**Unit Essential Question:** *What are the effects of an asteroid collision and how can we prevent a future one?*

**Introduction**

At the end of the Lift-Off Task, students were introduced to the motivation behind this unit—an impending asteroid collision with Earth. In this task, they will learn more about how this phenomenon is not new, and that there is great evidence suggesting that a collision of this magnitude has indeed happened before. In stations, students will analyze different pieces of evidence that document the existence, diversity, extinction, and change of life forms on Earth over time. By observing similar patterns of change in the data, they will be able to confirm that a major asteroid collision occurred 65 million years ago and it had drastic effects. By gathering this evidence, students will be able to explain to the public in their project why it is so important that they do everything they can to prevent something like this happening again.

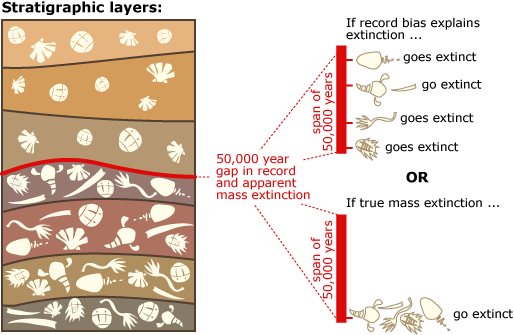
**Alignment Table**

|  |  |  |  |
| --- | --- | --- | --- |
| **Performance Expectations** | **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| **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 Science and Engineering Practices**   * Constructing Explanations   + 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. | | | |
| **Equity and Groupwork**   * Discuss how data provides evidence of a great asteroid collision. * Share CER reports and learn from others. | | | |
| **Language**   * Use analytical terminology to discuss graphs. * Write a CER report. * Use the Stronger Clearer protocol to strengthen the language of an explanation. | | | |

**Learning Goals**

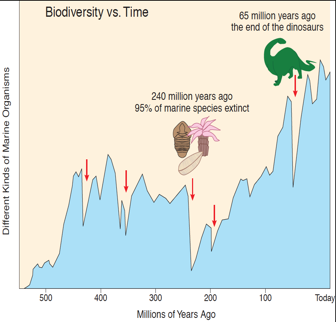
This learning task asks students to analyze the fossil record for evidence that a mass extinction occurred in the past due to an asteroid collision. More specifically, the purpose is to:

* Engage prior knowledge of asteroid collisions and dating soil layers.
* Analyze and interpret data for patterns in fossil data that document mass extinction of species.
* Explain whether a large asteroid has hit Earth before and what the consequences were.
* Use the “Stronger and Clearer” method to revise the language and ideas in their CER paragraph.
* Apply knowledge of a past asteroid collision to justify protecting Earth against another collision.



**Content Background for Teachers**

According to abundant evidence, an asteroid approximately 6 miles across collided with Earth 65 million years ago. The impact created a huge explosion that killed many organisms and thrust debris into the atmosphere, dramatically altering the climate. This led to the extinction of millions of species, most notably the dinosaurs.

In the stations, students will be able to look at re-creations of soil layers and the associated fossils to do their own fossil analysis, as well as look at graphs and written data created from scientific fossil analysis.

Across all stations, they will find evidence that there are striking “breaks” that occur in the fossil sequence—these are the mass extinctions that have occurred several times throughout the history of life on Earth. A mass extinction can be defined as a widespread and rapid decrease in the biodiversity of life on Earth. As is the case today, habitat loss and climate change were major contributors to mass extinction.

Students will also find that in the case of the mass extinction 65 million years ago, scientists have gathered enough evidence to determine what caused this mass extinction—a large asteroid impact. The following are a few lines of evidence that help to prove this: Iridium, a common component of asteroids, can be found in the 65 million year old soil layer at many points around the world. The same soil layer contains grains of quartz (a type of rock) that were deformed by high shock pressures, as would occur in a giant explosion. The same soil layer also contains enough soot to correspond to burning down all of the forests of the world. This suggests that massive fires were touched off at the time of impact. For more information on the fossil and soil data, please see the station cards associated with this task.

This mass extinction event serves as the background and the motivation for students’ culminating project for this unit. In this task, students examine soil and fossil evidence that not only proves that an asteroid collided with Earth 65 million years ago, but also that it had dramatic consequences. By doing so, students will be able to justify the need behind them finding a solution to thwart the impending collision described in their culminating project.

