BIOLOGY (BIO)

BIO 102. Ecosystem Ecology and Biogeochemistry. 3 Units.
An introduction to ecosystem ecology and terrestrial biogeochemistry. This course will focus on the dynamics of carbon and other biologically essential elements in the Earth System, on spatial scales from local to global.

BIO 103. HUMAN AND PLANET HEALTH. 2 Units.
Two of the biggest challenges humanity has to face - promoting human health and halting environmental degradation ¿ are strongly linked. The emerging field of Planetary Health recognizes these inter-linkages and promotes creative, interdisciplinary solutions that protect human health and the health of the ecosystems on which we depend. Through a series of lectures and case-study discussions, students will develop an in-depth understanding of the ¿Planetary Health¿ concept, its foundation, goals, priority areas of action, methods of investigation, and the most relevant immediate challenges.
Same as: BIO 203

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. 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.
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. NOTE: All classes take place at Jasper Ridge Biological Preserve.
Same as: EARTHSYS 105A

BIO 105B. Ecology and Natural History of Jasper Ridge Biological Preserve. 4 Units.
Formerly 96B - Jasper Ridge Docent Training. Second 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. These topics are 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. NOTE: All classes take place at Jasper Ridge.
Same as: EARTHSYS 105B

BIO 109A. Building Blocks for Chronic Disease. 3 Units.
Researchers have come a long way in developing therapies for chronic disease but a gap remains between current solutions and the ability to address the disease in full. This course provides an overview to the underlying biology of many of these diseases and how they may connect to each other. A 'think outside of the box' approach to drug discovery is needed to bridge such a gap in solutions, and this course teaches the building blocks for that approach. Could Legoland provide the answer? This is a guest lecture series with original contributions from prominent thought leaders in academia and industry. Interaction between students and guest lecturers is expected. 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. Advances in Therapeutic Development: Neuronal Signaling and Immunology. 3 Units.
This is a seminar course focused on teaching students about novel research and applications in the fields of neuroscience and immunology. The course will cover topics that range from the neuronal pathways in opioid addiction and the mechanics of pain, to advances in immunotherapy. Students will engage with diverse material from leading neuroscience and cancer immunotherapy experts in the Bay Area. Guest lecturers will visit from both academia and neighboring pharmaceutical/biotechnology companies. Active participation is required. 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 10N. Using Physics to Explain Biology: Mechanistic Approaches to Plankton Ecology. 3 Units.
People often think of physics and biology as entirely separate scientific pursuits, but in fact the two can be productively combined. All plants and animals live in a physical environment, and the laws of physics that govern that environment often determine how organisms function and interact. In this seminar, we will explore the confluence of physics and biology through an in-depth look at how phytoplankton and zooplankton -- the small algae and animals that form the base of the oceans' food web -- are affected by the physical properties of their watery world. You will be amazed by our ability to explain the ecology of these organisms, and how important that ecology is to life on earth.

BIO 110. The Chromatin-Regulated 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. 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 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, EARTHSYS 217, 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 paleontological 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. Prokaryotic Biology - A Quantitative Approach. 3 Units.
To live, microbes have to successfully coordinate various cellular processes, in line with available resources and what environmental conditions demand. This course introduces quantitative advances in understanding this coordination and their consequences across scales: from molecular biology via growth to population dynamics and ecology. Dry lab sessions complement lectures to introduce computational approaches. Python based analysis tools will be introduced. Prerequisite: MATH 51 or MATH 19, 20,21. Recommended: microbiology (e.g. BIO 62 or 162) and molecular biology/biochemistry/genetics courses (e.g. BIO 82 or 83) and basic familiarity with coding.
Same as: BIO 220

BIO 121. ORNITHOLOGY. 2 Units.
Advanced undergraduate survey of ornithology, introducing students to the biology of birds and giving them to tools to use birds as model systems for research. Topics will include avian evolution, physiology, adaptations, behavior, and ecology. Focus throughout on identification of California birds and applications to current bird conservation issues. Course will include lectures and a field component which will expose students to standard avian research techniques such as mistnetting, banding, and point count surveys. Prerequisite: BIO 81 or BIO 105 or instructor approval.
Same as: BIO 221

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: Human Biology core or BIO 82, 83, 86, or with permission 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: APPPHYS 205, BIO 226

BIO 129. Fundamentals and Frontiers in Plant Biology. 3 Units.
This course will serve as a primer for all levels of graduate, co-term, and upper-level undergraduates interested in learning about the fundamental aspects of plant biology, the latest advances in tools, techniques, and theories that link basic science with translational science and applications for solving major societal challenges of today and tomorrow. In addition, this course will serve to introduce the breadth of plant research on campus and help solidify a cohort of students interested in plant biology.
Same as: BIO 229

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).
Same as: EARTHSYS 130A

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: APPPHYS 232, BIO 232, BIOPHYS 232, GENE 232

BIO 134. Molecular and cellular analysis of human cancer cell lines. 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 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.

