BIOLOGICAL SCIENCES

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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, the Clark Center and the Lokey Chemistry/Biology Building 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. More information is available at http://jasper1.stanford.edu.

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 on the Hopkins Marine Station web site at http://www-marine.stanford.edu.

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 41 or 52*	5
BIOSCI 42 or 53*	5
BIOSCI 43 or 51*	5
BIOSCI 44X	4
BIOSCI44Y (may be replaced by 4 units of 175H, or 176H)	4
BIOSCI 54 (in combination with 55, substitutes for BIOSCI 44X,Y)	3
BIOSCI 55	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. Stanford Introductory Seminars may not be used to fulfill this requirement.

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*
   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
   Genetics: BIOSCI 118*
   Molecular and Cellular Immunology: BIOSCI 230*
   Neurobiology: BIOSCI 154
   Prokaryote Genetics: BIOSCI 133*
   Cell Physiology: BIOSCI 160H
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 and 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; this policy does not apply to transfer credit.

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.

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	
General Education Requirements or electives	11	11	11
Totals	15	15	11

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 are 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 that 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. Stanford Introductory Seminars may not be used to fulfill this requirement
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.

Note: No general petitions are accepted for minor requirements.

HONORS PROGRAM

To graduate with departmental honors, a student must:

1. Complete at least 10 units of an approved (BIOSCI 199 or BIOSCI 199X) 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 (one paper copy and one electronic copy), which include student name, thesis title, research sponsor, and sponsor's department.

Further information on the honors program, including petition forms and examples of honors posters, theses, and proposals, is available in the office of the undergraduate research coordinator, Gilbert 118. 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://biohonors.stanford.edu. Questions should be directed to the Undergraduate Research Coordinator, Dr. Kristin Black (kblack@stanford.edu, 650-723-3767, Gilbert 118).

SPECIALIZED HONORS TRACKS

In addition to the general honors program described above, the Department of Biological Sciences offers these five specialized honors tracks for students wishing to concentrate their studies in particular areas of biology:

1. Biochemistry and Biophysics
2. Ecology and Evolutionary Biology
3. Marine Biology
4. Molecular and Cellular Biology
5. Neurobiology

Candidates for the B.S. degree in Biological Sciences with an area of specialization are expected to complete:

1. a specific set of cognate courses
2. a specific set of courses in the chosen area of specialization
3. an honors thesis.

For further information on the specialized track programs, including detailed descriptions of their specific requirements and deadlines, see http://www.stanford.edu/dept/biology/programs.html.

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; 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 CR/NC 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://gradadmissions.stanford.edu. 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, and marine track, integrative and organismal track, and molecular, cellular, developmental, and genetics track. 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.

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. Three quarters are required for ecology/evolution and marine students.
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 or BIOC 241, Biological Macromolecules
      Two or three additional courses are selected from the student's area of specialization. In addition, the following are required:
      BIOSCI 301. Frontiers in Biology (satisfies first-year talk requirement)
      MED 255. Responsible Conduct of Research
   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 that is evaluated by the advising committee, before the end of Spring Quarter of their first year. 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, i.e., 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 that is evaluated by the advising committee before the end of Spring Quarter of their first year. 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 3. Frontiers in Marine Biology—An introduction to contemporary research in marine biology, including ecology, conservation biology, environmental toxicology, behavior, biomechanics, evolution, neurobiology, and molecular biology. Emphasis is on new discoveries and the technologies used to make them. Weekly lectures by faculty from the Hopkins Marine Station.

1 unit, Aut (Somero)

BIOSCI 4. Introduction to Biotechnology—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, and genetically modified foods). GER:2b

4 units (Walbot) not given 2003-04

BIOSCI 8. Frontiers in Organismal Biology—Preference to freshmen and sophomores. How physiological systems respond to environmental factors over short-term and evolutionary-time courses.

1 unit, Aut (B. Block, C. Heller, Sapolsky)

STANFORD INTRODUCTORY SEMINARS

BIOSCI 5N. Thinking Critically About Environmental Problem Solving—Stanford Introductory Seminar. Some scientific claims are well founded; others are built on faulty logic that is subtle and difficult to detect; critical thinking helps differentiate between well-founded and bogus arguments. Examples from popular mysteries such as astrology and paranormal events, and the environment. Readings include Schick and Vaughn, *How to Think about Weird Things*, and Ehrlich and Ehrlich, *Betrayal of Science and Reason*.

