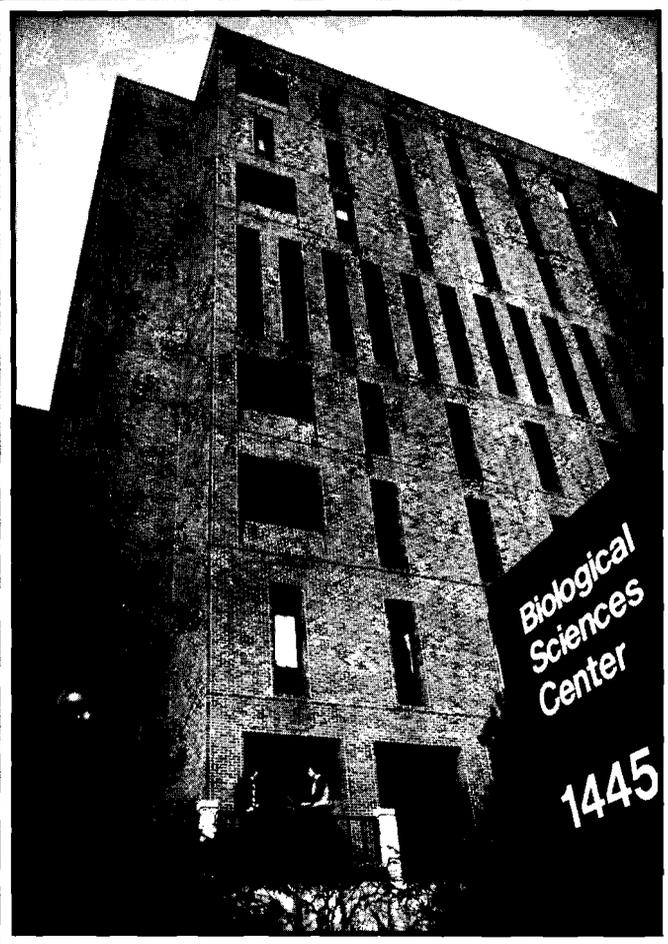


University of Minnesota Bulletin



College of Biological Sciences



UNIVERSITY OF MINNESOTA

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Microbiology (Medical School)—Dennis W. Watson, Head, 1460 Mayo Memorial Building, Minneapolis campus (373-8070)

James Ford Bell Museum of Natural History—Director (to be announced), 301 Bell Museum of Natural History, Minneapolis campus (373-3192)

Gray Freshwater Biological Institute—Richard S. Hanson, Professor and Director, P.O. Box 100, County Roads 15 and 19, Navarre, MN 55392 (471-8476)

Snyder Hall is located at 1475 Gortner Avenue, St. Paul, MN 55108.

Cover photos: *Front*, Biological Sciences Center, 1445 Gortner Avenue, St. Paul

Back, CBS student at a microscope, a symbol of the fundamental relationship between basic research and education

COLLEGE OF BIOLOGICAL SCIENCES

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This biennial bulletin focuses on the undergraduate offerings of the College of Biological Sciences on the Twin Cities campus of the University of Minnesota.

The *Class Schedule*, distributed with registration materials before the registration period each quarter, lists course offerings with prerequisites, class hours, rooms, and instructors. It also includes registration instructions, final exam schedules, and other useful information.

Students should also refer to the *General Information Bulletin*. Information about evening courses and summer school offerings is contained in the *Extension Classes Bulletin* and the *Summer Session Bulletin*, respectively.

Bulletin Use

The contents of this bulletin and other University bulletins, publications, or announcements are 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, creed, color, sex, national origin, or handicap. In adhering to this policy, the University abides by the requirements of Title IX of the Education Amendments of 1972, by Sections 503 and 504 of the Rehabilitation Act of 1973, and by other applicable statutes and regulations relating to equality of opportunity.

Inquiries regarding compliance may be directed to Lillian H. Williams, Director, Office of Equal Opportunity and Affirmative Action, 419 Morrill Hall, University of Minnesota, 100 Church Street S.E., Minneapolis, MN 55455, (612 373-7969), or to the Director of the Office of Civil Rights, Department of Education, Washington, DC 20202, or to the Director of the Office of Federal Contract Compliance Programs, Department of Labor, Washington, DC 20210.

Campus Contact

Kathleen F. Peterson
Director of Student Services
College of Biological Sciences
223 Snyder Hall
University of Minnesota
1475 Gortner Avenue
St. Paul, MN 55108
(612/373-3648)

The staff of the student services office will provide information about the College of Biological Sciences and career opportunities in the biological sciences and related areas.

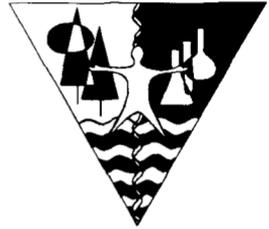
Access to Student Educational Records

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. The policy also permits students to review their educational records and to challenge the contents of those records.

Some student information—name, address, telephone number, date of enrollment and enrollment termination, college and class, major, adviser, and degrees earned—is considered public or directory information. To prevent release of such information outside the University while in attendance at the University, a student must notify the records office on his or her campus.

Students are notified annually of their right to review their educational records. The regents' policy, including a directory of student records, is available for review at the information booth in Williamson Hall, Minneapolis, and at records offices on other campuses of the University. Questions may be directed to the Office of the Coordinator of Student Support Services, 260E Williamson Hall (612 373-2106).

College of Biological Sciences



I. PROGRAMS AND SERVICES

Purpose

Many major problems confronting humankind are biological in nature; the well-being of all of us is intimately tied up with their solution. It is evident that the talents of our most able people must be applied to these problems if they are to be resolved. This will require an ability to use the fundamental concepts of physics, chemistry, and mathematics in order to gain a full appreciation of organisms at the molecular, cellular, organismal, and population levels. There is still great need for the specialist in biology who works in a well-circumscribed area, but there is an even greater need for the "integrator," that individual who has a depth of understanding in a range of areas and the capacity to work with highly complex physical-chemical reactions within dynamic systems. Individuals with this breadth and depth of training are now at the forefront in various aspects of human, animal, and plant research. Their findings will have a major impact on the behavioral sciences, the practice of human and animal medicine, the genetic improvement of agricultural species, and the persistence of ecosystems that are essential to the existence of humankind.

The College of Biological Sciences (CBS) has three primary commitments to helping the University maintain excellence in scholarship: to provide bioscience courses for other college units; to promote general education and to supplement study in fields based on bioscience; to provide a well-rounded curriculum for the bachelor of science (B.S.) degree program in bioscience; and to maintain an excellent faculty and modern facilities, both of which are essential to high quality teaching and research.

Undergraduate Programs

The bachelor of science is the baccalaureate degree offered by the College of Biological Sciences. Majors are offered in biochemistry, biology, botany, genetics and cell biology, and microbiology. The degree can be earned with honors if a student demonstrates a high level of academic achievement and satisfies specified requirements. Irrespective of major, each student must complete a common core sequence of courses in biology, the physical sciences, and mathematics. Students with a special interest in another area of study (e.g., ecology, behavioral biology, zoology) major in biology and include in their programs a suitable selection of advanced courses appropriate to their interests. An individually designed program is available to students with specific needs not accommodated by established major programs. All students are encouraged to explore the many ways to enrich their learning experiences through activities outside of the required curriculum (see Special Learning Opportunities, section II). Students are strongly encouraged to initiate independent research projects with faculty.

Core Curriculum—The core sequence of courses, outlined in section II, was designed in recognition that (1) there is an underlying similarity in the functioning of all biological systems at the molecular and cellular levels; (2) to effectively train students for careers as biologists, great emphasis must be given to training in the physical sciences; and (3) core courses should emphasize physical science methodologies in the solution of biologically important problems. Specific requirements for the various major fields of study are listed in section III.

Programs and Services

Liberal Education—The college faculty believes that all students, whatever their area of specialization or vocational goals, should hold in common the search for a liberal education. In the broadest sense, a liberal education frees individuals from the limitations of their powers of judgment and choice that result from ignorance. Specifically, a liberal education asks individuals 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 their 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, the College of Biological Sciences requires all students to distribute a portion of their course work in areas of study outside of those most directly linked to their specialized interests in science.

Professional Advancement and Career Opportunities—The bachelor of science degree qualifies graduates for a broad range of laboratory, office, or field positions with government agencies and in the private sector. CBS students entering full-time employment immediately following graduation frequently take research scientist and laboratory technician positions. More than half of CBS graduates elect to pursue advanced study immediately following receipt of the B.S. degree (approximately 35 percent are admitted to professional schools and 18 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 on request in 223 Snyder Hall.

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 the CBS Office of the Dean and department offices.

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

Biology—Kendall C. Corbin

Biochemistry—Peter J. Chapman

Botany—David J. McLaughlin

Cell and Developmental

Biology—Stuart F. Goldstein

Ecology—Elmer C. Birney

Genetics—D. Peter Snustad

Microbiology—P. Patrick Cleary

Plant Physiology—Thomas K. Soulen

Zoology—Donald E. Gilbertson

Academic Resources

Students should be aware of *primary sources of information* within the college. Each department has a *director of undergraduate studies* who has major responsibility for assisting undergraduate students (see section III). There is also a *director of graduate studies* for each of the programs administered by the faculty in the college. A special section describing *student services* available to CBS students appears later in this section of the bulletin. See also, Honors Program.

Administrative Structure—The College of Biological Sciences, which has faculty and facilities located on both the Minneapolis and St. Paul campuses, is organized into the following departments: Biochemistry, Botany, Ecology and Behavioral Biology, and Genetics and Cell Biology. The Department of Microbiology in the Medical School functions

as a department of the college for undergraduate education. In addition, CBS is responsible for the administration of several program units, including the Dight Institute for Human Genetics, the Gray Freshwater Biological Institute, and the Bell Museum of Natural History. An active field biology program is administered by the college, with facilities at the Lake Itasca Forestry and Biological Station and the Cedar Creek Natural History Area (at Bethel, Minnesota). A complete list of faculty is provided in section IV of this bulletin.

Faculty Advisers—A faculty adviser is identified for each upper division student in the biological sciences. The importance of the relationship between the faculty adviser and student cannot be overemphasized. Students will find it useful to consult their adviser regarding progress in specific courses, information about graduate study, designing a research project, and arranging work with members of the faculty in laboratory and field settings. Students are encouraged to meet with their adviser for assistance in goal setting, program planning, and similar matters. Students who wish to change advisers may arrange to do so through the student services office.

Students *must* visit their adviser during the last two weeks of spring quarter each year to plan their program for the coming year. Before seeing their adviser regarding curriculum planning, students should study the relevant bulletins carefully and be prepared to present a tentative program.

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, most without charge. Call 612/373-2423 for appointments or further information.

Dight Institute for Human Genetics—Located in the Botany Building at 400 Church Street S.E., Minneapolis, the Dight Institute provides genetic counseling free of charge for those requesting the service. Individuals may also call for information about various community medical resources, genetic services, and genetic organizations. Lectures and workshops are open to outside organizations without charge. Call 612/373-3792 for further 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 graduate students from several disciplines conduct basic research dealing with problems of fresh water. Group tours of the facility are available to the general public and may be arranged by calling the Freshwater Biological Research Foundation (612/471-8407).

Lake Itasca Forestry and Biological Station—Information about summer biology offerings is contained in the *Lake Itasca Biology Session Bulletin*. Reservations for and questions about the Itasca program should be directed to the Director, Field Biology Program, 349 Bell Museum of Natural History, University of Minnesota, 10 Church Street S.E., Minneapolis, MN 55455.

Student Organizations and Governance

Biological Sciences Student Board (BSSB)—The official voice of undergraduate students in the college is the Biological Sciences Student Board. Meetings of the board are open to any student interested in the biological sciences. Officers are elected from biology students in the College of Biological Sciences and College of Liberal Arts. The board elects student representatives to appropriate college committees (including CBS administration, educational policy, and long-range planning). Meeting notices are posted on college bulletin boards. Further information is available from the CBS student services office.

Student Representation on University Committees—Students interested in serving as representatives on all-University committees and governing bodies (e.g., the St. Paul Campus Board of Colleges) should watch for announcements about opportunities to file for positions. The *Minnesota Daily* carries such announcements, and they are also posted on campus bulletin boards.

Biological Sciences Alumni Society (BSAS)—The society was established and formally recognized by the University of Minnesota Alumni Association in 1980. The purpose of the society is to organize a professional association of significance to biological sciences alumni and former students, and to encourage and stimulate the relationship between the students, faculty, alumni, and community. The society has made a special commitment to sponsor programs that will enhance the opportunities available to current students and encourages the participation of student members. To facilitate a close working relationship, the president of the BSSB is a member of the board of directors of the alumni society. Alumni volunteers, working with the CBS Career Information Office, have developed a career information network to assist current students and graduates in exploring career options. The society sponsors undergraduate merit scholarships and is committed to the support of continuing education programs in the biological sciences. Further information may be obtained from the Office of the Dean, 123 Snyder Hall.

Student Services

Student Services Office—Prospective as well as current students should always feel welcome to discuss any questions or problems with a member of the advising staff in the student services office at 223 Snyder Hall, St. Paul campus (612/373-3648). This office is administratively responsible for admission, registration, degree requirements and procedures, maintenance of student records, and related functions. The staff members advise freshmen and sophomores and also assist upper division students and faculty advisers. Because the office is exceptionally busy at certain times during the year, appointments should be made by calling 612/373-3648.

Career Information Office—The Career Information Office is located at 229 Snyder Hall on the St. Paul campus (612/373-1651). The office provides information about career opportunities in the biological sciences at the B.S., M.S., and Ph.D. levels as well as assistance in selection of programs and completion of application procedures for post-graduate study. Information about scholarships and fellowships, summer employment, internships, and undergraduate research opportunities is also available. In addition, placement assistance in the form of a résumé filing service, listings of current job vacancies at all degree levels, and specific information about prospective employers is available.

Minority and Disadvantaged Student Affairs—The director of minority and disadvantaged student affairs is available to meet individually with students to explore potential interests in biology, to provide academic assistance when needed, and to help students overcome other barriers to achieving success in education. For more information, contact the student services office, 223 Snyder Hall.

All-University Student Services—Numerous specialized services are provided by the University for all students. See the *Student Directory* for listings of offices and units that offer specific services, including:

Boynton Health Service
Handicapped Resource Office
Housing Office
International Student Adviser's Office
Libraries
Minority and Special Student Affairs
Office of Student Financial Aid
Placement Offices

Recreational Sports
St. Paul Health Service
Student Counseling Bureau
Student Employment Service
Student Legal Service
Student Ombudsman Service
Student Organization Development Center
Veterans Programs



Student services staff (223 Snyder Hall): (L to R) Kathie Peterson, Thelma Wallace, Ellen Thurston, and Amy Winkel.

