
Biological Sciences

[2009-10 update to the *General Catalog*, changes highlighted]

The biological sciences at UC Santa Cruz are comprised of two academic departments: Ecology and Evolutionary Biology (courses BIOE) and Molecular, Cell, and Developmental Biology (courses BIOL). The two academic departments collectively sponsor the undergraduate program while each offers its own independent graduate program. Faculty within the biological sciences are affiliated with either Ecology and Evolutionary Biology, or Molecular, Cell, and Developmental Biology.

Undergraduate Program and Advising Office

387 Thimann Laboratories

(831) 459-4143

<http://undergrad.pbsci.ucsc.edu>

~~<http://biosei.ucsc.edu>~~

Undergraduate Program Description

The biological sciences have entered into an exciting new era in which phenomena that once seemed insoluble mysteries—such as embryonic development, the functions of the brain, and the dynamics of ecosystems—are now yielding their secrets as the technology to study them becomes more and more sophisticated. From molecular biology, with its potential to revolutionize medicine and agriculture, to ecology, with its lessons for the sustainable management of the environment, biologists are fully engaged in meeting the challenges of the future, helping to improve the quality of human life and to preserve habitats and biodiversity. Thus, it is no surprise that the biological sciences are at the heart of many of today's most pressing intellectual and social concerns.

The Departments of Ecology and Evolutionary Biology (EEB) and Molecular, Cell, and Developmental Biology (MCDB) offer a broad spectrum of courses that reflect the exciting new developments and directions in the field of biology. An outstanding group of faculty, each with a vigorous, internationally recognized research program, is available to teach courses in their specialties as well as core courses for the major. Areas of research strength within the departments include RNA molecular biology, molecular and cellular aspects of genetics and development, neurobiology, endocrinology, immunology, microbial biochemistry, plant biology, animal behavior, physiology, evolution, ecology, and marine biology. UCSC is unique in the UC system in providing exceptional opportunities for undergraduate research, allowing students to interact one-on-one with faculty and other researchers in a laboratory or field setting.

Biological Sciences Majors

Students may plan a program that leads to one of several B.A. or more advanced B.S. degrees. Students may choose from the following major options:

Majors jointly sponsored by Ecology and Evolutionary Biology (EEB) and Molecular, Cell, and Developmental Biology (MCDB):

Biology B.A. (general)

Biology B.S. (general)

[Biology B.A. \(education concentration\)](#)

Majors sponsored by Ecology and Evolutionary Biology (EEB):

Ecology and evolution B.S.

Marine biology B.S.

Plant sciences B.S.

Environmental studies/biology combined major B.A. (administered in conjunction with the Environmental Studies Department)

Majors sponsored by Molecular, Cell, and Developmental Biology (MCDB):

Health Sciences B.S.

Molecular, cell, and developmental biology B.S.

Neuroscience and behavior B.A.

Neuroscience and behavior B.S.

Biochemistry and molecular biology B.S. (administered in conjunction with the Chemistry- and Biochemistry Department)

Bioinformatics B.S. (administered in conjunction with the School of Engineering)

Bioengineering B.S. (administered in conjunction with the School of Engineering)

Advanced undergraduates, with the guidance of faculty mentors, have access to extensive departmental laboratory facilities for independent research. Fieldwork draws on a remarkable variety of terrestrial habitats, as well as ready access to Monterey Bay and the open Pacific. Marine studies are supported by a

coastal facility with running seawater, with a research vessel available for offshore work. Año Nuevo Island, north of Santa Cruz, is the site of extensive behavioral studies of marine mammals. Hospitals, convalescent and physical therapy centers, veterinary clinics, and other enterprises in the vicinity of the campus provide the opportunity to pursue field projects and internships comparable to on-the-job training. This array of opportunities for directed independent study enables biological science majors to enhance their upper-division programs to reflect and strengthen their own interests and goals in the sciences.

Prerequisites for the Biological Sciences

The introductory biology sequence, is prerequisite to virtually all upper-division biology courses. BIOL 20A has a prerequisite of Chemistry 1B, Chemistry 1B has a prerequisite of Chemistry 1A, and thus students cannot enroll in BIOL 20A until they have completed Chemistry 1A and 1B. Therefore, it is essential for students considering a major in the biological sciences to start chemistry as soon as possible. Students who have not taken Chemistry 1A or 1B but are prepared to begin biology may begin the introductory sequence with BIOE 20C. The entire introductory biology sequence should be taken the first and second year, concurrently with or following the general chemistry sequence (Chemistry 1A, 1B/M and 1C/N).

~~The biology placement examination is an online self-assessment tool to help students assess their academic preparation for introductory biology. All students interested in majoring in the biological sciences should take the biology placement exam at: <http://biosci.ucsc.edu/bioplacex.html>. Students who score below 35 on the placement exam should consider taking the introductory preparation course, BIOE 3, *Concepts in Biology*, before enrolling in the introductory series. Students scoring 35 or higher may begin the introductory sequence with either course BIOL 20A, *Cell and Molecular Biology* or BIOE 20C, *Ecology and Evolution*.~~

The Mathematics Department offers a placement exam several times a year. Biological science majors are expected to take this exam. If the results indicate a need for precalculus, students need to take Mathematics 3 as soon as possible. Students with even less preparation may need to take college algebra at another institution.

Students intending to major in health sciences should take the Spanish placement exam, offered by the language program, to determine with which course they should begin the Spanish sequence.

Course Substitution/Transfer Credit Policy

At least half of the upper-division courses (numbered 100–190) required for each major must be taken through the biological sciences program at UCSC, not as transfer credits from another department or institution. Transfer students are advised to contact the Biological Sciences Undergraduate Advising office before enrolling in numerous upper-division courses at other institutions. For more information on transferring courses to UCSC, please consult the ~~biological sciences~~ undergraduate web site at <http://biosci.undergrad.pbsci.ucsc.edu/>.

A maximum of one upper-division course requirement may be met with a research-based independent study or graduate-level UCSC biology course or a course offered by another UCSC department.

Declaration Process for Biological Sciences Majors

Declaration guidelines for biology majors can be found on the ~~biological sciences~~ undergraduate web site at <http://biosci.undergrad.pbsci.ucsc.edu/>.

Disciplinary Communication (DC) Requirement

Students of every major must satisfy that major's upper-division Disciplinary Communication (DC) requirement. The DC requirement will normally be met within one to three courses already required for the major. For detailed information on this major's DC requirement, consult your major adviser or see the 2010-11 general catalog.

Comprehensive Requirement

All majors in the biological sciences require a comprehensive requirement. This requirement can be satisfied in one of the following ways:

by passing course 190 Senior Seminar;

by receiving a passing grade in an internship, independent research laboratory, or field course:

Biological Sciences-EEB

BIOE 114L, *Field Methods in Herpetological Research*

BIOE 141L, *Behavioral Ecology Field Course*

BIOE 145L, *Field Methods in Plant Ecology*

BIOE 150L, *Ecological Field Methods*

BIOE 151, *Ecology and Conservation in Practice*

BIOE 158L, *Marine Ecology Lab*

BIOE 159, *Marine Ecology Field Quarter*

BIOE 161L, *Kelp Forest Ecology Lab*

BIOE 183, *Undergraduate Research in EEB*

Biological Sciences-MCDB

BIOL 100L, *Biochemistry Lab*

BIOL 105L, *Eukaryotic Genetics Lab*

BIOL 105M, *Microbial Genetics Lab*
BIOL 109L, *Yeast Molecular Genetics Lab*
BIOL 110L, *Cell Biology Lab*
BIOL 111L, *Immunology Lab*
BIOL 115L, *Eukaryotic Molecular Biology Lab*
BIOL 119L, *Microbiology Lab*
BIOL 120L, *Developmental Biology Lab*
~~BIOL 128L, *Neural Genetics Lab*~~
~~BIOL 185, *Hughes Undergraduate Research Lab*~~
BIOL 186, *Undergraduate Research in MCD*
BIOL 189, *Health Sciences Internship*

by completing a senior thesis. ~~See the biological sciences undergraduate web site for more information, including deadline, at <http://www.biology.ucsc.edu/advising/graduation/thesis.html>;~~

by achieving a graduate record examination (GRE) score at or above the 50th percentile on the biology subject test or the biochemistry, cell, and molecular biology subject test. Reports of GRE scores must be submitted to the biological sciences advising office before the last day of the graduating quarter;

by obtaining an medical college admission test (MCAT) score at or above the 50th percentile on the biological sciences section. Reports of MCAT scores must be submitted to the biological sciences advising office before the last day of the graduating quarter.

Letter Grade Policy

For all students entering UCSC in fall 2001 and later, all courses used to satisfy any of the biological sciences majors must be taken for a letter grade.

Major Disqualification Policy

The biological sciences departments have adopted a major disqualification policy that is intended to encourage students to take their performance in the introductory requirements seriously and to make a strong effort to pass the introductory courses.

Students who receive more than one No Pass, D, and/or F in the following introductory major requirements will not be permitted to major in any of the biological sciences majors:

BIOL 20A, *Cell and Molecular Biology*
BIOE 20B, *Development and Physiology*
BIOE 20C, *Ecology and Evolution*
~~BIOL 20L, *Experimental Biology Lab*~~Chemistry 1A, *General Chemistry*
Chemistry 1B, *General Chemistry*
Chemistry 1C, *General Chemistry*
Mathematics 11A, *Calculus with Applications*
Mathematics 11B, *Calculus with Applications*
Mathematics 19A, *Calculus for Science, Engineering, and Mathematics*
Mathematics 19B, *Calculus for Science, Engineering, and Mathematics*

Students will be assessed for disqualification after grades are submitted each quarter and at the end of each summer session.

