Requirements: Biology

Natural Sciences Division

The Kenyon College faculty voted to change from Kenyon units to semester hours. This change will go into effect for all students who start at the College in the fall of 2024. Both systems will be used throughout the course catalog with the Kenyon units being listed first.

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 (Introduction to Experimental Biology), the year-long introductory lab sequence and BIOL 115 (Energy in Living Systems) and BIOL 116 (Information in Living Systems), Energy and Information in Living Systems.

Upper-level courses are offered at the 200- and 300-level. 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 105, 106 and 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 satisfies the requirement.

Students can involve themselves in the department through the Biology Student Advisory Group, which meets with the chair and faculty members, or as an employee; 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 (Introduction to Experimental Biology), to be completed by end of sophomore year.
- BIOL 115 (Energy in Living Systems) and BIOL 116 (Information in Living Systems) (or equivalent with AP or IB credit), 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 (Mathematical Biology), CHEM 256 (Biochemistry) and ENVS 342 (Disease Ecology) can each count as one of the six required upper-division courses.
- Four upper-division laboratory courses (0.5 unit/4 semester hours of credit in [BIOL 385: Research in Biology] or [BIOL 497: Senior Honors, BIOL 498: Senior Honors] can serve as one 0.25-unit/2 semester hours laboratory course requirement).
- One year of introductory chemistry lecture work (or equivalent).

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

- Environmental biology
    - BIOL 228: Ecology
    - BIOL 241: Evolution
    - BIOL 253: Paleobiology
    - BIOL 261: Animal Behavior
    - BIOL 311: Seminar in Restoration Ecology
    - BIOL 328: Global Ecology and Biogeography

    - BIOL 352: Aquatic Systems Biology
    - ENVS 342: Disease Ecology

- Organismal biology/physiology
    - BIOL 211: Health Service and Biomedical Analysis
    - BIOL 238: Microbiology
    - BIOL 243: Animal Physiology
    - BIOL 245: Plant Physiology
    - BIOL 271: Human Physiology
    - BIOL 323: Photosynthesis
    - BIOL 358D: Neurobiology

- Cellular and molecular biology
    - BIOL 230: Computational Genomics
    - BIOL 238: Microbiology
    - BIOL 255: Genetic Analysis
    - BIOL 263: Molecular Biology
    - BIOL 266: Cell Biology
    - BIOL 315: Cell Signaling
    - BIOL 317: Cancer Biology
    - BIOL 321: Evolutionary Development Biology
    - BIOL 323: Photosynthesis
    - BIOL 345: Immunology
    - BIOL 375: Virology
    - CHEM 256: Biochemistry

Majors are strongly encouraged to take at least one year of mathematics and physics. Students planning graduate studies in any area of biology should also include organic chemistry. Majors are also encouraged to seek opportunities for independent research with faculty members, through BIOL 385 (Research in Biology), 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). Guidelines for the current academic year are available on the department website.

Advanced Courses

Many courses and labs are offered in alternating years; majors should plan carefully 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 241: Evolution
- BIOL 245: Plant Physiology
- BIOL 246: Plant Physiology Lab
- BIOL 253: Paleobiology
- BIOL 255: Genetic Analysis
- BIOL 256: Experimental Genetic Analysis
- BIOL 271: Human Physiology
- BIOL 311: Seminar in Restoration Ecology
- BIOL 315: Cell Signaling
- BIOL 317: Cancer Biology
- BIOL 321: Evolutionary Developmental Biology
- BIOL 323: Photosynthesis
- BIOL 328: Global Ecology and Biogeography
- BIOL 345: Immunology
- BIOL 352: Aquatic Systems Biology
- BIOL 353: Aquatic Systems Lab
- BIOL 358D: Neurobiology
- BIOL 359D: Experimental Neurobiology
- BIOL 375: Virology

Honors

The Honors Program in biology is an exciting opportunity for students to perform long-term research in collaboration with a faculty member of the Department of Biology. Please look at the course descriptions for BIOL 497 and BIOL 498 (Senior Honors).

