

# Biology

In the College of Sciences

BIOL

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## Faculty

Emeritus: Alexander, Alfred, Atkins, Avila, Barnett, Baxter, Bohnsack, Breindl, Carmichael, Carpenter, Chen, Clark, Cohn, Collier, B., Collier, G., Cox, Davis, C., Dexter, Diehl, Dowler, Ebert, Etheridge, Fisher, Ford, Futch, Hanscom, Hazen, Hemmingsen, Huffman, Hunsaker, Hurlbert, Johnson, A., Johnson, K., Kelly, Krekorian, Krisans, Kummerow, Monroe, Moore, Neel, Norland, Olson, Paolini, P., Parsons, Phelps, Phleger, Plymale, Ratty, Rinehart, Sabbadini, Schapiro, Shepard, Taylor, Thwaites, Van Steenberg, Wedberg, Wilson, Zedler, J., Zedler, P., Zyskind

Chair: Frey

Professors: Archibald, Bernstein, Berta, Bizzoco, Buono, Deutschman, Frey, Glembotski, Gottlieb, Harris, Maloy, McClenaghan, McGuire, Oechel, Perrault, Pozos, Reeder, Segall, Simpson, Sussman, Tsoukas

Associate Professors: Anderson, Bohonak, Burns, Edwards, Hedlin, Hovel, Hentschel, Kelley, Lipson, Rohwer, Waters, Williams, Zeller

Assistant Professors: Clark, Doran, Feuer, Lai, Lewison, Wolkowicz, Zayas

Lecturers: Garver, Martin, Norgard-Sumnicht, Paolini, M., Truesdale

## Offered by the Department

Doctor of Philosophy degree in biology and ecology.

Master of Arts degree in biology.

Master of Science degree in biology.

Master of Science degree in microbiology.

Major in biology with the B.A. degree in liberal arts and sciences.

Major in biology with the B.S. degree in applied arts and sciences.

Emphasis in bioengineering.

Emphasis in cellular and molecular biology.

Emphasis in ecology.

Emphasis in evolution and systematics.

Emphasis in marine biology.

Emphasis in zoology.

Major in microbiology with the B.A. degree in liberal arts and sciences.

Major in microbiology with the B.S. degree in applied arts and sciences.

Emphasis in clinical laboratory science and public health microbiology.

Program of study in biology in preparation for the single subject teaching credential in science.

Minor in biology.

Certificate in biotechnology.

## The Majors

**Biology.** The Department of Biology offers a dynamic and modern program in biology which prepares students both academically and practically for vocations in science and science-related fields or for entry into graduate studies. The major is designed to present a basic background in modern biology and in the supportive disciplines of chemistry, mathematics and physics, and to provide specialized training selected by the student from a variety of areas. The wide range of faculty expertise and research interest allows the department to offer a curriculum which includes general and advanced courses in plant and animal sciences, marine sciences, genetics and physiology, ecology, molecular biology, microbiology, immunology, endocrinology, entomology, evolution, and systematics. Formal programs of study within the major include Emphases in Bioengineering, Cell and Molecular Biology, Ecology, Evolution and Systematics, Marine Biology, and Zoology. Special studies opportunities with SDSU faculty and scientists at cooperating institutions allow qualified students to gain research experience on an individual basis.

The department offers a specific program of courses to fulfill the state of California's science requirements for the Single Subject Teaching Credential in Biological Science. Students successfully completing one of these programs may be certified by the department as having demonstrated subject competency as required in part for acceptance into College of Education single subject credential program.

The department also offers a program leading to the Biotechnology Certificate. The purpose of this program is to prepare undergraduate and graduate students for employment in public and private organizations utilizing biotechnology.

The rapid advances in theoretical and applied biology, the growing demands in health care and the expansion of general interest in and concern for the environment are just a few of the factors which continue to increase society's need for biologists. Some examples: a biology degree is the common precursor for the medical, dental, veterinarian and allied health professions; government agencies involved in environment protection, public health and conservation need ecologists, inspectors, laboratory technicians and wildlife, forest, coast and park managers; government and private agriculture agencies need entomologists and botanists; private companies, government laboratories and universities involved in biotechnology need microbiologists and molecular biologists; zoos, wild animal parks and aquaria need zoologists; the secondary school system needs biology teachers; textbook and scientific supply companies need science majors. Whether your goal is to work in a laboratory or a forest, there is opportunity for fulfillment and growth in the field of biology.

**Microbiology.** Microbiology is the study of bacteria, viruses, yeasts, molds, algae and protozoa. These microorganisms are found associated with plants and animals, in soil, and in fresh and marine waters. Many of the free-living species participate in maintaining the quality of our environment. Certain species affect the health and well-being of plants and animals, including humans, by causing infectious diseases. Microorganisms are often used in the molecular biology laboratory as research tools, for experiments in genetic engineering, and in the manufacture of food and chemicals.

The microbiology major is designed to provide the student with a background in basic biology, microbiology, and the disciplines of chemistry, mathematics and physics. The curriculum includes introductory and advanced courses (most with laboratories) in general and pathogenic microbiology, immunology, virology, physiology, and genetics as well as courses in food and industrial microbiology, marine microbiology, and molecular biology.

Microbiologists find positions with governmental agencies, in university and private research laboratories, in biotechnology, medical and industrial laboratories, in schools as teachers, with scientific supply companies, or with textbook companies. Depending on the situation, a microbiologist may conduct fundamental and applied research, identify disease-causing microorganisms in medical or veterinary specimens, participate in studies of the environment (e.g., soil, ocean, lakes), aid in the manufacture of pharmaceuticals, food, or beverages, or provide quality and safety control. The microbiology major is excellent preparation for entrance into medical, dental, veterinarian, and graduate schools. The Emphasis in Clinical Laboratory Science and Public Health Microbiology prepares students to become, after a postgraduate internship, licensed medical technologists or certified public health microbiologists.

## Impacted Programs

The biology and microbiology majors are impacted programs. To be admitted to the biology or microbiology major, students must meet the following criteria:

- Complete with a minimum GPA of 2.70 and a grade of C or higher: Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; Mathematics 121 and 122; and Physics 180A, 180B, 182A, 182B. These courses cannot be taken for credit/no credit (Cr/NC);

- b. Have a cumulative GPA of 2.60 or higher;
- c. Students choosing an emphasis in bioengineering have a different set of courses to complete in the preparation for the major. To be admitted to the major, bioengineering students must complete Biology 203, 203L, 204, 204L; Chemistry 200, 201, 232, 232L; Mathematics 150, 151; Physics 195, 196, 197 with at least a C in each course; and have a cumulative GPA of 2.70 or higher. Students may not elect credit/no credit grading for coursework needed to satisfy preparation for the major requirements.

To complete the major, students must fulfill the degree requirements for the major described in the catalog in effect at the time they are accepted into the premajor at SDSU (assuming continuous enrollment).

## Major Academic Plans (MAPs)

Visit <http://www.sdsu.edu/mymap> for the recommended courses needed to fulfill your major requirements. The MAPs Web site was created to help students navigate the course requirements for their majors and to identify which General Education course will also fulfill a major preparation course requirement.

