

# BIOLOGY

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## Interdepartmental Undergraduate Program

Iowa State University is a major center for research and education in the biological sciences. With over 200 faculty in the life sciences, students have the opportunity to learn from some of the nation's leaders in biological research and teaching and to participate in innovative, meaningful research projects that explore frontiers of biology. Few other universities have such a wealth of faculty expertise available to undergraduate students, making Iowa State's Biology Program the logical choice for those who want to participate in a thriving academic community.

The faculties of the Department of Ecology, Evolution, and Organismal Biology and the Department of Genetics, Development, and Cell Biology jointly offer the undergraduate biology major. This high quality academic program has the flexibility to accommodate a range of career goals while taking advantage of the university's strengths in science and technology. A bachelor's degree in biology provides excellent preparation for graduate study in biological disciplines ranging from the molecular to the ecological levels, and for entrance into various professional schools, such as human medicine, physical therapy, or veterinary medicine. The major is well suited for those who plan to teach biology, who wish to enter government or industrial employment in health or environmental professions, or who prefer educational breadth as an end in itself. By working with our professional and faculty advisers, it is possible to design a unique program of study that will meet student needs and objectives.

Students with special interests and aptitudes should consider combining biology with a minor or a second major in another subject, such as chemistry, environmental studies, journalism, mathematics, music, statistics, or many other subjects offered by the university.

## Customizing a degree

Biology encompasses an amazing diversity of disciplines and scales of study ranging from molecules to the biosphere. The Biology major offers a rich variety of coursework addressing most of the areas of biology.

The major's curriculum requirements offer tremendous flexibility in creating an individualized program of study to facilitate achievement of a student's career goals, while simultaneously assuring some exposure to all areas of biology and providing complementary knowledge from supporting courses in chemistry, physics, and math/statistics.

While flexibility is the hallmark of the Biology major, the breadth of the field can also be challenging. Thus, in an effort to provide more guidance to students who desire such, the major also provides five advising tracks, or areas of specialization, for students who wish to focus on subfields of biology or who have specific career goals in mind. Course plans for each area of specialization are listed on the Biology web site. The areas are:

**Pre-medical and Human Health Professions**—This area emphasizes preparation for further study in medical school or allied human health professions such as dentistry, optometry, genetic counseling, physical therapy, occupational therapy, physician assistant, nursing, chiropractic, and others. It also will prepare students for a broad range of careers in the biological sciences. Students are urged to determine the specific entrance requirements for the professional schools where they might study and to plan a program of study accordingly, in addition to following the basic plan.

**Pre-veterinary**—An eventual degree in Veterinary Medicine can lead to a wide variety of careers, including private clinical practice in small animal medicine or agricultural animal production. But, pre-veterinary students can also prepare themselves for careers in animal research, public health, laboratory animal medicine, food safety, regulatory medicine, and education. Specific requirements for entrance to the Iowa State Veterinary College or other schools should be consulted as programs of study are planned, in addition to following the basic plan.

**Molecular and Cellular Biology**—Students specializing in this field will explore the structure, function, and interactions of the molecules and sub-cellular features that make up living cells. This area is particularly designed for those who plan to pursue a career in research in molecular or cell biology or in related areas such as biochemistry, genetics, microbiology, developmental biology, human medicine, or veterinary medicine. Many students in this area will choose to go on to graduate school.

**Ecology and Conservation Biology**—Ecologists examine the interactions and relationships that living organisms have with each other and their environment. Conservation biologists study the nature and status of Earth's biodiversity with the aim of protecting species, their habitats, and ecosystems from excessive rates of extinction and loss. Students who choose this specialization may go on to work for a non-profit environmental group; an environmental consulting firm; a local, state, or federal agency; or other related organizations. Many students in this area will choose to go on to graduate school.

**Evolution and Biodiversity**—This area provides students with a sound understanding of evolutionary principles and the biological patterns that result from evolutionary change. Students have the opportunity to explore, in depth, the biodiversity found within a wide range of groups of organisms. Students who choose this specialization may go on to work for a non-profit environmental group; an environmental consulting firm; a local, state, or federal agency; or other related organizations. Many students in this area will choose to go on to graduate school.

## Other opportunities

**Teacher licensure**—Biology majors seeking recommendation for licensure to teach biology in secondary schools must meet requirements of the

Teacher Education Program as well as those of the Biology Program. In addition, they must apply formally for admission to the teacher education program. See the section on Teacher Education for a list of licensure areas, degree requirements, and other information about this program.

Undergraduate research—Students who have interests in biological research are encouraged to become involved in the research projects of faculty members on campus. Those doing so may receive credit for the experience in BIOL 499 Undergraduate Research Experience.

Making the effort to find a suitable research mentor and engaging in research work can be one of the most valuable experiences of an undergraduate education. Internship experiences are often available at other universities, zoos, museums, governmental and non-governmental entities focused on environmental issues, and industrial or government laboratories. Students participating in such projects may receive internship credit in BIOL 494 Biology Internship.

Field trip courses – The Biology Program offers two field trip courses: BIOL 393 (North American Field Trips in Biology) and BIOL 394 (International Field Trips in Biology). In recent years field trip opportunities to the Boundary Waters area of Minnesota, Honduras, and Spain have been available. These courses involve a pre-trip seminar followed by one-week to one-month long field trip at a time when academic year classes are not in session. The classes are low enrollment and allow extensive interaction between instructors and students in locations of biological interest.

International experience—Because major discoveries in science often result from global efforts, biology majors are encouraged to include an international or study abroad component in their degree programs. This can be done by participating in international field trips originating from the ISU campus in BIOL 394 International Field Trips in Biology. In addition, many students choose to study abroad, attending a university in another country for up to a year as an exchange student. Minors in a foreign language can also add an international emphasis to a degree in biology.

### Courses offered at other locations

In addition to biological science courses taught on campus, students may take courses at various remote locations and arrange to have the credits count toward the advanced courses required in the biology major.

Attending a summer field station adds an important component to an undergraduate program of study.

Gulf Coast Research Laboratory—The Gulf Coast Research Laboratory is affiliated with the University of Southern Mississippi. Iowa State students may register for marine biology courses and transfer credit to their degree programs under the number BIOL 480 Studies in Marine Biology. Written permission of the Biology Program Director is required for this arrangement.