II. DEGREE REQUIREMENTS AND PROCEDURES

Admission

The College of Biological Sciences is an upper division unit within the University. Students normally enter the college at the beginning of their junior year. Nevertheless, as soon as students decide they are interested in majoring in a bioscience area, they should contact the Office of Student Services, 223 Snyder Hall, University of Minnesota, 1475 Gortner Avenue, St. Paul, MN 55108, for advice and counseling. Course work in the biological sciences is based on a sound foundation in the mathematical and physical sciences as well as a broadly based background in the liberal arts. In preparation for admission to the College of Biological Sciences, students beginning their work at the University may enter any unit that enrolls freshmen and, with the advice and counsel of a biology adviser, take courses that will provide an adequate background. Students should refer to the bulletins of the various freshman-admitting colleges for information regarding their admission criteria.

Affirmative Action Policy

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 such minorities in biological science and allied professions.

The requirements for admission to CBS, an upper division college, consist of completion of a specified minimum number of college credits, completion of specific course work prerequisites, and achievement of a certain grade performance level in such course work. There is no limit on the number of students admitted. To the extent possible from the information available regarding a particular applicant, applications are given individualized attention, and 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.

Successful affirmative action, however, involves more than just sensitive evaluation at the point of admission. Through its Office of Minority and Disadvantaged Student Affairs, which reports directly to the college dean, the college provides academic and counseling/advising services to racial minority and other disadvantaged University students prior to application to CBS (see section I of this bulletin). The intent of such services is to help prospective students both increase their awareness of the opportunities for study and careers in biology and related professions and 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.

Admission Requirements

During their freshman and sophomore years, students should plan to complete, as a minimum, the beginning English composition course, mathematics, and general chemistry

requirements. They should take at least one quarter of biology to make certain they wish to concentrate in the biological sciences as well as to prepare for upper division courses in their junior year. Most students should take organic chemistry during their sophomore year, thereby allowing ample time for major course work and research experiences.

Specific requirements for admission are satisfactory completion of:

1. A minimum of 84 quarter credits with grades of A, B, C, or S before initial registration in the college.
2. Each of the following:
 - a. Two quarters of analytical geometry and calculus (Math 1211-1221 or equivalent)
 - b. Two quarters of general chemistry (Chem 1004-1005 or 1031-1032 or equivalent)
 - c. A course in general biology (Biol 1009) or exemption

Students who transfer courses from another institution should verify equivalency with the student services office. All students, especially those transferring from other institutions, are strongly encouraged to complete the third quarter of the calculus sequence (Math 1231) required for graduation prior to their first quarter of enrollment in CBS.

Admission Procedures

Admission Period—The deadline for receipt of complete applications (including transcripts) is July 15 for fall quarter (students are encouraged, however, to apply by May 15 to participate in annual program planning); October 15 for winter quarter; and February 15 for spring quarter.

Transfer From Other Colleges Within the University—A Request for Change of College Within the University form may be obtained from most college offices or from the Office of Admissions and Records. The completed application, along with two copies of the student's transcript, should be submitted to 223 Snyder Hall.

Admission From Outside the University With Advanced Standing—Students should apply to the Office of Admissions and Records, 130 Coffey Hall, University of Minnesota, 1420 Eckles Avenue, St. Paul, MN 55108, in advance of the dates stated above. Ordinarily, applications can be acted on before the transcript with the current quarter's grades has been submitted. Qualified students will be admitted, subject to the satisfactory completion of the current registration.

Adult Special Status—Registration as an adult special student provides the opportunity to take courses to meet special needs for students who do not wish to apply the course work toward a degree. However, subsequent admission to a degree program is possible upon recommendation of the college. In most cases, credit earned as an adult special student can be applied toward an undergraduate degree. Upon approval of the Graduate School, up to 40 percent of the course work for master's degree programs may be transferred from work taken as an adult special, summer session, or continuing education and extension student. Admission is completed through the Office of Admissions and Records, 130 Coffey Hall, or through the student services office, 223 Snyder Hall. Applications should be filed well in advance of the desired quarter of entrance.

Graduation Requirements

To earn a bachelor of science degree from the College of Biological Sciences, a student must complete all of the following:

Degree Requirements and Procedures

1. 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. See Credits and Grades, section II. CBS students may apply up to eight technical, non-liberal arts college credits toward their degrees. Check with an adviser in 223 Snyder Hall for details.
2. Credits in Residence—
 - a. A minimum of 45 credits in courses taken on the Twin Cities campus, 30 credits of which must be taken during the senior year (or the equivalent of the senior year for part-time students). Candidates for the B.S. degree must present 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.
 - b. A minimum of 36 credits as a student registered in the College of Biological Sciences.
 - c. 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 all 3xxx and 5xxx courses listed in this bulletin as well as appropriate advanced courses in mathematics, statistics, computer science, and the physical sciences.
3. English Communication Skills—Freshman composition (Comp 1011 or Rhet 1101-2 or equivalent) and one advanced course in writing to be selected from the following: Comp 3015 or 3027; Rhet 3551 or 3562.
4. Foreign Language—Either two years of study of a single foreign language in high school or three quarters (one year) of study of a single foreign language in college or demonstration of equivalent proficiency satisfactory to the appropriate language department.
5. 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

The mathematics and science course work that is required of CBS students (see items 6 and 7 below) will automatically satisfy the minimum University requirements for group A and group B. In addition, CBS students must complete 30 liberal education credits, including a *minimum* of 8 credits each in group C and group D. These 30 credits may include a few specific courses from group A; they may not include group B courses.

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*. In addition, students are encouraged to explore the course offerings of other units (e.g., rhetoric and agricultural economics). *Direct questions concerning acceptable courses to the student services office, 223 Snyder Hall.*

6. Physical Sciences and Mathematics—
 - a. Mathematics—A three-quarter analytic geometry and calculus sequence (Math 1211-1221-1231 or equivalent). A two-quarter course sequence in statistics (Stat 5021-5022 or PubH 5450-5451-5452-5453) may be substituted for the last quarter of calculus, by formal petition.
 - b. Chemistry—Each of the following:
 - General chemistry, two quarters (Chem 1004-1005 or 1031-1032 or equivalent)
 - Organic chemistry, two quarters with laboratory (Chem 3301-3302-3305-3306 or 3331-3332-3335 or equivalent)

A minimum of four additional credits in chemistry (e.g., Chem 1006 or 3100-3101 or 3303 or physical chemistry)

Students who plan to major in biochemistry are encouraged to take the sequences designed for chemistry majors (listed as options above).

- c. Physics—A three-quarter course, with laboratory, that requires college-level mathematics as a prerequisite (Phys 1271-1281-1291 with 1275-1285-1295 or 1104-1105-1106 with 1107-1108-1109. By petition, a two-quarter sequence (Phys 1041-1042 with 1045-1046) 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 the calculus-based sequence (Phys 1271, etc.).

7. Biological Sciences (the Core Curriculum)—

- a. General Biology (Biol 1009, five credits) or exemption granted by the student services office. Students with a good background from high school or individual study are encouraged to take the Biol 1009 exemption examination.
- b. The following three courses: Animal Biology (Biol 3011, five credits), Plant Biology (Biol 3012, five credits), Microbiology (Biol 5013, five credits)

Students who have completed a course in general zoology (Biol 1106 or equivalent) must satisfy the animal biology requirement with Biol 3111. Completion of a course in general botany (Biol 1103 or equivalent) will exempt the student from Biol 3012 if an upper division course requiring 3012 as a prerequisite is satisfactorily completed. Upper division courses used to demonstrate the student's proficiency in plant biology may also be used to fulfill item h below.

- c. Biochemistry (Biol 5001, four credits)
- d. Genetics (Biol 5003, four credits)
- e. Cell Biology (Biol 5004, three credits)
- f. Ecology (Biol 3041, four credits)
- g. Laboratory or fieldwork in one additional upper division biological sciences course. This is an "experience" requirement rather than a credit requirement, so credits earned may be used toward fulfilling item h below. A list of acceptable courses follows:

Biol 3042, 5112, 5125

BioC 5025, 5744

Bot 3109, 3201, 5103, 5105, 5111, 5132, 5205, 5206, 5211, 5212, 5231, 5251

EBB 5014, 5016, 5112, 5116, 5128, 5129, 5132, 5134, 5136, 5155, 5156, 5313, 5322, 5323, 5603, 5605, 5606, 5607

GCB 5001, 5002, 5011, 5015, 5030, 5135, 5605, 5606

MicB 5105, 5106, 5216, 5233, 5234, 5322, 5424

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

An independent research project is also strongly recommended. (A resource book listing available research opportunities is maintained by the student services office.)

- h. Nineteen additional upper division credits in mathematics and/or physical and/or biological sciences, including at least one of the following courses: Bot 3131, EBB 5156, GCB 5114 or 5134, MicB 5321. This includes work specified by the major department (see section III).

Honors

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 is designed to provide exposure to the breadth of biological inquiry.

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 research adviser from the college faculty and should 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, Bot 5990, EBB 5990, GCB 5990, or MicB 5990. An honors thesis, summarizing the research and written in the style of a publishable manuscript, is required of all 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—Three quarters of participation in the CBS Honors Seminar (Biol 3960) are required of all honors program participants. 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 present summaries of their project results.

Honors Program Admission—Qualified students should apply for admission to the honors program at the time of admission to the College of Biological Sciences. A minimum of four quarters of honors registration must be completed to fulfill the requirements for graduation with honors. Applicants should have a minimum grade point average of 3.20 and present reasonable evidence of potential to attain the grade point average required for graduation with honors (see below). Application forms are available in 223 Snyder Hall.

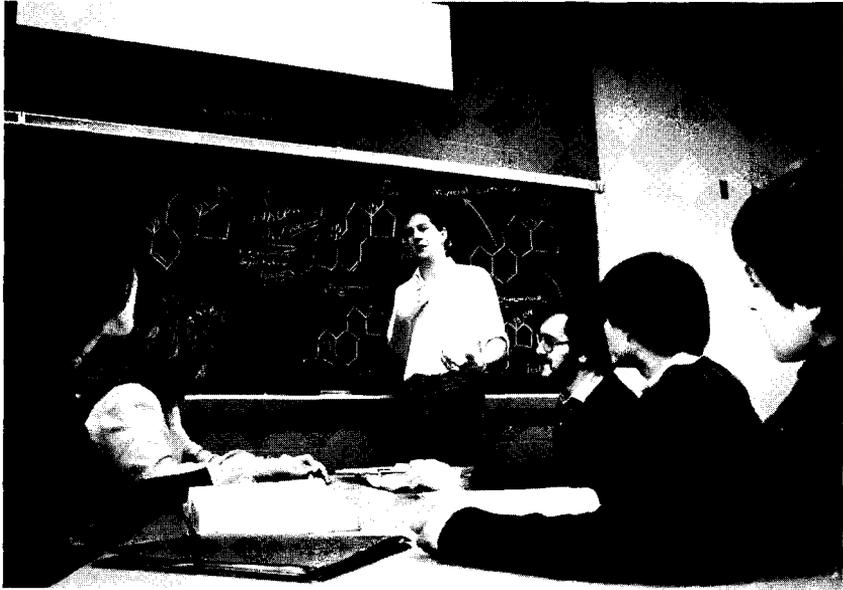
Graduation With Honors—Participation in the honors program is required for graduation with the traditional honors designations *cum laude*, *magna cum laude*, and *summa cum laude*. In addition to the requirements for graduation, candidates for graduation with honors must complete the following:

1. At least 60 credits in upper division courses (3xxx and 5xxx) at the University of Minnesota, Twin Cities campus
2. Two quarters (eight credits) of directed research, the results of which are to be reported in an acceptable honors thesis
3. Three CBS Honors Seminars (Biol 3960H)
4. One additional honors opportunity, which may be selected from the following:
 - a. An additional quarter (four credits) of participation in directed research
 - b. A College 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 student services office)
 - e. An 8xxx course (seniors only; requires permission)
5. The last 90 credits of A-N registration with the minimum grade point averages specified below:

<i>cum laude</i> :	minimum GPA of 3.25
<i>magna cum laude</i> :	minimum GPA of 3.40
<i>summa cum laude</i> :	minimum GPA of 3.60

Grades of N, which carry no grade points, are included in the computation of the grade point average. 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 student services office.



A student gives a presentation in a CBS Honors Seminar.

CBS SCIENCE REQUIREMENTS SUGGESTED TIME SEQUENCE

	Freshman			Sophomore			Junior			Senior			
	F	W	S	F	W	S	F	W	S	F	W	S	
Earliest Possible *													
Recommended ¹	—————												
Latest Possible	- - - - -												
A. PREREQUISITES													
Calculus (three quarters)	—————					- - -	- - -						
General Chemistry (two quarters)	—————					- - -	- - -						
Organic Chemistry (two quarters with lab)				—————					- - -	- - -			
Physics ² (three quarters)				—————								- - -	- - -
General Biology (one quarter)	—————					- - -							
B. BIOLOGY CORE³													
Biol 3011, Animal Biology				*	—————								- - -
Biol 3012, Plant Biology				*	—————								- - -
Biol 5013, Microbiology							—————					- - -	
Biol 3041, Ecology							—————					- - -	
Biol 5001, Biochemistry						*	—————					- - -	
Biol 5003, Genetics							—————					- - -	
Biol 5004, Cell Biology							—————					- - -	

¹The recommended time period for many sequences is longer than required in order to allow some flexibility as to when the sequence is started.

²Students needing physical chemistry (biochemistry majors) or general physiology (GCB 5114) must complete this sequence within the recommended period.

³The period indicated is recommended in order to leave the senior year open for advanced study and research.

Examination Programs

Special Examinations for Credit—A student who believes his or her knowledge is equal to that required to complete a particular course may apply to the college for permission to take a credit examination. If approval is granted after review of the application and the applicant's background, arrangements may be made with an instructor who regularly teaches the course to take the examination. A student must be currently enrolled to be eligible. A fee is charged for each examination. Often no grade is assigned.

College Level Examination Program (CLEP)—By passing one or more of the standardized examinations prepared by the College Entrance Examination Board, a student may sometimes earn credits to apply (as nonresidence credit without grade) toward the degree. CLEP credits do not count in calculating the number of S-N credits that may be earned at the University of Minnesota. Full information about CLEP tests may be obtained from the student services office, 223 Snyder Hall.

Special Learning Opportunities

Students are encouraged to explore learning experiences through activities outside of the usual curriculum. Many students plan projects they carry out under faculty supervision in research laboratories and in field settings; credit assignments are arranged on an individual basis through a variety of mechanisms (see Independent Study). Some students seek employment as undergraduate teaching and research assistants, as museum tour guides, or in similar positions. Most departments offer special seminars for undergraduates (see section III). A three-quarter course, Biology Colloquium, is intended for freshmen and sophomores who wish to explore the various fields and career alternatives within the biological sciences and who are interested in personal development and interaction with both faculty members and other students in a small group setting. The Biology Colloquium also provides an excellent opportunity for advanced students to gain experience by serving as student leaders for projects.

Individually Designed Degree Program—Each of the majors offered by CBS is built around a series of core courses that introduces students to many areas of biology and draws upon a basic preparation in mathematics, chemistry, and physics. These requirements were established after extensive consultation among faculty members and are considered appropriate for the majority of students seeking an undergraduate degree in the biological sciences. No set of requirements, however, can meet the needs of every individual. Recognizing this fact, the individually designed program was instituted during the 1976-77 academic year. The experimental status of this degree program option will be reviewed during the 1983-84 year. Before being admitted to the program, a student must submit a statement of goals and objectives to justify to the program admissions committee the reasons for designing a unique program. Applicants must have successfully completed 84 quarter credits prior to initial registration in the college, including a course in general biology (or exemption), two quarters of general chemistry, and a minimum of one quarter of calculus. Interested students should consult an adviser in the student services office at an early date.

