

# Biology

IN THE COLLEGE OF SCIENCES

**OFFICE:** Life Sciences 104

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**UNDERGRADUATE ADVISING OFFICE:** Life Sciences 135

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**WEBSITE:** <http://www.bio.sdsu.edu>

## Faculty

**Emeritus:** Archibald, Avila, Barnett, Baxter, Bernstein, Berta, Bizzoco, Bohnsack, Breindl, Carmichael, Carpenter, Chen, Clark, Collier B., Collier G., Cox, Deutschman, Dexter, Doran, Dowler, Ebert, Fisher, Ford, Franklin, Frey, Gottlieb, Hanscom, Hemmingsen, Huffman, Hurlbert, Johnson, Krekorian, McClenaghan, McGuire, Monroe, Neel, Norland, Paolini, P., Parsons, Perrault, Phleger, Plymale, Pozos, Ratty, Rinehart, Sabbadini, Shepard, Simpson, Tsoukas, Van Steenbergen, Wedberg, Williams, Zedler, J., Zedler, P., Zyskind

**Chair:** Zeller

**Associate Chair:** Hedin

**Vice Chair:** Harris

**Professors:** Anderson, Bohonak, Buono, Burns, Cripps, Dinsdale, Edwards, M., Edwards, R., Glembotski, Harris, Hedin, Hovel, Kelley, Lewison, Lipson, Long, Maloy, McClenaghan, Oechel, Reeder, Rohwer, Segall, Sussman, Waters, Welter, Wolkowicz, Zayas Ventura, Zeller

**Associate Professors:** Clark, Feuer, Hentschel, Kalyuzhnaya, Lai, Zona

**Assistant Professors:** Barber, Flores Renteria, Grainger, House, Luallen, Miller, Roach, Shikuma, Sukumaran, Xu

**Lecturers:** Ekdale, Garver, Martin, Norgard-Sumnicht, Paolini

## Offered by the Department

Doctor of Philosophy degree in biology, ecology, and evolutionary biology.

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 cellular and molecular biology.

Emphasis in ecology.

Emphasis in evolutionary biology.

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.

Teaching major in biology in preparation for the single subject teaching credential in science/biology.

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 bioinformatics, ecology, endocrinology, entomology, evolutionary biology, genetics and physiology,

immunology, marine sciences, microbiology, molecular biology, and plant and animal sciences. Formal programs of study within the major include Emphases in Cell and Molecular Biology, Ecology, Evolutionary Biology, 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 prepares students to become, after a postgraduate internship, licensed medical technologists or certified public health microbiologists.

## Advising

Students are required to meet with the undergraduate adviser and satisfy specific requirements in order to declare the major. Contact the biology advising office (LS-135) for admission criteria and procedures. All students admitted to the university with a declared major in biology are urged to meet with their undergraduate adviser within their first two semesters.

## 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 2.80 and a grade of C (2.0) or better: Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; and Mathematics 124. These courses cannot be taken for credit/no credit (Cr/NC);
- Have a cumulative GPA of 2.80 or better;

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 <https://sunspot.sdsu.edu/pubred/!mymap.disp> for the recommended courses needed to fulfill your major requirements. The MAPs website 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) (SIMS Code: 771402)**

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 124; Physics 180A, 180B, 182A, 182B. (37 units)

These preparation for the major courses may not be taken Cr/NC and must be completed with a grade of C (2.0) or better in each course. These courses require a minimum GPA of 2.80 (excluding Physics 180A, 180B, 182A, 182B).

**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 Placement Assessment with a score of 10 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 to include Biology 351, 352, 354, 366, 366L, Chemistry 365, and seven units of elective courses. Elective courses include all upper division biology courses numbered 350 and above (except Biology 497 and 499), and all upper division chemistry courses (except Chemistry 300, 308, 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, 512, 514, 515, 516A, 523, 524, 525, 526, 528, 530, 531, 535.

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.

## Biology Major

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

**(Major Code: 04011) (SIMS Code: 771401)**

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 124; Physics 180A, 180B, 182A, 182B. (37 units)

These preparation for the major courses may not be taken Cr/NC and must be completed with a grade of C (2.0) or better in each course. These courses require a minimum GPA of 2.80 (excluding Physics 180A, 180B, 182A, 182B).

