Environmental Science

Department Website: http://geosci.uchicago.edu

Program of Study

The Department of the Geophysical Sciences offers a BS degree in Environmental Science. The program is intended for students whose interests fall at the intersection of biology, chemistry, and earth sciences, and is designed to prepare them to enter a variety of interdisciplinary fields in the environmental sciences, including the interface of environmental science and public policy. Students are given the opportunity to study such topics as the biogeochemical cycles, environmental chemistry, microbiology, ecology, the chemistry and dynamics of the ocean and atmosphere, climate change, and environmentally relevant aspects of economics and policy. Students are encouraged to participate in the Semester in Environmental Science at the Marine Biological Laboratory, and undergraduate research is also strongly encouraged.

Program Requirements for the BS in Environmental Science

The requirements for the BS degree in Environmental Science involve completion of:

- six required courses that fulfill general education requirements for the physical sciences, biological sciences, and mathematics
- seven required science or mathematics courses
- eleven elective courses pertinent to the major from the electives lists below, which must include
  - four courses designated ENSC or GEOS
  - one course in Statistics, and two more in any of Mathematics, Statistics, or Computing
  - one to three courses in Social Science/Public Policy

Candidates for the BS in Environmental Science complete a year of chemistry, a year of mathematics (including Calculus I-II), and a year of biology (ENSC 24400 Ecology and Conservation, GEOS 27300 Biological Evolution-Advanced, and BIOS 20198 Biodiversity), as well as PHYS 13100 Mechanics or the equivalent. (Note that some advanced chemistry courses require further physics as a prerequisite.)

Students are encouraged to begin discipline-specific courses as early as possible. Required disciplinary courses include ENSC 13300 The Atmosphere, ENSC 23800 Global Biogeochemical Cycles, and ENSC 24400 Ecology and Conservation. (Note that ENSC 23800 Global Biogeochemical Cycles is typically offered every other year.) Of ENSC/GEOS science electives, one can be a field course, and one may be ENSC 29700 Reading and Research in Environmental Science. Students participating in the Semester in Environmental Science receive credit for four courses in environmental science, two of which can be used to substitute for ENSC 24400 Ecology and Conservation and ENSC 24500 Environmental Microbiology. ENSC 24100 Ecology - Marine Biological Laboratory substitutes for ENSC 24400 Ecology and Conservation, and ENSC 24200 Methods in Microbial Ecology - Marine Biological Laboratory substitutes for ENSC 24500 Environmental Microbiology.

The major is designed to be flexible enough to accommodate students whose primary interests cover various aspects of environmental science. Sample course schedules below give examples of course plans appropriate to students focusing on climatology, conservation, and biogeochemistry. Students with a focus on policy questions may take up to three courses in social science/public policy. These courses are available through undergraduate programs in Economics (http://collegecatalog.uchicago.edu/thecollege/economics/), Public Policy Studies (http://collegecatalog.uchicago.edu/thecollege/publicpolicystudies/), and Environmental and Urban Studies (http://collegecatalog.uchicago.edu/thecollege/environmentalstudies/), or through the Harris School of Public Policy (http://collegecatalog.uchicago.edu/harrispublicpolicy/courses/).

Because analysis of data and mathematical modeling are fundamental to environmental science, the major requires six courses in quantitative methods: a year of mathematics, one course in statistics, and two additional courses in mathematics, statistics, or computing.

Note that while students taking calculus through the more introductory MATH 13000s sequence are encouraged to complete the third quarter of calculus, MATH 13300 Elementary Functions and Calculus III, in the higher tracks Calculus III (e.g., MATH 15300 Calculus III) is not specifically required or recommended, as the first two courses offer a sufficiently comprehensive calculus training for students to move on to other courses. Depending on the choice of electives, students may credit as many as nine Mathematics/Statistics/Computing courses toward the major.

Summary of Requirements for the BS in Environmental Science

GENERAL EDUCATION

One of the following sequences:		200
CHEM 10100 & CHEM 10200	Introductory General Chemistry I and Introductory General Chemistry II	
CHEM 11100-11200	Comprehensive General Chemistry I-II *	

CHEM 12100 & CHEM 12200	Honors General Chemistry I and Honors General Chemistry II	
One of the following sequences:		200
MATH 13100-13200	Elementary Functions and Calculus I-II *	
MATH 15100-15200	Calculus I-II	
MATH 16100-16200	Honors Calculus I-II	
Both of the following: **		200
BIOS 20198	Biodiversity	
GEOS 27300	Biological Evolution-Advanced %	
Total Units		600