## Biology Major

### With the B.A. Degree in Liberal Arts and Sciences (Major Code: 04011)

All candidates for a degree in liberal arts and sciences must complete the graduation requirements listed in the section of this catalog on "Graduation Requirements." A total of 40 upper division units must be taken, of which 24 must be selected from the General Biology Degree Requirements and the list of courses acceptable for electives. No more than 48 units in biology courses can apply to the degree.

A minor is not required with this major.

**Language Requirement.** Competency (successfully completing the third college semester or fifth college quarter) is required in one foreign language to fulfill the graduation requirement. Refer to section of catalog on "Graduation Requirements."

**Graduation Writing Assessment Requirement.** Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

## Biology Major

### With the B.S. Degree in Applied Arts and Sciences (Major Code: 04011)

All candidates for a degree in applied arts and sciences must complete the graduation requirements listed in the section of this catalog on "Graduation Requirements." A total of 36 upper division units must be selected from the General Biology Degree Requirements and the list of courses acceptable for electives.

A minor is not required with this major.

### General Biology Degree Requirements

**Preparation for the Major.** Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; Mathematics 121 and 122; Physics 180A, 180B, 182A, 182B. (39 units)

These prerequisite courses may not be taken Cr/NC and must be completed with a minimum GPA of 2.70 and a grade of C or higher in each class.

**Graduation Writing Assessment Requirement.** Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

**Major.** A minimum of 24 upper division units for the B.A. degree or 36 upper division units for the B.S. degree to include Biology 352, 354, 366, 366L, and Chemistry 365. Elective courses include all upper division biology courses numbered 350 and above, and all upper division chemistry courses (except Chemistry 300, 308, 361, 497, 499, 560). A minimum of two elective courses must be biology laboratory courses, at least one of which must be an organismal level course selected from Biology 350, 458, 460, 512, 514, 515, 516A, 523, 524, 525, 526, 528, 530, 531, 535, 588.

All courses not included above must have specific approval of the department.

All upper division transfer courses in biology will calculate in the major GPA but will not fulfill any major requirements without specific department approval. This approval must be filed with the Office of Advising and Evaluations.

**Time Limitation.** All courses for the major must be completed within seven years of the granting of the undergraduate degree. Exceptions for individual courses must be approved by the department and be filed with the Office of Advising and Evaluations.

### Emphasis in Bioengineering

**Preparation for the Major.** Biology 203, 203L, 204, 204L; Chemistry 200, 201, 232, 232L; Electrical Engineering 204; Engineering Mechanics 200; Mechanical Engineering 101, 240; Mathematics 150, 151, 252; Physics 195, 196, 197. (54 units)

Prerequisite courses, listed in item c. of Impacted Programs, may not be taken Cr/NC and must be completed with a minimum GPA of 2.70 and a grade of C or higher in each class.

**Graduation Writing Assessment Requirement.** Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

**Major.** A minimum of 38 upper division units to include Biology 366, 366L and either Biology 350 or 590; Chemistry 365; Civil Engineering 301; Mathematics 342A; Mechanical Engineering 352, 490A\*, 490B; 12 units selected from the following courses, at least six of which must be biology courses: Biology 497 and 499 or Mechanical Engineering 499 (maximum 3 units); Biology 350, 474, 555, 567; either 556 or 557, 560, 575 or 590; Chemistry 431; Electrical Engineering 303, 503; Exercise and Nutritional Sciences 306; Mechanical Engineering 310, 312, 540, 580. Approval of the Emphasis in Bioengineering adviser is required for credit in Biology 497, 499, and other courses not listed above to be included in the emphasis. This approval must be filed with the Office of Advising and Evaluations.

All upper division transfer courses in biology will calculate in the major GPA but will not fulfill any major requirements without specific department approval. This approval must be filed with the Office of Advising and Evaluations.

**Time Limitation.** All courses for the major must be completed within seven years of the granting of the undergraduate degree. Exceptions for individual courses must be approved by the department adviser and be filed with the Office of Advising and Evaluations.

\*Additional prerequisites may be required.

### Emphasis in Cellular and Molecular Biology

**Preparation for the Major.** Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; Mathematics 121 and 122; Physics 180A, 180B, 182A, 182B. (39 units)

These prerequisite courses may not be taken Cr/NC and must be completed with a minimum GPA of 2.70 and a grade of C or higher in each class.

**Graduation Writing Assessment Requirement.** Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

**Major.** A minimum of 36 upper division units to include Biology 350, 352, 354, 366, 366L, 567, 567L, Chemistry 365, and at least 11 units of electives selected from Biology and Chemistry 496 and/or 596 (maximum 3 units), Biology 497 and 499 and Chemistry 498 and/or Chemistry 499 (maximum 3 units), Biology 510, 511, 528, 549, 551, 554, 555, 556, 557, 568, 570, 575, 576, 584, 485 or 585, 588, 590, and Chemistry 431. At least one course must be an organismal level course. Approval of the Emphasis in Cellular and Molecular Biology adviser is required for credit in Biology 497, Chemistry 498, Biology or Chemistry 496, 499, and 596 and other courses not listed above to be included in the emphasis. This approval must be filed with the Office of Advising and Evaluations.

Other than Biology 352, 354, 366, 366L and Chemistry 365, only one course in this emphasis may be used for credit in another emphasis offered by the department.

All upper division transfer courses in biology will calculate in the major GPA but will not fulfill any major requirements without specific department approval. This approval must be filed with the Office of Advising and Evaluations.

**Time Limitation.** All courses for the major must be completed within seven years of the granting of the undergraduate degree. Exceptions for individual courses must be approved by the department adviser and be filed with the Office of Advising and Evaluations.

### Emphasis in Ecology

**Preparation for the Major.** Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; Mathematics 121 and 122; Physics 180A, 180B, 182A, 182B. A computer programming course (e.g. Computer Science 106 or 107) is recommended. (39 units)

These prerequisite courses may not be taken Cr/NC and must be completed with a minimum GPA of 2.70 and a grade of C or higher in each class.

**Graduation Writing Assessment Requirement.** Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

**Major.** A minimum of 36 upper division units to include Biology 352, 354, 354L, 366, 366L, Chemistry 365, and at least 15 units of electives selected from Biology 496 and/or 596 (maximum 3 units), 497 and 499 (maximum 3 units), 508, 509, 512, 516A, 516B, 517, 526, 527, 528, 535, 537, 538, 540, 541, 544, 560, 597A. At least one of the above electives must be a laboratory course. The remaining units must include an organismal level course selected from Biology 350, 458, 460, 512, 515, 516A, 523, 524, 525, 526, 528, 530, 531, 535, 588. Other electives include all biology courses numbered 350 and above (except Biology 452), and all upper division chemistry courses (except Chemistry 300, 308, 361, 497, 499, 560). Approval of the Emphasis in Ecology adviser is required for credit in Biology 496, 497, 499, 596, and other courses not listed above to be included in the 15 units of ecology electives. This approval must be filed with the Office of Advising and Evaluations.

Other than Biology 352, 354, 366, 366L, and Chemistry 365, only one course in this emphasis may be used for credit in another emphasis offered by the department.

All upper division transfer courses in biology will calculate in the major GPA but will not fulfill any major requirements without specific department approval. This approval must be filed with the Office of Advising and Evaluations.

**Time Limitation.** All courses for the major must be completed within seven years of the granting of the undergraduate degree. Exceptions for individual courses must be approved by the department adviser and be filed with the Office of Advising and Evaluations.

