GEOSCIENCES (Div III)
Chair: Associate Professor Phoebe A. Cohen

- Alex A. Apotsos, Lecturer in Geosciences
- Alice C. Bradley, Assistant Professor of Geosciences; on leave 2022-2023
- Phoebe A. Cohen, Chair and Associate Professor of Geosciences
- José A. Constantine, Associate Professor of Geosciences
- Mea S. Cook, Professor of Geosciences, Faculty Fellow of the Davis Center and the Office of Institutional Diversity, Equity and Inclusion; affiliated with: The Davis Center, InstDiversity,Equity&Inclusion
- Rónadh Cox, Edward Brust Professor of Geology and Mineralogy; affiliated with: Williams-Mystic Program
- Ana C. Gonzalez-Nayeck, Visiting Lecturer in Geosciences
- Mike R. Hudak, Assistant Professor of Geosciences
- Paul M. Karabinos, Edna McConnell Clark Professor of Geology

MAJOR

The Geosciences major offers an understanding of the evolution of our planet and its interacting global systems. In this era of global change, geoscience provides the tools that can help us learn to live sustainably with our environment, and appreciate our place within the vastness of Earth history. Forces within the Earth create mountain ranges and ocean basins and drive the movements of continents. Wind, water and ice shape the surface of the Earth, making and changing the landscapes around us. Sedimentary rocks and the fossils within them teach us how life and climate have evolved over the vastness of time.

Geosciences graduates have a wide range of career options, both with and without graduate training. The many choices include environmental consulting, hazard assessment, hydrology, geomology, the energy and mining industries, outdoor education, and research and teaching in universities, colleges, and secondary schools. Many students choose to double-major in fields as diverse as Art, Economics, History, Physics, Mathematics, English, and Philosophy, and often find jobs where they can apply the synergies of their Geosciences double major. No matter what field they enter, all our Geosciences graduates pursue their lives and careers with a deeper appreciation for the natural world around them.

The major is designed to provide a solid grounding in the geosciences while being adaptable enough to accommodate diverse paths driven by student interests. There are no required courses, but students work through the menu below, which allows a lot of scheduling flexibility.

The requirements for the Geosciences major were revised in 2022. The new requirements are immediately below, and the old requirements follow. Students who entered Williams before fall 2020 are under the old requirements. Students who entered Williams in fall 2020 and after are under the new requirements. Both sets of requirements follow. If you have questions about the major, or how the different requirements apply to you, please contact the Geosciences Chair.

Geosciences major requirements for students who are entering Williams in or after fall 2020 or after:

The Geosciences major requires a minimum of nine courses, distributed by course level and topic group; one course can fulfill both a course level and topic group requirement. To complete the minimum nine courses, students can add electives at any level, as long as they have a GEOS prefix, and the total number of 100 levels does not exceed two.

Course Level Requirements:

At least one and at most two 100-level courses:
- GEOS 100 Introduction to Weather and Climate
- GEOS 101 Co-Evolution of Earth and Life
- GEOS 102 An Unfinished Planet
- GEOS 103 Global Warming and Environmental Change
- GEOS 104 Oceanography
- GEOS 107 Astrobiology

At least two 200-level courses selected from this group:
- GEOS 201 Field Methods and Structural Geology
- GEOS 202 Mineralogy
GEOS 205 Economic Geology and Earth Resources
GEOS 207 The Geoscience of Epidemiology in Public Health
GEOS 208 Understanding the Modern Carbon Cycle Through Stable Isotopes
MAST 211/GEOS 210 Oceanographic Processes (at Mystic)
GEOS 212 Paleobiology
GEOS 214 Mastering GIS
GEOS 215 Climate Changes
GEOS 217 Planets and Moons
GEOS 255 Environmental Observation

At least two 300-level courses selected from this group:

- GEOS 301 Geomorphology
- GEOS 302 Sedimentology
- GEOS 303 Igneous and Metamorphic Petrology
- GEOS 308 Life on Mars?
- GEOS 309 Modern Climate
- GEOS 324 Corals and Sea Level

At least one of the following 400-level courses:

- GEOS 401 Global Tectonics and the Rise of Mountains
- GEOS 404 Coastal Processes and Geomorphology
- GEOS 405 Geochemistry: Understanding Earth’s Environment
- GEOS 410 The Cryosphere
- GEOS 411 Geobiology
- GEOS 414 Reading Deep Time

Topic Group Requirements: Courses taken for the major must also include at least one and preferably two courses from each of the following three groups at the 200, 300, or 400 level. Note that 100-level courses do not fulfill topic group requirements.

Climate and Oceans (Group A electives), at least one and preferably two:

- GEOS 208 Understanding the Modern Carbon Cycle Through Stable Isotopes
- MAST 211/GEOS 210 Oceanographic Processes (at Mystic)
- GEOS 215 Climate Changes
- GEOS 227T Climate Data Analysis
- GEOS 228T Ocean Circulation and Climate
- GEOS 255 Environmental Observation
- GEOS 309 Modern Climate
- GEOS 405 Geochemistry: Understanding Earth’s Environment
- GEOS 410 The Cryosphere

Sediments and Life (Group B electives), at least one and preferably two:

- GEOS 207 The Geoscience of Epidemiology in Public Health
- GEOS 212 Paleobiology
- GEOS 301 Geomorphology
- GEOS 302 Sedimentology
- GEOS 308 Life on Mars?
- GEOS 312T Mass Extinctions: Patterns and Processes
- GEOS 414 Reading Deep Time
- GEOS 404 Coastal Processes and Geomorphology
GEOS 411 Geobiology

Solid Earth (Group C electives), at least one and preferably two:

- GEOS 201 Field Methods and Structural Geology
- GEOS 202 Mineralogy
- GEOS 205 Economic Geology and Earth Resources
- GEOS 217 Planets and Moons
- GEOS 220T Evolution of and on Volcanic Islands
- GEOS 250T Climate, Tectonics and Erosion
- GEOS 303 Igneous and Metamorphic Petrology
- GEOS 401 Global Tectonics and the Rise of Mountains

Geosciences major requirements for students who entered Williams prior to fall 2020:

At least one and at most two 100-level courses:

- GEOS 100 Introduction to Weather and Climate
- GEOS 101 Co-Evolution of Earth and Life
- GEOS 102 An Unfinished Planet
- GEOS 103 Global Warming and Environmental Change
- GEOS 104 Oceanography
- GEOS 107 Astrobiology

At least two 200-level courses selected from this group:

- GEOS 201 Field Methods and Structural Geology
- GEOS 202 Mineralogy
- GEOS 205 Economic Geology and Earth Resources
- MAST 211/GEOS 210 Oceanographic Processes (only offered at Williams-Mystic)
- GEOS 212 Paleobiology
- GEOS 214 Mastering GIS
- GEOS 215 Climate Changes
- GEOS 217 Planets and Moons
- GEOS 255 Environmental Observation

At least two 300-level courses selected from this group:

- GEOS 301 Geomorphology
- GEOS 302 Sedimentology
- GEOS 303 Igneous and Metamorphic Petrology
- GEOS 309 Modern Climate
- GEOS 314 Analytical Historical Geology
- GEOS 324 Corals and Sea Level

At least one of the following 400-level courses:

- GEOS 401 Global Tectonics and the Rise of Mountains
- GEOS 404 Coastal Processes and Geomorphology
- GEOS 405 Geochemistry: Understanding Earth’s Environment
- GEOS 410 The Cryosphere
- GEOS 411 Geobiology

To complete the minimum nine courses, students can add electives at any level, as long as they have a GEOS prefix, and the total number of 100 levels does not exceed two. In addition, majors must take at least two courses from each of the three disciplinary groupings (i.e. Climate & Oceans, Sediments & Life, and Solid Earth).
Climate and Oceans:
- GEOS 100 Introduction to Weather and Climate
- GEOS 104 Oceanography
- MAST 211/GEOS 210 Oceanographic Processes (only offered at Williams-Mystic)
- GEOS 215 Climate Changes
- GEOS 221T Climate Science and Politics
- GEOS 255 Environmental Observation
- GEOS 309 Modern Climate
- GEOS 324 Corals and Sea Level

Sediments and Life:
- GEOS 101 Co-Evolution of Earth and Life
- GEOS 103 Global Warming and Environmental Change
- GEOS 107 Astrobiology
- GEOS 212 Paleobiology
- GEOS 301 Geomorphology
- GEOS 302 Sedimentology
- GEOS 312T Mass Extinctions
- GEOS 314 Analytical Historical Geology

Solid Earth:
- GEOS 102 An Unfinished Planet
- GEOS 202 Mineralogy
- GEOS 201 Field Methods and Structural Geology
- GEOS 205 Economic Geology and Earth Resources
- GEOS 217 Planets and Moons
- GEOS 220T Evolution of and on Volcanic Islands
- GEOS 250T Tectonic Geomorphology and Landscape Evolution
- GEOS 303 Igneous and Metamorphic Petrology

PREPARATION FOR GRADUATE SCHOOL

Although many of our majors take geoscience jobs after graduation, many choose to go to graduate school, and most graduate programs will expect students to have a background in mathematics as well as a year or so of study in related sciences, in addition to the requirements of the Geosciences major. Students considering graduate work in geosciences should therefore consult with faculty to ensure that they plan wisely. The selection of outside courses will depend on the field in which a student wants to specialize. Graduate programs in solid-earth geosciences commonly expect entering students to have taken courses in chemistry. For those going into environmental geosciences, courses in chemistry, computer science and/or statistics are recommended. For those considering geobiology programs, biology courses are important. For students entering planetary geology, physics is recommended.

THE DEGREE WITH HONORS IN GEOSCIENCES

The degree with honors in Geosciences provides students with an opportunity to undertake an independent research project under the supervision of a faculty member, culminating in a thesis that demonstrates outstanding achievement of an original and innovative nature. In addition to the major requirements listed above, those who are candidates for the degree with honors take the following sequence in the Fall, Winter Study, and Spring of their senior year:

- GEOS 493-031-494 Senior Research and Thesis

The principal considerations in admitting a student to a program of independent research are interest and motivation, mastery of fundamental material and skills, and ability to pursue independent study successfully. Interested students should talk to members of the department about project options at any time, but generally no later than January of the Junior year.