Students may appeal their disqualification within the appeal period by writing a letter to the department chair. This appeal must be submitted to the advising office no later than 15 days from the date the disqualification notification was mailed, or the 10th day of classes in the quarter of their disqualification, whichever is later. The advising office will subsequently notify the student, the college, and the Office of the Registrar of the decision, no later than 15 days after the submission of the appeal.

A student who has been disqualified from the major may, no earlier than three months from the date of the disqualification, petition to be reinstated. This application will be considered only if there is substantial new evidence that the student is capable of making normal progress in the major.

Academic Advising

Academic advising is available at the Biological Sciences Undergraduate Advising office. Students should take full advantage of this opportunity and should keep in frequent touch with the office to stay informed about late announcements of courses, changes in scheduling, and opportunities for special study.

The ~~biological sciences~~ undergraduate web site (<http://biosei.undergrad.pbsci.ucsc.edu/>) serves as the program handbook containing advice and information pertinent to students' most frequently voiced questions. Each student in the major should review the information posted on the web site; for further assistance, contact the advising office.

Transfer Students

The faculty encourages applications from transfer students in the biological sciences. It is imperative transfer students complete science prerequisite courses before they transfer, especially a complete sequence of calculus, general chemistry, and introductory biology. Students should also take organic

chemistry, if possible. Students who transfer without having completed the prerequisite coursework may have difficulty enrolling in courses and may require more than two years to complete a biological sciences degree. Prospective transfer students should review the transfer guidelines at <http://bioe.undergrad.pbsci.ucsc.edu/advising/preparation/transfer.html> or contact the undergraduate advising office for further information.

Honors

Honors in the biological sciences majors are awarded to graduating students whose academic performance demonstrates excellence at a GPA of 3.5 or above. Highest honors are awarded to those students whose performance demonstrates the highest level of excellence and results in a GPA of 3.8 or above.

Double Majors

~~Students may not double major in general biology and any other biological sciences major; any combination of two EEB-sponsored majors (marine biology, ecology and evolution, plant sciences, environmental studies and biology combined); nor in the following combinations of MCDB-sponsored majors: molecular, cell and development biology and neuroscience and behavior; molecular, cell, and developmental biology and biochemistry and molecular biology; neuroscience and behavior and biochemistry and molecular biology.~~

Medical and Professional School Admission

Medical and professional school admissions requirements vary; students should verify that their coursework will satisfy the admissions requirements of the programs to which they plan to apply.

Education Abroad Opportunities

The UC education abroad program (EAP) offers qualified students unique opportunities to broaden their educational horizons. The biological sciences departments encourage interested students to participate. Many programs are in English-speaking countries or use English for advanced courses. Many programs offer small classes, extensive laboratories, and/or field research experience.

There are excellent programs for biological science students in Costa Rica, Australia, New Zealand, the United Kingdom, Denmark, and Germany, among others. The Costa Rica Tropical Biology Program is of note to students interested in tropical biology and ecology. Held spring and fall quarters at the Monteverde research station, this program gives students experience with hands-on field research, offers a homestay program, and carries credit for two upper-division biology courses. The University of Queensland (Australia) offers an intensive, full-semester marine science program, which includes a-stays at a-research stations on the Great Barrier Reef, and in near sheltered mangrove and seagrass habitats near Brisbane.

Students interested in study abroad need to get an early start on their basic science requirements, including chemistry, mathematics, and introductory biology and must declare their major prior to applying to go abroad. Visit the EAP office as soon as possible to begin planning, and seek advice about your schedule from the biological sciences undergraduate adviser and/or faculty adviser.

General Biology Majors and Minor

The general biology majors permit flexibility, but demand careful attention to one's own interests and plans. Each student should select courses on the basis of up-to-date information in consultation with a biology faculty adviser whose interests reflect the student's interests.

General Biology B.A. Major Requirements

Introductory Requirements

Introductory Biology: BIOL 20A, BIOE 20B, and 20C

General Chemistry: Chemistry 1A, 1B/M and 1C/N

Organic Chemistry: Chemistry 108A/L and 108B/M; or 112A/L, 112B/M, and 112C/N

Calculus: Mathematics 11A-B or 19A-B

Physics: Physics 7A/L and 7B/M

Advanced Requirements

A total of eight upper-division biology courses, as follows:

Biochemistry: BIOL 100 or the series BIOC 100A, and 100B, and 100C

(Upon completion of the series, BIOC 100C may be used to satisfy one elective)

Genetics: BIOL 105

Evolution: BIOE 109

Students must complete one upper-division biology course that includes regular laboratory or fieldwork. Students must fulfill the major distribution requirement, which includes one course from each of the following groups:

Cell/Developmental biology:

BIOL 110, *Cell Biology*

BIOL 111, *Immunology*

BIOL 115, *Eukaryotic Molecular Biology*

BIOL 119, *Microbiology*

BIOL 120, *Developmental Biology*

Physiology:BIOE 131/L, *Animal Physiology/Laboratory*~~BIOE 133/L, *Exercise Physiology/Laboratory*~~BIOE 135, *Plant Physiology*BIOL 113, *Endocrinology*BIOL 125, *Introduction to Neuroscience*BIOL 130/L, *Human Physiology/Laboratory***Ecology:**BIOE 107, *Ecology*BIOE 108, *Marine Ecology*~~BIOE 110/L, *Biology and Ecology of Vertebrates/Laboratory*~~~~BIOE 122/L, *Invertebrate Zoology/Laboratory*~~BIOE 125, *Marine Microbial Ecology*BIOE 140, *Behavioral Ecology*BIOE 141L, *Behavioral Ecology Field Course*BIOE 145L, *Field Methods in Plant Ecology*BIOE 145, *-Plant Ecology*BIOE 147, *Community Ecology*BIOE 149, *Disease Ecology*BIOE 155, *Freshwater Ecology*BIOE 161, *Kelp Forest Ecology*

Students must complete two additional upper-division biology electives chosen from Biological Sciences-EEB ~~100-180~~ or Biological Sciences-MCDB.

General Biology B.A. Sample Planners

Plan One is for first-year students placing into Mathematics 3 and taking Chemistry 1A:

Plan One			
<u>Year</u>	<u>Fall</u>	<u>Winter</u>	<u>Spring</u>
<u>1st</u> <u>(frsh)</u>	<u>MATH 3</u> <u>core</u>	<u>CHEM 1A</u> <u>MATH 11A</u> <u>gen ed</u>	<u>CHEM 1B/M</u> <u>MATH 11B</u> <u>gen ed</u>
<u>2nd</u> <u>(soph)</u>	<u>BIOL 20A</u> <u>CHEM 1C/N</u> <u>gen ed</u>	<u>BIOE 20B</u> <u>CHEM 108A/L</u> <u>gen ed</u>	<u>BIOE 20C</u> <u>CHEM 108B/M</u> <u>gen ed</u>

Plan Two is for first-year students placing into Mathematics 11A and taking Chemistry 1A:

Plan Two			
<u>Year</u>	<u>Fall</u>	<u>Winter</u>	<u>Spring</u>
<u>1st</u> <u>(frsh)</u>	<u>CHEM 1A</u> <u>Math 11A</u> <u>core</u>	<u>CHEM 1B/M</u> <u>MATH 11B</u> <u>gen ed</u>	<u>CHEM 1C/N</u> <u>BIOL 20A</u> <u>gen ed</u>
<u>2nd</u> <u>(soph)</u>	<u>BIOE 20B</u> <u>CHEM 108A/L*</u> <u>gen ed</u>	<u>BIOE 20C</u> <u>CHEM 108B/M*</u> <u>gen ed</u>	<u>elective</u> <u>BIOL 105</u> <u>gen ed</u>

*Students may use the three-quarter Chemistry 112 series to fulfill the organic chemistry requirement. ~~courses numbered 100-187L.~~

General Biology, Bioeducation Concentration, B.A.

The General Biology, Bioeducation Concentration, B.A. major is designed to meet the needs of students who plan careers as K-12 science teachers. It provides students with a rigorous education in biology through science breadth courses to prepare them for the state credentialing examinations (CSET) in biology/life sciences and general science, and courses covering education theory and practical teaching experience through internships in local schools.

General Biology, Bioeducation Concentration, B.A. Requirements

Introductory Requirements

Introductory Biology: BIOL 20A, BIOE 20B, and 20C

General Chemistry: Chemistry 1A, 1B/M, and 1C/N

Organic Chemistry: Chemistry 108A/L and 108B/M

Calculus: Mathematics 11A-B or 19A-B

Physics: Physics 7A/L and 7 B/M

Earth Sciences: Earth Sciences 20/L

Education: Education 50C

Astronomy: Astronomy 2

Advanced Requirements

A total of seven upper-division biology courses, as follows:

BIOL100, Biochemistry

BIOL 105, Genetics

BIOE 109, Evolution

BIOE 107, Ecology

Students must fulfill the major distribution requirement, which includes one course from each of the following groups:

Cell/developmental biology:

BIOL 110, Cell Biology

BIOL 115, Eukaryotic Molecular Biology

BIOL 119, Microbiology

BIOL 120, Developmental Biology

Physiology:

BIOE 131, Animal Physiology

BIOE 135, Plant Physiology

BIOL 113, Endocrinology

BIOL 130, Human Physiology

Biology Laboratory:

One five-~~unit~~credit upper-division biology laboratory course, or

BIOL 130L, Human Physiology Laboratory

BIOL 131L, Animal Physiology Laboratory

(Note: BIOL 130L and 131L do not carry W credit, nor do they satisfy the exit requirement. BIOL 135 cannot be used to satisfy the laboratory requirement in the Bioeducation concentration.)

