phsl 8104 or #)  
Survey of major topics in neurobiology.

**NSc 8325. Developmental Neuropsychobiology.** (3 cr, \$CPsy 8325; students taking course to fulfill core reqs for PhD in CPsy must take it A-F) Gunnar, C Nelson  
Research and theory on human brain and endocrine activity and their relations with behavioral development. Memory development, stress and coping in children, development of sex differences.

**NSc 8400. Neurobiology of Disease.** (2 cr; prereq 5111 or CBN 5111, 5112 or Phsl 5112, 5460 or #) Ross  
Major neurological diseases; pathogenic mechanisms of neurologic disease; potential applications of advances in basic neuroscience to human disease.

**NSc 8450. Teaching in Neuroscience.** (1 cr; prereq #)

Students serve as primary instructors in NSc 5150 and work with fellow students and faculty mentors to design curriculum, classroom sessions, exams, and course evaluations.

## Nursing (Nurs)

*Professor:* Sandra R. Edwardson, *dean*; Sheila A. Corcoran-Perry; Mark E. Nesbit; Muriel B. Ryden; A. Marilyn Sime; Mariah Snyder; Patricia S. Tomlinson

*Associate Professor:* Ellen C. Egan, *director of graduate studies*; Margaret J. Bull; Patricia Crisham; Sara S. DeHart; Laura J. Duckett; Bernadine M. Feldman; Cynthia R. Gross; LaVohn Josten; Barbara J. Leonard; Betty Lou Lia-Hoagberg; Ruth D. Lindquist; Marilee A. Miller

*Assistant Professor:* Melissa D. Avery; Linda H. Bearinger; Donna Z. Bliss; Derryl E. Block; Helen E. Hansen; Merrie J. Kaas; Kathleen Krichbaum; Marsha Lewis; Linda L. Lindeke; Carol Pederson; Janice Post-White

*Adjunct Assistant Professor:* Barbara Vellenga

*Other:* Donna J. Brauer; Christine A. Heine; Rhoda T. Hooper

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Emphases in the M.S. program include nurse education, nurse administration, advanced clinical practitioner in psychiatric mental health nursing, child and family nursing, adult health nursing, gerontology nursing, oncology nursing, nursing for children with special health needs, and public health nursing; or practitioner preparation as a nurse midwife, pediatric nurse practitioner, gerontological nurse practitioner, women's healthcare nurse practitioner, and family nurse practitioner. The Ph.D. program prepares creative and productive scholars in nursing. Students can gain a depth of knowledge and experience in the development and modification of health-related behaviors; human responses to environmental and life process events disruptive to health; phenomenon of health; organization and system of delivery of nursing knowledge; and organization and system of delivery of nursing care. An individualized program and independent research are planned by the student and adviser.

**Prerequisites for Admission**—In the M.S. program, a bachelor's degree with a major in nursing or evidence of ability in health promotion, community health nursing, leadership/management, teaching/counseling, and systematic investigation, as well as licensure as a registered nurse, are required. For the Ph.D. program, a master's degree with a strong background in the physical and/or behavioral sciences or a bachelor's degree with an exceptionally strong background are required.

**Special Application Requirements**—For the M.S. degree, three letters of reference and a goal statement are required. Graduate Record Examination (GRE) General Test scores are required for applicants with narrative transcripts from previous college work; the scores are recommended for students competing for a Graduate School Fellowship. For the Ph.D. degree, GRE General Test scores, two letters of reference, and a statement of goals, objectives, and research interest are required. The application deadlines for the M.S. program are December 15 for spring, summer, or fall quarter admission; April 15 for summer, fall, or winter quarter admission; and October 25 for winter, spring, or summer admission. Acceptance into the Graduate School before February 1 is required for the nurse practitioner areas of study. The application deadline for the Ph.D. program is January 25 for fall quarter admission.

**Master's Degree Requirements**—The Plan A program is individually planned with a faculty adviser and must include a course in nursing research methodology. The Plan B program must include 32 credits in the major distributed in specific categories; required are Nurs 8010, Nurs 8011, and Nurs 8014 (3 credits each) and 4 credits of 8050 for the Plan B project. For more information, see the School of Nursing publication *Graduate Study in Nursing*. A final oral examination is required for both plans.

Graduate students admitted as of fall 1990 must be registered in the Graduate School each quarter they work with advisers on research projects.

**Doctoral Degree Requirements**—Students plan with their advisers individualized programs of study and independent research subject to approval by a faculty committee. A total of 18 credits in a minor field or supporting program is required.

Graduate students admitted as of fall 1990 must be registered in the Graduate School each quarter they work with advisers on research projects.

**Language Requirement**—None.

**For Further Information and Applications**—Contact the School of Nursing, University of Minnesota, 6-101 Weaver-Densford Hall, 308 Harvard Street S.E., Minneapolis, MN 55455 (612/624-4454; fax 612/626-2359; e-mail hanso041@tc.umn.edu; <http://www.nursing.umn.edu/>).

Nurs 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Nurs 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Nurs 8888. Thesis Credits: Doctoral. (36 cr required)

## Theoretical and Ethical Foundations of the Discipline

Nurs 5711. Spirituality and Nursing Practice. (2-3 cr; prereq Nurs sr or RN [for undergrad cr] or RN with baccalaureate degree [for grad cr])  
Concept of spirituality as integral to the whole person.  
Spiritual nursing care interventions within context of nursing process.

Nurs 5738. Transcultural Nursing: Theories and Issues. (2-3 cr; prereq cultural anthropology course, Nurs grad student or RN or #)  
Cultural factors that influence theories, issues, and nursing care practice in diverse cultures and subcultures. Emphasis on nursing within international systems of healthcare and nursing practices related to health-illness systems in United States and worldwide.

Nurs 5902. Nursing and the Politics of Health. (3 cr; prereq grad student, #) Feldman, Josten  
Relationship of changing social policy to health services and impact on funding for nursing education, research, and service.

Nurs 5960. Advanced Public Health Nursing. (3 cr; prereq 8010 or ¶8010, Nurs grad student or nurse grad student in another field) Lia-Hoagberg  
Developing conceptual frameworks for advanced practice. National health priorities and assessment strategies.

Nurs 8010. Structure of the Discipline of Nursing. (3 cr; prereq Nurs grad student or #) Block, Egan, Sime, Vellenga  
Exploring purposes, characteristics, and kinds of structures with emphasis on theories, models, and conceptual frameworks.

Nurs 8011. Moral and Ethical Positions in Nursing. (3 cr; prereq Nurs grad student or #) Block, Corcoran-Perry, Crisham, Hooper  
Influence of moral and ethical positions on behavior and decision making in nursing. Emphasis on bases for positions taken, such as selected moral and ethical theory, rights and responsibilities, and conflict.

Nurs 8012. Conceptual Framework for Nursing Practice. (3 cr; prereq 8010, Nurs grad student or #) Egan  
Exploration and reconceptualization of assumptions, values, and beliefs underlying learner's view of nursing and nursing practice. Analysis of structure of a nursing conceptual framework and development of personal framework. Concept of intervention model and systematic process that underlies development of such a model.

Nurs 8110. Theoretical Foundations of the Discipline. (4 cr; prereq 8012 or equiv, knowledge of philosophy of science, Nurs grad student or #) Sime  
Analysis of knowledge systems and relevant research; identification of boundaries of knowledge and projection of needs for further knowledge development and testing.

Nurs 8111. Moral and Ethical Development in Nursing Science. (4 cr; prereq 8011 or equiv, Nurs grad student or #) Crisham  
Interaction between research and theory in moral judgment and behavior, applied ethics, and nursing.

Nurs 8220, 8221. Seminar: Developing Nursing Knowledge I, II. (1 cr; prereq Nurs PhD student or #; Nurs grad majors must take both courses)  
Critique of selected philosophical perspectives and research methodologies.

Nurs 8800. Phenomenon of Health. (3 cr; prereq Nurs grad student or #) Newman  
Examination of assumptions and scientific perspectives of differing views of health; articulation and evaluation of holistic view of person-environment and health.

Nurs 8802. Phenomenon of Health II. (3 cr; prereq 8800, #)  
Philosophical, theoretical, and methodological implications of nursing paradigm that incorporates transformative view of health as evolving pattern of the whole. Emphasis on integration of theory with appropriate methods of inquiry.

Nurs 8900. Theoretical Foundations of Health-Related Behaviors. (3 cr; prereq #) Snyder  
Research and theory in development and modification of health-related behaviors and human responses to events disruptive to health. Formulation of hypotheses for nursing research.

## Methodological Foundations of the Discipline

Nurs 5644. SPSS Programming and Data Analysis. (2 cr; prereq inferential statistics, grad or professional college student, # for undergrads)  
Collecting and analyzing data using SPSS for Windows. Statistics reviewed, emphasizing analysis and interpretation of output.

Nurs 5720. Written Communication Skills for Health Professionals. (3 cr; prereq knowledge of medical terminology) Schoenfelt  
Students critique each other's work for organization, style, clarity of presentation, conciseness, accuracy, transitions, consistency, and writing mechanics. Examination of journal articles, work of professional authors, and writing guidelines.

Nurs 5820. Decision Making in Healthcare. (3 cr; prereq grad student in health-related major) Corcoran-Perry  
Comparison of conceptual models of decision making. Developing plans for assessing, evaluating, teaching, and assisting others (health professionals, patients, and families) in making decisions about healthcare.

Nurs 8014. Research in Nursing. (3 cr; prereq inferential statistics) Block, Bull, DeHart, Duckett, Feldman, Lindquist, Vellenga  
Exploring research process and research methodologies appropriate to nursing. Analysis of research reports.

Nurs 8020. Evaluating Quality of Healthcare in Communities. (3 cr; prereq 8014 or equiv research course or #) Bull

Models and measurement related to evaluating quality in community health/long-term care. Distinguishing characteristics of long-term care from those of acute care.

Nurs 8050. Problems in Nursing. (1-9 cr; prereq #) Individual study of a problem.

Nurs 8051. Special Topics in Nursing Research. (1-9 cr)

Seminar and/or individual study in nursing research.

Nurs 8062. Qualitative Research in Nursing and Healthcare. (3-4 cr; prereq 8010 or 8014 or equiv or #) Bull

Characteristics of qualitative research methods such as ethnography, phenomenology, and grounded theory. Data collection, analysis, and applications in healthcare.

Nurs 8064. Research on Decision Making in Healthcare. (4 cr; prereq one grad-level research course) Corcoran-Perry

Analysis of selected conceptual models of decision making and critique of related studies. Formulation of research proposal to investigate decision making about healthcare by healthcare professionals, patients, and/or families.

Nurs 8114. Advanced Nursing Research. (4 cr; prereq 8014 or equiv, advanced inferential and non-parametric statistics, computer science, Nurs grad student or #) Bull, Sime

Testing and validating methods of study unique to nursing science.

Nurs 8115. Advanced Nursing Research Practicum. (1-6 cr [must complete 6 cr before or is granted; may be spread over 3 qtrs]; prereq Nurs doct student, #)

Participation as a collaborative team member in designing and/or implementing research; opportunities to synthesize knowledge in an area of study.

Nurs 8116. Principles and Methods of Implementing Research. (3 cr; prereq 8114 or other 8xxx research methods course, 2 grad stats courses, Nurs grad student) Gross

Integrates scientific, statistical, and practical aspects of research. Interrelationships among design development, sample selections, subject access, human subjects requirements, selection and evaluation of instruments, data management, analyses plans, and grant writing. Field experiences.

Nurs 8120. Conceptual and Methodological Issues in the Study of Family Health. (3 cr; prereq 5920, 8114 or equiv or #) Tomlinson

Formulating research designs for studying family health.

Nurs 8210. Theory Development in Nursing. (3 cr; prereq 8110, #) Egan

Examining strategies for theory development; synthesis of theoretical formulations in nursing using a selected strategy.

## Nursing Knowledge Underlying Clinical and Functional Specialization

### *Clinical Specialization*

Nurs 5634. Women's Issues: A Health Perspective. (3 cr; prereq upper div or grad student or #) Ringdahl

Multidisciplinary analysis of sexual and reproductive health, victimization, poverty, work, nutrition, physical activity, and mental health, emphasizing health promotion.

Nurs 5636. Menopause: A Multidimensional Approach. (2 cr; prereq upper div or grad student or #)

Physiological, developmental, historical, sociocultural, nursing, and medical perspectives. Issues and research regarding hormone replacement therapy; alternative interventions.

Nurs 5640. Common Response Patterns to Illness. (3 cr; prereq #; offered when feasible) Snyder

Nurs 5642. Behavioral Problems in Persons With Dementia. (2 cr; prereq grad student or upper div student with knowledge of research process, #) Ryden

Nature of aggression, agitation, and wandering in persons with dementia; theoretical perspectives for understanding such problems. Research studies about behavioral problems; relationship between knowledge about behavioral problems and clinical management.

Nurs 5650. Therapeutic Touch: Practice and Research. (2 cr; prereq Nurs student, #) Egan

Therapeutic touch as a healing modality. Explanations of its effects. Students learn and evaluate its practice. Analysis of research literature.

Nurs 5680. Theory and Practice of Occupational Health. (3 cr, \$PubH 5167)

Introduction to major concepts and issues in occupational health and safety. Students identify conceptual framework for working with aggregate populations of workers.

Nurs 5780. Multidisciplinary Perspectives on Aging. (4 cr, \$AdEd 5440, \$CPsy 5305, \$SHS 5009, \$PA 5414, \$Phar 5009, \$PubH 5737, \$Soc 5960, \$SW 5024)

Sociological, biological, and psychological aspects of aging, death, and bereavement; issues and problems of older adults in the United States; human services and their delivery systems (health, nutrition, long-term care, education); public policy and legislation; environment and housing; retirement.

Nurs 5810. Health Assessment for Advanced Nursing Practice. (3 cr; prereq Nurs grad student, #) Kubik

Health assessment skills; identifies variations across the life span. Performance and documentation of comprehensive, systematic, and integrated history and physical examination, while interpreting both normal and abnormal findings.

Nurs 5834. Primary Care: Reproductive Health. (4 cr; prereq Nurs grad student, ¶15835, ¶18030, concurrent with or completed course in health assessment and reproductive physiology, #) Avery

Explores theory, research, management of selected reproductive health concerns to provide basis for advanced nursing practice and nurse-midwifery.

Nurs 5835. Primary Care Practicum: Reproductive Health. (3 cr; prereq Nurs grad student, ¶5834, #)  
Application of standardized techniques to establish client-centered database focused on reproductive health. Implementation and evaluation of healthcare plans that include reproductive and sexuality counseling, family planning interventions, education, screening, and referral.

Nurs 5881. The Biology of Cancer. (3 cr, \$GCB 3008; prereq Biol 1009) McKinnell  
Biological aspects of etiology, phylogeny, and cellular processes involved in neoplasia. Growth and differentiation of normal and cancer cells. History of cancer research.

Nurs 5882. Practicum in Environmental and Occupational Health. (1-6 cr, \$PubH 5154; prereq environ health major or Nurs grad student) McGovern, Olson  
Students work with organizations with environmental and occupational health concerns, under joint supervision of faculty adviser and organization's staff.

Nurs 5883. Issues in Environmental and Occupational Health. (2 cr, \$PubH 5155; prereq #) McGovern, Olson  
The field, current issues, and principles and methods of environmental and occupational health protection. Independent field visits to observe, review, and analyze environmental/occupational health programs.

Nurs 5884. Employee Health Services and Cost Containment. (3 cr, \$PubH 5166; prereq occ hlth nurs or Nurs grad student) McGovern  
Trends in corporate health cost containment; implications regarding planning and financing of healthcare for employees and families. Associated role development of occupational health nurse specialists.

Nurs 5885. Theory and Practice of Occupational Health: Field Experience. (1 cr, \$PubH 5168; prereq 5680, PubH 5167) Olson  
Arranged field experience and seminar course. Application of occupational health and safety concepts within conceptual framework of occupational health. Builds on theories explored in Nurs 5680/PubH 5167.

Nurs 5886. Field Problems in Occupational Health. (3 cr, \$PubH 5218; prereq PubH 5211 or Nurs grad student or #) Olson  
Guided evaluation of potential occupational health problems; recommendations and design criteria for correction, if correction is needed.

Nurs 5888. Geriatric Assessment. (4 cr, \$SAPH 5870)  
Multidisciplinary approach; comprehensive assessment of function, health, quality of life, strengths, financial status, and diversity issues.

Nurs 5891. Human Reproductive Processes. (3 cr; prereq nurse practitioner student or #) Avery  
Development of placenta and fetus; female physiologic adaptations across reproductive life span. Physiologic relationship between pregnant woman and fetus, emphasizing biologic and environmental interactions.

Nurs 5917. Healthcare for Children and Youth With Special Healthcare Needs. (4 cr; prereq #) Leonard  
Growth and development, pathophysiology, specific conditions, and a holistic, family-centered, community-based, culturally competent, coordinated approach to assessment and intervention.

Nurs 5918. Healthcare for Children and Youth With Special Healthcare Needs Practicum. (5 cr; prereq 5917 or ¶5917, 5925, #) Lindeke  
Clinical course emphasizing assessment and management of acute and chronic conditions; holistic, family-centered, community-based, culturally competent, coordinated approach.

Nurs 5919. Assessment and Intervention Models in Families of Children with Special Healthcare Needs. (6 cr; prereq 5917, 5920, #) Lindeke, Tomlinson  
In-depth, systemic, and theory-based study of family health assessment methods and intervention models, for identifying and intervening in patterns of functioning in families in which children have complex healthcare needs.

Nurs 5920. Conceptualization of Family Health. (3 cr; prereq Nurs grad student, 8010 or #) Tomlinson  
Theoretical framework that serves as foundation for family nursing practice.

Nurs 5923. Primary Care Practicum: Health Assessment and Care of Well Infants, Children, and Adolescents. (5 cr; prereq Nurs grad student, 5810, ¶5924, #) Poe  
Clinical course for beginning PNP and FNP student.

Nurs 5924. Primary Care: Nursing Assessment and Health Promotion From Infancy Through Adolescence. (4-5 cr; prereq Nurs grad student, 5810, ¶5923, #) Poe  
Age-specific, family-centered prevention and health promotion services. Instruments and processes incorporated as means for establishing database. Emphasizes diagnostic reasoning and primary-care advanced-practice interventions.

Nurs 5925. Primary Care Practicum: Common Health Problems of Infants, Children, and Adolescents. (5 cr; prereq Nurs grad student, 5923, 5924, ¶5926, #) Poe  
Advanced clinical course. Assessment of minor acute and chronic illnesses and their impact on the individual and family, healthcare management, evaluation strategies, and follow-up care.

Nurs 5926. Primary Care: Common Acute and Chronic Conditions Experienced by Infants, Children, and Adolescents. (4 cr; prereq Nurs grad student, 5923, 5924, ¶5925, #) Poe  
Differentiation of health problems, interdisciplinary consultation and referral, and independent and collaborative healthcare management.

Nurs 5927. Primary Care: Assessment and Management of Families Experiencing Stress. (4 cr; prereq Nurs grad student, #)  
Assessing and analyzing impact of minor acute, chronic illness and disruptive behavior on families. Behavioral intervention models, incorporating variety of cultural values, beliefs, and behaviors.

## GRADUATE PROGRAMS

Nurs 5928. Primary Care: Pharmacotherapeutics. (3 cr; prereq Nurs grad student, #)  
Pharmacokinetics, pharmacoepidemiology, therapeutic dosages for various age groups, client patterns of drug use, prescriptive privileges, and prescription writing for advanced-practice nurses.

Nurs 5929. Primary Care: Synthesis of Advanced Pediatric Nursing Practice for the Child, Family, and Community. (7-9 cr; prereq Nurs grad student, 5925, 5926, #)  
Refines skills to effectively intervene with common pediatric physical/psychosocial concerns. Role implementation issues and development of an ideal practice model.

Nurs 5932. Primary Care: Assessment and Management of Adult and Elderly Health. (3-5 cr; prereq Nurs grad student, 5810, ¶5933, #)  
Advanced-practice course. Data-based primary care management of common acute and chronic conditions. Clinical reasoning, independent and collaborative practice healthcare plans.

Nurs 5933. Primary Care Practicum: Adult and Elderly Health. (5 cr; prereq Nurs grad student, 5810, ¶5932, #) Kubik  
Application of advanced-practice comprehensive health histories and physical assessments in formulating client-centered databases; development and implementation of care plans and follow-up evaluation of primary care.

Nurs 5940. Nursing Assessment of the Elderly. (2 cr; prereq basic course in health history-taking and physical assessment, #) Camillo  
Taking gerontological health histories and performing physical assessment. Emphasis on theoretically and empirically based variations of normal, common health disruptions; interpretation and classification of data.

Nurs 5941. Care of the Elderly I: Physiological Concepts. (2 cr; prereq #) Snyder  
Functional patterns related to physiological aspects of aging; research-based interventions used to maintain or restore optimal functioning of elderly.

Nurs 5942. Nursing Care of the Elderly I. (4 cr; prereq Nurs grad student, assessment of elderly course) Camillo, Snyder  
Managing healthcare of elderly; testing nursing interventions for maintaining and restoring health. Focuses on persons with physiological concerns.

Nurs 5943. Care of the Elderly II: Psychosocial Concepts. (2 cr; prereq Nurs grad student, knowledge of adult human development across life span or #) DeHart, Ryden  
Psychosocial assessment and research-based interventions for elderly clients; emphasizes promotion of health and supportive care.

Nurs 5944. Nursing Care of the Elderly II. (4 cr; prereq 5940, Nurs grad student, #) Camillo  
Managing healthcare of elderly clients; testing nursing interventions for maintaining and restoring health. Focus on persons whose presenting concerns are primarily psychosocial.

Nurs 5945. Nursing Care of the Elderly: Assessment and Management. (6 cr; prereq 5940, 5947) Camillo  
Database management of common acute and chronic conditions and physiological, psychosocial, and pharmacological interventions. Family and community resources incorporated into nursing care interventions. Protocols of care analyzed and developed. Methods of evaluating interventions.

Nurs 5947. Pharmacotherapeutics for the Elderly. (2 cr; prereq basic pharmacology course, grad student or #) Camillo  
Issues related to prescriptive practice and other regulations. Case-based protocols for specific acute and chronic illnesses with emphasis on pharmacokinetics and pharmacodynamics.

Nurs 5950. Physiological Manifestations of Cancer. (3 cr; prereq Nurs grad student, 8011 or #) Post-White  
In-depth analysis of physical responses to cancer and its treatments, focusing on underlying physiology, assessments and management of symptoms, and measurement of outcomes. Research critiqued for clinical application.

Nurs 5951. Oncology Practicum I. (3 cr; prereq Nurs grad student, 5950 or ¶5950) Post-White  
Clinical management of complex care of individuals with cancer across the life span, focusing on nursing assessment, interventions, and evaluation associated with physiological manifestations/symptoms. Collaborative role with interdisciplinary team.

Nurs 5952. Psychosocial Dimensions of Cancer. (3 cr; prereq grad Nurs student, 8011 or #) Post-White  
In-depth analysis of psychosocial responses to cancer and its treatment. Assessment and intervention with patients and family in helping them adapt to cancer diagnosis, treatment, and survival. Discussions of interventions based on critique of research.

Nurs 5953. Oncology Practicum II. (3 cr; prereq Nurs grad student, 5951, 5952 or ¶5952 or #) Post-White  
Clinical assessment and interventions related to patient's and family's psychosocial responses to cancer and its treatment. Interventions designed to assist patient and family in adapting to cancer as a chronic illness.

Nurs 5954. Oncology Issues. (2 cr; prereq 5950, 5952 or #) Post-White  
Ethical, legal, and sociocultural issues surrounding cancer prevention, early diagnosis, treatment, and care. Analysis of advanced practice roles in response to healthcare reform. Impact of cancer across the life span on patient, family, and community.

Nurs 5955. Oncology Practicum III. (3 cr; prereq Nurs grad student, 5953, 5954 or ¶5954 or #) Post-White  
Assessing cancer risk practices of individuals, families, and communities. Educating professionals and public regarding cancer risks, prevention, and early detection. Sociocultural factors.

Nurs 5970. Advanced Health Assessment and Intervention with Adolescents. (3 cr; prereq #) Bearinger

Synthesis of nursing, public health, and adolescent development knowledge, integrated with legal and ethical principles and health behavior models as a framework for developing clinical assessment and intervention strategies targeting risk factors associated with major morbidities of adolescents.

Nurs 8021. Community Health Nursing in Long-Term Care. (3 cr; prereq 8010, Nurs grad student or #) Bull

Systematic inquiry into nature of long-term care and community health nursing for families with adult members who have self-care limitations.

Nurs 8022. Clinical Investigation in Community Health Nursing in Long-Term Care. (5-6 cr; prereq ¶15330, ¶18011, ¶18021, #) Bull

Systematic inquiry and clinical investigation of nursing care problems for communities with families who have adult members with self-care limitations. Students design, implement, and evaluate interventions for selected populations.

Nurs 8030. Nursing Intervention Models. (4-8 cr [8 cr must be completed before cr is granted]; prereq 8011 or ¶18011, 8012, #) Avery, Bliss, Kaas, Leonard, Lindquist, Pederson, Tomlinson

Developing, providing, and evaluating nursing intervention with a specified client population. Students register for a section that focuses on a desired population.

Nurs 8040. Public Health Interventions Across the Life Span. (3 cr; prereq 5609 or ¶15609, 8011 or ¶18011, PubH 5330 or ¶1PubH 5330 or #) Bearinger  
Synthesis of life-cycle developmental approach and public health perspective with nursing and behavior change conceptual theories to develop intervention models that effectively address priority public health problems across the life span.

Nurs 8042. Community-Based Public Health Nursing Interventions. (3 cr; prereq Nurs grad student or nurse grad student in another field, 5960 or #) Josten, Lia-Hoagberg

Systematic inquiry into community-based intervention models that integrate nursing knowledge, clinical research, and public health knowledge. Emphasizes community organization and social change models and development of community-based nursing intervention models for practice.

Nurs 8060. Advanced Clinical Nursing. (3-9 cr; prereq #; offered when feasible)

Nurs 8313. Care of the Childbearing Family in Risk. (4-6 cr; prereq physiology, #) Avery  
Problems encountered during perinatal period with emphasis on nursing care of mothers with medical complications.

Nurs 8314. Nurse-Midwifery Management During Childbearing. (9-10 cr; prereq #) Avery  
For students wanting to complete requirements for nurse-midwifery certification. Emphasis on labor and delivery management with opportunity to improve skills throughout childbearing period.

Nurs 8400. Nursing Interventions for Adult Populations. (3 cr; prereq 8014 or equiv, 8012, #; offered when feasible) Snyder

Nurs 8421. Psychiatric-Mental Health Nursing: Group Dynamics and Leadership Skills. (3 cr; prereq 8030, #) Kaas, Lewis, Vellenga  
Group dynamics and process with emphasis on development of leadership skills. Integration and application of mental health concepts, clinical practice in group therapy.

Nurs 8422. Psychiatric-Mental Health Nursing: Family Dynamics and Therapy. (3 cr; prereq 8030, #) Kaas, Lewis, Vellenga  
Family dynamics, development, and communication patterns. Relationship of selected family to community using concepts from systems theory. Clinical practice in family therapy.

Nurs 8431. Childbearing-Childrearing Family Nursing: Theoretical Formulations. (4-6 cr; prereq 8030, #) Pederson  
Maintenance, promotion, improvement, and restoration of health in the childbearing-childrearing family unit. Theoretical concepts related to women, children and families, and family development.

Nurs 8450. Investigations of Stress and Coping from a Nursing Perspective. (3 cr; prereq grad in nursing or psychology or behavioral medicine, 8014 or equiv, #; offered when feasible) Snyder

### *Functional Specialization*

Nurs 8451. Teaching-Learning Process in Nursing. (4 cr; prereq 8030, ¶[course in learning theory, Nurs grad student or #) Krichbaum  
Use of theories of learning to develop an intervention model for teaching nursing. Testing the intervention model in simulated situations.

Nurs 8701. Nursing Administration I. (6 cr; prereq #) Hansen  
Intensive study of role of nursing administrator by application of major concepts in organization and management theories and nursing process to nursing administration. Emphasis on planning for and organizing nursing administration and assembling resources to carry out plans. Experiences planned to meet individual needs and to maximize previous experience and knowledge.

### *Nursing Role Development*

Nurs 5660. Basic Management in Long-Term Care Facilities. (1-4 cr; prereq current RN licensure, RN with baccalaureate degree for grad cr) Krichbaum  
Provides critical basis for practice of nursing management. Emphasis on analysis of management theory and its relevance to current practice. Theories of management, organization, regulation, and organization behavior.

Nurs 5890. Professional Issues in Nurse-Midwifery. (3 cr) Avery  
Professional roles and responsibilities, legislation, ethical dimensions, public policy, and clinical practice issues.

## GRADUATE PROGRAMS

Nurs 5934. Professional Issues for Advanced Practice Nursing. (2 cr; prereq Nurs grad student, #) Interdisciplinary team function, managed care, reimbursement, certification, ethical issues, and scope of advanced nursing practice.

Nurs 5946. Professional Issues in Advanced Gerontological Nursing Practice Roles. (2 cr; prereq 6 cr gerontological nursing focus or #) Feldman Professional and policy issues, including reimbursement, certification, professional relationships, standards of care, legislation and regulation as they pertain to nurse practitioners, professional practice, the healthcare system, and care of older adults.

Nurs 5948. Advanced-Practice Roles. (2-3 cr; prereq Nurs grad student, 12 grad cr) Snyder Advanced-practice roles within nursing care and healthcare delivery systems.

Nurs 5949. Practicum: Advanced Practice Nursing. (4-8 cr; prereq Nurs grad student, 12 grad cr, 5948 or ¶15948) Implementing and evaluating selected advanced practice roles.

Nurs 5963. Nursing Leadership for a Changing World. (3 cr; prereq Nurs grad student or nurse grad student in another field or #) Josten Visioning, change, organizational culture, power, negotiation, team building, forecasting, and personal growth analyzed to strengthen leadership skills for the future. Concepts within variety of nursing leadership roles (educator, manager, clinical specialist, consultant).

Nurs 5964. Public Health Nursing Leadership Practicum. (4 cr; prereq 5960, 5963 or ¶15963, 8010, 8040, #) Josten Developing knowledge of and skills for specific leadership role within the field. Leadership and role theory.

Nurs 5965. Special Problems of Management of Community-Based Nursing Services. (3 cr; prereq 8010 or ¶18010, 8011 or ¶18011, 8014 or ¶18014, clinical courses in student's area of study or #) Josten Management problems common to community-based nonprofit or public nursing services. Developing skill in management problem solving to address such problems as working with a governing board, nonprofit budgeting, and missed appointments.

Nurs 5968. School Nursing in the Educational System and the Community. (3 cr) Lia-Hoagberg Major school health issues, educational systems, and roles of school nurses working within their communities. School health problems, assessment and intervention strategies, integration of research findings and applications with individuals, families, and communities.

Nurs 8063. Nursing Consultation. (3 cr; offered when feasible)

Nurs 8315. Nurse-Midwifery Management: Intrapartal and Postpartal. (8-10 cr; prereq 8314) Avery Theory and clinical experience in management and care of the laboring woman/couple through the six-week restorative period. Early care of the newborn is an integrated component.

Nurs 8425. Psychiatric-Mental Health Nursing: Role Development. (6 cr; prereq #) Kaas, Lewis, Vellenga Theoretical and clinical components of modalities of psychiatric-mental health nursing intervention. Opportunity to clarify understanding of interdisciplinary roles and relationships in community mental health setting. Concepts from systems theory related to organizational structure of mental health facilities and community.

Nurs 8455. The Nurse Educator in Higher Education. (6 cr; prereq 8451, ¶)course in educational measurement, #) Krichbaum Analysis of roles and responsibilities of nurse educator in higher education. Data for analysis obtained through review of relevant literature and testing of roles in an academic setting.

Nurs 8600. Healthcare Institutions and Nursing Leadership. (3 cr; prereq Nurs grad student or #) Nature of experiencing and its modes; a person's relatedness to others and responsibility to the human community; characteristics of American society and their demonstration in healthcare institutions.

Nurs 8702. Nursing Administration II. (6 cr; prereq 8701, #) Hansen Intensive study of role of nursing administrator by application of major concepts in organization and management theory and nursing process to nursing administration. Emphasis on making operational and evaluating nursing administration goals.

### Special Topics Courses

Nurs 5609. Special Educational Experiences in Nursing. (1-6 cr; prereq Δ) Planned to meet individual student needs.

Nurs 5620. Independent Study in Nursing Topics. (1-9 cr; prereq #) Elective course planned to meet individual student needs.

Nurs 5799. Self-Directed Study as a Means of Accomplishing Nursing Electives. (Cr ar; prereq #) For students with a specific interest or wanting specific experience not provided in regularly offered courses. Student writes objectives and makes formal contract with instructor that specifies credits, types of experiences, and method of evaluation.

Nurs 8001. Special Educational Experiences in Nursing. (Cr ar; prereq #) Various learning experiences planned to meet individual needs.

Nurs 8009. Special Topics in Nursing. (Cr ar; prereq #)

Nurs 8509. Special Topics in Nursing Education. (Cr ar; prereq #)

Nurs 8609. Special Topics in Nursing Supervision. (Cr ar; prereq #)

## Nutrition (Nutr)

*Professor:* Joanne L. Slavin (food science and nutrition), *director of graduate studies;* Paul B. Addis (food science and nutrition); Linda J. Brady (food science and nutrition); Judith E. Brown (epidemiology); Francis F. Busta (food science and nutrition); Frank B. Cerra (surgery); Agnes S. Csallany (food science and nutrition); William R. Dayton (animal science); Mary E. Dempsey (biochemistry); John H. Himes (epidemiology); Ralph T. Holman (*emeritus:* food science and nutrition); Theodore P. Labuza (food science and nutrition); Arthur S. Leon (kinesiology and leisure studies); Allen S. Levine (food science and nutrition)

*Associate Professor:* Elaine Asp (food science and nutrition); Margot P. Cleary (Hormel Institute); Patricia J. Elmer (epidemiology); Daniel D. Gallaher (food science and nutrition); Craig A. Hassel (food science and nutrition); Lawrence H. Kushi (epidemiology); Marla M. Reicks (food science and nutrition); Mary T. Story (epidemiology); Sally Weisdorf (pediatric gastroenterology); Michael E. White (animal science)

*Assistant Professor:* Roderick A. Barke (surgery); Paul S. Brady (food science and nutrition); Timothy P. Carr (food science and nutrition); Mary C. Gannon (food science and nutrition); Debra P. Keenan (food science and nutrition); Darlene G. Kelly (food science and nutrition); Mindy S. Kurzer (food science and nutrition); Margaret C. Martini (food science and nutrition)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Three subspecialty areas are offered in the doctoral degree program: human nutrition, nutritional biochemistry, and public health nutrition. Thesis work can be conducted in the laboratory, clinic, or field, locally or internationally.

**Prerequisites for Admission**—A strong foundation in the biological and physical sciences is required. This background includes college mathematics through calculus, physics, the equivalent of one year of general and one year of organic chemistry, general biology, biochemistry, physiology, and two additional courses in the biological sciences. If there is evidence that the applicant has a good background in the sciences, some of the prerequisites can be met after admission.

Applicants interested in the M.S. degree with clinical emphasis must offer as prerequisites courses in general biology, human nutrition, microbiology, college algebra, one year each of general and organic chemistry, 20 or more

quarter credits in food science and nutrition, and a dietetic internship or equivalent.

Applicants to the Ph.D. program who have completed the M.S. degree with a clinical emphasis must have completed the requirements described in the first paragraph above under Prerequisites for Admission.

**Special Application Requirements**—Graduate Record Examination scores and three letters of recommendation evaluating the applicant's scholarship must be submitted. At least two letters should be from professorial-rank faculty.

**Master's Degree Requirements**—Students must develop and demonstrate general competence in nutrition, including knowledge of basic biochemistry, physiology, food chemistry, and statistics. In addition, students must develop a minor or coherent related field program in a discipline(s) closely allied to nutrition—e.g., biochemistry, cell biology, epidemiology, food science, microbiology, or physiology. An oral final examination is required for both plans.

**Doctoral Degree Requirements**—Programs are designed by the student and adviser to develop appropriate skills in research and scholarship. A more comprehensive knowledge is required in the subject matter listed above for the master's program. Core requirements include FScN courses 5622, 5623, 5624, 8101 (twice), and two 8xxx courses; and one course in biochemistry. Students complete a minor consisting of an individual subject (e.g., biochemistry) or a supporting program consisting of a cluster of subjects (e.g., biochemistry, physiology, and statistics).

**Language Requirements**—None, unless specified by an adviser.

**Minor Requirements for Students Majoring in Other Fields**—General competence in nutrition.

**For Further Information and Applications**—Contact the Nutrition Graduate Program, Department of Food Science and Nutrition, University of Minnesota, 1334 Eckles Avenue, St. Paul, MN 55108 (612/624-1290).

*Note*—The following courses are commonly selected for major and minor programs; other courses are also available.

## GRADUATE PROGRAMS

Nutr 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Nutr 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Nutr 8888. Thesis Credits: Doctoral. (36 cr required)

FScN 5612. Experimental Nutrition. (2 cr; prereq 3612, ¶Biol 5001) Gallaher  
Use and evaluation of methods and interpretation of results from clinical nutrition measures.

FScN 5614. Nutrition Education. (3 cr; prereq 3610) Keenan

Application of educational principles, models, and theories to development, delivery, and evaluation of nutrition lessons, curricula, and communications.

FScN 5622. Macronutrient Metabolism. (4 cr; prereq 3612, Biol 5001, Phsl 3051) Brady  
Physiological function and metabolic fate of carbohydrates, lipids, and proteins and their involvement in fulfilling energy needs for maintenance, growth, and work.

FScN 5623. Vitamin and Mineral Biochemistry. (4 cr; prereq 3612, Biol 5001, Phsl 3051) Gallaher  
Nutritional/biochemical and physiological function of essential vitamins and minerals in humans and experimental animal models.

FScN 5624. Human Protein and Energy Utilization. (4 cr; prereq 5622, 5623) Kurzer  
Regulation of human protein and energy use, interactions, adaptations; critical evaluations of methods of determining requirements; technical and ethical problems in human experimentation and determination of recommended levels of intake.

FScN 5643. World Food Problems. (3 cr, \$AgEc 5790, \$Agro 5200, \$CAPS 5280; prereq sr or grad student; limited enrollment) Brady, Schafer  
Multidisciplinary approach to social, economic, and technical problems of feeding world's growing population. Principles from social and economic sciences and from plant, animal, and food sciences for application to world food problems.

FScN 8101. Research Seminar. (1 cr; prereq #; S-N only)  
Discussion with faculty member(s) on research progress within the group, or review and discussion of current research literature related to food science and nutrition.

FScN 8603. Advanced Topics in Nutrition. (1-4 cr; prereq #)  
Review of recent research or presentation of special topics.

FScN 8621. Independent Study: Nutrition. (1-9 cr; prereq #)  
Independent study and written reports in nutrition.

Nutr 8745. Seminar. (1 cr [may be repeated for cr]; prereq #)  
Current topics in human nutrition.

Nutr 8990. Graduate Research. (2-5 cr; prereq #)  
Research in various areas in nutrition represented by staff interests.

PubH 5330. Epidemiology I. (4 cr; prereq public hlth or pharmacy or med school or nursing or dentistry or grad student or #) Luepker, Sellers

Basic epidemiologic principles applicable to infectious and noninfectious disease; host-agent-environment complex; factors underlying spread of infectious disease; lab applications of statistical and epidemiologic methods.

PubH 5386. Public Health Aspects of Cardiovascular Diseases. (3 cr; prereq 5330, 5450 or equiv) Elmer

Evaluating population studies and trials on cardiovascular diseases; modifiable risk factors for coronary heart disease; preventing other types of heart disease.

PubH 5387. Cancer Epidemiology. (3 cr; prereq 5330, 5340 or #) Potter, Robison

Epidemiologic aspects of cancer, including theories of carcinogenesis, incidence, site specific risk factors, and issues of cancer control and prevention.

PubH 5902. Maternal and Infant Nutrition. (3 cr; prereq 3xxx nutrition course or equiv or #) Brown  
Nutritional needs of childbearing women and infants, how to meet these through programs and services.

PubH 5914. Nutrition Intervention. (3 cr; prereq grad student or #) Jeffery, Kushi

Selecting appropriate nutrition intervention strategies for health programs, applying them to specific target audiences, and evaluating their usefulness in relation to program objectives.

PubH 5932. Nutrition: Adults and the Elderly. (3 cr; prereq grad student or #) Krinke

Review of current literature and research on nutrient needs and factors affecting nutritional status of adults and the elderly.

## Occupational Therapy (PMed)

*Associate Professor:* Judith Reisman, *director and director of graduate studies;* James Carey; Virgil Mathiowetz; Erica Stern

*Assistant Clinical Specialist:* Diane Anderson; Cheryl Meyers

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—M.S. (Plan A or Plan B).

**Curriculum**—This new graduate program, available beginning fall 1997, offers academic study and clinical education to prepare occupational therapy clinicians and researchers. Emphasis is on application of the critical thinking model to diverse areas of practice and to diagnostic groups in both clinic and community settings. Clinical education is available in such areas as physical disabilities, psychosocial dysfunction, and developmental

disabilities. Research emphasizes investigation of treatment effectiveness.

In addition to the courses listed below are several that are under development and will be added to those required in the curriculum. These courses will cover research, adult education, documentation, anatomy, healthcare management, neurorehabilitation, and clinical education.

**Prerequisites for Admission**—Individuals with a bachelor's degree in any field may apply.

### **Special Application Requirements**—

Applicants must submit a program application, including one to three letters of reference, Graduate Record Examination General Test scores (no minimum required for consideration), and evidence of work or volunteer experience in occupational therapy. International students must also submit TOEFL scores (550 minimum) and TSE (Test of Spoken English) scores (50 minimum). Prerequisite coursework in statistics, the biological sciences, developmental and abnormal psychology, and related areas is also required. Contact the program office for specific information.

**Degree Requirements**—Students take 84 credits of predetermined academic coursework, 16 credits of clinical education, and 16 thesis credits (Plan A) or 6 project credits (Plan B). Both plans require a final oral examination by committee.

**Language Requirement**—None.

### **For Further Information and Applications**—

Contact the Program in Occupational Therapy, University of Minnesota, Box 388 Mayo, 420 Delaware Street S.E., 426 Church Street S.E., Minneapolis, MN 55455 (mailing address) (612/626-5887; fax 612/625-7192; e-mail schmi039@tc.umn.edu). Program office is located at 271 Children's Rehabilitation Center, 426 Church Street S.E., Minneapolis campus.

OT 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

## Required Courses

PMed 5161. Theory of Physical Medicine and Rehabilitation Applied to Medical Sciences. (5 cr; prereq regis in OT or PT)

Lectures focus on fields of surgery, orthopedics, pediatrics, dermatology, medicine, neurology and speech. Correlation clinic includes presentation of patients and discussion of treatment problems.

PMed 5182. Functional Neuroanatomy and Neurophysiology. (5 cr; prereq regis in OT or PT) Neuroanatomic structures as functional systems; basic neurophysiologic concepts, emphasizing applications for understanding and treating physical dysfunctions.

PMed 5300. Concepts for Occupational Therapy Practice. (5 cr; prereq regis in OT) Critical thinking, ethics, professional resources/organizations, patient-therapist relationship. Fieldwork experience.

PMed 5311. Therapeutic Occupation: Individual Focus. (3 cr; prereq regis in OT) Foundation for therapeutic occupation, activity analysis, application to performance deficits.

PMed 5312. Therapeutic Occupation: Group Focus. (2 cr; prereq regis in OT) Development, practical application, and analysis of activity groups as therapeutic occupation.

PMed 5341. Introduction To Assessment and Intervention Processes. (5 cr; prereq regis in OT) Assessment concepts, techniques and application to populations with psychosocial and/or physical disabilities component deficits. Treatment planning and documentation.

PMed 5342. Compensatory Rehabilitation: Assessment and Intervention. (6 cr; prereq regis in OT) Assessment of daily-living performance areas; adaptations/techniques to compensate for performance deficits. Fieldwork experience.

PMed 5370. Theory of Occupation. (3 cr; prereq regis in OT) Occupational therapy frames of reference, role of activity, and historical development of profession.

PMed 5393. Kinesiology. (3 cr; prereq regis in OT) The analysis of body mechanics and coordinated movement.

PMed 5394. Orthotics. (4 cr; prereq regis in OT) Analysis, design, and construction of orthotic devices.

Neur 5121. Descriptive Neurology. (2 cr; prereq regis in OT or PT) Central and peripheral nervous system. Correlation of neuroanatomy, neurophysiology, clinical neurology, and pathology of the nervous system.

## Oral Biology (OBio)

*Professor:* Edward C. Combe (oral sciences); William H. Douglas (oral sciences); Gregory R. Germaine (oral sciences); Mark C. Herzberg (preventive sciences); William F. Liljemark (diagnostic/surgical sciences); Charles F. Schachtele (oral sciences); Burton L. Shapiro (oral sciences)

*Associate Professor:* Robert H. Ophaug (oral sciences), *director of graduate studies*; Ralph DeLong (restorative sciences); Kenneth M. Hargreaves (restorative sciences); Keith C. Kajander (oral sciences); Ambika Mathur (oral sciences); Joel D. Rudney (oral sciences); Larry F. Wolff (preventive sciences)

*Assistant Professor:* Pamela R. Erickson (preventive sciences); Tom W. Koriath (oral sciences)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Students are provided with a broad understanding of the orofacial region, its development (including aging), structure, function, and pathology. More specialized areas of interest, such as salivary glands and secretions, development of oral structures, mineral metabolism and nutrition, pulp biology, oral microbial ecology and physiology, mechanisms of microbial infection and immunity, and development and evaluation of dental materials are emphasized in advanced coursework and research. Individual programs are planned according to the student's specific areas of interest and may include courses from other disciplines as part of the major. A minor in a related nonclinical discipline is also required.

**Prerequisites for Admission**—Programs are designed for individuals who have completed requirements for graduation with high standing from dental or medical schools and desire to undertake advanced studies in oral biology. In some cases individuals who have not yet obtained the D.D.S. (D.M.D.) or M.D. degree, but who have demonstrated exceptional potential for graduate study, may be admitted for a combined program. Individuals with a bachelor's or master's degree who can demonstrate an appropriate background and an interest in oral biology are considered for admission.

**Special Application Requirements**—Applicants must submit three letters of recommendation from persons familiar with

their academic and research experience and a statement describing how training in oral biology will help them attain their professional objectives. Students may enter the program in any quarter, but fall quarter is recommended.

**Master's Degree Requirements**—The M.S. degree program generally requires two years or more. For Plan A (with thesis), the student must complete a minimum of 20 credits in the major, including the survey course in oral biology (8010), 4 credits of oral biology topics courses, and participate each quarter in the student seminar. Students must also complete a minor in a related nonclinical discipline (minimum 9 credits). Plan B does not include a research thesis, but involves additional coursework (minimum 44 credits, including a minor of at least 9 credits) and three papers, at least one of which includes a laboratory study. Students must maintain a cumulative grade point average (GPA) of at least 3.00 in both the major and minor. Only grades of A or B are acceptable in the core courses designated above. A final oral examination is required for both plans.

**Doctoral Degree Requirements**—Coursework for the Ph.D. degree is selected to give the student a broad background in oral biology plus advanced coursework more directly related to the student's research interests. Though there are no minimum credit requirements for the Ph.D. degree, all students register for the survey oral biology course (8010) and 8 credits of oral biology topics courses and participate each quarter in the student seminar. Depending on their research interests, most students are expected to take additional credits in biochemistry; molecular, cellular, developmental biology and genetics; neuroscience; and public health and a course (3 to 5 credits) in statistics or biostatistics to complete a core curriculum of 35-37 credits. A minor in a relevant nonclinical discipline is required. A cumulative GPA of at least 3.00 in both the major and minor is required. Only grades of A or B are acceptable in the core courses designated above. The preliminary written examination is taken before the end of the second year in residence. It consists of two research proposals, one representing the student's anticipated thesis research, and the other on a topic assigned by the graduate faculty. The preliminary oral examination consists primarily of a defense of the

two proposals described above. Students must present a research seminar (which is attended by the final examination committee) no later than six months before defense of the thesis.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—A minor in oral biology consists of 9 credits for the M.S. degree and 20 credits for the Ph.D. degree. The minor must include OBio 8010, at least two advanced courses in oral biology, and other coursework in consultation with the director of graduate studies.

**For Further Information and Applications**—Contact the Oral Biology Graduate Program, University of Minnesota, 17-252 Moos Health Sciences Tower, 515 Delaware Street S.E., Minneapolis, MN 55455 (612/624-9123).

OBio 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

OBio 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

OBio 8888. Thesis Credits: Doctoral. (36 cr required)

OBio 5001f. Methods in Research and Writing. (2 cr; prereq grad student) Kajander  
Process of scientific inquiry and reporting. Critical literature review and proposal writing.

OBio 8001. Research in Oral Biology. (Cr ar)

OBio 8002. Tutorial in Oral Biology. (Cr ar [2 hrs per wk=1 cr; may be repeated for cr])  
Quarter-long apprenticeship with faculty members to familiarize students with faculty research interests.

OBio 8010w. Oral Biology. (3 cr; prereq dental specialist and/or oral research trainee)  
Oral aspects of inflammation, wound healing, and immunology; plaque composition, formation, and metabolism; saliva glands, composition, and function; biochemistry of connective and mineralized tissues; neurobiology and pathophysiology of orofacial pain and sensations.

OBio 8021, 8022, 8023, 8024. Topics in Oral Biology. (1-3 cr per qtr [may be repeated for cr]; prereq #)  
Individual courses address specialized topic relevant to biology of orofacial region. Specific offerings for at least the next two years are listed below.

OBio 8021f. Salivary Glands and Secretions. (2 cr; offered even yrs) Germaine, Herzberg, Rudney, Shapiro  
Structure, development, and evolution of salivary glands; mechanisms and control of secretion of electrolytes and macromolecules; structure and function of mucins, antimicrobial and mineral binding proteins, and exocrinopathy of salivary glands.

OBio 8021f. Oral Microbiology. (1-2 cr; offered odd yrs) Liljemark, Schachtele, Wolff  
Lectures, assigned readings, and discussions on acquisition, distribution, and interactions of oral flora; mechanisms of dental plaque formation; etiology of dental caries and periodontal diseases; other oral bacterial infections; microbiology in dental specialty areas.

OBio 8022w. Molecular Mechanisms of Cellular and Microbial Adhesion. (2 cr; offered even yrs) Germaine, Herzberg, Liljemark, guest lecturers  
Biochemical basis of adhesion phenomena, focusing on cells of immune system, development and tissue formation, and bacterial colonization of the human.

OBio 8022w. Physical Biology of the Oral Cavity. (1-2 cr; offered odd yrs) DeLong, Douglas  
Structure and function of human masticatory system discussed from biophysical point of view. Mandibular form, movement, and infrastructure of hard tissues as related to occlusal wear and masticatory efficiency; role of saliva and salivary pellicle in reduction of interocclusal friction. Physical methods (artificial mouth), computational methods of stimulation, digitization and graphic representation of anatomical surfaces, and methods of clinical measurements.

OBio 8023s. The Secretory Immune System. (1-2 cr; offered odd yrs) Mathur  
Lectures and discussions of secretory immunoglobulin A system. Origin, structure, and synthesis of sIgA; induction and biological activity of sIgA; role of sIgA in oral health.

OBio 8024su. Genetics of Oral Diseases. (2 cr; offered SSI of even yrs) Shapiro  
Principles of medical genetics with emphasis on oral diseases. Twins, chromosomes, recombinant DNA, major gene traits, genes in populations, chromosomal abnormalities, complex traits, facial clefts, dental caries, periodontal diseases.

OBio 8024su. Biology of the Chemical Senses. (1-2 cr; offered SSI of odd yrs) Rudney, staff  
Review of topical areas in biology of taste and smell. Histology, physiology, receptor recognition of tastant and odorant molecules, clinical measurement, and pathobiology.

OBio 8030f,w,s. Seminar. (1 cr [may be repeated for cr])  
Faculty and student discussion of current topics in oral biology.

OBio 8101, 8102, 8103. Topics in Cariology. (1-2 cr; prereq #) Ophaug, staff  
Different topics or subject areas each quarter, announced in advance. Includes etiology, pathogenesis, diagnosis, epidemiology, contributing factors, and prevention of dental caries.

*Additional major coursework may be drawn from basic medical sciences and other areas appropriate to the individual program.*

## Otolaryngology (Otol)

*Professor:* George L. Adams, *head*; Frank M. Lassman (*emeritus*), *director of graduate studies*; Arndt J. Duvall III; S. K. Juhn; Robert H. Maisel; Robert H. Margolis; David A. Nelson; Peter A. Santi

*Clinical Professor:* Michael M. Paparella

*Associate Professor:* John H. Anderson; Lawrence R. Boies, Jr.; Peter A. Hilger; David B. Hom; Eric Javel; Samuel C. Levine

*Clinical Associate Professor:* Marcos V. Goycoolea; Stephen L. Liston

*Assistant Professor:* Kathleen A. Daly; Markus Gapany; George S. Goding, Jr.; David D. Hamlar, Jr.; Lisa L. Hunter; Mario J. Imola; Rick M. Odland; Franklin L. Rimell; Edward H. Szachowicz II

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S., M.S.Otol. (Plan A only) and Ph.D.Otol.

**Curriculum**—The graduate degree programs prepare students in both clinical and experimental aspects of otolaryngology. Rotations at the University of Minnesota Hospital and Clinic, Minneapolis Veterans Administration Medical Center, St. Paul-Ramsey Medical Center, and Hennepin County Medical Center provide a wide range of material for clinical education and surgical experience. Opportunities for independent research are provided by the research laboratories of audiology, auditory electrophysiology, auditory neurophysiology, biochemistry, electronmicroscopy, electrophysiology, histochemistry, morphometry, psychoacoustics, temporal bone pathology, tumor immunology, skin-flap physiology, laryngeal physiology, mandibular bone physiology, microvascular tissue transfer, and vestibular physiology. Graduates of the program have careers in teaching, research, and the professional practice of otolaryngology.

**Prerequisites for Admission**—Applicants must hold an M.D. degree from an approved medical school.

**Degree Requirements**—All graduate students in the program spend one year in general surgery and four years in otolaryngology. During the last four years, each fellow is required to spend six months in basic research

directed toward preparation of an acceptable thesis for a master's or doctoral degree. Most Ph.D. candidates require time beyond the four years to complete their research.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Department of Otolaryngology, University of Minnesota, Box 396 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (mailing address) (612/625-3200; fax 612/625-2101).

Otol 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Otol 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Otol 8888. Thesis Credits: Doctoral. (36 cr required)

Otol 5101f. Introduction to the Basic Sciences in Otolaryngology I: Ear. (3 cr; prereq #) Anderson, Daly, Duvall, Javel, Juhn, Lassman, Liston, Margolis, Santi  
Acoustics and psychoacoustics, temporal bone anatomy, external and middle ear mechanisms, cochlear physiology, auditory neurophysiology, ear embryology, ear biochemistry, fine structures, vestibular mechanisms and measurement.

Otol 5102s. Introduction to the Basic Sciences in Otolaryngology II: Head and Neck. (3 cr; prereq #) Adams, Daly, Gapany, Goding, Hilger, Hom, Imola, Liston, Santi, Szachowicz  
Laryngeal anatomy and physiology, nasal anatomy and physiology, immune biology, embryology of head and neck.

Otol 5970. Directed Studies. (Cr ar [may be repeated for cr]; prereq #)  
Directed readings and preparation of reports on selected topics.

Otol 8230. Clinical Otorhinolaryngology. (6 cr) Adams, Boies, Duvall, Gapany, Goding, Hamlar, Hilger, Hom, Imola, Levine, Maisel, Odland, Rimell, Szachowicz  
Diagnostic and management instruction and experience in all phases of clinical otorhinolaryngology. Both inpatient and outpatient services are provided at University of Minnesota Hospital and Clinic, St. Paul-Ramsey Medical Center, Veterans Administration Medical Center, and Hennepin County Medical Center.

Otol 8231. Surgery of the Ear, Nose, and Throat. (4 cr) Adams, Boies, Duvall, Gapany, Goding, Hamlar, Hilger, Hom, Imola, Levine, Maisel, Odland, Rimell, Szachowicz  
Surgical training and experience with a broad scope of surgical problems encountered in otorhinolaryngology provided at University of Minnesota Hospital and Clinic, St. Paul-Ramsey Medical Center, Veterans Administration Medical Center, and Hennepin County Medical Center.

Otol 8232. Maxillofacial Surgery. (1 cr) Adams, Boies, Duvall, Hamlar, Hilger, Imola, Maisel, Szachowicz

Basic science principles and management principles of maxillofacial diseases. Problems of maxillofacial trauma. Experience with these problems in the hospitals of the training program, especially the county hospitals.

Otol 8233. Plastic and Reconstructive Surgery of the Head and Neck. (1 cr) Adams, Boies, Duvall, Hamlar, Hilger, Hom, Imola, Maisel, Szachowicz

Teaching and practical training for otolaryngologic cosmetic surgery with emphasis on rhinoplasty and otoplasty.

Otol 8234. Anatomy of the Head and Neck and Temporal Bone Dissection. (2 cr) Gapany, Levine

Head and neck anatomy is studied from cadaver material through programmed learning. Temporal bones are dissected to learn anatomy and to practice all otologic surgical procedures.

Otol 8235. Roentgenology of the Head and Neck. (2 cr)

Experience in X-ray diagnostic procedures for otolaryngologic problems.

Otol 8236. Pharmacology in Otolaryngology. (2 cr)

General principles of pharmacology as they relate to otolaryngology.

Otol 8237. Endoscopy. (2 cr) Adams, Duvall, Goding, Maisel

Instruction, didactic and practical, in laryngoscopy, esophagoscopy, bronchoscopy, and mediastinoscopy. General management principles emphasized.

Otol 8238. Pathology of the Ear, Nose, and Throat. (2 cr) Adams, Duvall, Gapany, Goding, Maisel  
Gross pathology and histopathology of diseases of the ear, nose, throat, and related regions.

Otol 8239. Otoneurology. (2 cr) Anderson, Levine  
Instruction and experience in diagnosis and management of otoneurologic problems including training in electronystagmographic analysis of vestibular function.

Otol 8240. Allergy. (2 cr)

Concepts and management of otolaryngologic allergy.

Otol 8241. Tumor Clinic. (1 cr) Adams, Gapany, Goding, Hamlar, Imola, Maisel

Clinical head and neck oncology including consideration of etiology, treatment (both surgical and nonsurgical), and other principles of management.

Otol 8242. Audiology and Speech Pathology. (2 cr) Hunter, Margolis, staff

Fundamentals of audiology and speech pathology. Measurement and description of disorders of hearing, speech, and language in children and adults. Peripheral vs. central differential diagnostic signs. Hearing aids. Special educational management of children and adults. Community resources.

Otol 8243. Introduction to Research Methodology. (2 cr) Daly, Odland, staff  
Basic introduction to such topics as statistical methods, experimental design, and execution of otolaryngologic research. Required for all first-year otolaryngology residents.

Otol 8244. Seminar: Current Literature. (1 cr) Adams, Gapany  
Presentation and discussion of selected articles required for all residents.

Otol 8245. Master's Thesis Research. (Cr ar)

Otol 8246. Ph.D. Thesis Research. (Cr ar)

Otol 8247f. Physiology of Hearing. (3 cr, §NSc 8247; prereq #; offered alt yrs) Anderson, Javel, Santi  
Basic functional mechanisms of the auditory system, peripheral and central.

Otol 8248. Readings in Auditory Physiology. (1-3 cr; prereq #) Santi

Current research on biophysics and physiology of auditory system; specific topics selected for each student. Written reviews prepared and discussed.

Otol 8249. Seminar: Current Topics in Cochlear Anatomy. (1 cr; prereq #) Santi

Review of current research papers concerning cochlear anatomy and pathology.

Otol 8250. Advanced Biochemistry of the Auditory System. (2 cr; prereq MdBc 5100, MdBc 5101 or equiv or #) Juhn

Review of recent progress in biochemical aspects of auditory end organs.

Otol 8262. Advanced Clinical Audiology. (3 cr; prereq Otol grad major, 8242 or #) Margolis

Comprehensive reading and practicum experience in auditory evaluation of patients. Assumes basic knowledge of clinical audiology. Each session devoted to aspect of auditory evaluation or aural rehabilitation, including behavioral audiometry, electrophysiologic evaluation, hearing aid selection, and cochlear implants.

## Parasitology

See Veterinary Pathobiology under Veterinary Medicine.

## Pharmaceutics (Phm)

*Professor:* David J. W. Grant; Yueh-Erh Rahman; Edward G. Rippie; Ronald J. Sawchuk

*Adjunct Professor:* Michael J. Pikal; Aldo Rescigno

*Associate Professor:* Cheryl L. Zimmerman, *interim head*; Raj G. Suryanarayanan, *director of graduate studies*; Timothy S. Wiedmann

*Adjunct Associate Professor:* Walid M. Awni; Keith K. Chan; Lawrence J. Felice

*Assistant Professor:* Pei-Fan Bai

*Adjunct Assistant Professor:* George A. Agyilirah; Robert K. Schultz

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A only) and Ph.D.

**Curriculum**—Emphases are available in physical pharmacy, biopharmaceutics and pharmacokinetics. Coursework in supporting fields typically include chemistry, chemical engineering, mechanical engineering, physiology, biochemistry, cell biology, biometry, and pharmacology.

**Prerequisites for Admission**—A degree from a recognized college of pharmacy and an exceptional scholastic record are required. However, individuals from other academic fields (such as chemistry, engineering, biochemistry, and biology) may be admitted if their undergraduate coursework satisfies the prerequisites for graduate coursework in pharmaceutics. The degree program adviser may recommend additional background pharmacy coursework for such individuals.

**Special Application Requirements**—For applicants to both the M.S. and Ph.D. programs, recent Graduate Record Examination scores, a statement of career goals, and three letters of recommendation are required. Fall quarter admission is preferred; under exceptional circumstances other quarters may be considered.

**Master's Degree Requirements**—Required components of the program include advanced courses in pharmaceutics and chemistry. A complete list of degree program requirements may be obtained from the director of graduate studies. An oral final examination is required.

**Doctoral Degree Requirements**—Required components of the program include advanced courses in pharmaceutics, chemistry, mathematics, statistics, and pharmacology. A complete list of degree program requirements may be obtained from the director of graduate studies.

**Language Requirements**—For the master's degree, none. For the doctoral degree, one foreign language or a collateral field of knowledge chosen with the consent of the director of graduate studies is required. The choice of option must have the approval of the major adviser.

**For Further Information and Applications**—Contact the Department of Pharmaceutics, College of Pharmacy, University of Minnesota, 9-177 Weaver-Densford Hall, 308 Harvard Street S.E., Minneapolis, MN 55455 (612/624-5151; fax 612/626-2125).

Phm 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Phm 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Phm 8888. Thesis Credits: Doctoral. (36 cr required)

Phm 8100.\* Seminar: Pharmaceutics. (1 cr; required of pharmaceutics majors)

Phm 8101. Readings in Pharmaceutics. (1 cr) Current literature.

Phm 8105. Pharmacokinetics Research Seminar. (2 cr; prereq Phm grad specializing in pharmacokinetics) Sawchuk, Zimmerman  
Advanced topics in animal and human pharmacokinetics.

Phm 8200.\* Research Problems. (Cr ar) Experimental investigation of problems in pharmaceutics.

Phm 8410. Stabilization of Pharmaceuticals. (3 cr; prereq physical chem survey course) Wiedmann  
Application of physicochemical principles (e.g., chemical kinetics) to elucidate and minimize stability problems in pharmaceutical systems.

Phm 8420. Modeling Approaches in Pharmacokinetics. (3 cr; prereq Phmc 5680, Math 3211 or #; offered alt yrs) Sawchuk  
Application of compartmental, noncompartmental, and physiological model analyses to study of absorption, distribution, metabolism, and excretion of drugs.

Phm 8425. Advanced Topics in Pharmacokinetics. (3 cr; prereq 8420; offered alt yrs) Zimmerman

Nonlinear pharmacokinetics (concentration- and time-dependent), drug metabolite kinetics, kinetics of pharmacological response, population kinetics.

Phm 8430. Drug Transport and Absorption. (3 cr; prereq 5630, survey course in physical chem and in differential equations; offered alt yrs) Bai  
Correlation of drug absorption with physiology and properties of drugs; fundamental problems of peptide drug delivery; chemical and physical approaches to improving bioavailability; use of animal and theoretical models to evaluate and predict drug absorption.

Phm 8440. Physical Pharmacy. (4 cr; prereq Phmc 5680, physical chem survey course or #; 4 hrs per wk; offered alt yrs) Rippe  
Application of physical-chemical relationships between drugs and their formulations for optimization of bioavailability.

Phm 8441. Solid-State Properties of Drugs. (3 cr; prereq Phmc 5680, physical chem survey course or #; offered alt yrs) Suryanarayanan  
Physical and physicochemical properties of drugs in solid state as related to their bioavailability.

Phm 8450. Industrial Pharmacy. (3 cr; prereq Phmc 5605 or equiv or #; offered alt yrs) Schultz  
Design, manufacture, and evaluation of modern pharmaceutical dosage forms and delivery. Preformulation studies, oral liquid and solid pharmaceutical dosage forms and optimization. Pulmonary, transdermal, and parenteral deliveries, including veterinary drug delivery systems.

Phm 8460. Solubility Behavior of Drugs and Other Organic Compounds. (4 cr; prereq physical chem survey course or #; offered alt yrs) Grant  
Thermodynamics and kinetics of solubility and partitioning. Intermolecular interactions in pure state and in solution. Measurement and prediction of solubility and partitioning behavior. Functional group contributions. Molecular complexation and ion-pairing in solution.

Phm 8470. Biological Approaches to Drug Targeting. (3 cr; prereq biochem survey course; offered alt yrs) Rahman  
Concept of drug targeting. Characteristics of site-specific drug delivery systems. Biological, drug-related, and carrier-related factors. Therapeutic applications and critical evaluation of major drug carrier systems.

Phmc 5460. Pharmacokinetics. (4 cr; prereq 5452, Math 1221 or #) Zimmerman  
Physiological basis for drug absorption, distribution, metabolism, and excretion; using mathematical principles for designing dosage forms for individual patients.

Phmc 5681. Basic Pharmacokinetic Modeling. (2 cr; prereq 5680 with minimum grade of B; A-F only) Sawchuk  
Computer simulation of compartmental and physiologic modeling.

Phmc 5685. Clinical Pharmacokinetics. (2 cr; prereq 5680; A-F only) Sawchuk  
Applying knowledge of time-course behavior of a drug in the body to safe and effective therapeutic management of individual patients in a clinical setting. Selected research topics.

Phmc 5696. Parenteral Dosage Forms. (3 cr; prereq #)  
Theoretical and practical considerations in design, formulation, and evaluation.

Phmc 5999. Special Problems. (Cr ar; prereq #)  
Research in physical pharmacy, biopharmaceutics, or pharmacokinetics.

## Pharmacology (Phcl)

*Professor:* Horace H. Loh, *head*; Bianca M. Conti-Fine; Richard M. Eisenberg<sup>1</sup>; Robert P. Elde; Esam E. El-Fakahany; Patrick E. Hanna; Jordan L. Holtzman; Donald B. Hunninghake; Paul R. Pentel; Philip S. Portoghese; Michael A. Raftery; Alan R. Sinaiko; Norman E. Sladek; Sheldon B. Sparber; George J. Trachte<sup>1</sup>; Fatih M. Uckun; George L. Wilcox; Wellington G. Wood III; Ben G. Zimmerman

*Associate Professor:* Timothy F. Walseth, *director of graduate studies*; Jean F. Regal<sup>1</sup>, *associate director of graduate studies*, Duluth; Earl W. Dunham; Kenneth M. Hargreaves; Edward T. Knych<sup>1</sup>; Ping-Yee Law; Rita B. Messing; Louise M. Nutter; Aloysius J. Quebbemann; Sundaram Ramakrishnan; Virginia S. Seybold; Stanley A. Thayer; Kendall B. Wallace<sup>1</sup>

*Assistant Professor:* Frank H. Burton; Colin R. Campbell; Gregory J. Connell; Leonard Lichtblau; Daniel P. Romero; Paul J. Sammak; Li-Na Wei

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A only) at Duluth<sup>2</sup> (and under special circumstances at Twin Cities) and Ph.D.

**Curriculum**—Courses and research provide opportunities for training in biochemical, physiological, and behavioral pharmacology and toxicology. For qualified students, training in clinical pharmacology is available through the Division of Clinical Pharmacology.

**Prerequisites for Admission**—Applicants should be well grounded in the chemical and biological sciences and mathematics.

<sup>1</sup> University of Minnesota, Duluth

<sup>2</sup> For information on the M.S. degree program offered in conjunction with the University of Minnesota, Duluth, please contact the associate director of graduate studies on the Duluth campus.

**Special Application Requirements**—At least three letters of recommendation from former instructors or employers and scores from the General (Aptitude) Test of the Graduate Record Examination are required.

**Master's Degree Requirements**—Completion of a core curriculum consisting of 19 course credits in pharmacology is required, along with prerequisite courses in biochemistry, physiology, and statistics and 16 thesis credits. A list of degree program requirements may be obtained from the director of graduate studies. An oral final examination is required.

**Doctoral Degree Requirements**—Students must complete Phcl 5110, 5111 (or an acceptable alternative), 8110, 8111, 8112, 8204, 8217, and 8888. Prerequisite courses include physiology and biochemistry. Additional requirements are courses in statistics, biochemistry, physiology, and any others that may be specified by the major adviser.

**Language Requirements**—None.

**Minor and Supporting Program Requirements for Students Majoring in Other Fields**—Students must complete 18 credits of coursework. At least 15 credits must be completed in Phcl 5110 and 5111, or the equivalent, 8110, 8111, 8112, 8204, and 8217. The remaining credits can be completed in other advanced pharmacology courses.

**For Further Information and Applications**—Contact the Department of Pharmacology, University of Minnesota, 3-249 Millard Hall, 435 Delaware Street S.E., Minneapolis, MN 55455 (612/625-9997).

Phcl 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Phcl 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Phcl 8888. Thesis Credits: Doctoral. (36 cr required)

Phcl 5110. Pharmacology. (2 cr; prereq regis med or #) Hunninghake, staff  
Lectures and small groups on general principles of pharmacology and major classes of drugs.

Phcl 5111f,w†. Pharmacology. (3 cr fall, 4 cr wtr; prereq 5110 or #) Hunninghake, staff  
Continuation of 5110.

Phcl 5462. Neuroscience Principles of Drug Abuse. (2 cr; prereq #; offered alt yrs) Law, Wilcox  
Current research on drugs of abuse: their mechanisms of action, characteristics shared by various agents, and cellular and neural systems affected by them.

Phcl 8110f. Advanced Pharmacology I. (2 cr; prereq biochem and physiol bkgrnd, 5111 or ¶5110 or #) Loh, staff

Supplement to 5110. Contemporary research concepts and experimental approaches in different areas of investigative pharmacology. Emphasis on mechanisms of action of drugs on systems (whole animal), organ, and cellular levels.

Phcl 8111w. Advanced Pharmacology II. (3 cr; prereq biochem and physiol bkgrnd, 5111 or ¶5111 or #) Loh, staff

Supplement to 5111. Contemporary research concepts and experimental approaches in different areas of investigative pharmacology. Emphasis on mechanisms of action of drugs on cellular and molecular levels.

Phcl 8112s. Advanced Pharmacology III. (3 cr; prereq biochem and physiol bkgrnd, 5111 or #) Loh, staff

Supplement to 5111. Contemporary research concepts and experimental approaches in different areas of investigative pharmacology. Emphasis on mechanisms of action of drugs on cellular and molecular levels.

Phcl 8204. Seminar: Selected Topics in Pharmacology. (1 cr per qtr; prereq 5111 or #) Walseth, staff

Phcl 8207. Seminar: Psychopharmacology. (1 cr; prereq #) Sparber, staff  
Selected topics on behavioral aspects of drug action.

Phcl 8208s. Neuropsychopharmacology. (3 cr, \$NSc 8208; prereq 5111, Psy 5018, Psy 5062 or #; offered alt yrs) Sparber, staff

Lectures on methodologies currently used to study relationships between drugs and biochemical, behavioral, and neurophysiological consequences. Discussions of functional biogenic amine, peptidergic, and other pathways; how specific manipulations result in altered neuronal function and behavior; and theories of feedback mechanisms, induction, and inhibition. Theories of tolerance to and/or dependence on stimulants, hallucinogens, depressants, and opiates.

Phcl 8214s. Toxicology. (2 cr; prereq MdBc 5101 or #) Holtzman, Loh

Lectures on biochemical and molecular mechanisms of action by which drugs and other chemicals adversely alter human health.

Phcl 8216s. Immunopharmacology. (2 cr; prereq MicB 5216 or equiv or #; offered alt yrs) Regal  
Purported mediators of inflammatory process with reference to their actions on components of immune system and physiological response. Models for development of drugs useful in inflammatory disease as well as mechanisms of drugs currently in use. Lectures, assigned readings, discussion.

Phcl 8217f. Problems in Investigative Pharmacology. (2 cr; prereq #) Loh, staff  
Contemporary research problems, investigative approaches and methodologies in experimental pharmacology. Related to cardiovascular, renal, endocrine, and autonomic pharmacology; neuropharmacology; psychopharmacology; chemotherapy; toxicology; and molecular pharmacology.

Phcl 8219s. Advanced Toxicology. (1 cr; prereq 8214 or #; offered alt yrs) Holtzman, staff  
Lectures on the biochemical mechanisms of intoxication by selected compounds.

Phcl 8261. Molecular Toxicology. (3 cr; prereq 5262, Biol 5001, ¶|PubH 8261, #) Holtzman, staff  
Toxic actions and mechanisms of environmental chemicals at molecular level; emphasis on current research in selective toxicity.

Phcl 8269. Toxicology Seminar. (1 cr; prereq 8261, ¶|PubH 8269, #) Holtzman, staff  
Evaluation of toxicological studies. Students present data from literature or their own research.

## Philosophy (Phil)

*Professor:* Marcia M. Eaton, *chair*; Elizabeth S. Belfiore; Norman E. Bowie; Norman O. Dahl; Ronald N. Giere; Jeanette K. Gundel; Keith Gunderson; William H. Hanson; Geoffrey P. Hellman; Jasper Hopkins; Michael B. Kac; Douglas E. Lewis; Helen E. Longino; H. E. Mason; Joseph I. Owens; C. Wade Savage; Naomi B. Scheman; John R. Wallace

*Associate Professor:* C. Kenneth Waters, *director of graduate studies*; John H. Beatty; John M. Dolan; Sandra L. Peterson; Michael D. Root

*Assistant Professor:* Sarah W. Holtman

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) and Ph.D.

**Prerequisites for Admission**—Recognizing that evidence of ability to pursue graduate study in philosophy is diverse, the department does not specify prerequisites for admission. Normally, those admitted have a broad undergraduate background that includes some courses in philosophy.

**Special Application Requirements**—Students must submit a completed application, scores from the General (Aptitude) Test of the Graduate Record Examination, and two or three letters of recommendation—normally by January 7. Decisions can be expected in March.

Entry is usually in fall quarter, but may be permitted in other quarters in exceptional cases.

**Master's Degree Requirements**—Students must exhibit competence, through coursework or examination, in the history of philosophy. Students must pass a final oral examination on their work.

**Doctoral Degree Requirements**—Students must exhibit competence in the history of philosophy and logic and in the ability to pursue work on a range of philosophical topics in such areas as epistemology, metaphysics, and ethics or political philosophy.

**Language Requirements**—There is no general language requirement for the M.A. or Ph.D. degree.

**For Further Information and Applications**—Further details about the program are presented in two publications: *Graduate Studies: Philosophy and Department Degree Programs: M.A. and Ph.D.*, available from the Department of Philosophy, University of Minnesota, 355 Ford Hall, 224 Church Street S.E., Minneapolis, MN 55455 (612/625-6563; fax 612/626-8380; e-mail [umphil@tc.umn.edu](mailto:umphil@tc.umn.edu)).

Phil 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Phil 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Phil 8888. Thesis Credits: Doctoral. (36 cr required)

Phil 5004. Socratic Dialogues. (4 cr; prereq 3001 or #; offered when feasible) Dahl, Hopkins, Lewis, Peterson

Phil 5005. Plato. (4 cr; prereq 3001 or #; offered alt yrs) Hopkins, Peterson  
Analysis of major dialogues.

Phil 5008. Aristotle. (4 cr; prereq 1 qtr hist of phil or #; offered alt yrs) Dahl, Peterson  
Selected passages from major works.

Phil 5021. Medieval Philosophy. (4 cr; prereq 3001, 3002 or #; offered alt yrs) Hopkins  
Selected topics in writings of medieval philosophers; e.g., Augustine, Anselm, Aquinas, Scotus, and Ockham.

Phil 5033. Rationalism. (4 cr; prereq 3003 or #)  
Philosophies of Descartes, Spinoza, and Leibniz.

Phil 5034. Descartes. (4 cr; prereq 3003 or #; offered alt yrs) Lewis, Root  
Philosophical works.

## GRADUATE PROGRAMS

Phil 5035. Spinoza. (4 cr; prereq 3003 or #; offered when feasible) Lewis

Phil 5041. Locke. (4 cr; prereq 3003 or #; offered alt yrs) Gunderson, Lewis  
*The Essay Concerning Human Understanding.*

Phil 5042. Berkeley. (4 cr; prereq 3003 or #; offered when feasible) Lewis

Phil 5043. Hume. (4 cr; prereq 3003 or #; offered alt yrs) Lewis  
*Hume's Treatise and Inquiry.*

Phil 5046. Kant. (4 cr; prereq 3003 or 3004 or #; offered alt yrs) Dahl, Holtman  
Selected passages from major works.

Phil 5054. Kierkegaard. (4 cr; prereq 1 qtr hist of phil or #; offered when feasible) Mason

Phil 5068. Later Philosophy of Wittgenstein. (4 cr; prereq 5231 or 3003 or #; offered alt yrs) Mason, Scheman  
*Philosophical Investigations.*

Phil 5101. Metaphysics. (4 cr; prereq 1 qtr hist of phil or #; offered alt yrs) Dolan, Owens, Root  
Philosophical theories concerning nature of reality.

Phil 5105. Epistemology. (4 cr; prereq 1001 or #; offered alt yrs) Dolan, Root, Savage, Wallace, Waters  
Theories of origin, development, reliability, justification, and scope of knowledge.

Phil 5201. Symbolic Logic I. (5 cr; prereq 1001 or #) Dahl, Dolan, Hanson, Kac  
Development of a formalized language. Syntax and semantics of sentential and first-order predicate logic. Deductive systems.

Phil 5202. Symbolic Logic II. (5 cr; prereq 5201 or #) Dolan, Hanson, Hellman, Kac, Wallace  
Introduction to metatheoretic proofs and methods, including proof by mathematical induction; elements of set theory; metatheorems on soundness, consistency, completeness; extensions of elementary logic.

Phil 5203. Symbolic Logic III. (4 cr; prereq 5202; offered alt yrs) Dolan, Hanson, Hellman, Wallace  
Elementary theory of Turing machines and recursive functions, proofs of limitative results, undecidability of first-order predicate logic, incompleteness of number theory and undefinability of truth therein. Philosophical significance of these results.

Phil 5211. Modal Logic. (4 cr; prereq 5202 or Math 5162 or #; offered alt yrs) Hanson  
Axiomatic and semantic treatment of propositional and predicate logics; problems of interpreting modal languages.

Phil 5221. Philosophy of Logic. (4 cr; prereq 5202 or Math 5162 or #; offered alt yrs) Hanson, Hellman  
Attempts to answer the question, "What is logic?" Scope of logic; disputes about alternative logics; various theories on nature of logical truth (e.g., conventionalism, the view that logical truths are contingent).

Phil 5222. Philosophy of Mathematics. (4 cr; prereq 5202 or 5xxx math course; offered alt yrs) Hanson, Hellman

Study of major philosophical questions arising in connection with mathematics: What (if anything) is mathematics about? How do we know the mathematics we do? What is the relation between mathematics and the natural sciences?

Phil 5231. Philosophy of Language. (4 cr; prereq 1001, 5201 or #; offered alt yrs) Dolan, Kac, Mason, Owens, Peterson, Root, Wallace  
Central topics in the philosophy of language, theories of reference, linguistic truth, relation of language and thought, translation and synonymy.

Phil 5232. Topics in the Philosophy of Language. (4 cr; prereq 3231 or 5231 or #; offered when feasible) Dolan, Hellman, Kac, Mason, Owens, Peterson, Root, Wallace

Phil 5302. History of Ethics: Selected Classical Moralists. (4 cr; prereq 1003 or 1 qtr hist of phil or #; offered alt yrs) Dahl, Peterson  
Moral philosophy outside of British tradition (see 5301). Specific topics announced in *Class Schedule*.

Phil 5311. Ethical Theory. (4 cr; prereq 1003 or #; offered alt yrs) Bowie, Dahl, Holtman, Mason  
Investigation of representative theories on the nature and justification of moral judgments.

Phil 5312. Foundations of Ethics. (4 cr; prereq 1003 or #; offered alt yrs) Dahl, Holtman, Mason  
Discussion of the view that evaluative judgments cannot be based on factual considerations alone, and the relation of this view to the objectivity of ethics.

Phil 5315. Ethical Theory of Bioethics. (4 cr)  
Survey of normative ethical theories, focusing on key ethical notions relevant to bioethics, e.g., autonomy, utility, beneficence, paternalism, rights, justice, principlist and virtue ethics, and "ethics of care."

Phil 5321. Theories of Justice. (4 cr; prereq 1003 or 1004 or 5311 or #; offered alt yrs) Bowie, Holtman, Mason  
Philosophical accounts of the concept and principles of justice.

Phil 5324. Ethics and Education. (4 cr; prereq 8 cr phil or educ or #; offered when feasible) Scheman, Wallace

Phil 5325. Biomedical Ethics. (4 cr; prereq # for undergrads)  
Survey of topics and issues, including patients' rights and duties, informed consent, confidentiality, ethical issues in medical research, initiation and termination of medical treatment, euthanasia, abortion, maternal/fetal conflicts, allocation of medical resources.

Phil 5414. Political Philosophy. (4 cr; prereq 1004 or #; offered alt yrs) Bowie, Dolan, Hellman, Holtman, Root, Wallace  
Central concepts and principal theories of political philosophy.

Phil 5415. Philosophy of Law. (4 cr; prereq 1003 or 1004 or 3302 or social sci major or #) Holtman  
Analytical accounts of law and legal obligation.

Phil 5501. Principles of Aesthetics. (4 cr; prereq 3502 or #; offered alt yrs) Eaton, Gunderson  
Standards of evaluation; aesthetic experience; representation, meaning.

Phil 5504. Applied Aesthetics. (4 cr, §3504; prereq 3502 or 5501 or #)  
Application of concepts and theories in philosophy of art and aesthetics to practical problems in contemporary society, e.g., assessment of environmental values, artists' responsibilities, censorship.

Phil 5512. Philosophy and Literary Criticism. (4 cr; prereq 4 cr phil or #; offered alt yrs) Eaton, Gunderson  
Goals and aims of literary criticism and the problems which arise in attempting to justify various principles of criticism.

Phil 5514. Art and Language. (4 cr; prereq 3231, 3502, 5231, 5501 or #; offered alt yrs) Eaton, Gunderson, Mason, Root, Scheman  
Similarities and differences between verbal and nonverbal symbols; questions concerning extent to which art can be called a "language."

Phil 5521. Philosophy of Religion. (4 cr, §ReIS 5521; prereq 8 cr phil; offered alt yrs) Hopkins, Owens  
Conceptual problems arising from attempts to provide rational justification for religious belief.

Phil 5601. The Evaluation of Scientific Hypotheses. (4 cr; prereq 3601 or #) Giere, Hanson, Hellman, Savage, Waters  
Philosophical theories of the nature of scientific methods for evaluating scientific hypotheses, of role of experimentation in science, and of how hypotheses come to be accepted within a scientific community.

Phil 5602. The Nature of Scientific Theories. (4 cr; prereq 3601 or #) Giere, Hellman, Savage, Waters  
Contemporary issues concerning the nature and role of theories in science: their structure and their relations with models and laws, other forms of representation, experiment, and the world in general.

Phil 5603. Scientific Explanation. (4 cr; prereq 3601 or #; offered when feasible) Giere, Hellman, Savage, Waters

Phil 5604. Determinism and Causation. (4 cr; prereq courses in phil of sci or natural sci; offered when feasible) Hellman

Phil 5605. Time and Space. (4 cr; prereq courses in phil of sci or natural sci; offered when feasible) Savage

Phil 5606. Philosophy of Quantum Mechanics. (4 cr; prereq 3601 or Phys 3501 or Math 3142 or #) Hellman  
Introduction to problems of interpretation of ordinary (nonrelativistic) quantum mechanics: two-slit experiment, Schrödinger cat paradox (measurement problem), Einstein-Podolsky-Rosen paradox; leading approaches to interpretation (Copenhagen, hidden variables, universal wave function) and their connections with philosophical issues.

Phil 5607. Philosophy of the Biological Sciences. (4 cr; prereq courses in phil of sci or biol; offered when feasible) Beatty, Waters

Phil 5608. Theory and Measurement. (4 cr; prereq 5201 or #)  
Theory of measurement and its applications in philosophy of science, metaphysics, and epistemology.

Phil 5611. Philosophy of the Social Sciences I. (4 cr; prereq 12 cr phil or soc sci or #; offered when feasible) Root

Phil 5612. Philosophy of the Social Sciences II. (4 cr; 5611 recommended; offered when feasible) Root

Phil 5614. Philosophy of Psychology. (4 cr; prereq 3607 or 5601 or Psy 3051 or Psy 5011 or #) Savage  
Problems of and prospects in recent developments in psychology, cognitive science, and philosophy of mind.

Phil 5615. Minds, Bodies, and Machines. (4 cr; prereq 4 cr phil or #; offered alt yrs) Gunderson, Owens  
Philosophical relevance of cybernetics, artificial intelligence, and computer simulation.

Phil 5617. Twentieth-Century Philosophy of Science: Logical Empiricism. (4 cr; prereq phil major or phil grad student or #) Giere, Savage  
Historical development of logical empiricism from its European origins in first half of 20th century to its emergence as nearly universal account of science in post-war Anglo-American philosophy.