STUDY AWAY

Students planning to study off-campus should meet as early as possible with the Department Chair to plan and to discuss how potential courses
might be used in the major. Although most study-away programs do not offer geoscience courses, there are some that dovetail well with Geosciences. Examples include the Williams-Mystic program, the Frontiers Abroad program at Canterbury University in New Zealand, and the program at the University of Otago in New Zealand. Courses offered at Norwegian Technical Universities and at several universities in the United Kingdom have also been accepted. Up to two geoscience courses taken away from Williams can be counted toward the nine-course major. Be sure to meet with a Geosciences faculty advisor or Department Chair to discuss your plans and ideas for off-campus work.

FAQ

Students MUST contact departments/programs BEFORE assuming study away credit will be granted toward the major or concentration.

Can your department or program typically pre-approve courses for major/concentration credit?

Generally not until after a student returns and can provide course material for review (e.g. Syllabus and/or completed work such as exams, portfolios, lab reports and the like).

What criteria will typically be used/required to determine whether a student may receive major/concentration credit for a course taken while on study away?

Complete syllabus and course description, including readings, assignments, evaluation criteria.

Does your department/program place restrictions on the number of major/concentration credits that a student might earn through study away?

Yes. A maximum of two courses can be credited toward major requirements.

Does your department/program place restrictions on the types of courses that can be awarded credit towards your major?

No.

Are there specific major requirements that cannot be fulfilled while on study away?

No.

Are there specific major requirements in your department/program that students should be particularly aware of when weighing study away options? (Some examples might include a required course that is always taught in one semester, laboratory requirements.)

Students should consult with the chair or other department faculty members to plan ahead and make sure that requirements can be met.

Give examples in which students thought or assumed that courses taken away would count toward the major or concentration and then learned they wouldn’t:

None to date.

GEOS 100  (S)  Introduction to Weather and Climate

Cross-listings:  GEOS 100  ENVI 100

Primary Cross-listing

How is it that we have such a hard time predicting if it's going to rain next week, but we can be confident in projections of future climate change decades from now? This course will explore the atmosphere and how air moves and changes, understanding the wind, clouds, precipitation, and extreme events (including thunderstorms, hurricanes, and tornados) that form our weather. Building off of our understanding of the atmosphere, we’ll look at longer time scales to develop a basic understanding of earth’s climate, global heat and moisture transport, climate change, and the ways that humans can change our planet. We will look at weather and climate models to learn how to scientists and meteorologists predict future conditions. Labs will include local field trips, bench top experiments, and running a climate model on a computer. This course is in the Oceans and Climate group for the Geosciences major.

Requirements/Evaluation:  lab assignments, a midterm, and a final exam
**GEOS 101  (F)  The Co-Evolution of Earth and Life**

**Cross-listings:** GEOS 101  ENVI 105

**Primary Cross-listing**

Our planet is about 4.6 billion years old and has supported life for at least the last 3.5 billion of those years. This course will consider the inter-related nature of Earth and the life that inhabits it, starting with the first living organisms and progressing to the interaction of our own species with the Earth today. Students will investigate the dynamic nature of the Earth-life system, examine many of its feedbacks, and learn about the dramatic changes that have occurred throughout the history of the Earth. We will ask questions such as: How did the Earth facilitate biologic evolution, and what effects did those biologic events have on the physical Earth? When did photosynthesis evolve, how can we detect that in the rock record, and how did this biological event lead to profound changes in the environment? How and why did animals evolve and what role did environmental change play in the radiation of animal life? How did the rise and radiation of land plants affect world climate? How do plate tectonics, glaciation, and volcanism influence biodiversity and evolutionary innovation? What caused mass extinctions in the past and what can that teach us about our current extinction crisis? Labs will involve hands-on analysis of rocks, fossils, and real-world data as well as conceptual and analytical exercises; field trips will contextualize major events in Earth history and will help students learn to read the rock record. Through these investigations, the class will provide a comprehensive overview of Earth history, with special attention paid to the geological and paleontological history of the northeastern United States. This course is in the Sediments and Life group for the Geosciences major.

**Class Format:** one laboratory per week plus one all-day field trip

**Requirements/Evaluation:** lab work, short quizzes, midterms, an independent project, and a final exam

**GEOS 102  (S)  An Unfinished Planet**

The Earth is a work-in-progress, an evolving planet whose vital signs--as expressed by earthquakes, volcanic eruptions, and shifting plates--are still strong. In a geological time frame, nothing on Earth is permanent: ocean basins open and close, mountains rise and fall, continental masses collide and pull apart. There is a message here for all of us who live, for an infinitesimally brief time, on the moving surface of the globe. This course uses the plate tectonics model--one of the fundamental scientific accomplishments of the past century--to interpret the processes and products of a changing Earth. The emphasis will be on mountain systems (on land and beneath the oceans) as expressions of plate interactions. Specific topics include the rocks and structures of modern and ancient mountain belts, the patterns of global seismicity and volcanism, the nature of the Earth's interior, the changing configurations of continents and ocean basins through time, and, in some detail, the formation of the Appalachian Mountain system and the
A course on the geology of New England, including readings from physical geology textbooks, primary sources, and selected writings by John McPhee. A required all-day field trip on the last Monday of the semester to the Connecticut Valley and the highlands of western Massachusetts.

**Class Format:** lecture three hours per week and lab (several involving field work) two hours per week;

**Requirements/Evaluation:** three hour-tests and weekly lab work

**Prerequisites:** none

**Enrollment Limit:** 40

**Enrollment Preferences:** first year and second year students, Geosciences majors

**Expected Class Size:** 40

**Grading:** yes pass/fail option, no fifth course option

**Distributions:** (D3)

**Attributes:** ENVI Natural World Electives, EXPE Experiential Education Courses, GEOS Group C Electives - Solid Earth

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**GEOS 103 (F) Global Warming and Environmental Change**

**Cross-listings:** ENVI 103, GEOS 103

**Primary Cross-listing**

Earth is the warmest it has been for at least five centuries, and the surface of our planet is responding. From extreme floods and drought to landslides and wildfires, the natural processes that shape Earth’s surface are tied to temperature and precipitation. People are beginning to feel the impacts, but in different ways depending on where they call home. In this course, we will investigate how climate change is altering landscapes and the natural processes that support them, highlighting all the ways that people are being affected today. Ultimately, we will develop an understanding of the consequences of climate change that connects physical processes with geography. Specific topics include foundations of the Earth system, plate tectonics and the construction of landscapes, Earth materials, rivers and flooding, hillslope processes, coastal processes, and climate impacts on natural resources such as fresh water and soil. Labs will use local field sites and analytical exercises to evaluate recent cases that reflect an interaction of the landscape and climate. We will also visit and engage with Black communities and community leaders across New England who are grappling with the unjust distribution of resources to mitigate climate impacts and who have been disproportionate bearers of environmental risk.

**Requirements/Evaluation:** written reports from laboratories and readings, class participation, a midterm and final exam

**Prerequisites:** none

**Enrollment Limit:** 48

**Enrollment Preferences:** first year and second year students, Geosciences majors and Environmental Studies majors and concentrators

**Expected Class Size:** 48

**Grading:** yes pass/fail option, no fifth course option

**Distributions:** (D3)

**Attributes:** ENVI Natural World Electives, EXPE Experiential Education Courses

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**Fall 2022**

**LEC Section: 01** MWF 10:00 am - 10:50 am  José A. Constantine

**LAB Section: 02** T 1:00 pm - 3:00 pm  José A. Constantine

**LAB Section: 03** R 1:00 pm - 3:00 pm  José A. Constantine

**Spring 2023**

**LEC Section: 01** MWF 10:00 am - 10:50 am  Paul M. Karabinos

**LAB Section: 02** M 1:00 pm - 3:00 pm  Paul M. Karabinos

**LAB Section: 03** W 1:00 pm - 3:00 pm  Paul M. Karabinos

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**ENVI 103 (D3) GEOS 103 (D3)**

**Attributes:** ENVI Natural World Electives, EXPE Experiential Education Courses
GEOS 104  (F)  Oceanography

Cross-listings: MAST 104  GEOS 104  ENVI 104

Primary Cross-listing

The oceans cover three quarters of Earth’s surface, yet oceanography as a modern science is relatively young: the first systematic explorations of the geology, biology, physics and chemistry of the oceans began in the late 19th century. This introduction to ocean science includes the creation and destruction of ocean basins with plate tectonics; the source and transport of seafloor sediments and the archive of Earth history they contain; currents, tides, and waves; photosynthesis and the transfer of energy and matter in ocean food webs; the composition and origin of seawater, and how its chemistry traces biological, physical and geological processes; oceans and climate change; and human impacts.

Class Format: three 50-minute lecture/discussion meetings each week; 2-hour lab every second week; one all-day field trip to the Atlantic coast of New England.

Requirements/Evaluation: lab activities (25%), homework (25%), quizzes (5%), three exams (45%)

Prerequisites: none

Enrollment Limit: 48

Enrollment Preferences: first year and second year students, Geosciences majors, Maritime Studies concentrators

Expected Class Size: 48

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3)

This course is cross-listed and the prefixes carry the following divisional credit:

MAST 104 (D3) GEOS 104 (D3) ENVI 104 (D3)

Attributes: ENVI Natural World Electives  EXPE Experiential Education Courses  GEOS Group A Electives - Climate + Oceans

Fall 2022

LEC Section: 01  MWF 9:00 am - 9:50 am  Mea S. Cook

LAB Section: 02  W 1:00 pm - 3:00 pm  Mea S. Cook

LAB Section: 03  R 1:00 pm - 3:00 pm  Mea S. Cook

GEOS 106  (F)  Being Human in STEM  (DPE)

Cross-listings: PHYS 106  GEOS 106  STS 106

Secondary Cross-listing

This course combines academic inquiry and community engagement to investigate the themes of diversity and social climate within STEM (science, technology, engineering and mathematics) disciplines. Students will examine how diverse identities including but not limited to gender, race, disability, sexuality, national origin, socioeconomic status, religion, and ethnicity shape the STEM experience both at Williams and nationally. We will ground our understanding through critical reading of primary scholarly research on topics such as implicit bias, identity threat, and effects of team diversity on excellence. From there, we will execute small group projects. Students will design, execute, and evaluate interventions that relate to the course goals and that have direct relevance to Williams students, faculty, and staff. For example, a student group could implement a survey of minoritized STEM students, or create a qualitative interview-based assessment of how socioeconomic status impacts students’ abilities to participate in STEM fields. Course work includes weekly readings, reflective/opinion writing, in class discussion, and the development and presentation of a group project.

