

University of Minnesota

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Bulletin

APRIL 30, 1971

college of biological sciences

HOW TO USE THIS BULLETIN

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

SECTION I—GENERAL INFORMATION

SECTION II—ADMISSIONS AND DEGREE PROCEDURES

- Admission Requirements, page 6.
- Credits and Grading Procedures, page 7.
- Requirements for Graduation, page 12.
- College and University Services, page 16.

SECTION III—CURRICULAR REQUIREMENTS AND COURSE DESCRIPTIONS

This section contains the specific curricular requirements for the fields of work plus the descriptions of undergraduate courses and a listing of graduate courses offered in the College of Biological Sciences.

All students and prospective students also need to refer to the *General Information Bulletin*. In addition, some will wish to refer to the following bulletins:

- College of Liberal Arts Bulletin*
- Graduate School Bulletin*
- Medical School Bulletin*
- Institute of Technology Bulletin*
- College of Veterinary Medicine Bulletin*
- School of Dentistry Bulletin*
- College of Pharmacy Bulletin*
- College of Agriculture Bulletin*
- College of Forestry Bulletin*
- College of Home Economics Bulletin*

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

The days and hours when classes meet and the place of the meeting are contained in the *Class Schedule* published just before the registration period each quarter.

UNIVERSITY OF MINNESOTA

Board of Regents

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COLLEGE OF BIOLOGICAL SCIENCES

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Albert W. Frenkel, Professor and Head, 8 Botany Building, Minneapolis Campus (373-2211)

Ecology and Behavioral Biology

Alan J. Brook, Professor and Head, 339 James Ford Bell Museum of Natural History, Minneapolis Campus (373-5177)

Genetics and Cell Biology

Frederick Forro, Jr., Professor and Head, 227 Snyder Hall, St. Paul Campus (373-0966)

Microbiology (Medical School)

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

Zoology

Magnus Olson, Professor and Head, 108 Zoology Building, Minneapolis Campus (373-3649)

Dight Institute of Human Genetics

Sheldon C. Reed, Professor and Director, 10 Zoology Building, Minneapolis Campus (373-3798)

V. Elving Anderson, Professor and Assistant Director, 6 Zoology Building, Minneapolis Campus (373-3639)

James Ford Bell Museum of Natural History

Harrison B. Tordoff, Director, 301 James Ford Bell Museum of Natural History, Minneapolis Campus (373-2423)

Faculty of the College of Biological Sciences

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Professor

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LaVell M. Henderson, Ph.D.
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Samuel Kirkwood, Ph.D.
Irvin E. Liener, Ph.D.
Walter O. Lundberg, Ph.D.
Palmer Rogers, Ph.D.
Hermann Schlenk, Ph.D.
Max O. Schultze, Ph.D.
Ulysses S. Seal, Ph.D.

Associate Professor

Victor Bloomfield, Ph.D.
Peter J. Chapman, Ph.D.
Robert L. Glass, Ph.D.
Rex E. Lovrien, Ph.D.
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Assistant Professor

John S. Anderson, Ph.D.
Dolph Klein, Ph.D.
Kenneth G. Mann, Ph.D.

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Albert W. Frenkel, Ph.D.
Eville Gorham, Ph.D.

John W. Hall, Ph.D.
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Thomas Morley, Ph.D.
Gerald B. Ownbey, Ph.D.
Douglas C Pratt, Ph.D.

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Willard L. Koukkari, Ph.D.
Thomas K. Soulen, Ph.D.

Assistant Professor

David J. McLaughlin, Ph.D.
Terry L. Shininger, Ph.D.
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Mary Ellen Burke, Ph.D.

Department of Ecology and Behavioral Biology

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D. Frank McKinney, Ph.D.
David F. Parmelee, Ph.D.
Richard E. Phillips, Ph.D.
Joseph Shapiro, Ph.D.
John R. Tester, Ph.D.
Harrison B. Tordoff, Ph.D.
Herbert E. Wright, Jr., Ph.D.,
D.Sc.

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Robert O. Megard, Ph.D.
Philip W. Ogilvie, Ph.D.
Donald B. Siniff, Ph.D.

Assistant Professor

Elmer C. Birney, Ph.D.
Robert K. Maxwell, Ph.D.
John G. McColl, Ph.D.

**Department of Genetics and
Cell Biology**

Regents' Professor

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Professor

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Richard S. Caldecott, Ph.D.
Franklin D. Enfield, Ph.D.
Frederick Forro, Jr., Ph.D.
Sheldon C. Reed, Ph.D.
Murray D. Rosenberg, M.D., Ph.D.
Irwin Rubenstein, Ph.D.
Leon A. Snyder, Ph.D.
Val W. Woodward, Ph.D.

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Alan B. Hooper, Ph.D.
D. Peter Snustad, Ph.D.

Assistant Professor

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Daniel L. Hartl, Ph.D.

Department of Zoology

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David J. Merrell, Ph.D.

Magnus Olson, Ph.D.
Nelson T. Spratt, Jr., Ph.D.
James C. Underhill, Ph.D.
Franklin G. Wallace, Ph.D.

Associate Professor

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Charles W. Huver, Ph.D.
Norman S. Kerr, Ph.D.
William D. Schmid, Ph.D.
Akhouri A. Sinha, Ph.D.
Dwain W. Warner, Ph.D.

Assistant Professor

Franklin Barnwell, Ph.D.
Donald E. Gilbertson, Ph.D.
Stuart F. Goldstein, Ph.D.
Ross G. Johnson, Ph.D.
Philip J. Regal, Ph.D.
Judson D. Sheridan, Ph.D.

**James Ford Bell Museum
of Natural History**

Harrison B. Tordoff, Director
R. E. Barthelemy, Public Education
Coordinator
Elmer C. Birney, Curator of
Mammalogy
Robert C. Bright, Curator of
Paleontology
Kendall W. Corbin, Curator of
Systematics
Charles W. Huver, Curator of
Fishes
David F. Parmelee, Chairman,
Field Biology Program
Christopher Ray, Curator of Exhibits
Philip J. Regal, Curator of
Herpetology
James C. Underhill, Associate
Curator of Fishes
Dwain W. Warner, Curator of
Ornithology

Contributing Faculty from Other University Units

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Professor

Robert W. Bernlohr, Ph.D.
Gerhard K. Brand, M.D.
Martin Dworkin, Ph.D.
Palmer Rogers, Ph.D.
Edwin L. Schmidt, Ph.D.
Dennis W. Watson, Ph.D.

Associate Professor

Russell C. Johnson, Ph.D.
Peter G. W. Plagemann, Ph.D.
James T. Prince, Ph.D.

Assistant Professor

James F. Zissler, Ph.D.

College of Biological Sciences

SECTION I

GENERAL INFORMATION

ORGANIZATION AND OBJECTIVES

The excitement that now centers around the activities of biologists in universities and research institutes stems from the fact that many major problems confronting mankind 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 brought to bear on these problems if they are to be resolved. This is because their resolution will require an understanding of, and an ability to use, the most profound concepts in physics, chemistry, and mathematics in addition to an appreciation of organisms when viewed at the molecular, cellular, organismal, and population levels. There is still great need for the specialist in biology who works in a well circumscribed area but there is an even greater need for the "integrator," that unique individual who has a depth of knowledge in a range of areas and the capacity to work with highly complex physical-chemical reactions in the milieu of dynamic systems.

During the last decade it has become apparent that knowledge of the structure and functioning of biological systems was increasing at such a rapid rate that extensive revisions were needed in both the undergraduate and graduate bioscience curricula. In the course of discussions as to how these revisions could be effected an all-University committee, with the counsel of an expert panel from other universities, concluded that a College of Biological Sciences should be established which would serve as a focal point for course offerings and research in biology. Following the approval of the University of Minnesota Faculty Senate, the proposal to establish a new college was submitted to and approved by the Board of Regents. Thus, the first such college in the nation was administratively and budgetarily established on September 1, 1965.

The college has three primary commitments in helping the University maintain excellence in scholarship among the broadest possible spectrum of the student body: first, to provide bioscience courses for other collegiate units for the purpose of general education as well as to assist in the development of majors in fields which are based on a thorough grounding in bioscience; second, to provide a substantial curriculum that leads to the granting of bachelor of science degrees in bioscience; and, finally, to provide opportunities for research and teaching at the graduate level that assures high standards and the maintenance of an excellent faculty.

DEGREE OFFERINGS

Undergraduate Programs

The bachelor of science degree is the only degree offered by the College of Biological Sciences and it can be earned with honors if the student attains a

high level of excellence and satisfies other specified requirements. It is possible to obtain the degree with a major in biology, biochemistry, botany, microbiology, or zoology. Irrespective of the major, however, each student must complete the same core sequence of courses in biology, the physical sciences, and mathematics. Students with a grade point average of 2.50 or above may take advantage of the opportunity to carry out a research problem during 1 or more quarters of the senior year, under the guidance of a research adviser.

The core sequence of courses, listed on page 13 and described on pages 18, 19 was designed in recognition of the following considerations: (1) that there is an underlying similarity in the functioning of all biological systems when viewed at the molecular and cellular levels; (2) that to train students for careers as biologists great emphasis must be given to training in the physical sciences; and (3) that to maintain student interest core courses should be taught so that they emphasize physical science methodologies in the solution of biologically important problems.

The bachelor of science degree is designed to provide a student with a background in the physical, mathematical, and biological sciences that will give him a thorough basis on which to build should he choose to pursue a graduate degree in bioscience or to enter the fields of medicine, veterinary medicine, or education. Should a student choose to end his formal education with the Bachelor's degree, he would have a sufficient level of sophistication in biosciences and a sufficiently broad background in liberal education to assume any one of a variety of office, laboratory, or field positions with governmental agencies and industry. There are biology programs differing somewhat in depth of penetration offered in other colleges of the University, the details of which can be found in the *College of Liberal Arts Bulletin*, the *College of Agriculture Bulletin*, and the *College of Education Bulletin*. Students who achieve the Master's or Ph.D. degrees can anticipate opportunities for employment in universities, junior colleges, high schools, federal agencies, state agencies, and industry.

Graduate Programs

Graduate study at the University of Minnesota is coordinated and administered by the Graduate School through the members of various graduate faculties responsible for specific program areas of education, plus graduate group committees, and an executive committee of the Graduate School responsible for graduate school policy and maintenance of academic standards. In this way, members of departments, schools, and colleges throughout the University cooperate in the offering of advanced study and training in a wide range of academic fields. The faculty of the College of Biological Sciences play a major role in offering graduate degrees in biological science areas. A student should refer to the *Graduate School Bulletin* for details relating to general policies regarding admission requirements, registration procedures, general opportunities for financial aid, and requirements for graduate degrees. In the College of Biological Sciences there are available graduate programs in biology, biochemistry, botany, ecology, genetics, and zoology. The program in biology typically emphasizes one of the following areas: cell biology, behavioral biology, developmental biology, and evolutionary and systematic biology. However, unique programs may be designed under special circumstances.

