

College of Biological Sciences

UNIVERSITY OF MINNESOTA

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Biological
Sciences
B u l l e t i n

On the cover

The cover shows the crystal structure of ferritin, the protein that concentrates and stores iron in all plant, animal, and bacterial cells. The protein is made of 24 subunits packed in a sphere. Various styles of representing the protein are shown that are useful in analyzing different aspects of protein structure and function: a space filling model, an enlargement of the inset box as a ball-and-stick model, a ribbon model, and an abstract model showing the packing symmetry of the 24 subunits. For references and further information on proteins and structural biology, visit the College of Biological Sciences home page at <http://www.cbs.umn.edu> on the World Wide Web.

Graphic contributed by Hiroki Morizono from the laboratory of Norma Allewell, Biochemistry Department, College of Biological Sciences.

Celebrating **CBS** *at 30*

College of Biological Sciences

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Welcome to CBS!

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 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.

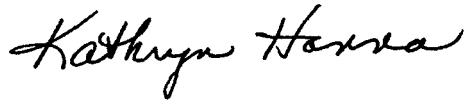
Today, our knowledge of biology is in a period of expansion that has few precedents. Forty-three years ago the chemical nature of genetic material began to be understood; 23 years ago an approach to the isolation of particular genes was proposed; today cells with artificially constructed genomes are used in areas from environmental cleanup 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 being part of the effort that brings about these new discoveries.

Our research 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. CBS faculty 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, because this is the best way to discover what biological sciences are all about. We believe strongly that all educated people should have a significant acquaintance with biology, and we present several courses for non-majors to address this need. CBS has become a national leader in innovative teaching approaches and we share with students the excitement of learning in new ways. Recognizing 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.



Kathryn Hanna, Assistant Dean

CBS Mission Statement

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

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

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

College of Biological Sciences Directory

Office of the Dean, 123 Snyder Hall (St. Paul) 624-2244
Dean, Robert P. Elde; Assistant Dean, Kathryn Hanna

Student Services

Advising and Registration, 223 Snyder Hall (St. Paul) 624-9717
Kathleen Peterson, Leah Clark, Becky Raiche

Honors Program, 223 Snyder Hall (St. Paul) 625-5296
Dr. Franklin Barnwell

Minority Affairs, 123 Snyder Hall (St. Paul) 624-3060
Dr. Val Woodward

Services for Disabled Students, 124E Snyder Hall (St. Paul) 624-1257
Kathy Ball

Career Information Center, 217 Snyder Hall (St. Paul) 624-9270
Kathleen Peterson

Professional Learning Experience Program, 217 Snyder Hall (St. Paul) 624-9270
Amy Winkel

International Education, 611 Biological Sciences Center (St. Paul) 625-1958
Dr. Willard Koukkari

Biology Colloquium, 305 Bell Museum of Natural History (Mpls.) 626-1674
Kathryn Hanna, Dr. Velta Sparmins, Dr. John Tester, Dr. James Waddell

Community Outreach, 217 Snyder Hall (St. Paul) 624-9717
William Ganzlin

Departments, Institutes, and Programs

Advanced Biosciences Computing Center, 247 Gortner Laboratory (St. Paul) 625-9284

Biochemistry, 140 Gortner Laboratory (St. Paul) 624-7755

Biological Process Technology Institute, 240 Gortner Laboratory (St. Paul) 624-6774

Cedar Creek Program, 511 Ecology Building (St. Paul) 625-5740

Developmental Biology Center, 4-122 Malcolm Moos Health Sciences Tower (Mpls.) ... 624-3110

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

General Biology, P180 Kolthoff Hall (Mpls.) 625-6636

Genetics and Cell Biology, 250 Biological Sciences Center (St. Paul) 624-3003

Institute of Human Genetics, 4-122 Malcolm Moos Health Sciences Tower (Mpls.) 624-3110

Instructional Computing Center, 122 Snyder Hall (St. Paul) 625-2273

Itasca Biology Program, 303 Ecology Building (St. Paul) 624-6743

Microbiology, 1460 Mayo Memorial Building (Mpls.) 624-6190

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

Plant Molecular Genetics Institute, 220 Biological Sciences Center (St. Paul) 625-3129

Teaching Laboratory Support Staff, 121 Biological Sciences Center (St. Paul) 624-2789

Directors of Undergraduate Study

Biochemistry, Dr. Clare Woodward, 244 Gortner Laboratory (St. Paul) 624-4714

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

Ecology, Evolution, and Behavior,
Dr. Richard Phillips, 316 Ecology Building (St. Paul) 624-7238

Genetics and Cell Biology, 250 Biological Sciences Center (St. Paul) 624-3003

Microbiology, Dr. Palmer Rogers, 925 Mayo Memorial Building (Mpls.) 624-7140

Plant Biology, Dr. Thomas Soulen, 768 Biological Sciences Center (St. Paul) 625-2761

Beginning College in Biology

If you're about to begin college and think biology may be your area of interest, there are some important questions you need to consider (if you've already completed one or two years of college work and are thinking of transferring to the University of Minnesota, you may want to go directly to page 17, where we discuss the transfer process).

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

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

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

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

Yes! Biology continues to play a critical role in our society and will be important in helping us address many of our most serious concerns and problems in this country. Our placement reports of recent graduates tell us that nearly 50 percent choose to go directly on to school for advanced degrees (both graduate and professional degree programs) and that 45 percent secure full-time employment, almost all of them in jobs related to biology. The future remains very promising!

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

It's good news especially for students in the sciences. The fact that our faculty are so actively involved in research means that our students have extraordinary opportunities for very personal involvement in research and exposure to the latest scientific findings.

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

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

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

A lot, actually. Because we're a college, we provide you with all the specialized services you'd expect from the college you choose. The only difference is that all our specialized services relate *specifically* to your interests in biology. We have an advising staff of biologists who can help you prepare for college, explore your career interests in biology, plan your program of study, and help you to become involved in our programs. Not only that, but we have our own honors program, our own internship program, a committed faculty of more than 90 (actually there are more than 1,000 life sciences faculty on campus), and we even have our own highly specialized Career Center to help you prepare for the biology career you choose.



CBS students study a wide range of topics in biology.

Can I begin as a freshman in biology at the University?

Of course. In fact, there are several ways you can do this. You can spend your first year or two in the College of Liberal Arts (CLA). (This is usually the choice of students whose interests tend toward medical sciences and also the social sciences, arts, and humanities.) Or you might choose to spend your first year or two in the College of Agricultural, Food, and Environmental Sciences (COAFES) (especially if your interests are related more to ecology, environmental science, veterinary biology, or maybe agricultural science.)

But what if I'm not sure. Can I end up in the "wrong college"?

No. You will be taking the *same* University courses (including biology courses) no matter what college you start in. There are no disadvantages to either CLA or COAFES. There is no such thing as "the wrong college." It's all one University of Minnesota biology program. The access points are just different.

Then why can't I start out as a freshman in CBS?

There are a few reasons. One is that we know lots of freshmen change their major the first year in college. This is true nationally, not just at the University. If you're in CBS and decide not to major in biology, then it *could* turn out to feel like the "wrong" college. And we don't want that to happen to you. Besides, there are lots of advantages to being a freshman in either CLA or COAFES (scholarships for freshmen, good honors programs, access to exciting opportunities *besides* biology).

But what will happen if I want to be in CBS after my freshman or sophomore year and I can't get in?

That's not going to happen if you're making satisfactory progress in your courses. There's no enrollment limit in CBS so we admit all qualified students (those who complete our required courses [your biology adviser will help you choose these!] with C's or better). So there's really nothing to worry about.

What should I do if I'd like to learn more about biology at the University of Minnesota to help me decide if CBS is the right place for me?

You should attend one of our Visit Days. Visit Days are offered once each month during the academic year. Each full-day Visit Day provides students with an opportunity to explore careers in the life sciences, meet CBS faculty and students, and tour research laboratories and the St. Paul campus. Each month a different career is explored, such as molecular biology, genetics, ecology and the environment, and medicine/veterinary medicine. Call (612) 624-9717 to request a CBS Visit Day brochure.

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 underrepresented in the professional biological sciences and in allied professions, such as the health sciences, which depend upon undergraduate education in biology. They are also underrepresented in the college's undergraduate enrollment. The purpose of the CBS affirmative action policy is to attract, admit, and graduate increased numbers of individuals from underrepresented racial minority groups, both to enhance the educational benefits all students derive from a diverse student body and to increase the representation of 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 underrepresented 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." —CBS graduate

"CBS makes the large university a very small, family-like experience. Advising is terrific! The opportunities to become involved in campus activities, clubs, and research are abundant."—CBS graduate

Our students choose CBS 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. In fact, nearly a third 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.

About half of CBS graduates elect to pursue advanced study immediately after earning the B.S. degree (about 25 to 30 percent are admitted to professional schools and 15 to 20 percent enter graduate programs); the percentage of each graduating class that pursues advanced training increases over time. Details about follow-up studies of graduates, both bachelor of science and advanced, are available upon request in 223 Snyder Hall.

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

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 obtain off-campus internships in private industry, government agencies, and the nonprofit sector. Other students seek employment as undergraduate teaching and research assistants or museum tour guides. Most departments offer special seminars for undergraduates.

Biology Colloquium—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 Wolf Center, or behind-the-scenes at the Minnesota Zoo. In addition, students are encouraged to begin exploring their own interests through participation in a research project. 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

“CBS provided me with a great opportunity to do research in medicine. Most colleges do not offer this type of research experience.”

—CBS graduate

“I think what is impressive about CBS is its successful combination of a wide range of course offerings, diverse research opportunities, and a faculty that is approachable and dedicated to students.”

—CBS graduate

Each spring an Undergraduate 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)

"I feel that interning is a very important part of anyone's college education. It helped me gain experience that I couldn't have gained anywhere else and I am thankful for the opportunity."—PLEP student

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

Previous PLEP students have studied hazardous waste disposal with Northern States Power, gained laboratory experience in private industry, completed animal behavior studies in northern Minnesota, and ecology studies in Costa Rica, to name a few projects. Organizations sponsoring PLEP opportunities include educational institutions, government agencies, businesses, and nonprofit organizations. Both paid and volunteer positions are available throughout the year and some offer credit. Students with specific interests may design their own internship and PLEP will help them find a sponsoring organization. The CBS Alumni Society provides a few stipends each year for students who participate in unpaid internship opportunities.

"As a biology major the majority of my classes revolved around the scientific theory and lab work. While these things interest me, I have always felt that there has been a gap in my education. How do these theories I learn in school affect the 'real world'? How can I apply

science to help the public make better decisions about what it is doing to the environment? It was through the Sierra Club that I finally felt this gap in my education closing. For the first time I was able to look at what I had learned in school with a critical eye."—PLEP student

Honors—CBS 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.)

Study Abroad

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

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

Two of the University's interdisciplinary field study programs abroad easily permit study in the biological sciences. Minnesota Studies in International Development (MSID) offers two-quarter winter/spring internships in Ecuador, India, Jamaica, Kenya, Morocco, or Senegal, preceded by on-campus preparatory courses in the fall; a number of MSID's grassroots internships have dealt with environmental issues. The Student Project for Amity among Nations (SPAN) consists of a summer independent study project on a topic of the student's choosing, preceded by a year's on-campus preparation and followed by project write-up in the fall; the four destinations change from year to year. The University also cosponsors two specialized options for CBS students: a marine biology program in Denmark, and a tropical biology and conservation program in Costa Rica.

Integrated study programs permit students to take regular foreign university courses alongside host-country nationals. The University's student exchanges and consortium

memberships provide access to biology courses at universities in many countries. Courses taught in English are available in Australia, Canada, Fiji, Finland, Kenya, Malta, the Philippines, Sweden, Singapore, Tasmania, Zambia, and the United Kingdom. Students with sufficient language fluency may choose to study in universities using Chinese, Estonian, Filipino, Finnish, French, German, Hungarian, Italian, Korean, Portuguese, Russian, Spanish, or Swedish.

Study abroad options are not limited to University of Minnesota programs. For example, recent students have taken advantage of opportunities to study genetics in Russia, the biology of koala bears in Australia, marine biology in the West Indies, and chimpanzee behavior in West Africa.

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

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 nonaccredited 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.

Audited Courses—With instructor permission, course enrollment without credit is open to those who register as auditors or visitors. Students may participate in classroom and other activities and take exams. No credit is awarded and no grade assigned. Audited course credits are included in the quarterly tuition credit total

and the regular course fee is assessed. Audited courses may not be taken later for credit. They appear on students' records with the symbol V.

Individually Designed Program—The Individually Designed Program (IDP) in CBS is 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 biocinematography, scientific illustration, genetic counseling, environmental health, patent law, and natural history.

Student Organizations

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

Biochemistry Club—The Biochemistry Club strengthens ties between biochemistry students and faculty, provides a source of individualized professional advice on career goals to each biochemistry major, helps undergraduates identify biochemistry labs for directed research, and helps students keep abreast of new advances in biochemistry. For more information, contact the Office of Student Services (612/624-9717) or the biochemistry department office (612/624-7755).

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 Office of Student Services (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 Office of Student Services (612/624-9717) or the ecology, evolution, and behavior department office (612/625-5700).

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

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

Biology Club—All life science majors are encouraged to participate in the Biology Club. The club was established to ensure full participation of students from groups currently underrepresented in science and to foster contact among biology students and faculty. It

meets for monthly dinners and discussion and provides both academic and social experiences for its members. For more information, contact Ann Reid (612/625-2275).

Biological Sciences Alumni Society (BSAS)—The society provides a professional association for biological sciences graduates, and encourages relationships among current students, faculty, alumni, and the community. The society has made a special commitment to enhance opportunities for current students and encourages them to participate in all of its programs, often at discounted ticket prices. The president of the Biological Sciences Student Association serves on the board of directors of the alumni society. Alumni volunteers have cooperated with the CBS Career 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 and internship grants, a mentor program for students, 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. For more information, contact Kathryn Hanna, assistant dean, 123 Snyder Hall (612/624-2244) or the Minnesota Alumni Association, 501 Coffman Memorial Union, 300 Washington Ave. S.E., Minneapolis, MN 55455 (612/624-2323).

Student Services

"CBS gave me the feeling of being in a small college—personal attention and recognition—and the benefits of being at a University with research exposure and class variety."—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 provided by CBS's faculty and Office of Student Services. Upon admission to the college, as early as the sophomore year, students are assigned to a CBS faculty adviser

in their particular area of interest. In addition, Office of Student Services staff are available by appointment for students to discuss a wide array of student concerns. Summarized below are the types of advising services available through a combination of faculty and professional advising.

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

Prospective Student Activities

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

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
- Biology Colloquium
- Biological Sciences Student Association
- CBS club activities
- Alumni Society
- Mentor program

Major and Faculty Advising

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

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

Career Information Center—The CBS Career Information Center (CIC) helps students explore the varied career options available to biology graduates. 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 career and employer information, as well as connections to professionals in many fields of interest. 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. CIC staff also offer an annual course, Biol 1961—Careers in Biology.

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 director 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 Dr. Val Woodward, 123 Snyder Hall (612/624-3060).

