Pharmaceutical Sciences/Medicinal Chemistry, Ph.D.

SCHOOL OF PHARMACY (http://www.temple.edu/pharmacy)

About the Program

The School of Pharmacy offers a graduate program leading to the M.S. and the Ph.D. in Pharmaceutical Sciences with a concentration in Medicinal Chemistry. The program is designed to prepare students for positions in the pharmaceutical industry, government agencies, and faculty positions in schools of pharmacy.

Time Limit for Degree Completion: 7 years

Campus Location:
Health Sciences, Main

Students may take a majority of required and elective courses at the Health Sciences and Main campuses. Some courses may be offered at the Fort Washington campus. Research must be carried out at the Health Sciences campus under the supervision of an advisor who is a member of the Graduate Faculty.

Full-Time/Part-Time Status:
Full-time status is highly preferred due to the nature of ongoing research.

Interdisciplinary Study:
The program encourages interdisciplinary coursework, research, and collaborations among faculty and students with interests in Biochemistry, Molecular Modeling, Organic Chemistry, and Pharmacology.

Areas of Specialization:
The focus is Medicinal and Pharmaceutical Chemistry, including design and synthesis of ligands for cholinergic receptors and ligands for retinoic acid receptors, novel anticonvulsants, and the development of analytical methodologies.

Job Prospects:
The program is primarily concentrated to provide research scientists for the pharmaceutical industry, government agencies, and faculty positions in schools of pharmacy.

Non-Matriculated Student Policy:
Non-matriculated students are able to take up to 9 credits before formal application must be made to the program.

Financing Opportunities:
Support options include University Fellowships, Teaching Assistantships (TAs), and Research Assistantships (RAs). Recipients are determined on a competitive basis during the admission process.

Fellows and both TAs and RAs receive a stipend and full tuition remission (up to 9 credits per term). Applications should include:

1. a statement of previous teaching and/or research experience, areas of interest, and future goals;
2. official transcripts; and
3. a curriculum vitae.

The department attempts to make offers of assistantships on or before May 1. June 1 is the final date for acceptance or declination of department offers.

Admission Requirements and Deadlines

Application Deadline:

Fall: December 15

All applications are evaluated together after the deadline.
APPLY ONLINE to this graduate program (http://www.temple.edu/apply/common/appcheck.asp).

Letters of Reference:
Number Required: 3

From Whom: Letters of recommendation should be obtained from college/university faculty members familiar with the applicant's academic competence and professionals in a supervisory position.

Coursework Required for Admission Consideration:
It is recommended that applicants complete the courses taken in obtaining a B.S. in Biochemistry, Chemistry (preferably Organic Chemistry), or Pharmacy (or their equivalent as determined by the School of Pharmacy) before entering the program.

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 Biochemistry, Chemistry (preferably Organic Chemistry), or Pharmacy is required.

Statement of Goals:
The Statement of Goals should be approximately 500-1,000 words and should include the following elements: your specific interest in Temple's program; your research goals; your future career goals; and your academic and research achievements.

Standardized Test Scores:
The GRE is required. The GRE scores should be in the 65th percentile or above.

Minimum TOEFL score needed to be accepted: 100 iBT or 600 PBT.

Resume:
A resume is encouraged.

Program Requirements

General Program Requirements:

Number of Didactic Credits Required Beyond the Baccalaureate: 40

Required Courses:

Core Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOC 8203</td>
<td>Physical Methods in Organic Chemistry</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 5201</td>
<td>Physical Methods in Organic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>PS 8002</td>
<td>Pharmaceutical Analysis</td>
<td>3</td>
</tr>
<tr>
<td>PS 8009</td>
<td>Advanced Medicinal Chemistry I</td>
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</tr>
<tr>
<td>PS 8051</td>
<td>Seminar in Pharm Science</td>
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</tr>
<tr>
<td>PS 8121</td>
<td>Survey of Pharmaceutical Sciences</td>
<td>1</td>
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<tr>
<td>PS 8403</td>
<td>Pharmacogenomics</td>
<td>2</td>
</tr>
</tbody>
</table>

Elective courses should be taken primarily in Chemistry, although courses in Pharmacology and Computer and Information Science may also be taken.

