

College of Biological Sciences

UNIVERSITY OF MINNESOTA

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College of Biological Sciences

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Introduction

Information Resources—This biennial bulletin focuses on the undergraduate offerings of the College of Biological Sciences (CBS) on the Twin Cities campus of the University of Minnesota. Major requirements, brief course descriptions, and faculty information are provided.

The *Class Schedule*, distributed with registration materials each quarter, lists current course offerings scheduled for the term, including class hours, rooms, and instructors. It also includes registration instructions, final exam schedules, and other useful information. Information about evening courses and summer school offerings is in the *Extension Classes Bulletin* and the *Summer Session Bulletin*, respectively.

A bachelor of arts (B.A.) degree with a major in biology is available through the College of Liberal Arts (CLA). The core course requirements for this degree are the same as those for the bachelor of science (B.S.) degree. However, the B.A. student must fulfill the additional CLA requirements that are outlined in the *College of Liberal Arts Bulletin*. A student interested in teaching biology at the secondary level should consult the College of Education office for information about the specialized curriculum that is available.

CBS policies, and other specific information of interest to enrolled students, may be found in the *CBS Student Handbook*.

For More Information—Contact the Director of Student Services, College of Biological Sciences, 223 Snyder Hall, University of Minnesota, 1475 Gortner Avenue, St. Paul, MN 55108 (612/624-9717).

Policies

Bulletin Use—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.

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, 420 S.C. 20000e; by the requirements of Title IX of the Education Amendments of 1972; by Sections 503 and 504 of the Rehabilitation Act of 1973; 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 Patricia A. Mullen, 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).

Immunization—Students born after 1956 who take more than one University class are required under Minnesota law to submit an Immunization Record form.

The form, which is sent along with the official University admission letter, must be filled out and returned to Boynton Health Service within 45 days of the first term of enrollment in order for students to continue registering for classes 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.

Planning to Transfer?

Minnesota's public colleges and universities are working to make transfer easier. You can help if you **PLAN AHEAD, ASK QUESTIONS, and USE PATHWAYS** created by transfer agreements.

Preparing for Transfer

If you are currently enrolled in a college or university:

- Discuss your plans with the campus transfer specialist in the Office of Student Services, 223 Snyder Hall (612/624-9717).
- Call or visit your intended transfer college. You should obtain the following materials and information:
 - college catalog
 - transfer brochure
 - information on admissions criteria and on materials required for admission (e.g., portfolio, transcripts, test scores). Note that some majors have limited enrollments or their own special requirements such as a higher grade point average.
 - information on financial aid (how to apply and by what date)
- After you have reviewed these materials, make an appointment to talk with an adviser/counselor in the college or program you want to enter. Be sure to ask about course transfer and admission criteria.

If you are not currently enrolled in a college or university, you might begin by meeting with a transfer specialist or an admission officer at your intended transfer college to plan the steps you need to take.

Understanding How Transfer of Credit Works

- The receiving college or university decides what credits transfer and whether those credits meet its degree requirements. The accreditation of both your sending and your receiving institution can affect the transfer of the credits you earn.
- Institutions accept credits from courses and programs like those they offer. They look for similarity in course goals, content, and level. "Like" transfers to "like."
- Not everything that transfers will help you graduate. Baccalaureate degree programs usually count credits in three categories: general education, major/minor courses and prerequisites, and electives. The key question is, "Will your credits fulfill requirements of the degree or program you choose?"
- If you change your career goal or major, you might not be able to complete all degree requirements within the usual number of graduation credits.

Applying for Transfer Admission

- Application for admission is always the first step in transferring. Fill out the application as early as you can prior to the deadline. Enclose the application fee.
- Request that official transcripts be sent from every institution you have attended. You might be required to provide a high school transcript or GED test scores as well.
- Recheck to be certain you supplied the college or university with all the necessary paperwork. Most colleges make no decisions until all required documents are in your file.
- If you have heard nothing from your intended college of transfer after one month, call to check on the status of your application.
- After the college notifies you that you have been accepted for admission, your transcribed credits will be evaluated for

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transfer. A written evaluation should tell you which courses transfer and which do not. How your courses specifically meet degree requirements may not be decided until you arrive for orientation or have chosen a major.

- If you have questions about your evaluation, call the Office of Admissions and ask to speak with a credit evaluator. Ask why judgments were made about specific courses. Many concerns can be cleared up if you understand why decisions were made. If not satisfied, you can appeal. See “Your Rights as a Transfer Student” below.

Your Rights as a Transfer Student

- A clear, understandable statement of an institution’s transfer policy.

- A fair credit review and an explanation of why credits were or were not accepted.

- A copy of the formal appeals process.

Usual appeals steps are: 1) Student fills out an appeals form. Supplemental information you provide to reviewers—a syllabus, course description, or reading list—can help. 2) Department or committee will review. 3) Student receives, in writing, the outcome of the appeal. 4) Student can appeal decision to the Office of Student Services, 223 Snyder Hall (612/624-9717).

- At your request, a review of your eligibility for financial aid or scholarships.

For help with your transfer questions or problems, see your campus transfer specialist.



College of Biological Sciences Directory

Office of the Dean	123 Snyder Hall	624-2244
Dean, P. T. Magee; Associate Dean, Sally Jorgensen; Assistant Dean, Kathryn Hanna		
Student Services		
Advising and Registration	223 Snyder Hall	624-9717
Kathleen Peterson, Leah Clark, Becky Raiche		
Honors Program	223 Snyder Hall	625-5700
Dr. Franklin Barnwell		
Minority Affairs	123 Snyder Hall	624-3060
Dr. Val Woodward		
Services for Disabled Students	124E Snyder Hall	624-1257
Kathy Ball		
Career Information Center	217 Snyder Hall	624-9270
Kathleen Peterson		
Professional Learning Experience Program	217 Snyder Hall	624-9270
Amy Winkel		
International Education	611 BioSci	625-1958
Dr. Willard Koukkari		
Biology Colloquium	305 Bell Museum	626-1674
Dr. Albert Frenkel, Kathryn Hanna, Dr. Velta Sparrins, Dr. James Underhill		
Community Outreach	217 Snyder Hall	624-9717
William Ganzlin		

Departments, Institutes, and Programs

Bell Museum of Natural History	300 Bell Museum (Mpls.)	624-1852
Biochemistry	140 Gortner (St. Paul)	624-7755
Biological Process Technology Institute	240 Gortner (St. Paul)	624-6774
Cedar Creek Program	511 Ecology (St. Paul)	625-5740
Ecology, Evolution, and Behavior	100 Ecology (St. Paul)	625-5700
General Biology	P180 Kolthoff (Mpls.)	625-6636
Genetics and Cell Biology	250 BioSci (St. Paul)	624-3003
Gray Freshwater Biological Institute	Navarre, MN	471-8476
Institute of Human Genetics	4-122 Moos Tower (Mpls.)	624-3110
Instructional Computing Center	122 Snyder (St. Paul)	625-2273
Itasca Biology Program	303 Ecology (St. Paul)	624-6743
Microbiology	1460 Mayo (Mpls.)	624-6190
Molecular Biology Computer Center	247 Gortner (St. Paul)	625-9284
Plant Biology (Botany)	220 BioSci (St. Paul)	625-1234
Plant Molecular Genetics Institute	411 Borlaug (St. Paul)	625-1213
Teaching Laboratory Support Staff	121 BioSci (St. Paul)	624-2789

Directors of Undergraduate Study

Biochemistry	Dr. Clare Woodward	244 Gortner	624-4714
Biology	Kathryn Hanna	123 Snyder	624-2244
Ecology, Evolution, and Behavior	Dr. Richard Phillips	316 Ecology	625-5727
Genetics and Cell Biology	Dr. Norman Kerr	254 BioSci	624-1789
Microbiology	Dr. Palmer Rogers	925 Mayo	624-7140
Plant Biology	Dr. Thomas Soulen	660 BioSci	625-2761

Message from the Dean

The College of Biological Sciences is one of the youngest colleges on the University of Minnesota Twin Cities campus. Its founding in 1965 grew out of the University's recognition that biology had become a scholarly endeavor of great importance to society and the state. The college recognizes this social importance and the responsibility imposed by its mission to seek excellence in teaching, research, and service in all areas of the complex discipline of biology.

Today, our knowledge of biology is in a period of expansion that has few precedents. Thirty-nine years ago the chemical nature of genetic material began to be understood; 19 years ago an approach to the isolation of particular genes was proposed; today cells with artificially constructed genomes are used in areas from environmental cleanup to cancer chemotherapy. Similar advances in our understanding of the environment have come about in the past 20 years. The pace at which knowledge about biology is increasing makes it exciting to open the morning paper; a new breakthrough seems to come every week. Most exciting, however, is being part of the effort that brings about these new discoveries.

Our research in the College of Biological Sciences is extremely broad. It includes studies of the molecular basis of phenomena as disparate as bacterial growth and mammalian behavior. It extends, sometimes in a single department, from the analysis of gene expression to the interaction of forest populations over the past several thousand years. CBS faculty study diverse organisms, from bacteria that degrade toxic compounds to lions in East Africa.

Our undergraduate and graduate teaching lies at the heart of the college's mission. We try to ensure that every undergraduate major will have an independent laboratory or field research experience, because this is the best way to discover what biological science is all about. We feel strongly that all educated people should have a significant acquaintance with biology, and we present several courses for non-majors to address this need. CBS has become a national leader



in innovative teaching approaches and we share with students the excitement of learning in new ways. Recognizing the enormous pool of untapped talent that lies in groups not well-represented today in academic science, we are working hard to recruit women and minorities into our discipline.

Almost every problem that society will face in the next 50 years has a significant biological component and few can be solved if we neglect this critical area. We are committed to providing the education needed by every citizen to understand and help solve these problems. We welcome students who share with us interest in and excitement about the rapidly developing field of biology.

A handwritten signature in black ink that reads "P. T. Magee". The signature is written in a cursive, slightly slanted style.

P. T. Magee, Dean

Programs and Services



Programs and Services

Our Affirmative Action Commitment

The College of Biological Sciences, in accordance with policies established by the Board of Regents, affirms its support of affirmative action in admissions to the college. Racial minorities continue to be severely underrepresented in the professional biological sciences and in allied professions, such as the health sciences, which depend upon undergraduate education in biology. They are also underrepresented in the college's undergraduate enrollment. The purpose of the CBS affirmative action policy is to attract, admit, and graduate increased numbers of individuals from underrepresented racial minority groups, both to enhance the educational benefits all students derive from a diverse student body and to increase the representation of minorities in biological science and allied professions.

Successful affirmative action, however, involves more than just sensitive evaluation at the point of admission. Through its Office of Minority Student Affairs, which reports directly to the college dean, the college provides academic and counseling/advising services to racial minority and other underrepresented University students before application to CBS (see Student Services, in the first section of this bulletin). The intent of such services is to help prospective students increase their awareness of the opportunities for study and careers in biology and related professions and to enhance their prospects of being accepted for admission to CBS. Such services continue to be available to students subsequent to enrollment in CBS, to help them successfully complete their undergraduate degree programs.

Undergraduate Programs

"CBS has all the advantages of a small college—personalized instruction and help, small classes—combined with the advantages of a major university—world-renowned instructors, excellent facilities, and most importantly, encouragement to expand

classroom learning with research experience. Quite simply, it's the best of all possible worlds."—Michael Walker, CBS graduate

Our students choose CBS because we have a program of exceptionally high quality, offered by professors who are well-recognized in their fields. As students begin to plan for a specific career they are urged to supplement their course work with research experiences and internships to further develop their skills and prepare for successful entry into their chosen professions. Students are assisted in exploring their career interests in biology through the Biology Colloquium, a broad selection of course offerings, and special programs offered through the CBS Career Information Center.

Careers in Biology

Biology encompasses many fields of study and appeals to students with diverse interests. Career opportunities are equally broad. While students might be drawn to some majors because of their direct application to vocations in the marketplace, most students will select a biology major because it is the subject they most enjoy learning about. Happily, they will discover that their career choices are limited only by their imagination, individual interests, and acquired skills.

Many students study biology as preparation for professional training in the health sciences. Since the entry requirements for the health sciences generally include similar courses to those required in CBS (math, chemistry, physics, and biology), students will find that a biology major provides the right foundation to explore and prepare for these fields of study. In fact, more than a fourth of our graduates each year choose to continue their education in health fields including medicine, dentistry, veterinary medicine, osteopathy, podiatry, optometry, and others.

CBS students beginning full-time employment immediately following graduation frequently take research scientist

and laboratory technician positions. Others pursue a wide array of occupations requiring a liberal education and a bachelor's degree, from business fields (e.g., sales, quality control, communications) to public service (e.g., environmental control, public education). While national statistics have often depicted a limited and competitive market for biology majors, CBS graduates have proven to be unusually successful in gaining employment in their chosen professional fields. Some students are combining biology with other fields, such as engineering, graphic arts, or law. Those graduates who choose to continue their study are regularly admitted to top-notch graduate schools and professional programs.

About half of CBS graduates elect to pursue advanced study immediately following receipt of the B.S. degree (about 25 to 30 percent are admitted to professional schools and 20 to 25 percent enter graduate programs); the percentage of each graduating class that pursues advanced training increases over time. Details about follow-up studies of graduates, both bachelor of science and advanced, are available upon request in 223 Snyder Hall.

A student interested in teaching biology at the secondary level should consult the College of Education office for information about the specialized curriculum that is available.

Special Learning Opportunities

Students are encouraged to explore the full scope of learning experiences available, including those beyond the required curriculum. Many students plan projects they carry out under faculty supervision in research laboratories and in the field. Some students seek employment as undergraduate teaching and research assistants or museum tour guides. Most departments offer special seminars for undergraduates.

Biology Colloquium—This is a unique class, organized and run by students, recommended for those who wish to explore the various fields and career alternatives in

the biological sciences. Offered each quarter, the class gives students the chance to interact with biology faculty and students with similar interests. The colloquium offers both large group seminars, featuring prominent scientists discussing their research programs, and small group tours to research facilities on and off campus, such as the Raptor Rehabilitation Center, the Mayo Clinic, or behind-the-scenes at the Minnesota Zoo. In addition, students are encouraged to begin exploring their own interests through participation in a research project. The colloquium student leaders will help you find the project that fits your interests and allows you to earn University credit.

Socially, colloquium students always find time for fun, too, whether on a field trip or studying together in the colloquium student room. Upper division biology majors gain important leadership and communication experience as colloquium leaders.

Undergraduate Research

"CBS provided me with a great opportunity to do research in medicine. Most colleges do not offer this type of research experience."—Todd Reil, CBS graduate

"I think what is impressive about CBS is its successful combination of a wide range of course offerings, diverse research opportunities, and a faculty that is approachable and dedicated to students."—Sirid-Aimee Kellermann, CBS graduate

Each spring an Undergraduate Research Symposium is held to recognize the accomplishments of students participating in undergraduate research projects. The objectives of directed research are to provide students with experience in research and to obtain new information about the biological system under investigation. Students work largely on their own initiative and at their own pace, under the guidance of a University faculty or staff member.

Students may choose to earn academic credit for their research experiences, or they may wish to apply for special grants that provide students with a research stipend. The

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CBS Career Information Center maintains a Research Opportunities Notebook to help students find interesting research projects in laboratories throughout the University.

Professional Learning Experience Program (PLEP)

"Seeing principles learned in the classroom applied on the job is a great motivation to continue learning."

"Not only was my internship fun, it was a tremendous boost to my résumé and job qualifications."—PLEP participants

The PLEP goal is to assist students in obtaining career-related experience to supplement their academic credentials. Experiential learning opportunities integrate classroom study with a work/learning assignment in the student's area of professional interest. Previous PLEP students have studied hazardous waste disposal with NSP, gained lab experience in private industry, completed animal behavior studies in northern Minnesota and ecology studies in Costa Rica, to name a few projects. Organizations sponsoring PLEP opportunities include educational institutions, government agencies, businesses, and non-profit organizations. Both paid and volunteer positions are available throughout the year, and some offer credit. Students with specific interests may design their own internship and PLEP will help them find a sponsoring organization. The CBS Alumni Society provides a few stipends each year for students who participate in unpaid internship opportunities.

Honors—CBS offers a specialized Honors Program for the most capable and motivated students. The Honors Program emphasizes undergraduate research and specialized seminars to bring students together to discuss biological issues of critical importance to society. (See full program description later in this bulletin.)

Study Abroad

CBS students recognize the need to prepare themselves to be citizens of a multicultural

society, a global economy, and an increasingly interdependent world. The college encourages them to enhance their education by taking advantage of international programs sponsored by the University.

The two types of study abroad that best lend themselves to study in the biological sciences are field study and integrated classroom study.

Two of the University's interdisciplinary field study programs abroad easily permit study in the biological sciences. Minnesota Studies in International Development (MSID) offers two-quarter winter/spring internships in Ecuador, India, Jamaica, Kenya, Morocco, or Senegal, preceded by on-campus preparatory courses in the fall; a number of MSID's grassroots internships have dealt with environmental issues. The Student Project for Amity among Nations (SPAN) consists of a summer independent study project on a topic of the student's choosing, preceded by a year's on-campus preparation and followed by project writeup in the fall; the four destinations change from year to year. The University also cosponsors two specialized options for CBS students: a marine biology program in Denmark, and a tropical biology and conservation program in Costa Rica.

Integrated study programs permit students to take regular foreign university courses alongside host-country nationals. The University's student exchanges and consortium memberships provide access to biology courses at universities in many countries. Courses taught in English are available in Australia, Canada, Fiji, Finland, Kenya, Malta, the Philippines, Sweden, Singapore, Tasmania, Zambia, and the United Kingdom. Students with sufficient language fluency may choose to study in universities using Chinese, Estonian, Filipino, Finnish, French, German, Hungarian, Italian, Korean, Portuguese, Russian, Spanish, or Swedish.

Study abroad options are not limited to University of Minnesota programs. For example, recent students have taken advantage of opportunities to study genetics

in Russia, the biology of koala bears in Australia, marine biology in the West Indies, and chimpanzee behavior in West Africa.

The college also encourages study abroad for language acquisition or culture learning. The resulting credits can be used as liberal arts electives or, in some cases, to satisfy CBS distribution requirements. The University sponsors or cosponsors a broad range of intensive short-term language programs and area studies programs.

Special Exams for Credit—Students earn college-level credit for prior learning and independent preparation through a variety of programs:

CLEP—College Level Examination Program. By passing one or more of these standardized exams, students may earn credit toward University of Minnesota degrees.

AP—Advanced Placement. These exams provide college credit for accelerated or advanced courses completed in high school.

University Special Exams—Students who have acquired special knowledge of a subject, either through individual study or experience in a non-accredited program, may arrange to earn credit by exam for most University courses. Students must be currently enrolled to be eligible to earn credits by exam.

Individually Designed Program—The Individually Designed Program (IDP) in CBS is designed for students whose interdisciplinary interests and goals cannot be met by a traditional biological sciences major. Requirements for the IDP are flexible. Except for prerequisite courses (a course in general biology, two quarters of general chemistry and at least one quarter of calculus), there are no specific course requirements, although there are minimum credit requirements in the selected areas of concentration. IDP students are expected to choose one area of concentration from within the biological sciences and one or two others from programs outside of CBS.

IDP majors generally have a thematic or career orientation. To be accepted into the program, applicants must present a statement of goals and objectives to the program admissions

committee, clarifying their need for designing a unique program. Some of the careers for which IDP students have prepared themselves are bio-cinematography, scientific illustration, genetic counseling, environmental health, patent law, and natural history.

Student Organizations

Biological Sciences Student Association (BSSA)—Through the BSSA, biology undergraduates can officially serve on college committees and voice student concerns. The BSSA plans educational and social activities throughout the year. Information is available in the CBS Office of Student Services. All University of Minnesota biology students are invited to attend. Involvement in the association is an excellent way to meet faculty and students.

