

Seminars on Science

EARTH: INSIDE AND OUT

Syllabus

Course Title

Earth: Inside and Out: Dynamic Earth Systems

Course Description

Though the geologic record is incredibly ancient, it has only been studied intensely since the end of the 19th century. Since then, research in fields such as plate tectonics and climate change, and exploration of the deep sea floor and the inner Earth have vastly increased our understanding of geological processes. This course delves into the five questions listed below in order to understand how our dynamic planet evolved and what processes continue to shape it. In the process, learners will get to know the museum's Hall of Planet Earth, explore geologic time, and gain an understanding of how scientists study vast Earth systems.

- How do geologists “read” the rocks? Determining the age of rocks is key to the concept of geologic time and to understanding the Earth, because in geology the present is the key to the past.
- How has the Earth evolved? Understanding how the atmosphere evolved over time — and how the emergence of life affected the process — exemplifies the way scientists make historical deductions from rocks.
- What causes climate and climate change? Studying the geologic record shows that we are living in an interglacial interval a mere 10,000 years long, between much longer Ice Ages.
- Why are there ocean basins, mountains, and continents? The course ventures next into Earth's dynamic interior, where the continuous motion of the mantle drives plate tectonics and helps shape conditions on the planet's surface.
- Why is the Earth habitable? Finally, a journey to volcanic springs on the deep-sea floor reveals that organisms can live on the chemical energy of the Earth. This discovery has led to profound reflections about the ways in which the various parts of our planet, including living systems, interact with each other.

Class Schedule

This is a six-week online graduate course with an additional week for assignment completion. The course is asynchronous and does not have specific meeting times. Assignments and discussions change on a weekly basis. Students are expected to complete work within the specific week it is assigned.

For the current schedule of offerings, please visit www.amnh.org/learn/calendar.php.

Instructors

This graduate course is co-taught by an experienced educator along with a research scientist. **For example**, a recent course featured:

Ms. Pat Raynock

Palisades High School
Kintnersville, PA

Dr. Edmond Mathez

Department of Earth and Planetary Sciences
American Museum of Natural History

For current instructor information, please contact seminfo@amnh.org.

Format

1. **Earth: Inside and Out** is a six-week online graduate course with an additional week for assignment completion. Enrollment is restricted to current or future educators. No prior course in evolutionary science is required.
2. **Weekly activities** involve mapping, observing, recording and reflecting on local geologic features. They introduce the technology, tools and processes that scientists use to build models and evaluate evidence. Computer interactives, image galleries, and videos will help learners visualize and master the content.
3. **Online discussions** encourage reflection on course content, support and model the inquiry process, and sustain interaction between the offering scientists, seminar instructors, and course members.
4. **Final course projects** support either the development of a proposal planning how you might research a question related to a seminar topic you find particularly interesting or the creation of inquiry-based lesson plans focused on a key course concept that you might incorporate into your teaching practice.

Required Textbook

This course requires the following textbook.

The Earth Machine: The Science of a Dynamic Planet

By Edmond A. Mathez, James D. Webster

Hardcover: 378 pages

Publisher: Columbia University Press; (April 30,2007)

ISBN: 0231125798

Required Materials

You will need to locate a geologic map of your local area. We recommend that you begin your search at the nearest library. The links below may also help you locate materials.

FINDING MAPS IN BOOKS AND PERIODICALS

<http://www.lib.berkeley.edu/EART/how2find.html>

GEOLOGIC MAPS IN LIBRARIES

<http://www.sdc.ucsb.edu/~mary/library.html>

Additionally, a CD-ROM supplied by AMNH contains material documenting Scientists at Work and the Los Alamos National Laboratory. If you do not receive the CD-ROM within the first week, please contact your Instructor.

Recommended Resources

The following resources are recommended as general references but are not required.

