BIOLOGY (BIO)

BIO 104. Advance Molecular Biology: Epigenetics and Proteostasis. 5 Units.
Molecular mechanisms that govern the replication, recombination, and expression of eukaryotic genomes. Topics: DNA replication, DNA recombination, gene transcription, RNA splicing, regulation of gene expression, protein synthesis, and protein folding. Satisfies Central Menu Area 1. Prerequisite: Biology core or BIO 83 (BIO 82 and 86 are strongly recommended).
Same as: BIO 200

BIO 105A. Ecology and Natural History of Jasper Ridge Biological Preserve. 4 Units.
Formerly 96A - Jasper Ridge Docent Training. First of two-quarter sequence training program to join the Jasper Ridge education/docent program. The scientific basis of ecological research in the context of a field station, hands-on field research, field ecology and the natural history of plants and animals, species interactions, archaeology, geology, hydrology, land management, multidisciplinary environmental education; and research projects, as well as management challenges of the preserve presented by faculty, local experts, and staff. Participants lead research-focused educational tours, assist with classes and research, and attend continuing education classes available to members of the JRBP community after the course.
Same as: EARTHSYS 105A

BIO 105B. Ecology and Natural History of Jasper Ridge Biological Preserve. 4 Units.
Formerly 96B - Jasper Ridge Docent Training. First of two-quarter sequence training program to join the Jasper Ridge education/docent program. The scientific basis of ecological research in the context of a field station, hands-on field research, field ecology and the natural history of plants and animals, species interactions, archaeology, geology, hydrology, land management, multidisciplinary environmental education; and research projects, as well as management challenges of the preserve presented by faculty, local experts, and staff. Participants lead research-focused educational tours, assist with classes and research, and attend continuing education classes available to members of the JRBP community after the course.
Same as: EARTHSYS 105B

BIO 107. Human Physiology Laboratory. 4 Units.
This laboratory course is active and inquiry based. Aspects of exercise and temperature are explored; however, the specific questions the class tackles differ each quarter. Samples of past questions: Does lactic acid accumulation correlate with exercise fatigue at different exercise and body temperatures? Does palm cooling during exercise mitigate the effect of body temperature on fatigue with or without evaporative cooling? Students participate both as experimenters and as subjects of the experiments in two-person teams. Participants must be in good physical condition, though not necessarily athletes, and must be willing to participate in strenuous exercise routines under adverse environmental conditions. Varsity athletes concurrently participating in a spring sport must consult the instructor before applying. Discussion sessions include student presentations of journal articles, data analyses, and feedback on individual WIM research proposals. By application only, see sites.stanford.edu/bio107/humbio136 for the application form.
Prerequisite: Bio 42 or HumBio 4A. Satisfies WIM for Biology.
Same as: HUMBIO 136

BIO 108. Essential Statistics for Human Biology. 4 Units.
Introduction to statistical concepts and methods that are essential to the study of questions in biology, environment, health and related areas. The course will teach and use the computer language R and Python (you learn both, choose one). Topics include distributions, probabilities, likelihood, linear models; illustrations will be based on recent research.
Same as: HUMBIO 85A

BIO 109A. The Human Genome and Disease. 3 Units.
The variability of the human genome and the role of genomic information in research, drug discovery, and human health. Concepts and interpretations of genomic markers in medical research and real life applications. Human genomes in diverse populations. Original contributions from thought leaders in academia and industry and interaction between students and guest lecturers. Students with a major, minor or coterm in Biology. 109A/209A or 109B/209B may count toward degree program but not both.
Same as: BIOC 109A, BIOC 209A, HUMBIO 158

BIO 109B. The Human Genome and Disease: Genetic Diversity and Personalized Medicine. 3 Units.
Continuation of 109A/209A. Genetic drift: the path of human predecessors out of Africa to Europe and then either through Asia to Australia or through northern Russia to Alaska down to the W. Coast of the Americas. Support for this idea through the histocompatibility genes and genetic sequences that predispose people to diseases. Guest lectures from academia and pharmaceutical companies. Prerequisite: Biology or Human Biology core. Students with a major, minor or coterm in Biology. 109A/209A or 109B/209B may count toward degree program but not both.
Same as: BIOC 109B

BIO 10AX. Conservation Photography. 2 Units.
Account of the genre of conservation photography and strategic use of visual communication in the environmental arena. Introduction to use of digital SLR cameras and digital image processing. Case studies of conservation issues accompanied by multimedia platforms including images, video, and audio. Theory and application of photographic techniques. Lectures, tutorials, demonstrations, and field trips. Individual and group projects.
BIO 10SC. Natural History, Marine Biology, and Research. 2 Units.
Monterey Bay is home to the nation’s largest marine sanctuary and also home to Stanford’s Hopkins Marine Station. This course, based at Hopkins, explores the spectacular biology of Monterey Bay and the artistic and political history of the region. We will conduct investigations across all of these contexts toward an inclusive understanding of place, ultimately to lead us to explore our own lives in relation to the natural world, historical and cultural milieu, and the direction of our individual life path. The location at the entry point to the Big Sur Coast of California provides a unique outdoor laboratory in which to study the biology of the bay and the adjacent coastal lands. It is also an area with a deep cultural, literary and artistic history. We will meet marine biologists, experts in the literary history of Cannery Row and the writings of John Steinbeck, local artists and photographers, experts in the neurosciences of creativity, as well as people who are very much involved in the forces and fluxes that steer modern culture. This rich and immersive approach provides students a rare opportunity to reflect on their relationships to nature, culture, and their own individual goals. The course emphasizes interactions and discussions. We will be together all of the time, either at our base at the Belden House in Pacific Grove, hiking and camping in Big Sur’s pristine Big Creek Reserve on the rocky coast, and traveling to the Tassajara Mountain Zen Center in the Ventana wilderness for several days. This is not an ordinary academic experience, instead it is an adventure of a personal, intellectual, spiritual and physical kind. We welcome people with wide interests; artists, poets, writers, engineers, scientists and musicians. Mostly we invite people with an open mind and a sense of adventure. Students are expected to read the several books provided as introductory material before the course begins, and each is also expected to become our local expert in an area such as plant identification, bird identification, poetry, weather prediction, photography, history, ethnography, etc. The course requires an individual research project of your choice on a topic related to the general theme. Final reports will be presented at the last meeting of the group and may involve any medium, including written, oral, and performance media. Note: This course will be held at the Hopkins Marine Station in the Monterey region. Transportation and housing will be provided nearby. Transportation to campus from the housing site will be provided once students arrive to campus on Monday, September 4 (Labor Day). Transportation to campus from the Belden House in Pacific Grove will be provided on Saturday, September 23.

BIO 110. Chromatin Regulation of the Genome. 3 Units.
Maintenance of the genome is a prerequisite for life. In eukaryotes, all DNA-templated processes are tightly connected to chromatin structure and function. This course will explore epigenetic and chromatin regulation of cellular processes related to aging, cancer, stem cell pluripotency, metabolic homeostasis, and development. Course material integrates current literature with a foundational review of histone modifications and nucleosome composition in epigenetic inheritance, transcription, replication, cell division and DNA damage responses. Prerequisite: BIO 41 or BIO 83 or consent of instructor. Same as: BIO 210

BIO 112. Human Physiology. 4 Units.
Human physiology will be examined by organ systems: cardiovascular, respiratory, renal, gastrointestinal and endocrine. Molecular and cell biology and signaling principles that underlie organ development, pathophysiology and opportunities for regenerative medicine are discussed, as well as integrative control mechanisms and fetal development. Prerequisite: Human Biology core or Biology Foundations or equivalent or consent of instructor. Same as: HUMBIO 133

BIO 113. Fundamentals of Molecular Evolution. 4 Units.
The inference of key molecular evolutionary processes from DNA and protein sequences. Topics include random genetic drift, coalescent models, effects and tests of natural selection, combined effects of linkage and natural selection, codon bias and genome evolution. Satisfies Central Menu Areas 1 or 4. Prerequisites: Biology core or BIO 82, 85 or graduate standing in any department, and consent of instructor. Same as: BIO 244

BIO 115. The Hidden Kingdom - Evolution, Ecology and Diversity of Fungi. 4 Units.
Fungi are critical, yet often hidden, components of the biosphere. They regulate decomposition, are primary partners in plant symbiosis and strongly impact agriculture and economics. Students will explore the fascinating world of fungal biology, ecology and evolution via lecture, lab, field exercises and Saturday field trips that will provide traditional and molecular experiences in the collection, analysis and industrial use of diverse fungi. Students will chose an environmental niche, collect and identify resident fungi, and hypothesize about their community relationship. Prerequisite: Bio 43 or BIO 81, 85 recommended. Same as: BIO 239

