BIOLOGICAL SCIENCES

Emeriti: (Professors) Winslow R. Briggs, Donald Kennedy,* David D. Perkins, Peter Ray, Robert Schimke, Dow O. Woodward, Charles Yanofsky*; (*Professor, Research*) R. Paul Levine
Chair: H. Craig Heller
Professors: Bruce S. Baker, Steven Block, Allan M. Campbell, Mark W. Denny, Paul R. Ehrlich, David Epel, Marcus W. Feldman, William F. Gilly, Philip C. Hanawalt, H. Craig Heller, Patricia P. Jones, Susan K. McConnell, Ron R. Kopito, Sharon R. Long, Harold A. Mooney, Steven Palumbi, Dennis Powers, Joan Roughgarden, Robert M. Sapolsky, Stephen H. Schneider, Robert D. Simoni, George N. Somero, Chris R. Somerville, Marc Tessier-Lavigne, Stuart H. Thompson, Shirpad Tuljapurkar, Peter Vitousek, Virginia Walbot, Ward B. Watt
Associate Professors: Barbara A. Block, Martha S. Cyert, Deborah M. Gordon, Michael A. Simon, Tim Stearns
Assistant Professors: David Ackerly, Brendan Bohannan, William F. Burkholder, Guowei Fang, Judith Frydman, Elizabeth A. Hadly, Liqun Luo, Fiorenza Micheli, Mary Beth Mudgett, Dmitri Petrov, Michael F. Rexach
Professor (Research): Robert Metzenberg, Jr.
Courtesy Professors: Joseph Berry, Arthur R. Grossman, Richard G. Klein
Courtesy Associate Professors: Kathryn Barton, Christopher B. Field
Courtesy Assistant Professor: Zhi-Yong Wang
Lecturers: Kristin Black, Shyamala D. Malladi, David Muir, James Watanabe, Melanie Yelton
Librarian: Michael Newman

* Recalled to active duty.

Mail Code: 94305-5020
Department Phone: (650) 723-1826
Web site: http://www.stanford.edu/dept/biology

Courses given in Biological Sciences have the subject code BIOSCI. For a complete list of subject codes, see Appendix B.

The facilities and personnel of the Department of Biological Sciences are housed in the Gilbert Building, Herrin Laboratories, Herrin Hall, the Jasper Ridge Biological Preserve on the main campus, and at the Hopkins Marine Station in Pacific Grove on Monterey Bay.

The department provides: (1) courses designed for the nonmajor, (2) a major program leading to the B.S. degree, (3) a minor program, (4) a coterminal program leading to the M.S. degree, (5) a terminal program leading to the M.S. degree, and (6) a program leading to the Ph.D. degree.

Course and laboratory instruction in the Department of Biological Sciences conforms to the "Policy on the Use of Vertebrate Animals in Teaching Activities," the text of which is available at http://www.stanford.edu/dept/DoR/rph/8-2.html.

The Jasper Ridge Biological Preserve is a 1,200 acre natural area containing an unusual diversity of plant communities. It is managed solely for teaching and research purposes and is available to investigators from various institutions. Stanford-based research at Jasper Ridge currently concentrates on physiological, ecological, and population studies.

Special laboratory facilities for marine research are described in the pamphlet *Hopkins Marine Station*, available at the department's student services office (Gilbert 108) or from Hopkins Marine Station.

The department's large collections of plants (Dudley Herbarium), fishes, reptiles, and amphibians, as well as smaller collections of birds, mammals, and invertebrates, are housed at the California Academy of Sciences in San Francisco, where they, and extensive collections of the academy, are available to those interested in the systematics of these groups. Entomological collections, restricted to those being used in particular research projects, are housed in the Herrin Laboratories. No general collections are maintained except for teaching purposes.

The Falconer Biology Library in Herrin Hall contains over 1,200 current subscriptions and an extensive collection of monographs and reference works. A specialized library is maintained at the Hopkins Marine Station.

UNDERGRADUATE PROGRAMS

BACHELOR OF SCIENCE

ADVISING

Most members of the Biological Sciences faculty are available for advising on such academic matters as choice of courses and career plans. The student services office maintains a current list of faculty advisers, advising schedules, and research interests.

The student services office is prepared to answer questions on administrative matters, such as requirements for the major, approved out-of-department electives, transfer course evaluations, and petition procedures. This office also distributes the department's *Bachelor of Science Handbook*, which delineates policies and requirements, as well as other department forms and information handouts.

Each undergraduate student interested in the major in Biological Sciences is required to select a department adviser as part of the major declaration process. Students who plan to attend medical or graduate school, enroll in the honors or coterminal programs, take courses at Hopkins Marine Station, or attend one of the overseas campuses will find their faculty adviser particularly helpful.

REQUIREMENTS

Candidates for the B.S. degree must complete:

Core Courses and Electives—

Courses	*Units*
BIOSCI 44X	4
BIOSCI 44Y (may be replaced by 4 units of 175H, or 176H)	4
BIOSCI 41 or 52*	5
BIOSCI 42 or 53*	5
BIOSCI 43 or 51*	5
Total	23
Electives	24

* Letter grade only.

Required Cognate Courses—Students may take up to two cognate courses credit/no credit (CR/NC).

1. Introductory, organic, and physical chemistry with lab: CHEM 31 (or 32), 33, 35, 36, 130 (or 132), 131, 135 (or 171). For those interested in ecology and evolution biology, an advanced Mathematics course of 100-level or above may be substituted for 130 or 132.
2. General Physics: PHYSICS 21, 22, 23, 24; or 51, 53, 55.
3. Math through calculus: MATH 19, 20, 21; or 41, 42.
4. One additional course in Mathematics, Statistics, or Computer Science: MATH 51 or beyond; BIOSCI 141 (if taken to fulfill additional cognate requirement, this does not count toward the 24 elective unit requirement), or PSYCH 10; STATS 60 or beyond; or CS 106A or X.

Electives must be 100-level or above and selected from the offerings in the Department of Biological Sciences or from the list of approved out-of-department electives. This list may be obtained from the student services office.

The program for the junior and senior year should include a total of 24 elective units beyond the core. The courses making up these units should include at least one course from at least three of the following four areas. The rest of the 24 units can include more courses from this central menu, courses available in diverse areas directly after the core, or advanced courses for which menu courses are prerequisites. A complete central menu course listing including inactive and alternate year courses is available in the student services office. Active central menu courses are:

1. *Molecular*
   - Biochemistry: BIOC 200
   - Cell Biology: Intracellular Trafficking and Organelle Biogenesis: BIOSCI 126*
   - Cell Biology: Molecular Organization: BIOSCI 128*
   - Developmental Genetics: BIOSCI 132*
   - Fundamentals of Molecular Evolution: BIOSCI 113
   - Genetics: BIOSCI 118*
   - Molecular Biology: BIOC 201
   - Molecular and Cellular Immunology: BIOSCI 230*
   - Prokaryote Genetics: BIOSCI 133*

2. *Cell/Developmental*
   - Cell Biology: Intracellular Trafficking and Organelle Biogenesis: BIOSCI 126*
   - Cell Biology: Cellular Dynamics: BIOSCI 129
   - Cell Biology: Molecular Organization: BIOSCI 128*
   - Developmental Genetics: BIOSCI 132*
   - Genetics: BIOSCI 118*
   - Molecular and Cellular Immunology: BIOSCI 230*
   - Neurobiology: BIOSCI 154
   - Prokaryote Genetics: BIOSCI 133*
3. *Organismal*
   - Comparative Animal Physiology: BIOSCI 162H
   - Ecological and Evolutionary Physiology: BIOSCI 171H
   - Ecology and Evolution of Plants: BIOSCI 138
   - Human Physiology: BIOSCI 112
   - Introductory Plant Biology: BIOSCI 120
   - Invertebrate Zoology: BIOSCI 161H
   - Microbiology: MI 185
   - Nerve, Muscle, and Synapse: BIOSCI 167H/267H
   - Neurobiology: BIOSCI 153
   - Neurobiology: BIOSCI 154
   - Neurobiology & Behavior: BIOSCI 169H
   - Plant Physiological Ecology: BIOSCI 124
   - Plant Physiology: BIOSCI 256
   - Vertebrate Biology: BIOSCI 110 (lecture only)
   - Viruses: BIOSCI 213
4. *Ecology and Evolution*
   - Behavioral Ecology: BIOSCI 145
   - Biogeography: BIOSCI 121
   - Ecology and Evolution of Plants: BIOSCI 138
   - Ecology of Microorganisms: BIOSCI 127/220
   - Evolution: BIOSCI 143/243
   - Evolutionary Paleobiology: BIOSCI 136
   - Fundamentals of Molecular Evolution: BIOSCI 113
   - Marine Ecology: BIOSCI 172H/272H
   - Oceanic Biology: BIOSCI 163H
   - Plant Physiological Ecology: BIOSCI 124
   - Principles of Ecology: BIOSCI 142
   - Principles and Practice of Biosystematics: BIOSCI 184

* May be used to satisfy either area I or area II requirement.