**Graduation Writing Assessment Requirement.** Passing the Writing Placement Assessment with a score of 10 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 351, 352, 354, 366, 366L, Chemistry 365, and 19 units of elective courses. Elective courses include all upper division biology courses numbered 350 and above, Biology 497 and 499 (maximum six units), and all upper division chemistry courses (except Chemistry 300, 308, 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, 512, 514, 515, 516A, 523, 524, 525, 526, 528, 530, 531, 535.

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 Cellular and Molecular Biology

**(SIMS Code: 771433)**

**Preparation for the Major.** Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; Mathematics 124; Physics 180A, 180B, 182A, 182B. (37 units)

These preparation for the major courses may not be taken Cr/NC and must be completed with a grade of C (2.0) or better in each course. These courses require a minimum GPA of 2.80 (excluding Physics 180A, 180B, 182A, 182B).

**Graduation Writing Assessment Requirement.** Passing the Writing Placement Assessment with a score of 10 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 351, 352, 354, 366, 366L, 567, Chemistry 365, and 15 units of electives selected from the courses listed below. At least two courses must be selected from Biology 350, 464, 480, 490, 510, 528, 549, 554, 556, 557, 562, 567L, 568 [or Bioinformatics and Medical Informatics 568], 570, 575, 576, 584, 485 or 585, 589, 590, Chemistry 432, or Biology and Chemistry 496 and/or 596 (maximum three units). 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, 512, 514, 515, 516A, 523, 524, 525, 526, 528, 530, 531, or 535. Other electives include all biology courses numbered 350 and above (except Biology 452), Biology 497 and 499 (maximum six units), and all upper division chemistry courses (except Chemistry 300, 308, 497, 499, and 560). Approval of the emphasis adviser is required for credit in Chemistry 498 and 499, Biology or Chemistry 496 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.

## Biology

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

(SIMS Code: 771434)

**Preparation for the Major.** Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; Mathematics 124; Physics 180A, 180B, 182A, 182B. A computer programming course (e.g. Computer Science 107) is recommended. (37 units)

These preparation for the major courses may not be taken Cr/NC and must be completed with a grade of C (2.0) or better in each course. These courses require a minimum GPA of 2.80 (excluding Physics 180A, 180B, 182A, 182B).

**Graduation Writing Assessment Requirement.** Passing the Writing Placement Assessment with a score of 10 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 351, 352, 354, 354L, 366, 366L, Chemistry 365, and 17 units of electives selected from the courses listed below. At least two courses must be selected from Biology 509, 512, 514, 516A, 516B, 517, 518, 526, 527, 527L, 528, 535, 540, 542, 544 [or Environmental Science 544], 560, 562, or Biology 496 and/or 596 (maximum three units). At least one course must be an organismal course selected from Biology 458, 512, 514, 515, 516A, 523, 524, 525, 526, 528, 530, 531, or 535. Other electives include all biology courses numbered 350 and above (except Biology 452), Biology 497 and 499 (maximum six units), and all upper division chemistry courses (except Chemistry 300, 308, 497, 499, and 560). Approval of the emphasis adviser is required for credit in Biology 496, 596, and other courses not listed above to be included in the ecology 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 adviser and be filed with the Office of Advising and Evaluations.

### Emphasis in Evolutionary Biology

(SIMS Code: 771439)

**Preparation for the Major.** Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; Mathematics 124; Physics 180A, 180B, 182A, 182B. (37 units)

These preparation for the major courses may not be taken Cr/NC and must be completed with a grade of C (2.0) or better in each course. These courses require a minimum GPA of 2.80 (excluding Physics 180A, 180B, 182A, 182B).

**Graduation Writing Assessment Requirement.** Passing the Writing Placement Assessment with a score of 10 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 351, 352, 354, 366, 366L, 509, Chemistry 365, and 16 units of electives selected from the courses listed below. At least two courses must be selected from Biology 458, 510, 512, 515, 518, 523, 524, 525, 526, 527, 527L, 528, 530, 531, 568 [or Bioinformatics and Medical Informatics 568], 576, or Biology 496 and/or 596

(maximum three units). 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 458, 512, 515, 523, 524, 525, 526, 528, 530, or 531. Other electives include all biology courses numbered 350 and above (except Biology 452), Biology 497 and 499 (maximum six units), and all upper division chemistry courses (except Chemistry 300, 308, 497, 499, and 560). Approval of the emphasis adviser is required for credit in Biology 496, 596, and other courses not listed above to be included in the evolutionary biology 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 adviser and be filed with the Office of Advising and Evaluations.

