Earth Explorers

The Department of Geosciences at Princeton University

Atmosphere & Ocean Sciences  ▪  Biogeochemistry  ▪  Climate Science  ▪  Environmental Science  ▪  Geology  ▪  Geophysics  ▪  Paleontology
Introduction to Geosciences

The field of geosciences is central to many of the most pressing issues of today’s world: Earth resources and energy; natural hazards; human/environment interaction; and climate change. Through diverse coursework, small class sizes, and strong field and laboratory programs, the Department of Geosciences empowers students to understand how Earth works and how to solve real-world problems.

Undergraduates studying geosciences often pursue careers in basic research, the energy industry, and education. Geosciences also provides a foundation for careers in applied research, environmental consulting, engineering, public policy, conservation, resource economics, environmental education, and general consulting.

The Department of Geosciences offers a concentration in one of three tracks: Environmental Biogeochemistry (EBC), Ocean, Atmosphere, & Climate (OAC), and Geophysics & Geology (GPG). Princeton University, in collaboration with Geosciences, offers a Planets and Life Certificate Program in Astrobiology. The Department of Civil and Environmental Engineering, in collaboration with Geosciences, also offers a certificate in Geological Engineering.

(Cover) Fiona West ’16 and Alyson Beveridge ’16 at the top of the ancient sand dunes of the Entrada Formation, looking over a valley of fossil dinosaurs hidden in the Chinle Formation below. Kitchen Mesa, Ghost Ranch, NM, 2014. Photo by: Christine Chen ’13 [GEO 201]

(Right) Maricela Coronado ’17 samples an approximately 66 million year old red bole on a research trip to the Rajahmundry Quarry in India, 2015. Photo by: Kyle Samperton *16 [Keller, Schoene]
Geosciences Concentration

Geoscience is a unique blend of lab experiments, field observation, data analysis, and computer modeling. Courses in geosciences apply principles of biology, chemistry, physics, and mathematics to real Earth problems, deal with length scales from global to atomic, and consider time scales from billions of years to less than a second. The flexible academic program allows students to develop individualized courses of study.

Geosciences Prerequisite Requirements:
All concentrators are required to take two introductory Geoscience courses: One introductory course must be GEO 202 or GEO 203. The other introductory course can be GEO 201, GEO 202, GEO 203, GEO 255, or a GEO freshman seminar with permission of the Undergraduate Work Committee (UWC). Students with adequate preparation may proceed directly to GEO 300-level courses with the consent of a member of the UWC, but this cannot substitute for one of the seven upper-level geosciences courses. Other introductory geosciences courses, such as GEO 102 and GEO 103, are intended primarily for nonscience majors and are not ideal for students anticipating majoring in geosciences. GEO 201 or GEO 255 (but not both) may be counted as a GEO 300-level course with permission of the UWC, but cannot substitute for GEO 202 or GEO 203. Please note that no other GEO 200 level courses or other courses satisfy this requirement.

General Requirements:
The following courses are required for graduation (with at most one pass/D/fail). AP credit may be used to place into a more advanced course, but it does not provide credit toward the geosciences concentration.

Mathematics Prequisite: MAT 104 or MAT 175 or a more advanced course in math. AP credit does not fulfill this requirement.

Geosciences Core Science Requirements: Students must complete two of the following core science requirements at Princeton: PHY 104, CHM 202, COS 226, MAT 202 and MOL 215. AP credits do not fulfill this requirement, but students with AP credit may choose to substitute a more advanced course to satisfy a core science requirement. For example, CHM 215 or CHM 301 could substitute for CHM 202. Students interested in graduate school are encouraged to take more than these minimum basic science requirements.

Departmental Requirements:
Concentrators are required to take seven upper-level geosciences courses (300 level or higher, not including GEO 503).

Upper Level Science Courses: Up to two of the following classes may be substituted for GEO 300+ classes. Students may substitute other advanced science courses not listed below with permission of the UWC: APC 350, AST 204, AST 301, CHM 303, CHM 304, CHM 305, CHM 306, CEE 205, CEE 303, CEE 305, CEE 306, CEE 365, COS 323, COS 333, EEB 324, EEB 355, ENV 302, MAE 221, MAE 222, MAE 223, MAE 305, MAE 306, MAT 323, MAT 325, MOL 342, MOL 345, ORF 405, PHY 208, PHY 301, PHY 304, and PHY 305. Students are urged to consult with the departmental representative or their junior or senior adviser before choosing departmental courses outside geosciences. In general, the department is flexible about course selections and requirements; however, we must ensure a degree of coherency in the curriculum of each student.

Junior Colloquium. This is a weekly luncheon meeting, convened during the fall term, to acquaint juniors with research and career opportunities. This is mandatory for all geosciences majors (including those in the geological engineering program).

Read more about required independent work in the Geosciences here: www.princeton.edu/geosciences/undergraduate/
Departmental Tracks

ENVIRONMENTAL BIOGEOCHEMISTRY (EBC)

Study the geochemical and biological processes modifying Earth’s surface (atmosphere, soils, sediments, oceans). How do biogeochemical interactions modify the behavior of elements and molecules responsible for global climate change, ecological variations and toxicity, and bioaccumulation of anthropogenic contaminants.

