The Department of Earth and Space Sciences prepares students for careers in geoscience and geoscience education. The U.S. Bureau of Labor Statistics states that employment of geoscientists is projected to grow by 21% from 2010 to 2020, faster than the average for all occupations. This geoscience degree prepares students for entry-level positions in such occupations and is also a strong foundation for people interested in pursuing advanced degrees. Geoscience is an integrated study of Earth, its geologic history, composition and structure, resources, natural hazards, atmosphere and oceans, and its environment in space. Geoscientists study such phenomena as earthquakes, landslides, floods, volcanoes, coastal erosion, and how these natural hazards impact humans. Geoscientists explore for mineral, energy, and water supplies. Geoscientists also attempt to make predictions about Earth's future based on the past. Since most human activities are related to interaction with the physical components of Earth, geoscience plays a unique and essential role in today's rapidly changing world. The Department of Earth and Space Sciences offers two bachelor of science degree programs and a certification program in general science. The department also offers minors in astronomy, geology, earth science, and science education. All programs emphasize analytical skills and build on course work in mathematics, chemistry, physics, and statistics. Written and oral communication is emphasized in a majority of the course work.

- **The B.S. in Geoscience** program offers two areas of concentration that share a common core of geology courses. Students completing either concentration are prepared for careers as professional geoscientists and possess the educational requirements to seek licensure as certified professional geologists. The Geology Concentration (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/earth-space-sciences/geoscience-bs-concentration-geology) leads to occupations in managing and exploring for water, energy, and mineral resources; environmental protection, remediation, and management; mitigation of natural hazards; design of land development and management plans; geotechnical consulting; and research. Its curriculum emphasizes depth in the traditional disciplines of geology such as mineral and rock formation, paleontology, structural geology, geomorphology, and hydrogeology. The Earth Systems Concentration (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/earth-space-sciences/geoscience-bs-concentration-earth-systems) is intended for students who want a broader understanding of geoscience, astronomy, and human interactions with the environment. In addition to the geology core, students in this concentration take required courses in oceanography, meteorology, and astronomy. This concentration is excellent preparation for students pursuing careers in geoscience, the environmental industry, resource management, environmental law, or environmental policy.

- **The B.S. in Education in Earth and Space Sciences** is a professional degree program designed to prepare certified secondary school teachers with an overall science exposure and specialization in the Earth and space sciences. The program meets all guidelines established by the National Council for Accreditation of Teacher Education (NCATE), the Pennsylvania Department of Education (PDE), and the National Science Teachers' Association (NSTA) for Earth and space science certification.

- **The certification program in General Science** enables recipients to teach science in grades 6-9. The certification program meets all guidelines established by the National Council for Accreditation of Teacher Education (NCATE) and the Pennsylvania Department of Education (PDE).

All students must consult with their advisor regularly to ensure timely completion of the degree. Students in the B.S. in education program will have a second advisor in the College of Education and Social Work to help them meet the secondary education requirements.

### Programs

#### Majors in Earth and Space Sciences

- **B.S. in Geoscience - Geology Concentration** (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/earth-space-sciences/geoscience-bs-concentration-geology)
- **B.S. in Geoscience - Geology Concentration to M.S. in Geoscience Accelerated Program** (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/earth-space-sciences/geoscience-bs-concentration-geology)
- **B.S. in Geoscience - Earth Systems Concentration to M.S. in Geoscience Accelerated Program** (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/earth-space-sciences/geoscience-bs-concentration-earth-systems)
- **B.S.Ed. in Earth and Space Sciences** (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/earth-space-sciences/earth-space-sciences-bsed)

#### Minors in Earth and Space Sciences

- **Astronomy** (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/earth-space-sciences/astronomy-minor)
- **Earth Science** (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/earth-space-sciences/earth-science-minor)
- **Geology** (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/earth-space-sciences/geology-minor)
- **Science Education** (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/earth-space-sciences/science-education-minor)

#### Certificates in Earth and Space Sciences

- **General Science Certification** (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/earth-space-sciences/general-science-certification)

#### Graduate Opportunities

See the graduate catalog for more information on the Earth and Space Sciences programs. (http://catalog.wcupa.edu/graduate/sciences-mathematics/earth-space-sciences)

#### Policies

- **See undergraduate admissions information.** (http://catalog.wcupa.edu/general-information/admissions-enrollment/undergraduate-admissions)
- **See academic policies.** (http://catalog.wcupa.edu/undergraduate/academic-policies-procedures)

All undergraduate students are held to the academic policies and procedures outlined in the undergraduate catalog. Students are encouraged to review departmental handbooks for program tips, suggested course sequences, and explanations of procedures. When
applicable, additional policies for specific department programs may be listed below.

