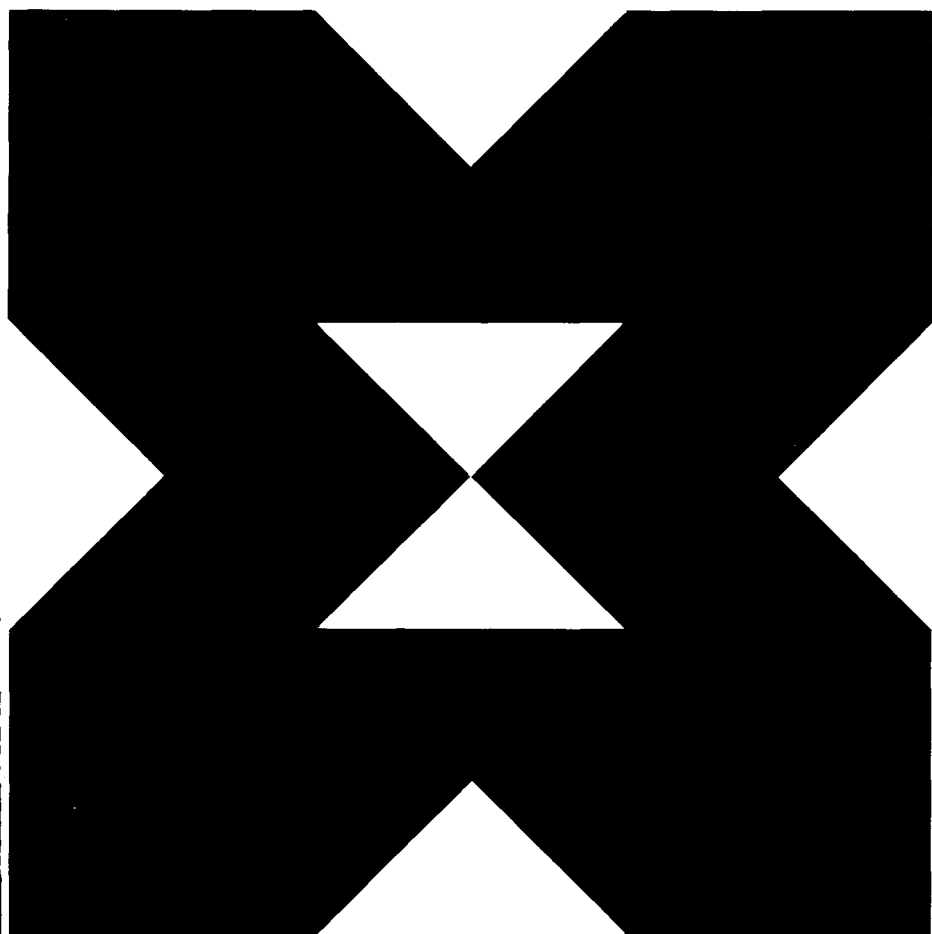


UNIVERSITY
OF MINNESOTA
BULLETIN

1977-1979

MAY 9, 1977

COLLEGE OF BIOLOGICAL SCIENCES





UNIVERSITY OF MINNESOTA

Board of Regents

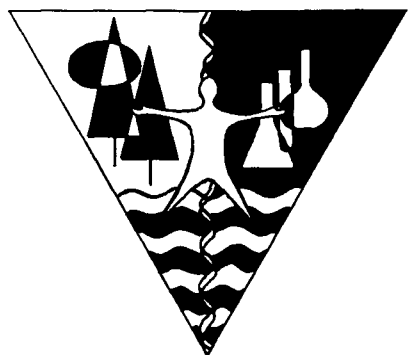
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College of Biological Sciences Administration

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College of
Biological Sciences

UNIVERSITY OF MINNESOTA

How To Use This Bulletin

This bulletin is the basic source of information about the College of Biological Sciences. It is arranged in four sections:

Section I—Organization and Objectives

- Purpose
- Administrative Structure
- College Governance
- Student Organizations
- Programs
- Community Outreach
- Student Personnel Services
- Statement on Human Rights

Section II—Admission, Academic Regulations, and Degree Procedures

- Admission
- Requirements for Graduation
- Examination Programs
- Special Learning Opportunities
- Registration
- Credits and Grades
- Satisfactory Progress
- Class Attendance, Examinations, Other Regulations
- Application to Graduate

Section III—Curricular Requirements and Course Descriptions

- Curricular Requirements for Major Fields
- Undergraduate Course Descriptions
- List of Graduate Courses (see *Graduate School Bulletin* for descriptions)
- Related Courses Recommended From Other Colleges

Section IV—Departmental Offices and Faculty

For more information, consult the *Lake Itasca Biology Session Bulletin* and the *Graduate School Bulletin*. All students and prospective students should also refer to the *General Information Bulletin*. Information on evening courses and summer school offerings are contained in the *Extension Classes Bulletin* and the *Summer Session Bulletin*, respectively. For information about programs in related areas, consult the following bulletins:

<i>College of Liberal Arts Bulletin</i>	<i>Graduate Programs in the Health Sciences Bulletin</i>
<i>College of Agriculture Bulletin</i>	<i>Medical School Bulletin</i>
<i>Institute of Technology Bulletin</i>	<i>College of Veterinary Medicine Bulletin</i>
<i>College of Forestry Bulletin</i>	<i>School of Dentistry Bulletin</i>
<i>College of Home Economics Bulletin</i>	<i>College of Pharmacy Bulletin</i>

All of these bulletins are available at the information booth in Morrill Hall or may be obtained by writing to the Office of Admissions and Records, 231 Pillsbury Drive S.E., University of Minnesota, Minneapolis, Minnesota 55455.

Address all correspondence and inquiries concerning biological sciences programs to the College of Biological Sciences, 123 Snyder Hall, 1475 Gortner Avenue, University of Minnesota, St. Paul, Minnesota 55108.

College of Biological Sciences

I. ORGANIZATION AND OBJECTIVES

Purpose

The excitement that now centers on the activities of biologists in universities and research institutes stems from the fact that 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. Their resolution will require an understanding of and an ability to use the most profound concepts in physics, chemistry, and mathematics, in addition to an appreciation of organisms when viewed 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 unique individual who has a depth of knowledge in a range of areas and the capacity to work with highly complex physical-chemical reactions in the milieu of dynamic systems.

The College of Biological Sciences has three primary commitments in helping the University maintain excellence in scholarship: first, to provide bioscience courses for other collegiate units for the purpose of general education as well as to supplement study in fields that are based on a thorough grounding in bioscience; second, to provide a well-rounded curriculum for the bachelor of science degree program in bioscience; and, finally, to maintain an excellent faculty and modern facilities, both of which are essential to high quality teaching and research.

Administrative Structure

The College of Biological Sciences (CBS), 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 at the undergraduate level. In addition, CBS is responsible for the administration of several program units, including the Dight Institute for Human Genetics, the Freshwater Biological Institute, and the Bell Museum of Natural History. An active field biology program is also 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 college offices and faculty is provided in section IV of this bulletin.

Students should be aware of primary sources of information within the college. Each department has a director of undergraduate studies who has major responsibility for assisting undergraduate students (see section III). There is also a director of graduate studies (see below) for each of the programs administered by the faculty in the college. These individuals can be helpful to prospective students.

A special section describing personnel services available to CBS students is provided below.

College Governance

The College of Biological Sciences has a number of governance and policy committees whose membership includes both students and staff. Standing commit-

Organization and Objectives

tees of the college are the Administrative Committee, the Consultative Committee (grievances and appeals), the Educational Policy Committee, and the Tenure Committee. The college faculty as a whole serves as a functional department in the College of Liberal Arts in order to assure coordination of those aspects of education in biology that contribute to a liberal education.

Student Organizations

Biological Sciences Student Board—The official voice of undergraduate students in the college is the Biological Sciences Student Board. Meetings of the board are open to any student interested in the biological sciences. Officers are elected from biology students in the Colleges of Biological Sciences and Liberal Arts. The board elects student representatives to appropriate college committees.

Student Representation on University Committees—Students interested in serving as a representative on an all-University committee 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.

St. Paul Campus Board of Colleges—The St. Paul Campus Board of Colleges directs and coordinates student activities and encourages student leadership on the St. Paul campus. Its membership is drawn from the Colleges of Agriculture, Forestry, Home Economics, Veterinary Medicine, and Biological Sciences. The board cooperates with the Twin Cities Student Assembly and the Twin Cities Campus Assembly Committee on Student Affairs. Students interested in becoming a member should watch for announcements about filing for elections.

Programs

UNDERGRADUATE PROGRAMS

The bachelor of science degree is offered by the College of Biological Sciences in several areas of study. The degree can be earned with honors if a student attains a high level of performance and satisfies specified requirements. Majors are offered in biology, biochemistry, botany, and microbiology. Irrespective of major, each student must complete a common core sequence of courses in biology, the physical sciences, and mathematics.

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

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 is one that frees individuals from the limitations placed on their powers of judgment and choice that result from ignorance. Specifically, a liberal education asks of individuals that they seek control over the general intellectual instruments for acquiring and communicating knowledge, primarily the instruments of language and number; understanding of the ways in which 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 expects all students to distribute a portion of their course work in areas of study other than those most closely linked to their specialized interests.

Students are encouraged to explore the many ways to enrich learning beyond the usual curriculum. Many students plan projects that 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 section II, Registration). Some students seek employment as undergraduate teaching and research assistants, as museum tour guides, or in similar positions. Most departments offer special seminars for undergraduates (see section III). A 3-quarter course, Biology Colloquium, is open to 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 in the projects undertaken.

The bachelor of science degree is designed to give students a background in the physical, mathematical, and biological sciences that will provide a firm foundation should they choose to pursue graduate study in bioscience or to enter such fields as medicine, veterinary medicine, dentistry, agriculture, or education. For students who choose to end their formal education with the bachelor's degree, the curriculum provides a sufficiently broad background to assume any one of a variety of office, laboratory, or field positions in governmental agencies and the private sector. The results of an alumni survey showed that among individuals granted the bachelor's degree from CBS between 1965 and 1972 one-half went directly on to advanced study (19 percent attended medical school, 5 percent were admitted to dental school, 25 percent went into a graduate program). Another 25 percent of the graduates were employed in jobs directly related to their biology training (job titles most frequently reported at this level included "junior scientist" and "laboratory technician"). These statistics apply to first occupation only; through time, the percentage of graduates going on for advanced training increased. Students who earn the master's or doctor's degree can anticipate opportunities for employment in colleges and universities, high schools, federal and state agencies, and the private sector.

GRADUATE PROGRAMS

Graduate study at the University of Minnesota is coordinated and administered by the Graduate School through the members of various graduate faculties responsible for specific areas of study, through specific policy and review committees, and through an executive committee of the Graduate School responsible for overall policy and maintenance of academic standards. In this way, members of departments, schools, and colleges throughout the University cooperate in offering advanced study and training in a wide range of academic fields. Students should refer to the *Graduate School Bulletin* for details on general policies regarding admission requirements, registration procedures, general opportunities for financial aid, and requirements for graduate degrees.

The faculty of the College of Biological Sciences plays a major role in offering graduate degrees in biological science areas. Graduate programs in the college are available in biology, biochemistry, botany, ecology, genetics, and zoology. The program in biology typically emphasizes one of the following areas: cellular and developmental biology, behavioral biology, or evolutionary and systematic biology. However, unique programs may be designed under special circumstances.

Organization and Objectives

The *Graduate School Bulletin* and all necessary application materials may be obtained from the Graduate School, 322 Johnston Hall, 101 Pleasant Street S.E., University of Minnesota, Minneapolis, Minnesota 55455. Questions regarding specific bioscience programs should be addressed to the director of graduate studies in the appropriate program area:

Biology—Richard S. Caldecott

Biochemistry—Finn Wold

Botany—Albert W. Frenkel

Ecology—Harrison B. Tordoff

Genetics—D. Peter Snustad

Zoology—Stuart Goldstein

Community Outreach

Bell Museum of Natural History—Located at 17th 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. The museum is open from 9 a.m. to 5 p.m. Monday through Saturday, until 9 p.m. on Wednesday, and from 2 to 5 p.m. on Sunday. Groups of 10 or more who wish to visit the museum should make reservations. Guided tours are available to groups upon advance request. The 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. Natural history films are shown at scheduled times during the year. All museum programs are open to the public without charge. Telephone (612) 373-2423 for appointments or further information.

Dight Institute for Human Genetics—Located in the Botany Building at 400 Church Street S.E., Minneapolis, the Dight Institute provides genetic counseling free of charge for those requesting the service. Tests are provided to determine biochemical defects in babies and specific traits carried by adults. Lectures and workshops are open to outside organizations without charge. Telephone (612) 373-3792 for further information.

Student Personnel Services

College Offices—Students should always feel welcome to discuss any questions or problems with a member of the staff in the college office at 223 Snyder Hall, St. Paul campus. This office is administratively responsible for admissions, registration, degree regulations and procedures, maintenance of student records, and similar functions. The staff members of the college office advise prebiology students and also assist both upper division students and faculty advisers. Because the college office is exceptionally busy during registration periods, students should, whenever possible, initiate contacts and transact college business at other times.

While most questions of undergraduate students can best be answered in the undergraduate college office, students can also visit the Office of the Dean at 123 Snyder Hall on the St. Paul campus.

Career Information Office—The Career Information Office was established in 1975. 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 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, books listing current job vacancies at all degree levels, and specific information about appropriate employers is available. Current and prospective students should familiarize themselves with the services of the office, located in 229 Snyder Hall on the St. Paul campus; telephone (612) 373-1651.

Faculty Advisers—Each student in the College of Biological Sciences is assigned a faculty adviser. 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 college office.

Students *must* visit their adviser during the last 2 weeks of spring quarter each year to plan their program for the coming year and to prereserve classes for fall quarter. Before seeing their adviser regarding curriculum planning, students should study the relevant bulletins carefully and be prepared to present a tentative program.

Each department in the college has a director of undergraduate studies who can be of special help to undergraduate students seeking information about the department.

The honors coordinator for students in the College of Liberal Arts is Professor Barnwell.

All-University Personnel Services—Numerous specialized personnel services are provided by the University for all students. (See the *General Information Bulletin* and the *Student-Staff Directory* for details and listings of services.)

Campus Assistance Center: 107 Temporary North of Appleby, Minneapolis (373-1234)

Counseling: Student Counseling Bureau, 101 Eddy Hall, Minneapolis (373-4193); 190 Coffey Hall, St. Paul (373-1140)

Employment (part-time): Student Employment Service, 30 Wulling Hall, Minneapolis (373-3674)

Financial Help: Student Financial Aid, 107 Armory, Minneapolis (373-4021); 190 Coffey Hall, St. Paul (373-1197)

Foreign Students: International Student Adviser, 717 East River Road, Minneapolis (373-4094)

Handicapped Students, Aid for: Rehabilitation Services Office, N588 Elliott Hall, Minneapolis (376-3143)

Health Problems: Boynton Health Service, 410 Church Street S.E., Minneapolis (373-3141); St. Paul Health Service, Cleveland at Dudley (373-0960)

Housing: Comstock Hall, Minneapolis (373-7542); 190 Coffey Hall, St. Paul (373-0822)

Legal Problems: Legal Aid Clinic, 110 Temporary North of Appleby, Minneapolis (373-9980)

Study Skills Improvement: See Student Counseling Bureau

Veterans Benefits: Educational Benefits, Book Store/Admissions and Records, Minneapolis (373-5609); Assistance and Outreach, Book Store/Admissions and Records (376-4566) or 190 Coffey Hall, St. Paul (373-1150)

Student Ombudsman Service: 102 Johnston Hall, Minneapolis (373-9788); 101 Coffey Hall, St. Paul (376-1214)

Statement on Human Rights

The Board of Regents has committed itself and the University of Minnesota to the policy that there shall be no discrimination on the basis of race, creed, color, sex, or national origin. In adhering to this policy, the University abides by the requirements of Titles VI and VII of the Civil Rights Act of 1964, Revised Order No. 4, Executive Orders 11246 and 11375, Sections 799A and 845 of the Public Health Service Act, and other federal regulations and pertinent acts of Congress.