BIO 116. Ecology of the Hawaiian Islands. 4 Units.
Terrestrial and marine ecology and conservation biology of the Hawaiian Archipelago. Taught in the field in Hawaii as part of quarter-long sequence of courses including Earth Sciences and Anthropology. Topics include ecological succession, plant-soil interactions, conservation biology, biological invasions and ecosystem consequences, and coral reef ecology. Restricted to students accepted into the Earth Systems of Hawaii Program. Same as: EARTHSYS 116

BIO 117. Biology and Global Change. 4 Units.
The biological causes and consequences of anthropogenic and natural changes in the atmosphere, oceans, and terrestrial and freshwater ecosystems. Topics: glacial cycles and marine circulation, greenhouse gases and climate change, tropical deforestation and species extinctions, and human population growth and resource use. Prerequisite: Biology or Human Biology core or BIO 81 or graduate standing. Same as: EARTHSYS 111, ESS 111

BIO 119. Evolution of Marine Ecosystems. 3-4 Units.
Life originally evolved in the ocean. When, why, and how did the major transitions occur in the history of marine life? What triggered the rapid evolution and diversification of animals in the Cambrian, after more than 3.5 billion years of Earth’s history? What caused Earth’s major mass extinction events? How do ancient extinction events compare to current threats to marine ecosystems? How has the evolution of primary producers impacted animals, and how has animal evolution impacted primary producers? In this course, we will review the latest evidence regarding these major questions in the history of marine ecosystems. We will develop familiarity with the most common groups of marine animal fossils. We will also conduct original analyses of palaeontological data, developing skills both in the framing and testing of scientific hypotheses and in data analysis and presentation. Same as: EARTHSYS 122, GEOLSCI 123, GEOLSCI 223B

BIO 120. Bacteria in Health and Disease. 3 Units.
Enrollment limited to junior and senior undergraduates, graduate students and medical students. Introduces students to the bacteria that live in and on humans and, in some cases, can cause disease and sometimes death. Topics include the biology of the interaction of the simple microbe with complex human biology and the factors that determine whether or not we coexist relatively peacefully, suffer from overt disease, or succumb to the bacterial onslaught. Same as: MI 120
BIO 124. Topics in Cancer Biology. 3 Units.
This discussion-based course will explore the scientific tools used to study the molecular and genetic basis of cancer and to develop treatments for this disease. Topics covered may include cancer models, traditional and targeted cancer therapies, and the development of resistance to treatment. Students will develop skills in critical reading of primary research articles and will also complete a final project. Prerequisites: Biology/Human Biology core or BIO 82, 83, 86, or of instructor.

BIO 126. Introduction to Biophysics. 3-4 Units.
Core course appropriate for advanced undergraduate students and graduate students with prior knowledge of calculus and a college physics course. Introduction to how physical principles offer insights into modern biology, with regard to the structural, dynamical, and functional organization of biological systems. Topics include the roles of free energy, diffusion, electromotive forces, non-equilibrium dynamics, and information in fundamental biological processes. Same as: APPPHY 205, BIO 226

BIO 12N. Sensory Ecology of Marine Animals. 3 Units.
Animals living in the oceans experience a highly varied range of environmental stimuli. An aquatic lifestyle requires an equally rich range of sensory adaptations, including some that are totally foreign to us. In this course we will examine sensory system in marine animals from both an environmental and behavioral perspective and from the point of view of neuroscience and information systems engineering.

BIO 130. Ecosystems of California. 4 Units.
California is home to a huge diversity of ecosystem types and processes. This course provides an introduction to the natural history, systematics, and ecosystem ecology of California ecosystems, based on a combination of lectures, student-led projects, and weekend field trips. Ecosystems to be explored will range from coasts to mountains and from desert to wetlands. Requirements include three essays and participation in three field trips (of six options).

BIO 131. Complex Systems Lab. 1 Unit.
Applications of complex systems will be explored in this seminar through lectures, discussions, and a class project. Lecture topics include a discussion of chaos in weather modeling and aircraft turbulence, application of network science to understand Ebola and the ALS ice bucket challenge, and self-organized processes such as crowd dynamics and Wikipedia. The first half of the course will emphasize complex systems applications. Students will apply complex systems analysis techniques to their personal research, a current event, or a classic complex systems experiment. Projects can include topics such as calculating the fractal dimension of a forest, simulating crowd dynamics, studying the degree distribution of social networks, or making a Van der Pol oscillator. Graduate student led seminar. Can be repeated for credit.

BIO 132. Advanced Imaging Lab in Biophysics. 4 Units.
Laboratory and lectures. Advanced microscopy and imaging, emphasizing hands-on experience with state-of-the-art techniques. Students construct and operate working apparatus. Topics include microscope optics, Koehler illumination, contrast-generating mechanisms (bright/dark field, fluorescence, phase contrast, differential interference contrast), and resolution limits. Laboratory topics vary by year, but include single-molecule fluorescence, fluorescence resonance energy transfer, confocal microscopy, two-photon microscopy, microendoscopy, and optical trapping. Limited enrollment. Recommended: basic physics, basic cell biology, and consent of instructor. Same as: APPPHY 232, BIO 232, BIOPHYS 232, GENE 232

BIO 133. Network analysis for community ecology and conservation research. 2 Units.
Graduate student led seminar. Plant-pollinator, predator-prey, and parasite-host are all examples of species interactions that can be analyzed using species interaction networks. Network analysis is an incredible tool to understand how ecological communities are impacted by environmental stressors like human development and climate change. In this class, we will review and discuss relevant scientific literature and learn how to manipulate, visualize, and interpret species interaction network data. Students will develop grant-writing skills by producing a culminating research proposal and we will take a field trip to practice species interaction sampling techniques. Prerequisites: BIO 43 or BIO 81 or BIO 85.

BIO 134. Molecular and cellular analysis of mutant p53 in mammalian cells. 4 Units.
This laboratory course will use cultured mammalian cells to study whether drug treatment can restore function to mutant versions of the tumor suppressor p53. Students will perform a variety of cellular and molecular techniques, including RT-PCR, western blot, and immunofluorescence to test certain abilities of their mutant in the presence and absence of the drug. The project will culminate with student-designed experiments testing a functional aspect of p53 and presentation of the results for both expert and lay audiences. Strongly suggested prerequisite: BIO 45, BIO 82, 83, 86.

This advanced course explores the science of valuing nature, beginning with its historical origins, and then its recent development in natural (especially ecological), economic, psychological, and other social sciences. We will use the ecosystem services framework (characterizing benefits from ecosystems to people) to define the state of knowledge, core methods of analysis, and research frontiers, such as at the interface with biodiversity, resilience, human health, and human development. Intended for diverse students, with a focus on research and real-world cases. To apply, please email the instructor (gdaily@stanford.edu) with a brief description of your background and research interests. Same as: BIO 238, EARTHSYS 139

BIO 140. The Science of Extreme Life of the Sea. 3 Units.
Covers the way marine animals and plants live in extreme environments by examining morphological, ecological, and genetic adaptations to low temperature, high heat, deep water, etc. We also cover extreme ecosystems such as fast swimming, small and large body size, and novel reproductive systems. Lecture material is punctuated with a series of tutorials on narrative writing skills in science, especially creative non-fiction, memoirs, braided essays and short fiction. The goal is to integrate quantitative thinking about the life sciences with creative writing that brings facts to life. Prerequisites: core courses in biology, creative writing, environmental sciences or engineering. Two lectures back to back on Tuesdays with a Writing Intermezzo between.