BIO 135. Neuroethology. 3 Units.
Neuroethology is the study of the neural basis of animal behavior. We will explore the neural mechanisms of natural behaviors in a diverse set of organisms. Topics include molecular mechanisms of nervous system function, predator-prey interactions, social behavior, and other complex behaviors like learning and memory, navigation, and communication. Assessment includes group oral presentations of scientific papers, weekly homework prompts that lead into a mini grant proposal, and scientific writing and communication with the broader public on a neuroethological topic. Prerequisites: BIO 84.
Same as: BIO 235

BIO 136. Macroevolution. 3 Units.
The course will focus on the macroevolution of animals. We will be exploring how paleobiology and developmental biology/genomics have contributed to our understanding of the origins of animals, and how patterns of evolution and extinction have shaped the diversity of animal forms we observe today.
Same as: BIO 236, GEOLSCI 136, GEOLSCI 236

BIO 137. Plant Genetics. 3-4 Units.
Gene analysis, mutagenesis, transposable elements; developmental genetics of flowering and embryo development; biochemical genetics of plant metabolism; scientific and societal lessons from transgenic plants. Satisfies Central Menu Area 2. Prerequisite: Biology core or consent of instructor. Satisfies WIM in Biology.

BIO 138. Ecosystem Services: Frontiers in the Science of Valuing Nature. 3 Units.
This course explores the science of valuing nature, beginning with its historical origins and then a primary focus on its recent development and frontiers. The principal aim of the course is to enable new research and real-world applications of InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) tools and approaches. We will discuss the interconnections between people and nature and key research frontiers, such as in the realms of biodiversity, resilience, human health, poverty alleviation, and sustainable development. The science we¿ll explore is in the service of decisions, and we will use examples from real life to illustrate why this science is so critical to informing why, where, how, and how much people need nature. Prerequisite. Basic to intermediate GIS skills are required (including working with raster, vector and tabular data; loading and editing rasters, shapefiles, and tables into a GIS; understanding coordinate systems; and performing basic raster math).
Same as: BIO 238, EARTHSYS 139, EARTHSYS 239

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 lifestyles 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. 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 associations (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: BIO83 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 the 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. All students will be expected to conduct a literature research exercise leading to a written report, addressing a topic of their choosing, derived from any of the themes discussed in class. Satisfies Central Menu Area 4 for Biology majors. Prerequisite: BIO 101 or BIO 43 or HUMBIO 2A or BIO 81 and 84 or consent of instructor.
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. Genes and Disease. 3 Units.
Students in this course will uncover key principles of genetics and molecular biology through investigation of case studies of human disease and novel therapeutic approaches in development. This course will require close reading and discussion of primary literature and will emphasize and support the development of critical skills in scientific communication. Students will utilize a variety of mediums to convey scientific information to a range of audiences in a series of projects completed during the quarter. Prerequisites: BIO 82, 83 and 86 or equivalent.

BIO 147. Ecosystem Ecology and Biogeochemistry. 3 Units.
An introduction to ecosystem ecology and terrestrial biogeochemistry. This course will focus on the dynamics of carbon and other biologically essential elements in the Earth System, on spatial scales from local to global. Prerequisites: Biology 117, Earth Systems 111, or graduate standing.
Same as: BIO 240, EARTHSYS 147, EARTHSYS 247

BIO 148. Evolution of Terrestrial Ecosystems. 4 Units.
The what, when, where, and how do we know it regarding life on land through time. Fossil plants, fungi, invertebrates, and vertebrates (yes, dinosaurs) are all covered, including how all of those components interact with each other and with changing climates, continental drift, atmospheric composition, and environmental perturbations like glaciation and mass extinction. The course involves both lecture and lab components. Graduate students registering at the 200-level are expected to write a term paper, but can opt out of some labs where appropriate.
Same as: BIO 228, EARTHSYS 128, GEOLSCI 128, GEOLSCI 228

BIO 149. The Neurobiology of Sleep. 4 Units.
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. nnPreference to seniors and graduate students. nnEnrollment 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 undergraduates with backgrounds 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. Assessment based on in-class participation and short weekly papers. Enrollment limited to 15; application required. Apply at https://forms.gle/UE8EcQi3jS6do31a7 by 4:30pm on Wednesday, September 9, 2020.

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 microscope 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: 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. Highly recommended: BioCore or BIO 82, 83, 86, or consent of instructor.

BIO 155. Cell and Developmental Biology of Plants. 3 Units.
In this course we will learn how plants are built at different organizational scales from the cell, tissue, organ and organ system level. We will also learn about the experimental methods used to study plants at these different organizational levels and how to interpret and evaluate experiments that use such methods. Broadly relevant skills that will be cultivated in the course include: evaluating primarily literature, identifying gaps in knowledge, formulating research questions and designing new experimental strategies. Prerequisites: BIO 80 series.
Same as: BIO 255

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. Prerequisites: 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 5 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 161. Organismal Biology Lab. 4 Units.
This laboratory is a genuine research experience course where students will contribute to original research in a field of organismal biology. The course will consist of two modules: In the first module, students will perform a drug screen for novel compounds that influence animal behavior. In the second module, students will use gene editing technologies to test the role of specific proteins involved in mental diseases. Students will work collaboratively to collect and analyze data and will learn to communicate their findings clearly through oral and written formats. Prerequisites: BIO 82 or BIO 84 required or concurrent.