Requirements for the Minor

The biology minor requires a minimum of 2.75 units/22 semester hours of credit earned in the major curriculum to include the following:

- BIOL 109Y and 110Y (Introduction to Experimental Biology)
- BIOL 115 (Energy in Living Systems) and 116 (Information in Living Systems)
- Two upper-level lectures (1.0 units/8 semester hours) and at least one upper-level lab (0.25 units/2 semester hours). Two semesters of BIOL 385 (Research in Biology) satisfies the upper-level laboratory requirement. MATH 258 (Mathematical Biology) and CHEM 256 (Biochemistry) count as an upper level lecture course.

Transfer Credit Policy

Students studying off campus may count one upper-level lecture/discussion course and one upper-level lab course toward the major; the specific courses must be approved by the department chair. Transfer students must consult with the registrar and a program co-director to assess appropriate course equivalency credit.

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), CHEM 256 (Biochemistry) and ENVS 342 (Disease Ecology) can serve as upper-division lecture courses for the biology major.

Courses in Biology

AP/IB Biology

BIOL 0 **Credits: 0.5/4**

Conservation Biology

BIOL 106 **Credits: 0.5/4**

Conservation biology is an integrative discipline that encompasses aspects of evolution, ecology and population biology to understand conservation-related issues in a changing world. Students learn how genetic, physiological, behavioral, ecological and anthropogenic factors influence population dynamics, and how management practices can ameliorate impacts on biodiversity. This does not count toward the major or minor. No prerequisite.

Life of the Past

BIOL 108 **Credits: 0.5/4**

Fossils fascinate and educate. This course explores the history of paleobiology from when fossils were first recognized as evidence of ancient life forms to the present day, when modern techniques allow us to determine details such as the color, sex and running speed of an animal that died tens of millions of years ago. Our investigation includes the clues fossils might hold to how the former organisms they represent lived and died – a sort of “Jurassic CSI.” We explore

the use of fossils as tools for interpreting the environments in which ancient organisms lived, and survey certain exceptional fossil finds that reveal evidence of interactions between individuals (e.g., predation, escapes from predation and parasitism). As new fossil finds regularly generate headlines across the globe, time is set aside for evaluation of recent discoveries in light of the concepts learned in the course. If your news feed commonly includes stories about bone beds, mass extinctions, dinosaurs and whales with legs, then this course will be of interest to you. No prerequisite.

Introduction to Experimental Biology

BIOL 109Y Credits: 0.25/2 QR

This is the first laboratory course a student takes and is a prerequisite for all upper-division laboratory courses- required for the major. Students are introduced to the processes of investigative biology and scientific writing. 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 and management, 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 laboratory notebooks, lab performance and scientific papers, as well as oral and written presentations summarizing the independent project. Prerequisite: completion or concurrent enrollment in BIOL 115 or equivalent.

Introduction to Experimental Biology

BIOL 110Y Credits: 0.25/2 QR

This is the first laboratory course a student takes and is a prerequisite for all upper-division laboratory courses- required for the major. Students are introduced to the processes of investigative biology and scientific writing. 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. Prerequisite: BIOL 109Y and 115 or equivalent.

Energy in Living Systems

BIOL 115 Credits: 0.5/4

This course is required for the major (AP or IB credit can be applied), therefore, biology majors should take this class prior to the junior year. 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. No prerequisite. Offered every year.

Information in Living Systems

BIOL 116 Credits: 0.5/4

This course is required for the major, therefore, biology majors should take this class prior to the junior year. 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. Prerequisite: BIOL 115 or equivalent. Offered every year.

Health Service and Biomedical Analysis

BIOL 211 Credits: 0.5/4

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 meets 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 have four hours a week of reading, and a minimum of four hours a week of service. Students' assignments 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.