Class Format: class discussions, group project work (out of class time required)

Requirements/Evaluation: short response papers, class discussion participation, leading class discussions, group work, and final project

Enrollment Limit: 15

Enrollment Preferences: DIV III majors; statement of interest may be requested

Expected Class Size: 15

Grading: no pass/fail option, yes fifth course option

Unit Notes: does not count towards GEOS or PHYS major credit

Distributions: (D3) (DPE)

This course is cross-listed and the prefixes carry the following divisional credit:
PHYS 106 (D3) GEOS 106 (D3) STS 106 (D2)

**Difference, Power, and Equity Notes:** This course explicitly addresses the intersection of marginalized identities and the STEM experience. Students will learn how to critically address how issues such as gender, race, ethnicity, and disability impact participation in and the experience of STEM fields. For example, students will read and critique literature documenting bias in STEM fields, and will also learn about and create interventions that can address these biases.

Not offered current academic year

**GEOS 107 (F) Astrobiology**

**Cross-listings:** GEOS 107 ASTR 107

**Primary Cross-listing**

Astrobiology is the study of the origin, evolution, and distribution of life in the universe. As such it is an inherently interdisciplinary field, incorporating all of the basic natural sciences: biology, chemistry, physics, astronomy, and the earth sciences, as well as aspects of philosophy, sociology, and engineering. Questions we will seek answers to in this class include: How, why, when, and where did life evolve on Earth, and what does that tell us about how it might evolve elsewhere? What are the chances that there is life on other planets and moons in our solar system, and why? Are there habitable planets elsewhere in the universe, and will we ever truly know if any of them contain life? We will approach these questions using a combination of lectures, activities, labs, homework assignments, and visits from some of the country's leading Astrobiology researchers. Examples of lab and homework activities include exploring our definition of life by making observations about living and non-living systems, examining evidence for ancient habitable environments in rocks, and modeling chemical fingerprinting tools used by Mars rovers. Assessment will be based on participation, quizzes, labs and homework assignments, and a final group project where students will present a mock NASA mission proposal. This course requires no previous experience in the sciences. This course is in the Sediments and Life group for the Geosciences major.

**Class Format:** Lectures will be partially flipped with student responsible for watching videos before class; class time will be split between short lectures, small group activities, and class discussions. Lab groups will meet in person every other week and have group project work on alternate weeks that may be done virtually or in person.

**Requirements/Evaluation:** Assessment will be based on participation, quizzes, labs and homework assignments, and a final group project where students will present a mock NASA mission proposal.

**Prerequisites:** none

**Enrollment Limit:** 46

**Enrollment Preferences:** first year and second year students, Geosciences majors

**Expected Class Size:** 46

**Grading:** yes pass/fail option, yes fifth course option

**Unit Notes:** This course counts towards the GEOS Group B Electives - Sediments and Life

**Distributions:** (D3)

This course is cross-listed and the prefixes carry the following divisional credit:

GEOS 107 (D3) ASTR 107 (D3)

**Attributes:** GEOS Group B Electives - Sediments + Life

Not offered current academic year

**GEOS 111 (F) Radical Science- How Geology Changed the Way We See the World (WS)**

Copernicus shocked Europe when he suggested that the Earth is not the center of the universe. Hutton and other geologists made an equally radical proposal more than two centuries later when they introduced the concept of deep time and argued that the Earth was much older than 6,000 years, as determined by biblical scholars. Several decades later, Darwin and Wallace shook the foundation of western philosophy once more when they proposed that organisms evolved. When geologists reinterpreted landscape features once attributed to the great flood as evidence for past continental glaciation, the concept of extreme climate change through time sprang to life. During the 20th century, the permanence of Earth's geography was challenged by the continental drift hypothesis, which was initially rejected for decades until it reemerged as plate tectonic theory. This tutorial explores how geologic breakthroughs challenged western views of humans as the center of creation living in a world with limited change. There will be weekly tutorial meetings with pairs of students, and students will alternate writing papers on assigned topics. This course is in the Solid Earth group for the Geosciences major.

**Requirements/Evaluation:** five 5-page papers and five oral critiques of partner's papers
Prerequisites: none
Enrollment Limit: 10
Enrollment Preferences: First year students then second year students
Expected Class Size: 10
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (WS)

Writing Skills Notes: Students will write five 5-page papers and will receive peer and instructor feedback on how to improve their writing skills and formulate sound arguments.

Attributes: GEOS Group C Electives - Solid Earth

Fall 2022
TUT Section: T1 TBA Paul M. Karabinos

GEOS 201 (F) Field Methods and Structural Geology (WS)

Geologic history is preserved in rocks and it can be deciphered using fundamental principles such as superposition and cross-cutting relationships. Field observations are essential to understanding the rock record, and data and interpretations are encoded in geologic maps. This course introduces students to topographic and geologic maps, best practices for geologic field work, the field identification of common minerals and rocks, geologic contacts, and structures such as folds, and faults. Students will develop skills for presenting field data in papers, figures, and oral presentations. This course is in the Solid Earth group for the Geosciences major.

Class Format: lecture and discussion, three hours per week and laboratory, three hours per week
Requirements/Evaluation: short weekly writing assignments will form the basis for two 10-page papers based on field trips and a final independent project
Prerequisites: none
Enrollment Limit: 16
Enrollment Preferences: Geosciences majors or students with a strong interest in geosciences
Expected Class Size: 12
Grading: no pass/fail option, no fifth course option
Materials/Lab Fee: $15 for field supplies
Distributions: (D3) (WS)

Writing Skills Notes: There will be two 10-page papers, each based on four field trips. Students will submit short field descriptions and figures with captions after each field trip. The shorter assignments will be incorporated in two papers. Students will receive from the instructor timely comments on their writing skills, with suggestions for improvement.

Attributes: GEOS Group C Electives - Solid Earth

Fall 2022
LEC Section: 01 MWF 11:00 am - 12:15 pm Paul M. Karabinos
LAB Section: 02 M 1:00 pm - 4:00 pm Paul M. Karabinos

GEOS 202 (F) Mineralogy

This course could be subtitled "An Introduction to Earth Materials and Analytical Techniques." As the basis for all subsequent solid-earth courses in the major, it provides a systematic framework for the study of minerals--Earth's building blocks: their physical and chemical properties at all scales and the common analytical methods used to identify and interpret them. The course progresses from hand-specimen morphology and crystallography through element distribution and crystal chemistry to the phase relations, compositional variation, and mineral associations within major rock-forming mineral systems. Laboratory work includes the determination of crystal symmetry; mineral separation; the principles and applications of optical emission spectroscopy; wavelength- and energy-dispersive x-ray spectrochemical analysis; x-ray diffraction; the use of the petrographic microscope; and the identification of important minerals in hand specimen and thin section. This course is in the Solid Earth group for the Geosciences major.
Class Format: Lecture three hours per week and laboratory three hours per week; independent study of minerals in hand specimen; one afternoon field trip

Requirements/Evaluation: one hour test, lab work, and a final exam

Prerequisites: one 100-level GEOS course or permission of instructor

Enrollment Limit: 14

Enrollment Preferences: sophomores and juniors planning to take GEOS 301, 302 and/or 303 in the subsequent year

Expected Class Size: 12

Grading: yes pass/fail option, no fifth course option

Distributions: (D3)

Attributes: EXPE Experiential Education Courses GEOS Group C Electives - Solid Earth MTSC Courses

Not offered current academic year

GEOS 205  (F)  Economic Geology and Earth Resources

Cross-listings: GEOS 205  ENVI 207

Primary Cross-listing

“If it can't be grown, it must be mined.” We depend on the solid Earth for a huge array of resources. The metal in your soda can, the plastic in your Nalgene, the components of your computer, the glass in your window, the hydrocarbons being burned to keep you warm in the winter or to transport you in cars or aircraft, the cars and aircraft themselves: all are made of materials mined from the Earth. Right now there are more people building more houses, paving more roads, making more vehicles, more electronics, and more plastic packaging—all with geologic materials. As demand soars in both established and growing economies, and as we realize the environmental damage that can result from resource extraction and processing, the importance of understanding Earth's resources increases. Finding new deposits and managing those we have requires insight into the geology that underlies the location and origin of strategic Earth materials. This class introduces the geologic processes that control formation, distribution, and extent of materials reserves: dimension stone and gravel, base and precious metal ores, gemstones, petroleum, nuclear energy sources, and specialty materials for medical, technological, and military uses. This course is in the SOLID EARTH GROUP for the Geosciences major.

Class Format: 2.5 hours lecture per week and one 3 hour lab per week, including some field labs

Requirements/Evaluation: one hour exam, a final exam, lab exercises, and a group project

Prerequisites: one 100-level GEOS course or permission of instructor

Enrollment Limit: 18

Enrollment Preferences: sophomores and Geosciences majors

Expected Class Size: 18

Grading: no pass/fail option, no fifth course option

Distributions: (D3)

This course is cross-listed and the prefixes carry the following divisional credit:

GEOS 205 (D3) ENVI 207 (D3)

Attributes: ENVI Natural World Electives GEOS Group C Electives - Solid Earth

Not offered current academic year

GEOS 207  (S)  The Geoscience of Epidemiology and Public Health  (DPE)

Cross-listings: ENVI 201  GEOS 207

Primary Cross-listing

The Coronavirus pandemic has highlighted the many ways that diseases can be transmitted in the environment. As a society we are becoming aware of the many ways that geological processes and materials and influence human health, in ways both beneficial and dangerous. This course unites geoscience, biomedicine and public health approaches to address a wide range of environmental health problems. These include water-related illnesses (e.g. diarrhea, malaria); minerals and metals, both toxic (e.g. asbestos, arsenic) and essential (e.g. iodine); radioactive poisoning (e.g. radon gas); and the transport of pathogens by water and wind. In many cases, the environmental health problems disproportionately affect marginalised populations, contributing to greater disease and death among poor communities and populations of colour. We will examine the broad array of dynamic connections between human health and the natural world. We will discuss the social justice implications of a range of environmental health
problems. And we will examine current research into how coronaviruses, such as the one causing COVID-19, are transported in the environment. This course is in the Sediments and Life group for the Geosciences Major.

