Biology

Courses offered by the Department of Biology are listed under the subject code BIO on the Stanford Bulletin's ExploreCourses web site.

The department provides:

- a major program leading to the B.S. degree
- a minor program
- a coterminal program leading to the M.S. degree
- a doctoral program leading to the Ph.D. degree, and
- courses designed for the non-major.

Mission of the Undergraduate Program in Biology

The mission of the undergraduate program in Biology is to provide students with in-depth knowledge in the discipline, from molecular biology to ecology. Students in the program learn to think and analyze information critically, to draw connections among the different areas of biology, and to communicate their ideas effectively to the scientific community. The major exposes students to the scientific process through a set of core courses and electives from a range of subdisciplines. The Biology major serves as preparation for professional careers, including medicine, dentistry, veterinary sciences, teaching, consulting, research, and field studies.

Learning Outcomes (Undergraduate)

The department expects undergraduate majors in the program to be able to demonstrate the following learning outcomes. These learning outcomes are used in evaluating students and the department's undergraduate program. Students are expected to demonstrate:

1. the ability to use discipline-specific tools and content knowledge to analyze and interpret scientific data, to evaluate the significance of the data, and to articulate conclusions supportable by the data.
2. the ability, independently and collaboratively, to formulate testable scientific hypotheses and to design approaches to obtain data to test the respective hypotheses.
3. the ability to communicate content understanding and research outcomes effectively using various media.

Mission of the Graduate Program in Biology

For graduate-level students, the department offers resources and experience learning from and working with world-renowned faculty involved in research on ecology, neurobiology, population biology, plant and animal physiology, biochemistry, immunology, cell and developmental biology, genetics, and molecular biology.

The M.S. degree program offers general or specialized study to individuals seeking biologically oriented course work, and to undergraduate science majors wishing to increase or update their science background or obtain advanced research experience.

The training for a Ph.D. in Biology is focused on learning skills required to be a successful research scientist and teacher, including how to ask important questions and then devise and carry out experiments to answer these questions. Students work closely with an established advisor and meet regularly with a committee of faculty members to ensure that they understand the importance of diverse perspectives on experimental questions and approaches. Students learn how to evaluate critically pertinent original literature in order to stay abreast of scientific progress in their areas of interest. They also learn how to make professional presentations, write manuscripts for publication, and become effective teachers.

Learning Outcomes (Graduate)

The purpose of the master's program is to further develop knowledge and skills in Biology and to prepare students for a professional career or doctoral studies. This is achieved through completion of courses, in the primary field as well as related areas, and experience with independent work and specialization.

The Ph.D. is conferred upon candidates who have demonstrated substantial scholarship and the ability to conduct independent research and analysis in Biology. Through completion of advanced course work and rigorous skills training, the doctoral program prepares students to make original contributions to the knowledge of Biology and to interpret and present the results of such research.

Facilities

The offices, labs, and personnel of the Department of Biology are located in the Gilbert Biological Sciences, Herrin Laboratories, Herrin Hall, James H. Clark Center, Larry I. Lokey Laboratory, and Jerry Yang and Akiko Yamazaki Environment and Energy (Y2E2) buildings. Along with the Carnegie Institution of Washington all are on the main campus. Jasper Ridge Biological Preserve (JRBP) is located near Stanford University's campus in the eastern foothills of the Santa Cruz Mountains. Hopkins Marine Station is on Monterey Bay in Pacific Grove.

Jasper Ridge Biological Preserve encompasses geologic, topographic, and biotic diversity within its 1,189 acres and provides a natural laboratory for researchers from around the world, educational experiences for students and docent-led visitors, and refuge for native plants and animals. See the JRBP (http://jrbp.stanford.edu) web site.

Hopkins Marine Station, located 90 miles from the main University campus in Pacific Grove, was founded in 1892 as the first marine laboratory on the west coast of North America. For more information, including courses taught at Hopkins Marine Station with the subject code BIOHOPK, see the "Hopkins Marine Station (http://exploreddegrees.stanford.edu/schoolofhumanitiesandsciences/biology/%20/schoolofhumanitiesandsciences/biologyhopkinsmarinestation)" section of this bulletin.

The department's large collections of plants (Dudley Herbarium), fish, reptiles, and amphibians, as well as smaller collections of birds, mammals, and invertebrates, are housed at the California Academy of Sciences in San Francisco, where they, and extensive collections of the Academy, are available to those interested in the systematics of these groups. Entomological collections, restricted to those being used in particular research projects, are housed in the Herrin Laboratories. No general collections are maintained except for teaching purposes.

The Robin Li and Melissa Ma Science Library (http://library.stanford.edu/libraries/science/about), located in the Sapp Center for Science Teaching and Learning, supports research and teaching for the Department of Biology and other related disciplines. A specialized library is maintained at Hopkins Marine Station.

Biology Course Numbering System

The department uses the following course numbering system:

<table>
<thead>
<tr>
<th>Number</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>000-099</td>
<td>Introductory and Foundations</td>
</tr>
<tr>
<td>100-199</td>
<td>Undergraduate</td>
</tr>
<tr>
<td>200-299</td>
<td>Advanced Undergraduate, Coterminal and PhD</td>
</tr>
<tr>
<td>300+</td>
<td>PhD</td>
</tr>
</tbody>
</table>
Bachelor of Science in Biology

The undergraduate major in Biology can serve as a stepping-stone for a wide variety of career opportunities. For students planning to attend medical, dental, or veterinary school, or graduate school in biological and applied sciences, the biology major provides a strong foundation in the basic life sciences. This foundation of knowledge, plus laboratory experience, also prepares students well for research and technical positions in universities, government, and industry.

While a major in Biology provides an excellent background for these technical careers, it can also serve as a valuable and satisfying focus of a liberal arts education for those not planning careers in science-related fields. An understanding of basic biological principles is of increasing importance in today's world. A knowledgeable and concerned citizenry is the best guarantee that these issues will be resolved most effectively. Finally, an understanding of the processes of life can heighten our perception and appreciation of the world around us, in terms of its beauty, variety, and uniqueness.

Advising

Members of the Biology faculty are available for advising on such academic matters as choice of courses, research, suggested readings, and career plans. The student services office maintains a current list of faculty advisors, advising availability, and research interests.

The student services staff and BioBridge (https://biology.stanford.edu/academics/undergraduate-program/advising/biobridge-peer-advising), the department's peer advising group, are prepared to answer questions on administrative matters, such as requirements for the major, approved out-of-department electives, transfer course evaluations, and petition procedures. This office also distributes the department’s Bachelor of Science Handbook (https://stanford.app.box.com/v/bs-handbook), which delineates policies and requirements, as well as other department forms and informational handouts.

Each undergraduate interested in the Biology major is required to select a department faculty advisor as part of the major declaration process.

Degree Requirements

Candidates for the general Biology B.S. degree must complete the following requirements, which ranges from 88-102 total units. There is also an option to add honors to the major, regardless of whether a student wishes to complete the general major or a specific field of study. Honors requirements are explained in detail in the "Honors (https://exploredegrees.stanford.edu/schoolofhumanitiesandsciences/biology/#honors)" tab. Requirements for specific fields of study are explained in the "Fields of Study (p. 4)" tab.

Introductory Course

(must be taken for a letter grade):

Select one of the following:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>BIO 60 Problem solving in infectious disease</td>
</tr>
<tr>
<td></td>
<td>BIO 61 Science as a Creative Process</td>
</tr>
<tr>
<td></td>
<td>BIO 62 Microbiology Experiments</td>
</tr>
</tbody>
</table>

Foundational Courses

(must be taken for a letter grade):

Select 5 of the following:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>BIO 81 Introduction to Ecology</td>
</tr>
<tr>
<td></td>
<td>or BIOHOPK 81 Introduction to Ecology</td>
</tr>
<tr>
<td></td>
<td>BIO 82 Genetics</td>
</tr>
<tr>
<td></td>
<td>BIO 83 Biochemistry &amp; Molecular Biology</td>
</tr>
<tr>
<td></td>
<td>BIO 84 Physiology</td>
</tr>
<tr>
<td></td>
<td>or BIOHOPK 84 Physiology</td>
</tr>
<tr>
<td></td>
<td>BIO 85 Evolution</td>
</tr>
<tr>
<td></td>
<td>or BIOHOPK 85 Evolution</td>
</tr>
<tr>
<td></td>
<td>BIO 86 Cell Biology</td>
</tr>
</tbody>
</table>

Foundational Lab Courses

Two Courses Required:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>BIO 45 Introduction to Laboratory Research in Cell and Molecular Biology</td>
</tr>
<tr>
<td>4-5</td>
<td>BIO 46 Introduction to Research in Ecology and Evolutionary Biology</td>
</tr>
<tr>
<td></td>
<td>or BIO 47 Introduction to Research in Ecology and Evolutionary Biology</td>
</tr>
<tr>
<td></td>
<td>or BIOHOPK 47 Introduction to Research in Ecology and Ecological Physiology</td>
</tr>
</tbody>
</table>

Required Foundational Breadth Courses

(One course from this section may be taken credit/no credit):

<table>
<thead>
<tr>
<th>Units</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CHEM 31A Chemical Principles I</td>
</tr>
<tr>
<td></td>
<td>or CHEM 31B Chemical Principles II</td>
</tr>
<tr>
<td></td>
<td>or CHEM 31X Chemical Principles Accelerated</td>
</tr>
<tr>
<td>5</td>
<td>CHEM 33 Structure and Reactivity of Organic Molecules</td>
</tr>
<tr>
<td>5</td>
<td>CHEM 35 Organic Chemistry of Bioactive Molecules</td>
</tr>
</tbody>
</table>

Mathematics

Select one of the following options:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course</th>
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</thead>
<tbody>
<tr>
<td>5-10</td>
<td>MATH 19 Calculus</td>
</tr>
<tr>
<td></td>
<td>&amp; MATH 20 and Calculus</td>
</tr>
<tr>
<td></td>
<td>&amp; MATH 21 and Calculus</td>
</tr>
<tr>
<td></td>
<td>MATH 51 Linear Algebra, Multivariable Calculus, and Modern Applications (or beyond)</td>
</tr>
<tr>
<td></td>
<td>CME 100 Vector Calculus for Engineers</td>
</tr>
</tbody>
</table>

Physics

Select one of the following Series:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-12</td>
<td>PHYSICS 20 Series</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 21 Mechanics, Fluids, and Heat</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 22 Mechanics, Fluids, and Heat Laboratory</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 23 Electricity, Magnetism, and Optics</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 24 Electricity, Magnetism, and Optics Laboratory</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 40 Series</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 41 Mechanics</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 43 Electricity and Magnetism</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 45 Light and Heat</td>
</tr>
</tbody>
</table>

Statistics

Select one of the following courses:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5</td>
<td>BIO/STATS 141 Biostatistics 1</td>
</tr>
<tr>
<td></td>
<td>BIOHOPK 174H Experimental Design and Probability 1</td>
</tr>
<tr>
<td></td>
<td>STATS 60 Introduction to Statistical Methods: Precalculus</td>
</tr>
</tbody>
</table>

Total Units: 33-47
If taken to fulfill the foundational breadth requirement, these courses do not count toward the 23 elective unit requirement.

