



College of Science and Mathematics

## Department of Biology

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## B.S. in Biology

Options:

- Ecology and Evolutionary Biology
- Molecular, Cellular, and Developmental Biology
- Organismic and General Biology
- Physiology and Anatomy

## M.S. in Biology

## M.S. in Marine Science

## Minor in Biology

## Biotechnology Certificate

## Single Subject

## Teaching Credential in Science

## Preprofessional advising in:

- Dentistry
- Forestry
- Medicine
- Pharmacy
- Veterinary Medicine

## Faculty and Facilities

Faculty expertise spans the range of biology from molecular to ecological, with a broad representation of taxonomic specialties. Laboratories in upper-division major courses are taught by faculty, and individualized student/faculty research participation through independent study is encouraged.

The department is housed in a well-equipped, modern science building. Excellent greenhouse and animal care facilities provide support to the instructional program. Fresno's proximity to both the Sierra Nevada crest and the Pacific coast, provides an "outdoor laboratory" with numerous field trip opportunities that are rarely equalled at other institutions. Students with interests in marine biology can study at the Moss Landing Marine Laboratories (MLML).

## Biology

Biology is the scientific study of life: its properties, its complexity, and its incredible variety. Biological studies may focus on objects as small as molecules or as large as whales. They range from the inner workings of cells to the structure of whole ecosystems, and they lead biologists from the tops of mountains and the deepest ocean trenches into sophisticated modern laboratories.

The Department of Biology offers a diversified undergraduate program that matches the breadth and excitement of modern biology and prepares students for the hundreds of career opportunities that use biology as a foundation. The Bachelor of Science degree is awarded to those students who successfully complete the core program and one of the following four options:

1. **Organismic and General Biology** allows students to develop a broad program that cuts across taxonomic lines or to specialize in a particular taxonomic group. This option is also appropriate for students planning to enter the field of clinical laboratory technology.
2. **Molecular, Cellular, and Developmental Biology** utilizes advanced technology to uncover the fundamental unifying processes of living things.
3. **Physiology and Anatomy** seeks to understand the mechanisms that operate within the individual organism.
4. **Ecology and Evolutionary Biology** focuses on the interrelationships between living organisms and their environments.

The biology major we offer has three programmatic goals:

1. To provide students with a solid foundation in all aspects of modern biology and also the intellectual skills that will serve as the basis for a lifetime of future achievement.
2. To provide students with the specialized educational opportunities that will allow them to compete successfully for careers in the biological sciences or for advanced studies in major doctoral programs.
3. To provide preprofessional students with the knowledge needed for advanced study in the many fields that build upon a biological foundation.

Our undergraduate biology major is excellent preparation for graduate programs in medicine, dentistry, pharmacy, forestry, veterinary medicine, optometry, doctoral programs, and many others.

The department offers a Master of Science degree in Biology for qualified students who wish to explore some part of biology in greater depth. It also participates in a postbaccalaureate certificate program in biotechnology.

Advising is an integral part of the departmental program and all biology majors are assigned Advisers. This student/faculty collaboration on program planning is undoubtedly one of the main reasons for the postgraduate successes of our students.

## Faculty

Fred E. Schreiber, *Interim Chair*  
 Brian Tsukimura, *Graduate Coordinator*  
 Bert Tribbey, *Marine Science Coordinator*  
 Gregor M. Cailliet, *Moss Landing  
 Marine Laboratories Coordinator*  
 David M. Andrews, *Credential Adviser*  
 Undergraduate advisers are assigned by  
 the department chair.

Raymond H. Abhold	Shirley A. Kovacs
Jorge A. Benitez	Thomas E.
Alejandro	Mallory
Calderon-Urrea	James P. Prince
David L. Chesemore	Vivian A. Vidoli
S. Fai Cheuk	Lorraine Wiley
William K. Collin	Alice D. Wright
Stephen Ervin	Lenore Yousef
David E. Grubbs	Frederick W.
Ethelynda E. Harding	Zechman
Ruth A. Kern	

## Bachelor of Science Degree Requirements

### Biology Major

The Bachelor of Science degree in Biology is a 124-unit program. Of the total, 42 units are required to satisfy the university's General Education Program and 22 units are required by the Department of Biology to satisfy the core curriculum in biology. The core curriculum is a sequence of six courses required to be taken by all biology majors. The core curriculum builds the foundation upon which all further learning in biology will be based. Additional requirements, varying from 25-41 units depending upon the option choice the student selects, are specified courses from related fields outside the Department of Biology.

Each biology major must select one of the four option choices to complete the Biology Bachelor of Science degree requirements. All of the four option choices are flexibly designed. As a result, virtually any career goal in the life sciences and related fields can be accommodated by selecting the most appropriate option and by judiciously choosing specific courses within that option.

Academic advising is essential in making these option and course selections. Therefore, all biology majors are assigned faculty Advisers. Students majoring in biology should report to the Department of Biology office for assignment of an appropriate adviser. Students should meet with their adviser a minimum of two times a semester so the adviser can review the student's program and progress.

Students planning for graduate and professional schools should be aware that entrance requirements for those programs will often exceed the minimal requirements for a Biology B.S. degree, particularly in the ancillary fields of chemistry, physics, and mathematics. An adviser should be consulted for specific information on graduate and professional school requirements.

## Biology Core

The biology core is required of all majors (see *Advising Notes* for all options, page 364.)

### Units

BIOSC 1A, 1B, 130, 140A-B, 180 ..... 22

In addition to the core, all majors must complete major and additional requirements in one of the four options described as follows:

## Organismic and General Biology Option

This versatile option is designed for students who wish to explore the breadth of modern biology. It is highly recommended for students preparing for teaching careers. It is equally useful as preparation for a large variety of careers including clinical laboratory technology, and for additional studies in graduate and professional schools. By carefully selecting courses, students may use this option to obtain strong preparation for careers as botanists, zoologists, entomologists, microbiologists; or they may select courses that produce a broadly based program that does not emphasize a particular taxonomic group. Advising is critically important in this option. Students must consult a faculty adviser for help in determining the appropriate selection of courses and special requirements for their chosen fields.

### Units

**Major requirements**..... 42

*Biology Core* ..... (22)

*Option requirements* ..... (20)

A. Select one course from each of the following five listings ..... (16-20)

1. BOT 131, 132, 142, 144; MICRO 140, 181, 185; M SCI 131

2. MICRO 171; ZOOL 120, 141, 148, 150, 171, 174, 177; M SCI 112, 113, 114

3. BOT 133, 137; ECOL 174; PHYAN 134, 135, 158; M SCI 122; ZOOL 132

4. BOT 130; GENET 172; MICRO 161; PHYAN 151, 158, 160, 163

5. ECOL 151, 152, 158; 162; M SCI 103

### B. Biological

Science Electives ..... (0-4)

Select one or more Biology Department courses to complete the option. Only one elective course may, be lower division.

**Additional requirements** ..... 22

1. CHEM 3A, 8, and 150 ..... (10)  
 2. MATH 70 or 75 ..... (4)  
 3. MATH 101 or PSYCH 42 or M SCI 104 ..... (4)  
 4. One course selected from PHYS 2A; M SCI 142, 143; GEOL 1; SW 101 ..... (4)

**General Education** ..... 51

**Electives and remaining degree requirements\*** ..... 18

(See *Degree Requirements*); may be used toward a dual major or minor.