General Biology, Bioeducation Concentration, -B.A. Sample Planners

Plan One is for first-year students placing into Mathematics 3 and BIOE 3:

Year	Fall	Winter	Spring
1st (frsh)	CHEM 1A MATH 3 core	CHEM 1B/M MATH 11A BIOE 3	CHEM 1C/N MATH 11B gen ed
2nd (soph)	BIOL 20A gen ed EDUC 50C	BIOE 20B CHEM 108A/L gen ed	BIOE 20C CHEM 108B/M gen ed

Plan Two is a more rigorous schedule for first-year students placing into Mathematics 11A and BIOE/BIOL 20A:

Plan Two			
Year	Fall	Winter	Spring
1st (frsh)	CHEM 1A Math 11A core	CHEM 1B/M MATH 11B gen ed	CHEM 1C/N BIOL 20A gen ed
2nd (soph)	BIOE 20B CHEM 108A/L* gen ed	BIOE 20C CHEM 108B/M EDUC 50C	BIOL 100 BIOL 105 gen ed

*Students may use the three-quarter Chemistry 112 series to fulfill the organic chemistry requirement.

Plan One is for students who need to take pre-calculus (MATH 3) and remedial biology (BIOE 3)

Plan One			
Year	Fall	Winter	Spring

Plan One			
1st (frsh)	CHEM 1A MATH 3 Core <i>15 credits/units</i>	CHEM 1B/M MATH 11A BIOE 3 <i>17 credits/units</i>	CHEM 1C/N MATH 11B gen ed <i>17 credits/units</i>
2nd (soph)	BIOL 20A gen ed EDUC 50C <i>12 credits/units</i>	BIOE 20B CHEM 108A/L gen ed <i>17 credits/units</i>	BIOE 20C CHEM 108B/M gen ed <i>17 credits/units</i>
3rd (junior)	BIOL 100 PHYS 7A/L Gen ed <i>16 credits/units</i>	BIOL 105 EART 20/L PHYS 7B/M <i>17 credits/units</i>	Biology Lab: Physiology Gen ed EDUC 100C <i>17 credits/units</i>
4th (senior)	BIOE 109 EDUC: Diversity ASTR 2 <i>15 units/credits</i>	BIOE 107 Gen ed EDUC 185L <i>12 units/credits</i>	Cell and Development Gen ed EDUC 185C <i>15 units/credits</i>

Plan Two is for first-year students placing into MATH 11A and BIOE/BIOL 20A:

Plan Two			
Year	Fall	Winter	Spring
1st (frsh)	CHEM 1A MATH 11A Core <i>15 credits/units</i>	CHEM 1B/M MATH 11B Gen ed <i>17 credits/units</i>	CHEM 1C/N BIOL 20A Gen ed <i>17 credits/units</i>
2nd (soph)	BIOL 20AB CHEM 108A/L EDUC 50C <i>17 credits/units</i>	BIOE 20C CHEM 108B/M EDUC 50C <i>14 credits/units</i>	BIOL 100 Gen ed elective <i>15 credits/units</i>
3rd (junior)	Gen ed BIOL 105 PHYS 7A/L <i>16 credits/units</i>	EART 20/L Physiology PHYS 7B/M <i>17 credits/units</i>	Biology Lab Gen ed EDUC 100C <i>12 credits/units</i>

General Biology B.A. Sample Planners

Plan One is for first-year students placing into Mathematics 3 and BIOE 3 (taking Chemistry 1A):

Plan One			
Year	Fall	Winter	Spring
1st (frsh)	Chem 1A gen ed Math 3 core	Chem 1B/M 1A Math 11A BIOE 3 gen ed	Chem 1C/N/B/M Math 11B gen ed
2nd (soph)	BIOL 20A gen ed Chem 1C/M gen ed	BIOE 20B Chem 108A/L gen ed	BIOE 20C Chem 108B/M gen ed

Plan Two is a more rigorous schedule for first-year students placing into Mathematics 11A and BIOE/BIOL 20 (taking Chemistry 1A):

Plan Two			
Year	Fall	Winter	Spring

Plan Two			
1st (fresh)	Chem 1A Math 11A core	Chem 1B/M Math 11B gen-ed	Chem 1C/N BIOL 20A gen-ed
2nd (soph)	BIOE 20B Chem 108A/L gen-ed	BIOE 20C Chem 108B/M gen-ed	BIOL 100 BIOL 105 gen-ed

~~*Students may use the three-quarter chemistry 112 series to fulfill the organic chemistry requirement.~~

General Biology B.S. Major Requirements

Introductory Requirements

Introductory Biology: BIOL 20A, BIOE 20B, and 20C

General Chemistry: Chemistry 1A, 1B/M and 1C/N

Organic Chemistry: Chemistry 108A/L and 108B/M or 112A/L, 112B/M, and 112C/N

Calculus: Mathematics 11A-B or 19A-B; and 22

Physics: Physics 6A/L, 6B/M, and 6C/N

Advanced Requirements

A total of nine upper-division biology courses, as follows:

Biochemistry: BIOL 100 or the series BIOC 100A, and 100B, and 100C

(Upon completion of the series, BIOC 100C may be used to satisfy one elective)

Genetics: BIOL 105

Evolution: BIOE 109

Students must complete two upper-division biology courses that include regular laboratory or fieldwork

Students must fulfill the major distribution requirement, which includes one course from each of the following groups:

Cell/developmental biology:

BIOL 110, *Cell Biology*

BIOL 111, *Immunology*

BIOL 115, *Eukaryotic Molecular Biology*

BIOL 119, *Microbiology*

BIOL 120, *Developmental Biology*

Physiology:

BIOE 131/L, *Animal Physiology/Laboratory*

~~BIOE 133/L, *Exercise Physiology/Laboratory*~~

BIOE 135-, *Plant Physiology*

BIOL 113, *Endocrinology*

BIOL 125, *Introduction to Neuroscience*

BIOL 130/L, *Human Physiology/Laboratory*

Ecology:

BIOE 107, *Ecology*

BIOE 108, *Marine Ecology*

~~BIOE 110/L, *Biology and Ecology of Vertebrates/Laboratory*~~

~~BIOE 122/L, *Invertebrate Zoology/Laboratory*~~

BIOE 125, *Marine Microbial Ecology*

BIOE 140, *Behavioral Ecology*

BIOE 141L, *Behavioral Ecology Field Course*

BIOE 145, *-Plant Ecology*

BIOE 147, *Community Ecology*

BIOE 149, *Disease Ecology*

BIOE 155, *Freshwater Ecology*

BIOE 161, *-Kelp Forest Ecology*

Students must complete three additional upper-division biology electives chosen from Biological Sciences-EEB courses ~~numbered 100-180~~ or Biological Sciences-MCDB courses ~~numbered 100-187L~~.

General Biology B.S. Sample Planners

Plan One is for first-year students placing into Mathematics 3 and ~~BIOE-3~~ [taking Chemistry 1A](#):

Plan One			
Year	Fall	Winter	Spring
1st (frsh)	Chem-1A gen ed Math-MATH 3 core	Chem 1B MΔ Math-MATH 11A BIOE-3 gen ed	Chem-CHEM 1C/N B/M Math-MATH 11B gen ed
2nd (soph)	BIOL-20A Chem 1C/N Math-MATH 22 gen ed	BIOE 20A B Chem-CHEM 108A/L gen ed	BIOE 20B C Chem-CHEM 108B/M gen ed

Plan Two is a more rigorous schedule for first-year students placing into Mathematics 11A and [taking Chemistry 1A](#) ~~BIOE/BIOL-20~~:

Plan Two			
Year	Fall	Winter	Spring
1st (frsh)	Chem-CHEM 1A Math-MATH 11A core	Chem-CHEM 1B/M Math-MATH 11B gen ed	Chem-CHEM 1C/N Math-MATH 22 BIOL 20A
2nd (soph)	BIOL 20B Chem-CHEM 108A/L* gen ed	BIOE 20C Chem-CHEM 108B/M* gen ed	BIOL-100 elective BIOL 105 gen ed

*Students may use the three-quarter ~~C~~chemistry 112 series to fulfill the organic chemistry requirement.

General Biology Minor Requirements

In addition to the introductory biology, chemistry, mathematics, and physics (as listed above), students are required to take a total of five upper-division biology courses including courses BIOL 100, BIOL 105, and the three distribution requirement courses; one must include a laboratory. There is no senior comprehensive requirement for the minor. Please contact the Biological Sciences Undergraduate Advising office for further information.

Degree Programs Sponsored by Ecology and Evolutionary Biology

Ecology and Evolution Major

Program Description

The ecology and evolution major provides students with interdisciplinary skills necessary for understanding and solving complex problems in ecology, evolution, behavior, and physiology. While some of these disciplines focus on molecular or chemical mechanisms, they all address questions on larger spatial and temporal scales that can be applied to important environmental problems, including genetic and ecological aspects of conservation biology and biodiversity.

Students majoring in ecology and evolution will receive a B.S. degree based on an integrated series of courses providing breadth in fundamental areas of biology and allied sciences that enhance understanding of evolutionary and ecological processes. The capstone of this curriculum is a suite of field courses providing students unique opportunities to learn and conduct research in a host of ecological systems. Students are encouraged to take field courses in their areas of specialization. Other opportunities include participation in research projects with faculty sponsors and the intensive Education Abroad Programs in Costa Rica (tropical biology) and Australia (marine sciences).

