# Requirements: Biology

*Natural Sciences Division*

## The Biology Curriculum

The biology curriculum structures learning based on the scientific process of discovery: observation, interpretation, experimentation, analysis and the formation of new hypotheses. Through exploration of recent developments in the broad range of biological fields, students examine details in the context of basic principles. Students experience the dynamic nature of biological science by participating in laboratory work and research projects that form the backbone of the program. The curricular design offers many choices to students, allowing non-majors to explore any one field of biology in depth or to examine biology in the context of human issues having sociological, economic and political importance, such as health care, biotechnology and the environment.

Introductory and foundation courses are offered at the 100-level. These consist of BIOL 109Y-110Y, the year long introductory lab sequence and BIOL 115 and 116, Energy and Information in Living Systems.

Upper-level courses are offered at the 200 and 300 levels. Courses at the 200 level are designed for sophomores and juniors who have completed at least part of the introductory-level curriculum. Reading assignments include textbooks, primary literature and other advanced sources. Courses at the 300 level are designed for juniors and seniors who have completed the entire introductory-level curriculum and at least one 200-level course. Primary literature and other advanced sources form a substantial portion of the reading, and extensive student-directed work is expected. In addition, senior Biology and Molecular Biology majors must take a 400-level senior seminar, as part of their Senior Capstone in Biology.

In addition to the biology major, major programs in biochemistry and in molecular biology are available. These programs combine work in biology and chemistry to prepare students for graduate work or employment entailing research on the molecular basis of biological systems. Information on course requirements for these major programs is detailed in the biochemistry and molecular biology section.

Non-majors can choose innovative topical courses that approach biological issues in a human context (BIOL 102, 103, 104, 105, 106, 107). These courses are designed for students with minimal backgrounds in biology. The foundation courses — BIOL 115 and 116 — allow more in-depth study. Several courses also serve the interdisciplinary concentration in environmental studies.

For students considering medical, dental, nursing or veterinary postgraduate programs, there is usually a requirement of a minimum of two semesters of biology with the corresponding laboratory work. BIOL 115 and 116 plus the laboratory sequence BIOL 109Y-110Y satisfy this requirement.

Students can involve themselves in the department through the Biology Student Advisory Group, which meets with the chair and faculty members, or as employees ranging from laboratory teaching assistants to research assistants.

Majors are encouraged to participate in the department through research with faculty members and by their active role in hiring faculty, suggesting curriculum changes, inviting and hosting seminar speakers and planning social events.

## Requirements for the Major

- BIOL 109Y–110Y, to be completed by end of sophomore year
- BIOL 115 and 116 (or specific exemption by AP or IB), must be completed within the first four semesters
    - Advanced courses may be taken after completion of BIOL 115 and 116 so students can begin advanced lecture courses while completing BIOL 109Y–110Y
- Six upper-division lecture courses, including at least one 300-level course and one 400-level course. MATH 258 and CHEM 256 can each count as one of the six required upper-division courses
- Four upper-division laboratory courses (0.5 unit of credit in [BIOL 385, 386] or [BIOL 497, 498] can serve as one 0.25-unit laboratory course requirement)
- One year of Introductory Chemistry lecture (or equivalent)

In order to fulfill the diversification requirements for upper-level courses, biology majors will need to take at least one upper-level lecture course in each of the following three categories to graduate:

- Environmental biology: BIOL 228, 241, 251, 253, 261, 311, 328, 352 and 362
- Organismal biology/physiology: BIOL 211, 233, 238, 243, 245, 323, 336 and 358
- Cellular and molecular biology: BIOL 238, 255, 263, 266, 315, 321, 323, 333, 375 and CHEM 256

We strongly encourage majors to take at least one year of mathematics and physics. Students planning graduate studies in any area of biology should also include organic chemistry. We encourage majors to seek opportunities for independent research with faculty members, through Research in Biology (BIOL 385) honors research and the Summer Science Scholars Program.

## Senior Capstone

The Senior Capstone for all biology majors consists of a detailed analysis of a research field, focusing on a critique of a particular research article. In addition, all majors must attend a specified number of guest lectures in the Biology Seminar Series and take a standardized assessment exam. Seniors must also enroll in BIOL 475 Senior Seminar in Biology.

## Advanced Courses

Many courses and labs are offered in alternating years, so care should be taken in planning the major to suit individual goals. The following list indicates which courses are normally taught on alternating-year schedules. Please note that the schedule can vary from these guidelines; students should consult the department chair or course instructor if particular courses are needed.

Courses that may be offered in alternating years (or less frequently) include: BIOL 211, 233, 234, 241, 245, 246, 251, 253, 255, 256, 266, 267, 311, 315, 321, 322, 323, 328, 333, 336, 346, 349, 352, 353, 358, 359, 362 and 375.

## Honors

The Honors Program in biology is an exciting opportunity for students to perform research in collaboration with a faculty member of the Department of Biology. Prior to enrollment in senior honors, students are expected to complete at least one semester of Research in Biology (BIOL 385), although two semesters are recommended, and participate in the Summer Science Scholars Program. Students must have an overall GPA of at least 3.33 and a GPA of 3.33 in biology.