GEOPHYSICS & GEOLOGY (GPG)

Study the structure and evolution of Earth as a physical system, by theory, experiment, observation, and numerical simulation. The emphasis is on physical processes of global relevance including the history of Earth and life in the rock record. The quantitative concepts and techniques covered in class are also relevant to applied sciences and industry.

OCEAN, ATMOSPHERE & CLIMATE (OAC)

Study the coupled ocean and atmosphere system as it interacts with life to set the physical and chemical conditions of Earth’s surface. Students with backgrounds in subjects as diverse as chemistry, biology, physics, public policy, and economics with an interest in climate and global environmental conditions will find this track a challenging and relevant addition to their coursework.
Introductory Courses

FRS - GLOBAL CHANGE AND THE IMPACT OF HUMAN ACTIVITIES ON THE BIOSPHERE EBC, OAC*
The biogeochemical cycles of major nutrients (C, N, P) and contaminants (Hg, As) in oceanic and terrestrial ecosystems are examined in the context of global change. A one-week field trip to Everglades National Park in Florida is mandatory. [Kraepiel]

FRS - STATE OF THE EARTH: SHIFTS AND CYCLES OAC, GPG*
How have Earth and human histories been recorded in the geology of Princeton, the Catskills, France and Spain, and what experiments can you do to query such archives of the past? This seminar provides students with practical experience making geological and geophysical observations designed to shed light on the interplay between cycles, shifts and noise, tectonics, climate, and weather. A one-week field trip to France/Spain is mandatory. [Maloof, Simons]

GEO 102A (without lab) & 102B (with lab) - CLIMATE: PAST, PRESENT & FUTURE
An introduction to the processes and conditions that control Earth’s climate; an overview of past climate evolution on various time scales, from the full sweep of Earth time to the period of human history; and an investigation of ongoing and predicted future climate changes, including the potential for human activities to alter climate and the impacts of climate change on environment and society. Intended for students not concentrating in science or engineering. [Sigman]

GEO 103 - NATURAL DISASTERS
This course examines natural (and some society-induced) hazards and the importance of public understanding of related issues. Learn about the geological processes that underlie hazards, and discuss policy implications. Topics include earthquakes, volcanoes, landslides, tsunami, hurricanes, floods, meteorite impacts, and global warming. Three one-hour lectures and a three laboratory each week. Intended primarily for non-science majors. [Rubin]

*7-day field trip during Fall/Spring Break
GEO 201 - Methods in Data Analysis and Scientific Writing (ENV) GPG, OAC, EBC*
Drone-derived models of landscapes, geo-referenced field observations of the natural world, and data mining of the primary literature combined with quantitative modeling to answer questions like how has climate changed in the past, how is it changing now, and how do we measure it. Students will build on what they learned as freshmen in the Writing Seminars. [Maloof, Irwin Wilkins]

GEO 202 - OCEAN, ATMOSPHERE & CLIMATE OAC
An introduction to the ocean, atmosphere, and climate from the perspective of oceanography. Topics include coastal processes and ecosystems; open ocean processes including atmospheric circulation and surface ocean ecosystems; deep ocean circulation and chemical cycling, climate history of Earth and impacts of humans on the earth system (e.g. ocean resources and climate change). [Sarmiento]

GEO 203 - FUNDAMENTALS OF SOLID EARTH SCIENCE (CEE) GPG
A quantitative introduction to Solid Earth system science, focusing on the underlying physical and chemical processes and their geological and geophysical expression. The course investigates the Earth starting from its accretion, differentiation, and evolution, and discusses how these processes create and sustain habitable conditions. Topics include nucleosynthesis, planetary thermodynamics, plate tectonics, seismology, geomagnetism, petrology, sedimentology and the global carbon cycle. Two field trips. [Higgins, Irving]

GEO 255A – LIFE IN THE UNIVERSE (AST, EEB, CHM)
This course introduces students to a new field, Astrobiology, where scientists trained in biology, chemistry, astronomy and geology combine their skills to discover life’s origins and to seek extraterrestrial life. Topics include the origin of life on Earth and the prospects of life on Mars, Europa and extra-solar planets. [Onstott, Turner, Landweber]

(Bottom far left) Will van Cleve ’17 and Henry Ogilby ’17, Top Guns, pilot the drone in the Little Sahara Dunes, Utah. (Bottom middle left) Telling the eBee RTK surveyor where to fly remotely at Antelope Island State Park, Utah. Photos by: Akshay K. Mehra ’17 [GEO 201]

(Center right) Jenn Kasbohm *18 measures cross strata in oolite dunes at Joulters Cays on Andros Island, Bahamas. (Below right) Preston Kemery ’15, Anna van Brummen ’16 and Jenn Kasbohm ’18 measure and sample a coastal sediment core on Andros Island, Bahamas. Photos by: Prof. Adam Maloof [GEO 370]

(Bottom) This fossil snail assemblage lived just before the end-Cretaceous mass extinction in the Krishna-Godavari Basin (Rajahmundry) of SE India. Samples were collected during a field trip in 2015 where the main objective was to radiometrically date associated lava flows and better define the age and duration of the K-T boundary by Prof. Gerta Keller, Prof. Blair Schoene, Kyle Samperton *16 and Maricela Coronado ’17. Photo by: Kyle Samperton *16 [Keller, Schoene]
Intermediate Courses

