# Biology (M.S.)

## About The Program:

The M.S. in Biology offers students rigorous advanced study of the Biological Sciences. Broad preparation is offered in major research areas in Biology through a variety of formal courses and advanced seminars. Students are encouraged to take courses in related sciences. Preparation for both research and teaching is important.

**Career Options:** The department produces well-trained biologists who find work in the health professions, pharmaceutical or biotechnology fields, and government or academia.

**Prerequisites for Admission:** Bachelor's Degree in a science field and a solid background of Biology with at least eight undergraduate Biology courses and one year of Chemistry, Physics, and Calculus.

**Areas of Specialization:** Faculty members specialize in the areas of

- Aquatic and Terrestrial Ecology
- Biochemistry
- Biophysics
- Cell Biology
- Computational Genomics
- Developmental Biology
- Evolutionary and Organismal Biology
- Genetics
- Molecular Biology
- Molecular Evolution
- Neurobiology
- Virology

## Requirements of Programs:

- **Total Credit Hours**: 30
- **Culminating Events**:
  *Thesis:*
  The master's thesis is an original empirical study that demonstrates the student's knowledge of research methods and mastery of her/his primary area of interest. The thesis should be limited to a specific problem in the Biological Sciences and investigated under the direct supervision of a major advisor.
  A student preparing to defend a master's thesis should confirm a date and time with her/his committee, composed of both the major advisor and another member of the Graduate Faculty. The student should then register with the Graduate Secretary. After the date, time, and room are approved, the Biology Department posts flyers announcing the defense.
  The student's committee is responsible for evaluating the thesis and its oral defense in a public presentation. The committee votes to pass or fail the thesis and defense at the end of the public presentation. If revisions are required, the committee must approve the changes.

## Required Courses

**Introduction to Graduate Research -** This course will provide entering doctoral students in Biology with a broad perspective on philosophical and scientific reasoning, introduce overarching principles in both bioethics and biostatistics, and initiate student development through exercises that emphasize both written and oral communication skills necessary for a successful career in the sciences.

### Two 3-Credit Graduate Seminar Courses

*Select Three from the Following Courses:*

**Evolution -** A lecture and discussion course for upper-level science majors and graduate students. Topics covered include Darwinism and neo-Darwinian theory, including adaptation, natural selection, sexual selection, and speciation.

**Evolutionary Genetics Genomics –** This class covers fundamental principles of population and comparative genetics with special attention given to recent advances in genomics. The scope of the class ranges from understanding variation at the population level to addressing species-level questions. Topics covered include classical population genetics, quantitative genetics, comparative genomics, phylogenomics and speciation. Lectures, assignments and discussions will explore theoretical and recent empirical advances.

**Behavioral Genetics –** This course is an introduction to the interdisciplinary field - behavioral genetics - that combines behavioral sciences and genetics and unifies the long-standing debate on what underlies complex human behavior: "nurture" or "nature." This course will discuss the genetic approaches used to dissect out the genetic determinant of complex human traits. For example, students will learn about genes that influence learning and memory, intelligence (IQ), cognitive disabilities, personality disorders, psychopathology, antisocial behavior, substance abuse, and sexual orientation. In addition, the interplay of environment and genetic factors that create individual differences in behavior will be explored. Because this field represents the intersection between what is known and what might be known in the future about complex and potentially controversial behaviors and characteristics, students will be encouraged to discuss contemporary ethical issues regarding human behavior in realm of the scientific evidence presented.

**Animal Behavior –** This course will examine how animals behave, and investigate the proximate (neurological and developmental) and ultimate (functional and evolutionary) explanations for these behaviors. The ecological and evolutionary processes that shape animal behavior will be examined through the study of classic theories and major principles of animal behavior, including a weighing of the experimental and observational evidence for each idea. Concepts will be illustrated with examples from a wide range of taxonomic groups of animals in diverse ecosystems, and emerging theories in animal behavior will be discussed. We will conclude with applications of animal behavior for conservation.

**Conservation Biology –** The Earth harbors an incredible diversity of species and communities, most still poorly understood by science. This biodiversity is essential to the functioning of natural ecosystems and provides a wide array of priceless services to people today and a treasure of benefits for the future.

