



University
of Minnesota
Bulletin

1981-83

College of
Biological Sciences

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—Purpose, Organization, and Services

Section II—Admission, Academic Regulations, and Degree Requirements

Section III—Major Requirements and Course Descriptions

Section IV—Departmental Offices and Faculty

OTHER SOURCES OF INFORMATION

Additional information about biology offerings is contained in the *Lake Itasca Biology Session Bulletin*. Reservations for and questions concerning the Itasca program should be directed to the Chairman, Field Biology Program, 349 Bell Museum of Natural History, 10 Church Street S.E., University of Minnesota, Minneapolis, Minnesota 55455.

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

For information about programs in related areas, consult the following bulletins:

College of Agriculture Bulletin

College of Forestry Bulletin

*College of Home Economics
Bulletin*

College of Liberal Arts Bulletin

College of Pharmacy Bulletin

Medical School Bulletin

*College of Veterinary Medicine
Bulletin*

Graduate School Bulletin

*Graduate Programs in the Health
Sciences Bulletin*

Institute of Technology Bulletin

School of Dentistry Bulletin

All of these publications are available at the information booth in Williamson Hall (Minneapolis campus) and the bulletin room in Coffey Hall (St. Paul campus), or they may be obtained by writing to the Office of Admissions and Records, 110 Williamson Hall, 231 Pillsbury Drive S.E., University of Minnesota, Minneapolis, Minnesota 55455.

Equal Opportunity

The University of Minnesota is committed to the policy that all persons shall have equal access to its programs, facilities, and employment without regard to race, creed, color, sex, national origin, or handicap. In adhering to this policy, the University abides by the requirements of Title IX of the Education Amendments of 1972, by Sections 503 and 504 of the Rehabilitation Act of 1973, and by other applicable statutes and regulations relating to equality of opportunity.

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

College of Biological Sciences

I. PURPOSE, ORGANIZATION, AND SERVICES

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 ability to use the fundamental concepts of physics, chemistry, and mathematics in order to gain a full 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. Individuals with this breadth and depth of training are now at the forefront in various aspects of human, animal, and plant research. The prospects are that during the next two decades their findings will have a major impact on the behavioral sciences, the practice of human and animal medicine, the genetic improvement of agricultural species, and the persistence of ecosystems that are essential to the existence of humankind.

The College of Biological Sciences 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 for undergraduate education. In addition, CBS is responsible for the administration of several program units, including the Dight Institute for Human Genetics, the Gray Freshwater Biological Institute, and the Bell Museum of Natural History. An active field biology program is 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.

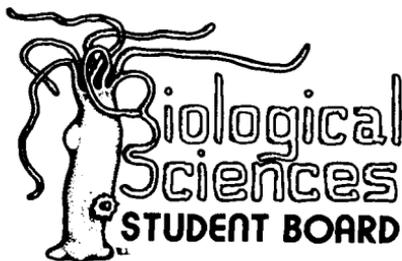
A special section describing personnel services available to CBS students appears later in this section of the bulletin.

College Governance

The College of Biological Sciences has a number of governance and policy committees whose membership includes both students and staff. Standing committees of the college are the Administrative Committee, Consultative Committee, Educational Policy Committee, and 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 the study of biology and its contribution 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 College of Biological Sciences and College of Liberal Arts. The board elects student representatives to appropriate college committees.



Student Representation on University Committees—Students interested in serving as representatives on all-University committees 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 members should watch for announcements about filing for elections.

Alumni Society for the Biological Sciences

The Biological Sciences Alumni society was established and formally recognized by the University of Minnesota Alumni Association in 1980. The purpose of the society is to organize a professional association of significance to biological sciences alumni and former students, to promote excellence within the College of Biological Sciences and among its alumni, and to encourage and stimulate the relationship between the college, alumni, and community. The society has made a special commitment to sponsor programs that will enhance the opportunities available to current students and encourages the participation of student members; to facilitate a close working relationship, the president of the Biological Sciences Student Board is a member of

the board of directors of the alumni society. Alumni volunteers, working with the CBS Career Information Office, have developed a career information network to assist current students and graduates in exploring career options. The society is also committed to the support of continuing education programs in the biological sciences.



Francis Crick (left) addresses the first meeting of the Biological Sciences Alumni Society. Glenn Ward (right), B.S. '76, is president of the alumni society.

Programs

UNDERGRADUATE PROGRAMS

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

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

Liberal Education—The college faculty believes that all students, whatever their area of specialization or vocational goals, should hold in common the search for a liberal education. In the broadest sense, a liberal education frees individuals from the limitations 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

Purpose, Organization, and Services

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 requires all students to distribute a portion of their course work in areas of study outside of those most directly linked to their specialized interests in science.

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

GRADUATE PROGRAMS

Graduate study at the University of Minnesota is coordinated and administered by the Graduate School. Refer to the *Graduate School Bulletin* for details about general policies regarding admission requirements, registration procedures, financial aid, and requirements for graduate degrees.

The faculty of the College of Biological Sciences plays a major role in offering graduate degree programs in biological science areas. The specific programs the college contributes to include biochemistry, biology (evolutionary and systematic biology, individually designed programs), botany, cell and developmental biology, ecology, genetics, and zoology.

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—Huber Warner

Botany—Douglas C. Pratt

Cell and developmental

biology—Ross G. Johnson

Ecology—Edward J. Cushing

Genetics—Robert K. Herman

Zoology—Donald E. Gilbertson

Community Outreach

Bell Museum of Natural History—Located at Church and University Avenues S.E., Minneapolis, this museum features diorama exhibits of Minnesota wildlife, the Touch and See Room, and the Jaques Gallery of natural history art. It also houses extensive research collections of birds, mammals, reptiles, amphibians, and fish as well as the University's natural history library. The museum is open from 9 a.m. to 5 p.m. Monday through Saturday, and from 1 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 Blue Heron Bookshop offers an excellent selection of field guides and other natural history books for adults and children as well as records of bird and animal calls. 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. Individuals may also call for information about various community medical resources, genetic services, and genetic organizations. Lectures and workshops are open to outside organizations without charge. Telephone (612) 373-3792 for further information.

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

Student Personnel Services

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

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



Student services staff (223 Snyder Hall), clockwise from lower left: Sandi Rexeisen, Kathie Peterson, Jean Pates, Amy Winkel. Fred Forro (right) is director of minority and disadvantaged student affairs.

Purpose, Organization, and Services

Minority and Disadvantaged Student Affairs—The college is eager to respond to the special needs of minority and disadvantaged students. The director of minority and disadvantaged student affairs is available to meet individually with students to explore potential interests in biology, to provide academic assistance when needed, and to help students overcome other barriers to achieving success in education. Students are encouraged to visit with the director, Professor Fred Forro, at his office, 206 Biological Sciences Center, St. Paul campus, or by telephone (612) 376-5475.

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

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

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

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

The honors coordinator for biology students in the College of Liberal Arts is Kathleen Peterson.

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 about and listings of offices and units that offer specific services, including the Campus Assistance Center, Student Counseling Bureau (includes help with improving study skills), Student Employment Service (for part-time employment), Office of Student Financial Aid, International Student Advisers Office, Rehabilitation Services Office (offers aid for handicapped students), Boynton Health Service, St. Paul Health Service, Legal Aid Clinic, Veterans Programs, and Student Ombudsman Service.

Access to Student Educational Records

In accordance with regents' policy on access to student records, information about a student generally may not be released to a third party without the student's permission. The policy also permits students to review their educational records and to challenge the contents of those records.

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

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

II. ADMISSION, ACADEMIC REGULATIONS, AND DEGREE REQUIREMENTS

Admission

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

AFFIRMATIVE ACTION POLICY

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

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

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

ADMISSION REQUIREMENTS

During their freshman and sophomore years, students should plan to complete, as a minimum, the English composition, mathematics, and general chemistry requirements. They should take at least one quarter of biology to make certain they wish to concentrate in the biological sciences as well as to prepare for upper division courses in their junior year. Most students take organic chemistry during their sophomore year, thereby providing more time in the senior year for advanced course work and research experiences.

Admission, Academic Regulations, and Degree Requirements

Specific requirements for admission are satisfactory completion of:

1. A minimum of 84 quarter credits with grades of A, B, C, or S before initial registration in the college.
2. Each of the following:
 - a) Two quarters of analytical geometry and calculus (Math 1211-1221 or equivalent)
 - b) Two quarters of general chemistry (Chem 1004-1005 or 1031-1032 or equivalent)
 - c) A course in general biology (Biol 1011) or exemption.

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

CBS ADMISSION PROCEDURES

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

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

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 stated above. Ordinarily, applications can be acted on before the transcript with the current quarter's grades has been submitted. Qualified students will be admitted, subject to the satisfactory completion of the current registration.

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

Requirements for Graduation

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 grades of A, B, C, or S. (Credits of D may be counted only if they are balanced by appropriate credits of A or B.) See Grades, section II. CBS students may apply up to eight technical, non-liberal-arts college credits toward their degrees. Check with an adviser in 223 Snyder Hall for details.
2. Credits in Residence—
 - (a) 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 (or the equivalent of the senior year for part-time students).

- (b) Completion of a minimum as 36 credits as a student registered in the College of Biological Sciences.
- (c) Completion on the Twin Cities campus of a minimum of 30 credits in 3000- and 5000-level courses that are specifically required for the student's major. Ordinarily this will include all 3000- and 5000-level 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 of the college in which the student initially registered. Ordinarily this is a two-quarter course.
- 4. Foreign Language—Completion of either (a) two years of study of a single foreign language in high school, or (b) three quarters (one year) of study of a single foreign language in college or demonstration of equivalent proficiency satisfactory to the appropriate language department.
- 5. Completion of the all-University liberal education distribution requirements:
 - Group A—Communication, Language, and Symbolic Systems
 - Group B—Physical and Biological Sciences
 - Group C—The Individual and Society
 - Group D—Literary and Artistic Expression

The mathematics and physical and biological sciences course work that is required of CBS students (see items 6 and 7 below) will automatically satisfy the minimum University requirements for group A and group B. In addition, CBS students must complete 30 credits, including a minimum of 8 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.

A list of courses recommended to meet the liberal education group distribution requirements and descriptions of courses can be found in the *College of Liberal Arts Bulletin*. Direct questions concerning acceptable courses to the college office, 223 Snyder Hall.

The group distribution requirements are currently under review. Consult the college office for a list of acceptable courses. CBS normally accepts any course identified by the College of Liberal Arts for groups A, C, and D (see the *CLA Bulletin*). In addition, students are encouraged to explore the course offerings of other units (e.g., rhetoric, agricultural economics, family social science).

- 6. Physical Sciences and Mathematics—
 - (a) Mathematics—Completion of a three-quarter analytic geometry and calculus sequence (Math 1211-1221-1231 or 1311-1321-1331 or equivalent). A two-quarter course sequence in statistics (Stat 5021-5022 or PubH 5450-5451-5452-5453) may be substituted for the last quarter of calculus, by formal petition.
 - (b) Chemistry—Each of the following:
 - General chemistry, two quarters (Chem 1004-1005 or 1031-1032 or equivalent).
 - Organic chemistry, two quarters with laboratory (Chem 3301-3302-3305-3306 or 3331-3332-3335 or equivalent).
 - A minimum of four additional credits in chemistry (e.g., Chem 1006 or 3100-3101 or 3303 or physical chemistry).Students who plan to major in biochemistry are encouraged to take the sequences designed for chemistry majors (listed as options above).
 - (c) Physics—Completion of a three-quarter course, with laboratory, that requires college-level mathematics as a prerequisite (Phys 1271-1281-1291 with 1275-1285-1295 or 1104-1105-1106 with 1107-1108-1109. By petition, a two-quarter sequence (Phys 1031-1032 with 1035-1036) plus an additional five credits of mathematics, statistics, computer programming, or physical science chosen in consultation with the major adviser may be substituted.
Biochemistry and microbiology majors are advised to take the calculus-based sequence (Phys 1271 etc.).

7. Biological Sciences (Core Curriculum)—

- (a) General Biology (Biol 1011, five credits) or exemption granted by the college office. Students with a good background from high school or individual study are encouraged to take the Biol 1011 exemption examination.
- (b) All of the following three courses: Animal Biology (Biol 3011, five credits), Plant Biology (Biol 3012, five credits), Microbiology (Biol 5013, five credits).
Courses completed at other institutions in general zoology, animal biology, general botany, or plant biology, or three 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 exempted 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 demonstrate the student's proficiency in animal and plant biology courses may also be used to fulfill item (h) below.
- (c) Biochemistry (Biol 5001, four credits).
- (d) Genetics (Biol 5003, four credits).
- (e) Cell Biology (Biol 5004, three credits).
- (f) Ecology (Biol 3041, 4 credits).
- (g) Laboratory or fieldwork in one additional upper division biological sciences course. This is an "experience" requirement rather than a credit requirement, so credits earned may be used toward fulfilling item (h) below. A list of acceptable courses is included at the end of this section.
- (h) 19 additional upper division credits in mathematics and/or physical and/or biological sciences, including at least one of the following courses: Bot 3131, EBB 5156, GCB 5114 or 5134, MicB 5321. This includes work specified by the major department (see section III).

