

BIOLOGICAL SCIENCES

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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 work and laboratory instruction in the Department of Biological Sciences conform to the "Policy on the Use of Vertebrate Animals in Teaching Activities" section of this bulletin.

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
Biology 44X	4
Biology 44Y (may be replaced by 4 units of 175H)	4
Biology 41 or 51*	5
Biology 42 or 52*	5
Biology 43 or 53*	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: Chemistry 31 (or 32), 33, 35, 36, 130 (or 132), 131, 135 (or 171). For those interested in ecology and evolution biology, an advanced math course of 100-level or above may be substituted for 130 or 132.
2. General Physics: Physics 21, 22, 23, 24; or 41, 43, 45, 47.
3. Math through calculus: Mathematics 19, 20, 21; or 41, 42.
4. One additional course in mathematics, statistics, or computer science: Mathematics 51 or beyond; Biology 141 (if taken to fulfill additional cognate requirement, this does not count toward the 24 elective unit requirement), or Psychology 10; Statistics 60 or beyond; or Computer Science 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. Biology majors *must* include two courses of at least 3 units each taught by two different Biological Sciences faculty members in the courses they take to fulfill the department's 24 elective unit requirement. Courses that are "team taught" by a Biological Sciences professor and a non-Biological Sciences professor will only count as 1/2 credit towards the faculty requirement. A list of Biological Sciences professors is available 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: Biochem. 200

Cell Biology—Molecular Organization: Bio. 128*
 Developmental Genetics: Bio. 132*
 Genetics: Bio. 118*
 Molecular Biology: Biochem. 201
 Prokaryote Genetics: Bio. 133*

2. Cell/Developmental

Cell Biology—Cellular Dynamics: Bio. 129
 Cell Biology—Molecular Organization: Bio. 128*
 Cell Physiology: Bio. 160H
 Developmental Genetics: Bio. 132*
 Genetics: Bio. 118*
 Prokaryote Genetics: Bio. 133*

3. Organismal

Comparative Animal Physiology: Bio. 162H
 Ecological and Evolutionary Physiology: Bio. 171H
 Ecology and Evolution of Plants: Bio. 138
 Human Physiology: Bio. 112
 Invertebrate Zoology: Bio. 161H
 Microbiology: Microbio. & Immun. 185
 Neurobiology: Bio. 153
 Neurobiology: Bio. 154
 Neurobiology & Behavior: Bio. 169H
 Plant Physiology: Bio. 256
 Vertebrate Biology: Bio. 110 (lecture only)
 Viruses: Bio. 213

4. Ecology and Evolution

Biogeography: Bio. 121
 Evolutionary Paleobiology: Bio. 136
 Behavioral Ecology: Bio. 145
 Oceanic Biology: Bio. 163H
 Principles of Ecology: Bio. 142
 Principles and Practice of Biosystematics: Bio. 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, 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 Mathematics 19, 20, 21, or Mathematics 41, 42 are minimum math 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

Bio. 41. Principles of Biology *	5		
Bio. 42. Principles of Biology*		5	
Bio. 43. Principles of Biology*			5
Bio. 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
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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 which 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.
4. All courses, other than the Biology Core (51, 52, or 53; or 41, 42, or 43), must be at or above the 100-level
5. Courses used to fulfill the minor may not be used to fulfill any other department degree requirements (minor or major).
6. At least one course from the Biology Core must be taken.
7. The Biology Core Laboratory (44X and 44Y) does not count towards the minor degree.
8. 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.)
9. 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 (Bio. 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 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 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; office hours posted quarterly).

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 Preprofessional Advising office (Undergraduate Advising Center, Sweet Hall).

COTERMINAL B.S./M.S. DEGREE

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 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) At least 9 of the 36 units must be 3-unit or more upper-division courses from the Department of Biological Sciences, taken from three different Biology faculty members. Teaching and research units do not fulfill this requirement.
 - c) 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.
 - d) Up to 18 of the 36 units may be a combination of biological research and teaching (Biology courses 175H, 198, 199, 290, 291, or 300).
2. The remaining 9 units may come from any other Stanford course work 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 request application information, instructions, and ma-

terials 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 12 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 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), a second course that can be either a core course or central menu course, and a third department course recommended to be an advanced course in the student's area of specialization.
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.

