

# DEPARTMENT OF EARTH SCIENCES

College of Arts and Sciences  
Department of Earth Sciences  
221 McGilvrey Hall  
Kent Campus  
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www.kent.edu/earth-sciences

## Undergraduate Programs

- Earth Science - B.A.
- Geology - B.A.
- Geology - B.S.

## Minors

- Geology
- Earth Science
- Environmental Geology
- Paleontology

## Graduate Programs

- Applied Geology - Ph.D.
- Geology - M.S.

## Department of Earth Sciences Faculty

- Clement, Susanne M. (1995), Professor, Ph.D., Kent State University, 2005
- Gallagher, Timothy M. (2020), Assistant Professor, Ph.D., University of Michigan, 2016
- Hacker, David B. (1989), Professor, Ph.D., Kent State University, 1998
- Holm, Daniel K. (1992), Professor, Ph.D., Harvard University, 1992
- Ortiz, Joseph D. (2001), Professor, Ph.D., Oregon State University, 1995
- Schweitzer, Carrie E. (1994), Professor, Ph.D., Kent State University, 2000
- Singer, David M. (2012), Associate Professor, Ph.D., Stanford University, 2008
- Singh, Kuldeep (2017), Assistant Professor, Ph.D., University of Texas at Austin, 2013
- Smith, Alison J. (1990), Professor, Ph.D., Brown University, 1991
- Taylor, Eric S. (2012), Associate Professor, Ph.D., The Ohio State University, 2012
- Tessin, Allyson (2020), Assistant Professor, Ph.D, University of Michigan-Ann Arbor, 2016
- Wells, Neil A. (1984), Professor, Ph.D., University of Michigan-Ann Arbor, 1984

## Earth Science (ESCI)

**ESCI 11040 HOW THE EARTH WORKS (KBS) 3 Credit Hours**  
Explores processes that shape Earth's landscapes (e.g., volcanism, flooding, landslides, sea-level rise, mountain building) and that are of vital interest to humans (e.g., earthquakes, groundwater, energy and mineral resources, climate change).

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Basic Sciences, TAG Science, Transfer Module Natural Sciences

**ESCI 11041 HOW THE EARTH WORKS LABORATORY (KBS) (KLAB) 1 Credit Hour**

Students study earth materials (e.g., mineral crystals, common and unusual rock specimens) and Google Earth images. Students conduct experiments demonstrating processes at earth's surface such as groundwater pollution, flooding and earthquakes.

**Pre/corequisite:** ESCI 11040.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Basic Sciences, Kent Core Basic Sciences Lab, TAG Science, Transfer Module Natural Sciences, TAG Natural Science Lab

**ESCI 11042 EARTH AND LIFE THROUGH TIME (KBS) 3 Credit Hours**

Explores major events in the history of Earth, including mass extinctions, Snowball Earth hypothesis, birth and death of oceans, growth of continents, explosion of life, dinosaurs and the inter-relatedness of earth and life processes.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Basic Sciences, TAG Science, Transfer Module Natural Sciences

**ESCI 11043 EARTH AND LIFE THROUGH TIME LABORATORY (KBS) (KLAB) 1 Credit Hour**

Students conduct lab experiments involving fossils, rocks and sedimentary features, a river process simulator and the concept of deep time.

**Pre/corequisite:** ESCI 11042.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Basic Sciences, Kent Core Basic Sciences Lab, TAG Science, Transfer Module Natural Sciences, TAG Natural Science Lab

**ESCI 21062 ENVIRONMENTAL EARTH SCIENCE (KBS) 3 Credit Hours**

Application of Earth science to environmental problems, including natural resource extraction, water supply, pollution, waste disposal, landslides, floods and land use planning.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Basic Sciences, Transfer Module Natural Sciences

**ESCI 21080 ALL ABOUT THE OCEANS (KBS) 3 Credit Hours**

Explores the many fascinating (and some still little known) features and processes of the Earth's oceans, including mid-ocean ridges, hydrothermal vents, tsunamis, tides, rogue waves, marine life and the role of the ocean in climate change.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Basic Sciences, Transfer Module Natural Sciences

**ESCI 22000 DEGREE AND CAREER PATHS IN EARTH SCIENCES (ELR) 1 Credit Hour**

Provides students with an overview of career paths and opportunities in the Geology and Earth Science majors. Components of the course include a journal club; informational presentations by geoscientists in industry, government and academia; and skills training needed for the majors.

Required overnight field trip.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Standard Letter

**Attributes:** Experiential Learning Requirement

**ESCI 23063 EARTH MATERIALS I 4 Credit Hours**

Occurrence, associations, characteristics, crystallography and crystal chemistry of common minerals. Laboratory identification emphasizing physical properties. Required field trip.

**Prerequisite:** ESCI 11041 or ESCI 11043.

**Pre/corequisite:** CHEM 10060.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 3 lecture, 2 lab

**Grade Mode:** Standard Letter

**Attributes:** TAG Science

**ESCI 31070 EARTH MATERIALS II (WIC) 4 Credit Hours**

Occurrence and origin of igneous, sedimentary and metamorphic rocks. Laboratory identification, description and classification of hand specimens. Required field trip.