**Electives**
23 units required, distributed as follows:

- Biology (BIO) or Hopkins Marine Station (BIOHOPK) courses numbered 100 or above.
- No more than 6 units from any combination of these courses may be applied toward the total number of elective units:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 196A</td>
<td>Biology Senior Reflection</td>
<td>3</td>
</tr>
<tr>
<td>BIO 196B</td>
<td>Biology Senior Reflection</td>
<td>3</td>
</tr>
<tr>
<td>BIO 196C</td>
<td>Biology Senior Reflection</td>
<td>3</td>
</tr>
<tr>
<td>BIO 197WA</td>
<td>Senior Writing Project: The Personal Essay in Biology</td>
<td>3</td>
</tr>
<tr>
<td>BIO 198</td>
<td>Directed Reading in Biology</td>
<td>1-15</td>
</tr>
<tr>
<td>BIO 198X</td>
<td>Out-of-Department Directed Reading</td>
<td>1-15</td>
</tr>
<tr>
<td>BIO 199</td>
<td>Advanced Research Laboratory in Experimental Biology</td>
<td>1-15</td>
</tr>
<tr>
<td>BIO 199W</td>
<td>Senior Honors Thesis: How to Effectively Write About Scientific Research</td>
<td>3</td>
</tr>
<tr>
<td>BIO 199X</td>
<td>Out-of-Department Advanced Research Laboratory in Experimental Biology</td>
<td>1-15</td>
</tr>
<tr>
<td>BIO 290</td>
<td>Teaching of Biology</td>
<td>1-5</td>
</tr>
<tr>
<td>BIO 291</td>
<td>Development and Teaching of Core Experimental Laboratories</td>
<td>1-2</td>
</tr>
<tr>
<td>BIO 296</td>
<td>TA Training in Biology</td>
<td>1</td>
</tr>
<tr>
<td>BIOHOPK 198H</td>
<td>Directed Instruction or Reading</td>
<td>1-15</td>
</tr>
<tr>
<td>BIOHOPK 199H</td>
<td>Undergraduate Research</td>
<td>1-15</td>
</tr>
<tr>
<td>BIOHOPK 290H</td>
<td>Teaching of Biological Science</td>
<td>1-15</td>
</tr>
</tbody>
</table>
- One course applied toward the elective unit requirement may be taken CR/NC.

**Writing in the Major**
Students must take one of the following courses to fulfill the Writing in the Major requirement in Biology:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 46</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
</tr>
<tr>
<td>BIO 47</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
</tr>
<tr>
<td>BIO 107</td>
<td>Human Physiology Laboratory</td>
</tr>
<tr>
<td>BIO 168</td>
<td>Explorations in Stem Cell Biology</td>
</tr>
<tr>
<td>BIO 196A</td>
<td>Biology Senior Reflection</td>
</tr>
<tr>
<td>BIO 197WA</td>
<td>Senior Writing Project: The Personal Essay in Biology</td>
</tr>
<tr>
<td>BIO 199W</td>
<td>Senior Honors Thesis: How to Effectively Write About Scientific Research</td>
</tr>
<tr>
<td>BIOHOPK 47</td>
<td>Introduction to Research in Ecology and Ecological Physiology</td>
</tr>
<tr>
<td>BIOHOPK 172H</td>
<td>Marine Ecology. From Organisms to Ecosystems</td>
</tr>
</tbody>
</table>

Note: BIO 107, BIO 168, BIO 196A, BIO 197WA, BIO 199W, and BIOHOPK 172H can also count toward the elective requirement.

**Typical Schedule for a Four-Year Program**

<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Principles I (CHEM 31A)</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculus (MATH 19)</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshman requirements, seminars, or WAYS</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical Principles II (CHEM 31B)</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculus (MATH 20)</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem solving in infectious disease (BIO 60)</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshman requirements, seminars, or WAYS</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structure and Reactivity of Organic Molecules (CHEM 33)</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculus (MATH 21)</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction to Statistical Methods: Precalculus (STATS 60)</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshman requirements, seminars, or WAYS</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year Total:</td>
<td>16 16 18</td>
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</table>

<table>
<thead>
<tr>
<th>Second Year</th>
<th>Units</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genetics (BIO 82)</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic Chemistry of Bioactive Molecules (CHEM 35)</td>
<td>5</td>
<td></td>
<td></td>
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<tr>
<td>WAYS, PWR</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biochemistry &amp; Molecular Biology (BIO 83)</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physiology (BIO 84)</td>
<td>4</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Introduction to Laboratory Research in Cell and Molecular Biology (BIO 45)</td>
<td>4</td>
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</tr>
<tr>
<td>WAYS</td>
<td>4</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Cell Biology (BIO 86)</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction to Research in Ecology and Evolutionary Biology (BIO 47)</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WAYS</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biology Electives</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year Total:</td>
<td>17 16 14</td>
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<td></td>
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<table>
<thead>
<tr>
<th>Third Year</th>
<th>Units</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abroad</td>
<td></td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Electives</td>
<td></td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>WAYS</td>
<td>4</td>
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<tr>
<td>Electives</td>
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<td>Year Total:</td>
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<table>
<thead>
<tr>
<th>Fourth Year</th>
<th>Units</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electives</td>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Mechanics, Fluids, and Heat (PHYSICS 21)</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanics, Fluids, and Heat Laboratory (PHYSICS 22)</td>
<td>1</td>
<td></td>
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</tr>
<tr>
<td>Electives</td>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Electricity, Magnetism, and Optics (PHYSICS 23)</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity, Magnetism, and Optics Laboratory (PHYSICS 24)</td>
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</tr>
<tr>
<td>Electives</td>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Year Total:</td>
<td>8 8 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Units in Sequence: 135

1. This schedule varies slightly if the student takes CHEM 31X in place of CHEM 31A & CHEM 31B.
2. The schedule varies slightly depending on which 5 Bio Foundations courses the student chooses to take, and if any of them will be taken at Hopkins Marine Station.
Honors
To graduate with departmental honors, a student must conduct an independent research project typically over the course of at least one year; projects are started no later than Autumn or Winter Quarter of the junior year. Research must be done in a Biology Department lab or a lab in another department for which the student has obtained prior approval. Administrative steps include:

1. Submit an approved honors proposal to the department’s student services office two quarters prior to graduation. For instance, students graduating Spring Quarter must submit petitions no later than Autumn Quarter of the same academic year.
2. Complete at least 10 units of an approved research project in from the same lab. Students conducting research in a lab outside of the department of Biology must submit an Out of Department Research Petition (https://stanford.app.box.com/v/198x-199x-petition) either before they start their research, or if research was started prior to declaring the Biology major, as soon as their major declaration is approved. Only research units from BIO or BIOHOPK are counted toward the 10 unit requirement:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 199</td>
<td>Advanced Research Laboratory in Experimental Biology</td>
<td>1-15</td>
</tr>
<tr>
<td>BIO 199X</td>
<td>Out-of-Department Advanced Research Laboratory in Experimental Biology</td>
<td>1-15</td>
</tr>
<tr>
<td>BIOHOPK 199H</td>
<td>Undergraduate Research</td>
<td>1-15</td>
</tr>
</tbody>
</table>

3. Obtain at least a 3.0 (B) grade point average (GPA) in all Biology major requirements taken at Stanford (foundational, breadth, and elective courses). Grades earned from these teaching and research are not computed into this GPA:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 198</td>
<td>Directed Reading in Biology</td>
<td>1-15</td>
</tr>
<tr>
<td>BIO 198X</td>
<td>Out-of-Department Directed Reading</td>
<td>1-15</td>
</tr>
<tr>
<td>BIO 199</td>
<td>Advanced Research Laboratory in Experimental Biology</td>
<td>1-15</td>
</tr>
<tr>
<td>BIO 199X</td>
<td>Out-of-Department Advanced Research Laboratory in Experimental Biology</td>
<td>1-15</td>
</tr>
<tr>
<td>BIO 290</td>
<td>Teaching of Biology</td>
<td>1-5</td>
</tr>
<tr>
<td>BIO 291</td>
<td>Development and Teaching of Core Experimental Laboratories</td>
<td>1-2</td>
</tr>
<tr>
<td>BIO 296</td>
<td>TA Training in Biology</td>
<td>1</td>
</tr>
<tr>
<td>BIOHOPK 199H</td>
<td>Undergraduate Research</td>
<td>1-15</td>
</tr>
<tr>
<td>BIOHOPK 290H</td>
<td>Teaching of Biological Science</td>
<td>1-15</td>
</tr>
</tbody>
</table>

4. If graduating in Spring, participate in the annual Achauer Undergraduate Biology Honors Symposium by presenting a poster or giving an oral presentation. The symposium is typically held at the end of May. Students graduating in Autumn, Winter, or Summer Quarter must produce a poster in the quarter in which they graduate to be displayed at the symposium, however their attendance is optional.
5. Complete and, by the published deadline within the quarter graduation is expected, submit online an honors thesis approved by at least two readers. At least one reader must be from the faculty of the Department of Biology, and both readers must be Academic Council members. The title page of the honors thesis must include student name, thesis title, name and department of research sponsor, and name and department of second reader. Students must submit this page with original ink signatures to the student services office by the published deadline for the quarter in which graduation is expected.

Further information on the honors program is available in the student services office in Gilbert 108, as well as on the Honors Program and Undergraduate Research in Biology (https://biology.stanford.edu/academics/undergraduate-program/honors-program) website.

Fields of Study
In addition to the undergraduate general major, the department offers the following seven fields of study for students wishing to concentrate their studies in particular areas of biology:

1. Biochemistry and Biophysics
2. Computational Biology
3. Ecology and Evolution
4. Marine Biology
5. Microbes and Immunity
6. Molecular, Cellular, and Developmental Biology
7. Neurobiology

These fields of study are declared on Axess at the time of the major declaration; they appear on both the transcript and on the diploma.

Writing in the Major for the B.S. Degree in Biology with a Field of Study
Students must take one of the following courses to fulfill the Writing in the Major requirement in Biology:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 46</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
<td></td>
</tr>
<tr>
<td>BIO 47</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
<td></td>
</tr>
<tr>
<td>BIO 107</td>
<td>Human Physiology Laboratory</td>
<td></td>
</tr>
<tr>
<td>BIO 168</td>
<td>Explorations in Stem Cell Biology</td>
<td></td>
</tr>
<tr>
<td>BIO 196A</td>
<td>Biology Senior Reflection</td>
<td></td>
</tr>
<tr>
<td>BIO 197WA</td>
<td>Senior Writing Project: The Personal Essay in Biology</td>
<td></td>
</tr>
<tr>
<td>BIO 199W</td>
<td>Senior Honors Thesis: How to Effectively Write About Scientific Research</td>
<td></td>
</tr>
<tr>
<td>BIOHOPK 47</td>
<td>Introduction to Research in Ecology and Ecological Physiology</td>
<td></td>
</tr>
<tr>
<td>BIOHOPK 172H</td>
<td>Marine Ecology: From Organisms to Ecosystems</td>
<td></td>
</tr>
</tbody>
</table>

Note: BIO 107, BIO 168, BIO 196A, BIO 197WA, BIO 199W, and BIOHOPK 172H can also count toward the elective requirement.

