

# BIOLOGY, HOPKINS MARINE STATION

Courses offered by the Hopkins Marine Station are listed under the subject code BIOHOPK on the Stanford Bulletin's ExploreCourses web site.

The Hopkins Marine Station, located 90 miles from the main University campus in Pacific Grove, was founded in 1892 as the first marine laboratory on the west coast of North America. The modern laboratory facilities on the 11-acre campus on Cabrillo Point house nine faculty, all members of the Department of Biology. The Miller Library has a collection of literature in marine science. The Hopkins faculty offers undergraduate and graduate courses in biology which focus on the marine realm and involve topics including oceanography, environmental and comparative physiology, molecular evolution, biomechanics, cellular biology, conservation biology, and neurobiology and behavior. Most courses have laboratory sections that exploit the potential of working with readily available marine plants and animals. Small class sizes encourage close student-faculty interactions. Undergraduates have opportunities to carry out research projects with Hopkins faculty during the academic year or summer months.

Courses at Hopkins Marine Station can satisfy many requirements, from Ways to major and minor requirements in departments housed in the Schools of Engineering, Humanities and Sciences, and Earth, Energy, and Environmental Sciences. Students are encouraged to check with their department's student services office to see which courses at Hopkins may be used to fulfill major or minor requirements.

## Summer Program at Hopkins Marine Station

The summer program is open to advanced undergraduate, graduate students, and postdoctoral students, and to teachers whose biological backgrounds, teaching, or research activities can benefit from a summer's study of marine life. Applications, deadlines, and further information are available at the Hopkins Marine Station (<http://hopkins.stanford.edu>) web site.

*Emeriti Professors:* David Epel, George N. Somero

*Director:* Stephen R. Palumbi

*Professors:* Barbara A. Block, Larry Crowder, Giulio De Leo, Mark W. Denny, William F. Gilly, Fiorenza Micheli, Stephen R. Palumbi, Stuart H. Thompson

*Associate Professor:* Christopher Lowe

*Assistant Professor:* Jeremy A. Goldbogen

*Lecturer:* James Watanabe

## Courses

### BIOHOPK 43. Plant Biology, Evolution, and Ecology. 5 Units.

Introduction to biology in a marine context. Principles of plant biology: physiology, structure, diversity. Principles of evolution: macro and microevolution, population genetics. Ecology: the principles governing the distribution and abundance of organisms; population, community, and ecosystem ecology. Equivalent to BIO 43. Corequisite: BIOHOPK 47.

### BIOHOPK 47. Core Laboratory in Plant Biology, Ecology and Evolution. 5 Units.

Laboratory and field projects provide working familiarity with the concepts, organisms, and techniques of plant and evolutionary biology, and ecology. Emphasis is on hands-on experimentation in the marine environment, analysis of data, and written and oral presentation of the experiments. Equivalent to BIO 44Y. Corequisite: BIOHOPK 43. Satisfies WIM in Biology.

### BIOHOPK 150H. Ecological Mechanics. 3 Units.

(Graduate students register for 250H.) The principles of life's physical interactions. We will explore basic physics: fluid mechanics, thermal dynamics, and materials science to see how the principles of these fields can be used to investigate ecology at levels from the individual to the community. Topics include: diffusion, boundary layers, fluid-dynamic forces, locomotion, heat-budget models, fracture mechanics, adhesion, beam theory, the statistics of extremes, and the theory of self-organization. Open to students from all backgrounds. Some familiarity with basic physics and calculus advantageous but not necessary. Same as: BIOHOPK 250H

### BIOHOPK 152H. Physiology of Global Change. 2 Units.

(Graduate students register for 252H.) Global change is leading to significant alterations in several environmental factors, including temperature, ocean acidity and oxygen availability. This course focuses on: (i) how these environmental changes lead to physiological stress and (ii) how, and to what extent, are organisms able to adapt through short-term acclimatization and evolutionary adaptation to cope with these stresses. A major focus of the class is to link changes in species' distribution patterns with underlying physiological mechanics that establish environmental optima and tolerance limits. Same as: BIOHOPK 252H

### BIOHOPK 153H. Current Topics and Concepts in Quantitative Fish Dynamics and Fisheries Management. 1 Unit.

(Graduate students register for 253H) The course will focus on extensive reading of seminal and reference papers published in the literature in the last decade on modeling population biology, community dynamics and fishery management in the marine environment. Basic knowledge of population dynamics is welcome. The goal is to develop an appreciation on both traditional and cutting-edge modeling approaches to study the dynamics and management of marine populations subjected to natural or anthropogenic shocks and pressures. Same as: BIOHOPK 253H

### BIOHOPK 154H. Animal Diversity: An Introduction to Evolution of Animal Form and Function from Larvae to Adults. 7 Units.