## Requirements for the Minor

The biology minor requires a minimum of two and three quarter (2.75) units of credit earned in the major curriculum to include the following:

- BIOL 109Y–110Y
- BIOL 115 and 116
- Two upper-level lectures (1.0 units) and at least one upper-level lab (0.25 units). Two semesters of BIOL 385 would satisfy the upper-level laboratory requirement, and one year of Individual Study (BIOL 393, 394) would satisfy one upper-level lecture course requirement in the minor.

## Transfer Credit Policy

All transfer credit to be counted for the biology major must be approved in advance by the department chair.

## Cross Listed Courses

The following courses are cross-listed in the biology department to satisfy natural-sciences diversification:

ENVS 112 Introduction to Environmental Studies
MATH 258 Mathematical Biology
MATH 258 Mathematical Biology and CHEM 256 Biochemistry can serve as upper-division lecture courses in the biology major.

## Courses in Biology

### *BIOL 103 BIOLOGY IN SCIENCE FICTION*

Credit: 0.5

Science-fiction literature and film extend our awareness of the natural world in amazing ways, as seen in the film "Avatar." Yet real biology is often more amazing than science fiction. This course explores biology through science fiction, and through nonfiction biology more amazing than fiction. We meet human mutants in the "X-Men" and we meet real human mutants in the medical literature. We explore human evolution through Vonnegut's "Galapagos" and discover bizarre living creatures through Herbert's "Dune" and Crichton's "Jurassic Park." We model growth and explosion of populations in "Star Trek's" "The Trouble with Tribbles," and show how global climate change disrupts the marine ecosystem as in Slonczewski's "A Door into Ocean." Students learn to blog science, an important form of online nonfiction writing. Students may not take this course as pass/D/fail. No prerequisite. Generally offered every other year.

## *BIOL 105 BIOLOGY OF EXERCISE*
Credit: 0.5

This course examines the physiological response of the human body to exercise. Questions considered include: What limits human exercise performance? How does nutrition influence exercise? What are the mechanisms involved in increased performance during training? How does exercise influence health? Students directly evaluate the scientific basis of physiological knowledge through the analysis of experimental methods and data. Students write essays that explain recent scientific research to readers without technical training. Does not count toward the major or minor. No prerequisite. Generally offered every other year.

## *BIOL 106 CONSERVATION BIOLOGY*
Credit: 0.5

Conservation biology introduces students to subjects in biology that are central to questions about sustaining species and ecosystems. Students will use a series of case studies to learn the scientific methodology and fundamental principles that must be applied to issues of conserving biological diversity. Case studies will illustrate aquatic and terrestrial habitats; population and ecosystem levels of organization; and principles of evolution, population biology and ecosystem biology. BIOL 106 is appropriate for first-year students and can count toward the core course requirement for the Environmental Studies Concentration. No prerequisite. Offered every other year.

## *BIOL 107 SCALING IN BIOLOGY: WHY SIZE MATTERS*
Credit: 0.5 QR

While biologists seek general principles that explain the common characteristics of all organisms, we too often ignore that most obvious of traits: an organism's size. In this course, we will explore how size determines the form, function, pace and complexity of life. Our questions will span realms from the minuscule (how do bacteria swim?) to the gigantic (is Earth a super-organism?) to the fantastic (what would it cost to feed King Kong?). Living things span an amazing range of sizes, and by using size as a lens for studying life, we will develop a quantitative framework for comparing not just apples and oranges, but bacteria and blue whales. Surreal perspectives on biology such as Swift's "Gulliver's Travels" and films like "A Fantastic Voyage" will further highlight the truly amazing nature of biological reality. No prerequisite.

## *BIOL 109Y INTRODUCTION TO EXPERIMENTAL BIOLOGY*
Credit: 0.25 QR

This is the first laboratory course a student takes and is a prerequisite for all upper-division laboratory courses. Students are introduced to the processes of investigative biology and scientific writing. It is not designed to accompany any particular core lecture course. Laboratories cover topics presented in the core lecture courses, BIOL 115 and 116, and introduce a variety of techniques and topics, including field sampling, microscopy, PCR, gel electrophoresis, enzyme biochemistry, physiology, evolution and population biology. The course emphasizes the development of inquiry skills through active involvement in experimental design, data collection, statistical analysis, integration of results with information reported in the literature and writing in a format appropriate for publication. The year culminates in six-week student-designed investigations that reinforce the research skills developed during the year. Evaluation is based on short reports, quizzes, lab performance and scientific papers, as well as oral and written

presentations based on the independent project. Enrollment is limited to 16 students in each section. Students enrolled in this course will be automatically added to BIOL 110Y for the spring semester. Prerequisite: completion or concurrent enrollment in BIOL 115 or equivalent.