It is also the policy of the University of Minnesota not to discriminate on the basis of sex in its educational programs, admissions, activities, or employment policies as required by Title IX of the Education Amendments of 1972.

Inquiries regarding compliance may be directed to Lillian H. Williams, Director, Office of Equal Opportunity and Affirmative Action, 419 Morrill Hall, 100 Church Street S.E., Minneapolis, Minnesota 55455, (612) 373-7969, or to the Director of the Office of Civil Rights, Department of Health, Education, and Welfare, Washington, D.C. 20201.



A profile of the biological sciences complex: Gortner Laboratory, Snyder Hall, and the Biological Sciences Center.

II. ADMISSION, ACADEMIC REGULATIONS, AND DEGREE PROCEDURES

Admission

ADMISSION REQUIREMENTS

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 college office at 223 Snyder Hall, St. Paul campus, 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 entry into 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 member of the biology faculty, take courses that will provide the most adequate background. Students should refer to the bulletins of the various colleges for information regarding their admission criteria.

During their freshman and sophomore years, students should plan to complete their English composition, mathematics, and, as a minimum, general chemistry requirements. They should take at least 1 quarter of biology to make certain they wish to concentrate in the biological sciences as well as to be prepared for upper division courses in their junior year. Many students take organic chemistry during their sophomore year, while others complete the physics requirement as a sophomore and take organic chemistry during the first 2 quarters of their junior year.

CBS ADMISSION PROCEDURES

Students normally enter the College of Biological Sciences at the beginning of their junior year. 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) 10 credits of analytical geometry and calculus (Math 1211-1221)
 - b) 10 credits of general chemistry (Chem 1004-1005 or 1031-1032)
 - c) A course in general biology (Biol 1011) or exemption.

All students, especially those transferring from other institutions, should complete the third quarter of the sequence (Math 1231) required for graduation prior to their first quarter in attendance in CBS.

Admission Period—The deadline for receipt of complete applications (including transcripts) is July 15 for fall quarter (applications received prior to May 15 will be handled together and will have priority); October 15 for winter quarter; and February 15 for spring quarter.

Transfer From Other Colleges Within the University—A Transfer of College Within the University form may be obtained from the Office of Admissions and Records. The completed application, along with two copies of the student's transcript, should be turned in either at 223 Snyder Hall or 130 Coffey Hall, St. Paul.

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

Special Status—Registration as a special student provides the opportunity for men and women to undertake work in individual courses or groups of courses to meet special needs when they do not wish to apply the course work toward a degree. However, subsequent admission to a degree program is possible upon recommendation of the college. In most cases, credit earned as a special student can be applied toward a degree. Only 1 quarter of work as a special student may be used toward a Graduate School degree. Admission is completed through the Office of Admissions and Records, 130 Coffey Hall, St. Paul. Applications should be filed well in advance of the quarter of entrance.

Requirements for Graduation

In order to earn a bachelor of science degree from the College of Biological Sciences, a student must fulfill all of the following requirements:

1. Completion of a minimum of 180 credits with a grade of A, B, C, or S. (Credits of D may be counted only if they are balanced by appropriate credits of A or B.)
2. Credits in Residence—
 - a. Completion of a minimum of 45 credits in courses taken on the Twin Cities campus, 30 credits of which must be taken during the senior year.
 - b. Completion of 3 quarters of work (approximately 45 credits) as a full-time student while registered in the College of Biological Sciences.
 - c. Completion on the Twin Cities campus of a minimum of 30 credits in courses numbered 3xxx or 5xxx that are specifically required for the student's major. Ordinarily this will include all 3xxx and 5xxx courses listed in this bulletin as well as appropriate advanced courses in mathematics, statistics, computer science, and the physical sciences.
3. English Communication Skills—Satisfactory completion of the requirement as stated by the college in which the student initially registered. Ordinarily this is a 2-quarter course.
4. Foreign Language—Completion of either (a) 2 years of study of a single foreign language in high school, or (b) 3 quarters (15 credits) of a single foreign language or demonstration of equivalent proficiency satisfactory to the appropriate language department. (French, German, or Russian is especially recommended.)
5. Completion of the all-University liberal education distribution requirements:
Group A—Communication, Language, and Symbolic Systems
Group B—Physical and Biological Sciences
Group C—Man and Society
Group D—Artistic Expression

The mathematics and physical and biological sciences course work that is required of CBS students (see below) will automatically satisfy the minimum University requirements for Group A and Group B. CBS students must complete 30 additional credits, with a minimum of two courses (8-10 credits) each in Group C and Group D. These 30 credits may include courses from Group A, with the exception of mathematics, statistics, computer science, and accounting; they may not include Group B courses.

The following list of suggested courses is provided to help students select courses to fulfill the requirements for the various liberal education distribution groups. A much more extensive listing can be found in the *College of Liberal Arts Bulletin*; in addition, distribution group designators follow descriptions of most courses in that bulletin.

Requirements for Graduation

6. Physical Sciences and Mathematics—

- (a) Mathematics—Completion of a 3-quarter, 15-credit analytic geometry and calculus sequence (Math 1211-1221-1231 or 1311-1321-1331). A 2-quarter course sequence in statistics (Stat 5021-5022 or PubH 5450-5451-5452-5453) may be substituted for the last quarter of calculus with permission of the student's major adviser and the college office.
- (b) Chemistry—Each of the following:
 - General chemistry, 10 credits (Chem 1004-1005 or 1031-1032).
 - Organic chemistry, 10-12 credits (Chem 3301-3302-3305-3306 or 3331-3332-3335).
 - A minimum of 4 additional credits in chemistry (i.e., Chem 1006 or 3100-3101 or physical chemistry or additional organic chemistry).
 - Students planning a major in biochemistry are encouraged to take the sequences designed for chemistry majors; these are listed as options above. Chemistry course numbers have changed recently; students who have completed Chem 1034, 3034, or Chem 3301-3302 prior to fall 1976 have already met the organic chemistry requirement.
- (c) Physics—Completion of a 3-quarter course, with laboratory, that requires college-level mathematics as a prerequisite (Phys 1271-1281-1291 with 1275-1285-1295 [15 credits] or 1104-1105-1106 [15 credits]). With permission of the student's major adviser and the college office, a 10-credit, 2-quarter sequence (Phys 1031-1032) plus an additional 5 credits of mathematics, statistics, computer programming, or physical science chosen in consultation with the major adviser may be substituted.

7. Biological Sciences (Core Curriculum)—

- (a) General Biology (Biol 1011, 5 credits) or exemption granted by the college office. Students with a good background from high school or individual study should take the Biol 1011 exemption examination.
- (b) Two of the following three courses: Animal Biology (Biol 3011, 5 credits), Plant Biology (Biol 3012, 5 credits), Microbiology (Biol 3013, 4 credits).
 - Courses completed at other institutions in general zoology, animal biology, general botany, or plant biology, or 3 quarters of general biology, may be used in lieu of Biol 3011 and/or 3012 if the student satisfactorily completes an appropriate upper division course that requires the emptied course as a prerequisite. Completion of Biol 1103 (General Botany) will exempt the student from Biol 3012 if an upper division course requiring 3012 as a prerequisite is satisfactorily completed. Biol 1106 (General Zoology) may *not* be substituted for Biol 3011. Upper division courses used to validate the student's experience in lower division organismal biology courses may also be used to fulfill item (h) below.
- (c) Biochemistry (Biol 3021, 4 credits).
- (d) Genetics (Biol 3033, 4 credits).
- (e) Cell Biology (Biol 3034, 3 credits).
- (f) Ecology (Biol 3041, 4 credits).
- (g) Laboratory in two additional biological sciences courses. This is an "experience" requirement rather than a credit requirement, so credits earned may be used toward fulfilling item (h) below.
- (h) 24 additional upper division credits in mathematics and/or physical and/or biological sciences, including at least *one* of the following courses: Bot 3131, EBB 5156, GCB 5114, MicB 5321. This includes work specified by the major department (see section III).

COURSES RECOMMENDED TO MEET LIBERAL EDUCATION DISTRIBUTION REQUIREMENTS

Group A—Communication, Language, and Symbolic Systems

Afro 1101, 1102, 1103
Anth 5161
Clas 1015, 1048, 3048, 5101
Comm. Comp—All courses not used to meet the English composition requirement, Engl 3851
Foreign Language—All skill courses not used to meet the foreign language requirement
Hum 1101
Jour 1001, 1011, 1101
Ling—All courses
Phil 1001, 3201, 3202, 3231, 3631
Rhet 3280, 3551, 3562
Spch 1101, 1102, 1110, 3601, 3605, 3620, 3641

Group C—Man and Society

Afro 1015, 1025, 1036, 1441, 1442, 3001, 3002, 3003, 3011-3012, 3021-3022, 3061, 3062, 3072, 3081-3082, 3091-3092, 3098, 3340, 3401, 3455
AgEc 1020, 1030, 1040, 3610
AmIn 3026, 3036
AmSt—All courses
Anth—All courses except 3386, 5183
Arch 1001, 1002, 1003
Chic 1105, 1106, 1107, 3211, 3212, 3221, 3324, 3335, 3345, 3615
Clas 1001, 1002, 1003, 1004, 1005, 1006, 1012, 1019, 1042, 1061, 3070, 3071, 3072, 3073, 3219
CJS—All courses
CPsy—All courses
Econ—All courses
FSoS 1001, 1002, 1025, 3015, 3260, 5001
Foreign Language—All culture courses
Geog—All courses except those assigned to Group A and Group B
Hist—All courses
HMed—All courses
HSci—All courses
Hum—All courses except 1101, 3014, 3044, 3055, 3071, 3755
Jour 3021, 3776
JwSt 1034, 3034, 3115, 3125, 3126, 3142, 3143, 3521
Lib 5101, 5221
PA—All courses
Phil 1002, 1003, 1004, 1410, 3001, 3002, 3003, 3004, 3302, 3614
Pol—All courses
Psy—All courses except 3031, 3061, 3801, 5062, 5071
RelS—All courses
Soc—All courses except those assigned to Group A
Spch 3211, 3401, 3402, 3431
SSci 3101
SW—All courses
WoSt 1005, 1006, 1977, 3302, 3303

Group D—Artistic Expression

Afro 1301, 3055, 3057, 3101, 3102, 3105, 3108, 3301
AmIn 3221, 3242
AmSt—All courses
Arch 1022, 1023, 1121
ArH—All courses
ArS—All courses
Chic 3507, 3508, 3511, 3513
Clas 3081, 3082, 3083
Comp 1111-1112, 1113-1114, 3101, 3104
CSci 3002
Dsgn 1501, 1521, 1541
Engl—All literature courses
Foreign Language—All foreign language literature courses
Hum—All courses except 1101, 3009, 3044, 3061, 3099, 3204, 3501, 3502, 3503
Mus—All courses
PE 1024, 1124, 1224, 1324, 1325, 1425, 1426, 1515-1615-1715, 1517, 1518-1618-1718, 3180, 3390, 3391, 3392, 3395, 3396, 3397
Phil 3502
Rhet 3321, 3322, 3323, 3324, 3371, 3372, 3373, 3381, 3471, 3473
Spch 1104, 3201, 3202, 3203, 3204
Th—All courses
WoSt 3103, 3501, 3502, 3631, 3701

GRADUATION WITH HONORS

In order to graduate with honors, a student must fulfill each of the following requirements:

1. Completion of at least 60 credits in upper division courses (3xxx and 5xxx level) at the University of Minnesota, Twin Cities campus.
2. Completion of two college seminars chosen from the following: Biol 3950, BioC 3094, BioC 3960, Bot 3950, EBB 3960, MicB 5900, GCB 3960.
3. Participation in a supervised research program for at least 1 quarter and completion of a paper summarizing the research that is acceptable to the faculty member supervising the research. In the case of candidates graduating summa cum laude, the paper must be approved by two additional members of the faculty chosen with approval of the college office; at least one of the readers must be from the major department.
4. Success in earning superior grades with no Ds or Ns and a maximum of 10 credits of C in the last 90 credits of A-N registration required to earn the degree, meeting the following standards:

cum laude: A minimum of 23 credits of A. Each credit of C must be balanced by an additional credit of A.

magna cum laude: A minimum of 36 credits of A. Each credit of C must be balanced by an additional credit of A.

summa cum laude: A minimum of 54 credits of A. Each credit of C must be balanced by an additional credit of A.

If a portion of the last 90 credits have been transferred from another institution, the proportion of residence credits of A must at least equal the proportion of transfer credits of A.

5. Students planning to graduate with honors in microbiology must include specific courses in their program in addition to the college requirements (see section III).

Application for graduation with honors must be completed at least 2 quarters prior to completion of the degree. Application forms are available in the college 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 review of the application and the applicant's background leads to approval, arrangements may be made with the appropriate instructor (one who regularly teaches the course in question) to take the examination. A student must be currently enrolled to be eligible. In some cases, the class load should be lowered in order to prepare for a special examination. There is no fee for examinations taken during the first quarter of enrollment at the University. A fee of \$20 is charged for each examination successfully completed after the first quarter of enrollment. Usually no grade is assigned; credits count toward a degree as nonresidence credit.

Special Examination for Proficiency—To meet a prerequisite or satisfy a requirement, a student may ask college permission to take an examination to demonstrate proficiency. No credit is awarded and no fee is charged for this type of examination.



Nancy Becker assists a student during registration.



Between classes in Kolthoff Hall.

College Level Examination Program (CLEP)—By passing one or more of the nationally standardized examinations prepared by the College Entrance Examination Board, a student may, either before starting college work or during it, earn up to 32 credits to apply (as nonresidence credit without grade) toward the degree. Such credits do not count in calculating the percentage of S-N credits. Full information about CLEP tests may be obtained from the College of Liberal Arts Office of Special Learning Opportunities, 201a Wesbrook Hall.

Special Learning Opportunities

Students are encouraged to explore with college office staff members and with advisers and instructors the many ways to enrich learning beyond the required curriculum. The college offers opportunities for a variety of types of individual study in regular courses or in subjects not covered in the current curriculum. Refer to the information below on Independent Study for registration details.

Individually Designed Program—Each of the majors offered by CBS is built around a series of core courses that introduce students to the many areas of biology and draw upon a basic preparation in mathematics, chemistry, and physics. These requirements were established after extensive consultation among faculty members and are considered to be 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, a newly approved degree option, the individually designed program, was instituted during the 1976-77 academic year. A maximum of 15 students may be accepted to the program during each year of an initial 3-year trial period. Before being admitted to the program, a student must submit a statement of his or her 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), 10 credits of general chemistry, and a minimum of 5 credits of calculus. Interested students should consult an adviser in the college office at an early date.

Registration

The first obligation of the student is proper registration. Upon registering for specific courses and paying fees for a given quarter, the student has a contract with the University whereby the various colleges concerned agree to make certain instruction and other facilities available to that student. Errors, late registration, failure to observe established procedures, or excessive changes in registration not only cause an imposition on others but are costly and time-consuming for the individual.

The days, hours, and places of meeting of classes are contained in the *Class Schedule*, which is published prior to the registration period each quarter. Students should consult the *Class Schedule* for course prerequisites, limitations on enrollment, and special registration procedures (also see below). Students who miss opening classes may lose their places in the courses for which they are registered.

ANNUAL PROGRAM PLANNING

During the last 2 weeks of spring quarter all students are required to meet with their adviser to plan their program for the coming year. Newly admitted students and those who have applied for admission to the college should come to the college

Admission, Academic Regulations, and Degree Procedures

office, 223 Snyder Hall, to be assigned an adviser and plan their program. Return of the Annual Program Plan, signed by the student and the adviser, to 223 Snyder Hall completes prerereservation for fall quarter (see below).

PRERESERVATION

About 10 days before the beginning of the official registration periods for the winter and spring quarters, "prereservation" for College of Biological Sciences courses is held for all CBS and CLA biology majors. Students should read the Official Daily Bulletin column in the *Minnesota Daily* for notice of the precise dates. At this time, students request that space be held for them in specific courses offered by CBS departments.

