Biology, Ph.D.

COLLEGE OF SCIENCE AND TECHNOLOGY

Learn more about the Doctor of Philosophy in Biology.

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 (see http://igem.temple.edu/education/overview), 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 biotechnology, health professions, and pharmaceutical fields, or in academia or government.

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
Spring: October 15; August 1 international

To be considered for a University fellowship, applicants should have an essentially complete application on file by January 5.

Matriculation in the Fall is highly recommended. Late applications may be considered for admission.

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 and 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: In approximately 500 to 1,000 words, describe your interest in Temple's program, research goals, and academic and research achievements.

Standardized Test Scores:
GRE: Required, with a combined minimum score of 305 on the quantitative and verbal reasoning sections.

Applicants who earned their baccalaureate degree from an institution where the language of instruction was other than English, with the exception of those who subsequently earned a master's degree at a U.S. institution, must report scores for a standardized test of English that meet these minimums:

- TOEFL iBT: 90
- IELTS Academic: 6.5
- Duolingo: 110
- PTE Academic: 61

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 or started a Ph.D. program at another institution may apply for advanced standing. Students are awarded varying numbers of credit of advanced standing, up to a maximum of 21, on a case-by-case basis. The credits must be equivalent to coursework offered at Temple, with a grade of "B" or better having been earned in the course(s).

Program Requirements

General Program Requirements:
Number of Credits Required Beyond the Baccalaureate: 36

Required Courses:

Code	Title	Credit Hours
Core Courses		
BIOL 8003	Introduction to Graduate Research	3
BIOL 8220	Seminar [1]	3
Three 8000-level Biology seminars [2]		9
Two additional graduate-level courses [3]		6
Electives		
Select three from the following:		9
BIOL 5101	Evolution	
BIOL 5111	Genomics in Medicine	
BIOL 5112	Fundamentals of Genomic Evolutionary Medicine	
BIOL 5114	Evolutionary Ecology	
BIOL 5128	Genomics and Infectious Disease Dynamics	
BIOL 5241	Genomics and Evolutionary Biology of Parasites and Other Dependent Species	
BIOL 5254	Animal Behavior	
BIOL 5275	Ecology of Invasive Species	
BIOL 5301	Cell Biology	
BIOL 5307	Conservation Biology	
BIOL 5312	Biostatistics	
BIOL 5321	Plant Community Ecology	
BIOL 5322	Biology of Plants	

BIOL 5323	Global Change Science: Analytics with R	
BIOL 5335	Polar Biology - Life at the Extremes	
BIOL 5337	Comparative Biomechanics	
BIOL 5338	Epigenetics	
BIOL 5358	Cellular/Molecular Neuroscience	
BIOL 5361	Molecular Neuropharmacology	
BIOL 5366	Stem Cell Biology	
BIOL 5403	Genomics	
BIOL 5416	Tropical Marine Biology: Belize	
BIOL 5428	Virology	
BIOL 5429	Developmental Genetics	
BIOL 5436	Freshwater Ecology	
BIOL 5452	Systems Neuroscience	
BIOL 5454	Neurological Basis of Animal Behavior	
BIOL 5456	Organization and Development of the Nervous System	
BIOL 5464	Biochemistry of Embryogenesis	
BIOL 5465	Mammalian Development	
BIOL 5466	Contemporary Biology	
BIOL 5469	Molecular Biology	
BIOL 5471	Cell Proliferation	
BIOL 5474	Physical Biochemistry	
BIOL 5475	General Biochemistry I	
BIOL 5476	General Biochemistry II	
BIOL 5479	Biotechnology	
BIOL 5501	Analytical Biotechnology	
BIOL 5502	Microbial Biotechnology	
EES 5011	Remote Sensing and GIS	
Research Courses [4]		**6**
BIOL 9994	Preliminary Examination Preparation	
BIOL 9998	Pre-Dissertation Research / Elevation to Candidacy	
BIOL 9999	Dissertation Research	
Total Credit Hours		36

1 Students take 1 credit of BIOL 8220 in the Fall and 2 credits of BIOL 8220 in the Spring.

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

3 Additional courses are selected from 8000-level seminars or from 5000-level Biology courses. With approval from the student's advisor and the Graduate Chair, two non-Biology graduate-level courses that align with the student's career goals may be taken.

