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## Connecting with Evolution

### About This Design

<b>Type of Design:</b>	Teaching for Understanding
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<b>Description:</b>	Using technology to help students develop an understanding of evolution. Consistent with Massachusetts science standards for middle school biology.
<b>Grade Level(s):</b>	Middle School High School
<b>Topic(s) Addressed:</b>	Biology Life Sciences

### Throughlines

#### *Evolution*

Groups of organisms change over time in response to changes in the environment.

Associations:

- *UG1 A: Geologic forces and evolution* (Unit Level Understanding Goals)
- *UG2: Evidence of evolution: What scientists do* (Unit Level Understanding Goals)
- *Geology as a backdrop* (Ongoing Assessment)
- *PoU 2: Geology and change* (Performances of Understanding)
- *PoU 3: Being a researcher* (Performances of Understanding)
- *PoU 4: Being a paleontologist* (Performances of Understanding)
- *Researching geologic time* (Ongoing Assessment)
- *UG [Main] Evolution: what it means and how it happens* (Unit Level Understanding Goals)
- *UG1: Understanding geologic time* (Unit Level Understanding Goals)
- *Exhibit for Natural History Museum* (Ongoing Assessment)

#### *What paleontologists do*

How do paleontologists and other scientists develop theories about how and why organisms evolve over time?

Associations:

- *PoU 1: Introduction to geologic time* (Performances of Understanding)
- *UG2: Evidence of evolution: What scientists do* (Unit Level Understanding Goals)
- *PoU 3: Being a researcher* (Performances of Understanding)
- *PoU 4: Being a paleontologist* (Performances of Understanding)
- *Researching geologic time* (Ongoing Assessment)

- *Exhibit for Natural History Museum* (Ongoing Assessment)

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### *Geologic time*

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The earth's history is vast, and humans have only been here for a comparatively minuscule amount of time. During earth's history, the climate, land mass configuration, and extinction events have affected how organisms have developed over time.

#### Associations:

- *PoU 1: Introduction to geologic time* (Performances of Understanding)
  - *PoU 1: Introduction to geologic time* (Performances of Understanding)
  - *PoU 2: Geology and change* (Performances of Understanding)
  - *PoU 3: Being a researcher* (Performances of Understanding)
  - *PoU 4: Being a paleontologist* (Performances of Understanding)
  - *Introduction to geologic time: scale* (Ongoing Assessment)
  - *Geology as a backdrop* (Ongoing Assessment)
  - *Geologic time: Jeopardy game* (Ongoing Assessment)
  - *Researching geologic time* (Ongoing Assessment)
  - *Exhibit for Natural History Museum* (Ongoing Assessment)
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### *Target of difficulty*

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Evolution is a difficult topic for students to understand, because it happens so slowly and because there are so many common misunderstandings about it. Evolution is important to understand because it provides the basis for much of modern biology.

Geologic time is an essential component to understanding evolution in that evolutionary forces work very slowly, and without a conception of the lengths of time involved, evolution itself does not make sense.

Students have probably already developed an idea of how evolution happens; as part of this curriculum the teacher will encourage the students to share their understandings of evolution. Through the learning process, these preliminary understandings will be revisited, and the class will evaluate which understandings make sense based on their research.

Different technologies can serve to enhance understanding of this topic in several ways, including providing multiple modes of representation of difficult subject matter, supporting mechanisms for thoughtful communication between students, and allowing access to a broad range of data sources for independent research.

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## Generative Topics

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### *Evolutionary patterns and principles*

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How can students develop deep understanding of evolutionary patterns and principles?

This topic is generative because it:

- **Relates to students' expertise and experience**  
Kids are fascinated by dinosaurs (a quick search on Google reveals 3.5 million sites containing the words "kids" and "dinosaurs"). This early interest might not necessarily extend into high school, but I would hazard a guess that an average 9th grader could more easily differentiate between a stegosaurus and a brontosaurus than between, say, Barry Goldwater and Herbert Hoover. This unit would build on this probable early interest or at least exposure to dinosaurs to introduce other creatures and time periods. Understanding organisms and geologic time are essential to understanding evolution. Also, how is evolution *not* interesting? This subject digs at who we are as a species. Also, the recent escalation to the ongoing debate makes this a particularly appropriate time

to explore how we know what we know about evolution.