**Total**..... 124

\*It is anticipated that 9 units of the General Education requirement will be met by the following major and additional required courses: MATH 75, CHEM 3A, and BIOSCI 1A. Consult your major academic adviser for details.

## Molecular, Cellular, and Developmental Biology Option

This degree option is intended for students who wish to study the molecular mechanisms underlying cellular structure and function as well as the molecular and cellular interactions occurring in the operation and development of organ systems. Molecular biology combines the knowledge and techniques of genetics, cell biology and biochemistry, forming a basis for in-depth inquiry into all aspects of biology. The option introduces students to molecular inquiry at several levels of organization and provides the requisite background for the many career opportunities in biotechnology. The

option also provides a solid foundation for graduate and professional studies emphasizing cellular and molecular processes, including the postbaccalaureate certificate of advanced studies in biotechnology offered by this department. Students preparing for the biotechnology certificate program should select a general microbiology course with laboratory and a biochemistry laboratory course among their elective courses.

**Units**

**Major requirements..... 40**

*Biology Core* ..... (22)

*Option requirements* ..... (18)

- A. Molecular Biology ..... (4)  
GENET 142
- B. Cell Structure and Development ..... (3-4)  
Select one from the following list: BOT 133, 137; GENET 172, PHYAN 134, 158
- C. Cellular/Molecular Physiology of Organisms/Organ Systems..... (3-5)  
Select one from the following list: BOT 142; MICRO 161, 171, 181, 185; PHYAN 140, 160 (with lab 160L or without), 165; ZOOL 148
- D. Molecular/Cellular Techniques ..... (3-4)  
Select one from the following list: ECOL 174; GENET 171, 182

*Note: A minimum of two laboratory experiences from B, C, and D are required.*

- E. Seminar ..... (1)  
GENET 170
- F. Choose one additional course from above or any upper-division biology course, including independent study or research ..... (0-4)

**Additional requirements ..... 37**

- 1. CHEM 1A-B, 128A-B, 129A, 150 or 155 .... (21)
- 2. PHYS 2A-B..... (8)
- 3. MATH 70 or 75 ..... (4)
- 4. MATH 101 or PSYCH 42 .... (4)

**General Education ..... 51**

**Electives and remaining degree requirements\* ..... 5**

(See *Degree Requirements*); may be used toward a dual major or minor.)

**Total..... 124**

\*It is anticipated that 9 units of the General Education requirement will be met by the following major and additional required courses: MATH 75, CHEM 1A, and BIOSCI 1A. Consult your major academic adviser for details.

**Physiology and Anatomy Option**

This degree program is designed to help students understand basic cellular phenomena and to analyze complex multicellular biological systems in preparation for medical, clinical, academic or research careers that require physiology as a foundation. The ultimate goal of physiology is to understand, in physical and chemical terms, the mechanisms that operate in living organisms. This option encompasses three major branches of physiology: cellular; systemic; and whole organism. Physiology is one of the central disciplines in biology and is of particular importance in the health professions and agriculture. This option offers excellent preprofessional preparation for medicine, dentistry, pharmacy, various careers requiring physiology, and for advanced graduate study. Students planning to enter professional and graduate programs should elect CHEM 1A-B and 128A-B rather than CHEM 3A and 8, and should consult an adviser about additional mathematics requirements as well.

**Units**

**Major requirements..... 42**

*Biology Core* ..... (22)

*Option requirements* ..... (20)

- A. Select one course from each of these three lines..... (9-12)
  - 1. *Anatomy*. BOT 133; PHYAN 130, 134, 135; ZOOL 132, 141
  - 2. *Molecular and Cellular Biology*. BOT 137; GENET 172; MICRO 161; PHYAN 160 and 160L
  - 3. *Organismal Physiology*. BOT 130; PHYAN 151

- B. Select two additional courses from the following list or from other courses listed in category A ..... (6-8)

GENET 172;  
PHYAN 64 or 65, 140, 158, 163, 165, 172

- C. Biological Science Electives ..... (5)

Select sufficient Biology Department courses to complete the option. Only one elective course may be lower division.

**Additional requirements ..... 29-38**

- 1. CHEM 3A or 1A-B, 8 or 128A-B, 109 or 129A, 150 or 155 ..... (13-22)
- 2. PHYS 2A-B ..... (8)
- 3. MATH 70 or 75 ..... (4)
- 4. MATH 101 or PSYCH 42 ..... (4)

**General Education ..... 51**

**Electives and remaining degree requirements\* ..... 2-11**

(See *Degree Requirements*); may be used toward a dual major or minor.

**Total..... 124**

\*It is anticipated that 9 units of the General Education requirement will be met by the following major and additional required courses: MATH 75, CHEM 1A, and BIOSCI 1A. Consult your major academic adviser for details.

**Ecology and Evolutionary Biology Option**

This degree program is intended for students who wish to study the interrelationships between living things and their environments. This option has a strong field component that takes full advantage of the outstanding natural environments conveniently located near our campus. Students in this program gain an in-depth understanding of ecology and evolution, and acquire the skills to apply that understanding to important question in freshwater, marine, and terrestrial systems, in fisheries and wildlife management, or other branches of applied ecology. Students completing this option are well prepared for entry into a wide range of environmental careers with governmental field research agencies, in

agriculture-related areas, environmental microbiology, environmental law and consulting firms, or for graduate programs leading to advanced degrees in ecology, management, and evolution. Students may obtain an emphasis in marine science by selecting electives offered at the Moss Landing Marine Laboratories. Faculty advising plays an important role in this program. Students must consult an adviser for help in selecting courses appropriate to their interests and career objectives.

## Units

### Major requirements..... 47

Biology Core ..... (22)

Option requirements ..... (25)

#### A. Ecosystem Ecology.

Select one course from the following ..... (4)

ECOL 151, 152;  
M SCI 103\*\*

At least one botany (BOT) or microbiology (MICRO) course must be selected from the following categories B-E.

#### B. Physiology. Select one course

from the following..... (3-4)

BOT 130, BOT 142;  
ECOL 174; MICRO  
161; PHYAN 151

#### C. Morphology and Classification.

Select one course from the following ..... (3-4)

BOT 131, 132, 142,  
144; ECOL 174;  
MICRO 140; ZOOL  
120, 132, 141, 150;  
M SCI 124\*\*, 131\*\*

#### D. Autecology and Population Ecology.

Select one course from the following ..... (3-4)

ECOL 162, 171,  
172, 174; ZOOL  
152; M SCI 110\*\*,  
161\*\*

#### E. Biological

Science Electives ..... (9-12)

Select sufficient Biology Department courses, including those listed in categories A, B, and C, to complete the option. Only one elective course may be lower division.

### Additional requirements ..... 21-22

1. CHEM 3A, 8, and 150 ... (10)

2. MATH 70 or 75 ..... (4)

3. MATH 101  
or PSYCH 42 ..... (4)

4. Consult your adviser to select one course from the following ..... (3-4)

PHYS 2A; M SCI  
142\*\*, 143\*\*; GEOL  
2, 112; SW 101

General Education ..... 51

Electives and remaining

degree requirements\* ..... 13-14

(See *Degree Requirements*); may

be used toward a dual major or minor.

