**Unit Essential Question:** *Why do species change over time and should we intervene?*

**Introduction**

In the last task, students saw how a species can change over time, using the specific example of Peppered Moths. In this task, they take a step back by looking at what evidence we have that species have changed over Earth’s long history. In order to do this, they explore the fossil record and how scientists have organized Earth’s 4.6 billion-year-old history into the geologic time scale. This will serve as the foundation for them to think about how the kinds of environmental changes that are happening now have happened in the past. Students will find that we can learn from the fossil record and past incidents of environmental change to predict how current environmental change caused by humans might affect species in our world.

**Alignment Table**

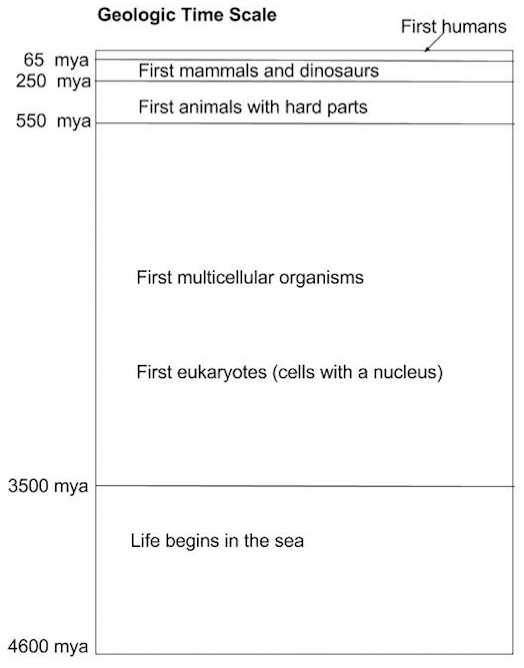
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| **Performance Expectations** | **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| **MS-ESS1-4.  Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth’s 4.6-billion-year-old history.**[Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth’s history. Examples of Earth’s major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.] [*Assessment Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them.*] | **Constructing Explanations and Designing Solutions** Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. | **ESS1.C: The History of Planet Earth** The geologic time scale interpreted from rock strata provides a way to organize Earth’s history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. | **Scale, Proportion, and Quantity**   * Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. |
| **MS-LS4-1.  Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.** [Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.] | **Analyzing and Interpreting Data**   * Analyze and interpret data to determine similarities and differences in findings. | **LS4.A: Evidence of Common Ancestry and Diversity** The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. | **Patterns**   * Graphs, charts, and images can be used to identify patterns in data. * Patterns can be used to identify cause and effect relationships. (*Supplementary)* |
| **Supplementary Crosscutting Concepts**   * Stability and Change   + Stability might be distributed either by sudden events or gradual changes that accumulate over time. | | | |
| **Equity and Groupwork**   * Construct a shared analysis of a rock sample. * Discuss a scientific article. | | | |
| **Language**   * Orally discuss data. * Read and annotate an article. * Write an explanation using evidence. | | | |

**Learning Goals**

This learning task explores how the fossil record can be used as evidence for how the geologic time scale organizes Earth’s 4.6 billion-year-old history. More specifically, the purpose is to:

* Use a common example to engage student understanding of time scale.
* Explore a rock sample as evidence of the fossil record.
* Write a CER report explaining how the geologic time scale is used to organize Earth’s history.
* Read and annotate an article linking mass extinctions and changes in the Earth’s climate.
* Apply knowledge of the fossil record and geologic time scale to make a mock fossil record showing a change in species over time due to climate change and/or other environmental changes.

**Content Background for Teachers**

**** In 7th grade, students experienced the history of Earth in terms of geologic processes, such as plate tectonics and the rock cycle. In this task, students revisit Earth’s history, focusing in on the history of life on Earth. This requires them to build on learning experiences from previous units and courses that looked at distribution of fossils and rocks.