Summer Biological Field Stations—Courses taken at summer field stations may be transferred to Iowa State University as credit in BIOL 481 Summer Field Studies. Such stations are found throughout the country and often offer courses that emphasize the adaptation of plants and animals to unique environments. See [www.biology.iastate.edu](http://www.biology.iastate.edu) (<http://www.biology.iastate.edu/>) for links to Iowa Lakeside Laboratory and other field stations in different biomes, e.g., marine/coastal, Great Lakes, taiga, deciduous forests, deserts, Rocky Mts., etc.

Organization for Tropical Studies—Iowa State students may register for courses in tropical biology taught in Costa Rica by the Organization for Tropical Studies. Credit is transferred to Iowa State as BIOL 482 Tropical Biology. For further information, contact the Biology Student Services Office in 103 Bessey Hall.

## Undergraduate Study

Biology majors start their studies in the biological sciences by taking a two-semester long Principles of Biology course sequence:

BIOL 211	Principles of Biology I	3
BIOL 211L	Principles of Biology Laboratory I	1
BIOL 212	Principles of Biology II	3
BIOL 212L	Principles of Biology Laboratory II	1

During the first year, students also take BIOL 110 Introduction to Biology and BIOL 111 Opportunities in Biology, which are half semester courses designed to introduce the student to the discipline of biology and opportunities for careers in biology. Students transferring into the Biology major take BIOL 112 in place of BIOL 110.

Students then explore, in any order depending on their interests, four upper-level core courses including: concepts of ecology in BIOL 312; the principles of genetics in BIOL 313 and BIOL 313L; cell and molecular biology in BIOL 314; and evolutionary biology in BIOL 315. Biology majors must take an additional 21 credits of advanced biological science courses at the 300 level, or above, from an approved list of courses. Many of these courses have as prerequisites BIOL 211/L and BIOL 212/L, so students do not need to complete the four upper-level core courses before taking advanced courses. Of these advanced courses, at least 9 credits must be taken as BIOL courses, and a minimum of two laboratory or field courses must also be included from an approved list.

Biology majors should carefully consider their selection of upper-level courses to allow them to emphasize one, or more, of the sub-disciplines of Biology relevant to their post-baccalaureate objectives. Most biology courses numbered 300 or above can be used to satisfy the additional credit requirement. Some courses taught in other departments can also be applied to the biology major. Advanced students should consider

including 500 level courses in their programs. The Biology Program's web site has a complete listing of acceptable upper-level life science courses.

Biology majors must demonstrate competency in their understanding of the biological sciences. A 2.0 cumulative average is required in biology and advanced biology coursework. In order to graduate, a student must have a cumulative average in the major of at least 2.00.

## General requirements

Students may earn the B.S. degree in Biology from either the College of Liberal Arts and Sciences or from the College of Agriculture and Life Sciences. Students in the College of Liberal Arts and Sciences must fulfill the foreign language and general education requirements for that college. Students in the College of Agriculture and Life Sciences must meet the general education requirements for that college. Contact the Student Services Office for details regarding differences in general education and course requirements that are specific to these colleges.

Supporting course requirements-- Understanding biology requires a basic understanding of the physical sciences and mathematics. Consequently, a minimum number of credits in general chemistry, organic chemistry, biochemistry, and physics is required. See the Biology Program Web Site for specific supporting science requirements.

The Math requirement is competency based. After demonstrating competency in algebra and trigonometry, biology majors must take two semesters of calculus; or two semesters of Statistics; or one semester of calculus and one semester of Statistics chosen from a list of approved courses available on the Biology Program Web Site and in the Biology Program Office.

Given the important role of communications in the modern sciences, biology majors must demonstrate communication competency by earning a minimum of C in ENGL 250 Written, Oral, Visual, and Electronic Composition or equivalent composition courses and in one advanced writing course numbered ENGL 302 through ENGL 316, or JL MC 347, or SP CM 212. (Students in the College of Agriculture and Life Sciences are required to earn a C or better in ENGL 150, as well.)

## Minor

A minor in Biology is offered by the Biology Program. The minor requires 15 credits in Biology and includes the completion of the specific courses listed below and 7 credits in biology courses numbered 300 or above. Nine (9) credits of the required courses must apply only to the minor. For more information, see the Biology Program web site or contact the Student Services Office in 103 Bessey Hall.

BIOL 211	Principles of Biology I	3
BIOL 211L	Principles of Biology Laboratory I	1
BIOL 212	Principles of Biology II	3

BIOL 212L	Principles of Biology Laboratory II	1
<b>Total Credits</b>		<b>8</b>

## Graduate Study

Biology is an undergraduate major only. Persons interested in graduate study in the biological sciences should apply directly to one of the life science graduate programs at Iowa State University. Interdepartmental graduate offerings in Bioinformatics and Computational Biology; Ecology and Evolutionary Biology; Genetics; Molecular, Cellular and Developmental Biology; Neuroscience; Plant Biology; Toxicology; Immunobiology; and Environmental Science are also available. (See Index.)

A non-thesis master's degree in Interdisciplinary Graduate Studies (biological sciences) has been established particularly for those who wish to have a more diversified program of advanced study than that generally permitted by specific departments and programs.

## Curriculum in Biology

Administered by the Departments of Ecology, Evolution, and Organismal Biology; and Genetics, Development and Cell Biology. Students should consult the Biology Student Services Office, 103 Bessey (or biology@iastate.edu) for the appropriate course selections for professional or graduate school preparation.

### Total Degree Requirement: 120 cr.

Only 65 cr. from a two-year institution may apply which may include up to 16 technical cr.; 9 P-NP cr. of free electives; 2.00 minimum GPA.

### Biology: 23.5 cr.

2.00 GPA average required.

BIOL 110	Introduction to Biology	1
BIOL 111	Opportunities in Biology	0.5
BIOL 211	Principles of Biology I	3
BIOL 211L	Principles of Biology Laboratory I	1
BIOL 212	Principles of Biology II	3
BIOL 212L	Principles of Biology Laboratory II	1
BIOL 312	Ecology	4
BIOL 313	Principles of Genetics	3
BIOL 313L	Genetics Laboratory	1
BIOL 314	Principles of Molecular Cell Biology	3
BIOL 315	Biological Evolution	3
<b>Total Credits</b>		<b>23.5</b>

**Advanced Biology: 21 cr.**

2.00 GPA average required. See the Biology Program web site for list of approved Advanced Biology courses, or consult an adviser in the Biology Student Services office, 103 Bessey Hall.

