Biology (BIOL)

Course information contained within the Bulletin is accurate at the time of publication in June 2025 but is subject to change. For the most up-to-date course information, please refer to the Course Catalog.

BIOL 0848. DNA: Friend or Foe. 3 Credit Hours.
This course explores the intersection of scientific knowledge with real-world applications and ethical considerations. The first module of the course focuses on the basic principles of genetics and how hereditary traits are transmitted. The second module consists of the study of genomics, including recent medical advances and the impact of the Human Genome Project. The third module explores the social, ethical, and legal issues related to personal genetics, ancestry, personalized medicine, genetic testing, genome editing (e.g., CRISPR), and the use of DNA in law enforcement. This course has both a lecture and lab component. NOTE: A grade of C- or higher in this course fulfills a Science & Technology (GS) requirement for students under GenEd and the Science & Technology Second Level (SB) requirement for students under Core. Students cannot receive credit for this course if they have successfully completed Biology 0948.

Course Attributes: GS

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

BIOL 0948. Honors DNA: Friend or Foe. 3 Credit Hours.
This course explores the intersection of scientific knowledge with real-world applications and ethical considerations. The first module of the course focuses on the basic principles of genetics and how hereditary traits are transmitted. The second module consists of the study of genomics, including recent medical advances and the impact of the Human Genome Project. The third module explores the social, ethical, and legal issues related to personal genetics, ancestry, personalized medicine, genetic testing, genome editing (e.g., CRISPR), and the use of DNA in law enforcement. This course has both a lecture and lab component. NOTE: A grade of C- or higher in this course fulfills a Science & Technology (GS) requirement for students under GenEd and the Science & Technology Second Level (SB) requirement for students under Core. Students cannot receive credit for this course if they have successfully completed Biology 0848.

Course Attributes: GS, HO

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

BIOL 1001. Human Biology. 4 Credit Hours.
This course is typically offered in Fall, Spring, and Summer I.
An introduction to the principles of biology using the human as a model organism. The course covers biomolecules; the heredity, development, structure and function of the human body; and the relationship of humans to their environment. NOTE: (1) Laboratory requires dissection. Not available for Biology major credit; no credit if Biology 1011 (C083) is previously taken. (2) This course can be used to satisfy the university Core Science & Technology First Level (SA) requirement.

Course Attributes: SA

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

Pre-requisites: Minimum grade of C- in (any MATH course numbered 0701 to 0702 (may be taken concurrently), any MATH course numbered 0800 to 4999 (may be taken concurrently), 'Y' in MC3, 'Y' in MC4, 'Y' in MC5, 'Y' in MC6, 'Y' in MC3A, 'Y' in MC6A, STAT 1001, 'Y' in STT2, STAT 1102, STAT 1902, 'Y' in MATW, 'Y' in MC3S, 'Y' in MC3D, 'Y' in MC3O, 'Y' in MC3T, or 'Y' in MC6T)

BIOL 1004. Medical Terminology for Pre-Health Postbaccalaureates. 1 Credit Hour.
In this course, students will learn to understand the terms used in medicine. This course focuses on teaching the meanings of root words and how they are put together so that students can break down the meanings of complex medical terms. Understanding medical terms is necessary for clear communication between healthcare providers when caring for patients.

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

BIOL 1009. Biological Reasoning. 3 Credit Hours.
This course is typically offered in Fall.
This course is a transition semester of biology to be taken before Introductory Biology 1111 or 1112 for students who have not had advanced biology in high school or who wish to increase their reasoning skills before taking the Introductory Biology sequence. The course will focus on the analysis of biological data as well as understanding how these data support or contradict foundational concepts including biological evolution, structure and function, information exchange, energy transformation and flow and systems. The course format will involve group exercises designed to increase diagrammatic and quantitative reasoning in biology using examples from introductory textbooks. Understanding and developing concept maps will provide students with an effective approach for studying biology. The course will prepare students for the content and pace required to be successful in the Introductory Biology sequence.

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

Pre-requisites: Minimum grade of C- in (MATH 0702 (may be taken concurrently), any MATH course numbered 0800 to 4999 (may be taken concurrently), 'Y' in MC3, 'Y' in MC4, 'Y' in MC5, 'Y' in MC6, 'Y' in MC3A, 'Y' in MC6A, STAT 1001, 'Y' in STT2, STAT 1102, STAT 1902, 'Y' in MATW, 'Y' in MC3S, 'Y' in MC3D, 'Y' in MC3O, 'Y' in MC3T, or 'Y' in MC6T)

BIOL 1011. General Biology I. 4 Credit Hours.
This course is typically offered in Fall and Summer I.
General introductory biology for non-biology majors. Topics include cell physiology (introduction), origins of life, taxonomy, principles of evolution, animal evolution, and a survey of physiology. NOTE: (1) Laboratory required. (2) This course can be used to satisfy the university Core Science & Technology First Level (SA) requirement. To determine if this course in combination with another course can satisfy the GenEd Science & Technology requirement, see your advisor.

Course Attributes: SA

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

Pre-requisites: Minimum grade of C- in (any MATH course numbered 0701 to 0702 (may be taken concurrently), any MATH course numbered 0800 to 4999 (may be taken concurrently), 'Y' in MC3, 'Y' in MC4, 'Y' in MC5, 'Y' in MC6, 'Y' in MC3A, 'Y' in MC6A, STAT 1001, 'Y' in STT2, STAT 1102, STAT 1902, 'Y' in MATW, 'Y' in MC3S, 'Y' in MC3D, 'Y' in MC3O, 'Y' in MC3T, or 'Y' in MC6T)

BIOL 1012. General Biology II. 4 Credit Hours.
This course is typically offered in Spring and Summer II.
General introductory biology for non-biology majors. Topics include biological molecules, biochemistry, molecular biology, and genetics. NOTE: (1) Laboratory required. (2) This course can be used to satisfy the university Core Science & Technology Second Level (SB) requirement. To determine if this course in combination with another course can satisfy the GenEd Science & Technology requirement, see your advisor.

Course Attributes: SB

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

Pre-requisites: Minimum grade of C- in (any MATH course numbered 0701 to 0702 (may be taken concurrently), any MATH course numbered 0800 to 4999 (may be taken concurrently), 'Y' in MC3, 'Y' in MC4, 'Y' in MC5, 'Y' in MC6, 'Y' in MC3A, 'Y' in MC6A, STAT 1001, 'Y' in STT2, STAT 1102, STAT 1902, 'Y' in MATW, 'Y' in MC3S, 'Y' in MC3D, 'Y' in MC3O, 'Y' in MC3T, or 'Y' in MC6T)

BIOL 1082. Introduction to Independent Research. 1 to 4 Credit Hour.
This course is typically offered in Fall, Spring, Summer I and Summer II.
Research under the direction of a faculty member in the Department of Biology or affiliated department. All students must obtain the approval of the Biology Faculty Advisor, who will complete the registration. Students must have completed fewer than 30 credits. Not available for major credit, CR/NC only. This course is repeatable.

Repeatability: This course may be repeated for additional credit.

BIOL 1111. Introduction to Organismal Biology. 0 or 4 Credit Hours.
This course, with Biology 1112 or 2112, makes up the introductory series for Biology majors. Biology 1111 is designed to be taken during the first year. This course covers evolutionary principles, an introduction to ecology, and anatomy and physiology of plants and animals with an emphasis on vertebrate systems. Concepts and facts discussed in lecture will be closely integrated with laboratory observation and experimentation. NOTE: This is part of the introductory series for Biology majors. There are weekly laboratories that emphasize hands-on experience with living material.
Two sections are required for this course. This course requires registration for a 0.0 credit Recitation section in addition to the 4.0 credit Lecture & Laboratory section. The Recitation sections corresponding to a course are listed under the same course number as the Lecture & Laboratory sections, but have unique section numbers.

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

Pre-requisites: Minimum grade of C- in (MATH 0702, any MATH course numbered 0800 to 4999 (may be taken concurrently), 'Y' in MC3, 'Y' in MC4, 'Y' in MC5, 'Y' in MC6, 'Y' in MC3A, 'Y' in MC6A, STAT 1001, 'Y' in STT2, STAT 1102, STAT 1902, 'Y' in MATW, 'Y' in MC3S, 'Y' in MC3D, 'Y' in MC3O, 'Y' in MC3T, or 'Y' in MC6T)

BIOL 1112. Introduction to Biomolecules, Cells and Genomes. 4 Credit Hours.
This course (or Biology 2112), with Biology 1111, makes up the introductory series for Biology majors. Biology 1112 is designed to be taken in either semester of the Freshman year. While either 1112 or 2112 will satisfy the requirement for Biology majors and the prerequisites for the 2nd level core Biology courses, students who are interested in focusing on Biochemistry are encouraged to take 2112 instead. This course will be an introduction to the Biology of organisms at the cellular and sub-cellular levels, and will provide an introduction to the fundamental concepts of cell biology, molecular biology, and genetics. Topics covered include the flow of information from DNA to RNA to proteins and the implications for evolution, metabolic pathways, photosynthesis, and cell changes during mitosis and meiosis. Finally, the course will introduce students to cutting-edge tools in bioinformatics and genomics. There are weekly laboratories that reinforce the concepts covered during the lecture and emphasize generating and analyzing data in the Cell and Molecular Biology disciplines.

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

Pre-requisites: Minimum grade of C- in (MATH 0702, any MATH course numbered 0800 to 4999 (may be taken concurrently), 'Y' in MC3, 'Y' in MC4, 'Y' in MC5, 'Y' in MC6, 'Y' in MC3A, 'Y' in MC6A, STAT 1001, 'Y' in STT2, STAT 1102, STAT 1902, 'Y' in MATW, 'Y' in MC3S, 'Y' in MC3D, 'Y' in MC3O, 'Y' in MC3T, or 'Y' in MC6T)

BIOL 1211. Basic Core Introduction to Biology for Pre-Medical Post-Baccalaureates II. 4 Credit Hours.
This course is typically offered in Spring.
Biology 1211 begins with a survey of the cell theory, basic microbiology, and embryogenesis, the process whereby cells are organized into the tissues that make up the major organ systems. The structure, function, and coordination of each of the major organ systems are examined. The course concludes with a study of evolutionary biology topics including natural selection, genetic drift, and speciation.

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

Pre-requisites: Minimum grade of C in CHEM 1052.

BIOL 1911. Honors Introduction to Organismal Biology. 4 Credit Hours.
This course, with Biology 1112/1912 or 2112/2912, makes up the introductory series for Biology majors. Biology 1911 is designed to be taken during the first year. This course covers evolutionary principles, an introduction to ecology, and anatomy and physiology of plants and animals with an emphasis on vertebrate systems. Concepts and facts discussed in lecture will be closely integrated with laboratory observation and experimentation. NOTE: (1) This course can substitute for Biology 1111 as part of the introductory series for Biology majors. (2) This course can be used to satisfy the university Core Science & Technology First Level (SA) requirement. To determine if this course in combination with another course can satisfy the GenEd Science & Technology requirement, see your advisor.