Biology 203: Advanced Genetics

Biology 214: Cell Biology of Physiological Process

Biochemistry 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) and one representative from the Graduate Studies Committee. (Three to five representatives from the Graduate Studies Committee are chosen to be available for these committees.)
 - 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 and the Graduate Committee representative.
- 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 publicize the exam and 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 Bio. 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 Developmental Biology 210; Molecular and Cellular Physiology 215; Neurobiology 200, 216, 230; or Psychology 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 nine quarters of full-time 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 meets 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

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)

9S. Introduction to Genetics—The basic principles and concepts of genetics at the classical, molecular, and population levels. Topics: mendelian genetics, cytogenetics, gene mapping, prokaryotic genetics, DNA structure and replication, transcription and translation, mutagenesis and DNA repair, recombinant DNA technology, genomics, regulation of gene expression, and population genetics. Model organisms used in genetic research; human examples when appropriate. Emphasis is on genetic analysis, including problem-solving.

3 units, Sum (Fowler)

STANFORD INTRODUCTORY SEMINARS

Enrollment in seminars 11 through 37 are either open primarily to freshmen or sophomores. See <http://www.stanford.edu/group/introsems/> for applications or more information.

11N. Stanford Introductory Seminar: Biotechnology in Everyday Life—Preference to freshmen. The science making transgenic plants and animals possible. Current and future applications of biotechnology, and the ethical issues raised. GER:2a (DR:5)

3 units, Aut (Walbot)

12N. Stanford Introductory Seminar: The Origin of Species—Preference to freshmen. Close reading of Darwin’s *Origin of Species* and additional secondary sources. Focus is on the logic of Darwin’s argument (what was the best evidence for evolution at the time the book was written?). What were the weakest points and missing pieces? How does each chapter contribute to the overall argument? How was Darwin’s thinking influenced by social conditions in his day? Oral presentations and a paper required. GER:2a (DR:5)

3 units (Ackerly) alternate years, given 2001-02

13N. Stanford Introductory Seminar: Environmental Problems and Solutions—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 (DR:5)
3 units, Spr (Ehrlich)

14N. Stanford Introductory Seminar: Plants and Civilization—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 (DR:5)
3 units, Spr (Mooney)

15N. Stanford Introductory Seminar: Environmental Literacy—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 various sources of expertise for the above be assessed, what components of several examples of environmental debates deal with factual and theoretical issues, and which are the political value judgments? Student-led discussions, student peer review and revised term papers, and oral paper presentation. GER:2a (DR:5)
3 units (Schneider) alternate years, given 2001-02

16N. Stanford Introductory Seminar: Island Ecology—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 (DR:5)
3 units, Win (Vitousek) alternate years, not given 2001-02

18N. Stanford Introductory Seminar: Plant Genetic Engineering—Preference to freshmen. Flavr-Savr tomatoes, Round-Up Ready soybeans, plastic plants. Lectures, readings, and discussions about genetically modified plants. A survey of crop modifications that have been made or are currently in development. Discussions of the scientific basis of genetic engineering in plants and its social, economic, and environmental consequences. Oral presentations and short term papers. GER:2a (DR:5)
3 units (C. Somerville, S. Somerville) not given 2000-01

19N. Stanford Introductory Seminar: Sex and Gender—An Evolutionary Perspective—Preference to freshmen. Themes: the feminist literature on gender and its social construction, mathematical theory for the evolution of sexual reproduction, and case studies of gender characteristics among animals and plants. Evolutionary studies from biology contribute to the understanding of gender, a topic mostly considered in the humanities and social sciences. Readings/discussion, term paper. Computer programming. GER:4c (DR:†)
3 units, Win (Roughgarden)

21N. Stanford Introductory Seminar: Readings in Molecular Biology and Genetics—Preference to freshmen. In-depth discussion of original research papers, parallel to what is being lectured on concurrently in Bio. 52. How to critically read original research papers to interpret and evaluate experimental findings on your own. Corequisite: 41.
3 units, Aut (Baker) alternate years, not given 2001-02

22N. Stanford Introductory Seminar: Infection and Immunity—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 written reports. Prerequisite: good biology background, AP biology or introductory college biology (41 or 42, or Human Biology 2A, 3A).

