

Minors

Astrobiology—Astrobiology is the study of life in the universe. The astrobiology minor is designed to educate students in this interdisciplinary field covering the varied scientific disciplines that contribute to our general understanding of life, the origin of life, the past history of life on Earth, possible futures for life on Earth, and the possible existence of life on other planetary environments. The principle goal of the minor is to develop student's literacy in astrobiology so that they can critically evaluate claims related to this field that they encounter well after their college education has ended.

Climatology—Climate is a central component of the physical environment, playing an important role in a wide range of human activities. The ability to force changes in the global climate system may be one of the more significant ways in which human society will impact Earth's physical environment in the near future.

The Climatology minor in the College of Earth and Mineral Sciences is an interdisciplinary program drawing from the fields of meteorology, geography, and geosciences. The minor provides an overview of the physical processes that control present-day climate. It also provides an introduction to the history of climate change through geologic time, and presents some of the causes and consequences of potential future climate change and variability.

Earth and Sustainability—By the time current undergraduates send their children to college, Earth's population will have increased to more than eight billion people. One or more metropolitan areas in our increasingly crowded world will have experienced a devastating earthquake or volcanic eruption, sea level rise will be inundating low-lying coastal cities such as Jakarta along with whole island nations, energy resources will be less available and more expensive, and our climate will be warmer and characterized by more frequent extreme weather events.

How we choose to plan for and attempt to mitigate these "grand challenges" will have consequences for individuals, nations, and our global socioeconomic and political systems.

The goal of this minor is to dramatically increase geoscience literacy of undergraduate students, including the large majority that do not major in the geosciences, and especially adult learners through the online program, such that they are better positioned to make sustainable decisions in their lives and as part of the broader society.

Earth Systems—Pursuing a minor in Earth Systems can help you build a better understanding of the global extent and impact of environmental problems. This minor focuses on a large-scale and interdisciplinary approach to questions of global change and the interactions of the physical and human environments. It provides a wider interdisciplinary perspective for majors in the traditional Earth science disciplines (geography, geoscience, and

meteorology), and provides an introduction to Earth sciences and a broad exposure to Earth systems/environmental studies for other science and engineering majors.

Electrochemical Engineering—Addressing society’s clean energy needs and demands is the core focus of the electrochemical engineering minor. The minor integrates skill sets in fundamentals of electrochemistry (e.g. chemistry, physics, mathematics, thermodynamics, and chemical kinetics) and electrochemical engineering applications (batteries, solar, flow and fuel cells, electrochemical synthesis and corrosion) to ensure successful career opportunities and growth within electrochemical power generation industries, government agencies, and academia.

The curriculum should allow students in energy related programs such as chemical, civil, electrical, environmental, mechanical, and materials science and engineering to readily take advantage of the minor and be better prepared for careers in clean power generation and future green technologies.

Electronic and Photonic Materials—Electronic and photonic materials, such as those used to create transistors on a computer chip or semiconductor lasers in a compact disc player, have greatly changed modern life. Without them, computer, telecommunication systems, compact disc players, video cameras, and all the electronics with which we have become accustomed would not be possible. The study of electronic and photonic materials is a natural bridge between the fields of electrical engineering and materials science. Training in the field of electronic and photonic materials requires studying the processing and characterization of these materials to help engineers develop ways to lower cost and improve performance. This knowledge will help prepare students to enter the semiconductor industry or pursue graduate studies.

Energy, Business, and Finance—Through the energy business and finance minor, you can get an overview of the financial, investment, and management concepts applied to private sector organizations that emphasize the Earth and its environment, the energy and mineral industries, or the development of new and enhanced materials. The minor focuses on the leadership and information strategies characteristic of enterprises that are succeeding in a rapidly integrating global economy.

The minor provides science and engineering students an introduction to basic entrepreneurial and business concepts to help prepare them for success in a changing professional environment. It also provides other Penn State students an opportunity to focus on business strategies in the Earth resources, environmental, and materials industries.

Energy Engineering—The minor in Energy Engineering is designed to provide students in engineering, science, and energy business and finance (EBF) with additional courses, exposure, and experiences to the principles and applications of energy engineering. Courses include thermal sciences; petroleum and natural gas processing; renewable/sustainable energy; chemistry of fuels; electrochemical, chemical, and nuclear energy conversion

processes; physical processes in energy engineering; air pollution; and green engineering and environmental compliance.

Environmental Inquiry-- Prepare for addressing environmental issues through the environmental inquiry major. In this minor, you can gain the multiple perspectives necessary for understanding environmental issues as well as increase your skills in collaborating with those from very different disciplinary backgrounds to find acceptable solutions.

Students will be challenged to move beyond the channels of thinking characteristic of their own discipline to new ways of knowing, new sensitivities, and new analytical approaches. The program will engage students actively in learning experiences outside their major course of study. The minor offers seven specializations: Biodiversity and Ecosystems, Energy Resources, Environment and Society, Environmental Explorations, Human Settlements, Ideas about the Environment, and Water Resources.

