Why study biology at the University of Denver?
The department of biological sciences offers graduate programs at the doctoral (PhD) or master’s (MS) level. Students earn a degree in biological studies with a concentration in either cell and molecular biology or biology, ecology and evolution. Both program tracks involve a combination of course work, lab or field research and a defended thesis or dissertation. Students begin their research under the direction of a faculty member during the first year. All students are expected to present their work at scientific meetings and publish their work in peer-reviewed scientific journals. Doctoral students also have the opportunity to participate in teaching undergraduate courses.

Research areas
The PhD and MS programs are centered on primary research that coincides with faculty experience and expertise. Students will conduct their research in a university environment using state-of-the-art techniques and facilities. The current research emphases of the department are:

- Cell and molecular biology is supported by major research facilities that include real-time PCR instruments, a DNA WAVE HPLC, a Hitachi transmission electron microscope and an Olympus Fluoview 1000 confocal microscope and other advanced imaging systems.
- Biology, ecology and evolution takes advantage of unique field study sites that include an alpine research station on Mt. Evans in the Arapaho National Forest and collaborative research opportunities with the Denver Botanic Gardens.

Career opportunities
A student who completes the MS degree is in a strong position to pursue a range of postgraduate opportunities, including a career in biotech, academic or government lab or agency, or continued studies in a professional or PhD program. The doctoral degree carries the credential for a professional career in research or academics.

Doctor of Philosophy in Biological Sciences with a concentration in Biology, Ecology and Evolution, Doctor of Philosophy in Biological Sciences with a Concentration in Cell and Molecular Biology

Application Deadlines
- Fall 2018 Priority Deadline: January 15, 2018
- Fall 2018 Final Submission Deadline: September 14, 2018

Admission Requirements
- Online application
- $65.00 Application Fee
- University Minimum Degree and GPA Requirements
- Transcripts: One official transcript from each post-secondary institution.
- GRE: The Graduate Record Examination (GRE) is required. Scores must be received directly from the appropriate testing agency by the deadline. The institution code for the University of Denver is 4842.
- Letters of Recommendation: Three (3) letters of recommendation are required. Letters should be submitted by recommenders through the online application.
- Personal Statement: A personal statement of at least 300 words is required. The statement should include information concerning your career goals, life, education, practical experience, special interests and specific purpose for applying to the University of Denver.
- Prerequisites: Students with an undergraduate major in chemistry, physics or mathematics and minimal preparation in biological sciences also will be considered but may be required to take undergraduate courses when the prerequisites are lacking. Course prerequisites include: one year of general chemistry, one year of calculus (recommended), one year of physics, two years of biology and one year of organic chemistry.
Additional Standards for Non-Native English Speakers

Official scores from the Test of English as a Foreign Language (TOEFL), International English Language Testing System (IELTS) or Cambridge English: Advanced (CAE) are required of all graduate applicants, regardless of citizenship status, whose native language is not English or who have been educated in countries where English is not the native language. The minimum TOEFL/IELTS/CAE test score requirements for the degree program are:

- Minimum TOEFL Score (paper-based test): 550
- Minimum TOEFL Score (internet-based test): 80
- Minimum IELTS Score: 6.5
- Minimum CAE Score: 169

- **English Conditional Admission Offered:** In cases where minimum TOEFL/IELTS/CAE scores were not achieved or no English proficiency test was taken, the Biological Sciences program may offer English Conditional Admission (ECA) to academically qualified non-native English speakers.

Read the English Language Proficiency policy for more details.

Read the English Conditional Admission (ECA) policy for more details.

Read the Required Tests for GTA Eligibility policy for more details.

Additional Standards for International Applicants

Per Student & Exchange Visitor Program (SEVP) regulation, international applicants must meet all standards for admission before an I-20 or DS-2019 is issued, [per U.S. Federal Register: 8 CFR § 214.3(k)] or is academically eligible for admission and is admitted [per 22 C.F.R. §62]. Read the Additional Standards For International Applicants policy for more details.

Financial Aid

There are many different options available to finance your education. Most University of Denver graduate students are granted some type of financial support. Our Office of Financial Aid is committed to helping you explore your options.

