ECOLOGY AND EVOLUTIONARY BIOLOGY

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FACULTY OF THE DEPARTMENT OF ECOLOGY AND EVOLUTIONARY BIOLOGY

Professors  Leo Buss, † Nicholas Christakis, † Peter Crane, Michael Donoghue, † Vivian Irish, † Kenneth Kidd, David Post, Jeffrey Powell, Richard Prum, † Eric Sargis, † Oswald Schmitz, † David Skelly, Stephen Stearns, Paul Turner (Chair), † J. Rimas Vaišnys, Günter Wagner

Associate Professors  † Alison Galvani, Walter Jetz, Thomas Near, † Jeffrey Townsend, David Vasseur

Assistant Professors  † Forrest Crawford, Carla Staver

Senior Lecturer  Marta Martínez Wells

Lecturers  Gisella Caccone, Mary Beth Decker, Linda Puth

† A joint appointment with primary affiliation in another department or school.

The Department of Ecology and Evolutionary Biology (EEB) offers broad education in the biological sciences. The subject matter includes molecules, cells, organs, organisms, and ecosystems and the evolutionary processes that shape them. The department offers a B.A. and a B.S. degree. The B.A. program is intended for students who are interested in ecology, evolution, and organismal diversity as part of a liberal education but do not intend to pursue graduate work in the discipline. The B.S. program is designed for students planning to attend medical or veterinary school or to pursue graduate study in ecology and evolutionary biology, other biological disciplines, or the environmental sciences. The two programs share the same prerequisites and core requirements but differ in their electives and senior requirements.

Students majoring in EEB select one of two tracks. The requirements for Track 1 emphasize courses appropriate for careers in ecology, evolutionary biology, and environmental science; Track 2 is most appropriate for premedical and preveterinary students because it allows them to use as electives many courses required by medical schools. The EEB major offers opportunities for independent research in both laboratory-based and field-based scientific investigations.

Courses for nonmajors  Several EEB courses have no college-level prerequisites and are suitable for nonmajors. These include all 100-level offerings as well as 200-level courses that deal with particular organism groups such as plants, fish, mammals, birds, or insects.

Prerequisites  The prerequisites for the major are intended to provide core scientific literacy; they include courses in biology, chemistry, physics, and mathematics. The introductory biology sequence BIOL 101, 102, 103, and 104 is required. Also required are a two-term lecture sequence in chemistry, or CHEM 118, taken with their associated laboratories, and one term of organic chemistry with laboratory. CHEM 124, 125, or CHEM 174, 175, taken with CHEM 222L, 223L, satisfies both chemistry requirements. Two terms of physics are required, PHYS 170, 171 or higher, and one term of mathematics, MATH 115 or higher or STAT 101–106. A different statistics course approved by the director of undergraduate studies may be substituted for the mathematics prerequisite.

Acceleration credit awarded in chemistry, mathematics, and physics, or completion of advanced courses in those departments, is accepted in place of the corresponding prerequisites for the EEB major. Students who have mathematics preparation equivalent to MATH 115 or higher are encouraged to take a statistics course (most often STAT 101–106) and/or additional mathematics courses such as MATH 120, 121, 222, or 225. Because chemistry courses are prerequisite to several EEB courses, students are strongly urged to take general and organic chemistry in the freshman and sophomore years. Students who place out of general chemistry should take organic chemistry during their freshman year. Finishing the prerequisites early allows for a more flexible program in later years.

Placement  Students can place out of the introductory biology sequence (BIOL 101, 102, 103, 104) only by means of the biology placement examination administered jointly by the biological science departments, EEB, MB&B, and MCDB. For information about the placement examination, refer to the Calendar for the Opening Days of College and the Freshman Web site (http://yalecollege.yale.edu/new-students/class-2019/academic-information/special-programs-placement-and-preregistration/biology).

