This is the College of Biological Sciences section of the 2000-2002 University of Minnesota Undergraduate Catalog.

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The mission of the College of Biological Sciences (CBS) is to provide outstanding educational opportunities to undergraduate and advanced students and carry out world-class research in areas of modern biology from the molecular to the ecosystem level. To accomplish this mission, it is necessary to integrate a strong basic research program with both traditional and innovative classroom teaching and with intensive mentoring of students at all levels.

As part of its mission, the college is dedicated to providing basic biological science education and sharing expertise with students and colleagues in other disciplines at the University of Minnesota, such as agriculture, natural resources, engineering, health sciences, and liberal arts.

The college is committed to outreach to the general community and cooperation with other educational institutions. College members actively participate in the scientific community and in the leadership of professional organizations, and they contribute to the administration and governance of the University.

Research and Teaching Facilities

CBS has faculty and facilities on both Minneapolis and St. Paul campuses. The college is organized into the following departments: Biochemistry, Molecular Biology, and Biophysics; Ecology, Evolution, and Behavior; Genetics, Cell Biology, and Development; and Plant Biology. The Department of Microbiology and the Department of Neuroscience, both of which are housed in the Medical School, also function as CBS departments for undergraduate education. A description of departments and their major degree requirements may be found beginning on page 86.

In addition, CBS is responsible for the administration of several instructional programs, research institutes, shared-use laboratories, and an active field biology program, with facilities at several locations around the state (see below). A complete list of faculty is provided in the Faculty and Administration section of this catalog.

Advanced Bioscience Computing Center (ABCC)—In 46 Gortner Laboratory of Biochemistry, the center is one of the better equipped NMR labs in North America.

High Field Nuclear Magnetic Resonance Facility—In the new Basic Sciences & Biomedical Engineering building, this is one of the better equipped NMR labs in North America.

Imaging Center—In 35 Snyder Hall, the center is a self-service facility open to University students, faculty, and staff and investigators outside the University in support of their teaching and research activities. The center specializes in light and electron optical methods, with expertise in immunofluorescence and confocal imaging. Training and technical help are provided to meet imaging needs (612-624-3454).

Institute of Human Genetics—The institute’s major objective is to develop an interdisciplinary approach to studying and applying new developments in human genetics. It develops technologies necessary for understanding the structure, function, and expression of human chromosomes and genes for the prevention,
diagnosis, and therapy of inborn and acquired genetic disorders. The institute’s programs include genetic services (Molecular Diagnostics Laboratory, microchemical facility, gene therapy program) and programs in molecular, behavioral, clinical, and population genetics, as well as genetic counseling.

Instructional Computing Center—Biology students have access to a well-equipped Macintosh computing facility in 406 Biological Sciences Center and a Windows facility in 170 Ecology Building. Priority in the computer center is given to undergraduates working on coursework-related materials. Students can use programs for word processing, graphing, drawing, or spreadsheets and access to many electronic databases and file servers around the world, as well as their own electronic mail service. The center houses specialized software, such as programs to help students prepare for the Graduate Record Examination (GRE). Hours for each computing lab are posted on the lab doors.

Jane Goodall Institute’s Center for Primate Studies—This branch of the Jane Goodall Institute studies chimp behavior and houses all 38 years’ worth of Goodall’s records from Tanzania’s Gombe National Park.

Lake Itasca Forestry and Biological Station—At the headwaters of the Mississippi River in northern Minnesota, the field station is in an unparalleled ecological area where three great plant regions of the United States meet. These 50 square miles of protected forest provide unique opportunities for the study of varied ecosystems and of fauna and flora with southern, northern, and western origins. Diverse lakes and wetlands provide unusual field advantages for aquatic studies. Information about the highly popular summer biology offerings is in the Summer Session Catalog. Reservations for and questions about the Itasca program should be addressed to the Director, Lake Itasca Program, University of Minnesota, 220 Biological Sciences Center, 1445 Gortner Avenue, St. Paul MN 55108 (612-625-1799).

Mass Spectrometry Center—Opened in April 1999, this facility offers a MALDI mass spectrometer and a state-of-the-art electrospray device. Both are available to all University biologists as well as outside researchers.

Plant Molecular Genetics Institute—The institute fosters research in molecular biology and genetics of economically important plants and relevant model plant systems, develops genetic engineering methodologies for application to crop improvement, educates future plant biology researchers and teachers, maintains an interdisciplinary environment in which to explore and develop new ideas and experimental approaches in plant molecular biology, and provides a focus for external communication to aid recruitment and funding. Institute faculty members come from two colleges (Biological Sciences and Agricultural, Food, and Environmental Sciences) and six departments (agronomy and plant genetics; biochemistry, molecular biology and biophysics; genetics, cell biology and development; horticultural science; plant biology; and plant pathology). The institute supports seminars and symposia on topics related to plant molecular biology and provides funds for speakers and visiting scientists (612-625-2225).

Beginning College in Biology

If you’re about to begin college and think biology may be your area of interest, there are some important questions you need to consider. (If you’ve already completed one or two years of college work and are thinking of transferring to the University of Minnesota, see “Transfer Admission” in the General Information section of this catalog.)

How do I know if biology is a good choice for me?

Some students have known for many years that they want to major in biology when they get to college. They’re the ones who have had a lifelong interest in some part of biology—maybe it’s understanding diseases or animals in their habitats, or perhaps genetics has always fascinated them. Other students don’t really become interested in biology until high school, when some “great teacher” or exciting course helps them determine that this might really be an interest. Still others really aren’t sure at all. They aren’t ready yet to decide on a college major, but biology seems to be a possibility. Or perhaps biology seems to be a good choice because of what they’d like to do after college—maybe medical school, or preserving our natural environment, or agricultural or food technology, medical research, or possibly biotechnology.

If you fit in any of these areas and have a strong high school background in science and math, then you should consider a major in biological sciences!

Is biology a good choice right now? Do biology careers look promising for the future?

Yes! Biology continues to play a critical role in our society and will be important in helping us address many of our most serious concerns and problems in this country. Our placement reports of recent graduates tell us that over 90 percent choose to go directly on to school for advanced degrees (both graduate and professional degree programs) and that approximately 50 percent secure full-time employment, almost all of them in jobs related to biology. Our Career Center continues to work closely with employers anxious to hire well-trained biology graduates. The future remains very promising!

The University of Minnesota is classified as a research university. What does this mean for undergraduates?

It’s good news, especially for students in the sciences. Because our faculty members are so actively involved in research, students have extraordinary opportunities for personal involvement in research and exposure to the latest scientific findings.

Is involvement in research really available for all students, or is it an opportunity reserved only for honors students?

Most of our students participate in research. And they’re involved all over the University—in medicine, dentistry, pharmacy, veterinary medicine, agriculture, and natural resources. Modern biology requires hands-on training in addition to classroom and laboratory instruction. Without some research experience, students find it difficult to get admitted to some of the more competitive graduate biology programs. Some employers prefer to hire only those biology graduates who have research or internship experience.

The University has a College of Biological Sciences rather than just a department. What does this mean for students?

A lot, actually. Because we’re a college, we provide you with all the specialized services you’d expect from a college. The only difference is that all our specialized services relate specifically to your interests in biology.
We have an advising staff of biologists who can help you prepare for college, explore your career interests in biology, plan your program of study, and help you become involved in our programs. We also have our own honors program, internship program, and committed faculty of more than 120 (actually, there are more than 1,000 life sciences faculty on campus). We even have our own highly specialized Career Center to help you prepare for the biology career you choose.

**Can I begin as a freshman in CBS at the University?**
Yes! CBS admitted its first freshman class in fall 1997. We’re excited to have these students now more directly involved with us, right from the beginning of their college careers. We’ve designed a number of new specialized programs and seminars specifically for freshmen.

**What if I’m not sure about my major? I’m interested in biology, but also in French and geography. Can I end up in the “wrong” college?**
No. You’ll be taking the same University courses (including biology courses) no matter what college you start in. There are no disadvantages to being in College of Liberal Arts (CLA) as opposed to CBS. There is no such thing as “the wrong college.” If you are really unsure of your major, you will find CLA to be a good place from which to explore all your academic interests.

**What should I do to learn more about biology at the University to help me decide if CBS is the right place for me?**
Attend one of our Visit Days, offered regularly throughout the academic year. A full-day Visit Day provides you with an opportunity to explore careers in the life sciences, meet CBS faculty and students, and tour research laboratories and the St. Paul campus. Each Visit Day program explores a different career in biology, such as molecular biology, genetics, ecology and the environment, and medicine/veterinary medicine. To request a CBS Visit Day brochure, call 612-624-9717.

**Admission**
Students may enter CBS at the beginning of their freshman, sophomore, junior, or senior year. For those students who choose to begin at another institution or even in a different college at the University, transfers into CBS are welcome at any point in their undergraduate program. CBS faculty and staff can help students select appropriate coursework for transferring to the college. During the freshman and sophomore years, students should plan to complete, at least, the beginning English composition course, mathematics, general chemistry, and general biology. Most students take organic chemistry during their sophomore year, thereby allowing ample time for major coursework and research experience.

