Biology

General Information

Degrees and Areas of Concentration

The Department of Biology provides academic programs leading to the B.A. or B.S. in Biology. In cooperation with the College of Education, the department offers the B.S. in Secondary Education with a major in biology and the B.A. or B.S. in Biology with teacher certification. It also offers graduate work leading to the Master of Science and the Doctor of Philosophy degrees in Biology. Biology faculty members are engaged in teaching and research in areas ranging from cell and molecular biology to population and community studies.

Minor in Biology

Students majoring in another discipline may earn a minor in biology by completing a prescribed course of study. Unique programs can be developed to coordinate with special career objectives.

Departmental Honors

The Department of Biology offers an Honors Program to train students in conducting research in areas of biological research currently under study in the Department.

Graduate Studies

The Department of Biology offers graduate work leading to the M.S. and Ph.D. degrees in biology. Graduate students will normally work toward an M.S. or Ph.D. degree in two broad areas of biology: a) cellular, molecular, and developmental biology, or b) ecology, evolution, and systematics. Students in the M.S. and Ph.D. programs also have the opportunity to do their graduate work in collaboration with scientists at the Missouri Botanical Garden, the Donald Danforth Plant Science Center, or the Saint Louis Zoo through cooperative graduate programs.

Facilities

Department facilities include research and teaching laboratories, environmental chambers, greenhouses, and a large array of supporting modern research instrumentation. Graduate research can be pursued using facilities of the Missouri Botanical Garden, the Donald Danforth Plant Science Center, or the Saint Louis Zoo. Several sites within an hour of campus are suitable for regional field studies, including state parks, wildlife conservation areas, the Shaw Nature Reserve, and Washington University's Tyson Research Center. UMSL is a member of the St. Louis University Research Station Consortium that operates Lay and Reis Field Stations in Missouri and is also a member of the Organization for Tropical Studies, which operates three field stations in Costa Rica. CEIBA Biological Centre in Guyana has hosted several UMSL courses and student researchers. Student researchers work independently at research stations throughout the tropics.

Cooperative Programs

The department participates in a cooperative consortium program in biology with Washington University, Saint Louis University, Southern Illinois University-Edwardsville, and the Missouri Botanical Garden.

Program Objectives and Career Prospects

The degree program at the baccalaureate level is designed to prepare the student for further professional training in areas such as medicine, dentistry, veterinary medicine, optometry, plant science, conservation, and related areas or for further graduate training in research in biology.

The Undergraduate Certificates in Biotechnology and Conservation Biology are for majors interested in careers in biotechnology and associated areas and in conservation, respectively.

The Master of Science program is an extension of the undergraduate program and provides the research-oriented training and education necessary for students to enter doctoral programs in biology and develops professional biologists qualified to function in responsible technical positions. It also trains students to become effective secondary school and junior college biology teachers.

The Graduate Certificates in Biotechnology and in Tropical Biology and Conservation provides professional training in the areas of biotechnology and conservation.

The Ph.D. program prepares students to be research biologists in academics or other professional fields in ecology, evolution and systematic and cellular and molecular biology. Employment opportunities are available in college or university research and teaching, in government and public institutions such as museums, botanical gardens and conservation organizations, and in industry.

Undergraduate Studies

General Education Requirements

Students must satisfy the university and college general education requirements (http://bulletin.umsl.edu/generaleducationrequirements). Some Biology courses may be used to meet the science and mathematics requirement of the university.

Candidates for the B.A. degree must fulfill the foreign language requirement of the College of Arts and Sciences. There is no foreign language requirement for the B.S. degree.

Satisfactory/Unsatisfactory Option

Up to 18 credit hours may be taken on a satisfactory/unsatisfactory (s/u) basis. Excluded from this option are required courses in biology, chemistry, physics, and mathematics.

Non-major biology courses

The following 1000 level biology courses do not count toward the biology credit hours required for a major in biology. Moreover, if biology majors take these courses, they are treated as biology courses when computing the 70 credit hours outside of biology needed to be included in the 120 total credit hours required for graduation.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1012</td>
<td>General Biology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 1013</td>
<td>General Biology Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 1102</td>
<td>Human Biology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 1113</td>
<td>Human Physiology And Anatomy I</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 1141</td>
<td>Human Physiology And Anatomy II</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 1162</td>
<td>General Microbiology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 1999</td>
<td>Evolution For Everyone</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 1202</td>
<td>Environmental Biology</td>
<td>3</td>
</tr>
</tbody>
</table>

Declaring the Biology Major

Students seeking to major in biology are first designated as pre-biology majors until they have successfully completed Genetics, BIOL 2012, in
residence with a grade of C or better. Students who have completed a Genetics course elsewhere will have to either pass a proficiency examination in Genetics or complete BIOL 2012 in residence with a grade of C or better. Students may then declare biology as their major. BIOL 2012 must be completed successfully within two attempts, including excused withdrawals.

Degree Requirements

Bachelor of Arts in Biology

The B.A. degree provides maximum flexibility for biology majors to pursue an undergraduate liberal arts course of study that can lead to professional careers in medicine, allied health, public and environmental health, law, and graduate studies in the life sciences. Candidates must have a cumulative grade point average of 2.0 or better in biology courses. Effective fall semester 2009, candidates must also earn a minimum grade of C- in all core courses.

All B.A. degree majors must take at least 39 credit hours but not more than 50 hours in appropriate biology course work. Transfer student must satisfactorily complete at least 18 credit hours of UMSL biology course work (including one laboratory) at the 2000 level or above before receiving work (including one laboratory) at the 2000 level or above before receiving

Elective Courses

Three additional biology lecture courses, at the 2000 level or higher are required. They may be selected from any of the lecture or lecture-laboratory courses offered. Selection of these courses should reflect the career interest of the student. Biology courses taken to fulfill basic skill requirements (e.g., statistics requirement or biochemistry option) can be used to satisfy this requirement.

At least two biology lecture courses taken as part of the core or as electives must be at the 4000 level or higher. No more than one of these higher level courses can be used to fulfill other requirements (e.g., diversity or statistics requirements, or biochemistry option).

Laboratory Course Requirements

Three biology laboratory courses at the 2000 level or higher are required. They may be taken from any of the lecture-laboratory or laboratory courses offered. Two credit hours of BIOL 3699, BIOL 4299, BIOL 4905, or BIOL 4915 (no combination of these courses allowed) can be used to fulfill one laboratory requirement. Students may take CHEM 4733 to satisfy one of these laboratory course requirements, but students may not use both BIOL 4713 and to CHEM 4733 fulfill this requirement.

Basic Skills Requirement

A well-rounded biologist needs certain skills outside the biology subject matter. The basic skills requirement is designed to provide the student with a background in communication skills and knowledge in associated science areas.

Communication Skills. Courses in foreign languages and in writing are required for development of the basic communication skills needed to transmit scientific information. The following satisfy this requirement:

Foreign Language

The foreign language requirement of the College of Arts & Sciences fulfills the departmental requirement.

Writing

ENGL 3160 Writing In The Sciences (strongly preferred) 3
or ENGL 3100 Junior-Level Writing

Total Hours 6

Associated Science Area. The following courses or their equivalents must be successfully completed in science areas related to biology:

PHYSICS 1011 Basic Physics I 4
PHYSICS 1012 Basic Physics II 4
CHEM 1111 Introductory Chemistry I 5
CHEM 1121 Introductory Chemistry II 5
CHEM 2612 Organic Chemistry I 3

Select one of the following: 2-3

CHEM 2223 Quantitative Analysis
CHEM 2622 Organic Chemistry II
CHEM 2633 Organic Chemistry Laboratory
BIOL/CHEM 4712 Biochemistry

Total Hours 34-36
Bachelor of Science in Biology

The B.S. degree in biology is designed to prepare students for basic technical positions and graduate studies in the life sciences. Candidates for the degree have the same core courses and general education requirements as those seeking the Bachelor of Arts degree, as well as additional requirements in depth of study, laboratory experience, communication skills, and background in associated science areas. Candidates must have a cumulative grade point average of 2.0 or better in biology courses. Effective Fall semester 2009, candidates must earn a minimum grade of C- in all core courses.

There is no foreign language requirement for the B.S. degree. However, students should realize that the literature for biological studies is in many different languages and the ability to extract information from this literature is an important skill.

To fulfill the requirements for the B.S. degree a minimum of 44 hours but not more than 50 hours must be completed in appropriate biology course work. Transfer students must satisfactorily complete at least 22 credit hours of UMSL biology course work (including two laboratory courses) at the 2000 level or higher before receiving a B.S. degree in biology.

Lecture and Seminar Course Requirements

Core Courses

The following biology courses or their equivalents are required:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1821</td>
<td>Introductory Biology: Organisms And The Environment</td>
<td>5</td>
</tr>
<tr>
<td>BIOL 1831</td>
<td>Introductory Biology: From Molecules To Organisms</td>
<td>5</td>
</tr>
<tr>
<td>BIOL 2012</td>
<td>Genetics</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 3302</td>
<td>Introduction To Evolution</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 3622</td>
<td>Cell Biology</td>
<td>3</td>
</tr>
</tbody>
</table>

Select one of the following: 2-6

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4889</td>
<td>Senior Seminar</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEC ED 4985 &amp; BIOL 4986</td>
<td>Curriculum And Methods Of Teaching Life Sciences and Laboratory In Teaching Life Sciences (for those seeking teacher certification)</td>
<td>3</td>
</tr>
</tbody>
</table>

Select one of the following diversity courses: 3-5

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 2102</td>
<td>General Ecology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 2402</td>
<td>Vertebrate Anatomy, Evolution and Ecology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 2482</td>
<td>Microbiology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 2501</td>
<td>Biology Of Plants</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 4402</td>
<td>Ornithology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 4422</td>
<td>Entomology</td>
<td>3</td>
</tr>
</tbody>
</table>

Elective Courses

Four additional biology lecture courses at the 2000 level or higher are required. They may be selected from any of the lecture or lecture-laboratory courses offered. Selection of these courses should reflect the career interest of the student and may be selected from optional academic tracks (see below). Biology courses taken to fulfill basic skill requirements (e.g., statistics requirement or biochemistry option) can be used to satisfy this requirement.

At least two biology lecture courses taken as electives must be at the 4000 level or higher. No more than one of these higher level courses can be used to fulfill other requirements (e.g., statistics requirement or biochemistry option).

Laboratory Course Requirements

Four biology laboratory courses at the 2000 level or higher are required. They may be selected from any of the lecture-laboratory or laboratory courses offered. Two credit hours of BIOL 3699 (p. 1), BIOL 4905 (p. 1), or BIOL 4915 (p. 1) (no combination of these courses allowed) can be used to fulfill one laboratory requirement. Students may take CHEM 4733 (p. 1) to satisfy one of these laboratory course requirements, but students may not use both BIOL 4713 (p. 1) and CHEM 4733 (p. 1) to fulfill this requirement.

Basic Skills Requirement

A well-rounded biologist needs certain skills outside the biology subject matter. The basic skills requirement is designed to provide the student with a background in communication skills and knowledge in associated science areas.

Communication Skills

Courses in both formal speaking and writing are required for development of the basic communication skills needed to transmit scientific information.