HOW TO REGISTER

Detailed instructions are issued with registration materials. Much of the inconvenience often associated with registration can be avoided by carefully reading these instructions. Personnel in the college office will try to answer any questions students may have. The steps involved in registration are as follows:

1. Prereserve CBS courses in 223 Snyder Hall.
2. Continuing students and new advanced standing students obtain registration materials, including the registration permit, from 223 Snyder Hall. Students in the process of transferring from another University of Minnesota college usually obtain their registration permit from the college they are leaving.
3. Plan a tentative course program. This often includes a meeting with the adviser. Obtain the adviser's signature if required.
4. Reserve class places in Class Reservations offices. Enrollment in many courses is controlled. The titles of these courses are listed in boldface type in the *Class Schedule*. Class entry cards must be obtained from an appropriate Class Reservations office (223 Snyder for CBS courses; 12 Johnston Hall for CLA courses and certain mathematics, chemistry, and physics courses; Architecture Court for Institute of Technology courses, etc.) Courses listed in the *Class Schedule* in lightface type are not controlled and do not require permits. Pick up cards for CBS courses (reserved during the prerereservation period) in 223 Snyder Hall.
5. Turn in registration materials at 130 Coffey Hall, St. Paul, in exchange for a fee statement. The fee statement shows the deadline for payment without late-fee penalty. Fees may be paid by mail or in person.
6. Pay fees. See the current *General Information Bulletin* for information about fees and expenses.

Registration Dates—For continuing students, these dates are scheduled during August for fall registration and during the last 4 weeks of fall and winter quarters for winter and spring registrations. Specific dates are announced in the Official Daily Bulletin column in the *Minnesota Daily*.

Admission to Closed Sections—Limits on class or section sizes are established to accommodate the maximum number of students who can be taught effectively in a given course or, in some cases, by size of the classroom to be used. Instructors order books and make other plans according to expected enrollments, and difficult problems arise if these limits are not observed. Permission to enter a closed section is, therefore, a privilege that cannot be extended frequently.

Information on courses and sections of courses that remain open is available at the college office and in Johnston Hall and is updated several times daily.

Waiting lists are kept for closed courses reserved at 223 Snyder Hall. Students who do not attend the first meeting of a course and who have not made prior arrangements with the instructor lose their place in the course. Other students on a waiting list and in attendance on the first day may then be permitted to enter.

Permission to Enter Courses—Special permission is needed to enter some courses. Course listings in this bulletin and in the *Class Schedule* indicate by symbols when permission of the instructor (#) or department (Δ) is required. To register for such courses, written permission must be presented to the Class Reservations office.

Independent Study—All independent study, directed study, or extra credit registrations require instructor and departmental approval. Registration materials include information about procedures for such registrations. Approval must be obtained before registration can be completed.

Y Registration permits students to complete a course in their own way without class attendance. Students must meet such course conditions as examinations and other work on which they and the instructor agree. The usual fees, deadlines, grading systems, and other regulations apply. Instructor and departmental permission are required.

X Registration allows students to earn 1 to 3 extra credits in a course already taken or in progress by exploring more deeply 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 and *Directed Research* registrations allow students to undertake and complete academic work of their own design under the guidance of an instructor in a field to which the work is relevant. Students work largely on their own initiative and at their own speed, often in the instructor's research laboratory. Credit assignments vary, but work normally averages 30 hours a quarter for each credit. Regular evaluation and grading procedures apply. Advance approval of the instructor is required.

Directed Instruction provides students with an opportunity to participate in teaching a course with whose subject matter they are well acquainted. Instructor and departmental permission are required. From 1 to 5 credits are awarded per quarter. A maximum of 8 such credits may be counted toward the total required for graduation.

Auditing Courses—Auditing or visiting a course involves enrollment and attendance but does not permit active participation in classroom or other activities. No credit is granted, and no grade is assigned. Other conditions apply to this form of registration: (1) college permission, which will not be given until the controlled-registration period has ended, is required for enrollment; (2) the course may not be taken later for credit; (3) the regular fee is paid for the course; and (4) the course will appear on the transcript with the symbol "V."

Repeating a Course—Students may repeat a course they have failed without securing special permission. Both the old and the new grade will be included on the academic record. It is not mandatory to repeat a failed course unless it is needed to meet a prerequisite or other requirement.

Repeating a course for which credit has already been received is rarely permitted. College approval is required for this purpose.

Other No-Credit Courses—Arrangements may be made in some circumstances to fully participate in a course's work and receive a grade under a no-credit registra-

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tion (i.e., the grade does not count). College permission is necessary. The plan is sometimes employed by students who wish to review work previously taken.

CHANGES OF REGISTRATION—CANCEL-ADD

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 canceling or adding by an instructor is not sufficient. The change in registration must be officially recorded. Failure to adhere to these guidelines can be costly in terms of time or credit and can deny other students places in classes.

The steps in either canceling or adding a course are as follows:

1. Obtain a cancel-add form from the college office, 223 Snyder Hall.
2. Obtain college approval when necessary (see below).
3. Check with the appropriate Class Reservations office if the change occurs during the first 2 weeks of a quarter (unless the course involved is not a reserved class).
4. Turn in the cancel-add form at 130 Coffey Hall, St. Paul.
5. If the change alters the total credit load so that it falls above or below 12 credits, apply for an altered fee statement at 130 Coffey Hall.

When to Cancel-Add—Cancel-adds will *not* be accepted until the alphabetical registration period has ended. (This assures a first chance for every student.) Exceptions will be granted only to correct serious hour conflict problems or errors made by college or University staff.

Late Additions and Cancellations—Registration changes (especially additions) after a quarter opens are discouraged. However, students are permitted to add classes during the first week of a quarter or to cancel through the second week by simply filing the cancel-add form. Consultation with the instructor and adviser is recommended.

After the first week, courses may be added only with written permission of the instructor. A student may cancel after the second week of a quarter only once during an academic year—never more often except under extraordinary circumstances and with college approval. Cancellation after the last day of classes is rarely approved.

Canceling Out of College—To leave the University during a given quarter, a student must cancel all current registration (mere absence from classes does not constitute official withdrawal). When a student cancels out of school or plans not to return in a succeeding quarter, the student should state that intent at the college office, cancel any existing registrations, and check his or her financial status at 130 Coffey Hall.

Credits and Grades

Maximum and Minimum Credit Loads—Most students register for 15 or 16 credits of course work each quarter. In cases where outside jobs or responsibilities demand 20 or more hours of time a week, students are advised to take a reduced course load; if outside activities take more than 30 hours, the student should register for yet fewer credits. In general, it is unwise to work more than 15 to 20 hours a week while attending college.

The maximum credit load is normally 19 credits a quarter. Heavier loads require college approval.

Credit Value—A credit represents about 3 hours of work a week or about 30 hours in a 10-week quarter. Thus, a 4-credit course requires about 120 hours per quarter of acceptable work. The time may be spent in various combinations of class, laboratory, homework, and other study.

Grades—There are five permanent passing grades: A, representing achievement that is outstanding relative to the level necessary to satisfy course requirements; B, representing achievement that is significantly above the level necessary to satisfy course requirements; C, representing achievement that satisfies the basic course requirements in every respect; D, representing achievement that is worthy of credit even though it does not fully satisfy the basic course requirements in every respect (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 that meet science or math requirements); and S, representing achievement that is satisfactory to the instructor, for the program in which the student is registered.

In connection with all achievement symbols, but especially in connection with S, the instructor is obligated to define to a class in its early meetings, as explicitly as possible, the performance that will be necessary to earn each grade.

An N grade is assigned when the student does not earn an S or a D or higher and is not assigned an I. It stands for *no credit*.

The symbol I (incomplete) is assigned when some required work is unfinished and, in the instructor's opinion, the possibility of earning credit exists. An I becomes an N when work is not completed by the end of the next quarter of residence.

A symbol W (withdrawal) indicates that a student has been permitted to cancel officially without grade.

A symbol X may be reported in continuation courses for which a grade cannot be determined until the sequence is completed. When the sequence is completed, each X is changed to a permanent grade.

A registration symbol V (visitor) indicates registration as an auditor or visitor, a noncredit, nongrade registration.

S-N Registration—Students are permitted to register for certain courses (subject to the restrictions outlined below) under the S-N grading system. The S-N grading system is designed to encourage students to take a greater variety of courses. Freeing students to some extent from the pressure of grades, this system encourages students to pursue their learning more for its own sake, studying for personally motivated inquiry rather than as a response to specific classroom demands. With college permission, the S-N system is also used for certain courses in which it is impractical to evaluate student achievement more precisely.

The decision to take a given course on the S-N system must be indicated on the registration blank. The following restrictions govern those who may elect S-N grading and the number and types of courses that may be taken under the system:

1. Except as qualified below, students have the option of registering for any course on an S-N basis. A change in registration to A-N from S-N or from S-N to A-N may not be made after the end of the second week of classes.
2. Candidates for the bachelor's degree must present a minimum of 75 percent of their University of Minnesota residence credits required for graduation in courses in which a grade of A, B, C, or D¹ has been received. Any or all

¹Credits of D must be balanced by credits of A or B.

- portions of a sequence course may be taken on the S-N basis. No waiver of prerequisite is implied.
3. Students may not register on an S-N basis for courses used to satisfy college graduation requirements in mathematics and in the physical or biological sciences, unless such courses are offered on an S-N only basis. All other courses offered to satisfy requirements may be taken on either A-N or S-N.
 4. If approved by the major department and the major adviser, students may take courses to be used to fulfill the additional upper division credits in mathematics, physical sciences, or biological sciences on S-N.
 5. Courses specified by CBS departments as prerequisite for their major work must be taken by prospective majors on the A-N basis. Exceptions may be authorized by a department or by an instructor in a major course.
 6. The above options are not meant to encourage every student to use them. Students who plan to apply to a graduate or professional school will find themselves at a serious disadvantage if they cannot present on A-N almost all work relevant to their proposed specialization.

Satisfactory Progress

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

If students are concerned about their progress, they should consult early with their instructors, adviser, or staff in the college office. Students who are temporarily handicapped by conditions beyond their control (illness, family emergencies, etc.) may wish to discontinue their registration until these conditions have improved. When discontinuance takes place at any time other than the end of the quarter, the college office can assure that courses in progress will be recorded as Ws.

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

Students who fail to attain 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 taken off probation when academic work has improved enough to promise continuous progress toward a degree.

Suspension From College—Accumulation of an excessive amount of substandard work usually means that a student is jeopardizing the likelihood of graduating from CBS or of transferring to another institution. 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 on the basis of all the 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. College office personnel and faculty advisers are available for consultation concerning alternatives to college requirements, transfer to other institutions, and prospects for eventual readmission to CBS.

Readmission to the College—Students suspended from the college may return only upon approval of the college office. Strong assurance that the factors that caused 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 from suspended students for readmission are normally considered after an interval of at least a year. Students demonstrating their readiness for readmission in less than a year will be considered on an individual basis.

Class Attendance, Examinations, Other Regulations

Class Attendance—Students have a responsibility for class attendance. All departments hold students responsible for the work in their courses but differ somewhat in their treatment of absences. Students must, therefore, learn the policy of each instructor and, if they have a legitimate excuse, arrange with the instructor to make up any work missed. Either the instructor or student may consult with the college office concerning the validity of the excuse.

Students who miss opening classes may lose their places in the courses for which they are registered.

Final Examinations—The all-University final examination schedule is published each quarter in the *Class Schedule*. Students are required to take examinations at the scheduled time. Students who have a conflict between examinations or have three examinations within a 16-hour period should report the problem to the college office prior to the beginning of the examination period. This will permit adjustments to be made. Students who miss a final examination should immediately notify the instructor.

When a student misses a final examination, an I or N is recorded, depending on the student's standing at the time. It is necessary to obtain the instructor's permission to make up an examination.

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

Appeals and Suggestions—The adviser or a staff member in the college office is a good source for interpretation of college procedures and regulations.

If an individual is dissatisfied with a college or department procedure after the initial contact, he or she should go to the person or office that is the source of the problem. Each department has a grievance committee, as does the college, comprised of both student and faculty membership. Advice from staff in the college office may also be helpful.

Application to Graduate

Filing the Application—Two quarters before they intend to graduate, students must file an application for graduation at 223 Snyder Hall. On filing this application, a senior balance sheet listing the remaining requirements to be completed for the degree is sent to the student and to the Office of Admissions and Records.

Admission, Academic Regulations, and Degree Procedures

Credits in Graduate School—Seniors who lack no more than 9 credits of the 180 required for the bachelor's degree may petition to take a limited amount of work for graduate credit. Previous approval must be obtained from the Graduate School. Such work will not count toward the bachelor's degree.

With approval of the College of Biological Sciences and the Graduate School, students admitted to a graduate program and lacking no more than 6 credits of the total required to complete the bachelor's degree may register in the Graduate School as well as in CBS.



Kathie Peterson and undergraduate Peggy Mann review career planning materials.



Rose Relopez and Donna Smith preparing for spring prereservation.

CBS SCIENCE REQUIREMENTS SUGGESTED TIME SEQUENCE

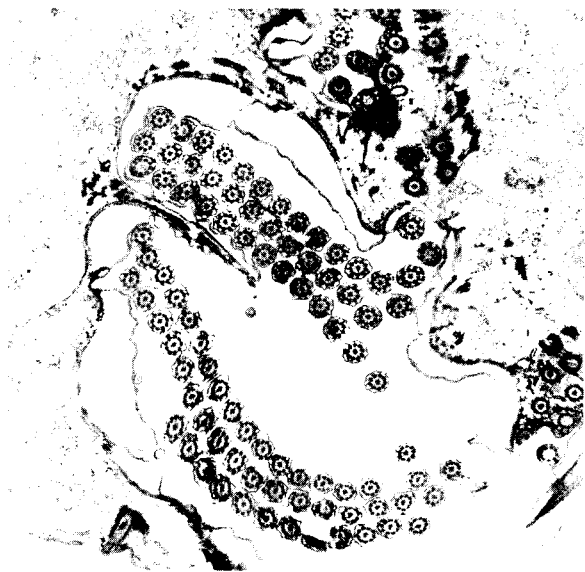
	Freshman			Sophomore			Junior			Senior			
	F	W	S	F	W	S	F	W	S	F	W	S	
Recommended ¹	██████████												
Latest Possible	▤▤▤▤▤▤												
A. PREREQUISITES													
Calculus (15 cr)	██████████						▤▤▤▤▤▤						
General Chemistry ² (10 cr)	██████████			▤▤▤▤									
Organic Chemistry ² (10 cr)				██████████			▤▤▤▤						
Physics ³ (15 cr)				██████████			██████████			▤▤▤▤▤▤			
General Biology (5 cr)	██████████			▤▤▤									
B. BIOLOGY CORE⁴													
Biol 3011, Animal Biology				*	██████████						▤▤▤		
Biol 3012, Plant Biology				*	██████████						▤▤▤		
Biol 3013, Microbiology							██████████			▤▤▤			
Biol 3021, Biochemistry							*	██████████			▤▤▤		
Biol 3033, Genetics							██████████			▤▤▤			
Biol 3034, Cell Biology							██████████			▤▤▤			
Biol 3041, Ecology				*	██████████						▤▤▤		

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

²Biochemistry majors must take the 15-credit, 3-quarter sequence.

³Students needing physical chemistry (biochemistry majors) or general physiology *must* complete this sequence within the recommended period.

⁴The period indicated is recommended in order to leave the senior year open for advanced study and research. Although some of the core courses may be taken earlier (*), after completion of the prerequisites, these courses are usually filled by more advanced students. Obviously, all of the courses cannot be postponed until the latest possible time.



An electron micrograph showing the oral cavity of *Tetrahymena pyriformis*, a freshwater ciliated protozoan.



Doris M. Preus using the transmission electron microscope.

III. CURRICULAR REQUIREMENTS AND COURSE DESCRIPTIONS

Course Numbering System—The first digit of each course number indicates the minimum class standing level expected of the student, according to the following system:

- 1001 to 1998—primarily for freshmen and sophomores
- 3001 to 3998—open to juniors and seniors
- 5001 to 5998—open to juniors, seniors, and graduate students
- 8001 to 8998—open to graduate students only

The final three digits "970" indicate "directed study."

