

College of Biological Sciences

UNIVERSITY OF MINNESOTA

BULLETIN

1991-1993



The College of

Biological Sciences

helps society meet the

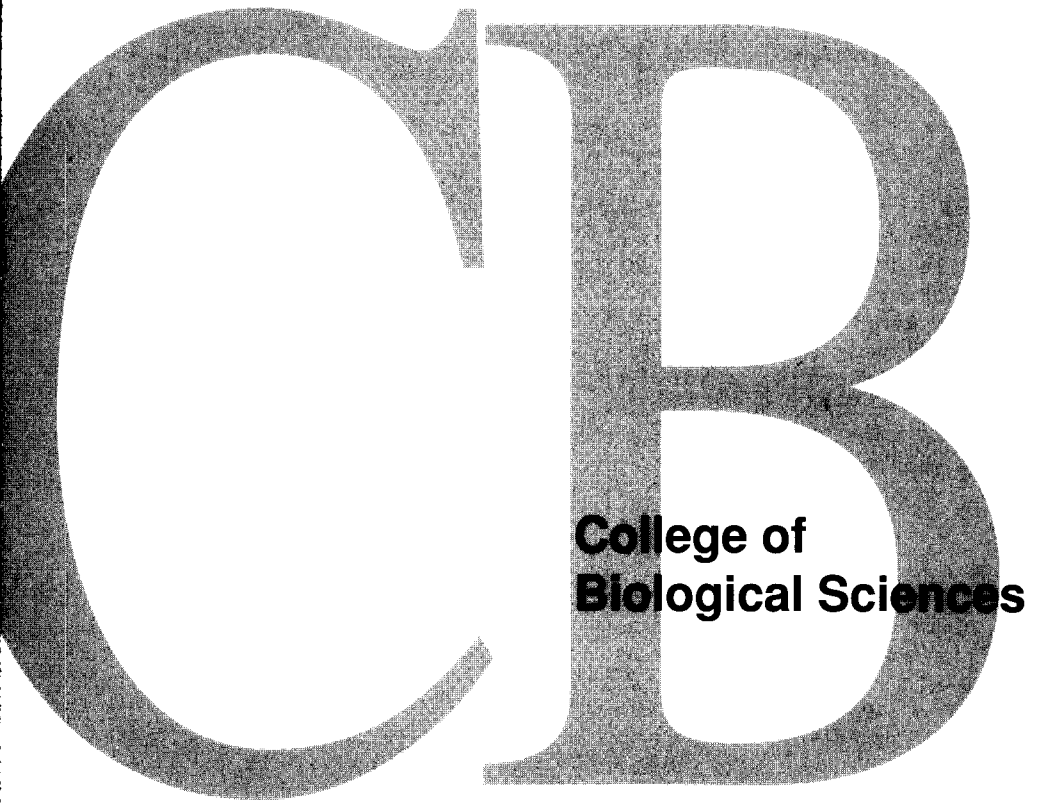
challenges we face in:

❖ **disease control**

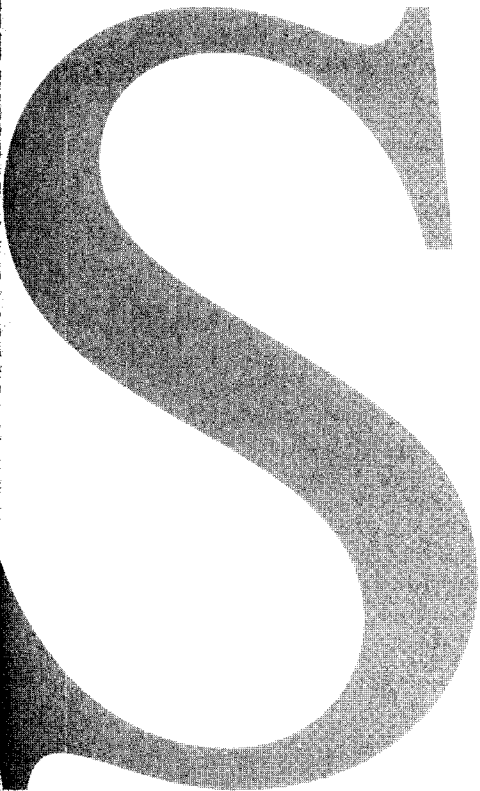
a CBS senior,

majoring in

biology.



College of Biological Sciences



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Introduction

Information Resources—This biennial bulletin focuses on the undergraduate offerings of the College of Biological Sciences (CBS) on the Twin Cities campus of the University of Minnesota. It includes brief CBS course descriptions, faculty information, and major requirements for students pursuing the B.S. degree in biochemistry; biology; ecology, evolution, and behavior; genetics and cell biology; microbiology; and plant biology.

The *Class Schedule*, distributed with registration materials each quarter, lists current course offerings scheduled for the term, including class hours, rooms, and instructors. It also includes registration instructions, final exam schedules, and other useful information. Information about evening courses and summer school offerings is contained in the *Extension Classes Bulletin* and the *Summer Session Bulletin*, respectively.

A bachelor of arts (B.A.) degree with a major in biology is available through the College of Liberal Arts (CLA). The core course requirements for this degree are the same as those for the bachelor of science (B.S.) degree. However, the B.A. student must fulfill the additional CLA requirements that are outlined in the *College of Liberal Arts Bulletin*. A student interested in teaching biology at the secondary level should consult the College of Education office for information about the postbaccalaureate program that is available.

College of Biological Sciences policies, and other specific information of interest to enrolled students, may be found in the *CBS Student Handbook*.

For More Information—Contact the Director of Student Services, College of Biological Sciences, 223 Snyder Hall, University of Minnesota, 1475 Gortner Avenue, St. Paul, MN 55108 (612/624-9717).

Policies

Bulletin Use—The information in this bulletin and other University bulletins, publications, or announcements is subject to change without notice. University offices can provide current information about possible changes.

Equal Opportunity—The University of Minnesota is committed to the policy that all persons shall have equal access to its programs, facilities, and employment without regard to race, color, creed, religion, national origin, sex, age, marital status, disability, public assistance status, veteran status, or sexual orientation. In adhering to this policy, the University abides by the Minnesota Human Rights Act, Minnesota Statute Ch. 363; by the Federal Civil Rights Act, 420 S.C. 2000e; by the requirements of Title IX of the Education Amendments of 1972; by Sections 503 and 504 of the Rehabilitation Act of 1973; by Executive Order 11246, as amended; by 38 U.S.C. 2012, the Vietnam Era Veterans Readjustment Assistance Act of 1972, as amended; and by other applicable statutes and regulations relating to equality of opportunity.

Inquiries regarding compliance may be directed to Patricia A. Mullen, Director, Office of Equal Opportunity and Affirmative Action, 419 Morrill Hall, 100 Church Street S.E., University of Minnesota, Minneapolis, MN 55455, (612) 624-9547.

Immunization—As of July 1, 1990, students born after 1956 who take more than one University class are required under Minnesota law to submit an Immunization Record form.

The form, which is sent along with the official University admission letter, must be filled out and returned to Boynton Health Service within 45 days of the first term of enrollment in order for students to continue registering for classes at the University. Complete instructions accompany the form.

Extracurricular Events—No extracurricular events that require the participation of students may be scheduled from the beginning of study day to the end of finals week. Exceptions to this policy may be granted by the Senate Committee on Educational Policy through whatever procedure it determines most feasible. The Senate advises all faculty that students who are unable to complete course requirements during finals week shall be provided an alternative and timely opportunity to do so.

College of Biological Sciences Directory

Office of the Dean 123 Snyder Hall 624-2244
Dean P. T. Magee, Associate Dean Sally Jorgensen

Student Services

Advising and Registration 223 Snyder Hall 624-9717
Kathleen Peterson, Leah Clark, Amy Winkel
Honors Program 223 Snyder Hall 625-4466
Dr. Franklin Barnwell
Minority Affairs 123 Snyder Hall 624-2244
Alonzo Newby
Services for Disabled Students 124E Snyder Hall 624-1257
Kathy Ball
Career Information Center 217 Snyder Hall 624-9270
Kathleen Peterson
Professional Learning Experience Program 217 Snyder Hall 624-9270
Amanda Martin
International Education 611 BioSci Center 625-1958
Dr. Willard Koukkari
Biology Colloquium P-154 Kolthoff Hall 626-1674
Dr. David Parmelee, Dr. Albert Frenkel,
Dr. Murray Rosenberg,
Dr. James Underhill
Community Outreach 217 Snyder Hall 624-9717
William Ganzlin

Departments, Institutes, and Programs

Bell Museum of Natural History 300 Bell Museum (Mpls.) 624-1852
Biochemistry 140 Gortner Lab (St. Paul) 624-7755
Biological Process Technology Institute 240 Gortner Lab (St. Paul) 624-6774
Cedar Creek Program 304 Zoology (Mpls.) 434-5131
Ecology, Evolution, and Behavior 109 Zoology (Mpls.) 625-4466
General Biology P180 Kolthoff Hall (Mpls.) 625-6636
Genetics and Cell Biology 250 BioSci Center (St. Paul) 624-3003
Gray Freshwater Biological Institute Navarre, MN 471-8476
Institute of Human Genetics 4-122 Moos Tower (Mpls.) 624-3110
Instructional Computing Center 122 Snyder Hall (St. Paul) 625-2273
Lake Itasca Program 306 Zoology (Mpls.) 625-9165
Microbiology 1460 Mayo (Mpls.) 624-6190
Molecular Biology Computer Center 247 Gortner Lab (St. Paul) 625-9284
Plant Biology 220 BioSci Center (St. Paul) 625-1234
Plant Molecular Genetics Institute 211 Borlaug Hall (St. Paul) 625-6282
Teaching Laboratory Support Staff 121 BioSci Center (St. Paul) 624-2789

Directors of Undergraduate Study

Biochemistry Dr. James Fuchs 144 Gortner Lab 624-1215
Biology Dr. Sally Jorgensen 123 Snyder Hall 624-2244
Ecology, Evolution, and Behavior Dr. John Tester 305 Zoology 625-8462
Genetics and Cell Biology Dr. Norman Kerr 254 BioSci Center 624-1789
Microbiology Dr. Palmer Rogers 925 Mayo 624-7140
Plant Biology Dr. Thomas Soulen 660 BioSci Center 625-2761

Message From the Dean

Message From the Dean

The College of Biological Sciences is one of the youngest colleges on the University of Minnesota Twin Cities campus. Its founding in 1965 grew out of the University's recognition that biology had become a scholarly endeavor of great importance to society and to the state. The college recognizes this social importance and the responsibility imposed by its mission to seek excellence in teaching, research, and service in all areas of the complex discipline of biology.

Today, our knowledge of biology is in a period of expansion that has few precedents. Thirty-seven years ago the chemical nature of genetic material began to be understood; 17 years ago an approach to the isolation of particular genes was proposed; today cells with artificially constructed genomes are used in areas from environmental clean-up to cancer chemotherapy. Similar advances in our understanding of the environment have come about in the past 20 years. The pace at which knowledge about biology is increasing makes it exciting to open the morning paper; a new breakthrough seems to come every week. Most exciting, however, is to be part of the effort.

Our research endeavor in the College of Biological Sciences is extremely broad. It includes studies of the molecular basis of phenomena as disparate as bacterial growth and mammalian behavior. It extends, sometimes in a single department, from the analysis of gene expression to the interaction of forest populations over the past several thousand years. Faculty in CBS study diverse organisms, from bacteria that degrade toxic compounds to lions in East Africa.

Our undergraduate and graduate teaching lies at the heart of the college's mission. We try to ensure that every undergraduate major will have an independent laboratory or field research experience, since this is the best way to discover what biological science is all about. We feel strongly that all educated



people should have a significant acquaintance with biology, and we present several courses for non-majors to address this need. Realizing the enormous pool of untapped talent that lies in groups not well-represented today in academic science, we are working hard to recruit women and minorities into our discipline.

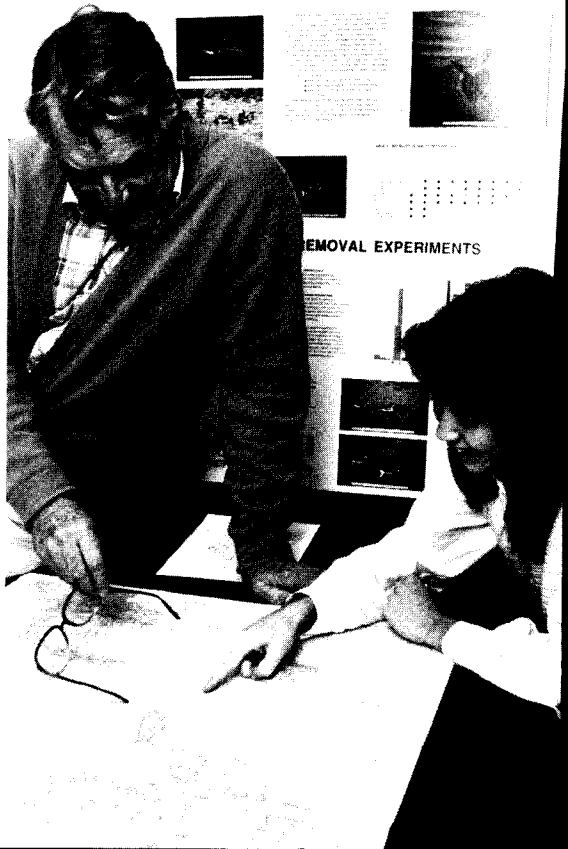
Almost every problem that society will face in the next 50 years has a significant biological component, and few can be solved if we neglect this critical area. We are committed to providing the education needed by every citizen to understand and help solve these problems. We welcome students who share with us interest in and excitement about the rapidly developing field of biology.

A handwritten signature in cursive script that reads "P. T. Magee".

P. T. Magee, Dean

College of Biological Sciences

Programs and Services





Our Affirmative Action Commitment

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

Successful affirmative action, however, involves more than just sensitive evaluation at the point of admission. Through its Office of Minority Student Affairs, which reports directly to the college dean, the college provides academic and counseling/advising services to racial minority and other under-represented University students before

application to CBS (see Student Services, in the first section of this bulletin). The intent of such services is to help prospective students increase their awareness of the opportunities for study and careers in biology and related professions and to enhance their prospects of being accepted for admission to CBS. Such services continue to be available to students subsequent to enrollment in CBS, to help them successfully complete their undergraduate degree programs.

Undergraduate Programs

"CBS has all the advantages of a small college—personalized instruction and help, small classes—combined with the advantages of a major university—world-renowned instructors, excellent facilities, and most importantly, encouragement to expand classroom learning with research experience. Quite simply, it's the best of all possible worlds."

—Michael Walker, CBS Student

Our students choose the College of Biological Sciences because we have a program of exceptionally high quality, offered by professors who are well-recognized in their fields. As students begin to plan for a

specific career they are urged to supplement their coursework with research experiences and internships to further develop their skills and prepare for successful entry into their chosen professions. Students are assisted in exploring their career interests in biology through the Biology Colloquium, a broad selection of course offerings, and special programs offered through the CBS Career Information Center.

Careers in Biology

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 will 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 as preparation for professional training in the health sciences. Since the entry requirements for the health sciences generally include similar courses to those required in CBS (math, chemistry, physics, and biology), students will find that a biology major provides the right foundation to explore and prepare for these fields of study. Approximately a fourth of our graduates each year choose to continue their education in health fields including medicine, dentistry, veterinary medicine, osteopathy, podiatry, optometry, and others.

CBS students beginning full-time employment immediately following graduation frequently take research scientist and laboratory technician positions. Others pursue a wide array of occupations requiring a liberal education and a bachelor's degree, from business fields (e.g., sales, quality control, communications) to public service (e.g., environmental control, public education). While national statistics have often

depicted a limited and competitive market for biology majors, CBS graduates have proven to be unusually successful in gaining employment in their chosen professional fields. 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.

Almost half of CBS graduates elect to pursue advanced study immediately after receiving the B.S. degree (approximately 25% are admitted to professional schools and 20% 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 upon request in 223 Snyder Hall.

A student interested in teaching biology at the secondary level should plan to complete a bachelor's degree in biology and then go on for specialized training through the College of Education's postbaccalaureate program.

The College of Biological Sciences hosts a biannual Career Information Fair to help students explore the vast array of careers in the biological sciences.

Special Learning Opportunities

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 seek employment as undergraduate teaching and research assistants or museum tour guides. Most departments offer special seminars for undergraduates.

Biology Colloquium—This is a unique class, organized and run by students, recommended for those who wish to explore the various fields and career alternatives in the biological sciences. Offered each quarter,

the class 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 Mayo Clinic, 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. The colloquium student leaders will help you find the project that fits your interests and allows you 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.

Undergraduate Research

"The opportunities to do research with a CBS faculty member make this a special college. I do not believe I could have gotten a better background in the biological sciences anywhere."

—Grant Anderson, CBS graduate

"I think the best thing about the College of Biological Sciences is the opportunity to do undergraduate research. My work with Dr. John Anderson has not only given me laboratory experience, but has given me a clearer understanding of what a scientist does. I have a much better idea of what I want to do with my future now."

—Michelle Anderson, CBS graduate

Each spring an Undergraduate Life Sciences Research Symposium is held to recognize the accomplishments of students participating in undergraduate research projects. The objectives of directed research are to provide students with experience in research and to obtain new information about the biological system under investigation. Students work largely on their own initiative and at their own pace, under the guidance of 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 students with a research stipend. The CBS Career Information Center maintains a Research Opportunities Notebook to help students find interesting research projects in laboratories throughout the University.

Professional Learning Experience Program (PLEP)

"Seeing principles learned in the classroom applied on the job is a great motivation to continue learning."

"Not only was my internship fun, it was a tremendous boost to my résumé and job qualifications."

—PLEP participants

The PLEP goal is to assist students in obtaining career-related experience to supplement their academic credentials. Experiential learning opportunities are designed to integrate classroom study with a work/learning assignment in the student's area of professional interest. Previous PLEP students have studied mountain goats in Switzerland, gained lab experience in private industry, completed animal behavior studies in northern Minnesota and ecology studies in Ecuador, to name a few projects. Organizations sponsoring PLEP opportunities include educational institutions, government agencies, businesses, and non-profit 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.

Honors—The College of Biological Sciences offers a specialized Honors Program for the most capable and motivated students. The Honors Program emphasizes undergraduate research and specialized seminars to bring students together to discuss biological issues of critical importance to society. (See full program description later in this bulletin.)

International Opportunities—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 offers them opportunities to enhance their education by taking advantage of international programs sponsored by the University. The opportunities include exchange programs for study abroad, special travel programs, and individualized research and internship experiences for students with more specialized interests.

Recent students have taken advantage of opportunities to study genetics in the Soviet Union, the biology of Koala bears in Australia, marine biology in the West Indies, and chimpanzee behavior in West Africa.