Formal Speaking

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMM 1040</td>
<td>Introduction To Public Speaking</td>
<td>3</td>
</tr>
</tbody>
</table>

Writing

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGL 3160</td>
<td>Writing In The Sciences (strongly preferred)</td>
<td>3</td>
</tr>
<tr>
<td>or ENGL 3110</td>
<td>Junior Level Writing For International Students</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Hours 6

Associated Science Area

The following courses or their equivalents must be successfully completed:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYSICS 1011</td>
<td>Basic Physics I</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 1012</td>
<td>Basic Physics II</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 1111</td>
<td>Introductory Chemistry I</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 1121</td>
<td>Introductory Chemistry II</td>
<td>5</td>
</tr>
</tbody>
</table>
In addition to fulfilling the coursework required for a B.S. or B.A. in Biology and the Honors Thesis itself, students must:

1. carry at least a 3.3 GPA,
2. complete a minimum 2 credit hours of BIOL 4905 (Research).

### Academic Tracks within the Major of Biology

Biology majors may choose to focus their elective hours in a particular sub-discipline of biology, or academic track. These tracks are groups of departmental courses that fit within sub-disciplines of biology and are recommendations for students wanting to pursue careers in specific sub-disciplines. Academic tracks are NOT majors and are only intended to serve as guides for courses within a particular area of biology and are represented by current faculty expertise. Selecting an academic track does not prevent a student from taking courses in another track. Students should not expect to take all recommended courses for each academic track. Students may choose not to select an academic track. Currently, the Biology Department offers three academic tracks: Cell and Molecular Biology, Ecology, Evolution and Conservation Biology; and Pre-professional/Health Sciences.

#### Cell and Molecular Biology Track

- **BIOL 2102** General Ecology 3
- **BIOL 2103** General Ecology Laboratory 2
- **BIOL 2402** Vertebrate Anatomy 3
- **BIOL 2403** Vertebrate Anatomy Laboratory 2
- **BIOL 2482** Microbiology 3
- **BIOL 2483** Microbiology Laboratory 2
- **BIOL 2501** Biology Of Plants 5
- **BIOL 3102** Animal Behavior 3
- **BIOL 3103** Animal Behavior Laboratory 2
- **BIOL 3202** Conservation Biology 3
- **BIOL 3203** Conservation Biology Laboratory 2
- **BIOL 3802** Vertebrate Physiology 3
- **BIOL 3803** Vertebrate Physiology Lab 2
- **BIOL 4102** Behavioral Ecology 3
- **BIOL 4122** Biometry 3
- **BIOL 4182** Population Biology 3
- **BIOL 4192** Applications of Geographic Information Systems 5

### Departmental Honors Thesis

The Department of Biology offers the more motivated and highly achieving students the opportunity to present primary research in the form of a written Honors Thesis. The first step in conducting an undergraduate thesis is to identify a faculty research mentor; the mentor, along with two UMSL faculty members, will be readers of the thesis. It is highly recommended that students arrange to work full time on their honors thesis during the summer between the junior and senior years. Some funds are available from university, the Harris World Ecology Center, and departmental fellowships, but in more cases support will come from the sponsoring lab.

The thesis will be written in the form of a scientific manuscript and presented orally in an advertised public forum by the first of the month in which graduation is to occur. The readers of the thesis will decide on the appropriate level of honors, and will report their recommendation to the Dean of Arts and Sciences, so that the student is recognized at graduation as having graduated with Honors in Biology (or High Honors in Biology).
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4222</td>
<td>Tropical Ecology And Conservation</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 4245</td>
<td>Field Biology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 4299</td>
<td>Practicum In Conservation</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 4402</td>
<td>Ornithology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 4403</td>
<td>Ornithology Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 4422</td>
<td>Entomology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 4423</td>
<td>Entomology Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 4501</td>
<td>Flowering Plant Families: Phylogeny And Diversification</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Pre-professional/Health Sciences Track</td>
<td></td>
</tr>
<tr>
<td>BIOL 2402</td>
<td>Vertebrate Anatomy</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 2403</td>
<td>Vertebrate Anatomy Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 2482</td>
<td>Microbiology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 2483</td>
<td>Microbiology Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 3802</td>
<td>Vertebrate Physiology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 3803</td>
<td>Vertebrate Physiology Lab</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 4442</td>
<td>Developmental Biology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 4550</td>
<td>Bacterial Pathogenesis</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 4602</td>
<td>Molecular Biology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 4622</td>
<td>Cellular Basis of Disease</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 4652</td>
<td>Virology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 4712</td>
<td>Biochemistry</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 4822</td>
<td>Introduction To Neuroscience</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 4842</td>
<td>Immunobiology</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>BIOL 4245</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>BIOL 4299</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>BIOL 4402</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>BIOL 4403</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>BIOL 4422</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>BIOL 4423</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>BIOL 4501</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>BIOL 4245</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>BIOL 4299</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>BIOL 4402</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>BIOL 4403</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>BIOL 4422</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>BIOL 4423</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>BIOL 4501</td>
<td>5</td>
</tr>
</tbody>
</table>

**Bachelor of Science in Education with Emphasis in Biology**

The B.S. Ed. is a professional degree designed for individuals who wish to pursue a teaching career in biology in the secondary schools. The biology requirements parallel those for the B.A. degree with the exception that SEC ED 4985 (p. 1), Curriculum and Methods of Teaching Life Sciences, and BIOL 4986 (p. 1), Laboratory in Teaching Life Sciences, are substituted for BIOL 4889 (p. 1), Senior Seminar. Students must also fulfill the requirements for the B.S. Ed. degree as prescribed by the College of Education.

**Bachelor of Arts in Biology with Teacher Certification**

Biology majors interested in teaching biology in secondary schools may obtain teacher certification in cooperation with the College of Education by fulfilling the B.A. or B.S. with certain prescribed courses in biology, with the exception of BIOL 4889 (p. 1), Senior Seminar, and in addition, completing the following courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYCH 1003</td>
<td>General Psychology</td>
<td>3</td>
</tr>
<tr>
<td>TCH ED 2209</td>
<td>Foundations of Teaching in American Schools</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 3160</td>
<td>Writing In The Sciences</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Select one of the following:</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>HIST 1001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BIOL 4822</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>BIOL 4842</td>
<td>3</td>
</tr>
</tbody>
</table>

Because specific biology courses are required for teaching endorsement, students are advised to contact the Department of Biology AND the College of Education for special advising regarding teacher certification.

**Minor in Biology**

Students may minor in biology by completing a minimum of 19 credit hours in biology, of which at least 9 hours of the biology course credits must be taken in residence at UMSL.

Requirements are:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1821</td>
<td>Introductory Biology: Organisms And The Environment</td>
<td>5</td>
</tr>
<tr>
<td>BIOL 1831</td>
<td>Introductory Biology: From Molecules To Organisms</td>
<td>5</td>
</tr>
<tr>
<td>BIOL 2012</td>
<td>Genetics</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Two additional courses totaling no less than 6 credit hours. At least one course should be at the 3000 level or above.</td>
<td>6</td>
</tr>
</tbody>
</table>

**Total Hours 19**

All students must plan an appropriate course of study in consultation with an advisor, and the program must be given prior approval by the Chairperson of the Department of Biology. Under certain circumstances, a student may deviate from the prescribed course of study and substitute...
a group of courses that exhibit a coherent area of specialization to coordinate with a career objective.

Candidates must have a cumulative grade point average of 2.0 or better in the minor, courses may be taken on a satisfactory/unsatisfactory (s/u) basis.

**Minor in Environmental Studies**

This is an interdisciplinary program that integrates the natural and physical sciences with the social sciences and humanities to study current environmental problems resulting from human population growth, global climate change, overuse of natural resources, pollution and biodiversity loss. A minimum 18 hours are required, 9 of which must be in the natural and physical sciences, including the listed Honors College courses, and 9 must be from the social sciences and humanities. Both BIOL 1202 (Environmental Biology) and POL SCI 3480 Environmental Politics must be completed as part of the total 18 hours. A total of 12 hours must be taken at or above the 2000 level, with one additional course at or above the 3000 level besides POL SCI 3480. At least 9 hours must be taken while in residence at UMSL. A minimum GPA of 2.0 is required.

- **ANTHRO 1005** Introduction To Biological Anthropology 4
- **ANTHRO 3270** Human Ecology, Cultural Collapse, and Sustainable Developments 3
- **BIOL 1202** Environmental Biology 3
- **BIOL 1821** Introductory Biology: Organisms And The Environment 5
- **BIOL 2102** General Ecology 3
- **BIOL 2103** General Ecology Laboratory 2
- **BIOL 2501** Biology Of Plants 5
- **BIOL 3202** Conservation Biology 3
- **BIOL 3203** Conservation Biology Laboratory 2
- **BIOL 3302** Introduction To Evolution 3
- **BIOL 4102** Behavioral Ecology 3
- **BIOL 4192** Applications of Geographic Information Systems 5
- **BIOL 4222** Tropical Ecology And Conservation 3
- **BIOL 4245** Field Biology 3
- **BIOL 4270** Global Climate Change 3
- **BIOL 4402** Ornithology 3
- **BIOL 4422** Entomology 3
- **BIOL 4501** Flowering Plant Families: Phylogeny And Diversification 5
- **ECON 4160** Geospatial Analysis In The Social Sciences 3
- **ECON 4170** Fundamentals Of Cost-Benefit Analysis 3
- **ECON 4550** Natural Resource Economics 3
- **GEOL 1002** Historical Geology 4
- **HONORS 2050** Inquiries In The Natural Sciences 1-3
- **HONORS 2051** Inquiries in the Sciences: Laboratory or Field Work 1
- **INTL BUS 4281** Entrepreneurship in the Global Environment 3
- **PHIL 2255** Environmental Ethics 3
- **POL SCI 3480** Environmental Politics 3
- **POL SCI 3595** Studies In Comparative Politics 3
- **POL SCI 3850** International Organizations And Global Problem-Solving 3
- **POL SCI 3900** Special Readings 1-10
- **POL SCI 4460** Urban Planning And Politics 3

**Undergraduate Certificate in Biochemistry**

The university offers a certificate program for science majors who are interested in careers in biochemistry. The Biochemistry Certificate is an interdisciplinary specialization that may be earned within either a biology or chemistry major. To earn the certificate, biology majors must enroll in the Biochemistry Certificate Program upon the completion of 60 credit hours, fulfill all the science (biology, chemistry, math, and physics) course requirements for the B.S. degree in biology, and successfully complete the following courses:

- **CHEM 2622** Organic Chemistry II 3
- **BIOL/CHEM 4712** Biochemistry 3
- **CHEM 2223** Quantitative Analysis 3
- **CHEM 2633** Organic Chemistry Laboratory 2
- **BIOL 4713** Techniques In Biochemistry 2
- **CHEM 4722** Advanced Biochemistry 3

Select three of the following: 8-10

- **BIOL 2482** Microbiology
- **BIOL 2483** Microbiology Laboratory
- **BIOL 4442** Developmental Biology
- **BIOL 4602** Molecular Biology
- **BIOL 4612** Molecular Genetics Of Bacteria
- **BIOL 4614** Biotechnology Laboratory I
- **BIOL 4622** Cellular Basis of Disease
- **BIOL 4632** Nucleic Acid Structure And Function
- **BIOL 4842** Immunobiology

**Undergraduate Certificate in Biotechnology**

The university offers an undergraduate certificate program for biology majors who are interested in careers in biotechnology including biochemistry, microbiology, molecular biology, cell biology, and developmental biology. To earn the certificate, biology majors must enroll in the Biotechnology Certificate Program upon the completion of 60 credit hours, fulfill all the science (biology, chemistry, math, and physics) course requirements for the B.S. degree in biology, and successfully complete the following courses:

- **BIOL 2013** Genetics Laboratory 2
- **BIOL 2482** Microbiology 3
- **BIOL 2483** Microbiology Laboratory 2
- **CHEM 2622** Organic Chemistry II 3
- **BIOL 4614** Biotechnology Laboratory I 4
- **BIOL/CHEM 4712** Biochemistry 3
- **BIOL 4602** Molecular Biology 3
- **BIOL 4612** Molecular Genetics Of Bacteria
- **BIOL 4713** Techniques In Biochemistry 2
- **CHEM 4733** Biochemistry Laboratory 1

Select one of the following: 3-4

- **BIOL 4615** Biotechnology Laboratory II
- **BIOL 4622** Cellular Basis of Disease

**Total Hours** 24-26
### Undergraduate Certificate in Conservation Biology

The Certificate in Conservation Biology is a multidisciplinary program of study integrating theoretical and applied topics associated with conservation biology. The certificate is intended for undergraduate students with majors in biology or in any other field who wish to develop a specialization in conservation. The certificate is offered by the Department of Biology in cooperation with the departments of Anthropology, Economics, History, Political Science, Social Work, and Sociology. Building on a core curriculum, students can elect courses from these departments to complete their requirements. Regularly enrolled undergraduates at UMSL or individuals with baccalaureate degrees who wish to receive a Certificate in Conservation Biology are eligible to participate in the conservation certificate program. To participate, students must apply to the certificate program. Application forms are available from the Biology Department. Guidelines for admission to the certificate program are also available. Individuals with baccalaureate degrees who are interested in this certificate must apply to the university as unclassified undergraduates. The certificate requires completion of 21 credit hours, outlined below. Students should consult the Bulletin with regard to prerequisites for any of the courses listed here.