International Education—The University's study abroad catalog describes a broad range of study abroad opportunities. Students can learn

more about their options through an advising appointment at the International Study and Travel Center (ISTC), 102 Nicholson Hall (612/625-1150), and by consulting with the PLEP coordinator in 217 Snyder Hall (612/624-9270). Special information is also posted outside 123 Snyder Hall. After identifying one or more programs of interest, students should see a study abroad adviser in 104 Nicholson Hall (612/624-4525) for more detailed program information and application instructions, and to discuss credit and financial aid. CBS students must also review their plans with an adviser in 223 Snyder Hall (612/624-9717) and are also encouraged to meet with Dr. Willard Koukari, CBS international education officer, 611 Biological Sciences Center (612/625-1958).

Student Facilities

Student/Faculty Lounge—Biology undergraduates are invited to use the 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. The lounge is furnished with a small reference collection and current journals covering many fields of interest in biology.

Computer Access—All students have access to microcomputer facilities throughout the Twin Cities campus. These computing labs have both Macintosh and DOS-based systems. A listing of the location and hours of these facilities is available at the computing labs and on Gopher.

In addition, biology students have access to well-equipped microcomputing facilities in the college: a Macintosh lab in 122 Snyder Hall and a DOS-based lab in 170 Ecology. Because the labs are primarily for instructional needs, priority is given to courses. The 170 Ecology lab is heavily booked for courses, but the 122 Snyder Hall lab is mostly an open lab. In both labs, students can use programs for word processing, graphing, drawing, or spreadsheets. Students can also access many electronic databases and file servers around the world, as well as their own electronic mail service. The 122 Snyder Hall lab provides specialized software such as programs to help prepare for the Graduate Record Examination (GRE).

Libraries—The University of Minnesota library system ranks among the largest American university libraries, with more than 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 CBS Reading Room, and the Entomology, Fisheries, and Wildlife Library.

Financial Assistance

The University of Minnesota Office of Scholarships and Financial Aid is located in 210 Fraser Hall on the Minneapolis campus and 197 Coffey Hall on the St. Paul campus (612/624-1665). Prospective or newly admitted students may also wish to consult with high school counselors. The office provides assistance by phone from 8:00 a.m.-4:00 p.m., Monday through Friday. Walk-in assistance is available in the Minneapolis office from 9:00 a.m.-3:00 p.m. on Mondays, Tuesdays, Wednesdays, and Fridays and from noon to 3:00 p.m. on Thursdays. The office in Coffey Hall is open on a more limited basis.

Bioscience Scholarships and Grants

Prospective 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—awards 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.

Richard S. Caldecott Award—in honor of CBS's first dean. Competitive scholarship awarded to the outstanding senior in CBS.

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 students attending the Itasca summer session to help defray the cost of tuition and living expenses. The awards are 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 near Afton, Minnesota, or surrounding area.

INCSTAR Award—recognizes outstanding academic achievements by minority students in biochemistry and microbiology.

LaVell M. Henderson/Henrietta Miller Scholarship—award presented to an outstanding senior biochemistry student who has demonstrated research capabilities.

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

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

Murray Rosenberg Fund—in memory of Professor Rosenberg of GCB, provides travel grants for CBS students who wish to perform service in a health-related field to help people in need in non-English-speaking countries or economically depressed areas of the U.S. Applications are due November 15 and April 15.

PLEP Grants for Unpaid Internships—The Biological Sciences Alumni Society provides stipends for students who participate in unpaid or fee-requiring biology-related PLEP internships that do not earn University credit. Check in 217 Snyder Hall for application materials.

Harold P. Morris Memorial Scholarship—in memory of University alumnus H.P. Morris. Multiyear grant to support outstanding students from northwest Minnesota studying genetics or biochemistry. Application: Open, depending on availability of funds.

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 Larson, 612/625-8200. Application deadline: Winter.

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—for 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 or otherwise. Cash prize, plus initiation fee and admission to membership in Sigma Xi.

George T. Walker Prizes—to be used in the senior year by students in chemistry, selected on the basis of aptitude in science and promise in research. Two undergraduate cash prizes, plus initiation fee and admission to membership in Sigma Xi.

Olson-Wallace Award in Zoology—for 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 (UROP)

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.

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 two opportunities to apply for research funds each year: October 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. 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: Chad Weinstein, 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 currently enrolled sophomores or juniors 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: Chad Weinstein, CLA Honors Division. Application deadline: December.

Study Abroad

A number of University and national scholarships exist for study abroad. Deadlines are often far in advance of the study.

Information is available in the International Study and Travel Center, 102 Nicholson Hall (612/626-9000).

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: Toby Egan (612/624-5101). Nomination deadline: late winter quarter.



Admission to CBS

Students may enter the College of Biological Sciences at the beginning of their sophomore, 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 are happy to help you select appropriate coursework for transferring to the college. 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 take organic chemistry during their sophomore year, thereby allowing ample time for major coursework and research experience.

Applications are given individualized attention. Factors such 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 Biol 1009 or 1201-1202, Chem 1051-1052, and Math 1251-1252 with grades of at least a C (or equivalent courses with grades of at least a C), are required for admission at the junior level. Equivalent courses are transferable. Students who are admitted as sophomores 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 1051-1052 (or equivalent); Math 1251 and 1252 (or equivalent); and a college-level biology course. Admitted students will receive a letter of acceptance from both the Office of Admissions and CBS with information about orientation dates and registration.

All new students, freshmen as well as transfers, are also expected to meet the high school preparation requirements for admission to the University of Minnesota: four years of English; three years of math; three years of science; two years of a single second language; and two years of social sciences. In some cases, students may be admitted with course deficiencies with the expectation that these will be addressed in the first year in residence.

Procedure Check Lists

I. Application for Admission From Outside the University

Transfer students may apply directly to 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 recommend that you also apply to the College of Agricultural, Food, and Environmental Sciences 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 Agricultural, Food, and Environmental Sciences 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. Application deadlines are

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

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

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

Questions? Call the CBS Office of Student Services 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

English Proficiency—If English is not your native language, you may be required to take the Test of English as a Foreign Language (TOEFL) or the Michigan English Language Assessment Battery (MELAB). To register for the TOEFL, contact the

agency that handles TOEFL registration in your country or write to the Educational Testing Service (Box 899, Princeton, NJ 08540 USA) at least 10 weeks before any scheduled test date. If you are already in the Twin Cities area, you may register for the MELAB with the Minnesota English Center, 320 16th Avenue S.E., University of Minnesota, Minneapolis, MN 55455, or call (612) 624-1503. To register for the MELAB outside the Twin Cities area, contact the English Language Institute, Testing and Certification Division, University of Michigan, Ann Arbor, MI 48109 USA, or call (313) 764-2416.

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 CBS 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

Students who wish to transfer to CBS from another college on the Twin Cities campus or from one of the coordinate campuses should submit a Change of College form to the Office of the Registrar. Deadlines are

<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 the Office of the Registrar, 150 Williamson Hall, or from the Office of the Registrar—St. Paul, 130 Coffey Hall. Forward the application to the Office of the Registrar, University of Minnesota, 150 Williamson Hall, 231 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/625-5333).

Questions? Call the CBS Office of Student Services 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 (see above).

All new students will attend a CBS 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.

III. Application for Admission With Adult Special Status

Adult special status is for those who already have a degree and want to take courses for personal or professional 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 the Office of Admissions, 240 Williamson Hall, 231 Pillsbury Dr. S.E., Minneapolis, MN 55455 (612/625-2008 or, toll free in United States, 1-800-752-1000).

Deadlines for adult special applications are

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

Residency and Reciprocity

Residence—Because the University is a state institution, Minnesota residents pay lower tuition than nonresidents and, in many programs, receive priority consideration for admission. To qualify for resident status, students must reside in Minnesota for at least one calendar year before the first day of class attendance. For more information, contact the Resident Classification and Reciprocity Office, 240 Williamson Hall, 231 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/625-6330), or the residency office on your campus.

Reciprocity—The University has reciprocity agreements with North Dakota, South Dakota, Wisconsin, and Manitoba. The University also participates in a reciprocity program with Kansas, Michigan, Missouri, and Nebraska, for students in the following undergraduate colleges: Agricultural, Food, and

Environmental Sciences; Architecture and Landscape Architecture; Biological Sciences; Education and Human Development; Human Ecology; Natural Resources; Carlson School of Management; Pharmacy; Dental Hygiene; School of Nursing; and Institute of Technology. If you are a resident of any of these states or this province, you may qualify for reciprocity tuition rates, which are lower than nonresident tuition rates and, in some cases, comparable to resident rates. For more information, contact the Resident Classification and Reciprocity Office, 240 Williamson Hall, 231 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/625-6330), or the residency office on your campus.

Degree Requirements

The CBS bachelor of science degree program 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 limitations of their powers of judgment and choice that result from ignorance. It provides students with the skills to seek: control over the general intellectual instruments for acquiring and communicating knowledge, primarily the instruments of language and number; understanding of the ways scientists contribute to knowledge; historical and philosophical perspective on the nature of students' own lives and the world in which they live; and appreciation of the creative insights into life and nature provided by literature and the arts. To help achieve these goals, the University requires all students to distribute a portion of their coursework in areas of study outside of those most directly linked to their specialized interests in science.

II. Physical Sciences and 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 to appreciate living organisms at all levels from molecules to ecosystems.

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

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

Physics includes the study of atoms and their interactions, mechanics, heat, sound, electricity and magnetism, and the properties of light. It is the basis for our understanding of photosynthesis, blood and 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. Some courses introduce students to various kinds of organisms—animal, plant and microorganisms. Biochemistry introduces students to organic compounds of importance to organisms, to enzyme-catalyzed reactions, and to the metabolic pathways by which energy is used. Cell biology examines the structure and function of cells in some depth. Genetics introduces students to mechanisms of heredity, including both molecular genetics and population genetics. Ecology, evolution, and behavior introduces students to populations, evolution, and the behavior of animals.

IV. Specialization in the Major—In addition to completing the required courses in biology, students take additional courses to expand on some aspects of biology. They may do so either by

Freshman Liberal Education Requirements

(effective fall 1994 and later for freshmen enrolling with fewer than 39 credits)

A liberal education introduces you to the modes of inquiry and subject matter of the major branches of knowledge, including the factual information and theoretical or artistic constructs that form their foundations; the "ways of knowing"—the kinds of questions asked and how insight, knowledge, and data are acquired and used; the changes over time of their central ideas or expressive forms; and the interrelationships among them and with human society in general. To these ends, study by all undergraduate students on the Twin Cities campus is guided by a common framework.

The Diversified Core Curriculum

Physical and Biological Sciences. Comprehension of physical and biological principles; understanding of and ability to use the methods of scientific inquiry—the ways in which scientists investigate physical and biological phenomena; and appreciation of the importance of science and the value of a scientific perspective.

Requirement: A minimum of three courses totaling at least 12 credits, including one course with a laboratory or field experience in the physical sciences and one course with a laboratory or field experience in the biological sciences.

History and Social Sciences. Knowledge of how historians and social scientists describe and analyze human experiences and behavior; study of the interrelationships among individuals, institutions, structures, events, and ideas; understanding of the roles individuals play in their historical, cultural, social, economic, and political worlds.

Requirement: A minimum of three courses totaling at least 12 credits, including one course with historical perspective.

Arts and Humanities. Understanding of approaches to the human condition through works of art, literature, and philosophy; knowledge of how artists create and humanistic scholars think; ability to make aesthetic judgments.

Requirement: A minimum of three courses totaling at least 12 credits including courses in two of the following: literature, philosophical perspective, and visual or performing arts.

Mathematical Thinking. Acquisition of mathematical modes of thinking; ability to evaluate arguments, detect fallacious reasoning, and evaluate complex reasoning chains; appreciation of the breadth of applications of mathematics and its foundations.

Requirement: A minimum of one course totaling at least four credits.

The Designated Themes of Liberal Education

The designated themes of liberal education offer a dimension to liberal learning that complements the diversified core curriculum. Each of the themes focuses on an issue of compelling importance to the nation and the world, the understanding of which is informed by many disciplines and interdisciplinary fields of knowledge.

Requirement: A minimum of six courses (or five courses if one includes an approved practicum), including one course in each of the following:

Cultural Diversity. Understanding of the roles gender, ethnicity, and race play in structuring the human experience in and developing the social and cultural fabric of the United States.

International Perspectives. Comprehension of the ways in which you are part of a rapidly changing global environment dominated by the internationalization of most human endeavors.

Environment. Knowledge of the interaction and interdependence of the biophysical systems of the natural environment and human social and cultural systems.

Citizenship and Public Ethics. Reflection on and determination of a clearer sense of your present and future civic relationships and your obligations to the community.

Writing Skills

The ability to communicate effectively is a hallmark of a liberally educated individual and a key to a successful and satisfying life. To encourage refining of writing skills, the liberal education curriculum includes both writing courses and writing across the curriculum.

Requirement: All students will complete the writing requirement specified by the college awarding their baccalaureate degree.

You may satisfy the liberal education requirements with a number of courses and credits different from those of other students because some courses serve multiple goals in the curriculum; e.g., some courses will satisfy a diversified core requirement and a designated theme requirement, and other courses will satisfy the requirements for each of two themes. Thus, you may satisfy the designated theme requirements with a smaller number of courses than is stated in the requirement. Each quarter, the *Class Schedule* will publish the requirements and list all courses that satisfy them. In addition, the *Class Schedule* will list which of these courses are offered that quarter and which are tentatively scheduled for the subsequent quarters during the academic year.

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 B.S. from CBS, a student must complete a minimum of 180 credits with grades of A, B, C, or S. 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 or 1201-1202, Chem 1051-1052, and 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. must have a minimum of 75 percent of their University of Minnesota residence credits (required for graduation) in courses in which grades of A, B, C, or D have been received.
- b. A minimum of 36 credits as a student registered in CBS. 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 any 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 or 3027 or 3033 or 3085; Rhet 3562.
2. Foreign Language—Either two high school years or one college year of study of a single foreign language or demonstration of equivalent proficiency satisfactory to the appropriate language department.
3. *The University's liberal education distribution requirements for freshmen who entered the University before fall 1994 or transfer students who enter before fall 1996:*

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 required of CBS students (see items 4 and 5 below) will automatically satisfy the minimum University requirements for Groups A and B listed above. In addition, CBS students under the old liberal education distribution requirements must complete 30 credits from Groups C, D, World Studies, and Cultural Pluralism, including a *minimum* of 8 credits each in Groups C and 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 the CBS Office of Student Services. Direct questions concerning acceptable courses to the Office of Student Services, 223 Snyder Hall.

The University's liberal education diversified core, designated themes, and writing skills curriculum is required for freshmen and transfer students with fewer than 39 credits entering a degree program on the Twin Cities campus for the first time fall quarter 1994. This curriculum will be required of all students beginning fall 1996.

