Integrative Biology

College of Letters and Science (http://ls.berkeley.edu)
Department Office: 3060 Valley Life Sciences Building, (510) 642-5024

Chair: John Huelsenbeck, PhD
Department Website: Integrative Biology (http://ib.berkeley.edu)

Overview

The Department of Integrative Biology offers a program of instruction that focuses on the integration of structure and function that influences the biology, ecology, and evolution of organisms. It investigates integration at all levels of organization from molecules to the biosphere, and in all branches of the tree of life: plants, animals, fungi, and microbes.

The department draws from many traditional and emerging fields and levels of biological organization in forging new research directions and answering traditional questions in new ways. The faculty has special strengths in the disciplines of functional morphology, organismal physiology, animal behavior, biomechanics, ecology, systematic biology, paleobiology, population genetics, and evolution.

Students who major in integrative biology will gain both a broad and deep knowledge in the biological sciences, which provides an excellent foundation for those interested in the biology of organisms, populations, and communities, particularly students who might wish to pursue graduate studies in any of the subdisciplines listed above or related emerging research areas. It also provides superb training for students interested in health-related professions (medicine, dentistry, veterinary medicine, physical therapy, nursing, pharmacy, optometry, etc.) or allied careers in biology (e.g., psychology, sociobiology, forestry, wildlife conservation, environmental and resource management, law, etc.).

Through laboratory and/or field courses, independent research projects, or involvement in faculty or graduate student research, students will gain an understanding of scientific logic and methods, through experimental or comparative approaches, including the investigation of historical patterns and processes.

Courses for Nonmajors

The department offers a series of courses for students not specializing in integrative biology. These courses provide instruction in the general principles of biology from a variety of viewpoints, ranging from the molecular level through behavior and evolution. Each year, a variety of seminars are available for freshmen (IB 24) and sophomores (IB 39, IB 84) to introduce them to areas of integrative biology.

Major Requirements

Note: All courses must be taken for a letter grade.

Lower Division

The foundation for this major includes a basic one-year course in biology, general chemistry, organic chemistry, physics, and one year of mathematics. Additional coursework in mathematics, statistics, biochemistry, and multiple languages may be helpful for those planning on graduate and/or professional studies.

Required of all students in the major: Biology 1A (3), 1AL (2), 1B (4); Chemistry 1A (3), 1AL (2), 3A (3), 3AL (2), 3B (3), 3BL (2); (3); Mathematics 1A (4) and 1B (4) or 10A (4) and 10B (4); Physics 8A (4), 8B (4).

With approval of an adviser, more advanced courses may be substituted for those listed above.

Upper Division

This curriculum is designed to provide the intellectual tools and techniques necessary to conduct multidisciplinary work in the areas of organismal biology and to prepare students as broad-thinking biologists. No formal specialization is possible as an undergraduate; however, as of fall 2010, students can select courses to reflect interests and areas of focus in one of two "tracks" within the major in order to meet all upper division requirements.

Students must complete at least one course in evolution/genetics, as well as two courses that include laboratory and/or field work to provide experience and methodologies for study of both living and extinct organisms; three or more additional courses from designated requirement lists (totaling at least 24 upper division units) will complete the undergraduate major in integrative biology.

All students will complete one course from a designated list of evolution/genetics courses, and will select one of two tracks:

1. Ecology, Evolution and Organismal Biology
2. Human Biology and Health Science

Within each track, at least three additional Integrative Biology courses, falling under designated categories (Ecology, Behavior, and Diversity or Structure, Function, and Human Health), to be selected in consultation with a department adviser, and at least two courses that include significant laboratory or field biology components will be required.

The minimum total upper division units required to complete the major is 24. Students should plan to take additional upper division courses to reflect areas of interest and intellectual development. In order to meet this minimum, a list of select courses from alternative departments will be provided to allow for some upper division elective coursework. Further, up to three units of upper division, inquiry-based research may be counted toward major completion. Please contact departmental advisers for details.

Note: Students who declared Integrative Biology prior to fall 2010 shall contact the Undergraduate Student Services office in 3060 VSLB for specific questions or concerns regarding major completion.

The department website (http://ib.berkeley.edu) presents greater information about planning a major within this field, such as lists of courses applicable to each major requirement and sample semester-by-semester course schedule plans. Please visit the website (http://ib.berkeley.edu) to explore undergraduate requirements and options.

