ECOLOGY AND EVOLUTIONARY BIOLOGY

Osborn Memorial Laboratories, 203.432.3837
http://eeb.yale.edu
M.S., Ph.D.

Chair
Thomas Near

Director of Graduate Studies
Erika Edwards

Professors Richard Bribiescas (Anthropology), Nicholas Christakis (Sociology), Michael Donoghue, Casey Dunn, Erika Edwards, Alison Galvani (Public Health), Vivian Irish (Molecular, Cellular, & Developmental Biology), Walter Jetz, Thomas Near, David Post, Jeffrey Powell, Richard Prum, Eric Sargsis (Anthropology), Oswald Schmitz (Forestry & Environmental Studies), David Skelly (Forestry & Environmental Studies), Stephen Stearns, Paul Turner, J. Rimas Vaisnys (Electrical Engineering), Günter Wagner

Associate Professors Forrest Crawford (Public Health), James Noonan (Genetics), Jeffrey Townsend (Public Health), David Vasseur

Assistant Professors Craig Brodersen (Forestry & Environmental Studies), Liza Comita (Forestry & Environmental Studies), Alvaro Sanchez, Carla Staver

Senior Lecturer Marta Martinez Wells

Lecturers Adalgisa Caccone, Linda Puth

FIELDS OF STUDY
The Department of Ecology and Evolutionary Biology (E&EB) offers training programs in organismal biology, ecology, and evolutionary biology including molecular evolution, phylogeny, molecular population genetics, developmental evolution, and evolutionary theory.

SPECIAL ADMISSIONS REQUIREMENTS
Applicants should have had training in one of the following fields: biology, mathematics, chemistry, physics, statistics, and/or geology. Candidates are selected, regardless of their major, based on overall preparation for a career in research in ecology and evolutionary biology. Some, planning for careers in applied fields, may have prepared with courses in public policy, economics, and agriculture.

SPECIAL REQUIREMENTS FOR THE PH.D. DEGREE
Each entering student, in consultation with the director of graduate studies (DGS), develops a specific program of courses, seminars, laboratory research, and independent reading tailored to the student’s interests, background, and goals. There are normally no foreign language requirements. All first-year students carry out two research rotations. Students have the option of a rotation over their first summer. Students must participate in (1) E&EB 500 and E&EB 501, Advanced Topics in Ecology and Evolutionary Biology; (2) E&EB 545, a course on the responsible conduct of research; (3) weekly E&EB seminars; and (4) symposia of faculty and graduate student research. In addition, during their first two years of study, graduate students must enroll in a minimum of three additional graduate-level courses (numbered 500 and above); a grade of H must be earned in two of these. Teaching experience is regarded as an integral part of the graduate training program. All students are required to teach three courses, normally at a level 20, typically during their first two years of study.

By the middle of the fourth term of study, each student organizes a formal preprospectus consultative meeting with the student’s advisory committee to discuss the planned dissertation research. Before the beginning of the fifth term, students present and defend their planned dissertation research at a prospectus meeting, at which the department determines the viability and appropriateness of the student’s Ph.D. proposal. A successful prospectus meeting and completion of course requirements results in admission to candidacy for the Ph.D. The remaining requirements include completion, presentation, and successful defense of the dissertation, and submission of copies of the dissertation to the Graduate School and to the Center for Science and Social Science Information.

In cases where the dissertation committee decides that preliminary field work during the summer after the fourth term is necessary prior to the prospectus, the prospectus meeting can be delayed by one term. A request for a delay must come from the dissertation committee adviser and must be approved by the DGS. In these exceptional cases, admission to candidacy may not be required for registration for the third year of graduate study.

HONORS REQUIREMENT
Students must meet the Graduate School’s requirement of Honors in two courses by the end of the fourth term of study. The E&EB department also requires an average grade of at least High Pass in course work during the first two years of study.
MASTERS DEGREE

M.S. (en route to the Ph.D.) Students must pass ten graduate-level courses. At least four courses must be taken for a grade, and students must earn Honors in two courses and maintain an overall average of High Pass. Required courses are: E&EB 500 and E&EB 501, Advanced Topics in Ecology and Evolutionary Biology; E&EB 445, Responsible Conduct of Research; E&EB 901, Research Rotation I; and E&EB 902, Research Rotation II. A minimum of five additional graduate-level courses (four taken for a grade) are required.