COURSES THAT SATISFY GRADUATION REQUIREMENT 7G

Biol 3042, 5065, 5112

BioC 5025, 5745

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

EBB 5014, 5016, 5112, 5115, 5116, 5129, 5132, 5134, 5136, 5155, 5156, 5159, 5313, 5322, 5323, 5603, 5605, 5606, 5609

GCB 3011/5011, 5013, 5015, 5030, 5115, 5135, 5605, 5606, 5610

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

In addition, all CBS courses offered at the Lake Itasca Forestry and Biological Station are acceptable. Appropriate independent study courses (e.g., 3990 and 5970 offerings) may be used, by petition.

GRADUATION WITH HONORS

The purpose of the honors program is to recognize and promote outstanding academic achievement. The nucleus of the program is directed research in biology, since it is the most significant and challenging experience that the college faculty can offer to qualified undergraduates. Another facet of the program is the CBS Honors Seminar, which is designed to provide exposure to the breadth of biological inquiry.

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

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

Participation in a minimum of two quarters (a total of eight credits) of research is required; students may register in BioC 3990, Bot 3990, EBB 3990, GCB 3990, or MicB 3990. An honors thesis summarizing the research and written in the style of a publishable manuscript is required of all students. The thesis must be approved by the faculty member supervising the research and by two other members of the faculty (at least one of whom must be from the major department) chosen with approval of the college office.

College of Biological Sciences Honors Seminar—Three quarters of participation in the CBS Honors Seminar (Biol 3960) are required of all honors program participants. In the fall quarter, the seminar will be a forum to discuss special topics focused on a theme of general relevance to all biologists. In the spring quarter, seniors nearing completion of their directed research projects will present summaries of their projects and the results obtained.

Entry Into the Honors Program—Qualified students should apply for admission to the honors program at the time of admission to the College of Biological Sciences. Students are cautioned that a minimum of four quarters of honors registration must be completed to fulfill the requirements for graduation with honors (see below). Applicants should have a minimum grade point average of 3.20 and present reasonable evidence of being able to attain the grade point average required for graduation with honors (see Graduation With Honors, item 5, below). Application forms are available in the college office, 223 Snyder Hall.

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

1. Completion of at least 60 credits in upper division courses (3000 and 5000 levels) at the University of Minnesota, Twin Cities campus.
2. Completion of two quarters (eight credits) of directed research, the results of which are to be reported in an acceptable honors thesis.
3. Completion of three CBS Honors Seminars (Biol 3960).
4. Completion of one additional honors opportunity, which may be selected from the following:
 - a. an additional quarter (four credits) of participation in directed research
 - b. the College Honors Seminar offered by the Honors Division of the College of Liberal Arts
 - c. an upper division honors course (3000- or 5000-level course designated by H)
 - d. an honors contract (see college office)
 - e. an 8000-level course (seniors only; requires permission)
5. Completion of the last 90 credits of A-N registration with the minimum grade point averages specified below:

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

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

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

CBS SCIENCE REQUIREMENTS SUGGESTED TIME SEQUENCE

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

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

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

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



LaVell Henderson, associate dean, and Kathie Peterson, director of student services.

GRADUATION WITH A DOUBLE MAJOR OR WITH TWO DEGREES

Students with special interests may wish to pursue a double major or simultaneously earn a B.S. degree in the College of Biological Sciences and a second degree from another college. Students interested in these options should consult their advisers and the appropriate college offices at the earliest possible date.

Examination Programs

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

College Level Examination Program (CLEP)—By passing one or more of the standardized examinations prepared by the College Entrance Examination Board, a student may earn up to 32 credits to apply (as nonresidence credit without grade) toward the degree. CLEP credits do not count in calculating the number of S-N credits that may be earned at the University of Minnesota. Full information about CLEP tests may be obtained from the College of Liberal Arts Office of Special Learning Opportunities, B-18 Johnston Hall.

Special Learning Opportunities

Students are encouraged to explore the many ways to enrich their learning experiences through activities outside of 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 Independent Study, later in this section of the bulletin). Some students seek employment as undergraduate teaching and research assistants, as museum tour guides, or in similar positions. Most departments offer special seminars for undergraduates (see section III). A three-quarter course, Biology Colloquium, is 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 for the projects undertaken.

Individually Designed Degree 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, the individually designed program was instituted during the 1976-77 academic year. The experimental status of this degree program option will be reviewed during the 1981-82 year. Before being admitted to the program, a student must submit a statement of her or his goals and objectives to justify to the program admissions committee the reasons for designing a unique program. Applicants must have successfully completed 84 quarter credits prior to initial registration in the college, including a course in general biology (or exemption), two quarters of general chemistry, and a minimum of one quarter of calculus. Interested students should consult an adviser in the college office at an early date.

Registration¹

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

The days, hours, and places of meeting of classes appear 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 the first class session may lose their places in the courses for which they are registered.

ANNUAL PROGRAM PLANNING

During the last two 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 office, 223 Snyder Hall, to receive materials and instructions. The Annual Program Plan, signed by the student and the adviser, must be returned to 223 Snyder Hall to complete prereservation for fall quarter.

¹Effective during 1982, the University of Minnesota will initiate computerized registration. This change will affect prereservation and registration procedures. Contact the college office for details.

PRERESERVATION¹

Prior to the beginning of the official registration periods for the winter and spring quarters, course "prereservation" is held for all CBS and CLA biology majors. Prereservation for fall quarter classes is completed during annual program planning (see above). Prereservation permits students to request that space be held for them in most required science and mathematics courses. Specific dates and details are distributed with registration materials each quarter and are mailed to new students.

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 on the specified dates.
2. CBS students obtain registration materials, including the registration permit, from 223 Snyder Hall. Students in the process of transferring from another University of Minnesota college should first obtain their registration permit from the college they are leaving.
3. Complete a tentative course program. This often includes a meeting with the adviser. Obtain the adviser's signature if required (see registration materials).
4. Reserve class places. Enrollment in many courses is controlled. The titles of these courses are listed in boldface type in the *Class Schedule*. Class entry cards for controlled courses offered by other colleges may be obtained at the time step five is completed. Courses listed in the *Class Schedule* in lightface type are not controlled and do not require cards. Pick up cards for prereserved courses in 223 Snyder Hall.
5. Turn in registration materials at 130 Coffey Hall, St. Paul, and obtain a fee statement. The fee statement specifies 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 four 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* or may be obtained in the college office.

Admission to Closed Sections—Limits on class or section enrollment are established to accommodate the maximum number of students who can be taught effectively in a given course or, in some cases, because of the 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 in 223 Snyder Hall, in 130 Coffey Hall, and in 12 Johnston Hall. This information is updated several times daily.

Waiting lists are kept for closed upper division biology courses in 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

¹ Effective during 1982, the University of Minnesota will initiate computerized registration. This change will affect prereservation and registration procedures. Contact the college office for details.

Admission, Academic Regulations, and Degree Requirements

instructor (#) or department (Δ) is required. To register for such courses, written permission must be presented in order to obtain class entry cards.

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

A written contract must be reviewed by the instructor and approved by the departmental office at the time of registration. The contract between the student and faculty member should state the following:

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

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

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

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

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

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

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

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 and instructor's signature when necessary (see below).
3. Turn in the cancel-add form at 130 Coffey Hall, St. Paul.
4. If the change alters the total credit load, 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 every student a chance to register.) 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 or cancel classes through the second week of a quarter 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 and approval of the college office. A student may cancel after the second week of a quarter only once during an academic year; only under extraordinary circumstances and with college approval will additional cancellations be permitted. Cancellation after the last day of classes is rarely approved. Any course canceled after the second week of classes will be recorded as a withdrawal (W) on the transcript.

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 the next quarter, the student should inform the staff 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—Full-time students register for 12 to 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. In general, it is unwise to devote more than 15 to 20 hours a week to work or outside activities while attending college.

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

Credit Value—A credit requires about 3 hours of work a week or about 30 hours in a 10-week quarter. Thus, a 4-credit course represents about 120 hours per quarter of acceptable work. 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; and S, representing achievement that is satisfactory to the instructor for the program in which the student is registered. In order to be used for credit toward graduation, each credit of D must be balanced by a credit of A or B in a course at the same level; each credit of D earned in courses meeting specific science or math requirements must also be balanced by a credit of A or B in courses that meet science or math requirements.

Admission, Academic Regulations, and Degree Requirements

In connection with all grades, 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 in residence.

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

A symbol X is 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, nongraded registration.

S-N Registration—Students are permitted to register for certain courses (subject to the restrictions outlined below) under the S-N grading system. Freeing students to some extent from the pressure of grades, the S-N grading system is designed to encourage students to take a greater variety of courses. With college permission, the S-N system is also used for certain courses in which it is impossible or undesirable to evaluate student achievement more precisely.

The decision to take a given course on the S-N system must be indicated on the registration form. Except as qualified below, students have the option of registering for any course on an S-N basis. Registration on the S-N basis does not imply any waiver of course prerequisites. Any or all portions of a sequence course may be taken on the S-N basis. A change in registration to A-N from S-N or vice versa may not be made after the end of the second week of classes.

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 grades of A, B, C, or D¹ have been received.

Students may not register on an S-N basis for courses used to satisfy specific college graduation requirements in mathematics and in the physical or biological sciences, unless such courses are offered on an S-N only basis.

If approved by the major department and the major adviser, students may take on the S-N basis elective courses that are used to fulfill the additional upper division credits in mathematics, physical sciences, or biological sciences (see Requirements for Graduation, item 7h, earlier in this section of the bulletin).

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 of a major course.

Students who plan to apply to a graduate or professional school should be aware that they will be at a serious disadvantage if they cannot present on A-N grading almost all work relevant to their proposed specialization.

Satisfactory Progress

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

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

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

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

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

Students are released from probation when academic work has improved enough to demonstrate promise for continuous progress toward a degree.

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

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

Readmission to the College—Students suspended from the college may return only upon approval of the college office. Strong assurance that the factors that caused the suspension have been corrected, together with convincing evidence that improved work will follow, must be presented to obtain approval. Students are readmitted on probation and are subject to immediate suspension if their work again becomes unsatisfactory.

Petitions for readmission from suspended students are normally considered after an interval of at least a year.

Class Attendance, Examinations, Other Regulations

Class Attendance—Students are expected to attend classes for which they are registered. 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 for each course 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 end of the quarter. 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 a similar matter—with a staff member in the college office. Exemptions are granted occasionally to aid students in achieving educational goals.

Appeals and Suggestions—The adviser or a staff member in the college office is a good source for information about 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, composed of both student and faculty members. Advice from staff members 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. Specific application deadlines are included with the registration materials distributed each quarter. After filing the graduation application, each student will receive a senior balance sheet listing the remaining requirements to be completed for the degree.

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

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



A CBS graduate shares a proud moment with his parents after the 1980 commencement ceremony.



Olive-sided Flycatcher. Artwork by David Parmelee.



III. MAJOR REQUIREMENTS AND COURSE DESCRIPTIONS

Course Numbering System and Other Course Information—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 sophomores, 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 studies courses and "990" indicate directed research courses.

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 course instructor.

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 the department, division, or school offering the course is required prior to registration.
- † All courses preceding the dagger must be completed before credit will be granted for any quarter of the sequence.
- H Honors section of a regular course.
- f,w,s,su Following a course number indicate fall, winter, spring, and summer quarters.

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

Biochemistry

Director of Undergraduate Studies—1981-82: John Gander; 1982-83: Irvin Liener

Biochemistry is the study of the molecules, especially macromolecules such as proteins and nucleic acids, that occur in living organisms. The major in biochemistry is designed for students who 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.

Major 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, 5950, Chem 5601) are recommended. In some cases, BioC 5751-5752 may be accepted as a substitute for 5002 and special topics.

Inorganic Chemistry—

Chem 1006 (Students who have completed Chem 1031-1032, 1133 may be exempted from Chem 1004-1005-1006.)

Organic Chemistry—

(a) Chem 3333, 3336. In addition, 5365 is recommended.

or

(b) Chem 3303. In addition, 5365 is recommended.

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, 3221 is recommended.