#### Core Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 2102</td>
<td>General Ecology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 3202</td>
<td>Conservation Biology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 3203</td>
<td>Conservation Biology Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 4299</td>
<td>Practicum In Conservation</td>
<td>2</td>
</tr>
</tbody>
</table>

#### Electives

The remaining 11 credits must be selected from courses listed below. Five credits must be taken from within biology and 6 credits outside biology, from at least two departments.

- **Anthropology**
  - ANTHRO 2120 Native Peoples Of North America (p. 1)
  - ANTHRO 2131 Archaeology Of Missouri (p. 1)
  - ANTHRO 2132 Archaeology Of North America (p. 1)

- **Biology**
  - BIOL 3123 Tropical Resource Ecology Field Studies (p. 1)
  - BIOL 4102 Behavioral Ecology (p. 1)
  - BIOL 4112 Evolution Of Animal Sociality (p. 1)
  - BIOL 4182 Population Biology (p. 1)
  - BIOL 4245 Field Biology (p. 1)
  - BIOL 4402 Ornithology (p. 1)
  - BIOL 4403 Ornithology Laboratory (p. 1)
  - BIOL 4422 Entomology (p. 1)
  - BIOL 4423 Entomology Laboratory (p. 1)
  - BIOL 4501 Flowering Plant Families: Phylogeny And Diversification (p. 1)

- **Economics**
  - ECON 3300 International Economic Analysis (p. 1)
  - ECON 3301 International Finance (p. 1)
  - ECON 4550 Natural Resource Economics (p. 1)

- **History**
  - HIST 3000 Selected Topics In History (p. 1)

- **Political Science**
  - POL SCI 3480 Environmental Politics (p. 1)
  - POL SCI 3590 Women and Leadership World-Wide: Breaking the Glass Ceiling (p. 1)
  - POL SCI 3850 International Organizations And Global Problem-Solving (p. 1)
  - POL SCI 4510 Comparative Public Policy And Administration (p. 1)

**Total Hours** 21

### Pre-professional Graduation

The Department of Biology sponsors a 3+4 Program for the UMSL College of Optometry.

In this program students may be admitted to the College of Optometry after completing three years (90 semester hours) of study in the Department of Biology. The undergraduate degree is granted when students satisfactorily complete the first year of optometry school. One or more of the following conditions must be met in order to qualify for the undergraduate degree. All general education requirements and all requirements for the major, except electives, must be completed. Any deficiency in required courses must be remedied with courses taken at UMSL within three years after entering the College of Optometry. Up to 6 hours from the College of Optometry may be substituted for undergraduate degree requirements, with approval of the Department of Biology.

**UMSL – Logan College (3+3 program)**

The Department of Biology has developed a 3+3 articulation agreement with Logan College of Chiropractic (LCC). This program enables qualified students the opportunity to complete a Bachelor of Science degree in Biology for the University of Missouri – St. Louis as well as a Doctor of Chiropractic for Logan College of Chiropractic in six years.
The program is only open to students who enter UMSL as first-time freshmen.

Participants must complete their first 90 hours of college work (3 years) at UMSL following a prescribed curriculum.

Participants who have achieved at least 3.25 GPA at UMSL will automatically be granted admission by Logan College of Chiropractic.

After successfully completing an additional 30 credit hours (4th year) at Logan, a student will receive a BS in Biology degree from UMSL.

After completing two additional years at Logan, the student will receive a doctorate in chiropractic.

The acceptance of transfer credits or testing toward completion of degree requirements shall be governed by current policies of UMSL. However, no more than 20 credits of required courses, and NONE of the science credits required for admission to LCC may be earned via examination or transfer from another school

LCC shall accept, for the entrance date of their choice, all students who successfully complete the Pre-Chiropractic Program with a cumulative GPA of 3.25 or higher and meet all other criteria for admission

Students who earn less than a 3.25 GPA, but at least a 2.50 GPA, will be eligible for admission to LCC, and will receive appropriate consideration in the admission process for having completed the UMSL Pre-Chiropractic Program, but will not receive the assurance of a seat reserved for students earning a 3.25 or higher GPA

Students will make application to LCC one year in advance of their desired entrance date and will complete all required application procedures thereafter in a timely manner, including submission of recommendation and a satisfactory interview.

This program offers benefits to students (six years instead of seven from high school to doctorate). The University of Missouri courses are listed below:

**General Education Requirements**

**Humanities:** 9
- Select from General Education List

**Social Sciences (One course must be a Psychology):** 9
- Select from General Education List of courses meeting Social Science Gen. Ed requirements.

**American History & Government** 3

**Choose**

Select one of the following: 3
- MATH 1310 Elementary Statistical Methods
- or MATH 1320 Applied Statistics I
- or BIOL 4122 Biometry
- COMM 1040 Introduction To Public Speaking
- ENGL 1100 First-Year Writing
- ENGL 3160 Writing In The Sciences

**Major**

Foundation courses:
- BIOL 1821 Introductory Biology: Organisms And The Environment 5
- BIOL 1831 Introductory Biology: From Molecules To Organisms 5

**Total Hours** 88-90

The remaining 30 hours to be taken at Logan include:

- Transfer Credits (34):
  - Anatomy I / Lab (6)
  - Spinal Anatomy / Lab (5)
  - Biochemistry I / Lab (4)
  - Histology / Cell Biology / Lab (5)
  - Anatomy II / Lab (6)
  - Neuroanatomy / Lab (5)
  - Biochemistry II (4)
  - Physiology I (4)
  - Microbiology / Lab (4)

**Graduate Studies**

The graduate program offers both Masters and Ph.D. degrees, as well as Graduate Certificates in Biotechnology and Tropical Biology and Conservation.

**Advisors**

All graduate students will have a faculty advisor. In the event that a student’s interest changes or the faculty advisor feels the student’s direction no longer falls with his/her area of expertise, the student and advisor should discuss whether a change of advisor is warranted. The graduate director must be notified in writing of any change in advisors. If a student or advisor is uncomfortable discussing the issue directly with the other, he/she is encouraged to meet with the director of the graduate program.

**Graduate Assistantships**

Stipends for teaching and research assistantships are awarded on a competitive basis to qualified graduate students in masters or PhD. Programs. Tuition fees are waived for graduate assistants. Applications for assistantships must be sent to the Director of Graduate Studies in the Department of Biology and received by December 15.
Master of Science in Biology

The Department of Biology offers three ways of achieving the Master of Science degree. The first is a 30 credit hour non-thesis option suitable for those who may already have extensive research experience, for educators who seek to upgrade their academic skills but do not require research experience, or for those who need to broaden their biological background. The second is a 32 credit hour Professional Science track that includes a strong business component for students who are interested in learning more about the business aspects of companies. This track may not be appropriate for students who are interested in pursuing a PhD or working primarily as laboratory scientists. The third is a 30 credit hour traditional apprenticeship in research leading to a written thesis. All students admitted to the graduate program are considered to be in the non-thesis program unless they have been accepted into an individual faculty lab. Starting with a common core, both the thesis and non-thesis option may be developed into a final degree program in either of two broad areas in biology:

1. Cell and Molecular Biology or

Non-thesis students may also elect to take courses in both areas. Only the non-thesis option is available in the Professional Science emphasis.

M.S. Admission Requirements

Applicants to the M.S. program must submit completed application and personal data forms, three letters of recommendation from undergraduate faculty or work supervisors, and transcripts of all previous work. Submission of Graduate Record Examination scores, although not required, is highly recommended and will be helpful for positive consideration of admittance. Admission as a regular graduate student requires graduation from an accredited college with a minimum grade point average overall and in biology courses of 3.0 (where A = 4.0).

All foreign applicants, except those from countries where English is the primary language, must take the TOEFL. Ordinarily, a score of 213 on the computer-based exam (550 on the paper-based exam) or better is required.

In addition to the Graduate School admission requirements, applicants should have completed advanced undergraduate biology courses including genetics, biochemistry, and evolution. Courses in organic chemistry, college physics, and calculus are also expected, and a course in statistics is highly recommended.

Students admitted to the degree program who have not met some of the prerequisites may be asked to pass appropriate courses before graduating. These courses will be agreed upon by the student’s advisor and the student during the first semester of enrollment. In particular, undergraduate deficiencies in genetics and either biochemistry or evolution shall be made up by taking the appropriate course(s). Three credits of BIOL 4920 Selected Topics can be given to graduate students for BIOL 2012 (Genetics) or BIOL 3302 (Evolution), if they receive a grade of B or better for all undergraduate course work and complete a graduate level paper assigned by the instructor. Instructor consent is required.

General Requirements

All students are required to take at least 4 but no more than 8 hours of BIOL 6889, Graduate Seminar. However, Professional Science masters students must take only 4 credit hours total of BIOL 6889. Thesis students are required to take BIOL 5179, Ethical Issues in Biology. Students are expected to maintain a GPA of 3.0 or better. Students may choose to specialize in either Cellular and Molecular Biology (CMB) emphasis area or the Ecology, Evolution and Systematics (EES) emphasis area, and appropriate courses in each area will be recommended by the student’s advisor. The Professional Science emphasis area in CMB has specific course requirements that are described below.

Non-thesis Option

Including the general requirement, students must take at least 30 graduate credit hours, of which at least half must be at the 5000 or 6000 level. No more than 5 hours of BIOL 6905, Graduate Research, may be counted toward the degree.

Thesis Option

The student and advisor work together to develop a research plan. The thesis proposal must be approved by the student’s adviser and advisory committee before the student enrolls in more than 4 credit hours of BIOL 6905, Graduate Research, and before the student has completed 15 credit hours in the master’s program. No more than 13 hours of BIOL 6905, Graduate Research, may be counted toward 30 hours of the degree. A thesis embodying results of original research shall be submitted to and approved by the Department of Biology and the Graduate School. This approval requires both a written thesis and oral presentation and defense.

Professional Science in Cellular and Molecular Biology Emphasis

This track requires a total of 32 credit hours, of which at least half must be at the 5000-level or above. Students will take 21 credit hours in Biology, 9 hours in business courses, and 2 credit hours of internship/practicum. Professional Science students: 1) must take 2 seminars (4 credit hours total) of BIOL 6889, 2) are limited to a maximum of 2 credit hours of Topics In Cellular and Molecular Biology (BIOL 5069) and 3) cannot count any hours of Graduate Research (BIOL 6905) as part of the 32 credit hour total.