### Emphasis in Evolution and Systematics

**Preparation for the Major.** Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; Mathematics 121 and 122; Physics 180A, 180B, 182A, 182B. (39 units)

These prerequisite courses may not be taken Cr/NC and must be completed with a minimum GPA of 2.70 and a grade of C or higher in each class.

**Graduation Writing Assessment Requirement.** Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

**Major.** A minimum of 36 upper division units to include Biology 352, 354, 366, 366L, 509, Chemistry 365, and at least 12 units of electives selected from Biology 496 and/or 596 (maximum 3 units), 497 and 499 (maximum 3 units), 458, 460, 508, 510, 511, 512, 515, 523, 524, 525, 526, 527, 528, 530, 531, 546, 568, 576, 588. Two of the above electives must be laboratory courses, one of which must be an organismal level course selected from Biology 458, 512, 515, 523, 524, 525, 526, 528, 530, 531. Other electives include all biology courses numbered 350 and above (except Biology 452), and all upper division chemistry courses (except Chemistry 300, 308, 361, 497, 499, 560). Approval of the Emphasis in Evolution and Systematics adviser is required for credit in Biology 496, 497, 499, 596, and other courses

not listed above to be included in the 12 units of evolution and systematics electives. This approval must be filed with the Office of Advising and Evaluations.

Other than Biology 352, 354, 366, 366L, and Chemistry 365, only one course in this emphasis may be used for credit in another emphasis offered by the department.

All upper division transfer courses in biology will calculate in the major GPA but will not fulfill any major requirements without specific department approval. This approval must be filed with the Office of Advising and Evaluations.

**Time Limitation.** All courses for the major must be completed within seven years of the granting of the undergraduate degree. Exceptions for individual courses must be approved by the department adviser and be filed with the Office of Advising and Evaluations.

### Emphasis in Marine Biology

**Preparation for the Major.** Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; Mathematics 121 and 122; Physics 180A, 180B, 182A, 182B. (39 units)

These prerequisite courses may not be taken Cr/NC and must be completed with a minimum GPA of 2.70 and a grade of C or higher in each class.

**Graduation Writing Assessment Requirement.** Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

**Major.** A minimum of 36 upper division units to include Biology 352, 354, 366, 366L, Chemistry 365, and at least 15 units of electives selected from Biology 496 and/or 596 (maximum 3 units), 497 and 499 (maximum 3 units), 512, 514, 515, 516A, 516B, 517, 541. At least two of the above electives must be laboratory courses, at least one of which must be one of the organismal courses Biology 512, 514, 515, 516A. The remaining units must be selected from biology courses numbered 350 and above (except Biology 452), all upper division chemistry courses (except Chemistry 300, 308, 361, 497, 499, 560), and may include three units selected from Economics 454, Geography 504, Geological Sciences 540, 545. Approval of the Emphasis in Marine Biology adviser is required for credit in Biology 496, 497, 499, 596, and other courses not listed above to be included in the 15 units of marine biology electives. This approval must be filed with the Office of Advising and Evaluations.

Other than Biology 352, 354, 366, 366L, and Chemistry 365, only one course in this emphasis may be used for credit in another emphasis offered by the department.

All upper division transfer courses in biology will calculate in the major GPA but will not fulfill any major requirements without specific department approval. This approval must be filed with the Office of Advising and Evaluations.

**Time Limitation.** All courses for the major must be completed within seven years of the granting of the undergraduate degree. Exceptions for individual courses must be approved by the department adviser and be filed with the Office of Advising and Evaluations.

### Emphasis in Zoology

**Preparation for the Major.** Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; Mathematics 121 and 122; Physics 180A, 180B, 182A, 182B. (39 units)

These prerequisite courses may not be taken Cr/NC and must be completed with a minimum GPA of 2.70 and a grade of C or higher in each class.

**Graduation Writing Assessment Requirement.** Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

**Major.** A minimum of 36 upper division units to include Biology 352, 354, 366, 366L, Chemistry 365, and at least 15 units of electives selected from Biology 496 and/or 596 (maximum 3 units), 497 and 499 (maximum 3 units), and 515, 516A, 526, 588 (invertebrate group), 512, 523, 524, 525 (vertebrate group), 508, 509, 510, 511, 527, 540, 546, 560, 576 (general zoology group). At least three units must be selected from each of the three groups. Two or more of the above

electives must be laboratory courses, at least one of which must be an organismal level course selected from Biology 512, 515, 516A, 523, 524, 525, 526. The remaining units must be selected from biology courses numbered 350 and above (except Biology 452), and all upper division chemistry courses (except Chemistry 300, 308, 361, 497, 499, 560). Approval of the Emphasis in Zoology adviser is required for credit in Biology 496, 497, 499, 596, and other courses not listed above to be included in the 15 units of zoology electives. This approval must be filed with the Office of Advising and Evaluations.

All upper division transfer courses in biology will calculate in the major GPA but will not fulfill any major requirements without specific department approval. This approval must be filed with the Office of Advising and Evaluations.

Other than Biology 352, 354, 366, 366L, and Chemistry 365, only one course in this emphasis may be used for credit in another emphasis offered by the department.

**Time Limitation.** All courses for the major must be completed within seven years of the granting of the undergraduate degree. Exceptions for individual courses must be approved by the department adviser and be filed with the Office of Advising and Evaluations.

### Microbiology Major

**With the B.A. Degree in Liberal Arts and Sciences**  
(Major Code: 04111)

All candidates for a degree in liberal arts and sciences must complete the graduation requirements listed in the section of this catalog on "Graduation Requirements." No more than 48 units in biology courses can apply to the degree.

A minor is not required with this major.

**Preparation for the Major.** Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; Mathematics 121 and 122; Physics 180A, 180B, 182A, 182B. (39 units)

These prerequisite courses may not be taken Cr/NC and must be completed with a minimum GPA of 2.70 and a grade of C or higher in each class.

**Language Requirement.** Competency (successfully completing the third college semester or fifth college quarter) is required in one foreign language to fulfill the graduation requirement. It is recommended that students select French, German, or Russian to satisfy this requirement. Refer to section of catalog on "Graduation Requirements."

**Graduation Writing Assessment Requirement.** Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

**Major.** A minimum of 31 upper division units to include Biology 350, 352, 354, 366, 366L, 528 or 584, 549, 567, 567L, Chemistry 365.

All courses not included above must have the prior approval of the Microbiology adviser and be filed with the Office of Advising and Evaluations.

All upper division transfer courses in biology will calculate in the major GPA but will not fulfill any major requirements without specific department approval. This approval must be filed with the Office of Advising and Evaluations.

**Time Limitation.** All courses for the major must be completed within seven years of the granting of the undergraduate degree. Exceptions for individual courses must be approved by the department and be filed with the Office of Advising and Evaluations.

### Microbiology Major

**With the B.S. Degree in Applied Arts and Sciences**  
(Major Code: 04111)

All candidates for a degree in applied arts and sciences must complete the graduation requirements listed in the section of this catalog on "Graduation Requirements."

A minor is not required with this major.

**Preparation for the Major.** Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; Mathematics 121 and 122; Physics 180A, 180B, 182A, 182B. (39 units)

These prerequisite courses may not be taken Cr/NC and must be completed with a minimum GPA of 2.70 and a grade of C or higher in each class.