Biochemistry and Biophysics
Candidates for the Biochemistry and Biophysics field of study must complete the following, as well WIM requirement above, for a total ranging from 90-102 units:

Introductory Course (must be taken for a letter grade):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 60</td>
<td>Problem solving in infectious disease</td>
<td>4</td>
</tr>
<tr>
<td>BIO 61</td>
<td>Science as a Creative Process</td>
<td></td>
</tr>
<tr>
<td>BIO 62</td>
<td>Microbiology Experiments</td>
<td></td>
</tr>
</tbody>
</table>

Foundational Courses (must be taken for a letter grade):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 60</td>
<td>Problem solving in infectious disease</td>
<td>4</td>
</tr>
<tr>
<td>BIO 61</td>
<td>Science as a Creative Process</td>
<td></td>
</tr>
<tr>
<td>BIO 62</td>
<td>Microbiology Experiments</td>
<td></td>
</tr>
</tbody>
</table>

Further information on the honors program is available in the student services office in Gilbert 108, as well as on the Honors Program and Undergraduate Research in Biology (https://biology.stanford.edu/academics/undergraduate-program/honors-program) website.
All of the following: 16
- BIO 82 Genetics
- BIO 83 Biochemistry & Molecular Biology
- BIO 84 Physiology
  or BIOHOPK 84 Physiology
- BIO 86 Cell Biology

Select 1 of the following: 4
- BIO 81 Introduction to Ecology
  or BIOHOPK 81 Introduction to Ecology
- BIO 85 Evolution
  or BIOHOPK 85 Evolution

Foundational Lab Courses
Two Courses Required:
- BIO 45 Introduction to Laboratory Research in Cell and Molecular Biology 4
- BIO 46 Introduction to Research in Ecology and Evolutionary Biology 4-5
  or BIO 47 Introduction to Research in Ecology and Evolutionary Biology
  or BIOHOPK 47 Introduction to Research in Ecology and Ecological Physiology

Required Foundational Breadth Courses
(One course from this section may be taken credit/no credit):

Chemistry
The following CHEM courses are required:
- CHEM 31A & CHEM 31B Chemical Principles I and Chemical Principles II 5-10
  or CHEM 31X Chemical Principles Accelerated
- CHEM 33 Structure and Reactivity of Organic Molecules 5
- CHEM 35 Organic Chemistry of Bioactive Molecules 5

Mathematics
Select one of the following options: 5-10
- MATH 19 Calculus
  & MATH 20 and Calculus
  & MATH 21 and Calculus
- MATH 51 Linear Algebra, Multivariable Calculus, and Modern Applications (or beyond)
- CME 100 Vector Calculus for Engineers

Physics
PHYSICS 40 Series 12
- PHYSICS 41 Mechanics
- PHYSICS 43 Electricity and Magnetism
- PHYSICS 45 Light and Heat

Statistics
Select one of the following courses: 3-5
- BIO/STATS 141 Biostatistics
- BIOHOPK 174H Experimental Design and Probability
- STATS 60 Introduction to Statistical Methods: Precalculus

Total Units 35-47

1 If taken to fulfill the foundational breadth requirement, these courses do not count toward the 23 elective unit requirement.

Electives
23 units required. Students must take the 3 required courses listed, as well as three courses in Biochemistry and Biophysics from the approved list. The remainder of the 23 units of electives may be any BIO or BIOHOPK course at the 100-level or above, or from the list of approved out-of-department electives. Up to 6 units of teaching and research are allowed. Only one course can be taken credit/no credit.

Select three of the following: 9-13
- APPPHYS 294 Cellular Biophysics
- BIO 126 Introduction to Biophysics
- BIO 132 Advanced Imaging Lab in Biophysics
- BIO 152 Imaging: Biological Light Microscopy
- BIO 154 Molecular and Cellular Neurobiology
- BIO 214 Advanced Cell Biology
- BIOE 101 Systems Biology
- BIOE 103 Systems Physiology and Design
- BIOE 211 Biophysics of Multi-cellular Systems and Amorphous Computing
- BIOE 220 Introduction to Imaging and Image-based Human Anatomy
- BIOE 231 Protein Engineering
- BIOE 241 Biological Macromolecules
- BIOMEDIN 210 Modeling Biomedical Systems: Ontology, Terminology, Problem Solving
- BIOPHYS 241 Biological Macromolecules
- BIOPHYS 242 Methods in Molecular Biophysics
- CHEM 183 Biochemistry II
- CHEM 184 Biological Chemistry Laboratory
- CHEM 185 Biophysical Chemistry
- CS 279 Computational Biology: Structure and Organization of Biomolecules and Cells
- CSB 210 Cell Signaling
- CSB 220 Chemistry of Biological Processes
- EE 236A Modern Optics
- MCP 256 How Cells Work: Energetics, Compartment, and Coupling in Cell Biology
- PHYSICS 105 Intermediate Physics Laboratory I: Analog Electronics
- STATS 191 Introduction to Applied Statistics

Computational Biology
Candidates for the Computational Biology field of study must complete the following, as well as the WIM requirement above, for a total ranging from 90-102 units:

Introductory Course
(must be taken for a letter grade):
Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 60</td>
<td>Problem solving in infectious disease</td>
</tr>
<tr>
<td>BIO 61</td>
<td>Science as a Creative Process</td>
</tr>
<tr>
<td>BIO 62</td>
<td>Microbiology Experiments</td>
</tr>
</tbody>
</table>

Foundational Courses
(must be taken for a letter grade):

Select 5 of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 81</td>
<td>Introduction to Ecology</td>
</tr>
<tr>
<td>BIO 81</td>
<td>Introduction to Ecology</td>
</tr>
<tr>
<td>BIO 82</td>
<td>Genetics</td>
</tr>
<tr>
<td>BIO 83</td>
<td>Biochemistry &amp; Molecular Biology</td>
</tr>
<tr>
<td>BIO 84</td>
<td>Physiology</td>
</tr>
<tr>
<td>BIO 84</td>
<td>Physiology</td>
</tr>
<tr>
<td>BIO 85</td>
<td>Evolution</td>
</tr>
<tr>
<td>BIO 85</td>
<td>Evolution</td>
</tr>
<tr>
<td>BIO 86</td>
<td>Cell Biology</td>
</tr>
</tbody>
</table>

Foundational Lab Courses

Two Courses Required:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 45</td>
<td>Introduction to Laboratory Research in Cell and Molecular Biology</td>
</tr>
<tr>
<td>BIO 46</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
</tr>
<tr>
<td>or BIO 47</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
</tr>
<tr>
<td>or BIOHOPK 47</td>
<td>Introduction to Research in Ecology and Evolutionary Physiology</td>
</tr>
</tbody>
</table>

Required Foundational Breadth Courses
(One course from this section may be taken credit/no credit):

Chemistry
The following CHEM courses are required:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 31A</td>
<td>Chemical Principles I</td>
</tr>
<tr>
<td>&amp; CHEM 31B</td>
<td>Chemical Principles II</td>
</tr>
<tr>
<td>&amp; CHEM 31X</td>
<td>Chemical Principles Accelerated</td>
</tr>
<tr>
<td>CHEM 33</td>
<td>Structure and Reactivity of Organic Molecules</td>
</tr>
<tr>
<td>CHEM 35</td>
<td>Organic Chemistry of Bioactive Molecules</td>
</tr>
</tbody>
</table>

Mathematics
Select one of the following options:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 19</td>
<td>Calculus</td>
</tr>
<tr>
<td>&amp; MATH 20</td>
<td>and Calculus</td>
</tr>
<tr>
<td>&amp; MATH 21</td>
<td>and Calculus</td>
</tr>
<tr>
<td>MATH 51</td>
<td>Linear Algebra, Multivariable Calculus, and Modern Applications (or beyond)</td>
</tr>
<tr>
<td>CME 100</td>
<td>Vector Calculus for Engineers</td>
</tr>
</tbody>
</table>

Physics
Select one of the following Series:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYSICS 21</td>
<td>Mechanics, Fluids, and Heat</td>
</tr>
<tr>
<td>PHYSICS 22</td>
<td>Mechanics, Fluids, and Heat Laboratory</td>
</tr>
<tr>
<td>PHYSICS 23</td>
<td>Electricity, Magnetism, and Optics</td>
</tr>
</tbody>
</table>

Units

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
</tr>
</tbody>
</table>

Statistics
The following course is required:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO/STATS 141</td>
<td>Biostatistics 1</td>
</tr>
</tbody>
</table>

Total Units

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>35-47</td>
</tr>
</tbody>
</table>

1. If taken to fulfill the foundational breadth requirement, this course cannot count toward the 23 elective unit requirement.

Electives
23 units required. Students must take the 2 required courses listed, as well as three courses in Computational Biology from the approved list. The remainder of the 23 units of electives may be any BIO or BIOHOPK course at the 100-level or above, or from the list of approved out-of-department electives. Up to 6 units of teaching and research are allowed. Only one course can be taken credit/no credit.

Ecology and Evolution
Candidates for the Ecology and Evolution field of study must complete the following, as well as the WIM requirement above, for a total ranging from 88-102 units:

Introductory Course
(must be taken for a letter grade):
Select one of the following:  

<table>
<thead>
<tr>
<th>Units</th>
<th>BIO 60</th>
<th>Problem solving in infectious disease</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BIO 61</td>
<td>Science as a Creative Process</td>
</tr>
<tr>
<td></td>
<td>BIO 62</td>
<td>Microbiology Experiments</td>
</tr>
</tbody>
</table>

**Foundational Courses**  
(must be taken for a letter grade):

<table>
<thead>
<tr>
<th>Units</th>
<th>BIO 81</th>
<th>Introduction to Ecology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>or BIOHOPK 81</td>
<td>Introduction to Ecology</td>
</tr>
<tr>
<td></td>
<td>BIO 82</td>
<td>Genetics</td>
</tr>
<tr>
<td></td>
<td>BIO 85</td>
<td>Evolution</td>
</tr>
<tr>
<td></td>
<td>or BIOHOPK 85</td>
<td>Evolution</td>
</tr>
</tbody>
</table>

Select 2 of the following:  

<table>
<thead>
<tr>
<th>Units</th>
<th>BIO 83</th>
<th>Biochemistry &amp; Molecular Biology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BIO 84</td>
<td>Physiology</td>
</tr>
<tr>
<td></td>
<td>or BIOHOPK 84</td>
<td>Physiology</td>
</tr>
<tr>
<td></td>
<td>BIO 86</td>
<td>Cell Biology</td>
</tr>
</tbody>
</table>

**Foundational Lab Courses**

Two Courses Required:  

<table>
<thead>
<tr>
<th>Units</th>
<th>BIO 45</th>
<th>Introduction to Laboratory Research in Cell and Molecular Biology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BIO 46</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
</tr>
<tr>
<td></td>
<td>or BIO 47</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
</tr>
<tr>
<td></td>
<td>or BIOHOPK 47</td>
<td>Introduction to Research in Ecology and Ecological Physiology</td>
</tr>
</tbody>
</table>

**Required Foundational Breadth Courses**  
(One course from this section may be taken credit/no credit):

Unit  

**Chemistry**

The following CHEM courses are required:

<table>
<thead>
<tr>
<th>Units</th>
<th>CHEM 31A</th>
<th>Chemical Principles I</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&amp; CHEM 31B</td>
<td>Chemical Principles II</td>
</tr>
<tr>
<td></td>
<td>or CHEM 31X</td>
<td>Chemical Principles Accelerated</td>
</tr>
<tr>
<td></td>
<td>CHEM 33</td>
<td>Structure and Reactivity of Organic Molecules</td>
</tr>
<tr>
<td></td>
<td>CHEM 35</td>
<td>Organic Chemistry of Bioactive Molecules</td>
</tr>
</tbody>
</table>

**Mathematics**

Select one of the following options:  

<table>
<thead>
<tr>
<th>Units</th>
<th>MATH 19</th>
<th>Calculus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&amp; MATH 20</td>
<td>and Calculus</td>
</tr>
<tr>
<td></td>
<td>&amp; MATH 21</td>
<td>and Calculus</td>
</tr>
<tr>
<td></td>
<td>MATH 51</td>
<td>Linear Algebra, Multivariable Calculus, and Modern Applications (or beyond)</td>
</tr>
<tr>
<td></td>
<td>CME 100</td>
<td>Vector Calculus for Engineers</td>
</tr>
</tbody>
</table>

**Physics**

Select one of the following Series:  

<table>
<thead>
<tr>
<th>Units</th>
<th>PHYSICS 21</th>
<th>Mechanics, Fluids, and Heat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PHYSICS 22</td>
<td>Mechanics, Fluids, and Heat Laboratory</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 23</td>
<td>Electricity, Magnetism, and Optics</td>
</tr>
</tbody>
</table>

**Electives**

23 units required. Students must take five courses in Ecology and Evolution from the approved list. The remainder of the 23 units of electives may be any BIO or BIOHOPK course at the 100-level or above, or from the list of approved out-of-department electives. Up to 6 units of teaching and research are allowed. Only one course can be taken credit/no credit.