**Requirements**

**Freshmen**
1. Submit a completed application by Dec. 15, the University’s priority deadline, or before the freshman class fills.
2. Have completed or are completing:
   a. four years of high school mathematics with one year each of algebra, geometry, and algebra II (trigonometry, precalculus, or calculus in the fourth year are strongly recommended).
   b. three years of high school science, including one year each of biology, chemistry, and physics.
   c. other high school preparation requirements (see “Freshman Admission” in the General Information section of this catalog).
3. Meet ACT or SAT aptitude rating standards set by CBS. For more information, contact the Office of Student Services (612-624-9717) or the Office of Admissions (612-625-2008).

**Students with any post-high school college level work**
1. Grades of at least C- in the following:
   a. one semester or two quarters of college-level calculus.
   b. one semester or two quarters of inorganic chemistry.
   c. one semester or one quarter of biology.
2. A 2.50 overall GPA (if transferring to the University and seeking direct admission to CBS).

Admitted students receive a letter of acceptance and welcome from both the Office of Admissions and CBS with information about orientation dates and registration.

**Application for admission from outside the University**
Students who do not meet freshman admission requirements, or who apply after CBS’s freshman class has filled, may begin their program as prebiology students in CLA and then transfer to CBS as sophomores or juniors.

Students who want to transfer to CBS from within the University system must complete required coursework in chemistry (Chem 1021-1022), math (Math 1271-1272), and biology (Biol 1009 or 1101).

Transfer students may apply directly to CBS. To be admitted as a sophomore or junior, certain requirements must be completed before admission (see requirements for students with college level work completed). If these requirements have not been completed at the time of application, students should also apply to CLA as prebiology students. Acceptance into a prebiology program requires that students meet CLA admission standards (see the CLA section of this catalog). Acceptance into prebiology ensures that students will have contact with a biology adviser early in their academic career.

**Note:** Freshmen and transfer students who must first complete work as prebiology majors in another University college before entering CBS should apply between October 1 and December 15 of the year before desired admission to ensure consideration before the priority deadline.

Applications to the University of Minnesota, Twin Cities may be requested from the Office of Admissions (612-625-2008 or, toll free in the United States, 1-800-752-1000).

For more information, contact the Office of Student Services (612-624-9717).

**Orientation**
Before classes begin, freshmen and transfer students are invited to attend a New Student Program/Orientation. It acquaints students with the campus and provides information about the college and the University. Students spend part of the session with an adviser who helps them plan their biology program. Participation in orientation is required.

Freshmen attend a series of programs and seminars throughout the first year to fully acquaint them with CBS faculty, staff, and students and inform them about special opportunities for biology students.
Transfer students also attend a CBS orientation/reception during the first week of the semester. Information is presented about research and internship opportunities, as well as information critical to preparing for a biology profession.

**Undergraduate Programs**

Students choose CBS because it has programs of exceptionally high quality offered by professors well-recognized in their fields. As students begin planning for a specific career, they should supplement their coursework with research experiences and internships to further develop their skills and prepare for their chosen professions. Students are assisted in exploring their career interests in biology through the Biology Colloquium, freshman seminars, a broad selection of course offerings, and special programs offered through the CBS Career Center, including an annual course, Biol 2001—Careers in Biology.

The CBS bachelor of science degree program comprises four essential elements. Each is important in preparing students to be leaders in their chosen professions in an increasingly complex and interdisciplinary world.

**I. Liberal Education**—A liberal education frees individuals from the limitations of their powers of judgment and choice that result from ignorance. It provides students with the skills to seek:

- control over the general intellectual instruments for acquiring and communicating knowledge, primarily the instruments of language and number;
- understanding of the ways scientists contribute to knowledge;
- historical and philosophical perspective on the nature of students’ own lives and the world in which they live;
- and appreciation of the creative insights into life and nature provided by literature and the arts.

To help achieve these goals, the University requires all students to distribute a portion of their coursework in areas of study outside of those most directly linked to their specialized interests in science.

**II. Physical Sciences and Mathematics**—Biology as a science relies heavily on the tools of mathematics and physical science. Organisms consist of molecules that obey the rules of physics and chemistry; these rules are often stated using mathematics.

Modern biologists in the field and in the laboratory must be able to use fundamental principles of mathematics, chemistry, and physics to appreciate living organisms at all levels from molecules to ecosystems.

Mathematics is a tool that underlies all of science. It permits the description of the kinetics of reactions occurring in organisms, is used to model population growth and distribution, and forms a basis for statistical analysis of data.

Chemistry is the study of molecules and their interactions. Phenomena such as nerve impulses, the exchange of gases in respiration, water balance, and the conversion of food energy to useful work by organisms require an understanding of chemistry. Organisms are composed of organic molecules. An understanding of these molecules and their reactive groups is essential to an understanding of biological phenomena such as metabolism, gene function, and nutrient cycling in ecosystems.

Physics includes the study of atoms and their interactions, mechanics, heat, sound, electricity and magnetism, and the properties of light. It is the basis for our understanding of photosynthesis, blood and airflow, mutations, and energy pyramids in ecosystems. It underlies most of the instruments and techniques used by biologists: pH meters, spectrophotometers, thermometers, microscopes, centrifuges, computers, the use of radiation to induce mutations, and the use of radioactive tracers.

**III. Biology Core Curriculum**—Specialists working in well-circumscribed areas will always be important in biology, but today there is a growing need for people whose understanding ranges across the disciplines of biology. Students are introduced to diverse aspects of biology by completing a set of core courses. Some courses introduce students to various kinds of organisms—animals, plants, and microorganisms. Biochemistry introduces students to organic compounds of importance to organisms, to enzyme-catalyzed reactions, and to the metabolic pathways by which energy is used. Cell biology examines the structure and function of cells in some depth. Genetics introduces students to mechanisms of heredity, including both molecular genetics and population genetics. Ecology, evolution, and behavior introduce students to populations, evolution, and the behavior of animals.

**IV. Specialization in the Major**—In addition to completing the required courses in biology, students take courses to expand on some aspects of biology. They may do so either by completing a biology major, which allows for more breadth in choosing electives, or by completing one of several department majors (biochemistry; ecology, evolution, and behavior; genetics, cell biology and development; microbiology; neuroscience; and plant biology). These more specialized majors each have required courses, as specified by the department. In addition to electives, most students will plan to complete
The University offers a variety of life sciences courses in addition to those offered by CBS. In addition to courses offered by CBS, appropriate elective courses may be found in a number of areas, including agronomy and plant genetics (Agro), animal science (AnSc), anthropology (Anth), biophysics (BPhy), chemical engineering (ChemEn), chemistry (Chem), computer science (CSci), entomology (Ent), fisheries and wildlife (FW), food science and nutrition (FSnN), forest resources (FR), geology (Geo), history of medicine and science (HMed, HSci), horticultural science (Hort), laboratory medicine (LaMP), mathematics (Math), natural resources and environmental studies (NRES), pharmacology (Phcl), philosophy (Phil), physics (Phys), physiology (Phsl), plant pathology (PlPa), psychology (Psy), public health (PubH), soil science (Soil), statistics (Stat), veterinary biology (VB), and veterinary pathobiology (VPB).

Graduate Programs

Graduate study at the University is coordinated and administered by the Graduate School. For information about general policies regarding admission requirements, registration procedures, financial aid, and requirements for graduate degrees, see the Graduate School Catalog. Application materials may be obtained from CBS department offices.

Questions regarding specific bioscience programs should be addressed to the director of graduate studies in the appropriate program area.

The 1995 National Research Council Report ranked the Department of Ecology, Evolution, and Behavior as one of the nation's top 15.

Recommended Related Coursework

The University offers a variety of life sciences courses in addition to those offered by CBS. In addition to courses offered by CBS, appropriate elective courses may be found in a number of areas, including agronomy and plant genetics (Agro), animal science (AnSc), anthropology (Anth), biophysics (BPhy), chemical engineering (ChemEn), chemistry (Chem), computer science (CSci), entomology (Ent), fisheries and wildlife (FW), food science and nutrition (FSnN), forest resources (FR), geology (Geo), history of medicine and science (HMed, HSci), horticultural science (Hort), laboratory medicine (LaMP), mathematics (Math), natural resources and environmental studies (NRES), pharmacology (Phcl), philosophy (Phil), physics (Phys), physiology (Phsl), plant pathology (PlPa), psychology (Psy), public health (PubH), soil science (Soil), statistics (Stat), veterinary biology (VB), and veterinary pathobiology (VPB).

Honors Program

The CBS honors program has two components. Freshmen and sophomores participate in the CBS/CLA lower division honors program, which is for students in all areas of arts and sciences. The program provides specially designed courses and opportunities for involvement in a mix of academic, social, and preprofessional cocurricular activities.