Total Credit Hours: 17

Culminating Events:

Preliminary Examination:
The purpose of the preliminary examination is to demonstrate critical and interpretive knowledge in specialized areas of the discipline. The examination evaluates the student's ability to apply specific research foci to anticipated practical problems in the field. Students who accumulate 40 didactic credits are eligible to take the exam.

The preliminary exam consists of two sections. The first is a written section consisting of questions from the student's Doctoral Advisory Committee (DAC). Each member of the DAC submits a question and then judges the quality of the student's answer based on criteria such as accuracy, thoroughness, and originality. They then share that score and their rationale for it with the other members of the DAC. The evaluators look for a breadth and depth of understanding of concepts in the areas being tested; application of knowledge; and the ability to write technical prose in a manner consistent with scientists in the field. The second section of the preliminary exam includes the preparation of a research proposal approved by the DAC and a 30-minute oral summary of the proposal followed by an oral defense of the proposal.
Students who are preparing to take their preliminary examination should confirm a time and date with the Director of Graduate Studies and register with the Administrative Assistant in the Office of Graduate Studies. The student and Director receive confirmation of the time, date, room, and proctor for the examination.

Dissertation Proposal:
The dissertation proposal demonstrates the student's knowledge of and ability to conduct the proposed research. The proposal should consist of:

1. The context and background surrounding a particular research problem;
2. an exhaustive survey and review of literature related to the problem; and
3. a detailed methodological plan for investigating the problem.

The proposal should be completed and approved no more than one year after completing the preliminary exam. Upon approval, a doctoral student is promoted to a Ph.D. candidate, and a timeline for completing the investigation and writing process are established.

Dissertation:
The doctoral dissertation is an original, theoretical, and/or empirical study that makes a significant contribution to the field. It should expand existing knowledge and demonstrate the student's knowledge of research methods and a mastery of her/his primary area of interest. The dissertation should be rigorously investigated; uphold the ethics and standards of the field; demonstrate an understanding of the relationship between the primary area of interest and the broader field; and be prepared for publication in a professional journal.

The Dissertation Examining Committee (DEC)is formed to oversee the student's doctoral research. It is charged with evaluating the student's dissertation and oral defense, including the student's ability to express verbally her/his research question, methodological approach, primary findings, and implications. The DEC, which includes the members of the DAC, is comprised of at least three Graduate Faculty members. Two members, including the Chair, must be from the School of Pharmacy. The Chair is responsible for overseeing and guiding the student's progress, coordinating the responses of the Committee members, and informing the student of her/his academic progress. At least one additional Graduate Faculty member from outside the School of Pharmacy must be included on the DEC. This outside examiner should be identified no later than the beginning of the academic term in which the student will defend the dissertation. The DEC members vote to pass or fail the dissertation and the defense at the conclusion of the public presentation.

Committee compositions must be approved by the departmental graduate committee. If a student needs to change a member of a committee, the new member must be approved by the departmental graduate committee and by the Graduate School. The changes must be documented with the Graduate Secretary and the Graduate School using the Request for Change in Dissertation Committee (http://www.temple.edu/grad/forms/documents/Diss_Comm.Change_09.pdf) form.

Students who are preparing to defend their dissertation should confirm a time and date with their DEC and register with the Office of Graduate Studies at least 15 days before the defense is to be scheduled. The Office of Graduate Studies arranges the time, date, and room and forwards to the student the appropriate forms. After the Graduate Secretary has made the arrangements, the student must send the Graduate School a completed Announcement of Oral Defense (http://www.temple.edu/grad/forms/documents/Diss_Defense_Announce_09.pdf) form at least 10 days before the defense date. The department posts flyers announcing the defense.

Contacts

Program Web Address:

http://pharmacy.temple.edu/academics/graduate-program-thesis-based-ms-and-phd-degrees

Department Information:
Dept. of Pharmaceutical Sciences Office of Graduate Studies
School of Pharmacy
3307 N. Broad Street, Suite 528
Philadelphia, PA 19140

tusggrad@temple.edu
215-707-4972

Mailing Address for Application Materials:
Office of Graduate Studies
School of Pharmacy
3307 N. Broad Street, Suite 528 (602-00)
Philadelphia, PA 19140

Department Contacts:

Admissions:
Sophon Din
Biology 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.

