

BIOLOGY, HOPKINS MARINE STATION

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Courses offered by Hopkins Marine Station have the subject code BIOHOPK, and are listed in the "Courses in Hopkins Marine Station" section of this bulletin.

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 ten 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 are offered in Winter, Spring, and Summer quarters.

Courses at Hopkins Marine Station can satisfy many requirements, from the Natural Sciences GER to major and minor requirements in departments housed in the Schools of Engineering, Humanities and Sciences, and Earth Sciences. Students are encouraged to check with their Student Services Office to see what specific courses at Hopkins can 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 available at <http://hopkins.stanford.edu>.

BIOLOGY, HOPKINS MARINE STATION (BIOHOPK) COURSES

For information on the Hopkins Marine Station, see the "Biology, Hopkins Marine Station" section of this bulletin.

UNDERGRADUATE COURSES IN BIOLOGY, HOPKINS MARINE STATION

BIOHOPK 43. Plant Biology, Evolution, and Ecology

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 44Y. GER:DB-NatSci

5 units, Spr (Denny, M; Palumbi, S; Watanabe, J)

BIOHOPK 44Y. Core Experimental Laboratory

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. GER:DB-NatSci, WIM

5 units, Spr (Denny, M; Palumbi, S; Watanabe, J)

BIOHOPK 56H. History and Philosophy of Science

The nature of scientific inquiry, its logic, historical patterns, and sociology. Emphasis is on the unique aspects of the biological sciences.

2 units, Spr (Somero, G), alternate years, not given next year

BIOHOPK 161H. Invertebrate Zoology

(Same as BIOHOPK 261H. 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. Prerequisite: Biology core or consent of instructor. GER:DB-NatSci

5 units, Win (Watanabe, J)

BIOHOPK 163H. Oceanic Biology

(Same as BIOHOPK 263H. 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. Recommended: PHYSICS 21 or 51, CHEM 31, Biology core, or consent of instructor. GER:DB-NatSci

4 units, Win (Denny, M; Somero, G)

BIOHOPK 164H. Marine Botany

(Same as BIOHOPK 264H. Graduate students register for 264H.) Introduction to plants in the sea. Phytoplankton and oceanic productivity; macrophytes and nearshore ecology; marine angiosperms from taxonomical, physiological, and ecological perspectives. Lectures, lab. Prerequisite: Biology core or consent of instructor. GER:DB-NatSci

5 units, Win (Staff), alternate years, not given next year

BIOHOPK 166H. Molecular Ecology

(Same as BIOHOPK 266H. 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. GER:DB-NatSci

5 units, Win (Palumbi, S)

BIOHOPK 167H. Nerve, Muscle, and Synapse

(Same as BIOHOPK 267H. 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. Prerequisites: PHYSICS 23, 28, 43, or equivalent; CHEM 31, 135; calculus; or consent of instructor. GER:DB-NatSci

5 units, Spr (Gilly, W), not given next year

BIOHOPK 170H. Topics in Marine Biology

(Same as BIOHOPK 270H. Graduate students register for 270H.) A topic of current interest to marine science explored through primary literature. Prerequisite: Biology core or consent of instructor. May be repeated for credit.

1 unit, Win (Block, B; Thompson, S)

BIOHOPK 171H. Ecological and Evolutionary Physiology

(Same as BIOHOPK 271H. Graduate students register for 271H.) The interplay between environmental factors, such as temperature, light, nutrient supply, salinity, and oxygen availability, and adaptive change at the physiological level. Emphasis is on marine species and the roles played by physiological adaptations in establishing their distribution and performance. Prerequisite: Biology core or consent of instructor. GER:DB-NatSci

4 units, Win (Somero, G)

BIOHOPK 172H. Marine Ecology

(Same as BIOHOPK 272H. Graduate students register for 272H.) Focus is on quantitative approaches to questions in marine ecology and ecophysiology. Statistical methods, including multivariate statistical approaches and meta-analysis. Prerequisite: Biology core or consent of instructor. GER:DB-NatSci