MAJOR

ENSC 13300	The Atmosphere	100
ENSC 23800	Global Biogeochemical Cycles	100
ENSC 23900	Environmental Chemistry	100
ENSC 24400	Ecology and Conservation	100
CHEM 11300	Comprehensive General Chemistry III *	100
or CHEM 12300	Honors General Chemistry III	
One of the following:		100
PHYS 12100	General Physics I * ‡	
PHYS 13100	Mechanics	
PHYS 14100	Honors Mechanics	
One of the following:		100
MATH 18300	Mathematical Methods in the Physical Sciences I	
MATH 20250	Abstract Linear Algebra	
PHYS 22000	Introduction to Mathematical Methods in Physics	
BIOS 20152	Introduction to Quantitative Modeling in Biology (Advanced)	
MATH 13300	Elementary Functions and Calculus III *	
MATH 15300	Calculus III	
MATH 16300	Honors Calculus III	
Eleven electives as follows:		1100
Four courses designated ENSC or GEOS from List E-1: Physical and Biological Sciences		
One course from List E-2: Social Sciences		
Three courses from List E-3: Computational Sciences, of which one must be under the heading of Statistics		
Three more courses from any of the elective lists, but only up to two of these may be from List E-2: Social Sciences		
Total Units		1800

* Credit may be granted by examination.

** Only students majoring in Environmental Science or Geophysical Sciences may use this pairing toward the general education requirement in the Biological Sciences. Environmental Science and Geophysical Sciences majors can take these courses without the BIOS prerequisites (BIOS 20150-20151/20152) unless they pursue a double major in Biological Sciences. They are expected to show competency in mathematical modeling of biological phenomena covered in BIOS 20151/20152.

‡ PHYS 13100 or PHYS 14100 are the preferred courses. PHYS 12100 is allowable on a case-by-case basis but may not provide adequate preparation to allow for enrollment in higher level PHYS courses. Additionally, PHYS 12100 has a prerequisite of a year of Chemistry. Special petition to the department counselor is required for PHYS 12100 approval.

% Biological Evolution-Advanced has several cross-listings. Environmental Sciences majors *must* register for it under the GEOS 27300 listing.

Lists of Elective Courses

List E-1: Physical and Biological Sciences

Environmental Science

ENSC 21100	Energy: Science, Technology, and Human Usage	100
ENSC 24000	Geobiology	100

ENSC 24500	Environmental Microbiology	100
ENSC 29700	Reading and Research in Environmental Science	100

Semester in Environmental Science/MBL

The following courses are the College designations for the Semester in Environmental Science that is taught at the Marine Biological Laboratory (MBL) in Woods Hole, Massachusetts. One quarter at MBL counts for four courses: ENSC 23820, ENSC 24100, ENSC 29800, and an elective of ENSC 24200, ENSC 24300, or ENSC 28100. Admission to the Semester in Environmental Science program is by application, which must be received by the MBL generally in March of the year preceding the start of the semester. Admissions decisions will generally be sent in April. Note that these courses start at the beginning of September, typically four weeks prior to the start of the College's Autumn Quarter and are completed by the end of Autumn Quarter. More information on the course content and the application process, and deadlines can be found at college.uchicago.edu/academics/semester-environmental-science. (https://college.uchicago.edu/academics/semester-environmental-science/) Students participating in the Semester in Environmental Science receive credit for four courses in environmental science, two of which can be used to substitute for ENSC 24400 Ecology and Conservation and ENSC 24500 Environmental Microbiology. ENSC 24100 Ecology - Marine Biological Laboratory substitutes for ENSC 24400 Ecology and Conservation, and ENSC 24200 Methods in Microbial Ecology - Marine Biological Laboratory substitutes for ENSC 24500 Environmental Microbiology. ENSC 28100 Quantitative Environmental Analyses # Marine Biological Laboratory would count as a List E-3 elective.

ENSC 23820	Biogeochemical Analysis in Terrestrial and Aquatic Ecosystems # Marine Biological Laboratory ~	100
ENSC 24100	Ecology - Marine Biological Laboratory +	100
ENSC 29800	Independent Undergraduate Research in Environmental Sciences Marine Biological Laboratory ~	100
ENSC 24200	Methods in Microbial Ecology - Marine Biological Laboratory ++	100
ENSC 24300	Roles of Animals in Ecosystems # Marine Biological Laboratory ~	100

Field Courses in Environmental Science

The department sponsors field trips that range in length from one day to several weeks. Shorter field trips typically form part of lecture-based courses and are offered each year. (The trips are open to all students and faculty if space permits.) Longer trips are designed as undergraduate field courses, and one such course may be used as an elective science course for the major. Destinations of field courses have recently included Baja California and the Bahamas. (http://collegecatalog.uchicago.edu/thecollege/geophysicalsciences/#_msocom_1)

