

## Faculty

Christopher C. Glembotski, Ph.D., Professor of Biology,  
Chair of Department

J. David Archibald, Ph.D., Professor of Biology

Sanford I. Bernstein, Ph.D., Professor of Biology  
(Graduate Adviser, Biology Ph.D. program)

Annalisa Berta, Ph.D., Professor of Biology,  
Associate Chair of Department

Richard L. Bizzoco, Ph.D., Professor of Biology

Michael J. Breindl, Ph.D., Professor of Biology,  
Graduate Coordinator, Biology (Graduate Adviser, Microbiology)

Michael J. Buono, Ph.D., Professor of Biology

Lo-chai Chen, Ph.D., Professor of Biology

Roger A. Davis, Ph.D., Professor of Biology

Kathleen M. Fisher, Ph.D., Professor of Biology

Terrence G. Frey, Ph.D., Professor of Biology (Graduate Adviser,  
Molecular Biology)

Barbara B. Hemmingsen, Ph.D., Professor of Biology

Stuart H. Hurlbert, Ph.D., Professor of Biology

Gerald G. Johnson, Ph.D., Professor of Biology

Skaidrite Krisans, Ph.D., Professor of Biology,  
Associate Dean for Student Services, Graduate Division

Leroy R. McClenaghan, Jr., Ph.D., Professor of Biology

Kathleen L. McGuire, Ph.D., Professor of Biology

Walter C. Oechel Ph.D., Professor of Biology  
(Graduate Adviser, Ecology Ph.D. program)

Paul J. Paolini, Jr., Ph.D., Professor of Biology

Jacques Perrault, Ph.D., Professor of Biology

Robert S. Pozos, Ph.D., Professor of Biology

Roger A. Sabbadini, Ph.D., Professor of Biology

Michael G. Simpson, Ph.D., Professor of Biology

Constantine Tsoukas, Ph.D., Professor of Biology

Judith W. Zyskind, Ph.D., Professor of Biology

Vernon L. Avila, Ph.D., Associate Professor of Biology

Zac Hanscom, III, Ph.D., Associate Professor of Biology

Greg L. Harris, Ph.D., Associate Professor of Biology  
(Graduate Adviser, Physiology)

Anca Mara Segall, Ph.D., Associate Professor of Biology

Kathy S. Williams, Ph.D., Associate Professor of Biology

Todd W. Anderson, Ph.D., Assistant Professor of Biology

Andrew J. Bohonak, Ph.D., Assistant Professor of Biology

Colin J. Brauner, Ph.D., Assistant Professor of Biology

Kevin Burns, Ph.D., Assistant Professor of Biology (Graduate Adviser,  
Evolutionary Biology)

Douglas H. Deutschman, Ph.D., Assistant Professor of Biology  
(Graduate Adviser, Ecology)

James Diffendorfer, Ph.D., Assistant Professor of Biology

Marshal C. Hedin, Ph.D., Assistant Professor of Biology

Brian T. Hentschel, Ph.D., Assistant Professor of Biology

Kevin A. Hovel, Ph.D., Assistant Professor of Biology

David Lipson, Ph.D., Assistant Professor of Biology

Tod W. Reeder, Ph.D., Assistant Professor of Biology

Robert W. Zeller, Ph.D., Assistant Professor of Biology

## Associateships and Assistantships

Graduate teaching associateships and graduate assistantships in biology are available to a limited number of qualified students. Application blanks and additional information may be secured from the graduate coordinator in biology.

## General Information

The Department of Biology offers graduate study leading to the degrees of Master of Arts and Master of Science in biology and the Master of Science degree in microbiology. In addition, the Department of Biology offers a joint program leading to the Ph.D. with the University of California, San Diego, and the ecology group offers a joint program leading to the Ph.D. with the graduate group in ecology at the University of California, Davis.

A modern life science building provides facilities for graduate study in the biological sciences. Additional facilities available in the community include the San Diego Zoo hospital, the United States Department of Agriculture, Fish and Game Commission, the Hubbs-Sea World Research Institute, the San Diego Natural History Museum, and the Naval Underseas Center. San Diego State University also operates a marine laboratory on Mission Bay and has access to research sites in the Chihuahuah Valley, Fortuna Mountain, and Temecula (Riverside County).

## Section I. Master's Degree Programs

The Master of Arts degree in biology, with its foreign language requirement, is considered to be essentially an academic degree that serves as a stepping stone to certain higher degree programs. The Master of Science degrees in biology and microbiology are also acceptable as preparation for more advanced degree programs. Studies for degrees in biology must be completed in one of the research programs listed below.

## Admission to Graduate Study

In addition to the general requirements for admission to the University with classified graduate standing, as described in Part Two of this bulletin, a student must satisfy the following requirements before he/she will be considered for recommendation to enter the masters program.

1. Meet the requirements deemed equivalent to a baccalaureate degree in biology or microbiology at San Diego State University.
2. Have a grade point average of 2.75 or better on work taken for the baccalaureate degree.
3. Have a grade point average of 3.0 or better in upper division courses (at least 24 units) acceptable for the major.

4. Meet biology departmental expectations on the GRE General Test.
5. Have a score above the 60th percentile rank on the GRE Subject (Advanced) Test in Biology or Biochemistry.
6. Be considered as capable of graduate work in the biological sciences by two letters of reference submitted to the biology graduate coordinator.
7. Be accepted by a research program and be sponsored by a faculty member of the area.

NOTE: Admission to a research program within the biology graduate program will be limited to the number of students for which adequate facilities and faculty sponsorship are available. Students should therefore be as specific as possible in their indication of research interests and career goals. Individual research programs will admit students solely on the basis of merit in relation to space and faculty availability.