5 units, Win (Micheli, F)

BIOHOPK 174H. Experimental Design and Probability

(Same as BIOHOPK 274H. 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. GER:DB-NatSci. WIM

3 units, Spr (Watanabe, J)

BIOHOPK 175H. Problems in Marine Ecology and Ecophysiology

Field-based, emphasizing individual and small group research for advanced undergraduates. Students learn field and laboratory techniques to address ecological, ecophysiological, and biomechanical problems faced by marine organisms. Original research projects may be integrated with ongoing research programs in the Hopkins Marine Life refuge. Prerequisites: Biology core, consent of instructor. GER:DB-NatSci. WIM

3-10 units, Spr (Denny, M; Gilly, W)

BIOHOPK 178H. Polar Biology

(Same as BIOHOPK 278H.) Seminar. Adaptation to extreme environments by Arctic and Antarctic organisms, from microbes to diving mammals. The effects of global change on polar environments. Prerequisite: Biology core or consent of instructor.

2 units, Spr (Somero, G), alternate years, not given next year

BIOHOPK 182H. Stanford at Sea

(Same as BIOHOPK 323H, EESS 323, EARTHSYS 323. 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. GER:DB-NatSci

16 units, Spr (Block, B; Dunbar, R; Micheli, F), alternate years, not given next year

BIOHOPK 185H. Ecology and Conservation of Kelp Forest

Communities

(Same as BIOHOPK 285H.) Eight week course. Daily lectures, labs, and scuba dives focused on kelp forest communities. Physical environment, identification, and natural history of resident organisms; ecological processes that maintain biodiversity and community organization; field methods, data analysis, and research diving techniques. Field research component contribute to ongoing studies associated with Hopkins Marine Life Observatory. Training meets requirements for Stanford scientific diver certification. Prerequisites: BIO 42 and 43, or BIO 42 and BIOHOPK 43, or consent of instructor; and advanced scuba certification and scuba equipment.

12 units, Sum (Watanabe, J)

BIOHOPK 187H. Sensory Ecology

(Same as BIOHOPK 287H. 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.

2 units, Win (Thompson, S)

BIOHOPK 188H. Experimental Sensory Ecology

(Same as BIOHOPK 288H. Graduate students register for 288H.) Experimental methods and findings related to animal sensory capability in the context of marine environments. Focus is on current literature and hands-on experiments. Laboratory component explores sensory mechanisms using neurobiological methods and methods of experimental animal behavior. BIOHOPK 187H/287H is not a prerequisite. WIM

3 units, Spr (Thompson, S)

BIOHOPK 198H. Directed Instruction or Reading

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.

1-15 units, Aut (Staff), Win (Staff), Spr (Staff), Sum (Staff)

BIOHOPK 199H. Undergraduate Research

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

1-15 units, Aut (Staff), Win (Staff), Spr (Staff), Sum (Staff)

BIOHOPK 162H. Comparative Animal Physiology

(Same as BIOHOPK 262H. 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. Prerequisite: Biology core or consent of instructor. GER:DB-NatSci

5-8 units, given next year

BIOHOPK 173H. Marine Conservation Biology

(Same as BIOHOPK 273H. Graduate students register for 273H.) The science of preserving marine diversity. Goal is to introduce students to major conservation issues associated with marine ecosystems. Topics include decline of open ocean fisheries, salmon conservation, bycatch issues in fisheries, use of marine reserves, marine invasions, marine pollution, and global warming. Includes five lecturers from other universities who specialize in marine conservation.