No more than 6 units from any combination of individual instruction courses (175H, 176H, 198, 199, 290, 291, or 300) may be applied toward the total number of elective units. No more than 6 units applied toward the elective unit requirement may be taken CR/NC.

Students intending to pursue research careers in biology, especially in ecology, population genetics, or theoretical biology, should be aware that MATH 19, 20, 21, or MATH 41, 42 are minimum mathematics requirements for the B.S. degree in Biological Sciences. Substantial additional training in mathematics, including differential equations, linear algebra, and probability theory, is often highly advisable. Students should consult the Biological Sciences faculty to discuss individual needs.

Additionally, even though only two or three quarters of physics are required, students should be aware that many graduate and professional schools (for example, Medicine and Education) require a year of general physics with a lab. Biological Sciences majors are therefore advised to take the year-long physics sequence PHYSICS 21, 22, 23, 24, 25, 26 (or PHYSICS 41, 43, 45, 46, 47, 48).

For students considering residence at Hopkins Marine Station during the junior or senior year, or an overseas program, the department recommends fulfilling as many University General Education Requirements as possible in the first two years at Stanford.

TYPICAL SCHEDULE FOR A FOUR-YEAR MINIMUM PROGRAM

FIRST YEAR

Course No. and Subject	*Qtr. and Units*		
	A	*W*	*S*
CHEM 31, 33, 35, 36.	4	4	7
MATH 19, 20, 21. Calculus and Analytic Geometry	3	3	4
Freshman requirements or electives	8	8	6
Totals	15	15	17

SECOND YEAR

BIOSCI 41. Principles of Biology *	5		
BIOSCI 42. Principles of Biology*		5	
BIOSCI 43. Principles of Biology*			5
BIOSCI 44. Core Experimental Laboratory		4	4
CHEM 130 or 132, 131, 135 (or 171) Organic and Physical Chemistry	8	3	
General Education Requirements or electives	3	5	8
Totals	16	17	17

* Letter grade only.

THIRD YEAR

PHYSICS 21, 22, 23, 24. Introductory Physics	4	4	4
General Education Requirements or electives	11	11	11
Totals	15	15	15

FOURTH YEAR

Electives	15	15	15

TRANSFER STUDENTS

Because of differences between Stanford undergraduate courses and prerequisites and those of many other institutions, transfer students may face problems not encountered by entering freshmen. Transfer students are strongly urged to visit the student services office in Gilbert 108 during transfer orientation to obtain information on credit evaluations. Course catalogs, syllabi, and/or lecture notes from the former institution are necessary in the evaluation and accreditation process. Transfer students are encouraged to find a faculty adviser soon after arrival.

All transfer courses intended to fulfill department requirements must be evaluated on Evaluation of Transfer Course Content forms (available in the student services office), which is kept in the student's file. This department procedure is in addition to the process of having units earned at other institutions transferred for Stanford credit and appear on the Stanford transcript.

The department authorizes transfer credit only for courses whose content parallels the Stanford courses and that have comparable prerequisites (not merely a comparable course title). To substitute a course taken elsewhere for an upper-division Stanford course, course content must be approved by a department faculty member teaching in the area of the course. Submit as complete a course description as practical (including prerequisites and their descriptions) using the Evaluation of Course Content form available in the student services office before taking an off-campus course. Credit for natural history, culture biology, and similar courses is rarely appropriate and can be obtained only by meeting the same criteria outlined above. Verification of performance and the number of units are determined after completing the course. Students must provide exams, reading lists, term papers, and other materials for the evaluation. Credit is not allowed for projects for which the student was paid, nor is credit allowed for work of a purely technical or clinical nature.

MINORS

Minor declaration forms must be submitted to the department, via Axess, no later than two quarters prior to the student's intended quarter of degree conferral. The Biological Sciences minor requires a minimum of six courses meeting the following criteria:

1. All courses must be taken for a letter grade.
2. All courses must be worth 3 or more units.
3. All courses, other than the Biology Core (51, 52, or 53; or 41, 42, or 43), must be at or above the 100-level
4. Courses used to fulfill the minor may not be used to fulfill any other department degree requirements (minor or major).
5. At least one course from the Biology Core must be taken.
6. The Biology Core Laboratory (44X and 44Y) does not count towards the minor degree.
7. All courses must be Department of Biological Sciences elective courses or recognized out-of-department elective courses. (See the "Out-of-Department Electives" list available in the student services office.)
8. Elective credit for research (199) is limited to a maximum of 3 units.

HONORS PROGRAM

To graduate with departmental honors, a student must:

1. Complete at least 10 units of an approved (BIOSCI 199) research project.
2. Obtain at least a 3.0 (B) grade point average (GPA) in all Biological Sciences major requirements taken at Stanford (cognate, core, and elective courses). Grades earned from teaching (290 and 291) and research (175H, 176H, and 199) are not computed into this GPA.
3. Submit an honors petition proposal to the department's undergraduate research coordinator the fifth Friday of the quarter, two quarters prior to graduation. For instance, students graduating Spring Quarter must submit petitions no later than mid-Autumn Quarter.
4. If graduating in June, participate in the Biological Sciences Honors Symposium by presenting a poster or giving an oral presentation. The symposium is at the end of May. If graduating Autumn or Winter Quarter, produce a poster.
5. Complete and submit, by the end of the quarter of graduation, two signed and bound copies of an honors thesis approved by at least two readers (one of whom must be from the faculty of the Department of Biological Sciences and both must be Academic Council members). In addition, students must submit two copies of the honors thesis abstract, which includes name, thesis title, sponsor, and department.

Further information on the honors program, including petition forms and examples of honors posters, theses, and proposals, is available in the Group Study Room in Falconer Library. Also, see the web page "Research and Honors" for more information about the honors program, including requirements, research sponsors, and petition and thesis deadlines at http://www.stanford.edu/dept/biology/undergrad/honors/. Questions should be directed to the undergraduate research coordinator, Dr. Kristin Black (kblack@stanford.edu, 650-723-3767; Gilbert 118).

PREMEDICAL, PREDENTAL, AND PREPARAMEDICAL REQUIREMENTS

Premedical, predental, and preparamedical students who are not biology majors should take at least the following courses in Biological Sciences: 44X, 44Y, 51, 52, 53; or 41, 42, 43 and such upper-division electives as may be recommended by Stanford's Undergraduate Advising Center, Sweet Hall.

COTERMINAL B.S. AND M.S. DEGREES

The Department of Biological Sciences admits a limited number of undergraduate students to work for coterminal B.S. and M.S. degrees in Biological Sciences. Students must apply to the program between their eighth and eleventh quarters. They are required to submit a complete application, which includes a statement of purpose, a Stanford transcript, official GRE or MCAT scores, two letters of recommendation from faculty members in this department, and a list of courses in which they intend to enroll to fulfill degree requirements. A minimum GPA of 3.0 is necessary in all courses required for the undergraduate degree in Biological Sciences. Students must meet all requirements for both the B.S. and M.S. degrees. They must complete 15 full-time quarters (or the equivalent), or three full quarters after completing 180 units. Unit requirements for a coterminal program are 180 units for the bachelor's degree and 45 units for the master's degree. A more detailed description of the coterminal master's degree program may be obtained from the student services office.

GRADUATE PROGRAMS

MASTER OF SCIENCE

For information on the University's basic requirements for the M.S. degree, see the "Graduate Degrees" section of this bulletin.

The M.S. degree program offers general or specialized study to individuals seeking biologically oriented course work, and to undergraduate science majors wishing to increase or update their science background or obtain advanced research experience. Students who have majored in related fields are eligible to apply, but must complete, or have completed by the time of graduation, the equivalent of a Stanford B.S. in Biological Sciences.

The M.S. program consists of Department of Biological Sciences (or otherwise preapproved) course work totaling at least 45 units at or above the 100 level of academic credit, distributed as follows:

1. A minimum of 36 units must be Department of Biological Sciences courses or approved out-of-department electives (a list is available in the student services office).
   a) At least 18 of these 36 units must be courses designated primarily for graduate students (generally at the 200-level or above), excluding research and teaching units.
   b) Up to 9 of these 36 units may be advanced-level cognate courses in chemistry, computer science, mathematics, physics, or statistics beyond the level required for the undergraduate degree.
   c) Up to 18 of the 36 units may be a combination of biological research and teaching (BIOSCI 175H, 176H, 198, 199, 290, 291, or 300).
2. The remaining 9 units may come from any other Stanford course work at or above the 100 level other than research or teaching.

Each candidate designs a coherent program of study in consultation with her or his department adviser. Although there are no specific courses required, program proposals must adhere to department parameters.

A program proposal signed by the student's adviser, and approved by the chair of the M.S. Committee, must be filed during the first month of the first quarter of enrollment. Students may take only 6 units on a credit/no credit basis and must receive a grade of 'B-' or better in all courses taken for the degree.

To apply, students submit an application for admission to the M.S. program, two letters of recommendation, official transcripts, and official Graduate Record Examination (GRE) scores. Applicants should plan on taking the GRE at least one month prior to the application deadline to insure that the official scores are available when applications are evaluated. Applications are accepted for Autumn Quarter only; the deadline is March 15. Financial support is not available from either the department or the University for students in this program.