**Prerequisite:** ESCI 23063.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 3 lecture, 2 lab

**Grade Mode:** Standard Letter

**Attributes:** Writing Intensive Course

**ESCI 31080 STRUCTURAL GEOLOGY 4 Credit Hours**

Mechanical principles of rock deformation. Structures in sedimentary igneous and metamorphic rocks. Required field trip.

**Prerequisite:** ESCI 11041 or ESCI 11043.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 3 lecture, 2 lab

**Grade Mode:** Standard Letter

**ESCI 32066 GEOMORPHOLOGY 4 Credit Hours**

Earth's surface features as functions of geological structures, processes and time. Landform analysis using topographic maps and some stereographic aerial photos. Trigonometry recommended.

**Prerequisite:** ESCI 11041 or ESCI 11043.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 3 lecture, 2 lab

**Grade Mode:** Standard Letter

**ESCI 33025 WATER AND THE ENVIRONMENT 3 Credit Hours**

How water moves on the surface and in the subsurface, with an emphasis on societal issues such as pollution, the conservation and management of water resources, and the impacts of environmental change.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 34061 PRINCIPLES OF PALEONTOLOGY 4 Credit Hours**

Concepts applied to study of commonly preserved invertebrate organisms; identification of common North American fossils. Required field trip.

**Prerequisite:** BSCI 10002 or BSCI 10110 or ESCI 11043.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 3 lecture, 2 lab

**Grade Mode:** Standard Letter

**ESCI 40095 SELECTED TOPICS IN EARTH SCIENCES 1-3 Credit Hours**

(Slashed with ESCI 50095) (Repeatable for credit) Selected topics presented by visiting professors or one-time offerings presented by regular faculty.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 1-3 lecture

**Grade Mode:** Standard Letter

**ESCI 40096 INDIVIDUAL INVESTIGATION IN EARTH SCIENCES 1-3 Credit Hours**

(Repeatable for credit) Directed field, laboratory and/or library research. Written report required. Maximum 3 credit hours applied toward bachelor's degree.

**Prerequisite:** Special approval.

**Schedule Type:** Individual Investigation

**Contact Hours:** 1-3 other

**Grade Mode:** Standard Letter-IP

**ESCI 40380 BIOGEOCHEMISTRY 3 Credit Hours**

(Cross-listed with BSCI 40380)(Slashed with BSCI 50380, BSCI 70380 and ESCI 50380) Course explores the chemical, physical, geological and biological processes and reactions that shape the world around us, and provides tools for understanding human alterations to global systems. In this course, we explore elemental cycles in diverse terrestrial and aquatic ecosystems, as well as assess how humans have drastically altered these elemental cycles on a global scale and the implications of these changes for biological systems.

**Prerequisite:** Minimum C grade in BSCI 10110 and BSCI 10120; or minimum C grade in ESCI 11041 or ESCI 11043; and minimum C grade in CHEM 10060 and CHEM 10062.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 41025 GENERAL GEOPHYSICS 3 Credit Hours**

(Slashed with ESCI 51025) Course explores how different geophysical signals are generated by, or propagate through, the Earth, and how geophysical data is collected, processed and interpreted in order to answer questions about the Earth's interior. Techniques covered include seismic reflection, seismic refraction, gravity and magnetism. Strong emphasis on worked examples and case studies.

**Prerequisite:** ESCI 31080 and MATH 12002; and PHY 13001 or PHY 23101.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 41073 GEOLOGY OF OHIO 3 Credit Hours**

(Slashed with ESCI 51073) Minerals, rocks, fossils, structural geology, physiography, environmental geology and geologic resources. Required field trips. Does not count toward the Geology major.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 41077 GEOLOGY OF THE NATIONAL PARKS 3 Credit Hours**

(Slashed with ESCI 51077) Introduction to the geology of selected major national parks, emphasizing basic geological principles and the processes that have produced the spectacular scenery, rocks and fossils in each park. Does not count toward the Geology major.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 41079 ALL ABOUT DINOSAURS 3 Credit Hours**

Dinosaurs (and some relatives) and their world, emphasizing how to interpret evidence concerning their history, biology and evolutionary relationships. Does not count toward the Geology major.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 41080 TECTONICS AND OROGENY 3 Credit Hours**

(Slashed with ESCI 51080) This course examines the forces that drive plate motions and mountain building, techniques for reconstructing those motions over a range of timescales, and how the lithosphere deforms and drives rock creation and destruction at plate boundaries, particularly in the Western United States and the Appalachians. Required field trip to the Appalachians.