Required Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 6889</td>
<td>Graduate Seminar (must be taken twice)</td>
<td>4</td>
</tr>
</tbody>
</table>

Choose three of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 6602</td>
<td>Advanced Molecular Biology</td>
</tr>
<tr>
<td>BIOL 6612</td>
<td>Advanced Molecular Genetics Of Bacteria</td>
</tr>
<tr>
<td>BIOL 6615</td>
<td>Advanced Biotechnology Laboratory II</td>
</tr>
<tr>
<td>BIOL 6622</td>
<td>Advanced Cellular Basis of Disease</td>
</tr>
<tr>
<td>BIOL 6632</td>
<td>Advanced Nucleic Acid Structure And Function</td>
</tr>
<tr>
<td>BIOL 6642</td>
<td>Advanced Plant Biology And Biotechnology</td>
</tr>
</tbody>
</table>

Elective Courses in Biology

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4713</td>
<td>Techniques In Biochemistry</td>
</tr>
<tr>
<td>BIOL 4842</td>
<td>Immunobiology</td>
</tr>
<tr>
<td>BIOL 5069</td>
<td>Topics In Cellular And Molecular Biology</td>
</tr>
<tr>
<td>BIOL 6442</td>
<td>Advanced Developmental Biology</td>
</tr>
<tr>
<td>BIOL 6550</td>
<td>Advanced Bacterial Pathogenesis</td>
</tr>
<tr>
<td>BIOL 6602</td>
<td>Advanced Molecular Biology</td>
</tr>
<tr>
<td>BIOL 6612</td>
<td>Advanced Molecular Genetics Of Bacteria</td>
</tr>
<tr>
<td>BIOL 6622</td>
<td>Advanced Cellular Basis of Disease</td>
</tr>
<tr>
<td>BIOL 6632</td>
<td>Advanced Nucleic Acid Structure And Function</td>
</tr>
<tr>
<td>BIOL 6642</td>
<td>Advanced Plant Biology And Biotechnology</td>
</tr>
<tr>
<td>BIOL 6652</td>
<td>Advanced Virology</td>
</tr>
<tr>
<td>BIOL 6920</td>
<td>Topics In Biology (when relevant)</td>
</tr>
</tbody>
</table>

University of Missouri-St. Louis
Doctor of Philosophy in Biology

The doctoral program emphasizes empirical and theoretical approaches to biological research. Students are required to integrate basic skills in biology with focal studies in an emphasis area. The program is designed to provide research experience and training appropriate for advanced positions in academic research and teaching, government and public agencies, and industry.

Ph.D. Admission Requirements

Applicants to the Ph.D. program must submit a formal application to the Graduate Admissions Office. In addition, the applicant should arrange to have sent: three letters of recommendation from faculty members at previously attended colleges or universities, GRE scores (Verbal, Quantitative, and Analytical), and transcripts of all postsecondary academic work. Admission to the Ph.D. program normally requires a minimum grade point average overall and in biology courses of 3.0 (where A=4.0). Applicants from countries where English is not a primary language are required to take the TOEFL examination. Scores must be submitted before admission can be decided. Ordinarily, a score of 550 or better is required.

Applicants should have a bachelor's or M.S. degree from an accredited United States college or university or evidence of equivalent training at an accredited institution outside the United States. They should have the appropriate background for graduate work in biology, including courses in genetics, biochemistry, and evolution. Courses in organic chemistry, college physics, and calculus are expected. A course in statistics is recommended. Students admitted to the Ph.D. program who have not met all the prerequisites may be required to make up deficiencies before admission to candidacy. The deficiencies will be decided during orientation meetings prior to the start of the second semester. Three credits of BIOL 4920 (p. 1) Selected Topics can be given to graduate students for BIOL 2012 (p. 1) or BIOL 3302 (p. 1) if they receive a grade of B or better for all undergraduate course work and complete a graduate-level paper assigned by the instructor. Instructor consent is required.

Ph.D. Degree Requirements

In addition to the general requirements of the Graduate School, the basic requirements for the Ph.D. degree in Biology include 60 graduate credit hours. At least 30 of the 60 hours must be taken at the 5000 or 6000 level. With the explicit consent of the advisory committee, students may take for graduate credit up to 3 credit hours of 3000 level courses in allied departments. All students are required to take BIOL 5179 (p. 1). Ethical Issues in Biology. Courses in biology at the 3000 level and below are not available for graduate credit. At least 31 of the 60 hours must be taken while in residence at the University of Missouri-St. Louis. Graduate credit for course work transferred from another program is subject to approval by the graduate committee and by the Graduate School. Graduate courses taken elsewhere will be considered for transfer credit during orientation meetings conducted prior to the start of the second semester of enrollment.

The requirements for all Ph.D. students include:

• 30 hours of course work, including:
  • At least 6 credits of BIOL 6889 (p. 1), Graduate Seminar
  • One credit of BIOL 5179 (p. 1), Ethics in Biology (to be taken the first semester)
  • BIOL 4122 (p. 1), Biometry, or an equivalent undergraduate course in statistics. This requirement is normally waived if the student has already taken an undergraduate course in statistics and received a B- or higher. Bioinformatics can also be substituted for BIOL 4122 (p. 1) Biometry.

The maximum number of credit hours that may be applied toward the 60-hour requirement is limited as stated below:

• BIOL 6889 (p. 1), Graduate Seminar: 10 hours
• BIOL 6905 (p. 1), Graduate Research: 30 hours

A combination of 6 total credit hours of the following:

• BIOL 5059 (p. 1), Topics in Ecology, Evolution, and Systematics
• BIOL 5069 (p. 1), Topics in Cellular and Molecular Biology
• BIOL 5079 (p. 1), Topics in Floristic Taxonomy

Emphasis area requirements

Each Ph.D. student is associated either with the Cellular and Molecular Biology (CMB) emphasis area, or the Ecology, Evolution and Systematics (EES) emphasis area. Each of these areas has its own course requirements in addition to the University-wide and department-wide requirements listed above.

Ecology, Evolution and Systematics

BIOL 5312 Theory Of Systematics 3
BIOL 6182 Advanced Population Biology 3
BIOL 5192 Community Ecology 3

Cellular and Molecular Biology

Select three of the following: 1 9-10

BIOL 6602 Advanced Molecular Biology
BIOL 6612 Advanced Molecular Genetics Of Bacteria
BIOL 6615 Advanced Biotechnology Laboratory II
BIOL 6622 Advanced Cellular Basis of Disease
BIOL 6632 Advanced Nucleic Acid Structure And Function
BIOL 6642 Advanced Plant Biology And Biotechnology
An equivalent graduate level course at another university may be substituted for one of the required courses, if approved by the Graduate Director.

Maintenance of Status
All students are expected to maintain a GPA of 3.0 or better. Students will normally meet formally with their thesis committee, or if that has not been formed, with their advisor each year to maintain their status in the program.

First-Year Experience
Ph.D. students in the Cellular and Molecular Biology emphasis area typically rotate through three different labs during their first semester before choosing/being accepted by a particular dissertation advisor. Ph.D. students in the Ecology Evolution and Systematics emphasis area typically are accepted by a particular dissertation advisor as part of the Ph.D. program application/acceptance process. All students are expected to become involved in research by the spring semester of their first year.

Qualifying Examination
All students must pass a qualifying examination consisting of a written and oral component. Students beginning studies in the fall semester will normally take the qualifying examination at the end of their fourth semester of full-time study. Doctoral students who have earned an M.S. degree previously are encouraged to take the examination in their first year.

The examination for Ecology, Evolution and Systematics students evaluates knowledge of fundamental principles presented in formal courses and in papers of special importance in the field. The written exam will be given in April at the end of the spring semester, and the oral portion immediately afterwards.

The Qualifying Examination for Cellular and Molecular students is composed of a written portion in which the student prepares a formal research proposal on a topic different from that of her/his doctoral dissertation research, and an oral portion during which the student defends the research proposal as well as his/her knowledge of the fundamental concepts of molecular biology, cell biology, and biochemistry.

Admission to Candidacy
To be admitted to candidacy, students must satisfy the requirements of the Graduate School, which includes passing all qualifying examinations and completing all required course work.

Dissertation Proposal
All students must defend orally a written dissertation proposal to their dissertation committee. The approved proposal must be submitted to the director of graduate studies in biology. Doctoral students may not enroll in more than 4 credits of graduate research (BIOL 6905 (p. 1)) before they have received approval for their dissertation proposal. The proposal is to be successfully defended by the end of the sixth semester.

Dissertation
A dissertation embodying the results of original research shall be submitted to and approved by the Department of Biology and the Graduate School. The general regulations of the Graduate School concerning the preparation of the dissertation must be met. These rules include a public oral defense of the written dissertation. Dissertations are to be presented in a style appropriate for one or more publications in scientific journals.

Teaching
At least one semester of supervised teaching is required of all doctoral students.

Graduate Certificate in Biotechnology
The Graduate Certificate in Biotechnology is offered for students with a bachelor's degree who wish to obtain advanced level training in those fields of biology that pertain to biotechnology without necessarily earning a master's degree. Students who enter this program may have a variety of interests, including biochemistry, microbiology, molecular biology, cell biology, developmental biology, or molecular evolution.

For more information about our graduation rates, the median debt of students who completed this graduate certificate program, and other important information, please visit our Gainful Employment Disclosure website: http://umsl.edu/go/Bom.

Admission
Students who wish to earn a Graduate Certificate in Biotechnology must apply to the Biotechnology Certificate Program for admission to the program. Students must be enrolled in the graduate program at the University of Missouri-St. Louis either as non-degree students or as master's students.

Students who wish to obtain a Master's degree with a Biotechnology Certificate must be accepted into the Master's degree program in Biology as well as into the Biotechnology Certificate Program. Students who apply to the certificate program as non-degree students will earn only the certificate.

Students must have at least a 3.0 GPA for undergraduate course work to be accepted into the program. The minimum course prerequisites for admission to the program are undergraduate courses in genetics, cell biology, and biochemistry.

Requirements
Students must maintain a minimum GPA of 3.0 to remain in the certificate program. The certificate is awarded after completion of the courses listed below. Students enrolled in the Master's program may simultaneously earn a graduate degree and count the appropriate courses from the list below toward the Biotechnology Certificate.

The biotechnology certificate requires 18 credit hours of course work:

Electives
Select 11 credits from the following:

Biology

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 6612</td>
<td>Advanced Molecular Genetics Of Bacteria</td>
<td>3</td>
</tr>
</tbody>
</table>

1. An equivalent graduate level course at another university may be substituted for one of the required courses, if approved by the Graduate Director.
The Graduate Certificate in Tropical Biology and Conservation is intended for students who wish to pursue a career in conservation biology or ecology from either a research or practical standpoint. The certificate is awarded after completion of 18 credit hours of core courses in ecology, evolution and genetics. Students may simultaneously earn a graduate degree and count credits outside biology with a maximum of 7 outside biology. A maximum of 3 credits may be taken at institutions other than UMSL.

Requirements

The certificate is awarded after completion of 18 credit hours of core courses and electives with a minimum of 12 credits at the 5000 or 6000 level. Up to 3 credits may be taken at the 2000 - 3000 level upon permission of the Graduate Committee. Electives must include a minimum of 3 credits outside biology with a maximum of 7 outside biology. A maximum of 3 credits may be taken at institutions other than UMSL. Students may simultaneously earn a graduate degree and count credits earned in their degree program toward the certificate when appropriate.