MASTER OF ARTS IN TEACHING

The Master of Arts, Teaching degree is offered jointly by this department and the School of Education. The degree is intended for candidates who have a teaching credential and wish to strengthen their academic preparation. The program consists of a minimum of 25 units in the teaching field and 12 units in the School of Education. Detailed requirements are outlined in the "School of Education" section of this bulletin or may be obtained from the Admissions Director, School of Education.

TEACHING CREDENTIALS

For information concerning the requirements for teaching credentials, consult the "School of Education" section of this bulletin or address an inquiry to the Credential Administrator, School of Education.

DOCTOR OF PHILOSOPHY

For information on the University's basic requirements for the Ph.D., see the "Graduate Degrees" section of this bulletin.

Preparation for Graduate Study—Students seeking entrance to graduate study in Biological Sciences ordinarily should have the equivalent of an undergraduate major in Biological Sciences at Stanford. However, students from other disciplines, particularly the physical sciences, are also encouraged to apply. Such students are advised at the time of initial registration on how they should complete background training during the first year of graduate study. In addition to the usual basic undergraduate courses in biology, it is recommended that preparation for graduate work include courses in chemistry through organic chemistry, general physics, and mathematics through calculus.

Application, Admission, and Financial Aid—Prospective graduate students should apply online at http://apply.embark.com/grad/stanford. Prospective students may also request application information, instructions, and materials from Graduate Admissions, the Registrar's Office. The department's program is divided into three separate tracks: Ecology/Evolution Biology, Integrative and Organismal, and Molecular/Cell Biology. Applications to the three tracks are evaluated separately; all

applicants should specify the track which interests them. The deadline for receiving applications is December 15.

Scores on the general test and the advanced biology, biochemistry, cellular and molecular biology, or chemistry test of the Graduate Record Examination (GRE) are required. Applicants should plan on taking the GRE at least one month prior to the application deadline to insure that the official scores are available when applications are evaluated.

Competition for admission to the Ph.D. program is keen and in recent years it has been possible to offer admission to only 10 percent of the applicants.

Admitted students normally are offered financial support in the form of Stanford Presidential Graduate Fellowships, biology research assistantships, NIH traineeships, or Biological Sciences fellowships.

Qualified applicants should apply for predoctoral national competitive fellowships, especially those from the National Science Foundation and the Howard Hughes Medical Institute. Applicants to the Ph.D. program should consult their financial aid officers for information and applications.

General Departmental Requirements—An admitted applicant is required to fulfill the requirements of the University as outlined in the "Graduate Degrees" section of this bulletin and the department requirements stated below.

Each student must take at least 3 units of course work under each of four or more Stanford faculty members. Course work is planned in consultation with an advising committee assigned for his or her track. In addition, all students must take a course on the ethical conduct of research, which includes the ethics courses in the Medical School or another similar department-approved course.

1. Teaching experience and training are part of the graduate curriculum. Each student assists in teaching one course in the department's core lecture (41, 42, or 43) or lab courses (44X, 44Y), and a second course that can be either a core course or central menu course.
2. Graduate seminars devoted to the discussion of current literature and research in particular fields of biology are an important means of attaining professional perspective and competence. Seminars are presented under individual course listings or are announced by the various research groups. A department seminar meets on most Mondays at 4 p.m. Topics of current biological interest are presented by speakers from Stanford and other institutions and are announced in the weekly *Stanford Report*. Graduate students are expected to attend.
3. Third Year and Beyond: each student must meet with the Advising Committee beginning the third year, and each year thereafter prior to the end of the Spring Quarter. The committee signs a form to ensure compliance. During Autumn Quarter of the fourth year, candidates must meet with their committee to evaluate the project and to discuss financial support, if required, beyond the fourth year. Advanced students are encouraged to meet with their committee at least twice a year.

Academic requirements for the three tracks are as follows:

Molecular/Cell Ph.D. Track Requirements—

1. *First Year:*
   a) *Advising Committee:* shortly after arrival, each entering student meets with the First-Year Advising Committee. The committee reviews the student's previous academic work and current goals and advises the student on a program of Stanford courses, some of which may be required and others recommended. Satisfactory completion of the Core Curriculum (below) is required of all students.
   b) *Core Curriculum:* all students are required to take the following courses for a letter grade, unless previous course work has fulfilled these requirements:

      BIOSCI 203. Advanced Genetics
      BIOSCI 214. Cell Biology of Physiological Process
      BIOC 201. Advanced Molecular Biology

      A fourth course is selected from the student's area of specialization.
   c) *Lab Rotations:* successful completion of rotations in three different laboratories is required of all first-year students. As lab space is limited, students with a definite interest in a particular lab should make arrangements as early as possible. Written petitions for exemptions to requirements "Core Curricula" and "Lab Rotations" are considered by the advising committee. Approval is contingent upon special circumstances and is not routinely granted.
   d) *Dissertation Lab:* by the end of Spring Quarter, each first-year student is expected to have selected a lab in which to perform dissertation research and to have been accepted by the faculty member in charge. Students and faculty must wait until April 15 to discuss the choice of a dissertation lab. In consultation with that faculty member (who at this point becomes the student's adviser), the student chooses a projected field of expertise that is broader than the research of the adviser's lab, such as Developmental Biology or Plant Biology. Students electing to do a summer rotation at the Hopkins Marine Station may postpone selection of a lab for their dissertation research until the end of Summer Quarter.
   e) *Seminar:* each student must present a public seminar that is evaluated by two faculty members. Evaluation consists of meeting with each faculty member within one week following the seminar to obtain feedback and signatures. Faculty may require an additional seminar presentation.
2. *Second Year*: each student must pass a two-part qualifying exam.
   a) *Area Proposal:* the area proposal is a research proposal that lies within the student's field of expertise, but is in an area other than that of the proposed dissertation research. The written proposal should be prepared in the same detail as a grant application, including references, plans for specific experiments, and discussion of the interpretation of possible experimental results. The written proposal must be turned in to the chair of the Graduate Studies Committee by the end of Autumn Quarter. Before the end of Winter Quarter, the student is examined orally on the contents of the written proposal and on general knowledge in the student's projected field of expertise, including important cognate areas. The oral examination is administered by the dissertation advising committee (consisting of the adviser and three other faculty members who have agreed to serve on the committee).
   b) *Dissertation Proposal:* before the end of Spring Quarter of the second year, the student must prepare a dissertation proposal that outlines the student's projected dissertation research. An expert assessment of the current literature is expected. After submission of the proposal to the dissertation advising committee, an oral examination is held. The student's adviser is not present at the examination, which is administered by the other members of the dissertation advising committee.

      Advancement to candidacy is contingent on satisfactory completion of both proposals and oral exams. The deadline for completion is mid-May, before the annual faculty meeting devoted to evaluation of student progress. Failure to complete these requirements on schedule results in the withholding of the graduate stipend.
3. *Third Year and Beyond:*
   a) *Dissertation and Dissertation Defense:* the finished dissertation must be turned in to the student's reading committee at least one month before the oral exam is planned. The reading committee is comprised of at least three faculty members, two of whom must be Stanford Academic Council members, and is generally comprised of members who have served on the oral examination committee. At least three weeks before the oral exam, the student checks in with the committee and must incorporate any changes they require by the time of the exam. The exam cannot be formally scheduled or publicly announced until the student receives comments; however, the student should make informal arrangements with the committee earlier to ensure that everyone is available on the projected date. A minimum of three weeks is required by the student services office to schedule appropriate rooms.

Integrative/Organismal Ph.D. Track Requirements—

1. *First Year:* each entering student is assigned a supervisory committee of three faculty members whose function is to develop an appropriate schedule of required and recommended courses and to meet once each quarter with the student during the first year.

a) All students are required to take BIOSCI 306, Current Topics in Integrative and Organismal Biology. Students specializing in integrative biology may also be asked to take appropriate graduate-level courses such as DBIO 210; MCP 215; NBIO 200, 216, 230; or PSYCH 228.
b) *First-Year Paper:* each student must prepare and submit a paper, before the end of Spring Quarter their first year, that is evaluated by the advising committee. This paper should be a step toward the development of a dissertation proposal and may consist of an analysis of new data or a literature review and synthesis. Evaluation is in written form by two faculty members.

2. *Second Year:* the student is expected to write a major dissertation proposal. The proposal is evaluated by a committee of three faculty (the dissertation advising committee) in an oral presentation. This is to be completed by the end of Spring Quarter of the second year. Advancement to candidacy depends on satisfactory completion of the dissertation proposal. Failure to complete these requirements on schedule results in the withholding of the graduate stipend.
3. *Third Year and Beyond:*
   a) *Dissertation and Dissertation Defense:* at least one month before the oral exam takes place, the student must submit his or her dissertation to the dissertation advising committee, which then becomes the dissertation reading committee. At least two weeks before the oral exam, the student must incorporate into the dissertation any changes required by the committee. The exam cannot be formally scheduled or publicly announced until that time.