Survey of invertebrate diversity, emphasizing form and function of both adult and larval life history stages. Focuses on how morphology, life histories, and development contribute to current views of the evolutionary diversification of multicellular animals. Labs are a hands-on exploration of animal diversity using local marine species as examples, as well as techniques of obtaining, handling, and maintaining larvae from early development through settlement. Lectures, labs, plus field trips. Satisfies Central Menu Area 3 for Bio majors. Prerequisite: Biology core or consent of instructors. Same as: BIOHOPK 254H

**BIOHOPK 155H. Developmental Biology and Evolution. 4 Units.**

(Graduate students register for 255) This course focusses on how animals form their basic body plans; from the formation of their germ layers; ectoderm, endoderm and mesoderm, to how they are organized along the main developmental axes; the anteroposterior and dorsoventral axes. The course will focus in part on the molecular mechanisms that underlie these developmental decisions from work carried out in established developmental model species. However, we will also explore the current understanding of how these mechanisms evolved from new insights from emerging models representing a broad range of animal phyla. The setting at Hopkins Marine Station will allow us to carry out experiments from animals collected in the field, and the course will involve a substantial lab component to complement concepts and approaches presented in lecture. nPre-requisites : Biocore or by permission of instructor.

Same as: BIOHOPK 255H

**BIOHOPK 156H. Hands-On Neurobiology: Structure, Function and Development. 6 Units.**

This laboratory course will examine neural and neuromuscular systems at a cellular level in selected vertebrate and invertebrate taxa using anatomical, physiological and molecular approaches. Intracellular dye injections and confocal microscopy will be used to visualize neuronal structure. Ca-imaging will permit functional analysis of living neurons. Electrical recording methods will be used to explore principles of excitability, synaptic transmission, sensory pathways and neural integration. Development of neural systems will be studied using molecular visualization methods. Work in the lab will be supplemented with informal lectures and discussions, and results of the labs will be reviewed weekly. Two 4-hour afternoon lab sessions per week.

Same as: BIOHOPK 256H

**BIOHOPK 160H. Developmental Biology in the Ocean: Diverse Embryonic & Larval Strategies of marine invertebrates. 5-8 Units.**

(Graduate students register for 261H). Lab course is designed to introduce students to the diversity in the early developmental strategies of marine invertebrates and how an understanding of these microscopic life histories is key to understanding the evolutionary diversification of phyla and the distribution of their more familiar adults. Emphasis is on hands-on collection, spawning, observation and manipulation of embryos and their larvae.

Same as: BIOHOPK 260H

**BIOHOPK 161H. Invertebrate Zoology. 5 Units.**

(Graduate students register for 261H.) Survey of invertebrate diversity emphasizing form and function in a phylogenetic framework. Morphological diversity, life histories, physiology, and ecology of the major invertebrate groups, concentrating on local marine forms as examples. Current views on the phylogenetic relationships and evolution of the invertebrates. Lectures, lab, plus field trips. Satisfies Central Menu Area 3 for Bio majors. Prerequisite: Biology core or consent of instructor.

Same as: BIOHOPK 261H

**BIOHOPK 162H. Comparative Animal Physiology. 5 Units.**

(Graduate students register for 262H.) How animals work. Topics: physiology of respiration, circulation, energy metabolism, thermal regulation, osmotic regulation, muscle physiology, and locomotion. Evolutionary and ecological physiology. Lectures, lab, and field research. An option to combine the course work with a more intensive research focus, with more units, is available. Satisfies Central Menu Area 3 for Bio majors. Prerequisite: Biology core or consent of instructor.

Same as: BIOHOPK 262H

**BIOHOPK 163H. Oceanic Biology. 4 Units.**

(Graduate students register for 263H.) How the physics and chemistry of the oceanic environment affect marine plants and animals. Topics: seawater and ocean circulation, separation of light and nutrients in the two-layered ocean, oceanic food webs and trophic interactions, oceanic environments, biogeography, and global change. Lectures, discussion, and field trips. Satisfies Central Menu Area 4 for Bio majors. Recommended: PHYSICS 21 or 51, CHEM 31, Biology core, or consent of instructor.

Same as: BIOHOPK 263H

**BIOHOPK 165H. The Extreme Life of the Sea. 3 Units.**

(Graduate students register for 265H). Lecture course that explores the way marine species live in extreme ocean habitats. We will cover the deepest, hottest, coldest, and shallowest habitats and the biggest, fastest, most fecund, oldest and smallest species. We will focus on the molecular, physiological and ecological adaptations that allow species to thrive in these unusual environments.

Same as: BIOHOPK 265H

**BIOHOPK 166H. Molecular Ecology. 5 Units.**

(Graduate students register for 266H.) How modern technologies in gene sequencing, detection of nuclear nucleotide polymorphisms, and other approaches are used to gather data on genetic variation that allow measurement of population structure, infer demographic histories, inform conservation efforts, and advance understanding of the ecology of diverse types of organisms.