Biology advanced courses (from approved list)	9
Additional approved biology advanced courses	12
<b>Total Credits</b>	<b>21</b>

**Mathematical Sciences 7 cr.**

Students in College of Agriculture and Life Sciences must have a Math and Statistics.

MATH 160 or 165 and STAT 101 or 104

Or		
MATH 165	Calculus I	8
& MATH 166	and Calculus II	

Or		
STAT 101 or 104 and STAT 301		4-7

**Physical Sciences**

General Chemistry: 5 cr. minimum

CHEM 163	College Chemistry	5
& 163L	and Laboratory in College Chemistry	

Or		
CHEM 177	General Chemistry I	5
& 177L	and Laboratory in General Chemistry I	

CHEM 178	General Chemistry II	4
& 178L	and Laboratory in College Chemistry II	

Organic Chemistry: 4 cr. minimum

CHEM 231	Elementary Organic Chemistry	4
& 231L	and Laboratory in Elementary Organic Chemistry	

Or		
CHEM 331	Organic Chemistry I	4
& 331L	and Laboratory in Organic Chemistry I	

Biochemistry: 3 cr.

BBMB 316	Principles of Biochemistry	3
Or		

BBMB 404	Biochemistry I	3
Or		

BBMB 420	Mammalian Biochemistry	3
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Physics: 5 cr. minimum

PHYS 115	Physics for the Life Sciences	5
& 115L	and Laboratory in Physics for the Life Sciences	

Or		
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PHYS 111	General Physics	10
& PHYS 112	and General Physics	

**International Perspective: 3 cr.****U.S. Diversity: 3 cr.****Communication/Information Literacy**

Students must earn a C or better in ENGL 250 and the advanced communication course. Additionally, students in the College of Agriculture and Life Sciences must earn a C or better in ENGL 150.

ENGL 150	Critical Thinking and Communication	3
ENGL 250	Written, Oral, Visual, and Electronic Composition	3
LIB 160	Information Literacy	1
SP CM 212	Fundamentals of Public Speaking	3
or ENGL 312	Biological Communication	

<b>Total Credits</b>		<b>10</b>
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**Humanities and Social Sciences**

Chosen from approved lists.

LAS - Biology

Note: Students must have completed 3 years of a single world language or take 4-8 credits of university level world language.

Humanities	12
Social Sciences	9

<b>Total Credits</b>	<b>21</b>
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**Humanities and Social Sciences**

Chosen from approved lists.

CALS - Biology

Note: Students in CALS - Biology must take an approved speech course and an approved Math and Statistics course.

Humanities	3
Social Sciences	3

Ethics	3
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<b>Total Credits</b>	<b>9</b>
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**Biology, B.S.****Freshman**

Fall	Credits Spring	Credits
ENGL 150 or 250	3 BIOL 111	0.5
LIB 160	1 BIOL 212	3
BIOL 110	1 BIOL 212L	1
BIOL 211	3 Chemistry*	4
BIOL 211L	1 MATH/STAT Choice	4
CHEM 163/L or 177/L	5 Social Science Choice	3

Humanity	3	
	<b>17</b>	<b>15.5</b>
<b>Sophomore</b>		
<b>Fall</b>	<b>Credits Spring</b>	<b>Credits</b>
ENGL 250 or Elective	3 BIOL 313	3
Chemistry or Biochemistry*	4-3 BIOL 313L	1
BIOL 312	4 Biochemistry / Elective*	3
SP CM 212	3 Ethics	3
Advanced Biology	3 Advanced Biology with Lab	4
	<b>17-16</b>	<b>14</b>
<b>Junior</b>		
<b>Fall</b>	<b>Credits Spring</b>	<b>Credits</b>
BIOL 314	3 BIOL 315	3
PHYS 111 or PHYS 115*	5 PHYS 112 / Elective*	5-3
Advanced Biology	3 Advanced Biology	4
MATH/STAT Choice	4 U.S. Diversity / Elective	3
	<b>15</b>	<b>15-13</b>
<b>Senior</b>		
<b>Fall</b>	<b>Credits Spring</b>	<b>Credits</b>
Advanced Biology	4 Advanced Biology with Lab	4
International Perspective / Elective	3 Minor or Elective	11
Minor or Electives	8	
	<b>15</b>	<b>15</b>

\* Students should meet with a Biology Program Adviser to determine the proper plans for chemistry, math and physics before selecting those options above.

Students must have 120 credits minimum to graduate students are required to take 21 credits in advanced biology of which 9 credits must be from the Biology Program (BIOL), and 2 advanced BIOL courses must have a lab or field component.

#### Courses primarily for undergraduates:

##### BIOL 101: Introductory Biology

(3-0) Cr. 3. F.S.SS.

Life considered at cellular, organism, and population levels. Function and diversity of the living world. Presentation of basic biological principles as well as topics and issues of current human interest. Does not satisfy biology major requirements.

##### BIOL 110: Introduction to Biology

Cr. 1. F.

Orientation to the scope of the biological sciences, and discussion of professional opportunities. Required of first year biology majors. Offered on a satisfactory-fail basis only.

##### BIOL 111: Opportunities in Biology

(1-0) Cr. 0.5. S.

Introduction to biological science disciplines and professional opportunities through faculty presentations which examine a variety of current research topics. Offered on a satisfactory-fail basis only.

##### BIOL 112: Transfer Student Orientation

Cr. 1. F.S.

Orientation to opportunities in Biology. Review of degree requirements and other information. Intended for students transferring from other academic institutions. Offered on a satisfactory-fail basis only. Offered on a satisfactory-fail basis only.

##### BIOL 155: Human Biology

(3-0) Cr. 3. F.S.

A survey course of human biology, including principal structures and functions of the body systems and the diseases and disorders associated with them. Designed to meet general education requirements in natural science. Not recommended for those seeking a career in the allied health professions or for students majoring in life science. Does not satisfy biology major requirements.

##### BIOL 173: Environmental Biology

(Cross-listed with ENV S). (3-0) Cr. 3. F.S.

An introduction to the structure and function of natural systems at scales from the individual to the biosphere and the complex interactions between humans and their environment. Discussions of human population growth, biodiversity, sustainability, resource use, and pollution. Does not satisfy biology major requirements.

##### BIOL 201: Introduction to Environmental Issues

(Cross-listed with ENSCI, ENV S). (2-0) Cr. 2. F.