## *BIOL 110Y INTRODUCTION TO EXPERIMENTAL BIOLOGY*

Credit: 0.25 QR

This is the first laboratory course a student takes and is a prerequisite for all upper-division laboratory courses. Students are introduced to the processes of investigative biology and scientific writing. It is not designed to accompany any particular core lecture course. Laboratories cover topics presented in the core lecture courses, BIOL 115 and 116, and introduce a variety of techniques and topics, including field sampling, microscopy, PCR, gel electrophoresis, enzyme biochemistry, physiology, evolution and population biology. The course emphasizes the development of inquiry skills through active involvement in experimental design, data collection, statistical analysis, integration of results with information reported in the literature and writing in a format appropriate for publication. The year culminates in six-week student-designed investigations that reinforce the research skills developed during the year. Evaluation is based on short reports, quizzes, lab performance and scientific papers, as well as oral and written presentations based on the independent project. Enrollment is limited to 16 students in each section. Prerequisite: completion or concurrent enrollment in BIOL 115 or equivalent.

## *BIOL 115 ENERGY IN LIVING SYSTEMS*

Credit: 0.5

Energy flow is a unifying principle across a range of living systems, from cells to ecosystems. With energy flow as a major theme, this course covers macromolecules, cells, respiration and photosynthesis, physiology and homeostasis, population and community interactions, and ecosystems. Throughout the course, the diversity of life is explored. The course also introduces students to the process of scientific thinking through discussion of research methodology and approaches. This course is required for the major and as such, Biology majors should take this class prior to the junior year. No prerequisite. Offered every year.

## *BIOL 116 INFORMATION IN LIVING SYSTEMS*

Credit: 0.5

How is information generated, transmitted, stored and maintained in biological systems? The endeavor to understand the flow of biological information represents a fundamental undertaking of the life sciences. This course examines the mechanisms of heredity, the replication and expression of genetic information and the function of genes in the process of evolution, with an emphasis on the tools of genetics and molecular biology to address research questions in these areas. This course is required for the major and as such, Biology majors should take this class prior to the junior year. Prerequisite: BIOL 115, permission of instructor, or equivalent. Offered every year.

## *BIOL 211 HEALTH SERVICE AND BIOMEDICAL ANALYSIS*

Credit: 0.5

Students volunteer weekly at Knox Community Hospital, College Township Fire Department, or another designated health provider. We study health research topics including articles from biomedical journals. The academic portion of the class will meet as a three-hour seminar. Students read and critique articles on topics such as: diabetes in the community; pain-killers and drug

addiction; AIDS and STIs; influenza transmission; and socioeconomic status and health disparities. Outside of class, students will have four hours/week reading, and a minimum of four hours/week service. Student assignments will include keeping a journal on their service and class presentations related to the reading and their service. This counts toward the upper-level organismal biology/physiology requirement for the major. Prerequisite: one year of biology or chemistry and permission of instructor.

## *BIOL 228 ECOLOGY*

Credit: 0.5

Ecology is the study of the distribution and abundance of organisms and the structure and dynamics of the biosphere. Topics will include physiological ecology, population ecology, competition, predator-prey systems, mutualism, succession, energy and nutrient dynamics, and the ecology of communities, ecosystems and the biosphere. We also will explore the influence of humans on natural systems. Students will use theoretical models and primary literature to supplement the text, lectures and discussions. Co-enrollment in BIOL 229 is highly recommended. This counts toward the upper-level environmental biology requirement for the major. Prerequisite: BIOL 115 or equivalent or permission of instructor.

## *BIOL 229 ECOLOGY LABORATORY*

Credit: 0.25

This course examines techniques for studying ecological principles in the field and laboratory, with primary emphasis on terrestrial systems. Students will learn experimental design, sampling protocols and quantitative methods including spatial analysis with geographic information systems. Topics may include limits to distribution, interactions with the physical environment, population dynamics, species interactions, carbon sequestration and biodiversity. Studies will include physically demanding fieldwork in local habitats in varying weather conditions. Prerequisite: BIOL 109Y–110Y, BIOL 115, and completion or concurrent enrollment in BIOL 228 or permission of instructor.

## *BIOL 230 COMPUTATIONAL GENOMICS*

Credit: 0.5

This course will focus on the analysis of genomic and transcriptomic data obtained through next-generation sequencing technologies. Topics will include genome sequencing and assembly, polymorphism and variant analysis, population and evolutionary genomics, differential expression, co-expression networks and data visualization. Readings will largely be drawn from the primary literature, and will include a combination of methods articles and research articles that apply these methods to address biological questions. Students will carry out their own analyses by applying these methods to available datasets. Programming will mainly be done in R and unix; familiarity with R is expected. This counts as an upper-level in cellular/molecular biology and as an intermediate level course in Scientific Computing. Prerequisite: BIOL 116 and either BIOL109-110Y or STAT106, or permission of instructor. May be offered in alternating years.

## *BIOL 233 PLANT BIOLOGY*

Credit: 0.5

This course is an introduction to plant life strategies and plant evolutionary principles that have produced present day plant biodiversity. The focus is reproductive but also includes the chemical

foundation for survival interactions with other species. Student projects will examine the threats to plant biodiversity and the repercussions for humanity. Learning goals include understanding the underlying principles of plant evolution, plant reproduction and plant survival strategies. For every biological scientist, students will gain experience in alternative life strategies to those found in animals that will benefit them in developing out-of-the-box thinking and analysis of biological questions. This counts toward the upper-level organismal biology/physiology requirement for the major. Prerequisite: BIOL 109Y–110Y or permission of instructor.

