GEOSCIENCES (Div III)
Chair: Associate Professor Mea Cook


On leave fall/spring: J. Constantine

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, gemology, 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. The new requirements are immediately below, and the old requirements follow. Students who entered Williams in fall 2019 or after are under the new requirements. Students who entered Williams before fall 2019 are under the old requirements but may opt into the new requirements. Please talk to the Geosciences chair if you have questions about the major requirements.

Geosciences major requirements for students who entered Williams in fall 2019 or after:

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

At least two 200-level courses selected from this group:
GEOS 201 Geomorphology
GEOS 202 Mineralogy
GEOS 203 Field Methods and Structural Geology
GEOS 205 Earth Resources
GEOS 210 Oceanographic Processes
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 Structural Geology
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 411 Geobiology

Finally, students must take enough electives to bring the total to a minimum of nine courses.

In addition, courses taken for the major must include at least two courses from each of the following three groups:

**Climate and Oceans:**
- GEOS 100 Introduction to Weather and Climate
- GEOS 104 Oceanography
- GEOS 210 Oceanographic Processes
- GEOS 215 Climate Changes
- 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 201 Geomorphology
- GEOS 212 Paleobiology
- GEOS 302 Sedimentology
- GEOS 312T Mass Extinctions
- GEOS 314 Analytical Historical Geology

**Solid Earth:**
- GEOS 102 Unfinished Planet
- GEOS 202 Mineralogy
- GEOS 203 Field Methods and Structural Geology
- GEOS 205 Earth Resources
- GEOS 217 Planets and Moons
- GEOS 220T Evolution of and on Volcanic Islands
- GEOS 250T Tectonic Geomorphology and Landscape Evolution
- GEOS 301 Structural Geology
- GEOS 303 Igneous and Metamorphic Petrology

**Geosciences major requirements for students who entered Williams before fall 2019:**

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

**At least two 200-level courses selected from this group:**
- GEOS 201 Geomorphology
GEOS 202 Mineralogy
GEOS 203 Field Methods and Structural Geology
GEOS 205 Earth Resources
GEOS 210 Oceanographic Processes
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 Structural Geology
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 411 Geobiology

Finally, students must take enough electives to bring the total to a minimum of nine courses.

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 12  (W) Geology of the National Parks

Cross-listings:  ENVI 12  GEOS 12

Primary Cross-listing

A vicarious trip through a variety of the national parks of the U.S. and Canada to appreciate the geological basis of their spectacular scenery. Parks will be selected to portray a wide range of geological processes (volcanism, desert and coastal erosion, mountain building, glaciation, etc.). We will meet most mornings during the first two weeks for highly illustrated classes supplemented by the interpretation of topographic and geologic maps and by out-of-class study of rock samples. Reading will be from a paperbound text PARKS AND PLATES and from short publications of the U.S. Geological Survey and natural history associations linked to the parks. The second part of the month will involve independent study and meetings with the instructor to prepare an oral report about the geology of a park of the student’s choice. These reports during the last week will be comprehensive and well illustrated, using PowerPoint and pertinent maps and samples. A detailed outline and list of references will be provided to the group at the time of the presentation.

Requirements/Evaluation: final project or presentation; participation in class meetings

Prerequisites: none

Enrollment Limit: 10

Enrollment Preferences: preference to first-year students who have had no previous college study of geology

Grading: pass/fail only
Materials/Lab Fee: approximately $150 for books

This course is cross-listed and the prefixes carry the following divisional credit:
ENVI 12 GEOS 12

Winter 2020
LEC Section: 01    TBA    Bud Wobus

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

Winter 2020
LEC Section: 01    TBA    Mea S. Cook

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

Class Format: thesis
Grading: pass/fail only

Winter 2020
HON Section: 01    TBA    Mea S. Cook

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

Winter 2020
IND Section: 01    TBA    Mea S. Cook

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.