BIO 162. Mechanisms of Tissue Regeneration. 3 Units.
Many organisms possess a remarkable ability to repair and regenerate damaged organs and tissues. This course will explore the cellular and developmental mechanisms used to achieve regeneration. Students will learn the basic developmental and cellular mechanisms underlying the original formation of organs during normal development and how these mechanisms are modified during the regenerative process. The course will also consider how our expanding knowledge of regeneration mechanisms could be used to promote medically useful regeneration in humans. The course will involve extensive reading and analysis of primary literature. Prerequisites: BIO 86 and BIO160 or by consent of instructor.

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 16N. Island Ecology. 3 Units.
Preference to freshmen. How ecologists think about the world. Focus is on the Hawaiian Islands: origin, geology, climate, evolution and ecology of flora and fauna, and ecosystems. The reasons for the concentration of threatened and endangered species in Hawaii, the scientific basis for their protection and recovery. How knowledge of island ecosystems can contribute to ecology and conservation biology on continents.

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: BIO 83, and BIO 82 and/or BIO 84.

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, 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 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 176. The Developmental Basis of Animal Body Plan Evolution. 4 Units.
Animals are grouped into phyla with defined organizational characteristics such as multicellularity, axis organization, and nervous system organization, as well as morphological novelties such as eyes, limbs and segments. This course explores the developmental and molecular origins of there animal innovations. Offered alternate years. Prerequisites: None.
Same as: BIO 276

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: Declared Biology majors must have taken BIO 82 (Genetics) and BIO 83 (Biochemistry). Enrollment for undergraduates is limited to Biology majors in junior or senior year. Co-term or Ph.D. students in basic life sciences departments such as Biology, Bioengineering, and Genetics may also enroll in BIO 278. Apply at https://forms.gle/4NTtcBdWYMqRFvGc9.
Same as: BIO 278

BIO 179. Integrated Valuation of Ecosystem Services and Tradeoffs. 1-3 Unit.
This course explores the science of valuing nature, through two interwoven pathways. One is biophysical, focused on human dependence and impacts on Earth¿s life-support systems. If well managed, lands, waters, and biodiversity yield a flow of vital benefits that sustain and fulfill human life. A wild bee buzzes through a farm, pollinating vegetables as it goes. Nearby, wetlands remove chemicals from the farm¿s runoff, protecting a source of drinking water. In parklands at a city¿s edge, kids play and adults walk and talk, their exposure to nature promoting physical activity and improved mental health. The trees help maintain a favorable climate, locally and globally. We¿ll develop a framework and practical tools for quantifying this stream of benefits from nature to people.nThe second pathway is social, economic, and philosophical, weaving through concepts of well-being, human development, and conservation ¿ and the ethics and effects of their pursuit. We will look back, ahead into the future, and inward, taking a global view and considering diverse cultural perspectives. Our discussions will be situated in the context of the COVID-19 pandemic, movements for racial justice and socioeconomic equity, and efforts to enable people and nature to thrive in cities and countries worldwide.nAll of the science we¿ll explore is in service of decisions. We will dive into real-world examples to see how science can inform why, where, how, and how much people need nature. We will learn the basics of the InVEST tools (for Integrated Valuation of Ecosystem Services and Tradeoffs) to quantify benefits of nature, the equitability in access to these benefits, and the transformation of policy, finance, management, and practice to sustain and enhance them. nThe course is intended for diverse, advanced students, with interests in research and in moving from science to action for a more just and sustainable world. The instructors aim to provide an enjoyable and productive opportunity to connect ¿ remotely and yet with a lot of heart as well as intellectual drive and commitment, bringing empathy, flexibility and hopefully some humor to the day-to-day challenges we are all facing in different difficult ways. Prerequisite: Basic to intermediate GIS (Geographic Information Systems) skills are necessary. We will help with these, but not teach GIS specifically in class. Basic skills include, for example: working with raster, vector and tabular data; loading rasters, shapefiles, and tables into a GIS; changing the symbology of rasters and shapefiles in your chosen GIS; editing raster and shapefile attribute tables; understanding coordinate systems and how to re-project layers; looking at individual raster cell values; and performing basic raster math.
Same as: BIO 279

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, GEOLSCI 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 187. Mathematical Population Biology. 3 Units.
Mathematical models in population biology, in biological areas including demography, ecology, epidemiology, evolution, and genetics. Mathematical approaches include techniques in areas such as combinatorics, differential equations, dynamical systems, linear algebra, probability, and stochastic processes. Math 50 or 60 series is required, and at least two of (Bio 81, Bio 82, Bio 85) are strongly recommended.
Same as: CME 187

BIO 193. Interdisciplinary Approaches to Human Health Research. 1 Unit.
For undergraduate students participating in the Stanford ChEM-H Undergraduate Scholars Program. This course will expose students to interdisciplinary research questions and approaches that span chemistry, engineering, biology, and medicine. Focus is on the development and practice of scientific reading, writing, and presentation skills intended to complement hands-on laboratory research. Students will read scientific articles, write research proposals, make posters, and give presentations.
Same as: BIOE 193, CHEM 193, CHEMENG 193