**Requirements/Evaluation:** Evaluation will be based on short weekly writing assignments as well as an individual project and poster presentation.

**Prerequisites:** No prerequisites

**Enrollment Limit:** 34

**Enrollment Preferences:** Preference to first-years, sophomores, and prospective Geosciences majors

**Expected Class Size:** 30

**Grading:** yes pass/fail option, yes fifth course option

**Distributions:** (D3) (DPE)

This course is cross-listed and the prefixes carry the following divisional credit:

ENVI 201 (D3) GEOS 207 (D3)

**Difference, Power, and Equity Notes:** Through a series of case studies, we will examine ways in which marginalised groups (whether due to poverty, race, or ethnicity) are disproportionately affected by environmental health issues. Themes of power and equity in terms of decision making, access to knowledge, and funding availability, will be woven into all aspects of the class and will underpin our analysis of the science.

**Attributes:** ENVI Natural World Electives GEOS Group B Electives - Sediments + Life PHLH Nutrition, Food Security + Environmental Health

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**GEOS 208 (F) The Modern Carbon Cycle: the Story from Stable Isotopes**

Burning fossil fuels, industrial agriculture, and microbial processes all emit greenhouse gases to the atmosphere, and therefore contribute to climate change. But in what proportions? Enter stable isotopes. Everything around you—including the lithosphere, biosphere and hydrosphere—contains a mixture of carbon of mass 12 or 13. By learning the processes that control the ratio of these two stable isotopes in different Earth materials, we can better understand the modern carbon cycle, including its inputs and outputs, transformative processes, and interaction with global climate. In this course, we will review the basics of stable carbon isotope theory and analysis and use these tools to better understand the carbon cycle on different spatial and temporal scales. We will consider how to model both global and local sources of carbon to the atmosphere, both conceptually and through simple box models using stable isotopes. In lab, students will write models in R (no prior experience required), prepare organic and inorganic materials for carbon isotope analysis by a commercial laboratory, and correct and analyze real isotope data. This course is in the Oceans and Climate Group for the Geoscience major.

**Class Format:** 2.5 hours lecture per week and one 3 hour lab per week

**Requirements/Evaluation:** Weekly lab assignments, bi-weekly (open book) quizzes, a final project including a written report and oral presentation.

**Prerequisites:** one 100-level GEOS course or permission of instructor

**Enrollment Limit:** 15

**Enrollment Preferences:** sophomore and junior GEOS majors

**Expected Class Size:** 15

**Grading:** no pass/fail option, yes fifth course option

**Distributions:** (D3)

**Attributes:** GEOS Group A Electives - Climate + Oceans

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**Spring 2023**

LEC Section: 01    Cancelled
LAB Section: 02    Cancelled

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**GEOS 210 (F)(S) Oceanographic Processes**

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**Fall 2022**

LEC Section: 01    TR 9:55 am - 11:10 am    Ana C. Gonzalez-Nayeck
LAB Section: 02    T 1:00 pm - 4:00 pm    Ana C. Gonzalez-Nayeck
LAB Section: 03    W 1:00 pm - 4:00 pm    Ana C. Gonzalez-Nayeck

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**GEOS 210 (F)(S) Oceanographic Processes**
**Cross-listings:** GEOS 210  MAST 211

**Secondary Cross-listing**

Part of the Williams-Mystic Coastal and Ocean Studies Program, this course provides an introduction to physical, geological, chemical, and biological oceanography. Using local field sites as well as places visited on field seminars, we will investigate why the Earth has oceans, why they are salty, how they move and flow, reasons for sea level change on both long and short timescales, and how our oceans interact with the atmosphere to control global climate. We will emphasise societal interactions with the ocean, and will consider coastal processes including land loss. We will apply an environmental justice and anti-racist lens to our discussions. Field work will take place on shores in southern New England, as well as during field seminars on the Atlantic ocean, the West Coast and the Mississippi River Delta. This course is in the Oceans and Climate group for the Geosciences major.

**Class Format:** Flipped classroom will focus on active learning using data-based exercises. Mini-symposia will involve student research and discussion.

**Requirements/Evaluation:** graded lab exercises, mini-symposium participation, and a research project

**Prerequisites:** none

**Enrollment Limit:** 24

**Enrollment Preferences:** none

**Expected Class Size:** 10

**Grading:** no pass/fail option, no fifth course option

**Unit Notes:** This course is taught at our Mystic Seaport campus. Students must be enrolled in the Williams-Mystic Coastal and Ocean Studies Program.

**Distributions:** (D3)

This course is cross-listed and the prefixes carry the following divisional credit:

GEOS 210 (D3)  MAST 211 (D3)

**Attributes:** ENVI Natural World Electives  EXPE Experiential Education Courses  GEOS Group A Electives - Climate + Oceans

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**GEOS 212 (S) Paleobiology**

**Cross-listings:** GEOS 212  BIOL 211

**Primary Cross-listing**

The fossil record is a direct window into the history of life on Earth and contains a wealth of information on evolution, biodiversity, and climate change. This course investigates the record of ancient life forms, from single-celled algae to snails to dinosaurs. We will explore how, why, when, and where fossils form and learn about the major groups of fossilized organisms and how they have changed through time. In addition, we will cover a range of topics central to modern paleobiology. These include: how the fossil record informs our understanding of evolutionary processes including speciation; the causes and consequences of mass extinctions; how fossils help us tell time and reconstruct the Earth's climactic and tectonic history; statistical analysis of the fossil record to reconstruct biodiversity through time; analysis of fossil morphology to recreate the biomechanics of extinct organisms; and using fossil communities to reconstruct past ecosystems. Laboratory exercises will take advantage of Williams' fossil collections as well as published datasets to provide a broad understanding of fossils and the methods we use to study the history of life on Earth, including using the programming language R (no previous experience is required). We will also view a diversity of fossils in their geologic and paleo-environmental context on our field trip to Eastern New York. This course is in the Sediments and Life group for the Geosciences major.

**Class Format:** One day field trip to the the Paleozoic of New York State

**Requirements/Evaluation:** Weekly lab assignments, frequent short quizzes and writing assignments, and a final project with a written and oral presentation component.

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Prerequisites: any 100-level GEOS course or BIOL 102, 203 or 205

Enrollment Limit: 24

Enrollment Preferences: sophomore and junior GEOS majors

Expected Class Size: 20

Grading: no pass/fail option, no fifth course option

Unit Notes: does not satisfy the distribution requirement for the Biology major

Distributions: (D3)

This course is cross-listed and the prefixes carry the following divisional credit:

GEOS 212 (D3) BIOL 211 (D3)

Attributes: EXPE Experiential Education Courses GEOS Group B Electives - Sediments + Life MAST Interdepartmental Electives

Not offered current academic year

GEOS 214 (S) Mastering GIS

Cross-listings: GEOS 214 ENVI 214

Primary Cross-listing

The development of Geographic Information Systems (GIS) has allowed us to investigate incredibly large and spatially complex data sets like never before. From assessing the effects of climate change on alpine glaciers, to identifying ideal habitat ranges for critically endangered species, to determining the vulnerability of coastal communities to storms, GIS has opened the door for important, large-scale environmental analyses. And as these technologies improve, our ability to understand the world grows ever greater. This course will teach you how to use GIS to investigate environmental problems. We will review fundamental principles in geography, the construction and visualization of geospatial datasets, and tools for analyzing geospatial data. Special attention will also be given to analysis of remotely sensed (satellite) imagery and to collection of field data. By the end of the course, you will be able to conduct independent GIS-based research and produce maps and other geospatial imagery of professional quality.

Class Format: lecture, three hours per week and laboratory, three hours per week

Requirements/Evaluation: weekly lab exercises, weekly quizzes, and a research project

Prerequisites: at least one course in Geosciences or Environmental Studies

Enrollment Limit: 18

Enrollment Preferences: Geosciences majors and Environmental Studies majors and concentrators.

Expected Class Size: 18

Grading: yes pass/fail option, no fifth course option

Distributions: (D3)

This course is cross-listed and the prefixes carry the following divisional credit:

GEOS 214 (D3) ENVI 214 (D3)

Attributes: ENVI Natural World Electives EXPE Experiential Education Courses

Spring 2023

LEC Section: 01  TR 11:20 am - 12:35 pm  José A. Constantine

LAB Section: 02  T 1:00 pm - 4:00 pm  José A. Constantine

LAB Section: 03  R 1:00 pm - 4:00 pm  José A. Constantine

GEOS 215 (S) Climate Changes (QFR)

Cross-listings: ENVI 215 GEOS 215

Primary Cross-listing

Paleoclimatology is the reconstruction of past climate variability and the forces that drove the climate changes. The Earth's climate system is experiencing unprecedented and catastrophic change because of anthropogenic emission of greenhouse gases and land use change. Paleoclimatology allows humans to put modern climate changes into the context of the history of this planet, and shows how and why it is
unprecedented and catastrophic. Each climate event we study from Earth’s past teaches us lessons on why the climate system responds to anthropogenic perturbations, what climate changes we’re committed to in the future, how long-lasting they will be, and what climate consequences we can avoid if we take action and reduce greenhouse gas emissions sooner. In this course, we will discuss the major mechanisms that cause natural climate variability, how climate of the past is reconstructed, and how climate models are used to test mechanisms that drive climate variation. With these tools, you will analyze and interpret data and model simulations from climate events from Earth’s history, and apply these findings to anthropogenic climate changes happening now and that are projected to happen in the future. Laboratories and homework will emphasize developing problem solving skills as well as sampling and interpreting geological archives of climate change. This course is in the Oceans and Climate group for the Geosciences major.