3 units, Spr (Jones)

26N. Stanford Introductory Seminar: Maintenance of the Genome—Preference to freshmen. The blueprint for life is entrusted to the DNA molecules in all living cells. Focus is on the systems that scan the cellular DNA for alterations and then make repairs to ensure genomic stability in the face of natural endogenous threats to DNA and due to radiation and chemicals in the external environment. Redundancy of the genetic message ensured by the complementary DNA strands in the double helix facilitates the recovery of information through excision repair when one of the strands is damaged, or when incorrect base pairings or small loops of unpaired bases occur. The predisposition to cancer involves a defect in DNA repair. New mechanistic understandings and their indications have made DNA repair important for investigations in oncology, aging, developmental biology, environmental health, and neurobiology. GER:2a (DR:5)

3 units, Spr (Hanawalt)

27N. Stanford Introductory Seminar: Nature and Nurture in Brain Development—Preference to freshmen. The brain consists of billions of neurons that are precisely interconnected in circuits that ultimately underlie our ability to think, behave, and perceive the world around us. During development, these neurons are born, migrate into position, and extend axons over long distances in order to contact appropriate target cells, wiring themselves into a particular circuit. The wiring of the brain is influenced by innate, genetically-driven processes and by our life experiences. The biological mechanisms that guide the development of neuronal circuits in animal model systems and humans. The relative influences of nature and nurture on neural development. Readings from the primary scientific literature focus student discussions. Corequisite: 42.

3 units (McConnell) alternate years given 2001-02

29N. Stanford Introductory Seminar: The Outer Limits of Life—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 (DR:5)
3 units, Spr (Bohannon)

37Q. Stanford Introductory Seminar: Evolution in Action—Preference to sophomores; companion course for those who are taking the Biology core. The study of natural selection: how can we find out whether evolution is occurring now in a natural population; based on a long-term study by Peter and Rosemary Grant of natural selection in the Darwin finches of the Galapagos Islands, finches which were also important to Darwin's formulation of the idea of evolution by natural selection. Readings in a popular account of the study and research of evolution by natural selection. Student research project; field trip to the California Academy of Sciences in San Francisco to look at specimens of finches. Goal is to develop ideas about what natural selection is and how it is studied empirically by ecologists. Corequisite: 43.

3 units, Aut (Gordon)

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: Chemistry 31 (or 32), 33, 35; Mathematics 19, 20, 21, or 41, 42.

41. Evolution, Genetics, Genomes and Biochemistry—Topics: 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 (Long, Simon, Simoni, Watt)

42. Molecular Cell Biology, Developmental Biology, and Neurobiology—Topics: 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, Long, Luo, Sapolsky)

43. Physiology, Ecology, and Behavioral Biology—Topics: 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, Jones, Ray)

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: Chemistry 31, 33. Recommended: Biological Sciences or Human Biology core and statistics; 44X and Y should be taken sequentially in same year. (WIM)

44X. *4 units, Win (Malladi, Yelton)*

44Y. *4 units, Spr (Malladi, Yelton)*

96A,B. Jasper Ridge Biological Preserve Docent Training Program—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 JRPB community after preparation.

2 units, Win, Spr (Vitousek)

INTERMEDIATE UNDERGRADUATE AND GRADUATE

106Z. Man-Environment Interactions: Case Studies from Central Chile—(Enroll in Overseas Studies 106H.)

5.5 units, Aut (Hajek)

110. Vertebrate Biology—(Enroll in Human Biology 110.)

3-4 units, Spr (Porzig)

110L. Vertebrate Biology Lab—(Enroll in Human Biology 110L.)

3 units, Spr (Porzig)

112/212. Human Physiology—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. Lectures/discussion. Prerequisite: Biological Sciences or Human Biology core.

