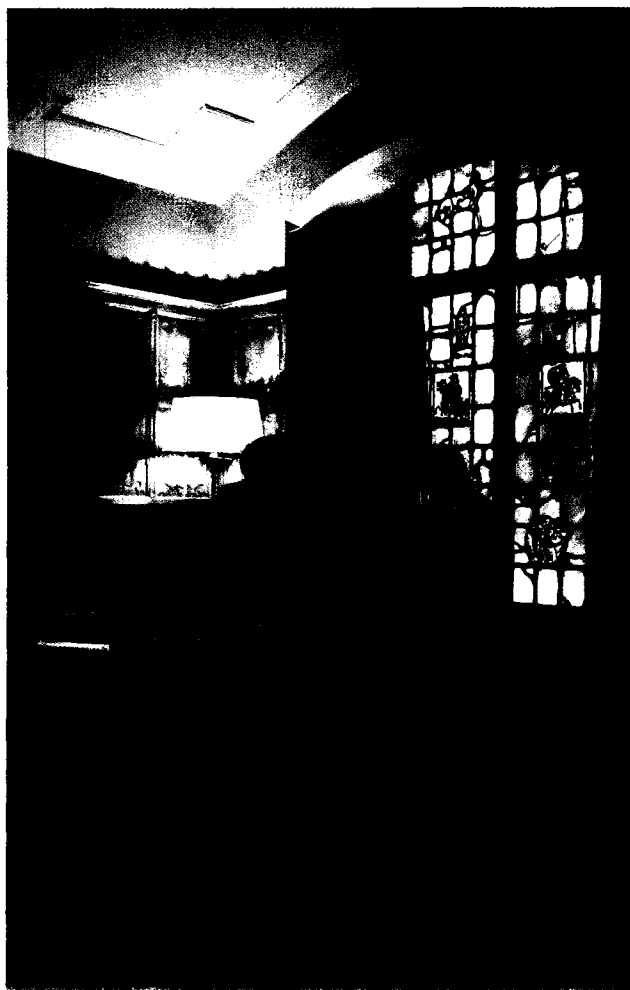


# University of Minnesota Bulletin 1985-87



# 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 (612/373-3648).

## 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, or veteran status. 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, Acting Director, Office of Equal Opportunity and

Affirmative Action, 419 Morrill Hall, University of Minnesota, 100 Church Street S.E., Minneapolis, MN 55455 (612/373-7969), or to the Director of the Office of Civil Rights, Department of Education, Washington, DC 20202, or to the Director of the Office of Federal Contract Compliance Programs, Department of Labor, Washington, DC 20210.

## Postal Statement

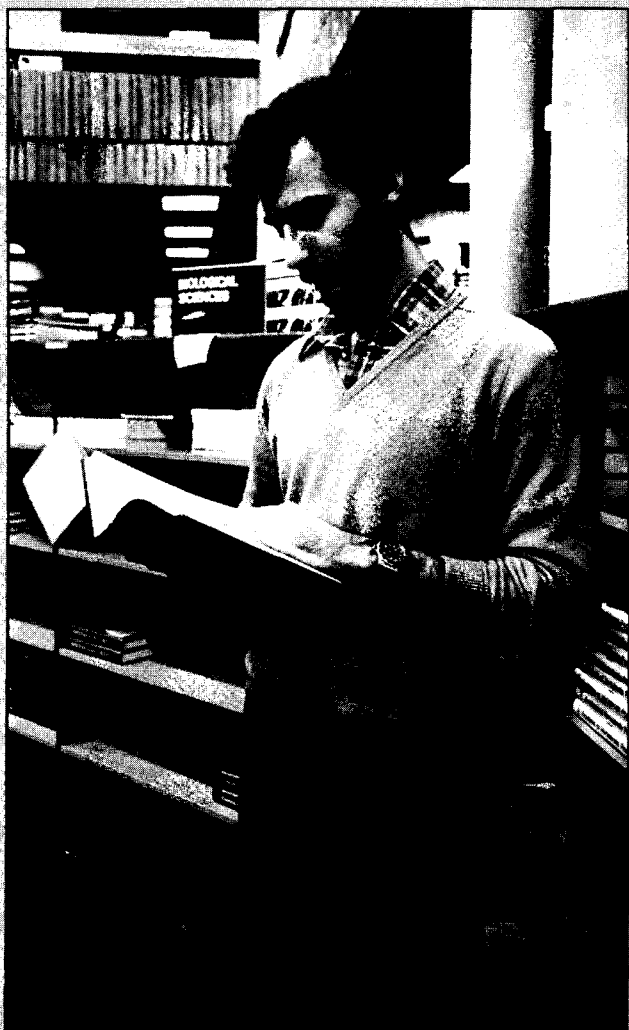
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*Cover Photo:* The James Ford Bell Library is part of the vast University of Minnesota library system open to all students.

# Programs and Services



# Programs and Services

## Purpose

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

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

## Undergraduate Programs

The bachelor of science is the baccalaureate degree offered by the College of Biological Sciences. Majors are offered in biochemistry, biology, botany, genetics and cell biology, and microbiology. The degree can be earned with honors if a stu-

dent 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) 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 as biologists, great emphasis must be given to training in the physical sciences; and (3) core courses should emphasize physical science methodologies in the solution of biologically important problems. Specific requirements for the various major fields of study are listed under Major Requirements and Course Descriptions.

**Liberal Education**—The college faculty believes that all students, whatever their area of specialization or vocational goals, should hold in common the search for a liberal education. In the broadest sense, a liberal education frees individuals from the limitations of their powers of judgment and choice that result from ignorance. Specifically, a liberal education asks individuals to seek: control over the general intellectual instruments for ac-

quiring and communicating knowledge, primarily the instruments of language and number; understanding of the ways scientists contribute to knowledge; historical and philosophical perspective on the nature of their own lives and the world in which they live; and appreciation of the creative insights into life and nature provided by literature and the arts. To help achieve these goals, the College of Biological Sciences requires all students to distribute a portion of their course work in areas of study outside of those most directly linked to their specialized interests in science.

**Professional Advancement and Career Opportunities**—The bachelor of science degree qualifies graduates for a broad range of laboratory, office, or field positions with government agencies and in the private sector. CBS students entering full-time employment immediately following graduation frequently take research scientist and laboratory technician positions. More than half of CBS graduates elect to pursue advanced study immediately following receipt of the B.S. degree (approximately 35% are admitted to professional schools and 18% enter graduate programs); the percentage of each graduating class that pursues advanced training increases over time. Details about follow-up studies of graduates, both bachelor of science and advanced, are available on request in 223 Snyder Hall.

## Graduate Programs

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

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

*Biochemistry*—John Lipscomb

*Botany*—Iris D. Charvat

*Cell and Developmental*

*Biology*—Stuart F. Goldstein

*Ecology*—Kendall W. Corbin

*Genetics*—Michael J. Simmons

*Microbiology*—Peter G. W. Plageman

*Plant Physiology*—Thomas K. Soulen

*Zoology*—Donald E. Gilbertson

## Academic Resources

Students should be aware of *primary sources of information* within the college. Each department has a *director of undergraduate studies* who has major responsibility for assisting undergraduate students (see 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). A complete list of faculty is provided in the last section of this bulletin.

**Faculty Advisers**—A faculty adviser is identified for each upper division student

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## Programs and Services

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

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

**Bell Museum of Natural History**—Located at Church and University Avenues S.E., Minneapolis, this museum features diorama exhibits of Minnesota wildlife, the Touch and See Room, and the Jaques Gallery of natural history art. It also houses extensive research collections of birds, mammals, reptiles, amphibians, and fish as well as the University's natural history library. Groups of 10 or more who wish to visit the museum should make reservations. Guided tours are available to groups upon advance request. Interested students may gain valuable experience and part-time employment as museum tour guides. The Blue Heron Bookshop offers an excellent selection of field guides and other natural history books for adults and children as well as records of bird and animal calls. Public programs are offered at scheduled times during the year. All museum programs are open to the public, many without charge. Call 612/373-2423 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 field research, but also provides unique opportunities for research projects and summer employment. For student opportunities, contact the student services office (612/373-3648) or the Program Director of Cedar Creek Natural History Area (612/373-5646).

**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 612/373-3792 for further information.

**Gray Freshwater Biological Institute**—Located at the junction of County Roads 15 and 19 in Navarre, the Gray Freshwater Biological Institute is a research facility where faculty and staff members, postdoctoral fellows, and graduate students from several disciplines conduct basic research dealing with problems of fresh water. Group tours of the facility are available to the general public and may be arranged by calling the Freshwater Biological Research Foundation (612/471-8407).

**Institute for Advanced Studies in Biological Process Technology**—The institute, part of the Biotechnology Research Center, takes advantage of the unusual breadth of interest and expertise of faculty at the University to investigate molecular and cell biology, bioreactor technology, and separation processes, as they relate to biotechnology. The institute promotes collaboration between University researchers and industry, strengthens the ability to meet increasing demands for students trained jointly in biological and engineering disciplines, and meets the nation's needs for coordination between basic research efforts and industrial applications.

**Lake Itasca Forestry and Biological Station**—Information about summer biology offerings is contained in the *Itasca Biology Program Bulletin*. Reservations for and questions about the Itasca program should be directed to the Director, Itasca

Biology Program, 349 Bell Museum of Natural History, University of Minnesota, 10 Church Street S.E., Minneapolis, MN 55455 (612/373-1292).

## Student Organizations and Governance

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

**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 (373-3648) or the genetics and cell biology department office (373-0966).

**Microbiology Club**—The Microbiology Club was formed in 1983 and became the first student chapter of the American Society of Microbiologists. News of the club's activities can be found in the student services office (373-3648) or the microbiology department office (373-9501).

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

**Biological Sciences Alumni Society (BSAS)**—The society was established and formally recognized by the University of Minnesota Alumni Association in 1980. The purpose of the society is to organize a professional association of significance to biological sciences alumni and former students, and to encourage and stimulate the relationship between the students, faculty, alumni, and community. The society has made a special commitment to sponsor programs that will enhance the opportunities available to current students and encourages the participation of student members. To facilitate a close working relationship, the president of the BSSB is a member of the board of directors of the alumni society. Alumni volunteers, working with the CBS Career Information Office, have developed a career information network to assist current students and graduates in exploring career options. The society sponsors undergraduate merit scholarships, 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 (373-1190).

## Student Services

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

**Career Information Office**—The Career Information Office is located at 229



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## Programs and Services

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Snyder Hall on the St. Paul campus (612/373-1651). The office provides information about career opportunities in the biological sciences at the B.S., M.S., and Ph.D. levels as well as assistance in selection of programs and completion of application procedures for 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.