Potential EEB majors are expected to take the mathematics placement test. Those who place above the level of MATH 112 may proceed to prerequisite courses for the EEB major; those who place into MATH 112 must take calculus before other prerequisites. The Chemistry department arranges placement in chemistry courses.

Requirements of the major  Beyond the prerequisites, the B.A. requires three lecture courses and one laboratory, for three and one-half course credits, and the senior requirement. In Track 1, the required courses are E&EB 220, 225, and a lecture course on organismal diversity chosen from E&EB 246–272, along with its associated laboratory. Required courses in Track 2 include E&EB 290, 291L, BENG 350, and MCDB 300.

The B.S. requirements are the same as those for the B.A., with the addition of at least two electives, for two course credits, in either Track 1 or Track 2. At least one of the electives must be a lecture or a seminar. Most EEB, MCDB, or MB&B courses numbered 200 or above
qualify as electives, as do most research courses and laboratories in a biological sciences department or in the Medical School. Courses from other departments may qualify with permission of the director of undergraduate studies.

**Substitutions permitted** Two upper-level courses in Geology and Geophysics (excluding paleobiology courses), Mathematics, Computer Science, or Engineering and Applied Science can be substituted for the required term of organic chemistry and laboratory. The second term of organic chemistry and laboratory and up to two terms of physics laboratories are allowed as electives. Courses from other departments may also be suitable as electives. All substitutions require the permission of the director of undergraduate studies. College seminars may not be counted toward the requirements of the major.

**Senior requirement** Students in the B.A. degree program fulfill the senior requirement either by completing one term of independent study in E&EB 470 or by writing a senior essay. The senior essay may be related to the subject matter of a course, but the essay is a separate departmental requirement in addition to any work done in a course and does not count toward the grade in any course. Students intending to write a senior essay must obtain an approval form from the office of the director of undergraduate studies and have it signed by the essay adviser before the end of the course selection period. Essays must be submitted to the director of undergraduate studies by the last day of classes.

Students in the B.S. degree program fulfill the senior requirement by completing one term of original research in E&EB 475, 495, or 496. Additional research courses may be taken as electives in E&EB 474 and may be taken before the senior year.

**Credit/D/Fail** No course taken Credit/D/Fail may be counted toward the EEB major, including prerequisites.

**Limit on research courses** While independent research courses may be taken multiple times for credit, there are restrictions on the number of such courses that can be included in a student’s curriculum. See Course Credits and Course Loads (http://catalog.yale.edu/ycps/academic-regulations/course-credits-course-loads) in the Academic Regulations.

**Graduate courses of interest to undergraduates** Graduate courses in the biological and biomedical sciences that may be of interest to undergraduates are listed in the Graduate School’s online bulletin (http://www.yale.edu/primer/bulletin/htmlfiles/grad), and many are posted on the Biological and Biomedical Sciences Web site (http://bbs.yale.edu). Additional information is available from the director of undergraduate studies and the director of graduate studies. Undergraduates with an appropriate background may enroll with the permission of the director of graduate studies and the instructor.

**Advising** Freshmen considering a major in Ecology and Evolutionary Biology are invited to consult with the director of undergraduate studies. After the freshman year, students should choose an adviser from the department faculty who has interests comparable to their own and/or is a fellow of their residential college. For additional information, visit the EEB departmental Web site (http://eeb.yale.edu). The course schedules of all EEB majors (including sophomores intending to major in EEB) must be signed by a faculty member in EEB; the signature of the director of undergraduate studies is not required. Students whose regular adviser is on leave can consult the director of undergraduate studies to arrange for an alternate.

**Study abroad** Participation in study abroad field programs is encouraged. Credit for such programs may apply toward the major; interested students should consult the director of undergraduate studies prior to going abroad.