Discussion of current and emerging environmental issues such as human population growth, energy use, loss of biodiversity, water resources, and climate change.

##### BIOL 204: Biodiversity

(Cross-listed with ENV S). (4-0) Cr. 2. S.

*Prereq: One course in life sciences*

Survey of the major groups of organisms and biological systems. Definition, measurements, and patterns of distribution of organisms. Sources of information about biodiversity. Does not satisfy biology major requirements. Half semester course.

**BIOL 211: Principles of Biology I**

(3-0) Cr. 3. F.S.

*Prereq: High school biology*

Introduction to the nature of life, including the diversity of microbial, plant, and animal life; the nature of heredity; evolution; and principles of ecology. Intended for life science majors.

**BIOL 211L: Principles of Biology Laboratory I**

(0-3) Cr. 1. F.S.

*Prereq: Credit or enrollment in BIOL 211*

Laboratory to accompany 211.

**BIOL 212: Principles of Biology II**

(3-0) Cr. 3. F.S.

*Prereq: High School Biology; high school chemistry or credit or enrollment in CHEM 163 or CHEM 177*

Introduction to the chemical, molecular, and cellular basis of life; form and function of microbial, plant, and animal life. Intended for life science majors.

**BIOL 212L: Principles of Biology Laboratory II**

(0-3) Cr. 1. F.S.

*Prereq: credit or enrollment in BIOL 212*

Laboratory to accompany 212.

**BIOL 251: Biological Processes in the Environment**

(Cross-listed with ENSCI). (3-0) Cr. 3. S.

Principles of Biology from the level of macromolecules to the biosphere. Biological processes that affect environmental systems: including metabolism, energy pathways, biochemical reactions in cells, plant and microbial structure and function, element and water cycles.

**BIOL 255: Fundamentals of Human Anatomy**

(3-0) Cr. 3. F.

*Prereq: High School Biology and Chemistry, or BIOL 101*

An introduction to human anatomy, beginning with cells and tissues, surveying all body systems, relating form to function. Systems covered include: integumentary, bones and joints, muscles, nervous, sensory, endocrine, circulatory, lymphatic, respiratory, digestive, urinary, and reproductive. Pre-Medical students should consider Biol 351 for their anatomy background. Does not satisfy biology major requirements.

**BIOL 255L: Fundamentals of Human Anatomy Laboratory**

(0-3) Cr. 1. F.

*Prereq: Credit or enrollment in BIOL 255*

Investigation of human anatomy using models and dissections of preserved organs and model mammals. Pre-Medical students should consider 351 for their anatomy background. Does not satisfy biology major requirements.

**BIOL 256: Fundamentals of Human Physiology**

(3-0) Cr. 3. S.

*Prereq: High School Biology and Chemistry, or BIOL 101, or BIOL 255 (recommended)*

An introduction to human physiology, studying the function of all body systems. Systems covered include: integumentary, bones and joints, muscles, nervous, sensory, endocrine, circulatory, lymphatic and immune, respiratory, digestive, urinary, and reproductive. Pre-Medical students should consider 335 for their physiology background. Does not satisfy biology major requirements.

**BIOL 256L: Fundamentals of Human Physiology Laboratory**

(0-3) Cr. 1. S.

*Prereq: Credit or enrollment in BIOL 256*

Student-conducted experiments investigating concepts of human physiology with computer data acquisition and analysis. Interpretation of experimental results and preparation of lab reports. Pre-Medical students should consider 335 for their anatomy and physiology background. Does not satisfy biology major requirements.

**BIOL 307: Women in Science and Engineering**

(Cross-listed with WGS). (3-0) Cr. 3. Alt. F., offered odd-numbered years.

*Prereq: 200 level course in science, engineering or women's studies; ENGL 250*

The interrelationships of women and science and engineering examined from historical, sociological, philosophical, and biological perspectives. Factors contributing to under-representation; feminist critiques of science; examination of successful strategies. Does not satisfy biology major advanced credit requirements.

Meets U.S. Diversity Requirement

**BIOL 312: Ecology**

(Cross-listed with A ECL, ENSCI). (3-3) Cr. 4. F.SS.

*Prereq: BIOL 211, BIOL 211L, BIOL 212, and BIOL 212L*

Fundamental concepts and principles of ecology dealing with organisms, populations, communities, and ecosystems. Laboratory and field exercises examine ecological principles and methods as well as illustrate habitats.

**BIOL 313: Principles of Genetics**

(Cross-listed with GEN). (3-0) Cr. 3. F.S.SS.

*Prereq: BIOL 211, BIOL 211L, BIOL 212, and BIOL 212L*

Introduction to the principles of transmission and molecular genetics of plants, animals, and bacteria. Recombination, structure and replication of DNA, gene expression, cloning, quantitative genetics, and population genetics. Students may receive graduation credit for no more than one of the following: Gen 260, Gen 313 and 313L, Gen 320, Biol 313 and 313L, and Agron 320.

**BIOL 313L: Genetics Laboratory**

(Cross-listed with GEN). (0-3) Cr. 1. F.S.

*Prereq: Credit or enrollment in BIOL 313*

Laboratory to accompany 313. Students may receive graduation credit for no more than one of the following: Biol 313 and 313L, Gen 260, Gen 313, Gen 320, and Agron 320.

**BIOL 314: Principles of Molecular Cell Biology**

(3-0) Cr. 3. F.S.

*Prereq: BIOL 211, BIOL 211L, BIOL 212, BIOL 212L*

Integration of elementary principles of metabolism, bioenergetics, cell structure, and cell function to develop a molecular view of how the cell works.

**BIOL 315: Biological Evolution**

(3-0) Cr. 3. F.S.

*Prereq: BIOL 211, BIOL 211L, BIOL 212, BIOL 212L.*

The mechanisms of evolution. Topics in microevolution: population genetics, natural selection, genetic variation, and adaptation. Macroevolution: speciation, extinction, phylogeny, and major evolutionary patterns.

**BIOL 322: Introduction to Bioinformatics and Computational Biology**

(Cross-listed with BCBIO, GEN). (3-0) Cr. 3. F.

*Prereq: BIOL 212*

Genome sequencing, assembly, structural and functional annotation, and comparative genomics. Investigating these topics will develop skills in programming and scripting (Perl and/or Python), the use of biological databases, sequence alignment, similarity search, identification of sequence patterns, construction of phylogenetic trees, and comparative genomics.

