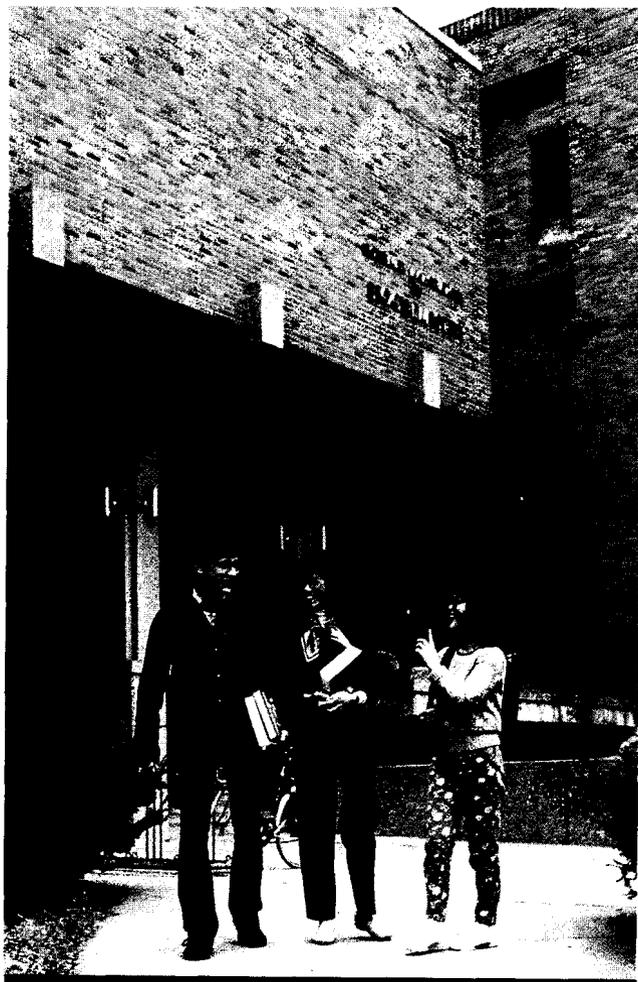


Biological Sciences University of Minnesota Bulletin 1987-89



Biological Sciences

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Introduction

Resources

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.

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

Policies

Bulletin Use—The 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, religion, color, sex, national origin, handicap, age, veteran status, or sexual orientation. 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; by Executive Order 11246, as amended: 38 U.S.C. 2012; by the Vietnam Era Veterans Readjustment Assistance Act of 1972, as amended; and by other applicable statutes and regulations relating to equality of opportunity.

Inquiries regarding compliance may be directed to Patricia Mullen, Director, Office of Equal Opportunity and Affirma-

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

Postal Statement

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Programs and Services



Programs and Services

Purpose

Many of the most serious problems facing human societies today are biological. The well-being of all of us will depend on intelligent solutions to these problems. Coping with over-population, preserving natural ecosystems, keeping our air and water clean, improving productivity of plants and animals through genetic engineering, and improving our knowledge of medicine and human genetics are some of our biological concerns. The talents of our most able people must be applied to these problems if they are to be resolved.

At one end of the spectrum, biologists may work on the global effects of rain forest destruction; at the other end, researchers are now seriously discussing the prospects of identifying every gene in every human chromosome, an unimaginable task only two decades ago.

Modern biologists in the field and in the laboratory must be able to use fundamental principles of chemistry, mathematics, and physics in order to appreciate living organisms at all levels from molecules to ecosystems. Specialists, working in well circumscribed areas, will always be important in biology, but an even greater challenge is emerging: a new need for people whose understanding ranges across the disciplines of biology and who can provide leadership in the future. The common theme that unifies biology is evolution, the study of the processes that tie all living things together through their descent from shared ancestors.

The College of Biological Sciences (CBS) has three main goals:

- to provide excellent instruction for persons preparing for careers in biology.
- to provide bioscience instruction for students majoring in other fields, so that as citizens they can make well-informed decisions.
- to encourage and support biological research of the highest quality.

Our excellent faculty and modern facilities are the essential resources required for meeting these goals.

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. CBS offers minors in biology and botany to students with an interest in these areas who are not majoring in a bioscience field. Students with a special interest in another area of study (e.g., ecology, behavioral biology, zoology) can 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). Students are strongly encouraged to initiate independent research projects with faculty.

Core Curriculum—The core sequence of courses, outlined under Degree Requirements and Procedures, 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 in biology, 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 under Major Requirements and Course Descriptions.

Liberal Education—The college faculty believes that all students, whatever their area of specialization or professional

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 coursework 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 research and scientific support 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 (see Professional Learning Experience Program). Approximately half of CBS graduates elect to pursue advanced study immediately following receipt of the B.S. degree (approximately 30-35% are admitted to professional schools and 15-20% 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 gen-

eral 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:

Biochemistry—Gary L. Nelsestuen
Botany—David D. Biesboer
Cell and Developmental

Biology—Ross G. Johnson
Ecology—Kendall W. Corbin
Genetics—Perry B. Hackett
Microbiology—Peter G. W. Plagemann
Plant Physiology—Ernest E. Banttari
Zoology—Elmer C. Birney

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 Major Requirements and Course Descriptions). 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 Laboratories, the Gray Freshwater Biological Institute, the Bell Museum of Natural History, and the Institute for Advanced Studies in Biological Process Technology. 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). The Plant Molecular Genetics Institute is administered by CBS in conjunction with the College of Agriculture. A complete list of faculty is provided in the last section of this bulletin.

Other resources include the Biochemistry Library which supports courses and research in the College of Biological Sciences. Books, serial publications, and titles are available on biochemistry, genetics, cell biology, cell culture, and scanning electron microscopy. The library is open Monday-Friday (612/624-1292). The Biological Sciences Greenhouse, on the St. Paul campus, is a teaching and research facility with standard bench space. Three landscaped rooms exhibit the flora of the tropics, subtropics, and desert (612/625-4788). The Herbarium contains over 7,800 specimens of fungi, lichens, mosses, gymnosperms, and angiosperms collected mainly on the North American continent. This collection is primarily a major resource for botanically oriented research both at the University and at other institutions (612/625-0215).

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 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, many are free to University of Minnesota students. Call 612/624-1852 for appointments or further information.

Cedar Creek Natural History Area—Located within commuting distance of campus, Cedar Creek not only serves as the site of ecological and behavioral field research, but also provides unique opportunities for student projects and summer employment. For student opportunities, contact the student services office (612/624-9717) or the Program Director of Cedar Creek Natural History Area (612/625-8462).

Dight Laboratories—Located in the Botany Building at 400 Church Street S.E., Minneapolis, the Dight Laboratories provide a research and training oriented focal point for human behavioral genetics. Emphasis is on biochemical approaches to normal and pathological behavior. Call 612/626-2996 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 Freshwa-

ter Biological Research Foundation (612/471-8407).

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

Institute of Human Genetics—The principal mission of the institute is to perform research to increase knowledge and to train scientists in the genetic mechanisms underlying normal and aberrant biological phenomena in higher animal systems, including man. The institute is receptive to the needs of the existing genetically oriented programs in the various schools at the University and is developing the following genetic programs to include a molecular approach to genetically based problems: (1) Molecular Genetics; (2) Behavioral Genetics; (3) Clinical Genetics; (4) Population Genetics; and (5) Genetic Services, which includes a Molecular Diagnostics Laboratory and a Microchemical Facility. The institute's integrated approach to research and problem-solving will allow for the rapid and direct transfer of basic knowledge to the technology-oriented developments within the institute and other sciences at the University. Call 612/624-3110 for further information.

Lake Itasca Forestry and Biological Station—Information about summer biology offerings is contained in the *Summer Session Bulletin*. Reservations for and

questions about the Itasca program should be directed to the Director, Itasca Biology Program, 305 Zoology Building, University of Minnesota, 318 Church Street S.E., Minneapolis, MN 55455 (612/625-9165).

General Biology Program—Located in Kolthoff Hall at 225 Pleasant Street S.E., Minneapolis, the General Biology Program administers beginning biology courses for most University students, serving approximately 3,500 students per year. Call 612/625-6636 for more information.