As juniors and seniors, CBS students are involved in a program designed around their interests in biology. This program recognizes and promotes outstanding academic achievement. The nucleus of the program is directed research in biology, the most significant and challenging experience the faculty can offer qualified undergraduates. Another facet of the program is the CBS honors seminar, which provides exposure to the breadth of biological inquiry and allows honors students to get to know each other.

The honors experience culminates in the Undergraduate Research Symposium and honors dinner, which celebrate students' research accomplishments and academic achievements.

Honors Program Admission—Freshmen apply to the honors program when they apply to the University. Students may apply to the upper division CBS program at the end of the sophomore year. At least two semesters of honors registration must be completed to fulfill the requirements for graduation with honors. Applicants should have a 3.50 minimum GPA and present reasonable evidence of potential to attain the GPA required for graduation with honors (see below). Applications are available in 223 Snyder Hall.

Direct Research—This provides students with research experience and obtains new information about the biological system under investigation. Honors program participants should select a research adviser from the college faculty and start on a project early in their junior year or as soon thereafter as possible. Participation in at least two semesters (6 credits) of directed research is required; students may register in BioC 4794W/4994, EEB 4794W/4994, GCD 4794W/4994, MicB 4794W/4994, Nsc 4794W/4994, or PBio 4794W/4994. Students who participated in the Undergraduate Life Sciences Summer Research Program or who received Undergraduate Research Opportunities Program grants may petition to use this work to fulfill up to three of the six research credits. An honors thesis, summarizing the research and written in the style of a publishable manuscript, is required. The thesis must be approved by the faculty member supervising the research and by two other faculty (at least one of whom must be from the major department), chosen with college approval.

Honors Seminar—Honors program graduates must participate in two semesters of Biol 3960—Honors Seminar. In fall semester, the seminar is a forum to discuss special topics focused on a theme of general relevance to all biologists. In spring semester, seniors nearing completion of their directed research projects must present summaries of their project results. Students must take a seminar in the fall and follow that with a seminar in the spring semester preceding graduation. They are also encouraged to enroll in the spring semester seminar before the senior year.

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

1. at least 40 credits in upper division courses (3xxx-5xxx) at the University of Minnesota, Twin Cities
2. two semesters (6 credits) of directed research, the results of which are to be reported in an acceptable honors thesis
3. two CBS honors seminars (Biol 3960), one of which must be completed during fall semester and the other during the last spring semester in residence
4. one additional honors opportunity, which may be selected from

Biochemistry, Molecular Biology, and Biophysics—David Bernlohr, 624-2712, and Michael Sanders, 624-9637
Conservation Biology—Francesca Cuthbert, 624-1756
Ecology, Evolution, and Behavior—Elmer C. Birney, 624-6293
Genetic Counseling—Bonnie LeRoy, 624-7193
Microbial Engineering—Michael Sadowsky, 625-1722
Microbiology, Immunology, and Molecular Pathobiology—David Sherman, 626-0199
Molecular, Cellular, Developmental Biology, and Genetics—Perry B. Hackett, 624-6736
Neuroscience—John Soechting, 625-7961
Plant Biological Sciences—David Marks, 625-6737
a. an additional semester (2 credits) of participation in directed research
b. an honors seminar offered by the CLA Honors Division
c. an upper division honors course (3xxx-5xxx)
d. an 8xxx course (seniors only; requires permission)
5. the last 60 credits of A-F registration with the minimum GPAs specified below:
   - cum laude: 3.50 minimum GPA
   - magna cum laude: 3.66 minimum GPA
   - summa cum laude: 3.75 minimum GPA

   Grades of F and N, which carry no grade points, are included in the computation of the CBS honors GPA. If a portion of the last 60 credits completed has been transferred from another institution, the proportion of residence credits with grades of A must at least equal the proportion of transfer credits with grades of A.

For More Information—Once admitted, students should also consult the CBS Student Handbook and feel free to discuss questions with an Office of Student Services adviser, 223 Snyder Hall.

Graduation Requirements
To earn a B.S. from CBS, students must complete at least 120 credits with grades of A, B, C, or S. Grades of D or D+ are not accepted in any of the math, chemistry, physics or biological sciences courses used to meet requirements for the major.

Course Requirements
English Communication Skills—See “Writing Requirement” under Liberal Education Requirements on page 35 of this catalog.

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

Liberal Education—The University’s liberal education diversified core, designated themes, and writing skills curriculum is required for all students completing a degree program on the Twin Cities campus.
   - Physical and biological sciences
   - History and social sciences
   - Arts and humanities
   - Mathematical thinking
   - Cultural diversity
   - International perspectives
   - Environment
   - Citizenship and public ethics
   - Writing skills

   Mathematics and science coursework required of CBS students ordinarily satisfies the minimum University requirements for physical and biological sciences and mathematical thinking.

Physical Sciences and Mathematics—CBS majors require at least one year of calculus, one year of physics, and chemistry through organic. See specific requirements included with the description of each major beginning on page 86.

Biological Sciences—Each major has a defined list of required courses in general and organismal biology, and components of the biology core curriculum. Requirements are listed with each major beginning on page 86.

Advising
The size and diversity of the University offers unlimited opportunities for students to explore and develop their academic, professional, and personal interests.

Both current and prospective students are well-served by the advising services, resources, and programs provided by CBS’s faculty and Office of Student Services. CBS students are assigned to a faculty adviser in their particular area of interest. In addition, Office of Student Services staff members are available by appointment for students to discuss an array of student concerns. Summarized below are the types of advising services available through a combination of faculty and professional advising.

The Office of Student Services performs a variety of other essential functions in the college, including admission, student orientation and registration, academic progress review, and degree certification.

Prospective Student Activities
Admission counseling
Career transitions
Prospective student information
High school and community college visits
College tours
Summer science program
Visit Days
Welcome Fair

New Student Advising
Orientation
New student reception
Course planning
Freshman seminars and special events
Exploration of life sciences majors
Campus resource information

Developmental Advising
Intellectual and personal growth
Career directions
Goal setting
 Clarifying values
Decision making
Refining skills
Developing leadership

Peer Advising/Networking
Honors
Biology Colloquium
Biological Sciences Student Association
CBS club activities
Alumni society
Mentor programs
Biology House

Major and Faculty Advising
Program planning
Career exploration/planning
Professional Learning Experience Program (PLEP)
Undergraduate research
 Seminars
Preparation for graduate and professional school programs

Program Planning—This annual, shared planning activity should form the basis of an ongoing relationship between the faculty adviser and student. The importance of the relationship between faculty adviser and student cannot be overemphasized. Students will find it useful to consult their advisers to discuss progress in specific courses, obtain information about graduate study, design a research project, plan internships, or arrange to work with faculty in laboratory and field settings.
Special Learning Opportunities and Resources

Students are encouraged to explore the full scope of learning experiences available, including those beyond the required curriculum. Many students plan projects they carry out under faculty supervision in research laboratories and in the field. Some students obtain off-campus internships in private industry, government agencies, and the nonprofit sector. Other students seek employment as undergraduate teaching and research assistants or museum tour guides. Most departments offer special seminars for undergraduates.

Biology Colloquium (Biol 1020)—This is a unique course, organized and run by students, recommended for those who wish to explore the various fields and career alternatives in the biological sciences. Offered each semester, the course gives students the chance to interact with biology faculty and students with similar interests. The colloquium offers both large group seminars, featuring prominent scientists discussing their research programs, and small group tours to research facilities on- and off campus, such as the Raptor Rehabilitation Center, the Wolf Center, or behind-the-scenes at the Minnesota Zoo. In addition, students are encouraged to begin exploring their own interests through participation in a research project. Colloquium student leaders help students find projects that fit their interests and allow them to earn University credit.

Socially, colloquium students always find time for fun, too, whether on a field trip or studying together in the colloquium student room. Upper division biology majors gain important leadership and communication experience as colloquium leaders.

Freshman Seminars—Small classes, taught by the University’s finest faculty, Students explore exciting ideas and concepts and also learn more about the University and the wide range of services available.

Multicultural Affairs—CBS seeks to increase the number of students of color who enroll in and successfully complete its courses and majors. The college provides students of color with mathematics and science tutors, faculty mentors, and research experiences. The coordinator for recruitment and retention is available to work with individuals or groups of students to explore potential interests in biology, provide academic assistance, identify employment opportunities and alternative sources of financial aid, assist in leadership development, and help overcome barriers to educational success. For more information, contact Verna L. Holoman, 123 Snyder Hall (612-625-8752).

Professional Learning Experience Program (PLEP)—Offered by the CBS Career Center, PLEP provides experiential education information and opportunities to students year-round, specializing in biology-related internships, community service opportunities, and study-travel internships. Experiential learning programs promote academic and professional competence, skills development, career exploration, personal growth, and social responsibility through student involvement in structured work situations. CBS promotes excellence among University students by helping them integrate their classroom study with practical learning experience in the academic, public, and private sectors. Participating in PLEP allows students interested in biology to begin career planning and exploration early in their academic careers.