3 units, Spr (Root)

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

3 units, Spr (Preston)

BIOSCI 11N. Biotechnology in Everyday Life—Stanford Introductory Seminar. Preference to freshmen. The science that makes transgenic plants and animals possible. Current and future applications of biotechnology and the ethical issues raised.

3 units, Aut (Walbot)

BIOSCI 14N. Plants and Civilization—Stanford Introductory Seminar. Preference to freshmen. 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; viticulture, and wine and beer making; the spice route; the use of plants as medicine; fungi in human affairs; the global spread of weeds; engineering plants for the future; the importance of tea, coffee, sugar, potatoes, natural dyes, and rubber in societal affairs and change. GER:2a

3 units, Spr (Mooney)

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, Spr (Vitousek) alternate years, not given 2004-05

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, Spr (C. Somerville, S. Somerville)

BIOSCI 19N. Diversity, Gender, and Sexuality—Stanford Introductory Seminar. Preference to freshmen. The diversity of gender expression and sexuality among vertebrates and human cultures, and the developmental biology of sexual differentiation in humans. How science studies contribute to the understanding of gender, a topic primarily treated in the humanities and social sciences. Focus is on Roughgarden, *Evolution's Rainbow: Diversity, Gender, and Sexuality in Nature and People*. Term paper. GER:4c

3 units, Spr (Roughgarden)

BIOSCI 21N. Genes and Behavior—Stanford Introductory Seminar. Preference to sophomores. The genetic and evolutionary basis for complex innate behavioral patterns in animals. Readings from primary scientific literature, and Olivia Judson, *Dr. Tatiana's Sex Advice for All Creation*.

3 units, Aut (Baker)

BIOSCI 22N. Infection, Immunity, and the Public's Health—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 SARS, 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, preferably introductory college biology (41 or 42, or HUMBIO 2A, 3A).

3 units, Spr (Jones)

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. Oral presentations and short term paper. GER:2a

3 units, Spr (Hanawalt)

BIOSCI 29N. The Origin and Limits of Life—Stanford Introductory Seminar. Preference to freshmen. The origin of life on earth, with an emphasis on life on the early earth and the living relics of such life on the modern earth. Topics include: the environment of the early earth; the geological record of the earliest forms of life; current life at extremes of temperature; pH, salinity, and pressure; and the search for life elsewhere in the solar system. Students have access to Stanford's rock collection containing the oldest evidence of life on earth. Field trips to extreme environments. Research project, term paper. GER:2a

3 units, Win (Bohannan, Lowe)

BIOSCI 31Q. Ants: Behavior, Ecology, and Evolution—Stanford Introductory Seminar. Preference to sophomores. Behavior: the organization of colonies, how they operate without central control, how they resemble other complex systems like brains. Ecology: how populations of colonies change, comparing the ecology of a species in S.W. American desert and invasive Argentine ants. Evolution: why are there so many species of ants; how are they alike, how do they differ, and why? Ants as the theme for exploring how to do research in animal behavior, ecology, and evolution. Research project on the invasive Argentine ant: its distribution on campus, foraging trails, and nest structure.

3 units, Aut (Gordon)

BIOSCI 106Q. The Heart of the Matter—Stanford Introductory Seminar. (Same as GENE 106Q.) 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. GER:2a

3-4 units, Win (Myers, Simoni)

CORE

BIOSCI 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, Biochemistry, and Molecular Biology—Emphasis is on macromolecules (proteins, lipids, carbohydrates, and nucleic acids) and how their structure relates to function and higher order assembly; molecular biology, genome structure and dynamics, gene expression from transcription to translation.

5 units, Aut (Simon, Simoni)

BIOSCI 42. Cell Biology and Animal Physiology—Cell structure and function; basic principles of animal physiology (immunology, renal, cardiovascular, sensory, and motor physiology); neurobiology from cellular and developmental to neural regulation of physiology.

5 units, Win (Cyert, C. Heller, Sapolsky)

BIOSCI 43. Plant Biology, Evolution, and Ecology—Principles of evolution: macro- and microevolution and population genetics. Ecology: the principles underlying the exchanges of mass and energy between organisms and their environments; population, community, and ecosystem ecology; populations, evolution, and global change.