ENSC 29002	Field Course in Modern and Ancient Environments	100

Geophysical Sciences

GEOS 21000	Mineralogy	100
GEOS 21400	Thermodynamics and Phase Change	100
GEOS 22060	What Makes a Planet Habitable?	100
GEOS 22200	Geochronology	100
GEOS 22700	Analytical Techniques in Geochemistry	100
GEOS 23205	Introductory Glaciology	100
GEOS 23600	Chemical Oceanography	100
GEOS 24220	Climate Foundations	100
GEOS 24230	Geophysical Fluid Dynamics: Foundations	100
GEOS 24240	Geophysical Fluid Dynamics: Rotation and Stratification	100
GEOS 24250	Geophysical Fluid Dynamics: Understanding the Motions of the Atmosphere and Oceans	100
GEOS 24300	Paleoclimatology	100
GEOS 24750	Humans in the Earth System	100
GEOS 25400	Intro to Numerical Techniques for Geophysical Sciences	100
GEOS 26100	Phylogenetics and the Fossil Record	100
GEOS 26300	Invertebrate Paleobiology and Evolution	100
GEOS 28600	The Science of Landscapes	100

Chemistry

CHEM 20100	Inorganic Chemistry I	100
CHEM 20200	Inorganic Chemistry II	100
CHEM 22000	Organic Chemistry I	100

CHEM 22100	Organic Chemistry II	100
CHEM 22200	Organic Chemistry III	100
CHEM 23300	Intermediate Organic Chemistry *	100
CHEM 26100	Quantum Mechanics **	100
CHEM 26200	Thermodynamics	100
CHEM 26300	Chemical Kinetics and Dynamics	100

Biology and Ecology***

BIOS 20200	Introduction to Biochemistry	100
BIOS 23232	Ecology and Evolution in the Southwest	100
BIOS 23252	Field Ecology	100
BIOS 23254	Mammalian Ecology	100
BIOS 23258	Molecular Evolution I: Fundamentals and Principles	100
BIOS 23266	Evolutionary Adaptation	100
BIOS 23289	Marine Ecology	100
BIOS 23404	Reconstructing the Tree of Life: An Introduction to Phylogenetics	100
BIOS 23406	Biogeography	100
BIOS 25206	Fundamentals of Bacterial Physiology	100

Physics

PHYS 12200	General Physics II ‡	100
PHYS 12300	General Physics III ‡	100
PHYS 13200	Electricity and Magnetism	100
PHYS 13300	Waves, Optics, and Heat	100
PHYS 14200	Honors Electricity and Magnetism	100
PHYS 14300	Honors Waves, Optics, and Heat	100
PHYS 18500	Intermediate Mechanics	100
PHYS 22500	Intermediate Electricity and Magnetism I	100
PHYS 22600	Electronics	100
PHYS 22700	Intermediate Electricity and Magnetism II	100

~ Counts as a List E-1 elective

\+ Substitutes for the required course ENSC 24400 Ecology and Conservation. Students cannot get credit for taking both.

++ Substitutes for the List E-1 course ENSC 24500 Environmental Microbiology. Students cannot get credit for taking both.

~~ Counts as a List E-3 elective

* Enrollment in CHEM 23300 requires a grade of C or higher in CHEM 22200 or 23200

** Prerequisites include MATH 18500 and PHYS 13300

*** ENSC majors can take these courses without the BIOS prerequisites (20150-20151) unless they pursue a double major in biology. Students are expected to show competency in the mathematical modeling of biological phenomena covered in BIOS 20151.

‡ PHYS 13200-13300 or PHYS 14200-14300 are the preferred sequences. PHYS 12200-12300 is allowable on a case-by-case basis but may not provide adequate preparation to allow for enrollment in higher level PHYS courses. Special petition to the department counselor is required for PHYS 12100-12200-12300 approval.

List E-2: Social Sciences

Microeconomics Foundations

Students may take one of the following:

ECON 10000	Principles of Microeconomics	100
ECON 20000	The Elements of Economic Analysis I *	100
ECON 20100	The Elements of Economic Analysis II *	100
PBPL 20000	Economics for Public Policy	100
PPHA 32300	Principles of Microeconomics and Public Policy I *	100
PPHA 32400	Principles of Microeconomics and Public Policy II *	100

Other Social Science Electives

(Note that many courses below require microeconomics as a prerequisite)