**REQUIREMENTS OF THE MAJOR**

**Prerequisites** BIOL 101, 102, 103, 104; 2-term chem lecture sequence or CHEM 118, with labs; 1 term of organic chem with lab

CHEM 174, 175 (or CHEM 124, 125) with 222L, 223L satisfies both chem requirements; PHYS 170, 171 or higher; MATH 115 or higher or STAT 101–106

**Number of courses** B.A. – 3½ course credits (not incl senior req); B.S. – 5½ course credits (not incl senior req)

**Specific courses required**

**Track 1** – E&EB 220, 225; 1 from E&EB 246–272, with lab; **Track 2** – E&EB 290, 291L, BENG 350, MCDB 300

**Distribution of courses** B.S. – 2 electives

**Substitutions permitted** Other stat course approved by DUS for math or stat prereq; two upper-level courses in G&G, Math, Comp Sci, or E&AS for organic chem and lab, with DUS permission; the second term of organic chem and lab and two physics labs for electives, with DUS permission

**Senior requirement** B.A. – E&EB 470 or senior essay; B.S. – E&EB 475, 495, or 496

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**Introductory Courses**

*E&EB 106a / HLTH 155a / MCDB 106a, Biology of Malaria, Lyme, and Other Vector-Borne Diseases*  
Alexia Belperron
Introduction to the biology of pathogen transmission from one organism to another by insects; special focus on malaria, dengue, and Lyme disease. Biology of the pathogens including modes of transmission, establishment of infection, and immune responses; the challenges associated with vector control, prevention, development of vaccines, and treatments. Intended for non-science majors; preference to freshmen and sophomores. Prerequisite: high school biology. SC

*E&EB 115a / F&ES 315a, Conservation Biology*  
Linda Puth and Jeffrey Powell
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. SC
* E&EB 125b / G&G 125b, History of Life  Derek Briggs
Examination of fossil and geologic evidence pertaining to the origin, evolution, and history of life on Earth. Emphasis on major events in the history of life, on what the fossil record reveals about the evolutionary process, on the diversity of ancient and living organisms, and on the evolutionary impact of Earth’s changing environment.  SC

E&EB 145b, Plants and People  Linda Puth
The interaction of plants and people throughout history explored from biological, historical, anthropological, and artistic perspectives. Basic botany; plants in the context of agriculture; plants as instruments of trade and societal change; plants as inspiration; plants in the environment. Includes field trips to the greenhouses at Yale Marsh Botanical Garden, the Yale Peabody Museum and Herbarium, the Yale Farm, and the Yale Art Gallery.  SC

E&EB 210a / STAT 101a, Introduction to Statistics: Life Sciences  Jonathan Reuning-Scherer
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.  QR

E&EB 246a, 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. To be taken concurrently with E&EB 247L. Prerequisite: a general understanding of biology and evolution.  SC

E&EB 247La, Laboratory for Plant Diversity and Evolution  Michael Donoghue
Hands-on experience with the plant groups examined in the accompanying lectures. Local field trips. To be taken concurrently with E&EB 246.  SC ½ Course cr

E&EB 250a, Biology of Terrestrial Arthropods  Marta Wells
Evolutionary history and diversity of terrestrial arthropods (body plan, phylogenetic relationships, fossil record); physiology and functional morphology (water relations, thermoregulation, 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).  SC

E&EB 251La, Laboratory for Biology of Terrestrial Arthropods  Marta Wells
Comparative anatomy, dissections, identification, and classification of terrestrial arthropods; specimen collection; field trips. Concurrently with or after E&EB 250.  SC ½ Course cr

* E&EB 272b, 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. Enrollment limited to 50.  SC

* E&EB 273Lb, Laboratory for Ornithology  Richard Prum
Laboratory and field studies of avian morphology, diversity, phylogeny, classification, identification, and behavior. Enrollment limited to 12.  SC ½ Course cr

Intermediate and Advanced Courses
Prerequisites for all intermediate and advanced E&EB courses are BIOL 101, 102, 103, and 104, or permission of the instructor.