Class Format: lecture

Requirements/Evaluation: Lab assignments, a midterm, and a final exam

Prerequisites: none

Enrollment Limit: 40

Enrollment Preferences: first-years and sophomores

Expected Class Size: 40

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 100 (D3) ENVI 100 (D3)

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

Spring 2020

LEC Section: 01 MWF 9:00 am - 9:50 am Alice C. Bradley

LAB Section: 02 M 1:00 pm - 3:00 pm Alice C. Bradley

LAB Section: 03 T 1:00 pm - 3:00 pm Alice C. Bradley

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: lecture; one laboratory per week plus one all-day field trip

Requirements/Evaluation: evaluation will be based on lab work, short quizzes, midterms, an independent project, and a final exam

Prerequisites: none

Enrollment Limit: 30

Enrollment Preferences: underclassmen

Expected Class Size: 30

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 101 (D3) ENVI 105 (D3)
Fall 2019

LEC Section: 01  MWF 10:00 am - 10:50 am  Phoebe A. Cohen
LAB Section: 02  M 1:00 pm - 3:00 pm  Phoebe A. Cohen
LAB Section: 03  T 1:00 pm - 3:00 pm  Phoebe A. Cohen

**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 accrete and separate. 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 geological assembly of New England. Readings will be from a physical geology textbook, a primary source supplement, selected writings of John McPhee, and references about the geology of the Northeast.

**Class Format:** lecture, three hours per week; lab (several involving field work), two hours per week; one required all-day field trip on the last Monday of the semester to the Connecticut Valley and the highlands of western Massachusetts

**Requirements/Evaluation:** evaluation will be based on two hour-tests, weekly lab work, and a scheduled final exam

**Prerequisites:** none

**Enrollment Limit:** 40

**Enrollment Preferences:** first-year and sophomore students

**Expected Class Size:** 40

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

**Distributions:** (D3)

Attributes: ENVI Natural World Electives  EXPE Experiential Education Courses  GEOS Group B Electives - Sediments + Life

Spring 2020

LEC Section: 01  MWF 10:00 am - 10:50 am  Bud Wobus
LAB Section: 02  W 1:00 pm - 3:00 pm  Bud Wobus
LAB Section: 03  R 1:00 pm - 3:00 pm  Bud Wobus

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

**Cross-listings:** GEOS 103  ENVI 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 soil erosion, the natural processes that shape the Earth's surface are tied to temperature and precipitation, and as those change, the landscape reacts. People are beginning to feel the impacts, but in different ways depending on where we call home. Our ability to cope with the changes also depends are where we are, with low-income nations the least able to implement costly adaptive strategies. In this course, we will take a tour of the planet, investigating how climate change is altering landscapes and the natural processes that support them. Ultimately, we will develop an understanding of the consequences of climate change that connects physical processes with the geography of place. 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 freshwater and soil. Labs will use local field sites and analytical exercises to evaluate recent cases that reflect an interaction of the landscape and climate.

**Class Format:** lecture/discussion, three hours per week; laboratory, two hours per week in alternate weeks/occasional field trips

**Requirements/Evaluation:** evaluation based on written reports from laboratories, class participation, weekly quizzes, a midterm and final exam

Attributes: ENVI Natural World Electives  EXPE Experiential Education Courses  GEOS Group C Electives - Solid Earth
This course is cross-listed and the prefixes carry the following divisional credit:

GEOS 103 (D3) ENVI 103 (D3)

Attributes: ENVI Natural World Electives  EXPE Experiential Education Courses

Not offered current academic year

GEOS 104 (F) Oceanography

Cross-listings: GEOS 104  ENVI 104  MAST 104

Primary Cross-listing

The oceans cover about 72% of Earth’s surface, yet we know the surface of Venus better than our own ocean floors. Why is that? This integrated introduction to the oceans covers formation and history of the ocean basins; the composition and origin of seawater; currents, tides, and waves; ocean-atmosphere interactions; oceans and climate; deep-marine environments; coastal processes; productivity in the oceans; and human impacts. Coastal oceanography will be investigated on an all-day field trip, hosted by the Williams-Mystic program in Connecticut. This course is in the Oceans and Climates group for the Geosciences major.

Class Format: lecture/discussion, three hours per week; laboratory, two hours per week in alternate weeks/one all-day field trip

Requirements/Evaluation: evaluation will be based on two hour exams, lab work, participation in the field trip, and a final exam

Prerequisites: none

Enrollment Limit: 48

Enrollment Preferences: first-year and sophomore students, MAST concentrators

Expected Class Size: 48

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

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

Fall 2019

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: GEOS 106 PHYS 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 if course over-enrolls

**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:

GEOS 106 (D3) PHYS 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.