Master of Science in Biological Sciences with a Concentration in Biology, Ecology and Evolution, Master of Science in Biological Sciences with a Concentration in Cell and Molecular Biology

Application Deadlines

- Fall 2018 Priority Deadline: January 15, 2018
- Fall 2018 Final Submission Deadline: September 14, 2018

Admission Requirements

- Online admission application
- $65.00 Application Fee
- University Minimum Degree and GPA Requirements
- Transcripts: One official transcript from each post-secondary institution.
- GRE: The Graduate Record Examination (GRE) is required. Scores must be received directly from the appropriate testing agency by the deadline. The institution code for the University of Denver is 4842.
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Read the English Language Proficiency (http://bulletin.du.edu/graduate/admission-and-enrollment-policies/additional-standards-for-non-native-english-speakers/english-language-proficiency-ielts-toefl) policy for more details.


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Financial Aid
There are many different options available to finance your education. Most University of Denver graduate students are granted some type of financial support. Our Office of Financial Aid is committed to helping you explore your options.

Graduate studies in the department of biological sciences provide graduate students with a set of structured core classes that establish a strong foundation of basic knowledge in cell and molecular biology or ecology and evolution and that allow the knowledge to be built upon in subsequent specialized courses and independent research. Research areas are usually linked to the interest of the supervising faculty member. The department’s current research strengths center around the two areas: cell and molecular biology (biophysics, neuroscience, neuroendocrinology, cell signaling and physiology, developmental biology, aging, molecular forensics and molecular evolution) and ecology and evolution (biogeochemistry, conservation biology, restoration ecology, molecular evolution). To complete research commitments, MS students generally work with a major professor of choice in the laboratory and/or field for about two years, while PhD students generally work for five years.

DOCTOR OF PHILOSOPHY IN BIOLOGICAL SCIENCES WITH A CONCENTRATION IN BIOLOGY, ECOLOGY AND EVOLUTION

Degree Requirements
The major requirements for completion of the PhD degree are 90 quarter hours of graduate course work and research credit, completion of all candidacy exams, and successful defense of the PhD dissertation. Graduate Students must maintain a minimum GPA of 3.0 and make adequate progress on research as assessed by their adviser and dissertation committee.

Coursework Requirements
The course work includes the following graduate core curriculum:

<table>
<thead>
<tr>
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<tbody>
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<td>Grad Sem: Ecology &amp; Evolution</td>
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<tr>
<td>BIOL 4091</td>
<td>Ecology and Evolution Research Methods</td>
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<tr>
<td>BIOL 4090</td>
<td>Biostatistics</td>
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<td>Foundations in Literature: Ecology</td>
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<td>Independent Research PhD</td>
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</table>
Courses that the dissertation committee judges to complement the student’s major field also may be used.

**Total Credits**

0

**Non-coursework requirements**

Additional requirements are attendance at departmental seminars, passing performance in the qualifying examination and the research proposal examination, presentation of one departmental seminar per year, completion of a research dissertation of publishable quality, and successful oral defense of the dissertation. PhD students are required to pass both a qualifying exam and research proposal exam to advance to candidacy.

Up to 10 quarter hours of graduate credit (or a blanket transfer of 45 quarter hours from a previous master's program) may be accepted as transfer credit with approval of the departmental graduate committee and the Office of Graduate Studies.

**DOCTOR OF PHILOSOPHY IN BIOLOGICAL SCIENCES WITH A CONCENTRATION IN CELL AND MOLECULAR BIOLOGY**

**Degree Requirements**

The major requirements for completion of the PhD degree are 90 quarter hours of graduate course work and research credit, completion of all candidacy exams, and successful defense of the PhD dissertation. Graduate Students must maintain a minimum GPA of 3.0 and make adequate progress on research as assessed by their adviser and dissertation committee.

**Coursework Requirements**

The course work includes the 20-credit graduate core curriculum:

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<td>Advanced Cell Signaling</td>
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<td>BIOL 4310</td>
<td>Foundations in Literature: Cell and Molecular Biology (3 terms required)</td>
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<tr>
<td>BIOL 4150</td>
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Courses that the dissertation committee judges to complement the student’s major field also may be used.

**Non-coursework requirements**

Additional requirements are attendance at departmental seminars, passing performance in the qualifying examination and the research proposal examination, presentation of one departmental seminar per year, completion of a research dissertation of publishable quality, and successful oral defense of the dissertation. PhD students are required to pass both a qualifying exam and research proposal exam to advance to candidacy.

Up to 10 quarter hours of graduate credit (or a blanket transfer of 45 quarter hours from a previous master's program) may be accepted as transfer credit with approval of the departmental graduate committee and the Office of Graduate Studies.

**MASTER OF SCIENCE IN BIOLOGICAL SCIENCES WITH A CONCENTRATION IN BIOLOGY, ECOLOGY AND EVOLUTION**

**Degree Requirements**

The major requirements for completion of the MS degree are 45 quarter hours of course work and research credit, and successful defense of the MS thesis. Graduate Students must maintain a minimum GPA of 3.0 and make adequate progress on research as assessed by the major adviser and thesis committee.

