Biology, Ph.D.

COLLEGE OF SCIENCE AND TECHNOLOGY (http://cst.temple.edu)

About the Program

The Ph.D. 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.

Time Limit for Degree Completion: 7 years

Campus Location: Main

Full-Time/Part-Time Status: Full-time study is required.

Interdisciplinary Study: The program encourages interdisciplinary research and coursework in Biochemistry, Chemistry, Computer Science, Environmental Science, Engineering, Mathematics, and Physics. Special interdisciplinary programs in which faculty from the Biology Department participate include the Center for Biotechnology, Center for Computational Genetics and Genomics, the Institute for Computational Molecular Science, the Institute for Genomics and Evolutionary Medicine, and the Environmental Studies and Neuroscience Programs.

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, and Virology.

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

Non-Matriculated Student Policy: Non-matriculated students may enroll in a total of three courses (9 credits) with permission of the instructor and the department.

Financing Opportunities: Temple University offers a limited number of Fellowships to support outstanding students in the doctoral program. Fellowships typically provide support, including a stipend and tuition, for two years.

Additional support is available in the form of Teaching and Research Assistantships. The principal duties of a Teaching Assistant include assisting faculty in the classroom; offering field and laboratory instruction; preparing materials for demonstration; conducting tutorials and laboratory sessions; and grading labs, quizzes, and tests. Attendance at weekly laboratory preparation sessions is required. The duties of a Research Assistant vary depending on the faculty member or principal investigator who is directing a specific research project. The appropriate project(s) are determined by consultation between the student and the student’s academic and research advisors. Research Assistants are expected to devote 20 hours per week to research obligations. Both Teaching and Research Assistantships typically provide a nine-month academic-year stipend and full tuition remission (up to 9 credits per term), but are generally awarded on a per term basis. Summer stipends are also available. Assistantships are awarded competitively.

Admission Requirements and Deadlines

Application Deadline:

Fall: December 15; November 15 international
Spring: October 15; August 1 international

Matriculation in the Fall is highly recommended.

APPLY ONLINE to this graduate program

Letters of Reference:

Number Required: 3

From Whom: Letters should be obtained from college/university faculty, preferably those in laboratory science areas, who are familiar with the applicant’s academic and/or research abilities.

Coursework Required for Admission Consideration: Applicants should have a solid background in Biology and should have taken at least eight undergraduate Biology courses, as well as one year each of Calculus, Chemistry, and Physics. The Biology Department Graduate Committee may allow exceptions to these course requirements after review.

Master's Degree in Discipline/Related Discipline: A master's degree is not required.
Bachelor's Degree in Discipline/Related Discipline: A baccalaureate degree in Biology or another science field is required.

Statement of Goals: Approximately 500-1,000 words include your interest in Temple's program, your research goals, and your academic and research achievements.

Standardized Test Scores:
GRE: Required. Combined minimum score of 305 on the quantitative and verbal reasoning sections
TOEFL: 90 iBT or 575 PBT minimum

Transfer Credit: Graduate credits from an accredited institution may be transferred into the Biology program. The credits must be equivalent to coursework offered by the Biology Department at Temple University. A grade of "B" or better must have been earned for the credits to transfer. The Biology Department Graduate Committee makes recommendations to the Department Chair for transferring credit on an individual basis. The maximum number of credits a student may transfer is 6.

Advanced Standing: A student who has completed a master's degree at another institution may apply for advanced standing. Students are awarded varying numbers of credit of advanced standing. This differs from transfer credit in that the number of credits awarded is recorded on the transcript without specific information about the courses transferred. The effect of having advanced standing is to reduce the total number of credits the student is required to take at Temple University.

Program Requirements

General Program Requirements:
Number of Didactic Credits Required Beyond the Master's: 10

Required Courses:

