Term Information

Effective Term	Autumn 2022
Previous Value	*Autumn 2020*

Course Change Information

What change is being proposed? (If more than one, what changes are being proposed?)

Request this existing course be included in the new GE Theme Origins and Evolution.

What is the rationale for the proposed change(s)?

The new GE Theme Origins and Evolution has been approved and this course is a natural fit.

What are the programmatic implications of the proposed change(s)?

(e.g. program requirements to be added or removed, changes to be made in available resources, effect on other programs that use the course)?

None.

Is approval of the requrest contingent upon the approval of other course or curricular program request? No

Is this a request to withdraw the course? No

General Information

Course Bulletin Listing/Subject Area	Earth Sciences
Fiscal Unit/Academic Org	School of Earth Sciences - D0656
College/Academic Group	Arts and Sciences
Level/Career	Undergraduate
Course Number/Catalog	2122
Course Title	Climate and Life Over Billions of Years on Earth
Transcript Abbreviation	Earth Climate Life
Course Description	Origin and evolution of Earth, including its physical, chemical and biological components; principles of geologic inference and their application to interpreting Earth.
Semester Credit Hours/Units	Fixed: 4

Offering Information

Length Of Course	14 Week, 12 Week, 8 Week, 7 Week, 6 Week, 4 Week
Flexibly Scheduled Course	Sometimes
Does any section of this course have a distance education component?	No
Grading Basis	Letter Grade
Repeatable	No
Course Components	Laboratory, Lecture
Grade Roster Component	Lecture
Credit Available by Exam	No
Admission Condition Course	No
Off Campus	Never
Campus of Offering	Columbus, Lima, Mansfield, Marion, Newark, Wooster
Previous Value	*Columbus, Lima, Mansfield, Marion, Newark*

Prerequisites and Exclusions

Prerequisites/Corequisites	
Exclusions	Not open to students with credit for 1122.
Electronically Enforced	Yes

Cross-Listings

Cross-Listings

Subject/CIP Code

Subject/CIP Code	40.0601
Subsidy Level	General Studies Course
Intended Rank	Freshman, Sophomore, Junior, Senior

Requirement/Elective Designation

Required for this unit's degrees, majors, and/or minors
General Education course:
Physical Science; Origins and Evolution
The course is an elective (for this or other units) or is a service course for other units

Previous Value

Required for this unit's degrees, majors, and/or minors
General Education course:
Physical Science
The course is an elective (for this or other units) or is a service course for other units

Course Details

Course goals or learning objectives/outcomes

- • Learn how to identify and classify common rocks
  • Explain how plate tectonics relate to other geologic processes
- • Learn how to use proxies to interpret ancient environments
  • Develop hypotheses and evaluate those hypotheses based on collected data
- • Gain skills in scientific research
  • Learn the theory of evolution and evidence of evolution in the fossil record
  • Understand how changes in the environment impact the history of life
- • Understand controls on global climate change
  • Gain critical thinking skills and practice applying knowledge to new situations
- • Gain experience and proficiency using Microsoft Excel to organize and analyze data

Content Topic List

- Origin of Earth
- Origin of life
- Plate tectonics and climate
- Sedimentary rocks
- Ice Ages
- Mass extinctions
- Precambrian Earth history
- Paleozoic Earth history
- Mesozoic Earth history
- Cenozoic Earth history

Sought Concurrence

No

Attachments

- EARTHSC 2122 OE responses to application ELO.docx: Theme application

  (Other Supporting Documentation. Owner: Griffith,Elizabeth M)

- EARTHSC 2122 syllabus DRAFT to submit by Liz.docx: New Syllabus

  (Syllabus. Owner: Griffith,Elizabeth M)

Comments

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Griffith,Elizabeth M	06/08/2022 09:54 AM	Submitted for Approval
Approved	Griffith,Elizabeth M	06/08/2022 09:56 AM	Unit Approval
Pending Approval	Vankeerbergen,Bernadette Chantal	06/08/2022 09:56 AM	College Approval

Earth Sciences 2122: Climate and Life over Billions of years on Earth
School of Earth Sciences

Instructor [varies by year/semester]:
Email:
Office:
Office hours:

Credit hours: 4 credit hours

Course Format: Course meetings (in person) comprise lectures, discussions, group activities, and lab exercises, so please always be prepared to participate.