**Financial Support**—A limited number of small scholarships are available to particularly meritorious students, through the sponsorship of the Biological Sciences Alumni Society. In some instances, small competitive grants to support undergraduate research may be available through a formal application process. 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 offices and units that offer specific services, including:

Boynton Health Service  
Housing Office  
International Student Adviser's Office  
Libraries  
Minority and Special Student Affairs  
Office for Students with Disabilities  
Office of Student Financial Aid

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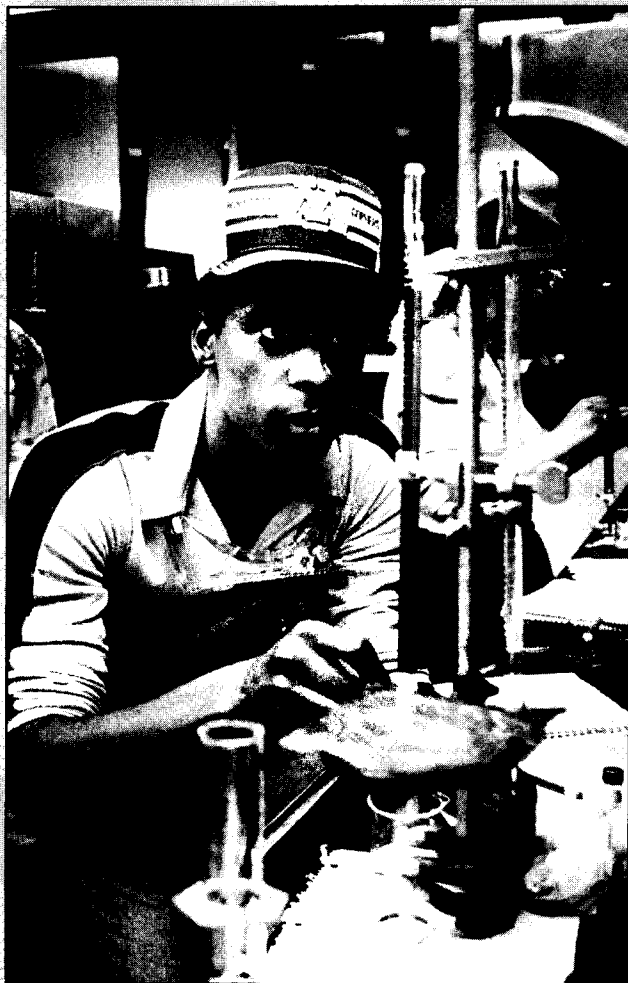
Placement Offices  
Recreational Sports  
St. Paul Health Service  
Student Counseling Bureau  
Student Employment Service  
Student Legal Service  
Student Ombudsman Service  
Student Organization Development Center  
Veterans Programs

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

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

# 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. Course work in the biological sciences is based on a sound foundation in the mathematical and physical sciences as well as a broadly based background in the liberal arts. In preparation for admission to the College of Biological Sciences, students beginning their work at the University may enter any unit that enrolls freshmen and, with the advice and counsel of a biology adviser, take courses that will provide an adequate background. Students should refer to the bulletins of the various colleges for information regarding their admission criteria.

## Affirmative Action Policy

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

The requirements for admission to CBS, an upper division college, consist of completion of a specified minimum number of college credits, completion of

specific course work prerequisites, and achievement of a certain grade performance level in such course work. There is no limit on the number of students admitted. To the extent possible from the information available regarding a particular applicant, applications are given individualized attention, and such factors as racial and cultural background and economic or educational disadvantage are considered carefully to prevent excluding students whose academic potential for success might be misjudged based on traditional predictors alone.

Successful affirmative action, however, involves more than just sensitive evaluation at the point of admission. Through its Office of Minority and Disadvantaged Student Affairs, which reports directly to the college dean, the college provides academic and counseling/advising services to racial minority and other disadvantaged University students prior to application to CBS (see 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 course work and research experiences.

Specific requirements for admission are satisfactory completion of:

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

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

### Admission Procedures

**Admission Period**—The deadline for receipt of complete applications (including transcripts) is July 15 for fall quarter (students are encouraged, however, to apply by May 15 to participate in annual program planning); 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, along with two copies of the student's transcript, should be submitted to 223 Snyder Hall.

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

**Adult Special Status**—Registration as an adult special student provides 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 course work for master's degree programs may be transferred from work taken as an adult special, summer session, or continuing education and extension student. Admission is completed through the Office of Admissions and Records, 130 Coffey Hall (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 mini-

# 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 <sup>1</sup>	—————											
Latest Possible												
<b>A. Prerequisites</b>												
Calculus (three quarters)		—————		—	—	—	—					
General Chemistry (two quarters)	—————			—	—							
Organic Chemistry (two quarters with lab)				—————			—	—	—			
Physics <sup>2</sup> (three quarters)				—————			—————			—	—	—
General Biology (one quarter)	—————					—						
<b>B. Biology Core<sup>3</sup></b>												
Biol 3011, Animal Biology				*		—————						—
Biol 3012, Plant Biology				*		—————						—
Biol 5013, Microbiology							—————					—
Biol 5041, Ecology							—————					—
Biol 5001, Biochemistry						*	—————			—		
Biol 5003, Genetics							—————			—————		—
Biol 5004, Cell Biology							—————			—————		—

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

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

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

imum of 75% of their University of Minnesota residence credits (required for graduation) in courses in which grades of A, B, C, or D have been received.

b. A minimum of 36 credits as a student registered in the College of Biological Sciences.

c. A minimum of 30 credits on the Twin Cities campus in 3xxx and 5xxx courses that are specifically required for the student's major. Ordinarily this will include 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 Rhet 1101/1104 or equivalent) and one advanced course in writing to be selected from the following: Comp 3015 or 3027; Rhet 3551 or 3562.

4. Foreign Language—Either two years of study of a single foreign language in high school or three quarters (one year) of study of a single foreign language in college or demonstration of equivalent proficiency satisfactory to the appropriate language department.

5. The all-University liberal education distribution requirements:

Group A—Language, Logic, Mathematics, and the Study of Argument

Group B—The Physical and Biological Universe

Group C—The Individual and Society

Group D—Literary and Artistic Expression

The mathematics and science course work that is required of CBS students (see items 6 and 7) 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.

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 4 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 three-quarter course, with laboratory, that requires college-level mathematics as a prerequisite (Phys 1271-1281-1291 with 1275-1285-1295 or 1104-1105-1106 with 1107-1108-1109). By petition, a two-quarter sequence (Phys 1041-1042 with 1045-1046) plus an additional 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 the 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

## Degree Requirements and Procedures

background from high school or individual study are encouraged to take the Biol 1009 exemption examination.

b. The following three courses: Animal Biology (Biol 3011, 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 5001, 5002, 5011, 5015, 5030, 5605, 5606

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 participants. In the fall quarter, the seminar is a forum to discuss special topics focused on a theme of general rele-

vance 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 at the time of admission to the College of Biological Sciences. 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 3.20 and present reasonable evidence of potential to attain the grade point average required for graduation with honors (see below). Application forms are available in 223 Snyder Hall.

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

1. At least 60 credits in upper division courses (3xxx and 5xxx) at the University of Minnesota, Twin Cities campus
2. Two quarters (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-N registration with the minimum grade point averages specified below:

*cum laude*: minimum 3.25 GPA

*magna cum laude*: minimum 3.40 GPA

*summa cum laude*: minimum 3.60 GPA

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



## Degree Requirements and Procedures

University of Minnesota. Full information about CLEP tests may be obtained from the student services office, 223 Snyder Hall.

### Special Learning Opportunities

Students are encouraged to explore learning experiences through activities outside of the usual curriculum. Many students plan projects they carry out under faculty supervision in research laboratories and in field settings; credit assignments are arranged on an individual basis through a variety of mechanisms (see Independent Study). Some students seek employment as undergraduate teaching and research assistants, as museum tour guides, or in similar positions. Most departments offer special seminars for undergraduates (see 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 next page). Students who miss the first class session may lose their places in courses for which they are registered.

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

**Registration Dates**—For continuing students, these dates are scheduled during August for fall registration and during the last four weeks of fall and winter quarters for winter and spring registrations, respectively. Specific dates are announced in the Official Daily Bulletin column in the *Minnesota Daily*. 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 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 grades. Both the old and the new grade will be included on the academic record. Students are *not required* to repeat a failed course unless it is needed to meet a prerequisite or other requirement.

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

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

**Late Additions and Cancellations**—Registration changes (especially additions) after a quarter opens are discouraged. However, students are per-

## Degree Requirements and Procedures

mitted 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 and approval of the college. During weeks three to five, changes in registration require approval of both the instructor and the student services office. Cancellation after the sixth week of class requires a petition to the scholastic standing committee and will be allowed only for unusual circumstances.

**Cancelling Out of College**—To leave the University during a given quarter, a student must cancel all current registration 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 course work each quarter. When outside jobs or responsibilities demand 20 or more hours of time a week, students are advised to take a reduced course load. In general, it is unwise to devote more than 15 to 20 hours a week to work or outside activities while attending college. A credit load exceeding 19 credits per quarter requires college approval. 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, home-work, and other study.

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

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

### Satisfactory Progress

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

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

**Scholastic Probation**—Students are expected to complete a minimum of 50% 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 per-

centages 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 standard work usually places a student in jeopardy of not graduating. Continuation in the college is, therefore, not likely to serve that student's interests, and he or she may be suspended from further registration.

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

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

## Regulations

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

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

## Graduation

**Filing the Application**—Two quarters before they intend to graduate, students must file an application for graduation 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 advisers and the appropriate college offices at the earliest possible date.

**Credits in Graduate School**—Seniors who have a maximum of nine credits to complete for the bachelor's degree may petition to take a limited amount of work for graduate credit. Previous approval must

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## Degree Requirements and Procedures

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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, division, or school 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—**  
Robert Glass

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, 3336. (In addition, 5365 is recommended.) or Chem 3303. (In addition, 5365 is recommended.)

**Analytical Chemistry**—Chem 1133. (In addition, 5133 is recommended.) or Chem 3100, 3101. (In addition, 5126 or 5133 is recommended.)

**Mathematics**—Math 3211. (In addition, 3221 is recommended.)

**Physical Chemistry**—Chem 5533, 5534, 5535 plus 5536 or 5538 or Chem 5520, 5521.

German is the recommended foreign language.

## Courses

**1301f,w. 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.

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

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

**1303w,s. ELEMENTARY BIOCHEMISTRY LABORATORY.** (2 cr; prereq 1301 or Chem 1002) Problems and exercises in chemical and biochemical techniques. Discussion of methods and concepts.

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

**Biol 5001f,w,s,su. BIOCHEMISTRY.** (4 cr, §5001; prereq Biol 1009, 12 cr organic chemistry or #) Biochemistry and biophysics of cells; emphasis on enzyme catalysis, cellular energetics, biosynthesis of cellular constituents and cellular regulatory mechanisms.