BIO 141. Biostatistics. 3-5 Units.
Introductory statistical methods for biological data: describing data (numerical and graphical summaries); introduction to probability; and statistical inference (hypothesis tests and confidence intervals). Intermediate statistical methods: comparing groups (analysis of variance); analyzing species interactions (linear and logistic regression); and methods for categorical data (contingency tables and odds ratio). Course content integrated with statistical computing in R. Same as: STATS 141
BIO 142. Molecular Geomicrobiology Laboratory. 3-4 Units.
In this course, students will be studying the biosynthesis of cyclic lipid biomarkers, molecules that are produced by modern microbes that can be preserved in rocks that are over a billion years old and which geologist use as molecular fossils. Students will be tasked with identifying potential biomarker lipid synthesis genes in environmental genomic databases, expressing those genes in a model bacterial expression system in the lab, and then analyzing the lipid products that are produced. The overall goal is for students to experience the scientific research process including generating hypotheses, testing these hypotheses in laboratory experiments, and communicating their results through a publication style paper. Prerequisites: BIOB3 and CHEM35 or permission of the instructor.
Same as: EARTHSYS 143, ESS 143, ESS 243

BIO 144. Conservation Biology: A Latin American Perspective. 3 Units.
Principles and application of the science of preserving biological diversity. Conceptually, this course is designed to explore 4 major components relevant to the conservation of biodiversity, as exemplified by the Latin American region. The conceptual frameworks and principles, however, should be generally applicable, and provide insights for all regions of the world, including those of lesser biodiversity. Satisfies Central Menu Area 4 for Bio majors. Prerequisite: BIO 101 or BIO 43 or HUMBIO 2A or BIO 81 and 84 or consent of instructor. Graduate level students will be expected to conduct a literature research exercise leading to a written paper, addressing a topic of their choosing, derived from any of the themes discussed in class.
Same as: BIO 234, HUMBIO 112

BIO 145. Ecology and Evolution of Animal Behavior. 3 Units.
Ecological and evolutionary perspectives on animal behavior; with an emphasis on social and collective behavior. This is a project-based course in a lecture/seminar format. Seminars will be based on discussion of journal articles. Independent research projects on the behavior of animals on campus. Prerequisites: Biology or Human Biology core or BIO 81 and 85 or consent of instructor; Biology/ES 30. Recommended: statistics.
Same as: BIO 245

BIO 146. Population Studies. 1 Unit.
Series of talks by distinguished speakers introducing approaches to population and resource studies.

BIO 149. The Neurobiology of Sleep. 4 Units.
Preference to seniors and graduate students. The neurochemistry and neurophysiology of changes in brain activity and consciousness associated with the sleep/wake cycle. Behavioral and neurobiological phenomena including sleep regulation, sleep homeostasis, circadian rhythms, sleep disorders, sleep function, and the molecular biology of sleep. Enrollment limited to 16.
Same as: BIO 249, HUMBIO 161

BIO 150. Human Behavioral Biology. 5 Units.
Multidisciplinary. How to approach complex normal and abnormal behaviors through biology. How to integrate disciplines including sociobiology, ethology, neuroscience, and endocrinology to examine behaviors such as aggression, sexual behavior, language use, and mental illness.
Same as: HUMBIO 160

BIO 151. Mechanisms of Neuron Death. 3 Units.
For Biology majors with background in neuroscience. Cell and molecular biology of neuron death during neurological disease. Topics: the amyloid diseases (Alzheimer’s), prion diseases (kuru and Creutzfeldt-Jakob), oxygen radical diseases (Parkinson’s and ALS), triplet repeat diseases (Huntington’s), and AIDS-related dementia. Student presentations. Enrollment limited to 15; application required.

BIO 152. Imaging: Biological Light Microscopy. 3 Units.
This intensive laboratory and discussion course will provide participants with the theoretical and practical knowledge to utilize emerging imaging technologies based on light microscopy. Topics include microscopy optics, resolution limits, Köhler illumination, confocal fluorescence, two-photon, TIRF, FRET, photobleaching, super-resolution (SIM, STED, STORM/PALM), tissue clearing/CLARITY/light-sheet microscopy, and live-cell imaging. Applications include using fluorescent probes to analyze subcellular localization and live cell-translocation dynamics. We will be using a flipped classroom for the course in that students will watch iBiology lectures before class, and class time will be used for engaging in extensive discussion. Lab portion involves extensive in-class use of microscopes in the CSIF and NMS core microscopy facilities.
Same as: CSB 222, MCP 222

BIO 153. Cellular Neuroscience: Cell Signaling and Behavior. 4 Units.
Neural interactions underlying behavior. Prerequisites: PSYCH 1 or basic biology.
Same as: PSYCH 120

BIO 154. Molecular and Cellular Neurobiology. 4 Units.
For advanced undergraduate students. Cellular and molecular mechanisms in the organization and functions of the nervous system. Topics: wiring of the neuronal circuit, synapse structure and synaptic transmission, signal transduction in the nervous system, sensory systems, molecular basis of behavior including learning and memory, molecular pathogenesis of neurological diseases. Satisfies Central Menu Areas 2 or 3 for Bio majors. Highly recommended: BioCore or BIO 82, 83, 86, or consent of instructor.

BIO 155. Developmental Neurobiology. 4 Units.
For advanced undergraduate and coterminal students. The principles of nervous system development from the molecular control of patterning, cell-cell interactions, and trophic factors to the level of neural systems and the role of experience in influencing brain structure and function. Topics: neural induction and patterning cell lineage, neurogenesis, neuronal migration, axonal pathfinding, synapse elimination, the role of activity, critical periods, and the development of behavior. Satisfies Central Menu Areas 2 or 3. Prerequisite: BIO 42 or BIO 82, 83, 84, 86. Same as: BIO 258

BIO 157. Biochemistry and Molecular Biology of Plants. 3-4 Units.
Biochemical and molecular basis of plant growth and adaptation. Topics include: hormone signal transduction; photoreceptor chemistry and signaling; metabolite sensing and transport; dynamics of photosynthesis; plant innate immunity and symbiosis. Lectures and readings will emphasize research methods. Prerequisite: Biology core or equivalent, or consent of instructor.

BIO 158. Developmental Neurobiology. 4 Units.
For advanced undergraduates and coterminal students. The principles of nervous system development from the molecular control of patterning, cell-cell interactions, and trophic factors to the level of neural systems and the role of experience in influencing brain structure and function. Topics: neural induction and patterning cell lineage, neurogenesis, neuronal migration, axonal pathfinding, synapse elimination, the role of activity, critical periods, and the development of behavior. Satisfies Central Menu Areas 2 or 3. Prerequisite: BIO 42 or BIO 82, 83, 84, 86. Same as: BIO 258

BIO 16. Conservation Storytelling: Pre-course for BOSP South Africa. 1 Unit.
Limited to students admitted to the BOSP South Africa overseas seminar. Through 4 workshop meetings, students will develop and pitch story ideas, form teams in which a writer and a photographer agree to collaborate on a story, and conduct background research prior to departing for South Africa.

BIO 160. Developmental Biology. 4 Units.
This course will cover the molecular mechanisms underlying the generation of diverse cell types and tissues during embryonic and post-embryonic animal development. Topics include the role of cell-cell communication in controlling developmental decisions, the organization and patterning of large groups of cells via morphogen signaling, the specification of individual cell types, and the role of stem cells in development. The course emphasizes the experimental logic and methods of research in developmental biology and includes discussions of research papers.
BIO 167. Insulin and carbohydrate metabolism in health and disease a history of advances 1850 to current. 3 Units.
The quest to understand how the body uses sugar and the overlapping quest for a diabetes cure have resulted in discoveries in every branch of biology. Topics include insulin production, structure, and evolution; transduction of the insulin signal; transport of sugar into cells; sugar storage and release; how the brain transports and uses sugar; growth control; pancreas development; genetic and environmental causes of diabetes; engineering solutions to diabetes (artificial pancreas, stem cells), glucose homeostasis (modeling insulin action). Prerequisites: BIO 41, 42.

BIO 168. Explorations in Stem Cell Biology. 3 Units.
A discussion-based course for advanced undergraduates. The purpose of this course is to introduce students to key topics in stem cell biology and foster the development of strong scientific writing skills. We will review and discuss some landmark and current primary literature in the stem cell field. Topics will include embryonic and adult stem cells, cellular reprogramming and stem cells in disease and regenerative medicine. Students will present a current research paper in their preferred stem cell topic area and compose a novel research proposal. Prerequisites: Biology or Human Biology core or BIO 82, 83, 86. Satisfies WIM in Biology.

BIO 171. Principles of Cell Cycle Control. 3 Units.
Genetic analysis of the key regulatory circuits governing the control of cell division. Illustration of key principles that can be generalized to other synthetic and natural biological circuits. Focus on tractable model organisms; growth control; irreversible biochemical switches; chromosome duplication; mitosis; DNA damage checkpoints; MAPK pathway-cell cycle interface; oncogenesis. Analysis of classic and current primary literature. Satisfies Central Menu Area 2.
Same as: BIO 271, CSB 271

BIO 172. Ecological Dynamics: Theory and Applications. 4 Units.
Structured population models with age and phenotypic variation. Integral population models, model fitting and dynamics. Fitness and dynamic heterogeneity. Examples from natural populations (sheep, roe deer, plants, birds). Graduate students will be responsible for additional problem sets. Prerequisites: calculus and linear algebra.
Same as: BIO 272

BIO 173. Chemical Biology. 3 Units.
Chemical biology is an integrative discipline that seeks to apply chemical tools and approaches to understand biology. This course will introduce students to various methods and approaches used in this field, with an emphasis on the use of natural products and synthetic small molecules as probes of biological function. Specific examples will be used to illustrate the ramifications of chemical biology with molecular, cell and developmental biology. The interaction between disease and drug discovery will be considered in detail. Prerequisites: Completion of BioCore (BIO 41, 42, 43), or BIO 82 and BIO 83.

