



Twin Cities Campus

Earth Sciences Ph.D.

Department of Earth Sciences

College of Science and Engineering

Link to a [list of faculty](#) for this program.

Contact Information:

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Website: <http://www.esci.umn.edu/programs/graduate>

- Program Type: Doctorate
- Requirements for this program are current for Spring 2021
- Length of program in credits: 48
- This program does not require summer semesters for timely completion.
- Degree: Doctor of Philosophy

Along with the program-specific requirements listed below, please read the [General Information](#) section of the catalog website for requirements that apply to all major fields.

The modern earth sciences are a remarkable synthesis of the physical and biological sciences. They are at the forefront of inquiry into and solutions of most of the major issues involving the global environment: climate, oceans, freshwater in all its forms, natural resources, and natural disasters. Like no other field, they integrate all the systems, from surface to great depth, from physics to chemistry to biology, and over all of geologic time and all geographic scales. The program includes the fields of structural geology, tectonics, petrology, hydrogeology, geomorphology, sedimentology, surface processes, geochemistry, geobiochemistry, geobiology, paleontology and paleobiology, chemical oceanography, mineralogy, mineral and rock magnetism, rock and mineral physics, geodynamics, seismology, geostatistics, planetary geology, and geophysics and applied geophysics.

Students complete one of the following tracks: Geology, Geophysics, Biogeology, Hydrogeology, or Earth Sciences.

Program Delivery

This program is available:

- via classroom (the majority of instruction is face-to-face)

Prerequisites for Admission

The preferred undergraduate GPA for admittance to the program is 3.00.

Bachelor's degree in geology, geophysics, earth and material sciences, chemistry, physics, biology, or environmental science.

Other requirements to be completed before admission:

At least one year of study each in calculus, chemistry, and physics is required. In general, an outstanding academic record is expected.

Special Application Requirements:

Materials for a complete application file include the student's statement of purpose, an optional diversity statement, three letters of recommendation, transcripts, and the Application for Admission. Applications are considered at any time; however, to be considered for financial aid, all materials must be submitted by December 15. Studies may begin in any semester or summer session, although fall semester is preferable.

International applicants must submit score(s) from one of the following tests:

- TOEFL
 - Internet Based - Total Score: 79
 - Internet Based - Writing Score: 21
 - Internet Based - Reading Score: 19
- IELTS
 - Total Score: 6.5

Key to [test abbreviations](#)(TOEFL, IELTS).

For an online application or for more information about graduate education admissions, see the [General Information](#) section of the catalog website.



Program Requirements

12 credits are required in the major.

12 credits are required outside the major.

24 thesis credits are required.

This program may be completed with a minor.

Use of 4xxx courses toward program requirements is permitted under certain conditions with adviser approval.

A minimum GPA of 3.0 is required for students to remain in good standing.

Coursework offered on both the A-F and S/N grading basis must be taken A-F. A maximum of 4.0 units of ESCI 8994 is allowed to count toward the degree.

Required Courses (3 credits)

Take 1 credit of ESCI 8980. Both courses should be taken in the first year of study.

[ESCI 8001](#) - Introductory Graduate Seminar (2.0 cr)

[ESCI 8980](#) - Seminar: Current Topics in Earth & Environmental Sciences (1.0 - 4.0 cr)

Outside Coursework (12 credits)

Select 12 credits from the following in consultation with the advisor. Other courses may be applied to this requirement with advisor and director of graduate studies approval.

[ANTH 5403](#) - Quantitative Methods in Biological Anthropology (4.0 cr)

[CEGE 4501](#) - Hydrologic Design (4.0 cr)

[CEGE 4512](#) - Open Channel Hydraulics (3.0 cr)

[CEGE 5541](#) - Environmental Water Chemistry (3.0 cr)

[CEGE 5551](#) - Environmental Microbiology (3.0 cr)

[CEGE 5552](#) - Environmental Microbiology Laboratory (1.0 cr)

[CHEM 4501](#) - Introduction to Thermodynamics, Kinetics, and Statistical Mechanics (3.0 cr)

[CSCI 5304](#) - Computational Aspects of Matrix Theory (3.0 cr)

[CSCI 5521](#) - Machine Learning Fundamentals (3.0 cr)

[CSCI 5609](#) - Visualization (3.0 cr)

[EE 5531](#) - Probability and Stochastic Processes (3.0 cr)

[EE 5571](#) - Statistical Learning and Inference (3.0 cr)

[EEB 5053](#) - Ecology: Theory and Concepts (4.0 cr)