Students who do not meet all of the above requirements for admission with classified graduate standing may be admitted with conditionally classified graduate standing upon the recommendation of the research program. Students so admitted will be advised as to the nature of their deficiency and the time to be allowed to achieve full classified graduate standing.

Students applying for admission should electronically submit the University application available at [www.csumentor.edu](http://www.csumentor.edu).

The following materials should be submitted as a complete package directly to the Department of Biology:

- (1) Two sets of official transcripts (in sealed envelopes) from each issuing institution;
- (2) Personal statement;
- (3) Resume or curriculum vitae;
- (4) Three letters of recommendation in sealed and signed envelopes (form available online or may be obtained from department).

Mail or deliver your complete admissions package to:

Department of Biology  
Graduate Coordinator  
San Diego State University  
5500 Campanile Drive  
San Diego, CA 92182-4614

## Biology

### Advancement to Candidacy

All students must satisfy the general requirements for advancement to candidacy, including the foreign language requirement for the Master of Arts degree, as stated in Part Two of this bulletin. Satisfactory progress on the thesis research will be prerequisite to obtaining departmental approval for advancement.

### Specific Requirements for the Master of Arts Degree in Biology

In addition to meeting the requirements for classified graduate standing and the basic requirements for the master's degree as described in Part Two of this bulletin, the student must complete a graduate program of 30 units of upper division and graduate courses selected, with the approval of the graduate coordinator, from the biological sciences as listed below, or from closely related fields. At least 15 of the units selected must be in 600- and 700-numbered courses, including Biology 799A, Thesis. A maximum of six units of the required 30 units may be selected from acceptable courses offered in the College of Education. A reading knowledge of scientific French, German, Russian, or Spanish, and a final oral examination in the field of the thesis and its implications in the broad fields of biology are also required.

### Specific Requirements for the Master of Science Degree in Biology

In addition to meeting the requirements for classified graduate standing and the basic requirements for the master's degree as described in Part Two of this bulletin, the student must complete a graduate program of 30 units of upper division and graduate courses selected, with the approval of the graduate coordinator, from the biological sciences as listed below, or from closely related fields. At least 15 of the units selected must be in 600- and 700-numbered courses, including Biology 799A, Thesis. A maximum of six units of the required 30 units may be selected from acceptable courses offered in the College of Education. A final oral examination in the field of the thesis and its implication in the broad fields of biology is also required.

The department expects students to complete all degree requirements within seven years. The graduate coordinator, in some circumstances, may permit a student to validate a course for recency only by repeating the outdated course or an equivalent course (see section of this Bulletin on "Degree Time Limitations").

### Master's Degree Research Programs

**Ecology (Major Code: 04201):** The overall program emphasizes quantitative approaches to ecological research and the framing of problems within the general context of ecological theory. Faculty and student research currently falls into the areas of limnology, marine ecology, plant community ecology and primary productivity, physiological plant ecology, marine aquaculture and fisheries ecology, animal population ecology and energetics, ecological genetics, ecosystems management, and systems ecology. Program adviser, L. McClenaghan.

**Evolutionary Biology (Major Code: 04071):** This research program is broadly concerned with the biology and evolution of whole organisms. The student has a wide variety of research areas from which to choose, including morphology, systematics, paleontology, natural history, behavior, comparative physiology, developmental biology, population genetics, coevolution, and evolutionary theory. Many groups of organisms are studied, including marine and terrestrial invertebrates, vertebrates, and plants. Program adviser, Reeder.

In addition to the emphases described above, a number of faculty have active research programs in marine biology and accept graduate students in this area.

**Microbiology (Major Code: 04111):** A separate graduate degree is offered in microbiology. Program adviser, Breindl.

**Molecular Biology (Major Code: 04161):** The program area is concerned with biology at the molecular level, with particular emphases on the correlation of structure and function of macromolecules, catalysis and control, molecular genetics, regulation of gene expression, and the molecular basis of cellular architecture, cell movement, bioenergetics and membrane function (administered through Molecular Biology Institute). Program adviser, Sabbadini.

**Physiology (Major Code: 04101):** The major subareas of interest represented by the faculty in the physiology program area include comparative cellular physiology (especially osmoregulation, endocrinology and sensory physiology), photobiology, radiation biology, nerve and muscle physiology, and plant ecophysiology. Program adviser, Harris.

## Microbiology

### Advancement to Candidacy

All students must satisfy the general requirements for advancement to candidacy, as stated in Part Two of this bulletin. Satisfactory progress on the thesis research will be prerequisite to obtaining departmental approval for advancement.

## Specific Requirements for the Master of Science Degree in Microbiology

(Major Code: 04111)

In addition to meeting the requirements for classified graduate standing and the basic requirements for the master's degree as described in Part Two of this bulletin, the student must complete a graduate program of 30 units of upper division and graduate courses selected, with the approval of the graduate adviser, from the biological sciences and closely related fields. All students entering the Master of Science program in microbiology will be required to take an advanced course in molecular biology. Students who achieve a sufficiently high score on the molecular biology entrance examination given to all incoming microbiology M.S. students may be excused from this requirement.

Not less than 18 units must be selected from courses in the area of microbiology. Among the 600- and 700-numbered courses selected, the student's program must include Biology 799A, Thesis, and at least four units of seminar. A maximum of six units of the required 30 units may be selected from acceptable courses offered in other related areas, including the College of Education and the Graduate School of Public Health.

A final oral examination on the field of the thesis and its implication in the broad fields of microbiology is required.

### Section II. Doctoral Programs

San Diego State University is in the process of securing approval for a joint Ph.D. program in Evolutionary Biology with the University of California, Berkeley. For further information, contact the Department of Biology.