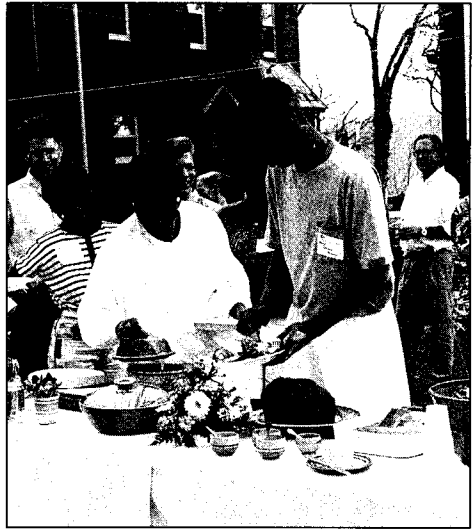
Special Exams for Credit—Students earn college-level credit for prior learning and independent preparation through a variety of programs:

CLEP—College Level Examination Program. By passing one or more of these standardized exams, students may earn credit toward University of Minnesota degrees.

AP—Advanced Placement. These exams provide college credit for accelerated or advanced courses completed in high school.

University Special Exams—Students who have acquired special knowledge of a subject, either through individual study or experience in a non-accredited program, may arrange to earn credit by exam for most University courses. Students must be currently enrolled to be eligible to earn credits by exam.

Individually Designed Program—The Individually Designed Program (IDP) in the College of Biological Sciences is designed for students whose interdisciplinary interests and goals cannot be met by a traditional biological sciences major. Requirements for the IDP are flexible. Except for prerequisite courses (a course in general biology, two quarters of general chemistry and at least one quarter of calculus), there are no specific



course requirements, although there are minimum credit requirements in the selected areas of concentration. IDP students are expected to choose one area of concentration from within the biological sciences and one or two others from programs outside of CBS.

IDP majors generally have a thematic or career orientation. To be accepted into the program, applicants must present a statement of goals and objectives to the program admissions committee, clarifying their need for designing a unique program. Some of the careers for which IDP students have prepared themselves are bio-cinematography, scientific illustration, genetic counseling, environmental health, patent law, and natural history.

Student Organizations

Biological Sciences Student Association (BSSA)—Through the BSSA, biology undergraduates can officially serve on college committees and voice student concerns. The BSSA plans educational and social activities throughout the year. Information is available in the CBS Student Services Office. All University of Minnesota biology students are invited to attend. Involvement in the association is an excellent way to meet faculty and students.

Genetics and Cell Biology Club—Students formed the Genetics and Cell Biology 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 Student Services Office (612/624-9717) or the genetics and cell biology department office (612/624-3003).

Ecology Club—The Ecology Club was established in 1991 to bring together students interested in the ecological and environmental problems of the world. The purpose of the meetings is basically educational; however, each activity is planned to bring together students and faculty in an informal, social atmosphere. For more information, contact the Student Services Office (612/624-9717) or the ecology, evolution, and behavior department office (612/625-4466).

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 Student Services Office (612/624-9717) or the microbiology department office (612/624-6190).

Bailey Hall Biology Club (BHBC)—All Bailey Hall Dorm residents interested in life sciences are encouraged to participate in BHBC. The club was established to foster contact among biology students as well as with faculty. BHBC meets for monthly dinners and discussions and provides academic and social experiences for its members.

Biological Sciences Alumni Society (BSAS)—The society provides a professional association for biological sciences graduates, and encourages relationships

between 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 Information Center to develop the Career Information Network, an innovative program to help current students and graduates explore career options. The society sponsors undergraduate merit scholarships, undergraduate research grants, student activities, and supports continuing education programs in the biological sciences. Student and alumni volunteers have also assisted the college with student recruitment, especially of women and minorities. Further information on BSAS may be obtained from the Office of the Dean, 123 Snyder Hall (612/624-2244) or from the Minnesota Alumni Association, 100 Morrill Hall, 100 Church Street S.E., Minneapolis, MN 55455 (612/624-2323).

Student Services

"Since CBS is a small college, it has the unique ability to offer a personalized undergraduate experience and access to the extensive scientific community at the University of Minnesota."

—Kathryn Nelson, CBS graduate

The size and diversity of the University of Minnesota 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 of the college Student Services Office. Members of the advising staff are available by appointment for students to discuss a wide array of concerns. Upon admission to the college as juniors and seniors, students are also

assigned to a CBS faculty adviser in their particular area of interest. Summarized below are the types of advising services available. The student services office 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

- Admissions counseling
- Career transitions
- Prospective student information
- High school and community college visits
- College tours
- Summer science program
- Mentor program

New Student Advising

- Orientation
- Course planning
- Exploration of life science 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 Program
- Biology Colloquium
- Biological Sciences Student Association
- CBS club activities
- Alumni Society

Major and Faculty Advising/Mentoring

- Program planning
- Career exploration/planning
- PLEP
- Undergraduate research
- Seminars

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, and arrange to work with faculty in laboratory and field settings.

Career Information Center (CIC)—The CBS Career Information Center helps students explore the varied career options available to graduates in biology. Undergraduates are encouraged to consult with the center early to investigate careers, learn about career preparation, and begin to make decisions. The CIC provides extensive



Programs and Services

career and employer information, as well as connections to professionals in many fields. Contacts made through the Professional Learning Experience Program, the biannual Career Information Fair, and the Alumni Career Network program ensure that students make well-informed career decisions.

As graduation approaches, the CIC assists students in applying to graduate schools and professional health sciences programs. For those choosing to enter the job market directly, the center provides assistance in building job search skills (including résumé writing and interviewing), as well as job books and a specialized résumé distribution service.

Minority Affairs—The coordinator of minority affairs is available to meet individually with students to explore potential interests in biology, to provide academic assistance (including individual tutoring, when needed), and to help students overcome barriers to educational success. Students are encouraged to ask about financial aid and scholarship opportunities. For more information, contact Alonzo Newby, 123 Snyder Hall, 612/624-2244.

International Education—Information on opportunities for study and research abroad is posted outside 123 Snyder Hall and in the special international activities section of Student Services in 229 Snyder Hall. Interested students are also encouraged to meet with Dr. Willard Koukkari, International Education Officer for the College (611 BioScience Center, 612/625-1958).

Student Facilities

Student/Faculty Lounge—Undergraduate biology students are invited to use the newly renovated student/faculty lounge in 128 Snyder Hall on the St. Paul campus. The lounge is an excellent place to study, relax between classes, and meet with other students and faculty. The lounge is furnished with a small reference collection and current journals covering many fields of interest in biology.

Computer Access—Computers are available for undergraduate students to use for course-related assignments. The computers are located in the new Instructional Computing Lab, 122 Snyder Hall and in the Molecular Biology Computer Center, 247 Gortner Lab. Students are encouraged to investigate some of the exciting new software that has been developed for the biological sciences.

Libraries—The University of Minnesota library system ranks among the largest American university libraries, with over four million catalogued volumes. In addition to science and technology collections in Walter Library and the St. Paul Central Library, biological sciences students also benefit from specialized collections in the Bio-Medical Library, the Biochemistry Library, the Entomology, Fisheries and Wildlife Library, and the Natural History Library.

Financial Assistance

The University of Minnesota Office of Student Financial Aid is located at 210 Fraser Hall (612/624-1665). The office is open to serve students from 8 a.m. to 6 p.m. Mondays and 8 a.m. to 4 p.m. Tuesday through Friday. Prospective or newly admitted students may also wish to consult with high school counselors.

Bioscience Scholarships and Grants

Biology students are encouraged to apply for both need-based and merit scholarships to help pay college tuition. CBS students may qualify for one of the following scholarships or grant awards:

Biological Sciences Senior Scholarships—award given by the Biological Sciences Alumni Society to recognize and reward students who show initiative, enthusiasm, and commitment to their program in the biological sciences.

Stanley Dagley Scholarship—annual award to a deserving undergraduate in memory of Regents' Professor Stanley Dagley, biochemistry.

Michael C. Loveless Scholarship—annual award to a deserving senior in CBS with demonstrated leadership abilities, given in memory of Mike Loveless (class of 1986), an outstanding former CBS student.

Itasca Director's Fund Scholarship—award presented to a student attending the Itasca summer session to help defray the cost of tuition and living expenses. The award is made possible by many former students and staff who retain fond feelings for the field station.

Eloise Newcomb Pittman Scholarship—given when appropriate to an outstanding female student in plant sciences.

Belwin Undergraduate Scholarship for Field Study—supports research relating to the natural environment. The research must include some field work at the Belwin Nature Center or surrounding area.

Leon A. Snyder Award—given in memory of Professor Snyder of the Genetics and Cell Biology Department to a deserving undergraduate student in biology.

Applications for all scholarships and awards listed above are due May 1. Applications must be accompanied by the CBS Scholarship Application Cover Sheet.

LaVell M. Henderson/Henrietta Miller Scholarship—presented to an outstanding senior biochemistry student who has demonstrated research capabilities. Application deadline: December 15.

Philip C. Hamm Memorial Scholarship—encourages and rewards undergraduate students who show promise as research scientists in the plant sciences. Two scholarships of \$500 each. Campus contact: Dr. Philip Olson, 612/625-8200. Application deadline: March.

Carol E. Macpherson Scholarship—awarded to females 28 years or older who have been out of college for at least 5 years. Application deadline: late March.

Sigma Xi Awards

Nominations for Sigma Xi awards are made by Sigma Xi members with a letter of recommendation and appropriate supporting documentation. The executive committee of Sigma Xi chooses the winner of the following three awards:

Thomas F. Andrews Prize—open to students in any school or college of the University, who have demonstrated proficiency in independent research in science and who have not yet obtained a baccalaureate degree. Papers and other evidence of research work offered in application may be used by the student for thesis purposes if so desired. The award involves a cash prize plus initiation fees and admission to membership in Sigma Xi.

George T. Walker Prizes—given to senior students in chemistry who are selected on the basis of aptitude in science and promise in research. The award consists of two undergraduate cash prizes, plus initiation fee and admission to membership in Sigma Xi.

Olson-Wallace Award in Zoology—given to an undergraduate or graduate student for original research in the zoological sciences in the broadest sense. The research is to be in the form of a thesis, a paper published in a reviewed scientific journal, or a paper presented at a national meeting. This award was established in 1978 in honor of Magnus Olson and Franklin G. Wallace, emeriti CBS zoology faculty.

Undergraduate Research Opportunity Program Grants

The University of Minnesota's Undergraduate Research Opportunities Program offers financial awards to undergraduates for research, scholarly, or creative projects undertaken in partnership with a faculty member.

Programs and Services

UROP affords undergraduates the unique educational experience of collaborating with a faculty member on the design and implementation of a project. At the same time, faculty have the opportunity to work closely with students and receive valuable assistance with their own research or professional activity. UROP adds a new dimension to the undergraduate experience. It encourages students to conduct research and pursue academic interests outside of their regular courses by employing them to work on special projects.

UROP applications are judged on the basis of the quality of the proposed project and the educational benefit to the student. Since funding is limited, awards are granted to the strongest proposals. There are three opportunities to apply for research funds each year: November, January, and April.

National Scholarships

Harry S. Truman Scholarship—For undergraduate study leading to graduate study and a career in public service. Applicants must be U.S. citizens or nationals, currently-enrolled juniors with a minimum 3.00 GPA at time of application, and seniors in 1991-1992 year. Award covers college fees up to \$10,000 for up to three years. (105 scholarships available nationwide, at least one award given to a Minnesota resident). Campus contact: Philip K. Wagner, CLA Honors Division. Application deadline: late October.

Barry M. Goldwater Scholarship—For undergraduate study leading to graduate study and a career in mathematics or the natural sciences (normally does not include engineering or the health sciences). Applicants must be U.S. citizens and must be currently-enrolled sophomores with a 3.00 GPA at time of application. Award covers all college fees to a maximum of \$7,000 for up to two years. (300 scholarships nationwide, at least two given to Minnesota residents). Campus contact: Philip K. Wagner, CLA Honors Division. Application deadline: early January.

Cambridge Exchange Scholarship—For one additional senior year of study for a University of Minnesota student at Cambridge University, England. Applicants must be U.S. citizens or permanent residents with a minimum 3.50 GPA; preference usually given to students with more than 135 credits at time of application who are making regular progress toward a bachelor's degree. (One award). Campus contact: Philip K. Wagner, CLA Honors Division. Application deadline: mid-March.

Study Abroad

The University of Minnesota International Study and Travel Center administers two scholarship programs for undergraduates who wish to study abroad (102 Nicholson Hall, 612/626-9000).

Dunn Peace Research Scholarship—Provides a \$1500 award for overseas research relevant to issues of international peace. Application deadline: mid-March.

International Student Identity Card Scholarship—Provides travel subsidies (\$200 to \$1500) for students who are planning study or service projects in developing countries. Application deadline: October and March.

Leadership Awards

Donald R. Zander—for outstanding leadership, service, and academic achievements. Nomination deadline: late winter quarter.

Dean E. M. Freeman—for outstanding leadership on the St. Paul Campus. Nomination deadline: early spring quarter.

President's Leadership and Service Award—presented to the top one-half of one-percent of the student body for exceptional leadership and service to the University and/or surrounding community. Campus contact: Roger Harrold, 612/624-5101. Nomination deadline: March.

College of Biological Sciences

Admission Procedures and Degree Requirements



Admission Procedures and Degree Requirements



Admission to CBS

Students normally enter CBS at the beginning of their junior or senior year. The first years may be completed in another unit within the University, at a community college, or at any four-year college or university. CBS faculty and staff would be happy to assist you in selecting appropriate coursework for transferring to the college. CBS plans to begin admitting sophomore students in fall 1993. Information is available from the student services office. During the freshman and sophomore years, students should plan to complete, as a minimum, the beginning English composition course, mathematics, general chemistry, and general biology. Most students will take organic chemistry during their sophomore year, thereby allowing ample time for major coursework and research experience.

To the extent possible, from the information available regarding a particular applicant, applications are given individualized attention. Such factors as racial and cultural background and economic or educational disadvantage are considered carefully to prevent excluding students whose academic potential for success might be misjudged based on traditional predictors alone.

Acceptance to CBS

Successful completion of 84 quarter credits (with a GPA of at least 2.00) including General Biology 1009, General Chemistry 1004 and 1005, and Calculus 1251 and 1252 (with grades of at least a C, or equivalent courses with grades of at least a C) are required for admission. Applications can be acted on before grades from current coursework are available. Qualified students will be admitted subject to satisfactory completion of current registration. Equivalent courses are transferable. Students who are admitted as sophomores beginning in the fall 1993 must meet the following requirements: a minimum of 40 credits with a GPA of 2.50 or better, including grades of C or better in Chem 1004-1005 (or equivalent); Math 1251 (or equivalent); and a college-level biology course. Admitted students will receive a letter of acceptance from both the Office of Admissions and the College of Biological Sciences with information about orientation dates and registration.

Procedure Checklists

I. Application for Admission From Outside the University

Transfer students should apply directly to the College of Biological Sciences (CBS). Because CBS is an upper division unit within the University, certain requirements must be completed before admission. If these requirements have not been completed at the time of application, we will recommend that you be admitted to the College of Agriculture or College of Liberal Arts as a "pre-biology" student. Acceptance into a "pre-biology" program requires that you meet the admission standards for the College of Agriculture or the College of Liberal Arts. See their college bulletins for specific requirements. Acceptance into "pre-biology" ensures that you will have contact with a biology adviser early in your academic career. Students eligible for admission directly to CBS should follow these deadlines:

<i>Fall quarter:</i>	June 1
<i>Winter quarter:</i>	October 15
<i>Spring quarter:</i>	January 15
<i>Summer quarter:</i>	May 1

New freshmen as well as transfer students who elect to complete their prerequisite coursework in the College of Liberal Arts should apply between *October 1 and December 15* of the year before desired admission.

Applications to the University may be requested from:

Office of Admissions, 612/625-2008
1-800-752-1000 (toll free)

Questions? Call the CBS Student Services Office at 612/624-9717.

International Students

Deadlines for applications from international students are:

<i>Fall quarter:</i>	June 1
<i>Winter quarter:</i>	October 1
<i>Spring quarter:</i>	January 1

Orientation Procedures

Before classes begin, you will be invited to attend a New Student Program/Orientation session. It will acquaint you with the campus and provide information about the college and the University. Part of the time will be spent with an adviser who will help you plan your biology program. You are urged to participate. Failure to attend will result in a late registration date and difficulty obtaining needed courses.

Transfer students will also attend a College of Biological Sciences orientation/reception during the first week of the quarter. Information will be presented about research and internship opportunities as well as other important information critical to your success in preparing for a profession in biology.

II. Application for Transfer From Within the University System

Students who wish to transfer to the College of Biological Sciences from another college on the Twin Cities campus or from one of the coordinate campuses should submit a Transfer of College form to the Office of Admissions. Deadlines are as follows:

<i>Fall quarter:</i>	June 1
<i>Winter quarter:</i>	October 15
<i>Spring quarter:</i>	January 15
<i>Summer quarter:</i>	May 1

Transfer applications may be requested from your admissions and records office and forwarded to:

Office of the Registrar
University of Minnesota
150 Williamson Hall
231 Pillsbury Drive S.E.
Minneapolis, MN 55455
Phone: 612/625-5333

Questions? Call the CBS Student Services Offices at 612/624-9717.

Orientation Procedures

If you are transferring from a coordinate campus, you will be invited to a New Student Program/Orientation session. It will

Admission Procedures and Degree Requirements

acquaint you with the Twin Cities campus and you will receive general information about the college. Part of the time will be spent with an adviser who will help you plan your biology program. You are urged to participate. Failure to attend will result in a late registration date and difficulty obtaining needed courses.

All new students will attend a College of Biological Sciences orientation/reception during the first week of the quarter. Information will be presented about research and internship opportunities as well as other important information critical to your success in preparing for a profession in biology.

Application for Admission With Adult Special Status

The adult special status is for those who have completed a degree already and who want to take courses for personal interest or to meet admission requirements for advanced programs. A degree transcript must be submitted with the application. Adult special applications may be requested from and returned to:

Office of Admissions
240 Williamson Hall
231 Pillsbury Dr. S.E.
Minneapolis, MN 55455
Phone: 612/625-2008
1-800-752-1000 (toll free)

The deadlines for receipt of complete Adult Special applications:

<i>Fall quarter:</i>	September 1
<i>Winter quarter:</i>	December 1
<i>Spring quarter:</i>	March 1
<i>Summer quarter:</i>	May 1

Access to Student Educational Records

In accordance with regents' policy on access to student records, information about a student generally may not be released to a third party without the student's permission. (Exceptions under the law include state and

federal educational and financial aid institutions.) The policy also permits students to review their educational records and to challenge the contents of those records.

Some student information—name, address, telephone number, dates of enrollment and enrollment termination, college and class, major, adviser, academic awards and honors received, and degrees earned—is considered public or directory information. Students may prevent the release of public information only during their terms of enrollment. To do so, they must notify the records office on their campus.

Students have the right to review their educational records. The regents' policy, including a directory of student records, is available for review at the Williamson Hall Information Center, Minneapolis, and at records offices on other campuses of the University. Questions may be directed to the Office of the Registrar, 150 Williamson Hall (612/625-5333).

Degree Requirements

The bachelor of science degree program in the College of Biological Sciences is composed of 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 ignorance that limits their powers of judgment and choice. It provides students with the skills for acquiring and communicating knowledge; 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, CBS 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 Math—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.