**BIOL 328: Molecular and Cellular Biology of Human Diseases**

Cr. 3. F.

*Prereq: BIOL 212*

Survey of molecular, genetic, and cellular aspects of human diseases. Fundamental concepts of cell biology and how they are linked to the pathologies of different classes of human diseases. Recent scientific advances with an emphasis on new methods of diagnosis and treatment.

**BIOL 335: Principles of Human and Other Animal Physiology**

(3-0) Cr. 3. S.

*Prereq: BIOL 211, BIOL 212*

Introduction to physiology of metabolic function in mammals and other animals. Metabolic processes and their interactions with various subsystems, approached from an organismal perspective. Integration of cellular, gastrointestinal, cardiovascular, respiratory, and renal processes, relevant to their control and integration at the nervous and endocrine system levels. Functional aspects of organismal physiology, energy and water balances, physiology of rest exercise, and environmental stress.

**BIOL 335L: Principles of Human and Other Animal Physiology Laboratory**

(0-3) Cr. 1. S.

Optional laboratory to accompany Biology 335. Student-conducted experiments investigating concepts of physiology.

**BIOL 336: Ecological and Evolutionary Animal Physiology**

Cr. 3.

*Prereq: BIOL 211, BIOL 212*

Study of mechanisms by which animals perform life-sustaining functions; the evolution and adaptive significance of physiology traits, the diversity of physiological mechanisms, and how physiology and ecology interact.

**BIOL 344: Human Reproduction**

(Cross-listed with WGS). (3-0) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: BIOL 212*

Biology of human reproduction, including reproductive systems, hormones, and endocrinology of pregnancy, presented from a clinically-oriented perspective. Reviews health-related conditions such as infertility, sexually-transmitted diseases, and complicated pregnancy.

**BIOL 349: The Genome Perspective in Biology**

(Cross-listed with GEN). (2-2) Cr. 3. S.

*Prereq: GEN 313 or GEN 320*

Analysis of genome, RNA, and protein data using computer technology to answer biological questions on topics ranging from microbial diversity to human health. An introduction for students in the life sciences to the fields of genomics, bioinformatics and systems.

**BIOL 350: Comprehensive Human Anatomy**

(3-3) Cr. 4. F.

*Prereq: Credit in BIOL 211 and BIOL 212*

Comprehensive survey of human anatomy, emphasizing structural and functional relationships of major organ systems. Compartmental study of normal anatomy; practical clinical application of anatomical regions. Laboratory using 3-dimensional software to study anatomy in augmented reality. Recommended for pre-medical and pre-health professional students.

**BIOL 351: Comparative Chordate Anatomy**

(3-4) Cr. 5. S.

*Prereq: BIOL 212, junior classification*

The evolution of chordates as reflected in the anatomy of extinct and living forms. Lecture topics include the history and diversity of chordates, comparisons of anatomic structures among major groups, and the adaptive significance of anatomic structures. Laboratory involves dissection of representative species.

**BIOL 352: Vertebrate Histology**

(3-3) Cr. 4. Alt. S., offered odd-numbered years.

*Prereq: BIOL 212*

Microanatomy of animal cells, tissues, and organs; histology from a functional perspective; ultra-structure of cells, the four primary tissues, and different anatomical organs, focusing- on function and clinical significance.

**BIOL 353: Introductory Parasitology**

(Cross-listed with MICRO, V PTH). (3-0) Cr. 3. S.

*Prereq: BIOL 212*

Biology and host-parasite relationships of major groups of animal parasites, and techniques of diagnosing and studying parasites.

**BIOL 354: Animal Behavior**

(3-0) Cr. 3. F.

*Prereq: BIOL 212*

Ethological and sociobiological approaches to animal behavior. Genetic and developmental aspects of behavior, biological rhythms, orientation (including navigation, migration), communication, and social behavior (mating, aggression, parental care).

**BIOL 354L: Laboratory in Animal Behavior**

(0-3) Cr. 1. F.

*Prereq: Credit or enrollment in BIOL 354*

Laboratory techniques for observation, description and analysis of animal activities; independent projects.

**BIOL 355: Plants and People**

(3-0) Cr. 3. S.

*Prereq: Credit in BIOL 211 and BIOL 211L*

Uses of plants and fungi by humans and the importance of plants in the past, present, and future. Discussion of fruits, vegetables, grains, herbs, spices, beverages, oils, fibers, wood, medicines, and drugs, in the context of their agricultural, cultural, and economic roles in modern societies. Emphasis on origins and worldwide diversity of culturally important plants, their characteristics, and uses.

**BIOL 356: Dendrology**

(Cross-listed with FOR). (2-2) Cr. 3. F.

*Prereq: BIOL 211*

Identification and ecology of North American woody plant species. Importance of woody plants in timber production and wildlife habitat. Historical conditions of North American forest regions will also be addressed.

**BIOL 357: Biology of Plants**

Cr. 3. F.

*Prereq: BIOL 211 and BIOL 212 (BIOL 211L and 212L recommended)*

Study of the general biology of plants, including plant cells and functions, basic anatomy of tissues, meristems, and organs; adaptive morphological features. Review of processes of photosynthesis, respiration, basic plant metabolic functions, and plant reproduction. Survey of evolutionary aspects of all major groups of land plants, and relationships of plants to their environment. Intended for Biology and other life science undergraduate majors.

**BIOL 364: Invertebrate Biology**

Cr. 3-4. F.

*Prereq: BIOL 211, 212*

Emphasis on diversity, development, physiology, and behavior of invertebrate organisms- the "spineless wonders" of the world. Laboratory involves hands-on study and investigation of living invertebrates.

**BIOL 365: Vertebrate Biology**

(Cross-listed with A ECL). (3-2) Cr. 4. F.

*Prereq: BIOL 211, BIOL 211L, BIOL 212, BIOL 212L*

Evolution, biology, and classification of fish, amphibians, reptiles, birds, and mammals. Emphasis on a comparative analysis of the structure and function of organ systems. Laboratory exercises concentrate on morphology and identification of orders of vertebrates.

**BIOL 366: Plant Systematics**

(2-4) Cr. 4. S.

*Prereq: BIOL 211*

Introduction to plant phylogenetic systematics, plant classification, survey of flowering plant families, and identification and field study of local plants.

**BIOL 370: GIS for Ecology and Environmental Science**

(Cross-listed with ENSCI). Cr. 1-6. Repeatable. F.S.