Annual Program Planning

During the last two weeks of spring quarter all students are required to meet with their faculty adviser to plan a program for the coming year. Newly admitted students and applicants to the college should come to the student services office, 223 Snyder Hall, to receive materials and instructions. The Annual Program Plan, signed by the student and the adviser, must be returned to 223 Snyder Hall.

Registration

Consult the quarterly *Class Schedule* for detailed information on all registration procedures, grading policies, final examination schedules, and tuition and fees.

A student's first obligation is proper registration. Upon registering and paying fees, the student essentially enters a contract with the University whereby the various colleges offering the courses agree to make certain instruction and facilities available to that student. Errors in registration, late registration, failure to observe procedures, or excessive changes in registration cause an imposition on others and are costly and time-consuming.

The days, hours, and meeting places of classes appear in the quarterly *Class Schedule*. Consult the *Class Schedule* for course prerequisites, limitations on enrollment, and special registration procedures (also see below). Students who miss the first class session may lose their places in courses for which they are registered.

Detailed registration instructions are issued before each quarter; contact the student services office for more information. Much of the inconvenience often associated with registration can be avoided by carefully reading these instructions and the *Class Schedule*.

Registration Dates—For continuing students, these dates are scheduled during August for fall registration and during the last four weeks of fall and winter quarters for winter and spring registrations, respectively. Specific dates are announced in the Official Daily Bulletin column in the *Minnesota Daily* or may be obtained in the student services office.

Course Closures—Information on courses and sections of courses that remain open is available at the college office in 223 Snyder Hall, in 130 Coffey Hall, and in 18 Johnston Hall. This information is updated daily.

Independent Study—All independent study, directed study, or extra credit registrations require prior instructor and department approvals. Registration materials include information about procedures for such registrations. A written contract must be reviewed by the instructor and approved by the department office at the time of registration. The contract, between the student and faculty member, should state the following:

1. The objectives of the project
2. The method of achieving the objectives
3. The procedure for evaluating the outcome of the project
4. The expected number of quarters to complete the project
5. The expected number of credits to be awarded per quarter
6. The grading system to be used

Y Registration permits students to complete a course independently without class attendance. Students must complete such course requirements as examinations and other work on which they and the instructor agree. The usual fees, deadlines, grading systems, and other regulations apply. Instructor and department permission are required.

X Registration allows students to earn one to three extra credits in a course already taken or in progress by exploring in depth a topic drawn from or related to the course's content. Permission of the instructor (with whom the extra work is planned) and the department is required.

Directed Studies (5970) and *Directed Research (5990)* registrations allow students to complete academic work of their own design under the guidance of an instructor in an appropriate field. Students work largely on their own initiative and at their own speed, often in the instructor's research laboratory. Credit assignments vary, but normally an average of 30 hours of work a quarter are required for each credit earned. Regular evaluation and grading procedures apply. Advance approval of the instructor and department is required.

Directed Instruction provides students with an opportunity to participate in teaching courses in subjects with which they are well acquainted. Instructor and department permission are required. From one to five credits are awarded per quarter. A maximum of eight such credits may be counted toward the total required for graduation.

Repeating a Course—Students may repeat courses that have *not* been completed satisfactorily, including courses in which they received D grades. Both the old and the new grade will be included on the academic record. Students are *not required* to repeat a failed course unless it is needed to meet a prerequisite or other requirement.

Repeating a course that has already been completed satisfactorily requires college approval. The first passing grade is used in calculating the student's grade point average.

Cancelling and Adding Courses—A registration is an agreement that the student will complete the work for which he or she has enrolled. The agreement may be changed by completing the procedure commonly called "cancel-adding." Merely ceasing to attend a class or to do assigned work does not release a student from the agreement. Informal approval of either cancelling or adding by an instructor is not sufficient.

Late Additions and Cancellations—Registration changes (especially additions) after a quarter opens are discouraged. However, students are permitted to add classes during the first week or cancel classes through the second week of a quarter by filling out a Course Enrollment Request form appropriately, obtaining required signatures, and turning the form in at the Registration Center. Consultation with the instructor and adviser is recommended.

After the first week, courses may be added only with written permission of the instructor and approval of the college. Cancellation after the sixth week of class requires a petition to the scholastic standing committee and will be allowed only for unusual circumstances.

Cancelling Out of College—To leave the University during a given quarter, a student must cancel all current registration (absence from classes does not constitute official withdrawal). Inform the student services office and cancel any existing registrations at the Office of Admissions and Records, 130 Coffey Hall.

Credits and Grades

Maximum and Minimum Credit Loads—Full-time students register for 12 to 16 credits of course work each quarter. When outside jobs or responsibilities demand 20 or more hours of time a week, students are advised to take a reduced course load. In general, it is unwise to devote more than 15 to 20 hours a week to work or outside activities while attending college. A credit load exceeding 19 credits per quarter requires college approval.

Credit Value—A credit requires about 3 hours of work a week or about 30 hours in a 10-week quarter. Thus, a 4-credit course represents about 120 hours per quarter of acceptable work. Most CBS courses are scheduled to include one 45-minute class meeting per week per credit. The total time required may be spent in various combinations of class, laboratory, homework, and other study.

S-N Registration—The University uses two grading systems: the traditional letter grade (A-N) system and the satisfactory-no credit (S-N) system. Freeing students to some extent from the pressure of grades, the S-N grading system is designed to encourage students to take a greater variety of courses. With college permission, the S-N system is also used for certain courses in which it is impossible or undesirable to evaluate student achievement precisely. A change in registration to A-N from S-N or vice versa may not be made after the end of the second week of classes. Students may not register on an S-N

Degree Requirements and Procedures

basis for courses used to satisfy *specific college graduation requirements in mathematics and the physical or biological sciences*, unless such courses are offered on an S-N only basis. Exceptions may be authorized by petition.

Students who plan to apply to a graduate or professional school should plan to register for A-N grading on almost all work relevant to their proposed specialization.

Satisfactory Progress

Students are expected to make satisfactory progress toward the bachelor's degree. This usually means earning grades of A, B, C, or S in most courses and completing all courses taken.

Students concerned about their progress should consult early with their instructors, their adviser, or staff members in the student services office. Students who are temporarily handicapped by conditions beyond their control (e.g., illness, family emergencies) may wish to discontinue their registration. Permission to officially withdraw after the sixth week of the quarter requires permission from the scholastic standing committee.

Scholastic Probation—Students are expected to complete a minimum of 50 percent of the credits for which they register each quarter and a minimum of 75 percent of the credits for which they register each year with grades of A, B, C, or S. These percentages apply to credits for which students are registered after the tenth day of classes each quarter.

Students who fail to complete the required percentages are subject to probation—the signal that academic progress is not satisfactory. Students on probation who do not improve their academic record may be suspended from the college. If a heavy load of outside work, campus activity, or other concerns interferes with academic achievement, students are expected to make immediate adjustments and seek appropriate assistance. Students are released from probation when academic work has improved enough to demonstrate promise for continuous progress toward a degree.

Suspension From College—Accumulation of an excessive amount of substandard work usually places a student in jeopardy of not graduating. Continuation in the college is, therefore, not likely to serve that student's interests, and he or she may be suspended from further registration.

The decision to suspend a student is made after careful examination of evidence in each individual case and after consultation with the student. A suspension is rescinded only after the college is convinced that changes in the student's academic performance are probable. Student services office personnel and faculty advisers are available for consultation concerning possible alternatives to college requirements, transfer to other institutions, and prospects for readmission to CBS.

Readmission—Students suspended from the college may return only upon approval of the college. Strong assurance that the factors that caused the suspension have been corrected, together with convincing evidence that improved work will follow, must be presented to obtain approval. Students are readmitted on probation and are subject to immediate suspension if their work again becomes unsatisfactory. Petitions for readmission from suspended students are normally considered after an interval of at least a year.

Regulations

A student may discuss a request for exemption from a college regulation—concerning late registration, course withdrawal, examination scheduling, or a similar matter—with a staff member in the student services office. Exemptions are granted occasionally to aid students in achieving educational goals.

The adviser or a staff member in the student services office is a good source for information about college procedures and regulations. If an individual is dissatisfied with a college or department procedure, however, he or she should go to the appropriate person or office. Each department has a grievance committee, as does the college, composed of students and faculty members. Advice from staff members in the student services office may also be helpful.

Graduation

Filing the Application—Two quarters before they intend to graduate, students must file an application for graduation at 223 Snyder Hall. Specific application deadlines are included with the registration materials distributed each quarter. After filing, each student will receive a senior balance sheet listing the remaining requirements to be completed for the degree.

Graduation With a Double Major or Two Degrees—Students with special interests may wish to pursue a double major or simultaneously earn a B.S. degree in CBS and a second degree from another college. Students interested in these options should consult their advisers and the appropriate college offices at the earliest possible date.

Credits in Graduate School—Seniors who have a maximum of nine credits to complete for the bachelor's degree may petition to take a limited amount of work for graduate credit. Previous approval must be obtained from the Graduate School. Such work will not count toward the bachelor's degree.

With approval of the College of Biological Sciences and the Graduate School, students admitted to a graduate program who have a maximum of six credits to complete for the bachelor's degree may register in the Graduate School as well as in CBS.



A CBS graduate shares a proud moment with his parents after commencement.

III. 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:

§ Credit will not be granted if the course listed after the section mark has been taken for credit.

¶ Concurrent registration is allowed (or required) in the course listed after the paragraph mark.

Permission to Register form, completed and signed by the instructor, is required for registration.

△ Permission to Register form, completed and signed by the department, division, or school offering the course is required prior to registration.

† All courses preceding the dagger 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 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 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.

Biochemistry (BioC)

Director of Undergraduate Studies—1983-84: Gary Nelsestuen; 1984-85: Janet Schottel

Biochemistry is the study of the molecules, especially macromolecules such as proteins and nucleic acids, that occur in living organisms. The major in biochemistry is designed for students who plan to pursue graduate study in biochemistry or in the biochemical aspects of the biological, medical, or agricultural sciences. It also offers preparation for chemists in entry-level biochemical positions in industry. The curriculum differs from that leading to the bachelor of science degree in chemistry in that substantial training in the biological sciences is included at the expense of additional courses in analytical, inorganic, and physical chemistry.

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 laboratory courses. Research options are available through BioC 5990 and through 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 following (where optional sequences exist, recommended courses are listed first):

Biochemistry—BioC 3960, 5002, 5025. In addition, advanced and special topics courses (e.g., 5744, 5950) are recommended. In some cases, BioC 5751-5752 may be accepted as a substitute for 5002 and special topics.

Inorganic Chemistry—Chem 1006 (Students who have completed Chem 1031-1032, 1133 may be exempted from Chem 1004-1005-1006.) One of the following courses may be substituted for Chem 1006: Chem 5122 or 5126 or 5127 or BioC 5744.

Organic Chemistry—

Chem 3333, 3336. In addition, 5365 is recommended.

or

Chem 3303. In addition, 5365 is recommended.

Analytical Chemistry—

Chem 1133. In addition, 5133 is recommended.

or

Chem 3100, 3101. In addition, 5126 or 5133 is recommended.

Mathematics—Math 3211. In addition, 3221 is recommended.

Physical Chemistry—

Chem 5533, 5534, 5535 plus 5536 or 5538

or

Chem 5520, 5521 plus six additional credits in physical and/or biological sciences.

German is the recommended foreign language.

1301f,w. ELEMENTARY BIOCHEMISTRY I. (5 cr. §Chem 1002 or 3301; not intended for majors; prereq Chem 1001 or 1005) Glass, Jenness

The chemistry of carbon compounds that occur in nature. Composition, structures, and properties of the major components of plant, animal, and bacterial cells.

1302w,s. ELEMENTARY BIOCHEMISTRY II. (3 cr; prereq 1301 or Chem 1002)

Biochemical principles; reactions of organic compounds in the living cell. Metabolic pathways, energy considerations, and biosynthetic processes; emphasis on aspects essential to an understanding of plant and animal nutrition and physiology.

1303w,s. ELEMENTARY BIOCHEMISTRY LABORATORY. (2 cr; prereq 1301 or 1301)

Problems and exercises in chemical and biochemical techniques. Discussion of methods and concepts.

3960f,w,s. RESEARCH TOPICS IN BIOCHEMISTRY. (1 cr per qtr; offered S-N only)

Lectures and discussions on current research in the department.

Biol 5001f,w,s,su. BIOCHEMISTRY. (4 cr, §Biol 3021, §5001; prereq Biol 1009. 12 cr organic chemistry or #)

Biochemistry and biophysics of cells; emphasis on enzyme catalysis, cellular energetics, biosynthesis of cellular constituents and cellular regulatory mechanisms.

5002w,s. BIOCHEMISTRY TOPICS. (3 cr; prereq Biol 5001)

Biol 5001 and BioC 5002 constitute a two-quarter sequence for undergraduate and graduate students lacking physical chemistry, and serve as prerequisite for certain advanced courses.

5003. PLANT BIOCHEMISTRY. (3 cr; prereq Biol 5001 or equiv; BioC 5002 recommended)

Roles of membranes and subcellular organelles in metabolism and regulation of metabolic pathways in plants. Relationship between structure and function. Reaction mechanisms and control of metabolite flux on metabolic pathways.

5025f,w,s. LABORATORY IN BIOCHEMISTRY. (2 cr; prereq Biol 5001 or *Biol 5001)

Discussions of techniques and problem-solving approaches illustrated with laboratory experiments and demonstrations.

5271. VITAMINS. (3 cr; prereq 5752 or 5002 or #)

Lectures and assigned readings on biochemistry of vitamins and their physiological action.

5522f. PHYSICAL BIOCHEMISTRY: SOLUTION STRUCTURE AND INTERMOLECULAR FORCES. (4 cr, §Chem 5522, §MdBc 5522; prereq 2 qtrs physical chemistry; Biol 5001 desirable)

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

Major Requirements and Course Descriptions

- 5523w. PHYSICAL BIOCHEMISTRY: SPECTROSCOPIC METHODS.** (4 cr. §Chem 5523, §MdBc 5523; prereq 2 qtrs physical chemistry; Biol 5001 desirable)
Optical and magnetic resonance spectroscopy. Basic physical principles of spectroscopy and their application to the study of structure and dynamics in proteins, lipids, nucleic acids, and synthetic analogs.
- 5524s. PHYSICAL BIOCHEMISTRY: ENZYME KINETICS.** (4 cr. §Chem 5524, §MdBc 5524; prereq 2 qtrs physical chemistry, BioC 5751 or MdBc 5751 or equiv)
Lectures, assigned readings, and problem sets describing the use of steady state and transient kinetics for the investigation of enzymes and enzyme systems.
- 5744w. BIOCHEMISTRY LABORATORY: THEORY AND PRACTICE.** (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.
- 5751f-5752w-5753s. GENERAL BIOCHEMISTRY.** (4 cr per qtr, §MdBc 5751-5752-5753; prereq 3 qtrs organic chemistry, 2 qtrs physical chemistry, 1 qtr biochemistry or #)
Structure, function, metabolism, and metabolic regulation of components in biological systems.
- 5950f,w,s. SPECIAL TOPICS.** (1-5 cr; prereq #, Δ)
- 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)
Laboratory or field investigation of selected areas of research.