Lecture: M, W, F [3 x 55min periods], 110 Orton Hall
Laboratory sessions: Th [1 x 1hr50min period]; Mendenhall Lab 163

Textbook (recommended):
Babcock, L.E., 2009, *Visualizing Earth History*. John Wiley & Sons, Hoboken, New Jersey, 449 p. ISBN: 978-0-471-72490-2.

Catalog Course Description: Origin and evolution of Earth, including its physical, chemical and biological components; principles of geologic inference and their application to interpreting Earth.

Course Overview: In EARTHSC 2122, we will examine the basic principles and methods of the modern historical earth sciences, including sedimentary rocks and their importance as records of earth history, relative age determination, absolute age determination, fossils and fossilization, stratigraphy, evolution, and controls on global climate change. We will also examine the basic facts and theories of modern historical earth sciences, including origin of the earth and solar system, and history of the earth and life on earth during the Precambrian, Paleozoic, Mesozoic, and Cenozoic periods.

Students starting at Ohio State in Autumn 2022 and beyond*: EARTHSC 2122 will count as any one (and only one) three-credit course in the* ***Origins and Evolution*** *new General Education (GE) Theme. Note: Even though it is a 4 credit course due to the required laboratory, it is not considered an integrative practice course and only partially fulfills the GE Theme* Origins and Evolution*.*

The goals of the *Origins and Evolution* GE Theme:

Successful students will:

1. Analyze the origins and evolution of natural systems, life, humanity, or human culture at a more advanced and in-depth level than in the Foundations component.

2. Integrate approaches to the origins and evolution of natural systems, life, humanity, or human culture by making connections to their own experiences and by making connections to work they have done in previous classes and/or anticipate doing in the future.
3. Appreciate the time depth of the origins and evolution of natural systems, life, humanity, or human culture, and the factors that have shaped them over time.
4. Understand the origins and evolution of natural systems, life, humanity, or human culture, and the factors that have shaped them over time.

More specifically, the Expected Learning Outcomes for this theme are:
Successful students will be able to:
1.1 Apply their understanding of scientific methods to quantitative calculations.
1.2 Engage in critical and logical thinking about the origins and evolution of the universe, physical systems, life on Earth, humanity, or human culture.
2.1 Identify, describe, and synthesize approaches to or experiences of origins and evolution questions in different academic and non-academic contexts.
2.2 Demonstrate a developing sense of self as a learner through reflection, self-assessment, and creative work, building on prior experiences to respond to new and challenging contexts.
3.1 Illustrate the time depth of the universe, physical systems, life on Earth, humanity, or human culture by providing examples or models.
3.2 Explain scientific methods used to reconstruct the history of the universe, physical systems, life on Earth, humanity, or human culture and specify their domains of validity.
3.3 Engage with current controversies and problems related to origins and evolution questions.
4.1 Describe how the universe, physical systems, life on Earth, humanity, or human culture have evolved over time.
4.2 Summarize current theories of the origin and evolution of the universe, physical systems, life on Earth, humanity, or human culture.

How will *this* course fulfill the goals and Expected Learning Outcomes? This course will introduce you to the fundamentals of geology, the scientific method, and critical thinking about the complexities of the natural world. You will study in detail the history of our planet Earth. We will discuss the origin of our planet, and how it has changed over the last 4.5 billion years. We will discuss the origin of life on Earth, and how it too has changed through geologic time. Changes to the Earth and its inhabitants will be discussed in the context of physical, chemical, and biological processes that collectively comprise the Earth system. All of this information provides context for understanding how the Earth is changing now, and what the future of our planet may look like.

The course provides some basic knowledge of Earth system science, an understanding of Earth materials and processes, and an understanding of how the Earth has evolved through geologic time. This includes an understanding of the interrelationship between life forms and changes in Earth systems such as climate and sea level. Together, this information will help you to become better informed citizens, and better prepared to address some current societal issues.