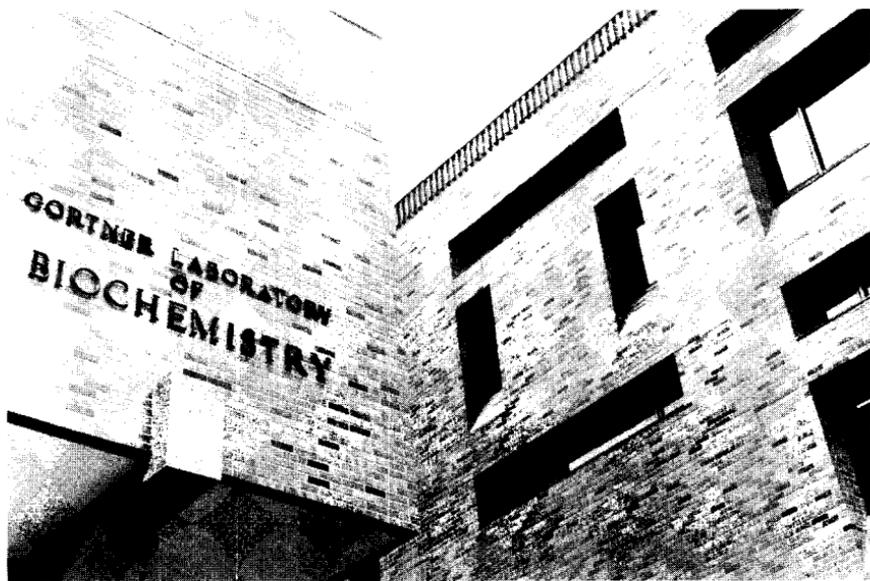
Physical Chemistry—

(a) Chem 5533, 5534, 5535 plus 5536 or 5538

or

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

German is the foreign language of choice.



COURSES—BIOCHEMISTRY (BioC)

- 1301f,w. ELEMENTARY BIOCHEMISTRY I.** (5 cr, §Chem 1002 or 3301; not intended for majors; prereq Chem 1001 or 1005) Glass, Jenness
The chemistry of carbon compounds that occur in nature. Composition, structures, and properties of the major components of plant, animal, and bacterial cells.
- 1302w,s. ELEMENTARY BIOCHEMISTRY II.** (3 cr; prereq 1301 or Chem 1002)
Biochemical principles; reactions of organic compounds in the living cell. Metabolic pathways, energy considerations, and biosynthetic processes; emphasis on aspects essential to an understanding of plant and animal nutrition and physiology.
- 1303w,s. ELEMENTARY BIOCHEMISTRY LABORATORY.** (2 cr; prereq 1301 or ¶1301)
Problems and exercises in chemical and biochemical techniques. Discussion of methods and concepts.
- 3960f,w,s. RESEARCH TOPICS IN BIOCHEMISTRY.** (1 cr per qtr; offered S-N only)
Lectures and discussions on current research in the department.
- 3990. UNDERGRADUATE RESEARCH.** (1-3 cr per qtr; prereq #, Δ)
Individual research for undergraduates.
- Biol 5001f,w,s,su. BIOCHEMISTRY.** (4 cr, §Biol 3021, §5001; prereq Biol 1011, 12 cr organic chemistry)
Biochemistry and biophysics of cells; emphasis on enzyme catalysis, cellular energetics, biosynthesis of cellular constituents and cellular regulatory mechanisms.
- 5002w,s. BIOCHEMISTRY TOPICS.** (3 cr; prereq Biol 5001)
Topics not covered in Biol 5001. Biol 5001 and BioC 5002 constitute a two-quarter sequence for undergraduate and graduate students lacking physical chemistry and serve as prerequisites for certain advanced courses.
- 5025f,w,s. LABORATORY IN BIOCHEMISTRY.** (2 cr; prereq Biol 5001 or ¶Biol 5001)
Discussions of techniques and problem-solving approaches illustrated with laboratory experiments and demonstrations.
- 5271. VITAMINS.** (3 cr; prereq 5752 or 5002 or #)
Lectures and assigned readings on biochemistry of vitamins and their physiological action.
- 5522f. PHYSICAL BIOCHEMISTRY OF SOLUTIONS.** (4 cr, §Chem 5522; prereq 2 qtrs physical chemistry...Biol 5001 desirable)
Physical chemistry of equilibrium and transport of phenomena in solution, with application to biochemical systems. Macromolecular solutions and phase transitions, protein polymerization, micelle formation, sedimentation equilibrium and velocity, translational and rotational diffusion, viscosity.
- 5523w. PHYSICAL BIOCHEMISTRY: STRUCTURE AND INTERMOLECULAR FORCES.** (4 cr, §Chem 5523; prereq 2 qtrs physical chemistry...Biol 5001 desirable)
Methods of structure determination of biological macromolecules. Scattering and diffraction, optical and magnetic resonance spectroscopy. Application to proteins, nucleic acids, and synthetic analogs.
- 5524s. PHYSICAL BIOCHEMISTRY AND ENZYME KINETICS.** (4 cr, §Chem 5524; prereq 2 qtrs physical chemistry... Biol 5001 desirable)
Application of thermodynamics and enzyme kinetics; solvent effect, structure-function relation.
- 5744w. BIOCHEMICAL ANALYSIS.** (2 cr; prereq ¶5745 or #, cr in analytical chemistry and 5002 or equiv)
Numerical problems in biochemistry and analytical biochemistry. Lectures and problem sets.
- 5745w. BIOCHEMICAL ANALYSIS LABORATORY.** (2 cr; prereq ¶5744, previous lab work in analytical and organic chemistry)
Isolation and characterization of proteins, carbohydrates, and lipids. Experimental methods in ligand binding, bioenergetics, spectrophotometry, chromatography, and electrophoresis.
- 5751f-5752w-5753s. GENERAL BIOCHEMISTRY.** (4 cr per qtr, §MdBc 5751-5752-5753; prereq 3 qtrs organic chemistry, 2 qtrs physical chemistry, 1 qtr biochemistry or #)
Structure, function, metabolism, and metabolic regulation of components in biological systems.
- 5950f,w,s. SPECIAL TOPICS.** (1-5 cr; prereq #, Δ)
- 5970. DIRECTED STUDIES.** (1-3 cr per qtr; prereq #, Δ)
Offered to enable students to make up certain deficiencies in background course work.

FOR GRADUATE STUDENTS ONLY

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

- 8094. RESEARCH AND LITERATURE REPORTS**
- 8194. GRADUATE SEMINAR**
- 8211. CARBOHYDRATES**
- 8221. ENZYMES**
- 8225. TRACER TECHNIQUES**

Major Requirements and Course Descriptions

8231. LIPIDS

8250. SPECIAL TOPICS IN BIOCHEMISTRY

8260. ADVANCED PHYSICAL BIOCHEMISTRY

8261. PROTEINS

8290. CURRENT RESEARCH TECHNIQUES

8501. BIOCHEMICAL EVOLUTION

8746. BIOCHEMISTRY LABORATORY PROJECTS AND ADVANCED TECHNIQUES

8764. METALLOPROTEINS: STRUCTURE AND FUNCTION

8990. GRADUATE RESEARCH

RECOMMENDED RELATED COURSES OFFERED BY OTHER COLLEGES

Students interested in additional course work are encouraged to consider offerings of other academic units. Courses for this purpose are recommended in plant sciences (PIPa, PIPh), nutrition (FScN), physiology (PhsI), computer science (CSci), biophysics (BPhy), organic chemistry (Chem), and chemical engineering (ChEn). Students should consult their advisers for further details.

Biology

Director of Undergraduate Studies—Professor Sam Kirkwood

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

The biology program is designed to provide the student with a broadly based but thorough undergraduate education in the biological sciences. The biology major must complete the graduation requirements outlined in section II. The distribution of the 24 additional upper division credits in the mathematical, biological, and/or physical sciences is determined by the student in consultation with his or her adviser. Students may request a faculty adviser from any of the departments of the college. A prospective major should begin general chemistry and mathematics course work as early as possible.

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

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

General Education—Courses especially appropriate for non-science and non-biology majors include 1011, 1101, 1102, 1103, 1105, 1106, 1108, 3051, 3112; Bot 1009, 1012, 3071; EBB 3001, 3004, GCB 3002, 3008, 3022, 3201.

COURSES—BIOLOGY (Biol)

0001su. **PREPARATION FOR BIOLOGY.** (No cr. §1011; does not count toward any CBS or CLA degree)

Recitations and laboratory exercises concerning topics in mathematics, chemistry, and biology identified as especially important for satisfactory performance subsequently in 1011.

1011f,w,s,su. **GENERAL BIOLOGY.** (5 cr)

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

1011H. **HONORS COURSE: GENERAL BIOLOGY.** (5 cr; prereq honors division or 3-4 yrs high school mathematics, high school chemistry or Δ)

For description, see 1011. Intended especially for honors students or others with the requisite background who plan to major in a life science discipline.

- 1101f,w,s. **HEREDITY AND HUMAN SOCIETY.** (4 cr, §GCB 3002; no cr if taken after 5003 or GCB 3022; for students in programs not directly related to biological sciences) V Woodward
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; students who plan to major in biology in CLA or in any bioscience major in CBS should take 3012) Wetmore, Biesboer, Koukkari
Levels of organization of plants, plant function, plant growth and development, plant reproduction.
- 1105w. **ECOLOGY AND EVOLUTION.** (4 cr; prereq 1011 or 1101; offered winter 1983 and alt yrs) Birney
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.
- 1109f. **MAN, NATURE, AND DISEASE.** (4 cr; prereq 1011) Gilbertson
The study of disease as a natural phenomenon, with emphasis on the natural history of disease from a worldwide perspective.
- 1951f-1952w-1953s. **BIOLOGY COLLOQUIUM.** (1 cr/1 or 2 cr/1 or 2 cr; for prospective majors; S-N only; prereq 1011 or §1011, #)
Provides an orientation to the biological sciences as well as the opportunity for interaction with other biology students and faculty members. Encourages active participation in education.
- 3011f,w,s,su. **ANIMAL BIOLOGY.** (5 cr; prereq 1011, Chem 1005) Goldstein, W Herman, Rottmann
Comparison of ways different phyla have solved similar physiological problems. Laboratory includes survey of major animal groups and physiological experiments.
- 3012f,w,s. **PLANT BIOLOGY.** (5 cr, §1103; prereq 1011, Chem 1005) Charvat, McLaughlin
Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants.



Major Requirements and Course Descriptions

- 3041f,w,s,su. ECOLOGY.** (4 cr; prereq Math 1231 or #)
Interactions of plant and animal populations and their environments. Organization, functioning, and development of ecological systems, population growth and regulation. Human impact on the biosphere in modern times.
- 3042f,w,s. LABORATORY IN ECOLOGY.** (2 cr; prereq 3041 or EBB 3004 or #)
Student research projects on selected ecological problems.
- 3051f,su. 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.
- 3112w. BIOLOGICAL RHYTHMS.** (4 cr; §5112; prereq 1011 or #) Koukkari, Regal
Timing mechanisms and rhythms of organisms in physiological processes, ecological adaptation, and health; current hypotheses concerning their cellular nature.
- 3950Hf,w,s. UNDERGRADUATE SEMINAR.** (2 cr per qtr; S-N only; prereq # or Δ)
Each quarter different members of the faculty lead groups of students in discussions of topics of current interest.
- 3960Hf,s. HONORS SEMINAR.** (1 cr per qtr; prereq Δ ; limited to participants in the CBS Honors Program) Staff
Oral reports on topics of current interest to biologists. Progress reports on laboratory and field research by students.
- 3980f,w,s. DIRECTED INSTRUCTION.** (1-5 cr per qtr; prereq #, Δ) Staff
- 5001f,w,s,su. BIOCHEMISTRY.** (4 cr; §3021, §BioC 5001; prereq 1011, 12 cr organic chemistry or #)
Biochemistry and biophysics of cells; emphasis on enzyme catalysis, cellular energetics, biosynthesis of cellular constituents, and cellular regulatory mechanisms.
- BioC 5025f,w,s. LABORATORY IN BIOCHEMISTRY.** (2 cr; prereq Biol 5001 or §Biol 5001)
Discussions of techniques and problem-solving approaches illustrated with laboratory experiments and demonstrations.
- 5003f,w,s. GENETICS.** (4 cr; §3033, §GCB 3022, §GCB 5022; prereq 5001)
Introduction to the nature of genetic information, its transmission from parents to offspring, its expression in cells and organisms, and its course in populations.
- 5004f,w,s. CELL BIOLOGY.** (3 cr; §3034; prereq 5001)
Structures and functions of membranes, organelles, and other macromolecular aggregates found in plant, animal, and bacterial cells. Cell form and movement, intercellular communication, transport, and secretion.
- 5013f,w (formerly Biol 3013). MICROBIOLOGY.** (5 cr; §MicB 3103, §MicB 5105, §VPB 3103; prereq 5001) Chapman, Dworkin, C Woodward
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Emphasis on molecular structure in relation to bacterial function.
- 5061w. DEVELOPMENTAL BIOLOGY.** (3 cr; prereq 5003 and 5004)
Developing systems and control mechanisms of development, from the molecule to the organism.
- 5112. RHYTHMS AND CIRCADIAN REGULATION.** (4 cr; §3112; primarily for grad students; prereq 15 cr biology, 10 cr chemistry or #) Koukkari
Timing mechanisms and rhythms of organisms in physiological processes, ecological adaptation, and health; current hypotheses concerning their cellular and molecular nature. Laboratory experience arranged.
- 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) Staff
- 5951. THE BIOLOGIST AS SCIENTIST, EDUCATOR, AND CITIZEN.** (3 cr; prereq 15 cr biological sciences)
Cunningham, Hooper, V Woodward
Role of scientists 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