## *BIOL 238 MICROBIOLOGY*

Credit: 0.5

Microbes inhabit the most extreme environments on earth, ranging from superheated sulfur vents on the ocean floor to alkaline soda lakes. In medicine, newly discovered bacteria and viruses cause a surprising range of diseases, including heart disease; they may even hold the key to human aging. Yet other species live symbiotically with us, keeping us healthy, and even regulate our brain. Still other microbes, such as nitrogen fixers, are essential to the entire biosphere. This course covers microbial cell structure and metabolism, genetics, nutrition and microbial communities in ecosystems, and the role of microbes in human health and disease. This can count towards the upper-level lecture in organismal biology/physiology or cellular/molecular requirements for the major. Prerequisite: BIOL 116.

## *BIOL 239 EXPERIMENTAL MICROBIOLOGY*

Credit: 0.25

In this course, students will learn the classic techniques of studying bacteria, protists and viruses in medical science and in ecology, and will practice microbial culture and examine life cycles, cell structure and metabolism and genetics. High-throughput methods of analysis are performed, such as use of the microplate UV-VIS spectrophotometer and whole-genome sequencing. For the final project, each student surveys the microbial community of a particular habitat, using DNA analysis and biochemical methods to identify microbial isolates. Prerequisite: BIOL 109Y–110Y or a chemistry lab course and completion or concurrent enrollment in BIOL 238.

## *BIOL 241 EVOLUTION*

Credit: 0.5

Evolution is the major unifying theory of biology; the unity of fundamental processes, species diversity and adaptive characteristics of organisms are consequences of evolution and can be fully understood only in this light. Evolutionary processes also have major impacts on humans. This course introduces the processes of evolution, most of which can be examined in contemporary time through experiment, theory and simulation, and by examining pattern in nature. The class format will combine lecture and discussion. Topics will include basic Darwinian arguments, modern population genetics, adaptation, speciation, reconstructing phylogenetic history, macroevolution and the consequences of evolution for conservation and human health. Examples will be drawn from all levels of biology, from molecular to ecological studies. Students will read and discuss original literature, utilize computer simulations and prepare a final paper and presentation.This counts toward the upper-level environmental biology requirement for the major. Prerequisite: BIOL 116 or permission of instructor.

## *BIOL 243 ANIMAL PHYSIOLOGY*
Credit: 0.5

Animal physiology examines the processes of animal cells, tissues and organ systems. In this class, we will seek to understand how physiological processes relate to the survival of an animal in its environment. We will use three primary approaches: (1) comparative, contrasting animals that live in different environments; (2) environmental, exploring how animals survive in challenging environments; and (3) structure-function, examining how the anatomy of a system relates to its function. Each of the primary animal organ systems (nerve, muscle, cardiovascular, respiratory, gastrointestinal, renal and excretory) will be covered in detail. Readings from the primary research literature will be assigned. This counts toward the upper-level organismal biology/physiology requirement for the major. Prerequisite: BIOL 115, equivalent or permission of instructor.

## *BIOL 244 EXPERIMENTAL ANIMAL PHYSIOLOGY*
Credit: 0.25

This laboratory class explores the techniques, equipment and experimental designs common to animal physiology. Topics may include muscle physiology, cardiac physiology, salt and water balance, metabolism, and exercise physiology. A variety of experimental techniques will be used. Students will participate in experimental design, perform experiments and present results in oral and written form. Students also will read and analyze relevant papers from the primary literature. Prerequisite: BIOL 109Y-110Y and completion of or concurrent enrollment in BIOL 243.

## *BIOL 245 ENVIRONMENTAL PLANT PHYSIOLOGY*
Credit: 0.5

Plants, like all life forms, survive in communities with a diversity of organisms and in a changing and demanding environment. Plant life benefits from and is challenged by relationships with other species and by the environment. Plants have evolved a fundamentally different pattern of living from organisms of other kingdoms; the physiological strategies that have evolved to meet the challenges of a predominantly stationary life that relies on resources of the immediate environment are marvelous, intriguing and enlightening. Our focus is on the structural and physiological processes that manage the intersections with the environment and with other organisms. The subject is presented through examination of fundamental concepts in plant physiology and current literature. This counts toward the upper-level lecture in organismal biology/physiology requirement for the major. Prerequisite: BIOL 115 or equivalent. Generally offered every other year.

## *BIOL 246 ENVIRONMENTAL PLANT PHYSIOLOGY LAB*
Credit: 0.25

This course will examine techniques for investigating plant physiological responses to environmental stimuli in both laboratory and field settings. Students will learn to use instrumentation to measure processes related to CO2 acquisition and loss (photosynthetic CO2 assimilation, electron transport and respiration) and plant water status (water potential). Using these methods and an experimental approach, we will explore topics such as plant resource-use physiology, environmental impacts on leaf physiology and resource impacts on growth and allocation. These topics and processes will be examined in the context of natural and agroecosystem responses to climate change. During the semester, students will become familiar

with the primary literature in the field, design and conduct experiments and communicate their results in written and oral form. Prerequisite: BIOL 109Y–110Y or permission of instructor. Prerequisite or corequisite: BIOL 245.