Understanding important aspects of the Earth system, and developing the curiosity to make learning a lifelong process are key objectives of this course. Specifically, at the end of the course, you will:

- Understand Earth's history and evolution, including that of its inhabitants and its climate, through geologic time.
- Understand the tools and techniques used to interpret Earth history and evolution. These includes natural evidence of change on Earth, and technological tools.
- Have a better awareness and understanding of the relevance and impact of Earth system science on human society, and the relationship between societal needs, goals, and activities and the Earth systems. The dependence of our society on knowledge about Earth systems, Earth materials, and biological evolution, together with an understanding of feedback mechanisms among Earth systems, are important learning outcomes.
- Be able to assess more critically problems in Earth system science, and understand how science and technology can address matters related to changing conditions on Earth.

Student Responsibility: You are expected to read this syllabus and follow instructions given here, as well as on the course's Carmen page. Note that the outline of lectures and labs is a projection and intended to be a guide. The outline of lectures and labs is subject to change. Any significant departures will be announced on Carmen or in lab, and you are expected to be alert to any such changes.

Lecture and lab attendance is expected.

A large amount of information must be digested in this fast-paced course. *You are responsible for all material covered in the course*. The lectures will be available through links on Carmen, making it accessible to you at your convenience. The lectures, labs, and textbook are closely integrated, and you are responsible for material covered in each of those sources.

Assessment will take three forms: 1, quizzes scheduled over a "lecture" day; 2, lab reports; and 3, a book report. Quizzes will cover material from lectures and labs; this material is supplemented by information in the textbook. The emphasis will be lecture material, but that material is reinforced in the labs, so you are expected to know that material as well. *You can expect that the quizzes will cover any of the material discussed in lecture*, some of which also will be reinforced in lab. The textbook provides further reinforcement and supplemental information, in case you are unclear as to what you may have in your lecture notes. You are expected to read the textbook and the lab materials. The textbook is easy to access. A personal hard copy is not necessary, as it is possible to obtain digital copies, at a fraction of the cost of a paper copy, online. Most important diagrams for the course are in the textbook. They are also on the Powerpoints, which are available on the Carmen page for the course. You are expected to know the primary subdivisions of the geologic time scale. A recent version, approved internationally, is available at www.stratigraphy.org. This is the version that you are expected to know.

The quizzes will be multiple choice/short answer format. They shall be available online for one day only, at approximately two-week intervals. You are to complete the quizzes and return them electronically at the end of the open time interval.

Quizzes and labs will require you to know: 1, definitions of important words and concepts used in Earth system history; 2, major concepts applicable to Earth history (with examples); 3, the geologic time scale; 4, how to identify the types of rocks, fossils, and sedimentary structures that are covered in the course; 5, the ages and major characteristics of important fossil groups covered in the course. Most importantly, you will be required to integrate these types of information to solve practical or scientific problems.

It is to your advantage to bring your textbook (or a digital copy) to each lab. Lab sheets will be provided for you on Carmen. The textbook will help in making the labs more manageable.

You will be expected to pick a book centering on an Earth history theme (such as evolution, extinction, dinosaurs, fossils, climate change, among others), read it, and summarize in one or two pages (single-spaced) the main concepts of the book, plus what you learned from it. Please include the title and author of the book. Before selecting your book, please provide me with the title, for approval.

Please bring to my attention any concerns you may have about the course, including whether you feel you are likely to experience any impairments to learning. That includes reticence about attending in-person lectures or labs. We are in the midst of a serious health situation, and I want you to remain safe, but also feel comfortable with your learning environment. It is important that you will be able to overcome any challenges to learning that may be encountered this semester. Please be especially mindful and respectful of others during this challenging time. I do expect that you will extend to others the same courtesies you would like others to extend to you. Please observe good hygiene practices, and ensure that you are vaccinated (unless you have medical conditions that could endanger you). You are welcome to wear a facemask indoors.

Quizzes and grades
Quizzes will be given at roughly two-week intervals, and cover recently discussed material. The lab grade will be based on lab exercises (no separate lab exams).