Sample Four Year Plans

Biology BA (p. 12) Biology BS (p. 13)

Biology BA

First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Hours</th>
<th>Spring</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTDSIC 1003</td>
<td>1 General Education</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>ENGL 1100</td>
<td>3 MATH 1035</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>MATH 1030</td>
<td>3 CHEM 1111</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
**General Education**

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1821</td>
<td>5</td>
</tr>
</tbody>
</table>

**Second Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1121</td>
<td>5</td>
</tr>
<tr>
<td>MATH 1800</td>
<td>5</td>
</tr>
<tr>
<td>BIOL 1831</td>
<td>5</td>
</tr>
<tr>
<td>MATH 1800</td>
<td>5</td>
</tr>
</tbody>
</table>

**Third Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 2223, 2622, 2633, or 4712 ²</td>
<td>2-3</td>
</tr>
<tr>
<td>BIOL 3622</td>
<td>3</td>
</tr>
<tr>
<td>PHYSICS 1012</td>
<td>4</td>
</tr>
<tr>
<td>General Education</td>
<td>3</td>
</tr>
<tr>
<td>Elective or minor</td>
<td>3</td>
</tr>
</tbody>
</table>

**Fourth Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGL 3160</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 2000+ level lab course</td>
<td>2-3</td>
</tr>
<tr>
<td>BIOL 4000+ level lecture course</td>
<td>3</td>
</tr>
<tr>
<td>General Education</td>
<td>3</td>
</tr>
<tr>
<td>Elective or minor</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total Hours: 120-123**

1. INTDSC 1003 is required only for first-time freshmen and transfer students with less than 24 college credits.
2. CHEM 2633 is a 2 credit hour course. The Biology diversity course taken in the Spring semester must be 5 credit hours in order to meet the 120 hours required for the degree.
3. The general education courses listed assumes the U.S. History/ Government requirement is fulfilled with a Social/Behavioral Science or Humanities general education course.

Please Note: This plan is an example of what a four year plan could look like for a typical student. Placement exam scores in math as well as the completion of coursework may change the plan. It should not be used in the place of regular academic advising appointments. All students are encouraged to meet with their advisor each semester. All requirements are subject to change.

**BIOLOGY BS**

**First Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTDSC 1003</td>
<td>5</td>
</tr>
<tr>
<td>ENGL 1100</td>
<td>3</td>
</tr>
<tr>
<td>MATH 1030</td>
<td>3</td>
</tr>
</tbody>
</table>

**Second Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1831</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 1121</td>
<td>5</td>
</tr>
<tr>
<td>MATH 1800</td>
<td>5</td>
</tr>
<tr>
<td>General Education</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 2612</td>
<td>3</td>
</tr>
</tbody>
</table>
**Biology**

**Biol 1102 Human Biology: 3 semester hours**
Lectures and readings concerned with the reproduction, development, genetics, functional anatomy, behavior, ecology, and evolution of the human species. Three hours lecture per week. Fulfills Science/Math requirement.

**Biol 1131 Human Physiology and Anatomy I: 4 semester hours**
Prerequisite: Biol 1012 or its equivalent. The basic aspects of the structure of the healthy human body and how it functions. Special emphasis is on how the human body adapts itself to its environment and how changes affect physiological activities. Three hours lecture and two hours laboratory per week.

**Biol 1141 Human Physiology and Anatomy II: 4 semester hours**
Prerequisite: Biol 1131. A continuation of Biol 1131. A study of the basic aspects of human physiology and anatomy. Three hours lecture and two hours laboratory per week.

**Biol 1162 General Microbiology: 3 semester hours**
Prerequisite: Biol 1012 or its equivalent. A survey of microbiology structure, genetics, and physiology. Special emphasis will be placed on the transmission and control of such organisms as it relates to the maintenance of human health. Three hours lecture per week.

**Biol 1202 Environmental Biology: 3 semester hours**
An examination of the biological basis of current environmental problems, with emphasis upon resources, energy, pollution and conservation. Three hours lecture per week. Fulfills Science/Math requirement.

**Biol 1212 Applied Environmental Sciences: 4 semester hours**
In a combined lecture/laboratory setting, students will get hands-on experience collecting and testing environmental samples for abiotic factors such as contaminants, and experimentally assessing the impact of those contaminants on the biological communities contained within the samples. Important approaches include global positioning and information technologies, microscopy, microbiological techniques, genomics, and quantitative analytical measures for assessing the physical, biological and chemical properties of collected samples.

**Biol 1821 Introductory Biology: Organisms and the Environment: 5 semester hours**
Prerequisites: A minimum of high school chemistry, ENGL 1100 or equivalent (may be taken concurrently), and placement into college algebra or higher. Required for students intending to major in biology or take specified biology courses at the 2000 level or above. This course presents an introduction to some of the principles of biology and scientific methodology applied to the organism and supraorganism levels of biology. Topics to be covered include: ecology, evolution, diversity, and population biology. Three hours of lecture and one hour of discussion per week.

**Biol 1831 Introductory Biology: From Molecules to Organisms: 5 semester hours**
Prerequisites: A minimum of high school chemistry and MATH 1030; ENGL 1100 or equivalent (may be taken concurrently). Required for students intending to major in biology or take specified biology courses at the 2000 level or above. This course presents and introduction to some of the principles of biology and scientific methodology applied to the molecular/ cellular through organ system levels of organization. Topics include: cell structure, metabolism, reproduction, heredity and major physiological processes regulated by organ systems. Three hours of lecture, three and one half hours of lab, and one hour of discussion per week.

**Biol 1999 Evolution for Everyone: 3 semester hours**
Evolution for Everyone explores the development of our current understanding by examining modern and ancient controversies, and by studying major processes by which change occurs. Lectures will present overviews and many examples on topics in history, mechanisms, and outcome of evolutionary change, and students will participate in classroom and online discussions based on readings, computer exercises, and data collection and analysis. Course may not be applied towards major in Biology. Not eligible for credit with Biol 3302 (Introduction to Evolution) required for Biology majors.

**Biol 2012 Genetics: 3 semester hours**
Prerequisites: Biol 1831 (majors must also take Biol 1821), MATH 1030, and CHEM 1111 or (CHEM 1081 plus CHEM 1091). Fundamental principles of inheritance, including classical genetic theory as well as recent advances in the molecular basis of heredity. Three hours of lecture per week. Fulfills Science/Math requirement.

**Biol 2013 Genetics Laboratory: 2 semester hours**
Prerequisites: Concurrent registration in Biol 2012, or by permission of instructor. Laboratory to accompany Biol 2012. Three and one-half hours of organized laboratory time per week. Students may need to return to the laboratory at unscheduled times to complete some exercises.

**Biol 2102 General Ecology: 3 semester hours**
Prerequisites: Biol 1821 and Biol 1831. An examination of the relationships between living organisms and their environment. Three hours lecture per week. Fulfills Science/Math requirement.

**Biol 2103 General Ecology Laboratory: 2 semester hours**
Prerequisites: Biol 2102 required (may be taken concurrently); a general statistics course strongly recommended. An analysis of environmental factors influencing the abundance and distribution of living organisms. Some classes will be held at field sites in and around St. Louis. Three and one-half hours of laboratory or field work per week.

**Biol 2402 Vertebrate Anatomy: 3 semester hours**
Prerequisites: Biol 1821 and Biol 1831. Development, structure, function, interrelationships, and zoogeography of vertebrate animals with particular attention to phylogenetic aspects. Three hours of lecture per week. Fulfills Science/Math requirement.

**Biol 2403 Vertebrate Anatomy Laboratory: 2 semester hours**
Prerequisite: Biol 2402 (may be taken concurrently). Laboratory to accompany Biol 2402. Morphological analysis and systematic survey of major vertebrate groups. Overview of the vertebrate life forms and their adaptations to habitats and resources. Three and one-half hours of laboratory per week.

**Biol 2482 Microbiology: 3 semester hours**
Prerequisites: Biol 1831 (majors must also take Biol 1821), MATH 1030, and CHEM 1111. Study of microorganisms, their metabolism, genetics, and their interaction with other forms of life. Three hours of lecture per week.

**Biol 2483 Microbiology Laboratory: 2 semester hours**
Prerequisite: Biol 2482 (may be taken concurrently). Experimental studies and procedures of microbiological techniques. Three and one-half hours of organized laboratory time per week. Students will need to return to the laboratory at unscheduled times to complete some exercises.
**BIOL 2501 Biology Of Plants: 5 semester hours**
Prerequisites: BIOL 1821 and BIOL 1831. A general discussion of the plant groups from algae through angiosperms. Plant morphology, physiology, reproduction and ecology will be discussed in lecture (three hours per week). The laboratory (three and one half hours per week) involves examination of representatives of the plant kingdom and experimentation in plant physiology and genetics. Fulfills both a lecture and laboratory requirement.

**BIOL 3001 Experiential Practicum in Biosciences: 1 semester hour**
Prerequisites: Consent of Biology Curriculum Committee. Credit for off-campus bioscience projects providing extraordinary student experience and service to a community in need.

**BIOL 3102 Animal Behavior: 3 semester hours**
Prerequisites: BIOL 1821 and BIOL 1831. The study of invertebrate and vertebrate behavior, including neurophysiological, hormonal, developmental, genetic, ecological and evolutionary aspects of behavior; behavior interactions within and between populations. Three hours of lecture per week.

**BIOL 3103 Animal Behavior Laboratory: 2 semester hours**
Prerequisites: BIOL 3102 (may be taken concurrently). Observational and experimental studies of animal behavior in the field and laboratory. Three and one-half hours of formal laboratory time per week, but additional time may be required for independent projects. Some activities involve field trips or trips to the St. Louis Zoo.

**BIOL 3202 Conservation Biology: 3 semester hours**
Prerequisites: BIOL 1821 and BIOL 1831. Introduction to the principles and theories of conservation biology. Course topics include biodiversity, extinctions, population modeling, habitat fragmentation, conservation area management, restoration ecology, and social science elements of conservation strategies. Class sessions will include lectures, discussions, and simulation exercises. Three hours of lecture per week.

**BIOL 3203 Conservation Biology Laboratory: 2 semester hours**
Prerequisite: BIOL 3202 (recommended to be taken concurrently). Laboratory to accompany BIOL 3202. Laboratory will include computer simulations of conservation problems using existing software, 2-3 field trips to local conservation projects, and field interviews with governmental and nongovernmental agencies. Three and one-half hours of laboratory per week.

**BIOL 3302 Introduction To Evolution: 3 semester hours**
Prerequisites: BIOL 1821 and BIOL 1831, and MATH 1030; BIOL 2012 strongly recommended. Introduction to the theory, events, and processes of organic evolution.

**BIOL 3622 Cell Biology: 3 semester hours**
Prerequisites: BIOL 1831, BIOL 2012, CHEM 2612, and MATH 1030. Examination of the organization and basic processes of cells including tissues, organelles, glycolysis, respiration, photosynthesis, trafficking, cytoskeleton, signal transduction, and cell division.

**BIOL 3699 Undergraduate Internship In Biotechnology: 1-4 semester hours**
Prerequisites: BIOL 1821, BIOL 1831, and CHEM 1111 and CHEM 1121 and consent of instructor. Concurrent enrollment in CHEM 2612 or higher is strongly encouraged. A 2.5 GPA and enrollment in the undergraduate Biotechnology Certificate Program is required. Internship will consist of a period of observation, experimentation and on-the-job training in a biotechnology laboratory. The laboratory may be industrial or academic. Credit will be determined by the number of hours a student works each week and in consultation between the intern's supervisor and instructor. Internship assignments will be commensurate with the education and experience of the student. Two credits may be used to fulfill the lab requirement.