Geologists organize this huge time scale in a variety of ways, based on data from fossils that were found in layers of sedimentary rock. This is known as the fossil record. Each layer of rock provides a snapshot of what the world looked like when that layer was formed, including the species that were present at that time. By looking at the sequence of layers, scientists are able to develop a relative timeline showing how environmental conditions and species have changed over time. Generally, the higher layers correspond to later periods of time and lower layers correspond to earlier periods of time. It is important that students realize that the fossils in rock strata provides evidence of relative ages of rock layers but does not reveal absolute ages. Note: radioactive dating is taught at later age levels.

By looking at the fossil record, scientists have developed a geologic time scale to organize Earth’s 4.6-billion-year-old history. This is very difficult for students to experience and understand since it is such a long period of time, so offering multiple ways for students to visualize such a timeline is helpful.

**Academic Vocabulary**

* Scale
* Geologic time scale
* Fossil record
* Diversity
* Extinction
* Stability and change
* Climate
* Species

**Time Needed (Based on 45-Minute Periods)**

3-5 Days

* Engage and Explore: 1-2 periods
* Explain and Elaborate: 1-2 periods
* Evaluate and Reflection: 1 period

**Materials**

* Unit 3, Task 1 Student Version

Explore

* Rock Sample Resource Cards (1-2 per group). Optional: laminate or put in sheet protectors

Elaborate

* Article Resource Card (1 per person)

Evaluate

* Project Organizer Handout

**Instructions**

**Engage**

1. Introduce Task 1: In the Lift-Off Task, we saw an example of a population of moths that changed over time. Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?
   * Before you pass out their student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.
2. Transition to Task 1: The Peppered Moths were a unique example because the change in population happened very quickly. Most changes in species take place slowly, over thousands or hundreds of thousands of years. How can we visualize such a large amount of time?
   * Now pass out their Task 1 student guide.
3. One way to think about such a large amount of time is to create a timeline broken up by important events. Have students try this out with something familiar: a timeline of their life from birth to today.
   * You may want to show your own timeline of events in your life from birth to today. You can then compare your timeline and students’ timelines to show differences in scale (i.e., one year on your timeline will be relatively shorter than the students).
4. In pairs, have students imagine that the timeline on their student guide represents their life, including big milestones from birth to today (we recommend that students pick 10 important events in their life). Have students brainstorm how they might break up this timeline with important events and how the resulting periods would be described. They should answer the questions on their student guide to guide them through this process.
   * This exercise helps students to familiarize them with the process of creating a time scale, similar to the way scientists create the geologic time scale. In doing so, students are engaging with the crosscutting concept of **Scale, Proportion, and Quantity**, as they create a scaled model that shows significant life events and the time between those events.
   * This activity also emphasizes the crosscutting concept of **Stability and Change**, as students observe periods of their life that are relatively stable, periods that show gradual change, and periods that experience sudden events.
5. Optional: Share out a few timelines. The use of equity sticks is encouraged for more equitable participation (See “How To Use This Curriculum” for more details).

**Explore**

1. The introduction on the student guide connects the student timeline to scientific timelines to help them explore the science content in this section.

* It also highlights two terms that are potentially new to students—**fossil record** and **geologic time scale**—so we recommend reviewing these first.

1. Introduce the students to the geologic time scale pictured on the student guide, discussing the type of details annotated on the image.
2. Assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Materials Manager, Facilitator, Reporter, Harmonizer.
   * Ask Facilitator to read the directions and to make sure everyone understands the task.
   * Ask the Materials Manager to gather any materials needed to complete the task.
   * Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone’s voice is heard.
   * Ask the Reporter to make sure each person in the group is recording their analysis in the student guides.
3. Pass out the Rock Sample resource card to each group (We recommend providing 1-2 copies so students collaborate and share ideas). In this section of the task, groups analyze the rock sample and compare it with the geologic time scale.

* This gives students an opportunity to engage with the science and engineering practice of **Analyzing and Interpreting Data**, specifically asking students to determine similarities and differences in fossils between the different layers.