A hyphen between course numbers (e.g., 3142-3143-3144) indicates a sequence of courses that must be taken in the order listed.

A comma between course numbers (e.g., 1234, 1235, 1236) indicates a series of courses that may be entered any quarter.

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

Prerequisites should be considered as guides to the background a student is expected to have. When a prerequisite is listed, an equivalent course may be substituted. In case of question, consult the instructor of the particular course.

Symbols—The following symbols are used throughout the course descriptions in lieu of page footnotes:

- § Credit will not be granted if the equivalent course listed after the section mark has been taken for credit.
- ¶ Concurrent registration is allowed (or required) in the course listed after the paragraph mark.
- # Consent of the instructor is required prior to registration.
- △ Consent of department, division, or school offering the course is required prior to registration.
- † All courses preceding the dagger must be completed before credit will be granted for any quarter of the sequence.
- H Honors section of a regular course.

Class Scheduling—Students should consult the quarterly *Class Schedule* to learn the hour and place of meeting for specific courses.

Biochemistry (BioC)

Director of Undergraduate Studies—1977-78 Professor C. Woodward; 1978-79 Professor Glass

The major in biochemistry is designed for students who contemplate 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 3990 and through the honors program. It is advisable to start planning the research component of the major program as early as possible, and interested students are urged, in consultation with their adviser, to make arrangements for their senior research project during their junior year.

Curricular Requirements and Course Descriptions

In addition to the general requirements for graduation from the College of Biological Sciences, biochemistry majors must complete the following (*where optional sequences exist, recommended courses are listed first*):

Biochemistry—BioC 3960, 5002, 5025. In addition, advanced and special topics courses (e.g., 5745, 5764, 5950, Chem 5601) are recommended. In some cases, BioC 5751-5752 may be accepted as a substitute for 5002 and special topics.

Organic Chemistry—

(a) Chem 3333, 3336

or

(b) Chem 3303, 3307

Analytical Chemistry—

(a) Chem 1133. In addition, 5133 is recommended.

or

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

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

Physical Chemistry—

(a) Chem 5533, 5534, 5535 (formerly 5502, 5503, 5505) plus Chem 5536 or 5538

or

(b) Chem 5520, 5521 plus 6 additional credits in physical and/or biological sciences for this sequence.

German is the foreign language of choice.

COURSES—BIOCHEMISTRY

1301f,w. ELEMENTARY BIOCHEMISTRY I. (5 cr, §Chem 1002 or 3301; prereq Chem 1001 or 1005) Glass, Jenness
The chemistry of carbon compounds that occur in nature. Composition, structures, and properties of the major components of plant, animal, and bacterial cells.

1302w,s. ELEMENTARY BIOCHEMISTRY II. (3 cr; prereq 1301 or Chem 1002)
Biochemical principles; reactions of organic compounds in the living cell. Metabolic pathways, energy considerations, and biosynthetic processes; emphasis on aspects essential to an understanding of plant and animal nutrition and physiology.

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

3960f,w,s. RESEARCH TOPICS IN BIOCHEMISTRY. (1 cr; offered S-N only; prereq sr or 3rd-4th jr biochemistry major)
Lectures and discussions on current research in the department.

3990. UNDERGRADUATE RESEARCH. (1-3 cr; prereq sr biochemistry major, B avg or #, and Δ)
Research problems for B.S. degree (thesis optional)

5001f,w,s,su. BIOCHEMISTRY. (3 cr, §Biol 3021; prereq Biol 1011, 10 cr organic chemistry)
Biochemistry and biophysics of cells; emphasis on enzyme catalysis, cellular energetics, biosynthesis of cellular constituents and cellular regulatory mechanisms.

5002w. BIOCHEMISTRY TOPICS. (3 cr; prereq 5001 or Biol 3021)
Topics not covered in 5001. 5001-5002 constitutes a 2-quarter sequence for undergraduate and graduate students lacking physical chemistry and serves as a prerequisite for certain advanced courses.

5025f,w,s. LABORATORY IN BIOCHEMISTRY. (2 cr; prereq 5001 [Biol 3021] or 15001 [Biol 3021])
Discussions of techniques and problem-solving approaches illustrated with laboratory experiments and demonstrations.

5522f. PHYSICAL BIOCHEMISTRY OF SOLUTIONS. (4 cr, §Chem 5522; prereq 2 qtrs physical chemistry...5001 [Biol 3021] desirable)
Physical chemistry of equilibrium and transport phenomena in solution, with application to biochemical systems. Electrolyte and polyelectrolyte solutions, solutions of macromolecules, binding of substrates, diffusion and sedimentation, viscosity, diffusion-controlled kinetics, interfacial phenomena: colloids and micelles.

- 5523w. PHYSICAL BIOCHEMISTRY: STRUCTURE AND INTERMOLECULAR FORCES.** (4 cr, §Chem 5523; prereq 2 qtrs physical chemistry...5001 [Biol 3021] desirable)
 Methods of structure determination of biological macromolecules. Scattering and diffraction, optical and magnetic resonance spectroscopy. Helix-coil transition theory. Application to proteins, nucleic acids, and synthetic analogs.
- 5524s. PHYSICAL BIOCHEMISTRY: DYNAMICS.** (4 cr, §Chem 5524; prereq 2 qtrs physical chemistry...5001 [Biol 3021] desirable)
 Application of thermodynamics, statistical mechanics, and chemical kinetics; solvent effect structure-function relation.
- 5744w. BIOCHEMICAL ANALYSIS.** (2 cr, §5745; prereq 5025 with grade of B or better, 5751 [or 5002] or §5751 [or §5002], cr in analytical chemistry, or #)
 Discussion of biochemical techniques. Designed for students who do not desire further laboratory experience.
- 5745w. BIOCHEMICAL ANALYSIS.** (4 cr, §5744; prereq 5025 with grade of B or better, 5751 [or 5002] or §5751 [or §5002], cr in analytical chemistry, or #)
 Discussion and laboratory experiments in biochemical techniques.
- 5751-5752w. GENERAL BIOCHEMISTRY.** (4 cr per qtr, §MdBc 5751-5752; prereq Biol 3021 or equiv, 2 qtrs physical chemistry or regis in 2nd qtr of physical chemistry)
 Offered jointly by Departments of Biochemistry (College of Biological Sciences) and Biochemistry (Medical School). Structure, function, metabolism, and metabolic regulation of components in biological systems. Previously 5741-5742-5743.
- 5764f. METALLOPROTEINS: STRUCTURE AND FUNCTION.** (3 cr; prereq 5001, 5002...5523 recommended)
 Wood, Muenck
 Magnetic resonance techniques. Transition metals in enzyme-catalyzed reactions.
- 5950f,w,s. SPECIAL TOPICS.** (1-5 cr; prereq #, Δ)
- 5970. DIRECTED STUDIES.** (1-3 cr; prereq #, Δ)
 Offered to enable students to make up deficiencies in background course work.

FOR GRADUATE STUDENTS ONLY

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

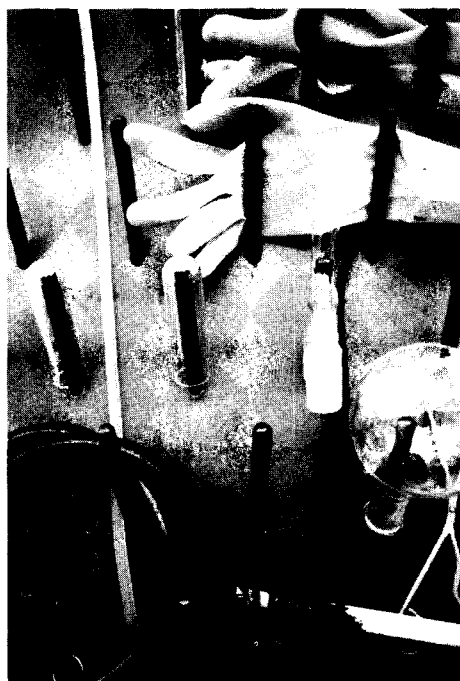
- 8091f. GRADUATE STUDENT ORIENTATION**
- 8094. RESEARCH AND LITERATURE REPORTS**
- 8194. GRADUATE SEMINAR**
- 8211. CARBOHYDRATES**
- 8221. ENZYMES**
- 8225. TRACER TECHNIQUES**
- 8231. LIPIDS**
- 8250. SPECIAL TOPICS IN BIOCHEMISTRY**
- 8261. PROTEINS**
- 8271. VITAMINS**
- 8290. CURRENT RESEARCH TECHNIQUES**
- 8746. BIOCHEMISTRY LABORATORY PROJECTS AND ADVANCED TECHNIQUES**
- 8990. GRADUATE RESEARCH**

RECOMMENDED RELATED COURSES FROM OTHER COLLEGES

Students interested in additional course work are encouraged to consider options offered by other academic units. Courses in plant sciences (PIPa, PIPh), nutrition (FScN), physiology (PhsI), computer science (CSci), biophysics (BPhy), organic chemistry (Chem), and chemical engineering (ChE) represent some of these alternatives. Students should consult their adviser for further details.



Dr. Vic Bloomfield supervising the alignment of a laser light scattering apparatus for the study of virus assembly.



Biology (Biol)

Director of Undergraduate Studies—Professor Kerr

The biology major is designed to provide the student with a broadly based but thorough undergraduate education in the biological sciences. In addition to the core course requirements for graduation, the biology major must complete 24 additional upper division credits in the mathematical, biological, and/or physical sciences. The distribution of these credits is determined by the student in consultation with his or her adviser, who is a member of the faculty of one of the departments of the college. A prospective biology 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 the specialized curriculum that is available.

COURSES—BIOLOGY

- 1011f,w,s,su. GENERAL BIOLOGY.** (5 cr)
Introduction to the principles of biology. The cell, metabolism, heredity, reproduction, ecology, and evolution.
- 1011H. GENERAL BIOLOGY.** (5 cr)
Same as above.
- 1101f,w,s. HEREDITY AND HUMAN SOCIETY.** (4 cr, §GCB 3002; no cr if taken after 3032 or 3033 or GCB 3022; for students in programs not directly related to biological sciences) Fan, Woodward
Principles of heredity and their social and cultural implications.
- 1102f,w. MICROBES AND MAN.** (4 cr)
Microorganisms in relationship to humans and their environment in the processing and preservation of food, waste disposal, and environmental factors; bacterial products of industrial and pharmaceutical importance; role of microorganisms in recycling elements of the biosphere; microorganisms and disease.
- 1103f,w,s,su. GENERAL BOTANY.** (5 cr, §3012; prereq 1011) Wetmore, Charvat
Levels of organization of plants, plant function, plant growth and development, plant reproduction.
- 1105w. ECOLOGY AND EVOLUTION.** (4 cr; prereq 1011 or 1101) Pace
Understanding of evolutionary processes is developed through examination of interactions of organisms with their environments. Predictions about living systems, including that of humans.
- 1106f,w,s,su. GENERAL ZOOLOGY.** (5 cr; prereq 1011)
Survey of animal phyla; structure, function, behavior, adaptation, and evolutionary relationships.
- 1107w. INTRODUCTION TO BEHAVIORAL BIOLOGY.** (5 cr; prereq 1011) Hopkins
Central ideas in behavior: control of movement, ontogeny, hormone and sensory systems, behavioral evolution, social behavior. Behavior of primates.
- 1951f-1952w-1953s. BIOLOGY COLLOQUIUM.** (2/1-2/1-2 cr; for prospective majors; S-N only; prereq 1011 or ¶1011, #)
Encourages and allows active participation in education. Provides an orientation to the biological sciences as well as interaction with other biology students and faculty members.
- 3011f,w,s,su. ANIMAL BIOLOGY.** (5 cr; prereq 1011, Chem 1005)
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; prereq 1011, Chem 1005) Pratt, Koukari, Hirsch
Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants.
- 3013f,w,s. MICROBIOLOGY.** (4 cr, §MicB 3103, §MicB 5105; prereq 3021) Chapman, Dworkin, C Woodward
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Emphasis on molecular structure in relation to bacterial function.

Curricular Requirements and Course Descriptions

- 3021f,w,s,su. BIOCHEMISTRY.** (4 cr, §BioC 5001; prereq 1011, 10 cr organic chemistry)
Biochemistry and biophysics of cells; emphasis on enzyme catalysis, cellular energetics, biosynthesis of cellular constituents and cellular regulatory mechanisms.
- BioC 5025f,w,s. LABORATORY IN BIOCHEMISTRY.** (2 cr; prereq BioC 5001 [or Biol 3021] or †BioC 5001 [or †Biol 3021])
Discussions of techniques and problem-solving approaches illustrated with laboratory experiments and demonstrations.
- 3033f,w,s. GENETICS.** (4 cr, §3032; prereq 3021)
Introduction to the nature of genetic information, its transmission from parents to offspring, its expression in cells and organisms, and its course in populations.
- GCB 5030f,w,s. LABORATORY: GENETICS.** (2 cr; prereq GCB 3022 or GCB 5022 or Biol 3032 or #)
Investigative approaches to analysis of genetic problems. Focus on a given organism or related group of organisms may differ from quarter to quarter.
- 3034f,w,s. CELL BIOLOGY.** (3 cr, §3032; prereq 3021)
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.
- 3041f,w,s,su. ECOLOGY.** (4 cr, §5041; prereq biology major, Math 1231, or #, Δ)
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.
- 3042f,w,s,su. LABORATORY IN ECOLOGY.** (2 cr; prereq 3041 or 5041 or EBB 3004 or #)
Student research projects on selected ecological problems.
- 3051f,w,s. BIOLOGY AND THE FUTURE OF MAN.** (4 cr; S-N only) Pratt, Gorham
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.
- 3950f,w,s. UNDERGRADUATE SEMINAR.** (1 cr; S-N only; prereq #, Δ)
Each quarter different members of the faculty lead groups of seniors in discussions of topics of current interest.
- 3980f,w,s. DIRECTED INSTRUCTION.** (1-5 cr; prereq #, Δ)
- 5041f,w,s,su. ECOLOGY.** (3 cr, §3041; for grad students only; prereq Math 1231 or #, Δ)
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.
- 5061w,s. DEVELOPMENTAL BIOLOGY.** (3 cr; prereq 3032 or 3033 and 3034 or #) Charvat, Rottmann
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.
- 5501s. BIOCHEMICAL EVOLUTION.** (4 cr; prereq 5 cr biochemistry) Kirkwood, Jenness, Seal
Molecular evolution covering prebiotic evolution and the phylogeny of important functional molecules and biochemical systems in living organisms.
- 5950. SPECIAL TOPICS IN BIOLOGY.** (1-5 cr per qtr; prereq Δ)
- 5951. THE BIOLOGIST AS SCIENTIST, EDUCATOR, AND CITIZEN.** (3 cr; prereq 15 cr biological sciences) Hooper, Cunningham
The role of the scientist in decision making and persuasion; teaching methods in biology; the organizational structure of the academic and governmental worlds.

COURSES OFFERED AT LAKE ITASCA FORESTRY AND BIOLOGICAL STATION

- 5870su. ITASCA SEMINAR.** (Cr ar; prereq #) Staff
Topic selected and scheduled during registration by interested staff members and students.
- 5890su. RESEARCH PROBLEMS AT ITASCA IN ECOLOGY AND BEHAVIORAL BIOLOGY; OR ENTOMOLOGY, FISHERIES, AND WILDLIFE; OR PLANT PATHOLOGY; OR SOIL SCIENCE; OR ZOOLOGY.** (Cr ar; prereq #) Staff
Undergraduate and graduate students may develop a short-term research project in any departmental area listed above during one or both terms.