BIO 174. Human Skeletal Anatomy. 5 Units.
Study of the human skeleton (a. k. a. human osteology), as it bears on other disciplines, including medicine, forensics, anthropology, and paleoanthropology (human evolution). Basic bone biology, anatomy, and development, emphasizing hands-on examination and identification of human skeletal parts, their implications for determining an individual's age, sex, geographic origin, and health status, and for the evolutionary history of our species. Three hours of lecture and at least three hours of supervised and independent study in the lab each week.
Same as: ANTHRO 175, ANTHRO 275, BIO 274, HUMBIO 180

BIO 175. Collective Behavior and Distributed Intelligence. 3 Units.
This course will explore possibilities for student research projects based on presentations of faculty research. We will cover a broad range of topics within the general area of collective behavior, both natural and artificial. Students will build on faculty presentations to develop proposals for future projects.
Same as: SYMSYS 275

BIO 177. Plant Microbe Interaction. 3 Units.
Molecular basis of plant symbiosis and pathogenesis. Topics include mechanisms of recognition and signaling between microbes and plant hosts, with examples such as the role of small molecules, secreted peptides, and signal transduction pathways in symbiotic or pathogenic interactions. Readings include landmark papers together with readings in the contemporary literature. Prerequisites: Biology core and two or more upper division courses in genetics, molecular biology, or biochemistry. Recommended: plant genetics or plant biochemistry.
Same as: BIO 277

BIO 178. Microbiology Literature. 3 Units.
For advanced undergraduates and first-year graduate students. Critical reading of the research literature in prokaryotic genetics and molecular biology, with particular applications to the study of major human pathogens. Classic and foundational papers in pathogenesis, genetics, and molecular biology; recent literature on bacterial pathogens such as Salmonella, Vibrio, and/or Yersinia. Diverse experimental approaches: biochemistry, genomics, pathogenesis, and cell biology. Prerequisites: Biology Core and two upper-division courses in genetics, molecular biology, or biochemistry.
Same as: BIO 278

BIO 180. Microbial Physiology. 3 Units.
Introduction to the physiology of microbes including cellular structure, transcription and translation, growth and metabolism, mechanisms for stress resistance and the formation of microbial communities. These topics will be covered in relation to the evolution of early life on Earth, ancient ecosystems, and the interpretation of the rock record. Recommended: introductory biology and chemistry.
Same as: EARTHSYS 255, ESS 255, GEO/SCI 233A

BIO 182. Modeling Cultural Evolution. 3 Units.
Seminar. Quantitative models for the evolution of socially transmitted traits. Rates of change of learned traits in populations and patterns of cultural diversity as a function of innovation and cultural transmission. Learning in constant and changing environments. Possible avenues for gene-culture coevolution.
Same as: BIO 282

BIO 183. Theoretical Population Genetics. 3 Units.
Models in population genetics and evolution. Selection, random drift, gene linkage, migration, and inbreeding, and their influence on the evolution of gene frequencies and chromosome structure. Models are related to DNA sequence evolution. Prerequisites: calculus and linear algebra, or consent of instructor.
Same as: BIO 283

BIO 196A. Biology Senior Reflection. 3 Units.
Capstone course series for seniors. Creative, self-reflective and scientifically relevant projects conceived, produced and exhibited over the course of three quarters. Explore scientific content of personal interest through creative forms including but not limited to writing, music, fine arts, performing arts, photography, film or new media. A written essay on the creative process and scientific significance of the selected topic will accompany the creative work. Completed projects may be included in a creative portfolio. Required enrollment in 196A,B,C. Satisfies WIM in Biology. May be repeat for credit.

BIO 196B. Biology Senior Reflection. 3 Units.
Capstone course series for seniors. Creative, self-reflective and scientifically relevant projects conceived, produced and exhibited over the course of three quarters. Explore scientific content of personal interest through creative forms including but not limited to writing, music, fine arts, performing arts, photography, film or new media. A written essay on the creative process and scientific significance of the selected topic will accompany the creative work. Completed projects may be included in a creative portfolio. Required enrollment in 196A,B,C. May be repeat for credit.
BIO 196C. Biology Senior Reflection. 3 Units.
Capstone course series for seniors. Creative, self-reflective and scientifically relevant projects conceived, produced and exhibited over the course of three quarters. Explore scientific content of personal interest through creative forms including but not limited to writing, music, fine arts, performing arts, photography, film or new media. A written essay on the creative process and scientific significance of the selected topic will accompany the creative work. Completed projects may be included in a creative portfolio. Required enrollment in 196A,B,C. May be repeat for credit.

BIO 197WA. Senior Writing Project: The Personal Essay in Biology. 3 Units.
Seminar focused on writing. Compose, workshop and revise scientifically relevant and personal essays in biology directed at a mainstream audience, interweaving research, interview, memoir, and other elements of nonfiction craft. Satisfies WIM in Biology.

BIO 198. Directed Reading in Biology. 1-15 Unit.
Individually arranged under the supervision of members of the faculty.

BIO 198X. Out-of-Department Directed Reading. 1-15 Unit.
Individually arranged under the supervision of members of the faculty. Credit for work arranged with out-of-department faculty is restricted to Biology majors and requires department approval. See https://biology.stanford.edu/academics/undergraduate-research/directed-reading for information and petitions. May be repeated for credit.

BIO 199. Advanced Research Laboratory in Experimental Biology. 1-15 Unit.
Individual research taken by arrangement with in-department instructors. See http://biohonors.stanford.edu for information on research sponsors, units, and credit for summer research. May be repeated for credit.

BIO 199W. Senior Honors Thesis: How to Effectively Write About Scientific Research. 3 Units.
Workshop. For seniors pursuing an honors thesis in a biology-focused major or program. Focus on improving scientific writing and synthesizing in the context of students' individual research projects. Complete literature review which will form the basis for the thesis introduction. Develop methods section of the thesis. Small seminar-style discussion sections with research-based discussions, student led PowerPoint presentations, and writing workshops. Co-requisite: Concurrent enrollment in 199 or 199X or equivalent. Satisfies WIM in Biology.

BIO 199X. Out-of-Department Advanced Research Laboratory in Experimental Biology. 1-15 Unit.
Individual research by arrangement with out-of-department instructors. Credit for 199X is restricted to declared Biology majors and requires department approval. See https://biology.stanford.edu/academics/undergraduate-research/research for information on research sponsors, units, petitions, deadlines, credit for summer research, and out-of-Stanford research. May be repeated for credit.

BIO 200. Advance Molecular Biology: Epigenetics and Proteostasis. 5 Units.
Molecular mechanisms that govern the replication, recombination, and expression of eukaryotic genomes. Topics: DNA replication, DNA recombination, gene transcription, RNA splicing, regulation of gene expression, protein synthesis, and protein folding. Satisfies Central Menu Area 1. Prerequisite: Biology core or BIO 83 (BIO 82 and 86 are strongly recommended). Same as: BIO 104

BIO 202. Ecological Statistics. 3 Units.
Intended for graduate students (and advanced undergraduates in special circumstances with consent of instructors) in biology and related environmental sciences, this course is an introduction to statistical methods for ecological data analysis, using the programming language R. The course will have lectures, discussions, and independent research projects using the students own data or simulated or publicly available data.

BIO 204. Neuroplasticity: From Synapses to Behavior. 3 Units.
This course will focus on neuroplasticity from a broad perspective, from molecular cellular mechanism to its involvement in behavior and diseases. Emphasis will be on: a) molecular and cellular mechanisms underlying various forms of neuroplasticity; b) the neuroplasticity during brain development; c) the neuroplasticity in adult brain with respect to learning and memory; and d) maladaptive neuroplasticity in neurodegenerative disease and drug addiction. This course is designed for Ph.D. students from both the Biology and Neuroscience programs. Open to advanced undergraduates by consent of instructor.