Physical and biological sciences
History and social sciences
Arts and humanities

ADMISSION PROCEDURES AND DEGREE REQUIREMENTS

Mathematical thinking
Cultural diversity
International perspectives
Environment
Citizenship and public ethics
Writing skills

Students completing the *new* liberal education requirements must include three courses (at least 12 credits total) in history and social sciences, including one course with historical perspective; three courses (minimum 12 credits) in arts and humanities, including courses in two of the following: literature, philosophical perspective, and visual or performing arts; and a minimum of six courses, including one course in each of the following theme areas: cultural diversity, international perspectives, environment, and citizenship and public ethics (see page 20). A list of approved courses can be found in the introductory section of the quarterly *Class Schedule*.

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 may be substituted for the third quarter of calculus (Stat 3011-3012 or Stat 5021). Biochemistry majors, however, are required to complete the three-quarter calculus sequence and Math 3251.

b. Chemistry—Each of the following: general chemistry, two quarters (Chem 1051-1052 or equivalent); organic chemistry, two quarters with laboratory (Chem 3301-3302 with 3305-3306 or equivalent).

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) 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 (e.g., Phys 1251-1252-1253).

5. Biological Sciences

a. Biology major requirements

1) General and organismal biology. Choose one of the following sequences:

—(preferred) Biol 1201-1202-1203, plus one organismal course (3011 or 3012/3812 or 5013)

—or Biol 1201-1202, 3011, 3012/3812, 5013

—or Biol 1009, 3011, 3012/3812, 5013

2) Biochemistry: BioC 3021 or 5331

3) Genetics: Biol 5003

4) Cell Biology: Biol 5004

5) Ecology: Biol 5041/5841

6) 16 additional upper division credits in mathematics and/or physical and/or biological sciences (Phsl 3051 may not be used for this requirement).

7) Laboratory or field work in two additional upper division biological sciences courses. Credits earned may be used toward fulfilling item 6 above. A list of acceptable courses follows:

Biol 5125

BioC 5025, 5990 (4 cr minimum*)

EEB 5014, 5016, 5129, 5134, 5157, 5607,

5621, 5990 (4 cr minimum*)

GCB 5015, 5030, 5605, 5990 (4 cr minimum*)

MicB 5234, 5322, 5425, 5990 (4 cr minimum*)

PBio 3109, 3201, 5103, 5105, 5107, 5111,

5132, 5231, 5990 (4 cr minimum*)

All CBS courses offered at the Lake Itasca Forestry and Biological Station 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 fieldwork requirements, students must complete a minimum of 4 credits under the 5990 course number. Biology majors may satisfy both of the lab/field course requirements through Directed Research only if 4 credits of 5990 are completed in each of two different labs. A maximum of 10 credits of 5990 will count toward the 16 upper division elective credits required for the biology major.*

b. Genetics and cell biology major core requirements (see additional major requirements on page 35).

1) General and organismal biology. Choose one of the following sequences:

—(preferred) Biol 1201-1202-1203 plus one organismal course (3011 or 3012/3812 or 5013)

—or Biol 1201, 1202, 3011, 3012/3812, 5013

—or Biol 1009, 3011, 3012/3812, 5013

2) Biochemistry: BioC 3021 or 5331

3) Genetics: Biol 5003

4) Cell Biology: Biol 5004

5) One course from the ecology/evolution/systematics/behavior list (see the core course list at the end of this section). If a course is chosen that is also listed under Area 3 for the GCB major, it will count toward the 27 required credits in the major.

c. Biochemistry; ecology, evolution, and behavior; microbiology; and plant biology major core requirements (see additional major requirements on pages 30, 31, 37, and 39).

1) General and organismal biology
—(preferred) Biol 1201-1202-1203 or Biol 1009 plus two courses from 3011, 3012/3812, 5013

2) One course each from three of the following areas (see the core course list that follows):

- Biochemistry
- Genetics/cell biology/development
- Integrative/organismal biology/physiology
- Ecology/evolution/systematics/behavior

The additional major requirements listed later in this bulletin for each major (see pages 30, 31, 37, and 39) may overlap with the core areas. Consult an adviser for clarification.

Biology Core Course List for BioC, EEB, GCB, and PBio Majors

Biochemistry

- BioC 3021—Biochemistry
- BioC 5301—Ecological Biochemistry
- BioC 5331-32-33—Biochemistry
- BioC 5401—Metabolism and its Regulation
- BioC 5525—Physical Biochemistry: Solution Structure and Interactions of Biological Macromolecules
- BioC 5526—Physical Biochemistry: Spectroscopic Methods I
- BioC 5527—Physical Biochemistry: Spectroscopic Methods II
- BioC 5528—Physical Biochemistry: Enzyme Kinetics
- BioC 5529—Protein Structure and Folding
- PBio 5182—Plant Metabolism
- PBio 5186—Topics in Plant Biochemistry

Genetics/Cell Biology/Development

- Biol 5003—Genetics
- Biol 5004—Cell Biology
- Biol 5125—Recombinant DNA Laboratory

CBS Science Requirements: Suggested Time Sequence

	Key:											
	* Earliest possible ■ Recommended ▨ Latest possible (see note 1 below)											
	Freshman			Sophomore			Junior			Senior		
	F	W	S	F	W	S	F	W	S	F	W	S
A. Prerequisites												
Calculus (3 quarters)												
General Chemistry (2 quarters)												
Organic Chemistry (2 quarters with lab)				*								
Physics (3 quarters); see note 2 below	*											
General Biology 1009 or 1201-1202-1203	*											
B. Biology Core (see note 3 below); check individual majors for core requirements												
Biol 3011, Animal Biology				*								
Biol 3012 or 3812, Plant Biology				*								
Biol 5013, Microbiology									*			
Biol 5041 or 5841, Ecology				*								
BioC 3021 or 5331, Biochemistry					*							
Biol 5003, Genetics						*						
Biol 5004, Cell Biology							*					
Notes:												
1. The recommended time period for many sequences is longer than required to allow some flexibility as to when the sequence is started.												
2. The physical chemistry courses required for biochemistry majors, as well as some of the elective physiology courses, must be preceded by the complete physics sequence.												
3. The period indicated is recommended to leave the senior year open for advanced study and research.												

GCB 5034—Intermediate Molecular Genetics
 GCB 5035—Intermediate Cell Biology
 GCB 5015—Histology: Cell and Tissue Organization
 GCB 5061—Developmental Biology
 GCB 5114—General Physiology
 GCB 5134—Endocrinology
 PBio 5109—Molecular Genetics and Biochemistry of Yeasts
 PBio 5111—Plant Cell, Tissue, and Organ Development
 PBio 5141—Plant Cell Biology
 PBio 5184—Plant Growth and Development

**Integrative/Organismal Biology/
 Physiology**

Biol 3011—Animal Biology (if not used for the general and organismal biology requirement)
 Biol 3012/3812—Plant Biology (if not used for the general and organismal biology requirement)
 Biol 3112—Biological Rhythms and Timing Mechanisms
 Biol 5013/MicB 5105—Microbiology (if not used for the general and organismal biology requirement)
 MicB 5218—Immunology
 MicB 5232—Medical Microbiology
 MicB 5234—Immunology and Medical Micro Lab
 MicB 5321—Physiology of Bacteria
 MicB 5322—Microbial Diversity and Physiology Lab
 MicB 5352—Applied Microbial Biochemistry
 MicB 5424—Biology of Viruses
 MicB 5425—Virology and Microbial Genetics Lab
 EEB 5129—Mammology
 EEB 5134—Introduction to Ornithology
 EEB 5136—Ichthyology
 EEB 5156—Comparative Animal Physiology
 EEB 5834—Field Ornithology
 EEB 5838—Field Studies in Mammology
 Ent 3005—Introductory Entomology
 PBio 3131/5131—Survey of Plant Physiology
 PBio 5132—Plant Physiology Laboratory
 PBio 5183—Water, Minerals, Translocation
 Phsl 3052/53; 3055/56—Principles of Physiology

**Ecology/Evolution/
 Systematics/Behavior**

Biol 5041/5841—Ecology
 EEB 3111/3811—Introduction to Animal Behavior
 EEB 5008—Quaternary Ecology
 EEB 5014—Ecology of Vegetation
 EEB 5016—Ecological Plant Geography
 EEB 5044—Evolution
 EEB 5051—Analysis of Populations
 EEB 5052—Theoretical Population Ecology
 EEB 5063—Evolutionary Ecology of Insect Populations
 EEB 5064—The Process of Evolution
 EEB 5122—Plant/Animal Interactions
 EEB 5321—Evolution of Social Behavior
 EEB 5323—Mechanisms of Behavior
 EEB 5324—Evolution of Primate Social Behavior
 EEB 5325—Behavioral Ecology
 EEB 5607—Ecology of Fishes
 EEB 5608—Ecosystems: Form and Function
 EEB 5601—Limnology
 EEB 5607—Ecology of Animal Plankton
 EEB 5814—Plant Community Ecology

EEB 5817—Vertebrate Ecology
 MicB 5611—Microbial Ecology
 PBio 3201—Introductory Plant Systematics
 PBio 5103—Algae, Fungi, and Bryophytes
 PBio 5105—Morphology of Vascular Plants
 PBio 5221—Plant Molecular Evolution
 PBio 5231—Introduction to the Algae
 PBio 5801—Plains and Boreal Flora

Course requirements for the MicB major automatically satisfy the college core biology requirements.

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.”
 —Honors Program graduate

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 provides exposure to the breadth of biological inquiry and allows honors students to get to know each other.

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

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 college faculty and start on a research project early in their junior year or as soon thereafter as possible. Participation in a minimum of two quarters (a total of eight credits) of research is required; students may register in BioC 5990, EEB 5990, GCB 5990, MicB 5990, or PBio 5990. Students who participated in the Undergraduate Life Sciences Summer Research Program or who received UROP grants may

petition to use this work to satisfy up to four of the eight credits of research. 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 major department), chosen with approval of 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. 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 enroll in 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 GPA of 3.40 and present reasonable evidence of potential to attain the GPA required for graduation with honors (see below). Applications 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 permission)
5. The last 90 credits of A-F registration with the minimum GPAs specified below:
cum laude: minimum 3.40 GPA
magna cum laude: minimum 3.60 GPA
summa cum laude: minimum 3.80 GPA

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

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

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 Office of Student Services, 223 Snyder Hall.

Major Requirements and Course Descriptions

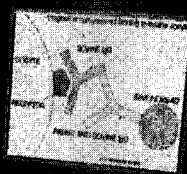
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ul, MN 55108

DR. RALPH KILLERMAN & DR. ALICE G. HUNTER
Dept. of Animal Science, Univ. of Minnesota, St. Paul, MN 55108

Abstract text describing research findings.

Abstract text describing research findings.



Abstract text describing research findings.



Abstract text describing research findings.



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 required (or allowed) in the course listed after this symbol.

..... Approval of the instructor is required for registration.

Δ Approval of the department offering the course is required for registration.

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

H Honors course.

f, w, s, su

..... Following a course number, these symbols indicate fall, winter, spring quarter, summer session.

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—
Kathryn Hanna

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 16 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 course work as early as possible.

Also, 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. through CBS. 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 and Human Development office for information about the specialized curriculum that is available.

General Education—Courses especially appropriate for non-science and non-biology majors include BioC 1401; Biol 1009, 1051, 1101, 1103, 1106/1806, 1201, 1202, 1301, 3051, 3112; EEB 1019, 3001, 3006, 3111; GCB 3002, 3008, 3022; MicB 3103; PBio 1009, 1012.

Minor Sequence

Required Preparatory Courses—Biol 1009 or 1201-1202-1203

Minor Requirements—1) Minimum of 15 3xxx-5xxx cr chosen from courses carrying the following designators: BioC, Biol, EEB, GCB, MicB, PBio, Phsl.

MAJOR REQUIREMENTS AND COURSE DESCRIPTIONS

2) One course about animals, Biol 1106/1806 or 3011, and one course about plants, Biol 1103 or 3012/3812 (unless student has completed Biol 1201-1202-1203).

The minor program must be approved by an Office of Student Services adviser, 223 Snyder Hall. CBS majors and CLA biology and microbiology majors are not eligible for the minor.

Biol Courses

Biol 1009. GENERAL BIOLOGY. (5 cr; for majors requiring a comprehensive survey of biology in one qtr; high school chemistry strongly recommended; pre-biology majors see Biol 1201-1202-1203, nonscience majors see 1201) Biology principles. The cell, metabolism, heredity, reproduction, ecology, evolution. Lab.

Biol 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.

Biol 1051. ENVIRONMENTAL STUDIES. (4 cr, §3051, §ES 1051)

Principles of ecology and current environmental issues including air and water pollution, human population growth, toxic and hazardous wastes, urbanization, land use, biological diversity, energy, environmental health, conservation history, attitudes towards nature, environmental politics, and ethics. Meets environmental theme for liberal education curriculum.

Biol 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.

Biol 1103. GENERAL BOTANY. (5 cr, §3012, §3812; prereq 1009 or 1202; students who plan to major in biology in CLA or in any bioscience major in CBS should take 3012 or 3812) Plant organization, function, growth and development, reproduction. Lab.

Biol 1106. GENERAL ZOOLOGY. (5 cr, §1806; prereq 1009 or 1202) Survey of animal phyla; structure, function, behavior, adaptation, evolutionary relationships. Lab includes dissections.

Biol 1201. EVOLUTIONARY AND ECOLOGICAL PERSPECTIVES. (5 cr) Origins and foundations of modern evolutionary thought, putting evolutionary theory to work; evolution and ecology. Lab. Can be taken as a single course or as the first in the Biol 1201-1202-1203 sequence.

Biol 1202. MOLECULAR AND CELLULAR PERSPECTIVES. (5 cr, §1009; prereq 1201, Chem 1051 or equiv) Chemistry of living things, cell structure and transport, energy processing in cells, introduction to primary metabolism, molecular genetics, cell physiology, regulation of development. Lab. To be taken as the second course in the Biol 1201-1202-1203 sequence.

Biol 1203. ORGANISMAL ADAPTATION AND DIVERSITY. (5 cr, §1103, §1106, §1806; prereq 1201, Chem 1051 or equiv or #) How plants, animals, and microbes adapt to similar environmental challenges, commonalities in these adaptations, evolutionary diversity of organisms. Lab includes dissections.

Biol 1941. PREPARATION FOR GRADUATE PROGRAMS IN BIOLOGY. (1 cr; prereq #; S-N only) Study habits, time and money management, course participation, personal sacrifices.

Biol 1951, 1952, 1953. BIOLOGY COLLOQUIUM. (1 cr each; 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.

Biol 1960. BIOLOGY COLLOQUIUM PROJECT. (1 cr; prereq 1951 or 1952 or 1953, ¶1951 or ¶1952 or ¶1953, #; S-N only) Individual project or research undertaken by a student concurrently enrolled in Biol 1951, 1952, or 1953, supervised by a faculty sponsor.

Biol 1961. CAREERS IN BIOLOGY. (1 cr; prereq 1951 or 1952 or 1953; S-N only) Exploration of career options in biological sciences. Introduction to career life planning techniques and decision-making skills. Interest, aptitude, and skills assessment. Preparation for an internship experience.