**Academic Vocabulary**

* Extinction (Mass)
* Layers
* Fossil
* Biodiversity
* Pattern

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

5 Days

* Engage and Explore: 1 period
* Explore (continued): 1 period
* Explain: 1 period
* Elaborate: 1 period
* Evaluate and Reflection: 1 period

**Materials**

* Unit 1, Task 1 Student Version

Explore

* Resource Cards 1 - 5: two - three per station

Evaluate

* Project Organizer Handout

**Instructions**

**Engage**

1. Introduce Task 1: In the Lift-Off Task, we heard about a theory of an asteroid collision with Earth 65 million years ago. 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: In the Culminating Project Challenge, we found out that an asteroid, called *Etiam*, is headed towards Earth, so we need to learn everything we can to help prevent this. There is a theory that a large asteroid hit Earth 65 million years ago. What might be the consequences of an asteroid colliding with Earth?
   * Now pass out their Task 1 student guide.
3. Students pool the prior knowledge of their group members to see if they can guess what asteroid collision this refers to—the one that killed the dinosaurs.

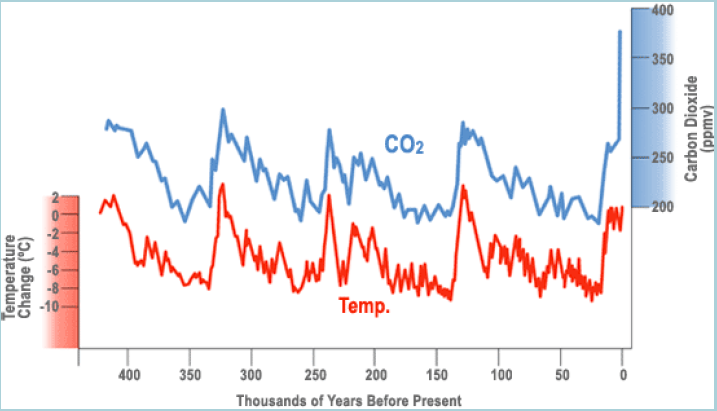
* Share out a few guesses. Most likely, there will be at least one group in your class who can identify this asteroid collision. If no groups come up with this guess, identify it as the one that killed the dinosaurs.

1. Introduce students to the kind of data they will be analyzing in this task: the fossil record.

* In this portion of the Engage, pairs of students will use logic to think about what layers are the oldest and the youngest.
  + 1. If students are stuck, present scenarios that help them think about layering (for example, would the most recent leaves dropped from a tree be on the top layer or buried underneath the soil?) Students may also use the organisms in the layers as clues (for example, there is a human skull at the top layer).
* Students will then choose one species from the drawing and hypothesize why it has changed from generation to generation. This will build off prior knowledge of adaptation processes from earlier grades. It also encourages students to begin exploring the crosscutting concept of **Patterns**, as they use the image to identify patterns in this particular source of data—the fossil record.
* We recommend that you also ask students to share out a few responses, so all students begin the *Explore* with similar understandings. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See “How To Use This Curriculum” for more details).

**Explore**

1. The introduction on their student guides sets the context in which they are collecting data and the reason why it is so important they collect this data, so we recommend reading this aloud.
   * In this section of the task, each group of students will visit stations to look at evidence for one type of event in the fossil record—an asteroid collision and the corresponding mass extinction. This gives students practice at **Analyzing and Interpreting Data**, as they look for similarities and differences amongst the data that might give them clues about an asteroid collision 65 million years ago.
2. We recommend first modeling general graph analysis skills.
   * Optional: project the graph below for students to analyze. Emphasize that while this graph has nothing to do with the task, it will help them practice how to analyze graphs like the ones they will see today.



DATA: Petit, J.R., et al., 2001; NOAA/NGDC Paleoclimatology Program, Boulder CO, USA.

* Have students first look at the axes and what is being graphed. With a partner, have students describe what the graph is about in their own words (this isn’t the analysis… but it helps them get acquainted with the graph. Note that 0 is present (maybe write this on the board).
* Provide some questions and criteria for analysis.
  + What is the graph measuring, according to the axes?
  + Describe patterns (repetitions) using axes labels.
  + Describe exceptions to patterns… are there parts of the graph that are different than the pattern?
  + If there is no pattern, say there is no pattern.
* Provide some sentence starters
  + If there are patterns: “As \_\_\_\_\_\_\_\_\_ increases/decreases, \_\_\_\_\_\_\_\_\_\_\_ increases/decreases…” (Hint: Look for patterns of peaks).
  + If there are exceptions to patterns: “However, from (some part of the graph)… we can see a difference in the pattern.” (Hint: Look for an area that doesn’t look like the pattern of peaks).
* Graph conclusions: Both temperature change and carbon dioxide decreased and increased from 450,000 years ago to the present. From about 440,000 years ago to 330,000 years ago, temperature change and carbon dioxide decreased. There were some small increases and decreases in the overall pattern during this time. Then there was a jump in both carbon dioxide and temperature. There were three more cycles like this. The carbon dioxide and temperature changes paralleled each other, but just before the present, the carbon dioxide increased to more than it was at any other point on the graph and the temperature didn’t increase so dramatically.
* Lastly, write the following graph analysis facilitating questions on the board that students may use as they analyze the graphs in the stations:
  + What does each axis of the graph say? What are the units?
  + What does the graph measure?
  + What patterns do you notice on the graph?
  + Are there any exceptions to the pattern?