Yet human threats to biodiversity have led us to the brink of the sixth major extinction event in Earth's history. Which populations, species, communities, and ecoregions are most diverse? Which are most threatened, and by which human activities? What is the contribution of biodiversity to human livelihoods? What does the science suggest is needed to conserve biodiversity? How might this best be done given social, economic, and political realities? These questions and more will be examined in this course, focusing on the key principles of conservation biology and the application of those principles to local, national, and international examples.

**Herpetology –** Herpetology Reptiles and amphibians comprise nearly 7,400 species and can be found on every major and minor landmass in the world except Antarctica. This course will provide a broad, evolutionary survey of the major groups of reptiles and amphibians ("herps"). We will cover topics about their basic biology, including anatomy, physiology, ecology, behavior, and conservation. The laboratory will emphasize taxonomic characters and identification of living and preserved specimens, with emphasis on species found in North America. Additionally several field trips (conducted during lab hours and spring break) will reinforce course material through hands-on experience.

**Biostatistics –** Biostatistics is an important part of the research activities related to biological and medical issues. Statistics is used to analyze phenomena with random properties and is often essential to draw the right conclusions based on a data set. The course will be designed to cover different statistical methods for data analysis mainly applied to medical and biological problems. Advanced undergraduate and graduate students with interests in medicine and biomedical research will benefit most from the course. However statistical methods that can be applied to behavioral science and ecology will also be covered.

**Plant Community Ecology –** This class focuses on fundamental principles in community ecology as they relate to plant systems. The scope of the class ranges from plant-environment interactions and species interactions, to the relationship among communities at larger spatial scales. Lectures and small group discussions will also highlight theoretical and empirical advances made in ecology through classic and contemporary studies of plant communities.

**Biology of Plants –** This course examines current knowledge of higher plants, with an emphasis on Arabidopsis and maize. Topics include plant reproduction, self-incompatibility, polyploidy in plants, sex chromosomes in plants, chloroplast structure and function, light and dark reaction of photosynthesis, nitrogen fixation, phytochromes, DNA and histone methylation and epigenetics, embryonic pattern formation in plants, chemical signaling in plants, leaf morphogenesis, flower development, and stem cell populations in plants.

**Comparative Biomechanics –** An overview of biomechanics with emphasis on locomotion. Students gain a working knowledge of the breadth of biomechanical study ranging across organismal and environmental scales.

**Epigenetics –** The term "epigenetics" describes a heritable effect on chromosome or gene function that is not accompanied by a change in DNA sequence. Recent findings suggest an important role of epigenetics in both normal development and cancer. This course provides an overview of the field and examines selected phenomena in several eukaryotes, mechanisms regulating these effects, and their phenotypic consequences when normal regulation is lost. Topics include gene regulation through

chromatin modification (acetylation, methylation), genomic imprinting, mechanisms of silencing (including small interfering RNAs), and the role of epigenetics in human diseases and cancer.

**Cellular/Molecular Neuroscience -** The course will focus on the molecular and cellular basis of neurological processing. The fundamentals of action potential generation, synaptic and receptor potentials generation and neuron-neuron communication will be discussed. The contemporary understanding of sensory processing will be covered in great detail with a particular focus on molecular sensors of light, sound, odorants, taste and touch and the signal transduction pathways that underlie the five senses.

**Stem Cell Biology –** The purpose of this course is two-fold. The first is to present the developmental biology of stem cells, with an overview of the various types of stem cells that exist and an emphasis on embryonic stem cells. The overview will include the important functional differences between embryonic, hematopoietic, and adult stem cells as well as the differences in their biomedical potentials. Techniques such as somatic cell nuclear transfer (SCNT) and other methods for the derivation of stem cell lines will be outlined so that differences that may seem subtle at first glance are clarified. The second purpose is to look into the larger debate on human embryonic stem cell research while continually drawing connections to the established fields of bioethics, politics, and philosophy. The course will ground the issues by looking at the history of the debate over the embryo, with careful attention paid to the language used in arguments. An exploration of important social, ethical, political, and economic issues and how they arose with respect to the stem cell debate will round out the remainder of the course.

**Genomics –** Genomics is the study of the mechanisms of gene inheritance and gene expression as they are manifested across the entire genome. Students will learn about genome-related technologies, including genome sequencing and mapping. They will also learn about genome structure and how genomes vary across species, as well as the forces driving these evolutionary changes. Students will also learn how to carry out genome-level data analyses. NOTE: Prior to fall 2015, this course was titled "Genomics and Proteomics."