[EEB 5407](#) - Ecology (3.0 cr)

[EEB 5601](#) - Limnology (3.0 cr)

[ESPM 5402](#) - Biometeorology (3.0 cr)

[FNRM 5114](#) - Hydrology and Watershed Management (3.0 cr)

[FNRM 5131](#) - Geographical Information Systems (GIS) for Natural Resources (4.0 cr)

[FNRM 5203](#) - Forest Fire and Disturbance Ecology (3.0 cr)

[FNRM 5262](#) - Remote Sensing and Geospatial Analysis of Natural Resources and Environment (3.0 cr)

[LAAS 5311](#) - Soil Chemistry and Mineralogy (3.0 cr)

[LAAS 5425](#) - Atmospheric Processes I: Thermodynamics and Dynamics of the Atmosphere (3.0 cr)

[LAAS 5426](#) - Atmospheric Processes II: Radiation, Composition, and Climate (3.0 cr)

[LAAS 5515](#) - Soil Formation: Earth Surface Processes and Biogeochemistry (3.0 cr)

[LAAS 5621](#) - Environmental Genomics and Microbiomes (3.0 cr)

[MATH 5485](#) - Introduction to Numerical Methods I (4.0 cr)

[MATH 5486](#) - Introduction To Numerical Methods II (4.0 cr)

[MATS 5517](#) - Microscopy of Materials (3.0 cr)

[MATS 8001](#) - Structure and Symmetry of Materials (3.0 cr)

[MATS 8002](#) - Thermodynamics and Kinetics (3.0 cr)

[MATS 8003](#) - Electronic Properties (3.0 cr)

[STAT 8101](#) - Theory of Statistics 1 (3.0 cr)

[STAT 8102](#) - Theory of Statistics 2 (3.0 cr)

Elective Courses

Select courses from the following as needed, in consultation with the advisor, to complete the minimum number of course credits required.

[ESCI 4203](#) - Environmental Geophysics (3.0 cr)

[ESCI 4204](#) - Geomagnetism and Paleomagnetism (3.0 cr)

[ESCI 4211](#) (*Inactive*)(3.0 cr)

[ESCI 4212](#) - Geodynamics (3.0 cr)



ESCI 4401 - Aqueous Environmental Geochemistry (3.0 cr)
ESCI 4402 - Biogeochemical Cycles in the Ocean (3.0 cr)
ESCI 4501 - Structural Geology (3.0 cr)
ESCI 4502 - Tectonic Styles (3.0 cr)
ESCI 4602 - Sedimentology and Stratigraphy (3.0 cr)
ESCI 4701 - Geomorphology (4.0 cr)
ESCI 4702 - General Hydrogeology (4.0 cr)
ESCI 4703 - Glacial Geology (4.0 cr)
ESCI 4801 - Geomicrobiology (3.0 cr)
ESCI 4911 - Advanced Field Geology (4.0 cr)
ESCI 5093 *(Inactive)*(1.0 - 4.0 cr)
ESCI 5102 - Climate Change and Human History (3.0 cr)
ESCI 5201 - Time-Series Analysis of Geological Phenomena (3.0 cr)
ESCI 5203 - Mineral and Rock Physics (3.0 cr)
ESCI 5204 - Geostatistics and Inverse Theory (3.0 cr)
ESCI 5302 - Isotope Geology (3.0 cr)
ESCI 5351 *(Inactive)*(3.0 cr)
ESCI 5353 - Electron Microprobe Theory and Practice (3.0 cr)
ESCI 5402 - Science and Politics of Global Warming (3.0 cr)
ESCI 5403 - Computer Applications in Earth & Environmental Sciences (3.0 cr)
ESCI 5503 - Advanced Petrology (3.0 cr)
ESCI 5705 - Limnogeology and Paleoenvironment (3.0 cr)
ESCI 5805 - Standards and Practices for Professional Geoscientists (3.0 cr)
ESCI 5971 - Field Hydrogeology (2.0 cr)
ESCI 5980 - Seminar: Current Topics in Earth Sciences (1.0 - 4.0 cr)
ESCI 8203 - Environmental Geophysics (3.0 cr)
ESCI 8204 - Geomagnetism and Paleomagnetism (3.0 cr)
ESCI 8243 - Principles of Rock Magnetism (1.0 - 3.0 cr)
ESCI 8353 - Phase Equilibrium in Mineral Systems (3.0 cr)
ESCI 8354 - Igneous Petrology (3.0 cr)
ESCI 8355 - Metamorphic Petrology (3.0 cr)
ESCI 8401 - Aqueous Environmental Geochemistry (3.0 cr)
ESCI 8402 - Biogeochemical Cycles in the Ocean (3.0 cr)
ESCI 8501 - Structural Geology (4.0 cr)
ESCI 8502 - Tectonic Styles (3.0 cr)
ESCI 8511 - Mechanics of Sediment Transport (3.0 cr)
ESCI 8601 - Introduction to Stream Restoration (3.0 cr)
ESCI 8602 - Stream Restoration Practice (2.0 cr)
ESCI 8701 - Geomorphology (4.0 cr)
ESCI 8712 - Transport Phenomena and Analytical Geohydrology (3.0 - 4.0 cr)
ESCI 8718 - Numerical Methods in Hydrogeology (4.0 cr)
ESCI 8801 *(Inactive)*(3.0 cr)
ESCI 8970 - Seminar: Current Topics in Earth Sciences (1.0 - 4.0 cr)
ESCI 8994 - Research in Earth Sciences (1.0 - 4.0 cr)