SECTION II

ADMISSION AND DEGREE PROCEDURES

ADMISSION REQUIREMENTS

General

The College of Biological Sciences (often referred to as CBS) is an Upper Division unit within the University. Therefore, students normally enter the college at the beginning of their junior year. Nevertheless as soon as students ascertain that they have an interest in a major in biology they are urged to contact the college offices at 104 Zoology Building or 123 Snyder Hall for advice and counseling. Course work in the biological sciences is based on a sound preparation in the mathematical and physical sciences as well as a broadly based preparation in the liberal arts. In preparation for entry into the College of Biological Sciences, students beginning their work at the University may enter any unit enrolling freshmen and, with the advice and counsel of a member of the biology faculty, take courses that will provide the most adequate preparation. Students should refer to the bulletins of the respective colleges for information regarding admission criteria.

During their freshman and sophomore years students should plan to complete their English Composition requirement. They should take at least 1 quarter of biology to make certain they wish to concentrate in the biological sciences as well as to be ready for Upper Division courses in their junior year. They should begin (and, if possible, complete) the mathematics requirement. As a minimum, they should complete their general chemistry. Many students take organic chemistry during their sophomore year while others complete the physics requirement as sophomores and take organic chemistry during the first 2 quarters of their junior year.

CBS Admission Procedures

Students normally enter the College of Biological Sciences at the beginning of their junior year. Specific requirements are:

1. Satisfactory completion of the equivalent of 75 quarter credits with at least a 2.00 grade point average.
2. The completion of 30 credits in mathematics, physical and/or biological sciences (with at least a 2.50 grade point average in biological science courses). Included in the above must be 5 credits of biology, 10 credits of chemistry, and 10 credits of mathematics or exemption from the equivalent number of courses.

Transfer from Other Colleges Within the University—A "Transfer of College Within the University" form may be obtained from the Office of Admissions and Records. Transfer application deadlines of September 1, December 1, and March 1 have been set for the fall, winter, and spring terms, respectively. The completed application form along with two copies of the student's transcript are to be turned in at 130 Coffey Hall, St. Paul.

Admission from Outside the University with Advanced Standing—Application should be made to the Office of Admissions and Records, 130 Coffey Hall, St. Paul. Ordinarily applications can be acted on before the transcript with the current quarter's grades has been submitted. Thus if an application is made by May 1, the student should be informed of the action before June 1 of the same year. The student will be admitted, subject to the satisfactory completion of his current registration.

Adult Special Status

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

Human Rights

The Board of Regents has committed itself and the University of Minnesota to the policy that there shall be no discrimination in the treatment of persons because of race, creed, color, sex, or national origin. This is a guiding policy in the admission of students in all colleges and in their academic pursuits. It is also to be a governing principle in University-owned and University-approved housing, in food services, student unions, extracurricular activities, and all other student and staff services. This policy must also be adhered to in the employment of students either by the University or by outsiders through the University and in the employment of faculty and civil service staff.

CREDIT AND GRADING PROCEDURES

Credits—The amount of course work is expressed in *credits*. Each credit demands, on the average, 3 hours a week of a student's time: that is, 1 class hour with 2 hours of preparation, or 3 hours of laboratory work.

Most students take about 15 credits of work each quarter. To take less than 12 a student must secure permission of his adviser and of the college office. If a student holds a job requiring more than 20 hours of work a week, he is advised to take no more than 12 credits and if he must work 30 hours or more, he should take less. In general it is unwise to work more than 15 to 20 hours a week while going to college.

The maximum number of credits for which a student may register is ordinarily 17. After 1 quarter of residence, registration for 18 credits is permitted provided the student has a scholarship average of 2.50 for the quarter before registration and no failure for the quarter immediately preceding registration. Registration for credits in excess of these limits must be approved by the college office.

Admission and Degree Procedures

Examination for Credit—Credit for material mastered outside of class (exclusive of high school work) may be obtained by special examination. A student who believes that he is as well informed in a particular subject as the students successfully completing the course should apply to the college office for a special examination. If the application is approved, a special faculty committee will be appointed to administer the examination. The fee for such an examination is \$20. Usually no grade is assigned. A "student" is defined as being registered in a degree program at the time he takes the examination. The college may in some cases allow a student to carry less than 12 credits in a quarter in which the student is preparing for such an examination.

Examination to Demonstrate Proficiency in Prerequisite Courses—If a student wishes to carry a course for which he does not have the prerequisite, he may apply to the college office for permission to take an examination to demonstrate his proficiency in the prerequisite. A satisfactory showing in the examination will admit the student to the course but will not entitle him to credit in the prerequisite course. There is no fee for this examination. If, by some mistake, a student takes a course without fulfilling a prerequisite, he may not later take this prerequisite course for credit except by permission of the college office.

Independent Study—Many regular courses include substantial amounts of independent study in the form of library and laboratory projects, and can be taken on an "independent study basis" with permission of the faculty teaching the course and the appropriate department head. Each department has a special number under which a student can design his own independent study project after consultation with appropriate faculty. Interested students can obtain more details from the college office.

Credits in Graduate School—If a student is lacking not more than 9 credits for graduation, he may, upon petition, obtain graduate credits for a limited amount of work taken as an undergraduate. No graduate credit will be given unless he has made previous arrangements with the Graduate School. Courses taken for graduate credit will not carry credit toward the Bachelor's degree.

With the permission of the college office, an undergraduate lacking not more than 6 credits for graduation may be registered in the Graduate School while completing requirements for the Bachelor's degree.

Credits in Professional Schools—The University of Minnesota Medical School, School of Dentistry, and College of Veterinary Medicine often admit students who have not yet completed the requirements for a baccalaureate degree. Such students who have previously registered in the College of Biological Sciences and who have completed all graduation requirements except the total number of credits and the 20 additional Upper Division credits in science and/or mathematics may receive a B.S. degree from CBS with a major in the appropriate professional field after satisfactory completion of 3 quarters of full-time study in the professional school.

Courses Without Credit—Under certain circumstances, a student may register for a course without credit with the permission of the instructor and the college office. This will entitle him to participate in class activities to an extent agreed upon in advance with the instructor. The usual arrangement, when per-

mission is granted, is for full participation with a final grade recorded on the permanent record, but the credits and grade points do not count in computing the grade point averages in the college. The procedure is particularly useful for returning students who may wish to repeat a course for review.

Audited Courses—Auditing a course differs from taking it without credit in that the student may not normally participate in the activities of the class or take the final examination, and no grade is recorded. Moreover, he may not later take for credit a course that he has audited. If a student wishes to audit, he must obtain the approval of the college office. The course will count as part of the academic load for fee purposes but not for determining credit load.

Grades—(See also P-N Grading System below) There are four permanent passing grades, A (highest), B, C, and D (lowest), showing the quality of work in a course. Though D is a passing grade, any D must be balanced by a grade of B or better in order to maintain the C average required for graduation. A grade of F (failure) indicates that the student did not successfully complete the course.

The symbol I (incomplete) is assigned when the instructor has insufficient information to assign a grade. It indicates that some required work is unfinished or that the student, though officially registered, did not appear or left without officially cancelling. A student may earn a permanent grade in place of an I with permission of the instructor (or of the department when the instructor is not available). For the convenience of both students and instructors, I's should be made up early in the next regular quarter of attendance, but instructors may extend the time if they believe delay is justified. Students do not have to be registered in order to make up I's.

An I which is not made up remains on the student's record; it does not count in the grade point average. When an I is made up, it is removed from the record.

A registration symbol W (withdrawal) indicates that a student has been permitted to cancel officially without grade. It is assigned during the first 6 weeks irrespective of the student's class standing. After that time a W is recorded only if he is doing passing work.

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

A registration symbol V (visitor) indicates registration as an auditor or visitor.

P-N Grading System—The college is currently experimenting with a new grading system, directed toward encouraging students to take a greater variety of courses. Freed to some extent from the pressure of grades (legitimate and realistic as those pressures may be in general) the new system encourages students to pursue their learning more for its own sake, studying for personally motivated inquiry rather than as a response to specific classroom demands.

P stands for "pass" and N for "no credit." Neither counts in the grade point average, but credits of P count toward graduation. The dividing line between P and N is approximately the same as that between D and F.

The decision to take a given course on the P-N system must be indicated on the registration blank. The restrictions on who may elect P-N and how many and what courses may be taken are as follows:

Admission and Degree Procedures

1. Except as qualified below, the student has the option of registering for any course on a P-N basis. A change to A-F from P-N or from P-N to A-F registration may not be made after the end of the second week of classes.
2. A candidate for the Bachelor's degree from the college must present a minimum of 75 percent of his University of Minnesota residence course credits required for graduation in courses in which he has received a grade of A, B, C, or D. Any or all portions of a sequence course may be taken on the P-N basis. No waiver of prerequisite is implied.
3. Students may not register on a P-N basis for courses used to satisfy college graduation requirements in mathematics, the physical or biological sciences, or for courses in their major unless such courses are offered for majors on a "P-N only" basis. All other courses offered to satisfy requirements may be taken on either A-F or P-N.
4. If approved by the major department, students may take mathematics and physical science courses beyond those required by the college for graduation under P-N with the consent of their major adviser.
5. Courses specified by departments as prerequisite for their major work must be taken by prospective majors on the A-F basis rather than P-N. Exceptions may be authorized by a department or the instructor in the major course which follows.
6. Regulations concerning incompletes and cancellations, noted above, apply as well to P-N registrations except that N (no grade) should be read wherever F (fail) appears.

Grade Points—The quality of work is indicated by *grade points*. Grade points are assigned to course grades as follows: to each credit with the grade of A, 4 grade points; to each credit with the grade of B, 3 grade points; to each credit with the grade of C, 2 grade points; to each credit with the grade of D, 1 grade point. An F carries no grade points. Thus for a 3-credit course completed with a grade of B a student would be assigned 9 grade points.

Grade Point Average—Grade point average is defined as the number of grade points earned divided by the total number of credits for which grades (A, B, C, D, F) have been recorded. A grade point ratio of 2.00 (C average) is the minimum standard required for satisfactory progress toward degrees in the college.

Satisfactory Progress—A student is expected to make satisfactory progress toward his degree. To do so, he must maintain at least a C average and must complete with grades of A, B, C, D, or P a minimum of 36 credits each year (defined as 3 consecutive quarters of registration). (Normally a student is expected to complete 45 credits a year.)

If a student will be unable to complete 36 credits a year because he must work for more than 20 hours a week, or because of family or personal difficulties, and he receives permission to be a part-time student at the time of registration, the requirement that he must complete at least 36 credits a year will be adjusted.