Ecology

BIOL 228 Credits: 0.5/4

Ecology is the study of the distribution and abundance of organisms and the structure and dynamics of the biosphere. Topics 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 explore the influence of humans on natural systems. Students use theoretical models and primary literature to supplement the text, lectures and discussions. This counts toward the upper-level environmental biology requirement for the biology major and as an elective for the environmental studies major. Co-enrollment in BIOL 229 is highly recommended. Prerequisite: BIOL 115 or equivalent.

Ecology Laboratory

BIOL 229 Credits: 0.25/2

This course examines techniques for studying ecological principles in the field and laboratory, with primary emphasis on terrestrial systems. Students 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 include physically demanding fieldwork in local habitats in varying weather conditions. This counts toward the upper-level laboratory requirement for the biology major and as an elective for the environmental studies major. Co-enrollment in BIOL 228 is highly recommended. Prerequisite: BIOL 109Y-110Y, BIOL 115. Prerequisite or corequisite: BIOL 228.

Computational Genomics

BIOL 230 Credits: 0.5/4

This course focuses on the analysis of genomic and transcriptomic data obtained through next-generation sequencing technologies. Topics include genome sequencing and assembly, polymorphism and variant analysis, population and evolutionary genomics, differential expression, co-expression networks and data visualization. Readings are largely drawn from the primary literature and include a combination of methods articles and research articles that apply these methods to address biological questions. Students carry out their own analyses by applying these methods to available datasets. Programming is mainly done in R and unix; familiarity with R is expected. This counts toward an upper-level course in cellular/molecular biology or an upper-level laboratory, and also serves as an intermediate-level course in program in computing. Prerequisite: BIOL 116 and either BIOL 109-110Y or STAT 106. Offered in alternating years.

Microbiology

BIOL 238 Credits: 0.5/4

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 counts toward the upper-level lecture in organismal biology/physiology or cellular/molecular requirements for the major. Prerequisite: BIOL 116.

Experimental Microbiology

BIOL 239 Credits: 0.25/2

In this course, students learn the classic techniques of studying bacteria, protists and viruses in medical science and ecology, and 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. This counts toward the upper-level laboratory requirement. Prerequisite: BIOL 109Y-110Y or a chemistry lab course. Prerequisite or corequisite: BIOL 238.

Evolution

BIOL 241 Credits: 0.5/4

Evolution is the major unifying theory of biology. This course introduces the processes of evolution, most of which can be examined in contemporary time through experiment, theory, simulation and examination of patterns in nature. The class format combines lecture, activities and discussions. Topics include Darwinian natural selection, population genetics, adaptation, speciation, reconstructing phylogenetic history, macroevolution, sexual selection, and the consequences of evolution for conservation and human health. Examples are drawn from all levels of biology, from molecular to ecological. Students read, analyze and discuss primary literature in the evolutionary biology. This counts toward the upper-level environmental biology requirement for the major. Prerequisite: BIOL 116.

Animal Physiology

BIOL 243 Credits: 0.5/4

Animal physiology examines the processes of animal cells, tissues and organ systems. In this course, we seek to understand how physiological processes relate to the survival of an animal in its environment. We 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 organ system (nerve, muscle, cardiovascular, respiratory, gastrointestinal, renal and excretory) is covered in detail. Readings from the primary research literature are assigned. Students complete a project in which they write a physiology research paper for both scientific and general audiences. This counts toward the upper-level organismal biology/physiology requirement for the major. Prerequisite: BIOL 115 or equivalent.

Experimental Animal Physiology

BIOL 244 Credits: 0.25/2

This laboratory course 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 are used. Students participate in experimental design, perform experiments and present results in oral and written form. They also read and analyze relevant papers from the primary literature. This counts toward the upper-level laboratory requirement. Prerequisite: BIOL 109Y-110Y. Prerequisite or corequisite: BIOL 243.