**Prerequisite:** ESCI 31080.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 41085 MASS EXTINCTIONS: CAUSES AND CONSEQUENCES 3 Credit Hours**

Investigation of the causes and consequences of extinction in marine and terrestrial ecosystems using paleontological, geochemical, sedimentological and stratigraphical information; emphasizing an Earth System Science approach to the Big Five mass extinctions as well as the possible sixth extinction occurring now.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 41092 SUMMER FIELD CAMP (ELR) 6 Credit Hours**

(Repeatable for credit) (Slashed with ESCI 51092) Five weeks devoted to geologic mapping and solving structural and stratigraphic problems in the Black Hills of South Dakota.

**Prerequisite:** ESCI 31070 and ESCI 31080.

**Schedule Type:** Practical Experience

**Contact Hours:** 18 other

**Grade Mode:** Standard Letter

**Attributes:** Experiential Learning Requirement

**ESCI 42030 REMOTE SENSING 3 Credit Hours**

(Cross-listed with GEOG 49230, GEOG 59230, GEOG 79230) (Slashed with ESCI 52030, ESCI 72030) Computer analysis of multispectral satellite datasets. Applications in terrestrial earth science are emphasized.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 42035 DATA ANALYSIS IN THE EARTH SCIENCES 3 Credit Hours**

(Slashed with ESCI 52035) Application of scientific methods to geologic data in the field and laboratory, including methods for collection, analysis, modelling and presentation of data, within the framework of formulation and testing of scientific hypotheses. Provides the background necessary for upper-division earth science courses.

**Prerequisite:** None.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ESCI 42036 PHYSICAL HYDROGEOLOGY LABORATORY 1 Credit Hour**

(Slashed with ESCI 52036) Laboratory course offering fundamental training for professional hydrogeologists in field, laboratory and analytical techniques. Required weekend field trip.

**Prerequisite:** Junior standing.

**Corequisite:** ESCI 42066.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ESCI 42060 EARTH OBSERVING 3 Credit Hours**

(Slashed with ESCI 52060 and ESCI 72060) Students are introduced to visible, thermal and LiDAR remote sensing methods. Visible and near infrared multispectral and hyperspectral data sets are used for a wide variety of research including land use change, water quality research and agricultural remote and proximal sensing. Thermal remote sensing can be used to characterize surface temperature changes, earth materials and thermal stresses on plants. LiDAR provides the ability to measure variations in surface topography and can “see” through clouds and jungle canopy and even penetrate aquatic environments to measure algal biomass and suspended sediment. Remote sensing is the use of instrumentation to obtain spectral and spatial information about an object or surface without direct contact. All matter interacts with electromagnetic energy through thermal emittance, absorption, transmittance, reflectance and/or scattering. Different materials have distinct electromagnetic signatures depending on their composition, structure and the nature of the energy with which the material is interacting. This course focuses primarily on multispectral and hyperspectral visible remote sensing, but the field of remote sensing makes use of information throughout the electromagnetic spectrum to sense the environment around us. Note that most of the data sets that are examined and analyzed in this course are multispectral Landsat images. Students are encouraged to explore various topics or geographic regions for their class project. It is recommended that students take an introductory GIS class prior to enrollment.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 42065 WATERSHED HYDROLOGY 3 Credit Hours**

(Slashed with ESCI 52065) Watershed hydrology is the study of water movement, storage and transformation across landscapes. Course covers such basic questions like: “Where does water go when it rains?” and “What pathways does water take to the stream channel?”. Students examine the processes of precipitation, evapotranspiration, infiltration, streamflow generation and streamflow. They learn about how they are measured, how to analyze the data and how these hydrologic processes are regulated by landscape characteristics, human activities and climate dynamics.

**Prerequisite:** MATH 11022 and junior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 42066 PHYSICAL HYDROGEOLOGY 3 Credit Hours**

(Slashed with ESCI 52066) Principles of water flow in hydrologic cycle, soil and aquifer hydraulic properties, groundwater flow, surface water-groundwater interactions and geochemical evolution of groundwater. Application of principles for evaluation of water resources; emphasizing utilization, conservation and management of groundwater resources in a changing environment.

**Prerequisite:** MATH 12002 or any higher level MATH course.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 42068 CONTAMINANT HYDROLOGY AND HYDROGEOLOGY 3 Credit Hours**

(Slashed with ESCI 52068) An introduction to the basic principles of chemical and physical behavior of contaminants introduced by humans into the environment. Students are expected to understand concepts and work practical quantitative problems.

**Prerequisite:** MATH 12002 or any higher level MATH course.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 43040 PRINCIPLES OF GEOCHEMISTRY 3 Credit Hours**

(Slashed with ESCI 53040) Introduction to chemical thermodynamics and its applications in solving geochemical problems. Distributions of elements and isotopes in the Earth and laws governing these distributions.

**Prerequisite:** CHEM 10060 and CHEM 10061 and ESCI 31070 and MATH 12002.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 43042 ENVIRONMENTAL GEOCHEMISTRY 3 Credit Hours**

(Slashed with ESCI 53042 and ESCI 73042) Explores chemical processes that influence the natural environment, including anthropogenic impacts.