Class Format: This class has three scheduled lectures per week, and one lab meeting per week which will consist of field excursions, lab exercises, problem solving and discussion

Requirements/Evaluation: lab exercises and homework (25%), three quizzes (50%), and a final project (25%)

Prerequisites: 100-level course in GEOS, CHEM, or PHYS or ENVI 102 or permission of instructor

Enrollment Limit: 24

Enrollment Preferences: Geosciences majors and Environmental Studies majors and concentrators and Maritime Studies concentrators

Expected Class Size: 16

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
ENVI 215 (D3) GEOS 215 (D3)

Quantitative/Formal Reasoning Notes: Labs and homework include quantitative problem solving, visualization and analysis of quantitative data, and scientific computing with Matlab. No previous programming experience is assumed.

Attributes: ENVI Natural World Electives EVST Environmental Science EXPE Experiential Education Courses GEOS Group A Electives - Climate + Oceans MAST Interdepartmental Electives

Spring 2023

LEC Section: 01 MWF 9:00 am - 9:50 am Mea S. Cook
LAB Section: 02 W 1:00 pm - 4:00 pm Mea S. Cook
LAB Section: 03 T 1:00 pm - 4:00 pm Mea S. Cook

GEOS 217 (S) Planets and Moons

Cross-listings: ASTR 217 GEOS 217

Primary Cross-listing

This course examines the history and geology of the solar system. No two planets are exactly alike, and as we acquire more data and higher-resolution images, our sense of wonder grows. However, we can't hike around and hammer rocks on Venus or Titan, so we have to infer composition, form, texture and process from remotely-captured images and sparse chemical and spectral data. We will consider the origin of the solar system, the formation and evolution of planetary bodies, and the role of impacts, volcanism, tectonics and geomorphology in shaping them. We will summarize basic geological concepts of stratigraphy, structure and chronology and show how they can be applied off-world. We will review solar system exploration, and will include planetary data in lab exercises. This course is in the Solid Earth group for the Geosciences major.

Requirements/Evaluation: Reading journal, lab exercises, class participation

Prerequisites: any 100-level GEOS or any 100-level ASTR course, or permission of instructor

Enrollment Limit: 20

Enrollment Preferences: Geosciences majors, Astronomy/Astrophysics majors, and sophomores

Expected Class Size: 12

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3)

This course is cross-listed and the prefixes carry the following divisional credit:
ASTR 217 (D3) GEOS 217 (D3)
Attributes: GEOS Group C Electives - Solid Earth

Not offered current academic year

GEOS 220  (F)  Evolution of and on Volcanic Islands  (WS)

Cross-listings: GEOS 220  ENVI 219

Primary Cross-listing

Plate tectonic theory accounts for the vast majority of volcanic islands in ocean basins. They form above mantle plume hot spots (Hawaiian and Galapagos Islands), subduction zones (Aleutian and Indonesian arcs), and mid-ocean ridges (Azores and Ascension Island). Iceland is unusual because it is located above a hot spot and the mid-Atlantic ridge. Each plate tectonic setting produces chemically distinctive magmas, and the lifespan of volcanic islands varies widely. Islands above hot spots may be geographically remote and emergent for only several million years, but be part of a long-lived sequence of islands that persists for over a hundred million years. In contrast, island arc volcanoes belong to long geographically continuous chains of volcanoes, commonly in close proximity to continents. This tutorial explores the geologic evolution and lifespan of volcanic islands from formation to submergence, and searches for correlations between these characteristics and plate tectonic setting. We will also consider how geographic isolation, areal extent, lifespan, and climate affect biological evolution on volcanic islands. There will be weekly tutorial meetings with pairs of students, and students will alternate writing papers on assigned topics. This course is in the Solid Earth group for the Geosciences major.

Class Format: One-hour weekly meetings with tutorial partner and instructor

Requirements/Evaluation: five 5-page papers and critiques of partner's papers

Prerequisites: 100-level GEOS course or permission of instructor

Enrollment Limit: 10

Enrollment Preferences: Geosciences majors and students with a demonstrated interest in geosciences

Expected Class Size: 10

Grading: no pass/fail option, no fifth course option

Distributions: (D3)  (WS)

This course is cross-listed and the prefixes carry the following divisional credit:

GEOS 220  (D3) ENVI 219  (D3)

Writing Skills Notes: Students will write five 5-page papers and will receive instructor feedback on how to improve their writing skills and formulate sound arguments.

Attributes: ENVI Natural World Electives  GEOS Group C Electives - Solid Earth

Not offered current academic year

GEOS 221  (F)  Examining Inconvenient Truths: Climate Science meets U.S. Senate Politics  (WS)

Cross-listings: GEOS 221  ENVI 222  LEAD 221

Primary Cross-listing

Former President Barack Obama once said: "There's one issue that will define the contours of this century more dramatically than any other, and that is the urgent threat of a changing climate." While consensus regarding the causes and impacts of climate change has been growing steadily among scientists and researchers (and to some extent, the general public) over the past two decades, the U.S. has yet to confront this issue in a manner consistent with its urgency. This lack of action in the U.S. is at least partly due to the fact that science provides necessary but insufficient information towards crafting effective climate change legislation and the unfortunate fact that climate change has become a highly partisan issue. The primary objective of this tutorial will be to help students develop a greater understanding of the difficulties associated with crafting climate change legislation, with an emphasis on the role of science and politics within the legislative process. To this end, the tutorial will address how the underlying scientific complexities embedded in most climate policies (e.g., offsets, carbon capture and sequestration, uncertainty and complexity of the climate system, leakage) must be balanced by and blended with the different operational value systems (e.g., economic, social, cultural, religious) that underlie U.S. politics. Over the course of this tutorial, students will develop a nuanced sense of how and when science can support the development of comprehensive national climate change legislation within the current partisan climate. This course will take a practical approach, where students will draft weekly policy-oriented documents (e.g., policy memos, action memos, research briefs) targeted to selected members of the current U.S. Senate Environment and Public Works Committee, the committee that has historically held jurisdiction over a majority of the major climate change bills that have moved through the legislative process. This course is in the Oceans and Climate group for the Geosciences major.
Requirements/Evaluation: weekly papers (2 - 5 pages in length) and a final oral presentation
Prerequisites: none
Enrollment Limit: 10
Enrollment Preferences: sophomores, Geosciences and Environmental Studies juniors and seniors
Expected Class Size: 10
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (WS)

This course is cross-listed and the prefixes carry the following divisional credit:
GEOS 221 (D3) ENVI 222 (D3) LEAD 221 (D3)

Writing Skills Notes: You will learn to write in a variety of policy-focused formats
Attributes: ENVI Environmental Policy EXPE Experiential Education Courses GEOS Group A Electives - Climate + Oceans

Not offered current academic year

GEOS 226 (S) The Oceans and Climate (WS)

Cross-listings: GEOS 226 ENVI 226 ENVI 252 MAST 226

Primary Cross-listing
The oceans are a fundamental part of Earth's climate system. Ocean currents redistribute heat and water vapor around the globe, controlling temperature and precipitation patterns. Marine phytoplankton blooms and air-sea gas exchange modulate the atmospheric carbon dioxide concentration. The dynamic interaction of the atmosphere and the sea surface results in multi-year climate variations such as the El Niño-Southern Oscillation. This course will examine gradual and abrupt climate shifts from Earth's history and the ocean's role in driving, amplifying or dampening the changes, the ocean's response to anthropogenic greenhouse gas emissions, and the projected impacts of continued emissions and climate change on the ocean in the coming decades and millennia. We will analyze articles from the scientific literature that lay out the theory on the ocean's influence on climate, reconstruct past climate and ocean changes, test the mechanisms responsible for those changes, and with that knowledge, project the consequences of continued anthropogenic greenhouse gas emissions. Topics may include the climate effects of opening and closing seaways with plate tectonics, ocean feedbacks that amplify the intensity of ice ages, the instability of ocean circulation during ice-sheet retreat, the evolution of the El Niño-Southern Oscillation with changing carbon dioxide through the geologic past and the next century, ocean heat and carbon dioxide uptake during the last century and into the future, and the impact on sea level, seafloor methane reservoirs, ocean acidification, oxygenation and marine ecosystems. This course is in the Oceans and Climate group for the Geosciences major.

Requirements/Evaluation: evaluation will be based on the critical analysis of reading from the scientific literature through discussion, writing and revision
Prerequisites: at least one GEOS course
Enrollment Limit: 10
Enrollment Preferences: students with a strong interest in Geosciences and Geosciences majors
Expected Class Size: 10
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (WS)

This course is cross-listed and the prefixes carry the following divisional credit:
GEOS 226 (D3) ENVI 226 (D3) ENVI 252 (D3) MAST 226 (D3)

Writing Skills Notes: each student will write five 5-page position papers and five 1-page response papers; students will give and receive feedback through peer review and tutorial meeting discussions and will develop their writing and critical analysis skills through revision
Attributes: ENVI Natural World Electives GEOS Group A Electives - Climate + Oceans MAST Interdepartmental Electives

Not offered current academic year

GEOS 227 (S) Climate Data Analysis

Cross-listings: GEOS 227 ENVI 226

Primary Cross-listing
In this tutorial, students will learn how to access and work with the datasets that show how our climate is changing. The course introduces a series of analytical methods used in climate science, and students then apply those 'recipes' to data of their choosing to research parts of the climate system. Over the course of the term, a student might investigate the seasonality of global atmospheric carbon dioxide levels, maps of sea level anomalies, and the impact El Niño patterns have on Western US rainfall. Students will present their findings, and their insights into the particular aspect of the climate system, at weekly tutorial meetings. Analytical approaches covered in the class include climatologies, time series analysis (trends, periodicity, and autocorrelation), anomaly maps, composites, and zonal/meridional averaging. As for regions and climate systems students can explore: the sky is the limit. This course is in the Oceans and Climates group for the Geosciences major.

Class Format: Asynchronous recorded lectures will provide instruction on new analytical techniques every two weeks. Students will meet in pairs for one hour every week with the instructor: each student will present the results of their data analysis and their interpretation for discussion every other week.