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 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.
The goal of this class is to train students in effective scientific communication. It is designed to serve students working on their senior honors research to help facilitate the completion of their honors thesis. Topics covered will include elevator pitches, creating and improving the sections of the thesis, oral presentations and posters in the context of students¿ individual research projects. Emphasis will be on building and practicing the skills for 1) completing your thesis, poster and presentations and 2) gaining a conceptual understanding of effective scientific writing and communication that will be applicable more broadly. Satisfies the WIM requirement 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. 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 203. HUMAN AND PLANET HEALTH. 2 Units.
Two of the biggest challenges humanity has to face - promoting human health and halting environmental degradation ¿ are strongly linked. The emerging field of Planetary Health recognizes these inter-linkages and promotes creative, interdisciplinary solutions that protect human health and the health of the ecosystems on which we depend. Through a series of lectures and case-study discussions, students will develop an in-depth understanding of the ¿Planetary Health¿ concept, its foundation, goals, priority areas of action, methods of investigation, and the most relevant immediate challenges.
Same as: BIO 103

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. The Chromatin-Regulated 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 211. Proteostasis: From Basic Principles to Aging and Neurodegeneration. 3 Units.
The control of cellular protein homeostasis, also called Proteostasis, is emerging as the central cellular process controlling the stability, function and quality control of the proteome and central to our understanding of a vast range of diseases. The proteostasis machinery maintains the function of destabilized and mutant proteins; assists the degradation of damaged and aggregated proteins and monitors the health of the proteome, adjusting it in response to environmental or metabolic stresses. Proteostasis disfunction is linked to diseases ranging from neurodegeneration to aging.nThis class will introduce students to the exciting cutting edge discoveries in this field through presentations by leaders in the field and discussions of primary literature illustrating how understanding proteostasis can be leveraged to understand fundamental biological processes, such as evolution and aging and to ameliorate a wide range of diseases.

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. Advanced undergraduates may participate with the permission of the Course Director.
Same as: BIOC 224, MCP 221

BIO 220. Prokaryotic Biology - A Quantitative Approach. 3 Units.
To live, microbes have to successfully coordinate various cellular processes, in line with available resources and what environmental conditions demand. This course introduces quantitative advances in understanding this coordination and their consequences across scales: from molecular biology via growth to population dynamics and ecology. Dry lab sessions complement lectures to introduce computational approaches. Python based analysis tools will be introduced. Prerequisite: MATH 51 or MATH 19, 20,21. Recommended: microbiology (e.g. BIO 62 or 162) and molecular biology/biochemistry/genetics courses (e.g. BIO 82 or 83) and basic familiarity with coding.
Same as: BIO 120

BIO 221. ORNITHOLOGY. 2 Units.
Advanced undergraduate survey of ornithology, introducing students to the biology of birds and giving them to tools to use birds as model systems for research. Topics will include avian evolution, physiology, adaptations, behavior, and ecology. Focus throughout on identification of California birds and applications to current bird conservation issues. Course will include lectures and a field component which will expose students to standard avian research techniques such as mistnetting, banding, and point count surveys. Prerequisite: BIO 81 or BIO 105 or instructor approval.
Same as: BIO 121

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, PHYSICS 223

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. 3 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 228. Evolution of Terrestrial Ecosystems. 4 Units.
The what, when, where, and how do we know it regarding life on land through time. Fossil plants, fungi, invertebrates, and vertebrates (yes, dinosaurs) are all covered, including how all of those components interact with each other and with changing climates, continental drift, atmospheric composition, and environmental perturbations like glaciation and mass extinction. The course involves both lecture and lab components. Graduate students registering at the 200-level are expected to write a term paper, but can opt out of some labs where appropriate.
Same as: BIO 148, EARTHSYS 128, GEOLSCI 128, GEOLSCI 228

BIO 229. Fundamentals and Frontiers in Plant Biology. 3 Units.
This course will serve as a primer for all levels of graduate, co-term, and upper-level undergraduates interested in learning about the fundamental aspects of plant biology, the latest advances in tools, techniques, and theories that link basic science with translational science and applications for solving major societal challenges of today and tomorrow. In addition, this course will serve to introduce the breadth of plant research on campus and help solidify a cohort of students interested in plant biology.
Same as: BIO 129

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 and regulation of immune responses; infectious diseases and vaccines; allergy, inflammation, and autoimmunity. COVID-19 will be featured as a major example. Lectures and discussion in class and in sections. 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 231. Structural Equation Modeling for Ecologists. 1 Unit.
We will focus on learning to use structural equation modeling (SEM) as a technique for ecological inference. Class will include short lectures, paper discussions, and SEM coding workshops in R. Meetings will generally last only 60 minutes.