ECON 10200	Principles of Macroeconomics	100
ENST 23550	Urban Ecology and the Nature of Cities	100
ENST 24102	Environmental Politics	100
ENST 28220	Global Energy & Climate Challenge: Economics, Science & Policy	100
PBPL 23100	Environmental Law	100
PBPL 24701	U.S. Environmental Policy	100
PBPL 26530	Environment, Agriculture, and Food: Economic and Policy Analysis	100
PPHA 36921	Energy Economics and Policy	100
PPHA 36930	Environmental Economics: Theory and Applications	100
PPHA 38900	Environmental Science/Policy	100
PPHA 39901	Policy Approaches to Mitigating Climate Change	100

* Must be taken in sequence

** Acceptable only if a microeconomics course is also taken

List E-3: Computational Sciences

Semester in Environmental Science/MBL

ENSC 28100	Quantitative Environmental Analyses # Marine Biological Laboratory *	100

Mathematics

MATH 15300	Calculus III	100
or MATH 16300	Honors Calculus III	
MATH 15910	Introduction to Proofs in Analysis	100
or STAT 24300	Numerical Linear Algebra	
MATH 18300	Mathematical Methods in the Physical Sciences I	100
MATH 18400	Mathematical Methods in the Physical Sciences II	100
MATH 21100	Basic Numerical Analysis	100
MATH 20250	Abstract Linear Algebra	100
BIOS 20152	Introduction to Quantitative Modeling in Biology (Advanced)	100
BIOS 26210	Mathematical Methods for Biological Sciences I	100
BIOS 26211	Mathematical Methods for Biological Sciences II	100

Physics

PHYS 22000	Introduction to Mathematical Methods in Physics **	100
PHYS 22100	Mathematical Methods in Physics ***	100

Statistics

Students may take any course in statistics at the 22000 level or higher, but recommended courses are shown below. Some courses require one of the first three as a prerequisite.

Students may take one of the following:		
PPHA 31200	Mathematical Statistics for Public Policy I ‡ ~ ^	100
PPHA 31300	Mathematical Statistics for Public Policy II ‡ ~ ^	100
STAT 22000	Statistical Methods and Applications §§ ^	100
STAT 23400	Statistical Models and Methods ‡‡ ^	100
STAT 24400	Statistical Theory and Methods I §	100
STAT 24500	Statistical Theory and Methods II §	100
STAT 22400	Applied Regression Analysis	100
STAT 22600	Analysis of Categorical Data	100
STAT 26100	Time Dependent Data	100
PPHA 34600	Program Evaluation	100

The 30000 (and above) level courses listed below are a joint offering of the Department of Statistics and the Department of Public Health Studies, and may be suitable for Environmental Science majors.

STAT 31900	Introduction to Causal Inference	100

STAT 35800	Statistical Applications	100
STAT 36900	Applied Longitudinal Data Analysis	100

Computing

CMSC 12100	Computer Science with Applications I +	100
CMSC 12200	Computer Science with Applications II	100
CMSC 12300	Computer Science with Applications III	100
CMSC 23710	Scientific Visualization	100

* This is not a stand-alone course, but part of the Semester in Environmental Science/MBL.

** Would generally substitute for MATH 18300-18400.

*** Recommended in addition to MATH 18300-18400 for advanced students—covers partial differential equations

‡ Must be taken as a sequence

~ PPHA 31200 and PPHA 31300 each count as 100 credits and can be taken individually.

‡‡ Higher programming component than STAT 22000

§ Recommended for advanced students. Must be taken as a sequence to be credited. STAT 24400-24500 have no prerequisite, but it is possible to take both STAT 23400 and STAT 24400-24500.

§§ AP credit for STAT 22000 does not count toward the major requirements. Students with AP credit for STAT 22000 should plan to take at least three other courses from List E-3: Computational Sciences, one of which must be under the heading of Statistics.

+ Students seeking to double major in Computer Science must complete CMSC 12100-12200-12300 as a sequence per the Computer Science rule.

^ Students may only receive credit for one of these four courses.

Grading

Students majoring in Environmental Science must receive quality grades in all courses taken to meet requirements in the major.

Honors

The BS degree with honors is awarded to students who meet the following requirements: (1) a GPA of 3.25 or higher in the major and of 3.0 or higher overall; (2) completion of a paper based on original research, supervised and approved by a faculty member in geophysical sciences; (3) an oral presentation of the thesis research. All theses will be examined by the supervisor and a second reader from the faculty. Manuscript drafts will generally be due in the sixth week of the quarter in which the student will graduate (fifth week in Summer Quarter), and final manuscripts and oral presentations in the eighth week (seventh week in Summer Quarter).

Students are strongly encouraged to reach out to potential faculty supervisors no later than their third year, since theses generally arise out of research projects already begun with faculty members. When a thesis topic is determined, students should notify the undergraduate adviser of their intent to complete a thesis and confirm their eligibility. ENSC 29700 Reading and Research in Environmental Science can be devoted to the preparation of the required paper; however, students using this course to meet a requirement in the major must take it for a quality grade.