Final grades will be calculated as follows:

Quizzes	=	65%
Lab	=	25%
Book report	=	10%

Grading Scale: When all of the points are totaled, the following scale will be used to assign a final letter grade--- 93-100 A; 91-92.99 A-; 89-90.99 B+; 80-88.99 B; 78-79.99 B-; 76-77.99 C+; 65-75.99 C; 63-64.99 C-; 61-62.99 D+; 50-60.99 D; <50 E

Academic Misconduct: *Any material submitted in Earth Science 2122 must represent your own work. Violations of this standard will be referred to the University Committee of Academic Misconduct (COAM) as required by Faculty Rules.*

It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct http://studentlife.osu.edu/csc/.

If you have any questions about whether you are acting in accordance with the Code of Student Conduct, please ask me BEFORE an assignment is turned in.

Statement on University Expectations regarding 2:1 ratio of student effort: In an effort to establish educational standards and expectations for all institutions of higher education in the state, the Ohio Board of Regents has established formal guidelines to standardize the length of semesters, academic years, and define the practical meaning of each semester hour of credit. As part of these guidelines, the Board of Regents' guidelines state that one semester credit hour will be awarded for a minimum of 750 minutes of formalized instruction, and that **"students will be expected to work at out-of-class assignments on a regular basis, which, over the length of the course, would normally average two hours of out-of-class study for each hour of formal class activity."** Out class meets for approximately 4.5 hours per week, therefore, you should expect to spend **9 hours/week on out of class work**.

Student Accommodations: **The University strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability (including mental health, chronic or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. SLDS contact information: slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue**.

Statement on Diversity: The Ohio State University affirms the importance and value of diversity in the student body. Our programs and curricula reflect our multicultural society and global economy and seek to provide opportunities for students to learn more about persons who are different from them. We are committed to maintaining a community that recognizes and values the inherent worth and dignity of every person; fosters sensitivity, understanding, and mutual respect among each member of our community; and encourages each individual to strive to reach his or her own potential. Discrimination against any individual based upon protected status, which is defined as age, color, disability, gender identity or expression, national origin, race, religion, sex, sexual orientation, or veteran status, is prohibited.

Statement on Sexual Misconduct/Relationship Violence: Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories (e.g., race). If you or someone you know has been sexually harassed or assaulted, you may find the appropriate resources at http://titleix.osu.edu or by contacting the Ohio State Title IX Coordinator at titleix@osu.edu

Land Acknowledgement: The Ohio State University acknowledges that its campuses have long served as sites of meeting and exchange for Indigenous peoples, including those in historical times known as the Shawnee, Miami, Wyandotte, Delaware, and the People of Fort Ancient, Hopewell, and Adena cultures, also known as the earthworks builders, as well as other tribal nations of the region. The Ohio State University honors and respects the diverse Indigenous peoples connected to this land in which we gather.

Mental Health: As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know are suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental health services available on campus via the Office of Student Life's Counseling and Consultation Service (CCS) by visiting ccs.osu.edu or calling 614-292-5766. CCS is located on the 4th Floor of the Younkin Success Center and 10th Floor of Lincoln Tower. You can reach an on call counselor when CCS is closed at 614-292-5766 and 24 hour emergency help is also available through the 24/7 National Suicide Prevention Hotline at 1-800-273-TALK or at suicidepreventionlifeline.org.

Statement on copyright: The materials used in connection with this course may be subject to copyright protection and are only for the use of students officially enrolled in the course for the educational purposes associated with the course. Copyright law must be considered before copying, retaining, or disseminating materials outside of the course.

DATES	**TOPICS AND ASSOCIATED READINGS (subject to change)**

<u>Foundational Principles</u>

Week 1 — Introduction to Earth System History: How Physical, Chemical, and Biological Processes Shape Our Planet

Lab: No lab this week

Week 2 — Earth Materials: What Rocks, Minerals, and Sediments Tell Us About Earth History and How Earth has Changed Through Time
Principles of Earth History
Discussion of book report

Reading: Babcock, Chapters 1, 2

Reading for lab preparation:
"Earth Materials and Features" (Babcock, Chapter 2)

Lab: Plate Tectonics

Week 3 — Geologic Time and Proxies for Global Change: The Material Basis for Interpreting the Age of the Earth, and Earth's Evolution

Reading: Babcock, Chapter 3

Lab: Mineral Identification

Assignment: Study and assimilate the **Geologic Time Scale**.