Environmental Systems Engineering—If you are interested in environmental issues associated with the extraction, processing, and use of mineral and energy resources and their solutions, you should consider pursuing a minor in environmental systems engineering. The program provides an opportunity for students to understand and appreciate the relationship between energy and the environment, be exposed to the basic courses in environmental systems engineering, and to appreciate and evaluate the impact of environmental pollution control on viability of the profitability and feasibility of operations associated with the safe extraction, processing, and utilization of mineral and energy resources.

Geographic Information Science—Geographic Information Science (GIScience) is one of four key sub-disciplines within Geography (along with human geography, physical geography, and environment-society geography). Its primary areas of study include cartography (map making), remote sensing, and geographic information systems. Students who study GIScience learn how to use the latest tools and techniques to visually represent and analyze spatial data in order to understand and address real-world environmental and social problems. Applications of geographic information science range from emergency response to natural resource management to social policy analysis to location intelligence for business.

Geography—The Geography minor can complement most majors in the social sciences, physical sciences, biological sciences, and technical disciplines. The Geography minor is flexible so that students can tailor their course choices to accommodate individual interests. A broadly-based approach to selecting minor courses can be appropriate for students whose majors are highly specialized or narrowly focused. Alternatively, students may choose to fulfill Geography minor requirements with a particular content emphasis, such as an interest in environmental issues or urban and regional planning. Looking through course

choices and talking with geography staff can make earning the Geography minor an important enhancement to one's academic program.

Geophysics—Obtaining a minor in geophysics can help you learn how to apply physics, quantitative, and technical skills from your major to the geophysical aspects of Earth science. Whether you're interested in seismology, volcanology, natural hazards, environmental geophysics, or petroleum and mineral exploration, the minor can help you build a broader skillset.

For students majoring in Geosciences, the completion of the minor will strengthen their physics/quantitative background and develop links between theory and application for these technical and quantitative skills.

The minor will prepare students for graduate programs in geophysics, and/or employment opportunities in the environmental and exploration industries.

Geosciences—The Geosciences minor provides a foundation in the physical and material aspects of the solid Earth, as well as an introduction to field techniques and technical writing. The flexible minor allows you to select from a choice of advanced courses and tailor your interests.

Some areas that graduates with the Geosciences minor may work in include Earth materials, evolution of the Earth and life, hydrogeology, environmental geology, natural hazards, plate tectonics, geophysics, and climate change.

Information Science and Technology for EMS—Information systems are a core component of any research, educational, or industrial enterprise in the Earth and materials sciences. In addition, the science and engineering disciplines represented in the college have a particular focus on numerical modeling and simulation systems, and on the analysis and management of very large data sets. The EMS - IST minor provides students a basic introduction to information sciences and information technology through courses in the core curriculum of the College of Information Sciences and Technology. Students then select from a group of interdisciplinary EMS courses that focus on the particular interests of the college.

Meteorology—Broaden your education by seeking a minor the applied science of meteorology. You will consult with a meteorology adviser to choose elective courses from a variety of specialties, including air quality studies, atmospheric dynamics, atmospheric physics, climatology, computer applications, and weather analysis and forecasting. This minor will help prepare students for professional employment with industry, private consulting firms, government, and the armed forces or for further study toward graduate degrees normally required for research, university, or management positions.

Mining Engineering—The minor in Mining Engineering, designed for students majoring in a technical major such as science or engineering, offers a specialized program for students. The demand for professionals with the training and skills for a career in the minerals- and energy-recovery profession far exceeds the supply. Mineral exploration and evaluation, mine development, marketing, health and safety, environmental protection, and mine management are all areas of industry employment.

Petroleum and Natural Gas Engineering—The minor in petroleum and natural gas engineering is for students interested in the drilling and production of oil and gas. It provides an opportunity for students to understand and appreciate the relationship between petroleum and natural gas demand, production and their environmental impact. Students are exposed to the basic courses in petroleum and natural gas extraction, particularly as they relate to drilling, production and characterization.

Graduates of this minor find rewarding careers across the globe as engineers for governmental and regulatory bodies, oil and gas producing companies, and other independent and service companies in the energy sector.

Polymer Science—The science of long-chain molecules is the focus of the polymer science minor. The goal of the polymer science minor is to produce graduates who have a first-hand knowledge of the relationships between the synthesis, structure, properties and processing of polymer materials. Polymers have certain unique chemical and physical properties, and understanding these properties involves aspects of organic chemistry, physical chemistry, analytical chemistry, contemporary physics (particularly theories of the solid state and solution), chemical engineering, mechanical engineering, and electrical engineering.

There is a growing demand for what can be called engineering technologists, those skilled in the art of designing processes for producing specific products.