Previous PLEP students have studied marine biology at marine institutes and local facilities, gained laboratory experience in private industry, studied animal behavior in northern Minnesota, and completed ecology studies in Costa Rica, to name a few projects. Organizations sponsoring PLEP opportunities include educational institutions, government agencies, businesses, and nonprofit organizations. Both paid and volunteer positions are available throughout the year and some offer credit. Students with specific interests may design their own internship and PLEP will help them find a sponsoring organization. The CBS Alumni Society provides stipends each year for students who participate in unpaid internships. CBS students may receive financial support for their research activities through the University’s Undergraduate Research Opportunities Program (See “Undergraduate Research” in the General Information section of this catalog). Students can earn credit for a structured professional learning experience through registration in Biol 3610—Internship: Professional Experience in Biological Sciences.

Undergraduate Research—Each spring an Undergraduate Research Symposium is held to recognize the accomplishments of undergraduates participating in life sciences research projects. Students do research work largely on their own and at their own pace, supervised by a University faculty or staff member. Students may choose to earn academic credit for their research experiences, or they may wish to apply for special grants that provide a research stipend. The CBS Career Center maintains a research opportunities database to help students find interesting research projects in laboratories throughout the University.

Scholarships

Students are encouraged to apply for both need- and merit-based CBS scholarships. Applications for all scholarships and awards are due March 15. For more information and applications, contact the Office of Student Services (612-624-9717).

International Programs

CBS students recognize the need to prepare themselves to be citizens of a multicultural society, a global economy, and an increasingly interdependent world. The college encourages them to enhance their education by taking advantage of international programs sponsored by the University.

Previous PLEP students have studied marine biology at marine institutes and local facilities, gained laboratory experience in private industry, studied animal behavior in northern Minnesota, and completed ecology studies in Costa Rica, to name a few projects. Organizations sponsoring PLEP opportunities include educational institutions, government agencies, businesses, and nonprofit organizations. Both paid and volunteer positions are available throughout the year and some offer credit. Students with specific interests may design their own internship and PLEP will help them find a sponsoring organization. The CBS Alumni Society provides stipends each year for students who participate in unpaid internships. CBS students may receive financial support for their research activities through the University’s Undergraduate Research Opportunities Program (See “Undergraduate Research” in the General Information section of this catalog). Students can earn credit for a structured professional learning experience through registration in Biol 3610—Internship: Professional Experience in Biological Sciences.

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Students are encouraged to apply for both need- and merit-based CBS scholarships. Applications for all scholarships and awards are due March 15. For more information and applications, contact the Office of Student Services (612-624-9717).

International Programs

CBS students recognize the need to prepare themselves to be citizens of a multicultural society, a global economy, and an increasingly interdependent world. The college encourages them to enhance their education by taking advantage of international programs sponsored by the University.

The college also encourages study abroad for language acquisition or culture learning. The resulting credits can be used as general electives or, in some cases, to satisfy liberal education requirements. The University sponsors or cosponsors a broad range of intensive short-term language programs and area studies programs.

The two types of study abroad that best lend themselves to study in the biological sciences are field study and integrated classroom study.

For more information, see “Study Abroad” in the General Information section of this catalog.
Career Information

Biology encompasses many fields of study and appeals to students with diverse interests. Career opportunities are equally broad. While students might be drawn to some majors because of their direct application to vocations in the marketplace, most students select a biology major because it is the subject they most enjoy learning about. Happily, they will discover that their career choices are limited only by their imagination, individual interests, and acquired skills.

Many students study biology to prepare for professional training in the health sciences. Because entry requirements for the health sciences generally include similar courses to those required in CBS (mathematics, chemistry, physics, and biology), students find that a biology major provides the right foundation to explore and prepare for these fields of study. In fact, nearly a third of CBS graduates each year choose to continue their education in health fields, including medicine, dentistry, veterinary medicine, osteopathy, physicians assistant, and optometry.

CBS students beginning full-time employment immediately following graduation frequently take research scientist and laboratory technician positions. Others pursue an array of occupations requiring a liberal education and bachelor’s degree, from business fields (e.g., sales, quality control, communications) to public service (e.g., environmental control, public education). CBS graduates have been unusually successful in gaining employment in their chosen professional fields, even at times when the market was limited and competitive. Right now, given the importance of biology in so many aspects of U.S. society and economy, the market for CBS graduates is very strong. Biologists are clearly in demand. Employers have come to realize that the University is a good place to find well-trained biologists as student interns and as employees. Some students are combining biology with other fields, such as engineering, graphic arts, or law. Those graduates who choose to continue their study are regularly admitted to top-notch graduate schools and professional programs.

About half of CBS graduates elect to pursue advanced study immediately after earning the B.S. degree (about 30 percent are admitted to professional schools and 20 percent enter graduate programs); the percentage of each graduating class that pursues advanced training increases over time. Details about follow-up studies of graduates, both bachelor of science and advanced, are available on request in 223 Snyder Hall.

Career Center—The CBS Career Center helps students explore the varied career options available to biology graduates. Undergraduates are encouraged to consult with Career Center staff early to investigate careers, learn about career preparation, and begin to make decisions. The center provides extensive career and employer information, and connections to professionals in many fields of interest. Contacts made through the Professional Learning Experience Program, annual Career and Internship Fair, and Alumni Career Network ensure that students make well-informed career decisions. Career Center staff also offer an annual course, Biol 2001—Careers in Biology.

As graduation approaches, the center assists students in applying to graduate schools and professional health sciences programs. For those choosing to enter the job market directly, the center helps develop job search skills (including résumé writing and interviewing) and provides placement assistance in the form of job listings and a specialized résumé distribution service. For more information, visit the center’s Web site at <biosci.cbs.umn.edu/admin/student_services/>.

Students interested in teaching biology at the secondary level should consult the College of Education and Human Development for information about the specialized curriculum that is available.

Student Organizations

Achieving Excellence in Mathematics and Science (AEIMS)—All life sciences majors are encouraged to participate in AEIMS with students from other sciences, mathematics, and engineering. The club was established to ensure full participation of students from groups currently underrepresented in science and to foster interaction among diverse life sciences students and faculty. AEIMS activities include monthly issue-oriented meetings, organized community service projects, group study sessions, and social events. For more information, contact Verna L. Holoman (612-625-8752).

Biochemistry Club—This club strengthens ties between biochemistry students and faculty, provides a source of individualized professional advice on career goals to each biochemistry major, helps undergraduates identify biochemistry labs for directed research, and helps students keep abreast of new advances in biochemistry. For more information, contact the Office of Student Services (612-624-9717) or the Department of Biochemistry, Molecular Biology and Biophysics (612-624-7760).

Biological Sciences Alumni Society (BSAS)—The society provides a professional association for biological sciences graduates and encourages relationships among current students, faculty, alumni, and the community. The society has made a special commitment to enhance opportunities for current students and encourages them to participate in all of its programs, often at discounted ticket prices. The president of the Biological Sciences Student Association serves on the board of directors of the alumni society. Alumni volunteers have cooperated with the CBS Career Center to develop the Career Information Network, an innovative program to help current students and graduates explore career options. The society sponsors undergraduate scholarships, undergraduate research and internship grants, and a mentor program. The society supports continuing education programs in the biological sciences. Student and alumni volunteers from the society have also assisted the college with student recruitment, especially of women and minorities. For more information, contact Paul Germescheid, CBS Alumni Relations, 123 Snyder Hall (612-624-3752), or the Minnesota Alumni Association, 200 Oak Street Suite 200, Minneapolis, MN 55455 (612-624-2323).

Biological Sciences Student Association (BSSA)—Through BSSA, biology undergraduates can take on leadership roles in the college. BSSA plans educational and social activities throughout the year and invites all University biology students to attend its meetings and events. BSSA is a major contributor to Biology Week. Involvement in the association is an excellent way to meet faculty and students. For more information, contact the Office of Student Services (612-624-9717).

Club Itasca—Through this club the University community is informed about the important contributions field stations make to learning, especially in the sciences. An important focus of Club Itasca is to promote the Lake Itasca Forestry and Biological Station. The club sponsors social events and regularly scheduled visits and field trips to field stations. For more information, contact the Itasca office on campus (612-624-6743).
**Ecology Club**—This club was established in 1991 to bring together students interested in the ecological and environmental problems of the world. The meetings are basically educational; however, each activity is planned to bring together students and faculty in an informal, social atmosphere. For more information, contact the Office of Student Services (612-624-9717) or the ecology, evolution, and behavior department (612-625-5700).

**Genetics, Cell Biology and Development Club**—Students formed this club to bring together students, faculty, and staff interested in these disciplines. Members enjoy speakers, educational experiences, and social activities. For more information, contact the Office of Student Services (612-624-9717) or the genetics, cell biology and development department (612-624-3003).

**International Student Science and Cultural Exchange Club**—This club provides an opportunity for international students to interact with one another and with the campus community. Meetings provide a forum for learning about the home countries of CBS students and exploring important features of their cultures. All members of the science community are invited to participate. For more information, contact Kathie Peterson, ISSCEC adviser (612-624-9717).