Week 4 — Geologic Time and Proxies for Global Change (continued)

Lab: Rock Identification: Igneous and Metamorphic Rocks

QUIZ 1: Intro through Earth Materials

Week 5 — Life on Earth and its Fossil Record: How We Use Fossils and Other Evidence to Interpret Biological Evolution

Reading: Babcock, Chapter 4

Lab: Rock Identification: Sedimentary Rocks

QUIZ 2: Principles of Earth History through Proxies for Global Change

Week 6 Life on Earth and its Fossil Record (continued)

Lab: Sedimentary Structures

QUIZ 3: Life on Earth and its Fossil Record

Week 7 Biologic Evolution: Changes in Life Forms on Ecological through Geological Time Scales

Reading: Babcock, Chapter 5

Lab: Making of North America

Week 8 Biologic Evolution (continued)

QUIZ 4: Biologic Evolution

Week 9 Interpreting Sedimentary Environments and Global Change: The Context For Understanding Geologic, Oceanic, and Climatic Change

Reading: Babcock: Chapter 6

Lab: Fossil Identification

Week 10 Plate Tectonics in Earth History: How Fossils and the Record of Geologic and Climatic Changes Revolutionized Thinking about Earth Evolution

Reading: Babcock, Chapter 7

Lab: Fossil Identification

QUIZ 5: Sedimentary Environments through Plate Tectonics

Week 11 Precambrian World: Origin and Early Evolution of Earth; Origin and Early Evolution of Life

Reading: Babcock, Chapters 8, 9

Lab: Paleoecology and Biostratigraphy

Week 12 Paleozoic World: Evolution of Early Marine Life Forms; Evolution of Land-dwellers

Reading: Babcock, Chapter 10
Lab: No lab this week

Week 12 Paleozoic World (continued)

Reading: Babcock, Chapter 11

Lab: Facies Mapping

QUIZ 6: Precambrian through Paleozoic

Week 13 Mesozoic World: Evolutionary Diversification on Land, in the Oceans, and in the Air

Reading: Babcock, Chapter 12

Lab: No lab this week

Week 14 Mesozoic World (continued)
Cenozoic World

Reading: Babcock, Chapter 12

Lab: Relative Age Dating

Week 15 Cenozoic World: The Modern World takes Shape; Glacial-interglacial Cycles and Their Impact on Global Climate and Biologic Evolution

Lab: Paleoclimate and climate cycles (virtual; optional)

QUIZ 7: Mesozoic through Cenozoic

Book report due

Responses for:

EARTHSC 2122 Climate and Life over Billions of years on Earth

Overview

Courses that are accepted into the General Education (GE) Themes must meet two sets of Expected Learning Outcomes (ELOs): those common for all GE Themes and one set specific to the content of the Theme. This form begins with the criteria common to all themes and has expandable sections relating to each specific theme. A course may be accepted into more than one Theme if the ELOs for each theme are met. Courses seeing approval for multiple Themes will complete a submission document for each theme. Courses seeking approval as a 4-credit, Integrative Practices course need to complete a similar submission form for the chosen practice. It may be helpful to consult your Director of Undergraduate Studies or appropriate support staff person as you develop and submit your course.

Please enter text in the boxes to describe how your class will meet the ELOs of the Theme to which it applies. Please use language that is clear and concise and that colleagues outside of your discipline will be able to follow. You are encouraged to refer specifically to the syllabus submitted for the course, since the reviewers will also have that document Because this document will be used in the course review and approval process, you should be *as specific as possible*, listing concrete activities, specific theories, names of scholars, titles of textbooks etc.

General Expectations of All Themes

GOAL 1: Successful students will analyze an important topic or idea at a more advanced and in-depth level than the foundations. Please briefly identify the ways in which this course represents an advanced study of the focal theme. In this context, 'advanced' refers to courses that are e.g., synthetic, rely on research or cutting-edge findings, or deeply engage with the subject matter, among other possibilities.