GEO 361 - PHYSICS OF EARTH, THE HABITABLE PLANET (ENV) OAC
This class discusses fundamental aspects of Earth’s climate with a focus on the fundamental atmospheric processes that render Earth “habitable,” and how they may respond to the forcing originating from natural (such as volcanoes) and anthropogenic (such as emission of carbon dioxide and ozone-depleting gases) processes. [Fueglistaler]

GEO 362 - Earth’s Climate History OAC, GPG
The nature and causes of major events in Earth’s 4 billion year climate history. The course integrates topics in stable isotope geochemistry that are fundamental to understanding surface processes, past and present. [Bender]

GEO 363 - ENVIRONMENTAL GEOCHEMISTRY: CHEMISTRY OF THE NATURAL SYSTEMS (CHM) EBC, OAC, GPG
The interaction between atmosphere and continent; special emphasis on atomic theory, chemical bonding, crystal chemistry, reaction equilibrium, and soil geochemistry. [Myneni]

GEO 365 - EVOLUTION & CATASTROPHES OAC, GPG*
Examines the major stages and critical events in the history of the Earth, with emphasis on the fossil record of biological evolution and the environmental record of mass extinction. [Keller]

GEO 366 - CLIMATE Change: SCIENTIFIC BASIS, POLICY IMPLICATIONS (ENV) EBC, OAC
An exploration of the causes and potential consequences of human-induced climate change and their implications for policy responses. [Oppenheimer]

Testimonial from ANDREW BUDNICK ’13

“Unlike a lot of geosciences majors, I had a good idea that when I came to Princeton I wanted to major in geology. I had known since 8th grade in fact, when I took a fantastic middle school geology class. And it only took a freshman seminar and a few interactions with the faculty for me to make up my mind fully—I am now a geoscience major getting ready to write my first junior paper.

What interested me most in the Geosciences Department, aside from my initial interest in the subject, was how close all of the students and faculty were. Because the number of undergraduates in the department is small, it’s possible to get to know everybody and form a tightly knit group. At the same time, the department faculty is world-class, and they get to dedicate more time to each student because of the small class size.

I’m studying things that are immediately relevant to issues such as climate change and oil dependence, which requires deep knowledge in a broad range of scientific fields. Also, I get to take amazing trips to all corners of the globe with my friends for my work. It’s hard to argue with that!”

*7-day field trip during Fall/Spring Break
GEO 370 - SEDIMENTOLOGY (CEE, ENV) EBC, OAC, GPG* The physics and chemistry of the Earth surface processes that generate, transport, and deposit sediments. Emphasis is on the interpretation of sedimentary records of modern and ancient environmental change. [Maloof]

GEO 371 - GLOBAL GEOPHYSICS (PHY) GPG An introduction to global geophysics. Topics include Earth’s shape, gravitational and magnetic field, seismology, and geodynamics. [Simons]

GEO 372 - ROCKS GPG* An introduction to the processes that govern the distribution of different rocks and minerals in the Earth. Learn to make observations from the microscopic to continental scale and relate these to theoretical and empirical thermodynamics. The goal is to understand the chemical, structural, and thermal influences on rock and mineral formation and how this in turn influences the plate tectonic evolution of our planet. [Schoene]

GEO 373 - STRUCTURAL GEOLOGY GPG* An introduction to the physics and geometry of brittle and ductile deformation in Earth’s crust. Deformation is considered at scales from atomic to continental, in the context of mountain building, rifting, and the origin of topography. [Maloof, Schoene]

GEO 374 - PLANETARY SYSTEMS: THEIR DIVERSITY AND EVOLUTION GPG Origin of the solar system and the internal structures, surface features, atmospheres and habitability of major planetary bodies. [Onstott]

GEO 378 - MINERALOGY GPG A survey of the structure and crystal chemistry of major rock-forming minerals. Topics include: symmetry, crystallography, physical and chemical properties of minerals, mineral thermodynamics, systematic mineralogy, and techniques of modern mineralogy. Includes a weekly laboratory and a one-day field trip. [Duffy]

*7-day field trip during Fall/Spring Break
Advanced Courses

**GEO 415 - ATMOSPHERIC SCIENCE** OAC
This course discusses aspects of weather and climate, from phenomenological and analytical points of view. Complements material in GEO 423. [Fueglistaler]

**GEO 417 - ENVIRONMENTAL MICROBIOLOGY** (CEE, EEB) EBC, OAC
The role of bacteria in elemental cycles, in soil, sediment, and marine and freshwater communities, and in bioremediation and chemical transformations. [Ward]

**GEO 418 - ENVIRONMENTAL AQUEOUS GEOCHEMISTRY** (CHM) EBC
Application of quantitative chemical principles to the study of natural waters; equilibrium computations, weathering processes, precipitation of chemical sediments, and water pollution. [Morel]

**GEO 419 - PHYSICS AND CHEMISTRY OF EARTH’S INTERIOR** (PHY) GPG
Physics and chemistry of Earth materials and the nature of dynamic processes in Earth’s interior. [Duffy]