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<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>BIOL 8003</td>
<td>Introduction to Graduate Research</td>
<td>3</td>
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<tr>
<td>BIOL 8220</td>
<td>Seminar (1 s.h. in the Fall and 2 s.h. in the Spring)</td>
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<td></td>
<td>Five 3-s.h. Graduate Seminars</td>
<td>15</td>
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Select other coursework from the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>BIOL 5101</td>
<td>Evolution</td>
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<td>BIOL 5225</td>
<td>Evolution Genetics Genomics</td>
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<td>BIOL 5232</td>
<td>Behavioral Genetics</td>
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<td>BIOL 5254</td>
<td>Animal Behavior</td>
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<td>BIOL 5307</td>
<td>Conservation Biology</td>
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<td>BIOL 5311</td>
<td>Herpetology</td>
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<td>BIOL 5312</td>
<td>Biostatistics</td>
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<td>BIOL 5321</td>
<td>Plant Community Ecology</td>
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<td>BIOL 5322</td>
<td>Plant Genetics</td>
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<td>BIOL 5337</td>
<td>Comparative Biomechanics</td>
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<td>BIOL 5338</td>
<td>Epigenetics</td>
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<td>BIOL 5358</td>
<td>Cellular/Molecular Neuroscience</td>
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<td>BIOL 5366</td>
<td>Stem Cell Biology</td>
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<tr>
<td>BIOL 5403</td>
<td>Genomics &amp; Proteomics</td>
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<tr>
<td>BIOL 5416</td>
<td>Tropical Marine Biology: Belize</td>
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<tr>
<td>BIOL 5428</td>
<td>Virology</td>
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<td>BIOL 5429</td>
<td>Developmental Genetics</td>
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<td>BIOL 5436</td>
<td>Freshwater Ecology</td>
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<tr>
<td>BIOL 5452</td>
<td>Systems Neuroscience</td>
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<tr>
<td>BIOL 5454</td>
<td>Neurological Basis of Animal Behavior</td>
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<tr>
<td>BIOL 5456</td>
<td>Organization and Development of the Nervous System</td>
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<tr>
<td>BIOL 5464</td>
<td>Biochemistry of Embryogenesis</td>
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<td>BIOL 5465</td>
<td>Mammalian Development</td>
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<tr>
<td>BIOL 5466</td>
<td>Contemporary Biology</td>
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<tr>
<td>BIOL 5469</td>
<td>Molecular Biology</td>
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<tr>
<td>BIOL 5471</td>
<td>Cell Proliferation</td>
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<td>BIOL 5474</td>
<td>Physical Biochemistry</td>
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<tr>
<td>BIOL 5475</td>
<td>General Biochemistry I</td>
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<td>BIOL 5476</td>
<td>General Biochemistry II</td>
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<td>BIOL 5479</td>
<td>Biotechnology</td>
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<td>BIOL 5501</td>
<td>Analytical Biotechnology</td>
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<td>BIOL 5502</td>
<td>Microbial Biotechnology</td>
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**Total Credit Hours**: 21

1 One 3-credit seminar may be replaced with three 1-credit seminars.

**Additional Requirements:**
All graduate-level courses must be passed with a "B-" or better.

All Ph.D. candidates must have experience teaching at Temple University. A minimum teaching requirement of two terms may be satisfied by serving as a Teaching Assistant in the Biology Department.

Attendance at scheduled departmental colloquia is required.

**Culminating Events:**

**Preliminary Examination:**
The student independently prepares a written proposal and submits it to the Graduate Committee by April 1 of the student's fourth term. The proposal should follow the general format of a postdoctoral proposal to a federal granting agency (e.g., NIH). It should include background surrounding a particular research problem, including literature related to the problem, and a detailed methodological plan for investigating the problem. The sections of the written proposal should include Title; Abstract (not to exceed 300 words); Specific Aims; Background and Significance; Preliminary Data; Experimental Design, including Rationale, Specific Methods, Interpretation of Possible Results, and Pitfalls and Alternative Strategies; and References in PNAS format. It should be 15 to 20 pages in length. The research advisor is not to make direct contributions to the brief.

The Area Committee has two weeks in which to review the written proposal, and the student is allowed only one re-write. If the proposal is not accepted after the first re-write, the student is considered to have failed the exam. If the written proposal is accepted, an oral examination is scheduled through the Graduate Secretary and held within two weeks. The oral examination tests the student's understanding of the background and substance of the research proposal and her/his understanding of the area of specialization in which the research is embedded.

The preliminary examination is administered by the Preliminary Examination Committee in the absence of the research advisor. A minimum of three examiners serve on the Preliminary Examination Committee. The full exam, both written and oral, is graded by the Preliminary Examination Committee, and one of the following grades is assigned: Fail, Promising, Pass, High Pass, or Pass with Distinction. The evaluators look for a breadth and depth of understanding of specific research areas; a critical application of that knowledge to specific biological phenomena; and an ability to write a proposal in a manner consistent with scientists in the student's specialization. The student is notified of the grade the day the exam is taken. A passing grade requires a 2/3 majority of the Preliminary Examination Committee. The grade of Promising denotes that an exam must be retaken. Examinations that are to be retaken must be completed before October 1 of the following academic year.