Fall 2019

SEM Section: 01  W 1:10 pm - 3:50 pm  Savan Kharel, Phoebe A. Cohen

GEOS 201  (F) Geomorphology

**Cross-listings:** ENVI 205  GEOS 201

**Primary Cross-listing**

Geomorphology is the study of landforms, the processes that shape them and the rates at which surface processes change the landscape in which we live. The course is designed for Geosciences majors and for environmental studies students interested in surficial geologic processes and their importance in shaping the physical environment. We emphasize the influence of climatic, tectonic, and volcanic forces on landform evolution over relatively short periods of geologic time, generally thousands to a few millions of years. At this time scale, the influence of human activity and climate change on geomorphic processes is strong, perhaps dominant, in many geologic environments. Many of our examples analyze human interaction - planned or unplanned-- with geomorphic processes. Labs focus on field measurements of channels and landscapes in the Williamstown area as well as on the analysis of topographic maps and imagery.

**Class Format:** lecture/discussion, three hours per week; laboratory, three hours per week/student projects; weekend field trip to the White Mountains

**Requirements/Evaluation:** evaluation will be based on two hour exams, a project, lab work and class participation

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

**Enrollment Limit:** 18

**Expected Class Size:** 15

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

**Distributions:** (D3)

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

ENVI 205 (D3) GEOS 201 (D3)

**Attributes:** AMST Space and Place Electives ENVI Natural World Electives EVST Environmental Science EXPE Experiential Education Courses

Not offered current academic year

GEOS 202  (S) 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.

Class Format: lecture, three hours per week; laboratory, three hours per week; independent study of minerals in hand specimen; one afternoon field trip

Requirements/Evaluation: evaluation will be based on 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: no pass/fail option, no fifth course option

Distributions: (D3)

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

Spring 2020

LEC Section: 01  TR 8:30 am - 9:45 am  Bud Wobus
LAB Section: 02  T 1:00 pm - 4:00 pm  Bud Wobus

GEOS 203  (F)  Field Methods and Structural Geology  (WS)

The structure of the Earth's crust is constantly changing and the rocks making up the crust must deform to accommodate these changes. Rock deformation occurs over many scales ranging from individual mineral grains to mountain belts. This course deals with the geometric description of structures and the large scale forces responsible for crustal deformation. The laboratories introduce students to best practices for geologic field work, the field identification of common minerals and rocks, geologic contacts, geologic maps and cross sections, folds, and faults. Students will develop skill for presenting field data in papers, figures, and oral presentations.

Class Format: lecture/discussion, three hours per week; laboratory, three hours per week

Requirements/Evaluation: short weekly writing assignments, two 10-page papers based on field trips, and a one-hour exam

Prerequisites: any 100-level Geosciences course or permission of instructor

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 for evaluation by the instructor and peers. The shorter assignments will be incorporated in the field reports. Students will receive from the instructor timely comments on their writing skills, with suggestions for improvement.

Attributes: GEOS Group C Electives - Solid Earth

Fall 2019

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

GEOS 205  (F)  Economic Geology and Earth Resources

Cross-listings: ENVI 207  GEOS 205

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; 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:
ENVI 207 (D3) GEOS 205 (D3)
Attributes: ENVI Natural World Electives GEOS Group C Electives - Solid Earth

Fall 2019
LEC Section: 01 TR 11:20 am - 12:35 pm Ronadh Cox
LAB Section: 02 R 1:00 pm - 4:00 pm Ronadh Cox

GEOS 210  (F)(S)  Oceanographic Processes
Cross-listings: MAST 211 GEOS 210
Secondary Cross-listing
This course examines ocean and coastal environmental science issues including carbon dioxide and the ocean's role in climate, El Niño and other ocean-atmosphere oscillations that influence our weather, coastal erosion and other hazards, coastal pollution, and fisheries. The focus is on controlling processes with regional comparisons. Blue water oceanography is conducted in the Atlantic and comparative coastal oceanography includes trips to southern New England shores, and the West and Gulf coasts of the US as part of the Williams-Mystic program.
Class Format: lecture/laboratory, including coastal and near-shore field trips, 11 days offshore, and a laboratory or field research project
Requirements/Evaluation: two tests, a research project, and a presentation
Extra Info: offered only at Mystic Seaport
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 211 (D3) GEOS 210 (D3)
Attributes: ENVI Natural World Electives EVST Living Systems Courses EXPE Experiential Education Courses GEOS Group A Electives - Climate + Oceans