Scholastic Probation—Whenever a student's record indicates that he is in serious academic difficulty, he is placed on probation. This is to alert him to

the urgent need to improve his grades and to afford him special assistance in analyzing his problems. If a student on probation does not demonstrate the likelihood of going ahead successfully in the college by showing significant improvement, his registration in the college will be discontinued. A student who believes that heavy outside work, extracurricular participation, or other competing activities may be interfering with his academic achievement should make immediate adjustments; such factors will not be acceptable as excuses for failure to improve.

Students will be placed on probation because of frequent cancellations and incompletes as well as below-average grades. A student will automatically be on probation if any one of the following circumstances prevail: a deficiency in his grade point average continues beyond 1 quarter; he has been on probation previously and falls below a C average in either his CBS or all-University course work; he is not earning credits at a rate which indicates he will earn the minimum of 36 during the school year.

Exclusion from College—Although each case will be treated individually, a student may expect to be excluded from further registration in CBS for lack of normal progress under either of the following three conditions:

1. A student lacks sufficient grade points to maintain a C average and either (a) fails to remove his grade point deficiency, or (b) increases his grade point deficiency.
2. A student fails to complete with a passing grade 36 or more credits each year. In this instance he may expect to be required to complete credits in Summer Session or in the Extension Division before being permitted to register once again during the school year in CBS.
3. If a student is pursuing an appropriate course but is handicapped by conditions he cannot control (ill health, family emergencies, etc.) he may be required to discontinue his registration until these conditions have improved. When discontinuance takes place at any time other than the end of the quarter, action by the college office can be taken to assure that the course will be recorded as canceled without grade.

Readmission to College—Students excluded from CBS are allowed to return only with the permission of the college office. Students classified as discontinued must present evidence that the conditions which hindered their work have been remedied.

Petitions for readmission are normally considered only after an interval of 1 year. Such petitions must present specific evidence that the student is likely to succeed with college work.

Extension courses or work in another college, taken while a student is excluded from CBS, require approval of the college office before they can be used for credit toward graduation.

Students who return under the provision of the preceding paragraphs will be automatically on strict probation. They may be dropped at any time their work is unsatisfactory.

Class Attendance—Every student has a responsibility for class attendance. All departments hold students responsible for work in a course but differ somewhat in their treatment of absences. The student must, therefore, learn the policy of his particular instructor and (if he has a legitimate excuse such as

Admission and Degree Procedures

illness) arrange with him for making up the work. 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 course 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. If any student has a conflict in examinations or if he has three examinations in a 16-hour period, he should report the problem to the college office prior to the beginning of the examination period. This will permit adjustments to be made. If a student misses a final examination, he should make immediate contact with his instructor.

Official Daily Bulletin—Students are held responsible for announcements affecting them if they have been published in the Official Daily Bulletin in the University newspaper, the *Minnesota Daily*.

Repeating a Course—A student may, without special permission, repeat a course which he has failed; both the old and new grades will then stand on the record. A student need not repeat a failed course, however, unless it is prerequisite to other courses he wishes to take or is required for graduation.

A student may not, without permission from the college office, repeat a course for which he has already received credit. When permission is given, the college will determine how the second grade shall be counted in the grade point average. Usually it does not count.

Canceling out of College—If a student should need to cancel out of college during a quarter or plans not to return in the succeeding quarter, he should report to the Admissions and Records Office (130 Coffey Hall, St. Paul) to check on his financial status, to cancel courses for the current or succeeding quarter, to discuss his academic standing and possibilities of return or transfer, to determine the grades to be awarded, to ascertain the wisdom of the decision to cancel, to assess financial needs, to consider job placement, etc. Failure to cancel officially will result in I's in all courses.

REQUIREMENTS FOR GRADUATION

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

1. Completion of a total of not less than 180 credits.
2. Completion of not less than 45 credits in courses taken at the Twin Cities Campus and at least 2 quarters (30 credits) of the senior year.
3. Attainment of a grade point average of at least 2.00 computed in each of the following ways: (a) in all work presented from the University and *in toto*, and (b) in all work done while in CBS.
4. Mathematics—(a) Completion of a 3-quarter, 15-credit College Algebra and Calculus sequence (Math 1-411, 1-421, 1-431 [or] Math 1-211, 1-221, 1-231 [or] Math 1-311, 1-321, 1-331) and (b) completion of one of the following: Math 3-211, or Math 3-221, or Math 3-066 or CICS 3-101 or Math 3-511.
5. Chemistry—(a) General Chemistry (Chem 1-004, 1-005, 1-006 [14 cr] or Chem 1-031, 1-032, 1-033 [15 cr]) and (b) Organic Chemistry (Chem 3-301, 3-302 [10 cr]).

6. Physics—Completion of a 3-quarter course, with laboratory, that requires college-level mathematics as a prerequisite (Ph 1-271, 1-281, 1-291 with 1-275, 1-285, 1-295 [or] 1-104, 1-105, 1-106 [15 cr]).
7. Biological Sciences
 - (a) General Biology (either Biol 1-002 [10 cr] or Biol 1-051 [3 cr] or Biol 1-011 [5 cr] or permission of college office). Students with a good background from high school or individual study should take the Biol 1-011 exemption examination.
 - (b) Two of the following three courses: Biol 3-011, Animal Biology (5 cr); Biol 3-012, Plant Biology (5 cr); Biol 3-013, Microbiology (4 cr)
 - (c) Biol 3-021, Biochemistry (4 cr)
 - (d) Biol 3-032, Genetics and Cell Biology (5 cr)
 - (e) Biol 3-041, Ecology (4 cr)
 - (f) A 5-credit course in physiology which includes laboratory chosen from one of the following: Biol 5-052, Bot 3-131 with 3-132, Bot 5-141 with 5-142, MicB 5-321 with 5-322, Zool 5-104.
 - (g) Laboratory in two additional biological sciences courses. This may be satisfied either by taking courses which are coordinated with several of the above courses (Biol 3-025, 3-035, 3-045, 5-605) or by taking two additional courses listed in this bulletin which include laboratory work.
 - (h) 20 additional Upper Division credits in mathematics and/or physical or biological science. This includes work specified by the major department.
8. Liberal Education Requirements (see below)

Liberal Education Requirements

The University of Minnesota believes that all of its students, whatever their area of specialization or their vocational goals, should hold in common the search for a liberal education. In the broadest sense a liberal education is one which frees us from the limitations placed by ignorance on our powers of judgment and choice. More specifically, a liberal education asks of us that we seek control over the general intellectual instruments for acquiring and communicating knowledge, primarily the instruments of language and number; that we seek understanding of the ways in which scientists contribute to man's knowledge of himself and his environment; that we seek historical and philosophical perspective on the nature of our own lives and the world in which we live; and that we seek appreciation of the creative insights into life and nature provided by literature and the arts. To help students achieve the goals of liberal education, the College of Biological Sciences expects each student to distribute some part of his course work in areas of study other than those most closely linked to his specialized or vocational interests. The following are minimal:

- a. English Communication Skills: Satisfaction of the requirement as stated by the college in which a student initially registered (ordinarily this is a 2- or 3-quarter course).
- b. Foreign Language: Either (a) 2 years of study of a single foreign language in high school, or (b) completion of 3 quarters (15 credits) of a single foreign language or demonstration of equivalent proficiency as determined by the appropriate language department (French, German, or Russian are especially recommended).
- c. A minimum of 30 credits outside of categories of mathematics (Group A, Area 2) and the physical and biological sciences (Group B). Of these

Admission and Degree Procedures

30 credits, a minimum of two courses (8-10 credits) in each of the following: Man and Society (Group C) and Artistic Expression (Group D).

The following lists provide suggestions for course selections in the various liberal education groups:

Group A: Communication, Language, Symbolic Systems

Area 1: *Linguistics, Rhetoric, Logic, Philosophic Analysis*

Afro 1-101/1-102/1-103
Clas 1-048, 3-048
CIPh 3-773
Comp 1-027/1-028, 5-101/5-102/5-103
Engl 3-601, 5-633, 5-645, 5-646, 5-666, 5-667, 5-674
Foreign Languages—all skill courses not used to meet foreign language requirements
Jour 1-001, 1-011, 1-012
Lat 3-011
Ling 1-001/1-002/1-003, 3-001/3-002, 3-003, 3-005
Phil 1-001, 1-011, 3-601, 5-101, 5-105, 5-231
Rhet 1-147
Spch 1-101, 1-102, 1-106, 1-108, 1-110, 3-108, 3-601, 3-605, 3-615, 3-620, 3-621, 3-641, 5-404, 5-603, 5-611, 5-616

Area 2: *Mathematics* (see p 12)

Group B: Physical and Biological Sciences (see p 13)

Group C: Man and Society

Area 1: *Analysis of Human Behavior and Institutions*

Afro 1-036/1-037, 3-061, 3-091/3-092, 5-001/5-002, 5-900
AgEc 1-010, 1-020, 1-030
AmIn 3-061, 5-121, 5-131
Anthropology—all courses not listed under Group C, Area 2
Criminal Justice Studies—all courses
Economics—all courses except 3-021, 5-021
FamS 1-001, 1-025, 3-001, 3-015
Geography—all courses except 1-425
Jour 1-003, 1-701, 3-021, 5-611, 5-721
Phil 1-003, 1-004, 3-415, 5-054, 5-401
Political Science—all courses except 3-085 and those listed under Group C, Area 2
Psy 1-001/1-002, 1-004/1-005, 1-006, 3-970
SW 3-001
SSci 1-201, 3-101, 3-102, 3-103, 3-104, 3-105
Sociology—all courses except 3-801/3-802 and those listed under Group C, Area 2
Spch 1-103, 3-401, 5-602

Area 2: *Development of Civilization: Historical and Philosophical Studies*

Afro 3-081/3-082
American Studies—all courses
Anth 1-001, 3-511, 5-111, 5-331, 5-521, 5-522, 5-532, 5-533, 5-591
Arab 3-511/3-512/3-513, 3-531, 3-551/3-552/3-553
Clas 1-001, 1-002, 1-003, 1-004, 1-005, 1-006, 1-042, 1-142
Econ 3-021, 5-021
Geography—all courses except 1-425
Heb 3-501, 3-502
History—all courses
Humanities—all courses
Indc 1-501, 1-502, 1-503, 1-504, 1-505, 1-506
Jour 5-601, 5-603, 5-615
Ortl 3-501, 3-502
PO 3-501, 3-502
Phil 1-002, 3-001, 3-002, 3-003, 3-004, 5-003, 5-005, 5-008, 5-033, 5-034, 5-035, 5-036, 5-041, 5-042, 5-043, 5-044, 5-301, 5-302

Pol 1-041, 3-561, 3-562
SSci 3-201/3-202, 3-508
Soc 5-305, 5-701, 5-705

Group D: Artistic Expression

Area 1: *Literature*

American Studies—all courses

Clas 1-046

English—all courses except those listed in Group A, Area 1

Foreign Languages—all Upper Division foreign literature courses not used to meet the foreign language requirement

Humanities—all courses

Indc 5-302, 5-401, 5-802

Jour 5-171, 5-606

Rhet 1-401, 1-421/1-422/1-423, 1-442, 1-451, 1-301/1-302, 1-312, 1-313

Area 2: *The Arts*

Afro 1-301

AmIn 5-211

Art History—all courses

HEc 1-501, 1-521, 1-523, 1-525, 1-531, 1-533

Studio Arts—all courses

LA 1-021, 3-062/3-063

Music—all courses

Theatre—all courses

HONORS PROGRAM

To be admitted to the Honors Program students should complete an application form at one of the college offices as soon as they have been admitted to the College of Biological Sciences. Ordinarily students who have a 3.00 overall grade point average and a 3.00 grade point average in courses in or prerequisite to the major are eligible to apply for honors. The application must be approved by the student's major adviser.