Ecology/Evolution Ph.D. Track Requirements—

1. *First Year:* each entering student is assigned a supervisory committee of three faculty members whose function is to develop an appropriate schedule of required and recommended courses and to meet once each quarter with the student during the first year.
   a) The "Committee of the Whole," that is, all ecology and evolution biology faculty, may meet with each student individually early in the first year.
   b) *First-Year Paper:* each student must prepare and submit a paper, before the end of Spring Quarter their first year, that is evaluated by the advising committee. This paper should be a step toward the development of a dissertation proposal and may consist of an analysis of new data or a literature review and synthesis. Evaluation is in written form by two faculty members.
2. *Second Year:* the student is expected to write a major dissertation proposal. The proposal is evaluated by a committee of three faculty (the dissertation advising committee) in an oral presentation. This is to be completed by the end of Spring Quarter of the second year. Advancement to candidacy depends on satisfactory completion of the dissertation proposal. Failure to complete these requirements on schedule will result in withholding of the graduate stipend.
3. *Third Year and Beyond:*
   a) *Dissertation and Dissertation Defense:* at least one month before the oral exam takes place, the student must submit his or her dissertation to the dissertation advising committee, which then becomes the dissertation reading committee. At least two weeks before the oral exam, the student must incorporate into the dissertation any changes required by the committee. The exam cannot be formally scheduled or publicly announced until that time.

Residency Requirement—A minimum of 135 units of graduate registration is required of each candidate. The department normally accepts only full-time students for study leading to the Ph.D. degree.

COURSES

(WIM) indicates that the course satisfies the Writing in the Major requirements.

Additional courses not listed here are frequently offered by selected postdoctoral or advanced Ph.D. personnel in the areas of their special research competence. They are listed in the quarterly *Time Schedule*, with course descriptions available in the student services office.

INTRODUCTORY

BIOSCI 2. Current Research Topics in Biological Sciences—Primarily for sophomores, enrollment limited to prospective and declared Biological Sciences majors. Weekly seminars by faculty on current research in biological sciences. Molecular biology and genetics; theory and mathematics in biology; ecology, physiology, and the environment; molecular and cellular aspects of neurobiology, immunology, and developmental biology; biological chemistry; behavioral biology; evolution.

1 unit, Aut, Win (Black)

BIOSCI 4. Introduction to Biotechnology—Introduces the scientific basis for key biotechnologies (cell transformation, DNA cloning, organismal cloning) and contemporaneous societal reactions to such new technologies. Focus is on defining current issues with specific technologies (use of DNA screening in forensics, animal cloning, genetically modified foods). GER:2b

4 units, Aut (Walbot)

STANFORD INTRODUCTORY SEMINARS

BIOSCI 5N. Thinking Critically About Environmental Problem Solving—Stanford Introductory Seminar. Preference to freshmen.

3 units, Win (Root)

BIOSCI 7N. Edible Botany—Stanford Introductory Seminar. An introduction to plant structure, function, development, and ecology through examination of plants used for food. Topics include basic botanical concepts, the ecology of food production, biogeograpy of domestication, and the characteristics of major plant groups. Demonstrations, field trips, presentation of student projects.

3 units, Spr (Preston)

BIOSCI 13N. Environmental Problems and Solutions—Stanford Introductory Seminar. Preference to freshmen. Students do independent investigations of current environmental problems, analyzing differing views of them and discussing possible solutions. Each student gives two seminar presentations and leads two seminar discussions. Short, documented position papers are written for policy makers. GER:2a

3 units, Spr (Ehrlich)

BIOSCI 14N. Plants and Civilization—Stanford Introductory Seminar. Preference to freshmen. Lectures, readings, and discussions on the role of plants in the development of civilization. Topics: the use of forests, woodlands, and grazing lands; centers of origins and spread of crops; the development of grains and fruits; viticulture; the spice route; the use of plants as medicine; fungi in human affairs; the global spread of weeds; engineering plants for the future. GER:2a

3 units (Mooney) not given 2002-03

BIOSCI 15N. Environmental Literacy—Stanford Introductory Seminar. Preference to freshmen. Lack of public understanding of the details of most environmental problems is cited as a cause of environmental deterioration. Good citizenship requires literacy about the elements of the scientific and decision making processes that accompany most environmental issues: what can happen, what are the odds, how can the credibility of sources of expertise be assessed, which components of environmental debates deal with factual and theoretical issues, and which are political value judgments? Student-led discussions, student peer review and term papers, and oral paper presentation. GER:2a

3 units, Win (Schneider) alternate years, not given 2003-04

BIOSCI 16N. Island Ecology—Stanford Introductory Seminar. Preference to freshmen. Introduction and illustration of the ways that ecologists think about the world. Focus is on the Hawaiian Islands: their origin, geology, climate, the evolution and ecology of their flora and fauna, and the distribution and functioning of Hawaiian ecosystems. The reasons for the concentration of threatened and endangered species in Hawaii, the scientific basis for their protection and recovery. The ways in which knowledge of island ecosystems can contribute to ecology and conservation biology on continents. GER:2a

3 units, Win (Vitousek)

BIOSCI 18N. Plant Genetic Engineering—Stanford Introductory Seminar. Preference to freshmen. Flavr-Savr tomatoes, Round-Up Ready soybeans, plastic plants. Genetically modified plants. A survey of crop modifications that have been made or are currently in development. The scientific basis of genetic engineering in plants and its social, economic, and environmental consequences. Oral presentations and short term papers. GER:2a

3 units (C. Somerville, S. Somerville) not given 2002-03

BIOSCI 20N. Sending Signals to Cells—Stanford Introductory Seminar. Cells must be able to adapt quickly to changes in their growth conditions; human cells respond to the presence of hormones and growth factors by rapidly changing their growth and metabolism. When cells respond inappropriately to their environment, uncontrolled growth of cancer can result. How do cells sense changes in their extracellular environment? How do they react to these changes? The molecular mechanisms by which cells interact with their environment and the biological consequences of these interactions. Fundamental principles illustrated by experimental studies and primary scientific literature.

3 units, Spr (Cyert)

BIOSCI 21N. Mood Genes: The Origins for Mania and Depression—Stanford Introductory Seminar. Preference to sophomores. Manic depression as a model to explore the roles of genes and the environment in particular human behaviors. Emphasis is on modern genetics. Topics: tools to address whether there are genetic components to a behavior; problems with defining a human behavior; what is the meaning of a genetic basis to components of a behavior; and using molecular genetic approaches to identify how genes affect a behavior. The tools of modern genetic analysis used to dissect biological processes. Original research papers discussed each week. How to read original research papers critically; how to evaluate experimental findings. Required paper.

3 units, Aut (Baker)

BIOSCI 22N. Infection and Immunity—Stanford Introductory Seminar. Preference to sophomores. The causes and prevention of infectious diseases, focusing on the interplay between pathogens and the immune system that determines the outcome of the disease. The basic principles of microbiology, immunology, and epidemiology. Discussion of diseases of the past and present (including AIDS, TB, and malaria); the roles of geographical, societal, and biological factors in disease emergence, spread, and prevention. Primary scientific literature, student-led discussions, and research projects. Prerequisite: good biology background, introductory college biology (41 or 42, or HUMBIO 2A, 3A, or AP biology).

3 units (Jones) not given 2002-03

BIOSCI 26N. Maintenance of the Genome—Stanford Introductory Seminar. Preference to freshmen. Focus is on the enzymatic maintenance systems that scan cellular DNA for alterations and make repairs to ensure genomic stability in the face of natural endogenous threats to DNA and those due to radiation and chemicals in the external environment. Redundancy of the genetic message ensured by complementary DNA strands facilitates recovery of information when, e.g., one of the strands is damaged. Predisposition to cancer often implicates a defect in a DNA repair gene. Relevance for oncology, aging, developmental biology, environmental health, and neurobiology. GER:2a

3 units, Spr (Hanawalt)

BIOSCI 27N. Nature and Nurture in Brain Development—Stanford Introductory Seminar. Preference to freshmen. The brain consists of billions of neurons precisely interconnected in circuits that underlie our ability to think, behave, and perceive. During development, these neurons are born, migrate into position, and extend axons over long distances to contact appropriate target cells, wiring themselves into a particular circuit. The wiring of the brain is influenced by genetically driven processes and by our experiences. The biological mechanisms that guide the development of neuronal circuits in animal model systems and humans. The relative influences of nature and nurture. Prerequisite: 42.

3 units (McConnell) alternate years, not given 2002-03

BIOSCI 28N. Molecular Basis of Cancer—Stanford Introductory Seminar. Preference to freshmen. Current knowledge on the molecular basis of cancer. Topics: cell cycle regulation, oncogenes, tumor suppressor genes, telomere biology, angiogenesis, and apoptosis. Current cancer biology literatures.