Plant Molecular Genetics Institute—The institute draws together faculty from CBS and the College of Agriculture to finance, coordinate, and promote research and graduate education in this important area of the biological and agricultural sciences. Research and teaching programs emphasize molecular genetic approaches to study basic plant processes and promote plant improvement.

Student Organizations and Governance

Biological Sciences Student Association (BSSA)—Through the BSSA, biology undergraduates can officially serve on college committees and voice their concerns. The BSSA plans educational and social activities throughout the year. Information is available in the undergraduate lounge (213 Snyder Hall) and in the CBS student services office. All University of Minnesota biology students are invited to attend. This is an excellent way to meet faculty and students.

Genetics and Cell Biology Club—Students formed the Genetics and Cell Biology Club to bring together students, faculty, and staff interested in these disciplines, and to facilitate visits by speakers, schedule educational experiences, and provide social activities for the membership. Any student, staff, or faculty member is eligible to join. For more information, contact the student services office (612/624-9717) or the genetics and cell biology department office (612/624-3003).

Society of Microbiology—The society provides a forum in which students and faculty can meet informally to share common interests in the biological sciences. The society elects members at the beginning of the year. All meetings and activities reflect members' interests. Individual letters are sent to announce topics, times, and places. Members of the Society of Microbiology are official members of the Student Chapter of the American Society of Microbiology (ASM). Contact with the ASM provides information on microbiology lectures, meetings, seminars, and local job listings. Activities include an open panel discussion between faculty members and students on microbiological issues. A wine and cheese party is held, and there are tours and talks given by professors, often with visits to local industries working in immunology, genetics, and other fields in biology. For more information, contact the student services office (612/624-9717) or the microbiology department office (612/624-6190).

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 BSSA 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, undergraduate research, and other student activities, 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 (612/624-2244).

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 (612/624-9717). 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 advis-

ers. Because the office is exceptionally busy and to assure availability of advisers, appointments must be made by calling 612/624-9717.

Professional Learning Experience (PLE) Program—The goal of the PLE program is to assist students in obtaining career-related experience to supplement their academic credentials. Experiential learning opportunities are designed to integrate classroom study with a work/learning assignment in the student's area of professional interest. Organizations sponsoring these opportunities include educational institutions, foundations, governmental units, and industry. Students can acquire experience in research, teaching, program development, administration, or business. Both paid and unpaid positions are available throughout the year, some offering academic credit.

Career Information Office—The Career Information Office is located at 229 Snyder Hall on the St. Paul campus (612/624-9270). 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 Services

programs and completion of application procedures for postgraduate 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, including individual tutoring, 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.

Office of International Education—Established to direct international education and research within the College of Biological Sciences, this office coordinates international activities between the college and the rest of the University. Each spring, a workshop on an international topic is sponsored, and seminars and lectures are arranged jointly with other colleges. Funds and grants are secured for international projects. Information on study and research abroad, for students and faculty, can be found on the international section of the bulletin board outside the college office (612/625-2244).

Financial Support—A limited number of small scholarships are available to particularly meritorious students, through the sponsorship of the Biological Sciences Alumni Society. The BSAS and University Research Opportunities Program (UROP) provide competitive grants to support undergraduate research. 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-Staff Directory* for listings of of-

fices and units that offer specific services, including:

- Boynton Health Service
- Housing Services
- Libraries
- Minority and Special Student Affairs
- Office for Students with Disabilities
- Office of International Education
- Office of Student Financial Aid
- Placement Offices
- Recreational Sports
- St. Paul Health Service
- Student Employment Service
- Student Legal Service
- Student Ombudsman Service
- Student Organization Development Center
- University Counseling Services
- Veterans Programs

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, academic awards, honors received, 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 center in Williamson Hall, Minneapolis, and at records offices on other campuses of the University. Questions may be directed to the Office of Registration, Student Records, and Scheduling, 150 Williamson Hall (612/625-5333).

Degree Requirements and Procedures



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. Coursework 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 freshman-admitting unit 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 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 coursework prerequisites, and achievement of a certain grade performance level in such coursework. 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 the first section 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 coursework 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); November 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 should be submitted to Admissions and Records in St. Paul or Minneapolis.

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. International students should apply to the Admissions Office, 240 Williamson Hall, University of Minnesota, 231 Pillsbury Drive S.E., Minneapolis, MN 55455. Ordinarily, applica-

tions can be acted on before the grades from coursework in progress are available. Qualified students will be admitted, subject to the satisfactory completion of the current registration.

Adult Special Status—Registration as an adult special student provides an opportunity to individuals who have completed a degree to take additional courses to meet special needs. 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 coursework 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 (240 Williamson Hall for International Students). 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:

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.

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% of their University of Minne-

Degree Requirements and Procedures

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 5041, 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.

²The physical chemistry course required for biochemistry majors, and some of the general physiology courses, must be preceded by the complete physics sequence.

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

sota 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 any 3xxx and 5xxx course 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 Rheta 1101/1151 or equivalent) and one advanced course in writing to be selected from the following: Comp 3015 or 3027; Rheta 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 coursework that is required of CBS students (see items 6 and 7) 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 courses under World Studies and 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* and the CBS student services office. **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 5450-5452 or one quarter of PubH 5400 with one quarter of CSci 3104) may be substituted for the last quarter of calculus. Biochemistry majors are required to complete the three-quarter calculus sequence.

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, 3303, or 3304, 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 full-year course, with laboratory, that requires college-level mathematics as a prerequisite (Phys 1271-1281-1291 or 1311-1321-1331-1341 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 5 credits of mathematics, statistics, computer programming, or physical science chosen in consultation with the major adviser may be substituted.

Biochemistry and microbiology majors are advised to take a calculus-based sequence (Phys 1271, etc.).

7. Biological Sciences (the Core Curriculum)—

a. General Biology (Biol 1009, 5 credits) or exemption granted by the student services office. Students with a good background from high school or individual

Degree Requirements and Procedures

study are encouraged to take the Biol 1009 exemption examination.

b. The following three courses: Animal Biology (Biol 3011, 5 credits), Plant Biology (Biol 3012, 5 credits), Microbiology (Biol 5013, 5 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 other than Biol 5041 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, 4 credits)

d. Genetics (Biol 5003, 4 credits)

e. Cell Biology (Biol 5004, 3 credits)

f. Ecology (Biol 5041, 4 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, 5211, 5212, 5231

EBB 5014, 5016, 5112, 5116, 5128, 5129,

5132, 5134, 5136, 5156, 5322, 5323,

5605, 5606, 5607, 5621

GCB 5002, 5011, 5015, 5030, 5605

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

5352, 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 (excluding HSci), including at least *one* of the following physiology courses: Bot 3131, EBB

5156, GCB 5114 or 5134, MicB 5321. This includes work specified by the major department (see Major Requirements and Course Descriptions).

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 8 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—Two quarters of participation in the CBS Honors Seminar (Biol 3960H) are required of all honors program graduates. In the fall quarter, the seminar is a forum to discuss special topics focused on a theme of general relevance to all biologists. In the spring quarter, seniors nearing completion of their directed research projects are required to present summaries of their project results.

Students are required to take a seminar in the fall, and follow that with a seminar in the spring quarter preceding graduation. Students are encouraged to attend in the spring quarter preceding their fall quarter Honors Seminar registration.

Honors Program Admission—Qualified students should apply for admission to the honors program as soon as they have been admitted to the college. A minimum of three quarters of honors registration must be completed to fulfill the requirements for graduation with honors. Applicants should have a minimum grade point average of 3.40 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 (8 credits) of directed research, the results of which are to be reported in an acceptable honors thesis

3. Two CBS Honors Seminars (Biol 3960H), one of which must be completed during fall quarter and the other during the last spring quarter in residence

4. One additional honors opportunity, which may be selected from the following:

a. An additional quarter (2 credits) of participation in directed research

b. An Honors Seminar offered by the Honors Division of the College of Liberal Arts

c. An upper division honors course (3xxx or 5xxx course designated by *H*)

d. An honors contract (see student services office)

e. An 8xxx course (seniors only; requires permission)

5. The last 90 credits of A-F registration with the minimum grade point averages specified below:

cum laude: minimum 3.40 GPA

magna cum laude: minimum 3.60 GPA

summa cum laude: minimum 3.80 GPA



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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.