Students must earn a minimum of 30 credits after application has been approved. The student's work is reviewed each quarter by the college office to ascertain that his work continues to be of honors caliber.

In order to graduate with honors, a student must have completed the following requirements:

1. Completion of at least 60 credits in Upper Division courses at the University of Minnesota.
2. Fulfillment of a minimum grade point average computed in all University of Minnesota courses and in all courses taken while in the College of Biological Sciences. The degree of honors will be determined in the following way: A 3.00 grade point average for *cum laude*; a 3.25 grade point average for *magna cum laude*; and a 3.40 grade point average (plus approval of the supervised research paper by an appointed faculty panel as of *summa* quality) for *summa cum laude*.
3. Completion of two College Honors Seminars, either in the College of Biological Sciences or the College of Liberal Arts.
4. Participation in a supervised research program for at least 1 quarter and the organization of a paper summarizing the student's research which is acceptable to the faculty member supervising this research.

STUDENT PERSONNEL SERVICES

Faculty Advisers—Each student in the College of Biological Sciences will be assigned a faculty adviser. The student is encouraged to consult frequently with his adviser regarding curricular planning and progress in specific courses as well as any other matters which relate to his University experience.

Before seeing the adviser regarding curricular planning, the student should study the relevant bulletins carefully and be prepared to present a tentative program as well as a current copy of the transcript of credit already earned at the University or elsewhere. If a student should wish to change his adviser, this can be arranged through the college office, 104 Zoology Building

College Offices—A student should always feel welcome to discuss any questions or problems he may have with a member of the staff in either college office, 104 Zoology Building (Minneapolis Campus) or 123 Snyder Hall (St. Paul Campus).

All-University Personnel Services—Several specialized personnel services are provided by the University for all students. (See *General Information Bulletin* for details.)

CLA Placement Office: 17 Johnston Hall.

Financial Help: Office of Student Financial Aid, 107 Armory Building.

Foreign Students: Foreign Student Adviser, 717 East River Road.

Health Problems: University Health Service Building or the St. Paul Campus Health Service.

Housing: On-Campus Residence, 180 Wesbrook Hall; Off-Campus Residence, 209 Eddy Hall.

Legal Problems: Legal Aid Clinic, 214 TNM.

Part-Time Job (on or off campus): Student Employment Service, 30 Wulling Hall.

Personal Problems: Student Counseling Bureau, 101 Eddy Hall.

Speech and Hearing Difficulties: Speech and Hearing Clinic, 110 Shevlin Hall.

Student Activities: Student Activities Bureau, 110 TNM; Coffman Union Program Office, 229 Coffman Memorial Union; or the St. Paul Student Center.

Study Skills Improvement: Reading and Study Skills Clinic, 101 Eddy Hall.

Veterans' Benefits: 105 Morrill Hall.

Scholarships—Undergraduate scholarships are available to seniors majoring in biochemistry. For all-University scholarships, information can be obtained at 107 Armory Building on the Minneapolis Campus.

SECTION III

CURRICULAR REQUIREMENTS AND COURSE DESCRIPTIONS

Course Numbering System—The *first* digit indicates the level of the courses as follows:

- 1-001 to 1-998—open to freshmen and sophomores
- 3-001 to 3-998—open to juniors and seniors
- 5-001 to 5-998—open to juniors, seniors, and graduate students
- 8-001 to 8-998—open to graduate students only

A *final* digit "0" identifies courses which may be repeated. The number "-970" indicates "directed study." The numbers "-800 to -900" following the first digit indicate courses offered in Lake Itasca Biology sessions.

Abbreviated Departmental Prefix—The abbreviated prefix of three or four letters before the course number indicates the department's name (e.g., Biol for Biology).

Symbols—The following symbols are used throughout the course descriptions of all bulletins to denote common and recurring items of information; no page footnotes are used for these symbols.

- † To receive credit, all courses listed before single dagger must be completed
- ‡ Students may enter any quarter preceding double dagger
- § No credit is given if credit has been received for equivalent course listed after section mark
- ¶ Concurrent registration is allowed with the course listed after paragraph mark
- # Consent of instructor is required for registration
- △ Consent of department is required for registration

It is to be understood that when prerequisites are listed, an equivalent course may be substituted. Prerequisites should be considered as guides to the background a student is expected to have. In case of question, consult the instructor in the particular course.

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

BIOLOGY (Biol)

Major Advisers for College of Education—Professors Barnwell, Hall, Jenness, Snustad, Soulen

Major Advisers for College of Biological Sciences—selected from among CBS faculty

The bachelor of science degree in biology is designed to provide the student with the opportunity to obtain a broadly based but thorough undergraduate education in the biological sciences. For graduation, in addition to the core course requirements for graduation, the biology major must complete 20 additional Upper Division credits in the mathematical, biological, and physical sciences. The distribution of these credits is determined by the student in con-

Curricular Requirements — Course Descriptions

sultation with his adviser. A prospective biology major should begin his physical science requirements in general chemistry and mathematics very early in his college career.

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 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 with the College of Education where a specialized curriculum is available or with one of the advisers noted above.

COURSES — BIOLOGY

- 1-011f,w,s,su. GENERAL BIOLOGY.** (5 cr)
An introduction to biology; its importance and relationship to the life of man.
- 3-011f,w. ANIMAL BIOLOGY.** (5 cr, §Zool 1-013; prereq 1-002 or 1-011 or Δ , Chem 1-005) Herman, Gilbertson
Survey of types of animals; emphasis on the varied ways in which different animals have solved similar problems.
- 3-012w,s. PLANT BIOLOGY.** (5 cr, §Bot 1-001; prereq 1-002 or 1-011 or Δ , Chem 1-005) Pratt, McLaughlin, Shininger
Comparative study of growth, development, and function in plants; emphasizes adaptations which have evolved in various groups of plants providing suitable means of support; transport of materials, nutrition, and reproduction; evolution and diversity of plant life.
- 3-013f,w,su. MICROBIOLOGY.** (4 cr, §MicB 5-105, §MicB 3-103; prereq 1-002 or 1-011 or Δ , Chem 3-302 or #) Dworkin, Chapman, Klein
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Some emphasis is placed on molecular structure in relation to bacterial function.
- 3-021f,s. BIOCHEMISTRY.** (4 cr; prereq 1-002 or 1-011 or Δ , Chem 3-302) Kirkwood, Dagley
Introduction to the biochemistry and biophysics of cells with emphasis on enzyme catalysis, cellular energetics, biosynthesis of cellular constituents, and cellular regulatory mechanisms.
- 3-025f,s. LABORATORY IN BIOCHEMISTRY.** (1 cr; prereq 3-021 or §3-021) Chapman, Warner
Laboratory course to accompany Biol 3-021.
- 3-032f,w,s. GENETICS AND CELL BIOLOGY.** (5 cr, §GCB 3-022; prereq 3-021)
Introduction to the principles of heredity and cell biology, with consideration of both procaryotic and eucaryotic organisms.
- 3-041f,s. ECOLOGY.** (4 cr; prereq 1 qtr calculus, 3-032, or #) Corbin, McColl, Tester
Interactions of plant and animal populations and their environments. The organization, functioning, and development of ecological systems; population growth and regulation. Modern man's impact on the biosphere.
- 3-045f,s. LABORATORY IN ECOLOGY.** (1 cr; prereq 3-041) Wright, Tester
Laboratory course to accompany Biol 3-041.
- 3-051f. BIOLOGY AND THE FUTURE OF MAN.** (4 cr; offered P-N only) Pratt, Gorham
A 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.
- 3-950f,w,s. UNDERGRADUATE SEMINAR.** (1-2 cr; prereq 2.50 GPA and #) Staff
Seminars will describe the principles of many different experimental techniques. The purpose of the seminars is to acquaint students with the uses, limitations, and sensitivity of physical, chemical, and biological techniques used by the biologist.

- 5-052w,s. **GENERAL PHYSIOLOGY.** (5 cr; prereq 3-011, 3-021, Phys 1-106, or Phys 1-291/1-295) Sheridan, Goldstein
Lectures, discussions, and laboratory. A quantitative approach to the study of cell function with emphasis on the application of physical and chemical principles. Major topics covered include transport, electrical activity of cell membranes, and cell contractility.
- 5-061w,s. **DEVELOPMENTAL BIOLOGY.** (3 cr; prereq 3-032) Spratt, McLaughlin
The study of developing systems and of the control mechanisms of development, from the molecule to the organism.
- 5-065w,s. **LABORATORY IN DEVELOPMENTAL BIOLOGY.** (2 cr; prereq 5-061 or ¶5-061) Spratt, McLaughlin
Laboratory course to accompany Biol 5-061.
- 5-501s. **BIOCHEMICAL EVOLUTION.** (4 cr; prereq 5 cr biochemistry) Kirkwood, Jenness
Lectures and assigned reading on molecular evolution covering prebiotic evolution and the phylogeny of important functional molecules and biochemical systems in living organisms.
- 5-601f,s. **GENERAL CYTOLOGY.** (3 cr, §3-032, §GCB 3-012, §GCB 5-051; prereq 10 cr in biology, botany or zoology, elementary genetics or #) Johnson, Cunningham
Introductory analysis of structure growth and function of cells and organelles.
- 5-605f,s. **GENERAL CYTOLOGY LABORATORY.** (3 cr; prereq 5-601 or ¶5-601 or 3-032 or ¶3-032 or #)
Experimental approaches to cell structure and function including specialized forms of light microscopy, autoradiography, cell fractionation, and an introduction to electron microscopy.
- 5-951w. **THE BIOLOGIST AS SCIENTIST, EDUCATOR, AND CITIZEN.** (3 cr; prereq 15 cr biological sciences) Hooper and staff
The role of the scientists in decision making and persuasion; teaching methods in biology; the organizational structure of the academic and governmental world.