3 units, Spr (Fang)

BIOSCI 29N. The Outer Limits of Life—Stanford Introductory Seminar. Preference to freshmen. Introduction to the diversity of microbial life, emphasizing microbes that define the biochemical limits of life and which have unique life histories. Topics: microbial evolution and early life; life at extremes of temperature, pH, salinity, radiation, and pressure; microbial life deep in the earth's crust; life without oxygen; intimate associations between microbes and other organisms; applications of microbial diversity research in engineering, medicine, and astrobiology. Discussion, oral presentation, and short term paper. GER:2a

3 units (Bohannan) not given 2002-03

BIOSCI 36N. Physiology of Human Performance—Stanford Introductory Seminar. Laboratory-oriented. Students conduct studies on each other and possibly on volunteers. The studies involve physical activity and measurement of physiological variables before, during, and after physical activity. Focus is on the physiological systems underlying the capacity for physical activity and on the limits to increasing strength, power output, and endurance. For students interested and involved in sports, physical fitness, and conditioning. Applicants must be willing to engage in strenuous physical activity as part of the course requirements. An equal number of male and female students preferred.

3 units, Aut (Heller, Grahn)

BIOSCI 106Q. The Heart of the Matter—(Same as GENE 106Q.) Stanford Introductory Seminar. Preference to sophomores. The molecular and biochemical basis of life. Emphasis is on the methods and scientific logic that lead to advances in knowledge. The human heart and circulatory system is the unifying theme for topics such as the constituents and activities of cells, tissues, and organs; the chemicals and proteins that carry on life processes; the biotechnology revolution; the role of genes in human disease and normal functions; and the Human Genome Project. How scientific knowledge is built up through research; how biology initiates advances in medicine; and how science, engineering, and economics interact in biotechnology. Student presentations, demonstrations, and field trips.

3-4 units, Win (Myers, Simoni)

CORE

41,42,43. Principles of Biology—Comprehensive study of the principles of modern biological sciences, taken in sequence, preferably in the sophomore year. Biology majors must take for a letter grade. Prerequisites: CHEM 31 (or 32), 33, 35; MATH 19, 20, 21, or 41, 42.

BIOSCI 41. Genetics and Biochemistry—The diversity of life and macroevolution; structural and molecular genetics; biochemical principles emphasizing macromolecules (proteins, lipids, carbohydrates, and nucleic acids) and how their structure relates to function and to higher order assembly; genome structure and dynamics.

5 units, Aut (Simon, Simoni)

BIOSCI 42. Cell Biology, Developmental Biology, and Neurobiology—Gene expression from transcription to translation; cell structure and function; basic concepts in determination, differentiation, and morphogenesis; neurobiology from cellular and developmental to neural regulation of physiology.

5 units, Win (Cyert, Luo, Sapolsky)

BIOSCI 43. Physiology, Ecology, and Evolution—Physiology; immunology; the principles underlying the exchanges of mass and energy between organisms and their environments; the organ system specializations which utilize these principles in adapting organisms to different environments; mechanisms by which the function of each system is controlled and regulated; behavioral, population, community, and ecosystem ecology; populations, evolution, and global change.

5 units, Spr (Vitousek, Gordon, Heller, Ray)

BIOSCI 44X,Y. Core Experimental Laboratory—Two quarters of lab projects provide a working familiarity with the concepts, organisms, and techniques of modern biological research. Emphasis is on experimental design, analysis of data, and written and oral presentation of the experiments. Lab fee. Prerequisites: CHEM 31, 33. Recommended: Biological Sciences or Human Biology core and statistics; 44X and Y should be taken sequentially in same year. (WIM)

4 units, **44X:** *Win,* **44Y:** *Spr (Malladi, Yelton)*

BIOSCI 96A,B. Jasper Ridge Docent Training—Multidisciplinary environmental education class with hands-on experience and exposure to field research. The natural history of plants and animals, ecology, archaeology, geology, land management, and active research projects of the preserve are presented by experts and staff. Two quarter preparation for Stanford and community students to join the community education program. Participants are required to lead interpretive tours as docents and participate in continuing education classes available to members of the JRBP community after preparation.

2 units, **A:** *Win (Vitousek),* **B:** *Spr (Staff)*

INTERMEDIATE UNDERGRADUATE AND GRADUATE

BIOSCI 101. Ecology—Introduction to the principles of ecology. Topics: interactions of organisms with their environment, dynamics of populations, species interactions, structure and dynamics of ecological communities, biodiversity. Prerequisites: 43 or 51, or consent of instructor. Recommended: statistics.

3 units, Aut (Ackerly, Bohannan)

BIOSCI 102. Demography of Humans and Other Species—(Same as HUMBIO 137.) The past century has seen enormous demographic change around the world, from fertility transitions to aging. Methods and applications of demography. Methods include demographic measures and estimates; mortality and lifetables; fertility and marriage; population projection or humans and other species. Applications include study of trends and patterns in human mortality and fertility; the life cycle perspective; development, human capital, and inequality; aging and public pensions; using and interpreting population projections. Prerequisites: calculus and basic statistics, or consent of instructor.

3 units, Aut (Tuljapurkar)

BIOSCI 109/209. The Human Genome—(Graduate students register for 209; same as HUMBIO 114.)

3 units (Heller, Kumm) not given 2002-03

BIOSCI 110. Vertebrate Biology—(Enroll in HUMBIO 110.)

3-4 units, Spr (Porzig) alternate years, not given 2003-04

BIOSCI 110L. Vertebrate Biology Lab—(Enroll in HUMBIO 110L.)

3 units, Spr (Porzig) alternate years, not given 2003-04

BIOSCI 112/212. Human Physiology—(Graduate students register for 212.) The functioning of organ systems, emphasizing mechanisms of control and regulation. Topics: structure and function of endocrine and central nervous systems, cardiovascular physiology, respiration, salt and water balance, exercise and gastrointestinal physiology. Prerequisite: Biological Sciences or Human Biology core.

4 units (Baker) alternate years, given 2003-04

BIOSCI 117. Biology and Global Change—(Same as EARTHSYS 111.) The biological causes and consequences of anthropogenic and natural changes in the atmosphere, oceans, and terrestrial and freshwater ecosystems. Topics: glacial cycles and marine circulation, greenhouse gases and climate change, tropical deforestation and species extinctions, and human population growth and resource use. Prerequisites: Biological Sciences or Human Biology core or graduate standing in any department. (WIM)

3 units, Win (Matson, Vitousek, Mooney)

BIOSCI 118/218. Genetic Analysis of Biological Processes—(Graduate students register for 218.) Basic genetic principles and their experimental applications. Emphasis is on the identification and use of mutations to study cellular function. Prerequisite: Biology core.

5 units, Spr (Baker)

BIOSCI 120. General Botany—Introduction to plant development, structure, and function in an ecological and evolutionary context. Themes include comparative morphology, systematics and diversity, and ecological interactions such as herbivory, competition, and mutualism. Prerequisites: Biology or Human Biology core; consent of instructor.

5 units, Aut (Preston)

BIOSCI 121. Biogeography—Global distributions of organisms through the Phanerozoic, with emphasis on historical causes. Topics: plate tectonics, island biogeography, climatic change, dispersal, vicariance, ecology of invasions, extinction, gradients, diversity.

3 units (Hadly) not given 2002-03

BIOSCI 124/224. Plant Physiological Ecology: From Leaf to Globe—(Graduate students register for 224.) A functional approach to understanding terrestrial vegetation. Prerequisites: 51, 53 or 42, 43; or consent of instructor.

4 units, Win (Berry, Field)

BIOSCI 125. Ecosystems of California—The principles of ecosystem functions, with emphasis on the vegetation components and on California systems. Prerequisite: 51, or HUMBIO 2A.

3-4 units (Mooney) not given 2002-03

BIOSCI 126. Cell Biology: Intracellular—Organelle biogenesis and intracellular trafficking. Topics include composition and permeability of biological membranes, nucleocytoplasmic transport, the nucleoplasm, the secretory pathway, the endocytic pathway, and signal transduction across the plasma membrane. Emphasis is on the molecular mechanisms underlying cellular processes, and the experimental strategies and methods used to uncover them. The molecular nature of human disease, and related research that led to Nobel Prizes in Physiology or Medicine.

4 units, Win (Rexach)

BIOSCI 129. Cellular Dynamics—The principles of eukaryotic cellular function, emphasizing how cellular structures carry out important cell processes. Topics: cell cycle, mitosis, cytoskeleton and cell motility, cell-cell interactions, and signal transduction. Experimental logic and interpretation of experimental results. Prerequisite: Biological Sciences core.

4 units, Spr (Stearns, Nelson)

BIOSCI 133. Genetics of Prokaryotes—Analysis of prokaryotic genes and genomes with emphasis on the evolution of genetic systems. Prerequisite: Biological Sciences core.

3 units, Aut (Campbell)

BIOSCI 134. Replication of DNA—Modes of DNA replication and their control in prokaryotes and eukaryotes. Structures, properties and functions of the many recently discovered DNA polymerases. Emphasis is on experimental approaches and their limitations. Review of current research literature. Opportunity to lead class discussion on a specialized topic chosen in consultation with the instructor. Problem set and short term paper. Enrollment limited to 26 advanced undergraduates. Prerequisites: Biology Core. Recommended: 118.

3 units, Aut (Hanawalt)

BIOSCI 136. Evolutionary Paleobiology—A paleontological approach to evolutionary theory. Topics: history of life, speciation, heterochrony, evolutionary constraint, coevolution, macroevolution, the Cambrian Explosion, mass extinctions, taphonomy, life on land, life in the sea, life in the air.