BIO 208. Spanish in Science/Science in Spanish. 2 Units.
For graduate and undergraduate students interested in the natural sciences and the Spanish language. Students will acquire the ability to communicate in Spanish using scientific language and will enhance their ability to read scientific literature written in Spanish. Emphasis on the development of science in Spanish-speaking countries or regions. Course is conducted in Spanish and intended for students pursuing degrees in the sciences, particularly disciplines such as ecology, environmental science, sustainability, resource management, anthropology, and archeology. Same as: EARTHSYS 207, LATINAM 207

BIO 210. Chromatin Regulation of the Genome. 3 Units.
Maintenance of the genome is a prerequisite for life. In eukaryotes, all DNA-templated processes are tightly connected to chromatin structure and function. This course will explore epigenetic and chromatin regulation of cellular processes related to aging, cancer, stem cell pluripotency, metabolic homeostasis, and development. Course material integrates current literature with a foundational review of histone modifications and nucleosome composition in epigenetic inheritance, transcription, replication, cell division and DNA damage responses. Prerequisite: BIO 41 or BIO 83 or consent of instructor. Same as: BIO 110

BIO 214. Advanced Cell Biology. 4 Units.
For Ph.D. students. Taught from the current literature on cell structure, function, and dynamics. Topics include complex cell phenomena such as cell division, apoptosis, signaling, compartmentalization, transport and trafficking, motility and adhesion, and differentiation. Weekly reading of current papers from the primary literature. Preparation of an original research proposal. Prerequisite for advanced undergraduates: BIO 129A or 160, and consent of instructor. Same as: BIO 224, MCP 221

BIO 222. Exploring Neural Circuits. 3 Units.
Seminar. The logic of how neural circuits control behavior; how neural circuits are assembled during development and modified by experience. Emphasis is on primary literature. Topics include: neurons as information processing units; simple and complex circuits underlying sensory information processing and motor control; and development and plasticity of neural circuits. Advanced undergraduates and graduate students with background in physical science, engineering, and biology may apply to enroll. Enrollment is by application only. Recommended: background in neuroscience.

BIO 223. Stochastic and Nonlinear Dynamics. 3 Units.
Theoretical analysis of dynamical processes: dynamical systems, stochastic processes, and spatiotemporal dynamics. Motivations and applications from biology and physics. Emphasis is on methods including qualitative approaches, asymptotics, and multiple scale analysis. Prerequisites: ordinary and partial differential equations, complex analysis, and probability or statistical physics. Same as: APPPHYS 223, BIOE 213
BIO 226. Introduction to Biophysics. 3-4 Units.
Core course appropriate for advanced undergraduate students and graduate students with prior knowledge of calculus and a college physics course. Introduction to how physical principles offer insights into modern biology, with regard to the structural, dynamical, and functional organization of biological systems. Topics include the roles of free energy, diffusion, electromotive forces, non-equilibrium dynamics, and information in fundamental biological processes. Same as: APPPHYS 205, BIO 126

BIO 227. Foundations of Community Ecology. 2 Units.
Discussion of classic papers in community ecology (Forbes, Clements, Gleason, Grinnell, Lindeman, Preston, Elton, Hutchinson, May, MacArthur, Odum, Connell, Paine, Tilman, etc.) and contemporary papers on related topics, to develop historical perspectives to understand current issues and identify future directions. Prerequisite for undergraduates: consent of instructor.

BIO 230. Molecular and Cellular Immunology. 4 Units.
Mechanisms of immune responses in health and disease; innate and adaptive immunity; development of the immune system; molecular biology, structure, and function of antibodies and T-cell receptors; cellular basis of immune responses and their regulation; genetic control of immune responses and disease susceptibility; immunotherapies for treating diseases. Lectures and discussion in class and in sections. Satisfies Central Menu Areas 1 or 2. For upper class undergraduate and graduate students who have not had an introductory immunology course. Prerequisites for undergraduates: Biology Core, Human Biology Core, or BIO 83 and 86, or consent of instructor. For graduate students: College-level molecular biology, biochemistry, and cell biology, or consent of instructor.

BIO 230A. Molecular and Cellular Immunology Literature Review. 1 Unit.
Special discussion section for graduate students. Supplement to BIO 230. Pre- or corequisite: BIO 230 or other introductory immunology course.

BIO 232. Advanced Imaging Lab in Biophysics. 4 Units.
Laboratory and lectures. Advanced microscopy and imaging, emphasizing hands-on experience with state-of-the-art techniques. Students construct and operate working apparatus. Topics include microscope optics, Koehler illumination, contrast-generating mechanisms (bright/dark field, fluorescence, phase contrast, differential interference contrast), and resolution limits. Laboratory topics vary by year, but include single-molecule fluorescence, fluorescence resonance energy transfer, confocal microscopy, two-photon microscopy, microendoscopy, and optical trapping. Limited enrollment. Recommended: basic physics, basic cell biology, and consent of instructor. Same as: APPPHYS 232, BIO 132, BIOPHYS 232, GENE 232

BIO 234. Conservation Biology: A Latin American Perspective. 3 Units.
Principles and application of the science of preserving biological diversity. Conceptually, this course is designed to explore 4 major components relevant to the conservation of biodiversity, as exemplified by the Latin American region. The conceptual frameworks and principles, however, should be generally applicable, and provide insights for all regions of the world, including those of lesser biodiversity. Satisfies Central Menu Area 4 for Bio majors. Prerequisite: BIO 101 or BIO 43 or HUMBIO 2A or BIO 81 and 84 or consent of instructor. Graduate level students will be expected to conduct a literature research exercise leading to a written paper, addressing a topic of their choosing, derived from any of the themes discussed in class. Same as: BIO 144, HUMBIO 112

BIO 238. Ecosystem Services: Frontiers in the Science of Valuing Nature. 3 Units.
This advanced course explores the science of valuing nature, beginning with its historical origins, and then its recent development in natural (especially ecological), economic, psychological, and other social sciences. We will use the ecosystem services framework (characterizing benefits from ecosystems to people) to define the state of knowledge, core methods of analysis, and research frontiers, such as at the interface with biodiversity, resilience, human health, and human development. Intended for diverse students, with a focus on research and real-world cases. To apply, please email the instructor (gdaily@stanford.edu) with a brief description of your background and research interests. Same as: BIO 138, EARTHYS 139

BIO 239. The Hidden Kingdom - Evolution, Ecology and Diversity of Fungi. 4 Units.
Fungi are critical, yet often hidden, components of the biosphere. They regulate decomposition, are primary partners in plant symbiosis and strongly impact agriculture and economics. Students will explore the fascinating world of fungal biology, ecology and evolution via lecture, lab, field exercises and Saturday field trips that will provide traditional and molecular experiences in the collection, analysis and industrial use of diverse fungi. Students will choose an environmental niche, collect and identify resident fungi, and hypothesize about their community relationship. Prerequisite: Bio 43 or BIO 81, 85 recommended. Same as: BIO 116

BIO 244. Fundamentals of Molecular Evolution. 4 Units.
The inference of key molecular evolutionary processes from DNA and protein sequences. Topics include random genetic drift, coalescent models, effects and tests of natural selection, combined effects of linkage and natural selection, codon bias and genome evolution. Satisfies Central Menu Areas 1 or 4. Prerequisites: Biology core or BIO 82, 85 or graduate standing in any department, and consent of instructor. Same as: BIO 113

BIO 245. Ecology and Evolution of Animal Behavior. 3 Units.
Ecological and evolutionary perspectives on animal behavior, with an emphasis on social and collective behavior. This is a project-based course in a lecture/seminar format. Seminars will be based on discussion of journal articles. Independent research projects on the behavior of animals on campus. Prerequisites: Biology or Human Biology core or BIO 81 and 85 or consent of instructor; Biology/ES 30. Recommended: statistics. Same as: BIO 145

BIO 247. Genomic approaches to the study of human disease. 3 Units.
This course will cover a range of genetic and genomic approaches to studying human phenotypic variation and disease. We will discuss the genetic basis of Mendelian and complex diseases, as well as clinical applications including prenatal testing, and pediatric and cancer diagnostics. The course will include lectures as well as critical reading and discussion of the primary literature. Prerequisite: BIO 82 or equivalent. Open to advanced undergraduate students. Same as: GENE 247

BIO 249. The Neurobiology of Sleep. 4 Units.
Preference to seniors and graduate students. The neurochemistry and neurophysiology of changes in brain activity and conscious awareness associated with changes in the sleep/wake state. Behavioral and neurobiological phenomena including sleep regulation, sleep homeostasis, circadian rhythms, sleep disorders, sleep function, and the molecular biology of sleep. Enrollment limited to 16. Same as: BIO 149, HUMBIO 161
**BIO 24N. Visions of Paradise: Garden Design. 3 Units.**
Through literature readings and field trips to local gardens learn the principles and esthetics of classic garden designs: Italian Renaissance, botanical teaching, Japanese, English cottage, and others. Design a personal vision of paradise with details of species, visual and scent impact, water features, and hardscape. Open your eyes to a new appreciation of the world of plants and learn some physiology and genetics that explains the specific properties of individual species.