**Plant Biology Club**—Through this club, students have the chance to interact with other students and faculty interested in plants. Participants enjoy speakers and other educational experiences, usually in an informal, social atmosphere. For more information, contact the Office of Student Services (612-624-9717) or the plant biology department (612-625-1234).

**Society for Microbiology**—The society provides a forum in which students and faculty can meet informally to share common interests in microbiology. All meetings and activities reflect members’ interests. Members are officially part of the Student Chapter of the American Society for Microbiology (ASM), which provides information on microbiology lectures, meetings, seminars, and local job listings. Activities include discussions of microbiological issues, social events, and visits to local employers. For more information, contact the Office of Student Services (612-624-9717) or the microbiology department (612-624-6190).
Directory

(area code 612)

Office of the Dean
123 Snyder Hall (St. Paul)
624-2244

Robert P. Elde, dean
belde@cbs.umn.edu

Kathryn Hanna, associate dean
k Hanna@cbs.umn.edu

Student Services
Advising and Registration
223 Snyder Hall (St. Paul)
624-9717
cbs-advisor@cbs.umn.edu

Kathleen Peterson, kathiep@cbs.umn.edu
Leah Clark
Jessica Murra
David Peterson

Biography
305 Bell Museum of Natural History (Mpls.)
626-1674

Kathryn Hanna, k Hanna@cbs.umn.edu
Richard Phillips
James Waddell

Career Center
213 Snyder Hall (St. Paul)
624-9270

Kathleen Peterson, kathiep@cbs.umn.edu
Amy Winkel, amyw@cbs.umn.edu

Community Outreach and Freshman Programming
223 Snyder Hall (St. Paul)
624-9717, cbs-advisor@cbs.umn.edu

Services for Disabled Students
123 Snyder Hall (St. Paul)
624-1257

Kathy Ball

Honors Program
223 Snyder Hall (St. Paul)
625-5296

Franklin Barnwell

International Education
610 Biological Sciences Center (St. Paul)
625-1958

Willard Koukkari

Multicultural Affairs
123 Snyder Hall (St. Paul)
625-8752

Verna L. Holoman, v Holoman@cbs.umn.edu

Professional Learning Experience Program
213 Snyder Hall (St. Paul)
624-9270

Amy Winkel amyw@cbs.umn.edu

Recruitment andRetention in the Life Sciences
123 Snyder Hall (St. Paul)
625-8752

Verna L. Holoman, v Holoman@cbs.umn.edu

Departments, Institutes, and Programs
Advanced Bioscience Computing Center
46 Gortner Laboratory of Biochemistry (St. Paul)
625-9284

Alumni Relations
123 Snyder Hall (St. Paul)
624-3752
Paul Germscheid

Biochemistry, Molecular Biology, and Biophysics
140 Gortner Laboratory of Biochemistry (St. Paul) and 6-155 Jackson Hall (Mpls.)
625-6100
Charles Louis, head, louis003@tc.umn.edu

Biological Sciences
123 Snyder Hall (St. Paul)
625-3133
James Fuchs, faculty adviser

Biological Process Technology Institute
240 Gortner Laboratory of Biochemistry (St. Paul)
624-6774
Kenneth Valenta, director, valenta@cbs.umn.edu

CBS Networking Services Center
St. Paul
625-9284

Debbie Parker, manager, dparker@cbs.umn.edu

Cedar Creek Natural History Area
509 Ecology Building (St. Paul)
625-5743

Cedar Creek area
434-5131

G. David Tilman, director, tilman@lter.umn.edu

Developmental Biology Center
4-122 Malcolm Moos Health Sciences Tower (Mpls.)
625-0642

Michael B. O’Connor, moconnor@mail.med.umn.edu

Ecology, Evolution, and Behavior
100 Ecology Building (St. Paul)
625-5700

Robert W. Sterner, head
stern007@tc.umn.edu

Electronic Instrument Services
25 Biological Sciences Center (St. Paul)
625-8267

General Biology Program
P180 Kelthoff Hall (Mpls.)
625-6636

John S. Anderson, director, anderson049@tc.umn.edu

Genetics, Cell Biology, and Development
250 Biological Sciences Center, (St. Paul)
624-3003 and 6-160 Jackson Hall (Mpls.)
624-3110
gcd@biosci.cbs.umn.edu

Anthony J. Faras, head
faras@mail.med.umn.edu

Imaging Center
35 Snyder Hall, (St. Paul)
624-3454

Mark Sanders, director, msanders@cbs.umn.edu

Institute of Human Genetics
7-218 Malcolm Moos Health Sciences Tower (Mpls.)
625-1609

Harry Orr, director, hhg@mail.med.umn.edu

Instructional Computing Center
406 Biological Sciences Center and 170 Ecology (St. Paul)
624-2789

Lake Itasca Program
220 Biological Sciences Center (St. Paul)
625-1799

David Biesboer, director, dbiesboer@tc.umn.edu

Microbiology (Medical School)
1460 Mayo Memorial Building (Mpls.)
624-4442

Ashley T. Haase, head, ashley@lenti.med.umn.edu

Neuroscience
6-145 Jackson Hall (Mpls.)
626-6800

Timothy J. Ebner, head
ebner001@tc.umn.edu

Plant Biology
220 Biological Sciences Center (St. Paul)
625-1234

Plant Molecular Genetics Institute
220 Biological Sciences (St. Paul)
625-2225

Nevin D. Young, director, nevin@tc.umn.edu

Teaching Laboratory Support Staff
123 Biological Sciences Center (St. Paul)
624-2789

Jane Phillips, coordinator

Directors of Undergraduate Studies

Biochemistry
158 Gortner Laboratory of Biochemistry (St. Paul)
624-6275

Janet Schottel, janet@CBS.umn.edu

Biology
123 Snyder Hall (St. Paul)
624-2244

Kathryn Hanna, k Hanna@cbs.umn.edu

Ecology, Evolution, and Behavior
412 Ecology Building (St. Paul)
625-5296

Franklin H. Barnwell, barnwell@CBS.umn.edu

Genetics, Cell Biology, and Development
250 Biological Sciences Center (St. Paul)
624-5399

Stuart Goldstein, golds004@tc.umn.edu

Microbiology
1435 Mayo Memorial Building (Mpls.)
624-9933

Leslie Schiffer, schiff@lenti.med.umn.edu

Neuroscience
6-145 Jackson Hall (Mpls.)
625-7623

Richard Poppele, dick@tc.umn.edu

Plant Biology
768 Biological Sciences Center (St. Paul)
625-2761

Thomas Soul, soul001@tc.umn.edu
B.S. Biochemistry

Biochemistry

Department of Biochemistry, Molecular Biology, and Biophysics

Biochemistry studies molecules found in living organisms, particularly proteins, nucleic acids, lipids, and carbohydrates. The biochemistry major differs from the chemistry major in that biochemistry emphasizes the integration of chemical principles into biological processes from molecular genetics to enzymology.

The B.S. program in biochemistry prepares students for graduate study in biochemistry or a related biological science, medical or veterinary school, or entry-level biochemical positions in industry.

Biochemistry is an experimental science, and majors, especially those planning to pursue graduate studies in the field, should become acquainted with laboratory research approaches beyond those in the formal lab courses. Research options are available through BioC 4994—Directed Research and the Honors Program. Students should start planning the research component of their major program as early as possible and should make arrangements for their senior research project during their junior year, in consultation with their adviser.

Degree Requirements

Students must complete 120 credits, including at least 70 credits in the major.

The biochemistry major is based on a broad foundation in the physical sciences (mathematics, chemistry, and physics) and an extensive knowledge of the cellular, molecular, and genetic aspects of biology, in addition to formal course and laboratory work in biochemistry.

Required Courses

Complete requirements in the categories of general and organismal biology, biology core, biochemistry courses, and electives in the major. The following courses must be taken A-F, unless the course is only offered S-N.

General and Organismal Biology—Choose sequence A or B:

Sequence A. (preferred)
Biol 1001—Introductory Biology I: Evolutionary and Ecological Perspectives
Biol 1002—Introductory Biology II: Molecular, Cellular, and Developmental Perspectives

Sequence B.
Biol 1009—General Biology
Choose one organismal course or course pair from the following list:
Biol 3211 and Biol 2005, Biol 3002 and Biol 3005, or Biol 3007

Biology Core—Complete each of the following:
BioC 4331—Biochemistry I: Structure, Catalysis and Metabolism in Biological Systems
Bio 4003—Genetics
Bio 4004—Cell Biology

Plus choose option a or b:

a. Biol/MicB 3301—Biology of Microorganisms
b. Choose one course or course pair from the following:
   integrative/organismal biology/physiology area: Biol 2012, Biol 2022, Biol 3211 and Biol 2005, Biol 3002 and 3005, Biol 3007, if not used to fulfill the general and organismal biology requirements listed above
   ecology/evolution/behavior area: Biol 3407 or Biol 3409 or Biol 3411

Biochemistry Courses—Complete each of the following:
BioC 3960—Research Topics in Biochemistry
BioC 4025—Laboratory in Biochemistry
BioC 4332—Biochemistry II: Molecular Mechanisms of Signal Transduction and Gene Expression
BioC 4521—Introduction to Physical Biochemistry
or Chem 3501 and 3502—Physical Chemistry I-II

Electives in the Major
Six credits of electives in biochemistry or related biological disciplines (one course must include an upper division laboratory experience).