4 units (Hadly) not given 2002-03

BIOSCI 137. Plant Genetics—Gene analysis, mutagenesis, and transposable elements; developmental genetics of flowering and embryo

development; biochemical genetics of plant metabolism; lessons from transgenic plant studies. Prerequisites: 41,42, 43 or 51, 52, or consent of the instructor.

3 units (Walbot) not given 2002-03

BIOSCI 138/238. Ecology and Evolution of Plants—(Graduate students register for 238.) Introduction to ecology and evolution of plants. Topics: plants in the environment, natural selection in plant populations, population dynamics, evolution of life history, sustainable harvesting from natural populations. Prerequisite: 43 or 51, or consent of the instructor. Recommended: statistics.

3 units (Ackerly) alternate years, given 2003-04

BIOSCI 138A/238A. Plant Ecology Lab—(Graduate students register for 238A.) Introduction to ecological research on plants. Weekly lab sessions at Jasper Ridge Biological Preserve to conduct field research projects. Must be taken concurently with 138.

2 units (Ackerly) not given 2002-03

BIOSCI 139. Biology of Birds—The ways birds interact with their environments and each other, emphasizing studies that had impact in the fields of population biology, community ecology, and evolution. Students become familiar with local bird communities; emphasis is on field research. One one-hour lecture and one three to five hour lecture or field trip per week. Enrollment limited to 20. Prerequisites: 43 or 51 or equivalent, and consent of instructor. Recommended: birding experience.

3 units (Ehrlich) not given 2002-03

BIOSCI 140. Population Biology of Butterflies—Field work on Euphydryas populations now under study on campus and elsewhere in California. This course is offered as participation in research when conditions permit; decisions not made until Winter Quarter. Prerequisites: 43 or 51, and consent of instructor.

2-5 units, Spr (Ehrlich)

BIOSCI 141. Biostatistics—(Same as STATS 141.) Introduction to the statistical analysis of biological data. Topics: discrete and continuous distributions, testing hypotheses and confidence procedures, fixed and random effects analysis of variance, regression, and correlation. Wilcoxon and other nonparametric procedures, inference on contingency tables and other data arising from counts. Tests of goodness of fit. Emphasis is on finding numerical solutions to biostatistical problems, and practical interpretations and their implications. GER:2c

4-5 units, Aut (Holmes)

BIOSCI 143/243. Evolution—(Graduate students register for 243.) The basic facts and principles of the evolution of all life. The logic of and evidence for the correctness of Darwin's argument for evolution by natural selection. How Mendelian genetics was integrated into evolutionary thinking. The integration of physiological and ecological perspectives into the study of evolutionary adaptation within species. Species formation and evolutionary divergence among species. Patterns of evolution over long time scales.

3 units, Win (Watt)

BIOSCI 144. Conservation Biology—(Same as HUMBIO 119.) Introduction to the science of preserving biological diversity, its principles, policy, and application. Topics: biology of small populations, extinction, minimum viable population analysis, habitat fragmentation, reserve design and management, the Endangered Species Act, and conflict mediation. Case studies and local field trips. Four units for students who take the recommended field trips. Prerequisite: 43, HUMBIO 2A or consent of instructor.

3-4 units (Boggs, Launer) not given 2002-03

BIOSCI 145/245. Behavorial Ecology—(Graduate students register for 245.) Animal behavior from an evolutionary and ecological perspective. Topics: foraging, territoriality, reproductive behavior, social groups. Lecture/seminar format; seminars include discussion of journal articles. Independent research projects. Prerequisites: Biological Sciences or Human Biology core, or consent of instructor. Recommended: statistics. (WIM)

4 units, Spr (Gordon) not given 2003-04

BIOSCI 146. Population Studies—Series of talks by distinguished speakers, introducing a variety of approaches to population and resource studies.

1 unit, Win (Feldman)

BIOSCI 147/247. Controlling Climate Change in the 21st Century—(Graduate students register for 247; same as EARTHSYS 147/247.) The science, economics, and environmental diplomacy of global climate change. Topics: the science of climate change, climate change and global environmental law; global economic approaches to carbon abatement, taxes, and tradable permits; joint implementation, consensus, and division in the European Union; gaining the support of China, other developing countries, and U.S. corporations; alternative energy and energy efficiencies for less carbon-intensive electric power and transport. Enrollment limited to 12 seniors.

3 units, Spr (Schneider, Rosencranz)

BIOSCI 148/248. Biosystematics and Evolution—(Graduate students register for 248.) Panel discussion and outside speakers cover topics of current interest in the systematics and evolution of living diversity; sponsored jointly with the California Academy of Sciences.

1 unit (Watt) not given 2002-03

BIOSCI 149/249. Neural Basis of Sleep and Circadian Rhythms—(Graduate students register for 249.) How the activity of the brain is affected by changes in the sleep/wake state. The neurochemistry of changes in brain activity and conscious awareness associated with changes in the sleep/wake state. Behavioral and neurobiological phenomena of sleep homeostasis, REM-sleep regulation, circadian rhythms, hibernation, and anesthesia. Enrollment limited to 30. Prerequisite: basic understanding of the nervous system (at least one of 42 or 53, HUMBIO 4A, PSYCH 70, or consent of instructor).

4 units, Win (Heller, Franken, O'Hara, Ruby) alternate years, not given 2003-04

BIOSCI 150/250. Human Behavioral Biology—(Graduate students register for 250.) The biological basis of normal and abnormal human behavior is examined to train students in approaching complex behaviors in a multidisciplinary way. Relevant disparate disciplines (sociobiology, ethology, neuroscience, and endocrinology) are integrated in the examination of behaviors such as aggression, sexual behavior, language use, mental illness.

2-6 units (Sapolsky) alternate years, given 2003-04

BIOSCI 151. Mechanisms of Neuron Death—Open to Biology majors with a strong background in neuroscience. The cell and molecular biology of neuron death during neurological disease. Topics: the amyloid diseases (Alzheimer's), prion diseases (kuru and Creutzfeldt-Jakob), oxygen radical diseases (Parkinson's and ALS), triplet repeat diseases (Huntington's), and AIDS-related dementia. Student presentations. Enrollment limited to 15.

3 units, Aut (Sapolsky)

BIOSCI 152. Imaging: Biological Light Microscopy—(Same as MCP 222.) Survey of instruments which use light and other radiation for analysis of cells in biological and medical research. Topics: basic light microscopy through confocal fluorescence and video/digital image processing. Lectures on physical principles; involves partial assembly and extensive use of lab instruments. Lab. Prerequisites: some college physics, Biological Sciences core.

3 units, Spr (Smith, Meyer)

BIOSCI 153. Cellular Neuroscience: Cell Signaling and Behavior—(Enroll in PSYCH 120.)

4 units, Aut (Wine)

BIOSCI 154/254. Molecular and Cellular Neurobiology—(Graduate students register for 254; same as NBIO 254.) For advanced undergraduates and graduate students. Focus is on cellular and molecular mechanisms in the organization and functions of the nervous system. Topics: cell biology of the neuron, wiring of the neuronal network, synapse structure and synaptic transmission, signal transduction in the nervous system, molecular basis of behavior including learning and memory, molecular pathogenesis of neurological diseases. Prerequisite for undergraduates: Biological Sciences core or equivalent, plus at least one of 118, 128, 129, or 153, or consent of the instructors.

4 units, Aut (Luo, Stryer)

BIOSCI 156/256. Plant Physiology—(Graduate students register for 256.) The physiological function of land plants: photosynthetic energy and gas exchange, and their regulation; water and photosynthate long-distance transport; mineral nutrient ion uptake and transport; growth at cellular and organismal levels, and its hormonal regulation; responses to light, gravity, and temperature. Prerequisite: Biological Sciences core.

4 units, Win (Ray, Somerville)

BIOSCI 158/258. Neural Development—(Graduate students register for 258.) For advanced undergraduates and coterminal students. The principles of nervous system development from the molecular control of patterning, cell-cell interactions, and trophic factors to the level of neural systems and the role of experience in influencing brain structure and function. Topics: neural induction and patterning cell lineage, neurogenesis, neuronal migration, axonal pathfinding, synapse elimination, the role of activity, critical periods, and the development of behavior. Enrollment limited to 75. Prerequisites: 42 or 53, or equivalent.

4 units, Spr (McConnell, Tessier-Lavigne) alternate years, not given 2003-04

BIOSCI 160. Developmental Biology—The principles of developmental biology. Focus is on the molecular mechanisms underlying the generation of diverse cell types and tissues during embryonic and post-embryonic development in animals. Prerequisite: Biological Sciences core.

4 units, Aut (Simon, McConnell)

BIOSCI 184/284. Principles and Practice of Biosystematics—(Graduate students register for 284.) The principles and major operating procedures of systematic biology; the classification of organisms and of the relationships among them. Concepts and issues common to the study of all organisms; examples from particular groups of creatures.

