The earth, environmental, and planetary sciences encompass a wide range of inquiries into the physical, chemical, and biological processes that shape the earth and the planets. Application of these inquiries to understanding a planet's evolution through time is a unique attribute of geological investigations. Knowledge of the past and present reveals the constraints of our environment and serves as a guide for the future.

In recent years, significant advances have been made in the understanding of Earth's interior, the nature of surface and near-surface processes, the history of the Earth's climate, the ecology of living and ancient organisms, and the comparative geology of other planets. Geological knowledge is fundamental to resource conservation, land use planning and other environmental concerns.

Department faculty have active research programs to investigate planet formation and evolution, and Earth and environmental history. The department offers degree programs leading to the Bachelor of Arts (BA) and Bachelor of Science (BS) in geological sciences, BA in environmental geology, BA in environmental studies, Master of Science (MS), and Doctor of Philosophy (PhD). The Environmental Studies Program (http://bulletin.case.edu/collegeofartsandsciences/environmentalstudiesprogram/) is described elsewhere in this bulletin.

**Department Faculty**

Steven A. Hauck, II, PhD  
(Washington University in St. Louis)  
*Professor and Chair*  
Geodynamics

Ralph P. Harvey, PhD  
(University of Pittsburgh)  
*Professor*  
Planetary geology

Peter L. McCall, PhD, JD  
(Yale University)  
*Professor; Director, Environmental Studies Program*  
Benthic ecology; paleoecology

Beverly Z. Saylor, PhD  
(Massachusetts Institute of Technology)  
*Professor*  
Sedimentary geology

James A. Van Orman, PhD  
(Massachusetts Institute of Technology)  
*Professor*  
Geochemistry

Peter J. Whiting, PhD  
(University of California, Berkeley)  
*Professor; Associate Dean, College of Arts and Sciences*  
Geomorphology; surface water hydrology; environmental geology

**Adjunct Faculty**

Mulugeta Alene Araya, PhD  
(University of Turin/University of Genoa)  
*Adjunct Associate Professor*  
Structural geology

Jeffrey Balcerski, PhD  
(Case Western Reserve University)  
*Adjunct Assistant Professor*  
Planetary geology

Andrew Dombard, PhD  
(Washington University in St. Louis)  
*Adjunct Associate Professor, University of Illinois-Chicago*  
Planetary geophysics

Joseph Hannibal, PhD  
(Kent State University)  
*Adjunct Associate Professor, Cleveland Museum of Natural History*  
Invertebrate paleontology

Nathan Jacobson, PhD  
(University of California)  
*Adjunct Associate Professor*  
Zhicheng Jing, PhD  
(Yale University)  
*Adjunct Associate Professor*  
Elham Mohsenian, PhD  
(University of Leoben)  
*Adjunct Assistant Professor*  
Michael Ryan, PhD  
(Univ of Calgary)  
*Adjunct Associate Professor*  
David Saja, PhD  
(University of Pennsylvania)  
*Adjunct Assistant Professor, Cleveland Museum of Natural History*  
Mineralogy

**Emeritus**

Gerald Matisoff, PhD  
(Johns Hopkins University)  
*Professor Emeritus*  
Sedimentary and environmental geochemistry

Samuel M. Savin, PhD  
(California Institute of Technology)  
*Jesse Earl Hyde Professor Emeritus of Geological Sciences and Dean Emeritus, College of Arts and Sciences*  
Isotope geochemistry
Francis Stehli, PhD  
(Columbia University)  
*Professor Emeritus*  
Paleontology and stratigraphy

**Visiting Faculty**

Sharmila Giri, PhD  
(University of Miami)  
*Visiting Assistant Professor*  
Biogeochemistry

Nick Sutfin, PhD  
(Colorado State University)  
*Visiting Assistant Professor*  
Fluvial geomorphology

**Undergraduate Programs**

**Majors**

Students in Earth, Environmental, and Planetary Sciences obtain a solid background in basic science and mathematics as well as intensive training in the major. In addition, because of the wide variety of ways in which geologic knowledge can be applied, all students are encouraged to take electives in subjects appropriate to their personal objectives, which may range from the engineering applications of geology to the socioeconomic and legal systems bearing on environmental issues. The undergraduate programs stress practical experience and fieldwork as well as classroom study. The environmental geology major combines courses in geological sciences with courses in basic and applied sciences to provide students with an understanding of environmental problems, with employable skills, and with a background for graduate study or professional school.

All students participate in a three-semester Senior Project sequence in which they propose a research project, conduct the research, write a thesis, and present it to the department.

**Geological Sciences Major (BA)**

Required courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEPS 101</td>
<td>The Earth and Planets</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 110</td>
<td>Physical Geology</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 115</td>
<td>Introduction to Oceanography</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 119</td>
<td>Geology Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>EEPS 210</td>
<td>Earth History: Time, Tectonics, Climate, and Life</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 301</td>
<td>Stratigraphy and Sedimentation</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 315</td>
<td>Structural Geology and Geodynamics</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 317</td>
<td>Introduction to Field Methods</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 341</td>
<td>Mineralogy</td>
<td>4</td>
</tr>
<tr>
<td>EEPS 344</td>
<td>Igneous and Metamorphic Petrology</td>
<td>4</td>
</tr>
<tr>
<td>EEPS 360</td>
<td>Summer Field Camp</td>
<td>6</td>
</tr>
<tr>
<td>EEPS 390</td>
<td>Introduction to Geological Research</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 391</td>
<td>Senior Project</td>
<td>2</td>
</tr>
<tr>
<td>EEPS 392</td>
<td>Professional Presentation</td>
<td>2</td>
</tr>
<tr>
<td>EEPS 393</td>
<td>Environmental Geology</td>
<td>2</td>
</tr>
</tbody>
</table>

Nine hours of approved electives (at least two of these courses must be at the 200 level or higher)  

**Additional Required Courses**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 105</td>
<td>Principles of Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 106</td>
<td>Principles of Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 113</td>
<td>Principles of Chemistry Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>MATH 125</td>
<td>Math and Calculus Applications for Life, Managerial, and Social Sci I</td>
<td>4</td>
</tr>
<tr>
<td>or MATH 121</td>
<td>Calculus for Science and Engineering I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 126</td>
<td>Math and Calculus Applications for Life, Managerial, and Social Sci II</td>
<td>4</td>
</tr>
<tr>
<td>or MATH 122</td>
<td>Calculus for Science and Engineering II</td>
<td>4</td>
</tr>
<tr>
<td>or MATH 124</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 115</td>
<td>Introductory Physics I</td>
<td>4</td>
</tr>
<tr>
<td>or PHYS 121</td>
<td>General Physics I - Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>or PHYS 123</td>
<td>Physics and Frontiers I - Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>or PHYS 124</td>
<td>Physics and Frontiers II - Electricity and Magnetism</td>
<td>4</td>
</tr>
</tbody>
</table>

**Total Units**  
70

EEPS 360 Summer Field Camp provides comprehensive field training in the summer between the junior and senior years (this course necessitates transfer credit, which must be approved by the department).