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 the 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. All students will be expected to conduct a literature research exercise leading to a written report, addressing a topic of their choosing, derived from any of the themes discussed in class. Satisfies Central Menu Area 4 for Biology majors. Prerequisite: BIO 101 or BIO 43 or HUMBIO 2A or BIO 81 and 84 or consent of instructor.
Same as: BIO 144, HUMBIO 112

BIO 235. Neuroethology. 3 Units.
Neuroethology is the study of the neural basis of animal behavior. We will explore the neural mechanisms of natural behaviors in a diverse set of organisms. Topics include molecular mechanisms of nervous system function, predator-prey interactions, social behavior, and other complex behaviors like learning and memory, navigation, and communication. Assessment includes group oral presentations of scientific papers, weekly homework prompts that lead into a mini grant proposal, and scientific writing and communication with the broader public on a neuroethological topic. Prerequisites: BIO 84.
Same as: BIO 135

BIO 236. Macroevolution. 3 Units.
The course will focus on the macroevolution of animals. We will be exploring how paleobiology and developmental biology/genomics have contributed to our understanding of the origins of animals, and how patterns of evolution and extinction have shaped the diversity of animal forms we observe today.
Same as: BIO 136, GEOLSCI 136, GEOLSCI 236

BIO 238. Ecosystem Services: Frontiers in the Science of Valuing Nature. 3 Units.
This course explores the science of valuing nature, beginning with its historical origins and then a primary focus on its recent development and frontiers. The principal aim of the course is to enable new research and real-world applications of InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) tools and approaches. We will discuss the interconnections between people and nature and key research frontiers, such as in the realms of biodiversity, resilience, human health, poverty alleviation, and sustainable development. The science we¿ll explore is in the service of decisions, and we will use examples from real life to illustrate why this science is so critical to informing why, where, how, and how much people need nature. Prerequisite. Basic to intermediate GIS skills are required (including working with raster, vector and tabular data; loading and editing rasters, shapefiles, and tables into a GIS; understanding coordinate systems; and performing basic raster math).
Same as: BIO 138, EARTHSYS 139, EARTHSYS 239

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 chose an environmental niche, collect and identify resident fungi, and hypothesize about their community relationship. Prerequisite: BIO 81, 85 recommended.
Same as: BIO 115

BIO 240. Ecosystem Ecology and Biogeochemistry. 3 Units.
An introduction to ecosystem ecology and terrestrial biogeochemistry. This course will focus on the dynamics of carbon and other biologically essential elements in the Earth System, on spatial scales from local to global. Prerequisites: Biology 117, Earth Systems 111, or graduate standing.
Same as: BIO 147, EARTHSYS 147, EARTHSYS 247

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. 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.
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. nnPreference to seniors and graduate students. nnEnrollment 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 251. Quantitative Evolutionary Dynamics and Genomics. 3 Units.
The genomics revolution has fueled a renewed push to model evolutionary processes in quantitative terms. This course will provide an introduction to quantitative evolutionary modeling through the lens of statistical physics. Topics will range from the foundations of theoretical population genetics to experimental evolution of laboratory microbes. Course work will involve a mixture of pencil-and-paper math, writing basic computer simulations, and downloading and manipulating DNA sequence data from published datasets. This course is intended for upper level physics and math students with no biology background, as well as biology students who are comfortable with differential equations and probability.
Same as: APPPHYS 237

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 255. Cell and Developmental Biology of Plants. 3 Units.
In this course we will learn how plants are built at different organizational scales from the cell, tissue, organ and organ system level. We will also learn about the experimental methods used to study plants at these different organizational levels and how to interpret and evaluate experiments that use such methods. Broadly relevant skills that will be cultivated in the course include: evaluating primarily literature, identifying gaps in knowledge, formulating research questions and designing new experimental strategies. Prerequisites: BIO 80 series.
Same as: BIO 155

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. Prerequisites: BIO 82, 83, 84, 86.
Same as: BIO 158

BIO 25Q. Cystic fibrosis: from medical conundrum to precision medicine success story. 3 Units.
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?nnThrough 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 and astronomical drug costs.

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.nnnThis class is open to both graduate and undergraduate students, but requires sufficient backgrounds in college level genetics, cell biology and biochemistry. Undergraduates who are interested are required to contact the course director first.
Same as: GENE 267, NENS 267

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, STATS 345

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 273A. Environmental Microbiology I. 3 Units.
Basics of microbiology and biochemistry. The biochemical and biophysical principles of biochemical reactions, energetics, and mechanisms of energy conservation. Diversity of microbial catabolism, flow of organic matter in nature: the carbon cycle, and biogeochemical cycles. Bacterial physiology, phylogeny, and the ecology of microbes in soil and marine sediments, bacterial adhesion, and biofilm formation. Microbes in the degradation of pollutants. Prerequisites: CHEM 33,CHEM 121 (formerly CHEM 35), and BIOSCI 83, CHEMENG 181, or equivalents.
Same as: CEE 274A, CHEMENG 174, CHEMENG 274

BIO 273B. Microbial Bioenergy Systems. 3 Units.
Introduction to microbial metabolic pathways and to the pathway logic with a special focus on microbial bioenergy systems. The first part of the course emphasizes the metabolic and biochemical principles of pathways, whereas the second part is more specifically directed toward using this knowledge to understand existing systems and to design innovative microbial bioenergy systems for biofuel, biorefinery, and environmental applications. There also is an emphasis on the implications of rerouting of energy and reducing equivalents for the fitness and ecology of the organism. Prerequisites: CHEMENG 174 or 181 and organic chemistry, or equivalents.
Same as: CEE 274B, CHEMENG 456