In this course, students analyze three broad, synthetic themes: 1, *geologic time* (which provides the temporal context for Earth's origin, and for major geologic, biologic, and astronomical events); 2, *physical, chemical, and biological evolution* (change through time, including origin of life, chemical cycling, geologic cycling); and 3, *plate tectonics* (including changes to the surface and near-surface environments through time). Students learn to think about Earth as a series of connected, integrated physical, chemical, and biological systems. Discussions in lectures, and hand-on lab exercises, emphasize synthetic, integrative solutions to questions about the origin and evolution of the planet at a more advanced and in-depth level than that of our foundation courses.

ELO 1.1 Engage in critical and logical thinking about the topic or idea of the theme. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students will engage in critical, logical thinking each week as they explore Earth Materials, Life on Earth and its Fossil Record and Biologic Evolution in lecture discussions, and hands-on lab exercises (Mineral Identification, Rock Identification, Sedimentary Structures, Fossil Identification, Paleoecology and Biostratigraphy, Facies Mapping, Paleoclimate and Climate Cycles). Students will learn how they can be used to infer Earth history and biological evolutionary processes (for example in a lab exercise on Phylogenetic Interpretation) and rates. Students will engage in critical thinking as they integrate multiple forms of information leading to the theoretical underpinnings and development of

Plate Tectonics. Students will engage in critical thinking as they work through an exercise in Phylogenetic Interpretation, producing a hypothetical evolutionary tree.

ELO 1.2 Engage in an advanced, in-depth, scholarly exploration of the topic or idea of the theme. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students will: 1, develop an understanding of Earth's history and evolution, including its biological origins and evolution in habitants, through time (e.g., discussions of Life on Earth and its Fossil record, Biologic Evolution); 2, develop an understanding of the tools and techniques used to interpret Earth history (e.g., discussions of Earth Materials, Geologic Time, Plate Tectonics; and lab exercises with background reading on Rock Identification, Fossil Identification, Sedimentary Structures, Phylogenetic Interpretation, Paleoecology and Biostratigraphy, Facies Mapping, Relative Age Dating, Paleoclimate and Climate Cycles); 3, become better aware of the impact of Earth system science on human society (e.g., lecture discussions on Introduction to Earth System History, Earth Materials, Geologic Time and Proxies for Global Change); and 4, learn to critically assess how science and technology address issues of changing conditions on this planet (e.g., lecture discussions on Earth Materials, Geologic Time and Proxies for Global Change, plate Tectonics).

GOAL 2: Successful students will integrate approaches to the theme by making connections to out-of-classroom experiences with academic knowledge or across disciplines and/or to work they have done in previous classes and that they anticipate doing in future.

ELO 2.1 Identify, describe, and synthesize approaches or experiences as they apply to the theme. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students become keenly aware of the interdisciplinary nature of the Earth sciences, and their relevance to societal issues (especially in discussions on Introduction to Earth System History, Earth Materials, Biologic Evolution). Students make frequent use of the principle of uniformitarianism—using knowledge of present-day natural processes, of which they are aware through prior experience, to make inferences about processes in deep time, and to project forward to the future (discussion of Geologic Time; lab exercises on Sedimentary Structures, Fossil Identification). Students come to understand fossilization history by integrating their prior knowledge of biologic cycling with knowledge of the chemical composition of organic materials and sedimentary patterns (discussion of Life on earth and its Fossil Record). Phylogenetic interpretation requires students to draw on biologic (morphological, genealogical) information to interpret evolutionary history. In discussions of Earth Materials and in the labs on Rock Identification, students engage with ways in which critical Earth materials impact our everyday lives.

ELO 2.2 Demonstrate a developing sense of self as a learner through reflection, self-assessment, and creative work, building on prior experiences to respond to new and challenging contexts. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students explore fundamental data sources used to interpret the origin and evolution of the Earth each week in lecture discussions and also in many of the lab exercises (notably Mineral Identification, Rock Identification, Sedimentary Structures, Fossil Identification), progressively building as they go (Mineral Identification to Rock Identification) and integrating the fundamentals to master increasingly complex problems (exercises in Paleoecology and Biostratigraphy, Phylogenetic Interpretation, Facies Mapping, Paleoclimate and Climate Cycles). Through lecture discussions and labs, students build on earlier lab experiences throughout the semester to develop an understanding of how fossils and radiometric isotopes are used to tell geologic time; and how fossils, sedimentary deposits, and geochemical tools can be used to explain changes in plate position, oceanographic conditions, and climate through time (Geologic Time and Proxies for Global Change).