1. We also recommend modeling the process of analyzing and interpreting the data on the station cards with Station Card 1.

* Project Station Card 1 and look at the picture together.
* Model how to fill out the data analysis chart, including discussing and recording responses to the discussion questions.
* Optional: provide students with fossil “samples” to look at as they examine the station card (https://www.carolina.com/earth-science-fossils-geologic-time/mesozoic-fossil-collection/GEO5322.pr?intid=jl\_pdp&jl\_ctx=on\_site).

1. Assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Materials Manager, Facilitator, Harmonizer, and Recorder.
   * Ask Facilitator to read the directions and to make sure everyone understands the task.
   * Ask the Materials Manager to handle any resources 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 Recorder to make sure the group is recording their data analysis in their student guides.
2. Set up 4+ stations around the room for Station Cards 2 - 5 (you may need to have duplicate stations depending on the number of student groups you have). At each station, lay out 2-3 copies of one station card.

* Students will circulate between the stations to gather evidence. It is recommended that you set a specific time for each station (approximately 7 minutes) so students really spend time doing deep analysis of the data.
* Walk around and listen to the kind of evidence students are discussing.
  + Try not to provide any explicit analysis, but you may point out parts of the data to focus on if students are struggling.
  + The discussion questions provided on the station cards are meant to provide facilitation and scaffolding for the data analysis.
  + As students analyze the data, you should begin to notice students finding **Patterns** both within one station as well as between stations. This continues students’ engagement with the crosscutting concept highlighted in this task, as students use graphs, charts, and images to identify patterns in the data.
* Students should fill out the data collection table in their student guide in order to record and organize their findings.

1. Optional: Conduct a whole-class debrief that brings out the **patterns** students saw in the data.
   * Students should notice related patterns of high extinction rates, decreased biodiversity, change in soil composition, and changes in the complexity of organisms, which represent times of mass extinctions.
   * Again, the use of equity sticks is encouraged for more equitable participation in class-wide discussions like these (See “How To Use This Curriculum” for more details).

Sample Student Data Analysis Chart

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Type of Data**  **(Graph, image, description, etc)** | **Observations: What do you see?** | **Responses to the Discussion Questions** |
| **Resource Card 1** | Image | I see many different layers of soil. The layers below the red line have lots of different organisms, while above the red line there are less. | 1. The layers below the red line have more organisms and there is a greater variety in type. The layers above the red line show the opposite. 2. A mass extinction |
| **Resource Card 2** | Description | There is not only evidence in fossil data but also soil data for an asteroid collision. The fossil record shows “breaks” in the sequence. The soil shows a layer 65 million years ago that contains iridium, quartz, and soot—all evidence for an asteroid collision. | 1. There are “breaks” in the fossil record. 2. Iridium, commonly found in asteroids, is in the layer from 65 million years ago. There is also deformed quartz from an explosion and soot from the subsequent burning. 3. The soil evidence shows that an asteroid collision was the cause of the mass extinction shown in the fossil record (effect). |
| **Resource Card 3** | Graph | The graph shows many large dips in biodiversity over time, shown with red arrows. The dip 65 million years ago involves the end of the dinosaurs. | 1. It does not. Sometimes it dips a lot or a little and, sometimes it increases. 2. The red arrows represent times where biodiversity of marine organisms has decreased a lot.    1. The cause could be something like an asteroid collision or a dramatic change in climate. 3. There is also a large dip in biodiversity, specifically the end of the dinosaurs. |
| **Resource Card 4** | Graph | There are 5 spikes in the extinction rate over the history of life on Earth. The rest consists of much smaller spikes in extinction rate. | 1. The dips in biodiversity are at the same points as the spikes in extinction rate.    1. Less biodiversity means the death of many species, which thus means a higher extinction rate. 2. Mass extinction is when lots of species go extinct suddenly, but background extinction seems to be when fewer species go extinct.    1. If it is big enough, most likely a mass extinction because it has a huge impact and can change the climate. |
| **Resource Card 5** | Image | It looks like there were once many different kinds of leaves, but after the K-T line, the leaves are much more similar. | 1. The layer below the dotted line has much more variety in the types of organisms. 2. Most of them became extinct because of some drastic change in environment.    1. It could have been an asteroid collision. 3. Some of the fossils stay the same one layer to the next, while others seem to show gradual changes, for example in size and shape. |