**Tropical Marine Biology: Belize –** An introduction to the largest coral barrier reef in the Atlantic Ocean. Course lectures begin at Temple (approximately Dec 29-Jan 31; holidays excluded) followed by a week of lectures, field trips and field or laboratory projects in Belize. Lectures include coral biology, reef geology and ecology, coral reef microbiota, food chains and nutrient transfer in coral reefs, reef community organization, the biology of reef fishes, commensal and symbiotic interactions of reef organisms, and other appropriate topics. Group student team projects and lectures are required. Note: Additional requirements include cost of air travel to a foreign country between fall and spring semesters, a current passport, and snorkeling equipment.

**Virology –** The role of viruses in human diseases, and their potential as tools for research and clinical interventions. The course will focus on virus-induced diseases in man including polio, rabies, hepatitis, herpes, and influenza; recently discovered viruses such as HIV and HTLV-1 will also be studied. Virus-host interactions and the mechanisms involved in disease progression, therapeutic strategies, and vaccines, strategies for viral entry, evasion of the immune system, transmission, and the subversion of host-cell machinery will be emphasized. Potential uses of viruses as vector for gene therapy of genetic disorders, cancers, and infectious diseases will also be discussed.

**Developmental Genetics –** The role of genes in the determination and differentiation of eukaryotes. Emphasis on the regulation of gene function and on the genetic and molecular interactions which control the processes of development.

**Freshwater Ecology –** The interrelationships between biological, chemical, and physical factors in freshwater environments. Lectures and laboratories address general ecological principles (population dynamics, community structure, energy flow, and nutrient cycling) as they apply to plants and animals in lakes, ponds, streams and wetlands. Note: Students are required to participate in up to two field trips, one of which includes weekend travel.

**Systems Neuroscience –** A comparative survey of vertebrate and invertebrate nervous systems intended to acquaint the student with their structure, function and development at several levels of complexity.

**Neurological Basis of Animal Behavior –** An exploration of the relationship of neural activity and connectivity to behavior. Topics include motor control, object recognition and learning. Examples from both vertebrate and invertebrate species. Analytic and synthetic approaches.

**Organization and Development of the Nervous System –** This course covers developmental, anatomical and integrative aspects of the nervous system. The relationship of form to function will be studied in a variety of systems both invertebrate and vertebrate. The course is intended to complement Neurobiology 352/452 so that students will have a perspective on neuroscience ranging from the molecular to the systems level.

**Biochemistry of Embryogenesis –** This course will compare and contrast key biochemical mechanisms of embryonic development in a variety of model organisms ranging from humans to plants. We will examine the roles of enzymes, peptides, small RNA molecules and chromatin structure during embryogenesis. Topics will include micro RNAs, modification of DNA structure, and effects of mutation on enzyme activity. These basic principles will then be applied to subjects such as cell communication, stem cells, and cloning. Course material will be drawn from the experimental literature.

**Mammalian Development**

**Contemporary Biology (with approval)**

**Molecular Biology -** A background knowledge of biochemistry and basic genetics at the undergraduate level is desirable. Structure, function and interaction of proteins and nucleic acids; building macromolecular complexes; techniques in molecular biology; introduction to molecular genetics and genomics; DNA replication and repair; transcription at the level of both genes and genomes; role of chromatin in gene regulation; non-coding RNAs; RNA processing; RNA interference; protein synthesis and its regulation; introduction to proteomics; transposons; regulatory proteins in eukaryotes.

**Cell Proliferation –** Discussion of cell proliferation and its control; assay systems, comparisons of proliferating cells with nonproliferating cells, controls of cell division and how that control is modified in proliferative diseases such as cancer, the relationships between proliferation and differentiation.

**Physical Biochemistry –** The course covers those aspects of computer simulation of molecular dynamics, quantum mechanics, and statistical mechanics of use to biochemist and biologist interested in molecular modeling. The course is intended to be computer intensive.

**General Biochemistry I –** Properties of water (pH and buffers); metabolism of carbohydrates, amino acids, fatty acids, and phospholipids properties of biomacromolecules proteins, and nucleic acids; DNA structure and replication; protein synthesis; energy generation; catalysis and control of enzymatic activity and interrelationships among the metabolic pathways.

**General Biochemistry II –** Emphasis on the biochemical reactions in various metabolic pathways. Biosynthesis and degradation of carbohydrates, lipids, proteins and amino acids. Regulation and integration of metabolic pathways. Bioenergetics and oxidative phosphorylation. Signal transduction. Transcription, translation and their control.