**Graduation Writing Assessment Requirement.** Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

**Major.** A minimum of 36 upper division units to include Biology 350, 352, 354, 366, 366L, 528 or 567L, 549, 567, 584, Chemistry 365, and at least four to five units of electives selected from Biology and Chemistry 496 and 596 (maximum 3 units), Biology 497 and 499 (maximum 3 units), Biology 528, 551, 554, 555, 556, 557, 567L, 568, 584, 485 or 585, 590, Chemistry 431. Approval of the Microbiology adviser is required for credit in Biology 496, 497 and 499, 596, and other courses not listed above to be included in the electives. This approval must be filed with the Office of Advising and Evaluations.

All upper division transfer courses in biology will calculate in the major GPA but will not fulfill any major requirements without specific department approval. This approval must be filed with the Office of Advising and Evaluations.

**Time Limitation.** All courses for the major must be completed within seven years of the granting of the undergraduate degree. Exceptions for individual courses must be approved by the department and be filed with the Office of Advising and Evaluations.

### Emphasis in Clinical Laboratory Science and Public Health Microbiology

The emphasis in clinical laboratory science and public health microbiology is a program of required and elective courses which prepares students for the Public Health Microbiologist and Clinical Laboratory Scientist academic certification and licensing examinations.

**Preparation for the Major.** Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L, 251; Mathematics 121 and 122; Physics 180A, 180B, 182A, 182B. (44 units)

These prerequisite courses (excluding Chemistry 251) may not be taken Cr/NC and must be completed with a minimum GPA of 2.70 and a grade of C or higher in each class.

**Graduation Writing Assessment Requirement.** Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

**Major.** A minimum of 36 upper division units to include at least 30 units from Biology 350, 352, 354, 366, 366L, 485 or 585, 549, 584, Chemistry 365, and Biology 528 or 567L with approval of the microbiology adviser. The remaining units to be selected from Biology 528, 551, 554, 555, 556, 557, 567L, 588, 590, Chemistry 431. To be included in this major courses not listed above must have the prior approval of the Microbiology adviser and be filed with the Office of Advising and Evaluations.

All upper division transfer courses in biology will calculate in the major GPA but will not fulfill any major requirements without specific department approval. This approval must be filed with the Office of Advising and Evaluations.

**Time Limitation.** All courses for the major must be completed within seven years of the granting of the undergraduate degree. Exceptions for individual courses must be approved by the department and be filed with the Office of Advising and Evaluations.

## Biology Major

In preparation for the Single Subject Teaching Credential in Science/Biological Sciences

With the B.S. Degree in Applied Arts and Sciences

(Major Code: 04011)

Students applying to the College of Education's graduate program for the Single Subject Teaching Credential in Science/Biological Sciences must be certified by this department for subject matter competency. This certification requires earning a B or better in Biology 452 and either (1) passing the required examinations (CSET), or (2) completing the subject matter preparation program described below.

Certification through the accomplishment of appropriate coursework requires (1) completion of the courses described under the General Biology Degree Requirements, B.S. degree (preparation for the major and major) including the following electives in the major: Biology 354L, 436\*, 452, and at least one course from Biology 458, 460, 515, 523, 524, 525, 526, 530 or 531 (it is recommended that Biology 497, 499 be taken as electives for the major); (2) earning a B or better in Biology 452, (3) completing Geological Sciences 101 and 104, Teacher Education 211, Health and Human Services 280, Natural Science 315, Special Education 450, and Education 451. No course-work substitutions are permitted for the SSTC program of study. The Department of Biology credential adviser (LS-135) must be consulted for certification.

Please refer to the Teacher Education section of this catalog for other requirements and prerequisites for the credential program.

**Time Limitation.** All courses for the major must be completed within seven years of the granting of the undergraduate degree. Exceptions for individual courses must be approved by the department and be filed with the Office of Advising and Evaluations.

All courses not included above must have the prior approval of the department and the substitution filed with the Office of Advising and Evaluations.

\*Additional prerequisites required.

## Biology Minor

Biology 100, 100L or 203, 203L are prerequisites to the biology minor and do not count towards the units in the minor; some areas include additional prerequisites not counted towards the minor.

The minor in biology consists of a minimum of 16-22 units to include Biology 204, 204L, and at least 12 units of upper division courses selected from one of the areas below. At least one of the selected courses must be a biology laboratory course numbered 350 or above. A maximum of three units of Biology 497 and 499 may be included in the minor with prior approval of the department. For courses requiring Biology 215 as a prerequisite, a college level course in statistics may be acceptable with the approval of the instructor. Basic chemistry, such as Chemistry 100 or 200, is strongly recommended. Courses may be substituted for those in groupings below with approval of the biology adviser, and this approval must be filed with the Office of Advising and Evaluations.

### General Biology

Required: At least four courses with one course from each of the following areas: Evolution and Genetics (3 units): Biology 319 or 352; Ecology and the Environment (3 units): Biology 315, 324, 326, 327, or 354; Human Biology (3 units): Biology 307 or 336; Biology Laboratory (2-4 units): Biology 354L, 436, 458, 515, 516A, 517, 523, 524, 525, 526, 528, 530, 531, 535, 588. Requirements for all biology minors (above) apply.

### Cellular and Molecular Biology

Prerequisites: Biology 203, 203L, Chemistry 200, 201, 232, 232L, 365. At least 12 units of the following electives: Biology 350, 352, 366, 366L, 499, 549, 551, 554, 555, 567, 570, 575, 576, 584, 590, 594, and 485 or 585, and 556 or 557. Requirements for all biology minors (above) apply.

### Ecology

Prerequisites: Biology 203, 203L. Required: Biology 354. Electives: Biology 315, 324, 327, 354L, 509, 512, 514, 515, 516A, 517, 523, 524, 525, 526, 527, 528, 531, 540, 541, 544, 588. Requirements for all biology minors (above) apply.

### Elementary Education

Required: Biology 315, 336, 436, at least two units of Biology 497 and 499, and a minimum of two units of electives selected from any upper division biology course. A college level course in chemistry is strongly recommended to complement this minor. Requirements for all biology minors (above) apply.

### Evolutionary Biology

Prerequisites: Biology 203, 203L. Required: Biology 319 or 352. Electives: Biology 319, 352, 508, 509, 512, 523, 524, 525, 526, 527, 530, 531. Requirements for all biology minors (above) apply.

### Human Biology

Required: Biology 261 or 336 or 590. Electives: Biology 307, 319, 326, 336, 352, 436, and 590. Requirements for all biology minors (above) apply.

### Marine Biology

Prerequisites: Biology 203, 203L. Required: Biology 324. Electives: Biology 512, 514, 515, 516A, 517, and 541. Requirements for all biology minors (above) apply.

### Plant Biology

Prerequisites: Biology 203, 203L. Required: Biology 458 or 460 or 530 or 531 or 535. Electives: Biology 326, 458, 460, 530, 531, 535. Requirements for all biology minors (above) apply.

Courses in the minor may not be counted toward the major, but may be used to satisfy preparation for the major and general education requirements, if applicable. A minimum of six upper division units must be completed at San Diego State University.