Biol 3003. INTRODUCTION TO COMPUTING IN BIOLOGY. (2 cr; prereq 1009 or 1202 or equiv, declared biological sciences major, Δ ; S-N only) Hands-on use of microcomputers to introduce students in biology to how computers can help them manipulate data, prepare graphs and graphics, perform literature searches, prepare posters and reports, and communicate with others through the use of the computer network.

Biol 3011. ANIMAL BIOLOGY. (5 cr, §1106, §1806, §Phsl 3051; prereq 1009 or 1202, Chem 1052) Comparison of ways different phyla have solved similar physiological problems. Lab includes survey of major animal groups and physiological experiments and dissections.

Biol 3012. PLANT BIOLOGY. (5 cr, §1103, §3812; prereq 1009 or 1202, Chem 1052) Plant diversity and evolution; structure and function of the plant cell and the whole organism; growth and development of plants. Lab.

Biol 3051. ENVIRONMENTAL STUDIES. (4 cr, §1051, §ES 1051; biological sciences students may not apply these credits toward the major) Principles of ecology and current environmental issues including air and water pollution, human population growth, toxic and hazardous wastes, urbanization, land use, biological diversity, energy, environmental health, conservation history, attitudes toward nature, environmental politics, and ethics. Meets environmental theme for liberal education curriculum.

Biol 3111. ANIMAL BIOLOGY. (4 cr, §3011, §Phsl 3051; prereq 1106 or 1806, Chem 1052) Comparative physiology of various animal groups; coordination, movement, support, excretion, reproduction.

Biol 3112. BIOLOGICAL RHYTHMS AND TIMING MECHANISMS. (4 cr, §5112; prereq 1009 or 1202 or #) Timing mechanisms and rhythms of organisms in physiological processes, ecological adaptation, and health; current hypotheses concerning their cellular and molecular nature. Individual projects.

Biol 3950H. UNDERGRADUATE SEMINAR. (2 cr per qtr; S-N only)
Each quarter different faculty members lead groups of students in discussions on topics of current interest.

Biol 3960H. HONORS SEMINAR. (1 cr per qtr; S-N only; prereq Δ; 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.

Biol 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.

Biol 5003. GENETICS. (4 cr, §GCB 3022; prereq 5001 or BioC 3021 or BioC 5331)
Introduction to the nature of genetic information, its transmission from parents to offspring, its expression in cells and organisms, and its course in populations.

Biol 5004. CELL BIOLOGY. (4 cr; prereq 5001 or BioC 3021 or BioC 5331, 5003 or BioC 5333)
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.

Biol 5013. MICROBIOLOGY. (5 cr, §MicB 3103, §MicB 5105, §VPB 3103; prereq 5001 or BioC 3021 or BioC 5331)
Taxonomy, anatomy, physiology, biochemistry, and ecology of microbes. Emphasis on molecular structure in relation to bacterial function. Lab.

Biol 5041. ECOLOGY. (4 cr, §5841; prereq 1203 or 1103 or 1106 or 1806 or 3011 or 3012 or 3812, Math 1142 or Math 1251; A-F only)
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.

Biol 5125. RECOMBINANT DNA LABORATORY. (4 cr, §5825, §MicB 5425; prereq application, Δ)
Basic recombinant DNA techniques. Methods for growing, isolating, and purifying recombinant DNAs and cloning vectors.

Biol 5150. INTRODUCTION TO NEUROSCIENCE. (3 cr, §NSc 5150, §Phsl 5150; prereq 3011 or equiv or Phsl 3055-3056, BioC 3021 or equiv or #)
Survey of neuroscience from invertebrates to humans. Ion channels and membrane currents, neurotransmitters and signal transduction, neuroanatomy, sensory and motor systems, learning and memory, emotion, disease states, neural networks, development.

Biol 5950. SPECIAL TOPICS IN BIOLOGY. (1-5 cr per qtr)

Biol 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

Biol 1806. ZOOLOGY (5 cr, §1106.; prereq 1009 or 1202, Δ)
Survey of animal phyla; structure, function, behavior, adaptation and evolutionary relationships. Lab.

Biol 3812. PLANT BIOLOGY. (5 cr, §1103, §3012; prereq 1009 or 1202, Chem 1052, Δ)
Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants. Field trips.

Biol 5816. FIELD BIOLOGY PHOTOGRAPHY. (5 cr; prereq intro biology course, Δ; 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.

Biol 5825. RECOMBINANT DNA LABORATORY. (3 cr, §5125, §MicB 5425; prereq application, Δ)
Basic recombinant DNA techniques. Methods for growing, isolating, and purifying recombinant DNAs and cloning vectors.

Biol 5841. ECOLOGY. (5 cr, §5041; prereq 1203 or 1103 or 1106 or 1806 or 3011 or 3012 or 3812, Math 1142 or Math 1251, Δ; A-F only)
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.

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

Biol 5890. RESEARCH PROBLEMS AT ITASCA IN ECOLOGY, EVOLUTION, BEHAVIOR, ENTOMOLOGY, FISHERIES, WILDLIFE, PLANT PATHOLOGY, SOIL SCIENCE, OR ZOOLOGY. (Cr ar; prereq #, Δ)
Undergraduate and graduate students may develop a short-term research project in any area listed above during one or both terms.

Courses Offered in Denmark Through the Danish International Study Program (DiS)

Biol 3991. MARINE BIOLOGY OF EUROPEAN COASTAL WATERS. (4.5 cr; prereq 1 yr college biology incl lab, 1 college chemistry course, Δ)
Marine biology using Baltic and North Seas as focus for study. Biology of coastal waters, interactions between organisms and their environment, methods used by marine researchers to investigate biological systems. Students conduct simple experiments during field trips. Given in Copenhagen area, with study tour in northern and western Denmark.

MAJOR REQUIREMENTS AND COURSE DESCRIPTIONS

Biol 3992. BIOLOGICAL OCEANOGRAPHY. (4.5 cr; prereq 1 yr college biology incl lab, 1 college chemistry course, Δ)

Interaction among biology, physics, and chemistry in the ocean, with special reference to unique characteristics of North and Baltic Seas. Effects of light, temperature, salinity, density, pressure, and limiting chemical constituents on marine biological systems. Problems in fisheries management. Given in Denmark.

Biol 3993. MARINE BIOLOGICAL SCIENCE

PROJECT. (9 cr; prereq 3991, 3992 or equiv, 1 yr college biology incl lab, 1 college chemistry course, Δ)

Research project with practical field components. Students use scientific libraries of various research institutions, engage in discussions and seminars with leading Danish and German scientists, and conduct experiments on research ship and at Marine Biological Laboratory. Given in Denmark.

Biol 3994. ECOLOGY AND HUMAN IMPACT IN THE

NORTH AND BALTIC SEAS. (4.5 cr; prereq 1 yr of college biology incl lab, 1 college chemistry course, Δ)

Ecosystems of North and Baltic Seas and how natural and human activities threaten their integrity. Given in Copenhagen area, with study tour in northern and western Denmark.

Biol 3995. MARINE VERTEBRATE BIOLOGY. (4.5 cr; prereq 1 yr of college biology, Δ)

Ecology and physiology of marine fish, birds, and mammals. Factors controlling vertebrate distribution and abundance. Role of vertebrates in marine ecosystems. Ecological impact of habitat alteration, pollution, fishing, and hunting, with emphasis on North and Baltic Seas. Given in Denmark.

Biochemistry (BioC)

Director of Undergraduate Studies—

Clare K. Woodward

Biochemists study molecules found in living organisms, particularly proteins, nucleic acids, lipids, and carbohydrates. The major in biochemistry is for students who plan to pursue graduate study in biochemistry or a related biological science, attend medical or veterinary school, or seek entry-level biochemical positions in industry. The biochemistry major differs from the chemistry major in that biochemistry emphasizes the integration of chemical principles into biological processes from molecular genetics to enzymology.

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 lab courses. Research options are available through BioC 5990 and 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 (see pages 21-24), biochemistry majors must complete the requirements listed below. The following major requirements are used in partial fulfillment of the college graduation requirements 5.c (see Admission Procedures and Degree Requirements, page 23). Biochemistry majors are expected to meet with their faculty adviser for assistance in designing the elective portion of the major. Students may choose a special emphasis in areas such as molecular biology or biophysics.

Biochemistry—BioC 3960, 5331, 5332, 5333, 5025

Organic Chemistry—Chem 3303

Mathematics—Math 3251

Physical Chemistry—Chem 5501-5502 or 5534, 5535 (5533 is optional and requires Math 3252 as a prerequisite). A physical chemistry lab (5538 or 5540) is recommended but not required for those taking the three-quarter sequence.

Biology—Biol 5003, 5004 (these courses will satisfy one of the elective components of the biology core, listed under 5.c.2) on page 23). Biochemistry majors must also select a course from the integrative/organismal biology/physiology or ecology/evolution/systematics/behavior core course lists.

One additional biology lab or field-based course (see list of options, page 23).

BioC Courses

BioC 1401. ELEMENTARY BIOCHEMISTRY. (4 cr, §3001; prereq Chem 1001 or one qtr college chemistry) Elementary survey of biochemistry beginning with a brief introduction to organic chemistry. Intended for students who need a general, non-intensive knowledge of the scope of biochemistry.

BioC 3021. BIOCHEMISTRY. (4 cr, §Biol 5001; prereq Biol 1009 or 1202, 8 cr organic chemistry) Fundamentals of biochemistry, including structure and function of proteins, nucleic acids, lipids and carbohydrates; metabolism and regulation of metabolism; quantitative treatments of chemical equilibria, enzyme catalysis and bioenergetics; and the chemical basis of genetic information flow.

BioC 3960. RESEARCH TOPICS IN BIOCHEMISTRY. (1 cr per qtr; S-N only) Lectures and discussions on current research in the department.

BioC 5025. LABORATORY IN BIOCHEMISTRY. (2 cr; prereq 3021 or 5331 or Biol 5001 or concurrent regis in any of the previously listed courses)

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

BioC 5301. ECOLOGICAL BIOCHEMISTRY. (3 cr; prereq 3021 or 5331 or #)

Biochemistry of environmental processes, including biochemistry of organismal interactions, biological responses to environmental stress, gene transfer in the environment, and effects and fate of environmental toxins.

BioC 5331. STRUCTURE, CATALYSIS, AND METABOLISM IN BIOLOGICAL SYSTEMS. (4 cr, §3021, §Biol 5001; prereq Biol 1009 or Biol 1202, 2 qtrs organic chemistry or #)

Structure and function of biological molecules emphasizing protein structure, catalysis, and intermediary metabolism. Enzyme kinetics, thermodynamics, and the role of cofactors in catalysis.

BioC 5332. ENERGY AND SIGNAL TRANSDUCTION IN BIOLOGICAL SYSTEMS. (4 cr; prereq 5331 or #)

Biological membrane structure and membrane-associated proteins emphasized. Processes such as transport, oxidation/reduction, photosynthesis, electron transfer mechanisms, membrane receptors, signal transduction, and specific regulatory systems.

BioC 5333. MOLECULAR MECHANISMS OF GENE ACTION. (4 cr; prereq 5332 or #)

Gene action mechanisms. Structure and function of nucleic acids and the regulatory process involved in gene expression from a biochemical point of view.

BioC 5352. APPLIED MICROBIAL BIOCHEMISTRY. (4 cr, §MicB 5352; prereq BioC 3021 or BioC 5331 or MicB 5321, intro microbiology course or #)

Biochemistry of microorganisms and enzymes of industrial interest. Overview of heterologous peptide overproduction by microorganisms and yeasts; polymer, antibiotic, organic acid, and amino acid production; genetics of industrially useful microorganisms; biological systems useful for biotransformations and environmental remediation; introduction to fermentation technology.

BioC 5401. METABOLISM AND ITS REGULATION. (3 cr; prereq 3021 or 5331)

Principles determining metabolism of both common and unusual compounds in plants, animals, and microbes. Regulation of carbon and energy flow in whole organisms.

BioC 5418. TOPICS IN MOLECULAR IMMUNOLOGY. (4 cr; prereq MicB 5218; A-F only)

Molecular interactions among proteins and peptides involved in immune recognition.

BioC 5525. PHYSICAL BIOCHEMISTRY: SOLUTION STRUCTURE AND INTERACTIONS OF BIOLOGICAL MACROMOLECULES. (4 cr, §Chem 5525, §MdBc 5525; prereq 5331 or equiv, 2 qtrs physical chemistry)

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.

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

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

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

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

BioC 5528. PHYSICAL BIOCHEMISTRY: ENZYME KINETICS. (4 cr, §Chem 5528, §MdBc 5528; prereq 2 qtrs physical chemistry, 5331 or BioC/MdBc 8001 recommended)

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

BioC 5529. PROTEIN STRUCTURE AND FOLDING. (4 cr, §Chem 5529, §MdBc 5529; prereq 5331 or equiv, 1 qtr physical chemistry or #)

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

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

BioC 5970. DIRECTED STUDIES. (Cr ar [10 cr max of 5970 or 5990 may count toward major requirement]; prereq #, Δ; S-N only)

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

BioC 5990. DIRECTED RESEARCH. (Cr ar [10 cr max of 5970 or 5990 may count toward major requirement]; prereq #, Δ; S-N only)

Lab or field investigation of selected areas of research.

For Graduate Students Only

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

BioC 8001. ADVANCED BIOCHEMISTRY I: PROTEIN STRUCTURE AND FUNCTION

BioC 8002. ADVANCED BIOCHEMISTRY II: MOLECULAR BIOLOGY

BioC 8003. ADVANCED BIOCHEMISTRY III: REGULATION OF METABOLISM AND BIOLOGICAL PROCESSES

BioC 8094. RESEARCH AND LITERATURE REPORTS

BioC 8194. GRADUATE SEMINAR

BioC 8206. CELL SIGNALLING AND METABOLIC REGULATION

BioC 8213. ADVANCED MOLECULAR BIOLOGY I

BioC 8214. ADVANCED MOLECULAR BIOLOGY II

BioC 8230. MEMBRANE BIOCHEMISTRY

BioC 8290. CURRENT RESEARCH TECHNIQUES

BioC 8990. GRADUATE RESEARCH

Ecology, Evolution, and Behavior (EEB)

Director of Undergraduate Studies—
Richard Phillips

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, EEB majors must include a core course from two of the following areas: biochemistry, genetics/cell biology/development, or integrative/organismal biology/physiology, and all of the following:

- a. Biol 5041/5841 (if not used to satisfy 5.c.2) on page 23).
- b. EEB 3111/3811 (4 cr).
- c. EEB 5044 (4 cr) or 5064 (4 cr).
- d. EEB 5156 (3 cr) or PBio 3131 (4 cr) or PBio 5131 (4 cr) or EEB 5323 (3 cr) or AnSc 3301 (6 cr).
A physiology lab (EEB 5157 or PBio 5132) is strongly recommended.
- e. 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. Students unable to attend a field station may satisfy this requirement by completing EEB 5134 and EEB 5129 plus EEB 5014 or 5016.
- 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. Students are encouraged to select courses in consultation with their faculty adviser and the

director of undergraduate studies; other courses may be substituted by petition (see especially Group II below).