Additional information on the department, faculty, courses, and facilities is available from Deanna Brunson, Office of the Director of Graduate Studies, Department of Ecology and Evolutionary Biology, Yale University, PO Box 208106, New Haven CT 06520-8106; e-mail, deanna.brunson@yale.edu; tel., 203.432.3837; fax, 203.432.2374; website, http://eeb.yale.edu.

COURSES

E&EB 500a and E&EB 501b, Advanced Topics in Ecology and Evolutionary Biology  Erika Edwards
Topics to be announced. Graded Satisfactory/Unsatisfactory.

E&EB 510a, Introduction to Statistics: Life Sciences  Jonathan Reuning-Scherer and Walter Jetz
Statistical and probabilistic analysis of biological problems, presented with a unified foundation in basic statistical theory. Problems are drawn from genetics, ecology, epidemiology, and bioinformatics.

E&EB 515a, Conservation Biology  Linda Puth
An introduction to ecological and evolutionary principles underpinning efforts to conserve Earth’s biodiversity. Efforts to halt the rapid increase in disappearance of both plants and animals. Discussion of sociological and economic issues.

E&EB 520a, General Ecology  David Vasseur and Ann Staver
A broad consideration of the theory and practice of ecology, including the ecology of individuals, population dynamics and regulation, community structure, ecosystem function, and ecological interactions on broad spatial and temporal scales. Topics such as climate change, fisheries management, and infectious disease are placed in an ecological context.

E&EB 525b, Laboratory for Principles of Evolution, Ecology, and Behavior  Marta Wells
Experimental approaches to organismal and population biology, including study of the diversity of life.

E&EB 530a, Field Ecology  Linda Puth
A field-based introduction to ecological research. Experimental and descriptive approaches, comparative analysis, and modeling are explored through field and small-group projects.

E&EB 535a, Evolution and Medicine  Stephen Stearns
Introduction to the ways in which evolutionary science informs medical research and clinical practice. Diseases of civilization and their relation to humans’ evolutionary past; the evolution of human defense mechanisms; antibiotic resistance and virulence in pathogens; cancer as an evolutionary process. Students view course lectures online; class time focuses on discussion of lecture topics and research papers.

E&EB 545a, Responsible Conduct of Research  Erika Edwards
This five-week discussion seminar considers issues related to the responsible conduct of research. Topics addressed include research misconduct, plagiarism, data acquisition and management, mentoring and collaboration, authorship and peer review, the use of animals and humans in scientific research, sexual harassment, diversity, and balancing professional and personal life. Graded Satisfactory/Unsatisfactory.

E&EB 546a, Plant Diversity and Evolution  Michael Donoghue
Introduction to the major plant groups and their evolutionary relationships, with an emphasis on the diversification and global importance of flowering plants.

E&EB 547La, Laboratory for Plant Diversity and Evolution  Michael Donoghue
Hands-on experience with the plant groups examined in the accompanying lectures; local field trips.

E&EB 550a, Biology of Terrestrial Arthropods  Marta Wells
Evolutionary history and diversity of terrestrial arthropods (body plan, phylogenetic relations, fossil record); physiology and functional morphology (water relations, thermo-regulation, energetics of flying and singing); reproduction (biology of reproduction, life cycles, metamorphosis, parental care); behavior (migration, communication, mating systems, evolution of sociality); ecology (parasitism, mutualism, predator-prey interactions, competition, plant-insect interactions).

E&EB 551La, Laboratory for Biology of Terrestrial Arthropods  Marta Wells
Comparative anatomy, dissections, identification, and classifications of terrestrial arthropods; specimen collection; field trips.
E&EB 555a, Invertebrates  Casey Dunn
An overview of animal diversity that explores themes including animal phylogenetics (evolutionary relationships), comparative studies of evolutionary patterns across species, organism structure and function, and the interaction of organisms with their environments. Most animal lineages are marine invertebrates, so marine invertebrates are the focus of most of the course. Concurrent enrollment in E&EB 556 is not required.