### Secondary Education

Prerequisite: College level course in statistics. Required: Biology 354, 452, and either 458 or 460. Electives (at least one course from each group): Biology 336, 560, 590; Biology 524, 525, 526, 527. Basic courses in genetics, microbiology, and organic chemistry are recommended. (20-21 units)

Courses in the minor may not be counted toward the major, but may be used to satisfy preparation for the major and general education requirements, if applicable. A minimum of six upper division units must be completed at San Diego State University.

## Biotechnology Certificate

Matriculated students must apply for admission to the program before completion of 15 certificate units and must complete all prerequisite and required courses with a GPA of 2.5 or better.

The certificate requires 13 prerequisite units – Biology 350, 366, 366L, Chemistry 365 and 24-28 certificate units including Biology 497, 567, 567L, and 499 (5 units as approved by the certificate adviser), 594, and three electives selected from Biology 549, 554, 570, 575, 584, 585, 590. Prerequisite and certificate courses may be utilized in the biology, chemistry, and microbiology majors and minors as appropriate.

Courses in the certificate may not be counted toward the minor.

## Courses (BIOL)

Refer to *Curricula and Courses and University Policies* sections of this catalog for explanation of the course numbering system, unit or credit hour, prerequisites, and related information.

### LOWER DIVISION COURSES

#### BIOL 100. General Biology (3) [GE]

Prerequisite recommended: Concurrent registration in Biology 100L.

A beginning course in biology stressing processes common to living organisms. Not applicable to biological sciences majors; see Biology 203, 203L, 204, 204L. Not open after Biology 203, 204.

#### BIOL 100L. General Biology Laboratory (1) [GE]

Three hours of laboratory.

Prerequisite: Credit or concurrent registration in Biology 100.

A laboratory course in biology stressing processes common to living organisms. Not applicable to biological sciences majors; see Biology 203, 203L, 204, 204L. Not open after Biology 203L, 204L.

**BIOL 101. World of Animals (3) [GE]**

Animal adaptation and diversity and their relationship to the development of evolutionary theory. Not applicable to biological sciences majors. Not open after Biology 203, 204.

**BIOL 101L. World of Animals Laboratory (1) [GE]**

Three hours of laboratory.

Prerequisite: Credit or concurrent registration in Biology 101.

Laboratory course on evolution and diversity of animals involving field trips and laboratory investigations. Not applicable to biological sciences majors. Not open after Biology 203L, 204L.

**BIOL 203. Principles of Cell and Molecular Biology (3)**

Prerequisites: Chemistry 200 and satisfaction of the English Placement Test requirement. Credit or concurrent registration with a grade of B or better in Biology 203L.

Principles of biology applying to all organisms, including basic biochemistry, cell structure, membrane transport, energy metabolism, cell division, classical and molecular genetics, gene expression, development, and recombinant DNA. Same course as lecture portion of Biology 201A. (Biology 203 and 203L formerly numbered Biology 201A.)

**BIOL 203L. Principles of Cell and Molecular Biology Laboratory (1)**

Three hours of laboratory.

Prerequisites: Chemistry 200 and satisfaction of the English Placement Test requirement. Concurrent registration in Biology 203.

Laboratory experiences designed to demonstrate and reinforce concepts presented in lecture through active scientific investigation and experiences in observing, identifying, describing, and explaining evolution of cellular processes, and in applying laboratory methods and procedures relevant to molecular biology. Same course as laboratory portion of Biology 201A. (Biology 203 and 203L formerly numbered Biology 201A.)

**BIOL 204. Principles of Organismal Biology (3)**

Prerequisites: Satisfaction of the English Placement Test requirement and concurrent registration in Biology 204L. Recommended: Completion of Biology 203 and 203L.

Principles of biology applying to all organisms, including systematics and diversity of bacteria, protista, fungi, plants and animals, and concepts of physiology, reproduction, development and differentiation, ecology and the causes of endangerment of a species. Same course as lecture portion of Biology 201B. (Biology 204 and 204L formerly numbered Biology 201B.)

**BIOL 204L. Principles of Organismal Biology Laboratory (1)**

Three hours of laboratory.

Prerequisites: Satisfaction of the English Placement Test requirement and concurrent registration in Biology 204. Recommended: Completion of Biology 203 and 203L.

Laboratory experiences demonstrate and reinforce concepts and descriptive information presented in lecture through active scientific investigation and experience in observing, identifying, and classifying life, in analyzing the structural features of life, and in evaluating their adaptive significance. Same course as laboratory portion of Biology 201B. (Biology 204 and 204L formerly numbered Biology 201B.)

**BIOL 211. Fundamentals of Microbiology (2)**

Prerequisites: Biology 203 and 203L; or Biology 100 and Chemistry 100 or 102 or 130.

Microorganisms of the environment, including disease-producing organisms, their actions and reactions. For nursing, nutrition, and kinesiology (prephysical therapy) majors. Not applicable to biological sciences majors; see Biology 350. Same course as lecture portion of Biology 210. (Biology 211 and 211L formerly numbered Biology 210.)

**BIOL 211L. Fundamentals of Microbiology Laboratory (2)**

Six hours of laboratory.

Prerequisites: Credit or concurrent registration with a grade of C or better in Biology 211. Biology 203 and 203L; or Biology 100 and Chemistry 100 or 102 or 130.

Fundamentals of microbiology, including study of bacteria, fungi, protozoa, and algae of environment, including disease-producing organisms, their actions and reactions. Same course as laboratory portion of Biology 210. (Biology 211 and 211L formerly numbered Biology 210.)

**BIOL 212. Human Anatomy (4)**

Two lectures and six hours of laboratory.

Prerequisite: Biology 100 or 203.

Gross and microscopic anatomy of organ system of human body.

**BIOL 215. Biostatistics (3) [GE]**

Two lectures and three hours of laboratory.

Prerequisites: Credit or concurrent registration in Biology 203, 203L or 204, 204L and Mathematics 121 or 141.

Methods and experience in defining and solving quantitative problems in biology, including design of experiments, and parametric and nonparametric statistical techniques. Students with credit or concurrent registration in the following lower division courses will be awarded a total of four units for the two (or more) courses: Biology 215; Administration, Rehabilitation and Postsecondary Education 201; Civil Engineering 160; Economics 201; Political Science 201; Psychology 270; Sociology 201; Statistics 119, 250.

**BIOL 246. Colloquium in Biomedical Sciences (1)**

Prerequisite: University level biology course.

Current biomedical research projects ranging from cell biology to behavioral research. Research paper required. Maximum credit two units.

**BIOL 247. Advanced Degree Programs in the Sciences: Application Strategies (1) Cr/NC**

Two hours of activity.

Prerequisite: Junior or senior standing.

Instruction in preparing competitive applications to sciences' M.S. and Ph.D. degree programs to include development of the required personal statement. Introduction to sources of financial support, such as national fellowship programs, and development of interview skills and materials. Maximum credit one unit for any combination of Biology 247, 248, 249, 250A-250B-250C.

**BIOL 248. Careers in Biological Sciences (1) Cr/NC**

Career opportunities in biological sciences. Specialists in major biological areas will present information about their fields and how best to prepare for careers. Maximum credit one unit for any combination of Biology 247, 248, 249, 250A-250B-250C.

**BIOL 249. Career Choices in the Health Professions (1) Cr/NC**

Career opportunities in allied health professions; trends in health care; discussion of medical ethics; practicing professionals will present about their fields and how best to prepare for careers in their area of health care. Maximum credit one unit for any combination of Biology 247, 248, 249, 250A-250B-250C.