5 units, Spr (Gordon, Mudgett, Petrov)

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 54. Genes, Genomes, and Proteins: Introduction to Advanced Independent Research Laboratory—Preference to sophomores. First of two-part sequence. For students interested in pursuing research-oriented careers in biological sciences. The impact of genomic information on experimental biology. Recently developed techniques at a conceptual level and examples of their application to biology. Emphasis is on primary scientific literature and hands-on analyses of genome information using online databases and computational tools. Topics include microarray analysis, the use of comprehensive genome-wide mutant collections, and investigation of the proteome. Limited enrollment. Prerequisite: consent of instructors. 54,55 substitutes for 44X,Y to fulfill Biological Sciences major lab requirement. (WIM)

3 units, Win (Cyert, Stearns)

BIOSCI 55. Advanced Independent Research Laboratory—Preference to sophomores. Second of two-part sequence. For students interested in pursuing research-oriented careers in biological sciences. Project lab course using a modern research laboratory with cutting-edge technologies introduced in 54 to investigate gene and protein function on a genomic level to understand how cells work. Students design and execute original research projects using the yeast *Saccharomyces cerevisiae* to explore fundamental questions in eukaryotic cell biology. Limited enrollment. Prerequisite: 54, consent of instructors. 54,55 substitutes for 44X,Y to fulfill Biological Sciences major lab requirement. (WIM)

5 units, Spr (Cyert, Stearns)

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 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 demographic change around the world, from fertility transitions to aging. Demographic measures and estimates; mortality and life tables; fertility and marriage; population projection of 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. GER:2a

3 units, Aut (Tuljapurkar)

BIOSCI 104/200. Advanced Molecular Biology—(Graduate students register for 200.) 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.

5 units, Win (Fang, Frydman)

BIOSCI 109/209. The Human Genome and Disease: Evolution, Drift, and Populations—(Graduate students register for 209; same as HUMBIO 114.) The variability of the human genome and the role of genomic information in research, drug discovery, and human health. Overview of the concepts and interpretations of genomic markers in medical research and real life applications. Human genomes in diverse populations. Original contributions from thought leaders in academia and industry and direct interaction between students and guest lecturers.

3 units, Spr (R. Heller)

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

3-4 units (Porzig) alternate years, given 2004-05

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, Win (C. Heller, Garza) alternate years, not given 2004-05

BIOSCI 113/244. Fundamentals of Molecular Evolution—(Graduate students register for 244.) The inference of key molecular evolutionary processes from DNA and protein sequences. Topics include random genetic drift, effects and tests of natural selection, combined effects of linkage and natural selection, concerted evolution, gene duplication and evolution of novel functions, and genome evolution. Prerequisites: Biological Sciences core or graduate standing in any department, and consent of instructor.

4 units, Win (Petrov) not given 2004-05

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.

3 units, Win (Mooney, Vitousek)

BIOSCI 118/218. Genetic Analysis of Biological Processes—(Graduate students register for 218.) Basic genetic principles and their experi-

mental 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 broad-scale evolutionary trends. Prerequisites: Biology or Human Biology core; consent of instructor. GER:2a

3-5 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, Spr (Hadly) alternate years, not given 2004-05

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

4 units, Win (Berry, Field, Mooney)

BIOSCI 125. Ecosystems of California—Distribution, functioning, human utilization, and management through time. Prerequisite: 51 or HUMBIO 2A.

3-4 units, Spr (Mooney)

BIOSCI 126/226. Cell Biology: Intracellular Trafficking and Organelle Biogenesis—(Graduate students register for 226.) 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.

4 units, Win (Rexach)

BIOSCI 127/220. Ecology of Microorganisms—(Graduate students register for 220.) 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 (Bohannan) not given 2003-04

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 (Nelson)

BIOSCI 133. Genetics of Prokaryotes—Genetic approaches for understanding cellular processes in bacteria, including metabolism, adaptive and stress responses, signal transduction, gene expression, genetic exchange and recombination, chromosome dynamics and evolution, cell division, motility, surface attachment, and developmental responses. Emphasis is on the power of effectively combining genetics with biochemistry, microscopy, and genomics. Prerequisite: Biological Sciences core.

3 units, Aut (Burkholder, 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: Biological Sciences core. Recommended: 118.

3 units, Win (Burkholder, Hanawalt)

BIOSCI 135. Biological Clocks—The biological basis for endogenous timekeeping in organisms from flies to human beings. How biological clocks are constructed at the molecular, tissue, and behavioral levels and how they keep animals synchronized to their environment. Models and mechanisms of circadian rhythms, annual rhythms, molecular oscillators, and hibernation; human applications. Prerequisites: Biological Sciences or Human Biology core, or consent of instructor.