**Geological Sciences Major (BS)**

One of the following (EEPS 110 is preferred):  

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEPS 101</td>
<td>The Earth and Planets</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 110</td>
<td>Physical Geology</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 115</td>
<td>Introduction to Oceanography</td>
<td>1</td>
</tr>
<tr>
<td>EEPS 210</td>
<td>Earth History: Time, Tectonics, Climate, and Life</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 301</td>
<td>Stratigraphy and Sedimentation</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 315</td>
<td>Structural Geology and Geodynamics</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 317</td>
<td>Introduction to Field Methods</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 341</td>
<td>Mineralogy</td>
<td>4</td>
</tr>
<tr>
<td>EEPS 344</td>
<td>Igneous and Metamorphic Petrology</td>
<td>4</td>
</tr>
<tr>
<td>EEPS 360</td>
<td>Summer Field Camp</td>
<td>6</td>
</tr>
<tr>
<td>EEPS 390</td>
<td>Introduction to Geological Research</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 391</td>
<td>Senior Project</td>
<td>2</td>
</tr>
<tr>
<td>EEPS 392</td>
<td>Professional Presentation</td>
<td>2</td>
</tr>
<tr>
<td>Twenty-one hours of approved electives (at least two of these courses must be at the 200 level or higher)</td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>

**Additional Required Courses**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>CHEM 105</td>
<td>Principles of Chemistry I</td>
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<tr>
<td>CHEM 106</td>
<td>Principles of Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 113</td>
<td>Principles of Chemistry Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>ENGR 131</td>
<td>Elementary Computer Programming</td>
<td>3</td>
</tr>
<tr>
<td>MATH 121</td>
<td>Calculus for Science and Engineering I</td>
<td>4</td>
</tr>
</tbody>
</table>
In the above majors, the student and his or her advisor will design the program of study in order to outline an initial program of studies for the Geological Sciences MS degree. Additional meetings with the advisor should take place before the student registers for subsequent semesters, and from the faculty of the department. The assignment will be based on the background and interests of the student. The advisor may be changed with the approval of the student's Graduate Committee. The student shall be taken to alleviate the deficiencies. Background deficiencies will normally be made up in the first year of graduate study. Some remedial coursework may not count toward graduate credit.

### Advisor

Each incoming graduate student will be assigned an advisor from the faculty of the department. The assignment will be based on the background and interests of the student. The advisor may be changed with the approval of the student's Graduate Committee. The student should meet with their advisor before registration for the first semester of study in order to outline an initial program of studies for the Geological Sciences MS degree. Additional meetings with the advisor should take place before the student registers for subsequent semesters, and from

### Background Required of Entering Students

The coursework background of all incoming graduate students is evaluated at the time of admission. If deficiencies are deemed to exist in some areas, admission may be contingent upon completion of background courses. After arrival, the coursework background of each incoming graduate student will be reviewed by the student's advisor to determine whether background deficiencies exist for their planned program of study. A student whose background is deemed deficient will, in consultation with their faculty advisor, determine which courses shall be taken to alleviate the deficiencies. Background deficiencies will normally be made up in the first year of graduate study. Some remedial coursework may not count toward graduate credit.

### Geological Sciences MS

The Department of Earth, Environmental, and Planetary Sciences offers the following degree programs:

- Geological Sciences MS
- Geological Sciences PhD

Both programs are flexible so as to meet the needs of the individual student. General areas of study include benthic ecology, biostratigraphy and paleontology, environmental and urban geology, geomorphology, limnology, paleoclimatology, petrology, sedimentary geochemistry, sedimentation and stratigraphy, stable isotope studies, meteoritics, planetary materials, geodynamics of planetary interiors, and planetary geology.

More specific information is available from the departmental office, the departmental webpage (https://eeps.case.edu/), and the Office of Admission of the School of Graduate Studies (https://case.edu/gradstudies/prospective-students/admissions-information/).

### Graduate Programs

#### Minor

Students may complete a minor in geological sciences by taking at least 15 hours of course work.

- Up to three of the following courses:
- EEPS 119 Geology Laboratory
- EEPS 110 Physical Geology
- EEPS 115 Introduction to Oceanography
- EEPS 117 Weather and Climate

**Total Units:** 15

#### Background Required of Entering Students

The coursework background of all incoming graduate students is evaluated at the time of admission. If deficiencies are deemed to exist in some areas, admission may be contingent upon completion of background courses. After arrival, the coursework background of each incoming graduate student will be reviewed by the student's advisor to determine whether background deficiencies exist for their planned program of study. A student whose background is deemed deficient will, in consultation with their faculty advisor, determine which courses shall be taken to alleviate the deficiencies. Background deficiencies will normally be made up in the first year of graduate study. Some remedial coursework may not count toward graduate credit.

### Advisor

Each incoming graduate student will be assigned an advisor from the faculty of the department. The assignment will be based on the background and interests of the student. The advisor may be changed with the approval of the student's Graduate Committee. The student should meet with their advisor before registration for the first semester of study in order to outline an initial program of studies for the Geological Sciences MS degree. Additional meetings with the advisor should take place before the student registers for subsequent semesters, and from

### Environmental Geology Major

#### Required courses:

- EEPS 110 Physical Geology
- EEPS 119 Geology Laboratory
- EEPS 210 Earth History: Time, Tectonics, Climate, and Life
- EEPS 220 Environmental Geology
- EEPS 303 Environmental Law
- EEPS 305 Geomorphology and Remote Sensing
- EEPS 317 Introduction to Field Methods
- EEPS 321 Hydrogeology
- EEPS 390 Introduction to Geological Research
- EEPS 391 Senior Project
- EEPS 392 Professional Presentation
- Nine hours of approved electives (three additional courses at the 200 level or higher which relate to the science or societal implications of environmental concerns. Must be approved by department advisor.)