**Coursework Requirements**

The course work includes the following graduate core curriculum:

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& BIOL 4332  and Foundations in Literature: Conservation Biology
BIOL 4231  Responsible Conduct in Rsrch
BIOL 4991  Independent Study (*)
or BIOL 4995  Independent Research
• Courses the thesis committee judges to complement the student’s major field also may be used.

Non-coursework Requirements
Additional requirements are attendance at all departmental seminars, a thesis based on a research project approved by the thesis committee, and a successful oral defense of the thesis.

MASTER OF SCIENCE IN BIOLOGICAL SCIENCES WITH A CONCENTRATION IN CELL AND MOLECULAR BIOLOGY

Degree Requirements
The major requirements for completion of the MS degree are 45 quarter hours of course work and research credit, and successful defense of the MS thesis. Graduate Students must maintain a minimum GPA of 3.0 and make adequate progress on research as assessed by the major adviser and thesis committee.

Coursework Requirements
The course work includes the 16-credit graduate core curriculum:

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Non-coursework requirements
Additional requirements are attendance at all departmental seminars, a thesis based on a research project approved by the thesis committee and a successful oral defense of the thesis.

Courses
BIOL 3010 Evolution and Speciation (4 Credits)
Theories and supporting evidence explaining evolution from origin of universe to complex interrelationships of species. Prerequisites: BIOL 1010, BIOL 1011 and BIOL 2510.

BIOL 3020 Aquatic Ecology (4 Credits)
An introduction to the ecology of fresh-water and marine organisms including aquatic adaptations, community organization, food chains, nutrient cycling and man's impact on aquatic ecosystems. Prerequisite: BIOL 2010 or instructor’s permission.

BIOL 3030 Alpine Ecology (4 Credits)
Ecology of alpine and subalpine regions of Colorado; organization and distribution of communities and populations, succession, energy flow, nutrient cycling, population adaptations in life-history physiology, behavior and morphology. Prerequisite: BIOL 2010.
BIOL 3035 Invasive Species Ecology (4 Credits)
This course investigates those plants and animal species that have dramatically expanded their ranges and cause ecological harm. Topics covered include the mechanisms of ecological impacts across the globe, how invasive species are used to test basic ecological theory, the application of this research for managing real species, and related issues such as the debate within the scientific community about the term "invasive." We use a case-study approach, and students have the opportunity to go into the field as a class to observe the real invasions and learn sampling methods.

BIOL 3044 Coral Reef Ecology (3 Credits)
Ecology of coral reefs; organization and distribution of reefs; review of reef organisms and their interactions with each other and their physical environment; threats to coral reef reef conservation. Prerequisite: (BIOL 2010 or BIOL 2050) OR (GEOG 1201, GEOG 1202, and GEOG 1203).

BIOL 3045 Coral Reef Ecology Lab (1 Credit)
Ecology of coral reefs laboratory to supplement lecture material; travel to the Caribbean over spring break to observe coral reefs firsthand; introduction to research methods. SCUBA certification and permission of instructor required. A travel and dive fee is associated with this course.

BIOL 3055 Ecology of the Rockies (4 Credits)
A week in residence at the Mt. Evans Field Station prior to the start of fall quarter includes field projects dealing with ecology and environmental issues. On campus classes involve data analysis and interpretation and formal scientific communication. Themes include terrestrial and aquatic ecosystems, taxonomic groups ranging from conifer stands to aquatic insects and mountain goats. Lab fee associated with this course. Prerequisite: BIOL 2010 or permission of instructor.

BIOL 3060 Tropical Ecology (3 Credits)
Biological composition of tropical ecosystems; biodiversity, biogeochemistry; causes and biological consequences of tropical deforestation; ecologically based approaches toward sustainable tropical forest use. Includes laboratory. Prerequisite: BIOL 2010.

BIOL 3070 Ecological Field Methods (4 Credits)
Series of field exercises for students to learn principles and procedures of field methodology, data analysis and technical writing in ecology; problems drawn from population, community and ecosystem ecology. Lab fee associated with this course. Prerequisite: BIOL 2010.

BIOL 3085 Insect Ecology (4 Credits)
A general introduction to insect biology and the science of entomology. Arthropods are the most diverse group of animals on Earth and insects account for more than half of all known living organisms. This course explores the biodiversity of insects on Earth, insect morphology and physiology. The evolutionary history and taxonomy of key orders of insects is emphasized as well as the importance of insects to our everyday lives. Prerequisites: BIOL 1010, BIOL 1011, and BIOL 2010.