- **Is approachable from multiple entry points with available resources**

Students can learn about evolution through class discussion, reading material, and multimedia exploration. Also, fossils (physical evidence of evolution) will be used as primary learning materials. Incorporating these interesting and unusual objects into the classroom could spur interest that might not be generated solely by pictures of ancient creatures.

- **Is complex, addresses many important ideas and skills**

Evolution is not yet fully understood, even by experts! There are unsolved questions and debates (such as the debate around punctuated equilibrium) that are very much open to scientific inquiry. Evolution is an important idea to understand in that the study of biology would be incomplete without it. How would someone approach questions about why life is as it is without understanding the forces that stimulate change? Studying evolution involves important skills, such as critical thinking and using data to develop informed opinions.

- **Connects to the teacher's passions**

For me, this project connects to my passions in that I've always been very interested in paleontology and natural history. For some teachers, this could be a difficult topic to teach; if a teacher did not believe in evolution but wanted to teach it anyway (to fulfill state curriculum standards, for instance) I would imagine that there might be passion, just not necessarily *for* the topic! In this were the case, I would hope that the materials used would be generative enough to pique students' interest and stimulate ongoing critical inquiry into questions raised by this unit.

- **Is "bottomless," generates further thinking and inquiry**

Evolution is certainly bottomless in that we don't entirely understand it yet! There is the room and the need for critical inquiry in this area, and I would hope that students are inspired rather than daunted by the fuzzy areas.

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## Unit Level Understanding Goals

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### *UG [Main] Evolution: what it means and how it happens*

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Students will come to understand causes of evolution and diversity and how paleontologists and other scientists develop scientific theories about how living things change over time. Students will also come to understand how environmental changes can affect the success of organisms.

Associations:

- *Evolution* (Throughlines)

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### *UG1: Understanding geologic time*

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Students will come to understand how earth has changed through history in relation to geologic time. They will understand how the different time periods correlate to types of life, and will use specific examples of fossilized animals to develop connections with these ages.

Associations:

- *Geologic time: Jeopardy game* (Ongoing Assessment)
- *Evolution* (Throughlines)
- *PoU 1: Introduction to geologic time* (Performances of Understanding)
- *PoU 1: Introduction to geologic time* (Performances of Understanding)
- *PoU 2: Geology and change* (Performances of Understanding)
- *PoU 3: Being a researcher* (Performances of Understanding)
- *PoU 4: Being a paleontologist* (Performances of Understanding)

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### *UG1 A: Geologic forces and evolution*

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Students will come to understand several examples of how geologic forces have led to changes in groups of organisms (*knowledge*). They will be able express coherent explanations for the relationships between these

geologic situations and populations of organisms, using a variety of narrative formats (*forms*). Examples include:

- Temperate, shallow seas covering most of the earth during the Devonian, and the explosion of varieties of marine life during this time
- Recovery from a mass extinction and subsequent low diversity of organisms during the Early Triassic.

Associations:

- *Evolution* (Throughlines)
- *PoU 2: Geology and change* (Performances of Understanding)
- *Introduction to geologic time: scale* (Ongoing Assessment)
- *Geology as a backdrop* (Ongoing Assessment)

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*UG2: Evidence of evolution: What scientists do*

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Students will come to understand several ways in which paleontologists use fossils to understand how organisms change over time, including: studying population sizes, morphology, and predation patterns.

**Dimension of understanding:**

Students will learn how scientists do their job (*knowledge*) and then use these skills for building and validating their own knowledge of the subject (*methods*).