E&EB 556a, Laboratory for Invertebrates  Casey Dunn
The study of invertebrate anatomy and diversity in a laboratory and field setting. Activities include examination of live animals and museum specimens, as well as local field trips. Some field trips fall on weekends. Must be taken concurrently with E&EB 555. ½ Course cr

E&EB 564a, Ichthyology  Richard Harrington
A survey of fish diversity, including jawless vertebrates, chimaeras and sharks, lungfishes, and ray-finned fishes. Topics include the evolutionary origin of vertebrates, the fossil record of fishes, evolutionary diversification of major extant fish lineages, biogeography, ecology, and reproductive strategies of fishes.

E&EB 565La, Laboratory for Ichthyology  Richard Harrington

E&EB 626b, Plant Structure and Function  Erika Edwards
An examination of the relationship between the structure of plants and their physiological systems, and the role of the environment in shaping the evolution and diversity of vascular plants. Lectures focus on exploring the basics of plant morphology, and the anatomical and physiological adaptations of leaves, stems, and roots to different habitats. A comparative, phylogenetic approach is emphasized. This is a hybrid lecture/lab course: the first two-thirds of the course consists of chalkboard lectures by the instructor and the last third is an intensive period of data collection and analysis, providing students with firsthand experience in measuring and interpreting plant functional traits. Students work on a set of group projects that are designed to test long-standing assumptions about the evolution and adaptive nature of certain plant traits. Projects differ from year to year, and although the general theme is chosen by the instructor, students are expected to play a large role in experimental design and focus. Students leave the class with a solid foundation both in plant anatomy and ecomorphology and in applying a phylogenetic comparative approach to studies of organismal biology; and they gain firsthand experience in data collection, experimental design, data analysis, and the collaborative presentation of a scientific study. Permission of the instructor required. Must be taken in conjunction with E&EB 627L.

E&EB 627Lb, Plant Structure and Function Lab  Erika Edwards
An examination of the relationship between the structure of plants and their physiological systems, and the role of the environment in shaping the evolution and diversity of vascular plants. Lectures focus on exploring the basics of plant morphology, and the anatomical and physiological adaptations of leaves, stems, and roots to different habitats. A comparative, phylogenetic approach is emphasized. This is a hybrid lecture/lab course: the first two-thirds of the course consists of chalkboard lectures by the instructor and the last third is an intensive period of data collection and analysis, providing students with firsthand experience in measuring and interpreting plant functional traits. Students work on a set of group projects that are designed to test long-standing assumptions about the evolution and adaptive nature of certain plant traits. Projects differ from year to year, and although the general theme is chosen by the instructor, students are expected to play a large role in experimental design and focus. Students leave the class with a solid foundation both in plant anatomy and ecomorphology and in applying a phylogenetic comparative approach to studies of organismal biology; and they gain firsthand experience in data collection, experimental design, data analysis, and the collaborative presentation of a scientific study. Must be taken in conjunction with E&EB 626. ½ Course cr

E&EB 650b, Biology of Insect Disease Vectors  Brian Weiss
Insects transmit pathogens that cause many emerging and reemerging human and agriculture-related diseases. Many of these diseases, which are referred to as neglected tropical diseases (NTDs), have a dramatically negative impact on human health in the developing world. Furthermore, they cause indirect devastation by significantly reducing agricultural productivity and nutrient availability, exacerbating poverty and deepening disparities. This course introduces students to the biological interactions that occur between major groups of important disease vectors and the pathogens they transmit. Lectures cover current research trends that relate to the ecology and physiology of insect vectors. Course content focuses on how these aspects of vector biology relate to the development and implementation of innovative and effective disease control strategies. Prerequisite: full year of college/university-level biology, or permission of the instructor.

E&EB 672b, Ornithology  Richard Prum
An overview of avian biology and evolution, including the structure, function, behavior, and diversity of birds. The evolutionary origin of birds, avian phylogeny, anatomy, physiology, neurobiology, breeding systems, and biogeography.