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-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.
Repeatability:

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 5455. 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.
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. 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 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: 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 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. 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 waived) of the program. The core courses are BIOL 5501, 5502, 5503, 5504, 5505, 5506, and 5525. 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.

Chemistry Courses

CHEM 5001. Advanced Inorganic Chemistry I. 3 Credit Hours.
Group theory and its applications to chemical systems. Molecular orbital theory and spectroscopy. Descriptive chemistry of transition metal and organometallic compounds.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
CHEM 5103. Advanced Instrumental Methods. 3 Credit Hours.
Recent developments in electrochemical and electroanalytical techniques, including voltammetric and potentiostatic procedures and the basics of
instrumental design. Applications to organic chemistry, trace analysis, chromatographic detectors, and electrokinetics discussed.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CHEM 5107. Drug Analysis. 4 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.

CHEM 5108. Investigative Chemistry. 4 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.

CHEM 5201. Physical Methods in Organic Chemistry. 3 Credit Hours.
Principles and applications of important physical and spectroscopic methods: IR, UV, NMR, MS, ESR, ORD, and CD in structure determination.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CHEM 5202. Organic Reaction Mechanisms. 3 Credit Hours.
This course is an introductory overview of organic structure and most common organic reaction mechanisms.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CHEM 5205. Organic Syntheses. 3 Credit Hours.
Scope and limitations of modern synthetic methods, including silicon reagents, organometallic and radical chemistry.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CHEM 5301. Quantum Chemistry. 3 Credit Hours.
Introduction to quantum mechanics and its application to chemical systems.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CHEM 5302. Statistical Thermodynamics. 3 Credit Hours.
The basic concept of statistical mechanical ensembles and their application.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CHEM 5305. Chemical Kinetics. 3 Credit Hours.
A study of the dynamics of chemical reactions.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CHEM 5358. Cellular/Molecular Neuroscience. 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.

CHEM 5401. Biochemistry I. 3 Credit Hours.
A survey of the biological macromolecules (proteins, nucleic acids, carbohydrates, and lipids) correlating their structures with their chemical properties
and biological functions.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CHEM 5505. Advanced Polymer Structure and Properties. 3 Credit Hours.
Polymers are ubiquitous in many new (scaffolds for tissue engineering, hip replacements) and old (textiles, engineering resins, flocculants) applications,
and are often used in composites with inorganic materials. In order to better understand the use and novel developments of polymers, this course will
provide the fundamentals of synthesis, polymer structure/property relationships, and characterization methods.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CHEM 5701. Teaching of Chemistry. 0 to 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.

CHEM 8000. Special Topics in Inorganic Chemistry. 3 Credit Hours.
A survey of a topic chosen by the instructor. Topics could include bioinorganic chemistry, organometallic chemistry, solid state and materials chemistry,
and catalysis.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.
CHEM 8200. Special Topics in Organic Chemistry. 3 Credit Hours.
Advanced lecture course; subject matter varies from semester to semester.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CHEM 8201. The Chemistry of Natural Products. 3 Credit Hours.
Biogenetic classification, classical and modern synthetic approaches to polyketides, steroids, terpenes, and alkaloids.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CHEM 8202. Organometallic Chemistry. 3 Credit Hours.
A survey of the chemistry of organic compounds of the main and transition elements, with emphasis on their reactions and applications.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CHEM 8205. Heterocyclic Chemistry. 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.

CHEM 8210. Special Topics in Organic Chemistry. 3 Credit Hours.
Advanced lecture course; subject matter varies from semester to semester.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CHEM 8300. Special Topics in Physical Chemistry. 3 Credit Hours.
Advanced lecture course, subject matter varies from semester to semester.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CHEM 8301. Molecular Spectroscopy. 3 Credit Hours.
Absorption, emission and scattering of light by molecular system. Discussion of basic principles and experimental techniques.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CHEM 8302. Computational Chemistry. 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.

CHEM 8303. Modern Meth in Exp Chem. 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.