FOR GRADUATE STUDENTS ONLY(For course descriptions, see the *Graduate School Bulletin*)**8710. TUTORIAL IN DEVELOPMENTAL BIOLOGY****8950. GRADUATE SEMINAR****8970. SPECIAL TOPICS****8990. GRADUATE RESEARCH****Botany (Bot)****Director of Undergraduate Studies—Professor Soulen**

The program for the major 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 should take Bot 3131 (or 5131) and 5132 to fulfill the physiology requirement. In fulfillment of part of the 24 additional science and mathematics credits required for graduation, botany students are required to take 15 upper division credits in botany; these should include courses in anatomy (3109 or 5111), taxonomy (3201 or 5801), and morphology (5103 or 5105—it is recommended that both be taken).

COURSES—BOTANY

- 1009s. MINNESOTA PLANT LIFE.** (4 cr; suitable for nonmajors) Morley
Identification of the more common and conspicuous Minnesota plants with some discussion of their basic distinctions, life cycles, habitat requirements, distribution, and ecological relations. Lectures, demonstrations, six or seven field trips.
- 1012f. PLANTS USEFUL TO MAN.** (4 cr; for majors or nonmajors) Jonas
Roles that plants have played in human biological and cultural development. Lectures and demonstration of material.
- 3003. FIELD BOTANY.** (4 cr; intended for prospective teachers; prereq 1009 or Biol 1011 or 1103, and #: offered when feasible)
Plants in nature, their recognition, geographical distribution, reproductive habits, growth and seasonal development, and uses by aboriginal people. Use of the out-of-doors for teaching natural history. Weekly field trips.
- 3071s. PLANTS AND HUMAN AFFAIRS.** (4 cr; prereq #) Jonas
Reciprocal and deterministic interaction between plants and humans as illustrated by events and developments in agriculture, industry, trade, domestic and foreign affairs, medicine, religious customs, and the arts.
- 3109f. PLANT ANATOMY.** (5 cr; prereq Biol 1103 or 3012) Hall
Structure and development of plants with special reference to vascular plants.
- 3131f,w,s. SURVEY OF PLANT PHYSIOLOGY.** (4 cr, \$5131, \$PIPh 3131, \$PIPh 5131; prereq Biol 1103 or 3012, Chem 3301 or BioC 1301) Soulen, Koukkari, Pratt, Guilfoyle, Jendrisak
Physiological principles underlying processes that occur in living plants with emphasis on higher plants. Growth and development, mineral nutrition, water relations and metabolism, including respiration, photosynthesis.
- 3201w. INTRODUCTORY TAXONOMY.** (3 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; prereq #)
Biological topics of current interest.
- 3970f,w,s,su. INDEPENDENT STUDY.** (1-5 cr per qtr; prereq #)
Individual study on selected topics or problems with emphasis on selected readings and use of scientific literature.
- 3990f,w,s,su. RESEARCH PROBLEMS.** (1-5 cr per qtr; prereq #)
Individual research for undergraduates.
- 5103f. BIOLOGY OF NONVASCULAR PLANTS.** (5 cr; prereq Biol 1103 or 3012) McLaughlin
Algae, fungi, lichens, and bryophytes. Characteristics of groups, evolutionary relationships, life cycles,

Curricular Requirements and Course Descriptions

comparative morphology (including ultrastructure), comparative nutrition. Laboratory emphasizes living material and isolation of algae and fungi into culture.

- 5105w. MORPHOLOGY OF VASCULAR PLANTS.** (5 cr; prereq Biol 1103 or 3012 or #) Hall
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) Hirsch
Microscopic structure of vascular plants; development in root, stem, and leaf.
- 5131f,w,s. SURVEY OF PLANT PHYSIOLOGY.** (4 cr, §3131, §PIPh 3131, §PIPh 5131; prereq Biol 1103 or 3012, Chem 3301 or BioC 1301) Soulen, Koukkari, Pratt, Guilfoyle, Jendrisak
Physiological principles underlying processes that occur in living plants, with emphasis on higher plants. Growth and development, mineral nutrition, water relations, and metabolism including respiration and photosynthesis. Includes a weekly discussion section.
- 5132s. PLANT PHYSIOLOGY LABORATORY.** (2 cr; prereq 3131 or 5131 or f3131 or f5131)
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, courses in biology, physics, and organic chemistry or biochemistry) Smith, Parsons
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, courses in biology and organic chemistry) Brun, Guilfoyle
Growth of higher plants; division and differentiation of cells, development of plant organs, effects of external factors on plant growth, photosynthesis and respiration in relation to plant development, and nature and action of plant growth substances.
- 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 1977-78 and alt yrs) Morley
Characteristics and relationships of orders and families of flowering plants on a world-wide basis.
- 5212w. PRINCIPLES OF ANGIOSPERM PHYLOGENY.** (3 cr; prereq 3201 or #; offered 1978-79 and alt yrs)
Morley
Evolutionary relationships and the various means of judging them within the angiosperms. Laboratory investigation of representative and critical groups.
- 5231s. INTRODUCTION TO THE STUDY OF ALGAE.** (5 cr; prereq 10 cr in botany or biology or #; offered 1978-79 and alt yrs)
Structure, reproduction, and life histories of major algal divisions.
- 5251s. PHYLETIC PALEOBOTANY.** (5 cr; prereq Biol 1103 or 3012) Hall
Anatomy, morphology, and evolution of fossil vascular plants. Angiosperm paleofloristics and paleoecology, excluding the Quaternary.
- 5970f,w,s,su. BASIC BOTANY.** (Cr ar; prereq Biol 1103 or 3012 and #)
Individual work in some special discipline.

COURSES OFFERED AT LAKE ITASCA FORESTRY AND BIOLOGICAL STATION

- 5801su. SUMMER FLORA OF MINNESOTA.** (5 cr; limited to 20 students; prereq course in taxonomy; offered annually)
Survey of the summer flowering plants and ferns of the state with particular reference to the local flora. Identification by technical keys; important plant families; field recognition of common species; habitat preferences; collecting methods; literature; taxonomic methods.
- 5805su. AQUATIC FLOWERING PLANTS.** (5 cr; limited to 20 students; prereq course in taxonomy; offered annually)
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; offered annually)
The taxonomy and morphology of freshwater algae as related to ecology. Culturing techniques and identification of field collections, and utilization of this information in teaching and research emphasized.

- 5815su. BRYOPHYTES.** (5 cr; limited to 20 students; prereq 10 cr biology or #; offered when feasible)
Field and laboratory study of the mosses and liverworts of Minnesota with emphasis on their local ecology and taxonomy.
- 5821su. LICHENS.** (5 cr; limited to 20 students; prereq 10 cr in botany or zoology or #; offered when feasible)
Taxonomy, ecology, and floristics of lichens of northern Minnesota; identification, sampling methods, microchemistry as a taxonomic tool.

FOR GRADUATE STUDENTS ONLY

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

8950f,w,s. SEMINAR

8970f,w,s,su. SPECIAL TOPICS

8990f,w,s,su. RESEARCH PROBLEMS

RECOMMENDED RELATED COURSES FROM OTHER COLLEGES

Botany majors should consult the bulletins of other University of Minnesota colleges for additional courses of interest, in such areas as:

Entomology, Plant Pathology, Plant Physiology, Soil Science (College of Agriculture)

Microbiology (Medical School)

Geology (Institute of Technology)

Ecology and Behavioral Biology (EBB)

Director of Undergraduate Studies—Professor Underhill

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 program a suitable selection of advanced courses appropriate to their interests.

COURSES—ECOLOGY AND BEHAVIORAL BIOLOGY

INTRODUCTORY ECOLOGY AND BEHAVIORAL BIOLOGY

- 3001w. INTRODUCTION TO ECOLOGY.** (4 cr; open to jrs and above but not to biology majors) Corbin
Basic concepts in ecology dealing with the organization, development, and functioning of ecosystems; population growth and regulation. Human impact on such systems.
- 3004w. FUNDAMENTALS OF ECOLOGY.** (4 cr; not open to biology majors; prereq Biol 1011, college algebra)
Tester
Relationships between organisms and their environment; ecosystem structure and function emphasizing energy flow, biogeochemical cycling and succession; population dynamics; introduction to regional biotic communities.
- 3097w. (formerly Zool 3097). POPULATION BIOLOGY.** (4 cr; prereq Biol 3032 or 3033 or GCB 3022) Merrell
Principles of population biology. Adaptation of natural populations to their environment and genetic mechanisms by which they respond to environmental change.
- 3101f,w. ECOLOGY FOR ENGINEERS AND PHYSICAL SCIENTISTS.** (4 cr, §3001; not open to biology majors; prereq Math 1231) Megard, Bright
Description and analysis of the spatial and temporal interactions between populations in ecosystems with emphasis on the processes affecting populations and the transformations of energy and materials in the biosphere. Lectures and recitations.
- 3111s. VERTEBRATE BEHAVIOR.** (4 cr, §AnSc 3111; prereq Biol 1106 or 3011, or #) Phillips
Introduction to the nature and variety, development, motivation, and evolution of animal behavior, emphasizing social interactions and communication.
- 3960f. RESEARCH TOPICS IN ECOLOGY AND BEHAVIORAL BIOLOGY.** (1 cr; S-N only; prereq sr or 3rd-qr jr in CBS)
Lectures and discussions on current research in the department.

Curricular Requirements and Course Descriptions

3990f, w, s. RESEARCH PROBLEMS. (1-6 cr; prereq #)
Individual research for undergraduate majors in biology.

COMMUNITY ECOLOGY AND PALEOECOLOGY

5014f. ECOLOGY OF PLANT COMMUNITIES. (5 cr; prereq 3004 or Biol 3041, 1 qtr statistics or #) Cushing
Methods of describing, sampling, and classifying plant communities; theory of their structure, development, and stability of the interactions among their constituent populations. Field trips to examine local vegetation types; analysis of quantitative data.

5016s. ECOLOGICAL PLANT GEOGRAPHY. (5 cr; prereq 3004 or Biol 3041, Bot 3201 or ¶Bot 3201 or #) Cushing
Vegetation regions of the world in general and North America in detail; ecological principles of plant distribution; interpretation of regional and temporal pattern(s) in the distribution of vegetation and taxonomic groups. Field trips to floristic regions of Minnesota.

POPULATION AND EVOLUTIONARY BIOLOGY

5031s. EVOLUTIONARY ECOLOGY. (3 cr; prereq Biol 3041 or equiv, and #; offered 1977 and alt yrs) Corbin
Evolutionary concepts and theory applied to the study of populations, communities, and ecosystems. Current literature and research emphasized.

5044su (formerly Zool 5096). EVOLUTION. (4 cr; prereq Biol 1106 or 3011) Merrell
Survey of evidence for and causes of biological evolution.

5052w. THEORETICAL POPULATION ECOLOGY. (4 cr; prereq Biol 3041 or 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.

5054f (formerly EBB 5017). PREDATORS. (3 cr; prereq 5052 or #) Taylor
Energetics, ecology, and evolution of vertebrate and invertebrate predators and insect parasitoids.

5055f (formerly EBB 5021). PREDATION LABORATORY. (2 cr; prereq 5054 or ¶5054 and #) Taylor
Individual projects in the behavior and population ecology of predators.

5062f (formerly Zool 5171). GENETICS AND SPECIATION. (4 cr; prereq 15 cr biology incl genetics, #) Merrell
Application of genetic principles to problems of speciation and evolution.

ORGANISMAL BIOLOGY AND PHYSIOLOGICAL ECOLOGY

5112s (formerly Zool 5071). 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. (formerly Zool 5124). VERTEBRATE BIOLOGY. (4 cr; prereq Biol 1106 or 3011) Underhill
Vertebrates; their biology, taxonomy, and distribution.

5115f (formerly Zool 5125). VERTEBRATE FAUNA LABORATORY. (2 cr; prereq 5114 and #; offered 1977 and alt yrs) Underhill
Vertebrate groups native to Minnesota and neighboring states.

5116f (formerly Zool 5093). INTRODUCTION TO ANIMAL PARASITOLOGY. (5 cr; prereq Biol 1106 or 3011) Gilbertson
Elementary course dealing with parasitic protozoa, worms, and arthropods and their relation to diseases of humans and animals.

5118w. SYMBIOSIS. (4 cr; prereq Biol 1106 or 3011) Gilbertson
Interactions of organisms of different species living in intimate physiological association.

5122f. 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.

5129f (formerly Zool 5129). MAMMALOGY. (5 cr, §FW 5129; prereq Biol 1106 or 3011 or #) Birney
Recent families and orders of mammals of the world and of genera and species of mammals of North America, with emphasis on morphology, evolution, and zoogeographic history.

5132s (formerly Zool 5128). HERPETOLOGY. (5 cr; prereq Biol 1106 or 3011 or #) Regal
Distribution, classification, and evolution of amphibians and reptiles of the world. Physiological, morphological, and behavioral aspects of adaptive trends. Laboratory and lecture.

5134s (formerly Zool 5077). INTRODUCTION TO ORNITHOLOGY. (5 cr; prereq Biol 1106 or 3011) Warner
Laboratory and field course in structure, classification, distribution, migration, habits, habitats, and identification of birds. Weekend trips scheduled.

Ecology and Behavioral Biology

- 5136s (formerly Zool 5121). ICHTHYOLOGY.** (4 cr; prereq 15 cr incl Biol 1106 or 3011) Huver
Biology of fishes including development, systematics, anatomy, physiology and ecology.
- 5154w. BEHAVIORAL AND PHYSIOLOGICAL ECOLOGY.** (3 cr; prereq adv course work in physiology, behavior, or ecology) Regal
Ecological approach to behavioral and physiological control systems including mechanisms by which animals regulate their positions in time and space and regulate the internal milieu. Orientation, learning and adaptation of behavior, heat and water regulation, bioenergetics, biological rhythms.
- 5155w,s. LABORATORY IN BEHAVIORAL AND PHYSIOLOGICAL ECOLOGY.** (3 cr; prereq 5154, #) Regal
Emphasis on individual directed projects.
- 5156s (formerly Zool 5104). 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. Introduction to the passive organism; environmental stresses and biological mechanisms by which they are counteracted.
- 5158s (formerly EBB 5561). PHYSIOLOGICAL PLANT ECOLOGY.** (3 cr; prereq Biol 3012 or Bot 3131 or 5131 or #) Morrow
The physical state, distribution and availability to plants of water, nutrients, light, and carbon. Physiological and morphological adaptations of plants for obtaining and retaining these resources. Resource allocation strategies in diverse environments
- 5159s. PHYSIOLOGICAL PLANT ECOLOGY LABORATORY.** (2 cr; prereq 5158 or # 5158 or #) Morrow
Field and laboratory measurements of physiological and morphological responses of plants to their environment.

BEHAVIOR

- 5314w. NEUROETHOLOGY.** (3 cr, §AnSc 5314; prereq Biol 3011 or AnSc 1300 or #; offered 1977 and alt yrs) Phillips
Current concepts of neurological and neurochemical bases of animal behavior, including reception, coding, transmission and storage of information; levels of integration, central control of input and output; spontaneity development, and learning.
- 5322w. (formerly EBB 5022). COMPARATIVE ETHOLOGY.** (4 cr; prereq #) McKinney
Evolution and adaptive significance of behavior, primarily in vertebrates, with emphasis on comparative methods.

LIMNOLOGY AND ECOSYSTEM ECOLOGY

- 5601f. LIMNOLOGY.** (4 cr, §Geo 5601; prereq Chem 1005 or #) Shapiro
Description and analysis of the events occurring in lakes, reservoirs, and ponds, beginning with their origins and progressing through a study of their physics, chemistry, and biology. Interrelationships of these parameters and effects of civilization of lakes. Laboratory and field trips.
- 5602f. CASE STUDIES IN LIMNOLOGY.** (3 cr; prereq 5601 or Geo 5601 and #; offered 1978 and alt yrs) Shapiro
Interactions between physical, chemical, and biological phenomena in lakes; relationships between lakes, watersheds, and human activities.
- 5603s. PLANKTON POPULATIONS.** (5 cr; prereq 5601 or 5812, Biol 3041 or #; lab fee required) Megard
Biology of plankton and analysis of the maintenance and regulation of planktonic populations. Laboratory studies of the taxonomy, morphology, and biology of plankton. Two Saturday field trips.
- 5608f. ECOSYSTEMS: FORM AND FUNCTION.** (3 cr; prereq 3004 or 5601 or Biol 3041, Chem 1002 or 1005) Gorham
Nature and development of terrestrial, wetland, and aquatic ecosystems. Analysis of energy flow and element cycling in relation to environmental controls, self-regulation, natural and human disturbances.
- 5609f. ECOSYSTEMS LABORATORY.** (2 cr; prereq 5608 or *5608) Gorham
A field and laboratory course to accompany 5608.
- 5612s. BIOGEOCHEMICAL CYCLES.** (3 cr; prereq Biol 3041 or 5041, Biol 3021 [or BioC 5001] or MicB 5321 or #) Wood
Biogeochemical cycles for essential, nonessential, and toxic elements in the biosphere. Emphasis on human impact on biogeochemical cycles and on the connections between these cycles.
- 5970f,w,s. DIRECTED STUDIES.** (Cr ar; prereq .)