**5002w,s. BIOCHEMISTRY TOPICS.** (3 cr; prereq Biol 5001) Biol 5001 and BioC 5002 constitute a two-quarter sequence for undergraduate and graduate students lacking physical chemistry, and serve as prerequisites for certain advanced courses.

**5025f,w,s. LABORATORY IN BIOCHEMISTRY.** (2 cr; prereq Biol 5001 or ¶Biol 5001) Discussions of techniques and problem-solving approaches illustrated with laboratory experiments and demonstrations.

**5525 (formerly 5522). 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.

**5526 (formerly 5523, 8260). 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 (formerly 5523). 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 (formerly 5524). 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.

**5744w. 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.

**5751f-5752w-5753s. GENERAL BIOCHEMISTRY.** (4 cr per qtr, §MdBc 5751-5752-5753; prereq 3 qtrs organic chemistry, 2 qtrs physical chemistry, 1 qtr biochemistry or #) Structure, function, metabolism, and metabolic regulation of components in biological systems.

**5950f,w,s. SPECIAL TOPICS.** (1-5 cr; prereq #, Δ)

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



# Major Requirements and Course Descriptions

**5990. DIRECTED RESEARCH.** (Cr ar; prereq #,  $\Delta$ )

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**

**8210. ADVANCED TOPICS IN DNA BIOCHEMISTRY**

**8212. ADVANCED TOPICS IN RNA BIOCHEMISTRY**

**8215. ADVANCED TOPICS IN LIPID BIOCHEMISTRY**

**8220. ADVANCED TOPICS IN CARBOHYDRATE BIOCHEMISTRY**

**8225. TRACER TECHNIQUES**

**8230. ADVANCED TOPICS IN MEMBRANE BIOCHEMISTRY**

**8232. ADVANCED TOPICS IN 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.

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

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

**1106f,w,s,su. GENERAL ZOOLOGY.** (5 cr; prereq 1009)  
Survey of animal phyla; structure, function, behavior, adaptation, and evolutionary relationships.

**1951f, 1952w, 1953s. BIOLOGY COLLOQUIUM.** (1 cr/f, 1 or 2 cr/w,s; for prospective majors; S-N only; prereq 1009 or ¶1009)  
Orientation to the biological sciences; opportunity for interaction with other biology students and faculty members.

**3011f,w,s,su. ANIMAL BIOLOGY.** (5 cr, §1106; prereq 1009, Chem 1005) Goldstein, Kerr, Rosenberg  
Comparison of ways different phyla have solved similar physiological problems. Laboratory includes survey of major animal groups and physiological experiments.

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

**3042f,w,s. FIELD PROBLEMS IN ECOLOGY.** (2 cr; prereq 5041 or EBB 3004 or #)  
Student research projects on selected ecological problems.

**3051f,su. 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.

**3112w. BIOLOGICAL RHYTHMS.** (4 cr, §5112; prereq 1009 or #) Koukkari, Regal  
Timing mechanisms and rhythms of organisms in physiological processes, ecological adaptation, and health; current hypotheses concerning their cellular nature.

**3950Hf,w,s. UNDERGRADUATE SEMINAR.** (2 cr per qtr; S-N only)  
Each quarter different faculty members lead groups of students in discussions on topics of current interest.

**3960Hf,s. HONORS SEMINAR.** (1 cr per qtr; S-N only; prereq  $\Delta$ ; limited to participants in CBS Honors Program) Staff  
Oral reports on topics of current interest to biologists. Progress reports on laboratory and field research by students.

**3980f,w,s. DIRECTED INSTRUCTION.** (1-5 cr per qtr; prereq #) Staff

**5001f,w,s,su. BIOCHEMISTRY.** (4 cr, §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.

**5003f,w,s,su. 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.

**5004f,w,s,su. CELL BIOLOGY.** (3 cr; prereq 5001) Blumenfeld, Cunningham, Hooper  
Structures and functions of membranes, organelles, and other macromolecular aggregates found in plant, animal, and bacterial cells. Cell form and movement, intercellular communication, transport, and secretion.

**5013f,w. 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.

**5041f,w,su. ECOLOGY.** (4 cr; prereq 1009, 1103, 1106 or 3011 or 3012, Math 1211 or #)  
Interactions of plant and animal populations and their environments. Organization, functioning, and development of ecological systems; population growth and regulation. Human impact on the biosphere in modern times.

**5061. DEVELOPMENTAL BIOLOGY.** (3 cr; prereq 5003 and 5004) Kerr  
Developing systems and control mechanisms of development, from the molecule to the organism.

**5065. LABORATORY IN DEVELOPMENTAL BIOLOGY.** (2 cr; prereq 5061 or ¶5061)  
Laboratory to accompany 5061.

# Major Requirements and Course Descriptions

**5112. RHYTHMS AND CIRCADIAN REGULATION.** (5 cr, §3112; prereq 15 cr biology, 10 cr chemistry or #) Koukkari

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

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

**5501s. BIOCHEMICAL EVOLUTION.** (4 cr; prereq 5 cr biochemistry) Seal

Molecular evolution covering prebiotic evolution and the phylogeny of important functional molecules and biochemical systems in living organisms.

**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  $\Delta$ ) 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

**5816. FIELD BIOLOGY PHOTOGRAPHY.** (5 cr; A-N only; prereq  $\Delta$ , 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  $\Delta$ )

**5870su. ITASCA SEMINAR.** (1 cr; prereq  $\Delta$ ) Staff  
Topic selected and scheduled during registration by interested staff members and students.

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

**8910f. WORKSHOP ON TEACHING COLLEGE BIOLOGY**

**8950. GRADUATE SEMINAR**

**8970. SPECIAL TOPICS**

**8990. GRADUATE RESEARCH**

## Botany (Bot)

**Director of Undergraduate Studies—**  
Tom Soulen

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

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

## 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

**1009s. MINNESOTA PLANT LIFE.** (4 cr; suitable for nonmajors) Morley  
Identification of the more characteristic and conspicuous Minnesota plants, including many lower forms, with discussion of their basic distinctions, life cycles, habitat requirements, distribution, vegetation types, and ecological relations. Lectures, demonstrations, six field trips.

**1012. PLANTS USEFUL TO HUMANS.** (4 cr; for majors or nonmajors) Jonas  
Roles that plants have played in human biological and cultural development. Lectures and demonstrations.

**Biol 1103w,s,su. 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, Charvat  
Levels of organization of plants, plant function, plant growth and development, plant reproduction.

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

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

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

**3201w. INTRODUCTORY TAXONOMY.** (4 cr; prereq Biol 1103 or 3012) Morley  
Taxonomy of ferns, gymnosperms, and flowering plants (representative material drawn largely from Minnesota spring flora). Families of plants and their relationships; floral structure and function; taxonomic terms; nomenclature; literature; methods of collection and identification. Two or three field trips.

**3950f,w,s,su. UNDERGRADUATE PROSEMINAR.** (1 cr per qtr; prereq #)  
Biological topics of current interest.

**5103f. BIOLOGY OF NONVASCULAR PLANTS.** (5 cr; prereq Biol 1103 or 3012; offered 1986-87 and alt yrs) McLaughlin  
Algae, fungi, lichens, and bryophytes. Characteristics of groups, evolutionary relationships, life cycles, comparative morphology (including ultrastructure), comparative nutrition. Laboratory emphasizes living material and isolation of algae and fungi into culture.

**5105. MORPHOLOGY OF VASCULAR PLANTS.** (5 cr; prereq Biol 1103 or 3012 or #)  
Vegetative and reproductive structure of living and fossil vascular plants. Evolutionary relationships based on phylogenetic principles.

**5111w. DEVELOPMENTAL PLANT ANATOMY.** (5 cr; prereq Biol 1103 or 3012) Biesboer  
Microscopic structure of vascular plants; development in root, stem, and leaf.

**5131f,s. SURVEY OF PLANT PHYSIOLOGY.** (4 cr, §3131, §PIPh 3131, §PIPh 5131; prereq Biol 1103 or 3012, BioC 1302 or ¶BioC 1302 or Biol 5001) Soulen, Frenkel  
Physiological principles underlying processes that occur in living plants, with emphasis on higher plants. Growth and development, mineral nutrition, transport, water relations, and metabolism especially emphasizing photosynthesis and nitrogen assimilation. Includes a weekly discussion section.

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

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

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

**5184f. PLANT GROWTH AND DEVELOPMENT.** (3 cr, §PIPh 5184; prereq 5131 or equiv) 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.

# Major Requirements and Course Descriptions

**5205s. FLORA OF MINNESOTA.** (4 cr; prereq 3201 or #) Ownbey

Vascular plants of Minnesota; taxonomic and floristic relationships; geographical distribution and variation; collection and identification. Field trips.

**5211f. SURVEY OF ANGIOSPERM FAMILIES.**

(5 cr; prereq 3201 or #; offered 1985-86 and alt yrs) Morley

Characteristics and relationships of orders and families of flowering plants on a worldwide basis.

**5212f. PRINCIPLES OF ANGIOSPERM PHY-**

**LOGENY.** (3 cr; prereq 3201 or #; offered 1986-87 and alt yrs) Morley

Evolutionary relationships and the various means of judging them within the angiosperms. Laboratory investigation of representative and critical groups.

**5231f. INTRODUCTION TO THE ALGAE.** (5 cr;

prereq 10 cr in botany or biology or #; offered 1985-86 and alt yrs) McLaughlin

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

**5960f,w,s,su. SPECIAL TOPICS.** (Cr ar; prereq #.

Δ) Staff

Treatment in depth of a specialized botanical topic.

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

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

**5990. DIRECTED RESEARCH.** (Cr ar; prereq #,

Δ)

Laboratory or field investigation of selected areas of research.

## Courses Offered at Lake Itasca Forestry and Biological Station

**5801su. PLAINS AND BOREAL FLORA.** (5 cr; limited to 20 students; prereq course in taxonomy, Δ; offered annually)

Survey of the summer flowering plants and ferns of the state with particular reference to the local flora. Identification by technical keys; important plant families; field recognition of common species; habitat preferences; collecting methods; literature; taxonomic methods.

**5803su. PLANT SPECIATION.** (5 cr; prereq course in genetics or #, Δ; limited to 20 students; offered when feasible)

A study of variation within and between wild populations of plants and its theoretical role in speciation. Natural hybridization and its effects.

**5805su. AQUATIC FLOWERING PLANTS.** (5 cr; limited to 20 students; prereq course in taxonomy, Δ; offered when feasible)

The higher plants of aquatic and marsh habitats. Identification and collection; association of species; relations to the habitat; adaptive morphology and food value to wildlife.