Books:

The Dynamic Earth: An Introduction to Physical Geology, 5th edition

by Brian J. Skinner, Stephen C. Porter

Paperback: 648 pages; Dimensions (in inches): 0.88 x 10.83 x 8.56

Publisher: John Wiley & Sons; 5th edition (2004)

ISBN: 0471152285

Earth: Inside and Out

by Edmond A. Mathez, American Museum of Natural History

Paperback: 238 pages; Dimensions (in inches): 0.71 x 9.24 x 7.54

Publisher: New Press; (May 2001)

ISBN: 1565845951

Rare Earth: Why Complex Life is Uncommon in the Universe

by Peter Douglas Ward, Donald Brownle

Hardcover: 368 pages; Dimensions (in inches): 1.30 x 9.58 x 6.44

Publisher: Copernicus Books; 1st edition (January 2000)

ISBN: 0387987010

Essays in Books:

Early Life on Earth

(Specific article: Walter, M.R., 1994, "Stromatolites: The main geological source of information on the evolution of the early benthos.")

by Stefan Bengtson

Hardcover: 656 pages; Dimensions (in inches): 1.50 x 10.50 x 7.50

Publisher: Columbia University Press; 0 edition (April 15, 1994)

ISBN: 0231080883

Earth's Earliest Biosphere: Its Origin and Evolution

(Specific article: Walker, J.C.G., C. Klein, M. Schidlowski, J.W. Schopf, D.J. Stevenson, and M.R. Walter, 1983, "Environmental evolution of the Archean-early proterozoic Earth.")

by J. William Schopf

Paperback:

Publisher: Princeton University Press; (January 1984)

ASIN: 0691023751

Periodicals:

Kasting, J.F., 1993. "Earth's early atmosphere."

Science, 259, pp. 920-926.

Broecker, W.S., and G.H. Denton. (1990). "What drives glacial cycles?"

Scientific American, 262, January, pp 49-56.

Tunncliffe, V., 1992, "Hydrothermal-vent communities of the deep sea."

American Scientist, 80, July-August, pp. 336-34.

Support Services

Technical support is available for technical issues on a 24/7 basis. Please call (303) 873-0005 or email helpdesk@amnh.college.com.

Grading

Assessments are based on a detailed grading rubric developed for this course:

Course Assignments	30%
Course Participation & Communication	40%
Final Project	30%

1. **Course assignments** will include reflection questions and written assignments.
2. **Class participation** will be evaluated based on the quality and consistency of contribution to the discussion forum. The grades for participation will be posted two weeks after each question opens.
3. **Final Project:** There are two options for the course project:

Option I: Teaching Practice

This option is for learners who would like an opportunity to develop an application based on the course content that could be taught to students or other educators. The final form may be a unit or workshop plan (if it will be used as part of a professional development experience).

Option II: Research Question

This option is for learners who would like an opportunity to further explore and grapple with the science and skills presented in this course. The task is to develop a research question of interest based on some element of the content presented in the course.

4. **Policy:** Everything submitted as an assignment, project, or discussion post must be an original work. References to resource materials are expected and proper citation is required.

Weekly Overview and Expectations

Week 1: Introduction to Earth: Inside and Out

This first week, learners meet Drs. Ed Mathez and Ro Kinzler and are introduced to the Museum's Hall of Planet Earth. They tackle the fundamental question of how the Earth works and the challenges of studying enormous systems that operate across vast reaches of time. Understanding begins with observation, so learners look at the Earth's early atmosphere, the Ice Age, the planet's churning interior, and submarine hot springs for clues about how the planets systems interact.

Expectations

- Review the course orientation.
- Gain insight into how Earth scientists "know" the Earth through observation.
- Become familiar with the American Museum of Natural History's Hall of Planet Earth
- Participate in the Icebreaker Discussion
- Respond to the Discussion Question: Observing the Earth
- Obtain a geologic map of your county or state.

Week 2: How do Scientists Read Rocks? The Age of the Earth

Nearly everything we know about the Earth is relayed through rocks. They are evidence that geologists use to deduce the history of a part of our planet. Determining the age of individual rocks, their composite minerals, and even the Earth itself, is critical. Radioactive dating helps geologists determine how old (or young) a rock may be. Why are the oldest rock samples on Earth significantly younger than the planet itself? What tools and processes have scientists used to estimate the age of the Earth? This week learners will review the past and current science behind dating rocks, and begin to observe and describe a local geologic feature.