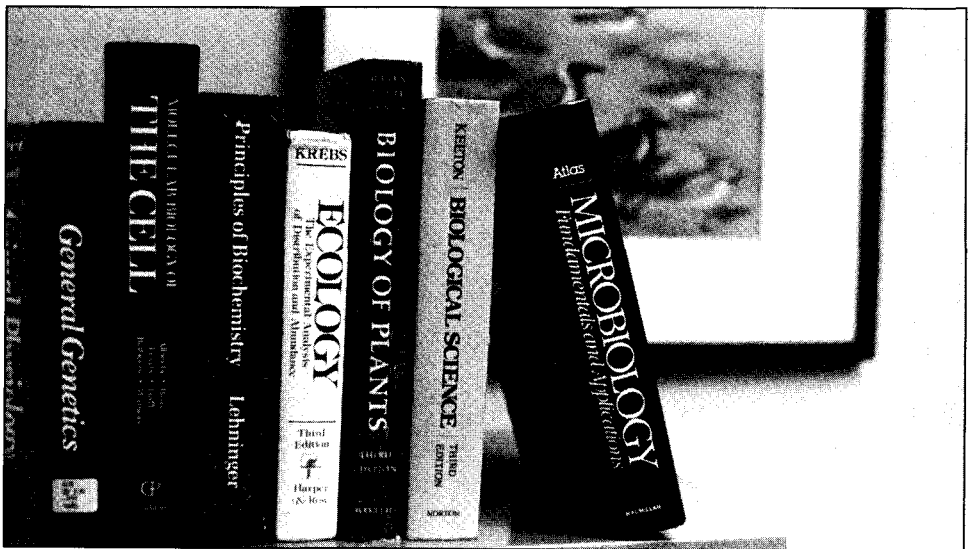
Modern biologists in the field and in the laboratory must be able to use fundamental principles of mathematics, chemistry, and physics in order to appreciate living organisms at all levels from molecules to ecosystems.

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 and gene function.

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 air flow, 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. The 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. Three of these courses introduce students to various kinds of organisms and their functioning: animal biology, plant biology, and microbiology. 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 introduces students to populations, evolution, and the behavior of animals.

IV. Specialization in the Major—In

addition to completing the core curriculum, students take additional 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 departmental majors (biochemistry; ecology, evolution, and behavior; genetics and cell biology; microbiology; and plant biology). These more specialized majors each have required courses as specified by the department. In addition to elective courses most students will plan to complete a research project in their special area of interest; each department offers credit for Directed Study (5970) and Directed Research (5990).

Requirements for Graduation

To earn a bachelor of science degree from the College of Biological Sciences, a student must complete a minimum of 180 credits with grades of *A*, *B*, *C*, or *S*. In order to be used for credit toward graduation, each credit of *D* must be balanced by a credit of *A* or *B* in a course at the same level; each credit of *D* earned in courses meeting specific science or math requirements must also be balanced by a credit of *A* or *B* in courses at the same level that meet those requirements. Grades of *D* are not accepted in courses specifically required for admission—Biol 1009, Chem 1004-1005, Math 1251-1252 or their equivalents.

CBS students may apply up to eight technical, non-liberal arts college credits toward their degrees (e.g., credits in physical education or military science). Check with an adviser in 223 Snyder Hall for details.

Residency Requirements

a. A minimum of 45 credits in courses taken on the Twin Cities campus. Candidates for the B.S. degree must present a minimum of 75% of their University of Minnesota residence credits (required for graduation) in courses in which grades of *A*, *B*, *C*, or *D* have been received.

b. A minimum of 36 credits as a student registered in the College of Biological Sciences. These credits may also apply toward a) above.

c. A minimum of 30 credits on the Twin Cities campus in 3xxx and 5xxx courses that are specifically required for the student's major. Ordinarily this will include 3xxx and 5xxx course listed in this bulletin as well as appropriate advanced courses in mathematics, statistics, computer science, and the physical sciences.

Course Requirements

1. English Communication Skills—Writing practice (freshman composition; Comp 1011 or Rhet 1101 or equivalent) and one advanced course in writing to be selected from the following: Comp 3015, 3027, or 3033; Rhet 3562.

2. Second Language—Either two years of study of one second language in high school or three quarters (one year) of study of one second language in college or demonstration of equivalent proficiency satisfactory to the appropriate language department.

3. The all-University liberal education distribution requirements:

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

Group B—The Physical and Biological Universe

Group C—The Individual and Society

Group D—Literary and Artistic Expression

The mathematics and science coursework that is required of CBS students (see items 4 and 5) will automatically satisfy the minimum University requirements for group A and group B. In addition, CBS students

**CBS Science Requirements
Suggested Time Sequence**

	Freshman			Sophomore			Junior			Senior		
	F	W	S	F	W	S	F	W	S	F	W	S
Earliest Possible *												
Recommended ¹	—————											
Latest Possible	- - - - -											
A. Prerequisites												
Calculus (three quarters)	—————			- - - - -			- - - - -					
General Chemistry (two quarters)	—————			- - - - -								
Organic Chemistry (two quarters with lab)			*	—————			- - - - -					
Physics ² (three quarters)				—————						- - - - -		
General Biology (one quarter)	—————			- - - - -								
B. Biology Core³												
Biol 3011, Animal Biology			*	—————								- -
Biol 3012 or 3812, Plant Biology			*	—————								- -
Biol 5013, Microbiology						*	—————					- -
Biol 5041 or 5841, Ecology				- - - - -			—————					- -
Biol 5001, Biochemistry						*	—————					- -
Biol 5003, Genetics						*	—————					- -
Biol 5004, Cell Biology						*	—————					- -

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

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

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

Admission Procedures and Degree Requirements

must complete 30 credits from Groups C, D, World Studies, and Cultural Pluralism, including a *minimum* of 8 credits each in group C and group D.

A list of courses recommended to meet each group distribution requirement and descriptions of courses can be found in the *College of Liberal Arts Bulletin* and in the *CBS Student Handbook*. Direct questions concerning acceptable courses to the Student Services Office, 223 Snyder Hall.

4. Physical Sciences and Mathematics—

a. Mathematics—A three-quarter analytic geometry and calculus sequence (Math 1251-1252-1261 or equivalent). A two-quarter course sequence in statistics or statistics and computer science may be substituted for the third quarter of calculus (Stat 3011-3012, or PubH 5450-5452, or PubH 5450 with CSci 3104, or PubH 5450 with HInf 5430). Biochemistry majors, however, are required to complete the three-quarter calculus sequence.

b. Chemistry—Each of the following: General chemistry, two quarters (Chem 1004-1005 or 1031-1032 or equivalent); Organic chemistry, two quarters with laboratory (Chem 3301-3302-3305-3306 or 3331-3332-3335 or equivalent). Students who plan to major in biochemistry are encouraged to take the sequences designed for chemistry majors (listed as options above).

c. Physics—A full-year course, with laboratory, that requires college-level mathematics as a prerequisite (Phys 1251, 1252, 1253, (1254 optional) or 1104-1105-1106 with 1107-1108-1109). By petition, a two-quarter sequence (Phys 1041-1042 with 1045-1046) plus an additional four to five credits of mathematics, statistics, computer programming, or physical science chosen in consultation with the major adviser may be substituted. Biochemistry and microbiology majors are advised to take a calculus-based sequence (Phys 1251, etc.).

5. Biological Sciences (the Core Curriculum)—

a. General Biology (Biol 1009, 5 cr, or equivalent, or exemption). Students with a strong background from high school or individual study are encouraged to take the Biol 1009 exemption exam.

b. Animal Biology (Biol 3011, 5 cr, or Biol 3111, 4 cr, if the student has completed general zoology with a lab). Those students who have completed a general zoology course *or* the appropriate component of a year long general biology course with a grade of *A* or *B* may also complete the animal biology requirement by satisfactorily completing one of the following courses in physiology: EEB 5156, GCB 5114, or GCB 5134. This 5xxx-level physiology course may count towards item i below.

c. Plant Biology (Biol 3012 or 3812, 5 cr). Students who have completed a course in general botany may validate the Biol 3012 requirement by taking an upper division course in plant biology (*minimum* 3 credits) that has Biol 3012 as a prerequisite; credits from the upper division course will count towards item i below.

d. Biochemistry (Biol 5001, 4 cr).

e. Genetics (Biol 5003, 4 cr).

f. Cell Biology (Biol 5004, 3 cr).

g. Microbiology (Biol 5013, 5 cr).

h. Ecology (Biol 5041 or 5841, 4 cr).

i. Nineteen upper division credits in mathematics and/or physical and/or biological sciences. This includes work specified for departmental majors (see Major Requirements and Course Descriptions).

j. Laboratory or field work in two additional upper division biological sciences courses. Credits earned may be used toward fulfilling item i above. A list of acceptable courses follows:

Biol 5112, 5125

BioC 5025, 5744, 5990 (4 cr minimum/see note below*)

EEB 5014, 5016, 5129, 5134, 5156, 5607, 5621, 5990 (4 cr minimum/see note below*)

GCB 5015, 5030, 5605, 5990 (4 cr minimum/see note below*)

MicB 5234, 5322, 5425, 5990 (4 cr minimum/see note below*)

PBio 3109, 3201, 5103, 5105, 5107, 5111, 5132, 5231, 5990 (4 cr minimum/see note below*)

All CBS courses offered at the Lake Itasca Forestry and Biological Station except Biol 3812, are acceptable.

*An independent research project is *strongly* recommended for every student. To use one of the department Directed Research courses to satisfy one of the upper division lab or field work requirements, students must complete a minimum of four credits under the 5990 course number.

Honors Program

"The CBS Honors Program is a big plus for students planning on a science career, whether academic, medical, commercial, or other. It can be a valuable tool for providing much needed experience and insight for your life."

—John Hollerud, former Honors Program student

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

Directed Research—The objectives of directed research are to provide participants with experience in research and to obtain new information about the biological system under investigation. A goal of the Honors Program is to promote research of a quality that warrants publication in a professional journal. Honors Program participants should select a research adviser from the biology faculty and start on a research project early



Admission Procedures and Degree Requirements

in their junior year or as soon thereafter as possible. Participation in a minimum of two quarters (a total of eight credits) of research is required; students may register in BioC 5990, EEB 5990, GCB 5990, MicB 5990, or PBio 5990. An honors thesis, summarizing the research and written in the style of a publishable manuscript, is required of all honors students. The thesis must be approved by the faculty member supervising the research and by two other members of the faculty (at least one of whom must be from the college).

Honors Seminar—Two quarters of participation in the CBS Honors Seminar (Biol 3960H) are required of all Honors Program graduates. In the fall quarter, the seminar is a forum to discuss special topics focused on a theme of general relevance to all biologists. In the spring quarter, seniors nearing completion of their directed research projects are required to present summaries of their project results and to prepare a research poster for presentation at our annual Undergraduate Life Sciences Research Symposium. Students are required to take a seminar in the fall, and follow that with a seminar in the spring quarter preceding graduation. They are also encouraged to attend the spring quarter seminar before the senior year.

Honors Program Admission—Qualified students should apply for admission to the Honors Program as soon as they have been admitted to the college. A minimum of three quarters of honors registration must be completed to fulfill the requirements for graduation with honors. Applicants should have a minimum grade point average of 3.40 and present reasonable evidence of potential to attain the GPA required for graduation with honors (see below). Application forms are available in 223 Snyder Hall.

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

1. At least 60 credits in upper division courses (3xxx and 5xxx) at the University of Minnesota Twin Cities campus
2. Two quarters (8 credits) of directed research, the results of which are to be reported in an acceptable honors thesis
3. Two CBS honors seminars (Biol 3960H), one of which must be completed during fall quarter and the other during the last spring quarter in residence
4. One additional honors opportunity, which may be selected from the following:
 - a. An additional quarter (2 credits) of participation in directed research
 - b. An honors seminar offered by the Honors Division of the College of Liberal Arts
 - c. An upper division honors course (3xxx or 5xxx course designated by H)
 - d. An 8xxx course (seniors only; requires Graduate School permission)
5. The last 90 credits of A-F registration with the minimum grade point averages specified below:

cum laude: minimum 3.40 GPA

magna cum laude: minimum 3.60 GPA

summa cum laude: minimum 3.80 GPA

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

Students planning to graduate with honors in microbiology must include specific courses in their programs in addition to meeting the college requirements. A listing of these requirements is included in the *CBS Student Handbook* or may be obtained from the student services office.

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

College of Biological Sciences

Major Requirements and Course Descriptions



Major Requirements and Course Descriptions

Course Numbers and Symbols—Courses primarily for freshmen and sophomores are numbered 1000 through 1998; for sophomores, juniors, and seniors, 3000 through 3998; for juniors, seniors, and graduate students, 5000 through 5998. Courses numbered 8000 and above are restricted to graduate students.

The following symbols are used throughout the descriptions:

, The comma, used in prerequisite listings, means “and.”

§ Credit will not be granted if credit has been received for the course listed after this symbol.

¶ Concurrent registration is allowed (or required) in the course listed after this symbol.

Registration Override Permit, completed and signed by the instructor, is required for registration.

Δ Registration Override Permit, completed and signed by the department offering the course, is required before registration.

† All courses preceding this symbol must be completed before credit will be granted for any quarter of the sequence.

H Honors course.

Directed studies course numbers end in “970” and directed research in “990.”

Sequence courses, separated by hyphens (e.g., 3142-3143-3144), must be taken in the order listed.

Series courses, separated by commas (e.g., 1234, 1235, 1236), may be entered any quarter.

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

Prerequisites should be considered as guides. When a prerequisite is listed, an equivalent course may be substituted. Consult the course instructor for more information.

Biology (Biol)

Director of Undergraduate Studies—Sally Jorgensen

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

The biology program provides the student with a broadly based, thorough undergraduate education in the biological sciences. Biology majors must complete the graduation requirements outlined under Admission Procedures and Degree Requirements. The distribution of the 19 additional upper division credits in the mathematical, biological, and/or physical sciences is determined by each student in consultation with the adviser. Students may request a faculty adviser from any of the departments of the college. A prospective major should begin general chemistry and mathematics coursework as early as possible.

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

A student interested in teaching biology at the secondary level should consult the College of Education office for information about the postbaccalaureate program.

General Education—Courses especially appropriate for non-science and non-biology majors include BioC 3001, 3031; Biol 1008, 1009, 1101, 1103, 1106, 1301, 3051, 3112; EEB 3001, 3111; GCB 3002, 3008, 3022; MicB 3103; PBio 1009, 1012.

Minor Sequence

Required Preparatory Courses—Biol 1009
Minor Requirements—Minimum of 15 3xxx-5xxx cr chosen from courses carrying the following designators: BioC, Biol, EEB, GCB, MicB, PBio, Phsl.

One course about animals, Biol 1106 or 3011, and one course about plants, Biol 1103 or 3012.

The minor program must be approved in the student services office, 223 Snyder Hall.

Biol Courses

1008. INTRODUCTORY BIOLOGY: AN EVOLUTIONARY APPROACH. (4 cr)

Description of evolution as the unifying principle in biology; organization and change in the biological world and the origin of humans.

1008H. INTRODUCTORY BIOLOGY: AN EVOLUTIONARY APPROACH. (4 cr)

For description, see 1008. Intended especially for honors students or their equivalent who plan to major in a life science discipline.

1009. GENERAL BIOLOGY. (5 cr)

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

1009H. GENERAL BIOLOGY. (5 cr; prereq honors division or 3-4 yrs high school mathematics, high school chemistry or Δ)

For description, see 1009. Intended especially for honors students or others with the requisite background who plan to major in a life science discipline.

1101. HEREDITY AND HUMAN SOCIETY. (4 cr, §GCB 3002; no cr if taken after 5003 or GCB 3022; for students in programs not directly related to biological sciences)

Principles of heredity and their social and cultural implications.

1103. GENERAL BOTANY. (5 cr, §3012; prereq 1009; students who plan to major in biology in CLA or in any bioscience major in CBS should take 3012)

Plant organization, function, growth and development, reproduction. Lab.

1106. GENERAL ZOOLOGY. (5 cr; prereq 1009)

Survey of animal phyla: structure, function, behavior, adaptation, and evolutionary relationships. Lab.

1301. HUMAN REPRODUCTION AND DEVELOPMENT. (4 cr; prereq 1009 or equiv)

Human development from gametogenesis to senescence. Ovulation, sperm release, fertilization, transit of early embryo to uterus, implantation, fetal membranes, cellular differentiation, organogenesis, birth, adolescence, puberty, and senescence. Congenital defects, birth control, multiple births, and human cytogenetics in relation to development. *In vitro* fertilization.

1951, 1952, 1953. BIOLOGY COLLOQUIUM. (1 cr/f, 1 or 2 cr/w,s; S-N only)

Introduction to the diversity of biology through seminars, lab tours, undergraduate research, trips to Itasca Biological Station, and interaction with other biology students and faculty.

3009H. GENERAL BIOLOGY: A QUANTITATIVE APPROACH. (5 cr, §1009H; prereq college-level chemistry, at least 1 yr each of calculus and physics, permission of CBS or CLA or IT honors office)

Introduction to the principles of biology with emphasis on quantitative aspects. The cell, metabolism, physiology, heredity, ecology, and evolution. Lab.

3011. ANIMAL BIOLOGY. (5 cr, §1106; prereq 1009, Chem 1005)

Comparison of ways different phyla have solved similar physiological problems. Lab includes survey of major animal groups and physiological experiments.

3012. PLANT BIOLOGY. (5 cr, §1103, §3812; prereq 1009, Chem 1005)

Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants. Lab.

3051. BIOLOGY AND THE FUTURE OF THE EARTH. (4 cr; bioscience students may not apply these credits toward major)

Nontechnical discussion of current environmental issues, including air and water pollution, human population growth, toxic and hazardous wastes, urbanization, resource economics, biological diversity, energy, health, and environmental ethics.

3111. ANIMAL BIOLOGY. (4 cr, §3011; prereq 1009, 1106, Chem 1005)

Comparative physiology of various animal groups; coordination, movement, support, excretion, reproduction.

3112. BIOLOGICAL RHYTHMS. (4 cr, §5112; prereq 1009 or #)

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

3950H. UNDERGRADUATE SEMINAR. (2 cr per qtr; S-N only)

Each quarter different faculty lead students in discussions on topics of current interest.

3960H. HONORS SEMINAR. (1 cr per qtr; prereq Δ ; S-N only; limited to participants in CBS Honors Program)

Oral reports on topics of current interest to biologists. Progress reports on laboratory and field research by students.

3980. DIRECTED INSTRUCTION. (1-3 cr per qtr; prereq #; S-N only; Up to 8 cr may apply toward major)

Leadership opportunities for upper division students wishing to assist with the Biology Colloquium.

5001. BIOCHEMISTRY. (4 cr; prereq 1009, 12 cr organic chemistry or #)

Biochemistry and biophysics of cells; emphasis on enzyme catalysis, cellular energetics, biosynthesis of cellular constituents, and cellular regulatory mechanisms.