Topics include atmospheric chemistry and air pollution, energy and climate change, toxic organic compounds, water chemistry and water pollution, metals, soils, sediments and waste disposal. Environmental problem-solving using steady state and non-steady state box models, thermodynamics and energy transfer and chemical reactions and equilibria. Required half-day field trip.

**Prerequisite:** CHEM 10060 and CHEM 10061.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 43043 ENVIRONMENTAL MINERALOGY 3 Credit Hours**

(Slashed with ESCI 53043) Explores reactions between minerals and aqueous solutions, focusing on their role in chemical weathering, contaminant mobility, microbe-mineral interactions and an understanding of mineral-water interface processes and mechanisms at the molecular level. Through a series of case studies, the course explores the societal impacts of environmental contaminants and the potential role of remediation.

**Prerequisite:** ESCI 23063.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 43044 ENVIRONMENTAL ISOTOPES 3 Credit Hours**

(Slashed with ESCI 53044 and ESCI 73044) Stable isotope geochemistry can be used as a tool to explore a wide array of processes across the Earth and environmental sciences. Course begins by focusing on traditional applications of oxygen, hydrogen, carbon and sulfur stable isotopes to understand the water and carbon cycles. Subsequently, students are introduced to emerging stable isotope techniques and non-traditional stable isotope systems. Lectures are supplemented with exercises that incorporate real data and discussions based on the recent scientific literature.

**Prerequisite:** CHEM 10060 and CHEM 10061.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 43189 WICKED PROBLEMS: TACKLING GLOBAL ISSUES IN THE 21ST CENTURY (DIVG) (ELR) 3 Credit Hours**

(Cross-listed with GEOG 43189 and POL 43189) This course provides an overview and analysis of the United Nations Sustainable Development Goals (SDG), as well as strategies that can be used for tackling them. The SDGs address the most serious problems faced by humankind today. These include poverty, hunger, inequality, climate change, economic development and environmental sustainability. A key characteristic of the SDGs is that they are known as "wicked problems." Wicked problems are complex issues that resist conventional approaches to problem solving, and for which existing solutions often create unintended consequences that only make the original problem worse. Emphasis is placed on problems of collective action, evidence-based public policies and interdisciplinary approaches to addressing global issues. Registration in Florence semester abroad required.

**Prerequisite:** None.

**Schedule Type:** International Experience, Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**Attributes:** Diversity Global, Experiential Learning Requirement

**ESCI 43500 ENVIRONMENTAL SOIL SCIENCE 3 Credit Hours**

(Slashed with ESCI 53500) Soil is a critical natural resource that sustains human life. In this course, students explore the geochemical composition of soils and the physical, biological and chemical processes involved in rock weathering, soil formation and the environmental transport of nutrients and toxic elements.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 44025 GEOLOGIC HAZARDS AND DISASTERS 3 Credit Hours**

(Slashed with ESCI 54025) Explores the geological processes that drive a broad range of different natural hazards (including earthquakes, volcanoes, landslides and floods), and how they interact with human behavior to produce geologic risks and disasters. Through discussion of historical and topical events, students focus on the dual challenges of combining uncertain and incomplete information from various geological and historical sources into realistic assessments of future risks; and the communication of accurate, relevant, actionable information about these risks to the public and authorities.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 44040 EARTH'S ENERGY TRANSITION 3 Credit Hours**

(Slashed with ESCI 54040 and ESCI 74040) Society is faced with a growing climate crisis but has most of the tools and technological knowhow needed to address the problems. This class explores mitigation and adaptation approaches necessary for a successful energy transformation by assessing Earth energy sources from a systems perspective.

**Prerequisite:** None.

**Schedule Type:** Seminar

**Contact Hours:** 3 other

**Grade Mode:** Standard Letter

**ESCI 44070 SEDIMENTOLOGY AND STRATIGRAPHY 4 Credit Hours**

(Slashed with ESCI 54070) Course explores the processes that control the production, transport, deposition and alteration of sediments. Students learn how to reconstruct past environments, ranging from mountain streams to the deep ocean, based on the physical and geochemical characteristics of sedimentary rocks. Techniques to document and interpret spatial patterns in sediment deposition are covered and tied into various modern-day challenges, such as climate and sea level change. Lectures are integrated with in-class activities, examples from cutting-edge research, laboratory exercises and a field trip.

**Pre/corequisite:** ESCI 31070.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 3 lecture, 2 lab

**Grade Mode:** Standard Letter

**ESCI 44072 MARINE PROCESSES 3 Credit Hours**

(Slashed with ESCI 54072) This course is an exploration of the mechanisms (geological, physical, chemical and biological) through which the ocean operates, and how it influences climate on seasonal, inter-annual, glacial-interglacial and over deep time. Emphasis is placed on understanding the relative importance of these processes and how they have varied through time, and the potential outcomes of human-induced changes to these processes.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 44074 PALEOCEANOGRAPHY 3 Credit Hours**

(Slashed with ESCI 54074) A broad spectrum of geological approaches, including paleontology, geochemistry and stratigraphy, are employed to interpret the history of the Earth's oceans.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 50095 SELECTED TOPICS IN EARTH SCIENCES 1-3 Credit Hours**