**5811su. FRESHWATER ALGAE.** (5 cr; limited to 20 students; prereq 10 cr botany, biology or zoology, Δ; offered annually)

The developmental morphology and taxonomy of freshwater algae, including the relationship of algae to their environment. Identification of field collections by technical keys, collecting and analytical methods, and utilization of information for recognizing distribution patterns.

**5815su. BRYOPHYTES.** (5 cr; limited to 20 students; prereq 10 cr biology or #, Δ; offered when feasible)

Field and laboratory study of the mosses and liverworts of Minnesota.

**5821su. LICHENS.** (5 cr; limited to 20 students; prereq 10 cr in botany or zoology or #, Δ; offered when feasible)

Taxonomy, ecology, and floristics of lichens of northern Minnesota; identification, sampling methods, microchemistry as a taxonomic tool.

**5825. BIOLOGY OF THE FERNS.** (5 cr; prereq Δ; offered when feasible)

Field and laboratory study of the lower vascular plants (including the ferns, horsetails, club mosses, and quillworts), their evolution, classification, morphology, and ecology. Emphasis on field exploration for rare taxa, including natural hybrid forms and life cycles.

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

Individual research for undergraduates and graduates.

## For Graduate Students Only

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

**8301. POLLEN MORPHOLOGY AND QUATERNARY PALYNOLOGY**

**8950f,w,s. SEMINAR**

**8970. SPECIAL TOPICS**

**8990f,w,s,su. RESEARCH PROBLEMS**

## Ecology and Behavioral Biology (EBB)

**Director of Undergraduate Studies—**  
Frank Barnwell

Ecologists study the evolutionary adaptations of plants and animals to the environment. The ecological perspective encompasses the growth and maintenance of populations and their interactions in communities, and the interrelationships among organisms and physical events in terrestrial and aquatic ecosystems. The

behavioral biology perspective deals with adaptations to the environment, mechanisms of behavior, and the evolution of social systems.

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

**3960f. RESEARCH TOPICS IN ECOLOGY AND BEHAVIORAL BIOLOGY** (1 cr per qtr; S-N only; prereq #)

Lectures on and discussion of current research in the department.

**5970. DIRECTED STUDIES.** (Cr ar, §3970; prereq #, 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 #; offered 1985-86 and alt yrs) 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 1986-87 and alt yrs) 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) Merrell  
Survey of evidence for and causes of biological evolution.

**5051. ANALYSIS OF POPULATIONS.** (4 cr, §8001; 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.

**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.

# Major Requirements and Course Descriptions

## Organismal Biology and Physiological Ecology

**5112. INVERTEBRATE BIOLOGY.** (5 cr; prereq Biol 1106 or 3011 or #) Barnwell  
Morphology, physiology, behavior, ecology, and evolution of invertebrate groups. Laboratory study of living marine, freshwater, and terrestrial representatives.

**5114w. VERTEBRATE BIOLOGY.** (4 cr; prereq Biol 1106 or 3011; offered 1985-86 and alt yrs) Birney  
Vertebrates; their biology, taxonomy, and distribution.

**5116. INTRODUCTION TO ANIMAL PARASITOLOGY.** (5 cr; prereq Biol 1106 or 3011) Gilbertson  
Parasitic protozoa, worms, and arthropods and their relation to diseases of humans and animals.

**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 1985-86 and alt yrs)  
Patterns and problems in evolution at the species level and above in the context of an introduction to vertebrate phylogeny, ecology, and adaptations. Lectures, demonstrations, and field trips.

**5129. MAMMALOLOGY.** (5 cr, §FW 5129; prereq Biol 1106 or 3011 or #; offered 1986-87 and alt yrs) 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 1986-87 and alt yrs) Regal  
Distribution, classification, and evolution of amphibians and reptiles of the world. Physiological, morphological, and behavioral aspects of adaptive trends. Laboratory and lecture.

**5134. INTRODUCTION TO ORNITHOLOGY.** (5 cr; prereq Biol 1106 or 3011) Tordoff, Warner  
Laboratory and field course in structure, classification, distribution, migration, habits, habitats, and identification of birds. Weekend trips scheduled.

**5136. ICHTHYOLOGY.** (4 cr; prereq 15 cr incl Biol 1106 or 3011) Underhill  
Biology of fishes including development, systematics, anatomy, physiology, and ecology.

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

The environment imposes passive stresses upon organisms—not equilibrium. Various physiological adaptations allow maintenance of homeostasis. The passive organism: environment "stresses" and biological mechanisms by which they are counteracted.

## Behavior

**5149. BEHAVIORAL GENETICS.** (4 cr; A-N only; prereq Biol 5003 or GCB 3022/5022 or equiv) Merrell  
Application of genetic principles to the study of behavior with primary emphasis on animal behavior.

**5321. EVOLUTION OF SOCIAL BEHAVIOR.** (4 cr; prereq Biol 1106 or 3011 or #) McKinney  
Introduction to current theories and concepts relating to mating systems, spacing systems, and cooperative behavior in animals.

**5322. COMPARATIVE ETHOLOGY.** (4 cr; prereq 5321 or ¶5321, #) McKinney  
Evolution and adaptive significance of behavior, primarily in vertebrates. Emphasis on comparative methods.

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

**5604. BIOLOGICAL LIMNOLOGY.** (3 cr; prereq 5601 or 5612 or #) Megard  
Survey of the taxonomy and natural history of planktonic and benthic organisms in lakes and streams, descriptions of planktonic and benthic populations, and analyses of processes that regulate population densities of aquatic organisms.

**5605. LABORATORY IN BIOLOGICAL LIMNOLOGY.** (2 cr; prereq 5601 or 5812 or #) Megard  
The morphology and identification of planktonic and benthic organisms in lakes and streams, use of sampling equipment and instruments in the field, and analysis of field data.

**5606. ECOLOGY OF FISHES.** (5 cr; prereq Biol 1106 or 3011, EBB 5136 plus 10 cr in the biological sciences; offered 1985-86 and alt yrs) Underhill  
Ecological requirements of fishes with emphasis on nongame species; habitat, food, interactions among species, and behavioral, anatomical, and physiological adaptations. Fishes in the aquatic ecosystem with emphasis on fresh waters.

**5607. ECOLOGY OF ANIMAL PLANKTON.** (4 cr; prereq Biol 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.** (3 cr; prereq 3004 or 5601 or Biol 5041, Chem 1002 or 1005; offered 1986-87 and alt yrs) Davis  
Nature and development of terrestrial wetland, and aquatic ecosystems. Analysis of energy flow and element cycling in relation to environmental controls, self-regulation, natural and human disturbances.

**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, Shapiro  
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

**3800su. INTRODUCTION TO FIELD RESEARCH.** (10 cr; limited to 20 students; prereq two courses in biology, Δ; hrs ar)

An intensive course on how to do research. A series of ecological and behavioral projects provide an introduction to the biology of forests, prairies, lakes, and marshes of the Itasca region while serving to develop individual abilities in the planning and design of experiments, acquisition and analysis of data, and the preparation of field reports. Intended for undergraduates with little or no previous experience in field biology.

**5812su. COMPARATIVE LIMNOLOGY.** (5 cr; limited to 20 students; prereq 15 cr biology, 5 cr chemistry, Δ; offered annually)  
General limnology of lakes with emphasis on the biology of lakes in the Itasca region as related to their physical and chemical stratification in summer. Team projects in field research.

**5814su. COMMUNITY STRUCTURE AND FUNCTION.** (5 cr; limited to 20 students; prereq course in ecology, Δ; offered annually) Staff  
Communities represented in Itasca Park and vicinity, with emphasis on vegetation. Patterns of distribution of the communities, their interaction with the environment, and their dynamic relationships. Methods of community description and analysis.

**5815su. 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.

**5817s,su. VERTEBRATE ECOLOGY.** (5 cr; prereq course in ecology, #, Δ)  
Field studies on populations and their relationships to local environments; habitat analysis and ecological research methods. Designed primarily for students with fisheries and wildlife management interests.

**5820su. 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.

**5831su. 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.

**5832su. 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.

**5834s,su. FIELD ORNITHOLOGY.** (5 cr; prereq Biol 1106, Δ; offered annually)  
Emphasis on the breeding season, biology, and behavioral ecology of birds in the Itasca Park region. Field trips taken to a variety of habitats to learn bird identification and observe and practice techniques for conducting field studies. Laboratory sessions investigate family distinctions and species identification. Individual field projects. Designed primarily for students with fisheries and wildlife management interests.

## For Graduate Students Only

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

- 8004w. TOPICS IN ECOLOGICAL GENETICS
- 8014s. PALEOECOLOGICAL METHODS
- 8061. SOCIAL SYSTEMS
- 8081w. NEUROETHOLOGY
- 8091w. HORMONES AND BEHAVIOR
- 8162w. WINTER ECOLOGY
- 8390. GRADUATE SEMINAR



## Major Requirements and Course Descriptions

### 8391. ADVANCED WORK IN ECOLOGY AND BEHAVIORAL BIOLOGY

### 8400. POPULATION BIOLOGY SEMINAR

### 8410. COMMUNITY ECOLOGY SEMINAR

### 8420. POPULATION BIOLOGY RESEARCH SEMINAR

### 8500. WRITING RESEARCH PROPOSALS

### 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 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 (two quarters)
- b. Biol 3950H

### c. Two of the following laboratories:

BioC 5025: Laboratory in Biochemistry  
Biol 5125: Recombinant DNA Laboratory

GCB 5001: Scanning Electron Microscopy Laboratory

GCB 5002: Transmission Electron Microscopy Laboratory

GCB 5015: Histology Laboratory

GCB 5030: Laboratory: Genetics

GCB 5605: Cell Biology Laboratory

### d. Two of the following advanced courses:

GCB 5031: Advanced Genetics I

GCB 5032: Advanced Genetics II

GCB 5033: Population and Quantitative Genetics

GCB 5048: Advanced Cell Biology I

GCB 5049: Advanced Cell Biology II

### e. One of two physiology courses:

GCB 5114 or GCB 5134.

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

## Courses

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

Human genetics; study of individuals, families, populations, and races with respect to differences in intelligence, behavior, disease, and other matters of social concern.

**3008. THE BIOLOGY OF CANCER.** (3 cr; prereq Biol 1009) McKinnell, Sheppard

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

**3022f, w, s, su. GENETICS.** (4 cr, §Biol 5003; not intended for biology majors; prereq Biol 1009) Enfield, Snyder

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

**3960. RESEARCH TOPICS.** (1 cr; S-N only; prereq Biol 5001) V Woodward

Discussions of faculty research.

**5001f. SCANNING ELECTRON MICROSCOPY LAB.** (4 cr; S-N only; prereq #) Johnson, Kuehn

Operation of scanning electron microscope (SEM) and preparation of biological samples for SEM analysis; use of SEM for research work. Charges for supplies and microscope time must be covered by student (\$200-\$400).