Required Courses From Other Programs
The following courses must be taken A-F, unless the course is only offered S-N.

Math 1271-1272 or 1281-1282—Calculus I-II
Chem 1021-1022—Chemical Principles I-II
Chem 2301-2302—Organic Chemistry I-II
Chem 2311—Organic Lab
Chem 3501-3502—Physical Chemistry I-II
or BioC 4521—Introduction to Physical Biochemistry.
Phys 1201-1202—General Physics I-II
or Phys 1301-1302—Introductory Physics I-II

Note: Grades in all chemistry, math, physics, biochemistry and biological sciences courses taken to complete requirements in the major must be at least C-.

Minor Requirements

Students must complete BioC 4331, 4332, and 4025.

Biology

B.S.

Students in this major develop the skills necessary to tackle complex problems within the biological sciences. Biology examines the fundamental concepts of nature and all aspects of the living environment, from the molecular level to the biosphere. Biology can open doors to many specialized fields, including genetics, biotechnology, environmental biology, and medicine.

The biology B.S. program can prepare students for further study in graduate or professional schools, and also trains students for careers in industry, education, or government.

Degree Requirements

Students must complete at least 120 credits, including at least 69 credits in the major. The biology curriculum also includes courses in biology, chemistry, physics, and mathematics.

Required Courses

Complete requirements in the categories of general and organismal biology, biology core, and electives in the major. The following courses must be taken A-F, unless the course is only offered S-N.

General and Organismal Biology—Choose sequence A or B:

Sequence A. (preferred)
Biol 1001—Introductory Biology I: Evolutionary and Ecological Perspectives
Biol 1002—Introductory Biology II: Molecular, Cellular, and Developmental Perspectives

Sequence B.
Biol 1009—General Biology
Choose one organismal course or course pair from the following list:
Biol 3211 and Biol 2005, Biol 3002 and Biol 3005, or Biol 3007

Biology Core—Complete each of the following:
BioC 4331—Biochemistry I: Structure, Catalysis and Metabolism in Biological Systems
Bio 4003—Genetics
Bio 4004—Cell Biology

Plus choose option a or b:

a. Biol/MicB 3301—Biology of Microorganisms
b. Choose one course or course pair from the following:
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   ecology/evolution/behavior area: Biol 3407 or Biol 3409 or Biol 3411

Required Courses From Other Programs
The following courses must be taken A-F, unless the course is only offered S-N.

Math 1271-1272 or 1281-1282—Calculus I-II
Chem 1021-1022—Chemical Principles I-II
Chem 2301-2302—Organic Chemistry I-II
Chem 2311—Organic Lab
Chem 3501-3502—Physical Chemistry I-II
or BioC 4521—Introduction to Physical Biochemistry.
Phys 1201-1202—General Physics I-II
or Phys 1301-1302—Introductory Physics I-II

Minor Requirements

Students must complete at least 69 credits in the major. The biology curriculum also includes courses in biology, chemistry, physics, and mathematics.

 Required Courses

Complete requirements in the categories of general and organismal biology, biology core, and electives in the major. The following courses must be taken A-F, unless the course is only offered S-N.

General and Organismal Biology—Choose sequence A or B:

Sequence A. (preferred)
Biol 1001—Introductory Biology I: Evolutionary and Ecological Perspectives
Biol 1002—Introductory Biology II: Molecular, Cellular, and Developmental Perspectives

Sequence B.
Biol 1009—General Biology
Choose one organismal course or course pair from the following list:
Biol 3211 and Biol 2005, Biol 3002 and Biol 3005, or Biol 3007

Biology Core—Complete each of the following:
BioC 4331—Biochemistry I: Structure, Catalysis and Metabolism in Biological Systems
Bio 4003—Genetics
Bio 4004—Cell Biology

Plus choose option a or b:

a. Biol/MicB 3301—Biology of Microorganisms
b. Choose one course or course pair from the following:
   integrative/organismal biology/physiology area: Biol 2012, Biol 2022, Biol 3211 and Biol 2005, Biol 3002 and 3005, Biol 3007, if not used to fulfill the general and organismal biology requirements listed above
   ecology/evolution/behavior area: Biol 3407 or Biol 3409 or Biol 3411

Biochemistry Courses—Complete each of the following:
BioC 3960—Research Topics in Biochemistry
BioC 4025—Laboratory in Biochemistry
BioC 4332—Biochemistry II: Molecular Mechanisms of Signal Transduction and Gene Expression
BioC 4521—Introduction to Physical Biochemistry
or Chem 3501 and 3502—Physical Chemistry I-II

Electives in the Major
Six credits of electives in biochemistry or related biological disciplines (one course must include an upper division laboratory experience).

Required Courses From Other Programs
The following courses must be taken A-F, unless the course is only offered S-N.

Math 1271-1272 or 1281-1282—Calculus I-II
Chem 1021-1022—Chemical Principles I-II
Chem 2301-2302—Organic Chemistry I-II
Chem 2311—Organic Lab
Chem 3501-3502—Physical Chemistry I-II
or BioC 4521—Introduction to Physical Biochemistry.
Phys 1201-1202—General Physics I-II
or Phys 1301-1302—Introductory Physics I-II

Note: Grades in all chemistry, math, physics, biochemistry and biological sciences courses taken to complete requirements in the major must be at least C-.

Minor Requirements

Students must complete BioC 4331, 4332, and 4025.
**Sequence B.**

Biol 1009—General Biology

Choose two organismal biology courses or course pairs from the following list: Biol/MicB/VPB 3022, Biol 2012, Biol 2022, Biol 3211 and Biol 2005, Biol 3002 and Biol 3005, Biol 3007, Biol/MicB 3301

**Biology Core—Complete each of the following:**

Biol/BioC 3021—Biochemistry

Biol 4003—Genetics

Biol 4004—Cell Biology

Choose one course from Biol 3407, Biol 3409, and Biol 3411

**Electives in the Major—Complete each of the following:**

Eleven additional upper division credits* in mathematics, physical, biological science and/or computer science. (Phys 3051 may not be used to fulfill this requirement).

Laboratory or fieldwork in two additional upper division biological science courses or course pairs. Credits earned may be applied toward fulfilling the 11 upper division credits above. A list of acceptable courses follows:

Biol 3211 and Biol 2005, Biol 3002 and 3005, Biol 3007, or Biol/MicB 3301, if not used to satisfy the general and organismal biology requirement.


All 38xx or 48xx CBS courses offered at the Lake Itasca Forestry and Biological Station are acceptable

**Required Courses From Other Programs**

Math 1271-1272 or 1281-1282—Calculus I-II

Chem 1021—Chemical Principles I

Chem 2301–2302—Organic Chemistry I-II

Ch 3211—Organic Lab

Phys 121-122—General Physics I-II

or Phys 1301-1302—Introductory Physics I-II

*Upper division electives (3xxx, 4xxx, or 5xxx courses having Biol 1002 or 1009 as a prerequisite) may be selected from any CBS department, as well as appropriate mathematics, physical science, and computer science courses.

**An independent research project is strongly recommended for every student. To apply a Directed Research course to satisfy one of the upper division lab or fieldwork requirements, students must complete at least 3 credits under the 4794W/4994 course number. Biology majors may satisfy both of the lab/field course requirements through Directed Research only if 3 credits of 4794W/4994 are completed in each of two different labs. A maximum of 6 credits of 4794W/4994 counts toward the 11 upper division elective credits.

Note: Grades in all chemistry, math, physics, and biological sciences courses used to complete requirements in the major must be at least C-. All courses in the major must be taken A-F unless the course is only offered S-N.

**Minor Requirements**

To declare a biology minor, students must make an appointment (and bring a transcript). Call 612-624-9717. All courses must be completed with a grade of at least C-.

**Required Courses for the Minor**

1. Biol 1001 and 1002 and one organismal course
   or Biol 1009 and two organismal courses in different areas. (3xxx organismal courses count toward the 15-credit requirement under 3.)
2. Chem 1021 (Note: students also need organic chemistry for some courses on the organismal course options list below)
3. 15 upper division credits (3xxx, 4xxx, or 5xxx, with at least 3 cr at 4xxx) in biological sciences including:
   One of EEB 3001, Biol/BioC 3021, GCD 3022, Biol 3407, Biol 4003, or BioC 4331.
   An additional lab or field course. If directed research (Biol 4794W or Biol 4994) is used, it must be at least 2 credits.
   At least 10 credits at the U of MN, Twin Cities campus.