4 units (Heller, Harris) alternate years, given 2001-02

117. Biology and Global Change—(Same as Earth Systems 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.

3 units, Win (Matson, Vitousek, Mooney)

118. Genetic Analysis of Biological Processes—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)

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 2001-02

124. Plant Physiological Ecology: From Leaf to Globe—A functional approach to understanding terrestrial vegetation. Prerequisites: 51, 53 or 42, 43; or consent of instructor.

4 units (Mooney, Berry, Field) alternate years, given 2001-02

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

3-4 units, Spr (Mooney)

128. Cell Biology: Molecular Organization—The biochemistry and biophysics of macromolecules, emphasizing how macromolecules interact to form complex cellular structures. Topics: protein biosynthesis and folding, structure assembly and functions of biological membranes, and mechanisms of membrane trafficking. Experimental logic and critical interpretation of experimental data. Prerequisite: Biological Sciences core.

4 units, Win (Kopito, Frydman)

129. Cell Biology: 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)

130. Algae/Fungi—Introduction to these groups, their utilization in molecular biology in studying biological problems, and their ecological significance. Lectures, lab, field trips. Prerequisite: Biological Sciences core or consent of instructor.

4 units (Grossman) alternate years, given 2001-02

132. Developmental Genetics—The uses of the tools of modern genetics to understand outstanding questions in developmental biology.

3 units (Baker) alternate years, given 2001-02

133. Genetics of Prokaryotes—Analysis of prokaryotic genes and genomes with emphasis on the evolution of genetic systems. Prerequisite: 41 or 52.

3 units, Aut (Campbell)

134. Replication of DNA—Modes of DNA replication and their control in prokaryotic and eukaryotic systems. Emphasis is on experimental approaches and their limitations. Critical review of current literature in seminar format. Lectures and student reports on specialized topics. Enrollment limited to 14 advanced undergraduates. Prerequisites: 41 or 52 and/or consent of instructor.

3 units (Hanawalt) not given 2000-01

136. Evolutionary Paleobiology—A paleontological approach to evolutionary theory. Topics: history of life, speciation, heterochrony, evolu-

tionary constraint, coevolution, macroevolution, the Cambrian Explosion, mass extinctions, taphonomy, life on land, life in the sea, life in the air.

4 units, Win (Hadly)

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, 52, or consent of the instructor.

3 units (Walbot) alternate years, given 2001-02

138. Ecology and Evolution of Plants—Introduction to the basic principles of ecology and evolutionary biology, focusing on plants. Topics: plants in the environment, population dynamics, natural selection in plant populations, the origin and maintenance of diversity, speciation, extinction, conservation of plant populations. Limited enrollment, lab with field trips and independent projects. Prerequisite: 43 or 51, or consent of the instructor. Recommended: statistics.

3-5 units (Ackerly) alternate years, given 2001-02

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) alternate years, given 2001-02

140. Population Biology of Butterflies—Field work on *Euphydryas* populations now under study on campus and elsewhere in California. Prerequisites: 43 or 51, and consent of instructor.

2-5 units, Spr (Ehrlich)

141. Biostatistics—Introduction to the statistical analysis of biological data. Lectures, discussion, and student exercises.

4-5 units, Win (Feldman)

142/242. Principles of Ecology—(Graduate students register for 242; same as Geophysics 142.) Introduction to ecology, emphasizing ecological theory and the population and community scales of organization, using primarily zoological examples. Evolutionary processes in ecology. Prerequisites: first-year calculus (Mathematics 19-21 or higher). Recommended: 43 or 51.

4 units, Aut (Roughgarden)

144. Conservation Biology—(Same as Human Biology 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 illustrate topics. Prerequisite: 43 or 51, Human Biology 2A, or consent of instructor.