(Slashed with ESCI 40095)(Repeatable for credit) Selected topics presented by visiting professors or one-time offerings presented by regular faculty.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 1-3 lecture

**Grade Mode:** Standard Letter

**ESCI 50380 BIOGEOCHEMISTRY 3 Credit Hours**

(Cross-listed with BSCI 50380)(Slashed with BSCI 40380, BSCI 70380 and ESCI 40380) Course explores the chemical, physical, geological and biological processes and reactions that shape the world around us, and provides tools for understanding human alterations to global systems. In this course, we explore elemental cycles in diverse terrestrial and aquatic ecosystems, as well as assess how humans have drastically altered these elemental cycles on a global scale and the implications of these changes for biological systems.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 51025 GENERAL GEOPHYSICS 3 Credit Hours**

(Slashed with ESCI 41025) This course will explore how different geophysical signals are generated by, or propagate through, the Earth, and how geophysical data is collected, processed and interpreted in order to answer questions about the Earth's interior. Techniques covered include seismic reflection, seismic refraction, gravity, and magnetism. There will be a strong emphasis on worked examples and case studies.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 51073 GEOLOGY OF OHIO 3 Credit Hours**

(Slashed with ESCI 41073) Minerals, rocks, fossils, structural geology, physiography, environmental geology and geologic resources. Required field trips. Does not count toward the Geology major.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 51077 GEOLOGY OF THE NATIONAL PARKS 3 Credit Hours**

(Slashed with ESCI 41077) Introduction to the geology of selected major national parks, emphasizing basic geological principles and the processes that have produced the spectacular scenery, rocks and fossils in each park. Does not count toward the Geology major.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 51080 TECTONICS AND OROGENY 3 Credit Hours**

(Slashed with ESCI 41080) This course examines the forces that drive plate motions and mountain building, techniques for reconstructing those motions over a range of timescales, and how the lithosphere deforms and drives rock creation and destruction at plate boundaries, particularly in the Western United States and the Appalachians. Required field trip to the Appalachians.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 51092 SUMMER FIELD CAMP 6 Credit Hours**

(Repeatable for credit) (Slashed with ESCI 41092) Five weeks devoted to geologic mapping and solving structural and stratigraphic problems in the Black Hills of South Dakota.

**Prerequisite:** Graduate standing.

**Schedule Type:** Practical Experience

**Contact Hours:** 18 other

**Grade Mode:** Standard Letter

**ESCI 52030 REMOTE SENSING 3 Credit Hours**

(Cross-listed with GEOG 59230) (Slashed with ESCI 42030, ESCI 72030, GEOG 49230, GEOG 79230) Computer analysis of multispectral satellite datasets. Applications in terrestrial earth science are emphasized.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 52035 DATA ANALYSIS IN THE EARTH SCIENCES 3 Credit Hours**

(Slashed with ESCI 42035) Application of scientific methods to geologic data in the field and laboratory, including methods for collection, analysis, modelling and presentation of data, within the framework of formulation and testing of scientific hypotheses. Provides the background necessary for upper-division earth science courses.

**Prerequisite:** Graduate standing.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ESCI 52036 PHYSICAL HYDROGEOLOGY LABORATORY 1 Credit Hour**

(Slashed with ESCI 42036) Laboratory course offering fundamental training for professional hydrogeologists. Required weekend field trip.

**Prerequisite:** Graduate standing.

**Corequisite:** ESCI 52066.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ESCI 52060 EARTH OBSERVING 3 Credit Hours**

(Slashed with ESCI 42060 and ESCI 72060) Students are introduced to visible, thermal and LiDAR remote sensing methods. Visible and near infrared multispectral and hyperspectral data sets are used for a wide variety of research including land use change, water quality research and agricultural remote and proximal sensing. Thermal remote sensing can be used to characterize surface temperature changes, earth materials and thermal stresses on plants. LiDAR provides the ability to measure variations in surface topography and can "see" through clouds and jungle canopy and even penetrate aquatic environments to measure algal biomass and suspended sediment. Remote sensing is the use of instrumentation to obtain spectral and spatial information about an object or surface without direct contact. All matter interacts with electromagnetic energy through thermal emittance, absorption, transmittance, reflectance and/or scattering. Different materials have distinct electromagnetic signatures depending on their composition, structure and the nature of the energy with which the material is interacting. This course focuses primarily on multispectral and hyperspectral visible remote sensing, but the field of remote sensing makes use of information throughout the electromagnetic spectrum to sense the environment around us. Note that most of the data sets that are examined and analyzed in this course are multispectral Landsat images. Students are encouraged to explore various topics or geographic regions for their class project. It is recommended that students take an introductory GIS class prior to enrollment.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 52065 WATERSHED HYDROLOGY 3 Credit Hours**