Expectations

- Investigate how scientists have come to understand the age of the Earth.
- Learn about a quantitative geologic time scale.
- Study radiometric dating and other ways in which scientists determine the age of rocks.
- Examine how half-life determines rates of decay.
- Choose a geologic feature in your area and describe it in detail.
- Respond to the Discussion Question: The Age of Rocks
- Respond to the Discussion Question: The Importance of Time

Week 3: How Has the Earth Evolved? The Evolution of the Atmosphere

The atmosphere is part of the Earth system, and its history is part of the story of our planet. When asked, "Has the evolution of the Earth influenced the evolution of life?" most people would say yes. On the other hand, when asked, "Has the evolution of life influenced the evolution of the Earth?" many might say no. But in fact life has profoundly influenced the evolution of the Earth's atmosphere, and thus of the planet as a whole. This week, learners examine what rocks tell us about the composition of the early atmosphere. They also continue to research a local geologic feature, and begin to consider final project options.

Expectations

- Study how rocks provide evidence about the origin and composition of the early atmosphere.
- Analyze how the composition of the early atmosphere differs from today's.
- Evaluate how the evolution of life on Earth is linked to the oxygenation of the atmosphere.
- Determine how the geologic record can provide evidence for models that try to describe the conditions on Earth when life emerged.

- Examine the principle of uniformitarianism — the idea that the present is the key to the past.
- Use a geologic map to research a geologic feature in your local area, identify its types of rock, and describe its age and history.
- Respond to the Discussion Question: The Present is the Key to the Past.
- Present preliminary thoughts on the Final Project.

Week 4: What Causes Climate and Climate Change? Ice Ages

Climate is the long-term state of weather. As discussed in Week 3, the Earth's geological systems are deeply interrelated. Climate is a particularly complex system controlled by the interaction of the atmosphere, ocean, and other Earth systems, and not immune to the effect of human activities. This week, learners examine how geologists deduce what past climate or paleoclimate was like, examine the Younger Dryas as an example of dramatic climate change over a short period of time, and investigate the connection between the oceans, the atmosphere, and climate.

Expectations

- Determine how scientists describe the "ages" of the earth.
- Analyze shared understandings of what causes geologic change.
- Learn how rocks can provide evidence of ancient climate.
- Study how climate records provide information and clues to understanding today's global climate system.
- Consider an example of dramatic climate change.
- Determine how different forcings affect climate over different time scales.
- Learn about how the oceans, the atmosphere, and climate are connected.
- Respond to the Discussion Question: Global Warming
- Respond to the Discussion Question: Past Climate Records

Week 5: Why are there Ocean Basins, Mountains and Continents? The Impact of Mantle Convection on the Changing Surface of the Earth

The flow of solid rock in the Earth's mantle (convection) is the engine that drives the movements of rocky plates on the Earth's surface (plate tectonics). These movements, in turn, open and close ocean basins, thrust mountains skyward, and shift and reshape continents. This week learners investigate how convection works, and how plate tectonics cause earthquakes to occur, volcanoes to erupt, and mountains to rise up. Learners will study how computer modeling is used to describe and study mantle convection, and then evaluate two different mantle convection models.

Expectations

- Determine how specific variables control rock deformation.
- Review the physical properties of the rocks in the Earth's mantle.
- Study mantle convection and current hypotheses that explain the flow of heat within the mantle.
- Analyze the causes of tectonic plate movement.
- Discover how modeling can be used as a tool in Earth science.
- Complete the Assignment: Bunge and Mantle Convection by examining two different computer-generated mantle convection models and use evidence to evaluate these models.
- Respond to the Discussion Question: Modeling as an Earth Science Tool
- Respond to the Discussion Question: Describing how rocks flow
- Complete an outline of the Final Project

Week 6: Why is the Earth Habitable? Deep-Sea Hydrothermal Vents

Life on Earth is possible because of the "Goldilocks effect": it's in just the right place (neither too close nor too far from the Sun) and is made of just the right stuff (water plus the six elements of which 95% of life consists). Everywhere on the planet that they've looked, scientists have found life — even in around deep-sea hydrothermal vents, where superheated water spews into the frigid blackness of the ocean floor. This week focuses on the variety of life forms in this extreme environment, and how their discovery speaks to larger questions such as where did life first evolve? And where and how might life (as we know it) exist on other planetary bodies?

Expectations

- Determine why deep-sea vents are important.
- Examine life systems that are supported by energy within the Earth.
- Analyze the relationship between organisms that depend on chemical energy and larger questions related to the origin of life.
- Respond to the Discussion Question: Life in the Universe
- Complete the Final Project