Course Attributes: HO, SA

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

Pre-requisites: Minimum grade of C- in (MATH 0702, any MATH course numbered 0800 to 4999 (may be taken concurrently), 'Y' in MC3, 'Y' in MC4, 'Y' in MC5, 'Y' in MC6, 'Y' in MC3A, 'Y' in MC6A, STAT 1001, 'Y' in STT2, STAT 1102, STAT 1902, 'Y' in MATW, 'Y' in MC3S, 'Y' in MC3D, 'Y' in MC3O, 'Y' in MC3T, or 'Y' in MC6T)

BIOL 1912. Honors Introduction to Biomolecules, Cells and Genomes. 4 Credit Hours.
This course (or Biology 2912), with Biology 1911, makes up the introductory series for Biology majors in the Honors Program. Biology 1912 is designed to be taken in the Spring of the Freshman year. While either 1912 or 2912 will satisfy the requirement for Biology majors and the prerequisites for the 2nd level core Biology courses, students who are interested in focusing on Biochemistry are encouraged to take 2912 instead. This course will be an introduction to the Biology of organisms at the cellular and sub-cellular levels, and will provide an introduction to the fundamental concepts of cell biology, molecular biology, and genetics. Topics covered include the flow of information from DNA to RNA to proteins and the implications for evolution, metabolic pathways, photosynthesis, and cell changes during mitosis and meiosis. Finally, the course will introduce students to cutting-edge tools in bioinformatics and genomics. There are weekly laboratories that reinforce the concepts covered during the lecture and emphasize generating and analyzing data in the Cell and Molecular Biology disciplines.

Course Attributes: HO

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

Pre-requisites: Minimum grade of C- in (MATH 0702, any MATH course numbered 0800 to 4999 (may be taken concurrently), 'Y' in MC3, 'Y' in MC4, 'Y' in MC5, 'Y' in MC6, 'Y' in MC3A, 'Y' in MC6A, STAT 1001, 'Y' in STT2, STAT 1102, STAT 1902, 'Y' in MATW, 'Y' in MC3S, 'Y' in MC3D, 'Y' in MC3O, 'Y' in MC3T, or 'Y' in MC6T)

BIOL 2001. Clinical Microbiology. 4 Credit Hours.
This course is typically offered in Fall.
This course is an introduction to the microorganisms that cause infectious diseases around the world. The nonspecific and specific host defense mechanisms are discussed. Methods for diagnosis, including culturing and immunological procedures, are covered. Other topics include disinfection, sterilization, standard precautions, antimicrobials, disease prevention and control. Laboratory related learning experiences, involving the testing of scientific principles related to lecture/discussion content, are integrated to support concepts introduced during lectures. NOTE: Not available for Biology major credit.

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

Pre-requisites: Minimum grade of C- in (CHEM 1021, CHEM 1031, or CHEM 1951), (BIOL 1012, BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, or 'Y' in BIOW), and KINS 1224.

BIOL 2003. Introductory Laboratory 1 for Transfer Students. 1 Credit Hour.
This course is typically offered in Fall and Spring.
For transfer students only. Instruction to satisfy the laboratory component of Biology 1111 (1911) for students who transfer courses from other institutions that are similar in topic to those offered by the Biology Department, but lack a laboratory. This course allows such students to register solely for the laboratory component of the relevant course. This course does not serve as a Biology elective.

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

BIOL 2004. Introductory Laboratory 2 for Transfer Students. 1 Credit Hour.
For transfer students only. Instruction to satisfy the laboratory component of Biology 1112 (1912) or Biology 2112 (2912) for students who transfer courses from other institutions that are similar in topic to those offered by the Biology Department, but lack a laboratory. This course allows such students to register solely for the laboratory component of the relevant course. This course does not serve as a Biology elective.

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

BIOL 2005. Laboratory for Transfer Students. 1 Credit Hour.
This course is typically offered in Fall and Spring.
For transfer students only. Instruction to satisfy the laboratory component of either Biology 2296 or Biology 3096 for students that transfer courses from other institutions that are similar in topic to those offered by the Biology Department, but lack a laboratory. This course allows such students to register solely for the laboratory component of the relevant course. This course does not serve as a Biology elective.

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

BIOL 2082. Independent Research I. 1 to 4 Credit Hour.
This course is typically offered in Fall, Spring, Summer I and Summer II.
Research under the direction of a faculty member in the Department of Biology or affiliated department. All students must obtain the approval of the Biology Faculty Advisor, who will complete the registration. Students must have completed at least 30 s.h. (Sophomore, Junior, or Senior standing). Not available for major credit. This course is repeatable, but students must select the CR/NC grade mode for all repeat course attempts.

Repeatability: This course may be repeated for additional credit.

BIOL 2112. Introduction to Cellular and Molecular Biology. 4 Credit Hours.
This course is typically offered in Fall and Spring.
This course (or Biology 1112), with Biology 1111, makes up the introductory series for Biology majors. This course provides an introduction to the fundamental concepts of biochemistry, cell biology, molecular biology and genetics. Topics covered include the structure of important biological macromolecules, enzyme kinetics, metabolic pathways, photosynthesis, cell changes during mitosis and meiosis, DNA replication, transcription, translation and genetic analysis. NOTE: This course is part of the introductory series for Biology majors. There are weekly laboratories that emphasize hands-on experience with living material.

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

Pre-requisites: Minimum grade of C- in (CHEM 1031, CHEM 1951, or 'Y' in CHM1), (CHEM 1032 (may be taken concurrently), CHEM 1952 (may be taken concurrently), or 'Y' in CHM2), and (MATH 1022 (may be taken concurrently), any MATH course numbered 1038 to 4999 (may be taken concurrently), 'Y' in MC6, 'Y' in MA04, 'Y' in MC6A, 'Y' in MATW, or 'Y' in MC6T)

BIOL 2133. Human Anatomy. 3 Credit Hours.
The fundamentals of human anatomical structure are examined. A primary goal will be the development of a comprehensive vocabulary, including the learning of Latin and Greek root words underlying medical terminology. Students will progress from a review of the history of anatomy; to the study of anatomy at the microscopic level of cells, organelles and tissues; and finally to the organ systems level. Muscular, skeletal, nervous, endocrine, cardiovascular, gastrointestinal and respiratory systems will be covered.

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

BIOL 2207. Genetics. 3 Credit Hours.
Examines the basic principles and problems of classical, biochemical, and molecular genetics. NOTE: BIOL 2297 Research Techniques in Genetics is a required co-requisite WI course.

Co-requisites: BIOL 2297.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW), and (CHEM 2201 (may be taken concurrently) or CHEM 2921 (may be taken concurrently))

BIOL 2211. Introduction to Biology II for Pre-Health Postbaccalaureates. 4 Credit Hours.
This course is typically offered in Spring.
Biology 2211 begins with a survey of the cell theory, basic microbiology, and embryogenesis, the process whereby cells are organized into the tissues that make up the major organ systems. The structure, function, and coordination of each of the major organ systems are examined. The course concludes with a study of evolutionary biology topics including natural selection, genetic drift, and speciation. Note: To register for this course, students must satisfy the prerequisites or obtain permission from the program director.

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

Pre-requisites: Minimum grade of C in CHEM 1052 and BIOL 2212.

BIOL 2212. Introduction to Biology I for Pre-Health Postbaccalaureates. 4 Credit Hours.
This course is typically offered in Fall.
Biology 2212 examines living systems at the most fundamental levels. Topics include chemical bonds, the unique properties of water, carbon chemistry, the structures and functions of macromolecules, as well as the thermodynamic and kinetic properties of enzymes. At the cellular level, we will study the components of cell-to-cell communication, cellular signaling, the regulation of the cell cycle, and cell motility. An examination of the processes of gene expression and DNA replication lead into studies on chromosome behavior during meiosis and the field of genetics. This course finishes with a survey of viruses, biotechnology, and two compelling biological processes: cancer and aging. Note: To register for this course, students must satisfy the prerequisites or obtain permission from the program director.

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

Pre-requisites: Minimum grade of C in CHEM 1052 and CHEM 2251 (may be taken concurrently)

BIOL 2227. Principles of Ecology. 3 Credit Hours.
This course provides an overview of ecology from the level of the individual organism to populations, communities and ecosystems. It examines the physical, chemical, and biological components of ecological interactions, and includes a comparative treatment of terrestrial and aquatic ecosystems.

Course Attributes: SE, SF

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW)

BIOL 2228. Ornithology. 3 Credit Hours.
The course focuses on how the study of birds has contributed to our understanding of basic principles in evolution, ecology, biogeography, behavior, neurobiology, life history theory, biodiversity and conservation. Lectures, small group discussions from primary literature, case studies and field work during the laboratory, will highlight these empirical advances. The course is available for all biology majors, but is geared specifically for those majoring in Ecology, Evolution and Biodiversity.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, or HORT 2221)

BIOL 2233. Mammalian Anatomy. 4 Credit Hours.
This course is typically offered in Fall.
A study of the development and gross anatomy of the human. In the laboratory, the dissection of the cat, together with pertinent illustrations from humans and other animals, provides a comparative survey of the anatomical structure of mammals.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW) and (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW)

BIOL 2234. Dinosaur Paleobiology. 3 Credit Hours.
Examines "non-avian dinosaurs" as objects of valid scientific inquiry and where appropriate, evaluates media hype surrounding them. Among topics examined in detail are: evolutionary relationships (including phylogeny, together with relationships to modern birds), ecology (including survey of other Mesozoic vertebrate groups, important invertebrates, plant life, biogeography), anatomy (hard and soft tissues), physiology (particularly but not limited to understanding dinosaur temperature regulatory physiology, paleoneurology, molecular traces, growth), behavior (locomotion, posture, reproduction, etc.), and how these animals are reconstructed and restored as living animals (including what is actually known from fossil evidence). This course highlights how applying basic biological principles is used to gain significant insights about what can actually be known about long extinct animals.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, or 'Y' in BIOW)

BIOL 2235. General Histology. 4 Credit Hours.
This course is typically offered in Spring.
A study of the fundamental techniques used in preparing tissues for microscopic examinations, followed by a detailed study of the various types of normal tissues and organs in mammals with emphasis on correlations between structure and function.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW)

BIOL 2241. Invertebrate Biology. 4 Credit Hours.
This course is typically offered in Spring.
An introduction to the biology of the invertebrate phyla including insects. Demonstrations of the patterns of invertebrate evolution by consideration of morphology, behavior, development, physiology, and ecology of representative organisms.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW)

BIOL 2296. Genetics. 4 Credit Hours.
This course is typically offered in Spring.
Examines the basic principles and problems of classical, biochemical, and molecular genetics. NOTE: Required for majors in Biology. There are weekly laboratories that emphasize hands-on experience with living material.

Course Attributes: WI

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW), and (CHEM 2201 (may be taken concurrently) or CHEM 2921 (may be taken concurrently))

BIOL 2297. Research Techniques in Genetics. 3 Credit Hours.
This is the companion course to Genetics, whose dual purposes are to teach you the techniques used by geneticists to elucidate key genetic principles and for you to learn to communicate your findings in IMRD format. Major techniques covered include molecular cloning, PCR, restriction mapping, and gene mapping. You will gain hands-on experience working with several genetic model organisms, clone a gene, determine which variant of a particular gene you have, and delve into the vast (and ever-growing) genetic databases. This course will fulfill 3 credits of the writing intensive requirement.

Co-requisites: BIOL 2207.

Course Attributes: WI

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW), and (CHEM 2201 (may be taken concurrently) or CHEM 2921 (may be taken concurrently))

BIOL 2311. Human Evolution. 3 Credit Hours.
Since we last shared a common ancestor with chimpanzees, over six million years ago, the human species experienced a series of unusual adaptations so that today humans dominate planet earth and are Master of Arts and letters, science, and technology. Humans are both highly intelligent and highly social, so that when we work together extraordinary and unpredictable things can happen. This course will cover the evolutionary history of humans from several biological perspectives.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW) and (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW)

BIOL 2512. Genomic Foundations of Medicine. 3 Credit Hours.
At the beginning of the 21st century, the genome sequence of only a single human being was completed. Since that time, the application of genomics has grown exponentially. Genomics is now revolutionizing the practice of medicine such that almost every area of medicine has been affected. The practice of medicine thus now requires grounding in genomic principles and knowledge and understanding how current genomic knowledge is scientifically justified. This course introduces major medical disorders affecting humans and surveys their genetic and genomic basis.