Major Requirements and Course Descriptions

5003. GENETICS. (4 cr, §GCB 3022, §GCB 5022; prereq 5001)

Introduction to the nature of genetic information, its transmission from parents to offspring, its expression in cells and organisms, and its course in populations.

5004. CELL BIOLOGY. (3 cr; prereq 5001)

Structures and functions of membranes, organelles, and other macromolecular aggregates found in plant, animal, and bacterial cells. Cell form and movement, intercellular communication, transport, and secretion.

5013. MICROBIOLOGY. (5 cr, §MicB 3103, §MicB 5105, §VPB 3103; prereq 5001)

Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Emphasis on molecular structure in relation to bacterial function. Lab.

5041. ECOLOGY. (4 cr, §5841; prereq 1103 or 1106 or 3011 or 3012, Math 1142 or 1211)

Growth, structure, and evolution of populations. Pairwise biotic interactions between species and their effect on the diversity and structure of natural communities. Nutrient dynamics, function, productivity, and temporal stability of ecosystems. Lab.

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

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

5125. RECOMBINANT DNA LABORATORY. (4 cr, §MicB 5125; prereq application necessary, Δ)

Introduction to basic recombinant DNA techniques. Methods for growing, isolating, and purifying recombinant DNAs and cloning vectors.

5950. SPECIAL TOPICS IN BIOLOGY. (1-5 cr per qtr; prereq Δ)

5951. SOCIAL USES OF BIOLOGY. (4 cr; prereq 10 cr sciences; S-N only)

Influence of biological science on the quality of human life: agriculture, medicine, occupational health, environmental science, and theories of human nature. Responsibilities and roles of biologists in policy formulation in the scientific and political world.

Courses Offered at Lake Itasca Forestry and Biological Station

3812. PLANT BIOLOGY. (5 cr, §1103, §3012; prereq 1009, Chem 1005)

Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants. Field trips.

5810. TOPICS IN ENVIRONMENTAL EDUCATION FOR ELEMENTARY TEACHERS. (5 cr; prereq Δ)

Intensive two-week Environmental Education Institute to instruct elementary teachers in several areas of ecology and environmental concerns. Uses ecosystem studies as basis for study, emphasizes on integrating these concepts into elementary school curriculum.

5816. FIELD BIOLOGY PHOTOGRAPHY. (3 cr; prereq D, course in beginning biology; A-F only)

Field photography techniques for documentation of insects, vertebrates, aquatic organisms, and habitats of the Itasca area. Emphasis on general photographic principles and applied advanced techniques using flash, reversed lenses, and infra-red photoelectric tripping devices. On-site processing of color slides and black and white films. No previous processing experience required.

5841. ECOLOGY. (5 cr, §5041; prereq 1103 or 1106 or 3011 or 3012, Math 1142 or 1211, Δ)

Growth, structure, and evolution of populations. Pairwise biotic interactions between species and their effect on the diversity and structure of natural communities. Nutrient dynamics, function, productivity, and temporal stability of ecosystems. Field work at the Itasca station.

5850. SPECIAL TOPICS IN BIOLOGY. (Cr ar, 1-10 cr per qtr; prereq Δ)

5870. ITASCA SEMINAR. (1 cr; prereq Δ)

Topic selected and scheduled during registration by interested staff members and students.

5890. RESEARCH PROBLEMS AT ITASCA IN ECOLOGY, EVOLUTION, AND BEHAVIOR; OR ENTOMOLOGY, FISHERIES, AND WILDLIFE; OR PLANT PATHOLOGY; OR SOIL SCIENCE; OR ZOOLOGY. (Cr ar; prereq #, Δ)

Undergraduate and graduate students develop a short-term research project in any area listed above during one or both terms.

Biochemistry (BioC)

Director of Undergraduate Studies—

James Fuchs

Biochemistry is the study of the molecules, especially macromolecules such as proteins and nucleic acids, that occur in living organisms. The major in biochemistry is for students who plan to pursue graduate study in biochemistry or in the biochemical aspects of the biological, medical, or agricultural sciences. It also offers preparation for chemists in entry-level biochemical positions in industry. The curriculum differs from that leading to the bachelor of science degree in chemistry in that substantial training in the biological sciences is included at the expense of additional courses in analytical, inorganic, and physical chemistry.

Biochemistry is an experimental science, and majors, especially those who plan to pursue graduate studies in the field, should

become acquainted with laboratory research approaches beyond those introduced in the formal laboratory courses. Research options are available through BioC 5990 and through the Honors Program. Students should start planning the research component of their major program as early as possible and should make arrangements, in consultation with their adviser, for their senior research project during their junior year.

In addition to the general requirements for graduation from CBS, biochemistry majors must complete the requirements listed below. (Where optional sequences exist, recommended courses are listed first.) The following major requirements are used in partial fulfillment of the college graduation requirements 5i and 5j (see Admission Procedures and Degree Requirements earlier in this bulletin):

Biochemistry—BioC 3960, 5002, 5025. In addition, advanced and special topics courses (e.g., 5744, 5950) are recommended. In some cases, BioC 5751-5752 may be accepted as a substitute for 5002 and special topics (3960).

Organic Chemistry—Chem 3333 (in addition, 5365 is recommended), or Chem 3303 (in addition, 5365 is recommended).

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

Mathematics—Math 3311 (in addition, 3321 is recommended).

Physical Chemistry—Chem 5533, 5534, 5535, 5540, or Chem 5520, 5521.

BioC Courses

3001. ELEMENTARY BIOLOGICAL CHEMISTRY. (4 cr; prereq 1 qtr college chemistry) Principles of chemistry important to biological systems. Organic, inorganic, and physical chemistry needed to understand biochemistry. An alternative prerequisite to BioC 3031.

3031. SURVEY OF BIOCHEMISTRY. (4 cr; prereq 2 qtrs of organic chemistry or 3001)

Structure, function, and nomenclature of biological molecules, including proteins, carbohydrates, lipids, and nucleic acids. Mechanism of enzyme and coenzyme reactions. Metabolic pathways. Nucleic acid function and protein synthesis.

3960. RESEARCH TOPICS IN BIOCHEMISTRY. (1 cr per qtr; S-N only)

Lectures and discussions on current research in the department.

Biol 5001. BIOCHEMISTRY. (4 cr; prereq Biol 1009, 12 cr organic chemistry or #)

Biochemistry and biophysics of cells; emphasis on enzyme catalysis, cellular energetics, biosynthesis of cellular constituents, and cellular regulatory mechanisms.

5002. BIOCHEMISTRY TOPICS. (3 cr; prereq 3031 with grade of B or better or 5001)

Biol 5001 and BioC 5002 constitute a two-quarter sequence for undergraduate and graduate students lacking physical chemistry, and serve as prerequisites for certain advanced courses.

5025. LABORATORY IN BIOCHEMISTRY. (2 cr; prereq 3031 with grade of B or better or Biol 5001 or ¶5001)

Discussions of techniques and problem-solving approaches illustrated with laboratory experiments and demonstrations.

5525. PHYSICAL BIOCHEMISTRY: SOLUTION STRUCTURE AND INTERACTIONS OF BIOLOGICAL MACROMOLECULES. (4 cr, §Chem 5525, §MdBc 5525; prereq 2 qtrs physical chemistry, Biol 5001 or equiv)

Physical chemistry of equilibrium, transport, and scattering phenomena in solution, with application to proteins and nucleic acids. Inter-molecular forces, macromolecular dynamics, conformational transitions, binding thermodynamics, methods for determining biopolymer size and shape, including sedimentation, diffusion, viscosity, electrophoresis, and scattering.

5526. PHYSICAL BIOCHEMISTRY: SPECTROSCOPIC METHODS I. (4 cr, §Chem 5526, §MdBc 5526; prereq 2 qtrs physical chemistry)

Lectures on fundamental spectroscopic principles, with emphasis on the development of magnetic resonance theory used in the study of biological macromolecules.

5527. PHYSICAL BIOCHEMISTRY: SPECTROSCOPIC METHODS II. (4 cr, §Chem 5527§, MdBc 5527; prereq 2 qtrs physical chemistry, BioC/MdBc 5526)

Application of optical and magnetic resonance techniques to the study of structure and dynamics in proteins, lipids, nucleic acids, and synthetic analogs.

5528. PHYSICAL BIOCHEMISTRY: ENZYME KINETICS. (4 cr, §Chem 5528, §MdBc 5528; prereq 2 qtrs physical chemistry; 5002 or BioC/MdBc 5751 or equiv desirable)

Theory and application of steady-state and transient kinetics to the study of enzymes, enzyme systems, and cellular regulation.

Major Requirements and Course Descriptions

5529. PROTEIN STRUCTURE AND FOLDING. (4 cr, §Chem 5529, §MdBc 5529; prereq Biol 5001 or equivalent; 1 qtr physical chemistry or #)

Protein structure, stability, folding, and molecular modeling. Emphasis on results from X-ray crystallography, solution thermodynamics, NMR, computer graphics, and protein engineering.

5744. ANALYTICAL BIOCHEMISTRY. (4 cr; prereq previous lab work in analytical and organic chemistry, #) Principal techniques of biochemistry experimental work; instrumentation and methods for isolation and characterization of proteins, lipids, and carbohydrates. Chromatography, electrophoresis, spectrophotometry, potentiometry, and fluorimetry.

5751-5752-5753. GENERAL BIOCHEMISTRY. (4 cr per qtr, §MdBc 5751-5752-5753; prereq 3 qtrs organic chemistry, 2 qtrs physical chemistry, 1 qtr biochemistry or #)

Comprehensive discussion of structure, function, metabolism, and metabolic regulation of components in biological systems.

5950. SPECIAL TOPICS. (1-5 cr; prereq #, Δ)

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

5990. DIRECTED RESEARCH. (Cr ar; prereq #, Δ) Laboratory or field investigation of selected areas of research.

For Graduate Students Only

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

8094. RESEARCH AND LITERATURE REPORTS

8194. GRADUATE SEMINAR

8206. CELL SIGNALING AND METABOLIC REGULATION I

8213. ADVANCED MOLECULAR BIOLOGY I

8214. ADVANCED MOLECULAR BIOLOGY II

8225. TRACER TECHNIQUES

8230. ADVANCED TOPICS IN MEMBRANE BIOCHEMISTRY

8250. SPECIAL TOPICS IN BIOCHEMISTRY

8290. CURRENT RESEARCH TECHNIQUES

8990. GRADUATE RESEARCH

Botany Major/See Plant Biology, below

Ecology, Evolution, and Behavior (EEB)

Director of Undergraduate Studies—John R. Tester

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

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

The Department of Ecology, Evolution, and Behavior participates in teaching the core curriculum in biology and offers an undergraduate major in ecology, evolution, and behavior.

In addition to general requirements for graduation from CBS, ecology, evolution and behavior graduates will be expected to complete the following major requirements, which may be used in partial fulfillment of the college graduation requirements 5i and 5j (see Admission Procedures and Degree Requirements earlier in this bulletin):

a. EEB 3111 (4 cr)

b. EEB 5044 (4 cr); Biol 1008 (4 cr) may be substituted if taken as a freshman or sophomore

c. EEB 5156 (5 cr), or PBio 3131 (4 cr) with PBio 5132 (2 cr), or PBio 5131 (4 cr) with PBio 5132 (2 cr)

d. Field experience in biology (at least 5 cr for courses that involve extensive field experience); the Lake Itasca Forestry and Biological Station and other field stations offer a variety of suitable courses; other appropriate experience or courses may be substituted by petition

e. EEB 3960 (2 cr) or Biol 3950H (2 cr)

f. At least two courses from Group I (see below) must be included in the upper division credits in mathematics and/or physical sciences and/or biological sciences required for graduation; appropriate courses may also satisfy the field experience requirement (d above). Students are encouraged to select courses in consultation with the faculty adviser and the director of undergraduate studies; other courses may be substituted by petition (see especially Group II below).

Recommended Courses, Group I:

Community Ecology and Paleoecology

- EEB 5008. Quaternary Ecology (4 cr)
- EEB 5014. Ecology of Plant Communities (5 cr)
- EEB 5016. Ecological Plant Geography (5 cr)

Population and Evolutionary Biology

- EEB 5051. Analysis of Populations (4 cr)
- EEB 5052. Theoretical Population Ecology (4 cr)
- EEB 5063. Evolutionary Ecology of Insect Populations (3 cr)
- EEB 5065. Theoretical Evolutionary Ecology (3 cr)

Organismal Biology and Physiological Ecology

- EEB 5122. Plant/Animal Interactions (4 cr)
- EEB 5129. Mammalogy (5 cr)
- EEB 5134. Introduction to Ornithology (5 cr)
- EEB 5136. Ichthyology (4 cr)
- EEB 5156. Comparative Animal Physiology (5 cr)
(if not used to meet physiology requirement)

Behavioral Biology

- EEB 5321. Evolution of Social Behavior (4 cr)
- EEB 5325. Behavioral Ecology (4 cr)

Limnology and Ecosystem Biology

- EEB 5601. Limnology (4 cr)
- EEB 5606. Ecology of Fishes (3 cr)
- EEB 5607. Ecology of Animal Plankton (4 cr)
- EEB 5608. Ecosystems: Form and Function (4 cr)
- EEB 5621. Limnology Laboratory (2 cr)

Recommended Courses, Group II:

- Anthropology
- Climatology/Meteorology
- Earth Sciences
- Entomology
- Fisheries
- Forestry
- Mathematics
- Psychology
- Public Health
- Statistics
- Wildlife Biology

EEB Courses

3001. INTRODUCTION TO ECOLOGY. (4 cr; open to jrs and above but not to biology majors) Basic concepts in ecology; the organization, development, and functioning of ecosystems; population growth and regulation. Human impact on ecosystems.

3101. ECOLOGY FOR ENGINEERS AND PHYSICAL SCIENTISTS. (4 cr, §3001; prereq Math 1241; not open to biology majors)

Description and analysis of the spatial and temporal interactions between populations in ecosystems; processes affecting populations; transformations of energy and materials in the biosphere. Lectures and recitations.

3111. INTRODUCTION TO ANIMAL BEHAVIOR.

(4 cr, §AnSc 3111; prereq Biol 1008 or 1009 or #) Survey of the biological study of animal behavior, including questions of causation, development, function, and evolution; emphasizes the evolution of adaptive behavior, especially social behavior, in the natural environment.

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

Lectures on and discussion of current research in the department.

Biol 5041. ECOLOGY. (4 cr, §5841; prereq 1103 or 1106 or 3011 or 3012, Math 1142 or 1211)

Growth, structure, and evolution of populations. Pairwise biotic interactions between species and their effect on the diversity and structure of natural communities. Nutrient dynamics, function, productivity, and temporal stability of ecosystems. Lab.

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

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

5990. DIRECTED RESEARCH. (Cr ar; prereq #, Δ)

Laboratory or field investigation of selected areas of research.

Community Ecology and Paleoecology

5008. QUATERNARY ECOLOGY. (4 cr; prereq Biol 5041 or 5841 or #)

Impact of changes in the physical and biological environment during the Quaternary Period on plants and animals. Changes in evolutionary rates, geographical distributions, community composition, and fluctuations in population sizes. Impact of prehistoric human culture on the environment, including ecosystem-level changes recorded in sedimentary sequences. Recent climatic changes. General principles of analysis and methods of investigation and interpretation.

5014. ECOLOGY OF PLANT COMMUNITIES. (5 cr; prereq Biol 5041 or 5841, 1 qtr statistics or #; offered when feasible)

Methods of describing, sampling, and classifying plant communities; theory of their structure and development, and of the stability of the interactions among their constituent populations. Field trips to examine local vegetation types; analysis of quantitative data.

Major Requirements and Course Descriptions

5016. ECOLOGICAL PLANT GEOGRAPHY. (5 cr; prereq Biol 5041 or 5841, PBio 3201 or ¶Biol 3201 or #; offered when feasible)

Vegetation regions of the world in general and North America in detail; ecological principles of plant distribution; interpretation of regional and temporal patterns in the distribution of vegetation and taxonomic groups. Field trips to floristic regions of Minnesota.

Population and Evolutionary Biology

5044. EVOLUTION. (4 cr; prereq Biol 1103 or 3012, 1106 or 3011)

Survey of evidence for and causes of biological evolution.

5051. ANALYSIS OF POPULATIONS. (4 cr; prereq Biol 5041 or 5841 or #)

Factors in the regulation, growth, and general dynamics of populations. Data needed to describe populations, population growth, population models, and regulatory mechanisms.

5052. THEORETICAL POPULATION ECOLOGY.

(4 cr; prereq Biol 5041 or 5841 or #; offered when feasible)

Theories of population ecology, including models of growth and regulation of single populations, and of interactions between populations, including competition, predation, mutualism; emphasizes assumptions and rationales of models and their predictions for dynamics, stability, and diversity of communities.

5063. EVOLUTIONARY ECOLOGY OF INSECT POPULATIONS. (3 cr; prereq Biol 5041 or 5841 or #; offered when feasible)

Dynamics and regulation of insect populations; life history evolution; cytogenetic patterns, reproductive competition, mating systems, and modes of speciation; mechanisms and implications of frequency dependent coevolution.

5065. THEORETICAL EVOLUTIONARY ECOLOGY. (3 cr; prereq Math 1241, one 5000-level course in ecology or evolution or behavior or #)

Evolutionary approaches to ecology and behavior based on applying optimization and game theory techniques. Topics include optimal foraging theory, evolution of life histories, animal behavior in contest situations.

Organismal Biology and Physiological Ecology

5122. PLANT/ANIMAL INTERACTIONS. (4 cr; prereq Biol 1106 or 3011, 1103 or 3012, 10 cr in biological sciences or #; offered when feasible)

Herbivory, pollination, seed dispersal. Implications of interaction for plants and animals at organismal, population, and community levels. Coevolution.

5129. MAMMALOGY. (5 cr, §FW 5129; prereq Biol 1106 or 3011 or #)

Recent families and orders of mammals of the world and genera and species of mammals of North America, with emphasis on morphology, evolution, and zoogeographic history.

5134. INTRODUCTION TO ORNITHOLOGY. (5 cr; prereq Biol 1106 or 3011)

Laboratory and field course in structure, classification, distribution, migration, habits, habitats, and identification of birds. Weekend trips.

5136. ICHTHYOLOGY. (4 cr; prereq 15 cr incl Biol 1106 or 3011)

Biology of fishes including development, systematics, anatomy, physiology, and ecology.

5156. COMPARATIVE ANIMAL PHYSIOLOGY.

(5 cr; prereq Biol 1106 or 3011, Chem 3302 or #)

The passive organism: environment "stresses" and biological mechanisms by which they are counteracted.

Behavior

5321. EVOLUTION OF SOCIAL BEHAVIOR. (4 cr; prereq Biol 1106 or 3011 or #)

Introduction to current theories and concepts relating to mating systems, spacing systems, and cooperative behavior in animals.

5325. BEHAVIORAL ECOLOGY. (4 cr; prereq 3111 or 5321 or Biol 5041 or 5841 or #)

Evolutionary principles applied to the study of aggressive competition, mating systems, cooperation, and parental investment. Optimization models used to examine foraging strategies, predator/prey interactions, and territoriality. Evolution of sex, sexual selection, and dispersal.