Total ..... 124

\*It is anticipated that 9 units of the General Education requirement will be met by the following major and additional required courses: MATH 75, CHEM 1A, and BIOSCI 1A. Consult your major academic adviser for details.

\*\* MSCI courses are offered only at Moss Landing Marine Laboratory.

### Advising Notes for All Options within the Bachelor of Science in Biology

1. B.S. biology majors who have taken introductory sequences other than BIOSCI 1A and 1B must consult with their faculty adviser or department chair for equivalency evaluation prior to beginning their upper-division coursework.

2. CHEM 1A may be taken as a substitute for CHEM 3A, and CHEM 128A and 128B may substitute for CHEM 8. The reverse substitutions are not permissible. Premedical students should take CHEM 1A and 1B and 128A and 128B instead of CHEM 3A and 8.

3. B.S. biology majors selecting options in Molecular and Cellular Biology or in Physiology can complete a Minor in Chemistry with the addition of CHEM 105. Consult the chemistry department chair for details (see *Chemistry Minor*).

4. No General Education Integration course offered by the Department of Biology may be used to satisfy the General Education requirements for biology majors.

5. CR/NC grading is not permitted in the biology major.

6. General Education, additional, and elective requirements may be used toward a dual major or minor (see *Dual Major* or departmental *minor*). Consult the appropriate department chair, program coordinator, or faculty adviser for additional information.

### Suggested Sequence of Courses for B.S. Degree in Biology

The following comments on timing and sequence are intended for full-time students who plan to complete the B.S. degree in four years. Students with extensive extracurricular obligations should make appropriate timing adjustments to avoid overloads. See your adviser for assistance.

A total of 124 units must be completed for all biology B.S. degree options. In addition to courses required for the major, full-time students should add General Education requirements and electives to bring semester totals to 15-17 units. Electives may include minor and credential requirements. (See *Degrees and Credentials*.)

During the first two years, both resident and transfer students should complete most General Education requirements, BIOSCI 1A and 1B, all lower-division additional requirements for the option they have selected, and any lower-division electives that might be selected within that option. BIOSCI 130, 140A-B, and statistics should be completed as early as possible but no sooner than the term in which 60 units of coursework are completed and preferably no later than the end of the third year. The remainder of the third and fourth years should be spent completing requirements for the selected option, for General Education, and for the electives in biology and other fields. BIOSCI 180 is a senior requirement and must be taken during the fourth year.

### Biology Minor

The Minor in Biology may be earned by completing the 22-unit biology core: BIOSCI 1A, 1B, 130, 140A-B, 180.

### Bachelor of Arts in Natural Sciences

#### Teaching Credential — Biology Emphasis

The B.A. in Natural Sciences serves as a waiver program for the Single Subject Teaching Credential in Science. This degree program is designed for students who wish to become high school science teachers. The full program is described in the Natural Science section in this catalog. The program consists of two parts. The Core requirements are courses required of all natural science students and the Emphasis provides training in biology, chemistry, earth science, or physics. Students

may also earn the credential while obtaining a degree in biology. The B.A. in Natural Sciences with the Biology Emphasis is as follows.

	<i>Units</i>
<b>Core requirements</b> .....	<b>37-38</b>
<i>Biology</i> <sup>1</sup> .....	(12-13)
BIOSC 1A or BIOL 15 <sup>1</sup> , BIOSC 1B, BIOSC 130	
<i>Chemistry</i> .....	(10)
CHEM 1A, 1B	
<i>Geology</i> <sup>1</sup> .....	(8)
GEOL 1 and 3 (or 15), GEOL 168	
<i>Natural Science</i> .....	(3)
N SCI 106	
<i>Physical Science</i> .....	(4)
P SCI 21	
<b>Biology Emphasis</b> .....	<b>42-44</b>
CHEM 8 or 128A .....	(3)
PHYS 2A, 2B <sup>2</sup> .....	(8)
P SCI 168 .....	(3)
MATH 70 or 75 .....	(4)
MATH 101 or PSYCH 42 .....	(4)
BIOSC 140A, 140B, 180 .....	(10)
MICRO 140 .....	(4)
Select one course:	
BOT 131, 132, 144; MICRO 171; ECOL 151, 152, 162; ZOOL 120, 141, 148, 150, 174, 177 ...	(3-4)
Select one course:	
BOT 130; MICRO 161; PHYAN 151, 163 .....	(3-4)
<b>General Education</b> .....	<b>51</b>
<b>Electives and remaining degree requirements</b> <sup>3,4</sup> .....	<b>0-6</b>
<b>Total</b> .....	<b>124</b>

**Advising Notes for the Natural Sciences Major**

1. BIOL 15 and GEOL 15 are part of the Humans and the Natural Environment Cluster. See the *Natural Science Interdisciplinary Courses* section in this catalog. GEOL 15 is equivalent to GEOL 1 and 3.
2. Substitutions may be made with the permission of the appropriate department

chair. PHYS 4A-B-C with labs 4AL, 4BL is recommended instead of PHYS 2A-B for those students well-prepared for physics.

3. This figure takes into account that 9-12 units required for the major are expected to count toward General Education as follows: CHEM 1A (3 units), BIOSC 1A or BIOL 15 (3 units), GEOL 168 (3 units), and 3 units if MATH 75 is selected. Consult your major adviser for details.
4. Students should be sure to take sufficient upper-division units in their General Education courses and electives to satisfy the university requirement of 40 upper-division units for graduation.

**Graduate Programs**

The Biology Department offers the Master of Science degree in Biology with the opportunity for specialization in several areas of study. Among these areas are ecologically oriented field studies; molecular and cellular biology; physiology at both invertebrate and vertebrate levels; entomology; microbiology; parasitology; botany; systematics; animal behavior. The program also prepares candidates for teaching various biological science disciplines at the primary and secondary education levels. A further objective of the master's program is to provide a foundation for those seeking advanced education at universities offering the doctorate or other professional degrees. The Biology Department has further informational materials available upon request.

The Biology Department and the university are located in a region uniquely suited to the pursuit of projects that are environmentally oriented. High Sierra, foothill, coastal, and forest environments are all within three hours drive of California State University, Fresno. Facilities are available at the campus for studies involving genetic recombination, electron microscopy, use of radioactive materials, and metabolic studies on all living forms. Cooperation with local physicians and hospitals provides additional opportunities to pursue medically oriented research.

The Biology Department is a member of a consortium that manages and operates the Moss Landing Marine Laboratory (MLML). MLML is located on the California coastline between Santa Cruz and Monterey. A master's candidate interested in pursuing marine science studies must

meet California State University, Fresno Biology Department master's candidate requirements as well as those of MLML. Such candidates are encouraged to consult the Biology Department's MLML coordinator for information and to read the MLML information presented at the end of this section.

**Master of Science Degree Requirements**

The Master of Science degree program in Biology assumes preparation equivalent to a California State University, Fresno undergraduate major in biology. Students having undergraduate majors in fields other than the biological sciences may enter the program, but may reasonably expect additional requirements to produce equivalent preparation.