#### Additional Required Courses

- BIOL 114 Principles of Biology
- CHEM 105 Principles of Chemistry I
- CHEM 106 Principles of Chemistry II
- CHEM 113 Principles of Chemistry Laboratory
- ESTD 101 Introduction to Environmental Thinking
- STAT 201 Basic Statistics for Social and Life Sciences
- MATH 125 Math and Calculus Applications for Life, Managerial, and Social Sci I
- or MATH 121 Calculus for Science and Engineering I
- MATH 126 Math and Calculus Applications for Life, Managerial, and Social Sci II
- or MATH 122 Calculus for Science and Engineering II
- PHYS 115 Introductory Physics I
- or PHYS 121 General Physics I - Mechanics
- or PHYS 123 Physics and Frontiers I - Mechanics

**Total Units:** 67

In the above majors, the student and his or her advisor will design the remainder of the curriculum based on individual interests, in accordance with departmental and college requirements. Through the Integrated Graduate Studies Program (http://bulletin.case.edu/undergraduatestudies/gradprofessional/#accelerationtowardgraduatedegreestext), students may earn a bachelor's and a master's degree in five years. Special programs, such as interdisciplinary majors, also may be arranged.

#### Minor

Students may complete a minor in geological sciences by taking at least 15 hours of course work.

- Up to three of the following courses:
- EEPS 119 Geology Laboratory
- EEPS 110 Physical Geology
- EEPS 115 Introduction to Oceanography

**Total Units:** 15

#### Graduate Programs

The Department of Earth, Environmental, and Planetary Sciences offers the following degree programs:

- Geological Sciences MS
- Geological Sciences PhD

Both programs are flexible so as to meet the needs of the individual student. General areas of study include benthic ecology, biostratigraphy and paleontology, environmental and urban geology, geomorphology, limnology, paleoclimatology, petrology, sedimentary geochemistry, sedimentation and stratigraphy, stable isotope studies, meteoritics, planetary materials, geodynamics of planetary interiors, and planetary geology.

More specific information is available from the departmental office, the departmental webpage (https://eeps.case.edu/), and the Office of Admission of the School of Graduate Studies (https://case.edu/gradstudies/prospective-students/admissions-information/).
time to time, to review and update this program and discuss the student’s progress.

The Graduate School requires that each student file an official Program of Study with the Office of Graduate Studies before they can receive a degree. Normally, this document is submitted during the second semester, subject to later revisions as conditions necessitate.

**Graduate Committee Progress Reports**

In addition to the regular, continuous contact the student has with their advisor, the student will receive an annual review of their progress from their Graduate Committee. These progress reports will be based on coursework performance and Graduate Committee discussions with the faculty advisor.

**MS Requirements**

Students must satisfy the university requirements stipulated in the General Bulletin as well as the departmental requirements described below. A minimum of 30 hours of credit beyond the bachelor’s degree is required for the MS, and the student must spend at least one year in full-time residence at CWRU. Full-time graduate study consists of 12 semester hours, or 9-10 semester hours where the student has contractual assistantship obligations to the department.

Every graduate student must register once for EEPS 490, a three-credit course. As part of EEPS 490, the student will develop skills in preparing a research project and writing a research grant proposal. Registration for this course is typically in the spring of the first year of the program.

All graduate students are expected to regularly attend Earth, Environmental, and Planetary Sciences Seminars.

The university requires that students maintain a cumulative grade-point average of at least 2.75 for all courses; the department requires a 3.0 cumulative average for Earth, Environmental, and Planetary Sciences courses. Courses below the 300 level may not be counted for degree credit. With the approval of the Graduate Committee, a maximum of 6 hours of graduate-level credit may be transferred from another university. Transfer credit will not be given for courses used for degree credit by the student elsewhere. A student will be terminated for any of the following reasons:

- A grade of F in any Earth, Environmental, and Planetary Sciences course
- More than one grade of C or lower in Earth, Environmental, and Planetary Sciences courses
- More than one grade of F in a non-Earth, Environmental, and Planetary Sciences course
- A grade of F that is not converted within one calendar year

Any 300-level Earth, Environmental, and Planetary Sciences course in which a grade of C or below is obtained will not be counted toward the degree requirements. No course in which a grade of D or below is earned will be counted toward the degree requirements.

Students can complete degree requirements for a Geological Sciences MS under one of two tracks: thesis-focused or project-focused.

**Thesis-focused MS**

During the second semester, the student will present their thesis prospectus. This will usually be done at a seminar open to the department and will typically follow the work in EEPS 490. The seminar consists of a discussion of the project and the general field in which it lies in order to determine the preparedness and capabilities of the student and the practicability of the project.

A thesis describing original and independent research by the student is required for the MS degree under the thesis-focused track. In preparing the thesis, the student will have the guidance of one or more advisors, and the thesis should be submitted with their approval. Approval of the format of the thesis must be obtained from the Graduate Office at least one month before graduation (see “Instruction for the Preparation of Theses and Dissertations,” available on request in the Office of Graduate Studies). The thesis must be orally defended before the project committee in an examination which is open to the public. The defense must be taken at least one week before the granting of the degree. In practice, a longer period of time should be allowed so that the student can incorporate any corrections suggested at the defense.

**Project-focused MS**

This requires a comprehensive oral examination involving knowledge of the principles of a student’s area of study. This examination is usually given in the final semester. The examination will be given by a committee consisting of the student’s advisor and at least two other faculty members selected by the advisor. The examination is open to other faculty members who may ask questions but have no vote in the grading. One question will be given to the student by the examining committee, not more than seven days nor less than two days prior to the examination. This question will be conceptual in nature and will test the student’s ability to reason and find a method of solution for a particular problem. The examination will begin with a discussion of this question. A unanimous vote of the committee is required to pass the examination. If two-thirds of the members vote to recommend passing, the committee may then consider passing the student contingent upon the fulfillment of other conditions. A unanimous vote is required for the stipulation of specific conditions.

If the examination is not passed, the student may retake it after a successful petition to the Graduate Committee, but re-examination must be before the end of the first month of the next semester. No examinations will be given later than the last day of classes. A student who fails re-examination or is denied re-examination is terminated from the Geological Sciences MS program.