Limnology and Ecosystem Ecology

5601. LIMNOLOGY. (4 cr, §Geo 5601; prereq Chem 1005 or #)

Description and analysis of the events in lakes, reservoirs, and ponds, beginning with their origins and progressing through their physics, chemistry, and biology. Interrelationships of these parameters and effects of civilization on lakes.

5606. ECOLOGY OF FISHES. (3 cr; prereq Biol 1106 or 3011, EEB 5136, 10 cr in biological sciences; offered when feasible)

Ecological requirements of fishes, with emphasis on nongame species: habitat, food, interactions among species, and behavioral, anatomical, and physiological adaptations. Fishes in the aquatic ecosystem, with emphasis on fresh waters.

5607. ECOLOGY OF ANIMAL PLANKTON. (5 cr; prereq Biol 5041 or 5841, EEB 5601 or #; offered when feasible)

Biology of animal plankton, including distribution of zooplankton in lakes, ecosystem functions such as grazing and remineralization, determination of production, physiological responses to contaminated environments, and important aspects of behavior.

5608. ECOSYSTEMS: FORM AND FUNCTION.

(4 cr; prereq 5601 or Biol 5041 or 5841 or equiv) Nature and development of terrestrial wetland and aquatic ecosystems. Analysis of energy flow and element cycling in relation to environmental controls, self-regulation, natural and human disturbances.

5621. LIMNOLOGY LABORATORY. (2 cr, §Geol 5621; prereq 5601 or Geol 5601 or #)

Principal techniques for obtaining information about environmental conditions in lakes and streams. Procedures for measuring the abundance and population dynamics of aquatic organisms, with emphasis on plankton. Field instruments, sampling devices, chemical analysis, microscopy, and data analysis. One Saturday field trip.

Courses Offered at Lake Itasca Forestry and Biological Station**5817. VERTEBRATE ECOLOGY.** (5 cr; prereq course in ecology, Δ)

Field studies on vertebrate populations and their relationships to local environments; habitat analysis and ecological research methods. Students work individually and as a team investigating factors influencing the distribution and abundance of selected vertebrates in various habitats. A research-oriented course supplemented with lectures and field trips.

5834. FIELD ORNITHOLOGY. (5 cr; prereq course in general biology incl study of zoology, Δ)

Emphasis on breeding season, biology, and behavioral ecology of birds in the Itasca Park region. Field trips taken to a variety of habitats to learn bird identification and observe and practice techniques for conducting field studies. Laboratory sessions investigate family distinctions and species identification. Individual field projects.

Biol 5841. ECOLOGY. (5 cr, §Biol 5041; prereq 1103 or 1106 or 3011 or 3012, Math 1142 or 1211, Δ)

Growth, structure, and evolution of populations. Pairwise biotic interactions between species and their effect on the diversity and structure of natural communities. Nutrient dynamics, function, productivity, and temporal stability of ecosystems. Field work at the Itasca station.

Interested students should also check the course listings in the *Courses on the Environment* bulletin.

History of Science and Technology (HSci)

University courses providing historical analyses of science, medicine, and technology can be found in the College of Liberal Arts and Institute of Technology bulletins. Courses dealing specifically with the history of biology are listed below.

3201/5201, 3202/5202. HISTORY OF BIOLOGY. (4 cr per qtr)

Scientific, philosophical, and social factors in development of biology; changing styles of biological reasoning and changing relationships between biological and physical sciences. **3201/5201:** Biology from antiquity through early modern period. **3202/5202:** Biology in 19th and 20th centuries.

3244. HISTORY OF ECOLOGY AND ENVIRONMENTALISM. (4 cr, §5244)

Historical examination of two views of ecology: a scientific discipline about the interactions between organisms and environments, and the environmental movement of the sixties, Earth First, and Green politics. Conservation, the Dustbowl era, population control, the DDT controversy, international environmental issues.

5242. THE DARWINIAN REVOLUTION. (4 cr; prereq Biol 1009 or 1101 or #)

Pre-Darwinian conceptions of nature; development and reception of Darwin's theory of evolution by natural selection; broader context of Darwinian revolution, including religious thought, political theory, and views about the proper scientific methodology.

5511. HISTORY OF SCIENTIFIC METHODOLOGY. (4 cr)

Changing views of aims and methods of science as seen through the eyes of philosopher-scientists of the past: how notions of "explanation," "hypothesis," and "evidence," have changed through time.

For Graduate Students Only

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

8004. TOPICS IN ECOLOGICAL GENETICS**8014. PALEOECOLOGICAL METHODS****8061. SOCIAL SYSTEMS****8081. NEUROETHOLOGY****8162. WINTER ECOLOGY****8390. GRADUATE SEMINAR****8400. POPULATION BIOLOGY SEMINAR****8410. COMMUNITY ECOLOGY SEMINAR****8420. POPULATION BIOLOGY RESEARCH SEMINAR****8430. EVOLUTIONARY GENETICS SEMINAR****8510. BEHAVIORAL BIOLOGY SEMINAR****8602. ADVANCED LIMNOLOGY****8990. GRADUATE RESEARCH****Genetics and Cell Biology (GCB)**

Director of Undergraduate Studies—
Norman S. Kerr

Genetics is the study of inheritance, including molecular mechanisms of gene organization and expression, human genetics, and the behavior of genes in populations of organisms. Study in cell and developmental biology seeks to answer basic questions regarding organization, composition, function, and assembly of cells and cellular components, and their regulation during the processes of cellular growth and differentiation.

Major Requirements and Course Descriptions

The genetics and cell biology (GCB) major provides special educational opportunities for undergraduate students through group discussion of current research problems and techniques, enhanced practical experience with relevant systems and methodology, additional advanced courses, and close interaction with faculty actively investigating contemporary problems and reviewing current literature in the field. This major prepares undergraduates for advanced study and for positions in the rapidly growing field of biotechnology and in medical, industrial, or other scientific laboratories.

In addition to the general requirements for graduation from CBS, genetics and cell biology majors must complete the following major requirements, which may be used in partial fulfillment of the college graduation requirements, 5i and 5j (see Admission Procedures and Degree Requirements earlier in this bulletin):

GCB majors must complete 27 additional credits, including:

GCB 3960. Research Topics (1 cr)
(Students are urged to complete the above course as soon as possible after they decide to major in GCB)

Biol 3950H. Undergraduate Seminar (2 quarters) 4 cr total

The value of the undergraduate seminar is at least two-fold: (1) It permits students to meet in small groups and practice both oral and written communication; (2) it requires students to explore an aspect of biology in depth.

BioC 5025. Lab in Biochemistry (2 cr) and 20 additional credits in life sciences and/or physical sciences and/or mathematics and/or statistics and/or computer science, chosen in consultation with their major adviser.

The 20 credits must include two additional laboratory experiences, totalling a minimum of 4 cr, one of which must be in GCB¹. Students are urged to include GCB 5990, Directed Research, as one or both of these experiences. A maximum of 8 credits of 5990 may be used towards the 20-credit total.

The 20 credits must include at least 3 credits from Area 1 and 3 credits from Area 2; it may include not more than 4 credits from Area 4:

Area 1: Genetics

- GCB 5024. The Genetics of Development (4 cr)²
- GCB 5034. Intermediate Molecular Genetics (4 cr)²
- GCB 5030. Laboratory: Genetics (2 cr)
- GCB 5042. Quantitative Genetics (4 cr)
- Biol 5125. Recombinant DNA Laboratory (4 cr)
- GCB 5073. Advanced Human Genetics (4 cr)²
- GCB 5915. Computer Applications in Molecular Biology (2 cr)
- PBio 5109. Molecular Genetics Yeast & Fungi (4 cr)

Area 2: Cell and Developmental Biology

- GCB 5035. Intermediate Cell Biology (4 cr)
- GCB 5061. Developmental Biology (4 cr)
- GCB 5015. Histology: Cell & Tissue Organization (5 cr)
- GCB 5605. Cell Biology Lab (2 cr)
- GCB 5114. General Physiology (3 cr)
- GCB 5134. Endocrinology (4 cr)
- PBio 5151. Plant Cell Biology (4 cr)

Area 3: Courses from other departments. (This list is not all-inclusive. Other courses may be approved by your major adviser.)

- BioC 5002. Biochemistry Topics (3 cr)
- Biol 3112. Biological Rhythms (4 cr)
- Chem 3100, 3101. Quantitative Analysis (5 cr)
- Chem 3303. Elementary Organic Chemistry III (4 cr)
- Chem 3304. Elementary Bio-Organic Chemistry (4 cr)
- Chem 5520-5521. Elementary Physical Chemistry (6 cr)
- CSci 3102. Introduction to Pascal Programming (4 cr)
- EEB 5044. Evolution (4 cr)
- GCB 3008. The Biology of Cancer (3 cr)
- GCB 5013. Mammalian Reproduction (4 cr)
- PBio 3131. Survey of Plant Physiology (4 cr)
- PBio 5111. Plant Cell, Tissue, and Organ Development (5 cr)
- MicB 5218. Immunology (3 cr)
- MicB 5321. Physiology of Bacteria (3 cr)
- MicB 5424. Virology (3 cr)
- Stat 5021. Statistical Analysis³ (5 cr)

¹Biol 5125 should be considered a GCB course for purposes of this requirement.

²These courses are taken primarily by graduate students; undergraduates should have excellent grades in Biol 5003 and Biol 5004 and/or should consult with the instructor before registering.

³Biology students seem to have little difficulty with this accelerated statistics sequence. Stat 3011-3012 may be substituted. If statistics was used to fulfill the CBS mathematics or physics requirements, it may not also be used in the major.

Area 4: History and Philosophy of Science

- Biol 5951. Social Uses of Biology (4 cr)
 HSci 3202. History of Biology (4 cr)
 HSci 5242. The Darwinian Revolution (4 cr)
 Phil 3601. Scientific Thought (4 cr)
 Phil 5603. Philosophy of Science: Change (4 cr)
 Phil 5607. Philosophy of Science: Biology (4 cr)

GCB Courses

3002. HUMAN GENETICS, SOCIAL AFFAIRS. (3 cr
 4 cr with term paper), §3022 or §Biol 1101, §Biol
 5003; for students in programs not directly related to
 biological sciences)

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

3008. THE BIOLOGY OF CANCER. (3 cr; prereq
 Biol 1009)

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

3022. GENETICS. (4 cr, §Biol 5003; not intended for
 biology majors; prereq Biol 1009)

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

3960. RESEARCH TOPICS. (1 cr; prereq 15 cr
 biology; S-N only)

Description of department's faculty ongoing research.
 Introduces sophomores and juniors who are potential
 GCB majors to department faculty, the diversity of
 faculty research activities, and the opportunities for
 undergraduate research in GCB.

5013. MAMMALIAN REPRODUCTION. (4 cr; prereq
 Biol 3011, Biol 5001 or #; offered when feasible)

Introduction to biological aspects of mammalian
 reproduction with emphasis on eutherians. Selected
 topics and examples used to discuss basic problems,
 current concepts, and patterns of reproduction at
 molecular, cellular, and organismal levels.

**5015. HISTOLOGY: CELL AND TISSUE ORGANI-
 ZATION.** (5 cr; prereq Biol 5004 or #)

Structure and function of vertebrate tissues and organs.
 Lectures combine electron microscopy, light micros-
 copy, physiology, and cell biology of higher animals.
 Labs concentrate on light microscopy of mammalian
 tissues.

5022. GENETICS. (3 cr, §3022, §Biol 5003; not open
 to grad students in genetics)

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

5024. THE GENETICS OF DEVELOPMENT. (4 cr;
 prereq Biol 5003 or #)

Introduction to current concepts and experimental
 approaches concerning the genetic basis of morphogen-
 esis and metazoan development. Concentrates on
 organisms amenable to genetic analysis, including
 certain prokaryotes and single-cell eucaryotes,
 nematodes, and *Drosophila*.

5030. LABORATORY: GENETICS. (2 cr; prereq 3022
 or 5022 or Biol 5003)

Investigative approaches to analyzing genetic problems.
 Focus on a given organism or related group of organisms
 may vary.

5034. INTERMEDIATE MOLECULAR GENETICS.
 (4 cr; prereq Biol 5003, 5004)

Molecular genetics of prokaryotes and eukaryotes,
 concentrating on the characterization and regulation of
 expression of genes and the techniques used to study
 gene expression. For advanced bioscience undergradu-
 ates and graduate students outside of CBS programs.

5035. INTERMEDIATE CELL BIOLOGY. (4 cr;
 prereq Biol 5004 or #)

Introduction to current literature in cell biology. Selected
 scientific papers illustrate new concepts and new
 experimental approaches to basic questions of cell
 organization and function. Topics vary but include
 membranes, secretion, endocytosis, the cytoskeleton,
 and the nucleus.

5042. QUANTITATIVE GENETICS. (4 cr; prereq
 5033; Stat 5301 recommended; S-N only)

Selection with reference to population changes in gene
 frequencies and means of quantitative characters.
 Information required for predicting effects of selection
 and related research. Emphasis on logical analysis.

5061. DEVELOPMENTAL BIOLOGY. (3 cr, §Biol
 5011; prereq Biol 3011 or 3111, Biol 5004)

Animal embryology; morphogenesis and cellular
 differentiation with emphasis on vertebrates and pattern
 formation. Control mechanisms of development.

5073. ADVANCED HUMAN GENETICS. (4 cr; prereq
 5034 or #)

Application of molecular, biochemical, chromosomal,
 and population genetics to human variation and disease.
 Abnormal chromosome number and structure; abnormal
 enzyme, structural protein, receptor and transport;
 analysis of inheritance patterns; behavioral genetics;
 genetic basis of common disease.

5114. GENERAL PHYSIOLOGY. (3 cr; prereq Biol
 3011, 5001, Phys 1109 or 1295)

Quantitative approach to studying cell function with
 emphasis on applying physical and chemical principles.
 Transport, electrical activity of cell membranes, cell
 contractility.

5134. ENDOCRINOLOGY. (4 cr; prereq Biol 3011,
 5001 or #)

Survey of structure and function of invertebrate and
 vertebrate endocrine systems.

5605. CELL BIOLOGY LABORATORY. (2 cr; prereq
 Biol 5004 or §Biol 5004 or #)

Experimental approaches to cell structure, function, and
 replication, including microscopy, autoradiography, cell
 fractionation, and molecular and chemical analyses.

**5915. COMPUTER APPLICATIONS IN MOLECUL-
 AR BIOLOGY.** (2 cr; prereq Biol 5003 or equiv)

Introduction to computational molecular
 biology. Introduction to usage of computers, problems
 that can be solved using computational methods, and
 hands-on sessions in which students learn how to use
 available tools.

Major Requirements and Course Descriptions

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

5990. DIRECTED RESEARCH. (Cr ar; prereq #, Δ)
Laboratory or field investigation of selected areas of research.

For Graduate Students Only

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

8060. CURRENT TOPICS

8131. ADVANCED GENETICS I

8132. ADVANCED GENETICS II

8148. ADVANCED CELL BIOLOGY I

8149. ADVANCED CELL BIOLOGY II

8213. ADVANCED MOLECULAR BIOLOGY I

8214. ADVANCED MOLECULAR BIOLOGY II

8900. SEMINAR

8910. JOURNAL CLUBS

8912. GENETIC COUNSELING SEMINAR I

8913. GENETIC COUNSELING SEMINAR II

8914. GENETIC COUNSELING SEMINAR III

8950. PRACTICUM: TEACHING IN GENETICS

8960. PRACTICUM: TEACHING IN CELL AND DEVELOPMENTAL BIOLOGY

8970. DIRECTED STUDY

8990. RESEARCH

Microbiology (MicB)

Medical School

Director of Undergraduate Studies—
Palmer Rogers

The program in microbiology prepares the student for work as a practicing microbiologist or for graduate work.

The field of microbiology embraces a multitude of areas of fundamental and applied research. Microbiologists have an interest in the basic role played by microbes, such as bacteria, fungi, and viruses, in the world in which we live. Microbiologists may be interested in basic biological mechanisms, such as DNA replication or the regulation of protein synthesis. They may study fundamental issues concerning human and animal diseases such as the mechanisms of viral and bacteriological infection, immunity and autoimmune disease, and viral-induced cancer. Many aspects of agriculture are under investigation by microbiologists; among them are specific fungal and bacterial symbionts essential for maximum growth of certain plants and

bacteria and fungi essential for maintenance and production of natural soil fertility. Microbiologists are also active in many industrial and pharmaceutical fields involving production and discovery of new antibiotics; manufacture of cheese, beer, wine, and other foods; pasteurization in canning and food processing; and even decontamination of space vehicles.

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

MicB 5900

Two of the following: MicB 5234, 5322, 5425, or directed research, MicB 5990, a minimum of 8 credits in one laboratory

Three of the following: MicB 5218, 5232, 5321, 5352, 5424

Chem 3100-3101

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

Students planning to graduate with honors in microbiology must include specific courses in their program in addition to the college requirements. A listing of these requirements may be obtained from the department office, 1460 Mayo Memorial Building (Minneapolis), or from the CBS student services office (223 Snyder Hall, 612/624-9717).

MicB Courses

3103.¹ GENERAL MICROBIOLOGY. (5 cr, §5105, §Biol 5013, §VPB 3103; prereq soph with C avg in courses prereq to major sequence or jr with 10 cr chemistry, 5 cr biological sciences or #)
Morphology, physiology, taxonomy, and ecology of bacteria. Applications of fundamental principles. Lab.

Biol 5013.¹ MICROBIOLOGY. (5 cr, §MicB 3103, §MicB 5105, §VPB 3103; prereq Biol 5001)
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Molecular structure in relation to bacterial function.

5105.¹ BIOLOGY OF MICROORGANISMS. (5 cr, §Biol 3103, §Biol 5013, §VPB 3103; prereq 5 cr biological sciences, Biol 5001 or #)
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Molecular structure in relation to bacterial function. Lab.

5106. ADVANCED GENERAL MICROBIOLOGY LABORATORY. (3 cr; prereq MicB 5105 or equiv)

Isolation from natural sources of a wide variety of microorganisms such as *Clostridium*, yeast, *Caulobacter*, myxobacteria, *Leptospira*, photosynthetic bacteria, *Bdellovibrio*, luminescent bacteria, and others. Lab only.

5125. LABORATORY IN RECOMBINANT DNA TECHNOLOGY. (4 cr, §Biol 5125; application necessary, Δ)

Introduction to basic recombinant DNA techniques. Methods for growing, isolating, and purifying recombinant DNAs and cloning vectors.

5218. IMMUNOLOGY. (3 cr; prereq Biol 5001)

Cellular, protein, and genetic bases of humoral immunity; methods used to measure antibodies and antigens. T lymphocytes: interaction of T helper cells with B lymphocytes and other T cells in cell-mediated immunity. Clinical immunology: immunodeficiency, allergy, autoimmunity, transplantation.

5232. MEDICAL MICROBIOLOGY. (3 cr; not open to medical students; prereq 5218, 5105 or 3103 or 8110 or Biol 5013)

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

5234.¹ IMMUNOLOGY AND MEDICAL MICROBIOLOGY LABORATORY. (3 cr; prereq 5218 or ¶5218, 5232 or ¶5232)

Laboratory exercises demonstrate principles that determine the outcome of host-parasite interactions. Experiments focus on methods basic to host defense and immunology, including the immunochemical and microbiological methods used to diagnose infectious disease.