**GEO 422 - DATA, MODELS & UNCERTAINTY** EBC, OAC, GPG
An introduction to data analysis and interpretation in the natural sciences. Topics include statistics, time series analysis, and matrix-based inverse theory. [Simons]

**GEO 423 - DYNAMIC METEOROLOGY** OAC
This course provides the rigorous introduction to the moving atmosphere needed to understand Earth’s weather and climate. The fundamental forces of the atmosphere will be described and conservation laws will be developed. Approximations relevant to Earth’s large-scale circulation and regional-scale extreme events will be discussed. Complements material in GEO 415. [Medvigy]

**GEO 424 - SEISMOLOGY** (CEE) GPG
Review of basic concepts in seismology. Topics to be covered: theories of wave propagation in the earth, instrumentation, Earth’s structure and tomography, theory of the seismic source, physics of earthquakes, and seismic hazard assessment. Emphasis will be placed on how quantitative mathematical and physical methods are used to understand complex natural processes, such as earthquakes. [Tromp]

**GEO 425 - INTRODUCTION TO OCEAN PHYSICS FOR CLIMATE** (MAE) OAC
Detailed examination of thermohaline and wind-driven circulation and the ocean as a major influence on the atmosphere and global environment. [Vecchi, Legg]
GEO 428 - BIOLOGICAL OCEANOGRAPHY (EEB) EBC, OAC
Biological processes in the context of their chemical and physical environment; properties of seawater and atmosphere that affect life in the ocean; primary production and marine food webs. [Ward]

GEO 430 - CLIMATE AND THE TERRESTRIAL BIOSPHERE EBC, OAC
An exploration of the key mechanisms that link climate (e.g., cloudiness, rainfall, and temperature) with the terrestrial biosphere (e.g., ecosystem composition, structure, and functioning), and how these mechanisms are altered by humans. [Medvigy]

GEO 441 - COMPUTATIONAL GEOPHYSICS (CEE) OAC, GPG
Finite-difference, pseudospectral, finite-element, and spectral-element methods presented and applied to a number of geophysical problems including heat flow, deformation, and wave propagation. Students will program simple versions of these methods. [Tromp]

GEO 442 - GEODYNAMICS (PHY) GPG
An advanced introduction to setting up and solving boundary value problems important to the Solid Earth sciences. Topics include elasticity and plate flexure, heat and fluid flow, with applications to mantle convection, magma transport, structural geology, and the thermal evolution of the terrestrial planets. [Rubin]

GEO 464 - RADIOGENIC ISOTOPES GPG
Theory and methodology of radiogenic isotope geochemistry, as applied to topics in the geosciences, including the formation and differentiation of the Earth and solar system, thermal and temporal evolution of orogenic belts, and the rates and timing of important geochemical, biotic, and climatic events in earth history. [Schoene]

GEO 470 - ENVIRONMENTAL CHEMISTRY OF SOILS (CHM) EBC
Inorganic and organic constituents of aqueous, solid and gaseous phases in soils, and the fundamental chemical processes that govern reactions between these constituents. [Myneni]

Specimens from Geosciences’ Mineral Collection (approx. 10,000 specimens).

Above is a mineral commonly referred to as “fool’s gold,” Pyrite (iron sulfide, FeS2). Considered a “classic” locality by collectors. The Ibex mine where the mineral comes from was well known for amazing pyrites as well as its silver production. [Duffy]

Luca Bindi, Professor of Mineralogy and Crystallography at the Department of Earth Sciences of the University of Florence, Italy, discovered the sample of Aguilarite (Ag4SeS) in the collection during an autumn 2012 visit to Princeton. Aguilarite is an extremely rare mineral, intermediate in composition between two more common minerals, acanthite, and naumannite. [Duffy]

Agate with black center and white border, surrounded by crystalline quartz from Brazil. It is one of the many beautiful specimens donated to the collection by the late Archibald M. MacMartin, class of 1868. MacMartin enriched Princeton’s holdings by some 2,500 specimens, representing a range of classic localities throughout Europe and the United States. [Duffy]
Field trips are an important component of many undergraduate Geoscience classes. A number of Geoscience courses require extended field trips during the semester breaks. These field trips provide students with critical ‘hands-on’ learning experiences and applications of classroom learning, introduces them to the real world of research science in the field, and teaches them to think and reason on their feet while confronted with problems that often require an interdisciplinary science approach. Field trip funds are provided by the Geosciences Department.
FRS – GLOBAL CHANGE AND THE IMPACT OF HUMAN ACTIVITIES ON THE BIOSPHERE  A one-week field trip to the Florida Everglades during the spring break is mandatory to evaluate water quantity and quality in the context of geology, chemistry, and biology of the ecosystem. During this trip students observe the environment and collect samples that are subsequently analyzed in the laboratory at Princeton University. The resulting data is interpreted, synthesized, and written up for a final class report.