Biochemistry Club—The Biochemistry Club strengthens ties between biochemistry students and faculty, provides a source of individualized professional advice on career goals to each biochemistry major, helps undergraduates identify biochemistry labs for directed research, helps students keep abreast of new advances in biochemistry and related areas, increases interactions between students and visiting seminar speakers, and enhances social interactions between biochemistry students and faculty. For more information, contact the Office of Student Services (612/624-9717) or the bio-chemistry department office (612/624-7755).

Genetics and Cell Biology Club—Students formed the Genetics and Cell Biology Club to bring together students, faculty, and staff interested in these disciplines. Members enjoy speakers, educational experiences, and social activities. For more information, contact the Office of Student Services (612/624-9717) or the genetics and cell biology department office (612/624-3003).

Ecology Club—The Ecology Club was established in 1991 to bring together students interested in the ecological and environmental problems of the world. The purpose of the meetings is basically

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educational; however, each activity is planned to bring together students and faculty in an informal, social atmosphere. For more information, contact the Office of Student Services (612/624-9717) or the ecology, evolution, and behavior department office (612/625-5700).

Society for Microbiology—The society provides a forum in which students and faculty can meet informally to share common interests in microbiology. All meetings and activities reflect members' interests. Members are officially part of the Student Chapter of the American Society for Microbiology (ASM), which provides information on microbiology lectures, meetings, seminars, and local job listings. Activities include discussions of microbiological issues, social events, and visits to local employers. For more information, contact the Office of Student Services (612/624-9717) or the microbiology department office (612/624-6190).

Plant Biology Club—offers students chances to interact with other students and also with faculty interested in plants. Participants enjoy speakers and other educational experiences, usually in an informal, social atmosphere. For more information, contact the Office of Student Services (612/624-9717) or the plant biology department office (612/625-1234).

Biology Club—All life science majors are encouraged to participate in the Biology Club. The club was established to ensure full participation of students from groups currently underrepresented in science and to foster contact among biology students and faculty. It meets for monthly dinners and discussion and provides both academic and social experiences for its members. For more information, contact Kathy Ball (612/624-1257).

Biological Sciences Alumni Society (BSAS)—The society provides a professional association for biological sciences graduates, and encourages relationships among current students, faculty, alumni, and the community. The society has made a special commitment to enhance opportunities for current students

and encourages them to participate in all of its programs, often at discounted ticket prices. The president of the Biological Sciences Student Association serves on the board of directors of the alumni society. Alumni volunteers have cooperated with the CBS Career Information Center to develop the Career Information Network, an innovative program to help current students and graduates explore career options. The society sponsors undergraduate merit scholarships, undergraduate research and internship grants, a mentor program for students, and supports continuing education programs in the biological sciences. Student and alumni volunteers have also assisted the college with student recruitment, especially of women and minorities. Further information on BSAS may be obtained from the Office of the Dean, 123 Snyder Hall (612/624-2244) or from the Minnesota Alumni Association, 501 Coffman Memorial Union, 300 Washington Ave. S.E., Mpls MN 55455 (612/624-2323).

Student Services

"CBS gave me the feeling of being in a small college—personal attention and recognition and the benefits of being at a University with research exposure and class variety."—Bianca Williamson, CBS graduate

The size and diversity of the University of Minnesota offers unlimited opportunities for students to explore and develop their academic, professional, and personal interests.

Both current and prospective students are well-served by the advising services, resources, and programs provided by CBS's faculty and Office of Student Services. Upon admission to the college, as early as the sophomore year, students are assigned to a CBS faculty adviser in their particular area of interest. In addition, Office of Student Services staff are available by appointment for students to discuss a wide array of student concerns. Summarized below are the types of advising services available through a combination of faculty and professional advising.



The Office of Student Services performs a variety of other essential functions in the College including admission, student orientation and registration, academic progress review and degree certification.

Prospective Student Activities

- Admissions counseling
- Career transitions
- Prospective student information
- High school and community college visits
- College tours
- Summer science program
- Mentor program

New Student Advising

- Orientation
- Course planning
- Exploration of life science majors
- Campus resource information

Developmental Advising

- Intellectual and personal growth
- Career directions
- Goal setting
- Clarifying values
- Decision making
- Refining skills
- Developing leadership

Peer Advising/Networking

- Honors
- Biology Colloquium
- Biological Sciences Student Association
- CBS club activities
- Alumni Society

Major and Faculty Advising

- Program planning
- Career exploration/planning
- PLEP
- Undergraduate research
- Seminars
- Graduate School

Program Planning—This annual, shared planning activity should form the basis of an ongoing relationship between the faculty adviser and student. The importance of the relationship between faculty adviser and student cannot be overemphasized. Students will find it useful to consult their advisers to discuss progress in specific courses, to obtain information about graduate study, design a research project, plan internships, and arrange to work with faculty members in laboratory and field settings.

Career Information Center—The CBS Career Information Center helps students explore the varied career options available to

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graduates in biology. Undergraduates are encouraged to consult with the center early to investigate careers, learn about career preparation, and begin to make decisions. The CIC provides extensive career and employer information, as well as connections to professionals in many fields of interest. Contacts made through the Professional Learning Experience Program, the biannual Career Information Fair, and the Alumni Career Network program ensure that students make well-informed career decisions.

As graduation approaches, the CIC assists students in applying to graduate schools and professional health sciences programs. For those choosing to enter the job market directly, the center provides assistance in building job search skills (including résumé writing and interviewing), as well as job books and a specialized résumé distribution service.

Minority Affairs—The director of minority affairs is available to meet individually with students to explore potential interests in biology, to provide academic assistance (including individual tutoring, when needed), and to help students overcome barriers to educational success. Students are encouraged to ask about financial aid and scholarship opportunities. For more information, contact Dr. Val Woodward, 123 Snyder Hall (612/624-3060).

International Education—The University's study abroad catalog describes a broad range of study abroad opportunities. Students can learn more about their options through an advising appointment at the International Study and Travel Center (ISTC), 102 Nicholson Hall (612/625-1150), and by consulting with the PLEP coordinator in 217 Snyder (612/624-9270). Special information is also posted outside 123 Snyder Hall. After identifying one or more programs of interest, students should see a study abroad adviser in 104 Nicholson Hall (612/624-4525) for more detailed program information and application instructions, and to discuss credit and financial aid. CBS students must also review their plans with an adviser in 223 Snyder Hall (612/624-9717) and are also encouraged to meet with Dr. Willard Koukkari, CBS

international education officer, 611 Biological Sciences Center (612/625-1958).

Student Facilities

Student/Faculty Lounge—Undergraduate biology students are invited to use the student/faculty lounge in 128 Snyder Hall on the St. Paul campus. The lounge is an excellent place to study, relax between classes, and meet with other students. The lounge is furnished with a small reference collection and current journals covering many fields of interest in biology.

Computer Access—Computers are available for undergraduate students to use for course-related assignments. The computers are located in the new Instructional Computing Lab, 122 Snyder Hall, and in the Molecular Biology Computer Center, 247 Gortner Lab. Students are encouraged to investigate some of the exciting new software that has been developed for the biological sciences. All University of Minnesota students are given an E-mail address by which they can access Gopher and the wide range of databases and information resources available through Gopher.

Libraries—The University of Minnesota library system ranks among the largest American university libraries, with more than four million catalogued volumes. In addition to science and technology collections in Walter Library and the St. Paul Central Library, biological sciences students also benefit from specialized collections in the Bio-Medical Library, the Biochemistry Library, and the Entomology, Fisheries, and Wildlife Library.

Financial Assistance

The University of Minnesota Office of Student Financial Aid is located at 210 Fraser Hall (612/624-1665). The office is open to serve students from 8 a.m. to 5:30 p.m. Mondays and 8 a.m. to 4 p.m. Tuesday through Friday with somewhat more limited hours during the summer. Prospective or newly admitted students may also wish to consult with high school counselors.

Bioscience Scholarships and Grants

Prospective students are encouraged to apply for both need-based and merit scholarships to help pay college tuition. CBS students may qualify for one of the following scholarships or grant awards:

Biological Sciences Senior Scholarships—awards given by the Biological Sciences Alumni Society to recognize and reward students who show initiative, enthusiasm, and commitment to their program in the biological sciences.

Richard S. Caldecott Award—in honor of CBS's first dean. Competitive scholarship for attendance at Gray Freshwater Biological Institute's summer session, or for the outstanding CBS senior.

Stanley Dagley Scholarship—annual award to a deserving undergraduate in memory of Regents' Professor Stanley Dagley, biochemistry.

Michael C. Loveless Scholarship—annual award to a deserving senior in CBS with demonstrated leadership abilities, given in memory of Mike Loveless (class of 1986), an outstanding former CBS student.

Itasca Director's Fund Scholarship—award presented to students attending the Itasca summer session to help defray the cost of tuition and living expenses. The awards are made possible by many former students and staff who retain fond feelings for the field station.

Eloise Newcomb Pittman Scholarship—given when appropriate to an outstanding female student in plant sciences.

Belwin Undergraduate Scholarship for Field Study—supports research relating to the natural environment. The research must include some field work at the Belwin Nature Center or surrounding area.

Leon A. Snyder Award—given in memory of Professor Snyder of the Genetics and Cell Biology Department to a deserving undergraduate student in biology.

Applications for all scholarships and awards listed above are due May 1.

Applications must be accompanied by the CBS Scholarship Application Cover Sheet.

Murray Rosenberg Fund—in memory of Professor Rosenberg of GCB, provides travel grants for CBS students who wish to perform service in a health-related field to help people in need in non-English-speaking countries or economically depressed areas of the U.S. Applications are due October 15 and April 15.

LaVell M. Henderson/Henrietta Miller Scholarship—award presented to an outstanding senior biochemistry student who has demonstrated research capabilities. Application deadline: December 15.

Harold P. Morris Memorial Scholarship—in memory of U of M alumnus H.P. Morris. Multi-year grant to support outstanding students from northwest Minnesota studying genetics or biochemistry. Application: Open, depending on availability of funds.

Philip C. Hamm Memorial Scholarship—encourages and rewards undergraduate students who show promise as research scientists in the plant sciences. Two scholarships of \$500 each. Campus contact: Dr. Philip Larson, 612/625-8200. Application deadline: Winter.

Carol E. Macpherson Scholarship—awarded to females 28 years or older who have been out of college for at least 5 years. Application deadline: late March.

Sigma Xi Awards

Nominations for Sigma Xi awards are made by Sigma Xi members with a letter of recommendation and appropriate supporting documentation. The executive committee of Sigma Xi chooses the winner of the following three awards:

Thomas F. Andrews Prize—for students in any school or college of the University, who have demonstrated proficiency in independent research in science and who have not yet obtained a baccalaureate degree. Papers and other evidence of research work offered in application may be used by the student for thesis purposes or otherwise.

Programs and Services

Cash prize, plus initiation fee and admission to membership in Sigma Xi.

George T. Walker Prizes—to be used in the senior year by students in chemistry, selected on the basis of aptitude in science and promise in research. Two undergraduate cash prizes, plus initiation fee and admission to membership in Sigma Xi.

Olson-Wallace Award in Zoology—for an undergraduate or graduate student, for original research in the zoological sciences in the broadest sense. The research is to be in the form of a thesis, a paper published in a reviewed scientific journal, or a paper presented at a national meeting. This award was established in 1978 in honor of Magnus Olson and Franklin G. Wallace, emeriti CBS zoology faculty.

Undergraduate Research Opportunity Program Grants

The University of Minnesota's Undergraduate Research Opportunities Program offers financial awards to undergraduates for research, scholarly, or creative projects undertaken in partnership with a faculty member.

UROP affords undergraduates the unique educational experience of collaborating with a faculty member on the design and implementation of a project. At the same time, faculty have the opportunity to work closely with students and receive valuable assistance with their own research or professional activity. UROP adds a new dimension to the undergraduate experience. It encourages students to conduct research and pursue academic interests outside of their regular courses by employing them to work on special projects.

UROP applications are judged on the basis of the quality of the proposed project and the educational benefit to the student. Since funding is limited, awards are granted to the strongest proposals. There are two opportunities to apply for research funds each year: October and April.

National Scholarships

Harry S Truman Scholarship—For undergraduate study leading to graduate study and a career in public service. Applicants must be U.S. citizens or nationals, currently-enrolled juniors with a minimum 3.00 GPA at time of application. Award covers college fees up to \$10,000 for up to three years. (105 scholarships available nationwide, at least one award given to a Minnesota resident). Campus contact: Paul Jeffries, CLA Honors Division. Application deadline: late October.

Barry M. Goldwater Scholarship—For undergraduate study leading to graduate study and a career in mathematics or the natural sciences (normally does not include engineering or the health sciences). Applicants must be U.S. citizens and currently-enrolled sophomores with a 3.00 GPA at time of application. Award covers all college fees to a maximum of \$7,000 for up to two years. (300 scholarships nationwide, at least two given to Minnesota residents). Campus contact: Paul Jeffries, CLA Honors Division. Application deadline: December.

Study Abroad

A number of University and national scholarships exist for study abroad. Deadlines are often far in advance of the study. Information is available in the International Study and Travel Center, 102 Nicholson Hall (612/626-9000).

Leadership Awards

Donald R. Zander—for outstanding leadership, service, and academic achievements. Nomination deadline: late winter quarter.

Dean E. M. Freeman—for outstanding leadership on the St. Paul campus. Nomination deadline: early spring quarter.

President's Leadership and Service Award—presented to the top one-half of one percent of the student body for exceptional leadership and service to the University and/or surrounding community. Campus contact: Roger Harrold (612/624-5101). Nomination deadline: March.

Admission Procedures and Degree Requirements



Admission Procedures and Degree Requirements

Admission to CBS

Students may enter CBS at the beginning of their sophomore, junior or senior year. The first years may be completed in another unit within the University, at a community college, or at any four-year college or university. CBS faculty and staff would be happy to assist you in selecting appropriate coursework for transferring to the college. During the freshman and sophomore years, students should plan to complete, as a minimum, the beginning English composition course, mathematics, general chemistry, and general biology. Most students will take organic chemistry during their sophomore year, thereby allowing ample time for major coursework and research experience.

To the extent possible from the information available regarding a particular applicant, applications are given individualized attention. Such factors as racial and cultural background and economic or educational disadvantage are considered carefully to prevent excluding students whose academic potential for success might be misjudged based on traditional predictors alone.

Acceptance to CBS

Successful completion of 84 quarter credits (with a GPA of at least 2.00) including General Biology 1009 or 1201-1202, General Chemistry 1051-1052, and Calculus 1251-1252 with grades of at least a C (or equivalent courses with grades of at least a C), are required for admission at the junior level.

Applications can be acted on before grades from current coursework are available. Qualified students will be admitted subject to satisfactory completion of current registration. Equivalent courses are transferable. Students who are admitted as sophomores must meet the following requirements: a minimum of 40 credits with a GPA of 2.50 or better, including grades of C or better in Chem 1051-1052 (or equivalent); Math 1251 (or equivalent); and a college-level biology course. Admitted students will receive a letter of acceptance from both the Office of Admissions and the College of Biological Sciences with information about orientation dates and registration.

All new students, freshmen as well as transfers, are also expected to meet the high school preparation requirements for admission to the University of Minnesota: four years of English; three years of math; three years of science; two years of a single second language, two years of social sciences. In some cases, students may be admitted with course deficiencies, with the expectation that these will be addressed in the first year in residence.

Procedure Check Lists

I. Application for Admission From Outside the University

Transfer students may apply directly to CBS. Because CBS is an upper division unit within the University, certain requirements must be completed before admission. If these requirements have not been completed at the time of application, we recommend that you also apply to the College of Agriculture or College of Liberal Arts as a "pre-biology" student. Acceptance into a "pre-biology" program requires that you meet the admission standards for the College of Agriculture or the College of Liberal Arts. See their college bulletins for specific requirements. Acceptance into "pre-biology" ensures that you will have contact with a biology adviser early in your academic career. Application deadlines are as follows:

<i>Fall quarter:</i>	June 1
<i>Winter quarter:</i>	October 15
<i>Spring quarter:</i>	January 15
<i>Summer quarter:</i>	May 1

Note: New freshmen as well as transfer students who must first complete work as a "pre-biology" major in another University college should apply between *October 1 and December 15* of the year before desired admission to ensure consideration before the priority deadline.

Applications to the University of Minnesota-Twin Cities may be requested from the Office of Admissions (telephone 612/625-2008 or, toll free in the United States, 1-800-752-1000).

Questions? Call the CBS Office of Student Services at 612/624-9717.

International Students

Deadlines for applications from international students are:

<i>Fall quarter:</i>	June 1
<i>Winter quarter:</i>	October 1
<i>Spring quarter:</i>	January 1

English Proficiency—If English is not your native language, you may be required to take the Test of English as a Foreign Language (TOEFL) or the Michigan English Language Assessment Battery (MELAB). To register for the TOEFL, contact the agency that handles TOEFL registration in your country or write to the Educational Testing Service (Box 899, Princeton, NJ 08540 USA) at least 10 weeks before any scheduled test date. If you are already in the Twin Cities area, you may register for the MELAB with the Minnesota English Center, 320 16th Ave. S.E., University of Minnesota, Minneapolis, MN 55455, or call (612) 624-1503. To register for the MELAB outside the Twin Cities area, contact the English Language Institute, Testing and Certification Division, University of Michigan, Ann Arbor, MI 48109 USA, or call 313/764-2416.

Orientation Procedures

Before classes begin, you will be invited to attend a New Student Program/Orientation session. It will acquaint you with the campus and provide information about the college and the University. Part of the time will be spent with an adviser who will help you plan your biology program. You are urged to participate. Failure to attend will result in a late registration date and difficulty obtaining needed courses.

Transfer students will also attend a College of Biological Sciences orientation/reception during the first week of the quarter. Information will be presented about research and internship opportunities as well as other important information critical to your success in preparing for a profession in biology.

II. Application for Transfer From Within the University System

Students who wish to transfer to the College of Biological Sciences from another college

on the Twin Cities campus or from one of the coordinate campuses should submit a Transfer of College form to the Office of the Registrar. Deadlines are as follows:

<i>Fall quarter:</i>	June 1
<i>Winter quarter:</i>	October 15
<i>Spring quarter:</i>	January 15
<i>Summer quarter:</i>	May 1

Transfer applications may be requested from the Office of the Registrar, 150 Williamson Hall, or from the Office of the Registrar—St. Paul, 130 Coffey Hall. Forward the application to the Office of the Registrar, University of Minnesota, 150 Williamson Hall, 231 Pillsbury Drive S.E., Minneapolis, MN 55455. Phone: 612/625-5333.

Questions? Call the CBS Office of Student Services at 612/624-9717.

Orientation Procedures

If you are transferring from a coordinate campus, you will be invited to a New Student Program/Orientation session (see above).

All new students will attend a College of Biological Sciences orientation/reception during the first week of the quarter. Information will be presented about research and internship opportunities as well as other important information critical to your success in preparing for a profession in biology.

III. Application for Admission With Adult Special Status

The adult special status is for those who have completed a degree already and who want to take courses for personal interest or to meet admission requirements for advanced programs. A degree transcript must be submitted with the application. Adult special applications may be requested from the Office of Admissions, 240 Williamson Hall, 231 Pillsbury Dr. S.E., Minneapolis, MN 55455. Phone: 612/625-2008 or 1-800-752-1000 (toll free in continental United States).

The deadlines for receipt of complete adult special applications:

<i>Fall quarter:</i>	September 1
<i>Winter quarter:</i>	December 1
<i>Spring quarter:</i>	March 1
<i>Summer quarter:</i>	May 1

Admission Procedures and Degree Requirements

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 only during their terms of enrollment. To do so, they must notify 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, and at records offices on other campuses of the University. Questions may be directed to the Office of the Registrar, 150 Williamson Hall (612/625-5333).