Plant Physiology

BIOL 245 Credits: 0.5/4

This course examines the physiological, anatomical and ecological adaptations that allow plants to survive in terrestrial environments. We explore how plants function, focusing on the diverse strategies that have evolved to fix atmospheric carbon into carbohydrate, anatomical structures that facilitate water and sugar movement across vast distances within the plant body, plant nutrition and relationships that allow plants to obtain resources when constrained by a sessile lifestyle. Simultaneously, we explore how plants respond to key environmental drivers such as carbon dioxide, water, vapor pressure and temperature, and how these responses contribute to plant biogeography. Primary literature readings are assigned throughout the semester to examine current topics in depth. This counts toward the upper-level lecture in organismal biology/physiology requirement for the major. Prerequisite: BIOL 115 or equivalent. Generally offered every year.

Experimental Plant Physiology

BIOL 246 Credits: 0.25/2

This course examines techniques for investigating plant physiological responses to environmental stimuli in both laboratory and greenhouse settings. Students learn to ask pertinent questions, formulate appropriate hypotheses, and practice and hone laboratory skills to measure photosynthetic physiology using both instantaneous (gas exchange) and integrated

approaches (stable isotope analysis). We also examine methods for assessing plant water status (water potential). Using these methods and an experimental approach, we explore the drivers affect plant carbon-water relations. While the focus of the course is on vascular plant physiology, we also examine the diversity of photosynthetic organisms through comparative studies with bryophytes, lichens and cyanobacteria. This counts toward the upper-level laboratory requirement. Prerequisite or corequisite: BIOL 109Y-110Y and 245 or 323.

Comparative Vertebrate Anatomy

BIOL 247 Credits: 0.5/4

This course explores questions of how and why vertebrates came to be structured the way they are. We use both comparative and functional approaches to study how the anatomy of vertebrates has evolved and diversified over hundreds of millions of years. We examine how anatomy relates to function; for example, how do different musculoskeletal arrangements allow for different types of movement? We 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 and nervous) is covered in detail. Students read and analyze papers from the primary literature. This counts toward the upper-level organismal biology/physiology requirement for the major. Prerequisite: BIOL 116 and concurrent enrollment in BIOL 248. Generally offered every year.

Comparative Vertebrate Anatomy Lab

BIOL 248 Credits: 0.25/2

This course is a hands-on exploration of the anatomy of vertebrates. Students 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 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 also perform experiments in biomechanics to understand how vertebrate form shapes function and movement. Dissections are required. Students are tested via practical quizzes and exams. This counts toward the upper-level laboratory requirement. Prerequisite: BIOL 116 and concurrent enrollment in BIOL 247. Generally offered every year.

Paleobiology

BIOL 253 Credits: 0.5/4

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, allow for the reconstruction of paleoenvironments. We explore techniques used to infer how organisms functioned within their life environments and how they interacted with other life forms. The course also surveys 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 constitute a significant portion of the final grade, and at least one field trip is required. This counts toward the upper-level environmental biology requirement for the major. Prerequisite: BIOL 116.

Genetic Analysis

BIOL 255 Credits: 0.5/4

This course introduces both principles and experimental approaches related to heredity in a wide variety of organisms. Topics include classical transmission genetics, chromosomal structure, extranuclear heredity, population and evolutionary genetics, and molecular analysis of genes and chromosomes. As genetic analysis can be used to dissect many biological processes, we also address how geneticists approach problems and advance scientific understanding, focusing our discussions around primary literature. This counts toward the upper-level cellular/molecular requirement for the major. Prerequisite: BIOL 116. Generally offered every year.

Experimental Genetic Analysis

BIOL 256 Credits: 0.25/2

This laboratory course introduces both genetic concepts and genetic approaches commonly used to understand biological processes, including both forward and reverse genetic approaches. We primarily use the model plant Physcomitrium patens as our experimental organism, although the techniques used in this course can be applied to any organism amenable to genetic analysis. This counts toward the upper-level laboratory requirement. Prerequisite: BIOL 109Y-110Y and 116. Prerequisite or corequisite: BIOL 255.