BIOL 3090 Microbial Ecology (4 Credits)
Interactions among microorganisms and their environment. Impact of ecological principles on microbial diseases, pollutant degradation, nutrient cycles and global change. Prerequisites: BIOL 1010, BIOL 1020, AND BIOL 2010.

BIOL 3100 Histology: Medical Microanatomy (4 Credits)
Microscopic organization of tissues and organs; correlation of organization of organs with functions and pathologies; emphasis on mammalian systems. Includes laboratory. Lab fee associated with this course. Prerequisite: BIOL 2120.

BIOL 3110 Special Topics: Biology (1-5 Credits)
Topics of special interest to teaching/research faculty of department presented as needed to complement and expand existing curriculum. May be repeated for credit. PREREQUISITES: BIOL 1010.

BIOL 3120 General Microbiology (4 Credits)
Fundamental principles of microorganisms in the world and in disease; role of bacteria in biological phenomena. Includes laboratory. Lab fee associated with this course. Prerequisite: BIOL 2120.

BIOL 3130 Molecular Evolution (4 Credits)
Evolution of macromolecules and reconstruction of evolutionary history of genes and organisms. Prerequisite: BIOL 2510 or permission of instructor.

BIOL 3135 Topics in Cell Motility (4 Credits)
Fibrous elements of the cytoskeleton and associated proteins and their role in cellular motility is examined in detail. The physical forces involved in cellular motile function is applied in understanding cellular motile behavior. Prerequisite: BIOL 2120.

BIOL 3150 Intracellular Dynamics (4 Credits)
Focuses on spatial and temporal control of intracellular processes with an emphasis on neuronal and endocrine cells. Topics include vesicular traffic, protein targeting, dynamics and spatial organization of signaling complexes. Emphasis on modern techniques of cell and molecular biology with examples from primary literature. Prerequisite: BIOL 2120.

BIOL 3160 Biophysics: Ion Channels & Disease (4 Credits)
Examines ion channel structure and function and the ways in which this information provides insight into human disease. The focus is on the use of biophysical techniques in combination with molecular and genetic analysis of channel genes. General Physics recommended. Prerequisite: BIOL 2120.

BIOL 3200 Invertebrate Evolution (4 Credits)
Introduction to remarkable diversity of invertebrate life, both in terms of numbers of species, novel body plan and physiological adaptations. Includes laboratory. Prerequisites: BIOL 1010, BIOL 1011.

BIOL 3230 Nutrition (3 Credits)
Investigation of metabolism, all nutrients and various applications of nutrition to sports and healthy living. Prerequisite: BIOL 3250.
BIOL 3250 Human Physiology (5 Credits)
Functional relationships of human organ systems with coordinated laboratory activities and experiments that demonstrate and test physiological principles. Lab fee associated with this course. Prerequisites: BIOL 1010.

BIOL 3260 Nutrition (3 Credits)
From physiological and biochemical perspectives, this course explores the relationships of energy metabolism, nutrients, vitamins and minerals to human health. Prerequisite: BIOL 3250.

BIOL 3300 Biodiversity-Flowering Plants (4 Credits)
Basic techniques and principles of systematics with application to the origin, evolution, radiation, classification and biodiversity of flowering plants (angiosperms). Lab fee associated with this course. Prerequisites: (BIOL 1010 AND BIOL 1011) or (GEOG 1201, GEOG 1202, AND GEOG 1203), OR instructor’s permission.

BIOL 3400 Ornithology (4 Credits)
Biology of birds with emphasis on ecology and behavior; field and laboratory work to stress bird identification and ecological relationships of birds. Lab fee associated with this course. Prerequisites: BIOL 1010, BIOL 1011.

BIOL 3410 Animal Behavior (4 Credits)
This class examines animal behavior from an evolutionary and ecological perspective. The course provides the background needed to understand behavioral evolution, including a focus on the inheritance of behavior, natural selection, sexual selection, and kin selection. This class studies the evolution of a variety of behaviors, including communication and displays, mate choice, parental care, cooperation, mating systems, social behavior, habitat selection, foraging, and anti-predator behavior. The emphasis is on theoretical principles, design of experiments, and interpretation of data. Prerequisites: BIOL 1010 and BIOL 1011, AND BIOL 2010. RECOMMENDED PREREQUISITE: BIOL 2090.

BIOL 3560 Molecular Biology Laboratory (4 Credits)
Laboratory based course that covers techniques in gene excision, cloning and reinsertion and gene sequencing. Lab fee associated with this course. Prerequisite: BIOL 2510, or permission of instructor.