Select 5 of the following:  

<table>
<thead>
<tr>
<th>Units</th>
<th>BIO 105A</th>
<th>Ecology and Natural History of Jasper Ridge Biological Preserve</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BIO 105B</td>
<td>Ecology and Natural History of Jasper Ridge Biological Preserve</td>
</tr>
<tr>
<td></td>
<td>BIO 113</td>
<td>Fundamentals of Molecular Evolution</td>
</tr>
<tr>
<td></td>
<td>BIO 116</td>
<td>Ecology of the Hawaiian Islands</td>
</tr>
<tr>
<td></td>
<td>BIO 117</td>
<td>Biology and Global Change</td>
</tr>
<tr>
<td></td>
<td>BIO 138</td>
<td>Ecosystem Services: Frontiers in the Science of Valuing Nature</td>
</tr>
<tr>
<td></td>
<td>BIO 144</td>
<td>Conservation Biology: A Latin American Perspective</td>
</tr>
<tr>
<td></td>
<td>BIO 145</td>
<td>Ecology and Evolution of Animal Behavior</td>
</tr>
<tr>
<td></td>
<td>BIO 146</td>
<td>Population Studies</td>
</tr>
<tr>
<td></td>
<td>BIO 174</td>
<td>Human Skeletal Anatomy</td>
</tr>
<tr>
<td></td>
<td>BIO 182</td>
<td>Modeling Cultural Evolution</td>
</tr>
<tr>
<td></td>
<td>BIO 183</td>
<td>Theoretical Population Genetics</td>
</tr>
<tr>
<td></td>
<td>BIOHOPK 161H</td>
<td>Invertebrate Zoology</td>
</tr>
<tr>
<td></td>
<td>BIOHOPK 163H</td>
<td>Oceanic Biology</td>
</tr>
<tr>
<td></td>
<td>BIOHOPK 172H</td>
<td>Marine Ecology: From Organisms to Ecosystems</td>
</tr>
<tr>
<td></td>
<td>BIOHOPK 173H</td>
<td>Marine Conservation Biology</td>
</tr>
<tr>
<td></td>
<td>BIOHOPK 174H</td>
<td>Experimental Design and Probability</td>
</tr>
<tr>
<td></td>
<td>BIOHOPK 182H</td>
<td>Stanford at Sea</td>
</tr>
<tr>
<td></td>
<td>BIOHOPK 187H</td>
<td>Sensory Ecology</td>
</tr>
<tr>
<td></td>
<td>BIOHOPK 268H</td>
<td>Disease Ecology: from parasites evolution to the socio-economic impacts of pathogens on nations</td>
</tr>
<tr>
<td></td>
<td>EARTHSYS 128</td>
<td>Evolution of Terrestrial Ecosystems</td>
</tr>
<tr>
<td></td>
<td>EARTHSYS 142</td>
<td>Remote Sensing of Land</td>
</tr>
<tr>
<td></td>
<td>EARTHSYS 144</td>
<td>Fundamentals of Geographic Information Science (GIS)</td>
</tr>
<tr>
<td></td>
<td>EARTHSYS 158</td>
<td>Geomicrobiology</td>
</tr>
<tr>
<td></td>
<td>OSPAUSTL 10</td>
<td>Coral Reef Ecosystems</td>
</tr>
</tbody>
</table>
OSPAUSTL 25  Freshwater Systems
OSPAUSTL 30  Coastal Forest Ecosystems

1. Only 6 units can be counted from BIOHOPK 182H.
2. OSPAUSTL 10, 25, 30 count as 2 units each for a total of 6 units toward electives.

Marine Biology

Candidates for the Marine Biology field of study must complete the following, as well as the WIM requirement above, for a total ranging from 88-102 units:

**Introductory Course**

(must be taken for a letter grade):

Select one of the following:

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 60</td>
<td>Problem solving in infectious disease</td>
</tr>
<tr>
<td>BIO 61</td>
<td>Science as a Creative Process</td>
</tr>
<tr>
<td>BIO 62</td>
<td>Microbiology Experiments</td>
</tr>
</tbody>
</table>

**Foundational Courses**

(must be taken for a letter grade):

Select 2 of the following:

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 81</td>
<td>Introduction to Ecology</td>
</tr>
<tr>
<td>or BIOHOPK 81</td>
<td>Introduction to Ecology</td>
</tr>
<tr>
<td>BIO 82</td>
<td>Genetics</td>
</tr>
<tr>
<td>BIO 85</td>
<td>Evolution</td>
</tr>
<tr>
<td>or BIOHOPK 85</td>
<td>Evolution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 83</td>
<td>Biochemistry &amp; Molecular Biology</td>
</tr>
<tr>
<td>BIO 84</td>
<td>Physiology</td>
</tr>
<tr>
<td>or BIOHOPK 84</td>
<td>Physiology</td>
</tr>
<tr>
<td>BIO 86</td>
<td>Cell Biology</td>
</tr>
</tbody>
</table>

**Foundational Lab Courses**

Two Courses Required:

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
</tr>
<tr>
<td>4-5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 45</td>
<td>Introduction to Laboratory Research in Cell and Molecular Biology</td>
</tr>
<tr>
<td>BIO 46</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
</tr>
<tr>
<td>or BIO 47</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
</tr>
<tr>
<td>or BIOHOPK 47</td>
<td>Introduction to Research in Ecology and Ecological Physiology</td>
</tr>
</tbody>
</table>

**Required Foundational Breadth Courses**

(One course from this section may be taken credit/no credit):  

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 31A &amp; CHEM 31B</td>
<td>Chemical Principles I and Chemical Principles II</td>
</tr>
<tr>
<td>or CHEM 31X</td>
<td>Chemical Principles Accelerated</td>
</tr>
<tr>
<td>CHEM 33</td>
<td>Structure and Reactivity of Organic Molecules</td>
</tr>
<tr>
<td>CHEM 35</td>
<td>Organic Chemistry of Bioactive Molecules</td>
</tr>
</tbody>
</table>

**Mathematics**

Select one of the following options:  

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 19</td>
<td>Calculus</td>
</tr>
<tr>
<td>&amp; MATH 20</td>
<td>and Calculus</td>
</tr>
<tr>
<td>&amp; MATH 21</td>
<td>and Calculus</td>
</tr>
<tr>
<td>MATH 51</td>
<td>Linear Algebra, Multivariable Calculus, and Modern Applications (or beyond)</td>
</tr>
<tr>
<td>CME 100</td>
<td>Vector Calculus for Engineers</td>
</tr>
</tbody>
</table>

**Physics**

Select one of the following Series:  

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYSICS 21</td>
<td>Mechanics, Fluids, and Heat</td>
</tr>
<tr>
<td>PHYSICS 22</td>
<td>Mechanics, Fluids, and Heat Laboratory</td>
</tr>
<tr>
<td>PHYSICS 23</td>
<td>Electricity, Magnetism, and Optics Laboratory</td>
</tr>
<tr>
<td>PHYSICS 24</td>
<td>Electricity, Magnetism, and Optics Laboratory</td>
</tr>
<tr>
<td>PHYSICS 40</td>
<td>Mechanics</td>
</tr>
<tr>
<td>PHYSICS 43</td>
<td>Electricity and Magnetism</td>
</tr>
<tr>
<td>PHYSICS 45</td>
<td>Light and Heat</td>
</tr>
</tbody>
</table>

**Statistics**

Select one of the following courses:  

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO/STATS 141</td>
<td>Biostatistics</td>
</tr>
<tr>
<td>BIOHOPK 174H</td>
<td>Experimental Design and Probability</td>
</tr>
<tr>
<td>STATS 60</td>
<td>Introduction to Statistical Methods: Precalculus</td>
</tr>
</tbody>
</table>

**Total Units**  

33-47

If taken to fulfill the foundational breadth requirement, these courses do not count toward the 23 elective unit requirement.

**Electives**

23 units required. Students must take five courses in Marine Biology from the approved list. The remainder of the 23 units of electives may be any BIO or BIOHOPK course at the 100-level or above, or from the list of approved out-of-department electives. Up to 6 units of teaching and research are allowed. Only one course can be taken credit/no credit.

Select 5 of the following:  

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-23</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 116</td>
<td>Ecology of the Hawaiian Islands</td>
</tr>
<tr>
<td>BIOHOPK 150H</td>
<td>Ecological Mechanics</td>
</tr>
<tr>
<td>BIOHOPK 173H</td>
<td>Marine Conservation Biology</td>
</tr>
<tr>
<td>BIOHOPK 177H</td>
<td>Dynamics and Management of Marine Populations</td>
</tr>
<tr>
<td>BIOHOPK 179H</td>
<td>Physiological Ecology of Marine Megafauna</td>
</tr>
<tr>
<td>BIOHOPK 182H</td>
<td>Stanford at Sea</td>
</tr>
<tr>
<td>BIOHOPK 185H</td>
<td>Ecology and Conservation of Kelp Forest Communities</td>
</tr>
<tr>
<td>BIOHOPK 187H</td>
<td>Sensory Ecology</td>
</tr>
<tr>
<td>EARTHSYS 117</td>
<td>Earth Sciences of the Hawaiian Islands</td>
</tr>
<tr>
<td>EARTHSYS 118</td>
<td>Heritage, Environment, and Sovereignty in Hawaii</td>
</tr>
<tr>
<td>OSPAUSTL 10</td>
<td>Coral Reef Ecosystems</td>
</tr>
<tr>
<td>OSPAUSTL 25</td>
<td>Freshwater Systems</td>
</tr>
<tr>
<td>OSPAUSTL 30</td>
<td>Coastal Forest Ecosystems</td>
</tr>
</tbody>
</table>
Only 6 units can be counted from BIOHOPK 182H. OSPAUSTRL 10, 25, 30 count as 2 units each for a total of 6 units toward electives. Together, these courses count as two courses toward the Marine Biology requirement.

**Microbes and Immunity**

Candidates for the Microbes and Immunity field of study must complete the following, as well as the WIM requirement above, for a total ranging from 88-102 units:

**Introductory Course**

(must be taken for a letter grade):

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BIO 60</td>
<td>Problem solving in infectious disease</td>
</tr>
<tr>
<td></td>
<td>BIO 61</td>
<td>Science as a Creative Process</td>
</tr>
<tr>
<td></td>
<td>BIO 62</td>
<td>Microbiology Experiments</td>
</tr>
</tbody>
</table>

**Foundational Courses**

(must be taken for a letter grade):

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BIO 81</td>
<td>Introduction to Ecology</td>
</tr>
<tr>
<td></td>
<td>or BIOHOPK 81</td>
<td>Introduction to Ecology</td>
</tr>
<tr>
<td></td>
<td>BIO 82</td>
<td>Genetics</td>
</tr>
<tr>
<td></td>
<td>BIO 83</td>
<td>Biochemistry &amp; Molecular Biology</td>
</tr>
<tr>
<td></td>
<td>BIO 84</td>
<td>Physiology</td>
</tr>
<tr>
<td></td>
<td>or BIOHOPK 84</td>
<td>Physiology</td>
</tr>
<tr>
<td></td>
<td>BIO 85</td>
<td>Evolution</td>
</tr>
<tr>
<td></td>
<td>or BIOHOPK 85</td>
<td>Evolution</td>
</tr>
<tr>
<td></td>
<td>BIO 86</td>
<td>Cell Biology</td>
</tr>
</tbody>
</table>

**Foundational Lab Courses**

Two Courses Required:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>BIO 45</td>
<td>Introduction to Laboratory Research in Cell and Molecular Biology</td>
</tr>
<tr>
<td>4-5</td>
<td>BIO 46</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
</tr>
<tr>
<td></td>
<td>or BIO 47</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
</tr>
<tr>
<td></td>
<td>or BIOHOPK 47</td>
<td>Introduction to Research in Ecology and Ecological Physiology</td>
</tr>
</tbody>
</table>