CHEM 8310. Special Topics in Analytical Chemistry. 3 Credit Hours.
Advanced lecture course, subject matter varies from semester to semester.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CHEM 8400. Special Topics in Biochemistry. 3 Credit Hours.
Advanced lecture course; subject matter varies from semester to semester.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CHEM 8401. Bioinorganic Chemistry. 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.

CHEM 8501. High Polymer Chemistry. 3 Credit Hours.
Introduction to the important theoretical and practical aspects of high polymer chemistry.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
CHEM 8985. Teaching in Higher Ed: Phys Sci. 1 to 3 Credit Hour.
Teaching in Higher Education: Physical Sciences. This course focuses on learning theory and the best teaching practices, with the aim of preparing students for effective higher education teaching.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CHEM 9300. Seminar in Physical Chemistry. 1 Credit Hour.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CHEM 9900. Seminar. 2 Credit Hours.
Formal presentation of research topics by graduate students. Regular attendance required of all graduate students.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CHEM 9991. Research. 1 to 6 Credit Hour.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CHEM 9994. Preliminary Examination Preparation. 1 to 6 Credit Hour.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CHEM 9996. Master’s Thesis. 1 to 6 Credit Hour.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CHEM 9998. Pre-Dissertation Research. 1 to 3 Credit Hour.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CHEM 9999. Doctoral Dissertation. 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.

Pharmaceutical Sciences Courses

PS 5451. Statistical Quality Control. 3 Credit Hours.
An introduction to statistical concepts, this course reviews control charts for variables, probability theory, control charts for attributes, and acceptance sampling systems. Class discussions include application to quality control of pharmaceutical manufacturing. Note: Not open to students who have taken the former PHARMACEUTICS 451.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 5471. Biotechnology: Bioprocess Basic. 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.

PS 5477. Good Manufacturing Practices. 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.

PS 5478. High Purity Water System. 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.

PS 5492. Productions-Parenterals. 3 Credit Hours.
This course reviews the theory and practice involved in the preparation of sterile, injectable products, covering formulation, manufacturing, facility requirements, validation and regulatory issues. Upon completion of the course, students will develop an understanding of the routes of administration of injectable drugs and the types of injections, current formulation methods, aseptic manufacturing processes, requirements for sterile manufacturing facilities, and validation, compliance and regulatory issues. Note: Not open to students who have taken the former PHARMACEUTICS 492.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
PS 5493. Sterilization Processes. 3 Credit Hours.
This course surveys sterilization processes used in the pharmaceutical, medical device, in-vitro diagnostic, and biotech industries. Current methods of sterilization are discussed, including thermal, gaseous, radiation, filtration, and aseptic processing. Students learn basic aspects of sterilization science as well as design, review, and audit sterilization validations and processes according to industry practices. Note: Not open to students who have taken the former PHARMACEUTICS 493.

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

PS 5499. Pharmaceutical Drug Dosage Forms. 3 Credit Hours.
Through an overview of drug dosage form design and manufacturing technology, principles of pharmaceutical processing and pharmaceutical dosage form design (including preformulation and biopharmaceutics) are discussed, including dosage forms such as tablets, capsules, modified dosage forms, semi-solid products, and transdermal delivery systems.

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

PS 5501. Development -Parenterals. 3 Credit Hours.
A study of the theory and practice in the development of parenteral products; dosage form design, formulation, solubility/physical pharmacy, excipients, assays, stability, physiochemical properties of biomolecules, delivery systems for controlled/sustained release and manufacturing methods. Note: Not open to students who have taken the former PHARMACEUTICS 501.

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

PS 5575. Regulatory Sciences. 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.

PS 8000. Topics in Pharmaceutical Sciences. 1 to 3 Credit Hour.
Topics vary; specific topic(s) announced prior to the start of the semester.

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

PS 8001. Principles of Drug Action/Pharmacokinetics. 3 Credit Hours.
This course presents the fundamental principles of pharmacology, medicinal chemistry, and pharmacokinetics needed to understand their application in drug discovery and developmental processes. The material, presented in an integrated manner, includes the molecular mechanisms of drug action, structure-activity relationships, and the time-course of drug absorption and disposition.

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

PS 8002. Pharmaceutical Analysis. 3 Credit Hours.
Application of chemical analysis as it relates to pharmaceuticals and pharmaceutical manufacturing. Classical separation methods including GC, HPLC, and NMR as well as, hyphenated techniques (GC-MS & HPLC-MC) will be explored. The student will also be introduced to immunologic antibody based procedures and emerging technologies.