FRS – STATE OF THE EARTH: SHIFTS AND CYCLES  In this Freshman Seminar, students will combine field observations of the natural world with quantitative modeling and interpretation to answer questions like: How have Earth and human histories been recorded in the geology of Princeton, the Catskills, and France/Spain, and what experiments can you do to query such archives of the past? In the classroom, through problem sets, and around campus, students will gain practical experience collecting geological and geophysical data in geographic context, and analyzing these data using statistical techniques such as regression and time series analysis, with the programming language Matlab. During the required one-day trip to the Catskills and week-long Fall break trip to Spain, students will engage in research projects that focus on the cycles and shifts in Earth’s shape, climate, and life that occur now on timescales of days, and have been recorded in rocks over timescales of millions of years.

GEO 202 – OCEAN, ATMOSPHERE & CLIMATE  This course includes one-day or overnight trips to coastal environments to investigate processes that shape the shoreline and to collect water samples for physical, chemical and biological analyses.

GEO 203 – FUNDAMENTALS OF SOLID EARTH SCIENCE  Field trips for this course give students hands-on experience with concepts they learn about in class and grapple with in problem sets. Start with a look at the local geology: why does Washington Road go down a hill? Why is Nassau Hall built of such a poor building stone? A weekend field trip in October gives a deeper look into the physical and chemical processes that control the properties and behavior of the solid Earth. Sites visited have included the Catskills of New York, the folded Appalachians of Pennsylvania, the highlands of New Jersey and the New Jersey coastal plain. During Reading Period, the class spends a day at the American Museum of Natural History in New York City.

GEO 363 – ENVIRONMENTAL GEOCHEMISTRY  Several weekend field trips are organized during the fall semester. These trips are to the Hackensack River Estuary and Newark Bay (NJ), Pine Barrens (NJ), and the coal mines of Pottsville and surrounding areas (PA). The goal of these trips are to collect soil and sediment cores and examine chemical variations in their profiles, collect water samples and conduct analysis to evaluate important biogeochemical variables, and
introduce students to the variations in the biogeochemistry of pristine and polluted environments.

GEO 365 – EVOLUTION AND CATASTROPHES  A one-week field trip during the semester break is mandatory. During this trip students visit localities where rocks detail the transitions across major mass extinctions, and climatic and environmental changes. They are actively involved in fieldwork, including digging trenches to expose fresh rocks, observing, describing and measuring rock sequences, and collecting sediment samples for analysis in the laboratory. Evenings are devoted to lectures, discussions of the day’s work, and reports. The results of fieldwork and laboratory analyses form the basis for the term report. Past field trips have visited Mexico, Texas, Tunisia, Morocco, Egypt, Israel, and the Alps.

GEO 370 – SEDIMENTOLOGY  This course has three regional weekend field trips designed to complement problem sets and take students to the New Jersey Pine Barrens, Eastern Kentucky Appalachia, and the Catskills Mountains of New York. The fourth is a mandatory spring-break field trip with varying locations (e.g., Bahamas, New Mexico) where students focus on specific research projects that range from dune migration and tidal channel dynamics, to generating records of sea level rise in the Caribbean or climate change in the American West. The field data collected on this trip are the focus of the final research projects.

past field trips have visited Mexico, Texas, Tunisia, Morocco, Egypt, Israel, and the Alps.

GEO 372 – ROCKS  Students participate in a mandatory one-week field trip over spring break. In the field, students learn to make observations in order to untangle the complicated tectonic and thermal histories recorded by rocks in the Earth’s crust and mantle. Students visit modern continental rifts and active faults, super volcanoes, deep crustal terranes exhumed during mountain building, and granitic batholiths. The main objective is to collect rock samples and field data that form the basis of students’ final projects. Past excursions have included northern New Mexico and southern California.

GEO 373 – STRUCTURAL GEOLOGY  This course involves local field trips to observe rocks that were deformed during Appalachian mountain building events, and a fall break field trip to a more distant location (typically the southwestern U.S.) Students learn to observe and measure large and small scale structures and determine the mechanisms that deform Earth’s crust during episodes of mountain building and rifting. Field work involves making geologic and structural maps in beautiful areas.
GEOLOGICAL ENGINEERING CERTIFICATE PROGRAM (ABET Accredited)

Geological Engineering is the application of science to problems and projects involving Earth, its physical environment, Earth materials, and natural resources. The curriculum is offered in a cooperative effort between the Department of Civil and Environmental Engineering and the Department of Geosciences, and is specially designed for the student who wishes to build upon the freshman and sophomore mathematics and engineering courses as a basis for studies in Geosciences.

All Geological Engineering students must acquire a strong background in Mathematics and the Basic Sciences, followed by specific courses in Engineering Sciences that stress basic geological, geophysical, and geochemical principles. These are followed by a sequence of four Engineering Design courses which are complemented by electives. The electives should form a coherent sequence of at least four courses in the student’s area of interest. Engineering Design must be a significant component of the thesis for students in the Geological Engineering Certificate, which is accredited by the Engineering Accreditation Commission of ABET.

Math and Basic Science Requirements
- MAT 201
- PHY 103, 104
- CHM 201/2
- COS 126

Engineering Science Requirements
- CEE 205, 303, 306, 308, 361, 316
- GEO 203
- CEE 365 or GEO 373
- GEO 363 or 418
- MAE 305 or APC 350
- Any two from: CEE 471, 461 or 477
- CEE 478 Senior Thesis — All Seniors write a thesis and give an oral presentation (in both GEO and CEE departments) on a subject chosen by the student with the advice of their advisors.