Degree Requirements

The CBS bachelor of science degree program is composed of four essential elements. Each is important in preparing students to be leaders in their chosen professions in an increasingly complex and interdisciplinary world.

I. Liberal Education—A liberal education frees individuals from the limitations of their powers of judgment and choice that result from ignorance. It provides students with the skills to seek: control over the general intellectual instruments for acquiring and communicating knowledge, primarily the instruments of language and number; understanding of the ways scientists contribute to knowledge; historical and philosophical perspective on the nature of students' own lives and the world in which they live; and appreciation of the creative

insights into life and nature provided by literature and the arts. To help achieve these goals, CBS requires all students to distribute a portion of their coursework in areas of study outside of those most directly linked to their specialized interests in science.

II. Physical Sciences and Math—Biology as a science relies heavily on the tools of mathematics and physical science. Organisms consist of molecules that obey the rules of physics and chemistry; these rules are often stated using mathematics.

Modern biologists in the field and in the laboratory must be able to use fundamental principles of mathematics, chemistry, and physics to appreciate living organisms at all levels from molecules to ecosystems.

Mathematics is a tool that underlies all of science. It permits the description of the kinetics of reactions occurring in organisms, is used to model population growth and distribution, and forms a basis for statistical analysis of data.

Chemistry is the study of molecules and their interactions. Phenomena such as nerve impulses, the exchange of gases in respiration, water balance, and the conversion of food energy to useful work by organisms require an understanding of chemistry. Organisms are composed of organic molecules. An understanding of these molecules and their reactive groups is essential to an understanding of biological phenomena such as metabolism and gene function.

Physics includes the study of atoms and their interactions, mechanics, heat, sound, electricity and magnetism, and the properties of light. It is the basis for our understanding of photosynthesis, blood and air flow, mutations, and energy pyramids in ecosystems. It underlies most of the instruments and techniques used by biologists: pH meters, spectrophotometers, thermometers, microscopes, centrifuges, computers, the use of radiation to induce mutations, and the use of radioactive tracers.

III. The Biology Core Curriculum—Specialists working in well-circumscribed areas will always be important in biology, but today there is a growing need for people

whose understanding ranges across the disciplines of biology. Students are introduced to diverse aspects of biology by completing a set of core courses. Some courses introduce students to various kinds of organisms—animal, plant and microorganisms. Biochemistry introduces students to organic compounds of importance to organisms, to enzyme-catalyzed reactions, and to the metabolic pathways by which energy is utilized. Cell biology examines the structure and function of cells in some depth. Genetics introduces students to mechanisms of heredity, including both molecular genetics and population genetics. Ecology, evolution, and behavior introduces students to populations, evolution, and the behavior of animals.

IV. Specialization in the Major—In addition to completing the required courses in biology, students take additional courses to expand on some aspects of biology. They may do so either by completing a biology major, which allows for more breadth in choosing electives, or by completing one of several departmental majors (biochemistry; ecology, evolution, and behavior; genetics and cell biology; microbiology; and plant biology). These more specialized majors each have required courses as specified by the department. In addition to elective courses most students will plan to complete a research project in their special area of interest; each department offers credit for Directed Study (5970) and Directed Research (5990).

Requirements for Graduation

To earn a bachelor of science degree from the College of Biological Sciences, a student must complete a minimum of 180 credits with grades of *A*, *B*, *C*, or *S*. In order to be used for credit toward graduation, each credit of *D* must be balanced by a credit of *A* or *B* in a course at the same level; each credit of *D* earned in courses meeting specific science or math requirements must also be balanced by a credit of *A* or *B* in courses at the same level that meet those requirements. Grades of *D* are not accepted in courses specifically required

for admission—Biol 1009 or 1201-1202, Chem 1051-1052, Math 1251-1252 or their equivalents.

CBS students may apply up to eight technical, non-liberal arts college credits toward their degrees (e.g., credits in physical education or military science). Check with an adviser in 223 Snyder Hall for details.

Residency Requirements

- A minimum of 45 credits in courses taken on the Twin Cities campus. Candidates for the B.S. must have a minimum of 75 percent of their University of Minnesota residence credits (required for graduation) in courses in which grades of *A*, *B*, *C*, or *D* have been received.
- A minimum of 36 credits as a student registered in CBS. These credits may also apply toward a) above.
- A minimum of 30 credits on the Twin Cities campus in 3xxx and 5xxx courses that are specifically required for the student's major. Ordinarily this will include any 3xxx and 5xxx course listed in this bulletin as well as appropriate advanced courses in mathematics, statistics, computer science, and the physical sciences.

Course Requirements

- English Communication Skills—Writing practice (freshman composition; Comp 1011 or Rhet 1101/1104 or equivalent) and one advanced course in writing to be selected from the following: Comp 3015 or 3027 or 3033 or 3085; Rhet 3562.
- Foreign Language—Either two high school years or one college year of study of a single foreign language or demonstration of equivalent proficiency satisfactory to the appropriate language department.
- The all-University liberal education distribution requirements:
 - Group A*—Language, Logic, Mathematics, and the Study of Argument
 - Group B*—The Physical and Biological Universe
 - Group C*—The Individual and Society
 - Group D*—Literary and Artistic Expression

Admission Procedures and Degree Requirements

The mathematics and science coursework required of CBS students (see items 4 and 5) will automatically satisfy the minimum University requirements for Groups A and B. In addition, CBS students must complete 30 credits from Groups C, D, World Studies, and Cultural Pluralism, including a *minimum* of 8 credits each in Groups C and D. A list of courses recommended to meet each group distribution requirement and descriptions of courses can be found in the *College of Liberal Arts Bulletin* and the CBS Office of Student Services. Direct questions concerning acceptable courses to the Office of Student Services, 223 Snyder Hall.

The University of Minnesota is implementing a new liberal education curriculum fall 1994. Check in 223 Snyder Hall for changes affecting CBS students.

4. Physical Sciences and Mathematics

a. Mathematics—A three-quarter analytic geometry and calculus sequence (Math 1251, 1252, 1261 or equivalent). A two-quarter course sequence in statistics or statistics and computer science may be substituted for the third quarter of calculus (Stat 3011-3012 or Stat 5021, or PubH 5450-5452, or PubH 5450-5415, or PubH 5450 with HInf 5430). Biochemistry majors, however, are required to complete the three-quarter calculus sequence.

b. Chemistry—Each of the following: general chemistry, two quarters (Chem 1051-1052 or equivalent); organic chemistry, two quarters with laboratory (Chem 3301-3302-3305-3306 or equivalent).

c. Physics—A full-year course, with laboratory, that requires college-level mathematics as a prerequisite (Phys 1251-1252-1253 [1254 optional] or 1104-1105-1106 with 1107-1108-1109). By petition, a two-quarter sequence (Phys 1041-1042) plus an additional five credits of mathematics, statistics, computer programming, or physical science chosen in consultation with the major adviser may be substituted. Biochemistry and microbiology majors are advised to take a calculus-based sequence (e.g., Phys 1251-1252-1253).

5. Biological Sciences

a. Requirements for biology and genetics and cell biology majors

1) General and organismal biology.

Choose one of the following:

(preferred) Biol 1201-1202-1203, one organismal course

Biol 1201-1202, 3011, 3012/3812, 5013

Biol 1009, 3011, 3012/3812, 5013

2) Biochemistry: BioC 3021 or 5331

3) Genetics: Biol 5003

4) Cell Biology: Biol 5004

5) Ecology: Biol 5041/5841

6) 16 additional upper division credits in mathematics and/or physical and/or biological sciences. GCB majors should refer to page 34 for specific requirements for the major.

7) Laboratory or field work in two additional upper division biological sciences courses. Credits earned may be used toward fulfilling item 6 above. A list of acceptable courses follows:

Biol 5125

BioC 5025, 5744, 5990 (4 cr minimum*)

EEB 5014, 5016, 5129, 5134, 5156, 5607,

5621, 5990 (4 cr minimum*)

GCB 5015, 5030, 5605, 5990 (4 cr minimum*)

MicB 5234, 5322, 5425, 5990 (4 cr minimum*)

PBio 3109, 3201, 5103, 5105, 5107, 5111,

5132, 5231, 5990 (4 cr minimum*)

All CBS courses offered at the Lake Itasca Forestry and Biological Station are acceptable.

**An independent research project is strongly recommended for every student. To use one of the department Directed Research courses to satisfy one of the upper division lab or field work requirements, students must complete a minimum of 4 credits under the 5990 course number. Biology majors may satisfy both of the lab/field course requirements through Directed Research only if 4 credits of 5990 are completed in each of two different laboratories.*

b. Requirements for biochemistry; ecology, evolution and behavior; microbiology; and plant biology majors.

1) General and organismal biology

(preferred) Biol 1201-1202-1203 or Biol 1009 plus two courses from 3011, 3012/3812, 5013

2) One course each from three of the following areas*:

Biochemistry

Genetics/Cell Biology/Development

Integrative/Organismal Biology/Physiology

Ecology/Evolution/Systematics/Behavior

3) 20 additional upper division credits in mathematics and/or physical and/or biological sciences. This includes work specified for the majors (see Major Requirements and Course Descriptions)

4) Laboratory or field work in two additional upper division biological sciences courses. Credits earned may be used toward fulfilling item 3) above. A list of acceptable courses is included under item 7) above.

**A list of suitable courses may be obtained in 223 Snyder Hall.*

CBS Science Requirements: Suggested Time Sequence

Key: Earliest Possible = * Recommended = ■ (see note 1 below) Latest Possible =	Freshman			Sophomore			Junior			Senior		
	F	W	S	F	W	S	F	W	S	F	W	S

A. Prerequisites

Calculus (3 quarters)	■											
General Chemistry (2 quarters)	■											
Organic Chemistry (2 quarters with lab)				*			■					
Physics (3 quarters); see note 2 below	*			■			■					
General Biology 1009 or 1201-1202-1203	■			■								

B. Biology Core (see note 3 below); check individual majors for core requirements

Biol 3011, Animal Biology	*			■			■					
Biol 3012 or 3812, Plant Biology	*			■			■					
Biol 5013, Microbiology							*			■		
Biol 5041 or 5841, Ecology				*			■			■		
BioC 3021 or 5331, Biochemistry				*			■			■		
Biol 5003, Genetics							*			■		
Biol 5004, Cell Biology							*			■		

Notes:

1. The recommended time period for many sequences is longer than required to allow some flexibility as to when the sequence is started.
2. The physical chemistry courses required for biochemistry majors, as well as some of the elective physiology courses, must be preceded by the complete physics sequence.
3. The period indicated is recommended to leave the senior year open for advanced study and research.

Honors Program

"The CBS Honors Program is a big plus for students planning on a science career, whether academic, medical, commercial, or other. It can be a valuable tool for providing much needed experience and insight for your life."—John Hollerud, former Honors Program student

The purpose of the Honors Program is to recognize and promote outstanding academic achievement. The nucleus of the program is directed research in biology, the most significant and challenging experience the faculty can offer to qualified undergraduates. Another facet of the program is the CBS Honors Seminar, which provides exposure to

the breadth of biological inquiry and allows honors students to get to know each other.

The honors experience culminates in the Undergraduate Research Symposium and honors dinner which celebrate students' research accomplishments and academic achievements.

Directed Research—The objectives of directed research are to provide participants with experience in research and to obtain new information about the biological system under investigation. A goal of the Honors Program is to promote research of a quality that warrants publication in a professional journal. Honors Program participants should select a

Admission Procedures and Degree Requirements

research adviser from the college faculty and start on a research project early in their junior year or as soon thereafter as possible.

Participation in a minimum of two quarters (a total of eight credits) of research is required; students may register in BioC 5990, EEB 5990, GCB 5990, MicB 5990, or PBio 5990. Students who participated in the Undergraduate Life Sciences Summer Research Program or who received UROP grants may petition to use this work to satisfy up to four of the eight credits of research. An honors thesis, summarizing the research and written in the style of a publishable manuscript, is required of all honors students. The thesis must be approved by the faculty member supervising the research and by two other members of the faculty (at least one of whom must be from the major department), chosen with approval of the college.

Honors Seminar—Two quarters of participation in the CBS Honors Seminar (Biol 3960H) are required of all Honors Program graduates. In the fall quarter, the seminar is a forum to discuss special topics focused on a theme of general relevance to all biologists. In the spring quarter, seniors nearing completion of their directed research projects are required to present summaries of their project results. Students are required to take a seminar in the fall, and follow that with a seminar in the spring quarter preceding graduation. They are also encouraged to attend the spring quarter seminar before the senior year.

Honors Program Admission—Qualified students should apply for admission to the Honors Program as soon as they have been admitted to the college. A minimum of three quarters of honors registration must be completed to fulfill the requirements for graduation with honors. Applicants should have a minimum GPA of 3.40 and present reasonable evidence of potential to attain the GPA required for graduation with honors (see below). Applications are available in 223 Snyder Hall.

Graduation With Honors—Participation in the Honors Program is required for graduation with the traditional honors designations *cum laude*, *magna cum laude*, and *summa cum laude*. In addition to the requirements for graduation, candidates for graduation with honors must complete the following:

1. At least 60 credits in upper division courses (3xxx and 5xxx) at the University of Minnesota Twin Cities campus
2. Two quarters (8 credits) of directed research, the results of which are to be reported in an acceptable honors thesis
3. Two CBS honors seminars (Biol 3960H), one of which must be completed during fall quarter and the other during the last spring quarter in residence
4. One additional honors opportunity, which may be selected from the following:
 - a. An additional quarter (2 credits) of participation in directed research
 - b. An honors seminar offered by the Honors Division of the College of Liberal Arts
 - c. An upper division honors course (3xxx or 5xxx course designated by H)
 - d. An honors contract (see Office of Student Services)
 - e. An 8xxx course (seniors only; requires permission)
5. The last 90 credits of A-F registration with the minimum GPAs specified below:
cum laude: minimum 3.40 GPA
magna cum laude: minimum 3.60 GPA
summa cum laude: minimum 3.80 GPA

Grades of N, which carry no grade points, are included in the computation of the GPA. If a portion of the last 90 credits completed has been transferred from another institution, the proportion of residence credits with grades of A must at least equal the proportion of transfer credits with grades of A.

Students planning to graduate with honors in microbiology must include specific courses in their programs in addition to meeting the college requirements. A listing of these requirements may be obtained from the Office of Student Services.

For More Information—Once admitted, students should also consult the *CBS Student Handbook* and feel free to discuss individual questions with an adviser in the CBS Office of Student Services, 223 Snyder Hall.

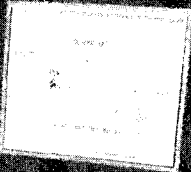
Major Requirements and Course Descriptions

SIRD-AIMEE KELLERMANN & DR. ALAN G. HUNTER

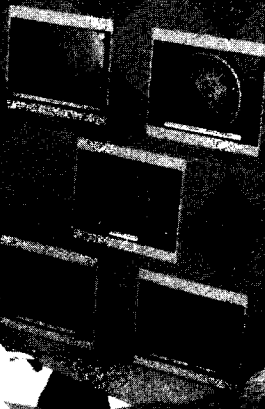
Dept. of Animal Science, Univ. of Minnesota, St. Paul, MN 55108

Thrombolytic proteolysis (TAP) is an enzyme, present on the surface of mammalian sperm. This enzyme is not associated with sperm and does not appear to be associated with the sperm head. In this study, we have reported the purification, characterization and properties of sperm TAP. It is a member of the trypsin family of serine proteases. The enzyme is active against a variety of substrates and is not inhibited by EDTA.

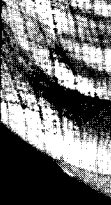
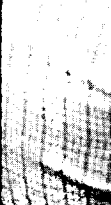
Abstracts
1. The sperm TAP is a member of the trypsin family of serine proteases. It is active against a variety of substrates and is not inhibited by EDTA.
2. The sperm TAP is a member of the trypsin family of serine proteases. It is active against a variety of substrates and is not inhibited by EDTA.
3. The sperm TAP is a member of the trypsin family of serine proteases. It is active against a variety of substrates and is not inhibited by EDTA.



RESULTS
The sperm TAP is a member of the trypsin family of serine proteases. It is active against a variety of substrates and is not inhibited by EDTA. The enzyme is active against a variety of substrates and is not inhibited by EDTA. The enzyme is active against a variety of substrates and is not inhibited by EDTA.



Mutant
MN 55108



Major Requirements and Course Descriptions

Course Numbers and Symbols—Courses primarily for freshmen and sophomores are numbered 1000 through 1998; for sophomores, juniors, and seniors, 3000 through 3998; for juniors, seniors, and graduate students, 5000 through 5998. Courses numbered 8000 and above are restricted to graduate students.

The following symbols are used throughout the descriptions:

, The comma, used in prerequisite listings, means “and.”

§ Credit will not be granted if credit has been received for the course listed after this symbol.

¶ Concurrent registration is allowed (or required) in the course listed after this symbol.

Registration Override Permit, completed and signed by the instructor, is required for registration.

Δ Registration Override Permit, completed and signed by the department offering the course is required before registration.

† All courses preceding this symbol must be completed before credit will be granted for any quarter of the sequence.

H Honors course.

f, w, s, su Following a course number, these symbols indicate fall, winter, spring quarter, summer session.

Directed studies course numbers end in “970” and directed research, in “990.”

Sequence courses, separated by hyphens (e.g., 3142-3143-3144), must be taken in the order listed.

Series courses, separated by commas (e.g., 1234, 1235, 1236), may be entered any quarter.

A prerequisite course listed by number only (e.g., prereq 5246) is in the same department as the course being described.

Prerequisites should be considered as guides. When a prerequisite is listed, an equivalent course may be substituted. Consult the course instructor for more information.

Biology (Biol)

Director of Undergraduate Studies—
Kathryn Hanna

Biologists are concerned with the fundamental properties of living things, from the interactions of molecules unique to life through the maintenance and integration of organisms and the interactions of populations in space and time.

The biology program provides the student with a broadly based, thorough undergraduate education in the biological sciences. Biology majors must complete the graduation requirements outlined under Admission Procedures and Degree Requirements. The distribution of the 16 additional upper division credits in the mathematical, biological, and/or physical sciences is determined by each student in consultation with the adviser. Students may request a faculty adviser from any of the departments of the college. A prospective major should begin general chemistry and mathematics course work as early as possible.

A bachelor of arts degree with a major in biology is available through the College of Liberal Arts. The core course requirements for this degree are the same as those for the B.S. However, the B.A. student must fulfill the additional CLA requirements that are outlined in the *College of Liberal Arts Bulletin*.

A student interested in teaching biology at the secondary level should consult the College of Education office for information about the specialized curriculum that is available.

General Education—Courses especially appropriate for non-science and non-biology majors include BioC 1401; Biol 1009, 1101, 1103, 1106/1806, 1201, 1202, 1301, 3051, 3112; EEB 1019, 3001, 3111; GCB 3002, 3008, 3022; MicB 3103; PBio 1009, 1012.

Minor Sequence

Required Preparatory Courses—Biol 1009 or 1201-1202

Minor Requirements—Minimum of 15 3xxx-5xxx cr chosen from courses carrying the following designators: BioC, Biol, EEB, GCB, MicB, PBio, Phsl.

One course about animals, Biol 1106/1806 or 3011, and one course about plants, Biol 1103 or 3012/3812.

The minor program must be approved in the Office of Student Services, 223 Snyder Hall.

Biol Courses

1009. GENERAL BIOLOGY. (5 cr)
Introduction to the principles of biology. The cell, metabolism, heredity, reproduction, ecology, and evolution. Lab.

1009H. GENERAL BIOLOGY. (5 cr; prereq honors division or 3-4 yrs high school mathematics, high school chemistry or Δ)
For description, see 1009. Intended especially for honors students or others with the requisite background who plan to major in a life science discipline.