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

PS 8003. Pharmaceutical Manufacturing I: Preformulation/Formulation. 3 Credit Hours.
Presents techniques relevant to all aspects of preformulation and formulation phases, as well as principles and mechanisms of incompatibility and stability testing.

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

PS 8004. Pharmaceutical Manufacturing II. 3 Credit Hours.
Presents processing and principles that apply to solid dosage form design and product development.

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

PS 8005. Pharmaceutical Biotechnology. 3 Credit Hours.
This course will introduce students to pharmaceutical biotechnology, biophysical, and chemical aspects of biotech products and their pharmaceutical formulations and clinical applications. Amino acids, proteins, peptides, and nucleotides are of particular interest. The principles of pharmaceutical formulation of biotech products and physicochemical evaluation of formulations will be extensively discussed. Also, pharmacokinetics of biologics and current analytical methods used in pharmaceutical biotechnology will be introduced.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
PS 8006. Physical Pharmacy I. 3 Credit Hours.
The emphasis of this course is to form bridge between the concepts of physical pharmacy and the application of pharmaceutical sciences. Students will understand basic aspects of intermolecular forces, physical properties of solutions, ionic equilibria, buffers and isotonic solutions, solubility and partition phenomena, complexation and protein binding, reaction kinetics, mass transport, dissolution phenomena, interfacial phenomena, and rheology. Pharmaceutical applications based on the basic principles will be discussed as well. Students will be expected to be able to apply the basic concepts from this course to typical formulation and stability issues of pharmaceutical dosage forms. A previous course is physical chemistry.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8007. Applied Biopharmaceutics. 3 Credit Hours.
Presents the interrelationships of the physicochemical properties of the drug and the dosage form, to the route of administration and to the rate and extent of systemic absorption. Drug absorption mechanisms, physiological and GIT constraints on dosage form transit and bioavailability, effect of formulation parameters, dissolution methodologies, in-vitro/in-vivo correlation of drug product performance as well as SUPAC, ICH and FDA guidelines on development and approval process will be covered. Formulation strategies for optimum therapeutic outcome via application of pharmaceutical sciences to the design of drug delivery systems is provided.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8008. Advanced Principles of Pharmacokinetics. 3 Credit Hours.
An advanced course in the theory and application of pharmacokinetics and pharmacodynamics.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8009. Advanced Medicinal Chemistry I. 3 Credit Hours.
Discussions of the organic chemistry of drug action and drug design. Current topics in the field are discussed using examples from the recent literature. The design, synthesis and structure activity relationships for major therapeutic drug classes are discussed in detail.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8011. Advanced Medicinal Chemistry II. 3 Credit Hours.
Continued discussions of the organic chemistry of drug action and drug design with current topics discussed using examples from the recent literature. Students review the current literature, give presentations and write research proposals based on their readings and class materials.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8012. Radioisotope Methodology. 3 Credit Hours.
Introductory discussion of the characteristics and properties of ionizing radiation, methods of detection (gas ionization, scintillation, both liquid and solid spectroscopy), radiation standards for safety and protection, and basic evaluation of biological hazards and effects.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8051. Seminar in Pharm Science. 1 Credit Hour.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