**Geological Sciences PhD**

The mission of the graduate program in Earth, Environmental, and Planetary Sciences at Case Western Reserve University is to train the coming generations of professional earth, environmental, and planetary scientists. Professional scientists in these disciplines work in a wide range of environments, including, but not limited to, colleges and universities; commercial and nonprofit research laboratories; mining, energy, and environmental consulting industries; local, state, and federal regulatory agencies; federal research laboratories; and museums.

Research opportunities in the graduate program are available in field and observational, experimental, and theoretically based disciplines. These include benthic ecology, surface processes, soil erosion, sediment transport, stratigraphy, geologic sequestration of carbon, geochemistry, meteorites, planetary materials, planetary geology and geophysics, and high-pressure mineral physics and chemistry. Faculty and students conduct field research on five continents, perform experiments at world-class facilities such as the Advanced Photon Source at Argonne National Laboratory, the Cleveland Museum of Natural History, and the NASA Glenn Research Center, and participate in a NASA spacecraft mission.
For students who wish to be admitted to the PhD program, a bachelor’s degree in the earth, environmental, or planetary sciences or a related technical field is expected.

The program of research within the Department of Earth, Environmental, and Planetary Sciences addresses state and regional needs by providing students with training in technical research and technical communication skills, promoting an engaged scientific community and fostering a scientifically informed public through outreach and educational activities. Technical skills in the earth, environmental, and planetary sciences are crucial for fostering a workforce capable of addressing needs in natural resource utilization, management, and regulation.

**Background Required of Entering Students**

The coursework background of all incoming graduate students is evaluated at the time of admission. If deficiencies are deemed to exist in some areas, admission may be contingent upon completion of background courses. After arrival, the coursework background of each incoming graduate student will be reviewed by the student’s advisor to determine whether background deficiencies exist for their planned program of study. A student whose background is deemed deficient will, in consultation with their faculty advisor, determine which courses shall be taken to alleviate the deficiencies. Background deficiencies will normally be made up in the first year of graduate study. Some remedial coursework may not count toward graduate credit.

**Advisor**

Each incoming graduate student will be assigned an advisor from the faculty of the department. The assignment will be based on the background and interests of the student. The advisor may be changed with the approval of the Graduate Committee. The student should meet with their advisor before registration for the first semester of study in order to outline an initial program of study for the PhD degree. Additional meetings with the advisor should take place before the student registers for subsequent semesters, and from time to time, to review and update this program and discuss the student’s progress.

On passing the PhD candidacy examination, the student selects a faculty member who agrees to be their dissertation advisor. Upon notification of the Graduate Committee, the dissertation advisor assumes the advisory responsibilities formerly held by the faculty advisor and, in addition, supervises the student’s dissertation research. The dissertation advisor, in consultation with the Graduate Committee, selects two additional faculty to form the student’s Advisory Committee.

The Graduate School requires that each student file an official Program of Study with the Office of Graduate Studies before they can receive a degree. Normally this document is submitted during the second semester, subject to later revisions as conditions necessitate.

**Graduate Committee Progress Reports**

In addition to the regular, continuous contact the student has with the dissertation advisor, the student must call a meeting of the Advisory Committee once each semester to report and discuss their progress on the dissertation. No later than two weeks following this meeting, the Advisory Committee must submit a written report on the student’s progress to the Graduate Committee. The Graduate Committee in turn will send a report to the student, evaluating their progress, before the beginning of the next semester. A student who has not yet been admitted to candidacy will be sent a progress report from the Graduate Committee after each fall semester on the basis of their coursework performance and the Graduate Committee’s discussion with the faculty advisor.

**PhD Requirements**

The student must satisfy the university requirements stipulated in the General Bulletin as well as the departmental requirements described below. The formal fulfillment of residency requires continuous registration in at least six consecutive academic terms (fall, spring and/or summer). Full-time graduate study consists of 12 semester hours, or 9-10 semester hours if the student has contractual assistantship obligations to the department. It is a university requirement that the PhD be completed within five consecutive calendar years, including leaves of absence, from the initial registration in EEPS 701 Dissertation Ph.D.

A student without a master’s degree will devote at least 36 hours during the first two years to a program approved by the advisor and submitted to the Graduate Committee. For a student already holding a master’s degree, at least 18 hours will be devoted to a one-year program approved by the Graduate Committee. The objective of the program is to broaden the student’s knowledge at an advanced level in a manner consistent with their interests.

Every graduate student must register once for EEPS 490, a three-credit course. As part of EEPS 490 the student will develop skills in preparing a research project and writing a research grant proposal. Registration for this course is typically in the spring of the first year of the program.

All graduate students are expected to regularly attend Earth, Environmental, and Planetary Sciences Seminars.

The university requires a minimum grade-point average of 2.50 after 12 semester hours, 2.75 after 21 semester hours, and 3.00 for graduation; the department requires a 3.0 average for Earth, Environmental, and Planetary Sciences courses. Courses below the 300 level may not be counted for degree credit. With the approval of the Graduate Committee, a maximum of 6 hours of graduate-level credit may be transferred from another university. Transfer credit will not be given for courses used for degree credit by the student elsewhere. A student will be terminated for any of the following reasons:

- A grade of F in any Earth, Environmental, and Planetary Sciences course
- More than one grade of C or lower in Earth, Environmental, and Planetary Sciences courses
- More than one grade of F in a non-Earth, Environmental, and Planetary Sciences course
- A grade of I that is not converted within one calendar year.

Any 300-level Earth, Environmental, and Planetary Sciences course in which a grade of C or below is obtained will not be counted toward the degree requirements. No course in which a grade of D or below is earned will be counted toward the degree requirements.

**PhD Candidacy Examination**

A student is admitted to candidacy for the PhD degree upon passing the general examination described below. Acceptance as a PhD candidate in the department implies that the student has demonstrated sufficient knowledge of their field and the ability to do independent, original research. The candidacy examination has both oral and written parts, reflecting the necessity for a scientist to disseminate research results both orally and in writing.

**Nature of the Examination**

The examination consists of one oral and two written parts. All are to be completed within a two-week period. The oral part and one of the written parts focus on a proposition presented by the student. The other written
part is comprehensive in nature. The examination normally takes place during the last month of the third semester for students entering without a master’s degree and during the last month of the second semester for students entering with a master’s degree.