At least 10 credits on the A/F grading system.

**Organismal course options:**

Biol 2012—General Zoology with lab

Biol 2022—General Botany with lab

Biol/MicB 2032—General Microbiology with lab

Biol 3002—Plant Biology Function
   and Biol 3005—Plant Function Laboratory

Biol 3007—Plant Biology: Diversity and Adaptation with lab

Biol 3211—Animal Physiology
   and Biol 2005—Animal Diversity Laboratory

Biol/MicB 3301—Biology of Microorganisms

Biol 4125—Recombinant DNA Laboratory

EEB 4014—Ecology of Vegetation

EEB 4016—Ecological Biogeography

EEB 4129—Mammology

EEB 4134—Ornithology

EEB 4136—Icthyology

EEB 4605—Limnology Laboratory

EEB 4994 or 4974*—Directed Research

GCD 4015—Genetics Laboratory

GCD 4025—Cell Biology Laboratory

GCD 4111—Histology: Cell and Tissue Organization

GCD 4794W or 4994*—Directed Research

MicB 4215—Advanced Laboratory: Microbial Physiology and Diversity

MicB 4235—Advanced Laboratory: Virology, Immunology and Microbial Genetics

MicB 4794W or 4994*—Directed Research

Nsc 4794W or 4994*—Directed Research

PsBio 4404—Developmental Plant Anatomy

PsBio 4511—Flowering Plant Systematics

PsBio 4794W or 4994*—Directed Research

PsBio 5416—Plant Morphology, Development and Evolution

* Must complete at least 2 credits of research (4994 or 4974) in one lab to use for a lab requirement. 4974 is directed research with a Writing Intensive component.

All 38xx Lake Itasca Field Station courses satisfy field requirement

**Ecology, Evolution, and Behavior**

**Department of Ecology, Evolution, and Behavior**

B.S.

This program brings together the conceptually linked fields of ecology, evolution, and behavior.

Ecology examines the growth and maintenance of populations and their interactions in communities, and interrelationships among organisms and physical events in terrestrial and aquatic ecosystems. Evolution investigates the origin and change of biological diversity by studying evolutionary patterns and processes at various temporal and spatial scales. Behavioral biology explores behavioral adaptations to the environment, mechanisms of behavior, and the evolution of social systems.
Degree Requirements
Students must complete at least 120 credits, including at least 72 credits in the major. The program also includes coursework in math, physics, and chemistry.

Required Courses
Complete requirements in the categories of general and organismal biology, biology core, and electives in the major. The following courses must be completed with A-F grades unless they are offered S-N only.

General and Organismal Biology—Choose sequence A or B:

**Sequence A. (preferred)**
- Biol 1001—Introductory Biology I: Evolutionary and Ecological Perspectives
- Biol 1002—Introductory Biology II: Molecular, Cellular and Developmental Perspectives

Choose at least two organismal courses or course pairs representing two kingdoms (plant, animal, or microorganismal) from Biol 2012, Biol 2022, Biol 3007, Biol 3002 and 3005, Biol/MicB/VPB 2032, Biol 3211 and 2005, Biol/MicB 3301, Ent 3005, EEB 4129, EEB 4134, EEB 4136

**Sequence B.**
- Biol 1009—General Biology

Choose three organismal courses or course pairs representing three kingdoms (plant, animal, or microorganismal) from Biol 2012, Biol 2022, Biol 3007, Biol 3002 and 3005, Biol/MicB/VPB 2032, Biol 3211 and 2005, Biol/MicB 3301, Ent 3005, EEB 4129, EEB 4134, EEB 4136

**Biology Core—Complete each of the following:**
- Biol/BioC 3021—Biochemistry
- At least two courses from Biol 3407, Biol 3409, and Biol 3411
- Other physical, mathematical, or computer science credits used to fulfill this requirement

**Electives in the Major—Complete each of the following:**

- Six credits of EEB-designated courses at the 4xxx level or above (the third course from the biology core, category B above may be used to fulfill this requirement)
- At least 3 credits of biological sciences courses at the 3xxx level or above. Other physical, mathematical, or computer science credits may be substituted with adviser’s permission if they are not used to fulfill the requirements for general and organismal biology and biology core categories listed above.

Elective coursework in biology, chemistry, physics, and mathematics.

Degree Requirements
Students must complete at least 120 credits, including at least 75 credits in the major. Requirements include coursework in biology, chemistry, physics, and mathematics.

Required Courses
Complete requirements in the categories of general and organismal biology, biology core, and electives in the major.

General and Organismal Biology—Choose sequence A or B:

**Sequence A. (preferred)**
- Biol 1001—Introductory Biology I: Evolutionary and Ecological Perspectives
- Biol 1002—Introductory Biology II: Molecular, Cellular, and Developmental Perspectives

One organismal course or course pair from the following list: Biol/ MicB/VPB 2032, Biol 2012, Biol 2022, Biol 3211 and 2005, Biol 3002 and 3005, Biol 3007, Biol/MicB 3301

**Sequence B.**
- Biol 1009—General Biology
Two organismal courses or course pairs from the following list: Biol/ MicB/VPB 2032, Biol 2012, Biol 2022, Biol 3211 and 2005, Biol 3002 and 3005, Biol 3007, Biol/MicB 3301

**Biology Core—Complete each of the following:**
- Biol/BioC 3021—Biochemistry
- Biol 4003—Genetics
- Biol 4004—Cell Biology

Choose one course from Biol 3407, Biol 3409, Biol 3411

**Electives in the Major—Complete each of the following:**

Eighteen additional credits in life sciences, physical science, mathematics, statistics and/or computer science, chosen in consultation with the major adviser. The 18 credits must include:

- At least one genetics course from EEB 5033, GCD 4034, GCD 4143, Psy 5137
- At least one course in cell biology from GCD 4036, GCD 4111, GCD 4134, MicB 4131, PBio 5414
- At least one course in developmental biology from GCD 4151 or GCD 4161 or PBio 5416

One laboratory course from the following: Bio 4025, Biol 4125, GCD 4015, GCD 4025, GCD 4111, MicB 4235

At least 2 credits of GCD 4794W or 4994—Directed Research. At least 2 credits and a maximum of 6 credits of GCD 4794W/4994 may be applied toward the 18-credit total.

Biol 3700 is recommended.

Required Courses From Other Programs
Math 1271-1272 or 1281-1282—Calculus I-II
Chem 1021-1022—Chemical Principles I-II
Chem 2301-2302—Organic Chemistry I-II
Chem 3211—Organic Lab
Phys 1201-1202—General Physics I-II
or Phys 1301-1302—Introductory Physics I-II

Note: Grades in all chemistry, math, physics, and biological sciences courses taken to meet requirements in the major must be at least C-. All courses in the major must be taken A-F unless the course is only offered S-N.

Genetics, Cell Biology, and Development

Department of Genetics, Cell Biology, and Development

B.S.
This program prepares undergraduates for advanced study and careers in the rapidly growing field of biotechnology and in medical, industrial, or other scientific laboratories.

Microbiology

Department of Microbiology

B.S.
This program prepares students for work as practicing microbiologists or for graduate study.

The field of microbiology embraces many areas of fundamental and applied research. These include the basic role of microbes, such as bacteria, fungi, and viruses, and basic biological mechanisms involving microorganisms such as DNA replication or regulation of protein synthesis. Microbiologists study fundamental issues of human and animal diseases such as the mechanisms of viral and bacteriological infection, immunity, autoimmune disease, and viral-induced cancer.
Areas of agricultural research include fungal and bacterial symbionts essential for maximum growth of organisms required for natural soil fertility. Microbiologists also work in industrial and pharmaceutical fields involving production and discovery of new antibiotics; manufacture of cheese, beer, wine, and other foods; pasteurization in canning and food processing; and even decontamination of space vehicles.

**Degree Requirements**

Students must complete at least 120 credits, including at least 75 credits in the major.

**Required Courses**

Complete requirements in the areas of general and organismal biology, biology core, and electives in the major.

**General and Organismal Biology**—Choose sequence A or B:

**Sequence A. (preferred)**

Biol 1001—Introductory Biology I
Biol 1002—Introductory Biology II

**Sequence B.**

Biol 1009—General Biology

Choose one of the following course pairs: Biol 3211 and Biol 2005, or Biol 3002 and 3005

**Biology Core**—Complete each of the following:

Biochemistry courses: Biol/BioC 3021 or BioC 4331
Genetics courses: GCD 302 or Biol 4003
Microbiology course: Biol/MicB 3301—Biology of Microorganisms

**Electives in the Major**

Choose four courses from MicB 4111, MicB 4121, MicB 4131, MicB 4141, MicB 4151, MicB 5352

Advanced laboratory courses—Choose option a or b:

a. MicB 4215—Advanced Laboratory: Microbial Physiology and Diversity
   and MicB 4235—Advanced Laboratory: Virology, Immunology and Microbial Genetics

b. MicB 4215 or MicB 4235 plus 6 credits of MicB 4794W/4994—Directed Research, completed in one lab

**Required Courses From Other Programs**

Math 1271-1272 or 1281-1282—Calculus I-II
Chem 1021-1022—Chemical Principles I-II
Phys 1301-1302—Introductory Physics I-II
   or Phys 1201-1202—General Physics I-II

Note: Grades in all chemistry, math, physics, and biological sciences courses taken to complete requirements in the major must be at least C-. All courses in the major must be taken A-F unless the course is only offered S-N.

