AMERICAN MUSEUM & NATURAL HISTORY

Seminars on Science

EVOLUTION

Syllabus

Course Title
Evolution: Modern Evolutionary Biology

Course Description
This course draws on the Museum's long-standing leadership in the fields of paleontology, geology, systematics, and molecular biology to tell a modern story of evolution. Students will learn why evolution is the fundamental concept that underlies all life sciences and how it contributes to advances in medicine, public health and conservation.

The course begins by looking at how Charles Darwin developed his groundbreaking views on evolution by observing patterns in nature. Darwin's work and the perspectives of the authoring scientists - a paleontologist and an ornithologist - lay out some of the evidence for evolution. We then examine the use of molecular and phylogenetic techniques to reconstruct evolutionary history and determine the place of an organism on the Tree of Life, which documents the evolutionary relationships among all species. Mechanisms of evolution and speciation are then covered and are followed by the origin and evolution of humans. The course concludes by examining the practical impact of evolution in the areas of human health, agriculture and conservation.

Course participants will gain a firm understanding of the basic mechanisms of evolution --- including the process of speciation --- and how these systems have given rise to the great diversity of life in the world today. They will also explore how new ideas, discoveries and technologies are modifying prior evolutionary concepts.

Each week begins with a Scientist Profile, in which students will meet a scientist involved in some aspect of evolutionary research. Profiles will include, for example, a paleontologist reconstructing the history of a group of mammals and a molecular biologist battling a rapidly evolving virus. Additional weekly essays will contextualize and develop the material presented in each Profile. Ultimately, the course will explain how evolution works and how we know what we know. The numerous lines of evidence supporting the theory of evolution — including the Tree of Life, fossils, homologies, cellular/molecular data, artificial selection, and embryology — will be woven throughout the course.

Objectives

Students will conclude the course with a firm grasp of:

1. What evolution is and the evidence supporting it
2. The major mechanisms of evolution
3. How scientists study evolution
4. How evolution is relevant to our lives

Please refer to the Weekly Schedule below for a detailed outline of the course.

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. Lorraine Bertan
Department of Education
American Museum of Natural History

Dr. Niles Eldredge
Curator, Division of Paleontology
American Museum of Natural History

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

Format

1. **Evolution** 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** include essays and textbook readings that immerse learners in Evolutionary Biology. Weekly **Scientist Profiles** will add a human face to cutting-edge research and societal implications of this science. 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. We recommend acquiring it through the website of the American Institute of Biological Sciences (www.aibs.org), where it is available in both hardcopy and as an electronic download.

Evolutionary Science and Society: Educating a New Generation, Joel Cracraft and Rodger W. Bybee (ed.), American Institute of Biological Sciences, Washington D.C., 2004

Recommended Textbooks

The following textbooks are recommended as general references on evolution but are not required. Please note: The Ridley book may be considered more accessible than Futuyma, while Futuyma tends to examine material in greater depth.

Evolution (3rd ed.), Mark Ridley, Blackwell Publishing Ltd., UK, 2004

Evolution, Douglas J. Futuyma, Sinauer Associates, Sunderland, MA, 2005

Support Services

Technical support is available for technical issues on a 24/7 basis. Please call (303) 873-0005 or email helpdesk@amnh.ecollege.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: What is the evidence for evolution?
Charles Darwin developed his groundbreaking views on evolution by observing patterns in nature. We begin the course with a profile of Darwin and look at some of the evidence that led him to propose his theory. We also meet the course's authoring scientists, Niles Eldredge and Joel Cracraft, and get their perspectives as a

paleontologist and an ornithologist respectively. Each will explain why evolution is the cornerstone of his field of study, some of the basic evidence for evolution, and what his research has taught him.

Expectations

- Review the course orientation
- Understand how Darwin's observations led him to propose the mechanism of natural selection as an explanation for what he saw.
- Explore how fossils provide evidence for two of Darwin's key assertions: (1) that if life evolved we should see tree-like "nested patterns of resemblance" among living things; and (2) a general sequence of primitive to more advanced forms of organisms in the history of life.
- Examine the history of evolutionary thought through the use of classification systems and evolutionary trees.
- Participate in the Icebreaker Discussion

Week 2: How do we reconstruct evolutionary history?