- 5850. SPECIAL TOPICS IN BIOLOGY.** (1-5 cr per qtr; prereq Δ)
- 5870su. ITASCA SEMINAR.** (Cr ar; prereq #, Δ) 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
 8910f. WORKSHOP ON TEACHING COLLEGE BIOLOGY
 8950. GRADUATE SEMINAR
 8970. SPECIAL TOPICS
 8990. GRADUATE RESEARCH

Botany

Director of Undergraduate Studies—Professor Tom Soulen

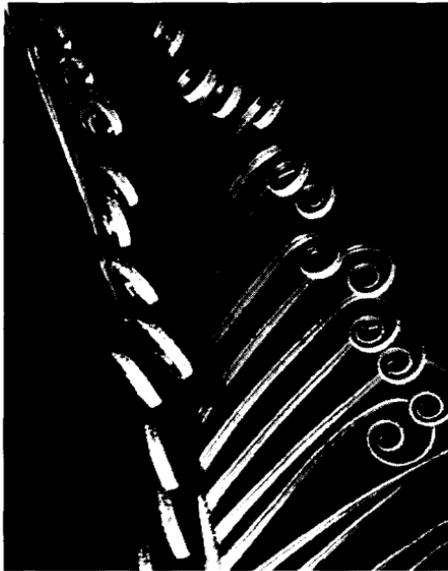
Botanists study such varied topics as the structure, function, development, classification, evolution, worldwide distribution, and importance of plants ranging from algae and fungi to flowering plants; the molecular basis of plant evolution and development; the mechanisms through which plants convert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

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

COURSES—BOTANY (Bot)

- 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,s. 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.
- Biol 1103f,w,s,su. GENERAL BOTANY. (5 cr. \$Biol 3012; prereq Biol 1011, students who plan to major in biology in CLA or in any bioscience major in CBS should take Biol 3012) Wetmore, Biesboer, Koukkari
 Levels of organization of plants, plant function, plant growth and development, plant reproduction.
- 3012w,s. PLANT BIOLOGY. (5 cr, \$1103; prereq 1011, Chem 1005) Charvat, McLaughlin
 Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants.
- 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, BioC 1302 or BioC 1302 or Biol 5001) Soulen, Guilfoyle, Jendrisak
 Physiological principles underlying processes that occur in living plants with emphasis on higher plants. Growth and development, mineral nutrition, transport, water relations, and metabolism especially emphasizing photosynthesis and nitrogen assimilation. For lab, see 5132.
- 3201w. INTRODUCTORY TAXONOMY. (4 cr; prereq Biol 1103 or 3012) Morley
 Taxonomy of ferns, gymnosperms, and flowering plants (representative material drawn largely from Minnesota spring flora). Families of plants and their relationships; floral structure and function; taxonomic terms; nomenclature; literature; methods of collection and identification. Two or three field trips.
- 3950f,w,s,su. UNDERGRADUATE PROSEMINAR. (1 cr per qtr; prereq #)
 Biological topics of current interest.

Major Requirements and Course Descriptions



- 3970f,w,s,su. INDEPENDENT STUDY.** (1-5 cr per qtr; prereq #, Δ)
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 #, Δ)
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, comparative morphology (including ultrastructure), comparative nutrition. Laboratory emphasizes living material and isolation of algae and fungi into culture.
- 5105s. 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.
- 5111f. DEVELOPMENTAL PLANT ANATOMY.** (5 cr; prereq Biol 1103 or 3012) Biesboer
Microscopic structure of vascular plants; development in root, stem, and leaf.
- 5131f,w,s. SURVEY OF PLANT PHYSIOLOGY.** (4 cr, §3131, §PIPh 3131, §PIPh 5131; prereq Biol 1103 or 3012, BioC 1302 or ¶BioC 1302 or Biol 5001) Soulen, Guilfoyle, Jendrisak, Frenkel
Physiological principles underlying processes that occur in living plants, with emphasis on higher plants. Growth and development, mineral nutrition, transport, water relations, and metabolism especially emphasizing photosynthesis and nitrogen assimilation. Includes a weekly discussion section.
- 5132f,w. PLANT PHYSIOLOGY LABORATORY.** (2 cr; prereq 3131 or 5131 or ¶3131 or ¶5131) Jendrisak, Frenkel
Laboratory course to accompany 3131 or 5131.
- 5182s. PLANT METABOLISM.** (3 cr, §PIPh 5182; prereq 5131 or equiv. course in biochemistry) Soulen
Plant metabolism: photosynthesis, respiration, and the synthesis of macromolecules by plants. Structure-function relations at the plant, cell, and subcellular levels. Energy flow in the plant system and regulation of plant metabolism.
- 5183w. WATER, MINERALS, AND TRANSLOCATION.** (4 cr, §PIPh 5183; prereq 5131 or equiv) Simmons, Stadelmann
Membrane phenomena and osmotic properties of cells. Uptake, movement, and loss of water in plants; effects of external factors. Translocation of organic substances. Absorption, distribution, and function of inorganic elements.
- 5184f. PLANT GROWTH AND DEVELOPMENT.** (3 cr, §PIPh 5184; prereq 5131 or equiv) Guilfoyle
A survey of plant growth and development ranging from germination to death, with emphasis on physiology, biochemistry, and molecular biology. Topics include developmental processes related to mobilization of macromolecules during germination, cell division and cell extension during axis growth, photomorphogenesis, chloroplast and microbody ontogeny, flowering, fruit and seed formation, senescence, and how plant growth substances control these developmental events.

- 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.
- 5206s. **MINNESOTA VASCULAR PLANTS.** (5 cr, \$5205; prereq 3201 and #) Ownbey
Vascular plants of Minnesota with emphasis on plants important to wildlife; identification, classification, distribution, ecology; term paper. Accelerated class for wildlife students attending Itasca spring session.
- 5211f. **SURVEY OF ANGIOSPERM FAMILIES.** (5 cr; prereq 3201 or #; offered 1981-82 and alt yrs) Morley
Characteristics and relationships of orders and families of flowering plants on a worldwide basis.
- 5212w. **PRINCIPLES OF ANGIOSPERM PHYLOGENY.** (3 cr; prereq 3201 or #; offered 1982-83 and alt yrs) Morley
Evolutionary relationships and the various means of judging them within the angiosperms. Laboratory investigation of representative and critical groups.
- 5231s. **INTRODUCTION TO THE ALGAE.** (5 cr; prereq 10 cr in botany or biology or #; offered 1980-81 and alt yrs)
Structure, reproduction, and life histories of major algal divisions.
- 5960f,w,s,su. **SPECIAL TOPICS.** (Cr ar; prereq #, Δ) Staff
Treatment in depth of a specialized botanical topic.
- 5970f,w,s,su. **BASIC BOTANY.** (Cr ar; prereq Biol 1103 or 3012, #, Δ)
Individual work in some special discipline.

COURSES OFFERED AT LAKE ITASCA FORESTRY AND BIOLOGICAL STATION

- 5801su. **PLAINS AND BOREAL FLORA.** (5 cr; limited to 20 students; prereq course in taxonomy, Δ; offered annually)
Survey of the summer flowering plants and ferns of the state with particular reference to the local flora. Identification by technical keys; important plant families; field recognition of common species; habitat preferences; collecting methods; literature; taxonomic methods.
- 5805su. **AQUATIC FLOWERING PLANTS.** (5 cr; limited to 20 students; prereq course in taxonomy, Δ; 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, Δ; offered annually)
The developmental morphology and taxonomy of freshwater algae, including the relationship of algae to their environment. Identification of field collections by technical keys, collecting and analytical methods, and utilization of information for recognizing distribution patterns.
- 5815su. **BRYOPHYTES.** (5 cr; limited to 20 students; prereq 10 cr biology or #, Δ; offered when feasible)
Field and laboratory study of the mosses and liverworts of Minnesota.
- 5821su. **LICHENS.** (5 cr; limited to 20 students; prereq 10 cr in botany or zoology or #, Δ; offered when feasible)
Taxonomy, ecology, and floristics of lichens of northern Minnesota; identification, sampling methods, microchemistry as a taxonomic tool.
- 5890su. **RESEARCH PROBLEMS.** (1-5 cr per qtr; prereq #, Δ)
Individual research for undergraduates and graduates.

FOR GRADUATE STUDENTS ONLY

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

8301. **POLLEN MORPHOLOGY AND QUARTERNARY PALYNOLOGY**
8950f,w,s. **SEMINAR**
8990f,w,s,su. **RESEARCH PROBLEMS**

RECOMMENDED RELATED COURSES OFFERED BY OTHER COLLEGES

Students interested in botany should consult the bulletins of other University of Minnesota colleges for additional courses of interest. Courses are recommended in such areas as entomology, plant pathology, plant physiology, soil science (College of Agriculture); and geology (Institute of Technology).

Ecology and Behavioral Biology

Director of Undergraduate Studies—Professor James Underhill

Ecologists study the evolutionary adaptations of plants and animals to the environment. The ecological perspective encompasses the growth and maintenance of populations and their

Major Requirements and Course Descriptions

interactions in communities, and the interrelationships among organisms and physical events in terrestrial and aquatic ecosystems. The behavioral biology perspective deals with adaptations to the environment, mechanisms of behavior, and the evolution of social systems.

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

COURSES—ECOLOGY AND BEHAVIORAL BIOLOGY (EBB)

INTRODUCTORY ECOLOGY AND BEHAVIORAL BIOLOGY

- 3001w,s. **INTRODUCTION TO ECOLOGY.** (4 cr; open to jrs and above but not to biology majors) Corbin, Siniff
Basic concepts in ecology; the organization, development, and functioning of ecosystems; population growth and regulation. Human impact on ecosystems.
- 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. **POPULATION BIOLOGY.** (4 cr; prereq Biol 5003 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.
- 3101w. **ECOLOGY FOR ENGINEERS AND PHYSICAL SCIENTISTS.** (4 cr, §3001; not open to biology majors; prereq Math 1231) Bright
Description and analysis of the spatial and temporal interactions between populations in ecosystems; processes affecting populations; transformations of energy and materials in the biosphere. Lectures and recitations.
- 3111s. **VERTEBRATE BEHAVIOR.** (4 cr, §AnSc 3111; prereq Biol 1106 or 3011 or #) Phillips
The nature, variety, development, motivation, and evolution of animal behavior emphasizing social interactions and communication.
- 3960f. **RESEARCH TOPICS IN ECOLOGY AND BEHAVIORAL BIOLOGY.** (1 cr per qtr; S-N only; prereq #)
Lectures on and discussion of current research in the department.
- 3990f,w,s. **RESEARCH PROBLEMS.** (1-6 cr per qtr; prereq #, Δ) Staff
Individual research for undergraduate majors in biology.

COMMUNITY ECOLOGY AND PALEOECOLOGY

- 5008s. **QUATERNARY ECOLOGY.** (4 cr; prereq Biol 3041 or #) Davis, Cushing
Impact of changes in the physical and biological environment during the Quaternary period on plants and animals; examines such changes as evolutionary rates, geographical distributions, community composition and fluctuations in population sizes. Impact of prehistoric human culture on the environment, including ecosystem-level changes recorded in sedimentary sequences. Recent climatic changes. Emphasis on general principles of analysis and methods of investigation and interpretation.
- 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 and development, and of the 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, Bor 3201; offered 1983 and alt yrs) Cushing
Vegetation regions of the world in general and North America in detail; ecological principles of plant distribution; interpretation of regional and temporal patterns in the distribution of vegetation and taxonomic groups. Field trips to floristic regions of Minnesota.

POPULATION AND EVOLUTIONARY BIOLOGY

- 5031s. **EVOLUTIONARY ECOLOGY.** (3 cr; prereq Biol 3041 or equiv. #; offered 1981 and alt yrs) Corbin
Evolutionary concepts and theory applied to the study of populations, communities, and ecosystems. Current literature and research emphasized.
- 5044f. **EVOLUTION.** (4 cr; prereq Biol 1106 or 3011) Merrell
Survey of evidence for and causes of biological evolution.
- 5052f. **THEORETICAL POPULATION ECOLOGY.** (4 cr; prereq Biol 3041 or #) Tilman
Theories of population ecology, including models of growth and regulation of single populations, and of interactions between populations, including competition, predation, mutualism; emphasizes assumptions and rationales of models and their predictions for dynamics, stability, and diversity of communities.

- 5053s. **THEORY OF STRUCTURED POPULATIONS.** (4 cr; prereq Math 1231, Biol 3041 or equiv, EBB 5052 or equiv; offered 1981 and alt yrs) Abrams
Mathematical models of populations with regard to genetic, age, size, and/or spatial structure. Evolution of population structure and influence on population dynamics. Genetic feedback. Optimal life histories.
- GCB 5062w (formerly EBB 5062). **GENETICS AND SPECIATION.** (4 cr; prereq 15 cr biology incl genetics, #) Merrell
Application of genetic principles to problems of speciation and evolution.
- GCB 5063s. **THEORETICAL POPULATION GENETICS.** (3 cr; prereq GCB 5033 or #; familiarity with differential and integral calculus) Simmons
Population genetics theory as related to problems of natural populations.