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

Pre-requisites: Minimum grade of C- in (BIOL 2112, BIOL 2912, BIOL 1112, or BIOL 1912)

BIOL 2525. Nutrigenomics: From Molecular Nutrition to Disease Prevention. 3 Credit Hours.
Nutrigenomics is a field of study that explores the relationship between nutrition and genetics. It focuses on how diet interacts with an individual's genes, influencing health and susceptibility to diseases. Nutrigenomics examines how variations in an individual's genetic makeup can impact their response to specific diet and food choices. By understanding these interactions, nutrigenomics aims to provide guidance on the optimal diet for optimal health and manage chronic diseases. In this course, students will delve into the fascinating world of nutrigenomics, exploring the cutting-edge research and applications that are revolutionizing the field of nutrition. Through a combination of theoretical knowledge and practical insights, students will gain a deep understanding of how nutrients and bioactive compounds in food interact with the human genome. We will examine the influence of genetic variations on individual responses to specific nutrients and explore how dietary factors can modulate gene expression, metabolism, and physiological processes. The course will cover a range of topics, starting with an introduction to basic genetics and the fundamentals of nutrition. Students will then delve into the exciting field of nutrigenomics, examining the latest advancements in genomic medicine and molecular technologies that are shaping our understanding of the Genome-Food interface.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111 or BIOL 1911) and (BIOL 1112, BIOL 1912, BIOL 2112, or BIOL 2912)

BIOL 2812. Fundamentals of Medical Genetics. 3 Credit Hours.
The course will focus on the fundamental understanding of molecular and cellular genetic diversity and their link to human diseases. Students will learn in-depth understanding of molecular genetics, inheritance patterns, human chromosomal disorders, genetics testing and counseling, population genetics, cancer genetics, pharmacogenomics, and treatment and gene therapy.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW), and (BIOL 2296 (may be taken concurrently) or (BIOL 2207 (may be taken concurrently) and BIOL 2297 (may be taken concurrently)))

BIOL 2912. Honors Introduction to Cellular and Molecular Biology. 4 Credit Hours.
This course is typically offered in Fall.
This course (or Biology 1912), with Biology 1911 or Biology 1111, makes up the introductory series for Biology majors. This course provides an introduction to the fundamental concepts of biochemistry, cell biology, molecular biology and genetics. Topics covered include the structure of important biological macromolecules, enzyme kinetics, metabolic pathways, photosynthesis, cell changes during mitosis and meiosis, DNA replication, transcription, translation and genetic analysis. NOTE: (1) This course can substitute for Biology 2112 as part of the introductory series for Biology majors. There are weekly laboratories. (2) This course can be used to satisfy the university Core Science & Technology Second Level (SB) requirement. To determine if this course in combination with another course can satisfy the GenEd Science & Technology requirement, see your advisor.

Course Attributes: HO, SB

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

Pre-requisites: Minimum grade of C- in (CHEM 1031, CHEM 1951, or 'Y' in CHM1), (CHEM 1032 (may be taken concurrently), CHEM 1952 (may be taken concurrently), or 'Y' in CHM2), and (MATH 1022 (may be taken concurrently), any MATH course numbered 1038 to 4999 (may be taken concurrently), 'Y' in MC6, 'Y' in MA04, 'Y' in MC6A, 'Y' in MATW, or 'Y' in MC6T)

BIOL 3011. Integrative Cell and Tissue Biology. 3 Credit Hours.
This course will provide essential information on how cells work together in tissue and organ function. Students will be provided with modern key concepts on system biology paradigms in the analysis of biological processes. Topics covered in this course will include genome-scale in silico models, dissecting transcriptional control networks, circadian rhythms, applicability of modern system biology in human disease and cancer. In the first part of the course, students will learn about the "omics" science, and how omics technologies are used to measure and functionally characterize bio-molecular networks in cells or tissues. In the second part of the course, students will learn about omics applications to understand cell-type diversity of human organ systems, cellular alteration and disease.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111 or BIOL 1911) and (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, or 'Y' in BIOW)

BIOL 3082. Independent Research II. 1 to 4 Credit Hour.
This course is typically offered in Fall, Spring, Summer I and Summer II.
Research under the direction of a faculty member in the Department of Biology or affiliated department. All students must obtain the approval of the Biology Faculty Advisor, who will complete the registration. Students must have completed at least 60 credits (Junior or Senior standing). Not available for major credit. This course is repeatable, but students must select the CR/NC grade mode for all repeat course attempts.

Repeatability: This course may be repeated for additional credit.

BIOL 3083. Directed Readings. 3 Credit Hours.
This course is typically offered in Fall, Spring, Summer I and Summer II.
Prerequisites: Junior standing and a GPA of 3.2 or better with recommendation of a faculty sponsor and approval of the Biology Honors Committee. This course is repeatable. A tutorial opportunity for a student to work with a faculty member to investigate areas of study not covered by courses in the department. Available as an elective for Biology major credit by petition to the Biology Honors Committee prior to registration. The student must make a written agreement with a Biology faculty member detailing the course of study to be followed and the mechanism of evaluation. NOTE: Agreement must be submitted to the Biology Undergraduate Advisor and the Biology Honors Committee for approval. This course can be taken a maximum of two times; only one of these can count toward Biology elective requirements as well as GPA requirements.

Repeatability: This course may be repeated for additional credit.

BIOL 3091. Research Methods. 3 Credit Hours.
This course is typically offered in Spring.
Research Methods is required for all of the TUteach with Teaching majors. It is one of several content courses specially designed to meet the needs of future teachers. Sections meet two hours per week for non-traditional, interactive lectures and two hours per week for lab. The course is cross-listed in Biology, Chemistry, Earth and Environmental Science, and Physics. The goals of the course are (1) to provide students with the tools that scientists use to solve scientific problems; (2) to give students the opportunity to use these tools in a laboratory setting; (3) to make students aware of how scientists communicate with each other through peer-reviewed scientific literature; and (4) to enable students to understand how scientists develop new knowledge and insights, the most important of which are eventually presented in textbooks and taught in conventional science classes. Students design and carry out four independent inquiries, which they write up and present in the manner that is common in the scientific community. The inquiries incorporate mathematics and the various science disciplines, thus the team of instructors teaching this course have expertise in different disciplines and are available to supervise all students as they work on their inquiries in the lab. The combination of Research Methods and the TUteach course "Perspectives on Science and Mathematics" (Philosophy 2196) provides prospective science and mathematics teachers with an in-depth understanding of how the scientific enterprise works. NOTE: Biology 3091 is only available for major credit in the Biology with Teaching BS program.

Repeatability: This course may be repeated for additional credit.

Pre-requisites: Minimum grade of C- in (SCTC 1289 or SCTC 1389)

BIOL 3096. Cell Structure and Function. 4 Credit Hours.
This course is typically offered in Fall.
The chemistry and biological functions of important small molecules and macromolecules of the cell. Concept: the functions of cells are rooted in structures, and the structures themselves derive their characteristics from their chemical components. NOTE: Required for majors in Biology. There are weekly laboratories that emphasize hands-on experience with living material.

Course Attributes: WI

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW), (CHEM 2201 (may be taken concurrently) or CHEM 2921 (may be taken concurrently)), and (PHYS 1021 (may be taken concurrently), PHYS 1061 (may be taken concurrently), PHYS 1961 (may be taken concurrently), PHYS 2021 (may be taken concurrently), or PHYS 2921 (may be taken concurrently))

BIOL 3101. Evolution. 3 Credit Hours.
This course is typically offered in Fall.
Students acquire a strong foundation in evolutionary biology, including its historical development and basic concepts such as the origin of life, natural selection, adaptation, population genetics, speciation, phylogeny, coevolution, taxonomy, and biogeography. Students who successfully complete the course will also have a broad understanding of the planetary environment, the fossil and molecular records of life, conservation of biodiversity, and astrobiology.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW) and (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW)

BIOL 3111. Genomics in Medicine. 3 Credit Hours.
This course is typically offered in Fall.
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.

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

Pre-requisites: Minimum grade of C- in (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, or 'Y' in BIOW)

BIOL 3112. Fundamentals of Genomic Evolutionary Medicine. 3 Credit Hours.
This course is typically offered in Spring.
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.

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

Pre-requisites: Minimum grade of C- in (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW)

BIOL 3113. Genome Analytics. 3 Credit Hours.
The completion of the Human Genome Project in 2003 began a revolution in the diagnostics, treatment, and prevention of human disease. As a part of this revolution, many areas of biology have become data-driven and quantitative. Modern genomic biology, biomedicine, and evolutionary genomics, are vitally dependent on key bioinformatic tools and algorithms. This course is designed to introduce students to key informatics and algorithmic concepts widely used in bioinformatics and computational biology, and to equip them with operational knowledge of the 'must-know' tools used by scientists and practitioners today. Students will complete an independent project using the tools and techniques learned in the course, integrating literature review, new analyses of published data using software tools and pipelines, data visualization and interpretation, and formal report writing. This course takes the approach of discovery-based learning. Each lecture will be structured to cover one discrete topic, with a brief background, introduction of key concepts, tutorials, and guided software exercises.

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

Pre-requisites: Minimum grade of C- in (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, or 'Y' in BIOW) and BIOL 2207.

BIOL 3114. Evolutionary Ecology. 3 Credit Hours.
This course is typically offered in Fall.
The field of evolutionary ecology deals broadly with understanding how organisms adapt to their abiotic and biotic environments. What is the adaptive significance and evolutionary potential of phenotypic variation in natural populations? How do ecological interactions and genetic constraints shape the course of evolution? The class will cover fundamental ecological and evolutionary 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. Topics covered include adaptation and constraint, phenotypic plasticity, life history evolution, ecological speciation, and evolutionary conservation biology. Lectures, assignments, and discussions will explore theoretical and recent empirical advances in the field.

Course Attributes: SI

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

Pre-requisites: Minimum grade of C- in BIOL 2227.

BIOL 3115. Disturbance Ecology. 3 Credit Hours.
Nature is dynamic, and ecosystems across the globe are defined by their disturbance regimes. Disturbances can be caused by storms, floods, fire, and species interactions. Disturbances can reset an ecosystem and understanding resilience to disturbance is a cornerstone of contemporary ecology. Further, as climate change alters the frequency and severity of storms and other natural events, disturbance regimes are changing, and understanding these dynamics can help predict and mitigate future impacts. In this course students will learn the conceptual foundations of disturbance ecology, while having hands-on opportunities to study disturbance dynamics in the field. Training in field methods and data analysis will be provided. This course is taught at the Temple Ambler Field Station on the Ambler Campus, with natural areas that recently incurred damage from an EF2 tornado. Students should expect to be outdoors regularly, learning about ecological disturbance and recovery as it unfolds in these environments in real time. Students without the designated prerequisites may be considered for registration with instructor permission.

Course Attributes: SF

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

Pre-requisites: Minimum grade of C- (except where noted) in (BIOL 1111, BIOL 1911, BOT 1112 (C or higher), or HORT 1211)

BIOL 3128. Genomics and Infectious Disease Dynamics. 3 Credit Hours.
This course is typically offered in Fall.
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.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW) and (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, or 'Y' in BIOW)

BIOL 3181. Cooperative Research in Biochemistry. 3 Credit Hours.
This course is typically offered in Fall, Spring, Summer I and Summer II.
Independent research carried out in an off-campus laboratory. A Biochemistry faculty member and the research director of the off-campus laboratory will jointly supervise research. Written permission must be obtained in advance from the supervising faculty member and one of the co-administrators. Student must present a seminar on campus describing the scientific aims of the project, the experimental design, and the conclusions drawn from the experiments. NOTE: Restricted to Biochemistry majors enrolled in the Cooperative Program.