**Required Foundational Breadth Courses**

(One course from this section may be taken credit/no credit):

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MATH 19</td>
<td>Calculus</td>
</tr>
<tr>
<td></td>
<td>&amp; MATH 20</td>
<td>and Calculus</td>
</tr>
<tr>
<td></td>
<td>&amp; MATH 21</td>
<td>and Calculus</td>
</tr>
<tr>
<td></td>
<td>MATH 51</td>
<td>Linear Algebra, Multivariable Calculus, and Modern Applications (or beyond)</td>
</tr>
<tr>
<td></td>
<td>CME 100</td>
<td>Vector Calculus for Engineers</td>
</tr>
</tbody>
</table>

**Physics**

Select one of the following Series:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-12</td>
<td>PHYSICS 20 Series</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PHYSICS 21</td>
<td>Mechanics, Fluids, and Heat</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 22</td>
<td>Mechanics, Fluids, and Heat Laboratory</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 23</td>
<td>Electricity, Magnetism, and Optics</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 24</td>
<td>Electricity, Magnetism, and Optics Laboratory</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 40 Series</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PHYSICS 41</td>
<td>Mechanics</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 43</td>
<td>Electricity and Magnetism</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 45</td>
<td>Light and Heat</td>
</tr>
</tbody>
</table>

**Statistics**

Select one of the following courses:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5</td>
<td>BIO/STATS 141</td>
<td>Biostatistics</td>
</tr>
<tr>
<td>1</td>
<td>BIOHOPK 174H</td>
<td>Experimental Design and Probability</td>
</tr>
<tr>
<td></td>
<td>STATS 60</td>
<td>Introduction to Statistical Methods: Precalculus</td>
</tr>
</tbody>
</table>

Total Units: 33-47

If taken to fulfill the foundational breadth requirement, these courses do not count toward the 23 elective unit requirement.

**Electives**

23 units required. Students must take the 3 required courses listed, as well as two courses in Microbiology and Immunology from the approved list. The remainder of the 23 units of electives may be any BIO or BIOHOPK course at the 100-level or above, or from the list of approved out-of-department electives. Up to 6 units of teaching and research are allowed. Only one course can be taken credit/no credit.

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>BIO 178</td>
<td>Microbiology Literature (offered in 2019-20)</td>
</tr>
<tr>
<td></td>
<td>or MI 185</td>
<td>Topics in Microbiology</td>
</tr>
<tr>
<td>4</td>
<td>CHEM 141</td>
<td>The Chemical Principles of Life I</td>
</tr>
<tr>
<td>4</td>
<td>CHEM 143</td>
<td>The Chemical Principles of Life II</td>
</tr>
<tr>
<td>4-8</td>
<td>Select two of the following:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BIO 132</td>
<td>Advanced Imaging Lab in Biophysics</td>
</tr>
<tr>
<td></td>
<td>BIO 177</td>
<td>Plant Microbe Interaction</td>
</tr>
<tr>
<td></td>
<td>BIO 178</td>
<td>Microbiology Literature</td>
</tr>
<tr>
<td></td>
<td>BIO 180</td>
<td>Microbial Physiology</td>
</tr>
<tr>
<td></td>
<td>BIO 230</td>
<td>Molecular and Cellular Immunology</td>
</tr>
<tr>
<td></td>
<td>BIOE 115</td>
<td>Computational Modeling of Microbial Communities</td>
</tr>
<tr>
<td></td>
<td>BIOHOPK 274</td>
<td>Hopkins Microbiology Course</td>
</tr>
<tr>
<td></td>
<td>CEE 177</td>
<td>Aquatic Chemistry and Biology</td>
</tr>
<tr>
<td></td>
<td>CEE 274A</td>
<td>Environmental Microbiology I</td>
</tr>
<tr>
<td></td>
<td>CEE 274B</td>
<td>Microbial Bioenergy Systems</td>
</tr>
<tr>
<td></td>
<td>CEE 274D</td>
<td>Pathogens and Disinfection</td>
</tr>
<tr>
<td></td>
<td>EARTHSYS 158</td>
<td>Geomicrobiology</td>
</tr>
<tr>
<td></td>
<td>HUMBIO 155H</td>
<td>Humans and Viruses I</td>
</tr>
<tr>
<td></td>
<td>IMMUNOL 201</td>
<td>Advanced Immunology I</td>
</tr>
</tbody>
</table>
Molecular, Cellular, and Developmental Biology

Candidates for the Molecular, Cellular, and Developmental Biology field of study must complete the following, as well as the WIM requirement above, for a total ranging from 88-102 units:

**Introductory Course**
(must be taken for a letter grade):

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>BIO 60</td>
<td>Problem solving in infectious disease</td>
</tr>
<tr>
<td></td>
<td>BIO 61</td>
<td>Science as a Creative Process</td>
</tr>
<tr>
<td></td>
<td>BIO 62</td>
<td>Microbiology Experiments</td>
</tr>
</tbody>
</table>

**Foundational Courses**
(must be taken for a letter grade):

All of the following:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>BIO 82</td>
<td>Genetics</td>
</tr>
<tr>
<td></td>
<td>BIO 83</td>
<td>Biochemistry &amp; Molecular Biology</td>
</tr>
<tr>
<td></td>
<td>BIO 84</td>
<td>Physiology</td>
</tr>
<tr>
<td></td>
<td>or BIOHOPK 84</td>
<td>Physiology</td>
</tr>
<tr>
<td></td>
<td>BIO 86</td>
<td>Cell Biology</td>
</tr>
</tbody>
</table>

Select 1 of the following:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>BIO 81</td>
<td>Introduction to Ecology</td>
</tr>
<tr>
<td>or BIOHOPK 81</td>
<td>Introduction to Ecology</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BIO 85</td>
<td>Evolution</td>
</tr>
<tr>
<td>or BIOHOPK 85</td>
<td>Evolution</td>
<td></td>
</tr>
</tbody>
</table>

**Foundational Lab Courses**

Two Courses Required:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>BIO 45</td>
<td>Introduction to Laboratory Research in Cell and Molecular Biology</td>
</tr>
<tr>
<td></td>
<td>BIO 46</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
</tr>
<tr>
<td>or BIO 47</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
<td></td>
</tr>
<tr>
<td>or BIOHOPK 47</td>
<td>Introduction to Research in Ecology and Ecological Physiology</td>
<td></td>
</tr>
</tbody>
</table>

**Required Foundational Breadth Courses**
(One course from this section may be taken credit/no credit):

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>BIO 158</td>
<td>Developmental Neurobiology</td>
</tr>
<tr>
<td>or BIO 160</td>
<td>Developmental Biology</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHEM 141</td>
<td>The Chemical Principles of Life I</td>
</tr>
<tr>
<td></td>
<td>CHEM 143</td>
<td>The Chemical Principles of Life II</td>
</tr>
</tbody>
</table>

Select 2 of the following:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-10</td>
<td>BIO 110</td>
<td>Chromatin Regulation of the Genome</td>
</tr>
<tr>
<td></td>
<td>BIO 124</td>
<td>Topics in Cancer Biology</td>
</tr>
<tr>
<td></td>
<td>BIO 154</td>
<td>Molecular and Cellular Neurobiology</td>
</tr>
<tr>
<td></td>
<td>BIO 158</td>
<td>Developmental Neurobiology</td>
</tr>
<tr>
<td></td>
<td>BIO 160</td>
<td>Developmental Biology</td>
</tr>
<tr>
<td></td>
<td>BIO 167</td>
<td>Insulin and carbohydrate metabolism in health and disease a history of advances 1850 to current</td>
</tr>
</tbody>
</table>

**Chemistry**

The following CHEM courses are required:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>CHEM 31A &amp; CHEM 31B or CHEM 31X</td>
<td>Chemical Principles I and Chemical Principles II</td>
</tr>
<tr>
<td></td>
<td>CHEM 33</td>
<td>Structure and Reactivity of Organic Molecules</td>
</tr>
<tr>
<td></td>
<td>CHEM 35</td>
<td>Organic Chemistry of Bioactive Molecules</td>
</tr>
</tbody>
</table>

**Mathematics**

Select one of the following options:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-10</td>
<td>MATH 19 &amp; MATH 20 &amp; MATH 21</td>
<td>Calculus and Calculus</td>
</tr>
<tr>
<td></td>
<td>MATH 51</td>
<td>Linear Algebra, Multivariable Calculus, and Modern Applications (or beyond)</td>
</tr>
<tr>
<td></td>
<td>CME 100</td>
<td>Vector Calculus for Engineers</td>
</tr>
</tbody>
</table>

**Physics**

Select one of the following Series:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-12</td>
<td>PHYSICS 21</td>
<td>Mechanics, Fluids, and Heat</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 22</td>
<td>Mechanics, Fluids, and Heat Laboratory</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 23</td>
<td>Electricity, Magnetism, and Optics</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 24</td>
<td>Electricity, Magnetism, and Optics Laboratory</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PHYSICS 41</td>
<td>Mechanics</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 43</td>
<td>Electricity and Magnetism</td>
</tr>
<tr>
<td></td>
<td>PHYSICS 45</td>
<td>Light and Heat</td>
</tr>
</tbody>
</table>

**Statistics**

Select one of the following courses:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5</td>
<td>BIO/STATS 141</td>
<td>Biostatistics</td>
</tr>
<tr>
<td></td>
<td>BIOHOPK 174H</td>
<td>Experimental Design and Probability</td>
</tr>
<tr>
<td></td>
<td>STATS 60</td>
<td>Introduction to Statistical Methods: Precalculus</td>
</tr>
</tbody>
</table>

Total Units: 33-47

1 If taken to fulfill the foundational breadth requirement, these courses do not count toward the 23 elective unit requirement.

**Electives**

23 units required. Students must take the 3 required courses listed, as well as two courses in Molecular, Cellular, and Developmental Biology from the approved list. The remainder of the 23 units of electives may be any BIO or BIOHOPK course at the 100-level or above, or from the list of approved out-of-department electives. Up to 6 units of teaching and research are allowed. Only one course can be taken credit/no credit.
Neurobiology

Candidates for the Neurobiology field of study must complete the following, as well as the WIM requirement above, for a total ranging from 88-102 units:

### Introductory Course

*(must be taken for a letter grade):*

Select one of the following:

- BIO 60: Problem solving in infectious disease
- BIO 61: Science as a Creative Process
- BIO 62: Microbiology Experiments

### Foundational Courses

*(must be taken for a letter grade):*

All of the following:

- BIO 82: Genetics
- BIO 83: Biochemistry & Molecular Biology
- BIO 84: Physiology
- or BIOHOPK 84: Physiology
- BIO 85: Cell Biology

Select 1 of the following:

- BIO 81: Introduction to Ecology
- BIOHOPK 81: Introduction to Ecology
- BIO 85: Evolution
- or BIOHOPK 85: Evolution

### Foundational Lab Courses

Two Courses Required:

- BIO 45: Introduction to Laboratory Research in Cell and Molecular Biology 4
- BIO 46: Introduction to Research in Ecology and Evolutionary Biology 4-5
  
  or BIO 47: Introduction to Research in Ecology and Evolutionary Biology
  
  or BIOHOPK 47: Introduction to Research in Ecology and Ecological Physiology

### Required Foundational Breadth Courses

*(One course from this section may be taken credit/no credit):*

**Chemistry**

The following CHEM courses are required:

- CHEM 31A: Chemical Principles I
- & CHEM 31B: Chemical Principles II
  
  or CHEM 31X: Chemical Principles Accelerated
  
- CHEM 33: Structure and Reactivity of Organic Molecules 5
- CHEM 35: Organic Chemistry of Bioactive Molecules 5

**Mathematics**

Select one of the following options: 5-10

- MATH 19 & MATH 20 & MATH 21: Calculus and Calculus and Calculus
- MATH 51: Linear Algebra, Multivariable Calculus, and Modern Applications (or beyond)
- CME 100: Vector Calculus for Engineers

**Physics**

Select one of the following Series: 10-12

- PHYSICS 20 Series
  
  PHYSICS 21: Mechanics, Fluids, and Heat
  
  PHYSICS 22: Mechanics, Fluids, and Heat Laboratory
  
  PHYSICS 23: Electricity, Magnetism, and Optics
  
- PHYSICS 40 Series
  
  PHYSICS 41: Mechanics
  
- PHYSICS 43: Electricity and Magnetism
- PHYSICS 45: Light and Heat

**Statistics**

Select one of the following courses: 3-5

- BIO/STATS 141: Biostatistics
- BIOHOPK 174H: Experimental Design and Probability
- STATS 60: Introduction to Statistical Methods: Precalculus

Total Units 33-47

1. If taken to fulfill the foundational breadth requirement, these courses do not count toward the 23 elective unit requirement.