**BIO 254. Molecular and Cellular Neurobiology. 3-5 Units.**
For graduate students. Includes lectures for BIO 154. Cellular and molecular mechanisms in the organization and functions of the nervous system. Topics: wiring of the neuronal circuit, synapse structure and synaptic transmission, signal transduction in the nervous system, sensory systems, molecular basis of behavior including learning and memory, molecular pathogenesis of neurological diseases.
Same as: NBIO 254

**BIO 258. Developmental Neurobiology. 4 Units.**
For advanced undergraduates and coterminal students. The principles of nervous system development from the molecular control of patterning, cell-cell interactions, and trophic factors to the level of neural systems and the role of experience in influencing brain structure and function. Topics: neural induction and patterning cell lineage, neurogenesis, neuronal migration, axonal pathfinding, synapse elimination, the role of activity, critical periods, and the development of behavior. Satisfies Central Menu Areas 2 or 3. Prerequisite: BIO 42 or BIO 82, 83, 84, 86.
Same as: BIO 158

**BIO 25Q. Cystic fibrosis: from medical conundrum to precision medicine success story. 3 Units.**
Preference to sophomores. The class will explore cystic fibrosis (CF), the most prevalent fatal genetic disease in the US, as a scientific and medical whodunit. Through reading and discussion of medical and scientific literature, we will tackle questions that include: how was life expectancy with CF increased from weeks to decades without understanding the disease mechanism? Why is the disease so prevalent? Is there an advantage to being a carrier? Is CF a single disease or a continuum of physiological variation ¿or what is a disease? How did research into CF lead to discovery of the underlying cause of most other genetic diseases as well? Through critical reading of the scientific and medical literature, class discussion, field trips and meetings with genetic counselors, caregivers, patients, physicians and researchers, we will work to build a deep understanding of this disease, from the biochemical basis to the current controversies over pathogenic mechanisms, treatment strategies and the ethics and economics of genetic testing andastronomical drug costs.

**BIO 263. Neural Systems and Behavior. 4 Units.**
The field of neuroethology and its vertebrate and invertebrate model systems. Research-oriented. Readings include reviews and original papers. How animal brains compare; how neural circuits are adapted to species-typical behavior; and how the sensory worlds of different species represent the world. Lectures and required discussions. Satisfies Central Menu Area 3 for Bio majors. Prerequisites: BIO 42, HUMBIO 4A.

**BIO 267. Molecular Mechanisms of Neurodegenerative Disease. 4 Units.**
The epidemic of neurodegenerative disorders such as Alzheimer's and Parkinson's disease occasioned by an aging human population. Genetic, molecular, and cellular mechanisms. Clinical aspects through case presentations.

**BIO 268. Statistical and Machine Learning Methods for Genomics. 3 Units.**
Introduction to statistical and computational methods for genomics. Sample topics include: expectation maximization, hidden Markov model, Markov chain Monte Carlo, ensemble learning, probabilistic graphical models, kernel methods and other modern machine learning paradigms. Rationales and techniques illustrated with existing implementations used in population genetics, disease association, and functional regulatory genomics studies. Instruction includes lectures and discussion of readings from primary literature. Homework and projects require implementing some of the algorithms and using existing toolkits for analysis of genomic datasets.
Same as: BIOMEDIN 245, CS 373, GENE 245, STATS 345

**BIO 269. Hopkins Microbiology Course. 3-12 Units.**
Same as: BIOSCI 274, CEE 274A and CEE 274B, or equivalents.

**BIO 271. Principles of Cell Cycle Control. 3 Units.**
Genetic analysis of the key regulatory circuits governing the control of cell division. Illustration of key principles that can be generalized to other synthetic and natural biological circuits. Focus on tractable model organisms; growth control; irreversible biochemical switches; chromosome duplication; mitosis; DNA damage checkpoints; MAPK pathway-cell cycle interface; oncogenesis. Analysis of classic and current primary literature. Satisfies Central Menu Area 2.
Same as: BIO 171, CSB 271

**BIO 272. Ecological Dynamics: Theory and Applications. 4 Units.**
Structured population models with age and phenotypic variation. Integral population models, model fitting and dynamics. Fitness and dynamic heterogeneity. Examples from natural populations (sheep, roe deer, plants, birds). Graduate students will be responsible for additional problem sets. Prerequisites: calculus and linear algebra.
Same as: BIO 172

**BIO 274. Human Skeletal Anatomy. 5 Units.**
Study of the human skeleton (a. k. a. human osteology), as it bears on other disciplines, including medicine, forensics, archaeology, and paleoanthropology (human evolution). Basic bone biology, anatomy, and development, emphasizing hands-on examination and identification of human skeletal parts, their implications for determining an individual's age, sex, geographic origin, and health status, and for the evolutionary history of our species. Three hours of lecture and at least three hours of supervised and independent study in the lab each week.
Same as: ANTHRO 175, ANTHRO 275, BIO 174, HUMBIO 180

**BIO 274S. Hopkins Microbiology Course. 3-12 Units.**
(Formerly GES 274S.) Four-week, intensive. The interplay between molecular, physiological, ecological, evolutionary, and geochemical processes that constitute, cause, and maintain microbial diversity. How to isolate key microorganisms driving marine biological and geochemical diversity, interpret culture-independent molecular characterization of microbial species, and predict causes and consequences. Laboratory component: what constitutes physiological and metabolic microbial diversity, how evolutionary and ecological processes diversify individual cells into physiologically heterogeneous populations; and the principles of interactions between individuals, their population, and other biological entities in a dynamically changing microbial ecosystem. Prerequisites: CEE 274A and CEE 274B, or equivalents.
Same as: BIOHOPK 274, CEE 274S, ESS 253S
BIO 277. Plant Microbe Interaction. 3 Units.
Molecular basis of plant symbiosis and pathogenesis. Topics include mechanisms of recognition and signaling between microbes and plant hosts, with examples such as the role of small molecules, secreted peptides, and signal transduction pathways in symbiotic or pathogenic interactions. Readings include landmark papers together with readings in the contemporary literature. Prerequisites: Biology core and two or more upper division courses in genetics, molecular biology, or biochemistry. Recommended: plant genetics or plant biochemistry.
Same as: BIO 177

BIO 278. Microbiology Literature. 3 Units.
For advanced undergraduates and first-year graduate students. Critical reading of the research literature in prokaryotic genetics and molecular biology, with particular applications to the study of major human pathogens. Classic and foundational papers in pathogenesis, genetics, and molecular biology; recent literature on bacterial pathogens such as Salmonella, Vibrio, and/or Yersinia. Diverse experimental approaches: biochemistry, genomics, pathogenesis, and cell biology. Prerequisites: Biology Core and two upper-division courses in genetics, molecular biology, or biochemistry.
Same as: BIO 178

BIO 27S. Evolution: From DNA to Dinosaurs. 3 Units.
This course centers on the fundamental idea of evolution, which impacts fields as disparate as genetics to paleontology. You will learn about the history of evolutionary thought, including Darwin's idea of evolution by natural selection, and explore evolutionary timescales both small and large. Topics include population genetics, genomics, molecular evolution, evolutionary forces, formation of new species, evolutionary divergences in the history of life, and evidence of evolution, including patterns from DNA and the fossil record.

BIO 282. Modeling Cultural Evolution. 3 Units.
Seminar. Quantitative models for the evolution of socially transmitted traits. Rates of change of learned traits in populations and patterns of cultural diversity as a function of innovation and cultural transmission. Learning in constant and changing environments. Possible avenues for gene-culture coevolution.
Same as: BIO 182

BIO 283. Theoretical Population Genetics. 3 Units.
Models in population genetics and evolution. Selection, random drift, gene linkage, migration, and inbreeding, and their influence on the evolution of gene frequencies and chromosome structure. Models are related to DNA sequence evolution. Prerequisites: calculus and linear algebra, or consent of instructor.
Same as: BIO 183

BIO 286. Natural History of the Vertebrates. 4 Units.
Broad survey of the diversity of vertebrate life. Discussion of the major branches of the vertebrate evolutionary tree, with emphasis on evolutionary relationships and key adaptations as revealed by the fossil record and modern phylogenetics. Modern orders introduced through an emphasis on natural history, physiology, behavioral ecology, community ecology, and conservation. Lab sessions focused on comparative skeletal morphology through hands-on work with skeletal specimens. Discussion of field methods and experience with our local vertebrate communities through field trips to several of California's distinct biomes. Prerequisite: Biology core.