1. As students complete the questions to help them analyze the rock sample, they will be emphasizing the three different crosscutting concepts described below:
   * **Stability and Change**: Students find examples of species that have remained stable over multiple time periods while others have gradually changed over time. Students should also observe that certain components in the soil and the disappearance of species in the fossil record may illustrate sudden changes in stability.
   * **Patterns:** Students use images of a rock sample and the geologic time scale to identify patterns in the data, specifically patterns of extinction.
   * **Scale, Proportion, and Quantity:** Using the same scale, students place the rock sample within the correct portion of the geologic time scale.
2. Possible responses to the questions are as follows:
   * 1a and 1b: Ammonites remain stable over the first two layers. There are some changes in species over the first two layers while others remain the same, but there appears to be a big extinction and appearance of new species between layers 2 and 3.
   * 2 and 2a: Between layers 1 and 2 and between layers 2 and 3, there are extinctions and new species arise. I think both were caused by some environmental change since the soil between the layers contains ash and iridium. Both a volcanic eruption and asteroids could lead to a big environmental change and leave those markers in the soil.
   * 3: I think this sample belongs in the top three layers because there are three layers separated by major events. In the geologic time scale, the notes about what species existed match up with the rock sample.

**Explain**

1. This section asks students to explain their analysis from the Explore. This CER paragraph emphasizes the crosscutting concept of **Scale, Proportion, and Quantity**, by asking students to explain how the geologic time scale is a model that helps us study Earth’s 4600 million-year-old history, which is otherwise too large to visualize. They should use evidence from the rock sample and geologic time scale to help support their explanation, thus also practicing the skill of **Constructing Explanations.**
   * Facilitating questions are provided on their student guide, including:
     1. What does the geologic time scale show?
     2. Why is it helpful?
     3. What seem to be the rules for how the geologic time scale is broken up and organized?
   * Optional scaffold: Agree on a claim together as a class and brainstorm an example of a piece of evidence that could be used to support the claim.

Optional Sentence Stems to Provide:

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| **Claim** | The geologic time scale is a model that helps us study Earth’s 4.6 billion-year-old history by… |
| **Evidence & Reasoning** | The geologic time scale is helpful because…  The geologic time scale is made up of…  Scientists use evidence from…  For example, in the rock sample…  From layer to layer, you can see..  Between the layers…  \_\_\_\_....shows evidence of some environmental change.  This matches the geologic time scale because…  Analyzing the rock sample helps us understand geologic time scale because…  The geologic time scale is separated according to…  The geologic time scale tells us…  \_\_\_\_…explains how the geologic time scale is organized. |

Sample CER Report

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| **Claim** | The geologic time scale is a model that helps us study Earth’s 4.6 billion-year-old history by separating the long history using major events. |
| **Evidence &**  **Reasoning** | The geologic time scale is helpful because it breaks up Earth’s long chunks into smaller periods that we can see. It is made up of layers, separated by major events in Earth’s history. Scientists use evidence from the fossil record to decide how to organize the time scale. Analyzing the rock sample is a similar process to the way scientists made the geologic time scale. In the rock sample, there were multiple layers of soil containing different species. From layer to layer, some species disappeared while new ones reappeared. Between the layers, there were layers of soil that showed evidence of some environmental change; such as ash from a volcanic eruption or iridium from an asteroid collision. This matches the geologic time scale, which is also split into three layers at the top and has similar species. The geologic time scale thus tells us the timeline of when species disappear and new species appear. |

1. Optional peer review: Have table partners switch CER reports and make suggestions for revisions.

* This can also be a good option for formative assessment. Collect student work to identify trends in students’ ability to use multiple pieces of evidence from the rock sample in their explanation. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

**Elaborate**

1. This part of the task begins to connect the content of this task to their culminating project. So far, students have explored evidence that species change over time and have begun to predict why. Scientists have engaged in the same endeavor, examining mass extinctions throughout Earth’s history to try to figure out the causes behind it and the resulting effects.
   * Students may remember this from when they explored this Performance Expectation in Unit 1.
2. We recommend reading the introduction and the instructions on the student guide aloud as a class. Students will individually read and annotate the article you provide in order to learn more about past climate change and current climate change.