Juniors and seniors are encouraged to pursue independent study research (IB 199 or IB 191) under the sponsorship of a faculty member. Interested students should have completed at least 60 units of credit and be in good academic standing. One can consider possible research opportunities by visiting the webpages (http://ib.berkeley.edu/research) of

various Department of Integrative Biology faculty, graduate students, and affiliated research centers, museums, and collections.

Note: Transfer students with 56-70 units must complete all lower division requirements before transferring to UC Berkeley.

Honors Program

Students with a minimum UC grade point average (GPA) of 3.3 overall *and* in the major should consider participating in the honors program. They must identify an appropriate faculty sponsor who agrees to advise them on an original research project they wish to do and enroll in two semesters (six units) of the honors thesis course (H196A-196B). These students must present the results of that work in the form of a written report, the honors thesis, and a poster presentation at Cal Day. In order to graduate with honors, students must maintain a minimum 3.3 GPA overall *and* in the major.

Graduate Program in Integrative Biology

Biological phenomena occur at various levels of structural organization, ranging from molecules to organisms, and from populations to the global ecosystem. Integrative Biology takes a whole-organism approach, extending from the genome and proteome through organismal traits (phenotypes), to communities and ecosystems. Through the coordinated study of multiple levels of biological organization over a broad range of spatial and temporal scales, Integrative Biology offers a unique approach to understanding fundamental questions concerning the evolution and maintenance of biological diversity, including organismal form and function, and ecological and ecosystem processes. This multidimensional approach underpins our graduate program, where students combine observational, experimental, and comparative approaches with the development of theory, and apply concepts and techniques from the biological sciences and other disciplines.

Students in the PhD program generally apply to work with one or two faculty members whose research interests match those of the applicant. Some groups in the department employ a system of rotation among several labs. Requirements include passage of a qualifying exam, one year of teaching experience, and an advanced evolution course. The central part of the program is the dissertation, incorporating original research that builds on the student's particular interest and background.

For more information please go to our website. (http://ib.berkeley.edu)

Research Facilities

The Botanical Garden, located on 34 acres in Strawberry Canyon, provides opportunities for research with living plants, supplies and teaching material for classes on campus, and serves as an outdoor laboratory for students. Independent student and internship opportunities are available in horticulture and plant conservation. The garden is organized primarily by geographic region: California, South America, Mexico/Central America, South Africa, Australasia, Mediterranean, Eastern North America, and Asia. Specialized collections include succulents and cacti, carnivorous plants, orchids, ferns, roses, tropical plants, a Chinese medicinal herb garden, and an herb garden. Laboratory and greenhouse facilities are available at the Botanical Garden Plant Conservation Research Center. For further information about events, programs, and opportunities, go to the Botanical Garden website. (http://botanicalgarden.berkeley.edu) Inquiries can be addressed to the director by mail at UC Botanical Garden, 200 Centennial Drive #5045, Berkeley, CA 94720-5045; emailed to garden@berkeley.edu , or by calling (510) 643-2755.

The Cancer Research Laboratory (CRL) is a research institute on the Berkeley campus that carries on a research, teaching, and service program designed to foster interdepartmental participation in cancer research. The central research program represents a multidisciplinary approach to an understanding of the mechanism of neoplastic transformation using a variety of systems. Graduate student and postdoctoral research programs are supported in various areas of tumor biology: biochemistry, cell biology, endocrinology, genetics, immunology, molecular biology, and tumor virology. Currently, CRL provides advanced technical resources to cancer and biomedical researchers in the areas of advanced microscopy, flow cytometry, gene targeting/transgenic mouse technology, human stem cell facility, and an infectious disease facility. Instrumentation in the facilities is operated by highly trained staff who offer instruction in the methods and techniques associated with each facility. For more information, go to the CRL website. (http://biology.berkeley.edu/crl)

The Center for Interdisciplinary Bio-inspiration in Education and Research (CIBER) has been established to lead in the development of a new field of Integrative Systems Biomechanics that moves biology toward greater integration with other disciplines such as physics, mathematics and engineering to a degree not seen before. The discipline focuses on the physics of how organisms function and interact with their environment. The goal is to discover basic physical principles that can be applied to a diversity of organisms and unique innovations. The fluid and solid mechanics of organisms are examined using direct experimentation, comparative and phylogenetic approaches and both mathematical and physical modeling. Using this approach, the next generation of scientists and engineers will gain experience in collaboration across disciplines as well as how to extract principles in biology that inspire novel design in engineering. In addition to developing innovative methods of teaching and research, CIBER has established an interdisciplinary teaching laboratory that allows students in undergraduate as well as graduate courses to address challenging problems that will give them a meaningful interdisciplinary learning experience. These facilities are being used in a number of existing and new courses, at both the undergraduate and graduate levels. For more information on CIBER, see the website. (http://ciber.berkeley.edu)