1101. HEREDITY AND HUMAN SOCIETY. (4 cr, §GCB 3002; no cr if taken after 5003 or GCB 3022; for students in programs not directly related to biological sciences)
Principles of heredity and their social and cultural implications.

1103. GENERAL BOTANY. (5 cr, §3012, §3812; prereq 1009 or 1202; students who plan to major in biology in CLA or in any bioscience major in CBS should take 3012 or 3812)
Plant organization, function, growth and development, reproduction. Lab.

1106. GENERAL ZOOLOGY. (5 cr, §1806; prereq 1009 or 1202)
Survey of animal phyla; structure, function, behavior, adaptation, and evolutionary relationships. Lab.

1201. EVOLUTIONARY AND ECOLOGICAL PERSPECTIVES. (5 cr, § 1008)
Origins and foundations of modern evolutionary thought, putting evolutionary theory to work; evolution and ecology. Lab. Can be taken as a single course or as the first in the Biol 1201-1202-1203 sequence.

1202. MOLECULAR AND CELLULAR PERSPECTIVES. (5 cr, §1009; prereq 1201, 1 qtr college chemistry)
Chemistry of living things, cell structure and transport, energy processing in cells, introduction to primary metabolism, molecular genetics, cell physiology, and regulation of development. Lab. To be taken as the second course in the Biol 1201-1202-1203 sequence.

1301. HUMAN REPRODUCTION AND DEVELOPMENT. (4 cr; prereq 1009 or 1202 or equiv)
Human development from gametogenesis to senescence. Ovulation, sperm release, fertilization, transit of early embryo to uterus, implantation, fetal membranes, cellular differentiation, organogenesis, birth, adolescence, puberty, and senescence. Congenital defects, birth control, multiple births, and human cytogenetics in relation to development. *In vitro* fertilization.

1951, 1952, 1953. BIOLOGY COLLOQUIUM. (1 cr/f, 1 or 2 cr/w.s.; S-N only)

Introduction to the diversity of biology through seminars, lab tours, undergraduate research, trips to Itasca Biological Station, and interaction with other biology students and faculty.

3003. INTRODUCTION TO COMPUTING IN BIOLOGY. (2 cr; prereq 1009 or 1202 or equiv, declared bioscience major, Δ)

Hands-on use of microcomputers to introduce students in biology to how computers can help them manipulate data, prepare graphs and graphics, perform literature searches, prepare posters and reports, and communicate with others through the use of the computer network.

3009H. GENERAL BIOLOGY: A QUANTITATIVE APPROACH. (5 cr, §1009H or 1202; prereq college-level chemistry, at least 1 yr each of calculus and physics, permission of CBS, CLA, or IT honors office)
Introduction to the principles of biology with emphasis on quantitative aspects. The cell, metabolism, physiology, heredity, ecology, and evolution. Lab.

3011. ANIMAL BIOLOGY. (5 cr, §1106, §1806; prereq 1009 or 1202, Chem 1052)

Comparison of ways different phyla have solved similar physiological problems. Laboratory includes survey of major animal groups and physiological experiments.

3012. PLANT BIOLOGY. (5 cr, §1103, § 3812; prereq 1009 or 1202, Chem 1052)

Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants. Lab.

3051. BIOLOGY AND THE FUTURE OF THE EARTH. (4 cr; bio sci students may not apply these credits toward the major)

Nontechnical discussion of current environmental issues including air and water pollution, human population growth, toxic and hazardous wastes, urbanization, resource economics, biological diversity, energy, health, and environmental ethics.

3111. ANIMAL BIOLOGY. (4 cr, §3011; prereq 1009 or 1202, 1106 or 1806, Chem 1052)

Comparative physiology of various animal groups; coordination, movement, support, excretion, reproduction.

3112. BIOLOGICAL RHYTHMS AND TIMING MECHANISMS. (4 cr, §5112; prereq 1009 or 1202 or #)

Timing mechanisms and rhythms of organisms in physiological processes, ecological adaptation, and health; current hypotheses concerning their cellular and molecular nature. Individual projects.

3950H. UNDERGRADUATE SEMINAR. (2 cr per qtr; S-N only)

Each quarter different faculty members lead groups of students in discussions on topics of current interest.

3960H. HONORS SEMINAR. (1 cr per qtr; S-N only; prereq Δ ; limited to participants in CBS Honors Program)
Oral reports on topics of current interest to biologists. Progress reports on laboratory and field research by students.

3980. DIRECTED INSTRUCTION. (1-3 cr per qtr; prereq #; S-N only; up to 8 cr may apply toward major)
Leadership opportunities for upper division students wishing to assist with the Biology Colloquium.

Major Requirements and Course Descriptions

5003. GENETICS. (4 cr, §GCB 3022, §GCB 5022; prereq 5001 or BioC 3021 or BioC 5331)

Introduction to the nature of genetic information, its transmission from parents to offspring, its expression in cells and organisms, and its course in populations.

5004. CELL BIOLOGY. (3 cr; prereq 5001 or BioC 3021 or BioC 5331)

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.

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. Lab.

5041. ECOLOGY. (4 cr, §5841; prereq 1103 or 1106 or 1806 or 3011 or 3012 or 3812, Math 1142 or 1251)

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. Lab.

5125. RECOMBINANT DNA LABORATORY. (4 cr, §5825, §MicB 5125, §MicB 5425; application necessary; prereq Δ)

Basic recombinant DNA techniques. Methods for growing, isolating, and purifying recombinant DNAs and cloning vectors.

5950. SPECIAL TOPICS IN BIOLOGY. (1-5 cr per qtr)

5951. SOCIAL USES OF BIOLOGY. (4 cr; prereq 10 cr sciences; S-N only)

Influence of biological science on the quality of human life: agriculture, medicine, occupational health, environmental science, and theories of human nature. Responsibilities and roles of biologists in policy formulation in the scientific and political world.

Courses Offered at Lake Itasca Forestry and Biological Station

1806. ZOOLOGY (5 cr, §1106.; prereq 1009 or 1202, Δ)

Survey of animal phyla; structure, function, behavior, adaptation and evolutionary relationships. Lab.

3812. PLANT BIOLOGY. (5 cr, §1103, §3012; prereq 1009 or 1202, Chem 1052, Δ)

Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants. Field trips.

5810. TOPICS IN ENVIRONMENTAL EDUCATION FOR ELEMENTARY TEACHERS.

(5 cr; prereq Δ)

Intensive two-week Environmental Education Institute to instruct elementary teachers in several areas of ecology and environmental concerns. Uses ecosystem studies as basis for study, emphases on integrating these concepts into elementary school curriculum.

5816. FIELD BIOLOGY PHOTOGRAPHY. (5 cr; prereq course in beginning biology, Δ; A-F only)

Field photography techniques for documentation of insects, vertebrates, aquatic organisms, and habitats of the Itasca area. Emphasis on general 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 films. No previous processing experience required.

5825. RECOMBINANT DNA LABORATORY. (4 cr; §5125, §MicB 5125, §MicB 5425; prereq Δ, application) Basic recombinant DNA techniques. Methods for growing, isolating, and purifying recombinant DNAs and cloning vectors.

5841. ECOLOGY. (5 cr, §5041; prereq 1103 or 1106 or 1806 or 3011 or 3012 or 3812, Math 1142 or 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. Field work at the Itasca station.

5850. SPECIAL TOPICS IN BIOLOGY. (Cr ar, 1-10 per qtr; prereq Δ)

5890. RESEARCH PROBLEMS AT ITASCA IN ECOLOGY, EVOLUTION, AND BEHAVIOR; OR ENTOMOLOGY, FISHERIES, AND WILDLIFE; OR PLANT PATHOLOGY; OR SOIL SCIENCE; OR ZOOLOGY. (Cr ar; prereq #, Δ)

Undergraduate and graduate students may develop a short-term research project in any area listed above during one or both terms.

Biochemistry (BioC)

Director of Undergraduate Studies—Clare Woodward

Biochemists study the molecules that are found in living organisms, particularly proteins, nucleic acids, lipids, and carbohydrates. The major in biochemistry is for students who plan to pursue graduate study in biochemistry or a related biological science, attend medical school, or seek entry-level biochemical positions in industry. The biochemistry major differs from the chemistry major in that there is greater emphasis on courses in the biological sciences.

Biochemistry is an experimental science, and majors, especially those who plan to pursue graduate studies in the field, should become acquainted with laboratory research approaches beyond those introduced in the formal lab courses. Research options are available through BioC 5990 and the Honors Program. Students should start planning the

research component of their major program as early as possible and should make arrangements, in consultation with their adviser, for their senior research project during their junior year.

In addition to the general requirements for graduation from CBS, biochemistry majors must complete the requirements listed below. The following major requirements are used in partial fulfillment of the college graduation requirements 5.b.3 and 5.b.4 (see Admission Procedures and Degree Requirements, page 22). Biochemistry majors are expected to meet with their faculty adviser for assistance in designing the elective portion of the major. Students may choose a special emphasis in areas such as molecular biology or biophysics.

Biochemistry—BioC 3960, 5331, 5332, 5333; 5025 or 5744

Organic Chemistry—Chem 3303

Mathematics—Math 3251

Physical Chemistry—Chem 5520, 5521 or Chem 5533, 5534, 5535 and 5538 or 5540

Biology—Biol 5003, 5004 (these courses will satisfy one of the elective components of the biology core, listed under 5.b.2) in the previous section on degree requirements.)

BioC Courses

1401. ELEMENTARY BIOCHEMISTRY. (4 cr, §3001, prereq Chem 1001 or one qtr college chemistry) Elementary survey of biochemistry beginning with a brief introduction to organic chemistry. Intended for students who need a general, non-intensive knowledge of the scope of biochemistry.

3021. BIOCHEMISTRY. (4 cr, §Biol 5001; prereq Biol 1009 or 1202, 8 cr organic chemistry) Fundamentals of biochemistry, including structure and function of proteins, nucleic acids, lipids and carbohydrates; metabolism and regulation of metabolism; quantitative treatments of chemical equilibria, enzyme catalysis and bioenergetics; and the chemical basis of genetic information flow.

3960. RESEARCH TOPICS IN BIOCHEMISTRY. (1 cr per qtr; S-N only) Lectures and discussions on current research in the department.

5025. LABORATORY IN BIOCHEMISTRY. (2 cr; prereq Biol 5001 or BioC 3021 or BioC 5331 or concurrent registration in any of the previously listed courses) Discussions of techniques and problem-solving approaches illustrated with lab experiments and demonstrations.

5301. ECOLOGICAL BIOCHEMISTRY. (3 cr; prereq Biol 5001 or BioC 3021 or grade of B or better in BioC 3031 or #)

Biochemistry of environmental processes, including biochemistry of organismal interactions, biological responses to environmental stress, gene transfer in the environment, and effects and fate of environmental toxins.

5331. STRUCTURE, CATALYSIS, AND METABOLISM IN BIOLOGICAL SYSTEMS. (4 cr, §3021, §Biol 5001; prereq Biol 1009 or Biol 1202, 2 qtrs organic chemistry or #)

Structure and function of biological molecules emphasizing protein structure, catalysis, and intermediary metabolism. Enzyme kinetics, thermodynamics, and the role of cofactors in catalysis.

5332. ENERGY AND SIGNAL TRANSDUCTION IN BIOLOGICAL SYSTEMS. (4 cr; prereq 5331 or #) Biological membrane structure and membrane-associated proteins emphasized. Processes such as transport and oxidation/reduction, photosynthesis, membrane receptors, signal transduction, and specific regulatory systems.

5333. MOLECULAR MECHANISMS OF GENE ACTION. (4 cr; prereq 5332 or #)

Gene action mechanisms. Structure and function of nucleic acids and the regulatory process involved in gene expression from a biochemical point of view.

5401. METABOLISM AND ITS REGULATION (formerly 5002). (3 cr; prereq Biol 5001 or BioC 3021 or BioC 5331)

Principles determining metabolism of both common and unusual compounds in plants, animals, and microbes. Regulation of carbon and energy flow in whole organisms.

5525. PHYSICAL BIOCHEMISTRY: SOLUTION STRUCTURE AND INTERACTIONS OF BIOLOGICAL MACROMOLECULES. (4 cr, §Chem 5525, §MdBe 5525; prereq 2 qtrs physical chemistry, Biol 5001 or BioC 3021 or BioC 5331 or equiv)

Physical chemistry of equilibrium, transport, and scattering phenomena in solution, with application to proteins and nucleic acids. Inter-molecular forces, macromolecular dynamics, conformational transitions, binding thermodynamics, methods for determining biopolymer size and shape, including sedimentation, diffusion, viscosity, electrophoresis, and scattering.

5526. PHYSICAL BIOCHEMISTRY: SPECTROSCOPIC METHODS I. (4 cr, §Chem 5526, §MdBe 5526; prereq 2 qtrs physical chemistry)

Fundamental spectroscopic principles with emphasis on the development of magnetic resonance theory used in the study of biological macromolecules.

5527. PHYSICAL BIOCHEMISTRY: SPECTROSCOPIC METHODS II. (4 cr, §Chem 5527, §MdBe 5527; prereq 2 qtrs physical chemistry, BioC/MdBe 5526)

Applications of optical and magnetic resonance techniques to the study of structure and dynamics in proteins, lipids, nucleic acids, and synthetic analogs.

Major Requirements and Course Descriptions

5528. PHYSICAL BIOCHEMISTRY: ENZYME KINETICS. (4 cr. §Chem 5528, §MdBc 5528; prereq 2 qtrs physical chemistry, BioC/MdBc 5751 or BioC 5002 or equiv recommended)

Theory and application of steady-state and transient kinetics to the study of enzymes, enzyme systems, and cellular regulation.

5529. PROTEIN STRUCTURE AND FOLDING. (4 cr. §Chem 5529, §MdBc 5529; prereq BioC 3021 or BioC 5331 or Biol 5001 or equiv. 1 qtr physical chemistry or #)

Protein structure, stability, folding, molecular modeling. Emphasis on results from X-ray crystallography, solution thermodynamics, NMR, computer graphics, and protein engineering.

5744. ANALYTICAL BIOCHEMISTRY. (4 cr; prereq previous lab work in analytical and organic chemistry, #) Principal techniques of biochemistry experimental work; instrumentation and methods for isolation and characterization of proteins, lipids, and carbohydrates. Chromatography, electrophoresis, spectrophotometry, potentiometry, and fluorimetry.

5970. DIRECTED STUDIES. (Cr ar; prereq #, Δ) Individual study on selected topics with emphasis on selected readings and use of scientific literature.

5990. DIRECTED RESEARCH. (Cr ar; prereq #, Δ) Lab or field investigation of selected areas of research.

For Graduate Students Only

(For descriptions, see the *Graduate School Bulletin*)

8001. ADVANCED BIOCHEMISTRY I: PROTEIN STRUCTURE AND FUNCTION

8002. ADVANCED BIOCHEMISTRY II: MOLECULAR BIOLOGY

8003. ADVANCED BIOCHEMISTRY III: REGULATION OF METABOLISM AND BIOLOGICAL PROCESSES

8094. RESEARCH AND LITERATURE REPORTS

8194. GRADUATE SEMINAR

8206. CELL SIGNALLING AND METABOLIC REGULATION I

8213. ADVANCED MOLECULAR BIOLOGY I

8214. ADVANCED MOLECULAR BIOLOGY II

8225. TRACER TECHNIQUES

8230. MEMBRANE BIOCHEMISTRY

8290. CURRENT RESEARCH TECHNIQUES

8990. GRADUATE RESEARCH

Botany Major (See plant biology, below)

Ecology, Evolution, and Behavior (EEB)

Director of Undergraduate Studies—
Richard Phillips

Ecologists study the evolutionary adaptations of plants and animals to the environment. The ecological perspective encompasses the growth and maintenance of populations and their interactions in communities, and the interrelationships among organisms and physical events in terrestrial and aquatic ecosystems. The behavioral biology perspective deals with adaptations to the environment, mechanisms of behavior, and the evolution of social systems.

The Department of Ecology, Evolution, and Behavior participates in teaching the core curriculum in biology and offers an undergraduate major in ecology, evolution, and behavior.

In addition to general requirements for graduation from CBS, ecology, evolution, and behavior students must complete the following major requirements, which may be used in partial fulfillment of the college graduation requirements 5.b.3 and 5.b.4 (see Admission Procedures and Degree Requirements, page 22):

- a. Biol 5041/5841 (if not used to satisfy b2 above).
- b. EEB 3111 (4 cr).
- c. EEB 5044 (4 cr) or 5064 (4 cr); Biol 1008 (4 cr) may be substituted if taken as a freshman or sophomore.
- d. EEB 5156 (5 cr), or PBio 3131 (4 cr) with PBio 5132 (2 cr), or PBio 5131 (4 cr) with PBio 5132 (2 cr) or EEB 5323 (3 cr) or AnSc 3301 (6 cr). Students who select EEB 5323 should note that this course does not meet a lab or field course requirement (see 5.b.4) above.
- e. Field experience in biology (at least 5 cr for courses that involve extensive field experience); the Lake Itasca Forestry and Biological Station and other field stations offer a variety of suitable courses; other appropriate courses may be substituted by petition.

- f. At least two courses from Group I (see below) must be included in the upper division credits in mathematics and/or physical sciences and/or biological sciences required for graduation. Students are encouraged to select courses in consultation with the faculty adviser and the director of undergraduate studies; other courses may be substituted by petition (see especially Group II below).

Recommended Courses, Group I:

Community Ecology and Paleocology

- EEB 5004—Earth System: Geosphere/Biosphere Interactions (4 cr)
- EEB 5008—Quaternary Ecology (4 cr)
- EEB 5014—Ecology of Vegetation (5 cr)
- EEB 5016—Ecological Plant Geography (5 cr)

Population and Evolutionary Biology

- EEB 5033—Population and Quantitative Genetics (4 cr)
- EEB 5044—Evolution (4 cr) (if not used to meet requirement c. above)
- EEB 5051—Analysis of Populations (4 cr)
- EEB 5052—Theoretical Population Ecology (5 cr)
- EEB 5064—The Process of Evolution (4 cr) (if not used to meet requirement c. above)
- EEB 5065—Theoretical Evolutionary Ecology (3 cr)

Organismal Biology and Physiological Ecology

- EEB 5122—Plant/Animal Interactions (4 cr)
- EEB 5129—Mammalogy (5 cr)
- EEB 5134—Introduction to Ornithology (5 cr)
- EEB 5136—Ichthyology (4 cr)
- EEB 5156—Comparative Animal Physiology (5 cr) (if not used to meet physiology requirement d. above)

Behavioral Biology

- EEB 5321—Evolution of Social Behavior (4 cr)
- EEB 5323—Mechanisms of Behavior (3 cr) (if not used to meet physiology requirement)
- EEB 5324—Evolution of Primate Social Behavior (3 cr)
- EEB 5325—Behavioral Ecology (4 cr)

Limnology and Ecosystem Biology

- EEB 5601—Limnology (4 cr)
- EEB 5606—Ecology of Fishes (3 cr)
- EEB 5607—Ecology of Animal Plankton (5 cr)
- EEB 5608—Ecosystems: Form and Function (4 cr)
- EEB 5621—Limnology Laboratory (2 cr)

Recommended Courses, Group II:

- Anthropology
- Climatology/Meteorology
- Earth Sciences
- Entomology
- Fisheries
- Forestry
- Mathematics
- Psychology
- Public Health
- Statistics
- Wildlife Biology

EEB Courses

1019. OUR CHANGING PLANET. (4 cr, §Ast 1019, §Geo 1019)

Interrelationships among Earth's subsystems—solid earth, oceans, atmosphere, and biosphere—and solar and galactic super-systems. Interactions of the natural cycles, their rates and feedbacks, and human impacts.

3001. INTRODUCTION TO ECOLOGY. (4 cr; open to jrs and above but not biology majors)

Basic concepts in ecology; organization, development, and functioning of ecosystems; population growth and regulation. Human impact on ecosystems.