## Biology (Cell and Molecular)

(Major Code: 04011)

The cooperating faculties of the Departments of Biology at the University of California, San Diego and at San Diego State University offer a joint doctoral program in biology (cell and molecular). The research interests of the participating faculty members cover a wide range of biological problems.

At SDSU, the major areas of research at the graduate level and the participating faculty members include:

**Biological structures:** J. Love.

**Cardiovascular molecular biology:** R. Davis, C. Glembotski, S. Krisans, R. Sabbadini.

**Cell and molecular immunology:** K. McGuire, C. Tsoukas.

**Gene expression:** G. Harris, W. Stumph, R. Zeller, J. Zyskind.

**DNA recombination and chromosome structure:** A. Segall.

**Membrane transport and energy transduction:** T. Frey.

**Molecular biology of RNA viruses and bacteriophage:** M. Breindl, J. Perrault.

**Substructure and function in motile cells:** S. Bernstein, R. Bizzoco, P. Paolini.

### Program

#### Undergraduate Preparation for Admission

Applicants for admission to the doctoral program offered jointly by UCSD and SDSU must present evidence of adequate preparation and

capacity for advanced work in biology. There are no inflexible requirements for entrance to graduate study in this program, but a strong background in biology, mathematics, chemistry, and physics is recommended. The applicant must have a bachelor's degree or the equivalent from an accredited institution of higher learning with training comparable to that provided by the University of California's and San Diego State University's undergraduate programs. Admission to the program requires acceptance by each institution on recommendation of the participating departments at UCSD and SDSU. It is understood that acceptance of a student into the joint program by each of the departments will be conditioned by their respective standards for graduate admissions and also by available facilities.

#### Application

Students applying for admission to the joint doctoral program in biology should electronically submit the University application available at [www.csumentor.edu](http://www.csumentor.edu).

Applicants must have the GRE results forwarded by the Educational Testing Service (official copy requested at time of test; SDSU code 4682). The general GRE is required. The TOEFL score is required if postsecondary instruction was in a language other than English.

The following materials should be submitted as a complete package directly to the Department of Biology:

- (1) Two sets of official transcripts (in sealed envelopes) of all previous academic work;
- (2) Statement of professional goals;
- (3) Resume or curriculum vitae;
- (4) Department application and residence form ([www.bio.sdsu.edu/cmb/phd\\_app\\_proced.html](http://www.bio.sdsu.edu/cmb/phd_app_proced.html), or may be obtained from the department);
- (5) Three letters of recommendation in sealed and signed envelopes (form available online or may be obtained from the department).

Mail or deliver your complete admissions package to:  
Biology Joint Doctoral Program Coordinator  
Department of Biology  
San Diego State University  
5500 Campanile Drive  
San Diego, CA 92182-4614

#### Residency Requirements

After formal admission to the joint doctoral program, the student must spend at least one academic year in full-time residence at each of the two campuses. The definition of residence must be in accord with the regulations of the University of California, San Diego, and San Diego State University.

#### Advising Committee

Upon admission to the program the joint doctoral graduate adviser will establish an advising committee for the student. This committee will consist of three faculty members. In consultation with the student, the committee will develop the student's course of study and will establish the student's joint qualifying committee.

#### Course Requirements

There is no specific number of courses required for the doctoral program in biology, except a one-year graduate course including genetics, cellular and molecular biology. Prior to taking the qualifying examination, every student is expected to have a firm understanding of modern biological principles. Usually students will be expected to complete a set of at least four laboratory rotations, and such rotations may be fulfilled on either campus.

Coursework may be selected from offerings at either UCSD or SDSU.

### Qualifying Examinations

#### Qualifying Committee

The qualifying committee consists of five faculty members, at least two from UCSD (one of whom must be a full-time faculty member in the Biology Department). The dissertation adviser may be a member of the qualifying committee. The members of the qualifying committee will be selected by the advising committee in consultation with the student. In order to provide continuity between examinations, at least one member of the qualifying committee shall be a member of the SDSU Executive Committee. Final appointment of qualifying committee members will be made jointly by the Graduate Deans of SDSU and UCSD.

The qualifying committee will be responsible for carrying out the qualifying examination, and the chair of this committee will report the outcome of the examination and any related academic recommendations to the Executive Committee. The chair will also provide a written evaluation of the student's performance. The chair of the qualifying committee is responsible for notifying the members of the time and place of the examination, and the student is responsible for obtaining all required documents necessary for the examination four weeks before the scheduled examination time.

#### Qualifying Examination

The examination will be administered in one session and consists of two parts.

**First Part:** Oral presentation of thesis research results and proposed thesis plan (duration is 40-50 minutes, similar to a formal seminar presentation, slides, etc.). The student should come prepared to defend the overall experimental design, including possible outcomes and interpretations, and be thoroughly familiar with the literature in his or her chosen field. A major portion of this examination will be devoted to background information so that a student can demonstrate the context in which the proposed research project lies. A succinctly written version of the proposed thesis plan (maximum 14 double spaced pages) should be provided to committee members at least two weeks before the presentation. Prior written approval by all SDSU Qualifying Committee members stating that the written thesis proposal is sufficiently developed must be obtained before the oral presentation takes place.

**Second Part:** In consultation with the members of the Qualifying Committee, the student will select two subject areas broadly related to the thesis research. Two members of the Qualifying Committee with expertise in these areas will serve as primary mentors. The student will carry out literature research in each of the topics and select three to four research papers in each area to be discussed during the examination. Each of the papers to be discussed must meet the approval of the two primary mentors. The student will be expected to answer questions on the selected papers, relevant background, and potentially related topics. A major goal of this portion of the examination is to test the student's ability to extract information from the literature, to critically and objectively analyze this information, and to formulate a thorough knowledge base of the subject area.