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 nonresident 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 the usual curriculum. Many students plan projects they carry out under faculty supervision in research laboratories and in field settings; credit assignments are ar-

ranged 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 (see Professional Learning Experience Program). Most departments offer special seminars for undergraduates (see Major Requirements and Course Descriptions). 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. 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

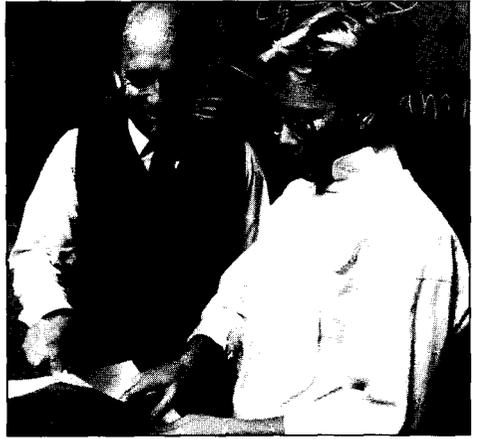
Consult the quarterly *Class Schedule* for detailed information on all registration procedures, grading policies, final examination schedules, and tuition and fees.

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 May for fall registration and during the last four weeks of fall and winter quarters for winter and spring registrations, re-



spectively. Specific dates are announced in the Official Daily Bulletin column in the *Minnesota Daily*. Students must pick up registration materials in 223 Snyder Hall.

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, must 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

Degree Requirements and Procedures

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 is required for each credit earned. Regular evaluation and grading procedures apply. Advance approval by the instructor and department is required.

Repeating a Course—Students may repeat courses that have *not* been completed satisfactorily, including courses in which they received D or F 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.

Petitions and Appeals—Students who need to request permission to depart from usual procedures and regulations must complete a petition form available in 223 Snyder Hall. Consult a student services adviser on the procedures. Petitions are reviewed by the CBS Scholastics Committee. Check in 223 Snyder for meeting times. The results of the petition must be picked up in the college office.

Cancelling and Adding Courses—A registration is an agreement that the stu-

dent 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 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. During weeks three to five, changes in registration require approval of the instructor. Cancellations or additions after the sixth week of class require 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 at the Office of Admissions and Records, 130 Coffey Hall, and inform the student services office. Absence from class does not constitute official withdrawal.

Credits and Grades

Maximum and Minimum Credit Loads—Full-time students register for 12 to 16 credits of coursework 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. No minimum credit load is required in CBS to maintain student status.

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-F) 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-F 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 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-F 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 of-

ficially 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% of the credits for which they register each quarter and a minimum of 75% 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

Degree Requirements and Procedures

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 and pay the graduation fee in 130 Coffey 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 major or degree from another college. Students interested in these options should consult their advis-

ers 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.

Major Requirements and Course Descriptions



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 this symbol has been taken for credit.
- ¶ Concurrent registration is allowed (or required) in the course listed after this symbol.
- # Registration Override Permit, completed and signed by the instructor, is required for registration.
- △ Registration Override Permit, completed and signed by the department offering the course is required prior to registration.
- † All courses preceding this symbol must be completed before credit will be granted for any quarter of the sequence.

H Honors course.

f,w,s,su Following a course number 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—
Peter Chapman

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 requirements listed below. (Where optional sequences exist, recommended courses are listed first.) The following major requirements are used in partial fulfillment of the college graduation requirements 7g and 7h (see Degree Requirements and Procedures):

*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.

Organic Chemistry—Chem 3333. (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.

German is the recommended foreign language.

Courses

1301. ELEMENTARY BIOCHEMISTRY I.

(5 cr, §Chem 1002 or 3301; not intended for majors; prereq Chem 1001 or 1005)

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

1302. 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.

1303. ELEMENTARY BIOCHEMISTRY

LABORATORY. (2 cr; prereq 1301 or Chem 1002)

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

3960. RESEARCH TOPICS IN BIOCHEMISTRY.

(1 cr per qtr; offered S-N only)

Lectures and discussions on current research in the department.

Biol 5001. BIOCHEMISTRY. (4 cr, §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.

5002. 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 prerequisites for certain advanced courses.

5025. LABORATORY IN BIOCHEMISTRY. (2 cr;

prereq Biol 5001 or §Biol 5001)

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

5525. PHYSICAL BIOCHEMISTRY: SOLUTION STRUCTURE AND INTERACTIONS OF BIOLOGICAL MACROMOLECULES. (4 cr, §MdBc

5525, §Chem 5525; prereq 2 qtrs physical chemistry, Biol 5001 or equivalent)

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



Major Requirements and Course Descriptions

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

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

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

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

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

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

5744. ANALYTICAL BIOCHEMISTRY. (4 cr; prereq previous lab work in analytical and organic chemistry, #)

Principal techniques of biochemistry experimental work; instrumentation and methods for isolation and characterization of proteins, lipids, and carbohydrates. Chromatography, electrophoresis, spectrophotometry, potentiometry and fluorimetry.

5751-5752-5753. 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.

5950. 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 descriptions, see the *Graduate School Bulletin*)

8094. RESEARCH AND LITERATURE REPORTS

8194. GRADUATE SEMINAR

8213. ADVANCED MOLECULAR BIOLOGY I

8214. ADVANCED MOLECULAR BIOLOGY II

8220. ADVANCED TOPICS IN CARBOHYDRATE BIOCHEMISTRY

8225. TRACER TECHNIQUES

8230. ADVANCED TOPICS IN MEMBRANE BIOCHEMISTRY

8232. ADVANCED TOPICS IN PROTEINS AND ENZYMES I

8233. ADVANCED TOPICS IN PROTEINS AND ENZYMES II

8250. SPECIAL TOPICS IN BIOCHEMISTRY

8290. CURRENT RESEARCH TECHNIQUES

8746. BIOCHEMISTRY LABORATORY PROJECTS AND ADVANCED TECHNIQUES

8990. GRADUATE RESEARCH

Biology (Biol)

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 under Degree Requirements and Procedures. 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, 1103, 1106, 3051,

3112; Bot 1009, 1012; EBB 3001; GCB 3002, 3008, 3022; MicB 1101.

Minor Sequence

Required Preparatory Courses—Biol 1009

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

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

The minor program must be approved in the student services office, 223 Snyder Hall.

Courses

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. 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)

For description, see 1009. Intended especially for honors students or others with the requisite background who plan to major in a life science discipline.

1101. HEREDITY AND HUMAN SOCIETY. (4 cr, §GCB 3002; no cr if taken after 5003 or GCB 3022; for students in programs not directly related to biological sciences) Fan, V Woodward

Principles of heredity and their social and cultural implications.

1103. 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
Levels of organization of plants, plant function, plant growth and development, plant reproduction.

1106. GENERAL ZOOLOGY. (5 cr; prereq 1009)

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

1301. HUMAN REPRODUCTION AND DEVELOPMENT. (4 cr; prereq 1009 or equiv) McKinnell

Human development from gametogenesis to senescence. Ovulation, sperm release, fertilization, transit of early embryo to uterus, implantation, fetal membranes, cellular differentiation, organogenesis, birth, adolescence, puberty, and senescence. Congenital defects, birth control, multiple births, and human cytogenetics in relation to development. *In vitro* fertilization.

1951, 1952, 1953. BIOLOGY COLLOQUIUM. (1 cr/ f, 1 or 2 cr/w.s; 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.

3011. 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.

3012. PLANT BIOLOGY. (5 cr, §1103; prereq 1009, Chem 1005) Charvat, Wetmore

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

3042. FIELD PROBLEMS IN ECOLOGY. (2 cr; prereq 5041 or #)

Student research projects on selected ecological problems.

3051. BIOLOGY AND THE FUTURE OF MAN. (4 cr; S-N only) Cunningham

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.

3112. 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.

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

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

3960H. HONORS SEMINAR. (1 cr per qtr; S-N only; prereq Δ ; limited to participants in CBS Honors Program) Staff

Oral reports on topics of current interest to biologists. Progress reports on laboratory and field research by students.