Repeatability: This course may be repeated for additional credit.

BIOL 3201. Human Genetics. 3 Credit Hours.
This course covers a broad range of concepts that are critical to understanding the molecular and cellular basis of human genetics as well as genetic disease. Topics include gene structure and regulation, chromosomal structure and behavior during gamete formation, mutations that disrupt embryonic/fetal development and cellular biochemical pathways, as well as biostatistical methods used in disease gene identification and risk assessment. This course will build upon the basic genetic knowledge acquired in BIOL 1112 (Introduction to Biomolecules, Cells and Genomes) or BIOL 2112 (Introduction to Cellular and Molecular Biology).

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

Pre-requisites: Minimum grade of C- in (BIOL 1112, BIOL 1912, BIOL 2112, or BIOL 2912)

BIOL 3204. Cell Structure and Function. 4 Credit Hours.
This course is typically offered in Fall.
The chemistry and biological functions of important small molecules and macromolecules of the cell. Concept: the functions of cells are rooted in structures, and the structures themselves derive their characteristics from their chemical components. There are weekly laboratories that emphasize hands-on experience with living material. Prior to Fall 2023, this course was taught as a WI-course, BIOL 3096.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW), (CHEM 2201 (may be taken concurrently) or CHEM 2921 (may be taken concurrently)), and (PHYS 1021 (may be taken concurrently), PHYS 1061 (may be taken concurrently), PHYS 1961 (may be taken concurrently), PHYS 2021 (may be taken concurrently), or PHYS 2921 (may be taken concurrently))

BIOL 3212. Introduction to Bioinformatics and Computational Biology. 3 Credit Hours.
Introduction to Bioinformatics and Computational Biology presents students without a computational background with an initial presentation of the biological questions that can be addressed computationally using mostly online tools. Beginning with an introduction to the scientific hypothesis testing and computational biology, students will subsequently be introduced to searching the scientific literature and biological datasets and databases, concepts in the organization of genes and genomes, sequence searching (BLAST), pairwise and multiple sequence alignment, phylogenetic tree reconstruction, protein structure and homology modeling, and finally modeling function in metabolic pathways. This course is designed as an applied course and as a prerequisite for more advanced conceptual and technological courses in the department.

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

Pre-requisites: Minimum grade of C- in (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW)

BIOL 3214. Theoretical Population Genetics. 3 Credit Hours.
This course explores the causes and consequences of genetic variation within and between populations. We can now obtain large-scale genetic variation data from a variety of species, and this data can be used to make inferences about demographic history, natural selection, gene flow, and a variety of other evolutionary processes. This course focuses on developing the theoretical machinery necessary to understand the factors that shaped the observed genetic variation, and examines how patterns of genetic variation inform our understanding of those forces. By developing probabilistic models of evolution based on coalescent theory and diffusion theory, students in the course will learn to apply statistical methods such as maximum likelihood and Bayesian inference to genetic data. Students will also gain familiarity with commonly used population genetics software.

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

Pre-requisites: Minimum grade of C- in (MATH 1042, MATH 1942, MATH 1044, or 'Y' in MATW) and BIOL 3101.

BIOL 3225. Evolutionary Genetics and Phylogenetics. 3 Credit Hours.
Modern evolutionary theory addresses various research questions, from the diversity of life to human health and disease. This course covers general principles of population genetics and phylogenetics, emphasizing the value of explicit models and assumptions when making inferences from molecular data. We will explore commonly used methods to describe and study genetic variation and patterns across organizational levels, from loci and genomes to clades above the species level. Such methods will be discussed in the context of research problems in epidemiology, molecular ecology, and systematics.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, or 'Y' in BIOW), (BIOL 3101 or BIOL 3112), and (SCTC 1013 or Complete 2 of the following: (MATH 1041, MATH 1941, or 'Y' in MATW) and (MATH 1042, MATH 1942, MATH 1044, or 'Y' in MATW))

BIOL 3232. Behavioral Genetics. 3 Credit Hours.
This course is typically offered in Fall.
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.

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297) or BIOL 2296)

BIOL 3241. Genomics and Evolutionary Biology of Parasites and Other Dependent Species. 3 Credit Hours.
This course is typically offered in Spring.
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.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111 or BIOL 1911) and (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW)

BIOL 3243. Parasitology. 4 Credit Hours.
This course is not offered every semester.
This course will introduce students to the basic concepts of parasitology, including types of animal associations, adaptations to parasitic mode of life, and evolution of parasitism. Parasite life cycles (infection, transmission, pathology, symptoms, diagnosis, treatment) and control of medically and economically important parasites are the main emphasis of this course. Includes a laboratory.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW) and (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW)

BIOL 3244. Experimental Marine Biology. 4 Credit Hours.
This course is typically offered in summer.
Experimental Marine Biology is an upper level Biology course focused on the types of experiments that are used to further the science of Marine Biology. The course will be structured around three themes: Oceanography, Physiology, and Ecology. The Oceanography section will examine the marine environment in terms of the physics of current flow and the chemical properties of seawater. The Physiology section will examine how different organisms respond to these abiotic factors. In the Ecology section, we will discuss how organisms interact with each other as individuals and populations, and how communities and ecosystems are structured.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW)

BIOL 3245. Marine Ecology. 4 Credit Hours.
This course is occasionally offered in Fall.
A survey of the concepts of aquatic ecology in estuarine and marine ecosystems, emphasizing the organization and maintenance of the major aquatic communities in response to the physical, chemical, and biological characteristics of the environment, modes of energy transfer, physiological adaptation, life history characteristics, and functional morphology. Laboratory exercises stress comparative measurement of biological diversity in the marine environment. NOTE: One or more field trips required.

Course Attributes: SI

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

Pre-requisites: Minimum grade of C- in BIOL 2227.

BIOL 3254. Animal Behavior. 3 Credit Hours.
This course is typically offered in Spring.
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.

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

Pre-requisites: Minimum grade of C- in (BIOL 2227, BIOL 3101, or 'Y' in BIO5)

BIOL 3255. Critical Thinking in Biology. 3 Credit Hours.
The course is designed to improve students' critical thinking in broad areas of biology. Introductory lectures outline the elements and criteria that compose critical thinking, followed by student presentations and discussions based on the primary literature to promote development of this type of thinking in each student. For each session of class, one student will lead the discussion. Discussions will range in content from evolution to ecology and from molecular biology to the pathogenesis of human and animal diseases. Student presentations (one per student), twice weekly homework assignments (20 total), and oral participation in the scientific presentations throughout the semester will be used for grading.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, or 'Y' in BIOW), and (CHEM 2201, CHEM 2921, CHEM 2202 (may be taken concurrently), or CHEM 2922 (may be taken concurrently))

BIOL 3265. Developmental Biology. 3 Credit Hours.
This course is typically offered in Fall.
This course provides an introduction to invertebrate and vertebrate development. It combines the description of classical examples of experimental embryology with the current study of the mechanisms of development, differentiation, and growth in animals at the molecular, cellular, and genetic levels. Topics covered include embryonic patterning, cell-cell interactions, growth factors and signal transduction, transcriptional control mechanisms and regulatory network, evolutionary mechanisms as well as the discussion of relevant diseases.

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297) or BIOL 2296)

BIOL 3268. Fundamentals of Cell and Cancer Biology. 3 Credit Hours.
This course examines cellular structures and biochemical pathways including those that, while mutated, lead to cellular transformation and formation of cancer.

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

BIOL 3275. Ecology of Invasive Species. 3 Credit Hours.
This course is typically offered in Fall.
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.

Course Attributes: SE, SF, SP

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

Pre-requisites: Minimum grade of C- in (BIOL 2227 or 'Y' in BIO5)

BIOL 3301. Advanced Cell Biology. 3 Credit Hours.
This course is typically offered in Fall.
Fundamental knowledge in cell biology will be discussed. Topics include DNAs, RNAs, proteins, cell structure, cell motility, bio-membrane, endocytosis, nucleocytoplasmic transport, vesicular transport, cancers, visualizing macromolecular trafficking in cells with advanced microscopy imaging techniques, and stories of Nobel Prize Winners. Current journal articles reporting up-to-date developments in molecular cell biology will be covered as well. (Prior to Fall 2016, this course was titled "Cell Biology.")

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

Pre-requisites: Minimum grade of C- in (BIOL 3204 or BIOL 3096)

BIOL 3307. Conservation Biology. 3 Credit Hours.
This course is typically offered in Fall.
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.

Course Attributes: SE, SF, SP, SS

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

Pre-requisites: Minimum grade of C- in BIOL 2227.

BIOL 3311. Herpetology. 4 Credit Hours.
This course is typically offered in Spring.
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.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW) and (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW)

BIOL 3312. Biostatistics. 3 Credit Hours.
This course is typically offered Fall, Spring and Summer I semesters.
It serves as a general introductory biostatistics course tailored for undergraduate students. The lectures encompass fundamental concepts, theories, and a variety of statistical analyses. Students will engage in hands-on activities, including manual execution of statistical tests and computer labs where they will learn to apply programming with R to solve real-life biostatistical challenges using data sourced from biomedical research. No prior coding experience is required. In addition to R programming, the computer labs will introduce students to utilizing Microsoft Excel and GraphPad/Prism for statistical analyses. The course aims to equip students with essential knowledge and skills in biostatistical analyses, which are invaluable for their research or further studies in graduate and professional schools and their preparation for standardized exams such as MCAT. Furthermore, these competencies are highly relevant for careers in the biotech and pharmaceutical industries.

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

Pre-requisites: Minimum grade of C- in (MATH 1041, MATH 1941, any MATH course numbered 1042 to 3080 (may be taken concurrently), or 'Y' in MATW), (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW), and (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW)

BIOL 3316. Tropical Marine Biology. 4 Credit Hours.
This course is typically offered in Fall of odd years.
A survey of marine biology focusing on coral reefs of the Atlantic Ocean. Course lectures given at Temple University include regular meetings during the fall semester plus some meetings between semesters during December and January. The course work at Temple is supplemented by a required week of lectures, field trips and field projects on Ambergris Caye in Belize (Central America). Lecture topics include coral biology, reef geology and ecology, coral reef biota, food webs 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 projects and presentations are required. Additional requirements include a current passport and snorkeling equipment. NOTE: Requires fall plus inter-session attendance, including air travel to a foreign country between fall and spring semesters. Room, board, and boat use in Belize are covered by the course fee; air transportation to Belize is not included. The course web site survey or an application available from the instructor must be completed prior to registration.

Course Attributes: SE, SI

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

BIOL 3317. General Microbiology. 4 Credit Hours.
This course is typically offered in Spring.
A general survey of bacteria and archaea. Topics include: classification; physiology, growth, and environmental impact; genetics and gene recombination; evolutionary relationships. Laboratory topics include pure culture, identification, growth characteristics, and genetics.

Course Attributes: SI

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

Pre-requisites: Minimum grade of C- in (BIOL 3096, BIOL 3204, BIOL 3324, or BIOL 4375)

BIOL 3318. Microbial Ecology. 3 Credit Hours.
Microbial Ecology is an interdisciplinary course that applies ecological theory to the study of microorganisms and their interactions within the environment. This course will explore the ecological principles governing microbial communities, focusing on how microorganisms interact with each other and with their physical and biotic surroundings. Topics will include the roles of microbes in nutrient cycling, primary production, and ecosystem functioning, as well as their impact on biodiversity via microbial symbiosis and ecosystem stability. Students will learn about the dynamics of microbial communities using concepts such as niche theory, competition, mutualism, succession, and ecosystem services. By examining microbial processes through the lens of ecological theory, students will gain an understanding of how microbes shape ecosystem functions on both a local and global scale. Case studies will cover microbial communities in soil, water, the human microbiome, and extreme environments. Special attention will be given to the mechanisms underlying microbial interactions, their response to environmental stressors, and how microbial communities contribute to ecological resilience.