**Neuroscience**

**Department of Neuroscience**

**B.S.**

Neuroscience seeks to understand the brain and behavior, and how we perceive, move, think, and remember. Important aspects of behavior can be examined at the level of individual nerve cells, their properties, and the ways they communicate with one another. Many of these basic issues can be studied directly at the molecular level.

The neuroscience major is designed to provide an introduction to these basic areas of investigation by emphasizing the interdisciplinary nature of the subject.

The major prepares undergraduates to pursue advanced studies in neuroscience; a professional degree in medicine or psychology; or careers in the rapidly growing areas of the pharmaceutical, medical, or biotechnology industries.

**Degree Requirements**

Students must complete at least 120 credits, including at least 89 credits in the major. Requirements also include courses in biology, chemistry, physics, and mathematics.

**Required Courses**

Complete requirements in categories of general and organismal biology, biology core, neuroscience courses, and electives in the major.

**General and Organismal Biology**—Choose sequence A or B:

**Sequence A. (preferred)**

Biol 1001—Introductory Biology I: Evolutionary and Ecological Perspectives
Biol 1002—Introductory Biology II: Molecular, Cellular, and Developmental Perspectives

**Sequence B.**

Biol 1009—General Biology

Choose Biol 3211—Animal Physiology
   or Phsl 3051—Human Physiology

**Biology Core**—Complete each of the following:

Biol/BioC 3021—Biochemistry
   or BioC 4331—Biochemistry I: Structure, Catalysis, and Metabolism in Biological Systems
Biol 4003—Genetics
Biol 4004—Cell Biology
Biol 3407—Ecology
   or Biol 3409—Evolution
   or Biol 3411—Introduction to Animal Behavior

**Neuroscience Courses**—Complete each of the following:

Biol/NSc 3101—Introduction to Neuroscience I: From Molecules to Madness
Biol/NSc 3102—Introduction to Neuroscience II: Biological Basis of Behavior
Biol/NSc 3105-3115—Neurobiology Laboratory I-II
At least 2 credits of Track 1 or 2
Track 1: Nsc 4794W/4994—Directed Research
Track 2: Nsc 4793W/4993—Directed Studies
Students in Track 2 must also choose one laboratory or field course from the following list (these lab courses may not be used to satisfy requirements for the general and organismal biology requirement listed above):
Biol 3002 and 3005; Biol 3007; Bio/MicB 3301; Biol 4125; Bio/C 4025; Bio/C 4794W/4994; EEB 4014; EEB 4016; EEB 4129; EEB 4134; EEB 4136; EEB 4605; EEB 4607; EEB 4631; EEB 4794W/4994; GCD 4111; GCD 4015; GCD 4025; GCD 4794W/4994; MicB 4215; MicB 4235; MicB/C 4794W/4994; PBio 4321; PBio 4404; PBio 4511; PBio 5416; PBio 4794W/4994; any 38xx or 48xx CBS course offered at the Lake Itasca Forestry and Biological Station.

Electives in the Major
Choose at least 12 credits from groups A-D from the following list, with at least one course from each group:

Group A—Cell and molecular neurobiology
Nsc 4151, Nsc 5461, Bio/C/Phsl 5444

Group B—Sensory and motor systems
EEB 5323, Nsc/Psych 5031, Nsc/Psych 5034, Nsc/Ent 5481, Psy 3031, Psy 5036, Nsc/Psych 5037, Psy 5058

Group C—Behavior
Biol 3411 (if not used to fulfill the biology core requirements listed above), EEB 5321, EEB 5327, Nsc 5661, Psy 3051, Psy 3061

Group D—History and philosophy of science
Hsci 3211, Hsci 3242, Phil 3601, Phil 4607

Required Courses From Other Programs
Math 1271-1272 or 1281-1282—Calculus I-II
Chem 1021-1022—Chemical Principles I-II
Chem 2301-2302—Organic Chemistry I-II
Chem 2311—Organic Lab
Phys 1201-1202—General Physics I-II or Phys 1301-1302—Introductory Physics I-II

Note: Grades in all chemistry, math, physics, and biological sciences courses taken to meet requirements in the major must be at least C-. All courses in the major must be taken A-F unless the course is only offered S-N.

Plant Biology

Department of Plant Biology

B.S.
Teaching and research programs in the Department of Plant Biology include molecular, biochemical, cellular, developmental, physiological, organismal, ecological, and evolutionary biology of plants, algae, and fungi.

Current faculty research interests include gene expression, chromosome structure, plant growth substances, signal transduction, plant responses to stress, the plant cytoskeleton and cell morphogenesis, metabolic activities during development, cellular structure and ultrastructure of vascular and nonvascular plants, aquatic biology, lichenology, molecular evolution and systematics, fungal/plant interactions, biological rhythms, and fungal diversity.

Plant biology majors follow one of two tracks. One track fits the needs of students who are primarily interested in organismal or environmental biology, while the other track is appropriate for students who are attracted to molecular, cellular, and development biology.

Degree Requirements
Students must complete at least 120 credits, including 66 credits in the major. The program also includes coursework in mathematics, physics, and chemistry.

Required Courses
Complete requirements in categories of general and organismal biology, biology core, laboratory or fieldwork, and electives in the major.

General and Organismal Biology—Choose sequence A or B:

Sequence A. (preferred)
Biol 1001—Introductory Biology I: Evolutionary and Ecological Perspectives
Biol 1002—Introductory Biology II: Molecular, Cellular, and Developmental Perspectives
Plus either Biol 3002 and 3005, or Biol 3007

Sequence B.
Biol 1009—General Biology
Plus Biol 3002 and 3005, and Biol 3007
Students who decide to major in plant biology after taking a course in general botany may substitute that course for either Biol 3002 and 3005, or Biol 3007.

Biological Core
Bio/Biol 3021—Biochemistry
Bio 4003—Genetics
or Biol 4004—Cell Biology
Biol 3407—Ecology
or Biol 3409—Evolution
or Biol 3411—Introduction to Animal Behavior

Laboratory or Fieldwork
Choose two courses from the following list. These courses may not be used to satisfy requirements listed above for general and organismal biology, but may be used to fulfill the requirements for electives in the major, listed below.

Biol/MicB 3301; Biol/Nsc/Phsl 3105 and 3115; Biol 4125; Bio/C 4025; Bio/C 4794W/4994; EEB 4014; EEB 4016; EEB 4129; EEB 4134; EEB 4136; EEB 4605; EEB 4607; EEB 4631; EEB 4794W/4994; GCD 4111; GCD 4015; GCD 4025; GCD 4794W/4994; MicB 4215; MicB 4235; MicB/C 4794W/4994; PBio 4321; PBio 4404; PBio 4511; PBio 5416; PBio 4794W/4994; any 38xx or 48xx CBS course offered at the Lake Itasca Forestry and Biological Station (x8xx).

Electives in the Major
Choose three courses from the following list, with at least one course each from Group A (integrative and organismal biology) and Group B (cellular and subcellular biology). The two additional courses taken by a student who uses PBio 5412 to partially fulfill this requirement must be from different groups. Other appropriate courses may be substituted by petition.

Group A (integrative and organismal biology)
Pbio 4321—Taxonomy of Minnesota Flora or PBio 4511—Flowering Plant Systematics
PBio 4404—Developmental Plant Anatomy
PBio 5412—Plant Physiology
PBio 5416—Plant Morphology, Development and Evolution
EEB 4014—Ecology of Vegetation or EEB 5122—Plant Interactions with Animals and Microbes

Group B (cellular and subcellular biology)
PBio 5412—Plant Physiology
PBio 5414—Plant Cell and Molecular Biology or PBio 5640—Discussions in Plant Molecular Biology
Bio/C 5401—Advanced Metabolism and its Regulation

Required Courses From Other Programs
Math 1271-1272 or 1281-1282—Calculus I-II
Chem 1021-1022—Chemical Principles I-II
Chem 2301-2302—Organic Chemistry I-II
Chem 2311—Organic Lab
Phys 1201-1202—General Physics I-II or Phys 1301-1302—Introductory Physics I-II

Note: Grades in all chemistry, math, physics, and biological sciences courses taken to meet requirements in the major must be at least C-.

All courses in the major must be taken A-F unless the course is only offered S-N.

Minor Requirements
Students must complete four courses in this list:
Biol 3002—Plant Biology: Function
Biol 3005—Plant Function Laboratory
Biol 3007—Plant Biology: Diversity and Adaptation
Choose one course from PBio 4321, 4404, 4511