Students who wish to submit a single paper to meet the honors requirement in Environmental Science and the BA paper requirement in another major should discuss their proposals with the undergraduate advisers from both programs no later than the end of third year. Certain requirements must be met. A consent form, to be signed by the undergraduate advisers, is available from the College adviser. It must be completed and returned to the College adviser by the end of Autumn Quarter of the student's year of graduation.

Sample BS Programs

Each student will design an individual plan of course work, choosing from a wide range of selections that take advantage of rich offerings from a variety of subdisciplines. The sample programs that appear below are merely for the purpose of illustration; many other variations would be possible. NOTE: Courses that meet general education requirements and are required for the major are not listed.

Environmental Geochemistry

ENSC 23820	Biogeochemical Analysis in Terrestrial and Aquatic Ecosystems # Marine Biological Laboratory	100
ENSC 28100	Quantitative Environmental Analyses # Marine Biological Laboratory	100
ENSC 29800	Independent Undergraduate Research in Environmental Sciences Marine Biological Laboratory	100
BIOS 20200	Introduction to Biochemistry	100
BIOS 26210	Mathematical Methods for Biological Sciences I	100

BIOS 26211	Mathematical Methods for Biological Sciences II	100
CHEM 22000	Organic Chemistry I	100
CHEM 22100	Organic Chemistry II	100
PBPL 20000	Economics for Public Policy	100
STAT 22000	Statistical Methods and Applications	100

Environmental Microbiology

ENSC 23820	Biogeochemical Analysis in Terrestrial and Aquatic Ecosystems # Marine Biological Laboratory	100
ENSC 24000	Geobiology	100
ENSC 24100	Ecology - Marine Biological Laboratory	100
ENSC 24200	Methods in Microbial Ecology - Marine Biological Laboratory	100
ENSC 24500	Environmental Microbiology	100
ENSC 29800	Independent Undergraduate Research in Environmental Sciences Marine Biological Laboratory	100
BIOS 23404	Reconstructing the Tree of Life: An Introduction to Phylogenetics	100
BIOS 25206	Fundamentals of Bacterial Physiology	100
BIOS 26210	Mathematical Methods for Biological Sciences I	100
BIOS 26211	Mathematical Methods for Biological Sciences II	100
PBPL 20000	Economics for Public Policy	100
STAT 22000	Statistical Methods and Applications	100

Environmental Science and Public Policy

ENSC 21100	Energy: Science, Technology, and Human Usage	100
ENSC 29002	Field Course in Modern and Ancient Environments	100
BIOS 23406	Biogeography	100
ENST 21800	Economics and Environmental Policy	100
PPHA 32300	Principles of Microeconomics and Public Policy I	100
PPHA 32400	Principles of Microeconomics and Public Policy II	100
STAT 22400	Applied Regression Analysis	100

Environmental Science Courses

ENSC 13300. The Atmosphere. 100 Units.
This course introduces the physics, chemistry, and phenomenology of the Earth's atmosphere, with an emphasis on the fundamental science that underlies atmospheric behavior and climate. Topics include (1) atmospheric composition, evolution, and structure; (2) solar and terrestrial radiation in the atmospheric energy balance; (3) the role of water in determining atmospheric structure; and (4) wind systems, including the global circulation, and weather systems.
Instructor(s): T. Shaw Terms Offered: Spring
Prerequisite(s): MATH 13100-MATH 13200
Equivalent Course(s): GEOS 13300, ENST 13300

ENSC 13400. Global Warming: Understanding the Forecast. 100 Units.
This course presents the science behind the forecast of global warming to enable the student to evaluate the likelihood and potential severity of anthropogenic climate change in the coming centuries. It includes an overview of the physics of the greenhouse effect, including comparisons with Venus and Mars; an overview of the carbon cycle in its role as a global thermostat; predictions and reliability of climate model forecasts of the greenhouse world. This course is part of the College Course Cluster program, Climate Change, Culture, and Society. (L)
Instructor(s): D. MacAyeal Terms Offered: PHSC 13400 was last offered in Autumn 2019 and has been replaced by PHSC 13410
Prerequisite(s): Some knowledge of chemistry or physics helpful.
Equivalent Course(s): PHSC 13400, ENST 12300, GEOS 13400

