EARTH AND PLANETARY SCIENCES

Kline Geology Laboratory, 203.432.3124
http://earth.yale.edu
M.S., M.Phil., Ph.D.

Chair
David Bercovici

Director of Graduate Studies
Maureen Long

Professors Jay Ague, David Bercovici, Ruth Blake, Mark Brandon, Derek Briggs, David Evans, Alexey Fedorov, Debra Fischer, Jacques Gauthier, Shun-ichiro Karato, Jun Korenaga, Maureen Long, Jeffrey Park, Peter Raymond, Danny Rye, James Saiters, Ronald Smith, Mary-Louise Timmermans, John Wettlaufer

Associate Professor Noah Planavsky

Assistant Professors Bhart-Anjan Bhullar, Pincelli Hull, Juan Lora, Alan Rooney, Lidya Tarhan

FIELDS OF STUDY
Fields include geochemistry and petrology, geophysics, ice physics, mineral physics, seismology and geodynamics, structural geology and tectonics, paleontology and paleoecology, oceanography, meteorology, cryospheric dynamics, and climatology.

Students admitted in 2020 or earlier have the option of receiving a degree in either Geology and Geophysics or Earth and Planetary Sciences. Students admitted in 2021 and subsequent years will receive a degree in Earth and Planetary Sciences.

SPECIAL REQUIREMENTS FOR THE PH.D. DEGREE
There is no formal language requirement and no required curriculum. Students plan their course of study in consultation with their adviser to meet individual interests and needs and to lay the foundations for dissertation research. At the end of the first year the faculty reviews the standing of each student. A student recommended for continuation in the Ph.D. program will be so notified. Some students may be encouraged at that time to pursue only the M.S. degree. At the end of the second year the faculty reviews each student's overall performance to determine whether the student is qualified to continue for the Ph.D. degree. In order to qualify, a student must have met the Graduate School Honors requirement and maintained a better than passing record in the areas of concentration. Also, a student must have satisfied the requirements of the Qualifying Exam by having completed two Research Discourses termed (according to their degree of development) the Minor and the Major Discourses. The Major Discourse will be presented at the Qualifying Presentation, followed by an extended question period wherein the student must successfully defend both Discourses. Remaining degree requirements include a dissertation review in the third year; the preparation and defense of the dissertation; and the submission of the dissertation to the Graduate School.

Teaching experience is regarded as an integral part of the graduate training program in Earth and Planetary Sciences. For this reason, all students are required to serve as teaching fellows for two terms during the course of their predoctoral training. Students who require additional support from the Graduate School must teach additional terms, if needed, after they have fulfilled the academic teaching requirement.

In addition to all other requirements, students must successfully complete EPS 710, Responsible and Ethical Conduct of Research, prior to the end of their first year of study.

MASTER’S DEGREES
M.Phil. See Degree Requirements under Policies and Regulations.

M.S. Awarded only to students who are not continuing for the Ph.D. Students are not admitted for this degree. Minimum requirements include satisfactory performance in a course of study (typically six or more courses with at least one Honors grade in a graduate-level class) that is approved by the director of graduate studies (DGS), and a research project with the approval of the DGS and the student’s thesis committee.

Program materials are available at http://earth.yale.edu or upon request to the Director of Graduate Studies, Department of Earth and Planetary Sciences, Yale University, PO Box 208109, New Haven CT 06420-8109; e-mail, dgs@eps.yale.edu.

COURSES
EPS 520b, Physics and Chemistry of Earth Materials II Shun-ichiro Karato
Basic principles that control the transport properties of Earth materials. Chemical reactions, anelasticity, diffusion, kinetics of reaction, and mass/energy transport.
EPS 521b, Geophysical Fluid Dynamics  Mary-Louise Timmermans  
A survey of fluid dynamics, with applications to oceans and atmospheres. Mathematical models illustrate the fundamental dynamical principles of geophysical fluid phenomena such as large-scale flows, waves, boundary layers, and flow stability. Concepts are investigated through laboratory experiments in a rotating water tank. Prerequisite: differential equations and introductory fluid mechanics.

EPS 528a, 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.

EPS 533a, Physical Oceanography  Alexey Fedorov  
An introduction to ocean dynamics and physical processes controlling the large-scale ocean circulation, ocean stratification, the Gulf Stream, wind-driven waves, tides, tsunamis, coastal upwelling, and other oceanic phenomena. Equations of motion. Modern observational, theoretical, and numerous other techniques used to study the ocean. The ocean role in climate and global climate change.

EPS 538a / ASTR 520a, Computational Methods in Astrophysics and Geophysics  Paolo Coppi  
The analytic and numerical/computational tools necessary for effective research in astronomy, geophysics, and related disciplines. Topics include numerical solutions to differential equations, spectral methods, and Monte Carlo simulations. Applications are made to common astrophysical and geophysical problems including fluids and N-body simulations.