FOR GRADUATE STUDENTS ONLY

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

- 8094. RESEARCH AND LITERATURE REPORTS**
- 8194. GRADUATE SEMINAR**
- 8210. ADVANCED TOPICS IN DNA BIOCHEMISTRY**
- 8212. ADVANCED TOPICS IN RNA BIOCHEMISTRY**
- 8215. ADVANCED TOPICS IN LIPID BIOCHEMISTRY**
- 8220. ADVANCED TOPICS IN CARBOHYDRATE BIOCHEMISTRY**
- 8225. TRACER TECHNIQUES**
- 8230. ADVANCED TOPICS IN MEMBRANE BIOCHEMISTRY**
- 8232. ADVANCED TOPICS IN PROTEIN BIOCHEMISTRY**
- 8233. ADVANCED TOPICS IN ENZYME BIOCHEMISTRY**
- 8250. SPECIAL TOPICS IN BIOCHEMISTRY**
- 8260. ADVANCED PHYSICAL BIOCHEMISTRY**
- 8290. CURRENT RESEARCH TECHNIQUES**
- 8501. BIOCHEMICAL EVOLUTION**
- 8746. BIOCHEMISTRY LABORATORY PROJECTS AND ADVANCED TECHNIQUES**
- 8764. METALLOPROTEINS: STRUCTURE AND FUNCTION**
- 8990. GRADUATE RESEARCH**

Biology (Biol)

Director of Undergraduate Studies—LaVell Henderson

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 is designed to provide the student with a broadly based, thorough undergraduate education in the biological sciences. The biology major must complete the

graduation requirements outlined in section II. The distribution of the 19 additional upper division credits in the mathematical, biological, and/or physical sciences is determined by the student in consultation with his or her 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. 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.

General Education—Courses especially appropriate for non-science and non-biology majors include BioC 1301, 1302, 1303; Biol 1008, 1009, 1101, 1102, 1103, 1106, 1109, 3051, 3112; Bot 1009, 1012, 3071; EBB 3001, 3004; GCB 3002, 3008, 3022; MicB 1101.

1008. INTRODUCTORY BIOLOGY: AN EVOLUTIONARY APPROACH. (4 cr)

Description of evolution as the unifying principle in biology; organization and change in the biological world and the origin of humans.

1008H. INTRODUCTORY BIOLOGY: AN EVOLUTIONARY APPROACH. (4 cr)

For description, see 1008. Intended especially for honors students or their equivalent who plan to major in a life science discipline.

1009 (formerly 1011). GENERAL BIOLOGY. (5 cr, §1011)

Introduction to the principles of biology. The cell, metabolism, heredity, reproduction, ecology, and evolution. Includes laboratory.

1009H. GENERAL BIOLOGY. (5 cr, §1011; 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.

1101f,w,s. 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) V Woodward, Fan

Principles of heredity and their social and cultural implications.

1102f,w. MICROBES AND MAN. (4 cr)

Microorganisms in relationship to humans and their environment in the processing and preservation of food, waste disposal, and environmental factors; bacterial products of industrial and pharmaceutical importance; role of microorganisms in recycling elements of the biosphere; microorganisms and disease.

1103f,w,s,su. GENERAL BOTANY. (5 cr, §3012; prereq 1009; students who plan to major in biology in CLA or in any bioscience major in CBS should take 3012) Wetmore, Biesboer, Koukkari, Charvat

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

1106f,w,s,su. GENERAL ZOOLOGY. (5 cr; prereq 1009)

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

1109f. MAN, NATURE, AND DISEASE. (4 cr; prereq 1009) Gilbertson

The study of disease as a natural phenomenon; the natural history of disease from a worldwide perspective.

1951f, 1952w, 1953s. BIOLOGY COLLOQUIUM. (1 cr f, 1 or 2 cr w,s; for prospective majors: S-N only; prereq 1009 or *1009, #)

Orientation to the biological sciences; opportunity for interaction with other biology students and faculty members.

3011f,w,s,su. ANIMAL BIOLOGY. (5 cr, §1106; prereq 1009, Chem 1005) Goldstein, Kerr, Rosenberg

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

3012f,w,s. PLANT BIOLOGY. (5 cr, §1103, prereq 1009, Chem 1005) Charvat, McLaughlin, Wetmore

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

3041f,w,s,su. ECOLOGY. (4 cr; prereq 1009, Math 1211 or #)

Interactions of plant and animal populations and their environments. Organization, functioning, and development of ecological systems: population growth and regulation. Human impact on the biosphere in modern times.

Major Requirements and Course Descriptions

- 3042f.w.s. FIELD PROBLEMS IN ECOLOGY.** (2 cr; prereq 3041 or EBB 3004 or #)
Student research projects on selected ecological problems.
- 3051su. BIOLOGY AND THE FUTURE OF MAN.** (4 cr; S-N only)
Nontechnical discussion of biological factors affecting the quality of life, e.g., pollution, chemical and biological warfare, population growth, food supply, resource sufficiency, value of wilderness, genetics and eugenics, public health, aging, behavior control, and biological aspects of ethics, morals, and societal organization.
- 3111. ANIMAL BIOLOGY.** (4 cr, §3011; prereq 1009, 1106, Chem 1005) Goldstein, Kerr, Rosenberg
Comparative physiology of various animal groups; coordination, movement, support, excretion, reproduction.
- 3112w. BIOLOGICAL RHYTHMS.** (4 cr, §5112; prereq 1009 or #) Koukkari
Timing mechanisms and rhythms of organisms in physiological processes, ecological adaptation, and health; current hypotheses concerning their cellular nature.
- 3950Hf.w.s. UNDERGRADUATE SEMINAR.** (2 cr per qtr; S-N only; prereq # or #)
Each quarter different faculty members lead groups of students in discussions on topics of current interest.
- 3960Hf.s. HONORS SEMINAR.** (1 cr per qtr; S-N only; prereq #); limited to participants in CBS Honors Program) Staff
Oral reports on topics of current interest to biologists. Progress reports on laboratory and field research by students.
- 3980f.w.s. DIRECTED INSTRUCTION.** (1-5 cr per qtr; prereq #) Staff
- 5001f.w.s.su. BIOCHEMISTRY.** (4 cr, §3021, §BioC 5001; prereq 1009, 12 cr organic chemistry or #)
Biochemistry and biophysics of cells; emphasis on enzyme catalysis, cellular energetics, biosynthesis of cellular constituents, and cellular regulatory mechanisms.
- BioC 5025f.w.s. LABORATORY IN BIOCHEMISTRY.** (2 cr; prereq Biol 5001 or # Biol 5001)
Discussions of techniques and problem-solving approaches illustrated with laboratory experiments and demonstrations.
- 5003f.w.s.su. GENETICS.** (4 cr, §GCB 3022, §GCB 5022; prereq 5001) R Herman, Simmons, Snustad
Introduction to the nature of genetic information, its transmission from parents to offspring, its expression in cells and organisms, and its course in populations.
- 5004f.w.s.su. CELL BIOLOGY.** (3 cr; prereq 5001) Blumenfeld, Cunningham, Hooper
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.
- 5013f.w (formerly 3013). MICROBIOLOGY.** (5 cr, §MicB 3103, §MicB 5105, §VPB 3103; prereq 5001) Chapman, Dworkin, C Woodward
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Emphasis on molecular structure in relation to bacterial function.
- 5061. DEVELOPMENTAL BIOLOGY.** (3 cr; prereq 5003 and 5004) Kerr
Developing systems and control mechanisms of development, from the molecule to the organism.
- 5112. RHYTHMS AND CIRCADIAN REGULATION.** (5 cr, §3112; prereq 15 cr biology, 10 cr chemistry or #) Koukkari
Timing mechanisms and rhythms of organisms in physiological processes, ecological adaptation, and health; current hypotheses concerning their cellular and molecular nature. Laboratory experience arranged.
- 5125f.w.s. RECOMBINANT DNA LABORATORY.** (4 cr; prereq #) Hackett, Messing, others
Introduction to basic recombinant DNA techniques. Methods for growing, isolating, and purifying recombinant DNAs and cloning vectors.
- 5501s. BIOCHEMICAL EVOLUTION.** (4 cr; prereq 5 cr biochemistry) Seal
Molecular evolution covering prebiotic evolution and the phylogeny of important functional molecules and biochemical systems in living organisms.
- 5950. SPECIAL TOPICS IN BIOLOGY.** (1-5 cr per qtr; prereq #, #) Staff
- 5951. SOCIAL USES OF BIOLOGY.** (4 cr; S-N only; prereq 10 cr sciences) Cunningham, Hooper, V Woodward
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

- 5816. FIELD BIOLOGY PHOTOGRAPHY.** (5 cr; A-N only; prereq #, course in beginning biology; limited to 20 students)
Applied photographic techniques for field documentation of biological subjects and events. Practical solutions to problems encountered in the photography of living plants and animals in natural habitats.
- 5850. SPECIAL TOPICS IN BIOLOGY.** (Cr var, 0-10 per qtr; prereq #)
- 5870su. ITASCA SEMINAR.** (1 cr; prereq #) Staff
Topic selected and scheduled during registration by interested staff members and students.

5890su. RESEARCH PROBLEMS AT ITASCA IN ECOLOGY AND BEHAVIORAL BIOLOGY; OR ENTOMOLOGY, FISHERIES, AND WILDLIFE; OR PLANT PATHOLOGY; OR SOIL SCIENCE; OR ZOOLOGY. (Cr:ar; prereq #, ^) Staff

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

FOR GRADUATE STUDENTS ONLY

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

8710. TUTORIAL IN DEVELOPMENTAL BIOLOGY

8910f. WORKSHOP ON TEACHING COLLEGE BIOLOGY

8950. GRADUATE SEMINAR

8970. SPECIAL TOPICS

8990. GRADUATE RESEARCH

Botany (Bot)

Director of Undergraduate Studies—Tom Soulen

Botanists 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 program in botany is designed to provide a comprehensive and well-balanced undergraduate education in biology with a concentration in the plant sciences. In completing the core curriculum, students must take Bot 3131 (or 5131) and 5132 to fulfill the physiology requirement. In fulfillment of part of the 19 additional science and mathematics credits required for graduation, students are required to take 15 upper division credits in botany; these must include courses in anatomy (3109 or 5111), taxonomy (3201 or 5801), and morphology (5103 or 5105—it is recommended that both morphology courses be taken).

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

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.

1012f. PLANTS USEFUL TO MAN. (4 cr; for majors or nonmajors) Jonas

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

Biol 1103f,w,s,su. GENERAL BOTANY. (5 cr, §Biol 3012; prereq Biol 1009; students who plan to major in biology in CLA or in any bioscience major in CBS should take Biol 3012) Wetmore, Biesboer, Koukkari, Charvat
Levels of organization of plants, plant function, plant growth and development, plant reproduction.

Biol 3012f,w,s. PLANT BIOLOGY. (5 cr, §1103; prereq 1009, Chem 1005) Charvat, McLaughlin, Wetmore
Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants.

3109f. PLANT ANATOMY. (5 cr; prereq Biol 1103 or 3012) Hall

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

3131f,w,s. SURVEY OF PLANT PHYSIOLOGY. (4 cr, §5131, §PIPh 3131, §PIPh 5131; prereq Biol 1103 or 3012, BioC 1302 or *BioC 1302 or Biol 5001) Soulen, Guilfoyle

Physiological principles underlying processes that occur in living plants with emphasis on higher plants. Growth and development, mineral nutrition, transport, water relations, and metabolism especially emphasizing photosynthesis and nitrogen assimilation. For lab, see 5132.

3201f. INTRODUCTORY TAXONOMY. (4 cr; prereq Biol 1103 or 3012) Morley

Taxonomy of ferns, gymnosperms, and flowering plants (representative material drawn largely from Minnesota spring flora). Families of plants and their relationships; floral structure and function; taxonomic terms; nomenclature; literature; methods of collection and identification. Two or three field trips.

Major Requirements and Course Descriptions

- 3950f.w.s.su. UNDERGRADUATE PROSEMINAR.** (1 cr per qtr; prereq #)
Biological topics of current interest.
- 5103f. BIOLOGY OF NONVASCULAR PLANTS.** (5 cr; prereq Biol 1103 or 3012) McLaughlin
Algae, fungi, lichens, and bryophytes. Characteristics of groups, evolutionary relationships, life cycles, comparative morphology (including ultrastructure), comparative nutrition. Laboratory emphasizes living material and isolation of algae and fungi into culture. Offered 1984-85.
- 5105. MORPHOLOGY OF VASCULAR PLANTS.** (5 cr; prereq Biol 1103 or 3012 or #)
Vegetative and reproductive structure of living and fossil vascular plants. Evolutionary relationships based on phylogenetic principles.
- 5111w. DEVELOPMENTAL PLANT ANATOMY.** (5 cr; prereq Biol 1103 or 3012) Biesboer
Microscopic structure of vascular plants: development in root, stem, and leaf.
- 5131f.w.s. SURVEY OF PLANT PHYSIOLOGY.** (4 cr, §3131, §PIPh 3131, §PIPh 5131; prereq Biol 1103 or 3012, BioC 1302 or *BioC 1302 or Biol 5001) Soulen, Guilfoyle, Frenkel
Physiological principles underlying processes that occur in living plants, with emphasis on higher plants. Growth and development, mineral nutrition, transport, water relations, and metabolism especially emphasizing photosynthesis and nitrogen assimilation. Includes a weekly discussion section.
- 5132f. PLANT PHYSIOLOGY LABORATORY.** (2 cr; prereq 3131 or 5131 or *13131 or *5131) Frenkel
Laboratory course to accompany 3131 or 5131.
- 5182s. PLANT METABOLISM.** (3 cr, §PIPh 5182; prereq 5131 or equiv, course in biochemistry) Soulen
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.
- 5183w. WATER, MINERALS, AND TRANSLOCATION.** (4 cr, §PIPh 5183; prereq 5131 or equiv) Markhart, Stadelmann
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.
- 5184f. PLANT GROWTH AND DEVELOPMENT.** (3 cr, §PIPh 5184; prereq 5131 or equiv) Guilfoyle
A survey of plant growth and development ranging from germination to death, with emphasis on physiology, biochemistry, and molecular biology. Topics include developmental processes related to: mobilization of macromolecules during germination, cell division and cell extension during axis growth, photomorphogenesis, chloroplast and microbody ontogeny, flowering, fruit and seed formation, senescence, and how plant growth substances control these developments.
- 5205s. FLORA OF MINNESOTA.** (4 cr; prereq 3201 or #) Ownbey
Vascular plants of Minnesota; taxonomic and floristic relationships; geographical distribution and variation; collection and identification. Field trips.
- 5211f. SURVEY OF ANGIOSPERM FAMILIES.** (5 cr; prereq 3201 or #: offered 1983-84 and alt yrs) Morley
Characteristics and relationships of orders and families of flowering plants on a worldwide basis.
- 5212f. PRINCIPLES OF ANGIOSPERM PHYLOGENY.** (3 cr; prereq 3201 or #: offered 1984-85 and alt yrs) Morley
Evolutionary relationships and the various means of judging them within the angiosperms. Laboratory investigation of representative and critical groups.
- 5231s. INTRODUCTION TO THE ALGAE.** (5 cr; prereq 10 cr in botany or biology or #: offered 1984-85 and alt yrs)
Structure, reproduction, and life histories of major algal divisions.
- 5960f.w.s.su. SPECIAL TOPICS.** (Cr ar; prereq #, Δ) Staff
Treatment in depth 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)
Laboratory or field investigation of selected areas of research.