- g. One additional lab or field-based biology course (see course options, page 22).

Recommended Courses, Group I:

Community Ecology and Paleocology

- EEB 5004—Earth System: Geosphere/Biosphere Interactions (4 cr)
- EEB 5008—Quaternary Ecology (4 cr)
- EEB 5014—Ecology of Vegetation (5 cr)
- EEB 5016—Ecological Plant Geography (5 cr)

Population and Evolutionary Biology

- EEB 5033—Population and Quantitative Genetics (4 cr)
- EEB 5044—Evolution (4 cr)
(if not used to meet requirement c. above)
- EEB 5051—Analysis of Populations (4 cr)
- EEB 5052—Theoretical Population Ecology (5 cr)
- EEB 5064—The Process of Evolution (4 cr)
(if not used to meet requirement c. above)

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 (3 cr)
(if not used to meet physiology requirement d. above)
- EEB 5157—Animal Physiology Laboratory (3 cr)

Behavioral Biology

- EEB 5321—Evolution of Social Behavior (4 cr)
- EEB 5323—Mechanisms of Behavior (3 cr) (if not used to meet physiology requirement d) above)
- EEB 5324—Evolution of Primate Social Behavior (3 cr)
- EEB 5325—Behavioral Ecology (4 cr)

Limnology and Ecosystem Biology

- EEB 5601—Limnology (4 cr)
- EEB 5607—Ecology of Animal Plankton (5 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

EEB 1019. OUR CHANGING PLANET. (4 cr, §Ast 1019, §Geo 1019)

Interrelationships among Earth's subsystems—solid earth, oceans, atmosphere, and biosphere—and solar and galactic super-systems. Interactions of the natural cycles, their rates and feedbacks, and human impacts.

EEB 3001. INTRODUCTION TO ECOLOGY. (4 cr; open to jrs and above but not biology majors)

Basic concepts in ecology; organization, development, and functioning of ecosystems; population growth and regulation. Human impact on ecosystems.

EEB 3006. VISIONS OF NATURE: THE NATURAL WORLD AND POLITICAL THOUGHT. (4 cr; biological sciences students may not apply these credits toward the major)

Theories about the organization of nature and their significance for the development of ethics, religion, political and economic philosophy, civics, and environmentalism in Western and other civilizations.

EEB 3111. INTRODUCTION TO ANIMAL BEHAVIOR. (4 cr, §3811, §AnSc 3111; prereq Biol 1009 or Biol 1201 or Biol 1202 or #)

Causation, development, function, and evolution; emphasizes evolution of adaptive behavior, especially social behavior, in the natural environment.

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

EEB 5965. DECISION ANALYSIS. (4 cr; prereq must be in conservation biology graduate program or #)
Active learning class explores how decision analysis techniques and modeling can be used to clarify conservation biology issues.

Biol 5041. ECOLOGY. (4 cr, §5841; prereq 1203 or 1103 or 1106 or 1806 or 3011 or 3012 or 3812, Math 1142 or Math 1251)

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.

EEB 5970. DIRECTED STUDIES. (Cr ar [10 cr max of 5970 or 5990 may count toward major requirement]; prereq #, Δ; S-N only)

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

EEB 5990. DIRECTED RESEARCH. (Cr ar [10 cr max of 5970 or 5990 may count toward major requirement]; prereq #, Δ; S-N only)

Lab or field investigation of selected areas of research.

Community Ecology and Paleocology

EEB 5004. EARTH SYSTEM: GEOSPHERE/BIOSPHERE INTERACTIONS. (4 cr, §Geo 5631; prereq Geo 3202, 3301 or #)

Interdisciplinary study of global change forcing mechanisms, feedbacks and dynamics on various time scales, using paleorecord to illustrate processes.

EEB 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.

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

Methods of describing, sampling, and classifying vegetation; spatial and temporal variation of vegetation on landscapes; theory of structure and dynamics of plant communities. Field trips to local vegetation types; analysis of quantitative data.

EEB 5016. ECOLOGICAL PLANT GEOGRAPHY. (5 cr; prereq Biol 5041 or Biol 5841, PBio 3201 or ¶PBio 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

EEB 5033. POPULATION AND QUANTITATIVE GENETICS. (4 cr; prereq Biol 5003 or GCB 3022, course in biometry or statistics or #)

Genetic basis of microevolutionary change. Allelic frequency dynamics, with particular emphasis on natural selection and adaptive topography. Molecular evolution, additive genetic variance, consequences of artificial selection and current topics.

EEB 5044. EVOLUTION. (4 cr; prereq Biol 1106 or Biol 1806 or Biol 3011, Biol 1103 or Biol 3012 or Biol 3812)

Evidence for and causes of biological evolution.

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

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

EEB 5052. THEORETICAL POPULATION ECOLOGY. (5 cr; prereq Biol 5041 or Biol 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.

EEB 5064. THE PROCESS OF EVOLUTION. (4 cr; prereq Biol 5041 or Biol 5841 or #)

Mechanistic bases of evolution, including causes and consequences of natural selection, stochastic consequences of Mendelian segregation, and their combined influences on the structure of natural and captive populations. Lab exercises based on "Populus" computer simulation software.

Organismal Biology and Physiological Ecology

EEB 5122. PLANT/ANIMAL INTERACTIONS. (4 cr; prereq Biol 1106 or Biol 1806 or Biol 3011, Biol 1103 or Biol 3012 or Biol 3812, 10 cr biological sciences or #) Herbivory, pollination, seed dispersal. Implications of interactions for plants and animals at organismal, population, and community levels.

EEB 5129. MAMMALOLOGY. (5 cr, §FW 5129; prereq Biol 1106 or Biol 1806 or Biol 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.

EEB 5134. INTRODUCTION TO ORNITHOLOGY. (5 cr; prereq Biol 1106 or Biol 1806 or Biol 3011) Lab and field course in structure, classification, distribution, migration, habits, habitats, and identification of birds. Weekend trips.

EEB 5136. ICHTHYOLOGY. (4 cr; prereq 15 cr incl Biol 1106 or Biol 1806 or Biol 3011) Biology of fishes including development, systematics, anatomy, physiology, and ecology.

EEB 5156. COMPARATIVE ANIMAL PHYSIOLOGY. (3 cr; prereq Biol 1106 or Biol 1806 or Biol 3011, Chem 3302 or #)

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

EEB 5157. ANIMAL PHYSIOLOGY LABORATORY. (3 cr; prereq 5156 or 5323 or AnSci 3301 or ¶AnSci 3301 or Biol 3011 or Biol 3111 or Ent 5030 or FW 5459 or GCB 5114 or #; A-F only)

Recording and analysis of bioelectric events, transduction of force and displacement into electrical signals, respirometry, spectrophotometry. Independent or team research projects required.

Behavior

EEB 5321. EVOLUTION OF SOCIAL BEHAVIOR. (4 cr; prereq Biol 1106 or Biol 1806 or Biol 3011 or #) Current theories and concepts relating to mating systems, spacing systems, and cooperative behavior in animals.

EEB 5323. MECHANISMS OF BEHAVIOR. (3 cr; prereq 3111 or Biol 3011 or #) Neural and hormonal mechanisms that mediate adaptive behavior in invertebrate and vertebrate animals, using a series of well-studied examples to illustrate general principles.

EEB 5324. EVOLUTION OF PRIMATE SOCIAL BEHAVIOR. (3 cr; prereq 3111 or #) Ecological factors that influence variation in the demography, social structure and social behavior of non-human primates. Application of current evolutionary theory (e.g., kin selection, reciprocity) to the understanding of social behavior.

EEB 5325. BEHAVIORAL ECOLOGY. (4 cr; prereq 3111 or 5321 or Biol 5041 or Biol 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, dispersal.

Limnology and Ecosystem Ecology

EEB 5601. LIMNOLOGY. (4 cr, §Geo 5601; prereq Chem 1052 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.

EEB 5607. ECOLOGY OF ANIMAL PLANKTON. (5 cr; prereq 5601, Biol 5041 or Biol 5841 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.

EEB 5608. ECOSYSTEMS: FORM AND FUNCTION. (4 cr; prereq 5601 or Biol 5041 or Biol 5841 or equiv, an advanced course in writing such as Comp 3015 or 3027 or 3033 or 3085 or Rhet 3562)

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.

EEB 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 special emphasis on plankton. Field instruments, sampling devices, chemical analysis, microscopy, and analysis of data. One Saturday field trip.

Courses Offered at Lake Itasca Forestry and Biological Station

EEB 5814. PLANT COMMUNITY ECOLOGY. (5 cr; prereq ecology course, D; A-F only)

Communities represented in Itasca Park and vicinity, with emphasis on vegetation. Patterns of distribution of the communities, their interaction with the environment, and their dynamic relationships. Methods of community description and analysis.

EEB 5817. VERTEBRATE ECOLOGY. (5 cr; prereq ecology course, Δ)

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

EEB 5834. FIELD ORNITHOLOGY. (5 cr; prereq general biology course including study of zoology, Δ) Emphasis on the 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. Lab sessions investigate family distinctions and species identification. Individual field projects.

EEB 5839. FIELD STUDIES IN MAMMALOLOGY. (5 cr; prereq college-level biology course including study of animals or #, Δ; A-F only)

Identification, distributions, community interactions, ecophysiology, population ecology.

BIOL 5841. ECOLOGY. (5 cr, §Biol 5041; prereq 1203 or 1103 or 1106 or 1806 or 3011 or 3012 or 3812, Math 1142 or Math 1211 or Math 1251, 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. Fieldwork at the Itasca station.

For Graduate Students Only

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

EEB 8003. ECOLOGICAL MODELING

EEB 8061. SOCIAL SYSTEMS

EEB 8300. TOPICS IN EVOLUTION

EEB 8390. GRADUATE SEMINAR

EEB 8391. ADVANCED WORK IN ECOLOGY AND BEHAVIORAL BIOLOGY

EEB 8400. POPULATION BIOLOGY SEMINAR

EEB 8410. COMMUNITY ECOLOGY SEMINAR

EEB 8420. POPULATION BIOLOGY RESEARCH SEMINAR

EEB 8430. EVOLUTIONARY GENETICS SEMINAR

EEB 8500. WRITING RESEARCH PROPOSALS

EEB 8510. BEHAVIORAL BIOLOGY SEMINAR

EEB 8602. ADVANCED LIMNOLOGY

EEB 8612. WINTER ECOLOGY

EEB 8990. GRADUATE RESEARCH

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

Genetics and Cell Biology (GCB)

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.

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 (see 5.b. on page 22), genetics and cell biology majors must complete the following major requirements.

GCB majors must complete 27 additional credits, including:

- a. GCB 3960 (1 cr) (Students should complete this course as soon as possible after they decide to major in GCB)
- b. Biol 3950H (two quarters, 4 cr) 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.
- c. BioC 5025. Lab in Biochemistry (2 cr)
- d. 20 additional credits in life sciences and/or physical science and/or mathematics and/or statistics and/or computer science, chosen in consultation with major adviser. The 20 credits must include two additional laboratory experiences, totaling a minimum of 4 cr, one of which must be in GCB. (Biol 5125 may be considered a GCB course for purposes of this requirement.) Students should include GCB 5990, Directed Research, as one or both of these experiences. A minimum of 4 and 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

- Biol 5125—Recombinant DNA Laboratory (4 cr)*
- EEB 5033—Population and Quantitative Genetics (4 cr)
- GCB 5024—Genetics of Development (4 cr)**
- GCB 5030—Laboratory: Genetics (2 cr)*
- GCB 5034—Intermediate Molecular Genetics (4 cr)
- GCB 5043—Human Genetics (4 cr)
- GCB 5073—Advanced Human Genetics (4 cr)**
- Micb 5425—Virology and Molecular Genetics Laboratory (3 cr)*
- PBio 5109—Molecular Genetics and Biochemistry of Yeasts and Filamentous Fungi (4 cr)**
- Psy 5137—Introduction to Behavioral Genetics (4 cr) (prereqs waived for CBS students)

MAJOR REQUIREMENTS AND COURSE DESCRIPTIONS

Area 2: Cell and Developmental Biology

GCB 5015—Histology: Cell and Tissue Organization (5 cr)*
GCB 5035—Intermediate Cell Biology (4 cr)
GCB 5061—Developmental Biology (4 cr)
GCB 5114—General Physiology (3 cr)
GCB 5134—Endocrinology (4 cr)
GCB 5605—Cell Biology Laboratory (2 cr)*
PBio 5151—Plant Cell Biology (4 cr)**

* *Lab courses.*

** *Courses taken primarily by graduate students; undergraduates should have excellent grades in Biol 5003 and/or Biol 5004.*

Area 3: Courses from other departments.

(This list is not all-inclusive.)

BioC 5401—Metabolism and Regulation (3 cr)
Biol 5150—Introduction to Neuroscience (3 cr)
Chem 3100, 3101—Quantitative Analysis (5 cr)
Chem 3303—Elementary Organic Chemistry III (4 cr)
Chem 5501-5502—Elementary Physical Chemistry (6 cr)
CSci 3102—Introduction to PASCAL Programming (4 cr)
EEB 5044—Evolution (4 cr)
EEB 5064—The Process of Evolution (4 cr)
GCB 3008—The Biology of Cancer (3 cr)
Math 3251—Multivariable Differential Calculus (4 cr)
MicB 5218—Immunology (3 cr)
MicB 5321—Physiology of Bacteria (3 cr)
MicB 5424—Biology of Viruses (4 cr)
PBio 3131—Survey of Plant Physiology (4 cr)
PBio 5111—Plant Cell, Tissue, and Organ Development (5 cr)
Stat 5021—Statistical Analysis (5 cr)

Area 4: History and Philosophy of Science

Biol 5951—Social Uses of Biology (4 cr)
HSci 3202—History of Biology (Physiology and Cell Theory) (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

GCB 3002. HUMAN GENETICS, SOCIAL AFFAIRS. (3 cr [4 cr with term paper], §3022, §Biol 1101, §Biol 5003; for students in programs not directly related to biological sciences) Heredity and basic genetic mechanisms with emphasis on humans. Relationship between human genetics and disease, family planning, gender, behavior, and race. Ethical/societal issues concerning human genetics and modern genetic technologies.

GCB 3008. THE BIOLOGY OF CANCER. (3 cr; prereq Biol 1009 or 1202) Biological aspects of etiology, phylogeny, and cellular processes involved in neoplasia. Growth and differentiation of normal and cancer cells. History of cancer research.

GCB 3022. GENETICS. (4 cr, §Biol 5003; not for biology majors; prereq Biol 1009 or 1202) Mechanisms of heredity, their implications for biological populations, and applications to practical problems.

GCB 3960. RESEARCH TOPICS. (1 cr; prereq 15 cr biology; S-N only) Ongoing department faculty research. Introduces sophomores and juniors who are potential GCB majors to department faculty, the diversity of faculty research activities, and opportunities for GCB undergraduate research.

GCB 5015. HISTOLOGY: CELL AND TISSUE ORGANIZATION. (5 cr; prereq Biol 5004 or #) Structure and function of vertebrate tissues and organs. Lectures combine electron microscopy, light microscopy, physiology, and cell biology of higher animals. Labs concentrate on light microscopy of mammalian tissues.