*Prereq: Six credits in biological and /or physical sciences, and permission of instructor.*

Introduction to geographic information systems (GIS) with emphasis on ecological and environmental applications. No prior GIS experience required. Guided, individualized study of topics based on student background and interest. For students with prior experience, topics and activities are selected to build upon any previous experience and minimize duplication to previous GIS coursework. Potential topics include: basic concepts of GIS, data structures, database management, spatial analysis, modeling and visualization of ecological and environmental data. Case studies in ecological and environmental applications using ArcGIS. Offered on a satisfactory-fail basis only.



**BIOL 371: Ecological Methods**

(Cross-listed with A ECL). (2-3) Cr. 3. F.

*Prereq: A ECL 312; STAT 101 or STAT 104*

Quantitative techniques used in management of natural resources with emphasis on inventory and manipulation of habitat and animal populations.

**BIOL 381: Environmental Systems I: Introduction to Environmental Systems**

(Dual-listed with EEOB 581). (Cross-listed with ENSCI, ENV S). Cr. 3-4. F.

*Prereq: 12 credits of natural science including biology and chemistry*

Introduction to the structure and function of natural environmental systems. Emphasis on the analysis of material and energy flows in natural environmental systems and the primary environmental factors controlling these systems.

**BIOL 382: Environmental Systems II: Analysis of Environmental Systems**

(Dual-listed with EEOB 582). (Cross-listed with ENSCI). (2-2) Cr. 3. S.

*Prereq: ENSCI 381*

Continuation of EnSci 381. Systems approach to the analysis of material and energy flows in natural environmental systems and the primary environmental factors controlling these systems.

**BIOL 393: North American Field Trips in Biology**

Cr. 1-4. Repeatable.

*Prereq: Two courses in the biological sciences and by approval of application*

Extended field trips, usually during break periods, to North American locations of interest to biologists. Inquire in the Biology Program Office, 103 Bessey Hall, for trip schedule.

**BIOL 393A: North American Field Trips in Biology: Pre-trip Seminar**

(1-0) Cr. 1. Repeatable.

*Prereq: Two courses in the biological sciences and by approval of application*

Discussion of relevant biological and cultural topics during semester preceding extended field trips to North American locations of interest to biologists.

**BIOL 393B: North American Field Trips in Biology: North American Field trip**

Cr. 1-3. Repeatable.

*Prereq: Two courses in the biological sciences and by approval of application*

Extended field trip under supervision of faculty member, usually during break periods, to North American locations of interest to biologists. Inquire in the Biology Program Office, 103 Bessey Hall, for trip schedule. Report required.

**BIOL 394: International Field Trips in Biology**

Cr. 1-4. Repeatable.

*Prereq: Two courses in the biological sciences and by approval of application*

Extended field trips, usually during break periods, to international locations of interest to biologists. Inquire in the Biology Program Office, 103 Bessey Hall, for trip schedule.

Meets International Perspectives Requirement.

**BIOL 394A: International Field Trips in Biology: Pre-trip Seminar**

(1-0) Cr. 1. Repeatable.

*Prereq: Two courses in the biological sciences and by approval of application*

Discussion of relevant biological and cultural topics during semester preceding extended field trip to international locations of interest to biologists.

Meets International Perspectives Requirement.

**BIOL 394B: International Field Trips in Biology: Field Trip to International Location**

Cr. 1-3. Repeatable.

*Prereq: Two courses in the biological sciences and by approval of application*

Extended field trips, under supervision of faculty member, usually during break periods, to international locations of interest to biologists. Inquire in the Biology Program Office, 103 Bessey Hall, for trip schedule.

Meets International Perspectives Requirement.

**BIOL 402: Introduction to Pathology**

(Cross-listed with V PTH). (3-0) Cr. 3. F.

*Prereq: BIOL 211 and BIOL 212 with labs*

Introductory exploration of pathology as a medical discipline. This includes study of disease mechanisms via an introduction to general pathology topics (cell degeneration, necrosis, disturbances of growth, disturbances of blood flow, inflammation, neoplasia) and organ system-specific response to injury.

**BIOL 414: Life History and Reproductive Strategies**

(Dual-listed with EEOB 514). (3-0) Cr. 3. Alt. F., offered odd-numbered years.

*Prereq: BIOL 315 or equivalent recommended.*

Evolution of ecological adaptations at the individual, population, and species level. Emphasis is on evolutionary mechanisms and adaptive strategies related to life histories and reproduction; age and size at maturity; lifespan and senescence; offspring size/number trade-offs; sex and mating systems; sex determination and sex ratios.

**BIOL 423: Developmental Biology**

(3-0) Cr. 3. S.

*Prereq: BIOL 313*

Principles of embryogenesis and animal development. Establishment of body axes, organ and limb development, and specification of cell fates. Emphasis on cell signaling and the control of gene expression within the context of a developing organism. Medically relevant subjects will be discussed, including stem cells, cancer biology, fertilization, and cloning.

**BIOL 423L: Developmental Biology Laboratory**

(0-3) Cr. 1. Repeatable, maximum of 4 times. S.

*Prereq: Credit or enrollment in BIOL 423 or permission of the instructor.*

Experiments and explorations illustrating fundamental principles of multicellular development.

**BIOL 428: Cell Biology**

(3-0) Cr. 3. S.

*Prereq: BIOL 314*

Cell structure and function in health and disease. Emphasis on cellular dynamics, transport, organelle biogenesis and signaling, and how defects in these processes disrupt cell function.

**BIOL 430: Principles of Plant Physiology**

(3-0) Cr. 3. S.

*Prereq: BIOL 212; CHEM 231 or CHEM 332*

An overview of classical and current concepts, principles, and approaches regarding the basic mechanisms of plant function underlying growth, development, and survival of plants. Topics covered include environmental and developmental signals, plant hormone action, signal transduction, mineral nutrition, water relations, metabolism, and photosynthesis.

**BIOL 434: Endocrinology**

(Dual-listed with EEOB 534). (3-0) Cr. 3. S.

*Prereq: BIOL 211, BIOL 212*

Chemical integration of vertebrate organisms. The structure, development, and evolution of the endocrine glands and the function and structure of their hormones.

**BIOL 436: Neurobiology**

(3-0) Cr. 3. F.