For Graduate Students Only

- 8-710. Tutorial in Developmental Biology
8-950. Graduate Seminar
8-970. Special Topics
8-990. Graduate Research
8-910. Teaching College Biology

BIOCHEMISTRY (BioC)

Director of Undergraduate Studies—Professor Henderson

A major in biochemistry is designed for students who contemplate graduate study in biochemistry or the biochemical aspects of biological, medical, or agricultural sciences. It also will provide the courses which prepare the chemist for a biochemical position in industry at the bachelor of science level. The curriculum differs largely 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. The program is a carefully planned sequence of required courses with a small number of free electives.

In addition to the general requirements for graduation from the College of Biological Sciences, the bachelor of science degree in biochemistry requires:

Biochemistry—BioC 5-001, 5-002 (or) 5-741, 5-742 (5-745, 5-746 suggested)**

** Students who expect to undertake a graduate program in biochemistry should enroll in BioC 5-741, 5-742, 5-745, and 5-746 instead of BioC 5-001 and 5-002. Students with a grade of A or B in Biol 3-021 and 3-025 are exempted from BioC 5-001.

Curricular Requirements — Course Descriptions

Physical Chemistry—Chem 5-501, 5-502, 5-503, 5-510, 5-511††
Analytical Chemistry—Chem 3-100, 3-101
Additional Organic Chemistry—Chem 3-303, Chem 3-304
Mathematics—Math 3-445
German is the foreign language of choice

COURSES — BIOCHEMISTRY

- 1-301f,s. ELEMENTARY BIOCHEMISTRY I.** (5 cr, §Chem 3-301; prereq Chem 1-005)
A survey of organic chemistry and biochemistry comprising lectures on the chemistry of carbon compounds which occur in nature. Special emphasis will be placed on the composition, structures, and properties of the major components of plant, animal, and bacterial cells.
- 1-302w. ELEMENTARY BIOCHEMISTRY II.** (4 cr; prereq 1-301)
Introduction to the reaction of organic compounds in the living cell. Survey of metabolic pathways, energy considerations, and biosynthetic processes with emphasis on those aspects essential to an understanding of plant and animal nutrition and physiology. One period per week will be devoted to laboratory experiments designed to acquaint students with biochemical reactions.
- 3-094. UNDERGRADUATE SEMINAR.** (1 cr; prereq sr biochem maj)
Discussion and reports.
- 3-990. UNDERGRADUATE RESEARCH.** (1-3 cr; prereq sr biochem maj)
Research problems for B.S. thesis (optional).
- 5-001w/5-002s. INTRODUCTION TO BIOCHEMISTRY.** (4 cr each; prereq Chem 3-302 or §)
Introduction to the fundamentals of the composition, chemical properties, reactions, and interactions of biological materials; these are illustrated in part through laboratory exercises performed by the student.
- 5-522f. BIOPHYSICAL CHEMISTRY: STRUCTURE.** (4 cr; prereq 2 qtrs physical chemistry...BioC 5-741 or 5-002 desirable) Bloomfield, Bryant
Methods of structure determination of biological macromolecules. Molecular weight determination, hydrodynamics, scattering and diffraction, optical and magnetic resonance spectroscopy. Application to proteins, nucleic acids, polysaccharides, synthetic analogs, and membrane transport.
- 5-523w. BIOPHYSICAL CHEMISTRY: ENERGETICS.** (3 cr; prereq 2 qtrs physical chemistry...5-741 or 5-002 desirable) Lovrien, Miller
Energetics of biochemical reactions. Titration, binding, and folding stabilization in macromolecules. Conformational changes and cooperative behavior. Coupling and energy gradients in transport.
- 5-524s. BIOPHYSICAL CHEMISTRY: DYNAMICS.** (4 cr; prereq 2 qtrs physical chemistry ...5-741 or 5-002 desirable) Lumry, Barnett
Application of thermodynamics, statistical mechanics, and chemical kinetics, solvent effect structure-function relation.
- 5-741f/5-742w/5-743s. GENERAL BIOCHEMISTRY.** (3 cr each, §MdBc 5-741/5-742/5-743; prereq Chem 3-303, Chem 5-501 or Chem 5-520 or ¶Chem 5-501 or ¶Chem 5-520, or §)
Offered jointly by Department of Biochemistry (College of Biological Sciences) and Department of Biochemistry (Medical School). Series of lectures on chemical nature, properties, biochemical reactions, and intermediate metabolism of components of biological systems.
- 5-745f/5-746w. GENERAL BIOCHEMISTRY LABORATORY.** (3 cr each; prereq ¶5-741/5-742, cr in analytical chemistry and §)
Laboratory course to accompany BioC 5-741/5-742.

†† Students who do not expect to undertake a graduate program in biochemistry may substitute Chem 5-520 and 5-221 plus 12 additional credits in physical and/or biological sciences for the Chem 5-501, 5-502, 5-503, 5-510, 5-511 and the Math 3-445 listing.

- 5-747s. **ADVANCED BIOCHEMICAL TECHNIQUES.** (3 cr; prereq 5-746, §5-743 and §) Laboratory in modern methods for study of enzymatic and metabolic reactions.
- 5-970. **DIRECTED STUDIES.** (1-3 cr; prereq §, Δ) Offered to enable students to make up certain deficiencies in background course work.

For Graduate Students Only

- 8-091f. Graduate Student Orientation
 8-094. Research and Literature Reports
 8-194. Graduate Seminar
 8-211. Advanced Carbohydrate Chemistry
 8-221s. Advanced Enzyme Chemistry
 8-225f. Tracer Techniques
 8-231s. Advanced Lipid Chemistry
 8-241s. Metabolism of Nucleic Acids
 8-250. Special Topics in Biochemistry
 8-261w. Advanced Protein Chemistry
 8-271f. Vitamins
 8-990. Graduate Research

BOTANY (Bot)

Director of Undergraduate Studies—Professor Frenkel

The program for the B.S. degree in botany provides the opportunity for a student to obtain a comprehensive and well-balanced undergraduate education in biology while achieving some degree of concentration in the plant sciences. In completing the core curriculum, students should elect Bot 3-131, 3-132 (or) 5-141, 5-142 to fulfill the physiology requirement. In fulfillment of part of the 20 science and math credits required for graduation, botany students are required to take the following:

- Bot 5-105—Morphology of Vascular Plants
 (or) Bot 5-103—Biology of Nonvascular Plants
 Biol 5-061 and 5-065—Developmental Biology and Laboratory
 Bot 3-201—Elementary Taxonomy
 (or) Bot 5-801—Summer Flora of Minnesota

COURSES — BOTANY

- 1-001w.s. **GENERAL BOTANY.** (5 cr; prereq Biol 1-011)
 Levels of organization of plants, plant function, plant growth and development, plant reproduction.
- 1-009s. **MINNESOTA PLANT LIFE.** (4 cr; suitable for nonmajors) Morley
 Nontechnical survey of all the groups of plants native to Minnesota; special reference to identification and distribution.
- 1-012f,w. **PLANTS USEFUL TO MAN.** (4 cr; for majors or nonmajors) Lawrence, Jonas
 Survey of the roles which plants have played in man's biological and cultural development. Lectures and demonstration of material.
- 3-003s. **FIELD BOTANY.** (4 cr; prereq 1-009 or 1-012, or Biol 1-011 or §) Lawrence
 Plants in nature, their recognition, geographical distribution, reproductive habits, growth and seasonal development, and uses by aboriginal man. Use of the out-of-doors for teaching natural history. Weekly field trips.
- 3-071f. **PLANTS AND HUMAN AFFAIRS.** (4 cr; prereq 1-009 or 1-012 desirable) Jonas, Lawrence
 A consideration of the reciprocal and deterministic interaction between plants and man as illustrated by events and developments in agriculture, industry, trade, domestic and foreign affairs, medicine, religious customs, and the arts.

Curricular Requirements — Course Descriptions

- 3-109w. **PLANT ANATOMY.** (5 cr; prereq 1-001 or Biol 1-002 or Biol 3-012) Hall
Structure and development of plants with special reference to vascular plants.
- 3-131f,s. **SURVEY OF PLANT PHYSIOLOGY.** (3 cr; prereq 1-001 or Biol 1-002 or Biol 3-012, Chem 3-301 or BioC 1-301) Staff
Physiological principles underlying the processes which occur in living plants, with emphasis on higher plants. Growth and development, mineral nutrition, water relations and solute metabolism, respiration, and photosynthesis.
- 3-132f,s. **PLANT PHYSIOLOGY LABORATORY.** (2 cr; prereq 3-131 or ¶3-131)
Laboratory course to accompany Bot 3-131.
- 3-201s. **ELEMENTARY TAXONOMY.** (3 cr; prereq 1-001 or Biol 1-002 or Biol 3-012) Morley
Introduction to taxonomy of ferns, gymnosperms, and flowering plants, with 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.
- 3-950f,w,s. **UNDERGRADUATE PROSEMINAR.** (1 cr per qtr; prereq major in biological sciences, #)
A discussion of biological topics of current interest.
- 3-990f,w,s. **RESEARCH PROBLEMS.** (1-5 cr per qtr; prereq major in biological sciences, #)
Individual research for undergraduate majors.
- 5-103f. **BIOLOGY OF NONVASCULAR PLANTS.** (5 cr; prereq 1-001 or Biol 3-012) McLaughlin, Wetmore
An introduction to the algae, fungi, lichens, and bryophytes. Characteristics of the groups, evolutionary relationships, life cycles, comparative morphology (including ultrastructure) and comparative nutrition. Living materials will be emphasized in the laboratory.
- 5-105f. **MORPHOLOGY OF VASCULAR PLANTS.** (5 cr; prereq 5-101 or #) Abbe
Vegetative and reproductive structure of living and fossil vascular plants. Their evolutionary relationships based on phylogenetic principles.
- 5-111w. **DEVELOPMENTAL PLANT ANATOMY.** (5 cr; prereq 1-001 or Biol 1-002 or Biol 3-012) Abbe
Microscopic structure of vascular plants with particular attention to development in the root, stem, and leaf.
- 5-141s. **SURVEY OF PLANT PHYSIOLOGY.** (3 cr; prereq 1-001 or Biol 1-002 or Biol 3-012, 1 yr physics, course in organic chemistry) Frenkel
A critical study of the physiological processes which occur in living plants, with emphasis on higher plants. Growth and development, energy relations, mineral nutrition, water relations, respiration, photosynthesis, and nitrogen metabolism.
- 5-142s. **PLANT PHYSIOLOGY LABORATORY.** (2 cr; prereq 5-141 or ¶5-141)
Laboratory course to accompany Bot 5-141.
- 5-182s. **PLANT PHYSIOLOGY.** (3 cr; prereq 5 cr in biochemistry)
The plant cell and its organelles, metabolism, including photosynthesis, and genetic control of physiological processes, with emphasis throughout on the dynamic aspects of these processes.
- 5-183w. **PLANT PHYSIOLOGY.** (3 cr; prereq 1-001 or Biol 1-002 or Biol 3-012, Chem 3-302, physics)
A discussion of membrane phenomena, water relations, mineral metabolism, and translocation in plants.
- 5-184f. **PLANT PHYSIOLOGY.** (3 cr; prereq 1-001 or Biol 1-002 or Biol 3-012, Chem 3-302, physics)
The growth of higher plants, including regulation by hormones, light, and temperature.
- 5-205s. **FLORA OF MINNESOTA.** (4 cr; prereq 3-201 or #) Ownbey
The vascular plants of Minnesota; taxonomic and floristic relationships; geographical distribution and variation; collecting and identification; field trips.