Major Requirements and Course Descriptions

3980. DIRECTED INSTRUCTION. (1-5 cr per qtr; S-N only; prereq #) Staff

Leadership opportunities for upper division students wishing to assist with the Biology Colloquium.

5001. BIOCHEMISTRY. (4 cr, \$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.

5003. GENETICS. (4 cr, \$GCB 3022, \$GCB 5022; prereq 5001) R Herman, Rubenstein, 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.

5004. CELL BIOLOGY. (3 cr; prereq 5001) Blumenfeld, Brooker, 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.

5013. MICROBIOLOGY. (5 cr, \$MicB 3103, \$MicB 5105, \$VPB 3103; prereq 5001) Dworkin
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Emphasis on molecular structure in relation to bacterial function.

5041. ECOLOGY. (4 cr; prereq 1009, 1103, 1106 or 3011 or 3012, Math 1142 or 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.

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.

5125. RECOMBINANT DNA LABORATORY. (4 cr; prereq #) Hackett, Das, Shaw, others
Introduction to basic recombinant DNA techniques. Methods for growing, isolating, and purifying recombinant DNAs and cloning vectors.

5506. BIOTRANSFORMATIONS OF ORGANIC COMPOUNDS. (5 cr; prereq chemistry through organic; 1 yr biol; 1 yr phys; 1 qtr bioc, micro recommended; must apply at the student services office for permission to register)

Lecture course describing the microbiology, biochemistry, and genetics of bacteria that grow on or transform organic compounds.

5507. BIOTRANSFORMATIONS OF ORGANIC COMPOUNDS LABORATORY. (5 cr; prereq 5506 or #5506; must apply at the student services office for permission to register)

Laboratory course to accompany 5506.

5950. SPECIAL TOPICS IN BIOLOGY. (1-5 cr per qtr; prereq Δ) Staff

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

5041. ECOLOGY. (4 cr; prereq Math 1142 or 1211, Biol 1103, 1106, or 3011 or 3012)

Growth, structure, and evolution of populations. Pairwise biotic interactions between species and their effect on the diversity and structure of natural communities. Nutrient dynamics, function, productivity, and temporal stability of ecosystems.

5816. FIELD BIOLOGY PHOTOGRAPHY. (3 cr; A-F only; prereq Δ , 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 ar, 0-10 per qtr; prereq Δ)

5870. ITASCA SEMINAR. (1 cr; prereq Δ) Staff
Topic selected and scheduled during registration by interested staff members and students.

5890. 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 #, Δ) 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 descriptions, see the *Graduate School Bulletin*)

8710. TUTORIAL IN DEVELOPMENTAL BIOLOGY

8910. 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).

Minor Sequence

Required Preparatory Courses—Biol 1009, 1103 or 3012.

Minor Requirements—Three courses plus one seminar to total a minimum of 15 cr in botany, chosen from: 3131, 3109 or 5111, 3201, 5103, 5105.

The program must be approved by the director of undergraduate studies.

Courses

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

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

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

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

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

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

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

3109. PLANT ANATOMY. (5 cr; prereq Biol 1103 or 3012) Biesboer
Structure and development of plants with special reference to vascular plants.

3131. 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, Gleason
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.

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

5001. BASIC BOTANY. (Cr ar; prereq Biol 1008 or 1009, #, Δ)
Individual work in a fundamental aspect of the discipline.

5103. ALGAE, FUNGI, AND BRYOPHYTES. (5 cr; prereq Biol 1103 or 3012; offered 1988-89 and when feasible) McLaughlin
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.

5105. MORPHOLOGY OF VASCULAR PLANTS. (5 cr; prereq Biol 1103 or 3012 or #)
Ferns and their allies, Gymnosperms (cycads, Ginkgo, conifers) and Angiosperms (flowering plants). Comparative morphology of vegetative and reproductive structures; life cycles; evolutionary relationships.

5111. PLANT CELL, TISSUE AND ORGAN DEVELOPMENT. (5 cr; prereq Biol 1103 or 3012) Biesboer
Microscopic structure of vascular plants; development in root, stem, and leaf.

5131. 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, Frenkel, Gleason
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. Weekly discussion section.

Major Requirements and Course Descriptions

5132. PLANT PHYSIOLOGY LABORATORY. (2 cr; prereq 3131 or 5131 or *3131 or *5131) Frenkel
Laboratory course to accompany 3131 or 5131.

5141. PLANT CELL BIOLOGY. (4 cr; prereq Biol 5004 or equiv) Wick
Structural, functional, developmental, and biochemical aspects of cellular components and processes specific to algae, fungi, and higher plants. Cell walls, dictyosome activity, plastids, plant cytoskeleton, modes of plant cytokinesis, cell-cell communication, lectins and cell recognition, vacuoles, cytoplasmic streaming.

5182. PLANT METABOLISM. (3 cr, \$PIPh 5182; prereq 5131 or equiv, course in biochemistry)
Plant metabolism: photosynthesis, respiration, and the synthesis of macromolecules by plants. Structure-function relations at the plant, cell, and subcellular levels. Energy flow in the plant system and regulation of plant metabolism.

5183. WATER, MINERALS, AND TRANSLOCATION. (4 cr, \$PIPh 5183; prereq 5131 or equiv) Markhart
Membrane phenomena and osmotic properties of cells. Uptake, movement, and loss of water in plants; effects of external factors. Translocation of organic substances. Absorption, distribution, and function of inorganic elements.

5184. PLANT GROWTH AND DEVELOPMENT. (3 cr, \$PIPh 5184; prereq 5131 or equiv) Hackett, others
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.

5231. INTRODUCTION TO THE ALGAE. (5 cr; prereq 10 cr in botany or biology or #; offered when feasible) McLaughlin
Structure, reproduction, and life histories of major algal divisions.

5235. ALGAL PHYSIOLOGY. (3 cr; prereq BioC 1302 or Biol 5001; offered when feasible) Gleason
Photosynthesis, carbon metabolism, nitrogen fixation and assimilation, and secondary metabolism in algae. Algal genetics and use of mutants in physiological studies. Algal interactions with environmental parameters and other organisms.

5960. 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

5801. 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.

5811. 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.

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

For Graduate Students Only

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

8287. PLANT MOLECULAR BIOLOGY

8301. POLLEN MORPHOLOGY AND QUATERNARY PALYNOLOGY

8950. SEMINAR

8970. SPECIAL TOPICS

8990. 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 interest. Students with an interest in this area may request a faculty adviser from the EBB department and should ask the director of undergraduate studies or the student services office about special department activities for undergraduates, and about the status of the forthcoming EBB major.

Courses

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

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

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. INTRODUCTION TO ANIMAL BEHAVIOR. (4 cr, §AnSc 3111; prereq Biol 1106 or 3011 or #) Pusey

The nature, variety, development, motivation, and evolution of animal behavior emphasizing social interactions and communication.

3990. RESEARCH TOPICS IN ECOLOGY AND BEHAVIORAL BIOLOGY. (1 cr per qtr; S-N only; prereq #)

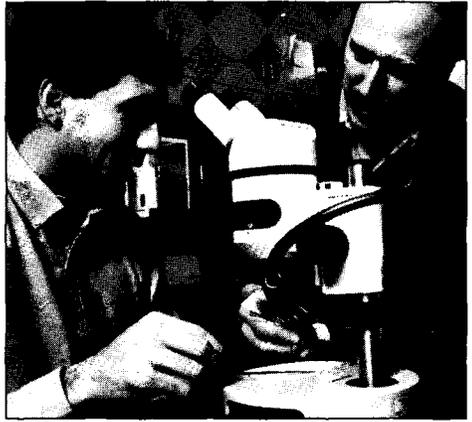
Lectures on and discussion of current research in the department.

5970. DIRECTED STUDIES. (Cr ar, §3970; prereq #, Δ)

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

5990. DIRECTED RESEARCH. (Cr ar, §3990; prereq #, Δ)

Laboratory or field investigation of selected areas of research.