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 276. The Developmental Basis of Animal Body Plan Evolution. 4 Units.
Animals are grouped into phyla with defined organizational characteristics such as multicellularity, axis organization, and nervous system organization, as well as morphological novelties such as eyes, limbs and segments. This course explores the developmental and molecular origins of there animal innovations. Offered alternate years. Prerequisites: None.
Same as: BIO 176

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: Declared Biology majors must have taken BIO 82 (Genetics) and BIO 83 (Biochemistry). Enrollment for undergraduates is limited to Biology majors in junior or senior year. Co-term or Ph.D. students in basic life sciences departments such as Biology, Bioengineering, and Genetics may also enroll in BIO 278. Apply at https://forms.gle/4NTtcBdWYMqRFvGc9.
Same as: BIO 178

BIO 279. Integrated Valuation of Ecosystem Services and Tradeoffs. 1-3 Unit.
This course explores the science of valuing nature, through two interwoven pathways. One is biophysical, focused on human dependence and impacts on Earth¿s life-support systems. If well managed, lands, waters, and biodiversity yield a flow of vital benefits that sustain and fulfill human life. A wild bee buzzes through a farm, pollinating vegetables as it goes. Nearby, wetlands remove chemicals from the farm¿s runoff, protecting a source of drinking water. In parklands at a city¿s edge, kids play and adults walk and talk, their exposure to nature promoting physical activity and improved mental health. The trees help maintain a favorable climate, locally and globally. We¿ll develop a framework and practical tools for quantifying this stream of benefits from nature to people.nThe second pathway is social, economic, and philosophical, weaving through concepts of well-being, human development, and conservation ¿ and the ethics and effects of their pursuit. We will look back, ahead into the future, and inward, taking a global view and considering diverse cultural perspectives. Our discussions will be situated in the context of the COVID-19 pandemic, movements for racial justice and socioeconomic equity, and efforts to enable people and nature to thrive in cities and countries worldwide.nAll of the science we¿ll explore is in service of decisions. We will dive into real-world examples to see how science can inform why, where, how, and how much people need nature. We will learn the basics of the InVEST tools (for Integrated Valuation of Ecosystem Services and Tradeoffs) to quantify benefits of nature, the equitability in access to these benefits, and the transformation of policy, finance, management, and practice to sustain and enhance them. nThe course is intended for diverse, advanced students, with interests in research and in moving from science to action for a more just and sustainable world. The instructors aim to provide an enjoyable and productive opportunity to connect ¿ remotely and yet with a lot of heart as well as intellectual drive and commitment, bringing empathy, flexibility and hopefully some humor to the day-to-day challenges we are all facing in different difficult ways. Prerequisite: Basic to intermediate GIS (Geographic Information Systems) skills are necessary. We will help with these, but not teach GIS specifically in class. Basic skills include, for example: working with raster, vector and tabular data; loading rasters, shapefiles, and tables into a GIS; changing the symbology of rasters and shapefiles in your chosen GIS; editing raster and shapefile attribute tables; understanding coordinate systems and how to re-project layers; looking at individual raster cell values; and performing basic raster math.
Same as: BIO 179

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 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 28S. Molecular Genetics and Biotechnology. 3 Units.
This course covers the fundamentals of molecular genetics, including principles of how genes work, how gene expression is regulated in both prokaryotes and eukaryotes, and how signals are passed from cells to cells that are far away. We will also explore key advances in biotechnology, including cloning, sequencing, and next-generation sequencing, and discuss case studies involving cancer, Huntington¿s Disease, and more.

BIO 290. Teaching Practicum in Biology. 1-5 Unit.
Open to upper-division undergraduates and graduate students. Practical, supervised teaching experience in a biology lab or lecture course. Training often includes attending lectures, initiating and planning discussion sections, and assisting in the preparation course materials. May be repeated for credit.nPrerequisite: consent of instructor.

BIO 291. Development and Teaching of Core Experimental Laboratories. 1-2 Unit.
Development and Teaching of Core Experimental LaboratoriesnPreparation for teaching the core experimental lab courses (45 and 47). Emphasis is on practicing the lab, speaking, and writing skills. Taken simultaneously while teaching (for BIO 45) or during the previous quarter (for teaching BIO 47). May be repeated for credit. Meeting times TBD.

BIO 292. Curricular Practical Training. 1 Unit.
This course is required for international students who are participating in professional internships in organizations (e.g. research institutes, education, medicine, business, policy) with a focus in the biological sciences. Students will be engaged in on-the-job training under the guidance of experienced, on-site supervisors. This course meets the requirements for curricular practical training (CPT) for students with F-1D/S status. Prior to the internship, students are required to submit a concise report detailing the proposed project and work activities. After the internship, students are required to submit a summary of the work completed, skills learned, and reflection of the professional growth gained as a result of the internship. This course may be repeated for credit. Prerequisite: Qualified offer of employment and consent of advisor.