## *BIOL 247 COMPARATIVE VERTEBRATE ANATOMY*

Credit: 0.5

This course will explore questions of how and why vertebrates came to be structured the way they are. We will use both comparative and functional approaches to study how the anatomy of vertebrates has evolved and diversified over hundreds of millions of years. We will examine how anatomy relates to function; for example, how do different musculoskeletal arrangements allow for different types of movement? We will investigate anatomical adaptations to a variety of environments to understand how different vertebrates have solved anatomical and biomechanical problems. Each of the primary vertebrate organ systems (integument, skeleton, muscle, cardiovascular, respiratory, gastrointestinal, urogenital, nervous) will be covered in detail. Students will read and analyze papers from the primary literature. This counts toward the upper-level organismal biology/physiology requirement for the major. Prerequsite: BIOL 116 and concurrent enrollment in BIOL 248, Vertebrate Anatomy Laboratory. Generally offered every year.

## *BIOL 248 COMPARATIVE VERTEBRATE ANATOMY LAB*

Credit: 0.25

This course is a hands-on exploration of the anatomy of vertebrates. Students will learn to identify major components of all of the primary vertebrate organ systems (integument, skeleton, muscle, cardiovascular, respiratory, gastrointestinal, urogenital and nervous). To understand patterns of vertebrate evolution, we will examine and compare specimens from all major vertebrate groups, including mammals, birds, cartilaginous fishes, ray-finned fishes, amphibians and non-avian reptiles, including extinct organisms. We will also perform experiments in biomechanics to understand how vertebrate form shapes function and movement. Dissections are required. Students will be tested via practical quizzes and exams. Prerequisite: BIOL 116 and concurrent enrollment in BIOL 247. Generally offered every year.

## *BIOL 253 PALEOBIOLOGY*

Credit: 0.5

This course examines the use of fossils as tools for interpreting Earth's ancient oceans and the life they once supported. Methods for inferring physical and chemical aspects of marine settings (e.g., oxygen levels, salinity variation) and the use of major marine fossil taxa as past analogues of modern organisms, will allow for the reconstruction of paleoenvironments. We will explore techniques used to infer how organisms functioned within their life environments and how they interacted with other life forms, and we will survey major events in the history of Earth's oceans and marine biota, including some significant fossil locations (i.e., Lagerstätten), as a means of introducing major ecological principles. Laboratories and exercises involving fossil specimens will constitute a significant portion of the final grade, and at least one field trip will be required. This counts toward the upper-level environmental biology requirement for the major. Prerequisite: BIOL 116 or permission of instructor.

## *BIOL 255 GENETIC ANALYSIS*
Credit: 0.5

This course introduces both principles and experimental approaches related to heredity in a wide variety of organisms from bacteria to humans. Topics will include classical transmission genetics, chromosomal structure, extranuclear heredity, epigenetics, population and evolutionary genetics and molecular analysis of genes and chromosomes. As genetic analysis can be used to dissect many biological processes, we also will address how geneticists approach problems and advance scientific understanding, focusing our discussions around primary literature. This counts as an upper-level in cellular/molecular biology. Prerequisite: BIOL 116. May be offered in alternating years.

## *BIOL 256 EXPERIMENTAL GENETIC ANALYSIS*
Credit: 0.25

This laboratory course introduces both genetic concepts and genetic approaches commonly used to understand biological processes, including both forward and reverse genetic approaches. We will primarily use the model plant Physcomitrella patens as our experimental organism, although the techniques used in this course can be applied to any organism amenable to genetic analysis. Prerequisite: BIOL 109Y–10Y and 116. Prerequisite or corequisite: BIOL 255.

## *BIOL 261 ANIMAL BEHAVIOR*
Credit: 0.5

The evolution and ecology of animal behavior is explored in detail. The diversity of behavior and the ecological consequences of behavior will be studied, with emphasis on how research programs are designed to answer questions. We investigate animal behavior from both proximate and ultimate perspectives across a broad range of behavioral phenomena. Outside of class, each student chooses an animal around which to build a semester-long investigation of animal behavior that emphasizes original observation and data collection. This counts toward the upper-level environmental biology requirement for the major. Prerequisite: BIOL 115 or 116 or permission of instructor.

## *BIOL 262 EXPERIMENTAL ANIMAL BEHAVIOR*
Credit: 0.25

This laboratory applies the principles of experimental design and inference to the study of animal behavior. There will be both laboratory and field components. Students should be aware that animals do not always "behave" in discrete, three-hour time periods, and that some work may have to be arranged outside of the regularly assigned class period. Prerequisite: BIOL 109Y–110Y. Prerequisite or corequisite: BIOL 261.