**BIOL 3802 Vertebrate Physiology: 3 semester hours**
Prerequisites: BIOL 1821 and BIOL 1831 and CHEM 1111 or CHEM 1081 plus CHEM 1091. Basic functional aspects of organ systems in relation to the physiochemical properties of protoplasm. Three hours lecture per week. Fulfills Science/Math requirement.

**BIOL 3803 Vertebrate Physiology Lab: 2 semester hours**
Prerequisite: BIOL 3802 (may be taken concurrently). Instrumental and experimental studies in physiology. Three and one-half hours laboratory per week.

**BIOL 4102 Behavioral Ecology: 3 semester hours**
Prerequisite: BIOL 3102 (BIOL 3302 recommended). The evolution and ecology of animal behavior. Topics include the theoretical framework for making predictions, foraging, decision making, sensory ecology, sexual selection, mating systems, sociality and groups, cooperation, signal use and communication. Three hours of lecture per week. Students may not receive credit for both BIOL 4102 and BIOL 6102.

**BIOL 4122 Biometry: 3 semester hours**
Prerequisites: MATH 1030 and a minimum of 15 hours in biology. Reviews descriptive, analytical, and experimental methods useful for the statistical study of biological phenomena. Students will develop the skills needed to better appreciate and evaluate the published literature, as well as the ability to design their own research programs. Topics include: the collection and summarization of biological observations; development, design, and testing of hypothesis; analysis and presentation of data. Three hours of lecture per week. Fulfills the statistics requirement for the B.A. or B.S. degree in biology.

**BIOL 4182 Population Biology: 3 semester hours**
Prerequisite: BIOL 2102 and BIOL 2012 (BIOL 3302 recommended) Introduces concepts and mathematical models of population ecology and population genetics. By integrating the ecology and genetics of populations, the course goal is to understand the processes that contribute to microevolution of populations. Topics include: demography, metapopulation biology, natural selection, migration, gene flow, and genetic drift. Three hours of lecture per week. Students may not receive credit for both BIOL 4182 and BIOL 6182.
**Biol 4192 Applications of Geographic Information Systems: 5 semester hours**
Prerequisites: BIOL 2102, BIOL 4122 or equivalent, and consent of instructor. Geographic Information Systems (GIS) are sophisticated computer-based systems for analysis, capture, presentation, and maintenance of geographically referenced data. This course provides a foundation in using GIS for spatial analysis. Although biological examples are primarily used, examples from a range of disciplines are employed to emphasize the use of GIS as a tool to support analysis and decision-making. Students will have hands-on use of GIS software during each session. An independent research project applying the spatial analysis tools learned in GIS to biological research will be required. Five hours of combined lecture and computer operations, plus 2-3 hours of open lab per week. Fulfills both a lecture and a laboratory requirement. Students may not receive credit for both BIOL 4192 and BIOL 6192.

**Biol 4222 Tropical Ecology And Conservation: 3 semester hours**
Prerequisite: BIOL 2102, BIOL 4182, or BIOL 5192, or equivalent. This course will cover research areas in tropical population, community and ecosystem ecology, with emphasis on inter-species and environment-organism interactions, population control factors, and genetic structure of populations. Topics include the current status and causes of tropical habitat destruction, ongoing attempts to manage those habitats, and development of strategies leading to sustained use of non-renewable resources. Three hours of lecture per week. Students may not receive credit for both BIOL 4222 and BIOL 6222.

**Biol 4245 Field Biology: 3 semester hours**
Prerequisite: Three biology courses and consent of instructor. Intensive study of the flora and fauna of selected natural areas of North America, including an extended field trip. Details of the field trip and course schedule will be posted in the Biology department preceding registration for the term in which the course will be offered. Students will be required to pay costs of travel and of the field trip. This is a laboratory course appropriate for advanced undergraduates and non-thesis Master of Science students.

**Biol 4270 Global Climate Change: 3 semester hours**
Prerequisites: BIOL 3302 or consent of instructor. Topics included are fundamental physical, meteorological, and biological circumstances of global climate change, as well as predictions of its future effects on biological diversity, including humans, and how those estimates are made. In addition, basic environmental economics and politics of climate change at local and global levels will be included. The course will be taught as a series of lectures and discussions led by guest experts in each of the subdisciplines covered. Students may not receive credit for both BIOL 4270 and BIOL 6270.

**Biol 4299 Practicum In Conservation: 2 semester hours**
Prerequisites: Consent of instructor and BIOL 3202. This course is generally restricted to students officially enrolled in the Certificate Program in Conservation Biology. The course provides practical experience with conservation or environmental agencies. Specific placement will be selected according to student's interests and career goals as well as availability of agency openings. Course requirements include practical experience and final report on practicum experience.

**Biol 4308 Transmission Electron Microscopy Hours: 3 semester hours**
Same as PHYSICS 4308. Course introduces students to transmission electron microscopy techniques and their applications to solving challenging materials and biological problems. Course includes fundamental principles (electron optics), electron-specimen interactions, diffraction of electrons, image formation and interpretation, image processing and analysis, energy dispersive X-ray spectroscopy, electron energy loss spectroscopy, and sample preparation of both biological and non-biological systems. Laboratory experiments will provide students "hands-on" experience with TEM operations and problem solving skills. Successful completion of the course enables students to independently operate transmission electron microscopes to perform basic research experiments. This course is ideal for students interested in ultrastructural or nanocharaterization of biological or materials systems. Two classroom hours and two hours of laboratory per week.

**Biol 4402 Ornithology: 3 semester hours**
Prerequisites: BIOL 2102 and junior standing. Introduction to avian biology and ecology. Material to be covered will include basic adaptations of anatomy, physiology, and behavior of birds. There will be a strong emphasis on avian ecology and conservation. Specific topics will include flight, reproductive behavior, migration, foraging behavior, community structure, and current conservation concerns. The diversity of birds will be emphasized through comparisons between temperate and tropical regions. Three hours of lecture per week.

**Biol 4403 Ornithology Laboratory: 2 semester hours**
Prerequisites: BIOL 4402 (may be taken concurrently), or consent of instructor. This course will introduce students to methods of identifying and studying birds. Labs will almost entirely be comprised of field trips to local areas and will emphasize diversity of birds, adaptations shown by different groups, and means of identification, particularly of birds found in Missouri. Field projects will focus on techniques for censusing birds, sampling foraging behavior, and studying habitat selection. Indoor periods will cover internal and external anatomy of birds. Slides and field trips to the St Louis Zoo will be used to survey the diversity of birds worldwide. Three and one-half hours of laboratory per week. Longer (e.g., Saturday) field trips will be made when appropriate.

**Biol 4422 Entomology: 3 semester hours**
Prerequisites: BIOL 1821 and BIOL 1831. 9 additional hours of biology and upper-division standing. Development, structure, function, behavior and ecology of insects, including a systematic survey of the orders of Insecta. Three hours of lecture per week.

**Biol 4423 Entomology Laboratory: 2 semester hours**
Prerequisites: BIOL 4442 (may be taken concurrently). Laboratory to accompany BIOL 4422. Studies of the morphology, physiology, and behavior of insects to give a sampling of biological studies of the class Insecta. Formation of a collection of insects, comprising a systematic survey of orders and principal families, will be an integral part of the course and will require additional time beyond the official lab hours. Three and one-half hours of lab per week.
BIO 4442 Developmental Biology: 3 semester hours
Prerequisites: BIOL 2012 and BIOL 3622. A study of the basic principles that shape the embryonic and post-embryonic development of animals with an emphasis on the underlying cellular and molecular mechanisms. Specific topics include fertilization, determination of cell fate and differentiation, cell migration, establishment of the body plan, formation of selected organs and organ systems, stem cells, and limb regeneration. Environmental influences on development and the impact of developmental biology on modern medicine are also discussed. Three hours of lecture/discussion per week. Students may not receive credit for both BIOL 4442 and BIOL 6442.

BIO 4501 Flowering Plant Families: Phylogeny And Diversification: 5 semester hours
Prerequisites: BIOL 1821, BIOL 1831 and junior standing or consent of instructor. Focusing on the flowering plant families of North America, the aim of the course is to give an understanding of their phylogeny and diversification. Student will also gain an understanding of plant morphology and anatomy, a basis for further developing their knowledge of plants. Three hours of lecture and three to four hours of laboratory per week. Students may need to return to the laboratory at unscheduled times.

BIO 4502 Evolution of Cognition: 3 semester hours
Prerequisites: BIOL 3102 or Consent of Instructor; BIOL 3302 and PSYCH 2211 are strongly recommended. The evolutionary ecology of animal cognitive abilities. Topics include learning, memory, perception, navigation, and communication from an evolutionary perspective. The focus is on cognitive abilities as adaptations, which have evolved to solve specific environmental problems. Topics include empirical methods for assessing cognitive ability, experimental design, theoretical approaches for generating predictions, and the parsimonious interpretation of data. Two hours of lecture and one hour of discussion per week.

BIO 4550 Bacterial Pathogenesis: 3 semester hours
Prerequisites: BIOL 2012 and BIOL 2482. Examination of the strategies bacterial pathogens use to infect animals. Topics include host immune responses to infection, bacterial virulence factors, regulation of bacterial virulence, and the cellular and molecular approaches used to study hostparasite interactions. Three hours of lecture per week. Students may not receive credit for both BIOL 4550 and BIOL 6550.

BIO 4602 Molecular Biology: 3 semester hours
Prerequisites: BIOL 2012 and CHEM 2612. A study of the principles of molecular biology, with emphasis on understanding the genetic regulation of DNA, RNA, and protein synthesis and function in eukaryotic cells. Three hours of lecture per week. Students may not receive credit for BIOL 4602 and either BIOL 6602, or any course previously called Gene Expression in Eukaryotes or Advanced Gene Expression in Eukaryotes.

BIO 4612 Molecular Genetics Of Bacteria: 3 semester hours
Prerequisites: BIOL 2012 and BIOL 2482. A study of the molecular biology of gene replication, transfer, and expression in bacterial cells. Topics include DNA replication, transcription and translation, mutagenesis, DNA repair and recombination, gene transfer, and the regulation of genes and global expression systems. Three hours of lecture per week. Student may not receive credit for BIOL 4612 and either BIOL 6612 or any course previously called Gene Expression in Prokaryotes or Advanced Gene Expression in Prokaryotes.

BIO 4614 Biotechnology Laboratory I: 4 semester hours
Prerequisites: BIOL 2012 or consent of instructor. An introduction to the fundamental concepts that underlie the field of biotechnology. Both the basic principles of molecular biology and hand-on experience with the techniques of the field will be addressed through lectures, discussions, and a series of laboratory exercises. Two hours of lecture and four hours of laboratory per week. Fulfills a laboratory requirement only; may not be used to fulfill the higher level (4000-5000) lecture course requirement for the B.A. or B.S. degree in biology. Students may not receive credit for BIOL 4614 and a comparable biotechnology course from another institution.

BIO 4615 Biotechnology Laboratory II: 4 semester hours
Prerequisites: BIOL 4614 and either BIOL 4602 or BIOL 4612, or consent of instructor. An in-depth look at theory and practice of biotechnology. Lectures and discussion will examine the underlying principles, and laboratory exercises will present hands-on experience with current techniques. One hour of lecture and six hours of laboratory per week. Fulfills a laboratory requirement only; may not be used to fulfill the higher level (4000-5000) lecture course requirement for the B.A. or B.S. degree in biology. Students may not receive credit for BIOL 4615 and BIOL 6615.