1-3 units, alternate years, not given this year

BIOHOPK 184H. Holistic Biology: Monterey Bay and the Sea of Cortez

(Same as BIOHOPK 284H. Graduate students register for 284H.) For majors and non-majors. Complexity in natural systems from complementary points of view, including scientific, historical,

philosophical, and literary. The work and writings of Ed Ricketts and John Steinbeck and historical and contemporary works concerning marine ecology and fisheries. Field work, laboratory studies with living invertebrates, and an individual research project. Course includes a component in Baja California, Mexico. Only 6 units may count towards the Biology major. GER:DB-NatSci

16 units, alternate years, not given this year

GRADUATE COURSES IN BIOLOGY, HOPKINS MARINE STATION

Primarily for graduate students; undergraduates may enroll with consent of instructor.

BIOHOPK 261H. Invertebrate Zoology

(Same as BIOHOPK 161H. 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. Prerequisite: Biology core or consent of instructor.

5 units, Win (Watanabe, J)

BIOHOPK 263H. Oceanic Biology

(Same as BIOHOPK 163H. 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. Recommended: PHYSICS 21 or 51, CHEM 31, Biology core, or consent of instructor.

4 units, Win (Denny, M; Somero, G)

BIOHOPK 264H. Marine Botany

(Same as BIOHOPK 164H. Graduate students register for 264H.) Introduction to plants in the sea. Phytoplankton and oceanic productivity; macrophytes and nearshore ecology; marine angiosperms from taxonomical, physiological, and ecological perspectives. Lectures, lab. Prerequisite: Biology core or consent of instructor.

5 units, Win (Staff), alternate years, not given next year

BIOHOPK 266H. Molecular Ecology

(Same as BIOHOPK 166H. 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.

5 units, Win (Palumbi, S)

BIOHOPK 267H. Nerve, Muscle, and Synapse

(Same as BIOHOPK 167H. 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. Prerequisites: PHYSICS 23, 28, 43, or equivalent: CHEM 31, 135; calculus; or consent of instructor.

5 units, Spr (Gilly, W), not given next year

BIOHOPK 270H. Topics in Marine Biology

(Same as BIOHOPK 170H. Graduate students register for 270H.) A topic of current interest to marine science explored through primary literature. Prerequisite: Biology core or consent of instructor. May be repeated for credit.

1 unit, Win (Block, B; Thompson, S)

BIOHOPK 271H. Ecological and Evolutionary Physiology

(Same as BIOHOPK 171H. Graduate students register for 271H.) The interplay between environmental factors, such as temperature, light, nutrient supply, salinity, and oxygen availability, and adaptive change at the physiological level. Emphasis is on marine species and the roles played by physiological adaptations in establishing their distribution and performance. Prerequisite: Biology core or consent of instructor.

4 units, Win (Somero, G)

BIOHOPK 272H. Marine Ecology

(Same as BIOHOPK 172H. Graduate students register for 272H.) Focus is on quantitative approaches to questions in marine ecology and ecophysiology. Statistical methods, including multivariate statistical approaches and meta-analysis. Prerequisite: Biology core or consent of instructor.

5 units, Win (Micheli, F)

BIOHOPK 274. Hopkins Microbiology Course

(Same as BIO 274S, CEE 274S, EESS 253S. 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,B. or equivalents.

9-12 units, Sum (Spormann, A; Francis, C)

BIOHOPK 274H. Experimental Design and Probability

(Same as BIOHOPK 174H. 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.

3 units, Spr (Watanabe, J)

BIOHOPK 277H. Biomechanics, Ecological Physiology, and Genetics of Intertidal Communities

Four week course. Introduction to the mechanical and physiological design of wave-swept organisms. How different abiotic stresses (wave exposure, wind speed, temperature, light) influence marine animals and plants, and adaptive responses to these stresses. Lab introduces methods for measuring environmental stress and organismal responses. Recommended: background in algology, intertidal ecology, or invertebrate zoology; basic physics and calculus.

4 units, Sum (Denny, M; Palumbi, S; Somero, G), not given next year

BIOHOPK 278H. Polar Biology

(Same as BIOHOPK 178H.) Seminar. Adaptation to extreme environments by Arctic and Antarctic organisms, from microbes to diving mammals. The effects of global change on polar environments. Prerequisite: Biology core or consent of instructor.