**Dissertation:**
The doctoral dissertation is an original empirical study that demonstrates the student's knowledge of research methods and mastery of her/his primary area of research.

The Doctoral Advisory Committee includes a minimum of four members: three from the department, including the advisor, and one from outside the department. Departmental members must be Graduate Faculty or equivalent research faculty and are chosen by the student and advisor. The Doctoral Advisory Committee is to be formed within 2 to 3 months after successful completion of the preliminary examination, with the exception of the outside member who may be chosen just prior to the Initial Dissertation Defense. The student may petition the Biology Department Graduate Committee to change an advisor or committee member.

The Initial Dissertation Defense is to be an open defense to which faculty and graduate students are invited. It is conducted significantly in advance of writing the final draft of the dissertation and is administered by the Dissertation Examining Committee, including the outside member. This is to be arranged by the dissertation advisor and the results reported to the Chair of the Graduate Committee and the Department Chair in writing, signed by committee members.

The Final Doctoral Examination is to consist of a formal departmental colloquium open to the public, but conducted by the Doctoral Advisory Committee. The outside examiner need not be present. The student then meets with the Dissertation Examining Committee after the colloquium for the Final Dissertation Defense. The penultimate version of the dissertation must be approved by the Doctoral Advisory Committee at least two weeks before the Graduate School deadline for submission of final copies.

The scheduling of the Final Dissertation Defense is to be arranged by the dissertation advisor. The Graduate School must be notified at least 10 working days in advance. Announcements of the dissertation defense are posted around the Biology Department and sent via e-mail or listserv.
Contacts

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https://bio.cst.temple.edu/

Department Information:
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Department Chairperson:
Allen Nicholson
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215-204-8854