Certificate Elective Requirements
Four or more (maximum one 200-level) of the following courses that form a coherent sequence in the student’s area of interest:
- CEE 262, 263, 362, 264, 366, 376, 460, 461, 472, 477
- MAE 221, 222, 323
- ORF 301, 307
- CHM 303, 306, 307

The Program in Planets and Life is an interdepartmental multidisciplinary plan of study. The goal is to provide students with an understanding of the fundamental astrophysical, chemical, biological, and geological principles, and engineering challenges that will guide our search for life in extreme environments on Earth and on other planets and satellites in the Solar System and among neighboring planetary systems. The Certificate Program draws faculty and other resources from Astrophysics, Chemistry, Ecology and Evolutionary Biology, Electrical Engineering, Geosciences, Mechanical and Aerospace Engineering, Operations Research and Financial Engineering, and the Woodrow Wilson School.

Program of Study: By the appropriate choice of courses, a student may satisfy the requirements of the program and the department of concentration, as well as the University distribution. Students may take the following course of study:

1. Fall semester core course AST/CHM/EEB/GEO 255
2. Students must take an additional four cognate courses. Only two of these can be in the student’s department of concentration. Cognate courses must be approved by the program chairperson
3. Participation in a noncredit Planets and Life Undergraduate Colloquium is strongly encouraged. This colloquium will aid in thesis research and writing, and assist in identifying resources
4. Independent research on topics relevant to the certificate program must be approved by the program chairperson and the undergraduate representative in the student’s department of concentration
5. At least one JP or part of the senior thesis must include a chapter on an astrobiology theme

For more information and a complete list of cognate courses visit: www.princeton.edu/astrobiology

Qualifying courses in GEOSCIENCES:

GEO 362 – Earth’s Climate History
GEO 363 – Environmental Geochemistry: Chemistry of the Natural Systems
GEO 370 – Sedimentology
GEO 371 – Global Geophysics
GEO 372 – Rocks
GEO 373 – Structural Geology
GEO 374 – Planetary Systems: Their Diversity and Evolution
GEO 378 – Mineralogy
GEO 417 – Environmental Microbiology
GEO 425 – Introduction to Ocean Physics for Climate
GEO 428 – Biological Oceanography
GEO 442 – Geodynamics
GEO 523 – Geomicrobiology
Testimonial from JOAN CANNON ’15

““The Geosciences Department was my home for 3 years. No other major can compare with the amount of time professors spend with GEO students, the small class sizes, the amount of resources the department provides for learning and research, the number of field trips that students participate in around the country and world, and the camaraderie of the department as a whole. I am so grateful to the GEO staff, faculty, graduate students, and my fellow GEO undergraduate majors for making my academic experience at Princeton an incredible one!”

Testimonial from PRESTON KEMENY ’15

“It is difficult to stress how extensively the department of geosciences influenced both my growth as a scholar and my overall experience at Princeton. Through seminars and field trips, independent research and tea time, Guyot and its inhabitants became my academic home and family at the university. I find geoscience fascinating because it applies chemistry, physics, and biology to study Earth, taking from each field its most powerful tools but without focusing too narrowly on any one technique. Within the department I thus had the opportunity to study topics ranging from crystal symmetry to mass extinction events, isotope geochemistry to inverse modeling, and always with brilliant professors who strove to create an inviting and invigorating dialogue. Aside from the breadth of its subject, the GEO department shines relative to other concentrations because of the quality of its faculty. Every professor is approachable and extremely willing to invest time and resources into hard-working students; I’m still only beginning to appreciate the rarity of this caliber of mentorship. Outside of the classroom, the GEO department provides unparalleled opportunities for fieldwork. Beginning with freshman seminars, it enables all students to study abroad. Through this fieldwork I learned not only the specifics of a given outcrop or feature, but more broadly about the process and techniques of scientific research itself.

My only regret about concentrating in GEO is that I didn’t join the department sooner, for it is the best kept secret at Princeton.”

Testimonial from CHRISTINE CHEN ’13

“If you’re a science-y person but don’t know what you want to study, you can’t go wrong with geosciences. Before college, the idea of choosing a major was incredibly intimidating. I knew that I was interested in science, but between chemistry, biology, physics, and computer science, I had absolutely no clue which subject I enjoyed the most. I loved them all—what if I chose wrong? That’s when I discovered geosciences, perhaps better known as Earth science, the all-encompassing field that seeks foremost to understand the planet Earth. I realized that I didn’t have to choose at all; Earth science combined every discipline of the natural and physical sciences into an integrated study of the planet and the processes that make Earth what it is today. It was as simple as that, and after cavorting around the Mono-Inyo Craters and the star sand dunes of Death Valley on a GEO class trip during freshman fall, I was hooked. I like to think that I’ve returned to my roots as a kid who watched Bill Nye the Science Guy and Magic School Bus. Rocks, earthquakes, dinosaurs, and volcanoes—those were the stuff of legends back then, and I can hardly believe that I am actually allowed to have this much fun learning about the Earth.”
Testimonial from OWEN COYLE ’12

“I came to the Princeton GEO department by a rather roundabout way. I always loved Math and Science, but I came into Princeton wanting to study genetics in the MOL department. I pursued this line of study Freshman year but began wondering whether I might find a major that allowed me to study the natural environment a bit more interesting.