5235. MICROORGANISMS AND DISEASE. (4 cr; not open to biology or microbiology majors; prereq 10 cr chemistry, 5 cr biological sciences or #)

Same as 5233 without lab.

5321. PHYSIOLOGY OF BACTERIA. (3 cr; prereq 3103 or 5105 or Biol 5013 or VPB 3103, Biol 5001, 3 cr genetics)

Chemical and physical organization of bacteria as related to function; growth; energy metabolism including oxidations and fermentations; nutritional requirements; antimicrobial agents; autotrophic mechanisms; microbial differentiation.

5322. MICROBIAL DIVERSITY AND PHYSIOLOGY LABORATORY. (3 cr; prereq 5321 or ¶5321 or equiv)

Isolation from natural sources and study of the physiology and metabolism of a wide variety of microorganisms such as *Clostridium*, yeast, *Caulobacter*, myxobacteria, *Leptospira*, photosynthetic bacteria, *Bdellovibrio*, luminescent bacteria, and others. Lab only.

5352. APPLIED MICROBIOLOGY. (4 cr; prereq 5321 or #)

Microbial adaptation to various environments; role of microorganisms in the earth's biogeochemical cycles. Application of microbial systems to industrial processes; basic principles of fermentation technology; microbial bioconversions and product formation. Biodegradation of chemicals.

5424.¹ VIROLOGY. (3 cr; prereq 5321 or Biol 5001 or #)

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

5425. VIROLOGY AND MICROBIAL GENETICS LABORATORY. (3 cr; prereq Biol 5001, GCB 3022 or 5022, or Biol 5003, MicB 5424 or ¶5424)

Modern techniques in virology and microbial genetics: animal cell culture, virus infectivity titrations, analysis of viral nucleic acids and proteins by radiolabeling, gel electrophoresis and blot hybridizations, cell transformation by tumor viruses and DNA, analysis and mapping of mutants in microorganisms.

5611. MICROBIAL ECOLOGY. (3 cr, §Soil 5605; prereq 3103 or 5105 or Biol 5013 or Soil 5610 or #; A-F only)

Interrelationship of microorganisms with terrestrial, aquatic, and organismal environments; survey of bacterial, fungal, and algal components of ecosystems; evolution and structure of microbial communities; population interactions within ecosystems; quantitative and habitat ecology; biogeochemical cycling; and biotechnological approaches to the study of microbial ecology.

5900. TOPICS IN MICROBIOLOGY. (1 cr; open to microbiology sr majors; A-F only)

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

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

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

5990. DIRECTED RESEARCH. (Cr ar; prereq #, Δ)

Laboratory or field investigation of selected areas of research.

For Graduate Students Only

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

8110. BIOLOGY OF MICROORGANISMS**8112. MICROBIAL GENETICS****8121. ADVANCED IMMUNOLOGY LABORATORY: MONOCLONAL ANTIBODY APPLICATIONS****8216. FRONTIERS OF IMMUNOLOGY I: IMMUNOCHEMISTRY****8217. FRONTIERS OF IMMUNOLOGY II: MOLECULAR IMMUNOLOGY****8218. FRONTIERS OF IMMUNOLOGY III: CLINICAL IMMUNOLOGY**

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

Major Requirements and Course Descriptions

8231. ADVANCED TOPICS IN MOLECULAR PATHOGENESIS

8421. VIROLOGY AND TUMOR BIOLOGY

8911. COLLOQUIUM IN MICROBIOLOGY

8990. RESEARCH IN MICROBIOLOGY

Plant Biology (PBio) Major

Director of Undergraduate Studies—Tom Soulen

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

The major in plant biology provides a comprehensive and well-balanced undergraduate education in biology with a concentration in the plant sciences. Students are required to take 21 upper division credits in Plant Biology (PBio) chosen from: 3109, 3131 (or 5131), 3201, 5103, 5105, 5111, 5132, 5141, 5231. All these courses fulfill the "upper division science and mathematics credits" requirement 5i under Admission Procedures and Degree Requirements for graduation. Under certain circumstances, an appropriate course may be substituted. In selecting courses, students should consult the director of undergraduate studies, who must approve all programs.

Minor Sequence

Required Preparatory Courses—Biol 1009, 1103 or 3012.

Minor Requirements—Three courses plus one seminar to total a minimum of 15 cr in plant biology, chosen from: 3131, 3109 or 5111, 3201, 5103, 5105.

The program must be approved by the director of undergraduate studies.

PBio Courses

1009. MINNESOTA PLANT LIFE. (4 cr; suitable for nonmajors)

Identification of the more characteristic and conspicuous Minnesota plants, including many lower forms, with discussion of their basic distinctions, life cycles, habitat requirements, distribution, vegetation types, and ecological relations. Lectures, demonstrations, six field trips.

1012. PLANTS USEFUL TO HUMANS. (4 cr; for majors or nonmajors)

Roles that plants play and have played in human biological and cultural development. Lectures and demonstrations.

Biol 1103. GENERAL BOTANY. (5 cr, §Biol 3012; prereq Biol 1009; students who plan to major in biology in CLA or in any bioscience in CBS should take Biol 3012)

Organization levels of plants; plant function, growth and development, reproduction. Lab.

Biol 3012. PLANT BIOLOGY. (5 cr, §Biol 1103; §Biol 3812; prereq Biol 1009, Chem 1005)

Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants. Lab.

3109. PLANT ANATOMY. (5 cr; prereq Biol 1103 or 3012; offered alt yrs)

Structure and development of plants with special reference to vascular plants.

3131. SURVEY OF PLANT PHYSIOLOGY. (4 cr, §5131, §PIPh 3131, §PIPh 5131; prereq Biol 1103 or 3012, BioC 3031 or ¶BioC 3031 or Biol 5001)

Physiological principles underlying processes that occur in living plants, with emphasis on higher plants. Growth and development, mineral nutrition, transport, water relations, and metabolism, emphasizing photosynthesis and nitrogen assimilation. For lab, see 5132.

3201. INTRODUCTORY PLANT SYSTEMATICS. (4 cr; prereq Biol 1103 or 3012)

Systematics of the flowering plants of the world. Ecology, geography, origins, and evolution of flowering plants; family characteristics; floral structure, function, and evolution; pollination biology; methods of phylogenetic reconstruction; molecular evolution; taxonomic terms; methods of collection and identification. Two field trips.

3960. RESEARCH TOPICS IN PLANT BIOLOGY. (1 cr; prereq Biol 1103 or 3012; S-N only)

For undergraduates interested in plant biology. Lecture, discussion, and demonstration of faculty research interests.

5001. BASIC BOTANY. (Cr ar; prereq Biol 1008 or 1009, #, Δ)

For beginning graduate students who need to strengthen their botanical background.

5103. ALGAE, FUNGI, AND BRYOPHYTES. (5 cr; prereq Biol 1103 or 3012; offered when feasible)
Characteristics of groups, evolutionary relationships, life cycles, comparative morphology (including ultrastructure), comparative nutrition. Laboratory emphasizes living material and isolation of algae and fungi into culture.

5105. MORPHOLOGY OF VASCULAR PLANTS. (5 cr; prereq Biol 1103 or 3012 or #; offered alt yrs)
Ferns and their allies, Gymnosperms (cycads, Ginkgo, conifers) and Angiosperms (flowering plants). Comparative morphology of vegetative and reproductive structures; life cycles; evolutionary relationships.

5107. MYCOLOGY: BASIDIOMYCETES. (4 cr; prereq PIPa 5105 or equiv or PBio 5103 or introductory microbiology or #; offered alt yrs)
Ecology, evolutionary relationships, systematics (taxonomy and nomenclature), morphology (including ultrastructure and life cycles of the basidiomycetes). Laboratories parallel lectures, with living and preserved representatives of the Uredinales, Auriculariales, Septobasidiales, Exobasidiales, Sporobolomycetales, Ustilaginales, Tilletiales, Tremellales, Dacrymycetales, Tulasnellales, Aphylliphorales, Agaricales, and Gasteromycetes.

5109. MOLECULAR GENETICS AND BIOCHEMISTRY OF YEASTS AND FILAMENTOUS FUNGI. (4 cr, §PIPa 5109; prereq one course each in genetics and biochemistry or #)
Chromosome structure and function, regulation of nuclear gene expression, mitochondrial gene organization and expression, membrane and organelle biogenesis, cell cycle regulation, morphogenesis, mating and reproduction, recombination and gene switching, spore formation and germination, viruses, plasmids, toxins.

5111. PLANT CELL, TISSUE, AND ORGAN DEVELOPMENT. (5 cr; prereq Biol 1103 or 3012; offered alt yrs)
Microscopic structure of vascular plants; development in root, stem, and leaf.

5131. SURVEY OF PLANT PHYSIOLOGY. (4 cr, §3131, §PIPh 3131, §PIPh 5131; prereq Biol 1103 or 3012, BioC 3031 or ¶BioC 3031 or Biol 5001)
Physiological principles underlying processes that occur in living plants, with emphasis on higher plants. Growth and development, mineral nutrition, transport, water relations, and metabolism, emphasizing photosynthesis and nitrogen assimilation. Weekly discussion section.

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

5141. PLANT CELL BIOLOGY. (4 cr; prereq Biol 5004 or equiv; offered alt yrs)
Structural, functional, developmental, and biochemical aspects of cellular components and processes specific to plants. Cell walls, dictyosome activity, plastids, plant cytoskeleton, modes of plant cytokinesis, cell-cell communication, lectins and cell recognition, vacuoles, cytoplasmic streaming.

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

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

5184. PLANT GROWTH AND DEVELOPMENT. (3 cr, §PIPh 5184; prereq 5131 or equiv)
Survey of plant growth and development ranging from germination to death, with emphasis on physiology, biochemistry, and molecular biology. Topics include developmental processes related to: mobilization of macromolecules during germination, cell division and extension during axis growth, photomorphogenesis, chloroplast and microbody ontogeny, flowering, fruit and seed formation, senescence, and how plant growth substances control these developments.

5186. TOPICS IN PLANT BIOCHEMISTRY. (3 cr; prereq Biol 5001 or BioC 5331; offered alt yrs)
Biochemical processes unique to plants, with emphasis on structures of the macromolecules involved and their reactions and regulation. Major topics: light reactions of photosynthesis, secondary metabolism, and carbohydrates. Minor topics: carbon dioxide fixation and nitrogen fixation.

5203. HERBARIUM TECHNIQUES. (1 cr; prereq 1009 or 3201 or equiv; S-N only)
A "hands-on" approach to museum curation procedures in the herbarium. Students are exposed to all aspects of herbarium management and assist with some curation of plant specimens.

5221. PLANT MOLECULAR EVOLUTION. (3 cr; prereq GCB 3022 or 5022 or Biol 5003; offered alt yrs)
Applications of molecular genetics to the study of processes and products of evolution. Topics include phylogenetic reconstruction, chromosomal evolution, multigene families, molecular aspects of morphological change, role of transposons in evolution, DNA sequence evolution, and measures of genetic diversity.

5231. INTRODUCTION TO THE ALGAE. (5 cr; prereq 10 cr in plant biology or biology or #; offered when feasible)
Structure, reproduction, and life histories of major algal divisions.

5960. SPECIAL TOPICS. (Cr ar; prereq #, Δ)
Treatment in depth of a specialized botanical topic.

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

5990. DIRECTED RESEARCH. (Cr ar; prereq #, Δ)
Laboratory or field investigation of selected areas of research.

Major Requirements and Course Descriptions

Courses Offered at Lake Itasca Forestry and Biological Station

Biol 3812. PLANT BIOLOGY. (5 cr, §1103, §3012; prereq 1009, Chem 1005)
Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants. Field trips scheduled at Itasca.

5801. PLAINS AND BOREAL FLORA. (5 cr; prereq course in taxonomy, Δ; offered when feasible)
Survey of the summer flowering plants and ferns of the state with particular reference to the local flora. Identification by technical keys; important plant families; field recognition of common species; habitat preferences; natural history and population biology of selected important species.

5811. FRESHWATER ALGAE. (5 cr; prereq 10 cr plant biology, biology or zoology or equiv, Δ; offered when feasible)
Morphology, systematics, and distribution of the local algal flora. Collection, preservation, numeration, and culture techniques; identification of field collections using appropriate technical literature. Ecological implications of species interactions, algal associations, and indicator taxa.

5890. RESEARCH PROBLEMS. (1-5 cr per qtr; prereq Δ)
Individual research for undergraduates and graduates.

For Graduate Students Only

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

8287. PLANT MOLECULAR BIOLOGY
8301. POLLEN MORPHOLOGY AND QUATERNARY PALYNOLOGY
8950. SEMINAR
8990. RESEARCH PROBLEMS

Recommended Related Coursework

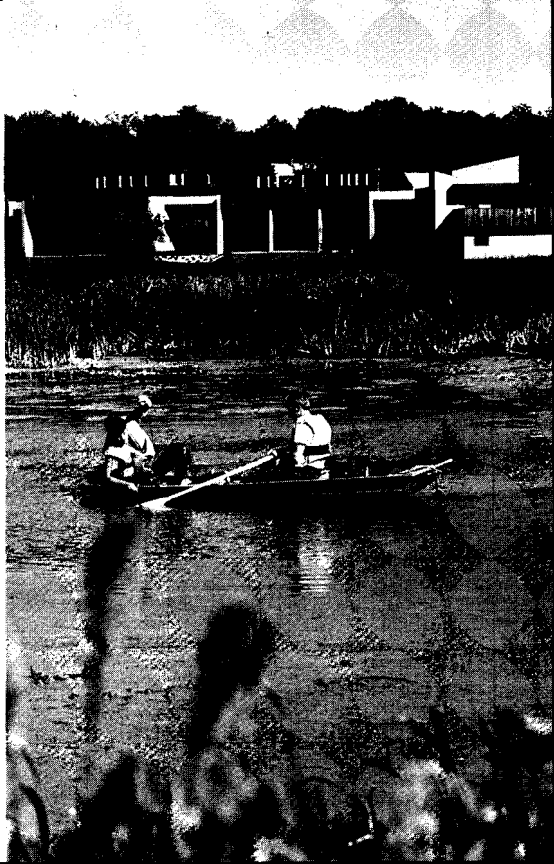
The University of Minnesota offers a wide variety of courses in the life sciences in addition to those found in CBS. Students are encouraged to consult the bulletins of several colleges to explore courses in related areas (College of Agriculture, College of Human Ecology, College of Liberal Arts, College of Natural Resources, Institute of Technology, Health Sciences, Public Health). Courses are recommended in:

anatomy (CBN)
animal science (AnSc)
anthropology (Anth)
biophysics (BPhy)
chemical engineering (ChEn)
chemistry (Chem)
computer science (CSci)
entomology (Ent)
fisheries and wildlife (FW)
food science and nutrition (FScN)
forest resources (FR)
geology (Geo)
history of medicine & science (HMed, HSci)
laboratory medicine (LaMP)
mathematics (Math)
natural resources and environmental studies (NRES)
pharmacology (Phcl)
philosophy (Phil)
physics (Phys)
physiology (Phsl)
plant sciences (PIPa)
psychology (Psy)
public health (PubH)
soil science (Soil)
statistics (Stat)
veterinary biology (VB)
veterinary pathobiology (VPB)

More complete information on courses from related programs is available in the student services office, 223 Snyder Hall (St. Paul).

College of Biological Sciences

Research and Teaching Facilities



Research and Teaching Facilities

Research and Teaching Facilities

The College of Biological Sciences has faculty and facilities located on both the Minneapolis and St. Paul campuses. The college is organized into the following departments: Biochemistry; Ecology, Evolution, and Behavior; Genetics and Cell Biology; and Plant Biology. The Department of Microbiology, in the Medical School, also functions as a department of the college for undergraduate education. A full description of each of these departments and their major degree requirements may be found in the fourth section of this bulletin.

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 last section of this bulletin.

Special Research and Teaching Centers

Bell Museum of Natural History—Located at Church and University Avenues S.E., Minneapolis, this museum features diorama exhibits of Minnesota wildlife, the Touch and See Room, and the Jaques Gallery of natural history art. It also houses extensive research collections of birds, mammals, reptiles, amphibians, and fish as well as the University's natural history library. Groups of 10 or more who wish to visit the museum should make reservations. Guided tours are available to groups upon advance request. Interested students may gain valuable experience and part-time employment as museum tour guides. The Blue Heron Bookshop offers an excellent selection of field guides and other natural history books for adults and children as well as records of bird and animal calls. Public programs are offered at scheduled times during the year. All museum programs are open to the public,



and many are free to University of Minnesota students. Call 612/624-1852 for appointments or further information.

Biological Sciences Greenhouse and Herbarium—Located on the St. Paul campus, the greenhouse is a teaching and research facility with standard bench space. Three landscaped rooms exhibit the flora of the tropics, subtropics, and desert (612/625-4788).

The Herbarium contains over 780,000 specimens of fungi, lichens, mosses, gymnosperms, and angiosperms collected mainly on the North American continent. This collection is a major resource for botanically oriented research both at the University and at other institutions (612/625-0215).

Cedar Creek Natural History Area—Located within commuting distance of campus, Cedar Creek not only serves as the site of ecological and behavioral field research, but also provides unique opportunities for student projects and summer employment. For student opportunities, contact the Student Services Office (612/624-9717) or the Program Director of Cedar Creek Natural History Area (612/625-8462).

General Biology Program—Located in Kolthoff Hall at 225 Pleasant Street S.E., Minneapolis, the General Biology Program administers beginning biology courses for most University students, serving approximately 3,200 students per year. The college takes its responsibility for introductory instruction in biology very seriously; students will meet CBS' finest instructors in these courses and enjoy personal attention in laboratory sections. Call 612/625-6636 for more information.

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

Institute for Advanced Studies in Biological Process Technology—The institute, established in 1985, takes advantage of the unusual breadth of interest and expertise of faculty at the University to investigate cell population biology, membrane biology, molecular genetics, and protein structure and function as they relate to biological process technology. The institute's Central Research Facility (CRF) is a new shared-use facility, a university-wide laboratory equipped with state-of-the-art equipment to facilitate research in fermentation, animal and plant cell culture technology, and large-scale separation of biological molecules. The institute promotes collaboration between University researchers and industry, meeting increasing demands for students trained jointly in biological and engineering disciplines (612/624-6774).

Institute of Human Genetics—The major objective of the institute is to develop an interdisciplinary approach to the study and application of new developments in human genetics. The institute will develop 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. These developments and their applications will affect not only the genetics of humans, but other animal species, including agriculturally-important species.

The following genetic programs have been developed within the institute: (a) molecular genetics, (b) behavioral genetics, (c) clinical genetics, (d) population genetics, (e) genetic services (Molecular Diagnostics Laboratory, Microchemical Facility, Gene Therapy Program (612/624-3110).