COURSES OFFERED AT LAKE ITASCA FORESTRY AND BIOLOGICAL STATION

- 5801su. PLAINS AND BOREAL FLORA.** (5 cr; limited to 20 students; prereq course in taxonomy, Δ; offered annually)
Survey of the summer flowering plants and ferns of the state with particular reference to the local flora. Identification by technical keys; important plant families; field recognition of common species; habitat preferences; collecting methods; literature; taxonomic methods.
- 5805su. AQUATIC FLOWERING PLANTS.** (5 cr; limited to 20 students; prereq course in taxonomy, Δ)
The higher plants of aquatic and marsh habitats. Identification and collection; association of species; relations to the habitat; adaptive morphology and food value to wildlife.
- 5811su. FRESHWATER ALGAE.** (5 cr; limited to 20 students; prereq 10 cr botany, biology or zoology, Δ; offered annually)
The developmental morphology and taxonomy of freshwater algae, including the relationship of algae to their environment. Identification of field collections by technical keys, collecting and analytical methods, and utilization of information for recognizing distribution patterns.

5815su. BRYOPHYTES. (5 cr; limited to 20 students; prereq 10 cr biology or #. . . . offered when feasible)
Field and laboratory study of the mosses and liverworts of Minnesota.

5821su. LICHENS. (5 cr; limited to 20 students; prereq 10 cr in botany or zoology or #. . . . offered 1984 and all yrs)
Taxonomy, ecology, and floristics of lichens of northern Minnesota; identification, sampling methods, microchemistry as a taxonomic tool.

5825. BIOLOGY OF THE FERNS. (5 cr; prereq offered when feasible)
Field and laboratory study of the lower vascular plants (including the ferns, horsetails, club mosses, and quillworts), their evolution, classification, morphology, and ecology. Emphasis on field exploration for rare taxa, including natural hybrid forms and life cycles.

5890su. RESEARCH PROBLEMS. (1-5 cr per qtr; prereq)
Individual research for undergraduates and graduates.

FOR GRADUATE STUDENTS ONLY

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

8301. POLLEN MORPHOLOGY AND QUATERNARY PALYNOLOGY

8950f,w,s. SEMINAR

8990f,w,s,su. RESEARCH PROBLEMS

Ecology and Behavioral Biology (EBB)

Director of Undergraduate Studies—Frank Barnwell

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 and Behavioral Biology participates in teaching the core curriculum in biology. Students with a special interest in ecology and/or behavioral biology major in biology and include in their programs a suitable selection of advanced courses appropriate to their interests. Students with an interest in this area may request a faculty adviser from the EBB department and should ask the director of undergraduate studies about special department activities for undergraduates.

3001. INTRODUCTION TO ECOLOGY. (4 cr; open to jrs and above but not to biology majors) Corbin, Siniff
Basic concepts in ecology; the organization, development, and functioning of ecosystems; population growth and regulation. Human impact on ecosystems.

3004. FUNDAMENTALS OF ECOLOGY. (4 cr; not open to biology majors; prereq Biol 1009, college algebra) Tester
Relationships between organisms and their environment; ecosystem structure and function emphasizing energy flow, biogeochemical cycling and succession; population dynamics; introduction to regional biotic communities.

3101. ECOLOGY FOR ENGINEERS AND PHYSICAL SCIENTISTS. (4 cr, \$3001; not open to biology majors; prereq Math 1231) Bright
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. VERTEBRATE BEHAVIOR. (4 cr, \$AnSc 3111; prereq Biol 1106 or 3011 or #) Phillips
The nature, variety, development, motivation, and evolution of animal behavior emphasizing social interactions and communication.

3960f. RESEARCH TOPICS IN ECOLOGY AND BEHAVIORAL BIOLOGY. (1 cr per qtr; S-N only; prereq #)
Lectures on and discussion of current research in the department.

5970. DIRECTED STUDIES. (Cr ar, \$3970; prereq #,)
Individual study on selected topics or problems with emphasis on selected readings and use of scientific literature.

5990. DIRECTED RESEARCH. (Cr ar, \$3990; prereq #,)
Laboratory or field investigation of selected areas of research.

Major Requirements and Course Descriptions

COMMUNITY ECOLOGY AND PALEOECOLOGY

- 5008. QUATERNARY ECOLOGY.** (4 cr; prereq Biol 3041 or #) Davis
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 PLANT COMMUNITIES.** (5 cr; prereq 3004 or Biol 3041, 1 qtr statistics or #) Cushing
Methods of describing, sampling, and classifying plant communities; theory of their structure and development, and of the stability of the interactions among their constituent populations. Field trips to examine local vegetation types; analysis of quantitative data.
- 5016. ECOLOGICAL PLANT GEOGRAPHY.** (5 cr; prereq 3004 or Biol 3041, Bot 3201; offered 1984-85 and all yrs)
Cushing
Vegetation regions of the world 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

- 5031. EVOLUTIONARY ECOLOGY.** (3 cr; prereq Biol 3041 or equiv. #: offered 1984-85 and all yrs) Corbin
Evolutionary concepts and theory applied to the study of populations, communities, and ecosystems. Current literature and research emphasized.
- 5044. EVOLUTION.** (4 cr; prereq Biol 1106 or 3011) Merrell
Survey of evidence for and causes of biological evolution.
- 5051 (formerly 8001). ANALYSIS OF POPULATIONS.** (4 cr. §8001; prereq 3004 or Biol 3041 or #) Siniff
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.** (4 cr; prereq Biol 3041 or #) Tilman
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.

ORGANISMAL BIOLOGY AND PHYSIOLOGICAL ECOLOGY

- 5112. INVERTEBRATE BIOLOGY.** (5 cr; prereq Biol 1106 or 3011 or #: offered 1984-85 and all yrs) Barnwell
Morphology, physiology, behavior, ecology, and evolution of invertebrate groups. Laboratory study of living marine, freshwater, and terrestrial representatives.
- 5114w. VERTEBRATE BIOLOGY.** (4 cr; prereq Biol 1106 or 3011)
Vertebrates: their biology, taxonomy, and distribution.
- 5116. INTRODUCTION TO ANIMAL PARASITOLOGY.** (5 cr; prereq Biol 1106 or 3011) Gilbertson
Parasitic protozoa, worms, and arthropods and their relation to diseases of humans and animals.
- 5116f. SYMBIOSIS.** (3 cr; prereq Biol 1106 or 3011) Gilbertson
Interactions of organisms of different species living in intimate physiological association.
- 5122. PLANT/ANIMAL INTERACTIONS.** (4 cr; prereq Biol 3011, 3012 or #) Morrow
Herbivory, pollination, seed dispersal. Implications of interaction for plants and animals at organismal, population, and community levels. Coevolution.
- 5128. ADAPTATION AND MACROEVOLUTION: VERTEBRATES.** (4 cr; prereq Biol 1106 or 3011; offered 1983-84 and all yrs)
Patterns and problems in evolution at the species level and above in the context of an introduction to vertebrate phylogeny, ecology, and adaptations. Lectures, demonstrations, and field trips.
- 5129. MAMMALOLOGY.** (5 cr. §FW 5129; prereq Biol 1106 or 3011 or #) Birney
Recent families and orders of mammals of the world and of genera and species of mammals of North America, with emphasis on morphology, evolution, and zoogeographic history.
- 5132. HERPETOLOGY.** (5 cr; prereq Biol 1106 or 3011 or #: offered 1984-85 and all yrs) Regal
Distribution, classification, and evolution of amphibians and reptiles of the world. Physiological, morphological, and behavioral aspects of adaptive trends. Laboratory and lecture.
- 5134. INTRODUCTION TO ORNITHOLOGY.** (5 cr; prereq Biol 1106 or 3011) Tordoff, Warner
Laboratory and field course in structure, classification, distribution, migration, habits, habitats, and identification of birds. Weekend trips scheduled.
- 5136. ICHTHYOLOGY.** (4 cr; prereq 15 cr incl Biol 1106 or 3011) Underhill
Biology of fishes including development, systematics, anatomy, physiology, and ecology.

- 5156. COMPARATIVE ANIMAL PHYSIOLOGY.** (5 cr; prereq Biol 1106 or 3011; Chem 3302 or #) Schmid
The environment imposes passive stresses upon organisms — not equilibrium. Various physiological adaptations allow maintenance of homeostasis. The passive organism: environment "stresses" and biological mechanisms by which they are counteracted.

BEHAVIOR

- 5149. BEHAVIORAL GENETICS.** (4 cr; A-N only; prereq Biol 5003 or GCB 3022 5022 or equiv) Merrell
Application of genetic principles to the study of behavior with primary emphasis on animal behavior.
- 5154f. BEHAVIORAL AND PHYSIOLOGICAL ECOLOGY.** (3 cr; prereq advanced course work in either physiology, behavior, or ecology) Regal
Aspects of the adaptation of organisms to environments. Orientation, learning and adaptation of behavior, heat and water regulation, bioenergetics, biological rhythms.
- 5155. LABORATORY IN BEHAVIORAL AND PHYSIOLOGICAL ECOLOGY.** (3 cr; prereq 5154, #) Regal
Emphasis on individual directed projects.
- 5313. INVERTEBRATE BEHAVIOR.** (5 cr; prereq Biol 1106 or 3011 or #; offered 1983-84 and all yrs) Barnwell
Survey of simple to complex behaviors in invertebrate animals in relation to morphology, ecology, and evolution. Laboratory projects with marine, freshwater, and terrestrial representatives.
- 5321. EVOLUTION OF SOCIAL BEHAVIOR.** (4 cr; prereq Biol 1106 or 3011 or #) McKinney
Introduction to current theories and concepts relating to mating systems, spacing systems, and cooperative behavior in animals.
- 5322. COMPARATIVE ETHOLOGY.** (4 cr; prereq 5321 or *5321, #) McKinney
Evolution and adaptive significance of behavior, primarily in vertebrates. Emphasis on comparative methods.
- 5323. MECHANISMS OF ANIMAL BEHAVIOR.** (5 cr; prereq Biol 3011 or 1 qtr of animal physiology)
Survey of animal behavior mechanisms: their organization and functions. Analysis of behavior sequences, motor coordination, fixed action patterns, sensory systems. Release mechanisms, animal communication, orientation behavior, feedback mechanisms and control, behavior of small neural networks. Laboratory included.

LIMNOLOGY AND ECOSYSTEM ECOLOGY

- 5601. LIMNOLOGY.** (4 cr, §Geo 5601; prereq Chem 1005 or #) Gorham, Shapiro
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.
- 5603. PLANKTON POPULATIONS.** (5 cr; prereq 5601 or 5812, Biol 3041 or #; offered 1984-85 and all yrs) Megard
Biology of plankton and analysis of the maintenance and regulation of planktonic populations. Laboratory studies of the taxonomy, morphology, and biology of plankton. Two Saturday field trips.
- 5604. BIOLOGICAL LIMNOLOGY.** (3 cr; prereq 5601 or 5612 or #) Megard
Survey of the taxonomy and natural history of planktonic and benthic organisms in lakes and streams, descriptions of planktonic and benthic populations, and analyses of processes that regulate population densities of aquatic organisms.
- 5605. LABORATORY IN BIOLOGICAL LIMNOLOGY.** (2 cr; prereq 5601 or 5812 or #) Megard
The morphology and identification of planktonic and benthic organisms in lakes and streams, use of sampling equipment and instruments in the field, and analysis of field data
- 5606. ECOLOGY OF FISHES.** (5 cr; prereq Biol 1009 or 1106 or equiv plus 10 cr in the biological sciences; offered 1984-85 and alt yrs) Underhill
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.** (4 cr; prereq Biol 3041, EBB 5601 or #) McNaught
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.
- 5608f. ECOSYSTEMS: FORM AND FUNCTION.** (3 cr; prereq 3004 or 5601 or Biol 3041, Chem 1002 or 1005; offered 1983-84 and alt yrs) Davis
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.
- 5612. BIOGEOCHEMICAL CYCLES.** (3 cr; prereq Biol 3041, Biol 5001, or MicB 5321 or #) Wood
Biogeochemical cycles for essential, nonessential, and toxic elements in the biosphere. Emphasis on human impact on biogeochemical cycles and on the connections between these cycles.

Major Requirements and Course Descriptions

- 5613. ASSESSING THE ECOLOGICAL EFFECTS OF POLLUTION.** (4 cr; prereq Biol 3041 or equiv. Chem 3301, 3302) Gorham
Assessment of effects upon species and ecosystems, methodological problems, initial phases of investigating a new pollutant, problems of prediction.

COURSES OFFERED AT LAKE ITASCA FORESTRY AND BIOLOGICAL STATION

- 3800su. INTRODUCTION TO FIELD RESEARCH.** (10 cr; limited to 20 students; prereq two courses in biology, Δ ; hrs ar)
An intensive course on how to do research. A series of ecological and behavioral projects provide an introduction to the biology of forests, prairies, lakes, and marshes of the Itasca region while serving to develop individual abilities in the planning and design of experiments, acquisition and analysis of data, and the preparation of field reports. Intended for undergraduates with little or no previous experience in field biology.
- 5812su. AQUATIC ECOLOGY.** (5 cr; limited to 20 students; prereq 15 cr biology, 5 cr chemistry, Δ ; offered annually)
General limnology of lakes with emphasis on the biology of lakes in the Itasca region as related to their physical and chemical stratification in summer. Team projects in field research.
- 5814su. COMMUNITY STRUCTURE AND FUNCTION.** (5 cr; limited to 20 students; prereq course in ecology, Δ ; offered annually) Staff
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.
- 5817s,su. VERTEBRATE ECOLOGY.** (5 cr; prereq course in ecology, #, Δ)
Field studies on populations and their relationships to local environments; habitat analysis and ecological research methods. Designed primarily for students with fisheries and wildlife management interests. (Lab charge required.)
- 5820su. WETLAND ECOLOGY.** (10 cr; limited to 15 students; prereq 15 cr biology, Δ ; introductory chemistry, course in plant identification, Biol 3041 recommended) Gorham
Nature, origin, and development of lake, marsh, swamp, and bog ecosystems; environmental control and productivity.
- 5834s,su. FIELD ORNITHOLOGY.** (5 cr; prereq Biol 1106, Δ ; offered annually)
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. Designed primarily for students with fisheries and wildlife management interests. (Lab charge required.)