BIO 4662 Plant Molecular Biology and Genetic Engineering: 3 semester hours
Prerequisites: BIOL 2012. Topics may include molecular and cellular aspects of plant growth, development, and responses to environmental stress and pathogen attack, using the experimental approaches of genetics, molecular biology, and biochemistry. Plant growth manipulation and genetic engineering, including techniques required for DNA transfer and plant regeneration, as well as current and potential future applications, such as engineered resistance to stress, developmental engineering, and metabolic engineering, also will be covered. Three hours of lecture per week. Students may not receive credit for both BIOL 4662 and BIOL 6632.

BIO 4642 Plant Molecular Biology and Genetic Engineering: 3 semester hours
Prerequisites: BIOL 2012 or consent of instructor. An introduction to the fundamental concepts that underlie the field of biotechnology. Both the basic principles of molecular biology and hand-on experience with the techniques of the field will be addressed through lectures, discussions, and a series of laboratory exercises. Two hours of lecture and four hours of laboratory per week. Fulfills a laboratory requirement only; may not be used to fulfill the higher level (4000-5000) lecture course requirement for the B.A. or B.S. degree in biology. Students may not receive credit for BIOL 4614 and a comparable biotechnology course from another institution.

BIO 4650 Virology: 3 semester hours
Prerequisites: BIOL 2012 and BIOL 3622. This first half of the course entails a comparative study of the structure, replication, and molecular biology of viruses. The second half of the course focuses on the pathogenesis, control, and evolution of animal viruses. Three hours of lecture per week. Students may not receive credit for both BIOL 4652 and BIOL 6652.
**BIOL 4662 Human Pathology:** 3 semester hours
Prerequisites: BIOL 3622 or consent of the instructor. A study of disease processes as they affect the human body. The course will examine both the proximate causes and underlying mechanisms of disease. Specific conditions will be used to illustrate application of clinical approaches in determining the origin, development, and effects of a disease.

**BIOL 4712 Biochemistry:** 3 semester hours
Prerequisites: CHEM 2612 and either BIOL 1831 or CHEM 2622. (Same as CHEM 4712) Examines the chemistry and function of cell constituents, and the interaction and conversions of intracellular substances. Students may not receive credit for both BIOL 4712 and CHEM 4712.

**BIOL 4713 Techniques in Biochemistry:** 2 semester hours
Prerequisites: BIOL 4712 or CHEM 4712 (may be taken concurrently). Laboratory activities introducing fundamental qualitative and quantitative biochemical techniques. Student evaluation will be based on laboratory participation, student laboratory reports, and written examinations. Three and one-half hours of organized laboratory time per week. Students may need to return to the laboratory at unscheduled times to complete some experiments.

**BIOL 4797 Biochemistry and Biotechnology Seminar:** 1 semester hour
Prerequisites: Same as CHEM 4797. Senior standing in the Biochemistry and Biotechnology program. This course will focus on selected publications related to biochemistry and biotechnology from both refereed journals and news sources. Students are expected to participate in discussions and to prepare oral and written presentations. Completion of the Major Field Achievement Test in Biochemistry & Biotechnology is a course requirement. May not be taken for graduate credit.

**BIOL 4822 Introduction To Neuroscience:** 3 semester hours
Prerequisite: BIOL 3802 or consent of instructor. The study of nervous systems, featuring the cellular bases of initiation and conduction of the impulse, synaptic transmission, and the network integrative function of invertebrate and vertebrate nervous systems. This course emphasizes the multidisciplinary nature of the neurosciences, including anatomical, physiological and molecular approaches to understanding neural function. Three hours of lecture per week.

**BIOL 4842 Immunobiology:** 3 semester hours
Prerequisite: BIOL 3622 and CHEM 2612. The fundamental principles and concepts of immunology and immunochemistry. Emphasis on the relation of immunological phenomena to biological phenomena and biological problems. Three hours lecture per week.

**BIOL 4889 Senior Seminar:** 2 semester hours
Prerequisites: BIOL 1821, BIOL 1831, BIOL 2012, and BIOL 3302, with a total of at least 30 credits in Biology. Oral and written presentation by students of selected scientific papers or articles. Students are expected to participate in discussions of oral presentations by other students. May not be taken for graduate credit.

**BIOL 4905 Research:** 1-3 semester hours
Prerequisites: Consent of faculty research advisor. Research in an area selected by the student in consultation with and under the direct supervision of an UMSL biology faculty research adviser. Research opportunities are subject to availability and must be approved in advance of beginning research. The project may include the reading of pertinent literature, laboratory or field experience, including keeping of a logbook, and a summary paper and a presentation, all based on an average 8 hours per week per credit during a 15 week semester at the discretion of the instructor. Credit arranged. Course may be repeated for a total of up to 5 credit hours. A maximum of one lab requirement may be satisfied using any two BIOL 4905 credits. Additional credits may be applied toward the total biology hours required for the biology BA or BS. May not be taken for graduate credit.

**BIOL 4915 Biology Internship:** 1-3 semester hours
Prerequisites: Consent of faculty research advisor; generally restricted to junior and senior standing. Research in an area selected by the student to be conducted off-campus in a lab of a professional researcher or faculty person (the internship mentor) other than those in UMSL Biology. Research opportunities are subject to availability and must be approved in advance of beginning research by an UMSL biology faculty liaison and the internship mentor. The project normally includes the reading of pertinent literature, laboratory or field experience, including keeping of a logbook, and a summary paper and a presentation, all based on an average 8 hours per week per credit during a 15 week semester. Credit arranged. This course and BIOL 4905 may be repeated in any combination for a total of up to 5 credit hours. A maximum of one lab requirement may be satisfied using any two BIOL 4905 and/or BIOL 4915 credits. Additional credits may be applied toward the total biology hours required for the biology BA or BS.

**BIOL 4920 Selected Topics:** 1-10 semester hours
Prerequisite: Junior standing and consent of instructor. Selected topics in biology. The topics will vary each semester. Topics offered for the following semester will be available in the departmental office. Credit arranged. May be taken more than once for credit.

**BIOL 4986 Laboratory In Teaching Life Sciences:** 2 semester hours
Same as SEC ED 4986. Prerequisite: TCH ED 3310. Discussion, development, utilization, and evaluation of equipment, materials, and techniques applicable to instruction in the life sciences. Must be taken concurrently with SEC ED 4985.

**BIOL 5059 Topics In Ecology, Evolution, And Systematics:** 1 semester hour
Prerequisites: Consent of faculty research advisor. Research in an area selected by the student in consultation with and under the direct supervision of an UMSL biology faculty research adviser. Research opportunities are subject to availability and must be approved in advance of beginning research. The project may include the reading of pertinent literature, laboratory or field experience, including keeping of a logbook, and a summary paper and a presentation, all based on an average 8 hours per week per credit during a 15 week semester at the discretion of the instructor. Credit arranged. Course may be repeated for a total of up to 5 credit hours. A maximum of one lab requirement may be satisfied using any two BIOL 4905 and/or BIOL 4915 credits. Additional credits may be applied toward the total biology hours required for the biology BA or BS. May not be taken for graduate credit.

**BIOL 5079 Topics In Floristic Taxonomy:** 1 semester hour
Prerequisite: BIOL 2501 or equivalent, and graduate standing. Seminar course in systematics of higher plants, arranged in the Cronquist sequence of families, covering morphology, anatomy, palynology, biogeography, chemo systematics, cytology, and other aspects of plant classification and phylogenetics. Given at the Missouri Botanical Garden. One hour per week.
**BIOL 5089 Topics In Animal Behavior: 1 semester hour**  
Prerequisites: Graduate standing. Presentation and discussion of current research articles and/or student and faculty research projects in animal behavior, including ecology, evolution, genetics, and mechanisms of behavior. May be repeated.

**BIOL 5099 Biology Colloquium: 1 semester hour**  
Prerequisites: Graduate standing. Attendance is required for the Biology weekly seminar series, consisting of research presentations by department faculty and invited speakers. Class sessions will include discussion of scientific research and presentation practices.

**BIOL 5123 Advanced Tropical Resource Ecology Field Studies: 2 semester hours**  
Prerequisites: BIOL 5122 (may be taken concurrently). The field component to the lecture and seminar course. Examines the patterns of use and exploitation of resources in the topics by humans in the context of the theories of behavioral ecology. Two weeks of intensive field research and lectures in Guyana, South America during the second and third weeks of Summer Session I (trip costs to be borne by the student). Students may not receive credit for both BIOL 3123 and BIOL 5123. Offered in odd numbered years.

**BIOL 5177 Graduate Research Writing Workshop in Biology: 1 semester hour**  
Prerequisites: Graduate standing. This hands-on course is designed to give Biology graduate students practical assistance and advice on writing, including grant proposal content and organization, writing succinctly but clearly, and editing. The course format will include both informational lectures with discussions and working sessions focused on writing and critiquing drafts. Students are recommended to begin the class ready to write at least one aim of a grant or thesis proposal. Course is graded on a satisfactory/unsatisfactory basis.

**BIOL 5178 Introduction to Graduate Research in Biology: 1 semester hour**  
Prerequisites: Graduate standing or consent of instructor. A discussion-based class to introduce new PhD and thesis MS students to the Biology department, graduate school, and best research practices.

**BIOL 5179 Ethical Issues in Biology: 1 semester hour**  
Prerequisites: Graduate Standing. Using readings and discussions, students will explore ethical issues in Biology in both professional and social realms. Professional topics include authorship, grants accounting, and academic misconduct; social topics include ethical foundations of basic and applied science, government regulation of science, environmental and individual protection, and current issues. Course graded on a satisfactory/unsatisfactory basis.

**BIOL 5192 Community Ecology: 3 semester hours**  
Prerequisites: Graduate standing and either BIOL 2102 and BIOL 4182 or an equivalent course. Studies of structure and organization of natural communities stressing the abundance and distribution of species, the regulation of species diversity, and the evolution of demographic parameters in populations.

**BIOL 5302 Advanced Evolution: 3 semester hours**  
Prerequisites: BIOL 3002 or graduate standing. Explores advanced topics in the study of adaptation and the origin of species. Covers phenomena both within populations (e.g. natural selection, sexual selection, and molecular evolution) and between populations (e.g. speciation, coevolution, competition, gene flow, biogeography, and comparative phylogenetics), with a particular focus on recent primary literature.

**BIOL 5312 Theory Of Systematics: 3 semester hours**  
Prerequisites: BIOL 1821, BIOL 1831 and at least one course beyond the introductory level dealing with animal, plant, or microbial diversity (such as BIOL 2482, BIOL 2501, BIOL 2402, BIOL 4482, BIOL 4501, BIOL 4402, BIOL 4422) or consent of instructor. Course investigates the theory of classification, phylogenetic analysis, systematic biology, and their relation to systematic practice. Will cover goals and schools of systematics, characters and homology, analysis of molecular and morphological data and underlying assumptions, species concepts, classification, naming, and the connections between evolutionary biology and systematics. The course is appropriate for upper level undergraduates & graduate students in all disciplines, animal, plant, and microbial, as an introduction to systematic methods. Three hours of lecture per week.

**BIOL 5436 Applied Bioinformatics: 3 semester hours**  
Prerequisites: BIOL 4712 or BIOL 4602 or consent of instructor. This course provides a survey of the various computational approaches that can be used to solve biological problems. Specific attention will be focused on biological databases and methods for using and interpreting database information, sequence alignments, functional genomics, structure prediction, high-throughput analyses, and proteomics. Three hours of lecture per week.

**BIOL 5798 Practicum in Science in Business: 1-2 semester hours**  
Same As CHEM 5798. Prerequisites: Graduate standing and enrollment in a Professional Science emphasis in Chemistry, Biochemistry & Biotechnology, or Biology. Students will integrate and apply their scientific expertise to a practical, business-related problem. The course will emphasize interdisciplinary team-work as well as both written and oral communication skills.