Specific Expectations of Courses in Origins and Evolution

GOAL 1. Students will analyze the origins and evolution of natural systems, life, humanity, or human culture at a more advanced and in-depth level than in the Foundations component.

ELO 1.1 Apply their understanding of scientific methods to quantitative calculations. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students use quantitative or semi-quantitative methods in various ways as they explore use of the tools needed to interpret Earth history. For example, the geologic time scale is calibrated to numerical age estimates. With lecture discussion (Geologic Time) and lab exercises (Paleoecology and Biostratigraphy, Paleoclimate and Climate Cycles), students learn to link the relative geologic time scale to a reference scale of numerical time calculated from ratios of radiogenic isotopes. Ratios of stable isotopes used to compile chemostratigraphic scales form part of the relative time scale reference, and students gain understanding of how measurements are made (discussion in Geologic Time). In learning phylogenetic procedure, students convert morphologic (shape and size) data to a semi-quantitative scale, and then process the information to arrive at an evolutionary hypothesis (discussion in Biologic Evolution). In every lecture discussion and in every lab exercise, quantitative scale is emphasized, as Earth processes and evolutionary processes operate within a considerable range of scales and rates. In discussion of Plate Tectonics, for example, students learn how small differences in the specific gravities of rocks add up to large changes at the surface on a planetary scale and over sufficiently long time frames.

ELO 1.2 Engage in critical and logical thinking about the origins and evolution of the universe, physical systems, life on Earth, humanity, or human culture. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students learn what we know, and how we know, about the origin of our Solar System, our Earth, the origin and evolution of life on Earth, the composition of the Earth and changes to its surface, and the changing composition of the ocean-atmospheric system (discussion primarily in Precambrian World). The early evolution of hominins is addressed (discussion in Cenozoic World). Especially in lectures, competing ideas and testing strategies are discussed. In lab exercises, thinking about biological evolution is most directly addressed in the Phylogenetic Interpretation and Biostratigraphy and Paleoecology exercises. Evolving sedimentary environments and their related ecosystems are most directly addressed in the Facies Mapping and Paleoclimate and Climate Cycles exercises.

GOAL 2. Students will integrate approaches to the origins and evolution of natural systems, life, humanity, or human culture by making connections to their own experiences and by making connections to work they have done in previous classes and/or anticipate doing in the future.

ELO 2.1 Identify, describe, and synthesize approaches to or experiences of origins and evolution questions in different academic and non-academic contexts. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students examine the earliest physical evidence of life on Earth (discussed in Precambrian World), and examine some classic evolutionary sequences, both from the standpoint of genetic evidence alone and mixed data sources (including fossils; discussed in Precambrian World, Paleozoic World, Mesozoic World, Cenozoic World)). Comparisons between evolutionary sequences reconstructed from the fossil record are compared with molecular clock estimations of divergence times. Varied techniques of evolutionary hypothesis representation are discussed and students critically assess their explicit and implicit assumptions. In the Phylogenetic Interpretation exercise, students assess the assumptions, and evaluate their own ability to make decisions about evolutionary affinity, as they build a cladistic-type phylogenetic hypothesis. Students have an opportunity to discuss concepts originating from religious interpretation, and balanced by decisions reached in the American legal system concerning belief systems and evidence-based philosophical systems (discussion raised in Introduction to Earth System History).