3 units, Spr (C. Heller, Ruby)

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, Win (Hadly)

BIOSCI 137/237. Plant Genetics—(Graduate students register for 237.) Gene analysis, mutagenesis, and transposable elements; developmental genetics of flowering and embryo development; biochemical genetics of plant metabolism; lessons from transgenic plant studies. Prerequisites: Biological Sciences core or consent of the instructor.

3 units, Spr (Walbot, Barton) alternate years, not given 2004-05

BIOSCI 138/238. Ecology and Evolution of Plants—(Graduate students register for 238.) 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, Spr (Ackerly) alternate years, not given 2004-05

BIOSCI 138A/238A. Plant Ecology Lab—(Graduate students register for 238A.) Weekly lab sessions at Jasper Ridge Biological Preserve to conduct field research projects. Corequisite: 138.

2 units, Spr (Ackerly) alternate years, not given 2004-05

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, Spr (Root) alternate years, not given 2004-05

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), Win (Feldman)

BIOSCI 142. Topics in Theoretical Ecology—Introductory. Issues include foraging theory, demography and life history theory, population dynamics and species interactions including ecosystem stability, ecological economics and marine reserve design, evolutionary theory, evolutionary ecology, and evolution of gender sexuality and family structure. Prerequisites: 43 or 101, calculus, and computer programming. Recommended: linear algebra and differential equations.

3 units, Win (Roughgarden) alternate years, not given 2004-05

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, Win (Boggs, Launer)

BIOSCI 145/245. Behavioral 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. This course does not fulfill the Biology lab requirement. (WIM)

4 units, Spr (Gordon)

BIOSCI 146. Population Studies—Series of lectures by distinguished speakers introducing current research on population studies and resource use.

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 EU; 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.

3 units (Schneider, Rosencranz) alternate years, given 2004-05

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, Win (Watt) alternate years, not given 2004-05

BIOSCI 149/249. Principles of Sleep Research—(Graduate students register for 249.) Preference to seniors and graduate students. The neurochemistry and neurophysiology of changes in brain activity and conscious awareness associated with changes in the sleep/wake state. Behavioral and neurobiological phenomena including sleep regulation, sleep homeostasis, circadian rhythms, sleep disorders, sleep function, and the molecular biology of sleep. Enrollment limited to 16.

4 units, Aut (Franken, C. Heller)

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.

6 units, Spr (Sapolsky) alternate years, not given 2004-05

BIOSCI 151. Mechanisms of Neuron Death—Open to Biology majors with a strong background in neuroscience. 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 (S. 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 (Luo, Stryer) not given 2003-04

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 (Ray, C. Somerville) not given 2003-04

BIOSCI 158/258. Developmental Neurobiology—(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. Prerequisite: 42 or equivalent.

4 units (McConnell, Tessier-Lavigne) alternate years, given 2004-05

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 (McConnell, Simon) alternate years, given 2004-05

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 (Ackerly, Watt, Gosliner, Jablonski)

BIOSCI 187/287. Biochemistry—(Graduate students register for 287; same as CHEM 187, CHEMENG 187.) Structure and function of biological molecules, enzyme kinetics and mechanisms, bioenergetics, pathways of intermediary metabolism and their control, and membrane structure and function. Lectures on special topics. Clinical correlations. Prerequisites: organic chemistry, cell biology, or consent of instructor.

4-5 units, Win (Khosla)

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.

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 191. Research in Bird Biology—Semi-independent field research in ornithology, emphasizing ecological relationships. Projects involve research, planned and carried out by the student in consultation with the instructor. Results are written in publication format. Enrollment limited. Prerequisites: 43 or 51, concurrent or subsequent enrollment in 139, and consent of instructor.

3 units, Win, Spr (Ehrlich, Root)

BIOSCI 193. Undergraduate Journal Club—Weekly discussion, led by students and facilitated by faculty, for reading scientific literature and presenting papers. 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, Aut, Win, Spr (Staff)

BIOSCI 198X. Out-of-Department Directed Reading—Individually arranged under the supervision of members of the faculty. Credit for work arranged with out-of-department faculty is restricted to Biological Sciences majors and requires department approval. See http://biohonors.stanford.edu for information and petitions, or email kblack@stanford.edu for more information.

1-15 units, Aut, Win, Spr (Staff)

BIOSCI 199. Undergraduate Research with BIOSCI Faculty—Individual research taken by arrangement with in-department instructors. See http://biohonors.stanford.edu for information on research sponsors, units, petitions, deadlines, and credit for summer research, or email kblack@stanford.edu.