- 5-231f. **INTRODUCTION TO THE STUDY OF ALGAE.** (5 cr; prereq 10 cr in botany or biology or #; offered 1972-73 and alt yrs) Brook
Structure, reproduction, and life histories of major algal divisions.
- 5-801su. **SUMMER FLORA OF MINNESOTA.** (5 cr; prereq 3-201 or #; offered at Itasca)
Survey of the flowering plants and ferns of the state with particular reference to the local flora. Collection and identification; distribution in Minnesota; literature and taxonomic methods.
- 5-805su. **AQUATIC FLOWERING PLANTS.** (5 cr; prereq 3-201 or #; offered at Itasca)
Higher plants of aquatic and marsh habitats. Identification and collection; association of species; relations to the habitat; adaptive morphology and food value to wild-life. Association of species; relation to the habitat.
- 5-811su. **FRESHWATER ALGAE.** (5 cr; prereq 10 cr in biology or #; offered at Itasca)
Morphology and taxonomy of freshwater algae; collection and identification of local algae.
- 5-815su. **BRYOPHYTES.** (5 cr; prereq 10 cr in biology or #; offered 1971 at Itasca)
Field and laboratory study of the mosses and liverworts of Minnesota.
- 5-821su. **LICHENS.** (5 cr; prereq 10 cr in botany or zoology or #; offered 1972 at Itasca)
Taxonomy, ecology, and floristics of the lichens of northern Minnesota; identification, sampling methods, microchemistry as a taxonomic tool.
- 5-970f,w,s. **BASIC BOTANY.** (Cr ar; prereq 1-001 or Biol 1-002 or Biol 3-012 and #) Staff
Individual work in some special discipline.

For Graduate Students Only

- 8-950. Seminar
8-970. Special Topics
8-990. Graduate Research Problems

Students should consult the bulletins of other colleges for additional courses of interest to botany majors in such areas as:

- Entomology, Plant Pathology, Soil Science (College of Agriculture)
Microbiology (Medical School)
Geology (Institute of Technology)

ECOLOGY AND BEHAVIORAL BIOLOGY (EBB)

Director of Undergraduate Studies—Professor Brook

The Department of Ecology and Behavioral Biology participates in teaching the core curriculum. Students with a special interest in ecology and/or behavioral biology will take their undergraduate degrees in biology and include in their programs a suitable selection of advanced courses appropriate to their interests.

COURSES — ECOLOGY AND BEHAVIORAL BIOLOGY

- 1-003f. **THE FINAL CRISIS.** (3 cr, §1-004) Brook

(This is a television course through the Extension Division of the University of Minnesota)

The ecological crisis, its crucial implications for man's future existence, and the current critical necessity for the development of an ecological awareness.

- 1-004w,s. **ECOLOGY AND MAN.** (4 cr, §1-003; prereq Biol 1-011) Brook

A presentation of the basic concepts of ecology with special reference to man's increasing impact and exploitation of the environment and stressing the biosphere's limits with respect of energy, resources, and space.

Curricular Requirements — Course Descriptions

- 1-005w. INTRODUCTION TO EVOLUTIONARY BIOLOGY.** (4 cr, §Zool 3-096; not open to CBS majors; prereq Biol 1-011 or GCB 1-101) Birney, Regal
History and basis of evolutionary thought, with consideration of the history and future of man.
- 3-001w. INTRODUCTION TO ECOLOGY.** (4 cr, §1-003, 1-004; open to jrs and above, but not to biology majors)
A survey of the basic concepts in ecology dealing with the organization, development, and functioning of ecosystems; population growth and regulation. Man's impact on such systems will be considered throughout.
- 3-004w. FUNDAMENTALS OF ECOLOGY.** (4 cr; not open to biology majors; prereq Biol 1-002 or Biol 1-011) 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.
- 3-101f,w,s. ECOLOGY FOR ENGINEERS AND PHYSICAL SCIENTISTS.** (4 cr, §1-003, 1-004, 3-001; not open to biology majors; prereq Math 1-230) Staff
A course for engineers and physical science students to present a scientifically sound understanding of the basis for the existence and continued existence of life on the earth.
- 3-990f,w,s. RESEARCH PROBLEMS.** (1-6 cr; prereq #) Staff
Individual research for undergraduate majors in biology.
- 5-014f. ECOLOGY OF PLANT COMMUNITIES.** (5 cr; prereq 3-004 or Biol 3-041) Cushing
Description, classification, and mapping of plant communities, and theory of their structure, interrelationships, development, and stability. Field trips to local vegetation types; analysis of quantitative data.
- 5-015w. STRUCTURE AND FUNCTION OF ECOSYSTEMS.** (5 cr; prereq Biol 3-045 or #) McColl
Energy exchange and cycles of water and nutrients in relation to biological productivity and development and regulation of ecosystems.
- 5-016s. ECOLOGICAL PLANT GEOGRAPHY.** (3 or 5 cr; prereq 3-004 or Biol 3-041 or #; offered 1971-72 and alt yrs) Lawrence, Cushing
Ecological principles of plant distribution and landscape analysis, vegetation regions of North America, interpretation of regional vegetation patterns.
- 5-017s. ECOLOGICAL LIFE HISTORIES OF PLANTS.** (5 cr; prereq Biol 3-045, Bot 3-132 and #; offered 1972-73 and alt yrs) Staff
Influence of environmental factors on each developmental stage of life cycle under natural conditions. Individual species assigned for study at Cedar Creek Natural History Area. Weekly half-day field trips.
- 5-018su. WETLAND ECOLOGY.** (5 cr; prereq 15 cr in biological sciences, introductory chemistry, or #...Biol 3-041 recommended; offered at Itasca) Staff
Nature, origin, and development of lake, marsh, swamp, and bog ecosystems; environmental control and productivity.
- 5-019su. QUATERNARY PALEOECOLOGY.** (5 cr; prereq 3-001 or Biol 3-041 or #; offered 1972 and alt yrs at Itasca)
Methods and techniques in the reconstruction of past communities and ecosystems from fossil evidence in deposits of Quaternary age. Field and laboratory methods in the collection and description of stratigraphic sequences and the identification and quantitative analysis of fossil assemblages.
- 5-022w. ANIMAL BEHAVIOR.** (4 cr; prereq #) McKinney
Introduction to ethology; the causation, development, evolution, and adaptive significance of behavior.
- 5-023w. BEHAVIORAL ADAPTATIONS.** (5 cr; prereq Biol 3-041 and Ecol 5-022 and #) McKinney
Lectures and discussions on current problems in areas of overlap between ethology, ecology, and evolution with special emphasis on social systems, spacing mechanisms, and communication.

Ecology and Behavioral Biology

- 5-024f. ENVIRONMENTAL MEASUREMENT AND ANALYSIS I.** (4 cr; prereq 1 yr physics, 1 yr calculus) Maxwell
The use of the continuity principle in relating meteorological parameters to biologic systems and the modeling of environmental interactions with organisms.
- 5-025w. ENVIRONMENTAL MEASUREMENT AND ANALYSIS II.** (4 cr; prereq 5-024) Maxwell
The elements of a measuring system and the determination of meteorological parameters to study the physical relationships between an organism and its environment.
- 5-026su. ENVIRONMENTAL MEASUREMENT AND ANALYSIS III.** (2-5 cr; prereq 5-025 or #; also offered at Itasca) Maxwell
Field application of the principles of biometeorology and basic measuring systems presented in Ecol 5-024 and 5-025.
- 5-027w. HUMAN POPULATION, ENVIRONMENT, AND RESOURCES.** (4 cr) Serrin
Discussion of local, national, and world demographic problems. Impact of population on environment, resources and resource allocation; ecological implications. Birth and death control programs. Demographic models; optimal rate predictions.
- 5-028s. ADVANCED ECOSYSTEM ANALYSIS.** (5 cr; prereq 5-015) McColl
Individual projects including literature review, field data collection and/or laboratory analysis and synthesis of results. Projects will relate to cycling of water or chemical elements, or to energy flow in ecosystems at the Cedar Creek Natural History Area. Weekly half-day field trips.
- 5-029w. POPULATION ECOLOGY.** (4 cr; prereq 3-004 or Biol 3-041, one course in statistics) Tester, Siniff
Factors involved in the regulation, growth, and general dynamics of populations will be considered. The major areas to be considered include (a) data which are needed to describe populations, (b) population growth, (c) consideration of population models, and (d) intensive discussion of regulatory mechanisms.
- 5-812su. AQUATIC ECOLOGY.** (5 cr; prereq 15 cr incl Biol 1-002 or Biol 3-011 or Zool 1-013; offered at Itasca) Staff
Conditions for life in the water and distribution of aquatic animals.
- 5-813su. ADVANCED LIMNOLOGY.** (5 cr; prereq 5-812; offered at Itasca) Megard
Current topics in limnological research with emphasis on the analysis of aquatic productivity. Lectures, laboratory, and field work.
- 5-814su. COMMUNITY STRUCTURE AND FUNCTION.** (5 cr; prereq 3-004 or Biol 3-041 or #; offered at Itasca) 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.
- 5-815su. FIELD ETHOLOGY.** (5 cr; prereq Biol 3-011...Zool 5-077 or Zool 5-834 recommended; offered at Itasca) Staff
Studies of behavioral evolution, motivation, and ontogeny stressing the relationship between environment and behavior by using field research techniques.
- 5-816su. ECOLOGY OF FRESHWATER ALGAE.** (5 cr; prereq Bot 5-231 or Bot 5-811 or #; offered at Itasca) Brook
Aspects of algal ecology in lakes and ponds; phytoplankton, benthos, and periphyton; also in streams, bogs, soils, and other terrestrial habitats. Laboratory instruction in relevant research techniques.
- 5-817su. VERTEBRATE ECOLOGY.** (5 cr, §Ent 162; prereq 3-004 or Biol 3-041; offered at Itasca) Siniff, Tester
Field work on populations and their relationships to local environments; habitat analysis and ecological research methods. Individual and team research projects, field trips, and lectures.
- 5-818su. QUANTITATIVE ECOLOGY.** (5 cr; prereq 9 cr in ecology; offered at Itasca) Bray, Siniff
Lectures, discussions, and field studies on populations, communities, and ecosystems. Emphasis on methods of sampling and measuring ecological parameters and on data analysis and interpretation.