(Slashed with ESCI 42065) Watershed hydrology is the study of water movement, storage and transformation across landscapes. This course will answer basic questions like: "Where does water go when it rains?" and "What pathways does water take to the stream channel?". Students will examine the processes of precipitation, evapotranspiration, infiltration, streamflow generation, and streamflow. They will learn about how they are measured, how to analyze the data, and how these hydrologic processes are regulated by landscape characteristics, human activities and climate dynamics.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 52066 PHYSICAL HYDROGEOLOGY 3 Credit Hours**

(Slashed with ESCI 42066) Principles of water flow in hydrologic cycle, soil and aquifer hydraulic properties, groundwater flow, surface water-groundwater interactions and geochemical evolution of groundwater. Application of principles for evaluation of water resources; emphasizing utilization, conservation and management of groundwater resources in a changing environment.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 52068 CONTAMINANT HYDROLOGY AND HYDROGEOLOGY 3 Credit Hours**

(Slashed with ESCI 42068) An introduction to the basic principles of chemical and physical behavior of contaminants introduced by humans into the environment. Students are expected to understand concepts and work practical quantitative problems.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 53040 PRINCIPLES OF GEOCHEMISTRY 3 Credit Hours**

(Slashed with ESCI 43040) Introduction to chemical thermodynamics and its applications in solving geochemical problems. Distributions of elements and isotopes in the Earth and laws governing these distributions.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 53042 ENVIRONMENTAL GEOCHEMISTRY 3 Credit Hours**

(Slashed with ESCI 43042 and ESCI 73042) Explores chemical processes that influence the natural environment, including anthropogenic impacts. Topics include atmospheric chemistry and air pollution, energy and climate change, toxic organic compounds, water chemistry and water pollution, metals, soils, sediments and waste disposal. Environmental problem-solving using steady state and non-steady state box models, thermodynamics and energy transfer and chemical reactions and equilibria. Required half-day field trip.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 53043 ENVIRONMENTAL MINERALOGY 3 Credit Hours**

(Slashed with ESCI 43043) Explores reactions between minerals and aqueous solutions, focusing on their role in chemical weathering, contaminant mobility, microbe-mineral interactions and an understanding of mineral-water interface processes and mechanisms at the molecular level. Through a series of case studies, the course explores the societal impacts of environmental contaminants and the potential role of remediation.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 53044 ENVIRONMENTAL ISOTOPES 3 Credit Hours**

(Slashed with ESCI 43044 and ESCI 73044) Stable isotope geochemistry can be used as a tool to explore a wide array of processes across the Earth and Environmental Sciences. This course will begin by focusing on traditional applications of oxygen, hydrogen, carbon, and sulfur stable isotopes to understand the water and carbon cycles. Subsequently, students will be introduced to emerging stable isotope techniques and non-traditional stable isotope systems. Lectures will be supplemented with exercises that incorporate real data and discussions based on the recent scientific literature.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 53500 ENVIRONMENTAL SOIL SCIENCE 3 Credit Hours**

(Slashed with ESCI 43500) Soil is a critical natural resource that sustains human life. In this course, students explore the geochemical composition of soils and the physical, biological and chemical processes involved in rock weathering, soil formation and the environmental transport of nutrients and toxic elements.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 54025 GEOLOGIC HAZARDS AND DISASTERS 3 Credit Hours**

(Slashed with ESCI 44025) Explores the geologic processes that drive a broad range of different natural hazards (including earthquakes, volcanoes, landslides and floods), and how they interact with human behavior to produce geological risks and disasters. Through discussion of historical and topical events, students focus on the dual challenges of combining uncertain and incomplete information from various geological and historical sources into realistic assessments of future risks; and the communication of accurate, relevant, actionable information about these risks to the public and authorities.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 54040 EARTH'S ENERGY TRANSITION 3 Credit Hours**

(Slashed with ESCI 44040 and ESCI 74040) Society is faced with a growing climate crisis but has most of the tools and technological knowhow needed to address the problems. This class explores mitigation and adaptation approaches necessary for a successful energy transformation by assessing Earth energy sources from a systems perspective.

**Prerequisite:** Graduate standing.

**Schedule Type:** Seminar

**Contact Hours:** 3 other

**Grade Mode:** Standard Letter

**ESCI 54070 SEDIMENTOLOGY AND STRATIGRAPHY 4 Credit Hours**

(Slashed with ESCI 44070) This course explores the processes that control the production, transport, deposition, and alteration of sediments. Students will learn how to reconstruct past environments ranging from mountain streams to the deep ocean based on the physical and geochemical characteristics of sedimentary rocks. Techniques to document and interpret spatial patterns in sediment deposition will be covered and tied into various modern day challenges, such as climate and sea level change. Lectures are integrated with in-class activities, examples from cutting-edge research, laboratory exercises and a fieldtrip.