Same as: BIOHOPK 266H

**BIOHOPK 167H. Nerve, Muscle, and Synapse. 5 Units.**

(Graduate students register for 267H.) Fundamental aspects of membrane excitability, nerve conduction, synaptic transmission, and excitation-contraction coupling. Emphasis is on biophysical, molecular, and cellular level analyses of these processes in vertebrate and invertebrate systems. Labs on intra- and extracellular recording and patch clamp techniques. Lectures, discussions, and labs. Satisfies Central Menu Area 3 for Bio majors Prerequisites: PHYSICS 23, 28, 43, or equivalent; CHEM 31, calculus; or consent of instructor.

Same as: BIOHOPK 267H

**BIOHOPK 168H. Disease Ecology: from parasites evolution to the socio-economic impacts of pathogens on nations. 3 Units.**

(Graduate students register for 268H.) Course will lead participants on a journey through the dynamics of infectious diseases that will start at the smallest level from within-host parasite dynamics and will progressively scale up to parasite evolution, disease ecology, public health policies, disease driven poverty traps and the socio-economic impact of infectious diseases on nations. The course will be organized around case studies, including among the others, schistosomiasis, malaria, cholera and sleeping sickness. Participants will have the opportunity to develop a capstone project.

Same as: BIOHOPK 268H

**BIOHOPK 172H. Marine Ecology: From Organisms to Ecosystems. 5 Units.**

(Graduate students register for 272H.) This course incorporates the approaches of experimental ecology, biomechanics (ecomechanics), and physiology to develop an integrated perspective on the factors that govern the structures of marine ecosystems and how environment change, including anthropogenic influences, affects ecosystems' species composition and health. Focus is on rocky intertidal, kelp forest, estuarine, and midwater ecosystems of Monterey Bay. Experimental projects done in the field offer experience in a variety of ecological techniques and in analysis of ecological data. Students will engage in presentation and debates of current topics in marine ecology and conservation. Satisfies Central Menu Area 4 for Bio majors. Prerequisite: Biology core or consent of instructor. Fulfills WIM in Biology.

Same as: BIOHOPK 272H

**BIOHOPK 173H. Marine Conservation Biology. 4 Units.**

(Graduate students register for 273H.) Introduction to the key concepts of ecology and policy relevant to marine conservation issues at the population to ecosystems level. Focus on the origin and maintenance of biodiversity and conservation applications from both the biology and policy perspectives (for example, endangered species, captive breeding, reserve design, habitat fragmentation, ecosystem restoration/rehabilitation). Also includes emerging approaches such as ecosystem based management, ocean planning, and coupled social-ecological systems. The course will include lectures, readings and discussions of primary literature, and attendance at seminars with visiting scholars. Prerequisite: introductory biology; suggested: a policy and/or introductory ecology course.

Same as: BIOHOPK 273H

**BIOHOPK 174H. Experimental Design and Probability. 3 Units.**

(Graduate students register for 274H.) Variability is an integral part of biology. Introduction to probability and its use in designing experiments to address biological problems. Focus is on analysis of variance, when and how to use it, why it works, and how to interpret the results. Design of complex, but practical, asymmetrical experiments and environmental impact studies, and regression and analysis of covariance. Computer-based data analysis. Prerequisite: Biology core or consent of instructor.

Same as: BIOHOPK 274H

**BIOHOPK 177H. Dynamics and Management of Marine Populations. 4 Units.**

(Graduate students register for 277H.) Course examines the ecological factors and processes that control natural and harvested marine populations. Course emphasizes mathematical models as tools to assess the dynamics of populations and to derive projections of their demographic fate under different management scenarios. Course objectives will be met by a combination of theoretical lectures, assigned readings and class discussions, case study analysis and interactive computer sessions.

Same as: BIOHOPK 277H

**BIOHOPK 179H. Physiological Ecology of Marine Megafauna. 3 Units.**

(Graduate students register for 279H.) The ocean is home to the largest animals of all-time. How, when, and why did gigantism evolve in different taxa? What are the consequences of large body size? This course will focus on how biological processes scale with body size, with an emphasis on oceanic megafauna including marine mammals, birds, fishes, and reptiles. In particular, the course will explore the functional mechanisms that generate the scaling relationships for physiological and ecological traits, such as metabolism, ecosystem function and body size evolution. Students will also be introduced to state-of-the-art technologies used to study marine megafauna in some of the most logistically challenging habitats on earth.

Same as: BIOHOPK 279H

**BIOHOPK 180H. Air and Water. 3 Units.**

(Graduate students register for 280H.) Introduction to environmental physics. The physical properties of life's fluids compared and contrasted. How and why life has evolved differently on land than in water. Topics: density, viscosity, diffusion, thermal properties, sound, light, evaporation, and surface tension. Recommended: PHYSICS 21, 23, or 51, 53; calculus; Biology core; or consent of instructor.