### Electives

23 units required. Students must take the 5 required courses listed. The remainder of the 23 units of electives may be any BIO or BIOHOPK course at the 100-level or above, or from the list of approved out-of-department courses.
electives. Up to 6 units of teaching and research are allowed. Only one course can be taken credit/no credit.

5 Required Courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 149 or BIO 150 or NBIO 206</td>
<td>The Neurobiology of Sleep</td>
<td>4-6</td>
</tr>
<tr>
<td>BIO 154</td>
<td>Molecular and Cellular Neurobiology</td>
<td>4</td>
</tr>
<tr>
<td>BIO 158</td>
<td>Developmental Neurobiology</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 141</td>
<td>The Chemical Principles of Life I</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 143</td>
<td>The Chemical Principles of Life II</td>
<td>4</td>
</tr>
</tbody>
</table>

Hopkins Marine Station

For additional information, see the "Biology, Hopkins Marine Station (http://exploredegrees.stanford.edu/schoolofhumanitiesandsciences/biologyhopkinsmarinestation)" section of this bulletin or the Hopkins Marine Station web site (http://hopkins.stanford.edu).

Courses offered by the Department of Biology are listed under the subject code BIOHOPK on the Stanford Bulletin’s ExploreCourses website.

Summer Program at Hopkins Marine Station

The summer program is open to advanced undergraduate, graduate students, and postdoctoral students, and to teachers whose biological backgrounds, teaching, or research activities can benefit from a summer’s study of marine life. Applications, deadlines, and further information are available at http://hopkins.stanford.edu.

Courses

Courses at Hopkins Marine Station can satisfy many requirements, from Ways to major and minor requirements in departments housed in the Schools of Engineering, Humanities and Sciences, and Earth Sciences. Students are encouraged to check with their department's student services office to see which courses at Hopkins may be used to fulfill major or minor requirements.

Students may go to Hopkins as early as Spring Quarter in the sophomore year, and can also go in the junior and/or senior year to take elective courses. The following Hopkins Marine Station courses may be used toward the Biology degree requirements:

Foundations and Foundational Labs

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOHOPK 81</td>
<td>Introduction to Ecology</td>
<td>4</td>
</tr>
<tr>
<td>BIOHOPK 84</td>
<td>Physiology</td>
<td>4</td>
</tr>
<tr>
<td>BIOHOPK 85</td>
<td>Evolution</td>
<td>4</td>
</tr>
<tr>
<td>BIOHOPK 47</td>
<td>Introduction to Research in Ecology and Ecological Physiology (formerly BIOHOPK 44Y)</td>
<td>5</td>
</tr>
</tbody>
</table>

Electives

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOHOPK 150H</td>
<td>Ecological Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>BIOHOPK 152H</td>
<td>Physiology of Global Change</td>
<td>2</td>
</tr>
<tr>
<td>BIOHOPK 153H</td>
<td>Current Topics and Concepts in Quantitative Fish Dynamics and Fisheries Management</td>
<td>1</td>
</tr>
<tr>
<td>BIOHOPK 154H</td>
<td>Animal Diversity: An Introduction to Evolution of Animal Form and Function from Larvae to Adults</td>
<td>7</td>
</tr>
<tr>
<td>BIOHOPK 155H</td>
<td>Developmental Biology and Evolution</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOHOPK 156H</td>
<td>Hands-On Neurobiology: Structure, Function and Development</td>
<td>6</td>
</tr>
<tr>
<td>BIOHOPK 160H</td>
<td>Developmental Biology in the Ocean: Diverse Embryonic &amp; Larval Strategies of marine invertebrates</td>
<td>5-8</td>
</tr>
<tr>
<td>BIOHOPK 161H</td>
<td>Invertebrate Zoology</td>
<td>5</td>
</tr>
<tr>
<td>BIOHOPK 162H</td>
<td>Comparative Animal Physiology</td>
<td>5</td>
</tr>
<tr>
<td>BIOHOPK 163H</td>
<td>Oceanic Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIOHOPK 165H</td>
<td>The Extreme Life of the Sea</td>
<td>3</td>
</tr>
<tr>
<td>BIOHOPK 166H</td>
<td>Molecular Ecology</td>
<td>5</td>
</tr>
<tr>
<td>BIOHOPK 167H</td>
<td>Nerve, Muscle, and Synapse</td>
<td>5</td>
</tr>
<tr>
<td>BIOHOPK 168H</td>
<td>Disease Ecology: from parasites evolution to the socio-economic impacts of pathogens on nations</td>
<td>3</td>
</tr>
<tr>
<td>BIOHOPK 172H</td>
<td>Marine Ecology: From Organisms to Ecosystems</td>
<td>5</td>
</tr>
<tr>
<td>BIOHOPK 173H</td>
<td>Marine Conservation Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIOHOPK 173HA</td>
<td>Marine Conservation Biology - Seminar and Discussion Only</td>
<td>1-2</td>
</tr>
<tr>
<td>BIOHOPK 174H</td>
<td>Experimental Design and Probability</td>
<td>3</td>
</tr>
<tr>
<td>BIOHOPK 177H</td>
<td>Dynamics and Management of Marine Populations</td>
<td>4</td>
</tr>
<tr>
<td>BIOHOPK 179H</td>
<td>Physiological Ecology of Marine Megafauna</td>
<td>3</td>
</tr>
<tr>
<td>BIOHOPK 180H</td>
<td>Air and Water</td>
<td>3</td>
</tr>
<tr>
<td>BIOHOPK 181H</td>
<td>Physiology of Global Change</td>
<td>2</td>
</tr>
<tr>
<td>BIOHOPK 182H</td>
<td>Stanford at Sea (only 6 units may count towards the major)</td>
<td>16</td>
</tr>
<tr>
<td>BIOHOPK 184H</td>
<td>Holistic Biology (only 6 units may count towards the major)</td>
<td>16</td>
</tr>
<tr>
<td>BIOHOPK 185H</td>
<td>Ecology and Conservation of Kelp Forest Communities</td>
<td>5</td>
</tr>
<tr>
<td>BIOHOPK 187H</td>
<td>Sensory Ecology</td>
<td>4</td>
</tr>
<tr>
<td>BIOHOPK 189H</td>
<td>Sustainability and Marine Ecosystems</td>
<td>3</td>
</tr>
<tr>
<td>BIOHOPK 264H</td>
<td>POPULATION GENOMICS</td>
<td>1-2</td>
</tr>
<tr>
<td>BIOHOPK 274</td>
<td>Hopkins Microbiology Course</td>
<td>9-12</td>
</tr>
<tr>
<td>BIOHOPK 275H</td>
<td>Synthesis in Ecology</td>
<td>2</td>
</tr>
</tbody>
</table>

Research and/or Teaching (maximum 6 units combined)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOHOPK 198H</td>
<td>Directed Instruction or Reading</td>
<td>1-15</td>
</tr>
<tr>
<td>BIOHOPK 199H</td>
<td>Undergraduate Research</td>
<td>1-15</td>
</tr>
<tr>
<td>BIOHOPK 290H</td>
<td>Teaching of Biological Science</td>
<td>1-15</td>
</tr>
<tr>
<td>BIOHOPK 300H</td>
<td>Research</td>
<td>1-15</td>
</tr>
</tbody>
</table>

See Biology degree requirements above for further information. Many of the Hopkins Marine Station courses may be used to fulfill department major requirements.

Minor in Biology

Students interested in the minor in Biology must declare the minor and submit their course plan online via Axess no later than two quarters prior to the student’s intended quarter of degree conferral. The Biology minor requires a minimum of six courses meeting the following criteria:

- All courses must be taken for a letter grade.
- All courses must be worth or approved for 3 or more units.
- At least 3 courses must be taken at the 100-level or higher. The only courses below 100 that are allowable are BIO/BIOHOPK courses at the 60- and 80- level, and OSPAUSTL 10, 25, or 30. Note: OSPAUSTL 10, 25, 30 together count as 2 courses toward the minor.
• Courses used to fulfill the minor may not be used to fulfill any other department degree requirements (minor or major).
• Stanford Introductory Seminars may not be used to fulfill the minor requirements.
• All courses must be chosen from the offerings of the Department of Biology or the Hopkins Marine Station, or from the list of approved out-of-department electives for the minor (https://stanford.box.com/v/OODEMinor). Any approved out of department elective must be approved for at least 3 units.
• At least two courses from the Biology Foundations must be taken:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 81</td>
<td>Introduction to Ecology</td>
<td>4</td>
</tr>
<tr>
<td>or BIOHOPK 81</td>
<td>Introduction to Ecology</td>
<td></td>
</tr>
<tr>
<td>BIO 82</td>
<td>Genetics</td>
<td>4</td>
</tr>
<tr>
<td>BIO 83</td>
<td>Biochemistry &amp; Molecular Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIO 84</td>
<td>Physiology</td>
<td>4</td>
</tr>
<tr>
<td>or BIOHOPK 84</td>
<td>Physiology</td>
<td></td>
</tr>
<tr>
<td>BIO 85</td>
<td>Evolution</td>
<td>4</td>
</tr>
<tr>
<td>or BIOHOPK 85</td>
<td>Evolution</td>
<td></td>
</tr>
<tr>
<td>BIO 86</td>
<td>Cell Biology</td>
<td>4</td>
</tr>
</tbody>
</table>

• A third Bio Foundations course may be taken OR students may take one introductory Biology course from the following list:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 60</td>
<td>Problem solving in infectious disease</td>
<td>4</td>
</tr>
<tr>
<td>BIO 61</td>
<td>Science as a Creative Process</td>
<td>4</td>
</tr>
<tr>
<td>BIO 62</td>
<td>Microbiology Experiments</td>
<td>4</td>
</tr>
</tbody>
</table>

• The Biology Core Laboratory courses do not count towards the minor:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 45</td>
<td>Introduction to Laboratory Research in Cell and Molecular Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIO 46</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIO 47</td>
<td>Introduction to Research in Ecology and Evolutionary Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIOHOPK 47</td>
<td>Introduction to Research in Ecology and Ecological Physiology</td>
<td>5</td>
</tr>
</tbody>
</table>

• If taken for at least 3 units, independent research conducted in a Biology lab may count as 1 course. Note: Research done in a non-Biology lab cannot be counted toward the minor. Directed reading, either in department or out of the department, also cannot count toward the minor.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 199</td>
<td>Advanced Research Laboratory in Experimental Biology</td>
<td>1-15</td>
</tr>
<tr>
<td>BIOHOPK 199H</td>
<td>Undergraduate Research</td>
<td>1-15</td>
</tr>
</tbody>
</table>

Not allowable:

- BIO 198 Directed Reading in Biology
- BIO 198X Out-of-Department Directed Reading
- BIO 199X Out-of-Department Advanced Research Laboratory in Experimental Biology

**Master of Science in Biology**

For information on the University's basic requirements for the M.S. degree, see the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees/#masterstext)" section of this bulletin. Students considering this degree option should meet with staff in the student services office prior to applying.