## *BIOL 263 MOLECULAR BIOLOGY*
Credit: 0.5

The molecular and genomic basis of life is at the heart of modern biology. In this course, we will learn techniques and explore research questions at the forefront of molecular research, focusing on the mechanisms by which the information of the genome is expressed to form the functional molecules of living cells and organisms. The processes of DNA replication, recombination and repair, transcription, and translation are discussed in the context of current research, frequently

using primary literature. The function of genes and the regulation and measurement of gene expression are treated in depth. Students analyze and publish interactive tutorials on the structure and function of macromolecules. This course presumes a strong background in the basics of protein structure/function, central dogma processes, fundamental molecular techniques for manipulating nucleic acids and proteins and general chemistry. Note: For further study of the function of proteins, membranes and cellular processes, the complementary course BIOL 266 is recommended. This counts toward the upper-level cellular/molecular biology requirement for the major. Prerequisite: BIOL 116 and CHEM 122 and 123 or CHEM 124 and 126. Recommended prerequisite or corequisite: CHEM 231 and 232.

## *BIOL 264 GENE MANIPULATION*

Credit: 0.25

This course teaches advanced methods of gene isolation, manipulation and characterization. An assortment of the following techniques will be covered: the isolation of DNA and RNA from tissues and cells; recombinant DNA technique; expression of genes in heterologous systems; the polymerase chain reaction (PCR); measurement of gene expression, and bioinformatics and sequence analysis. Prerequisite: BIOL 109Y–110Y and either CHEM 122 and 123 or CHEM 124 and 126. Corequisite: BIOL 263 or permission of instructor.

## *BIOL 266 CELL BIOLOGY*

Credit: 0.5

This course is designed to introduce studenst to the wide variety of questions being asked by researchers in this exciting field and the approaches they are taking to answer these questions. This course complements BIOL 263 in content, concentrating on the nongenomic aspects of the cell. We will cover topics such as biological membranes and ion channels, cell organelles and their function, cell regulation, and intercellular and intracellular communication. This counts toward the upper-level cellular/molecular biology requirement for the major. Prerequisite: BIOL 116. Prerequisite or corequisite: CHEM 121 or 122. Generally offered every other year..

## *BIOL 267 EXPERIMENTAL CELL BIOLOGY*

Credit: 0.25

This laboratory course is designed to complement BIOL 266. The topics covered in the laboratory will expose the student to some of the standard techniques used in modern cell biology. The laboratories also will illustrate some of the fundamental ideas of the field. Instead of covering a wide variety of techniques and preparations superficially, we will concentrate on a select few, covering them in greater depth. Some topics that will be covered are protein separation, cell permeability and cell motility. Prerequisite: BIOL 109Y–10Y. Prerequisite or corequisite: BIOL 266. Generally offered every other year.

## *BIOL 311 SEMINAR IN RESTORATION ECOLOGY*

Credit: 0.5

This course will examine the ecological theory and practice of restoration ecology through lectures, class discussion, field trips and a class project on restoration design. The science of ecosystem restoration has grown dramatically over the past decades, emerging as an active subdiscipline of biology. The challenges of restoration are many and include our incomplete understanding of the complexity of ecosystems and the limits this places on our ability to predict ecosystem response to restoration efforts. Restoration ecology spans a range of activities and scales, ranging from the systematic, long-term restoration of major ecosystems such as the Everglades or the Colorado River watershed, to small-scale restoration projects such as the prairie and wetland restoration projects at Kenyon's Brown Family Environmental Center. This course we will focus on the causes of ecosystem degradation, methods to quantify ecosystem response, the application of concepts such as ecological integrity, ecosystem resilience and alternative stable states. This counts toward the upper-level environmental biology requirement for the major. Prerequisite: BIOL 115 and a 200-level Biology course or permission of instructor.

## *BIOL 315 CELL SIGNALING*

Credit: 0.5

Cell signaling, a molecular choreography, allows cells to respond to changes in their internal and external environment. This vast and exciting field of study underpins one of the pillars of life, the ability of organisms to sense and respond to changing conditions. This course introduces students to the major players in signal transduction and how they coordinate to mount an effective cellular response, with a focus on techniques used to study pathways. Examples of particular pathways examined may include chemotaxis in bacteria, mating response in yeast, energy homeostasis in animals and phototropism in plants. Students are expected to actively participate in class discussions of assigned readings and critically evaluate primary literature. As a final project, students teach their peers about a pathway of interest. BIOL 263 is recommended but not required. This counts toward the upper-level cellular/molecular biology requirement for the major. Prerequisite: CHEM 121 or equivalent, BIOL 116, any 200-level biology course and junior or senior standing.

## *BIOL 321 EVOLUTIONARY DEVELOPMENTAL BIOLOGY*

Credit: 0.5

This course addresses the mechanisms responsible for building multicellular eukaryotic organisms, framed in the context of the evolution of developmental processes and patterns. We will explore the similarities in molecular and cellular mechanisms governing development across broad groups of organisms, as well as the changes in these processes that have resulted in novel forms. Class discussions will be based on primary literature as well as other texts, with particular attention devoted to the experimental basis for current scientific understanding. This counts toward the upper-level cellular/molecular biology requirement for the major. Prerequisite: BIOL 116 and any 200-level BIOL course. Generally offered every other year.