**Prerequisite:** Graduate standing.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 3 lecture, 2 lab, 1 other

**Grade Mode:** Standard Letter

**ESCI 54072 MARINE PROCESSES 3 Credit Hours**

(Slashed with ESCI 44072) This course is an exploration of the mechanisms (geological, physical, chemical and biological) through which the ocean operates, and how it influences climate on seasonal, inter-annual, glacial-interglacial and over deep time. Emphasis is placed on understanding the relative importance of these processes and how they have varied through time, and the potential outcomes of human-induced changes to these processes.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 54074 PALEOCEANOGRAPHY 3 Credit Hours**

(Slashed with ESCI 44074) A broad spectrum of geological approaches, including paleontology, geochemistry and stratigraphy, are employed to interpret the history of the Earth's oceans.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 60084 GEOLOGY GRADUATE STUDENT ORIENTATION 1 Credit Hour**

(Slashed with ESCI 70084) Introduction to departmental resources, procedures and expectations, as well as approaches to successfully conduct research at a graduate level. Training and experience in presentation of data and college teaching of applied geology, as well as a discussion forum on professional ethics and responsibilities.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Satisfactory/Unsatisfactory

**ESCI 60085 DATA ANALYSIS AND PRESENTATION 1 Credit Hour**

This course focuses on the skills and issues surrounding data production and analysis in the earth sciences. It provides students the opportunity to familiarize themselves with strategies for managing and presenting data that they generate as part of their graduate studies. The course requires a commitment to regular readings and discussions.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Standard Letter

**ESCI 60086 FIELD METHODS IN THE EARTH SCIENCES 1 Credit Hour**

This course focuses on the skills necessary for sample and data collection in the field. Additionally, it provides strategies for successfully leading safe, inclusive field work both within academia and other career sectors. The course requires a commitment to weekly readings and discussions.

**Prerequisite:** Graduate standing.

**Schedule Type:** Seminar

**Contact Hours:** 1 other

**Grade Mode:** Satisfactory/Unsatisfactory

**ESCI 60087 WRITING IN THE EARTH SCIENCES 1 Credit Hour**

(Slashed with ESCI 70087) Focuses on the strategies for achieving regular and productive academic writing and the craft of writing for the scientific literature. The course is designed for students who have a major writing project that will take most or all of the semester, such as a dissertation, thesis or dissertation proposal. The course requires commitment to weekly writing progress and provides weekly opportunities for peer review and peer support.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Standard Letter

**ESCI 60091 SEMINAR 1-2 Credit Hours**

(Repeatable for credit)(Slashed with ESCI 70091) Topics in geology and earth science; varies per course offering.

**Prerequisite:** Graduate standing.

**Schedule Type:** Seminar

**Contact Hours:** 1-2 other

**Grade Mode:** Standard Letter

**ESCI 60095 SELECTED TOPICS IN EARTH SCIENCES 1-3 Credit Hours**

(Repeatable for credit) Selected topics presented by visiting professors or one-time offerings presented by regular faculty.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 1-3 lecture

**Grade Mode:** Standard Letter

**ESCI 60098 RESEARCH 1-15 Credit Hours**

(Repeatable for credit) Research for master's level students. Credits earned may be applied toward degree if department approves.

**Prerequisite:** Graduate standing.

**Schedule Type:** Research

**Contact Hours:** 1-15 other

**Grade Mode:** Satisfactory/Unsatisfactory-IP



**ESCI 60199 THESIS I 2-6 Credit Hours**

Thesis students must register for a total of 6 hours, 2 to 6 hours in a single semester distributed over several semesters if desired.

**Prerequisite:** Graduate standing.

**Schedule Type:** Masters Thesis

**Contact Hours:** 2-6 other

**Grade Mode:** Satisfactory/Unsatisfactory-IP

**ESCI 60299 THESIS II 2 Credit Hours**

Thesis students must continue registration each semester until all degree requirements are met.

**Prerequisite:** ESCI 60199; and graduate standing.

**Schedule Type:** Masters Thesis

**Contact Hours:** 2 other

**Grade Mode:** Satisfactory/Unsatisfactory-IP

**ESCI 60391 GEOCHEMINAR 1 Credit Hour**

(Repeatable for credit) In this course, students gain understanding of advanced techniques in geochemistry by presenting information from primary literature and discussing data processing and analysis of their research.

**Prerequisite:** Graduate standing.

**Schedule Type:** Seminar

**Contact Hours:** 1 other

**Grade Mode:** Standard Letter

**ESCI 70084 GEOLOGY GRADUATE STUDENT ORIENTATION 1 Credit Hour**

(Slashed with ESCI 60084) Introduction to departmental resources, procedures and expectations, as well as approaches to successfully conduct research at a graduate level. Training and experience in presentation of data and college teaching of applied geology, as well as discussion forum on professional ethics and responsibilities.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Satisfactory/Unsatisfactory

**ESCI 70087 WRITING IN THE EARTH SCIENCES 1 Credit Hour**

(Slashed with ESCI 60087) Focuses on the strategies for achieving regular and productive academic writing and the craft of writing for the scientific literature. The course is designed for students who have a major writing project that will take most or all of the semester, such as a dissertation, thesis or dissertation proposal. The course requires commitment to weekly writing progress and provides weekly opportunities for peer review and peer support.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Standard Letter