E&EB 220a / EVST 223a, General Ecology  Ann Staver and David Vasseur
The theory and practice of ecology, including the ecology of individuals, population dynamics and regulation, community structure, ecosystem function, and ecological interactions at broad spatial and temporal scales. Topics such as climate change, fisheries management, and infectious diseases are placed in an ecological context. Prerequisite: MATH 112 or equivalent.  SC

* E&EB 223Lb, Evolution, Functional Traits, and the Tree of Life  Marta Wells
Study of evolutionary novelties, their functional morphology, and their role in the diversity of life. Introduction to techniques used for studying the diversity of animal body plans. Evolutionary innovations that have allowed groups of organisms to increase their diversity.  SC ½ Course cr

E&EB 225b, Evolutionary Biology  Thomas Near and Paul Turner
An overview of evolutionary biology as the discipline uniting all of the life sciences. Reading and discussion of scientific papers to explore the dynamic aspects of evolutionary biology. Principles of population genetics, paleontology, and systematics; application of evolutionary thinking in disciplines such as developmental biology, ecology, microbiology, molecular biology, and human medicine.  SC
Psychology: AdvSci NeuroTrk

* E&EB 233a / HLTH 250a, 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 on line; class time focuses on discussion of lecture topics and research papers. Prerequisite: BIOL 101–104.  WR, SC
E&EB 275b / EVST 400b, Biological Oceanography  Mary Beth Decker
Exploration of a range of coastal and pelagic ecosystems. Relationships between biological systems and the physical processes that control the movements of water and productivity of marine systems. Anthropogenic impacts on oceans, such as the effects of fishing and climate change. Includes three Friday field trips. Enrollment limited to 15. SC

E&EB 290b, Comparative Anatomy of Vertebrates  Günter Wagner
A survey of the structure, variation, and evolution of major vertebrate groups. Topics include the microanatomy of major organ systems, the embryology of the vertebrate body plan, and the structure and evolution of the major organ systems such as the locomotory system, sensory organs, digestive tract, reproductive tract, and nervous system. SC

* E&EB 291Lb, Comparative Anatomy of Vertebrates Laboratory  Thomas Stewart
Microscopic examination of histological and embryological preparations. Dissection of selected vertebrate species including shark, bony fish, frog, lizard, and rat. To be taken with E&EB 290. SC ½ Course cr

E&EB 320b, Advanced Ecology  David Vasseur
An advanced treatment of ecology, including species interactions, species coexistence theory, species-environment interactions, the maintenance and consequences of biological diversity, spatial ecology, food webs, and eco-evolutionary interactions. Prerequisites: E&EB 220 and 225, or with permission of instructor. SC

* E&EB 342b / ANTH 335b, 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. Recommended preparation: ANTH 116. SC

* E&EB 380b, 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. After E&EB 220 and 225, or with permission of instructor. SC

E&EB 428a / AMTH 428a / G&G 428a / PHYS 428a, Science of Complex Systems  Jun Korenaga
Introduction to the quantitative analysis of systems with many degrees of freedom. Fundamental components in the science of complex systems, including how to simulate complex systems, how to analyze model behaviors, and how to validate models using observations. Topics include cellular automata, bifurcation theory, deterministic chaos, self-organized criticality, renormalization, and inverse theory. Prerequisite: PHYS 301, MATH 247, or equivalent. QR, SC

* E&EB 460b / HLTH 480b, Studies in Evolutionary Medicine I  Stephen Stearns
Principles of evolutionary biology applied to issues in medical research and practice. Lactose and alcohol tolerance; the "hygiene hypothesis"; genetic variation in drug response and pathogen resistance; spontaneous abortions, immune genes, and mate choice; the evolution of aging; the ecology and evolution of disease; the emergence of new diseases. Students develop proposals for research to be conducted during the summer. Admission by competitive application; forms are available on the EEB Web site (http://www.eeb.yale.edu). SC

* E&EB 461a / HLTH 481a, Studies in Evolutionary Medicine II  Paul Turner
Continuation of E&EB 460. Prerequisite: E&EB 460 or permission of instructor. SC