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

Pre-requisites: Minimum grade of C- in BIOL 2227.

BIOL 3321. Plant Community Ecology. 3 Credit Hours.
This course is typically offered in Fall.
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.

Course Attributes: SE, SI, SS

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

Pre-requisites: Minimum grade of C- in BIOL 2227.

BIOL 3322. Biology of Plants. 3 Credit Hours.
This course is typically offered in Fall.
Plant Biology examines the current cellular, molecular and developmental aspects of higher plants, with an emphasis on Arabidopsis and maize. Topics include plant reproduction, embryonic pattern formation in plants, self-incompatibility, sex chromosomes in plants, polyploidy, chemical signaling in plants including PIN efflux carriers, phytochromes and cryptochromes, chloroplast structure and function, the light reaction of photosynthesis, stem cell populations in plants, leaf morphogenesis, flower development, DNA and histone methylation and epigenetics, RNA silencing in plants, plant genomics, plant viruses, and genetic engineering of monocot and dicot plants.

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

Pre-requisites: Minimum grade of C- in (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, or 'Y' in BIOW) and (BIOL 2227, BIOL 3204 (may be taken concurrently), BIOL 3324 (may be taken concurrently), or BIOL 4375 (may be taken concurrently))

BIOL 3323. 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.

Course Attributes: SE, SF, SS

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

Pre-requisites: Minimum grade of C- in BIOL 2227.

BIOL 3324. Molecular Biology. 3 Credit Hours.
A comprehensive introduction to molecular genetics and the biochemistry of DNA, RNA, and proteins. The structure and expression of genes in both prokaryotes and eukaryotes will be discussed with special emphasis on DNA replication, transcription, and translation. Current journal articles covering recent developments in modern molecular biology and genetic engineering will be covered.

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297) or BIOL 2296) and (CHEM 2201, CHEM 2211, or CHEM 2921)

BIOL 3325. Research Techniques in Molecular Biology. 3 Credit Hours.
This course is typically offered in Spring.
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.

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297) or BIOL 2296)

BIOL 3327. 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.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, or 'Y' in BIOW) and (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, or 'Y' in BIOW)

BIOL 3328. Virology. 3 Credit Hours.
This course is typically offered in Fall.
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.

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297), BIOL 2296, BIOL 3204, BIOL 3096, or BIOL 3324)

BIOL 3329. Developmental Genetics. 3 Credit Hours.
This course is not offered every year.
The role of genes during the periods of determination and differentiation in eukaryote development. Emphasis on the regulation of gene function and the relationship between gene function and the molecular and developmental interactions that culminate in the adult phenotype.

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297) or BIOL 2296) and (BIOL 3204 or BIOL 3096)

BIOL 3333. Advanced Techniques in Microscopy. 4 Credit Hours.
This course is typically offered in Spring.
A survey of modern techniques in microscopy. Students will acquire a thorough grounding in general principles of optics and their application to the microscope. We will cover the theory of many methods current in Biology and Medicine, including: phase, interference contrast, and fluorescence microscopy, confocal microscopy, video microscopy, and digital image processing and analysis. This course includes extensive laboratory experience.

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

Pre-requisites: Minimum grade of C- in (BIOL 3204 or BIOL 3096)

BIOL 3334. Mammalian Physiology. 4 Credit Hours.
This course is typically offered in Spring.
Emphasis on the physiology of normal animals; consideration of disease states as counter-illustrations. Certain comparative aspects of physiology are introduced. Discussions of function extend to the physical and biochemical level.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, BIOE 3725, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, BIOE 3725, or 'Y' in BIOW), (CHEM 1032, CHEM 1952, or 'Y' in CHM2), (MATH 1042, MATH 1044, MATH 1942, MATH 1951, any MATH course numbered 2043 to 3080 (may be taken concurrently), or 'Y' in MATW), and (PHYS 1022 (may be taken concurrently), PHYS 1062 (may be taken concurrently), PHYS 2022 (may be taken concurrently), or PHYS 2922 (may be taken concurrently))

BIOL 3335. Life at the Extremes - Polar Biology. 3 Credit Hours.
"Life at the Extremes - Polar Biology" 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.

Course Attributes: SE, SI

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, or 'Y' in BIOW) and (BIOL 1112 (may be taken concurrently), BIOL 1912 (may be taken concurrently), BIOL 2112 (may be taken concurrently), BIOL 2912 (may be taken concurrently), or 'Y' in BIOW)

BIOL 3336. Freshwater Ecology. 4 Credit Hours.
This course is typically offered in Fall of even years.
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.

Course Attributes: SE, SI

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

Pre-requisites: Minimum grade of C- in BIOL 2227.

BIOL 3337. Comparative Biomechanics. 3 Credit Hours.
This course is typically offered in Fall.
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.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW), (MATH 1042, MATH 1044, MATH 1942, MATH 1951, 'Y' in MA07, or 'Y' in MATW), and (PHYS 1021, PHYS 1061, PHYS 1961, PHYS 2021, or PHYS 2921)

BIOL 3352. Systems Neuroscience. 3 Credit Hours.
This course is typically offered in Fall and Spring.
Study of the structure and function of the central nervous system (CNS) with a focus on the functional brain at a systems level. Systems level questions include how circuits are formed and used anatomically and physiologically to produce physiological functions, such as reflexes, sensory integration, motor coordination, emotional responses, learning and memory.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW), (CHEM 2201 (may be taken concurrently) or CHEM 2921 (may be taken concurrently)), and (MATH 1042, MATH 1044, MATH 1942, MATH 1951, any MATH course numbered 2043 to 3080 (may be taken concurrently), 'Y' in MA07, or 'Y' in MATW)

BIOL 3354. Neural Basis of Animal Behavior. 3 Credit Hours.
This course is typically offered in Fall.
An exploration of the relationship of neural activity and connectivity to behavior. Topics include motor control, object recognition, and feedback. Examples from both vertebrate and invertebrate species. Analytic and synthetic approaches.

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

Pre-requisites: Minimum grade of C- in BIOL 3352.

BIOL 3356. Organization and Development of the Nervous System. 3 Credit Hours.
This course is typically offered in Spring.
This course covers developmental and anatomical aspects of the nervous system. The relationship of form to function will be studied in a variety of both invertebrate and vertebrate systems. The course is intended to complement BIOL 3352 Systems Neuroscience so that students will have a perspective on neuroscience ranging from the molecular to the systems level.

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

Pre-requisites: Minimum grade of C- in (BIOL 3204, BIOL 3096, or BIOL 3352)

BIOL 3358. Cellular and Molecular Neuroscience. 3 Credit Hours.
This course is typically offered in Spring.
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.

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

Pre-requisites: Minimum grade of C- in (BIOL 3204 or BIOL 3096) and BIOL 3352.

BIOL 3361. Molecular Neuropharmacology. 3 Credit Hours.
This course will be offered every year in the Fall semester.
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 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).

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

Pre-requisites: Minimum grade of C- in BIOL 3352.

BIOL 3363. Mammalian Development. 3 Credit Hours.
This course is not offered every year.
This course covers normal and abnormal embryonic and fetal development; sources of totipotent, pluripotent and determined embryonic and fetal stem cells; the production of gynogenotes and androgenotes and the evaluation of these embryos to determine the contribution of maternal and paternal genomes to the developing embryo; epigenetic and X chromosome imprinting; the use of transgenes to correct genetic defects in developing embryos; and the function of specific genes in determining body pattern.

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

Pre-requisites: Minimum grade of C- in BIOL 3265.

BIOL 3364. Theory and Applications of Cancer Biology. 3 Credit Hours.
Students will be working at the Sbarro Institute for Cancer Research and Molecular Medicine, in collaboration with the Department of Medicine, Surgery and Neurosciences at the University of Siena. The program is overseen by Dr. Antonio Giordano, MD, PhD, Temple University professor and director of the Sbarro Health Research Organization, Dr. Luigi Pirtoli, MD, PhD, professor and director of the Radiation Oncology Unit at the University Hospital of Siena, and faculty and researchers at the University of Siena. Students will begin the program at the IES Abroad Siena Center with a comprehensive orientation, before beginning their six weeks of research. Throughout the program students will participate in cultural field trips, basic Italian language training and guided visits to Italian hospitals or labs. NOTE: This course may only be taken by students accepted into the Temple Education Abroad Summer in Italy Siena Biomedical Research Program.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111 or BIOL 1911), (BIOL 1112, BIOL 1912, BIOL 2112, or BIOL 2912), and ((BIOL 2207 and BIOL 2297), BIOL 2296, BIOL 3204, or BIOL 3096)

BIOL 3365. The New Neuroimmunology. 3 Credit Hours.
This course is typically offered in Spring.
It is now recognized that there is extensive communication between the immune and nervous systems. This course will examine the mechanisms and effects of this communication. Potential topics include effects of immune molecules on neuronal synaptic structure and function over the lifespan, and the implications for learning and memory; the biological basis of sickness behavior and links to depression and PTSD; possible effects of the microbiome on brain development and function; and links between immune deregulation and neurodegenerative disease.

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

Pre-requisites: Minimum grade of C- in BIOL 3352.

BIOL 3366. Applications of Biotechnology to Historical Preservation. 3 Credit Hours.
This course is central to the Temple Summer in Sicily Study Abroad experience, the Sicily Applied Biotechnology Program. In collaboration with Prof. Franco Palla, coordinator of the 5-year degree in conservation of cultural heritage at the University of Palermo, Italy, students will apply the tools of enzyme biochemistry, protein purification and biochemical techniques, microbe specific metabolic pathways, and biotechnological techniques of DNA sequencing to artifact preservation and restoration. Students will visit specific archeological sites and receive demonstrations of preservation and restoration field work. Students in their sophomore or junior year of study in degree programs within the Biology or Chemistry departments are eligible. Other students, particularly those in Engineering or Architecture programs, may also be considered.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW) and (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW)

BIOL 3367. Endocrinology. 3 Credit Hours.
This course is typically offered in Fall.
Broad coverage of "chemical messengers," occurrence, biochemistry, and physiology. Vertebrate endocrinology with minor treatment of invertebrates and plants.

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

Pre-requisites: Minimum grade of C- in (BIOL 3204 or BIOL 3096)

BIOL 3368. Biology of Cancer. 3 Credit Hours.
This course is typically offered in Spring.
Biology of Cancer presents a series of topics that describe the biochemical pathways that drive normal cellular behavior, and how mutations in components of these biochemical pathways can lead to loss of normal cell function, and transformation of a normal cell to a tumor cell. Topics include cellular receptors and signaling, the cell cycle, the roles of oncogenes and tumor suppressor genes, apoptosis, metastasis, tumor immunology, and the rational treatment of cancer. Biology of Cancer is taught by a team of instructors, wherein each instructor will lecture on a topic related to their own biomedical research.

