

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.

Lists 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 |
| GEOS 24260 | Radiation | 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 |
| ENST 28220 | Global Energy & Climate Challenge: Economics, Science & Policy | 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.