Ecology and Evolution B.S. Major Requirements

Introductory Requirements

Introductory Biology: BIOL 20A, BIOE 20B, and 20C

General Chemistry: Chemistry 1A, 1B/M and 1C/N

Calculus: Mathematics 11A-B or 19A-B

Biostatistics: Applied Mathematics and Statistics 7/L

Physics: Physics 7A/L and 7B/M

Advanced Requirements

A total of eleven upper-division courses; two must include laboratory or fieldwork.

Genetics: BIOL 105

Ecology: BIOE 107

Evolution: BIOE 109

One of the following physiology courses:

BIOE 131/L, *Animal Physiology/Laboratory*

BIOE 135, *Plant Physiology*

One of the following organism courses:

~~BIOE 110/L, *Biology and Ecology of Vertebrates/Laboratory*~~

BIOE 117/L, *Systematic Botany of Flowering Plants/Laboratory*

BIOL 119/L, *Microbiology/Laboratory*

BIOE 120/L, *Marine Botany/Laboratory*

BIOE 122/L, *Invertebrate Zoology/Laboratory*

Elective list for Ecology and Evolution Major

Three topical electives chosen from the following:

BIOE 108, *Marine Ecology*

~~BIOE 110/L, *Biology and Ecology of Vertebrates/Laboratory*~~

BIOE 112/L, *Ornithology/Laboratory*

BIOE 114/L, *Herpetology/Laboratory*

BIOE 117/L, *Systematic Botany/Laboratory*

BIOE 120/L, *Marine Botany/Laboratory*

BIOE 122/L, *Invertebrate Zoology/Laboratory*

BIOE 125, *Marine Microbial Ecology*

BIOE 127/L, *Ichthyology/Laboratory*

BIOE 129/L, *Biology of Marine Mammals/Laboratory*

BIOE 131/L, *Animal Physiology/Laboratory*

~~BIOE 133/L, *Exercise Physiology*~~

BIOE 135, *Plant Physiology*

BIOE 140, *Behavioral Ecology*

BIOE 141L, *Behavioral Ecology Field Course*

BIOE 145, *Plant Ecology*

BIOE 145L, *Field Methods in Plant Ecology*

BIOE 147, *Community Ecology*

BIOE 149, *Disease Ecology*

BIOE 150, *Ecological Field Methods*

BIOE 150L, *Ecological Field Methods Laboratory*

BIOE 151ABCD, *Ecology and Conservation in Practice*

BIOE 155, *Freshwater Ecology*

BIOE 158L, *Marine Ecology Laboratory*

BIOE 159ABCD, *Marine Ecology Field Quarter*

BIOE 161, *Kelp Forest Ecology*

BIOE 161L, *Kelp Forest Ecology Laboratory*

BIOE 163, *Ecology of Reefs, Mangroves, and Seagrasses*

BIOE 165, *Marine Conservation Biology*

~~BIOE 167, *Ocean Ecosystems*~~

BIOE 172/L, *Population Genetics/Laboratory*

BIOL 100, *Biochemistry*

BIOL 110, *Cell Biology*

BIOL 115, *Eukaryotic Molecular Biology*

BIOL 119, *Microbiology*

BIOL 119L, *Microbiology Laboratory*

BIOL 120, *Development*

BIOL 120L, *Development Laboratory*

Three general electives chosen from the following:

Biological Sciences-EEB

any BIOE course numbered 100-180

Biological Sciences-MCDB

BIOL 100, *Biochemistry*

BIOL 110, *Cell Biology*

BIOL 115, *Eukaryotic Molecular Biology*

BIOL 119, *Microbiology*

BIOL 119L, *Microbiology Laboratory*

BIOL 120, *Development*

BIOL 120L, *Development Laboratory*

Chemistry

CHEM 108A, *Organic Chemistry*

CHEM 108B, *Organic Chemistry*

Earth Sciences

EART 100/L, *Vertebrate Paleontology*

EART 102, *Marine Geology*

EART 105, *Coastal Geology*

EART 122, *Paleoceanography*

Environmental Studies

ENVS 104A, *Introduction to Environmental Field Methods*

ENVS 108/L, *General Entomology/Laboratory*

ENVS 115A/L, *GIS and Environmental Applications/Exercises in GIS*

ENVS 120, *Conservation Biology*

ENVS 122, *Tropical Ecology and Conservation*

ENVS 123, *Animal Ecology and Conservation*

ENVS 129, *Integrated Pest Management*

ENVS 130A/L, *Agroecology and Sustainable Agriculture/Laboratory*

ENVS 130B, *Principles of Sustainable Agriculture*

ENVS 131/L, *Insect Ecology/Laboratory*

ENVS 138/L, *Field Ethnobotany/Laboratory*

ENVS 160, *Restoration Ecology*

ENVS 161A/L, *Soils and Plant Nutrition/Laboratory*

ENVS 162, *Plant Physiological Ecology*

ENVS 163/L, *Plant Disease Ecology/Laboratory*

ENVS 167, *Freshwater and Wetland Ecology*

ENVS 168, *Biochemistry and the Global Environment*

Psychology

PSYC 123, *Behavioral Neuroscience*

One of the following may also be used as an upper-division [general](#) elective:

Biological Sciences-EEB

BIOE 183L, *Undergraduate Research in EEB*

~~BIOE 188, *Supervised Teaching*~~

BIOE 195, *Senior Thesis*

BIOE 198, *Independent Field Study*

BIOE 199, *Tutorial*

Environmental Studies

ENVS 183, *Environmental Studies Internship*

Ecology and Evolution B.S. Sample Planners

Plan One is for first-year students placing into Mathematics 3 and ~~BIOE 3~~[taking Chemistry 1A](#):

Plan One

Plan One			
Year	Fall	Winter	Spring
1st (frsh)	Chem-1A gen ed Math-MATH 3 core	CHEM 1A/B/M Math-MATH 11A BIOE-3 gen ed	CHEM 1B/M/C/N Math-MATH 11B gen ed
2nd (soph)	BIOE-20C-CHEM 1C/N AMS 7/L-BIOE 20C gen ed	BIOL 20A Phys-PHYS 7A/L gen ed	BIOE 20B Phys-PHYS 7B/M gen ed

Plan Two is a more rigorous schedule for first-year students placing into Mathematics 11A and [taking Chemistry 1A/BIOE/BIOL 20](#):

Plan Two			
Year	Fall	Winter	Spring
1st (frsh)	Chem-CHEM 1A Math-MATH 11A core	Chem-CHEM 1B/M Math-MATH 11B gen ed	Chem-CHEM 1C/N BIOE 20C gen ed
2nd (soph)	BIOL 20A AMS 7/L gen ed	BIOE 20B Physics-PHYS 7A/L gen ed	BIOE-105 elective Physics-PHYS 7B/M gen ed

Marine Biology Major

Program Description

UCSC is situated within five miles of Monterey Bay and its great diversity of coastal marine ecosystems; nature reserves; state, federal, and private marine research institutions and resource management agencies. These resources, combined with on-campus computing and analytical facilities and the Long Marine Laboratory, make UCSC an exceptional campus for the study of marine biology and its application to coastal conservation and management. Descriptions of nearby environments, institutions, and facilities are available through the Ecology and Evolutionary Biology Department web site at <http://www.biology.ucsc.edu/eeb/index.html>.

The marine biology major is designed to introduce students to marine organisms and the biological and physical processes that affect these organisms, their populations, and their coastal and oceanic ecosystems. The emphasis is on basic principles that help us understand the processes that shape life in marine environments. The marine biology major is a demanding program that offers a B.S. degree and requires several more courses than the general biology B.A. major.

Marine Biology B.S. Major Requirements

Introductory Requirements

Introductory Biology: BIOL 20A, BIOE 20B, and 20C

General Chemistry: Chemistry 1A, 1B/M and 1C/N

Calculus: Mathematics 11A-B or 19A-B

Biostatistics: Applied Mathematics and Statistics 7/L

Physics: Physics 7A/L and 7B/M

Advanced Requirements

A total of 11 upper-division courses; two must include laboratory or fieldwork.