* E&EB 469a or b, Tutorial  Marta Wells
Individual or small-group study for qualified students who wish to investigate an area of ecology or evolutionary biology not presently covered by regular courses. A student must be sponsored by a faculty member who sets requirements and meets weekly with the student. One or more written examinations and/or a term paper are required. To register, the student must submit a written plan of study approved by the faculty instructor to the director of undergraduate studies. Students are encouraged to apply during the term preceding the tutorial. Proposals must be submitted no later than the first day of the second week of the term in which the student enrolls in the tutorial. The final paper is due in the hands of the director of undergraduate studies by the last day of reading period in the term of enrollment. In special cases, with approval of the director of undergraduate studies, this course may be elected for more than one term, but only one term may be counted as an elective toward the requirements of the major. Normally, faculty sponsors must be members of the EEB department.

* E&EB 470a or b, Senior Tutorial  Marta Wells
Tutorial for seniors in the B.A. degree program who elect a term of independent study to complete the senior requirement. A student must be sponsored by a faculty member who sets requirements and meets weekly with the student. One or more written examinations and/or a term paper are required. To register, the student must submit a written plan of study approved by the faculty instructor to the director of undergraduate studies. Students are encouraged to apply during the term preceding the tutorial. Proposals must be submitted no later than the first day of the second week of the term in which the student enrolls in the tutorial. The final paper is due in the hands of the director of undergraduate studies by the last day of reading period in the term of enrollment. Normally, faculty sponsors must be members of the EEB department. Enrollment limited to seniors. Fulfills the senior requirement for the B.A. degree.

* E&EB 474a or b, Research  Marta Wells
One term of original research in an area relevant to ecology or evolutionary biology. This may involve, for example, laboratory work, fieldwork, or mathematical or computer modeling. Students may also work in areas related to environmental biology such as policy,
The research project may not be a review of relevant literature but must be original. In all cases students must have a faculty sponsor who oversees the research and is responsible for the rigor of the project. Students are expected to spend ten hours per week on their research projects. Using the form available from the office of undergraduate studies or from the Classes server, students must submit a research proposal that has been approved by the faculty sponsor to the director of undergraduate studies, preferably during the term preceding the research. Proposals are due no later than the first day of the second week of the term in which the student enrolls in the course. The final research paper is due in the hands of the director of undergraduate studies by the last day of reading period in the term of enrollment.

* **E&EB 475a or b, Senior Research**  Marta Wells

One term of original research in an area relevant to ecology or evolutionary biology. This may involve, for example, laboratory work, fieldwork, or mathematical or computer modeling. Students may also work in areas related to environmental biology such as policy, economics, or ethics. The research project may not be a review of relevant literature but must be original. In all cases students must have a faculty sponsor who oversees the research and is responsible for the rigor of the project. Students are expected to spend ten hours per week on their research projects. Using the form available from the office of undergraduate studies or from the Classes server, students must submit a research proposal that has been approved by the faculty sponsor to the director of undergraduate studies, preferably during the term preceding the research. Proposals are due no later than the first day of the second week of the term in which the student enrolls in the course. The final research paper is due in the hands of the director of undergraduate studies by the last day of reading period in the term of enrollment. Enrollment limited to seniors. Fulfills the senior requirement for the B.S. degree.

* **E&EB 495a and E&EB 496b, Intensive Senior Research**  Marta Wells

One term of intensive original research during the senior year under the sponsorship of a Yale faculty member. Similar to other research courses except that a more substantial portion of a student’s time and effort should be spent on the research project (a minimum average of twenty hours per week). A research proposal approved by the sponsoring faculty member must be submitted to the director of undergraduate studies; forms are available from the office of undergraduate studies. For research in the fall term, approval is encouraged during the spring term of the junior year. Proposals are due no later than the first day of the second week of the term in which the student enrolls in the course. The final research paper is due in the hands of the director of undergraduate studies by the last day of reading period in the term of enrollment. One term of intensive research fulfills a portion of the senior requirement for the B.S. degree.  2 Course cr per term