3-4 units, Win (Boggs, Launer)

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. (WIM)

4 units, Spr (Gordon)

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

1 unit, Win (Feldman)

147. Controlling Climate Change in the 21st Century—(Same as Human Biology 147.) 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, Aut (Schneider, Rosencranz)

148. Colloquium on Biosystematics and Evolution—Panel discussion and outside speakers cover diverse 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 2001-02

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 (Sapolsky) alternate years, given 2001-02

151. Mechanisms of Neuron Death—Open to Biology majors with a strong background in neuroscience. Seminar on the cell and molecular biology of neuron death during neurological disease. Topics: the amyloid diseases (Alzheimer's), prion diseases (kuru and Creutzfeldt-Jacob), oxygen radical diseases (Parkinson's and ALS), triplet repeat diseases (Huntington's), and AIDS-related dementia. Lectures, discussions, and student presentations. Enrollment limited to 16.

3 units, Aut (Sapolsky)

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

4 units, Aut (Wine)

154/254. Molecular and Cellular Neurobiology—(Graduate students register for 254; same as Neurobiology 254.) Lecture/seminar for advanced undergraduates and graduate students, focusing 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, Schulman)

158. Developmental Neurobiology—Lecture/seminar for advanced undergraduates and coterminal master's 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; and 153 or Neurobiology 200, or consent of instructor.

4 units, Spr (McConnell) alternate years, not given 2001-02

184/284. Principles and Practice of Biosystematics—The basic principles and major operating procedures of systematic biology; the study of 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)
alternate years, not given 2001-02*

HOPKINS MARINE STATION

Note that several of these courses can be used to fulfill department menu requirements and that completion of the Biological Sciences core is a prerequisite for all of these courses. For course descriptions, see the "Hopkins Marine Station" section of this bulletin.

56H. Seminar: History and Philosophy of Science
2 units (Somero) alternate years, given 2001-02

160H/260H. Cell Physiology
4 units, Win (Epel)

161H/261H. Invertebrate Zoology
5 units, Win (Watanabe)

162H/262H. Comparative Animal Physiology
5 units, Spr (B. Block) alternate years, not given 2001-02

163H/263H. Principles of Oceanic Biology
4 units, Win (Denny, Somero)

164H/264H. Marine Botany
5 units, Win (Staff) alternate years, not given 2001-02

165H/265H. Air and Water
3 units, Spr (Denny) alternate years, not given 2001-02

166H/266H. Locomotion
3 units (Denny) alternate years, given 2001-02

167H/267H. Nerve, Muscle, and Synapse
5 units, Win (Gilly)

168H/268H. Seminar: Cellular Signal Transduction
1 unit, Spr (Thompson)

169H/269H. Neurobiology and Behavior
5 units, Win (Thompson)

170H/270H. Seminar: Topics in Marine Biology
1 unit, Win (Staff)

171H/271H. Ecological and Evolutionary Physiology
4 units, Win (Somero)

172H/272H. Marine Ecology
5 units, Spr (Micheli)

173H/273H. Marine Conservation Biology
3 units (B. Block) alternate years, given 2001-02

174H/274H. Experimental Design and Probability
3 units, Spr (Watanabe)

175H. Problems in Marine Ecology and Ecophysiology
*8 units, Spr (Denny, Micheli, Somero, Watanabe,
Epel, B. Block)*

176H. Experimental Neurobiology
8 units, Spr (Gilly, Thompson)

177H. Seminar: Cell Physiology of Stress
2 units, Spr (Epel) alternate years, not given 2001-02

178H. Seminar: Deep Sea Biology

2 units, Spr (Somero) alternate years, not given 2001-02

179H. Subtidal Communities
6 units, Sum (Watanabe)

180H/280H. Problems in Subtidal Ecology
6 units, Sum (Watanabe)

277H. Biomechanics and Ecological Physiology of Intertidal Communities
4 units, Sum (Denny, Somero) alternate years, not given 2001-02

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 Bio. 2.

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)

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. Current research topics in biology. Limited enrollment. Prerequisite: Biological Sciences core. Recommended: 199.

1 unit, Aut, Win, Spr (Black)

194/294. Seminar in Environmental Policy Research—Principles of and current problems in environmental policy. Lectures, student presentations, and intensive library research or participation in group research project required. May be repeated for credit. Prerequisite: consent of instructor.