Same as: BIOHOPK 280H

**BIOHOPK 181H. Physiology of Global Change. 2 Units.**

(Graduate students register for 281H.) Global change is leading to significant alterations in several environmental factors, including temperature, ocean acidity and oxygen availability. This course focuses on: (i) how these environmental changes lead to physiological stress and (ii) how, and to what extent, are organisms able to adapt through short-term acclimatization and evolutionary adaptation to cope with these stresses. A major focus of the class is to link changes in species' distribution patterns with underlying physiological mechanics that establish environmental optima and tolerance limits.

Same as: BIOHOPK 281H

**BIOHOPK 182H. Stanford at Sea. 16 Units.**

(Graduate students register for 323H.) Five weeks of marine science including oceanography, marine physiology, policy, maritime studies, conservation, and nautical science at Hopkins Marine Station, followed by five weeks at sea aboard a sailing research vessel in the Pacific Ocean. Shore component comprised of three multidisciplinary courses meeting daily and continuing aboard ship. Students develop an independent research project plan while ashore, and carry out the research at sea. In collaboration with the Sea Education Association of Woods Hole, MA. Only 6 units may count towards the Biology major.

Same as: BIOHOPK 323H, EARTHSYS 323, ESS 323

**BIOHOPK 184H. Holistic Biology. 16 Units.**

(Graduate students register for 284H.) For majors and non-majors. Complexity in natural systems is examined from complementary points of view, including scientific, historical, philosophical and literary. Lectures and discussions will focus on the writings of Ed Ricketts and John Steinbeck, poetry of Robinson Jeffers and on historical and contemporary works concerning marine and fresh-water systems, resource management and climate change. A group project with individual contributions will be carried out and presented at a symposium. This course will involve a significant amount of creative writing, and it satisfies the Writing in Major requirement for Biology. It is open to all majors and classes. Only 6 units may count towards the Biology major.

Same as: BIOHOPK 284H

**BIOHOPK 185H. Ecology and Conservation of Kelp Forest Communities. 5 Units.**

(Graduate students register for 285H.) Five week course. Daily lectures, labs, and scuba dives focused on kelp forest biology. Topics include identification and natural history of resident organisms, ecological processes that maintain biodiversity and community organization, field methods, data analysis, and research diving techniques. Class projects contribute to ongoing studies associated with Hopkins Marine Life Observatory. It is recommended that students complete one of Stanford's Scientific Diver Training sessions, offered during spring break and the week before the course starts, although this is not a requirement. Prerequisites: consent of instructor; advanced scuba certification and scuba equipment.

Same as: BIOHOPK 285H

**BIOHOPK 187H. Sensory Ecology. 4 Units.**

(Graduate students register for 287H.) Topics: the ways animals receive, filter, and process information gleaned from the environment, sensory receptor mechanisms, neural processing, specialization to life underwater, communication within and between species, importance of behavior to ecosystem structure and dynamics, impact of acoustic and light pollution on marine animals. Emphasis is on the current scientific literature. The laboratory portion of the class explores sensory mechanisms using neurobiological methods and methods of experimental animal behavior.

Same as: BIOHOPK 287H

**BIOHOPK 189H. Sustainability and Marine Ecosystems. 3 Units.**

(Graduate students register for 289H.) The health of marine ecosystems is in decline due to overfishing, pollution, habitat damage, invasive species, and climate change. Because human communities are tightly coupled to coastal marine resources, understanding pathways to sustainability require understanding as much about humans as about the ocean. In this course, we explore factors that contribute to the sustainability and resilience of marine ecosystems and the human communities that depend upon them. This course is based on readings in the primary literature, discussions, and student projects.

Same as: BIOHOPK 289H

**BIOHOPK 198H. Directed Instruction or Reading. 1-15 Unit.**

May be taken as a prelude to research and may also involve participation in a lab or research group seminar and/or library research. Credit for work arranged with out-of-department instructors restricted to Biology majors and requires department approval. May be repeated for credit. (Staff).

**BIOHOPK 199H. Undergraduate Research. 1-15 Unit.**

Qualified undergraduates undertake individual work in the fields listed under 300H. Arrangements must be made by consultation or correspondence.

**BIOHOPK 234H. Topics in Comparative and Environmental Physiology. 1 Unit.**

Seminar and discussion focused on current topics and research at the interface of physiology and ecology.

**BIOHOPK 250H. Ecological Mechanics. 3 Units.**

(Graduate students register for 250H.) The principles of life's physical interactions. We will explore basic physics, fluid mechanics, thermal dynamics, and materials science to see how the principles of these fields can be used to investigate ecology at levels from the individual to the community. Topics include: diffusion, boundary layers, fluid-dynamic forces, locomotion, heat-budget models, fracture mechanics, adhesion, beam theory, the statistics of extremes, and the theory of self-organization. Open to students from all backgrounds. Some familiarity with basic physics and calculus advantageous but not necessary.