Accelerated Program Policy
Refer to the Accelerated Programs page (http://catalog.wcupa.edu/undergraduate/accelerated-programs) for more information.

Faculty
Professors
Richard M. Busch (rbusch@wcupa.edu) (1990)
A.B., Franklin and Marshall College; M.A., Temple University; Ph.D., University of Pittsburgh
Marc Gagné (mgagne@wcupa.edu) (1999)
Assistant Chairperson, Earth and Space Sciences
B.S., University of Montreal; Ph.D., University of Georgia
Martin Helmke (mhelmke@wcupa.edu) (2005)
B.S., Antioch College; Ph.D., Iowa State University
Timothy Lutz (tlutz@wcupa.edu) (1998)
B.A., Wesleyan University; Ph.D., University of Pennsylvania
Yong Hoon Kim (ykim@wcupa.edu) (2016)
B.S., Seoul National University, Korea; Ph.D., University of South Carolina
Christopher Roemmele (croemmele@wcupa.edu) (2017)
B.A., Franklin and Marshall; M.A., Kean University; Ph.D., Purdue University

Associate Professors
Howell Bosbyshell (hbosbyshell@wcupa.edu) (2011)
Graduate Coordinator, Earth and Space Sciences
B.S., West Chester University; Ph.D., Bryn Mawr College
Cynthia Hall (chall@wcupa.edu) (2008)
B.S., Howard University; Ph.D., Georgia Institute of Technology
Joby Hilliker (jhilliker@wcupa.edu) (2004)
Chairperson, Earth and Space Sciences
B.S., M.S., Ph.D., Pennsylvania State University
Daria Nikitina (dnikitina@wcupa.edu) (2006)
M.S., Moscow State University; Ph.D., University of Delaware
Karen M. Schwarz (kschwarz@wcupa.edu) (2005)
B.S., New Mexico Institute of Mining and Technology; Ph.D., Arizona State University

Assistant Professors
Yong Hoon Kim (ykim@wcupa.edu) (2016)
B.S., M.S., Seoul National University, Korea; Ph.D., University of South Carolina
Christopher Roemmele (croemmele@wcupa.edu) (2017)
B.A., Franklin and Marshall; M.A., Kean University; Ph.D., Purdue University

Courses
ESC
ESC 199. Transfer Credits (Graduate). 1-10 Credits.
Transfer Credits.
Repeatable for Credit.

ESL
ESL 199. Transfer Credits. 1 Credit.
Transfer Credits.
Repeatable for Credit.

ESS
ESS 101. Introduction to Geology. 3 Credits.
LEC (2), LAB (2)
The earth’s composition and history; the processes that occur on and within the earth. Two hours of lecture and two hours of lab.
Gen Ed Attribute: Science Distributive Requirement.
Typically offered in Fall, Spring & Summer.

ESS 102. Humans and the Environment. 3 Credits.
A study of the ability of humans to survive and maintain their life quality, considering the limited resources and recycling capacity of planet Earth. Note: Students completing ESS 102 may not take SCB 102 or ENV 102 for credit.
Gen Ed Attribute: Interdisciplinary Requirement.
Typically offered in Fall, Spring & Summer.
Cross listed courses SCB 102, ENV 102, ESS 102.

ESS 111. Other Worlds, Other Stars. 3 Credits.
An introductory course in astronomy. Topics will focus on the observable changes in the night sky, the properties of light, the laws of motion, the formation and composition of the solar system, extra solar planets, the properties of stars, stellar evolution and stellar death.
Gen Ed Attribute: Science Distributive Requirement.
Typically offered in Fall & Spring.

ESS 112. Galaxies and Cosmology. 3 Credits.
An introductory general education course in astronomy. Topics will focus on the properties of light and matter, the evolution of stars and galaxies, and the expansion, structure, history and fate of the universe. Three hours of lecture.
Gen Ed Attribute: Science Distributive Requirement.
Typically offered in Fall & Spring.

ESS 125. Volcanoes. 3 Credits.
LEC (3), LAB (2)
Where do volcanoes occur and why? What happens when volcanoes erupt, and what controls eruptions? What roles have volcanoes played in human history and human culture? How do geologists study volcanoes in order to forecast eruptions and reduce the risks for human populations? This course explores these questions using print, multimedia and Internet sources. Students will learn how to interpret geological information in order to assess volcanic hazards and forecast volcanic eruptions.
Typically offered in Fall & Spring.