3101. ECOLOGY FOR ENGINEERS AND PHYSICAL SCIENTISTS. (4 cr, §3001; prereq Math 1261; not open to biology majors)

Description and analysis of the spatial and temporal interactions between populations in ecosystems; processes affecting populations; transformations of energy and materials in the biosphere. Lectures and recitations.

3111. INTRODUCTION TO ANIMAL BEHAVIOR. (4 cr, §AnSc 3111; prereq Biol 1008 or 1009 or 1201 or 1202 or #)

Causation, development, function, and evolution; emphasizes evolution of adaptive behavior, especially social behavior, in the natural environment.

Biol 5041. ECOLOGY. (4 cr, §5841; prereq 1103 or 1106 or 1806 or 3011 or 3012 or 3812, Math 1142 or 1251)

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.

5970. DIRECTED STUDIES. (Cr ar; prereq #, Δ)

Individual study on selected topics or problems with emphasis on selected readings and use of scientific literature.

5990. DIRECTED RESEARCH. (Cr ar; prereq #, Δ)

Lab or field investigation of selected areas of research.

Community Ecology and Paleocology

5004. EARTH SYSTEM: GEOSPHERE/BIOSPHERE INTERACTIONS. (4 cr, §Geo 5631; prereq Geo 3202, 3301 or #)

Interdisciplinary study of global change forcing mechanisms, feedbacks and dynamics on various time scales, using paleorecord to illustrate processes.

Major Requirements and Course Descriptions

5008. QUATERNARY ECOLOGY. (4 cr; prereq Biol 5041 or 5841 or #)

Impact of changes in the physical and biological environment during the quaternary period on plants and animals. Changes in evolutionary rates, geographical distributions, community composition and fluctuations in population sizes. Impact of prehistoric human culture on the environment, including ecosystem-level changes recorded in sedimentary sequences. Recent climatic changes. General principles of analysis and methods of investigation and interpretation.

5014. ECOLOGY OF VEGETATION. (5 cr; prereq Biol 5041 or 5841, 1 qtr statistics or #; offered when feasible)

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 local vegetation types; analysis of quantitative data.

5016. ECOLOGICAL PLANT GEOGRAPHY. (5 cr; prereq Biol 5041 or Biol 5841, PBio 3201 or PPBio 3201 or #; offered when feasible)

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.

Population and Evolutionary Biology

5033. POPULATION AND QUANTITATIVE GENETICS. (4 cr; prereq Biol 5003 or GCB 3022, course in biometry or statistics or #)

Genetic basis of microevolutionary change. Allelic frequency dynamics, with particular emphasis on natural selection and adaptive topography. Molecular evolution, additive genetic variance, consequences of artificial selection and current topics.

5044. EVOLUTION. (4 cr; prereq Biol 1106 or Biol 1806 or Biol 3011, Biol 1103 or Biol 3012 or Biol 3812)

Evidence for and causes of biological evolution.

5051. ANALYSIS OF POPULATIONS. (4 cr; prereq Biol 5041 or Biol 5841 or #)

Factors involved in the regulation, growth, and general dynamics of populations. Data needed to describe populations, population growth, population models, and regulatory mechanisms.

5052. THEORETICAL POPULATION ECOLOGY. (5 cr; prereq Biol 5041 or Biol 5841 or #; offered when feasible)

Theories of population ecology, including models of growth and regulation of single populations, and of interactions between populations, including competition, predation, mutualism; emphasizes assumptions and rationales of models and their predictions for dynamics, stability, and diversity of communities.

5064. THE PROCESS OF EVOLUTION. (4 cr; prereq Biol 5041 or Biol 5841 or #)

Mechanistic bases of evolution, including causes and consequences of natural selection, stochastic consequences of Mendelian segregation, and their combined influences on the structure of natural and captive populations. Lab exercises based on "Populus" computer simulation software.

5065. THEORETICAL EVOLUTIONARY ECOLOGY. (3 cr; prereq Math 1261, one 5xxx-level course in ecology or evolution or behavior or #)

Evolutionary approaches to ecology and behavior based upon application of optimization and game theory techniques. Optimal foraging theory, evolution of life histories, animal behavior in contest situations.

Organismal Biology and Physiological Ecology

5122. PLANT/ANIMAL INTERACTIONS. (4 cr; prereq Biol 1106 or Biol 1806 or Biol 3011, Biol 1103 or Biol 3012 or Biol 3812, 10 cr biological sciences or #; offered when feasible)

Herbivory, pollination, seed dispersal. Implications of interaction for plants and animals at organismal, population, and community levels. Coevolution.

5129. MAMMALOLOGY. (5 cr, \$FW 5129; prereq Biol 1106 or Biol 1806 or Biol 3011 or #)

Recent families and orders of mammals of the world and genera and species of mammals of North America, with emphasis on morphology, evolution, and zoogeographic history.

5134. INTRODUCTION TO ORNITHOLOGY. (5 cr; prereq Biol 1106 or Biol 1806 or Biol 3011)

Lab and field course in structure, classification, distribution, migration, habits, habitats, and identification of birds. Weekend trips.

5136. ICHTHYOLOGY. (4 cr; prereq 15 cr incl Biol 1106 or Biol 1806 or Biol 3011)

Biology of fishes including development, systematics, anatomy, physiology, and ecology.

5156. COMPARATIVE ANIMAL PHYSIOLOGY. (5 cr; prereq Biol 1106 or Biol 1806 or Biol 3011, Chem 3302 or #)

The passive organism: environment stresses and biological mechanisms by which they are counteracted.

Behavior

5321. EVOLUTION OF SOCIAL BEHAVIOR. (4 cr; prereq Biol 1106 or Biol 1806 or Biol 3011 or #)

Current theories and concepts relating to mating systems, spacing systems, and cooperative behavior in animals.

5323. MECHANISMS OF BEHAVIOR. (3 cr; prereq 3111 or Biol 3011 or #)

Neural and hormonal mechanisms that mediate adaptive behavior in invertebrate and vertebrate animals, using a series of well-studied examples to illustrate general principles.

5324. EVOLUTION OF PRIMATE SOCIAL BEHAVIOR. (3 cr; prereq 3111 or #)

Ecological factors that influence variation in the demography, social structure and social behavior of non-human primates. Application of current evolutionary theory (e.g. kin selection, reciprocity) to the understanding of social behavior.

5325. BEHAVIORAL ECOLOGY. (4 cr; prereq 3111 or 5321 or Biol 5041 or Biol 5841 or #)

Evolutionary principles applied to the 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, dispersal.

Limnology and Ecosystem Ecology

5601. LIMNOLOGY. (4 cr, §Geol 5601; prereq Chem 1052 or #)

Description and analysis of the 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.

5606. ECOLOGY OF FISHES. (3 cr; prereq 5136 plus 10 cr biological sciences; offered when feasible)

Ecological requirements of fishes with emphasis on nongame species; habitat, food, interactions among species, and behavioral, anatomical, and physiological adaptations. Fishes in the aquatic ecosystem with emphasis on fresh waters.

5607. ECOLOGY OF ANIMAL PLANKTON. (5 cr; prereq 5601, Biol 5041 or Biol 5841 or #: offered when feasible)

Biology of animal plankton, including distribution of zooplankton in lakes, ecosystem functions such as grazing and remineralization, determination of production, physiological responses to contaminated environments, and important aspects of behavior.

5608. ECOSYSTEMS: FORM AND FUNCTION. (4 cr; prereq 5601 or Biol 5041 or Biol 5841 or equiv)

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.

5621. LIMNOLOGY LABORATORY. (2 cr, §Geol 5621; prereq 5601 or Geol 5601 or #)

Principal techniques for obtaining information about environmental conditions in lakes and streams. Procedures for measuring the abundance and population dynamics of aquatic organisms, with special emphasis on plankton. Field instruments, sampling devices, chemical analysis, microscopy, and analysis of data. One Saturday field trip.

Courses Offered at Lake Itasca Forestry and Biological Station

5814. PLANT COMMUNITY ECOLOGY. (5 cr; prereq ecology course, Δ)

Communities represented in Itasca Park and vicinity, with emphasis on vegetation. Patterns of distribution of the communities, their interaction with the environment, and their dynamic relationships. Methods of community description and analysis.

5817. VERTEBRATE ECOLOGY. (5 cr; prereq ecology course, Δ)

Field studies on vertebrate populations and their relationships to local environments; habitat analysis and ecological research methods. Students work as a team investigating factors influencing distribution and abundance of selected vertebrates in various habitats. Research-oriented course supplemented with lectures and field trips.

5832. NATURAL HISTORY OF VERTEBRATES. (5 cr; prereq Biol 1106 or Biol 1806, Δ)

Taxonomic survey of local vertebrates, exclusive of birds, and study of morphological, physiological, and behavioral adaptations to different habitats.

5834. FIELD ORNITHOLOGY. (5 cr; prereq general biology course including study of zoology, Δ)

Emphasis on the breeding season, biology, and behavioral ecology of birds in the Itasca Park region. Field trips taken to a variety of habitats to learn bird identification and observe and practice techniques for conducting field studies. Laboratory sessions investigate family distinctions and species identification. Individual field projects.

5839. FIELD STUDIES IN MAMMOLOGY. (5 cr; prereq college-level biology course including study of animals or #, Δ)

Identification, distributions, community interactions, ecophysiology, population ecology.

BIOL 5841. ECOLOGY. (5 cr, §Biol 5041; prereq 1103 or 1106 or 1806 or 3011 or 3012 or 3812, Math 1142 or 1211 or 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. Field work at the Itasca station.

For Graduate Students Only

(For descriptions, see the *Graduate School Bulletin*)

8002. STATISTICAL ANALYSIS OF ECOLOGICAL SYSTEMS

8004. TOPICS IN ECOLOGICAL GENETICS

8014. PALEOECOLOGICAL METHODS

8061. SOCIAL SYSTEMS

8162. WINTER ECOLOGY

8300. TOPICS IN EVOLUTION

8390. GRADUATE SEMINAR

8400. POPULATION BIOLOGY SEMINAR

8410. COMMUNITY ECOLOGY SEMINAR

8420. POPULATION BIOLOGY RESEARCH SEMINAR

8430. EVOLUTIONARY GENETICS SEMINAR

8510. BEHAVIORAL BIOLOGY SEMINAR

8602. ADVANCED LIMNOLOGY

8990. GRADUATE RESEARCH

Interested students should also check the *Courses on the Environment* bulletin.

History of Science and Technology (HSci)

HSci 3201/5201, 3202/5202. HISTORY OF BIOLOGY. (4 cr per qtr)

Scientific, philosophical, and social factors in development of biology; changing styles of biological reasoning and changing relationships between biological and physical sciences. *3201/5201*: Biology from antiquity through early modern period. *3202/5202*: Biology in 19th and 20th centuries.

Major Requirements and Course Descriptions

5242. THE DARWINIAN REVOLUTION. (4 cr; prereq Biol 1009 or 1202 or 1101 or #)
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 the proper scientific methodology.

Genetics and Cell Biology (GCB)

Director of Undergraduate Studies—
Norman S. Kerr

Genetics is the study of inheritance, including molecular mechanisms of gene organization and expression, human genetics, and the behavior of genes in populations of organisms. Study in cell and developmental biology seeks to answer basic questions regarding organization, composition, function, and assembly of cells and cellular components, and their regulation during the processes of cellular growth and differentiation.

The genetics and cell biology (GCB) major provides special educational opportunities for undergraduate students through group discussion of current research problems and techniques, enhanced practical experience with relevant systems and methodology, additional advanced courses, and close interaction with faculty actively investigating contemporary problems and reviewing current literature in the field. This major prepares undergraduates for advanced study and for positions in the rapidly growing field of biotechnology and in medical, industrial, or other scientific laboratories.

In addition to the general requirements for graduation from CBS, genetics and cell biology majors must complete the following major requirements, which may be used in partial fulfillment of the college graduation requirements 5.a.6 and 5.a.7 (see Admission Procedures and Degree Requirements, page 22):

GCB majors must complete 27 additional credits, including:

- GCB 3960 (1 cr) (Students should complete this course as soon as possible after they decide to major in GCB)
- Biol 3950H (two quarters, 4 cr) The value of the undergraduate seminar is at least two-fold: (1) It permits students to meet in

small groups and practice both oral and written communication; (2) it requires students to explore an aspect of biology in depth.

- BioC 5025. Lab in Biochemistry (2 cr)
- 20 additional credits in life sciences and/or physical science and/or mathematics and/or statistics and/or computer science, chosen in consultation with major adviser. The 20 credits must include two additional laboratory experiences, totalling a minimum of 4 cr, one of which must be in GCB. (Biol 5125 may be considered a GCB course for purposes of this requirement.) Students should include GCB 5990, Directed Research, as one or both of these experiences. A maximum of 8 credits of 5990 may be used towards the 20-credit total.

The 20 credits must include at least 3 credits from Area 1 and 3 credits from Area 2; it may include not more than 4 credits from Area 4:

Area 1: Genetics

- Biol 5125—Recombinant DNA Laboratory (4 cr)*
- EEB 5033—Population and Quantitative Genetics (4 cr)
- GCB 5024—Genetics of Development (4 cr)**
- GCB 5030—Laboratory: Genetics (2 cr)*
- GCB 5034—Intermediate Molecular Genetics (4 cr)
- GCB 5042—Quantitative Genetics (4 cr)**
- GCB 5073—Advanced Human Genetics (4 cr)**
- PBio 5109—Molecular Genetics and Biochemistry of Yeasts and Filamentous Fungi (4 cr)**
- Psy 5137—Introduction to Behavioral Genetics (4 cr)

Area 2: Cell and Developmental Biology

- GCB 5015—Histology: Cell and Tissue Organization (5 cr)*
- GCB 5035—Intermediate Cell Biology (4 cr)
- GCB 5061—Developmental Biology (4 cr)
- GCB 5114—General Physiology (3 cr)
- GCB 5134—Endocrinology (4 cr)
- GCB 5605—Cell Biology Laboratory (2 cr)*
- PBio 5151—Plant Cell Biology (4 cr)**

*Lab courses.

**Courses taken primarily by graduate students; undergraduates should have excellent grades in Biol 5003 and/or Biol 5004.

Area 3: Courses from other departments. (This list is not all-inclusive.)

- BioC 5401—Metabolism and Regulation (3 cr)
 Chem 3100, 3101—Quantitative Analysis (5 cr)
 Chem 3303—Elementary Organic Chemistry III (4 cr)
 Chem 5520-5521—Elementary Physical Chemistry (6 cr)
 CSci 3102—Introduction to PASCAL Programming (4 cr)
 EEB 5044—Evolution (4 cr)
 EEB 5064—The Process of Evolution (4 cr)
 GCB 3008—The Biology of Cancer (3 cr)
 Math 3251—Multivariable Differential Calculus (4 cr)
 MicB 5218—Immunology (3 cr)
 MicB 5321—Physiology of Bacteria (3 cr)
 MicB 5424—Biology of Viruses (4 cr)
 PBio 3131—Survey of Plant Physiology (4 cr)
 PBio 5111—Plant Cell, Tissue, and Organ Development (5 cr)
 Stat 5021—Statistical Analysis (5 cr)

Area 4: History and Philosophy of Science

- Biol 5951—Social Uses of Biology (4 cr)
 HSci 3202—History of Biology (Physiology and Cell Theory) (4 cr)
 HSci 5242—The Darwinian Revolution (4 cr)
 Phil 3601—Scientific Thought (4 cr)
 Phil 5603—Philosophy of Science: Change (4 cr)
 Phil 5607—Philosophy of Science: Biology (4 cr)

GCB Courses

3002. HUMAN GENETICS, SOCIAL AFFAIRS. (3 cr [4 cr with term paper], §3022, §Biol 1101, §Biol 5003; for students in programs not directly related to biological sciences)

Heredity and basic genetic mechanisms with emphasis on humans. Relationship between human genetics and disease, family planning, gender, behavior, and race. Ethical/societal issues concerning human genetics and modern genetic technologies.

3008. THE BIOLOGY OF CANCER. (3 cr; prereq Biol 1009 or 1202)

Biological aspects of etiology, phylogeny, and cellular processes involved in neoplasia. Growth and differentiation of normal and cancer cells. History of cancer research.

3022. GENETICS. (4 cr, §Biol 5003; not for biology majors; prereq Biol 1009 or 1202)
 Mechanisms of heredity, their implications for biological populations, and applications to practical problems.

3960. RESEARCH TOPICS. (1 cr; prereq 15 cr biology; S-N only)

Ongoing department faculty research. Introduces sophomores and juniors who are potential GCB majors to department faculty, the diversity of faculty research activities, and opportunities for GCB undergraduate research.

5015. HISTOLOGY: CELL AND TISSUE ORGANIZATION. (5 cr; prereq Biol 5004 or #)

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.

5024. THE GENETICS OF DEVELOPMENT. (4 cr; prereq Biol 5003 or #)

Current concepts and experimental approaches concerning the genetic basis of morphogenesis and metazoan development. Concentration on organisms amenable to genetic analysis, including certain prokaryotes and single-cell eukaryotes, nematodes, and *Drosophila*.

5030. LABORATORY: GENETICS. (2 cr; prereq 3022 or Biol 5003 or BioC 5333)

Investigative approaches to analysis of genetic problems. Focus on a given organism or related group of organisms may differ from quarter to quarter.

5034. INTERMEDIATE MOLECULAR GENETICS. (4 cr; prereq Biol 5003, 5004)

Molecular genetics of prokaryotes and eukaryotes concentrating on the characterization and regulation of expression of genes, and the techniques used to study gene expression. For advanced bioscience undergraduates and graduate students outside of CBS programs.

5035. INTERMEDIATE CELL BIOLOGY. (4 cr; prereq Biol 5004 or #)

Current literature in cell biology. Selected scientific papers illustrate new concepts in and experimental approaches to cell organization and function. Topics vary but include membranes, secretion, endocytosis, the cytoskeleton, and the nucleus.

5042. QUANTITATIVE GENETICS. (4 cr; prereq 5033; Stat 5301 recommended; S-N only)

Selection with reference to population changes in gene frequencies and means of quantitative characters. Information required for predicting effects of selection and related research. Emphasis on logical analysis.

5061. DEVELOPMENTAL BIOLOGY. (4 cr; prereq Biol 3011 or 3111, Biol 5004)

Animal embryology; morphogenesis and cellular differentiation with an emphasis on vertebrates and on pattern formation. Control mechanisms of development.

5073. ADVANCED HUMAN GENETICS. (4 cr; prereq 5034 or #)

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; genetic basis of common disease.

5114. GENERAL PHYSIOLOGY. (3 cr; prereq Biol 3011 or Biol 3111, Biol 5001 or BioC 3021 or BioC 5331, Phys 1109 or Phys 1295 or Phys 1253)

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.

5134. ENDOCRINOLOGY. (4 cr; prereq Biol 3011 or Biol 3111, Biol 5001 or BioC 3021 or BioC 5331 or #)

Survey of structure and function of invertebrate and vertebrate endocrine systems.

Major Requirements and Course Descriptions

5605. CELL BIOLOGY LABORATORY. (2 cr; prereq Biol 5004 or ¶Biol 5004 or #)

Experimental approaches to cell structure, function, and replication, including microscopy, autoradiography, cell fractionation, and molecular and chemical analyses.

5970. DIRECTED STUDIES. (Cr ar; prereq #, Δ)

Individual study on selected topics or problems with emphasis on selected readings and use of scientific literature.

5990. DIRECTED RESEARCH. (Cr ar; prereq #, Δ)

Laboratory or field investigation of selected areas of research.