Requirements/Evaluation: Five 3-4 page papers including figures made from analyzing data.

Prerequisites: At least one GEOS or ENVI course

Enrollment Limit: 10

Enrollment Preferences: Students with a strong interest in Geosciences and Geoscience majors.

Expected Class Size: 10

Grading: no pass/fail option, no fifth course option

Distributions: (D3)

This course is cross-listed and the prefixes carry the following divisional credit:

GEOS 227 (D3) ENVI 226 (D3)

Attributes: ENVI Natural World Electives EVST Environmental Science GEOS Group A Electives - Climate + Oceans

Not offered current academic year

GEOS 234 (S) Introduction to Materials Science (QFR)

Cross-listings: GEOS 234 PHYS 234

Secondary Cross-listing

Materials Science is the study of how the microscopic structure of materials—whether steel, carbon fiber, glass, wood, plastic, or mayonnaise—determines their macroscopic mechanical, thermal, electric, and other properties. Topics of this course include classifying materials; material structure; thermodynamics and phase transformations; material properties and testing; how solids bend, flow, and ultimately break; and how to choose the right material for design applications. Materials Science is a highly interdisciplinary field and as a result the course prerequisites are broad but also flexible. Interested students who are unsure about their preparation are strongly encouraged to contact the instructor.

Class Format: lecture (3 hours per week) plus three to four small-group laboratory sessions throughout the semester (to be scheduled with instructor)

Requirements/Evaluation: weekly problem sets, class participation, and midterm and final exams, all of which have a substantial quantitative component

Prerequisites: high school physics and chemistry, preferably at the AP level, and MATH 140 or AP Calculus (BC), and one 200-level PHYS, CHEM, or GEOS course; or permission of instructor

Enrollment Limit: 20

Enrollment Preferences: based on students' scientific background and seniority

Expected Class Size: 10

Grading: yes pass/fail option, yes fifth course option

Unit Notes: This course does not count toward the Geosciences major.

Distributions: (D3) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:

GEOS 234 (D3) PHYS 234 (D3)

Attributes: MTSC Courses

Not offered current academic year
GEOS 255 (F) Environmental Observation

Cross-listings: GEOS 255 ENVI 255

Primary Cross-listing

To study the environment, we need to observe and measure it. We collect data--numbers that represent system states--and analyze them to create understanding of the world we live in. Advances in technology create more opportunities to discover how the planet works. Through a survey of observational approaches (including weather stations, direct sampling, remote sensing, community-based monitoring, and other techniques), this course will investigate the process of turning a physical property in the environment into a number on a computer and then into meaningful information. We will explore both direct field measurements and remote sensing techniques, diving into how to choose the appropriate sensor for a scientific question, how sensors work, analysis approaches and statistical methods, and how to interpret the resulting data. We will also learn how to mitigate measurement bias through a combination of lab experiments and field work and how to make interpretations of measurements that accurately reflect what is being measured. The course will focus on the near-surface environment, including the atmosphere, water, and biosphere. Students will carry out a research project using observation techniques covered in class to explore a scientific question of interest. This course is in the Oceans and Climate group for the Geosciences major.

Requirements/Evaluation: Weekly labs, four quizzes, and a final project

Prerequisites: at least one prior course in GEOS or ENVI

Enrollment Limit: 20

Enrollment Preferences: sophomores, then GEOS majors

Expected Class Size: 10

Grading: no pass/fail option, no fifth course option

Distributions: (D3)

This course is cross-listed and the prefixes carry the following divisional credit:
GEOS 255 (D3) ENVI 255 (D3)

Attributes: ENVI Natural World Electives EXPE Experiential Education Courses GEOS Group A Electives - Climate + Oceans

Not offered current academic year

GEOS 301 (F) Geomorphology

Cross-listings: GEOS 301 ENVI 205

Primary Cross-listing

Geomorphology is the study of landforms, the processes that shape them, and the rates at which these processes change the landscape in which we live. The course is designed for Geosciences majors and for environmental studies students interested in the evolution of Earth's surface and the ways our activities are changing the planet. We will examine the ways in which climatic, tectonic, and volcanic forces drive landscape evolution over relatively short periods of geologic time, generally thousands to a few millions of years. More recently, the impacts of human activity in reshaping landscapes, determining the movement of water, and changing climate could not be clearer. We will also examine how these impacts are affecting communities, including causes and possible solutions to environmental injustice. We will learn a range of practical skills for describing physical environments and for predicting how they change, including field surveys, GIS analysis, and numerical modelling. This course is in the Sediments and Life group for the Geosciences major.

Class Format: lecture, three hours per week and laboratory, three hours per week

Requirements/Evaluation: weekly lab exercises, a research project, and a midterm and final exam

Prerequisites: At least one 100-level and one 200-level GEOS or ENVI course or permission of instructor

Enrollment Limit: 18

Enrollment Preferences: GEOS and ENVI majors

Expected Class Size: 18

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3)

This course is cross-listed and the prefixes carry the following divisional credit:
GEOS 301 (D3) ENVI 205 (D3)

Attributes: AMST Space and Place Electives ENVI Natural World Electives EVST Environmental Science EXPE Experiential Education Courses
GEOS 302 (S) Sedimentology (WS)
Sediments and sedimentary rocks are the book in which Earth’s history is recorded, where we read the stories of ancient oceans and continents, and how life evolved. Sand and dirt preserve information about the rocks that were eroded to form them, the fluids and forces that transported them, the ways in which they were deposited, and the ecosystems that they supported. Understanding sediments is also fundamental to society, for many kinds of civil engineering as well as pollution and environmental remediation. We will investigate sediment composition, fluid mechanics, bedforms, and depositional environments, building to an integrated understanding of erosion, deposition, and changes over time. We will also acknowledge and examine the roles that racism and colonialism have played in sedimentologic research. This course is in the Sediments and Life group for the Geosciences major.

Class Format: lecture/discussion three hours per week and laboratory three hours per week; field trips: two half-day and one all-day

Requirements/Evaluation: lab and field exercises, writing assignments, participation in discussions

Prerequisites: At least one course in GEOS Group B (Solid Earth) AND one course in GEOS Group C (Sediments and Life); or permission of instructor

Enrollment Limit: 15

Enrollment Preferences: Geosciences majors

Expected Class Size: 12

Grading: yes pass/fail option, no fifth course option

Distributions: (D3) (WS)

Writing Skills Notes: Weekly 2-3 page writing assignments will be thoroughly edited for style, grammar, and syntax; each student will compile their papers as a growing body of work, and each new assignment will be read and edited in the context of previous submissions.

Attributes: EXPE Experiential Education Courses  GEOS Group B Electives - Sediments + Life  MAST Interdepartmental Electives

Not offered current academic year

GEOS 303 (S) Igneous and Metamorphic Petrology
Using plate tectonics and the geologic assembly of New England as a template, this course explores the origin of crystalline rocks—volcanic, plutonic, and metamorphic—that comprise 94% of the Earth’s crust. Field and lab studies are the crux of the course, supported by experimental work and thermodynamic principles. Chemical and mineralogical compositions and rock fabrics provide evidence for crystallization environments and tectonic settings, past and present. This course is in the Solid Earth group for the Geosciences major.

Class Format: Discussion, three hours per week and laboratory, two hours per week; several field trips during lab hours.

Requirements/Evaluation: lab work, one hour test, and a final exam

Prerequisites: GEOS 202 or permission of instructor

Enrollment Limit: 10

Enrollment Preferences: GEOS majors

Expected Class Size: 7

Grading: yes pass/fail option, no fifth course option

Distributions: (D3)

Attributes: GEOS Group C Electives - Solid Earth

Not offered current academic year

GEOS 304 (S) Mineralogy and Petrology
Minerals are Earth’s basic building blocks. They form, deform, and transform in response to environment conditions, and in doing so, they record a wide range of processes in the Earth system. In this course, we will use minerals to understand the geologic record at multiple timescales, from the slow process of continental assembly and break-up to rapid processes such as volcanic eruptions and biogeochemical cycles. Central to this analysis is rock and mineral characterization. Therefore, laboratory and field studies will hone fundamental observational skills of minerals at multiple scales, from atomic scale crystalline structures to macroscopic physical properties in hand sample. Discussion of experimental and natural data (phase
relationships, thermodynamics, and major and trace element geochemistry) in conjunction with these petrographic approaches, will create a framework for interpreting the dynamic processes and geologic settings where igneous and metamorphic rocks form. The semester will culminate in a final project that applies both the observation and interpretive skills developed, giving students the chance to collect data and "read the geologic record" left behind in rocks from around the world.

Class Format: three lectures per week with two lab sections.
Requirements/Evaluation: This class may include field trips, problem sets, 2-3 exams and an final project
Prerequisites: 1 100-level GEOS course
Enrollment Limit: 24
Enrollment Preferences: GEOS majors who have taken at least one 100-level GEOS course.
Expected Class Size: 24
Grading: yes pass/fail option, no fifth course option
Distributions: (D3)
Attributes: GEOS Group C Electives - Solid Earth

GEOS 308 (S) Life on Mars?
On February 18th, 2021, the Perseverance Rover landed in the Jezero Crater on Mars, with the objective to "seek signs of ancient life and collect samples of rock and regolith (broken rock and soil) for possible return to Earth." In this course, we will investigate what "signs" would point to ancient or modern life, both on the Martian surface and in the chemistry of any samples (eventually) returned to Earth. Topics to be covered include the visual and chemical evidence for life on Earth and its application to Martian environments; if and how compounds indicative of life could be preserved in Martian rocks; insights from Earth analogues for Mars environments; the potential for modern subsurface life on Mars; and whether life on Earth could have originated on Mars. In lab, we will grow our own microbial mats, and characterize the visual and chemical characteristics that make them "alive."
As a final project, students will prepare a mock manuscript for publication in the journal Astrobiology. This course is in the Sediments and Life Group for the Geoscience major.