ORGANISMAL BIOLOGY AND PHYSIOLOGICAL ECOLOGY

- 5112s. **INVERTEBRATE BIOLOGY.** (5 cr; prereq Biol 1106 or 3011 or #; offered 1981 and alt yrs) Barnwell
Morphology, physiology, behavior, ecology, and evolution of invertebrate groups. Laboratory study of living marine, freshwater, and terrestrial representatives.
- 5113su. **BIOLOGY OF LOCAL INVERTEBRATES.** (5 cr; prereq Biol 1011 or 1106 or equiv) Gilbertson
Taxonomic and ecological survey of local invertebrates. Emphasis on aquatic species in their natural environments.
- 5114w. **VERTEBRATE BIOLOGY.** (4 cr; prereq Biol 1106 or 3011) Huver
Vertebrates: their biology, taxonomy, and distribution.
- 5116w,su. **INTRODUCTION TO ANIMAL PARASITOLOGY.** (5 cr; prereq Biol 1106 or 3011; offered 1981 and alt yrs) Gilbertson
Elementary course dealing with parasitic protozoa, worms, and arthropods and their relation to diseases of humans and animals.
- 5118f. **SYMBIOSIS.** (3 cr; prereq Biol 1106 or 3011) Gilbertson
Interactions of organisms of different species living in intimate physiological association.
- 5122s. **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.
- 5128s. **ADAPTATION AND MACROEVOLUTION: VERTEBRATES.** (4 cr; prereq Biol 1106 or 3011; offered 1982 and alt yrs)
Patterns and problems in evolution at the species level and above are discussed in the context of an introduction to vertebrate phylogeny, ecology, and adaptations. Lectures, demonstrations, and field trips.
- 5129f. **MAMMALOLOGY.** (5 cr, §FW 5129; prereq Biol 1106 or 3011 or #) Birney
Recent families and orders of mammals of the world and of genera and species of mammals of North America, with emphasis on morphology, evolution, and zoogeographic history.
- 5132s. **HERPETOLOGY.** (5 cr; prereq Biol 1106 or 3011 or #; offered 1982 and alt yrs) Regal
Distribution, classification, and evolution of amphibians and reptiles of the world. Physiological, morphological, and behavioral aspects of adaptive trends. Laboratory and lecture.
- 5134w,s. **INTRODUCTION TO ORNITHOLOGY.** (5 cr; prereq Biol 1106 or 3011) Tordoff, Warner
Laboratory and field course in structure, classification, distribution, migration, habits, habitats, and identification of birds. Weekend trips scheduled.
- 5136s. **ICHTHYOLOGY.** (4 cr; prereq 15 cr incl Biol 1106 or 3011) Huver
Biology of fishes including development, systematics, anatomy, physiology, and ecology.
- 5156s. **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. Introduces student to the passive organism: environment "stresses" and biological mechanisms by which they are counteracted.
- 5158f. **PLANT ADAPTATION.** (3 cr; prereq Biol 3012 or Bot 3131 or 5131 or #) Morrow
The nature, 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. An accompanying laboratory experience may be arranged through independent study; consult the instructor.
- 5159f,s. **PHYSIOLOGICAL PLANT ECOLOGY LABORATORY.** (2 cr; prereq 5158 or 5158 or #; offered 1981-82 and alt yrs) Morrow
Field and laboratory measurements of physiological and morphological responses of plants to their environment.

BEHAVIOR

- 5154f. **BEHAVIORAL AND PHYSIOLOGICAL ECOLOGY.** (3 cr; prereq advanced course work in either physiology, behavior or ecology) Regal
Aspects of the adaptation of organisms to environments. Orientation, learning and adaptation of behavior, heat and water regulation, bioenergetics, biological rhythms.

Major Requirements and Course Descriptions



5155. **LABORATORY IN BEHAVIORAL AND PHYSIOLOGICAL ECOLOGY.** (3 cr; prereq 5154, #) Regal
Emphasis on individual directed projects.
- 5312s. **NEUROBIOLOGY.** (3 cr; prereq Biol 3011 or #...GCB 5114 highly recommended) Hopkins
Biological survey of nervous systems: their anatomy, integrative physiology, development, and function in behavior.
- 5313s. **INVERTEBRATE BEHAVIOR.** (5 cr; prereq Biol 1106 or 3011 or #; offered 1982 and alt yrs) Barnwell
Survey of simple to complex behaviors in invertebrate animals in relation to morphology, ecology, and evolution. Laboratory projects with marine, freshwater, and terrestrial representatives.
- 5321f. **EVOLUTION OF SOCIAL BEHAVIOR.** (4 cr; prereq Biol 1106 or 3011 or #) McKinney
Introduction to current theories and concepts relating to mating systems, spacing systems, and cooperative behavior in animals.
- 5322w. **COMPARATIVE ETHOLOGY.** (4 cr, §5022; prereq 5321 or §5321, #) McKinney
Evolution and adaptive significance of behavior, primarily in vertebrates, with emphasis on comparative methods.
- 5323w. **MECHANISMS OF ANIMAL BEHAVIOR.** (5 cr; prereq Biol 3011 or 1 qtr of animal physiology) Hopkins
A survey of animal behavior mechanisms: their organization and their functions. Analysis of behavior sequences, motor coordination, fixed action patterns, sensory systems, and release mechanisms, mechanisms of animal communication, orientation behavior, feedback mechanisms and control, behavior of small neural networks. Laboratory included.

LIMNOLOGY AND ECOSYSTEM ECOLOGY

- 5601f,w. **LIMNOLOGY.** (4 cr, §Geo 5601; prereq Chem 1005 or #) Gorham, 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.
- 5603f. **PLANKTON POPULATIONS.** (5 cr; prereq 5601 or 5812, Biol 3041 or #; offered 1982 and alt yrs) Megard
Biology of plankton and analysis of the maintenance and regulation of planktonic populations. Laboratory studies of the taxonomy, morphology, and biology of plankton. Two Saturday field trips.
5604. **BIOLOGICAL LIMNOLOGY.** (3 cr; prereq 5601 or 5612 or #) Megard
Survey of the taxonomy and natural history of planktonic and benthic organisms in lakes and streams, descriptions of planktonic and benthic populations, and analyses of processes that regulate population densities of aquatic organisms.
5605. **LABORATORY IN BIOLOGICAL LIMNOLOGY.** (2 cr; prereq 5601 or 5812 or #) Megard
The morphology and identification of planktonic and benthic organisms in lakes and streams, use of sampling equipment and instruments in the field, and analysis of field data.
5606. **ECOLOGY OF FISHES.** (5 cr; prereq Biol 1011 or 1106 or equiv plus 10 cr in the biological sciences) Underhill
Ecological requirements of fishes with emphasis on nongame species; habitat, food, interactions between species, and behavioral, anatomical, and physiological adaptations. The role of fishes in the aquatic ecosystem with emphasis on fresh waters.
- 5608f. **ECOSYSTEMS: FORM AND FUNCTION.** (3 cr; prereq 3004 or 5601 or Biol 3041, Chem 1002 or 1005; offered 1982 and alt yrs) Davis
Nature and development of terrestrial, wetland, and aquatic ecosystems. Analysis of energy flow and element cycling in relation to environmental controls, self-regulation, natural and human disturbances.
- 5612s. **BIOGEOCHEMICAL CYCLES.** (3 cr; prereq Biol 3041, Biol 5001 or MicB 5321 or #) Wood
Biogeochemical cycles for essential, nonessential, and toxic elements in the biosphere. Emphasis on human impact on biogeochemical cycles and on the connections between these cycles.
- 5613w. **ASSESSING THE ECOLOGICAL EFFECTS OF POLLUTION.** (4 cr; prereq Biol 3041 or equiv, Chem 3301, 3302) Gorham
Assessment of effects upon species and ecosystems, methodological problems, initial phases of investigating a new pollutant, problems of prediction.
- 5970f,w,s. **DIRECTED STUDIES.** (Cr ar; prereq #, Δ)



COURSES OFFERED AT LAKE ITASCA FORESTRY AND BIOLOGICAL STATION

3800su. FIELD PROBLEMS IN ECOLOGY AND BEHAVIOR. (10 cr; limited to 20 students; prereq two courses in biology, Δ ; hrs ar)

The theory of natural selection used as the basis for development of questions on the ecology and behavior of living organisms. Numerous group and individual field projects performed on a diversity of plants and animals from the Itasca region, using experimental and comparative methods. Intended for undergraduates with little or no previous experience in field biology.

5812su. AQUATIC ECOLOGY. (5 cr; limited to 20 students; prereq 15 cr biology, 5 cr chemistry, Δ ; offered annually)

General limnology of lakes with emphasis on the biology of lakes in the Itasca region as related to their physical and chemical stratification in summer. Team projects in field research.

5814su. COMMUNITY STRUCTURE AND FUNCTION. (5 cr; limited to 20 students; prereq course in ecology, Δ ; offered annually) Staff

Communities represented in Itasca Park and vicinity and their dynamic relationships. Relationships of local communities to the flora and fauna as a whole. Use of modern methods of community analysis and measurement of environmental factors.

5815su. FIELD ETHOLOGY. (10 cr; limited to 15 students per section; prereq course in behavior, Δ ; ... course in statistics recommended)

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

5817s,su. VERTEBRATE ECOLOGY. (5 cr; prereq course in ecol, #, Δ)

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.

5820su. WETLAND ECOLOGY. (10 cr; limited to 15 students; prereq 15 cr biology, Δ ; ... introductory chemistry, course in plant identification, Biol 3041 recommended) Gorham

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

5831su. NATURAL HISTORY OF INVERTEBRATES. (5 cr; limited to 20 students; prereq Biol 1106, Δ ; offered when feasible)

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

Major Requirements and Course Descriptions

5832su. **NATURAL HISTORY OF VERTEBRATES.** (5 cr; limited to 20 students; prereq Biol 1106, Δ ; offered when feasible)
Taxonomic survey of local vertebrates, exclusive of birds, and study of morphological, physiological, and behavioral adaptations to different habitats.

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

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

8012s. THEORETICAL COMMUNITY ECOLOGY

8014s. PALEOECOLOGICAL METHODS

8051. BEHAVIORAL ADAPTATIONS

8061. SOCIAL SYSTEMS

8071. ANIMAL COMMUNICATION

8081w. NEUROETHOLOGY

8091w. HORMONES AND BEHAVIOR

8162w. WINTER ECOLOGY

8390. GRADUATE SEMINAR

8391. ADVANCED WORK IN ECOLOGY AND BEHAVIORAL BIOLOGY

8800su. ADVANCED FIELD ECOLOGY (ITASCA)

8990. GRADUATE RESEARCH

RECOMMENDED RELATED COURSES OFFERED BY OTHER COLLEGES

Students interested in additional course work are encouraged to review the bulletins of other University of Minnesota colleges. Courses are recommended in such areas as animal science, entomology, soil science (College of Agriculture); anthropology, psychology (College of Liberal Arts); chemical engineering, geology, mathematics (Institute of Technology); and veterinary biology (College of Veterinary Medicine).

Genetics and Cell Biology

Director of Undergraduate Studies—Professor Val W. Woodward

Genetics is the study of inheritance, including molecular mechanisms of gene action, human genetics, and the behavior of genes in populations of organisms. Cell and developmental biology encompasses the study of the organization, composition, function, and assembly of cells and cellular components, and their regulation during the processes of cellular growth and differentiation.

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 and developmental biology major in biology and include in their programs a suitable selection of advanced courses appropriate to their interests. Students with an interest in this area should request a faculty adviser from the GCB department.