Courses

BIOL 5101. Evolution. 3 Credit Hours.
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.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5225. Evolution Genetics Genomics. 4 Credit Hours.
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.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5226. Innovative Biomodels and Concepts. 3 Credit Hours.
The aim of this course is to familiarize students with current concepts, models, and cutting-edge technologies applicable in different bioindustries. The scope of topics ranges from the implementation of discoveries stemming from molecular genetics, cell biology and nanotechnology in different industries to integration of omics techniques in personalized medicine, drug discovery and pharmacovigilance. Note: Non-STEM graduates will be required to enroll as non-matriculated in at least two Biology Foundation courses recommended by the PSM in Bioinnovation Steering Committee.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
BIOL 5227. Biomarkers and Biotargets: Research and Commercialization. 3 Credit Hours.
This course focuses on the evolution of biomarker and biotarget research, with emphasis on biomarker validation and biotarget druggability. The students will analyze real-life examples of biomarkers and biotargets in medicine, drug development, and environmental science. The formation of therapeutic target databases and development of multi-target agents will be critically evaluated. Note: Non-STEM graduates will be required to enroll as non-matriculated in at least two Biology Foundation courses recommended by the PSM in Bioinnovation Steering Committee.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5228. Epigenetics, Genetics: Applications in Drug Design and Drug Response. 3 Credit Hours.
This course focuses on applications of current epigenetics knowledge in health industries. Special emphasis is on epigenetic and genetic testing in clinical settings, epigenetic and genetic determinants of drug response as well as drug- and environment-induced modulation of epigenetic status. Note: Non-STEM graduates will be required to enroll as non-matriculated in at least two Biology Foundation courses recommended by the PSM in Bioinnovation Steering Committee.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5229. Systems Biology: Principles and Applications. 3 Credit Hours.
This course provides an overview of Systems Biology technologies and the scientific challenges in applicability of system biology paradigms in the analysis of biological processes. Topics covered include the use of genome-scale in silico models and dissecting transcriptional control networks. By successfully completing this course, the students will obtain background on theoretical and modeling techniques, and software platforms for Systems Biology. Note: Non-STEM graduates will be required to enroll as non-matriculated in at least two Biology Foundation courses recommended by the PSM in Bioinnovation Steering Committee.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5232. Behavioral Genetics. 3 Credit Hours.
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.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5233. Effective Dissemination of Bio-discoveries through Traditional and New Media. 1.5 Credit Hour.
The students will learn contemporary methods of effective dissemination of research findings and concepts to professional and lay audiences. Current real-life findings will be presented through slide and video development, press releases, and the use of social media. In addition, the students will learn the ways to communicate scientific data through abstracts, posters, and papers and will critically analyze the content and style of selected scientific material. Furthermore, different types of funding proposals will be reviewed and grant development will be practiced.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5235. Milestones in Clinical Translation of Biodiscoveries. 1.5 Credit Hour.
The goal of this course is to familiarize the students with clinical trial design and principles of pharmacovigilance. Topics will include clinical trial phases and examples of clinical trial design for selected biologic drugs. Case studies of drug safety-driven FDA decisions will also be evaluated. The comparison between regulatory requirements of the U.S. and international agencies will be discussed.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5236. Bioadvanced Screening in Health Disparity. 1.5 Credit Hour.
This course focuses on the effects of nutrients, bioactive food components and environment on public health, medical treatments and applications for improving human health.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5237. Virtual Reality in Bioindustry and Medicine. 1.5 Credit Hour.
The goal of this course is to provide the students with a background on Virtual Reality and its applications in medicine, laboratory research, training and education in bioindustry.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
BIOL 5254. Animal Behavior. 3 Credit Hours.
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.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5301. Cell Biology. 3 Credit Hours.
Advanced knowledge in cell biology will be discussed. Topics include macromolecules, cell structure, cell motility, bio-membrane, endo- and exocytosis, nucleocytoplasmic transport, visualizing cells and macromolecules with advanced microscopy imaging. Current journal articles reporting recent developments in modern cell biology will be also covered.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5307. Conservation Biology. 3 Credit Hours.
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.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5311. Herpetology. 4 Credit Hours.
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.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5312. Biostatistics. 3 Credit Hours.
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.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5321. Plant Community Ecology. 3 Credit Hours.
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.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5322. Plant Genetics. 3 Credit Hours.
Current molecular and genetic analyses of classical problems in the genetics of higher plants.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5325. Recombinant DNA Techniques. 4 Credit Hours.
Laboratory instruction in molecular biology and recombinant DNA techniques. The course will provide practical experience in modern cloning, hybridization, and DNA sequencing technology.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.
Biology, Ph.D.

BIOL 5337. Comparative Biomechanics. 3 Credit Hours.
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.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5338. Epigenetics. 3 Credit Hours.
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.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5358. Cellular/Molecular Neuroscience. 3 Credit Hours.
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.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5366. Stem Cell Biology. 3 Credit Hours.
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.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5403. Genomics & Proteomics. 3 Credit Hours.
The course objectives are to understand structure and function of proteins and how mutations result in disease, to learn modern methods of analyzing proteins, expose students to genomic and proteomic data bases, to introduce data mining and foster experimental design in genomics, to discover basic biology in the context of applied research, to use case study methods to examine genome expression in context, to become proficient with computer tools for proteomics and genomics, to appreciate the benefits of using math to understand biology, to gain practical experience and exposure to "practical" genomics and proteomics.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5411. Structural Bioinformatics. 3 Credit Hours.
This course will cover the basic concepts of protein structure analysis, with focus on database searching and molecular modeling techniques. A broad qualitative overview of macromolecular structure and protein folding will be provided before addressing the issues of sequence alignment, secondary structure calculation, and tertiary structure prediction. The course will also cover few selected advanced topics such as prediction of quaternary structure, Hidden Markov Models, and other approaches for building probabilistic models of sequence ensembles. Computer-based activities will allow students to develop a strong familiarity with molecular visualization software and web-based tools.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5416. Tropical Marine Biology: Belize. 4 Credit Hours.
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.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
BIOL 5427. Immunology. 3 Credit Hours.
The purpose of the Immunology course is to provide a comprehensive overview of the immune system that in its normal function protects each of us from the harmful effects of microbial invaders. The lectures will describe the general properties and development of immunity, the condition of being protected from infection by microorganisms or the effects of foreign molecules. They will provide systemic coverage of immune responses to viruses, bacteria, protozoa and roundworms as well as the practical aspects of vaccine development. Additional lectures will include a description of various types of primary immunodeficiencies, most prevalent autoimmune disease and cancer.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5428. Virology. 3 Credit Hours.
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-I 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.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5429. Developmental Genetics. 3 Credit Hours.
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.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5433. Advanced Techniques in Microscopy. 3 Credit Hours.
This course will provide a survey of modern techniques in microscopy. Students will acquire a thorough grounding in general principles of optics and conventional microscopy, and learn the theory of many methods current in biology and medicine, fluorescence, confocal microscopy, video microscopy, and digital image processing and analysis. Note: This course includes extensive laboratory experience.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5436. Freshwater Ecology. 4 Credit Hours.
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.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5452. Systems Neuroscience. 3 Credit Hours.
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.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5454. Neurological Basis of Animal Behavior. 3 Credit Hours.
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.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5456. Organization and Development of the Nervous System. 3 Credit Hours.
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.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