Fall 2019
LEC Section: 01 TBA Lisa A. Gilbert
Spring 2020
LEC Section: 01 TBA Lisa A. Gilbert
GEOS 212  (S)  Paleobiology

Cross-listings:  BIOL 211  GEOS 212

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. In addition to the intellectual discovery of fossils as organic relics and the ways in which fossils have been used to support conflicting views on nature, geologic time, and evolution, 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:  lecture/laboratory; field trip to the Paleozoic of New York State

Requirements/Evaluation:  lab assignments, short quizzes and writing assignments, and a final exam

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

Enrollment Limit:  15

Enrollment Preferences:  sophomore and junior GEOS majors

Expected Class Size:  12

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:

BIOL 211 (D3) GEOS 212 (D3)

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

Spring 2020

LEC Section: 01    TR 9:55 am - 11:10 am     Phoebe A. Cohen

LAB Section: 02    W 1:00 pm - 4:00 pm     Phoebe A. Cohen

GEOS 214  (F)  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 tools have 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 tools 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; laboratory, three hours per week

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

Prerequisites:  at least one introductory course in BIOL, ENVI, or GEOS

Enrollment Limit:  20

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

Expected Class Size:  20
GEOS 214 (D3) ENVI 214 (D3)
Attributes: ENVI Natural World Electives EVST Methods Courses EXPE Experiential Education Courses

Fall 2019
LEC Section: 01 MW 11:00 am - 12:15 pm Alex A. Apotsos
LAB Section: 02 M 1:00 pm - 4:00 pm Alex A. Apotsos
LAB Section: 03 W 1:00 pm - 4:00 pm Alex A. Apotsos

GEOS 215 (F) Climate Changes
Cross-listings: ENVI 215 GEOS 215
Primary Cross-listing
In recent years, there has been a growing public and scientific interest in the Earth's climate and its variability. This interest reflects both concern over future climate changes resulting from anthropogenic increases in atmospheric greenhouse gases and growing recognition of the economic impact of "natural" climate variability (for example, El Niño events), especially in the developing world. Efforts to understand the Earth's climate system and predict future climate changes require both study of parameters controlling present day climate and detailed studies of climate changes in the past. In this course, we will review the processes that control the Earth's climate, like solar radiation, the greenhouse effect, ocean circulation, configuration of continents, and positive and negative feedbacks. At the same time, we will review the geological record of climate changes in the past, examining their causes. Laboratories and problem sets will emphasize developing problem solving skills as well as sampling and interpreting geological archives of climate change.

Class Format: lecture, three hours per week; one three-hour lab per week
Requirements/Evaluation: evaluation will be based on lab exercises and problem sets (25%), three hour exams (50%), and a final project (25%) where students will collect, analyze, and interpret data
Prerequisites: 100-level course in GEOS, CHEM, or PHYS or permission of instructor
Enrollment Limit: 14
Enrollment Preferences: Geosciences majors
Expected Class Size: 14
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3)
This course is cross-listed and the prefixes carry the following divisional credit:
ENVI 215 (D3) GEOS 215 (D3)
Attributes: ENVI Natural World Electives EVST Environmental Science EXPE Experiential Education Courses MAST Interdepartmental Electives
Not offered current academic year

GEOS 217 (S) Planets and Moons
Cross-listings: ASTR 217 GEOS 217
Primary Cross-listing
This course will examine 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.