3 units (Ehrlich) alternate years, given 2001-02

198. Directed Instruction/Reading—May be taken as a prelude to research. Read/discuss biology-related literature with a faculty sponsor, possible participation in a lab or research group seminars, and library research. 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/>, Research and Honors under "Research Courses" for information on research sponsors, units, petition instructions, deadlines, credit for summer research, and out-of-Stanford research, or email kblack@leland for more information.

198H. Directed Instruction/Reading—For work done under supervision of Hopkins Marine Station faculty.

199. Undergraduate Research—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/>, Research and Honors under "Research Courses" for information on research sponsors, units, petition instructions, deadlines, credit for summer research, and out-of-Stanford research, or email kblack@leland for more information.

199H. Undergraduate Research—For undergraduate research done under supervision of Hopkins Marine Station faculty.

ADVANCED UNDERGRADUATE AND GRADUATE

203. Advanced Genetics—(Same as Genetics 203.) Explores 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 Suzuki, et al, or Hartl, et al.

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

205. DNA Repair and Mutagenesis—Interactions of endogenous and environmental mutagens with 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. The relationships of DNA repair to mutagenesis and carcinogenesis. Lectures/discussion of selected topics and review of current research literature. Prerequisites: 41 or 52, 118, and/or consent of instructor.

3 units, Spr (Hanawalt)

207. The Life and Death of Proteins—How proteins are made and degraded in the cell. Critical reading/discussion of primary literature. Selected “case studies” follow the evolution of scientific ideas, and evaluate how different experimental approaches can 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 (Frydman) alternate years, given 2001-02

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

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

209. Advanced Neurosciences Laboratory—The use of equipment and techniques required to record and analyze extracellular and intracellular activity in vertebrates, or other state-of-the-art neuroscience techniques. In-depth training in a subset of these techniques as applied to a specific research project. Students present/critically evaluate representative neuroscience methodologies in weekly discussion groups. Enrollment limited to 10; admission by application (available in Student Services office). Prerequisites: Biological Sciences or Human Biology core sequence and core lab (44 or equivalent). Recommended: some advanced course work in neurobiology.

4 units, Win (Heller, Grahn)

211. Biophysics of Sensory Transduction—The diverse 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, e.g., sensitivity, amplification, encoding, adaptation, and the molecular basis of cellular signaling. Lectures and student-led presentations cover interdisciplinary aspects of biology and physics. Prerequisites: familiarity with undergraduate physics (with calculus) and basic biology.

4 units, Spr (S. Block)

213. Viruses—Principles of virus growth, genetics, architecture, and assembly. The relation of temperate viruses and other episomes to the host cell. Prerequisite: 41 or 52. Recommended: 118.

3 units, Win (Campbell)

214. Cell Biology of Physiological Processes—(Same as Molecular and Cellular Physiology 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. Must be taken concurrently with 214A-H. Prerequisites: Biological Sciences core, Biochemistry 201.

4 units, Win (Rexach, Nelson, Frydman, Jackson, Theriot, Fang)

214A,B,C,D,E,F,G,H. Cell Biology of Physiological Processes—(Same as Molecular and Cellular Physiology 221A-H.) Required course taken with 211, taught by medical school faculty. Meant to expand on the topics covered in 214. Students must register for only one section. Prerequisites: Biological Sciences core, Biochemistry 201.

2 units, Win (Staff)

215. Biochemical Evolution—Lectures/discussion covering the biochemical viewpoints on diverse aspects of 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, Win (Watt)

216. Ecosystem Ecology and Global 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 coterminous students.

3 units, Spr (Vitousek) alternate years, not given 2001-02

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 Civil and Environmental Engineering 163, and math through differential equations, or consent of instructor.

3 units (Schneider) alternate years, given 2001-02

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 (Bohannon)

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. Prerequisites for undergraduates: Biological Sciences or a Human Biology core, or consent of instructor.