Animal Behavior

BIOL 261 Credits: 0.5/4

This course is a general introduction to animal behavior. We examine behavior within the framework of Tinbergen’s four areas of inquiry: causation (mechanisms), development, function and evolution (phylogeny), with an emphasis on behavioral ecology and the process by which questions in animal behavior are answered. An important part of class is the reading and discussion of primary literature. This counts toward the upper-level environmental biology requirement for the major. Prerequisite: BIOL 115 or 116.

Experimental Animal Behavior

BIOL 262 Credits: 0.25/2

This course is an introduction to the study of animal behavior by observation and experimentation. Strong emphasis is placed on hypothesis formation, experimental design, testing and communicating findings in professional science writing. We work with a number of different animal species in both the field and the lab. 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. This counts toward the upper-level laboratory requirement. Prerequisite: BIOL 109Y–110Y. Prerequisite or corequisite: BIOL 261.

Molecular Biology

BIOL 263 Credits: 0.5/4

The molecular and genomic basis of life is at the heart of modern biology. In this course, we 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. This counts toward the upper-level cellular/molecular biology requirement for the major. Note: For further study of the function of proteins, membranes and cellular processes, the complementary course BIOL 266 ("Cell Biology") is recommended. Prerequisite: BIOL 116 and CHEM 122 and 123 or CHEM 124 and 126.

Gene Manipulation

BIOL 264 Credits: 0.25/2

This skills lab course teaches fundamental methods of gene isolation, manipulation and characterization. An assortment of the following techniques is 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. This counts toward the upper-level laboratory requirement. Prerequisite: BIOL 109Y-110Y and either CHEM 122 and 123 or CHEM 124 and 126. Prerequisite or corequisite: BIOL 263.

Cell Biology

BIOL 266 Credits: 0.5/4

This course introduces students to the wide variety of questions being asked by researchers in this exciting field and the approaches they are taking to answer them. This course complements BIOL 263 in content, concentrating on the nongenomic aspects of the cell. We 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.

Experimental Cell Biology

BIOL 267 Credits: 0.25/2

This laboratory course is designed to complement BIOL 266. The topics covered in the laboratory expose the student to some of the standard techniques used in modern cell biology. The laboratories also illustrate some of the fundamental ideas of the field. Instead of covering a wide variety of techniques and preparations superficially, we concentrate on a select few, covering them in greater depth. Some topics to be covered are protein separation, cell permeability and cell motility. This counts toward the upper-level laboratory requirement. Prerequisite: BIOL 109Y-110Y. Prerequisite or corequisite: BIOL 266. Generally offered every other year.

Human Physiology

BIOL 271 Credits: 0.5/4

Human physiology is the study of how the human body operates at a molecular, cellular and organ system level. This course builds upon fundamental biological concepts to support students in connecting basic biology to human health and disease. Human physiology has an application-based approach with analysis of medical case studies to emphasize and reinforce the principles of physiology. This counts toward the organismal biology/physiology requirement for the major. Prerequisite: BIOL 115 and 116.

Seminar in Restoration Ecology

BIOL 311 Credits: 0.5/4

This course examines 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. We 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.

Cell Signaling

BIOL 315 Credits: 0.5/4

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. Junior or senior standing.

Cancer Biology

BIOL 317 Credits: 0.5/4

Cancer, a collection of diseases characterized by uncontrolled cell division, is the second leading cause of death in the United States. Nearly 40% of Americans will receive a cancer diagnosis in their lifetime. In this advanced seminar, students investigate the molecular, genetic and cellular basis of cancer, including the role of mutagenesis in development of cancers as well as the fundamental cellular processes of signal transduction, cell proliferation and programmed cell death that are disrupted in cancerous cells. Students explore the mechanisms underlying diagnostic tools and therapies for patients and how knowledge of basic cancer biology can be leveraged to develop novel treatment methods. Cancer causes, prevention and epidemiology inform consideration of all topics. Student presentations and student-led discussion of primary literature form the foundation of course activities, while the capstone experience is the production of a substantial writing assignment that integrates course concepts to investigate a fundamental aspect of cancer biology and its clinical implications. All participants should have a strong background in biochemistry and molecular cell biology. This counts toward the cellular and molecular diversity requirement for the major and an upper-level biology elective for the

BCHM and MBIO majors. Prerequisite: A 200- or 300-level biology course in the category of cellular and molecular biology.