ESS 130. Our Coastal Ocean. 3 Credits.
LEC (2), LAB (2)
This course examines the physical and biological processes at work in the coastal oceans. The content will be discussed in the framework of regional examples.
Gen Ed Attribute: Science Distributive Requirement.
Typically offered in Fall & Spring.

ESS 170. Introduction to Our Atmosphere. 3 Credits.
Why is the sky blue? What will the weather be tomorrow? What makes tomatoes? How did the ozone hole develop? What is the greenhouse effect? This class will use these questions and others to investigate the basic physical processes that determine the weather and climate on earth. A student who has successfully completed ESS 370 may not subsequently receive credit for ESS 170.
Gen Ed Attribute: Science Distributive Requirement.
Distance education offering may be available.
Typically offered in Fall & Spring.

ESS 201. Field Geology. 3 Credits.
An introduction to the basic methods of geologic data collection in the field; analysis, and presentation; literature research; and report writing. One weekend field trip is required.
Pre / Co requisites: ESS 201 requires a prerequisite of ESS 101.
Gen Ed Attribute: Writing Emphasis.
Typically offered in Fall & Spring.
ESS 204. Historical Geology. 3 Credits.
LEC (2), LAB (2)
An examination of how Earth has evolved over geologic time, from its origin as a tiny lifeless planetesimal to its present state as a dynamic planetary system teaming with life. Rocks, fossils, and other evidence of Earth’s past are analyzed and evaluated with knowledge of modern physical and biological processes to infer Earth’s history, understand its present state, and predict its future. Laboratory included. Recommended for students who have completed ESS 101 or another introductory (100-level) science course.
Gen Ed Attribute: Writing Emphasis.
Typically offered in Fall & Spring.

ESS 301. Environmental Geochemistry. 3 Credits.
An introduction to principles and applications of geochemistry to geologic systems, including surface and ground waters, soils, and rocks.
Pre / Co requisites: ESS 301 requires prerequisites of CHE 103 and ESS 101.
Typically offered in Spring.

ESS 302. Mineralogy. 3 Credits.
LEC (2), LAB (2)
In-depth survey of the formation, identification, classification, and uses of minerals. Principles of symmetry, crystallography, crystal chemistry, and optical mineralogy. Laboratory and field examination and analysis of minerals.
Pre / Co requisites: ESS 302 requires prerequisites of ESS 101 and ESS 204 and CHE 103.
Typically offered in Fall.

ESS 307. Geology of the Solar System. 3 Credits.
The geology, origin, evolution, and properties of planets, comets, asteroids, moons, and meteorites.
Typically offered in Spring.

ESS 311. Introduction to Astronomy. 3 Credits.
LEC (0), LAB (0)
LAB, LEC An introduction to astronomy and astrophysics. Topics include celestial mechanics, the properties of light, matter and energy, the formation of stars and planets, stellar evolution, galaxies, and cosmology. Two hours of lecture and two hours of lab.
Pre / Co requisites: ESS 311 requires a prerequisite of MAT 115 or MAT 143 or MAT 131 or MAT 161.
Typically offered in Fall.

ESS 321. Geometrics. 3 Credits.
Application of computational and statistical methods to geologic problems. Geologic sampling, data comparisons in environmental, petrologic, paleontologic, and geochemical problems.
Typically offered in Fall.

ESS 323. Gen’l Geol Field Studies of SE Pennsylvania. 3 Credits.
Occurrence, relationships, and geologic history of the rocks, minerals, and soils of this area, studied at representative locations.
Pre / Co requisites: ESS 323 requires prerequisite of ESS 302.
Typically offered in Summer.

ESS 327. Electron Microscopy I. 3 Credits.
A one-semester lecture/laboratory course in theory operation and applications of electron beam technology in scientific research. Students receive hands-on training and complete a brief research project of their choosing.
Pre / Co requisites: ESS 327 requires prerequisite: 6 credits of science.
Typically offered in Fall & Spring.

ESS 330. Introduction to Oceanography. 3 Credits.
LEC (2), LAB (2)
A survey of our present knowledge of the waters and floors of the oceans.
Pre / Co requisites: ESS 330 requires prerequisite of ESS 101.
Typically offered in Fall & Spring.

ESS 331. Introduction to Paleontology. 3 Credits.
LEC (2), LAB (2)
Identification and study of common fossils in order to understand their life processes and geologic significance.
Gen Ed Attribute: Writing Emphasis.
Typically offered in Spring.