BIOL 5464. Biochemistry of Embryogenesis. 3 Credit Hours.
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.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.
BIOL 5465. Mammalian Development. 3 Credit Hours.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5466. Contemporary Biology. 3 Credit Hours.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5467. Endocrinology. 3 Credit Hours.
Broad coverage of “chemical messengers”, occurrence, biochemistry, and physiology. Vertebrate endocrinology with minor treatment of invertebrates and plants.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5469. Molecular Biology. 3 Credit Hours.
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.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5471. Cell Proliferation. 3 Credit Hours.
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.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5474. Physical Biochemistry. 3 Credit Hours.
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.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5475. General Biochemistry I. 3 Credit Hours.
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.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5476. General Biochemistry II. 3 Credit Hours.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5479. Biotechnology. 3 Credit Hours.
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.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5501. Analytical Biotechnology. 3 Credit Hours.
This course provides a comprehensive survey of current techniques in biomolecule measurement and analysis in the biotechnology laboratory.
Level Registration Restrictions: May not be enrolled in one of the following: Undergraduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5502. Microbial Biotechnology. 3 Credit Hours.
Course covers uses 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).
Level Registration Restrictions: May not be enrolled in one of the following: Undergraduate
College Restrictions: Must be enrolled in one of the following Colleges: Engineering, Medicine, Pharmacy, Science & Technology
Repeatability: This course may not be repeated for additional credits.
BIOL 5503. Biotechnology Laboratory I. 3 Credit Hours.
The biotechnology laboratory course is designed for students in the Professional Science Master’s Program in Biotechnology. Students in the program will be recruited from Science, Technology, Engineering and Math (STEM) undergraduate majors and this hands-on course is designed with this understanding. The course will introduce students to some of the basic laboratory approaches used in the analysis of biologically-active environmental contaminants and in the synthesis of new and existing drugs. The first part of the course will emphasize molecular biological tools useful in drug design and contaminant analysis. The second part of the course will emphasize the chemical analysis of biologically-active compounds. The course will be problem-oriented with small team participation. The course will prepare students for a research project as part of the requirements for completion of the Professional Science Master's in Biotechnology.
Level Registration Restrictions: May not be enrolled in one of the following: Undergraduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5504. Biotechnology Laboratory II. 3 Credit Hours.
The biotechnology laboratory course is designed for students in the Professional Science Master’s Program in Biotechnology. Students in the program will be recruited from Science, Technology, Engineering and Math (STEM) undergraduate majors and this hands-on course is designed with this understanding. The first part of the course will introduce students to microorganisms relevant to human and environmental health, for example pathogenic organisms as well as antibiotic-producing organisms. The second part of the course will focus on genomic and proteomic techniques and the use of bioinformatics in drug design, bioremediation and related challenges. The course will be problem-oriented with small team participation. The course will prepare students for a research project as part of the requirements for completion of the Professional Science Master’s in Biotechnology.
Level Registration Restrictions: May not be enrolled in one of the following: Undergraduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5505. Ethics Regulation and Policy in Biotechnology. 3 Credit Hours.
The Bioethics, Policy and Regulation course is designed for students in the Professional Science Master's Program in Biotechnology. This course will provide an understanding of ethical decisions, governmental regulations and policies in biotechnology. A case study approach will be used to provide a framework for discussions of policy and ethical decision making. Guest speakers will provide insights from legal and governmental perspectives on emerging and current biotechnology applications.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOL 5506. Professional Development Seminar for PSM in Biotechnology. 1 Credit Hour.
The PSM program prepares graduates for careers in biotechnology-related fields with a strong emphasis on skill areas that include management, policy and regulation in addition to scientific discovery. This course will provide students with career exposure through interviews with professionals in government and industry and will assist students in developing a career plan. Students will develop a white paper on the current state of Biotechnology based on new advances and challenges in the past year. Members of the advisory board will participate in facilitating the course.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits
Pre-requisites:
(BIOL 5501)|Minimum Grade of B-|May not be taken concurrently)
AND (BIOL 5503)|Minimum Grade of B-|May not be taken concurrently)
AND (BIOL 5505)|Minimum Grade of B-|May not be taken concurrently).