GCB 5024. THE GENETICS OF DEVELOPMENT. (4 cr; prereq Biol 5003 or #) Current concepts and experimental approaches concerning the genetic basis of morphogenesis and metazoan development. Concentration on organisms amenable to genetic analysis, including certain prokaryotes and single-cell eukaryotes, nematodes, and *Drosophila*.

GCB 5030. LABORATORY: GENETICS. (2 cr; prereq 3022 or Biol 5003 or BioC 5333) Investigative approaches to analysis of genetic problems. Focus on a given organism or related group of organisms may differ from quarter to quarter.

GCB 5034. INTERMEDIATE MOLECULAR GENETICS. (4 cr; prereq Biol 5003, Biol 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 undergraduates and graduate students outside of CBS programs.

GCB 5035. INTERMEDIATE CELL BIOLOGY. (4 cr; prereq Biol 5004 or #) Current literature in cell biology. Selected scientific papers illustrate new concepts in and experimental approaches to cell organization and function. Topics vary but include membranes, secretion, endocytosis, the cytoskeleton, and the nucleus.

GCB 5043. HUMAN GENETICS. (3 cr; prereq 3022 or Biol 5003 or #) Principles of human genetics at the molecular, cellular, individual, and populations levels. Chromosomal and biochemical disorders; gene mapping; mutation and natural selection; variation in intelligence and behavior; genetic screening, counseling and therapy.

GCB 5061. DEVELOPMENTAL BIOLOGY. (4 cr; prereq Biol 3011 or Biol 3111, Biol 5004) Animal embryology; morphogenesis and cellular differentiation with an emphasis on vertebrates and on pattern formation. Control mechanisms of development.

GCB 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.

GCB 5114. GENERAL PHYSIOLOGY. (3 cr; prereq Biol 3011 or Biol 3111, Biol 5001 or BioC 3021 or BioC 5331, Phys 1109 or Phys 1253)

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

GCB 5134. ENDOCRINOLOGY. (4 cr; prereq Biol 3011 or Biol 3111, Biol 5001 or BioC 3021 or BioC 5331 or #) Survey of structure and function of invertebrate and vertebrate endocrine systems.

GCB 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.

GCB 5970. DIRECTED STUDIES. (Cr ar [10 cr max of 5970 or 5990 may count toward major requirement]; prereq #, Δ; S-N only)

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

GCB 5990. DIRECTED RESEARCH. (Cr ar [10 cr max of 5970 or 5990 may count toward major requirement]; prereq #, Δ; S-N only)

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 IN PRACTICE

8913. PSYCHOLOGICAL ISSUES IN GENETIC COUNSELING

8914. ETHICAL AND LEGAL ISSUES IN GENETIC COUNSELING

8970. DIRECTED STUDY

8990. RESEARCH

Molecular, Cellular, Developmental Biology and Genetics

8920. SPECIAL TOPICS

8950. TEACHING PRACTICUM

8970. DIRECTED STUDIES

8990. RESEARCH

History of Science and Technology (HSci)

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

Scientific, philosophical, and social factors in the 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 the 19th and 20th centuries.

HSci 5242. THE DARWINIAN REVOLUTION. (4 cr; prereq Biol 1009 or Biol 1101 or Biol 1202 or #)

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

Microbiology (MicB)

Medical School

Director of Undergraduate Studies—
Palmer Rogers

The microbiology program prepares students for work as practicing microbiologists or for graduate work.

The field of microbiology embraces a multitude of areas of fundamental and applied research. Microbiologists have in common an interest in the basic role played by microbes, such as bacteria, fungi, and viruses, in the world in which we live. Microbiologists may be interested in basic biological mechanisms, such as DNA replication or the regulation of protein synthesis, that are currently under study employing microorganisms. They may study fundamental issues concerning human and animal diseases such as the mechanisms of viral and bacteriological infection, immunity and autoimmune disease, and viral-induced cancer. 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.

MAJOR REQUIREMENTS AND COURSE DESCRIPTIONS

In addition to the general requirements for graduation from CBS (see pages 21-23), microbiology majors must complete the following:

Biochemistry: BioC 3021 or 5331

Chemistry: Chem 3100, 3101

Ecology: Biol 5041 or 5841 or MicB 5611

Genetics: Biol 5003 or GCB 3022

Microbiology: MicB 5105 or Biol 5013,
MicB 5900

Four of the following: MicB 5218, 5232, 5321, 5352, 5424, 5611 (if not used to fulfill ecology requirement)

Two of the following: MicB 5234, 5322, 5425; or directed research, MicB 5990, a minimum of 8 credits in one lab. Directed research may only be used to meet one of the lab requirements.

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 Office of Student Services, 223 Snyder Hall (612/624-9717).

MicB Courses

MicB 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 #; not for biology majors) 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 or BioC 3021 or BioC 5331)

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

MicB 5105.¹ BIOLOGY OF MICROORGANISMS. (5 cr, §Biol 5013, §MicB 3103, §VPB 3103; prereq Biol 5001 or BioC 3021 or BioC 5331 or #)

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

MicB 5218. IMMUNOLOGY. (3 cr; prereq Biol 5001 or BioC 3021 or BioC 5331)

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.

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

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.

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

Principles that determine the outcome of host-parasite interactions. Host defense and immunology methods, including immunochemical and microbiological methods used to diagnose infectious disease.

MicB 5235. MICROORGANISMS AND DISEASE. (3 cr, §5233; not open to microbiology majors; does not count toward the 16 upper division elective credits in the biology major; prereq 10 cr chemistry, 5 cr biological sciences or #) Nature of microorganisms, immunology, medical bacteriology, virology, mycology, and principles of disease control.

MicB 5321. PHYSIOLOGY OF BACTERIA. (3 cr; prereq 3103 or 5105 or Biol 5013 or VPB 3103, Biol 5001 or BioC 3021 or BioC 5331, 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.

MicB 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.

MicB 5352. APPLIED MICROBIAL BIOCHEMISTRY. (4 cr, §BioC 5352; prereq BioC 3021 or BioC 5331 or MicB 5321, intro microbiology course or #)

Biochemistry of microorganisms and enzymes of industrial interest. Overview of heterologous peptide overproduction by microorganisms and yeasts; polymer, antibiotic, organic acid, and amino acid production; genetics of industrially useful microorganisms; biological systems useful for biotransformations and environmental remediation; introduction to fermentation technology.

MicB 5424. BIOLOGY OF VIRUSES. (3 cr; prereq Biol 5003 and one of the following: Biol 5004 or Biol 5013 or MicB 5105)

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.

MicB 5425.¹ VIROLOGY AND MICROBIAL GENETICS LABORATORY. (3 cr, §Biol 5125; prereq 5424 or ¶5424, BioC 3021 or BioC 5331 or Biol 5001, GCB 3022 or Biol 5003,)

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.

¹ *Microscope required. Students may obtain use of microscope by purchasing two microscope cards from the bursar.*

MicB 5611. MICROBIAL ECOLOGY. (3 cr, §Soil 5605; prereq 3103 or 5105 or Biol 5013 or Soil 5610 or #) 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; biotechnical approaches to studying microbial ecology.

MicB 5900. TOPICS IN MICROBIOLOGY. (1 cr; prereq 5105 or Biol 5013; open to microbiology sr majors; A-F only) Seminars on research programs, historical perspectives, significant emerging fields, professional societies and publications, and career opportunities.

MicB 5970. DIRECTED STUDIES. (Cr ar [10 cr max of 5970 or 5990 may count toward major requirement]; prereq #, Δ; S-N only)

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

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

For Graduate Students Only

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

MicB 8110. BIOLOGY OF MICROORGANISMS

MicB 8112. MICROBIAL GENETICS

MicB 8216. FRONTIERS OF IMMUNOLOGY I: MOLECULAR IMMUNOLOGY

MicB 8217. FRONTIERS OF IMMUNOLOGY II: CELLULAR IMMUNOLOGY

MicB 8218. FRONTIERS OF IMMUNOLOGY III: CLINICAL IMMUNOLOGY

MicB 8231. ADVANCED TOPICS IN MOLECULAR PATHOGENESIS

MicB 8421. VIROLOGY AND TUMOR BIOLOGY

MicB 8911. COLLOQUIUM IN MICROBIOLOGY

MicB 8990. RESEARCH IN MICROBIOLOGY

Plant Biology (PBio)

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. As part of the general requirements for graduation from CBS (see 5.c., page 23), plant biology majors must include one course from three of the following areas: biochemistry, genetics/cell biology/development, integrative/organismal biology/physiology, or ecology/evolution/systematics/behavior. They must also complete the following major requirements:

Biol 1103 or 3012 or 3812 (if not used to satisfy requirement 5.c.1) above)

Biol 3950H: Undergraduate Seminar (2 cr)

20 credits from groups A-E below, with at least one course each from groups A-D and no more than one course from group E (may not include courses listed under 5.c above)

Lab or fieldwork in two additional upper division biological sciences courses, one of which should be a PBio course. Directed Research (numbered 5990 in any of the college's departments) may serve as one of the lab courses, provided the student completes 4 or more credits of 5990.

A. Plant Cell and Molecular Biology

GCB 5034—Intermediate Molecular Genetics (4 cr)

PBio 5109—Molecular Genetics and Biochemistry of Yeasts and Filamentous Fungi (4 cr)

PBio 5141—Plant Cell Biology (4 cr)

PBio 5186—Topics in Plant Biochemistry (3 cr)

B. Plant Physiology

PBio 3131/5131—Survey of Plant Physiology (4 cr)

PBio 5182—Plant Metabolism (3 cr)

PBio 5183—Water, Minerals, and Translocation (4 cr)

PBio 5184—Plant Growth and Development (3 cr)

C. Plant Structure/Diversity/Development

PBio 3109—Plant Anatomy (5 cr)*

PBio 5103—Algae, Fungi, Bryophytes (5 cr)*

PBio 5105—Morphology of Vascular Plants (5 cr)*

PBio 5107—Mycology: Basidiomycetes (4 cr)*

PBio 5111—Plant Cell, Tissue, and Organ Development (5 cr)*

PBio 5231—Introduction to the Algae (5 cr)*

PBio 5811—Freshwater Algae (5 cr)*

D. Ecology/Systematics/Evolution

EEB 5014—Ecology of Vegetation (5 cr)*

EEB 5016—Ecological Plant Geography (5 cr)*

EEB 5122—Plant/Animal Interactions (4 cr)

PBio 3201—Introductory Plant Systematics (4 cr)*

PBio 5221—Plant Molecular Evolution (3 cr)

PBio 5801—Plains and Boreal Flora (5 cr)*

E. History and Philosophy of Science

HSci 3201/3202—History of Biology (4 cr each)

HSci 5242—The Darwinian Revolution (4 cr)

Phil 3601—Scientific Thought (4 cr)

Phil 5607—Philosophy of Science: Problems of the Biological Sciences (4 cr)

* Lab courses.

MAJOR REQUIREMENTS AND COURSE DESCRIPTIONS

PBio Courses

PBio 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.

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

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

Biol 1103. GENERAL BOTANY. (5 cr, §Biol 3012, §Biol 3812; prereq Biol 1009 or Biol 1202; students who plan to major in biology in CLA or in any major in CBS should take 3012 or 3812)

Levels of organization of plants, plant function, plant growth and development, plant reproduction.

Biol 3012. PLANT BIOLOGY. (5 cr, §Biol 1103, §Biol 3812; prereq Biol 1009 or Biol 1202, Chem 1052)

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

PBio 3109. PLANT ANATOMY. (5 cr; prereq Biol 1103 or Biol 3012 or Biol 3812; offered alt yrs)

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

PBio 3131. SURVEY OF PLANT PHYSIOLOGY. (4 cr, §5131; prereq Biol 1103 or Biol 3012 or Biol 3812, Biol 5001 or BioC 3021 or BioC 5331)

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.

PBio 3201. INTRODUCTORY PLANT SYSTEMATICS. (4 cr; prereq Biol 1103 or Biol 3012 or Biol 3812)

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.

PBio 3960. RESEARCH TOPICS IN PLANT BIOLOGY.

(1 cr; prereq Biol 1103 or Biol 3012 or Biol 3812; S-N only) For undergraduates interested in plant biology. Lecture, discussion, and demonstration of faculty research interests.

PBio 5001. BASIC BOTANY. (Cr ar; prereq Biol 1009 or Biol 1202, #, Δ)

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

PBio 5103. ALGAE, FUNGI, AND BRYOPHYTES.

(5 cr; prereq Biol 1103 or Biol 3012 or Biol 3812; offered when feasible)

Characteristics of groups, evolutionary relationships, life cycles, comparative morphology (including ultrastructure), comparative nutrition. Lab emphasizes living material and isolation of algae and fungi into culture.

PBio 5105. MORPHOLOGY OF VASCULAR PLANTS. (5 cr; prereq Biol 1103 or Biol 3012 or Biol 3812 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.

PBio 5107. MYCOLOGY: BASIDIOMYCETES. (4 cr; prereq 5103 or PIPa 5105 or equiv or intro 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, Aphylllophorales, Agaricales, and Gasteromycetes.

PBio 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.

PBio 5111. PLANT CELL, TISSUE AND ORGAN DEVELOPMENT. (5 cr; prereq Biol 1103 or Biol 3012 or Biol 3812; offered alt yrs)

Microscopic structure of vascular plants; development in root, stem, and leaf.

PBio 5131. SURVEY OF PLANT PHYSIOLOGY. (4 cr, §3131; prereq BioC 3021 or BioC 5331 or Biol 5001, Biol 1103 or Biol 3012 or Biol 3812)

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.

PBio 5132. PLANT PHYSIOLOGY LABORATORY. (2 cr; prereq 3131 or ¶3131 or 5131 or ¶5131)

Lab 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.

PBio 5182. PLANT METABOLISM. (3 cr, 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.

PBio 5183. WATER, MINERALS, AND TRANSLOCATION. (4 cr, 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.

PBio 5184. PLANT GROWTH AND DEVELOPMENT.

(3 cr, prereq 3131 or 5131 or equiv)
Plant growth and development from germination to death with emphasis on physiology, biochemistry, and molecular biology. 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.

PBio 5186. TOPICS IN PLANT BIOCHEMISTRY.

(3 cr; prereq BioC 3021 or BioC 5331 or Biol 5001; offered alt yrs) Biochemical processes unique to plants, with emphasis on structures of the macromolecules involved and the reaction and their regulation. Major topics: light reactions of photosynthesis, secondary metabolism, and carbohydrates. Minor topics: carbon dioxide fixation and nitrogen fixation.

PBio 5203. HERBARIUM TECHNIQUES.

(1 cr; prereq 1009 or 3201 or equiv; S-N only)
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.

PBio 5221. PLANT MOLECULAR EVOLUTION.

(3 cr; prereq Biol 5003 or GCB 3022; offered alt yrs) Applications of molecular genetics to the study of processes and products of evolution. Specific 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.

PBio 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.

PBio 5960. SPECIAL TOPICS.