4 units, Spr (Watt, Gosliner, Jablonski, Ackerly) not given 2003-04

HOPKINS MARINE STATION

For courses offered at the Hopkins Marine Station, see the "Hopkins Marine Station" section of this bulletin which follows immediately after this section. Several of the Hopkins Marine Station courses can be used to fulfill department menu requirements. Completion of the Biological Sciences core is a prerequisite for all Hopkins Marine Station courses.

UNDERGRADUATE, INVOLVING INDIVIDUAL WORK

Students majoring in Biological Sciences are encouraged to pursue directed reading and research opportunities. An introduction to research is provided by BIOSCI 2.

BIOSCI 193. Undergraduate Journal Club—Weekly discussion led by students and facilitated by faculty. Practice critically reading scientific literature and presenting papers in a small, informal journal club format. Contact Kristin Black (kblack@stanford.edu) by the fifth week of the previous quarter if requesting a particular research topic. Minimal enrollment required. Prerequisite: Biological Sciences core, consent of instructor. Recommended: 199.

1 unit, Aut, Win, Spr (Black)

BIOSCI 198. Directed Reading in Biological Sciences

1-15 units, any quarter (Staff)

BIOSCI 198X. Out-of-Department Directed Reading

1-15 units

BIOSCI 199. Undergraduate Research with BIOSCI Faculty—Individual research taken by arrangement with in-department or out-of-department instructors. Credit for work arranged with out-of-department instructors is restricted to Biological Sciences majors and requires department approval. See http://www.stanford.edu/dept/biology/undergrad/honors/ for information on research sponsors, units, petition instructions, deadlines, credit for summer research, and out-of-Stanford research, or email kblack@stanford.edu for more information.

BIOSCI 199H. Undergraduate Research—(Enroll in BIOHOPK 199H.)

BIOSCI 199X. Out-of-Department Undergraduate Research

1-15 units (Staff)

ADVANCED UNDERGRADUATE AND GRADUATE

BIOSCI 200. Advanced Molecular Biology—The principles of molecular biology, with emphasis on the molecular mechanisms that govern the replication, recombination, and expression of eukaryotic genomes. Topics: DNA replication, DNA recombination, gene transcription, RNA splicing, regulation of gene expression, protein synthesis, and protein folding. Prerequisite: Biological Sciences Core.

4 units, Aut (Fang, Frydman)

BIOSCI 203. Advanced Genetics—(Same as GENE 203, DBIO 203.) The genetic toolbox. Examples of analytic methods and modern synthetic genetic manipulation, including original papers. Emphasis is on use of genetic tools in dissecting complex biological pathways, developmental processes, and regulatory systems. Graduate students in biological sciences welcome; those with minimal experience in genetics should prepare themselves by working out problems in college level textbooks.

4 units, Aut (Botstein, Kim, Stearns, Villeneuve, Sidow)

BIOSCI 205. DNA Repair and Mutagenesis—Interactions of endogenous and environmental mutagens with cellular DNA. Responses of living systems to damaged DNA, including molecular mechanisms for DNA repair and recombinational modes. Inducible repair responses and error-prone mechanisms. Human hereditary deficiencies in DNA repair that predispose to cancer. Relationships of DNA repair to mutagenesis and carcinogenesis. Current research literature. Prerequisites: 41 or 52, 118, and/or consent of instructor.

3 units, Spr (Hanawalt)

BIOSCI 206. Field Studies in Earth Systems—(Same as EARTHSYS 189, GES 189.) For advanced upper-division undergraduates and graduate students in Earth Systems, Biological Sciences, or Geological and Environmental Sciences. Field-based, focusing on the components and processes by which terrestrial ecosystems function. Topics from biology, chemistry, ecology, geology, and soil science. Lecture, field, and lab studies emphasize standard field techniques, experimental design, analysis of data, and written and oral presentation. Small team projects test the original questions in the functioning of natural ecosystems. Admission by application; see *Time Schedule*. Prerequisites: 141 or GES 160, or equivalent.

5 units, Spr (Chiariello, Fendorf, Ackerly, Matson, E. Miller)

BIOSCI 207. Life and Death of Proteins—How proteins are made and degraded in the cell. Discussion of primary literature. Case studies follow the evolution of scientific ideas and evaluate how different experimental approaches contribute to our understanding of a biological problem. Topics: protein folding and assembly, mechanisms of chaperone action, sorting into organelles and the ubiquitin-proteasome pathway. Enrollment limited to 20.

3 units, Spr (Frydman) alternate years, not given 2003-04

BIOSCI 208. Developmental Biology—(Enroll in DBIO 210.)

5 units, Spr (Talbot, Fuller, Crabtree, Kingsley, Nusse, Scott, Seung Kim)

BIOSCI 211. Biophysics of Sensory Transduction—The mechanisms, neural and aneural, that organisms have evolved to detect physical cues from the environment. Sensory topics: vision, hearing, taste, olfaction, chemoreception, mechanoreception, electromagnetic sensing, and other modalities. Emphasis is on common and/or emergent biophysical themes, such as sensitivity, amplification, encoding, adaptation, and the molecular basis of cellular signaling. Lectures and student-led presentations cover interdisciplinary aspects of biology and physics. Prerequisites: undergraduate physics with calculus, and basic biology.

4 units, Spr (S. Block)

BIOSCI 213. Biology of Viruses—Principles of virus growth, genetics, architecture, and assembly. The relation of temperate viruses and other Bio Core episomes to the host cell. Prerequisite: Biological Sciences core. Recommended: 118.

3 units, Win (Campbell)

BIOSCI 214. Cell Biology of Physiological Processes—(Same as MCP 221, IMMUNOL 221.) The basic mechanisms of membrane and cellular biogenesis in relation to physiological processes. Emphasis is on the regulatory and signaling mechanisms involved in coordinating complex cellular phenomena, such as cellular organization, function, and differentiation. Topics: cellular compartmentalization, transport and trafficking of macromolecules, organelle biogenesis, cell division, motility and adhesion, and multicellularity. Prerequisites: Biological Sciences core, BIOC 201. Corequisite: 214A-H.

5 units, Win (Kopito, Nelson, Frydman, Jackson, Fang)

BIOSCI 214A,B,D. Cell Biology of Physiological Processes Discussion—(Same as MCP 221A,B,D.) Required course taken with 211, taught by medical school faculty, to expand on the topics covered in 214. Students register for only one section. Prerequisites: Biological Sciences core, BIOCHEM 201.

2 units, Win (Staff)

BIOSCI 215. Biochemical Evolution—Biochemical viewpoints on the evolutionary process. Topics: prebiotic biochemistry and the origins of life; adaptive organization of metabolism; enzyme polymorphisms and other biochemical aspects of population genetics; macromolecular phylogeny and protein clocks. Prerequisites: Biological Sciences core or substantial equivalent.

3 units, Aut (Watt)

BIOSCI 216. Terrestrial Biogeochemistry—Nutrient cycling and the regulation of primary and secondary production in terrestrial, freshwater, and marine ecosystems; land-water and biosphere-atmosphere interactions; global element cycles and their regulation; human effects on biogeochemical cycles. Prerequisite: graduate standing in science or engineering; consent of instructor for undergraduates or coterminal students.

3 units, Spr (Vitousek) not given 2003-04

BIOSCI 217. Climate Theory, Modeling, Applications, and Implications—The history of the coevolution of climate and life. Theories of climate, external and internal climatic forcings, definitions of climate and the climate system, and the rationale for climatic modeling. Hierarchy of climatic models; interactions among atmosphere, biosphere, oceans, hydrosphere, and cryosphere. Climatic predictability; implications of predictions and relevance to current controversies. Prerequisites: Biological Sciences core or CEE 163, and math through differential equations, or consent of instructor.

3-5 units (Schneider) not given 2002-03

BIOSCI 220. Ecology of Microorganisms—Interactions between microorganisms and their environments from an ecological and evolutionary perspective. Topics: nutrient acquisition and environmental sensing, behavioral ecology, growth of cells and populations, population interactions, communities, microbial biodiversity. Prerequisites: Biological Sciences core or equivalent, or consent of instructor. Recommended: 133, 142.

3 units, Win (Bohannan)

BIOSCI 221. Methods of Theoretical Population Biology—How problems in population biology are formulated theoretically and how models are analyzed using theoretical and computational numerical methods. Topics include linear and nonlinear models and dynamics, stochastic models, stability and bifurcations, and data-driven models, with applications in ecology and genetics.

4 units, Aut (Tuljapurkar)

BIOSCI 230. Molecular and Cellular Immunology—For graduate students and advanced undergraduates. The basic components of the immune system: structure and functions of antibody molecules; cellular basis of immunity and its regulation; molecular biology and biochemistry of antigen recognition structures and signaling pathways; genetics of immunity and disease susceptibility. Emphasis is on key experimental approaches that have advanced our understanding. Extra unit for discussion section on immunology literature. Prerequisites for undergraduates: Biological Sciences or Human Biology core, or consent of instructor.

4-5 units, Aut (Jones)

BIOSCI 241. Biological Macromolecules—(Enroll in SBIO 241.)

3-5 units, Aut (Puglisi, Block, Herschlag, Kirkegaard, McKay)

BIOSCI 258A. Neural Development—Seminar for graduate students, with optional lectures that meet jointly with 158. See 158.