Phil 5618. Twentieth-Century Philosophy of Science: The Historical School. (4 cr; prereq phil major or phil grad student or #) Giere, Savage, Waters  
Historical turn in Anglo-American philosophy of science beginning in 1960s with writings of Stephen Toulmin, Russell Hanson, Paul Feyerabend, and Thomas Kuhn and continuing with works of Imre Lakatos, Larry Laudan, and Dudley Shapere.

Phil 5622. Philosophy and Feminist Theory. (4 cr; prereq 8 cr phil or women's studies or #) Scheman  
Critical examination of encounters between philosophy and feminism; e.g., how has gender figured in traditional philosophical problems and methods, and how do theorizing and social role of theorist relate to politics of feminism?

## GRADUATE PROGRAMS

Phil 5701. Survey of Contemporary Philosophy. (4 cr; prereq 3003 or #; offered alt yrs) Lewis

Current systematic and critical philosophies as represented by their principal exponents.

Phil 5720, 5730. Studies in Contemporary Philosophers. (4 cr per qtr; prereq 3003 or #) Specific topics announced in *Class Schedule*.

Phil 5760, 5770. Selected Topics in Philosophy. (4 cr per qtr; prereq 4 upper div cr in phil or #)

Philosophical problems of contemporary interest. Specific topics announced in *Class Schedule*.

Phil 5781. Existentialism. (4 cr; prereq 3003 or 3004 or 5054 or #; offered alt yrs) Hopkins, Lewis, Mason

Writings of existentialist philosophers since Kierkegaard.

Phil 5970, 5990. Directed Study and Research. (1-5 cr per qtr; prereq #, Δ, CLA approval)

Phil 8090. Seminar in History of Philosophy. (4 cr [may be repeated for cr])

Phil 8110, 8120. Seminar: Metaphysics. (4 cr per qtr [may be repeated for cr]; prereq 5101 or #) Topics in metaphysics. Specific topics announced in *Class Schedule*.

Phil 8130, 8140. Seminar: Epistemology. (4 cr per qtr [may be repeated for cr]; prereq 5105 or #) Problems in the theory of knowledge. Specific topics announced in *Class Schedule*.

Phil 8131. Epistemology Survey. (4 cr) Problems in epistemology.

Phil 8180. Seminar: Philosophy of Language. (4 cr [may be repeated for cr])

Phil 8210. Seminar: Logical Theory. (4 cr [may be repeated for cr]; prereq 5201, 5202 or #) Selected topics in the philosophy of logic.

Phil 8220. Seminar: Philosophy of Mathematics. (4 cr; prereq 5203 or Math 5164 or 8xxx math course or #) Hanson, Hellman  
Topics such as significance of limitative metatheorems (Gödel, et al.), assessment of major foundational programs (set theoretic, modern Hilbertian, constructivist), modal and structuralist alternatives to standard platonism.

Phil 8310, 8320. Seminar: Moral Philosophy. (4 cr per qtr [may be repeated for cr]; prereq 5311 or #) Systematic study of concepts and problems relating to ethical discourse.

Phil 8315. Ethical Issues in Human Experimentation. (4 cr; prereq 5xxx ethics course) Evolution of ethical protections for human subjects, definition of research, informed consent, competency, and ethics of research on vulnerable subjects such as children, prisoners, and the mentally ill.

Phil 8321. Ethics Survey. (4 cr) Holtman, staff  
Problems in ethics.

Phil 8420. Seminar: Political Philosophy. (4 cr) Holtman  
Systematic study of selected problems in political philosophy.

Phil 8510. Seminar: Studies in Aesthetics. (4 cr [may be repeated for cr]) Eaton, Gunderson, Hellman  
Problems in aesthetics. Specific topics announced in *Class Schedule*.

Phil 8550. Seminar: Philosophy of Religion. (4 cr [may be repeated for cr]; prereq 5521 or #; offered when feasible) Hopkins

Phil 8600. Seminar: Philosophy of Science. (4 cr [may be repeated for credit]) Giere, Hellman, Savage, Waters

Phil 8605. Issues and Approaches in Philosophy of Science. (4 cr)  
Major contemporary approaches to philosophical study of general nature of science.

Phil 8606. Philosophy of Medicine and the Biomedical Sciences. (4 cr; prereq 5xxx ethics course)  
Aims and goals of medicine; concepts of health, illness, and disease; nature of reasoning in clinical medicine, theoretical evolution in medicine, and role of values in practice of medicine and healthcare.

Phil 8610. Seminar: Philosophy of the Physical Sciences. (4 cr [may be repeated for cr]; offered when feasible)

Phil 8620. Seminar: Philosophy of Biology. (4 cr [may be repeated for credit]) Beatty, Waters

Phil 8640. Seminar: Philosophy of Psychology. (4 cr, §CgSc 8000; prereq phil or psych grad student or #) Owens, Savage

Phil 8970, 8990. Directed Study and Research. (1-4 cr per qtr; prereq passing grade on written prelim exam for phil PhD, #)

**This is the Physical Therapy through Veterinary Pathobiology program and course sections of the 1996-1999 University of Minnesota Graduate School Catalog**

## Physical Education and Recreation

See Kinesiology and Leisure Studies.

## Physical Therapy (PMed)

*Professor:* Richard P. DiFazio, *director of graduate studies;* Robert P. Patterson

*Associate Professor:* James R. Carey; Corinne T. Ellingham; Judith E. Reisman; Glenn N. Scudder

*Assistant Professor:* LaDora V. Thompson

*Assistant Clinical Specialist:* Krista Coleman; Marguerite P. Gardner

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—M.S. (Plan A and Plan B).

### Advanced-Standing Master's (Plan A and Plan B)

**Curriculum**—This course of study is for students who already have a degree in physical therapy. It prepares students to teach, conduct clinical research, and develop specialized programs that represent innovations in patient care based on scholarly work. Unique research opportunities offered by the program include analysis of movement pathology for patients with disabilities and impairments across the life span.

**Prerequisites for Admission**—Candidates must be able to demonstrate good aptitude for academic, research, and clinical endeavors.

**Special Application Requirements**—Applicants should submit a résumé, a statement of goals, and three letters of reference attesting to their personal, academic, and professional qualifications to the director of graduate studies. Submission of Graduate Record Examination scores is recommended but not required. For international students, a TOEFL score of at least 620 is required. Fall or summer entry is advised for all applicants.

**Degree Requirements**—Completion of a physical therapy curriculum approved by the American Physical Therapy Association and the Council on Medical Education of the American Medical Association, or its equivalent, is required before graduation.

Completion of the curriculum may occur in conjunction with, or before, work on the master's degree.

For the master's degree, practicum courses are required in teaching, research, and clinical practice. Department seminar courses and courses in research design and instrumentation are also required. Research proposals for the Plan A thesis or Plan B paper must be approved by a department committee. A final oral examination is required.

**Language Requirement**—None.

### For Further Information and Applications—

Contact the Physical Therapy Program, University of Minnesota, Box 388 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (mailing address) (612/626-5887; fax 612/625-7192; e-mail barth003@tc.umn.edu; <http://physther.med.umn.edu>).

PT 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

### Entry-Level Master's (Plan B only)

**Curriculum**—This course of study prepares students to become physical therapists and is accredited by the Commission on Accreditation in Physical Therapy Education. It includes coursework in the medical and rehabilitation sciences important in understanding impaired human movement. The curriculum emphasizes the theory and application of evaluation and treatment procedures to rehabilitate such movement-related problems as pain, weakness, and joint immobility.

Students are required to complete 27 weeks of full-time clinical internship, divided into four periods that include acute care; outpatient, long-term rehabilitation; and an elected specialty site.

**Prerequisites for Admission**—Applicants must have a baccalaureate degree with a major in any field. Contact the program office for a list of prerequisite courses.

**Special Application Requirements**—A minimum GPA of 3.00 is required for all previous coursework. Scores from the Graduate Record Examination General Test are required. Applicants must also have volunteered or worked a minimum of 100 hours in a healthcare setting, preferably with exposure to physical therapy practice.

**Degree Requirements**—The minimum course credit requirement is 130-131 credits, with 102 credits in core academic courses, 8 credits in elective academic courses in related fields (or 9 credits in a single field for a designated minor), and 20 credits in clinical internship courses. A minimum GPA of 2.80 is required in all the professional courses. A final oral examination is required. Students should refer to the *Program in Physical Therapy Student Handbook* for other policies and requirements.

**Language Requirement**—None.

**For Further Information and Applications**—Contact the Physical Therapy Program, University of Minnesota, Box 388 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (mailing address) (612/626-5887; fax 612/625-7192; e-mail [barth003@tc.umn.edu](mailto:barth003@tc.umn.edu); <http://physther.med.umn.edu>).

PMed 5135. Pathokinesiology. (3 cr; prereq #) DIFabio

Lecture and lab emphasizing anatomical, physiological, and biomechanical aspects of normal and pathological human motion, including techniques for analysis.

PMed 5150. Kinesiological Electromyography and Nerve Conduction. (3 cr; prereq #)

Lecture and lab on instrumentation, physiological, anatomical, and kinesiological considerations related to electromyography and nerve conduction.

PMed 5161. Theory of Physical Medicine and Rehabilitation Applied to Medical Sciences. (5 cr; prereq regis in OT or PT)

Lectures focus on fields of surgery, orthopedics, pediatrics, dermatology, medicine, neurology, and speech. Correlation clinic includes presentation of patients and discussion of treatment problems.

PMed 5182. Functional Neuroanatomy and Neurophysiology. (5 cr; prereq regis in OT or PT) Reisman

Neuroanatomic structures as functional systems; basic neurophysiologic concepts, emphasizing applications for understanding and treating physical dysfunctions.

PMed 5215. Introduction to Physical Therapy Clinical Education. (1 cr; prereq regis in PT)

Attitudinal approach to healthcare using exposure to affective domain of patient care. Developing communication and observational skills and professional attitudes toward death and dying, aging process, and medical ethics. Supervised clinical education, group discussions, lectures, and tours.

PMed 5221. Therapeutic Procedures. (5 cr; prereq regis in PT)

Theory and techniques, therapeutic massage, ultraviolet radiation, medical and athletic bandaging, asepsis and isolation, thermotherapy, hydrotherapy, positive pressure devices, and volumetric measurements.

PMed 5222. Musculoskeletal Evaluation and Treatment I. (4 cr; prereq regis in PT)

Muscle and range-of-motion testing, strengthening exercises, and other exercises to increase joint range of motion.

PMed 5223. Electrotherapy and Electrophysiological Testing. (3 cr; prereq regis in PT)

Theory and technique of electrotherapeutic devices, kinesiological electromyography, and nerve conduction in physical therapy.

PMed 5231. Biomechanics. (5 cr; prereq regis in PT)

Forces and structures internal and external to the body responsible for normal and abnormal human movement. Muscle function, posture, and gait; analysis techniques.

PMed 5255su. Clinical Education in Physical Therapy. (Cr ar; prereq regis in PT)

Supervised clinical practice at affiliated hospitals.

PMed 5260. Professional Issues in Physical Therapy. (2 cr; prereq regis in PT)

Professional issues; trends in healthcare.

PMed 5281. Theory of Therapeutic Exercise I. (4 cr; prereq regis in PT)

Principles of physiology, physics, and neurology as basis for therapeutic exercise. Response of tissue to treatment for loss of mobility and strength; cardiopulmonary treatment.

PMed 5282. Theory of Therapeutic Exercise II. (4 cr; prereq regis in PT)

Principles of neurodevelopment, neurophysiology, and neurology as basis for therapeutic intervention in motor dysfunction.

PMed 5283, 5284. Musculoskeletal Evaluation and Treatment II, III. (4 cr per qtr; prereq regis in PT)

Problem-solving approach to evaluation, treatment, and prevention of musculoskeletal conditions across the life span.

PMed 5287. Neurorehabilitation I. (4 cr, \$5270; prereq regis in PT)

Problem-solving approach to evaluation and rehabilitation of patients with neurological conditions. Treatment procedures, orthotics, and equipment to improve function and prevent or decrease impairments.

PMed 5288. Neurorehabilitation II. (4 cr; prereq regis in PT)

Problem-solving approach to evaluation and rehabilitation of patients with neurological conditions. Issues related to architectural barriers, community resources, sexuality, and bowel and bladder management.

PMed 5289. Patient Assessment. (4 cr; prereq regis in PT)

Problem-solving approach to assessment and rehabilitation of patients with vascular disease, amputations, cancer, immunological disorders, and general medical/surgical rehabilitation conditions. Use of prosthetic and orthotic devices.

PMed 5290. Administration. (3 cr; prereq regis in PT)  
Physical therapy administration and management. Field experience with physical therapy consultants, teaching practicum, individual student projects, and pilot research studies for illustrating role of physical therapist in education, research, and consultation with professional colleagues.

PMed 5291. Specialty Practice in Physical Therapy. (3 cr; prereq regis in PT)  
Theory and techniques related to specialized areas in physical therapy practice, including sports medicine, burn therapy, women's health, nutrition, wellness, prevention, and industrial rehabilitation.

PMed 5293. Introduction to Research Design. (3 cr; prereq 5292, regis in PT)  
Predictive research; elementary statistical concepts; analysis of scientific literature; research proposals.

PMed 5294. Independent Study in Physical Therapy. (Cr ar; prereq regis in PT or #)

PMed 5295. Clinical Education in Physical Therapy. (15 cr; prereq regis in PT)  
Supervised clinical practice at affiliated hospitals.

PMed 5340. Human Growth and Development. (4 cr; prereq regis in PT)  
Developmental process throughout the life span, including physical, social, cognitive, and personality development; how genetic and environmental factors may influence the process.

PMed 5810. Assessment of the Elderly. (3 cr; prereq #) Ellingham, Thompson  
Lecture and lab on developmental aspects of aging, with emphasis on assessment of physical and functional capacity.

PMed 5814. Physiological Assessment in Physical Therapy. (1-3 cr) Thompson  
Lecture and lab sessions on physiological assessment of, for example, endurance, strength, and coordination.

PMed 5817. Special Topics in Physical Therapy. (1-3 cr)  
Lecture and lab sessions on such topics as low back pain, neuromuscular and musculoskeletal disorders, cardiopulmonary disease, and developmental disorders.

PMed 5831. Cardiopulmonary Physical Therapy. (3 cr; prereq regis in PT)  
Theory and techniques of cardiopulmonary evaluation and treatment; principles of exercise response and adaptations to aerobic training.

PMed 5841. Instrumentation and Analysis Techniques. (3 cr; prereq Phys 1031, 1032 or equiv) Patterson

PMed 8103. Physical Therapy Clinic. (Cr and hrs ar; prereq physical therapist)  
Clinical physical therapy in adult and pediatric rehabilitation.

PMed 8130. Current Literature Seminar in Physical Therapy. (1 cr per qtr) DiFabio, Scudder  
Current literature in physical therapy and related medical fields.

PMed 8135. Advanced Kinesiology. (3 cr) DiFabio  
Functional anatomy emphasizing anatomical, physiological, and biomechanical aspects of normal and pathological human motion. Lecture with lab to include various techniques available for analysis.

PMed 8150. Research Methodology in Physical Therapy: Electromyography and Nerve Conduction. (3 cr) Allison

PMed 8170. Special Topics in Physical Therapy. (1 cr per qtr; prereq #)  
Advanced seminar. Topics vary quarterly. Prepared papers required.

PMed 8185. Problems in Physical Therapy. (Cr ar; prereq physical therapist)

PMed 8188. Teaching Practicum. (Cr ar [max 8 cr]; prereq #)  
Supervised experience in teaching and evaluation; development of skills in effective use of instructional materials in lecture and lab courses.

PMed 8192w. Research Design in Physical Therapy. (3 cr; prereq #) DiFabio  
Critical appraisal of current medical literature; fundamentals of research design and techniques of medical writing.

PMed 8193.\* Research Problems in Physical Therapy. (Cr ar; prereq 8192 or #) DiFabio  
Independent study using methods of research appropriate to physical therapy.

PMed 8195. Research in Physical Therapy. (Cr ar; prereq 8192 or #) DiFabio

CBN 5058. Anatomy of the Extremities. (6 cr; prereq 1004, regis in OT or PT)

Neur 5121. Descriptive Neurology. (2 cr; prereq regis in OT or PT)  
Central and peripheral nervous system. Correlation of neuroanatomy, neurophysiology, clinical neurology, and pathology of the nervous system.

## Physics (Phys)

*Professor:* Marvin L. Marshak, *head*; Robert L. Lysak, *director of graduate studies*; Benjamin F. Bayman; John H. Broadhurst; Charles E. Campbell; C. Barry Carter; Keith S. Champlin; James R. Chelikowsky; Hans W. J. Courant; E. Dan Dahlberg; Kris D. Davidson; Dietrich K. Dehnard; Paul J. Ellis; Stephen Gasiorowicz; Robert D. Gehrz; Clayton F. Giese; Leonid Glazman; Allen M. Goldman; J. W. Halley; Kenneth Heller; Russell K. Hobbie; Yutaka Hosotani; Cheng-cher Huang; Thomas W. Jones; Joseph I. Kapusta; Paul J. Kellogg; Konrad Mauersberger; Larry McLerran; Keith A. Olive; Robert O. Pepin; William T. Peria; Earl A. Peterson; Ronald A. Poling; Serge Rudaz; Keith Ruddick; Mikhail Shifman;

Boris Shklovskii; Roger H. Stuewer; Yau-Chien Tang; David D. Thomas; Arkady Vainshtein; Oriol T. Valls; Mikhail Voloshin; C. J. Waddington; Thomas F. Walsh; Walter V. Weyhmann; William Zimmermann, Jr.

*Associate Professor:* Cynthia Cattell; Priscilla B. Cushman; Roger S. Jones; James Kakalios; Yuichi Kubota; Erwin Marquit; Roger W. Rusack

*Assistant Professor:* Eric Ganz; John R. Wygant

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Research areas in experimental physics are cosmic rays, earth's atmosphere, elementary particles, low temperature, mass spectroscopy, molecular collisions, nuclei, plasmas, solar system, and solid state. Research areas in theoretical physics are elementary particles, low temperature, nuclei, plasma, solid state, and statistical mechanics.

**Prerequisites for Admission**—For major work, an undergraduate major in physics or a strong undergraduate minor in physics is required.

**Special Application Requirements**—Teaching assistantships and a few fellowships are available on application to the School of Physics and Astronomy; three letters of recommendation are required. Submission of Graduate Record Examination scores is strongly recommended. Fall quarter entry is strongly recommended for students who have not completed previous graduate study.

**Special Examination**—During the week before the beginning of fall quarter, new graduate students are expected to participate in the department orientation program. At the start of orientation, a placement examination in quantum mechanics is given to help students decide which level of quantum mechanics to take during the first year.

**Master's Degree Requirements**—For both Plan A and Plan B, either the classical physics sequence 5051-5052-5053 or the quantum mechanics sequence 5151-5152-5153 is required. The minor or related field requirement may be satisfied by completion of courses in one or two areas outside the area of specialization. Some or all of these courses may be in physics.

The Plan B project requirement can be satisfied in one of the following ways: (1) completion of one to three papers written in connection with three courses (totaling at least 9 credits, with at least two courses in physics or astronomy) that are part of the student's program; (2) completion of a project while registered in 8500; the student must obtain approval of the project topic from a faculty member before registering for the course, and a written report on the project is required. In either case, the papers or written report must be made available to the student's final examination committee, which must certify that the Plan B project has been satisfactorily completed. A final oral examination is required.

**Doctoral Degree Requirements**—The course sequences 5051-5052-5053, 5151-5152-5153, and a year-long (3-credit total) seminar sequence in the student's research area are required. For the minor or supporting field, see Master's Degree Requirements above.

The department written examination, offered twice each year early in fall and spring quarters, must be passed by fall quarter of the second year to gain admission to the preliminary oral examination.

**Language Requirements**—There is no formal language requirement for the master's or doctoral degree. In individual instances, however, the thesis adviser may require a reading knowledge of one or more foreign languages if justified by the nature of the research topic.

**Minor Requirements for Students Majoring in Other Fields**—For admission to a physics minor, differential and integral calculus and one year of calculus-level college physics are required. For the Ph.D. minor, 18 credits in physics are required including either of the two sequences in classical physics—5021-5022-5023-5024 or 5051-5052-5053—or one of the two sequences in quantum physics—5101-5102 or 5151-5152-5153.

**For Further Information and Applications**—Contact the Physics Program, School of Physics and Astronomy, University of Minnesota, 145 Tate Lab of Physics, 116 Church Street S.E., Minneapolis, MN 55455 (612/624-6366; fax 612/624-4578; e-mail grad@physics.spa.umn.edu; http://www.spa.umn.edu).

**Note**—For courses in astronomy and astrophysics, biophysics, and geophysics, see these sections of the bulletin.

Phys 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Phys 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Phys 8888. Thesis Credits: Doctoral. (36 cr required)

Phys 5021-5022. Introduction to Analytic Mechanics. (4 cr per qtr; prereq 3011, Math 3231 or equiv; 3 lect, 1 problem hrs per wk)  
Analytic course in Newtonian mechanics. Vectors and vector operators; angular momentum; central force problem; systems of particles; tensors; rigid bodies, moving coordinate systems; continuous media; Lagrange's equations. Mathematics beyond prerequisites is developed as required.

Phys 5023-5024. Introduction to Electric and Magnetic Fields. (4 cr per qtr; prereq 3011, Math 3231 or equiv; 3 lect, 1 problem hrs per wk)  
Classical theory of electric and magnetic fields making free use of vector algebra and vector calculus. Maxwell's equations for free space and material media. Wave solutions.

Phys 5031-5032-5033. Topics in Mathematical Physics. (4 cr per qtr; prereq two 5xxx math courses; 3 lect, 1 problem hrs per wk)  
Survey of mathematical techniques needed for physics. Application of mathematical methods to physical problems.

Phys 5051-5052-5053. Classical Physics. (4 cr per qtr; prereq 5022, 5024, advanced calculus or #; 3 lect, 1 problem hrs per wk)  
Classical mechanics, special relativity, and classical electrodynamics. Application of advanced mathematical techniques.

Phys 5061. Computational Methods in the Physical Sciences I. (4 cr, §Ast 5061; prereq CLA jr or sr or IT upper div or grad student or #; 2 lect, 6 lab hrs per wk)  
Introduction to problem solving in physical sciences using computer programs. Emphasis on selected numerical methods and general spirit of mapping onto computational algorithms. Arranged lab at scientific computer workstation.

Phys 5062. Computational Methods in the Physical Sciences II. (4 cr, §Ast 5062; prereq CLA jr or sr or IT upper div or grad student, Phys/Ast 5061 or #; 2 lect, 6 lab hrs per wk)  
Introduction to advanced techniques in computer simulation through examples from classical statistical mechanics, classical electrodynamics, and fluid dynamics. Computer experiments using graphics capabilities of SUN systems.

Phys 5101-5102. Introduction to Quantum Mechanics. (4 cr per qtr; prereq 3512; 3 lect, 1 problem hrs per wk)

Mathematical techniques of quantum mechanics. Wave packets; Schrödinger equation; angular momentum; radial equation; spin; perturbation theory; collision theory.

Phys 5121. Methods of Experimental Physics: I. (5 cr; prereq 3513 or #; knowledge of computer programming desirable; 3 lect, 4 lab hrs per wk)  
Contemporary techniques. Includes probability and errors, introduction to analog and digital electronics, experimental strategy, and introduction to computer-based data acquisition and experimental control.

Phys 5122. Methods of Experimental Physics: II. (4 cr; prereq 5121 or #; 2 lect, 6 lab hrs per wk)  
Contemporary techniques. Includes applications of Fourier transforms, signal averaging and phase-lock detectors, high vacuum techniques, magnet and charged particle beam design. Lab: problems involving the use of microcomputers for data acquisition and experimental control.

Phys 5123. Methods of Experimental Physics: III. (4 cr; prereq 5122 or #; 8 lab hrs per wk)  
Contemporary techniques. Lab: choice of experimental projects in low temperature, solid state, nuclear, elementary particle, and cosmic ray physics.

Phys 5124. Experimental Project. (Cr ar; prereq 5123, #)  
Research project in area of contemporary interest in physics. Project must be approved by faculty coordinator before registration.

Phys 5151-5152-5153. Quantum Mechanics. (4 cr per qtr; prereq 5102 or equiv, advanced calculus or #; 3 lect, 1 problem hrs per wk)  
Development from first principles. Schrödinger equation, angular momentum, scattering, matrix representations, spin, approximation methods, interaction with electromagnetic field, systems of identical particles, applications to atomic systems.

Phys 5162. Introduction to Plasma Physics. (4 cr; prereq 5022, 5024 or #; offered alt yrs)  
Magnetohydrodynamics and properties of collisionless plasmas, with applications to the magnetic field of the earth and sun and to plasma confinement. Transport phenomena and effects of collisions.

Phys 5201-5202. Thermal and Statistical Physics. (4 cr per qtr; prereq 3513 or equiv; 4 lect hrs per wk)  
5201: Thermodynamics, statistical mechanics.  
5202: Applications of thermodynamics and statistical mechanics, kinetic theory, fluctuations, transport theory.

Phys 5211. Introductory Solid State Physics. (4 cr; prereq 5101, 5202 or equiv; 4 lect hrs per wk)  
Diffraction of waves in solids; electron band structure; crystal binding and vibrations; optical, dielectric, and magnetic properties of solids.

## GRADUATE PROGRAMS

Phys 5231-5232-5233. Introduction to Solid-State Physics. (4 cr per qtr; for grad students or advanced undergrads in physics, science, and engineering; 4 lect hrs per wk)

5231: Crystal structure and binding; diffraction; phonons; thermal and dielectric properties of insulators. 5232: Free electron model; band structure; semiconductors; diamagnetism and paramagnetism; ferromagnetism and antiferromagnetism. 5233: Optical phenomena, lasers; superconductivity; surface properties; ferroelectricity.

Phys 5301. Introduction to Nuclear Physics. (4 cr; prereq 5102 or equiv; 3 lect, 1 problem hrs per wk)  
Static properties and dynamic processes of atomic nuclei. Provides survey of field for nonspecialists and a first course for those intending to specialize in nuclear physics.

Phys 5371. Introduction to Elementary Particle Physics. (4 cr; prereq 5102 or equiv; 3 lect, 1 problem hrs per wk)

Relativistic kinematics; mass, spin, isopin, and strangeness of elementary particles; SU3 classification and the quark model; particle reactions and decays; experimental methods of detection and analysis.

Phys 5401. Introduction to Contemporary Problems in Cosmic Ray and Space Physics. (4 cr; primarily for students specializing in other branches of physics; prereq #; offered alt yrs)  
Cosmic rays, their characteristics and their motion in the interplanetary and interstellar medium. Topics in X-ray and radio astronomy.

Phys 5422. Introduction to Magnetospheric Physics. (3 cr; prereq 5022, 5024 or equiv)  
Interaction of magnetospheric physics with solar wind; single particle motions, radiation belts, and plasma convection; magnetic structure and currents; collective behavior, magnetohydrodynamic description of plasmas; discontinuities, boundary layers, and shocks; plasma waves and instabilities.

Phys 5461. Physics and Chemistry of the Earth's Upper Atmosphere. (4 cr; prereq general physics, calculus; offered alt yrs)  
Survey of atmosphere above 15 km; physics and chemistry of the stratosphere, mesosphere, and thermosphere; temperature and density profiles; major and minor constituents and their distributions; aspects of pollutants; reactions and rates; global variation of constituents; the energy budget of the atmosphere.

Phys 5551. Topics in Physics for Biology and Medicine: Mechanics and Molecular Physics. (5 cr; prereq general physics and calculus; offered alt yrs)  
Statics (forces in bones and joints). Graphical analysis. Statistical physics (entropy, reversibility, Boltzmann factor and Nernst equation, Brownian movement, free energy). Diffusion, bulk flow, and osmosis.

Phys 5552. Topics in Physics for Biology and Medicine: Electricity and Signals. (5 cr; prereq general physics and calculus; offered alt yrs)  
Electricity and circuits (electrocardiogram, networks, nerve conduction); transducers and amplifiers; oscillators; feedback and control; signal analysis (Fourier analysis, correlation functions, power spectra).

Phys 5553. Topics in Physics for Biology and Medicine: Light, Atoms, and Nuclei. (5 cr; prereq general physics and calculus; offered alt yrs)  
Atoms (dispersion, absorption, spectra, polarized light). X-rays (production, absorption, dosimetry). Nuclei (nuclear size, mass, decay).

Phys 5801. Modern Optics. (4 cr; prereq 5024 or #; 4 lect hrs per wk; offered alt yrs)  
Modern theoretical and experimental optics, broadly defined to include, for example, radio astronomy, matrix methods in geometrical optics including charged particle optics, optical detectors and noise, and phenomena in intense coherent radiation including nonlinear effects.

Phys 5805. Contemporary Optics. (4 cr; prereq #; 3 lect, 1 problem hrs per wk)  
Current developments in optics. Theory of lasers and of their application in holography, nonlinear optics, etc. Nonlinear optics. Optics of anisotropic media. Theory of image formation and spatial filtering. Properties of optical detectors.

Phys 5911. Concepts in Physics. (4 cr [no cr for physics majors]; prereq 3511, 3512, 3513, 3515 or equiv; 3 lect, 2 lab hrs per wk; offered alt yrs)  
Intermediate-level conceptual physics, primarily for science education majors. Conservation laws, basic interactions, models of matter, particles and waves, fields, reference frames, modern physics. Emphasis on physical phenomena, thematic development, physical reasoning, and unifying principles.

Phys 5924. History of 19th-Century Physics. (4 cr, \$HSci 5924; prereq general physics or #)  
Conceptual developments in physics in the 19th century (Young, Fresnel, Oersted, Ampère, Faraday, MacCullagh, Maxwell, Hertz, Lorentz, Lavoisier, Rumford, Dalton, Mayer, Joule, Helmholtz, Carnot, Clausius, Kelvin, Boltzmann, Mach, others). Relationships of these developments to social, philosophical, and theological influences.

Phys 5925. History of 20th-Century Physics. (4 cr, \$HSci 5925; prereq general physics or #)  
Conceptual developments in relativity (Michelson, Lorentz, Poincaré, Einstein, others), quantum mechanics (Planck, Einstein, Rutherford, Bohr, Sommerfeld, Ehrenfest, Pauli, Millikan, Compton, Heisenberg, de Broglie, Schrödinger, Born, others), and nuclear physics (Chadwick, Gamow, Fermi, others). Relationships of these developments to social, philosophical, and theological influences.

Phys 5940. Physics for High School Teachers: Experimental Foundations. (3-4 cr [may be repeated for cr]; no grad major or minor cr in physics; prereq general physics, #; 3 integrated lect-lab hrs per wk)  
Conceptual theme in physics and its experimental foundations. Typical themes are kinematics and dynamics from Aristotle through Einstein; nature of charge; nature of light; energy and thermodynamics; electricity, magnetism, and quantized fields; structure of matter.

Phys 5950. Seminar. (Cr ar; primarily for sr physics majors; prereq  $\Delta$ )

Phys 5970. Directed Studies. (1-5 cr; prereq #,  $\Delta$ ) Independent, directed study in areas arranged by student and faculty member.

Phys 5980. Research Seminar. (1 cr; primarily for beginning grads and advanced undergrad physics majors; 1 sem hr per wk) Introduction to research activities of School of Physics and Astronomy.

Phys 5990. Directed Research. (Cr ar; prereq jr,  $\Delta$ ) Problems, either experimental or theoretical, of special interest to student. Written reports.

*Special prerequisites are noted for certain courses below. Seminar, special topics, and research courses may be taken more than once for credit.*

Phys 8081-8082. General Relativity. (3 cr per qtr; prereq 5053 or #; offered alt yrs) Introduction to the physical basis of general relativity, its mathematical formulation, and its cosmological implications.

Phys 8083. Cosmology and Particle Physics. (3 cr; prereq 5371, 8082 or #; offered alt yrs) Construction of cosmological models directly from general relativity. Standard big-bang model; connection between early universe and particle physics. Big-bang nucleosynthesis, baryogenesis, inflation, and dark matter.

Phys 8121. Advanced Quantum Mechanics. (3 cr; prereq 5153 or #) Advanced topics in nonrelativistic quantum mechanics, with emphasis on the use of second quantization to treat many-body and radiating systems. Diagrammatic and Green's function techniques introduced.

Phys 8122. Relativistic Quantum Mechanics. (3 cr; prereq 8121 or #) Relativistic wave equations and their properties under Lorentz transformations. Application of relativistic perturbation theory to particle interactions with the electromagnetic field. Invariant interactions of elementary particles.

Phys 8123. Relativistic Quantum Field Theory. (3 cr; prereq 8122 or #) Renormalization theory, analytic properties of amplitudes, reduction formulas and dispersion relations.

Phys 8131. Symmetry and Its Applications to Physical Problems. (4 cr; prereq 5153 or #) Use of symmetry methods (group theory) to study systems too complicated for exact solution. Applications to atomic, molecular, nuclear, solid-state, and elementary particle physics.

Phys 8161. Atomic and Molecular Structure. (3 cr; prereq 5153 or #; offered when feasible)

Phys 8163-8164. Plasma Physics. (3 cr per qtr; prereq 5162; offered alt yrs) Study of properties of plasmas at an advanced theoretical level. Transport phenomena, radiation from plasma, thermonuclear machines and their instabilities, and waves in magnetized plasma.

Phys 8165. Advanced Topics in Plasma Physics. (Cr ar) Possible topics: theory of waves and instabilities in hot plasma.

Phys 8200. Seminar: Condensed Matter Physics. (Cr ar; prereq #; S-N only)

Phys 8211. Equilibrium Statistical Mechanics. (3 cr; prereq 5153 or #) Equilibrium properties of macroscopic classical and quantum systems. Simple interacting systems, phase transitions, and effects of external fields.

Phys 8212. Transport Theory. (3 cr; prereq 5153 or #) Transport and relaxation phenomena in classical and quantum systems. Irreversible thermodynamics, Boltzmann equation, and linear response theory.

Phys 8216. Many-Body Theory. (3 cr; prereq 8121 or #) Infinite systems of bosons and fermions using Hartee and Hartee-Fock approximations; diagrammatic techniques and Green's function methods.

Phys 8221-8222-8223. Solid-State Physics. (3 cr per qtr; prereq ¶5152-5153, 5211 or #) Fundamental properties of crystals; dynamics of the lattice and of electrons in a periodic structure. Effects of electric and magnetic fields on metals.

Phys 8233. Superconductivity. (3 cr; prereq #; offered when feasible)

Phys 8300. Seminar: Nuclear Physics. (Cr ar; prereq #; S-N only)

Phys 8311. Nuclear Structure. (3 cr; prereq 5151 or ¶5151) Low energy nucleon-nucleon interaction. Phenomenological and microscopic models of ground and excited states, including single particle and collective degrees of freedom.

Phys 8312. Nuclear Reactions. (3 cr; prereq 5152 or ¶5152) Nuclear reaction mechanisms and use of reactions to obtain information about nuclear structure and nuclear matter.

Phys 8313. Relativistic Nuclear Many-Body Theory. (3 cr; prereq 8122 or #) Relativistic field theory applied to many-body problem. Nuclear matter, quark-gluon plasma, symmetry restoration at high temperature; applications to neutron stars and early universe.

Phys 8370. Seminar: Elementary Particle Physics. (Cr ar; prereq #; S-N only)

Phys 8371-8372-8373. Elementary Particle Physics. (3 cr per qtr; prereq 8122 or #)  
Accelerators, particle detectors, and particle interactions in matter; basics of scattering and quark model; techniques and Feynman diagram calculation for electroweak interactions and chromodynamics; grand unification.

Phys 8381-8382-8383. Modern Quantum Field Theory and Its Applications. (3 cr; prereq 8123 or #; offered alt yrs)  
Review of general properties of field theory, renormalization of interacting scalar field theory, global and local symmetries, path integrals and functional formalism, quantization of non-Abelian gauge theories (quantum chromodynamics, Weinberg-Salam model, grand unified theories), renormalization group in particle physics and critical phenomena, lattice gauge theory.

Phys 8400. Seminar: Space Physics. (Cr ar; prereq #; S-N only)

Phys 8411. Cosmic Ray and Space Physics. (3 cr; prereq 5102, 5053 or #; offered alt yrs)  
Properties of energetic particles in both solar-terrestrial and astrophysical environments. The earth's radiation belts, effects of the earth's magnetic field on charged particles, energy and charge spectrum of cosmic rays, the structure and evolution of the galaxy, motion of particles in the galactic and intergalactic medium, and topics in X-ray and radio astronomy.

Phys 8421. Solar and Magnetospheric Physics. (3 cr; prereq #; offered alt yrs)  
Solar surface physics including photosphere, chromosphere, and corona; spectroscopic observations and their interpretation; solar active regions, sunspots, plagues; associated magnetic fields, optical, radio, and particle effects and the solar wind; the terrestrial magnetic field and trapped radiation, auroral phenomena, and geomagnetic storms.

Phys 8500. Plan B Project. (4 cr [no cr toward PhD]; prereq #; S-N only)  
May be taken once to satisfy project requirement for Plan B master's program. May appear on master's program but does not count toward 20-credit minimum in major field. Project topic to be arranged between student and instructor. Written report required.

Phys 8950. Seminar: Problems of Physics Teaching and Higher Education. (Cr ar; prereq #)  
Lectures and informal discussions of courses and curricula, techniques, and materials important in undergraduate physics instruction; relation to general problems of higher education.

Phys 8990. Research in Physics. (Cr ar; prereq #)

## Physiology

See Cellular and Integrative Physiology.

## Planning

See Public Affairs.

## Plant Biological Sciences (PBio)

*Regents' Professor:* Eville Gorham (ecology, evolution, and behavior); Ronald L. Phillips (agronomy and plant genetics)

*Professor:* Susan M. Wick (plant biology), *director of graduate studies;* Robert M. Brambl (plant biology); Mark L. Brenner (horticultural science); William R. Bushnell (plant pathology); John V. Carter (horticultural science); Edward J. Cushing (ecology, evolution, and behavior); John F. Doebley (plant biology); Gary M. Gardner (horticultural science); Burle G. Gengenbach (agronomy and plant genetics); Florence K. Gleason (plant biology); Peter H. Graham (soil, water, and climate); John W. Gronwald (agronomy and plant genetics); Wesley P. Hackett (horticultural science); Robert J. Jones (agronomy and plant genetics); Willard L. Koukkari (plant biology); Sagar V. Krupa (plant pathology); Paul H. Li (horticultural science); Albert H. Markhart (horticultural science); David J. McLaughlin (plant biology); Chester J. Mirocha (plant pathology); James A. Perry (forest resources); Peter B. Reich (forest resources); Irwin Rubenstein (plant biology); Michael J. Sadowsky (soil, water, and climate); Carolyn D. Silflow (genetics and cell biology); Steve R. Simmons (agronomy and plant genetics); D. Peter Snustad (genetics and cell biology); David A. Somers (agronomy and plant genetics); Joseph R. Sowokinos (horticultural science); Edward I. Sucoff (forest resources); Carroll P. Vance (agronomy and plant genetics); Clifford M. Wetmore (plant biology); Donald L. Wyse (agronomy and plant genetics)

*Associate Professor:* Deborah L. Allan (soil, water, and climate); Judith G. Berman (plant biology); David D. Biesboer (plant biology); Iris D. Charvat (plant biology); Glenn R. Furnier (forest resources); J. Stephen Gantt (plant biology); M. David Marks (genetics and cell biology); Neil E. Olszewski (plant biology); Ruth G. Shaw (ecology, evolution, and behavior); Alan G. Smith (horticultural science); Thomas K. Soulen (plant biology); Nevin D. Young (plant pathology)

*Assistant Professor:* Georgiana May (plant biology); Shahid Naem (ecology, evolution, and behavior); Cindy B. Tong (horticultural science)

*Adjunct Assistant Professor:* Paula M. Pijut (North Central Forest Experiment Station); Les J. Szabo (plant pathology)

*Research Associate:* Anita F. Cholewa (plant biology)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Plant biological sciences encompasses all aspects of the basic biology of both higher and lower plants. Major emphases include molecular and physiological approaches to development; physiological, structural, and functional studies at the cellular and organismal levels; systematic and evolutionary biology; and molecular genetics and applied biotechnology. Program faculty reside in eight plant-oriented departments in the Colleges of Agricultural, Food, and Environmental Sciences; Biological Sciences; and Natural Resources. Students in the program have the opportunity to study plants from the subcellular and molecular to the whole plant and community levels of biological organization. Opportunities also exist for laboratory and field research at state, national, and international levels. Each student's program is planned to meet individual requirements within the framework of a multidisciplinary core of coursework. Seminars are an integral part of the program.

**Prerequisites for Admission**—Prospective students are expected to have completed a year of coursework in at least three of the following four areas: differential and integral calculus, organic and inorganic chemistry, biology, and physics. For students of demonstrated ability, background deficiencies, as determined by the admissions committee, can be made up during the first year of graduate studies. All admitted students are assigned to an adviser in the graduate program before they begin their studies.

**Special Application Requirements**—Applicants must submit scores from the General Test of the Graduate Record Examination, three letters of recommendation from persons familiar with their scholarship and research potential, a complete set of official transcripts, and a clearly written statement of career interests, goals, and objectives. Students may apply at any time; however, submission of all application materials by January 15 is strongly encouraged to ensure priority consideration for fellowships and teaching and research assistantships awarded for the next academic year. Students can be admitted any quarter.

**Master's Degree Requirements**—Course programs are planned by the student in consultation with an advisory committee. Students are expected to take a minimum of six courses, including one course from each of four

discipline areas (cell and molecular biology; plant physiology; plant structure, diversity, and development; ecology, systematics, and evolution) and two or more courses from the primary area of specialization. As required by the Graduate School, the student must finish at least 20 credits in the major field and 8 credits in one or more related fields with a minimum GPA of 2.80. A thesis proposal and seminar are required.

**Doctoral Degree Requirements**—Specific course requirements are the same as for the master's degree with additional coursework to be approved by the student's advisory committee. All Ph.D. students are required to develop their teaching skills by participating in a teacher training program and then serving as a teaching assistant for two quarters. A dissertation proposal and two non-credit seminars are required of all Ph.D. students.

**Language Requirements**—None, except as specified by a faculty adviser in consultation with the student.

**For Further Information and Applications**—Contact the Director of Graduate Studies, Graduate Program in Plant Biological Sciences, University of Minnesota, 220 Biological Sciences Center, 1445 Gortner Avenue, St. Paul, MN 55108 (612/625-1234; fax 612/625-1738).

PBio 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

PBio 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

PBio 8888. Thesis Credits: Doctoral. (36 cr required)

PBio 5001. Basic Botany. (Cr ar, \$Bot 5001; prereq Biol 1008 or Biol 1009, #, Δ)  
For beginning graduate students who need to strengthen their botanical background.

PBio 5103f.\* Algae, Fungi, and Bryophytes. (5 cr, \$Bot 5103; prereq Biol 1103 or Biol 3012; offered alt yrs) McLaughlin  
Characteristics of groups, evolutionary relationships, life cycles, comparative morphology (including ultrastructure), comparative nutrition. Lab emphasizes living organisms and isolation of algae and fungi into culture.

PBio 5105w.\* Morphology of Vascular Plants. (5 cr; prereq Biol 1103 or Biol 3012 or #; offered alt yrs) May  
Examined from evolutionary perspective; vegetative and reproductive structures; life cycles. Extinct ancestors of vascular plants, ferns and lower plants, gymnosperms and angiosperms (flowering plants).

## GRADUATE PROGRAMS

PBIO 5107s. Mycology: Basidiomycetes. (4 cr; prereq PIPa 5105 or equiv or intro microbiol or 5103 or #: offered alt yrs) May, McLaughlin

Ecology, evolutionary relationships, systematics (taxonomy and nomenclature), morphology (including ultrastructure and life cycles of basidiomycetes). Labs parallel lectures, with living and preserved representatives of Uredinales, Auriculariales, Septobasidiales, Exobasidiales, Sporobolomycetales, Ustilaginales, Tilletiales, Tremellales, Dacrymycetales, Tulasnellales, Aphyllophorales, Agaricales, and Gasteromycetes.

PBIO 5109w. Molecular Genetics and Biochemistry of Yeasts and Filamentous Fungi. (4 cr, \$PIPa 5109; prereq one course each in genetics and biochem or #: offered alt yrs) Berman, Brambl  
Chromosome structure and function, regulation of nuclear gene expression, mitochondrial gene organization and expression, membrane and organelle biogenesis, cell cycle regulation, morphogenesis, mating and reproduction, recombination and gene switching, spore formation and germination, viruses, plasmids, and toxins.

PBIO 5111w.\* Plant Cell, Tissue, and Organ Development. (5 cr, \$Bot 5111; prereq Biol 1103 or Biol 3012; offered alt yrs) Biesboer  
Microscopic structure of vascular plants; development in root, stem, and leaf.

PBIO 5131f,s. Survey of Plant Physiology. (4 cr, \$3131; prereq BioC 3021 or BioC 5331 or Biol 5001, Biol 1103 or Biol 3012 or Biol 3812) Gantt, Gleason, Olszewski, Soulen  
Physiological principles underlying processes that occur in living plants, with emphasis on higher plants. Growth and development, mineral nutrition, transport, water relations, and metabolism, emphasizing photosynthesis and nitrogen assimilation. Weekly discussion section.

PBIO 5132f. Plant Physiology Laboratory. (2 cr; prereq 3131 or 5131 or \$3131 or \$5131)  
Lab to accompany PBIO 3131 or PBIO 5131.

PBIO 5141f. Plant Cell Biology. (4 cr, \$Bot 5141; prereq Biol 5004 or equiv; offered alt yrs) Wick  
Structural, functional, developmental, and biochemical aspects of cellular components and processes specific to plants. Cell walls, dictyosome activity, plastids, plant cytoskeleton, modes of plant cytokinesis, cell-cell communication, lectins and cell recognition, vacuoles, cytoplasmic streaming.

PBIO 5182s.\* Plant Metabolism. (3 cr; prereq 5131 or equiv, course in biochem) Soulen  
Plant metabolism including photosynthesis, respiration, and synthesis of macromolecules. Structure-function relations at the plant, cell, and subcellular level. Energy flow in the plant system and regulation of plant metabolism.

PBIO 5183w. Water, Minerals, and Translocation. (4 cr; prereq 5131 or equiv) Allan, Markhart  
Membrane phenomena and osmotic properties of cells. Uptake, movement, and loss of water in plants, including the effects of external factors. Translocation of organic substances. Absorption, distribution, and function of inorganic elements.

PBIO 5184f. Plant Growth and Development. (3 cr; prereq 3131 or 5131 or equiv) Olszewski, Smith  
Survey of plant growth and development ranging from germination to death, with emphasis on physiology, biochemistry, and molecular biology. Major topics include developmental processes related to: mobilization of macromolecules during germination; cell division and cell extension during axis growth; photomorphogenesis, chloroplast and microbody ontogeny; flowering, fruit and seed formation, senescence; and how plant growth substances control these developmental events.

PBIO 5186w. Topics in Plant Biochemistry. (3 cr; prereq BioC 5331 or Biol 5001; offered alt yrs) Gleason  
Biochemical processes unique to plants, with emphasis on structures of macromolecules involved and their reactions and regulation. Major topics: light reaction of photosynthesis, secondary metabolism, and carbohydrates. Minor topics: carbon dioxide fixation and nitrogen fixation.

PBIO 5203w. Herbarium Techniques. (1 cr; prereq 1009 or 3201 or equiv) Cholewa  
Hands-on approach to museum curating procedures in the herbarium. Students are exposed to all aspects of herbarium management and assist with some curating of plant specimens.

PBIO 5221w. Plant Molecular Evolution. (3 cr; prereq Biol 5003 or GCB 3022; offered alt yrs) Doebley, May  
Application of molecular genetics to study of evolution. Phylogenetic reconstruction, chromosomal evolution, multigene families, molecular aspects of morphological changes, role of transposons in evolution, DNA sequence evolution, and measures of genetic diversity.

PBIO 5231f. Introduction to the Algae. (5 cr, \$Bot 5231; prereq 10 cr botany or biology or #: offered alt yrs) McLaughlin  
Structure, reproduction, and life histories of major algal divisions.

PBIO 5801su. Plains and Boreal Flora. (5 cr, \$Bot 5801; prereq taxonomy course, Δ; offered when feasible in Lake Itasca Biology Session)

PBIO 5890su. Research Problems. (1-5 cr, \$Bot 5890; prereq Δ; offered in Lake Itasca Biology Session)  
Individual research for undergraduates and graduates.

PBIO 5960f,w,s.\* Special Topics. (Cr ar; prereq #, Δ)  
Treatment in depth of a specialized botanical topic.

PBIO 5970f,w,s,su. Directed Studies. (Cr ar, \$Bot 5970; prereq #, Δ)  
Individual study of selected topics or problems with emphasis on selected readings and use of scientific literature.

PBIO 5990f,w,s,su. Directed Research. (Cr ar, \$Bot 5990; prereq #, Δ)  
Lab or field investigation of selected areas of research.

PBIO 8287s. Plant Molecular Biology. (3 cr, \$Bot 8287; prereq BioC 5753 or GCB 5034; offered alt yrs) Gantt, Olszewski

Gene expression and regulation, gene structure, gene transfer in higher plants.

PBIO 8301w.\* Pollen Morphology and Quaternary Palynology. (3-5 cr, \$Bot 8301; prereq plant taxonomy or #) Cushing

Morphology and nomenclature of pollen grains and peridophyte spores, survey of pollen and spores of major plant families, lab techniques. Research topics in pollen analysis of Quaternary sediments and pollen morphology.

PBIO 8910. Journal Club. (1 cr; prereq  $\Delta$ )  
Critical evaluation of selected current literature.

PBIO 8950f,w,s. Seminar. (1 cr, \$Bot 8950; prereq #)

PBIO 8990f,w,s,su.\* Research Problems.  
(Cr ar, \$Bot 8990; prereq #,  $\Delta$ )

## Other Acceptable Courses

Certain courses from other University departments and colleges that are listed in this bulletin are acceptable as part of a major in plant biological sciences. The following are examples of acceptable courses:

Agro 8050. Physiology of Field Crops

Agro 8230. Cytogenetics

Biol 5125. Recombinant DNA Laboratory

EEB 5014. Ecology of Vegetation

FR 8101. Research Problems: Forest-Tree Physiology

GCB 8148, 8149. Advanced Cell Biology I-II

Hort 8045. Plant Response to Environmental Stress

MicB 5321. Physiology of Bacteria

PIPa 5206. Biology of Fungi

Soil 5241. Microclimatology

## Plant Breeding

*Professor:* Peter D. Ascher; David W. Davis (*emeritus*); Burle G. Gengenbach; Florian I. Lauer (*emeritus*); Carl A. Mohn; James H. Orf; Ronald L. Phillips; Donald C. Rasmusson; David A. Somers; Robert E. Stucker; Deon D. Stuthman

*Adjunct Professor:* Robert H. Busch; Howard W. Rines

*Associate Professor:* Nancy J. Ehлке, *director of graduate studies*; John Doebley; James J. Luby; Mark S. Strefeler; Nevin D. Young

*Adjunct Assistant Professor:* JoAnn F. Lamb

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Graduate study in plant breeding is available through the Department of Agronomy and Plant Genetics and the Department of Horticultural Science. Students may emphasize applied breeding or more basic aspects of plant breeding and genetics, including biotechnology. The program is intended for qualified students who wish to prepare for research and teaching positions in universities, government agencies, private industry, and international agricultural agencies.

A wide range of courses in plant breeding and genetics is offered. In addition, courses are available in several disciplines related to plant breeding and plant genetics. The course list below emphasizes breeding, genetics, cytogenetics, and molecular, physiological, and population genetics. For additional courses that may be included in a plant breeding major, see the agronomy, genetics, and horticulture sections of this bulletin.

**Prerequisites for Admission**—Applicants should have completed the bachelor's degree in agriculture or a related field and have a good background in biological and other sciences. Students with an inadequate background are asked to make up deficiencies before starting the graduate program.

**Special Application Requirements**—Three letters of recommendation and a statement outlining career goals and experience are required. Graduate Record Examination scores are strongly encouraged. Information about graduate assistantships is available from either of the two departments administering the program. Students are admitted in any quarter.

### Master's and Doctoral Degree

**Requirements**—Information about the M.S. and Ph.D. programs is available from either of the two departments administering the program.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Department of Agronomy and Plant Genetics, University of Minnesota, 411 Borlaug Hall, 1991 Upper Buford Circle, St. Paul, MN 55108 (612/625-7773); or the Department of Horticultural Science, University of Minnesota, 305 Alderman Hall, 1970 Folwell Avenue, St. Paul, MN 55108 (612/624-5300).

*Note*—For descriptions of courses, consult the course listings of the respective departments.

PIBr 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

PIBr 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

PIBr 8888. Thesis Credits: Doctoral. (36 cr required)

Agro 5020w. Introduction to Plant Breeding. (4 cr; prereq GCB 3022 or Hort 3003 or equiv) Orf

Agro 5310su,f. Orientation to Field Crop Breeding. (1 cr; prereq 5020 or #) Stuthman

Agro 8200f. Plant Breeding Principles and Methods I. (3 cr; prereq 5020, Stat 5301 or equiv) Rasmusson

Agro 8210s. Plant Breeding Principles and Methods II. (3 cr; prereq 8200, Stat 5301, GCB 5042)

Agro 8220f. Application of Quantitative Genetics to Plant Breeding. (3 cr; prereq 8210, 8260, GCB 5042 or #) Ehлке

Agro 8230f. Cytogenetics. (4 cr; prereq GCB 5034 or #; 3 lect, 2 lab hrs per wk) Phillips

Agro 8240w. Cellular and Molecular Genetics of Plant Improvement. (3 cr; prereq GCB 5034) Gengenbach, Somers

Agro 8250s. Advanced Plant Genetics. (2 cr; prereq 8240 or GCB 8131; offered alt yrs) Gengenbach, Somers

Agro 8270f,w. Seminar: Plant Breeding. (1 cr)

Agro 8280s. Current Topics in Plant Breeding. (2 cr; prereq 8210 or #) Stuthman

Agro 8330f,w,s,su. Research in Plant Genetics. (Cr ar)

Agro 8340f,w,s,su. Directed Studies for Thesis Research. (Cr ar; prereq PhD student in agro or in plant breeding or #; S-N only)

Biol 5003f,w,s. Genetics. (4 cr, §GCB 3022, §GCB 5022; prereq 5001 or BioC 3021 or BioC 5331)

FR 5152.\* Forest Genetics. (3 cr; prereq Biol 1103, Stat 3011) Mohn

GCB 5034w. Intermediate Molecular Genetics. (4 cr; prereq Biol 5003, 5004, advanced bioscience undergrad or non-bioscience grad student) Shaw

GCB 8131w. Advanced Genetics I. (4 cr, §5031; prereq 3022 or Biol 5003, Biol 5001 or BioC 5751 or #) Lefebvre

GCB 8132f. Advanced Genetics II. (4 cr, §5032) Hackett

Hort 8022w. Breeding Asexually Propagated Crops. (3 cr; prereq Agro 5020; offered alt yrs)

Hort 8023f.\* Evolution of Crop Plants. (3 cr) Ascher

Hort 8063f.\* Seminar: Discussions in Horticultural Plant Breeding. (1 cr; prereq #) Luby  
Stat 5301. Designing Experiments. (5 cr, §5163; prereq 3012 or 5021 or 5133 or 5153 or #)

## Plant Pathology (PIPA)

*Professor:* Neil A. Anderson, *head*; Sagar V. Krupa, *director of graduate studies*; Ernest E. Bantari; Robert A. Blanchette; Robert M. Brambl; William R. Bushnell; James V. Groth; Philip O. Larsen; Kurt J. Leonard; Benham E. L. Lockhart; David H. MacDonald; Richard A. Meronuck; Chester J. Mirocha; Robert F. Nyvall; James A. Percich; Francis L. Pfleger; Ward C. Stienstra; Richard J. Zeyen

*Associate Professor:* Roger K. Jones; Linda L. Kinkel; Donald V. McVey; Carol E. Windels; Nevin D. Young

*Assistant Professor:* Ruth Dill-Macky; Deborah A. Samac; Les J. Szabo

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Plant pathology interfaces with all plant science disciplines and with food sciences and veterinary medicine. Areas of concentration include biological control of plant disease, forest pathology and microbial degradation of wood, microbial ecology, mycotoxicology, physiological and molecular plant-microbe interactions, disease resistance, environmental pollution and climate change, and virology. The course of study varies with the requirements of the area of concentration and interests of the student.

**Prerequisites for Admission**—Master's degree applicants must have a sound college background in the basic biological and physical sciences and mathematics, including 35 quarter credits in biology with at least one course in each of the following areas: botany, zoology, genetics, plant physiology, and microbiology. Applicants must also have completed at least one course in inorganic chemistry, organic chemistry, biochemistry, and physics. If deficiencies exist in the prerequisites, they must be corrected during the first year of the graduate program. All students accepted into the department with a B.S. degree are admitted into the M.S. degree program. After a minimum of two quarters, students who qualify

may elect to change their degree status to a Ph.D. program. Criteria for the change includes scholastic standing, potential for success in completing a Ph.D., and writing competency. Such a change in status must be approved by the appropriate departmental committees and the director of graduate studies. Ph.D. applicants must satisfy all the prerequisites for the master's degree program in plant pathology or have a master's degree in plant pathology or in a field of natural science.

**Special Application Requirements—**Graduate Record Examination scores are required for all students and TOEFL scores are required for international students. A statement of objectives and three letters of recommendation are required of all students and must be submitted to the department.

**Master's Degree Requirements—**Students must take or have taken the equivalent of PIPa 5201 and 5202. Students are also required to take PIPa 5204 and one quarter of PIPa 8201. Remaining coursework is determined by the student's graduate advisory committee and the director of graduate studies according to general Graduate School requirements. The final examination for coursework and thesis defense is oral.

**Doctoral Degree Requirements—**Students must take three quarters (6 credits) of PIPa 8200 and two quarters of PIPa 8201. Students entering the doctoral program without having taken the equivalent of PIPa 5201, 5202, and 5204 are required to take these courses. The written comprehensive examination, which covers the major and related field(s), is administered each January. Thesis defense involves a research seminar followed by an oral examination.

**Language Requirements—**A foreign language is usually not required for either the M.S. or the Ph.D. degree. Knowledge of a foreign language may be necessary, however, for students doing research in certain geographic areas outside the English-speaking countries.

**Minor Requirements for Students Majoring in Other Fields—**For M.S. students, 9 credits are required. For Ph.D. students, 18 credits are required. The graduate student develops a comprehensive program in consultation with the student's academic adviser and the director of graduate studies in plant pathology.

### **For Further Information and Applications—**

Contact the Department of Plant Pathology, University of Minnesota, 495 Borlaug Hall, 1991 Buford Circle, St. Paul, MN 55108 (612/625-8200; e-mail [anna@pucini.crl.umn.edu](mailto:anna@pucini.crl.umn.edu); <http://www.plpa.agri.umn.edu>).

PIPa 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

PIPa 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

PIPa 8888. Thesis Credits: Doctoral. (36 cr required)

PIPa 5090. Issues in Plant Pathology. (Cr ar; prereq grad student or #)

Seminars, discussion, and workshops. Consult *Class Schedule* or department for current offerings.

PIPa 5109w. Molecular Genetics and Biochemistry of Yeasts and Filamentous Fungi. (4 cr, \$PIPa 5109; prereq one course each in genetics and biochem or #; offered alt yrs) Berman, Brambl

Chromosome structure and function, regulation of nuclear gene expression, mitochondrial gene organization and expression, membrane and organelle biogenesis, cell cycle regulation, morphogenesis, mating and reproduction, recombination and gene switching, spore formation and germination, viruses, plasmids, and toxins.

PIPa 5102su. Ecology of Fungi. (3 cr; prereq 5 cr botany or #)

Ecological studies and identification of fungi. Fungal symbioses, morphology, coevolution, and applicable ecological theory. Student teams determine species richness in aquatic, grassland, and forest habitats.

PIPa 5201f. Biology of Plant Diseases. (5 cr; prereq Biol 3012 or equiv) Percich  
Interaction of pathogens with plants; epidemiology and control measures appropriate to plant disease. Lab stressing plant pathogen isolation, culture inoculation, and recovery from infected plants; pathogenesis and plant defense mechanisms.

PIPa 5203s. Physiological and Molecular Plant-Microbe Interactions. (3 cr; prereq intro course in biochem or plant physiology or #) Young, Zeyen

Genetics, physiology, and molecular biology of plant-microbe interactions. Communication between plants and microbes, signal transduction, control of gene expression, symbiosis and parasitism, plant host response mechanisms, plant disease physiology.

PIPa 5204su (formerly 5650). Field Plant Pathology. (2 cr; prereq 3001 or 3002 or 5201, 5202) MacDonald, staff

Characteristics and management of plant diseases in field, forest, golf course, greenhouse, and urban environments.

## GRADUATE PROGRAMS

PIPa 5205su (formerly 5750). Plant Disease Diagnosis. (2 cr; prereq intro plant path course or #; two 2-hr labs) Lockhart

Principles and methodology of diagnosing problems affecting plant health. Biotic and abiotic disease agents, disease diagnosis at both field and lab levels, and current detection methods using immunological and electrophoretic techniques.

PIPa 5206f (formerly 5105). Biology of Fungi. (4 cr; prereq Biol 1009 or #) Anderson, Groth, Percich  
Survey of fungal kingdom, including recognition of all major fungi groups and their roles in ecosystems and human affairs, environmental and nutritional needs, and modes of dissemination and survival. Representative species of fungi observed and manipulated in lab.

PIPa 5209s. Biochemistry of Plant Disease. (3 cr; prereq organic chem or biochem or equiv; offered alt yrs) Mirocha

Biochemistry of metabolic reactions in diseased plants: phytoalexins, phytotoxins, induced resistance mechanisms, carbon metabolism, metabolic sinks.

PIPa 5211w (formerly 8111). Fungal Genetics. (4 cr; prereq intro genetics; offered alt yrs) Anderson, Groth  
Attributes of genetics of fungi using classical approaches, including mendelian and quantitative traits, ecological and population genetics, incompatibility systems, tetrad analysis, heterokaryosis, somatic recombination, plasmids, genetics of parasitism, and molecular genetics techniques.

PIPa 5212s (formerly 5050). Diseases of Forest and Shade Trees. (4 cr) Blanchette  
Biology of tree diseases and ecological relationships among trees, microbes, and environment. Lecture, discussion, lab.

PIPa 5213s. Plant Nematology. (4 cr; prereq 3001 or 5201, 3002 or 5200; offered alt yrs) MacDonald  
Modified case study approach to evaluating the significance of plant parasitic nematodes in Upper Midwest field, garden, turfgrass, and greenhouse situations.

PIPa 5214f (formerly 5005). Plant Virology. (4 cr; prereq PBio 3012 or equiv; offered alt yrs) Banttari, Lockhart

Importance, symptomatology, transmission, and identification of viroid, virus, and virus-like diseases of plants. Epidemiology and principles of control. Biological and biochemical properties of virus, viroid, and virus-like pathogens. Lab exercises including current techniques for plant virus identification and characterization, using transmission, immunodiagnosis, electron microscopy, and other experimental manipulation of these pathogens.

PIPa 5215s. Insects in Relation to Plant Diseases. (3 cr; prereq 1 course each in entomology and plant path or #: offered alt yrs) Lockhart, Ragsdale  
Insect transmission and dissemination of plant pathogens; plant insect relationships; habits of principal insect vectors.

PIPa 5500w. Epidemiology and Ecology of Plant Disease. (3 cr; prereq 5002 or 5050 or #) Kinkel

Concepts and methodology in quantitative study of plant disease epidemics, emphasizing ecology of interacting host plant and microbial populations. Disease forecasting, disease in natural (nonagricultural) systems, and biological and chemical approaches to disease control.

PIPa 5999. Special Workshop in Plant Pathology. (1-4 cr; prereq #)  
Offered off campus. Consult *Class Schedule* or department for current offerings.

PIPa 8000f. Supervised Teaching Experience. (2 cr; prereq #) Young  
Classroom or extension teaching experience in one of the following departments: agronomy and plant genetics; soil, water, and climate; plant pathology; or horticultural science. Discussion of teaching topics to strengthen skills and develop personal teaching philosophy.

PIPa 8090. \* Advanced Procedures and Research in Plant Pathology. (Cr ar)  
Special assignment of work in lab and field problems in pathological research.

PIPa 8200f,w. Current Topics in Plant Pathology. (2 cr; prereq #)

PIPa 8201w. Seminar. (1 cr)  
Critical review and presentation of current problems and progress in plant pathology; presented by graduate students, invited specialists, and faculty.

PIPa 8500. Research in Plant Pathology. (1-8 cr)  
Lab or field research in selected areas of plant pathology.

## Political Psychology

*Professor:* Eugene Borgida (psychology); William Brustein (sociology); Karlyn K. Campbell (speech-communication); Ronald J. Faber (journalism and mass communication); William H. Flanigan (political science); David W. Johnson (educational psychology); Paul E. Johnson (information and decision sciences); Geoffrey M. Maruyama (educational psychology); James R. Rest (educational psychology); W. Phillips Shively (political science); Mark Snyder (psychology); James A. Stimson (political science); John L. Sullivan (political science); Auke Tellegen (psychology)

*Associate Professor:* Patricia G. Avery (curriculum and instruction); Martha H. Gonzales (psychology); Martin W. Sampson III (political science); John M. Taborn (Afro-American studies); Albert R. Tims, Jr. (journalism and mass communication)

*Assistant Professor:* Wendy M. Rahn (political science)

**Course of Study**—Minor in political psychology, applicable to doctoral programs only.

**Curriculum**—Political psychology is an interdisciplinary minor that is concerned with psychological aspects of political behavior and

encompasses a variety of interdisciplinary research perspectives. Its roots lie in research in social and political attitudes and cognition, judgment and decision making, group relations, personality and leadership, and political socialization. The curriculum provides students with broad theoretical and methodological foundations for research in political psychology.

**Prerequisites for Admission**—Admission to the political psychology graduate minor is contingent upon prior admission to the Graduate School and a doctoral program in a degree-granting department. Applicants are required to demonstrate knowledge of research methods useful in the study of political psychology by successfully completing (grade of B or above) two or more of the following: EPsy 8261, 8262, or 8266; Pol 8121, 8123, or 8127; Psy 5206 or 8884; Soc 8812 or 8813; or Stat 5021 or 5302. Admission to the minor program is by permission of the director of graduate studies in political psychology.

**Minor Requirements**—Students seeking to complete the political psychology minor at the Ph.D. level are required to take the following core courses: Pol 8307, Pol 8308, Pol 8309 (or Psy 8211, Psy 8212, Psy 8213), Pol 8310, and Psy 8201. The minor requires a minimum of 21 credits. Additional credits beyond the required courses must be selected from a designated course list that includes about 45 courses from 12 departments. Additional credits must also be distributed across two of four modules: psychological aspects of political behavior; political socialization and human development; politics in sociocultural context; and psychological approaches to political decision making in public policy and international relations. Credits from courses in the student's major department, however, do not count toward the minor.

**Language Requirements**—None specific to the minor program.

**For Further Information and Applications**—Contact the Doctoral Minor in Political Psychology, Center for the Study of Political Psychology, University of Minnesota, 1282 Social Sciences Building, 267 19th Avenue South, Minneapolis, MN 55455 (612/624-0864; fax 612/626-7599; e-mail polipsyc@polisci.umn).

## Political Science (Pol)

*Regents' Professor:* Frank J. Sorauf

*Professor:* Edwin Fogelman, *chair*; Mary G. Dietz, *director of graduate studies*; Charles H. Backstrom; Terence W. Ball; Raymond D. Duvall; James Farr; William H. Flanigan; John R. Freeman; Virginia H. Gray; Robert T. Holt; Ethan B. Kapstein; Samuel Krislov; Robert B. Kvavik; Paul C. Light; Thomas M. Scott; W. Phillips Shively; Steven S. Smith; James A. Stimson; John L. Sullivan

*Associate Professor:* Lisa Disch; Lawrence R. Jacobs; Daniel Kelliher; August H. Nimtz, Jr.; Martin W. Sampson; Kathryn A. Sikkink

*Assistant Professor:* Evelyn B. Davidheiser; Jeffrey W. Legro; Ido Oren; Richard M. Price; Wendy M. Rahn; Diana E. Richards

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Ph.D.; M.A. (Plan A and Plan B), as part of the Ph.D. program; special M.A., considered terminal; joint M.A./Ph.D. program with the Hubert H. Humphrey Institute of Public Affairs.

**Curriculum**—The curriculum is divided into five subfields: formal models and methodology, political theory, American politics, international relations, and comparative politics.

**Prerequisites for Admission**—For a detailed statement of prerequisites, contact the director of graduate studies.

**Special Application Requirements**—All students, except those in the special master's program, are admitted directly into the Ph.D. program. The following should be sent directly to the department: Graduate Record Examination scores; a complete set of transcripts in addition to that required by the Graduate School; a brief statement expressing the applicant's purpose and goals in pursuing graduate work (in addition to and separate from the statement required as part of the Graduate School application form); three letters of recommendation from professors who know the applicant's academic work, particularly in political science; and samples of the applicant's written work (papers written for political science courses preferred). Send photocopies of written work; the department cannot guarantee that materials will be returned.

Graduate study in the Ph.D. program must begin in fall quarter; the application deadline is December 15. Graduate study in the special M.A. program may begin in any quarter; application deadlines are those established by the Graduate School.

The department and the Humphrey Institute of Public Affairs jointly offer a program that leads to an M.A. in public affairs and a Ph.D. in political science. To be eligible, students must be admitted separately by political science and public affairs. Normally, students begin their study in public affairs and later apply to the Ph.D. program in political science. However, students may begin in either program, so it is possible to apply initially to either program or both. Students interested in this joint degree program should contact the director of graduate studies.

**Master's Degree Requirements**—Students in the Ph.D. program may earn an M.A. while completing the Ph.D. requirements. The special master's program annually admits a small number of students with clear, career-oriented goals. The degree is not a research degree and does not ordinarily lead to the Ph.D. degree. Programs are tailored to individual needs. Individuals with an interest in foreign or domestic government employment should apply to programs offered, for example, by the Hubert H. Humphrey Institute of Public Affairs.

For further information about master's degree requirements, contact the Department of Political Science.

**Doctoral Degree Requirements**—Required coursework includes three of four core seminars (8200, 8300, 8400, 8600) plus 8101, 8102, and 8103. In addition to seminar work, two substantial research papers are required.

**Language Requirements**—For the master's degree, none. For the doctoral degree, students must demonstrate either proficiency in two languages, high proficiency in one language, proficiency in one language and a research tool, or high proficiency in a research tool.

**Minor Requirements for Students Majoring in Other Fields**—For the Ph.D. degree, at least 9 credits of 8xxx courses and an examination must be included in the minor program.

**For Further Information and Applications**—Contact the Department of Political Science, University of Minnesota, 1414 Social Sciences Building, 267 19th Avenue South, Minneapolis, MN 55455 (612/624-4144; fax 612/626-7599; e-mail [polisci@polisci.umn.edu](mailto:polisci@polisci.umn.edu)).

Pol 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Pol 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Pol 8888. Thesis Credits: Doctoral. (36 cr required)

Pol 8990. Directed Readings in Political Science. (1-7 cr; prereq 45 cr 8xxx pol sci courses)

### Political Science Methodology

Pol 8101. Scope and Methods of Political Science. (3 cr; prereq pol sci grad major or Δ) Farr, Fogelman

The field of political science; epistemological problems in political inquiry; political values and their relationship to inquiry; approaches to the study of politics.

Pol 8102. Approaches to Political Research. (3 cr; prereq pol sci grad major or Δ) Flanigan, Holt, Shively  
Constructing a problem in political research; development and articulation of political theories; conceptualization and measurement; designs for research. Critical evaluation of examples of political research.

Pol 8103. Political Science as a Profession. (3 cr; prereq pol sci grad major)

Acquaints future political scientists with intellectual issues, techniques, and resources pertinent to their future professional roles. Modules in teaching (required module), writing and applying for grants and sponsored research, and writing for publication; students must complete at least two modules.

Pol 8140. Individual Readings and Research in Methodology. (1-3 cr; prereq pol sci grad major or #, Δ)

Pol 8150. Research Seminar: Methodology. (3 cr; prereq pol sci grad major or #)

Supervised research and research training in selected topics and problems.

Pol 8160. Selected Topics in Models and Methods. (3 cr; prereq pol sci grad major or #)  
Readings and research in special topics or problems.

### *Formal Models and Methodology of Political Analysis*

Pol 8120. Positive Theory. (3 cr; prereq pol sci grad major or #; offered alt yrs) Richards

Extensive survey of positive political theory and rational-choice models. Individual preferences and utility theory, social welfare functions, collective action and externalities, markets and elections, and spatial models of electoral competition.

Pol 8121. Introduction to Quantitative Analysis. (4 cr; prereq pol sci grad major or Stat 5021 or #) Flanigan, Stimson

Survey of data collection; levels of measurement; measures of association; substantive exercises in political analysis.

Pol 8122. Formal Models. (3 cr; prereq 1 yr calculus or equiv, pol sci grad major or #; offered alt yrs) Richards  
Survey of the application and use of mathematical models in political science. Emphasis on structure of assumptions, logical deduction, and empirical testing of a wide class of models. Mathematical techniques covered may include mathematical programming, difference and differential equations, and stochastic processes.

Pol 8123. Advanced Topics in Regression Analysis. (4 cr; prereq 8121 or equiv or #; lab section required; offered alt yrs) Freeman, Stimson  
General linear model; extensions of linear model; problems in regression analysis; causal models.

Pol 8124. Game Theory. (3 cr; prereq pol sci grad major or #; offered alt yrs) Richards  
Theory and application of games in political science. Utility theory, two-person games and solution concepts. N-person games, the power index, and coalition theory. Applications drawn from voting analysis, institutional designs, international relations, and regulation theory.

Pol 8125. Dynamic Analysis. (4 cr; prereq 8121 or equiv or #; lab section required; offered alt yrs) Freeman, Stimson  
Time series regression analysis; simultaneous equations; stochastic processes.

Pol 8127. Measurement Theory. (4 cr; prereq 8121 or equiv or #; lab section required; offered when feasible) Sullivan

## Political Theory

Pol 5610. Topics in Political Theory. (4 cr; 3051 or 1061 or 8 cr social sci or #)  
Topics specified in *Class Schedule*.

Pol 8200. Understanding Political Theory. (4 cr; prereq pol sci grad major or Δ) Ball, Dietz  
Introduction to major approaches and concepts in political theory.

Pol 8240. Individual Reading and Research in Political Thought. (3 cr per qtr; prereq pol sci grad major or #, Δ)

Pol 8260. Topics in Political Theory. (3 cr; prereq pol sci grad major or #)  
Readings and research in special advanced topics or problems.

## Development of Western Political Thought

Pol 5654. Development of Political Thought: Ancient and Medieval (Plato to Aquinas). (4 cr; 1061 or 9 cr social sci recommended) Ball, Dietz  
Thucydides; classical Greek thought; Plato and Aristotle; rise of empire and Roman thought; Augustine; Middle Ages; Aquinas.

Pol 5655. Development of Political Thought: Early Modern (Renaissance to the Age of Revolution). (4 cr; 1061 or 9 cr social sci recommended) Ball, Dietz, Farr  
Renaissance; Machiavelli; More; Reformation; Luther; Calvin; liberalism; Hobbes and Locke; Enlightenment; Montesquieu; Rousseau.

Pol 5656. Development of Political Thought: Modern. (4 cr; prereq 1061 or 9 cr social sci) Dietz, Fogelman  
French Revolution and reaction; Burke; utilitarianism; Bentham; Hegel; socialism; Marx; rise of democracy; Mill; Tocqueville; other selected mainly 19th-century thinkers.

Pol 5657. The Development of Political Thought: Contemporary. (4 cr; 1061 or 9 cr social sci recommended) Disch, Farr  
Twentieth-century thinkers and issues: Weber, Dewey, Lenin, Arendt, Camus, Sartre, Weil, de Beauvoir, Orwell, Marcuse, Popper, Rawls, Habermas, Foucault, liberalism, socialism, feminism, pragmatism, postmodernism.

Pol 8201, 8202, 8203, 8204. Development of Political Thought. (3 cr per qtr; prereq pol sci grad major or #) Ball, Dietz, Disch, Farr, Fogelman  
In general, topics in 8201 relate to ancient and medieval, in 8202 to early modern, in 8203 to modern, and in 8204 to contemporary political thought.

Pol 8215. American Political Thought. (3 cr; prereq pol sci grad major or #) Ball, Farr  
Major issues and thinkers (e.g., political leaders, novelists, academics). Relation of political thought to problems of American culture.

## Analytical and Political Inquiry

Pol 8220. Philosophy of Political Inquiry. (3 cr; prereq pol sci grad major or #) Ball, Farr  
Issues and themes in philosophy of social sciences as they relate to political science theories and practices. Explanation, interpretation, criticism, theories, and theory change discussed in context of competing models of political inquiry.

Pol 8231. Democratic Theory. (3 cr; prereq pol sci grad major or #) Disch, Farr  
Classical and modern theories of democracy including consideration of historical roots and philosophical foundations of the theories, the majority principle, role of the democratic citizen and representative institutions, with attention to the significance of recent social science findings regarding classical democratic theory formulations.

## American Politics

Pol 5303. The American Democracy. (4 cr; prereq 1001 or equiv or #) Jacobs  
American political system, its institutions and processes. Political decision making, influence, and elites. Ideals and reality of democracy in the United States.

## GRADUATE PROGRAMS

Pol 8300. American Politics. (4 cr; prereq pol sci grad major or  $\Delta$ ) Flanigan, Gray, Smith, Sorauf  
Introduction to main themes of research in American politics, institutions, law, and policy.

Pol 8340. Individual Reading and Research in American Politics. (3 cr per qtr; prereq pol sci grad major or #, $\Delta$ )

Pol 8350. Research Seminar: American Politics. (3 cr; prereq pol sci grad major or #)  
Supervised research and research training in selected topics or problems.

Pol 8360. Topics in American Politics. (3 cr; prereq pol sci grad major or #)  
Readings and research in special topics or problems.

### *Individual Political Behavior*

Pol 5710. Advanced Topics in Politics and Behavior. (4 cr; prereq 3051 or #)  
Topics of current analytic or policy importance in political behavior.

Pol 5765. Political Psychology of Conformity, Enmity, and Heroism. (4 cr; prereq 1001 or equiv or #) Sullivan  
Conformity and obedience in politics; spiral of silence and groupthink; pathways from conformity and obedience to malignant political aggression; psychological basis and political use of torture, terrorism, and genocide; role of individual, group, and institutional preconditions and consequences; political altruism and heroism in face of malignant aggression; role of ordinary people and extraordinary leadership; case studies.

Pol 5766. American Political Culture and Values. (4 cr; prereq 3085 or equiv or #) Rahn, Sullivan  
Empirical analysis of basic political values: individualism, freedom, and equality; dominant beliefs about democratic principles, postmaterialism, and capitalism; citizenship and political participation; political intolerance and patriotism; heroism and political leadership.

Pol 5767. Public Opinion and Voting Behavior. (5 cr; prereq 1001 or equiv or #) Flanigan, Rahn, Stimson  
Major factors influencing electoral decisions; political attitude formation and change. Data analysis lab required.

Pol 8301. Public Opinion and Political Participation. (3 cr; prereq pol sci grad major or #) Flanigan, Stimson  
Description and analysis of public opinion, opinion leaders, and opinion elites; attitudinal and social determinants of voting behavior, campaign participation, and other political activity; analysis and interpretation of electoral decisions.

Pol 8307, 8308, 8309. Proseminar in Political Psychology. (1 cr per qtr, \$Psy 8211, 8212, 8213; prereq pol psych grad minor) Rahn, Sullivan  
Required for Ph.D. minor in political psychology. Background, issues, and trends. Current research topics and methods. Faculty colloquium series and student research presentations.

Pol 8310. Political Psychology. (3 cr; prereq pol sci grad major or pol psych minor or #) Rahn, Sullivan  
Personality and political behavior, political learning, operant subjectivity and Q-methodology, emotion and political cognition. Focuses on individual-level political thinking and behavior.

### *Organizational Political Behavior*

Pol 5737. American Political Parties. (4 cr; prereq 1001 or equiv or #) Backstrom, Sorauf  
American two-party system; party influence in legislatures and executives; decline of parties and their future.

Pol 5738. American Political Campaigns and Elections. (4 cr; prereq 1001 or equiv or #) Backstrom, Flanigan  
National, state, and local campaigns and elections, research in local political parties and campaigns.

Pol 8303. Political Parties. (3 cr; prereq pol sci grad major or #) Backstrom, Sorauf  
Party systems and subsystems; party organizational characteristics, goals, and incentives; distribution of power and authority within the party; chief party functions; party as an organizer of governmental power; determinants of party structure and role.

Pol 8305. Interest Groups. (3 cr; prereq pol sci grad major or #) Flanigan, Gray, Jacobs  
Description and analysis of role of interest groups; leadership, maintenance of following, and representation of values; theories of groups, group behavior, and overlapping group membership; interest group relations with other political organizations.

### *National Governmental Processes*

Pol 5523. The Politics of the Regulatory Process. (4 cr; prereq 1001 or equiv or #; offered alt yrs) Krislov  
Operations of regulatory agencies considered in political and legal environment. Federal administrative law principles, informal procedures, interest group activity. Philosophy of regulation. Politics and processes of deregulation.

Pol 8312. Legislative Process. (3 cr; prereq pol sci grad major or #) Backstrom, Smith  
National and state legislatures; their internal organization; party organizations and influences with legislatures; interest groups and other external influences; legislative roles and behavior; policymaking processes in American legislatures.

Pol 8313. Executive Process. (3 cr; prereq pol sci grad major or #) Jacobs, Light  
The political executive, cabinets, and staff aides; relations with legislatures; the executive as party and popular leader; the executive and administrative agencies.

Pol 8314. Judicial Process. (3 cr; prereq pol sci grad major or #) Krislov  
Judicial systems and roles; selection of judges; organizing and supporting litigation; influences on judicial decisions; impact and enforcement of judicial decisions; courts and other institutions of government.

Pol 8317. Organizational Behavior. (3 cr; prereq pol sci grad major or #) Light  
Organization theory and models; bureaucracy in a political system; impact of organization on individual political opinion and behavior; decision making and bargaining within political institutions and organizations.

### *State and Local Government*

Pol 5315. State Government and Politics. (4 cr; prereq 1001 or equiv or #) Backstrom, Gray  
Political institutions, political behavior, and public policies in American states; comparisons among states, between state and national political systems.

Pol 5327. Local Government and Politics. (4 cr; prereq 1001 or equiv or #) Backstrom, Scott  
Development and role of American local government; forms and structures; relationships with states and the federal government; local politics and patterns of power and influence.

Pol 8321. Urban Politics. (3 cr; prereq pol sci grad major or #) Backstrom, Scott  
Selection of local leadership; relationship of the political system to governmental forms and social institutions; role and impact of political institutions; policymaking at the local level; studies in policy problems; the emerging metropolis.

Pol 8325. State Politics and Intergovernmental Relations. (3 cr; prereq pol sci grad major or #) Gray  
Application of comparative method to study of American state politics; emphasis on measurement of concepts, usefulness of conceptual frameworks, analytic techniques, and selection of units of analysis.

### *Public Law and Judicial Process*

Pol 5501. Principles of American Constitution I. (5 cr; prereq 1001 or equiv) Krislov  
Nature of constitutions, judicial review, organization and powers of national government; nation-state, and interstate relations.

Pol 5502. Principles of American Constitution II. (5 cr; prereq 1001 or equiv, 5501 or 3309 or sr) Krislov  
Due process; civil rights and civil liberties.

Pol 8314. Judicial Process. (3 cr; prereq pol sci grad major or #) Krislov  
For description, see National Governmental Processes subdivision of American Politics subfield listing.

Pol 8331. Constitutional Law. (3 cr; prereq pol sci grad major or #) Krislov

### *Public Policy*

Pol 5322. Rethinking American Social Policy. (4 cr; prereq 1001 or equiv or # or non-pol sci grad student) Gray, Jacobs  
American government actions affecting the distribution of social benefits such as healthcare, education, and housing; social burdens such as taxation and regulation of social conduct. Relationships between government action and social problems; possibilities for change.

Pol 5323. American Defense Policy. (4 cr; prereq 3836 or 6 cr ROTC or non-pol sci grad student or #; offered when feasible)

Pol 8335. Public Policy. (3 cr; prereq pol sci grad major or #) Gray, Jacobs  
Politics of the policymaking process; interest group, client and constituent pressures; decision making and bargaining in policymaking; topics in major areas of regulation, planning, fiscal, and welfare policy.

Pol 8412. American Foreign Policy. (3 cr; prereq 8411 or #) Sampson  
For description, see Foreign Policy subdivision of International Relations subfield listing.

### *International Relations*

Pol 5810. Advanced Topics in International Politics and Foreign Policy. (1-4 cr; prereq 3835 or 3836 or non-pol sci grad student or #)  
Topics of current analytic or policy importance in international relations and foreign policy. Topics vary.

Pol 8400. International Relations. (4 cr; prereq pol sci grad major or Δ) Duval, Legro, Oren, Price, Sampson  
Introduction to analysis of international relations and foreign policy.

Pol 8440. Individual Reading and Research in International Relations. (1-3 cr; prereq pol sci grad major or #, Δ)

Pol 8450. Research Seminar: International Politics and Foreign Policy. (3 cr; prereq pol sci grad major or #)  
Supervised group research and research training in selected topics or problems. Recent topics have included psychology and foreign policy, and international finance.

Pol 8460. Topics in International Politics. (3 cr; prereq pol sci grad major or #)  
Readings and research in advanced topics or problems. Recent topics have included global environmental issues, morality in world politics, and norms and institutions in world politics.

### *International Politics*

Pol 5875. U.S. Foreign Economic Policy. (4 cr; prereq 3836 or non-pol sci grad student or #)  
Issues and processes related primarily to economic aspects of U.S. foreign policy; global and regional trade, investment, monetary, and aid policies; implications for U.S. defense and domestic policies; problems of coordinating information gathering, decision making, and implementing foreign policy apparatus under non-crisis conditions.

Pol 5881. International Law. (5 cr; prereq 3835 or non-pol sci grad student or #) Price  
How and why international law matters. Obligation, territory, laws of war, international criminal law, human rights, environment, and law of the sea.

## GRADUATE PROGRAMS

Pol 5883. International Organizations. (4 cr; prereq 3835 or non-pol sci grad student or #; offered alt yrs) Duvall, Price

International politics of cooperation in institutional arenas; decision making in the United Nations and related agencies; organizational impact on international conflict, international economic and social relations.