FOR GRADUATE STUDENTS ONLY

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

- 8004w. TOPICS IN ECOLOGICAL GENETICS**
- 8012s. THEORETICAL COMMUNITY ECOLOGY**
- 8014s. PALEOECOLOGICAL METHODS**
- 8051. BEHAVIORAL ADAPTATIONS**
- 8061. SOCIAL SYSTEMS**
- 8081w. NEUROETHOLOGY**
- 8091w. HORMONES AND BEHAVIOR**
- 8162w. WINTER ECOLOGY**
- 8390. GRADUATE SEMINAR**
- 8391. ADVANCED WORK IN ECOLOGY AND BEHAVIORAL BIOLOGY**
- 8800su. ADVANCED FIELD ECOLOGY (ITASCA)**
- 8990. GRADUATE RESEARCH**

Genetics and Cell Biology (GCB)

Director of Undergraduate Studies—Val Woodward

Genetics is the study of inheritance, including molecular mechanisms of gene organization and expression, human genetics, and the behavior of genes in the 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 major is new; it received formal approval in 1983. This program is designed to provide 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:

- a. GCB 3960 (two quarters)
- b. Biol 3950H
- c. Two of the following laboratories:
 - BioC 5025: Laboratory in Biochemistry
 - Biol 5125: Recombinant DNA Laboratory
 - GCB 5001: Scanning Electron Microscopy Laboratory
 - GCB 5002: Transmission Electron Microscopy Laboratory
 - GCB 5015: Histology Laboratory
 - GCB 5030: Laboratory: Genetics
 - GCB 5605: Cell Biology Laboratory
- d. Two of the following advanced courses:
 - GCB 5031: Advanced Genetics I
 - GCB 5032: Advanced Genetics II
 - GCB 5033: Population and Quantitative Genetics
 - GCB 5048: Advanced Cell Biology I
 - GCB 5049: Advanced Cell Biology II
- e. One of two physiology courses: GCB 5114 or GCB 5134.

Requests for substitutions should be submitted to the GCB director of undergraduate studies.

- 3022f. 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) V E Anderson
Human genetics; study of individuals, families, populations, and races with respect to differences in intelligence, behavior, disease, and other matters of social concern.
- 3008. THE BIOLOGY OF CANCER.** (3 cr; prereq Biol 1009) McKinnell, Sheppard
Biological aspects of etiology, phylogeny, and cellular processes involved in neoplasia. Growth and differentiation of normal and cancer cells. The history of cancer research.
- 3022f.w,s,su. GENETICS.** (4 cr, §Biol 5003; not intended for biology majors; prereq Biol 1009) Enfield, Snyder
Mechanisms of heredity, their implications for biological populations and applications to practical problems.
- 3201s. MOLECULAR BIOLOGY FOR ENGINEERS AND PHYSICAL SCIENTISTS.** (3 cr [4 cr with term paper]; prereq 2 qtrs chemistry, Math 1231 or 1331 or 1621 or #; not open to biology majors) Rubenstein
Modern molecular biology emphasizing the principles of biological structures and mechanisms of function at the macromolecular and cellular levels of organization.
- 3960. RESEARCH TOPICS.** (1 cr; S-N only; prereq Biol 5001)
Discussions of faculty research.
- 5001f (replaces 5610). SCANNING ELECTRON MICROSCOPY LAB.** (4 cr; S-N only; prereq #) Johnson
Operation of scanning electron microscope (SEM) and preparation of biological samples for SEM analysis; use of SEM for research work. Charges for supplies and microscope time must be covered by student (\$200-\$400).
- 5002s (replaces 5610). TRANSMISSION ELECTRON MICROSCOPY LAB.** (4 cr; S-N only; prereq #) Johnson
Operation of transmission electron microscope (TEM) and preparation of biological samples for TEM analysis; thin sectioning of tissues selected by student. Charges for microscope time and supplies must be covered by student (\$175-\$200).
- 5011w. GENERAL AND COMPARATIVE EMBRYOLOGY.** (4 cr; prereq Biol 1106 or 3011) McKinnell
Embryological development of vertebrates.

Major Requirements and Course Descriptions

- 5013s. MAMMALIAN REPRODUCTION.** (4 cr; prereq Biol 3011, Biol 5001 or #) Sinha
Interdisciplinary approaches in evaluating biological phenomena of reproduction incorporating basic problems, current concepts and ideas in the field. Three lectures and discussions, and an hour of independent studies research or lab work.
- 5015. HISTOLOGY: CELL AND TISSUE ORGANIZATION.** (5 cr; prereq Biol 1106 or 3011, plus 4 addtl cr in the biological sciences) Cunningham
Cellular orientation used to explore organization of differentiated cells and tissues (epithelia, connective, muscle, and nerve) as they facilitate specialized functions. Lab combines experience with techniques (phase and fluorescent microscopy, autoradiography, and paraffin sectioning), EM demonstrations, and studies of prepared microscope slides.
- 5022f, w.s.su. GENETICS.** (3 cr; §3022, §Biol 5003; not open to grad students in genetics) Enfield, Snyder
Mechanisms of heredity, their implications for biological populations, and applications to practical problems.
- 5024. THE GENETICS OF DEVELOPMENT.** (4 cr; prereq Biol 5003 or #) R Herman
Introduction to current concepts and experimental approaches concerning the genetic basis of morphogenesis and metazoan development. Organisms that are amenable to genetic analysis, including certain prokaryotes and single-cell eukaryotes, nematode and *Drosophila*.
- 5030. LABORATORY: GENETICS.** (2 cr; prereq 3022 or 5022 or Biol 5003 or #)
Investigative approaches to analysis of genetic problems. Focus on a given organism or related group of organisms may differ from quarter to quarter.
- 5031w. ADVANCED GENETICS I.** (4 cr; prereq 3022 or Biol 5003 and Biol 5001 or BioC 5751, or #) Lefebvre, Snyder
Mechanics of inheritance. Comparative organization of genetic material in prokaryotic and eucaryotic organisms. Mutation, complementation, and recombination as operational criteria for genetic analysis.
- 5032s. ADVANCED GENETICS II.** (4 cr; prereq 5031) Hackett
Action of the gene in molecular, cellular, and organismal development. Mechanisms of storage of genetic information, modes of information transfer, and mechanism of regulating these processes in various biological systems.
- 5033s. POPULATION AND QUANTITATIVE GENETICS.** (4 cr; prereq 3022 or Biol 5003, course in biometry or statistics or #) Curtsinger
Genetic variation in quantitative traits with special attention to fitness. Causes of change of equilibria in gene frequencies, heterosis and inbreeding depression, consequences of natural and artificial selection.
- 5042f. QUANTITATIVE GENETICS.** (4 cr; S-N only; prereq 5033; Stat 5301 recommended) Enfield
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.
- 5043f. HUMAN GENETICS.** (3 cr; prereq 3022 or Biol 5003 or #) V E Anderson
Principles of human genetics at the molecular, cellular, individual, and population levels. Chromosomal and biochemical disorders; gene mapping; mutation and natural selection; variation in intelligence and behavior; genetic screening, counseling, and therapy.
- 5044w. HUMAN POPULATION GENETICS.** (4 cr; prereq 5043, biostatistics [PubH 5452 or equiv] or #) V E Anderson
Biometric methods for research in human genetics. Use of genetic concepts and appropriate statistical techniques in exploring new problems. Use of statistical packages and genetic programs to analyze population data and model genetic systems. Individual study of current problems, and group discussion.
- 5045s. MOLECULAR PRINCIPLES OF BEHAVIOR.** (3 cr; prereq BioC 5002 or #: offered 1982-83 and alt yrs) Sheppard
Relationships between biochemistry and behavior with emphasis on diseases of human behavior, i.e., the psychoses, alcoholism, epilepsy. Simple biological systems used to study behavior.
- 5046s. HUMAN BIOCHEMICAL GENETICS.** (3 cr; prereq 5031, 5043, BioC 5002 or equiv, Biol 5004 or equiv or #: offered 1983-84 and alt yrs) Sheppard
Basic genetic, biochemical, and pathologic principles of inherited human metabolic disorders.
- 5048f. ADVANCED CELL BIOLOGY I.** (4 cr; prereq Biol 5001) Iwanij, Johnson, Sillow
Eukaryotic systems with emphasis on the structure, function, and chemistry of cell organelles: selected specialized cells. Membranes and secretion, including membrane methodologies, structure, function, synthesis, and turnover; cell surfaces, protein synthesis, glycosylation, membrane fusion, lysosomes, and endocytosis.
- 5049w. ADVANCED CELL BIOLOGY II.** (4 cr; prereq 5048, Biol 5003) Iwanij, Johnson, Sillow
Eukaryotic systems with emphasis on the structure, function, and chemistry of cell organelles: selected specialized cells. Motility, the cell nucleus and metabolically active membranes; roles of microtubules and microfilaments in cell locomotion, shape changes, cytokinesis, ciliary beating, and organelle redistribution; cell cycle, chromosomal structure, replication, and mitosis; compartmentalization and autonomy of mitochondria and chloroplasts, the role of peroxisomes, and detoxification by the endoplasmic reticulum.
- 5052s. QUANTITATIVE TECHNIQUES, CELL BIOLOGY.** (4 cr; prereq calculus, introductory cellular or molecular biology, biochemistry recommended) Rosenberg, Rubenstein
Use and detection of radioisotopes; theory and practice of analytical and preparative ultracentrifugation, chromatography, spectroscopy, and electron microscopy; tissue culture and subcellular particle fractionation.

- 5062w. GENETICS AND SPECIATION.** (4 cr; prereq 15 cr biology incl genetics) Merrell
Application of genetic principles to problems of speciation and evolution.
- 5063s. THEORETICAL POPULATION GENETICS.** (3 cr; prereq college level calculus, basic statistics and genetics; offered 1983-84 and alt yrs) Simmons
Population genetics theory as related to problems of natural history.
- 5114. GENERAL PHYSIOLOGY.** (3 cr; prereq Biol 3011, 5001, Phys 1109 or 1295) Goldstein
Quantitative approach to the study of cell function with emphasis on application of physical and chemical principles. Transport, electrical activity of cell membranes, cell contractility.
- 5134w. ENDOCRINOLOGY.** (4 cr; prereq Biol 3011, 5001 or #) W Herman
Survey of structure and function of invertebrate and vertebrate endocrine systems.
- 5135s. ENDOCRINOLOGY LABORATORY.** (2 cr; prereq 5134) W Herman
Assigned exercises demonstrating basic endocrine techniques. Student research projects arranged in consultation with instructor.
- 5605. CELL BIOLOGY LABORATORY.** (2 cr; prereq Biol 5004 or # Biol 5004 or #) Blumenfeld
Experimental approaches to cell structure, function, and replication, including microscopy, autoradiography, cell fractionation, and molecular and chemical analyses.
- 5606f. BIOLOGICAL ELECTRON MICROSCOPY.** (3 cr; prereq Biol 5004 or #) Cunningham
Theory and operation of transmission and scanning electron microscopes. Demonstrations and discussion of preparation techniques for biological material including freeze-etching, autoradiography, thin sectioning, negative staining, cytochemistry, and metal shadowing.
- 5970f,w,s,su. DIRECTED STUDIES.** (Cr ar; prereq #, Δ)
Individual study on selected topics or problems with emphasis on selected readings and use of scientific literature.
- 5990f,w,s,su. DIRECTED RESEARCH.** (Cr ar; prereq #, Δ)
Laboratory or field investigation of selected areas of research.

FOR GRADUATE STUDENTS ONLY

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

- 8060. CURRENT TOPICS**
- 8900. SEMINAR**
- 8910. JOURNAL CLUBS**
- 8920. SPECIAL TOPICS**
- 8970. DIRECTED STUDY**
- 8990. RESEARCH**

History of Science and Technology (HSci)

Institute of Technology

Coordinator—Roger H. Stuewer, 428 Tate Laboratory of Physics

This is an interdisciplinary program, drawing faculty from both CBS and IT. Courses in this area focus on the origins and development of science and technology and their relations to the social, cultural, and philosophical currents of their time. Courses may be taken to support existing majors as well as to broaden knowledge of the nature and development of science and technology. The introductory courses (1711,2,3/3711,2,3 and 1811,2,3/3811,2,3) satisfy distribution requirements for group C, Individual and Society.

- 1711, 1712, 1713. TECHNOLOGY AND WESTERN CIVILIZATION.** (4 cr per qtr. §3711, §3712, §3713) Layton
History and sociocultural relations of Western technology. 1711: The relations of technology to culture from the Bronze Age to the Middle Ages. 1712: Technology and science in the Renaissance; technology and the scientific revolution; emergence of industrialism. 1713: Diffusion of the industrial revolution; technological development and its impact on industry, government, and society.
- 1811, 1812, 1813. INTRODUCTION TO HISTORY OF SCIENCE.** (4 cr per qtr. §3811, §3812, §3813) Shapiro
1811: Babylonian and Egyptian science; Greek natural philosophy, mathematics, astronomy, and biology; the Aristotelian world; decline and transmission of Greek science. 1812: Medieval background; the "experimental philosophy"; dissecting and describing nature; anatomy, circulation, and respiration; Copernican revolution; physical world of Kepler, Galileo, Descartes, and Newton; science and the popular imagination. 1813: 19th and 20th centuries; Newtonian triumph, romantic reaction, and modern revolution; the aether, electrical and optical, to Einstein; history of the earth; evolution before and after Darwin; nuclear physics and nuclear weapons.