Community Ecology and Paleoecology

5008. QUATERNARY ECOLOGY. (4 cr; prereq Biol 5041 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 Biol 5041, 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 Biol 5041, Bot 3201 or #; offered when feasible) Bright, 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

5044. EVOLUTION. (4 cr; prereq Biol 1106 or 3011)

Survey of evidence for and causes of biological evolution.

5051. ANALYSIS OF POPULATIONS. (4 cr; prereq Biol 5041 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.

Major Requirements and Course Descriptions

5052. THEORETICAL POPULATION ECOLOGY. (4 cr; prereq Biol 5041 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.

5063. EVOLUTIONARY ECOLOGY OF INSECT POPULATIONS. (3 cr; prereq Biol 5041 or #) Alstad

Dynamics and regulation of insect populations; life history evolution; cytogenetic patterns, reproductive competition, mating systems, and modes of speciation; mechanisms and implications of frequency dependent coevolution.

5065. THEORETICAL EVOLUTIONARY ECOLOGY. (3 cr; prereq Math 1231, one 5000-level course in ecology, evolution, or behavior, or #) Abrams

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

Organismal Biology and Physiological Ecology

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.

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 when feasible)

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 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 when feasible) 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

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

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.

5323. MECHANISMS OF ANIMAL BEHAVIOR. (5 cr; prereq Biol 3011 or 1 qtr of animal physiology)

Barnwell, Phillips
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.

5325. BEHAVIORAL ECOLOGY. (4 cr; prereq 5321 or #) Packer

Ecological determinants of foraging behavior, social organization, demography, and life-history strategies.

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.

5606. ECOLOGY OF FISHES. (5 cr; prereq Biol 1106 or 3011, EBB 5136 plus 10 cr in the biological sciences; offered when feasible) 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 5041, 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.

5608. ECOSYSTEMS: FORM AND FUNCTION.

(4 cr; prereq 5601 or Biol 5041, or equiv) Davis, Gorham

Nature and development of terrestrial wetland, and aquatic ecosystems. Analysis of energy flow and element cycling in relation to environmental controls, self-regulation, natural and human disturbances.

5613. ASSESSING THE ECOLOGICAL EFFECTS OF POLLUTION.

(4 cr; prereq Biol 5041 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.

5621. LIMNOLOGY LABORATORY.

(2 cr, §Geol 5621; prereq EBB 5601 or Geol 5601 or #) Megard
Principal techniques for obtaining information about environmental conditions in lakes and streams. Procedures for measuring the abundance and population dynamics of aquatic organisms, with special emphasis on plankton. Field instruments, sampling devices, chemical analysis, microscopy, and analysis of data. One Saturday field trip.

Courses Offered at Lake Itasca Forestry and Biological Station

3800. 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.

5814. 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.

5815. FIELD ETHOLOGY.

(5 cr; limited to 20 students; prereq course in behavior, Δ; course in statistics recommended)

Field course emphasizing the methods of studying behavior of wild animals. Quantitative techniques; sound recordings and sound tape analysis, capturing and marking techniques. An individual research project and term paper on the social behavior of one species is required. Individual projects require considerable outside time.

5817. 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.

5820. WETLAND ECOLOGY.

(10 cr; limited to 15 students; prereq 15 cr biology, Δ; introductory chemistry, course in plant identification, Biol 5041 recommended) Gorham

Nature, origin, and development of lake, marsh, swamp, and bog ecosystems; environmental control and productivity.

5831. NATURAL HISTORY OF INVERTEBRATES.

(5 cr; limited to 20 students; prereq Biol 1106, Δ)

Advanced taxonomic and ecological survey of local fauna and independent ecological studies of several taxonomic groups.

5832. NATURAL HISTORY OF VERTEBRATES.

(5 cr; limited to 20 students; prereq Biol 1106, Δ)

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

5834. FIELD ORNITHOLOGY.

(5 cr; prereq 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.

For Graduate Students Only

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

8004. TOPICS IN ECOLOGICAL GENETICS**8014. PALEOECOLOGICAL METHODS****8061. SOCIAL SYSTEMS****8081. NEUROETHOLOGY****8162. WINTER ECOLOGY****8390. GRADUATE SEMINAR****8400. POPULATION BIOLOGY SEMINAR****8410. COMMUNITY ECOLOGY SEMINAR****8420. POPULATION BIOLOGY RESEARCH SEMINAR****8500. WRITING RESEARCH PROPOSALS****8510. BEHAVIORAL BIOLOGY SEMINAR****8602. ADVANCED LIMNOLOGY****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

Major Requirements and Course Descriptions

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 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 major requirements, which may be used in partial fulfillment of the college graduation requirements, 7g and 7h (see Degree Requirements and Procedures):

- a. GCB 3960 (one quarter)
- b. Biol 3950H (two quarters)
- c. Twenty credits chosen from the following list of courses that must include two laboratory experiences (identified by an *), one course from area 5 and no more than one course from area 7.

C-1 Molecular Biology

- *BioC 5025: Laboratory: Biochemistry (2 cr)
- GCB 5032: Advanced Genetics II (4 cr)
- *Biol 5125: Laboratory: Recombinant DNA (4 cr)

C-2 Genetics

- *GCB 5030: Laboratory: Genetics (2 cr)
- GCB 5031: Advanced Genetics I (4 cr)
(B or better in 3022 or Biol 5003, or #)
- GCB 5032: Advanced Genetics II (4 cr)
- GCB 5033: Population and Quantitative Genetics (4 cr)
- GCB 5024: Genetics of Development (4 cr)
- GCB 5043: Human Genetics (3 cr)

C-3 Cell Biology

- *GCB 5015: Histology: Cell and Tissue Organization (5 cr)

- *GCB 5605: Cell Biology Laboratory (2 cr)
- GCB 5052: Quantitative Techniques, Cell Biology (4 cr)
- GCB 5048: Advanced Cell Biology I (B or better in 5004, or #) (4 cr)
- GCB 5049: Advanced Cell Biology II (4 cr)
- *GCB 5001: Scanning Electron Microscopy Laboratory (4 cr)
- *GCB 5002: Transmission Electron Microscopy Laboratory (4 cr)
- C-4 Developmental Biology
 - GCB 5061: Developmental Biology (3 cr)
 - GCB 5024: Genetics of Development (4 cr)
- C-5 Physiology
 - GCB 5114: General Physiology (3 cr)
 - GCB 5134: Endocrinology (4 cr)
- C-6 Directed Research/Studies (no more than 3 credits)
 - *GCB 5990: Directed Research (can be used to satisfy one of two laboratory experiences—cr ar)
 - GCB 5970: Directed Studies (cr ar)
- C-7 History and Philosophy of Science
 - HSci 3202: History of Biology: (Physiology and Cell Theory). (4 cr)
 - HSci 3203: History of Biology: (Evolution and Genetics since 1700). (4 cr)
 - HSci 5242: Evolution Before and After Darwin (4 cr)
 - Phil 3601: Scientific Thought (4 cr)
 - Phil 5603: Philosophy of Science: Scientific Change (4 cr)
 - Phil 5606: Philosophy of Science: Problems of the Biological Sciences (4 cr)

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

Courses

3002. HUMAN GENETICS, SOCIAL AFFAIRS.

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

3022. GENETICS. (4 cr, §Biol 5003; not intended for biology majors; prereq Biol 1009)

Mechanisms of heredity, their implications for biological populations, and applications to practical problems.

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

Biol 5001) V Woodward
Discussions of faculty research.

5002. TRANSMISSION ELECTRON MICROSCOPY LAB. (4 cr; S-N only; prereq #) Kuehn
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.

5011. GENERAL AND COMPARATIVE EMBRYOLOGY. (4 cr; prereq Biol 1106 or 3011) McKinnell
Embryological development of vertebrates.

5013. MAMMALIAN REPRODUCTION. (4 cr; prereq Biol 3011, Biol 5001 or #; offered when feasible) Sinha
Introduction to biological aspects of mammalian reproduction with emphasis on eutherians. Selected topics and examples used to discuss basic problems, current concepts, and patterns of reproduction at molecular, cellular, and organismal levels.

5015. HISTOLOGY: CELL AND TISSUE ORGANIZATION. (5 cr; prereq Biol 1106 or 5004 or #) Cunningham
Structure and function of vertebrate tissues and organs. Lectures combine electron microscopy, light microscopy, physiology, and cell biology of higher animals. Labs concentrate on light microscopy of mammalian tissues.