Pol 5885. International Conflict and Security. (4 cr; prereq 3835 or non-pol sci grad student or #) Legro, Oren, Price

Use of military force in international politics, including threat perception, nuclear strategy, arms races and arms control, and ethical perspectives on war.

Pol 5886. International Diplomacy, Bargaining and Negotiation. (4 cr; prereq 3835 or non-pol sci grad student or #; offered alt yrs) Legro Strategies and processes of international diplomacy, bargaining and negotiation to resolve contemporary international disputes, including international security, arms limitation, and disarmament.

Pol 5889. The Politics of Global Economic Relations. (4 cr; prereq 3835 or non-pol sci grad student or #) Duvall, Legro

Trade, aid, investment, and international monetary relations as political-economic processes; role of multinational corporations; problems of dependence and interdependence; strategic issues in international economic relations.

Pol 8401. Advanced International Relations Theory. (3 cr; prereq pol sci grad major or #) Duvall, Legro, Oren, Price

Basic theories and approaches to study of international politics; survey of representative theoretical and applied works; central issues and problems of continuing relevance to scholarship in international politics.

Pol 8402. Conflict Dynamics and Security. (3 cr; prereq pol sci grad major or #) Oren

Contending major theories concerning incidence and causes of various forms of conflict in the international system, especially war; role of arms races, alliances, international crises in the conflict process.

Pol 8404. International Hierarchy. (3 cr; prereq pol sci grad major or #) Duvall

Asymmetric structures and processes of international relations; systemic conditions and implications of informal empire and structures of dependency and hegemony.

Pol 8405. International Political Economy.

(3 cr; prereq pol sci grad major or #) Duvall, Freeman  
Political implications and political bases of international economic relations; policy coordination under complex interdependence; political constraints of economic dependence; political determinants of economic foreign policy.

### *Foreign Policy*

Pol 5323. American Defense Policy. (4 cr; prereq 3836 or non-pol sci grad student or 6 cr ROTC or #; offered when feasible)

Pol 8411. Foreign Policy and Decision Making. (3 cr; prereq pol sci grad major or #) Sampson

Foreign policy choice processes from cognitive psychology, organizational behavior, cultural, issue-context, rational choice, institutional, and related perspectives.

Pol 8412. American Foreign Policy. (3 cr; prereq 8411 or #) Sampson

Processes of American foreign policy decision making and implementation; recent American foreign policies regarding such areas as strategy, economics, arms control, and energy, and impact of these policies on the international environment.

### *Comparative Politics*

Pol 5410. Advanced Topics in Government and Politics. (4 cr; prereq 3051 or non-pol sci grad student or #)

Topics of current analytic or policy importance in comparative politics. Topics vary.

Pol 8600. Introduction to Comparative Politics. (4 cr; prereq pol sci grad major or Δ) Holt, Kelliher, Sikkink

Main analytic approaches to comparative political analysis.

Pol 8640. Individual Readings and Research in Comparative Politics. (3 cr per qtr; prereq pol sci grad major or #, Δ)

Pol 8650. Research Seminar: Comparative Politics. (3 cr; prereq pol sci grad major or #)  
Supervised research and research training in selected topics and problems.

Pol 8660. Topics in Comparative Politics. (3 cr; prereq pol sci grad major or #)

Readings and research in special advanced topics or problems.

### *Comparative Analysis*

Pol 5481. Comparative Political Economy. (4 cr; prereq 3051 or non-pol sci grad student or #) Freeman  
How politics shapes and is shaped by economic relations within nation-states; economic determinants of voting; political-business cycles; business and unions as interest groups; the political determinants of government spending patterns.

Pol 8633. Comparative Sociopolitical Change. (3 cr; prereq pol sci grad major or #) Davidheiser, Nimitz

Critical evaluation of the literature and theoretical perspectives; comparative examination of social and political change and the interrelationship between both processes.

Pol 8637. Comparative Political Economy. (3 cr; prereq pol sci grad major or #) Duvall, Freeman  
Comparison of political and economic systems of industrialized countries; political-business cycles, business and unions as interest groups; patterns of government spending.

Pol 8641. Comparative Mass Political Behavior. (3 cr; prereq pol sci grad major or #) Kelliher, Nimtz, Shively

Mass political behavior, examined from a cross-national perspective: the development of political participation, mobilization and its effects; the development of political cleavages and of political parties as vehicles of conflict; modes of political behavior under varied systems of representation and under varied party systems.

Pol 8643. Comparative Political Organizations. (3 cr; prereq pol sci grad major or #) Holt

Structures and behavior of political parties and interest groups in different political environments; evaluation of theoretical approaches and comparative frameworks.

Pol 8645. Comparative Analysis of Elites in an Institutional Context. (3 cr; prereq pol sci grad major or #) Nimtz

Comparative analysis of political elites in a variety of social settings; recruitment patterns; leadership training and attitudes; elite behavior in civil and military bureaucracies and legislative structures; impact of elites on political change.

### *Country and Regional Studies*

Pol 5461. Western European Government and Politics. (5 cr; prereq 3051 or non-pol sci grad student or #) Holt, Shively

Political institutions in their social setting; problems of power and responsibility, government stability; political decision making, government and the economic order.

Pol 5471. Politics of Russia and the Commonwealth of Independent States. (4 cr; prereq 3051 or non-pol sci grad student or #) Davidheiser

Politics in the former Soviet Union, now the Commonwealth of Independent States. Evolution of the system: theories of revolution and their relation to Russia's experience in 1917; emergence and breakdown of stable Soviet government. Current attempts to re-establish political stability and cope with problems facing political system in Commonwealth and Russia.

Pol 5473. Chinese Government and Politics. (4 cr) Kelliher

Traditional Chinese society; fragmentation of China and rise of the Communists to power; sources and nature of Communist Chinese ideology; institutional character of the Communist Party system; sources of power; role of the party and functional groups; patterns of change.

Pol 5477. Middle Eastern Government and Politics. (4 cr; prereq 3051 or non-pol sci grad student or #) Sampson

Domestic politics of Turkey, Iran, selected Arab states, and Israel with emphasis on ruling elites and linkages between regimes and societies. Secular/religious tensions, political aspects of ethnic diversity, and political effects of economic change.

Pol 5478. Government and Politics of African Countries. (4 cr; prereq 3051 or non-pol sci grad student or #) Nimtz

Political institutions and behavior of sub-Sahara African countries in their social and cultural settings; influence of class and tribal structure; parties and elections; source and nature of ideologies; economic and social policies.

Pol 5479. Latin American Government and Politics. (5 cr, \$5455; prereq 3051 or non-pol sci grad student or #) Sikkink

Latin American political heritage, political processes, and contemporary public policy issues; problems of social, economic, and political change in selected countries.

Pol 8601. Government and Politics in Western Europe. (3 cr; prereq pol sci grad major or #) Kvavik, Shively

Analysis of political institutions; political development; social structures; ideologies; parties and pressure groups; voting behavior.

Pol 8605. Government and Politics of Africa. (3 cr; prereq pol sci grad major or #) Nimtz

Political systems and processes of African countries with emphasis on local politics and problems of political change, political ideology, and political leadership.

Pol 8608. Government and Politics of Russia and the Commonwealth of Independent States. (3 cr; prereq pol sci grad major or #) Davidheiser

Sources of stability and instability; evolution of institutions; relationship of social forces to political structures; economic policy; ethnic politics.

Pol 8611. Chinese Politics. (3 cr; prereq pol sci grad major or #) Kelliher

Social divisions and sources of change since 1949, including class conflict, ideological controversy, reform, relations between state and society, issues of equality, debates over development strategy, and Chinese conceptions of democracy.

Pol 8619. Government and Politics of Latin America. (3 cr; prereq pol sci grad major or #) Sikkink

Political institutions and processes with emphasis upon selected countries; social and economic basis of politics; parties and interest groups; political instability and change.

### Portuguese

See Hispanic and Luso-Brazilian Literatures and Linguistics.

## Psychology (Psy)

*Regents' Professor:* Ellen S. Berscheid; Willard W. Hartup (child development)

*Professor:* Eugene Borgida, *chair*; Matthew McGue, *associate chair*; John P. Campbell, *director of graduate studies*; Phillip L. Ackerman; Thomas J. Bouchard, Jr.; Dwight A. Burkhardt; James N. Butcher; Marilyn E. Carroll (psychiatry); Robert A. Cudeck; Mark L. Davison (educational psychology); René V. Dawis; Marvin D. Dunnette; Byron Egeland (child development); Patricia Faunce (University Counseling and Consulting Services); Paul W. Fox; Jo-Ida C. Hansen; William G. Iacono; Paul E. Johnson (information and decision sciences); Ruth Kanfer; Daniel J. Kersten; Thomas J. Kiresuk (psychiatry); Eric Klinger (social sciences, Morris campus); Gordon E. Legge; Gloria R. Leon; Rodney G. Loper (University Counseling and Consulting Services); David T. Lykken; David H. Olson (family social science); J. Bruce Overmier; Herbert L. Pick, Jr. (child development); Mark Snyder; Sheldon B. Sparber (pharmacology); L. Alan Sroufe (child development); Auke Tellegen; Neal F. Viemeister; Richard A. Weinberg (child development); David J. Weiss; James E. Ysseldyke (educational psychology)

*Associate Professor:* Charles R. Fletcher; Patricia A. Frazier; Martha H. Gonzales; William M. Grove; Carol H. Pazandak (College of Liberal Arts administration); Gail B. Peterson; Carolyn L. Williams (epidemiology)

*Assistant Professor:* Kathy J. Christensen (neurology); John C. Gonsiorek; Harriett L. C. Haynes (University Counseling and Consulting Services); Chad J. Marsolek; Deniz S. Ones; Alexander J. Rothman

*Clinical Assistant Professor:* Susan Nicol; Linda K. Van Egeren

*Research Associate:* James P. Cleary (medicine); Darwin D. Hendel (Academic Affairs)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Ph.D. and M.A. (Plan A and Plan B). Except for the specialty in psychometrics, students are admitted only for the Ph.D.; the M.A. is generally offered as part of the Ph.D. program, with some specialties requiring an M.A. (Plan A) as part of the Ph.D.

**Curriculum**—Doctoral program specialties are offered in clinical (adult or child clinical/developmental psychopathology), cognitive and biological, counseling, industrial/organizational, school, and social psychology; biological psychopathology; differential/behavior genetics; personality research; and psychometrics. An M.A. program is offered in psychometrics.

**Prerequisites for Admission**—Prospective students generally have completed at least 15 quarter credits in psychology, including one course in statistics or psychological measurement. Applicants to clinical psychology also must have completed at least one course in abnormal psychology. An undergraduate major in psychology is desirable, but not necessary.

**Special Application Requirements**—A department application, a statement of career goals, three letters of recommendation, and scores from the General Test of the Graduate Record Examination (GRE) should accompany applications for both the M.A. and Ph.D. programs. The GRE Subject Test in psychology is recommended. Applications are accepted only for fall admission; the deadline is January 15. Minimum acceptable GPAs and GRE scores and other specific requirements are available from the psychology graduate admissions office.

**Master's Degree Requirements**—Each student's program is individually planned in consultation with the adviser. The minimum course credit requirement is 28 credits for Plan A (excluding thesis credits) and 44 credits for Plan B.

**Doctoral Degree Requirements**—In addition to the requirements of the Graduate School, students must satisfy the general area distribution requirement of selected courses in four areas (total of 32-40 credits) outside their specialty and a preliminary examination covering the major area of concentration. There are no other general departmental course requirements. Each student's program is individually planned in consultation with the adviser to meet both the individual's goals and the area requirements. The programs in clinical psychology and counseling psychology include specific requirements for applied coursework and for practicum and internship experience. Each specialty area also requires completion of a series of Ph.D.-level seminars that teach scholarship and research skills.

**Language Requirement**—None.

**Minor Requirements for Students Majoring in Other Fields**—For a Ph.D. minor, requirements are designed according to individual student needs, and generally include 20-28 course credits. For a designated M.A. minor, a minimum of 9 course credits is required.

**For Further Information and Applications—**  
 Contact the Department of Psychology,  
 University of Minnesota, 105 Elliott Hall, 75  
 East River Road, Minneapolis, MN 55455  
 (612/625-8520; fax 612/626-2079; e-mail  
 prahl001@tc.umn.edu).

Psy 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Psy 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Psy 8888. Thesis Credits: Doctoral. (36 cr required)

Psy 5011. Theories of Learning and Cognition. (4 cr; prereq 3011 or #) Peterson  
 Learning theories and contemporary theories of information processing and cognition. Examples from human and animal research.

Psy 5012-5013. Psychology of Learning. (4 cr per qtr; prereq 1005, 3011 or EBB 3111 or #, except for grad students) Overmier  
 Classical conditioning, instrumental learning, and elementary cognitive processes. Evaluation of relevant theories. Emphasis on animal models.

Psy 5014. Psychology of Human Learning and Memory. (4 cr; prereq 1005 or 3011 or 3051 or #, except for students in honors sequence and grad students) Fox  
 Processes and principles in human learning, memory, and cognition.

Psy 5015. Cognitive Processes. (4 cr; prereq 3011 or 3051 or 5014, except for students in honors sequence and grad students)  
 Cognitive processes in human pattern recognition, attention, and memory.

Psy 5031. Perception. (4 cr, §NSc 5031; prereq 3051 or 3031 or #) Legge  
 Data and principles of visual perception: color vision, pattern vision, object recognition, abnormal vision, and physiological optics.

Psy 5034. Psychobiology of Vision. (4 cr, §NSci 5034; prereq 3031 or #) Burkhardt  
 Analysis of properties and biological bases of sensory perception in humans and animals. Emphasis on color vision, visual sensitivity and adaptation, and nerve cell circuits of eye and brain.

Psy 5036. Vision: Computational Theory to Neural Systems. (4 cr; prereq 3031, Math 3261 or equiv, CSci 3113 or equiv or #) Kersten  
 Applications of psychology, neuroscience, and computer science to understanding design principles underlying visual perception. Comparisons of biological and physical processing of images with respect to image formation, encoding, filtering, scene inference, and recognition.

Psy 5037. Psychology of Hearing. (4 cr; prereq 3031 or #) Viemeister  
 Biological and physical aspects of hearing; auditory psychophysics; theories and models of hearing; perception of complex sounds, including music and speech; clinical and other applications.

Psy 5038. Introduction to Neural Networks. (4 cr; prereq 3061 or 5061, Math 3261 or equiv or #) Kersten  
 Parallel distributed processing models in neural and cognitive science. Linear models, Hebbian rules, self-organization, non-linear networks, information optimization, and representation of information. Applications to sensory processing, perception, learning, and memory.

Psy 5051. Psychology of Human-Machine Interaction. (4 cr; prereq 3051 or 3031 or #) Legge  
 Psychological perspectives on human-machine interaction and factors that limit performance. Cognitive and perceptual aspects of computer use, telepresence, and design and evaluation of sensory aids.

Psy 5054. Psychology of Language. (4 cr; prereq 3011, except for students in honors sequence and grad students) Fletcher  
 Theories and experimental evidence involved in past and present conceptions of psychology of language.

Psy 5061. Biological Psychology. (4 cr, §3061; prereq 1005 or Biol 1009 or #)  
 Physiological and neuroanatomical mechanisms underlying behavior of animals. Neural basis of learning and memory, sleep, wakefulness, attention processes. Effects of drugs on behavior.

Psy 5101. Personality. (4 cr, §3101; prereq 5862 or ¶5862, honors or grad student) Tellegen  
 Introduction to and evaluation of major alternative theoretical perspectives, research methods, and empirical issues.

Psy 5121. History and Systems of Psychology. (4 cr; prereq 8 cr 5xxx psych courses or equiv or grad student or #) Ackerman  
 Survey of history, methods, and content of modern psychological theory, research, and application. Schools of psychology (e.g., structuralism, functionalism, behaviorism, gestalt psychology) and central theories of psychology reviewed in their historical and philosophical contexts.

Psy 5135. Introduction to Individual Differences. (4 cr, §3135; prereq 3801 or equiv, 5862 or #) Bouchard  
 Differential methods in study of human behavior. Overview of nature of psychological traits and influence of age, sex, heredity, and environment in causation of individual and group differences in ability, personality, interests, and attitude.

Psy 5136. Human Abilities. (4 cr; prereq 3135 or 5135, 5862 or equiv or #) Ackerman  
 Theory, methods, and applications of research in human abilities. Intelligence, aptitude, achievement, specific abilities, information processing/learning and intelligence, aptitude/treatment interactions, and quantitative measurement issues.

## GRADUATE PROGRAMS

Psy 5137. Introduction to Behavioral Genetics. (4 cr; prereq 3135 or 5135 or #) McGue  
Application of genetic methods to study of human and animal behavior. Emphasis on use of genetic designs and methods to address psychologically relevant questions concerning nature and etiology of individual differences in behavior. Examples include intelligence, schizophrenia, manic depressive illness, alcoholism.

Psy 5138. Psychology of Aging. (4 cr; prereq 3135 or 5135, 5862 or #) McGue  
Analysis of behavioral changes that occur in mid and late adulthood, from psychological, biological, and sociological perspectives. Description of methodologies appropriate for studying behavioral change and application to cognitive, personality, and mental health changes associated with aging.

Psy 5141. Psychology of Women. (4 cr; prereq 1001) Frazier  
Survey of current theory and research regarding psychology of women and psychological sex differences. Topics unique to women (e.g., pregnancy) and sex differences in personality, abilities, and behavior.

Psy 5202. Attitudes and Social Behavior. (4 cr; prereq 3201 or #) Borgida  
Survey of attitude theory, measurement, and persuasion research in social psychology. Focus on structure, function, and formation of attitudes; relationship between attitudes and various social behaviors; basic principles of persuasion.

Psy 5204. Psychology of Interpersonal Relationships. (4 cr; prereq honors or grad student or 3201 or #) Berscheid  
Theory and research of interpersonal relationships, focusing on dyadic interaction processes and patterns and their implications for the individual. Issues in relationship research methodology; developmental, sociobiological, social psychological approaches to relationships; processes of relationship initiation, development, maintenance, and dissolution.

Psy 5205. Applied Social Psychology. (4 cr; prereq 3201 or grad student or #) Gonzales  
Overview of field. Applications of social psychology research and theory to criminal justice system, media, behavioral medicine, desegregation, institutions, and energy conservation programs.

Psy 5206. Research Methods in Social Psychology. (4 cr; prereq #) Rothman  
Overview of experimental and quasi-experimental methods suitable for research in social psychology. Statistical, interpretive, operational, and ethical issues in social psychological research.

Psy 5207. Personality and Social Behavior. (4 cr; prereq 3101 or 3201 or # except for honors and grad students) Snyder  
Conceptual and methodological strategies for scientific study of individuals and their social worlds; applications of theory and research to issues of self, identity, and social interaction.

Psy 5501. Vocational Psychology. (4 cr; prereq 3801 or #) Dawis  
Individual differences analysis of the work personality and the work environment; vocational development and vocational choice; work adjustment; work motivation and performance; work satisfaction and satisfactoriness; psychological problems connected with work.

Psy 5604H. Abnormal Psychology. (4 cr, \$3604; prereq honors major or # for grad students) Leon  
Comprehensive review of psychopathological disorders. Etiology, diagnostic criteria, and clinical research findings emphasized.

Psy 5606. Clinical Psychophysiology. (4 cr; prereq 1004, 1005 or equiv, 3061 or 5061, 3604 or 5604H or #) Iacono  
Psychophysiological methods used in studies of major psychopathological disorders.

Psy 5701. Personnel and Industrial Psychology. (4 cr; prereq 3801 or equiv, 8 cr psych or #) Campbell  
Applying principles of individual differences and psychological measurement to problems of recruiting, selecting, and appraising members of ongoing organizations. Job analysis, job behavior description, models of complex performance, performance measurement, selection and placement strategies, utility of personnel decision-making procedures, and minority group employment issues.

Psy 5702. Psychology of Individual Behavior in Organizations. (4 cr; prereq 3801 or equiv, 8 cr psych or #) Kanfer  
Application of psychological research and methodology to study of human behavior in organizations. Measurement of work-related beliefs and attitudes, interpersonal relations, effects of group processes on problem solving and decision making, organizational socialization, leadership, supervision, organizational structure and climate.

Psy 5703. Psychology of Organizational Training and Development. (4 cr; prereq 3801 or equiv, 8 cr psych or #) Campbell  
Theories, methods, and research pertaining to improving performance of individuals at work through learning and instruction: training needs analysis, models of instructional design, aptitude-treatment interactions, training evaluation, knowledge structures, specific training programs.

Psy 5705. Work Motivation. (4 cr; prereq 3801 or equiv, 8 cr psych or #) Kanfer  
Motivational processes and job satisfaction in organizational contexts. Motivational process theories of task behavior and performance, goal setting, turnover/withdrawal, work attitudes, and interpersonal influences.

Psy 5862. Psychological Measurement: Theory and Methods. (4 cr; prereq 3801 or equiv, honors or grad student or #) Weiss  
Types of measurement (tests, scales, inventories) and their construction; theory and measurement of reliability and validity.

Psy 5865. Measurement of Latent Traits. (4 cr; prereq 5862 or #; offered alt yrs) Weiss  
Theory and methods for the measurement of latent psychological variables using dichotomous item response theory methodology. One-, two-, and three-parameter models. Item calibration, scoring, information, and applications to instrument construction, equating, bias, adaptive testing and mastery testing.

Psy 5960. Topics in Psychology. (1-5 cr per qtr; prereq 1001, #)  
Special classes or seminars offered infrequently for juniors, seniors, and graduate students. Topics listed in the psychology office.

Psy 8004. Seminar: Philosophical Psychology. (3 cr; prereq logic or phil course, psych or phil PhD major or #; offered alt yrs) Grove  
Selected philosophical and methodological problems.

Psy 8010. Advanced Topics in Learning. (3 cr; prereq 5012-5013 or #; S-N only) Overmier  
Critical analysis of contemporary topics in learning and behavior theory.

Psy 8020. Seminar: Conditioning and Learning. (3 cr; prereq 5011 or 5012 or psych grad student or #; S-N only) Overmier, staff  
Review and discussion of ongoing research and prospectives on future research.

Psy 8026. Neuro-Immune Interactions. (3 cr, \$Nsc 8026, \$PNI 8026, \$VMic 8026; prereq MicB 5218 or equiv, Nsc 5111 or equiv)  
Regulatory systems (neuroendocrine, cytokine, and autonomic nervous systems) linking brain and immune systems in brain-immune axis. Functional effects of bidirectional brain-immune regulation.

Psy 8031. Seminar: Visual Perception. (3 cr; prereq 5031 or #) Legge  
Physiological, psychological, and cognitive determinants of visual perception. Discussion of current research.

Psy 8037. Psychophysics and Audition. (3 cr; prereq #) Viemeister  
Modern and classical psychophysics. Psychophysical and physiological correlates of audition. Theories of hearing.

Psy 8040-8041. Psychophysiology. (4 cr per qtr; prereq #) Iacono, Lykken  
Basic principles and techniques; electrodermal, cardiovascular, EEG, EMG, and other physiological response systems having psychological relevance. Includes lab experience.

Psy 8056. Seminar: Psychology of Language. (3 cr; prereq 5054, #) Fletcher

Psy 8070. Seminar: Psychopharmacology. (1 cr; prereq #) Carroll, Hatsukami, Overmier, Sparber, staff  
Selected topics in drug-behavior research.

Psy 8107. Cross-Cultural Study of Personality. (3 cr; prereq 5101, 5604 or equiv or #) Butcher  
Methodological issues and status of current research.

Psy 8114-8115†. The Scientific Study of Psychopathology. (3 cr per qtr; prereq #)  
Theory and research in psychopathology; evaluation of current experimentation in various behavior disorders.

Psy 8120. Personality, Therapy, and Women. (4 cr; prereq 5101, 8 cr psych or #) Faunce  
Personality theories as they relate to women; ways of helping women; new concepts and theories about women.

Psy 8121. Achievement Motivation and Women. (3 cr; prereq 8 cr psych, grad student, #) Faunce  
Theories, concepts, and perspectives relevant to female achievement and achievement motivation.

Psy 8201. Social Cognition. (3 cr; prereq #) Borgida  
Theory and research in stereotyping, social inference, and person memory.

Psy 8202. Advanced Social Psychology—Close Relationships. (3 cr; prereq #; offered when feasible) Berscheid

Psy 8203. Impression Management. (3 cr; prereq #; 8208 recommended) Gonzales  
Discussion of classic and contemporary theory and research concerning interpersonal strategies of impression management.

Psy 8204-8205-8206. Seminar: Research in Social Psychology. (3 cr per qtr; prereq PhD candidate in psychology, #) Berscheid, Borgida, Gonzales, Rothman, Snyder  
Survey of contemporary theoretical positions and related research.

Psy 8208. Advanced Social Psychology—The Self. (3 cr; prereq #) Snyder  
Discussion of social psychological theory and research concerning the self and social behavior.

Psy 8209. Social Psychology and Health Behavior. (3 cr; prereq 5202 or 8201 or #) Rothman  
Social psychological analysis of process by which people develop beliefs about health and illness; relationship between these beliefs and adoption of health-relevant behaviors.

Psy 8211, 8212, 8213. Proseminar in Political Psychology. (1 cr per qtr, \$Pol 8307, 8308, 8309; prereq pol psych grad minor) Borgida  
Required for Ph.D. minor in political psychology. Background, issues, and trends. Current research topics and methods. Faculty colloquium series and student research presentations.

Psy 8410. Perspectives in Learning, Perception, and Cognition. (1 cr; S-N only) Broen, Overmier, Yonas, staff  
Presentations, analyses, and discussions of current research in learning, perception, and cognition with multidisciplinary orientation.

Psy 8501. Counseling Psychology I: History and Theories. (3 cr; prereq counseling psych grad student or #) Frazier  
Theories of counseling, their psychological assumptions and implications for practice.

## GRADUATE PROGRAMS

Psy 8502. Counseling Psychology II: Assessment. (4 cr; prereq counseling psych grad student or #) Dawis  
Counseling use of selected assessment procedures and instruments including intelligence, abilities, interests, needs, values, and personality.

Psy 8503. Counseling Psychology III: Interviewing and Theories. (4 cr; prereq 8501, 8502, counseling psych grad student or #) Counseling psychology staff  
Emphasis on development of counseling skills and strategies of behavior change in the interview; research on counseling effectiveness.

Psy 8514-8515-8516. Practicum in Student Counseling. (4 cr per qtr; prereq 8501, 8502, 8503 or equiv; S-N only) Loper, staff  
Counseling experience with students in an academic setting; emphasis is on the educational, vocational, and personal problems of college students.

Psy 8517-8518-8519. Practicum in Counseling Psychology. (1-4 cr per qtr; prereq 8501, 8502, 8503 or equiv or # if not in counseling psych program; S-N only) Hansen  
Beginning counseling practice experience in public and private mental health agencies.

Psy 8520-8521-8522. Pre-Practicum in Applied Psychology. (1-6 cr per qtr; prereq counseling psych grad student or #: S-N only) Keierleber, Pazandak  
Counseling observation and experience in applied settings.

Psy 8541. Multicultural Issues in Counseling. (2 cr; prereq counseling psych grad student or #) Haynes  
Increasing counselors' sensitivity to cultural values and biases they bring to their work with clients of diverse backgrounds. Issues important to diverse populations that may influence counseling.

Psy 8542. Ethical Issues in Psychology. (3 cr; prereq counseling or clinical psych grad student or #) Frazier, Grove

Psy 8544, 8545, 8546, 8547, 8548, 8549. Seminar: Research in Counseling Psychology. (1 cr per qtr; prereq counseling psych grad student or # for 8544, 8544 or # for 8545-8549; S-N only) Dawis, Frazier, Hansen  
Presentation and discussion of research in counseling psychology with emphasis on quantitative methods; process, outcome, and vocational research; and research with diverse populations. 8544: Introduction to counseling research. 8545: Process research. 8546: Outcome research. 8547: Vocational research. 8548: Diverse populations. 8549: Quantitative methods.

Psy 8560. Advanced Practicum/Internship in Counseling Psychology. (1-6 cr per qtr [max 24 cr]; prereq #: S-N only) Hansen

Psy 8564. Seminar: Vocational Counseling for Work Adjustment. (2 cr; prereq counseling psych grad student or #: S-N only; offered alt yrs) Dawis  
Topics and problems in vocational counseling for work adjustment. Research, operationalization, and application of theory of work adjustment to vocational counseling.

Psy 8574. Seminar: Strong Interest Inventory. (2 cr; prereq counseling psych grad student or #: S-N only; offered alt yrs) Hansen  
Lectures and discussion on history and development of Strong Interest Inventory. Scale construction methodology; research applications; interpretation and use of instrument.

Psy 8611, 8612, 8613. Professional Methods in Clinical Psychology I: Assessment. (4 cr per qtr; prereq clinical psych major) Butcher, Grove, Tellegen, staff  
Theory and practice in clinical application of assessment techniques and interviewing. Lab: observation, administration, scoring, interpretation.

Psy 8620. Practicum in Clinical Psychology. (1-6 cr; prereq #: S-N only) Leon  
Field experience in professional work in clinical settings.

Psy 8621, 8622. Professional Methods in Clinical Psychology II. (3, 4 cr per qtr; prereq clinical psych major, 8611, 8612, 8613) Leon  
Seminar on theories of individual and group treatment techniques. Lectures on and demonstrations of contemporary theories of methods of psychological intervention with adults and children. 8621: Theories of intervention. 8622: Adult behavior therapy.

Psy 8631, 8632. Professional Methods in Clinical Psychology III. (1-3, 3 cr per qtr; prereq clinical psych major, 8611, 8612, 8613) Ayers, Fischler, lacono  
Lectures, demonstrations, and supervised experience in the application of treatment techniques with psychologically disturbed persons in community and clinical settings. 8631: Community psychology and crisis intervention. 8632: Descriptive psychopathology.

Psy 8640. Seminar: Topics in Clinical Psychology. (1-6 cr; prereq #: S-N only) Clinical psychology staff  
Discussion of various topics in clinical psychology of interest to class and instructor.

Psy 8660. Seminar: The Psychopathic Personality: Theory and Research. (2 cr; prereq #) Lykken  
Research-oriented consideration of the nature and etiology of psychopathic behavior.

Psy 8664. Personality Assessment. (4 cr; prereq #) Tellegen  
Current methodological issues and important substantive developments and findings.

Psy 8690. Seminar: Research and Clinical Practice in Human Sexuality. (3 cr; prereq #) Current findings, issues, and developments in sex research and practice of sex therapy from multidisciplinary approach. For students with research interests in or contact with patients who have sexual difficulties, disorders, or dysfunction.

Psy 8701-8702. Seminar: Industrial and Organizational Psychology. (4 cr per qtr; prereq #: offered alt yrs) Campbell, Dunnette, Kanfer

Psy 8703, 8704. Seminar: Industrial and Organizational Psychology. (4 cr per qtr; prereq #: offered alt yrs) Campbell, Dunnette, Kanfer

Psy 8881-8882-8883†. Seminar: Psychometric Methods. (1 cr per qtr; prereq #) Weiss  
Reviews and individual research on current topics in psychological measurement, statistics.

Psy 8884. Methods for Multivariate Data Analysis. (4 cr; prereq EPsy 5261, EPsy 8260, 8261, 8262 or #) Cudeck

Survey of topics in applied multivariate data analysis, including aspects of multiple regression, discriminant analysis, classification, multivariate hypothesis tests, principal components, and canonical correlation. Extensive use of computer exercises.

Psy 8900. Seminar in Behavioral Genetics.

(2 cr; prereq #) McGue  
Advanced topics in human and animal behavioral genetics. Joint faculty and student participation in team teaching. Focuses on current literature, doctoral thesis research in progress, and faculty research.

Psy 8970. Seminar: Special Areas of Psychology and Related Sciences. (1-6 cr; prereq #: offered when demand warrants)

Psy 8980. Directed Teaching in Psychology. (1-6 cr; prereq #)  
Supervised experience in teaching psychology.

Psy 8990.\* Research Problems. (1-6 cr; prereq #)

## Psychoneuroimmunology (PNI)

*Professor:* Burt M. Sharp (medicine), *director of graduate studies;* Alvin J. Beitz (veterinary pathobiology); Michael P. Murtaugh (veterinary pathobiology); J. Bruce Overmier (psychology); Phillip K. Peterson (medicine); Philip S. Portoghese (medicinal chemistry); Virginia S. Seybold (cell biology and neuroanatomy)

*Associate Professor:* Marilyn E. Carroll (psychiatry); Wyrta Heagy (medicine); Martha A. Mellencamp (clinical and population sciences); Thomas W. Molitor (clinical and population sciences)

*Assistant Professor:* Chun C. Chao (medicine); Kristin M. Linner (medicine); Shannon G. Matta (medicine); Nahid Shahabi (medicine)

**Course of Study**—Minor in psychoneuroimmunology, applicable to doctoral programs only.

**Curriculum**—Psychoneuroimmunology (PNI) is a new field that seeks to elucidate the bidirectional connections between the central nervous system and the immune system, and the effect of these connections on the functioning of each system. These connections involve soluble

factors, secreted primarily by the neuroendocrine system and peripheral immune tissues, and neural innervation of immune tissues by the autonomic system. PNI research also considers the effects of psychological function on the immune system and underlying mechanisms. PNI is an interdisciplinary effort at the interface of neuroscience, immunology, psychology, endocrinology, microbiology, and medicinal chemistry.

**Prerequisites for Admission**—Admission to the psychoneuroimmunology graduate minor is contingent upon prior admission to a doctoral degree-granting program within the Graduate School and is by permission of the director of graduate studies in psychoneuroimmunology.

**Minor Requirements**—The following core courses are required: CBN 5111, MicB 8217, Phl 5112, and PNI 8026 (cross-listed with NSc, Psy, and VMic 8026), as is participation in a colloquium (no credit) and the PNI and addiction seminar series (no credit). The minor requires a minimum of 18 graduate-level quarter credits. It is suggested that credits beyond the required courses be selected from the elective courses. Alternative selections may be applied toward the minor if they are approved by the student's program adviser and the director of graduate studies in PNI. Credits from courses in the student's major program will not count toward the minor.

**For Further Information and Applications**—Contact Thomas W. Molitor, Ph.D., Department of Clinical and Population Sciences, University of Minnesota, 300E Veterinary Teaching Hospitals, 1365 Gortner Avenue, St. Paul, MN 55108 (612/625-7244; fax 612/625-6241).

### Core Courses

CBN 5111. Human Neuroscience A

MIMP 8217. Frontiers of Immunology II: Cellular Immunology

Phl 5112. Human Neuroscience B

PNI 8026. Neuro-Immune Interactions. (3 cr, \$NSc 8026, \$Psy 8026, \$VMic 8026; prereq MicB 5218 or equiv, NSc 5111 or equiv)

Regulatory systems (neuroendocrine, cytokine, and autonomic nervous systems) linking brain and immune systems in brain-immune axis. Functional effects of bidirectional brain-immune regulation.

### *Elective Courses—PSYCHOLOGY*

Psy 5012. Psychology of Learning

Psy 8070. Psychopharmacology Seminar

### *Elective Courses—NEUROSCIENCE*

CBN 8222. Central Regulation of Autonomic Function

CBN 8223. Neurobiology of Endocrine Regulation

NSc 5462. Neuroscience Principles of Drug Abuse

NSc 5660. Behavioral Neuroscience

VPB 5102. Veterinary Neurobiology

VPB 5400. Veterinary Pharmacology and Therapeutics

VPB 5460. Neurochemical Communication

### *Elective Courses—IMMUNOLOGY*

CAPS 8193. Advances in Clinical Immunobiology

MicB 5218. Immunology

MicB 5424. Biology of Viruses

MicB 8231. Advanced Topics in Microbial Pathogenesis

MicB 8421. Eukaryotic Molecular Virology and Tumor Biology

MIMP 8216. Frontiers of Immunology I: Molecular Immunology

MIMP 8218. Frontiers of Immunology III: Clinical Immunology

## Public Affairs (PA)

*Professor:* G. Edward Schuh, *dean*; Richard S. Bolan, *director, planning degree program*; Dean E. Abrahamson; John S. Adams; John E. Brandl; Geraldine K. Brookins; John M. Bryson; Nancy N. Eustis; Stephen A. Hoenack; Morris M. Kleiner; Robert T. Kudrle; Paul C. Light; Samuel L. Myers, Jr.

*Associate Professor:* Sandra O. Archibald, *associate dean and director of graduate studies*; Sally J. Kenney; Sanders D. Korenman

*Assistant Professor:* Sheila D. Ards; Ragui Assaad; Deborah Levison; Thomas F. Luce

*Other:* Zbigniew M. Bochniarz; Harry C. Boyte; William A. Diaz; Charles B. Finn; Marsha A. Freeman; Barbara L. Lukermann; Cynthia L. Myntti

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Public Affairs: M.A. (Plan B only); Planning: M.Plan. (Plan B only); Science and Technology Policy: M.S. (Plan A only).

**Curriculum**—The master of arts (M.A.) program in public affairs provides a broad-based education that recognizes the variety of experiences, interests, and skills that students bring to their graduate studies. Beyond required skills courses, students tailor their program to fit their interests and career goals. The program offers primary and secondary concentrations so that students may strengthen their skills in management, policy analysis, or planning or deepen their knowledge in substantive issue areas, or both.

The master of planning (M.Plan.) program is a professional degree designed to train students for a broad range of planning positions in the United States and abroad. The program is accredited and recognized by the Planning Accreditation Board of the Association of the Collegiate Schools of Planning and the American Institute of Certified Planners. The program develops key skills and knowledge needed by planners, including policy, resource allocation, regulatory, and project management and operations planning.

The master of science (M.S.) program in science and technology policy provides students versed in a particular scientific or technical discipline with the social science skills necessary for analyzing the public policy implications of science- and technology-related questions. The program develops an understanding of the contribution of science and technology to economic growth and development, as well as a technical understanding of the impact of public and private policy strategies on humans and the environment. This expertise is essential for sound public sector decision making.

**Prerequisites for Admission**—The core curriculum for all three degrees assumes a knowledge of intermediate microeconomics and college-level algebra. Familiarity with the American political system is also recommended. Applicants with deficiencies may be admitted with the understanding that these deficiencies must be removed before enrollment. Special remedial courses in introductory microeconomics and quantitative methods are offered in the five weeks before the beginning of fall quarter. M.S. program applicants are expected to have undergraduate training in the biological or physical sciences or engineering.

**Special Application Requirements**—A statement of purpose and three letters of recommendation evaluating the applicant's potential for graduate study in public affairs should be sent directly to the Hubert H. Humphrey Institute of Public Affairs. All applicants must submit Graduate Record Examination scores. Admission is in fall quarter only. Complete applications must be postmarked by January 15 to ensure they are reviewed for fall admission and initial financial aid offers. Applications postmarked after January 15 are reviewed on a space-available basis.

**Master's Degree Requirements**—In each of the three degree programs, students complete a minimum of 64 graduate credits; for the M.S. degree, 16 of those credits are thesis credits. The three programs share a common set of core courses that covers fundamental knowledge and skills in politics, organizations, policy analysis, microeconomics, planning, and quantitative methods. These skills are required in nearly all public affairs careers. The core courses make up 24 credits of the M.A. and M.Plan. programs; the M.S. program has a modified core of 20 credits.

In addition to the core courses, M.A. and M.Plan. students take a minimum of 18 credits in a primary concentration and a minimum of 12 credits in a secondary concentration. An arranged internship of at least three months full-time, a Plan B paper, and a final oral examination are also required. The primary concentration for M.Plan. students is planning.

For the M.S. degree, in addition to the core courses, students take a minimum of 18 credits in a primary concentration and a minimum of 10 credits in a secondary concentration. A Plan A master's thesis is also required.

**Dual Degrees**—Dual degrees, consisting of a degree in public affairs or planning taken concurrently with a degree in law (J.D.), social work (M.S.W.), or political science (Ph.D.), are available. Applicants must submit separate applications to the two programs.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—For the master's degree, students complete at least 9 credits chosen from core courses or from a field of concentration.

For the doctoral degree, students complete at least 18 credits chosen from core courses and a field of concentration.

**For Further Information and Applications**—Contact the Director of Admissions, Hubert H. Humphrey Institute of Public Affairs, University of Minnesota, 225 Humphrey Center, 301 19th Avenue South, Minneapolis, MN 55455 (612/625-9505; <http://www.hhh.umn.edu>).

ScTP 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

PA 5001. Politics, Planning, and Decision Making. (4 cr; prereq PA or planning or sci and tech policy major or public hlth student or #) Boyte, Kenney  
Overview of policy process. Section 1: Agendas, bureaucratic politics, institutional analysis, implementation, and legal issues in public policy. Section 2: Planning and public decision making, including types of planning (policy, regulatory, budgetary, program, project) and planning processes. Section 3: Public philosophy, including classic concepts of public life, republican tradition, theories of public world and power, and concepts of political arts. All sections address ethics. Students take one section.

PA 5002. Planning and Management of Organizational Relations. (4 cr; prereq PA or planning or sci and tech policy major or public hlth student or #) Bryson, Diaz  
Overview of management of organizations and organizational behavior, including personnel management, conflict and negotiation, strategic planning, institutional design, and overall structure of public and non-profit organizations. Students organized into consulting teams to work with government and non-profit agencies to solve an organizational problem. Examination of real-world cases.

PA 5010. Intermediate Microeconomic Theory. (3 cr; prereq Econ 1101 or equiv, PA or planning or sci and tech policy major or public hlth student or #) Emphasizes microeconomic behavior, including utility theory, income and substitutions effects, pareto efficiency, and externalities.

PA 5011. Policy Analysis I: Applied Microeconomics for Policy Analysis. (4 cr; prereq intermediate microeconomics, PA or planning or sci and tech policy major or public hlth student or #) Brandl, Kudrle, Myers  
"Market failure" concepts. Overview of public finance. Cost-benefit analysis and other economic topics.

PA 5012. Policy Analysis II. (4 cr; prereq 5011, PA or planning or sci and tech policy major or public hlth student or #) Archibald, Hoenack, Korenman  
Microeconomic analysis, including public choice theory, economics of public sector, and market and nonmarket remedies. Application to specific policy problems.

## GRADUATE PROGRAMS

PA 5021. Quantitative Methods in Public Affairs and Planning I. (4 cr; prereq PA or planning or sci and tech policy major or public hlth student or #) Ards, Levison, Luce  
Basic statistical tools for empirical analysis in evaluation of public policy alternatives. Frequency distributions, descriptive statistics, elementary probability; binomial and normal distributions; estimation and hypothesis testing; analysis of variance; and introduction to simple and multiple regression and correlation. Quantitative analysis of data sets augment problem sets using University's Microcomputer Lab.

PA 5022. Quantitative Methods in Public Affairs and Planning II. (4 cr; prereq planning or sci and tech policy major or public hlth student or #) Assaad, Kleiner, Kudrle  
Advanced statistical methods and hypothesis testing. Regression analysis, bivariate and multivariate models and assumptions behind them, and problems using these models when such assumptions are not met; planning methodologies.

PA 5101. Intergovernmental Relations. (3 cr; prereq grad or public hlth student or adult spec or #) Jernberg, Luce  
Evolution of modern federal system of intergovernmental relations in United States. Comparisons with other federal nations. Administrative, fiscal, policy issues and problems. Impact of changes and proposals for change on operation and capacities of national, state, and local government units.

PA 5102. Legal Environment of Public Affairs. (3 cr; prereq grad or public hlth student or adult spec or #)  
Legal context of public policy and decision making. Role of courts in public participation, policymaking, and administration. Legal reasoning and use of law and legal resources in resolving policy issues and managing administrative processes.

PA 5111. Management of Public and Nonprofit Organizations. (3 cr; prereq grad or public hlth student or adult spec or #)  
Applying organizational and behavioral theory to management problems. Analysis of organizational effectiveness; strategies of institutional design and change; selection, training, motivation, control, evaluation, and reward of organization members; organizational leadership; techniques for improving public sector productivity, job satisfaction, quality of work life.

PA 5112. Organizational Design and Change. (3 cr; prereq 5002, grad or public hlth student or adult spec or #) Light  
Key concepts and specific change techniques. Public sector, nonprofit, and for-profit organizations. Single organization and inter-organizational networks.

PA 5113. Public Services Redesign. (3 cr; prereq grad or public hlth student or adult spec or #) Brandl  
Theory, strategy, politics, and some practical mechanics required to adapt public service system given constraints on resources and continuing pressure for effectiveness and equity. In-class and out-of-class interviews of persons involved in redesign.

PA 5114. Conflict Management: Theory and Practice. (3 cr; prereq grad or public hlth student or adult spec or #)

Integrates current theory with application models of interpersonal, group, organizational, and systemic conflict. Phases of negotiation and theory behind negotiation process within settings of interpersonal conflict, managerial mediation, large-group mediation, and alternatives for dispute resolution within and among corporate or organizational systems, e.g., mini-trials and summary jury trials.

PA 5121-5122†. Public Budgeting I-II. (4 cr per qtr; prereq grad or public hlth student or adult spec or #; sequence must be taken in same academic yr) Brandl

5121: Development of macroeconomic policy and institutions; fiscal processes and theory applied to national, state, and local government; relationship of fiscal and monetary policy to operating and capital budgets; problems of equity, efficiency, impact on sectors of economy of tax, budget, and monetary policies. 5122: Operating and capital budgets and budget processes in legislative and executive branches of federal, state, and local government; program planning evaluation and administration; techniques of budget and program analysis; use of budget as policy and management tool; analysis of fund flows within and among governments.

PA 5123. Financial Management in Public and Nonprofit Organizations. (3 cr; prereq grad or public hlth student or adult spec or #) Stevens  
Design, installation, and use of accounting and control systems in public and nonprofit agencies. Public accounting standards and practices. Financial administration. Debt management. Controllership and post auditing. Financial reporting. Contract and procurement management systems.

PA 5125. State and Local Public Finance. (3 cr; prereq grad or public hlth student or adult spec or #) Luce

Analysis of management, efficiency, and equity concerns associated with primary financial instruments used by U.S. state and local governments. Property, income, and sales taxation; user fees; debt instruments; tax increment financing; exactions; impact fees; intergovernmental grant systems. Emphasizes interstate comparisons of institutional arrangements and relationships between financing choices and public goals in different policy areas.

PA 5191, 5192, 5193, 5194, 5195, 5196, 5197, 5198, 5199. Topics in Public and Independent Sector Management. (3 cr per qtr; prereq grad or public hlth student or adult spec or #)  
Analysis of selected topics, e.g., public personnel policy and labor relations, affirmative action policy, compensation systems, services redesign, local administration, administrative support systems, operations management, procurement policy, negotiation and conflict resolution.

PA 5200. Introduction to Planning. (3 cr; prereq grad or public hlth student or adult spec or #) Lukermann

Concepts and issues in planning as a profession. Historical development of planning as a public activity; linkages to design professions and politics; organization and role of planning in public agencies and private organizations.

PA 5201. Planning Theory. (4 cr; prereq grad or public hlth student or adult spec or #) Bolan  
Theory of planned action. Philosophical roots of planning. Models of planned change. Planning theory and practice.

PA 5211. Group Techniques in Public Affairs and Planning. (4 cr; prereq grad or public hlth student or adult spec or #) Bryson  
Nature, role, uses, and limitations of group techniques in public affairs and planning; specific techniques. Interorganizational focus.

PA 5221. Law and Urban Affairs. (3 cr; prereq grad or public hlth student or adult spec or #)  
Law's role in local government services, urban development, land use, and quality of life.

PA 5230. Strategic Planning and Management. (3 cr; prereq grad or public hlth student or adult spec or #)  
Strategy formulation, adoption, and implementation in government and nonprofit agencies. Agency strengths and weaknesses, external opportunities and threats, including stakeholder management. Case examples.

PA 5231. Strategy and Tactics in Project Planning. (3 cr; prereq grad or public hlth student or adult spec or #)  
Effect of goals and contextual factors on planning. Appropriate strategic and tactical choices to make during planning process; case examples of planning for public programs, projects, products, or services.

PA 5251. Environmental Planning. (4 cr; prereq grad or public hlth student or adult spec or #)  
Relation among natural resources, ecology, and urban development; legal and regulatory context of environmental regulation; methods of environmental impact analysis.

PA 5252. Planning and Institutional Design. (3 cr; prereq grad or public hlth student or adult spec or #) Bolan  
Underlying elements of institutional dynamics; their impact on private and public decision making in economic, social, and political domains. Institutional influences on public policy, public planning, and planned social change.

PA 5291, 5292, 5293, 5294, 5295, 5296, 5297, 5298, 5299. Topics in Planning. (3 cr per qtr; prereq grad or public hlth student or adult spec or #)  
Analysis of topics, e.g., national urban policy, planning in post-industrial society, industrial policy, and public facility, telecommunications, social, and national economic planning. Workshops involve client projects.

PA 5301. Population and Policy in Developing Countries and the United States. (4 cr; prereq grad or public hlth student or adult spec or #) Levison  
Population growth and environment; mortality; diverse perspectives on nonmarital fertility, marriage, divorce, and cohabitation; cultural differences in family structure; aging. Basic demographic measures and methodology.

PA 5310. Policy and Evaluation Research. (3 cr; prereq grad or public hlth student or adult spec or #) Eustis  
Alternative frameworks for understanding policy and evaluation research. Measurement, experimental design, survey research, evaluation research, fieldwork. Studies critiqued. Emphasizes use of findings.

PA 5391, 5392, 5393, 5394, 5395, 5396, 5397, 5398, 5399. Topics in Policy Analysis. (Cr ar; prereq grad or public hlth student or adult spec or #)  
Advanced work in application of policy analysis techniques to complex policy problems.

PA 5401. Introduction to Social Policy. (3 cr; prereq grad or public hlth student or adult spec or #) Ards  
Public policies regarding satisfaction of human needs, e.g., health, education, employment, day care, and housing. Organizational framework, both public and private, for income transfer and provision of services. Historical and political context.

PA 5413. Seminar: Aging and Disability Policy. (3 cr; prereq grad or public hlth student or adult spec or #) Eustis  
Analysis of major issues in fields of aging and disability.

PA 5415. Economic and Demographic Aspects of Aging. (4 cr; prereq intro economics, grad or public hlth student or adult spec or #) Korenman  
Economic analysis of problems, challenges, and opportunities raised by an aging population in context of contemporary health, social, and economic policy debates.

PA 5422. Child Development and Social Policy. (3 cr; prereq grad or public hlth student or adult spec or #)  
How developmental and conceptual orientations affect policies concerning children and families. Developmental, psychological, and social research used to formulate effective policy for development of children and youth. Demographic, historical, and social trends that underlie assumptions driving policies directed at women and children.

PA 5430. Labor Policy. (3 cr; prereq 5021 or equiv, grad or public hlth student or adult spec or #) Kleiner  
Analysis of public policies regarding employment, unions, and labor markets. Public programs affecting wages, unemployment, training, worker mobility, security, and quality of work life. Policy implications of changing nature of work.

## GRADUATE PROGRAMS

PA 5432. Poverty and Public Policy. (4 cr; prereq grad or public hlth student or adult spec or #; familiarity with economics and statistics recommended) Korenman

Definitions, causes, and remedies of poverty. Past and current policies responding to poverty; political and economic feasibility of alternatives, emphasizing U.S. policy and comparisons to developing and other developed countries.

PA 5441. Survey of Women and Public Policy in the United States. (4 cr; prereq grad or public hlth student or adult spec or #) Kenney

The gendered nature of public policy: historical perspective on policies on welfare, unwed motherhood, and protective legislation. Focuses on employment discrimination to illustrate how law shapes public policies. How political systems shape feminist movements and their strategies.

PA 5442. Seminar on Women and Public Policy. (3 cr; prereq grad or public hlth student or adult spec or #) Kenney

Uses social movement literature on second wave feminism to examine feminist organizations. Recurring issues and conflicts within organizations and movements examined through comparative reading on Latin America, Eastern Europe, Britain, Italy, and Minnesota. Students write case study.

PA 5451. Racial Inequality and Public Policy. (4 cr; prereq grad or public hlth student or adult spec or #)

Historical roots of racial inequality in United States; current economic consequences; public policy developments since 1980.

PA 5490. Topics in Social Policy. (4 cr; prereq grad or public hlth student or adult spec or #)

PA 5491, 5492, 5493, 5494, 5495, 5496, 5497, 5498, 5499. Topics in Social Policy. (3 cr per qtr; prereq grad or public hlth student or adult spec or #)

Advanced analysis of topics, e.g., juvenile justice, underclass issues, comparable worth policy, redesign of services, healthcare cost containment.

PA 5501. Economic Development I. (4 cr; prereq grad or public hlth student or adult spec or #) Schuh

Sources of economic growth, two-sector growth models, agricultural development, import substitution industrialization, technology and income distribution, population, migration and human development, development and international relations.

PA 5502. Economic Development II. (4 cr; prereq grad or public hlth student or adult spec or #) Assaad

Development theory and practice; global, national, and regional levels of analysis. Development and environment, women and development, location of economic activity, deindustrialization and service economy, industrial policy and changing organization of work.

PA 5511. Community Economic Development. (3 cr; prereq grad or public hlth student or adult spec or #) Citizen empowerment movement, emphasizing smaller cities and towns, rural and regional issues, and neighborhoods. Community social systems and development, economic development strategies, tools for community analysis, and structural models of community change.

PA 5522. Development Planning and Policy. (4 cr; prereq 5022, 5501, 5502 or equiv or grad or public hlth student or adult spec or #) Assaad Assumptions and techniques at national, regional, and project levels. Macroeconomic accounting and modeling, input-output analysis and social accounting matrices, project planning and cost-benefit analysis.

PA 5591, 5592, 5593, 5594, 5595, 5596, 5597, 5598, 5599. Topics in Economic and Community Development. (Cr ar; prereq grad or public hlth student or adult spec or #) Advanced analysis of topics, e.g., specific client-related projects, Third World development, vitalization of distressed communities, industrial policy, capital markets, community-based economic development, neighborhood redevelopment, subsidies, and incentives.

PA 5601. Land Use. (4 cr; prereq grad or public hlth student or adult spec or #) Lukermann

Physical and spatial basis for community and regional development; role of public sector in guiding private development processes. Urban settlements; applied case studies examining public regulatory frameworks.

PA 5602. Metropolitan Analysis: Population and Housing. (4 cr; prereq grad or public hlth student or adult spec or #)

Urban systems and metropolitan areas, structure and growth; daily and simulated urban systems; metropolitan dynamics; social area analysis; transportation systems; travel behavior; land use; retail structure change.

PA 5603. Metropolitan Analysis II. (4 cr; prereq grad or public hlth student or adult spec or #) Adams

Urban systems and metropolitan areas, structure and growth; daily and simulated urban systems; metropolitan dynamics; social area analysis; transportation systems; travel behavior; land use; retail structure change. Neighborhood transition: conflicts in housing, location of facilities, urban renewal.

PA 5604. North American Cities. (4 cr; prereq grad or public hlth student or adult spec or #)

Emergence of towns and cities in North America; urban economy and its locational requirements, past and present; central place theory; comparisons of city systems in capitalist, socialist, and developing areas; structure and change of land used inside urban areas.

PA 5611. Housing Policy. (3 cr; prereq grad or public hlth student or adult spec or #)

Role of American national, state, and local governments in financing, control, taxation, and construction of housing.

PA 5621. Private Sector Development. (3 cr; prereq grad or public hlth student or adult spec or #) Role of various disciplines in the development community; investment objectives; effects of regulation. Development process from private participant's perspective.

PA 5622. Managing Urban Growth and Change. (4 cr; prereq grad or public hlth student or adult spec or #) Luce  
Theory and practice of promoting and controlling economic growth and change in urban areas. Critical examination of economic development and growth management tools available to state and local policymakers and historical context of their use in the United States; legal, social, and economic constraints in implementing local strategies; complex problems created by interactions among economic, social, and demographic trends in U.S. metropolitan areas.

PA 5664. Urban Geographic Information Systems and Analysis. (4 cr, §Geog 5564; prereq grad or public hlth student or adult spec or #) McMaster

PA 5691, 5692, 5693, 5694, 5695, 5696, 5697, 5698, 5699. Topics in Land Use and Human Settlements. (3 cr per qtr; prereq grad or public hlth student or adult spec or #) Analysis of large-scale planned communities, agricultural preservation, historical preservation, infrastructure planning and programming, and urban transportation policy.

PA 5701. Science and State. (4 cr; prereq grad or public hlth student or adult spec or #) Relationship of science and technology to ideological bases of society; technology's significance to policy process; analysis of society's institutions for governing technologies.

PA 5711. Energy Policy. (4 cr; prereq grad or public hlth student or adult spec or #) Abrahamson  
Role of energy in contemporary societies; means to supply energy services; life-cycle costing; energy supply and use patterns in industrialized and nonindustrialized countries; fuel cycles, environmental and social impacts, resource base, and relationship to energy policy options. Primarily lectures and readings.

PA 5713. Energy Regulation: Analysis and Advocacy. (3 cr; prereq grad or public hlth student or adult spec or #)  
Regulated utilities, including electric, telecommunications, and natural gas. Prepares students to participate in changing regulatory climate as analysts, managers, activists, and advocates.

PA 5721. Environmental Policy. (4 cr; prereq grad or public hlth student or adult spec or #) Abrahamson  
Major environmental issues and national and international responses; growing human enterprise; the changing climate, atmosphere, and hydrosphere; toxic and radioactive contamination; loss of biodiversity. Strategies for sustainable development.

PA 5731. Technology Policy. (4 cr; prereq grad or public hlth student or adult spec or #) Archibald  
Methodologies for exploring and assessing role of policy in development, diffusion, and adoption of technologies nationally and internationally; means to evaluate impacts of technology policy on sustainable economic growth and development, including social costs and benefits. Technological lock-in and increasing returns.

PA 5732. Science, Technology, and International Affairs. (3 cr; prereq grad or public hlth student or adult spec or #) Keller  
How science and technology directly affect global economic, political, and social environments; consequent alterations in international negotiation agendas and practical approaches available to nations.

PA 5741. Economics of Environmental and Resource Policy. (4 cr; prereq grad or public hlth student or adult spec or #) Archibald  
Develops appropriate economic concepts, methodologies, and policy mechanisms and applies them to environmental and natural resource problems. Social-benefit cost analysis, cost-effective policy mechanisms for pollution control, policies for renewable and nonrenewable resource use.

PA 5791, 5792, 5793, 5794, 5795, 5796, 5797, 5798, 5799. Topics in Technology, Energy, and Environmental Policy. (3 cr per qtr; prereq grad or public hlth student or adult spec or #) Topics include hazardous waste, energy efficiency, nuclear technologies, atmospheric carbon dioxide, water policy, telecommunications and information technology, risk assessment.

PA 5801. U.S. Foreign Policy: Process and Analysis. (4 cr; prereq Econ 3101, grad or public hlth student or adult spec or #) Kudrle  
Introduction to essential problems of economic and political relations among states, overview of U.S. foreign policy process. Topics include national security policy and foreign economic policy. Domestic economic context.

PA 5820. The Multinational Corporation. (4 cr; prereq intermediate microeconomics, grad or public hlth student or adult spec or #) Kudrle  
Economic, political, social, and legal significance of multinational corporation; major policy options open to both individual and international bodies.

PA 5830. U.S. Foreign Economic Policy Analysis. (4 cr; prereq Econ 1001, Econ 1002 or #, grad or public hlth student or adult spec or #) Kudrle  
Policy problems facing U.S. decision makers in areas of trade, investment, aid, and monetary affairs; close attention paid to domestic political context.

PA 5891, 5892, 5893, 5894, 5895, 5896, 5897, 5898, 5899. Topics in Foreign Policy. (Cr ar; prereq grad or public hlth student or adult spec or #) Analysis of such topics as management of international organizations, practice of diplomacy, management of foreign posts, and reexamination of disarmament strategies.

## GRADUATE PROGRAMS

PA 5901!, 5902!, 5903. Computer Applications in Public Affairs. (1 cr per qtr; prereq grad or public hlth student or adult spec or #) Finn  
Comprehensive introduction to computer systems and applications as used in fields of public affairs.

PA 5966. Application of Mediation Methods. (3 cr; prereq grad or public hlth student or adult spec or #)  
Training in specific skills and expectations needed to mediate a dispute.

PA 8191, 8192, 8193, 8194, 8195, 8196, 8197, 8198, 8199. Seminar/Workshop: Advanced Topics in Public and Independent Sector Management. (1-3 cr per qtr)  
Analysis of selected topics, e.g., public personnel policy and labor relations, affirmative action policy, compensation systems, services redesign, local administration, administrative support systems, operations management, procurement policy, negotiation and conflict resolution.

PA 8291, 8292, 8293, 8294, 8295, 8296, 8297, 8298, 8299. Advanced Topics in Planning. (3 cr per qtr)  
Advanced analysis of topics, e.g., national urban policy, planning in post-industrial society, industrial policy, and public facility, telecommunications, social, and national economic planning. Workshops involve client projects.

PA 8300. Case Studies in Policy Analysis. (3 cr; prereq 5011, 5012) Brandl  
Topics in microeconomics applied to systems problems of government. Market and nonmarket resource allocation; cost-effectiveness and cost-benefit analysis. Case method employed.

PA 8321. Analysis of Discrimination. (4 cr; prereq 5011 or #)  
Skills-based course; introduces students of policy analysis and applied social sciences to tools of measuring and detecting discrimination in market and non-market contexts. Applying labor econometric tools and research on race, ethnicity, and gender relations to problems of discrimination.

PA 8391, 8392, 8393, 8394, 8395, 8396, 8397, 8398, 8399. Workshop/Seminar: Advanced Topics in Policy Analysis. (Cr ar)  
Advanced work in application of policy analysis techniques to complex policy problems.

PA 8426. Human Resources and Organizational Performance. (4 cr; prereq 5022, macroeconomics)  
Impact of human resources policies and practices in organizational productivity and effectiveness. Role of government, unions, and private sector institutions in organizational effectiveness.

PA 8491, 8492, 8493, 8494, 8495, 8496, 8497, 8498, 8499. Workshop/Seminar: Advanced Topics in Social Policy. (3 cr per qtr)  
Advanced analysis of topics, e.g., juvenile justice, underclass issues, comparable worth policy, redesign of services, healthcare cost containment.

PA 8591, 8592, 8593, 8594, 8595, 8596, 8597, 8598, 8599. Workshop/Seminar: Advanced Topics in Economic and Community Development. (Cr ar)  
Advanced analysis of topics, e.g., specific client-related projects, Third World development, vitalization of distressed communities, industrial policy, capital markets, community-based economic development, neighborhood redevelopment, subsidies, and incentives.

PA 8691, 8692, 8693, 8694, 8695, 8696, 8697, 8698, 8699. Workshop/Seminar: Advanced Topics in Land Use and Human Settlements. (3 cr per qtr)  
Analysis of large-scale planned communities, agricultural preservation, historical preservation, infrastructure planning and programming, and urban transportation policy.

PA 8701, 8702, 8703, 8704, 8705, 8706. Technology, Energy, and Environmental Policy: Plan B Seminar. (1 cr per qtr; prereq 1st-yr PA grad student for 8701-8703, 2nd-yr PA grad student for 8704-8706)  
Required of public affairs M.A. students with primary concentration in technology, energy, and environmental policy.

PA 8791, 8792, 8793, 8794, 8795, 8796, 8797, 8798, 8799. Advanced Topics in Technology, Energy, and Environmental Policy. (3 cr per qtr) Abrahamson, Geesaman  
Topics include hazardous waste, energy efficiency, nuclear technologies, atmospheric carbon dioxide, water policy, telecommunications and information technology, risk assessment.

PA 8891, 8892, 8893, 8894, 8895, 8896, 8897, 8898, 8899. Workshop/Seminar: Advanced Topics in Foreign Policy. (Cr ar)  
Analysis of such topics as management of international organizations, practice of diplomacy, management of foreign posts, and reexamination of disarmament strategies.

PA 8901. Plan B Paper Tutorial. (4 cr; prereq PA or planning major, 5001, 5002, 5011, 5012, 5021, 5022; S-N only)  
Supervised research and writing for completing Plan B paper.

PA 8910. Independent Study. (1-3 cr [may be taken only once toward PA or planning master's]; prereq #)  
Individual reading or research project.

## Public Health (PubH)<sup>1</sup>

*Professor:* Michael L. Baizerman; Robert W. Blum; Judith E. Brown; Judith M. Garrard; Robert W. Jeffery; Michael D. Resnick; R. Ashley Robinson; Robert L. Veninga

*Associate Professor:* Lester E. Block, *director of graduate studies*; Mila A. Aroskar; Ann W. Garwick; Susan G. Gerberich; Barbara J. Leonard; Joan M. Patterson; Barbara A. Spradley; Carolyn L. Williams

*Adjunct Associate Professor:* Lee E. Schacht

*Assistant Professor:* Wendy L. Hellerstedt; Patricia M. McGovern; Marijo A. Wunderlich

**Course of Study**—Minor in public health, applicable to master's (M.A. and M.S.) and doctoral programs outside the School of Public Health.

**Curriculum and Minor Requirements**—Both the master's requirement of at least 12 graduate credits and the doctoral requirement of at least 21 graduate credits need to be taken from courses offered in the School of Public Health. The minor program is shaped to suit the particular needs and interests of the students with the proviso that a graduate-level course each in environmental health and in epidemiology be included. Suggested courses for this requirement include PubH 5151, PubH 5152, and PubH 5330. Alternative courses may be substituted with the approval of the public health adviser and director of graduate studies.

Courses for the minor program should be selected from among those offered in the School of Public Health in consultation with a faculty adviser assigned by the director of graduate studies in public health. Early planning is important, as public health courses frequently have prerequisites or enrollment limitations. Public health courses offered outside the School of Public Health may be taken with the approval of the public health adviser and director of graduate studies.

**Prerequisites for Admission**—Admission to the public health graduate minor is contingent upon prior admission to a master's or doctoral degree-granting program within the Graduate School. Students enrolled in graduate programs within the School of Public Health are not eligible for this minor.

**Special Application Requirements**—Students declaring a minor in public health should contact the director of graduate studies (DGS) in public health as early as possible. The DGS must approve the student's application *before* a minor program adviser(s) is assigned. Enrollment is contingent upon DGS approval and adviser assignment.

**Language Requirement**—None specific to the minor program.

**For Further Information and Applications**—Contact the Student Services Center, School of Public Health, University of Minnesota, Box 819 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (612/626-3500 or 1/800/774-8636; fax 612/626-6931; e-mail sph-uofm@greg2.sph.umn.edu; <http://www.sph.umn.edu>).

PubH 5003. Fundamentals of Alcohol and Drug Abuse. (2 cr, §5023; prereq educ major or #) Rothenberger Lecture, discussion, and special readings on scientific, sociocultural, and attitudinal aspects of alcohol and other drug abuse problems. Incidence, high risk populations, prevention, and intervention.

PubH 5004. Field Instruction in Public Health. (Cr ar; prereq #) Generalized, function- or discipline-oriented community experience under academic and professional supervision. Applying acquired knowledge and skills to relevant health issues and problems.

PubH 5005.\* Topics in Public Health. (Cr ar; prereq #) Directed instruction. Selected readings in public health with discussion based on these readings.

PubH 5010. Public Health Approaches to Aids. (3 cr; prereq upper div or grad-level student or #) Rothenberger Survey of HIV infection from public health perspective with emphasis on intervention.

PubH 5017. Culture and Health Behavior. (3 cr; prereq grad student or #) Williams For increasing cultural sensitivity regarding public health practice and individuals' health behaviors. Impact of cultural diversity on health behaviors. Etic (universal) and emic (culture-specific) approaches.

<sup>1</sup> *Inquiries concerning coursework leading to the master of public health or master of healthcare administration degree should be addressed to the Student Services Center of the School of Public Health, University of Minnesota, Box 819 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455. Applicants wishing to pursue an M.S. or Ph.D. degree in biostatistics; environmental health; epidemiology; health services research and policy (M.S.); or health services research, policy and administration (Ph.D.) should refer to the separate listings for these programs in this bulletin.*

## GRADUATE PROGRAMS

PubH 5020. Public Health Social Work Integrative Seminar. (3 cr, §SW 5020; prereq grad student in public hlth or social work or dual-degree MSW/MPH student or #) Bracht  
Integrated, synthesized public health social work philosophy; roles, function, knowledge, skills for practical application to major contemporary social health problems. Expansionistic, social epidemiological, conceptual problem analysis, and community intervention.

PubH 5022. Personal and Community Health. (2 cr, §5023; prereq educ major or #) Rothenberger  
Fundamental principles of health conservation and disease prevention.

PubH 5023. Basic Concepts in Personal and Community Health. (4 cr, §5022; prereq educ major or #) Rothenberger  
Scientific, sociocultural, and attitudinal aspects of communicable and degenerative diseases, environmental and occupational health hazards, and alcohol and drug problems. Role of education in health conservation, disease control, and drug abuse.

PubH 5026. Psychosocial Approaches to Health Behavior Change. (3 cr; prereq for fall qtr: community hlth educ major or #; for spring qtr: student in public hlth or grad student in epi or HSRP or HSRP&A or biostats or environ hlth or #) Finnegan, Lytle  
Foundations of community health education, with emphasis on individual behavior change.

PubH 5027. Community and Environmental Approaches to Health Behavior Change. (3 cr; prereq 5026, community hlth educ student or #) Wagenaar  
Socioenvironmental factors influencing health-related behavior. Role of groups, institutions, and social structures in encouraging healthy or unhealthy behavior. Interventions to improve health behavior through changes in social environment; economic, social, and political structures and practices creating barriers to effective interventions.

PubH 5028. Organizational and Institutional Settings of Community Health Education. (3 cr; prereq 5026, 5027, community hlth educ student or #) Wolfson  
Organizational and institutional factors that influence how community health interventions are conducted. Opportunities and constraints within which interventions are conducted.

PubH 5030. Prevention of High-Risk Behavior Among Adolescents. (3 cr; prereq community hlth educ or public hlth nutrition or epi MPH or epi grad student or #; 2nd-yr master's level and grad behav sci course recommended) Perry  
Definitions and etiology of high risk behaviors among adolescents; intervention programs. Review of current literature. Students design prevention program overview based on theory and etiological data using health education/behavior change methods.

PubH 5035. Applied Research Methods. (4 cr; prereq 5414 or 5450 or equiv, 5806 or 5852 or equiv, community hlth educ or public hlth nutrition student or #; 5420 recommended) French  
Complements MPH project work using forms, questionnaires, and interviews. Literature searching; scale construction; item analysis; data coding, entry, and analysis; report writing. Using computer software package for questionnaire development and data analysis.

PubH 5040. Dying and Death in Contemporary Society. (3 cr, §Hlth 5402, §Mort 5040, §HSU 5040; prereq hlth sci major or public hlth grad student or educ sr or mort sci major or #) Rothenberger  
Concepts, attitudes, ethics, and lifestyle management related to dying, death, grief, and bereavement. Emphasis on preparing community health and helping professionals and educators for educational activities in this area.

PubH 5049. Legislative Advocacy Skills for Public Health. (4 cr; prereq 5398, #) Forster  
Introduction to state legislature as arena for public health practice; develops skills necessary to operate in that arena. Analyzes emergence, development, and resolution of legislative issues of public health importance.

PubH 5061. Prevention and Control of Alcohol and Drug Problems. (3 cr; prereq public hlth student or #) Wolfson  
Theory and practice. Approaches include education, citizen action, and public policy.

PubH 5097. Topics: Selected Readings. (Cr ar; prereq hlth sci grad student)  
Topic in health education not covered in available courses.

PubH 5150. Topics: Environmental and Occupational Health. (Cr ar; prereq #)  
Selected readings and discussions of problems in environmental and occupational health.

PubH 5151. Environmental Health. (3 cr; prereq public hlth student or #) Greaves  
Methods for promoting human health and comfort by controlling environment.

PubH 5152. Environmental Health. (2 cr) Vesley  
General principles of environmental health relating to macro and micro environments and products consumed or used by people.

PubH 5154. Practicum in Environmental and Occupational Health. (1-6 cr, §Nurs 5882; prereq environ hlth major or nursing grad student)  
Assignments working with organizations on environmental and occupational health concerns, under joint supervision of faculty adviser and organization staff.

PubH 5155. Issues in Environmental and Occupational Health. (2 cr, §Nurs 5883; prereq #) Olson  
The field, current issues, and principles and methods of health protection. Independent field visits to observe, review, and analyze environmental and occupational health programs.

PubH 5156. Environmental Health Survey. (3 cr; prereq environ hlth major) Vesley  
Survey of environmental health programs (macro- and microenvironment, products used and consumed by people) and controversial issues associated with these programs.

PubH 5158. Health Risk Evaluation. (3 cr; prereq environ hlth major or #) Sexton  
General principles of health risk assessment and management: environmental pollutants; public domain and workplace, legislation and regulations.

PubH 5159. Seminar: Environmental Health. (2 cr; prereq environ hlth student)

PubH 5166. Employee Health Services and Cost Containment. (3 cr, \$Nurs 5884; prereq occupational hlth nursing student or nursing grad student) McGovern  
Trends in corporate health cost containment and their implications for planning and financing healthcare for employees and their families. Associated role development of occupational health nurse specialists.

PubH 5168. Theory and Practice of Occupational Health: Field Experience. (1 cr, \$Nurs 5885; prereq 5167 or Nurs 5680) Olson  
Arranged field experience, seminar. Applying occupational health and safety concepts.

PubH 5171. Environmental Microbiology. (4 cr; prereq MicB 3103 or #) Vesley  
Survival, dissemination, transportation, and significance of microorganisms in the environment; application of principles to environmental health problems.

PubH 5181. Air Pollution. (4 cr; prereq 2 yrs chem, general physics, calculus or #) Swackhamer  
Overview of current air pollution problems, sources of pollutants, gas phase and aerosol phase chemistry, fate of pollutants, and human health and materials effects.

PubH 5184. Measurement of Airborne Contaminants in Workplaces. (4 cr; prereq 5210, 5216 or #) Ramachandran, Vincent  
Lectures, lab, and field exercises involving calibration of field equipment for air contaminant analysis, inhalable and respirable aerosol mass sampling, dust counting and sizing, gas and vapor analysis, direct reading instruments, and sampling strategy.

PubH 5186. Environmental Chemistry. (3 cr; prereq general chem, organic chem or #) Swackhamer  
Air, water, and soil chemistry, emphasizing pollution; transport and behavior of pollutants; current topics.

PubH 5194. Injury Prevention in the Workplace, Community, and Home. (3 cr, \$5594) Gerberich  
Injury problems affecting public in workplace, community, and home; epidemiologic approach to strategies for prevention and control.

PubH 5195. Seminar: Safety in the Workplace. (1 cr, \$5595) Gerberich  
Hazard analysis and prevention and control of injuries to the worker.

PubH 5197. Topics: Injury Prevention in the Workplace, Community, and Home. (1-3 cr, \$5597; prereq #) Gerberich  
Selected projects: opportunity for students to pursue projects relevant to injury problems.

PubH 5201. Radiation Protection and Measurement. (2 cr) Barber  
Ionizing radiation sources, detection and measurement, protection principles, health implications.

PubH 5202. Radiation Laboratory. (1 cr; prereq 5201 or #5201) Barber  
Radiation lab for 5201.

PubH 5212. Ventilation Control of Environmental Hazards. (3 cr; prereq 5210 or #) Vincent

Theory and application of exhaust ventilation for controlling airborne environmental hazards. Principles of air movement and mixing, design of appropriate ventilation controls, and techniques for measuring and evaluating controls. For environmental health, engineering, and other students interested in industrial hygiene.

PubH 5216. Properties of Workplace Airborne Contaminants. (3 cr; prereq environ hlth major or grad student with physical sci or engineering or environmental sci background) Vincent  
Review of properties of aerosols and gaseous contaminants found in workplace atmospheres, exposure and health effects, monitoring, and ventilation for hazard control.

PubH 5218. Field Problems in Occupational Health. (3 cr, \$Nurs 5886; prereq 5210 or 5211, environ hlth major or nursing grad student or #) Olson  
Guided evaluation of potential occupational health problems; recommendations and design criteria for correction if indicated.

PubH 5221. Noise in the Workplace. (2 cr; prereq environ hlth major) Ward  
Nature of noise exposure in the workplace; physical description of sound and noise, measurement and dosimetry, possible ill-health effects (hearing loss), and control measures.

PubH 5233. Biological Safety. (2 cr; prereq #) Vesley  
Assessment of risk; primary barriers; lab design criteria; safety devices and equipment; personnel practices; sterilization and decontamination; lab animals; and shipping and disposal of biohazardous agents.

PubH 5239. Microbiology of the Human Environment: Seminar. (1 cr; prereq #) Vesley  
Topics of current research interest on infectious disease and injury prevention through environmental intervention.

PubH 5250. Environmental and Occupational Health Master's Project. (1-4 cr; prereq environ hlth major, #; S-N only)  
Directed study.

## GRADUATE PROGRAMS

PubH 5253. Introduction to Hazardous Waste Management. (3 cr) Thompson  
Review of roles of public and private sectors as generators, disposers, and regulators of hazardous wastes. Includes definitions, sources, transportation, handling, treatment, recovery, disposal, and public health implications.

PubH 5255. Hazardous Materials Management. (3 cr; prereq 5253 or equiv, master's student in div of environ and occupational hlth or #) Brosseau  
Proper management and use of hazardous materials. Overview of regulations concerning process safety, transport, air-water releases, hazard communication, and emergency response. Chemical properties and toxicity of hazardous materials, personnel protection, and air sampling techniques.

PubH 5261. General Environmental Toxicology. (3 cr; prereq environ hlth grad student or #, 1 yr each undergrad biol and chem; some biochem, organic chem, physiology recommended) Wattenberg  
Application of basic biochemical and physiological principles; assessment of potential health hazards; approaches to solution of problems.

PubH 5271. Occupational Epidemiology. (3 cr; prereq basic epi, biostats) Maldonado, Mandel  
Basic principles and concepts in ascertaining health effects in the workplace; review and discussion of strategies for identifying excess risk, evaluating strengths and weaknesses of research techniques, assessing bias and confounding.

PubH 5301. Perspectives: Interrelationships of People and Animals in Society Today. (2-3 cr, \$3301, \$CVM 3100, \$CVM 5100) Dunlop  
Social, economic, and health consequences of people/animal relationships, including issues such as pets and people sharing an urban environment, animal rights, and influence of differences within cultures regarding animal/human relationships.

PubH 5330. Epidemiology I. (4 cr; prereq public hlth or pharmacy or med school or nursing or dentistry or grad student or #)  
Basic epidemiologic principles applicable to infectious and noninfectious disease; host-agent-environment complex; factors underlying spread of infectious disease; lab applications of statistical and epidemiologic methods.

PubH 5333. Principles of Human Behavior I. (3 cr; prereq community hlth educ major or epi PhD student or #) Jeffery, Lando  
Theoretical perspectives on etiology and modification of health behavior in individuals and communities.

PubH 5335. Epidemiology and Control of Infectious Diseases. (3 cr; prereq epi MPH or epi grad student or #) Lifson  
Principles and methods. Strategies for disease control and prevention, including immunization. Relevance of modes of transmission of specific agents for disease spread and prevention. Public health consequences of infectious diseases at local, national, and international levels.

PubH 5336. Advanced Seminar in Infectious Disease Epidemiology. (1 cr; prereq 5330, 5335, #) Lifson  
Selected communicable diseases. How principles of infectious disease epidemiology are applied "in the real world" to contemporary or controversial issues, including developing prevention and control strategies.

PubH 5340. Epidemiology II: Strategies and Methods. (4 cr; prereq 5330, 1 biostats course or #) Arnett, Shahar  
Measures of disease occurrence, and strategies and design principles of etiologic and evaluative studies. Measurement problems, interactions, sensitivity and precision, validity and the need for data specification and control of variables.

PubH 5341. Epidemiology III: Interpretation of Data From Epidemiologic Research. (4 cr; prereq 5340, 5420, 5454, epi major or #) McGovern, Murray, Schreiner  
Analysis and interpretation of data, including use of standard computer packages.

PubH 5345. Epidemiologic Methods: Data Collection. (3 cr; prereq 5330, 5420, 5450, epi MPH major or #) Pirie  
Methods and techniques for collecting and managing epidemiologic research data, including practical aspects of sampling; response rates and bias; forms design; selecting and training interviewers; data preparation, entry, and cleaning; ethical issues in research.

PubH 5348. Writing Research Grants. (2 cr; prereq epi PhD or postdoc student or #) Luepker  
NIH-type grants. Mechanics of grant development and writing, principles of informed consent, budget development, grant review process, and funding source identification.

PubH 5363. Computer Applications in Epidemiology. (2 cr; prereq epi major or #) McGovern  
Epidemiological data collection and analysis with emphasis on microcomputer applications. Creation, maintenance, and analysis of a dataset; statistical power calculations. Software includes SAS, Epi Info, Egret, and Excel.

PubH 5370. Epidemiology of Alcohol and Other Drugs. (3 cr; prereq student in public hlth or pharmacy or med school or dentistry or grad student in epi or biostats or environ hlth or nursing or #) Wagenaar  
Population patterns regarding who uses which drugs, why they use them, and health consequences of alcohol and other drug use. Does not focus on treatment, care, rehabilitation, exploration of personal attitudes, or practices regarding alcohol or other drug use.

PubH 5379. Epidemiology Master's Project Seminar. (2 cr; prereq epi MPH or epi grad student)  
Required of epidemiology master's students. Present and discuss master's projects, which should be underway or near completion.

PubH 5381. Genetic Epidemiology. (4 cr; prereq 5330, 5414 or equiv, college coursework in genetics, hlth sci grad student or #) Sellers

Etiology, distribution, and control of diseases in groups of relatives and inherited causes of disease in populations. Associations (case-control family studies), concordance (twin studies), disease transmission (segregation analysis), and gene localization (gene mapping).

PubH 5383. Pathobiology of Human Diseases. (4 cr; prereq student in public hlth or med school or dentistry or pharmacy or grad student in epi or biostats or environ hlth or nursing or #) Crow  
Basic cell biology and pathology of human diseases. Immunology, infectious diseases, AIDS, cancer, hematology, diabetes, cholesterol, atherosclerosis, cardiovascular diseases, hypertension, nutritional diseases, pulmonary disorders, gastrointestinal disorders, liver diseases, and osteoporosis.

PubH 5384. Human Physiology. (4 cr; prereq epi MPH student or epi PhD student or #) Crow  
Basic human physiologic functions and mechanisms related to coronary heart disease, stroke, diabetes, exercise tolerance, and aging. Progressing from cellular function to organ function to coordinated body function. Consistency of internal environment, the need for homeostasis; adaptation to change, including chronic disease; energy use; integrated control systems; age and physiologic function.

PubH 5386. Public Health Aspects of Cardiovascular Diseases. (3 cr; prereq 5330, 5450 or equiv) Elmer, Folsom  
Evaluating population studies and trials on cardiovascular diseases; modifiable risk factors for coronary heart disease; preventing other types of heart disease.

PubH 5387. Cancer Epidemiology. (3 cr; prereq 5330, 5340 or #) Robison  
Epidemiologic aspects of cancer, including theories of carcinogenesis, incidence, site specific risk factors, and issues of cancer control and prevention.

PubH 5389. Nutritional Epidemiology. (3 cr; prereq 5330 or #) Elmer  
Methodologic issues of exposure to nutrient intakes, biological basis for nutrition and disease relationships, studies of specific chronic diseases and nutritional intake, and analytic issues related to designing and interpreting studies using nutritional measures.

PubH 5390. Smoking Intervention. (3 cr; prereq epi or community hlth educ major) Lando  
Impact of smoking on U.S. public health; overview of research on onset and prevention, factors maintaining dependence, cessation and intervention strategies, public health campaigns, public policies and second-hand smoking controversies, and international issues.

PubH 5391. Introduction to Behavioral Epidemiology. (3 cr; prereq student in public hlth or med school or dentistry or pharmacy or grad student in epi or biostats or environ hlth or nursing or #) Jones-Webb, Lando

Theoretical, measurement, and research issues in behavioral epidemiology. Life span patterns in developing, changing, and maintaining behaviors related to major chronic diseases. Risk-related behaviors from epidemiologic perspective, using concepts of prevalence, incidence, risk, and trends.

PubH 5393. Design and Analysis of Community Trials in Epidemiology. (4 cr; prereq 5341, 5454, epi MPH student or epi grad student or #) Murray

Design and analysis issues for epidemiologic studies evaluating effects of public health interventions applied at community level. Experimental and quasi-experimental designs and threats to validity that are important to these designs.

PubH 5394. Mass Communication and Public Health. (3 cr. \$Jour 5150; prereq credits in social or behavioral sci, PubH student or Jour grad student or #) Finnegan

Role, functions, and effects of mass media on public health; planned and unplanned effects; review of literature to understand how theories, models, and assumptions of mass communication research relate to public health.

PubH 5395. Obesity and Eating Disorders. (3 cr; prereq grad student or #) French, Jeffery  
Definition, measurement, and prevalence; social behavioral, physiological causes; health consequences; treatment, prevention.

PubH 5398. Public Health Policy as a Prevention Strategy. (3 cr; prereq epi or community hlth educ or public hlth nutrition major or #) Forster  
Philosophical, ethical, economic, political, and efficacy rationale for policy approach to prevention; historical and current application of prevention policy to public health problems.

PubH 5399. Topics in Epidemiology. (1-4 cr; prereq basic epi, biometry or #)  
One or more topics of current epidemiologic interest.

PubH 5404f. Introduction to Biostatistics and Statistical Decision. (4 cr; prereq HSRP&A student) Weckwerth

Variation; frequency distribution; probability; significance tests; estimation; trends; data handling; simple operations research applications. Statistical approach to rational administrative decision making. Lectures, lab exercises.

PubH 5409f. Biostatistics in Clinical Studies. (3 cr; prereq DDS or MD or DVM or PharmD or clinical nursing student) Keenan  
Introduction to statistical treatment of data from dental, medical, and veterinary research. Tabular, graphical, and numerical descriptive methods; random sampling; principles of statistical inference; confidence intervals; statistical tests of hypotheses using t and chi-square distributions. Interpretation of statistical analyses in clinical literature.

## GRADUATE PROGRAMS

PubH 5414f. Biostatistical Methods I. (4 cr, \$5450; prereq MPH or public hlth grad student or #) Le Basic quantitative methods for public health students, including tabular, graphical, and numerical descriptive methods; random sampling; principles of statistical inference; confidence intervals; statistical tests of hypotheses using t and chi-square distributions; interpretation of correlation and regression.