The Center for Stable Isotope Biogeochemistry (CSIB), located on campus, is an analytical facility established as a University education, research, training, and service unit. The center provides high precision, state-of-the-art instrumentation for analyzing the stable isotope composition of a diverse array of materials (e.g., plant and animal tissue samples, soils, atmospheric gasses, water, specific compounds, organic matter, etc.), as well as space for purifying, extracting, and preparing sample material for analysis. The center also serves as a focal point for research and training for many of our programs at Berkeley (e.g., in Biology, Ecology, Paleontology, Anthropology, Geography, Chemistry, Hydrology, Atmospheric, and Soil Sciences). The specialized equipment housed in the facility serves a broad range of student, postdoctoral, and faculty needs. This equipment includes several gas phase isotope ratio mass spectrometers (IRMS); these mass spectrometers have the capabilities of analyzing the isotopic composition of hydrogen, carbon, oxygen, nitrogen, and sulfur in biological and geological samples, gasses (biogenic and atmospheric), and water. In addition to the instrument laboratory, the center houses a fully-equipped sample extraction and preparation laboratory for handling a full range of sample types. For

more information, see the CSIB website. (http://ib.berkeley.edu/groups/biogeochemistry.html)

The Field Station for Behavioral Research is a research institute that supports behavioral studies on animals under natural and seminatural conditions. Situated on 20 acres of wooded hillside at the top of Strawberry Canyon two miles from the central campus, the field station maintains and observes a variety of animal species. Faculty from several Berkeley departments including Integrative Biology conduct research at the station. Its facilities are available for graduate and postdoctoral research with the approval of the director. People interested in the field station may contact the director via the Department of Integrative Biology.

The Gump South Pacific Research Station, French Polynesia, is located on Moorea (17° 30' S 149° 50' W), one of the Society Islands, 15 km northwest of the main island of Tahiti. Moorea offers diverse habitats ranging from coral reefs, lagoons, coastal beaches, freshwater streams, wetlands, and mountain forests. The Gump Station occupies 14 hectares (35 acres) of land from the shore to 149m (489ft) at the entrance to Cook's Bay, providing excellent access to the ocean, lagoon, and island interior. A range of housing options (shared dormitories, private bungalows) and laboratories allow long- and short-term research and education in a diversity of fields, including marine, freshwater, and terrestrial biology, evolutionary and conservation biology, archaeology, anthropology, ethnobotany, geology, and geomorphology. Facilities include boats and 4WD vehicles. A waterfront marine laboratory contains an open seawater system and equipment for UC Scientific Diving. A large climate controlled research building contains offices, library/conference room, and several laboratories including space for morphological work (high-quality microscopes) and molecular genetic analyses. The Station is connected to the Internet via multiple ADSL lines and has WIFI access in all common areas. For further information, contact Dr. Neil Davies, Executive Director,ndavies@moorea.berkeley.edu . More information can be found on the station website. (http://moorea.berkeley.edu)

The Human Evolution Research Center (HERC) is dedicated to the study of human origins and evolution. HERC represents an international focal point for field and laboratory research and education. It is a center for the study of the process and products of human evolution. Research by the HERC includes both field and laboratory investigation. The center's collections and facilities provide support to faculty and students working on important, large-scale investigations. These include The Middle Awash Project and The Revealing Hominid Origins Initiative (RHOI). For more information on HERC and RHOI, see the HERC website (http://herc.berkeley.edu) and the RHOI website, (http://rhoi.berkeley.edu) respectively.