COURSES—GENETICS AND CELL BIOLOGY (GCB)

- 3002f. **HUMAN GENETICS, SOCIAL AFFAIRS.** (3 cr | 4 cr with term paper). §3022, §Biol 1101, §Biol 5003; for students in programs not directly related to biological sciences) V E Anderson
Human genetics; study of individuals, families, populations, and races with respect to differences in intelligence, behavior, disease, and other matters of social concern.
- 3008w. **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.
- 3011w. **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 5003; not intended for 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); prereq 2 qtrs chemistry, Math 1231 or 1331 or 1621 or #; not open to biology majors
Modern molecular biology emphasizing the principles of biological structures and mechanisms of function at the macromolecular and cellular levels of organization.
3960. **RESEARCH TOPICS.** (1 cr; S-N only; prereq Biol 5003, 5004)
Discussions of faculty research.
- 3970f,w,s,su. **INDEPENDENT STUDY.** (Cr ar; prereq #, Δ)
Individual study on selected topics or problems with emphasis on selected readings and use of scientific literature.
- 3990f,w,s. **LABORATORY RESEARCH.** (Cr ar; prereq #, Δ)
Individual projects on selected topics and problems.
- 5011w. **GENERAL AND COMPARATIVE EMBRYOLOGY.** (4 cr, §3011; prereq Biol 1106 or 3011; for grad students only) McKinnell
Embryological development of vertebrates.
- 5013s. **COMPARATIVE MAMMALIAN REPRODUCTION.** (4 cr; prereq 3011 or 5011, Biol 5001 or #; offered 1980-81 and alt yrs) Sinha
Interdisciplinary approaches in evaluating biological phenomena of reproduction incorporating basic problems, current concepts and ideas in the field. Three lectures and discussions, and an hour of independent studies/research or laboratory work.
5015. **HISTOLOGY: CELL AND TISSUE ORGANIZATION.** (5 cr; prereq Biol 1106 or 3011, plus 4 addtl cr in the biological sciences) Johnson
Cellular orientation used to explore organization of differentiated cells and tissues (epithelia, connective, muscle, and nerve) as they facilitate specialized functions. Laboratory combines experience with techniques (phase and fluorescent microscopy, autoradiography, and paraffin sectioning), EM demonstrations, and studies of prepared microscope slides.
- 5022f,w,s,su. **GENETICS.** (3 cr, §3022, §Biol 5003; not open to grad students in genetics)
Mechanisms of heredity, their implications for biological populations, and applications to practical problems.
5030. **LABORATORY: GENETICS.** (2 cr; prereq 3022 or 5022 or Biol 5003 or #)
Investigative approaches to analysis of genetic problems. Focus on a given organism or related group of organisms may differ from quarter to quarter.
- 5031w. **INTERMEDIATE GENETICS I.** (4 cr; prereq 3022 or Biol 5003, BioC 5002 or 5752, or #) Snustad, Snyder
Mechanics of inheritance. Comparative organization of genetic material in prokaryotic and eucaryotic organisms. Mutation, complementation, and recombination as operational criteria for genetic analysis.
- 5032s. **INTERMEDIATE GENETICS II.** (4 cr; prereq 5031) P Hackett, 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.** (4 cr; prereq 3022 or Biol 5003, 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) Enfield
Selection with reference to population changes in gene frequencies and means of quantitative characters. Information required for predicting effects of selection and related research. Emphasis on logical analysis.
- 5043f. **HUMAN GENETICS.** (3 cr; prereq 3022 or Biol 5003 or #) V E Anderson
Principles of human genetics at the molecular, cellular, individual, and population levels. Chromosomal and biochemical disorders; gene mapping; mutation and natural selection; variation in intelligence and behavior; genetic screening, counseling, and therapy.
- 5044w. **HUMAN POPULATION GENETICS.** (4 cr; prereq 5043, biostatistics [PubH 5452 or equiv], or #)
Biometric methods for research in human genetics. Use of genetic concepts and appropriate statistical techniques in exploring new problems. Use of statistical packages and genetic programs to analyze population data and model genetic systems. Individual study of current problems, and group discussion.

Major Requirements and Course Descriptions

- 5045s. MOLECULAR PRINCIPLES OF BEHAVIOR.** (3 cr; prereq BioC 5002 or #) J Sheppard
Relationships between biochemistry and behavior with emphasis on diseases of human behavior, i.e., the psychoses, alcoholism, epilepsy. Simple biological systems used to study behavior.
- 5046s. HUMAN BIOCHEMICAL GENETICS.** (3 cr; prereq 5031, 5043, BioC 5002 or equiv, Biol 5004 or equiv or #)
Basic genetic, biochemical, and pathologic principles of inherited human metabolic disorders.
- 5047f. 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.
- 5048f. CELL BIOLOGY I.** (4 cr; prereq Biol 5001) Rosenberg, Johnson
Eukaryotic systems with emphasis on the structure, function, and chemistry of cell organelles; selected specialized cells also considered. Focus on membranes and secretion, including membrane methodologies, structure, function, synthesis, and turnover; cell surfaces, protein synthesis, glycosylation, membrane fusion, lysosomes and endocytosis.
- 5049w. CELL BIOLOGY II.** (4 cr; prereq 5048, Biol 5003) Hooper, Johnson
Eukaryotic systems with emphasis on the structure, function, and chemistry of cell organelles, selected specialized cells also considered. Focus on motility, the cell nucleus and metabolically active membranes and include roles of microtubules and microfilaments in cell locomotion, shape changes, cytokinesis, ciliary beating and organelle redistribution; cell cycle, chromosomal structure, replication, and mitosis; compartmentalization and autonomy of mitochondria and chloroplasts, the role of peroxisomes, and detoxification by the endoplasmic reticulum.
- 5052s. QUANTITATIVE TECHNIQUES, CELL BIOLOGY.** (4 cr; calculus, introductory cellular or molecular biology, biochemistry recommended) Rosenberg, Rubenstein
Use and detection of radioisotopes; theory and practice of analytical and preparative ultracentrifugation, chromatography, spectroscopy, and electron microscopy; tissue culture and subcellular particle fractionation.
- 5062w. GENETICS AND SPECIATION.** (4 cr; prereq 15 cr biology incl genetics) Merrell
Application of genetic principles to problems of speciation and evolution.
- 5063s. THEORETICAL POPULATION GENETICS.** (3 cr; prereq college level calculus, basic statistics and genetics; offered 1980-81 and alt yrs) Simmons
Population genetics theory as related to problems of natural history.
- 5114w. GENERAL PHYSIOLOGY.** (3 cr; prereq Biol 3011, 5001, Phys 1109 or 1295) Goldstein
Quantitative approach to the study of cell function with emphasis on application of physical and chemical principles. Transport, electrical activity of cell membranes, cell contractility.
- 5134w. ENDOCRINOLOGY.** (4 cr; prereq Biol 3011, 5001 or #) W Herman
Survey of structure and function of invertebrate and vertebrate endocrine systems.
- 5135s. ENDOCRINOLOGY LABORATORY.** (2 cr; prereq 5134) W Herman
Assigned exercises demonstrating basic endocrine techniques. Student research projects arranged in consultation with instructor.
- 5605. CELL BIOLOGY LABORATORY.** (2 cr; prereq Biol 5004 or # Biol 5004 or #)
Experimental approaches to cell structure, function, and replication, including microscopy, autoradiography, cell fractionation, and molecular and chemical analyses.
- 5606f. BIOLOGICAL ELECTRON MICROSCOPY.** (2 cr; prereq 5051 or Biol 5004 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.
- 5610f,w,s,su. LABORATORY IN ELECTRON MICROSCOPY.** (2-5 cr; S-N only; prereq 5606 or #5606, #) Cunningham
Practical application of laboratory techniques in biological electron microscopy through an independent research project. Intended primarily for graduate students who will use electron microscopy in their thesis research. Approximately 20 hours of microscopy time must be paid for through hourly charges.

FOR GRADUATE STUDENTS ONLY

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

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

RECOMMENDED RELATED COURSES OFFERED BY OTHER COLLEGES

Students are encouraged to explore additional course work offered by other departments and colleges. Courses for this purpose are recommended in such areas as entomology (Ent), laboratory medicine (LMed), and psychology (Psy).

History of Science and Technology

Institute of Technology

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

Courses in this area focus on the origins and development of science and technology and their relations to the social, cultural, and philosophical currents of their time. Courses may be taken to support existing majors as well as to broaden knowledge of the nature and development of science and technology. They may also be used to fulfill group C distribution requirements.

COURSES—HISTORY OF SCIENCE AND TECHNOLOGY (HSci)

- 1711, 1712, 1713. **TECHNOLOGY AND WESTERN CIVILIZATION.** (4 cr per qtr, \$3711, \$3712, \$3713) Layton
History and sociocultural relations of Western technology. 1711: The relations of technology to culture from the Bronze Age to the Middle Ages. 1712: Technology and science in the Renaissance; technology and the scientific revolution; emergence of industrialism. 1713: Diffusion of the industrial revolution; technological development and its impact on industry, government, and society.
- 1811, 1812, 1813. **INTRODUCTION TO HISTORY OF SCIENCE.** (4 cr per qtr, \$3811, \$3812, \$3813) Shapiro
1811: Babylonian and Egyptian science; Greek natural philosophy, mathematics, astronomy, and biology; the Aristotelian world; decline and transmission of Greek science. 1812: Medieval background; the "experimental philosophy"; dissecting and describing nature; anatomy, circulation, and respiration; Copernican revolution; physical world of Kepler, Galileo, Descartes, and Newton; science and the popular imagination. 1813: 19th and 20th centuries; Newtonian triumph, romantic reaction, and modern revolution; the aether, electrical and optical. to Einstein; history of the earth; evolution before and after Darwin; nuclear physics and nuclear weapons.
- 3201, 3202, 3203. **HISTORY OF BIOLOGY.** (4 cr per qtr, \$5201, \$5202, \$5203) Kottler
3201: Antiquity to 1700. Biology, medicine, and natural history in antiquity: Hippocrates, Aristotle, Galen. Revival of biology in Renaissance and 17th century: Vesalius and anatomy, Harvey and circulation. 3202: Physiology and cell theory since 1700. Conceptual development of the various branches of modern biology: physiology, chemistry, and the experimental method; embryology, descriptive and experimental; cytology and microscopy. 3203: Evolution and genetics since 1700. Darwin and evolution; Mendel and genetics.
- 3711, 3712, 3713. **TECHNOLOGY AND WESTERN CIVILIZATION.** (4 cr per qtr, \$1711, \$1712, \$1713)
For description, see 1711, 1712, 1713.
- 3811, 3812, 3813. **INTRODUCTION TO HISTORY OF SCIENCE.** (4 cr per qtr, \$1811, \$1812, \$1813)
For description, see 1811, 1812, 1813.
3825. **PHYSICS AND SOCIETY IN 20TH-CENTURY AMERICA.** (4 cr, \$3835, \$5825) Stuewer
Nineteenth-century heritage; 20th-century discoveries and physical theories; growth of physics in America after World War I: the intellectual migration of the 1930s; nuclear physics, the Manhattan project, and the atomic bomb; McCarthyism and Oppenheimer; current and past contributions of Minnesota physicists.
3835. **THE ATOMIC AGE.** (4 cr, \$3825, \$5825) Stuewer
Development of nuclear energy in the 20th century; construction and use of the bomb; postwar military and political impact.
5011. **THEORIES OF COLOR: NEWTON TO HELMHOLTZ.** (4 cr) Shapiro
History of physical and physiological investigations of color from the 17th to the mid-19th centuries, focusing on fundamental contributions of Newton, Young, Maxwell, and Helmholtz.
5111. **PHYSICAL SCIENCES IN ANTIQUITY.** (4 cr) Shapiro
Mathematics and astronomy in Babylonia; Greek mathematics, Euclid and Archimedes, Aristotle's physics and cosmology; the emergence of mathematical and experimental natural science in Greece; Ptolemaic astronomy.
- 5201, 5202, 5203. **HISTORY OF BIOLOGY.** (4 cr per qtr, \$3201, \$3202, \$3203)
For description, see 3201, 3202, 3203.
5242. **EVOLUTION BEFORE AND AFTER DARWIN.** (4 cr; prereq Biol 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.

Major Requirements and Course Descriptions

5311. **TECHNOLOGY IN AMERICAN LIFE.** (4 cr) Layton
Technology in America with emphasis on its impact on society and culture. Traces the growth of American technology in its cultural and intellectual context from colonial period to present.
5760. **SELECTED TOPICS.** (1-5 cr per qtr; prereq #)
5825. **PHYSICS AND SOCIETY IN 20TH-CENTURY AMERICA.** (4 cr, §3825, §3835) Stuewer
For description, see 3825.
5924. **HISTORY OF 19TH-CENTURY PHYSICS.** (4 cr, §Phys 5924; prereq general physics or #) Stuewer
Conceptual developments in physics in 19th century (Young, Fresnel, Oersted, Ampère, Faraday, MacCullagh, Maxwell, Hertz, Lorentz, Lavoisier, Rumford, Dalton, Mayer, Joule, Helmholtz, Carnot, Clausius, Kelvin, Boltzmann, Mach, others). Relationships to social, philosophical, and theological influences.
5925. **HISTORY OF 20TH-CENTURY PHYSICS.** (4 cr, §Phys 5925; prereq general physics or #) Stuewer
Conceptual developments in relativity (Michelson, Lorentz, Poincaré, Einstein, others), quantum mechanics (Planck, Einstein, Rutherford, Bohr, Sommerfeld, Ehrenfest, Pauli, Millikan, Compton, Heisenberg, de Broglie, Schrodinger, Born, others), and nuclear physics (Chadwick, Gamow, Fermi, others). Relationships to social, philosophical, and theological influences.
5970. **DIRECTED STUDIES.** (1-15 cr per qtr; prereq #)
Guided individual reading or study.
5990. **DIRECTED RESEARCH.** (1-15 cr per qtr; prereq #)

FOR GRADUATE STUDENTS ONLY

8900. **SEMINAR: HISTORY OF EARLY PHYSICAL SCIENCES.** (4 cr; prereq #) Shapiro
8910. **SEMINAR: HISTORY OF MODERN PHYSICAL SCIENCES.** (4 cr; prereq #) Stuewer
8920. **SEMINAR: HISTORY OF BIOLOGICAL SCIENCES.** (4 cr; prereq #) Kottler
8930. **SEMINAR: HISTORY OF TECHNOLOGY.** (4 cr; prereq #) Layton
8970. **DIRECTED STUDIES.** (1-5 cr per qtr [max 15 cr]; prereq #)
8990. **DIRECTED RESEARCH.** (1-5 cr per qtr [max 15 cr]; prereq #)

RECOMMENDED RELATED COURSES OFFERED BY OTHER COLLEGES

Students are encouraged to explore additional course work offered by other departments and colleges. Courses are recommended in the history of medicine and biological sciences (HMed).