Same as: BIOHOPK 150H

**BIOHOPK 252H. Physiology of Global Change. 2 Units.**

(Graduate students register for 252H.) Global change is leading to significant alterations in several environmental factors, including temperature, ocean acidity and oxygen availability. This course focuses on: (i) how these environmental changes lead to physiological stress and (ii) how, and to what extent, are organisms able to adapt through short-term acclimatization and evolutionary adaptation to cope with these stresses. A major focus of the class is to link changes in species' distribution patterns with underlying physiological mechanics that establish environmental optima and tolerance limits.

Same as: BIOHOPK 152H

**BIOHOPK 253H. Current Topics and Concepts in Quantitative Fish Dynamics and Fisheries Management. 1 Unit.**

(Graduate students register for 253H) The course will focus on extensive reading of seminal and reference papers published in the literature in the last decade on modeling population biology, community dynamics and fishery management in the marine environment. Basic knowledge of population dynamics is welcome. The goal is to develop an appreciation on both traditional and cutting-edge modeling approaches to study the dynamics and management of marine populations subjected to natural or anthropogenic shocks and pressures.

Same as: BIOHOPK 153H

**BIOHOPK 254H. Animal Diversity: An Introduction to Evolution of Animal Form and Function from Larvae to Adults. 7 Units.**

Survey of invertebrate diversity, emphasizing form and function of both adult and larval life history stages. Focuses on how morphology, life histories, and development contribute to current views of the evolutionary diversification of multicellular animals. Labs are a hands-on exploration of animal diversity using local marine species as examples, as well as techniques of obtaining, handling, and maintaining larvae from early development through settlement. Lectures, labs, plus field trips. Satisfies Central Menu Area 3 for Bio majors. Prerequisite: Biology core or consent of instructors.

Same as: BIOHOPK 154H

**BIOHOPK 255H. Developmental Biology and Evolution. 4 Units.**

(Graduate students register for 255) This course focusses on how animals form their basic body plans; from the formation of their germ layers; ectoderm, endoderm and mesoderm, to how they are organized along the main developmental axes; the anteroposterior and dorsoventral axes. The course will focus in part on the molecular mechanisms that underlie these developmental decisions from work carried out in established developmental model species. However, we will also explore the current understanding of how these mechanisms evolved from new insights from emerging models representing a broad range of animal phyla. The setting at Hopkins Marine Station will allow us to carry out experiments from animals collected in the field, and the course will involve a substantial lab component to complement concepts and approaches presented in lecture. nPre-requisites : Biocore or by permission of instructor.

Same as: BIOHOPK 155H

**BIOHOPK 256H. Hands-On Neurobiology: Structure, Function and Development. 6 Units.**

This laboratory course will examine neural and neuromuscular systems at a cellular level in selected vertebrate and invertebrate taxa using anatomical, physiological and molecular approaches. Intracellular dye injections and confocal microscopy will be used to visualize neuronal structure. Ca-imaging will permit functional analysis of living neurons. Electrical recording methods will be used to explore principles of excitability, synaptic transmission, sensory pathways and neural integration. Development of neural systems will be studied using molecular visualization methods. Work in the lab will be supplemented with informal lectures and discussions, and results of the labs will be reviewed weekly. Two 4-hour afternoon lab sessions per week.

Same as: BIOHOPK 156H

**BIOHOPK 260H. Developmental Biology in the Ocean: Diverse Embryonic & Larval Strategies of marine invertebrates. 5-8 Units.**

(Graduate students register for 261H). Lab course is designed to introduce students to the diversity in the early developmental strategies of marine invertebrates and how an understanding of these microscopic life histories is key to understanding the evolutionary diversification of phyla and the distribution of their more familiar adults. Emphasis is on hands-on collection, spawning, observation and manipulation of embryos and their larvae.

Same as: BIOHOPK 160H

**BIOHOPK 261H. Invertebrate Zoology. 5 Units.**

(Graduate students register for 261H.) Survey of invertebrate diversity emphasizing form and function in a phylogenetic framework. Morphological diversity, life histories, physiology, and ecology of the major invertebrate groups, concentrating on local marine forms as examples. Current views on the phylogenetic relationships and evolution of the invertebrates. Lectures, lab, plus field trips. Satisfies Central Menu Area 3 for Bio majors. Prerequisite: Biology core or consent of instructor.

Same as: BIOHOPK 161H

**BIOHOPK 262H. Comparative Animal Physiology. 5 Units.**

(Graduate students register for 262H.) How animals work. Topics: physiology of respiration, circulation, energy metabolism, thermal regulation, osmotic regulation, muscle physiology, and locomotion. Evolutionary and ecological physiology. Lectures, lab, and field research. An option to combine the course work with a more intensive research focus, with more units, is available. Satisfies Central Menu Area 3 for Bio majors. Prerequisite: Biology core or consent of instructor.