**BIOL 250. Preprofessional Topics (1) Cr/NC**

Designed to expose the preprofessional student to the profession of his/her choice through speakers and selected readings. Emphasis on alternatives and meeting stresses as a preprofessional student. Maximum credit one unit for any combination of Biology 247, 248, 249, 250A-250B-250C.

**A.** Topics in Medicine.

**B.** Topics in Dentistry.

**C.** Topics in Veterinary Medicine.

**BIOL 261. Human Physiology (4)**

Three lectures and three hours of laboratory.

Prerequisites: Biology 100 or 203 and Biology 212; Chemistry 102 (or 100 and credit or concurrent registration in Chemistry 130).

Human function viewed from cellular through organ system levels of organization. Intended primarily for prenursing students. Not applicable to biological sciences majors. Not open to students with credit in Biology 336, 436, or 590.

**BIOL 277. Medical Terminology (2)**

Prerequisites: Biology 204, 204L.

Words and word components used in medical and allied medical practice translated, investigated, and applied.

**BIOL 291. Biology Laboratory (1)**

Prerequisites: Recommendation by department and consent of instructor.

Special course to allow makeup of program laboratory deficiencies. Student will be assigned to a laboratory section of the appropriate course.

**A.** Laboratory for Biology 203, 203L. (Formerly numbered Biology 291B.)

**B.** Laboratory for Biology 204, 204L. (Formerly numbered Biology 291A.)

**C.** Laboratory for Biology 215.

**BIOL 296. Experimental Topics (1-4)**

Selected topics. 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.

**BIOL 299. Special Study (1-3)**

Individual research experience and interaction with researchers at an introductory level. Projects involve approximately 45 hours of laboratory or fieldwork per unit and a research report. Hours are flexible and arranged between the student and the researcher. Maximum credit four units.

**UPPER DIVISION COURSES  
(Intended for Undergraduates)**

**Writing Requirement: Completion of the Graduation Writing Assessment Requirement or the eligibility to enroll in an upper division writing course is a prerequisite for all upper division biology courses numbered 450 and above.**

**BIOL 305. Scientific Scuba Diving (3)**

Two lectures and three hours of laboratory.

Prerequisites: Upper division standing. Swimming competency evaluation, physical examination approval for scuba diving, waiver for scuba diving.

Entry level scientific diver training and certification course. Theory and practical diving skills to include diving physiology, hyperbaric conditions, medical hazards, proper selection, care and operation of diving equipment, marine environment, emergency procedures, scientific diving techniques and regulations. Not open to students with credit in Biology 306 or Exercise and Nutritional Sciences 320, 323, 324. Not applicable to biological sciences majors. (Formerly numbered Oceanography 305.)

**BIOL 306. Scientific Scuba Diving for Certified Divers (3)**

Two lectures and three hours of laboratory.

Prerequisites: Biology 305 and Advanced or Scientific Diving Certification, diving skills proficiency evaluation, acceptable openwater diving equipment, physical examination approval for scuba diving, waiver for scuba diving.

Scientific diving operations, techniques and procedures; dive planning and lead diver responsibilities; underwater work, mapping, search and salvage, navigation, deep, night and small boat diving; emergency procedures and rescue. Physics, physiology, medicine, decompression theory, oceanography, marine life and marine environment. Master Diver Certification. Not open to students with credit in Exercise and Nutritional Sciences 324. Not applicable to biological sciences majors. (Formerly numbered Oceanography 306.)

**BIOL 307. Biology of Sex (3) [GE]**

Prerequisite: Completion of the General Education requirement in Foundations of Learning II.A.2. Life Sciences. If a biological science course is not taken to satisfy General Education II.A.2. Life Sciences, a college course in biological science is required.

Reproductive adaptations in humans, and comparatively in other species. Topics include sex differences, mate choice and mating behavior, fertility regulation, fertilization and embryonic development, sex ratios, parental investment, effects of aging, and life history strategies. Not applicable to biological sciences majors.

**BIOL 315. Ecology and Human Impacts on the Environment (3) [GE]**

Prerequisite: Completion of the General Education requirement in Foundations of Learning II.A.2. Life Sciences. If a biological science course is not taken to satisfy General Education II.A.2. Life Sciences, a college course in biological science is required.

Ecological characteristics of natural ecosystems and basic effects of human society upon those systems, emphasizing resource management, food production, global environmental problems, and future directions. Not applicable to biological sciences majors.

**BIOL 319. Evolution (3) [GE]**

Prerequisite: Completion of the General Education requirement in Foundations of Learning II.A.2. Life Sciences. If a biological sciences course is not taken to satisfy General Education II.A.2. Life Sciences, a college course in biological sciences is required.

Modern theory of organic evolution with emphasis on processes involved as they relate to past, present, and future evolution of mankind. Not applicable to biological sciences majors; see Biology 352.

**BIOL 324. Life in the Sea (3) [GE]**

Prerequisite: Completion of the General Education requirement in Foundations of Learning II.A.2. Life Sciences. If a biological sciences course is not taken to satisfy General Education II.A.2. Life Sciences, a college course in biological sciences is required.

Overview of complexity of marine life. Diverse interactions of organisms in the intertidal zone, over the continental shelves and in the open oceans. Current controversies concerning the marine biosphere. Not applicable to biological sciences majors.

**BIOL 326. Plants, Medicines, and Drugs (3) [GE]**

Prerequisite: Completion of the General Education requirement in Foundations of Learning II.A.2. Life Sciences. If a biological sciences course is not taken to satisfy General Education II.A.2. Life Sciences, a college course in biological sciences is required.

Medicinal plants, toxic-poisonous plants, herbal medicines, psychoactive plants, preparation of medicines and mechanisms of action; current research results on medicinal plants and drugs used in diseases such as diabetes, cancer, and heart diseases. Not applicable to biological sciences majors.

**BIOL 327. Conservation of Wildlife (3) [GE]**

Prerequisite: Completion of the General Education requirement in Foundations of Learning II.A.2. Life Sciences. If a biological sciences course is not taken to satisfy General Education II.A.2. Life Sciences, a college course in biological sciences is required.

Global ecosystems and their dynamics, with emphasis on sustainable human use and preservation of biodiversity. Not applicable to biological sciences majors.

**BIOL 336. Principles of Human Physiology (3) [GE]**

Prerequisite: Completion of the General Education requirement in Foundations of Learning II.A.2. Life Sciences. If a biological sciences course is not taken to satisfy General Education II.A.2. Life Sciences, a college course in biological sciences is required.

Systems of the human body, their interrelationships and control systems which regulate them. Not open to students with credit in a college course in human physiology. Not applicable to biological sciences majors.

**BIOL 340A. Preventive Dentistry Program (1-2) Cr/NC**

Four hours of clinical and other activities per unit.

Prerequisites: Upper division standing and active pre dental file in the Preprofessional Health Advising Office.

Participation in clinic, dental observation, marketing activities and two field trips. Maximum credit four units. Not applicable to biological sciences majors.

**BIOL 340B. Preventive Dentistry Leaders (2-4)**

Four hours of activity per unit.

Prerequisites: Biology 340A and consent of instructor.

Supervision of one component of Preventive Dentistry Program. Maximum credit four units. Not applicable to biological sciences majors.