BIO 287A. Advanced Topics in Mathematical Evolutionary Biology. 3 Units.
Focused examination of specific topics in mathematical evolutionary biology. Course themes may include: mathematical properties of statistics used in human population genetics, mathematics of evolutionary trees, and the intersection of population genetics and phylogenetics.
BIO 30. Ecology for Everyone. 4 Units.
Everything is connected, but how? Ecology is the science of interactions and the changes they generate. This project-based course links individual behavior, population growth, species interactions, and ecosystem function. Introduction to measurement, observation, experimental design and hypothesis testing in field projects, mostly done in groups. The goal is to learn to think analytically about everyday ecological processes involving bacteria, fungi, plants, animals and humans. The course uses basic statistics to analyze data; there are no math prerequisites except arithmetic. Open to everyone, including those who may be headed for more advanced courses in ecology and environmental science.

BIO 300. Graduate Research. 1-10 Unit.
For graduate students only. Individual research by arrangement with in-department instructors.

BIO 300X. Out-of-Department Graduate Research. 1-10 Unit.
Individual research by arrangement with out-of-department instructors. Master’s students: credit for work arranged with out-of-department instructors is restricted to Biology students and requires approved department petition. See http://biohonors.stanford.edu for more information. May be repeated for credit.

BIO 301. Frontiers in Biology. 1-3 Unit.
Limited to and required of first-year Ph.D. students in molecular, cellular, and developmental biology. Current research in molecular, cellular, and developmental biology emphasizing primary research literature. Held in conjunction with the department’s Monday seminar series. Students and faculty meet weekly before the seminar for a student presentation and discussion of upcoming papers.

Required of first-year PhD students in population biology, and ecology and evolution. Major conceptual issues and developing topics. This course is open only to Biology PhD students and is not open to auditors.*

Required of first-year PhD students in population biology, and ecology and evolution. Major conceptual issues and developing topics. This course is open only to Biology PhD students and is not open to auditors.*

Required of first-year PhD students in population biology, and ecology and evolution. Major conceptual issues and developing topics. This course is open only to Biology PhD students and is not open to auditors.

BIO 313. Ethics in the Anthropocene. 1 Unit.
Today, in the Anthropocene, humankind impacts the environment on a massive scale, with severe outcomes for species, ecosystems, and landscapes. The consequences of this impact raise many ethical questions, with new dilemmas forcing us to consider new moral values and re-consider old ones. In this course, we will become acquainted with environmental conservation ethics and philosophy, and acquire the toolkit of concepts and ideas that will allow us to tackle the current environmental ethical debates. We will explore the role of ethics in the environmental and conservation sciences by discussing the philosophical foundations for moral values in the Anthropocene, as well as by examining practical current-day issues, such as reintroductions, invasive species and conservation advocacy.

BIO 327. Research Frontiers in Biodiversity and Ecosystem Services. 3 Units.
This advanced seminar explores research frontiers in the science of biodiversity and ecosystem services. We will begin with foundational work and then shift to key frontiers now opening up, including DNA barcoding, food web structure and ecosystem processes; remote sensing and modeling biodiversity change and ecosystem services; relating big data on natural capital and human well-being; and nature experience and human mental health. Students will lead discussions and make research presentations. To apply, please email the instructor (gdaily@stanford.edu).

BIO 329. Matrix Methods for Dynamic Models and Data Analysis. 1 Unit.

BIO 332. Neuroethology: The Neural Control of Behavior. 3 Units.
Preference to sophomores. Animal behavior offers insights about evolutionary adaptations and this seminar will discuss the origins of the study of animal behavior and its development to the present. How does the nervous system control behavior and how is it changed by behavior? We will analyze and discuss original research papers about the neural basis of behavior. The use and misuse of parallels between animal and human behavior. Possible field trip to observe animals in their natural habitat.

Same as: HUMBIO 91Q

BIO 330. Stochastic Methods for Simulation, Dynamics and Data Analysis. 1 Unit.

BIO 332. Evolutionary Genomics. 2 Units.
We will read classic and modern papers relevant to evolutionary genomics, and discuss. We will cover a broad range of topics, methods, and species.

BIO 33N. Conservation Science and Practice. 3 Units.
Preference to freshmen. This course will explore the potential for harmonizing people and nature, for achieving improved outcomes in the well-being of both as a result of conservation investments and interventions. We will consider biophysical, economic, social, and psychological perspectives, examining an array of conservation goals, from protecting endangered species to securing ecosystem services (such as flood control and climate stability) to alleviating poverty and improving mental well-being. We will also study the design and implementation of real conservation and human development efforts worldwide, among the many farmers, ranchers, fishing people, and others managing Earth’s lands and waters. Highlights include a field trip to Jasper Ridge Biological Preserve, Stanford’s very own nature reserve, and guest visits of some impressive conservation leaders internationally.

BIO 342. Plant Biology Seminar. 1-3 Unit.
Topics in plant biology presented at a weekly seminar. Topics announced at the beginning of each quarter. Current literature. May be repeated for credit. See https://dbp.carnegiescience.edu/events.

BIO 346. Advanced Seminar on Prokaryotic Molecular Biology. 1 Unit.
Enrollment limited to PhD students associated with departmental research groups in genetics or molecular biology.

Same as: CSB 346, GENE 346
BIO 34N. Hunger. 3 Units.
The biology of hunger and satiety, disease states that disrupt normal responses to hunger and satiety, starvation responses and adaptations to starvation in a variety of organisms, food production and distribution mechanisms, historic famines and their causes, the challenges of providing adequate food and energy for the Earth's growing population, local and global efforts to alleviate hunger, and hunger in fiction.

BIO 35N. Climate change ecology: Is it too late?. 3 Units.
This Introductory Seminar will explore the consequences of climate change on ecological communities, focusing on two emerging concepts: "disequilibrium," which emphasizes that it can take long time for communities to respond to climate change because of species interactions, and "historical contingency," which proposes that the order in which species invade and disappear as communities re-assemble in response to climate change will determine which species will persist. The seminar will involve lecture, discussion, writing, and visit to Jasper Ridge Biological Preserve.

BIO 375. Field Ecology & Conservation. 4 Units.
This course is based on question-driven research in the field, addressing both conceptual frameworks and methodological aspects of evolutionary ecology and conservation biology. It consists of faculty-led research projects and student independent projects. The field part takes place in a tropical rain forest research station in Mexico September 5-15, 2014. The field component is followed by sessions on campus, where the research data are analyzed, discussed and prepared as scientific papers. The training includes presentations of the papers in a mini-symposium organized as a professional meeting.

BIO 380. Career Exploration and Planning. 1 Unit.
In this course, students will discuss various career path options with a PhD in life sciences and learn to design their own path. Some classes will be led by invited guests from various professions. There may be field trips to local companies or organizations. Open to Biology PhD students in year 3 or beyond.

BIO 383. Seminar in Population Genetics. 1-3 Unit.
Literature review, research, and current problems in the theory and practice of population genetics and molecular evolution. May be repeated for credit. Prerequisite: consent of instructor.

BIO 384. Theoretical Ecology. 1-3 Unit.
Recent and classical research papers in ecology, and presentation of work in progress by participants. Prerequisite: consent of instructor.

BIO 386. Conservation and Population Genomics. 1 Unit.
This course will involve lecture, discussion, writing, and visit to Jasper Ridge Biological Preserve. Lab fee. Information about this class is available at http://biox.stanford.edu/courses/459.html. Recommended: basic mathematics, biology, chemistry, and physics.

BIO 459. Frontiers in Interdisciplinary Biosciences. 1 Unit.
Students register through their affiliated department; otherwise register for CHEMENG 459. For specialists and non-specialists. Sponsored by the Stanford BioX Program. Three seminars per quarter address scientific and technical themes related to interdisciplinary approaches in bioengineering, medicine, and the chemical, physical, and biological sciences. Leading investigators from Stanford and the world present breakthroughs and endeavors that cut across core disciplines. Pre-seminars introduce basic concepts and background for non-experts. Registered students attend all pre-seminars; others welcome. See http://biox.stanford.edu/courses/459.html. Recommended: basic mathematics, biology, chemistry, and physics.

Same as: BIOC 459, BIEO 459, CHEM 459, CHEMENG 459, PSYCH 459

BIO 46. Introduction to Research in Ecology and Evolutionary Biology. 4 Units.
The goal of this course is to develop an understanding of how to conduct ecological research, using a topic in Ecology, Evolutionary Biology, and Plant Biology as a practical example. This includes the complete scientific process: assessing background literature, generating testable hypotheses, learning techniques for field- and lab-based data collection, analyzing data using appropriate statistical methods, and writing and sharing results. To build these skills, this course focuses on the microorganisms associated with lichen epiphytes. Students, working in teams, develop novel research hypotheses and execute the necessary experiments and measurements to test these hypotheses. In addition, students will learn how to manipulate, visualize and analyze data in R. The capstone of the course is an oral defense of students’ findings, as well as a research paper in the style of a peer-reviewed journal article. Labs are completed both on campus and at Jasper Ridge. Lab fee. Information about this class is available at http://bio44.stanford.edu. Satisfies WIM in Biology.