The Jane Gray Research Greenhouse is operated by the Department of Integrative Biology and comprises approximately 2,400 square feet of state-of-the-art research space, used for projects by faculty and students. The climate management system is computer-controlled and monitors temperature, humidity, light energy, and wind speed and direction. The system's responses to these conditions can be controlled centrally or from a remote location through an on-screen ARGUS interface to gas heaters, evaporative coolers, vents, fans, and sunshades. The facility provides an ideal resource for plant growth investigations that require closely controlled and monitored conditions. For more information, see the Greenhouse website. (http://ib.berkeley.edu/jgrg/facilities/greenhouse)

The Museum of Paleontology (UCMP), a research institute for faculty, staff, students, and qualified visiting scholars, has one of the largest collections of fossil protists, invertebrates, plants, and vertebrates in the nation, as well as large collections of modern vertebrate skeletal elements and invertebrates. The collection is worldwide in scope and is especially strong in materials from western North America. Research activities include systematic, paleobiogeographic, paleoecologic, biostratigraphic, evolutionary, and theoretical paleobiologic studies. Field work on all continents by researchers and students associated with the museum continues to sustain substantial collection growth. Special facilities include molecular biology and fossil preparation laboratories, as well as specialized laboratories for microfossils, pollen, and cast production.

UCMP has an active education and outreach program, using the web as its primary venue for sharing science with a broader audience. The UCMP website (http://www.ucmp.berkeley.edu) contains a wealth of information on evolution, paleontology, systematics, and associated sciences, as well as access to collections data and specimen images. Requests for use of the collections or facilities should be mailed to the Director, Museum of Paleontology, Valley Life Sciences Building, University of California, Berkeley; Berkeley, CA 94720.

The Museum of Vertebrate Zoology is an Organized Research Unit affiliated with the Department of Integrative Biology and the Berkeley Natural History Museums. It was established in 1908 and has grown to be one of the largest and most important collections of amphibians, reptiles, birds, and mammals in the world. The museum has no public exhibits; it is primarily a research organization and a center for graduate and postdoctoral education. The museum's space in the Valley Life Sciences Building includes all of the collections as well as administrative and research offices for faculty, postdoctoral, and graduate students. In addition, there are laboratories for molecular genetics and biodiversity informatics. Research activities center on problems in evolutionary biology, with emphasis on systematics, ecology, functional and developmental morphology, behavior, population and conservation biology, and biogeography. Integration of field and laboratory methods is encouraged. For more information, write to the Director, Museum of Vertebrate Zoology, UC Berkeley; Berkeley, CA 94720, or, for the Hastings Reservation, to Dr. Mark Stromberg, Carmel Valley, CA 93925. More information can be found on the museum's website. (http://mvz.berkeley.edu)

The University and Jepson Herbaria offer a worldwide reference-research collection, laboratories, archive, and library that form a foundation for basic research in systematic botany, ecology, phytogeography, evolution, and comparative genomics. These resources are available not only to faculty, staff, and students but also to visiting scholars and biologists throughout the United States and other countries. Resources include:

1. The collection itself, more than 2.2 million specimens with special strengths in the angiosperm flora of California and elsewhere around the Pacific Rim, as well as in cryptogamic groups including ferns, bryophytes, fungi, and algae.
2. Modern laboratories for all types of plant studies, ranging from morphology/anatomy to molecular systematics.
3. Extensive electronic resources, including an online flora of California, and interface for accessing electronic records from all California herbaria, the world's standard index of algal nomenclature, to the tree of life for green plants.

See the website (http://ucjeps.berkeley.edu) at for more information. Inquiries should be addressed to: Director, University and Jepson Herbaria, University of California, Berkeley; Berkeley, CA 94720.

The University of California Natural Reserve System (NRS) was founded in 1965 to establish and maintain significant examples of

California's diverse aquatic and terrestrial ecosystems for university-level teaching, research, and public service. The 33 reserves are open to all qualified individuals and institutions for scholarly work in disciplines ranging from geology and environmental sciences to anthropology and art. For more information on the NRS, contact the UC Office of the President at (510) 987-0150 or go to the UC Office of the President website. (http://nrs.ucop.edu.) For specific information regarding the four reserves administered by the Berkeley campus, contact faculty reserve manager Mary Power at (510) 643-7776 or mepower@berkeley.edu . The Berkeley campus administers these four reserves:

- **The Angelo Coast Reserve** in Mendocino County is one of the most diverse reserves, with 26 terrestrial and four aquatic habitat types. Located along a belt of highly deformed, well-defined coastal ridges cut by the South Fork of the Eel River, the reserve contains the largest virgin Douglas fir community left in the state, as well as four undisturbed watersheds. It is part of the UNESCO California Coast Ranges Biosphere Reserve. For more information, contact Peter Steel at (707) 984-6653 or psteel@nature.berkeley.edu .
- **The Chickering American River Reserve** in Placer County is located in the sub-alpine headwaters basin of the North Fork of the American River. The reserve has diverse topography, soil, and moisture regimes on sedimentary, igneous, and metamorphic substrates. It supports approximately 1,000 plant species, unusual red fir and mixed-conifer old-growth forest communities, and a variety of large mammals. Long-term research continues on the endangered wolverine. For more information, contact James Kirchner at (510) 643-8559 or kirchner@geomorph.berkeley.edu .
- **The Hans Jenny Pygmy Forest Reserve** in Mendocino County supports elfin forests of endemic pygmy cypress, bishop pine, and unusual evergreen shrub species on highly podsolized, old marine terrace soils. This reserve is adjacent to lands managed by The Nature Conservancy. For more information, contact Ronald G. Amundson at (510) 643-7890 or earthy@nature.berkeley.edu.
- **The Hastings Natural History Reserve** in Monterey County contains a representative sample of California's interior Coast Range ecosystem, with annual and perennial grasslands, oak woodlands, chaparral, and running streams. The reserve has 620 vascular plant species and 166 bird species. While noted for its 50-year research history on vertebrate ecology and oak woodland biology, the reserve is also conducting important research on native grassland restoration. For more information, contact Mark Stromberg at (831) 659-2664 or stromber@berkeley.edu.

INTEGBI C13/ASTRON C13 Origins: from the Big Bang to the Emergence of Humans 4 Units
Department: Integrative Biology; Astronomy
Course level: Undergraduate
Terms course may be offered: Fall and spring
Grading: Letter grade.
Hours and format: 3 hours of Lecture and 2 hours of Discussion per week for 15 weeks.
This course will cover our modern scientific understanding of origins, from the Big Bang to the formation of planets like Earth, evolution by natural selection, the genetic basis of evolution, and the emergence of humans. These ideas are of great intrinsic scientific importance and also have far reaching implications for other aspects of people's lives (e.g., philosophical, religious, and political). A major theme will be the scientific method and how we know what we know.
Instructors: Marshall, Quataert

INTEGBI 24 Freshman Seminars 1 Unit
Department: Integrative Biology
Course level: Undergraduate
Terms course may be offered: Fall and spring
Grading: The grading option will be decided by the instructor when the class is offered.
Hours and format: 1 hour of Seminar per week for 15 weeks.
The Berkeley Seminar Program has been designed to provide new students with the opportunity to explore an intellectual topic with a faculty member in a small-seminar setting. Berkeley Seminars are offered in all campus departments, and topics vary from department to department and semester to semester.
Course may be repeated for credit as topic varies. Course may be repeated for credit when topic changes.

INTEGBI 31 The Ecology and Evolution of Animal Behavior 3 Units
Department: Integrative Biology
Course level: Undergraduate
Term course may be offered: Spring
Grading: Letter grade.
Hours and format: 2 hours of lecture, 1 hour of film/demonstration and 1 hour of discussion per week.
Prerequisites: Open to all students; designed for those not specializing in biology.
Principles of evolution biology as they relate to animal behavior and behavioral ecology with broad coverage of animal groups. Special attention will be paid to the emerging discipline of behavioral ecology. Students will receive no credit for Integrative Biology 31 after taking Integrative Biology 144, C144 or Psychology C115B. Instructor: Caldwell

INTEGBI N33 Topics in Paleontology: The Age of Dinosaurs 2 Units
Department: Integrative Biology
Course level: Undergraduate
Term course may be offered: Summer
Grading: Letter grade.
Hours and format: 4 hours of Lecture per week for 8 weeks.
Open without prerequisite to all students and designed for those not specializing in paleontology. Evolution history, and ecology of the dinosaurs and their world, including the earliest mammals and birds. More than one course in this series may be taken for credit with consent of instructor. Course may be repeated for credit when topic changes.

INTEGBI 35AC Human Biological Variation 4 Units
Department: Integrative Biology
Course level: Undergraduate
Term course may be offered: Fall
Grading: Letter grade.
Hours and format: 3 hours of lecture and 1 hour of discussion per week.
This course addresses modern human biological variation from historical, comparative, evolutionary, biomedical, and cultural perspectives. It is