When it came time to select courses for spring semester I decided to register for a GEO freshman seminar about the Florida Everglades, both because of its focus on the natural environment and because of the free trip to Florida during spring break. I didn’t know what I was getting myself into, but pretty soon I was bombing around marshes, taking tree cores, and cruising Florida Bay for water samples. More important than any of these experiences however, was a long conversation I had with one of my professors (Satish Myneni) as we drove to the Florida Keys. He mentioned how his research group was looking for a programmer to help them make a tool to analyze some mass spectrometry data they had collected. I had programmed in High School and told him I’d give it a shot. Because of my work with Satish I decided to take his Environmental Chemistry course the next fall, and from there I never looked back.

So that’s how I joined the department, but as for why I stayed here, and have been so happy with my experience in the GEO department comes down to a few things: I love how interdisciplinary the work in this department is; we get to use chemistry, math, computer science, biology, geology, and physics to look at how the Earth was in the past; and how it continues to evolve today. I love that our work very often takes us beyond the classroom and sometimes even out of the country to places that are wild and beautiful. I love that this whole huge field of Earth Science is still so young (plate tectonics was only accepted about 50 years ago) that it sometimes feels like a huge scientific frontier with revolutionary ideas just waiting to be discovered. More than any of this, however, I love the people who make up this department. We are a small and devoted group of people, equal parts brilliant and wonderful where everyone is on a first name basis. While I have always been in awe of the intellect around me here, I have never once been intimidated by it. I can’t imagine a better environment in which to learn and grow.”

Testimonial from AMY GOBEL ’12

“I joined the Geosciences Department because I read course reviews, when trying to decide how to study environmental chemistry. I noticed that an overwhelming theme for the other departments I was considering, was that students despised the required courses. But, in the Geosciences Department, I found not a single negative review. Small classes and invested faculty meant excellent instruction across the board. And while I didn’t appreciate it at the time, this also meant access to a range of research opportunities in environmentally-focused science that I would not find anywhere else on campus. The fact that I got to spend a summer in Bermuda didn’t hurt, either. I have spent two years tolerating “rocks for jocks” jokes, however, I feel this is the best department for my field of interest that I could have asked for.”
Testimonial from JACQUIE NESBIT ’12

“Why Jacquie became a Geo major:

Like many of my peers, I was first introduced to geology through a Freshman Seminar, Earth’s Changing Surface and Climate. I came to Princeton as a prospective EEB major; I had never even considered the possibility of studying rocks! The opportunity to do field work and original research as part of Freshman Seminar was the first time that I understood what it felt like to be a scientist. As I continued in the sciences at Princeton, I found myself more engaged in my courses in geology than chemistry, physics, or biology. In my Geo classes, even at the 200-level I felt like I was integrating basic knowledge with real research methods that would prepare me to do my own independent work in the future. I became very well-acquainted with my Geo professors—not only did they know me by name, but they were unmatched in their availability and dedication to helping me succeed. For me, other intro science courses never exceeded expectations as mere introductory requirements, but I loved my Geo classes and knew that I wanted to take more. Not only did I like the material, many classes involved field trips, which brought learning and class cohesion to a whole new level. The clear next step was to concentrate in geosciences, focusing on geology.

Why I like Geo:

Once I decided to be a Geo major, I knew immediately that I had made the right choice. The tight, welcoming community of undergrads, grad students, faculty, and staff cannot be matched! Additionally, Princeton Geosciences has given me opportunities that I would not have in other departments. Geo is unparalleled in its abundance of professors and select group of students. This advantageous ratio is beneficial in everything from getting your desired independent work advisor to developing strong relationships with multiple faculty members. Even as a freshman, I was given the opportunity to work in a research laboratory for one of my professors! Though my coursework has been challenging, my love of the earth, rocks, and science has only grown. I know that my Geosciences degree means I will graduate with a real skill set that will prepare for my future both academically and professionally.”

Testimonial from MICHAEL EDDY ’11

“My name is Michael Eddy and I think geology rocks. When I started school at Princeton I had no idea that I would join the Geosciences Department. However, within the first two years Guyot had become my new home. The department’s work combines three of my great passions: science, the outdoors, and travel. By my graduation, I had climbed volcanoes in Alaska, seen the K-T boundary in Tunisia, and done scientific research with professors who are on the cutting edge in their fields. These types of opportunities are unique to the Princeton Geosciences Department, and I encourage interested students to explore its opportunities.”
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(Center) Former Hess Postdoctoral fellow at Princeton Kevin Lewis (now Asst. Prof. at Johns Hopkins) and Hope Lorah ’17 using a portable magnetic susceptibility meter to look for cycles in the El Molino Formation during a research field trip to La Palca, Bolivia. (Far right) Adrian Tasistro-Hart ’17 stands at Paleosols in the El Molino Formation, Maragua, on the same research field trip to Bolivia. Photos by: Prof. Adam Maloof [Maloof, Schoene]
SENIOR THESIS TITLES