ELO 2.2 Demonstrate a developing sense of self as a learner through reflection, self-assessment, and creative work, building on prior experiences to respond to new and challenging contexts. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students explore fundamental data sources used to interpret the origin and evolution of the Earth (notably through exercises in Mineral Identification, Rock Identification, Sedimentary Structures, Fossil Identification), progressively building as they go through the semester and work through the labs (Mineral Identification to Rock Identification) and integrating the fundamentals to master increasingly complex problems (exercises in Paleoecology and Biostratigraphy, Phylogenetic Interpretation, Facies Mapping, Paleoclimate and Climate Cycles). Through lecture discussions (Geologic Time) and labs, students develop an understanding of how fossils and radiometric isotopes are used to tell geologic time; and how fossils, sedimentary deposits, and geochemical tools can be used to explain changes in plate position, oceanographic conditions, and climate through time (Plate Tectonics, Geologic Time discussions).

GOAL 3. Students will appreciate the time depth of the origins and evolution of natural systems, life, humanity, or human culture, and the factors that have shaped them over time.

ELO 3.1 Illustrate the time depth of the universe, physical systems, life on Earth, humanity, or human culture by providing examples or models. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students delve extensively into examples of deep time in physical Earth systems and life on Earth. It forms part of every major lecture discussion topic, and is explicitly covered in Geologic Time and Proxies for Global Change. Students learn about the geologic time scale, and how it is assembled. In lecture discussions on Geologic Time, students distinguish between the assessment of relative age (chronostratigraphy) and numerical estimates of age (geochronology). Students learn about the process of formalizing geologic time-stratigraphic units, and making the philosophical leap from tangible evidence to intangible time units. Lab exercises that draw on relative age dating information are Relative Age Dating, Paleoecology and Biostratigraphy, Paleoclimate and Climate Cycles.

ELO 3.2 Explain scientific methods used to reconstruct the history of the universe, physical systems, life on Earth, humanity, or human culture and specify their domains of validity. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

How deep time is perceived, and how it is measured, are treated using a varied array of scientific tools (Geologic Time and Proxies for Global Change). In this course, students integrate philosophical discussion of geologic time with practical methods used to measure it. Students learn how to apply tools used to measure, calibrate, or constrain the tangible evidence of the passage of time (fossils, isotopic records, sea level histories, etc.), and how radiometric and other techniques are used to add numerical estimates to the time dimension. In lab exercises, students apply some of the concepts of relative age dating (Relative Age Dating, Paleoecology and Biostratigraphy, Paleoclimate and Climate Cycles).

ELO 3.3 Engage with current controversies and problems related to origins and evolution questions. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

Various issues in evolution help to illustrate the nature of science: changing interpretations following acquisition of new and better data, and self-correcting. In this course, students engage with various current controversies in evolution, including rate of speciation (Biologic Evolution), the nature of the Ediacaran Biota (Precambrian World), forcing mechanisms of adaptive radiations (Paleozoic World) and extinctions (Mesozoic World, Cenozoic World), the origins of terrestrialization (Paleozoic World), and the origin of birds (Mesozoic World).

GOAL 4. Students will understand the origins and evolution of natural systems, life, humanity, or human culture, and the factors that have shaped them over time.

ELO 4.1 Describe how the universe, physical systems, life on Earth, humanity, or human culture have evolved over time. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

This course is a broad-ranging examination of the ideas, methods, and tools related to explaining how Earth's physical, chemical, and biological systems have evolved over geologic time. In this course, students spend all 15 weeks discussing, contemplating, assessing these matters, and all nine labs challenge them to apply their practical and reasoning skills to classic problems. In addition, students are challenged to read and summarize a topical book that treats one of the course's topics in detail, and produce a book report.

ELO 4.2 Summarize current theories of the origin and evolution of the universe, physical systems, life on Earth, humanity, or human culture. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students engage with a large number of current theories about the origin and evolution of the Earth's surface, its oceans, its atmosphere, and its biota. Among the topics addressed in lecture discussions are the earliest evidence for the age of Earth, oxygenation of the atmosphere-ocean system, circumstances surrounding the origin of life, differentiation of crustal rock and coalescing of continental crust to form continents (Precambrian World); supercontinent assembly-breakup cycles, climate cycles, sea level cycles (Precambrian World, Paleozoic World, Mesozoic World, Cenozoic World); and populating the oceans, land, and air, and extinctions (Paleozoic World, Mesozoic World, Cenozoic World).