The qualifying committee may specify a course of study to strengthen any weaknesses identified during the qualifying examination. Upon successful completion of the qualifying examination the student must make application to the office of Graduate Studies at UCSD for advancement to candidacy. Upon payment of the candidacy fee to UCSD, and after approval by the graduate deans on both campuses, the office of Graduate Studies at UCSD will notify the student of advancement to candidacy.

#### Joint Dissertation Committee

After a student is admitted to candidacy, a dissertation committee consisting of at least five faculty members is nominated by the graduate advisers and appointed jointly by the Graduate Deans at SDSU and UCSD. The student's dissertation research adviser will be the chair of this committee. At least one member of this committee must be from SDSU and one member must be a full-time faculty member from UCSD.

#### Dissertation

Following successful completion of the qualifying examination, the major remaining requirement for the Ph.D. degree will be satisfactory completion of a dissertation consisting of original and significant research carried out under the guidance of a faculty member. Requirements currently in force at UCSD and SDSU must be met for completing and filing the dissertation.

#### Award of the Degree

The Doctor of Philosophy degree in biology will be awarded jointly by the Regents of the University of California and the Trustees of The California State University in the names of both institutions.

#### Financial Support

The Department of Biology at SDSU endeavors to provide adequate support for all students so that full time can be devoted to research, training, and study. During 2000-01, support package included tuition, a stipend (approximately \$16,000), health coverage, and funds for research supplies. All students are required to obtain teaching experience, which is normally accomplished by appointment as a graduate teaching associate.

### Faculty

The following faculty members of the cooperating institutions participate in the joint doctoral program being available for direction of research and as members of joint doctoral committees.

#### San Diego State University:

Graduate Adviser S. Bernstein

Faculty: Bernstein, Bizzoco, Breindl, Davis, Frey, Glembotski, Harris, Krisans, Love (Chemistry), McGuire, Paolini, Perrault, Sabbadini, Scott (Psychology), Segall, Stumph (Chemistry), Tsoukas, Zeller, Zyskind.

#### University of California, San Diego:

Graduate Adviser: S. Brody

Faculty: All UCSD Biology Faculty

### Ecology

#### (Major Code: 04201)

The cooperating faculties of the Department of Biology, San Diego State University and the Graduate Group in Ecology, University of California, Davis offer a joint program in ecology leading to the Ph.D. The research interests of the participating faculty members cover a wide range of problems and represent the interdisciplinary nature of modern biology.

At SDSU, the research projects are underway concerning:

**Coastal and marine ecology:** Study of estuarine wetland functions, food webs, effects of natural and human disturbance, and interaction of native and exotic species. Population dynamics of invertebrates (esp. echinoderms). Community ecology of coral reefs, eelgrass beds, rocky shores, sandy beaches, the Salton Sea and other saline lakes.

**Physiological ecology:** Effects of global change (elevated CO<sub>2</sub> and climate change) on the structure and functioning of terrestrial ecosystems, including local chaparral, deserts, Alaska's North Slope, and vegetation near CO<sub>2</sub>-emitting springs. Comparative and ecological physiology of vertebrates.

**Population ecology:** Reproductive biology of marine plants (algae and seagrasses). Analysis of life history strategies in animal and plant populations. Responses of chaparral vegetation to fire. Study of insect population dynamics and insect-plant interactions in natural and disturbed habitats. Aquaculture of marine fish. Genetic variation in small mammals. Food choice and adequacy of diets of animals in captivity.

**Restoration and conservation ecology:** Application of ecological principles to conserve species, manage fire, restore disturbed habitats, and retain genetic diversity (esp. in marine plants). Development of methods for assessing, restoring and creating coastal wetland ecosystems. Evaluation of efforts to restore or create deserts, coastal sage scrub, vernal pool, and riparian ecosystems. Role of mycorrhizae and soil biology in restoring vegetation.

A complete list of SDSU faculty and their research interests can be obtained from the graduate adviser of the program.

### Program

#### Undergraduate Preparation for Admission

Applicants for admission to the doctoral program must present evidence of adequate preparation and capacity for advanced work in ecology. Preparation should include a strong background in biology, physics, chemistry, and mathematics. Applicants must have a bachelor's degree from an accredited college or university. Acceptance of a student into the joint program by each institution depends on meeting the standards of admission of the respective institutions and by available facilities for research and instruction.

#### Application

Application for admission must be made simultaneously to San Diego State University and the University of California, Davis. A complete application requires:

The appropriate application form.

Three letters of recommendation (send directly to Graduate Adviser, SDSU).

Transcripts of academic work already completed.

Results of the Graduate Record Examination, including the Advanced Biology Test score.

#### Residency Requirements

After formal admission to the joint doctoral program, the student must spend at least one academic year in full-time residence on each of the two campuses. The definition of residence must be in accord with the regulations of the University of California, Davis, and San Diego State University.

#### Advising Committee

Upon admission to the program, the doctoral graduate advisers of the two institutions will establish an advising committee for the student. This committee will consist of three faculty members chosen jointly from the two cooperating institutions. In consultation with the student, the committee will develop the student's course of study and will establish the student's joint qualifying committee. At least one member of the advising committee must be from SDSU and one from UCD.

#### Course Requirements

Upon arrival at SDSU the advising committee works with the student to develop a course of study, which involves coursework at both SDSU and UCD and core requirements at UCD (three quarters of Ecology 296, three Ecology 290 seminars, and Principles and Application of Ecological Theory [Ecology 200A, 200B]). Prior to taking the qualifying examination, students complete the course of study, including the three quarters at UCD, and develop a firm understanding of ecological principles and research methods.