Microbiology

Medical School

Director of Undergraduate Studies—Professor Palmer Rogers

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

The field of microbiology embraces a multitude of areas of fundamental and applied research. Microbiologists have in common an interest in the basic role played by microbes, such as bacteria, fungi, and viruses, in the world in which we live. Microbiologists may be interested in basic biological mechanisms, such as DNA replication or the regulation of protein synthesis, that are currently under study employing microorganisms. They may study fundamental issues concerning human and animal diseases such as the mechanisms of viral and bacteriological infection, immunity and autoimmune disease, and viral-induced cancer. Numerous aspects of agriculture are under investigation by microbiologists; among them are specific fungal and bacterial symbionts essential for maximum growth of certain plants and bacteria and fungi essential for maintenance and production of natural soil fertility. Microbiologists are also active in many industrial and pharmaceutical fields involving production and discovery of new antibiotics, manufacture of cheese, beer, wine and other foods, pasteurization in canning and food processing, and even decontamination of space vehicles.

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

MicB 5216 or 5218 and 5321, 5900

One of the following: MicB 5234, 5322, 5811 or the laboratory accompanying virology (5424) and immunology (5216)

Two of the following: MicB 5232, 5424, 5611

Chem 3100-3101

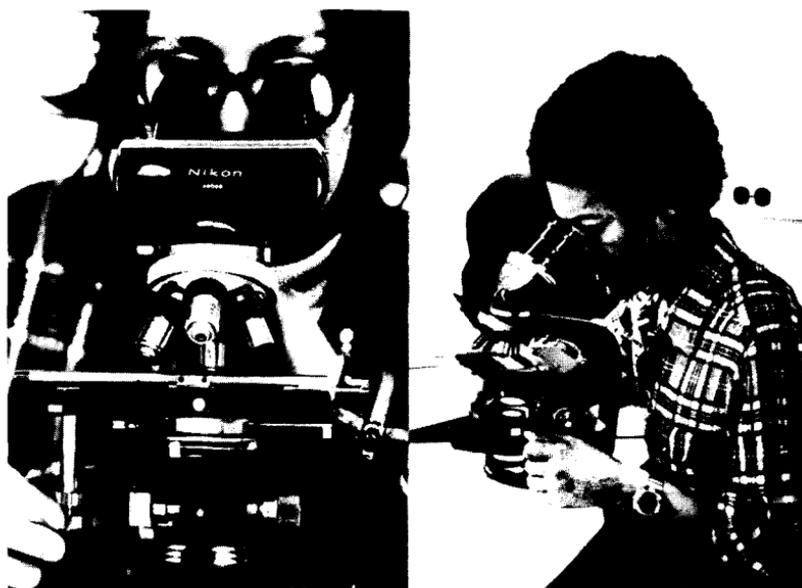
A sequence in physical chemistry (e.g., Chem 5520-5521) is highly recommended

Students planning to graduate with honors in microbiology must include specific courses in their program in addition to the college requirements. A listing of these requirements may be obtained from the departmental office, 1060 Mayo Memorial Building (Minneapolis), or from the undergraduate college office.

COURSES—MICROBIOLOGY (MicB)

1101. **ELEMENTARY MICROBIOLOGY.** (4 cr; prereq Biol 1011 or ϵ Biol 1011 or equiv; intended for students in CLA, dental hygiene, physical therapy, mortuary science...others with #; not intended for majors) Prince
Principles of microbiology; a general survey of pathogenic bacteria, molds, protozoa, and viruses; elements of immunity, sanitary analysis of water and milk, disinfectants and sterilants.
- 3103w.¹ **GENERAL MICROBIOLOGY.** (5 cr; ϵ 5105, ϵ Biol 5013, ϵ VPB 3103; 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. Applications of fundamental principles. Laboratory.
3970. **DIRECTED STUDIES.** (Cr ar; prereq #) Rogers, staff
Guided individual studies.
3990. **UNDERGRADUATE RESEARCH.** (Cr ar; prereq #) Rogers, staff
Guided individual research.
- Biol 5013 (formerly Biol 3013).¹ **MICROBIOLOGY.** (5 cr; ϵ MicB 3103, ϵ MicB 5105, ϵ VPB 3103; prereq Biol 5001) Chapman, Dworkin, C Woodward
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Molecular structure in relation to bacterial function.
- 5105.¹ **BIOLOGY OF MICROORGANISMS.** (4 cr; ϵ 3103, ϵ Biol 5013, ϵ VPB 3103; prereq 5 cr biological sciences, Biol 5001 or #) Dworkin
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Molecular structure in relation to bacterial function. Laboratory.
- 5216f. **IMMUNOLOGY.** (4 cr; prereq Biol 5001) Schmidtke, Gray
Nature of antigens and antibodies; chemical basis of serologic specificity; qualitative and quantitative aspects of antigen-antibody reactions; theories of antibody production; cellular antigens and blood grouping; nature of complement and its role in immunologic phenomena; mechanisms of hypersensitivity; hypersensitivity-like states and immunologic diseases; transplantation and tumor immunity, host-parasite interactions. Laboratory.
- 5218f. **IMMUNOLOGY.** (3 cr; prereq Biol 5001) Schmidtke, Gray
Same as 5216 without laboratory.
- 5232w. **MEDICAL MICROBIOLOGY.** (3 cr; not open to medical students; prereq 5105 or 3103 or 8110 or Biol 5013, 5216 or 5218) Cleary
Pathogenic bacteria and fungi; mechanisms of pathogenicity and virulence; properties of microorganisms and their animal hosts that influence the outcome of host-parasite relations analyzed from genetic and metabolic view.
- 5233f.¹ **MICROORGANISMS AND DISEASE.** (7 cr; not open to microbiology majors; prereq 10 cr chemistry and 5 cr biological sciences or #) Johnson
Nature of microorganisms, immunology, medical bacteriology, virology, mycology, parasitology, and principles of disease control. Laboratory.
- 5234.¹ **MEDICAL MICROBIOLOGY LABORATORY.** (2 cr; prereq 5232 or ϵ 5232) Cleary
Exercises demonstrating the principles and techniques employed in the study of the interactions between microorganisms and humans that lead to a diseased state.
5235. **MICROORGANISMS AND DISEASE.** (4 cr; not open to microbiology majors; prereq 10 cr chemistry and 5 cr biological sciences or #) Johnson
Same as 5233 without laboratory.
- 5321w. **PHYSIOLOGY OF BACTERIA.** (3 cr; prereq 3103 or 5105 or Biol 5013 or VPB 3103, 10 cr organic chemistry or biochemistry, 3 cr genetics) Rogers
Chemical and physical organization of bacteria as related to function; growth; energy metabolism including oxidations and fermentations; nutritional requirements; antimicrobial agents; autotrophic mechanisms; microbial differentiation.

¹Microscope required. Students may obtain use of microscope by purchasing a microscope card from the bursar.



5322w. **PHYSIOLOGY OF BACTERIA LABORATORY.** (2 cr; prereq 5321 or #5321, lab course in basic bacteriology) Rogers

Techniques employed in the study of bacterial physiology and metabolism.

5424s.¹ **BIOLOGY OF VIRUSES.** (4 cr; prereq 5321 or Biol 5001 and #) Plagemann

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

5611f. **MICROBIAL ECOLOGY.** (4 cr; prereq general microbiology course, Biol 5001 or #) Crawford

Microbial adaptation and diversity; role of microorganisms in natural processes; methods in microbial ecology; other topics of interest to microbial ecologists.

5900f,w,s. **TOPICS IN MICROBIOLOGY.** (1 cr; S-N only; open to microbiology sr majors) Rogers, Schmidt, staff

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

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**

¹Microscope required. Students may obtain use of microscope by purchasing a microscope card from the bursar.

8320. IMMUNOGENETICS

8323. REGULATION OF METABOLISM (offered when feasible)

8421. MOLECULAR BIOLOGY OF CANCER

8425. ADVANCED LABORATORY IN VIROLOGY AND ANIMAL CELL CULTURE

8911. COLLOQUIUM IN MICROBIOLOGY

8920. ADVANCES IN IMMUNOLOGY

8990. RESEARCH IN MICROBIOLOGY

RECOMMENDED RELATED COURSES OFFERED BY OTHER COLLEGES

Students are encouraged to consult the bulletins of other University of Minnesota colleges for additional courses of interest. Courses are recommended in such areas as food science and nutrition, laboratory medicine, public health, and veterinary pathobiology.

Zoology

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

COURSES—ZOOLOGY (Zool)

FOR GRADUATE STUDENTS ONLY

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

8970. GRADUATE SEMINAR

8980. SPECIAL RESEARCH FIELDS

8990. GRADUATE RESEARCH



Traill's Flycatcher. Artwork by David Parmelee.

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)

LaVell Henderson, Professor and Associate Dean, 140 Gortner Laboratory, St. Paul campus (373-1034).

Undergraduate College Office

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

Biochemistry

Victor Bloomfield, 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

Edward J. Cushing, Professor and Head, 108 Zoology Building, Minneapolis campus (373-5177)

Genetics and Cell Biology

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

Microbiology (Medical School)

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

James Ford Bell Museum of Natural History

Harrison B. Tordoff, Professor and Director, 301 Bell Museum of Natural History, Minneapolis campus (373-3192)

Dight Institute for Human Genetics

V. Elving Anderson, Professor and Acting 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)

General Biology Program

Norman S. Kerr, Professor and Chairman, P180 Kolthoff Hall, Minneapolis campus (373-3640)

Gray Freshwater Biological Institute

Richard S. Hanson, Professor and Director, P. O. Box 100, County Roads 15 and 19, Navarre, Minnesota 55392 (471-8476)

Faculty

Department of Biochemistry

Regents' Professor

Stanley Dagley, D.Sc.

Professor

Victor Bloomfield, Ph.D.
Peter J. Chapman, Ph.D.
John E. Gander, Ph.D.
Robert L. Glass, Ph.D.
LaVell M. Henderson, Ph.D.
Robert Jenness, Ph.D.
Samuel Kirkwood, Ph.D.
Irvin E. Liener, Ph.D.
Rex E. Lovrien, Ph.D.
Kenneth G. Mann, Ph.D.
Eckard Muenck, Ph.D.
Gary L. Nelsestuen, 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.
James A. Fuchs, Ph.D.
Gary R. Gray, Ph.D.
Clare K. Woodward, Ph.D.

Assistant Professor

Joachim W. Messing, Ph.D.

Department of Botany

Professor

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

Associate Professor

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

Assistant Professor

David D. Biesboer, 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.
Donald McNaught, Ph.D.
David J. Merrell, Ph.D.
David F. Parmelee, Ph.D.

Richard E. Phillips, Ph.D.
Philip J. Regal, Ph.D.
William D. Schmid, Ph.D.
Joseph Shapiro, Ph.D.
Donald B. Siniff, Ph.D.
John R. Tester, Ph.D.
Harrison B. Tordoff, Ph.D.
James C. Underhill, Ph.D.
Dwain W. Warner, Ph.D.

Adjunct Professor

Miron L. Heinselman, Ph.D.

Associate Professor

Franklin H. Barnwell, Ph.D.
Elmer C. Birney, Ph.D.
Robert C. Bright, Ph.D.
Kendall W. Corbin, Ph.D.
Donald E. Gilbertson, Ph.D.
Carl D. Hopkins, Ph.D.
Charles W. Huver, Ph.D.
Robert O. Megard, Ph.D.
Patrice A. Morrow, Ph.D.
G. David Tilman, Ph.D.

Assistant Professor

Peter A. Abrams, Ph.D.
Malcolm J. Kottler, Ph.D.

Department of Genetics and Cell Biology

Professor

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

Associate Professor

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

Assistant Professor

Perry B. Hackett, Ph.D.

Contributing Faculty From Other University Units

James Ford Bell

Museum of Natural History

Harrison B. Tordoff, Director
Elmer C. Birney, Curator of Mammalogy
Robert C. Bright, Curator of Paleontology
Kendall W. Corbin, Curator of Systematics
Carl D. Hopkins, Curator of Ethology
Charles W. Huver, Curator of Fishes
D. Frank McKinney, Curator of Ethology
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

Gray Freshwater Biological Institute

Professor

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

Associate Professor

Ronald L. Crawford, Ph.D.

Contributing Faculty From Other University Units

Department of Microbiology

(Medical School)

Regents' Professor

Dennis W. Watson, Ph.D.