5022. GENETICS. (3 cr, §3022, §Biol 5003; not open to grad students in genetics)
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 eucaryotes, nematode and *Drosophila*.

5030. LABORATORY: GENETICS. (2 cr; prereq 3022 or 5022 or Biol 5003, #)
Investigative approaches to analysis of genetic problems. Focus on a given organism or related group of organisms may differ from quarter to quarter.

5031. ADVANCED GENETICS I. (4 cr; prereq 3022 or Biol 5003 with grade of A or B and Biol 5001 or BioC 5751, or #) Lefebvre
Mechanics of inheritance. Comparative organization of genetic material in prokaryotic and eucaryotic organisms. Mutation, complementation, and recombination as operational criteria for genetic analysis.

5032. ADVANCED GENETICS II. (4 cr; prereq 5031) Hackett
Action of the gene in molecular, cellular, and organismal development. Mechanisms of information transfer and regulation of these processes in various biological systems analyzed with emphasis on examining original research.

5033. POPULATION AND QUANTITATIVE GENETICS. (4 cr; prereq 3022 or Biol 5003, course in biometry or statistics or #) Curtsinger
Introduction to genetic basis of microevolutionary change. Allelic frequency dynamics, with particular emphasis on natural selection and adaptive topography. Molecular evolution, additive genetic variance, consequences of artificial selection, and current topics.

5042. 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.

5043. 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.

5044. 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.

5048. ADVANCED CELL BIOLOGY I. (4 cr; prereq Biol 5004 with grade of A or B, or #) Iwanij, Johnson
Eucaryotic 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.

5049. ADVANCED CELL BIOLOGY II. (4 cr; prereq 5048, Biol 5003) Johnson, Silflow
Eucaryotic 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.

5052. QUANTITATIVE TECHNIQUES, CELL BIOLOGY. (4 cr; prereq calculus, introductory cellular or molecular biology, biochemistry recommended) Rubenstein, Mahoney
Use and detection of radioisotopes; theory and practice of analytical and preparative ultracentrifugation, chromatography, spectroscopy, and electron microscopy; tissue culture and subcellular particle fractionation.

Major Requirements and Course Descriptions

5061. DEVELOPMENTAL BIOLOGY. (3 cr; A-F only; prereq Biol 5003 and 5004) Kerr
Developing systems and control mechanisms of development, from molecule to organism.

5063. THEORETICAL POPULATION GENETICS. (3 cr; prereq college-level calculus, basic statistics and genetics; offered when feasible) Simmons
Population genetics theory as related to problems of natural history.

5073. ADVANCED HUMAN GENETICS. (4 cr; prereq 5031 or #) King, IHG faculty
Application of molecular, biochemical, chromosomal, and population genetics to human variation and disease. Abnormal chromosome number and structure; abnormal enzyme, structural protein, receptor and transport; analysis of inheritance patterns; behavioral genetics; genetic basis of common disease.

5114. GENERAL PHYSIOLOGY. (3 cr; prereq Biol 3011, 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.

5134. ENDOCRINOLOGY. (4 cr; prereq Biol 3011, 5001 or #) W Herman
Survey of structure and function of invertebrate and vertebrate endocrine systems.

5605. CELL BIOLOGY LABORATORY. (2 cr; prereq Biol 5004 or #Biol 5004 or #) Blumenfeld, Lefebvre
Experimental approaches to cell structure, function, and replication, including microscopy, autoradiography, cell fractionation, and molecular and chemical analyses.

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

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

For Graduate Students Only

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

8060. CURRENT TOPICS

8213. ADVANCED MOLECULAR BIOLOGY I

8214. ADVANCED MOLECULAR BIOLOGY II

8900. SEMINAR

8910. JOURNAL CLUBS

8920. SPECIAL TOPICS

8950. PRACTICUM: TEACHING IN GENETICS

8960. PRACTICUM: TEACHING IN CELL AND DEVELOPMENTAL BIOLOGY

8970. DIRECTED STUDY

8990. RESEARCH

History of Science and Technology (HSci)

Institute of Technology

Coordinator—Roger H. Stuewer, 438 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-2, the Individual and Society—the historical perspective.

Courses

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; the Industrial Revolution. 1713: Diffusion of the industrial revolution; technological development and its impact on industry, government, and society of the 19th and 20th centuries, especially in the United States.

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 scientific revolution; 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.

3201, 3202. HISTORY OF BIOLOGY. (4 cr per qtr, §5201, §5202) Beatty
Scientific, philosophical, and social factors in the development of biology; changing styles of biological reasoning, and changing relationships between the biological and physical sciences. *3201:* Biology from antiquity through the early modern period. *3202:* Biology in the 19th and 20th centuries.

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
Physical and physiological investigations of color from the 17th to the mid-19th centuries, focusing on fundamental contributions of Newton, Young, Maxwell, and Helmholtz.

5111. PHYSICAL SCIENCES IN ANTIQUITY. (4 cr) Shapiro
Mathematics and astronomy in Babylonia; Greek mathematics, Euclid and Archimedes; Aristotle's physics and cosmology; the emergence of mathematical and experimental natural science in Greece; Ptolemaic astronomy.

5201, 5202. HISTORY OF BIOLOGY. (4 cr per qtr, §3201, §3202)
For description, see 3201, 3202.

5242. THE DARWINIAN REVOLUTION. (4 cr; prereq Biol 1009 or 1101 or #) Beatty
Pre-Darwinian conceptions of nature; development and reception of Darwin's theory of evolution by natural selection; also the broader context of the Darwinian Revolution, including religious thought, political theory, and views about proper scientific methodology.

5311. TECHNOLOGY IN AMERICAN LIFE. (4 cr) Norberg
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
Developments in last century: factors affecting evolution of hardware and software, growth of the industry and its relation to other business areas, and changing relationships resulting from new data gathering and analysis techniques.

5511. WHAT SCIENCE WAS. (4 cr) Beatty
Changing views of the aims and methods of science as seen through the eyes of philosopher-scientists of the past; how notions of "explanation," "hypothesis," "evidence," etc. have changed through time.

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 of these developments 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). Relationships of these developments to social, philosophical, and theological influences.

5935. HISTORY OF NUCLEAR PHYSICS. (4 cr; prereq general physics or #) Stuewer
Experimental and theoretical developments in nuclear physics to World War II in their institutional, social, and political contexts. Life and work of Becquerel, Curie, Rutherford, Chadwick, Gamow, Lawrence, Fermi, Bohr, Hahn, Meitner, others.

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 #) Beatty

Major Requirements and Course Descriptions



8930. SEMINAR: HISTORY OF TECHNOLOGY. (4 cr; prereq #) Layton, Norberg

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, or the laboratories accompanying both virology (5424) and immunology (5216)
- Two of the following: MicB 5232, 5424, 5352

- 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.

Courses

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.

3103.¹ GENERAL MICROBIOLOGY. (5 cr, §5105, §Biol 5013, §VPB 3103; prereq soph with C avg in courses prereq to major sequence, or jr with 10 cr chemistry 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) Hanson, Schmidt
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 #) Hanson, Schmidt
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) Dworkin
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.

Biol 5125. LABORATORY IN RECOMBINANT DNA TECHNOLOGY. (4 cr, §Biol 5125; prereq #)
Introduction to basic recombinant DNA techniques. Methods for growing, isolating, and purifying recombinant DNAs and cloning vectors.

5216. IMMUNOLOGY. (4 cr; prereq Biol 5001) Gray
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.

5218. IMMUNOLOGY. (3 cr; prereq Biol 5001) Gray
Same as 5216 without laboratory.

5232. 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.

5233.¹ 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.

5234.¹ 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.

5235. 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.

5321. PHYSIOLOGY OF BACTERIA. (3 cr; prereq 3103 or 5105 or Biol 5013 or VPB 3103; Biol 5001; 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.

5322. 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.