Curricular Requirements — Course Descriptions

5-819su. **SOILS AND THE ECOSYSTEM.** (5 cr, §Soil 5-532; prereq 3-004 or Biol 3-041 or #; offered at Itasca) Farnum

Formation and distribution of soils in relationship to vegetation, climate, and other soil-forming factors. Interrelationships of soils in the ecosystem.

For Graduate Students Only

8-002s. **Quantitative Aspects of Ecological Systems**

8-390f,w,s. **Graduate Seminar**

8-391f,w,s. **Advanced Work in Ecology and Behavioral Biology**

GENETICS AND CELL BIOLOGY (GCB)

Director of Undergraduate Studies—Professor Forro

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

COURSES — GENETICS AND CELL BIOLOGY

1-101w,s. **HEREDITY AND HUMAN SOCIETY.** (4 cr, §3-002, §3-022, or §Biol 3-032; for students in programs not directly related to biological sciences)

The principles of heredity and their social and cultural implications. Emphasis is on man, his diversity, and the influence of social institutions on his evolution. Topics discussed include the genetic basis of sex, race and intelligence, and the problems raised by genetic engineering.

3-002s. **HUMAN GENETICS, SOCIAL AFFAIRS.** (3 cr, §1-101 or §3-022 or §Biol 3-032; for students in programs not directly related to biological sciences) Anderson, Reed

An introduction to human genetics with special emphasis on the study of individuals, families, populations, and races with respect to differences in intelligence, behavior, disease, and other matters of social concern.

3-022f,w,s. **GENETICS.** (4 cr; primarily designed for students other than CBS majors and CLA biology majors; prereq Biol 1-002 or 1-011)

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

3-970f,w,s. **INDEPENDENT STUDY.** (Cr ar; prereq #, Δ)

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

3-990f, w, s. **LABORATORY RESEARCH.** (Cr ar; prereq #, Δ)

Individual projects on selected topics and problems.

5-022f,w,s. **GENETICS.** (3 cr, §3-022, §Biol 3-032; not open to grad students in genetics)

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

5-023su. **GENETICS AND THE BIOLOGY OF POPULATIONS.** (3 cr; primarily designed for secondary school teachers; prereq §3-022 or #) Hartl

Emphasis is on elementary development of basic concepts in population genetics and population biology. Topics include population expansion and deterioration of the environment, analysis of gene frequency changes under natural and relaxed selection, genetic loads and reproductive excess, population genetics of quantitative characters, inbreeding, and the genetics of population isolates. Examples are to be drawn largely from human populations.

- 5-030f, w.s. **LABORATORY: GENETICS.** (2 cr; prereq 3-022, 5-022, Biol 3-032 or #)
Emphasis on investigative approaches to analysis of genetic problems. Attention will be focused on a given organism or related group of organisms which may differ from quarter to quarter.
- 5-031f. **INTERMEDIATE GENETICS I.** (3 cr; prereq 3-022 or Biol 3-032 and BioC 5-002 or BioC 5-742, or #)
The mechanics of inheritance. Comparative organization of genetic material in procaryotic and eucaryotic organisms. The use of mutation, complementation, and recombination as operational criteria for genetic analysis.
- 5-032w. **INTERMEDIATE GENETICS II.** (3 cr; prereq 5-031)
The action of the gene in molecular, cellular, and organismal development. The mechanisms of storage of genetic information, modes of information transfer, and mechanisms of regulating these processes in various biological systems.
- 5-033s. **INTERMEDIATE GENETICS III.** (3 cr; prereq 3-022 or Biol 3-032...a course in genetics, a course in biometry or statistics, or #)
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.
- 5-042f. **POPULATION, QUANTITATIVE GENETICS.** (3 cr; prereq 5-033...Biom 5-040 recommended)
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 is on logical analysis.
- 5-043s. **HUMAN GENETICS.** (3 cr; prereq 3-022 or Biol 3-032 or #)
Inherited characters in man, particularly in relation to medicine, with some reference to the relation of genetics in marriage and to social conditions.
- 5-044w. **METHODS IN HUMAN GENETICS.** (3 cr; prereq 5-043 and PubH 5-450 or equiv and #)
Methods for research in human genetics. Importance of appropriate statistical techniques. Use of genetic concepts in exploring new problems. Individual study of current problems and group discussion.
- 5-051w. **INTERMEDIATE CELL BIOLOGY.** (3 cr, §Biol 5-601; prereq #...introductory biochemistry and molecular genetics recommended)
Introductory analysis of structure, replication and function of general and specialized cell types at the microscopic and molecular level. Topics will include cell membranes, organelles, and macromolecular aggregates; cell division, secretion, regulation of macromolecule synthesis, and cellular differentiation.
- 5-052s. **QUANTITATIVE TECHNIQUES, CELL BIOLOGY.** (3 cr; prereq #...introductory cellular or molecular biology and biochemistry recommended)
A discussion of methods used to study the structure, growth, and function of cells. Techniques include tissue culture, cell synchronization, isolation of subcellular organelles, assessment of purity of fractions, compartmental analysis in eucaryotic systems, single cell electrophoresis, examples of some basic biological problems, and the design of pertinent experimental methods.
- 5-062w. **CELLULAR REGULATION.** (3 cr; prereq #)
Control of the biosynthesis and function of macromolecules. Topics to be discussed will include the induction and repression of enzyme synthesis, constitutivity, the specific activation and inhibition of enzyme activity by metabolic effectors, regulation of RNA and DNA synthesis, regulation of chromosome replication, steady states of growth and transitions between steady states of growth, control of cell division, and the cycle of cell duplication. Research with both procaryote and eucaryote systems will be discussed.
- 5-063s. **THEORETICAL POPULATION BIOLOGY.** (3 cr; prereq 5-033 or #, a familiarity with differential and integral calculus)
Special emphasis on population genetic theory as related to problems of natural populations. Includes the properties of finite populations, evolutionary cost and load, subdivided and fluctuating environments, fitness sets and optimization theory, population structure, competition and species packing, and genetic methods of population control.

Curricular Requirements — Course Descriptions

5-082s. MEMBRANES AND INTERFACES. (3 cr; prereq #)

The thermodynamics and statistical mechanics of interfaces; the electrical properties of interfaces; experimental methods for the study of gas/liquid and liquid/liquid interfaces; interfaces in biological systems; cell membranes; the plasma membrane; the mitochondrial membranes, special membranous systems within cells; methods for isolation of membranes; chemical reactions at interfaces; the dynamic properties of interfaces; model membrane systems; the cell surface region and cell-contact relations.

For Graduate Students Only

8-060. Current Topics

8-900. Seminar

8-910. Seminar: Genetics

8-990. Research

MICROBIOLOGY (MicB)

Faculty advisers—Professors Bernlohr, Brand, Dworkin, Johnson, Plagemann, Rogers, Schmidt, Zissler

The 4-year curriculum which leads to the degree of bachelor of science with a major in microbiology more than fulfills the requirements for a practicing microbiologist and also prepares a student for graduate work at any university.

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. The microbiologist may be interested in basic biological mechanisms, such as DNA replication or the regulation of protein synthesis, which are currently under study employing microorganisms. He may seek answers to fundamental problems in the human and animal diseases such as the mechanism of viral and bacteriological infection, immune mechanisms and auto-immune disease, and viral-induced cancer. Numerous aspects of agriculture are under investigation by microbiologists such as specific fungal and bacterial symbionts essential for maximal growth of some 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 cheeses, beer, wine, etc., pasteurization in canning and food processing, and even decontamination of space vehicles.

In addition to the areas of research open to the microbiologist, he may become a teacher and yet play a role in advancing our knowledge of science. Even if he selects a career outside of microbiology, he will find his training in this field invaluable in many related areas of biological research, industry, medicine, and public health.

In addition to completing the biology core curriculum and liberal education requirements, a student must take the following:

MicB 5-216, 5-217, 5-321

Two of the following: MicB 5-232, 5-612, 5-311

Chem 3-100, 3-101

A sequence in physical chemistry is highly recommended (e.g., Chem 5-501, 5-502, 5-504)

COURSES — MICROBIOLOGY

(Medical School)

- 1-011w,s. MICROBES AND MAN.** (4 cr, §3-103 or §5-105 or §Biol 3-013; prereq Biol 1-002 or Biol 1-011) Dagley, Chapman
Microorganisms in relationship to man and his environment including importance 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.
- 3-103f,w,s.** GENERAL MICROBIOLOGY.** (5 cr; prereq soph with C avg in courses prereq to major sequence, or jr with 10 cr in chemistry and 5 cr in biological sciences, or §) Schmidt, Johnson, Lindorfer
Lectures, demonstrations, and laboratory instruction in the morphology, physiology, taxonomy, and ecology of bacteria. Practical applications of fundamental principles.
- 5-105f,w,su.** BIOLOGY OF MICROORGANISMS.** (4 cr, §3-103 and §Biol 3-013; prereq 5 cr in biological sciences, Chem 3-302, or §) Dworkin, Chapman, Klein
Lectures, demonstrations, and laboratory exercises in taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Some emphasis is placed on molecular structure in relation to bacterial function.
- 5-216w. IMMUNOLOGY.** (3 cr; prereq 3-103 or 5-105 or Biol 3-013) 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.
- 5-217w. IMMUNOLOGY LABORATORY.** (2 cr; prereq ¶5-126) Gray
Laboratory course for MicB 5-216.
- 5-232s.** MEDICAL MICROBIOLOGY.** (5 cr; for other than medical students; prereq 5-216) Chapman
Pathogenic bacteria, fungi, and viruses, especially in their relationship to disease; principles of infection, pathogenesis, and immunity; emphasis on microbiological techniques for laboratory diagnosis.
- 5-311s. MICROBIAL GENETICS.** (4 cr; prereq Biol 3-013 or MicB 5-105, MicB 5-103, Biol 3-021, Biol 3-032 or §; offered 1972-73 and alt yrs) Zissler
Genetics of bacteria and their viruses. Fine structure of genetic material; genetic recombination; regulation of DNA, RNA, and protein synthesis.
- 5-321w. PHYSIOLOGY OF BACTERIA.** (3 cr; prereq 3-103 or 5-105, or Biol 3-013...10 cr in organic chemistry or biochemistry...3 cr in genetics) Rogers
Chemical and physical organization of bacteria as related to function; growth, energy metabolism including oxidations and fermentations; nutritional requirements; antimicrobial agents; autotrophic mechanisms; and microbial differentiation.
- 5-322w. PHYSIOLOGY OF BACTERIA LABORATORY.** (3 cr; prereq 5-321, §) Staff
Bacterial physiology and metabolic analysis techniques.
- 5-424s. BIOLOGY OF VIRUSES.** (4 cr; prereq 5-321 or Biol 3-021) Plagemann
Lectures and laboratory. Structure, composition, and properties of bacterial, plant, and animal viruses; their interaction with cells and effects on host cell metabolism; biochemistry of viral replication; techniques used in study of viruses and viral infections; viral tumorigenesis.
- 5-512s. GENERAL MYCOLOGY.** (3 cr; prereq 3-103 or 5-105 or Biol 3-013 or §; offered when feasible) Staff
Physiology, genetics, development, ecology, evolution, taxonomy, economic importance of yeasts, molds, actinomycetes, and other fungi.