Watersheds and Water Resources—Watersheds are important landscape features that control the biogeochemistry of natural waters. This interdisciplinary minor enables students to learn the fundamental processes governing the transport and chemical evolution of surface and subsurface waters. It provides a complement to elective and required coursework in Earth sciences, resource management, wastewater treatment, and/or environmental planning. Students in this program will learn to apply fundamental concepts of chemistry, biology, geoscience, and landscape evolution to processes operating at the watershed scale. Learning objectives for the minor include excellence in written and oral expression, the ability to collect and interpret data from dynamic natural systems, and rigor in scientific thought.

Certificates

Earth Sustainability Undergraduate Certificate—This certificate, which can be completed online through Penn State World Campus, is designed to provide students with the knowledge needed to make environmentally sustainable decisions. It increases geoscience literacy and addresses key sustainability issues, including the impact of climate change on Earth and its inhabitants, access to clean drinking water, sustainable energy, and the hazards posed by our overpopulated coastal regions.

The Earth Sustainability undergraduate certificate can help prepare you to become a steward of the green movement in education, politics, business, or law. You may also use this credential to jump-start a career in geosciences, emergency preparedness, environmental health and sustainability, land management and conservation, or natural resource management program.

Environment and Society—The 12-credit Certificate in Environment and Society Geography will engage students with issues, knowledge, and diverse forms of learning, analysis, and exposition related to the interactions of human societies and environments. This certificate is based on the twin foundations of this sub-field of geography, namely human-environment interactions and nature-society relations. Its purpose is to train students to use frameworks such as political ecology and environmental geography to provide the tools and concepts of change and sustainability necessary to analyze human-environment systems, environmental problems, and remediation across local-to-global scales, and the political economy of resource use and management.

Geographic Information Science—The 12-credit Geographic Information Science (GIS) certificate is aimed at students who wish to be current in geographical representation and geospatial analysis. Through courses for the GIS certificate, students will understand and know how to apply various GIS and geospatial analysis tools to represent, analyze, and advise on the geospatial dimensions of natural and social phenomena. Students will gain firsthand experience using the most up-to-date tools and techniques available in the field of GIS today. Areas of study include cartography, remote sensing, and geographic information systems.

Geospatial Big Data Analytics—Geospatial data are central to the challenges and opportunities for science and society that big data provide. Geospatial data derive from a rapidly expanding array of sources that include sensors (from satellites, to cameras and other sensing devices carried by UAVs, to distributed sensors monitoring energy consumption, pollution, traffic, and more with smart cities), GPS enabled devices (in vehicles, smart phones, cameras, human wearable devices, and even ones small enough to mount on migrating songbirds), citizen science efforts producing volunteered geospatial data, address-linked public health and many other records, retail transactions, and location-linked social media posts. As geospatial data become more ubiquitous, big digital geospatial data has become an essential part of geographic analysis.

Human Geography—Human geography, the study of human interactions across space, is vital to helping students understand the world by locating their lives within and across space and place. This 12-credit certificate will engage students with contemporary national and global issues as they locate patterns and processes of human-created change in local, regional, and global environments. Through courses for the certificate in human geography, students will understand and be able to articulate: why location matters to agricultural land use, industrial development, and urban design; the reasons for population growth and international migration; the consequences of economic development; the impacts of technological innovation, communication and industrialization; and other aspects of human life such as struggles over political power and control of territory that amplifies the inequalities between developed and developing economies.

Justice, Ethics, Diversity in Space—The 12-credit Justice, Ethics, Diversity in Space (JEDIS) certificate helps students to cultivate a diverse set of theoretical and methodological skills that geographers use to engage in a diverse and changing planet. Increasingly as students enter the workforce they will be challenged to not only interact with diverse populations, but will also have to understand the way diverse populations are impacted by a range of economic, political, and environmental challenges. They will also need to be exposed to ethical frameworks that can be productively leveraged within non-academic environments.

Landscape Ecology—Landscape ecologists are in increasing demand in the areas of conservation management, urban planning, and Earth system science. Landscape-level management also increasingly depends on an understanding of coupled natural-human systems, and landscape ecologists need to be trained to understand interdisciplinary linkages between social and ecological sciences, which is a strength in geographic thought.

Physical Geography—Physical geographers study Earth's physical environment and its interactions with human activities across spatial and temporal scales. Through courses for the 12-credit certificate in Physical Geography, students will understand and be able to articulate the geographic patterns and physical processes attending Earth's climate and landscape systems, including its hydrology, landforms, soils, and vegetation, along with the evidence for and impacts of past and contemporary environmental changes.

Weather Forecasting—Learning innovative forecasting techniques in this online certificate program can help you learn about meteorology, enrich your hobby, supplement your professional career, or build a preparatory foundation for future study or work. This certificate can be fully completed online through Penn State World Campus.

As a student in this program, you will have an opportunity to become a better-informed, critical consumer of weather-related news. Whether you are an amateur weather enthusiast or a weather-related industry professional, enrolling in this 12-credit certificate program can help you refine your skills to more effectively predict the weather.