BIOL 3570 Proteins in Biological Systems (3 Credits)
Proteins considered in their biological setting; protein synthesis and degradation; survey of protein functions in vivo; evolution of proteins; introduction to protein biotechnology. Prerequisites: BIOL 2120, CHEM 2451, CHEM 2452 and CHEM 2453.

BIOL 3610 Developmental Biology (4 Credits)
Processes and mechanisms of development, exemplified by higher animal embryogenesis, with consideration of microbial model systems. Prerequisite: BIOL 2120 and BIOL 2120.

BIOL 3620 Vertebrate Embryology (4 Credits)
Development processes in placental mammals; analysis of vertebrate cyto-differentiation and morphogenesis. Laboratory on embryonic anatomy of amphibians, birds and mammals. Prerequisites: BIOL 1010, BIOL 1011 and BIOL 2120. Corequisites: BIOL 1010.

BIOL 3630 Cell Biology of Development (4 Credits)
Every organism has a stereotypical shape, but how does this shape arise? This course examines the cellular and molecular mechanisms that direct the forming of body and tissue shape. Prerequisite: BIOL 2120.

BIOL 3640 Introductory Neurobiology (4 Credits)
Organization and function of vertebrate central nervous system; nature of action potential, biochemistry of neurotransmitters, neuropeptides, functional anatomy of nervous system, phylogeny of nervous system. Prerequisite: BIOL 2120.

BIOL 3641 Systems Neuroscience (4 Credits)
Structure and function of the brain and spinal cord, emphasis on functional systems including sensory perception, motor control and consciousness. Prerequisite: BIOL 3640.

BIOL 3642 Neuropharmacology (4 Credits)
How psychoactive drugs exert their effects on the nervous system; drugs of abuse and drugs used in the treatment of psychotic and neurodegenerative disorders. Prerequisite: BIOL 2120. Recommended prerequisites: BIOL 3640.

BIOL 3643 Developmental Neurobiology (4 Credits)
This course investigates the mechanisms involved in the maturation of neurons, and signals that direct neurons to their proper position in the central nervous system. Prerequisite: BIOL 3640.

BIOL 3644 Neuromuscular Pathophysiology (4 Credits)
Cellular and molecular basis for normal nerve and muscle functions and the alteration of these functions by toxins, trauma and diseases of the brain, nerves and muscles; how specific insults produce clinical symptoms and pathology. Prerequisite: BIOL 2120. Recommended Prerequisite: BIOL 3640 or BIOL 3250.

BIOL 3646 Seminar: Cognitive Neuroscience (2 Credits)
This seminar is the capstone course for the neuroscience portion of the cognitive neuroscience program. Seminar topics include but are not limited to neurological disorders, model systems in neuroscience and sensory systems.

BIOL 3650 Endocrinology (4 Credits)
Mechanisms of hormone action, evolution of vertebrate endocrine systems, analysis of function integration of hormonal responses in maintenance of homeostasis. Prerequisite: BIOL 2120.
BIOL 3655 Molecular Neuroendocrinology (4 Credits)
Advanced laboratory course that uses anatomical/immunological, biochemical and molecular approaches to analyze neuroendocrine pathways in the hypothalamus/pituitary system. Lab fee associated with this course. Prerequisites: BIOL 3650 and instructor's permission.

BIOL 3670 Molecular Immunology (4 Credits)
The ability to distinguish self from non-self is crucial to all organisms. In humans, organs, cells and other higher animals, this task falls to the immune system. Suppression of this system is key to numerous pathogenic viruses including Ebola and human immunodeficiency virus. The failure to adequately regulate immune response underlies allergic reactions, arthritis and diabetes. This course will introduce students to the organs, cells and molecules that underlie mammalian immune response; immunogenetics and the fundamental mechanisms of cell-mediated and humoral immune response; and the relationship of immune system to human disease. Prerequisite: BIOL 2510.

BIOL 3680 Advanced Techniques in Cell Biology (4 Credits)
Advanced laboratory course that covers current techniques used in cell biology research. Lab fee associated with this course. Prerequisite: BIOL 2120.

BIOL 3690 Advanced Topics in Regulation Biology (1-4 Credits)
Topics vary; may include endocrinology, physiology, or immunology; one topic per quarter. May be repeated for credit. Taught from original literature. Prerequisite: varies with topic and instructor; instructor's permission usually required.