5352. APPLIED MICROBIOLOGY. (4 cr; prereq 5321 or #) Flickinger, Hanson
Microbial adaptation to various environments; role of microorganisms in the earth's biogeochemical cycles. Application of microbial systems to industrial processes; basic principles of fermentation technology; microbial bioconversions and product formation. Biodegradation of chemicals.

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

Major Requirements and Course Descriptions

5424.¹ 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.

5900. 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. DIRECTED STUDIES. (Cr ar; prereq #, Δ)
Individual study on selected topics or problems with emphasis on selected readings and use of scientific literature.

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

For Graduate Students Only

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

8110. BIOLOGY OF MICROORGANISMS

8112. MICROBIAL GENETICS

8121. ADVANCED IMMUNOLOGY METHODS: IMMUNOCHEMISTRY

8123. ADVANCED IMMUNOLOGY METHODS: IMMUNOBIOLOGY

8202. ORAL MICROBIOLOGY

8218. FRONTIERS OF IMMUNOLOGY I: IMMUNOCHEMISTRY

8242. DIAGNOSTIC MICROBIOLOGY

8320. FRONTIERS OF IMMUNOLOGY II: IMMUNOBIOLOGY, IMMUNOGENETICS

8321. FRONTIERS OF IMMUNOLOGY III: CLINICAL IMMUNOLOGY

8421. MOLECULAR BIOLOGY OF CANCER

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 descriptions, see the *Graduate School Bulletin*.)

8970. GRADUATE SEMINAR

8980. SPECIAL RESEARCH FIELDS

8990. GRADUATE RESEARCH

Recommended Related Coursework

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

animal science (AnSc)

anthropology (Anth)

biophysics (BPhy)

chemical engineering (ChEn)

computer science (CSci)

entomology (Ent)

fish and wildlife (FW)

food science and nutrition (FS&N)

geology (Geo)

history of medicine & biological sciences (HMed)

laboratory medicine (LMed)

mathematics (Math)

organic chemistry (Chem)

philosophy (Phil)

physics (Phys)

physiology (Phsl)

plant sciences (PIPa, PIPh)

psychology (Psy)

public health (PubH)

soil science (Soil)

statistics (Stat)

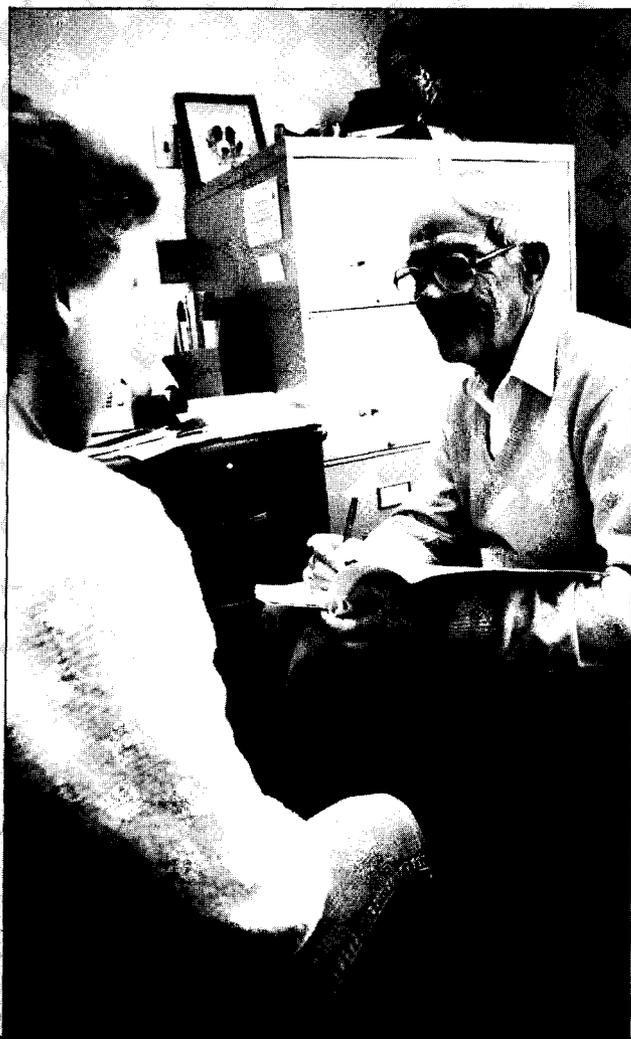
veterinary biology (VB)

veterinary pathobiology (VPB)

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

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

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Administration and Faculty

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College of Biological Sciences Administrators

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Darlene C. Joyce, Associate to the Dean,
123 Snyder Hall, St. Paul campus (624-
2244)
Kathleen F. Peterson, Director of Student
Services, 223 Snyder Hall, St. Paul cam-
pus (624-9717)
Kathleen Swart, Minority Affairs Officer,
223 Snyder Hall, St. Paul campus (625-
3809)
Willard L. Koukkari, International Edu-
cation Officer, 610 Biological Sciences
Center (625-1958)

Biochemistry—Victor Bloomfield, Profes-
sor and Head, 140 Gortner Laboratory, St.
Paul campus (624-7755)

Botany—Thomas Soulen, Associate Pro-
fessor and Head, 220 Biological Sciences
Center, St. Paul campus (625-1234)

Cedar Creek—John R. Tester, Professor
and Director, 304 Zoology Building, Min-
neapolis campus (625-8462) Cedar Creek
Area (434-5131)

Dight Laboratories—John R. Sheppard,
Professor and Director, 214 Botany Build-
ing, Minneapolis campus (626-2792)

Ecology and Behavioral Biology—
Franklin H. Barnwell, Professor and
Head, 109 Zoology Building, Minneapolis
campus (625-4466)

General Biology Program—Samuel Kirk-
wood and Michael J. Simmons, Co-Chair-
men (625-6636)

Genetics and Cell Biology—William S.
Herman, Professor and Head, 248 A Bio-
logical Sciences Center, St. Paul campus
(624-3003)

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

*James Ford Bell Museum of Natural His-
tory*—Donald Gilbertson, Professor and
Director, 301 Bell Museum of Natural
History, Minneapolis campus (624-2596)

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

*Institute for Advanced Studies in Biologi-
cal Process Technology*—Michael C.
Flickinger, Associate Professor and Direc-
tor, 240 Gortner Laboratory, St. Paul
campus (624-6774)

Plant Molecular Genetics Institute—Irwin
Rubenstein, Professor and Director, 348
Biological Sciences Center, St. Paul cam-
pus (624-2716)

Faculty

Department of Biochemistry

Regents' Professor Emeritus

*Stanley Dagley, D.Sc.

Professor

John S. Anderson, Ph.D.
 Victor Bloomfield, Ph.D.
 Peter J. Chapman, Ph.D.
 Robert L. Glass, Ph.D.
 Gary R. Gray, Ph.D.
 *Samuel Kirkwood, Ph.D.
 Irvin E. Liener, Ph.D.
 Rex E. Lovrien, Ph.D.
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 Gary L. Nelsestuen, Ph.D.
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 John M. Wood, Ph.D.
 Clare K. Woodward, Ph.D.

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Bianca Conti-Tronconi, M.D.
 Michael J. Flickinger, Ph.D.
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 Kamil Ugurbil, Ph.D.

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 Anath Das, Ph.D.
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Department of Botany

Regents' Professor

Herbert E. Wright, Ph.D.

Professor

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David D. Biesboer, Ph.D.
 Iris D. Charvat, Ph.D.
 Thomas K. Soulen, Ph.D.

Assistant Professor

Judith Berman, Ph.D.
 J. Stephen Gantt, Ph.D.
 Florence Gleason, Ph.D.
 Neil E. Olszewski, Ph.D.
 Susan M. Wick, Ph.D.

**Department of Ecology
 and Behavioral Biology**

Regents' Professor

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

Professor

Franklin H. Barnwell, Ph.D.
 Elmer C. Birney, Ph.D.
 Kendall W. Corbin, Ph.D.
 Edward J. Cushing, Ph.D.
 Donald E. Gilbertson, Ph.D.
 D. Frank McKinney, Ph.D.
 Donald McNaught, Ph.D.
 Robert O. Megard, Ph.D.
 Patrice A. Morrow, Ph.D.
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 G. David Tilman, Ph.D.
 Harrison B. Tordoff, Ph.D.
 James C. Underhill, Ph.D.