Same as: BIOHOPK 162H

**BIOHOPK 263H. Oceanic Biology. 4 Units.**

(Graduate students register for 263H.) How the physics and chemistry of the oceanic environment affect marine plants and animals. Topics: seawater and ocean circulation, separation of light and nutrients in the two-layered ocean, oceanic food webs and trophic interactions, oceanic environments, biogeography, and global change. Lectures, discussion, and field trips. Satisfies Central Menu Area 4 for Bio majors. Recommended: PHYSICS 21 or 51, CHEM 31, Biology core, or consent of instructor.

Same as: BIOHOPK 163H

**BIOHOPK 264H. POPULATION GENOMICS. 1-2 Unit.**

Introduces students to the analysis of single nucleotide polymorphism data from next generation sequencing projects. Computer analysis, hypothesis testing, and projects based on existing data sets will be pursued.

**BIOHOPK 265H. The Extreme Life of the Sea. 3 Units.**

(Graduate students register for 265H). Lecture course that explores the way marine species live in extreme ocean habitats. We will cover the deepest, hottest, coldest, and shallowest habitats and the biggest, fastest, most fecund, oldest and smallest species. We will focus on the molecular, physiological and ecological adaptations that allow species to thrive in these unusual environments.

Same as: BIOHOPK 165H

**BIOHOPK 266H. Molecular Ecology. 5 Units.**

(Graduate students register for 266H.) How modern technologies in gene sequencing, detection of nuclear nucleotide polymorphisms, and other approaches are used to gather data on genetic variation that allow measurement of population structure, infer demographic histories, inform conservation efforts, and advance understanding of the ecology of diverse types of organisms.

Same as: BIOHOPK 166H

**BIOHOPK 267H. Nerve, Muscle, and Synapse. 5 Units.**

(Graduate students register for 267H.) Fundamental aspects of membrane excitability, nerve conduction, synaptic transmission, and excitation-contraction coupling. Emphasis is on biophysical, molecular, and cellular level analyses of these processes in vertebrate and invertebrate systems. Labs on intra- and extracellular recording and patch clamp techniques. Lectures, discussions, and labs. Satisfies Central Menu Area 3 for Bio majors Prerequisites: PHYSICS 23, 28, 43, or equivalent; CHEM 31, calculus; or consent of instructor.

Same as: BIOHOPK 167H

**BIOHOPK 268H. Disease Ecology: from parasites evolution to the socio-economic impacts of pathogens on nations. 3 Units.**

(Graduate students register for 268H.) Course will lead participants on a journey through the dynamics of infectious diseases that will start at the smallest level from within-host parasite dynamics and will progressively scale up to parasite evolution, disease ecology, public health policies, disease driven poverty traps and the socio-economic impact of infectious diseases on nations. The course will be organized around case studies, including among the others, schistosomiasis, malaria, cholera and sleeping sickness. Participants will have the opportunity to develop a capstone project.

Same as: BIOHOPK 168H

**BIOHOPK 272H. Marine Ecology: From Organisms to Ecosystems. 5 Units.**

(Graduate students register for 272H.) This course incorporates the approaches of experimental ecology, biomechanics (ecomechanics), and physiology to develop an integrated perspective on the factors that govern the structures of marine ecosystems and how environment change, including anthropogenic influences, affects ecosystems' species composition and health. Focus is on rocky intertidal, kelp forest, estuarine, and midwater ecosystems of Monterey Bay. Experimental projects done in the field offer experience in a variety of ecological techniques and in analysis of ecological data. Students will engage in presentation and debates of current topics in marine ecology and conservation. Satisfies Central Menu Area 4 for Bio majors. Prerequisite: Biology core or consent of instructor. Fulfills WIM in Biology.

Same as: BIOHOPK 172H

**BIOHOPK 273H. Marine Conservation Biology. 4 Units.**

(Graduate students register for 273H.). Introduction to the key concepts of ecology and policy relevant to marine conservation issues at the population to ecosystems level. Focus on the origin and maintenance of biodiversity and conservation applications from both the biology and policy perspectives (for example, endangered species, captive breeding, reserve design, habitat fragmentation, ecosystem restoration/rehabilitation). Also includes emerging approaches such as ecosystem based management, ocean planning, and coupled social-ecological systems. The course will include lectures, readings and discussions of primary literature, and attendance at seminars with visiting scholars. Prerequisite: introductory biology; suggested: a policy and/or introductory ecology course.

Same as: BIOHOPK 173H

**BIOHOPK 274. 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: BIO 274S, CEE 274S, ESS 253S

**BIOHOPK 274H. Experimental Design and Probability. 3 Units.**

(Graduate students register for 274H.) Variability is an integral part of biology. Introduction to probability and its use in designing experiments to address biological problems. Focus is on analysis of variance, when and how to use it, why it works, and how to interpret the results. Design of complex, but practical, asymmetrical experiments and environmental impact studies, and regression and analysis of covariance. Computer-based data analysis. Prerequisite: Biology core or consent of instructor.