* We recommend instructing students to use whatever annotation strategy they are most comfortable with within your classroom.
* Optional: *Newsela* also has a geological time scale article entitled “Earth’s Systems: Geological Time,” which may be a helpful additional reading for students.

1. Students then answer the reading questions on their student guides as a group. Assign roles to each group. You may choose to assign students to the same roles as the Explore or switch students up within the roles. Possible responses to the questions are below:

* 1: The author claims that incidents of climate change in the past have been linked with past extinctions.
* Here students are using patterns in past data to identify the cause-and-effect relationship between changes in climate and extinction, thus emphasizing the crosscutting concept of **Patterns.**
* 2: He uses the Permian extinction and the end of Ordovician period as evidence. In the Permian extinction, there were high temperatures. At the end of the Ordovician period, it was a cooling period.
* 3: This article implies that since climate is currently drastically changing, we may be headed towards another mass extinction.

1. Optional: Share out students’ responses to the article in a class-wide discussion, using equity sticks for a more equitable discussion. Make explicit connections to how this inspires their culminating project.
2. Return to the whole-class concept map from the Lift-Off Task

* In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See “How To Use This Curriculum” for more details).
  + Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
  + Draw circles around each question and boxes around each concept.
  + Write connector words to describe connections between the concept boxes.
  + For this task, students may begin to connect some of their previous question circles to concept boxes about the following: the geologic time scale, the fossil record, the connection between climate and mass extinctions.
* Have students analyze the additions to the class concept map for as many examples of this task’s crosscutting concepts as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
  + **Patterns**: These could be phrases such as, “has in common with” “shares,” “is also shown in,” “is the same as,” “looks the same as,” etc.
  + **Scale, Proportion, and Quantity**: These could be phrases such as, “is proportional to,”“compared to,” “has a ratio of,” “is bigger/smaller than,” “is longer/shorter than,” etc.
  + **Stability and Change**: These could be phrases such as, “is changed by,” “is disrupted by,” “changes,” “disrupts,” “keeps the same,” etc.
* Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.

**Evaluate: Connecting to the Culminating Project**

1. Students independently complete the Task 1 section of the Unit 3 Project Organizer in class. Revisions can be done for homework, depending upon student’s needs and/or class scheduling.
2. Students have been tasked with arguing whether humans should intervene on the behalf of endangered or threatened species or let nature take its course. Their prompt is as follows:

Think about the species your group chose.

* Draw a pretend fossil record showing how the species has changed over time.
* How might the fossil record in the last 50 years show the species changing over time?
* Given how our planet is changing, predict what future layers might look like?

**Reflection**

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:

* At the beginning of this task, you were asked to draw a timeline of your life from birth to now. Look back at your timeline: after collecting all the evidence today, what additional similarities do you see between this timeline and the geologic time scale? What differences do you see in these two time scales? Use evidence from the two time scales to justify your response below.
* In this task, we focused on the crosscutting concepts of:
  + **Patterns:** Graphs, charts, and images can be used to identify patterns in data.
  + **Scale, Proportion, and Quantity*:*** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
  + **Stability and Change**: Stability might be distributed either by sudden events or gradual changes that accumulate over time.

Where did you see examples of **Patterns**; **Scale, Proportion and Quantity;** or **Stability and Change** in this task?

* Now that you have learned more about how we know that species have changed over time, what questions do you still have?

1. There are no right answers, but encourage students to look back at their student guides and their class concept map. They should not change their initial responses, but rather use this reflection space to add to their ideas and questions based on what they have learned through this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and gathering knowledge and skills for their final projects.

**Assessment**

1. You may collect students’ Project Organizer and assess using:
   * *Criteria of your choice.* We recommend using the 3-Dimensional Assessment matrix at the beginning of this document to inform your criteria.
   * This can be a formative tool to periodically look for trends in student understanding after the completion of a task. You can then use this formative data to inform any re-teaching as necessary.
2. You may also give students time to make revisions with one of the two options:

* Students may make changes to their Project Organizer according to your comments OR
* Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.