BIOL 3800 Human Molecular Biology (4 Credits)
Medical Genetics is the 24th member of the American Board of Medical Specialties. This course will introduce students to the fundamentals of molecular biology with an emphasis on understanding of how the field is applied in the context of medical diagnostics, personalized/precision medicine and other commercial applications. Students will be introduced to published research reports and provided with opportunities to critically examine the application of molecular biology to central questions in such areas as oncology, inherited diseases and genetically engineered organisms. Prerequisite: BIOL 2510.

BIOL 3910 Viruses & Infectious Human Diseases (4 Credits)
From sexually transmitted viruses to bacterial pneumonia, infectious pathogens are the number one threat to human health. This course will introduce students to prions, viruses and bacterial pathogens with an emphasis on those commonly encountered in clinical medical practice. Through the use of technical/scientific research journals, students will be encouraged to investigate the etiology, pathogenesis and treatment of human infectious disease with an emphasis on the clinical, molecular diagnostic and therapeutic aspects of the disease. Prerequisite: BIOL 2510. Recommended prerequisite: BIOL 3800.

BIOL 3950 Undergraduate Research (1-10 Credits)
Participation in faculty research programs by agreement between student and faculty member. Maximum of 5 quarter hours of BIOL 3950 and/or BIOL 3991 may be applied to the 45-quarter-hour requirement for a major in biological sciences.

BIOL 3991 Independent Study (1-10 Credits)
Topic in biology studied under faculty supervision. Student’s responsibility to identify faculty supervisor before registering for class. Maximum of 5 quarter hours of BIOL 3991 and/or BIOL 3950 may be applied toward the 45-quarter-hour requirement for a major in biological sciences.

BIOL 3992 Directed Study (1-10 Credits)

BIOL 3995 Independent Research (1-10 Credits)

BIOL 4010 Cellular Motile Function (2 Credits)
Current literature in area of cell motility; role of cytoskeletal elements as motile agents.
BIOL 4020 Microbial Genetic Model Syst (2 Credits)

BIOL 4030 Current Concepts in Evolution (2 Credits)
New ideas and theories in field of evolutionary biology.

BIOL 4040 Current Concepts-Animal Phys (2 Credits)
Selected topics in animal physiology.

BIOL 4050 Topics in Plant Biology (2 Credits)
Varying topics; areas of plant-animal interactions, co-evolution, plant ecology, plant biochemistry/physiology.

BIOL 4060 Gene Expression-Development (2 Credits)
Varying aspects of gene control in developing systems, a different aspect each time course is offered.

BIOL 4070 Hormone-Receptor Interaction (2 Credits)
Series of lectures; understanding molecular, cellular basis of hormone action; experimental analysis of binding of hormones with their receptors; structure-function relationships of hormone-receptor interactions; nature and action of mediators generated by hormone-receptor interaction.

BIOL 4080 Biological Membranes (2 Credits)

BIOL 4085 Accelerated Biostatistics (2 Credits)
This is an accelerated online statistics course for graduate students in Biology. Basic probability and hypothesis testing is the foundation of teaching applied statistics, including simple statistics (t-tests, F-tests, and chi square) and more advanced procedures (regression, correlation, analysis of variance). In addition, students learn more complex tools (multiple regression, multi-classification ANOVA, Student-Newman-Keuls tests), including non-parametric Tests (Mann-Whitney U, Sign test, Wilcoxon Rank Sum).

BIOL 4090 Biostatistics (4 Credits)
Statistic on biological research; emphasis on procedures, applications of regression, correlation, analysis of variance, and nonparametric tests. Include instruction on computer aided (Mac and PC) statistical analysis and presentation of results. Cross listed with BIOL 2090.

BIOL 4091 Ecology and Evolution Research Methods (1 Credit)
This course builds upon the concepts in BIOL 4090, Biostatistics, by covering in more detail and specificity issues involved in designing one's experiment to adequately test the hypotheses or describe the data of interest. Students bring and discuss their specific research projects as case studies to maximize the utility of the course.

BIOL 4100 Microbial Structure & Function (2 Credits)

BIOL 4110 Essentials of Immunology (2 Credits)

BIOL 4120 Human Chromosomes and Mutagenesis (2 Credits)

BIOL 4130 Microevolution (2 Credits)
Microevolution, the change of gene frequencies within populations; examination of forces that cause it, evaluation of its contribution to process of speciation.

BIOL 4140 Protein Biosynthesis (2 Credits)
Processes of protein synthesis in cells; emphasis on posttranslational modifications that occur to secretory proteins prior to secretion.