The M.S. degree program offers general or specialized study to individuals seeking biologically oriented course work and to undergraduate science majors wishing to increase or update their science background or obtain advanced research experience. Students who have majored in related fields are eligible to apply, but course work equivalent to the preparation of a Stanford B.S. in Biology may be required in addition to the general requirements. This includes course work in biology, chemistry, physics and mathematics. The M.S. program does not have an M.S. with a thesis option.

**Admissions**

The department only accepts M.S. program applications from matriculated Stanford students:

1. undergraduates wishing to pursue a coterminal M.S. degree.
2. graduate students from other Stanford programs wishing to pursue an M.S. degree.
3. current Biology Ph.D. students wishing to discontinue the Ph.D. program with an M.S. degree.

Undergraduates must apply in Autumn Quarter to begin the program in Spring Quarter or in Spring Quarter to begin the program the following Autumn or Winter Quarter. Graduate students may apply by the third week of any academic quarter.

**Required application materials**

1. Completed Coterminal Online Application (https://applyweb.com/stanterm)
2. A statement of purpose which explains why the student wishes to enter the program and what the student plans to accomplish while in the program. The statement should also supply information about the student's science capabilities if his or her undergraduate academic record does not accurately reflect them.
4. Two letters of recommendation, preferably from Biology faculty members in this department. If two such letters are not available, letters from faculty familiar with the student's ability to succeed in a graduate science curriculum are acceptable.
5. Application fee: an application fee is charged to all students regardless of outcome; application fee is applied directly to students' accounts.

**University Coterminal Requirements**

Coterminal master's degree candidates are expected to complete all master's degree requirements as described in this bulletin. University requirements for the coterminal master's degree are described in the "Coterminal Master's Program (http://exploredegrees.stanford.edu/cotermdegrees)" section. University requirements for the master's degree are described in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees/#masterstext)" section of this bulletin.

After accepting admission to this coterminal master's degree program, students may request transfer of courses from the undergraduate to the graduate career to satisfy requirements for the master's degree. Transfer of courses to the graduate career requires review and approval of both the undergraduate and graduate programs on a case by case basis.

In this master's program, courses taken three quarters prior to the first graduate quarter, or later, are eligible for consideration for transfer to the graduate career. No courses taken prior to the first quarter of the sophomore year may be used to meet master's degree requirements.
Course transfers are not possible after the bachelor’s degree has been conferred.

The University requires that the graduate adviser be assigned in the student’s first quarter even though the undergraduate career may still be open. The University also requires that the Master’s Degree Program Proposal be completed by the student and approved by the department by the end of the student’s first graduate quarter.

General Requirements

The M.S. program consists of Department of Biology and/or Hopkins Marine Station course work, approved out-of-department electives, and foundational breadth courses totaling at least 45 units at or above the 100-level (with the exception of BIO 196 A, B, & C), distributed as follows:

1. A minimum of 23 of the 45 units must be courses designated primarily for graduate students.

2. A minimum of 36 units must be chosen from the offerings in the Department of Biology (BIO), Hopkins Marine Station (BIOHOPK), the list of approved out-of-department electives (https://stanford.app.box.com/v/out-of-department-electives), research, teaching and/or foundational breadth courses.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 198</td>
<td>Directed Reading in Biology</td>
<td>1-15</td>
</tr>
<tr>
<td>BIO 198X</td>
<td>Out-Department Directed Reading</td>
<td>1-15</td>
</tr>
<tr>
<td>BIO 290</td>
<td>Teaching of Biology</td>
<td>1-5</td>
</tr>
<tr>
<td>BIO 291</td>
<td>Development and Teaching of Core</td>
<td>1-2</td>
</tr>
<tr>
<td>BIO 300</td>
<td>Research</td>
<td>1-10</td>
</tr>
<tr>
<td>BIO 300X</td>
<td>Out-Department Graduate Research</td>
<td>1-10</td>
</tr>
<tr>
<td>BIOHOPK 198H</td>
<td>Directed Instruction or Reading</td>
<td>1-15</td>
</tr>
<tr>
<td>BIOHOPK 290H</td>
<td>Teaching of Biological Science</td>
<td>1-15</td>
</tr>
<tr>
<td>BIOHOPK 300H</td>
<td>Research</td>
<td>1-15</td>
</tr>
</tbody>
</table>

- a. A maximum of 18 units may be a combination of Biology research, directed reading and/or teaching;
- b. A maximum of 9 units may be foundational breadth courses in chemistry, mathematics, statistics, computer science, and/or physics beyond the level required for the undergraduate degree in Biology and at least at the 100-level.

3. No more than 9 units may be other Stanford course work relevant to a student’s professional development. Students are required to petition for courses that fall into this category using the General Petition form (https://stanford.app.box.com/v/general-petition).

Each candidate designs a coherent program of study in consultation with her or his department advisor. Although there are no specific courses required, program proposals must adhere to department parameters.

In addition to the unit requirements outlined above, students must adhere to the following:

1. A program proposal, signed by the student’s advisor and approved by the chair of the M.S. committee, must be filed by the third week of the first quarter of enrollment. A revised program proposal is required to be filed whenever there are changes to a student’s previously approved program proposal.

2. Students may take only 6 units CR/NC.

3. Students must maintain a GPA of 3.0 or higher.

4. Students must receive a grade of ‘B’ or better in all courses taken for the degree.

Students not meeting these minimum requirements are subject to departmental academic review and/or dismissal.

The department’s Master of Science Handbook (listed on the department website (https://biology.stanford.edu/academics/coterminal-masters-program/forms)) has additional information about the program, University policy, and the department.

Doctor of Philosophy in Biology

For information on the University’s basic requirements for the Ph.D. degree, see the “Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)” section of this bulletin. The training for a Ph.D. in Biology is focused on learning skills required for being a successful research scientist and teacher, including how to ask important questions and then devise and carry out experiments to answer these questions. Students work closely with an established advisor and meet regularly with a committee of faculty members to ensure that they understand the importance of diverse perspectives on experimental questions and approaches. Students learn how to evaluate critically pertinent original literature in order to stay abreast of scientific progress in their areas of interest. They also learn how to make professional presentations, write manuscripts for publication, and become effective teachers.

Admissions

Students seeking entrance to graduate study in Biology ordinarily should have the equivalent of an undergraduate major in Biology at Stanford. However, students from other disciplines, particularly the physical sciences, are also encouraged to apply. Such students are advised at the time of initial registration on how they should complete background training during the first year of graduate study. In addition to the usual basic undergraduate courses in biology, it is recommended that preparation for graduate work include courses in chemistry through organic chemistry, general physics, and mathematics through calculus.

Application, Admission, and Financial Aid

Prospective graduate students must apply via Stanford’s online graduate application (http://gradadmissions.stanford.edu).

The training for a Ph.D. in Biology is focused on helping students achieve their goals of being a successful research scientist and teacher, at the highest level. Students work closely with an established advisor and meet regularly with a committee of faculty members to facilitate their progress. The Biology Ph.D. program is part of the larger Biosciences (https://biosciences.stanford.edu) community of Ph.D. programs at Stanford, which includes Ph.D. programs in Stanford School of Medicine.

There are three tracks within the Biology Ph.D. program: 1) Cell, Molecular and Organismal Biology, 2) Ecology and Evolution, and 3) Hopkins Marine Station. All are focused on excellence in research and teaching in their respective areas; where there are differences between the tracks, they are indicated in the links below.

Applicants are not required to take the Graduate Record Examination (GRE) general test nor the GRE subject test, but applicants who have taken either of these exams may choose to report their scores.

Admission to the Ph.D. program is competitive and in recent years it has been possible to offer admission to approximately 9-10 percent of the applicants.

Applicants who are eligible should apply for nationally competitive predoctoral fellowships, especially those offered by the National Science Foundation.

Admitted students are typically offered financial support in the form of Stanford Graduate Fellowships, research assistantships, NIH traineeships or biology fellowships.
General Requirements

All students must be enrolled in exactly 10 units during autumn, winter, spring and summer quarters until reaching Terminal Graduate Registration (TGR) status and are required to pass all courses in which they are enrolled. Students must earn a grade of ‘B-’ or better in all courses applicable to the degree that are taken for a letter grade. Satisfactory completion of each year’s general and track specific requirements listed below is required for satisfactory progress towards the degree. Students not making satisfactory degree progress are subject to departmental academic review and/or dismissal.

1. First year advising
   Each entering student meets with the first-year advising committee within the first two weeks of Autumn Quarter, Winter Quarter, and by May 15 of Spring Quarter. The committee reviews the student’s previous academic work and current goals and advises the student on a program of Stanford courses, some of which may be required and others recommended. Completion of the core curriculum listed below under “Track Specific Requirements” is required of all students.

2. Ethics
   Students must take a course on the ethical conduct of research. One of the two following courses should be taken in the first year of the program:

<table>
<thead>
<tr>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>MED 255</td>
</tr>
<tr>
<td>OR</td>
</tr>
<tr>
<td>BIO 313</td>
</tr>
</tbody>
</table>

3. Teaching
   Teaching experience and training are part of the graduate curriculum. Each student assists in teaching one course in:
   a. the intro/foundational level (BIO 40s, 60s, and 80s level courses).
      Note: Hopkins students complete at least one TA requirement on campus during the first year. Any remaining TA requirements can be completed at Hopkins.

<table>
<thead>
<tr>
<th>Units</th>
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<tbody>
<tr>
<td>BIO 45</td>
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<tr>
<td>BIO 46</td>
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<tr>
<td>BIO 47</td>
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<tr>
<td>BIO 60</td>
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<td>BIO 61</td>
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<td>BIO 62</td>
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<td>BIO 81</td>
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<td>BIO 82</td>
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<td>BIO 83</td>
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<td>BIO 84</td>
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<tr>
<td>BIO 85</td>
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<tr>
<td>BIO 86</td>
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</tbody>
</table>

   b. and a second course that can be either an intro/foundational course or other Biology or Hopkins Marine Station course.

4. Seminars
   Graduate seminars devoted to current literature and research in particular fields of biology are an important means of attaining professional perspective and competence. Seminars are presented under individual course listings or are announced by the various research groups. Topics of current biological interest are presented by speakers from Stanford and other institutions. During the first year of study, graduate students are required to attend seminars and make one formal seminar presentation which must be evaluated by a minimum of two Biology faculty members.

5. Fellowship application
   All eligible first year students must apply for a National Science Foundation (NSF) Graduate Research Fellowship.

6. Advisor/lab selection
   By May 1, each first-year student is required to have selected a lab in which to perform dissertation research and to have been accepted by the faculty member in charge.

7. Qualifying exam and admission to candidacy
   During the second year, students are required to write a dissertation proposal which is evaluated by a committee of faculty (the dissertation proposal committee) in an oral presentation. Track-specific deadlines are listed below. All students must be admitted to candidacy by the end of their second year. This is contingent upon satisfactory completion of course work, all first and second year requirements, the dissertation proposal and the University’s requirements for candidacy outlined in the Candidacy (http://exploredegrees.stanford.edu/graduatedegrees/#doctoraltex) section of this bulletin. If a student does not meet the requirements for admission to candidacy by the end of the second year, the student is subject to dismissal from the Ph.D. program.

8. Committee meetings
   Students must meet regularly with their advising committees. For more details, see the Biology Ph.D. Handbook (https://stanford.box.com/v/PhDHandbook).