For Graduate Students Only

(For descriptions, see the *Graduate School Bulletin*)

8060. CURRENT TOPICS

8131. ADVANCED GENETICS I

8132. ADVANCED GENETICS II

8148. ADVANCED CELL BIOLOGY I

8149. ADVANCED CELL BIOLOGY II

8213. ADVANCED MOLECULAR BIOLOGY I

8214. ADVANCED MOLECULAR BIOLOGY II

8900. SEMINAR

8910. JOURNAL CLUBS

8912. GENETIC COUNSELING IN PRACTICE

8913. PSYCHOLOGICAL ISSUES IN GENETIC COUNSELING

8914. ETHICAL AND LEGAL ISSUES IN GENETIC COUNSELING

8950. PRACTICUM: TEACHING IN GENETICS

8960. PRACTICUM: TEACHING IN CELL AND DEVELOPMENTAL BIOLOGY

8970. DIRECTED STUDY

8990. RESEARCH

Microbiology (MicB)

Medical School

Director of Undergraduate Studies—

Palmer Rogers

The microbiology program prepares students for work as practicing microbiologists or for graduate work.

The field of microbiology embraces a multitude of areas of fundamental and applied research. Microbiologists have in common an interest in the basic role played by microbes, such as bacteria, fungi, and viruses, in the world in which we live. Microbiologists may be interested in basic biological mechanisms,

such as DNA replication or the regulation of protein synthesis, that are currently under study employing microorganisms. They may study fundamental issues concerning human and animal diseases such as the mechanisms of viral and bacteriological infection, immunity and autoimmune disease, and viral-induced cancer. Many aspects of agriculture are under investigation by microbiologists; among them are specific fungal and bacterial symbionts essential for maximum growth of certain plants and bacteria and fungi essential for maintenance and production of natural soil fertility. Microbiologists are also active in many industrial and pharmaceutical fields involving production and discovery of new antibiotics; manufacture of cheese, beer, wine, and other foods; pasteurization in canning and food processing; and even decontamination of space vehicles.

To fulfill part of the upper division science and mathematics credits required for graduation (5.b.2., 3, and 4 on page 22), microbiology majors must complete the following:

Biochemistry: BioC 3021 or 5331

Chemistry: Chem 3100, 3101

Genetics: Biol 5003 or GCB 3022

Ecology/Environment: Biol 5041 or 5841 or MicB 5611

Microbiology: MicB 5105 or Biol 5013, MicB 5900

Four of the following: MicB 5218, 5232, 5321, 5352, 5424, 5611 (if not used to fulfill ecology requirement)

Two of the following: MicB 5234, 5322, 5425; or directed research, MicB 5990, a minimum of 8 credits in one laboratory. Directed research may only be used to meet one of the laboratory requirements.

Students planning to graduate with honors in microbiology must include specific courses in their program in addition to the college requirements. A listing of these requirements may be obtained from the department office, 1460 Mayo Memorial Building (Minneapolis), or from the CBS Office of Student Services, 223 Snyder Hall (612/624-9717).

MicB Courses

3103.¹ GENERAL MICROBIOLOGY. (5 cr, §5105, §Biol 5013, §VPB 3103; prereq soph with C avg in courses prereq to major sequence or jr with 10 cr chemistry, 5 cr biological sciences or #)
Morphology, physiology, taxonomy, and ecology of bacteria. Applications of fundamental principles. Lab.

Biol 5013,¹ MICROBIOLOGY. (5 cr, §MicB 3103, §MicB 5105, §VPB 3103; prereq Biol 5001 or BioC 3021 or BioC 5331)
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Molecular structure in relation to bacterial function. Lab.

5105.¹ BIOLOGY OF MICROORGANISMS. (5 cr, §Biol 5013, §MicB 3103, §VPB 3103; prereq 5 cr biological sciences, Biol 5001 or BioC 3021 or BioC 5331 or #)
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Molecular structure in relation to bacterial function. Lab.

5218. IMMUNOLOGY. (3 cr; prereq Biol 5001 or BioC 3021 or BioC 5331)
Cellular, protein, and genetic bases of humoral immunity; methods used to measure 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, autoimmunity, transplantation.

5232. MEDICAL MICROBIOLOGY. (3 cr; not open to med students; prereq 3103 or 5105 or Biol 5013, MicB 5218 or ¶MicB 5218)
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.

5234.¹ IMMUNOLOGY AND MEDICAL MICROBIOLOGY LABORATORY. (3 cr; prereq 5218 or ¶5218, 5232 or ¶5232)
Principles that determine the outcome of host-parasite interactions. Host defense and immunology methods, including immunochemical and microbiological methods used to diagnose infectious disease.

5235. MICROORGANISMS AND DISEASE. (3 cr, §5233; not open to microbiology majors; prereq 10 cr chemistry, 5 cr biological sciences or #)
Nature of microorganisms, immunology, medical bacteriology, virology, mycology, and principles of disease control.

5321. PHYSIOLOGY OF BACTERIA. (3 cr; prereq 3103 or 5105 or Biol 5013 or VPB 3103, Biol 5001 or BioC 3021 or BioC 5331, 3 cr genetics)
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.

5322. MICROBIAL DIVERSITY AND PHYSIOLOGY LABORATORY. (3 cr; prereq 5321 or ¶5321 or equiv)

Isolation from natural sources and study of the physiology and metabolism of a wide variety of microorganisms such as *Clostridium*, yeast, *Caulobacter*, myxobacteria, *Leptospira*, photosynthetic bacteria, *Bdellovibrio*, luminescent bacteria, and others. Lab only.

5352. APPLIED MICROBIOLOGY. (4 cr; prereq 5321 or #)

Microbial adaptation to various environments; role of microorganisms in the earth's biogeochemical cycles. Application of microbial systems to industrial processes; basic principles of fermentation technology; microbial bioconversions and product formation. Biodegradation of chemicals.

5424. BIOLOGY OF VIRUSES. (3 cr; prereq Biol 5003 and one of the following: Biol 5004 or Biol 5013 or MicB 5105)

Structure, composition, and properties of bacterial, plant, and animal viruses; interaction with cells, effects on host cell metabolism; biochemistry of viral replication; techniques in study of viruses and viral infections; viral tumorigenesis.

5425.¹ VIROLOGY AND MICROBIAL GENETICS LABORATORY. (3 cr, §Biol 5125, §MicB 5125; prereq BioC 3021 or BioC 5331 or Biol 5001, GCB 3022 or GCB 5022 or Biol 5003, MicB 5424 or ¶5424)

Techniques in virology and microbial genetics: 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.

5611. MICROBIAL ECOLOGY. (3 cr, §Soil 5605; prereq 3103 or 5105 or Biol 5013 or Soil 5610 or #)
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; biotechnical approaches to studying microbial ecology.

5900. TOPICS IN MICROBIOLOGY. (1 cr; A-F only; open to microbiology sr majors)

Seminars on research programs, historical perspectives, significant emerging fields, professional societies and publications, and career opportunities.

5970. DIRECTED STUDIES. (Cr ar; prereq #, Δ)
Individual study on selected topics or problems with emphasis on selected readings and scientific literature.

5990. DIRECTED RESEARCH. (Cr ar; prereq #, Δ)
Lab or field investigation of selected areas of research.

¹ Microscope required. Students may obtain use of microscope by purchasing two microscope cards from the bursar.

Major Requirements and Course Descriptions

For Graduate Students Only

(For descriptions, see the *Graduate School Bulletin*)

8110. BIOLOGY OF MICROORGANISMS

8112. MICROBIAL GENETICS

**8216. FRONTIERS OF IMMUNOLOGY I:
MOLECULAR IMMUNOLOGY**

**8217. FRONTIERS OF IMMUNOLOGY II:
CELLULAR IMMUNOLOGY**

**8218. FRONTIERS OF IMMUNOLOGY III:
CLINICAL IMMUNOLOGY**

**8231. ADVANCED TOPICS IN MOLECULAR
PATHOGENESIS**

8421. VIROLOGY AND TUMOR BIOLOGY

8911. COLLOQUIUM IN MICROBIOLOGY

8990. RESEARCH IN MICROBIOLOGY

Plant Biology (PBio)

Director of Undergraduate Studies—Tom Soulen

Plant biologists study such varied topics as the structure, function, development, classification, evolution, worldwide distribution, and importance of plants ranging from algae and fungi to flowering plants; the molecular basis of plant evolution and development; the mechanisms through which plants convert light into chemical energy; the use of plants in the interpretation of the history and prehistory of the world; and the impact of plants on human civilizations.

The major in plant biology provides a comprehensive and well-balanced undergraduate education in biology with a concentration in the plant sciences. In addition to the general requirements for graduation from CBS, plant biology majors must complete the following major requirements, which may be used in partial fulfillment of college graduate requirements 5.b.3 and 5.b.4 (see Admission Procedures and Degree Requirements, page 22):

Biol 1103 or 3012 or 3812 (if not used to satisfy requirement 5.b.2 above)

Biol 3950H: Undergraduate Seminar (2 cr)
20 credits from groups A-E below, with at least one course each from groups A-D and no more than one course from group E

One of the lab/field courses (requirement 5.b.4) should be a PBio course. Directed

Research (numbered 5990 in any of the college's departments) may serve as one of the lab courses, provided the student completes 4 or more credits of 5990.

A. Plant Cell and Molecular Biology

GCB 5034—Intermediate Molecular Genetics (4 cr)
PBio 5109—Molecular Genetics and Biochemistry of Yeasts and Filamentous Fungi (4 cr)
PBio 5141—Plant Cell Biology (4 cr)
PBio 5186—Topics in Plant Biochemistry (3 cr)

B. Plant Physiology

PBio 3131/5131—Survey of Plant Physiology (4 cr)
PBio 5182—Plant Metabolism (3 cr)
PBio 5183—Water, Minerals, and Translocation (4 cr)
PBio 5184—Plant Growth and Development (3 cr)

C. Plant Structure/Diversity/Development

PBio 3109—Plant Anatomy (5 cr)*
PBio 5103—Algae, Fungi, Bryophytes (5 cr)*
PBio 5105—Morphology of Vascular Plants (5 cr)*
PBio 5107—Mycology: Basidiomycetes (4 cr)*
PBio 5111—Plant Cell, Tissue, and Organ Development (5 cr)*
PBio 5231—Introduction to the Algae (5 cr)*
PBio 5811—Freshwater Algae (5 cr)*

D. Ecology/Systematics/Evolution

EEB 5014—Ecology of Vegetation (5 cr)*
EEB 5016—Ecological Plant Geography (5 cr)*
EEB 5122—Plant/Animal Interactions (4 cr)
PBio 3201—Introductory Plant Systematics (4 cr)*
PBio 5221—Plant Molecular Evolution (3 cr)
PBio 5801—Plains and Boreal Flora (5 cr)*

E. History and Philosophy of Science

HSci 3201/3202—History of Biology (4 cr each)
HSci 5242—The Darwinian Revolution (4 cr)
Phil 3601—Scientific Thought (4 cr)
Phil 5607—Philosophy of Science: Problems of the Biological Sciences (4 cr)

* Lab courses.

PBio Courses

1009. MINNESOTA PLANT LIFE. (4 cr; suitable for nonmajors)

Identification of the more characteristic and conspicuous Minnesota plants, including many lower forms, with discussion of their basic distinctions, life cycles, habitat requirements, distribution, vegetation types, and ecological relations. Lectures, demonstrations, six field trips.

1012. PLANTS USEFUL TO HUMANS. (4 cr; for majors or nonmajors)

Roles that plants play and have played in human biological and cultural development.

Biol 1103. GENERAL BOTANY. (5 cr, §Biol 3012, §3812; prereq Biol 1009 or Biol 1202; students who plan to major in biology in CLA or in any major in CBS should take 3012 or 3812)

Levels of organization of plants, plant function, plant growth and development, plant reproduction.

Biol 3012. PLANT BIOLOGY. (5 cr, §Biol 1103, §Biol 3812; prereq Biol 1009 or Biol 1202, Chem 1052)

Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants.

3109. PLANT ANATOMY. (5 cr; prereq Biol 1103 or Biol 3012 or Biol 3812; offered alt yrs)

Structure and development of plants with special reference to vascular plants.

3131. SURVEY OF PLANT PHYSIOLOGY. (4 cr, §5131; prereq Biol 1103 or Biol 3012 or Biol 3812, BioC 3031 or Biol 5001 or BioC 3021 or BioC 5331)

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. For lab, see 5132.

3201. INTRODUCTORY PLANT SYSTEMATICS.

(4 cr; prereq Biol 1103 or Biol 3012 or Biol 3812)

Systematics of the flowering plants of the world. Ecology, geography, origins, and evolution of flowering plants; family characteristics; floral structure, function and evolution; pollination biology; methods of phylogenetic reconstruction; molecular evolution; taxonomic terms; methods of collection and identification. Two field trips.

3960. RESEARCH TOPICS IN PLANT BIOLOGY.

(1 cr; prereq Biol 1103 or Biol 3012 or Biol 3812; S-N only)

For undergraduates interested in plant biology. Lecture, discussion, and demonstration of faculty research interests.

5001. BASIC BOTANY. (Cr ar; prereq Biol 1009 or Biol 1202, #, Δ)

For beginning graduate students who need to strengthen their botanical background.

5103. ALGAE, FUNGI, AND BRYOPHYTES. (5 cr; prereq Biol 1103 or Biol 3012 or Biol 3812; offered when feasible)

Characteristics of groups, evolutionary relationships, life cycles, comparative morphology (including ultrastructure), comparative nutrition. Lab emphasizes living material and isolation of algae and fungi into culture.

5105. MORPHOLOGY OF VASCULAR PLANTS.

(5 cr; prereq Biol 1103 or Biol 3012 or Biol 3812 or #; offered alt yrs)

Ferns and their allies, Gymnosperms (cycads, Ginkgo, conifers) and Angiosperms (flowering plants). Comparative morphology of vegetative and reproductive structures; life cycles; evolutionary relationships.

5107. MYCOLOGY; BASIDIOMYCETES. (4 cr; prereq 5103 or PIPa 5105 or equiv or intro microbiology or #; offered alt yrs)

Ecology, evolutionary relationships, systematics (taxonomy and nomenclature), morphology (including ultrastructure and life cycles of the basidiomycetes). Laboratories parallel lectures, with living and preserved representatives of the Uredinales, Auriculariales, Septobasidiales, Exobasidiales, Sporobolomycetales, Ustilaginales, Tilletiales, Tremellales, Dacrymycetales, Tulasnellales, Aphyllorphales, Agaricales, and Gasteromycetes.

5109. MOLECULAR GENETICS AND BIOCHEMISTRY OF YEASTS AND FILAMENTOUS FUNGI.

(4 cr, §PIPa 5109; prereq one course each in genetics and biochemistry or #)

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, toxins.

5111. PLANT CELL, TISSUE AND ORGAN DEVELOPMENT.

(5 cr; prereq Biol 1103 or Biol 3012 or Biol 3812; offered alt yrs)

Microscopic structure of vascular plants; development in root, stem, and leaf.

5131. SURVEY OF PLANT PHYSIOLOGY. (4 cr, §3131; prereq Biol 1103 or Biol 3012 or Biol 3812, BioC 3021 or BioC 3031 or BioC 5331 or Biol 5001)

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.

5132. PLANT PHYSIOLOGY LABORATORY. (2 cr; prereq 3131 or 5131 or §3131 or §5131)

Lab to accompany 3131 or 5131.

5141. PLANT CELL BIOLOGY. (4 cr; prereq Biol 5004 or equiv; offered alt yrs)

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.

5182. PLANT METABOLISM. (3 cr, prereq 5131 or equiv, course in biochemistry)

Plant metabolism: photosynthesis, respiration, and the synthesis of macromolecules by plants. Structure-function relations at the plant, cell, and subcellular levels. Energy flow in the plant system and regulation of plant metabolism.

5183. WATER, MINERALS, AND TRANSLOCATION.

(4 cr, prereq 5131 or equiv) Membrane phenomena and osmotic properties of cells. Uptake, movement, and loss of water in plants; effects of external factors. Translocation of organic substances. Absorption, distribution, and function of inorganic elements.

5184. PLANT GROWTH AND DEVELOPMENT.

(3 cr, prereq 3131 or 5131 or equiv)

Plant growth and development from germination to death with emphasis on physiology, biochemistry, and molecular biology. Developmental processes related to mobilization of macromolecules during germination, cell division and extension during axis growth, photomorphogenesis, chloroplast and microbody ontogeny, flowering, fruit and seed formation, senescence, and how plant growth substances control these developments.

Major Requirements and Course Descriptions

5186. TOPICS IN PLANT BIOCHEMISTRY. (3 cr; prereq Biol 5001 or BioC 3021 or BioC 5331; offered alt yrs)

Biochemical processes unique to plants, with emphasis on structures of the macromolecules involved and the reaction and their regulation. Major topics: light reactions of photosynthesis, secondary metabolism, and carbohydrates. Minor topics: carbon dioxide fixation and nitrogen fixation.

5203. HERBARIUM TECHNIQUES. (1 cr; prereq 1009 or 3201 or equiv; S-N only)

Hands-on approach to museum curation procedures in the herbarium. Students are exposed to all aspects of herbarium management and assist with some curation of plant specimens.

5221. PLANT MOLECULAR EVOLUTION. (3 cr; prereq Biol 5003 or GCB 3022; offered alt yrs)

Applications of molecular genetics to the study of processes and products of evolution. Specific topics include phylogenetic reconstruction, chromosomal evolution, multigene families, molecular aspects of morphological change, role of transposons in evolution, DNA sequence evolution, and measures of genetic diversity.

5231. INTRODUCTION TO THE ALGAE. (5 cr; prereq 10 cr in plant biology or biology or #; offered when feasible)

Structure, reproduction, and life histories of major algal divisions.

5960. SPECIAL TOPICS. (Cr ar; prereq #, Δ)

In-depth study of a specialized botanical topic.

5970. DIRECTED STUDIES. (Cr ar; prereq #, Δ)

Individual study on selected topics or problems with emphasis on selected readings and use of scientific literature.

5990. DIRECTED RESEARCH. (Cr ar; prereq #, Δ)

Lab or field investigation of selected areas of research.

Courses Offered at Lake Itasca Forestry and Biological Station

Biol 3812. PLANT BIOLOGY. (5 cr, §1103, §3012; prereq 1009 or 1202, Chem 1052, Δ)

Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants. Field trips.

5801. PLAINS AND BOREAL FLORA. (5 cr; prereq taxonomy course, Δ; offered when feasible)

Summer flowering plants and ferns of Minnesota with particular reference to local flora. Identification by technical keys; important plant families; field recognition of common species; habitat preferences; natural history and population biology of selected important species.

5811. FRESHWATER ALGAE. (5 cr; prereq 10 cr plant biology, biology or zoology or equiv, Δ)

Morphology, systematics, and distribution of the local algal flora. Collection, preservation, numeration, and culture techniques; identification of field collections using appropriate technical literature. Ecological implications of species interactions, algal associations, and indicator taxa.

5890. RESEARCH PROBLEMS. (1-5 cr per qtr; prereq Δ)

Individual research for undergraduates and graduates.

For Graduate Students Only

(For descriptions, see the *Graduate School Bulletin*)

8287. PLANT MOLECULAR BIOLOGY

8301. POLLEN MORPHOLOGY AND QUATERNARY PALYNOLOGY

8950. SEMINAR

8990. RESEARCH PROBLEMS

Recommended Related Coursework

The University offers a wide variety of life sciences courses in addition to those offered by CBS. Students are encouraged to consult the bulletins of several colleges to explore courses in related areas (Colleges of Agriculture, Human Ecology, Liberal Arts, and Natural Resources; Institute of Technology; Allied Health Programs; School of Public Health). A complete list is available in the *Directory of U of M Undergraduate Courses in Life Sciences Disciplines*. This resource, in electronic and booklet form, is available in the Instructional Computing Center in 122 Snyder Hall. Courses are recommended in:

Anatomy (CBN)
Animal science (AnSc)
Anthropology (Anth)
Biophysics (BPhy)
Chemical engineering (ChEn)
Chemistry (Chem)
Computer science (CSci)
Entomology (Ent)
Fisheries and wildlife (FW)
Food science and nutrition (FSn)
Forest resources (FR)
Geology (Geo)
History of medicine and science (HMed, HSci)
Horticultural science (Hort)
Laboratory medicine (LaMP)
Mathematics (Math)
Natural resources and environmental studies (NRES)
Pharmacology (Phcl)
Philosophy (Phil)
Physics (Phys)
Physiology (Phsl)
Plant pathology (PIPa)
Psychology (Psy)
Public health (PubH)
Soil science (Soil)
Statistics (Stat)
Veterinary biology (VB)
Veterinary pathobiology (VPB)

Research and Teaching Facilities



Research and Teaching Facilities

Research and Teaching Facilities

CBS has faculty and facilities on both the Minneapolis and St. Paul campuses. The college is organized into the following departments: Biochemistry; Ecology, Evolution, and Behavior; Genetics and Cell Biology; and Plant Biology (formerly Botany). The Department of Microbiology, in the Medical School, also functions as a department of the college for undergraduate education. A full description of each of these departments and their major degree requirements may be found in Major Requirements and Course Descriptions.