### Emphasis in Marine Biology

(SIMS Code: 771436)

**Preparation for the Major.** Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; Mathematics 124; Physics 180A, 180B, 182A, 182B. (37 units)

These preparation for the major courses may not be taken Cr/NC and must be completed with a grade of C (2.0) or better in each course. These courses require a minimum GPA of 2.80 (excluding Physics 180A, 180B, 182A, 182B).

**Graduation Writing Assessment Requirement.** Passing the Writing Placement Assessment with a score of 10 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 351, 352, 354, 366, 366L, Chemistry 365, and 19 units of electives selected from the courses listed below. At least three courses must be selected from Biology 512, 514, 515, 516A, 516B, 517, 518, 542, or Biology 496 and/or 596 (maximum three units). 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 512, 514, 515, or 516A. The remaining units must be selected from biology courses numbered 350 and above (except Biology 452), Biology 497 and 499 (maximum six units), and all upper division chemistry courses (except Chemistry 300, 308, 497, 499, and 560). Approval of the emphasis adviser is required for credit in Biology 496 and 596, and other courses not listed above to be included in the marine biology 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 adviser and be filed with the Office of Advising and Evaluations.

### Emphasis in Zoology

(SIMS Code: 771438)

**Preparation for the Major.** Biology 203, 203L, 204, 204L, 215; Chemistry 200, 201, 232, 232L; Mathematics 124; Physics 180A, 180B, 182A, 182B. (37 units)

These preparation for the major courses may not be taken Cr/NC and must be completed with a grade of C (2.0) or better in each course. These courses require a minimum GPA of 2.80 (excluding Physics 180A, 180B, 182A, 182B).

**Graduation Writing Assessment Requirement.** Passing the Writing Placement Assessment with a score of 10 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 351, 352, 354, 366, 366L, Chemistry 365, and 19 units of electives selected from the courses listed below. At least three courses must be selected from Biology 509, 510, 512, 515, 516A, 518, 523, 524, 525, 526, 527, 527L, 540, 560, 576, or Biology 496 and/or 596 (maximum three units). 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 512, 515, 516A, 523, 524, 525, or 526. The remaining units must be selected from biology courses numbered 350 and above (except Biology 452), Biology 497 and 499 (maximum six units), and all upper division chemistry courses (except Chemistry 300, 308, 497, 499, and 560). Approval of the emphasis adviser is required for credit in Biology 496, 596, and other courses not listed above to be included in the 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.

**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) (SIMS Code: 771452)**

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 124; Physics 180A, 180B, 182A, 182B. (37 units)

These preparation for the major courses may not be taken Cr/NC and must be completed with a grade of C (2.0) or better in each course. These courses require a minimum GPA of 2.80 (excluding Physics 180A, 180B, 182A, 182B).

**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 Placement Assessment with a score of 10 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 30 upper division units to include Biology 350, 351, 352, 354, 366, 366L, Chemistry 365, and nine units of electives selected from the courses listed below. At least two courses must be selected from Biology 464, 480, 485 or 585, 528, 549, 554, 556, 557, 562, 567, 567L, 568 [or Bioinformatics and Medical Informatics 568], 584, 590, Chemistry 432 or 432L. At least one of these courses must be a biology laboratory course. Other electives include all biology courses numbered 350 and above (except Biology 452, 497, and 499), and all upper division chemistry courses (except Chemistry 300, 308, 497, 499, and 560). Approval of the microbiology adviser is required for credit in Chemistry 498, Biology or Chemistry 496 and 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.

## Microbiology Major

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

**(Major Code: 04111) (SIMS Code: 771451)**

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 124; Physics 180A, 180B, 182A, 182B. (37 units)

These preparation for the major courses may not be taken Cr/NC and must be completed with a grade of C (2.0) or better in each course. These courses require a minimum GPA of 2.80 (excluding Physics 180A, 180B, 182A, 182B).