4 A minimum of 2 credits of BIOL 9999 must be taken.

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. The preliminary exam proposal 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 department 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 two to three 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

Department Web Address:

https://www.temple.edu/academics/degree-programs/biology-phd-st-biol-phd

Department Information:

Dept. of Biology
255 Biology-Life Sciences Building
1900 N. 12th Street
Philadelphia, PA 19122-6078
grad.bio@temple.edu
215-204-8877

Submission Address for Application Materials:

https://cst.temple.edu/academics/graduate-programs/apply-now

Department Contacts:

Admissions:
Sandhya Verma
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215-204-8854

Graduate Chairperson:
Richard Waring
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Department Chairperson:
Robert Sanders
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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 5111. Genomics in Medicine. 3 Credit Hours.
The completion of the Human Genome Project in 2003 began a revolution in the treatment of human disease. More than 10 years later, the promise of personalized genome-guided medical treatment is becoming reality. This course will explore how genomic information has enhanced our understanding of human genetic variation and disease susceptibility. Students will develop familiarity with main areas in genomic medicine through lectures from intra- and extramural experts, and they will be involved in classroom discussions. Students at the graduate level will complete an independent project focused on a particular disease topic, integrating literature review with new analyses of published data.

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

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

BIOL 5112. Fundamentals of Genomic Evolutionary Medicine. 3 Credit Hours.
Modern evolutionary theory offers a conceptual framework for understanding human health and disease. In this course we will examine human disease in evolutionary contexts with a focus on modern techniques and genome-scale datasets. We ask: What can evolution teach us about human populations? How can we understand disease from molecular evolutionary perspectives? What are the relative roles of negative and positive selection in disease? How do we apply evolutionary principles in diagnosing diseases and developing better treatments? Students will conduct case studies of a variety of diseases and phenotypes in a group setting. Students at the graduate level will complete an independent research project and assume leadership roles in group presentations.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.
College Restrictions: Must be enrolled in one of the following Colleges: Engineering, College of Public Health, Medicine, Lewis Katz School, Science & Technology.

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

BIOL 5114. Evolutionary Ecology. 3 Credit Hours.
In this course we will explore the interface of ecology and evolution. The field of evolutionary ecology deals broadly with questions such as: What are the ecological causes of evolution? How do ecological interactions shape the evolution of traits and origination (or extinction) of species? How does evolutionary history shape species interactions and community structure? How might evolution influence community or ecosystem processes? The class will cover fundamental theories and approaches used to address questions in evolutionary ecology, including molecular tools, modeling, manipulative field studies, and laboratory- or field-based common garden studies. Students will be engaged through a combination of lectures, inquiry-based activities, and small group discussions.

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

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

BIOL 5128. Genomics and Infectious Disease Dynamics. 3 Credit Hours.
Events such as the emergence of avian flu have increased public awareness about the need for incorporating ecology and evolution in decision-making processes that involve infectious diseases. It is evident for the public health community that molecular information, together with concepts from ecology and evolutionary biology, allows for testing of hypotheses and exploration of scenarios that otherwise could not be investigated by traditional epidemiological approaches. Understanding the ecological and evolutionary dynamics of infectious diseases requires the integration of information across organizational levels at various temporal and/or spatial scales. This requirement, together with novel molecular evolution, genomics, and mathematical modeling approaches, has positioned research on Genomics and Infectious Diseases Dynamics at the forefront of Public Health Genomics. The goal of this class is to discuss some of the biological processes leading to the emergence and re-emergence of infectious diseases stressing on evolutionary concepts within an epidemiological context. Basic concepts will be provided by the instructor as part of formal lectures. Our general objective (integrating evolutionary biology into epidemiology) will be fulfilled by discussing research articles. Such discussions will take place during the second half of the semester. "Emerging" perspectives such as One Health and Public Health Genomics will be integrated into the lectures and discussions.

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

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

BIOL 5131. Topics in Bioinformatics. 3 Credit Hours.
This course will be a keystone required course for all incoming students in a Bioinformatics Ph.D. program. Bioinformatics is a rapidly expanding research area at the intersections of biology, chemistry, mathematics/statistics, and computer science. The shared theme of this broad discipline is the application of sophisticated computing technologies to address questions on typically massive amounts of biological data. Because of the dynamic and broad nature of the field, a course is needed that will introduce new students to the breadth of the field while at the same time introducing topics at a level of depth and rigor appropriate for a Ph.D. program. This will be a team taught course, with one coordinator and up to seven research-active instructors. The course would consist of seven modules, each two weeks in length. Every year, the coordinator will identify faculty and topics so as to present a diverse cross-section of cutting-edge Bioinformatics. An important goal of this course is that it will introduce students to a broad sample of the faculty who are active in the Bioinformatics Ph.D. program.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.
College Restrictions: Must be enrolled in one of the following Colleges: Science & Technology.