The Proposition
The proposition consists of an original hypothesis identifying a problem or question in the earth, environmental, and planetary sciences and proposing an answer. In the presentation and defense of the proposition, the student is examined on their ability to identify a scientific problem and to formulate a sound, scientifically defensible solution. It is not the purpose of the examination to assess the logistics and feasibility of a dissertation topic. The student may consult with their faculty advisor and others in choosing the proposition, but the formulation of the proposition should be done by the student. After selecting the proposition topic in the first month of the semester in which the examination is to be taken, the student and the advisor set a timetable for the examination. At that time, the Examination Committee is chosen by the Graduate Committee in consultation with the student’s advisor. The Examination Committee consists of four faculty, up to two of whom may be from outside the Earth, Environmental, and Planetary Sciences department. The advisor has supervisory responsibility for administering the various parts of the examination, compiling the results, and reporting them to the Examining Committee.

Part 1: The Written Proposition
Two weeks before the oral presentation of the proposition, the student will submit to each member of the Earth, Environmental, and Planetary Sciences faculty, to each member of the Examining Committee, and to the department office (for file) a paper of about 8-10 pages, introducing and discussing the proposition. The format of the written presentation should be similar to that of an article submitted for publication in Geology or Science. The paper must be graded by each faculty examiner prior to the oral examination.

Part 2: The Comprehensive Examination
One week before the oral examination, the student will take a 3-hour written examination. This consists of four 45-minute sections, one written by each of the four faculty examiners. Each section may consist of one discussion question or a problem to solve and discuss and/or a series of short-answer questions covering a broad range of topics.

Part 3: The Oral Proposition
The oral examination usually will be no longer than 3 hours in length. It is initiated by a 20-minute formal presentation of the proposition by the candidate. Then the candidate is expected to answer questions about the proposition and its relation to the general field(s) in which it lies. Initially, the questions are centered on the proposition. The candidate may expect to be asked questions of an increasingly general nature as questioning proceeds.

Grading
Grades are assigned to the written proposition and the oral proposition by averaging the numerical grades assigned by each member of the Examining Committee. A grade of 85 is a passing grade for each of these two parts of the examination.

All three parts of the examination must be passed. If a student does not pass one or more parts of the examination, the Examining Committee will recommend whether the student should retake those parts of the examination which were failed, or should proceed to the MS degree. A student is not required to retake any of the three parts of the examination which they have passed. In the case of the comprehensive examination, no section which has been passed needs to be retaken. Portions of the examination that are retaken will generally be retaken within a month and in no case later than the end of the semester following the initial examination.

Acceptance as a PhD Candidate
Upon passing the candidacy examination, the department will formally accept the student as a PhD candidate. The student must subsequently register for a minimum of 1 hour of Dissertation Ph.D. (EEPS 701) in each succeeding semester. Prior to admission to candidacy, a student may register for 1 but not more than 3 hours of EEPS 701, and must maintain continuous registration in EEPS 701. See the General Bulletin for further details about dissertation registration.

Dissertation Prospectus
The prospectus is a written two-page document, with references, describing the student’s proposed dissertation research. It is submitted to the Advisory Committee early in the semester following admission to candidacy. The prospectus is also presented orally as a seminar open to the entire department. Announcement of the seminar and distribution of the written prospectus to all department faculty and graduate students are to take place two weeks ahead of time. The prospectus is not an examination of the student, but rather an examination of the suitability and feasibility of the dissertation project. After the seminar, the Advisory Committee will discuss with the student the suitability of the project and the adequacy of the student’s preparation for it.

Dissertation
A dissertation describing original and independent research by the candidate is required for the PhD degree. Not less than one academic year or its equivalent will be devoted to the dissertation research. In preparing the dissertation, the student will have the guidance of one or more advisors, and it will not usually be submitted without their approval. Approval of the format of the dissertation must be obtained from the Office of Graduate Studies at least one month before graduation.

Defense of Dissertation
The dissertation must be successfully defended in an oral examination before a faculty committee. The dissertation defense is open to the public. The examination committee is appointed by the Dean of Graduate Studies on recommendation by the department chair no later than three weeks before the date of the examination. The examining committee consists of not fewer than four university faculty, with at least one member from outside the department. The student must provide each member of the committee a copy of his/her completed dissertation at least 10 days prior to the examination. The defense must be taken at least one week before the granting of the degree. In practice, a longer period of time should be allowed so that the student can incorporate changes required as a result of the defense. Major changes can be required. Check the General Bulletin for further university-wide regulations about the dissertation defense.

Time Requirements
Students who obtain financial assistance from the department must make satisfactory progress toward fulfilling the degree requirements
in order to qualify for continued support. Normally, support will not be provided for more than eight semesters of graduate work.

**Exceptions**
Requests for exceptions must be submitted by petition to the Graduate Committee.

**Courses**

**EEPS 101. The Earth and Planets.** 3 Units.
An examination of the geological processes that have shaped the planets and moons of the inner solar system, focusing on those with relevance to our own planet Earth. Following an introduction to the fundamentals of planetary geology, lectures and exercises will explore how the inner planets (the asteroids, Mercury, Venus, Earth, the Moon, and Mars) exhibit the effects of planetary differentiation, impact cratering, volcanic activity, tectonics, climate, and interactions with life.

**EEPS 110. Physical Geology.** 3 Units.
Introduction to geologic processes and materials that shape the world we live in. Hydrologic cycle and evolution of landscapes. Earthquakes, volcanoes, plate tectonics, and geologic resources. Students desiring laboratory experience should enroll in EEPS 119 concurrently.

**EEPS 115. Introduction to Oceanography.** 3 Units.
The sciences of oceanography. Physical, chemical, biologic, and geologic features and processes of the oceans. Differences and similarities between the oceans and large lakes including the Great Lakes. Required: Sunday field trip.

**EEPS 117. Weather and Climate.** 3 Units.
Introduction to the study of weather and climate. Covers the basics of meteorology, climate zones, the hydrologic cycle, and weather prediction. Lectures address timely topics including greenhouse warming, past global climates, and recent advances in meteorology.

**EEPS 119. Geology Laboratory.** 1 Unit.
Principles and techniques common to the geological sciences including rock and mineral identification, map interpretation, land form analysis, application of geological information to engineering works, and more. One three-hour laboratory or field trip weekly. Recommended preparation: EEPS 110.

**EEPS 201. Formation and Evolution of a Habitable Planet.** 3 Units.
This course will provide an introduction to the formation and evolution of Earth with an emphasis on how our habitable planet has originated, developed, and sustained conditions suitable for life from a planetary science perspective. Topics include the Big Bang and formation of elements, formation of minerals and organic molecules, formation of the Solar System and planets, formation and differentiation of Earth’s interior, plate tectonics and internal circulation, interactions between interior, atmosphere, and oceans, climate regulation, co-evolution of life and planet, and habitability of other planets in the Solar System and in the universe.