Associations:

- *Evolution* (Throughlines)
- *PoU 1: Introduction to geologic time* (Performances of Understanding)
- *What paleontologists do* (Throughlines)
- *PoU 2: Geology and change* (Performances of Understanding)
- *PoU 3: Being a researcher* (Performances of Understanding)
- *PoU 4: Being a paleontologist* (Performances of Understanding)

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*UG3: Learning in a collaborative environment*

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Students will come to understand how to communicate respectfully and coherently on a message board system in order to develop their understanding of evolution.

Associations:

- *PoU: Building collaborative understanding* (Performances of Understanding)
- *Introduction to assessment* (Ongoing Assessment)
- *Daily check-in* (Ongoing Assessment)
- *Introduction to geologic time: scale* (Ongoing Assessment)
- *Geology as a backdrop* (Ongoing Assessment)
- *Geologic time: Jeopardy game* (Ongoing Assessment)
- *Exhibit for Natural History Museum* (Ongoing Assessment)

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[see where this fits at the end] *UG1 B ^2: Scientific theories: What exactly does this mean?*

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Students will come to understand the meaning of the term "scientific theory" and what other ideas are considered "scientific theories," such as gravity. They will come to understand the distinction between a "theory" and a "scientific theory."

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## Performances of Understanding

*PoU: Building collaborative understanding (Classification: guided)*

The students will regularly post and reply to messages in the h2o rotisserie system (<http://h2o.law.harvard.edu/index.jsp>).

For example, on the first day of the Geologic Time two day unit, students will be asked to each submit to the rotisserie a response to the question "What would you most like to know about your selected geologic time period?"

On the second day each student will respond to someone else's message. They won't answer the question (they probably would not be able to) but would instead be asked to provide a thoughtful, reasoned response as to where the first student should look to find their desired information.

Associations:

- *UG3: Learning in a collaborative environment* (Unit Level Understanding Goals)

*PoU 1: Introduction to geologic time (Classification: introductory)*

In this activity, students will come to understand some "big ideas" about geologic time, such as the names and relative lengths of time periods. They will also become experts in one particular time frame via a fossil specimen. This fossil specimen will later be used as the focus of research about how this type of organism changed over time.

First, the students will be directed to an interactive web site developed by the Smithsonian Institution (<http://www.nmnh.si.edu/paleo/geotime/>). They will be given a set amount of time to explore the site, and will be asked to read about areas that they find interesting, paying special attention to animal life.

At the end of this exploration, the students will report back to the class with ideas that they found interesting or problematic. At this point, the students are all "generalists" but have had the chance to focus on areas that they find particularly intriguing or compelling. The teacher will note all puzzles that the students present, and at the close of the discussion, will circle or otherwise highlight the puzzles which center on animal life.

Associations:

- *What paleontologists do* (Throughlines)
- *Geologic time* (Throughlines)
- *UG1: Understanding geologic time* (Unit Level Understanding Goals)
- *UG2: Evidence of evolution: What scientists do* (Unit Level Understanding Goals)
- *Geologic time* (Throughlines)
- *UG1: Understanding geologic time* (Unit Level Understanding Goals)

*PoU 2: Geology and change (Classification: guided)*

Using the Geologic Time site, students will explore how geological situations provide backdrops for organismic change. They will be able express coherent explanations for the relationships between these geologic situations and populations of organisms, using a variety of narrative formats. Examples of these types of interactions include:

- Temperate, shallow seas covering most of the earth during the Devonian, and the explosion of varieties of marine life during this time
- Recovery from a mass extinction and subsequent low diversity of organisms during the Early Triassic

Associations:

- *Evolution* (Throughlines)
- *Geologic time* (Throughlines)
- *UG1: Understanding geologic time* (Unit Level Understanding Goals)
- *UG1 A: Geologic forces and evolution* (Unit Level Understanding Goals)
- *UG2: Evidence of evolution: What scientists do* (Unit Level Understanding Goals)

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*PoU 3: Being a researcher* (Classification: guided)

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In the next activity, they can build on interest generated in the last activities. The teacher will have a variety of fossil specimens and will have labelled these according to the geologic age in which they lived. The students will be asked to pick one specimen that will be "theirs" and on which they will become an expert; both on the type of animal itself as well as the time period in which this specimen lived. The specimens will all be different species, and will be chosen based on specimen availability. The teacher should try to have an interesting variety of specimens that include extant (brachiopods, gastropods) and extinct (trilobite, ammonoid) types.