(Cr ar; prereq #, Δ)
In-depth study of a specialized botanical topic.

PBio 5970. DIRECTED STUDIES.

(Cr ar [10 cr max of 5970 or 5990 may count toward major requirement]; prereq #, Δ; S-N only)
Individual study on selected topics or problems with emphasis on selected readings and use of scientific literature.

PBio 5990. DIRECTED RESEARCH.

(Cr ar [10 cr max of 5970 or 5990 may count toward major requirement]; prereq #, Δ; S-N only)
Lab or field investigation of selected areas of research.

Courses Offered at Lake Itasca Forestry and Biological Station

Biol 3812. PLANT BIOLOGY.

(5 cr, §1103, §3012; prereq 1009 or 1202, Chem 1052, Δ)
Plant diversity and evolution; structure and function of the plant cell and of the whole organism; growth and development of plants. Field trips.

PBio 5801. PLAINS AND BOREAL FLORA.

(5 cr; prereq taxonomy course, Δ; offered when feasible)
Summer flowering plants and ferns of Minnesota with particular reference to 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.

PBio 5811. FRESHWATER ALGAE.

(5 cr; prereq 10 cr plant biology or 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.

PBio 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*)

PBio 8287. PLANT MOLECULAR BIOLOGY

PBio 8301. POLLEN MORPHOLOGY AND QUATERNARY PALYNOLOGY

PBio 8950. SEMINAR

PBio 8990. RESEARCH PROBLEMS

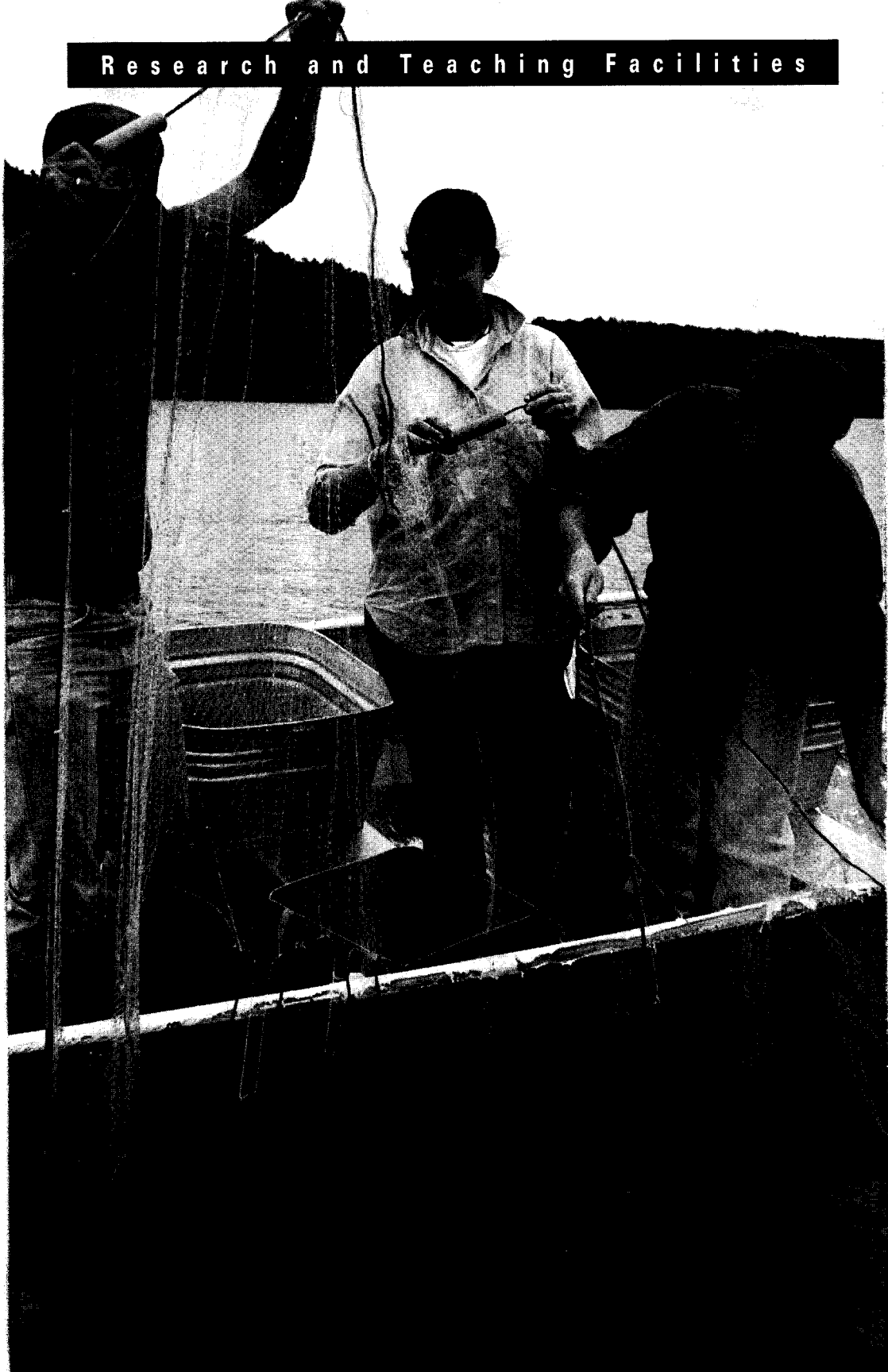
Recommended Related Coursework

The University offers a wide variety of life sciences courses in addition to those offered by CBS.

Students are encouraged to consult the bulletins of several colleges to explore courses in related areas (Colleges of Human Ecology, Liberal Arts, Natural Resources, and Agricultural, Food, and Environmental Sciences; Institute of Technology; Allied Health Programs; School of Public Health). A complete list is available in the *Directory of U of M Undergraduate Courses in Life Sciences Disciplines*. This resource, in electronic and booklet form, is available in the Instructional Computing Center in 122 Snyder Hall. Biology majors may petition to use many of these courses to count toward the 16 credits of upper division science/math elective work required for the major. 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 and science (HMed, HSci), Horticultural science (Hort), Laboratory medicine (LaMP), Mathematics (Math), Natural resources and environmental studies (NRES), Pharmacology (Phcl), Philosophy (Phil), Physics (Phys), Physiology (Phsl), Plant pathology (PIPa), Psychology (Psy), Public health (PubH), Soil science (Soil), Statistics (Stat), Veterinary biology (VB), Veterinary pathobiology (VPB).

Research and Teaching Facilities



Research and Teaching Facilities

CBS has faculty and facilities 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 Major Requirements and Course Descriptions.

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 Administration and Faculty.

Special Research and Teaching Centers

CBS Reading Room—Located on the fourth floor of the Biological Sciences Center on the St. Paul campus, this facility supports courses and research in CBS. Current journals in many areas of biology are available for use in the room (612/624-7752).

Biological Sciences Greenhouse—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).

Herbarium—The Herbarium contains more than 820,000 specimens of fungi, lichens, mosses, gymnosperms, and angiosperms collected mainly on the North American continent. This collection (sixth largest among university herbaria) is a major resource for botanically oriented research both at the University and other institutions. It also plays an important role of outreach to the public, offering assistance with identification of and information about plants (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 Office of Student Services (612/624-9717) or the Program Director of Cedar Creek Natural History Area (612/625-5740).

Developmental Biology Center—The University of Minnesota has launched a major initiative in developmental biology with researchers representing both the basic and clinical sciences. This field identifies mechanisms whereby a single cell, the fertilized egg, develops into a complex multicellular organism containing millions of cells that are organized into characteristic patterns with many different specialized functions. Developmental biology has become a central subject in biology of both medical and economic importance. The center serves as a resource for collaborative research (612/624-3110).

General Biology Program—Located in P180 Kolthoff Hall on the Minneapolis campus, 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.

Imaging Center—Located in 35 Snyder Hall, the center serves labs across the University with state-of-the-art equipment. It specializes in confocal imaging and has a variety of light, digitizing, and scanning electron microscopes. This fee-for-service facility is available to students, faculty, and staff for their teaching and research activities (612/624-3454).

Biological Process Technology Institute (BPTI)—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 BPTI Bioprocessing Pilot Facility (BPF) is a 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 institute's major objective is to develop an interdisciplinary approach to the study and application of new developments in human genetics. It develops technologies necessary for understanding the structure and expression of human chromosomes and genes for the prevention, diagnosis, and therapy of inborn and acquired genetic disorders. The institute's genetic programs include genetic services (Molecular Diagnostics Laboratory, microchemical facility, gene therapy program) and molecular, behavioral, clinical, and population genetics (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 study of varied ecosystems and of the 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, University of Minnesota, 303 Ecology Building, 1987 Upper Buford Circle, St. Paul MN 55108 (612/624-6743).

Instructional Computing Center—Biology students have access to a well-equipped Macintosh computing facility in 122 Snyder Hall and an IBM facility in 170 Ecology Building. Primarily for instructional needs,

priority in the computer center is given to undergraduates working on course-related materials. Students can use programs for word processing, graphing, drawing, or spreadsheets. Students can also access many electronic databases and file servers around the world, as well as their own electronic mail service. In addition, the center houses specialized software purchased for student use, such as programs to assist with preparation for the Graduate Record Examination (GRE). Hours for each computing lab are posted on the lab doors.

Advanced Bioscience Computing Center (ABCC)—Located in 247 Gortner Laboratory, the center serves more than 110 labs with advanced nucleic acid and peptide sequence analysis software. Molecular graphics facilities permit specialized research on the structure and function of DNA, RNA, and proteins. Student computers are available, as are workshops, a help line, and consulting. For more information, call (612) 625-9284.

Plant Molecular Genetics Institute—The institute fosters research in molecular biology and genetics of economically important plants and relevant model plant systems; develops genetic engineering methodologies for application to crop improvement; educates future plant biology researchers and teachers; maintains a stimulating interdisciplinary environment in which to explore and develop new ideas and experimental approaches in plant molecular biology; and provides a focus for external communication to aid recruitment and funding. Institute faculty come from two colleges (Biological Sciences and Agricultural, Food, and Environmental Sciences) and six departments (Genetics and Cell Biology, Agronomy and Plant Genetics, Biochemistry, Plant Biology, Horticulture, and Plant Pathology). 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 the following graduate programs: genetics, horticulture, microbiology, plant breeding, plant pathology, and plant biological sciences. Institute membership is determined by nomination and election by institute faculty (612/625-1213).

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 CBS department offices.

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

Biochemistry, Molecular Biology and Biophysics—John S. Anderson, 624-3662

Conservation Biology—
Donald B. Siniff, 624-6743

Ecology—Edward J. Cushing, 625-5713

Genetic Counseling—Bonnie Leroy, 624-7193

Microbial Engineering—
Friedrich Srienc, 624-9776

Microbiology, Immunology, and Molecular Pathobiology—Marc K. Jenkins, 626-2715

Molecular, Cellular, Developmental Biology and Genetics—Steven McLoon, 624-9812

Neuroscience—Robert F. Miller, 626-2914

Plant Biological Sciences—
Burle Gengenbach, 625-6282

Zoology—Elmer C. Birney, 624-6770



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. Major requirements, brief course descriptions, and faculty information are provided.

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 in the *Extension Classes Bulletin* and the *Summer Session Bulletin*, respectively.

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

Course Guide—The *Course Guide*, a quarterly publication distributed at the University Bookstores, provides course information in addition to college bulletins and the *Class Schedule*.

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

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, 42 U.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 the Americans With Disabilities Act of 1990; 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 the Office of Equal Opportunity and Affirmative Action, University of Minnesota, 419 Morrill Hall, 100 Church Street S.E., Minneapolis, MN 55455 (612/624-9547).

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, electronic (e-mail) address, telephone number, dates of enrollment and enrollment status (full time, part time, not enrolled, withdrawn and date of withdrawal), 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 150 Williamson Hall, 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).

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.

This publication is available in alternative formats upon request. Please contact the Office of Admissions, University of Minnesota, 240 Williamson Hall, 231 Pillsbury Drive S.E., Minneapolis, MN 55455 (612/625-2008; e-mail admissions@tc.umn.edu).

This bulletin also is available in electronic format on Internet and may be accessed via Gopher or the World Wide Web at <http://biosci.umn.edu/>.

Immunization—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 requiring student participation 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. The Senate advises all faculty that any exemption granted pursuant to this policy shall be honored and that students who are unable to complete course requirements during finals week shall be provided an alternative and timely opportunity to do so.

Smoke-Free Campus Policy—Smoking is prohibited in all facilities of the University of Minnesota, Twin Cities campus except for designated private residence hall rooms.

Planning to Transfer?

Minnesota’s public colleges and universities are working to make transfer easier. You can help if you **PLAN AHEAD, ASK QUESTIONS,** and **USE PATHWAYS** created by transfer agreements.

Preparing for Transfer

If you are currently enrolled in a college or university:

- Discuss your plans with the campus transfer specialist in the Office of Student Services, 223 Snyder Hall (612/624-9717).
- Call or visit your intended transfer college. You should obtain the following materials and information:
 - college catalog
 - transfer brochure
 - information on admissions criteria and on materials required for admission (e.g.,

portfolio, transcripts, test scores). Note that some majors have limited enrollments or their own special requirements such as a higher grade point average.

—information on financial aid (how to apply and by what date)

- After you have reviewed these materials, make an appointment to talk with an adviser/counselor in the college or program you want to enter. Be sure to ask about course transfer and admission criteria.

If you are not currently enrolled in a college or university, you might begin by meeting with a transfer specialist or an admission officer at your intended transfer college to plan the steps you need to take.

Understanding How Transfer of Credit Works

- The receiving college or university decides what credits transfer and whether those credits meet its degree requirements. The accreditation of both your sending and your receiving institution can affect the transfer of the credits you earn.
- Institutions accept credits from courses and programs like those they offer. They look for similarity in course goals, content, and level. “Like” transfers to “like.”
- Not everything that transfers will help you graduate. Baccalaureate degree programs usually count credits in three categories: general education, major/minor courses and prerequisites, and electives. The key question is, “Will your credits fulfill requirements of the degree or program you choose?”
- If you change your career goal or major, you might not be able to complete all degree requirements within the usual number of graduation credits.

Applying for Transfer Admission

- Application for admission is always the first step in transferring. Fill out the application as early as you can prior to the deadline. Enclose the application fee.

- Request that official transcripts be sent from every institution you have attended. You might be required to provide a high school transcript or GED test scores as well.
- Recheck to be certain you supplied the college or university with all the necessary paperwork. Most colleges make no decisions until all required documents are in your file.
- If you have heard nothing from your intended college of transfer after one month, call to check on the status of your application.
- After the college notifies you that you have been accepted for admission, your transcribed credits will be evaluated for transfer. A written evaluation should tell you which courses transfer and which do not. How your courses specifically meet degree requirements may not be decided until you arrive for orientation or have chosen a major.
- If you have questions about your evaluation, call the Office of Admissions and ask to speak with a credit evaluator. Ask why judgments were made about specific courses. Many concerns can be cleared up if you understand why decisions were made. If not satisfied, you can appeal. See “Your Rights as a Transfer Student” below.