ENSC 13410. Global Warming: Understanding the Forecast (Flipped Class) 100 Units.
This course presents the science behind the forecast of global warming to enable the student to evaluate the likelihood and potential severity of anthropogenic climate change in the coming centuries. It includes an overview of the physics of the greenhouse effect, including comparisons with Venus and Mars; predictions and reliability of climate model forecasts of the greenhouse world. This course is part of the College Course Cluster program, Climate Change, Culture, and Society. This course covers the same material as PHSC 13400, but is organized using a flipped classroom approach in order to increase student engagement and learning.
Instructor(s): D. Abbot Terms Offered: Autumn Spring

Prerequisite(s): Some knowledge of chemistry or physics helpful.
Equivalent Course(s): PHSC 13410, ENST 13410, GEOS 13410

ENSC 21100. Energy: Science, Technology, and Human Usage. 100 Units.
This course covers the technologies by which humans appropriate energy for industrial and societal use, from steam turbines to internal combustion engines to photovoltaics. We also discuss the physics and economics of the resulting human energy system: fuel sources and relationship to energy flows in the Earth system; and modeling and simulation of energy production and use. Our goal is to provide a technical foundation for students interested in careers in the energy industry or in energy policy. Field trips required to major energy converters (e.g., coal-fired and nuclear power plants, oil refinery, biogas digester) and users (e.g., steel, fertilizer production). This course is part of the College Course Cluster program: Climate Change, Culture and Society.
Instructor(s): E. Moyer
Prerequisite(s): Knowledge of physics or consent of instructor.
Note(s): See GEOS 24750/ENSC 21150.
Equivalent Course(s): GEOS 34705, GEOS 24705, ENST 24705

ENSC 21150. Humans in the Earth System. 100 Units.
Human activities now have global-scale impact on the Earth, affecting many major biogeochemical cycles. One third of the Earth's surface is now used for production of food for humans, and CO2, the waste product of human energy use, now substantially affects the Earth's radiative balance. This course provides a framework for understanding humanity as a component of Earth system science. The course covers the Earth's energy flows and cycles of water, carbon, and nitrogen; their interactions; and the role that humans now play in modifying them. Both agriculture and energy technologies can be seen as appropriation of natural energy flows, and we cover the history over which human appropriations have become globally significant. The course merges geophysical and biological sciences and engineering, and includes lab sessions and field trips to agriculture, water management, and energy facilities to promote intuition. One year of university-level science is recommended.
Terms Offered: Spring
Equivalent Course(s): GEOS 24750, ENST 24750, GEOS 34750

ENSC 23600. Chemical Oceanography. 100 Units.
This course explores the chemistry of the ocean system and its variations in space and time. The oceans play an essential role in most (bio)geochemical cycles, interacting in various ways with the atmosphere, sediments, and crust. These interactions can be understood through studying the geochemical and isotopic properties of the ocean, its inputs and outputs, and its evolution as recorded in marine sediments and sedimentary rocks. Topics include: the marine carbon cycle, nutrient cycling, chemical sediments, and hydrothermal systems.
Instructor(s): Clara Blättler Terms Offered: Spring
Prerequisite(s): Completion of one of the following Chemistry Sequences: CHEM 10100-10200-11300 Introductory General Chemistry I-II; Comprehensive General Chemistry III or CHEM 11100-11200-11300 Comprehensive General Chemistry I-II-III or CHEM 12100-12200-12300 Honors General Chemistry I-II-III AND either GEOS 13100 or GEOS 13200.
Equivalent Course(s): GEOS 23600, GEOS 33600

ENSC 23800. Global Biogeochemical Cycles. 100 Units.
This survey course covers the geochemistry of the surface of the Earth, focusing on biological and geological processes that shape the distributions of chemical species in the atmosphere, oceans, and terrestrial habitats. Budgets and cycles of carbon, nitrogen, oxygen, phosphorous, and sulfur are discussed, as well as chemical fundamentals of metabolism, weathering, acid-base and dissolution equilibria, and isotopic fractionation. The course examines the central role that life plays in maintaining the chemical disequilibria that characterize Earth's surface environments. The course also explores biogeochemical cycles change (or resist change) over time, as well as the relationships between geochemistry, biological (including human) activity, and Earth's climate.
Instructor(s): J. Waldbauer Terms Offered: Spring
Prerequisite(s): CHEM 11100-11200 or consent of instructor
Equivalent Course(s): GEOS 33800, GEOS 23800

ENSC 23820. Biogeochemical Analysis in Terrestrial and Aquatic Ecosystems # Marine Biological Laboratory. 100 Units.
This course examines the interface of biological processes with chemical processes in ecological systems. Course content emphasizes aquatic chemistry and the role of microbes in the cycling of nitrogen, carbon, and other elements. Effects of global changes on chemical cycling are emphasized.
Instructor(s): Marine Biological Laboratory Staff. Terms Offered: Autumn. L.
Prerequisite(s): Consent only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710 and BIOS 27712 along with one of BIOS 27713, BIOS 27714 or BIOS 27715.
Note(s): E.
Equivalent Course(s): BIOS 27711