Evolutionary Developmental Biology

BIOL 321 Credits: 0.5/4

This course addresses the mechanisms responsible for building multicellular eukaryotic organisms, framed in the context of the evolution of developmental processes and patterns. We 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 are 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 biology course. Generally offered every other year.

Photosynthesis

BIOL 323 Credits: 0.5/4

This course examines current biochemical, evolutionary and ecological topics in photosynthesis. Our understanding of photosynthetic processes is increasing rapidly, and in this class we read primary literature and book chapters to examine selected topics in depth. Topics 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 is on plant photosynthesis, we 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.

Global Ecology and Biogeography

BIOL 328 Credits: 0.5/4

This is a comprehensive course in the large-scale history and dynamics of the biosphere. The course focuses on ecoinformatics and macroecology, using computational approaches to describe and explain general patterns in the distribution, abundance and functioning of organisms. Special attention is given to geographical patterns of biodiversity and their basis in both ecological (dispersal, competition) and evolutionary (speciation, extinction) processes. The course also examines the large-scale interactions between Homo sapiens and the rest of the biosphere. Most of the reading is drawn from recent primary literature. Students develop data science skills including data archiving and manipulation, literate coding, visualization and

analysis, reproducibility, and code repositories. This counts toward the upper-level environmental biology requirement for the major. Prerequisite: BIOL 228, 241, 251, 253 or 261.

Ornithology

BIOL 330 Credits: 0.5/4

Ornithology is the scientific study of birds, integrating ecology, evolution, genetics, behavior, anatomy, and physiology. Students build upon their previous coursework in these sub-disciplines to deepen their knowledge across these scales of biological organization while focusing on birds. A synthesis project gives students practice with this integrative approach while connecting scientific knowledge to conservation problems and proposed solutions. This course relies extensively on discussion of the primary literature. This course counts toward either the organismal biology/physiology or environmental biology upper-level requirement for the major. Prerequisites: one of the following courses: BIOL 228, BIOL 241, BIOL 243, BIOL 247 or, BIOL 261 and concurrent enrollment in BIOL 331.

Ornithology in Practice

BIOL 331 Credits: 0.25/2

Ornithology is the scientific study of birds, integrating ecology, evolution, genetics, behavior, anatomy, and physiology. In practice, ornithology requires the ability to identify birds by sight and sound, both in the lab and the field. Almost all ornithological knowledge is built upon this foundational skill, and so this course teaches students to identify all orders of birds, the families of birds found in North America, and the species of birds regularly found in Ohio. Students also learn common methods for studying birds, including dissections, survey methods and analysis of survey data, mist-netting, and behavioral and/or physiological experiments. This course includes field trips to observe birds outside Gambier, including a day trip on a weekend to the National Aviary. Prerequisites: BIOL 109Y-110Y and concurrent enrollment in BIOL 330.

Immunology

BIOL 345 Credits: 0.5/4

The world around us is teeming with microorganisms, many of which are capable bringing us to our knees. Despite this looming devastation, most individuals manage to remain healthy, not succumbing to the ever-present pathogens in our environment. Immunology is the study of the cellular and molecular mechanisms employed to protect against infection. The cells and organs of the immune system are many and, consistent with this diversity, play many important roles in health and development. Every day, components of the immune system must identify harmful invaders and eliminate them, a process that requires critical distinction between host vs. harmful cells. They also provide long-lived protection against recurring infection. In this course, we embark on a journey through the immune system. We explore the mechanisms employed by the

innate immune system to provide first response to foreign invaders. Additionally, we dissect the complex processes by which cells of the adaptive immune system recognize and respond to pathogens and establish long-term immunity. Last, we explore the consequences of impaired immune response in a variety of contexts. This counts toward the upper-level cellular/molecular biology requirement for the major. Prerequisite: BIOL 255, 263, 266 or 238. Generally offered every other year.