4 units, Spr (McConnell) alternate years, not given 2003-04

BIOSCI 261A. Advanced Topics in Behavioral Biology—Seminar. The biological roots of aggression, competition, cooperation, and altruism. Prerequisite: 150/250.

2 units, **261A:** *Aut,* **261B:** *Win (Sapolsky)*

BIOSCI 274A. Environmental Microbiology I—(Enroll in CEE 274A.)

3 units, Aut, Sum (Achong)

BIOSCI 274B. Environmental Microbiology II—(Enroll in CEE 274B.)

3 units (Spormann) not given 2002-03

BIOSCI 274C. Environmental Microbiology Laboratory—(Enroll in CEE 274C.)

3 units, Spr (Spormann)

BIOSCI 283. Theoretical Population Genetics—Detailed survey of models in population genetics. Selection, random drift, gene linkage, migration and inbreeding, and the influence they have on the evolution of gene frequencies and chromosome structure. Models are related to DNA sequence evolution. Prerequisite: consent of instructor.

3 units, Aut (Feldman)

BIOSCI 290. Teaching of Biological Science—Open to upper-division undergraduates and graduate students. Practical experience in teaching lab biology or serving as an assistant in a lecture course. Prerequisite: consent of instructor.

BIOSCI 290R. Teaching of Biological Science
BIOSCI 290W. Teaching of Biological Science
BIOSCI 290X. Teaching of Biological Science

1-5 units, Aut, Win, Spr (Staff)

BIOSCI 291. Development and Teaching of Core Experimental Laboratories—Preparation for teaching the core experimental courses (44X and 44Y). Emphasis is on lab, speaking, and writing skills. Focus is on updating the lab to meet the changing technical needs of the students. Must be taken prior to teaching either of the above courses. Prerequisite: selection by instructor.

1-2 units, Aut, Win (Malladi, Yelton)

PRIMARILY FOR GRADUATE STUDENTS

BIOSCI 300. Graduate Research—For graduate students only. Individual research by arrangement with in-department or out-of-department instructors. Master's students: credit for work arranged with out-of-department instructors is restricted to Biological Sciences students and

requires an approved department petition. See http://www.stanford.edu/dept/biology/undergrad/honors/ for information on research sponsors, units, petition instructions, deadlines, credit for summer research, and out-of-Stanford research, or email kblack@stanford.edu for more information.

BIOSCI 300R. Graduate Research
BIOSCI 300W. Graduate Research
BIOSCI 300X. Out-of-Department Graduate Research
1-15 units (Staff)

BIOSCI 301. Frontiers in Biology—Current research in molecular, cellular, and developmental biology emphasizing critical evaluation of primary research literature. Held in conjunction with the Monday seminar series in Biological Sciences. Weekly student presentation and discussion of one or two papers related to the upcoming seminar. Limited to and required for all first-year Ph.D. students interested in molecular, cellular, and developmental biology in Biological Sciences.
1-3 units, Aut, Win (Cyert, Simoni)

BIOSCI 302,303,304. Current Topics in Population Biology—Required of first-year graduate students in population biology and open to all graduate students. Discussion of the major conceptual issues and developing topics in population biology.
1-3 units, **302:** *Aut,* **303:** *Win,* **304:** *Spr (Staff)*

BIOSCI 305. DNA Repair and Genetic Toxicology—Seminar. Literature review and discussion of current research, emphasizing experimental approaches for studying DNA damage processing in bacteria, yeast, and mammalian cells. Enrollment limited to graduate students and advanced undergraduate students doing research in this field. Prerequisite: consent of instructor.
1-3 units, Aut, Win, Spr (Hanawalt)

BIOSCI 306. Current Topics in Integrative Organismal Biology—Enrollment limited to graduate students doing research in this field.
1 unit, Aut (Staff)

BIOSCI 307. Seminar in Microbial Ecology and Evolution—Discussion of recent and classical research papers in microbial ecology and evolution, and presentation of research in progress by participants. Prerequisite: consent of instructor.
1 unit, Aut, Win, Spr (Staff)

BIOSCI 309. Topics in Invasion Biology—Theoretical and empirical studies of biological invasions. Possible topics: invasibility, invasion resistance, identification of potential invaders, invader effects on mutualisms, economic impact of invaders, biological control, ecological restoration. May be repeated for credit. Prerequisite: graduate student status.
1 unit, Aut (Staff)

BIOSCI 310. Biocomplexity and Ecoinformation—Focus is on scale dependence in the relationship between biodiversity and ecosystem function. Introduction to tools and methods for data synthesis and integration. Analysis of data on species richness and primary productivity. Prerequisite: consent of instructor.
1-2 units, Win (Staff)

BIOSCI 311. Molecular Evolution—Literature review and research discussion of current problems in molecular evolution and evolutionary genetics. Student participation required. Prerequisite: consent of instructor.
1-3 units, Win, Spr (Petrov)

BIOSCI 312. Ethical Issues in Ecology and Evolutionary Biology—Focus is on ethical issues addressed in the *Academic Daily* and others of importance to academics and scientists in the fields of ecology, behavior, and evolutionary biology. Discussions led by faculty and outside guests. Fulfills the required Ethics course for graduate students in Ecology and Evolutionary Biology. Prerequisite: graduate standing in the Ecology and Evolutionary Biology or Marine program, or consent of instructor.
1 unit, Aut (Ehrlich)

BIOSCI 315. Seminar in Biochemical Evolution—Literature review and discussion of current topics in biochemical evolution and molecular evolutionary genetics. Prerequisite: consent of instructor.
1-3 units, by arrangement (Watt)

BIOSCI 333. Evolutionary Ecology—Literature review and research discussion on a selected topic in ecology and evolution. Student participation required. Prerequisite: consent of instructor.
1-3 units (Ackerly) not given 2003-04

BIOSCI 342. Plant Biology Seminar—Topics announced at the beginning of each quarter. In-depth coverage of the current literature.
1-15 units, Spr (Walbot, Berry, Björkman, Briggs, Grossman, Hoffman, Long, Mooney, Ray, Vitousek)

BIOSCI 346. Advanced Seminar in Molecular Biology—Enrollment limited to graduate students directly associated with departmental research groups in genetics or molecular biology.
1-3 units, Aut, Win, Spr (Long, Campbell, Spormann, Grossman)-

BIOSCI 383. Seminar in Population Genetics—Literature review and research discussion of current problems in the theory and practice of population genetics and molecular evolution. Student participation required. Prerequisite: consent of instructor.
1-3 units, Aut, Win, Spr (Feldman)

BIOSCI 384. Theoretical Ecology—(Same as GEOPHYS 185Y/385Y.) Discussions of recent and classical research papers in ecology, and presentation of work in progress by participants. Prerequisite: consent of instructor.
1-2 units (Roughgarden)

BIOSCI 450. Introduction to Biotechnology—(Enroll in CHEMENG 450, BIOC 450.)
3 units, Spr (Robertson, Swartz)

BIOSCI 459. Frontiers in Interdisciplinary Biosciences—(Crosslisted in multiple departments in the schools of Humanities and Sciences, Engineering, and Medicine; students should enroll directly through their affiliated department, otherwise enroll in CHEMENG 459.) An introduction to cutting-edge research involving interdisciplinary approaches to bioscience and biotechnology; for specialists and non-specialists. Organized and sponsored by the Stanford BioX Program. Three seminars each quarter address a broad set of scientific and technical themes related to interdisciplinary approaches to important issues in bioengineering, medicine, and the chemical, physical, and biological sciences. Leading investigators from Stanford and throughout the world present the latest breakthroughs and endeavors that cut broadly across many core disciplines. Pre-seminars introduce basic concepts and provide background for non-experts. Registered students attend all pre-seminars in advance of the primary seminars, others welcome. Prerequisite: keen interest in all of science, engineering, and medicine with particular interest in life itself. Recommended: basic knowledge of mathematics, biology, chemistry, and physics.
1 unit, Aut, Win, Spr (Robertson)

OVERSEAS STUDIES

Courses approved for the Biological Sciences major and taught overseas can be found in the "Overseas Studies" section of this bulletin, or in the Overseas Studies office, 126 Sweet Hall.

BERLIN

BIOSCI 107Z. Environment, Science, and Society in Germany
3 units, Spr (Mooney)

BIOSCI 198. Directed Reading in Biological Sciences
3-5 units (Mooney)

OXFORD

BIOSCI 104Z. Science Behind the Policy and Policy Behind the Science: A UK and European Perspective
3 units, Spr (Epel)

BIOSCI 105Z. Cell and Developmental Biology: A British Sampler
4 units, Spr (Epel)

SANTIAGO

BIOSCI 106Z. Man-Environment Interactions: Case Studies from Central Chile—(Same as HUMBIO 106X, LATINAM 122X.)
5 units, Aut (Hajek)

This file has been excerpted from the *Stanford Bulletin, 2002-03,* pages 277-288. Every effort has been made to insure accuracy; late changes (after print publication of the bulletin) may have been made here. Contact the editor of the *Stanford Bulletin* via email at arod@stanford.edu with changes, corrections, updates, etc.