ENSC 23900. Environmental Chemistry. 100 Units.
The focus of this course is the fundamental science underlying issues of local and regional scale pollution. In particular, the lifetimes of important pollutants in the air, water, and soils are examined by considering the roles played by photochemistry, surface chemistry, biological processes, and dispersal into the surrounding

environment. Specific topics include urban air quality, water quality, long-lived organic toxins, heavy metals, and indoor air pollution. Control measures are also considered. This course is part of the College Course Cluster program: Climate Change, Culture, and Society.
Instructor(s): D. Archer Terms Offered: Autumn
Prerequisite(s): CHEM 11100-11200 or equivalent, and prior calculus course
Equivalent Course(s): ENST 23900, GEOS 23900, GEOS 33900

ENSC 24000. Geobiology. 100 Units.
Geobiology seeks to elucidate the interactions between life and its environments that have shaped the coevolution of the Earth and the biosphere. The course will explore the ways in which biological processes affect the environment and how the evolutionary trajectories of organisms have in turn been influenced by environmental change. In order to reconstruct the history of these processes, we will examine the imprints they leave on both the rock record and on the genomic makeup of living organisms. The metabolism and evolution of microorganisms, and the biogeochemistry they drive, will be a major emphasis.
Instructor(s): M. Coleman, J. Waldbauer
Prerequisite(s): GEOS 13100-13200-13300 or college-level cell & molecular biology
Equivalent Course(s): GEOS 36600, GEOS 26600

ENSC 24100. Ecology - Marine Biological Laboratory. 100 Units.
This course examines the structure and functioning of terrestrial and aquatic ecosystems including the application of basic principles of community and ecosystem ecology. The course also examines contemporary environmental problems such as the impacts of global and local environmental change on community composition and food webs within forest, grassland, marsh and nearshore coastal ecosystems on Cape Cod. This course examines the structure and functioning of terrestrial and aquatic ecosystems including the application of basic principles of community and ecosystem ecology. The course also examines contemporary environmental problems such as the impacts of global and local environmental change on community composition and food webs within forest, grassland, marsh and nearshore coastal ecosystems on Cape Cod.
Instructor(s): Marine Biological Laboratory Staff Terms Offered: Autumn. L.
Prerequisite(s): Consent only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27711 and BIOS 27712 along with one of BIOS 27713, BIOS 27714 or BIOS 27715.
Note(s): E.
Equivalent Course(s): BIOS 27710

ENSC 24200. Methods in Microbial Ecology - Marine Biological Laboratory. 100 Units.
This course explores the biology of microbes found in the environment, including relationships with the physical, chemical, and biotic elements of their environment. Emphasis is placed on understanding the science underlying the various methodologies used in the study of these organisms and systems. In the laboratory, students will work with the latest techniques to measure microbial biomass, activity, extracellular enzymes, and biogeochemical processes. Students are also introduced to molecular methods for assessing microbial genomic diversity.
Instructor(s): Marine Biological Laboratory Staff Terms Offered: Autumn. L.
Prerequisite(s): Consent only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710, BIOS 27711 and BIOS 27712.
Note(s): E.
Equivalent Course(s): BIOS 27714

ENSC 24300. Roles of Animals in Ecosystems # Marine Biological Laboratory. 100 Units.
This course addresses the question, How do animals, including man, affect the structure and function of ecosystems. The course takes an interdisciplinary approach focused on the interactions of animal diversity, migration patterns, population dynamics, and behavior with biogeochemical cycles, productivity, and transport of materials across ecosystems. This course is an elective option within the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA.
Instructor(s): Marine Biological Laboratory Staff Terms Offered: Autumn
Prerequisite(s): Consent only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710, BIOS 27711, and BIOS 27712.
Note(s): E.
Equivalent Course(s): BIOS 27715

ENSC 24400. Ecology and Conservation. 100 Units.
This course focuses on the contribution of ecological theory to the understanding of current issues in conservation biology. We emphasize quantitative methods and their use for applied problems in ecology (e.g., risk of extinction, impact of harvesting, role of species interaction, analysis of global change). Course material is drawn mostly from current primary literature; lab and field components complement concepts taught through lecture. Prerequisite(s): BIOS 20150, BIOS 20151 or BIOS 20152 Note(s): BIOS 20196 is identical to the previously offered BIOS 23251. Students who have taken BIOS 23251 should not enroll in BIOS 20196. Equivalent Course(s): ENSC 24400