BIOL 4150 Special Topics in Adv Biology (1-4 Credits)
Topics of special interests to teaching and research faculty presented as needed to complement and expand existing curriculum. May be taken more than once for credit.

BIOL 4155 Leadership in Science (1 Credit)
This course addresses the basic leadership skills necessary to succeed in the dynamic professional environment of the biomedical sciences. Topics covered include leadership strategies and professional negotiation, conflict resolution, and team-building. Students will determine leadership strengths and weaknesses and use case studies to strengthen their leadership practices.

BIOL 4190 Biometry (3 Credits)

BIOL 4210 Grad Sem: Cell Biology (2 Credits)
A series of student presentations focusing on varied topics involving cell biology. May be taken more than once for credit.

BIOL 4211 Advanced Cell Biology (3 Credits)
Students study the subcellular structure and organization of the cell. Organelle structure and function are examined in detail as well as biogenesis and degradation (turnover) of these subcellular structures. Cytoskeletal dynamics are also a major focus. Specific topics covered include cell division, macromolecular synthesis, membrane transport, cell-matrix and cell-cell communication, cell migration, cell differentiation, and mechanisms of cell death. The course follows a lecture format in conjunction with selected journal article presentations and discussions by the students. Cross listed with BIOP 4150.

BIOL 4212 Advanced Molecular Biology (3 Credits)
This course focuses on a detailed analysis of regulated gene expression. The topics include lectures and readings of relevant literature in areas covering gene regulation at multiple steps, including transcription, RNA processing, and translation. In particular, the logic of experimental design and data analysis are emphasized.
BIOL 4213 Advanced Cell Signaling (3 Credits)
Students in this course investigate a large array of cellular signal transduction cascades. Specific signaling pathways to be covered include growth factor receptors, cytokine receptors, steroid receptors, integrin-extracellular matrix, heterotrimeric G-protein coupled receptors, monomeric G-proteins, transcription factors, lipids, cytoskeleton, cell cycle, and apoptosis. Each of these topics is examined in the context of normal cell physiology as well as their roles in specific disease processes. The course follows a lecture format in conjunction with selected journal article presentations and discussions by the students.

BIOL 4220 Grad Sem: Ecology & Evolution (2 Credits)
A series of student presentations focusing on varied topics involving ecology and evolution. May be taken more than once for credit.

BIOL 4230 Grad Sem: Molecular Biology (2 Credits)
A series of student presentations focusing on varied topics involving ecology and evolution. May be taken more than once for credit.

BIOL 4231 Responsible Conduct in Rsrch (1 Credit)
This course covers several topics regarding guidelines for ethical practices in research. Topics include: data ownership, conflict of interest and commitments, human subjects, animal welfare, research misconduct, authorship, mentoring, peer review, and collaboration. The course includes an online training component and meets one hour each week to discuss these topics.

BIOL 4300 Fall Graduate Reviews in Biol (1 Credit)
Students participate in a required review session that precedes selected departmental seminar presentations by faculty and outside speakers, and participate in a discussion session with the seminar speaker.

BIOL 4301 Wntr Graduate Reviews in Biol (1 Credit)
Students participate in a required review session that precedes selected departmental seminar presentations by faculty and outside speakers, and participate in a discussion session with the seminar speaker.

BIOL 4302 Sprg Graduate Reviews in Biol (1 Credit)
Students participate in a required review session that precedes selected departmental seminar presentations by faculty and outside speakers, and participate in a discussion session with the seminar speaker.

BIOL 4303 Reviews in Biology (1 Credit)
The experience is built around the departmental seminar series offered every quarter.

BIOL 4310 Foundations in Literature: Cell and Molecular Biology (2 Credits)
Students participate in a weekly discussion group that focuses on recent papers from the primary literature in Cell and Molecular Biology.

BIOL 4311 Wntr Selected Top: Reg Bio (2 Credits)
Students participate in a weekly discussion group that focus on recent papers from the primary literature in regulatory biology.

BIOL 4312 Sprg Selected Top: Reg Bio (2 Credits)
Students participate in a weekly discussion group that focus on recent papers from the primary literature in regulatory biology.

BIOL 4322 Selected Tpcs: Molecular Biol (2 Credits)
The syllabus for the Selected Topics series varies each quarter. Each quarter a faculty member sets the theme for the quarter and identify a set of review articles to introduce the topic. The instructor leads the first session and provide important background material on the topic. Students select a paper from the primary literature to present to the class on the topic designated for the quarter.

BIOL 4330 Foundations in Literature: Ecology (2 Credits)
Students participate in a weekly discuss group that focuses on recent papers from the primary literature in Ecology.