EPS 556a, Introduction to Seismology  Maureen Long  
Earthquakes and seismic waves, P and S waves, surface waves and free oscillations. Remote sensing of Earth's deep interior and faulting mechanisms. Prerequisites: MATH 120, 222, and PHYS 181, or equivalents.

EPS 625a, Oceanography  Pincelli Hull and Noah Planavsky  
This course provides an introduction to the basics of oceanography. It is structured as an interdisciplinary overview, designed to ensure that graduate students working in the oceans (i.e., those from paleontology, geochemistry, and/or AOC) have the ability to form interdisciplinary collaborations through shared vocabulary and concepts, and to answer such basic questions as: what makes sea water salty? where is most life in the ocean? Topics are treated in interactive lectures, flipped classroom discussions/activities, and labs and are rigorously tested in one-on-one oral exams.

EPS 635a, Physical Oceanography  Alexey Fedorov  
This course covers several techniques of oceanic analysis, revisiting some classical results from global oceanography that helped to define our knowledge of Earth's interior. Wave-propagation behavior in the context of simple theories of ray tracing, tomography, shear-wave birefringence, free-oscillation frequency shifts, attenuation, receiver functions, surface-wave dispersion, and other observables.

EPS 636b / ANTH 636b / ARCG 636b, Geoarchaeology: Earth and Environmental Sciences in Archaeological Investigations  Ellery Frahm  
A survey of the numerous ways in which theories, approaches, techniques, and data from the earth and environmental sciences are used to address archaeological research questions. A range of interfaces between archaeology and the geological sciences are considered. Topics include stratigraphy, geomorphology, site formation processes, climate reconstruction, site location, and dating techniques.

EPS 650a, Deformation of Earth Materials  Shun-ichiro Karato  
Microscopic physics of deformation of minerals and rocks and its applications to global geophysics.

EPS 652a, Extraordinary Glimpses of Past Life  Derek Briggs  
Study of exceptionally well preserved fossil deposits (lagerstaetten) that contain nonmineralized animal skeletons and casts of the soft parts of organisms. Examples such as the Burgess Shale and Solnhofen limestones; what they can reveal about the history and evolution of life, ancient lifestyles and environments, and preservational processes.

EPS 658a, Seismic Data Analysis  Jeffrey Park  
This course covers several techniques of seismic data analysis, revisiting some classical results from global seismology that helped to define our knowledge of Earth's interior. Wave-propagation behavior in the context of simple theories of ray tracing, tomography, shear-wave birefringence, free-oscillation frequency shifts, attenuation, receiver functions, surface-wave dispersion, and other observables.

EPS 666a / AMTH 666a / ASTR 666a / MATH 666a, Classical Statistical Thermodynamics  John Wettlaufer  
Classical thermodynamics is derived from statistical thermodynamics. Using the multi-particle nature of physical systems, we derive ergodicity, the central limit theorem, and the elemental description of the second law of thermodynamics. We then develop kinetics, transport theory, and reciprocity from the linear thermodynamics of irreversible processes. Topics of focus include Onsager reciprocal relations, the Fokker-Planck equation, stability in the sense of Lyapunov, and time invariance symmetry. We explore phenomena that are of direct relevance to astrophysical and geophysical settings. No quantum mechanics is necessary as a prerequisite.

EPS 710a, Responsible and Ethical Conduct of Research  Staff  
A 5-to-6-week lecture course (1 hour) that is required of all graduate students and must be completed within the first year. Course topics include record keeping and data management/retention; plagiarism and fraud; collaboration, coauthorship, and ownership of research materials and intellectual property; laboratory dynamics and sexual harassment. EPS 710 is in addition to the existing online ethics module, The Yale Guide to Professional Ethics, that must be completed by all GSAS students within the first term of study, regardless of source of financial support.  o Course cr

EPS 721a, Topics in Geobiology  Lidya Tarhan and Alan Rooney  
In this seminar, students explore recent papers and emerging ideas concerning life-environment interactions through Earth's history.
EPS 744a or b, Seminar in Mantle and Core Processes  Staff
The seminar covers advanced topics concerning physical and chemical processes in the mantle and core of the Earth and planets. Specific topic and hour are arranged in consultation with enrolled graduate students.

EPS 750a, Seminar on Planetary Atmospheric Dynamics  Juan Lora
This seminar focuses on the physical processes, governing mechanisms, and general circulation that result in and control the climates of various planetary bodies. The course is structured around reading and discussing a selection of papers related to the dynamics of planetary atmospheres.

EPS 757b, Studies in Global Geoscience  David Evans
Reading seminar devoted to a specific geographic region of the Earth, selected as the destination of the departmental field trip for the current year. Topics of discussion include a broad range of geoscience disciplines, to be determined in part by the interests of participating students.

EPS 857b / ANTH 857b, Topics and Issues in Evolutionary Theory  Eric Sargis and Jacques Gauthier
Focus on classic and current literature in theoretical evolutionary biology, intended to give students intensive training in critical analysis of theoretical concepts and in scientific writing.