There are five steps that must be completed for the Master of Science degree in Biology:

1. Admission to graduate standing (constitutes admission to the university)
2. Admission to classified graduate standing (constitutes admission to the department program)
3. Advancement to candidacy (formalizes thesis committee and research project)
4. Completion of a thesis and associated requirements
5. Completion of all additional requirements for award of master's degree

Normal progress toward the Master of Science degree in Biology requires that classified graduate standing be achieved in the first semester of graduate study and that advancement to candidacy be granted the following semester. Completion of the thesis and all other program requirements will normally require two additional semesters of study. Procedures for completing these steps are outlined in the following sections. Students should meet with the departmental graduate coordinator at the earliest possible date. **Students are personally responsible for ensuring that all graduate degree requirements have been met in sequence; therefore, each student should read the procedures thoroughly to be sure all requirements are understood.**

**Admission to Graduate Standing**

Admission to the university is handled through the Admissions Office of California State University, Fresno. For admission to postbaccalaureate/graduate standing, a student must have completed a

four-year college program and hold an acceptable baccalaureate degree from an accredited institution with a grade point average of 2.5 in the last 60 units.

To be considered for classified standing in biology, the following additional steps are required of students planning to enter the biology graduate program.

1. Take the Aptitude and Subject Biology, or Molecular, Cellular, and Developmental sections of the Graduate Record Examination prior to application. Information about dates, fees, and application procedures may be obtained through the Division of Graduate Studies. The Biology Department requires that GRE advanced scores be current. Scores dating from five years previous to application are not considered valid.
2. Contact the graduate coordinator in the Biology Department prior to registration for assignment of a temporary faculty adviser who will assist in the planning of initial courses. Students may request the assignment of any biology faculty member to serve in this capacity.
3. Meet with the temporary adviser prior to registration and develop an approved initial program of at least 9 units that is mutually agreeable to the student and the adviser. These courses are to be entered on the "Approved Preliminary Program" form (available from the Biology Office) and signed by the student, temporary adviser, and departmental graduate coordinator. This will constitute the Approved Initial Graduate Program. These courses may or may not be included on your Advancement to Candidacy Application; make-up classes, for example, are not included. All students are required to have the "Approved Preliminary Program" form approved and on file prior to registration. Upon completion of conditional status, the student must file for classified standing.

## Admission to Classified Graduate Standing

Admission to classified graduate standing constitutes official admission into the graduate program in the Department of Biology and requires the approval of the Biology Department. Classified standing must be attained no later than the semester in which a student completes 10 units, including transfer and postbaccalaureate credit, to be used toward the master's degree; students

should attempt to obtain classified graduate standing as early as possible in their graduate careers to avoid possible loss of units. Normal progress toward the degree requires that this be accomplished in the first semester of graduate work.

Students applying for classified standing should be sure they have submitted an "Approved Preliminary Program" form to the departmental graduate coordinator.

Admission to classified graduate standing must be recommended by the graduate coordinator in consultation with the Graduate Committee of the Biology Department. To be recommended, the student must demonstrate competency in verbal or written communication, quantitative analytical skills and disciplinary knowledge.

Competencies may be demonstrated in the following manner:

1. For verbal or written communication, students must achieve either (1) 60th percentile on the verbal portion of the general GRE or (2) a grade of **B** or better in an upper-division writing course. In exceptional cases the Graduate Committee may consider alternative evidence of verbal or writing skills.
2. For quantitative analytical skills, students must achieve either (1) a quantitative GRE score of 60th percentile or better or (2) a **B** or better in a mathematics class at least at the level of MATH 70 (introductory calculus).
3. For disciplinary knowledge, students must achieve at least one of the following:
  - a. A score on the subject Biology section of the GRE of 60th percentile or better. The subject Biochemistry, Cell and Molecular Biology section will fulfill this requirement *only in conjunction with coursework in ecology*.
  - b. No less than a grade of **B** in each of the upper-division core courses or their equivalents. Equivalency will be determined by the graduate coordinator in consultation with faculty teaching the core courses at this university.
  - c. No less than a grade of **C** in each of the upper-division core courses or their equivalents, as well as an overall GPA of 3.0 or better for at least 25 semester units of upper-division lecture or lecture/laboratory courses in natural science.

On recommendation, students will be assigned to one of the following three categories:

1. Classified graduate standing will be assigned to students meeting the standards in verbal written communication, quantitative analytical skills, and disciplinary knowledge.
2. Conditional classified standing will be assigned to students meeting a majority of the classification standards yet having specific identifiable deficiencies that may be easily corrected within a single semester. While this classification gives students the opportunity to remedy identified deficiencies, those remedial courses taken to correct deficiencies may not be applied to the graduate program.
3. Nonclassified standing will be assigned to students who do not meet the classification standards or whose deficiencies will require more than one semester for remediation.

Students recommended for classified graduate standing may proceed with the completion of requirements for advancement to candidacy, the next step in the graduate program. Students granted conditional classified status or denied admission (remaining in postbaccalaureate unclassified standing) will not have been admitted to the graduate program in biology and must attempt to increase their classification score to gain classified standing. The graduate coordinator will provide further information on how this may be accomplished.

When any requirements for a change in graduate standing have been completed, the student must see the graduate coordinator and file appropriate forms with the graduate division.

## Advancement to Candidacy

Acceptance to **classified graduate standing** indicates that the student's academic background and perceived ability are sufficiently high to merit admission into the biology graduate program. **Advancement to candidacy** signifies that the student has developed a coherent program of study for the Master of Science degree that meets with the approval of the Biology Department. Advancement to candidacy requires the establishment of the Thesis Committee, identification of the thesis topic, and the approval of all coursework that must fit within the following framework:

<b>Courses in 200-series</b> .....	<b>21</b>
<b>Electives</b> .....	<b>9</b>
(May be 100- or 200-series)	
<b>Total</b> .....	<b>30</b>

No less than 18 units of the approved coursework must be in the biological sciences. Nine units must be completed prior to advancement to candidacy. The Biology Department also requires that at least 10 units of approved coursework be completed after advancement to candidacy.

Units completed during the semester that advancement is achieved will be considered to have been completed after advancement to candidacy. Students must also show competence in writing skills through an appropriate examination or course. Normal degree progress requires that advancement to candidacy be achieved in the semester following admission to classified standing. A student must be advanced to candidacy, possess a GPA of 3.0 or better, and file a Thesis Committee Assignment Form before enrolling in thesis (BIOL 299).

A complete list of the steps required for advancement to candidacy is available from the departmental graduate coordinator.

### **Completion of a Thesis**

The Master of Science in Biology requires completion of a research thesis (BIOL 299). The thesis must show originality, appropriate organization, clarity of purpose, critical analysis, and accuracy and completeness of documentation where needed. Critical and independent thinking are required. The finished thesis must meet standards appropriate for publication in the scholarly journals of the field. A colloquium is required of all students before graduation. Additional information on the completion of the thesis is available from the departmental graduate coordinator.

### **Completion of All Requirements for Award of Master of Science Degree in Biology**

In addition to the aforementioned requirements, in order to receive the Master of Science in Biology the student must:

1. Maintain a GPA of 3.0 or better in all graduate coursework undertaken from the date of embarking on the first course of the approved program. Students wishing to explore other academic areas

without jeopardizing this grade point average should attempt to use the *CR/NC* grade option for this purpose.