First, the students will return to the Smithsonian site to do in-depth research on their time period, and will compile information including (but not limited to):

- When was this time period?
- How was the earth configured at this time? What did the continents and oceans look like?
- What were the primary life forms at this time?

The students will be asked to make their research findings into question and answer format, and will determine the difficulty of each question. The teacher will use these questions and answers to create a class-wide geologic time Jeopardy game. (Thanks for the idea, Paul!)

The game can be used to start up the next class session, and can be used as review throughout the Evolution unit.

Associations:

- *Evolution* (Throughlines)
- *What paleontologists do* (Throughlines)
- *Geologic time* (Throughlines)
- *UG1: Understanding geologic time* (Unit Level Understanding Goals)
- *UG2: Evidence of evolution: What scientists do* (Unit Level Understanding Goals)

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*PoU 4: Being a paleontologist* (Classification: culminating)

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In this final, culminating performance the students will build on their understanding of geologic time and will come to understand how paleontological methods are used to develop and deepen the scientific theory of evolution.

The students will create an electronic "exhibit" about the natural history of the population of their organism. The exhibit could be in the form of a webpage, PowerPoint presentation, Word document, or any other medium that provides for multiple forms of representation.

To develop their exhibit, the students will do research studying about the population sizes, morphology, and predation patterns of the population of their organism throughout geologic time. The Smithsonian site will serve as a starting point. They will also be encouraged to use additional research materials found online through sources such as:

<http://geology.er.usgs.gov/paleo/mollusks.shtml>  
<http://www.ucmp.berkeley.edu/arthropoda/trilobita/trilobitalh.html>  
<http://www.uky.edu/KGS/coal/webfossil/pages/trilobites.html>  
[http://www.amnh.org/exhibitions/expeditions/treasure\\_fossil/Treasures/Ammonites/ammonite.html?aa](http://www.amnh.org/exhibitions/expeditions/treasure_fossil/Treasures/Ammonites/ammonite.html?aa)  
[http://www.amnh.org/exhibitions/expeditions/treasure\\_fossil/Treasures/Coelacanth/coelacan.html?sea](http://www.amnh.org/exhibitions/expeditions/treasure_fossil/Treasures/Coelacanth/coelacan.html?sea)

<http://animaldiversity.ummz.umich.edu/site/accounts/information/Crocodilia.html>

The students' exhibits will comprise a class Natural History Museum which would be shared with the broader community as a learning resource.

Associations:

- *Evolution* (Throughlines)
- *What paleontologists do* (Throughlines)
- *Geologic time* (Throughlines)
- *UG1: Understanding geologic time* (Unit Level Understanding Goals)
- *UG2: Evidence of evolution: What scientists do* (Unit Level Understanding Goals)

## Ongoing Assessment

*Introduction to assessment* (Classification: informal)

The teacher will openly share assessment standards with the students.

Associations:

- *UG3: Learning in a collaborative environment* (Unit Level Understanding Goals)

*Daily check-in* (Classification: informal)

At the beginning of every class, the students will each write down one question that they have from the day before. The teacher will scan these and give a quick review of any material that many class members found challenging. If any students are having particular trouble, this would be an opportunity for the teacher to know before the end of the unit. The students would also be able to assess where their understanding is in relation to the class as a whole.

Associations:

- *UG3: Learning in a collaborative environment* (Unit Level Understanding Goals)

*Introduction to geologic time: scale* (Classification: formal)

The students will be asked to compare three different visual representations of geologic time periods. Each representation will display the contrasts in length of geologic time periods in a different way, for example using the face of a clock (protozoa for 6 of the hours, humans for 2 minutes, etc.), as a book with chapters of different numbers of pages, etc.