BIOL 4331 Foundations in Literature: Evolution (2 Credits)
Students participate in a weekly discussion group that focuses on recent papers from the primary literature in Evolution.

BIOL 4332 Foundations in Literature: Conservation Biology (2 Credits)
Students participate in a weekly discussion group that focuses on recent papers from the primary literature in Conservation Biology.

BIOL 4440 Current Concepts-Animal Phys (2 Credits)

BIOL 4610 Developmental Biology (4 Credits)
The processes and mechanisms of development, exemplified by higher animal embryogenesis, with consideration of simpler model systems. Laboratory sessions use live materials; course finishes with individual projects. Prerequisite: BIOL 2510 or equivalent.

BIOL 4700 Human Molecular Biology (4 Credits)
Molecular basis of heredity and genetic control, using in-vitro systems and microbial and eukaryotic models; molecular basis of heredity and genetic regulation considering in-vitro systems as well as prokaryotic and eukaryotic models. Restricted to MBA Bioenterprize students.

BIOL 4710 Endocrinology: Chemical Communication Systems (4 Credits)
Mechanisms of hormone action, evolution of vertebrate endocrine systems, analysis of function integration of hormonal responses in maintenance of homeostasis. Restricted to MBA Bioenterprize students.

BIOL 4720 Neuropharmacology (4 Credits)
How psychoactive drugs exert their effects on the nervous system; drugs of abuse and drugs used in the treatment of psychotic and neurodegenerative disorders. Restricted to MBA Bioenterprize students.
BIOL 4730 Molecular Lab Techniques (4 Credits)
Techniques in gene excision, cloning and reinserterion; gene sequencing. Restricted to MBA Bioenterprize students.

BIOL 4731 Cell and Molecular Techniques (4 Credits)
Analysis of neuroendocrine systems using a multidisciplinary approach. Anatomical/immunological, biochemical and molecular approaches used to analyze neuroendocrine pathways in the hypothalamus/pituitary system. Restricted to MBA Bioenterprize students.

BIOL 4740 Microbiology (4 Credits)
Fundamental principles; role of bacteriology in biological phenomena. Includes laboratory. Restricted to MBA Bioenterprize students.

BIOL 4750 Immunology (4 Credits)
Organs, cells and molecules that underlie mammalian immune response; relationship of immune system to disease. Restricted to MBA Bioenterprize students.

BIOL 4760 Advanced Cell Biology (4 Credits)
Focuses on spatial and temporal control of intracellular processes with an emphasis on neuronal and endocrine cells. Topics include vesicular traffic, protein targeting, dynamics and spatial organization of signaling complexes. Emphasis on modern techniques of cell and molecular biology with examples from primary literature. Restricted to MBA Bioenterprize students.

BIOL 4850 Laboratory Skills for Forensic Serological Analysis (5 Credits)
This course is designed to provide students with two major educational skills. First, is a thorough understanding of the fundamental science behind the identification and serological analysis of biological evidence in a forensic context. Second, is a rigorously developed set of practical hands-on proficiencies with the major commercial assay systems used by forensic laboratories for the identification of blood, saliva, semen, and other biological material with potential probative value to a criminal investigation.

BIOL 4860 Laboratory Skills for Forensic Genetic Analysis (4 Credits)
This course is designed to provide students with two major educational skills. First, is a thorough understanding of the fundamental science behind the molecular genetic analysis of biological evidence in a forensic context. Second, is a rigorously developed set of practical hands-on proficiencies with the major commercial assay systems and software used by forensic laboratories for the determination and analysis of DNA profiles.

BIOL 4870 Medical Ethics (4 Credits)
This course presents knowledge and discussion of ethical issues that arise from advances in the biomedical sciences and medicine. Several specific ethical issues and policies related to methodologies and procedures, emerging medical technologies, treatment decisions, doctor-patient relationship, informed consent, medical experimentation/clinical research, and health care reform.

BIOL 4880 Capstone in Biomedical Sciences (4 Credits)
This is the capstone course for students enrolled in the Professional Science Masters program. In this course, students integrate advanced knowledge in science and math along with courses taken outside traditional science and math courses as their electives. This course incorporates lectures, guest speakers, and class discussions focusing on current issues or concerns in the chosen concentration. PSM students only. Requires instructor approval.

BIOL 4991 Independent Study (1-17 Credits)

BIOL 4992 Directed Study (1-10 Credits)

BIOL 4995 Independent Research (1-8 Credits)

BIOL 5991 Independent Study (1-17 Credits)

BIOL 5995 Independent Research PhD (1-8 Credits)