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297) or BIOL 2296) and (BIOL 3204 or BIOL 3096)

BIOL 3369. Approaches to Disease Modeling, Diagnosis and Therapy. 3 Credit Hours.
This course is typically offered in Summer.
This course is divided into three stages. The first stage describes current and developing techniques for the study of the pathogenesis and progression of various diseases, along with new models for drug screening and the potential application of stem cells for tissue regeneration and/or repair. The pathological conditions comprise neurological diseases, genetic disorders and cancer. One specific topic is the current status of late stage clinical trials for the treatment of Alzheimer's disease. The second stage focuses on the latest modalities for diagnosis and prognosis of cancer: detection of tumor markers, circulating tumor cells and circulating tumor DNA. The third stage discusses cancer therapy: drug discovery and/or development, mechanisms of drug resistance in malignant cells, gene therapy, radiation therapy and immunotherapy.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW) and (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW)

BIOL 3371. Cell Proliferation. 3 Credit Hours.
This course is typically offered in Spring.
Cell proliferation and its control: model systems, comparisons of proliferating cells with non-proliferating cells, controls of cell division and genomic stability and how that control is modified in proliferative diseases such as cancer, and the relationships between proliferation and differentiation. Readings will be taken from the literature.

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297) or BIOL 2296) and (BIOL 3204, BIOL 3096, BIOL 3324, or BIOL 4375)

BIOL 3372. The Molecular Regulation of Cell Migration and Morphogenesis During Development and Disease. 3 Credit Hours.
How cells move and how this process is regulated remains an active area of study. Disruption of cell migration is known to be causative for numerous human pathologies, and as such a major emphasis in the biological sciences is to discern and understand both the mechanisms and logic that drive such cellular migration. This course is an advanced cell biology course that will broadly examine how cell migration is controlled. Students will examine key signaling pathways that regulate cell polarization, cytoskeletal reorganization, cell adhesion and changes to the extracellular matrix for cell migration. Examples of cell migration and morphogenesis will be drawn from both developmental and diseases-based examples to illustrate both the mechanisms and roles of these key processes.

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

Pre-requisites: Minimum grade of C- in (BIOL 3204 or BIOL 3096)

BIOL 3373. Cell Signaling. 3 Credit Hours.
This course is typically offered in Spring.
The communication among cells is essential for the regulation of the development of an organism and for the control of its physiology and homeostasis. Aberrant cellular signaling events are often associated with human pathological conditions, such as cancer, neurological disorders, cardiovascular diseases and so on. The full characterization of cell signaling systems may provide useful insights into the pathogenesis of several human maladies. (Prior to spring 2017, this course was titled "Cell Signaling and Motility.)

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

Pre-requisites: Minimum grade of C- in (BIOL 3204, BIOL 3096, or BIOL 4375)

BIOL 3374. Physical Biochemistry. 3 Credit Hours.
This course is typically offered in Spring.
Physical Biochemistry emphasizes physical techniques that are used in modern biochemical research. Topics include proteomics, protein structure, protein folding, protein misfolding in neurological disorders, interaction of light with proteins including optogenetics, the light reaction of photosynthesis, nitrogen fixation, absorption spectroscopy, emission spectroscopy, bioluminescence and BRET, MALDI-TOF mass spectrometry, NMR spectroscopy, natural and artificial membranes, and single molecule methods in biochemistry.

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

Pre-requisites: Minimum grade of C- in (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW), (MATH 1042, MATH 1044, MATH 1942, MATH 1951, any MATH course numbered 2043 to 3080 (may be taken concurrently), 'Y' in MA07, or 'Y' in MATW), (PHYS 1061, PHYS 2021, or PHYS 2921), and (CHEM 1034 or CHEM 1954)

BIOL 3379. Biotechnology. 3 Credit Hours.
This course is typically offered in Spring.
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.

Repeatability: This course may be repeated for additional credit.

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297), BIOL 2296, BIOL 3204, BIOL 3096, or BIOL 3324)

BIOL 3380. 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.

Repeatability: This course may be repeated for additional credit.

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, or 'Y' in BIOW) and (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, or 'Y' in BIOW)

BIOL 3389. Field Research in Community Ecology. 3 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 course taught at Temple's Ambler Campus, students will gain hands-on experience designing and conducting field research in community ecology as the lab component of the course. While some activities will be in a classroom, most lab activities will be held outdoors, in the natural environments around Ambler Campus.

Course Attributes: SE, SI

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

Pre-requisites: Minimum grade of C- in (BIOL 1011, BIOL 1111, or BIOL 1911)

BIOL 3396. Scientific Writing for Biology: The Art of Communicating. 3 Credit Hours.
This course is designed for upper-level undergraduate students majoring in a natural science. This seminar course teaches students how to communicate scientific information in written and oral (PowerPoint) formats clearly and succinctly. The development and refinement of the primary research article represents the core of the course; however, other genres of scientific writing (and audiences) are explored. In addition, students develop their skills as revisers, editors, and reviewers through in-class exercises that focus on giving (and receiving) constructive criticism. As part of a secondary goal of the course, other professional forms of writing (e.g., cover letters, personal statements, and resumes) as well as careers in scientific writing are discussed.

Course Attributes: WI

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297) or BIOL 2296)

BIOL 3403. Genomic Biology. 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. A significant part of the course will cover genome-level data analyses, and students will complete assignments and exams to demonstrate understanding of the information present in genomes and how we know it. Note: Prior to fall 2016, the course title was "Genomics." Prior to fall 2015, the course title was "Genomics and Proteomics."

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297), BIOL 2296, BIOL 3101, or BIOL 3212)

BIOL 3511. Pathophysiology of Genomic Medicine. 3 Credit Hours.
Genomics is now revolutionizing the practice of medicine such that almost every area of medicine has been affected. In this companion course to Genomic Foundations of Medicine, we will examine the molecular and cellular consequences of genomic variation in a medical context, focusing on pathophysiology and its impact on cellular and physiological functioning.

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

Pre-requisites: Minimum grade of C- in BIOL 2512.

BIOL 3514. 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 course, and students are expected to work on computation problems in class using their laptop computers.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW), (MATH 1042, MATH 1044, MATH 1942, MATH 1951, any MATH course numbered 2043 to 3080 (may be taken concurrently), 'Y' in MA07, or 'Y' in MATW), and (BIOL 3312, CIS 1051, CIS 1951, PHYS 2511, or SCTC 1013)

BIOL 3681. Cooperative Studies. 2 to 4 Credit Hours.
This course is typically offered in Fall, Spring, Summer I and Summer II.
Students obtain a job through the Cooperative Placement Office. Course grade based entirely on a research paper, related in subject matter to the job, and prepared under the supervision of a Biology Department faculty member. NOTE: The student is responsible for finding a departmental supervisor. For students enrolled in a Cooperative Program; not available for Biology elective credit. This course is not repeatable.

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

BIOL 3685. Externship Studies. 3 Credit Hours.
This course is typically offered in Fall, Spring, Summer I and Summer II.
Students who are participating in a formal externship program may apply to receive credit for the experience. The program must require a minimum of 9 hours per week, and require a summary from the preceptor at the end of the experience. A faculty member of the Biology department shall serve as the liaison to the program. All students must obtain the approval of the Biology Undergraduate Committee prior to entering the externship. Students must have completed Biology 1111/1911 and Biology 1112/2912 or 2112/2912. NOTE: Grades will be on a credit/non-credit basis. Not available for major credit.

Repeatability: This course may be repeated for additional credit.

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW) and (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW)

BIOL 3941. Honors Broader Impacts: The Art of Scientific Communication. 3 Credit Hours.
Honors Broader Impacts: The Art of Scientific Communication is an upper-level honors course designed to integrate students from different disciplines around a discussion of the interpretation and presentation of scientific results to the public. The course will begin with a motivation for public engagement in the sciences and how science and scientists are viewed by the public. This will include a discussion of the National Science Foundation requirements for the "Broader Impacts" of their submitted proposals. The course will continue with the presentation, evaluation, and discussion of various examples of scientific outreach including film, fine art, music, and museum exhibits, as well as direct communication outlets such as blogs, social media, and press releases. Over the course of the semester, the students will engage with each other in the discussion of what makes an effective science communication strategy and work together to develop materials that communicate scientific to a broad audience. This will ideally involve a pairing of CST graduate students with Honors undergraduates from a wide variety of disciplines.

Course Attributes: HO

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

BIOL 4201. The Practice of Health Care: Competencies and Current Topics. 1 or 3 Credit Hour.
This course is designed for post-baccalaureate pre-health students in order to better prepare them to be compassionate, well-informed, and professional health-care providers in the current health-care system. The current health-care system is very complex, and the medical education system has to spend so much time teaching scientific and clinical information that it often does not have a substantial amount of time to devote to explicitly teaching the "unspoken curriculum" that all students are expected to learn. The "unspoken curriculum" includes topics such as teamwork, medical ethics, professionalism, and understanding medical literature. This course seeks to better prepare students to function well in the health-care system by exposing them to a wealth of relevant and interesting topics in the areas of professional development, medical ethics, recent research related to medical disorders, and the current state of medical practice.

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

BIOL 4218. Principles of Medical Genetics for Pre-Health Postbaccalaureates. 4 Credit Hours.
Understanding of genetics is central for many biological disciplines, including medicine. This course examines the basic principles and problems of classical, biochemical, and molecular genetics to enable the student to apply them in solving medical problems.

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

BIOL 4233. Human Anatomy for Pre-Health Postbaccalaureates. 4 Credit Hours.
The fundamentals of human anatomical structure are examined. A primary goal will be the development of a comprehensive vocabulary, including the learning of Latin and Greek root words underlying medical terminology. Students will progress from a review of the history of anatomy; to the study of anatomy at the microscopic level of cells, organelles and tissues; and finally to the organ systems level. Muscular, skeletal, nervous, endocrine, cardiovascular, gastrointestinal and respiratory systems will be covered.

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

BIOL 4234. Human Anatomy Lab for Pre-Health Postbaccalaureates. 1 Credit Hour.
This is a 1-credit lab to accompany the Human Anatomy Lecture 4233. It will emphasize the anatomical structures talked about in lecture. Students will dissect and make observations in order to identify major muscles along with their associated bones, nerves and arteries. In addition, after opening the thoracic and abdominal cavities students will identify the major organs of these cavities. Note: To register for this course, students must satisfy the prerequisite or obtain permission from the program director.

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

Pre-requisites: Minimum grade of C in BIOL 4233 (may be taken concurrently)

BIOL 4268. Fundamentals of Cell and Cancer Biology for Pre-Health Postbaccalaureates. 4 Credit Hours.
This course examines cellular structures and biochemical pathways including those that, while mutated, lead to cellular transformation and formation of cancer.

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

BIOL 4275. Fundamentals of Medical Biochemistry for Pre-Health Postbaccalaureates. 4 Credit Hours.
Biochemistry is fundamental to understanding pathophysiology, pharmacology, and other medical sciences. This course delves into the principles of biomolecular structure and function, kinetics, bioenergetics, biosignaling, and metabolism to prepare the student for understanding the molecular basis of medicine.

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

BIOL 4291. Extradepartmental Research. 1 to 4 Credit Hour.
This course is typically offered in Fall, Spring, Summer I and Summer II.
Research under the direction of a faculty member in an affiliated department. All students must obtain the approval of the Biology Faculty Advisor, who will complete the registration. Prerequisite: Senior standing. A student is eligible for "Distinction in Biology" upon: 1) achieving a minimum 3.2 major and cumulative GPA; 2) successful completion of Biology 4391 Accelerated Research in Biology, Biology 4291 Extradepartmental Research, or Biology 4396 Advanced Study in Biology, for a minimum of 6 s.h. over two semesters; 3) submission of a written research report to the faculty sponsor and/or presentation during the Biology Department's annual research poster exhibition or another Temple University research symposium, with approval. Students completing a minimum of 6 s.h. of a 4000-level Biology research course over two semesters may count that as one Biology Upper-Level Elective for the B.S. in Biology degree. This course is repeatable. Students wishing to complete additional credits of Biology 4291 beyond 8 s.h. may do so if they select the CR/NC grade option.