Instructor(s): C. Pfister, E. Larsen Terms Offered: Autumn. L.
Prerequisite(s): BIOS 20150, BIOS 20151 or BIOS 20152
Note(s): BIOS 20196 is identical to the previously offered BIOS 23251. Students who have taken BIOS 23251 should not enroll in BIOS 20196.
Equivalent Course(s): BIOS 20196

ENSC 24500. Environmental Microbiology. 100 Units.
The objective of this course is to understand how microorganisms alter the geochemistry of their environment. The course will cover fundamental principles of microbial growth, metabolism, genetics, diversity, and ecology, as well as methods used to study microbial communities and activities. It will emphasize microbial roles in elemental cycling, bioremediation, climate, and ecosystem health in a variety of environments including aquatic, soil, sediment, and engineered systems.
Instructor(s): M. Coleman Terms Offered: Autumn
Prerequisite(s): CHEM 11100-11200 and BIOS 20186 or BIOS 20197 or BIOS 20198
Equivalent Course(s): GEOS 26650, GEOS 36650

ENSC 25000. Biological Oceanography. 100 Units.
This intensive four-week course addresses fundamental oceanographic processes that maintain and structure marine biodiversity and productivity, including physical oceanographic processes of dispersal and upwelling, environmental selection, biogeography, nutrient dynamics, primary production, and food web dynamics. Students will design an original research project during an initial week-long shore component at Marine Biological Laboratory (MBL) in Woods Hole, MA, and then address their own questions by collecting samples and data aboard Sea Education Association (SEA)'s oceanographic research sailing vessel, the SSV Corwith Cramer, on a 10-day offshore voyage. At sea students will deploy oceanographic instruments, interpret various data streams, and work as research teams and watch members as they navigate and sail the vessel. During a final week-long shore component at MBL, students will analyze and interpret the data they collected and present their results in written and oral reports.
Instructor(s): SEA Staff. Terms Offered: Spring. MBL Spring Quarter- Biology. L.
Prerequisite(s): Second-year standing or greater (or by consent).
Note(s): Course meets for three weeks (5-6 days/week, 8 hours per day) at Marine Biological Laboratories, in Woods Hole Massachusetts as part of the Spring Quarter at MBL. For more information see https://college.uchicago.edu/academics/mbl-spring-quarter-biology E.
Equivalent Course(s): BIOS 27751

ENSC 28100. Quantitative Environmental Analyses # Marine Biological Laboratory. 100 Units.
This course emphasizes the application of quantitative methods to answering ecological questions. Students apply mathematical modeling approaches to simulating biological and chemical phenomena in terrestrial and marine ecosystems.
Instructor(s): Marine Biological Laboratory Staff Terms Offered: Autumn. L.
Prerequisite(s): Consent Only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710, BIOS 27711 and BIOS 27712.
Note(s): E.
Equivalent Course(s): BIOS 27713

ENSC 29002. Field Course in Modern and Ancient Environments. 100 Units.
This course uses weekly seminars during Winter Quarter to prepare for a one-week field trip over spring break, where students acquire experience with sedimentary rocks and the modern processes responsible for them, learn field methods, and complete an original research project. We consider biological as well as physical processes of sediment production, dispersal, accumulation, and post-depositional modification. Destinations vary; past trips have examined tropical carbonate systems of Jamaica and the Bahamas and subtropical coastal Gulf of California.
Instructor(s): S. Kidwell, M. LaBarbera Terms Offered: Winter
Note(s): Organizational meeting and deposit usually required in Autumn Quarter; interested students should contact an instructor in advance. Enrollment allowed by permission of instructor.
Equivalent Course(s): GEOS 39002, GEOS 29002

ENSC 29700. Reading and Research in Environmental Science. 100 Units.
Independent study; regular meetings with Geophysical Sciences faculty member required. Register by section corresponding to faculty supervisor.
Terms Offered: Autumn Spring Summer Winter
Prerequisite(s): Consent of instructor and departmental counselor
Note(s): Students are required to submit the College Reading and Research Course Form. Available to nonmajors for P/F grading. Must be taken for a quality grade when used to meet a requirement in the major.

ENSC 29800. Independent Undergraduate Research in Environmental Sciences Marine Biological Laboratory. 100 Units.
This course is the culmination of the Semester in Environmental Science at the Marine Biological Laboratory. An independent research project, on a topic in aquatic or terrestrial ecosystem ecology, is required. Students will participate in a seminar for scientific communication as well as submit a final paper on their project.
Instructor(s): Marine Biological Laboratory Staff Terms Offered: Autumn. L.

Prerequisite(s): Consent only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710 and BIOS 27711 along with one of BIOS 27713, BIOS 27714 or BIOS 27715.
Note(s): E.
Equivalent Course(s): BIOS 27712