**BIOL 341. The Human Body (3) [GE]**

Prerequisite: Completion of the General Education requirement in Foundations of Learning II.A.2. Life Sciences.

Survey of human body with emphasis on intricacy of design and integration of various organ systems. Not open to nursing, exercise and nutritional sciences, or biological sciences majors, or to students with credit in any college level human physiology or anatomy course.

**BIOL 344. Advanced Human Anatomy (2)**

One lecture and three hours of laboratory.

Prerequisites: Biology 212 and consent of instructor.

Advanced topics in human anatomy with emphasis toward dissection of human cadavers. Dissection techniques, pathology, and special training in prosection. Not applicable to biological sciences majors.

**BIOL 348. Health Professions Internship (1-3)**

Prerequisites: 3.0 overall GPA, completion of lower division writing competency requirement, and consent of instructor.

Internship in a health care setting; term paper required. Maximum credit three units. Not applicable to biological sciences majors.

**BIOL 350. General Microbiology (4)**

Two lectures and six hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L; Chemistry 232, 232L.

Actions and reactions of microorganisms in response to their environment, both natural and as changed by other organisms, including man. Also includes an introduction to pathogens.

### **BIOL 352. Genetics and Evolution (3)**

Prerequisites: Biology 203, 203L, 204, 204L, 215.  
Principles of transmission genetics, population genetics, and evolution.

### **BIOL 354. Ecology and the Environment (3)**

Two lectures and one hour of discussion.  
Prerequisites: Biology 203, 203L, 204, 204L, 215; and Mathematics 122

Fundamental concepts in population, community, and ecosystem ecology.

### **BIOL 354L. Experimental Ecology (2)**

One hour of discussion and three hours of laboratory.  
Prerequisites: Credit or concurrent registration in Biology 354.  
Methods of research in ecology; approaches to analysis of populations, communities, and ecosystems.

### **BIOL 366. Biochemistry, Cell and Molecular Biology II (4)**

Prerequisite: Chemistry 365.  
Concepts of modern integrated molecular biology, cell biology, and biochemistry.

### **BIOL 366L. Biochemistry, Cell and Molecular Biology Laboratory I (2)**

Six hours of laboratory.  
Prerequisites: Credit or concurrent registration in Biology 366.  
Basic laboratory approaches in biochemistry, cell biology, and molecular biology.

### **BIOL 436. Human Physiology Laboratory (2)**

One lecture and three hours of laboratory.  
Prerequisite: Credit or concurrent registration in Biology 336 or 590.

Human physiology and rationale of current week's laboratory and experimental outcomes of previous week's laboratory. Not open to students with credit in Biology 261.

### **BIOL 452. Science Concept Development and Integration (3)**

Two lectures and three hours of activity.  
Prerequisite: Senior standing, or participation in the science single subject credential program.

Development and integration of biological science content knowledge, introduction to learning theory, and transformation of knowledge. Designed for students preparing for the single subject teaching credential in life sciences.

### **BIOL 458. Plant Biology (4)**

Three lectures and three hours of laboratory.  
Prerequisites: Biology 203, 203L, 204, 204L.  
Cell biology and structure, photosynthesis, respiration, secondary metabolism, physiology of water relations and transport, growth and development, evolution of major groups, plant ecology of Southern California and topics related to agriculture.

### **BIOL 460. Economic Botany (3)**

Two lectures and three hours of laboratory.  
Prerequisites: Biology 203, 203L, 204, 204L.  
Plants of agricultural, economic, and historical importance. Topics include basic plant morphology, anatomy, and taxonomy, plant genetics, agricultural breeding and propagation techniques, vegetables and fruits, spices and herbs, beverage plants, woods and plant fibers.

### **BIOL 461. Underwater Research Methods and Techniques (3)**

Two lectures and three hours of laboratory.  
Prerequisites: Biology 204, 204L and Exercise and Nutritional Sciences 323 or Biology 306, and three upper division units in biology, Advanced Openwater or Scientific Scuba Diving Certification, diving skills proficiency evaluation, acceptable openwater diving equipment, medical examination, approval for scuba diving and waiver for scuba diving.

Preparation for scientific research underwater; scientific methods, techniques, operations and specialized equipment; scientific diver training and certification requirements; diving procedures and regulations; diving equipment; diving physiology hyperbaric conditions, fitness, practical diving skills, safety and emergency procedures.

### **BIOL 474. Histology (4)**

Two lectures and six hours of laboratory.  
Prerequisites: Biology 204, 204L. Recommended: Biology 212.  
Descriptive microscopic anatomy of cells, tissues and organs of mammals with special emphasis on humans.

### **BIOL 485. Principles of Immunology (3)**

Prerequisites: Biology 203, 203L, Chemistry 365, credit or concurrent registration in Biology 366.

Basic areas of immunology to include inflammation, generation of immune response, antibody production, lymphocyte development and function, hypersensitivities and AIDS, major histocompatibility complex and cytokines. Designed to give a basic background in the immune system.

### **BIOL 490. Undergraduate Honors Research (3)**

Prerequisites: Upper division standing with GPA of at least 3.20, four units of Biology 499, and approval of honors research program coordinator.

Experience in designing and carrying out independent research in a laboratory setting plus a written record of experimental design and results in the form of an honors research thesis to be presented at an undergraduate research forum and/or defended before a committee. Does not satisfy laboratory requirement in major. Maximum credit three units.

### **BIOL 496. Experimental Topics (1-4)**

Selected topics. May be repeated once 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.

### **BIOL 497. Undergraduate Research (1-3)**

Fifty hours of research per unit.  
Prerequisites: Upper division status in good standing and consent of instructor.

Individual research project, supervised by faculty. Research course with research paper or other presentation of results. Maximum credit six units applicable to general biology major, three units to microbiology major, for any combination of Biology 497 and 499.

### **BIOL 499. Special Study (1-3)**

Fifty hours of activity per unit.  
Prerequisites: Upper division status in good standing and consent of instructor.

Individual study, internship, other supervised laboratory or field project or experience. Credit involves 50 hour activity per unit per semester and a report. Maximum credit six units applicable to biology major, three units applicable to microbiology major, for any combination of Biology 497 and 499.

## **UPPER DIVISION COURSES (Also Acceptable for Advanced Degrees)**

**Writing Requirement: Completion of the Graduation Writing Assessment Requirement or the eligibility to enroll in an upper division writing course is a prerequisite for all upper division biology courses numbered 450 and above.**

### **BIOL 508. Coevolution (3)**

Prerequisites: Biology 352 and 354.  
Coevolution in interspecific interactions, like herbivory, predation, parasitism, competition, pollination, and mimicry.

### **BIOL 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.

### **BIOL 510. Molecular Evolution (3)**

Prerequisites: Biology 352 and 366 or graduate standing.  
Molecular evolution including concepts of homology and convergence, the nearly neutral theory of evolution, evolution of new protein function, detecting selection, multi-gene family evolution and evolutionary genomics.

**BIOL 511. Evolution of Development (3)**

Prerequisites: Biology 352 and 366.

Dynamic relationship between regulatory functions that control development and the evolutionary process, and vice versa, illustrated with evidence derived from developmental, phylogenetic, paleontological, computational, and ecological research. Emphasis on genomic regulatory networks of transcriptional regulatory elements and cell-signaling pathways.