There are millions of species on Earth today. The basis of evolution is the theory that all living things share a common ancestor, and that evolutionary mechanisms have driven that diversification. How do scientists determine relatedness between organisms, living and extinct? And how does this information illuminate the history of life? Dr. Maureen O'Leary is a paleontologist who studies how cetaceans (whales, dolphins and porpoises) evolved from terrestrial land mammals. The position of the cetaceans on the mammalian tree has been particularly controversial because of differing results from phylogenetic analyses based on molecular data versus morphological and fossil evidence. In the Scientist Profile, we learn how a paleontologist studies this branch of the Tree of Life to determine the history of whales, and why this knowledge is important. Additional essays provide a broader explanation of how the tree is constructed, how relationships among these diverse species support common ancestry, as well as an overview of the history of life.

Expectations

- Examine the intersection of systematics using paleontology and molecular biology through an exploration of whale evolution
- Explore the development of cladistics
- Understand how phylogenies are constructed
- Establish the basis of "tree thinking".
- Examine the history of life on Earth

Week 3: How does evolution work?

Species do not evolve in isolation from other species in their environment. The work of Dr. John Thompson, a biologist studying the coevolution of a species of moth and its host-plants, is featured this week. Coevolution is one of the major processes organizing the Earth's biodiversity as organisms evolve anything from mutually beneficial relationships to antagonistic responses to threats from other species. Essays by guest lecturers Dr. Douglas Futuyma and Dr. Rudolf Raff go on to explain the mechanics of evolution and the new science of Evo Devo (the convergence of evolutionary and developmental biology), which is revealing interesting insights into the history of life and the way genes create new adaptations.

Expectations

- Examine the role of coevolution in shaping species.
- Understand the concepts of natural selection, sexual selection, and genetic drift
- Explore Evolutionary Developmental Biology (Evo Devo) to gain insight into what it tells us about the way evolution works and the history of living things
- Present preliminary thoughts on the Final Project

Week 4: How do new species form?

This week we'll explore the debate among evolutionary biologists about how species are defined. Dr. Robert Zink, a research scientist and scholar in bird evolution, is at the center of this debate —challenging long-held

ideas about how species are ranked and classified. We'll learn what's at stake in how species are defined, and how he has pioneered the use of molecular data to understand evolutionary processes. From there we go on to explore the ongoing process of speciation. Course author Niles Eldredge gives us a personal look at how he came up with his revolutionary theory of Punctuated Equilibria.

Expectations

- Understand the Biological and Phylogenetic species concepts and explore how each is suited to different research questions.
- Explore how an understanding of speciation is important for conservation efforts.
- Understand the mechanisms of speciation.
- Examine what fossils tell us about patterns of evolution over long periods of time.

Week 5: How have humans evolved?

This look at human evolution reveals the complex web of factors, such as geography and culture, which affect the evolution of a species. We learn that the evolution of humans – as with most other organisms -- is not a story of steady process but one with many stops and starts. Dr. Ian Tattersall tells how we piece together fragments from our past to tell a story that still contains many mysteries. We also look at where humans fit with respect to other organisms on the Tree of Life and explore how human consciousness sets us apart from other animals.

Expectations

- Explore how human evolution is studied through fossils.
- Understand where humans fit on the Tree of Life
- Examine the diversity of hominid species through history
- Examine the movement of our species across the Earth
- Consider what "human consciousness" means
- Submit an outline for the Final Project

Week 6: How does evolution impact our lives?

An understanding of how evolution works is critical for modern medicine, agriculture, and conservation efforts. This week we wrap things up by looking at how evolutionary theory impacts our lives. The scientist profiled is Dr. Walter Fitch, a molecular biologist who developed two major methods for using amino acid and nucleic acid sequences to infer the evolutionary relationships of viruses. Fitch studies influenza viruses in an effort to determine which circulating strain is most likely to produce next year's epidemic. Finally, circling back to Darwin, we look at how his theory still holds up and at what Darwin's practices teach us about the nature of science.

Expectations

- Explore how a knowledge of evolution helps design disease fighting drugs
- Understand how phylogenetic principles help track changes in epidemiology.
- Examine how evolutionary theory helps in the development of high-yielding, disease resistant crops
- Consider how evolutionary theory helps in biodiversity conservation efforts
- Understand that Darwin's work is still relevant in today's society
- Complete the Final Project