BIO 47. Introduction to Research in Ecology and Evolutionary Biology. 4 Units.
The goal of this course is to develop an understanding of how to conduct ecological research, using a topic in Ecology, Evolutionary Biology, and Plant Biology as a practical example. This includes the complete scientific process: assessing background literature, generating testable hypotheses, learning techniques for field- and lab-based data collection, analyzing data using appropriate statistical methods, and finally writing and sharing results. To build these skills, this course will focus on nectar microbes at Stanford’s nearby Jasper Ridge Biological Preserve. Students, working in teams, will develop novel research hypotheses and execute the necessary experiments and measurements to test these hypotheses. The capstone of the course will be an oral defense of students’ findings, as well as a research paper in the style of a peer-reviewed journal article. Labs will be completed both on campus and at Jasper Ridge. Lab fee. Information about this class is available at http://bio44.stanford.edu. Satisfies WIM in Biology.
BIO 4N. Peopleomics: The science and ethics of personalized genomic medicine. 3 Units.
Exploration of the new field of personalized genomic medicine. Personalized medicine is based on the idea that each person’s unique genome sequence can be used to predict risk of acquiring specific diseases, and to make more informed medical choices. The science behind these approaches; where they are heading in the future; and the ethical implications such technology presents. Lectures augmented with hands-on experience in exploring and analyzing a real person’s genome.

BIO 50S. Introduction to Cancer Biology. 3 Units.
Introduction to the molecular basis of cancer. This course will examine the biological processes that are disrupted in cancer, such as DNA repair, cell cycle control and signaling pathways, as well as the science behind some current treatments. Prerequisites: general biology.

BIO 51S. The Gene: The History and Science of our Genetic Code. 3 Units.
This discussion-based course will use the novel “The gene” by Siddhartha Mukherjee and other selected readings to explore the science behind our genetic code. We will cover topics such as regulation of gene expression, inheritance, genetic testing, manipulation of the genome, and the relationship between genetics and identity. Prerequisites: Instructor consent, AP Biology Recommended.

BIO 52. I, Scientist: Diversity Improves the Scientific Practice. 1 Unit.
Disciplinary priorities, research agendas, and innovations are determined by the diversity of participants and problem-solving is more successful with a broad range of approaches. Using case studies in scientific research, we propose to use these insights to help our students learn why a diverse scientific community leads to better discovery and improves the relevance of science to society. Our premise is that a diverse set of perspectives will impact not only how we learn science, but how we do science.
Same as: CSRE 52H

BIO 5N. Tipping Point for Planet Earth: How Close Are We to the Edge?. 3 Units.
We will explore why the earth is headed toward a tipping point: a change that is so rapid, so extreme, and so unexpected that humanity may not be able to recover. We will cover synergies between people, stuff, storms, hunger, thirst, toxins, disease and war. Students will read chapters from the instructor’s new book, Tipping Point for Planet Earth, and will participate in class discussions. Each student will produce their own projects based on one of the course themes.

BIO 60. Problem solving in infectious disease. 4 Units.
Why is Lyme disease spreading? How does HIV become drug resistant? How do other animals affect our disease risk? In BIO 60 students will examine actual case studies to experience how different scientific approaches are used to battle infectious disease. They will evaluate information presented in the popular media and the scientific literature, and will directly participate in the scientific process through hands-on collection, documentation and analyses of authentic scientific data. Students will cultivate their scientific curiosity by discovering the natural world with a Foldscope, the ‘origami paper microscope’ (https://microcosmos.foldscope.com). Students will build critical thinking skills by creating hypotheses, and designing experiments that pertain to problems in infectious disease. Students will work in teams to expand their thinking and will practice communicating science to different audiences.

BIO 61. Science as a Creative Process. 4 Units.
What is the process of science, and why does creativity matter? We'll delve deeply into the applicability of science in addressing a vast range of real-world problems. This course is designed to teach the scientific method as it's actually practiced by working scientists. It will cover how to ask a well-posed question, how to design a good experiment, how to collect and interpret quantitative data, how to recover from error, and how to communicate findings. Facts matter! Course topics will include experimental design, statistics and statistical significance, formulating appropriate controls, modeling, peer review, and more. The course will incorporate a significant hands-on component featuring device fabrication, testing, and measurement. Among other "Dorm Science" activities, we'll be distributing Arduino microcontroller kits and electronic sensors, then use these items, along with other materials, to complete a variety of group and individual projects outside the classroom. The final course assignment will be to develop and write a scientific grant proposal to test a student-selected myth or scientific controversy. Although helpful, no prior experience with electronics or computer programming is required. Recommended for freshmen.
Same as: APPPHYS 61

BIO 62. Microbiology Experiments. 4 Units.
Micro-X is an on-ramp course in which we explore classic to modern bacteriology experiments with a focus on design and logic. Bacterial biochemistry, structure, metabolism, and genetics are covered in lecture. The lab includes microbial culture, microscopic examination, and bacteriophage discovery and characterization.

BIO 7N. Introduction to Conservation Photography. 3 Units.
Introduction to the field of conservation photography and the strategic use of visual communication in addressing issues concerning the environment and conservation. Students will be introduced to basic digital photography, digital image processing, and the theory and application of photographic techniques. Case studies of conservation issues will be examined through photographs and multimedia platforms including images, video, and audio. Lectures, tutorials, demonstrations, and optional field trips will culminate in the production of individual and group projects.

BIO 7S. Introduction to Biology. 3 Units.
Introduction to several major fields of biology, including biochemistry, cell biology, genetics, evolution, and biodiversity. Introduces the general approaches used by scientists to study life and explores recent advances in each area during weekly discussion section. Not intended for biology majors, but provides the foundation for higher-level biology courses. Prerequisite: high school biology.

BIO 7SL. Introduction to Biology Lab. 2 Units.
Optional laboratory to be taken with BIO7S. Introduction to basic biological laboratory techniques, including microscopy, identification of biomolecules, assaying enzyme activity, genetic manipulation of microorganisms, assaying the effects of gene mutation on protein function, and using PCR to genotype organisms.

BIO 802. TGR Dissertation. 0 Units.

BIO 81. Introduction to Ecology. 4 Units.
This course will introduce you to the first principles of the science of ecology, the study of interactions between organisms and their environment. Prerequisites: None.

BIO 82. Genetics. 4 Units.
The focus of the course is on the basic mechanisms underlying the transmission of genetic information and on the use of genetic analysis to study biological and medical questions. Major topics will include: (1) the use of existing genetic variation in humans and other species to identify genes that play an important role in determining traits and disease-susceptibility, (2) the analysis of mutations in model organisms and their use in the investigation of biological processes and questions and (3) using genetic information for diagnosis and the potential for genetic manipulations to treat disease. Prerequisites: None.
BIO 83. Biochemistry & Molecular Biology. 4 Units.
Introduction to the molecular and biochemical basis of life. Lecture topics include the structure and function of proteins, nucleic acids, lipids and carbohydrates, energy metabolism, signal transduction, epigenetics and DNA repair. The course will also consider how defects in these processes cause disease. Prerequisites: None.

BIO 84. Physiology. 4 Units.
The fundamental concepts and systems of animal and plant physiology are the subject matter of this course. Prerequisites: None.

BIO 85. Evolution. 4 Units.

BIO 86. Cell Biology. 4 Units.
This course will focus on the basic structures inside cells and how they execute cellular functions. Topics include organelles, membrane trafficking, the cytoskeleton, cell division, and signal transduction. Classic and recent primary literature will be incorporated into lectures with an emphasis on state of the art experimental approaches. Prerequisites: BIO 83 is highly recommended.

BIO 8N. Human Origins. 3 Units.
A survey of the anatomical and behavioral evidence for human evolution and of the increasingly important information from molecular genetics. Emphasis on the split between the human and chimpanzee lines 6-7 million years ago, the appearance of the australopiths by 4.1 million years ago, the emergence of the genus Homo about 2.5 million years ago, the spread of Homo from Africa 1.7-1.6 million years ago, the subsequent divergence of Homo into different species on different continents, and the expansion of fully modern humans (Homo sapiens) from Africa about 50,000 years ago to replace the Neanderthals and other non-modern Eurasians.

BIO 8S. Introduction to Human Physiology. 4 Units.
Normal functioning and pathophysiology of major organ systems: nervous, respiratory, cardiovascular, renal, digestive, and endocrine. Additional topics include integrative physiology, clinical case studies, and applications in genomics-based personalized medicine.