In addition, CBS is responsible for the administration of several instructional programs, research institutes, shared-use laboratories, and an active field biology program, with facilities at several locations around the state (see below). A complete list of faculty is provided in Administration and Faculty.

Special Research and Teaching Centers

Bell Museum of Natural History—Located at Church and University Avenues S.E., Minneapolis, this museum features diorama exhibits of Minnesota wildlife, the Touch and See Room, and the Jaques Gallery of natural history art. It also houses extensive research collections of birds, mammals, reptiles, amphibians, and fish as well as the University's natural history library. Groups of 10 or more who wish to visit the museum should make reservations. Guided tours are available to groups upon advance request. Interested students may gain valuable experience and part-time employment as museum tour guides. The Blue Heron Bookshop offers an excellent selection of field guides and other natural history books for adults and children as well as records of bird and animal calls. Public programs are offered at scheduled times during the year. All museum programs are open to the public, and many are free to University of Minnesota students. Call 612/624-1852 for appointments or further information.

Biochemistry Library—Located on the fourth floor of the Biological Sciences Center on the St. Paul campus, this special library supports courses and research in CBS. Books, serial publications, and titles are available on biochemistry, genetics, cell biology, cell culture, and scanning electron microscopy. The library is open Monday through Friday (612/624-1292).

Biological Sciences Greenhouse and Herbarium—Located on the St. Paul campus, the greenhouse is a teaching and research facility with standard bench space. Three landscaped rooms exhibit the flora of the tropics, subtropics, and desert (612/625-4788).

The Herbarium contains more than 820,000 specimens of fungi, lichens, mosses, gymnosperms, and angiosperms collected mainly on the North American continent. This collection is a major resource for botanically oriented research both at the University and at other institutions (612/625-0215).

Cedar Creek Natural History Area—Located within commuting distance of campus, Cedar Creek not only serves as the site of ecological and behavioral field research, but also provides unique opportunities for student projects and summer employment. For student opportunities, contact the Office of Student Services (612/624-9717) or the Program Director of Cedar Creek Natural History Area (612/625-5740).

General Biology Program—Located in Kolthoff Hall at 225 Pleasant Street S.E., Minneapolis, the General Biology Program administers beginning biology courses for most University students, serving approximately 3,200 students per year. The college takes its responsibility for introductory instruction in biology very seriously; students will meet CBS' finest instructors in these courses and enjoy personal attention in laboratory sections. Call 612/625-6636 for more information.

Gray Freshwater Biological Institute—

Located at the junction of County Roads 15 and 19 in Navarre, the Gray Freshwater Biological Institute is a research facility where faculty and staff members, postdoctoral fellows, and students from several disciplines conduct basic research dealing with problems of fresh water. For more information call the Gray Freshwater Institute (612/471-8476).

Institute for Advanced Studies in Biological Process Technology—

The institute, established in 1985, takes advantage of the unusual breadth of interest and expertise of faculty at the University to investigate cell population biology, membrane biology, molecular genetics, and protein structure and function as they relate to biological process technology. The institute's Central Research Facility (CRF) is a new shared-use facility, a university-wide laboratory equipped with state-of-the-art equipment to facilitate research in fermentation, animal and plant cell culture technology, and large-scale separation of biological molecules. The institute promotes collaboration between University researchers and industry, meeting increasing demands for students trained jointly in biological and engineering disciplines (612/624-6774).

Institute of Human Genetics—The institute's major objective is to develop an interdisciplinary approach to the study and application of new developments in human genetics. It develops technologies necessary for understanding the structure and expression of human chromosomes and genes for the prevention, diagnosis, and therapy of inborn and acquired genetic disorders. The institute's genetic programs include genetic services (Molecular Diagnostics Laboratory, microchemical facility, gene therapy program) and molecular, behavioral, clinical, and population genetics (612/624-3110).

Lake Itasca Forestry and Biological

Station—Located at the headwaters of the Mississippi River in northern Minnesota, the field station is in an unparalleled ecological

area where three great plant regions of the United States meet. These 50 square miles of protected forest provide unique opportunities for study of varied ecosystems and of the fauna and flora with southern, northern, and western origins. Diverse lakes and wetlands provide unusual field advantages for aquatic studies. Information about the highly popular summer biology offerings is contained in the *Summer Session Bulletin*. Reservations for and questions about the Itasca program should be addressed to the Director, Itasca Biology Program, 303 Ecology Building, University of Minnesota, 1987 Upper Buford Circle, St. Paul MN 55108 (612/624-6743).

Instructional Computing Center—Biology students have access to a well-equipped Macintosh computing facility in 122 Snyder Hall. Primarily for instructional needs, priority in the computer center is given to undergraduates working on course-related materials. Students can use programs for word processing, graphing, drawing, or spreadsheets. Students can also access many electronic databases and file servers around the world, as well as their own electronic mail service. In addition, the center houses specialized software purchased for student use, such as programs to assist with preparation for the Graduate Record Examination (GRE). The computer lab is open Monday through Thursday 8 a.m. to 8 p.m., Friday 8 a.m. to 6 p.m., and Saturday 10 a.m. to 4 p.m.

Molecular Biology Computing Center (MBCC)—Located in Gortner Lab, the center serves more than 90 labs with advanced nucleic acid and peptide sequence analysis software. The MBCC is one of several worldwide BIONET satellites with complete and continuously updated national databases. Molecular graphics facilities permit specialized research on the structure and function of DNA, RNA, and proteins. Student computers are available, as are workshops, a help line, and consulting. For further information, call 612/625-9284.

Research and Teaching Facilities

Plant Molecular Genetics Institute—The institute fosters research in molecular biology and genetics of economically important plants and relevant model plant systems; develops genetic engineering methodologies for application to crop improvement; educates future plant biology researchers and teachers; maintains a stimulating interdisciplinary environment in which to explore and develop new ideas and experimental approaches in plant molecular biology; and provides a focus for external communication to aid recruitment and funding. Institute faculty come from two colleges (Biological Sciences and Agriculture) and six departments (Genetics and Cell Biology, Agronomy and Plant Genetics, Biochemistry, Plant Biology, Horticulture, and Plant Pathology). The institute's research labs are those of present and newly recruited faculty. The institute supports seminars as well as frequent symposia on topics related to plant molecular biology and provides funds for speakers and visiting scientists. Faculty and students participate in the following graduate programs: genetics, horticulture, microbiology, plant breeding, plant pathology, and plant biological sciences. Institute membership is determined by nomination and election by institute faculty (612/625-1213).

Graduate Programs

Graduate study at the University of Minnesota is coordinated and administered by the Graduate School. Refer to the *Graduate School Bulletin* for details about general policies regarding admission requirements, registration procedures, financial aid, and requirements for graduate degrees. Application materials may be obtained from CBS department offices.

Questions regarding specific bioscience programs should be addressed to the director of graduate studies in the appropriate program area:

- Biochemistry*—John S. Anderson, 624-3662
Conservation Biology—Kendall W. Corbin, 624-6750
Ecology—Edward J. Cushing, 625-5713
Genetic Counseling—Bonnie Leroy, 624-0144
Microbial Engineering—Gary Dunny, 626-1217
Microbiology—Patrick M. Schlievert, 624-1484
Molecular, Cellular, Developmental Biology and Genetics—Paul A. Lefebvre, 624-4706
Neuroscience—Robert F. Miller, 626-2914
Plant Biological Sciences—Burle Gengenbach, 625-6282
Zoology—Elmer C. Birney, 624-6293

Administration and Faculty



Administration and Faculty

University Regents

Jean B. Keffeler, Minneapolis, Chair
Thomas R. Reagan, Gilbert, Vice Chair
Wendell R. Anderson, Wayzata
Julie A. Bleyhl, Madison
William E. Hogan II, Minnetonka
H. Bryan Neel III, Rochester
Mary J. Page, Olivia
Lawrence J. Perlman, Minneapolis
William R. Peterson, Eagan
Darrin M. Rosha, Owatonna
Stanley D. Sahlstrom, St. Cloud
Ann J. Wynia, St. Paul

University Administrators

Nils Hasselmo, President
Robert O. Erickson, Senior Vice President for Finance and Operations
Ettore F. Infante, Senior Vice President for Academic Affairs and Provost
C. Eugene Allen, Vice President for Agriculture, Forestry, and Home Economics
Shelley N. Chou, Interim Dean of the Medical School
Richard P. Elzay, Deputy Vice President for Health Sciences
Anne H. Hopkins, Vice President for Arts, Sciences, and Engineering
Marvalene Hughes, Vice President for Student Affairs
Anne C. Petersen, Vice President for Research and Dean of the Graduate School
Mark B. Rotenberg, General Counsel

College of Biological Sciences Administrators

This is a listing of deans, department heads, and directors; see also CBS Directory in the introduction for special program offices and directors of undergraduate study. A listing of all CBS faculty follows.

P. T. Magee, dean
123 Snyder Hall, St. Paul campus (612/624-2244)
Sally B. Jorgensen, associate dean
123 Snyder Hall, St. Paul campus (612/624-2244)
Kathryn Hanna, assistant dean
123 Snyder Hall, St. Paul campus (612/624-2244)
Kathleen F. Peterson, director of student services
223 Snyder Hall, St. Paul campus (612/624-9717)
Biochemistry—Norma Allewell, head, 140 Gortner Lab, St. Paul campus (624-7755)
Cedar Creek—G. David Tiltman, director, 509 Ecology, St. Paul campus (625-5743); Cedar Creek Area (434-5131)
Ecology, Evolution, and Behavior—Franklin H. Barnwell, head, 100 Ecology, St. Paul campus (625-5700)
General Biology Program—Susan M. Wick, director, P180 Kolthoff Hall, Minneapolis campus (625-6636)
Genetics and Cell Biology—Ross G. Johnson, head, 248A Biological Sciences Center, St. Paul campus (624-3003)

Gray Freshwater Biological Institute—Steven Eisenreich, interim director, P.O. Box 100, County Roads 15 and 19, Navarre, MN 55392 (471-8476)

Herbarium—Anita Cholewa, curator and coordinator, 842 Biological Sciences Center, St. Paul Campus (625-0215)

Institute for Advanced Studies in Biological Process Technology—Kenneth Valentas, interim director, 240 Gortner Lab, St. Paul campus (624-6774)

James Ford Bell Museum of Natural History—Kendall Corbin, acting director, 301 Bell Museum, Minneapolis campus (624-2596)

Lake Itasca Program—Donald Siniff, director, 303 Ecology, St. Paul campus (625-5732)

Microbiology (Medical School)—Ashley T. Haase, head, 1460 Mayo Memorial Building, Minneapolis campus (624-4442)

Molecular Biology Computer Center—Dan Prestridge, director, 247 Gortner Lab, St. Paul campus (625-9284)

Plant Biology—Irwin Rubenstein, head, 220 Biological Sciences Center, St. Paul campus (625-1234)

Plant Molecular Genetics Institute—Ronald L. Phillips, director, 411 Borlaug Hall, St. Paul campus (625-1213)

Faculty

Department of Biochemistry

Allewell, Norma M., professor and head
Ph.D., Yale University
Protein structure, function and design; mechanisms of biological recognition and communication; functional energetics of biological molecules; computer modeling.
624-3011
Anderson, John S., professor†
Ph.D., University of Nebraska
Structure and biosynthesis of bacterial cell walls and membranes.
624-3662
Barry, Bridgette A., assistant professor
Ph.D., University of California, Berkeley
Photosynthetic electron transfer.
624-6732
Bernlohr, David A., associate professor
Ph.D., University of Illinois, Urbana
Adipocyte gene expression; regulation of adipocyte metabolism.
624-2712
Bloomfield, Victor A., professor
Ph.D., University of Wisconsin, Madison
Physical biochemistry of nucleic acids and viruses; hydrodynamics and laser scattering; subunit assembly.
625-2268
Conti-Tronconi, Bianca M., professor
M.D., University of Milano, Italy
Structure and function of nicotinic receptors in brain and muscle; immunology of myasthenia gravis.
624-6796

Das, Anath, associate professor
Ph.D., University of Nebraska, Lincoln
Mechanisms of Ti-plasmid-mediated gene transfer into plant cells; gene expression and its regulation in higher plants.
624-3239

Flickinger, Michael C., associate professor
Ph.D., University of Wisconsin, Madison
Fermentation; cell culture technology; cellular energetics; regulation of protein synthesis; protein separation.
624-2782

Fuchs, James A., professor
Ph.D., Texas A&M University, College Station
Deoxynucleotide metabolism; DNA synthesis; regulation of metabolic pathways.
624-1215

Lovrien, Rex, professor
Ph.D., University of Iowa
Enzymology; thermodynamics; binding processes; protein crystallization.
624-2776

Nelstuen, Gary L., professor
Ph.D., University of Minnesota
Protein-membrane interactions; protein kinase C; complement; blood coagulation.
624-3622

Raftery, Michael A., professor
Ph.D., National University of Ireland, Galway
Biology and chemistry of cell surfaces; molecular mechanisms of synaptic transmission and axonal conduction.
624-9734

Schottel, Janet L., associate professor
Ph.D., Washington University
Nucleic acid biochemistry; molecular biology.
624-6275

Tsong, Tian Y., professor
Ph.D., Yale University
Physical biochemistry of proteins and cell membranes.
625-5262

Wackett, Lawrence P., associate professor
Ph.D., University of Texas, Austin
Biodegradation; dehalogenases; applications of enzymology in environmental detoxification and organic synthesis; oxygenases.
625-3785

Woodward, Clare K., professor*
Ph.D., Rice University
Protein chemistry; hydrogen exchange kinetics; NMR spectroscopy; protein folding.
624-4714

Department of Ecology, Evolution, and Behavior

Abrams, Peter A., professor
Ph.D., University of British Columbia
Marine ecology, mathematical ecology, and evolutionary ecology.
625-5722

Alstad, Donald N., associate professor
Ph.D., University of Utah
Population ecology and evolution of insects.
624-6748

Barnwell, Franklin H., professor and head*
Ph.D., Northwestern University
Invertebrate behavior and physiology, with emphasis on ecological relationships.
625-5296

Beatty, John H., associate professor
Ph.D., Indiana University
History and philosophy of biology.
624-6749

Birney, Elmer C., professor
Ph.D., University of Kansas
Mammalian evolution and ecology.
624-6293

Bright, Robert C., associate professor
Ph.D., University of Minnesota
Quaternary history.
624-4780

Corbin, Kendall W., professor
Ph.D., Cornell University
Evolutionary ecology and genetics; biochemical systematics.
624-6750

Curtsinger, James W., associate professor
Ph.D., Stanford University
Population/quantitative genetics, experimental and theoretical.
624-6746

Cushing, Edward J., professor
Ph.D., University of Minnesota
Paleoecology, ecology of plant communities.
625-5713

Davis, Margaret B., Regents' Professor
Ph.D., Harvard University
Paleoecology, paleolimnology, forest community ecology.
625-1717

Gorham, Eville, Regents' Professor
Ph.D., University of London, England
Chemical aspects of ecology, limnology, and soil science.
625-5708

Heinselman, Miron L., adjunct professor
Ph.D., University of Minnesota
Forest ecology, peatlands evolution.
644-2835

McKinney, D. Frank, professor
Ph.D., University of Bristol, England
Animal behavior.
624-6737

*Recipient of the Horace T. Morse-Minnesota Alumni Association Award for Outstanding Contributions to Undergraduate Education

†Recipient of the Stanley Dagley Distinguished Teacher Award

Administration and Faculty

McNaught, Donald, professor
Ph.D., University of Wisconsin
Zooplankton ecology, Great Lakes limnology, ecosystem
contamination.
625-1706

Mech, David L., adjunct professor
Ph.D., Purdue University
Carnivore ecology, predator-prey relations, mammalian
social ecology.
649-5231

Megarid, Robert O., professor
Ph.D., Indiana University
Limnology.
625-5707

Merrell, David, professor emeritus
Ph.D., Harvard University
Genetics.
625-5735

Morrow, Patrice, professor
Ph.D., Stanford University
Plant-insect interactions, community ecology.
625-5709

Murdock, Gordon, adjunct associate professor
Ph.D., Duke University
Invertebrate biology and museum studies.
624-6380

Naeem, Shahid, assistant professor
Ph.D. University of California, Berkeley
Ecology of populations, communities, and ecosystems.
624-6790

Packer, Craig, associate professor
Ph.D., University of Sussex, England
Behavioral ecology and sociobiology.
625-5729

Pastor, John, adjunct professor
Ph.D., University of Wisconsin
Nutrient cycling, animal-ecosystem interactions, forest
productivity, landscape and global ecology, northern
ecosystems.
218/720-4271

Phillips, Richard E., professor
Ph.D., Cornell University
Animal behavior, physiology.
624-7238

Pusey, Anne E., associate professor
Ph.D., Stanford University
Animal behavior.
625-5727

Regal, Philip J., professor
Ph.D., University of California, Los Angeles
Evolution, physiological ecology and behavior,
herpetology.
624-6751

Schmid, William D., professor
Ph.D., University of Minnesota
Comparative physiology, ecology.
624-6752

Shapiro, Joseph, professor
Ph.D., Yale University
Limnology.
624-0596

Shaw, Ruth, assistant professor
Ph.D., Duke University
Ecological genetics.
624-2706

Siniff, Donald B., professor
Ph.D., University of Minnesota
Vertebrate ecology: population ecology of large
mammals.
625-5732

Starfield, Anthony M., professor
Ph.D., University of Witwatersrand, Johannesburg, South
Africa
Ecological modeling.
625-5721

Tester, John R., professor
Ph.D., University of Minnesota
Vertebrate ecology, ecosystem ecology.
625-5731

Tilman, G. David, professor
Ph.D., University of Michigan
Experimental and theoretical population and community
ecology.
625-5743

Tordoff, Harrison B., professor emeritus
Ph.D., University of Michigan
Systematic and evolutionary biology, ornithology.
624-6787

Underhill, James C., professor emeritus
Ph.D., University of Minnesota
Ichthyology.
624-3367

Wright, Herbert E., Regents' Professor Emeritus
Ph.D., Harvard University
Quaternary paleoecology and glacial geology.
624-5215

Department of Genetics and Cell Biology

Blumenfeld, Martin, associate professor
Ph.D., Case Western Reserve University
Chromosomal organization including protein
modifications
624-7408

Brooker, Robert J., associate professor
Ph.D., Yale University
Molecular approaches to membrane transport; use of
mutants.
624-3053

Cunningham, William P., professor*,**
Ph.D., University of Texas, Austin
Pollutant effects on cell structure and function.
624-9266

Enfield, Franklin D., professor
Ph.D., University of Minnesota
Quantitative genetic variation from new mutations.
624-7706

Fan, David P., professor
Ph.D., Massachusetts Institute of Technology
Development of AIDS database; epidemiology of AIDS.
624-4718

Goldstein, Stuart F., associate professor
Ph.D., California Institute of Technology
Cell motility, especially flagellar beating.
624-5399

Hackett, Perry B., professor
Ph.D., University of Colorado Medical Center
Regulation of early gene expression in developing zebrafish zygotes; regulation of translation of *Rous sarcoma* virus and HIV in mRNAs.
624-6736

Hays, Thomas S., assistant professor
Ph.D., University of North Carolina
Mitotic mechanisms and chromosome motility; genetic analysis of microtubule and microtubule motor function in *Drosophila*; analysis of the dynein gene family in *Drosophila*.
625-5226

Herman, Robert K., professor
Ph.D., Yale University
Developmental genetics of the nematode, *C. elegans*.
624-6203

Herman, William S., professor
Ph.D., Northwestern University
Structure and function of arthropod peptide hormones.
625-2243

Hooper, Alan B., professor*
Ph.D., Johns Hopkins University
Mechanisms of nitrogen metabolism in bacteria.
624-4930

Iwanij, Victoria, associate professor
Ph.D., Rockefeller University
Expression and function of glucagon receptors.
624-4942

Johnson, Ross G., professor and head
Ph.D., Iowa State University
Cell communication mechanisms through gap junction channels.
624-1741

Kerr, Norman S., professor
Ph.D., Northwestern University
Developmental biology of the true slime molds.
624-1789

King, Richard A., professor
Ph.D., Minnesota, M.D., Jefferson Medical
Biochemical and molecular analysis of melanin metabolism; analysis of systemic Lupus erythematosus; genetic abnormalities of melanin synthesis.
624-0144

Lefebvre, Paul A., professor
Ph.D., Yale University
Genetic and molecular analysis of gene expression and flagellar protein assembly in *Chlamydomonas*.
624-4706

Magee, P. T., professor and dean**
Ph.D., University of California, Berkeley
Genetic structure and development in *Candida albicans*.
625-4732

Marks, M. David, assistant professor
Ph.D., Purdue University
Molecular genetics of determination and differentiation of trichomes in *Arabidopsis*.