2 units, Spr (Somero, G), alternate years, not given next year

BIOHOPK 285H. Ecology and Conservation of Kelp Forest Communities

(Same as BIOHOPK 185H.) Eight week course. Daily lectures, labs, and scuba dives focused on kelp forest communities. Physical environment, identification, and natural history of resident organisms; ecological processes that maintain biodiversity and community organization; field methods, data analysis, and research diving techniques. Field research component contributes to ongoing studies associated with Hopkins Marine Life Observatory. Training

meets requirements for Stanford scientific diver certification. Prerequisites: BIO 42 and 43, or BIO 42 and BIOHOPK 43, or consent of instructor; and advanced scuba certification and scuba equipment.

12 units, Sum (Watanabe, J)

BIOHOPK 287H. Sensory Ecology

(Same as BIOHOPK 187H. 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.

2 units, Win (Thompson, S)

BIOHOPK 288H. Experimental Sensory Ecology

(Same as BIOHOPK 188H. Graduate students register for 288H.) Experimental methods and findings related to animal sensory capability in the context of marine environments. Current literature and hands-on experiments. Laboratory explores sensory mechanisms using neurobiological methods and methods of experimental animal behavior. BIOHOPK 187H/287H is not a prerequisite.

3 units, Spr (Thompson, S)

BIOHOPK 290H. Teaching of Biological Science

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.

1-15 units, Win (Staff), Spr (Staff), Sum (Staff)

BIOHOPK 300H. Research

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); M. Denny: Biomechanics (the mechanical properties of biological materials and their consequences for animal size, shape, and performance); A. De Tomaso: Developmental and Comparative Immunology, Stem Cell Biology (evolution of self/non-self recognition systems); D. Epel: Developmental Biology (physiology and regulation of early embryonic development. Embryonic adaptation to environmental stress. W. Gilly: Neurobiology (analysis of giant axon systems in marine invertebrates from molecular to behavioral levels. 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); G. Somero: Ecological and Evolutionary Physiology (adaptations of marine organisms to the environment: temperature, pressure, desiccation, and oxygen availability); 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).

1-15 units, Aut (Staff), Win (Staff), Spr (Staff), Sum (Staff)

BIOHOPK 310H. Intertidal Natural History

Field-based. Local intertidal fauna and flora at Hopkins Marine Station. Students contribute to the development of a photographic key to the local organisms. May be repeated for credit.

2 units, Aut (Watanabe, J)

BIOHOPK 323H. Stanford at Sea

(Same as BIOHOPK 182H, EESS 323, EARTHSYS 323. 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.

16 units, Spr (Block, B; Dunbar, R; Micheli, F), alternate years, not given next year

BIOHOPK 262H. Comparative Animal Physiology

(Same as BIOHOPK 162H. 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. Prerequisite: Biology core or consent of instructor.

5-8 units, given next year

BIOHOPK 273H. Marine Conservation Biology

(Same as BIOHOPK 173H. Graduate students register for 273H.) The science of preserving marine diversity. Major conservation issues associated with marine ecosystems. Topics include decline of open ocean fisheries, salmon conservation, bycatch issues in fisheries, use of marine reserves, marine invasions, marine pollution, and global warming. Includes five lecturers from other universities who specialize in marine conservation.

1-3 units, alternate years, not given this year

BIOHOPK 284H. Holistic Biology: Monterey Bay and the Sea of Cortez

(Same as BIOHOPK 184H. Graduate students register for 284H.) For majors and non-majors. Complexity in natural systems from complementary points of view, including scientific, historical, philosophical, and literary. The work and writings of Ed Ricketts and John Steinbeck and historical and contemporary works concerning marine ecology and fisheries. Field work, laboratory studies with living invertebrates, and an individual research project. Course includes a component in Baja California, Mexico. Only 6 units may count towards the Biology major.

16 units, alternate years, not given this year