**ESCI 70091 SEMINAR 1-2 Credit Hours**

(Repeatable for credit)(Slashed with ESCI 60091) Topics in geology and earth science; varies per course offering.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Seminar

**Contact Hours:** 1-2 other

**Grade Mode:** Standard Letter

**ESCI 72030 REMOTE SENSING 3 Credit Hours**

(Cross-listed with GEOG 79230) (Slashed with ESCI 42030, ESCI 52030, GEOG 49230, GEOG 59230) Computer analysis of multispectral satellite datasets. Applications in terrestrial earth science are emphasized.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 72060 EARTH OBSERVING 3 Credit Hours**

(Slashed with ESCI 42060 and ESCI 52060) Students are introduced to visible, thermal and LiDAR remote sensing methods. Visible and near infrared multispectral and hyperspectral data sets are used for a wide variety of research including land use change, water quality research and agricultural remote and proximal sensing. Thermal remote sensing can be used to characterize surface temperature changes, earth materials and thermal stresses on plants. LiDAR provides the ability to measure variations in surface topography and can "see" through clouds and jungle canopy and even penetrate aquatic environments to measure algal biomass and suspended sediment. Remote sensing is the use of instrumentation to obtain spectral and spatial information about an object or surface without direct contact. All matter interacts with electromagnetic energy through thermal emittance, absorption, transmittance, reflectance and/or scattering. Different materials have distinct electromagnetic signatures depending on their composition, structure and the nature of the energy with which the material is interacting. This course focuses primarily on multispectral and hyperspectral visible remote sensing, but the field of remote sensing makes use of information throughout the electromagnetic spectrum to sense the environment around us. Note that most of the data sets that are examined and analyzed in this course are multispectral Landsat images. Students are encouraged to explore various topics or geographic regions for their class project. It is recommended that students take an introductory GIS class prior to enrollment.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 73042 ENVIRONMENTAL GEOCHEMISTRY 3 Credit Hours**

(Slashed with ESCI 43042 and ESCI 53042) Explores chemical processes that influence the natural environment, including anthropogenic impacts. Topics include atmospheric chemistry and air pollution, energy and climate change, toxic organic compounds, water chemistry and water pollution, metals, soils, sediments and waste disposal. Environmental problem-solving using steady state and non-steady state box models, thermodynamics and energy transfer and chemical reactions and equilibria. Required half-day field trip.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 73044 ENVIRONMENTAL ISOTOPES 3 Credit Hours**

(Slashed with ESCI 43044 and ESCI 53044) Stable isotope geochemistry can be used as a tool to explore a wide array of processes across the Earth and Environmental Sciences. This course will begin by focusing on traditional applications of oxygen, hydrogen, carbon, and sulfur stable isotopes to understand the water and carbon cycles. Subsequently, students will be introduced to emerging stable isotope techniques and non-traditional stable isotope systems. Lectures will be supplemented with exercises that incorporate real data and discussions based on the recent scientific literature.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ESCI 74040 EARTH'S ENERGY TRANSITION 3 Credit Hours**

(Slashed with ESCI 44040 and ESCI 54040) Society is faced with a growing climate crisis but has most of the tools and technological knowhow needed to address the problems. This class explores mitigation and adaptation approaches necessary for a successful energy transformation by assessing Earth energy sources from a systems perspective.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Seminar

**Contact Hours:** 3 other

**Grade Mode:** Standard Letter

**ESCI 80095 ADVANCED TOPICS IN EARTH SCIENCES 1-3 Credit Hours**

(Repeatable for credit) Advanced topics presented by visiting professors or one-time offerings presented by regular faculty.

**Prerequisite:** Doctoral standing; and special approval.

**Schedule Type:** Lecture

**Contact Hours:** 1-3 lecture

**Grade Mode:** Standard Letter

**ESCI 80098 RESEARCH 1-15 Credit Hours**

(Repeatable for credit) Research for doctoral students. Credits earned may be applied toward degree with departmental approval.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Research

**Contact Hours:** 1-15 other

**Grade Mode:** Satisfactory/Unsatisfactory-IP

**ESCI 80199 DISSERTATION I 15 Credit Hours**

(Repeatable for credit) Doctoral dissertation, for which registration in at least two semesters is required first of which will be semester in which dissertation work is begun and continuing until the completion of 30 hours.

**Prerequisite:** Admission to candidacy for doctoral degree; and doctoral standing.

**Schedule Type:** Dissertation

**Contact Hours:** 15 other

**Grade Mode:** Satisfactory/Unsatisfactory-IP

**ESCI 80299 DISSERTATION II 15 Credit Hours**

(Repeatable for credit) Continuing registration is required of doctoral students who have completed the initial 30 hours of dissertation, continuing until all degree requirements are met.

**Prerequisite:** ESCI 80199; and doctoral standing.

**Schedule Type:** Dissertation

**Contact Hours:** 15 other

**Grade Mode:** Satisfactory/Unsatisfactory-IP