BIO 294. Cellular Biophysics. 3 Units.
Physical biology of dynamical and mechanical processes in cells. Emphasis is on qualitative understanding of biological functions through quantitative analysis and simple mathematical models. Sensory transduction, signaling, adaptation, switches, molecular motors, actin and microtubules, motility, and circadian clocks. Prerequisites: differential equations and introductory statistical mechanics.
Same as: APPPHYS 294, BIOPHYS 294

BIO 296. Teaching and Learning in Biology. 1 Unit.
This course provides students teaching in the Department of Biology with basic training, support, and professional development in their teaching roles. Topics include student engagement, assessment, feedback and more. Should be taken concurrently with the first teaching position.

BIO 299. Biology PhD Lab Rotation. 1-10 Unit.
Limited to first year Biology PhD students. Lab rotations with Biosciences faculty.

BIO 2N. Ecology and Evolution of Infectious Disease in a Changing World. 3 Units.
This seminar will explore the ways in which anthropogenic change, climate change, habitat destruction, land use change, and species invasions effects the ecology and evolution of infectious diseases. Topics will include infectious diseases of humans, wildlife, livestock, and crops, effects of disease on threatened species, disease spillover, emerging diseases, and the role of disease in natural systems. Course will be taught through a combination of popular and scientific readings, discussion, and lecture. .

BIO 3. Frontiers in Marine Biology. 1 Unit.
An introduction to contemporary research in marine biology, including ecology, conservation biology, environmental toxicology, behavior, biomechanics, evolution, neurobiology, and molecular biology. Emphasis is on new discoveries and the technologies used to make them. Weekly lectures by faculty from the Hopkins Marine Station.

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.

BIO 302. Current Topics and Concepts in Population Biology, Ecology, and Evolution. 1 Unit.
Required of first-year PhD students in population biology, and ecology and evolution. Major conceptual issues and developing topics. This course isnnopen only to Biology PhD students and is not open to auditors.'.

BIO 303. Current Topics and Concepts in Population Biology, Ecology, and Evolution. 1 Unit.
Required of first-year PhD students in population biology, and ecology and evolution. Major conceptual issues and developing topics. This course isnnopen only to Biology PhD students and is not open to auditors.'.

BIO 304. Current Topics and Concepts in Population Biology, Ecology, and Evolution. 1 Unit.
Required of first-year PhD students in population biology, and ecology and evolution. Major conceptual issues and developing topics. This course isnnopen only to Biology PhD students and is not open to auditors.

BIO 305. Managing Your PhD. 1 Unit.
The course will focus on 5 themes for effectively managing your PhD: professionalism, scholarship, well-being, community-engagement and career development. We will meet every other week and have an active discussion-based class meeting for 2 hours. At the end of the quarter students and instructors will co-organize a departmental half-day workshop on a particular topic relevant to the topics covered in the class.

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 and 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 329. Matrix Methods for Dynamic Models and Data Analysis. 1 Unit.
Types of matrices in dynamic & stochastic models, covariances, rectangular data, networks. Spectral theorem, asymptotics, stability theory, Nonnegative matrices, ergodicity, Markov chains. Hermitian, covariance, SVD. Perturbation theory. Random matrix products, Lyapunov exponents. Open to Ph.D. students in Biology. Prerequisites: Calculus (AP level) required. Some knowledge of linear algebra, R, preferred.

BIO 330. Stochastic Methods for Simulation, Dynamics and Data Analysis. 1 Unit.
Markov chains: ergodicity, CLT, passage times, absorption. Simulation: random numbers, chains. Poisson processes: applications and simulation. Time series models. MCMC essentials. Open to Ph.D. students in Biology. Prerequisites: Calculus (AP level) and basic linear algebra required. Facility with linear algebra, R, preferred.

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 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://dpb.carnegiescience.edu/events.

BIO 346. Advanced Seminar in Microbial 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 355. Coral Reefs of the Western Pacific: Interdisciplinary Perspectives, Emerging Crises, and Solutions. 1 Unit.
This new graduate-level course focusses on the complex interplay of biology, physics, chemistry, and human activities that both promotes and limits the development of coral reefs. We will examine the ecology of these biodiverse systems as well as the service they provide in terms of rapid nutrient recycling, coastal protection, and maintenance of large populations of fish. New advances in our understanding of coral reefs will be highlighted, including the role of climate variability and micro- and mesoscale fluid flow in controlling reef growth and persistence, the physiology, genomics, and physics underpinning thermal resilience in corals, contributing and mitigating factors involved in the current decline of coral reefs, ocean acidification, fishing, reef-scale trophic modeling, ecological interactions and trophic cascades, and reefs as part of complex seascapes and linkages with other marine ecosystems. The course will conclude with an analysis of science to policy case studies and future opportunities. The faculty leaders collectively have over 100 years of field experience working in coral reefs of the Pacific and despite our forced online teaching and learning format will endeavor to bring the coral reef field experience to life for this class.
Same as: BIOHOPK 355, CEE 363I, ESS 355

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 380. Career Exploration and Planning. 1 Unit.
Thinking about and planning for life beyond graduate school is one of the most anxiety-provoking activities students face. In this course, students will share their personal stories and dilemmas about career decisions, discuss various career options with a PhD in life sciences, and learn to design their own path. There will be three career panels with invited guests from various career tracks, including research, teaching, administration, industry, startup, investment, law, journalism, policy, and more. Open to Biology PhD students in year 3 or beyond. The class will meet at Carnegie Institution for Science's conference room building 600, located at 260 Panama St, Stanford, CA 94305.