PS 8111. Introduction to Toxicology. 3 Credit Hours.
Toxicology is a multi-disciplinary science focused on the adverse effects of chemicals, drugs and environmental agents. In the first part of this course the basic principles of toxicology will be covered, including dose response relationships, mechanisms of toxicity and exposure. In the second part, target organs of toxicity will be presented with an overview of anatomy and physiology of different target organs (e.g., liver, kidney), as well as organ-specific response to toxic insult. In the final segment of the course, students will be exposed to a variety of areas of applied toxicology, including risk assessment, clinical & forensic toxicology, chemical carcinogenesis, reproductive toxicology and the role of toxicology in drug development.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8121. Survey of Pharmaceutical Sciences. 1 Credit Hour.
The goal of the course is to expose graduate students in the Department of Pharmaceutical Sciences to the faculty research in our department. Students will be presented with a number of research topics, including pharmaceutics, pharmacokinetics, medicinal chemistry, biotransformation, pharmacology, and physiology. In addition to the presentations by faculty members, several guest speakers will present their research topics and discuss their opinions on science careers outside of academia (i.e., industry, medical writing, medical science liaison, etc.). Through exposure to these diverse research topics, students will become more well-rounded scientists and become more aware of career opportunities that are available to them.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8122. Writing and Publishing a Review Article. 1 Credit Hour.
The purpose of this course is to research, write and submit a manuscript (review article) in English for publication in a refereed scientific journal.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
PS 8123. Bioinformatic Genes Drug. 1 Credit Hour.
The course is a one semester Research project focused on inherited factors that modulate drug response. The use of Web-based computer software for data mining, genetic variability in humans, detection and prediction of pharmacologically relevant genetic polymorphisms will be presented. The course is an introductory level course for students involved in research on Pharmacogenomics and Pharmacogenetics.

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

PS 8125. Journ Club/Pharmacodynam. 1 Credit Hour.
Course aims to keep participants up-to-date on current literature in the field. Participants will present the background, content, and implications of a paper of their choosing to the class. In addition, Temple researchers may present their ongoing research and/or review the current literature in the field. The goals of the course are to: 1) facilitate the sharing of knowledge and discussion of current information and 2) to aid students in the critical interpretation of the literature, and the presentation of the results to their colleagues.

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

PS 8126. Laboratory Experience in Pharmaceutical Sciences. 1 Credit Hour.
Students enrolled in this course will be mentored by a member of the graduate faculty in the department in order to become familiar with the research area of the instructor and the everyday workings of the laboratory. The techniques, instrumentation, and procedures covered during the semester will vary depending on the concentration of interest and may include medicinal chemistry/drug discovery, pharmaceutics/pharmacokinetics or pharmacodynamics/pharmacogenomics. Students will be exposed to a wide variety of experimental techniques and analytical instrumentation.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

PS 8127. Pharmacokinetics. 3 Credit Hours.
The objective of this course is to present the fundamental principles of pharmacokinetics (PK). The topics will include PK data analysis, dosage regimen design, and the determinants of drug absorption, distribution, metabolism, and excretion. Pharmacodynamics, the study of drug concentration - response relationships, will also be presented.

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

PS 8128. Principles in Drug Discovery. 3 Credit Hours.
In this course, students will receive an introduction to the fundamental principles of drug discovery and development, beginning with an historical overview of drug discovery.

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

PS 8129. Bioethics in Research. 2 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.

PS 8131. Principles of Biochemistry. 5 Credit Hours.
The course provides students with information regarding the chemical and physical properties of biomolecules. Moreover, the interrelated roles of these molecules in a functioning biological system are emphasized.

Department restrictions: Must be enrolled in one of the following Departments: Pharmacy:Pharmaceutical Scienc
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8132. Topics in Pharmaceutical Biotechnology. 2 Credit Hours.
This is a seminar course in which students will research and give oral presentations on topics of their choice within the broad subject of pharmaceutical biotechnology.

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

PS 8402. Pharmacodynamics. 3 Credit Hours.
This course covers the theoretical underpinnings and practical aspects of quantitative pharmacology. A key feature of the course is its concentration on the integrated study of a drug’s pharmacokinetics (transport to its site of action: including absorption, distribution, biotransformation, and excretion) and its mechanism of action at the site of action. Emphasis is placed on the mathematical foundations of such topics as drug-receptor theory, Schild analysis, Furchgott’s method, radioligand binding studies, PK/PD modeling, and isobolographic analysis of drug combinations.