Class Format: lecture and lab
**Requirements/Evaluation:** one mid-term and one final exam, 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:** no pass/fail option, no 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

Spring 2020

LEC Section: 01    MWF 10:00 am - 10:50 am    Ronadh Cox
LAB Section: 02    W 1:00 pm - 4:00 pm    Ronadh Cox

**GEOS 220 (S) Evolution of and on Volcanic Islands**

**Cross-listings:** ENVI 219  GEOS 220

**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.

**Class Format:** tutorial

**Requirements/Evaluation:** evaluation based on five written 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)

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

ENVI 219 (D3) GEOS 220 (D3)

**Attributes:** ENVI Natural World Electives

Not offered current academic year

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

**Cross-listings:** GEOS 221  ENVI 222

**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 craft 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.

Class Format: tutorial
Requirements/Evaluation: weekly papers and a final oral presentation
Prerequisites: none
Enrollment Limit: 10
Enrollment Preferences: second-year students, Geosciences and Environmental Studies third- and fourth-year students
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 221 (D3) ENVI 222 (D3)
Attributes: EXPE Experiential Education Courses

Not offered current academic year

GEOS 234 (S) Introduction to Materials Science  (QFR)
Cross-listings: PHYS 234 GEOS 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: based on 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
Distributions: (D3) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
PHYS 234 (D3) GEOS 234 (D3)
Attributes: MTSC Courses

Spring 2020
GEOS 250 (S) Tectonic Geomorphology and Landscape Development (WS)
Traditionally tectonics investigated processes operating deep in the crust and mantle, whereas geomorphology focused on surficial processes that shape the landscape. Tectonic geomorphology 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.

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, 201, 202, 301, 302, 303 or permission of instructor

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: 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

Spring 2020

TUT Section: T1 TBA Paul M. Karabinos

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, radar, 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.

Class Format: lecture

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

Prerequisites: at least one prior course in GEOS or ENVI

Enrollment Limit: 20

Enrollment Preferences: sophomores

Expected Class Size: 10

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

Fall 2019
LEC Section: 01    MWF 10:00 am - 10:50 am    Alice C. Bradley
LAB Section: 02    R 1:00 pm - 4:00 pm    Alice C. Bradley

GEOS 302  (S) Sedimentology  (WS)

Sediments and sedimentary rocks preserve information about the rocks that were eroded to form them, the fluids and forces that transported them, the mechanisms by which they were deposited, and the processes by which they were lithified. This course introduces the principles of sedimentology, including sediment composition, fluid mechanics, bedform analysis, and depositional environments. This course is in the Sediments and Life group for the Geosciences major.

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

Requirements/Evaluation: lab work, writing assignments, participation in discussions, and a final exam

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: no pass/fail option, no fifth course option

Distributions: (D3)  (WS)

Writing Skills Notes: 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

Spring 2020
LEC Section: 01    TR 11:20 am - 12:35 pm    Ronadh Cox
LAB Section: 02    R 1:00 pm - 4:00 pm    Ronadh Cox

GEOS 303  (F) 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.

Class Format: lecture/discussion, three hours per week; laboratory, three hours per week; several field trips including one full day trip to central New Hampshire

Requirements/Evaluation: evaluation will be based on lab work, one hour test, and a final exam

Prerequisites: GEOS 202 or permission of instructor

Enrollment Limit: none

Expected Class Size: 8

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

Distributions: (D3)

Attributes: GEOS Group C Electives - Solid Earth
GEOS 309 (F) Modern Climate

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.

Class Format: lecture and lab
Requirements/Evaluation: a series of lab projects, a midterm, and a final exam
Prerequisites: GEOS 100, GEOS 103, ENVI 102, GEOS 215, or permission of instructor
Enrollment Limit: 24
Expected Class Size: 15
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 309 (D3) ENVI 209 (D3)

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

GEOS 312 (S) Mass Extinctions: Patterns and Processes

Over the last 542 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 and groups like the dinosaurs vanished from the planet after over 100 million 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.

Class Format: tutorial
Requirements/Evaluation: evaluation will be based on four 4-5-page papers, one revision, tutorial presentations, the student's effectiveness as a critic, and 1 problem set
Prerequisites: GEOS 101 or GEOS 212; or permission of instructor + any 200 level GEOS course
Enrollment Limit: 10
Enrollment Preferences: GEOS majors
Expected Class Size: 10
Grading: no pass/fail option, no fifth course option
Distributions: (D3)

Not offered current academic year
GEOS 314 (S) Analytical Historical Geology (QFR)