E&EB 673Lb, Laboratory for Ornithology  Richard Prum
Laboratory and field studies of avian morphology, diversity, phylogeny, classification, identification, and behavior. Must be taken concurrently with E&EB 672. ½ Course cr

E&EB 678a, Mathematical Models and Quantitative Methods in Evolution and Ecology  Alvaro Sanchez De Andres
In this course, we focus on how quantitative approaches are used to allow scientific inference. We discuss general principles for generating hypotheses that are testable (i.e., quantifiable). The course also examines a variety of approaches used to model population-level processes in evolution and ecology, including an overview of population genetics, quantitative genetics, optimality models, game theory, and population dynamic equations. We also discuss experimental design, statistical analyses, inference, and other quantitative methods.
The course assumes a basic background in algebra, calculus, probability theory, and statistics. Please address any questions regarding the course to alvaro.sanchez@yale.edu.

**E&EB 680b, Life History Evolution**  Stephen Stearns
Life history evolution studies how the phenotypic traits directly involved in reproductive success are shaped by evolution to solve ecological problems. The intimate interplay between evolution and ecology.

**E&EB 713b, Concepts and Methods in Global Biodiversity Change Research in the Age of Big Data**  Walter Jetz
Biodiversity and the many functions it provides are changing worldwide, creating a critical need for a better understanding of mechanisms underpinning this change and the development of new information products to help monitoring and mitigation. New technologies, data, and methods, as well as conceptual advances, increasingly enable work addressing this challenge for species and communities at a global scale. We discuss these new opportunities and familiarize ourselves with recent research and new approaches to global biodiversity change. The course combines in-depth discussion of recent empirical work and hands-on examples of biodiversity change analysis workflows. On the technical front, we explore the use of remote sensing through Google Earth Engine (GEE) and work through R-based scripted examples of species distribution and community change modeling. The course is offered in collaboration with the Yale Center for Biodiversity and Global Change (https://bgc.yale.edu) and includes seminars and discussions with guest speakers.

**E&EB 725a, Scientific Writing for Ecology and Evolutionary Biology**  Ann Staver
This course provides guidance and practice for graduate students in grant and manuscript writing in the fields of ecology and evolutionary biology. Students produce one grant application (NSF GRFP/DDIG or similar) and one manuscript for publication (on a topic of their choice, to contribute to their thesis or other ongoing work).

**E&EB 810b, Dynamics of Evolving Systems**  J. Rimas Vaišnys
An introduction to the ways evolving biological systems can be described, modeled, and analyzed by using a dynamical systems approach. To use currently fashionable terminology, we develop an individual-based model of the behavior of biological populations, which leads to evolution as an emergent property. In this approach it is possible to construct populations of varying individuals, which can then be combined into larger assemblages, and to modify both the overall environment and the environments at the lower levels, so that aspects often neglected in modeling evolution can be explored and related to any available observational data. Extensive use of the software package Mathematica, but prior experience with the program is not required.

**E&EB 842b / ANTH 835b, Primate Diversity and Evolution**  Eric Sargis
The diversity and evolutionary history of living and extinct primates. Focus on major controversies in primate systematics and evolution, including the origins and relationships of several groups. Consideration of both morphological and molecular studies. Morphological diversity and adaptations explored through museum specimens and fossil casts.

**E&EB 900a or b, First-Year Introduction to Research and Rotations**  Erika Edwards

**E&EB 901a, Research Rotation I**  Erika Edwards

**E&EB 902b, Research Rotation II**  Erika Edwards

**E&EB 903b, Independent Study**  Erika Edwards
By arrangement with faculty. Approval of DGS required.

**E&EB 930a or b / G&G 703a or b, Seminar in Systematics**  Jacques Gauthier
A seminar on using molecular evolutionary models in Bayesian phylogenetic analyses. Topics are chosen by the participants but may include “models” in phylogenetics, understanding and comparison of model selection criteria, effects of model under- and overparameterization on parameter value estimates and phylogenetic inferences, and accommodating model uncertainty and model-averaging.

**E&EB 950a or b, Second-Year Research**  Staff
By arrangement with faculty.