COURSES OFFERED AT LAKE ITASCA FORESTRY AND BIOLOGICAL STATION

- 5807su (formerly Zool 5807). PROTOZOLOGY.** (5 cr; limited to 15 students; prereq Biol 1106 or equiv. offered when feasible)



Both photos on this page were taken at the Lake Itasca Forestry and Biological Station. Above: a view of the station facilities. Below: specimen collection.



Ecology and Behavioral Biology

Morphology, classification, growth, development, physiology, genetics, ecology, and distribution of protozoa. Laboratory emphasizes local protozoa and their habitats.

- 5812su. AQUATIC ECOLOGY.** (5 cr; limited to 20 students; prereq 15 cr biology, 5 cr chemistry; offered annually)
The nature, origin, development, and productivity of lakes, and conditions for plant and animal life in water. Individual and team projects in field and laboratory research.
- 5813su. TOPICS IN LIMNOLOGY.** (5 cr, limited to 12 students; prereq introductory course in limnology [5812 or 5601 or equiv]. prior completion of Bot 5811 recommended; offered when feasible)
Measurement and theoretical analysis of the relationships between photosynthesis and population dynamics of plankton. Lectures, laboratory, and fieldwork.
- 5814su. COMMUNITY STRUCTURE AND FUNCTIONING.** (5 cr; limited to 20 students; prereq course in ecology; offered annually)
Communities represented in Itasca Park and vicinity and their dynamic relationships. Relationships of local communities to the flora and fauna of Minnesota as a whole. Use of modern methods of community analysis and measurement.
- 5815su. FIELD ETHOLOGY.** (5 cr; limited to 15 students; prereq course in ornithology or ecology; offered annually)
Behavioral function, evolution, causation, and development, stressing the relationship between environment and behavior. Sound recording, motion picture photography, tape and film analysis, and marking techniques emphasized. An individual research project and term paper on the social behavior of one species of bird, mammal, frog, or dragonfly.
- 5816su. ECOLOGY OF FRESHWATER ALGAE.** (5 cr; limited to 12 students; prereq 5813, Bot 5811; offered when feasible)
Phytoplankton as a biotic community; its spatial and temporal distribution and consideration of factors influencing periodicity. Field and laboratory instruction in relevant research techniques
- 5817su. VERTEBRATE ECOLOGY.** (5 cr; limited to 15 students; prereq course in ecology; offered annually)
Field studies on populations and their relationships to local environments; habitat analysis and ecological research methods. Individual and team research projects, field trips, and lectures. Reports and complete data analysis required on two research projects.
- 5818su. QUANTITATIVE ECOLOGY.** (5 cr; limited to 15 students; prereq 9 cr in ecology, 1 qtr statistics or #; offered when feasible)
Design of field studies of populations, communities, and ecosystems. Emphasis on formulation and testing of hypotheses in the field, design of field sampling, and analysis and interpretation of data; not on particular field methods of collecting data. Several short field problems will be designed by the class, drawing on the collective technical and taxonomic expertise of students and instructor. Lectures on conventional ways of treating and presenting quantitative data and on basic statistical and mathematical models that are most useful to field ecology.
- 5819su. SOILS AND THE ECOSYSTEM.** (5 cr; limited to 20 students; prereq course in ecology; offered when feasible)
Functional and structural aspects of soils as a component of the ecosystem. Interrelationships of soil and vegetation on the landscape.
- 5820su. WETLAND ECOLOGY.** (5 cr; limited to 15 students; prereq 15 cr biology, introductory chemistry, or # ... Biol 3041 recommended; offered when feasible)
Nature, origin, and development of lake, marsh, swamp, and bog ecosystems; environmental control and productivity.
- 5821su. QUATERNARY PALEOECOLOGY.** (5 cr; limited to 15 students; prereq 1 qtr ecology or #; offered when feasible)
Problems and techniques in the reconstruction of past communities and ecosystems from fossil evidence in deposits from the Quaternary age; field and laboratory methods in collection and description of stratigraphic sequences, and identification and quantitative analysis of fossil assemblages.
- 5822su. REGIONAL LIMNOLOGY.** (5 cr; limited to 20 students; prereq 15 cr biology, 10 cr chemistry; offered when feasible)
Basic limnology, involving field and laboratory research on diverse lakes and ponds of the Itasca region. Emphasis on morphometric, physical, and chemical characteristics of aquatic ecosystems
- 5831su (formerly Zool 5814). NATURAL HISTORY OF INVERTEBRATES.** (5 cr; limited to 20 students; prereq Biol 1106; offered annually)
Advanced taxonomic and ecological survey of local fauna and independent ecological studies of several taxonomic groups
- 5832su (formerly Zool 5819). NATURAL HISTORY OF VERTEBRATES.** (5 cr; limited to 20 students; prereq Biol 1106; offered annually)
Taxonomic survey of local vertebrates, exclusive of birds, and study of morphological, physiological, and behavioral adaptations to different habitats

Curricular Requirements and Course Descriptions

5834su (formerly Zool 5834). FIELD ORNITHOLOGY. (5 cr; limited to 15 students; prereq Biol 1106; offered annually)

Field and laboratory studies, including bird identification, ecology and behavior, taxonomy.

5843su (formerly Zool 5843). ANIMAL PARASITES. (5 cr; limited to 15 students; prereq Biol 1106; offered when feasible)

Parasites of local fauna with special reference to helminths.

5869su (formerly Zool 5869). PHYSIOLOGICAL ECOLOGY. (5 cr; limited to 15 students; prereq course in physiology or ecology; offered when feasible)

Functional adaptations of organisms to various physical and biotic factors of the natural environment.

FOR GRADUATE STUDENTS ONLY

(For course descriptions, see the Graduate School Bulletin)

8001w. ANALYSIS OF POPULATIONS

8002s. STATISTICAL ANALYSIS OF ECOLOGICAL SYSTEMS

8003w. ECOLOGICAL MODELING

8004w. TOPICS IN ECOLOGICAL GENETICS

8051f. BEHAVIORAL ADAPTATIONS

8061f. SOCIAL SYSTEMS

8071s. ANIMAL COMMUNICATION

8162w. WINTER ECOLOGY

8390. GRADUATE SEMINAR

8391. ADVANCED WORK IN ECOLOGY AND BEHAVIORAL BIOLOGY

8990. GRADUATE RESEARCH

RECOMMENDED RELATED COURSES FROM OTHER COLLEGES

AnSc 3305. REPRODUCTIVE PHYSIOLOGY, ARTIFICIAL INSEMINATION, LACTATION

Anth 8431. SEMINAR: COMPARATIVE ETHOLOGY

ChEn 5755. BIOCHEMICAL ENGINEERING

Ent 3175. INTRODUCTORY ENTOMOLOGY

Ent 5025. INSECT MORPHOLOGY

Ent 5026. EMBRYOLOGY AND DEVELOPMENT OF INSECTS

Ent 5027. INSECT METABOLISM AND COORDINATION

Ent 5150. PRINCIPLES OF SYSTEMATIC ENTOMOLOGY

Ent 5275. MEDICAL ENTOMOLOGY

Geo 1601. MARINE SCIENCES

Geo 5151. INTRODUCTION TO PALEONTOLOGY

Geo 5152. INVERTEBRATE PALEONTOLOGY

Geo 5154. VERTEBRATE PALEONTOLOGY I

Math 5427. APPLIED MATHEMATICS FOR THE LIFE SCIENCES

Psy 3011. INTRODUCTION TO PSYCHOLOGY OF LEARNING

Psy 3031. SENSATION AND PERCEPTION

Psy 5012-5013. PSYCHOLOGY OF LEARNING

Psy 5031. PERCEPTION

Psy 5061. FUNDAMENTALS OF PHYSIOLOGICAL PSYCHOLOGY

Psy 5062. NEUROPSYCHOLOGY OF MOTIVATION AND LEARNING

Psy 5071. ANIMAL PSYCHOLOGY

Soil 5512. SOIL GEOGRAPHY

Soil 5632. SOIL MICROBIOLOGY AND PLANT GROWTH

Soil 5710. ADVANCED FOREST SOILS

VB 5120. COMPARATIVE VERTEBRATE MORPHOLOGY

VB 5310. MAMMALIAN ENDOCRINOLOGY AND REPRODUCTION

VB 5320. AVIAN PHYSIOLOGY

Genetics and Cell Biology (GCB)

Director of Undergraduate Studies—Professor R. K. Herman

The Department of Genetics and Cell Biology participates in teaching the core curriculum in biology. Students with a special interest in genetics and/or cell biology major in biology and include in their program a suitable selection of advanced courses appropriate to their interests.

COURSES—GENETICS AND CELL BIOLOGY

- 3002s. HUMAN GENETICS, SOCIAL AFFAIRS.** (3 cr [4 cr with term paper], §3022, §Biol 1101, §Biol 3032, §Biol 3033; 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 (formerly Zool 3333). THE BIOLOGY OF CANCER.** (3 cr; prereq Biol 1011) McKinnell
Biological aspects of etiology, phylogeny, and cellular processes involved in neoplasia. Growth and differentiation of normal and cancer cells. The history of cancer research.
- 3011 (formerly Zool 5052). GENERAL AND COMPARATIVE EMBRYOLOGY.** (5 cr, §5011; prereq Biol 1106 or 3011) McKinnell
Embryological development of vertebrates.
- 3022f,w,s,su. GENETICS.** (4 cr, §Biol 3032, §3033; designed primarily for students other than CBS majors and CLA biology majors; prereq Biol 1011)
Mechanisms of heredity, their implications for biological populations and applications to practical problems.
- 3201s. MOLECULAR BIOLOGY FOR ENGINEERS AND PHYSICAL SCIENTISTS.** (3 cr [4 cr with term paper]; not open to biology majors; prereq 2 qtrs chemistry, Math 1231 or 1331 or 1621 or #) Rubenstein
Modern molecular biology emphasizing the principles of biological structures and mechanisms of function at the macromolecular and cellular levels of organization.
- 3960s. RESEARCH TOPICS.** (1 cr; S-N only; for biology majors; prereq Biol 3032 or 3033 and 3034)
Discussions of faculty research.
- 3970f,w,s,su. INDEPENDENT STUDY.** (Cr ar; prereq # and Δ)
Individual study on selected topics or problems with emphasis on selected readings and use of scientific literature.
- 3990f,w,s,su. LABORATORY RESEARCH.** (Cr ar; prereq # and Δ)
Individual projects on selected topics and problems.
- 5011 (formerly Zool 5052). GENERAL AND COMPARATIVE EMBRYOLOGY.** (4 cr, §3011; for grad students only; prereq Biol 1106 or 3011) McKinnell
Embryological development of vertebrates.
- 5013s (formerly Zool 5127). COMPARATIVE MAMMALIAN REPRODUCTION.** (5 cr; prereq 3011 or EBB 5156 or 6 cr equiv, #; offered 1977 and alt yrs) Sinha
Interdisciplinary approaches in evaluating biological phenomena of reproduction incorporating basic problems, current concepts and ideas in the field. Four lectures and discussions, and an hour of independent studies/research or laboratory work.
- 5015 (formerly Zool 5066). HISTOLOGY.** (5 cr; prereq Biol 1106 or 3011)
Microscopic structure of tissues and organs.
- 5017f (formerly Zool 5107). PROTOZOOLOGY.** (4 cr; prereq #; offered 1978 and alt yrs) Kerr
Introduction to taxonomy, morphology, physiology, development, and genetics of free-living protozoa.
- 5022f,w,s,su. GENETICS.** (3 cr, §3022, §Biol 3032, §Biol 3033; not open to grad students in genetics)
Mechanisms of heredity, their implications for biological populations, and applications to practical problems.

Curricular Requirements and Course Descriptions

- 5030. LABORATORY: GENETICS.** (2 cr; prereq 3022 or 5022 or Biol 3032 or 3033 or #)
Investigative approaches to analysis of genetic problems. Focus on a given organism or related group of organisms may differ from quarter to quarter.
- 5031f. INTERMEDIATE GENETICS I.** (3 cr; prereq 3022 or Biol 3032 or 3033 and BioC 5002 or 5752, or #)
Mechanics of inheritance. Comparative organization of genetic material in procaryotic and eucaryotic organisms. Mutation, complementation, and recombination as operational criteria for genetic analysis.
- 5032w. INTERMEDIATE GENETICS II.** (3 cr; prereq 5031) R Herman
Action of the gene in molecular, cellular, and organismal development. Mechanisms of storage of genetic information, modes of information transfer, and mechanism of regulating these processes in various biological systems
- 5033s. INTERMEDIATE GENETICS III.** (3 cr; prereq 3022 or Biol 3032 or 3033, course in biometry or statistics, or #) Enfield
Genetic variation in quantitative traits with special attention to fitness. Causes of change of equilibria in gene frequencies, heterosis and inbreeding depression, consequences of natural and artificial selection.
- 5042f. POPULATION, QUANTITATIVE GENETICS.** (3 cr; S-N only; prereq 5033...Stat 5301 recommended) Comstock
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.
- 5043s. HUMAN GENETICS.** (3 cr; prereq 3022 or Biol 3032 or 3033 or #) V E Anderson
Inherited characters in humans, particularly in relation to medicine, relationships of genetics in marriage and social conditions.
- 5044w. METHODS IN HUMAN GENETICS.** (3 cr; prereq 5043, PubH 5450 and #) V E Anderson
Methods for research in human genetics. Importance of appropriate statistical techniques. Use of genetic concepts in exploring new problems. Individual study of current problems and group discussion.
- 5045s. MOLECULAR PRINCIPLES OF BEHAVIOR.** (3 cr; prereq BioC 5002 or #) 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.
- 5046f. MOLECULAR BIOLOGY OF GENETIC DISEASES.** (3 cr; prereq 5031, 5043, BioC 5002 or equiv, Biol 3032 or 3034 or equiv or #) Desnick
Basic genetic, biochemical and pathologic principles of inherited human metabolic disorders
- 5047s. GENE EXPRESSION DURING DEVELOPMENT.** (4 cr; prereq 5032) Blumenfeld
Control of gene expression during development; Drosophila development; differential gene expression; developmental changes in chromosome structure.
- 5051w. INTERMEDIATE CELL BIOLOGY.** (3 cr; prereq #...introductory biochemistry and molecular genetics recommended)
Analysis of structure, replication and function of general and specialized cell types at the microscopic and molecular level. Cell membranes, organelles, and macromolecular aggregates; cell division, secretion, regulation of macromolecular synthesis, and cellular differentiation.
- 5052s. QUANTITATIVE TECHNIQUES, CELL BIOLOGY.** (4 cr; prereq #...calculus, introductory cellular or molecular biology, biochemistry recommended) Rosenberg, Rubenstein
Use and detection of radioisotopes; theory and practice of analytical and preparative ultracentrifugation, chromatography, spectroscopy, and electron microscopy; tissue culture and subcellular particle fractionation.
- 5055s (formerly Zool 5164). FINE STRUCTURE OF ANIMAL CELLS.** (4 cr; prereq 5051 or Biol 3032 or 3034, #) Johnson
Cell structure and function are approached on an organelle basis, emphasizing ultrastructural research. Cell membranes, macromolecular synthesis, bioenergetics, cell movement.
- 5063s. THEORETICAL POPULATION GENETICS.** (3 cr; prereq 5033 or #, familiarity with differential and integral calculus) Simmons
Population genetic theory as related to problems of natural populations.
- 5082f. MEMBRANES AND INTERFACES.** (4 cr; prereq #) Rosenberg
Thermodynamics, statistical mechanics, electrical properties, and experimental systems for the study of interfaces. Isolation, dynamic properties, chemistry, and model systems of biological membranes. Cell surface and contact relations.
- 5114f.w (formerly Zool 5114). GENERAL PHYSIOLOGY.** (3 cr; prereq Biol 3011, 3021, Phys 1106 or 1295) Goldstein, Sheridan
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.
- 5115f.w (formerly Zool 5115). LABORATORY IN GENERAL PHYSIOLOGY.** (2 cr; prereq 5114 or *5114 or #) Goldstein, Sheridan
Emphasis on electrophysiological phenomena. Recitation and practical laboratory.