There is a five-year limit for completion of the Ph.D. in Ecology following advancement to candidacy.

## Qualifying Examinations

#### Qualifying Committee

A five-member committee, composed of appropriate numbers of faculty members from each of the cooperating institutions, will be recommended by the advising committee for each student and approved by the Graduate Deans from each institution. The student's dissertation adviser cannot be a member of the qualifying committee.

The qualifying committee will conduct an oral comprehensive qualifying examination, which will evaluate the student's understanding of modern biological principles. The examination will focus on

principles of ecology, research methods, and three areas related to the major research interest of the student. The purpose of this examination is to permit the student to demonstrate competence not only in the major research field but also in related areas of ecology.

The joint qualifying committee may specify a course of study to strengthen any weaknesses identified during the qualifying examination. Upon successful completion of the qualifying examination, the student must make application to the Graduate Division at UCD for advancement to candidacy. Upon payment of the candidacy fee to UCD, and after approval by the graduate deans on both campuses, the Graduate Division at UCD will notify the student of advancement to candidacy.

#### Joint Dissertation Committee

After a student is admitted to candidacy, a dissertation committee consisting of at least three faculty members is nominated by the graduate advisers and appointed jointly by the graduate deans at SDSU and UCD. The student's dissertation research adviser will be the chair of this committee. At least one member of this committee must be from SDSU and one member from UCD.

#### Dissertation

Following successful completion of the qualifying examination, the major remaining requirement for the Ph.D. degree will be satisfactory completion of a dissertation consisting of original and significant research carried out under the guidance of a faculty member. Requirements currently in force at UCD and SDSU must be met for completing and filing the dissertation.

#### Award of the Degree

The Doctor of Philosophy degree in ecology will be awarded jointly by the Regents of the University of California and the Trustees of The California State University in the names of both institutions.

#### Financial Support

The Department of Biology at SDSU endeavors to provide adequate support for all students so that full time can be devoted to research training and study. During 1997-98, the support included tuition, a stipend, and funds for research supplies. All students are required to obtain teaching experience, which is normally accomplished by appointment as a graduate teaching associate.

## Faculty

#### Graduate Advisers:

San Diego State University: W. Oechel  
University of California, Davis: H. Lieth

**SDSU Faculty:** Anderson, Chen, Deutschman,  
Diffendorfer, Hanscom, Hentschel,  
Hurlbert, McClenaghan, Oechel, K. Williams

## Courses Acceptable on Master's and Doctoral Degree Programs in Biology (BIOL)

### UPPER DIVISION COURSES

**Writing Requirements:** Completion of the English Placement Test and Writing Competency requirements is a prerequisite for all upper division biology courses numbered 350 and above.

#### 507. Topics in Ecology (2-4)

Two or three lectures and 0 to 6 hours of laboratory.

Prerequisite: Biology 354 and as may be indicated in the Class Schedule.

Treatment of particular advanced aspects of ecology not covered in regular courses, including insect ecology, intertidal ecology, and ecology of the Colorado River Delta. See Class Schedule for specific content. Maximum credit six units.

### 508. Coevolution (3)

Prerequisites: Biology 352 and 354.

Coevolution in interspecific interactions, like herbivory, predation, parasitism, competition, pollination, and mimicry.

### 509. Evolutionary Biology (3)

Two lectures and two hours of activity.

Prerequisite: Biology 352.

Evolutionary biology including genetics of populations, speciation, systematic biology, adaptation, role of development in evolution, evolution of behavior, and comparative biology. Evolutionary biology as the central organizing principle of biology.

### 512. Evolution and Ecology of Marine Mammals (3)

Two lectures and three hours of laboratory.

Prerequisites: Biology 352 and 354.

Biology of marine mammals to include pinniped, cetacean and sirenian evolution, diet and foraging strategies, social organization, reproductive strategies, echolocation, diving physiology, and conservation.

### 513. Marine Microbiology (2)

Prerequisites: Biology 350 or an introductory course in microbiology and consent of instructor.

Microbiological population of estuary and ocean waters; interrelationships with other organisms and the physical and chemical environment.

### 514. Marine Plant Biology (4)

Three lectures and three hours of laboratory.

Prerequisites: Biology 201 and six units of upper division coursework in the major.

Biology of algae and seagrasses, including identification, life histories, evolution, morphology, physiology, and ecology.

### 515. Marine Invertebrate Biology (4)

Two lectures and six hours of laboratory.

Prerequisite: Biology 201. Strongly recommended: Completion of three to six upper division units in the major.

Structure and function, ecology, behavior, physiology and phyletic relationships of marine invertebrate animals.

### 517. Marine Ecology (4)

Two lectures and six hours of laboratory.

Prerequisite: Biology 354.

Ecological concepts as applied to pelagic and benthic marine organisms and their environment. Field and laboratory experience in oceanographic techniques, particularly the coastal environment.

### 519. Aquaculture (3)

Prerequisite: Biology 201. Strongly recommended: Completion of three to six upper division units in the major.

Principles and practices of the farming of aquatic organisms.

### 520. Ichthyology (4)

Two lectures and six hours of laboratory.

Prerequisite: Biology 201. Strongly recommended: Completion of three to six upper division units in the major.

Identification, systematics, evolution, structure, physiology, behavior and ecology of fishes.

### 521. Advanced General Microbiology (2)

Prerequisites: Biology 350 or an introductory course in microbiology and consent of instructor.

Taxonomy, comparative physiology and ecology of representative microorganisms found in various natural environments.

### 521L. Advanced Microbiology Laboratory (3)

One lecture and six hours of laboratory.

Prerequisites: Biology 350, 366, 366L, and credit or concurrent registration in Biology 521 or 584. Strongly recommended: Credit or concurrent registration in an upper division writing course.