2. File an application for the granting of the Master of Science degree and pay the diploma fee. Applications should be submitted during the first two weeks of the semester (or the first week of a summer session) in which the degree is to be completed and are available from the Division of Graduate Studies, Thomas Administration, Room 132.

### **Master of Science Degree Requirements Marine Science Major**

This degree program — to be offered as an interdepartmental degree in cooperation with Moss Landing Marine Laboratories (MLML) — provides the opportunity for students to acquire a practical and theoretical education in the marine sciences to prepare them for careers as marine specialists, scientists, and teachers. The program at Moss Landing provides extensive field and laboratory work for advanced study in the marine sciences, which is not duplicated on individual CSU campuses.

The Master of Science in Marine Science degree program is administered through MLML and a consortium campus with emphasis on biology, geology, or other department, depending on the choice of the student. The prospective student must meet the entrance requirements for the home campus department and will be accepted into classified or conditionally classified status by normal procedures at that campus (see previous information for biology procedures summary). Conditionally classified students must become classified by home campus procedures. MLML may impose additional requirements for classification.

The Thesis Committee will be composed of at least three members, including one faculty member from MLML (who is ordinarily the thesis adviser) and, at the discretion of the home campus, a representative of that campus. The other member or members of the Thesis Committee may be from MLML, the home campus, or elsewhere with the approval of the thesis adviser. The final colloquium must be given at the home campus.

Additional MLML Degree Requirements Including Coursework. A student becomes eligible for the master's degree in marine science after the following requirements have been satisfied:

	<i>Units</i>
Courses in 100-series (requires any three of the following five courses: M SCI 103, M SCI 141, M SCI 142, M SCI 143, M SCI 144) .....	<b>12</b>
Courses in 200-series (including 2 units of M SCI 285T, 286T or 287T, and 4 units of M SCI 299) ....	<b>15</b>
Electives (course[s] in the 100- and/or 200-series) approved by Thesis Committee .....	<b>3</b>
<b>Total</b> .....	<b>30</b>

*Note:* Quantitative Marine Science, MSCI 104, does not count toward the degree.

### **Biotechnology Certificate Program**

California State University, Fresno offers a Certificate of Advanced Study Program in Biotechnology. This intensive one-year post-baccalaureate program emphasizes molecular biology and a wide range of laboratory skills at the forefront of modern biotechnology. The biotechnology field is growing rapidly and, as new products and applications are commercialized, there is increased need for highly skilled personnel capable of working in both research and production areas. Enrollment is limited to 12 to 15 students per year who work closely with faculty in a variety of lecture and laboratory courses. Among the techniques studied are purification of biological macromolecules, gene splicing, DNA sequencing, culturing of mammalian cells, hybridoma production, and plant cell culturing and cloning.

The certificate program can lead to potential careers in expanding fields, such as drug and hormone production in the pharmaceutical industry, monoclonal antibody production for medical diagnostics and therapeutics, crop improvement, industrial bioprocessing, forensic science, bioremediation, and medical research. The program also provides a background for further post-graduate studies in fields such as biochemistry, molecular biology, and agricultural biotechnology. Some of the courses may also be used at California State University, Fresno as components of master's degree programs in biology, chemistry, plant science, and related departments.



Program courses include: Molecular Biology (BIOL/CHEM 241A-B), Techniques in Protein Purification (BIOL/CHEM 242), Nucleic Acid Technology Lab (BIOL/CHEM 243), Cell Culture/Hybridoma Laboratory (BIOL/CHEM 244), Micropropagation (PLANT 102), and Seminar in Molecular Biology/Biotechnology (BIOL/CHEM 248).

Admission to the program requires a bachelor's degree with an overall GPA and science GPA of 3.0 or better. Upper-division courses in genetics (minimum 3 units), biochemistry with a laboratory (minimum 5 units), and microbiology with a laboratory (minimum 4 units) are also prerequisites for entrance into the program. Consult with the Biotechnology Program coordinator for determining recommended or equivalent courses.

## Upper-Division Course Numbers

Biology Department upper-division course numbers provide information on course level and scheduling. Courses with higher numbers have more prerequisites. Courses with numbers less than 120 are not intended for use on biology majors. Numbers in the range 120 to 149 are third year courses requiring only lower-division prerequisites; 150 to 169 courses require some part of the upper-division core as prerequisite; and course numbers 170 or greater are more specialized fourth year courses. For schedule planning, in general: **odd numbered upper-division courses are gener-**

**ally offered in the fall; even numbered courses are generally offered in the spring; course numbers ending in zero are offered both fall and spring; and courses offered irregularly end with a nine.**

## COURSES

### Biology (BIOL)

#### 10. Life Science (3)

Not open to students with credit in BIOSC 1A. How living things work and why they work that way. Biology from chemical and physical foundations to ecological and evolutionary processes. Biology and its relationship to human affairs. G.E. Breadth B2. (2 lecture, 2 lab hours)

#### 15. An Ecological Approach to Life Science (5)

Concurrent enrollment in GEOL 15, N SCI 15, S SCI 15 required. Portion of *Humans and the Natural Environment* Cluster. An introduction to biological concepts and investigational methods in the natural environment. Lecture, lab, and fieldwork. See *Humans and the Natural Environment*, Natural Science — Interdisciplinary Courses section. G.E. Breadth B2. (HNE program field trip fee, \$300)

#### 100. Nature Study (3)

Not allowable for credit for biological or physical science majors or minors. Prerequisite: a college level biology course. Evaluation of natural science programs at the elementary level; optional opportunities in developing K-9 environmental study material or designing environmental awareness topics for adult groups; emphasis on life science programs dealing with the interaction of man and the biosphere. (2 lecture, 3 lab hours)

#### 110. Human Ecology (3)

The study of the relationships between humans and their environment, both natural and manmade; emphasis on scientific understanding of root causes of current environmental problems.

#### 189T. Topics in Biology (1-4; max total 6)

Prerequisite: permission of instructor. Investigation of selected areas in the field of biology. (Lecture and/or laboratory)

#### 190. Independent Study (1-3; max total 6)

See *Academic Placement — Independent Study*. Approved for *SP* grading.

### Biological Science Core (BIOSC)

#### 1A. Introductory Biology (4)

Course one of two-semester sequence required of all biology majors. Thematic introduction to the unifying concepts of life science: chemical basis of life; cellular processes; energy metabolism; genetics; evolution. G.E. Breadth B2. (3 lecture, 3 lab hours)

#### 1B. Introductory Biology (5)

Prerequisite: BIOSC 1A. Course two of a two-semester sequence required of all biology majors. Continuation of thematic introduction to the unifying concepts of life science: classification and diversity of life; survey of the living organisms; physiology; ecology and environmental biology. (3 lecture, 6 lab hours)\*

#### 130. General Ecology (3)

Prerequisites: BIOSC 1A and 1B; an introductory statistics course; MATH 70 or equivalent recommended. Required of all biology majors. The structure, function, organization, and regulation of populations, communities, and ecosystems. The role of evolution in environmental relationships. (2 lecture, 3 lab or field hours)\*

#### 140A-B. Genetics and Cellular Biology (3-4)

Prerequisites: BIOSC 1A, 1B and CHEM 8 or 128A. Two-semester sequence required of all biology majors. Fundamentals of inheritance and cellular biology for both prokaryotic and eukaryotic systems, including an introduction to the underlying molecular mechanisms. BIOSC 140A and either CHEM 150 or 155 are prerequisites to BIOSC 140B. (A: 3 lecture hours; B: 3 lecture, 3 lab hours)

#### 180. Evolution (3)

Prerequisites: senior standing or permission of instructor; BIOSC 130, 140A-B. Required of all biology majors. Evolutionary processes and patterns. Satisfies the senior major requirement for the B.S. in Biology.