ESS 332. Advanced Oceanography. 3 Credits.
An advanced course in oceanography covering marine resources, oceanographic literature, animal-sediment relationships, field techniques, estuaries, salt marshes, sea level changes, and pollution.
Pre / Co requisites: ESS 332 requires prerequisite of ESS 330.
Typically offered in Spring.

ESS 336. Environmental Geology. 3 Credits.
The application of geological information to human problems encountered in natural phenomena, such as flooding, earthquakes, coastal hazards, and man-made concerns, including waste disposal, land use, and global change.
Pre / Co requisites: ESS 336 requires prerequisite of ESS 101.
Typically offered in Spring.

ESS 343. Geomorphology. 3 Credits.
Constructional and degradational forces that have shaped present landforms and are constantly reshaping and modifying landforms. Interpretation of geologic and topographic maps; field studies.
Pre / Co requisites: ESS 343 requires prerequisites of ESS 101 and ESS 204.
Typically offered in Spring.

ESS 344. Geomorphology II. 3 Credits.
A continuation of the study of earth surface processes. Interpretation of topographic maps and air photos.
Pre / Co requisites: ESS 344 requires prerequisite of ESS 343.

ESS 347. Earth & Space Science Seminar. 1 Credit.
One credit weekly seminar featuring guest lectures by Geoscience professionals, prominent scientists, faculty and students. Students will read professional literature, attend and participate in the lecture, and write a summary and/or analysis of each seminar.
Typically offered in Fall. Repeatable for Credit.

ESS 348. International Geology Field Studies. 3 Credits.
Field investigations of selected country’s physical environments focusing on geology and natural resources in relationship to cultural traditions, lifestyle and sustainability. Case studies of human adaptation to local and global environmental challenges will be considered. Two hours of lecture and two hours of lab.
Pre / Co requisites: ESS 348 requires prerequisite ESS 101 or ESS 102 or permission of instructor.
Repeatable for Credit.

ESS 355. Intermediate Astronomy. 3 Credits.
LEC (2), LAB (2)
An analytical and qualitative analysis of selected astronomical phenomena. Topics include telescope optics (including photographic and photoelectric attachments), lunar and planetary orbits, stellar motions and magnitudes, galactic classifications, and distances. Two hours of lecture and two hours of lab.
Pre / Co requisites: ESS 355 requires prerequisite of ESS 111.

ESS 362. History of Astronomy. 3 Credits.
Development of astronomical theories from the ancient Greeks until the 20th century.
Pre / Co requisites: ESS 362 requires prerequisite of ESS 111.

ESS 370. Introduction to Meteorology. 3 Credits.
LEC (2), LAB (2)
A study of the principles governing the earth’s atmosphere and how these principles determine weather conditions.
Pre / Co requisites: ESS 370 requires a prerequisite of MAT 115 or MAT 143 or MAT 131 or MAT 161.
Typically offered in Fall.

ESS 371. Advanced Meteorology. 3 Credits.
A continuation of the study of the principles governing the earth’s atmosphere and how these principles determine weather conditions.
Pre / Co requisites: ESS 371 requires prerequisite of ESS 370.
Typically offered in Spring.

ESS 394. Geology of Northwestern National Parks. 4 Credits.
This course includes a field trip to the national parks in South Dakota, Wyoming, Montana, Idaho, northern Utah, and Colorado. The purpose of the course is to look at the geologic features of the national parks in these states and to develop an appreciation of the geology and geologic history of the region.
Consent: Permission of the Department required to add.
ESS 395. Geology of Southwestern National Parks. 4 Credits.
The course includes a field trip to the national parks in New Mexico, Arizona, southern Utah, and Colorado to look at the geologic features of these parks and to develop an appreciation of the geology and geologic history of the region.
Consent: Permission of the Department required to add.

ESS 405. Igneous and Metamorphic Petrology. 3 Credits.
LEC (2), LAB (2)
Theories of the formation of igneous and metamorphic rocks based on field occurrence, physical properties, geochemistry, petrography, and classification and identification of rocks. Laboratory and field examination of rocks.
Pre / Co requisites: ESS 405 requires prerequisites of ESS 201 and ESS 302.
Typically offered in Spring.

ESS 420. Structural Geology. 3 Credits.
LEC (2), LAB (2)
Determination of the sequential development and the forces involved in the various structural features of the earth.
Pre / Co requisites: ESS 420 requires prerequisites of ESS 201 and ESS 302.
Typically offered in Spring.