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

Johnson, 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 (\$175-\$200).

**5011w. GENERAL AND COMPARATIVE**

**EMBRYOLOGY.** (4 cr; prereq Biol 1106 or 3011)

McKinnell

Embryological development of vertebrates.

**5013s. MAMMALIAN REPRODUCTION.** (4 cr;

prereq Biol 3011, Biol 5001 or #; offered 1986-87 and alt yrs) Sinha

Interdisciplinary approaches in evaluating biological phenomena of reproduction incorporating basic problems, current concepts and ideas in the field. Three lectures and discussions, and an hour of independent studies/research or lab work.

**5015. HISTOLOGY: CELL AND TISSUE**

**ORGANIZATION.** (5 cr; prereq Biol 1106 or 3011, plus 4 addtl cr in the biological sciences) Cunningham

Cellular orientation used to explore organization of differentiated cells and tissues (epithelia, connective, muscle, and nerve) as they facilitate specialized functions. Lab combines experience with techniques (phase and fluorescent microscopy, autoradiography, and paraffin sectioning), EM demonstrations, and studies of prepared microscope slides.

**5022f,w,s,su. GENETICS.** (3 cr, §3022, §Biol 5003;

not open to grad students in genetics) Enfield, Snyder  
Mechanisms of heredity, their implications for biological populations, and applications to practical problems.

**5024. THE GENETICS OF DEVELOPMENT.**

(4 cr; prereq Biol 5003 or #) R Herman

Introduction to current concepts and experimental approaches concerning the genetic basis of morphogenesis and metazoan development. Organisms that are amenable to genetic analysis, including certain prokaryotes and single-cell 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.

**5031w. ADVANCED GENETICS I.** (4 cr; prereq

3022 or Biol 5003 and Biol 5001 or BioC 5751, or #)

Lefebvre, Snyder

Mechanics of inheritance. Comparative organization of genetic material in prokaryotic and eucaryotic organisms. Mutation, complementation, and recombination as operational criteria for genetic analysis.

**5032s. ADVANCED GENETICS II.** (4 cr; prereq

5031) Hackett

Action of the gene in molecular, cellular, and organismal development. Mechanisms of storage of genetic information, modes of information transfer, and mechanisms of regulating these processes in various biological systems.

**5033s. POPULATION AND QUANTITATIVE**

**GENETICS.** (4 cr; prereq 3022 or Biol 5003, course in biometry or statistics or #) Curtsinger

Genetic variation in quantitative traits with special attention to fitness. Causes of change of equilibrium in gene frequencies, heterosis and inbreeding depression, consequences of natural and artificial selection.

**5042f. QUANTITATIVE GENETICS.** (4 cr; S-N

only; prereq 5033; Stat 5301 recommended) Enfield  
Selection with reference to population changes in gene frequencies and means of quantitative characters. Information required for predicting effects of selection and related research. Emphasis on logical analysis.

**5043f. HUMAN GENETICS.** (3 cr; prereq 3022 or

Biol 5003 or #) V E Anderson

Principles of human genetics at the molecular, cellular, individual, and population levels. Chromosomal and biochemical disorders; gene mapping; mutation and natural selection; variation in intelligence and behavior; genetic screening, counseling, and therapy.

**5044w. HUMAN POPULATION GENETICS.**

(4 cr; prereq 5043, biostatistics [PubH 5452 or equiv] or #) V E Anderson

Biometric methods for research in human genetics. Use of genetic concepts and appropriate statistical techniques in exploring new problems. Use of statistical packages and genetic programs to analyze population data and model genetic systems. Individual study of current problems, and group discussion.

**5045s. MOLECULAR PRINCIPLES OF BEHAVIOR.**

(3 cr; prereq BioC 5002 or #; offered 1985-86 and alt yrs) Sheppard

Relationships between biochemistry and behavior with emphasis on diseases of human behavior, i.e., the psychoses, alcoholism, epilepsy. Simple biological systems used to study behavior.

**5046s. HUMAN BIOCHEMICAL GENETICS.**

(3 cr; prereq 5031, 5043, BioC 5002 or equiv, Biol 5004 or equiv or #; offered 1986-87 and alt yrs) Sheppard

Basic genetic, biochemical, and pathologic principles of inherited human metabolic disorders.

**5048f. ADVANCED CELL BIOLOGY I.** (4 cr; prereq

Biol 5001) Iwanij, Johnson

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.

## Major Requirements and Course Descriptions

**5049w. 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.

**5052s. 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.

**5062w. GENETICS AND SPECIATION.** (4 cr; prereq 15 cr biology incl genetics; offered 1985-86 and alt yrs) Merrell  
Application of genetic principles to problems of speciation and evolution.

**5063s. THEORETICAL POPULATION GENETICS.** (3 cr; prereq college level calculus, basic statistics and genetics; offered 1986-87 and alt yrs) Simmons  
Population genetics theory as related to problems of natural history.

**5114f. GENERAL PHYSIOLOGY.** (3 cr; prereq Biol 3011, 5001, Phys 1109 or 1295) Goldstein  
Quantitative approach to the study of cell function with emphasis on application of physical and chemical principles. Transport, electrical activity of cell membranes, cell contractility.

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

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

**5606f. BIOLOGICAL ELECTRON MICROSCOPY.** (3 cr; prereq Biol 5004 or #) Cunningham  
Theory and operation of transmission and scanning electron microscopes. Demonstrations and discussion of preparation techniques for biological material including freeze-etching, autoradiography, thin sectioning, negative staining, cytochemistry, and metal shadowing.

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

**5990f,w,s,su. DIRECTED RESEARCH.** (Cr ar; prereq #,  $\Delta$ )  
Laboratory or field investigation of selected areas of research.

### For Graduate Students Only

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

**8060. CURRENT TOPICS**

**8900. SEMINAR**

**8910. JOURNAL CLUBS**

**8920. SPECIAL TOPICS**

**8970. DIRECTED STUDY**

**8990. RESEARCH**

## History of Science and Technology (HSci)

*Institute of Technology*

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

This is an interdisciplinary program, drawing faculty from both CBS and IT. Courses in this area focus on the origins and development of science and technology and their relations to the social, cultural, and philosophical currents of their time. Courses may be taken to support existing majors as well as to broaden knowledge of the nature and development of science and technology. The introductory courses (1711,2,3/3711,2,3 and 1811,2,3/3811,2,3) satisfy distribution requirements for group C-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; emergence of industrialism. 1713: Diffusion of the industrial revolution; technological development and its impact on industry, government, and society.

**1811, 1812, 1813. INTRODUCTION TO HISTORY OF SCIENCE.** (4 cr per qtr, \$3811, \$3812, \$3813) Shapiro

1811: Babylonian and Egyptian science; Greek natural philosophy, mathematics, astronomy, and biology; the Aristotelian world; decline and transmission of Greek science. 1812: Medieval background; the "experimental philosophy"; dissecting and describing nature: anatomy, circulation, and respiration; Copernican revolution: physical world of Kepler, Galileo, Descartes, and Newton; science and the popular imagination. 1813: 19th and 20th centuries; Newtonian triumph, romantic reaction, and modern revolution; the aether, electrical and optical, to Einstein; history of the earth; evolution before and after Darwin; nuclear physics and nuclear weapons.

**3201, 3202, 3203. HISTORY OF BIOLOGY.** (4 cr per qtr, \$5201, \$5202, \$5203)

3201: Antiquity to 1700. Biology, medicine, and natural history in antiquity: Hippocrates, Aristotle, Galen. Revival of biology in Renaissance and 17th century: Vesalius and anatomy, Harvey and circulation. 3202: Physiology and cell theory since 1700. Conceptual development of the various branches of modern biology: physiology, chemistry, and the experimental method; embryology, descriptive and experimental; cytology and microscopy. 3203: Evolution and genetics since 1700. Darwin and evolution; Mendel and genetics.

**3711, 3712, 3713. TECHNOLOGY AND WESTERN CIVILIZATION.** (4 cr per qtr, \$1711, \$1712, \$1713)

For description, see 1711, 1712, 1713.

**3811, 3812, 3813. INTRODUCTION TO HISTORY OF SCIENCE.** (4 cr per qtr, \$1811, \$1812, \$1813)

For description, see 1811, 1812, 1813.

**3825. PHYSICS AND SOCIETY IN 20TH-CENTURY AMERICA.** (4 cr, \$3835, \$5825) Stuewer  
Nineteenth-century heritage; 20th-century discoveries and physical theories; growth of physics in America after World War I: the intellectual migration of the 1930s; nuclear physics, the Manhattan project, and the atomic bomb; McCarthyism and Oppenheimer; current and past contributions of Minnesota physicists.

**3835. THE ATOMIC AGE.** (4 cr, \$3825, \$5825) Stuewer

Development of nuclear energy in the 20th century; construction and use of the bomb; postwar military and political impact.

**5011. THEORIES OF COLOR: NEWTON TO HELMHOLTZ.** (4 cr) Shapiro

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

**5201, 5202, 5203. HISTORY OF BIOLOGY.** (4 cr per qtr, \$3201, \$3202, \$3203)

For description, see 3201, 3202, 3203.

**5242. EVOLUTION BEFORE AND AFTER DARWIN.** (4 cr; prereq Biol 1009 or 1101 or #)

Philosophical conceptions of species; natural theology, design, and providential creation of species; Lamarck and evolution before Darwin; catastrophist and uniformitarian geology; Darwin and the background of the *Origin*; Darwin's early critics; evolutionary theory, 1882 to modern synthesis.

**5311. TECHNOLOGY IN AMERICAN LIFE.** (4 cr) Layton

Technology in America with emphasis on its impact on society and culture. Traces the growth of American technology in its cultural and intellectual context from colonial period to present.

**5321. HISTORY OF COMPUTING.** (4 cr) Norberg

A history of computing developments in the last century with attention to factors affecting the evolution of hardware and software, the growth of the industry and its relation to other business areas, and the changing relationships resulting from new data gathering and use techniques.

**5760. SELECTED TOPICS.** (1-5 cr per qtr; prereq #)

**5812. SCIENCE POLICY IN THE UNITED STATES SINCE WORLD WAR II.** (4 cr) Norberg

Effects of the science policy in postwar United States, 1945-1980: institutions, scientific groups, and technical processes and their interconnections for promotion and control of science and technology. Emphasis on federal government; consideration of state and local government.

**5825. PHYSICS AND SOCIETY IN 20TH-CENTURY AMERICA.** (4 cr, \$3825, \$3835) Stuewer

For description, see 3825.

**5924. HISTORY OF 19TH-CENTURY PHYSICS.** (4 cr, \$Phys 5924; prereq general physics or #)

Stuewer  
Conceptual developments in physics in 19th century (Young, Fresnel, Oersted, Ampère, Faraday, MacCullagh, Maxwell, Hertz, Lorentz, Lavoisier, Rumford, Dalton, Mayer, Joule, Helmholtz, Carnot, Clausius, Kelvin, Boltzmann, Mach, others). Relationships to social, philosophical, and theological influences.