**Biotechnology -** This course is designed to survey current issues in technologies including therapeutics and diagnostics, and to examine consequences of developments in this area. The course is designed in a Problem Based Learning format, where students research critical areas and provide oral and written reports for other members in the class. The course is organized by topics including Concepts in Genetics, Cloning and Ethics, Gene Therapy, Prenatal Diagnosis, Gene Therapy for Cancer, Cell Replacement Therapy, Genomics and Proteomics, Vaccines, Forensics, Plant Biotechnology, and Instrumentation. At the end of the course, each student makes a formal presentation on a specific advance in biotechnology.

**Analytical Biotechnology –** This course provides a comprehensive survey of current techniques of biomolecule measurement and analysis using biochemical testing as the basis of measurement in a biotechnology laboratory. The detection, purification, and characterization of biomolecules (proteins, nucleic acids, carbohydrates, and lipids) are major goals in biotechnological research and development. Specific biomolecules serve as markers for the accurate and sensitive diagnosis of disease, and afford drug targets for disease treatment. Biomolecules also can be indicators of harmful (or beneficial) environmental agents and conditions. New, highly sensitive and accurate analytical methods are now available for the detection of diverse biomolecules. Note: Biochemistry Majors who have completed CHEM 4375 or CHEM 4404 with a minimum grade of C may register for BIOL 5501 with permission from instructor.

**Microbial Biotechnology -** Course covers use of microorganisms in biotechnology. Includes recombinant DNA methodology and application of these approaches to production of medicines and for environmental remediation. Synthetic biology and metabolic engineering will also be covered (theory and concepts).

## Courses:

**Click HERE for more information on the courses below.**

- Evolution
- Genomics in Medicine
- Fundamentals of Genomic Evolutionary Medicine
- Evolutionary Ecology
- Genomics and Infectious Disease Dynamics
- Evolutionary Genetics Genomics
- Innovative Biomodels and Concepts
- Biomarkers and Biotargets: Research and Commercialization
- Epigenetics, Genetics: Applications in Drug Design and Drug Response

- Systems Biology: Principles and Applications
- Behavioral Genetics
- Effective Dissemination of Bio-discoveries through Traditional and New Media
- Bioinnovation Seminar
- Milestones in Clinical Translation of Biodiscoveries
- Bioadvanced Screening in Health Disparity
- Virtual Reality in Bioindustry and Medicine
- Dissemination of Biodiscoveries and Virtual Reality in Medicine
- Genomics and Evolutionary Biology of Parasites and Other Dependent Species
- Animal Behavior
- Ecology of Invasive Species
- Cell Biology
- Conservation Biology
- Herpetology
- Biostatistics
- Plant Community Ecology
- Biology of Plants
- Research Techniques in Molecular Biology
- Polar Biology - Life at the Extremes
- Comparative Biomechanics
- Epigenetics
- Cellular/Molecular Neuroscience
- Stem Cell Biology
- Genomics
- Structural Bioinformatics I
- Tropical Marine Biology: Belize
- Immunology
- Virology
- Developmental Genetics
- Advanced Techniques in Microscopy
- Freshwater Ecology
- Systems Neuroscience
- Neurological Basis of Animal Behavior
- Organization and Development of the Nervous System
- Biochemistry of Embryogenesis
- Mammalian Development
- Contemporary Biology
- Endocrinology
- Molecular Biology
- Cell Proliferation
- General Biochemistry I
- General Biochemistry II
- Biotechnology
- Analytical Biotechnology
- Microbial Biotechnology
- Biotechnology Laboratory I
- Biotechnology Laboratory II
- Ethics Regulation and Policy in Biotechnology
- Professional Development Seminar for PSM in Biotechnology
- Computational Genomics
- Ethics in Bioinformatics
- Nucleic Acid Technologies
- Introduction to Scientific and Regulatory Writing
- Introduction to Grant Writing
- Communicating Science to a Broader Audience / Non-Scientists
- Graduate Independent Study
- Teaching of Biology
- Introduction to Graduate Research
- Seminar in Neuroscience
- Research Techniques
- Teaching in Higher Education: Life Sciences
- Directed Readings
- Master's Research Projects
- Preliminary Examination Preparation
- Master's Thesis Research