**Graduation Writing Assessment Requirement.** Passing the Writing Placement Assessment with a score of 10 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, 351, 352, 354, 366, 366L, Chemistry 365, and 15 units of electives selected from the courses listed below. At least four courses must be selected from Biology 464, 480, 485 or 585, 528, 549, 554, 556, 557, 562, 567, 567L, 568 [or Bioinformatics and Medical Informatics 568], 584, 590, Chemistry 432 or 432L. At least one of these courses must be a biology laboratory course. Other electives include all biology courses numbered 350 and above (except Biology 452), Biology 497 and 499 (maximum six units), and all upper division chemistry courses (except Chemistry 300, 308, 497, 499, and 560). Approval of the microbiology adviser is required for credit in Chemistry 498, Biology or Chemistry 496 and 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

**(SIMS Code: 771453)**

The emphasis in clinical laboratory science 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 124; Physics 180A, 180B, 182A, 182B. (42 units)

These preparation for the major courses (excluding Chemistry 251) may not be taken Cr/NC and must be completed with a grade of C (2.0) or better in each course. These courses require a minimum GPA of 2.80 (excluding Chemistry 251, Physics 180A, 180B, 182A, 182B).

**Graduation Writing Assessment Requirement.** Passing the Writing Placement Assessment with a score of 10 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.** A minimum of 36 upper division units to include Biology 350, 351, 352, 354, 366, 366L, 480, 485, 584, Chemistry 365, and six units of electives selected from the courses listed below. At least two courses must be selected from Biology 464, 528, 549, 554, 556, 557, 567L, 590, Chemistry 432. At least one of these courses must be a biology laboratory course. Other electives include all biology courses numbered 350 and above (except Biology 452), Biology 497 and 499 (maximum six units), and all upper division chemistry courses (except Chemistry 300, 308, 497, 499, and 560). Approval of the microbiology adviser is required for credit in Chemistry 498, Biology or Chemistry 496 and 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.

### 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) (SIMS Code: 771405)**

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 grade of B (3.0) 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, 590\*, and at least one course from Biology 458, 515, 523, 524, 525, 526, 530 or 531 (it is recommended that Biology 497 or 499 be taken as electives for the major); (2) earning a grade of B (3.0) or better in Biology 452, (3) completing Geological Sciences 101, 104, and Physics 499 (History of Science and Technology). Teacher Education 280, Special Education 450, and Education 451 are recommended as Teacher Credential Program prerequisites. No coursework 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.

\*Biology 336 may be substituted for Biology 590 for SSTC/CSET waiver requirements only. Biology 336 will not satisfy any degree requirements for the major.

### Biology Minor

The minor in biology consists of a minimum of 16 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. Courses may be substituted for those in areas below with approval of the biology adviser, and this approval must be filed with the Office of Advising and Evaluations.

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.

The minor in biology requires prerequisite courses that do not count towards the units in the minor. See descriptions of each area below.

### General Biology

**(SIMS Code: 771401)**

Prerequisites: Biology 100, 100L or Biology 203, 203L and Chemistry 200. Required: Biology 204, 204L; 12 units of upper division biology to include at least two courses in ecology and evolution: Biology 315, 324, 327, 352, 354; at least one course in human biology: Biology 307 or 336; at least one upper division biology course with laboratory (2-4 units): see course descriptions.

### Cellular and Molecular Biology

**(SIMS Code: 771421)**

Prerequisites: Biology 203, 203L, Chemistry 200, 201, 232, 232L, 365. Required: Biology 204, 204L, and at least 12 units of the following electives: Biology 350, 351, 352, 366, 366L, 480, 510, 528, 549, 554, 567, 568 [or Bioinformatics and Medical Informatics 568], 570, 575, 576, 584, 589, 590, and 485 or 585, and 556 or 557. At least one elective must be a laboratory course.

### Ecology

**(SIMS Code: 771422)**

Prerequisites: Biology 203, 203L, Chemistry 200. Required: Biology 204, 204L, 354, and at least nine units of the following electives: Biology 315, 324, 327, 354L, 509, 512, 514, 515, 516A, 517, 518, 523, 524, 525, 526, 527, 527L, 528, 531, 540, 542, 544 [or Environmental Science 544]. At least one elective must be a laboratory course.

### Evolutionary Biology

**(SIMS Code: 771423)**

Prerequisites: Biology 203, 203L, Chemistry 200. Required: Biology 204, 204L, 352, and at least nine units of the following electives: Biology 509, 510, 512, 523, 524, 525, 526, 527, 527L, 530, 531. At least one elective must be a laboratory course.

### Marine Biology

**(SIMS Code: 771425)**

Prerequisites: Biology 203, 203L, Chemistry 200. Required: Biology 204, 204L, 324 and at least nine units of the following electives: Biology 512, 514, 515, 516A, 517, 518, and 542. At least one elective must be a laboratory course.