History of Science and Technology

- 5132s (formerly Zool 5132). INTERCELLULAR COMMUNICATION.** (4 cr; prereq 5114, Biol 3032 or 3034 or #: offered 1978 and alt yrs) Sheridan
Detailed discussion of the mechanisms of various forms of intercellular communication, including synaptic transmission, hormone action and transfer of small molecules via low resistance junctions. Emphasis on the role of the cell membrane in these processes.
- 5134w (formerly Zool 5134). ENDOCRINOLOGY.** (4 cr; prereq Biol 3011, 3021, or #) W Herman
Survey of structure and function of invertebrate and vertebrate endocrine systems.
- 5135s (formerly Zool 5135). ENDOCRINOLOGY LABORATORY.** (2 cr; prereq 5134, #) W Herman
Assigned exercises demonstrating basic endocrine techniques. Student research projects arranged in consultation with instructor.
- 5136f (formerly Zool 5136). ADVANCED ENDOCRINOLOGY.** (3 cr; prereq 5135 or #: offered 1977-78 and alt yrs) W Herman
Lectures on specific areas of current endocrinologic interest.
- 5605 (formerly Biol 5605). CELL BIOLOGY LABORATORY.** (2 cr; prereq 5051 or *5051 or Biol 3032 or 3033 and 3034 or *Biol 3034 or #)
Experimental approaches to cell structure, function, and replication; including microscopy, autoradiography, cell fractionation, and molecular and chemical analyses.
- 5606f,s (formerly Biol 5606). BIOLOGICAL ELECTRON MICROSCOPY.** (2 cr; prereq 5051 or Biol 3032 or 3033 and 3034 or #) Cunningham
Theory and operation of transmission and scanning electron microscopes. Demonstrations of preparation techniques for biological material including freeze-etching, autoradiography, thin sectioning, negative staining, cytochemistry, and metal shadowing.

FOR GRADUATE STUDENTS ONLY

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

8060. CURRENT TOPICS

8600. (formerly Biol 8600) f,w,s,su. LABORATORY IN ELECTRON MICROSCOPY

8900. SEMINAR

8970. DIRECTED STUDY

8990. RESEARCH

History of Science and Technology (HSci)

(Institute of Technology)

Coordinator—Roger H. Stuewer, 428 Physics

The history of science and technology studies the origins and development of science and technology and their relations to the social, cultural, and philosophical currents of their time. Courses in the field may be taken to support majors in existing departments or programs as well as to broaden knowledge of the nature and development of science and technology. They may also be used to fulfill Group C distribution requirements.

COURSES—HISTORY OF SCIENCE AND TECHNOLOGY

- 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 of the 19th and 20th centuries.
- 1811, 1812, 1813. INTRODUCTION TO HISTORY OF SCIENCE.** (4 cr per qtr, §3811, §3812, §3813) Shapiro
1811: Babylonian and Egyptian science; Greek natural philosophy, mathematics, astronomy, and biology; the Aristotelian world; decline and transmission of Greek science. 1812: Medieval background; the Scientific Revolution; the "experimental philosophy"; dissecting and describing nature; anatomy, circulation, and respiration; Copernican revolution; physical world of Kepler, Galileo, Descartes, and Newton; science and the popular imagination. 1813: 19th and 20th centuries; Newtonian triumph, romantic reaction, and modern revolution; the aether, electrical and optical; to Einstein; history of the earth, evolution before and after Darwin; nuclear physics and nuclear weapons.

Curricular Requirements and Course Descriptions

- 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; biology and society, race and eugenics.
- 3711, 3712, 3713. TECHNOLOGY AND WESTERN CIVILIZATION.** (4 cr per qtr, §1711, §1712, §1713)
See description of 1711, 1712, 1713.
- 3811, 3812, 3813. INTRODUCTION TO HISTORY OF SCIENCE.** (4 cr per qtr, §1811, §1812, §1813)
See description of 1811, 1812, 1813.
- 3825. PHYSICS AND SOCIETY IN 20TH-CENTURY AMERICA.** (4 cr, §3835, §5325)
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)
Development of nuclear energy in the 20th century; construction and use of the bomb; postwar military and political impact.
- 5111f. PHYSICAL SCIENCES IN ANTIQUITY.** (4 cr) Shapiro
Mathematics and astronomy in Babylonia; Greek mathematics, Euclid and Archimedes; Aristotle's physics and cosmology; the emergence of mathematical and experimental natural science in Greece; Ptolemaic astronomy.
- 5201, 5202, 5203. HISTORY OF BIOLOGY.** (4 cr per qtr, §3201, §3202, §3203)
See description of 3201, 3202, 3203.
- 5242. EVOLUTION BEFORE AND AFTER DARWIN.** (4 cr; prereq Biol 1011 or 1101 or #) Kottler
Philosophical conceptions of species; natural theology, design, and providential creation of species; Lamarck and evolution before Darwin; catastrophist and uniformitarian geology; Darwin and the background of the *Origin*; Darwin's early critics; evolutionary theory, 1882 to modern synthesis; social Darwinism.
- 5760. SELECTED TOPICS.** (1-5 cr per qtr; prereq #)
- 5825. PHYSICS AND SOCIETY IN 20TH-CENTURY AMERICA.** (4 cr, §3825, §3835) Stuewer
See description of 3825.
- 5924. HISTORY OF 19TH-CENTURY PHYSICS.** (4 cr §Phys 5924; prereq general physics or #) Stuewer
Internal conceptual developments in physics in 19th century (Young, Fresnel, Oersted, Ampere, 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
Internal conceptual developments in relativity (Michelson, Lorentz, Poincaré, Einstein, others), quantum mechanics (Planck, Einstein, Rutherford, Bohr, Sommerfeld, Ehrenfest, Pauli, Millikan, Compton, Heisenberg, deBroglie, Schrödinger, Born, others), and nuclear physics (Chadwick, Gamow, Fermi, others). Relationships to social, philosophical, and theological influences.
- 5970. DIRECTED STUDIES.** (1-15 cr per qtr; prereq #)
Guided individual reading or study.
- 5990. DIRECTED RESEARCH.** (1-15 cr per qtr; prereq #)

Microbiology (MicB)

Director of Undergraduate Studies—Professor Rogers

The 4-year curriculum that leads to the bachelor of science degree with a major 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, which are currently under study employing microorganisms. They may seek answers to fundamental problems con-



Dr. Jim Prince teaching an undergraduate microbiology course.



A microbiology lab in progress.

Curricular Requirements and Course Descriptions

cerning human and animal diseases such as the mechanism of viral and bacteriological infection, immune mechanisms 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 maximal 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 addition to the areas of research open to the microbiologist, opportunities are available in teaching. Students who select careers outside of microbiology will find the training in this field valuable in many related areas of biological research, industry, medicine, and public health.

In fulfillment of part of the 24 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 5234, 5322 or the laboratory accompanying virology (5424), and immunology (5216)

Two of the following: MicB 5232, 5424, 5611

Chem 3100-3101

A sequence in physical chemistry is highly recommended (e.g., Chem 5520-5521)

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 departmental office, 1060 Mayo Memorial Building (Minneapolis), or from the undergraduate college office.

COURSES—MICROBIOLOGY

3103w. GENERAL MICROBIOLOGY. (5 cr; prereq soph with C avg in courses prereq to major sequence, or jr with 10 cr in chemistry and 5 cr in biological sciences or #) Schmidt

Morphology, physiology, taxonomy, and ecology of bacteria. Practical applications of fundamental principles.

5105f. BIOLOGY OF MICROORGANISMS. (4 cr, §3103, §Biol 3013, §VB 3103; prereq 5 cr in biological sciences, Biol 3021 or #) Dworkin

Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Molecular structure in relation to bacterial function.

5216f. IMMUNOLOGY. (4 cr; prereq Biol 3021) Gray, Schmidtke

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 3021) Gray

Same as 5216 without laboratory.

5232w. MEDICAL MICROBIOLOGY. (3 cr; not open to med students; prereq 5216 or 5218 and 5105 or 3103 or 8110 or Biol 3013) Cleary

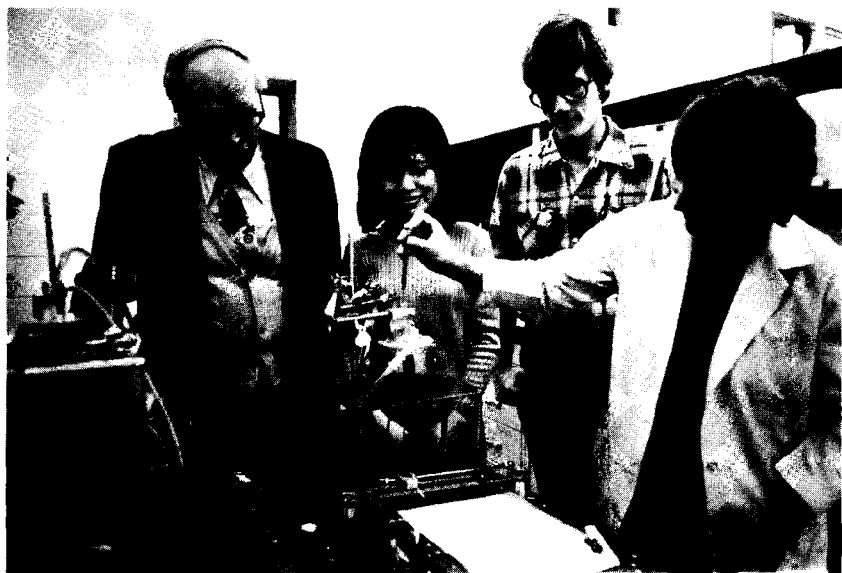
Pathogenic bacteria and fungi, mechanisms of pathogenicity and virulence, properties of microorganisms and their animal hosts that influence the fate of host-parasite relations analyzed from genetic and metabolic point of view.

5233f. MICROORGANISMS AND DISEASE. (7 cr; not open to microbiology majors; prereq 10 cr in chemistry and 5 cr in biological sciences or #) Johnson

Nature of microorganisms, immunology, medical bacteriology, virology, mycology, parasitology, and principles of disease control. Laboratory.

5234w. MEDICAL MICROBIOLOGY LABORATORY. (2 cr; prereq 5232 or 5232) Cleary

Demonstration of the principles that influence interactions of microorganisms and humans leading to a diseased state.



Dr. Stan Dagley is assisted in measuring oxygen consumption during a biochemical experiment.



An undergraduate laboratory experiment employing the centrifuge.

Curricular Requirements and Course Descriptions

- 5321w. PHYSIOLOGY OF BACTERIA.** (3 cr; prereq 3103 or 5105 or Biol 3013, 10 cr in organic chemistry or biochemistry, 3 cr in 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 and a lab course in basic bacteriology) Rogers
Techniques employed in the study of bacterial physiology and metabolism.
- 5424s. BIOLOGY OF VIRUSES.** (4 cr; prereq 5321, Biol 3021 or #) Plagemann
Structure, composition, and properties of bacterial, plant, and animal viruses; their interaction with cells and effects on host cell metabolism; biochemistry of viral replication; techniques used in study of viruses and viral infections; viral tumorigenesis. Laboratory.
- 5611f. MICROBIAL ECOLOGY.** (4 cr; prereq a general microbiology course, Biol 3021 or #) Crawford
Microbial adaptation and diversity; role of microorganisms in natural processes; methods in microbial ecology; other topics.
- 5900f,w,s. TOPICS IN MICROBIOLOGY.** (1 cr; open to microbiology srs; S-N only) Rogers
Seminars on research programs, historical perspectives, significant emerging fields, professional societies and publications, and career opportunities.
- 5970f,w,s,su. DIRECTED READINGS.** (Cr ar; prereq #) Staff

COURSES OFFERED AT LAKE ITASCA FORESTRY AND BIOLOGICAL STATION

- 5811sull. FIELD STUDIES IN MICROBIAL ECOLOGY.** (5 cr; limited to 12 students; prereq course in microbiology) Crawford
Field studies of natural microbial populations: enumeration of specific types of microorganisms in natural environments, enrichment techniques, submerged slide culture, and observations of natural microbiological phenomena.

FOR GRADUATE STUDENTS ONLY

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

- 8110. BIOLOGY OF MICROORGANISMS**
- 8112. MICROBIAL GENETICS**
- 8120. MICROBIOLOGY LABORATORY**
- 8121. ADVANCED IMMUNOLOGY LABORATORY**
- 8122. ADVANCED MICROBIOLOGY** (Offered when feasible)
- 8202. ORAL MICROBIOLOGY**
- 8218. IMMUNOCHEMISTRY AND IMMUNOBIOLOGY**
- 8234. ADVANCED MEDICAL MICROBIOLOGY**
- 8242. DIAGNOSTIC MICROBIOLOGY**
- 8323. REGULATION OF METABOLISM** (Offered when feasible)
- 8329. IMMUNOGENETICS**
- 8421. MOLECULAR BIOLOGY OF CANCER**
- 8425. ADVANCED LABORATORY IN VIROLOGY AND ANIMAL CELL CULTURE**
- 8911. COLLOQUIUM IN MICROBIOLOGY**
- 8920. ADVANCES IN IMMUNOLOGY**
- 8990. RESEARCH IN MICROBIOLOGY**

RECOMMENDED RELATED COURSES FROM OTHER COLLEGES

- FSCN 5120. FOOD MICROBIOLOGY**
- FScN 5122. SANITATION AND CONTROL OF MICROORGANISMS**
- FSCN 5123. MICROBIOLOGY OF FOOD FERMENTATIONS**
- LMed 5103. PRINCIPLES OF DIAGNOSTIC MICROBIOLOGY**
- LMed 5133. MEDICAL MYCOLOGY**

LMed 5136. ANAEROBIC BACTERIOLOGY

PubH 5171f. ENVIRONMENTAL MICROBIOLOGY

PubH 5342. PUBLIC HEALTH BACTERIOLOGY

VB 3103f,s. GENERAL MICROBIOLOGY (§MicB 3103)

Zoology (Zool)

The undergraduate major in zoology has been discontinued. Students interested in the study of animals should major in biology and complete appropriate courses.

Students admitted to the zoology major prior to spring quarter 1977 are required to complete, in addition to the core curriculum, a minimum of three courses (12-15 credits) in the major field; i.e., in courses formerly designated "Zool."

Courses formerly listed under the zoology course designator may now be found in the listings of the Departments of Ecology and Behavioral Biology (EBB) and Genetics and Cell Biology (GCB).