### Botany (BOT)

#### 10. Plant Biology (3)

Not open to students with credit in BIOSC 1B. Structure, function, and development of plants. G.E. Breadth B2. (2 lecture, 2 lab hours)

\* Late afternoon, Saturday and/or overnight field trips may be required.

**130. Plant Physiology (4)**

Prerequisites: BIOSC 1A and 1B; CHEM 1A or 3A; or permission of instructor; organic chemistry recommended. General metabolism and related processes. (2 lecture, 6 lab hours)

**131. Vascular Plants (4)**

Prerequisites: BIOSC 1A and 1B or permission of instructor. Morphology, reproduction, and evolution of the major groups of vascular plants (both living and extinct). Emphasis placed upon the seed plants. (2 lecture, 6 lab hours)

**132. Nonvascular Plants (3)**

Prerequisites: BIOSC 1A and 1B or permission of instructor. Comparative structure and phylogeny of the fungi, algae, mosses, and liverworts. (2 lecture, 3 lab hours)

**133. Plant Anatomy (3)**

Prerequisites: BIOSC 1A and 1B or permission of instructor. Structure and development of flowering plants at the cellular and tissue levels. (2 lecture, 3 lab hours)

**137. Plant Growth and Development (3)**

Prerequisites: BIOSC 140A or permission of instructor. Processes involved in plant growth with emphasis on the development of form in higher plants and the experimental approach. (2 lecture, 3 lab hours)

**142. Phycology (4)**

Prerequisites: BIOSC 1A and 1B or permission of instructor. Morphology, cytology, ecology, physiology, economic importance, and cultivation of the algae. (2 lecture, 6 lab or field hours)\*

**144. Plant Taxonomy (4)**

Prerequisites: BIOSC 1A and 1B or permission of instructor. Principles of plant classification; local flora. (1 lecture, 9 lab or field hours)\*

**Ecology (ECOL)****135. Marine Biology (3)**

Prerequisite: a college biology course. Introduction to the marine environment with emphasis on the biological aspects; systematics, ecology, and morphological and physiological adaptations of marine organisms, especially intertidal and shallow water forms; pollution; utilization of marine resources. (One field trip required)

**151. Terrestrial Ecology (4)**

Prerequisite: BIOSC 130. The interaction of organisms and communities with the

physical and biotic environment, with emphasis on the biotic communities of Central California. (3 lecture, 3 lab or field hours)\*

**152. Aquatic Ecology (4)**

Prerequisite: BIOSC 130. Physical-chemical features of inland waters as related to their biology; community structure and function, ecological interactions, adaptations, and identification of aquatic organisms. (3 lecture, 3 lab or field hours)\*

**162. Microbial Ecology (4)**

Prerequisites: BIOSC 130 and MICRO 140. Physiological ecology of microorganisms; interactions of microorganisms with abiotic and biotic factors in the environment; microbial habitats including soil, water, and organisms; techniques of microbial ecology (field and laboratory). (3 lecture, 3 lab hours)\*

**171. Fisheries Biology and Management (3)**

Prerequisite: BIOSC 130; statistics strongly recommended. Ecology and management of fisheries; techniques for studying fish populations; quantitative methods for assessing fish stocks; environmental requirements and habitat improvement methods; acquisition and application of information to obtain maximum benefit from fishery resources. Inland fisheries emphasized. (2 lecture, 3 lab or field hours)\*

**172. Wildlife Biology and Management (4)**

Prerequisite: BIOSC 130. Ecological theory and its use in the management of wildlife resources. Field and laboratory exercises designed for the application of techniques used in research and in making management decisions. (2 lecture, 6 lab or field hours)\*

(See also *BOT*, *MICRO*, *ZOOL* courses.)

**174. Systematic Biology (3)**

Prerequisite: BIOSC 1A and 1B; BIOSC 140A-B recommended. Modern theory and methods of phylogenetic analysis applied to the study of biodiversity and evolution. (2 lecture, 3 lab hours) (Formerly BIOL 189T)

**Genetics (GENET)****120. Introduction to Genetics (3)**

Not open to biology majors and students with credit in BIOSC 140A. Prerequisites: BIOSC 1A and 1B or equivalent. Principles of biological inheritance, including

gene structure, gene function, statistical methods, problem solving, and human genetics.

**142. Molecular Biology (4)**

Prerequisites: BIOSC 140A; CHEM 150 or 155. Corequisite: BIOSC 140B. The study of genome structure and fluidity, prokaryotic and eukaryotic gene expression, genomics, and bioinformatics. (3 lecture, 3 lab hours)

**170. Seminar in Cellular and Molecular Biology (1)**

Prerequisites: GENET 142 or permission of instructor. Trends and breakthroughs in cellular and molecular biology accessed through the primary literature. (1 seminar hour)

**171. Experimental Molecular Genetics (4)**

Prerequisite: BIOSC 140A-B. The nature of genetic information, its mutation, transfer, and recombination in cells. (2 lecture, 6 lab hours)

**172. Developmental Biology (4)**

Prerequisite: BIOSC 140A-B. Investigations concerning the variety of mechanisms acting during the several stages of development of the living organism, from gamete formation to morphological and biochemical differentiation of organ systems; emphasis on differential genetic control. (3 lecture, 3 lab hours)

**182. Microbial Genetics (4)**

Prerequisite: BIOSC 140A; MICRO 140 recommended. Genetic variation, gene transfer, and regulation of gene expression in model microbial systems and medically and industrially important microbes. (3 lecture hours, 3 lab hours)

**Microbiology (MICRO)****20. Introductory Microbiology (4)**

Not open to students with credit in MICRO 140. Prerequisites: CHEM 3A; CHEM 3B or 8; plus a college course in the biological sciences. Introduction to microbiology; principles and selected applications. (3 lecture, 3 lab hours)

**140. Microbiology (4)**

Prerequisites: BIOSC 1A, 1B; organic chemistry. Emphasis on prokaryotes (bacteria); microbial physiology, genetics, ecology, classification, and identification;

\* Late afternoon, Saturday and/or overnight field trips may be required.

applications of microbiology. Prerequisite to most upper-division microbiology courses. (2 lecture, 6 lab hours)

161. Microbial Physiology (4)  
Prerequisite: MICRO 140. Structure, function, energy metabolism, growth, and regulatory mechanisms of microorganisms. (2 lecture, 6 lab hours)

171. Protozoology (3)  
Prerequisites: BIOSC 130, 140A-B. The biology of protozoan organisms. (2 lecture, 3 lab hours)

181. Bacteriology of Human Disease (5)  
Prerequisite: MICRO 140; PHYAN 160 recommended. Bacterial, etiological agents of human disease. (3 lecture, 6 lab hours)

185. Virology (4)  
Prerequisite: MICRO 140; PHYAN 160 recommended. Inquiries into the unique nature of viruses; methods of analysis, structure, and replication. Virus-host interactions are described from bacterial, plant, and animal virus groups. Considerable emphasis is placed on diagnosis of viruses infecting humans including epidemiology and viro-pathology. (2 lecture, 6 lab hours)

(See also BOT 142; ECOL 162; GENET 171; PHYAN 160; ZOOL 148.)