Your Rights as a Transfer Student

- A clear, understandable statement of an institution’s transfer policy.
 - A fair credit review and an explanation of why credits were or were not accepted.
 - A copy of the formal appeals process.
- Usual appeals steps are: 1) Student fills out an appeals form. Supplemental information you provide to reviewers—a syllabus, course description, or reading list—can help. 2) Department or committee will review. 3) Student receives, in writing, the outcome of the appeal. 4) Student can appeal decision to the Office of Student Services, 223 Snyder Hall (612/624-9717).
- At your request, a review of your eligibility for financial aid or scholarships.

For help with your transfer questions or problems, see your campus transfer specialist.

University Regents

Thomas R. Reagan, Gilbert, Chair
 H. Bryan Neel III, Rochester, Vice Chair
 Wendell R. Anderson, Wayzata
 Julie A. Bleyhl, Madison
 William E. Hogan II, Minnetonka
 Jean B. Keffeler, Minneapolis
 Hyon T. Kim, St. Anthony
 Warren C. Larson, Bagley
 William R. Peterson, Eagan
 Jessica J. Phillips, Morris
 Stanley D. Sahlstrom, St. Cloud
 Patricia B. Spence, Rice

University Administrators

Nils Hasselmo, President
 Roger P. Paschke, Acting Senior Vice President for Finance and Operations
 Ettore F. Infante, Senior Vice President for Academic Affairs
 C. Eugene Allen, Provost for Professional Studies
 William R. Brody, Provost for the Academic Health Center
 W. Phillips Shively, Provost for Arts, Sciences, and Engineering
 McKinley Boston, Jr., Vice President for Student Development & Athletics
 Mark L. Brenner, Acting Vice President for Research and Acting Dean of the Graduate School
 Melvin George, Vice President for Institutional Relations
 Mark B. Rotenberg, General Counsel

College of Biological Sciences Administrators

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

Robert P. Elde, dean
 123 Snyder Hall, St. Paul campus (612/624-2244)

Kathryn Hanna, assistant dean
 123 Snyder Hall, St. Paul campus (612/624-2244)

Sally B. Jorgensen, coordinator of recruitment and retention for the life sciences
 123 Snyder Hall, St. Paul campus (612/625-2275)

Kathleen F. Peterson, director of student services
 223 Snyder Hall, St. Paul campus (612/624-9717)

Advanced Bioscience Computing Center—Dan Prestridge, director, 247 Gortner Laboratory, St. Paul campus (625-9284)

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

Biological Process Technology Institute—Kenneth Valentas, interim director, 240 Gortner Laboratory, St. Paul campus (624-6774)

Cedar Creek—G. David Tilman, director, 509 Ecology Building, St. Paul campus (625-5743); Cedar Creek Area (434-5131)

Developmental Biology Center—Chris Wylie, director, 4-122 Malcolm Moos Health Sciences Tower, Minneapolis campus (624-3110)

Ecology, Evolution, and Behavior—Patrice Morrow, head, 100 Ecology Building, St. Paul campus (625-5700)

General Biology Program—John Beatty, 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)

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

Imaging Center—Mark Sanders, director, 35 Snyder Hall, St. Paul campus (624-3454)

Lake Itasca Program—Donald Siniff, director, 303 Ecology Building, St. Paul campus (625-5732)

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

Plant Biology—Stephen Gantt, acting head, 220 Biological Sciences Center, St. Paul campus (625-1234)

Plant Molecular Genetics Institute—Neil E. Olszewski, director, 220 Biological Sciences Center, St. Paul campus (625-3129)

Faculty

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

† *Recipient of the Stanley Dagley Distinguished Teacher Award*

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

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 modeling.
624-9267

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

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

Bernlohr, David A., professor
Ph.D., University of Illinois, Urbana
Adipocyte gene expression; regulation of adipocyte metabolism; protein-lipid interactions.
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-Fine, 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, 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., associate professor
Ph.D., University of Wisconsin, Madison
Fermentation; cell culture technology; cellular energetics; regulation of protein synthesis; protein separation.
624-2782

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

Rafferty, 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., professor
Ph.D., Washington University
Nucleic acid biochemistry; molecular biology.
624-6275

Simon, Jeffrey A., assistant professor
Ph.D., Cornell University
Developmental gene expression; protein-protein and protein-DNA interactions.
624-5361

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

Wackett, Lawrence P., associate professor
Ph.D., University of Texas, Austin
Biodegradation; dehalogenases; applications of enzymology
in environmental detoxification and organic synthesis;
oxygenases.
625-3785

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

Alstad, Donald N., associate professor
Ph.D., University of Utah
Population ecology and evolution of insects.
624-6748

Barnwell, Franklin H., professor*
Ph.D., Northwestern University
Invertebrate behavior and physiology, with emphasis on
ecological relationships.
625-5296

Beatty, John H., associate professor
Ph.D., Indiana University
History and philosophy of biology.
624-6749

Birney, Elmer C., professor
Ph.D., University of Kansas
Mammalian evolution and ecology.
624-6293

Corbin, Kendall W., professor
Ph.D., Cornell University
Evolutionary ecology and genetics; biochemical
systematics.
624-6750

Curtsinger, James W., professor
Ph.D., Stanford University
Population/quantitative genetics, experimental and
theoretical.
624-6746

Cushing, Edward J., professor
Ph.D., University of Minnesota
Paleoecology, ecology of plant communities.
625-5713

Davis, Margaret B., Regents' Professor
Ph.D., Harvard University
Paleoecology, paleolimnology, forest community ecology.
625-1717

Gorham, Eville, Regents' Professor
Ph.D., University of London, England
Chemical aspects of ecology, limnology, and soil science.
625-5708

McKinney, D. Frank, professor
Ph.D., University of Bristol, England
Animal behavior.
624-6737

McNaught, Donald, professor
Ph.D., University of Wisconsin
Zooplankton ecology, Great Lakes limnology, ecosystem
contamination.
625-1706

Megard, Robert O., professor
Ph.D., Indiana University
Limnology.
625-5707

Merrell, David, professor emeritus
Ph.D., Harvard University
Genetics.
625-5735

Morrow, Patrice, professor and head
Ph.D., Stanford University
Plant-insect interactions, community ecology.
625-5709

Murdock, Gordon, adjunct associate professor
Ph.D., Duke University
Invertebrate biology and museum studies.
624-6380

Naeem, Shahid, assistant professor
Ph.D., University of California, Berkeley
Ecology of populations, communities, and ecosystems.
624-6790

Packer, Craig, professor
Ph.D., University of Sussex, England
Behavioral ecology and sociobiology.
625-5729

Phillips, Richard E., professor
Ph.D., Cornell University
Animal behavior, physiology.
624-7238

Pusey, Anne E., professor
Ph.D., Stanford University
Animal behavior.
625-5727

Regal, Philip J., professor
Ph.D., University of California, Los Angeles
Evolution, physiological ecology and behavior, herpetology.
624-6751

Schmid, William D., professor
Ph.D., University of Minnesota
Comparative physiology, ecology.
624-6752

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

Shaw, Ruth, associate professor
Ph.D., Duke University
Ecological genetics.
624-2706

Siniff, Donald B., professor
Ph.D., University of Minnesota
Vertebrate ecology; population ecology of large mammals.
625-5732

Starfield, Anthony M., professor
Ph.D., University of Witwatersrand, South Africa
Ecological modeling.
625-5721

Stern, Robert W., associate professor
Ph.D., University of Minnesota
Limnology: plankton ecology, food webs, aquatic
biogeochemistry

Tester, John R., professor
Ph.D., University of Minnesota
Vertebrate ecology, ecosystem ecology.
625-5731

Tilman, G. David, professor
Ph.D., University of Michigan
Experimental and theoretical population and community
ecology.
625-5743

Tordoff, Harrison B., professor emeritus
Ph.D., University of Michigan
Systematic and evolutionary biology, ornithology.
624-6787

Underhill, James C., professor emeritus
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; use of mutants.
624-3053

Cunningham, William P., professor*,**
Ph.D., University of Texas, Austin
Pollutant effects on cells.
624-9266

Fan, David P., professor
Ph.D., Massachusetts Institute of Technology
Development of AIDS database; epidemiology of AIDS.
624-4718

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

Hackett, Perry B., professor
Ph.D., University of Colorado Medical Center
Regulation of early gene expression in developing zebrafish
zygotes.
624-6736

Hays, Thomas S., associate professor
Ph.D., University of North Carolina
Analysis of microtubule and microtubule motor function in
Drosophila.
625-2226

Herman, Robert K., professor
Ph.D., Yale University
Developmental genetics of the 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
Liver specific gene expression.
624-4942

Johnson, Ross G., professor and head
Ph.D., Iowa State University
Cell communication mechanisms through gap junction channels.
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
Molecular analysis of melanin metabolism; genetic analysis
of systemic lupus erythematosus.
624-0144

Lefebvre, Paul A., professor
Ph.D., Yale University
Analysis of gene expression and flagellar protein assembly
in *Chlamydomonas*.
624-4706

Magee, P. T., professor**
Ph.D., University of California, Berkeley
Genetic structure and development in *Candida albicans*.
625-4732

Marks, M. David, assistant professor
Ph.D., Purdue University
Molecular genetics of determination and differentiation of
trichomes in *Arabidopsis*.
625-6737

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

Rougvie, Ann E., assistant professor
Ph.D. Cornell University
Genetic and molecular mechanisms of developmental timing
in *C. elegans*.
624-4708

Shaw, Jocelyn E., associate professor
Ph.D., University of Toronto
Regulation of development in *C. elegans*.
625-1912

Silflow, Carolyn D., professor
Ph.D., University of Georgia
Molecular genetic analysis of genes involved in microtubule
function in plant cells.
624-0729

Simmons, Michael J., professor*
Ph.D., University of Wisconsin, Madison
Drosophila genetics and population genetics; transposable
elements.
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
a-, B-, and x tubulin and other genes controlling components of the cytoskeleton in *Arabidopsis*.
624-3499

Woodward, Val W., professor*
Ph.D., Cornell University
Critique of biologizing human behavior.
624-3060

Department of Plant Biology

Berman, Judith G., associate 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

Doebly, John F., 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, associate 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

Koukkari, 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., associate professor
Ph.D., University of Minnesota
Plant molecular biology; gibberellins; genes affecting plant structure.
625-3129

Rubenstein, Irwin, professor
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 *Lemna*.
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

Biological Process Technology Institute

Brooker, Robert J., associate professor
Ph.D., Yale University
Biology of cell surfaces; molecular genetics.
624-3053

Flickinger, Michael C., associate professor
Ph.D., University of Wisconsin, Madison
Fermentation, kinetic models of cellular energetics and protein regulation.
624-9259

Sherman, David H., associate professor
Ph.D., Columbia University
Microbial genetics; immunogenetics.
625-1901

Srienc, Friedrich, associate professor
Ph.D., Technical University in Graz, Austria
Fermentation biochemical engineering.
624-9776

Wackett, Lawrence P., associate professor
Ph.D., University of Texas, Austin
Biodegradation, metalloenzymes, biotechnology.
625-3785

Plant Molecular Genetics Institute

Berman, Judith G., associate professor
Ph.D., Weizmann Institute of Science
Yeast molecular biology; telomere structure and function;
telomeric DNA-binding proteins.
625-1971

Brambl, Robert M., professor
Ph.D., University of Nebraska
Biochemistry of fungal spore germination; mitochondrial
biogenesis and regulation of membrane enzyme assembly.
625-7080

Brenner, Mark L., professor
Ph.D., Michigan State University
Role of endogenous plant growth substances in coordinately
controlled processes.
624-6735

Das, Anath, 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

Doebley, John F., professor
Ph.D., University of Wisconsin
Biochemistry of flowering plants; evolutionary genetics;
evolution of crop plants.
625-3702

Gallo-Meagher, Maria, assistant professor
Ph.D., North Carolina State University
Improvement of barley and wheat through molecular
biology and tissue cultures.
625-6228

Gant, J. Stephen, associate professor
Ph.D., University of California, Irvine
Control of cytoplasmic ribosome synthesis; regulation of
expression of nuclear encoded chloroplast ribosomal protein
genes.
625-4763

Gengenbach, Burle G., professor
Ph.D., University of Illinois
Biochemical, developmental and molecular genetic systems
of higher plants.
625-6282

Lefebvre, Paul A., professor
Ph.D., Yale University
Analysis of gene expression and flagellar protein assembly
in *Chlamydomonas*.
624-4706

Marks, M. David, assistant professor
Ph.D., Purdue University
Molecular genetics of determination and differentiation of
trichomes in *Arabidopsis*.
625-6737

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

Olszewski, Neil E., associate professor and director
Ph.D., University of Minnesota
Plant molecular biology; gibberellins; genes affecting plant
structure.
625-3129

Phillips, Ronald L., regents' professor
Ph.D., University of Minnesota
Plant molecular genetics.
625-1213

Rubenstein, Irwin, professor
Ph.D., University of California, Los Angeles
The structural organization and functional regulation of the
genes of the maize genome. Plant gene structure and
function; maize endosperm development.
624-2716

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

Silflow, Carolyn D., professor
Ph.D., University of Georgia
Molecular genetic analysis of genes involved in microtubule
function in plant cells.
624-0729

Smith, Alan G., professor
Ph.D., University of Florida
Growth and development of flowers and fruit.
624-2715

Snustad, D. Peter, professor*
Ph.D., University of California, Davis
a-, B-, and x-tubulin and other genes controlling
components of the cytoskeleton in *Arabidopsis*.
624-3499

Somers, David A., professor
Ph.D., Washington State University
Biochemical genetics and *in vitro* genetic manipulations of
plants.
625-5769

Szabo, Les, adjunct assistant professor
Ph.D., Oregon State University
Use of molecular genetics to study host-parasite interactions
of rust diseases on small cereal grains.
625-3780

Vance, Carroll P., professor
Ph.D., Ohio State University
Physiology, developmental biology and molecular control of
plant-microbe interaction in legumes and grasses.
625-5715

Young, Nevin D., associate professor
Ph.D., Yale University
Genetics of plant-pathogens interactions.
625-2225

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, associate professor
Ph.D., Tufts University
Virology.
626-0445

Dunny, Gary, professor
Ph.D., University of Michigan
Development mediated by bacterial pheromones.
625-9930

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., associate professor
Ph.D., University of Wisconsin, Madison
Microbial biochemistry.
624-9706

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.
625-7460

Jemmerson, Ronald, associate professor
Ph.D., Northwestern University
Immunology.
625-1402

Jenkins, Marc K., associate professor
Ph.D., Northwestern University
Immunology.
626-2715

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

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

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, associate professor
Ph.D., University of Hawaii
Soil microbiology.
624-2706

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

Scherer, Stewart, associate professor
Ph.D., Stanford University
Microbial pathogenesis; *Candida*.
624-9929

Schiff, Leslie, assistant professor
Ph.D., Tufts University
Mammalian retroviruses, virus-host cell interactions.
624-9333

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

Sherman, David, associate professor
Ph.D., Columbia University
Streptomyces; 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

Administration and Faculty 49
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 Advising 12
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