In this course you will learn to collect, interpret, and analyze deep time paleontological, stratigraphic, and sedimentological records through readings, labs, and projects all coordinated around a week long spring break trip to explore the House Range of Utah. The Cambrian and Ordovician successions of Utah’s West Desert offers an outstanding record of one of the most important periods in Earth history, tracking the rise of animal ecosystems and major increases in diversity. The first 6 weeks of class will be spent learning the fundamentals of quantitative methods in paleontology and stratigraphy. Labs will focus on skill building including learning basic coding in R, 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 geological mapping, measuring stratigraphic section, 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 determine what data we will collect in the field. Examples might be trilobite taxonomy and phylogenetic analyses, quantitative biostratigraphic correlation using conodont fossils, reconstructing paleoenvironment based on sedimentological analyses of thin sections, or building a sequence stratigraphic framework for a subset of the field locality.

Class Format: weekly lectures, paper discussions, and hands-on labs

Requirements/Evaluation: short papers and lab assignments, spring break field course participation (REQUIRED), and a final group project

Prerequisites: GEOS majors who have taken at least one of the following courses: GEOS 212, GEOS 203, GEOS 324, GEOS 401, GEOS 302, or permission of instructor

Enrollment Limit: 10

Enrollment Preferences: junior and senior Geosciences majors

Expected Class Size: 10

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

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 2020

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 324 (S) Corals and Sea Level

Cross-listings: MAST 324 ENVI 324 GEOS 324

Primary Cross-listing

In coastal communities, increasing flood damage from storm surges and chronic inundation by seawater are already happening as a result of sea level rise. How do we know what contributes to the observed change in sea level in the last century? What does the geological record teach us about what controls the natural variation in sea level on short and long timescales? How can we use this information to separate anthropogenic effects from natural change in modern systems? And how does this inform us on what to expect through the 21st century and beyond? In this course, we will examine how sea level is reconstructed using geological archives and how coral-based sea level data led to breakthroughs in our understanding of the long-term evolution of the ocean and climate, the controls in the timing of ice age cycles, the singularity of modern climate change, and how high the future seas will rise. During Spring Break, the class will travel to Barbados, a renowned locality for Quaternary sea level reconstruction, to observe modern and ancient reefs, and collect samples that will be the basis of individual or group projects in the second half of the semester. Participation in the Spring Break trip is not required for successful completion of the course, but course enrollment is necessary to attend the trip.

Class Format: lecture/laboratory

Requirements/Evaluation: short papers, labs, participation in discussion, and a research project

Prerequisites: GEOS 104 or GEOS 210 or GEOS 215 or MAST 311 or permission of instructor

Enrollment Limit: 10
Enrollment Preferences: Geoscience majors, students who commit to the Spring Break trip

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:

MAST 324 (D3) ENVI 324 (D3) GEOS 324 (D3)

Attributes: ENVI Natural World Electives EXPE Experiential Education Courses

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. After an introduction to the theory of plate tectonics, local field trips, supplemented by reading assignments, will illustrate how field observations can be used to reconstruct tectonic environments in ancient mountain belts. We will also use journal articles to explore ways in which plate tectonics help explain the evolution of mountain belts with special emphasis on the Appalachians.

Class Format: tutorial with weekly one-hour meetings; in addition, there will be five field trips early in the semester on Thursday from 11:20 to 3:50 pm

Requirements/Evaluation: six papers, three based on field trips and three based on journal articles, and critiques of partner's papers

Prerequisites: GEOS 301 or 303 or permission of instructor

Enrollment Limit: 10

Enrollment Preferences: senior Geosciences majors

Expected Class Size: 10

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

Materials/Lab Fee: $15 for field supplies

Distributions: (D3) (WS)

Writing Skills Notes: Six 5- to 10-page papers throughout the semester based on data collected during field trips (3) and journal articles (3). Students will receive from the instructor timely comments on their writing skills, with suggestions for improvement.