**5925. HISTORY OF 20TH-CENTURY PHYSICS.** (4 cr, \$Phys 5925; prereq general physics or #)

Stuewer  
Conceptual developments in relativity (Michelson, Lorentz, Poincaré, Einstein, others), quantum mechanics (Planck, Einstein, Rutherford, Bohr, Sommerfeld, Ehrenfest, Pauli, Millikan, Compton, Heisenberg, de Broglie, Schrödinger, Born, others), and nuclear physics (Chadwick, Gamow, Fermi, others). Relationships to social, philosophical, and theological influences.

**5970. DIRECTED STUDIES.** (1-15 cr per qtr; prereq #)

Guided individual reading or study.

## Major Requirements and Course Descriptions

**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 #)

**8930. SEMINAR: HISTORY OF TECHNOLOGY.** (4 cr; prereq #)

**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, 5355, 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 1Biol 1009 or equiv; intended for students in CLA, dental hygiene, physical therapy, mortuary science; others with #; not intended for majors) Prince

Principles of microbiology; a general survey of pathogenic bacteria, molds, protozoa, and viruses; elements of immunity, sanitary analysis of water and milk, disinfectants and sterilants.

**3103w.<sup>1</sup> 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.<sup>1</sup> MICROBIOLOGY.** (5 cr, \$MicB 3103, \$MicB 5105, \$VPB 3103; prereq Biol 5001) Crawford, Hanson  
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Molecular structure in relation to bacterial function.

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

**5105.<sup>1</sup> BIOLOGY OF MICROORGANISMS.** (5 cr, §3103, §Biol 5013, §VPB 3103; prereq 5 cr biological sciences, Biol 5001 or #) Crawford  
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Molecular structure in relation to bacterial function. Laboratory.

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

**5216f. 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.

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

**5232w. MEDICAL MICROBIOLOGY.** (3 cr; not open to medical students; prereq 5105 or 3103 or 8110 or Biol 5013, 5216 or 5218) Cleary  
Pathogenic bacteria and fungi, mechanisms of pathogenicity and virulence; properties of microorganisms and their animal hosts that influence the outcome of host-parasite relations analyzed from genetic and metabolic view.

**5233f.<sup>1</sup> 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.<sup>1</sup> MEDICAL MICROBIOLOGY LABORATORY.** (2 cr; prereq 5232 or §5232) Cleary  
Exercises demonstrating the principles and techniques employed in the study of the interactions between microorganisms and humans that lead to a diseased state.

**5235f. MICROORGANISMS AND DISEASE.** (4 cr; not open to microbiology majors; prereq 10 cr chemistry and 5 cr biological sciences or #) Johnson  
Same as 5233 without laboratory.

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

**5322w. PHYSIOLOGY OF BACTERIA LABORATORY.** (2 cr; prereq 5321 or §5321, lab course in basic bacteriology) Rogers  
Techniques employed in the study of bacterial physiology and metabolism.

**5353f. APPLIED MICROBIOLOGY.** (4 cr; prereq 5321 or #)  
Microbial adaptation to various environments; role of microorganisms in the earth's biogeochemical cycles. Application of microbial systems to industrial processes; basic principles of fermentation technology; microbial bioconversions and product formation. Biodegradation of chemicals.

**5355. GENETIC AND MOLECULAR ASPECTS OF BIOTECHNOLOGY.** (3 cr; prereq 5105 or equiv, 5321) Faras  
Principles and practices of the techniques and procedures of the new biotechnology including genetic engineering, recombinant DNA technology, and production of monoclonal antibodies.

**5424s.<sup>1</sup> 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.

**5900f,w,s. TOPICS IN MICROBIOLOGY.** (1 cr; S-N only; open to microbiology sr majors) Rogers  
Seminars on research programs, historical perspectives, significant emerging fields, professional societies and publications, and career opportunities.

**5970. 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**

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

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## Major Requirements and Course Descriptions

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8122. **ADVANCED MICROBIOLOGY** (offered when feasible)

8123. **ADVANCED IMMUNOLOGY METHODS: IMMUNOBIOLOGY**

8202. **ORAL MICROBIOLOGY**

8218. **FRONTIERS OF IMMUNOLOGY I: IMMUNOCHEMISTRY**

8234. **ADVANCED MEDICAL MICROBIOLOGY**

8242. **DIAGNOSTIC MICROBIOLOGY**

8320. **FRONTIERS OF IMMUNOLOGY II: IMMUNOBIOLOGY, IMMUNOGENETICS**

8321. **FRONTIERS OF IMMUNOLOGY III: CLINICAL IMMUNOLOGY**

8323. **REGULATION OF METABOLISM** (offered when feasible)

8421. **MOLECULAR BIOLOGY OF CANCER**

8425. **ADVANCED LABORATORY IN VIROLOGY AND ANIMAL CELL CULTURE**

8911. **COLLOQUIUM IN MICROBIOLOGY**

8990. **RESEARCH IN MICROBIOLOGY**

### Zoology (Zool)

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

### For Graduate Students Only

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

8970. **GRADUATE SEMINAR**

8980. **SPECIAL RESEARCH FIELDS**

8990. **GRADUATE RESEARCH**

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### Recommended Related Course Work

Students are encouraged to explore additional course work 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 (FScN)

geology (Geo)

history of medicine & biological sciences (HMed)

laboratory medicine (LMed)

mathematics (Math)

organic chemistry (Chem)

physics (Phys)

physiology (Phsl)

plant sciences (PIPa, PIPh)

psychology (Psy)

public health (PubH)

soil science (Soil)

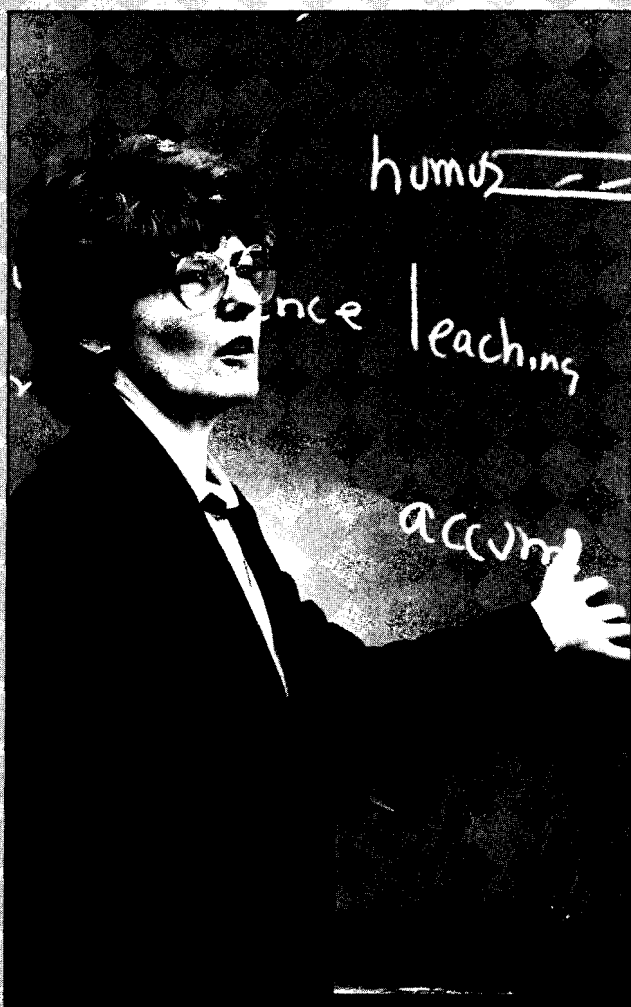
statistics (Stat)

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.

# Administration and Faculty





# Administration and Faculty

## University Regents

Charles F. McGuiggan, Marshall, Acting Chair

Wendell R. Anderson, Wayzata  
Charles H. Casey, West Concord  
Willis K. Drake, Edina  
Erwin L. Goldfine, Duluth  
Wally Hilke, St. Paul  
David M. Lebedoff, Minneapolis  
Verne E. Long, Pipestone  
Wenda W. Moore, Minneapolis  
David K. Roe, St. Paul  
Stanley D. Sahlstrom, Crookston  
Mary T. Schertler, St. Paul

## University Administrators

Kenneth H. Keller, President  
Stanley B. Kegler, Vice President for Institutional Relations  
David M. Lilly, Vice President for Finance and Operations  
V. Rama Murthy, Associate Vice President for Academic Affairs  
Neal A. Vanselow, Vice President for Health Sciences  
Frank B. Wilderson, Vice President for Student Affairs  
Vice President for Administration and Planning—to be appointed

## College of Biological Sciences Administrators

Douglas C. Pratt, Professor and Acting Dean, 123 Snyder Hall, St. Paul campus (373-1190)  
Darlene C. Joyce, Associate to the Dean, 223 Snyder Hall, St. Paul campus (373-1190)  
Kathleen Kearney Moore, Assistant to the Dean, 123 Snyder Hall, St. Paul campus (373-1190)  
Kathleen F. Peterson, Director of Student Services, 223 Snyder Hall, St. Paul campus (373-3648)  
Iris Charvat, Professor and Minority Affairs Officer, 223 Snyder Hall, St. Paul campus (373-3648)

*Biochemistry*—Victor Bloomfield, Professor and Head, 140 Gortner Laboratory, St. Paul campus (373-1303)

*Botany*—Thomas Soulen, Professor and Acting Head, 220 Biological Sciences Center, St. Paul campus (373-2211)

*Ecology and Behavioral Biology*—Edward J. Cushing, Professor and Head, 109 Zoology Building, Minneapolis campus (373-5177)

*Genetics and Cell Biology*—William S. Herman, Professor and Head, 250 Biological Sciences Center, St. Paul campus (373-0966)

*Microbiology (Medical School)*—Ashley T. Haase, Professor and Head, 1460 Mayo Memorial Building, Minneapolis campus (373-8070)

*James Ford Bell Museum of Natural History*—Donald Gilbertson, Professor and Director, 301 Bell Museum of Natural History, Minneapolis campus (373-3192)

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

*Institute for Advanced Studies in Biological Process Technology*—Michael J. Flickinger, Associate Professor and Director, 240 Gortner Laboratory, St. Paul campus

## Faculty

### Department of Biochemistry

*Regents' Professor*

Stanley Dagley, D.Sc.

*Professor*

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.  
Eckard Münck, Ph.D.  
Gary L. Nelsestuen, Ph.D.  
Ulysses S. Seal, Ph.D.  
John M. Wood, Ph.D.  
Clare K. Woodward, Ph.D.