1-15 units, Aut, Win, Spr (Staff)

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

1-15 units, Aut, Win, Spr, Sum (Staff)

BIOSCI 199X. Out-of-Department Undergraduate Research—Individual research by arrangement with out-of-department instructors. Credit for 199X is restricted to declared Biological Sciences majors and requires department approval. See http://biohonors.stanford.edu for information on research sponsors, units, petitions, deadlines, credit for summer research, and out-of-Stanford research, or email kblack@stanford.edu.

1-15 units, Aut, Win, Spr (Staff)

ADVANCED UNDERGRADUATE AND GRADUATE

BIOSCI 200. Advanced Molecular Biology—Emphasis is 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.

5 units, Win (Fang, Frydman)

BIOSCI 203. Advanced Genetics—(Same as GENE 203, DBIO 203.) For graduate students in biological sciences; may be appropriate for graduate students in other programs. The genetic toolbox. Examples of analytic methods, genetic manipulation, genome analysis, and human genetics. Emphasis is on use of genetic tools in dissecting complex biological pathways, developmental processes, and regulatory systems. Faculty-led discussions sections with critical evaluation of papers. Students with minimal prior experience in genetics should prepare themselves by working out problems in college level textbooks.

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

BIOSCI 205. DNA Repair and Genomic Stability—Interactions of endogenous and environmental mutagens with cellular DNA. Responses of living systems to damaged DNA, including molecular mechanisms for DNA repair, translesion DNA synthesis, 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. Term paper, oral final exam. Prerequisites: 41 or 52, and 118, or consent of instructor.

3 units, Spr (Ford, 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 (Chiariello, Fendorf, Freyberg, Matson, E. Miller, Ackerly) alternate years, given 2004-05

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 2004-05

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

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

BIOSCI 210. Signal Transduction Pathays and Networks—(Same as MPHA 210.) The molecular mechanisms through which cells receive and respond to external signals. Emphasis is on principles of cell signaling, the systems-level properties of signal transduction modules, and experimental strategies through which cell signaling pathways are being studied. Prerequisite: working knowledge of biochemistry and genetics.

4 units, Win (Ferrell, Meyer)

BIOSCI 211. Biophysics of Sensory Transduction—Neural and aneural mechanisms 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. Interdisciplinary aspects of biology and physics. Student presentations. Prerequisites: undergraduate physics, 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 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.) 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.

2-5 units, Win (Kopito, Frydman, Nelson)

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 (Vitousek) alternate years, given 2004-05

BIOSCI 219. Ubiquitin and Biology of the Cell—For graduate students and advanced undergraduates. The biochemistry, genetics, and molecular biology of the ubiquitin system and its central role in the biology of the eukaryotic cell. Topics: biochemistry and enzymology of the ubiquitin-dependent proteolysis, function of proteolysis in cell cycle control, transcriptional regulation, cellular signaling, vesicular trafficking, and quality control of misfolded proteins. The role of the ubiquitin system in the pathogenesis of neurodegenerative diseases and cancer. Student presentations. Prerequisites: 41, 42, 118 or equivalent.

5 units, Win (Fang, Kopito)

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, and microbial biodiversity. Prerequisite: Biological Sciences core or equivalent, or consent of instructor. Recommended: 133, 142.

3 units (Bohannan) not given 2003-04

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 vary from year to year but usually include stochastic models, stability and bifurcations, and data-driven models, with applications in ecology and genetics. Prerequisites: linear algebra, differential equations, and probability, or consent of instructor.

4 units, Aut (Tuljapurkar)

BIOSCI 223. Plant Taxonomy—Techniques for identification of genera and species of flowering plants, including the characteristics of flowering plant families important in identification of California species. Current concepts of major evolutionary patterns in flowering plants. Lab.

2-3 units (Staff) not given 2003-04

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; genetic control 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—(Same as BIOC 241, SBIO 241.) Introduction to the physical and chemical basis of macromolecular function. The forces that stabilize biopolymers with three-dimensional structures and their functional implications. Thermodynamics, molecular forces, and kinetics of enzymatic and diffusional processes, and relationship to their practical application in experimental design and interpretation. Biological function and the level of individual molecular interactions and at the level of complex processes. Case studies. Prerequisite: BIOC 200 or equivalent.