Class Format: 3 hours per week of class, 3 hours per week of lab
Requirements/Evaluation: Weekly lab assignments, two reports on primary literature, final paper in the style of a manuscript for publication
Prerequisites: any 100-level GEOS course
Enrollment Limit: 15
Enrollment Preferences: junior and senior GEOS majors, or permission of instructor
Expected Class Size: 12
Grading: no pass/fail option, no fifth course option
Distributions: (D3)
Attributes: GEOS Group B Electives - Sediments + Life

GEOS 309 (F) Modern Climate (QFR)
Cross-listings: GEOS 309 ENVI 209
Primary Cross-listing
What will happen to the Earth's climate in the next century? What is contributing to sea level rise? Is Arctic sea ice doomed? In this course we will
study the components of the climate system (atmosphere, ocean, cryosphere, biosphere and land surface) and the processes through which they interact. Greenhouse gas emission scenarios will form the basis for investigating how these systems might respond to human activity. This course will explore how heat and mass are moved around the atmosphere and ocean to demonstrate how the geographic patterns of climate change arise. We will also focus on climate feedback effects—like the albedo feedback associated with sea ice and glacier loss—and how these processes can accelerate climate change. In labs we will learn MATLAB to use process and full-scale climate models to investigate the behavior of these systems in response to increasing greenhouse gasses in the atmosphere. This course is in the Oceans and Climate group for the Geosciences major.

**Requirements/Evaluation:** 4 multi-week lab projects and several short quizzes

**Prerequisites:** Any of GEOS 100, GEOS 103, ENVI 102, GEOS 215, or permission of instructor

**Enrollment Limit:** 30

**Enrollment Preferences:** GEOS and ENVI majors

**Expected Class Size:** 20

**Grading:** yes pass/fail option, yes fifth course option

**Distributions:** (D3)  (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:

GEOS 309  (D3) ENVI 209  (D3)

**Quantitative/Formal Reasoning Notes:** Labs consist of a series of numerical climate modeling projects, which require significant quantitative and logical reasoning.

**Attributes:**  ENVI Natural World Electives  EVST Environmental Science  GEOS Group A Electives - Climate + Oceans

Not offered current academic year

**GEOS 312  (F) Mass Extinctions: Patterns and Processes**  (WS)

Over the last 541 million years of Earth history, five major mass extinctions have occurred, each dramatically changing the makeup and course of life on our planet. During some of these events, over 75% of all marine animal species went extinct; during others, groups like the dinosaurs vanished from the planet after tens of millions of years of ecological dominance. This tutorial course will explore the idea of extinction from the evolution of the concept in human thought to current research on the mechanisms and patterns of extinctions through time. We will examine what makes an extinction "mass", delve into the causes and consequences of the major mass extinction events of the Phanerozoic, and discuss the potential human-induced "6th extinction" event occurring in the present day. This course is in the Sediments and Life group for the Geosciences major.

**Class Format:** Weekly 1-hour tutorial meetings with pairs of students; one required all-day field trip.

**Requirements/Evaluation:** four 4-5-page papers, one revision, tutorial presentations, the student's effectiveness as a critic, and 1 problem set

**Prerequisites:** GEOS 107 or GEOS 212; or permission of instructor + any 200 level GEOS course

**Enrollment Limit:** 10

**Enrollment Preferences:** Geosciences majors

**Expected Class Size:** 10

**Grading:** no pass/fail option, no fifth course option

**Distributions:** (D3)  (WS)

**Writing Skills Notes:** This is a tutorial that involves students writing 4 original response papers and one substantial revision to their writing.

**Attributes:** GEOS Group B Electives - Sediments + Life

Fall 2022

TUT Section: T1  TBA  Phoebe A. Cohen

**GEOS 317  (S) Current topics in Planetary Geology**  (WS)

**Cross-listings:** GEOS 317  ASTR 317

**Primary Cross-listing**

We will look in detail at geological processes on rocky and icy bodies of the Solar System. Each week will have a specific theme, and students will read a series of scientific articles on that topic. The readings will form the basis for writing and discussion. Areas to be investigated may include ice...
ages on Mars, the origin of Earth's moon, tectonics on Venus, chaos terrain on Europa, geysers on Enceladus, cryovolcanism on Triton, methane lakes on Titan, the viability of mining in the Asteroid Belt, and the prospects for life on other worlds. This course is in the Solid Earth group for the Geosciences major.

**Class Format:** Students meet with the professor weekly, in pairs, with one student writing each week and the other critiquing; and both engaging in detailed discussion of the readings.

**Requirements/Evaluation:** Evaluation is based on written papers, critiques, and discussion.

**Prerequisites:** GEOS/ASTR 217 (Planets and Moons); OR any two courses at 200-level or higher in Geosciences and/or Astronomy; OR permission of instructor

**Enrollment Limit:** 10

**Enrollment Preferences:** Geosciences and Astronomy majors and prospective majors

**Expected Class Size:** 6

**Grading:** yes pass/fail option, yes fifth course option

**Distributions:** (D3) (WS)

This course is cross-listed and the prefixes carry the following divisional credit:

GEOS 317 (D3) ASTR 317 (D3)

**Writing Skills Notes:** This tutorial-style course focuses on writing, with 6 papers (5-7 pages) written bi-weekly throughout the semester, and partner critiques in alternate weeks.

**Attributes:** GEOS Group C Electives - Solid Earth

Not offered current academic year

**GEOS 350 (S) Climate, Tectonics, and Erosion (WS)**

Traditionally tectonics investigated processes operating deep in the crust and mantle, whereas geomorphology focused on surficial processes that shape the landscape. This course explores the complex interactions between tectonic and surficial processes. It has long been recognized that crustal uplift during mountain building creates new landscapes, but we now suspect that variations in erosion rate can fundamentally influence the development of mountains. Climate plays a central role in this feedback loop; the rise of mountains can change climate, and such changes can alter regional erosion rates. This course will examine how geologists use characteristic markers to estimate the amount of surface uplift, methods for determining uplift rate, surface response to faulting and folding, measuring displacement of the crust with GPS and interferometry methods, how mountain building affects erosion and exhumation rates, the limits to relief in mountains, and the interaction between mountains and climate. This course is in the Solid Earth group for the Geosciences major.

**Class Format:** After an initial group meeting, students will meet in pairs for one hour each week with the instructor; each student will orally present a written paper every other week for criticism during the tutorial session

**Requirements/Evaluation:** five 4- to 5-page papers based on journal articles

**Prerequisites:** at least one of the following courses: GEOS 101, 102, 103, 202, 203, 215, 302, 303, 303 or permission of instructor

**Enrollment Limit:** 10

**Enrollment Preferences:** Geosciences majors and students with a strong interest in Geosciences

**Expected Class Size:** 10

**Grading:** no pass/fail option, no fifth course option

**Distributions:** (D3) (WS)

**Writing Skills Notes:** Five 4- to 5-page papers distributed throughout the semester. Students will receive from the instructor timely comments on their writing skills, with suggestions for improvement.

**Attributes:** GEOS Group C Electives - Solid Earth

Not offered current academic year

**GEOS 401 (F) Global Tectonics and the Rise of Mountains (WS)**

Fifty years after the sea-floor spreading hypothesis was first verified using magnetic anomalies, we have spectacular data sets from paleomagnetism, seismology, volcanism, the Global Positioning System, and digital elevation models that provide rich details into the kinematics and mechanisms of present and past plate motions. We will read journal articles to explore how plate tectonics can help explain the evolution of mountain belts with
special emphasis on the Appalachians.

**Class Format:** Remote, weekly one-hour meetings with tutorial partner and instructor

**Requirements/Evaluation:** five papers based on journal articles, and critiques of partner's papers

**Prerequisites:** GEOS 203, 302, or 303 or permission of instructor

**Enrollment Limit:** 10

**Enrollment Preferences:** senior Geosciences majors, then juniors

**Expected Class Size:** 10

**Grading:** no pass/fail option, no fifth course option

**Unit Notes:** As a 400-level seminar, this capstone course is intended to build on and extend knowledge and skills students have developed during previous courses in the major

**Distributions:** (D3) (WS)

**Writing Skills Notes:** Five 5-page papers throughout the semester based on journal articles. Students will receive from the instructor timely comments on their writing skills, with suggestions for improvement.

**Attributes:** GEOS Group C Electives - Solid Earth

Not offered current academic year

**GEOS 404 (F) Coastal Processes and Geomorphology (QFR)**

**Cross-listings:** MAST 404 ENVI 404 GEOS 404

**Primary Cross-listing**

Can people live safely along the coast? Recent events like SuperStorm Sandy and the Tohoku Tsunami have shown us how the ocean can rise up suddenly and wreak havoc on our lives and coastal infrastructure. Only educated geoscientists can evaluate the risks and define informed strategies to prevent future coastal catastrophes. Currently almost half the global population lives within 100 km of the coast, with a large percent of those living in densely populated cities (e.g., New York, New Orleans, Los Angeles, Shanghai, Hong Kong, Cape Town, Sydney, Mumbai). Despite the growing risks and challenges associated with climate change and rising sea levels, the coastal population continues to grow rapidly. To help ensure these growing populations can live safely along the coast requires a detailed understanding of the processes that shape the coastal zone. These processes act across a variety of scales, from deep-time geologic processes that dictate coastal shape and structure, to decadal-scale processes that determine shoreline position and evolution, to weekly and daily processes such as storms and tides. This course will provide an in-depth look at the forces--wind, waves, storms, and people--that shape the coastal zone, as well as the geologic formations--sandy beaches, rocky cliffs, barrier islands, deltas, and coral reefs--that are acted upon and resist these forces. Coastal dynamics are strongly affected by human interventions, such as seawalls, dredged channels, and sand dune removal, as well as by sea level rise and changes in storm frequency and magnitude associated with climate change.

Finally, the course will provide students with a perspective on how the U.S. seeks to manage its coastal zone, focusing on sea level rise and coastal development. This class will include a quantitative lab that will use MATLAB software to model and evaluate various coastal processes. Students will gain a basic understanding of MATLAB functionality, and will be asked to independently apply what they have learned to various data sets provided by the instructor.

**Class Format:** lecture two times a week with a lab one time per week

**Requirements/Evaluation:** lab reports, quizzes, and an independent research project

**Prerequisites:** Either GEOS 104 or GEOS 210; or permission of instructor. No prior knowledge is necessary, but this course does build on principles used to explore complex scientific challenges.