ESS 435. Remote Sensing. 3 Credits.
LEC (1), LAB (2)
An introduction to the science and technology of remote sensing and the applications of remote sensing data to geology, oceanography, meteorology, and the environment. Includes a discussion of the history and principles of remote sensing; fundamentals of electromagnetic radiation; theory and types of active and passive remote sensing systems; fundamentals of image interpretation; digital analysis of LANDSAT and AVHRR data; operation of environmental satellites; and future imaging systems.
Typically offered in Spring.

ESS 439. Hydrogeology. 3 Credits.
This applied course covers groundwater flow, well hydraulics, water resources, contaminant transport, and groundwater remediation. Familiarity with calculus is recommended.
Pre / Co requisites: ESS 439 requires prerequisite of ESS 301.
Typically offered in Spring.

ESS 442. Geophysics. 3 Credits.
Gravitational, magnetic, seismic (refraction and reflection), and electrical properties of rocks and minerals in the earth. Physical principles of the earth; geophysics in relation to economic deposits.
Pre / Co requisites: ESS 442 requires prerequisites of PHY 140 or PHY 180 and MAT 162.

ESS 447. Earth and Space Science Seminar. 1 Credit.
A one credit weekly seminar featuring guest lectures by Geoscience professionals, prominent scientists, faculty and students. Each week students will read professional literature, attend and participate in the lecture, and write a summary and/or analysis of each seminar.
Pre / Co requisites: ESS 447 requires prerequisite of ESS 347 or department consent.
Typically offered in Fall.
Repeatable for Credit.

ESS 450. Sedimentation & Stratigraphy. 3 Credits.
LEC (2), LAB (2)
LAB, LEC Class, laboratory, and field studies of sediments, sedimentary rocks, depositional processes and environments, and diagenesis. Description, mapping, and correlation of strata to infer temporal-spatial relationships, locate resources, and interpret Earth history.
Pre / Co requisites: ESS 450 requires prerequisites: ESS 301, 302, 331 and 343.
Typically offered in Fall.

ESS 460. Internship. 1-18 Credits.
Contact department for more information about this course.
Repeatable for Credit.

ESS 480. Special Problems. 1-3 Credits.
Reports on special topics and current developments in the earth and space sciences.
Repeatable for Credit.

ESS 490. Fundamentals of Soils. 3 Credits.
LEC (2), LAB (2)
Soil properties, classification, and genesis from geologic, agricultural, and engineering perspectives. Topics include pedology, soil physics, geotechnical engineering, erosion, septic systems, soil contamination, and remediation.
Pre / Co requisites: ESS 490 requires prerequisite of ESS 101.
Typically offered in Fall.

ESS 491. Independent Studies. 1-3 Credits.
Contact department for more information about this course.
Repeatable for Credit.

SCE

SCE 320. Science Methods for Grades PK-4. 3 Credits.
A science methods course for PreK-4 teachers to master classroom and materials preparation and the design of developmentally effective instruction and assessment. Teachers learn methods that promote children’s ability to do inquiry and master PA academic standards in science and technology and environment and ecology.
Pre / Co requisites: Formal Admission Teacher Ed.
Typically offered in Fall, Spring & Summer.

SCE 330. Science Methods for Middle Level (4-8). 3 Credits.
A course to prepare the middle level teachers for teaching science with a focus on the developmental and pedagogical needs of middle level students. Teacher candidates will apply science content, develop knowledge how students learn science, explore materials and resources, and learn how to plan and access effective standards based middle level science instruction.
Pre / Co requisites: Formal Admission Teacher Ed.
Typically offered in Fall & Spring.

SCE 350. Science Education in the Secondary School. 3 Credits.
Philosophy, objectives, and methods of teaching science. This is an Early Field Experience course with observation hours are completed in schools. Students must have current clearances for TB, criminal background, FBI, and child abuse before they can be assigned to schools to perform course assignments/other requirements. For the WCU policies on clearances, select the "Teacher Education Center" on the College of Education Web site.
Pre / Co requisites: SCE 350 requires formal admission into teacher education.
Gen Ed Attribute: Diversity Requirement, Writing Emphasis.
Typically offered in Fall.

SCI

SCI 101. The Carbon Cycle. 3 Credits.
An exploration of how the carbon cycle connects earth and life, through photosynthesis, respiration, decay, rock formation and weathering, and plate tectonics. Humans have altered the carbon cycle by burning fossil fuels. Students investigate the carbon cycle on the WCU campus and consider the implications for global warming. Team taught with the Department of Biology.
Pre / Co requisites: SCI 101 requirement - Education majors only.
Typically offered in Fall & Spring.