Genetics: BIOL 105

Evolution: BIOE 109

One ecology course:

BIOE 107, *Ecology*

BIOE 108, *Marine Ecology*

One marine environment course:

~~BIOE 167, *Ocean Ecosystems*~~

BIOE 168, *Biological Oceanography*

Ocean Sciences 101, *Marine Environment*

One marine course:

BIOE 120/L, *Marine Botany/Laboratory*

BIOE 122/L, *Invertebrate Zoology/Laboratory*

BIOE 127/L, *Ichthyology/Laboratory*

BIOE 129/L, *Biology of Marine Mammals/Laboratory*

Elective list for Marine Biology Major

Three topical electives chosen from the following:

BIOE 108, *Marine Ecology*

BIOE 120/L, *Marine Botany/Laboratory*

BIOE 122/L, *Invertebrate Zoology/Laboratory*

~~BIOE 124/L, *Marine Plankton/Laboratory*~~

BIOE 125, *Marine Microbial Ecology*

BIOE 127/L, *Ichthyology/Laboratory*

BIOE 129/L, *Biology of Marine Mammals/Laboratory*

BIOE 155, *Freshwater Ecology*

BIOE 158L, *Marine Ecology Laboratory*

BIOE 159ABCD, *Marine Ecology Field Quarter*

BIOE 161, *Kelp Forest Ecology*

BIOE 161L, *Kelp Forest Ecology Laboratory*

BIOE 163, *Ecology of Reefs, Mangroves, and ~~Seagrasses~~Sea Grasses*

BIOE 165, *Marine Conservation Biology*

~~BIOE 167, *Ocean Ecosystems*~~

BIOE 168, *Biological Oceanography*

EART 102, *Marine Geology*

EART 105, *Coastal Geology*

EART 122, *Paleoceanography*

Three general electives chosen from the following:

Biological Sciences-EEB

Any BIOE course numbered 100-180

Biological Sciences-MCDB

BIOL 100, *Biochemistry*

BIOL 110, *Cell Biology*

BIOL 115, *Eukaryotic Molecular Biology*

BIOL 119, *Microbiology*

BIOL 119L, *Microbiology Laboratory*

BIOL 120, *Development*

BIOL 120L, *Development Laboratory*

Chemistry

CHEM 108A, *Organic Chemistry*

CHEM 108B, *Organic Chemistry*

Earth Sciences

EART 100/L, *Vertebrate Paleontology*

EART 102, *Marine Geology*

EART 105, *Coastal Geology*

EART 122, *Paleoceanography*

Environmental Studies

ENVS 104A, *Introduction to Environmental Field Methods*

ENVS 108/L, *General Entomology/Laboratory*

ENVS 115A/L, *GIS and Environmental Applications/Exercises in GIS*

ENVS 120, *Conservation Biology*

ENVS 122, *Tropical Ecology and Conservation*

ENVS 123, *Animal Ecology and Conservation*

ENVS 129, *Integrated Pest Management*

ENVS 130A/L, *Agroecology and Sustainable Agriculture/Laboratory*

ENVS 130B, *Principles of Sustainable Agriculture*

ENVS 131/L, *Insect Ecology/Laboratory*

ENVS 138/L, *Field Ethnobotany/Laboratory*
 ENVS 160, *Restoration Ecology*
 ENVS 161A/L, *Soils and Plant Nutrition/Laboratory*
 ENVS 162, *Plant Physiological Ecology*
 ENVS 163/L, *Plant Disease Ecology/Laboratory*
 ENVS 167, *Freshwater and Wetland Ecology*
 ENVS 168, *Biochemistry and the Global Environment*

Psychology

PSYC 123, *Behavioral Neuroscience*

One of the following may also be used as an upper-division [general](#) elective:

Biological Sciences-EEB

BIOE 183L, *Undergraduate Research in EEB*

~~BIOE 188, *Supervised Teaching*~~

BIOE 195, *Senior Thesis*

BIOE 198, *Independent Field Study*

BIOE 199, *Tutorial*

Marine Biology B.S. Sample Planners

Plan One is for first-year students placing into Mathematics 3 and [taking Chemistry 1A/BIOE-3](#):

Plan One			
Year	Fall	Winter	Spring
1st (frsh)	Chem-1A gen ed Math-MATH 3 core	Chem-CHEM 1A/B-M Math-MATH 11A BIOE-3 gen ed	Chem-CHEM 1B/M/C/N Math-MATH 11B gen ed
2nd (soph)	BIOE 20C Chem-HEM 1C/N AMS 7A - BIOE 20C gen ed	BIOL 20A Phys-PHYS 7A/L gen ed	BIOE 20B Phys-PHYS 7B/M gen ed

Plan Two is a more rigorous schedule for first-year students placing into Mathematics 11A and [taking Chemistry 1A/BIOE/BIOL-20](#):

Plan Two			
Year	Fall	Winter	Spring
1st (frsh)	Chem-CHEM 1A Math-MATH 11A core	Chem-CHEM 1B/M Math-MATH 11B gen ed	Chem-CHEM 1C/N BIOE 20C gen ed
2nd (soph)	BIOL 20A AMS 7/L gen ed	BIOE 20B Physics-PHYS 7A/L gen ed	BIOL-105 elective Physics-PHYS 7B/M gen ed

Plant Sciences Major

Program Description

UCSC has a strong program in the plant sciences (sometimes called botany). A fine natural environment, the campus Arboretum, the facilities under the Center for Agroecology and Sustainable Food Systems (especially the Farm and Garden), and an excellent greenhouse collection all enhance the resources that support our botanical programs.

The plant sciences major is designed for students with an interest in plant biology and its associated curricular fields such as plant ecology, plant physiology, plant pathology, plant molecular biology, soils, and applied plant sciences. After completion of the core courses, students can proceed in one of several directions depending on their interest. For example, a more in-depth study of physiology and molecular biology courses can serve as preparation for work in the biotechnology field or for graduate school; further studies in plant ecology, tropical ecology, or restoration ecology can lead to careers such as

resource ecologist or naturalist or to the pursuit of related fields in graduate school; upper-division training in agroecology can lead to careers in agriculture or food systems. A special feature of this major is a one-quarter internship and/or independent research requirement. There are many opportunities for internships both on the UCSC campus and in the community at large.

Plant Sciences B.S. Major Requirements

Introductory Requirements

Introductory Biology: BIOL 20A, BIOE 20B, and 20C

General Chemistry: Chemistry 1A, 1B/M and 1C/N

Calculus: Mathematics 11A-B or 19A-B

Biostatistics: Applied Mathematics and Statistics 7/L

Physics: Physics 7A/L and 7B/M

Advanced Requirements

A total of eleven upper-division courses; two of which must include laboratory or fieldwork.

Genetics: BIOL 105

Ecology: BIOE 107

Evolution: BIOE 109

One plant physiology course from the following:

BIOE 135, *Plant Physiology*

Environmental Studies 162, *Plant Physiological Ecology*

One botany course from the following:

BIOE 117/L, *Systematic Botany*

BIOE 120/L, *Marine Botany/Laboratory*

Elective list for Plant Sciences Major

Three topical electives chosen from the following:

Biological Sciences-EEB

BIOE 117/L, *Systematic Botany/Laboratory*

BIOE 120/L, *Marine Botany/Laboratory*

BIOE 135, *Plant Physiology*

BIOE 145, *Plant Ecology*

BIOE 145L, *Field Methods in Plant Ecology*

[BIOE 149, *Disease Ecology*](#)

BIOE 151ABCD, *Ecology and Conservation in Practice*

Biological Sciences-MCDB

BIOL 110, *Cell Biology*

BIOL 115, *Eukaryotic Molecular Biology*

Environmental Studies

ENVS 104A, *Introduction to Environmental Field Methods*

ENVS 129, *Integrated Pest Management*

ENVS 130A/L, *Agroecology and Sustainable Agriculture/Laboratory*

ENVS 130B, *Principles of Sustainable Agriculture*

ENVS 131/L, *Insect Ecology/Laboratory* ~~operator~~

ENVS 138/L, *Field Ethnobotany/Laboratory*

ENVS 160, *Restoration Ecology*

ENVS 161A/L, *Soils and Plant Nutrition/Laboratory*

ENVS 162, *Plant Physiological Ecology*

ENVS 163/L, *Plant Disease Ecology/Laboratory*

Three general electives chosen from the following:

Biological Sciences-EEB

Any BIOE course numbered 100-180

Biological Sciences-MCDB

BIOL 100, *Biochemistry*

BIOL 110, *Cell Biology*

BIOL 115, *Eukaryotic Molecular Biology*

BIOL 119, *Microbiology*

BIOL 119L, *Microbiology Laboratory*

BIOL 120, *Development*

BIOL 120L, *Development Laboratory*

Chemistry

CHEM 108A, *Organic Chemistry*

CHEM 108B, *Organic Chemistry*

Earth Sciences

EART 100/L, *Vertebrate Paleontology*

EART 102, *Marine Geology*

EART 105, *Coastal Geology*

EART 122, *Paleoceanography*

Environmental Studies

ENVS 104A, *Introduction to Environmental Field Methods*

ENVS 108/L, *General Entomology/Laboratory*

ENVS 115A/L, *GIS and Environmental Applications/Exercises in GIS*

ENVS 120, *Conservation Biology*

ENVS 122, *Tropical Ecology and Conservation*

ENVS 123, *Animal Ecology and Conservation*

ENVS 129, *Integrated Pest Management*

ENVS 130A/L, *Agroecology and Sustainable Agriculture/Laboratory*

ENVS 130B, *Principles of Sustainable Agriculture*

ENVS 131/L, *Insect Ecology/Laboratory*

ENVS 138/L, *Field Ethnobotany/Laboratory*

ENVS 160, *Restoration Ecology*

ENVS 161A/L, *Soils and Plant Nutrition/Laboratory*

ENVS 162, *Plant Physiological Ecology*

ENVS 163/L, *Plant Disease Ecology/Laboratory*

ENVS 167, *Freshwater and Wetland Ecology*

ENVS 168, *Biochemistry and the Global Environment*

Psychology

PSYC 123, *Behavioral Neuroscience*

One of the following may also be used as an upper-division [general](#) elective:

Biological Sciences-EEB

BIOE 183L, *Undergraduate Research in EEB*

~~BIOE 188, *Supervised Teaching*~~

BIOE 195, *Senior Thesis*

BIOE 198, *Independent Field Study*

BIOE 199, *Tutorial*

Environmental Studies

ENVS 183, *Environmental Studies Internship*

Plant Sciences B.S. Sample Planners

Plan One is for first-year students placing into Mathematics 3 and [taking Chemistry 1A](#) ~~BIOE 3~~:

Plan One			
Year	Fall	Winter	Spring
1st (frsh)	Chem-1A gen ed Math-MATH 3 core	Chem-CHEM 1A/B/M Math-MATH 11A BIOE-3 gen ed	Chem-CHEM 1B/M/C/N Math-MATH 11B gen ed
2nd (soph)	BIOE 30C chemHEM	BIOL 20A Phys-PHYS 7A/L	BIOE 20B Phys-PHYS 7B/M

Plan One			
	1/C/N AMS 74-BIOE 20C gen ed	gen ed	gen ed

Plan Two is a more rigorous schedule for first-year students placing into Mathematics 11A and [taking Chemistry 1A](#) ~~BIOE/BIOL 20~~:

Plan Two			
Year	Fall	Winter	Spring
1st (frsh)	Chem-CHEM 1A Math-MATH 11A core	Chem-CHEM 1B/M Math-MATH 11B gen ed	Chem-CHEM 1C/N BIOE 20C gen ed
2nd (soph)	BIOL 20A AMS 7/L gen ed	BIOE 20B Phys-PHYS 7A/L gen ed	BIOL 105 elective Phys-PHYS 7B/M gen ed

Degree Programs Sponsored by Molecular, Cell, and Developmental Biology

Health Sciences Major

Program Description

The B.S. major in health sciences is designed for students interested in careers in medicine or biomedical research and satisfies the admission requirements for most U.S. medical schools. It is based on the existing B.S. degree in molecular, cell, and developmental biology, with similar course requirements in chemistry, physics, and mathematics. Students are required to take five courses directly relevant to human health in addition to genetics, biochemistry, and cell biology. Students in this program must also fulfill Spanish language and health care internship requirements.

Health Sciences B.S. Major Requirements*

Introductory Requirements

Introductory Biology: BIOL 20A, BIOE 20B, and BIOL 20L

General Chemistry: Chemistry 1A, 1B/M and 1C/N

Organic Chemistry: Chemistry 108A/L and 108B/M, 108C recommended for pre-med students, or 112A/L, 112B/M, and 112C/N

Calculus: Mathematics 11A-B or 19A-B; and 22 (three quarters)

Physics: Physics 6A/L, 6B/M, and 6C/N

Advanced Requirements

A total of eight upper-division biology courses, as follows:

Four core courses:

Biochemistry: BIOL 100 or BIOC 100A, 100B, and 100C

Genetics: BIOL 105

Cell Biology: BIOL 110

Human Physiology with Lab: BIOL 130/L

Three of the following lecture courses:

~~BIOL 133/L, Exercise Physiology/Laboratory~~

BIOL 111, *Immunology*

BIOL 113, *Mammalian Endocrinology*

BIOL 114, *Cancer Cell Biology*

BIOL 115, *Eukaryotic Molecular Biology*

BIOL 119, *Microbiology*

BIOL 120, *Development*

BIOL 125, *Neuroscience*

BIOL 126, ~~Cancer Cell Biology~~ [Advanced Neural Development](#)

BIOL 127, *Neurodegenerative Disease*

BIOL 135/L, *Anatomy of the Human Body/Laboratory*

BIOL 178, *Stem Cell Biology*

BIOL 179, *Biotechnology and Drug Development*

Internship Requirement: BIOL189, *Health Sciences Internship*. The student must participate in a community health care service activity approved by the health sciences internship coordinator. Credit may be earned over multiple quarters.

Language Requirement: Spanish 1–4 or the equivalent and one quarter of Spanish for health care workers (Spanish 5M).

* Medical and professional school admissions requirements vary; students should verify that their coursework will satisfy the admissions requirements of the programs to which they plan to apply.

Health Sciences B.S. Sample Planners

Plan One is for first-year students placing into Mathematics 3 and [taking Chemistry 1A](#) ~~BIOE 3~~:

Plan One			
Year	Fall	Winter	Spring
1st (frsh)	Chem-1A gen ed Math-MATH 3 core	Chem 1A B-M Math-MATH 11A BIOE 3	Chem-CHEM 1B/M C-N Math-MATH 11B gen ed
2nd (soph)	BIOL 20A Chem-HEM 1C/N Math-MATH 22 gen ed	BIOL 20A/E-20B Chem-CHEM 108A/L gen ed	BIOE-20B-405 Chemistry-CHEM 108B/M gen ed

Plan Two is a more rigorous schedule for first-year students placing into Mathematics 11A and [taking Chemistry 1A](#) ~~BIOL 20~~:

Plan Two			
Year	Fall	Winter	Spring
1st (frsh)	Chem-CHEM 1A Math-MATH 11A core	Chem-CHEM 1B/M Math-MATH 11B gen ed	Chem-CHEM 1C/N Math-MATH 22 gen ed BIOL 20A
2nd (soph)	BIOE 20B BIOL 20A Chem-CHEM 108A/L* gen ed	BIOE-20B/L 105 Chem-CHEM 108B/M gen ed	BIOL 100 BIOL-405 elective** gen ed

* Students may use the three-quarter ~~C~~chemistry 112 series to fulfill the organic chemistry requirement.

**Students should take either an elective, a Spanish course, or the third quarter of organic chemistry.

Molecular, Cell, and Developmental Biology Major

Program Description

The molecular, cell, and developmental (MCD) biology major is designed for students interested in medical or other professional graduate programs and those preparing for careers in biotechnology industries. This major is more structured than the general biology major and requires that students pay careful attention to the prerequisites required for upper-division biology courses.

Molecular, Cell, and Developmental Biology B.S. Major Requirements

Introductory Requirements

Introductory Biology: BIOL 20A, BIOE 20B, and 20C

General Chemistry: Chemistry 1A, 1B/M and 1C/N

Organic Chemistry: Chemistry 108A/L and 108B/M or 112A/L, 112B/M, and 112C/N

Calculus: Mathematics 11A-B or 19A-B; and 22

Physics: Physics 6A/L, 6B/M, and 6C/N

Advanced Requirements

A total of nine upper-division biology courses, as follows:

Four core courses:

Biochemistry: BIOL 100 or the series BIOC 100A, and 100B, and 100C

(Upon completion of the series, BIOC 100C may be used to satisfy one elective)

Genetics: BIOL 105

Cell Biology: BIOL 110

Eukaryotic Molecular Biology: BIOL 115

Three of the following lecture courses:

BIOL 111, *Immunology*

BIOL 113, *Mammalian Endocrinology*

BIOL 114, *Cancer Cell Biology*

BIOL 119, *Microbiology*

BIOL 120, *Development*

BIOL 125, *Neuroscience*

BIOL 126, *Advanced Neural Development*

BIOL 127, *Neurodegenerative Disease*

BIOL 130/L, *Human Physiology/Laboratory*

BIOL 178, *Stem Cell Biology*

BIOL 179, *Biotechnology and Drug Development*

BIOE 109, *Evolution*

BIOE 135, *Plant Physiology*

Two of the following laboratory courses:

BIOL 100L, *Biochemistry Laboratory*

BIOL 105L, *Eukaryotic Genetics Laboratory*

BIOL 105M, *Microbial Genetics Laboratory*

BIOL 109L, *Yeast Molecular Genetics Laboratory*

BIOL 110L, *Cell Biology Laboratory*

BIOL 111L, *Immunology Laboratory*

BIOL 115L, *Eukaryotic Molecular Biology Laboratory*

BIOL 119L, *Microbiology Laboratory*

BIOL 120L, *Development Laboratory*

~~BIOL 128L, *Neural Genetics Laboratory*~~

BIOL 130/L, *Human Physiology/Laboratory**

BIOL 178L, *Protocols in Stem Cell Biology*

BIOL 180/L, *Research Programming for Biologists and Biochemists/Laboratory*

BIOL 181, *Computational Biology Tools*

~~BIOL 185L *Hughes Undergraduate Research Laboratory*~~

BIOL 186L, *Undergraduate Research in MCD*

BIOL 187L, *Molecular Biotechnology Laboratory*

BIOC 110, *Biochemistry Laboratory*

*BIOL 130/L meets either one lecture or one laboratory requirement, but not both.

Molecular, Cell and Developmental Biology B.S. Sample Planners

Plan One is for first-year students placing into Mathematics 3 and ~~BIOL 3~~ taking Chemistry 1A:

Plan One			
Year	Fall	Winter	Spring
1st (frsh)	Chem 1A gen ed Math MATH 3 core	Chem CHEM 1A/B/M Math MATH 11A BIOE 3	Chem CHEM 1B/M/C/N Math MATH 11B gen ed
2nd (soph)	Chem HEM ICN BIOL 20A Math MATH 22 gen ed	BIOE 2L 20A Chem CHEM 108A/L gen ed	BIOE 20B/C Chemistry CHEM 108B/M gen ed

Plan Two is a more rigorous schedule for first-year students placing into Mathematics 11A and ~~BIOL 20~~ BIOL 20:

Plan Two			
Year	Fall	Winter	Spring
1st (frsh)	Chem-CHEM 1A Math-MATH 11A core	Chem-CHEM 1B/M Math-MATH 11B gen ed	Chem-CHEM 1C/N Math-MATH 22 BIOL 20A
2nd (soph)	BIOE 20B Chem-CHEM 108A/L [†] gen ed	BIOE 20C Chem-CHEM 108B/M [†] gen ed	BIOE 100 elective BIOL 105 gen ed

* Students may use the three-quarter ~~C~~hemistry 112 series to fulfill the organic chemistry requirement.

