

# 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, 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 23900 Environmental Chemistry. (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 23900 Environmental Chemistry.

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, Public Policy Studies, and Environmental Studies, or through the Harris School of Public Policy (<http://harris.uchicago.edu>).

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 12100-12200	Honors General Chemistry I-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 §	
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 or CHEM 12300	Comprehensive General Chemistry III * Honors General Chemistry III	100
One of the following:		100
PHYS 12100	General Physics I * ‡	
PHYS 13100	Mechanics	
PHYS 14100	Honors Mechanics	
One of the following:		100
MATH 20000	Mathematical Methods for 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.

§ Biological Evolution has several cross-listings; Environmental Science majors *must* register for the course under the GEOS 27300 listing.

‡ 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.

## List of Elective Courses

### List E-1: Physical and Biological Sciences

#### Environmental Science

ENSC 21100	Energy: Science, Technology, and Human Usage	100
ENSC 23805	Stable Isotope Biogeochemistry	100
ENSC 24000	Geobiology	100
ENSC 24500	Environmental Microbiology	100
ENSC 25200	Global Warming: Understanding the Forecast	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 <https://college.uchicago.edu/academics/semester-environmental-science-ses>. 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 23900 Environmental Chemistry.

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
ENSC 28100	Quantitative Environmental Analyses – 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.

ENSC 29002	Field Course in Modern and Ancient Environments	100
ENSC 29005	Field Course in Environmental Science	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 23205	Introductory Glaciology	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 26100	Phylogenetics and the Fossil Record	100
GEOS 26300	Invertebrate Paleobiology and Evolution	100

#### Chemistry

CHEM 20100-20200	Inorganic Chemistry I-II	200
CHEM 22000-22100-22200	Organic Chemistry I-II-III	300
CHEM 23000-23100-23200	Honors Organic Chemistry I-II-III	300
CHEM 23300	Organic Chemistry of Proteins*	100
CHEM 26100-26200-26300	Quantum Mechanics; Thermodynamics; Chemical Kinetics and Dynamics**	300

#### Biology and Ecology\*\*\*

BIOS 20200	Introduction to Biochemistry	100
BIOS 22244	Introduction to Invertebrate Biology	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 & PHYS 12300	General Physics II and General Physics III ‡	200
PHYS 13200-13300	Electricity and Magnetism; Waves, Optics, and Heat	200
PHYS 14200-14300	Honors Electricity and Magnetism; Honors Waves, Optics, and Heat	200
PHYS 18500	Intermediate Mechanics	100
PHYS 19700	Statistical and Thermal Physics	100
PHYS 22500	Intermediate Electricity and Magnetism I	100
PHYS 22600	Electronics	100
PHYS 22700	Intermediate Electricity and Magnetism II	100

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

\*\* Prerequisites include MATH 20100 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 19800	Introduction to 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 19900	Introduction to Macroeconomics **	100
ECON 26500	Environmental Economics	100
ENST 24102	Environmental Politics	100
PBPL 21800	Economics and Environmental 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
PBPL 26531	Environment, Agriculture, and Food: Advanced Economic and Policy Analysis	100
PBPL 27750	Practicum in Environment, Agriculture, and Food Policy I	100
PBPL 27751	Practicum in Environment, Agriculture, and Food Policy II	100
PPHA 36921	Energy Economics and Policy	100
PPHA 36930	Environmental Economics	100
PPHA 38900	Environmental Science and 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****Mathematics**

MATH 15300 or MATH 16300	Calculus III Honors Calculus III	100
MATH 15910 or STAT 24300	Introduction to Proofs in Analysis Numerical Linear Algebra	100
MATH 20000-20100	Mathematical Methods for Physical Sciences I-II *	200

MATH 21100	Basic Numerical Analysis	100
MATH 20250	Abstract Linear Algebra	100
BIOS 20152	Introduction to Quantitative Modeling in Biology (Advanced)	100
BIOS 26210-26211	Mathematical Methods for Biological Sciences I-II	200

#### 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 & PPHA 31300	Mathematical Statistics for Public Policy I and Mathematical Statistics for Public Policy II †	
STAT 22000	Statistical Methods and Applications §§	
STAT 23400	Statistical Models and Methods ††	
STAT 24400-24500	Statistical Theory and Methods I-II §	200
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

GEOS 25400	Introduction to Numerical Techniques for the Geophysical Sciences	100
CMSC 12100-12200-12300	Computer Science with Applications I-II-III	300
CMSC 23710	Scientific Visualization	100
CMSC 28510	Introduction to Scientific Computing	100

\* Recommended prerequisite is MATH 19620 or MATH 15300 or MATH 16300

\*\* Would generally substitute for MATH 20000-20100

\*\*\* Recommended in addition to MATH 20000-20100 for advanced students—covers partial differential equations

† Must be taken as a sequence

†† 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.

#### 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 23805	Stable Isotope Biogeochemistry	100
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 26210-26211	Mathematical Methods for Biological Sciences I-II	200
CHEM 22000-22100	Organic Chemistry I-II	200
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 26210-26211	Mathematical Methods for Biological Sciences I-II	200
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 23805	Stable Isotope Biogeochemistry	100
ENSC 25200	Global Warming: Understanding the Forecast	100
ENSC 29002	Field Course in Modern and Ancient Environments	100
BIOS 23406	Biogeography	100
PBPL 21800	Economics and Environmental Policy	100
PPHA 31201 & PPHA 31301	Statistical Theory and Applications for Public Policy I and Statistical Theory and Applications for Public Policy II	200
PPHA 32300 & PPHA 32400	Principles of Microeconomics and Public Policy I and Principles of Microeconomics and Public Policy II	200
STAT 22400	Applied Regression Analysis	100





#### Font Notice

This document should contain certain fonts with restrictive licenses. For this draft, substitutions were made using less legally restrictive fonts. Specifically:

Times was used instead of Trajan.

Times was used instead of Palatino.

The editor may contact Leepfrog for a draft with the correct fonts in place.