Procedures and methods for isolation, characterization and identification of prokaryotes from soil, water and humans; includes both pathogenic and non-pathogenic prokaryotes.

### 523. Herpetology (4)

Two lectures and six hours of laboratory.

Prerequisite: Biology 201. Recommended: Biology 352.

Evolution, systematics, distribution, and ecology of amphibians and reptiles of the world.

### 524. Ornithology (4)

Two lectures, six hours of laboratory or field excursions, and a field project.

Prerequisite: Biology 201. Strongly recommended: Completion of three to six upper division units in the major.

Study and identification of birds, especially those of the Pacific Coast and the San Diego region.

### 525. Mammalogy (4)

Two lectures and six hours of laboratory.

Prerequisite: Biology 201. Strongly recommended: Completion of three to six upper division units in the major.

Evolution, systematics, distribution and ecology of mammals of the world.

### 526. Terrestrial Arthropod Biology (4)

Two lectures and six hours of laboratory.

Prerequisite: Biology 201. Strongly recommended: Biology 352 and completion of three to six upper division units in the major.

Structure, function, behavior, ecology, evolution, and relationships of major groups of terrestrial arthropods, including insects, arachnids, and myriapods. Identification and natural history of southern California diversity.

### 527. Animal Behavior (4)

Three lectures and three hours of laboratory.

Prerequisites: Biology 215; Biology 201 or Psychology 211 and 260 for psychology majors.

Biological bases of animal behavior with emphasis on the ethological approach, including the evolution and adaptive significance of behavior.

### 529. Molecular Methods in Ecology and Evolution (3)

Prerequisites: Biology 352 and Chemistry 365.

Molecular methods used in ecology and evolutionary biology with emphasis on types of questions addressed using such methods and data analysis.

### 530. Plant Systematics (4)

Two lectures and six hours of laboratory, field trips.

Prerequisite: Biology 201. Strongly recommended: Completion of three to six upper division units in the major.

Plant description, identification, classification, and nomenclature with emphasis on evolutionary patterns, interdisciplinary data acquisition, and phylogenetic analysis.

### 531. Taxonomy of California Plants (4)

Two lectures and six hours of laboratory.

Prerequisite: Biology 201. Strongly recommended: Completion of three to six upper division units in the major.

Fundamentals of plant taxonomy with emphasis on identification of plants native and naturalized to California. Plant collecting techniques. Field trips are required.

### 533. Plant Structure and Function (3)

Two lectures and three hours of laboratory.

Prerequisite: Biology 201. Strongly recommended: Completion of three to six upper division units in the major.

Relationships between plant structure and function. Morphology and anatomy of vascular plants considering specific function of plant organs. Approaches to solve plant morphological problems. Techniques of plant anatomy.

**535. Plant Ecology (4)**

Three lectures and three hours of laboratory.

Prerequisite: Biology 201. Strongly recommended: Completion of three to six upper division units in the major.

Plant adaptation and response to living and non-living environment including aspects of plant evolution, demography, ecophysiology community and ecosystem dynamics and soil-plant relationships. Terrestrial systems emphasized.

**538. Environmental Policy and Regulations (3)**

Prerequisite: Biology 354.

History of biological conservation and environmental laws; regulations governing biological resources; role of biologists; environmental impact analysis, operation of regulatory and resource agencies; biologists as expert witnesses; wetland protection and mitigation, state heritage programs, role of nongovernmental agencies.

**540. Conservation Ecology (3)**

Two lectures and three hours of laboratory.

Prerequisite: Biology 354.

Human impacts on ecosystems, the resultant endangerment and extinction of plant and animal species, and strategies for the protection and recovery of threatened forms.

**541. Ecology of Fishes and Fisheries Biology (3)**

Two lectures and two hours of activity/discussion.

Prerequisite: Biology 354. Recommended: Biology 520.

Ecology of fishes, including environmental constraints, habitats, feeding, behavior, growth, reproduction, biotic interactions, population dynamics and assemblage structure. Fisheries biology concepts, including stock recruitment models, climates and fisheries, density dependence and population regulation, and populations dynamics theory.

**549. Microbial Genetics and Physiology (3)**

Prerequisite: Biology 350 or 366.

Physiology of microbial growth, bacterial structure and function, genetics of bacteriophages and bacteria.

**550. Eukaryotic and Prokaryotic Molecular Biology (4)**

Prerequisites: Biology 352, 366, and Chemistry 365.

Gene structure, organization, and regulation in prokaryotes and eukaryotes. Mechanisms of RNA and protein synthesis. Dynamic aspects of the genome.

**551. Recombinant DNA (3) I, II**

Prerequisites: Biology 350, 366, 366L, Chemistry 365, and credit or concurrent registration in Biology 467 or 549.

Theory and practice of recombinant DNA techniques.

**551L. Recombinant DNA Laboratory (2)**

Six hours of laboratory.

Prerequisites: Biology 350, 366, 366L, Chemistry 365, and credit or concurrent registration in Biology 467 or 549.

A laboratory course in recombinant DNA techniques.

**552. Advanced Cell and Molecular Biology Laboratory (3)**

Nine hours of laboratory.

Prerequisite: Biology 366L. Credit in Chemistry 467L.

Laboratory experience for advanced undergraduates utilizing cell and molecular biological techniques. Independent research project guided by instructor.

**554. Molecular Virology (3)**

Prerequisites: Biology 366 and Chemistry 365. Credit or concurrent registration in Biology 467 or 549.

Molecular aspects of structure, genetics, and replication of viruses, virus-host interactions, pathogenesis of virus infections, diagnostic virology, and antiviral vaccines and drugs; emphasis on human pathogens.