## *BIOL 323 PHOTOSYNTHESIS*

Credit: 0.5

This course will examine current biochemical, evolutionary and ecological topics in photosynthesis. Our understanding of photosynthetic processes is increasingly rapidly, and in this class we will read primary literature and book chapters to examine selected topics in depth. Topics will include evolution of oxygenic photosynthesis, light acquisition, Rubisco carboxylation and oxygenation, and the impact of environmental drivers such as temperature and CO2 on carbon gain in agricultural

and unmanaged ecosystems. While the focus will be on plant photosynthesis, we will also explore cyanobacterial and algal systems to illustrate the photosynthetic diversity found in nature. This counts toward the upper-level organismal biology/physiology or cellular/molecular biology requirement for the major. Prerequisite: BIOL 115 and at least one 200-level biology lecture class.

## *BIOL 328 GLOBAL ECOLOGY AND BIOGEOGRAPHY*

Credit: 0.5

This is a comprehensive course in the large-scale history and dynamics of the biosphere. The course will focus on ecoinformatics and macroecology, using computational approaches to describe and explain general patterns in the distribution, abundance and functioning of organisms. Special attention will be given to geographical patterns of biodiversity and their basis in both ecological (dispersal, competition) and evolutionary (speciation, extinction) processes. The course will also examine the large-scale interactions between Homo sapiens and the rest of the biosphere. The course will be conducted seminar style, with most of the reading will be drawn from recent primary literature. The development of research methods using published data, computational tools and model output to address new ecological questions at continental to global scales will be an integral part of this course. This counts toward the upper-level environmental biology requirement for the major. Prerequisite: BIOL 228, 241, 251, 253 or 261 or permission of instructor. Generally offered every other year.

## *BIOL 333 ENVIRONMENTAL TOXICOLOGY*

Credit: 0.5

This course examines the mechanisms by which chemical contaminants impact molecular, organismal and ecological systems. Topics include sources and movement of contaminants in the environment, basics of toxicity testing, molecular mechanisms of contaminant effects and ecological risk assessment. The course uses readings from standard texts, the popular press and primary literature, placing particular emphasis on current experimental approaches and problem-solving methods. Rather than surveying a wide variety of topics superficially, the course will concentrate on selected issues and stories that illustrate important contemporary issues in environmental toxicology. This course emphasizes molecular biology techniques and counts toward the upper-level cellular/molecular biology requirement for the major. Prerequisite: BIOL 116 and at least one 200-level biology lecture course. Generally offered every other year.

## *BIOL 336 INTEGRATIVE BIOLOGY OF ANIMALS*

Credit: 0.5

This course will explore general principles in animal biology through a topics-based approach. We will develop integrative understandings of animals, studying them from genetic, molecular, biochemical, physiological, organismal, evolutionary and environmental frameworks. Although both invertebrate and vertebrate animals will be studied, invertebrates will be the primary focus because of the large number and spectacular diversity of invertebrate species. Emphasis will be placed upon understanding the experimental evidence that has led to the current understanding of animal biology and controversial topics in animal biology will be explored. This counts toward the upper-level organismal biology/physiology requirement for the major. Prerequisite: at least one 200- or 300-level biology lecture course.

## *BIOL 352 AQUATIC SYSTEMS BIOLOGY*

Credit: 0.5

This course is designed to introduce students to the study of freshwater ecosystems, including lakes, streams and wetlands. Human activities have had profound impacts on freshwater life and an understanding of the dynamics of freshwater systems is instrumental in determining how to protect and restore these habitats. We will examine the physical, chemical and biological factors influencing biological diversity and productivity and will emphasize the application of ecological principles to study these systems. Possible topics include the effects of agricultural run-off and eutrophication; erosion resulting from human development; the introduction of non-native species; toxic contaminants; and restoration techniques. Standard texts as well as primary literature will be used. This counts toward the upper-level environmental biology requirement for the major. Prerequisite: BIOL 115 or equivalent and at least one 200- or 300-level biology lecture course. Generally offered every other year.

## *BIOL 353 AQUATIC SYSTEMS LAB*

Credit: 0.25

In this laboratory course, students will employ methods used in the study of freshwater ecosystems. It is designed to complement either BIOL 251 or BIOL 352. Students will learn to identify freshwater organisms, quantify biological, chemical and physical parameters that affect these organisms, and design ecological experiments. Throughout the course, laboratories will emphasize hypothesis testing, quantitative methods and experimental design. Field trips will be taken to local natural habitats and many lab periods will be spent doing fieldwork. Prerequisite: BIOL 109Y-110Y. Prerequisite or corequisite: BIOL 251 or 352 or permission of instructor. Generally offered every other year.