PubH 5415w. Biostatistical Methods II. (3 cr, \$5452; prereq grade of B or better in 5409 or 5414 or 5450, MPH or hlth sci grad student or #) Goldman Continuation of basic statistical methods, including correlation, regression, analysis of variance and non-parametric tests. Introduction to use of computer packages for data analysis.

PubH 5420f. Statistical Computing I: Using Statistical Packages. (2 cr; prereq 5414 or ¶5414 or 5450 or ¶5450, health sci student, # for undergrads) Jeffries Use of statistical computer package SAS for analysis of biomedical data. Data manipulation, description, and basic statistical analyses (t-tests, chi squares, simple regression).

PubH 5421w. Statistical Computing II: Advanced Computational and Graphical Methods. (3 cr; prereq 5464, grad student, C or FORTRAN or #) Carlin UNIX-Workstation-based computing and graphical methods for biostatistical analysis. Linear systems, numerical integration and differentiation, optimization, Monte Carlo methods, design and analysis of simulation studies. Familiarity with SAS and a high-level programming language (C or FORTRAN).

PubH 5422s. Statistical Computing III: Data Collection and Management. (3 cr; prereq 5420 or 5464, 5462) Connett, Neaton Data collection methods, forms design, and data entry methods for clinical trials and epidemiological studies. Data editing methods, database design, and statistical report generation using NOMAD and SAS.

PubH 5450f,w,s. Biostatistics I. (4 cr, \$5414; prereq Math 1111 or Math 1201, hlth sci student, # for undergrad) Jeffries, Kjelsberg, Thomas Descriptive statistics; Gaussian probability models; point and interval estimation for means and proportions; hypothesis testing, including t-tests and chi-square tests; regression and correlation techniques; one-way analysis of variance; applications in health sciences using output from statistical packages.

PubH 5452w. Biostatistics II. (4 cr, \$5415; prereq 5420, grade of B or better in 5450 or #) Jeffries Analysis of variance and multiple regression for biological and health science data; estimation, testing, and prediction; underlying assumptions; model selection; applications.

PubH 5454s. Biostatistics III. (4 cr; prereq 5452, 5420 or equiv with #) Grambsch Analysis of categorical data; emphasizes log-linear models and inferences from observational data. Methods and applications of logistic regression and survival analysis, including Cox's proportional hazards model.

PubH 5456s. Biostatistics Consulting Seminar. (3 cr; prereq 5462, 5464, biostats student or #) Goldman

Roles and responsibilities of biostatistician as consultant and collaborator in health science research. Interpersonal communication. Consulting models and settings. Formulation of analysis problem.

PubH 5462w. Clinical Trials I. (3 cr; prereq 5452 or ¶5452 or 5465 or ¶5465, biostats or epi student or #) Neaton

Introduction and methodology of randomized clinical trials; design issues, case examples; operational aspects; elementary statistical methods and application to follow-up studies in medicine and public health.

PubH 5464. Biostatistical Inference I. (4 cr, \$5450; prereq Stat 5131 or ¶Stat 5131, biostats student or #) Thomas Exploratory data analysis using SAS and S-Plus, ANOVA, and classical non-parametrics, multiple comparisons, and power and sample-size determinations.

PubH 5465w. Biostatistical Inference II. (4 cr, \$5452; prereq Stat 5132 or ¶Stat 5132, biostats student or #) Anderson Multiple regression, matrix notation, polynomials, diagnostics, splines, and ANOVA as regression.

PubH 5466s. Biostatistical Inference III. (4 cr, \$5454; prereq Stat 5133 or ¶Stat 5133, biostats student or #) Connett Contingency tables, logistic regression, categorical outcome from cohort and case-control studies, and Poisson regression.

PubH 5468s. Written and Oral Communication in Biostatistics. (2 cr; prereq biostats grad student, #) Hodges Study and practice of written and graphical communication skills for various target audiences. Exercises, peer discussion. Plan B projects or other required writing and presentation may be used.

PubH 5470. Topics in Biostatistics. (Cr ar; prereq #) Selected readings with discussion based on these readings.

PubH 5605. Perinatal Health and Family Planning. (3 cr; prereq public hlth or grad student or #) Hellerstedt Perinatal and family planning issues, programs, services, and policies. Social, cultural, psychological, physical, environmental, economic, ethical, and political factors affecting family planning, pregnancy, and infant outcomes.

PubH 5606. Health of Infants and Young Children. (3 cr; prereq public hlth or grad student or #) Garwick Major causes of mortality and morbidity, public health interventions, and public policies that prevent disease/injury and enhance health in infants and young children. American populations at risk. For students already well grounded in a health-related discipline.

PubH 5607. Adolescent Health: Issues, Programs, and Policies. (3 cr; prereq public hlth or grad student or #) Story

Major public health issues and problems of adolescents in America; relationship between and among societal, political, economic, environmental, psychosocial, and cultural determinants that impact on adolescent health status and services.

PubH 5610. Principles of Maternal and Child Health. (3 cr; prereq public hlth or grad student or #) Introduction to current issues relating to health needs of families, mothers, and children, with emphasis on principles of primary care, health maintenance, preventive care, organization, and evaluation.

PubH 5613. Chronic Illness and Childhood Disability. (3 cr; prereq public hlth or grad student or #) Patterson

In-depth look at the epidemiology, identification, management, follow-up, and prevention of chronic and handicapping conditions of children. Community programs for emotional, physical, and intellectual handicaps.

PubH 5614. Field Experience in Maternal and Child Health. (Cr ar; prereq MCH student, #) Field experiences selected by students to meet their career goals.

PubH 5622. Women's Health: Issues and Controversies. (4 cr; University College only) Weiner Presented from a historical and public health perspective. Contrasts methods of healthcare delivery and professional and consumer education; current literature. Specific health needs of underserved women in the population.

PubH 5631. Program Evaluation in Maternal and Child Health. (3 cr, \$5852; prereq MCH or public hlth admin student, 5623 or 5806 or #) Wunderlich  
Selected theories and models of evaluation; strategies for collecting and analyzing evaluative information; ethical and political forces that shape evaluation design, implementation, and use.

PubH 5639. Prevention: Theory, Practice, and Application in Public Health Services. (4 cr; University College only) Shanedling  
Current issues and controversies concerning prevention and how it relates to health services. History, idea of prevention, terminology, life style intervention, programs and legislative issues, education, roles of public health practitioners, and implications for societal action.

PubH 5645. Families and Health. (3 cr; prereq student in public hlth or hlth sci or grad student in social or behavioral sciences or professional in hlth-related discipline or #) Patterson  
Family theory and research on family's impact on health. Implications for primary and secondary prevention in public health and educational programs, clinical practice, and public policy.

PubH 5647. Independent Study in Maternal and Child Health. (Cr ar; prereq #; MCH or grad student preferred)

PubH 5648. Topics in Maternal and Child Health. (Cr ar; prereq #)

PubH 5649. Maternal and Child Health Master's Project. (3-4 cr; prereq MCH grad student, #) Selected readings; paper or other project.

PubH 5650. Teenage Pregnancy and Parenting: Models for Intervention. (1 cr) Resnick  
Adolescent pregnancy, parenting, and sexual decision making from developmental perspective. Recommendations for counseling and teaching; prevention and intervention for schools, community, and youth-serving organizations; state and national policy.

PubH 5651. Critical Readings of Scientific Literature in Adolescent Health. (2 cr; prereq grad stat course) Resnick  
Basic analytic tools for critical reading and analysis of peer-reviewed publications from variety of professional perspectives.

PubH 5654. Adolescent Sexual Identity: Teen Risk and Professional Responsibility. (1 cr; prereq employment or BA in educ or hlth or social services) Yoakam  
Community impact on and response toward gay/lesbian/bisexual youth; interventions or roles of professionals in school and community.

PubH 5655. Sexual Orientation Issues for Adolescents. (3 cr; prereq BA or employment in educ or hlth or social service) Yoakum  
Adolescent sexuality and sexual orientation from perspective of individual identity; impact of community; response of youth-serving professionals toward gay/lesbian/bisexual youth and their families.

PubH 5700.\* Foundations of Public Health Administration Practice. (3 cr; prereq public hlth admin student or #) Block  
Planning, organization, and administration of public health agencies at state level and how these agencies function in relation to public health at federal and local levels. Opportunity to interact with practicing public health administrators and specialists.

PubH 5702. Policy Issues in Public Health Administration. (3 cr; prereq public hlth admin student or #) Block  
Policy development and implementation in public health-related agencies and organizations.

PubH 5707. Independent Study: Public Health Administration. (1-12 cr; prereq public hlth admin student or #)

PubH 5711. Public Health Law. (4 cr; prereq public hlth student or #) Feinwachs  
Basic concepts of the law, legislative process, legal bases for existence and administration of public health programs, legal aspects of current public health issues and controversies, and regulatory role of government in health services system.

## GRADUATE PROGRAMS

PubH 5720. Management Communications. (3 cr; prereq public hlth admin student)  
Role of communication in health services administration. Development of skills in presentational speaking, interviewing, and written communications. Case study analysis of communication problems in public health organizations.

PubH 5727. Health Leadership and Effecting Change. (3 cr; \$HSU 5007; prereq public hlth student or grad student or #)

Application of broad theoretical base in planned change to solve managerial and organizational problems in students' roles as leaders in health professions.

PubH 5733. Public Health Interventions Across the Life Span. (3 cr, \$Nurs 8040; prereq 5330 or #) Bearinger

Synthesis of life cycle developmental approach and public health perspective with nursing and behavior change conceptual models to develop intervention models that are effective in addressing priority public health problems across the life span.

PubH 5734. Ethical Dimensions of Public Health. (1 cr; prereq public hlth or grad student or #) Aroskar

Ethical issues and dilemmas that confront public health professionals and agencies. How ethics/values affect political, legal, economic, and cultural considerations.

PubH 5735. Public Ethics/Politics and Public Health. (2-3 cr; prereq public hlth or grad student or #) Aroskar

Ethics/values related to decision making in public health interventions. Responsibilities of state in relation to health, politics as public ethics, and distributive justice in pluralistic society.

PubH 5737. Topics: Multidisciplinary Perspectives on Aging. (4 cr, \$5520, \$AdEd 5440, \$CPsy 5305, \$HSU 5009, \$Nurs 5780, \$PA 5414, \$Phar 5009, \$Soc 5960, \$SW 5024)

Sociological, biological, and psychological aspects of aging; theories of aging; death and bereavement; issues and problems of older adults in the United States; human services and their delivery systems (health, nutrition, long-term care, education); public policy and legislation; environment and housing; retirement.

PubH 5739. Topics: Public Health Administration. (Cr ar; prereq public hlth admin student or #)

Selected readings in public health administration. Discussion.

PubH 5740. Organizational Behavior. (3 cr; prereq hlthcare admin student or #) Veninga

Human behavior in organizations; motivation, leadership, influence of organizational structure, informal group behavior, interpersonal relations, supervision. Preventing and solving problems among individuals and groups in organizations.

PubH 5742. Management of Healthcare Organizations. (3 cr; prereq hlthcare admin student or #) Reiling

Role of hospital in delivery of health services and relationships with other elements of healthcare system. Problems of achieving results, governance, medical staff, and role of administrator.

PubH 5743. Ethics in Healthcare Administration. (2 cr; prereq hlthcare admin or public hlth admin student or #) Aroskar

Ethical perspectives in management of healthcare organizations; components of decision-making framework; application of framework to selected ethical issues; analysis of institutional mechanisms for dealing with ethical problems.

PubH 5744. Principles of Problem Solving in Health Services Organizations. (3 cr; prereq hlthcare admin student or #) Dornblaser, staff

Lectures, seminars, and demonstrations on problem solving theory and technique. Management problem solving of cases. Solution of a management problem within health services organization and presentation of report.

PubH 5745. Advanced Problem Solving Project in Health Services Organizations. (5 cr; prereq 5744) Dornblaser, staff

Student groups define, analyze, and solve significant senior management-level operational problems or health public policy problems in Twin Cities health services organizations.

PubH 5747. Human Resources Management. (3 cr; prereq hlthcare admin or public hlth admin student or #) Langan

Introduction to concepts in human resources management as applied to health services organizations. Relationship between human resources management and general management, nature of work, nature of human resources, compensation and benefits, personnel planning, recruitment and selection, training and development, employee appraisal and discipline, and union-management relations.

PubH 5749. Long-Term Care Administration. (3 cr; prereq hlthcare admin or public hlth admin student or #) Grant

Overview of research-based knowledge for administering and designing services and programs in long-term care organizations and hospitals.

PubH 5750. Long-Term Care Industry. (3 cr; prereq hlthcare admin or public hlth admin student or #) Grant

Overview of organization, financing, and delivery of long-term care services to the aged. Demographic trends, financing structures, public policies, and solicited responses to long-term care issues.

PubH 5751. Principles of Management in Health Services Organizations. (3 cr) Veninga  
Lectures and case studies on the role of healthcare services administrators, principles of management, and the administrative process.

PubH 5753. Strategic Management in the Healthcare Industry. (3 cr; prereq MHA student or #) Seminar to evaluate application of organizational theory, organizational analysis, organizational behavior, and competitive analysis to providers, suppliers, and insurers in the healthcare industry.

PubH 5754. Marketing Health Services. (3 cr; prereq hlthcare admin or public hlth admin student or #) Hillestad

Managing marketing function: marketing planning, strategy, and management concepts. Identification of marketing problems and opportunities: construction, evaluation, and management of marketing plan.

PubH 5756. Financial Accounting in Health Organizations. (4 cr; prereq hlthcare admin or public hlth admin student or #)

Accounting principles and practices applicable to healthcare organizations with emphasis on hospitals and ambulatory care services; total financial requirements; cost-finding methodologies, third-party payer negotiation; internal control; internal and external financial reporting.

PubH 5757. Managerial Accounting in Health Organizations. (4 cr; prereq 5756, hlthcare admin or public hlth admin student or #)

Budgeting for hospitals; operational, capital, and cash flow requirements for other healthcare organizations.

PubH 5758. Strategic Financial Planning in Healthcare Organizations. (4 cr; prereq 5757, master of hlthcare admin or public hlth admin student) Riley  
Case studies and readings in the review and analysis of actual hospital financial statements, third-party payer costs reports, and other financial documents. Application of financial ratios to financial statement analysis.

PubH 5759. Healthcare Financial Management (Private Sector Emphasis). (4 cr; prereq 5756, 5757, MHA or public hlth admin or #; knowledge of spreadsheet software recommended) Connor

Principles of corporate finance and selected insurance concepts integrated and applied to healthcare with private sector emphasis. NPV, CAPM, capital and operating budgets, Medicare PPS and RBRVS, risk-adjusted capitation, healthcare reform.

PubH 5760. Operations Research and Control Systems for Hospitals. (3 cr, §HInf 5435; prereq 5404 or #) Potthoff

Decision-making framework for both operating and control systems in the hospital environment. Basic modeling techniques and examples of actual hospital applications.

PubH 5761. Quantitative Methods Applied to Health Administration Problems. (3 cr; prereq basic stats) Weckwerth

Application of quantitative methods, including analysis of cyclicities, PERT, data handling systems, simple ANOVA, linear programming, cost-benefit analysis, and inventory control to solve health problems at administrative levels.

PubH 5762. Information Technology in Healthcare. (3 cr; prereq hlthcare admin or public hlth admin or maternal and child hlth student or #) Potthoff

Aligning information technology (IT) with healthcare strategy, management processes, and operations. Analyzing organizational information needs; incorporating these needs into IT policy and planning; implementing IT policies.

PubH 5766. Applied Field Research I. (1 cr per sect; prereq hlthcare admin student or #) Weckwerth  
Under faculty supervision, students select topic of importance in healthcare administration and formulate research problem and approach for field study.

PubH 5767. Applied Field Research II. (2 cr; prereq MHA student or #) Weckwerth  
Under faculty supervision, students investigate alternative methodological approaches to study of topic selected in 5766 and carry out field research project.

PubH 5768. Applied Field Research III. (2 cr; prereq 5767 or #) Weckwerth  
With counsel of faculty adviser, students carry out research analysis of selected topic and prepare report on findings.

PubH 5770. Topics: Hospital and Healthcare Administration. (Cr ar; prereq hlthcare admin student or #)

Selected readings in hospital and healthcare administration with discussion based on these readings.

PubH 5771. Healthcare Financial Management (Public Sector Emphasis). (4 cr; prereq one college-level [3 cr] accounting course or #; knowledge of spreadsheet software recommended) Connor

Principles of finance and selected insurance concepts integrated into and applied to healthcare with public sector emphasis. NPV, public financing, capital and operating budgets, Medicare PPS and RBRVS, risk-adjusted capitation, and healthcare reform.

PubH 5772. Healthcare ISNs. (3 cr; prereq hlthcare admin student or #) Johnson  
Growth and development of integrated healthcare systems based on an open-systems perspective of health organizations. Process of development and strategies of various organizational arrangements. Implications for roles of managers, trustees, and physicians.

PubH 5790. Sociology of Medicine and Healthcare: An Introduction to Medical Sociology. (4 cr, §Soc 5855) Litman  
Social and psychological components of health and medical care. Organization and delivery of healthcare services, their problems and perspectives; focus on the patient, provider of care, and environment in which healthcare services are dispensed.

## GRADUATE PROGRAMS

PubH 5791. Public Health and Medical Care Organization. (3 cr; prereq public hlth or grad student) Resnick

Sociopolitical, economic, and moral/ethical issues confronting public health and medical care system in the United States. Trends in service provision, human resources, financing and health services organization, and implications for public health.

PubH 5792. Health Services Organizations in the Community. (1 cr; prereq MHA student or #) Reiling

Lectures about and on-site visits to health services organizations; emphasis on role of organization and administrator.

PubH 5796. Legal Considerations in Health Services Organizations. (3 cr; prereq hlthcare admin student or #) Feinwachs

Laws affecting administration of hospitals and other healthcare organizations; administrative law, corporate and business law, labor law, civil liability and tax-related issues. Legal issues relevant to the administrator, decision-making and planning process.

PubH 5806. Principles of Public Health Research. (3 cr; prereq grad student or public hlth student in stats or vital stats or #) Garrard

Evaluation of public health research literature and planning for independent research projects. Formulation of research question, research design, sampling techniques, use of research concepts, and data analysis. Data collection techniques including questionnaires, interviews, and data analysis.

PubH 5812. Managed Care I. (3 cr; prereq student in hlthcare admin or public hlth admin or HSRP or HSRP&A or #) Christianson

Development and organization of HMOs; risk sharing; provider contracts; utilization management; quality improvement.

PubH 5813. Managed Care II. (3 cr; prereq 5812) Christianson

HMO and PPO marketing and new product development; employer relations; Medicare and Medicaid contracting; budget process; financial performance; pricing; government regulation.

PubH 5852. Program Evaluation in Health and Mental Health Settings. (4 cr; prereq #) Garrard, Pirie

Overview of evaluation, models of evaluation, objectives of an evaluative study, sampling of subjects, methods of data collection, methodological designs, interpretation of data, preparation of final report, and ethical and political considerations.

PubH 5861. Health Insurance. (3 cr; prereq microecon theory intro course, grad student or #) Feldman, Nyman

Financing personal healthcare: theory of insurance, health insurance market, cost sharing, HMOs, PPOs, public and catastrophic health insurance, AIDS and insurance, the uninsured poor. Emphasis on public policy.

PubH 5862. Cost-Benefit, Cost-Effectiveness, and Decision Analysis in Healthcare. (3 cr; prereq 3-cr course in intermediate econ) Christianson  
Applications of cost-benefit, cost-effectiveness, and decision analysis techniques in evaluating healthcare programs; government regulations; new technologies; diagnosis and treatment protocols. Strengths, limitations, and appropriateness of different approaches.

PubH 5863. Quality Assurance. (2 cr) R L Kane, Lurie  
History of approaches to assessing and assuring care quality. Recent activities concerning small area variation, outcomes, appropriateness, and effectiveness. Theory and specifics of alternative approaches and their interpretation.

PubH 5868. Principles of Health Services Research. (3 cr) R L Kane  
Interdisciplinary contributions to health services; how health services research can influence policy; best case examples.

PubH 5870. Survey Research and Sample Design in Health Services Research. (3 cr) Moscovice

General, technical, and theoretical context of survey research in health services research. Survey and sample design issues, with extensive use of case examples.

PubH 5881. Topics in Health Services Research and Policy. (Cr ar; prereq #)  
New course offerings, selected readings, or individualized directed instruction.

PubH 5893. Health Economics I. (3 cr; prereq intro microeconomics, student in hlthcare admin or public hlth admin or HSRP or HSRP&A or #) Nyman  
Economic analysis of America's healthcare sector, emphasizing problems of pricing, production, and distribution. Healthcare services as one factor contributing to nation's health.

PubH 5894. Public Policy in Healthcare. (3 cr; prereq student in public hlth admin or MHA or HSRP or public affairs or #) Kralewski  
Development and present status of selected public policy issues in social, economic, and political contexts. Alternative courses of public action reviewed and their outcomes assessed.

PubH 5900. Public Health Nutrition: Principles and Programs. (3 cr; prereq public hlth nutrition student or #) Krinke  
Principles of public health nutrition, roles and functions of public health nutritionists, programs and delivery mechanisms for promoting nutritional status of populations. Students explore their beliefs and competencies in relation to principles and philosophy of public health nutrition.

PubH 5901. Seminar: Public Health Nutrition. (2 cr; prereq public hlth nutrition major or #) Krinke  
Enhances critical thinking and problem-solving skills, increases understanding of current issues regarding nutritional health of public, and promotes interaction among faculty and students.

PubH 5902. Maternal and Infant Nutrition. (3 cr; prereq 3xxx nutrition course or equiv or #) Brown  
Nutritional needs of childbearing women and infants, how to meet these through programs and services.

PubH 5905. Human Nutrition and Health. (3 cr; prereq jr or sr or grad-level student) Brown  
Science of human nutrition in relation to personal and community nutrition problems and concerns. Applied, introductory graduate-level course with labs.

PubH 5907. Dietary Assessment. (2 cr; prereq public hlth nutrition major or #)  
Methods for assessing dietary intake of populations and individuals; appropriate uses of dietary assessment methods in various public health, clinical, and research settings; evaluation and interpretation of dietary data.

PubH 5908. Anthropometric Assessment of Nutritional Status. (2 cr; prereq grad student, 5414 or 5450 or equiv) Himes  
Anthropometry as used to assess nutritional status; taking basic measurements; practical experience in anthropometry; conceptual rationales and interpretation of anthropometric data.

PubH 5909. Topics: Public Health Nutrition. (1-12 cr; prereq public hlth nutrition major or #)  
Faculty-supervised independent study in research topic.

PubH 5910. Critical Review of Research in Public Health Nutrition. (2 cr; prereq public hlth nutrition or MCH major or #, at least 1 grad course each in research, biostats, epi) Himes  
Application of principles of nutrition, epidemiology, and biostatistics to evaluation of scientific research in public health nutrition.

PubH 5914. Nutrition Intervention. (3 cr; prereq grad student or #) Neumark-Sztainer  
Selecting appropriate nutrition intervention strategies for health programs, applying them to target audiences, and evaluating their usefulness in relation to program objectives.

PubH 5920. Public Health Aspects of Nutrition Policy. (3 cr; prereq public hlth nutrition or community hlth educ or epi MPH or epi PhD or nutrition MS or nutrition PhD student or #) Kushi  
How nutrition policy is formulated; effect of policies. Policy approaches in nutrition and how they differ from other prevention approaches.

PubH 5932. Nutrition: Adults and the Elderly. (3 cr; prereq grad student or #) Krinke  
Review of current literature and research on nutrient needs and factors affecting nutritional status of adults and the elderly.

PubH 5933. Nutrition: Health/Disease Relationships. (3 cr; prereq 5330 or equiv, FScN 5622 or MdBc 5201 or equiv or #) Kushi  
Issues in nutrition and public health; biological and epidemiological bases for public health dietary recommendations. Relation of nutrition to heart disease, cancer, hypertension, obesity, and other conditions.

PubH 5935. Child and Adolescent Nutrition. (3 cr; prereq grad-level student or #) Story  
Current issues and literature. Major nutrition issues of youth; biological, cultural, and psycho-social factors influencing food behaviors; and strategies for improving nutritional health.

PubH 8150. Research: Environmental and Occupational Health. (1-8 cr; prereq #)  
Opportunities to pursue research in the importance of environmental and occupational stresses on human health.

PubH 8185. Analysis of Toxicants. (3 cr; prereq #; offered alt yrs) Swackhamer  
Application of principles of analytical chemistry to analysis of toxic chemicals in environmental samples, including air, soil, water, and tissue; survey of instrumental methods (gas and liquid chromatography, mass spectrometry, and atomic and molecular spectroscopy); interpretation of results; analytical quality control.

PubH 8191. Research: Injury Prevention in the Workplace, Community, and Home. (1-8 cr; prereq #) Gerberich  
Students develop independent and comprehensive research efforts relevant to injury prevention.

PubH 8192f, 8193w, 8194s. Occupational Injury Prevention and Safety Research Seminar. (1 cr per qtr; prereq environ hlth major or #) Gerberich, Maldonado  
Facilitates student research in Occupational Injury Prevention and Safety Program (OIPSP) through interdisciplinary involvement of OIPSP engineering and public health students.

PubH 8264. Human Diseases Caused by Environmental Agents. (3 cr; prereq 5261, 5262, #) Greaves  
Clinical presentation of disease; investigation of exposed populations and affected individuals.

PubH 8272. Validity Concepts in Epidemiologic Research. (2 cr; prereq 5341 with grade B or better or #) Maldonado  
Recognizing, understanding, evaluating, correcting, and preventing bias in epidemiologic studies.

PubH 8330. Research in Epidemiology. (1-8 cr; prereq epi MPH or grad student or #)  
Opportunities offered by the School of Public Health and by various cooperating organizations for qualified students to pursue research work.

PubH 8331. Field Practice in Epidemiologic Investigations. (1-8 cr; prereq epi MPH or grad student or #)  
Supervised participation in epidemiologic investigations in the field under the auspices of health agencies or faculty of the School.

PubH 8332. Readings in Epidemiology. (1-4 cr; prereq epi MPH or grad student or #)  
Readings in current research articles on epidemiology.

PubH 8379. Seminar in Epidemiology. (2 cr; prereq epi or physiological hygiene major)  
Discussion of selected current epidemiologic problems.

## GRADUATE PROGRAMS

PubH 8389. Seminar: Topics in Epidemiology. (3 cr; prereq epi or community hlth educ major; offered when feasible)

PubH 8420f. Survival Analysis. (3 cr; prereq 5466 or equiv, Stat 5133) Le  
Theory and applications of statistical methodologies in survival analysis, including estimation of survival curves and Cox's proportional hazards models. Application of parametric and non-parametric techniques in clinical trials and other health studies.

PubH 8421w. Analysis of Categorical Data. (3 cr; prereq 5466 including SAS, Stat 5133) Waller  
Analysis of categorical data with applications to clinical treatment evaluation, epidemiology, and other public health areas. Topics include log-linear, logit, and linear logistic models; power and robustness studied by exact and approximate methods.

PubH 8422w. Modern Non-Parametrics. (3 cr; prereq public hlth or grad student, 5466, Stat 5133 or #) Louis

Classical non-parametric inference, exact tests and confidence intervals for discrete data, robust estimates, the jackknife, bootstrap and cross-validation. Includes substantial computing, study of wide variety of models and applications, and formal development sufficient for understanding statistical structures and properties.

PubH 8429f. Probability Models for Biostatistics. (3 cr; prereq 8420-8421, Stat 5131-5132-5133, biostat grad student or #) Grambsch  
Basic models used for stochastic processes in biomedical sciences: Poisson processes, Markov chains, and Brownian motion. Probability structure and statistical inference for each process.

PubH 8430f. Sequential Analysis. (3 cr; prereq 8420, Stat 5133, FORTRAN, biostats student or #; offered alt yrs) Goldman, Grambsch, Louis  
Design and analysis of clinical trials using sequential methods. Use of Monte Carlo methods for studying operating characteristics of sequential tests; illustrations include various types of data. Wald and likelihood ratio theory; specific problems with testing binomial proportions and normal means.

PubH 8431w. Biostatistical Decision Theory. (3 cr; prereq Stat 5131-5132-5133, Stat 8311-8312, biostat grad student or #; offered alt yrs) Louis  
Bayes and empirical Bayes methods in a decision-theoretic framework for biostatistical analysis. These methods enable combining information from similar and independent experiments, yielding improved estimation of both individual and shared model characteristics.

PubH 8432s. Bioassay and Screening. (3 cr; prereq theoretical stats or #; offered alt yrs) Louis  
Properties of progressive disease models, including lead time produced by screening and length-biased sampling. Relates population screening and rodent bioassay models. Estimation approaches and study designs, including sequential methods. Examples include screening for breast cancer and cervical cancer.

PubH 8433s. Analysis of Longitudinal Data. (3 cr; prereq Stat 5131-5132-5133, Stat 8311-8312 or equiv, biostat grad student or #; offered alt yrs) Anderson

Methods of inference for outcome variables measured repeatedly in time or space; normal theory linear models and nonlinear, nonnormal models with emphasis on GLIM, including random effect; transitional and marginal models with applications to biomedical data.

PubH 8434w,s. Advanced Survival Analysis. (3 cr; prereq 8420, Stat 5133 or equiv; offered alt yrs) Grambsch

Martingale methods and counting process theory as applied to survival data, including martingale foundations, statistical tests for comparing survival among groups, Cox proportional hazards model, diagnostics and analysis of residuals, multivariate survival data, and extensions to event history analysis.

PubH 8435f. Seminar in Categorical Data. (3 cr; prereq Stat 5133, PubH 8421 or Stat 5421 or Stat 8431 or equiv course in categorical data or #; offered alt yrs)

Topics of current research interest in analysis of categorical data. Readings from recently published statistical methodology.

PubH 8436s. Spatial Biostatistics. (3 cr; prereq 8420, 8421, exper with statistical computing packages such as BMDP or SAS, programming exper with FORTRAN or C; offered alt yrs) Waller  
Introduction to statistical methodologies for analyzing spatial data. Tests for spatial autocorrelation, spatial prediction through kriging, random spatial processes, and tests for disease clustering.

PubH 8437s. Advanced Bayesian Methods. (3 cr; prereq 8431, Stat 5131-5132-5133, Stat 8311-8312, biostat grad student or #; offered alt yrs) Carlin  
Continuation of PubH 8431. Advanced data analytic and computing issues.

PubH 8449. Topics in Biostatistics. (Cr ar; prereq 5450, #)  
Special topics for advanced students.

PubH 8450. Research in Biostatistics. (Cr ar)  
Opportunity for qualified students to pursue research work.

PubH 8750. Seminar: Alternative Patterns of Healthcare. (4 cr; prereq HSRP&A or MHA student or #) Litman  
Alternative approaches to organization, financing, and delivery of ambulatory care, long-term care, maternal and child care, and mental health.

PubH 8760. Topics: Hospital and Healthcare Administration. (3 cr; prereq HSRP&A student)  
Independent study under tutorial guidance of selected problems and current issues in health and healthcare.

PubH 8761. Readings in Theory and Principles of Hospital and Healthcare Administration. (3 cr; prereq HSRP&A student or #)

PubH 8762w. Contemporary Problems of Hospital and Related Health Services. (3 cr) Weckwerth

Current concepts, problems, principles, and future developments in health and healthcare.

PubH 8763. External Forces Affecting Health Services Delivery. (3 cr; prereq HSRP&A student or #) Weckwerth

Development of concepts, models, and principles of financing, social policy making, organizing, and human resource development for health services delivery, including written papers, oral presentations, and cross examination.

PubH 8765. Seminar: Organization and Management Theory in Healthcare. (3 cr; prereq advanced stats, HSRP&A PhD student or #) Organizational, managerial, and administrative theories applied to contemporary health services research problems.

PubH 8770s. Seminar: Health and Human Behavior. (3 cr; prereq HSRP&A student or 5790 or Soc 5855 or #) Litman

Sociology of health and healthcare; social and personal components of behavior in sickness and in health; community health; and the relationship of social and cultural factors in organization and delivery of healthcare services.

PubH 8780. Advanced Statistical Methods in Healthcare Research. (3 cr; prereq 1 qtr each of applied and theoretical stats) Weckwerth  
Survey and analysis of application of nonparametric statistics to healthcare research.

PubH 8782. Research Practicum. (3 cr per qtr [max 6 cr]; prereq HSRP&A student or #) Litman, Weckwerth

Field experience in healthcare research. Supervised independent and team research on selected topics and problems in the field of healthcare.

PubH 8790.\* Seminar: Political Aspects of Healthcare. (3 cr; prereq HSRP&A student or #; offered winter of odd yrs) Litman  
Interrelationships between government, politics, and healthcare; the political and social basis of health legislation and community decision making in provision and modification of health services.

PubH 8796. Topics in Health Economics. (3 cr; prereq MHA student or #) Dahl

General principles of health economics applied to current issues in health. Implications for health policy derived and discussed.

PubH 8801. Seminar: Health Services Policy. (3 cr; prereq HSRP MS or HSRP&A PhD student or #) Kralewski, Moscovice

Overview of policy science. Evolution of health services policy in the United States, alternative policy-making models, and substantive policy areas.

PubH 8803. Long-Term Care: Principles and Policies. (3 cr; prereq grad-level course in hlthcare policy or #) R A Kane

Long-term care policy for functionally impaired persons, particularly the elderly. Team-taught from healthcare and social services perspective; grounded in research literature on evidence of program effects. Innovative programs addressing current disconnections.

PubH 8805. Applications of Sociological Theories to Health. (3 cr; prereq HSRP MS or HSRP&A PhD student or #)

Current and historical events in health arena from perspective of modern and classical sociological theories. Framework, or competing frameworks, to analyze healthcare systems and activities; methods to test applicability of theories.

PubH 8810-8811-8812†. Seminar: Research Studies in Healthcare. (3 cr per qtr; prereq HSRP MS or HSRP&A PhD student, Stat 5121, Stat 5122, Stat 5302 or # for 8810, 8810 or # for 8811, 8811 or # for 8812) Dowd, Finch

Review and appraisal of design, measurement, analysis, and findings of contemporary studies.

PubH 8813. Measurement of Health-Related Social Factors. (3 cr, SSAPh 8840; prereq intro stat course, understanding of simple correlations or #) Choi  
How social factors such as innovativeness, compliance, religiosity, and stress are measured and tested for reliability and validity. Relationships between theory, concepts, variables, data.

PubH 8820. Health Economics II. (3 cr; prereq 8761 or 8819, 1 qtr calculus, 1 qtr linear algebra or #) Manning

Application of microeconomic theory to healthcare decisions of consumers and producers under different assumptions about market structure and behavior.

PubH 8821. Health Economics III. (3 cr; prereq 8820 or #) Feldman

Examines application of microeconomic theory to health services research through selected reading from published and unpublished health economics literature.

PubH 8830-8831-8832†. Research Project in Healthcare. (1 cr; prereq HSRP MS or HSRP&A PhD student, Stat 5121, Stat 5122, Stat 5302 or #)  
Development and articulation of a research proposal.

PubH 8861. Topics in Theory and Principles of Health Services Research, Policy, and Administration. (3 cr; prereq HSRP&A student or #)

PubH 8880. Directed Research. (1-8 cr; prereq HSRP&A PhD student, #)

Guided research in health services research, policy, and administration.

PubH 8900. Seminar in Advanced Life Cycle Nutrition. (3 cr; prereq 5902 or 5932 or 5935 or equiv)  
Methodological issues of applied human nutrition investigation, current status of knowledge, and implication of research results to public health policies, programs, and future research.

## Quaternary Paleoecology

*Regents' Professor:* Margaret B. Davis (ecology, evolution, and behavior); Eville Gorham (ecology, evolution, and behavior); Herbert E. Wright, Jr. (*emeritus*: geology)

*Professor:* Subir K. Banerjee (geology and geophysics); Dwight A. Brown (geography); Edward J. Cushing (ecology, evolution, and behavior); Guy E. Gibbon (anthropology); Thomas C. Johnson (geology<sup>1</sup>); Kerry R. Kelts (geology and geophysics); Richard H. Skaggs (geography); Peter S. Wells (Center for Ancient Studies)

*Associate Professor:* Emi Ito (geology and geophysics), *director of graduate studies*; R. Lawrence Edwards (geology and geophysics); Edward A. Nater (soil, water, and climate); Janet D. Spector (anthropology)

*Adjunct Associate Professor:* Kenneth L. Cole (forest resources)

*Assistant Professor:* Katherine Klink (geography); Joy McCorrison (anthropology)

**Course of Study**—Minor in Quaternary paleoecology, applicable to master's (M.A. and M.S.) and doctoral programs.

**Curriculum**—This minor offers a structured interdisciplinary graduate curriculum for students working in Quaternary paleoecology. Students learn analytical techniques and research approaches that they can apply to their research from other disciplines.

Students develop their curricula with their major adviser and the Quaternary paleoecology director of graduate studies. Students must take a series of required courses, but some of the requirements may be waived depending on the student's background.

**Prerequisites for Admission**—Admission to the Quaternary paleoecology graduate minor is contingent on prior admission to a Graduate School degree-granting program.

**Special Application Requirements**—Students apply by sending a letter of application to the director of graduate studies as well as a letter of recommendation from their current adviser. Application may be made at any time.

**Requirements for the Minor**—Ph.D. students must take at least 20 credits from the list of courses below, including the three required courses. Master's students must take at least 12 credits from the list, including two of the three required courses. All students are required to maintain academic standards in accordance with those of the Graduate School and department.

**Language Requirements**—None specific to the minor program.

**For Further Information and Applications**—Contact Dr. Emi Ito, Director of Graduate Studies, Quaternary Paleoecology Graduate Program, University of Minnesota, 108 Pillsbury Hall, 310 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/624-7881; fax 612/625-3819; e-mail [eito@tc.umn.edu](mailto:eito@tc.umn.edu)).

### Required Courses

Anth 5176. Environmental Archaeology. (4 cr)

EEB 5004/Geo 5631. Earth System: Geosphere/Biosphere Interactions. (4 cr)

Geog 5423. Climate Models and Modeling. (4 cr)

### Other Courses

Anth 5960. Senior Seminar: Origins of Agriculture. (4 cr) (*Note:* This course's number may change after the 1997-98 academic year.)

CE 8550. Analysis and Modeling of Aquatic Environments. (4 cr)

EEB 5008. Quaternary Ecology. (4 cr)

EEB 5014. Ecology of Vegetation. (5 cr)

EEB 5016. Ecological Plant Geography. (5 cr)

EEB 5601. Limnology. (4 cr) (must also take lab EEB 5621 [2 cr])

FR 5114. Forest Hydrology. (4 cr)

Geo 5251. Geomorphology. (4-5 cr)

Geo 5261. Glacial Geology. (4-5 cr)

Geo 5311. Geochemical Processes. (4 cr)

Geo 5321. Isotope Geology. (4 cr)

Geo 5543. Paleomagnetism. (4 cr)

Geo 5603. Geological Limnology. (4 cr)

Geo 8262. Quaternary Paleoecology and Climate. (4 cr)

Geog 5426. Climate Variations. (4 cr)

Geog 5441. Quaternary Landscape Evolution. (4 cr)

Geog 5565. Geographical Analysis of Environmental Systems and Global Change. (4 cr)

PBio 8301. Pollen Morphology and Quaternary Palynology. (3-5 cr)

<sup>1</sup> University of Minnesota, Duluth

Soil 5210. Environmental Biophysics. (3 cr)

Soil 5360. Soil Clay Mineralogy. (3 cr) (must also take lab Soil 5361 [1-4 cr])

Soil 5515. Soil Development, Classification, and Geography. (4 cr) (must also take lab Soil 5510 [1 cr])

Soil 5605. Microbial Ecology. (3 cr)

## Recreation, Park, and Leisure Studies

See Kinesiology and Leisure Studies.

## Rehabilitation Science (PMed)

*Professor:* Richard P. DiFabio, *director of graduate studies;* Robert Patterson

*Associate Professor:* James R. Carey; Dennis Dykstra; Corinne T. Ellingham; Judith E. Reisman; Glenn N. Scudder; Erica B. Stern

*Assistant Professor:* LaDora V. Thompson

*Assistant Clinical Specialist:* Krista A. Coleman

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Rehabilitation scientists optimize the functional performance of individuals who have disabilities caused by accidents, injuries, birth trauma, disease, and aging. Practitioners in the field include physiatrists, physical therapists, occupational therapists, speech and language pathologists, vocational counselors, and rehabilitation engineers.

The program prepares rehabilitation scientists who will develop a theoretical and scientific basis for new or established therapeutic interventions. These individuals will also help fill a large and rapidly growing need for academicians who develop and lead educational programs.

Students select an area of emphasis in neuro-rehabilitation or musculoskeletal rehabilitation.

**Prerequisites for Admission**—Applicants must have a bachelor's degree or comparable foreign degree from an accredited program in physical therapy, occupational therapy, speech/

audiology, biomedical engineering or an M.D. from an approved medical school. A minimum undergraduate GPA of 3.00 is also required. International students applying from non-English speaking countries must have a TOEFL score of at least 550.

**Master's Degree Requirements**—This program, which also fulfills the didactic requirements of the American Board of Physical Medicine and Rehabilitation, usually requires three years to complete. For the minor field or area of emphasis, anatomy, physiology, biophysics, or pathology is highly recommended.

**Doctoral Degree Requirements**—A minimum of 70 course credits (excluding thesis credits) is required. Students take 25 credits from among core courses, including 9 credits of departmental seminars in rehabilitation science. A minor or supporting program and 12 credits of statistics are also required. The credits earned in core courses and statistics cannot be applied to the minor or supporting program requirement.

The preliminary written examination covers all coursework prior to the thesis proposal. A preliminary oral examination includes the thesis proposal. The final oral examination is the thesis defense.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Department of Physical Medicine and Rehabilitation, University of Minnesota, Box 297 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (mailing address) (612/626-5303).

RSc 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

RSc 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

RSc 8888. Thesis Credits: Doctoral. (36 cr required)

PMed 5150. Kinesiological Electromyography and Nerve Conduction. (3 cr; prereq #) Carey  
Lecture and lab on instrumentation, physiological, anatomical, and kinesiological considerations related to electromyography and nerve conduction.

PMed 5814. Physiological Assessment in Physical Therapy. (1-3 cr) Thompson  
Lecture and lab sessions on physiological assessment of, for example, endurance, strength, and coordination.

PMed 5841. Instrumentation and Analysis Techniques. (3 cr; prereq Phys 1031, 1032 or equiv) Patterson

PMed 5950. Bioelectric Measurements. (3 cr; prereq Phsl 5441, calculus, college physics) Patterson  
Electrodes, instrumentation, and processing requirements for endogenously generated electric potentials and electrical impedance of tissue. Electrode characteristics, signal processing, and interpretation of physiological events by ECG, EEG, EMG, and EOG. Measurement of respiration, blood flow and volume, and other physiological events by electrical impedance.

PMed 8135. Advanced Kinesiology. (3 cr) DiFabio  
Functional anatomy emphasizing anatomical, physiological, and biomechanical aspects of normal and pathological human motion. Lecture with lab to include various techniques available for analysis.

PMed 8192w. Research Design in Physical Therapy. (3 cr; prereq #) DiFabio  
Critical appraisal of current medical literature; fundamentals of research design and techniques of medical writing.

PMed 8205f,w,s,su. Readings in Physical Medicine and Rehabilitation. (2 cr per qtr)

PMed 8206f,w,s. Conference on Physical Medicine and Rehabilitation. (2 cr per qtr) Dykstra  
Topics vary quarterly. Prepared papers required.

PMed 8207. Basic and Applied Physiatry. (2 cr) Dykstra, Patterson, staff  
Assigned readings, lectures, and discussions on anatomic, physiologic, pathologic, biophysical, and psychological bases of physiatry.

PMed 8210f,w,s,su. Research in Physical Medicine. (Cr ar) DiFabio, Dykstra, Patterson, staff

PMed 8212f,w,s,su. Electromyography. (Cr ar; prereq #) Carey, Dykstra, staff  
Clinical and lab training in use and interpretation of electromyography.

PMed 8213f,w,s. Electrodiagnosis Conference. (Cr ar; prereq 8211 or #) Dykstra, staff  
Clinical presentation and discussion of cases examined in the Electrodiagnostic lab.

PMed 8214f,w,s. Readings in Electromyography. (1 cr; prereq #) Dykstra, staff  
Assigned readings and discussions on the anatomic, physiologic, pathologic, and technical developments in electromyography.

PMed 8220f,w,s. Seminar: Physical Medicine and Rehabilitation. (Cr ar)

## Religious Studies

*Professor:* Josef L. Altholz (history); Frederick M. Asher (art history); Bernard S. Bachrach (history); Roland A. Delattre (American studies); Caesar E. Farah (history); Jasper Hopkins (philosophy); Theofanis G. Stavrou (history); James D. Tracy (history); Gayle G. Yates (American studies)

*Associate Professor:* Philip H. Sellew (Classical and Near Eastern studies), *director of graduate studies;* William W. Malandra (Classical and Near Eastern studies); Jonathan Paradise (Classical and Near Eastern studies); Riv-Ellen Prell (anthropology)

*Lecturer:* David A. Shupe (University College)

**Course of Study**—Minor in religious studies, applicable to master's (M.A. and M.S.) and doctoral programs.

**Curriculum**—The interdisciplinary graduate minor in religious studies is for master's and doctoral students in fields such as history, classics, English, anthropology, philosophy, and American studies and is shaped to suit the particular needs and interests of the student. Courses are selected in consultation with the director of graduate studies from RelA 5xxx courses as well as appropriate 8xxx courses in related fields.

**Prerequisites for Admission**—Admission to the religious studies graduate minor is contingent on prior admission to a master's or doctoral degree-granting program within the Graduate School.

**Special Application Requirements**—Students who wish to plan or declare a graduate minor in religious studies should contact the director of graduate studies in the Department of Classical and Near Eastern Studies, which provides the administrative home for the minor. The director of graduate studies must approve the applicant's proposed course of study and sign the student's degree program form.

**Minor Requirements**—Master's students must complete at least 12 graduate credits in approved courses in at least two areas of study. Doctoral students must complete at least 20 graduate credits in approved courses in at least three areas of study and have a religious studies faculty member on their preliminary examination committees.

**Language Requirements**—None specific to the minor program.

**For Further Information and Applications—**  
Contact the Director of Graduate Studies,  
Department of Classical and Near Eastern  
Studies, University of Minnesota, 330 Folwell  
Hall, 9 Pleasant Street S.E., Minneapolis, MN  
55455 (612/625-5353).

## Religions in Antiquity (ReIA)

ReIA 5031. Traditional Religions of India. (4 cr, §1031, §3031, §SoAS 3031, §SoAS 5031) Malandra  
Historical survey of India's pre-Islamic religious traditions with emphasis on Hinduism and Buddhism (Theravada and Mahayana). Religion in context of history, society, ideological systems, literature, and visual arts.

ReIA 5035. Christian Religious Traditions. (4 cr, §3035, §ReIS 3035, §ReIS 5035)  
Historical structures, themes, and persons in Christianity's transition from minor Jewish sect to martyrdom to dominant religion to modern pluralism. In modern period, problematic situations of racism, nationalism, democracy, capitalism, imperialism, war, sexism, Marxism, secularization.

ReIA 5036. Religions of Islam. (4 cr, §3036, §MELC 3036, §MELC 5036) Farah  
Evolution of Islam in historical context; institutions that made for diversity and continuity: traditions, law, and observances of the faith; sectarian movements; philosophical and theological trends; modern developments: reformist, revolutionary, and militant.

ReIA 5071. Greek and Hellenistic Religions. (4 cr, §3071, §3071H, §Clas 3071, §Clas 3071H, §Clas 5071) Sellev  
Survey of ancient Greek religion from Bronze Age to Hellenistic times using literature, art, and archaeology. Prehistoric religion; Homer and Olympian deities; music, dance, and procession as ritual performance; prayer and sacrifice; temple architecture and sanctuaries; oracles; beliefs about death and the afterlife; mystery cults; philosophical religion; criticism of traditional myths; ruler cult; Near Eastern salvation religions.

ReIA 5072. The New Testament. (4 cr, §3072, §Clas 3072, §Clas 5072) Sellev  
Early Jesus movement in its social and historical setting: origins in Judaism; traditions about Jesus; Paul, his controversies, and his interpreters; questions of authority, religious practice, and structure in early communities; apocryphal literature and emergence of scriptural canon. Contemporary methods of New Testament study. Ancient sources studied as evidence for constructing critical history and in an attempt to appreciate their narrative structures; other literary techniques.

ReIA 5073. Roman Religion and Early Christianity. (4 cr, §3073, §Clas 3073, §Clas 5073) Nicholson, Sellev  
Etruscans; republican religion; appeal of non-Roman cults; ruler worship; Christians in Asia Minor, Egypt, and the West; popular piety, Christian and non-Christian; Rabbinic Judaism; varieties of Christianity in second and third centuries; influence of Greco-Roman culture on emerging church; Constantine and Julian.

ReIA 5080. New Testament Proseminar. (4 cr [max 12 cr]; prereq 3072 or 5072 or Clas 3072 or Clas 5072 or ReIS 3072 or ReIS 5072) Sellev  
Selected topics in academic study of the New Testament and ancient literatures closely related to it. Topics specified in *Class Schedule*.

ReIA 5089. Introduction to Biblical Archaeology. (4 cr, §3089, §Clas 3089, §Clas 5089)  
Archaeological data relevant to Jewish scriptures and New Testament; major sites in Holy Land and other areas of Mediterranean and Near East. Evidence of pottery, inscriptions, manuscripts, and coins; excavation methods; archaeology as a tool for study of ancient religions.

ReIA 5111. Interpretation of Myth. (4 cr, §Hum 5711; prereq jr or sr or #)  
Structure and function of myths. Myth as social charter, ideological system, and literary form. Readings in classic theories of myth and primary sources from India, Iran, Mesopotamia, Greece, Africa, North and South America.

ReIA 5413. Buddhism. (4 cr, §3413, §SALC 3413, §SALC 5413)  
Historical account of Buddhist religion: its rise, development, various schools, and common philosophical concepts. Focuses on Indian Buddhism, compares it with Hinduism, and discusses its demise and revival on Indian subcontinent.

ReIA 5501. Ancient Israel. (4 cr, §3501, §ANE 3501, §ANE 5501)  
History of Israel and development of its religion from earliest times. Foundation of the Hebrew people; patriarchal period; development of Israelite religious and legal institutions; conquest of Canaan; development of monarchy and United Kingdom.

ReIA 5505. Ancient Israel: Background of the Bible. (4 cr, §ANE 3505, §ANE 5505; prereq grad student or #)  
Hellenistic period. Period of Ezra and Nehemiah, Samaritans, apocalyptic and other eschatological types; Maccabean period; Sadducees, Pharisees, Zealots, Christians, Qumran, wisdom literature; Philo, Josephus; Jewish rights during Roman Empire. Evaluation of sources for historical reliability. Knowledge of Hebrew not required.

ReIA 5890. Seminar in Religious Studies. (5 cr for undergrads, 3 cr for grad students; prereq sr major or #)  
Conceptual and methodological issues in contemporary religious studies.

ReIA 5970. Directed Studies. (3-5 cr per qtr; prereq #, Δ, □)

ReIA 8970. Directed Studies. (2-5 cr; prereq Δ)

## Rhetoric and Scientific and Technical Communication

### SCIENTIFIC AND TECHNICAL COMMUNICATION

*Professor:* Billie J. Wahlstrom, *head*; Alan G. Gross; Mary M. Lay; Earl E. McDowell; Victoria M. Mikelonis-Paraskov; L. David Schuelke; W. Keith Wharton

*Associate Professor:* Ann Hill Duin, *director of graduate studies*; J. Michael Bennett; Laurie S. Hayes; Thomas M. Scanlan; Arthur E. Walzer

*Assistant Professor:* Laura J. Gurak

### RHETORIC AND SCIENTIFIC AND TECHNICAL COMMUNICATION

*Professor:* Karlyn K. Campbell (speech-communication); Terence G. Collins (General College); Shirley N. Garner (English); Michael F. Graves (curriculum and instruction); Alan G. Gross (rhetoric); Mary M. Lay (rhetoric); Earl E. McDowell (rhetoric); Victoria M. Mikelonis-Paraskov (rhetoric); Donald J. Ross, Jr. (English); L. David Schuelke (rhetoric); Robert L. Scott (speech-communication); Richard A. Swanson (vocational and technical education); Billie J. Wahlstrom (rhetoric)

*Associate Professor:* Ann Hill Duin (rhetoric), *director of graduate studies*; Lisa D. Albrecht (General College); Christopher M. Anson (English); William A. Babcock (journalism and mass communication); John H. Beatty (ecology, evolution, and behavior); J. Michael Bennett (rhetoric); Lillian S. Bridwell-Bowles (English); Rita Copeland (English); Laurie S. Hayes (rhetoric); Helen E. Longino (women's studies); Thomas M. Scanlan (rhetoric); Arthur E. Walzer (rhetoric)

*Assistant Professor:* Laura J. Gurak (rhetoric); Simon R. Hooper (curriculum and instruction)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Scientific and technical communication, M.S. (Plan A and Plan B); rhetoric and scientific and technical communication, M.A. (Plan A and Plan B) and Ph.D.

**Curriculum**—Two emphases are available in the scientific and technical communication (STC) master's program: theory and research in scientific and technical communication, and theory and practice in scientific and technical communication. Emphases in the master's and doctoral programs in rhetoric and scientific and technical communication (RSTC) are rhetorical theory, history, and criticism; culture and communication (international studies, gender studies, and science and technology studies); theory and research in STC pedagogy; and theory and research in communication technologies.

**Prerequisites for Admission**—All STC master's applicants are required to have a bachelor's degree from an accredited college or university; 30 credits in science, technology, mathematics, and/or engineering; 12 credits in advanced communication courses such as writing/editing, oral communication, visual communication, organizational communication, and communication theory; and 8 credits in computer science or management information systems, or demonstrated equivalent experience. The *Graduate Student Handbook* detailing prerequisites is available from the department.

**Special Application Requirements**—Three letters of recommendation, scores from the General Test of the Graduate Record Examination, two writing samples, and a professional objective statement. Nonnative speakers of English are required to take the Test of English as a Foreign Language (TOEFL) and have satisfactory scores. The letters of recommendation and writing samples may be used to support an application for financial aid. Admission to the M.S. program may begin in any quarter. M.A. and Ph.D. students will be admitted only in the fall quarter. The application deadline is January 15. Forms and instructions should be requested from the department. Students who wish to be considered for teaching assistant or research assistant positions should apply by January 15.

**Master's Degree Requirements**—The minimum requirement is 44 credits (normally 10 courses). For the M.S. degree with an emphasis on theory and research (Plan A), coursework must include Rhet 5180, 5500, 8110, 8210, 8510; 8 credits in a related field; 16 thesis credits; and additional rhetoric credits, totaling a minimum of 44 credits. For the M.S. degree with an emphasis on theory and practice (Plan B), coursework must include Rhet 5180, 8110, 8210, 8510; 8 credits in a related field; 8 credits in Rhet 8170 and 8171; and additional rhetoric credits, totaling 44 credits.

All M.A. students must take two courses in the rhetorical theory, history, and criticism core; one course in the culture and communication core; two courses from either the STC pedagogical theory and research core

or two courses from *STC* communication management theory and research core; 8 credits in a related area; 16 thesis credits for Plan A or 8 project credits for Plan B; and additional rhetoric credits, totaling a minimum of 44 credits.

**Doctoral Degree Requirements—Ph.D.**

students are required to earn 68 credits beyond the master's degree. This includes two courses in the rhetorical theory, history, and criticism core; Rhet 8100; one course in culture and communication (*international studies* core); 18 credits in a minor field or supporting program; and 36 dissertation credits. Students are required to demonstrate competency in a foreign language(s), a programming language(s), and/or statistics appropriate for dissertation research.

**Language Requirements—**For the master's degree, none. For the doctoral degree, see *Doctoral Degree Requirements* above.

**For Further Information and Applications—**

Contact the Department of Rhetoric, University of Minnesota, 201 Haecker Hall, 1364 Eckles Avenue, St. Paul, MN 55108 (612/624-4761; fax 612/624-3617; <http://rhetoric.agoff.umn.edu>).

Rhet 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Rhet 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Rhet 8888. Thesis Credits: Doctoral. (36 cr required)

**Rhetoric (Rhet)**

Rhet 5100. Technical Communication: Special Problems. (Cr ar; prereq #, Δ)  
Supervised reading, research, and work on advanced technical communication projects not covered in regularly scheduled courses.

Rhet 5105. Corporate Video for Technical Communicators. (4 cr, §3105)  
Video production, including video team roles, production technology, and the development process. Students apply rhetorical principles in analyzing video, develop a treatment, write a script, and prepare an annotated bibliography on a video-related topic.

Rhet 5165. Studies in Organizational Communication, Conflict, and Change. (4 cr; prereq fr comm req or equiv or grad student) Schuelke  
Roles of internal and external organizational communication, conflict-problem identification, and change processes. Contemporary theory and research in organizational development; problem identification and diagnosis. Change processes and applications to actual organizational settings.

Rhet 5170. Managerial Communications. (4 cr; prereq fr comm req or equiv or grad student) Wharton  
Analyzing manager's position in organizational communication network. Possible forms, contexts, and functions of manager's communication. Emphasis on assessing and developing personal competence and confidence in managerial communication. Lectures, discussions, readings, experiential exercises, and field research.

Rhet 5180. Internship in Scientific and Technical Communication. (2-6 cr; prereq *STC* major or grad student, #, Δ)  
On-the-job experience at the University or in industry or government.

Rhet 5258. Interviewing: Dynamics of Face-to-face Communication. (4 cr) McDowell  
Improving intrapersonal and interpersonal skills in interviewing situations. Participation in appraisal, reprimand, complaint, persuasion, and problem-solving techniques; counseling interviews; and a research interview project. Equal emphasis on interviewer and interviewee roles.

Rhet 5400. Communication Program Planning and Evaluation. (4 cr; prereq jr or sr or grad student or work exper in communication) Schuelke  
Examples, materials, and resources for planning, budgeting, and assessing organizational communication programs.

Rhet 5500. Research in Communication Strategies. (4 cr) McDowell  
Introduction to research design and methodology in communication. Emphasis on application of various research methods to particular communication strategies or settings.

Rhet 5531. Scientific and Technical Communication Course Development: Philosophy and Methodology. (4 cr; prereq 3562, *STC* sr or *STC* or *RSTC* grad student or #; A-F only) Wahlstrom, staff  
Theories and methodologies as they relate to composition and scientific and technical communication. Emphasis on learning to teach first-year college students written or oral persuasive strategies. Students practice assignment and course development, justification, and evaluation.

## GRADUATE PROGRAMS

Rhet 5532. Scientific and Technical Communication Course Development: Mentored Teaching. (2 cr; prereq 5531, STC or RSTC grad student or #; A-F only) Wahlstrom, staff  
Under faculty mentor, students teach course units, prepare and evaluate course assignments, conduct conferences with student writers or speakers, and help oversee education within actual course.

Rhet 5533. Scientific and Technical Communication Course Development: Teaching Seminar. (1 cr; prereq 5532, STC or RSTC grad student or #)  
Students share observations and solve teaching problems, usually concurrent with first teaching assignments.

Rhet 5540. Topics in Scientific and Technical Communication. (Cr ar; prereq #)  
Topics announced in *Class Schedule*.

Rhet 5560. Editing for Technical Communication. (4 cr; prereq STC premajor or major or grad student; A-F only) Gurak  
Introduction to editorial process; editor-writer relationship; copyediting; preparing scientific and technical documents; handling format, visuals, and quantitative materials.

Rhet 5562. Theory and Practice in International and Intercultural Communication. (4 cr; prereq 3562 or #) Mikelonis-Paraskov  
Differences among international, intercultural, and development communication. Cultural contexts examined by comparing research and theoretical models in the three types of communication and through interviews; case studies demonstrate impact of cultural contexts on business globalization.

Rhet 5573. Grant Proposal. (3 cr; prereq STC major, fr comm req, 3562 or grad student or #) Mikelonis-Paraskov  
Writing the grant proposal, including establishing credibility, problem statement, program objectives, plan of action, evaluation, budget presentations, and proposal summary. Serves both real and hypothetical situations.

Rhet 5581. Document Design. (4 cr; prereq 3562, STC sr or grad student; A-F only) Gurak, staff  
Designing a document to meet user's need, completing draft, and evaluating effectiveness. Forms and software documentation (user guides, reference manuals, tutorials, and input sheets) for databases, decision aids, computer-aided instruction, on-line programs, or visual displays. Mandatory lab time as part of project team of programmers, subject-matter specialists, and communication specialists.

Rhet 5600. Transfer of Technology. (4 cr; prereq work exper in scientific/technical comm or #) Schuelke  
Methods of transferring scientific and technical knowledge and practice. Review of research in diffusion and transfer methods at different technical levels. Tools, methodologies, and assessment procedures for managing program. Assessment and design plan.

Rhet 5680. Gender and the Rhetoric of Science and Technology. (4 cr; prereq 1101 or equiv) Lay  
How cultural gender roles and biological sex attributes influence communication within scientific and technical communities. Communication strategies of professional writers, scientists, and technologists.

Rhet 5700. Rhetorical Theory and Scientific and Technical Communication. (4 cr; prereq grad student or #; A-F only) Gross, Walzer  
Introduction to principles and history of rhetorical theory and criticism. Emphasizes classical theories, especially of Plato and Aristotle. Practice of rhetorical criticism of contemporary communication, including scientific communication. Contemporary scholarship in rhetoric of scientific and technical communication.

Rhet 5999. Special Workshop in Rhetoric. (1-4 cr; prereq #)  
Offered off campus. Consult *Class Schedule* or department for current offerings.

Rhet 8100. Research Methods in Rhetoric and Scientific and Technical Communication. (4 cr; prereq STC or RSTC grad student or #) Duin, Lay  
Nature of professionalism and of research in the field.

Rhet 8101. Rhetoric and Technical Communication Writing Seminar. (3 cr; prereq 8100, RSTC PhD student or #) Walzer  
Sites, genres, conventions, rules of evidence, and lines of argument in scholarly writing. Emphasizes clear and thoughtful written expression of scholarly ideas and concepts. Enables students to write a scholarly essay or comparable piece.

Rhet 8110. Theory and Research in Audience Analysis. (4 cr; prereq STC or RSTC grad student or #) Duin, Lay  
Review of research on human learning and understanding. Theories of audience analysis and preparation of written messages to reach defined audiences. Applications to problem-solving strategies in technical communication.

Rhet 8170-8171†. Design Project. (4 cr per qtr [8 cr req]; prereq STC Plan B grad student)  
Extended problem-solving situation in business, government, or industry in which student acts as consultant to explore a problem, identify possible solutions, introduce solution, and apply it. Scheduled workshops provide guidance, support, and research findings.

Rhet 8210. Theory and Research in Media Selection. (4 cr; prereq STC or RSTC grad student or #) Wahlstrom, staff  
To assist technical communication problem solvers in decision making. Survey of media available for transmitting messages between communication sources and receivers and analysis of factors that influence media choices.

Rhet 8258. Informational Research Interviewing in Scientific and Technical Communication. (3 cr; prereq STC or RSTC grad student or #; A-F only) McDowell  
Fundamentals of information-gathering and information-giving interviewing techniques, including interviewing process and types of interview guides and schedules, openings and closings, and sequences. Types of informational interviews: orientation, journalistic, probing, survey, and focus group.

Rhet 8500. Qualitative Research: Strategies in Technical Communication. (4 cr; prereq STC or RSTC grad student or #) McDowell, staff  
Qualitative methods of communication research, including qualitative observation and analysis, unobtrusive methods, focus group research, and organizational climate assessment. Students develop, conduct, and report on systematic qualitative research project.

Rhet 8510. Theory and Practice in Designing Messages. (4 cr; prereq STC or RSTC grad student or #) Gurak

Through case studies, how purpose and situation shape written discourse. Students develop and carry out strategies for delivering specific information to specific audience for specific purpose.

Rhet 8515. Topics in the Rhetoric of Science and Technology. (4 cr per qtr [max 16 cr]; prereq 5700 or Spch 5611 or equiv) Gross, Walzer  
Topics specified in *Class Schedule*.

Rhet 8525. Topics in Culture and Communication. (4 cr per qtr [max 12 cr]; prereq STC or RSTC grad student or #) Gurak, Lay, Mikelonis-Paraskov, Wahlstrom  
Topics, which vary, are drawn from international studies, gender studies, and science and technology studies. See *Class Schedule*.

Rhet 8535. Topics in Scientific and Technical Communication Pedagogy. (4 cr per qtr [max 12 cr]; prereq RSTC or STC grad student or #) Duin, staff  
Topics, which vary among theory and research, basic writing, and distance delivery, are specified in *Class Schedule*.

Rhet 8990. Special Problems in Rhetoric and Scientific and Technical Communication. (1-6 cr per qtr [max 6 cr]; prereq #, Δ)

## Russian Area Studies

*Professor:* Theofanis Stavrou (history), *director of graduate studies;* John S. Adams (geography); Iraj Bashiri (Institute of Linguistics and Asian and Slavic Languages and Literatures); Anatoly Liberman (German); Thomas S. Noonan (history); Herbert L. Pick, Jr. (child development); Richard Rudolph (history); Carol Urness (Bell Library); Rudolph Vecoli (history); Immigration History Research Center)

*Associate Professor:* Irina Corten (Institute of Linguistics and Asian and Slavic Languages and Literatures); Gary R. Jahn (Institute of Linguistics and Asian and Slavic Languages and Literatures); Leonard A. Polakiewicz (Institute of Linguistics and Asian and Slavic Languages and Literatures); Miranda Beaven Remnek (Slavic bibliographer, University Libraries)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degree Offered**—M.A. (Plan A and Plan B).

**Curriculum**—A wide range of courses are offered that deal with various aspects of the interdisciplinary study of the Russian area: language and literature, history, geography, political science, and economics. Coursework consists of a prescribed selection of core courses in the various disciplines, courses in an area of specialization, and one seminar.

**Prerequisites for Admission**—A bachelor's degree from an accredited university or college is required.

**Special Application Requirements**—The following must be forwarded directly to the department: three letters of recommendation, a copy of one or more papers representative of current level of scholarly development, and a statement of the student's purpose. Scores from the General Test of the Graduate Record Examination are required. Prospective students should contact the department for further information. Students are admitted each quarter.

**Degree Requirements**—Plan B students must take required courses in Russian literature (Russ 5421-5422), Russian history (two courses), and social science (Geog 5181 or equivalent; Pol 5471); take four further courses in one of the three areas of specialization (Russian history, Russian literature, or Soviet studies)—a list of acceptable courses is available from the department office; take one methodologies seminar (RAS 8061); demonstrate third-year-level proficiency in Russian by passing a special examination or earning a B or higher in specific coursework; and pass a final oral examination. Plan A students must fulfill these same requirements, except that they may take one less course in their area of concentration.

Plan A students must submit a thesis. Plan B students must submit three research papers (Plan B papers). Plan A theses and Plan B research papers should display familiarity with all the relevant bibliography on the topic, an awareness of the major issues, sustained analysis, substantial research in Russian language sources, and the use of other research and language tools where appropriate. Plan A theses and Plan B research papers must be read and approved by two members of the department's graduate faculty.

**For Further Information and Applications—** Contact Russian Area Studies, Area Studies Programs, University of Minnesota, 214 Social Sciences Building, 267 19th Avenue South, Minneapolis, MN 55455 (612/624-8543; fax 612/626-2242).

RAS 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

## Russian (Russ)

Russ 5104. Introduction to Literary Analysis. (4 cr; prereq 3103 or 13rd-yr Russian) Jahn  
Reading and analysis of selected poetry and prose; rudiments of studying Russian literature.

Russ 5106. Contemporary Russian Literature and Culture. (4 cr; prereq 3 yrs Russian, # for native speakers) Corten  
Current cultural and social issues in Russia through analysis of literary works and texts and Russian newspapers and periodicals. Taught in Russian.

Russ 5211. Modern Russian Literature in Translation. (4 cr, §3211) Corten  
Literary merit and cultural significance of the important works of Russian literature (1917 to present).

Russ 5404. Tolstoy in Translation. (4 cr, §3404) Jahn  
Novels, stories, and dramas.

Russ 5407. Stories and Plays of Anton Chekhov in Translation. (4 cr, §3407) Polakiewicz

Russ 5409. The 19th-Century Russian Novel in Translation. (4 cr, §3409) Polakiewicz  
Literary devices, ideas, and themes in five 19th century Russian novels. Intrinsic approach used in analyzing aesthetic merits of each work.

Russ 5411. Dostoevsky in Translation. (4 cr, §3411, §5401) Jahn  
An analytic approach to the novels.

Russ 5421. Literature: Middle Ages to Dostoevsky in Translation. (4 cr, §3421) Jahn  
Russian literature from about 1,000 A.D. through mid-19th century, emphasizing writers of first half of 19th century.

Russ 5422. Literature: Tolstoy to the Present in Translation. (4 cr, §3422) Corten  
Russian literature from mid-19th century to present: Realism, Modernism, Socialist Realism, and other developments since 1917, with view to language evolution and change.

Russ 5601. Translating Fiction From Russian to English. (4 cr; prereq 3 yrs college-level Russian or equiv, #) Corten  
Stylistic study of selected passages from 19th-century Russian classics and artistically suitable ways of rendering them in English. Individual projects translating modern Russian short stories into English with view to possible publication.

Russ 5900. Topics. (1-5 cr per qtr)

Russ 5970. Directed Readings. (1-5 cr per qtr; prereq upper div or grad student, #)

## Russian Area Studies (RAS)

RAS 8061. Scope and Methods of Russian Area Studies. (4 cr)  
Subfields, problems, and methodologies.

## Area Studies (Area)

Area 5950. Topics in Russian Area Studies. (4 cr)  
Topics in various disciplines of social sciences and humanities.

Area 5970. Directed Studies. (1-15 cr per qtr; prereq #, Δ, CLA approval)  
Guided individual reading or study.

Area 5990. Directed Research. (1-15 cr per qtr; prereq #, Δ, CLA approval)

## Central Asian Studies (CAS)

CAS 5311. Medieval Sages: Iran and Central Asia. (4 cr; prereq some background in Iranian or Central Asian or Islamic studies) Bashiri  
Intellectual life of the region from rise of the Ghaznavids (1000 A.D.) to fall of the Timurids (1500 A.D.).

CAS 5526. Islam and Communism. (4 cr, §3526, §MELC 3526, §MELC 5526) Bashiri  
Development of Islamic culture in Transoxiana; formation of Sufic orders; clash of Islamic principles with Soviet dicta; activities of Islamic institutions and of major Islamic centers in Soviet Union; Pan-Islamism.

CAS 5541. Russia and Central Asia. (4 cr) Bashiri  
Rise and fall of Mongol Empire, formation of Chaghatai Khanate and Golden Horde. Russian expansion into Central Asia and rivalry with Britain leading to the "Great Game." Russia and republics during Soviet period and after.

CAS 5601. Fiction: Iran and Central Asia. (4 cr, \$MELC 5601) Bashiri  
Social, political, and religious thought of Iranian and Central Asian fiction writers since beginning of 20th century, emphasizing themes of tradition, modernization, women's rights, and secularization.

CAS 5602. Persian Poetry. (4 cr, \$3602, \$MELC 3602, \$MELC 5602) Bashiri  
Major poetic works of Iran: quatrains of Omar Khayyam, sonnets of Hafiz; "new" Persian poetry, such as works of Farugh Farrokhzad.

CAS 5900. Readings in an Iranian Language. (1-4 cr per qtr [12 max cr], \$Per 5900; prereq Per 3013 or #) Bashiri  
Premedieval and medieval Iranian texts. Topics specified in *Class Schedule*.

CAS 5990. Directed Research. (Cr ar; prereq #)

## Polish (Plsh)

Plsh 5900. Topics. (4 cr)  
Topics specified in *Class Schedule*.

Plsh 5970. Directed Readings. (1-4 cr per qtr; prereq #, Δ, CLA approval)

## Slavic (Slav)

Slav 5900. Topics in Russian and East European Studies. (4 cr per qtr [max 12 cr])  
Topics specified in *Class Schedule*.

## Required Distribution Courses (Offered through other departments)

Geog 5181. Russia and Environs. (4 cr) Adams

Pol 5471. Politics of Russia and the Commonwealth of Independent States. (4 cr; prereq 3051 or non-pol sci grad student or #)  
Davidheiser

## Scandinavian Studies (Scan)

*Professor:* James A. Parente, Jr., *director of graduate studies;* Nils Hasselmo; Poul Houe; Anatoly Liberman; Göran Stockenström

*Associate Professor:* Kaaren Grimstad; William Mishler; Mariann Tiblin (Wilson Library)

*Assistant Professor:* Monika Zagar

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan B only) and Ph.D.

**Curriculum**—Students in the master's program emphasize one of the three Scandinavian languages and literatures, while

acquiring a thorough general knowledge of the other two. An M.A. program may also include Finnish. The program gives the student the opportunity to explore areas of personal interest. Students in the Ph.D. program concentrate on topic areas chosen in consultation with their adviser and the department's graduate faculty.

**Prerequisites for Admission**—Prospective students usually hold a bachelor's degree in Scandinavian or have some formal study of Scandinavian languages and literature at the undergraduate level. Applicants whose preparatory work shows gaps that can be remedied may be asked to complete supplemental work before admission.

**Special Application Requirements**—Three letters of recommendation from individuals qualified to discuss the applicant's academic performance, a complete set of transcripts (in addition to those sent to the Graduate School), Graduate Record Examination scores, a copy of one or more papers representative of the applicant's current level of scholarly development, and a statement of professional goals are required. Students generally are admitted in the fall quarter only. Applications for the Graduate School Fellowship and teaching assistantships must be received by January 15.

**Master's Degree Requirements**—Students must complete one course in bibliography; one course in literary criticism; a minimum of five literature courses (one in medieval or early modern literature; two in nineteenth-century literature; two in twentieth-century literature); one course in the history of the Scandinavian languages or Old Norse; and two courses outside the Scandinavian studies program, for a minimum total of 44 credits. One Plan B paper is required. The final examination is oral and is based on an individualized reading list in the student's primary Scandinavian language and on a list of 25 great works of Scandinavian literature.

**Doctoral Degree Requirements**—A minimum of 20 credits beyond the M.A. are required. Additionally, applicants must earn at least 18 credits in a minor or supporting program outside the Scandinavian program. In

consultation with an advisory committee, the doctoral student in Scandinavian languages and literature develops four research topics or fields of inquiry. One of these topics is the projected thesis topic. Students must complete two courses in literary criticism (which may be taken as part of the master's program) and demonstrate competence in the history and development of the Scandinavian languages.

**Language Requirements**—For the master's degree, a reading knowledge of one modern language in addition to the Scandinavian languages or Finnish is required. Finnish or Icelandic is acceptable if the primary language is a Scandinavian one; any modern Scandinavian language if Finnish is the primary one. For the doctoral degree, two non-Scandinavian languages, one of which must be German or French, are required in addition to the Scandinavian languages and Old Norse.

**Minor Requirements for Students Majoring in Other Fields**—The approval of the director of graduate studies is a prerequisite for minor work in the field. Coursework usually consists of no more than 12 credits for an M.A. minor and an additional 12 credits for a Ph.D. minor.

**For Further Information and Applications**—Contact the Department of German, Scandinavian, and Dutch, University of Minnesota, 205 Folwell Hall, 9 Pleasant Street S.E., Minneapolis, MN 55455 (612/625-2080; fax 612/624-8297; <http://macro.micro.umn.edu/german>).

*Courses identified by the §§ symbol do not require knowledge of the Scandinavian languages except for majors in Scandinavian. Courses in Scandinavian area studies are offered on a regular basis. For further information, see art history, geography, history, political science, and sociology.*

Scan 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Scan 8888. Thesis Credits: Doctoral. (36 cr required)

Scan 5201. §§Scandinavian Literature From the Late Middle Ages to the Enlightenment. (4 cr; prereq reading knowledge of a Scandinavian language for Scandinavian grads)  
Representative literary works from the 14th century to Bellman and Holberg.

Scan 5202. Scandinavian Literature From Romanticism to the Modern Breakthrough. (4 cr; prereq reading knowledge of a Scandinavian language for Scandinavian grads)  
Romantic and early realistic authors.

Scan 5421. Finnish Folklore: The Kalevala. (4 cr; offered alt yrs)  
Finnish national epic from a folkloristic point of view.  
Reading in translation.

Scan 5501. §§Scandinavian Mythology. (4 cr)  
Scandinavian myths based on the Poetic Edda and Prose Edda. All readings in translation.

Scan 5502. §§The Icelandic Saga. (4 cr)  
The saga literature, its origins and development.  
Readings in translation.

Scan 5511. Skaldic Poetry: Its Method. (4 cr; prereq a reading knowledge of Old Norse; offered when feasible)

Scan 5512. §§The Poetic Edda. (4 cr; prereq reading knowledge of Old Norse)  
Poems from the Poetic Edda (texts in Old Norse).

Scan 5611. §§Scandinavian Literature in Its European Context: Realism. (4 cr; offered alt yrs)  
Breakthrough of realism in Scandinavian literature in its European context. Representative European literary texts from the 19th century—dramas, novels, and criticism—read in translation.

Scan 5613. §§Contemporary Scandinavian Literature. (4 cr)  
Major trends after 1945. Readings in translation for nonmajors.

Scan 5614. §§The Drama of Ibsen and Strindberg. (4 cr)  
Later plays viewed in context of modern art and theatre with emphasis on different methods of visualizing the landscape of the soul on stage.

Scan 5615. §§Ibsen and the Beginnings of the Modern Drama. (4 cr)  
The plays of Ibsen; his role as the founder of modern European drama. Readings in translation for nonmajors.

Scan 5616. §§Strindberg and the Drama in Revolt and Transition. (4 cr)  
Strindberg as master of the naturalistic drama and as the father of modernity in European and American theatre.

Scan 5617. §§Scandinavian Literature in Its European Context: Symbolism. (4 cr; offered alt yrs)  
Representative European literary texts from late 19th and early 20th centuries—dramas, novels, and criticism—read in translation.

Scan 5618. §§Modern Scandinavian Drama. (4 cr)  
Scandinavian plays from the 20th century.

Scan 5619. §§Scandinavian Poetry Since 1890. (4 cr; prereq grad student, reading knowledge of a Scandinavian language)  
Representative poets since 1890.

Scan 5631. §§Nineteenth-Century Scandinavian Novel. (4 cr)  
Development from beginnings to end of 19th century.  
Readings in translation for nonmajors.

Scan 5632. §§Twentieth-Century Scandinavian Novel. (4 cr)  
Novels of Hamsun, Strindberg, Lagerkvist, others.  
Readings in translation for nonmajors.

Scan 5634. Scandinavian Women Writers. (4 cr)  
Writings of Karen Blixen in context of Scandinavian women's fiction.

Scan 5670. §§Topics in Scandinavian Studies. (4 cr per qtr)  
Topics announced before first class meeting. Readings in English for nonmajors. Meets with 3670.

Scan 5701-5702. Old Norse Language and Literature. (4 cr per qtr)  
Acquisition of a reading knowledge of Old Norse; linguistic, philological, and literary study of Old Norse language and literature.

Scan 5703. Old Norse: Saga Reading and Analysis. (4 cr; prereq 5702; offered alt yrs)  
(Continuation of 5702) Prose narrative in Old Norse; its literary content.

Scan 5704. History of the Scandinavian Languages. (4 cr)  
Scandinavian languages from the early Middle Ages to the present; cultural history. Readings in translation for nonmajors.

Scan 5711. Structure of the Scandinavian Languages. (4 cr; prereq intro ling course or #)  
Syntax and phonology of standard Danish, Norwegian, and Swedish. Readings in translation for nonmajors.

Scan 5970. Directed Studies. (1-5 cr; prereq #, Δ, CLA approval)  
Topics not covered by regular courses. Readings in Scandinavian literature in the original.

Scan 8201. Proseminar in Scandinavian Bibliography. (4 cr; required of all grad majors)  
Discussion of problems and approaches by staff members representing different specialties.

Scan 8202. Proseminar in Literary Methodology. (4 cr; required of all grad majors)

Scan 8501. Seminar: Medieval Scandinavian Languages and Literature. (3-4 cr; offered when feasible)

Scan 8601. Seminar: Scandinavian Novel. (3-4 cr; offered when feasible)

Scan 8611. Seminar: Scandinavian Drama. (3-4 cr; offered when feasible)

Scan 8621. Seminar: Scandinavian Poetry. (3-4 cr; offered when feasible)

Scan 8631. Seminar: Scandinavian Criticism. (3-4 cr; offered when feasible)

Scan 8702. Philological Proseminar II: Introduction to Philology With Special Emphasis on Methods. (2-4 cr)

Scan 8970. Research in Scandinavian Languages and Literature. (1-6 cr [may be repeated for cr])  
Guided research for advanced graduate students.

Scan 8975. Seminar: Scandinavian Immigrant Languages and Literature. (4 cr per qtr; prereq reading knowledge of one Scandinavian language, grad student; offered when feasible)

## Science and Technology Policy

See Public Affairs.

## Scientific and Technical Communication

See Rhetoric and Scientific and Technical Communication.

## Scientific Computation (SciC)

*Regents' Professor:* L. E. Scriven (chemical engineering and materials science)

*Professor:* Donald G. Truhlar (chemistry), *director of graduate studies*; Norma M. Allewell (biochemistry/biological sciences); Ronald E. Anderson (sociology); James R. Chelikowsky (chemical engineering and materials science); Efi Foufoula-Georgiou (civil and mineral engineering); Avner Friedman (mathematics); Daniel J. Kersten (psychology); Vipin Kumar (computer science); Mitchell B. Lusk (mathematics); Suhas V. Patankar (mechanical engineering); Linda R. Petzold (computer science); Youcef Saad (computer science); Ahmed Sameh (computer science); George R. Sell (mathematics); Charles C. S. Song (civil and mineral engineering); Harlan W. Stech<sup>1</sup> (mathematics and statistics); Ahmed H. Tewfik (electrical engineering); Tayfun E. Tezduyar (aerospace engineering and mechanics); David D. Thomas (biochemistry/medical school); Luke Tierney (statistics); Paul R. Woodward (astronomy); David A. Yuen (geology and geophysics)

*Associate Professor:* J. Bernardo Cockburn (mathematics); Lynne K. Edwards (educational psychology); Larry G. Hutchinson (linguistics); John L. Nieber (biosystems and agricultural engineering); Haesun Park (computer science); Michael R. Taaffe (operations and management science); Vaughan R. Voller (civil and mineral engineering)

<sup>1</sup> University of Minnesota, Duluth

*Assistant Professor:* Graham V. Candler (aerospace engineering and mechanics); Jeffrey J. Derby (chemical engineering and materials science); David M. Ferguson (medicinal chemistry)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A only) and Ph.D.

**Curriculum**—The graduate degree program in scientific computation encompasses coursework and research on the fundamental principles for using intensive computation to support research in the physical, biological, and social sciences and engineering. Emphasis is on research issues, state-of-the-art methods, and applying these methods to outstanding problems in science, engineering, and other fields that use scientific computation, numerical analysis and algorithm development, symbolic and logic analysis, high-performance computing tools, supercomputing and heterogeneous networks, and visualization. A handbook for prospective major students that describes the program and degree requirements in detail is available from the program.

**Prerequisites for Admission**—Both prospective graduate students and current graduate students in other programs may apply. Applicants fill out a form provided by the program as well as applicable Graduate School forms. A bachelor's degree in a field that uses scientific computation is required for admission. Applicants without such a degree who expect to obtain one before the date on which admission in the graduate program is sought may also apply.

**Special Application Requirements**—Three or more letters of recommendation and official transcripts for all previous undergraduate and graduate work are required for all applicants. Students are admitted each quarter.

**Master's Degree Requirements**—M.S. students must complete at least 28 course credits plus 16 thesis credits.

**Doctoral Degree Requirements**—Ph.D. students must complete at least 47 course credits plus 36 thesis credits. Students are required to pass written and oral preliminary examinations.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—Coursework consists of core and supplementary courses. Core courses for the minor include both SciC courses and pre-approved courses in other departments, a complete list of which is provided in the program's brochure. The minimum requirement for a *doctoral minor* is 18 graduate-level quarter credits, with at least 12 of these (at least four courses) selected from the minor core curriculum. The minimum requirement for a *master's minor* is 9 graduate-level quarter credits, with at least 6 of these (at least two courses) selected from the minor core curriculum. Students may use up to two courses from their major field for a doctoral minor or one course from the major field for a master's minor, provided that no rule exists prohibiting this in the major field and other courses are used to satisfy the major requirement.

Prospective minor students may request from the program a handbook that describes in detail the requirements for the minor and provides a list of pre-approved core courses.

**For Further Information and Applications**—Contact the Graduate Program in Scientific Computation, Minnesota Supercomputer Institute, University of Minnesota, 2051 SCC, 1200 Washington Avenue South, Minneapolis, MN 55414 (612/624-1556; fax 612/624-8861; e-mail [scic@msi.umn.edu](mailto:scic@msi.umn.edu); <http://www2.msi.umn.edu/SCP/scp.html>).

SciC 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr: doctoral student who has not passed oral prelims)

SciC 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

SciC 8888. Thesis Credits: Doctoral. (36 cr required)

## Core Courses

SciC 8001f. Parallel and High-Performance Computing. (4 cr; prereq undergrad degree in field using sci comp)  
Interdisciplinary overview of computer science aspects of scientific computation, both hardware and techniques. Parallel computing, architectures, programming, and algorithms; restructuring compilers; graphics and visualization; data structures; non-numerical algorithms; networks; operating systems; databases.

SciC 8002w. Advanced Numerical Methods. (4 cr; prereq undergrad degree in field using sci comp)  
 Interdisciplinary overview emphasizing computational aspects. Approximation methods for partial differential equations, numerical linear algebra, sparse matrix techniques, iterative methods, solution of eigenvalue problems, and case studies.

SciC 8003s. Modeling, Optimization, and Statistics. (4 cr; prereq undergrad degree in field using sci comp)

Interdisciplinary overview. Nonlinear equations and optimization, statistics, control theory, modeling, and simulation.

SciC 8011. Scientific Visualization. (3 cr; prereq undergrad degree in field using sci comp)  
 Basic issues, 3D graphics, representation of scientific data, modeling, visualization hardware, user interface techniques, commonly used algorithms and techniques for visualization, animation, examples of successful visualizations.