9. Individual Development Plan meetings
   Students must meet once a year with their advisor. For more details, see the Biology Ph.D. Handbook (https://stanford.box.com/v/PhDHandbook).

10. Publishable manuscript
    Each student must complete one publishable manuscript (paper) for which s/he is the major contributor.

11. Residency requirement
    A minimum of 135 units of graduate registration is required of each candidate at the time of graduation.

12. Doctoral dissertation
    A substantial draft of the dissertation must be submitted to the student’s oral examination committee at least one month before the oral exam is scheduled to take place. The dissertation must be presented to an oral examination committee (http://exploredegrees.stanford.edu/graduatedegrees/#doctoraltex) comprised of at least five faculty members. In addition, the final written dissertation must be approved by the student’s reading committee (http://exploredegrees.stanford.edu/graduatedegrees/#doctoraltex) (a minimum of three approved faculty), and submitted to the Registrar’s Office. Upon completion of this final requirement, a student is eligible for conferral of the degree.

Track Specific Requirements

In addition to the general requirements listed above, students must also complete requirements within their concentration. Written petitions for exemptions to core curriculum and lab rotation requirements are considered by the advising committee and the chair of the graduate studies committee. Approval is contingent upon special circumstances and is not routinely granted.
Cellular, Molecular, and Organismal Biology (CMOB)

1. Courses: Students are required to take the following courses prior to Spring Quarter of the 4th year, except for the required first year courses as noted:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 200</td>
<td>Foundations in Experimental Biology (must be taken Autumn of first year)</td>
<td>5</td>
</tr>
<tr>
<td>BIO 301</td>
<td>Frontiers in Biology (satisfies first-year seminar requirement; must be taken Autumn and Winter quarters of 1st year)</td>
<td>1-3</td>
</tr>
</tbody>
</table>

One additional course in each of the four scientific areas decided upon by the student and the advising committee

1. Cell Biology
2. Biology of Molecules
3. Genetics/Genomics
4. Quantitative Methods

2. Lab Rotations: First-year students are required to do their first rotation in the lab of a Department of Biology faculty member for at least five weeks. The total rotation time in labs of Department of Biology faculty must be at least ten weeks. Students are encouraged to do at least two rotations in the Department of Biology.

3. Two-part qualifying exam: Each student must pass the exam in their second year.
   a. Dissertation proposal: During Autumn Quarter of the second year, the student must prepare a written dissertation proposal that outlines the student’s projected dissertation research, including an expert assessment of the current literature; deadline is November 15.
   b. Oral examination: Held after submission of the written proposal to the dissertation proposal committee. The student should prepare a presentation of the goals of the thesis, typically including preliminary data, models, etc. as appropriate which are relevant to at least the first goal, and should be prepared thereafter to discuss questions raised by the committee in professional scientific depth. Deadline is June 15.

Hopkins Marine Station

1. Courses: Students are required to take the following courses prior to Spring Quarter of the fourth year, except for the required first year courses as noted:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BI 301</td>
<td>Frontiers in Biology</td>
<td>1-3</td>
</tr>
</tbody>
</table>
| OR
| BIO 302  | Current Topics and Concepts in Population Biology, Ecology, and Evolution | 1     |
| BIO 303  | Current Topics and Concepts in Population Biology, Ecology, and Evolution | 1     |
| BIO 304  | Current Topics and Concepts in Population Biology, Ecology, and Evolution | 1     |

Two additional Hopkins Marine Station courses (BIOHOPK). These may include BIOS mini courses offered at Hopkins.

Students may also be required to take a set of courses to be determined by the advising committee.

2. First-Year Paper: The paper should be read, commented upon and agreed to as satisfactory by two faculty by May 15. This paper should be a step toward the development of a dissertation proposal and may consist of an analysis of new data or a literature review of a potential thesis topic. This can be satisfied in a number of ways which all involve new writing, undertaken since entering the Stanford program. These may include:
   a. A new draft research manuscript; a previously published paper is not acceptable.
   b. Some other piece of new writing, such as a review paper from a course, or an initial literature review of a potential thesis topic. In this case the paper should ordinarily be not less than 10 double-spaced pages in usual sized font, and not more than 10 single spaced pages, plus references. It should be written in the style of a standard scientific paper.

3. Two-part qualifying exam: Each student must pass the exam in their second year.
   a. Dissertation proposal: During Spring Quarter of the second year, the student must prepare a written dissertation proposal that outlines the student’s projected dissertation research, including an expert assessment of the current literature; deadline is May 15.
   b. Oral examination: Held after submission of the written proposal to the dissertation proposal committee. The student should prepare a presentation of the goals of the thesis, typically including preliminary data, models, etc. as appropriate which are relevant to at least the first goal, and should be prepared thereafter to discuss questions raised by the committee in professional scientific depth. Deadline is June 15.

Ecology and Evolution

1. Courses: Students are required to take the following courses in their first year:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 302</td>
<td>Current Topics and Concepts in Population Biology, Ecology, and Evolution</td>
<td>1</td>
</tr>
<tr>
<td>BIO 303</td>
<td>Current Topics and Concepts in Population Biology, Ecology, and Evolution</td>
<td>1</td>
</tr>
<tr>
<td>BIO 304</td>
<td>Current Topics and Concepts in Population Biology, Ecology, and Evolution</td>
<td>1</td>
</tr>
</tbody>
</table>

Students specializing in ecology and evolution may be required to take additional courses as advised by committee.

2. First-year paper: The paper should be read, commented upon and agreed to as satisfactory by two EcoEvo faculty by May 15. This can be satisfied in a number of ways which all involve new writing, undertaken since entering the Stanford program. These may include:
   a. A new draft research manuscript (a previously published paper is not acceptable).
   b. Some other piece of new writing, such as a review paper from a course, or an initial literature review of a potential thesis topic. In this case the paper should ordinarily be not less than 10 double-spaced pages in usual sized font, and not more than 10 single spaced pages, plus references. It should be written in the style of a standard scientific paper.

3. Two-part qualifying exam: Each student must pass the exam in their second year. Students at Hopkins have the option of following the process of either the CMOB or Eco/Evo tracks (see above).

4. Graduate Student Symposium: All second- and fourth-year students are required to present at an annual student symposium (typically in February).
a. Second-Year Students: The first half of the symposium gives second-year graduate students a forum to present plans for their graduate work. Because each student’s research is different, there is no one-size-fits-all plan for these talks. But in general, these 20-minute presentations are meant to answer the questions: “What broad area of marine biology am I pursuing for my Ph.D.? What is known about this now? What am I planning broadly to contribute? What preliminary or initial data do I have?”

b. Fourth-Year Students: The presentation for fourth-year students comes in two parts:
   i. Each student prepare sa written overview of their doctoral research, including progress to date and plans for the final thesis. The document should be single spaced, 11-point (or larger) font, and should not exceed 3 pages (including figures and tables, but excluding references). In addition to this research overview, each student submits an up-to-date CV, and the research overview and CV should be submitted no later than one week before the symposium date. This deadline gives a panel of judges time to review the documents prior to the symposium. Please combine the research statement and CV into a single PDF file, and email it to both the director and associate director.
   ii. In the second half of the symposium, each fourth-year student presents to the judges and a general audience a 20-minute report on their Ph.D. research. Along with the written research overview, this is intended to give each student a chance to pull together their data and analyses to date, lay out initial conclusions, and explore what they mean in the context of their overall research interests and goals. As with the research overviews, these talks give students a chance to concentrate on what progress they have made along the complex path of their Ph.D., and what they are particularly excited about. Laying out plans for finishing the thesis should be a part of these talks, but should not be the main topic.
   iii. After the symposium, the judges meet to choose the most outstanding combination of research statement and oral presentation. This student receives the Lederberg Award.

Note: Written petitions for exemptions to requirements are considered by a student’s Advising Committee and the Graduate Studies Committee Chair. Approval is contingent on special circumstances and is not routinely granted.

Graduate Advising Expectations

The Department of Biology is committed to providing academic advising in support of graduate student scholarly and professional development. When most effective, this advising relationship entails collaborative and sustained engagement by both the advisor and the advisee.

All first-year Biology graduate students have an assigned First-Year Advising Committee (typically 2-3 Biology Department faculty members from the student’s proposed area of specialization). This committee evaluates the student’s academic and research background, recommends an academic program, helps the student select a thesis adviser and arrange lab rotations (if applicable), provide guidance in developing a dissertation project, review teaching opportunities and remind students of their academic and administrative responsibilities.

Graduate students are expected to select a thesis advisor before the end of the first year of the program. Students are encouraged to work collaboratively with their advisors to establish a dissertation project and form a Dissertation Reading Committee. Advancement to doctoral candidacy is expected to occur during the second year of the program.

Thesis advisers are expected to meet with graduate students at least once each year to discuss and help develop the students’ Individual Development Plans (IDP). Additionally, advisers and students should meet on a regular basis throughout the year to discuss the student’s professional development in key areas such as selecting courses, designing and conducting research, developing teaching pedagogy, navigating policies and degree requirements, and exploring academic opportunities and professional pathways.

Graduate students are active contributors to the advising relationship. They should proactively seek academic and professional guidance and take responsibility for informing themselves of policies and degree requirements for the Biology Ph.D. program.

As a best practice, advising expectations should be periodically discussed and reviewed to ensure mutual understanding. Both the advisor and the advisee are expected to maintain professionalism and integrity.

Academic progress and student completion of program requirements and milestones are monitored by the program director and staff, and are discussed by faculty at an annual meeting devoted to assessing graduate student progress. A detailed description of the program’s requirements, milestones, and advising expectations are listed in the Biology Ph.D. Student Handbook, found on the program website (https://biology.stanford.edu/academics/phd-program/forms).

Additionally, the program adheres to the advising guidelines and responsibilities listed by the Office of the Vice Provost for Graduate Education (https://vpge.stanford.edu/academic-guidance/advising-mentoring) (VPGE) and in the Graduate Academic Policies (https://gap.stanford.edu/handbooks/gap-handbook/chapter-3/subchapter-3/page-3-3-1) (GAP).


Emeritus Professor (Teaching): Carol L. Boggs

Chair: Tim P. Stearns


Professor (Research): Anthony Barnosky

Associate Professors: José R. Dinneny, Hunter B. Fraser, Tadashi Fukami, Christopher Lowe, Ashby Morrison, Mark J. Schnitzer, Jan M. Skotheim

Associate Professor (Research): Mary Hynes

Assistant Professors: Xiaoke Chen, Scott J. Dixon, Jessica L. Feldman, Jeremy A. Goldbogen, Erin Mordecai, Lauren O’Connell, Kabir Peay, M. Kristy Red-Horse


Courtesy Associate Professors: Kathryn Barton, David Ehrhardt, Jonathan Payne, Sue Rhee, Zhiyong Wang
Overseas Studies Courses in Biology

The Bing Overseas Studies Program (http://bosp.stanford.edu) manages Stanford study abroad programs for Stanford undergraduates. Students should consult their department or program’s student services office for applicability of Overseas Studies courses to a major or minor program.

The Bing Overseas Studies course search site (https://undergrad.stanford.edu/programs/bosp/explore/search-courses) displays courses, locations, and quarters relevant to specific majors.

For course descriptions and additional offerings, see the listings in the Stanford Bulletin’s ExploreCourses (http://explorecourses.stanford.edu) or Bing Overseas Studies (http://bosp.stanford.edu).

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>Coral Reef Ecosystems</td>
<td>OSPAUSTL 10</td>
</tr>
<tr>
<td>Freshwater Systems</td>
<td>OSPAUSTL 25</td>
</tr>
<tr>
<td>Coastal Forest Ecosystems</td>
<td>OSPAUSTL 30</td>
</tr>
<tr>
<td>The Cancer Problem: Causes, Treatments, and Prevention</td>
<td>OSPMADRD 50</td>
</tr>
</tbody>
</table>