Lake Itasca Forestry and Biological Station—Located 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 studying varied ecosystems and 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 contained in the *Summer Session Bulletin*. Reservations for and questions about the Itasca program should be addressed to the Director, Itasca Biology Program, 305 Zoology Building, University of Minnesota, 318 Church Street S.E., Minneapolis, MN 55455 (612/625-9165).

Instructional Computing Center—Biology students have access to a well-equipped MAC computing facility in 122 Snyder Hall. Designed primarily to meet instructional needs, priority use in the computer center is given to undergraduate students working on course-related materials. To assist with coursework, students can use programs for

word processing, graphing, drawing, or spreadsheets. In addition, the center houses specialized software purchased for student use, such as programs to assist with preparation for the Graduate Record Examination (GRE). The computer lab is open Monday through Thursday 8 a.m. to 8 p.m., Friday 8 a.m. to 6 p.m., and Saturday 10 a.m. to 4 p.m.

Molecular Biology Computer Center (MBCC)—Located in Gortner Lab, the center serves over 90 laboratories with advanced nucleic acid and peptide sequence analysis software. The MBCC is one of several worldwide BIONET satellites with complete and continuously updated national databases. Molecular graphics facilities permit specialized research on the structure and function of DNA, RNA, and proteins. Student computers are available, as are workshops, a helpline, and consulting. For further information, call 612/625-9284.

Plant Molecular Genetics Institute—The institute was organized to: (1) foster research in molecular biology and genetics of economically important plants and relevant model plant systems; (2) develop genetic engineering methodologies for application to crop improvement; (3) educate future plant biology researchers and teachers; (4) maintain a stimulating interdisciplinary environment in which to explore and develop new ideas and experimental approaches in plant molecular biology; and (5) provide a focus for external communication to aid recruitment and funding. The institute consists of faculty from existing departments. Members of the institute faculty come from two colleges (Biological Sciences and Agriculture) and six departments (Genetics and Cell Biology, Agronomy and Plant Genetics, Biochemistry, Plant Biology, Horticulture, and Plant Pathology). The institute's research laboratories are those of existing and/or newly recruited faculty. The institute supports seminars as well as frequent symposia on topics related to plant molecular biology and

provides funds for speakers and visiting scientists. Faculty and students participate in one of the following graduate programs: genetics, horticulture, microbiology, plant breeding, plant pathology, plant biological sciences. Membership in the institute is determined by nomination and election by institute faculty (612/625-6282).

Graduate Programs

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

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

Biochemistry—John S. Anderson, 624-3662

Cell and Developmental Biology—Carolyn D. Silflow, 624-0729

Conservation Biology—Francesca J. Cuthbert, 624-1756

Ecology—Edward J. Cushing, 625-9415

Genetics—Paul A. Lefebvre, 624-4706

Microbial Engineering—Gary Dunny, 626-1217

Microbiology—Patrick M. Schlievert, 624-1484

Neuroscience—Robert F. Miller, 626-2914

Plant Biological Sciences—David D. Biesboer, 625-1799

Zoology—Elmer C. Birney, 624-0578

College of Biological Sciences

Administration and Faculty



Administration and Faculty

University Regents

Elton A. Kuderer, Fairmont, Chair
Jean B. Keffeler, Minneapolis, Vice Chair
Wendell R. Anderson, Minneapolis
M. Elizabeth Craig, Minnetonka
H. Bryan Neel, Rochester
Alan C. Page, Minneapolis
Mary J. Page, Olivia
Thomas R. Reagan, Gilbert
David K. Roe, Minneapolis
Darrin M. Roshka, St. Paul
Stanley D. Sahlstrom, St. Cloud
Ann J. Wynia, St. Paul

University Administrators

Nils Hasselmo, President
Bob Erickson, Senior Vice President for Finance and Operations
Ettore Infante, Senior Vice President for Academic Affairs and Provost
C. Eugene Allen, Vice President for Agriculture, Forestry, and Home Economics
Robert E. Anderson, Vice President for Health Sciences
Richard B. Heydinger, Vice President for External Relations
Anne H. Hopkins, Vice Provost for Arts, Sciences, and Engineering
Marvalene Hughes, Vice President for Student Affairs
General Counsel, to be appointed

College of Biological Sciences Administrators

This is a listing of deans, department heads, and directors; see also CBS Directory in the first section of this bulletin for special program offices and directors of undergraduate study. A listing of all CBS faculty follows.

P. T. Magee, Dean
123 Snyder Hall, St. Paul campus (612/624-2244)

Sally B. Jorgensen, Associate Dean
123 Snyder Hall, St. Paul campus (612/624-2244)

Kathleen F. Peterson, Director of Student Services
223 Snyder Hall, St. Paul campus (612/624-9717)

Biochemistry—Norma Allewell, Head, 140 Gortner Lab, St. Paul campus (624-7755)

Cedar Creek—John R. Tester, Director, 304 Zoology Bldg., Minneapolis campus (625-8462); Cedar Creek Area (434-5131)

Ecology, Evolution, and Behavior—Franklin H. Barnwell, Head, 109 Zoology Bldg., Minneapolis campus (625-4466)

General Biology Program—Susan M. Wick, Director, P180 Kolthoff Hall, Minneapolis campus (625-6636)

Genetics and Cell Biology—Ross G. Johnson, Head, 248A Biological Sciences Center. St. Paul campus (624-3003)

Gray Freshwater Biological Institute—Steven Eisenreich, Interim Director, P.O. Box 100, County Roads 15 and 19, Navarre, MN 55392 (471-8476)

Herbarium—Anita Cholewa, Curator and Coordinator, 842 Biological Sciences Center, St. Paul Campus (625-0215)

Institute for Advanced Studies in Biological Process Technology—Michael C. Flickinger, Director, 240 Gortner Lab, St. Paul campus (624-6774)

James Ford Bell Museum of Natural History—Elmer C. Birney, Director, 301 Bell Museum, Minneapolis campus (624-2596)

Lake Itasca Program—Donald Siniff, Director, 306 Zoology Bldg., Minneapolis campus (625-9165)

Microbiology (Medical School)—Ashley T. Haase, Head, 1460 Mayo Memorial Bldg., Minneapolis campus (624-4442)

Molecular Biology Computer Center—Peter Saurugger, Director, 247 Gortner Lab, St. Paul campus (625-9284)

Plant Biology—Irwin Rubenstein, Head, 220 Biological Sciences Center, St. Paul campus (625-1234)

Plant Molecular Genetics Institute—Burle Gengenbach, Director, 250 Biological Sciences Center, St. Paul campus (625-6282)

Faculty

Department of Biochemistry

Allewell, Norma M., Professor and Head
Ph.D., Yale University
Protein structure, function and design; mechanisms of biological recognition and communication; functional energetics of biological molecules; computer modelling.
624-3011

Anderson, John S., Professor
Ph.D., University of Nebraska
Structure and biosynthesis of bacterial cell walls and membranes.
624-3662

Barry, Bridgette A., Assistant Professor
Ph.D., University of California, Berkeley
Photosynthetic electron transfer.
624-6732

Bernlohr, David A., Associate Professor
Ph.D., University of Illinois, Urbana
Adipocyte gene expression; regulation of adipocyte metabolism.
624-2712

Bloomfield, Victor A., Professor
Ph.D., University of Wisconsin, Madison
Physical biochemistry of nucleic acids and viruses; hydrodynamics and laser scattering; subunit assembly.
625-2268

Conti-Tronconi, Bianca M., Professor
M.D., University of Milano, Italy
Structure and function of nicotinic receptors in brain and muscle; immunology of myasthenia gravis.
624-6796

Das, Anath, Associate Professor
Ph.D., University of Nebraska, Lincoln
Mechanisms of Ti-plasmid-mediated gene transfer into plant cells; gene expression and its regulation in higher plants.
624-3239

Flickinger, Michael C., Professor
Ph.D., University of Wisconsin, Madison
Fermentation; cell culture technology; cellular energetics; regulation of protein synthesis; protein separation.
624-9706

Fuchs, James A., Professor
Ph.D., Texas A&M University, College Station
Deoxynucleotide metabolism; DNA synthesis; regulation of metabolic pathways.
624-1215

Lovrien, Rex, Professor
Ph.D., University of Iowa
Enzymology; thermodynamics; binding processes; protein crystallization.
624-2776

Nelsestuen, Gary L., Professor
Ph.D., University of Minnesota
Protein-membrane interactions; protein kinase C; complement; blood coagulation.
624-3622

Raftery, Michael A., Professor
Ph.D., National University of Ireland, Galway
Biology and chemistry of cell surfaces; molecular mechanisms of synaptic transmission and axonal conduction.
624-9734

Schottel, Janet L., Associate Professor
Ph.D., Washington University
Nucleic acid biochemistry; molecular biology.
624-6275

Tsong, Tian Y., Professor
Ph.D., Yale University
Physical biochemistry of proteins and cell membranes.
625-5262

Wackett, Lawrence P., Assistant Professor
Ph.D., University of Texas, Austin
Biodegradation; dehalogenases; applications of enzymology in environmental detoxification and organic synthesis; oxygenases.
471-9493

Wood, John M., Professor
Ph.D., University of Leeds, England
Metabolic cycles for toxic elements; principles of bioaccumulation; mechanism of action of enzymes that contain transition elements.
471-7777

Woodward, Clare K., Professor
Ph.D., Rice University
Protein chemistry; hydrogen exchange kinetics; NMR spectroscopy; protein folding.
624-4714

Department of Ecology, Evolution, and Behavior

Abrams, Peter A., Professor
Ph.D., University of British Columbia
Marine ecology, mathematical ecology, and evolutionary ecology.
625-0985

Alstad, Donald N., Associate Professor
Ph.D., University of Utah
Population ecology and evolution of insects.
625-0488

Barnwell, Franklin H., Professor and Head*
Ph.D., Northwestern University
Invertebrate behavior and physiology, with emphasis on ecological relationships.
625-4466

Beatty, John H., Associate Professor
Ph.D., Indiana University
History and philosophy of biology.
625-5174

Birney, Elmer C., Professor
Ph.D., University of Kansas
Mammalian evolution and ecology.
624-0578

Bright, Robert C., Associate Professor
Ph.D., University of Minnesota
Quaternary history.
624-2866

Corbin, Kendall W., Professor
Ph.D., Cornell University
Evolutionary ecology and genetics; biochemical systematics.
625-7618

Curtsinger, James W., Associate Professor
Ph.D., Stanford University
Population/quantitative genetics, experimental and theoretical.
625-4122

Cushing, Edward J., Professor
Ph.D., University of Minnesota
Paleoecology, ecology of plant communities.
625-9415

*Recipient of the Horace T. Morse-Minnesota Alumni Association Award for Outstanding Contributions to Undergraduate Education.

†Recipient of the Stanley Dagley Distinguished Teacher Award.

Administration and Faculty

Davis, Margaret B., Regents' Professor
Ph.D., Harvard University
Paleoecology, paleolimnology, forest community
ecology.
625-1102

Gorham, Eville, Regents' Professor
Ph.D., University of London, England
Chemical aspects of ecology, limnology, and soil
science.
625-4407

Heinselman, Miron L., Adjunct Professor
Ph.D., University of Minnesota
Forest ecology, peatlands evolution.
644-2835

McKinney, D. Frank, Professor
Ph.D., University of Bristol, England
Animal behavior.
624-1698

McNaught, Donald, Professor
Ph.D., University of Wisconsin
Zooplankton ecology, Great Lakes limnology,
ecosystem contamination.
625-7425

Mech, David L., Adjunct Professor
Ph.D., Purdue University
Carnivore ecology, predator-prey relations, mammalian
social ecology.
649-5231

Megard, Robert O., Professor
Ph.D., Indiana University
Limnology.
625-4610

Morrow, Patrice, Professor
Ph.D., Stanford University
Plant-insect interactions, community ecology.
625-3979

Murdock, Gordon, Adjunct Associate Professor
Ph.D., Duke University
Invertebrate biology and museum studies.

Packer, Craig, Associate Professor
Ph.D., University of Sussex, England
Behavioral ecology and sociobiology.
625-6137

Parmelee, David F., Professor
Ph.D., University of Oklahoma
Ornithology.
624-0225

Pastor, John, Adjunct Professor
Ph.D., University of Wisconsin
Nutrient cycling, animal-ecosystem interactions, forest
productivity, landscape and global ecology, northern
ecosystems.
218/720-4271

Phillips, Richard E., Professor
Ph.D., Cornell University
Animal behavior, physiology.
625-5686

Pusey, Anne E., Associate Professor
Ph.D., Stanford University
Animal behavior.
625-3252

Regal, Philip J., Professor
Ph.D., University of California, Los Angeles
Evolution, physiological ecology and behavior,
herpetology.
625-4669

Schmid, William D., Professor
Ph.D., University of Minnesota
Comparative physiology, ecology.
625-8630

Shapiro, Joseph, Professor
Ph.D., Yale University
Limnology.
624-0596

Siniff, Donald B., Professor
Ph.D., University of Minnesota
Vertebrate ecology; population ecology of large
mammals.
625-2435

Starfield, Anthony M., Professor
Ph.D., University of Witwatersrand, Johannesburg,
South Africa
Ecological modeling.
625-0926

Tester, John R., Professor
Ph.D., University of Minnesota
Vertebrate ecology, ecosystem ecology.
625-8462

Tilman, G. David, Professor
Ph.D., University of Michigan
Experimental and theoretical population and community
ecology.
625-6927

Tordoff, Harrison B., Professor Emeritus
Ph.D., University of Michigan
Systematic and evolutionary biology, ornithology.
624-4363

Underhill, James C., Professor
Ph.D., University of Minnesota
Ichthyology.
624-3367

Wright, Herbert E., Regents' Professor Emeritus
Ph.D., Harvard University
Quaternary paleoecology and glacial geology.
624-5215

Department of Genetics and Cell Biology

Blumenfeld, Martin, Associate Professor
Ph.D., Case Western Reserve University
Chromosomal organization.
624-7408

Brooker, Robert J., Associate Professor
Ph.D., Yale University
Molecular approaches to membrane transport.
624-3053

Caldecott, Richard S., Professor
Ph.D., State College of Washington
Radiation biology.
624-9509 or 626-1616

Crosby, Madeline A., Assistant Professor
Ph.D., California Institute of Technology
Developmental genetics of *Drosophila*.
624-3284

Cunningham, William P., Professor**
Ph.D., University of Texas, Austin
Pollutant effects on cell structure and function.
624-9266

Enfield, Franklin D., Professor
Ph.D., University of Minnesota
Nature of quantitative genetic variation in the flour
beetle and the cotton boll weevil.
624-7706

Fan, David P., Professor
Ph.D., Massachusetts Institute of Technology
Lymphokines and the development of cytotoxic
lymphocytes.
624-4718

Goldstein, Stuart F., Associate Professor
Ph.D., California Institute of Technology
Cell motility, especially flagellar beating.
624-5399

Hackett, Perry B., Associate Professor
Ph.D., University of Colorado Medical Center
Gene expression in viral infection; developing fish.
624-6736

Hays, Thomas S., Assistant Professor
Ph.D., University of North Carolina
Molecular mechanisms of microtubule-mediated motility
in *Drosophila*.
625-5226

Herman, Robert K., Professor
Ph.D., Yale University
Developmental genetics of the small nematode,
C. elegans.
624-6203

Herman, William S., Professor
Ph.D., Northwestern University
Structure and function of arthropod peptide hormones.
625-2243

Hooper, Alan B., Professor*
Ph.D., Johns Hopkins University
Mechanisms of nitrogen metabolism in bacteria.
624-4930

Iwanij, Victoria, Associate Professor
Ph.D., Rockefeller University
Expression and function of glucagon receptors.
624-4942

Johnson, Ross G., Professor and Head
Ph.D., Iowa State University
Role of gap junctions in intercellular communication.
624-1741

Kerr, Norman S., Professor
Ph.D., Northwestern University
Developmental biology of the true slime molds.
624-1789

King, Richard A., Professor
Ph.D., Minnesota, M.D., Jefferson Medical
Biochemical and molecular analysis of melanin
metabolism and genetic abnormalities of melanin
synthesis.
624-0144

Lefebvre, Paul A., Associate Professor
Ph.D., Yale University
Gene expression in *Chlamydomonas* with flagellar
regeneration.
624-4706

Magee, P. T., Professor
Ph.D., University of California, Berkeley
Genetics and development of *S. cerevisiae* and
C. albicans.
625-4732

McKinnell, Robert G., Professor
Ph.D., University of Minnesota
Invasiveness of herpes virus-induced tumor cells.
624-2285

Robert E. Pruitt, Assistant Professor
Ph.D., California Institute of Technology
Plant floral development and function.
624-3408

Rodell, Charles F., Professor
Ph.D., University of Minnesota
Ecological Genetics.
1-612-363-3174

Rosenberg, Murray D., Professor
M.D., Ph.D., Harvard University
Role of ectoenzymes in a variety of membrane
processes.
624-3607

*Recipient of the Horace T. Morse-Minnesota Alumni
Association Award for Outstanding Contributions to
Undergraduate Education.

**Recipient of the Continuing Education and Extension
Distinguished Teaching.

Administration and Faculty

- Shaw, Jocelyn E., Assistant Professor
Ph.D., University of Toronto
Regulation of development in *C. elegans* with genetic approaches.
625-1912
- Silflow, Carolyn D., Associate Professor
Ph.D., University of Georgia
Structure, organization, and regulation of tubulin genes in algae and higher plants.
624-0729
- Simmons, Michael J., Professor*
Ph.D., University of Wisconsin, Madison
Transposable genetic elements in *D. melanogaster*.
624-5354
- Sinha, Akhouri A., Professor
Ph.D., University of Missouri, Columbia
Stromal-epithelial interactions in tumors; protease involvement.
725-2000, ext. 2846
- Snustad, D. Peter, Professor*†
Ph.D., University of California, Davis
Regulation of gene expression in plants.
624-3499
- Woodward, Val W., Professor*
Ph.D., Cornell University
Critique of biologizing human behavior.
624-3060
- Department of Plant Biology**
- Berman, Judith G., Assistant Professor
Ph.D., Weizmann Institute of Science
Yeast molecular biology; telomere structure and function; telomeric DNA-binding proteins.
625-1971
- Biesboer, David D., Associate Professor
Ph.D., Indiana University
Developmental physiology and anatomy of secretory cells; tissue culture; secondary metabolism; biomass energy production; leafy spurge.
625-1799
- Brambl, Robert M., Professor
Ph.D., University of Nebraska
Biochemistry of fungal spore germination; mitochondrial biogenesis and regulation of membrane enzyme assembly.
625-7080
- Charvat, Iris D., Associate Professor*†
Ph.D., University of California, Santa Barbara
Development, physiology, and ultrastructure of lysosomal compartment of fungi and higher plants; ultrastructure of fungi and higher plants; Mycorrhizae.
625-3199
- Doebley, John F., Associate Professor
Ph.D., University of Wisconsin
Biosystematics of flowering plants; evolutionary genetics; evolution of crop plants.
625-3702
- Frenkel, Albert W., Professor Emeritus
Ph.D., University of California, Berkeley
Photosynthesis of higher plants, algae, and photosynthetic bacteria; photorespiration in green plants; porphyrin-sensitized photo-oxidation of biological interest.
625-4236
- Gantt, J. Stephen, Assistant Professor
Ph.D., University of California, Irvine
Control of cytoplasmic ribosome synthesis; regulation of expression of nuclear encoded chloroplast ribosomal protein genes.
625-4763
- Gleason, Florence K., Associate Professor
Ph.D., University of Iowa
Control of cell division and light-mediated regulation of metabolism in blue-green algae; secondary metabolism in freshwater algae.
625-4275
- Koukari, Willard L., Professor
Ph.D., University of New Hampshire
Physiology of growth and development; biological rhythms; photomorphogenesis; stress.
625-1958
- May, Georgiana, Assistant Professor
Ph.D., University of California, Berkeley
Molecular function and evolution of mating type genes in Agaric Basidiomycetes, particularly within the genus *Coprinus*.
625-1998
- McLaughlin, David J., Professor
Ph.D., University of California, Berkeley
Ultrastructure and evolution of fungi, especially basidiomycetes; development and physiology of fruiting in mushrooms.
625-5736
- Olszewski, Neil E., Assistant Professor
Ph.D., University of Minnesota
Plant molecular biology; gibberellins; genes affecting plant structure.
625-3129
- Pratt, Douglas C., Professor
Ph.D., University of Minnesota
Physiological and ecological aspects of biomass production on marginal lands; growth and physiology of mosses.
625-8258
- Rubenstein, Irwin, Professor and Head
Ph.D., University of California, Los Angeles
The structural organization and functional regulation of the genes of the maize genome.
624-2716

Soulen, Thomas K., Associate Professor*

Ph.D., University of Wisconsin

Higher plant metabolism as it relates to development, especially nitrogen metabolism; factors influencing flowering and growth of *Lemma*.