Thesis Credits (24 credits)

Take 24 doctoral thesis credits after passing the preliminary oral exam.

ESCI 8888 - Thesis Credit: Doctoral (1.0 - 24.0 cr)

Program Sub-plans

Students are required to complete one of the following sub-plans.

Students may not complete the program with more than one sub-plan.

Biogeology

Biogeology represents a rapidly growing area at the intersection between Earth and the life sciences. It includes research in microbial evolution and biochemistry, microbe/mineral chemical interactions, the role of organisms in basic geological processes, the principles through which organisms or organic compounds can be used to reconstruct surface conditions, biogeochemical cycling, pollution control and remediation, the origin of life on Earth, and astrobiology.

Required Courses (6 credits)

Take the following courses:

ESCI 8402 - Biogeochemical Cycles in the Ocean (3.0 cr)

ESCI 8801 *(Inactive)*(3.0 cr)



Earth Sciences

This generalist track exists for students whose curriculum and/or dissertation do not fit any of the other tracks. A curriculum specific to the student will be set through the compact process.

Required Courses (6 credits)

Select 6 credits from the following in consultation with the advisor:

ESCI 4xxx
ESCI 5xxx
ESCI 8xxx

Geology

Geology uses field observation, laboratory work, analog and computer modeling, chemical and biological probes and assays to understand Earth's coupled rock, water and biological systems, the underlying processes, and their history of interaction as evidenced in the rock record.

Required Courses (6 credits)

Select 6 credits from the following in consultation with the advisor:

ESCI 5302 - Isotope Geology (3.0 cr)
ESCI 5351 *{Inactive}*(3.0 cr)
ESCI 5353 - Electron Microprobe Theory and Practice (3.0 cr)
ESCI 5503 - Advanced Petrology (3.0 cr)
ESCI 5705 - Limnogeology and Paleoenvironment (3.0 cr)

Geophysics

Geophysics uses remote sensing probes (seismic waves, potential fields, etc.), laboratory simulation of deep Earth conditions and computer modeling of fluid and continuum mechanical dynamics to investigate the structure, composition, history and dynamics of solid Earth and other planets.

Required Courses (6 credits)

Take the following course:

ESCI 4211 *{Inactive}*(3.0 cr)

Select 3 credits from the following in consultation with the advisor:

ESCI 4212 - Geodynamics (3.0 cr)
ESCI 5201 - Time-Series Analysis of Geological Phenomena (3.0 cr)
ESCI 5203 - Mineral and Rock Physics (3.0 cr)
ESCI 5204 - Geostatistics and Inverse Theory (3.0 cr)
ESCI 8203 - Environmental Geophysics (3.0 cr)
ESCI 8204 - Geomagnetism and Paleomagnetism (3.0 cr)

Hydrogeology

Hydrogeology uses direct observation and remote sensing, computer modeling and laboratory simulation to constrain the interaction of water and rock in Earth's shallow subsurface. Freshwater is Earth's most precious and increasingly overexploited resource. Hydrogeology is a key discipline in the effective shepherding of this important reserve. This track establishes a baseline curriculum for hydrogeology at the graduate level. The compact process will identify additional coursework appropriate to the student's prior training and research directions.

Required Courses (6 credits)

Take the following courses:

ESCI 4702 - General Hydrogeology (4.0 cr)
ESCI 5971 - Field Hydrogeology (2.0 cr)