### Plant Biology

**(SIMS Code: 771426)**

Prerequisites: Biology 203, 203L, Chemistry 200. Required: Biology 204, 204L, 458 or 530 or 531 or 535. At least 8-9 units of the following electives (to total 12 upper division units): Biology 458, 530, 531, 535. At least one elective must be a laboratory course.

### Biotechnology Certificate

**(SIMS Code: 771479)**

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 25-29 certificate units including Biology 497 and/or 499 (5 units must be pre-approved by the certificate adviser), 567, 567L, 568 [or Bioinformatics and Medical Informatics 568], and three electives selected from Biology 510, 549, 554, 570, 575, 576, 584, 585, 589, 590, Chemistry 563, 564. Prerequisite and certificate courses may be utilized in the biology, chemistry, and microbiology majors and minors as appropriate.

**Courses** (BIOL)

Refer to *Courses and Curricula 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 or 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 or 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: Credit or concurrent registration in Chemistry 200 or 202 and satisfaction of the SDSU Written Communication Assessment requirement.

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.

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

Three hours of laboratory.

Prerequisites: Credit or concurrent registration with a grade of C (2.0) or better in Biology 203 and satisfaction of the SDSU Written Communication Assessment requirement.

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.

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

Prerequisite: Satisfaction of the SDSU Written Communication Assessment requirement. 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.

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

Three hours of laboratory.

Prerequisites: Credit or concurrent registration with a grade of C (2.0) or better in Biology 204 and satisfaction of the SDSU Written Communication Assessment requirement. 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.

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

Prerequisites: Biology 100 or 203 and 203L; or a grade of B (3.0) or better in high school biology. Credit or concurrent registration in 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.

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

Three hours of laboratory and two hours of activity.

Prerequisite: Credit or concurrent registration with a grade of C (2.0) or better in Biology 211.

Fundamentals of microbiology, including study of bacteria, fungi, protozoa, and algae of environment, including disease-producing organisms, their actions and reactions.

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

Two lectures and six hours of laboratory.

Prerequisite: Grade of C (2.0) or better in Biology 100, 203, or 211.

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 124, 141, or 150.

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; Linguistics 270; Political Science 201; Psychology 280; 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.

**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.

**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.

**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 250A-250B-250C.

**A.** Topics in Medicine.

**B.** Topics in Dentistry.

**C.** Topics in Veterinary Medicine.

## Biology

### **BIOL 251. Human Anatomy Internship (2)**

Six hours of laboratory.

Prerequisites: Biology 212 and consent of instructor.

Interns will master the material from human anatomy, develop and teach study skills, and apply skill set for administering a laboratory course in human anatomy. Maximum credit four units.

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

Three lectures and three hours of laboratory.

Prerequisites: Biology 212. Credit or concurrent registration in Chemistry 102 (or Chemistry 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 291C. Biostatistics Laboratory (1)**

Prerequisites: Recommendation by department and consent of instructor.

Special laboratory course designed for biology majors with credit in a statistics course other than 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 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 317. World of Dinosaurs (3) [GE]**

Prerequisite: Upper division standing.

Current theories and controversies surrounding the evolution and extinction of dinosaurs for non-science majors. Not applicable to biological sciences majors.

### **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 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. Not open to students with credit in Biology 540.

### **BIOL 335. 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 or exercise and nutritional sciences majors, or to students with credit in any college-level human physiology or anatomy course. Not applicable to biological sciences majors. (Formerly numbered Biology 341.)

### **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) Cr/NC**

Four hours of clinical and other activities.

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 six 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 351. Genetics (3)**

Two lectures and two hours of activity.

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

"Faulty" genes, genetic variation, human disorders. Big data, molecular, and transmission genetics.

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

Two lectures and two hours of activity.

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

Principles of population genetics and evolutionary biology.

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

Two lectures and one hour of discussion.

Prerequisites: Biology 203, 203L, 204, 204L, 215. Credit or concurrent registration in Mathematics 124.

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. Cell and Molecular Biology (3)**

Prerequisites: Biology 203 and 203L. Limited to Biology and Microbiology majors, Biology minors, and Chemistry majors with Emphasis in Biochemistry, SIMS Codes: 771401-771452 and 772609.

Fundamental processes of cell biology with an emphasis on cellular and molecular mechanisms common to eukaryotic organisms.