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

BIOL 5225. Evolutionary Genetics Genomics. 3 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 5234. Bioinnovation Seminar. 1.5 Credit Hour.
This course includes lectures and seminars on current topics in bioinnovation presented by experts in different disciplines and it will include seminars at the Fox School of Business and Management. By successfully completing this course, the students will obtain up-to-date knowledge of bioinnovative models.

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 5239. Dissemination of Biodiscoveries and Virtual Reality in Medicine. 3 Credit Hours.
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. Furthermore, this course will provide the students with a background on Virtual Reality and its applications in medicine, laboratory research, training and education in bioindustry.

Level Registration Restrictions: May not be enrolled in one of the following Levels: Undergraduate.

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

BIOL 5241. Genomics and Evolutionary Biology of Parasites and Other Dependent Species. 3 Credit Hours.
All known multicellular organisms harbor diverse assemblages of dependent species, many of which are considered parasites or pathogens. Yet, in spite of a growing awareness of the importance of dependent species in biodiversity and medicine, many studies are limited to assessing the consequences to their hosts. The goal of this seminar is to discuss some of the biological processes leading to the diversity of dependent species and their functional/evolutionary relationships with their hosts. This general objective will be fulfilled by discussing research articles on the genomics and evolution of dependent species, many of them considered parasites or pathogens. Students are also expected to gain proficiency in writing scientific review papers.

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 5275. Ecology of Invasive Species. 3 Credit Hours.
Species that are transported by humans from their native range and successfully establish and spread in a new environment are called invasive species. Invasive species can cause significant ecological and economic impacts and are a growing threat to native species and ecosystems across the globe. Recognition of this problem has led to a recent surge in research on invasive species and a better understanding of the ecology of invasions and approaches for improved prevention and control. Yet many challenges still hinder scientific and applied advancements in this emerging field. In this course we will investigate these challenges and the science of invasive species using interactive activities and student-driven projects.

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. Biology of Plants. 3 Credit Hours.
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.

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

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

BIOL 5323. Global Change Science: Analytics with R. 3 Credit Hours.
Learn how researchers use data to tackle global problems such as climate change, mass extinction, pandemics, and poverty. Explore interdisciplinary data, from economics to public health, and learn a marketable skill: R, an intuitive computer language. The course is project based, no prior coding experience is necessary, and no tests are given. Instead, student assessment is on project progress and communication of a global change problem of their choice. The most successful students leave class with the quantitative skills to go out and solve our most pressing 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 5325. Research Techniques in Molecular Biology. 3 Credit Hours.
Instruction in the techniques used in modern molecular biology and molecular genetics. This course takes a problem-oriented approach toward teaching the methods of DNA and RNA analysis that are used in determining the structure and function of genes. Practical experience in the preparation of DNA, modern cloning methods, restriction enzyme mapping, hybridization analysis, DNA sequencing, and PCR techniques will be provided. Students will carry out a research project during the course. NOTE: Biology 3324 is highly recommended, but not required. Also note: Prior to Spring 2017, the course title was "Recombinant DNA Techniques."

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

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

BIOL 5335. Polar Biology - Life at the Extremes. 3 Credit Hours.
"Polar Biology - Life at the Extremes" is an introduction to polar environments and the biology of aquatic and terrestrial organisms adapted to live in the Arctic and Antarctic. Similarities and differences between the poles as well as anthropogenic impacts on these remote environments will be addressed. Comparisons to other extreme environments will be included.