Physiology/Anatomy/  
Development (PHYAN)

### 33. Human Anatomy and Physiology (5)

Three units allowed for students with prior credit in human anatomy; 2 units allowed for students with prior credit in human physiology. An integrated study of the structure and function of the human body. (4 lecture, 3 lab hours) (Course fee, \$25)

64. Functional Human Anatomy (3)  
Not open to students with credit in PHYAN 33. Primarily for students in the health related and biological professions. The life continuum from conception to death. A systems approach to the gross and microscopic structures of the human body. (2 lecture, 3 lab hours) (Course fee, \$25)

65. Human Physiology (5)  
Not open to students with credit in PHYAN 33. College chemistry and human anatomy recommended. Homeostasis in the human body; how organ systems function to maintain life; dynamic and adaptive systems at the molecular, cellular, and organ level. (4 lecture, 3 lab hours)

110. Human Reproductive Physiology, Aging, and Death (3)  
Human reproduction, structures, functions, and control systems; the relationship between sexual reproduction and aging; the physiology and aging of specific systems, such as the cardiovascular system; medical and cultural definitions of death. G.E. Integration IB.

130. Neuroanatomy (4)  
Prerequisites: anatomy and physiology. Macroscopic and microscopic study of the structure and functional relationships of the mammalian nervous system. (3 lecture, 3 lab hours)

\*Late afternoon, Saturday and/or overnight field trips may be required.



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\*Late afternoon, Saturday and/or overnight field trips may be required.

M SCI 112, 113, 122, 1

4, 125. Biology electiv  
MSCI103,104. Marine Science (MSCI) 103. Marine Ecology (4) Prerequisites: ecology and statistics (or concurrent registration in MSCI 104) or permission of instructor. A field-oriented introduction to the interrelationships between marine and estuarine organisms and their environment **with emphasis on quantitative**

**data collection** and analysis. (2 lecture, 6 lab or field hours) 104. Quantitative Marine Science (4) Prerequisite: college mathematics. The mathematical methods for analysis of biological, chemical **and physical data from the marine environment**; experimental design, parametric and

nonparametric statistics. (3 lecture, 3 lab or field hours) 105. Marine Science Diving (3) Prerequisites: upper-division science major; thorough physical examination; ability to pass swimming test. **Skin and SCUBA diving course; pool-training culminates in 10 ocean dives.** Topics include diving physics, physiology, diving environments, night diving, and research diving. Successful completion give

NAUI and MLML certification. (1 lecture, 6 lab or field hours) 110. Introduction to Marine Behavior (4) Prerequisite: MSCI 103 or permission of instructor. Basic theoretical concepts of animal behavior, stressing the causation, **development, and evolution of behavior. E**

**phasis** is on the marine environment. (3 lecture and 3 lab hours) 112. Marine Birds and Mammals (4) Prerequisite: upper-division vertebrate zoology; MSCI 103 **recommended. Systematics, morphology, ecology, and general biology**

of marine birds and mammal (2 lecture, 6 lab or field hours) 113. Marine Ichthyology (4) Prerequisite: college zoology or equivalent. Taxonomy, morphology, and ecology of **marine fishes. Both field and laboratory work concentrate on the structure, function, and habits of marine fishes and the ecological interactions of these fishes with their b**

otic and ab

**tic** surroundings. (2 lecture, 6 lab or field hours) 122. Marine Invertebrate Embryology (4) Prerequisite

permission of instructor. Survey of principles of developmental biology, concentrating on experimental evidence obtained using invertebrate material. Laboratory observations cover the embryology of lower invertebrates, molluscs, crustacea, echinoderms, and protochordates. (2 lecture, 6 lab or field hours)

124. Marine Invertebrate Zoology I (4)  
Prerequisite: college zoology or permission of instructor; M SCI 103 recommended. A field-oriented introduction to the structure, systematics, evolution, and life histories of the major phyla. (2 lecture, 6 lab or field hours)

125. Marine Invertebrate Zoology II (3)  
Prerequisite: college zoology or permission of instructor; M SCI 103 and M SCI 124 recommended. A field-oriented introduction to the structure, systematics, evolution, and life histories of the minor phyla. (1 lecture, 6 lab or field hours)

131. Marine Botany (4)  
Prerequisite: M SCI 103 recommended. Introduction to the plants of the sea, marshes, and dunes, with emphasis on the morphology, taxonomy, and natural history of seaweeds and vascular plants. (2 lecture, 6 lab or field hours)

135. Physiology of Marine Algae (4)  
Prerequisites: M SCI 103, 131, 144. Develops physiological basis for understanding the adaptation of marine algae (seaweeds and microalgae) to their environment. Students will learn modern methods in physiological research, covering areas such as photosynthesis, respiration, enzyme activity, and biochemical composition. (2 lecture, 6 lab hours)

141. Geological Oceanography (4)  
Prerequisite: M SCI 142 or 143 or concurrently. Structures, physiography, and sediments of the sea bottom and shoreline. (2 lecture, 6 lab or field hours)

142. Physical Oceanography (4)  
Prerequisite: college algebra; college physics recommended. An introduction to the nature and causes of various oceanic motions including currents, waves, tides and mixing, and the physical properties of seawater including transmission of sound and light; does not require calculus. (3 lecture, 3 lab or field hours)

143. Chemical Oceanography (4)  
Prerequisite: one year of college chemistry. An introduction to the theoretical and

practical aspects of the chemistry of the oceans, including major salts, dissolved gases, nutrient ions, carbonate system, transient tracers, and shipboard sampling techniques. (2 lecture, 6 lab and field hours)

144. Biological Oceanography (4)  
Prerequisites: general biology and general chemistry. The ocean as an ecological system. Emphasis is on the complexity of organismal-environmental interaction of the plankton, the transfer of organic matter between trophic levels and nutrient cycles. Laboratory includes methods in sampling, shipboard techniques, identification of plankton, and current analytical techniques. (2 lecture, 6 lab or field hours)

161. Marine Fisheries (4)  
Prerequisite: college mathematics, M SCI 104, or permission of instructor; M SCI 103 recommended. An introduction to fishery biology, including the concepts of stock, recruitment, and yield; emphasizing the parameters abundance, age, growth, and mortality; discussion of hydrography and fishery ecology, management problems, world fisheries and mariculture; and collection and analysis of fishery data. (2 lecture, 6 lab or field hours)

173T. Topics in Marine Biology (1-4)  
Prerequisite: permission of instructor. The study of a selected area in marine biology (morphology, physiology, ecology, etc.). Subjects will vary depending on student demand and availability of instructors. (Lecture and/or laboratory)

174T. Topics in Oceanography (1-4)  
Prerequisite: permission of instructor. The study of selected areas in oceanography; subject varies depending on student demand and availability of instructors. (Lecture and/or laboratory)

175T. Topics in Marine Science (1-4)  
The study of a selected area in the marine sciences. The subjects vary depending on student demand and availability of instructors. (Lecture and/or laboratory)

177. Microscopic Techniques (3)  
Prerequisites: one semester college physics and permission of instructor. Principles and techniques of light and electron microscopy; consideration of brightfield, darkfield, phase contrast, and interference contrast light microscopy; episcopic and diascopic illumination systems; photomicrography; preparation of materials for and operation of the scanning electron microscope. (2 lecture, 3 lab hours)

180. Independent Study (1-4; max total 6)  
Prerequisite: permission of instructor. Faculty directed study of selected problems; open to undergraduate students with adequate preparation. Approved for SP grading.