BIOL 5582. Graduate Independent Study. 1 to 3 Credit Hour.
Explorative study or research initiated by a graduate student with faculty sponsorship and an approved independent study contract.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

BIOL 8001. Teaching of Biology. 2 Credit Hours.
Required of all first-year teaching assistants. Instruction in the art of teaching laboratories and recitations.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credits.

BIOL 8002. Teaching of Biology. 2 Credit Hours.
Required of all first-year teaching assistants. Instruction in the art of teaching laboratories and recitations.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

BIOL 8003. Introduction to Graduate Research. 3 Credit Hours.
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.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
**BIOL 8210. Seminar. 1 Credit Hour.**
Seminar. Topics will vary.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

**BIOL 8220. Seminar. 1 to 4 Credit Hour.**
Required Laboratory Research Rotation for all first year graduate students
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

**BIOL 8250. Seminar. 3 Credit Hours.**
Seminar. Topics will vary.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

**BIOL 8260. Seminar. 2 to 4 Credit Hours.**
Seminar. Topics will vary.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

**BIOL 8450. Seminar. 3 Credit Hours.**
Seminar. Topics will vary.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

**BIOL 8510. Seminar in Neuroscience. 3 Credit Hours.**
A discussion of recent advances in the clinical and experimental Neurosciences using original research papers or reviews. Particular topics are selected on the basis of student interests and background.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

**BIOL 8802. Research Techniques. 4 Credit Hours.**
Laboratory instruction in the biochemical and biophysical techniques used to investigate biological problems.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

**BIOL 8985. Teaching in Higher Education: Life Sciences. 1 to 3 Credit Hour.**
This course focuses on the research on how people learn and best teaching practices, with the aim of preparing students for effective higher education life science teaching.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

**BIOL 9283. Directed Readings. 1 to 9 Credit Hour.**
Directed study and discussion of the current research literature
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

**BIOL 9991. Graduate Research. 1 to 9 Credit Hour.**
Graduate Research while in the coursework phase of the program.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

**BIOL 9994. Preliminary Examination Preparation. 1 to 6 Credit Hour.**
Course for students in Ph.D. program who have completed coursework but have not passed Preliminary Exams nor reached candidacy.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

**BIOL 9995. Capstone Research Experience. 1 or 2 Credit Hour.**
The capstone research experience is designed to provide hands on training and additional intellectual development to prepare students for practical problem solving and project leadership after graduation. This could involve training in bench research, bioethics research, environmental research, bioinformatics research, project on Regulatory Affairs or other areas that students choose as an area they would like to pursue in the field of Biotechnology. It is meant to integrate what was learned in the core classes with practical experience in addressing real world problems. NOTE: The Capstone Research Experience is a culminating course of the PSM program, open only to PSM students with a minimum GPA of 3.0 who have taken all of the core courses (unless waivered) of the program. The core courses are BIOL 5501, 5502, 5503, 5504, 5505, 5506, and 5225. Students must also register for BIOL 5479 and CEE 5793.
Level Registration Restrictions: May not be enrolled in one of the following: Undergraduate
Repeatability: This course may be repeated for additional credit.
BIOL 9996. Master’s Thesis. 1 to 6 Credit Hour.
Thesis research to be carried out under the direction of a Graduate Faculty member.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

BIOL 9998. Pre-Dissertation Research. 1 to 6 Credit Hour.
Pre-dissertation/proposal research after Preliminary examinations until elevation to candidacy.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

BIOL 9999. Dissertation Research. 1 to 6 Credit Hour.
Dissertation research. Limited to Ph.D. students who have been elevated to candidacy.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Student Attribute restrictions: Must be enrolled in one of the following Student Attributes: Dissertation Writing Student
Repeatability: This course may be repeated for additional credit.