** Microscope required. Students may obtain use of microscope by purchasing \$3 microscope cards from bursar.

Curricular Requirements — Course Descriptions

- 5-612s. **ECOLOGY OF SOIL MICROORGANISMS.** (4 cr; prereq 3-103 or 5-105 or Biol 3-013, #; offered 1972-73 and alt yrs) Schmidt
(Same as Soil 5-612) Soil as a microhabitat; the nature of the microbial population of soil; interactions among microorganisms in the soil ecosystem; and significant activities of soil microorganism.
- 5-970f,w,s. **SPECIAL PROBLEMS.** (Cr ar; prereq #) Staff

ZOOLOGY (Zool)

Director of Undergraduate Studies—Professor Olson

This curriculum which leads to a degree of bachelor of science in zoology offers a broad and thoroughgoing education in biology and will also serve as preparation for graduate work in zoology. In addition to completing the core curriculum, students are required to take a minimum of three courses (12-15 credits) in zoology.

COURSES — ZOOLOGY

- 1-013f,w,s. **GENERAL ZOOLOGY.** (4 cr, §Biol 3-011; prereq Biol 1-011)
Lecture and laboratory. Survey of animal phyla; includes considerations of structure, function, behavior, adaptation, and evolutionary relationships.
- 3-096f. **ORGANIC EVOLUTION.** (4 cr; prereq 1-013 or Biol 1-002 or Biol 3-011) Merrell
Survey of evidence for and causes of evolution.
- 3-980f,w,s. **UNDERGRADUATE SEMINAR.** (1 cr per qtr; prereq sr major in biological sciences, #) Staff
A discussion of biological topics of current interest.
- 3-990f,w,s. **INDIVIDUAL WORK IN SOME SPECIAL DISCIPLINE.** (Cr ar; prereq 1-013 or Biol 1-002 or Biol 3-011 and #) Staff
- 5-052f. **GENERAL AND COMPARATIVE EMBRYOLOGY.** (5 cr; prereq 1-013 or Biol 1-002 or Biol 3-011) Spratt
Embryological development of vertebrate and invertebrate forms.
- 5-066f,s. **HISTOLOGY.** (5 cr; not open to regular 3-yr premed or predent students; prereq 1-013 or Biol 1-002 or Biol 3-011) Olson
Microscopic structure of tissues and organs.
- 5-071s. **INVERTEBRATE BIOLOGY.** (5 cr; prereq 1-013 or Biol 1-002 or Biol 3-011 or #) Barnwell
A survey of the morphology, physiology, behavior, ecology, and evolution of the invertebrate groups. The laboratory consists of the study of living marine, freshwater, and terrestrial representatives.
- 5-077s. **INTRODUCTORY ORNITHOLOGY.** (5 cr; prereq 1-013 or Biol 1-002 or Biol 3-011) Warner
Laboratory and field course in structure, classification, distribution, migration, habits, habitats, and identification of birds.
- 5-093f. **INTRODUCTION TO ANIMAL PARASITOLOGY.** (5 cr; prereq 1-013 or Biol 1-002 or Biol 3-011) Wallace
Elementary course dealing with parasitic protozoa, worms, and arthropods, and their relation to diseases of man and animals.
- 5-104f. **COMPARATIVE ANIMAL PHYSIOLOGY.** (5 cr; prereq 1-013 or Biol 1-002 or Biol 3-011, Chem 3-302 or #) Schmid
An introduction to animal physiology, emphasizing functional aspects of organ systems from a comparative viewpoint.

- 5-107f. **PROTOZOLOGY.** (4 cr; prereq #; offered 1971-72 and alt yrs) Kerr
Introduction to taxonomy, morphology, physiology, development, and genetics of free-living protozoa.
- 5-113f. **PHYSIOLOGY OF EXCITABLE CELLS.** (4 cr; prereq 5-104 or Biol 5-052 and #)
Sheridan
In depth study of the basic electrical and chemical properties of nerve, muscle, and sensory receptor cells.
- 5-121s. **ICHTHYOLOGY.** (4 cr; prereq 15 cr incl 1-013 or Biol 1-002 or Biol 3-011) Underhill
Taxonomy and habits of North American fishes, especially those of Upper Mississippi drainage.
- 5-124f. **VERTEBRATE BIOLOGY.** (4 cr; prereq 1-013 or Biol 1-002 or Biol 3-011 and #)
Underhill
Survey of the vertebrates; their biology, taxonomy, and distribution.
- 5-125f. **VERTEBRATE FAUNA LABORATORY.** (2 cr; prereq 5-124 or ¶5-124 and #)
Underhill
Survey of the vertebrate groups native to Minnesota and neighboring states.
- 5-128s. **HERPETOLOGY.** (5 cr; prereq 5-124; offered 1972-73 and alt yrs) Regal
Laboratory and lectures on the distribution, classification, and evolution of amphibians and reptiles of the world. Physiological, morphological, and behavioral aspects of adaptive trends.
- 5-129s. **ADVANCED MAMMALOLOGY.** (5 cr; prereq 5-124 or #; offered 1971-72 and alt yrs) Birney
Study of 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.
- 5-134w. **GENERAL AND COMPARATIVE ENDOCRINOLOGY.** (3 cr; prereq Biol 3-011, Biol 3-021, Chem 3-302 or #; offered 1971-72 and alt yrs) Herman
Survey of structure, function of invertebrate and vertebrate endocrine systems.
- 5-135s. **GENERAL AND COMPARATIVE ENDOCRINOLOGY LABORATORY.** (2 cr; prereq 5-134 and #; offered 1971-72 and alt yrs) Herman
Individual laboratory investigations of selected problems of endocrinology. Topics arranged by consultation with instructor.
- 5-136w. **ADVANCED GENERAL AND COMPARATIVE ENDOCRINOLOGY.** (2 cr; prereq 5-134 and 5-135 or #; offered 1972-73 and alt yrs) Herman
Lectures on several specific areas of current endocrinologic interest. Topics will vary, but will normally include such subjects as the endocrinology of special taxonomic groups, neurosecretion, hormone action, pheromones, hormone-like substances, plant hormones, hormone chemistry, etc.
- 5-144w. **PARASITIC PROTOZOA.** (4 cr; prereq 15 cr incl 1-013 or Biol 1-002 or Biol 3-011 and #) Wallace
Structure, life histories, and economic relations of protozoal parasites of man and animals; laboratory diagnosis.
- 5-146s. **EXPERIMENTAL PARASITOLOGY.** (4 cr; prereq 5-093 or #) Gilbertson
Discussion sessions and laboratory investigations designed to illustrate the relationships between metazoan parasites and their hosts.
- 5-164s. **FINE STRUCTURE OF ANIMAL CELLS.** (4 cr; prereq Biol 5-601 and #) Johnson
Cell structure and function is approached on an organelle basis, emphasizing ultrastructural research. Topics will include macromolecular synthesis, bioenergetics, cell movement, and cell division.
- 5-165s. **ADVANCED CYTOLOGY LABORATORY.** (2 cr; prereq 5-164 or ¶5-164 and #)
Johnson
Emphasis on individual projects. These may include autoradiography, cell culture, cell fractionation, or electron microscopy.

Curricular Requirements — Course Descriptions

- 5-169s. **PHYSIOLOGICAL ECOLOGY.** (4 cr; prereq 5-104 and Biol 3-041 or Biol 5-051, #...statistics recommended) Schmid
Functional adaptations of organisms to various physical and biotic factors of the natural environment.
- 5-171w. **GENETICS AND SPECIATION.** (4 cr; prereq 15 cr biology incl genetics) Merrell
Application of genetic principles to problems of speciation and evolution.
- 5-814su. **NATURAL HISTORY OF INVERTEBRATES.** (5 cr; prereq 1-013 or Biol 1-002; offered at Itasca)
Taxonomic and ecological survey of local fauna, detailed and independent ecological study of several taxonomic groups.
- 5-819su. **NATURAL HISTORY OF THE VERTEBRATES.** (5 cr; prereq 1-013 or Biol 1-002; offered at Itasca)
Taxonomic and biological survey of the local fauna, detailed and independent study of the vertebrate classes exclusive of the birds.
- 5-834su. **FIELD ORNITHOLOGY.** (5 cr; prereq 1-013 or Biol 1-002; offered at Itasca)
Field and laboratory studies of ecology and life histories of the birds in the Itasca Park region.
- 5-843su. **ANIMAL PARASITES.** (5 cr; prereq 1-013 or Biol 1-002; offered at Itasca)
Parasites of local fauna with special reference to helminths.

For Graduate Students Only

- 8-134. Recent Research in Comparative Endocrinology
8-271s. Topics in Ecological Genetics
8-282f. Physiology of Development: Chemical Embryology
8-283f. Physiology of Development: Differentiation
8-284f. Physiology of Development: Endocrines in Development
8-970f,w,s. Graduate Seminar
8-980. Special Research Fields
8-990f,w,s. Graduate Research

Related Courses Recommended from Other Colleges

- AnSc 5-314w. Behavioral Physiology
Ent 3-175s. Introductory Entomology
Ent 5-025f. Insect Morphology
Ent 5-026w. Embryology and Development of Insects
Ent 5-027s. Insect Metabolism and Coordination
Ent 5-150f. Principles of Systematic Entomology
Ent 5-275f. Medical Entomology
FW 3-277w. Mammalogy
VAna 5-120w. Essentials of Vertebrate Development and Structure
VPP 5-310s. General Endocrinology
VPP 5-311f. Reproductive Physiology
VPP 5-313w. Avian Physiology