Major Requirements and Course Descriptions

- 3201, 3202, 3203. HISTORY OF BIOLOGY.** (4 cr per qtr, §5201, §5202, §5203) Kottler
3201: Antiquity to 1700. Biology, medicine, and natural history in antiquity: Hippocrates, Aristotle, Galen. Revival of biology in Renaissance and 17th century: Vesalius and anatomy, Harvey and circulation. 3202: Physiology and cell theory since 1700. Conceptual development of the various branches of modern biology: physiology, chemistry, and the experimental method: embryology, descriptive and experimental: cytology and microscopy. 3203: Evolution and genetics since 1700. Darwin and evolution: Mendel and genetics.
- 3711, 3712, 3713. TECHNOLOGY AND WESTERN CIVILIZATION.** (4 cr per qtr, §1711, §1712, §1713)
For description, see 1711, 1712, 1713.
- 3811, 3812, 3813. INTRODUCTION TO HISTORY OF SCIENCE.** (4 cr per qtr, §1811, §1812, §1813)
For description, see 1811, 1812, 1813.
- 3825. PHYSICS AND SOCIETY IN 20TH-CENTURY AMERICA.** (4 cr, §3835, §5825) Stuewer
Nineteenth-century heritage: 20th-century discoveries and physical theories; growth of physics in America after World War I; the intellectual migration of the 1930s; nuclear physics, the Manhattan project, and the atomic bomb; McCarthyism and Oppenheimer; current and past contributions of Minnesota physicists.
- 3835. THE ATOMIC AGE.** (4 cr, §3825, §5825) Stuewer
Development of nuclear energy in the 20th century; construction and use of the bomb; postwar military and political impact.
- 5011. THEORIES OF COLOR: NEWTON TO HELMHOLTZ.** (4 cr) Shapiro
History of physical and physiological investigations of color from the 17th to the mid-19th centuries, focusing on fundamental contributions of Newton, Young, Maxwell, and Helmholtz.
- 5201, 5202, 5203. HISTORY OF BIOLOGY.** (4 cr per qtr, §3201, §3202, §3203)
For description, see 3201, 3202, 3203.
- 5242. EVOLUTION BEFORE AND AFTER DARWIN.** (4 cr; prereq Biol 1009 or 1101 or #) Kottler
Philosophical conceptions of species; natural theology, design, and providential creation of species; Lamarck and evolution before Darwin; catastrophist and uniformitarian geology; Darwin and the background of the *Origin*; Darwin's early critics; evolutionary theory, 1882 to modern synthesis.
- 5311. TECHNOLOGY IN AMERICAN LIFE.** (4 cr) Layton
Technology in America with emphasis on its impact on society and culture. Traces the growth of American technology in its cultural and intellectual context from colonial period to present.
- 5321. HISTORY OF COMPUTING.** (4 cr) Norberg
A history of computing developments in the last century with attention to factors affecting the evolution of hardware and software, the growth of the industry and its relation to other business areas, and the changing relationships resulting from new data gathering and use techniques.
- 5760. SELECTED TOPICS.** (1-5 cr per qtr; prereq #)
- 5825. PHYSICS AND SOCIETY IN 20TH-CENTURY AMERICA.** (4 cr, §3825, §3835) Stuewer
For description, see 3825.
- 5924. HISTORY OF 19TH-CENTURY PHYSICS.** (4 cr, §Phys 5924; prereq general physics or #) Stuewer
Conceptual developments in physics in 19th century (Young, Fresnel, Oersted, Ampère, Faraday, MacCullagh, Maxwell, Hertz, Lorentz, Lavoisier, Rumford, Dalton, Mayer, Joule, Helmholtz, Carnot, Clausius, Kelvin, Boltzmann, Mach, others). Relationships to social, philosophical, and theological influences.
- 5925. HISTORY OF 20TH-CENTURY PHYSICS.** (4 cr, §Phys 5925; prereq general physics or #) Stuewer
Conceptual developments in relativity (Michelson, Lorentz, Poincaré, Einstein, others), quantum mechanics (Planck, Einstein, Rutherford, Bohr, Sommerfeld, Ehrenfest, Pauli, Millikan, Compton, Heisenberg, de Broglie, Schrödinger, Born, others), and nuclear physics (Chadwick, Gamow, Fermi, others). Relationships to social, philosophical, and theological influences.
- 5970. DIRECTED STUDIES.** (1-15 cr per qtr; prereq #)
Guided individual reading or study.
- 5990. DIRECTED RESEARCH.** (1-15 cr per qtr; prereq #)
- FOR GRADUATE STUDENTS ONLY**
- 8900. SEMINAR: HISTORY OF EARLY PHYSICAL SCIENCES.** (4 cr; prereq #) Shapiro
- 8910. SEMINAR: HISTORY OF MODERN PHYSICAL SCIENCES.** (4 cr; prereq #) Stuewer
- 8920. SEMINAR: HISTORY OF BIOLOGICAL SCIENCES.** (4 cr; prereq #) Kottler
- 8930. SEMINAR: HISTORY OF TECHNOLOGY.** (4 cr; prereq #) Layton
- 8970. DIRECTED STUDIES.** (1-5 cr per qtr [max 15 cr]; prereq #)
- 8990. DIRECTED RESEARCH.** (1-5 cr per qtr [max 15 cr]; prereq #)

Microbiology (MicB)

Medical School

Director of Undergraduate Studies—Palmer Rogers

The program in microbiology is designed to prepare the student for work as a practicing microbiologist 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. Numerous 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.

In fulfillment of part of the 19 additional upper division science and mathematics credits required for graduation, microbiology majors must complete the following:

- MicB 5216 or 5218 and 5321, 5900
- One of the following: MicB 5106, 5234, 5322, 5811 or the laboratories accompanying both virology (5424) and immunology (5216)
- Two of the following: MicB 5232, 5351, 5355, 5424, 5611
- Chem 3100-3101
- A sequence in physical chemistry (e.g., Chem 5520-5521) is highly recommended

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 student services office.

1101. ELEMENTARY MICROBIOLOGY. (4 cr; prereq Biol 1009 or [†]Biol 1009 or equiv; intended for students in CLA, dental hygiene, physical therapy, mortuary science, others with #: not intended for majors) Prince
Principles of microbiology; a general survey of pathogenic bacteria, molds, protozoa, and viruses; elements of immunity, sanitary analysis of water and milk, disinfectants and sterilants.

3103w.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 and 5 cr biological sciences or #) Schmidt
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) Chapman, Dworkin, C Woodward, Schotter
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Molecular structure in relation to bacterial function.

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

5106. ADVANCED GENERAL MICROBIOLOGY LABORATORY. (3 cr; prereq MicB 5105 or equiv)
Isolation from natural sources of a wide variety of microorganisms such as *Clostridium*, yeast, *Caulobacter*, myxobacteria, *Leptospira*, photosynthetic bacteria, *Bdellovibrio*, luminescent bacteria, and others. Lab only.

¹Microscope required. Students may obtain use of microscope by purchasing 2 microscope cards from the bursar.

Major Requirements and Course Descriptions

- 5216f. IMMUNOLOGY.** (4 cr; prereq Biol 5001) Schlievert
Nature of antigens and antibodies; chemical basis of serologic specificity; qualitative and quantitative aspects of antigen-antibody reactions; theories of antibody production; cellular antigens and blood grouping; nature of complement and its role in immunologic phenomena; mechanisms of hypersensitivity; hypersensitivity-like states and immunologic diseases; transplantation and tumor immunity; host-parasite interactions. Laboratory.
- 5218f. IMMUNOLOGY.** (3 cr; prereq Biol 5001) Schlievert
Same as 5216 without laboratory.
- 5232w. MEDICAL MICROBIOLOGY.** (3 cr; not open to medical students; prereq 5105 or 3103 or 8110 or Biol 5013, 5216 or 5218) Cleary
Pathogenic bacteria and fungi, mechanisms of pathogenicity and virulence; properties of microorganisms and their animal hosts that influence the outcome of host-parasite relations analyzed from genetic and metabolic view.
- 5233f. MICROORGANISMS AND DISEASE.** (7 cr; not open to microbiology majors; prereq 10 cr chemistry and 5 cr biological sciences or #) Johnson
Nature of microorganisms, immunology, medical bacteriology, virology, mycology, parasitology, and principles of disease control. Lab.
- 5234. MEDICAL MICROBIOLOGY LABORATORY.** (2 cr; prereq 5232 or *5232) Cleary
Exercises demonstrating the principles and techniques employed in the study of the interactions between microorganisms and humans that lead to a diseased state.
- 5235f. MICROORGANISMS AND DISEASE.** (4 cr; not open to microbiology majors; prereq 10 cr chemistry and 5 cr biological sciences or #) Johnson
Same as 5233 without laboratory.
- 5321w. PHYSIOLOGY OF BACTERIA.** (3 cr; prereq 3103 or 5105 or Biol 5013 or VPB 3103, 10 cr organic chemistry or biochemistry, 3 cr genetics) Rogers
Chemical and physical organization of bacteria as related to function; growth; energy metabolism including oxidations and fermentations; nutritional requirements; antimicrobial agents; autotrophic mechanisms; microbial differentiation.
- 5322w. PHYSIOLOGY OF BACTERIA LABORATORY.** (2 cr; prereq 5321 or *5321, lab course in basic bacteriology) Rogers
Techniques employed in the study of bacterial physiology and metabolism.
- 5351. INDUSTRIAL MICROBIOLOGY.** (3 cr; prereq 5321 or #) Hanson
Application of microbial systems to industrial processes; basic principles of fermentation technology; microbial production of antibiotics, biochemicals, enzymes, hormones, bulk fuels, and chemical feedstocks. Applications and principles of immobilized cell and enzyme techniques.
- 5355. GENETIC AND MOLECULAR ASPECTS OF BIOTECHNOLOGY.** (3 cr; prereq 5105 or equiv. 5321) Faras
Principles and practices of the techniques and procedures of the new biotechnology including genetic engineering, recombinant DNA technology, and production of monoclonal antibodies.
- 5424s. BIOLOGY OF VIRUSES.** (4 cr; prereq 5321 or Biol 5001 or #) Plagemann
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. Lab.
- 5611f. MICROBIAL ECOLOGY.** (4 cr; prereq general microbiology course, Biol 5001 or #) Crawford
Microbial adaptation and diversity; role of microorganisms in natural processes; methods in microbial ecology; other topics of interest to microbial ecologists.
- 5900f.w.s. TOPICS IN MICROBIOLOGY.** (1 cr; S-N only; open to microbiology sr majors) Rogers
Seminars on research programs, historical perspectives, significant emerging fields, professional societies and publications, and career opportunities.
- 5970 (formerly 3970). DIRECTED STUDIES.** (Cr ar; prereq #, ...)
Individual study on selected topics or problems with emphasis on selected readings and use of scientific literature.
- 5990 (formerly 3990). DIRECTED RESEARCH.** (Cr ar; prereq #, ...)
Laboratory or field investigation of selected areas of research.

FOR GRADUATE STUDENTS ONLY

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

- 8110. BIOLOGY OF MICROORGANISMS**
- 8112. MICROBIAL GENETICS**
- 8121. ADVANCED IMMUNOLOGY LABORATORY**

¹Microscope required. Students may obtain use of microscope by purchasing 2 microscope cards from the bursar.

- 8122. ADVANCED MICROBIOLOGY (offered when feasible)
- 8202. ORAL MICROBIOLOGY
- 8218. IMMUNOCHEMISTRY AND IMMUNOBIOLOGY
- 8234. ADVANCED MEDICAL MICROBIOLOGY
- 8242. DIAGNOSTIC MICROBIOLOGY
- 8320. IMMUNOGENETICS
- 8323. REGULATION OF METABOLISM (offered when feasible)
- 8421. MOLECULAR BIOLOGY OF CANCER
- 8425. ADVANCED LABORATORY IN VIROLOGY AND ANIMAL CELL CULTURE
- 8911. COLLOQUIUM IN MICROBIOLOGY
- 8990. RESEARCH IN MICROBIOLOGY

Zoology (Zool)

Students interested in the study of animals may major in biology and elect, in consultation with their faculty adviser, appropriate courses of interest. Inasmuch as animals may be studied from the molecular, cellular, organismic, or population perspective, zoology courses will be found in many departments. Undergraduate CBS courses formerly listed under the zoology course designator may now be found in the listings of the Departments of Ecology and Behavioral Biology, and Genetics and Cell Biology.

FOR GRADUATE STUDENTS ONLY

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

- 8970. GRADUATE SEMINAR
- 8980. SPECIAL RESEARCH FIELDS
- 8990. GRADUATE RESEARCH

Recommended Related Course Work

Students are encouraged to explore additional course work offered by other academic units. Courses are recommended in:

- | | |
|--|-------------------------------|
| animal science (AnSc) | mathematics (Math) |
| anthropology (Anth) | organic chemistry (Chem) |
| biophysics (BPhy) | physics (Phys) |
| chemical engineering (ChEn) | physiology (Phys) |
| computer science (CSci) | plant sciences (PIPa, PIPh) |
| entomology (Ent) | psychology (Psy) |
| fisheries and wildlife (FW) | public health (PubH) |
| food science and nutrition (FScN) | soil science (Soil) |
| geology (Geo) | statistics (Stat) |
| history of medicine & biological sciences (HMed) | veterinary biology (VB) |
| laboratory medicine (LMed) | veterinary pathobiology (VPB) |

For information about programs in related areas, consult the appropriate bulletins available at the Information Booth in Williamson Hall, Minneapolis; the Reception area, 130 Coffey Hall, St. Paul; or various program offices.

IV. FACULTY

Department of Biochemistry

Regents' Professor

Stanley Dagley, D.Sc.

Professor

Victor Bloomfield, Ph.D.
Peter J. Chapman, Ph.D.
John E. Gander, Ph.D.
Robert L. Glass, Ph.D.
LaVell M. Henderson, Ph.D.
Robert Jenness, Ph.D.
Samuel Kirkwood, Ph.D.
Irvin E. Liener, Ph.D.
Rex E. Lovrien, Ph.D.
Eckard Muenck, Ph.D.
Gary L. Nelsestuen, Ph.D.

Ulysses S. Seal, Ph.D.
Huber R. Warner, Ph.D.
John M. Wood, Ph.D.
Clare K. Woodward, Ph.D.

Associate Professor

John S. Anderson, Ph.D.
James A. Fuchs, Ph.D.
Gary R. Gray, Ph.D.
Joachim W. Messing, Ph.D.

Assistant Professor

Janet L. Schottel, Ph.D.
Kamil Ugurbil, Ph.D.

Department of Botany

Professor

Albert W. Frenkel, Ph.D.
John W. Hall, Ph.D.
Herbert Jonas, Ph.D.
Willard L. Koukkari, Ph.D.
David J. McLaughlin, Ph.D.
Thomas Morley, Ph.D.
Gerald Ownbey, Ph.D.
Douglas C. Pratt, Ph.D.

Associate Professor

Iris D. Charvat, Ph.D.
Thomas J. Guilfoyle, Ph.D.
Thomas K. Soulen, Ph.D.
Clifford M. Wetmore, Ph.D.

Assistant Professor

David D. Biesboer, Ph.D.
Florence Gleason, Ph.D.

Department of Ecology and Behavioral Biology

Regents' Professor

Margaret B. Davis, Ph.D.
Herbert E. Wright, Ph.D.

Professor

Elmer C. Birney, Ph.D.
Kendal W. Corbin, Ph.D.
Edward J. Cushing, Ph.D.
Eville Gorham, Ph.D.
D. Frank McKinney, Ph.D.
Donald McNaught, Ph.D.
David J. Merrell, Ph.D.
David F. Parmelee, Ph.D.
Richard E. Phillips, Ph.D.
Philip J. Regal, Ph.D.
William D. Schmid, Ph.D.
Joseph Shapiro, Ph.D.
Donald B. Sniiff, Ph.D.
John R. Tester, Ph.D.

Harrison B. Tordoff, Ph.D.
James C. Underhill, Ph.D.
Dwain W. Warner, Ph.D.

Adjunct Professor

Miron L. Heinselman, Ph.D.

Associate Professor

Franklin H. Barnwell, Ph.D.
Robert C. Bright, Ph.D.
Donald E. Gilbertson, Ph.D.
Malcolm J. Kottler, Ph.D.
Robert O. Megard, Ph.D.
Patrice A. Morrow, Ph.D.
G. David Tilman, Ph.D.

Assistant Professor

Peter A. Abrams, Ph.D.
Donald N. Alstad, Ph.D.

Department of Genetics and Cell Biology

Regents' Professor Emeritus

Ralph E. Comstock, Ph.D.

Professor

V. Elving Anderson, Ph.D.
Richard S. Caldecott, Ph.D.
William P. Cunningham, Ph.D.
Franklin D. Enfield, Ph.D.
David P. Fan, Ph.D.
Robert K. Herman, Ph.D.
William S. Herman, Ph.D.
Alan B. Hooper, Ph.D.
Ross G. Johnson, Ph.D.
Norman S. Kerr, Ph.D.
Robert G. McKinnell, Ph.D.
David J. Merrell, Ph.D.
Murray D. Rosenberg, M.D., Ph.D.
Irwin Rubenstein, Ph.D.