SciC 8013. Computational Aspects of Finite Element Methods. (4 cr, SAEM 8601; prereq undergrad degree in field using sci comp or IT grad student)

Fundamental concepts and techniques. Preprocessing: grid generation and refinement, data structures. Postprocessing: visualization. Parallel implementation of finite element techniques. Examples from structural analysis, thermal analysis, and/or fluid dynamics.

SciC 8090. Topics in Scientific Computation. (1-4 cr; prereq #)

Interdisciplinary topics.

SciC 8101f,s. Supercomputer Research Seminar. (1 cr per qtr [may be repeated for cr, max 4 cr])  
 Series of seminars by visiting lecturers.

SciC 8500. Scientific Computation Directed Research. (1-6 cr per qtr; prereq #)

Original work in an area of scientific computation that supports research in physical, biological, or social sciences and engineering supervised by a graduate faculty member.

## Social and Administrative Pharmacy (SAPh)

*Professor:* Judith M. Garrard; Laël C. Gatewood; Theodor J. Litman; Peter C. Morley; Stephen W. Schondelmeyer; Stuart M. Speedie; Lawrence C. Weaver (*emeritus*); Vernon E. Weckwerth; Darwin E. Zasko

*Adjunct Professor:* Bertram A. Spilker

*Associate Professor:* Ronald S. Hadsall, *director of graduate studies*; Paul W. Abramowitz; Daniel M. Canafax; Thomas Choi; Robert J. Cipolle; James C. Cloyd; Courtney V. Fletcher; Cynthia R. Gross; Henry J. Mann; Linda M. Strand

*Assistant Professor:* John M. Coster; Charles E. Daniels; Raquel Rodriguez

*Adjunct Assistant Professor:* Bruce E. Scott

*Other:* Angelina M. Carlson; Alan H. Heaton; Thomas S. Rector; Sharon J. Rolnick

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Students are prepared for research and related activities investigating relationships between biological and physical factors in social settings that involve the drug use process. This flexible interdisciplinary program uses the resources of the University's many health and social science departments. Programs include courses and offerings from public health, management, sociology, psychology, and public affairs.

**Prerequisites for Admission**—Although the majority of students in the program are pharmacists, a pharmacy education is not required.

**Special Application Requirements**—Applicants must complete a department supplementary application form in addition to the Graduate School forms. The supplementary form along with three letters of recommendation should be sent directly to the department. Graduate Record Examination scores are required.

**Master's Degree Requirements**—Core department courses are required. For the Plan B option, a project and at least one Plan B paper are required. Degree requirements are flexible to accommodate many career objectives in the drug use area. For specific requirements see the descriptive department brochure. A final oral examination is required.

**Doctoral Degree Requirements**—Core department courses are required in addition to selected studies in other departments. Before emphasizing the Ph.D. thesis, students must pass three written preliminary examinations on subjects chosen from an extensive list. In addition to Graduate School requirements, students must make an oral presentation to a meeting of department faculty and graduate students on the rationale for the thesis and the proposed methodology.

For specific requirements see the descriptive department brochure.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—For the master's degree minor, 9 credits are required. For the Ph.D. minor, two quarters of the department seminar and 16 credits of other coursework in the department are required.

**For Further Information and Applications**—Contact the Department of Pharmacy Practice, College of Pharmacy, University of Minnesota, 7-115 Weaver-Densford Hall, 308 Harvard Street S.E., Minneapolis, MN 55455 (612/624-2112; fax 612/625-9931).

SAPh 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

SAPh 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

SAPh 8888. Thesis Credits: Doctoral. (36 cr required)

SAPh 5870. Geriatric Assessment. (4 cr; prereq grad student or post-doc fellow)

Multidisciplinary approach to comprehensive assessment of geriatric clients/patients; physical function, health status, quality of life, financial status, and diversity issues.

SAPh 8100. Seminar. (1 cr per qtr)

SAPh 8200. Research Problems. (Cr ar)

SAPh 8255. Drug Marketing. (3 cr; offered alt yrs) Hadsall

Historical development of distributive systems, underlying economic principles, marketing channels, agencies, institutions, functions, policies, and practices as they relate to the pharmaceutical industry.

SAPh 8420. Social and Behavioral Aspects of Pharmacy Practice. (3 cr)

Historical development of the profession, its growth and development, with emphasis on the forces of education, professionalization, attitude modification, and the changes occurring as a product of legal and organizational forces in society.

SAPh 8500, 8501, 8502. Pharmacy and Its Environment. (3 cr per qtr; offered alt yrs) Hadsall, Morley, Schondelmeyer, Strand  
Cultural foundations of pharmacy. Development of present state of pharmacy practice. Social-psychological factors in drug use, abuse, or nonuse by the patient and practitioner. Role of the pharmacist as health practitioner—within the profession, in relation to other health practitioners, and in relation to the general public.

SAPh 8610. Behavioral and Social Research Methodologies in the Health Sciences. (3 cr) Gross

Survey of research methodologies for studying social and behavioral aspects of healthcare. Development of strategies for selecting and modifying existing research tools for particular purposes. Ethics of doing research on humans.

SAPh 8611. Research Design. (3 cr; prereq 8610) Gross

Survey of behavioral and social measures and development of skills in research design. Students present their own research designs and measurement tools for class critique and conduct at least a pilot study.

SAPh 8612. Research Seminar. (2 cr)

Research issues, ideas, design, findings, and interpretations presented by students and faculty for discussion.

SAPh 8840. Social Measurement. (3 cr, \$PubH 8813) Choi

Essential methodological techniques in social research measurement and theory construction. Explaining and establishing the correspondence between unobservable concepts (such as innovativeness, compliance, religiosity, stress, power) and their empirical indicators. Methods, techniques such as factor analysis, issues in reliability, validity, and scale construction. Computer analysis of data (brief introductory session presented for those who have not used a computer). Measurement, theory construction, and their interrelationship: assessing reliability and validity of the measurement of concepts used in theoretical propositions, showing how propositions are derived from theory, ways of constructing a theory, and appropriateness of theories.

*Note—The following courses are described under Hospital Pharmacy in this bulletin: SAPh 8210, 8220, 8301, 8400, 8700, 8701, 8702, 8703.*

## Social and Philosophic Studies of Education

*Professor:* Ayers L. Bagley, *director of graduate studies;* John J. Cogan; Roland A. Delattre; Glenn L. Hendricks; Darrell R. Lewis; Karen Seashore Louis; Marion Lundy-Dobbert; Tim L. Mazzoni; Josef A. Mestenhauer

*Associate Professor:* Arthur M. Harkins; Jean A. King; Robert E. Orton; R. Michael Paige; Patrick J. Starr; Caroline S. Turner

*Senior Fellow:* Richard B. Heydinger; Dean Honetschlager

*Other:* Carol Boyer; Timothy J. Delmont; Gerald A. McIntosh

**Course of Study**—The graduate minor in social and philosophic studies of education (SPSE) serves M.A. and doctoral students in relevant fields such as American studies,

anthropology, education, English, history, philosophy, political science, sociology, and women's studies.

**Curriculum**—The graduate minor provides a multidisciplinary foundation for the study of education from the perspectives of history, philosophy, and the social sciences. The minor program is shaped to suit the particular needs and interests of the student at either the master's or doctoral level. Courses are selected in consultation with a faculty member in SPSE in the Department of Educational Policy and Administration (EdPA) from a list of courses at the 5xxx and 8xxx levels both in EdPA and in related fields.

**Prerequisites for Admission**—Admission to the SPSE graduate minor is contingent upon prior admission to a master's or doctoral degree-granting program within the Graduate School. Interested students should consult with a faculty member in SPSE in the Department of Educational Policy and Administration.

**Special Application Requirements**—Students who wish to plan or declare a graduate minor in SPSE should contact the director of graduate studies in the Department of Educational Policy and Administration, which provides the administrative home for the graduate minor. The director of graduate studies in this department must approve the applicant's proposed course of study and indicate that approval by signing the student's Degree Program form.

**Minor Requirements**—M.A. students must complete at least 12 graduate credits in SPSE-approved courses divided between two areas of study. Doctoral students must complete at least 18 graduate credits in SPSE-approved courses divided between two areas of study and have a faculty member in SPSE on their preliminary examination and final oral examination committees.

**Language Requirements**—None specific to the minor program.

**For Further Information and Application**—Contact the Department of Educational Policy and Administration, University of Minnesota, 330 Wulling Hall, 86 Pleasant Street S.E., Minneapolis, MN 55455 (612/624-1006; fax 612/624-3377).

**Distribution Requirements**—For the M.A. minor, at least two courses from each of Areas I and II; for the doctoral minor, at least three courses from each of Areas I and II.

*AREA I—HISTORY AND PHILOSOPHY OF EDUCATION*

EdPA 5101. Historical Foundations of Modern Education. (4 cr)

EdPA 5102. Education Imagery in Europe and America. (3 cr)

EdPA 5155. History of Western Educational Thought. (4 cr)

EdPA 5156. History of Ideas in American Education. (3 cr)

EdPA 5170. American Pragmatism and Education. (3 cr)

EdPA 5182. Comparative Philosophies of Education. (3 cr)

EdPA 5245. Ethics, Morality, and Values in Education. (3 cr)

EdPA 8261. Social and Philosophical Foundations of Education. (Cr ar)

Phil 5324. Ethics and Education. (4 cr)

WoSt 5103. Feminist Pedagogies. (4 cr)

*AREA II—SOCIAL SCIENCES AND EDUCATION*

EdPA 5131. Comparative Education. (4 cr)

EdPA 5171. Anthropology and Education. (4 cr)

EdPA 5174. Ethnographic Research Methods. (4 cr)

EdPA 5176. Ethnographic Research Skills Laboratory. (2 cr)

EdPA 5190. Sociology of Education. (4 cr)

EdPA 5202. Politics of Education. (3 cr)

EdPA 5209. Education in Future Social Systems. (3 cr)

EdPA 5211. Social Design and Educational Futures. (3 cr)

EdPA 5280. Introduction to the Economics of Education. (4 cr)

EdPA 8170. Seminar: Research Methods in Anthropology and Education. (1-3 cr)

EdPA 8175. General Systems Thinking for Analyzing Education. (4 cr)

EdPA 8268. Seminar: Social and Educational Futures. (1-6 cr)

EdPA 8340. Simulation in Educational Design. (3 cr)

## Social Work (SW)

*Professor:* Jean K. Quam, *director;* Michael Baizerman; Jerome Beker; Richard S. Bolan; Neil F. Bracht; Geraldine K. Brookins; Jeffrey Edleson; C. David Hollister; Rosalie Kane; David J. Klaassen; Dario Menanteau-Horta; Susan S. Meyers; Rama Pandey (*emeritus*); Ronald Rooney; Esther Wattenberg (*emeritus*); Shirley Zimmerman

*Associate Professor:* Irl E. Carter; Jane F. Gilgun; Linda Jones; Helen Q. Kivnick; Donald E. Maypole<sup>1</sup>; Mark S. Umbreit; Oliver J. Williams

*Assistant Professor:* Sandra Beeman; Mark G. Frenzel; Ronald L. Pitzer; James R. Reinardy; Kimberly J. Strom-Gottfried

*Instructor:* Nancy Johnston, *director of graduate studies;* Nancy Abramson; Sonia Davila-Williams; Gloria M. McGee; Maura Sullivan

*Other:* William Bradshaw; Kevin John Burke; Nan L. Kalke; Gail M. Walters

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S.W. and Ph.D.

**Curriculum**—Concentrations in the master's program include practice in two areas: 1) direct practice, and 2) human services management. Three dual programs are also available: M.S.W./master of public health, M.S.W./master of arts in public affairs, and M.S.W./M.Plan. in planning. The doctoral program prepares students for advanced levels of scholarship and research and provides intellectual leadership for the profession; it does not provide advanced training for clinical practice. The doctoral program emphasizes interdisciplinary study and development of analytic skills to accommodate the diverse interests of individual students.

**Prerequisites for Admission**—Applicants to the M.S.W. program must present 39 quarter credits in the social sciences, e.g., sociology, political science, economics, psychology, history, and anthropology. Applicants must also have completed one course each in statistics and human biology. One year of paid or volunteer social work experience is required of all applicants who do not have a bachelor's degree in social work. Doctoral applicants must have earned the master's degree in social work from a school of social work accredited by the Council on Social Work Education, and must

have a superior academic record. Significant experience in social work practice is preferred.

**Special Application Requirements**—Three letters of recommendation, a complete set of transcripts (in addition to that required by the Graduate School), an example of written work, a personal statement, and a department application form are required of all applicants. Graduate Record Examination (GRE) scores are not required for admission to the master's program, but are required from applicants who wish to be considered for a Graduate School Fellowship and from applicants who do not have an official grade point average from their undergraduate degree. GRE scores are required for admission to the doctoral program. The application deadline is January 15 for the master's program and January 5 for the doctoral program. Beginning students in either program are admitted fall quarter only.

**Master's Degree Requirements**—The master's degree requires the equivalent of two years of graduate study. A weekend studies option is available through University College (formerly Continuing Education and Extension). A part-time program of up to four years is available in both weekday and weekend studies options. A total of 75 credits is required for the two-year M.S.W. degree; a 51-credit advanced standing program is available to graduates of undergraduate social work programs accredited by the Council on Social Work Education. All credits must be completed within five years of the date of the earliest course students wish to apply to their M.S.W. program. A maximum of 38 quarter credits may be transferred toward the 75-credit M.S.W. degree from the following sources with the approval of the School of Social Work: up to 30 credits of graduate-level coursework from University College at the University of Minnesota; up to 12 credits of work at graduate level and quality completed as an adult special student at the University of Minnesota; up to 38 credits from another regionally and professionally accredited school of social work, if the student was registered as a graduate student in the program; and up to 12 credits of non-social work electives taken as a graduate student at another university.

For the 51-credit program, a maximum of 25 quarter credits may be transferred from the

<sup>1</sup> University of Minnesota, Duluth

following sources with the approval of the School of Social Work: 25 credits completed as a graduate student in another accredited M.S.W. program; up to 20 credits of graduate-level coursework from University College at the University of Minnesota; and up to 12 credits of non-social work electives taken as a graduate student in another university.

**Doctoral Degree Requirements**—Programs are designed by the student and adviser to develop appropriate skills in research and scholarship. Required components of the program are seminars in research methods, statistics, social welfare history, social policy, and social work practice, theory and model development, and teaching. The doctoral program gives preference to applicants with at least two years of post-master's degree work.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the School of Social Work, University of Minnesota, 400 Ford Hall, 224 Church Street S.E., Minneapolis, MN 55455 (612/624-5888).

SW 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

SW 8888. Thesis Credits: Doctoral. (36 cr required)

### Core M.S.W. Degree

SW 5111. Contemporary Policy and Programs in Social Welfare. (3 cr for grad students, 4 cr for undergrads; prereq grad standing or 12 cr social sciences)

Framework for analysis of concepts and principles in social policy for social welfare programs and services.

SW 5211. Advanced Theories of Human Growth and Change. (3 cr for grad students, 4 cr for undergrads; prereq grad standing or 12 cr social sciences)

Socio-psycho-biological factors associated with individual and group development as applied to social work practice.

SW 5349. Social Welfare in America. (3 cr for grad students, 4 cr for undergrads, §Hist 5349)  
Social services, public policies, and profession of social work—colonial era to present. Dependency, deviancy, crime, social security, public health, social reform, functions of public and voluntary institutions (charities, settlements).

SW 5601. Ethnocultural Concepts in Social Work Practice. (3 cr for grad students, 4 cr for undergrads)

Relation of ethnocultural concepts to development of social welfare policies and services and social work practice. Critical examination of commonalities of principle and cross-ethnic issues and practices among the four major ethnic minority groups of color (American Indian, Asian American, Black, and Hispanic). Contribution of each to effective interpersonal and intragroup relationships in social service delivery system.

SW 8010. Field Instruction I. (4 cr or cr ar [max 12 cr required]; hrs ar)

SW 8020. Field Instruction II. (4 cr or cr ar [max 12 cr required]; prereq 8010)

Field practice in social work process under direct supervision.

SW 8030. Field Instruction in Social Work III. (Cr ar; prereq 8020)

Field experience in social work under direct supervision.

SW 8400. Social Work Methods I. (3 cr; prereq ¶18010)

Development of conceptual understanding of, and skill in, the social work process using ecological and problem-solving models as approaches for analysis. Ethics, assessment, interview skills, goal-setting.

SW 8401. Social Work Methods II. (3 cr; prereq 8400, ¶18010)

Further development of conceptual understanding of, and skill in, using various roles and interventions in working with individuals, families, and groups.

SW 8402. Social Work Methods III. (3 cr; prereq 8400, 8401, ¶18010)

Issues and interventions in social work macro-practice, including organizational structure and analysis, community organizing, and working in task groups.

SW 8901. Social Work Research Methods. (3 cr)  
Logic, methods, and techniques of scientific inquiry in social work. Nature and functions of theory, models, assumptions, problem formulation, causal analysis, conceptualization, operationalism, and hypothesis formulation.

SW 8902. Direct Practice Evaluation. (3 cr; prereq 8901 or equiv)

Students design evaluations that incorporate current evaluation methods and principles derived from research, theory, practice wisdom, and their own experience. Evaluation methods include single-system designs, event analysis, client-focused evaluations, and practitioner-focused evaluations.

SW 8903. Program Evaluation. (3 cr; prereq 8901 or equiv)

Conceptual, methodological, political, psychological, and administrative factors related to conduct and consequences of social work program evaluation. Social programs as cause and effect models, types and strategies of evaluation, and appraisal of selected social work research literature.

### Other Social Work Courses

SW 5001. Conflict Management in the Workplace. (1 cr)

Strategies and techniques for managing conflict between individual employees or groups of employees in social service agencies. Communication skills for addressing and resolving conflict; structural interventions that go beyond specific individuals involved.

SW 5002. Strategic Planning and Marketing in Human Service Organizations. (1 cr)

Concepts and techniques, including mission assessment, environmental scanning, identification of threats and opportunities, visioning, and implementation. Students may draft strategic plan for their program or organization.

SW 5003. Leadership and Supervision for Human Service Organizations. (1 cr)

Principles and practices of successful leadership/followership and supervision. Students assess and adjust their own interactive skills and personal styles and apply a problem analysis model to specific situations in their own organizations.

SW 5004. Resource Development and Grant Writing for Human Service Organizations. (1 cr)

Identifying and pursuing best “fit” between an organization and funding sources to carry out the organization’s programs; built on marketing perspective. Students write and receive feedback on portions of an actual grant proposal to a foundation or corporation, including case statement, goals and objectives, budget, and evaluation methods.

SW 5010. Seminar: Special Topics. (Cr ar)  
Topics specified in *Class Schedule*.

SW 5020. Public Health/Social Work Integrative Seminar. (3 cr, \$PubH 5020; prereq MSW/MPH student or other grad public hlt or social work student)

Socializes students to integrated, synthesized PHSW philosophy, roles, functions, knowledge, and skills for practical application to major contemporary social health problems. Expansionistic, social epidemiological, conceptual problem analysis, and community intervention.

SW 5024. Multidisciplinary Perspectives on Aging. (4 cr, \$AdEd 5440, \$CPsy 5305, \$HSU 5009, \$PA 5671, \$PubH 5737, \$Soc 5960)  
Multidisciplinary introduction to aging and the aging process.

SW 5025. International Social Welfare. (3 cr; prereq 1001, 3984 or #)

Role of international social welfare in meeting basic human needs and promoting human rights, social justice, and peace; theories, models, and strategies of social welfare in different economic and political systems; emphasis on Third World.

SW 5026. Mediation and Conflict Resolution. (3 cr; prereq MSW student or grad student in conflict management minor)

Development of mediator skills for making informed decisions regarding appropriateness of mediation in relation to conflicts frequently confronting social work practitioners, such as divorce, neighborhood disputes, conflicts between parents and adolescents, conflicts between spouses, and crime victims and offenders.

SW 5027. Peace and Justice as Societal Values. (3 cr)

Direct, structural, and cultural violence; connection between peace and justice; role of personal empowerment, alternative institutions, and nonviolent action; global-national-local strategies for action.

SW 5028. Social Work in the Schools. (3 cr)

Applying social work methods and skills in school setting. Emphasizes developing clinical skills, consultation, advocacy, and use of community resources as a school social worker.

SW 5030. Child Abuse Prevention: Directed Field Experience and Integrative Seminar. (3 cr per qtr; prereq 5301, 5302, 5303)

Two-quarter sequence arranged by program adviser for the child abuse prevention specialization.

SW 5100. Youth in the World. (3 cr, \$YoSt 5100)  
Theoretical and conceptual framework for understanding adolescence, adolescents, and youth in context of everyday life, e.g., in school, at play, in the community, at home.

SW 5102. Survey of Women and Public Policy. (3 cr, \$WoSt 5502, \$PA 5441; prereq 5111, WoSt 1001 or #)

Social and economic problems and policy issues of special significance to women in United States.

SW 5123. Financial Management in Public and Nonprofit Organizations. (3 cr, \$PA 5123)

Design, installation, and use of accounting and control systems; public accounting standards and practices; financial administration; debt management; controllership and post auditing; financial reporting; contract and procurement management systems.

SW 5212. Social Work With Older Adults. (3 cr)

Introduction to social work knowledge, skills, and values for working with older adults. Theories on and attitudes toward aging, nature and limitations of gerontological social work, forces shaping delivery system and context of practice, major biopsychosocial dimensions in practice, different models of intervention. Emphasizes cultural competence in working with ethnic groups and special populations.

SW 5213. Life-Cycle Therapy. (3 cr; prereq at least 2 qtrs field placement/internship or equiv exper in pro practice)

Erikson’s eight psychosocial themes used for understanding client behaviors, experiences, feelings, thoughts, and attitudes. Charting a client’s life cycle as a basis for formulating and implementing life-cycle interventions.

SW 5234. Clinical Practice Within a Hospital and Healthcare Setting. (3 cr)  
 Focused, practice-oriented learning environment that builds upon previous experiential and academic learning.

SW 5301. Child Abuse Prevention I: Research and Theory. (3 cr; prereq admission to child abuse prevention specialization)  
 Prevention of child abuse and neglect; conceptual framework for developing primary and secondary preventive interventions.

SW 5302. Child Abuse Prevention II: Program Development, Implementation, and Evaluation. (3 cr; prereq 5301)  
 Prevention of child abuse and neglect; skills for program design, implementation, and evaluation for children at risk.

SW 5303. Child Abuse Prevention III: Strategies for Policy and Systems Change. (3 cr; prereq 5302)  
 Prevention of child abuse and neglect; understanding social policy and systems change for children at risk.

SW 5312. Seminar: Direct Work With Adolescents. (3 cr, \$YoSt 5312)  
 Direct work with troubled and at-risk adolescents in wide range of settings in which social workers are typically involved. Emphasizes young people in groups in the "life space," in everyday life, rather than in one-to-one, office-based interactions.

SW 5404. Social Work Practice in Child Welfare. (3 cr)  
 Advanced survey of child welfare policies; use of multisystemic interventions; impact of poverty, race, ethnicity, and gender on policy and practice; current developments in family preservation, relative placement, foster care, adoptions, and Indian Child Welfare; role of social work in child protection services.

SW 5414. Fundamentals of Social Group Work. (4 cr for undergrads, 3 cr for grad students; prereq 3005)  
 Principles of social group work practice applicable to both task and treatment groups. Small group as a social process to achieve task and treatment goals. Sociophilosophic orientation, theoretical frames of reference, application of structure, task and process variables, use of member-to-member interactions, group goal setting, and professional relationships with groups, individual members, and systems external to small groups.

SW 5424. Social Work With Involuntary Clients. (3 cr, \$8424)  
 Analysis of involuntary transactions experienced by social workers in variety of settings. Theory, ethics, and strategies for intervention.

SW 5425. Brief Treatment and the Task-Centered Model. (3 cr)  
 Theory and practice of brief treatment approaches to social work practice. Various time-limited models explored and contrasted, focusing on task-centered practice, a model that is both time-limited and empirically based. Emphasizes theoretical base and application of model in variety of social work situations.

SW 5498. Child Development and Social Policy. (3 cr, \$PA 5498)  
 Intersection of developmental conceptual orientations with policies that affect children and families. Basic developmental, psychological, and social research that either currently informs, or should inform, effective policy formulation for optimal development of children and youth. Analysis of demographic, historical, and social trends that underlie assumptions that drive policies directed at women and children.

SW 8104. Child Welfare and the Law. (3 cr; prereq 8121, 8402 or equiv)  
 Social work practice in juvenile court: child abuse and neglect reporting laws, risk assessment, reasonable efforts, case plan, custody proceedings, permanency planning, termination of parental rights, child testimony, social worker testimony, adoption laws.

SW 8121. Social Policy and Delivery Systems for Family and Children's Services. (3 cr; prereq 5111)  
 Application of theoretical social policy framework to goals, tasks, organization, and delivery arrangements of programs serving social welfare of families and children.

SW 8122. Health/Mental Health Policy. (3 cr; prereq 5111)  
 Political, economic, and policy issues pertinent to social work practitioners.

SW 8150. Special Topics in Social Policy. (Cr ar)

SW 8301. Introduction to Human Services Management Theory and Practice. (3 cr)  
 Principles and practices of management and administration, with emphasis on social work settings.

SW 8305. Community Development. (3 cr)  
 Process by which groups and individuals within a community work together to fulfill community needs through social services; principles of working with unifunctional and local organizations.

SW 8307. Advanced Training in Human Services Management. (3 cr)  
 Skill development and practice in personnel management, resource development, and strategic planning.

SW 8311. Issues and Interventions in Child Sexual Abuse. (3 cr, \$5311)  
 Major issues and interventions involved in child sexual abuse. Development of knowledge and skills in working with sexually abused children and their families. Perceptions of victims, perpetrators, mothers, and other family members; interviewing; justice system; child protection.

SW 8350. Planned Social Change. (3 cr)  
 Analysis of systems in social work practice for social change, including human needs, policy planning, programming, management, and community participation.

## GRADUATE PROGRAMS

SW 8406. Supervision and Consultation in Social Work Practice. (3 cr; prereq 8401, #)  
Principles and practices of first-line supervision in direct practice systems—administration, education, and support. Principles and methods of consultation and staff development.

SW 8407. Strategies of Family Intervention. (3 cr; prereq 8401 or #)  
Seminar in methods of and strategies for helping families cope with family problems.

SW 8408. Direct Work With Children and Their Families. (3 cr; prereq 8121, 8402 or equiv)  
Research, theory, and practice in child welfare settings: research and theory on attachment, resilience, and vulnerability; child protection investigation and interviewing; work with maltreated children and their families; AIDS, crack, and cocaine babies; child placement; and foster care.

SW 8421. Social Work Practice: Psychopathology and Intervention. (3 cr, \$5421)  
Roles and intervention strategies of social workers in variety of service settings. Problems frequently presented, treatment alternatives, interdisciplinary practice, and ethical issues.

SW 8422. Social Work Practice With Persons With Serious and Persistent Mental Illness. (3 cr, \$5422; prereq 8402 or 66 cr MSW student)  
Specialized training and conceptual framework for understanding serious and persistent mental illness as individual and social problem. De-institutionalized, community-based care and consumer issues.

SW 8424. Social Work With Involuntary Clients. (3 cr; prereq 8401)  
Analysis of involuntary transactions experienced by social workers in variety of settings. Theory, ethics, and strategies for intervention.

SW 8425. Task-Centered Practice. (3 cr; prereq 8401)  
Theory and practice of time-limited, empirically based approaches drawing primarily from task-centered approach. Emphasis on instruction: practice and feedback on specific task-centered skills.

SW 8426. Intervention With Battered Women and Their Families. (3 cr, \$5426)  
Current theories, research, and social work practice concerning battered women and their families.

SW 8427. Family-Centered, Home-Based Services. (3 cr)  
Problems of concern to families; empowering parents and providing them with support. For both academic and practice arenas. Family-oriented content specific to FCHBS area. For applying family-centered principles to students' practice settings.

SW 8450. Special Topics: Practice With Individuals, Families, and Groups. (1-4 cr; prereq 8401 or #)

SW 8970. Directed Study. (Cr ar; prereq #)  
Independent study under tutorial guidance.

SW 8990. Research Projects. (Cr ar [max 6 cr])  
Opportunity to pursue, individually or in small groups, a line of empirical research inquiry of interest to the student and relevant to the field of social work. Translates content from the introductory courses into a research design and study to broaden and deepen research knowledge and skills. Projects may be conducted in conjunction with field learning experiences or other coursework.

### Doctoral Courses

SW 8130. Seminar: History of Social Work. (3 cr per qtr; prereq 5349 or Hist 5349)  
Ways in which social movements and key individuals have influenced the development, current status, and future prospects for social welfare, social services, and social work.

SW 8180. Social Policy Formulation and Analysis. (3 cr; prereq PhD student or #)  
Formulation and analysis of various theoretical perspectives and conceptual frameworks and their application to social policy issues and problems, and social welfare systems and programs.

SW 8461. Theory and Model Development in Social Work. (3 cr; prereq MSW or #)  
Conceptual paradigms for development and testing of practice innovations in social work.

SW 8701. Social Work Teaching Methods. (3 cr; prereq PhD student or 2nd-yr MSW student or #)  
Pedagogical theory and curriculum content bases for social work instruction. Introduction to scholarship and service roles assumed by social work faculty.

SW 8702. Social Work Teaching Seminar. (1 cr per qtr [2-qtr regis required]; prereq soc wk PhD student or #)  
Teaching methods and issues related to effective teaching in social work programs. Must be taken during same academic year as teaching experience requirement.

SW 8703. Faculty Role: Scholarship, Teaching, and Service. (3 cr, \$FPCH 8703)  
Rooney  
Interdisciplinary orientation to faculty roles. Skills for developing scholarly focus, carrying out academic and grant writing, facilitating, learning, performing service, and managing time and priorities.

SW 8991. Research Seminar. (3 cr; prereq PhD student)

SW 8992. Research Seminar. (3 cr; prereq 8991, PhD student)  
Continuation of 8991.

## Youth Studies (YoSt)

YoSt 5100. Youth in the World. (3 cr, §SW 5100)

Theoretical and conceptual framework for understanding adolescence, adolescents, and youth in context of everyday life, e.g., in school, at play, in the community, at home.

YoSt 5120. Independent Study in Youth Studies. (Cr or [max 12 cr]; prereq #)

Independent reading or research under faculty supervision.

YoSt 5130. Special Topics in Youth Studies. (3-5 cr [max 15 cr]; prereq #)

Review of research and discussion. Topics announced in *Class Schedule*.

YoSt 5132. Experiential Learning. (3 cr; prereq CPsy 5303 or #)

Purposes and models of experiential learning in schools and youth-serving agencies. Development, implementation, and evaluation of such programs.

YoSt 5200. Youth Policy: Enhancing Healthy Development in Everyday Life. (3 cr)

Differs from typical approaches in which policy is problem-focused and directed at "risk reduction." This model is grounded in youth's everyday life.

YoSt 5201-5202-5203. Youth Work Practice: Internship and Seminar. (4 cr per qtr; prereq acceptance into YoSt collateral)

Two-hour seminar and 8 to 10 hours of fieldwork each week. Students reflect on and integrate knowledge about youth with ongoing experience in work with youth.

YoSt 5230. Work With Youth: Individual. (3 cr per qtr; prereq Soc 1001, Psy 1001, CPsy 5303 or #)

Basic assumptions underlying work with youth. Emphasis on how adolescents learn to get along with themselves. Special issues and concerns of adolescents and of persons who work with them.

YoSt 5231. Work With Youth: Family. (3 cr per qtr; prereq 5230, FSoS 5200 or #)

Theories and techniques of therapy for adolescents and their families. Emphasis on practical methods of structural change; developing effective communication and problem-solving systems.

YoSt 5232. Work With Youth: Group. (3 cr; prereq 5230)

Basic assumptions underlying work with youth. Special concern for adolescents: how they learn to get along with themselves, their role in the family, relationships with peers and on the job.

YoSt 5300. Enhancing Community for Healthy Youth Development. (3 cr; prereq 6 cr social sci, exper working with youth)

Recent foundation and government reports that address issues and practical problems of community building.

YoSt 5312. Seminar: Direct Work With Adolescents. (3 cr, §SW 5312)

Direct work with troubled and at-risk adolescents in wide range of settings in which social workers are typically involved. Emphasizes young people in groups in the "life space," in everyday life, rather than in one-to-one, office-based interactions.

YoSt 5330. Child and Adolescent Psychology for Practitioners. (3 cr; prereq courses in educational psychology, child or adolescent psychology)

Applying theory and research about children and adolescents, including how findings can be used and how theories can facilitate understanding behavior of young people.

YoSt 5331. Youth Agencies, Organizations, and Service Systems. (3 cr; prereq two courses in sociology/anthropology, work exper in youth agency or organization)

Major forms of youth agencies, organizations, systems. Sociopolitical structures, legitimacy, ideologies, goals, programs, services. Staff, legal and ethical issues, youth participation.

YoSt 5401. Communicating With Adolescents About Sexuality. (3 cr; prereq 6 cr social sciences, exper in youth work or #)

Sexual development and experience; emphasis on effective communication between adults and youth. Sexual patterns, variations, roles, power, exploration, education.

## Sociology (Soc)

*Professor:* William Brustein, *chair*; Ronald R.

Aminzade; Ronald E. Anderson; Dennis D. Brissett<sup>1</sup> (medicine); David Cooperman; George A. Donohue (*emeritus*); Bertram L. Ellenbogen (*emeritus*); Barry C. Feld (law); Robert Fulton; Joseph Galaskiewicz; David Halle; Arthur L. Johnson (*emeritus*); David Knoke; Candace Kruttschnitt; Barbara Laslett; Robert K. Leik; Theodor J. Litman (public health); Karen S. Louis (educational policy and administration); Carl Malmquist; Margaret M. Marini; Donald G. McTavish; Dario Menanteau-Horta (rural sociology); Jeylan T. Mortimer; Joel I. Nelson; Ira L. Reiss (*emeritus*); Joel B. Samaha (history); Mark Snyder (psychology); David A. Ward

*Associate Professor:* Jane D. McLeod, *director of graduate studies*; John Arthur<sup>1</sup> (sociology-anthropology); Rose M. Brewer (Afro-American and African studies); Michael D. Finch (public health); Robert E. Kennedy; Joachim J. Savelsberg; Stephan P. Spitzer

*Assistant Professor:* Yanjie Bian; Jeffrey P. Broadbent; Elizabeth Heger; Jennifer L. Pierce; Christopher Uggen

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Ph.D. and M.A. (Plan A and Plan B). Students are admitted only for the Ph.D.; the M.A. is part of the Ph.D. program.

<sup>1</sup> University of Minnesota, Duluth

**Curriculum**—Studies in principles of social science, classical and contemporary sociological theory, and statistics and research methodology provide background for more advanced work organized around the following substantive foci: law, criminology, and deviance; social self and life course; organizations and occupations; historical and comparative; family, gender, and human sexuality. Although these are the main substantive areas, individual programs can be developed in other specialties such as political sociology, stratification, and network analysis. Training for students interested in both academic and applied employment is generally available.

**Prerequisites for Admission**—A background in basic sociology, usually consisting of the equivalent of 18 quarter credits in undergraduate work, including 9 quarter credits of social science statistical methods, or an M.A. degree in sociology or a closely related field is required. Individuals who have completed fewer than 18 credits may be admitted but are generally required to complete background coursework in theory and statistics during their first year of residence.

**Special Application Requirements**—Applicants are evaluated on their general academic potential, commitment to the field, creativity, and potential for contribution to the field. In addition to the Graduate School application, applicants must submit the following: Graduate Record Examination scores; a complete set of transcripts in addition to that required by the Graduate School; an application for department support (if desired); a sample of written work, usually a term paper, written in English; three letters of recommendation; and a statement of professional objectives. The department accepts new students for fall admission only. The final application deadline for admittance is March 1. For maximum fellowship support, the final application deadline is January 1.

**Master's Degree Requirements**—The department requires a general academic program consisting of approximately two years of coursework (including the same required core courses as for the Ph.D.), written papers or thesis, and a final oral examination.

**Doctoral Degree Requirements**—The program consists of a period of concentrated coursework (or its equivalent), extensive preparation in an area of specialization, a mentored research practicum, the submission of a file of written work for review, and a doctoral dissertation. Details of requirements may be found in the department's *Guide to Graduate Study*.

**Language Requirements**—For the master's degree, none. For the doctoral degree, expertise in a foreign language may be used to fulfill outside course requirements for students planning to conduct comparative research.

**Minor Requirements for Students Majoring in Other Fields**—Six courses in sociology, including two 8xxx courses, are required. Courses should be chosen equally from two of the department's subfields.

**For Further Information and Applications**—An informational brochure covering specific admission and degree requirements is available from the Graduate Secretary, Department of Sociology, University of Minnesota, 909 Social Sciences Building, 267 19th Avenue South, Minneapolis, MN 55455 (612/624-2093; fax 612/624-7020; e-mail socdept@atlas.socsci.umn.edu).

Soc 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Soc 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Soc 8888. Thesis Credits: Doctoral. (36 cr required)

## Law, Criminology, and Deviance

Soc 5101. Sociology of Law. (4 cr; prereq 3101-3102 or #; 5705 recommended) Cooperman, Savelsberg  
Sociological analysis of law and society. Examination, through historical and cross-cultural materials, of social forces involved in the creation of legal norms (both civil and criminal), procedures of enforcement, and impact of law on social change.

Soc 5102. Criminology. (4 cr; prereq 3101-3102 or #) Kruttschnitt, Savelsberg, Ward  
Nature and types of crime, problems in measurement of incidence and trends, and review of sociological theories of crime causation. Implications for crime prevention and control.

Soc 5104. Community-Based Corrections. (4 cr; prereq 3102 or #) Ward  
Theories behind and structures of diversion, probation, parole, and other community corrections programs that are alternatives to imprisonment.

Soc 5105. Contemporary Corrections. (4 cr; prereq 3101-3102 or #; 5161, 5162 recommended) Ward  
Advanced study of correctional organizations including prisons and jails; probation and parole, department and community corrections. Penal policies and practices in the United States compared with advanced penal systems in other countries.

Soc 5108. Current Issues in Crime Control. (4 cr; prereq 3102 or #) Kruttschnitt, Savelsberg  
Selected current criminal justice policies examined from the perspective of courts, legislature, community, and interest groups; impact of policy changes on society and social control agencies.

Soc 5109. Domestic Criminal Violence. (4 cr; prereq 3101-3102 or #) Kruttschnitt  
Survey of research on family violence within criminological framework. Definition of domestic violence; empirical and theoretical approaches to study of domestic violence; response of social control agencies.

Soc 5111. Sociology of Deviant Behavior. (4 cr; prereq 3101, 3102 or #) Uggen  
Nature of deviant behavior, social process associated with careers of deviants, and relationship of deviancy to problems of social control.

Soc 5114. The Social Control of Women Offenders. (4 cr; prereq 3102 or #; offered alt yrs) Kruttschnitt  
Historical and current explanations for female criminality; current trends in women's participation in crime and their treatment in the legal system.

Soc 5125. Policing in American Society. (4 cr; prereq 3101-3102 or #; 5161, 5162 recommended; offered when feasible) Samaha, Ward

Soc 5135. White-Collar Crime. (4 cr; prereq 3101-3102 or #; 5161, 5162 recommended; offered alt yrs) Cooperman, Savelsberg  
Types of white-collar crime, broadly construed; roots in American society; responses offered by theoreticians and amateur and professional politicians.

Soc 5141. Juvenile Delinquency. (4 cr; prereq 3101, 3102 or #; 5161, 5162 recommended) Uggen  
Societal response to juvenile delinquency through regulatory agencies; characteristics of juvenile justice institutions.

Soc 5142. Juvenile Justice Law and Organization. (4 cr; prereq 3101-3102 or #; 5161, 5162 recommended; offered alt yrs) Malmquist  
Sociological perspective on historical evolution of the juvenile court; organizational relationships between court, police, and other agencies; policies on serious offenders and status offenders; processes of intake, diversion, pre-trial detention, waiver to adult court, and sentencing; conflicts over due process and treatment objectives; current movements to abolish juvenile justice.

Soc 5147. Sociology of Mental Disorders. (4 cr; prereq 1001 or #) Malmquist, McLeod, Spitzer  
Social definitions and origins of mental illness, its epidemiology, patterns of reaction to mental illness including sociological analysis of mental health programs and their effectiveness. Social policy implications of mental health definitions.

Soc 5148. Criminal Psychopathology. (4 cr; prereq sr or grad student; offered alt yrs) Malmquist  
Psychiatric and psychological aspects of antisocial and criminal behavior as related to issues faced in courts and criminal justice system.

Soc 5149. Killing. (4 cr; prereq sr or law or grad student) Malmquist, Ward  
Sociological, legal, and psychological aspects of diverse types of killing. "Normal" killings contrasted with pathological types. Mentally disturbed, sexual, gang, and terrorist killings and killings within families.

Soc 5161. Criminal Law in American Society. (4 cr) Samaha  
Purposes and basic principles of criminal law; proper limits of criminal sanction; suggested reforms in existing criminal law.

Soc 5162. Criminal Procedure in American Society. (4 cr) Samaha  
Examination and assessment of the state's power to intrude into lives of citizens and deprive them of life, liberty, and property in enforcing criminal law. Arrest, search, and seizure powers, pre-trial practices, and prisoners' rights. Suggested limits on discretionary power of police, prosecutors, judges, and corrections authorities.

Soc 8105. Seminar: Criminal Policy. (3 cr; offered when feasible) Ward

Soc 8148. Law, Society, and the Mental Health System. (3 cr; prereq grad student, 5148 or #; offered alt yrs) Malmquist  
Intensive survey of psychopathology, with reference to criminal behavior and the criminal justice system.

**Social Self and Life Course**

Soc 5205. Symbolic Interaction. (4 cr; prereq 3201 or 5201 or equiv or #) Spitzer  
 Methods of acquiring knowledge in social psychology; outstanding pieces of research. Social psychology of small groups, mass behavior, and making of political and economic choices. Current thinking and research in this field in light of concepts and theories presented in introductory courses in social psychology.

Soc 5211. Social Processes in Small Group Settings. (4 cr; prereq 3201 or 5201 or #; offered alt yrs) Anderson, Leik  
 Small group research and theory focusing on both lab and nonlab investigation of interpersonal exchange, communication structures, status and power relations, coalition formation, reference groups, role differentiation, group uniformity, social influence, and problem-solving behavior. Lab arranged.

Soc 5215. Self-Concept in Theory and Research. (4 cr; prereq jr or sr or grad student, 16 cr social sci and/or educ or #; offered alt yrs) Spitzer  
 Major sociological theories and assessment methodologies characterizing study of the self; application to and findings in topical areas such as crime and delinquency, mental illness, socialization, aging, drug abuse, group processes, and policy evaluation.

Soc 5555. Population Theory. (4 cr; prereq 3551 or #; offered when feasible) Kennedy

Soc 5561. Demographic Methods. (4 cr, \$PubH 5460; prereq 3551 or #) Kennedy  
 Demographic measures and concepts of fertility, mortality, and migration. Stable population methods and demographic estimates from incomplete data.

Soc 5855. Sociology of Medicine and Healthcare: An Introduction to Medical Sociology. (4 cr, \$PubH 5790; prereq jr or sr or grad student) Litman, McLeod  
 Social factors associated with incidence in physical and mental illness and its treatment. Social organization of medical institutions. Public needs and medical services. Sociology of aging; social problems of the aged.

Soc 5954. Sociology of Gender. (4 cr; prereq 3401 or #: offered alt yrs) Laslett, Pierce  
 Historical, contemporary, and feminist perspectives on social organization and construction of gender roles and relationships. How gender shapes and is shaped by elements of social organization such as family, economy, ideology, and the state.

Soc 5956. Sociology of Death. (4 cr; prereq jr or sr, 8 cr sociology or #) Fulton  
 Issues and problems that mortality presents in contemporary society.

Soc 8215. Theories of Social Psychology. (4 cr; prereq #) Marini, Mortimer, Spitzer, Sykes  
 Review of current social psychological theories in important areas such as attitudes, communication, interaction and small groups, with the intent of integrating these materials according to a superordinate theoretical perspective.

Soc 8551. Seminar: Problems in Population Research. (3 cr; offered when feasible) Kennedy

Soc 8855. Seminar: Health and Human Behavior. (3 cr, \$PubH 8770; prereq 5855 or #: offered alt yrs) Litman, McLeod  
 Social ecology of health; social and personal components of illness; health and the community; social and cultural aspects of healthcare services.

Soc 8956. Death, Grief, and Bereavement. (3 cr; prereq #: offered alt yrs) Fulton  
 Issues and problems that mortality presents to contemporary society.

**Occupations and Organizations**

Soc 5311. Sociology of Conflict. (4 cr; prereq 3401 or 5401 or equiv or #) Cooperman, Savelsberg  
 Theoretical, empirical study of group conflict. Methods and models. Animal conflict. Aggression and conflict. Types of conflict: feuds, community, ecologies of urban conflict, racial, internal war, revolution. Conflict and social organization: relation of stratification, industrial and social change to conflict.

Soc 5401. Social Organization. (4 cr [no cr for sociology majors], \$3401; prereq 8 cr sociology, anthropology, economics, political science or psychology) Galaskiewicz, Knoke, Nelson, Savelsberg  
 Theories of social structure, social stratification, community structure, status groups, nature of social power, social control processes, aspects of formal organizations, and rational actor models for decentralized social processes.

Soc 5411. Formal Organizations. (4 cr; prereq 3401 or 5401 or equiv or 8 cr sociology, anthropology, psychology, political science or economics; offered alt yrs) Galaskiewicz, Knoke  
 Sociological analysis of formal organizations. Theories of structure of and behavior in corporations and bureaucracies. Corporate structure explored from standpoint of role expectations, transaction costs, and structural responses to organizational failures. Power, conflict, and bargaining in organizational decision making. Course content varies.

Soc 8411. Seminar: Current Topics in the Study of Organizations. (3 cr; prereq 5411; offered when feasible) Knoke, Galaskiewicz

Soc 8415. Theories of Social Organization. (4 cr; prereq #) Galaskiewicz, Knoke, Nelson, Savelsberg  
 Survey of social organization; presentation and critical analysis. Major social organizational concepts, theoretical perspectives, and current theoretically relevant literature.

## Historical and Comparative

Soc 5301. Social Movements in a Changing Society. (4 cr; prereq 3401 or 5401 or equiv or #) Aminzade, Broadbent, Brustein  
Origins and organization of social movements. Dilemmas and challenges facing movement organizations. Strategies and tactics of protest movements. Relationship between social movements and political institutions, including parties, the state, and the mass media. Role of social movements in dynamics of social change.

Soc 5305. Environmental Sociology. (4 cr; prereq 1001 or environmental course or #) Broadbent  
Interaction between social and natural systems, especially societal causes of increasing pollution and ecosystem destruction. Culture, social relations, politics, and economics as causes and potential solutions.

Soc 5481. Comparative Asian Development. (4 cr, §EAS 5481; prereq sociology of development, Asian-related courses or #; offered alt yrs) Broadbent  
Comparison of political-economical and sociocultural institutions creating high-speed growth and other social and political effects in East Asia, focusing on Japan and the "four little tigers": Taiwan, South Korea, Hong Kong, and Singapore.

Soc 5483. Sociology of German Society. (4 cr) Savelsberg  
Comparative approach. Mannheim, Elias, and Weberians suggest how history affects 20th-century events. Special features of German society; interrelatedness of contemporary institutions (family, education, work, social movements, government, law); current events.

Soc 5755. Social Structure and Political Behavior. (4 cr; prereq 3401 or 5401 or equiv or #) Aminzade, Broadbent, Brustein  
Alternative theoretical perspectives on power, the state, political parties, and political change. Relationship between socioeconomic structures and political behavior. Nature and social origins of democratic and authoritarian forms of the state. Distribution of power in contemporary United States, Western Europe, and/or East Asia.

Soc 5954. Sociology of Gender. (4 cr; prereq 3401 or #; offered alt yrs) Laslett, Pierce  
See Social Self and Life Course for description.

Soc 8477, 8478. Research Seminar: Historical Sociology. (4 cr per qtr; prereq #) Aminzade, Laslett  
8477: General theoretical and methodological issues in historical sociology. Student submits proposal outlining research to be undertaken in 8478. 8478: Research project carried out under supervision of instructors; submission of research paper.

Soc 8755. Seminar: Research in Political Sociology. (4 cr; prereq 5755 or #; offered alt yrs) Aminzade, Broadbent, Brustein  
Problems of research in political sociology and political economy; theory and methodology for explaining relationships at micro and macro levels. Individualized research projects.

Soc 8794. Democracy: Theory and Practice. (4 cr; prereq #) Aminzade, Broadbent  
Recent theory and research on origins and character of democratic institutions, focusing on comparative/historical research on citizenship, representation, party systems, and dynamics of change in democratic political systems.

## Family, Gender, and Human Sexuality

Soc 5441. Work-Family Linkages. (4 cr; prereq 8 cr soc or #; offered alt yrs) Mortimer  
Theoretical and methodological approaches to work-family interface; effects of spouses' work characteristics on family, including child socialization; family's influence on male and female labor force participation and occupational attainment; changes in work organizations related to increase in female employment and dual-earner families.

Soc 5555. Population Theory. (4 cr; prereq 3551 or #; offered when feasible) Kennedy

Soc 5561. Demographic Methods. (4 cr, \$PubH 5460; prereq 3551 or #) Kennedy  
See Social Self and Life Course for description.

Soc 5954. Sociology of Gender. (4 cr; prereq 3401 or #; offered alt yrs) Laslett, Pierce  
See Social Self and Life Course for description.

Soc 8501. Seminar: Contemporary Research on Marriage and the Family. (4 cr; offered when feasible) Laslett, Reiss

## Social Theory

Soc 5701. Analytical Social Theory. (4 cr; prereq 8 cr social sci or #) Cooperman  
Standards for evaluating sociological explanations. Main types of sociological theory: systems, theories of conflict, exchange, network, interpretive. Current issues in theoretical analysis.

Soc 5703. Social Theory and Cultural Change. (4 cr; prereq 8 cr social sci or #) Cooperman, Fulton, Laslett, Marini  
Theories of social change; methodological problems. Comparative social thought and structure of antiquity as basic data for analysis.

Soc 5705. Background of Modern Social Thought. (4 cr; prereq 8 cr social sci or #) Brustein, Laslett, Marini  
Selections from original texts by Marx, Weber, Durkheim, Freud, and Gilman. Division of labor, social cohesion and social control, gender and social reproduction, class relations and social organization of production, norms and values, history.

Soc 8701. Seminar: Classical Sociological Theory. (4 cr; prereq 8711, 8725 or #) Broadbent, Brustein, Cooperman, Laslett, Marini, Savelsberg  
Considered on individual, small group, organizational, and societal levels. Theorists such as Marx, Simmel, Durkheim, Weber, Gilman, Merton, Parsons, Mead, and Blumer.

## GRADUATE PROGRAMS

Soc 8702. Seminar: Contemporary Sociological Theory. (4 cr; prereq 8701 or #) Aminzade, Broadbent, Brustein, Cooperman, Laslett, Marini, Pierce, Savelsberg  
Social exchange, rational choice, feminist, critical, structure/agency debates, post-structuralism, and network theories considered at different levels of analysis. Specific content varies with instructor.

Soc 8725. Seminar: Theory Construction. (4 cr; prereq 8711 or #) Broadbent, Cooperman, Knoke, Marini  
Structure of scientific theories and basic tools for developing and critiquing them. Types of theoretical statements, use of symbolic logic, concept formation, operationalization, confirmation status, determinacy of predictions, generalization, testability.

### Methodology

Soc 5801. Computer Methods in Social Research. (4 cr; offered alt yrs) Anderson  
Basic concepts of information processing for social science research; elementary computer programming; practice in the use of computers for data analysis in social science; selected problems of computer usage in sociology.

Soc 5812. Content Analysis Methods. (4 cr; prereq 3803 or equiv or #; offered alt yrs) McTavish  
Content analysis methods used in social science research emphasizing computer-based developments. Theory, concept and dictionary formation, interview and data preparation procedures, contextual and conceptual computer analysis, interpretation, integration into quantitative and qualitative research.

Soc 5821w. Evaluation Research. (4 cr; prereq 3801, 3802, 3803 or #) Spitzer  
Evaluation methodology; conducting evaluations of education and social action programs; special problems for social scientists doing evaluation research; differences between evaluation research and basic research.

Soc 8714. Comparative Sociology: Perspectives in Theory and Research. (3 cr; offered when feasible) Broadbent, Cooperman, Savelsberg

Soc 8812. Data Analysis I. (4 cr; prereq 3801, 3802, 3803 or 5021 or #) Bian, Knoke, Marini, McLeod, McTavish  
Multivariate techniques based on general linear model: multiple correlation and regression, analysis of variance, analysis of covariance, canonical correlation, discriminant analysis, exploratory and confirmatory factor analysis, logistic regression, and structural equation modeling. Application using computers.

Soc 8813. Data Analysis II. (4 cr; prereq 8812 or #) Bian, Knoke, Marini, McLeod, McTavish  
Methods of categorical data analysis, including log linear analysis and other discrete variable techniques. Event history, time-series, longitudinal data, and network analysis. Application using computers.

Soc 8814. Seminar: Design of Sociological Research I. (4 cr; prereq 1st-yr soc grad student or #) Bian, Marini, McLeod, McTavish  
Multiple objectives of social research and how they inform research design. Choice of unit of analysis, role of comparison, natural vs. controlled experiments, observational research, archival research, cross-sectional vs. over-time designs, ethical issues.

Soc 8815. Seminar: Design of Sociological Research II. (4 cr; prereq 8814 or #) Anderson, McLeod  
Measurement and quantitative and qualitative data collection and management. Review of approaches; validity; reliability; settings in which different types of data are collected and preserved; documentary sources; ethical issues; coding; content analysis; data storage, management, and retrieval.

Soc 8817-8818. Sociological Research Practicum. (5 cr per qtr; offered alt yrs) Anderson, McLeod, Pierce  
Direct experience with variety of research techniques.

Soc 8821. Seminar: Design of Qualitative Research. (3 cr; prereq #) Pierce  
Techniques of qualitative field research. Participant observation, ethnography, in-depth interviewing, grounded theory.

Soc 8822. Seminar: Analysis of Qualitative Research. (3 cr; prereq 8821, #) Pierce  
Techniques for analyzing qualitative data, grounded theory, naturalistic inquiry, data presentation techniques.

Soc 8831. Measurement. (3 cr; prereq 3803 or equiv; offered when feasible) Anderson, Leik

### Other Areas

Soc 5960. Topics in Sociology. (1-5 cr per qtr; prereq 1001)  
Special, one-time offerings for juniors, seniors, and graduate students; topics specified in *Class Schedule*.

Soc 5970. Directed Study. (1-5 cr per qtr; prereq #)  
Guided individual readings or study.

Soc 8090. Topics. (Cr ar; prereq #)  
Topics announced in *Class Schedule*. May also be taken as directed study (general seminar) by arrangement with an instructor in the department.

Soc 8711. Seminar: Principles of Social Science. (4 cr; prereq 1st-yr soc grad student or #) Aminzade, Broadbent, Cooperman, Knoke, Laslett, Marini, Savelsberg  
Goal of science and how it is furthered by theory and empirical research. Process by which a cumulative body of knowledge is developed; usefulness of that knowledge for improving human welfare.

Soc 8955. Seminar: Teaching Sociology on the College Level. (3 cr; prereq 2nd- or 3rd-yr sociology grad student or #) Aminzade, Kennedy, Spitzer  
Purposes; new developments. Relevant learning theories; opportunity to develop a plan for teaching a course, either individually or as part of a team.

## Soil Science (Soil)

*Professor:* H. H. Cheng, *head*; Raymond R. Allmaras; James L. Anderson; Paul R. Bloom; Charles E. Clapp; Terence H. Cooper; Robert H. Dowdy; Peter H. Graham; David F. Grigal; Satish C. Gupta; Gary L. Malzer; Jean A. Molina; John F. Moncrief; David J. Mulla; Gyles W. Randall; George W. Rehm; Donald C. Reicosky; Carl J. Rosen; Michael J. Sadovsky; Mark W. Seeley; Ward B. Voorhees

*Associate Professor:* Edward A. Nater, *director of graduate studies*; Deborah L. Allan; John M. Baker; William C. Koskinen; John A. Lamb; Dennis R. Linden; Pierre C. Robert; Michael P. Russelle; Michael A. Schmitt

*Assistant Professor:* James C. Bell; David R. Huggins; Clive F. Reece

*Adjunct Assistant Professor:* Brenton S. Sharratt

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Areas of concentration include genesis and classification, chemistry and fertility, microbiology and biochemistry, physics, and agricultural climatology. The course of study varies with the requirements of the area of concentration and the interests of the student. The minor, supporting, or related fields are usually selected in some allied field such as agronomy, botany, chemistry, microbiology, biochemistry, physics, geology, economics, forestry, agricultural engineering, or atmospheric science.

**Prerequisites for Admission**—The academic background normally required includes standard courses in college physics, chemistry (including quantitative analysis and organic or biochemistry), geology, microbiology, and mathematics, including one course in calculus, and an introductory course in soil science. For agricultural climatology, additional courses in mathematics, physics, meteorology, and engineering may be substituted. Candidates for the Ph.D. degree are normally required to have completed an acceptable master's degree thesis.

**Special Application Requirements**—A statement of career goals and three letters of recommendation evaluating the applicant's potential for graduate study should accompany applications to both the M.S. and Ph.D. programs. Submission of Graduate Record Examination scores is required of all native English speakers and is strongly recommended

for nonnative speakers (in addition to the TOEFL requirement); students whose native language is not English are expected to have ranked in the top 20 percent of their class. Students may be admitted in any quarter.

**Master's Degree Requirements**—Students must complete a minimum of 20 course credits in the major (excluding 5114) plus 16 master's thesis credits. Soil science coursework must include at least one core course in three of the five areas of concentration: soil chemistry-fertility, soil genesis-classification, soil physics, soil microbiology/biochemistry, and agricultural climatology. A seminar presentation and one colloquium are also required. A final oral examination is required.

**Doctoral Degree Requirements**—Students must complete or have completed at least one core course in three of the main areas of soil science listed under the M.S. degree requirements, two additional seminars, and two additional colloquia, plus 36 doctoral thesis credits. One of the required seminars outlines the proposed thesis research. A final oral examination is required.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Director of Graduate Studies, Department of Soil, Water, and Climate, University of Minnesota, 439 Borlaug Hall, 1991 Upper Buford Circle, St. Paul, MN 55108 (612/625-1244; fax 612/625-2208).

Soil 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Soil 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Soil 8888. Thesis Credits: Doctoral. (36 cr required)

Soil 5020. Environmental Impact Assessment. (4 cr; prereq jr or sr, 16 cr science, 5510, AgEc 3610 or #) Cooper Roles of government agencies, consultants, and private citizens in assessment process. Steps in writing an environmental impact statement (EIS). Case studies, writing additional components of EIS, and preparing an EIS for a small local project.

Soil 5022. Introductory Soil Science for Teachers. (4 cr, \$1020; prereq college chem course, educ degree, #) Cooper

Physical, chemical, and microbiological properties of soil. Using soil classification system to understand use of soil survey information for land use planning. Soil fertility concepts used in environmental planning and conservation decisions.

## GRADUATE PROGRAMS

Soil 5100. Problem Solving in Environmental Science. (5 cr; prereq sr)

Solving a real-world environmental problem. Students make oral and written presentations as members of a team.

Soil 5104. Computer Applications in Soil Science. (2 cr; prereq 1020 or 3125 or equiv, #) Robert

Practical problem-solving methods. Applications in soil climatology, chemistry-fertility-microbiology, genesis-inventory, and physics. Use of spreadsheets, relational databases, geographic information systems, and simulation models. Hands-on experience in computer lab. No computer programming experience required.

Soil 5110. Practicum Internship in Precision Agriculture. (2-4 cr; prereq sr or grad student, #) Practical experience in agri-industry or government agency.

Soil 5114I. Special Problems in Soils. (1-7 cr per qtr; prereq 3125, #, Δ) Independent study.

Soil 5183. Water Relations, Mineral Nutrition, and Translocation in Higher Plants. (4 cr; prereq PBio 3131 or equiv) Allan, Markhart  
Transport processes in plants, including water and nutrient absorption and distribution, effects of and adaptations to water and nutrient stress, functions of mineral nutrients, and translocation of photosynthates.

Soil 5210. Environmental Biophysics. (3 cr; prereq Math 1251, Phys 1041 or #) Reece  
Physical micro-environment and energy/mass exchange processes among soils, plants, animals, and atmosphere. Calculating energy (sensible, latent, radiation) and mass ( $H_2O$ ,  $CO_2$ , trace gases) transfer using mathematical models and energy budget analyses. Lecture and recitation.

Soil 5211. Environmental Instrumentation. (2 cr; prereq 5210, 5240 or #) Reece  
Measuring environmental variables and analyzing energy and mass exchange based on such measurements. Principles of operation of environmental instruments and sources of measurement errors. Hands-on use of instruments. Lab and lecture/recitation.

Soil 5232. Soil Physics. (4 cr; prereq Math 1142 or equiv or #) Gupta  
Basic physical laws governing processes occurring in soils and their quantification. Physical basis for water, air, and heat transport processes. Lectures, lab demonstrations, and problem-solving help sessions.

Soil 5241. Microclimatology. (3 cr, \$5240; prereq Math 1111 or 10 cr physics or #) D Baker  
Meteorology and climatology in relation to soil-atmosphere interface with emphasis on microclimate; physical processes taking place within microclimate; modification of microclimate by human activities, including agricultural practices; meteorological instruments and use of weather data.

Soil 5310. Soil Chemistry. (3 cr; prereq Chem 3100 or #) Bloom

Chemical processes in soil; composition of soil minerals and organic matter, solubility equilibria, adsorption/desorption, ion exchange, formation of soluble complexes, oxidation/reduction, acidity, alkalinity. Solution of problems related to environmental degradation, plant nutrition, and soil genesis.

Soil 5311. Soil Chemistry Laboratory. (2 cr; prereq ¶5310)

Lab exercises illustrate principles discussed in 5310. Techniques include pH, atomic adsorption spectrophotometry, ion specific electrodes, colorimetry, redox potential, and titration techniques.

Soil 5360. Soil Clay Mineralogy. (3 cr; prereq sr standing or grad student; offered alt yrs) Nater  
Structural chemistry, and origin and identification of crystalline and noncrystalline soil clay minerals. Extent, importance, and pedologic implications.

Soil 5361. Soil Clay Mineralogy Laboratory. (1-4 cr; prereq ¶5360, #)

Individual lab assignments emphasizing techniques of clay mineral identification and analysis. Emphasis on X-ray diffraction methods. Electron optical, thermal, selective dissolution, FTIR spectroscopic, and other methods of analysis.

Soil 5424. Applied Climatology. (3 cr, \$Geog 5424; prereq 5240 or Geog 3421 or #) D Baker

For advanced undergraduates and beginning graduate students with background in principles of climatology or microclimatology. Sources of climatic data, methods of analysis, and selected set of specific applications focusing on agricultural and environmental management problems.

Soil 5510. Field Study of Soils: Morphology. (1 cr; prereq 1020 or 3125 or #) Cooper

The art and science of writing and classifying soil profile descriptions.

Soil 5511. Field Study of Soils: Mapping. (1 cr; prereq 5510 or ¶5510)

The art and science of making soil maps based on soil profile descriptions.

Soil 5515. Soil Development, Classification, and Geography. (4 cr; prereq 3125 or #) Nater  
Soil profile characteristics; influence of parent material, climate, topography, vegetation, and time on soil development, system of soil classification, and geographical distribution of soil orders.

Soil 5550. Peatlands: Formation, Classification, and Utilization. (3 cr; prereq 1020 or 3125 or #) Grigal  
Formation, properties, and management of peatlands important to crop, forestry, and energy production in Minnesota and world. Lectures.

Soil 5555. Wetland Soils. (4 cr; prereq 1020 or 3125, 5510 or ¶5510 or #)

Formation, classification, and utilization of wetland soils, emphasizing hydric soil identification. Hydrologic and biochemical processes of soil; field-based exercises to map hydric soils.

Soil 5600. Principles of Waste Management. (4 cr, \$NRES 5600; prereq Biol 1009 or Chem 1051, Stat 3011 or #) Halbach

Issues, problems, and solutions in remedying waste stream generated by current society. Waste stream dynamics, MSW and yard waste composting, WTE incineration operation, ash disposal, recycling, landfill requirements, direct land disposal requirements, regulatory trends, and case studies.

Soil 5605. Microbial Ecology. (3 cr, \$MicB 5611; prereq 5610 or Biol 5013 or MicB 5105 or #) Sadowsky

Interrelationship of microorganisms with terrestrial, aquatic, and organismal environments; survey of bacterial, fungal, and algal components of ecosystems; evolution and structure of microbial communities; population interactions within ecosystems; quantitative and habitat ecology; biogeochemical cycling; and biotechnological approaches to study of microbial ecology.

Soil 5610. Soil Biology. (4 cr; prereq sr or grad student) Graham

The soil environment, its biological population. Role of living organisms in soil-plant environment and mineral transformations of agronomic importance (carbon, nitrogen, phosphorus, sulfur, heavy metals). Effects of soil microflora on soil fertility and plant nutrition. Lectures and recitation.

Soil 5611. Soil Biology Laboratory. (1 cr, ¶5610)

Techniques include counting microbes in soil, purification and classification of soil microorganisms, role of earthworms in nutrient cycling, nodulation and N<sub>2</sub> fixation, serology.

Soil 5710. Forest Soils. (3 cr; prereq 1020 or 3125) Grigal

Factors affecting tree growth; estimation, modification, and management effects on site productivity; regeneration.

Soil 5999. Special Workshop in Soil, Water, and Climate. (1-4 cr; prereq #)

Offered off campus. Consult *Class Schedule* or department for current offerings.

Soil 8000. Supervised Teaching Experience. (2 cr, \$Agro 8000, \$Hort 8000; prereq #) Allan  
Classroom or extension teaching experience in Department of Agronomy and Plant Genetics or Horticultural Science or Soil Science; participation in teaching topic discussions to strengthen skills and develop personal teaching philosophy.

Soil 8111f,w,s. Colloquia in Soil Science. (1 cr; prereq major or minor in soil sci or #)

Methodologies or rapidly developing areas of research not treated in existing courses. Lectures and discussions; some topics include visits to field sites and other laboratories.

Soil 8112. Colloquia in Soil Science II. (1-2 cr; prereq major or minor in soil sci or #)

Methodologies or rapidly developing areas of research not treated in existing courses. Lectures and discussions; some topics include visits to field sites and other laboratories.

Soil 8124.\* Research Problems in Soils. (2-5 cr; hrs ar)

Individual fieldwork lab in special problems in an area of soils other than that of the student's major thesis. Arrangements must be made in advance.

Soil 8128.\* Seminar: Soils. (1 cr)

Students, invited specialists, and faculty present significant concepts and research in soil, water, and climate sciences. Students must contact seminar committee representative at least one month before term begins to schedule a presentation.

Soil 8250. Advanced Soil Physics. (3 cr; prereq 5232, differential equations or #) Gupta

Methods of measuring or estimating thermal and hydraulic characteristics of soils. Sealing soil hydraulic parameters. Numerical and analytical solutions of heat and water flow equations. Spatial and temporal variability in soil physical properties. Predicting soil mechanical behavior during tillage and compaction.

Soil 8330. Advanced Soil Chemistry. (4 cr; prereq physical chem or #; offered alt yrs) Bloom

Using physical chemistry principles for studying chemical processes in soil; chemistry of carbonates, dissolution/precipitation equilibria, oxidation/reduction, kinetics, adsorption/desorption, ion exchange and speciation of ions in solution. Lectures and discussion of current literature.

Soil 8400. Advanced Topics in Soil Fertility. (3 cr; prereq 3416 or equiv; offered alt yrs) Allan

Soil testing, plant tissue analysis, application of amendments, models, and decision-making tools.

Soil 8630. Current Topics in Biological Nitrogen Fixation. (2 cr; prereq 5605 or 5610 or #; offered alt yrs) Graham

Selected topics including inoculant production and control; ecology of *Rhizobium* in the soil; legume-*Rhizobium* specificity; competition; C and N nutrition of legumes; and environmental factors affecting BNF.

## South Asian and Middle Eastern Languages and Cultures<sup>1</sup>

*Professor:* Indira Y. Junghare, *chair and director of graduate studies*; Frederick M. Asher (art history); Iraj Bashiri (Slavic and Central Asian languages and literatures); David Kopf (history); Joseph E. Schwartzberg (geography)

*Associate Professor:* William W. Malandra (Classical and Near Eastern studies); Martin W. Sampson (political science)

*Librarian:* Donald C. Johnson

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

---

<sup>1</sup> No new students will be accepted for the South Asian languages major during 1996-99.

**Degrees Offered**—South Asian Languages: M.A. (Plan A and Plan B) and Ph.D.

**Curriculum**—Concentrations are Hindi, Marathi, and Sanskrit. Programs focus on languages, literatures, cultural traditions, and contemporary problems of South Asia (countries of the Indian subcontinent and Himalayan borderlands).

**Special Application Requirements**—See the General Information section of this bulletin for Graduate School requirements.

**Master's Degree Requirements**—For the South Asian languages major, three years of study in one South Asian language or demonstration of equivalent level of proficiency is required. Besides language courses, Plan A requires two seminars and two non-language courses. Plan B requires two seminars and three courses on culture, history, literature, or religion, depending on the student's academic goals and subject to approval of the adviser. The final examination is oral.

**Doctoral Degree Requirements**—Four years of study in the language of concentration or demonstration of an equivalent level of proficiency and two years of study in a second South Asian (or related) language are required. The student is expected to enroll in seven non-language courses related to her or his academic goals. The student should have had at least one year in academic residence at Minnesota before taking the preliminary written and oral examinations.

**Language Requirements**—None for admission; for master's and doctoral programs, see above.

**For Further Information and Applications**—Contact the Department of South Asian and Middle Eastern Languages and Cultures, University of Minnesota, 188 Klæber Court, 320 16th Avenue S.E., Minneapolis, MN 55455 (612/624-4118).

SALC 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

SALC 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

SALC 8888. Thesis Credits: Doctoral. (36 cr required)

## Hindi (Hndi)

Hndi 5131-5132-5133. Intermediate Hindi. (5 cr per qtr; prereq 1103 or 5103 or #)

Hndi 5161-5162-5163. Advanced Hindi. (4 cr per qtr; prereq 3033 or 5133 or #) Junghare  
Reading and discussion of short stories and other literature.

Hndi 5701. Structure of Hindi. (4 cr; prereq 3031 or 5131 or #) Junghare

Intensive examination of structure of Hindi language with attention to syntactic and semantic structure.

Hndi 5710. Topics in Hindi Language and Literature. (5 cr) Junghare  
Specialized topic in either the linguistic structure of Hindi or Hindi literature. Topic varies with student and faculty interest.

Hndi 8990. Research. (Cr ar; prereq #)

## Marathi (Mar)

Mar 5101, 5102, 5103. Beginning Marathi. (5 cr per qtr, §1101, 1102, 1103) Junghare

Mar 5970. Directed Readings. (Cr ar) Junghare

## Sanskrit (Skt)

Skt 5131-5132-5133. Beginning Sanskrit. (5 cr per qtr) Malandra

Skt 5201-5202-5203. Intermediate Sanskrit. (5 cr per qtr; prereq 5133) Malandra

## South Asian Languages and Cultures (SALC)

SALC 5011. Indo-Aryan Linguistics. (4 cr) Junghare  
Phonological, morphological, and syntactic developments; Indo-European, Old Indo-Aryan, Middle Indo-Aryan, Hindi, and other major modern Indo-Aryan languages.

SALC 5036. The Religion of Islam. (4 cr, §3036, §ReIs 1036, §ReIs 3036, §ReIs 5036) Farah  
Evolution of Islam in historical context; institutions that made for diversity and continuity: traditions, law, and observances of the faith; sectarian movements; philosophical and theological trends; modern developments: reformist, revolutionary, and militant.

SALC 5090. Instruction in South Asian Languages. (Cr ar; offered when feasible)

SALC 5201. Ancient Indian Literature in Translation. (4 cr, §3201) Junghare  
Literary achievements of Indian civilization from ancient period.

SALC 5202. Modern Indian Literature in Translation. (4 cr, §3202) Junghare  
Literary achievements of Indian civilization from modern period.

## SOUTH ASIAN AND MIDDLE EASTERN LANGUAGES AND CULTURES

SALC 5203. Comparative Indian Literature in Translation. (4 cr, §3203) Junghare  
Comparative Indian literature of modern period.

SALC 5232. Early Buddhism, Caste, and Chauvinism. (4 cr, §Hum 5232, §RelS 5232; prereq jr or sr or grad student or #)  
Polemics and intellectual/social implications of early Buddhists rejecting caste traditions of Indian religions, which led to conversion of non-Hindus and missionary expansion of Buddhism.

SALC 5411. Introduction to Indian Philosophy. (4 cr, §3411) Junghare  
Major concepts; principal schools of Indian philosophy; traditional and contemporary views.

SALC 5412. Hinduism. (4 cr, §3412, §RelS 3412, §RelS 5412; 1504 or 3411 or RelS 1031 or # recommended) Junghare  
Development of Hinduism; sectarian trends, modern religious practices, myths and rituals, pilgrimage patterns and religious festivals, and interrelationship of Indian social structure and Hinduism.

SALC 5413. Buddhism. (4 cr, §3413, §RelS 3413, §RelS 5413) Junghare  
Historical account of Buddhist religion in terms of its rise, development, various schools, and common philosophical concepts. Focuses on Indian Buddhism, compares it with Hinduism, and discusses its demise and revival on Indian subcontinent.

SALC 5414. Comparative Religions of South Asia. (4 cr, §3414, §RelS 3414, §RelS 5414; 3412 or RelS 3413 recommended)  
Compares and contrasts basic philosophical concepts, literatures, ideologies, and ritualistic practices of Hinduism, Buddhism, and Jainism with those of Islam and Sikhism.

SALC 5500. Problems in Indian Philosophy. (4 cr, §Phil 5801; prereq 5 cr phil, 4 cr Indian phil or religion or #)  
Emphasizes analyses of mind and knowledge.

SALC 5710. Seminar in South Asian Languages and Literatures. (Cr ar)

SALC 5833. India's Gods and Goddesses. (4 cr, §Hum 5833, §RelS 5833; prereq Hum 1211 or RelS 1031 or SoAs 1504 or equiv, jr or sr or #)  
Societies give shape to their gods/goddesses and are in turn shaped by these mythological constructs. Indian history examined by following development of deities Krishna, Shiva, and Kali. Interactions of region, gender, class, in manifestations of art, drama, literature, ideology.

SALC 5940. Topics Proseminar. (1-4 cr)  
Selected topics in language, literature, or civilization.

SALC 5960. Topics in South Asian Languages and Cultures. (4 cr)  
Topics specified in *Class Schedule*.

SALC 5970. Directed Studies. (Cr ar; prereq #, Δ)  
Guided individual reading or study.

SALC 5990. Directed Research. (Cr ar; prereq #, Δ, □)

SALC 8710. Seminar: South Asian Languages and Literature. (Cr ar; prereq #)

SALC 8720. Seminar: Interdisciplinary Study of South Asian Topics. (5 cr; prereq #)  
Selected Indian topics: language problems, social structure, social and cultural change, law, and religion as seen from variety of disciplinary perspectives in both social sciences and humanities.

SALC 8730. Teaching South Asian Languages and Literature. (4 cr; prereq #)  
Fundamentals of language instruction as applied to South Asian languages and literature. Instruction in materials preparation and teaching or specific languages to a controlled group.

SALC 8990. Research. (Cr ar; prereq #)

### Middle Eastern Languages and Cultures (MELC)

The following courses relating to the Middle East are applicable to student programs focusing on those features of South Asia that overlap with the Middle East (e.g., the Arab world, Iran, Turkey). Some of these courses are also applicable to the M.A. program in Arabic.

MELC 5001. Introduction to Research in Arabic Studies. (4 cr, §Arab 5001)  
Survey of most important research bibliographies in Arabic and Islamic studies. Bibliographic references in English and possibly in Arabic if sufficient interest.

MELC 5036. The Religion of Islam. (4 cr, §3036, §Arab 3036, §Arab 5036, §RelA 3036, §RelA 5036)  
Evolution of Islam in historical context; institutions that made for diversity and continuity; traditions, law, and observances of the faith; sectarian movements; philosophical and theological trends; modern developments (reformist, revolutionary, and militant).

MELC 5311. Medieval Sages: Iran and Soviet Central Asia. (4 cr, §CAS 5311, §SCAS 5311; prereq some background in Iranian or Central Asian or Islamic studies) Bashiri  
Intellectual life of the region from rise of the Ghaznavids (1000 A.D.) to fall of the Timurids (1500 A.D.).

MELC 5501. Modern Arabic Poetry. (4 cr, §3301, §Arab 3301, §Arab 5501)  
Free verse movement and its major trends: post-romantic, social realist, symbolist, resistance, prose poem. Leading poets: al-Mal'ika, al-Sayyab, al-Bayati, Andunis, Hawi, Al-Khal, al-Fayturi, Abd-al-Sabur, Darwish, Sayigh, Jabra, al-Maghut. Cultural and historical context. Theoretical and critical essays. All readings in English.

## GRADUATE PROGRAMS

MELC 5502. The Arabic Novel in Translation. (4 cr, §3302, §Arab 3302, §Arab 5502)  
Novel as new literary genre in Arabic literature. Trends: realist, psychological, existentialist, feminist, post-modernist/fantastic/experimentalist. Major novelists: Mahfouz Ghanem, Salih, Jabra, Kanafani, El Saadawi, al-Shaykh, Munif, Habibi, al-Qa'id, al-Ghitany, Khoury. Cultural and historical context. Discursive writing and theoretical and critical essays. All readings in English.

MELC 5503. Arabic Drama. (4 cr, §3303, §Arab 3303, §Arab 5503)  
Drama as new genre in modern Arabic literature, influenced by European drama. Relation with traditional dramatic forms in Arabic literature and culture. Trends: "theater of the mind," social realist, existentialist, absurdist, experimentalist, epic, verse drama. Major playwrights: al-Hakim, Abd-al-Sabur, Diyab, Salem, Faraj, Idris, al-Maghut, al-'Ani, Wannus, al-Madani. Cultural and historical context. Theoretical and critical essays. All readings in English.

MELC 5505. Survey: The Middle East. (4 cr, §3505, §Arab 5505, §Hist 3505) Farah  
Cultural, religious, and scholarly achievements of Middle Eastern peoples from pre-Islamic times to present.

MELC 5508. Islam: Iran to India. (4 cr, §RelS 3508, §RelS 5508)  
Islam as a faith; formation of Perso-Islamic civilizations; historical, religious, and cultural developments from Samanids to revolution; Islam in South Asia; configuration of Indo-Islamic heritage; Sufi orders; syncretic and revivalist movements; challenges of modernity, contemporary Islam in India and Pakistan.

MELC 5523. The Middle East in World Affairs: The 19th Century. (4 cr, §Arab 5523)  
Structure of society; cultural and political impact of the West; revivalist and nationalist trends; reformist and separatist movements.

MELC 5526. Islam and Communism. (4 cr, §3526, §CAS 3526, §CAS 5526)  
Development of Islamic culture in Transoxiana; formation of Sufic orders; clash of Islamic principles with Soviet dicta; activities of Islamic institutions and of major Islamic centers in Soviet Union; Pan-Islamism.

MELC 5546. Theological and Mystical Doctrines of Islam. (4 cr, §Arab 5546, §RelA 5546)  
Classical works of scholastics and mystics; jurists and philosophers; landmarks of Islamic religious beliefs and institutions. Content analysis, beginning with the Qur'an and traditions.

MELC 5601. Fiction: Iran and Central Asia. (4 cr, §CAS 5601) Bashiri  
Social, political, and religious thought of Iranian and Central Asian fiction writers since beginning of 20th century, emphasizing themes of tradition, modernization, women's rights, and secularization.

MELC 5602. Persian Poetry. (4 cr, §3602, §CAS 3602, §CAS 5602) Bashiri  
Major poetic works of Iran: quatrains of Omar Khayyam, sonnets of Hafiz; "new" Persian poetry such as works of Farugh Farokhzad.

MELC 5730. Proseminar in Middle East History: 16th to 19th Centuries. (4 cr, §Hist 5730)  
Topics, which vary widely, on Mamluk, Safavid-Qajar, and Ottoman era concerning relations with each other and outside world, including political, diplomatic, and ideological orientations and conflicts; cultural and social trends; commerce; transformations due to Western impact, to secularization, and to modernization and colonial encroachments.

MELC 5940. Topics Proseminar. (1-4 cr)  
Selected topics in language, literature, or civilization.

MELC 5960. Topics in Middle Eastern Studies. (4 cr)  
Topics specified in *Class Schedule*.

MELC 5970. Directed Studies. (Cr ar)  
Guided individual reading or study.

MELC 5990. Directed Research. (Cr ar; prereq #, Δ, □)

## Spanish

See Hispanic and Luso-Brazilian Literatures and Linguistics.

## Speech-Communication (Spch)

*Professor:* Donald R. Browne, *chair*; Ernest Bormann (*emeritus*); Karlyn Kohrs Campbell; Sheldon Goldstein (Media Resources); Alan G. Gross (rhetoric); Dean E. Hewes; J. Vernon Jensen (*emeritus*); Josef A. Mestenhauser (educational policy and administration); Harold A. Miller (University College); Robert L. Scott; George L. Shapiro (*emeritus*); Robert P. Sonkowsky (Classical and Near Eastern studies)

*Associate Professor:* Edward A. Schiappa, *director of graduate studies*; Rosita Albert; David L. Rarick; Amy L. Sheldon

*Assistant Professor:* Becky L. Omdahl; Sian E. Owen-Cruise (General College); Kirt H. Wilson

*Lecturer:* Patricia Kovel-Jarboe; Becky S. Kroll

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) and Ph.D.

**Curriculum**—Emphases in the M.A. and Ph.D. programs are communication theory and research (including interpersonal, small group,

organizational, and intercultural communication); rhetoric and public address (including history of public address, rhetorical theory, and criticism); and electronic media (including history, cultural theory and criticism, programming, and social effects).

**Prerequisites for Admission**—All applicants must have completed at least 16 undergraduate credits in speech or communication courses related to their proposed area of emphasis in the department. A brochure detailing prerequisite requirements is available from the department. All prerequisites must be completed before admission.

**Special Application Requirements**—Applicants must submit scores from the Graduate Record Examination General Test, transcripts of all post-secondary academic work, and a written statement of academic and occupational objectives. Letters of recommendation are required of all applicants for assistantships or fellowships. Graduate study may begin in any quarter. A deadline of January 15 is recommended for students applying for teaching assistantships or University fellowships for the following academic year.

**Master's Degree Requirements**—All M.A. students must take Spch 5421 and 5615 and complete at least one 8xxx speech-communication seminar. Degree program requirements are flexible (see department brochure). For Plan A, a minimum of 20 course credits in the major is required, plus 8-9 credits outside the major and 16 thesis credits, for a minimum total of 44 credits. For Plan B, a minimum of 28 course credits in the major is required, plus 8-9 credits outside the major and one Plan B project, for a minimum total of 44 credits. An oral final examination is required for Plan A and Plan B.

**Doctoral Degree Requirements**—A minimum of 39 credits in speech-communication completed at Minnesota, including 15 credits in department seminars, are required. Students must acquire research competence in an approved methodology (see department brochure), or by demonstrating competence in a foreign language appropriate for their dissertation research.

**Language Requirements**—For the master's degree, none. For the doctoral degree, see Doctoral Degree Requirements above.

**For Further Information and Applications**—Contact the Department of Speech-Communication, University of Minnesota, 460 Folwell Hall, 9 Pleasant Street S.E., Minneapolis, MN 55455 (612/624-5800). A brochure detailing admission procedures and M.A. and Ph.D. programs is available.

Spch 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Spch 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Spch 8888. Thesis Credits: Doctoral. (36 cr required)

Spch 5110. Advanced Topics in Speech-Communication Theory. (4 cr [may be repeated for cr with #]; prereq 3211, 3401, 3601 [whichever is relevant to the topic])

Advanced theoretical problems. See department office for current topic.

Spch 5211. Contemporary Problems in U.S. Electronic Media. (4 cr; prereq 3211, sr status) Browne, Rarick

Problems affecting American commercial and educational electronic media. Media programming, controversial content, race/gender issues, management and government regulation, ethics.

Spch 5215. History of Television Programming. (4 cr; prereq 3211 or #) Browne  
Evolution of television program from pre-commercial beginnings to present. Key genres, persons, issues, and trends in development of prime-time television programming in the United States.

Spch 5231. Comparative Electronic Media Systems. (4 cr; prereq 3211 or #) Browne  
Historical, political, and sociological aspects of electronic media systems throughout the world (the United States, Canada, Great Britain, France, Germany, Russia, others). Regulation, impact on political, social, and economic development.

Spch 5232. International Electronic Media. (4 cr) Browne  
International (nation-to-nation) electronic media in the United States, Great Britain, Russia, Japan, and other countries. Theories of informing and persuading through electronic media; regulatory agreements; spectrum control; social and legal implications of new technologies.

Spch 5233. Electronic Media and National Development. (4 cr) Browne  
Use of electronic media to change social, political, economic, and cultural life. Use by developing nations to improve agricultural practices, hygienic standards, literacy, awareness of civic responsibility.

## GRADUATE PROGRAMS

Spch 5261. Communicative Processes in Electronic Media. (4 cr; prereq 3211 or #) Organizational practices of media communicators; media content as a link between communicators and audiences; how viewers use and process media content.

Spch 5281. Electronic Media Audience Analysis. (4 cr; prereq 3211) Rarick Methods of measuring and analyzing electronic media audiences. Structure and appeal of media programming. Theory and research in media impact on audiences.

Spch 5401. Advanced Theories of Communication. (4 cr; prereq 3401 or grad student) Hewes, Kinney, Omdahl Analysis of theories of communication, usefulness for particular purposes. Historical and conceptual development of theories of communication.

Spch 5402. Problems in Interpersonal Communication. (4 cr; prereq 3401 or #) Kinney, Omdahl Factors contributing to misunderstanding, not understanding, disagreement, and cessation of contact in dyads.

Spch 5403. Theory Construction and Analysis in Communication. (4 cr; prereq 3401 or #) Hewes, Omdahl Problems in development of communication theory. Existing theory. Relationship of theory to research.

Spch 5404. Language, Culture, and Education. (4 cr; prereq 3401 or #) Sheldon Psychological and social-psychological perspectives for study of language-communication; dimensions of language variation (dialects, codes, registers); implications for program development and instructional practices.