Same as: BIOHOPK 174H

**BIOHOPK 275H. Synthesis in Ecology. 2 Units.**

Introduction to frameworks and approaches to synthesizing large data sets, including meta-analysis and permutational multivariate analysis of variance. Hands-on data analysis sessions. May be repeated for credit.

**BIOHOPK 276H. Estimates and Errors: The Theory of Scientific Measurement. 3 Units.**

Measurement plays a fundamental role in science, but many biologists have no formal training in what it means to measure something. Errors are inevitable in any measurement. Which are inherent, and which can be controlled? How do errors propagate? How can you decide which data to reject? When are uncertainties normal? In this course we will work our way into the theory of measurement, covering some topics that overlap with inferential statistics (but from a new and perhaps more intuitive perspective), and extending beyond those basics to include spectral analysis and the dangers of measurement in the digital realm.

**BIOHOPK 277H. Dynamics and Management of Marine Populations. 4 Units.**

(Graduate students register for 277H.) Course examines the ecological factors and processes that control natural and harvested marine populations. Course emphasizes mathematical models as tools to assess the dynamics of populations and to derive projections of their demographic fate under different management scenarios. Course objectives will be met by a combination of theoretical lectures, assigned readings and class discussions, case study analysis and interactive computer sessions.

Same as: BIOHOPK 177H

**BIOHOPK 279H. Physiological Ecology of Marine Megafauna. 3 Units.**

(Graduate students register for 279H.) The ocean is home to the largest animals of all-time. How, when, and why did gigantism evolve in different taxa? What are the consequences of large body size? This course will focus on how biological processes scale with body size, with an emphasis on oceanic megafauna including marine mammals, birds, fishes, and reptiles. In particular, the course will explore the functional mechanisms that generate the scaling relationships for physiological and ecological traits, such as metabolism, ecosystem function and body size evolution. Students will also be introduced to state-of-the-art technologies used to student marine megafauna in some of the most logistically challenging habitats on earth.

Same as: BIOHOPK 179H

**BIOHOPK 280. Short Course on Ocean Policy. 3 Units.**

The course will introduce graduate students in the natural and social sciences to ocean policy and governance in the US at national, regional, state, and local levels. Together with leaders in ocean science and policy, students will examine pressing issues in ocean sustainability from natural science, social science, and legal and policy perspectives, with an emphasis on the role of science in the policy and governance processes. Students will learn and apply practical skills in communication, leadership and interdisciplinary problem-solving through participation in a group project, interactive discussions and simulations, and field trips. Prerequisite: consent of instructor and by application due in winter.

**BIOHOPK 280H. Air and Water. 3 Units.**

(Graduate students register for 280H.) Introduction to environmental physics. The physical properties of life's fluids compared and contrasted. How and why life has evolved differently on land than in water. Topics: density, viscosity, diffusion, thermal properties, sound, light, evaporation, and surface tension. Recommended: PHYSICS 21, 23, or 51, 53; calculus; Biology core; or consent of instructor.

Same as: BIOHOPK 180H

**BIOHOPK 281H. Physiology of Global Change. 2 Units.**

(Graduate students register for 281H.) Global change is leading to significant alterations in several environmental factors, including temperature, ocean acidity and oxygen availability. This course focuses on: (i) how these environmental changes lead to physiological stress and (ii) how, and to what extent, are organisms able to adapt through short-term acclimatization and evolutionary adaptation to cope with these stresses. A major focus of the class is to link changes in species' distribution patterns with underlying physiological mechanics that establish environmental optima and tolerance limits.

Same as: BIOHOPK 181H

**BIOHOPK 284H. Holistic Biology. 16 Units.**

(Graduate students register for 284H.) For majors and non-majors. Complexity in natural systems is examined from complementary points of view, including scientific, historical, philosophical and literary. Lectures and discussions will focus on the writings of Ed Ricketts and John Steinbeck, poetry of Robinson Jeffers and on historical and contemporary works concerning marine and fresh-water systems, resource management and climate change. A group project with individual contributions will be carried out and presented at a symposium. This course will involve a significant amount of creative writing, and it satisfies the Writing in Major requirement for Biology. It is open to all majors and classes. Only 6 units may count towards the Biology major.

Same as: BIOHOPK 184H

**BIOHOPK 285H. Ecology and Conservation of Kelp Forest Communities. 5 Units.**

(Graduate students register for 285H.) Five week course. Daily lectures, labs, and scuba dives focused on kelp forest biology. Topics include identification and natural history of resident organisms, ecological processes that maintain biodiversity and community organization, field methods, data analysis, and research diving techniques. Class projects contribute to ongoing studies associated with Hopkins Marine Life Observatory. It is recommended that students complete one of Stanford's Scientific Diver Training sessions, offered during spring break and the week before the course starts, although this is not a requirement. Prerequisites: consent of instructor; advanced scuba certification and scuba equipment.