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

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

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 5361. Molecular Neuropharmacology. 3 Credit Hours.
In this course we will examine how drugs interact with the nervous system. We will focus specifically on the cellular and molecular actions of drugs on synaptic transmission, as a mechanism for understanding the structure and function of the synapse. In addition, we will discuss how toxins and venoms affect synaptic transmission in nature as well as how they have been (and continue to be) used as research tools. We will study the neural substrates of drug action and the sequence of events from how a drug binds initially to its molecular target(s), the resulting changes in the function of its target, the influence of these changes on biochemical networks in neurons, the subsequent alterations in neuronal output, and in the circuit, including non-neuronal cells. Students will be able to appreciate the progress in the discovery of drugs used to treat in the clinic complex behaviors as well as major neural disorders (neuroinflammation, pain, migraine, sleep, neurodegeneration, addictive disorders, schizophrenia, etc.). In addition, we will learn about the process of drug approval (preclinical, clinical trials, drug monitoring, and FDA's role).

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 5389. Field Research in Community Ecology. 4 Credit Hours.
Many fundamental advances in community ecology have emerged from creative, well-designed field studies in natural ecosystems. Field research is therefore a cornerstone of contemporary community ecology. Through this summer course taught at Temple's Ambler Campus, students will gain hands-on experience designing and conducting field research in community ecology. While some activities will be in a classroom, most activities will be held outdoors, in the natural environments around Ambler Campus.

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. 3 Credit Hours.
This course will cover the process of gene inheritance and descriptions of genome structure, as well as a discussion of gene content and function across lineages. Students will learn about genome-related technologies, including genome sequencing. They will also learn about how genomes vary across species, as well as the forces driving these evolutionary changes. Students will complete quizzes and exams to demonstrate understanding of the information present in genomes and the processes that drove it.

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 I. 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-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.

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.
This course is typically offered in Fall and Spring.
Advanced discussion of selected topics.

This course is repeatable for credit.

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

Repeatability: This course may be repeated for additional credit.

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.
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.

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. 1.5 Credit Hour.
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.

Level Registration Restrictions: May not be enrolled in one of the following Levels: Undergraduate.

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

BIOL 5502. Microbial Biotechnology. 3 Credit Hours.
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).

Level Registration Restrictions: May not be enrolled in one of the following Levels: Undergraduate.
College Restrictions: Must be enrolled in one of the following Colleges: Engineering, Medicine, Lewis Katz School, 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 Levels: 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 Levels: 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 5509. Computational Genomics. 3 Credit Hours.
This is a course on the application of genome-related concepts to genome sequence data. Students will gain familiarity with both existing software and with basic programming (scripting) skills for problems in genomics. Further, students will come to understand the connections between standard computational and statistical approaches and their underpinnings in those fields increasingly dominated by genomic approaches. These include the fields of molecular evolution, population genetics, molecular genetics, molecular biology, and biochemistry. The course will be a hands-on computational lab course, with students working on problems and assignments in class using their laptop computers.

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 5403|Minimum Grade of B-|May not be taken concurrently.

BIOL 5511. Ethics in Bioinformatics. 2 Credit Hours.
This course will examine the social, legal, and privacy issues of applying computational approaches to large datasets including those from personal genome projects. The class will expose students to variation-based approaches in genomics, policies and strategies to share genomic data, database management and security, open-access and open-source philosophies, the ethics of collecting, storing, and disseminating human data, and HIPAA, FDA, and IRB regulatory policies for health care professionals and bioinformaticians. Students will be given the opportunity to discuss contemporary case studies, in addition to NIH-sanctioned online training modules (Responsible Conduct in Research).

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

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

BIOL 5514. Biological Models in Python. 3 Credit Hours.
This course provides an introduction to the field of computational biology by implementing biological models in the Python programming language. In addition to coverage of the basics of the Python language, topics will include: phylogenetic tree models, implementation of Markov models for biological problems, data structures and algorithms for the analysis of biological sequences, and the use of popular Python modules relevant for biological modeling. Prior basic knowledge of evolutionary theory and of genetics/genomics is expected. Some prior scripting experience is helpful, but students are not required to have an extensive coding background. This is a hands-on computational lab course, with students working on problems in class using their laptop computers.

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

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

BIOL 5521. Nucleic Acid Technologies. 1.5 Credit Hour.
This course provides a focused examination and analysis of the basic structures and properties of RNA and DNA; the enzymes that synthesize or modify these biomolecules; and biotechnological applications. The synthesis and purification of DNA and RNA will be reviewed along with detection methodologies, including enzymatic amplification, array analysis, and amplification-free (direct) approaches. Nucleic acid sequencing technologies, including the analysis of ancient or degraded DNA and emerging nanopore-based sequencing approaches, will be surveyed. Finally, the course will examine how the inherent ability of DNA and RNA to self-assemble can be harnessed to provide novel nanostructures with complex architectures, and that show promise in biomedical and biotechnological applications. Note: Biochemistry Majors who have completed CHEM 4375 or CHEM 4404 or BIOL 5501 with a minimum grade of C may register for BIOL 5521 with permission from instructor.