Spch 5405. Nonverbal Communication: Theory and Research. (4 cr) Omdahl Nonverbal (extralinguistic) elements and dimensions of interpersonal communication. Nonverbal categories examined include gesture, facial expression, posture, clothing, and environment.

Spch 5407. Communication and Interpersonal Conflict. (4 cr; prereq 3401, 3411) Theory and research on role of communication in conflict in groups, organizations, and interpersonal relationships. Communication in negotiations. Interventions into interpersonal conflicts.

Spch 5411. Small Group Communication Theory. (4 cr; prereq 3411 or #) Hewes Theories of communication within small, task-oriented group. Group cohesiveness, leadership, role structure, information processing, decision making.

Spch 5414. Communication and Community. (4 cr; prereq 3411 or #; S-N only) Authority and power in task-oriented groups. Tavistock-type small group, intergroup and large group lab experiences. Verbal and nonverbal processes in and among groups that affect leadership and followership.

Spch 5421. Quantitative Research in Communication. (4 cr; prereq 3401 or 5403 or #) Hewes, Kinney Review and discussion of experimental and descriptive research; analysis of research design and procedures; individual research projects.

Spch 5422. Interviewing and Communication. (4 cr; prereq 1101, 6 cr social sci or #) Rarick Theory and practice of communication in the information interview. Role of interpersonal perception, empathy, and cognitive structure in dyadic communication. Experience in interviewing and communication analysis. Applications to research in interpersonal and mass communication.

Spch 5431. The Process of Persuasion. (4 cr; prereq 3431) Albert, Kinney, Omdahl, Scott Theories of modern motivational communication. Process of social control through persuasive speech.

Spch 5451. Intercultural Communication. (4 cr; recommended 3401, Anth 1102 or other course in cultural anthropology or #) Albert Successful interpersonal communication across cultures. Verbal and nonverbal communication.

Spch 5452. Intercultural Interaction: Theory and Application. (4 cr; prereq #) Albert Small group interaction across cultures for international and U.S. students; readings, group discussions, role playing, simulations, lectures.

Spch 5461. Conversation Analysis. (4 cr, \$Ling 5751; prereq 3401, Ling 3001 or Ling 5001 or #) Sheldon Discourse processes involved in dyadic and multiparty conversation. Applying concepts through analysis of conversations.

Spch 5462. Field Research in Spoken Language. (4 cr, \$Ling 5752; prereq 5461 or #) Sheldon Transcribing, coding, and analyzing spoken and recorded conversations.

Spch 5602. Contemporary Political Persuasion. (4 cr; prereq 1101 or 1101H, 5431 or #) Campbell Ideologies in political persuasion.

Spch 5611. Classical Rhetoric. (4 cr; prereq 1101 or 1101H) Campbell, Schiappa, Scott Greek and Roman theories of speech making; historical and philosophical context and influence on education.

Spch 5615. Introduction to Rhetorical Criticism. (4 cr; prereq 1101 or 1101H; 3601 recommended) Campbell, Schiappa, Scott, Wilson Traditional and contemporary rhetorical theory and its application to contemporary public address.

Spch 5617. History and Criticism of American Public Address. (4 cr; prereq 1101 or 1101H, Psy 1001) Campbell, Wilson Survey: history and criticism of religious and reform speech in the United States from 1620 to 1920.

Spch 5618. History and Criticism of American Public Address. (4 cr; prereq 1101 or 1101H, Psy 1001) Campbell, Wilson  
Survey: history and criticism of political speech in the United States from the Revolution to the present.

Spch 5621. Woman's Rights/Woman Suffrage Rhetoric. (4 cr; prereq 5615 or #) Campbell  
History and criticism of rhetoric of woman's rights/woman suffrage movement in United States, 1835-1925.

Spch 5622. Contemporary Feminist Rhetoric. (4 cr; prereq 5615 or #) Campbell  
History and criticism of rhetoric of contemporary feminist movement in United States, 1945-present.

Spch 5625. Issues in Communication Ethics. (4 cr; prereq 3625 or #) Rarick  
Issues in ethical dimension of interpersonal, small group, public, and mass communication, clustered around communicator, receiver, message, medium, situation, and effects.

Spch 5970. Directed Readings. (Cr ar; prereq 9 cr upper division speech, #, Δ, □; S-N only)  
Directed reading and preparation of reports on selected subjects.

Spch 8110-8120-8130. Seminar: Advanced Speech Problems. (3 cr per qtr; prereq undergrad degree in spch-comm or equiv)  
Evaluation of research methods in speech-communication.

Spch 8210. Seminar: Selected Topics in U.S. Electronic Media. (3 cr [may be repeated for cr]; prereq 5211 or #; offered when feasible) Browne, Rarick

Spch 8211. Critical Communication Studies: History, Theory, Method. (3 cr) Schiappa  
Qualitative research methods for studying media institutions, texts, audiences, and contexts.

Spch 8231. Seminar: National and International Electronic Media Systems. (3 cr; prereq 5231 or 5232 or 5233 or #) Browne  
Historical and contemporary aspects of national and international electronic media systems. Roles of national and international regulatory bodies. Approaches to programming and evidence of effectiveness.

Spch 8401. Current Advanced Theories of Person-to-Person Communication. (3 cr; prereq 5401 or #)  
Readings and research on recent theorists of person-to-person communication. Tapes of natural conversations as illustrative raw material for application of theory.

Spch 8402. Seminar: Interpersonal Communication Problems. (3 cr) Kinney, Omdahl  
Evaluation and development of new perspectives for analysis, diagnosis, and management of interpersonal communication problems.

Spch 8411. Seminar: Small Group Communication. (3 cr; prereq 1101, 5411) Hewes  
Research problems and methods.

Spch 8421. Seminar: Communication and Negotiation. (3 cr; prereq 5411, 5441 or #) Hewes  
Influence of communication patterns on bargaining outcomes. Formal negotiation as a model for situations of partial conflict.

Spch 8440. Seminar: Topics in Organizational Communication. (3 cr; prereq 5441 or #)

Spch 8451. Seminar: Face-to-face Intercultural Communication. (3 cr; prereq, if US citizen, Anth 5102 or similar course in cultural anthropology or #: 5451 recommended) Albert  
Factors influencing face-to-face communication in varied cultures, concentrating upon task-oriented communication between North American and nationals in the host country. Verbal (linguistic) and nonverbal (nonlinguistic) dimensions of communication.

Spch 8452. Seminar: Facilitating Intercultural Communication. (3 cr; prereq 5451 or #: 8451 recommended) Albert  
Theories and techniques of managing effective interpersonal communication across cultural boundaries.

Spch 8501. Introduction to Survey Research in Speech-Communication. (3 cr; prereq Jour 8501 or #) Rarick  
Research-survey-based projects in broadcasting and public address. Design and execution of small scale, research-based survey; problems attendant upon execution of studies.

Spch 8502. Quantitative Research in Speech-Communication. (3 cr; prereq Jour 8501 or #: 8501 recommended) Hewes, Kinney, Rarick  
Design, execution, and reporting of quantitative studies in speech-communication. Experimental and field methods appropriate to specific problems. Research problem and technique defined each quarter.

Spch 8503. Historical and Descriptive Research in Speech-Communication. (3 cr) Browne  
Elements involved in conducting and analyzing historical and descriptive research in speech-communication; approaches to historical research, assessment of primary and secondary sources; execution of major research project.

Spch 8504. Seminar in Rhetorical Criticism. (3 cr) Campbell, Scott  
Theories of rhetorical criticism; methods of criticizing rhetorical discourse. Rhetoric as applied to literary studies and the growth of hermeneutics as vantage points for reassessing rhetorical methods.

Spch 8606. Seminar: Rhetorical Analysis of Campaigns and Movements. (3 cr; prereq 5431, 5617 or 5618, 10 cr social sci or #) Campbell, Scott  
Literature and methodology in historical and contemporary rhetorical campaigns and movements.

Spch 8611, 8612, 8613. Seminar in Rhetoric. (3 cr per qtr; prereq 5611 or #) Campbell, Scott  
History and criticism of rhetorical theory. Research in rhetoric.

Spch 8621. Seminar: History and Criticism of Public Address. (3 cr; prereq 5617, 5618 or Δ) Campbell, Scott  
Methods of rhetorical criticism. Application of method in individually selected research projects.

Spch 8625. Seminar: Communication Ethics. (3 cr; prereq 3625 or 5625 or #) Rarick  
Independent research on communication ethics in interpersonal, small group, public speaking, or mass communication.

Spch 8990. Research. (Cr ar, prereq #, Δ: S-N only)  
Open to graduate students engaged in research on special problems.

## Statistics (Stat)

*Professor:* Seymour Geisser, *director*, School of Statistics; Douglas M. Hawkins, *chair*, Department of Applied Statistics; Morris L. Eaton, *chair*, Department of Theoretical Statistics; Glen D. Meeden, *director of graduate studies*; Christopher Bingham; Kathryn M. Chaloner; R. Dennis Cook; James M. Dickey; John F. Geweke (economics); Kinley Lantzi; Bernard W. Lindgren; Thomas A. Louis (biostatistics); Christopher J. Nachtsheim (management sciences); Gary Oehlert; Ronald R. Regal<sup>1</sup>; William D. Sudderth; Luke Tierney; Sanford Weisberg

*Associate Professor:* Charles J. Geyer; Frank B. Martin; Ronald C. Pruitt

*Assistant Professor:* Birgit Grund; Christian Posse

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Students may specialize in any area of statistics or probability. The core program for all students has strong components of both theoretical and applied statistics.

**Prerequisites for Admission**—For admission to the master's program, familiarity with basic statistical concepts and methods, and mathematics through multivariable calculus and linear algebra, are required. For admission to the doctoral program, in addition to the above, knowledge of the elements of real analysis is required.

**Special Application Requirements**—Two letters of recommendation are required. Applicants are strongly encouraged to submit scores from the General (Aptitude) Test (and from the mathematics Subject Test for mathematics

majors) of the Graduate Record Examination. A minimum TOEFL score of 550 is required of applicants whose native language is not English. Applicants are considered for admission for fall, winter, spring, or summer terms; however, financial support is usually available only to those beginning fall quarter, on the basis of applications received by the preceding February 15 (February 1 for fellowships).

**Master's Degree Requirements**—For Plan B, which is ordinarily taken, the following courses in statistics are required: 5151-5152-5153, 5161-5162-5163 (if these or equivalent courses are not included in the student's undergraduate program), as well as 1 credit each in 8801 and 8900, the latter involving preparation and delivery of a seminar talk on a specific topic. Both written and oral final examinations are required.

**Doctoral Degree Requirements**—The preliminary written examination covers the material in 8151-8152-8153, 8162, 8311-8312, and Math 8656-8657-8658. In addition, students must complete a minimum of 27 credits in advanced statistics courses, distributed in at least three areas, as well as 3 credits in 8801 and one credit in 8900, the latter involving preparation and delivery of a seminar talk. A second seminar talk is required by the Graduate School in connection with the final defense of the student's thesis.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—For the master's degree, at least 12 credits in 5xxx or 8xxx statistics courses are required. For the doctoral degree, a theory sequence (5121-5122 or 5131-5132-5133) and familiarity with various statistical methods (e.g., 5201, 5301, 5302, 5401, 5421, 5601) are required. Typical programs contain 21 to 27 credits. The director of graduate studies should be consulted in advance for planning and approval of a balanced program.

**For Further Information and Applications**—Contact the School of Statistics, University of Minnesota, 270 Vincent Hall, 206 Church Street S.E., Minneapolis, MN 55455 (612/625-8046; fax 612/624-8868; e-mail info@stat.umn.edu).

<sup>1</sup> University of Minnesota, Duluth

Stat 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Stat 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Stat 8888. Thesis Credits: Doctoral. (36 cr required)

Stat 5021. Statistical Analysis. (5 cr, §3012; prereq college algebra)  
Intensive version of 3011-3012, for graduate students needing statistics as research technique.

Stat 5091. Statistical Methods for Quality Improvement. (4 cr; prereq 3012 or 3091 or 5021 or 5122 or 5132 or 5152, Math 1252)

Application of statistical concepts of random variability and sampling, statistical process control, Shewhart and accumulative charting, analysis of plant data, applications of trend surface analysis, analysis of variance and design of experiments, quality improvement by reduction of random variability.

Stat 5121-5122. Theory of Statistics. (5 cr per qtr, §5131-5132-5133; prereq Math 1252)

Univariate and multivariate distributions, law of large numbers, sampling, likelihood methods, estimation and hypothesis testing, regression and analysis of variance, confidence intervals, distribution-free methods.

Stat 5131f-5132w-5133s. Theory of Statistics. (4 cr per qtr, §5121-5122; prereq Math 3252)

*5131*: Probability models, univariate and bivariate distributions, independence, basic limit theorems.

*5132-5133*: Statistical decision theory, sampling, estimation, testing hypotheses, parametric and nonparametric procedures for one-sample and two-sample problems, regression, analysis of variance. More mathematical treatment than 5121-5122.

Stat 5151f-5152w-5153s. Theory of Statistics. (4 cr per qtr, §5121-5122, §5131-5132-5133; prereq Math 3252, stat grad student)  
A more in-depth version of 5131-5132-5133.

Stat 5161-5162-5163. Applied Statistical Methods. (4 cr per qtr, §5201, §5301, §5302, §5421; prereq §5131 or §5151, stat grad student or #)

*5161*: Simple and multiple regression; graphics. *5162*: Variance reduction designs for experiments; factorial, fractional, and confounded designs; optimal designs; analysis of covariance; unbalanced data analysis. *5163*: Advanced topics in linear regression; nonlinear models; generalized linear models; categorical data analysis; logistic regression.

Stat 5201. Sampling Methodology in Finite Populations. (4 cr; prereq 3091 or 5021 or 5121 or #)  
Simple random, systematic, stratified, and unequal probability sampling. Ratio and regression estimation. Multistage and cluster sampling.

Stat 5211. Theory of Sample Surveys. (4 cr; prereq 5122 or 5133 or 5153)  
Mathematical treatment of survey sampling, including stratified and multistage sampling, models for nonsampling errors.

Stat 5271, 5272. Bayesian Decision Making. (4 cr per qtr; prereq §5122 or §5132 or §5152 for 5271; 5122 or 5132 or 5152 for 5272; 5271 recommended for 5272)

*5271*: Axioms for personal probability and utility. Elements of statistical decision theory. Bayesian analysis of linear models. *5272*: Expected utility models for economic decisions under uncertainty. Applications to portfolio selection, forward and futures trading, betting, contingency markets, business planning.

Stat 5301. Designing Experiments. (5 cr, §5163; prereq 3012 or 5021 or 5133 or 5153 or #)

Control of variation, construction and analysis of complete and incomplete block, split plot, factorial, and groups of similar experiments. Confounding, crossover, and optimum seeking designs.

Stat 5302. Applied Regression Analysis. (5 cr, §5161; prereq 3012 or 5021 or 5133 or #)

Simple, multiple, and polynomial regression. Estimation, testing, and prediction. Stepwise and other numerical methods; examination of residuals; weighted least squares; nonlinear models; response surface. Experimental research and economic applications.

Stat 5401. Introduction to Multivariate Methods. (4 cr; prereq 5302 or 5133 or 5153)

Bivariate and multivariate distributions. Inference on multivariate normal distribution. Discrimination and classification. Multivariate analysis of variance. Partial, canonical correlation and independence. Principal component analysis, factor analysis, analysis of repeated measurements, cluster analysis, profile analysis.

Stat 5421. Analysis of Categorical Data. (4 cr, §5162; prereq 3012 or 5021 or 5133 or #)

Varieties of categorical data, cross-classifications and contingency tables, tests for independence. Multidimensional tables and log-linear models, maximum-likelihood estimation and tests of goodness of fit. Analysis of Markov chain data. Smoothing counts.

Stat 5601. Nonparametric Methods. (4 cr; prereq 5021 or 5122 or 5132 or 5152 or #)

Survey of necessary discrete and continuous probability distributions. Goodness of fit, sign tests, order statistics, rank tests for location and for scale, two-sample and k-sample comparisons, association. Emphasis on methods and applications.

Stat 5900. Tutorial Course. (Cr ar; prereq #)

Directed study in areas not covered by regular offerings.

Stat 5911, 5912, 5913. Topics in Statistics.

(3 cr per qtr [may be repeated for cr]; prereq 5162, 5122 or 5132 or #)

Topics vary according to student needs and available staff.

## GRADUATE PROGRAMS

Stat 8151-8152-8153. Mathematical Statistics. (4 cr per qtr; prereq 5133 or 5153 or #, advanced calculus, matrix algebra)  
*8151*: Probability distributions in statistical inference, derivations of sampling distributions. *8152*: Elements of decision theory, tests of hypotheses, principles and methods of estimation including confidence regions. *8153*: Introduction to sequential and nonparametric inference, and to large-sample theory.

Stat 8162. Computational Statistical Methods. (4 cr per qtr; prereq 8312, programming exper)  
Random variate generation, variance reduction techniques. Robust location estimation and regression, smoothing additive models, regression trees. Programming projects; basic programming ability and familiarity with standard high-level language (preferably FORTRAN or C) is essential.

Stat 8171-8172-8173. Theory of Inference. (3 cr per qtr; prereq 8153, Math 8658 or #)  
Topics may vary according to interests of instructors and students. Possible topics include conditional distributions and sufficiency, theory of estimation, comparison of various theories of statistical inference, Neyman-Pearson theory of hypothesis testing and its extensions, confidence regions, invariance, most stringent tests, nonparametric and sequential inference.

Stat 8191-8192. Large-Sample Theory. (3 cr per qtr; prereq 8153, Math 8658 or #; offered alt yrs)  
Types of convergence. Limit theorems. Asymptotic properties of sampling distributions. Asymptotic efficiency. Likelihood and other methods of inference. Categorical data.

Stat 8221. Topics in Sampling. (3 cr; prereq 8312; offered alt yrs)  
Stratification and clustering, double sampling, unequal probability sampling, analysis of data from complex surveys, superpopulation theory, Bayesian methods in sample surveys, nonresponse.

Stat 8311-8312. Linear Models. (4 cr per qtr; prereq 5122 or 5133 or 5153, linear algebra)  
Theory of the general linear model from coordinate-free geometric perspective. Estimation, distribution theory, testing, confidence statements, diagnostics, random effects models, Bayesian approaches.

Stat 8313. Topics in Experimental Design. (3 cr; prereq 8312)  
Bayesian design of experiments, repeated measures experiments, optimal design, algorithms for computing designs, design robustness.

Stat 8321. Linear and Nonlinear Regression. (3 cr; prereq 8312 or #)  
Advanced topics in linear regression, including computational methods, residual and influence analysis; incomplete data problems; nonlinear modeling and generalized linear models, including asymptotic theory, maximum likelihood estimation, measure of curvature; selected topics in robust methods.

Stat 8331. Statistical Computing. (3 cr per qtr; prereq 8162 or #; offered alt yrs)  
Structure of the computer. Basic numerical analysis for statisticians. Approximating probability and other functions. Random number generation. Linear models. Classification (analysis of variance) models. Optimization, nonlinear regression, and robust methods. Writing and evaluating statistical software.

Stat 8401. Topics in Multivariate Methods. (3 cr; prereq 8312)  
Multivariate analysis of variance, clustering, discrimination and classification, growth curve models, multidimensional scaling, correspondence analysis, projection pursuit, nonnormal methods.

Stat 8411-8412. Multivariate Analysis. (3 cr per qtr; prereq 8153)  
Multivariate normal distribution. Inference on the mean, covariance, and correlation and regression coefficients; related sampling distributions such as Hotelling's  $T^2$  and Wishart distributions. Multivariate analysis of variance. Principal components and canonical correlation. Discriminant analysis. Distribution of determinantal roots. Invariance, admissibility, minimax, and other properties of tests and estimates. Large-sample distributions.

Stat 8431. Theory of Categorical Data Analysis. (3 cr per qtr; prereq 5162 or #)  
Multidimensional cross-classified arrays, sampling models and statistical theory for categorical data. Model selection and simultaneous testing. Logit and multinomial response models. Models for mixed categorical/continuous data. Logistic regression. Analysis of ordered categorical variables. Multiplicative and multiplicative-interaction models. Latent-structure models. Bayesian estimation of cell frequencies. Computing algorithms.

Stat 8501-8502. Introduction to Stochastic Processes With Applications. (3 cr per qtr; prereq 5131 or 5151 or #; offered alt yrs)  
Markov chains, Markov processes, Poisson process, Brownian motion, and other stochastic models encountered in applications.

Stat 8511-8512. Time Series Analysis. (3 cr per qtr; prereq linear algebra, 5133 or 5153 or #)  
Basic concepts and examples of stochastic processes; classical analysis of trends, cycles, and autoregressive models; spectral analysis; linear operations, prediction and filtering; problems of inference.

Stat 8601. Topics in Robust Methods. (3 cr; prereq 8312, 8162; offered alt yrs)  
Robust estimation of location, influence functions, robust regression and testing, diagnostics and robustness.

Stat 8611-8612. Nonparametric Inference. (3 cr per qtr; prereq 8153 or #; offered alt yrs)  
Inference methods based on order statistics. U-statistics. Sign, rank, permutation, and run tests. Large-sample results. Confidence and tolerance regions. Asymptotic optimality. Categorical data. Estimation.

Stat 8731-8732. Statistical Decision Theory. (3 cr per qtr; prereq 8153, Math 8658 or #; offered alt yrs)  
Convex sets and functions. Elements of game theory. Wald's formulation; mixed randomized rules. Bayes rules, least favorable distributions. Minimax theorems. Admissibility and complete class theorems. Sufficiency. Invariance. Comparison of experiments. Compound and multiple-decision rules.

Stat 8751-8752. Sequential Analysis. (3 cr; prereq 8153; offered alt yrs)  
Wald's sequential probability ratio test and modifications. Sequential decision theory. Martingales. Sequential estimation, design, and hypothesis testing. Recent developments.

Stat 8801. Statistical Consulting. (1 cr per qtr [max 3 cr]; prereq stat grad major or #)  
Topics in data analysis and/or consulting with members of University research community through Statistical Center.

Stat 8900. Student Seminar. (1 cr; prereq stat grad major or #)  
Preparation and presentation of seminar on statistical topic.

Stat 8901. Directed Readings and Research. (1-3 cr; prereq #)  
Directed study in areas not covered by regular offerings.

Stat 8931-8932-8933-8934. Advanced Topics in Statistics. (3 cr per qtr [may be repeated for cr]; prereq #)  
Topics vary according to student needs and available staff.

Math 5681-5682-5683. Probability and Stochastic Processes

Math 8650-8651-8652. Theory of Probability

Math 8656-8657-8658. Measure Theory and Probability

Math 8690-8691-8692. Topics in the Theory of Probability

## Related Courses

A limited number of the following related courses may be used in constructing major and minor programs in statistics. To do so, the approval of the director of graduate studies should be obtained in advance. It is to be emphasized that many of these courses have considerable overlap in content and that such duplications are to be avoided.

Econ 8111-8112-8113. Introduction to Mathematical Economics

Econ 8201-8202-8203. Econometric Analysis

Econ 8211-8212-8213. Econometrics

EE 5700. Information Theory and Coding

EE 5702. Stochastic Processes and Optimum Filtering

EE 8220. Topics in Statistical Theory of Communication

EPsy 8260, 8261, 8262. Statistical Methods  
EPsy 8263. Design and Analysis of Experiments

EPsy 8264. Multiple Regression Analysis

EPsy 8279. Problems: Statistics for Students in Education and Psychology

IEOR 5030. Quality Control and Reliability

IEOR 5040. Introduction to Operations Research

IEOR 5441-5442. Operations Research II-III

IEOR 5550. Design and Analysis of Experiments I

PubH 5450. Biostatistics I

PubH 5452. Biostatistics II

PubH 5454. Biostatistics III

PubH 5462. Clinical Trials I

## Studies in Africa and the African Diaspora

*Regents' Professor:* Joanne B. Eicher (design, housing, and apparel)

*Professor:* Caesar E. Farah (Afro-American and African studies); Allen F. Isaacman (history; Afro-American and African studies); Ronald C. McCurdy (music; Afro-American and African studies); Philip W. Porter (geography; Afro-American and African studies); Earl P. Scott (geography; Afro-American and African studies)

*Associate Professor:* Louis R. Bellamy (theatre arts and dance); Rose M. Brewer (Afro-American and African studies); Susan N. G. Geiger (women's studies); August H. Nimitz, Jr. (political science; Afro-American and African studies); Angelita D. Reyes (women's studies); John M. Taborn (Afro-American and African studies); John S. Wright (Afro-American and African studies; English)

*Assistant Professor:* Charles Ben Pike (Afro-American and African studies), *director of graduate studies*; Teirab AshShareef (Afro-American and African studies); Victoria B. Coifman (Afro-American and African studies)

**Course of Study**—Minor in studies in Africa and the African diaspora, applicable to master's (M.A. and M.S.) and doctoral programs.

**Curriculum**—An interdisciplinary graduate minor in studies in Africa and the African diaspora is administered through the Department of Afro-American and African Studies. The minor program provides students from a variety of disciplines with a structured graduate curriculum that offers a systematic

understanding of the contemporary and historical experiences of peoples of Africa and of African descent. It is organized around a group of core seminars and focuses on two broad areas: 1) the humanities and the arts and 2) the social and behavioral sciences.

**Prerequisites for Admission**—Admission to the graduate minor in studies in Africa and the African diaspora is contingent upon prior admission to a master's or doctoral degree-granting program within the Graduate School.

**Special Application Requirements**—Completion of an application form by the end of winter quarter to be considered for acceptance into the minor program for the following academic year. It is expected that no more than 15 students will be admitted to this minor each year. An undergraduate major or minor in Afro-American and/or African studies is not required for admission to the program, but students are expected to have had sufficient background to begin graduate-level study.

**Minor Requirements**—The program requires a minimum of 11 graduate credits for a master's minor and 19 graduate credits for the Ph.D. minor. Each student for the minor is required to take a core seminar on Afro-American and African studies. Doctoral students take one additional seminar. Remaining courses are selected from one of the following areas: 1) the humanities and the arts or 2) the behavioral and social sciences. All courses for the minor must be outside the student's major field of study.

**Language Requirements**—None specific to the minor program.

**For Further Information and Applications**—Contact the Department of Afro-American and African Studies, University of Minnesota, 808 Social Sciences Building, 267 19th Avenue South, Minneapolis, MN 55455 (612/624-9847; fax 612/624-9383).

### Afro-American and African Studies (Afro)

Afro 5072. Racism: Social and Psychological Consequences for Black Americans. (4 cr, §3072) Taborn  
Racism and its effects on black Americans; definitions, determinants, and dynamics examined in an experiential context to reflect individual and institutional racism in milieus of student interest.

Afro 5142. Geography of East Africa. (4 cr, §Geog 5142)  
Physical and human geography of Kenya, Tanzania, and Uganda. Environment as resource; historical geography of colonial and postcolonial eras; geographical organization of human activity; regional contrasts.

Afro 5143. Geography of West Africa. (4 cr, §Geog 5143)  
West Africa from Senegal to Cameroon: social geography of resource use, population, settlement, economic development, and international relations.

Afro 5145f. Development in Africa. (4 cr, §Geog 5145, §IntR 5145; prereq #) Scott  
Economic, political, and social development in Africa from independence to present. Reordering of colonial landscapes, bases for North-South relations, big power interventions, and participation in world economy.

Afro 5181 (formerly 5182). Blacks in American Theatre, 1820-1960s. (4 cr, §Th 5181)  
Historical survey of significant events in development of American black theatrical tradition; essays, plays, playwrights, and theatres from early colonial references to Black Arts Movement.

Afro 5182 (formerly 5181). Contemporary Black Theatre, 1960-Present. (4 cr, §Th 5182)  
Essays, plays, playwrights, and theatres that have contributed significantly to contemporary black theatre, from beginning of Black Arts Movement to present.

Afro 5200. Black Americans and Mental Health. (4 cr; prereq grad student or #) Taborn  
Factors and issues affecting mental health of black Americans. Development process of the black person's mental health; current trends in public policy and mental health.

Afro 5301. African Literature: The Novel. (4 cr) Pike  
The novel in continental Africa in English, French, and African languages. Non-English materials in translation.

Afro 5341. Seminar in Contemporary Kenyan Literature. (4 cr; prereq one African studies course or #) Pike  
Novels of Ngugi, Mwangi, Njau, and Ruheni. Prose works and critical essays. All readings in English.

Afro 5352. Black Families in Comparative Perspective. (4 cr; prereq upper div or grad student) Brewer  
To understand, cross-culturally, family formation, social structure, and gender patterns of families of African descent. Black families in West Africa, the Caribbean, and the United States.

Afro 5401. Field Study in Afro-American and African Studies. (1-8 cr; prereq affiliated major or minor)  
Faculty-supervised experiences working with, relating to, and conducting focused research on Afro-American and African populations with goal of experiencing cultural diversity through concurrently acknowledging, affirming, studying, and becoming a participant-observer in a cultural milieu that is Afro-American and/or African diasporic.

Afro 5551. Use of Oral Traditions as Resources for History: Methods. (4 cr) Coifman  
Spoken information passed from person to person through time, mainly in nonliterate societies, as sources for writing history. Canons of history for analysis and critique of oral traditions, integration into written history.

Afro 5593. The Afro-American Novel. (4 cr, §Engl 5593) Wright  
Contextual readings of 19th- and 20th-century black novelists such as Charles Chesnutt, James Weldon Johnson, Zora Neale Hurston, Richard Wright, Chester Hines, Ann Petry, James Baldwin, John Williams, Toni Morrison, and Ishmael Reed.

Afro 5595. Afro-American Poetry. (4 cr, §Engl 5595) Wright  
Selected Afro-American poets from 18th to 20th century, including Phillis Wheatley, Paul Laurence Dunbar, Sterling Brown, Gwendolyn Brooks, Melvin Tolson, Robert Hayden, Amiri Baraka.

Afro 5596. Afro-American Autobiography. (4 cr, §Engl 5596) Wright  
Literary and intellectual traditions of black autobiography beginning with 18th-century slave narrative: Equiano, Douglass, DuBois, Hurston, Wright, Malcolm X, Angelou, and others.

Afro 5597. Seminar: The Harlem Renaissance. (4 cr, §Engl 5597) Wright  
Multidisciplinary review of Harlem Renaissance of Jazz Age: literature, popular culture, visual arts, political journalism, and black and white figures such as Jean Toomer, Claude McKay, Langston Hughes, Bessie Smith, DuBois Heyward, Carl Van Vechten, Eugene O'Neill, and Marcus Garvey.

Afro 5598. Seminar: The Black Arts Renaissance, 1960s and 1970s. (4 cr; prereq Afro studies major or minor or #) Wright  
Multidisciplinary perspectives on post-Civil Rights and Black Power Era "renaissance" of African-American art and politics (literature, popular culture, visual arts, political journalism, etc.). Research projects and papers. Complementary course to 5597.

Afro 5678. African-Arabic Fiction in Translation. (4 cr) AshShareef  
Continental African novels and short stories written in Arabic from Algeria, Egypt, Libya, Mauritania, Morocco, Sudan, Tunisia, and Western Sahara. Writers include Barrada, Idris, Mahfouz, al-Matwi, al-Qa'id, Rifaat, El-Saadawi, Salih, Shukri, Wattar, and el-Zayat. African-Arabic oral narrative as backdrop. Emphasis on 20th century. Cultural and historical context of texts. Theoretical and critical essays. All readings in English; no knowledge of Arabic required.

Afro 5701, 5702. Proseminar: Afro-American Studies. (4 cr per qtr, §3701, 3702; prereq #)  
Classic works in Afro-American studies. Comparatist framework for Afro-American studies; cultural criticism and related issues in multidisciplinary study.

Afro 5800. Afro-American Studies Interdisciplinary Seminar. (4 cr)  
Staffed by cooperating faculty from the social sciences and humanities. Emphasis on selected themes that benefit from interdisciplinary analysis.

Afro 5864, 5865. Afro-American History. (4 cr per qtr, §Hist 5864, 5865)  
Development of Afro-American ethnicity and culture, slavery, race relations, and public policy from period of slave trade to the present.

Afro 5876. Seminar: Approaches to African Development. (4 cr; prereq 1021) Coifman  
Study, critical analysis, and comparison of core documents relevant to development in Africa from the World Bank, Organization of African Unity, U.N. Economic Commission on Africa, and John-Paul II. Consideration of ethics.

Afro 5900. Afro-American Seminar. (2-4 cr; prereq jr or sr or grad student)  
Staffed by scholars of Afro-American experience. In-depth analyses and discussion of selected issues and themes.

Afro 5910. Topics in Afro-American/African Studies. (4 cr)  
Selected topics that vary quarterly. Topics specified in *Class Schedule*.

Afro 5970. Directed Studies. (1-6 cr; prereq #, Δ, CLA approval; qualified srs and grads may register with # for work on tutorial basis)

Afro 8101. Seminar: Introduction to Studies in Africa and the African Diaspora. (3 cr)  
Comparatist frameworks, related theories, and pivotal texts.

Engl 8590. Studies in Afro-American Literature

Fren 5289. Topics in African Literature

Geog 8140. Seminar: Africa

Hist 5436. Social History of African Women: 1850 to Present

Hist 5931. History of Africa: Social Groupings, Conflicts

Hist 5932. African Historiography

Hist 8944, 8945. African History

Pol 5478. Government and Politics of African Countries

Pol 8605. Government and Politics of Africa

## Studies of Science and Technology (SST)

*Professor:* Ronald N. Giere (philosophy); Keith Gunderson (philosophy); William H. Hanson (philosophy); Geoffrey Hellman (philosophy); Sally Gregory Kohlstedt (history of science and technology); Edwin T. Layton (history of science and technology); Helen E. Longino (women's studies); Arthur L. Norberg (history of science and technology); C. Wade Savage (philosophy); Robert W. Seidel (history of science and technology); Alan E. Shapiro (history of science and technology); Roger H. Stuewer (history of science and technology)

*Associate Professor:* John H. Beatty (history of science and technology); John M. Eyler (history of medicine); C. Kenneth Waters (philosophy)

**Course of Study**—Minor in studies of science and technology, applicable to master's (M.A. and M.S.) and doctoral programs.

**Curriculum**—Studies of science and technology (SST) deals with a rapidly expanding field that seeks to understand the conceptual foundations, historical development, and social context of science and technology. SST faculty are drawn from five research or teaching units dedicated in whole or in part to the history and philosophy of science and technology: the Departments of Philosophy, History of Science and Technology, History of Medicine; the Center for Philosophy of Science; and the Charles Babbage Institute for the History of Information Processing. The SST minor is for students from any major who want to gain a deeper understanding of the nature and development of science and technology. It should be particularly valuable for students who are planning teaching careers in science or engineering, or those majoring in philosophy or history of science and technology. It may also be of interest to students majoring in history, sociology, or related fields of study.

The SST minor provides introductory core courses in historiography and philosophy of science, followed by team-taught research seminars and other elective courses in four main research areas: models, theories, and reality; physical science; biological and biomedical sciences; and science, technology, and society. Seminar topics vary yearly, depending on faculty and student interest.

**Prerequisites for Admission**—Admission to the SST graduate minor is contingent upon prior admission to a master's or doctoral

degree-granting program within the Graduate School and is by permission of the director of graduate studies in SST.

**Minor Requirements**—Master's students are required to take 12 credits, which must include HSci 8111, Phil 8605, and one SST seminar (SST 8100, 8200, 8300, or 8400). Doctoral students are required to take 19 credits, which must include HSci 8111, Phil 8605, 3 credits in SST 8000, and two SST seminars (SST 8100, 8200, 8300, or 8400). Students may not use courses from their major departments other than those listed below to make up any remaining credits.

**Language Requirements**—None specific to the minor.

**For Further Information and Applications**—Contact the Director of Graduate Studies, Studies of Science and Technology, University of Minnesota, 309 Ford Hall, 224 Church Street S.E., Minneapolis, MN 55455 (612/625-6635).

### Core Courses

SST 8000. Colloquium. (1 cr [may be repeated for cr])

Nationally and internationally known scholars with diverse disciplinary and methodological backgrounds speak on variety of issues within the field.

HSci 8111. Historiography of Science and Technology. (4 cr)

Phil 8605. Issues and Approaches in Philosophy of Science. (4 cr)

### Elective Courses—Models, Theories, and Reality

SST 8100. Seminar: Models, Theories, and Reality. (4 cr [may be repeated for cr]; prereq HSci 8111 or Phil 8605 or #) Beatty, Giere, Gunderson, Hanson, Hellman, Savage, Shapiro, Stuewer, Waters  
Students participate in ongoing research on role of models and theories in science. Students prepare and present research papers as major part of course.

HSci 5113. Natural Philosophy in the Scientific Revolution. (4 cr) Shapiro

HSci 5511. History of Scientific Methodology. (4 cr) Beatty

Phil 5222. Philosophy of Mathematics. (4 cr) Hanson, Hellman

Phil 5601. The Evaluation of Scientific Hypotheses. (4 cr) Giere, Hanson, Hellman, Savage, Waters

Phil 5602. The Nature of Scientific Theories. (4 cr) Giere, Hellman, Savage, Waters

Phil 5603. Scientific Explanation. (4 cr) Giere, Hellman, Savage, Waters

Phil 5615. Minds, Bodies, and Machines. (4 cr) Gunderson

Phil 5617. Twentieth-Century Philosophy of Science: Logical Empiricism. (4 cr) Giere, Savage

Phil 5618. Twentieth-Century Philosophy of Science: The Historical School. (4 cr) Giere, Savage, Waters

### Elective Courses—Physical Science

SST 8200. Seminar: The Physical Sciences. (4 cr [may be repeated for cr]; prereq HSci 8111 or Phil 8605 or #) Hellman, Shapiro, Stuewer  
Students participate in ongoing research in history, philosophy, and social study of physical sciences. Students prepare and present research papers as major part of course.

HSci 5924. History of 19th-Century Physics. (4 cr) Stuewer

HSci 5925. History of 20th-Century Physics. (4 cr) Stuewer

HSci 5935. History of Nuclear Physics. (4 cr) Stuewer

HSci 8121. Foundations for Research in Ancient Science. (4 cr) Shapiro

HSci 8122. Foundations for Research in the Scientific Revolution. (4 cr) Shapiro

Phil 5604. Determinism and Causation. (4 cr) Hellman

Phil 5605. Time and Space. (4 cr) Savage

Phil 5606. Philosophy of Quantum Mechanics. (4 cr) Hellman

### Elective Courses—Biological and Biomedical Sciences

SST 8300. Seminar: The Biological and Biomedical Sciences. (4 cr [may be repeated for cr]; prereq HSci 8111 or Phil 8605 or #) Beatty, Eyler, Longino, Waters  
Students participate in ongoing research in history, philosophy, and social study of biological and biomedical sciences. Students prepare and present research papers as major part of course.

HMed 5002. Public Health Issues in Historical Perspective. (4 cr) Eyler

HMed 5035. The Germ Theory and the Medical Profession. (4 cr) Eyler

HSci 5201. History of Biology: Biology From Antiquity Through Early Modern Period. (4 cr) Beatty

HSci 5202. History of Biology: Biology in the 19th and 20th Centuries. (4 cr) Beatty

HSci 5242. The Darwinian Revolution. (4 cr) Beatty

Phil 5607. Philosophy of the Biological Sciences. (4 cr) Beatty, Waters

### Elective Courses— Science, Technology, and Society

SST 8400. Seminar: Science, Technology, and Society. (4 cr [may be repeated for cr]; prereq HSci 8111 or Phil 8605 or #) Beatty, Eyler, Kohlstedt, Layton, Longino, Norberg, Seidel, Stuewer  
Students participate in ongoing research on interactions involving science, technology, and society. Students prepare and present research papers as major part of course.

SST 8420. Social and Cultural Studies of Science. (4 cr, §CSDS 8910, §HSci 8420) Longino  
Review of recent work; theoretical and methodological differences among practitioners; selected responses from historians and philosophers of sciences.

HMed 5045. Medical Profession in America. (4 cr) Eyler

HMed 5120-5130. Historical Topics: Medicine and the Modern State. (4 cr per qtr) Eyler

HSci 5321. History of Computing. (4 cr) Norberg

HSci 5331. Technology and American Culture. (4 cr) Norberg

HSci 5332. Science and American Culture. (4 cr) Kohlstedt

HSci 5825. The Nuclear Age. (4 cr)

HSci 8941. Women in Science: Historical Perspectives. (4 cr) Kohlstedt

Phil 5770. Selected Topics in Philosophy: Ethical Issues in Biomedicine. (4 cr)

### Studio Arts

See Art.

### Surgery (Surg)

*Professor:* David L. Dunn, *head and director of graduate studies*; R. Morton Bolman; Henry Buchwald; Michael D. Caldwell; Frank B. Cerra; Bruce L. Cunningham; John P. Delaney; John Foker; Robert L. Goodale; Rainer W. G. Gruessner; Arthur J. Matas; Donald G. McQuarrie; J. Ernesto Molina; William D. Payne; David G. Reynolds; Sara J. Shumway; David E. R. Sutherland; John A. Weigelt

*Clinical Professor:* Arnold S. Leonard; John S. Najarian

*Associate Professor:* Jerome H. Abrams; Roderick A. Barke; William C. Engeland; Herbert B. Ward

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S.Exp.Surg. (Plan A only), M.S.Surg. (Plan A only), and Ph.D.Surg.

**Curriculum**—The program in general surgery trains medical doctors both for the practice of surgery and for academic positions. See the *Medical School Bulletin* for professional degree requirements; see below for academic degree requirements. Trainees spend two to three years in lab research, either in a basic science or in surgery, after which they enter into their senior residency and chief residency training. The fundamental laboratories of the Medical School offer numerous graduate courses closely related to surgery (see Anatomy, Biochemistry, Laboratory Medicine, Microbiology, Pathobiology, Pharmacology, and Physiology). These fields also offer opportunities for special investigative and research work. Supervised work is offered by the Department of Surgery in its experimental research laboratories, as well as in its hospital and outpatient departments, in the areas of surgical diagnosis and operative surgery, and in some surgical specialties (such as colon and rectal surgery, transplantation, thoracic and cardiovascular surgery, and pediatric surgery). The M.S. in experimental surgery program provides an opportunity to obtain practical research experience for those who are fully trained in clinical surgery.

**Prerequisites for Admission**—Applicants must hold an M.D. degree from an approved medical school.

**Master's Degree Requirements**—For the M.S. in experimental surgery, 40 credits (two years' work), including at least 30 in surgical research, are required. The minor consists of 9 credits in a nonclinical field. The final examination is an oral defense of the thesis.

For the M.S. in surgery, 70 credits (five years' work), including at least 20 in surgical research, and passage of the department surgical examination are required. The minor consists of 9 credits in a nonclinical field. The final examinations are an oral defense of the thesis and a written examination.

**Doctoral Degree Requirements**—Of the required 100 credits (six years' work), at least 40 must be in research (basic science lab credit may be interchangeable with surgical lab credit at department discretion). Passage of department surgical examination is also required. The minor consists of 18 to 24 credits in a nonclinical field.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Department of Surgery, University of Minnesota, Box 195 Mayo, 420 Delaware Street S.E., Minneapolis, MN 55455 (mailing address) (612/625-6483).

Surg 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Surg 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Surg 8888. Thesis Credits: Doctoral. (36 cr required)

Surg 8200. Clinical Surgical Problems in Management. (5 cr)

Graduate students act as house surgeons and are required to study all phases of patient care including diagnosis, pre- and postoperative management, and operative therapy. Graded responsibility offered under supervision of staff. Fellows operate under supervision beginning with simple procedures. When properly qualified, senior and chief residents manage entire care of some patients. Attendance at rounds, conferences, and seminars is mandatory.

Surg 8201. Surgical-Roentgenological Conference. (1 cr) Dunn, staff

Weekly review of films of all surgical patients presenting interesting roentgen findings. Staffs of the Departments of Radiology and Surgery.

Surg 8202. Surgical Research. (5 cr)

Properly qualified students undertake original investigation of problems in either experimental or clinical surgery.

Surg 8203. Surgery Complications and Research Conference. (1 cr) Dunn, staff

Evaluation of selected surgical patients including postoperative course. Current research problems are presented for discussion and critical evaluation.

Surg 8207. Transplantation and Bone Marrow Conference. (1 cr) Dunn

Current clinical and research problems are presented for interdepartmental discussion and evaluation.

## Sustainable Agriculture Systems (SAgr)

*Regents' Professor:* Vernon W. Ruttan

*Professor:* Craig C. Sheaffer (agronomy and plant genetics), *director of graduate studies;* Vernon B. Cardwell (agronomy and plant genetics); John V. Carter (horticultural science); Peter H. Graham (soil, water, and climate); Robert Philip King (applied economics); Richard A. Levins (applied economics); Jean-Alex E. Molina (soil, water, and climate); Roger D. Moon (entomology); James H. Orf (agronomy and plant genetics); Edward B. Radcliffe (entomology); Paul C. Rosenblatt (family social science); Steve R. Simmons (agronomy and plant genetics); Delane E. Welsch (applied economics)

*Associate Professor:* Deborah L. Allan (soil, water, and climate); David A. Andow (entomology); David D. Biesboer (plant biology); Sharon M. Danes (family social science); Jeffrey Lynn Gunsolus (agronomy and plant genetics); Emily E. Hoover (horticultural science); Kent D. Olson (applied economics); William F. Wilcke (biosystems and agricultural engineering)

*Assistant Professor:* Nicholas R. Jordan (agronomy and plant genetics); Susan Marie Galatowitsch (horticultural science); Marla Spivak (entomology)

*Adjunct Assistant Professor:* Helene Murray (agronomy and plant genetics)

**Course of Study**—Minor in sustainable agriculture systems, applicable to master's (M.A. and M.S.) and doctoral programs.

**Curriculum**—Sustainable agriculture systems is a structured interdisciplinary graduate minor program with a strong emphasis on systemic approaches to analyzing current food production systems in the United States and environmental, economic, and social conditions that influence changes in agriculture. Courses designed specifically for this program integrate biology, ecology, and agriculture, as well as sociology, history, philosophy, and economics.

Student interaction with groups and individuals involved with food production practices, policies, and education is an integral part of the program. SAgr 8010 provides a forum for students, faculty, and members of the agriculture community to discuss issues. In a required internship students broaden their understanding of food production, develop learning and thinking skills that will serve them in a variety of settings, and gain practical experience in an area that complements their studies.

**Prerequisites for Admission**—Admission to the graduate minor in sustainable agriculture systems is contingent upon prior admission to a master's or doctoral degree-granting program within the Graduate School. The minor complements major programs in ecology, conservation biology, forestry, sociology, geography, political science, and public affairs, as well as majors in the College of Agricultural, Food, and Environmental Sciences.

**Special Application Requirements**—Contact the director of graduate studies in sustainable agriculture systems for an Intent to Enroll form. Students are admitted each quarter.

**Minor Requirements**—The credit requirement for the minor is 9 credits for a master's program, 18 credits for a doctoral program. All students are required to take SAgr 8010 and SAgr 8020. For a Ph.D. program, students choose two of the remaining core courses and, in consultation with a faculty member from the minor, select their remaining courses from a list of electives from outside the major department.

**Language Requirements**—None specific to the minor program.

**For Further Information and Applications**—Contact the Director of Graduate Studies, Sustainable Agriculture Systems Minor, Minnesota Institute for Sustainable Agriculture, University of Minnesota, 411 Borlaug Hall, 1991 Upper Buford Circle, St. Paul, MN 55108 (612/625-8235; fax 612/625-1268; e-mail sheaf001@tc.umn.edu).

### Core Courses

SAgr 8010. Colloquium in Sustainable Agriculture. (2 cr) Sheaffer  
Issues affecting long-term viability of agriculture. Discussion involves individuals from farming communities, nonprofit groups, public agencies, and faculty from relevant departments. Field trips to production sites.

SAgr 8020. Field Experience in Sustainable Agriculture. (2-4 cr; prereq SAgr grad minor student, #)  
Eight- to ten-week internship with growers or organizations working with sustainable agriculture issues. Students analyze these issues in a term paper and seminar.

Agro 5070. Agroecology. (3 cr) Jordan

Agro 5095. History of U.S. Agriculture. (3 cr) Tjossem

Ent 5320. Ecology of Agriculture. (4 cr) Andow

## Theatre Arts

*Professor:* C. Lance Brockman, *chair*; Barbara Reid

*Associate Professor:* Jean A. Montgomery, *director of graduate studies*; Barbara M. Barker; Louis R. Bellamy; Maria Cheng; Glen W. Gadberry; Martin B. Gwinup; Nels Hennum; Stephen C. Kanee; Michal Kobialka; Elizabeth H. Nash; James Norwood

*Assistant Professor:* Nancy Houfek; Margaret L. Maddux; Joan A. Smith

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—Theatre Arts: M.F.A., Ph.D., and M.A. (Plan A and Plan B) as part of the Ph.D. program.

**Curriculum**—The Ph.D. in theatre arts certifies the mastery of the history, theory, and literature of theatre arts and the facility for applying and communicating that knowledge. Doctoral students are required to take nine core courses: eight consecutive courses in history, theory, and literature of theatre and one course in theatre historiography. Various seminars support these core courses. The M.A. emphasizes academic pursuits and is generally viewed as a prerequisite to work on the Ph.D. The five formal areas of study in both the Ph.D. and M.A. programs are theatre history and dramatic literature, playwriting and dramatic theory, acting, directing, and design and technical production. Candidates are required to take coursework in both academic and performance areas. Special facilities include the University's Performing Arts Archives and various language centers.

The three-year, performance-oriented M.F.A. degree offers three areas of specialization: acting, directing, or design and technical production. The *M.F.A. in acting*, an intensive, highly individualized professional actor training program, provides students with the physical, vocal, emotional, and intellectual skills necessary to succeed as working, growing artists. The *M.F.A. in directing*, an intensive course of study emphasizing performance, focuses on the advancement of intellectual and artistic skills and on the development of the leadership talent needed to make a significant contribution to contemporary theatre. The *M.F.A. in design and technical production*

provides a solid understanding of each area of design in order to communicate with other directors and designers. The student is expected to achieve proficiency in two of the three design areas (scenery/properties, costuming, and lighting) and a level of expertise in at least one of these areas. The M.F.A. degree is considered a terminal degree in these theatre arts areas.

**Prerequisites for Admission**—For all programs, a minimum of 18 undergraduate credits or the equivalent in theatre arts is required. Also required is a minimum 3.00 grade point average. International students must submit scores from the Test of English as a Foreign Language (TOEFL) by January 15; the minimum score for admission is 550. The master's degree is a prerequisite for admission to the Ph.D. program.

**Special Application Requirements**—The application deadline for all degree programs is January 15. Applications received after that date will be considered only if there is an opening in the particular program. M.A./Ph.D. students who want materials reviewed for the Graduate School Fellowship must submit them by January 5. Students are admitted in fall quarter only. Applicants for all degree programs except the M.F.A. in acting must submit scores from the Graduate Record Examination by February 1. Entry for the incoming classes for all three M.F.A. programs is fall of odd-numbered years.

The *M.F.A. in acting* requires an initial audition either through the U/RTA process or as an independent auditionee, plus a final callback audition by invitation in Minneapolis in early March. Acting candidates using the independent audition process must have completed their application to the Graduate School before scheduling an audition. All candidates for final invitational callbacks must have completed their application to the Graduate School before scheduling callback auditions. The *M.F.A. in directing* requires an audition by invitation in Minneapolis in early March after an initial screening of application files. The *M.F.A. in design and technical production* requires a portfolio review either through the Evanston U/RTA or by submitting

materials by February 1. Contact the director of graduate studies for specific information.

**General Degree Requirements**—There are limits to the number of credits in practicum and performance courses that may be used to satisfy degree requirements for the M.A. and the Ph.D. For the M.A. the limit is 12 credits; for the Ph.D., 24.

**Master of Arts Degree Requirements**—For the M.A. degree, Plan A, 12 credits of graduate work must be selected from history, theory, and dramatic literature; 12 credits from acting, design, directing, playwriting, and practicum; 8 credits from outside the department; 12 elective credits; and 16 thesis credits. For the M.A. degree, Plan B, 12 credits of graduate work must be selected from history, theory, and dramatic literature; 12 credits from acting, design, directing, playwriting, and practicum; 8 credits from outside the department; and 13 elective credits. Written examinations are required. Contact the director of graduate studies for specific details.

**Master of Fine Arts Degree Requirements**—For the M.F.A. degree, a *minimum* of 84 graduate credits is required, as is a final oral examination. Each program requires a final performance practicum, including a written record of it. For specific program requirements, contact the director of graduate studies.

**Doctoral Degree Requirements**—The program of study for each Ph.D. student is designed by the student and adviser to develop appropriate skills in research and scholarship. Central to this is the core curriculum of 36 credits in theatre history/dramatic literature and historiography. The student will demonstrate special competence in theatre history, theory, dramatic literature, and a performance area. The choice of a minor is subject to approval from the major and minor advisers. A supporting program (18-24 credits) may be substituted for the minor with approval from the major adviser and director of graduate studies. Students must pass written and oral examinations.

One foreign language is required, which may serve as the research technique for the dissertation, if appropriate. Typically students

consult with advisers or the director of graduate studies for other research options.

**Language Requirements**—For the master's degree, none. For the doctoral degree, one language is required. See Doctoral Degree Requirements above.

**For Further Information and Applications**—Contact the Department of Theatre Arts and Dance, University of Minnesota, 204 Middlebrook Hall, 412 22nd Avenue South, Minneapolis, MN 55455 (612/625-5029; fax 612/625-6334).

Th 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Th 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Th 8888. Thesis Credits: Doctoral. (36 cr required)

## Theatre Arts (Th)

### History and Dramatic Literature

Th 5131, 5132, 5133. Shakespeare. (4 cr per qtr; prereq 1101 or #) Norwood Seminar from perspectives of live theatre, staging in theatre, and film/television productions. Video clips from selected plays. *5131*: Comedies and romances. *5132*: Histories. *5133*: Tragedies.

Th 5171, 5172, 5173. History of Theatre. (4 cr per qtr) Gadberry  
Theatre as mirror of society. Aesthetics, philosophy, and techniques of theatre arts. *5171*: Origins to 1642. *5172*: Renaissance to 1875. *5173*: Theatre after 1875.

Th 5181. Blacks in American Theatre. (4 cr, §Afro 5181)  
Historical survey of significant events in development of American Black theatrical tradition; essays, plays, playwrights, and theatres from early colonial references to Black Arts Movement.

Th 5182. Contemporary Black Theatre: 1960-Present. (4 cr, §Afro 5182)  
Essays, plays, playwrights, and theatres that have contributed significantly to contemporary Black theatre, from beginning of Black Arts Movement to present.

Th 8102. Theatre Historiography. (4 cr) Kobialka  
Current trends in historiography; research strategies and methods. Required of all theatre doctoral students.

Th 8103. The Theatre Dramaturg. (4 cr; offered alt yrs)  
Role of dramaturg in theatrical performance: history, theory, practice.

Th 8111, 8112, 8113, 8114, 8115, 8116, 8117, 8118. History/Theory of Western Theatre. (4 cr per qtr) Gadberry, Kobialka  
Theories, arts, and crafts of theatre. *8111*: Ancient world. *8112*: Medieval. *8113*: Renaissance. *8114*: Rise of National Theatres. *8115*: 18th century. *8116*: Romanticism through Naturalism. *8117*: Symbolism through World War II. *8118*: 1945 to present.

Th 8120. Seminar in Theatre: Advanced Study of Selected Fields of Theatre. (4 cr per qtr [max 16 cr])  
Selected research topics from various fields and periods of theatre.

### Playwriting and Dramatic Theory

Th 5115. Playwriting I. (4 cr, \$EngW 5204; prereq #)  
Workshop for students with established competence.

Th 5116. Playwriting II. (4 cr, \$EngW 5205; prereq 5115, #)  
Workshop for students with advanced competence.

### Acting

Th 5321. Career Preparation for Actors. (4 cr; prereq 3323 or grad student)  
Information and techniques necessary for professional acting careers.

Th 5322. Acting for the Camera. (4 cr; prereq 3322 or grad student)  
Differences between stage acting and acting for the camera. Scenes enacted and played back on videotape for class critique.

Th 5331-5332-5333. Advanced Movement for Actors. (2 cr per qtr; prereq 3323, # by audition or grad student) Hennum  
Explores awareness, flexibility, observation, releasing, mime and mask, improvisation, verbal and nonverbal physical techniques. *5331*: Fundamentals; *5332*: Introduction to mime and mask; *5333*: Mime and mask.

Th 5334-5335. Stage Combat. (2 cr per qtr; prereq 3323, # by audition or grad student) Hennum  
Advanced movement techniques for the stage with focus on physical life of scenes of a violent nature. *5334*: Unarmed combat. *5335*: Armed combat.

Th 5341. Shakespearean Text Analysis. (4 cr; prereq 3341, 3321-3322 or grad student) Nash  
Analysis and performance of Shakespearean text.

Th 5342. Singing for Musical Theatre. (2 cr; prereq 3321-3322, #) Nash  
Analysis and performance of songs for musical theatre.

Th 8321-8322-8323. MFA Acting I. (3-3-4 cr; prereq MFA acting student or # by audition) Reid  
Advanced acting training. Internal approach based on Stanislavski's principles. *8321*: Preparation, elements of situation, given circumstances, and characterization. *8322*: Continued work on characterization and relationship leading to scene study. *8323*: Scene study leading to directed projects.

Th 8324-8325-8326. MFA Acting II. (3-4-3 cr; prereq MFA acting student or # by audition)  
Advanced techniques for performing classical and contemporary texts with extended vocal and physical demands. *8324*: Techniques applied to scenes and monologues from Shakespeare. *8325*: Advanced acting techniques and character analysis applied to a performance project from classical canon. *8326*: Advanced acting techniques applied to modern and post-modern texts.

Th 8330. Alexander Technique for MFA Actors. (1 cr; prereq MFA acting student or #)  
Principles of Alexander Technique to develop body-mind awareness, improve performance, and develop ease of movement and range of physical expression. Group and individual work.

Th 8341-8342. Vocal Production for MFA Actors I-II. (2 cr per qtr; prereq MFA acting student or #)  
*8341*: Physiology of human voice, phonetics, tonal placement, vowel standardization and articulation. *8342*: Theories of theatre speech and application of advanced voice and speech techniques to dramatic texts.

Th 8343-8344-8345. Vocal Production for MFA Actors III-IV-V. (2 cr per qtr; prereq MFA acting student or #) Houfek  
Use and application of spoken voice for stage. *8343*: Fundamentals of spoken voice: body awareness, breath and support, resonance. *8344*: Extended uses of spoken voice: pitch, rate, volume, and applications to poetic text. *8345*: Application of rhythm, musicality, placement, and articulation to dialect study for stage.

Th 8346. Advanced Text and Voice Production for MFA Actors. (2 cr; prereq MFA acting student or #) Nash  
Analysis and performance of texts by Congreve, Sheridan, and Shaw.

### Design and Technical Production

Th 5510f,s. Drawing and Rendering for Theatre Designers. (2 cr; prereq 3513 or 3515 or grad student, #) Brockman, staff  
Development of drawing (fall) and rendering (spring) skills necessary for presentation of theatre scene and costume designs.

Th 5511. Theatre Drafting and Graphics. (4 cr; prereq 3513, 3515 or equiv or #) Brockman, Gwinup, Montgomery  
Practical study of drafting skills for the theatre designer (scenery and lighting) and technical director. Interpretation of rendering, sketches, and models for realization on the stage.

Th 5515. Design Composition and Collaboration. (4 cr; prereq 3513 or equiv, #) Brockman, Kanee  
In-depth study of classical composition of art and its application to stage design and directing. Emphasis on creative development of good design composition through tools of classical composition and the organic collaborative process.

Th 5520. Scene Design. (4 cr [max 12 cr]; prereq 3513, 5511 or #) Brockman  
Theory and design of stage scenery. Development of scenic model and rendering.

Th 5530. Costume Design. (4 cr [max 12 cr]; prereq 3515 or #)  
Theory and design of costumes; special projects. Laboratory arranged.

Th 5532. Advanced Makeup for the Stage. (2 cr; prereq 1502 or equiv or grad student)  
Facial casting, prosthetics, and hair ventilating.

Th 5540. Lighting Design. (4 cr [max 12 cr]; prereq 3515, directing or #) Montgomery  
Theory of stage lighting design. Development of the lighting plot and paperwork. Laboratory arranged.

Th 5550. Theatre Sound Design. (2 cr [max 6 cr]; prereq 1504, 5564 or #) Gwinup  
Theory of and approaches to analysis and creation of auditory environment for theatrical productions. Listening, psychoacoustics, microphone techniques, script analysis, projects. Laboratory arranged.

Th 5560. Theatre Crafts Practicum. (1-4 cr per qtr [max 6 cr for undergrads]; prereq 3513 or 3515, #, Δ)  
Individual creative projects that further student's practical skills and knowledge in specialized craft areas of theatre.

Th 5561. Stage Craft. (4 cr; prereq 3513, 5511, #) Gwinup  
In-depth study and practical application of scenic materials, tools, and construction processes currently used in theatre. Laboratory arranged.

Th 5562. Scene Painting Techniques. (4 cr; prereq 3513 or #) Brockman  
Practical study of materials, layout, and painting techniques used in theatre. Emphasis on painting styles and texturing techniques.

Th 5563. Costume/Properties Crafts. (4 cr; prereq 3513 or grad student) Gwinup, guest instructors  
Accessories, fabric enhancement techniques, materials, construction techniques, tools, and processes.

Th 5564. Lighting and Sound Technology for the Theatre. (2 or 4 cr; prereq 3515 or equiv) Gwinup, Montgomery, guest instructors  
Equipment, techniques, control operation, wiring, and maintenance from practical standpoint. Laboratory arranged.

Th 8511. History of Theatre Decor and Dress I. (4 cr) Design faculty  
Theory and practice in history of decor and dress, research methods with emphasis on extracting essence of style for theatrical design and production. Covers classical through 17th century.

Th 8560. Theatre Crafts Practicum. (1-4 cr; prereq Δ, #) Design faculty  
Individual creative projects that further student's practical skills in specialized craft areas of theatre.

Th 8575. Seminar: Technical Production. (4 cr; prereq 5511, 5561 or #) Gwinup, guest instructors  
In-depth study and projects using technology necessary to realize current scenic requirements. Rigging, stage mechanics, management, and audience/shop safety.

## Directing

Th 5711. Advanced Stage Direction. (4 cr; prereq 3713 or grad student or #)  
Dramatic forms. Theory of rehearsal and production problems and direction of two one-act plays.

Th 5712. Stage Direction of Non-Realistic Theatre. (4 cr; prereq 5711, grad student or #) Kanee, staff  
Theory, technique, and production of 20th-century non-realistic theatre from Beckett to Müller; direction of two one-act or extended scenes from the genre.

Th 5716. Stage Management for the Theatre. (4 cr; prereq 3711 or ¶3711 or grad student) Montgomery  
Stage management as a specialized area. Theories and techniques of rehearsal and performance, organization and management in educational, community, and professional theatres.

Th 5718. Theatre Management and Promotion. (4 cr; prereq 1504) Wagner  
Introduction to theory, problems, and solutions of administrative planning, budgeting, advertising, and publicity for not-for-profit theatre.

Th 5720. Plays in Production and Performance. (2-4 cr per qtr [max 6 cr for undergrads]; prereq 5712, #, Δ) Kanee, staff  
Work in the field with a community, high school, touring or professional theatre group, or on campus to further develop expertise as a stage director.

Th 5728. Theatre Management Problems: Audience and Financial Development. (2 cr; prereq 5718) Wagner  
Practical analysis of audience and financial development problems in U.S. theatre. Concentrates on various solutions.

Th 5760. Advanced Stage Management. (1-3 cr per qtr [max 6 cr for undergrads]; prereq 5716 or ¶5716, #) Montgomery  
Practical experience in stage management for specific productions of the University Theatre with emphasis on rehearsal and performance.

Th 8711, 8712, 8713. Seminar: Stage Direction. (4 cr; prereq 5712 or equiv) Kanee, staff

Th 8730. One-Act Limited Workshop Production. (2 cr per qtr; prereq student in MFA directing program)  
Fully rehearsed and performed production of published or original one-act-length play with limited design and technical support.

## GRADUATE PROGRAMS

Th 8740. Supported Workshop Production. (4 cr per qtr; prereq student in MFA directing program) Fully rehearsed and performed production of published or original full-length play with budgeted design and technical support.

Th 8750. Mainstage Production. (6 cr per qtr; prereq student in MFA directing program) Rehearsed and performed mainstage production of published or original full-length play with generous design and technical support.

Th 8770. Advanced Directing Laboratory. (2 cr; prereq MFA director or #) Hennem, Kanee Theory and practice of advanced staging and interpretive directing problems. Staging techniques and conceptual thinking applied to variety of complex visual and textual situations.

### General

Th 5100. Theatre Practicum. (1-6 cr; prereq  $\Delta$ , written #)  
Arranged individual creative projects in production of a play as actor, designer, director, dramaturg, or playwright.

Th 5110. Theatre Performance. (1 cr per qtr [max 9 cr]; prereq written # after casting and/or assignment to a production; S-N only)  
Participation in the rehearsals and performances of a University Theatre production. Credit given for the quarter the performance takes place.

Th 5950. Topics in Theatre. (1-5 cr per qtr [max 12 cr]; prereq #,  $\Delta$ )  
Selected topics. Topics listed in *Class Schedule*.

Th 5970. Directed Readings. (1-6 cr per qtr; prereq 9 cr theatre, #,  $\Delta$ , CLA approval)  
Directed reading and preparation of reports on selected subjects.

Th 8100. Theatre Practicum. (1-6 cr; prereq  $\Delta$ , #)  
Arranged individual advanced creative projects in production of a play as actor, designer, director, dramaturg, or playwright.

Th 8980. Directed Instruction. (1-3 cr; prereq  $\Delta$ )  
Teaching experience in an area in which a graduate student does not hold a teaching assistantship but in which she or he may be required to teach when entering the field. Limited to students with appropriate coursework background.

Th 8990. Research. (Cr ar; prereq #,  $\Delta$ )  
Open to graduate students engaged in research on special problems.

### Dance (Dnce)

Dnce 5010-5020-5030. Advanced Modern I-II-III. (3 cr per qtr [max 9 cr each number]; prereq # or  $\Delta$  for 5010, # or  $\Delta$  or 5010 for 5020, # or  $\Delta$  or 5020 for 5030) Guest artist  
Continuation of technical development, emphasizing performance range and style. Study with 5-6 guests artists of renown with disparate aesthetics and technical styles.

Dnce 5040-5050-5060. Advanced Ballet I-II-III. (2 cr per qtr [max 6 cr each number]; prereq # or  $\Delta$  for 5040, # or  $\Delta$  or 5040 for 5050, # or  $\Delta$  or 5050 for 5060) Mathis

Continuation of intermediate technique, emphasizing musicality, performance, and stylistic differences. Practical work is conducted within context of study of choreographic and aesthetic development of ballet.

Dnce 5070-5080-5090. Advanced Jazz I-II-III. (1 cr per qtr [max 3 cr each number]; prereq # or  $\Delta$  for 5070, # or  $\Delta$  or 5070 for 5080, # or  $\Delta$  or 5080 for 5090) Sealy  
Continuation of technical development. Additional work on syncopation, performance projection, and specific jazz styles: swing, bebop, lyrical, funk, Latin.

Dnce 5100. Dance Practicum. (1-6 cr)  
Arranged individual creative projects in dance.

Dnce 5312-5313-5314. Composition IV-V-VI. (3 cr per qtr; prereq  $\Delta$  or 3313 for 5312,  $\Delta$  or 5312 for 5313,  $\Delta$  or 5313 for 5314) Guest artists  
Continuation of exploration of movement vocabulary through improvisation, analysis of form and structure, experimentation with tone and performance persona, exploration of effects of lights/costumes/text/props/music, development of larger ensemble works.

Dnce 5487. World Dance Studies. (4 cr) Maddux  
Dance as art, ritual, social activity, and entertainment in selected cultures of Asia, Africa, the Americas, and Eastern Europe. Comparative analysis from historical, visual, and ethnological perspectives.

Dnce 5616. Teaching Modern Dance. (4 cr; prereq intermediate competency in modern dance, # or  $\Delta$ )  
Principles and methods of dance pedagogy.

Dnce 5700. Workshop: Dance Performance. (3 cr; prereq enrollment in technique course,  $\Delta$ )  
Principles of technique, improvisation, choreography, music, design, and technical production as they relate to dance performance.

Dnce 5910. Topics in Dance. (1-5 cr per qtr [max 12 cr])  
Topics listed in *Class Schedule*.

Dnce 5920. Topics in Dance Performance. (1-3 cr [max 6 cr])  
Discussion of various aspects of performance and performing.

Dnce 5970. Directed Studies. (1-6 cr per qtr; prereq 9 cr dance, #,  $\Delta$ )  
Guided individual reading or study in dance.

### Therigenology

See Veterinary Medicine.

## Toxicology (Txcl)

*Professor:* W. Thomas Shier (medicinal chemistry), *director of graduate studies;* Yusuf J. Abul-Hajj (medicinal chemistry); Robert M. Carlson<sup>1</sup> (chemistry); Joseph DiSalvo<sup>1</sup> (physiology); Lester R. Drewes<sup>1</sup> (biochemistry and molecular biology); Patrick E. Hanna (medicinal chemistry); Chester J. Mirocha (plant pathology); Herbert T. Nagasawa (medicinal chemistry); Joseph R. Prohaska<sup>1</sup> (biochemistry and molecular biology); Lawrence B. Schook (veterinary medicine); Sheldon B. Sparber (pharmacology); Lawrence P. Wackett (biochemistry)

*Associate Professor:* Michael J. Murphy (veterinary diagnostic medicine), *associate director of graduate studies,* St. Paul campus; Jean F. Regal<sup>1</sup> (pharmacology), *associate director of graduate studies,* Duluth campus; David R. Brown (veterinary pathobiology); Vincent F. Garry (laboratory medicine and pathology); Randall E. Hicks<sup>1</sup> (biology); Richard G. Hoffman<sup>1</sup> (behavioral sciences); Michael E. McDonald<sup>1</sup> (chemical engineering); Gerald J. Niemi<sup>1</sup> (Center for Water and the Environment); Ashok K. Singh (veterinary diagnostic medicine); Kendall B. Wallace<sup>1</sup> (pharmacology)

*Adjunct Associate Professor:* Gerald T. Anklely (fisheries and wildlife); Vicki L. Horton (veterinary diagnostic medicine)

*Assistant Professor:* Robert R. Roy (pharmacy practice); Elizabeth V. Wattenberg (environmental and occupational health)

*Adjunct Assistant Professor:* Steven P. Bradbury<sup>1</sup> (U.S. Environmental Protection Agency); John W. Nichols<sup>1</sup> (medical and molecular physiology)

*Senior Research Associate:* Subhash C. Basak<sup>1</sup> (Center for Water and the Environment)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) under special circumstances and Ph.D.

**Curriculum**—This University-wide program provides comprehensive training in the broad scope of toxicology. Specialized training is available through advanced courses and research in a number of subdisciplines, including human health risk assessment; epidemiology; environmental chemistry and engineering; ecotoxicology; food additives and nutritional toxicology; biochemical and physiological mechanisms; histopathology; diagnostic and analytical toxicology; drug metabolism; chemical carcinogenesis; behavioral toxicology; and the toxicity of noxious agents to various organ systems (e.g., nervous, heart, liver, kidneys).

**Prerequisites for Admission**—All applicants should have a full year of biology, chemistry, and physics and have completed mathematics through calculus.

**Special Application Requirements**—Scores from the General (Aptitude) Test of the Graduate Record Examination and three letters of recommendation from college-level faculty or equivalent are required of all applicants.

**Master's Degree Requirements**—Completion of a core curriculum consisting of 12 credits in toxicology is required. Additional courses and credits are arranged on an individual basis. A final oral examination and research thesis defense is required.

**Doctoral Degree Requirements**—All students must complete a core curriculum composed of physiology (6 cr), biochemistry (8 cr), statistics (4 cr), and toxicology (15 cr). Additional advanced courses in toxicology or related fields may be specified by the major adviser. Students must complete and defend an original preliminary research proposal. The final requirement for graduation is the oral defense of the written research dissertation.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—Students must complete 12 credits of core courses and 6 credits of advanced courses in toxicology.

**For Further Information, Applications, and a List of Courses**—Contact the Toxicology Graduate Program, College of Pharmacy, University of Minnesota, 8-168 Weaver-Densford Hall, 308 Harvard Street S.E., Minneapolis, MN 55455.

Txcl 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Txcl 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Txcl 8888. Thesis Credits: Doctoral. (36 cr required)

Txcl 5164. Toxicology of Poisonous Plants. (1 cr, \$VDM 5164; prereq VPB 5401 or #) Murphy  
Toxicology and identification of poisonous plants.

Txcl 5165. Veterinary Toxicology. (2 cr, \$VDM 5165; prereq VB 5401 or #) Murphy  
Toxicology of minerals, pesticides, herbicides, venoms, and miscellaneous toxicants.

<sup>1</sup> University of Minnesota, Duluth

Txcl 5214. Principles of Toxicology. (4 cr; prereq Chem 5336, Chem 5337, Phsl 5927, Phsl 5928 or BioC 5751, BioC 5752, Phsl 5440, Phsl 5441, #) Shier, staff  
Includes factors that determine disposition of foreign chemicals in living systems.

Txcl 5215. Organ System Toxicology. (3 cr; prereq 5214, #) Murphy, staff  
Kinetic and dynamic determinants of target organ toxicity; pathological alterations in structure/function relationship for major organ systems.

Txcl 5216. Chemical and Environmental Toxicology. (4 cr; prereq 5214, #) Roy, staff  
Mechanisms of toxicity of specific classes of chemical agents; application of toxicology in various professional careers.

Txcl 8101-8102-8103†. Toxicology Seminar. (1 cr per qtr; prereq #)  
Issues in investigative toxicology research.

Txcl 8572. Investigative Toxicology. (2 cr; prereq 5214-5216)  
Current investigations in toxicological sciences.

Txcl 8800. Directed Research. (Cr ar)  
Experimental investigation of toxicological problems.

## Veterinary Biology

See Veterinary Medicine.

## Veterinary Medicine

Major and minor programs for the M.S. and Ph.D. degrees are available in the various disciplines offered by the College of Veterinary Medicine: theriogenology; veterinary biology; veterinary medicine; veterinary pathobiology; and veterinary surgery, radiology, and anesthesiology. Veterinary biology and veterinary pathobiology offer a combined D.V.M./Ph.D. program to selected students. An emphasis in veterinary public health within the M.P.H. degree is offered by the School of Public Health. For information about a major area, applicants should contact the director of graduate studies in the major field.

## Theriogenology

*Professor:* Bradley E. Seguin, *director of graduate studies;* Bo G. Crabo; Gary D. Dial; M. L. Fahning; Alan G. Hunter; Shirley D. Johnston; Han Soo Joo; Jonathon E. Wheaton

*Associate Professor:* William E. Marsh; Jerry D. Olson

*Assistant Professor:* Mats H. T. Troedsson

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Emphases in the major are food-producing and companion animals. Within these emphases, interest can be further directed to such areas as reproductive physiology, reproductive pathology, and infectious or managerial reproductive problems of animals.

**Prerequisites for Admission**—A D.V.M. degree or its foreign equivalent is required.

**Special Application Requirements**—At least three letters of recommendation, a statement of purpose, and a résumé detailing professional experiences and publications are required.

**Degree Requirements**—For the master's and doctoral degrees, at least one quarter of CAPS 8595 is required. The final examination for the master's degree includes a seminar and an oral examination.

**Language Requirements**—None.

**Minor Requirements for Students Majoring in Other Fields**—Students must have a D.V.M. degree or advanced training in the biological sciences to minor in theriogenology.

**For Further Information and Applications**—Contact the Theriogenology Graduate Program, Department of Clinical and Population Sciences, University of Minnesota, 435-H Animal Science/Veterinary Medicine, 1988 Fitch Avenue, St. Paul, MN 55108 (612/624-4741).

Tgen 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Tgen 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Tgen 8888. Thesis Credits: Doctoral. (36 cr required)

**Note**—In addition to the following courses, many other courses are commonly taken for the theriogenology major, especially among those listed for the animal physiology and animal science programs. The three programs also share a number of graduate faculty members.

CAPS 5515. Advanced Equine Theriogenology. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track)  
Teasing for estrus detection, rectal palpation and ultrasound examination of ovaries and pregnancy diagnosis, breeding management, vaginal examination, uterine culture and biopsy, intrauterine therapy, artificial insemination, semen collection and evaluation.

CAPS 5535. Advanced Dairy Palpation. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track)  
For developing technical skills of palpating reproductive tract of cow through rectum.

CAPS 5545. Advanced Dairy Theriogenology Management. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track)  
Two-week rotation of lecture and laboratory, including embryo transfer, breeding soundness evaluation, obstetrics, and reproductive management of dairy herd.

CAPS 5550. Diagnostics and Obstetrics in Theriogenology. (2 cr; prereq regis vet med or grad student or #) Fahning  
Lectures on diagnostic, therapeutic, and obstetrical procedures in theriogenology.

CAPS 5551. Theriogenology Diagnostics Laboratory. (1 cr; prereq regis vet med or grad student or #) Seguin, staff  
Demonstrations and laboratory practices in diagnostic and therapeutic procedures in theriogenology.

CAPS 5552. Veterinary Obstetrics Laboratory. (1 cr; prereq 5550 or #) Fahning  
Demonstrations and practices in application of obstetrical procedures.

CAPS 5570. Reproductive Diseases of Domestic Animals. (5 cr; prereq 5550 or #) Fahning, staff  
Lectures covering physiology and pathology of reproduction, artificial insemination, abortive diseases, postpartum injuries, and breeding management in domestic animals.

CAPS 5571. Reproduction and Infertility in the Horse. (1 cr; prereq 5570, regis vet med or grad student or #) Troedsson  
Lectures and demonstrations covering reproductive patterns, breeding practices, management, artificial insemination, economics of reproductive performance, and infertility in horses.

CAPS 5595. Advanced General Theriogenology. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track)  
Comparative theriogenology training program based on clinical case load in Veterinary Teaching Hospital and theriogenology field herds. Comparative teaching laboratories (e.g., semen evaluation). Students focus on species of interest (bovine, equine, small animal), depending on season and case load.

CAPS 8591, 8592, 8593. Advanced Endocrinology of Reproduction. (2 cr per qtr; prereq regis grad student)  
Review of endocrine patterns of domestic animals, emphasizing topics in theriogenology. Endocrine changes that occur with certain reproductive diseases. Application of hormone analysis to clinical diagnosis and herd monitoring.

CAPS 8594. Special Problems In Animal Reproduction. (Cr ar; prereq 5570 or #)  
Detailed discussion and laboratory study of specific reproductive disorders.

CAPS 8595. Seminar. (1 cr) Seguin, staff

## Veterinary Biology

*Professor:* Lawrence B. Schook, *chair*; Alvin J. Beitz; Thomas F. Fletcher; Esther M. Gallant; Alice A. Larson; Charles F. Louis; Michael P. Murtaugh; Scott M. O'Grady; Akhouri A. Sinha

*Associate Professor:* James R. Mickelson, *director of graduate studies*; David R. Brown; Victor S. Cox, Jr.; Sally E. Jorgensen; Mathur S. Kannan; John W. Osborn; Patrick T. Redig

*Adjunct Associate Professor:* Craig W. Beattie

*Assistant Professor:* Mitchell S. Abrahamsen; Vivek Kapur; Mark S. Rutherford; Stephanie J. Valberg

*Research Associate:* Frank G. Williams

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—This program provides students with a broad base of knowledge in biomedical sciences, followed by advanced training in a specific area of expertise within the program. Major research interests in the program focus on molecular biology, immunology, and genetics; neuroanatomy and neuropharmacology; gastrointestinal physiology and pharmacology; muscle physiology, pharmacology, and biochemistry; and animal biotechnology.

**Prerequisites for Admission**—Applicants for both degrees must have a background in chemistry, physics, mathematics, and biology that is acceptable to the graduate faculty. Some background work may be done after acceptance.

**Special Application Requirements**—A statement of career goals, Graduate Record Examination scores, and three letters of

recommendation evaluating the applicant's potential for graduate study are required. Additional information may be requested as necessary. For both the M.S. and the Ph.D. degree, requirements are individualized in accordance with the specialty area and interest of the student. Students are accepted for admission each quarter. Additional information is available from the director of graduate studies.

**Degree Requirements**—The final examination for the master's degree is oral.

**Language Requirements**—For the master's degree, none. For the doctoral degree, facility with a computer programming language may be required.

**Minor Requirements for Students Majoring in Other Fields**—Students should consult the director of graduate studies in veterinary biology.

**For Further Information and Applications**—Contact the Department of Veterinary Pathobiology, University of Minnesota, 295 Animal Science/Veterinary Medicine, 1988 Fitch Avenue, St. Paul, MN 55108 (612/624-2700).

VB 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

VB 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

VB 8888. Thesis Credits: Doctoral. (36 cr required)

VPB 5100. Veterinary Anatomy I. (6 cr; prereq #) Cox, Fletcher, Gallant  
Gross anatomic structure and function. The dog is used as a type species to introduce nomenclature and principles of mammalian gross anatomy. Cervical, thoracic, and abdominal viscera of the dog, cat, ruminant, horse, pig, and laboratory animals presented from comparative approach.

VPB 5102. Veterinary Neurobiology. (3 cr, §NSc 5102; prereq #) Beitz, Fletcher  
Structural and functional organization of the central nervous system of domestic animals.

VPB 5103. Veterinary Developmental Anatomy. (3 cr; prereq #) Cox, Fletcher  
Ontogenetic processes in organ systems of domestic animals and developmental anomalies of clinical significance.

VPB 5104-5105. Microscopic Anatomy of Domestic Animals. (5 cr for 5104, 4 cr for 5105; prereq #) Beitz, Czarnecki, Gallant  
Light microscopic and relevant ultrastructural studies of cells, tissues, and organ systems.

VPB 5110. Cytogenetic Evaluation of Animal Diseases. (1 cr; prereq regis 3rd- or 4th-yr vet med or grad student or #; offered when feasible) Weber

VPB 5126. Veterinary Anatomy II. (5 cr; prereq 5100 or #) Cox  
Comparative anatomy with emphasis on the pelvis, reproductive system, limbs, and head from a morphodynamic and radiographic approach. Species covered include horse, domestic ruminants, swine, dog, cat, and bird.

VPB 5149. Topics in Organology. (1-5 cr per qtr [may be repeated for cr]; prereq 5104 or equiv, #; offered when feasible) Czarnecki

VPB 5210f. Veterinary Biochemistry. (3 cr; prereq 1st-yr vet med or #) Louis, Mickelson  
Molecular nature of cells and tissues and ways in which dietary carbohydrates, lipids, and proteins are metabolized to generate energy for growth and maintenance of the animal.

VPB 5212w. Veterinary Biochemistry. (4 cr; prereq 5210 or #) Louis, Mickelson, Murtaugh  
Control and integration of metabolism in whole animal. Hormonal regulation, specialized metabolism in different mammalian tissues and species, and applications of molecular biology to animal health.

VPB 5306w. Animal Physiology. (5 cr; prereq regis vet med or #) O'Grady, Osborn  
Physiology of cell membranes and cardiovascular, renal, and body fluid systems of animals.

VPB 5308s. Animal Physiology. (4 cr; prereq regis vet med or #) O'Grady, Osborn  
Physiology of digestion, respiration, and mechanisms of temperature regulation and heat production in animals.

VPB 5310f. Animal Physiology. (3 cr; prereq 5308 or #) Hunter, Redig, Wheaton  
Physiology of endocrine and reproductive systems of animals.

VPB 5320w. Avian Physiology. (4 cr; prereq AnSc 3301 or 4 cr systemic physiology or equiv, #; offered alt yrs) Duke, El-Halawani, Redig  
Physiology of wild and domestic birds.

VPB 5400f. Veterinary Pharmacology and Therapeutics I. (3 cr per qtr, §NSc 5400; prereq 5310 or equiv or #) Larson  
General principles of drug action, drug disposition, and drug use, focusing on drug action in central and peripheral nervous systems. Pharmacology of autonomic drugs, anesthetics, tranquilizing agents, analeptics, anticonvulsants, and neuromuscular blockers.

VPB 5401w. Veterinary Pharmacology and Therapeutics II. (5 cr per qtr; prereq 5310, 5400 or #) Brown

Pharmacology of cardiopulmonary drugs (e.g., inhalational anesthetics, antiarrhythmic agents, cardiac glycosides), anti-inflammatory agents (e.g., NSAIDS, corticosteroids, antihistamines), and drugs affecting fluid and electrolyte homeostasis (e.g., diuretics, gastrointestinal drugs). Veterinary applications.

VPB 5402s. Veterinary Pharmacology and Therapeutics III. (3 cr; prereq 5401 or #) Kannan  
Pharmacology of sulfonamides, nitrofurans, arsenicals, antibiotics, coccidiostats and other antiprotozoan drugs, antifungal agents, anthelmintics, and other anti-infectious drugs. Principles and applications in prevention and treatment of microbial and parasitic diseases of domestic animals.

VPB 5444. Muscle Contraction. (3 cr; prereq undergrad biochem or physiology, #) Barnett, Gallant, Louis, Mickelson, Thomas  
Introduction to physiology, biochemical regulation, and physical chemistry of muscle contraction.

VPB 5460-5461. Cellular and Molecular Neuroscience. (3 cr per qtr; for 5460: §GCB 5460, §MdBc 5460, §NSc 5460, §Phcl 5460, §Phsl 5460; for 5461: §GCB 5461, §MdBc 5461, §NSc 5461, §Phcl 5461, §Phsl 5461; prereq biochem course)  
Gene structure and regulation, cloning and molecular strategies for studying gene function, ion channels and membrane excitability, synaptic transmission, receptor structure and function, and signal transduction.

VPB 8150. Research Problems in Veterinary Anatomy. (1-5 cr; prereq #; offered when feasible) Beitz, Cox, Czarnecki, Fletcher

VPB 8200. Mechanisms of Animal Health and Disease. (3 cr; prereq course in biochem, course in microbiol or immunology, #)  
Cellular basis for pathogenesis of animal diseases. Molecular and genetic mechanisms of host resistance, innate and acquired immunity, immune avoidance, and host/pathogen interactions. Emphasizes relationships to veterinary medicine and animal production.