“Parameterizing the KoK Effect: How Light Inhibition of Respiration Affects Ecosystem Carbon Budget Predictions”

“The Importance of Volcanic Rocks and Thin Sediments on Thermal Gradient”

“Studying Past Atmospheric CO₂ Concentrations Using Mass Spectrometer Analysis of Foraminifera-Bound Organic Matter”

“A Mechanistic Study of CO₂ Fixation In Marine Diatoms: The Effects of Diel Cycling, Temperature & Light Intensity On Thalassiosira weissflogii”

“Seasonality in the Antarctic Ocean: Late Summer Nitrate Isotope Measurements from the Pacific Sector and A Seasonal Model of the Upper Water Column”

“Calculating Mass Balance Per Degree for the Aleutian Crust Using a Novel Method”

“The Concentration and Isotopic Composition of Nitrate In the Water Column Along a Cross-Basin Transect of the North Atlantic Ocean”

“Constraining Deformation in the Skymo Lake Area of the North Cascades, WA: Implications for the Rapid Exhumation of Arc Middle Crust Along Strike-Slip Fault Systems”

“No Nitrification, No NO₃? The Importance of Nitrification in the Epipelagic North Atlantic”

Testimonial from CHARLOTTE CONNER ’14

“Looking back on my four years at Princeton, I cannot overstate how important being a part of the Geosciences department shaped my university experience. For my first course in the department as a sophomore, I travelled to the Alps with ten GEO upperclassmen. While I learned a lot in the course itself, what made the experience memorable was that I was exposed to the enthusiasm, generosity, and good humor that are characteristic of the GEO department. I can very honestly say that I met some of my best friends from the GEO department. What made GEO stand out for me is that everyone is so passionate about their research and their courses. Given the wide range of topics we can study, everyone is able to find their niche. Originally I was attracted to the Geosciences department because of its research on climate change; but throughout my years in the department I found my interests expand to areas I would have never even thought about before. For my own independent research projects, I worked with the archeology department to understand the chemistry of Ancient Cypriot cement, I modeled the effect of deforestation in Central America on precipitation patterns, and finally for my senior thesis I measured nitrogen isotope ratios in algae fossils to infer changes in ocean circulation at the time of the onset of the Northern Hemisphere Glaciations. Studying Geosciences at Princeton allowed me to develop my analytical skills in all the major sciences as well as to understand the interplay between the Earth systems and the importance of the Earth sciences to our society.”
“Stable isotope analysis of sunflower leaf respiration: the metabolic origin of the Kok Effect”

“Fluid Inclusions in Marine Halite as a Window into the MG Isotopic”

“An Integrated Chemo Stratigraphic Approach to Understanding The Siluro Devonian Positive Carbon Isotope Excursion”

“Using $^{15}$N/$^{14}$N in Diatom Fossils to Understand Changes In Surface Ocean Nutrient Dynamics 2.73 Ma”

“Using U-PB Geochronology to Constrain The Formation of a New Jersey Nelsonite”

“Precision and Accuracy of Low-Cost Global Positioning Augmentation Systems”

“Aerosols, Change Points, and the Evolving Land Carbon Sink”

“Diagenesis in the Great Bahamas Bank: An Analysis of Mg Isotopes in the Sediment Cores from ODP Site 1003”

“Updates to Leaf Respiration Parameterization: Assessing the Impact of Light Inhibition, Leaf Expansion, and a Warming Scenario for Carbon Budget Modeling”

“New Constraints on the Size of Io’s Core”

“A Species-Specific Approach to Predicting the Timing of Deciduous Leaf Emergence in the United States”

“Modeling Water Distributions Along the Brazos River”

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Testimonial from KATHLEEN RYAN ‘14

“I came to Princeton with a vague idea that I wanted to understand the natural world. I didn’t want to just pass science classes and earn a degree, I wanted to develop a literacy that would allow me to interrogate, understand, and appreciate the amazing environment around me on the smallest scales but also as an integrated whole. Looking back, this was perhaps quite a tall order. Nonetheless, the Department of Geosciences completely exceeded my expectations.

As an undergraduate member of the Department of Geosciences, you are not just a student. You are a growing, contributing member of a scientifically-oriented community. You are given the opportunity to explore natural systems in fun, intimate, and challenging classroom and field settings. You are given the responsibility of contributing to meaningful group projects and the challenge of creating high-quality independent work. You are valued for all of your interests and contributions, geoscientific and beyond, and you are supported as a student and as an alumnus, regardless of your developing career goals.

While I may not become a career geoscience researcher, I have no doubt that the Geosciences was the major for me. I faced real academic challenges in the department, but also found my greatest mentors and a few of my closest friends. This Department is the best Princeton has to offer.”
(Left) The bow of the S.A. Agulhas II as it slices through the pancake ice under a cloudy sky as seen by Preston Kemeny ’15 on a research cruise to Antarctica. Pancakes’ extend in all directions for many miles. Photo by: Preston Kemeny ’15

(Center) Ethan Campbell ’16 in front of the SA Agulhas II a few days before leaving on an oceanographic research cruise that will take him from Cape Town, South Africa, to the Antarctic winter sea-ice edge. Photo by: Dr. Susanne Fietz (Sigman)