**BIOL 512. Evolution and Ecology of Marine Mammals (3)**

Two lectures and three hours of laboratory.

Prerequisites: Biology 352 and 354.

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

**BIOL 514. Biology of the Algae (4)**

Three lectures and three hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L and six units of upper division coursework in the major.

Evolution, life histories, morphology, physiology, and ecology of micro and macro algae, with attention to both marine and freshwater taxa, and of sea-grasses.

**BIOL 515. Marine Invertebrate Biology (4)**

Two lectures and six hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L. 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.

**BIOL 516A. Marine Larval Ecology Research Part 1 (4)**

Three lectures and three hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L, 215.

Biology of marine invertebrate larvae. Biodiversity, evolution of complex life cycles, larval culture techniques, physiological and ecological consequences of environmental variability during larval development. Designing and peer reviewing original research proposals related to larval ecology.

**BIOL 516B. Marine Larval Ecology Research Part 2 (4)**

Three lectures and three hours of laboratory.

Prerequisites: Biology 516A and consent of instructor.

Research experience investigating marine invertebrate larval ecology.

**BIOL 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.

**BIOL 523. Herpetology (4)**

Two lectures and six hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L. Recommended: Biology 352.

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

**BIOL 524. Ornithology (4)**

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

Prerequisites: Biology 203, 203L, 204, 204L. 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.

**BIOL 525. Mammalogy (4)**

Two lectures and six hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L. Strongly recommended: Completion of three to six upper division units in the major.

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

**BIOL 526. Terrestrial Arthropod Biology (4)**

Two lectures and six hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L. 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.

**BIOL 527. Animal Behavior (3)**

Prerequisites: Biology 215; Biology 203, 203L, 204, 204L, or Psychology 211 and 260 for psychology majors.

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

**BIOL 528. Microbial Ecology (3)**

Two lectures and three hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L. Recommended: Biology 350 and 354.

Roles of microorganisms in soil, aquatic and marine ecosystems, microbial adaptations to the environment, and interactions within microbial communities and between microbes and multicellular organisms. Laboratory techniques to isolate and study microbes.

**BIOL 530. Plant Systematics (4)**

Two lectures and six hours of laboratory, field trips.

Prerequisites: Biology 203, 203L, 204, 204L. 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.

**BIOL 531. Taxonomy of California Plants (4)**

Two lectures and six hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L.

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

**BIOL 535. Plant Ecology (4)**

Three lectures and three hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L. Strongly recommended: Biology 354.

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.

**BIOL 537. Population Modeling for Conservation (3)**

Two lectures and three hours of laboratory.

Prerequisite: Biology 354.

Applied population modeling in context of conservation. How mathematical models can be used to simulate population dynamics of single and multiple species and rank conservation management options.

**BIOL 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.

**BIOL 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.

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

Two lectures and three hours of laboratory.

Prerequisite: Biology 354.

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.

**BIOL 544. Terrestrial Ecosystems and Climate Change (3)**

Prerequisite: Biology 354.

Controls on fluxes and stocks of nutrients within terrestrial ecosystems, ecosystem responses, feedbacks to climate change. Climate systems, water transport, production and decomposition, nutrient cycling, stable isotopes, spatial and temporal integration.

**BIOL 546. Systematics and Biodiversity (3)**

Two lectures and two hours of activity.

Prerequisite: Biology 352.

History, philosophy, and practical aspects of systematic biology, emphasizing pervasive role of phylogenetic data in evolutionary biology and other fields, phylogenetic structure of all lifeforms, and geographic patterns of diversity, endemism and imperilment.

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

Prerequisite: Biology 350 or 366.

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

**BIOL 551. Recombinant DNA (3)**

Prerequisites: Biology 350, 366, 366L, Chemistry 365, and credit or concurrent registration in Biology 549 or 567.

Theory and practice of recombinant DNA techniques.

**BIOL 554. Molecular Virology (3)**

Prerequisites: Biology 366 and Chemistry 365.

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.

**BIOL 555. Principles of Electron Microscopy (2)**

Prerequisites: Biology 204, 204L and Physics 180B.

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

**BIOL 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.

**BIOL 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.

**BIOL 560. Animal Physiology (3)**

Prerequisites: Biology 203, 203L, 204, 204L; 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.

**BIOL 561. Radiation Biology (3)**

Prerequisites: Biology 203, 203L, 204, 204L; 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.

**BIOL 567. Advanced Biochemistry, Cellular, and Molecular Biology (4)**

Prerequisites: Biology 366 and Chemistry 365.

Advanced concepts of cellular biology, molecular biology, and biochemistry. (Formerly numbered Biology 467.)

**BIOL 567L. Biochemistry, Cellular, and Molecular Biology Laboratory II (2)**

Six hours of laboratory.

Prerequisites: Biology 366, 366L, credit or concurrent registration in Biology 567. Recommended: Biology 350.

Intermediate laboratory approaches to biochemistry, cellular biology, and molecular biology at a level appropriate for both advanced undergraduate and graduate students. (Formerly numbered Chemistry 467L.)

**BIOL 568. Bioinformatics (3)**

Two lectures and three hours of laboratory.

Prerequisite: Biology 366.

Bioinformatics analysis methods and programming skills. Practical bioinformatic software for sequence analysis, bioinformatic algorithms and programming fundamentals.

**BIOL 570. Neurobiology (3)**

Prerequisite: Biology 366 or 590 or Psychology 360 for psychology majors.

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.

**BIOL 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.

**BIOL 576. Developmental Biology (3)**

Prerequisite: Biology 366. Strongly recommended: Biology 567.

Fundamental processes of development from fertilized egg to organism. Emphasis on cellular and molecular mechanisms common to development of metazoan organisms.

**BIOL 584. Medical Microbiology (3)**

Prerequisites: Biology 350 and 366.

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

**BIOL 585. Cellular and Molecular Immunology (3)**

Prerequisite: Biology 366. Recommended: Credit or concurrent registration in Biology 567 and 567L.

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.

**BIOL 588. General Parasitology (3)**

Two lectures and three hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L. Strongly recommended: Completion of six upper division units in the major.

Parasites of medical and veterinary importance with special reference to those of humans. Practical training in identification of common human and animal parasites. Parasitological examination of local wildlife, collection and preservation of parasites.

**BIOL 590. Physiology of Human Systems (4)**

Three lectures and one hour of discussion.

Prerequisites: Chemistry 365, Physics 180B, 182B; or for the bio-engineering emphasis: Physics 195, 196, 197. 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.

**BIOL 594. Biotechnology Research Rounds (2) Cr/NC**

Prerequisites: Biology 366 and credit or concurrent registration in Biology 567.

Research methods in biotechnology community. Speakers from local biotechnology companies and research institutes discuss power and limitations of current research methods being applied to develop new therapeutics. Evaluation of approaches, results, and utility of these technologies. Not applicable to biology or microbiology majors.

**BIOL 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. Credit for 596 and 696 applicable to a master's degree with approval of the graduate adviser.

**BIOL 597A. Univariate Statistical Methods in Biology (3)**

Two lectures and three hours of laboratory.

Prerequisite: Biology 352 or 354 or 366.

Application of univariate statistical techniques in biological sciences.

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**GRADUATE COURSES**  
**Refer to the Graduate Bulletin.**

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