*Prereq: BIOL 212*

Basic principles of brain function and development. Signaling of nerve cells, synaptic transmission, structure/function of ion channels and receptors, memory and synaptic plasticity, movement and central control, sensation and sensory processing, construction of neural circuits, early brain development, complex brain functions in health and disease.

**BIOL 444: Bioinformatic Analysis**

(Cross-listed with BCB, BCBIO, COM S, CPR E, GEN). (4-0) Cr. 4. F.

*Prereq: MATH 165 and Introductory Statistics (STAT 101, STAT 104, STAT 105, STAT 201, or STAT 330).*

Broad overview of bioinformatics with a significant problem-solving component, including hands-on practice using computational tools to solve a variety of biological problems. Topics include: bioinformatic data processing, Python programming, genome assembly, database search, sequence alignment, gene prediction, next-generation sequencing, comparative and functional genomics, and systems biology.

**BIOL 451: Plant Evolution and Phylogeny**

(Dual-listed with EEOB 551). (3-3) Cr. 4. F.

*Prereq: BIOL 315 or equivalent.*

Survey of land plant evolution; phylogenetic comparison of anatomical, reproductive, and life history specializations. Relationships among bryophytes, lycophytes, pteridophytes, gymnosperms, and angiosperms emphasizing significant evolutionary changes documented by paleobotanical, morphological, and molecular studies.

**BIOL 454: Plant Anatomy**

(3-3) Cr. 4. F.

*Prereq: BIOL 212L; BIOL 366 recommended*

Characteristics of cell and tissue types in vascular plants. Anatomy of developing and mature stems, roots, and leaves, including secondary (woody) growth. Introduction to the special anatomy of flowers and seeds.

**BIOL 455: Bryophyte and Lichen Biodiversity**

(Dual-listed with EEOB 555). (2-3) Cr. 3. S.

*Prereq: BIOL 211, BIOL 211L*

Introduction to the biology and ecology of mosses, liverworts, and lichens. Emphasis on identification and diversity of local representatives of these three groups of organisms. Required field trips and service-learning.

**BIOL 456: Principles of Mycology**

(Cross-listed with MICRO). (2-3) Cr. 3. F.

*Prereq: 10 credits in biological sciences*

Morphology, diversity and ecology of fungi; their relation to agriculture and industry and human health.

**BIOL 457: Herpetology**

(Cross-listed with A ECL). (2-0) Cr. 2. F.

*Prereq: BIOL 351 or BIOL 365*

Biology, ecology, and evolution of amphibians (salamanders, frogs, caecilians) and reptiles (lizards, snakes, tuatara, turtles, crocodilians). Emphasis on structure, physiological adaptation to different environments, behavior, reproduction, roles of amphibians and reptiles in ecosystems, and conservation. Laboratory focus on survey methods, identification, relationships, distribution, habits, and habitats of amphibians and reptiles.

**BIOL 457L: Herpetology Laboratory**

(Cross-listed with A ECL). (0-3) Cr. 1. F.

*Prereq: BIOL 351 or BIOL/A ECL 365; concurrent registration in BIOL 457 or A ECL 457*

Laboratory to accompany Biology/Animal Ecology 457. Focus on survey methods, identification, relationships, distribution, habits, and habitats of amphibians and reptiles.

**BIOL 458: Ornithology**

(Cross-listed with A ECL). (2-0) Cr. 2. S.

*Prereq: A ECL 365 or BIOL 351*

Biology, evolution, ecology and taxonomy of birds. Emphasis on structure, physiology, behavior, communication, navigation, reproduction, and conservation.

**BIOL 458L: Ornithology Laboratory**

(Cross-listed with A ECL). (0-3) Cr. 1. S.

*Prereq: BIOL 351 or AECL/BIOL 365. Concurrent enrollment in AECL/BIOL 458 is required.*

Laboratory complements lecture topics with emphasis on external anatomy, identification and distribution of Midwest birds, and field trips.

**BIOL 459: Mammalogy**

(Dual-listed with EEOB 559). (Cross-listed with A ECL). (2-0) Cr. 2. S.

*Prereq: BIOL 351 or A ECL 365*

Biology, ecology, and evolution of mammals. Emphasis on structure, physiological adaptation to different environments, behavior, reproduction, roles of mammals in ecosystems, and conservation.

**BIOL 459L: Mammalogy Laboratory**

(Cross-listed with A ECL). (0-3) Cr. 1. S.

*Prereq: BIOL 351 or BIOL/AECL 365; concurrent enrollment in AECL 459 or BIOL 459 required.*

Laboratory focus on identification, survey methods, distribution, habits, and habitats of mammals. Several field trips.

**BIOL 462: Evolutionary Genetics**

(Cross-listed with GEN). (3-0) Cr. 3. F.

*Prereq: BIOL 315*

The genetic basis of evolutionary processes in eukaryotic organisms. The role of genetic variation in adaptation, natural selection, adaptive processes, and the influence of random processes on evolutionary change.

**BIOL 464: Wetland Ecology**

(Dual-listed with EEOB 564). (Cross-listed with ENSCI). (3-0) Cr. 3. S.

*Prereq: 15 credits in biological sciences.*

Ecology, classification, creation and restoration, and management of wetlands. Emphasis on North American temperate wetlands.

**BIOL 465: Macroevolution**

(Dual-listed with EEOB 565). Cr. 3. Alt. S., offered even-numbered years.

*Prereq: BIOL 315*

The history and diversity of life on earth; evolutionary patterns and processes above the species level. Diversity from a phylogenetic perspective. Empirical exercises include: phylogeny estimation, ancestral states, estimating diversification rates, evaluating the tempo and mode of evolution, biogeographic patterns, and trait associations across the tree of life.

**BIOL 471: Introductory Conservation Biology**

(Cross-listed with A ECL). Cr. 3. S.

*Prereq: BIOL 312*

Examination of conservation issues from a population and community perspective. The role of genetics, demography, and environment in determining population viability, habitat fragmentation, reserve design, biodiversity assessment, and restoration ecology.

**BIOL 472: Community Ecology**

(3-0) Cr. 3. S.

*Prereq: BIOL 312*

The effect of interspecific interactions on the structure and dynamics of natural and managed communities; including concepts of guild structure and trophic web dynamics and their importance to the productivity, diversity, stability, and sustainability of communities. The implications of interspecific interactions in the management of wild species will be emphasized with illustrative case histories of interactions between plants, invertebrates, and vertebrates.

**BIOL 474: Plant Ecology**

(3-0) Cr. 3. S.