Walter Sauerbier, Ph.D.
John R. Sheppard, Ph.D.
Akhour A. Sinha, Ph.D.
D. Peter Snustad, Ph.D.
Leon A. Snyder, Ph.D.
Val W. Woodward, Ph.D.

Associate Professor

Martin Blumenfeld, Ph.D.
Stuart F. Goldstein, Ph.D.
Michael J. Simmons, Ph.D.

Assistant Professor

James W. Curtsinger, Ph.D.
Perry B. Hackett, Ph.D.
Victoria Iwanji, Ph.D.
Paul A. Lefebvre, Ph.D.
Carolyn D. Sillow, Ph.D.

James Ford Bell Museum of Natural History

Harrison B. Tordoff, Director
Elmer C. Birney, Curator of Mammalogy
Robert C. Bright, Curator of Paleontology
Kendall W. Corbin, Curator of Systematics
Malcom J. Kottler, Ph.D.
D. Frank McKinney, Curator of Ethology

David F. Parmelee, Director, Field
Biology Program
Philip J. Regal, Curator of Herpetology
James C. Underhill, Curator of Fishes
Dwain W. Warner, Curator of Ornithology

Gray Freshwater Biological Institute

Professor

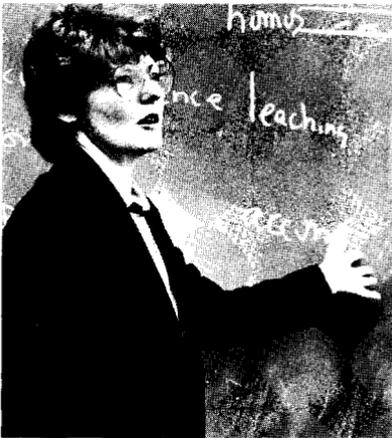
Richard S. Hanson, Ph.D.
Eckard Muenck, Ph.D.
John M. Wood, Ph.D.

Associate Professor

Ronald L. Crawford, Ph.D.

Assistant Professor

Florence L. Gleason, Ph.D.
Kamil Ugurbil, Ph.D.



Regents' Professor Margaret B. Davis



Regents' Professor Stanley Dagley

Contributing Faculty From Other University Units

Department of Microbiology

(Medical School)

Regents' Professor

Dennis W. Watson, Ph.D.

Professor

Dwight Anderson, Ph.D.
K. Gerhard Brand, M.D.
Francis Busta, Ph.D.
Peter Chapman, Ph.D.
Martin Dworkin, Ph.D.
David Fan, Ph.D.
Anthony Faras, Ph.D.
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Patrick Schlievert, Ph.D.
T. S. Tsien, Ph.D.
Robert Wohlhueter, Ph.D.

History of Science and Technology Program

(Institute of Technology)

Professor

Edwin T. Layton, Ph.D.
Roger H. Stuewer, Ph.D.

Associate Professor

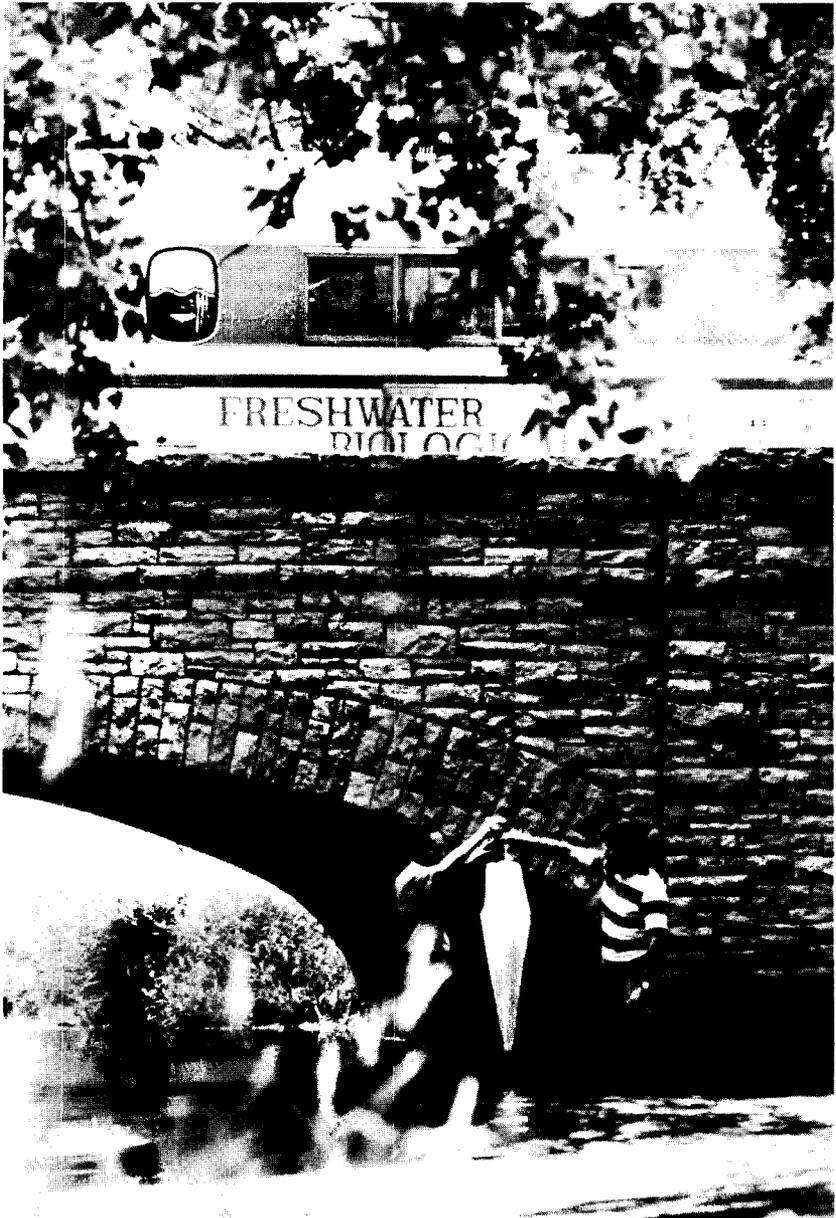
Malcolm Kottler, Ph.D.
Alan E. Shapiro, Ph.D.

Assistant Professor

Arthur L. Norberg, Ph.D.

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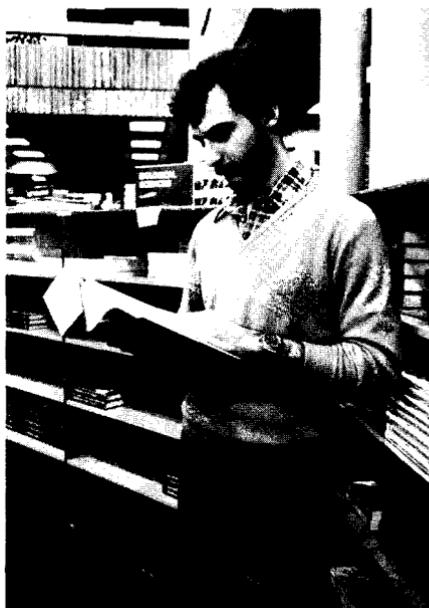
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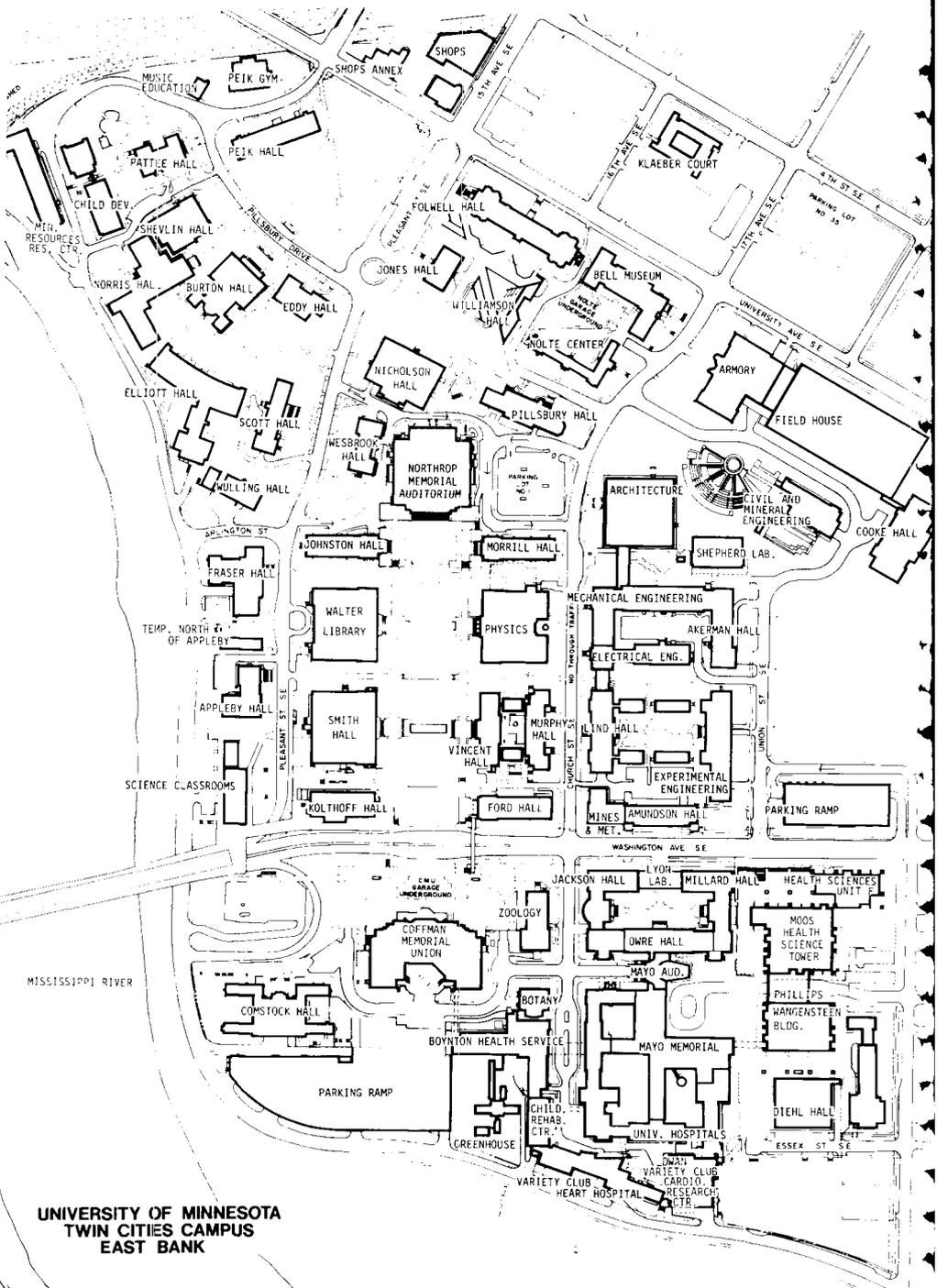


A fieldwork study is assisted by a mobile lab.



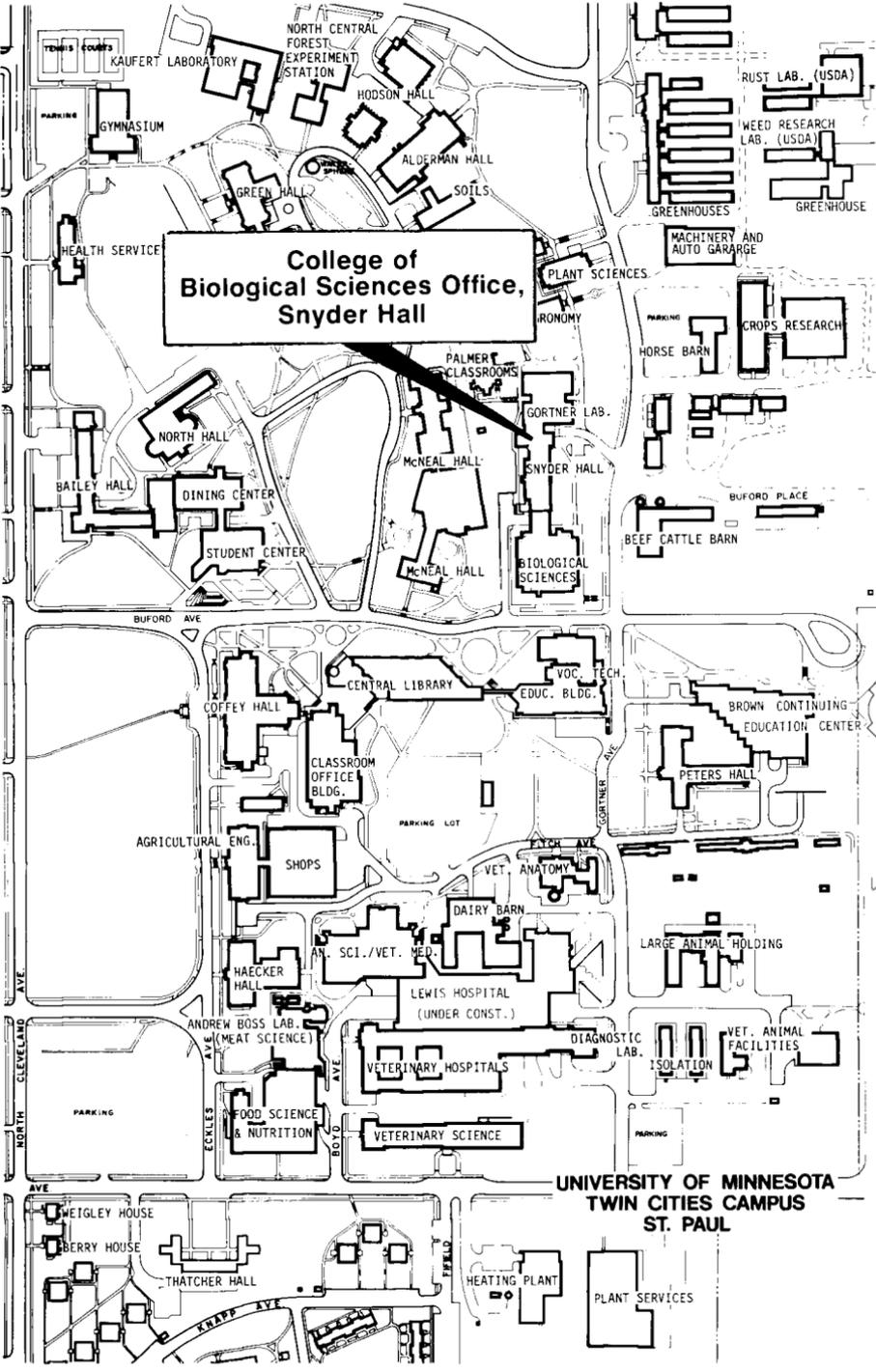
(Above) Dr. Iris Charvat assists two biology students. (Right) A student selects textbooks at the Minnesota Book Center, Minneapolis campus.





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