COURSES—ZOOLOGY

FOR GRADUATE STUDENTS ONLY

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

8970. GRADUATE SEMINAR

8980. SPECIAL RESEARCH FIELDS

8990. GRADUATE RESEARCH

IV. DEPARTMENTAL OFFICES AND FACULTY

College of Biological Sciences Offices

Office of the Dean

Richard S. Caldecott, Professor and Dean, 123 Snyder Hall, St. Paul campus (373-1190)

Undergraduate College Office

Kathleen F. Peterson, Assistant to the Dean for Student Services, 223 Snyder Hall, St. Paul campus (373-3648)

Biochemistry

Finn Wold, Professor and Head, 140 Gortner Laboratory, St. Paul campus (373-1303)

Botany

Douglas C. Pratt, Professor and Head, 220 Biological Sciences Center, St. Paul campus (373-2211)

Ecology and Behavioral Biology

Margaret B. Davis, Professor and Head, 108 Zoology Building, Minneapolis campus (373-5177)

Genetics and Cell Biology

Frederick Forro, Jr., Professor and Head, 250 Biological Sciences Center, St. Paul campus (373-0966)

Microbiology (Medical School)

Dennis W. Watson, Professor and Head, 1060 Mayo Memorial Building, Minneapolis campus (373-8070)

Dight Institute for Human Genetics

Sheldon C. Reed, Professor and Director, 8 Botany Building, Minneapolis campus (373-3792)

V. Elving Anderson, Professor and Assistant Director, 8 Botany Building, Minneapolis campus (373-3792)

Field Biology Program

David F. Parmelee, Professor and Chairman, 349 Bell Museum of Natural History, Minneapolis campus (373-1292)

Freshwater Biological Institute

John M. Wood, Professor and Director, P. O. Box 100, County Roads 15 and 19, Navarre, Minnesota 55392 (471-8476)

General Biology Program

Norman S. Kerr, Professor and Associate Dean (Undergraduate Programs), P180 Kolthoff Hall, Minneapolis campus (373-3650)

James Ford Bell Museum of Natural History

Harrison B. Tordoff, Professor and Director, 301 Bell Museum of Natural History, Minneapolis campus (373-2423)

Faculty

Department of Biochemistry

Professor

Victor Bloomfield, Ph.D.
 Stanley Dagley, Ph.D.
 John E. Gander, Ph.D.
 Robert L. Glass, Ph.D.
 LaVell M. Henderson, Ph.D.
 Robert Jenness, Ph.D.
 Samuel Kirkwood, Ph.D.
 Irvin E. Liener, Ph.D.
 Palmer Rogers, Ph.D.
 Ulysses S. Seal, Ph.D.
 Huber R. Warner, Ph.D.
 Finn Wold, Ph.D.
 John M. Wood, Ph.D.

Associate Professor

John S. Anderson, Ph.D.
 Peter J. Chapman, Ph.D.
 Rex E. Lovrien, Ph.D.
 Eckard Muenck, Ph.D.
 Gary L. Nelsestuen, Ph.D.
 Clare K. Woodward, Ph.D.

Assistant Professor

James A. Fuchs, Ph.D.
 Gary R. Gray, Ph.D.
 Joseph R. Lakowicz, Jr., Ph.D.

Department of Botany

Professor

Albert W. Frenkel, Ph.D.
 John W. Hall, Ph.D.
 Herbert Jonas, Ph.D.
 Thomas Morley, Ph.D.
 Gerald Ownbey, Ph.D.
 Douglas C. Pratt, Ph.D.

Associate Professor

Willard L. Koukkari, Ph.D.
 David J. McLaughlin, Ph.D.
 Thomas K. Soulen, Ph.D.
 Clifford M. Wetmore, Ph.D.

Assistant Professor

Iris D. Charvat, Ph.D.
 Thomas J. Guilfoyle, Ph.D.
 Ann M. Hirsch, Ph.D.
 Jerome J. Jendrisak, Ph.D.

Department of Ecology and Behavioral Biology

Regents' Professor

Herbert E. Wright, Ph.D.

Professor

Edward J. Cushing, Ph.D.
 Margaret B. Davis, Ph.D.
 Eville Gorham, Ph.D.
 D. Frank McKinney, Ph.D.
 David J. Merrell, Ph.D.
 David F. Parmelee, Ph.D.
 Richard E. Phillips, Ph.D.

William D. Schmid, Ph.D.
 Joseph Shapiro, Ph.D.
 Donald B. Siniff, Ph.D.
 John R. Tester, Ph.D.
 Harrison B. Tordoff, Ph.D.
 James C. Underhill, Ph.D.
 Dwain W. Warner, Ph.D.
 John M. Wood, Ph.D.

Adjunct Professor

Miron L. Heinselman, Ph.D.

Associate Professor

Franklin H. Barnwell, Ph.D.
 Elmer C. Birney, Ph.D.
 Robert C. Bright, Ph.D.
 Kendall W. Corbin, Ph.D.
 Donald E. Gilbertson, Ph.D.
 Charles W. Huver, Ph.D.
 Robert O. Megard, Ph.D.
 Philip J. Regal, Ph.D.

Assistant Professor

Carl D. Hopkins, Ph.D.
 Malcolm J. Kottler, Ph.D.
 Patrice A. Morrow, Ph.D.
 Ann E. Pace, Ph.D.
 Robert J. Taylor, Ph.D.
 G. David Tilman, Ph.D.

Department of Genetics and Cell Biology

Regents' Professor

Ralph E. Comstock, Ph.D.

Professor

V. Elving Anderson, Ph.D.
 Richard S. Caldecott, Ph.D.
 Franklin D. Enfield, Ph.D.
 Frederick Forro, Jr., M.D.
 Robert K. Herman, Ph.D.
 William S. Herman, Ph.D.
 Alan B. Hooper, Ph.D.
 Norman S. Kerr, Ph.D.
 Robert G. McKinnell, Ph.D.
 Sheldon C. Reed, Ph.D.
 Murray D. Rosenberg, M.D., Ph.D.
 Irwin Rubenstein, Ph.D.
 D. Peter Snustad, Ph.D.
 Leon A. Snyder, Ph.D.
 Val W. Woodward, Ph.D.

Associate Professor

William P. Cunningham, Ph.D.
 Robert J. Desnick, M.D., Ph.D.
 David P. Fan, Ph.D.
 Stuart F. Goldstein, Ph.D.
 Ross G. Johnson, Ph.D.
 John R. Sheppard, Ph.D.
 Judson D. Sheridan, Ph.D.
 Akhouri A. Sinha, Ph.D.

Assistant Professor

Martin Blumenfeld, Ph.D.
 Carol S. Deppe, Ph.D.
 Warren L. Rottmann, Ph.D.
 Michael J. Simmons, Ph.D.

Departmental Offices and Faculty

Freshwater Biological Institute

Professor

John M. Wood, Director

Associate Professor

Eckard Muenck, Ph.D.

Assistant Professor

Ronald L. Crawford, Ph.D.

Joseph R. Lakowicz, Jr., Ph.D.

James Ford Bell

Museum of Natural History

Harrison B. Tordoff, Director

Elmer C. Birney, Curator of Mammalogy

Robert C. Bright, Curator of Paleontology

Terry L. Chase, Coordinator of Exhibits

Kendall W. Corbin, Curator of Systematics

Cari D. Hopkins, Curator of Ethology

Charles W. Huver, Curator of Fishes

D. Frank McKinney, Curator of Ethology

Ann E. Pace, Curator of Public Education

David F. Parmelee, Chairman, Field

Biology Program

Philip J. Regal, Curator of Herpetology

James C. Underhill, Associate Curator of

Fishes

Dwain W. Warner, Curator of Ornithology

Contributing Faculty From Other University Units

Department of Microbiology

(Medical School)

Professor

Dwight Anderson, Ph.D.

Gerhard K. Brand, M.D.

Francis Busta, Ph.D.

Martin Dworkin, Ph.D.

Russell C. Johnson, Ph.D.

Peter G. W. Plagemann, Ph.D.

Palmer Rogers, Ph.D.

Edwin L. Schmidt, Ph.D.

Dennis W. Watson, Ph.D.

Associate Professor

Peter Chapman, Ph.D.

A. J. Faras, Ph.D.

Beulah Gray, Ph.D.

James T. Prince, M.S.

Bernard Reilly, Ph.D.

Charles Schachtele, Ph.D.

John Schmidtke, Ph.D.

James F. Zissler, Ph.D.

Assistant Professor

P. Paul Cleary, Ph.D.

Ronald Crawford, Ph.D.

H. Richard Gaumer, Ph.D.

Gregory Germaine, Ph.D.

History of Science and Technology Program

(Institute of Technology)

Professor

Edwin T. Layton, Ph.D.

Roger H. Stuewer, Ph.D.

Associate Professor

Alan E. Shapiro, Ph.D.

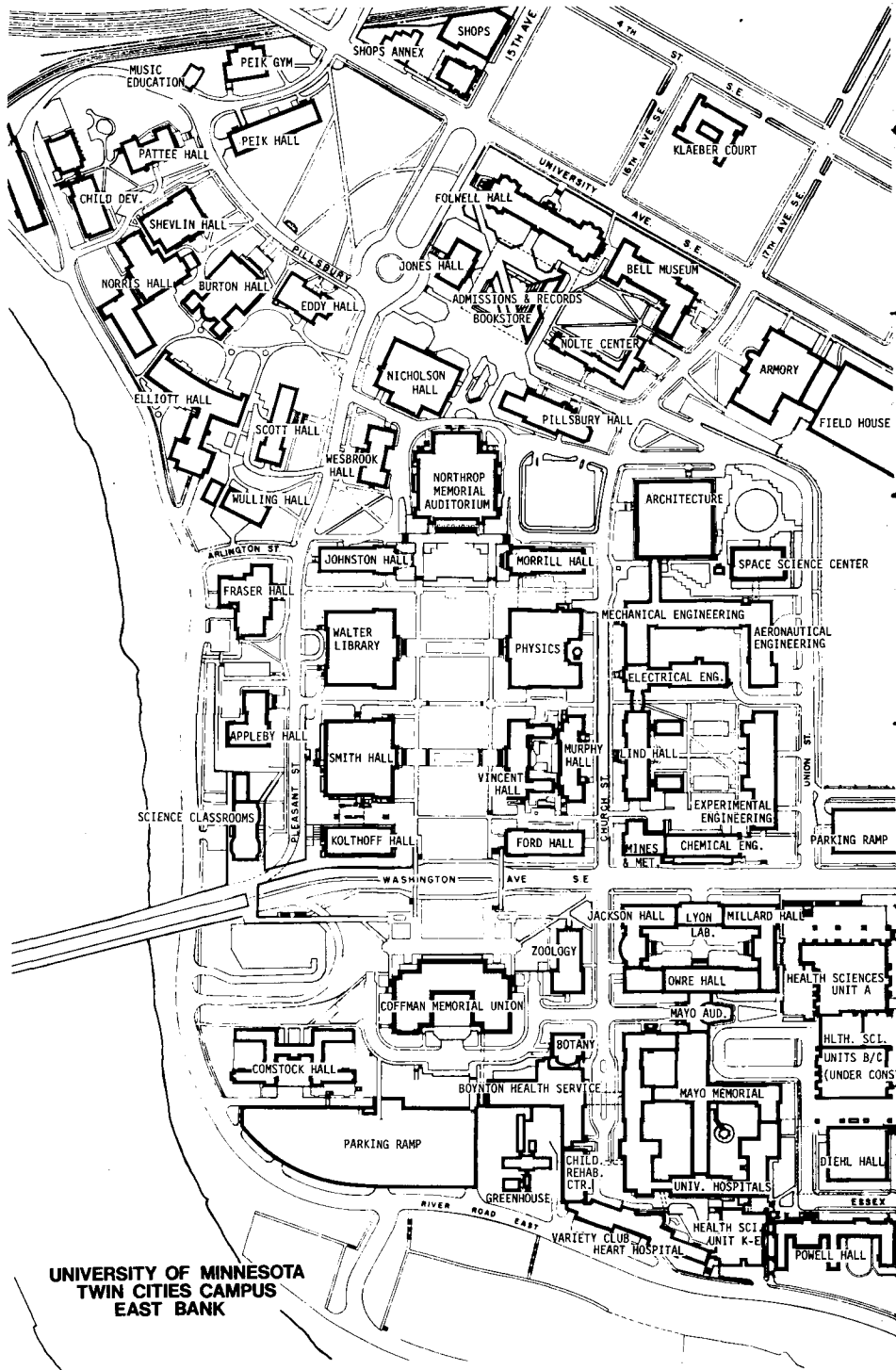
Assistant Professor

Malcolm Kottler, Ph.D.

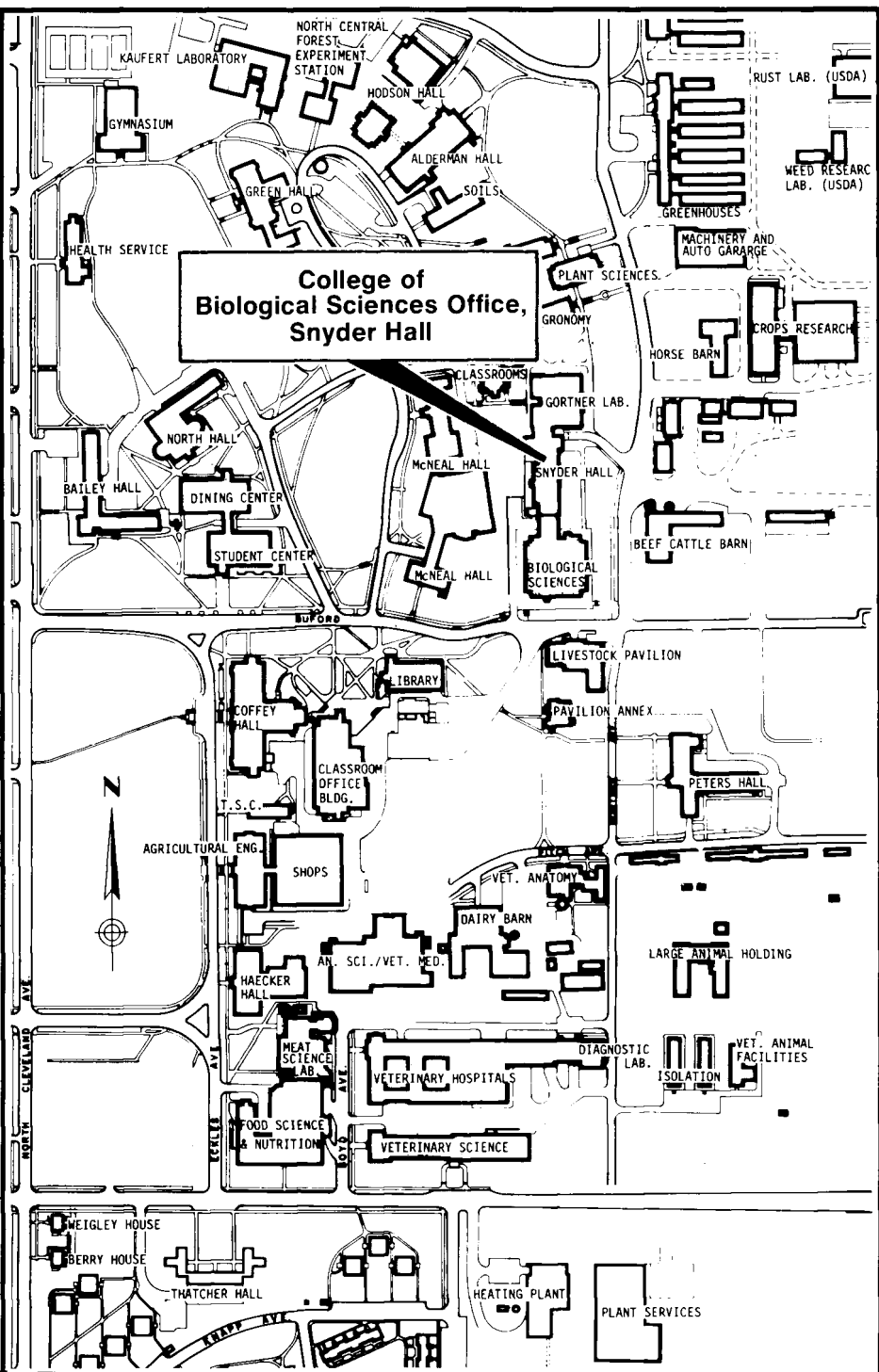
Campus Contact

Kathleen F. Peterson
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College of Biological Sciences
223 Snyder Hall
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St. Paul, Minnesota 55108
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The staff of the college office will provide additional information about the College of Biological Sciences as well as information on career opportunities in the biological sciences and related areas.



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**College of
Biological Sciences Office,
Snyder Hall**

Twin Cities Campus/St. Paul