## *BIOL 358 NEUROBIOLOGY*

Credit: 0.5

The study of the nervous system is a field that has experienced explosive growth in the past few decades. This course is designed to introduce the student to modern neurobiology by covering the basic foundations as well as the latest results from current research. Subject matter will range from the biophysics of membranes and ion channels, through sensory integration and simple behaviors, to the development of the nervous system. Rather than cover a wide variety of topics superficially, we will concentrate more time on selected topics that illustrate the current thinking of neurobiologists. Experience in math and/or physics is strongly recommended. This counts toward the upper-level organismal biology/physiology requirement for the major. Prerequisite: BIOL 116 and at least one biology lecture course at the 200-level or one 300-level NEUR lecture course. Generally offered every other year.

## *BIOL 359 EXPERIMENTAL NEUROBIOLOGY*

Credit: 0.25

This is a laboratory designed to complement the lecture course. We will concentrate either on the different intracellular and extracellular electrophysiological recording techniques commonly used in the field to illustrate both motor and sensory aspects of nervous-system function or on the molecular aspects of nervous system function molecular. We will conclude with a series of independent projects that will bring together the ideas covered earlier in the course. Prerequisite: BIOL 109Y-110Y. Prerequisite or corequisite: BIOL 358. Generally offered every other year.

## *BIOL 375 VIROLOGY*

Credit: 0.5

In this course, students examine the form and function of viruses through current research papers and through documentaries on viral disease. Specific viruses are examined in depth, exemplifying their roles in human and animal health, biotechnology and global ecology. Topics may include human papillomavirus, a DNA virus causing cancer; hepatitis C virus, a growing cause of liver failure; Ebola virus, an RNA virus with extraordinary virulence; influenza virus, an RNA virus of humans and animals with pandemic potential; and human immunodeficiency virus (HIV), the cause of AIDS. We investigate the use of HIV-derived viral vectors for gene therapy.This counts toward the upper-level cellular/molecular biology requirement for the major. Prerequisite: BIOL 238, 243, 263, 266 or 358. Prerequisite or corequisite: CHEM 231. Generally offered every other year.

## *BIOL 385 RESEARCH IN BIOLOGY*

Credit: 0.25

This combined discussion and laboratory course aims to develop abilities for asking sound research questions, designing reasonable scientific approaches to answer such questions, and performing experiments to test both the design and the question. We consider how to assess difficulties and limitations in experimental strategies due to design, equipment, organism selected and so on. The course provides a detailed understanding of selected modern research equipment. Students select their own research problems in consultation with one or more biology faculty members. This course is designed both for those who plan to undertake honors research in their senior year and for those who are not doing honors but want practical research experience. A student can begin the course in either semester. If a year of credit is earned, it may be applied toward one laboratory requirement for the major in biology. This course is repeatable for credit. Prerequisite: BIOL 109Y–110Y and 116 and permission of instructor.

## *BIOL 393 INDIVIDUAL STUDY IN BIOLOGY*

Credit: 0.25-0.5

This course provides the student with the opportunity to pursue an independent investigation of a topic of special interest not covered, or not covered in depth, in the current curriculum. The investigation, designed in consultation with the chosen faculty mentor, may be designed to earn .25 or .5 unit of credit in a semester. BIOL 393 is ordinarily is a library-oriented investigation. (For laboratory-oriented independent research, see BIOL 385 and 386.) Normally, students receive credit for no more than two semesters of individual study. Individual study does not fulfill the natural science diversification requirement, nor does it count toward the requirements for the major. Because students must enroll for individual studies by the end of the seventh day of classes, they should begin discussion of the proposed individual study well in advance, preferably the semester before, so that there is time to devise a syllabus and seek departmental approval before the established deadline.

## *BIOL 475 SENIOR SEMINAR*

Credit: 0.5

In this capstone seminar, students explore current research topics in biology. Each section will explore a different fundamental concept in biology that spans the range of biology from ecosystems to molecules. Students analyze, critique, and integrate information from research articles they connect specific studies to broader biological questions and they propose future work that refines and extends prior studies. Student communicate their insights and analyses in both oral and written formats. Assignments include short essays, student presentations, student-led classes, peer review, and writing workshops. This course counts toward the upper-level lecture course

requirement for the biology major. Prerequisite: senior standing and biology or molecular biology major.

## *BIOL 497 SENIOR HONORS*

Credit: 0.5

This course offers an in-depth research experience. Prior to enrollment in this course, students are expected to complete at least one semester of BIOL 385-386 and participate in the Summer Science Scholars program. Two semesters of BIOL 385–386 are recommended. Emphasis is on completion of the research project. Students also are instructed in poster production and produce one or more posters of their honors work for presentation at Kenyon and possibly at outside meetings. There will be oral progress reports, and students draft the Introduction and Methods section of the honors thesis. The letter grade is determined by the instructor and project advisor in consultation with the department. Students must have an overall GPA of at least 3.33 and a GPA of 3.33 in biology. Permission of instructor and department chair required. Prerequisite: BIOL 385 or 386 and permission of project advisor and department chair.

## *BIOL 498 SENIOR HONORS*

Credit: 0.5

This course continues the honors research project and gives attention to scientific writing and the mechanics of producing a thesis. A thesis is required and is defended orally to an outside examiner. The letter grade is determined by the instructor and project advisor in consultation with the department. Permission of instructor and department chair required. Prerequisite: BIOL 385 or 386 and 497.