Experimental Molecular Neuroscience

BIOL 350D Credits: 0.25/2

This laboratory course is the same as NEUR 350D. It is designed to complement NEUR 351D Molecular Neuroscience. We will apply concepts of gene expression and neural patterning to design and conduct a series of authentic experiments to answer a novel research question. Students use foundational techniques in the field, including recombinant gene technology, visualization of gene expression, and microscopy in intact vertebrate animals. This course counts toward the upper-level laboratory requirement for the Biology and Neuroscience majors. Prerequisite: BIOL 109-110Y; prerequisite or corequisite: NEUR/BIOL 351D Molecular Neuroscience. Offered every two years.

Molecular Neuroscience

BIOL 351D Credits: 0.5/4

This course is the same as NEUR 351D. This must be taken as BIOL 351D to count for the natural science diversification requirement. This course builds upon foundational concepts in neuroscience and biology to study key genes and signaling pathways that drive development, maintenance, communication and plasticity of neurons and glia. Basic principles covered include differential gene expression in the nervous system, biochemical properties of ion channels and receptors, and the role of regulatory/transport proteins in neurons and glia. We apply these and other concepts to sensory, motor and behavioral aspects of the nervous system, studying both normal and abnormal development and function in model organisms. The course emphasizes understanding historical and modern experimental design and molecular techniques. Critical reading and discussion of primary literature is an integral part of this class. This counts as an elective for the neuroscience, biology, and molecular biology majors. Prerequisite: 200- or 300-level NEUR course or 200-level BIOL course in the cell/molecular or organismal/physiology field.

Aquatic Systems Biology

BIOL 352 Credits: 0.5/4

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 examine the physical, chemical and biological factors influencing biological diversity and productivity, and emphasize the application of ecological principles to study these systems. Possible topics include the effects of agricultural runoff 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 are 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.

Aquatic Systems Lab

BIOL 353 Credits: 0.25/2

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

Neurobiology

BIOL 358D Credits: 0.5/4

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 ranges 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 concentrate 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.

Experimental Neurobiology

BIOL 359D Credits: 0.25/2

This is a laboratory designed to complement the lecture course. We 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 molecular function. We conclude with a series of independent projects that bring together ideas covered earlier in the course. This counts toward the upper-level laboratory requirement. Prerequisite: BIOL 109Y-110Y. Prerequisite or corequisite: BIOL 358. Generally offered every other year.

Virology

BIOL 375 Credits: 0.5/4

In this course, students examine the form and function of viruses through current research papers and 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. Generally offered every other year.

Research in Biology

BIOL 385 Credits: 0.25/2

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 pursuing 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.

Individual Study in Biology

BIOL 393 Credits: 0.25-0.5/2-4

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

0.25 or 0.5 unit of credit in a semester. BIOL 393 is ordinarily a library-oriented investigation. (For laboratory-oriented independent research, see BIOL 385.) 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.

Senior Seminar

BIOL 475 Credits: 0.5/4

In this capstone seminar, students explore current research topics in biology by writing a mini-review on a topic of their choice. In doing so, students analyze and integrate information from research articles that connect specific studies to broader biological questions and propose future work that refines and extends prior studies. Students communicate their insights in both oral and written formats. Assignments include short essays, student presentations, a general-audience piece and peer review. This course counts toward the upper-level lecture course requirement for the biology major. Senior standing and biology or molecular biology major.

Senior Honors

BIOL 497 Credits: 0.5/4

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 and participate in the Summer Science Scholars program. Two semesters of BIOL 385 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 are 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 and permission of project advisor and department chair.

Senior Honors

BIOL 498 Credits: 0.5/4

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 and 497.