The students will write a one page response to these representations. Which would they consider to be the most effective way to explain the lengths of geologic time periods, and why?

Associations:

- *Geologic time* (Throughlines)
- *UG1 A: Geologic forces and evolution* (Unit Level Understanding Goals)
- *UG3: Learning in a collaborative environment* (Unit Level Understanding Goals)

*Geology as a backdrop* (Classification: informal)

In groups, students will create a concept map to visually link geologic situations and populations. One member of each group will present their concept map to the class.

Associations:

- *Evolution* (Throughlines)
- *Geologic time* (Throughlines)
- *UG1 A: Geologic forces and evolution* (Unit Level Understanding Goals)
- *UG3: Learning in a collaborative environment* (Unit Level Understanding Goals)

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*Geologic time: Jeopardy game* (Classification: informal)

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Peer assessment will be in the form of competition in the classroom as the different students team up to answer the Jeopardy questions.

Associations:

- *UG1: Understanding geologic time* (Unit Level Understanding Goals)
- *Geologic time* (Throughlines)
- *UG3: Learning in a collaborative environment* (Unit Level Understanding Goals)

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*Researching geologic time* (Classification: formal)

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For the researching geologic time task, the students will answer questions about their geologic time period. These will be shared with the class and will form the basis of the Jeopardy quiz game.

Associations:

- *Evolution* (Throughlines)
- *What paleontologists do* (Throughlines)
- *Geologic time* (Throughlines)

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*Exhibit for Natural History Museum* (Classification: formal)

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The teacher will share a rubric with the students to explain her expectations for the exhibits. The rubric would include:

Is the description of her organism accurate/fact based?  
 Were a variety of resources used?  
 Did the student provide a reasonably thorough summary of the natural history of the population of their organism?  
 Does their exhibit include graphics/visuals?  
 Does their exhibit include appropriate/well written text?

Associations:

- *Evolution* (Throughlines)
- *What paleontologists do* (Throughlines)
- *Geologic time* (Throughlines)
- *UG3: Learning in a collaborative environment* (Unit Level Understanding Goals)

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## Technology

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*Technology: rationale*

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Several technologies are used to "support the understanding goals? in the Connecting with Evolution curriculum. The primary use of technology is through the Geologic Time site; the site allows students to

interact with the timescales to better understand how the different time units fit together. It also, in the words of Veenema and Gardner, "may enable ordinary students to gain an understanding that may have been accessible only in the extraordinary classrooms in the past" as they access information in multiple formats.

The h2o discussion board (<http://h2o.law.harvard.edu/index.jsp>) supports the understanding goal of "learning in a collaborative environment." This technology allows students to communicate in a different way than they do in class, and creates a space where all students have the opportunity to contribute equally to the discussion.

The culminating performance of understanding, the Natural History museum, leverages technology in several ways. First, students learn real-world skills as they create their electronic exhibits. They are also able to share their creations with their classmates and with the broader community.

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## Standards

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### *Massachusetts life science standards*

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This unit provides background and substance necessary for achieving the Mass. science standards for middle school biology. (See [http://www.doe.mass.edu/frameworks/scitech/2001/standards/ls6\\_8.html](http://www.doe.mass.edu/frameworks/scitech/2001/standards/ls6_8.html)).

#### **Evolution and Biodiversity**

Give examples of ways in which genetic variation and environmental factors are causes of evolution and the diversity of organisms.

#### **Recognize that evidence drawn from geology, fossils, and comparative anatomy provide the basis of the theory of evolution.**

Is the pterodactyl a flying reptile or the ancestor of birds? Discuss both possibilities based on the structural characteristics shown in pterodactyl fossils and those of modern birds and reptiles.

#### **Relate the extinction of species to a mismatch of adaptation and the environment.**

Relate how numerous species could not adapt to habitat destruction and overkilling by humans, e.g., woolly mammoth, passenger pigeon, great auk.

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