Neuroscience and Behavior Majors

Program Description

Neuroscience, the study of the nervous system and behavior of animals, is a frontier area in biology, touching psychology on the one hand and computer science on the other. The neuroscience and behavior majors provide students with rigorous preparation for graduate studies and research in the fields of neuroscience and behavior. The brain and determinants of behavior are studied at all levels, from biological molecules to individual nerve cells to functioning organisms to social behavior. The majors emphasize the interrelationship between the two fields, building on a common core of general and biological science course work. Students select a pathway in either behavior or molecular neuroscience. Rigorous course work is supplemented by opportunities for hands-on laboratory and field courses and independent research.

Neuroscience and Behavior B.A. Major Requirements

Introductory Course Requirements

Introductory Biology: BIOL 20A, BIOE 20B, and 20C

General Chemistry: Chemistry 1A, 1B/M and 1C/N

Organic Chemistry: Chemistry 108A/L and 108B/M or 112A/L, 112B/M, and 112C/N

Calculus: Mathematics 11A-B or 19A-B

Biostatistics: Applied Mathematics and Statistics 7/L

Physics: Physics 7A/L and 7B/M

Advanced Course Requirements

Five upper-division core courses to include:

Biochemistry: BIOL 100 or the series BIOC 100A, and 100B, and 100C

(Upon completion of the series, BIOC 100C may be used to satisfy one elective)

Genetics: BIOL 105

Cell Biology: BIOL 110

Neuroscience: BIOL 125

Behavioral Ecology: BIOE 140

Plus additional elective courses chosen from one of two areas of concentration:

Molecular Neuroscience Pathway (four courses)

BIOL 115, *Eukaryotic Molecular Biology*

BIOL 126, *Advanced Molecular Neuroscience*

One of the following ~~physiology or psychology courses~~electives:

[BIOL 127, *Neurodegenerative Disease*](#)

BIOL 130/L, *Human Physiology*

Psychology 121, *Perception*

Psychology 123, *Behavioral Neuroscience*

One of the following ~~biology~~laboratory courses:

BIOL 100L, *Biochemistry Laboratory*

BIOL 105L, *Eukaryotic Genetics Laboratory*

BIOL 109L, *Yeast Molecular Genetics Laboratory*

BIOL 110L, *Cell Biology Laboratory*

BIOL 111L, *Immunology Laboratory*

BIOL 115L, *Eukaryotic Molecular Biology Laboratory*

BIOL 120L, *Development Laboratory*

~~BIOL 128L, Neural Genetics Laboratory~~

BIOL 130/L, Human Physiology/Laboratory*

~~BIOL 178L, Protocols in Stem Cell Biology~~

BIOL 180/L, Research Programming for Biologists and Biochemists/Laboratory

BIOL 181, Computational Biology Tools

~~BIOL 185L, Hughes Undergraduate Research Laboratory~~

BIOL 186L, Undergraduate Research in MCD

BIOL 187L, Molecular Biotechnology Laboratory

Behavior Pathway (four courses)

~~BIOL 113, Mammalian Endocrinology~~

One of the following:

~~BIOE 112/L, Ornithology/Laboratory~~

~~BIOE 114/L, Herpetology/Laboratory~~

~~BIOE 129/L, Marine Mammals/Laboratory~~

~~BIOE 141L, Behavioral Ecology Field Course~~

~~BIOE 150, Ecological Field Methods~~

One of the following ~~physiology or psychology courses~~electives:

~~BIOE 110/L, Biology and Ecology of Vertebrates/Laboratory~~

~~BIOE 122/L, Invertebrate Zoology/Laboratory~~

~~BIOE 131/L, Animal Physiology/Laboratory~~

~~BIOE 133/L, Exercise Physiology/Laboratory~~

BIOL 120, Development

BIOL 127, Neurodegenerative Disease

BIOL 130/L, Human Physiology/Laboratory

Psychology 121, Perception

Psychology 123, Behavioral Neuroscience

Psychology 133, Psychology and Evolutionary Theory

One of the following laboratory courses:

~~BIOE 110/L, Biology and Ecology of Vertebrates/Laboratory~~

~~BIOE 122/L, Invertebrate Zoology/Laboratory~~

~~BIOE 131/L, Animal Physiology/Laboratory~~

~~BIOE 141L, Behavioral Ecology Field Course~~

~~BIOE 150L, Ecological Field Methods~~

~~BIOL 105L, Eukaryotic Genetics Laboratory~~

~~BIOL 130/L, Human Physiology Laboratory~~

~~BIOL 180/L, Research Programming for Biologists and Biochemists/Laboratory~~

~~BIOL 181, Computational Biology Tools~~

Computer Science ~~12A, Introduction to Programming~~~~5C, Introduction to Programming in C/C++~~

Computer Science ~~12B, Introduction to Data Structures~~~~5J, Introduction to Programming in Java~~

~~Computer Science 5P, Introduction to Programming in Python~~

*BIOL 130/L meets either a physiology or a laboratory requirement, but not both.

Neuroscience and Behavior B.A. Sample Planners

Plan One is for first-year students placing into Mathematics 3 and ~~BIOE 3~~~~aking Chemistry 1A~~:

Plan One			
Year	Fall	Winter	Spring
1st (frsh)	Chem 1A gen ed Math MATH 3 core	Chem CHEM 1A-B-M Math MATH 11A BIOE 3 gen ed	Chem 1B/M/C/N Math MATH 11B gen ed
2nd	BIOL	BIOE 20B	BIOE 20C

Plan One			
(soph)	20A ChemHEM 1C/N AMS 7/L-BIOL 20A gen ed	Chem-CHEM 108A/L gen ed	Chem-CHEM 108B/M gen ed

Plan Two is a ~~more rigorous schedule~~ for first-year students placing into Mathematics 11A and ~~taking Chemistry 1A~~BIOE/BIOL-20:

Plan Two			
Year	Fall	Winter	Spring
1st (frsh)	Chem-CHEM 1A Math-MATH 11A core	Chem-CHEM 1B/M Math-MATH 11B gen ed	Chem-CHEM 1C/N BIOL 20A gen ed
2nd (soph)	BIOE 20B AMS 7/L ChemHEM 108A/L* gen ed	BIOE 20C Chem-CHEM 108B/MA-L* gen ed	BIOL 105 Chem 108B/Melective gen ed

* Students may use the three-quarter ~~C~~chemistry 112 series to fulfill the organic chemistry requirement.

Neuroscience and Behavior B.S. Major Requirements

Introductory Course Requirements

Introductory Biology: BIOL 20A, BIOE 20B, and 20C

General Chemistry: Chemistry 1A, 1B/M and 1C/N

Organic Chemistry: Chemistry 108A/L and 108B/M or 112A/L, 112B/M, and 112C/N

Calculus: Mathematics 11A-B or 19A-B; and 22

Biostatistics: Applied Mathematics and Statistics 7/L

Physics: Physics 6A/L, 6B/M, and 6C/N

Advanced Course Requirements

Five upper-division core courses to include:

Biochemistry: BIOL 100 or the series BIOC 100A, and 100B, and 100C

(Upon completion of the series, BIOC 100C may be used to satisfy one elective)

Genetics: BIOL 105

Cell Biology: BIOL 110

Neuroscience: BIOL 125

Behavioral Ecology: BIOE 140

Plus additional elective courses chosen from one of two areas of concentration:

Molecular Neuroscience Pathway (five courses)

BIOL 115, *Eukaryotic Molecular Biology*

BIOL 126, *Advanced Molecular Neuroscience*

One of the following ~~physiology or psychology courses~~electives:

BIOL 130/L, *Human Physiology*

BIOL 127, *Neurodegenerative Disease*

Psychology 121, *Perception*

Psychology 123, *Behavioral Neuroscience*

Two of the following ~~biology~~-laboratory courses:

BIOL 100L, *Biochemistry Laboratory*

BIOL 105L, *Eukaryotic Genetics Laboratory*

BIOL 109L, *Yeast Molecular Genetics Laboratory*

BIOL 110L, *Cell Biology Laboratory*

BIOL 111L, *Immunology Laboratory*

BIOL 115L, *Eukaryotic Molecular Biology Laboratory*

BIOL 120L, *Development Laboratory*

~~BIOL 128L, Neural Genetics Laboratory~~

BIOL 130/L, *Human Physiology/Laboratory**

~~BIOL 178L, *Protocols in Stem Cell Biology*~~

BIOL 180/L, *Research Programming for Biologists and Biochemists/Laboratory*

BIOL 181, *Computational Biology Tools*

~~BIOL 185L, *Hughes Undergraduate Research Laboratory*~~

BIOL 186L, *Undergraduate Research in MCD*

BIOL 187L, *Molecular Biotechnology Laboratory*

Behavior Pathway (four courses)

BIOL 113, *Mammalian Endocrinology*

One of the following:

BIOE 112/L, *Ornithology/Laboratory*

BIOE 114/L, *Herpetology/Laboratory*

BIOE 129/L, *Marine Mammals/Laboratory*

BIOE 141L, *Behavioral Ecology Field Course*

BIOE 150, *Ecological Field Methods*

One of the following ~~physiology or psychology courses~~electives:

~~BIOE 110/L, *Biology and Ecology of Vertebrates/Laboratory*~~

BIOE 122/L, *Invertebrate Zoology/Laboratory*

BIOE 131/L, *Animal Physiology/Laboratory*

~~BIOE 133/L, *Exercise Physiology/Laboratory*~~

BIOL 120, *Development*

BIOL 130/L, *Human Physiology/Laboratory*

Psychology 121, *Perception*

Psychology 123, *Behavioral Neuroscience*

Psychology 133, *Psychology and Evolutionary Theory*

Two of the following laboratory courses:

~~BIOE 110/L, *Biology and Ecology of Vertebrates/Laboratory*~~

BIOE 122/L, *Invertebrate Zoology/Laboratory*

BIOE 131/L, *Animal Physiology/Laboratory*

BIOE 141L, *Behavioral Ecology Field Course*

BIOE 150L, *Ecological Field Methods*

BIOL 105L, *Eukaryotic Genetics Laboratory*

BIOL 130/L, *Human Physiology Laboratory*

BIOL 180/L, *Research Programming for Biologists and Biochemists/Laboratory*

BIOL 181, *Computational Biology Tools*

Computer Science 5C, *Introduction to Programming in C/C++*

Computer Science 5J, *Introduction to Programming in Java*

Computer Science 5P, *Introduction to Programming in Python*~~Computer Science 12A, *Introduction to Programming*~~

~~Computer Science 12B, *Introduction to Data Structures*~~

*BIOL 130/L meets either a physiology or a laboratory requirement, but not both.