## GRADUATE COURSES (See Course Numbering System.)

### Marine Science (M SCI)

202. Marine Instrumental Analysis (4)  
Prerequisites: M SCI 142, 143. Theory and use of advanced instrumentation; advanced field and laboratory techniques for the interpretation of data collected in marine science research. (2 lecture, 6 lab or field hours)

204. Sampling and Experimental Design (4)  
Prerequisites: M SCI 103, 104. Basic design of experiments and field sampling, including random sampling, systemic sampling, subsampling, survey techniques, and design of single and multifactor experiments using randomized and block experimental designs.

211. Ecology of Marine Birds and Mammals (4)  
Prerequisites: M SCI 103, 104, 112. Community approach to the ecology of marine birds and mammals using experimental and sampling methodology. Examines the distribution, abundance, trophic ecology, and behavior of birds and mammals in Elkhorn Slough and Monterey Bay. (2 lecture, 6 lab hours)

212T. Advanced Topics in Marine Vertebrates (1-4)  
Prerequisites: M SCI 112 or 113 and permission of instructor. Advanced considerations of the ecology, physiology, and phylogeny of fishes, birds, or mammals; emphasizing current literature and research. (Lecture and/or laboratory)

221T. Advanced Topics in Marine Invertebrates (1-4)  
Prerequisites: M SCI 124 and permission of instructor. Advanced considerations of the ecology, physiology, and phylogeny of the various invertebrate phyla emphasizing current literature and research. (Lecture and/or laboratory)

222. Biology of the Mollusca (4)  
Prerequisites: M SCI 124 and permission of instructor. Systematics, functional morphology, ecology, and physiology of

mollusca with emphasis on marine forms. (2 lecture, 6 lab or field hours)

## 231. Biology of Seaweeds (4)

Prerequisite: M SCI 131 or permission of instructor. Lectures-discussions on marine macroalgal biology with extensive reading of original literature. Ecologically oriented individual research projects involving laboratory culture and field experimentation. (2 lecture, 6 lab or field hours)

## 233T. Advanced Topics in Marine Ecology (1-4)

Prerequisites: MSCI 103 and permission of instructor. Selected topics and current issues in marine ecology; subjects vary depending on student demand and availability of instructors. (Lecture and/or laboratory)

## 234. Advanced

### Biological Oceanography (4)

Prerequisite: M SCI 144 or permission of instructor. Experimental techniques in biological oceanography with emphasis on problems important in plankton ecology. Lectures, labs, and discussions of current research problems. An individual research project involving analytical tools will be required. (2 lecture, 6 lab or field hours)

## 242. Plate Tectonics (3)

Prerequisite: M SCI 141 or permission of instructor. Historical background, modern theory, and geophysical evidence of continental drift; seafloor spreading and plate tectonics; examinations of the impact of the recent revolution in historical geology.

## 244. Paleooceanography (4)

Prerequisite: M SCI 141 or permission of instructor. Interdisciplinary studies of the provenance, biologic, and geologic composition of marine sediments and of the organisms contributing to their formation; sedimentary processes affecting these sediments. (2 lecture, 6 lab or field hours)

## 245. Deep Sea Sedimentation (4)

Prerequisite: M SCI 141 or permission of instructor. Study of the types of marine sediment found in the deepest parts of all oceans; the sedimentary processes responsible for the deposition, preservation, and redeposition of these sediments. (2 lecture, 6 lab or field hours)

## 251. Marine Geochemistry (4)

Prerequisite: quantitative analysis, year of calculus, or permission of instructor. Geochemical processes in the oceans; thermodynamics of low temperature aqueous reactions, weathering, oxidation-reduction

and biologically mediated reactions, processes occurring at the sea floor and air-sea interface. (2 lecture, 6 lab or field hours)

## 261. Ocean Circulation and Mixing (4)

Prerequisite: M SCI 142; college physics strongly recommended. Mathematical description of the distribution of properties (e.g., density, dissolved oxygen) in the oceans relating to physical and biochemical processes; theory of distribution of variables, geostrophic method. (3 lecture, 3 lab hours)

## 262. Satellite Oceanography (4)

Prerequisite: M SCI 142, 144, or permission of instructor; M SCI 263 and computer literacy recommended. Physical principles of remote sensing of earth's oceans, including satellite systems, oceanographic applications of satellite imagery, and image processing methods. Labs involved use PC and Unix workstation image processing. (2 lecture, 2 lab hours)

## 263. Application of Computers in Oceanography (4)

Prerequisites: M SCI 104, college math, permission of instructor. Lecture, discussion, practical experience with a multi-user computer for marine science applications: use of existing programs and subroutine libraries; computer communications; scientific programming for data I/O and analysis. Semester project required. (2 lecture, 6 lab hours)

## 271. Population Biology (3)

Prerequisites: M SCI 103 and 104 or permission of instructor. Principles of the interaction among marine organisms which result in the alternation of population structures, techniques for assessment, and management of animal populations. (2 lecture, 3 lab or field hours)

## 272. Subtidal Ecology (4)

Prerequisites: MLML diver certification and marine ecology; knowledge of marine algae, invertebrates, and statistics recommended. The ecology of nearshore rocky subtidal populations and communities with emphasis on kelp forests; lectures and discussions of original literature; fieldwork with SCUBA including group projects on underwater research techniques and community analysis, and individual research on ecological questions chosen by student. (2 lecture, 6 lab or field hours)

## 274T. Advanced Topics in Oceanography (1-4)

Prerequisite: permission of instructor. The study of a selected area in oceanography. Subjects vary depending on student demand and availability of instructors. (Lecture and/or laboratory)

## 280W. Scientific Writing (3)

Prerequisites: graduate standing, permission of instructor. Techniques and strategies of scientific writing used for proposals, journal submissions, and abstracts of meetings. Students will develop their writing skills by preparing, editing and rewriting manuscripts.

## 285T. Seminar in Marine Biology (2; max total 4)

Prerequisite: permission of instructor. Seminar will be held on topics changing each semester; each student will be required to give at least one seminar.

## 286T. Seminar in Marine Geology (2; max total 4)

Prerequisite: permission of instructor. Seminar will be held on topics changing each semester; each student will be required to give at least one seminar.

## 287T. Seminar in Oceanography (2; max total 4)

Prerequisite: permission of instructor. Seminar will be held on topics changing each semester; each student will be required to give at least one seminar.

## 295. Research in the Marine Sciences (1-4; max total 4)

Prerequisite: permission of instructor. Independent investigations of an advanced character for the graduate student with adequate preparation. (3 conference, lab, and field hours per unit)

## 299. Thesis (1-4; max total 4)

Prerequisite: See Criteria for Thesis and Project. Preparation, completion, and submission of an acceptable thesis for the master's degree. Approved for SP grading.