**EEPS 202. Global Environmental Problems.** 3 Units.
Global Environmental Problems is a course designed to provide students with an understanding of, and an appreciation for, human-influenced environmental changes that are global in scope. Accordingly, much of the material will focus on the nature and structure of natural global systems, how and where in those systems human influences occur, and will delve deeply into a few particular problems and solutions of current interest, such as population growth, climate change, ozone depletion, and fisheries, from a variety of viewpoints. Offered as ESTD 202 and EEPS 202.

**EEPS 205. Climate Change Science and Society.** 3 Units.
This course provides a synoptic, multi-disciplinary understanding of the past, present, and future of anthropogenic climate change by integrating three distinct fields: the earth and environmental sciences, biology and ecology, and history. What is changing in the global climate? Why? How do we know? What should we expect in the future? What can be done? No single discipline can answer these questions fully, and by organizing the course around these big questions, we will demonstrate how different disciplines each contribute essential answers. Course covers diverse sources of evidence for climate change in the past and present, the core mechanisms of climate change at different timescales and their consequences, the impact of climate change on human history and history of the discovery of climate change, climate models and ecological forecasts, the modern politics and diplomacy of climate, climate communication, and multiple paths forward for the earth’s physical, ecological, and social systems. Offered as BIOL 205, EEPS 205, and HSTY 205.

**EEPS 210. Earth History: Time, Tectonics, Climate, and Life.** 3 Units.
The discovery and measurement of deep time, tectonic cycles, and geochemical cycles. The origin of life, major fossil groups and their evolution over time. Earth systems history. Major tectonic, ecologic, and climatic events in the last 4.5 billion years.

**EEPS 215. Climate Crises in Earth History.** 3 Units.
The past century has seen three great revolutions in our understanding of how the earth works: a revolution our understanding of geologic time, construction of the tectonic cycle that creates continents and oceans, and most recently, the ability to trace using isotopes global geochemical cycles. One of these, the carbon cycle, is intimately tied to climate change. We now know there have been a handful of climate crises in earth history—at least five—during which the planet experienced large scale changes in a short time, and we live now in the midst of another. We will examine the large-scale workings of the earth system, how the carbon cycle interacts with climate on time scales from millions of years to millennia to decades, and get an accessible overview of what we know about ongoing climate change and its current and future impacts. No prior knowledge of geology is assumed, and the course is suitable for non-majors, though we will encounter a few equations, some graphs, and some very simple computer models.

**EEPS 220. Environmental Geology.** 3 Units.

**EEPS 225. Evolution.** 3 Units.
Multidisciplinary study of the course and processes of organic evolution provides a broad understanding of the evolution of structural and functional diversity, the relationships among organisms and their environments, and the phylogenetic relationships among major groups of organisms. Topics include the genetic basis of micro- and macro-evolutionary change, the concept of adaptation, natural selection, population dynamics, theories of species formation, principles of phylogenetic inference, biogeography, evolutionary rates, evolutionary convergence, homology, Darwinian medicine, and conceptual and philosophic issues in evolutionary theory. Offered as ANTH 225, BIOL 225, EEPS 225, HSTY 225, and PHIL 225.
EEPS 260. Introduction to Climate Change: Physics, Forecasts, and Strategies. 3 Units.
This is a one-semester introduction to the physical processes that determine Earth's past, present, and future climate. The course focuses on quantitatively understanding the human impact on climate, including the historical development of steadily more sophisticated physical models, and ever more complete data. Particular emphasis will be placed on understanding climate change projections, as well as the ethical, political, economic, and communications challenges associated with various strategies going forward. The course is appropriate for all majors. Offered as EEPS 260 and PHYS 260.

EEPS 301. Stratigraphy and Sedimentation. 3 Units.
Formation, distribution, and composition of sediments and sedimentary rocks. Modern depositional environments and their ancient analogues; principles of stratigraphic and biostratigraphic correlation. Two lectures and one laboratory per week. Offered as EEPS 301 and EEPS 401.

EEPS 303. Environmental Law. 3 Units.
Introduction to treatment of environmental issues in legal proceedings. Sources of environmental law, legal procedure, common law remedies (toxic torts and human health, nuisance, contract law), statutes and regulations, endangered species, public lands, toxins regulation, nuclear power, coal. The course employs the case method of reading and recitation of appellate judicial opinions. We read both classic cases in environmental law as well as current controversies. Offered as ESTD 303 and EEPS 303.

EEPS 305. Geomorphology and Remote Sensing. 3 Units.
Recognition and interpretation of land forms and their significance in revealing present and past geologic processes. Introduction to acquisition and analysis of data through aerial photography and satellite imagery. Two lectures and one laboratory weekly. Recommended preparation: EEPS 110 and EEPS 119. Offered as EEPS 305 and EEPS 405.

EEPS 307. Evolutionary Biology and Paleobiology of Invertebrates. 3 Units.
Important events in the evolution of invertebrate life; structure, function, and phylogeny of major invertebrate groups.

EEPS 315. Structural Geology and Geodynamics. 3 Units.
Theoretical analysis of deformation in earth materials, with illustrations of deformaionlal styles in various tectonic settings and the dynamics of the Earth's interior. Recommended preparation: EEPS 110. Offered as EEPS 315 and EEPS 415.

EEPS 317. Introduction to Field Methods. 3 Units.
Practice in field procedures, recognition and testing of hypotheses in the field, field mapping and analysis of sedimentary, igneous, and metamorphic rocks in deformed and tectonically active settings. Weekly meeting plus spring break field trip. Students required to pay partial cost of meals, lodging, and travel. Offered as EEPS 317 and EEPS 417. Prereq: EEPS 119.

EEPS 321. Hydrogeology. 3 Units.
Basic and applied concepts pertaining to the occurrence and movement of groundwater. Definitions, basic equations, applications to a variety of geologic settings, wells. Requires one Saturday field trip to make field measurements, collect and analyze data, and prepare a report. Offered as EEPS 321 and EEPS 421.

EEPS 330. Geophysical Field Methods and Laboratory. 4 Units.
Use of seismic refraction and reflection, gravity, electrical, magnetic, and electromagnetic methods to infer the earth's structure and composition. Application of inverse theory to estimate model parameters. Requires students to make field measurements, analyze data, and prepare a report. Includes several required Saturday field trips. Offered as EEPS 330 and EEPS 430.