VPB 8349. Research in Physiology. (Cr ar; prereq #; offered when feasible) Gallant, O'Grady, Osborn

VPB 8448. Problems in Veterinary Pharmacology. (Cr ar; prereq 5401 or equiv or #; offered when feasible) Brown, Kannan, Larson

VPB 8450. Drug-Receptor Interactions. (2 cr; prereq 5400, 5401 or equiv, calculus through differential equations, Chem 5520-5521 or equiv; offered alt yrs) Brown  
Dynamics of interaction between drugs and their receptors. Historical development of drug-receptor theory, factors affecting drug concentration in receptor compartment, determination of agonist and antagonist activity, and functional receptor classification.

VPB 8550. Seminar: Veterinary Biology. (1 cr; prereq #) Mickelson

## Veterinary Medicine

*Professor:* Trevor R. Ames; P. Jane Armstrong; Stephen I. Bistner; Gary D. Dial; Robert H. Dunlop; Ralph J. Farnsworth; John Fetrow; Sagar M. Goyal; David A. Halvorson; Robert M. Hardy; Shirley D. Johnston; Han Soo Joo; Jeff S. Klausner; Patrick J. McKeever; Thomas W. Molitor; Michael P. Murtaugh; K. V. Nagaraja; Phillip Ogburn; Carl A. Osborne; Carlos Pijoan; David J. Polzin; Michael M. Pullen; Jeffrey K. Reneau; R. Ashley Robinson; Vaithianathan Sivanandan; David G. Thawley

*Associate Professor:* Thomas H. Hostetter; Jody P. Lulich; William E. Marsh; Martha A. Mellencamp; Robert B. Morrison; William G. Olson; Ashok K. Singh; Tracy A. Turner

*Assistant Professor:* Calvin N. Kobluk; Daniel P. Shaw; Stephanie J. Valberg

*Research Associate:* Peter B. Bahnsen

*Associate Clinical Specialist:* Sheila M. F. Torres

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Emphases in the major are large, small, and comparative animal medicine. Emphasis can further be directed toward specific systems or population medicine.

**Prerequisites for Admission**—A D.V.M. degree or its foreign equivalent is required.

**Special Application Requirement**—A letter of intent is required stating career goals and defining the area of graduate study (e.g., subdiscipline or animal species). Also required are three letters of recommendation from individuals knowledgeable about the applicant's academic performance.

**Degree Requirements**—For the M.S. degree, an oral examination is required. Doctoral students are expected to write a thesis proposal and take a preliminary oral examination within three years of starting the program.

**Language Requirement**—None.

**Minor Requirements for Students Majoring in Other Fields**—The director of graduate studies determines these requirements, which vary with the major field, for each individual.

**For Further Information and Applications—**

Contact the Veterinary Medicine Graduate Program, Department of Clinical and Population Sciences, University of Minnesota, 225 Veterinary Teaching Hospitals, 1365 Gortner Avenue, St. Paul, MN 55108 (612/625-7755).

VMed 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

VMed 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

VMed 8888. Thesis Credits: Doctoral. (36 cr required)

VDM 5001. Ecotoxicology. (3 cr per qtr; prereq Biol 1005 or equiv, Chem 1001)  
Ecosphere and environment.

CAPS 5015. Advanced Veterinary Public Health (VPH) Clinic Rotation. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track)  
Preparation for health and socially responsible role in veterinary community medicine (rural and urban); preparation for federal accreditation; introduction to public practice veterinarians.

CAPS 5115. Advanced Large Animal Medicine. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track) Ames, Valberg, Wilson  
Medical diseases of horses, cattle, and small ruminants. History taking, clinical diagnosis, and patient management.

CAPS 5150. Diagnostic and Therapeutic Techniques. (1 cr) Ames, Valberg, Wilson  
Demonstration and application of diagnostic techniques and procedures and restraint of animals. Discussion of therapeutic regimens and demonstrations of therapeutic procedures.

CAPS 5151. Diagnostic and Therapeutic Techniques I. (1 cr; prereq CVM 5150 or #) Ames, Valberg, Wilson  
Application of general physical examination procedures, special diagnostic techniques, and therapeutic procedures to large animals.

CAPS 5153. Diagnostic and Therapeutic Techniques II. (1 cr; prereq #) Ames, Valberg, Wilson  
Demonstration and practice of restraint and diagnostic and therapeutic techniques for large animals.

CAPS 5160. Large Animal Medicine. (6 cr; prereq 5151 or #) Ames, Valberg, Wilson  
Diseases of ruminants covered on a system basis.

CAPS 5161. Large Animal Medicine. (5 cr; prereq 5160 or #) Ames, Valberg, Wilson  
Continuation of study of ruminant diseases and equine diseases on a system basis.

CAPS 5162. Large Animal Medicine. (6 cr; prereq 5161 or #) Ames, Pijoan, Valberg, Wilson  
Continuation of equine diseases and porcine diseases.

VDM 5164. Toxicology of Poisonous Plants. (1 cr, \$TxcL 5164; prereq VPB 5401 or #) Murphy  
Toxicology and identification of poisonous plants.

CAPS 5165. Introduction to Animal Nutrition. (2 cr; prereq VPB 5210, VPB 5212, VPB 5306 or #) Olson  
Requirements and functions of nutrients in large and small animals; sources of nutrients and evaluation of feedstuffs.

VDM 5165. Veterinary Toxicology. (3 cr; prereq 5164, VPB 5401) Murphy  
Toxicology of minerals, pesticides, herbicides, venoms, and miscellaneous toxicants. Recognition, diagnosis, and treatment of animal poisons.

SACS 5170. Small Animal Medicine. (4 cr; prereq #) Bistner, Hardy, Klausner, McKeever, Ogburn, Osborne, Torres  
Etiology, pathophysiology, diagnosis, prognosis, and treatment of disorders of various body systems of companion animals. Fundamental principles of diagnosis and treatment, and polysystemic disorders including nutritional abnormalities, immune-mediated diseases, infectious diseases, intoxications, and neoplasia.

SACS 5171. Small Animal Medicine. (4 cr; prereq 5170 or #) Bistner, Hardy, Klausner, McKeever, Ogburn, Osborne, Torres  
(Continuation of 5170.)

SACS 5172. Small Animal Medicine. (5 cr; prereq 5171 or #) Bistner, Hardy, Klausner, McKeever, Ogburn, Osborne, Torres  
(Continuation of 5171.)

CAPS 5182. Sheep and Goat Herd Health Management. (1 cr; prereq regis 3rd- or 4th-yr vet med or grad student or #) Wolf  
Sheep and goat breeds and breeding, reproduction, applied nutrition, housing, preventative medicine programs, and management practices.

CAPS 5190. Large Animal Internal Medicine I. (3 cr; prereq DVM, enrollment in SACS or CAPS clinical residency) Ames  
Pathophysiology, clinical manifestations, and therapeutic regimes for major organ systems of main large animal species.

CAPS 5191. Large Animal Internal Medicine II. (3 cr; prereq DVM, enrollment in SACS or CAPS clinical residency) Ames  
Pathophysiology, clinical manifestations, and therapeutic regimes used for major organ systems of main large animal species.

CAPS 5215. Advanced Large Animal Surgery. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track) Turner

Clinical rotation for diagnostic and therapeutic management in hospital setting of lameness and surgical diseases of equine, bovine, and small ruminant species.

CAPS 5225. Advanced Equine Lameness. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track) Turner

Two-week course involving clinical, didactic, and laboratory learning.

CAPS 5235. Advanced Equine Podiatry. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track) Turner

CAPS 5245. Advanced Bovine Surgery. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track) Trent

Technical and theoretical skills necessary for mixed or dairy practice that involves managing cow surgical diseases.

SACS 5250. Small Animal Dermatology. (1-2 cr; prereq regis 3rd- or 4th-yr vet med or grad student or #) McKeever, Torres

Pathogenesis, clinical features, diagnosis, and therapy of skin diseases of companion animals.

SACS 5251. Comparative Clinical Veterinary Dermatologic Pathology. (1 cr; prereq grad student or #) McKeever, Torres

Microscopic pathology of basic dermatologic reactions and variable disease states.

CAPS 5255. Advanced Equine Surgery. (4 cr; prereq regis 3rd- or 4th-yr grad student or # or IV track) Turner

Two-week clinical rotation through large animal hospital. Surgical and orthopedic diseases.

SACS 5256. Diseases of the Liver and Pancreas. (2 cr; prereq regis 3rd- or 4th-yr vet med or grad student or #) Hardy

Etiopathogenesis, diagnosis and treatment of hepatic and pancreatic diseases in companion animals.

SACS 5257. A Clinician's Analysis of Urinalysis. (1 cr; prereq completion of 1st 3 yrs of vet curriculum) Osborne

Overview of proper interpretation of urinalysis findings in patients with variety of disorders of various body systems.

SACS 5260. The Problem-Oriented Medical System. (1 cr; prereq #) Lulich, Osborne  
Introduction to fundamentals of problem definition and solution. Problem-oriented system of diagnosis and therapy, problem-oriented medical record.

SACS 5265. Comparative Cardiology. (2 cr; prereq regis 3rd- or 4th-yr vet med or grad student or #) Ogburn  
Helps students develop skills in recognition, definition, and resolution of problems involving the cardiovascular system.

CAPS 5270. Economics and Practice Management. (2 cr; prereq regis vet med or #)  
Basic economic concepts and terminology. Relationship of animal health to productivity; cost/benefit relationships for disease control programs; financial return and economic analysis of livestock operations; economics of practice management; trends in livestock production.

SACS 5270. Animal Behavior. (2 cr; prereq #) Redig

Principles of animal behavior; managing clinical behavioral problems primarily of companion and food animals.

CAPS 5271. Law and Ethics in Veterinary Medicine. (2 cr; prereq regis vet med or #) Waddell  
Discussion of legal and ethical issues in veterinary medicine.

SACS 5271. Hospital Management. (1 cr; prereq regis 3rd- or 4th-yr vet med or grad student or #) Hardy  
Lectures. Management of small animal hospital. Zoning restrictions, employee supervision, drug purchases, facilities, fees, and other pertinent information.

CAPS 5274. Orientation to the Job Market. (1 cr; prereq 5270 or #)

Review of veterinary business management; preparation for a professional position; choosing a practice; interviewing for an associate position; negotiating contracts; benefits; hours; covenants.

CAPS 5275. Diseases of Zoo Animals and Exotic Pets. (1 cr; prereq regis 3rd- or 4th-yr vet med or grad student or #) Farnsworth  
Diseases of and management procedures for zoo animals and exotic pets, restraint procedures, medication and diagnosis.

CAPS 5276. Advanced Zoo Animal Medicine. (1 cr; prereq regis 3rd- or 4th-yr vet med, 5275 or #) Farnsworth

Adaptation of existing veterinarian techniques and principles to practice of zoo animal medicine. Animal management and preventive medicine programs used in zoo animal medicine.

CAPS 5280. World Food Problems. (3 cr, \$AgEc 5790, \$FScN 5643, \$Soc 5675; prereq major in agriculture, veterinary medicine, nutritional sciences, social sciences or # or grad student with #) Pettigrew  
Multidisciplinary approach to the social, economic, and technical problems of feeding the world's growing population. Principles sought from social and economic, plant, animal, and nutritional sciences for their application to food problems.

SACS 5285. Canine Clinical Neurology. (1 cr; prereq regis 3rd- or 4th-yr vet med or grad student or #) Hardy

Anatomic and physiologic bases for neurological examination of the dog. Emphasizes clinical approach to neurology.

## GRADUATE PROGRAMS

SACS 5572. Reproductive Patterns and Infertility in the Dog and Cat. (1 cr; prereq CAPS 5570, regis 3rd- or 4th-yr vet med or grad student or #) Johnston

Lectures on reproductive patterns, breeding management, artificial insemination, and infertility in dogs and cats.

CAPS 5605. Analytical Techniques in Veterinary Medicine I. (3 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track) Marsh, Waddell

Developing and using computer systems for processing, analyzing, and interpreting animal health data.

Resources needed for research program. Developing critical approach to reading veterinary medical literature.

CAPS 5615. Advanced Swine Disease Diagnostics, Therapeutics, and Prevention. (4 cr; prereq IV track or grad or #) Joo, Morrison, Pijoan  
Two-week rotation deals primarily with on-farm disease diagnostics, treatment, and control programs.

VDM 5620. Scientific Writing and Speaking. (2 cr; prereq #; for grad students in hlth sciences) Goyal

Techniques of writing and publishing scientific papers and theses, including manuscript preparation, submission and review process, and proofreading and publishing process. Oral and poster presentations at scientific meetings covered.

CAPS 5625. Advanced Swine Production Systems. (4 cr; prereq grad student or IV track or #) Dial  
Comprehensive review of factors affecting biological productivity and financial competitiveness of commercial swine farms.

CAPS 5635. Advanced Swine Nutrition. (4 cr; prereq grad student or # or IV track) Dial  
Rotation focusing on nutrition and feeding management of pigs.

CAPS 5645. Advanced Swine Economics, Financial Management, and Marketing. (4 cr; prereq IV track or grad student or #) Marsh  
Manipulation, analysis, and interpretation of data from all phases of swine production, using biological and financial records. Case studies help develop analytic and diagnostic skills in identification of causes of suboptimal productivity. Financial analysis techniques used to develop cost-effective and feasible solutions to production problems; swine marketing alternatives.

CAPS 5650. Veterinary Epidemiology and Statistics. (4 cr; prereq 10 cr biology, 12 cr chemistry or #) King, Morrison  
Principles of epidemiology, biology, and veterinary public health. Biostatistics applied to the measurement of health and disease in populations.

CAPS 5651. Veterinary Community Medicine. (3 cr; prereq VPB 5703, VPB 5503 or equiv or #) Pullen, Robinson

Principles and practices of environmental health and food hygiene; includes meat, poultry, milk, and other foods as they are related to animal and human health. Diseases transmitted between animals and humans.

CAPS 5663. International Animal Disease Problems. (1 cr; prereq #) Robinson  
Diagnosis, transmission, and epidemiology of diseases not currently present in the United States. International role of veterinarians in reducing disease and increasing world animal production.

CAPS 5665. Monitoring and Surveillance of Disease. (Cr ar; prereq #; offered alt yrs) Robinson  
Seminars and discussions on techniques used to monitor disease in animal populations.

CAPS 5671. Biohazards in Veterinary Medicine. (Cr ar; prereq #) Goyal, Robinson  
Seminars and discussions on microbiological, toxicological, drug, and other hazards.

CAPS 5672. Perspectives: Animal-Human Relationships and Community Health. (2-3 cr; prereq #) Dunlop  
Same as PubH 5303. Perspectives on cultural, psychological, ethological, and environmental aspects of the interrelationships of people and animals as they affect individual and community health.

CAPS 5673. Problems in Disease Control and Eradication. (Cr ar; prereq PubH 5330 or #; offered alt yrs) Robinson

Past and present disease control and eradication programs, factors influencing success and failure. Development of models for disease control and eradication programs in the United States or a foreign country for group evaluation and analysis.

CAPS 5680. Problems in Veterinary Epidemiology and Public Health. (Cr ar; prereq 5650 or equiv or #) Robinson  
Individual study arranged with faculty member.

CAPS 5695. Advanced Epidemiology and Biostatistics. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track) Marsh, Morrison  
Strengths and limitations of statistical methodologies used in veterinary medicine and epidemiology. Designing feasible research program given constraints of funding, time, and facilities. Preparing detailed research proposal suitable for submission for competitive funding.

CAPS 5715. Advanced Equine Sports and Preventive Medicine. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track) Turner  
Rotation provides broad exposure to equine industry, emphasizing sports performance activities and role of veterinarian.

SACS 5802. Residency in Veterinary Dermatology. (Cr ar; prereq #) McKeever, Torres  
Rotations in veterinary dermatology clinics and review of dermatopathology slides submitted to Veterinary Diagnostic Laboratory. Rotations through Veterinary Internal Medicine and Human Dermatology Service (Medical School); dermatology journal club.

SACS 5812s. Companion Animal Oncology. (2 cr; prereq DVM or equiv; offered alt yrs) Klausner  
Principles of veterinary oncology; biological behavior, treatment, and prognosis of neoplastic disorders.

CAPS 5815. Advanced Dairy Disease Control, Parasitology, Youngstock Management. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track) Ames

Common infectious diseases and parasites that limit dairy calf performance.

CAPS 5825. Advanced Mastitis, Milking Machines, and Milk Quality. (4 cr; prereq grad student or # or IV track) Farnsworth

Rotation for training students to evaluate herd mastitis problems and provide recommendations for solutions.

CAPS 5835. Advanced Ruminant Nutrition. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track) W Olson

Nutrient requirements of ruminants, nutrient content of feed stuffs (primarily forages), energy utilization, protein and nonprotein nitrogen utilization, nutritional disorders, formulation of adequate rations, and techniques for analyzing rations. Strongly recommended for students interested in dairy and suggested for those interested in beef.

CAPS 5845. Advanced Dairy Nutrition. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track) J Olson

Principles, techniques, goals, and objectives of providing nutrition advice, counseling, and/or assessment to a dairy farm.

CAPS 5855. Advanced Dairy Record Analysis, Epidemiology, and Economics. (4 cr; prereq IV track or grad student or #) Fetrow  
Evaluation of a dairy herd as a whole using biological and economic records.

CAPS 5915. Advanced Building Design and Total Herd Evaluation. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track) Pijoon  
Housing, ventilation, equipment, and building design principles using epidemiologic approach to promoting animal health. Integration of total animal healthcare, environmental control, and herd management into herd veterinary services.

CAPS 5925. Advanced Beef Production Medicine. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track) Fetrow

CAPS 5945. Advanced Small Ruminant Health and Production. (4 cr; prereq regis 3rd- or 4th-yr vet med or grad student or # or IV track) Wolf

CAPS and SACS 5955. Advanced Directed Studies. (1-8 cr; prereq #)  
Study in veterinary science in areas arranged by the student and a faculty member.

SACS 8180. Advanced Clinical Neurology. (Cr ar; prereq #) Hardy

Diagnosis and therapy of neurologic diseases based on sound understanding of underlying fundamentals in neuroanatomy, neurophysiology, and neuropathology. Lectures, individual study, programmed learning texts, and discussion of material.

SACS 8190.\* Comparative Cardiovascular Diseases. (3 cr; prereq grad student) Ogburn  
Lectures, seminars, and special laboratory exercises on diseases of the cardiovascular system of domestic animals. Specialized methods of diagnosis emphasized. Research project in experimental or clinical cardiology required.

SACS 8192. Special Cardiology Clinics. (Cr ar; prereq grad student, #) Ogburn  
Intensive clinical studies in investigative clinical cardiology. Diagnosis and management of cardiovascular disease in small animals.

CAPS 8193. Advances in Clinical Immunology. (Cr ar; prereq grad student or #) Molitor

Students, faculty members, and guest speakers present seminars on current research in and clinical application of immunologic procedures in diagnosis, control, and treatment of disease processes in animals.

CAPS 8194.\* Problems in Diagnostic Virology, Serology, and Immunology. (Cr ar; prereq grad student or #) Molitor

Laboratory techniques of diagnostic virology, serology, and immunology. Research techniques of fluorescent antibody; determination of classes of immunoglobulins and immunostimulation of lymphocytes.

CAPS 8195.\* Preventive Veterinary Medicine. (Cr ar)

Application of the principles and practice of preventive veterinary medicine in food-animal production at the herd, state, national, or international levels.

SACS 8196.\* Internal Medicine in Small Companion Animals. (2 cr; prereq grad student, #) Bistner, Hardy, Klausner, McKeever, Ogburn, Osborne, Torres

Lectures, assigned readings, and discussions on internal medical problems of dogs and cats.

CAPS 8197. Metabolic and Nutritionally Induced Diseases of Cattle. (2 cr; prereq grad student, #) Olson

Etiology, pathogenesis, current research, treatment, and prevention of metabolic diseases including vitamin and mineral diseases and energy and protein abnormalities associated with production.

SACS 8197.\* Advanced Dermatologic Clinics. (Cr ar; prereq grad student, #) McKeever, Torres

In-depth clinical study of dermatologic disease states, diagnosis and therapy in animals.

SACS 8198. Problems in Veterinary Comparative Dermatology. (Cr ar; prereq grad student, #) McKeever

Individual research in selected problem.

CAPS 8199. Problems in Economics of Animal Health. (1-3 cr; prereq #) Marsh, Olson, staff  
Impact of animal disease on animal productivity and the return to investment in animal health by producers or the society studied using disease problems of current interest as subjects. Questions involving human health problems may be studied.

SACS 8200. Directed Studies in Veterinary Comparative Dermatology. (2 cr; prereq grad student, #) McKeever, Torres  
Readings and literature review.

CAPS and SACS 8290. Advanced Veterinary Medicine. (Cr ar; prereq CAPS 5162, SACS 5172, #) Ames, Hardy, Joo, Osborne, Pijoan, Robinson, staff  
Discussions of the diseases of organs or systems in animals from the following etiologic group: prenatal, metabolic, toxic infectious, physical influences.

CAPS and SACS 8291. Advanced Diagnosis and Therapeutics of Animal Diseases. (Cr ar; prereq CAPS 5162, SACS 5172, #) Ames, Hardy, Joo, McKeever, Ogburn, Olson, Osborne, Pijoan, Torres  
Detailed examination, discussions, and treatment of cases of animal diseases.

CAPS and SACS 8292. Seminar: Veterinary Medicine. (Cr ar; prereq grad student, #)

CAPS and SACS 8293. Medical Conference. (Cr ar; prereq CAPS 5162, SACS 5172, #)  
Medical, surgical, or obstetrical cases supported by anatomic, bacteriologic, pathologic, physiologic, pharmacologic, and radiologic evaluations whenever applicable.

CAPS and SACS 8299. Research in Veterinary Medicine. (Cr ar)  
Research problems relating to any aspect of internal medicine or to the various systems in animals.

CAPS 8690. Epidemiology of Zoonoses and Diseases Common to Humans and Animals. (Cr ar; prereq #) Robinson  
Major human zoonotic diseases; methods of transmission, diagnosis, control, and prevention.

CAPS 8790. Problems in Veterinary Clinical Pharmacology and Therapeutics. (3 cr; prereq grad student or #)

CAPS 8791. Seminar in Clinical Pharmacology and Therapeutics. (2 cr; prereq grad student or #)

## Veterinary Microbiology

See Veterinary Pathobiology.

## Veterinary Parasitology

See Veterinary Pathobiology.

## Veterinary Pathobiology

*Professor:* Lawrence B. Schook, *chair*; Bert E. Stromberg, *director of graduate studies*; William J. Bemrick (*emeritus*); James E. Collins; Gary E. Duke; Sagar Goyal; David A. Halvorson; David W. Hayden; Kenneth H. Johnson; Han Soo Joo; Harold J. Kurtz; Samuel K. Maheswaran; Thomas W. Molitor; Roger D. Moon; Michael P. Murtaugh; K. V. Nagaraja; John A. Newman; Victor Perman; Phillip K. Peterson; Carlos B. J. Pijoan; Michael Pullen; R. Ashley Robinson; George R. Ruth; Jagdev M. Sharma; V. Sivanandan; S. R. Tatini; Mary M. Walser; Douglas J. Weiss

*Associate Professor:* Russell F. Bey; Roland Gunther; Edward N. Janoff; Martha A. Mellencamp; Timothy D. O'Brien; Terrance P. O'Leary; Daniel P. Shaw

*Adjunct Associate Professor:* Marcus E. Kehrl, Jr.

*Assistant Professor:* Mitchell S. Abrahamsen; Vivek Kapur; Michael R. Riggs; Mark S. Rutherford

*Research Associate:* Connie J. Gebhart

*Lecturer:* Randy R. Simonson

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Along with program coursework, basic and applied research opportunities are offered in the areas of immunology, biotechnology, bacteriology, parasitology, anatomic and clinical pathology, and virology as related to animals. The graduate faculty encourage interdisciplinary interactions in related fields. For interested students, the Graduate School also offers a minor in psychoneuroimmunology.

**Prerequisites for Admission**—Applicants must have the background knowledge in biology, chemistry, and mathematics that is acceptable to the graduate faculty.

**Special Application Requirements**—A brief statement of career goals and accomplishments, three letters of recommendation evaluating the applicant's potential for graduate study, and Graduate Record Examination scores are required. Additional information may be requested. Students may enter at the beginning of any quarter, but fall quarter is preferred.

**Degree Requirements**—For the master's degree, students take a final oral examination. Students enrolled in the doctoral program are

expected to write a thesis proposal and take a preliminary oral examination after the second year of graduate study.

**Language Requirements**—None.

**For Further Information and Applications**—

Contact the Department of Veterinary PathoBiology, University of Minnesota, 205g Veterinary Science, 1971 Commonwealth Avenue, St. Paul, MN 55108 (612/624-2282; fax 612/625-0204).

VPB 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

VPB 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

VPB 8888. Thesis Credits: Doctoral. (36 cr required)

VPB 5504. Veterinary Clinical Pathology. (4 cr; prereq 5502 or #) Perman, Weiss  
Technique, application, and interpretation of laboratory tests used in clinical diagnosis.

VPB 5520. Advanced Veterinary Clinical Pathology. (1-3 cr; prereq 5204, #) Perman, Weiss  
Application of clinical laboratory methods.

VDM 5521. Surgical Pathology. (3 cr; prereq #) Collins, staff  
Preparation and interpretation of surgical and necropsy specimens.

VDM 5522. Diagnostic Pathology. (5 cr; prereq #) Collins, staff  
History, necropsy lesions, laboratory results, and histopathology in the diagnosis of animal diseases.

VPB 5523. Pathology of Spontaneous Diseases of Laboratory Animals. (2-3 cr; prereq #; offered alt yrs) Gunther  
Gross and microscopic pathology of laboratory animals.

VPB 5524. Pathology of Spontaneous Diseases of Poultry. (3 cr; prereq #; offered alt yrs) Walser  
Gross and microscopic pathology of spontaneous diseases of chickens, turkeys, and game birds.

VPB 5601. Veterinary Parasitology I. (4 cr; prereq 5501 or #) Stromberg  
Helminth parasites and parasitic diseases of animals with emphasis on principles of control.

VPB 5602. Veterinary Parasitology II. (4 cr; prereq 5601 or #) Stromberg  
Systematic and biologic study of protozoan and arthropod parasites of animals; emphasis on their relationships to diseases and principles of parasite control.

VDM 5622. Problems in Diagnostic Virology. (1-4 cr; prereq #) Goyal  
Laboratory techniques in diagnostic virology and viral research.

CAPS 5650. Veterinary Epidemiology and Statistics. (4 cr; prereq 10 cr biology, 12 cr chemistry or #) Diesch, Pullen, Robinson  
Principles of epidemiology, biology, and veterinary public health. Biostatistics applied to the measurement of health and disease in populations.

CAPS 5651. Veterinary Community Medicine. (3 cr; prereq VPB 5703, VPB 5503 or equiv or #) Diesch, Pullen, Robinson  
Principles and practice of environmental health and food hygiene including meat, poultry, milk, and other foods as related to animal and human health. Selected diseases transmitted between animals and humans.

CAPS 5665. Monitoring and Surveillance of Disease. (Cr ar; prereq #) Diesch, Robinson  
Seminars and discussions on techniques used to monitor disease in animal populations.

CAPS 5680. Problems in Veterinary Epidemiology and Public Health. (Cr ar; prereq 5650 or equiv or #) Diesch, Pullen, Robinson  
Individual study arranged with faculty member.

VPB 5701. Veterinary Immunology. (3 cr; prereq 3101, 1st-yr vet med, #) Sharma, staff  
Cellular and humoral immune responses, hypersensitivity, regulation of immune system, immunosuppression, autoimmunity, and vaccination.

VPB 5702. Pathogenic Bacteria and Fungi. (5 cr; prereq 5701 or equiv or #) Nagaraja, Rutherford, staff  
Lectures and laboratory on animal pathogens, with emphasis on basic mechanisms of infection.

VPB 5703. Veterinary Virology. (5 cr; prereq 5702 or equiv or #) Sivanandan, staff  
Lectures and laboratory on the basic techniques of virology; emphasis on viral and rickettsial agents causing animal diseases.

VPB 5704. Avian Diseases. (3 cr; prereq 5703, 5503 or #)  
Lectures on diseases involving poultry, cage and aviary birds.

VPB 5707. Poultry Disease Control. (3 cr; not open to vet med students; prereq AnSc 1100, Biol 1106, VPB 3103 or equiv)  
General anatomy; physiology of digestion and reproduction; prevention and control of the more important diseases affecting poultry.

VPB 5709. Preventive Avian Medicine. (1-2 cr; prereq regis 4th-yr vet med or grad student or #)  
Preventive avian disease programs and management practices. Visits to poultry and aviary establishments.

## GRADUATE PROGRAMS

VPB 5780. Applied Immunology. (1 cr; prereq vet med grad student or #) Maheswaran, staff  
Review of principles of immunology and their clinical application.

VPB 8026. Neuro-Immune Interactions. (3 cr, \$NSc 8026, \$PNI 8026, \$Psy 8026; prereq MicB 5218 or equiv, NSc 5111 or equiv) Molitor, Murtaugh, staff  
Regulatory systems (neuroendocrine, cytokine, and autonomic nervous systems) linking brain and immune systems in a brain-immune axis. Functional effects of bidirectional brain-immune regulation.

CAPS 8193.\* Advances in Clinical Immunobiology. (Cr ar; prereq grad student or #) Molitor  
Students, faculty members, and guest speakers present seminars on current research in and clinical application of immunologic procedures in diagnosis, control, and treatment of disease processes in animals.

CAPS 8194.\* Problems in Diagnostic Virology, Serology, and Immunology. (Cr ar; prereq grad student or #) Goyal, Molitor  
Laboratory techniques in diagnostic virology, serology, and immunology. Research techniques of fluorescent antibody; determination of classes of immunoglobulins and immunostimulation of lymphocytes.

VPB 8200. Mechanisms of Animal Health and Disease. (3 cr; prereq biochem course, microbiol or immunology course, #)

Cellular basis for pathogenesis of animal diseases. Molecular and genetic mechanisms of host resistance, innate and acquired immunity, immune avoidance, and host/pathogen interactions. Emphasizes relationships to veterinary medicine and animal production.

VPB 8500. Seminar: Veterinary Pathology. (1-3 cr; prereq 5503, #) O'Leary

VPB 8501s. Advanced Veterinary Basic Pathology. (4-6 cr; prereq #) Johnson, staff  
Basic mechanisms and concepts relating to reaction of tissue to injury. Emphasis on gross and microscopic interpretation of retrogressive cellular changes, cellular infiltrations, inflammation, and neoplasia. Requires completion of a special project selected in conjunction with course instructor.

VPB 8504s. Advanced Veterinary Histopathology. (1 cr; prereq 5502, 5503, #) Hayden  
Discussion and study of selected case materials from the veterinary anatomic, diagnostic, and surgical pathology programs.

VPB 8531. Hospital Pathology. (1-2 cr; prereq 5501, 5502, 5503, #) Hayden, staff  
Necropsy and surgical pathology techniques, examination of tissue for diagnosis, and preparation of reports and records.

VPB 8533. Problems: Pathology. (Cr ar; prereq #) Johnson, staff

VPB 8534. Problems: Clinical Pathology. (Cr ar; prereq #) Perman, Weiss

VPB 8648. Problems: Veterinary Parasitology. (Cr ar; prereq #) Stromberg, staff

CAPS 8690. Epidemiology of Zoonoses and Diseases Common to Humans and Animals. (Cr ar; prereq #) Diesch, Pullen, Robinson  
Major human zoonotic diseases; methods of transmission, diagnosis, control, and prevention.

VPB 8700. Seminar: Veterinary Pathobiology. (1 cr; prereq #)

VPB 8716. Colloquium on Current Topics in Avian Immunology. (2 cr; prereq MicB 5216, grad student; offered alt yrs) Nagaraja, Sharma, Sivanandan

VPB 8720. Advanced Veterinary Microbiology. (Cr ar; prereq #)

VPB 8721. Immunodiagnostic Techniques for Avian Diseases. (2 cr; prereq MicB 5216, grad student; offered alt yrs) Nagaraja, Sivanandan

VPB 8724. Advanced Veterinary Diagnostic Microbiology. (Cr ar; prereq #)  
Lectures and laboratory in techniques of diagnostic mycology, bacteriology, virology, and serology.

### Veterinary Pathology

See Veterinary Pathobiology.

### Veterinary Surgery, Radiology, and Anesthesiology

*Professor:* Daniel A. Feeney, *director of graduate studies*; Dennis D. Caywood; Carl R. Jessen; Gary R. Johnston, Alan J. Lipowitz; Marc R. Raffé; Roby C. Thompson; Larry J. Wallace

*Associate Professor:* David R. Brown; Mathur S. Kannan; Patrick T. Redig; Elaine P. Robinson; Ava M. Trent; Patricia A. Walter

*Assistant Professor:* Paula K. Hendrix; Calvin N. Kobluk; Elizabeth M. Santschi

*Clinical Professor:* Paul G. Gannon; Claude R. Swayze

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Prerequisites for Admission**—The D.V.M. degree or its foreign equivalent is required. The applicant must also have completed an internship program or the equivalent of at least one year of clinical experience since the award of the D.V.M. degree.

**Special Application Requirements**—A statement of preferred emphasis in the major and three letters of recommendation evaluating the applicant's potential must be submitted. Students may begin in any term, but fall quarter entry is preferred.

**Degree Requirements**—For both the M.S. and Ph.D. degrees, students must complete, or have completed, basic coursework relevant to their area of emphasis. For more information on coursework, contact the director of graduate studies. The minimum course credit requirement (excluding thesis credits) for the Plan A master's is 28 credits, which includes 8 credits in one or more related fields. For the Plan B master's, a minimum of 44 course credits is required. The final examination for the master's degree is oral. Ph.D. program requirements are designed by students and their committee.

**Language Requirements**—None.

**For Further Information and Applications**—Contact the Veterinary Surgery, Radiology, and Anesthesiology Graduate Program, Department of Small Animal Clinical Sciences, University of Minnesota, C-339 Veterinary Teaching Hospitals, 1352 Boyd Avenue, St. Paul, MN 55108 (612/625-7744).

VSRA 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

VSRA 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

VSRA 8888. Thesis Credits: Doctoral. (36 cr required)

SACS 5330. Wild Bird Medicine. (2 cr; prereq regis 3rd- or 4th-yr vet med or grad student or #) Summary of avian anatomy and physiology. Survey of diseases common to wild birds; surgical repair of common injuries and fractures.

SACS 5350. Principles of Veterinary Surgery. (5 cr; prereq VPB 5126 or #) Basic materials necessary for clinically managing large and small animal surgical patients. Aseptic technique, patient evaluation, physiologic responses of body systems to surgery, repair and healing of tissue, surgical anatomy.

SACS 5351. Veterinary Surgery. (5 cr; prereq CVM 5350 or #) Caywood, Lipowitz, Wallace Common surgical procedures applied to small animals.

CAPS 5352. Large Animal Surgery. (5 cr; prereq #) Kobluk, Trent, Turner Common surgical procedures applied to large animals.

CAPS 5355. Equine Colic Management. (2 cr; prereq 1st-yr vet med) Lecture and laboratory on principles and techniques involved in evaluation and treatment of equine colic cases. Successful completion is a prerequisite for colic team, CAPS 5356 and CAPS 5357.

CAPS 5356. Equine Colic Team. (1 cr; prereq vet med, 5355; 4-qtr course, cr granted upon completion of 4th qtr) Participation in clinical management of equine colic cases and periodic review of past cases, success rates, and topics in related fields.

SACS 5356. Small Animal Surgery Laboratory. (1 cr; prereq 5352 or #) Caywood, Lipowitz

CAPS 5357. Advanced Colic Team. (1 cr; prereq vet med, 5356; 4-qtr course, cr granted upon completion of 4th qtr) Participation in clinical management of cases and periodic review of past cases, success rates, and topics in related fields. Students act as team leaders during clinical management and assist in laboratory exercises for CAPS 5355.

SACS 5360. Small Animal Orthopedics. (2-3 cr; prereq regis 3rd- or 4th-yr vet med or grad student or #) Wallace Small animal orthopedic problems and surgical procedures to correct them.

SACS 5380. Anesthesiology and Critical Care. (3 cr; prereq 5170 or #) Raffe Principles and application of anesthesia. Management of severely injured patient.

SACS 5398. Independent Research in Veterinary Anesthesiology. (1-6 cr; prereq regis vet med or grad student or #) Raffe, Robinson Special problems course for evaluating research methods. Controlled study, prospective, and retrospective models of evaluation defined, critiqued, and used for experimental design and data collection. Analysis of data collection to validate research methods.

SACS 5451. Veterinary Radiology I. (1 cr; prereq #) Walter Radiographic interpretation of normal systems.

SACS 5452. Veterinary Radiology II. (3 cr; prereq 5451 or #) Feeney, Johnston, Walter Principles of radiography and radiographic interpretation of abnormal systems.

SACS 5453. Special Procedures in Veterinary Radiology. (2 cr; prereq regis 3rd- or 4th-yr vet med or grad student or #) Feeney, Johnston Contrast agents and imaging procedures used to examine various body systems or anatomical areas.

## GRADUATE PROGRAMS

SACS 5454. Roentgenology Bone—Large Animals. (1 cr; prereq regis 3rd- or 4th-yr vet med or grad student or #) Feeney, Johnston, Walter  
Roentgen signs of common bone diseases of large animals. Emphasis on the horse.

SACS 5455. Roentgenology Bone—Small Animals. (1 cr; prereq regis 3rd- or 4th-yr vet med or grad student or #) Feeney, Johnston, Walter  
Roentgen signs of common bone diseases of small animals.

CAPS 8390. Seminar: Veterinary Surgery. (Cr ar; prereq DVM or equiv) Kobluk, Trent, Turner

SACS 8390. Seminar: Veterinary Surgery. (Cr ar; prereq 5360, 5365 or equiv and #) Caywood, Lipowitz, Wallace

SACS 8391. Advanced Small Animal Surgery. (Cr ar; prereq 5360 or equiv, #) Caywood, Lipowitz, Wallace  
Surgery of various systems in small animals with preoperative and postoperative evaluation and treatment.

CAPS 8392. Advanced Large Animal Surgery. (Cr ar; prereq DVM or equiv, #) Kobluk, Trent, Turner  
Surgery of various systems in large animals with preoperative and postoperative evaluation and treatment.

CAPS 8393. Problems in Large Animal Orthopedics. (3 cr; prereq 5365 or equiv, #) Kobluk, Trent, Turner

SACS 8394. Surgery of the Gastrointestinal System. (Cr ar; prereq 5201 or equiv, #; offered when demand warrants) Caywood, Lipowitz, Wallace

SACS 8396. Advanced Veterinary Anesthesia. (Cr ar; prereq 5380 or equiv) Raffe, Robinson  
Principles of anesthesia; administration of local, regional, and general anesthesia in large or small animals.

SACS 8398.\* Research in Veterinary Anesthesia. (2-4 cr; prereq grad of professional vet curriculum, 8396, CAPS 8397 or equiv, #) Raffe, Robinson  
Special problems course for evaluating research methods. Controlled study, prospective, and retrospective models of evaluation defined, critiqued, and used for experimental design and data collection. Analysis of data collection to validate research methods.

SACS 8399. Seminar: Veterinary Anesthesia. (1-4 cr; prereq grad of professional vet curriculum, 8396, CAPS 8397 or equiv, #) Raffe, Robinson  
Topics in veterinary anesthesia and critical care in large and small animal species.

SACS 8410.\* Surgical Physiology. (2 cr; prereq 8391 or equiv, #; offered when demand warrants) Caywood, Lipowitz, Wallace

SACS 8420.\* Neurosurgery. (2-3 cr; prereq 8391 or equiv, #; offered when demand warrants) Wallace

SACS 8430. Thoracic and Cardiovascular Surgery. (3 cr; prereq 8391 or equiv, #; offered when demand warrants) Caywood, Lipowitz, Wallace

SACS 8471.\* Therapeutic Radiology. (Cr ar [max 2 cr]; prereq 5452 or equiv, #; offered every 3 yrs) Feeney, Jessen, Johnston, Walter  
General procedures in therapeutic radiology presently available in veterinary medicine. One credit equals approximately 10 lecture hours or 30 laboratory hours or 40 hours of preparation on paper.

SACS 8480. Seminar: Veterinary Radiology. (1 cr; prereq 5452 or equiv, #) Feeney, Jessen, Johnston, Walter  
Current reviews, reports, and discussion of problems.

SACS 8483. Abdominal Roentgenology. (Cr ar [max 3 cr]; prereq 5452 or equiv, #; offered alt yrs) Feeney, Johnston, Walter  
Soft tissue roentgenology of abdominal structures. One credit equals approximately 10 lecture hours, or 30 laboratory hours, or 40 hours of paper preparation.

SACS 8485. Thoracic Roentgenology. (Cr ar [max 3 cr]; prereq 5452 or equiv, #; offered alt yrs) Feeney, Johnston, Walter  
Soft tissue roentgenology of structures within the thorax with emphasis on pulmonary and mediastinal roentgenology. One credit equals approximately 10 lecture hours, 30 laboratory hours, or 40 hours of paper preparation.

SACS 8490. Problems in Diagnostic Roentgenology. (Cr ar [max 2 cr]; prereq 5452 or equiv, #) Feeney, Jessen, Johnston, Walter  
Problems associated with diagnostic procedures and their interpretation.

SACS 8491. Fundamentals of Nuclear Medicine. (Cr ar; prereq grad student, #; offered when feasible) Feeney, Jessen, Johnston, Walter

## Veterinary Pathobiology

See Veterinary Medicine.

## Veterinary Surgery, Radiology, and Anesthesiology

See Veterinary Medicine.

This is the Water Resources Science through Zoology program and course sections of the 1996-1999 University of Minnesota Graduate School Catalog

Vocational Education

See Work, Community, and Family Education.

Water Resources Science (WRS)

*Regents' Professor:* Eville Gorham (ecology, evolution, and behavior)

*Professor:* Patrick L. Brezonik (civil and mineral engineering), *director of graduate studies*; Anne E. Hershey (biology<sup>1</sup>), *associate director of graduate studies*; Dean E. Abrahamson (Humphrey Institute of Public Affairs); E. Calvin Alexander, Jr. (geology and geophysics); James L. Anderson (soil, water, and climate); Roger E. A. Arndt (civil engineering); Franklin H. Barnwell (ecology, evolution, and behavior); Paul R. Bloom (soil, water, and climate); Kenneth N. Brooks (forest resources); Dwight A. Brown (geography); Robert M. Carlson (chemistry<sup>1</sup>); H. H. Cheng (soil, water, and climate); Yosef Cohen (fisheries and wildlife); Dianne Dorland (materials processing engineering<sup>1</sup>); Daryl F. Dwyer (civil engineering); K. William Easter (applied economics); Cesar Farell (civil engineering); Efi Foufoula-Georgiou (civil engineering); Luther P. Gerlach (anthropology); Philip J. Gersmehl (geography); Sagar M. Goyal (veterinary diagnostic investigation); Hans M. Gregersen (forest resources); David F. Grigal (soil, water, and climate); John S. Gulliver (civil engineering); Satish C. Gupta (soil, water, and climate); Richard S. Hanson (microbiology); Roger LeB. Hooke (geology and geophysics); Thomas C. Johnson (geology<sup>1</sup>); Kerry R. Kelts (geology and geophysics); Andrew R. Klemer (biology<sup>1</sup>); Richard W. Lichty (economics<sup>1</sup>); Walter J. Maier (civil engineering); Michael E. McDonald (chemical engineering<sup>1</sup>); Donald C. McNaught (ecology, evolution, and behavior); Robert O. Megard (ecology, evolution, and behavior); John F. Moncrief (soil, water, and climate); Howard D. Mooers (geology<sup>1</sup>); David J. Mulla (soil, water, and climate); John L. Nieber (biosystems and agricultural engineering); Gary N. Parker (civil engineering); James A. Perry (forest resources); Hans-Olaf Pfannkuch (geology and geophysics); C. Ford Runge (applied economics); Mark W. Seeley (soil, water, and climate); Michael J. Semmens (civil engineering); Richard H. Skaggs (geography); Charles C. S. Song (civil engineering); Heinz G. Stefan (civil engineering); Otto D. L. Strack (civil engineering); Michael Sydor (physics<sup>1</sup>); G. David Tilman (ecology, evolution, and behavior); Graham A. Tobin (geography<sup>1</sup>); Elon S. Verry (forest resources); Melbourne C. Whiteside (biology<sup>1</sup>)

*Associate Professor:* Sandra O. Archibald (public affairs); Randal J. Barnes (civil engineering); David D. Biesboer (plant biology); Iris D. Charvat (plant biology); Charles J. Clanton (biosystems and agricultural engineering); Florence K. Gleason (plant biology); Randall E. Hicks (biology<sup>1</sup>); Ralph W. Holzenthal (entomology); Edward A. Nater (soil, water, and climate); Raymond M. Newman (fisheries and wildlife);

Christopher Paola (geology and geophysics); Robert W. Sterner (ecology, evolution, and behavior); Deborah L. Swackhamer (environmental and occupational health); Steven J. Taff (applied economics); Yacov Tsur (applied economics); Bruce N. Wilson (biosystems and agricultural engineering)

*Adjunct Associate Professor:* Bruce C. Vondracek (fisheries and wildlife)

*Assistant Professor:* James C. Bell (soil, water, and climate); Erik Thorson Brown (Large Lakes Observatory<sup>1</sup>); Susan M. Galatowitsch (horticultural science); Katherine Klink (geography); Mark A. Person (geology and geophysics); Clive F. Reece (soil, water, and climate)

*Adjunct Assistant Professor:* Paul D. Capel (civil engineering)

*Research Associate:* Richard P. Axler (Natural Resources Research Institute<sup>1</sup>); Carol A. Johnston (Natural Resources Research Institute<sup>1</sup>); Carl Richards (Natural Resources Research Institute<sup>1</sup>)

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—This University-wide program provides comprehensive training in water resources science, with integration across scientific disciplines. A structured interdisciplinary graduate curriculum is offered. The program includes a set of core courses plus electives in areas of specialization at the M.S. and Ph.D. levels, including limnology, aquatic biology, hydrologic sciences, watershed management, and water engineering. Approximately 80 courses offered within 15 other graduate programs are available to students majoring in water resources science.

**Prerequisites for Admission**—The graduate program in water resources science is flexible enough to accommodate students from a variety of backgrounds. Normally students have a bachelor's degree in physical or biological science or engineering. Recommended academic preparation includes one year (or two quarters) each of calculus, physics, and chemistry and one biology course. Further preparation may be expected from students wishing to specialize in certain areas of the program.

<sup>1</sup> University of Minnesota, Duluth

**Special Application Requirements—**

Applicants must submit three letters of recommendation to the director of graduate studies. These letters should be from professors qualified to estimate applicants' class rank and evaluate their ability to complete a program of graduate study or from persons who can assess their professional potential. These letters also may be used in applying for financial aid. Applicants must also submit a résumé of their academic history and professional experience and a statement of purpose, including the proposed area of emphasis. Applicants are strongly encouraged to submit results of the Graduate Record Examination (GRE). Those who have not taken the GRE are at a disadvantage in competing for financial aid. Students may be admitted any quarter but are strongly encouraged to begin fall quarter and to submit their application by January 15 in the year they expect to begin their studies.

**Master's Degree Requirements—**Coursework consists of a core of 22-24 credits, electives in a focus area, and at least 8 credits in one or more related fields. The core provides a broad background in hydrologic, chemical, and biological processes in aquatic systems; water quality management; and the legal, policy, and institutional aspects of water management. The Plan A (thesis) option is primarily for students who have had some undergraduate water-related coursework and have met some of the core requirements. This option also requires 16 thesis credits and the successful completion and defense of a thesis. The Plan B option requires a minimum of 40 course credits and up to 4 credits of independent study for a Plan B project that involves field, laboratory, or computer work and the analysis, synthesis, and/or interpretation of data.

**Doctoral Degree Requirements—**Students must complete the equivalent of the M.S. coursework (core courses and electives), additional focus in at least one emphasis area, and an appropriate supporting program or minor. Areas of specialization for the Ph.D. are similar to those for the M.S. Coursework is tailored to the needs and interests of students, consistent with program objectives and goals. The Ph.D. requires a minimum of 60 course credits, including at least 18 credits in a supporting program or minor.

**Language Requirements—**None.

**Minor Requirements for Students Majoring in Other Fields—**A 2-credit seminar on water resources management, a 4-credit course on water resources and institutions (water policy, law, management, and economics), one core course (3-4 credits), and elective course(s) are required. Completion of 13 credits is required for the master's degree and 21 credits for the doctoral degree. At least 11 credits for the doctoral degree must be selected from one of the categories listed under Curriculum above. The minor program must be approved by the water resources science director of graduate studies.

**For Further Information, Applications, and List of Courses—**Contact the Director of Graduate Studies, Water Resources Center, University of Minnesota, 1518 Cleveland Avenue North, Suite 302, St. Paul, MN 55108 (612/624-9282; fax 612/625-1263; e-mail [wrs@forestry.tc.umn.edu](mailto:wrs@forestry.tc.umn.edu)) or the Director of Graduate Studies, Water Resources Science, Department of Biology, 321 Life Sciences, University of Minnesota, Duluth, MN 55812 (218/726-8200; fax 218/726-8142).

WRS 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

WRS 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

WRS 8888. Thesis Credits: Doctoral. (36 cr required)

WRS 5010. Introduction to Field Research in Water Resources. (3 cr; prereq admission to WRS program or #)  
Field research techniques and opportunities during two-week summer excursion to regional sites. Data acquisition in large/small lakes, streams, and wetlands for biota and chemical/physical water quality; surface and groundwater hydrologic measurements and sampling.

WRS 5101. Water Resources: Individuals and Institutions. (4 cr) Brezonik, Brown  
Hydrologic cycle and its responses to human intrusion; societal efforts to control its spatial and temporal variability. Development of U.S. water policy and water laws; administrative structure for water resource management at various levels of government.

WRS 8100. Interdisciplinary Seminar in Water Resources. (2 cr; prereq admission to WRS program)  
Topic varies yearly.

## Wildlife Conservation (FW)

*Professor:* Yosef Cohen; Gary E. Duke; Donald B. Siniff; Anthony M. Starfield; John R. Tester

*Adjunct Professor:* L. David Mech

*Associate Professor:* James R. Kitts, *director of graduate studies*; David E. Andersen; James A. Cooper; Francesca Cuthbert; Peter A. Jordan; J. L. David Smith

*Adjunct Associate Professor:* Alfred H. Berner; David L. Garshelis; Richard O. Kimmel; Ronald L. Tilson; A. Richard Weisbrod

*Adjunct Assistant Professor:* Glenn D. Del Giudice

*Senior Research Associate:* John Pastor<sup>1</sup>

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—This program is administered within the Department of Fisheries and Wildlife. The wildlife conservation graduate program is an applied program emphasizing resource-management applications. For the M.S. degree, emphasis is on wildlife biology and related areas in ecology, animal behavior, and physiology as these relate to resource management and conservation problem-solving. For many students, the M.S. is a terminal degree leading to employment with government resource-management agencies. For the Ph.D. program, emphasis is on basic biology and ecology with concentrated work in independent, original research generally relating basic science to management/conservation challenges.

**Prerequisites for Admission**—For the M.S. program, a bachelor's degree with a biological sciences background is required, preferably with emphasis on terrestrial or wetland vertebrates and with a natural-resource management orientation. A strong background in physical sciences and mathematics is expected; familiarity with statistics and computer use is desirable. For the Ph.D. program, a master's degree in wildlife science or a closely related field is normally required.

**Special Application Requirements**—Three letters of recommendation are required from

persons able to evaluate the applicant's scholarship and professional experience. Also required are scores from the Graduate Record Examination (GRE) General Test. Applicants taking the examination should list the wildlife management major field code (0115). Applications are accepted at any time; however, because the faculty reviews most applications in late January for admission the following fall, applications should be sent before January 1.

**Master's Degree Requirements**—Plan A is recommended; Plan B is available under special circumstances. Students must become familiar with factors underlying wildlife population and habitat ecology, techniques in management, and the functioning of management agencies. Academic work includes graduate-level courses in animal ecology, wildlife management, and statistics. The Plan A thesis should involve at least one field season but no more than two. Plan B students undertake one to three projects involving field, laboratory, or planning work. An oral preliminary examination is required as well as a final seminar and oral defense of the thesis or Plan B papers.

**Doctoral Degree Requirements**—Programs include basic wildlife biology and development of analytical skills, and one or more additional areas of specialization. In addition to the final oral examination, students must give a public oral presentation describing the dissertation.

**Language Requirements**—For the M.S. degree, none. For the Ph.D. degree, a foreign language is required only when the advisory committee determines that a language is needed to support the student's research objectives. Symbolic language (computer programming) is recommended for all students.

**Minor Requirements for Students Majoring in Other Fields**—Programs are designed according to individual student needs, while insuring a comprehensive exposure to wildlife ecology and management.

**For Further Information and Applications**—Contact Karen Kanda, College of Natural Resources, University of Minnesota, 115 Green Hall, 1530 N. Cleveland Avenue, St. Paul, MN 55108 (612/624-2748; e-mail [kkanda@forestry.umn.edu](mailto:kkanda@forestry.umn.edu)).

<sup>1</sup> University of Minnesota, Duluth

## GRADUATE PROGRAMS

FW 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

FW 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

FW 8888. Thesis Credits: Doctoral. (36 cr required)

5129. Mammalogy. (5 cr, §EEB 5129; prereq Biol 1106 or 3011 or #) Birney

Recent families and orders of mammals of the world and genera and species of mammals of North America; emphasis on morphology, evolution, and zoogeographic history.

FW 5278. Special Lectures in Wildlife. (Cr ar; offered when feasible)

FW 5565. Fisheries and Wildlife Ecology and Management: Field Trip. (1 cr)

Ten-day field trip to Wyoming and points en route during spring break. Big game, waterfowl, and endangered species.

FW 5570. Avian Conservation. (4 cr; prereq EEB 5134 or grad student or #; offered alt yrs) Andersen, Cooper, Cuthbert

Current problems in avian conservation and management, with equal emphasis on non-game, wetland, and game birds.

FW 5600. Fisheries and Wildlife Techniques. (4 cr; prereq Biol 5041 or EEB 3001 or #; offered at Itasca)

Field techniques and skills; planning and implementing field projects; data collection and analysis using microcomputers; written reports and field journal.

FW 5603. Wildlife Habitats and Management. (3 cr; prereq 3052 or 3054 or grad student in biol or natural resources or #, NRES 1020 or computer competency) Jordan

Environmental interactions of wildlife at population and community levels; environmental threats from human activities; habitat-management practices; population management objectives, policies, and regulations.

FW 5620. Geographical Information Systems (GIS) for Fisheries, Wildlife, and Biological Conservation. (4 cr; prereq Biol 5041) Cohen

Hands-on experience with GIS as tool for understanding, analysis, and management of ecological systems. ARC/INFO as applied to problems in fisheries, wildlife, and biological conservation.

FW 5701f, 5702w. Senior Project. (1, 2 cr; prereq FW sr or grad student or #) Cooper

Problem-solving training. Management problem identification and analysis design, information and data gathering and analysis, and oral and written problem reporting. Problem selection influenced by guest speakers, resource agency contacts, and group discussions; topic is contemporary fisheries and wildlife management issue.

FW 8100. Seminar. (Cr ar)

Lectures by and discussions with faculty members, visiting scholars, and graduate students on current topics.

FW 8200. Seminar. (Cr ar)

Oral and written reports and discussion by students on selected topics from current literature in wildlife biology and management. Lectures by and discussions with faculty members and visiting specialists.

FW 8377.\* Research in Wildlife Biology. (Cr ar; prereq wildlife conserv grad student)

FW 8452. Conservation Biology: Genetic and Demographic Issues. (3 cr; prereq intro genetics course or #) Kapuscinski, Smith

Seminar on current conservation biology issues; genetic, demographic, and environmental analysis and management of populations; ecosystem conservation; case studies of species conservation strategies.

FW 8576. Wildlife Management: Large Mammals. (4 cr; prereq fisheries or wildlife conserv or ecol conserv biol grad student or #; offered alt yrs) Jordan

Comprehensive survey of ecology of ungulates and large carnivores, emphasizing North American species, with special reference to harvest, protection, and other management objectives.

FW 8579. Ecosystem Analysis and Simulations: A Numerical Approach. (5 cr; prereq 1 qtr calculus, 1 qtr statistics; offered alt yrs) Cohen

Systems analysis methods (e.g., state-space models, transfer functions) and numerical simulations in ecology and fisheries/wildlife management. Presentation of data in time and frequency domains, interpretation of results.

NRES 5575. Wetlands Conservation. (4 cr; prereq Biol 5041, EEB 3001 or EEB 3101 or #) Cooper  
Freshwater wetland classification, biota, current/historic status, value, and conservation strategies and the ecological principles used in wetland management. Meets concurrently with NRES 3575 plus one additional hour per week.

See Ecology (EEB) for other relevant courses.

## Work, Community, and Family Education<sup>1</sup>

*Professor:* Charles R. Hopkins, *chair*; George Copa; Richard A. Krueger; Judith J. Lambrecht; Gary N. McLean; Curtis D. Norenberg; Edgar Persons; Roland Peterson; David J. Pucel; Richard Swanson; Ruth Thomas

*Associate Professor:* Gary W. Leske, *director of graduate studies*; James M. Brown; Theodore Lewis; Jerry McClelland; Rosemarie J. Park; Jane Plihal; Marilyn M. Rossmann; James R. Stone III; Barbara A. Warren

*Assistant Professor:* James C. Kielsmeier<sup>2</sup>; Shari L. Peterson; Nancy J. Rohde

<sup>1</sup> Unless otherwise indicated, all faculty for work, community, and family education also hold a graduate faculty appointment in education.

<sup>2</sup> Holds graduate faculty appointment in work, community, and family education only.

*Lecturer:* Jeanette R. Daines; Sherry A. Schwartz

*Other:* Robert D. Shumer; Antony J. Warner

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.A. (Plan A and Plan B) in education (emphasis in work, community, and family education). Ph.D. in education (emphasis in work, community, and family education). Ed.D. in work, community, and family education.

**Curriculum**—The M.A. degree allows specialization in the following areas: adult education; agricultural education; business and marketing education; comprehensive work, community, and family education; extension education; family education; human resource development; industrial education; international vocational education and training; vocational education administration; and vocational special needs.

Two doctoral degrees are offered with specializations in adult education, agricultural education, business and marketing education, extension education, family education, human resource development, industrial education, international vocational education and training, and comprehensive work, community, and family education. The Ed.D. in work, community, and family education is designed for professionals who primarily synthesize and apply knowledge to problems of practice. The Ph.D. in education with emphasis in work, community, and family education is designed for professionals who are involved in research and generation of knowledge for the field.

**Prerequisites for Admission**—Prospective master's degree students generally have completed an undergraduate degree or extensive coursework in the specialization area. Others, however, may be admitted if they complete appropriate background preparation. Prospective doctoral degree students should have academic background and experience in at least one specialization area.

**Special Application Requirements**—Scores from the Miller Analogies Test or the Graduate Record Examination (GRE) are required for master's degree program applicants with a bachelor's degree from a U.S. institution. Master's degree applicants

should designate the specific specialization to which they seek admission. Scores from the GRE are required for doctoral degree program applicants with a bachelor's degree from a U.S. institution. Doctoral degree applicants should designate either the Ph.D. or the Ed.D. program and the specialization they want to pursue. Students are admitted each quarter.

**Master's Degree Requirements**—Each specialization has its own degree requirements. Students should consult the director of graduate studies for the appropriate planning document. A final oral examination is required.

**Doctoral Degree Requirements**—For the Ed.D. in work, community, and family education, the following is required: a minimum of 88 credits plus a 36-credit field study (thesis credits); at least 18 credits in the general aspects of work, community, and family education; at least 42 credits in the specialization/subspecialization, including a 6-credit internship; and at least 11 credits in research, including at least one statistics course.

For the Ph.D. the following is required: a minimum of 88 credits plus a 36-credit thesis; at least 24 credits in the general aspects of work, community, and family education; at least 24 credits in the specialization/subspecialization; and at least 24 credits in research.

Examinations focus on the general aspects of work, community, and family education; specialization/subspecialization; and research. For more information about the doctoral degrees, see the departmental degree handbooks.

**Language Requirement**—None.

**Minor, Supporting, or Related Field Requirements for Students Majoring in Other Fields**—Any work, community, and family education specialization (except the emphasis in the major field of education) may be used as a minor or supporting field for the doctoral degree, or as a related field for the master's degree. For students who choose one of these specializations as part of a doctoral supporting program (which consists of at least 18 credits total), a minimum of 12 credits in the chosen specialization is required. For students who choose a work, community, and family education specialization as a related field for the master's degree, a minimum of 8 credits in the chosen specialization is required.

### For Further Information and Applications—

Contact Gary Leske, Director of Graduate Studies, Department of Work, Community, and Family Education, University of Minnesota, R-350 VoTech Building, 1954 Buford Avenue, St. Paul, MN 55108 (612/624-1221; fax 612/625-8140; e-mail [votech@tc.umn.edu](mailto:votech@tc.umn.edu)).

Educ 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

WCFE 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr, \$VoEd 8666; doctoral student who has not passed oral prelims)

Educ 8777. Thesis Credits: Master's. (16 cr required; Plan A only with emphasis in VoEd)

Educ 8888. Thesis Credits: Doctoral. (36 cr required; PhD only)

Section 2. Work, Community, and Family Education

WCFE 8888. Thesis Credits: Doctoral. (36 cr required, \$VoEd 8888; EdD only)

### Adult Education (AdEd)

AdEd 5103. Adult Education Workshop. (1-12 cr [max 12 cr], \$Educ 5103; prereq practicing adult educator or #)

Topics appropriate to activities and interests of the participants.

AdEd 5104. Survey: Human Resource Development and Adult Education. (4 cr, \$HRD 5104) S Peterson, Stone, Swanson  
Literature, objectives, history, philosophy, research, institutions, issues, and trends.

AdEd 5110. The Status and Role of Women in American Society. (4 cr, \$Educ 5110; offered alt yrs) Park

The role of women in American history; perceptions of women in literature and art; attention to women in social studies curricula; human sexuality; male and female character-nature and/or nurture; choices of family and career.

AdEd 5201. Introduction to the Undereducated Adult. (3 cr, \$Educ 5201) Park  
Issues in literacy education, characteristics, problems, individual differences of the undereducated adult learner; traditional and innovative approaches for working with adults in literacy programs.

AdEd 5202. Adult Literacy: Diagnosis and Prescription. (3 cr, \$Educ 5202; prereq 5201 or #) Park  
Application of diagnostic information, instruments, and techniques to learning difficulties of adults in reading and mathematics programs.

AdEd 5203. Adult Literacy: Methods and Materials. (3 cr, \$Educ 5203; prereq 5202 or Elem 5331 or #) Park  
Teaching literacy skills to adults: basic theories, approaches, overview of methods and materials for implementation.

AdEd 5204. Literacy in Work Settings. (3 cr, \$VoEd/WCFE 5204) Park  
Overview of concepts in integrating literacy instruction into vocational training programs and work settings; diagnosis and methods of assessing needs of vocational students and workers on a job; techniques for building needs into training programs.

AdEd 5205. Field Experience in Adult Education. (4-8 cr [max 8 cr], \$Educ 5205; prereq #)  
Supervised fieldwork practice and seminars; presentations on and evaluations of adult education practices.

AdEd 5301. Designing the Adult Education Program. (3 cr, \$Educ 5301) Rohde  
Designing and implementing educational programs for adults: concepts, theories, determining needs, educational objectives, learning experiences, and evaluating outcomes.

AdEd 5401. Adult Learning and Development Through the Life Span. (3 cr, \$Educ 5401)  
S Peterson  
Physiological, social, and cultural bases of adult behavior; motivation, socialization, personality change as applied to education of adults.

AdEd 5411. Strategies for Teaching Adults. (3 cr, \$Educ 5411) Park  
Identification, classification and analysis of techniques used in teaching adults.

AdEd 5421. Distance Education. (3 cr) Rohde  
Theories, history, delivery systems, and present practice. Emphasizes practice in United States, but explores topics from international perspective.

AdEd 5440. Multidisciplinary Perspectives on Aging. (4 cr, \$CPsy 5305, \$HSU 5009, \$PA 5514, \$PubH 5737, \$Soc 5960, \$SW 5024)  
Multidisciplinary introduction to aging and the aging process.

AdEd 5450. Critical Pedagogy. (3 cr, \$FE 5450, \$VoEd/WCFE 5450) McClelland  
Critical pedagogy in schools and adult education; application to education for family, work, and community.

AdEd 5501. Continuing Education and the Professions. (3 cr, \$Educ 5501) Rohde  
Review of literature; analysis of philosophies, issues, and trends; emphasis on integrating personal growth, professional needs, and statutory requirements in continuing education programs.

AdEd 8100. Research in Adult Education. (3 cr, \$Educ 8100; prereq #, coursework in experimental design) Williams  
Review and analysis of current research and research procedures in adult education.

AdEd 8302. Problems: Adult Education. (1-9 cr, \$Educ 8302; prereq #)  
Individual research in area of adult education.

## Agricultural Education (AgEd)

AgEd 5010. Rural Leadership Development. (3 cr) R Peterson

Understanding role, function, and unique features of leaders in rural communities; importance of personal involvement to these roles; personal leadership and vision development for individuals and rural community groups.

AgEd 5023. Methods for Change in Developing Countries. (3 cr, §WCFE 5023) Persons

Strategies, programs, projects, and methodologies for individual and community economic and social change.

AgEd 5028. Teaching Methods in Agricultural Education. (5 cr) R Peterson

Methods in teaching agriculture in public schools; use of media, principles of learning, problem solving, test construction, classroom management and specific practice in problem-solving teaching techniques; use of competency-based individualized instruction as medium for course presentation and model for teaching methods.

AgEd 5032. High School Curriculum in Agriculture. (3 cr; prereq 10 cr educ) R Peterson  
Philosophy, organization, and administration of instruction in agriculture departments in secondary schools.

AgEd 5034. Procedures in Teaching Agriculture. (3 cr) R Peterson

New developments in methodology; assessment of innovations and procedures; consideration of various levels of instruction.

AgEd 5041. Workshop: Agricultural Education Technology. (1-6 cr [max 12 cr])  
New understandings, techniques, and materials in animal science, plant science, horticulture, soil science, agricultural mechanics, forestry, natural resources, youth organization, visual aids, and occupational exploration.

AgEd 5042. Agricultural Mechanics. (1-3 cr [max 12 cr])

Technical and managerial information, techniques, and materials. Facilitates participant's instructional planning, resource development, and instruction.

AgEd 5043. Farm Management. (1-3 cr [max 12 cr]) Persons

Application of agricultural economics theory, principles, techniques, and materials. Facilitates participants' instructional planning, resource development, and instruction. Topics vary with each offering.

AgEd 5049. Agricultural Education for Adults. (3 cr) Persons

Organization and implementation of systematic education programs for beginning and established farmers; organization of local programs to meet needs of production agriculture in areas of enterprises, agricultural mechanics, and management; development of continuing programs.

AgEd 5051. Enterprise Analysis. (3 cr) Persons  
Analyzing the farm business as a basis for identifying problems; planning learning experiences to improve farm management at the high school, young farmer, and adult levels.

AgEd 5052. Farm Business Management Education. (3 cr; prereq 5049 or #) Persons  
Administration, organization, and operation of farm business management education programs for adults; development and use of curriculum materials based on farm business record data.

AgEd 5055. Methods in Farming Systems Research and Extension. (3 cr)

Methodology for integrating research and extension programs designed to identify and solve farm family system problems using interdisciplinary and holistic approaches.

AgEd 5061. Program Planning and Evaluation. (3 cr) Persons

Developing a program of agricultural education in a community school, integration with total school program, administrative relationships, techniques and uses of program evaluation in planning.

AgEd 5071. Supervised Occupational Experiences in Agriculture. (3 cr) Leske  
Organization and administration of an occupational experience program in agriculture for high schools and area schools.

AgEd 5072. Practicum: Agricultural Business and Industry. (1-3 cr [max 9 cr]; prereq 5071 or #)

Leske, Norenberg  
Observation, study, and experience in agricultural business and industry; application to educational problems in agriculture.

AgEd 5078. FFA Organization and Management. (2 cr) Leske  
Development of FFA (vocational agribusiness education student organization) knowledge, organization and integration of activities into curriculum, management of chapter operations.

AgEd 5080. Organization and Management. (3 cr; prereq #) Leske

Administrative structure and function of subcollegiate programs.

AgEd 5081. Current Issues for the Beginning Agriculture Teacher. (1-3 cr [max 3 cr]; prereq #)

R Peterson  
Teaching methods, organizing learning resource materials, managing classroom and laboratory learning activities, curriculum planning and organization, managing discipline situations, school and community relationships for the beginning teacher.

AgEd 5082. Current Issues in Agricultural Education. (1-3 cr [max 9 cr]; prereq #) Leske,

Persons, R Peterson  
Emphasizes study and clarification of current issues, strategies of response, implications of response actions, and related leadership roles.

## GRADUATE PROGRAMS

AgEd 5087. Mentorship for Beginning Agriculture Teachers. (2 cr per qtr; prereq postbac student, less than 2 yrs tchg exper in agriculture, ¶15081, #; registration required in 3 consecutive qtrs) R Peterson  
Year-long program of professional development during induction year of teaching agriculture in public schools. Problem solving, issues and concerns of new teachers, and making a smooth transition into teaching profession.

AgEd 5090. Independent Study. (1-3 cr)  
Topics may be chosen to permit study of areas within education or to supplement areas of inquiry not provided in the regular course structure.

AgEd 5128. Methods of Teaching. (3 cr; prereq non-agricultural educ major and/or #) R Peterson  
Methods of teaching agriculture or related subjects; developing competencies in planning, organizing, implementing, and evaluating instruction, with practice in instructional techniques.

AgEd 5244. Topics in Program Planning for Extension Education. (1-6 cr [max 9 cr])  
Extension education programming in relation to situation and needs analysis; coordination of content, people, methodology; specific aspects in development of program models; managing resources.

AgEd 5245. Topics in Administering Extension Education. (1-6 cr [max 9 cr])  
Issues and current literature; focus on personnel hiring and supervision, financial management, leadership styles, long-range planning; application of theory to administrative practice.

AgEd 5246. Topics in Teaching and Delivering Extension Education. (1-6 cr [max 9 cr])  
Teaching techniques related to concepts of use of media, telecommunications, computers, group process methods, and experiential learning in extension education settings.

AgEd 5247. Topics in Evaluating Extension Education. (1-6 cr [max 9 cr] Krueger  
Overall evaluation design: choosing quantitative vs. qualitative evaluation methods; developing skills and conceptual frameworks to apply theory to extension settings.

AgEd 8001. Research in Agricultural Education. (Cr ar; prereq 15 cr educ)  
Selecting problems, preparing bibliographies, analyzing and interpreting data, and preparing manuscripts.

AgEd 8020. Seminar: Agricultural Education. (Cr ar) Peterson

AgEd 8091. Field Problems. (3 cr)  
Making investigations, gathering data, and formulating plans regarding agricultural education.

AgEd 8303. Seminar: Graduate Studies Review. (1-3 cr)  
Review of graduate studies in agricultural education being planned or recently completed.

## Business and Industry Education (BIE)

BIE 5002. Teaching Promotion Display. (3 cr, \$BME 5252)

Identifying materials and methods for teaching visual merchandising, sales promotion, advertising, public relations, and promotion planning.

BIE 5010. Introduction to Microcomputer Applications in Business and Industry Education. (3 cr, \$BME 5310)

Instructional uses of microcomputers; representative business and industry education applications, including word processing, databases, spreadsheets, and graphics.

BIE 5015. Advanced Word Processing Practicum. (3 cr, \$BME 5160)

Completion of projects using advanced editing and printing capabilities.

BIE 5020. Spreadsheet Analysis Using Microcomputers in Business and Industry Education. (3 cr; prereq 5010 or equiv)

Using spreadsheet software; instructional applications in business.

BIE 5025. Teaching Microcomputer Graphics in Business and Industry. (3 cr, \$BME 5335; prereq 5010 or equiv)

Representative microcomputer-based business graphics software packages; use for making instructional presentations; using simulated projects to teach applications in business and industry classrooms.

BIE 5030. Database Microcomputer Applications. (3 cr; prereq 5010 or equiv)

Using database software; instructional applications in business.

BIE 5035. Teaching Desktop Publishing. (3 cr, \$BME 5363; prereq 5010 or equiv)

Strategies for teaching skill development in page layout and design, text and graphic creation, file merging, printing, equipment and software requirements.

BIE 5040. Integrated Microcomputer Applications in Business and Industry Education. (3 cr, \$BME 5365; prereq 5010 or 5015 or 5020 or 5025 or 5030 or equiv) Lambrecht

Advanced business and industry computer applications integrating business word processing, spreadsheets, business graphics, and database software.

BIE 5080. Special Topics in Technical Updating. (1-6 cr)

Technological and procedural changes in business and industry content. Topics vary with each offering.

BIE 5113. Special Topics in Manufacturing. (1-6 cr, \$Ind 5133)

Topic not covered by available courses.

BIE 5123. Special Topics in Communications. (1-6 cr, \$Ind 5123)

Topic not covered by available courses.

**BIE 5133. Special Topics in Power and Energy.** (1-6 cr, §Ind 5143)  
Topic not covered by available courses.

**BIE 5143. Special Topics in Transportation.** (1-6 cr, §Ind 5153)  
Topic not covered by available courses.

**BIE 5150. Technical Development: Specialized.** (1-12 cr [max 18 cr], §Ind 5200; prereq #)  
Integration of specialized technical instruction in advanced and emerging areas into courses in industrial education.

**BIE 5253. Supervisory Training.** (3 cr, §HRD 5253; prereq VoEd/WCFE 5340) S Peterson, Rossmann  
Problems, practices, programs, issues, and methodologies related to preparing trainers of supervisors.

**BIE 5261. Sales Training.** (3 cr, §HRD 5261)  
Strategies and techniques for developing effective sales people.

**BIE 5262. Customer Service Training.** (3 cr, §BME 5262, §HRD 5262)  
Strategies of successful organizations; training practices to develop customer-oriented personnel.

**BIE 5300. Organizational Needs Assessment.** (3 cr, §HRD 5300) Swanson  
Organizational performance problems, problem causes, and recommendations of training solutions, and other intervention to improve performance in business, industry, and schools.

**BIE 5301. Student and Trainee Evaluation Systems.** (3 cr, §HRD 5301, §Ind 5301) Pucel, Swanson  
Test development, performance, and learning evaluation; affective evaluation, learning progress reporting systems.

**BIE 5303. Instructional Aids.** (3 cr, §Ind 5303; prereq educ major or grad student) Norenberg  
Planning, construction, use.

**BIE 5320. Vocational Guidance.** (3 cr, §Ind 5320)  
Self-assessment, use of occupational and labor market information, job-seeking skills, work and work satisfaction. For industrial teachers and trainers in school and industrial settings.

**BIE 5325. Foundations of Industrial Education.** (3 cr, §Ind 5325) Pucel, Lewis  
History, objectives, development, and current practices of the field.

**BIE 5344. Facilities and Management.** (3 cr, §Ind 5344; prereq 1300 or 5630 or #)  
Planning, evaluation, and management of industrial education shop and laboratory facilities.

**BIE 5365. Curriculum Development in Technology Education.** (4 cr, §Ind 5516) Lewis  
Nature of technological knowledge. Differing conceptions of technology. Comparison and contrast in structure of thinking between science and technology. Alternative ways of conceptualizing, developing, delivering, and managing technology curricula.

**BIE 5366. Management Development Practices.** (4 cr, §HRD 5366; prereq principles of mgmt or supervision course or #) McLean  
Problems, practices, programs, and methodologies relating to development of managers, including needs assessment, delivery modes, and evaluation; site visits and critiques.

**BIE 5400. Introduction to Business and Marketing Education.** (4 cr, §BME 5300) Hopkins, Lambrecht  
Conceptual models useful in design and delivery of programs in secondary and postsecondary schools, adult education settings, and business and industry.

**BIE 5440. Business Observation and Seminar.** (3-9 cr, §BME 5361)  
Current operating practices and career opportunities in business and industry combining planned experience in work environments and related seminars.

**BIE 5452. Methods of Teaching Business Concepts.** (4 cr) Hopkins, Lambrecht  
Recent research and developments in teaching concepts related to economics, business organization and management, business law, entrepreneurship, marketing, international business, information systems, accounting, risk management, and personal finance.

**BIE 5453. Consumer Education: Curriculum, Methods, and Materials.** (3-4 cr, §BME 5153; prereq FE 5153)  
Objectives, content, curriculum organization, teaching methods, materials, and evaluation methods for elementary, secondary, postsecondary, and adult levels.

**BIE 5457. Methods of Teaching for Business Employment.** (4 cr) Lambrecht  
Recent research and developments in teaching to prepare people for administrative support positions, accounting and information processing, sales and marketing, computer operations, and other occupations in which desktop publishing is a major employment responsibility.

**BIE 5462. Research and Methods in Teaching Accounting and Data Processing.** (4 cr, §BME 5162) Lambrecht  
Application of current research findings to teaching methodology and to curriculum and materials development; computerized accounting applications.

**BIE 5463. Teaching Keyboarding and Word Processing.** (3 cr) McLean  
Effective teaching strategies, expected learner outcomes, evaluation methods, criteria for selecting hardware and software, managing and organizing computer labs.

## GRADUATE PROGRAMS

**BIE 5485. Business and Industry Education Workshop.** (1-6 cr, §Ind 5306; prereq tchg exper, #)  
Areas of concentration vary with each offering.

**BIE 5490. Special Topics in Instruction.** (1-6 cr, §BME 5370)  
Planning and providing content, evaluating instruction.  
Topics vary with each offering.

**BIE 5495. Special Topics in Curriculum.** (1-6 cr, §BME 5380)  
Content development and evaluation of curriculum and curriculum materials. Topics vary with each offering.

**BIE 5500. Occupational Experience.** (1-5 cr [max 15 cr]; prereq #)  
Observation and employment in business and industry focused on developing technical or occupational competencies.

**BIE 5510. Internship: Business and Industry Education.** (1-12 cr [max 12 cr], §BME 8600)  
Practical experience in a business or industry professional educator or supervisory role, culminating in an integrating paper.

**BIE 5605. Critical Issues.** (3 cr, §Ind 5305; prereq educ major or grad student) Hopkins, Pucel  
Identification, analysis, and discussion of major current problems in the field.

**BIE 5630. Course Development.** (3 cr, §HRD 5630) Pucel  
Content identification, stating objectives, sequencing, lesson planning, and selection of methods and media for instruction.

**BIE 5660. Instructional Methods.** (3 cr, §HRD 5660) Lewis  
Implementation of instructional strategies and methods.

**BIE 5700. Field-Based Projects.** (1-6 cr [max 12 cr], §BME 5600; prereq adviser approval or #)  
Curricular, instructional, developmental, or evaluative problems and projects applicable to local school or business and industry situations.

**BIE 5752. Technical Skills Training.** (4 cr, §HRD 5752) Lewis  
Systems and process analysis and troubleshooting of work behavior; methods of design and development of training materials.

**BIE 5900. Directed Study.** (1-6 cr [max 12 cr], §Ind 5901; prereq adviser approval or #)  
In-depth individual learning, or supplementation of areas not covered in regular course structure.

**BIE 8900. Research Problems: Business and Industry.** (4-9 cr [max 9 cr]; prereq adviser approval)  
Individual research or conferences.

## Family Education (FE)

**FE 5001. Special Topics.** (1-6 cr, §HEEd 5001; S-N optional)  
Topics not covered by available courses.

**FE 5002. Thinking, Learning, and Teaching in Work, Family, and Community.** (3 cr, §VoEd/WCFE 5002) Thomas  
Theory and practice relevant to stimulating and supporting thinking and learning within and for the contexts of work, family, and community.

**FE 5003. Internship: Community/Work Settings.** (3-12 cr [max 12 cr], max 6 cr for MEd and MA programs; prereq #)  
Planned work experience focusing on educational competencies in these settings; students assume defined responsibilities of position.

**FE 5153. Consumer Education: Curriculum, Methods, and Materials.** (3 or 4 cr, §BME 5153, §HEEd 5153)  
Objectives, content, curriculum organization, teaching methods, materials, and evaluation methods for elementary, secondary, postsecondary, and adult levels.

**FE 5300. Family Education Curriculum.** (3 cr, §HEEd 5300) Thomas  
Research and theory, developing programs for all ages and evaluating materials.

**FE 5310. Methods in Teaching Family Education.** (3 cr, §HEEd 5310) McClelland  
Theory and relevant research; application to educational objectives, strategies, student needs, and program evaluation.

**FE 5315. Evaluation in Family Education.** (3 cr, §HEEd 5315) Plihal  
Collecting and interpreting evidence related to individual and program performance.

**FE 5320. Adult Education in Family Education.** (3 cr, §HEEd 5320) Plihal  
Planning a community program; teaching procedures; special problems.

**FE 5321. International Perspectives in Family Education.** (3 cr, §HEEd 5321; offered alt yrs)  
Examination of family education around world; commonalities and differences in purpose, problems, history, methods of delivery, and context.

**FE 5404. Introduction to Early Childhood Family Education Programs.** (1 cr, §HEEd 5404) Rossmann  
History, philosophy, and implementation of programs.

**FE 5405. Child Development and Parent Education.** (4 cr, §HEEd 5405) McClelland  
Objectives, content, curriculum organization, teaching methods, materials, and evaluation approaches for teaching youth and adults about social, cultural, psychological, economic, and technical aspects of child development, parenting, and parent-child interaction.

FE 5406. Special Topics in Parent and Family Education. (1-6 cr, \$HEEd 5406; S-N optional) Issues and current literature.

FE 5407. Family Education. (3 cr) Rossmann Objectives, content, curriculum, methods, materials, and evaluation for teaching diverse groups about family life.

FE 5408. Work-Family Relationships. (3 cr) Rossmann Examination of interactions between work and family with educational applications for youth and adults.

FE 5409. Group Methods for Parent and Family Education. (2 cr, \$HEEd 5409) Rossmann Development of skills for leading parent and family education groups.

FE 5410. Food and Nutrition Education. (1-4 cr [max 12 cr], \$HEEd 5410; offered when feasible)

FE 5411. Challenges in Sexuality Education. (4 cr) Rossmann Preparation to develop, deliver, and evaluate sexuality education. Strategies to help children and adults acquire information, form positive values, develop interpersonal skills, and exercise personal responsibility in sexual dimension of individual and family life.

FE 5416. Parent Education: Advanced. (3 cr, \$HEEd 5416; prereq 5405 or #) Thomas Evolving perspectives; emphasis on psychodynamic, conceptual-change approaches and reflective and dialogic approaches for working with parents in understanding beliefs and examining origins and consequences of beliefs; issues related to diversity and to self-awareness; ethics of professionals.

FE 5450. Critical Pedagogy. (3 cr, \$AdEd 5450, \$VoEd/WCFE 5450) McClelland Critical pedagogy in schools and adult education; application to education for family, work, and community.

FE 5500. Proseminar: Family Education. (2 cr, \$HEEd 550) Relation of processes and standards of rational thought to professional competence and goals of a graduate program.

FE 5510. History, Philosophy, and Professional Practice of Family Education. (3 cr; prereq postbac student in FE or #) Thomas Critical analysis of family education and the teaching of it; practical problems encountered by families; development of personal orientation to becoming a family education teacher.

FE 5511. Family Education Instruction in Secondary Schools. (5 cr, \$HEEd 5511) McClelland Curriculum perspectives and development, instructional methods, student evaluation.

FE 5600. Practicum: Adult Education. (1-9 cr, \$HEEd 5600; prereq 5320 or AdEd 5411 or #) Individual field assignments under supervision.

FE 5900. Independent Study in Family Education. (1-3 cr [max 12 cr], \$HEEd 5900; prereq #) Self-directed study with faculty advice in areas not covered by regular courses.

FE 8520. Seminar: History and Philosophy of Family Education. (2 cr, \$HEEd 8520) Data sources used to trace meaning of family education as field of study; relation of developments in field to intellectual forces in society; conceptual foundations.

FE 8900. Problems: Family Education. (1-9 cr, \$HEEd 8900) Independent study of current educational problems.

## Human Resource Development (HRD)

HRD 5104. Survey: Human Resource Development and Adult Education. (4 cr, \$AdEd 5104) S Peterson, Stone, Swanson General concepts in the field; literature, objectives, history, philosophy, research, institutions, issues, and trends.

HRD 5253. Supervisory Training. (3 cr, \$BIE 5253; prereq VoEd/WCFE 5340) S Peterson, Rossmann Problems, practices, programs, issues, and methodologies related to preparing trainers of supervisors.

HRD 5261. Sales Training. (3 cr, \$BIE 5261) Strategies and techniques for developing effective sales people.

HRD 5262. Customer Service Training. (3 cr, \$BIE 5262) Strategies of successful organizations; training practices to develop customer-oriented personnel.

HRD 5300. Organizational Needs Assessment. (3 cr, \$BIE 5300) Swanson Organizational performance problems and their causes; training solutions and other interventions to improve performance in business, industry, and schools.

HRD 5301. Student and Trainee Evaluation Systems. (3 cr, \$BIE 5301, \$Ind 5301) Pucel, Swanson Test development, performance, and learning evaluation; affective evaluation, learning progress reporting systems.

HRD 5366. Management Development Practices. (4 cr, \$BIE 5366; prereq principles of mgmt or supervision course or #) McLean Problems, practices, programs, and methodologies relating to development of managers, including needs assessment, delivery modes, and evaluation; site visits and critiques.

HRD 5630. Course Development. (3 cr, \$BIE 5630) Identifying content, stating objectives, sequencing, lesson planning, and selecting methods and media for instruction.

## GRADUATE PROGRAMS

HRD 5660. Instructional Methods. (3 cr, \$BIE 5660, \$Ind 5360) Lewis  
Implementating of instructional strategies and methods.

HRD 5750. Personnel Training and Development. (3-4 cr) Lewis, Swanson  
Acquiring skills in analysis, design, development, implementation, and evaluation.

HRD 5751. Motivational Training Practices. (3 cr)

Assessing need for, planning, developing, delivering, and appraising results of motivational training and development that involve motivational theory, principles, and practices.

HRD 5752. Technical Skills Training. (4 cr, \$BIE 5752) Lewis

Analyzing technical skills training practices in business and industry. Systems and process analysis and troubleshooting of work behavior; design methods and developing training materials.

HRD 5760. Organization Development. (3-4 cr) McLean, Pucel

Introduction to major concepts, skills, and techniques.