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

Fall 2019

TUT Section: T1 TR 11:20 am - 12:35 pm Paul M. Karabinos

LAB Section: T2 R 1:00 pm - 4:00 pm Paul M. Karabinos

GEOS 404 (S) 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, tests, and an independent research project

**Prerequisites:** GEOS 104, GEOS 210, or permission of instructor

**Enrollment Limit:** none

**Expected Class Size:** 10

**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:**

MAST 404 (D3) ENVI 404 (D3) GEOS 404 (D3)

**Attributes:** ENVI Natural World Electives

Spring 2020

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

**GEOS 405 (F) Geochemistry: Understanding Earth's Environment**

**Cross-listings:** GEOS 405 ENVI 405

**Primary Cross-listing**

Rocks, water, air, life: what comprises these interconnected components of the Earth system? How do they interact today, and how did these interactions differ in the past? In this course we will study how chemical elements are distributed in the Earth, cycle through the Earth system, and act together to produce a planet that is habitable. As Earth's landscapes and oceans, and the life they harbor, have evolved through time, they have left an imprint in the geological record that we can read using geochemical tools such as molecular fossils, elemental ratios, and stable and radioactive isotopes. Topics include the synthesis of elements in stars, the formation and differentiation of planet Earth; radiometric dating; the major constituents of the atmosphere, rain, rocks, rivers and the ocean; how they're linked by chemical weathering and biological activity; and reconstruction of past environments. Students will explore these topics through lecture; reading and discussing articles from the scientific literature; and collecting, analyzing and interpreting data from environmental samples.

**Class Format:** seminar/lab

**Requirements/Evaluation:** evaluation will be based on seminar discussions, papers, labs and final project

**Prerequisites:** two 200-level GEOS courses and at least one of GEOS 302 or 303

**Enrollment Limit:** 10

**Enrollment Preferences:** senior Geosciences 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 405 (D3) ENVI 405 (D3)

**Attributes:** ENVI Natural World Electives

Not offered current academic year

**GEOS 411 (F) Geobiology**

Geobiology--the study of interactions between earth and life over geologic timescales--is a new and interdisciplinary field that has grown out of exciting advances in earth and life sciences. During this course we will examine the many ways in which organisms -- from bacteria to trees -- have left their mark on our planet. Topics include the origin of life, the rise of oxygen in the earth's atmosphere, the evolution of biomineralization, the environmental context for animal evolution, the role of microbial communities in the earth system, the emergence of land plants, and the potential for planet-life
interactions elsewhere in our solar system. Geobiology incorporates tools and ideas from geochemistry, paleontology, microbiology, and sedimentology. Class time will be divided between lectures and student-led discussions of primary literature. Labs will be varied and involve everything from growing our own microbial ecosystems to querying online databases and analyzing geological, geochemical, genetic, and paleontological data. Our field trip will take us to Upstate New York where we will sample water from a stratified lake and visit ancient microbial fossil reefs. The final project will involve writing a proposal in small groups on a geobiological topic based on the style and format of a National Science Foundation grant, and presenting the idea to the class.

Class Format: seminar; two lecture/seminars a week plus a lab
Requirements/Evaluation: labs, short papers, final grant proposal and presentation
Prerequisites: GEOS 212 or GEOS 312T; or GEOS 101 + any 200-level GEOS course; or permission of instructor
Enrollment Limit: 15
Enrollment Preferences: Senior Geoscience majors
Expected Class Size: 10
Grading: no pass/fail option, yes fifth course option
Distributions: (D3)
Attributes: EXPE Experiential Education Courses

Not offered current academic year

GEOS 493 (F) Senior Thesis: Geosciences
Geosciences senior thesis. This is part of a full-year thesis (493-494).
Class Format: independent study
Grading: no pass/fail option, no fifth course option
Distributions: (D3)

Fall 2019
HON Section: 01 TBA Mea S. Cook

GEOS 494 (S) Senior Thesis: Geosciences
Geosciences senior thesis. This is part of a full-year thesis (493-494).
Class Format: independent study
Grading: no pass/fail option, no fifth course option
Distributions: (D3)

Spring 2020
HON Section: 01 TBA Mea S. Cook

GEOS 497 (F) Independent Study: Geosciences
Geosciences independent study.
Class Format: independent study
Grading: no pass/fail option, no fifth course option
Distributions: (D3)

Fall 2019
IND Section: 01 TBA Mea S. Cook

GEOS 498 (S) Independent Study: Geosciences
Geosciences independent study.

**Class Format:** lecture/discussion

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

**Distributions:** (D3)

Spring 2020

IND Section: 01    TBA    Mea S. Cook