Adjunct Professor

Miron L. Heinselman, Ph.D.
 David L. Mech, Ph.D.

Associate Professor

Peter A. Abrams, Ph.D.
 John H. Beatty, Ph.D.
 Robert C. Bright, Ph.D.

Assistant Professor

Donald N. Alstad, Ph.D.
 James W. Curtsinger, Ph.D.
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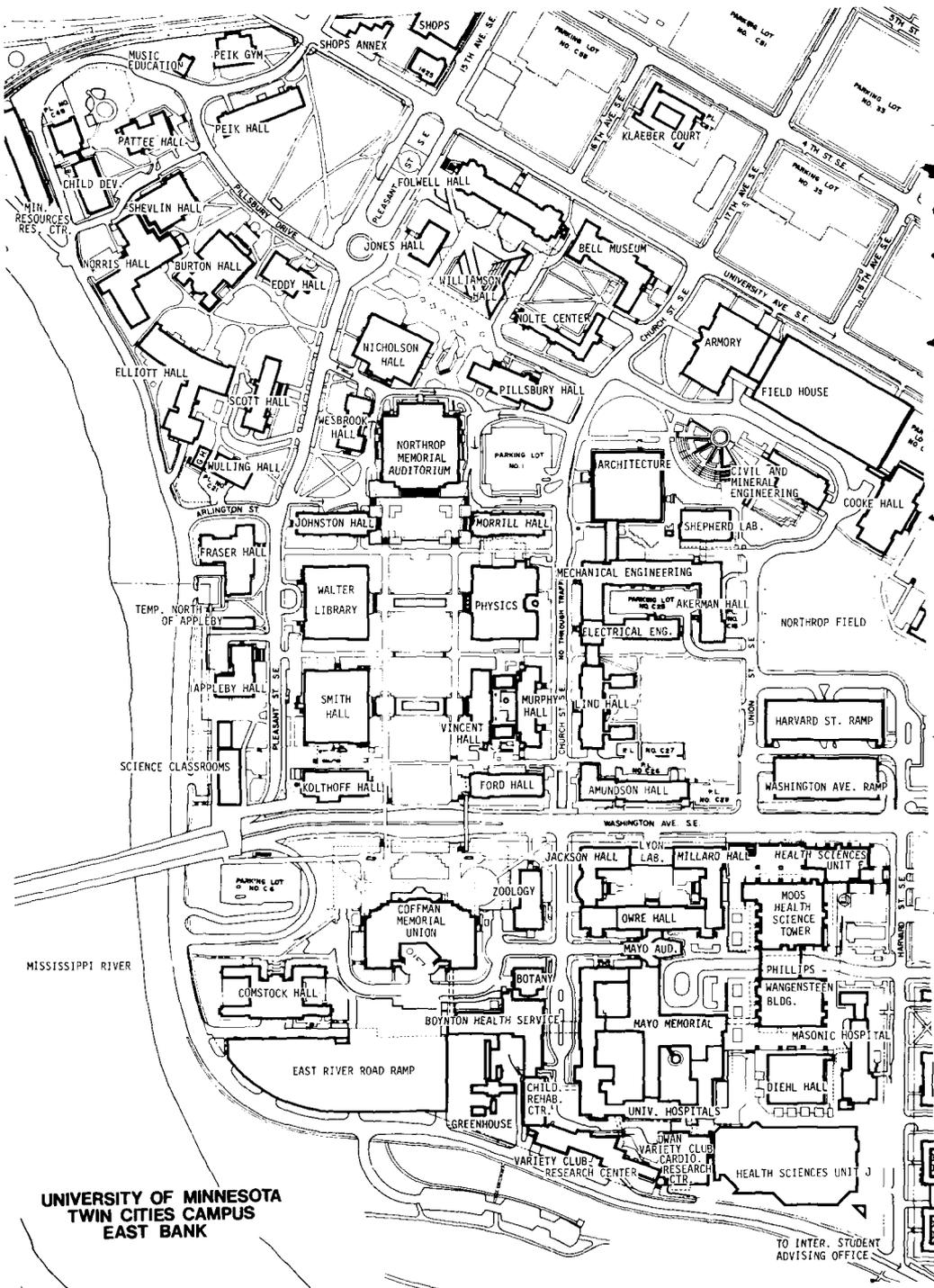
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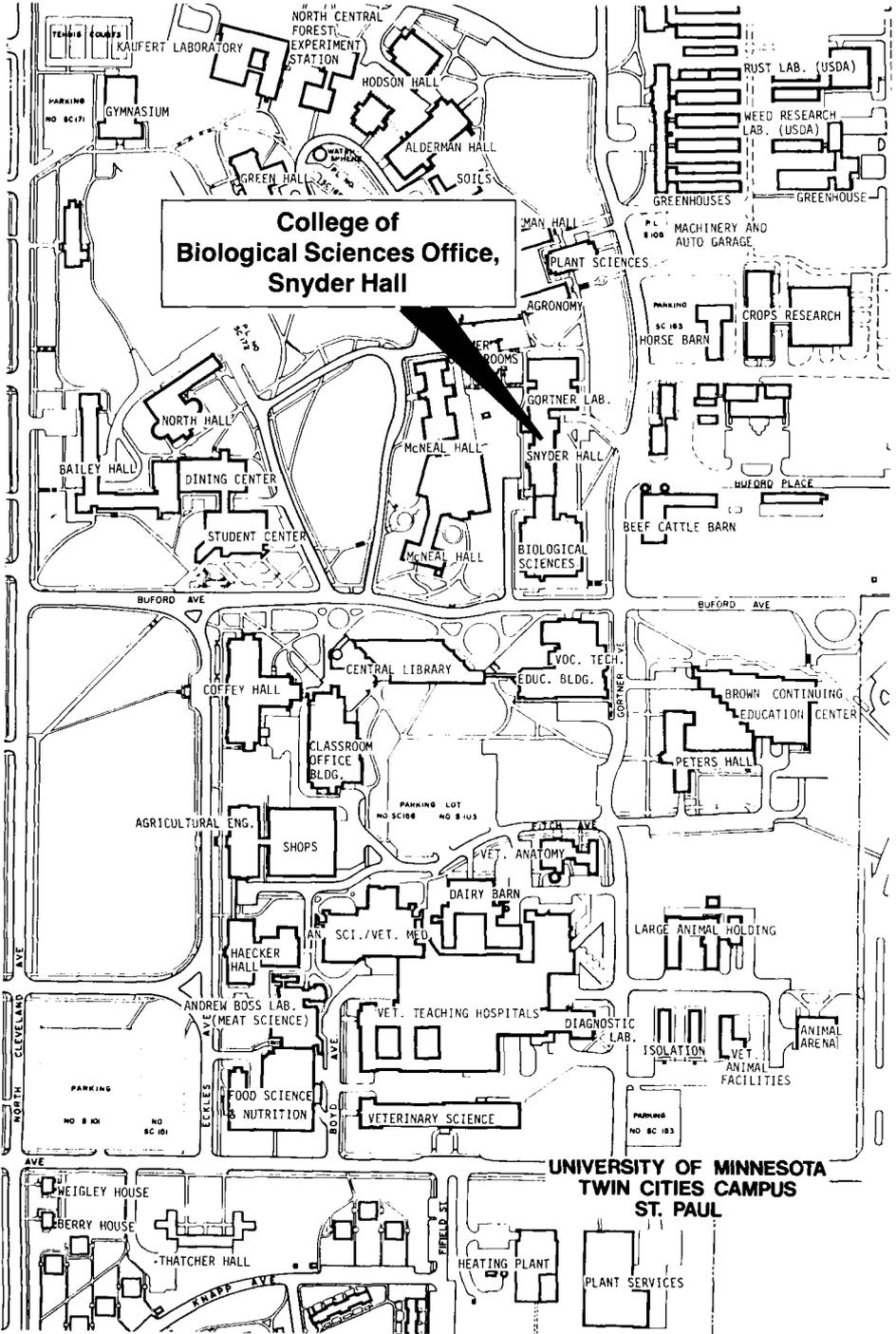
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