*Prereq: BIOL 312*

Principles of plant population and community ecology.

**BIOL 476: Functional Ecology**

(Dual-listed with EEOB 576). (3-0) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: BIOL 312*

The nature of adaptations to physical and biotic environments. Biophysical, biomechanical, and physiological bases of the structure, form, growth, distribution, and abundance of organisms.

**BIOL 480: Studies in Marine Biology**

Cr. 1-8. Repeatable.

Courses taken at Gulf Coast Research Laboratory and other marine biological stations are transferred to Iowa State University under this number.

**BIOL 481: Summer Field Studies**

Cr. 1-8. Repeatable.

Courses taken at summer biological field stations are transferred to Iowa State University under this number. See [www.biology.iastate.edu](http://www.biology.iastate.edu) for links to field stations located in different biomes: coastal, Great Lakes, taiga, deciduous forests, deserts, Rocky Mountains.

**BIOL 482: Tropical Biology**

Cr. 1-4. Repeatable, maximum of 8 credits.

*Prereq: One year of college biology; knowledge of Spanish desirable but not required*

Students registering for courses taught by the Organization for Tropical Studies will receive credit for this ISU course when requesting a transfer of credits.

**BIOL 483: Environmental Biogeochemistry**

(Cross-listed with ENSCI, GEOL). Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: Combined 12 credits in biology, chemistry, and physics.*

An exploration of biological, physical and geochemical impacts on the structure and function of ecosystems from local to global scales. Emphasis on the cycles of carbon, nitrogen, phosphorus, sulfur, and metals, and how these have been impacted by human activity. Topics may include biological feedbacks to climate change, microbial physiology and redox reactions, plant/soil feedbacks, terrestrial/aquatic linkages, early Earth processes and the origins of life.

**BIOL 484: Ecosystem Ecology**

(Cross-listed with ENSCI). (3-0) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: Combined 12 credits in biology, chemistry, and physics.*

Introduction of the study of ecosystems and the biological and physical factors that influence their properties and dynamics. Conceptual foundations for ecosystem studies. Interactions among organisms, biological diversity, and ecosystem attributes. Quantitative analyses of accumulations, transformations, and fluxes of nutrients, water, and energy within and among ecosystems. Global change issues.

**BIOL 486: Aquatic Ecology**

(Dual-listed with EEOB 586). (Cross-listed with A ECL, ENSCI). (3-0) Cr. 3. F.

*Prereq: Biol 312 or EnSci 381 or EnSci 402 or NREM 301*

Structure and function of aquatic ecosystems with application to fishery and pollution problems. Emphasis on lacustrine, riverine, and wetland ecology.

**BIOL 486L: Aquatic Ecology Laboratory**

(Dual-listed with EEOB 586L). (Cross-listed with A ECL, ENSCI). (0-3) Cr. 1. F.

*Prereq: Concurrent enrollment in BIOL 486*

Field trips and laboratory exercises to accompany 486. Hands-on experience with aquatic research and monitoring techniques and concepts.

**BIOL 487: Microbial Ecology**

(Dual-listed with EEOB 587). (Cross-listed with ENSCI, GEOL, MICRO). (3-0) Cr. 3. F.

*Prereq: Six credits in biology and 6 credits in chemistry*

Introduction to major functional groups of autotrophic and heterotrophic microorganisms and their roles in natural and environmental systems. Consequences of microbial activity on water chemistry, weathering, and precipitation/dissolution reactions will be emphasized.

**BIOL 488: Identification of Aquatic Organisms**

(0-3) Cr. 1. F.S.

On-line taxonomic and identification exercises to accompany 486. Instruction and practice in the identification of algae, aquatic macrophytes, zooplankton, and benthos.

**BIOL 489: Population Ecology**

(Dual-listed with EEOB 589). (Cross-listed with A ECL). (2-2) Cr. 3. Alt. F., offered even-numbered years.

*Prereq: BIOL 312, STAT 101 or STAT 104, a course in calculus, or graduate standing*

Concepts and theories of population dynamics with emphasis on models of growth, predation, competition, and regulation.

**BIOL 490: Independent Study**

Cr. 1. Repeatable, maximum of 9 credits. F.S.SS.

*Prereq: Permission of instructor.*

Independent study opportunities for undergraduate students in the biological sciences. No more than 9 credits in Biol 490 may be counted toward graduation and, of those, only 2 credits may be applied toward the Biology advanced course requirement.

**BIOL 491: Undergraduate Teaching Experience**

Cr. 1-2. Repeatable.

*Prereq: Permission of supervising staff*

For students registering to be undergraduate teaching assistants. Offered on a satisfactory-fail basis only. A maximum of 2 credits of BIOL 491 may be applied toward the Biology advanced course requirement.

**BIOL 492: Preparing for Graduate School in the Biological Sciences**

(1-0) Cr. 1. F.

*Prereq: For life science majors; Minimum requirement: sophomore standing.*

For students considering pursuing a graduate degree in the biological sciences. Professional development topics including the defining of academic and career areas of interest, finding and evaluating appropriate programs of graduate study, the graduate school application process, and developing a curriculum vita. Exploration of learning opportunities at field stations, research internships, and independent research activities.

**BIOL 494: Biology Internship**

Cr. 1-3. Repeatable. F.S.SS.

*Prereq: 8 credits in biology and permission of instructor*

Professional experiences in biological sciences. Intended for Biology majors. No more than 9 credits in BIOL 494 may be counted toward graduation and, of those, only 6 credits may be applied toward the Biology advanced course requirement.

**BIOL 495: Undergraduate Seminar**

Cr. 1-3. Repeatable. F.S.

*Prereq: Permission of instructor*

Content varies from year to year and may include detailed discussion of special topics in biology, current issues in biology, or careers in biology.

**BIOL 498: Cooperative Education**

Cr. R. Repeatable. F.S.SS.

*Prereq: Permission of the Biology Program cooperative education coordinator*

Required of all cooperative education students. Students must register for this course prior to commencing each work period.

**BIOL 499: Undergraduate Research Experience**

Cr. 1-3. Repeatable, maximum of 9 credits. F.S.SS.

*Prereq: Permission of instructor.*

Research opportunities for undergraduate students in the biological sciences. Intended for Biology majors. No more than 9 credits in Biol 499 may be counted toward graduation and, of those, only 6 credits may be applied toward the Biology advanced course requirement.