625-2761

Wetmore, Clifford M., Professor

Ph.D., Michigan State University

Taxonomy, ultrastructure, ecology, and phytogeography of lichens; herbarium computerization; Minnesota and upper Great Lakes lichen floras; lichens as indicators of air pollution.

625-6292

Wick, Susan M., Associate Professor

Ph.D., Stanford University

Plant cell and developmental biology; plant cytoskeleton; microtubules.

625-4718

James Ford Bell Museum of Natural History

Birney, Elmer C., Curator of Mammalogy and Director

Ph.D., University of Kansas

Mammalian evolution and ecology.

624-0578

Bright, Robert C., Curator of Invertebrate Biology

Ph.D., University of Minnesota

Quaternary history.

624-2866

McKinney, Frank, Curator of Ethology

Ph.D., University of Bristol, England

Animal behavior.

624-1698

Parmelee, David F., Curator of Ornithology

Ph.D., University of Oklahoma

Adaptations of charadriiform birds to Antarctic environments.

624-0225

Regal, Philip J., Professor

Ph.D., University of California, Los Angeles

Evolution, physiological ecology, and behavior.

625-4669

Tordoff, Harrison B., Professor Emeritus

Ph.D., University of Michigan

Systematic and evolutionary biology; ornithology.

624-4363

Underhill, James C., Curator of Ichthyology

Ph.D., University of Minnesota

Systematic biology; distribution of fishes.

624-3367

Gray Freshwater Biological Institute

Hanson, Richard S., Professor

Ph.D., University of Illinois, Urbana

Microbial biochemistry, ecology and genetics.

471-8476

Wackett, Lawrence P., Assistant Professor

Ph.D., University of Texas, Austin

Biodegradation, metalloenzymes, biotechnology.

471-9493

Wood, John M., Professor

Ph.D., University of Leeds, England

Biochemistry of human epidermis.

471-7777

Institute for Advanced Studies in Biological Process Technology

Brooker, Robert J., Associate Professor

Ph.D., Yale University

Biology of cell surfaces; molecular genetics.

624-3053

Dunny, Gary M., Associate Professor

Ph.D., University of Michigan

Microbial genetics; microbial development; intercellular chemical communication.

624-6774

Flickinger, Michael C., Director

Ph.D., University of Wisconsin, Madison

Fermentation, kinetic models of cellular energetics and protein regulation.

624-9706

Sherman, David H., Assistant Professor

Ph.D., Columbia University

Microbial genetics; immunogenetics.

624-6774

Srienc, Friedrich, Assistant Professor

Ph.D., Technical University in Graz, Austria

Fermentation biochemical engineering.

624-9776

Plant Molecular Genetics Institute

Berman, Judith G., Assistant Professor

Ph.D., Weizmann Institute of Science

Molecular structure and function of chromosomes.

625-1971

Brambl, Robert M., Professor

Ph.D., University of Nebraska

Regulation of gene expression in eukaryotes; coordination of nuclear and mitochondrial genetic systems.

625-7080

Brenner, Mark L., Professor

Ph.D., Michigan State University

Role of endogenous plant growth substances in coordinately controlled processes, specifically focusing on regulation of partitioning in soybean and corn plants.

624-6735

*Recipient of the Horace T. Morse-Minnesota Alumni Association Award for Outstanding Contributions to Undergraduate Education.
†Recipient of the Stanley Dagley Distinguished Teacher Award.

Administration and Faculty

- Das, Anath, Associate Professor
Ph.D., University of Nebraska, Lincoln
Mechanisms of TI-plasmid-mediated gene transfer into plant cells; gene expression and its regulation in higher plants.
624-3239
- Gantt, J. Stephen, Assistant Professor
Ph.D., University of California, Irvine
Gene expression in plants.
625-4763
- Gengenbach, Burle G., Director
Ph.D., University of Illinois
Biochemical and developmental genetic systems of higher plants.
625-6282
- Lefebvre, Paul A., Associate Professor
Ph.D., Yale University
Gene expression in *Chlamydomonas* with flagellar regeneration.
624-4706
- Olszewski, Neil E., Assistant Professor
Ph.D., University of Minnesota
Molecular mechanisms of gibberellin action in plant growth and development.
625-3129
- Phillips, Ronald L., Professor
Ph.D., University of Minnesota
Molecular cytogenetics of multigene systems.
625-1213
- Pruitt, Robert E., Assistant Professor
Ph.D., California Institute of Technology
Plant floral development and function.
624-3408
- Rubenstein, Irwin, Professor
Ph.D., University of California, Los Angeles
Structural organization and functional regulation of the genes of the maize genome.
624-2716
- Schottel, Janet L., Associate Professor
Ph.D., Washington University
Mechanism of pathogenicity for *S. scabies*; mechanism of mRNA turnover in *E. coli*.
624-6275
- Silflow, Carolyn D., Associate Professor
Ph.D., University of Georgia
Structure, organization, and regulation of tubulin genes in algae and higher plants.
624-0729
- Smith, Alan G., Assistant Professor
Ph.D., University of Florida
Molecular analysis of plant development with emphasis on gene expression during flower morphogenesis.
624-2715
- Snustad, D. Peter, Professor*
Ph.D., University of California, Davis
Regulation of gene expression in plants.
624-3499
- Somers, David A., Associate Professor
Ph.D., Washington State University
Applications of tissue culture and *in vitro* genetic manipulations to crop improvement..
625-5769
- Szabo, Les, Research Geneticist
Ph.D., Oregon State University
Molecular genetics of plant pathogenic fungi.
625-3780
- Vance, Carroll P., Professor
Ph.D., Ohio State University
Forage physiology host-microbial interactions, nitrogen fixation.
625-5715

Contributing Faculty from Other University Units

Department of Microbiology—Medical School

- Anderson, Dwight, Professor
Ph.D., University of Minnesota
Virology.
624-7989
- Bey, Russell, Associate Professor
Ph.D., University of Minnesota
Pathogenic mechanisms; immunology.
625-8111
- Cleary, P. Patrick, Professor
Ph.D., University of Rochester, New York
Molecular pathogenesis; Streptococci.
624-3932
- Conklin, Kathleen, Assistant Professor
Ph.D., Tufts University
Virology.
626-0445
- Dunny, Gary, Associate Professor
Ph.D., University of Michigan
Development mediated by bacterial pheromones.
626-1217
- Dworkin, Martin, Professor
Ph.D., University of Texas, Austin
Developmental biology; myxobacteria.
624-5634
- Faras, Anthony, Professor
Ph.D., University of Colorado
Virology.
624-9180
- Flickinger, Michael C., Professor
Ph.D., University of Wisconsin, Madison
Microbial biochemistry.
624-9706

Fontana, Donna, Assistant Professor
Ph.D., Michigan State University
Developmental biology; dictyostelium.
625-9930

Germaine, Gregory, Professor
Ph.D., University of Minnesota
Oral microbiology; microbial physiology.
624-0478

Gray, Beulah, Professor
Ph.D., University of Minnesota
Molecular pathogenesis and immunology; cystic fibrosis.
626-1470

Haase, Ashley T., Professor and Head
M.D., Columbia College of Physicians and Surgeons
Molecular pathogenesis; slow virus infections.
624-4442

Hanson, Richard S., Professor
Ph.D., University of Illinois, Urbana
Microbial ecology.
471-8476

Jemmerson, Ronald, Associate Professor
Ph.D., Northwestern University
Immunology.
625-1402

Jenkins, Marc K., Assistant Professor
Ph.D., Northwestern University
Immunology.
626-2715

Johnson, Russell C., Professor
Ph.D., University of Wisconsin
Molecular pathogenesis; lyme disease.
624-7944

Jordon, M. Colin, Professor
M.D., Creighton University
Virology; infectious diseases.
624-9996

Magee, P. T., Professor
Ph.D., University of California, Berkeley
Microbial genetics and physiology.
624-2244

McKay, Larry L., Professor
Ph.D., Oregon State University
Food and dairy microbiology.
624-5621

Plagemann, Peter G. W., Professor
Ph.D., Case Western Reserve University
Virology.
624-3187

Quie, Paul, Professor
M.D., Yale University
Medical microbiology; mycology.
624-5146

Reilly, Bernard, Associate Professor
Ph.D., Case Western Reserve University
Morphology; microbial genetics.
624-4433

Rogers, Palmer, Professor
Ph.D., Johns Hopkins University
Microbial physiology.
624-7140

Sadowsky, Michael, Assistant Professor
Ph.D., University of Hawai
Soil microbiology
624-2706

Sauerbier, Walter, Professor
Ph.D., J.W. Goethe Universitat, Federal Republic of Germany
Microbial genetics.
624-0996

Schachtele, Charles, Professor
Ph.D., University of Minnesota
Dental microbiology.
624-2630

Scherer, Stewart, Assistant Professor
Ph.D., Stanford University
Microbial pathogenesis; *Candida*.
625-7460

Schiff, Leslie, Assistant Professor
Ph.D., Tufts University
Mammalian retroviruses, virus-host cell interactions.
624-9933

Schlievert, Patrick M., Professor
Ph.D., University of Iowa
Molecular pathogenesis and immunology; streptococci and staphylococci.
624-1484

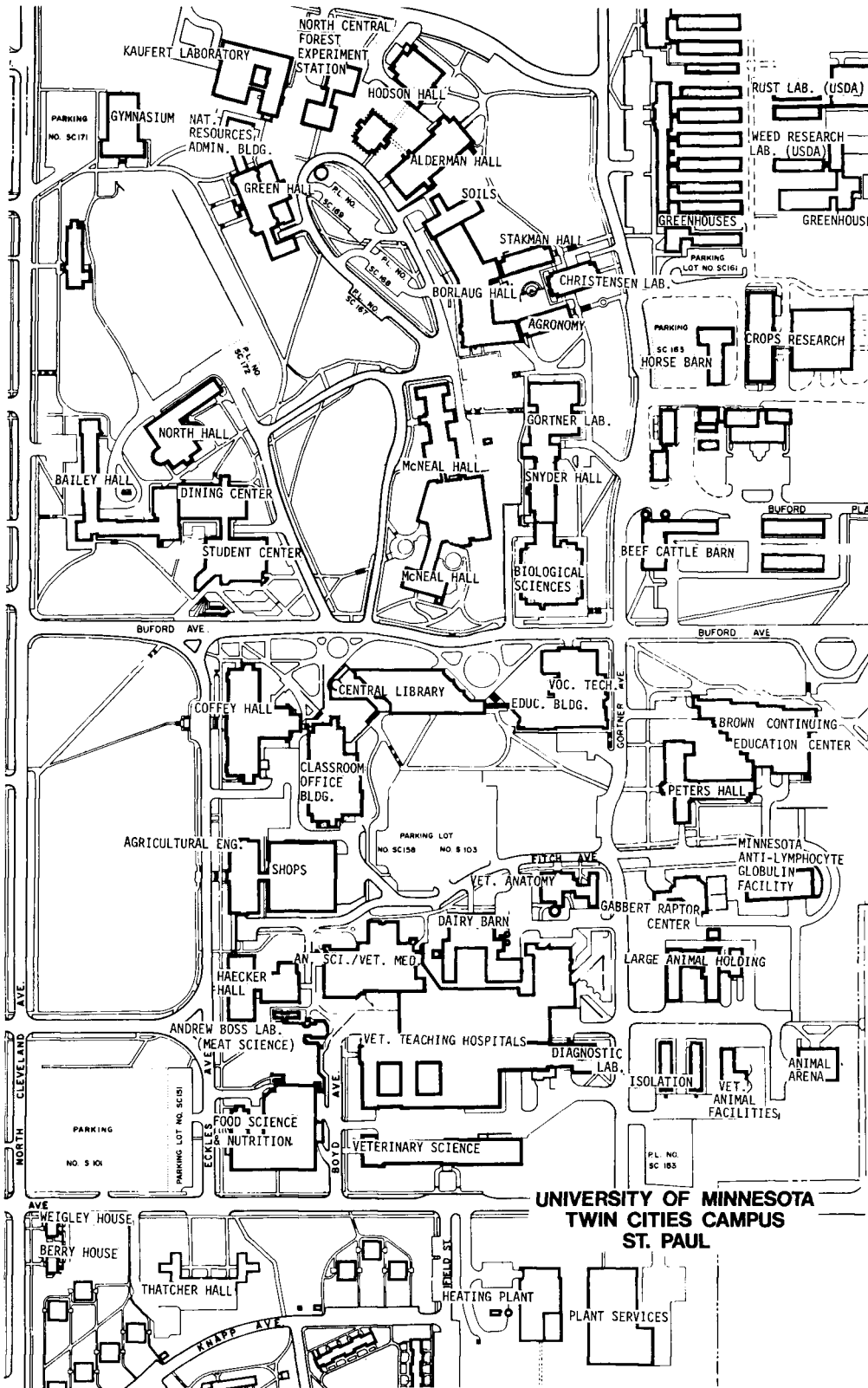
Sherman, David, Assistant Professor
Ph.D., Columbia University
Streptomycetes; biotechnology.
625-1901

Southern, Peter, Associate Professor
Ph.D., Edinburgh University
Molecular biology; viral pathogenesis.
625-2141

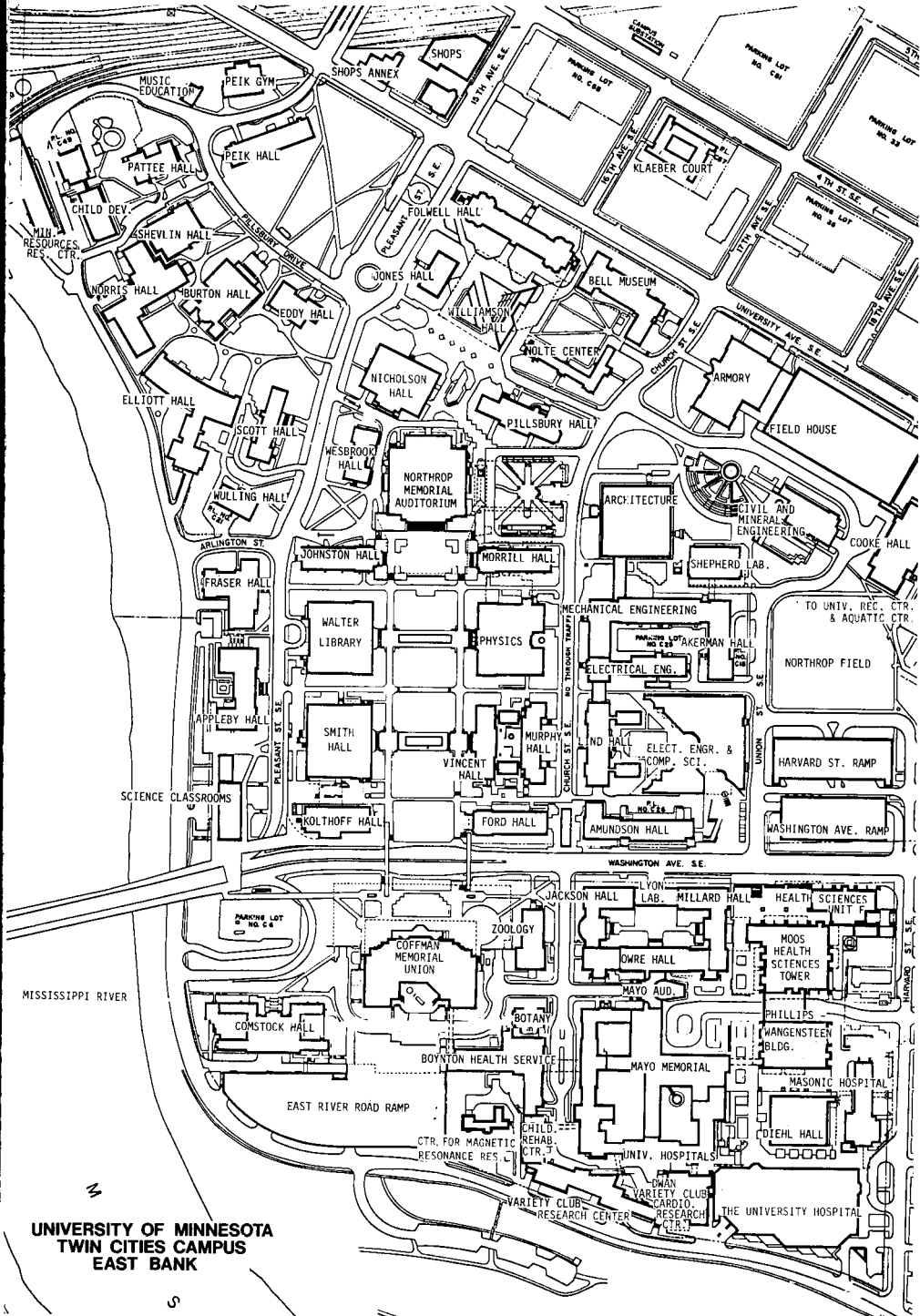
Watson, Dennis W., Regents' Professor Emeritus
Ph.D., University of Wisconsin, Madison
Immunology.
624-2468

Zissler, James F., Professor
Ph.D., University of Rochester, New York
Microbial genetics.
624-7673

**Recipient of the Horace T. Morse-Minnesota Alumni Association Award for Outstanding Contributions to Undergraduate Education.*



**UNIVERSITY OF MINNESOTA
TWIN CITIES CAMPUS
ST. PAUL**



**UNIVERSITY OF MINNESOTA
TWIN CITIES CAMPUS
EAST BANK**

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