Repeatability: This course may be repeated for additional credit.

BIOL 4327. Biological Impacts of Global Climate Change. 3 Credit Hours.
This course is typically offered in Fall.
This course will use primary research articles to examine the biological impacts of climate change, often mentioned as the greatest challenge facing humanity today. The course will focus on the climate change impacts on coastal and marine ecosystems; water resources and freshwater ecosystems; food and agriculture; forests, grasslands and deserts; biodiversity and protected areas; and population, health and human well-being. In addition to the biology, we will consider the overlapping social, economic, and ethical concerns rising from the climate changes. Class time will be devoted to reflections and reactions to readings and news articles, case studies, student presentations and lectures.

Course Attributes: SE, SF, SP, SS

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW), and BIOL 2227.

BIOL 4338. Epigenetics. 3 Credit Hours.
This course is not offered every year.
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.

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297), BIOL 2296, or 'Y' in BIO6)

BIOL 4341. Genome Editing. 3 Credit Hours.
Genome editing as such is not that new. Scientists have been "editing" genomes of bacteria, yeast and the mouse for some 30 years. Several recent technical advances, however, have pushed genome editing to the forefront of biological research. The first is discovery and development of nucleases, CRISPR/Cas9 in particular, which can be directed to cut DNA at just about any location. The second factor is a combination of stem cell technologies. They make it possible to produce stem cell out of many different tissues, which can then in turn be differentiated into various cell types, or carry out editing in the zygote. This will be a fast-paced seminar-like class. We will read and discuss primary research papers which describe advances relevant to the genome editing field, culminating in their application to edit the genomes of large mammals including the species Homo sapiens.

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297) or BIOL 2296)

BIOL 4342. Evolution of Infectious Disease. 3 Credit Hours.
Infectious diseases have been adapting to humans for as long as we have been organized into communities - from small agricultural ones to the megacities of the twenty-first century. Malaria, tuberculosis, and plague shaped important aspects of human history. And modern emerging pathogens like Zika, Ebola, avian influenza, and coronaviruses have shaped public health opinion and a new global response to the potential threat of deadly pandemics. This course will explore how infectious diseases adapt to and evolve in humans and human societies. Major topics covered will include how infectious diseases jump from animals to humans, how pathogens are forced into a race with the human immune system, why some diseases evolve to be benign and others deadly, and how pathogens evolve in response to human interventions like vaccination and drug treatment. Examples covered in this course will include influenza, malaria, HIV, dengue virus, and enteric infections. Students will learn the evolutionary principles underlying the constantly shifting relationship between these pathogens and their human hosts. Students will learn the basics of molecular evolution and phylogenetic interpretation, and students will be expected to understand introductory concepts and methods in mathematical population genetics. Note: Prior to Fall 2025, this course was titled "Evolutionary Genetics of Infectious Disease."

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, or 'Y' in BIOW), and BIOL 3101.

BIOL 4344. Research Techniques in Biochemistry. 4 Credit Hours.
This course is typically offered in Spring.
Laboratory instruction in techniques used to investigate biochemical problems. Techniques include spectrophotometry, various types of electrophoresis, separation of macromolecules, two-dimensional protein separation, affinity chromatography, isolation of plasmid DNA, Western Blot, immunoassay, enzyme kinetics, and radioisotope techniques. If time permits, students will be given a small research project.

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

Pre-requisites: Minimum grade of C- in (CHEM 4401 or BIOL 4375)

BIOL 4358. Cellular and Molecular Neuroscience. 3 Credit Hours.
This course is typically offered in Spring.
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.

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

Pre-requisites: Minimum grade of C- in (BIOL 3204 or BIOL 3096) and BIOL 3352.

BIOL 4361. Molecular Neuropharmacology. 3 Credit Hours.
This course will be offered every year in the Fall semester.
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 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).

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

Pre-requisites: Minimum grade of C- in BIOL 3352.

BIOL 4364. Biochemistry of Embryogenesis. 3 Credit Hours.
This course is typically offered in Fall.
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.

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297), BIOL 2296, or 'Y' in BIO6)

BIOL 4365. Evolutionary Developmental Biology: Evo-Devo. 3 Credit Hours.
This course is typically offered in Spring.
An overview of the relationship between organisms' development and phenotypic changes during evolution. Includes historical, theoretical and mechanistic themes of Evo-Devo, molecular and genetic basis of development and evolution.

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

Pre-requisites: Minimum grade of C- in (BIOL 2207, BIOL 2296, or BIOL 3101)

BIOL 4366. Stem Cell Biology. 3 Credit Hours.
This course is typically offered in Fall.
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.

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297), BIOL 2296, or 'Y' in BIO6) and (BIOL 3204, BIOL 3096, or 'Y' in BIO7)

BIOL 4367. Cancer Diagnostics and Therapeutics. 3 Credit Hours.
The course will provide novel insights for early diagnosis of cancer, new approaches for cancer therapy, drug delivery methods, and hints of personalized medicine. It will also highlight new opportunities and challenges associated with novel approaches and platforms for both diagnostics and therapeutics.

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

Pre-requisites: Minimum grade of C- in (BIOL 3204, BIOL 3096, (BIOL 2207 and BIOL 2297), or BIOL 2296)

BIOL 4370. Advanced Special Topics in Biochemistry. 3 Credit Hours.
This course is not offered every year.
Advanced lecture course. Subject matter varies from semester to semester.

This course is repeatable for credit.

Repeatability: This course may be repeated for additional credit.

Pre-requisites: Minimum grade of C- in (CHEM 4401 or BIOL 4375)

BIOL 4375. General Biochemistry I. 3 Credit Hours.
Properties of water (pH and buffers); chemistry of amino acids and proteins including non-covalent interactions; carbohydrates, nucleotides and nucleic acids; lipids and membranes; enzyme mechanisms and kinetics; control of enzyme activity; bioenergetics and oxidative metabolism; and chemistry of photosynthesis.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW), (CHEM 2202 (may be taken concurrently) or CHEM 2922 (may be taken concurrently)), and (MATH 1041, MATH 1941, MATH 1038, MATH 1042 (may be taken concurrently), MATH 1044 (may be taken concurrently), MATH 1942 (may be taken concurrently), MATH 1951 (may be taken concurrently), any MATH course numbered 2043 to 3080 (may be taken concurrently), 'Y' in MA06, or 'Y' in MATW)

BIOL 4376. 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.

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

Pre-requisites: Minimum grade of C- in (CHEM 4401 or BIOL 4375)

BIOL 4387. Research in Genomic Medicine and Medical Informatics. 1 to 4 Credit Hour.
Genomic Medicine begins with human patients. This hands-on, translational research course provides students with firsthand experience in the clinic or laboratory. Students will gain essential skills in patient engagement, bio-sample collection, medical informatics, and other core principles of genomic medicine. Participants will observe and participate in real-time research with clinical staff, using biobanking, genomic, and clinical data for translational research. Rotation options include Cardiology, Gastroenterology, Neurology, Surgery, and other specialties, based on faculty and student availability. NOTE: Not available for major credit. This course is not repeatable.

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

Pre-requisites: Minimum grade of C- in BIOL 3511 (may be taken concurrently)

BIOL 4391. Accelerated Research in Biology. 1 to 4 Credit Hour.
This course is typically offered in Fall, Spring, Summer I and Summer II.
Research under the direction of a faculty member in the Department of Biology. All students must obtain the approval of the Biology Faculty Advisor, who will complete the registration. Prerequisite: Senior standing. A student is eligible for "Distinction in Biology" upon: 1) achieving a minimum 3.2 major and cumulative GPA; 2) successful completion of Biology 4391 Accelerated Research in Biology, Biology 4291 Extradepartmental Research, or Biology 4396 Advanced Study in Biology, for a minimum of 6 s.h. over two semesters; 3) submission of a written research report to the faculty sponsor and/or presentation during the Biology Department's annual research poster exhibition or another Temple University research symposium, with approval. Students completing a minimum of 6 s.h. of a 4000-level Biology research course over two semesters may count that as one Biology Upper-Level Elective for the B.S. in Biology degree. This course is repeatable. Students wishing to complete additional credits of Biology 4391 beyond 8 s.h. may do so if they select the CR/NC grade option.

Repeatability: This course may be repeated for additional credit.

BIOL 4396. Advanced Study in Biology. 3 Credit Hours.
This is a writing-intensive research course focused around the independent research of a senior undergraduate in one of the research labs in Biology, or another approved school or department (research mentor must be approved by course instructor or major advisor). Ideally, the student will have conducted independent research in the mentor's laboratory prior to taking this course, although that is not a requirement. During lecture sessions, students will receive instruction in the elements of a scientific paper, writing effectively in the style of the subject, visually representing their data, and the process of submitting and reviewing a scientific paper. Over the course of the semester, the student will propose a specific topic for the manuscript, write a manuscript in the format of a journal in the field of study, and present the research in class. The research mentor will review the manuscript a minimum of two times during the semester, and the student will revise the manuscript accordingly. At the end of the semester, the final manuscript will be submitted to the mentor, who will provide their evaluation to the course instructor and will be factored into the final grade. Note: Students will be placed in major-specific sections that require permission of the Biology faculty advisor.

Course Attributes: SI, WI

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

Pre-requisites: Minimum grade of C- in ((BIOL 2207 and BIOL 2297) or BIOL 2296)

BIOL 4411. 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.

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

Pre-requisites: Minimum grade of C- in (BIOL 1111, BIOL 1911, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, or 'Y' in BIOW), (MATH 1042, MATH 1044, MATH 1942, MATH 1951, any MATH course numbered 2043 to 3080 (may be taken concurrently), or 'Y' in MATW), SCTC 1013, and BIOL 3312.

BIOL 4483. Accelerated Research in Biochemistry. 3 Credit Hours.
This course is typically offered in Fall, Summer I and Summer II.
This course is required for graduation with distinction in the major. Student presentation of research done in this course [and 4491 (0394)] or a comprehensive presentation of a topic selected jointly by student and advisor. Emphasis placed on analysis of experimental techniques, quantitative interpretation of the data, logical analysis of controls, and implication of the results. Admission to this course and the distinction track, as well as recommendation for graduation with distinction, must be approved by the Biochemistry Committee. Not available for Biology major credit.

Repeatability: This course may be repeated for additional credit.

BIOL 4491. Research in Biochemistry. 3 Credit Hours.
This course is typically offered in Fall, Spring, Summer I and Summer II.
Research under the supervision of one of the Biochemistry faculty. If repeated, a presentation of the student's research is required during the second semester. Upon successful completion of two semesters of Biology 4491 (0394), the student may petition for them to be counted as one of the Biochemistry electives. Not available for Biology major credit.

Repeatability: This course may be repeated for additional credit.

BIOL 4509. 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.

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

Pre-requisites: Minimum grade of C- in BIOL 3403 and (CIS 1051, CIS 1951, or SCTC 1013)

BIOL 4532. 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.

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

Pre-requisites: Minimum grade of C- in SCTC 2396 and ((BIOL 2207 and BIOL 2297), BIOL 2296, BIOL 3204, BIOL 3096, BIOL 3396, CHEM 3397, CHEM 3398, CHEM 4196, CIS 3296, CIS 4397, CIS 4398, EES 2096, EES 2097, ENVS 4198, MATH 3096, MATH 3098, MATH 4096, PHYS 2796, or PHYS 4796)

BIOL 4533. Communicating Science to a Broader Audience / Non-Scientists. 3 Credit Hours.
This writing intensive course is 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 emphasizes the communication of scientific theory and concepts to wide-ranging audiences, especially non-scientists. The class requires 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.