HRD 5761. Team Building in Organizations. (3 cr) McLean

Introduction to theories of and techniques for building effective work teams. Developing skills in facilitating team-building activities.

HRD 5762. Management of Conflict. (3 cr, \$VoEd 5762)

Types, sources, and diagnosis of conflict styles; skills and strategies for managing interpersonal, intergroup, and intragroup conflict.

HRD 5770. Human Resource Development: Special Topics. (1-4 cr) McLean, Swanson

Developments relating to problems, practices, programs, and methodologies in training and development; content varies with each offering.

HRD 5780. Internship: Human Resource Development. (Cr ar [max 15 cr]; prereq 5750)

Brown, McLean, Swanson

Students apply and contract for training or organization development positions; contracts describe specific training and development responsibilities to be fulfilled during internship.

HRD 5781. International Field Study in Human Resource Development. (4 cr) McLean, Swanson

Training, organization development, career development, and quality improvement theories and practices in selected nation.

HRD 5790. Strategic Planning in Human Resource Development. (3-4 cr; prereq 5750 or 5760) S Peterson, Swanson

Human capital as component of organizational strategic planning; analyzing and articulating practices.

HRD 5792. Managing Human Resource Development. (3 cr; prereq 5750, 5760 or #)  
Managing and leading human resource development activities in industry, business, and government to meet organizational objectives. Mission, staffing, resources, systems, process management, and reporting.

HRD 5793. International Human Resource Development. (4 cr) McLean  
Problems, practices, programs, theories, and methodologies in human resource development as practiced internationally and in cross-cultural settings.

HRD 5794. Consulting in Human Resource Development. (3 cr; prereq 5750 or 5760 or #) McLean

Analyzing marketing, subject matter expertise, organization, business principles, and communication skills as elements of consulting in business and industry human resource development.

HRD 5795. Quality Improvement: Human Resource Development Approach. (4 cr) McLean

Quality management and productivity improvement strategies from training and organization development perspective. Organization development interventions to implement three selected quality management strategies. Not a statistical process control course.

HRD 5798. Current Issues in Human Resource Development. (4 cr, \$VoEd 5798; prereq 5750, 5760 or #) Lewis, Swanson

Issues confronting practitioners in training and organization development; conflicting viewpoints and resolution options.

HRD 5808. Diversity Issues and Practices. (3 cr, \$VoEd/WCFE 5808) Brown

Collaborative diversity-related issues among educators and human resource development personnel. Nature of diverse populations, their unique learning/training needs, and effective diversity-related practices.

HRD 8750. Advanced Theories in Human Resource Development. (4 cr; prereq 5750, 5760 or #) Swanson

Critique of organizations as adaptive systems; role of human resource development in mediating among the organizational, process, and individual levels of performance.

## Work, Community, and Family Education (WCFE)

WCFE 5002. Thinking, Learning, and Teaching in Work, Family, and Community. (3 cr, \$FE 5002, \$VoEd 5002) Thomas

Theory and practice.

WCFE 5010. Technology and Public Ethics. (3 cr, \$VoEd 5010, \$WCFE 3010) Lewis

Nature of technology. Values and ethical issues relating to technology. Ways in which citizens can influence technological decisions in their communities.

WCFE 5021. Education Through Extension Methods. (3 cr, §AgEd 5021; prereq grad student or #) Norenberg  
Methods and techniques of formal and nonformal education used by Extension Service and other organizations.

WCFE 5023. Methods for Change in Developing Countries. (3 cr, §AgEd 5023)  
Devising strategies, programs, projects, and methodologies for individual and community economic and social change.

WCFE 5024. Extension History and Philosophy. (3 cr, §AgEd 5024)  
Origin, philosophy, historical development, objectives, and organizational structure of the Extension Service.

WCFE 5025. Extension Program Development. (3 cr, §AgEd 5025)  
Planning, implementing, and evaluating program development process.

WCFE 5026. Administering Non-Formal Education Programs. (3 cr, §AgEd 5026; prereq #)  
Administering Extension Service and other non-formal education agencies or programs at local, area, and state levels.

WCFE 5027. Practicum: Extension Experiences. (2-9 cr [max 9 cr], §AgEd 5027; S-N optional)  
Observing and participating in activities of Extension Service staff at county and state levels; staffing, program planning and development, and educational and administrative functions.

WCFE 5101. Special Topics in Curriculum. (1-6 cr [max 9 cr], §VoEd 5101)  
Topics vary, but course covers development and evaluation of curricula.

WCFE 5102. Special Topics in Administration. (1-6 cr [max 9 cr], §VoEd 5102)  
Topics vary, but course covers leadership and management of education programs.

WCFE 5200. Program Evaluation. (3 cr, §VoEd 5200) Krueger  
Designing and conducting program evaluations.

WCFE 5204. Literacy in Work Settings. (3 cr, §AdEd 5204, §VoEd 5204) Park  
Overview of concepts involved in integrating literacy instruction into vocational training programs and work settings; diagnosis and methods of assessing needs of vocational students and workers on a job; techniques for building needs into training programs.

WCFE 5274. Two-Year Postsecondary Institutions. (3 cr, §EdPA 5274, §VoEd 5274)  
Present status, development, functions, organization, curriculum, trends in postsecondary but nonbaccalaureate institutions.

WCFE 5284. Leadership Skills. (1 cr; §VoEd 5284)  
Applying leadership and management theory to education programs for youth and adults in school, industry, business, and community settings.

WCFE 5286. Marketing of Education and Training Programs. (3 cr, §VoEd 5286) Stone  
Application of comprehensive marketing model to design and delivery of education and training programs for institutions, programs, and specific course offerings. Market research, market segmentation, product positioning, alternative marketing mix strategies, and marketing planning.

WCFE 5300. Philosophy and Practice of Vocational Education. (3 cr, §VoEd 5300) Brown, Hopkins, Peterson  
Purposes, recipients, practices, legislation and funding, and socioeconomic contexts.

WCFE 5310. Advising Vocational Student Organizations. (2 cr, §VoEd 5310) Leske  
Value and purposes of vocational student organizations in curriculum. Tasks of adviser in designing, operating, and sustaining activities to enhance student leadership, personal development, and school-to-work transition.

WCFE 5330. Coordination Techniques in Cooperative Education. (3-4 cr, §AgEd 5071, §BME 5352, §HEEd 5106, §Ind 5310, §VoEd 5330) Brown, Leske, Stone  
Responsibilities of instructor-coordinator; guidance, selection, placement, supervision, and evaluation of students; articulation of related instruction; training sponsor identification, orientation, development, and evaluation; purposes and management of program.

WCFE 5340. Principles of Supervisory Management. (3 cr, §VoEd 5340) Rossmann  
For persons in education, business, industry, or service organizations.

WCFE 5400. Education for Work. (3 cr, §VoEd 5400; prereq 5300 or #) Copa, Leske, Stone  
Contextual bases underlying education for work; implications for practice.

WCFE 5410. Experiential Learning: Theory and Practice. (3 cr, §VoEd 5410)  
Analyzing students' own learning process; how experience is used in educational settings; shared decision making and group dynamics.

WCFE 5420. Youth in the World. (3 cr, §VoEd 5420, §YoSt 5100; prereq 5410 or #)  
Understanding youth, using "everyday life" experiences as levels of reality; range of ideas, social institutions, and organizations that reflect the ways societies and cultures understand and influence youth.

WCFE 5430. Organizational Approaches to Youth Development. (3 cr, §EdPA 5340, §VoEd 5430; prereq 5410 or #)  
Defining youth development within framework of formal and informal organizations; organizational systems responsible for youth development in the community; policy issues surrounding these systems.

## GRADUATE PROGRAMS

WCFE 5440. Issues: Youth Development. (3 cr, \$VoEd 5440; prereq 5410 or #)  
Healthy development of adolescents in relation to the family, community, and workplace; collaborative use of community resources to address these issues.

WCFE 5450. Critical Pedagogy. (3 cr, \$AdEd 5450, \$FE 5450, \$VoEd 5450) McClelland  
Critical pedagogy in schools and adult education; application to education for family, work, and community.

WCFE 5451. Microcomputer Instructional Utility Software. (2 cr, \$VoEd 5451; prereq microcomputer coursework or exper)  
Software for preparing tests, worksheets, learner reports and records, instructional inventory records, and classroom group presentations for vocational educators.

WCFE 5452. Authoring Instruction Using Microcomputers. (3 cr, \$VoEd 5452; prereq 5450 or equiv or #)  
Designing and preparing instructional materials using an authoring language.

WCFE 5490. Seminar in Youth Development. (1-6 cr, \$VoEd 5490)  
Concepts of healthy youth development used by youth workers as a framework for discussing personal experience, portfolio development, and other facets of their program work.

WCFE 5500. Introduction to Vocational Education Administration. (3 cr, \$VoEd 5500)  
Basic concepts of structure, financing, program planning and evaluation, law and liability, personnel policies, and the management of vocational education programs.

WCFE 5600. Planning Vocational Education. (3 cr, \$VoEd 5600; offered when feasible) Copa

WCFE 5700. Teaching Entrepreneurship: Small Business Management. (3 cr, \$VoEd 5700)  
Persons  
Organization, curriculum modification, and implementation of education programs.

WCFE 5800. Educating Persons With Special Learning Needs. (3 cr, \$VoEd 5800) Brown  
Identifying instructional procedures for students with disabilities and disadvantaging conditions in regular classroom/lab settings.

WCFE 5801. Educating Persons With Learning Disabilities. (1 cr, \$VoEd 5801)  
Educational traits of students with learning disabilities; instructional strategies for meeting their educational needs.

WCFE 5802. Educating Disadvantaged Vocational Students. (1 cr, \$VoEd 5802)  
Educational traits of disadvantaged vocational students; instructional strategies for meeting their educational needs.

WCFE 5804. Work Evaluation of Persons With Special Learning Needs. (3 cr, \$VoEd 5804)  
Overview of techniques, systems, and organizations that evaluate such students entering vocational education programs.

WCFE 5805. Occupational Analysis for Persons With Special Learning Needs. (3 cr, \$VoEd 5805)  
Overview of techniques, issues, and practices for analyzing and describing jobs and job settings into which vocational special needs learners may be placed or for which vocational training or vocational assessment systems may be developed.

WCFE 5806. Interagency Collaboration for At-Risk Populations. (3 cr, \$EdPA 5104, \$EPsy 5714, \$VoEd 5806) Brown  
Overview of interagency planning issues and practices for educational and human service organizations. Transition of students from school to work and community living, infant and preschool services, and use of locally based planning teams to achieve enhanced service coordination.

WCFE 5808. Diversity Issues and Practices. (3 cr, \$HRD 5808, \$VoEd 5808) Brown  
Collaborative diversity-related issues among educators and human resource development personnel. Nature of diverse populations, their unique learning/training needs, and effective diversity-related practices.

WCFE 5900. Using Work, Community, and Family Education Research. (3 cr, \$VoEd 5900; prereq grad program admission or #) Leske, Stone  
Role of education research in professional practice, significant problems of practice for research, alternative research modes, and synthesizing and applying research results.

WCFE 5920. Independent Study. (1-6 cr, \$VoEd 5920; prereq Δ)

WCFE 8100. Colloquium. (1-18 cr, \$VoEd 8100)  
Selected topics.

WCFE 8140. History and Philosophy of Education for Work, Community, and Family. (3 cr, \$VoEd 8120; A-F only for PhD and EdD students in WCFE) Thomas  
Philosophical views of and historical influences on research and practice in education for work, community, and family.

WCFE 8150. Comparative Systems in Education for Work, Community, and Family. (3 cr, \$VoEd 8110; A-F only for PhD and EdD students in WCFE) Copa, Lewis, McClelland  
Comparison of systems in education for work, community, and family within United States and between United States and other countries.

WCFE 8160. Critical Issues in Education for Work, Community, and Family. (3 cr, \$VoEd 8130; prereq 8140, 8150 or #; A-F only for PhD and EdD students in WCFE) Hopkins, Lewis, Stone

WCFE 8810. Internship. (1-15 cr [max 15 cr], \$VoEd 8810; prereq  $\Delta$ )  
Student applies for position in professional practice; individual arrangements describe specific responsibilities during internship period.

WCFE 8910. Positivistic Research. (3 cr, \$VoEd 8910; prereq 5900 or equiv or #) Brown, Lambrecht, Lewis  
Assumptions of, procedures for, and considerations in planning and conducting positivistic research.

WCFE 8920. Interpretive and Critical Science Research. (3 cr, \$VoEd 8920) Copa, Plihal  
Assumptions of, procedures for, and considerations in planning and conducting interpretive and critical science research.

WCFE 8990. Research Seminar. (1 cr per qtr [max 9 cr]; prereq 8910 or 8920 or  $\Delta$ ; only 2 cr apply to doct prog research core req)  
Developing, reporting, and evaluating research. Participants make and react to presentations.

## Zoology (Zool)

*Professor:* Elmer C. Birney, *director of graduate studies;* Franklin H. Barnwell; Kendall W. Corbin; James W. Curtsinger; Robert P. Elde; Stanley L. Erlandsen; William S. Herman; Robert G. McKinnell; Frank D. McKinney; Craig Packer; Richard E. Phillips; Anne E. Pusey; Philip J. Regal; William D. Schmid; Akhouri A. Sinha; Donald B. Siniff; Bert E. Stromberg

*Associate Professor:* John H. Beatty; Stuart F. Goldstein; Jay T. Hatch; Ralph W. Holzenthal; Scott M. Lanyon; Peter W. Sorensen; Robert M. Zink

*Assistant Professor:* Susan J. Weller

Please read the General Information section of this bulletin for Graduate School requirements that apply to all major fields.

**Degrees Offered**—M.S. (Plan A and Plan B) and Ph.D.

**Curriculum**—Emphases in areas of vertebrate and invertebrate zoology are available in the master's and doctoral programs.

**Prerequisites for Admission**—At least 15 credits of biological science, chemistry through organic, one year of physics, and mathematics through calculus are required for both programs. Deficiencies in the above work must be made up during the first year of graduate work.

**Special Application Requirements**—A statement of purpose, scores from the General (Aptitude) Test and the Subject (Advanced) Test in biology of the Graduate Record Examination, and three letters of recommendation should be sent to the director of graduate studies. The application deadline is January 7 for entry in the following fall quarter; fall quarter entry is preferred.

**Master's Degree Requirements**—Requirements for the major are flexible, but breadth in coursework is encouraged. Requirements for the major as well as the minor or supporting program are determined in consultation with the adviser and the director of graduate studies. The final examination is oral.

**Doctoral Degree Requirements**—The program is planned in consultation with the adviser and the director of graduate studies. Competence in statistics and computer science is required and field experience is strongly recommended for all Ph.D. students.

**Language Requirements**—For the master's degree, none. For the doctoral degree, one foreign language is required.

**For Further Information and Applications**—Contact the Zoology Graduate Program, University of Minnesota, 100 Ecology Building, 1987 Upper Buford Circle, St. Paul, MN 55108 (612/624-6770; fax 612/624-6777; e-mail [ecbirney@biosci.umn.edu](mailto:ecbirney@biosci.umn.edu)).

Zool 8666. Doctoral Pre-Thesis Credits. (max 18 cr per qtr; doctoral student who has not passed oral prelims)

Zool 8777. Thesis Credits: Master's. (16 cr required; Plan A only)

Zool 8888. Thesis Credits: Doctoral. (36 cr required)

For course descriptions, see Ecology and Molecular, Cellular, Developmental Biology and Genetics.

# **R e l a t e d   C o u r s e s**

**This is the Related Courses section of the 1996-1999  
University of Minnesota Graduate School Catalog**

Graduate degree programs do not exist in the following fields. However, students may earn graduate credit in courses related to their program in these fields.

## American Indian Studies (Amln)

### Amln 5251. American Indians and the Cinema.

(4 cr, §AmSt 5251) Libertus  
Images and stereotypes of tribal people in selected motion pictures, from silent documentaries to contemporary films.

### Amln 5461. North American Indian

**Architecture.** (4 cr, §Anth 5461, §Arch 5461; prereq arch or grad arch major or Amln studies major)  
Historic and contemporary overview; principles and theories.

## Contemporary Issues

### Amln 5341. Contemporary Indian Movements.

(4 cr)  
Indian organizations and social movements during the 20th century.

### Amln 5422. Change and Development in Indian Communities.

(4 cr; prereq 3112 or #)  
Sources, nature, and consequences of social and economic development and change in Indian communities.

## Tribal Development

### Amln 5411. Urban Indian Communities.

(4 cr)  
Social science and historical analysis of the rapid cityward Indian migration since World War II.

## Special Topics

### Amln 5920. Seminar in American Indian Studies.

(Cr ar; prereq in *Class Schedule*)  
Topics in American Indian history; varies yearly.

### Amln 5960. Topics in American Indian Studies.

(Cr ar)  
Topics listed in *Class Schedule*.

## Tutorial

### Amln 5970. Directed Studies.

(1-15 cr; prereq #, Δ or □)

### Amln 5990. Directed Research.

(1-15 cr; prereq by petition only, #, Δ, CLA approval)  
Independent research under the guidance of a faculty member.

## Anesthesiology (Anes)

*Associate Professor:* Ji-Chia Liao

*Assistant Professor:* Josephine Lo

### Anes 5186. Clinical Practice in Anesthesia.

(15 cr; prereq CRNA, regis BS in nurs anes, 5086, #)

### Anes 5386. Education in Nurse Anesthesia.

(1 cr; prereq CRNA, regis BS in nurs anes, #)

### Anes 8265f,w,s,su. General Anesthesia.

(12 cr)  
Instruction and experience in general anesthesia.

### Anes 8266f,w,s,su. Regional Anesthesia.

(4 cr)  
Observation, instruction, and administration of all types of local, regional, and spinal anesthesia.

### Anes 8267f,w,s,su. Pre- and Postanesthetic Evaluation.

(2 cr)  
Selection of proper anesthetic agent and technique, premedication, and observation of recovery from anesthesia.

### Anes 8268f,w,s,su. Seminar: Anesthesiology.

(2 cr)  
Review of literature, report of case problems, and discussion of research work in progress within the department.

It is recommended that fellows in anesthesiology also select from MdBc 5053, 5100, and PubH 5450.

## Biology (Biol)

### Biol 5003f,w,s. Genetics.

(4 cr, §GCB 3022, §GCB 5022; prereq 5001 or BioC 3021 or BioC 5331)  
Introduction to nature of genetic information, its transmission from parents to offspring, its expression in cells and organisms, and its course in populations.

### Biol 5004f,w,s. Cell Biology.

(4 cr; prereq 5001 or BioC 3021 or BioC 5331, Biol 5003 or BioC 5333)  
Structures and functions of membranes, organelles, and other macromolecular aggregates found in plant, animal, and bacterial cells. Cell form and movement, intercellular communication, transport, and secretion.

### Biol 5013. Microbiology.

(5 cr, §MicB 3103, §MicB 5105, §VPB 3103; prereq 5001 or BioC 3021 or BioC 5331)  
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Emphasis on molecular structure in relation to bacterial function.

### Biol 5125. Recombinant DNA Laboratory.

(4 cr, §5825, §MicB 5125, §MicB 5425; prereq application, Δ)  
Introduction to basic recombinant DNA techniques. Methods for growing, isolating, and purifying recombinant DNAs and cloning vectors.

### Biol 5816. Field Biology Photography.

(5 cr; prereq beginning biol course, Δ; limited to 20 students; A-F only)  
Techniques for documenting insects, vertebrates, aquatic organisms, and habitats of the Itasca area. Photographic principles and applied advanced techniques using flash, reversed lenses, and infra-red photoelectric tripping devices. On-site processing of color slides and black and white film. No previous processing experience required.

## RELATED COURSES

**Biol 5841. Ecology.** (5 cr, \$3008, \$5041; prereq 1103 or 1106 or 1806 or 3011 or 3012 or 3812, Math 1142 or Math 1251, Δ)  
Growth, structure, and evolution of populations. Pairwise biotic interactions between species and their effect on the diversity and structure of natural communities. Nutrient dynamics, function, productivity, and temporal stability of ecosystems. More field experience than in 5041.

**Biol 5890su. Research Problems at Itasca.** (Cr ar; prereq #, Δ)  
Undergraduate and graduate students develop short-term research project during one or both summer terms.

**Biol 5951. Social Uses of Biology.** (3 cr; prereq 10 cr sciences)  
Influence of biological science on quality of human life; agriculture, medicine, occupational health, environmental science, and theories of human nature. Responsibilities and roles of biologists in policy formulation in scientific and political world.

## Chicano Studies (Chic)

*Associate Professor:* Guillermo Rojas, *chair*; Dennis N. Valdes

**Chic 5901. Chicano Studies: Theory and Methodology.** (4 cr; prereq grad student or sr, #)  
Chicano studies scholarship in social sciences and humanities.

**Chic 5920. Topics in Chicano Studies.** (1-4 cr; prereq grad student or sr or #)  
Multidisciplinary themes. Topics vary quarterly.

**Chic 5970. Directed Studies.** (Cr ar; prereq #, Δ, CLA approval)

## Cultural Studies and Comparative Literature (CSCL)<sup>1</sup>

*Professor:* Richard D. Leppert; Harvey Sarles; Jochen Schulte-Sasse

*Associate Professor:* John Archer; John W. Mowitz; Gianna Pomata; Gary C. Thomas

*Assistant Professor:* Prabhakara Jha

**CSCL 5102. Cultural Politics.** (4 cr, \$Hum 5102; prereq jr or sr or grad student or #) Mowitz  
Examination of transformation of traditional domain of politics once legitimation and contestation of social power is conducted primarily within cultural sphere. How dynamics of marginalization, resistance, and reappropriation come to characterize cultural politics.

**CSCL 5154. Theoretical Constructions of Space.** (4 cr, \$Hum 5154; prereq jr or sr or grad student or #) Archer  
Theories of space drawn from such disciplines as anthropology, architecture, geography, history, landscape design, philosophy, planning, and sociology. Areas of intersection and difference; new and developing areas of inquiry. Theoretical integration of social and aesthetic concerns.

**CSCL 5178. The Political Discourse of Social Change.** (4 cr, \$Anth 5157, \$Hum 5178; prereq jr or sr or grad student or #) Josephides  
Tension between tradition and innovation (of ideas, techniques, material development) in contexts of rapid social change, especially when local cultures come into contact with outside, politically more forceful ones. Tradition as an already politicized discourse.

**CSCL 5256. Suburbia.** (4 cr, \$Hum 5256; prereq jr or sr or grad student or #) Archer  
Ideology and practice of suburbia, from origins in mid-18th-century Britain to present-day America; characteristic architectural and spatial forms in relation to social and political relations.

**CSCL 5301. Society, Ideology, and the Production of Art.** (4 cr, \$CSDS 5301, \$Hum 5301; prereq jr or sr or grad student) Leppert  
Recent critical theories on relation of arts to social and ideological forces; selected artifacts from Western culture (Renaissance to 20th century; high, popular, and mass culture). Music, visual art, literature.

**CSCL 5302. Aesthetics, Ideology, Valuation of Art.** (4 cr, \$CSDS 5302, \$Hum 5302; prereq jr or sr or grad student) Leppert  
Society, ideology, and aesthetic value in light of recent critical theories of visual art, music, and literature. Mediations of place, social class, gender, and ideology on aesthetic judgment in post-Renaissance Western culture.

**CSCL 5398. Phenomenology and Ethnography.** (4 cr, \$Anth 5394, \$Hum 5398; prereq jr or sr or grad student or #) Josephides  
Phenomenological/existentialist thought conceived as "the end of ideology"; its politicization during World War II; its use in reflexive anthropology conscious of its own colonial foundations; its use in attempts to understand The Other and in concepts of the person.

**CSCL 5711. Interpretation of Myth.** (4 cr, \$CSDS 5711, \$Hum 5711, \$ReIS 5111; prereq jr or sr or grad student) Josephides  
Structures and functions of myths. Myth as social charter, ideological system, and literary form. Readings in classic theories of myth and primary sources from India, Iran, Mesopotamia, Greece, Africa, North and South America.

**CSCL 5751. Basic Concepts of Cinema.** (4 cr, \$CLit 5221, \$Hum 5751) Mowitz  
Film, as a mass cultural phenomenon, in historical context; positions in current film theory; fundamentals of film analysis. Comparative perspective on mass culture employed throughout.

<sup>1</sup> See *Comparative Literature and Comparative Studies in Discourse and Society in the Graduate Programs* section of this bulletin for other graduate-level courses offered by the Cultural Studies and Comparative Literature Department.

**CSCL 5910. Topics in Cultural Studies and Comparative Literature.** (4 cr per qtr [max 15 cr]; prereq jr or sr or grad student or #)  
Topics specified in *Class Schedule*.

**CSCL 5910H. Topics in Cultural Studies and Comparative Literature: Honors.** (4 cr; prereq jr or sr or grad student, #)

**CSCL 5970. Directed Studies.** (Cr ar; prereq jr or sr or grad student, #, Δ, CLA approval)  
Guided individual reading or study.

**CSCL 5970H. Directed Studies: Honors.** (Cr ar; prereq jr or sr or grad student, #, Δ, CLA approval)

## Dermatology (Derm)

*Professor:* Mark V. Dahl

*Assistant Professor:* J. Corwin Vance

**Derm 8225f,w,s,su. Clinical Dermatology.** (Cr ar) Dahl, Lynch, Vance, staff  
Wards and outpatient departments of University Hospital, Veterans Administration Medical Center, Hennepin County Medical Center, and St. Paul-Ramsey Medical Center.

**Derm 8226f,w,s,su. Clinical Seminar: Dermatology.** (Cr ar) Dahl, Lynch, staff  
Conference twice weekly on diagnosis and treatment of skin conditions.

**Derm 8227f,w,s,su. Histology of the Skin.** (Cr ar) Kaye, Orkin, Peterson  
Histopathology, histochemistry, and fluorescent microscopy.

**Derm 8230f,w,s,su. Functional Biology of the Skin.** (Cr ar) Dahl, Lynch, staff

## Humanities (Hum)<sup>1</sup>

*Assistant Professor:* George Kliger

**Hum 5101. Foundations of Modern Education.** (4 cr, §3101, §EdPA 3101, §EdPA 5101)  
Analysis and interpretation of important elements in modern education derived from the Greeks, Romans, Middle Ages, Renaissance, Reformation, Enlightenment, and Industrial Revolution. Background course for all other courses in history and philosophy of education.

**Hum 5155. History of Western Educational Thought.** (4 cr, §3155, §EdPA 3155, §EdPA 5155)  
Major educational classics of Western civilization: Plato, Aristotle, Cicero, Quintilian, Montaigne, Milton, Locke, Rousseau, and others.

**Hum 5304. Theories of Ideology: Philosophical Views.** (4 cr; prereq jr or sr or grad student or #) Kliger  
Nature and function of ideology, including theories of Marx, Nietzsche, Freud, Mannheim, Althusser, Foucault, Habermas, and feminists.

**Hum 5545. Islamic Mysticism.** (4 cr, §3545, §Arab 3545, §Arab 5545)  
Rise of Sufism, from asceticism to theosophical mysticism; leading personalities, their beliefs and preachings; relationship to Orthodox Islam and non-Muslim mystical movements; concepts and organizations; place of Sufism in modern religious trends.

**Hum 5837. Nietzsche as Cultural Critic.** (4 cr; prereq jr or sr or grad student or #)  
Nietzsche's contributions to philosophy, psychology, and criticism of religion, culture, and society.

## International Relations (IntR)

**IntR 5701. Theories of International Development.** (4 cr; prereq IntR major or #)  
Interdisciplinary approaches to understanding contemporary development theory and practice. Selected theoretical framework and case studies illustrating complexities of development planning and implementation.

**IntR 5900. Topics in International Relations.** (1-4 cr; prereq 12 cr social science; offered when feasible)

**IntR 5970. Directed Studies.** (1-15 cr per qtr; prereq #, Δ, □)  
Tutorial for qualified seniors and graduate students.

**IntR 5990. Directed Research.** (1-15 cr per qtr; prereq #, Δ, □)  
Tutorial for qualified seniors and graduate students.

## Jewish Studies (JwSt)

*Professor:* Bernard Bachrach; Hyman Berman; David Cooperman; Jack Zipes

*Associate Professor:* Jonathan Paradise; Riv-Ellen Prell; Daniel Reisman; Philip Sellow

**JwSt 5900. Topics in Jewish Studies.** (4 cr, §RelS 3900)  
Historical, religious, sociological, anthropological, humanistic study of Judaism and the Jewish people. Approach and method of study vary with topic.

**JwSt 5970. Directed Readings.** (1-12 cr; prereq #, Δ, CLA approval)  
Guided individual reading or study.

<sup>1</sup> See *Cultural Studies and Comparative Literature above and Comparative Studies in Discourse and Society in the Graduate Programs section of this bulletin for other graduate-level courses formerly offered by the Humanities Department.*

## Language, Teaching, and Technology (LgTT)

### LgTT 5101. Technology in the Language Classroom. (3 cr; prereq Δ)

Theoretical background, application, and demonstration.

## Latin American Studies (LAS)

### LAS 5132. South America. (4 cr, §Geog 5132)

Weil

Physical resources, population, agriculture, manufacturing, and transportation in South America.

### LAS 5465. Housing in World Perspective I.

(4 cr, §DHA 5865; prereq 3463 or 3863 or #)

Social analysis of housing around the world; population, environment, and social organization of nations as contexts for national policy and for housing choices of households.

### LAS 5479. Latin American Government and Politics.

(5 cr, §Pol 5479) Sikkink

Latin American political heritage, political processes, and contemporary public policy issues; problems of social, economic, and political change in selected countries.

### LAS 5820. The Multinational Corporation.

(3 cr, §PA 5820; prereq intermediate microecon, adult spec or grad student or Δ) Kudrle

Economic, political, social, and legal significance of multinational corporation; major policy options open to both individual and international bodies.

## Area Studies (Area)

### Area 5930. Topics in Latin American Studies.

(2-4 cr)

### Area 5970. Directed Studies. (1-15 cr per qtr;

prereq #, Δ, □)

Tutorial for qualified seniors and graduate students.

### Area 5990. Directed Research. (1-15 cr per qtr;

prereq #, Δ, □)

Tutorial for qualified seniors and graduate students.

## Middle Eastern Languages and Cultures

For courses on the medieval and modern Middle East, see Middle Eastern Languages and Cultures (MELC) courses under South Asian and Middle Eastern Languages and Cultures in the Graduate Programs section.

## Neurosurgery (NSu)

*Professor:* Timothy J. Ebner; Donald L. Erickson; Stephen J. Haines; Walter C. Low; Robert E. Maxwell; Setti S. Rengachary; Gaylan L. Rockswold

*Associate Professor:* Walter A. Hall

### NSu 8305. Neurosurgical Diagnosis. (4 cr)

Maxwell, staff

The neurosurgical fellow assists in instruction of clinical clerks and interns, and studies problems in diagnosis at University and affiliated hospitals.

### NSu 8308. Neurosurgical Problems and Management. (4 cr)

Maxwell, staff

The neurosurgical fellow acts as house surgeon at University and affiliated hospitals.

### NSu 8311. Operative Neurosurgery. (4 cr)

Maxwell, staff

The neurosurgical fellow acts as first assistant at operations in University and affiliated hospitals, and later may be permitted to operate.

### NSu 8316. Neurosurgical Research. (6 cr)

Ebner, Hall, Low, staff

Problems in experimental or clinical neurosurgical sciences.

### NSu 8318. Neuroradiological Conference.

(1 cr) Maxwell, staff

Review of X-rays and case histories on neurosurgical service.

### NSu 8320. Neurosurgical Conference. (2 cr)

Haines, Maxwell, staff

In-depth review of selected topics in basic or clinical neurosurgery.

### NSu 8330. Neurosurgery Literature Seminar.

(2 cr) Maxwell, staff

Review and discussion of current literature relating to neurosurgery and the neurosciences.

## Ophthalmology (Oph)

*Professor:* Donald J. Doughman; Edward J. Holland; William Knobloch; Jonathan D. Wirtschafter

*Associate Professor:* J. Douglas Cameron; Robert D. Letson; J. Daniel Nelson; William B. Rathbun; C. Gail Summers

*Assistant Professor:* Agnes S. Huang; Martha M. Wright

### Oph 8101f,w,s,su. Clinical Ophthalmology.

(8 cr) Krachmer, staff

### Oph 8103. Pediatric Ophthalmology,

**Strabismus, and Hereditary Disorders.** (3 cr;

prereq grad physician or vet med grad student)

Summers

### Oph 8106. Strabismus Management. (1 cr;

prereq MD or vet med grad student) Summers

### Oph 8110. Optics, Refraction, and Contact Lens. (3 cr)

**Oph 8111. Intraocular Inflammation, Uveitis, Ocular Tumors.** (3 cr; prereq MD or vet med grad student; offered alt yrs) Neely

**Oph 8112. Retina and Vitreous.** (3 cr; prereq MD or vet med grad student; offered alt yrs) Knobloch

**Oph 8113. Basic and Clinical Neuro-Ophthalmology.** (3 cr; prereq MD or vet med grad student; offered alt yrs) Wirtschafter

**Oph 8116. Glaucoma, Lens, and Anterior Segment Trauma.** (3 cr; prereq MD or vet med grad student; offered alt yrs) Wright

**Oph 8117. Orbit, Plastics, and Trauma.** (3 cr; prereq MD or vet med grad student; offered alt yrs) Wirtschafter

**Oph 8118. General Medical Problems.** (3 cr; prereq MD or vet med grad student; offered alt yrs) Krachmer

**Oph 8119. Clinical Pathological Correlations in Ophthalmology.** (1 cr; prereq MD or vet med grad student) Cameron

**Oph 8120. Scope of Ophthalmic Pathology.** (2 cr; prereq MD or vet med grad student) Cameron

**Oph 8125, 8126. Diseases of the Cornea and External Eye.** (3 cr; prereq MD or vet med grad student; offered alt yrs) Holland

**Oph 8131f,w,s,u. Practical Ocular Surgery.** (3 cr) Krachmer, staff

**Oph 8142f,w,s,su. Ophthalmic Pathology Laboratory.** (2 cr) Cameron

**Oph 8152. Ophthalmology Laboratory.** (15 cr)

**Oph 8153. Research in Ophthalmology.** (Cr ar)

**Oph 8155. Special Topics in Ophthalmology.** (Cr ar)

**Oph 8701. Neuro-Ophthalmology.** (1 cr) Wirtschafter

## Pediatrics (Ped)

*Regents' Professor:* Alfred F. Michael, *head*; Paul G. Quie; James G. White

*Professor:* Bruce R. Blazar; David M. Brown; C. Carlyle Clawson; Patricia Ferrieri; Alfred J. Fish; G. Scott Giebink; Edward L. Kaplan; William Krivit; Russell V. Lucas, Jr.; S. Michael Mauer; James H. Moller; Mark E. Nesbit; Harvey L. Sharp; Kenneth F. Swaiman; Homer D. Venters; Warren J. Warwick

*Associate Professor:* Amos Deinard; Rolf R. Engel

**Ped 8204f,w,s,u. Residency in Pediatrics.** (Cr ar; prereq #) Michael, staff

One- to two-month rotations on the outpatient, inpatient, and special pediatric services of University Hospital and Clinic, Hennepin County Medical Center, Children's Hospital of St. Paul, St. Paul-Ramsey Medical Center, and Minneapolis Children's Health Center.

**Ped 8206f,w,s,su. Pediatric Special Interest.**

(Cr ar; for grads who have completed at least 1½ yrs general grad pediatric training; prereq #)

Advanced clinical and basic training in one or more of the following special fields: neurology, cardiology, pathology, endocrinology and metabolism, hematology, immunology, nephrology, infectious diseases, and community pediatrics. Clinical training is obtained in the inpatient and outpatient services of University and affiliated hospitals. Training in basic sciences related to these fields may be obtained in preclinical divisions of the Medical School.

## Psychiatry

*Professor:* Paula J. Clayton, *head*; Marilyn E. Carroll; Elke D. Eckert; Judith M. Garrard; James A. Halikas; Dorothy K. Hatsukami; John T. Kelly; Jerome L. Kroll; David T. Lykken; Thomas B. MacKenzie; Michael K. Popkin

*Clinical Professor:* Faruk S. Abuzzahab

*Associate Professor:* Gerald J. August; Carrie M. Borchardt; George M. Realmuto

*Assistant Professor:* Scott J. Crow; William H. Frey; Matt G. Kushner

## Adult Psychiatry (AdPy)

**AdPy 5800. Case Conference: Psychiatry in Medicine.** (1 cr; prereq MD or #) Colón

**AdPy 5920. Adult Psychopathology I.** (3 cr; prereq #)

Overview of major psychiatric illnesses, including affective, eating, and organic mental disorders; chemical dependency; schizophrenia; obsessive-compulsive disorder; dementia.

**AdPy 5921. Physiological Treatments I.** (3 cr; prereq #)

Overview, including ECT, psychotropic medication use, pharmacokinetics, and toxicity of psychopharmacological agents.

**AdPy 5922. Psychiatric Interviewing Styles.** (3 cr; prereq #)

Overview, emphasizing psychodynamic and psychoanalytic aspects of psychiatric interview; type of empirical interviewing stressed by DSM-III-R and necessary for completion of oral board examinations.

**AdPy 5923. Physiological Treatments II.** (3 cr; prereq 5921, #)

Pharmacological treatment of eating disorders, chemical dependency, organic mental disorder, schizophrenia, anxiety disorders, bipolar and schizoaffective disorders; drugs and memory; drug treatment of children and adolescents.

**AdPy 5924. Practical Psychotherapy, Crisis Intervention, and Emergency Management.**

(3 cr; prereq #)

Introduction to "dos and don'ts" of beginning therapy, supportive and confrontive short-term crisis intervention psychotherapy, and practical aspects of handling psychiatric crises in emergency room.

## RELATED COURSES

**AdPy 5925. Biological Psychiatry I.** (3 cr; prereq #)  
Concepts in neuroanatomy, neurophysiology, and neuropsychopharmacology that relate to biological psychiatry.

**AdPy 5926. Psychoanalytic Psychotherapy.** (3 cr; prereq #)  
Basics of psychoanalytic theory and psychodynamic practice. Designed to provide foundation for future coursework and therapy supervision in practical psychodynamic therapy.

**AdPy 5927. Biological Psychiatry II.** (3 cr; prereq 5925, #)  
Continuation of 5925.

**AdPy 5940. Forensic Psychiatry.** (6 cr; prereq #)  
Current concepts in area of psychiatry and law, including civil commitment, patient rights, criminal responsibility, competency to stand trial, disability determination, potential fitness in custody determinations, and mentally disordered sex offenders.

**AdPy 5942. Advanced Psychoanalytic Psychotherapy.** (6 cr; prereq 5926, 5936, #)  
Theory course taught by practicing psychoanalysts. Builds on previous psychoanalytic psychotherapy courses; advanced readings and psychoanalytic case presentations.

**AdPy 5944. Administrative Psychiatry.** (6 cr; prereq #)  
Administration of psychiatric healthcare organizations, including accreditation, licensing and federal standards, medical staff organization, peer review, systems of reimbursement and third party payment, types of organizations, personnel issues, cost of healthcare.

**AdPy 5946. Human Sexuality: Therapy and Counseling.** (6 cr; prereq #)  
Intensive seminar: normal sexual functioning, psychosocial disorders, and counseling and treatment options.

**AdPy 8205. Special Assignments in Psychiatry.** (1 cr; prereq MD, 8201, 8203)

**AdPy 8221. Seminar: Current Literature.** (1 cr; prereq #) Simon

**AdPy 8239. Continuous Case Seminar: Psychoanalytically Oriented Psychotherapy.** (1 cr; advanced psychiatric residents and psychology interns only; prereq #)

**AdPy 8244. Comparative Theories of Psychotherapy.** (3 cr; prereq #)

**AdPy 8970. Directed Studies.** (Cr ar [max 9 cr])

### Child and Adolescent Psychiatry (CAPy)

**CAPy 5201. Diagnostic Practicum in Child and Adolescent Psychiatry.** (Cr ar; prereq #)  
Experiences in psychiatric assessment of children, adolescents, and families in child and adolescent psychiatric care setting.

**CAPy 5203. Child and Adolescent Psychiatry for Psychology Interns.** (1-5 cr; prereq #)  
Experience in assessment and therapeutic interventions with children, adolescents, and families in an outpatient child and adolescent psychiatric care setting.

**CAPy 5204. Diagnostic Methods in Child and Adolescent Psychiatry.** (1 cr; prereq med student, #)  
Multidisciplinary evaluations of children, adolescents, and their families presented for discussion in an outpatient setting. Dynamic and diagnostic formulations, and disposition planning supervised in a clinical teaching conference setting. Knowledge base necessary to make clinical diagnosis. Major disorders of childhood; specific diagnostic criteria.

**CAPy 5520. Outpatient Clinical Child and Adolescent Psychiatry for Primary Care Trainees.** (4.5-9 cr; prereq med student, #)  
Supervised diagnostic and therapeutic experiences in outpatient multispecialty clinics with emphasis on integration of biological, familial, social, and psychological aspects of behavior.

**CAPy 5602. Introductory Readings in Child, Adolescent, and Family Psychiatry and Research Methods.** (Cr ar; prereq med student)  
Child development, diagnostic and therapeutic techniques, and psychopathology.

**CAPy 5603. Inpatient Clinical Child Psychiatry for Primary Care Physicians.** (9 cr for 6 wks full time; option: 18 cr for 12 wks full time; prereq med student, #)  
Diagnosis and treatment of children referred to the inpatient child psychiatric unit. Broad range of childhood disorders. Students responsible for patient management. Emphasis on involvement of family.

**CAPy 5608. Introduction to Family Therapy: Theory and Practice.** (3 cr; prereq MD and/or #, satisfactory completion of course in basic psychopathology [or its equiv], current supervised involvement with treatment of cases)  
Introduction to the ideas and treatment approaches of some of the major figures in the current clinical practice of psychotherapy with families: Carl Whitaker, Salvador Minuchin, Lyman Wynne, Jay Haley, Murray Bowen, Virginia Satir, David Olson, and others. Provides practice training experience in the problems and techniques for beginning family therapists through review and discussion of videotapes of current treatment cases of course participants.

**CAPy 5609. Introduction to Child Psychiatry.** (3 cr; prereq MD or #)  
Seminar relating to practice of child and adolescent psychiatry.

**CAPy 5620. Disruptive Behavior Disorders I: Attention Deficit Hyperactivity Disorder (ADHD) Throughout the Life Span.** (1 cr)  
Workshop reviews ADHD from beginnings in toddlerhood to manifestations during adult years. Diagnostic criteria for defining ADHD across the life span; disorders that frequently occur with ADHD; theories addressing biological, cognitive, and behavioral causes of ADHD.

**CAPy 5623. Affective Disorders and Suicide in Children and Adolescents: Perspectives on Prevalence, Etiology, and Prevention.** (1 cr)

Characteristics of depression and suicidal behavior in children and adolescents. Methods of crisis intervention, treatment, and prevention.

**CAPy 5624. Eating Disorders in Children and Adolescents: Medical and Psychological Perspectives.** (1 cr)

Clinical characteristics of obesity, anorexia, and bulimia nervosa in children and adolescents. Etiological factors and multidimensional-dimensional treatment approaches.

**CAPy 5627. Disruptive Behavioral Disorders II: Conduct and Oppositional Defiant Disorders in Childhood and Adolescence.** (1 cr)

Traditional definitions of conduct disorder; how conduct disorder affects home life, economic status, school performance, personality, and social behavior; factors that place children at risk for antisocial and aggressive behavior.

**CAPy 5629. Disruptive Behavioral Disorders IV: Medication and Behavioral Therapies.** (1 cr)

Workshop reviews evidence supporting biological bases of disruptive behavioral disorders; neuropharmacologic bases of drug actions on brain and neurotransmitter systems. Applying behavioral principles to manage disruptive behavior via classroom contingency management programs and behavioral family interventions.

**CAPy 5630. Psychotherapy in Children and Adolescents.** (1 cr)

Major schools of psychotherapeutic intervention. Short-term dynamic psychotherapy, behavioral therapy, cognitive-behavioral therapy, and family therapy; review of psychotherapy outcome research literature.

**CAPy 5631. Developmental Neuropsychiatry: Implication for Assessment of Behavioral and Cognitive Disorders.** (1 cr)

Workshop on major developmental, behavioral, and emotional childhood disorders from neuropsychiatric perspective, including infantile autism, attention deficit disorder, specific learning disabilities, language disorder, conduct disorder, and depression.

**CAPy 5632. Competence-Enhancement Training Programs for Children With Disruptive Behavior.** (1 cr)

Workshop focusing on skill-building approaches to treatment of behavioral, emotional, and academic problems in children. Such approaches teach children to "stop and think" and examine behavioral alternatives. Environmental engineering, contingency management, self-monitoring and self-instructional training, and problem-solving training. Application of comprehensive competence enhancement program to treatment of impulsivity in children with attention deficit disorder.

**CAPy 5633. Anxiety Disorders in Childhood and Adolescence.** (1 cr)

School phobia, panic attack, separation anxiety, obsessive-compulsive disorder. Strategies for prevention; biological, social, and psychodynamic influences; intervention approaches.

**CAPy 5634. Developmental Dyslexia: Theory, Research, and Clinical Differentiation.** (1 cr)

Dyslexia as major cause of educational failure in school children. Definition; neuropsychological and cognitive processes in relation to dyslexia. Interpreting deficits and assessing methods.

**CAPy 5635. Disruptive Behavioral Disorders V: Cognitive-Behavioral Therapies for Children and Adolescents.** (1 cr)

Theoretical basis and therapy outcome research literature. Problem-solving techniques, verbal self-instruction training, attributional retraining, and stress inoculation procedures applied to common problems, including anger/frustration management, conflict resolution, interpersonal problem solving, self-esteem enhancement, and negative thought/feeling management.

**CAPy 5636. Disruptive Behavioral Disorders III: Assessment Methods for the Diagnosis and Evaluation of Treatment Response.** (1 cr)

Workshop on assessment process for identifying and diagnosing children with disruptive behavioral disorders and for evaluating treatment response. Multistage diagnostic and functional assessment protocols.

**CAPy 5638. Prevention Science II: Designing Programs for the Prevention of Delinquency, Criminal Offending, and Substance Abuse.**

(1 cr)  
Workshop on current crisis regarding prevalence of delinquency, criminal offending, and substance abuse; possible developmental pathways leading to these conditions; current theories and approaches for treatment.

**CAPy 5639. Behavior Problems in Preschool Children.** (1 cr)

Behavior and emotional characteristics of infants and preschool children. Problems discussed include disturbances in regulation, attachment, sleep, and social development. Various approaches to assessment and intervention.

**CAPy 5640. Psychiatric Treatment of the Disruptive Disorders.** (1 cr)

Primary and associated behaviors of conduct disorder, oppositional defiant disorder, and attention deficit hyperactivity disorder. Specific psychiatric, behavioral, and innovative treatment strategies described in detail.

**CAPy 5641. Prevention Science I: Risk Factors, Protective Factors, and Models of Disorder.** (1 cr)

Importance of model building with respect to development of a disorder; types of interventions needed in prevention trials; strategies for designing prevention trials in the community; resiliency.

**CAPy 5642. Substance Abuse.** (1 cr)

Historical perspectives, epidemiology, and differential diagnosis. Predictors of various types of substance abuse. Assessment and evaluative methods for diagnosis. Current treatment and prevention approaches, emphasizing management of coexisting medical and psychiatric conditions. Substances covered include alcohol, cocaine, amphetamines, opiates, nicotine, and caffeine. Special attention given to adolescent use.

**CAPy 5643. Multicultural Issues in Assessment and Treatment of Children With Psychiatric Problems.** (1 cr)

Sociopolitical issues related to “labeling” and “managing” children from different cultural backgrounds who exhibit emotional and behavioral problems. Child development, family relations, and community structure for different cultural groups. Multiculturally sensitive assessment and treatment practices.

**CAPy 5644. Child Abuse/Neglect and Childhood Psychopathology: Implications for Assessment and Treatment.** (1 cr)

Types of child abuse/neglect; effects on children’s psychological development. Child, parent/family, and social factors that place children at risk. Assessment and intervention approaches.

**CAPy 5645. Innovative Methods in Psychotherapy.** (1 cr)

Workshop focusing on methods for time-limited treatment for children, adolescents, and adults. Basic principles common to effective psychotherapy. Short-term psychodynamic therapy, imagery, solution-oriented therapy, experiential therapies (including gestalt therapy), and narrative therapies and their use in individual, group, and family therapy.

**CAPy 5646. Methods of Measurement and Assessment in Psychopathology.** (1 cr)

For mental health, social service, and educational practitioners who deal with diagnostic and evaluative data. Standardization, reliability, and validity. Principles of test development; item analysis, factor analysis, derived scores, and scaling. Screening, diagnosis, and evaluation of psychiatric disorders in adults, adolescents, and children. Global assessment scales, structured diagnostic interviews, and personality inventories.

**CAPy 5647. Building Friendships and Peer Relationship Skills: Interventions for Socially Rejected Children.** (1 cr)

Behaviors and mechanisms related to peer rejection; social skills interventions.

**CAPy 5747. Prevention Science III: Building Friendships and Peer Relationship Skills—Interventions for Socially Rejected Children.**

(1 cr)  
Behaviors and mechanisms related to peer rejection; social skills interventions.

**CAPy 8100. Readings in Child, Adolescent, and Family Psychiatry.** (1 cr; prereq MD, #)

Comprehensive review of classical and contemporary literature in the field of child, adolescent, and family psychiatry including growth and development, diagnostic and therapeutic techniques, and psychopathology with supplemental coursework in other departments and schools.

**CAPy 8110. Diagnostic Methods in Child, Adolescent, and Family Psychiatry.** (1 cr; prereq MD, #)

Multidisciplinary evaluations of children, adolescents, and their families presented for discussion, dynamic and diagnostic formulations, and disposition planning in a conference setting.

**CAPy 8120. Therapeutic Methods in Child and Adolescent Psychiatry.** (1 cr; prereq MD, #)

Therapeutic techniques used in child, adolescent, and family psychiatry reviewed through presentation and discussion of ongoing cases.

**CAPy 8200. Outpatient Clinical Child and Adolescent Psychiatry.** (3 cr; 15 hrs per wk; prereq MD, #)

Supervised diagnostic and therapeutic experiences in an outpatient setting.

**CAPy 8212. Clinical Inpatient Child Psychiatry.** (3 cr; 15 hrs per wk ar; prereq MD, #)

Supervised diagnostic and therapeutic experiences in an inpatient, multidisciplinary child psychiatry unit with emphasis on group and milieu therapies.

**CAPy 8214. Inpatient Clinical Adolescent Psychiatry.** (3 cr; prereq MD, #)

Supervised diagnostic and therapeutic experiences in an inpatient, multidisciplinary adolescent psychiatry unit with emphasis on group and milieu therapies.

**CAPy 8216. Pediatric Psychiatry Liaison.** (3 cr; prereq MD, #)

Supervised consultation, diagnostic, and short-term therapy experiences in pediatrics and pediatric neurology.

**CAPy 8223. Family Therapy.** (1 cr; prereq MD, #)

Readings and illustrative family therapy examples reviewed to complement the concurrent clinical experiences.

**CAPy 8228. Research in Child and Adolescent Psychiatry.** (1 cr; prereq MD, #)

Research design and methodology and current research projects reviewed with faculty and invited guests.

**CAPy 8301. Seminar: Child, Adolescent, and Family Psychiatry.** (1 cr; prereq MD, #)

Current diagnostic, therapeutic, and theoretical issues in child, adolescent, and family psychiatry reviewed through clinical and didactic presentations and discussions by students, faculty, and invited guests.

## Radiology (Rad)

*Professor:* Kurt Amplatz; Robert J. Boudreau

*Associate Professor:* Marvin E. Goldberg; Donovan B. Reinke

*Assistant Professor:* Kent B. Remley

## Diagnostic Roentgenology

### Rad 5110. Research Problems in Radiology. (Cr ar)

Background and knowledge of radiologic research; in-depth study of one aspect of radiology. Research project (arrangements must be made with course director at least two weeks before course begins).

### Rad 5174s. Physics of Diagnostic Radiology. (3 cr) Ritenour

Physics of diagnostic imaging; CAT scanning and ultrasound.

## Nuclear Medicine

### Rad 5170f. Basic Radiological Physics. (3 cr; prereq #) Khan

Theoretical and experimental aspects of radiological physics.

### Rad 5171w. Physics of Nuclear Medicine. (3 cr; prereq 5170 or #) Ritenour

Theoretical and experimental applications of radionuclides in medicine and biology.

### Rad 5172s. Radiation Biology. (3 cr; prereq 5170 or #) Song

Effects of ionizing radiations on cells.

For additional coursework in radiology, see Therapeutic Radiology.

## Therapeutic Radiology (TRad)

*Professor:* John H. Kersey; Faiz M. Khan; Seymour H. Levitt; Mark E. Nesbit; Chang W. Song

### TRad 5170f. Basic Radiological Physics. (3 cr; prereq #) Khan, staff

Theoretical and experimental aspects of radiological physics. Physical properties of various ionizing radiations; interactions of ionizing radiations with matter; methods of radiation dose measurement.

### TRad 5171w. Medical Nuclear Physics. (3 cr; prereq 5170 or #) Loken, Morin

Theoretical and experimental applications of radionuclides in medicine and biology. Imaging devices and techniques, dynamic tracer analysis; internal emitter dosimetry. Radioimmunoassay and the statistics of counting.

### TRad 5172s. Radiation Biology. (3 cr; prereq 5170 or #) Song, staff

Effects of ionizing radiations on cells, tissues, and organisms; biochemical and physiological basis of radiation effects, biological rationale for radiation therapy practices.

### TRad 5173w. Physics of Radiation Therapy. (3 cr; prereq 5170 or #) Khan, staff

High energy and teletherapy machines. Measurements of radiation quality, output and depth dose distributions for clinical use. Calculation of treatment parameters. Beam modification and shaping. Treatment planning for fixed field and rotational therapy. Physics of intracavitary and interstitial therapy. Computer applications in treatment planning. Principles and criteria for radiation protection.

### TRad 5340f,w,s,su. Special Problems in Radiation Therapy. (Cr ar) Kim, Lee, Levitt, Potish

### TRad 5512f,w,s,su. Dosimetry of Internal and External Radiation. (1 cr) Khan

Basic principles of radiation dosimetry discussed in detail; clinical applications.

### TRad 5540f,w,s,su. Special Problems in Radiological Physics. (Cr ar) Khan, staff

### TRad 8300f,w,s,su. Radiation Therapy. (Cr ar) Kim, Lee, Levitt, Potish

In-service training in treatment and management of patients with malignant diseases.

### TRad 8310f,w,s,su. Fundamentals of Radiation Therapy. (1 cr) Kim, Lee, Levitt, Potish

Lectures on physical and clinical aspects of radiation therapy. Techniques of radiation therapy including radium and other isotopic implants.

### TRad 8315f,w,s,su. Radiation Therapy Pathology. (1 cr)

Weekly 1/2- to 2-hour seminar relating microscopic and gross anatomy of tumors to clinical findings, diagnostic workup, and therapy of patients receiving radiation therapy. Includes clinical descriptions of patients followed by comprehensive discussion of the microscopic, gross pathology, and overview of tumor pathology. Offered in conjunction with the Department of Laboratory Medicine and Pathology.

### TRad 8320f,w,s,su. Radiation Therapy Treatment Planning Problems. (1 cr)

Weekly 1/2- to 2-hour seminar. Treatment planning, computer treatment planning, treatment fields of patients under treatment, and treatment planning programs discussed with staff of the clinical and physics sections.

### TRad 8350f,w,s,su. Research in Radiation Therapy. (Cr ar)

### TRad 8450f,w,s,su. Research in Radiation Biology. (Cr ar)

# **G r a d u a t e O f f e r i n g s , D u l u t h C a m p u s**

**This is the Duluth Program and Course Designators section of  
the University of Minnesota 1996-1999 Graduate School Catalog**

## General Information

At the University of Minnesota, Duluth, the Graduate School offers programs for the *master of arts* degree in art (emphases in art studies and studio art), communication disorders, educational psychology (emphasis in counseling), and English (emphases in literary studies and English studies). Programs for the *master of science* degree are offered in applied and computational mathematics, biology, chemistry, computer science, geology, and physics. In addition, the *master of business administration*, *master of liberal studies*, *master of music*, and *master of social work* degrees are offered.

All-University M.S./Ph.D. programs in toxicology and water resources science are offered jointly with the Twin Cities campus. In addition, several graduate programs operate at the University of Minnesota, Duluth, under the aegis of the graduate program of their related department on the Twin Cities campus. Cooperative programs offered at both the master's and doctoral levels include interdisciplinary archaeological studies, biochemistry, microbiology, pharmacology, and physiology. Students interested in these programs should see the listing for each program in the Fields of Instruction section of this bulletin.

All programs are under the jurisdiction of the dean of the Graduate School and have admission, candidacy, and degree requirements comparable to their counterpart programs on the Twin Cities campus. General Graduate School regulations, including those for minimum degree requirements, apply to programs offered on the Duluth campus (see the General Information section at the beginning of this bulletin).

## Financial Aid and Other Assistance

Assistantships are normally granted through the individual departments subject to the stipulations described in the General Information section at the front of this bulletin. Information about these assistantships can be obtained by writing to the department director of graduate studies. With an assistantship

appointment of 25 percent or more, hospitalization and medical insurance coverage is provided at no additional cost.

Some residence counseling positions may be available. For information, write to the Housing Office, 149 Lake Superior Hall, University of Minnesota, Duluth, MN 55812.

Inquiries regarding loan funds, living accommodations, employment, and placement should be addressed to the Vice Chancellor for Academic Support and Student Life, 297 Darland Administration Building, University of Minnesota, Duluth, MN 55812.

## Program Statements

Brief descriptions of the various degree programs are listed below. Further details are available from the directors of graduate studies designated. Course offerings are listed in the *Duluth Bulletin*. General information concerning graduate work on the Duluth campus may be obtained from the Graduate School Office—Duluth, 431 Darland Administration Building, University of Minnesota, Duluth, MN 55812. Information is also available through the World Wide Web at <http://www.d.umn.edu/grad>.

## Applied and Computational Mathematics

**Director of Graduate Studies**—Associate Professor Barry R. James.

**Degree Offered**—M.S. (Plan A and B).

**Prerequisites for Admission**— Undergraduate degree with major in mathematics, statistics, or a field with a substantial background in mathematics or statistics (e.g., computer science or engineering). If certain prerequisites for graduate courses are lacking, they may be made up concurrently with graduate work within the first year. Scores from the General (Aptitude) Test of the Graduate Record Examination (GRE) are required of all applicants. Scores of the Test of English as a Foreign Language are required if the native language is not English.

**Thesis Emphases**—For Plan A: applied mathematics, statistics, mathematical modeling and simulation techniques.

**Major Requirements**—For Plans A and B: 25 credits of approved mathematics courses or seminars and demonstrated competence in basic material through a written examination. For Plan A: a thesis and a final oral examination on the thesis. For Plan B: a project and 16 additional credits from approved graduate-level mathematics or related courses.

**Related Field Requirements**—For Plans A and B: 8 credits in a related field(s) outside mathematics. Plan A students may choose minor requirements instead of related field requirements.

**Minor Requirements**—For Plan A: 9 credits from the same prefix area in a related field outside mathematics and statistics.

**Language Requirement**—None.

**Other Requirements**—Demonstrated intermediate-level competence in a modern scientific computer programming language such as FORTRAN, Pascal, or C.

## Art

**Director of Graduate Studies**—Associate Professor James Klueg.

**Degrees Offered**—M.A. (Plan B only) emphasis art studies; M.A. (Plan B only) emphasis studio art.

**Prerequisites for Admission**—The normal prerequisites for admission are an interest in personal development in studio; an interest in related areas such as art history, museum studies, humanities, or teaching; and a B.A., B.S., or B.F.A. degree in art. Individuals with undergraduate degrees in other disciplines who have completed a substantial number of art courses may be considered for admission. Students with minor deficiencies may be admitted with the provision that equivalent coursework or approved substitutions be completed during the first year of graduate study.

A portfolio of slides (15 to 20) of original work is required as part of the application. Other relevant visual material in the form of videotape or film may also be included. Applicants may be requested to submit actual

work. All supporting materials should be sent or hand-delivered to the director of graduate studies, Department of Art, at the time the application form is submitted to the Graduate School office. When feasible, applicants should schedule an on-campus interview.

Full-time attendance for three quarters and summer work would be the minimum time commitment to complete this degree; typically students take coursework over 5-6 quarters.

**Emphasis Art Studies**—Candidates may focus on one studio area or pursue work in several related studio areas. Art history is part of the related field requirement, and other approved courses may be elected from the humanities, education, or internships in museum practice or arts administration. Candidates will complete an approved 6- to 9-credit project and supporting paper, will participate in the graduate review studio sessions, and complete the oral examination. At least 44 quarter credits are required in the following areas: 20 to 29 credits in art, 9 credits in art history (related field), and 6 to 15 credits in other related areas, including the final project and supporting paper.

**Emphasis Studio Art**—Candidates work under the direction of a faculty member in the appropriate studio area and with faculty having related expertise. Participation in the periodic graduate reviews, a satisfactory exhibition of the student's work in the Tweed Museum of Art, and completion of an approved supporting paper are major requirements. An oral examination covering coursework and the area of the supporting paper is the final step toward completing the degree.

While students should have a major focus for their studio work, experience in a related studio area may be desirable. At least 44 quarter credits are required: 32 credits in studio art and 12 credits in art history (related field).

## Biology

**Director of Graduate Studies**—Associate Professor David J. Schimpf.

**Degree Offered**—M.S. (Plan A and B).

**Prerequisites for Admission**—Introductory biology plus at least 24 additional quarter credits of approved coursework in biology, inorganic and organic chemistry, introductory calculus, and a sequence in general or introductory physics (or equivalent analytical sciences) are required. Students with deficiencies may be admitted with the provision that equivalent coursework or approved substitutions be completed during the first year of graduate study. Students must submit test scores, not more than two years old, from the Graduate Record Examination (GRE) General Test (verbal, quantitative, and analytical sections) and from the Subject (Advanced) Test in biology as part of their application materials. If appropriate, scores from the biochemistry, cell and molecular biology Subject Test may be substituted for biology Subject Test scores.

Prior coursework and GRE scores will be used to ascertain proficiency in the areas of general biology, genetics, cell biology, and ecology. Such proficiency will be considered in the admission deliberations.

**Language Requirement**—None.

**Degree Requirements**—Candidates following either plan must present a department seminar near the end of their studies and must pass an oral final examination. For Plan A, 8 credits must be completed in a related field(s) or 9 credits in a minor field. For Plan B, 8 credits must be completed in a related field(s).

## Business Administration

**Director of Graduate Studies**—Professor Thomas B. Duff.

**Degree Offered**—M.B.A. (Plan B only).

**Language Requirement**—None.

**Credit Requirements**—A minimum of 45 credits.

**Major Requirements**—A total of 30 credits in the M.B.A. core is required. In addition, 9 credits in an M.B.A. research project are required for the field research option.

**Related Field Requirements**—A total minimum of 9 credits in supporting fields for the field research option, or a total minimum of 15 credits in supporting fields for the course-only option.

## Chemistry

**Director of Graduate Studies**—Professor Thomas J. Bydalek.

**Degree Offered**—M.S. (Plan A and B).

**Prerequisites for Admission**—Undergraduate chemistry major, including a junior-senior level course in inorganic chemistry, one year of physical chemistry, mathematics through calculus, and one year of college physics, preferably taught using calculus. Students lacking some of these prerequisites may make up deficiencies concurrently with graduate work.

**Thesis Emphases**—For Plan A, analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, physical chemistry.

**Major Requirements**—The specific program is worked out to best serve the interests of the student. All students will complete at least three of the five core courses: Chem 5710, 5720, 5730, 5740, and 5750.

**Other Requirements**—The final examination for both Plan A and Plan B is oral. For both Plan A and Plan B, proficiency examinations must be taken before initial registration, and attendance and presentation at the chemistry seminar are required. For Plan B, preparation of three papers in the major and related fields is required.

## Communication Disorders

**Director of Graduate Studies**—Associate Professor Faith C. Loven.

**Degree Offered**—M.A. (Plan B only).

**Prerequisites for Admission**—Bachelor's degree in communication disorders or 50 quarter credits in speech/language pathology, audiology, speech/language/hearing science, or related areas. Three letters of recommendation are also required.

**Language Requirement**—None.

**Major Requirements**—53 credits in communication disorders are required, including CD 5060, 5076, 5276, 5371, 5472 or 5476, 5500, 5505, 5575, 5600, 5956, 8100, 8176, 8205, 8305, and 8900.

**Other Requirements**—8 credits of coursework outside of communication disorders. Final written and oral examinations are required. Plan B projects must be completed in conjunction with CD 8900. All such projects must be planned and carried out in consultation with a faculty member from the department.

## Computer Science

**Director of Graduate Studies**—Associate Professor Carolyn J. Crouch.

**Degree Offered**—M.S. (Plan A and B).

**Prerequisites for Admission**—Applicants should have completed an undergraduate major in computer science. Other undergraduate majors who have substantial background in mathematics and basic core computer science may be considered for admission. Applicants lacking prerequisites may be admitted with the understanding that deficiencies be made up concurrently with graduate work within the first year. The Graduate Record Examination (GRE) General Test is required.

**Language Requirement**—None.

**Major Requirements**—A minimum of 49 credits of graduate coursework are required, which must include CS 8021, 8022, 8023, and 1 credit of the CS 8900 seminar, and 8 credits from one or more related fields outside of computer science (or 9 credits from a single related field to form an outside minor), as approved by the director of graduate studies.

**Other Requirements**—Plan A: 16 credits of CS 8777 (thesis); 12 credits from graduate-level courses in computer science, as approved by the director of graduate studies; and presentation of thesis results at a department colloquium. Plan B: a minimum of 20 credits from graduate-level courses in computer science, as approved by the director of graduate studies; completion of an approved Plan B

project (usually a significant programming project); and presentation of a department colloquium based on Plan B project work. All students must pass a final oral examination on their thesis or project, supporting area(s), and graduate-level computer science as reflected in the required courses and prerequisites.

## Educational Psychology

**Director of Graduate Studies**—Associate Professor Janine A. Watts.

**Degrees Offered**—M.A. (Plan B) with emphasis on school or community counseling.

**Prerequisites for Admission**—A minimum undergraduate GPA of 3.00 on a 4.00 scale, a minimum of 9 quarter credits in psychology, including an undergraduate inferential statistics course, the Graduate Record Examination General Test, evidence of social service experience, and three letters of recommendation. The application deadline for the following fall is March 15. Applications submitted after March 15 will be considered only if space is available.

**Language Requirement**—None.

**Major Requirements**—The program is two years of full-time study totaling 72 credits. This includes 54 graduate credits in core courses, including counseling theories and skills, group procedures, ethics, developmental guidance, cross-cultural counseling, family counseling, learning, consultation, tests and measurement, statistics, and research methods; a Plan B paper (3-9 credits); and three quarters (720 hours) of practicum (9 credits).

**Related Field Requirements**—A minimum of 8 credits must be taken outside the psychology department.

**Other Requirements**—A final written comprehensive examination on core and related coursework and an oral examination on the Plan B paper are required. School counselors are advised to take different electives than community counselors. Because licensure requirements are determined by state agencies and subject to change, contact the director of graduate studies for current requirements.

Students pursuing the community counseling emphasis should select electives that prepare them for licensure in the state where they will seek employment and/or electives that will enhance their work with specific populations.

## English

**Director of Graduate Studies**—Professor William A. Gibson.

**Degrees Offered**—M.A. (Plan B) with emphases on literary studies and on English studies.

The M.A. in English has two tracks. The M.A. (Plan B) with emphasis on literary studies is a traditional literary program. The M.A. (Plan B) with emphasis on English studies provides broad, balanced training in literature, linguistics, and rhetoric and composition. This major (both tracks) deals with subject matter appropriate for preparing to teach English.

**Prerequisites for Admission**—Students applying for admission to either of these programs must submit scores from the General Test of the GRE, two writing samples such as course papers, and three letters of recommendation. The entering student should have completed 44 credits in English (these may include credits in literature, language, and advanced composition), including 28 upper division credits.

### M.A. (Plan B) with Emphasis on Literary Studies

**Course Prerequisites**—Students must have completed, or complete as graduate students, upper division courses in Chaucer, Shakespeare, Milton, and the English language or English linguistics. Some course prerequisites may be taken concurrently with graduate work and used toward degree requirements.

**Language Requirement**—A reading knowledge of Latin, Greek, French, German, Italian, Spanish, Russian, or another approved language is required.

**Degree and Major Requirements**—A minimum of 44 credits is required. The major

must have at least 36 credits, including 12 credits in English proseminars and 4 credits of Engl 8906.

**Related Field Requirements**—Students must complete at least 8 credits in one or more related fields outside the major. Linguistics can be taken as a related field or as a designated minor.

**Other Requirements**—Students must complete a two-day, five-hour written examination containing the following sections: (1) analysis of a text selected before the examination; (2) discussion of questions on a reading list prepared by the candidate and approved by the examining committee; and (3) discussion of questions dealing with a related field.

Before taking the examination, the student must submit Plan B papers (normally three) or projects totaling 120 hours of effort. These projects will normally be completed in connection with graduate courses in English or in a related field. A completed project must be approved by a member of the graduate faculty.

### M.A. (Plan B) with Emphasis on English Studies

**Language Requirement**—Candidates may choose certification in a foreign language or complete 8 credits of graduate coursework in addition to the minimum required 44 credits. Certification is gained by demonstrating a reading knowledge of a foreign language appropriate for the candidate's area of study and approved by the English Graduate Committee. Candidates whose professional objectives are best served by completing the additional 8 credits will select graduate courses from the categories of literature and literary analysis, linguistics, and rhetoric and composition, or graduate courses closely related to the field of concentration chosen for the degree.

**Degree and Major Requirements**—A minimum of 44 credits is required. The major has 36 credits, consisting of 4 credits in Engl 8906; 8 credits in literature and literary analysis; 8 credits in linguistics, including Ling 5842; 8 credits in rhetoric and composition; and 8 credits of electives offered by the English or

composition departments at the 5xxx or 8xxx level. Students in residence during the regular academic year must take 12 credits in 8xxx courses.

**Related Field Requirements**—Students must complete at least 8 credits in one or more related fields outside the major. Linguistics can be taken as a related field or as a designated minor.

**Other Requirements**—Candidates will take a comprehensive examination, which will include both written and oral sections. The examination will test the student's knowledge in the following areas: literature and literary analysis, linguistics, rhetoric and composition, and the related field(s).

The Plan B project requirement is the same as that for the M.A. (Plan B) with emphasis on literary studies.

## Geology

**Director of Graduate Studies**—Associate Professor Penelope Morton.

**Degree Offered**—M.S. (Plan A and B).

**Prerequisites for Admission**—An undergraduate major in geology, geophysics, or a related earth science with a summer field camp (full time for at least five weeks) and one year each of college mathematics including calculus, college chemistry, and college physics. Scores from the Graduate Record Examination (GRE) General Test are required.

**Language Requirement**—None.

**Other Requirements**—A written candidacy examination during the second or third quarter and an oral final examination are required.

## Liberal Studies

**Director of Graduate Studies**—Professor James H. Fetzer.

**Degree Offered**—M.L.S. (Plan B only)

**Prerequisites for Admission**—Applications must include a narrative letter stating the reasons for wanting to pursue the M.L.S. and describing educational and career experiences.

**Language Requirement**—None.

**Major Requirements**—Completion of 44 credits in approved coursework, including 12 credits of required core courses and 32 credits of electives. The individually designed plan of study can include graduate courses in the humanities, social sciences, and natural sciences that meet personal and educational aims of the student.

**Related Field Requirements**—Because the program is interdisciplinary and composed of courses from several departments, the related field requirement is waived.

**Other Requirements**—One, two, or three research papers or projects in an approved area of interest must be submitted in addition to passing a final oral presentation/examination.

## Music

**Director of Graduate Studies**—Professor Judith A. Kritzmire.

**Degree Offered**—M.M. (Plan B only) with emphasis on music education.

**Prerequisites for Admission**—A bachelor's degree in music, scores from the Graduate Record Examination General Test, entrance examinations in music history and theory, and an entrance audition are required.

**Language Requirement**—None.

**Major Requirements**—A minimum of 33 credits in music education/education is required, of which 9 credits are the Plan B project.

**Related Field Requirements**—A minimum of 12 credits in music (e.g., history, theory, applied study, ensembles).

## Physics

**Director of Graduate Studies**—Assistant Professor Jonathan Maps.

**Degree Offered**—M.S. (Plan A and B).

**Prerequisites for Admission**—Undergraduate degree in physics or equivalent.

**Language Requirement**—None.

**Major Requirements**—At least 20 credits in six approved physics courses numbered above 5103, including at least 8 credits chosen from

Phys 5123 or 5124 or 5125 (no more than one of these three courses), and 5109, 5166, 5174, 5176, 5177, and 5178.

For a more interdisciplinary concentration—for example, in geophysics or physical limnology—an individualized program can be planned by the student and his or her adviser to suit the student's needs and interests. Such a program must be approved by the director of graduate studies.

**Related Field Requirements**—8 credits in related fields outside of physics, such as biology, chemistry, geology, or mathematics. A student who wants to complete a minor must complete 9 credits in a single department outside physics.

## Social Work

**Director of Graduate Studies**—Professor Dennis R. Falk.

**Degree Offered**—M.S.W. (Plan B only).

**Prerequisites for Admission**—Applicants for the 81-credit program must meet the following five prerequisites:

- the bachelor's degree must be from an accredited college or university;
- applicants must have at least 3 quarter credits in each of the following areas: human biology, sociology or anthropology, economics, political science, psychology, and statistics (the course in statistics may be taken during the first year after admission, but cannot be applied toward the M.S.W. program requirements);
- strong academic performance as demonstrated by a minimum cumulative undergraduate grade point average of 3.00;

- preference will be given to applicants with professional experience in human service settings; and
- demonstrated interest in becoming a social worker is required.

Applicants with a B.S.W. degree from a Council on Social Work Education accredited program may apply for the 51-credit advanced standing program. All other admission requirements are the same as in the 81-credit program.

**Language Requirement**—None.

**Degree Requirements**—A total of 81 credits of graduate-level work (51 credits for students admitted with advanced standing) is required. A minimum of 69 credits must be completed in social work courses (33 for students with advanced standing).

**Related Field Requirements**—At least one graduate elective course (minimum 3 credits) from outside the Department of Social Work is required.

**Other Requirements**—Included as part of the 81-credit program are 24 credits (960 hours) of field placement in human services agencies. Advanced standing student (51-credit program) are required to take 12 credits (480 hours) of field placement. Plan B projects are to be completed in conjunction with SW 8750. A final oral examination is required. A level of personal and professional competence, considered satisfactory for entrance into the profession of social work in the field of human services, as indicated by class evaluations and field placement evaluations, is required.

Below is an alphabetical listing of the designators under which courses are organized within the Graduate Programs and Related Courses sections of this bulletin. The listing is provided to help students find the full description of prerequisite courses and courses that are only partially described under interdisciplinary program listings that include courses from other fields.

Directly following each designator below is its referent, followed by a “see” note in cases where the program or unit name under which the courses are listed differs from the referent. For example, courses in Chinese (Chn) and in Japanese (Jpn) are found under East Asian Languages, Literatures, and Linguistics. Some designators below are used only for thesis credits, as when a program has no single identifying designator; for example, Business Administration uses twelve designators for its courses, but BA is used only for thesis credits. *Note*—Some designators that appear after the equivalent course marker § in prerequisite statements may not be found below, because they refer to a previous designator for that program.

Acct	Accounting—see Business Administration	Bldg	Building Science
AdEd	Adult Education—see Work, Community, and Family Education	BMEn	Biomedical Engineering
AdPy	Adult Psychiatry—see Psychiatry under Related Courses	BMSc	Biomedical Science
AEM	Aerospace Engineering and Mechanics	BPhy	Biophysical Sciences—see Biophysical Sciences and Medical Physics
Afro	Afro-American Studies—see Studies in Africa and the African Diaspora	CAPS	Clinical and Population Sciences—see Veterinary Medicine
AgEd	Agricultural Education—see Work, Community, and Family Education	CAPy	Child and Adolescent Psychiatry—see Psychiatry under Related Courses
AgET	Agricultural Engineering Technology—see Biosystems and Agricultural Engineering	CAS	Central Asian Studies—see Russian Area Studies
Agro	Agronomy and Plant Genetics—see Agronomy	CBio	Conservation Biology
Akka	Akkadian—see Classical and Near Eastern Studies	CBN	Cell Biology and Neuroanatomy—see Anatomy; Molecular, Cellular, Developmental Biology and Genetics
Amln	American Indian Studies—under Related Courses	CDis	Communication Disorders
AmSt	American Studies	CE	Civil Engineering
ANE	Ancient Near Eastern—see Classical and Near Eastern Studies	CgSc	Cognitive Science
Anes	Anesthesiology—under Related Courses	Chem	Chemistry
AnPl	Animal and Plant Systems—see Agronomy	ChEn	Chemical Engineering—see Chemical Engineering and Materials Science and Engineering
AnSc	Animal Sciences	Chic	Chicano Studies—under Related Courses
Anth	Anthropology	Chn	Chinese—see East Asian Languages, Literatures, and Linguistics
ApEc	Applied Economics—see Agricultural and Applied Economics	ChPh	Chemical Physics
Arab	Arabic	CI	Curriculum and Instruction
Arch	Architecture	Clas	Classics—see Classical and Near Eastern Studies
Area	Area Studies—see East Asian Studies; Russian Area Studies; Latin American Studies under Related Courses	CLit	Comparative Literature
Arm	Aramaic—see Classical and Near Eastern Studies	CLS	Clinical Laboratory Science
ArtH	Art History	CmpE	Computer Engineering
ArtS	Art	Copt	Coptic—see Classical and Near Eastern Studies
Ast	Astronomy—see Astrophysics	CPsy	Child Psychology
BA	Business Administration	CSci	Computer Science—see Computer and Information Sciences
BAE	Biosystems and Agricultural Engineering	C_SCL	Cultural Studies and Comparative Literature—under Related Courses
BFin	Finance—see Business Administration	CSDS	Comparative Studies in Discourse and Society
BGS	Business, Government, and Society—see Business Administration	CSDy	Control Science and Dynamical Systems
BIE	Business and Industry Education—see Work, Community, and Family Education	Dent	Dentistry
BioC	Biochemistry (College of Biological Sciences)—see Biochemistry, Molecular Biology, and Biophysics	Derm	Dermatology—under Related Courses
Biol	Biology—under Related Courses	DHA	Design, Housing, and Apparel
BLaw	Business Law—see Business Administration	Dnce	Dance—see Theatre Arts
		DSSC	Development Studies and Social Change
		Dtch	Dutch—see German

## COURSE DESIGNATORS

EAS	East Asian Studies	IDSc	Information and Decision Sciences—see Business Administration
Econ	Economics	IEOR	Industrial Engineering/Operations Research—see Mechanical Engineering and Industrial Engineering
EdAd	Educational Administration—see Educational Policy and Administration	InAr	Interdisciplinary Archaeological Studies
EdPA	Educational Policy and Administration	Ins	Insurance—see Business Administration
Educ	Education—see Curriculum and Instruction; Education; Kinesiology and Leisure Studies; Work, Community, and Family Education	IntR	International Relations—under Related Courses
EE	Electrical Engineering	IR	Industrial Relations
EEB	Ecology, Evolution, and Behavior—see Ecology	IRel	Interpersonal Relationships Research
Endo	Endodontics—see Dentistry	Ital	Italian—see French and Italian
Engl	English Language and Literature—see English	Jour	Journalism and Mass Communication—see Mass Communication
EngW	English: Creative and Professional Writing—see English	Jpn	Japanese—see East Asian Languages, Literatures, and Linguistics
Ent	Entomology	JwSt	Jewish Studies—under Related Courses
Entr	Entrepreneurship—see Business Administration	Kin	Kinesiology—see Kinesiology and Leisure Studies
EPSy	Educational Psychology	LA	Landscape Architecture
ESL	English as a Second Language	LAS	Latin American Studies—under Related Courses
FE	Family Education—see Work, Community, and Family Education	Lat	Latin—see Classical and Near Eastern Studies
ForP	Forest Products—see Forestry	LgTT	Language, Teaching, and Technology—under Related Courses
Fors	Forestry	Ling	Linguistics
FPCH	Family Practice and Community Health	LM	Logistics Management—see Business Administration
FR	Forest Resources—see Forestry	LS	Liberal Studies—see Liberal Studies
Fren	French—see French and Italian	Mar	Marathi—see South Asian and Middle Eastern Languages and Cultures
Frit	French and Italian	Math	Mathematics
FScN	Food Science and Nutrition—see Food Science; Nutrition	MatS	Materials Science—see Chemical Engineering and Materials Science and Engineering
FSoS	Family Social Science	MBA	Master of Business Administration—see Business Administration
FW	Fisheries and Wildlife—see Fisheries; Wildlife Conservation	MCDG	Molecular, Cellular, Developmental Biology and Genetics
GCB	Genetics and Cell Biology—see Molecular, Cellular, Developmental Biology and Genetics	MdBc	Biochemistry (Medical School)—see Biochemistry, Molecular Biology, and Biophysics
Geo	Geology and Geophysics	MdGk	Modern Greek—see Classical and Near Eastern Studies
GeoE	Geological Engineering	ME	Mechanical Engineering—see Mechanical Engineering and Industrial Engineering
Geog	Geography	MedC	Medical Chemistry
Ger	German	MELC	Middle Eastern Languages and Cultures—see South Asian and Middle Eastern Languages and Cultures
Gero	Gerontology	MeSt	Medieval Studies
GPhl	Germanic Philology	Mgmt	Management—see Business Administration
Grk	Greek—see Classical and Near Eastern Studies	MicB	Microbiology—see Microbiology, Immunology, and Molecular Pathobiology
HE	Human Ecology—see Design, Housing, and Apparel	MicE	Microbial Engineering
Hebr	Hebrew—see Classical and Near Eastern Studies	MIMP	Microbiology, Immunology, and Molecular Pathobiology
HInf	Health Informatics	Mktg	Marketing—see Business Administration
Hist	History	MOT	Management of Technology
HMed	History of Medicine—see History of Medicine and Biological Sciences	MSt	Museum Studies
Hndi	Hindi—see South Asian and Middle Eastern Languages and Cultures	MthE	Mathematics Education—see Curriculum and Instruction
Hort	Horticultural Science—see Horticulture		
HRD	Human Resources Development—see Work, Community, and Family Education		
HSci	History of Science and Technology		
Hum	Humanities—under Related Courses		
HumF	Human Factors—see Human Factors/Ergonomics		

MuEd	Music Education—see Music	SACS	Small Animal Clinical Sciences—see Veterinary Medicine
Mus	Music	SAgr	Sustainable Agricultural Systems
MusA	Music Applied—see Music	SALC	South Asian Languages and Cultures—see South Asian and Middle Eastern Languages and Cultures
NRES	Natural Resource and Environmental Studies—see Forestry	SAPH	Social and Administrative Pharmacy—see also Hospital Pharmacy
NSc	Neuroscience	Scan	Scandinavian—see Scandinavian Studies
NSu	Neurosurgery—under Related Courses	SciC	Scientific Computation
Nurs	School of Nursing—see Nursing	ScTP	Science and Technology Policy—see Public Affairs
Nutr	Nutrition	Skt	Sanskrit—see South Asian and Middle Eastern Languages and Cultures
OBio	Oral Biology	Slav	Slavic—see Russian Area Studies
OMS	Operations and Management Science—see Business Administration	Soc	Sociology
OPat	Oral Pathology—see Dentistry	Soil	Soil Science
Oph	Ophthalmology—under Related Courses	Span	Spanish—see Hispanic and Luso-Brazilian Literatures and Linguistics
ORad	Oral Radiology—see Dentistry	Spch	Speech-Communication
OSur	Oral and Maxillofacial Surgery—see Dentistry	SpPt	Spanish-Portuguese—see Hispanic and Luso-Brazilian Literatures and Linguistics
OT	Occupational Therapy	SST	Studies of Science and Technology
Otho	Orthodontics—see Dentistry	Stat	Statistics
Otol	Otolaryngology	Sum	Sumerian—see Classical and Near Eastern Studies
PA	Public Affairs	Surg	Surgery
Path	Pathobiology—see Microbiology, Immunology, and Molecular Pathobiology	SW	Social Work
PBio	Plant Biology—see Plant Biological Sciences	TESL	Teaching English as a Second Language—see English as a Second Language
Ped	Pediatrics—under Related Courses	Tgen	Teriogenology—see Veterinary Medicine
Pedo	Pediatric Dentistry—see Dentistry	Th	Theatre Arts
Pero	Periodontics—see Dentistry	TRad	Therapeutic Radiology—under Related Courses
Phcl	Pharmacology	Txcl	Toxicology
Phil	Philosophy	VB	Veterinary Biology—see Veterinary Medicine
Phm	Pharmaceutics	VDM	Veterinary Diagnostic Medicine—see Veterinary Medicine
Phmc	Pharmaceutics, Undergraduate—see Pharmaceutics	VMed	Veterinary Medicine
Phsl	Physiology—see Cellular and Integrative Physiology	VPB	Veterinary Pathobiology—see Veterinary Medicine
Phys	Physics	VSRA	Veterinary Surgery, Radiology, and Anesthesiology—see Veterinary Medicine
PIBr	Plant Breeding	WCFE	Work, Community, and Family Education
PIPa	Plant Pathology	WoSt	Women's Studies—see Feminist Studies
Plsh	Polish—see Russian Area Studies	WRS	Water Resources Science
PMed	Physical Medicine and Rehabilitation—see Occupational Therapy; Physical Therapy; Rehabilitation Science	YoSt	Youth Development and Research—see Social Work
PNI	Psychoneuroimmunology	Zool	Zoology
Pol	Political Science		
Port	Portuguese—see Hispanic and Luso-Brazilian Literatures and Linguistics		
Pros	Prosthodontics—see Dentistry		
Psy	Psychology		
PT	Physical Therapy		
PubH	Public Health—see also Biostatistics; Environmental Health; Epidemiology; Health Services Research and Policy; Health Services Research, Policy and Administration		
Rad	Radiology—under Related Courses		
RAS	Russian Area Studies		
Rec	Recreation, Park, and Leisure Studies—see Kinesiology and Leisure Studies		
RelA	Religions in Antiquity—see Religious Studies		
Rhet	Rhetoric—see Rhetoric and Scientific and Technical Communication		
RSc	Rehabilitation Science		
Russ	Russian—see Russian Area Studies		