4 units, Aut (Jones)

237. Introduction to Biotechnology—(Enroll in Chemical Engineering 450.)

3 units, Spr (Robertson, Swartz)

249. Neural Basis of Sleep and Circadian Rhythms—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,

Human Biology 4A, Psychology 70, or consent of instructor).
4 units, Aut (Heller, Edgar) alternate years, not given 2001-02

256. Plant Physiology—The physiological functions of land plants from analytical and quantitative points of view; photosynthetic energy and gas exchange; 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, temperature, etc. Prerequisite: Biological Sciences core.

4 units, Win (Ray)

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

4 units, Spr (McConnell) alternate years, not given 2001-02

274A. Environmental Microbiology I—(Enroll in Civil and Environmental Engineering 274A.)

3 units, Aut (Spormann)

274B. Environmental Microbiology II—(Enroll in Civil and Environmental Engineering 274B.)

3 units, Win (Spormann)

274C. Environmental Microbiology Laboratory—(Enroll in Civil and Environmental Engineering 274C.)

3 units, Spr (Spormann)

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)

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)

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.

2 units, Aut, Win (Malladi, Yelton)

PRIMARILY FOR GRADUATE STUDENTS

300. Research—For graduate students only. Individual research taken 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/>, Research and Honors under "Research Courses" for information on research sponsors, units, petition instructions, deadlines, credit for summer research, and out-of-Stanford research, or email kblack@leland for more information.

300H. Research—For graduate research done under supervision of Hopkins Marine Station faculty.

301. Current Topics in Molecular, Cell, Developmental, Genetics, and Integration Biology—Enrollment limited to Biological Sciences Ph.D. students in the first year of graduate study. Lectures in areas of the faculty's current research interests.

1 unit, Aut (Staff)

302,303,304. Current Topics in Ecology and Evolution—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.

302. *1 unit, Aut (Bohannon)*

303. *1 unit, Win (Bohannon)*

304. *1 unit, Spr (Bohannon)*

303. Concepts in Ecology and Evolution—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 unit, Win (Bohannon)

304. Concepts in Ecology and Evolution—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 unit, Spr (Bohannon)

305. Seminar on DNA Repair and Genetic Toxicology—Enrollment limited to graduate students and advanced undergraduate students doing research in this field. Literature review and discussion of current research, emphasizing experimental approaches for studying DNA damage processing in bacteria, yeast, and mammalian cells. Prerequisite: consent of instructor.

1-3 units, Aut, Win, Spr (Hanawalt)

306. Current Topics in Integrative Organismal Biology—Enrollment limited to graduate students doing research in this field.

1 unit, Aut (Staff)

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 (Bohannon)

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, qtr. by arrangement (Watt)

333. Seminar in 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, Spr (Ackerly) alternate years, not given 2001-02

341. Advanced Plant Physiological Ecology—Projects and discussion in research topics on plant physiological ecology.

3 units, Spr (Mooney, Berry, Field)

alternate years, not given 2001-02

342. Plant Biology Seminar—Topics announced at the beginning of each quarter. In-depth coverage of the current literature.

1 unit, Spr (Walbot, Berry, Björkman, Briggs, Grossman, Hoffman, Long, Mooney, Ray, Vitousek)

346. Advanced Seminar in Molecular Microbiology—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, Yanofsky)

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)

384. Seminar in Theoretical Ecology—(Same as Geophysics 185Y.) Discussions of recent and classical research papers in ecology, and presentation of work in progress by participants. Prerequisite: consent of instructor.

1-3 units, Spr (Roughgarden)

459. Frontiers in Interdisciplinary Biosciences—(Cross-listed in multiple departments in the schools of Humanities and Sciences, Engineering, and Medicine; students should enroll directly through their affiliated department, if at all possible.) Introduction to cutting-edge research involving interdisciplinary approaches to bioscience and bio-

technology; for specialists and non-specialists. Associated with Stanford's Clark Center for interdisciplinary Bioscience, and held in conjunction with a seminar series meeting twice monthly during 2000-01. Leading investigators from Stanford and throughout the world speak on their research; students also meet separately to present and discuss the ever-changing subject matter, related literature, and future directions. Prerequisite: keen interest in all of science, with particular interest in life itself. Recommended: basic knowledge of biology, chemistry, and physics.

2 units, Aut, Win, Spr (S. Block)