McKinnell, Robert G., professor*
Ph.D., University of Minnesota
Invasiveness of herpesvirus-induced tumor cells.
624-2285

Rodell, Charles F., professor
Ph.D., University of Minnesota
Ecological genetics.
1-363-3174

Rougvie, Ann E., assistant professor
Ph.D., Cornell University
Genetic and molecular mechanisms of developmental timing in *C. elegans*.
624-4708

Shaw, Jocelyn E., associate professor
Ph.D., University of Toronto
Regulation of development in *C. elegans*.
625-1912

Silflow, Carolyn D., professor
Ph.D., University of Georgia
Molecular genetic analysis of genes involved in microtubule function in plant cells.
624-0729

Simmons, Michael J., professor*
Ph.D., University of Wisconsin, Madison
Drosophila genetics and population genetics; transposable elements.
624-5354

Sinha, Akhouri A., professor
Ph.D., University of Missouri, Columbia
Stromal-epithelial interactions in tumors; protease involvement.
725-2000, ext. 2846

Snustad, D. Peter, Professor*†
Ph.D., University of California, Davis
Genetic control of the cytoskeleton in *Arabidopsis*; regulation of six glutamine synthetase genes in *Zea mays*.
624-3499

Woodward, Val W., professor*
Ph.D., Cornell University
Critique of biologizing human behavior.
624-3060

*Recipient of the Horace T. Morse-Minnesota Alumni Association Award for Outstanding Contributions to Undergraduate Education

†Recipient of the Stanley Daglex Distinguished Teacher Award

**Recipient of the Continuing Education and Extension Distinguished Teaching.

Administration and Faculty

Department of Plant Biology

Berman, Judith G., associate professor
Ph.D., Weizmann Institute of Science
Yeast molecular biology; telomere structure and function;
telomeric DNA-binding proteins.
625-1971

Biesboer, David D., associate professor
Ph.D., Indiana University
Developmental physiology and anatomy of secretory
cells; tissue culture; secondary metabolism; biomass
energy production; leafy spurge.,
625-1799

Brambl, Robert M., professor
Ph.D., University of Nebraska
Biochemistry of fungal spore germination; mitochondrial
biogenesis and regulation of membrane enzyme
assembly.
625-7080

Charvat, Iris D., associate professor*†
Ph.D., University of California, Santa Barbara
Development, physiology, and ultrastructure of
lysosomal compartment of fungi and higher plants;
ultrastructure of fungi and higher plants; Mycorrhizae.
625-3199

Doebley, John F., associate professor
Ph.D., University of Wisconsin
Biosystematics of flowering plants; evolutionary
genetics; evolution of crop plants.
625-3702

Frenkel, Albert W., professor emeritus
Ph.D., University of California, Berkeley
Photosynthesis of higher plants, algae, and
photosynthetic bacteria; photorespiration in green plants;
porphyrin-sensitized photo-oxidation of biological
interest.
625-4236

Gantt, J. Stephen, associate professor
Ph.D., University of California, Irvine
Control of cytoplasmic ribosome synthesis; regulation of
expression of nuclear encoded chloroplast ribosomal
protein genes.
625-4763

Gleason, Florence K., associate professor
Ph.D., University of Iowa
Control of cell division and light-mediated regulation of
metabolism in blue-green algae; secondary metabolism in
freshwater algae.
625-4275

Koukkari, Willard L., professor
Ph.D., University of New Hampshire
Physiology of growth and development; biological
rhythms; photomorphogenesis; stress.
625-1958

May, Georgiana, assistant professor
Ph.D., University of California, Berkeley
Molecular function and evolution of mating type genes in
agaric basidiomycetes, particularly within the genus
Coprinus.
625-1998

McLaughlin, David J., professor
Ph.D., University of California, Berkeley
Ultrastructure and evolution of fungi, especially
basidiomycetes; development and physiology of fruiting
in mushrooms.
625-5736

Olszewski, Neil E., associate professor
Ph.D., University of Minnesota
Plant molecular biology; gibberellins; genes affecting
plant structure.
625-3129

Pratt, Douglas C., professor
Ph.D., University of Minnesota
Physiological and ecological aspects of biomass
production on marginal lands; growth and physiology of
mosses.
625-8258

Rubenstein, Irwin, professor and head
Ph.D., University of California, Los Angeles
The structural organization and functional regulation of
the genes of the maize genome.
624-2716

Soulen, Thomas K., associate professor*
Ph.D., University of Wisconsin
Higher plant metabolism as it relates to development,
especially nitrogen metabolism; factors influencing
flowering and growth of *Lemna*.
625-2761

Wetmore, Clifford M., professor
Ph.D., Michigan State University
Taxonomy, ultrastructure, ecology, and phytogeography
of lichens; herbarium computerization; Minnesota and
upper Great Lakes lichen floras; lichens as indicators of
air pollution.
625-6292

Wick, Susan M., associate professor
Ph.D., Stanford University
Plant cell and developmental biology; plant cytoskeleton;
microtubules.
625-4718

James Ford Bell Museum of Natural History

Birney, Elmer C., curator of mammalogy
Ph.D., University of Kansas
Mammalian evolution and ecology.
624-6293

Bright, Robert C., curator of invertebrate biology
Ph.D., University of Minnesota
Quaternary history.
624-4780

Corbin, Kendall W., acting director
Ph.D., Cornell University
Evolutionary ecology and genetics.
624-6750

McKinney, Frank, curator of ethology
Ph.D., University of Bristol, England
Animal behavior.
624-6737

Regal, Philip J., professor
Ph.D., University of California, Los Angeles
Evolution, physiological ecology, and behavior.
625-6751

Underhill, James C., curator of ichthyology
Ph.D., University of Minnesota
Systematic biology; distribution of fishes.
624-3367

Zink, Robert, associate professor
Ph.D., University of California, Berkeley
Evolutionary genetics of birds.
624-7207

Gray Freshwater Biological Institute

Capel, Paul, adjunct assistant professor
Ph.D., University of Minnesota
Environmental fate of organic chemicals.
471-0438

Eisenreich, Steve, professor and director
Ph.D., University of Wisconsin, Madison
Environmental organic chemistry; lakes.
471-8476

Hanson, Richard S., professor
Ph.D., University of Illinois, Urbana
Microbial biochemistry, ecology and genetics.
471-7741

Institute for Advanced Studies in Biological Process Technology

Brooker, Robert J., associate professor
Ph.D., Yale University
Biology of cell surfaces; molecular genetics.
624-3053

Dunny, Gary M., professor
Ph.D., University of Michigan
Microbial genetics; microbial development; intercellular chemical communication.
626-1217

Flickinger, Michael C., associate professor
Ph.D., University of Wisconsin, Madison
Fermentation, kinetic models of cellular energetics and protein regulation.
625-2782

Sherman, David H., assistant professor
Ph.D., Columbia University
Microbial genetics; immunogenetics.
625-1901

Srienc, Friedrich, associate professor
Ph.D., Technical University in Graz, Austria
Fermentation biochemical engineering.
624-9776

Wackett, Lawrence P., associate professor
Ph.D., University of Texas, Austin
Biodegradation, metalloenzymes, biotechnology.
625-3785

Plant Molecular Genetics Institute

Berman, Judith G., associate professor
Ph.D., Weizmann Institute of Science
Structure and function of chromosomes, telomeres and plasmids in yeasts and *Chlamydomonas*
625-1971

Brambl, Robert M., professor
Ph.D., University of Nebraska
Regulation of gene expression in eukaryotes; coordination of nuclear and mitochondrial genetic systems.
625-7080

Brenner, Mark L., professor
Ph.D., Michigan State University
Role of endogenous plant growth substances in coordinately controlled processes, specifically focusing on regulation of partitioning in soybean and corn plants.
624-6735

Das, Anath, associate professor
Ph.D., University of Nebraska, Lincoln
Mechanisms of TI-plasmid-mediated gene transfer into plant cells; gene expression and its regulation in higher plants.
624-3239

Doebley, John F., associate professor
Ph.D., University of Wisconsin
Evolutionary genetics; plant evolution and development.
625-3702

Gantt, J. Stephen, associate professor
Ph.D., University of California, Irvine
Gene expression in plants.
625-4763

Gengenbach, Burt G., professor
Ph.D., University of Illinois
Biochemical genetics of amino acid and fatty acid pathways in maize; organelle molecular genetics.
625-6282

Lefebvre, Paul A., associate professor
Ph.D., Yale University
Genetic and molecular analysis of gene expression and flagellar protein assembly in *Chlamydomonas*.
624-4706

Marks, M. David, assistant professor
Ph.D., Purdue University
Molecular genetics of determination and differentiation of trichomes in *Arabidopsis*.

Olszewski, Neil E., associate professor
Ph.D., University of Minnesota
Molecular mechanisms of gibberellin action in plant growth and development.
625-3129

Phillips, Ronald L., professor and director
Ph.D., University of Minnesota
Plant molecular genetics and cytogenetics.
625-1213

Rubenstein, Irwin, professor
Ph.D., University of California, Los Angeles
Plant gene structure and function; maize endosperm development.
624-2716

*Recipient of the Horace T. Morse-Minnesota Alumni Association Award for Outstanding Contributions to Undergraduate Education
†Recipient of the Stanley Dagley Distinguished Teacher Award

Administration and Faculty

Schottel, Janet L., associate professor
Ph.D., Washington University
Mechanism of pathogenicity for *S. scabiei*; mechanism of mRNA turnover in *E. coli*.
624-6275

Sillflow, Carolyn D., professor
Ph.D., University of Georgia
Molecular genetic analysis of genes involved in microtubule function in plant cells.
624-0729

Smith, Alan G., assistant professor
Ph.D., University of Florida
Molecular analysis of plant development with emphasis on gene expression during flower morphogenesis.
624-2715

Snustad, D. Peter, professor*†
Ph.D., University of California, Davis
Genetic control of the cytoskeleton in *Arabidopsis*; regulation of six glutamine synthetase genes in *Zea mays*.
624-3499

Somers, David A., professor
Ph.D., Washington State University
Biochemical genetics and *in vitro* genetic manipulations of plants.
625-5769

Szabo, Les, research geneticist
Ph.D., Oregon State University
Molecular genetics of plant pathogenic fungi.
625-3780

Vance, Carroll P., professor
Ph.D., Ohio State University
Forage physiology, host-microbial interactions, nitrogen fixation.
625-5715

Young, Kevin D., assistant professor
Ph.D., Yale University
Molecular genetics of plant disease resistance.
625-2225

Contributing Faculty from Other University Units

Department of Microbiology—Medical School

Anderson, Dwight, professor
Ph.D., University of Minnesota
Virology.
624-7989

Bey, Russell, associate professor
Ph.D., University of Minnesota
Pathogenic mechanisms; immunology.
625-8111

Cleary, P. Patrick, professor
Ph.D., University of Rochester, New York
Molecular pathogenesis; Streptococci.
624-3932

Conklin, Kathleen, associate professor
Ph.D., Tufts University
Virology.
626-0445

Dunny, Gary, professor
Ph.D., University of Michigan
Development mediated by bacterial pheromones.
626-1217

Dworkin, Martin, professor
Ph.D., University of Texas, Austin
Developmental biology; myxobacteria.
624-5634

Faras, Anthony, professor
Ph.D., University of Colorado
Virology.
624-9180

Flickinger, Michael C., associate professor
Ph.D., University of Wisconsin, Madison
Microbial biochemistry.
624-9706

Fontana, Donna, assistant professor
Ph.D., Michigan State University
Developmental biology; dictyostelium.
625-9930

Germaine, Gregory, professor
Ph.D., University of Minnesota
Oral microbiology; microbial physiology.
624-0478

Gray, Beulah, professor
Ph.D., University of Minnesota
Molecular pathogenesis and immunology; cystic fibrosis.
626-1470

Haase, Ashley T., professor and head
M.D., Columbia College of Physicians and Surgeons
Molecular pathogenesis; slow virus infections.
624-4442

Hanson, Richard S., professor
Ph.D., University of Illinois, Urbana
Microbial ecology.
471-7741

Jemmerson, Ronald, associate professor
Ph.D., Northwestern University
Immunology.
625-1402

Jenkins, Marc K., associate professor
Ph.D., Northwestern University
Immunology.
626-2715

Johnson, Russell C., professor
Ph.D., University of Wisconsin
Molecular pathogenesis; lyme disease.
624-7944

McKay, Larry L., professor
Ph.D., Oregon State University
Food and dairy microbiology.
624-5621

Plagemann, Peter G. W., professor
Ph.D., Case Western Reserve University
Virology.
624-3187

Reilly, Bernard, associate professor
Ph.D., Case Western Reserve University
Morphology; microbial genetics.
624-4433

Rogers, Palmer, professor
Ph.D., Johns Hopkins University
Microbial physiology.
624-7140

Sadowsky, Michael, associate professor
Ph.D., University of Hawaii
Soil microbiology.
624-2706

Sauerbier, Walter, professor
Ph.D., J.W. Goethe Universitat, Federal Republic of
Germany
Microbial genetics.
624-0996

Scherer, Stewart, associate professor
Ph.D., Stanford University
Microbial pathogenesis; *Candida*.
624-6190

Schiff, Leslie, assistant professor
Ph.D., Tufts University
Mammalian retroviruses, virus-host cell interactions.
624-9933

Schlievert, Patrick M., professor
Ph.D., University of Iowa
Molecular pathogenesis and immunology; streptococci
and staphylococci.
624-1484

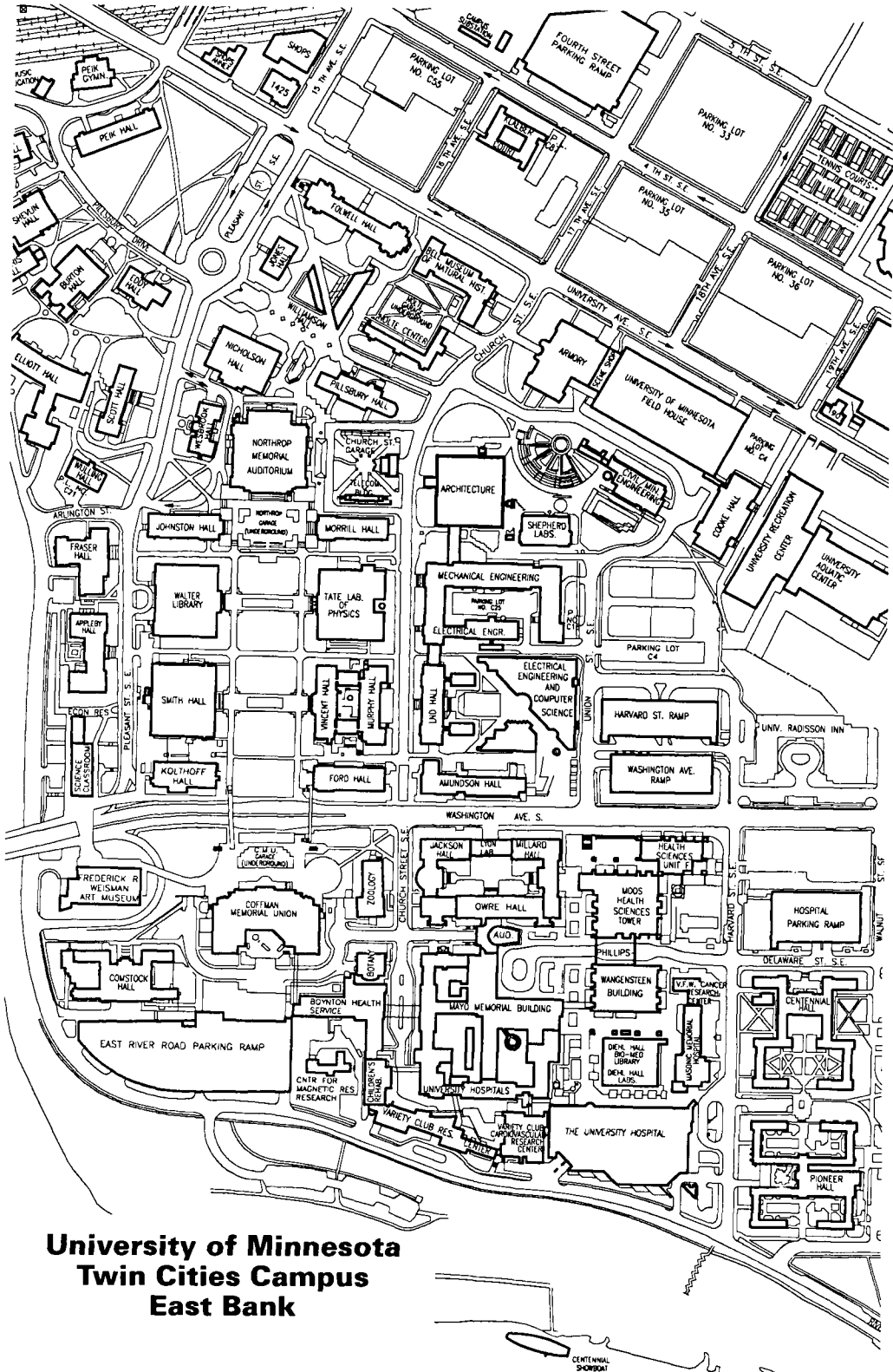
Sherman, David, assistant professor
Ph.D., Columbia University
Streptomyces; biotechnology.
625-1901

Southern, Peter, associate professor
Ph.D., Edinburgh University
Molecular biology; viral pathogenesis.
625-2141

Watson, Dennis W., Regents' Professor Emeritus
Ph.D., University of Wisconsin, Madison
Immunology.
624-2468

Zissler, James F., professor
Ph.D., University of Rochester, New York
Microbial genetics.
624-7673

*Recipient of the Horace T. Morse-Minnesota Alumni
Association Award for Outstanding Contributions to
Undergraduate Education
†Recipient of the Stanley Dagley Distinguished Teacher
Award



**University of Minnesota
Twin Cities Campus
East Bank**

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