**555. Principles of Electron Microscopy (1)**

Prerequisites: Biology 201 and Physics 180B.

Principles of scanning and transmission electron microscopy including theoretical basis of sample preparation.

**556. Scanning Electron Microscopy Laboratory (2)**

Six hours of laboratory.

Prerequisite: Credit or concurrent registration in Biology 555.

Biological specimen preparation and operation of scanning electron microscope.

**557. Transmission Electron Microscopy Laboratory (3)**

One lecture and six hours of laboratory.

Prerequisite: Credit or concurrent registration in Biology 555.

Biological sample preparation and operation of transmission electron microscope.

**560. Animal Physiology (3)**

Prerequisites: Biology 201 and 202; Chemistry 365; Physics 180B, 182A, and 182B.

Physiology of vertebrate and invertebrate animals with emphasis on diversity of solutions to physiological problems and on functional integration of organ systems.

**561. Radiation Biology (3)**

Prerequisites: Biology 100 or 201 and 202; Physics 180B, 182A, and 182B. Recommended: Biology 366.

Principles underlying radiological reactions of ionizing radiations. Effects of ionizing radiations at the biochemical, cell, organ, and organism levels.

**561L. Radiation Biology Laboratory (2)**

Six hours of laboratory.

Prerequisite: Credit or concurrent registration in Biology 561.

The laboratory determination of the effects of ionizing radiation on biological systems.

**563. Plant Physiology (3)**

Prerequisites: Biology 201 and Chemistry 365.

Activities of plants, including photosynthesis, ion transport, translocation, water relations, growth and development.

**565. Human Genetics (3)**

Prerequisites: Biology 352 and Chemistry 365. Recommended: Credit or concurrent registration in Biology 366.

Pedigree analysis, gene mapping, cytogenetic and molecular analysis of inherited disease and genetically controlled phenomena in humans.

**569. Molecular Pharmacology (3)**

Prerequisite: Biology 366.

Molecular mechanisms of drug action emphasizing pharmacokinetics, drug-receptor theory, signal transduction, physiological effects of drugs on nervous cardiovascular and endocrine systems. Includes discussion of molecular approaches to rational drug design, development, and testing in the pharmaceutical industry.

**570. Neurobiology (3)**

Prerequisite: Biology 366 or 590 or Psychology 260.

Structure and function of the nervous system to include cellular and molecular mechanisms underlying neuronal excitability and synaptic function, nervous system development, cellular and systems analysis of sensory, motor and higher brain functions. Emphasis on experimental approaches.

**575. Molecular Basis of Heart Disease (3)**

Prerequisite: Biology 366 or 590.

Current literature on the molecular basis of disordered physiology leading to heart disease.

**577. Embryology (4)**

Two lectures and six hours of laboratory.

Prerequisites: Biology 201 and 202. Strongly recommended: Completion of three to six upper division units in the major.

Studies in comparative gametogenesis, morphogenesis, and reproductive physiology.

**580. Cell Biology of the Blood (3)**

Prerequisites: Biology 366, 366L, Chemistry 365. Recommended: Concurrent registration in Biology 467 and Chemistry 467L.

Basic processes of cell development, inflammation, acquired immune response, and regulation of these processes by cytokines.

### 584. Medical Microbiology (2)

Prerequisites: Biology 336 and 350.

Discussion of major bacterial and viral pathogens; molecular mechanisms of pathogenesis, microbial toxins and antimicrobial agents; immune response to microbial infections; biochemical and molecular diagnostics.

### 585. Cellular and Molecular Immunology (3)

Prerequisites: Biology 366. Recommended: Credit or concurrent registration in Biology 467 and Chemistry 467L.

Cellular and molecular aspects of the immune response. Genetics of immunoglobulins, major histocompatibility complex, lymphocyte development and their manifestations on immune responsiveness, lymphokines immunopathologies including AIDS, and contemporary immunological techniques. Not open to students with credit in Biology 485.

### 588. Parasitology (2)

Prerequisite: Biology 201. Strongly recommended: Completion of three to six upper division units in the major.

Study of animal parasites with special reference to those of humans.

### 588L. Parasitology Laboratory (2)

Six hours of laboratory.

Prerequisite: Credit or concurrent registration in Biology 588.

Examination of animal parasites including identification of important human parasites; collection and preservation of local forms. (Formerly the laboratory portion of Biology 588.)

### 590. Physiology of Human Systems (4)

Three lectures and one hour of discussion.

Prerequisites: Chemistry 365, Physics 180B and 182B. Recommended: Biology 366.

Human physiology presented at both cellular and organ system levels; neurophysiology, muscle physiology, cardiovascular physiology and respiration, kidney function, hormone function and reproduction. For students majoring in a natural science or pre-professional studies.

### 592. Cell and Molecular Biology Laboratory (2)

Six hours of laboratory.

Prerequisite: Biology 350.

Laboratory course in advanced techniques in microbiology and cell and molecular biology.

### 594. Biotechnology Research Rounds (2)

Prerequisites: Biology 366 and credit or concurrent registration in Biology 467.

Latest research methods in the biotechnology community. Speakers from local biotechnology companies and research institutes will discuss the power and limitations of current research methods being applied to develop new therapeutics. Evaluation of approaches, results, and utility of these technologies.

### 595. Computers in Biomedical Research (3)

Prerequisite: Biology 366 or 590. Recommended: Computer Science 107.

Application of micro- and minicomputers to tasks encountered by biomedical scientists in research laboratories (data acquisition and reduction, experiment control) and by physicians in medical care delivery (noninvasive imaging, clinical laboratory automation, patient file processing).

### 596. Special Topics in Biology (1-4)

Prerequisite: Consent of instructor.