*Associate Professor*

John S. Anderson, Ph.D.  
Bianca Conti-Tronconi, M.D.  
Michael J. Flickinger, Ph.D.  
James A. Fuchs, Ph.D.  
Kamil Ugurbil, Ph.D.

*Assistant Professor*

David Bernlohr, Ph.D.  
Anath Das, Ph.D.  
Janet L. Schottel, Ph.D.  
William Sharrock, Ph.D.

**Department of Botany**

*Regents' Professor*

Herbert E. Wright, Ph.D.

*Professor*

Albert W. Frenkel, Ph.D.  
Thomas J. Guilfoyle, Ph.D.  
Willard L. Koukkari, Ph.D.  
David J. McLaughlin, Ph.D.  
Thomas Morley, Ph.D.  
Gerald Ownbey, Ph.D.  
Douglas C. Pratt, Ph.D.  
Clifford M. Wetmore, Ph.D.

*Associate Professor*

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

*Assistant Professor*

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

**Department of Ecology and Behavioral Biology**

*Regents' Professor*

Margaret B. Davis, Ph.D.  
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.

David J. Merrell, Ph.D.  
Patrice A. Morrow, Ph.D.  
David F. Parmelee, Ph.D.  
Richard E. Phillips, Ph.D.  
Philip J. Regal, Ph.D.  
William D. Schmid, Ph.D.  
Joseph Shapiro, Ph.D.  
Donald B. Siniff, Ph.D.  
John R. Tester, Ph.D.  
G. David Tilman, Ph.D.  
Harrison B. Tordoff, Ph.D.  
James C. Underhill, Ph.D.  
Dwain W. Warner, Ph.D.

*Adjunct Professor*

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

*Associate Professor*

Peter A. Abrams, Ph.D.  
Robert C. Bright, Ph.D.  
Robert O. Megard, Ph.D.

*Assistant Professor*

Donald N. Alstad, Ph.D.  
Craig Packer, Ph.D.  
Anne E. Pusey, Ph.D.

**Department of Genetics and Cell Biology**

*Professor*

V. Elving Anderson, Ph.D.  
Richard S. Caldecott, Ph.D.  
William P. Cunningham, Ph.D.  
Franklin D. Enfield, Ph.D.  
David P. Fan, Ph.D.  
Robert K. Herman, Ph.D.  
William S. Herman, Ph.D.  
Alan B. Hooper, Ph.D.  
Ross G. Johnson, Ph.D.  
Norman S. Kerr, Ph.D.  
Robert G. McKinnell, Ph.D.  
David J. Merrell, Ph.D.  
Murray D. Rosenberg, M.D., Ph.D.  
Irwin Rubenstein, Ph.D.  
John R. Sheppard, Ph.D.  
Akhouri A. Sinha, Ph.D.  
D. Peter Snustad, Ph.D.  
Leon A. Snyder, Ph.D.  
Val W. Woodward, Ph.D.

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## Administration and Faculty

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### *Associate Professor*

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

### *Assistant Professor*

James W. Curtsinger, Ph.D.  
Perry B. Hackett, Ph.D.  
Victoria Iwanij, Ph.D.  
Paul A. Lefebvre, Ph.D.  
Walter C. Mahoney, Ph.D.  
Carolyn D. Silflow, Ph.D.

### **James Ford Bell Museum of Natural History**

Donald E. Gilbertson, Director  
Elmer C. Birney, Curator of Mammalogy  
Robert C. Bright, Curator of Paleontology  
D. Frank McKinney, Curator of Ethology  
David F. Parmelee, Director, Itasca Biology Program  
Philip J. Regal, Curator of Herpetology  
James C. Underhill, Curator of Fishes  
Dwain W. Warner, Curator of Ornithology

### **Gray Freshwater Biological Institute**

#### *Professor*

Richard S. Hanson, Ph.D., Director  
Eckard Münck, Ph.D.  
John M. Wood, Ph.D.

#### *Associate Professor*

Ronald L. Crawford, Ph.D.  
Kamil Ugurbil, Ph.D.

#### *Assistant Professor*

Florence L. Gleason, Ph.D.

### **Institute for Advanced Studies in Biological Process Technology**

#### *Director*

Michael J. Flickinger, Ph.D.

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## **Contributing Faculty From Other University Units**

### **Department of Microbiology— Medical School**

#### *Regents' Professor Emeritus*

Dennis W. Watson, Ph.D.

#### *Professor*

Dwight Anderson, Ph.D.  
K. Gerhard Brand, M.D.  
Peter Chapman, Ph.D.  
P. Patrick Cleary, Ph.D.  
Ronald Crawford, Ph.D.  
Martin Dworkin, Ph.D.  
David Fan, Ph.D.  
Anthony Faras, Ph.D.  
Gregory Germaine, Ph.D.  
V. W. Greene, Ph.D.  
Ashley T. Haase, M.D.  
Richard S. Hanson, Ph.D.  
Alan Hooper, Ph.D.  
Russell C. Johnson, Ph.D.  
M. Colin Jordan, M.D.  
Peter G. W. Plagemann, Ph.D.  
Paul Quie, M.D.  
Palmer Rogers, Ph.D.  
Walter Sauerbier, Ph.D.  
Charles Schachtele, Ph.D.  
Edwin L. Schmidt, Ph.D.  
Richard Simmons, M.D.

#### *Associate Professor*

Russell Bey, Ph.D.  
Beulah Gray, Ph.D.  
William F. Liljemark, Ph.D.  
James T. Prince, M.S.  
Bernard Reilly, Ph.D.  
James F. Zissler, Ph.D.

#### *Assistant Professor*

Robert Click, Ph.D.  
William Schubach, M.D.

### **History of Science and Technology Program—Institute of Technology**

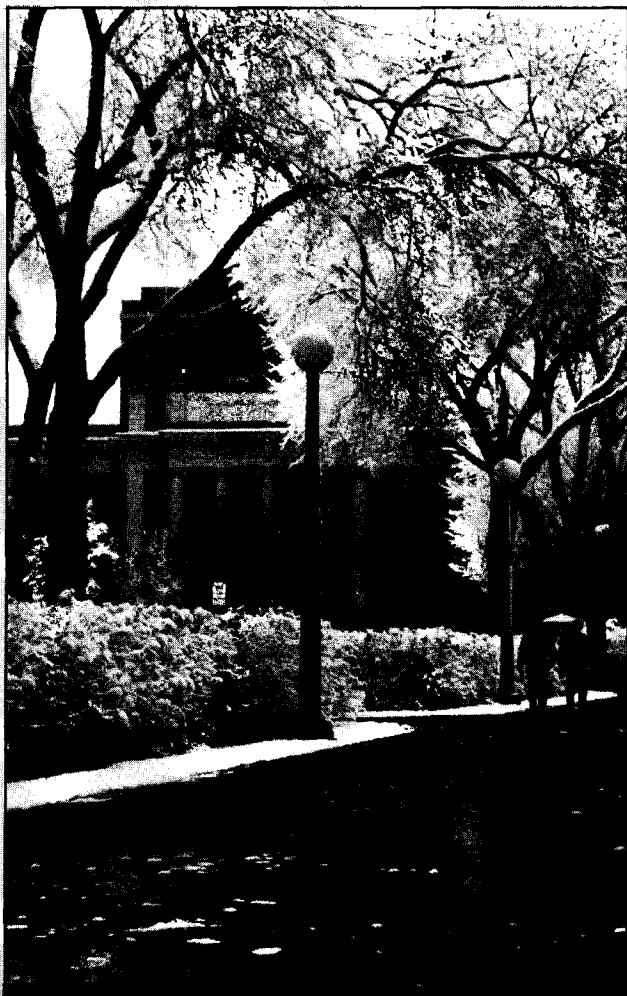
#### *Professor*

Edwin T. Layton, Ph.D.  
Alan E. Shapiro, Ph.D.  
Roger H. Stuewer, Ph.D.