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

PS 8403. Pharmacogenomics. 2 Credit Hours.
The course is a one semester course focused on inherited factors that modulate drug response. Special problems of genetic variability in humans, detection and prediction of pharmacologically relevant genetic polymorphisms will be discussed. The course will integrate current mechanistic knowledge of drugs, human genetics, data mining, and analytical tools to tailor drug administration for a specific genetic background.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
PS 8404. Pharmaceutical Sciences Literature Review. 2 Credit Hours.
This course is to expose graduate students to the current literature in Pharmaceutics, Pharmacodynamics and Drug Delivery. The goal of the course is to expose the student to a variety of literature articles pertaining to the physical, biologic, and formulation of pharmaceutical dosage forms. At the end of the course the student should be able to compare and critique articles from several journals common to the area of pharmaceutics, analyze literature articles as to the relevancy the results to the discussion, propose new research based on the current literature article, and be able to write an abstract for a review article based on several publications.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8464. Abuses of Drugs and Chemicals. 3 Credit Hours.
Pharmacology of drugs of abuse and related chemicals, the extent of drug abuse, factors fostering drug abuse, and treatment methods.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8478. Modified Release Dosage Forms. 3 Credit Hours.
The fundamentals involved in various extended release dosage forms and their modification for use in particular dosage formulations. Biopharmaceutical and pharmacokinetic aspects of extended-release dosage forms are discussed as well. Overview of polymeric excipients used in the formulation of extended-release dosage forms. Current commercial products under development 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.

PS 8484. Process Validation. 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.

PS 8502. Advanced Pharmacokinetic Modeling I. 2 Credit Hours.
This course will cover drug transport in biological systems and advanced topics in pharmacokinetics and pharmacodynamics. Course will also involve computer methods to derive models and discussion of current literature.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8552. Physical Pharmacy II. 3 Credit Hours.
The rheological behavior of polymer systems will be discussed. The physical chemical properties of proteins and peptides will be presented with formulation applications. This is an advanced course. Physical Pharmacy I is a prerequisite.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8583. Chemical Surfaces & Interfaces. 3 Credit Hours.
Topics: types and structure of surfactant molecules; properties of aqueous and non-aqueous surfactant solutions; foaming; micelle formation and solubilization. Binary systems; tenary systems; surfactant-water-amphiphile. Stabilization of emulsions and of solid/liquid dispersions. Biological applications.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8584. Advanced Drug and Gene Delivery Systems. 3 Credit Hours.
The application of nanometer to micrometer delivery systems for disease management has made tremendous advances in recent years. Products of nanotechnology are expected to revolutionize modern medicine due to their versatility in targeting tissues and controlling the release of drugs. Global initiatives are in place to support nanotechnology and nanomedicine. In this interactive course, students will learn the basic principles of advanced drug and gene delivery and its major biomedical applications. The methods or strategies of preparation and evaluation of the commonly used drug and gene delivery systems will be discussed. In addition, students will present selected focused topics on the novel drug and gene delivery systems under the instructors' guidance.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8586. Advanced Drug and Gene Delivery Systems. 3 Credit Hours.
The application of nanometer to micrometer delivery systems for disease management has made tremendous advances in recent years. Products of nanotechnology are expected to revolutionize modern medicine due to their versatility in targeting tissues and controlling the release of drugs. Global initiatives are in place to support nanotechnology and nanomedicine. In this interactive course, students will learn the basic principles of advanced drug and gene delivery and its major biomedical applications. The methods or strategies of preparation and evaluation of the commonly used drug and gene delivery systems will be discussed. In addition, students will present selected focused topics on the novel drug and gene delivery systems under the instructors' guidance.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

PS 8603. Dermatopharmaceutics. 3 Credit Hours.
Study of the physiology, biochemistry, immunology, skin permeability, and penetration enhancers as well as role of growth factors in healing after injuries. Semi-solid products, influence of formulation variables and their overall drug release capacities in-vitro and in-vivo will be evaluated. Transdermal, iontophoresis, sonophoresis topics, and bioequivalence/bioavailability of topical preparation 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.
PS 8985. Teaching in Higher Educ. 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.

PS 9994. Preliminary Examination Preparation. 1 to 6 Credit Hour.
This course fulfills the continuous enrollment requirement after coursework completion while preparing for the Preliminary examinations.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credit.

PS 9996. Master’s Research. 1 to 6 Credit Hour.
Master’s Research course appropriate for students finished with coursework and working with a faculty member on the thesis.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

PS 9998. Pre-Dissertation Research. 1 to 6 Credit Hour.
This course is appropriate for students finished with coursework and working on their dissertation proposal.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

PS 9999. Dissertation Research. 1 to 6 Credit Hour.
This course is limited to, and required of, students who have achieved candidacy and are now doing dissertation research.
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.