EEPS 336. Aquatic Chemistry. 4 Units.
Chemical equilibria occurring in natural waters. Quantitative methods of describing acid-base, metal ion/ligand, precipitation/dissolution, and oxidation/reduction reactions. Geochemical cycling of trace metals and nutrients. Offered as EEPS 336 and EEPS 436.

EEPS 340. Earth and Planetary Interiors. 3 Units.
Quantitative introduction to the composition, structure, dynamics, and evolution of Earth and other planets using principles of geophysics and geochemistry. Planetary formation and differentiation, composition and structure of Earth and planets, heat generation and heat flow, mantle convection and plate tectonics, planetary magnetism and core dynamics, chemical evolution of Earth and planets, extrasolar planets and super Earths. This course will be offered to both undergraduate students and graduates. In addition to the requirements for undergraduate students, graduate students will be asked to work on a small course project relevant to the subject of the course and submit a term paper based on this project by the end of semester. Offered as EEPS 340 and EEPS 440. Prereq: MATH 122 or MATH 126.

EEPS 341. Mineralogy. 4 Units.
Crystallography, hand specimen mineralogy and petrology, principles of crystal structure and crystal chemistry, elementary geochemistry and phase diagrams, and an introduction to the petrographic microscope. Three lectures and one three-hour laboratory weekly. Prereq: EEPS 119.

EEPS 344. Igneous and Metamorphic Petrology. 4 Units.
Composition, classification, and genesis of igneous and metamorphic rocks, emphasizing physical and chemical principles governing their origin. Laboratory study of rocks in thin section. Two lectures and two three-hour laboratories weekly. Prereq: EEPS 341.

EEPS 345. Planetary Materials. 1 - 3 Units.
An introduction to the materials that make up the solid matter of the solar system. Student presentations will review our current understanding of accessible primitive materials such as meteorites, cosmic dust, lunar and ancient terrestrial rocks, and their relationship to modern natural materials and solar system processes. Offered as EEPS 345 and EEPS 445.

EEPS 349. Geological Problems. 1 - 3 Units.
Special work arranged according to the qualifications of the student.

EEPS 350. Geochemistry. 3 Units.
Introduction to geochemistry. Properties of the elements, elemental and isotopic fractionation, element transport, geochemical systems, geochronology, mineral reactions, the solid Earth, Earth in the solar system. A quantitative approach to modeling geochemical processes will be emphasized throughout. Offered as EEPS 350 and EEPS 450.
EEPS 352. Biogeochemistry. 3 Units.
This course is intended for upper-level undergraduate and graduate students and will focus on global environmental changes and the intersections between biology, geology, chemistry and environmental sciences. Throughout the semester students will explore the cycling of biologically important elements (carbon, nitrogen, phosphorus) in order to understand their role in shaping ecosystem processes and in the development of life on Earth. In the first half of the class, students will explore the biological/chemical processes that shape the past, present and future Earth System. In the second half of the course, students will investigate inter-related nature of these processes/reactions in regulating global biogeochemical cycles. Topics to be covered in this class include the origin of the Earth, elements and life; the Gaia Hypothesis; Geochemical tools to study Earth processes; biological and chemical processes occurring on Earth’s surface; Global Climate/Environmental Change. Recommended Preparation: (CHEM 105 or CHEM 111) and (CHEM 106 or ENGR 145). Offered as EEPS 352 and EEPS 452.

EEPS 360. Summer Field Camp. 6 Units.
Six-week course in geologic field methods and mapping. Not offered at CWRU; must be taken at another college or university. Credits will be transferred.

EEPS 367. Topics in Evolutionary Biology. 3 Units.
The focus for this course on a special topic of interest in evolutionary biology will vary from one offering to the next. Examples of possible topics include theories of speciation, the evolution of language, the evolution of sex, evolution and biodiversity, molecular evolution. ANAT/ANTH/EEPS/PHTL/PHOL 467/Biol 468 will require a longer, more sophisticated term paper, and additional class presentation. Offered as ANTH 367, BIOL 368, EEPS 367, PHIL 367, ANAT 467, ANTH 467, BIOL 468, EEPS 467, PHIL 467 and PHOL 467. Prereq: EEPS 225 or equivalent.

EEPS 390. Introduction to Geological Research. 3 Units.
Examination of factors in the selection, design, and conduct of research projects and in the analysis and interpretation of research results. Consideration of ethical issues in scientific research. Development of a written research proposal and oral presentation of proposed research. Consultations with department faculty in development of research proposal. Research initiation. Offered as EEPS 390 and EEPS 490. Counts as SAGES Departmental Seminar.

EEPS 391. Senior Project. 2 Units.
Research project required of all department majors, based on formal project proposals presented to department faculty. Proposals may be submitted prior to the semester in which EEPS 391 is taken. Grading based on project progress presentation that will include a statement of the problem, a literature review, a description of their field/lab work and presentation of their data collected to date. This course is the first of a 2 semester Senior Capstone (EEPS 391, 392) sequence. Recommended preparation: EEPS 390. Counts as SAGES Senior Capstone.

EEPS 392. Professional Presentation. 2 Units.
Preparation and presentation of final written and oral reports on individual Senior Projects. Class meetings focus on group discussion of problem areas in analysis and interpretation of project results, and in styles of writing poster and oral presentation as demonstrated by practice examples. This course is the second in a two-course (EEPS 391, 392) Senior Capstone sequence. Counts as SAGES Senior Capstone.

EEPS 396. Undergraduate Research in Evolutionary Biology. 3 Units.
Students propose and conduct guided research on an aspect of evolutionary biology. The research will be sponsored and supervised by a member of the CASE faculty or other qualified professional. A written report must be submitted to the Evolutionary Biology Steering Committee before credit is granted. Offered as ANTH 396, BIOL 396, EEPS 396, and PHIL 396.

EEPS 401. Stratigraphy and Sedimentation. 3 Units.
Formation, distribution, and composition of sediments and sedimentary rocks. Modern depositional environments and their ancient analogues; principles of stratigraphic and biostratigraphic correlation. Two lectures and one laboratory per week. Offered as EEPS 301 and EEPS 401.