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

Six hours of laboratory.

Prerequisite: 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 464. Functional Genomics Laboratory (2)**

Six hours of laboratory.

Prerequisites: Biology 366 and 366L.

Practical research experience in cell and molecular biology using animal model of tissue regeneration. Analysis of gene expression, gene inhibition approaches, image data analysis, microscopy techniques, molecular genetic techniques.

**BIOL 480. Clinical Hematology (3)**

Prerequisites: Biology 203 and Chemistry 365 or 560. Recommended: Credit or concurrent registration in Biology 366 or Chemistry 563.

Theoretical and practical background for study of normal and pathological blood cells to include laboratory techniques. Course meets State of California requirements as a hematology course for students entering training programs in clinical laboratory sciences.

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

Prerequisites: Biology 203, 203L, Chemistry 365, credit or concurrent registration in Biology 366. Recommended: Biology 350.

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: Admission to the major with GPA of at least 3.20 and 15 units completed in the major. Two previous semesters of advanced upper division research in biology. Consent of instructor and undergraduate adviser.

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 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: Admission to the major with GPA of at least 2.70 and nine units completed in the major. Consent of instructor and undergraduate adviser.

Independent research project supervised by faculty. Data analysis and written or oral presentation of results. Maximum credit six units.

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

Fifty hours of activity per unit.

Prerequisites: Admission to the major with GPA of at least 2.70 and nine units completed in the major. Consent of instructor and undergraduate adviser.

Individual study, internship, other supervised laboratory or field project or experience. Credit involves 50 hour activity per unit per semester. Written or oral presentation of results required. Maximum credit six units.

**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 509. Advanced Evolution (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 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 phylogenetic 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.

## Biology

### **BIOL 517. Marine Ecology (3)**

Two lectures and three 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 518. Biology of Fishes (4)**

Three lectures and three hours of laboratory.

Prerequisite: Biology 354.

Ecology, anatomy, physiology, evolution, taxonomy, environmental constraints, habitats, feeding, behavior, growth, reproduction, biotic interactions, population dynamics, and assemblage structure. Fisheries biology concepts to include stock-recruitment models, density dependence and population regulation, management of fisheries, and conservation. Not open to students with credit in Biology 520 and 541.

### **BIOL 523. Herpetology (3)**

Two lectures and three 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 (3)**

Two lectures and three 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 203, 203L, 204, 204L, 215; 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 527L. Animal Behavior Laboratory (1)**

Three hours of laboratory.

Prerequisite: Credit or concurrent registration in Biology 527.

Animal behavior with emphasis on ethological approach to include evolution and adaptive significance of behavior, data collection and analysis, scientific writing and results.

### **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 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 542. Ecological Signaling in the Environment (3)**

Prerequisites: Biology 354 and Chemistry 201.

Ecological consequences of species interactions mediated by signals in terrestrial and aquatic ecosystems. Evaluating primary literature and conveying science to a broad audience.

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

(Same course as Environmental Science 544)

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 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 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 556. Scanning Electron Microscopy Laboratory (2)**

Six hours of laboratory.

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

Biological specimen preparation and operation of scanning electron microscope.

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

One lecture and six hours of laboratory.

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

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 562. Ecological Metagenomics (3)**

Two lectures and three hours of laboratory.

Prerequisites: Credit or concurrent registration in Biology 354 and 366.

Next generation DNA sequencing technology with emphasis on ecological applications in microbial communities. Metagenomic analysis of taxonomic identification, physiological function, and the ecological role of the microbial community in the broader ecosystem.

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

Prerequisites: Biology 366 and Chemistry 365.

Advanced concepts of cellular biology, molecular biology, and biochemistry.

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

Six hours of laboratory.

Prerequisites: Biology 366 and 366L. Recommended: Biology 350.

Intermediate laboratory approaches to biochemistry, cellular biology, and molecular biology at a level appropriate for both advanced undergraduate and graduate students.

**BIOL 568. Bioinformatics (3)**

(Same course as Bioinformatics and Medical Informatics 568)

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 589. Stem Cell and Regenerative Biology (3)**

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

Stem cell basics, cloning, tissue engineering, research on animal models of regeneration, political and ethical issues surrounding stem cell debate.

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

Three lectures and one hour of discussion.

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

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 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.

## GRADUATE COURSES

Refer to the *Graduate Bulletin*.