Advanced selected topics in modern biology. May be repeated with new content. See Class Schedule for specific content. Limit of nine units of any combination of 296, 496, 596 courses applicable to a bachelor's degree. Maximum combined credit of six units of 596 and 696 applicable to a 30-unit master's degree. Additional units acceptable with the approval of the graduate adviser.

### 597A. Univariate Statistical Methods in Biology (3)

Two lectures and three hours of laboratory.

Prerequisite: Biology 350 or 352 or 354 or 366.

Application of univariate statistical techniques in biological sciences.

### 598. Computational Biology (3)

Prerequisites: Computer Science 205 and consent of instructor.

Methods for analysis of biological systems at all levels of scale from macromolecules to ecosystems. Topics include macromolecular sequence analysis to determine structure and function and study phylogenetic relationships. Imaging in two to four dimensions. Mathematical modeling in biological sciences.

## GRADUATE COURSES

### 600. Seminar (2-3)

Prerequisite: Consent of instructor.

An intensive study in advanced biology. May be repeated with new content. See Class Schedule for specific content. Maximum credit six units applicable to a master's degree.

### 602. Experimental Design (4)

Two lectures and six hours of laboratory.

Prerequisite: One semester of statistics.

Principles, terminology, and practice of experimental design both in biology and natural and social sciences.

### 604. Seminar in Aquatic Ecology (2)

Prerequisite: Biology 354.

Ecological concepts as applied to the fresh water and marine environment. May be repeated with new content. See Class Schedule for specific content. Maximum credit four units applicable to a master's degree.

### 624. Population Genetics (3)

Prerequisite: Biology 352.

Theoretical and applied population genetics, including genetic diversity in natural populations, random drift, mutation, gene flow, natural selection, nucleotide variation and quantitative genetics.

### 630. Signal Transduction (3)

Prerequisites: Biology 366 and Chemistry 365.

Intracellular transduction pathways that regulate growth and death in neuronal, endocrine, muscle, and immune cells.

### 645. Theory and Principles of Ecology (3)

Prerequisites: Admission to graduate program in biology and approval of ecology graduate adviser.

Major theoretical concepts in ecology, topics of current interest, and historical context of central ideas in ecology, with emphasis on use of primary literature.

### 680. Seminar in Population Genetics (2)

Prerequisite: Biology 352.

Topics in population genetics such as effective population size, population subdivision, gene flow and natural selection. Theoretical expectations, empirical data analysis and project design.

### 688. Seminar in Terrestrial Ecology (2)

Prerequisite: Biology 354.

Ecological concepts as applied to the terrestrial environment. May be repeated with new content. See Class Schedule for specific content. Maximum credit four units applicable to a master's degree.

### 694. Advanced Topics in Virology (1-4)

Prerequisite: Biology 554.

May be repeated with new content. See Class Schedule for specific content. Maximum credit four units applicable to a master's degree.

### 696. Advanced Topics in Biology (1-3)

Prerequisite: Consent of instructor.

Intensive study in specific areas of biology. May be repeated with new content. See Class Schedule for specific content. Maximum credit six units applicable to a master's degree.

**735. Seminar in Biogeography (2)**

Prerequisite: Biology 354.

Concepts and principles of distributional history of plant and animal groups, and origins and dispersal of modern faunas and floras.

**740. Phylogenetic Systematics (3)**

Two lectures and three hours of laboratory.

Prerequisite: Biology 354.

Theory and methodology of phylogenetic systematics. Includes use of computer algorithms, survey of literature and preparation of a project in phylogenetic systematics. Not open to students with credit in Biology 740 (Seminar in Phylogenetic Systematics).

**750. Molecular Biophysics (3)**

Prerequisite: Chemistry 410A.

Description and analysis of biological processes and systems in terms of properties of molecules and of basic principles.

**766. Advanced Topics in Population and Community Ecology (2-4)**

Prerequisites: Biology 354 and consent of instructor.

Selected topics in population and community ecology. May be repeated with new content and consent of the graduate adviser in ecology. Maximum credit six units applicable to a master's degree.

**770. Seminar in Systematics and Evolution (2-3)**

Prerequisite: Consent of instructor.

Selected topics in systematics and evolution. May be repeated with new content. See Class Schedule for specific content. Maximum credit four units applicable to a master's degree.

**772. Seminar in Macroevolution (2)**

Prerequisite: Biology 354.

Examination of evolutionary processes and patterns at and above the species level.

**797. Research (1-3) Cr/NC/RP**

Research in one of the fields of biology. Maximum credit six units of 797 and 798 applicable to a master's degree.

**798. Special Study (1-3) Cr/NC/RP**

Prerequisite: Consent of staff; to be arranged with department chair and instructor.

Individual study. Maximum credit six units of 797 and 798 applicable to a master's degree.

**799A. Thesis or Project (3) Cr/NC/RP**

Prerequisites: An officially appointed thesis committee and advancement to candidacy.

Preparation of a project or thesis for the master's degree.

**799B. Thesis or Project Extension (0) Cr/NC**

Prerequisite: Prior registration in Thesis or Project 799A with an assigned grade symbol of RP.

Registration required in any semester or term following assignment of RP in Course 799A in which the student expects to use the facilities and resources of the university; also student must be registered in the course when the completed thesis or project is granted final approval.

**897. Doctoral Research (1-15) Cr/NC/RP**

Prerequisite: Admission to the doctoral program.

Independent investigation in the general field of the dissertation.

**899. Doctoral Dissertation (1-15) Cr/NC/RP**

Prerequisite: An officially constituted dissertation committee and advancement to candidacy.

Preparation of the dissertation for the doctoral degree. Enrollment is required during the term in which the dissertation is approved.