EEPS 405. Geomorphology and Remote Sensing. 3 Units.
Recognition and interpretation of land forms and their significance in revealing present and past geologic processes. Introduction to acquisition and analysis of data through aerial photography and satellite imagery. Two lectures and one laboratory weekly. Recommended preparation: EEPS 110 and EEPS 119. Offered as EEPS 305 and EEPS 405.

EEPS 415. Structural Geology and Geodynamics. 3 Units.
Theoretical analysis of deformation in earth materials, with illustrations of deformational styles in various tectonic settings and the dynamics of the Earth's interior. Recommended preparation: EEPS 110. Offered as EEPS 315 and EEPS 415.

EEPS 417. Introduction to Field Methods. 3 Units.
Practice in field procedures, recognition and testing of hypotheses in the field, field mapping and analysis of sedimentary, igneous, and metamorphic rocks in deformed and tectonically active settings. Weekly meeting plus spring break field trip. Students required to pay partial cost of meals, lodging, and travel. Offered as EEPS 317 and EEPS 417.

EEPS 421. Hydrogeology. 3 Units.
Basic and applied concepts pertaining to the occurrence and movement of groundwater. Definitions, basic equations, applications to a variety of geologic settings, wells. Requires one Saturday field trip to make field measurements, collect and analyze data, and prepare a report. Offered as EEPS 321 and EEPS 421.

EEPS 430. Geophysical Field Methods and Laboratory. 4 Units.
Use of seismic refraction and reflection, gravity, electrical, magnetic, and electromagnetic methods to infer the earth's structure and composition. Application of inverse theory to estimate model parameters. Requires students to make field measurements, analyze data, and prepare a report. Includes several required Saturday field trips. Offered as EEPS 330 and EEPS 430.

EEPS 436. Aquatic Chemistry. 4 Units.
Chemical equilibria occurring in natural waters. Quantitative methods of describing acid-base, metal ion/ligand, precipitation/dissolution, and oxidation/reduction reactions. Geochemical cycling of trace metals and nutrients. Offered as EEPS 336 and EEPS 436.

EEPS 437. Chemistry of Natural Waters. 3 Units.
Advanced topics in aquatic chemistry. Thermodynamics models for ion/ligand speciation in natural waters; origin and composition of seawater, chemical and mineralogical sequence during evaporation, chemical weathering, groundwater and river water chemistry, chemical cycling and a global mass balances; perturbations on natural systems by man. Predictive capabilities of box models.
EEPS 440. Earth and Planetary Interiors. 3 Units.
Quantitative introduction to the composition, structure, dynamics, and evolution of Earth and other planets using principles of geophysics and geochemistry. Planetary formation and differentiation, composition and structure of Earth and planets, heat generation and heat flow, mantle convection and plate tectonics, planetary magnetism and core dynamics, chemical evolution of Earth and planets, extrasolar planets and super Earths. This course will be offered to both undergraduate students and graduates. In addition to the requirements for undergraduate students, graduate students will be asked to work on a small course project relevant to the subject of the course and submit a term paper based on this project by the end of semester. Offered as EEPS 340 and EEPS 440. Prereq: MATH 122 or MATH 126.

EEPS 445. Planetary Materials. 1 - 3 Units.
An introduction to the materials that make up the solid matter of the solar system. Student presentations will review our current understanding of accessible primitive materials such as meteorites, cosmic dust, lunar and ancient terrestrial rocks, and their relationship to modern natural materials and solar system processes. Offered as EEPS 345 and EEPS 445.

EEPS 450. Geochemistry. 3 Units.
Introduction to geochemistry. Properties of the elements, elemental and isotopic fractionation, element transport, geochemical systems, geochronology, mineral reactions, the solid Earth, Earth in the solar system. A quantitative approach to modeling geochemical processes will be emphasized throughout. Offered as EEPS 350 and EEPS 450.

EEPS 452. Biogeochemistry. 3 Units.
This course is intended for upper-level undergraduate and graduate students and will focus on global environmental changes and the intersections between biology, geology, chemistry and environmental sciences. Throughout the semester students will explore the cycling of biologically important elements (carbon, nitrogen, phosphorus) in order to understand their role in shaping ecosystem processes and in the development of life on Earth. In the first half of the class, students will explore the biological/chemical processes that shape the past, present and future Earth System. In the second half of the course, students will investigate inter-related nature of these processes/reactions in regulating global biogeochemical cycles. Topics to be covered in this class include the origin of the Earth, elements and life; the Gaia Hypothesis; Geochemical tools to study Earth processes; biological and chemical processes occurring on Earth's surface; Global Climate/Environmental Change. Recommended Preparation: (CHEM 105 or CHEM 111) and (CHEM 106 or ENGR 145). Offered as EEPS 352 and EEPS 452.

EEPS 467. Topics in Evolutionary Biology. 3 Units.
The focus for this course on a special topic of interest in evolutionary biology will vary from one offering to the next. Examples of possible topics include theories of speciation, the evolution of language, the evolution of sex, evolution and biodiversity, molecular evolution. ANAT/ANTH/EEPS/PHIL/PHOL 467/BIOL 468 will require a longer, more sophisticated term paper, and additional class presentation. Offered as ANTH 367, BIOL 368, EEPS 367, PHIL 367, ANAT 467, ANTH 467, BIOL 468, EEPS 467, PHIL 467 and PHOL 467.

EEPS 490. Introduction to Geological Research. 3 Units.
Examination of factors in the selection, design, and conduct of research projects and in the analysis and interpretation of research results. Consideration of ethical issues in scientific research. Development of a written research proposal and oral presentation of proposed research. Consultations with department faculty in development of research proposal. Research initiation. Offered as EEPS 390 and EEPS 490. Counts as SAGES Departmental Seminar.

EEPS 506. Seminar in Geophysics. 1 - 3 Units.
Selected topics in geophysics: advanced research issues, classical papers, current state of the field, advanced techniques. Course content will vary depending on interests of students and faculty.

EEPS 509. Seminar: Graduate Research. 1 Unit.

EEPS 511. Special Readings in Geology. 1 - 6 Units.
Detailed study of a selected topic in geology under the guidance of a faculty member.

EEPS 512. Special Readings in Geology. 1 - 6 Units.
Detailed study of a selected topic in geology under the guidance of a faculty member.

EEPS 601. Special Problems and Research. 1 - 18 Units.
(Credit as arranged.)

EEPS 651. Thesis M.S.. 1 - 18 Units.
(Credit as arranged.)

EEPS 701. Dissertation Ph.D.. 1 - 9 Units.
(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.