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

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

BIOL 5522. Introduction to Scientific and Regulatory Writing. 3 Credit Hours.
This course introduces students to the two primary types of medical writing done by/for pharmaceutical and biotech companies. Specifically, students will learn how to research and write abstracts, posters, clinical reports and other research manuscripts, patient education materials, and slide kits. In addition, students will be introduced to the basics of strategic planning and consulting, including the creation of publication plans and meeting planning from a marketing perspective. Students will also learn the fundamentals of regulatory writing. Topics will include overviews of U.S. and international regulatory agencies, product life cycles, the conduct of clinical trials and reporting clinical trial results, and activities and documentation involved with submissions for marketing approval of treatments.

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

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

BIOL 5532. Introduction to Grant Writing. 3 Credit Hours.
This course is designed for students who plan to enter professional careers requiring knowledge of grant writing. The course will teach students the mechanics of proposal writing and the political and social aspects of "grantsmanship" as they develop their skills in identifying sources of grant funding, doing useful research to support their applications, and tailoring their proposals to specific audience interests. There will be several short writing assignments, an exam, and an independent project. Students may also be asked to engage in a collaborative grant project to help build their skills in collaboration.

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

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

BIOL 5533. Communicating Science to a Broader Audience / Non-Scientists. 3 Credit Hours.
This writing intensive course will be developed as a hybrid class with online and in-class components, with instructor/s interacting with students by editing multiple drafts of a paper requiring the students to communicate a science topic to readers with either no science background or backgrounds in other STEM fields. The learning goal of this course will be emphasizing the communication of scientific theory and concepts to wide-ranging audiences, especially non-scientists. The class will require students to demonstrate the ability to break down complex science into accurate, yet understandable explanations, by writing an article in the style of the New York Times science section, or a science report in a newspaper such as the Philadelphia Inquirer.

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

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

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 not 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. Master's Research Projects. 1 to 6 Credit Hour.
Short-term, limited research project or laboratory project in the field. This course is not the capstone project course, nor can it be used for thesis based research. The course is for master's students only, including PSM, MA or MS. This class will not confer full-time program status unless nine credits are taken.

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.
This course is required for students who are preparing for the preliminary or candidacy examination. Students should enroll after coursework is completed or when preparing for the candidacy exam until the time that the preliminary or candidacy examination is completed. This course will confer full-time status at the minimum credit hour registration limit of one credit. All students must complete a minimum of one credit of this course. Students must complete a total of 6 credit hours of 9994, 9998 and 9999.

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 Project. 1 to 6 Credit Hour.
Capstone project for master's students including students in PSM, MA or MS. This class will provide full-time status. Students in PSM programs need to register for at least one credit of this course to fulfill program requirements. Additional credits may be required for specific programs. Students in the MA program may satisfy this course requirement by completing a library thesis. This course will confer full-time status at the minimum credit hour registration limit of one credit.

Level Registration Restrictions: May not be enrolled in one of the following Levels: Undergraduate.

Repeatability: This course may be repeated for additional credit.

BIOL 9996. Master's Thesis Research. 1 to 6 Credit Hour.
Course for master's thesis research. Only intended for students in thesis bearing master's programs. A minimum of one credit is required. This course will confer full-time status at the minimum credit hour registration limit of one credit.

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 / Elevation to Candidacy. 1 to 6 Credit Hour.
This course is intended for students who are performing research prior to candidacy. Students can register for this course after required courses are completed. This course will confer full-time status at the minimum credit hour registration limit of one credit. Students must be registered for this course during the semester that they are to be elevated to candidacy examination. Students must complete a total of 6 credit hours of 9994, 9998 and 9999.

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.
The course is for Ph.D. students who have been elevated to candidacy. During the course of their candidacy students must complete a minimum of two credits of dissertation research. This course will confer full-time status at the minimum credit hour registration limit of one credit. Students must complete a total of 6 credit hours of 9994, 9998 and 9999.

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.