Neuroscience and Behavior B.S. Sample Planners

Plan One is for first-year students placing into Mathematics 3 and BIOE 3:

Plan One			
Year	Fall	Winter	Spring
1st (frsh)	Chem 1A gen ed Math MATH 3 core	Chem CHEM 1A/B/M Math MATH 11A BIOE 3gen ed	Chem CHEM 1B/M/C/N Math MATH 11B gen ed
2nd (soph)	BIOL 20A Chem CHEM 1/J/N	BIOL E 20A/B Chem CHEM 108A/L	BIOE 20B/C Chem CHEM 108B/M

Plan One			
	Math 22 gen ed	gen ed	gen ed

Plan Two is a more rigorous schedule for first-year students placing into Mathematics 11A and BIOE/BIOL 20:

Plan Two			
Year	Fall	Winter	Spring
1st (frsh)	Chem-CHEM 1A Math-MATH 11A core	Chem-CHEM 1B/M Math-MATH 11B gen ed	Chem-CHEM 1C/N Math-MATH 22 BIOL 20A
2nd (soph)	BIOE 20B Chem-CHEM 108A/L* gen ed	BIOE 20C Chem-CHEM 108B/M* gen ed	BIOL 100 BIOL 105 gen ed

* Students may use the three-quarter ~~C~~hemistry 112 series to fulfill the organic chemistry requirement.

Ecology and Evolutionary Biology

Ecology and Evolutionary Biology
A308 Earth and Marine Sciences
(831) 459-5358
<http://www.eeb.ucsc.edu/>

Graduate Program Description

The graduate program in ecology and evolutionary biology (EEB, courses BIOE) at UCSC is one of the premier programs in the country. This is due to the quality and commitment of the faculty, the long-standing tradition of the University of California, and the unique environment of the Santa Cruz campus. UCSC has been singularly blessed with varied and easily accessible marine and terrestrial resources for research. UCSC is ideal for marine research—having its own marine laboratory, a fleet of boats, and one of the most active scientific diving programs in the country. In close proximity to pinniped rookeries at the UC Reserve at Año Nuevo, the campus is located on Monterey Bay, which has the largest concentration of marine research programs in the country. In addition to state-of-the-art departmental laboratories, students have full access to the molecular ecology and evolutionary genetics (MEEG) facility and other analytical laboratories of the UCSC Institute of Marine Sciences.

Terrestrial biologists have access to all of California's natural environments through the University of California's natural reserve system; the diverse habitats on UCSC's 2,000-acre campus itself (mixed redwood forest, fossil sand dune associations, rolling pasture land, and chaparral) and on several adjacent preserves; the UCSC experimental farm and garden; extensive southern hemisphere plantings in the UCSC arboretum; and greenhouses and associated laboratory facilities. More than two-thirds of our faculty participate in field studies throughout the ~~P~~acific ~~B~~asin (from Alaska to Antarctica), in ~~pac~~ific ~~R~~im nations (in Latin America, the Far East, and Australia), and beyond.

The program in ecology and evolutionary biology is comprised of four core tracks: (1) population and community ecology, (2) evolutionary biology, (3) physiology and behavior including marine and terrestrial animals, and (4) systematics and biodiversity.

Degree Requirements

Ph.D. Requirements

~~Students must take BIOE 200A and 200B in the first year. BIOE 279 must be taken fall quarter of the first year; BIOE 293 is required four quarters thereafter. BIOE 294 must be taken every quarter that the student is in residence. Each Ph.D. student must complete at least two quarters as a teaching assistant during their graduate career.~~
~~Courses:~~

~~BIOE 200A. Scientific Skills~~

~~BIOE 200B. Advanced Organismal Biology~~

~~BIOE 279. Evolutionary Ecology~~

~~BIOE 293. Readings in Ecology and Evolution (or equivalent)~~

~~BIOE 294. Ecology, Evolutionary Biology Seminar (taken each quarter when in residence)~~

~~Each Ph.D. student should expect to complete at least two quarters as a teaching assistant during their graduate career.~~

During fall of the second year, students take a comprehensive examination. This is a two-part exam, written and oral, the goal of which is to examine the student's breadth and depth of knowledge of evolution, ecology, physiology, behavior, organismal, and general biology. A committee is comprised of four examiners selected by each student and the student's supervisor. Each student's area of research, together with the stated goal of the exam, should guide the composition of the student's committee.

During the sixth term, the student submits a dissertation research proposal to their dissertation committee and must defend it in a three-hour oral examination before the dissertation committee. The student advances to candidacy only after completing all course work, passing the written and oral portions of the comprehensive examination, writing and defending a dissertation research proposal, and presenting a candidacy seminar on his/her proposed research.

The student must submit his/her doctoral dissertation to the dissertation committee for tentative approval at least 60 days before presenting a formal, public doctoral research seminar. Also, the student must meet with the dissertation committee to defend the thesis at least one week prior to the public seminar. Before the dissertation is accepted for signature by the dissertation committee, at least one chapter must be submitted as a paper (not an abstract) to a refereed journal for publication.

M.A. Requirements

In addition to course work identified by the advisory committee or adviser, each student will be required to take BIOE 279, two quarters of BIOE 293, BIOE 294 and the appropriate lab course when in residence at the university (not in the field), and BIOE 297, as needed, to come up with 15 credits. BIOE 200A and 200B are recommended but not required.

The student must submit their thesis draft to the thesis committee for tentative approval at least 60 days before presenting a formal, public research seminar. Also, the student must meet with the thesis committee to defend the thesis at least one week prior to the public seminar. At that time, the committee may sign the cover page of the student's dissertation.

There is no requirement, but it is highly recommended, that at least one thesis chapter be submitted as a paper (not an abstract) to a refereed journal for publication.

Molecular, Cell, and Developmental Biology

Molecular, Cell, and Developmental Biology
225 Sinsheimer Laboratories
(831) 459-4986
<http://www.mcd.ucsc.edu/>

Graduate Program Description

The program in molecular, cell, and developmental (MCD) biology (courses BIOL) leads to either the Ph.D. or the M.A. and is designed to prepare students for careers in research, teaching, and biotechnology. Current research in MCD biology focuses on such topics as the structure and function of RNA, gene expression, signaling, cell division, development, and pathogenesis. A unique focus of the department is the center for the molecular biology of RNA.

Degree Requirements

Ph.D. and master's students complete the graduate core courses, BIOL 200A, 200B, and 200C, [and 200D](#) in the first year. Additional undergraduate courses required to strengthen the student's background may be assigned by the advisory committee during the initial advising meeting. Typically, these courses are Biochemistry 100A and BIOL 115. Students are required to participate in lab research meetings and departmental seminar series every quarter.

First-year Ph.D. students complete three 10-week laboratory rotations. Students choose their rotation laboratories in consultation with the Graduate Advisory Committee. The lab rotations give students a chance to learn about the diverse fields and methods of inquiry and to interact with members of the department. At the end of each quarter, students present a short talk to the department on their rotation project. At the end of spring quarter, students consult with rotation faculty to identify a permanent thesis laboratory.

Second-year Ph.D. students are required to submit two proposals—one on their proposed thesis work and a second on an unrelated MCDB research topic. The Ph.D. qualifying exam, taken in spring quarter of the second year, is an oral examination before a committee comprised of three internal reviewers and one external reviewer.

Once the qualifying exam is passed, students, in conjunction with their faculty adviser, select a committee to consult with in the development of their thesis. This committee monitors the student's progress and ultimately approves the final draft of the student's dissertation. The student must meet with the thesis committee at least once a year after passing the qualifying exam.

Students are advanced to candidacy following presentation of their research to the department in a seminar. This takes place no later than spring of the third year. Graduate students must take two approved advanced graduate electives. Students who enter the Ph.D. program with a Masters degree without doing rotations must complete an additional two approved graduate elective courses.

Ph.D. Requirements

- Completion of the graduate core course
- Completion of the *Practice of Science* course
- Completion of an oral qualifying exam
- Completion of an advancement to candidacy seminar
- Completion of two advanced graduate elective courses
- Yearly meetings with a thesis committee after the qualifying exam
- Completion of two quarters of service as a teaching assistant
- Completion of thesis research resulting in a dissertation of individual work
- Presentation of thesis defense in departmental seminar

M.A. Requirements

- Acceptance to the master's program requires a faculty sponsor. Interested applicants must contact faculty directly and procure sponsorship before beginning the application process.
- Completion of the graduate core course
- Completion of the *Practice of Science* course
- Write a master's thesis based on original research
- Presentation of thesis defense in departmental seminar