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 once a week reading and discussion group will consider how advances in genome technology have enabled new explorations in conservation and population biology. Papers to be read will include technical applications of new genome tools, the role of bioinformatics, and long-standing questions in conservation and population biology that might now be answered.

BIO 3N. Views of a Changing Sea: Literature & Science. 3 Units.
The state of a changing world ocean, particularly in the eastern Pacific, will be examined through historical and contemporary fiction, non-fiction and scientific publications. Issues will include harvest and mariculture fisheries, land-sea interactions and oceanic climate change in both surface and deep waters.

BIO 45. Introduction to Laboratory Research in Cell and Molecular Biology. 4 Units.
Investigate yeast strains that are engineered to express the human tumor suppressor protein, p53, and use modern molecular methods to identify the functional consequences of p53 mutations isolated from tumor cells. Learn about the protein's role as Guardian of the Genome through lectures and by reading and discussing journal articles. Use molecular visualization programs to examine the structure of normal and mutant p53 proteins. Learn about the assays used to study the ability of mutant p53 to direct expression of several reporter genes. During guided reflection, investigate further and identify what could be wrong with the p53 mutants you have been studying. Learn how to ask a question, test a hypothesis, conduct experiments and analyze data, and present your findings through a team oral presentation, as well as a scientific poster. Although there are no pre-requisites to enroll in this class, it will be helpful if you have already taken or are concurrently enrolled in the appropriate Biology Foundation classes (or HumBio core classes). Additionally, it will also be helpful if you have already taken CHEM 31X, or 31A & B, and 33.

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, BIOE 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 biological 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. IMPORTANT NOTE: Students who require BIO 46 to satisfy the WIM requirement for the Biology major MUST take this course for a letter grade.

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 biological 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, design 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 written in the style of a peer-reviewed journal article. Students will use data collected both in the lab and at Jasper Ridge Biological Preserve. Although there are no pre-requisites to enroll in the class, it will be helpful if you have already taken BIO 81 or relevant HumBio core class. nNote: Satisfies WIM (if taken for a letter grade) in Biology.

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 53. 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. This course is identical to Bio 7N, so students enrolled in the former should not take this course. Open to undergraduates and graduate students. Students must have access to a DSLR camera and lenses - we can accept up to 20 students who can share 10 course-provided cameras and lenses, by application. Application for camera use: https://forms.gle/1yAD3my8GoDseXw59.

BIO 57. THE STATE OF HUMANS AND THE PLANET. 4 Units.
How does human well-being affect their environment and the reverse? The goals of this course are to examine ways of measuring human and environmental well-being, their main interactions now and in the next several decades, and to identify challenges and gaps in our knowledge.

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. Enrollment limited; application required. Apply at http://web.stanford.edu/~thankes/bio62Winter2020.fb by November 15 to get preference for enrollment.

BIO 6N. Ocean Conservation: Pathways to Solutions. 3 Units.
We will learn how to design pathways to solutions by integrating social sciences and governance into our case studies. We will address both conventional (fisheries management, reducing the impacts of global shipping, marine protected areas) and emerging research and management approaches (marine spatial planning, dynamic ocean management, environmental DNA). Oceans are facing long-term challenges, like overfishing and pollution that we know how to solve, and emerging challenges, like climate change and ocean plastics, for which solutions are more elusive. Ultimately to achieve long-term sustainability, solutions have to work for both people and the planet. These puzzles offer challenging complex systems problems that will require our best interdisciplinary thinking to solve.

BIO 7N. 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 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.
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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, but BIO 83 is recommended.

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 focus of Physiology is on understanding how organisms tackle the physical challenges of life on Earth. This course will provide an overview of animal and plant physiology and teach an understanding of how organisms maintain homeostasis, respond to environmental cues and coordinate behaviors across multiples tissues and organ systems. We will examine the structure and function of organs and organ systems and how those systems are controlled and regulated to maintain homeostasis. Control and regulation requires information as does the ability to respond to environmental stimuli, so we will give special consideration to hormonal and neural information systems. We will also be concerned with the interactions and integration of the activities of the different organ systems we study. Prerequisites: none.

BIO 85. Evolution. 4 Units.
Understanding evolution is key to understanding the diversity of life on earth. We will be focusing on the fundamental principles of evolutionary biology from natural and sexual selection to the formation of new species. To understand these concepts we will delve into the mechanisms that underlie them. The course will also link these fundamental processes to important contemporary evolutionary topics such as the evolution of behavior, life history evolution, and human evolution. Prerequisites: BIO 60 or 61 or 62 or equivalent; recommended: BIO 82, or permission of instructor.

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 89SI. Evolutionary Medicine. 2 Units.
Why are body systems prone to disease? This course will explore theories about the evolutionary basis of diseases, including cancer, diabetes, and psychiatric disease. Students with a background in genetics, physiology, and evolution will synthesize these fields to better understand human health and disease. The course will involve readings from and discussions about the primary literature.

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.