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

Pre-requisites: Minimum grade of C- in SCTC 2396 and ((BIOL 2207 and BIOL 2297), BIOL 2296, BIOL 3204, BIOL 3096, BIOL 3396, CHEM 3397, CHEM 3398, CHEM 4196, CIS 3296, CIS 4397, CIS 4398, EES 2096, EES 2097, ENVS 4198, MATH 3096, MATH 3098, MATH 4096, PHYS 2796, or PHYS 4796)

BIOL 4591. Research in Neuroscience. 1 to 4 Credit Hour.
This course is typically offered in Fall, Spring, Summer I and Summer II.
Prerequisites: Senior standing and a GPA of 3.2 or above. Two-semester research sequence to be performed under the supervision of a faculty member conducting neuroscience research in the Department of Biology or affiliated department. Students must be Neuroscience majors. A written research report is required during the second semester. A student is eligible to apply for "Distinction in Neuroscience" upon: 1) successful completion of 6 s.h. of Biology 4591; 2) submission of a written research report to the faculty advisor; and 3) a poster presentation during the Biology Department's annual research poster exhibition. Not available for Biology major credit. This course is repeatable. Students wishing to complete additional credits of Biology 4591 beyond 8 s.h. may do so if they select the CR/NC grade option.

Repeatability: This course may be repeated for additional credit.

Pre-requisites: Minimum grade of C- (except where noted) in (BIOL 1111, BIOL 1911, 'Y' in BIO3, or 'Y' in BIOW), (BIOL 1112, BIOL 1912, BIOL 2112, BIOL 2912, 'Y' in BIO4, or 'Y' in BIOW), ((BIOL 2207 and BIOL 2297) or BIOL 2296), (BIOL 3204 or BIOL 3096), and BIOL 3352 (C or higher)

BIOL 4596. Introduction to Scientific and Regulatory Writing. 3 Credit Hours.
This course introduces students to the two primary types of medical writing in the pharmaceutical and biotech industries. Students will learn the fundamentals of drug development and the critical role of regulatory writing. Topics will include an overview of U.S. and international regulatory agencies, product life cycles, the conduct of clinical trials and reporting of clinical trial results, and documentation involved with submissions for marketing approval. Additionally, students will learn how to research and write abstracts, posters, and other research manuscripts, patient education materials, and slide decks. Students will be introduced to the basics of strategic planning, including the creation of publication plans and meeting planning for clinical trial dissemination to support the marketing of the drug. This course will meet weekly. The instructor will present material and interact with students who will author different types of documents and use multiple review/revision cycles to communicate science to physicians, scientists, and regulators.

Course Attributes: WI

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

Pre-requisites: Minimum grade of C- in (SCTC 2396, (BIOL 2207 and BIOL 2297), BIOL 2296, BIOL 3096, BIOL 3396, BIOL 4396, CHEM 3398, CHEM 4196, CHEM 4396, CHEM 4496, CIS 3296, CIS 4296, CIS 4396, CIS 4397, CIS 4398, CIS 4496, EES 2096, EES 2097, EES 4696, EES 4796, EES 4896, ENVS 4198, MATH 3096, MATH 3098, MATH 4096, PHYS 2796, or PHYS 4796)

BIOL 4597. Communicating Science to a Broader Audience / Non-Scientists. 3 Credit Hours.
An essential part of scientific writing includes communicating science to a broader audience. The majority of scientific publications are written by scientists to share results and discoveries with other scientists. This type of formal scientific writing is used in publications, congress activity (slide sets/posters), grant applications, and other deliverables. These are important mechanisms for disseminating scientific results to the scientific community, but this formalized structure of scientific writing ignores the majority of readers, the non-scientists. Communicating science to different audiences of non-scientists and for different situations is critically important: (1) Medical information must be shared with patients and families to inform decision-making and improve treatment compliance; (2) Scientific information relevant to world events must be shared with global citizens to understand the risks to public health (e.g., the COVID-19 pandemic) and the environment (e.g., global warming) and of the understanding of other issues; and (3) Scientific information must also be shared with other non-scientists to help inform government and non-government organizations to influence decision-making and structure policy. This course will teach science writers to reach different audiences by communicating science in a language and style that is accessible to all. This course will meet weekly. The instructor will present material and interact with students who will author different types of documents and use multiple review/revision cycles to communicate science topics to readers with no science background or limited backgrounds (e.g., other STEM fields).

Course Attributes: WI

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

Pre-requisites: Minimum grade of C- in (SCTC 2396, (BIOL 2207 and BIOL 2297), BIOL 2296, BIOL 3096, BIOL 3396, BIOL 4396, CHEM 3398, CHEM 4196, CHEM 4396, CHEM 4496, CIS 3296, CIS 4296, CIS 4396, CIS 4397, CIS 4398, CIS 4496, EES 2096, EES 2097, EES 4696, EES 4796, EES 4896, ENVS 4198, MATH 3096, MATH 3098, MATH 4096, PHYS 2796, or PHYS 4796)

BIOL 5027. Principles of Ecology. 3 Credit Hours.
The purpose of this course is to provide an overview of ecology from the level of individual organisms to populations, communities, ecosystems, and the biosphere. It examines the physical, chemical, and biological components of ecological interactions, and includes terrestrial and aquatic ecosystems.

Course Attributes: SF

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

BIOL 5028. Ornithology. 4 Credit Hours.
The course focuses on how the study of birds has contributed to our understanding of basic principles in evolution, ecology, biogeography, behavior, neurobiology, life history theory, biodiversity and conservation. Lectures, small group discussions from primary literature, case studies and field work during the laboratory will highlight these empirical advances. The course is available for all biology majors, but is geared specifically for those majoring in Ecology, Evolution and Biodiversity.

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

BIOL 5041. Invertebrate Biology. 4 Credit Hours.
An introduction to the biology of the invertebrate phyla including insects. Demonstrations of the patterns of invertebrate evolution by consideration of morphology, behavior, development, physiology, and ecology of representative organisms.

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

BIOL 5045. Marine Ecology. 4 Credit Hours.
A survey of the concepts of aquatic ecology in estuarine and marine ecosystems, emphasizing the organization and maintenance of the major aquatic communities in response to the physical, chemical, and biological characteristics of the environment, modes of energy transfer, physiological adaptation, life history characteristics, and functional morphology. Laboratory exercises stress comparative measurement of biological diversity in the marine environment.

Course Attributes: SI

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

BIOL 5052. Fundamentals of Sustainability Science and Environmental Justice. 3 Credit Hours.
How can we apply science to promote intergenerational equity in the face of global environmental change? This graduate-level course provides a transdisciplinary introduction to sustainability science, exploring the complex interactions between human and environmental systems. Students will become acquainted with the key concepts, issues, and debates of this integrative field to apply a systems-thinking approach to solve real-world sustainability problems.

Course Attributes: SF

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

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.

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.

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.

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.

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.

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.

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

BIOL 5225. Evolutionary Genetics and Phylogenetics. 3 Credit Hours.
Modern evolutionary theory addresses various research questions, from the diversity of life to human health and disease. This course covers general principles of population genetics and phylogenetics, emphasizing the value of explicit models and assumptions when making inferences from molecular data. We will explore commonly used methods to describe and study genetic variation and patterns across organizational levels, from loci and genomes to clades above the species level. Such methods will be discussed in the context of research problems in epidemiology, molecular ecology, and systematics.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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."

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

BIOL 5333. Human Anatomy. 4 Credit Hours.
Anatomy is the study of the structure of living systems. However, much of the progress in anatomy has come from studying the dead. A constant point of interest even in the beginnings of anatomy was not just understanding and naming the parts, but how these parts fit together and lead to what we observe in the living, called functional anatomy. At first this link only occurred at the gross scale, that which is observable to the naked eye. With the advent of the microscope came an interest in the anatomy of cells, microscopic anatomy. Between these two there was found an interest in embryology which later became developmental anatomy. Now with advances in anatomical imaging another suite of tools is available for the inspection, diagnosis, and treatment of anatomical issues. In this course we will utilize all of these viewpoints into the structure of the body to understand how we and the living things around us are put together, how these parts interact, and how we might better maintain or fix them should they break.

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.

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.

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.

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.

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).

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.

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

BIOL 5389. Field Research in Community Ecology. 3 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 course taught at Temple's Ambler Campus, students will gain hands-on experience designing and conducting field study research in community ecology. While some activities will be in a classroom, most field study activities will be held outdoors, in the natural environments around Ambler Campus.

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.

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.

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.

Course Attributes: SI

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.

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.

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.

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.

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.

Course Attributes: SI

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

BIOL 5441. Broader Impacts: The Art of Scientific Communication. 3 Credit Hours.
Broader Impacts: The Art of Scientific Communication is a graduate course designed to integrate Biology Graduate students with Honors undergraduates from different disciplines around a discussion of the interpretation and presentation of scientific results to the public. The course will begin with a motivation for public engagement in the sciences and how science and scientists are viewed by the public. This will include a discussion of the National Science Foundation requirements for the "Broader Impacts" of their submitted proposals. The course will continue with the presentation, evaluation, and discussion of various examples of scientific outreach including film, fine art, music, and museum exhibits, as well as direct communication outlets such as blogs, social media, and press releases. Over the course of the semester, the students will engage with each other in the discussion of what makes an effective science communication strategy and work together to develop materials that communicate the subjects of the graduate students' dissertation projects to a broad audience.

Course Attributes: SF

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.

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.

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.

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.

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

BIOL 5465. Mammalian Development. 3 Credit Hours.
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.

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.

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.

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.

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.

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.

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.

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.

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.

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).

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.

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.

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

BIOL 5505. Ethics Regulation and Policy in Biotechnology. 3 Credit Hours.
The rapid advances in scientific Research and Development (R&D) resulting in commercialization of innovative drugs and devices have promulgated seemingly retroactive regulations and policies to govern these technologies. This course studies some of the unintended consequences of R&D in the biotech sector. Examples of regulation and policy implemented after the fact are introduced through seminal papers / news articles and ethical dilemmas highlighted.

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

BIOL 5506. Professional Development Seminar (PSM). 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.

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

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.

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

Pre-requisites: Minimum grade of B- in BIOL 5403.

BIOL 5511. Ethics in Bioinformatics. 2 Credit Hours.
The rapid advances in scientific Research and Development (R&D) resulting in commercialization of innovative drugs and devices have promulgated seemingly retroactive regulations and policies to govern these technologies. This course studies some of the unintended consequences of R&D in the biotech sector. Examples of regulation and policy implemented after the fact are introduced through seminal papers / news articles and ethical dilemmas highlighted.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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

BIOL 8210. Seminar. 1 Credit Hour.
Seminar. Topics will vary.

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

Repeatability: This course may be repeated for additional credit.

BIOL 8250. Seminar. 3 Credit Hours.
Seminar. Topics will vary.

Repeatability: This course may be repeated for additional credit.

BIOL 8260. Seminar. 2 to 4 Credit Hours.
Seminar. Topics will vary.

Repeatability: This course may be repeated for additional credit.

BIOL 8450. Seminar. 3 Credit Hours.
Seminar. Topics will vary.

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.

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.

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.

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

Repeatability: This course may be repeated for additional credit.

BIOL 9991. Graduate Research Projects. 1 to 6 Credit Hour.
Short-term, limited research project or laboratory project in the field. The course is for doctoral or master's students, including PSM, MA or MS. This class will not confer full time program status unless nine credits are taken.

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.

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.

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.

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.

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.

Repeatability: This course may be repeated for additional credit.

BIOL A000. Elective UL. 0 Credit Hours.
Repeatability: This course may not be repeated for additional credits.