**Enrollment Limit:** 12

**Enrollment Preferences:** senior Geosciences majors, then juniors

**Expected Class Size:** 10

**Grading:** yes pass/fail option, yes fifth course option

**Unit Notes:** As a 400-level seminar, this capstone course is intended to build on and extend knowledge and skills students have developed during previous courses in the major. This course counts toward the GEOS Group B Electives - Sediments + Life.

**Distributions:** (D3) (QFR)

**This course is cross-listed and the prefixes carry the following divisional credit:**

MAST 404 (D3) ENVI 404 (D3) GEOS 404 (D3)
Quantitative/Formal Reasoning Notes: This course will involve the use of MATLAB software to quantitatively analyze coastal process and geomorphological data.

Attributes: ENVI Natural World Electives  GEOS Group B Electives - Sediments + Life

Fall 2022

LEC Section: 01     MWF 8:30 am - 9:45 am     Alex A. Apotsos

GEOS 410  (S)  The Cryosphere

Cross-listings: ENVI 410  GEOS 410

Primary Cross-listing

The Earth's climate system is often described in terms of its spheres, including the atmosphere, biosphere, lithosphere, oceans, and the cryosphere. The cryosphere is the naturally occurring ice on Earth in all its many forms: snow, glaciers, ice sheets, sea ice, frozen lakes and rivers, and permafrost (frozen soil). These parts of the climate system may seem remote, but have implications for climate and weather around the world. Melting glaciers and ice sheets have already contributed to sea level rise, and are projected to do so even more in the future. This course will explore the cryosphere, including snow, sea ice, permafrost, and glaciers through lectures, hands-on and data analysis labs, reading journal articles, and a final project. A spring break field trip to Alaska offers the opportunity to get boots-on-the-snow experience with glaciers, sea ice, and permafrost. As a 400-level seminar, this capstone course is intended to build on and extend knowledge and skills students have developed during previous courses in the major.

Class Format: Class periods and lab periods will be used interchangeably based on the weather. The spring break trip to Alaska is optional.

Requirements/Evaluation: Evaluation will be based on short papers, labs responses, and a research project

Prerequisites: GEOS 215 or GEOS 255 or GEOS 309 or MAST 311 or permission of instructor

Enrollment Limit: 10

Enrollment Preferences: Senior GEOS majors, then other GEOS majors and senior ENVI majors

Expected Class Size: 10

Grading: yes pass/fail option,  yes fifth course option

Unit Notes: As a 400-level seminar, this capstone course is intended to build on and extend knowledge and skills students have developed during previous courses in the major

Materials/Lab Fee: Labs will be outside during the winter: students should be prepared to dress appropriately for the weather.

Distributions: (D3)

This course is cross-listed and the prefixes carry the following divisional credit:

ENVI 410 (D3)  GEOS 410 (D3)

Attributes: ENVI Natural World Electives  GEOS Group A Electives - Climate + Oceans

Not offered current academic year

GEOS 414  (S)  Reading Deep Time  (QFR)

Ancient sedimentary rocks and the fossils they contain are time machines - direct windows into the deep history of life on Earth and the environments that life inhabited. In this course you will learn to "read" these deep time records by collecting, interpreting, and analyzing paleontological, stratigraphic, and sedimentological data. The course will be organized around a week-long spring break trip to explore the rocks of the House Range of Utah. The Cambrian and Ordovician strata of the House Range offers an outstanding record of one of the most important periods in Earth history, tracking the rise of animal ecosystems and major increases in fossil diversity. The first 6 weeks of class will be spent learning the fundamentals of quantitative methods in paleontology and stratigraphy (often referred to as historical geology). Labs will focus on skill building including learning basic coding in R (no experience needed or expected), and learning how to interpret paleontological, sedimentological, and stratigraphic data. We will also read widely on the field locality and on the Cambrian and Ordovician Periods. During the field trip, we will explore the House Range. Students will learn skills including interpreting geological maps, measuring stratigraphic sections, finding and identifying fossils, and correlating rock units across basins. We will collect samples and data on the field trip and bring them back to Williams. The second 6 weeks of the course will be spent processing and analyzing the samples and data collected during the field trip, culminating in final projects to be done in small groups. Students will help determine what data we will collect in the field and what projects emerge. Examples might be interpreting carbon isotopic analyses to reconstruct ancient oceanographic conditions, biostratigraphic correlation using fossils to reconstruct basin dynamics, determining paleoenvironment based on analyses of
thin sections, or digging into trilobite fossil preservation and evolutionary trends. Students will draw on previous experiences and course content in the Geosciences and bring small group research projects to completion by the end of the semester, which will be presented in poster form. This course fulfills the Geosciences Group B Elective: Sediments and Life.

**Class Format:** weekly lectures, paper discussions, and hands-on labs. Required week-long spring break field course.

**Requirements/Evaluation:** Short papers and lab assignments, spring break field course participation (REQUIRED), and a final group project presented in poster form.

**Prerequisites:** GEOS majors who have taken at least one of the following courses: GEOS 212, GEOS 203, GEOS 201, GEOS 301, GEOS 302, GEOS 312T, or permission of instructor.

**Enrollment Limit:** 12

**Enrollment Preferences:** Senior, and then Junior, Geosciences majors

**Expected Class Size:** 12

**Grading:** no pass/fail option, no fifth course option

**Unit Notes:** As a 400-level seminar, this capstone course is intended to build on and extend knowledge and skills students have developed during previous courses in the major

**Distributions:** (D3) (QFR)

**Quantitative/Formal Reasoning Notes:** This course will rely on the programming language R. Students will learn how to code in R, and will use R to analyze large data sets of geological data. The majority of labs, as well as the final project, will rely on R, statistical analyses, and wrangling data.

**Attributes:** GEOS Group B Electives - Sediments + Life

Spring 2023

SEM Section: 01  MW 11:00 am - 12:15 pm     Phoebe A. Cohen
LAB Section: 02  M 1:00 pm - 4:00 pm     Phoebe A. Cohen

**GEOS 493 (F) Senior Thesis: Geosciences**

Geosciences senior thesis; this is part of a full-year thesis (493-494).

**Grading:** no pass/fail option, no fifth course option

**Distributions:** (D3)

Fall 2022

HON Section: 01  TBA     Phoebe A. Cohen

**GEOS 494 (S) Senior Thesis: Geosciences**

Geosciences senior thesis; this is part of a full-year thesis (493-494).

**Grading:** no pass/fail option, no fifth course option

**Distributions:** (D3)

Spring 2023

HON Section: 01  TBA     Phoebe A. Cohen

**GEOS 497 (F) Independent Study: Geosciences**

Geosciences independent study.

**Grading:** no pass/fail option, no fifth course option

**Distributions:** (D3)

Fall 2022
GEOS 498 (S) Independent Study: Geosciences

Geosciences independent study.

Grading: no pass/fail option, no fifth course option

Distributions: (D3)

Spring 2023

IND Section: 01    TBA     Phoebe A. Cohen

Winter Study -----------------------------------------------------------------------------------------------

GEOS 13 (W) Ecosystems Past and Present: Mexico's Gulf of California

Wedged between mainland Mexico and the Baja California peninsula, the Gulf of California (also called the Sea of Cortez) is a marginal sea that extends from its opening with the Pacific Ocean for 1,100 km northwest to a blind-end at the Colorado River delta. Maximum water depth exceeds 2,500 m in tectonically active segments linked to spreading oceanic crust on the East Pacific Rise. Due to upwelling of nutrient-rich waters, the gulf is one of the most biologically fertile places on the planet. A dozen inter-related ecosystems are found in this special area, including rocky shores, coral reefs, coralline algae banks, clam flats, sandy beaches, coastal dunes, mangroves, closed microbial lagoons, estuaries with related deltas, open sea biome, hydrothermal springs, and at greatest depth mineral-laden black smokers. Each of these functional systems may be compared with direct counterparts preserved in the surrounding rock record dating back roughly 5 million years. The evolution of ecosystems within the Gulf of California up to the present day is outlined with an emphasis on ecosystem services that benefit human kind on multiple levels including geological heritage. During the final week of class, each student will make an oral presentation on a marine zone from another part of the world that entails a multiplicity of ecosystems similar to those in the Gulf of California. Potential topics may include tectonically active zones in the Caribbean, Mediterranean, and Red seas, as well as the Persian Gulf, Western Australia's Shark Bay, Indonesia's Malacca Strait, Japan's Inland Sea, and China's Yellow Sea.

Requirements/Evaluation: final project or presentation; class participation and delivery of an oral report (PowerPoint) on one of the suggested topics

Prerequisites: none

Enrollment Limit: 12

Enrollment Preferences: Priority to First-Year Students with a demonstrated interest in marine geology and biology.

Expected Class Size: NA

Grading: pass/fail only

Unit Notes: Markes Johnson is Professor Emeritus in the Geosciences Department at Williams College and the author of several books on the geology and ecology of Mexico's Baja California.

Attributes: STUX Winter Study Student Exploration

Winter 2023

LEC Section: 01    MTWR 10:00 am - 11:50 am     Markes E. Johnson

GEOS 22 (W) Geosciences Research

Students will spend part of Winter Study doing fieldwork collecting data. Back at Williams, they will analyze the data. Each student will have responsibility for a subset of the data, and the individual sub-projects will contribute to the overall research.

Class Format: to be arranged with instructor

Requirements/Evaluation: final project

Prerequisites: two Geosciences courses; permission of the instructor required before registering for the course

Enrollment Limit: 3

Expected Class Size: 3

Grading: pass/fail only
GEOS 31 (W)  Senior Thesis: Geosciences
To be taken by students registered for Geosciences 493-494.

Class Format: thesis
Grading:  pass/fail only
Distributions:  (D3)

GEOS 99 (W)  Independent Study: Geosciences
Open to upperclass students. Students interested in doing an independent project (99) during Winter Study must make prior arrangements with a faculty sponsor. The student and professor then complete the independent study proposal form available online. The deadline is typically in late September. Proposals are reviewed by the pertinent department and the Winter Study Committee. Students will be notified if their proposal is approved prior to the Winter Study registration period.

Class Format: independent study
Grading:  pass/fail only