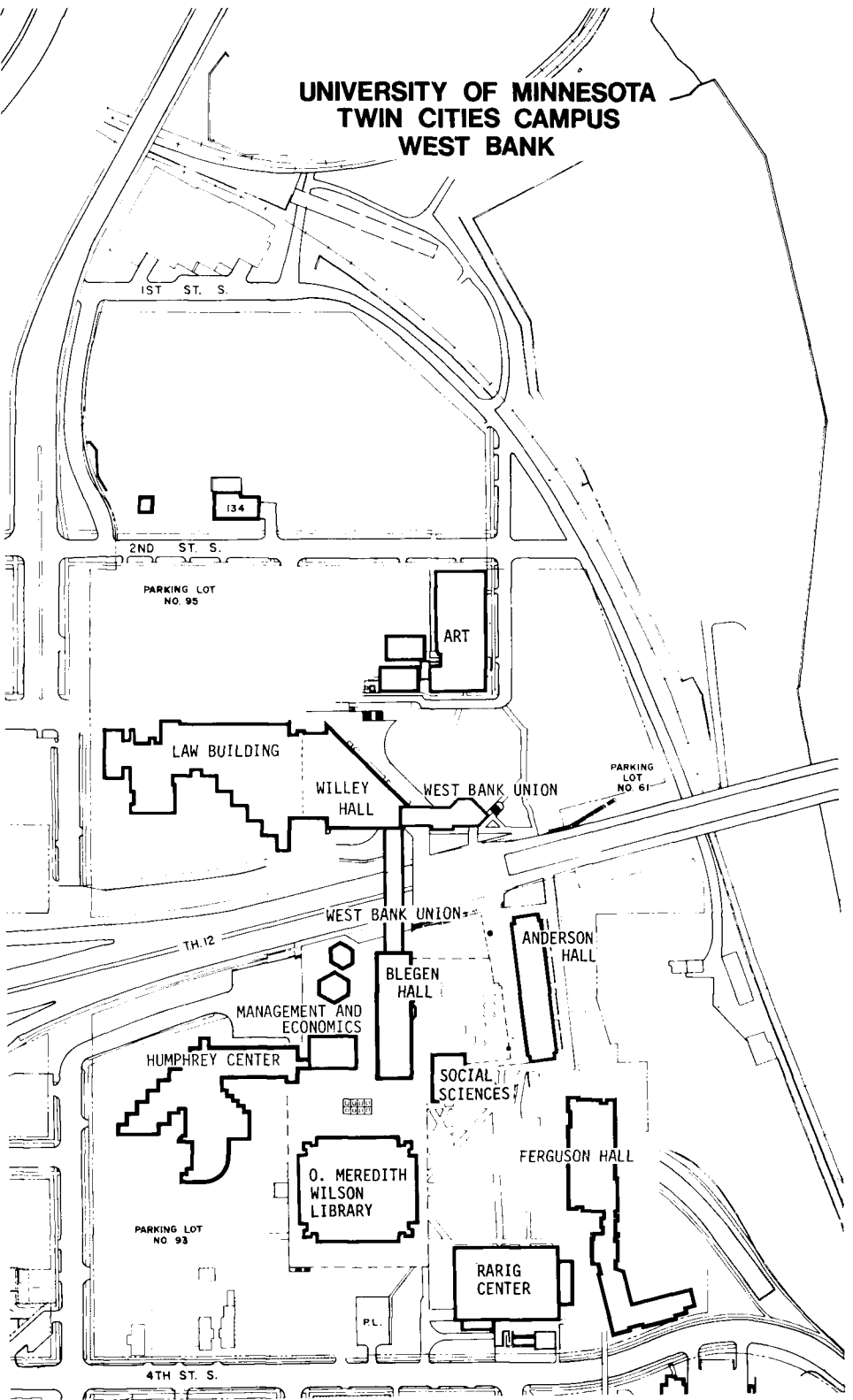
#### *Associate Professor*

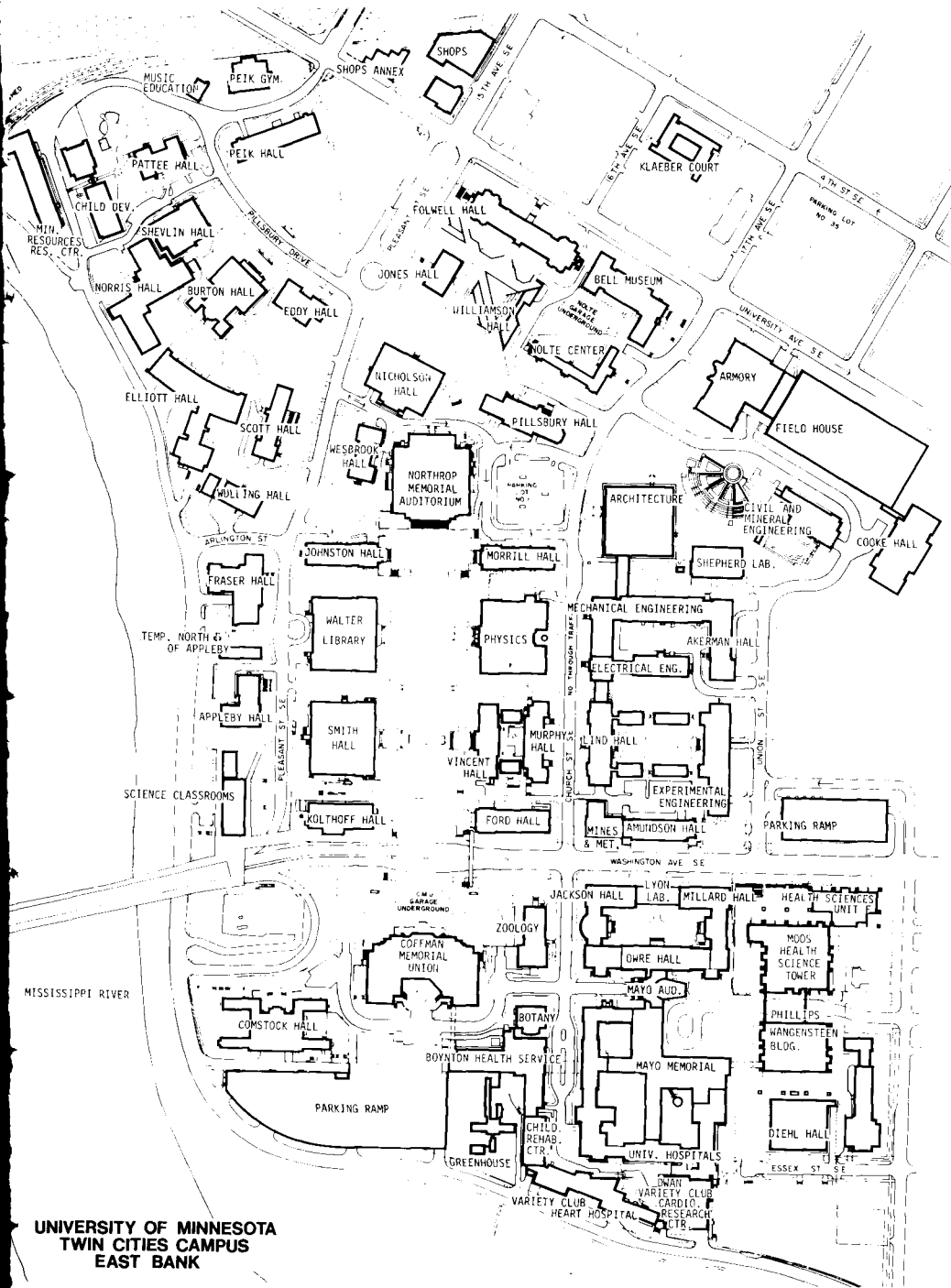
Arthur L. Norberg, Ph.D.

# Campus Maps

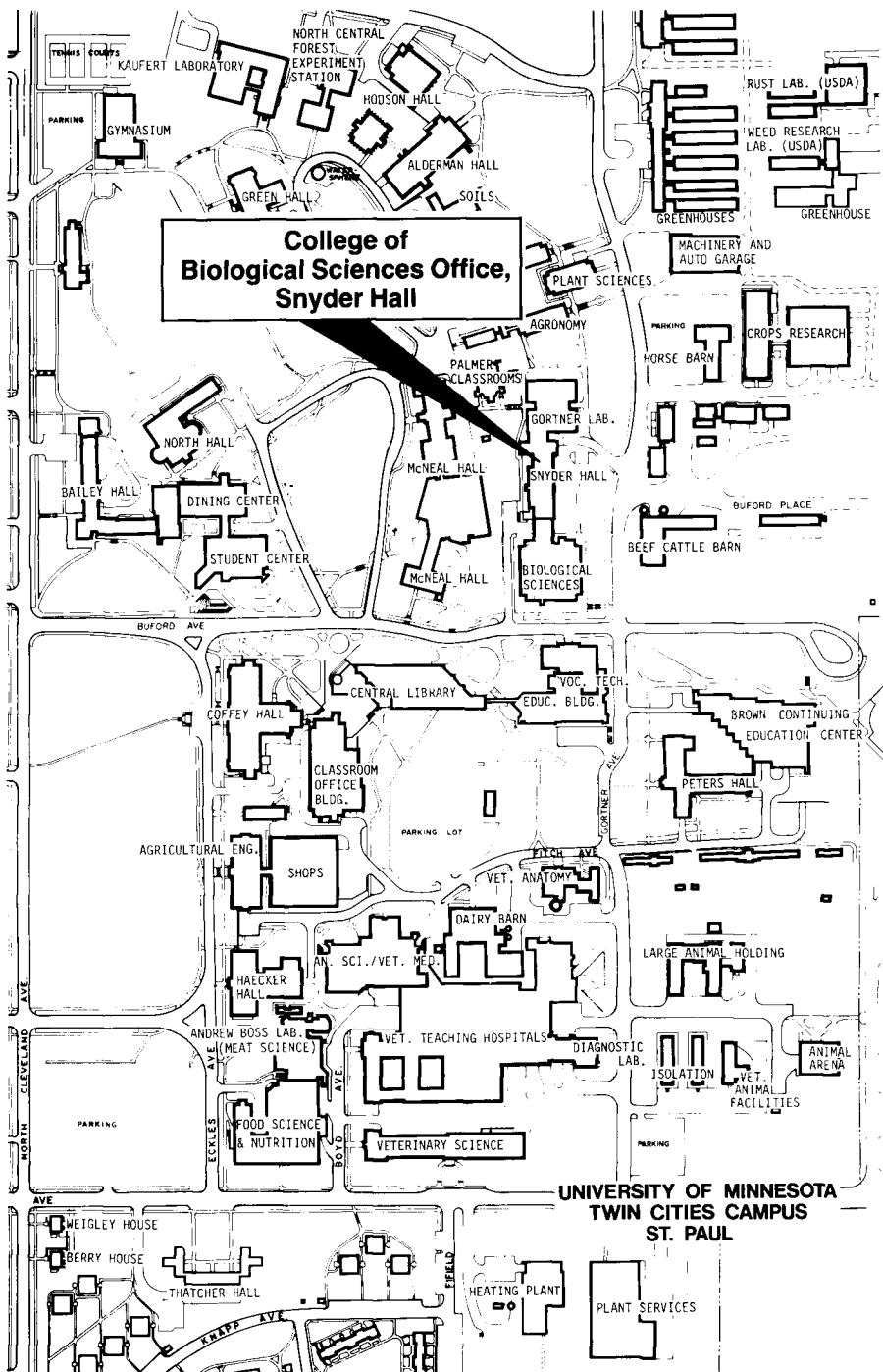


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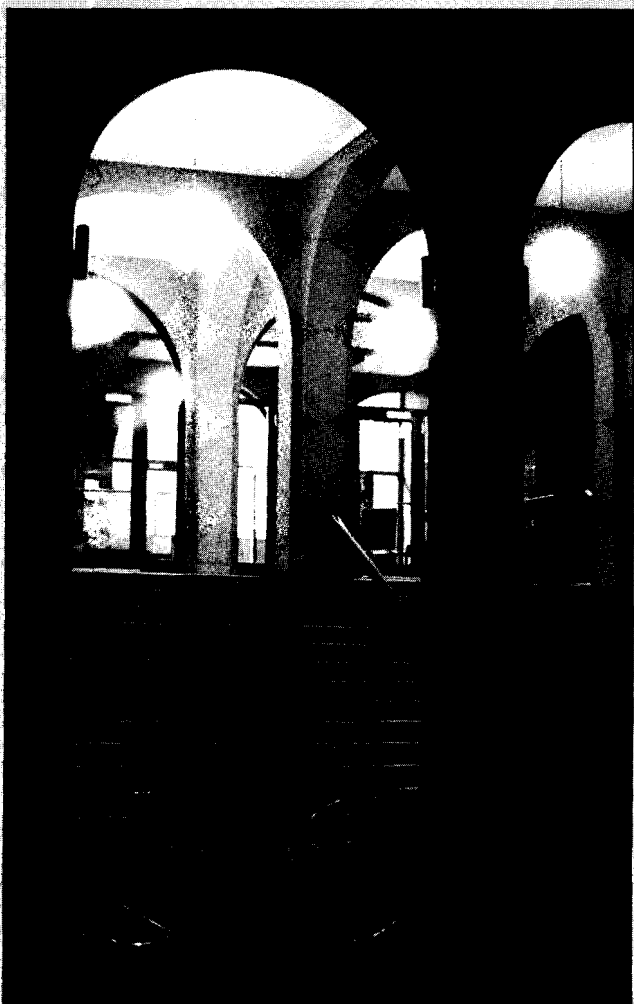
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**College of  
Biological Sciences Office,  
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**UNIVERSITY OF MINNESOTA  
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