**BIOL 5799 Internship in Sciences in Business: 1-2 semester hours**  
Same As CHEM 5799. Prerequisites: Graduate standing and enrollment in a Professional Science emphasis area in Chemistry, Biochemistry & Biotechnology, or Biology. The internship will consist of period of on-the-job training at a local company. Credit hours will be determined by the number of hours the student works each week and in consultation between the intern's supervisor and the course instructor. Internship assignments will be commensurate with the education and experience of the student, with an emphasis on work at the interface between the scientific and business components of the company. A written report describing the internship project is required.

**BIOL 6102 Advanced Topics In Behavioral Ecology: 3 semester hours**  
Prerequisite: BIOL 3102 (BIOL 3302 is recommended). The evolution and ecology of animal behavior. Topics include the theoretical framework for making predictions, foraging, decision making, sensory ecology, sexual selection, mating systems, sociality and groups, cooperation, and signal use and communication. Three hours of lecture per week. Assignments will include a heavy emphasis on theory and modelling approaches to behavioral ecology. Students may not receive credit for both BIOL 4102 and BIOL 6102.

**BIOL 6182 Advanced Population Biology: 3 semester hours**  
Prerequisites: BIOL 2012 (BIOL 3302 recommended). Introduces concepts and mathematical models of population ecology and population genetics. By integrating the ecology and genetics of population, the course goal is to understand the processes that contribute to microevolution of populations. Topics include: demography, metapopulation biology, natural selection, migration, gene flow, and genetic drift. A discussion section will focus on mathematical elements of population biology models. Three hours of discussion per week. Students may not receive credit for both BIOL 4182 and BIOL 6182.
BIOL 6192 Applications Of Geographic Information Systems: 5 semester hours
Prerequisites: BIOL 2102, BIOL 4122 or equivalent, and consent of instructor. Geographic Information Systems (GIS) are sophisticated computer-based systems for analysis, capture, presentation, and maintenance of geographically referenced data. This course provides a foundation in using GIS for spatial analysis. Although biological examples are primarily used, examples from a range of disciplines are employed to emphasize the use of GIS as a tool to support analysis and decision-making. Students will have hands-on use of GIS software using Windows 2000/NT based workstations during each session. An independent research project applying the spatial analysis tools learned in GIS to biological research will be required. Five hours of combined lecture and computer operations, plus 2-3 hours of open lab per week.

BIOL 6222 Advanced Tropical Ecology And Conservation: 3 semester hours
Prerequisite: BIOL 2102, BIOL 4182, or BIOL 5192, or their equivalent. This course will cover research areas in tropical population, community and ecosystem ecology, with emphasis on inter-species and environment-organism interactions, population control factors, and genetic structure of populations. Topics include the current status and causes of tropical habitat destruction, ongoing attempts to manage those habitats, and development of strategies leading to sustained use of non-renewable resources. A research proposal designed to investigate a current topic in tropical ecology will be required. Students may not receive credit for BIOL 4222 and BIOL 6222. Three hours of lecture per week.

BIOL 6250 Public Policy Of Conservation And Sustainable Development: 3 semester hours
Prerequisite: Same as POL SCI 6452. Graduate standing in Biology or Political Science and consent of instructor. Prior course in ecology recommended. This course will introduce the student to concepts and techniques for formulating, implementing, and analyzing public policy with an emphasis on environmental concerns, conservation, and sustainable development. The course will be team taught by a political scientist and a biologist. Course materials will include case studies that demonstrate the special problems of environmental policymaking in developing and developed economies.

BIOL 6270 Advanced Global Climate Change: 3 semester hours
Prerequisites: Graduate Standing or permission of the instructor. We will cover the fundamental physical, meteorological, and biological circumstances of global climate change, as well as predictions of its future effects on biological diversity, including humans, and how those estimates are made. We will also cover basic environmental economics and politics of climate change at local and global levels. The course will be taught as a series of lectures and discussions led by guest experts in each of the subdisciplines covered. Students may not receive credit for both BIOL 4270 and BIOL 6270.

BIOL 6299 Internship In Conservation Biology: 1-4 semester hours
Prerequisite: BIOL 6250 or BIOL 6212 and consent of the director of graduate studies in biology. Internships will consist of a period of study, observation and on-the-job training at a conservation or environmental agency. Specific placements will be selected according to student’s interests and career goals. Internships may vary from 2 weeks to 4 months in duration.

BIOL 6442 Advanced Developmental Biology: 3 semester hours
Prerequisites: BIOL 2012 and BIOL 3622. A study of the basic principles that shape the embryonic and post-embryonic development of animals with an emphasis on the underlying cellular and molecular mechanisms. Specific topics include fertilization, determination of cell fate and differentiation, cell migration, establishment of the body plan, formation of selected organs and organ systems, stem cells, and limb regeneration. Environmental influences on development and the impact of developmental biology on modern medicine are also discussed. Three hours of lecture/discussion per week. Students may not receive credit for both BIOL 4442 and BIOL 6442.

BIOL 6502 Advanced Evolution Of Cognition: 3 semester hours
Prerequisites: BIOL 3102 and BIOL 3302, or consent of instructor; PSYCH 2211 strongly recommended. The evolutionary ecology of animal cognitive abilities. Topics include learning, memory, perception, navigation, and communication from an evolutionary perspective. The focus is on cognitive abilities as adaptations, which have evolved to solve specific environmental problems. Topics include empirical methods for assessing cognitive ability, experimental design, theoretical approaches for generating predictions, and the parsimonious interpretation of data. Two hours of lecture and one hour of discussion per week. Students may not receive credit for both BIOL 4502 and BIOL 6502.

BIOL 6550 Advanced Bacterial Pathogenesis: 3 semester hours
Prerequisites: BIOL 2012 and BIOL 2482. Examination of the strategies bacterial pathogens use to infect animals. Topics include host immune responses to infection, bacterial virulence factors, regulation of bacterial virulence, and the cellular and molecular approaches used to study hostparasite interactions. Students may not receive credit for both BIOL 6550 and BIOL 4550. Students will be required to give an oral presentation and/or write an extra paper on a topic relevant to the course. Three hours of lecture per week.

BIOL 6602 Advanced Molecular Biology: 3 semester hours
Prerequisites: BIOL 2012 and CHEM 2612, or consent of instructor. A study of the principles of molecular biology, with emphasis on understanding the genetic regulation of DNA, RNA, and protein synthesis and function in eukaryotic cells. Three hours of lecture per week. Students will be required to give an oral presentation and/or write an extra paper on a topic relevant to the course. Students may not receive credit for both BIOL 6602 and BIOL 4602, or any course previously called Gene Expression in Eukaryotes or Advanced Gene Expression in Eukaryotes.

BIOL 6612 Advanced Molecular Genetics Of Bacteria: 3 semester hours
Prerequisites: BIOL 2012 and BIOL 2482. A study of the molecular biology of gene replication, transfer, and expression in bacterial cells. Topics include DNA replication, transcription and translation, mutagenesis, DNA repair and recombination, gene transfer, and the regulation of genes and global expression systems. Three hours of lecture per week. Students will be required to give an oral presentation and/or write an extra paper on a topic relevant to the course. Student may not receive credit for both BIOL 6612 and BIOL 4612 or any course previously called Gene Expression in Prokaryotes or Advanced Gene Expression in Prokaryotes.
**BIOL 6615 Advanced Biotechnology Laboratory II: 4 semester hours**
Prerequisites: BIOL 4614 and either BIOL 4602 or BIOL 4612, or consent of instructor. An in-depth look at the theory and practice of biotechnology. Lectures and discussion will examine the underlying principles, and laboratory exercises will present hands-on experience with current techniques. One hour of lecture and six hours of laboratory per week. Students will be required to give an oral presentation and/or write an extra paper on a topic relevant to the course. Students may not receive credit for both BIOL 6615 and BIOL 4615 or any course previously called Techniques in Molecular Biology or Advanced Techniques in Molecular Biology.

**BIOL 6618 Practical Next-Generation Sequencing: 3 semester hours**
Prerequisites: Consent of instructor. This is a laboratory course in practical next-generation sequencing. Roughly one-half of the course will focus on bench-top methods for generating sequencing libraries from total RNA as well as the use of next-generation sequencing instruments. The second half of the course will focus on computational methods for analyzing sequencing data, including data visualization and coding.

**BIOL 6622 Advanced Cellular Basis of Disease: 3 semester hours**
Prerequisites: BIOL 3622, or consent of instructor. A study of the structural organization and processes of eukaryotic cells, focusing on how defects in cellular function lead to genetic diseases and cancer. Topics of discussion may include membrane dynamics, intracellular trafficking, signal transduction, and the cell cycle. Three hours of lecture per week. Students may not receive credit for both BIOL 6622 and BIOL 4622.

**BIOL 6632 Advanced Nucleic Acid Structure And Function: 3 semester hours**
Prerequisites: BIOL 2012 and BIOL 4712 or equivalent, or consent of instructor. A comprehensive view of the structural properties of DNA and RNA that promote molecular interactions & biological function. Topics will include the physical properties of nucleic acids, the formation and biological importance of higher order structures, RNA enzymatic activities, nucleic acid-protein interactions, and RNA metabolism. Three hours of lecture and one hour of discussion per week. Students may not receive credit for both BIOL 6632 and BIOL 4632.

**BIOL 6642 Advanced Plant Biology And Biotechnology: 3 semester hours**
Prerequisites: Graduate standing. Topics may include molecular and cellular aspects of plant growth, development, and responses to environmental stress and pathogen attack, using the experimental approaches of genetics, molecular biology, and biochemistry. Plant growth manipulation and genetic engineering, including the techniques required for DNA transfer and plant regeneration, as well as current and potential future applications, such as engineered resistance to stress, developmental engineering, and metabolic engineering, also will be covered. Student may not receive credit for both BIOL 4642 and BIOL 6642.

**BIOL 6652 Advanced Virology: 3 semester hours**
Prerequisites: BIOL 2012, BIOL 3622, and graduate standing. This first half of the course entails a comparative study of the structure, replication, and molecular biology of viruses. The second half of the course focuses on the pathogenesis, control, and evolution of animal viruses. Three hours of lecture, one hour of discussion or seminar per week. Students may not receive credit for both BIOL 4652 and BIOL 6652.

**BIOL 6699 Graduate Internship In Biotechnology: 1-4 semester hours**
Prerequisites: Graduate standing and enrollment in graduate Biotechnology Certificate Program. 6 credit hours maximum (maximum of 8 combined credit hours of BIOL 6905 and internship) Internship will consist of period of observation, experimentation and on-the-job training in biotechnology laboratory. The laboratory may be industrial or academic. Credit will be determined by the number of hours the student works each week and in consultation between the intern's supervisor and the instructor. Internship assignments will be commensurate with the education and experience of the student.

**BIOL 6889 Graduate Seminar: 2 semester hours**
Presentation and discussion of various research problems in biology. Graduate student exposure to the seminar process.

**BIOL 6905 Graduate Research In Biology: 1-10 semester hours**
Research in area selected by student in consultation with faculty members.

**BIOL 6915 Graduate Research Practicum: 1-2 semester hours**
Prerequisite: Consent of instructor. This course is designed for graduate students wishing to pursue research experience in an area outside their dissertation topic. The project can be techniques-oriented or focused on a specific research question. The credit hours will depend on the time commitment to the project as decided by the supervisory faculty member.

**BIOL 6920 Topics In Biology: 1-5 semester hours**
In-depth studies of selected topics in contemporary biology. May be repeated.