Professor

Dwight Anderson, Ph.D.
K. Gerhard Brand, M.D.
Francis Busta, Ph.D.
Peter Chapman, Ph.D.
Martin Dworkin, Ph.D.
David Fan, Ph.D.
Anthony Faras, Ph.D.
V. W. Greene, Ph.D.
W. H. Hall, M.D., Ph.D.
Alan Hooper, Ph.D.
Howard Jenkin, Ph.D.
Russell C. Johnson, Ph.D.
Peter G. W. Plagemann, Ph.D.
Paul Que, M.D.
Palmer Rogers, Ph.D.
Charles Schachtele, Ph.D.
Edwin L. Schmidt, Ph.D.
Richard Simmons, M.D.
Henry Tsuchia, Ph.D.
Lewis Wannamacher, M.D.

Associate Professor

P. Patrick Cleary, Ph.D.
Ronald Crawford, Ph.D.

Gregory Germaine, Ph.D.
Beulah Gray, Ph.D.
Charles Muscoplat, Ph.D.
Gerald Needham, Ph.D.
James T. Prince, M.S.
Bernard Reilly, Ph.D.
James F. Zissler, Ph.D.

Assistant Professor

Russell Bey, Ph.D.
Robert Click, Ph.D.
Marc Collett, Ph.D.
Barry Handwerker, M.D.
Patrick Schlievert, Ph.D.
T. S. Tsien, Ph.D.
Robert Wohlhueter, Ph.D.

History of Science and Technology Program

(Institute of Technology)

Professor

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

Associate Professor

Alan E. Shapiro, Ph.D.

Assistant Professor

Malcolm Kottler, Ph.D.

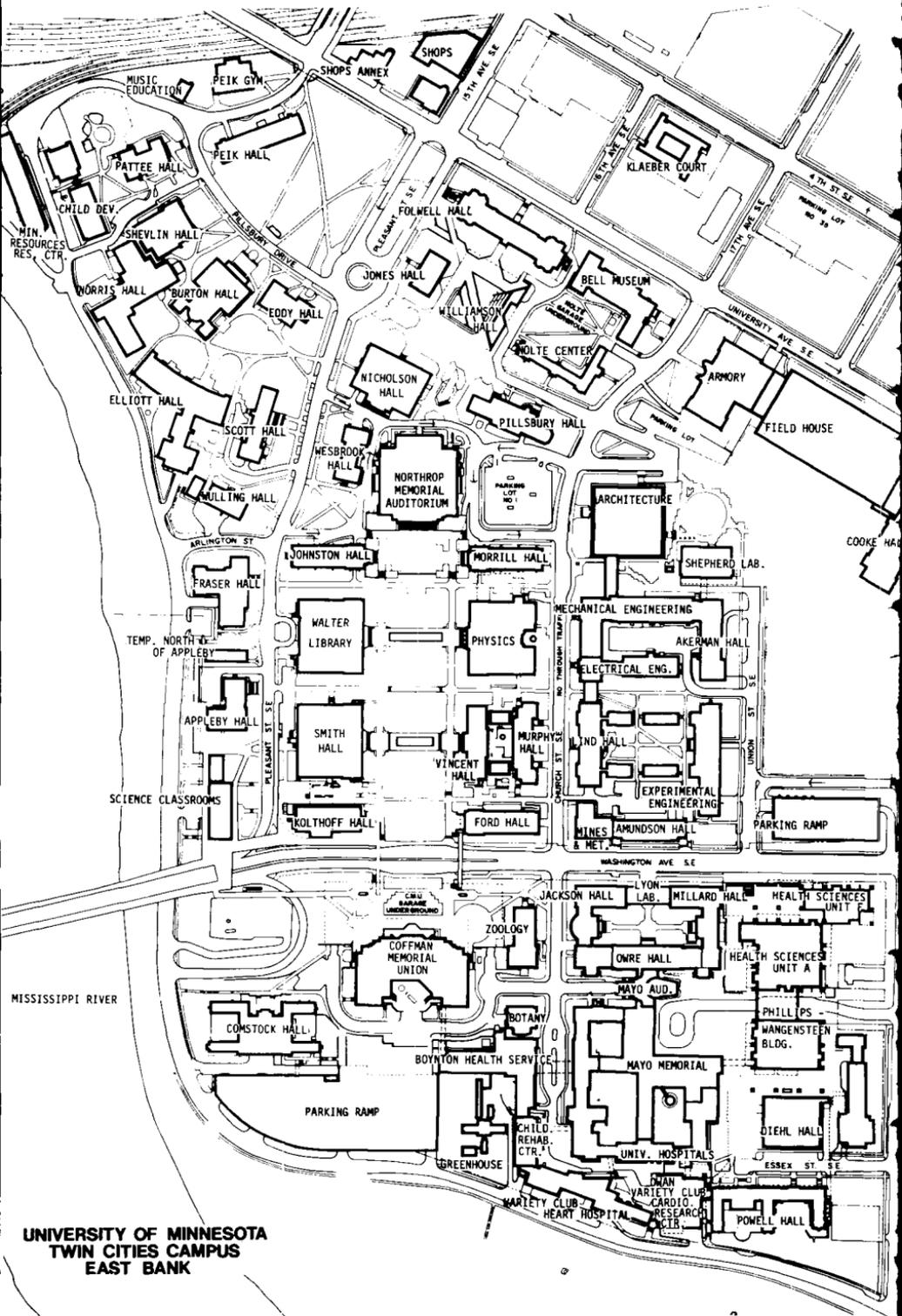
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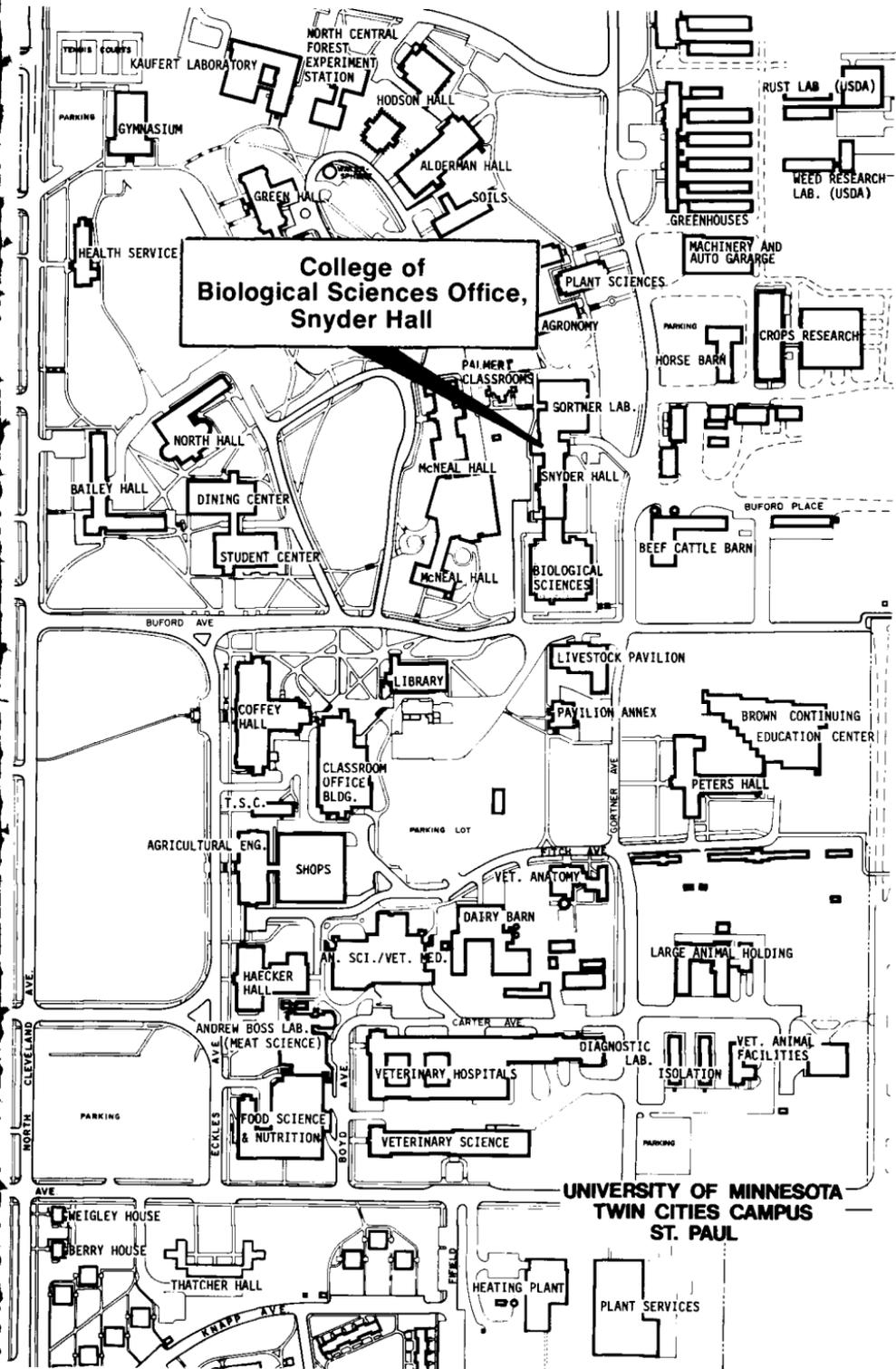
Campus Contact

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(612) 373-3648

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.



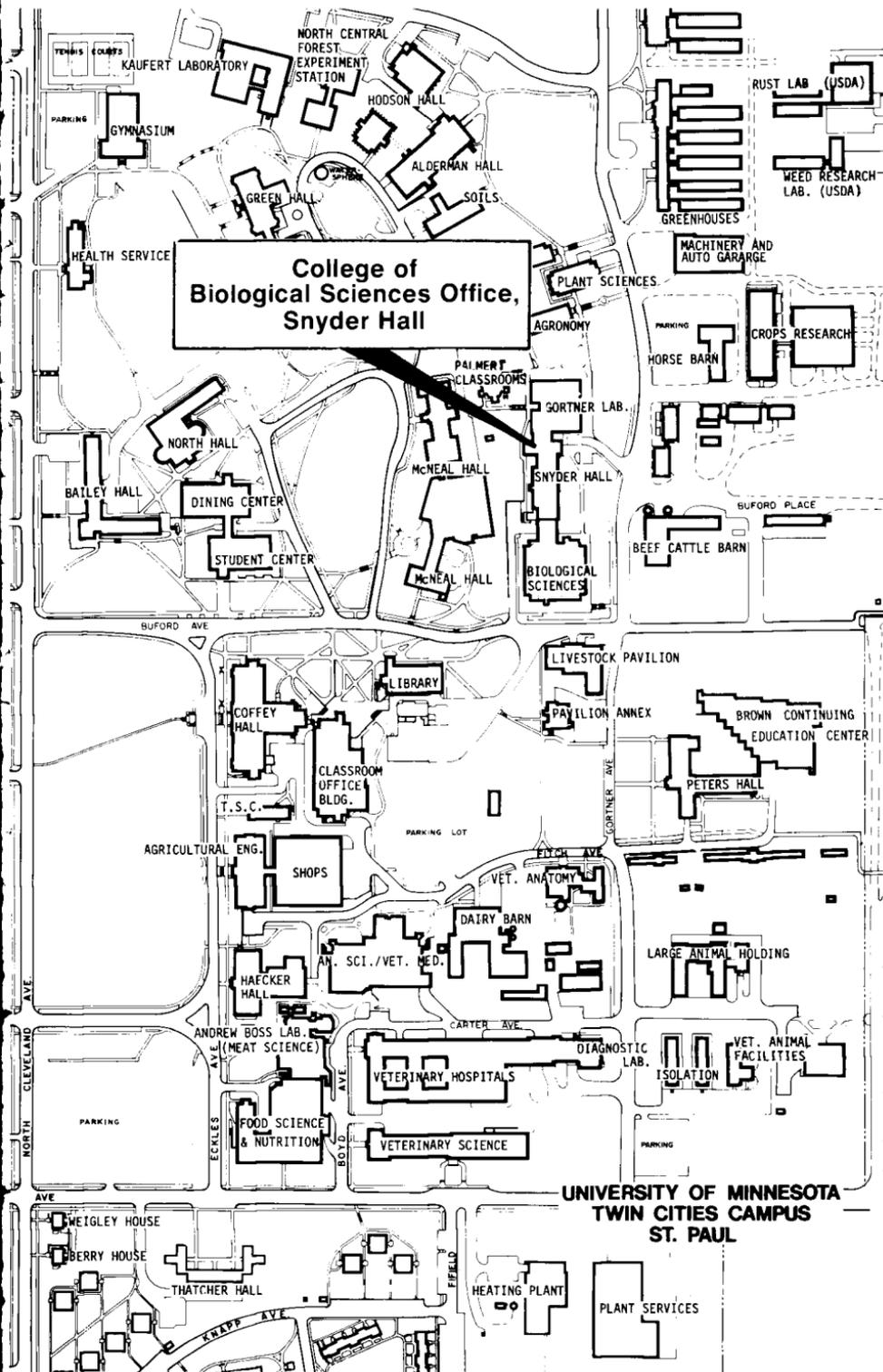
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