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

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

3 units (Sapolsky) not given 2003-04

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

3 units, Aut (Spormann), Sum (Staff)

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

3 units, Win (Spormann)

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, Spr (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.

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

BIOSCI 290X. Out-of-Department Teaching of Biological Science—Prerequisite: consent of instructor.

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://biohonors.stanford.edu 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.

1-15 units, Aut, Win, Spr, Sum (Staff)

BIOSCI 300X. Out-of-Department Graduate Research

1-15 units, Aut, Win, Spr, Sum (Staff)

BIOSCI 301. Frontiers in Biology—Current research in molecular, cellular, and developmental biology emphasizing primary research literature. Held in conjunction with the department's Monday seminar series. Students and faculty meet weekly before the seminar for a student presentation and discussion of 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 the Department of Biological Sciences.

1-3 units, Aut, Win (Burkholder, Mudgett)

BIOSCI 302. Current Topics in Population Biology—Required of first-year graduate students in population biology and open to all graduate students. Major conceptual issues and developing topics.

1 unit, Aut (Staff)

BIOSCI 303. Current Topics in Ecology and Evolution— Required of first-year graduate students in population biology and open to all graduate students. Major conceptual issues and developing topics.

1 unit, Win (Staff)

BIOSCI 304. Concepts in Population Biology—Required of first-year graduate students in population biology and open to all graduate students. Major conceptual issues and developing topics.

1 unit, 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, Win, Spr (Hanawalt)

BIOSCI 306. Current Topics in Integrative Organismal Biology—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 (Bohannan)

BIOSCI 312. Ethical Issues in Ecology and Evolutionary Biology—Focus is on ethical issues addressed in the *Academic Duty* and others of importance to academics and scientists in the fields of ecology, behavior, and evolutionary biology. Discussions led by faculty and outside guests. Satisfies ethics course requirement for 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, Aut, Win, Spr (Walbot, Long, Mudgett, C. Somerville, S. Somerville, Barton, Berry, Frommer, Grossman, Wang)

BIOSCI 344. Advanced Seminar in Cell Biology—Enrollment limited to graduate students associated with departmental research groups in cell biology.

1-3 units, Aut, Win, Spr (Burkholder, Cyert, Fang, Frydman, Kopito, Rexach, Stearns)

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 (Campbell, Long, Spormann, Grossman)

BIOSCI 358. Advanced Topics in Biological Sciences

1-3 units, Aut, Win, Spr (B. Baker, McConnell, Simon, Tessier-Lavigne)

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.) Recent and classical research papers in ecology, and presentation of work in progress by participants. Prerequisite: consent of instructor.

1-2 units, Aut, Win, Spr (Roughgarden)

BIOSCI 388. Communication and Leadership Skills—(Same as IPER 210.) Focus is on delivering information to policy makers and the lay public. How to speak to the media, congress, and the general public; how to write op-eds and articles for the general public; how to package ideas including titles, abstracts, and grant proposals. The peer-review process, and scientific talks to scientists and the general public. How to be science advocate.

2 units, Win (Root)

BIOSCI 450. Introduction to Biotechnology—(Enroll in CHEMENG 450, BIOC 450.)

3 units, Spr (Kao)

BIOSCI 459. Frontiers in Interdisciplinary Biosciences—(Crosslisted in multiple departments in the schools of Humanities and Sciences, Engineering, and Medicine. Students should enroll through their affiliated department; otherwise enroll in CHEMENG 459.) See CHEMENG 459 or http://biox.stanford.edu/chemeng_index.html for description.

1 unit, Aut, Win, Spr (Robertson)

OVERSEAS STUDIES

These courses are approved for the Biological Sciences major and taught overseas at the campus indicated. Students should discuss with their major advisers which courses would best meet individual needs. Descriptions are in the "Overseas Studies" section of this bulletin, or at the Overseas Studies Office, 126 Sweet Hall.

AUSTRALIA

BIOSCI 109Z. Coral Reef Ecosystems—(Same as CEE 168X, EARTHSYS 120X, HUMBIO 61X.)

3 units, Aut (Hoegh-Guldberg)

BIOSCI 110Z. Coastal Resource Management—(Same as CEE 168Y, EARTHSYS 121X, HUMBIO 62X.)

3 units, Aut (Johnstone)

BIOSCI 111Z. Coastal Forest Ecosystems—(Same as CEE 168Z, EARTHSYS 122X, HUMBIO 63X.)

3 units, Aut (Pole)