Same as: BIOHOPK 185H

**BIOHOPK 287H. Sensory Ecology. 4 Units.**

(Graduate students register for 287H.) Topics: the ways animals receive, filter, and process information gleaned from the environment, sensory receptor mechanisms, neural processing, specialization to life underwater, communication within and between species, importance of behavior to ecosystem structure and dynamics, impact of acoustic and light pollution on marine animals. Emphasis is on the current scientific literature. The laboratory portion of the class explores sensory mechanisms using neurobiological methods and methods of experimental animal behavior.

Same as: BIOHOPK 187H

**BIOHOPK 289H. Sustainability and Marine Ecosystems. 3 Units.**

(Graduate students register for 289H.) The health of marine ecosystems is in decline due to overfishing, pollution, habitat damage, invasive species, and climate change. Because human communities are tightly coupled to coastal marine resources, understanding pathways to sustainability require understanding as much about humans as about the ocean. In this course, we explore factors that contribute to the sustainability and resilience of marine ecosystems and the human communities that depend upon them. This course is based on readings in the primary literature, discussions, and student projects.

Same as: BIOHOPK 189H

**BIOHOPK 290H. Teaching of Biological Science. 1-15 Unit.**

Open to upper-division undergraduates and graduate students. Practical experience in teaching lab biology or serving as an assistant in a lecture course. Prerequisite: consent of instructor.nn (Staff).

**BIOHOPK 300H. Research. 1-15 Unit.**

Graduate study involving original work undertaken with staff in the fields indicated. B. Block: Comparative Vertebrate Physiology (biomechanics, metabolic physiology and phylogeny of pelagic fishes, evolution of endothermy); L. Crowder: Marine ecology, fisheries, bycatch, integrating science and policy, marine conservation; G. De Leo: Population dynamics and management, wildlife diseases, environmental policies and sustainable development; M. Denny: Biomechanics (the mechanical properties of biological materials and their consequences for animal size, shape, and performance); W. Gilly: Neurobiology (analysis of giant axon systems in marine invertebrates from molecular to behavioral levels); J. Goldbogen: Physiological and Behavioral Ecology (functional morphology and biomechanics of marine organisms); C. Lowe: Evolution of Development (origin of chordates, early evolution of body plans); F. Micheli: Marine Ecology (species interactions and community ecology, scale-dependent aspects of community organization, marine conservation and design of multi-species marine protected areas, behavioral ecology); S. Palumbi: Molecular Evolution (mechanisms of speciation, genetic differentiations of populations, use of molecular tools in conservation biology, design of marine protected areas); S. Thompson: Neurobiology (neuronal control of behavior and mechanisms of ion permeation, signal transduction, calcium homeostasis, and neurotransmission); J. Watanabe: Marine Ecology (kelp forest ecology and invertebrate zoology).

**BIOHOPK 315H. Career Development for Graduate Students. 2 Units.**

The course will cover multiple skills required to succeed in graduate school and beyond, including fund raising, publishing, selecting career options, job application and negotiation, and teaching, through lectures, group discussions, and practical exercises.

**BIOHOPK 320H. Physical Biology. 3 Units.**

Physics, mathematics, and biology are often studied as separate subjects. In this two-week intensive course we will attempt to bring them together in a dynamic combination of lectures and hands on projects. We will draw on the diverse flora and fauna of Monterey Bay for our experimental organisms, and will take advantage of the facilities at Hopkins Marine Station to explore questions at levels ranging from molecules to ecological communities.

**BIOHOPK 323H. Stanford at Sea. 16 Units.**

(Graduate students register for 323H.) Five weeks of marine science including oceanography, marine physiology, policy, maritime studies, conservation, and nautical science at Hopkins Marine Station, followed by five weeks at sea aboard a sailing research vessel in the Pacific Ocean. Shore component comprised of three multidisciplinary courses meeting daily and continuing aboard ship. Students develop an independent research project plan while ashore, and carry out the research at sea. In collaboration with the Sea Education Association of Woods Hole, MA. Only 6 units may count towards the Biology major. Same as: BIOHOPK 182H, EARTHSYS 323, ESS 323

**BIOHOPK 330H. Scientific Writing. 2 Units.**

This writer's seminar will workshop the elements of good scientific writing by focusing on a paper's Introduction. We will chart the elements of an effective Introduction, designed for different audiences and types of scientific journals. The course will provide participants with the chance to craft an Introduction to a current paper or proposal and have it evaluated in light of the ideal structure we define.

**BIOHOPK 801H. TGR Project. 0 Units.****BIOHOPK 802H. TGR Dissertation. 0 Units.**