**Explain**

1. This section of the task asks students to use all of the evidence they have gathered and come to a conclusion: Did a large asteroid hit Earth before? If so, what were the consequences? This emphasizes the crosscutting concept of **Patterns** as students use patterns in the data to identify a cause-and-effect relationship between the asteroid collision and the various effects.
2. Students write a CER paragraph to draw these conclusions.
   * They should include data analysis chart from the last section of the task as evidence. Here, students are **Constructing Explanations** using evidence 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.
   * Optional scaffold: Write a claim together as a class and brainstorm an example of a piece of evidence from the stations that could be used to support the claim.

Optional Sentence Stems to Provide:

|  |  |
| --- | --- |
| **Claim** | Based on the evidence, we can conclude that a large asteroid (has/has not) hit Earth before. The evidence suggests that the asteroid collision resulted in… |
| **Evidence** | There are several pieces of evidence for an asteroid collision 65 million years ago. When observing soil layers from 65 million years ago, you can see…  The soil layers also show…  When looking at the fossil record from 65 million years ago, we can also see…  This means that…  This can also be shown in a graph of… |
| **Reasoning** | All of these pieces of evidence show that…  The asteroid collision not only did \_\_\_, it led to…  This is what caused…  This is why we see \_\_\_\_ in the soil record at the same time as \_\_\_\_ in the fossil record.  If an asteroid collision happened today, … |

Sample CER Report

|  |  |
| --- | --- |
| **Claim** | Based on the evidence, we can conclude that a large asteroid has hit Earth before. The evidence suggests that the asteroid collision resulted in a mass extinction of species. |
| **Evidence** | There are several pieces of evidence for an asteroid collision 65 million years ago. When observing soil layers from 65 million years ago, you can see the presence of iridium, a common component of asteroids. The soil layers also show a presence of quartz deformed by a high-pressure shock and soot from the subsequent burning of forests around the world. When looking at the fossil record from 65 million years ago, we can also see a large decrease in biodiversity—in other words, that many species of organisms went extinct. This can also be shown in a graph of a high rate of extinction at this time. |
| **Reasoning** | All of these pieces of evidence show that there was an asteroid collision 65 million years. It not only distributed pieces of asteroid, but also caused massive fires and climate change. This in turn was what caused the mass extinction that followed, which is why we also see evidence of a mass extinction at the same time in the fossil record. If an asteroid collision happened today, we would likely see similar impacts. |

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

**Elaborate**

1. This part of the task gives students practice at checking for understanding amongst their peers and making revisions for both content and language.
   * This academic language tool is known as the “Stronger and Clearer” method, and will help students strengthen and clarify language and ideas in their CER report. As they talk to peers, they can build from their ideas and borrow language from their partners.
2. Introduce the purpose of the task, as outlined in their student guide.
   * Begin by having students look back at their own CER paragraph and recording any ideas and language they really liked from their own CER (chart provided in their student guide). This will not only help them start with a positive reflection of their own work, but will also give them practice with the process they will use in this activity.
3. This activity can be set up in different ways, but we recommend having students form two concentric circles, so that partners are facing each other.
   * Review the instructions aloud with students.
   * As students go through the “Stronger and Clearer” process, call out time reminders to students, so they stay on task (adjust times as needed to fit your students’ needs).
     1. 1 minute for each person to share, 1 minute to discuss each partner’s CER, 1 minute to record. These time breakdowns are written in the student guide as well.
   * After 5 minutes, ask students in the inner circle to rotate one space to the right, so they have a new partner. Repeat the process again.
   * Optional: Repeat this more times with more partners, so students have additional models to learn from.
4. Once finished with partner sharing, have students return to their seats to write a new version of their CER, incorporating the new ideas and language they have gathered.

* It is important to remind students that while learning from others is encouraged, direct copying is not acceptable.
* This is a great option for a formative assessment. Collect student work to identify trends in students’ ability to use multiple patterns as evidence for an explanation. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

1. 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: patterns in the fossil record, changes in biodiversity over time, and mass extinctions.
* Have students analyze the additions to the class concept map for as many examples of this task’s crosscutting concept 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.
* 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 1 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 designing a solution to prevent the impending collision of the asteroid *Etiam* with Earth. Their prompt is as follows: Today we learned that there has already been an asteroid collision in the past that had huge consequences. Use this ancient collision to justify your design solution:

* What evidence is there that this has happened before?
* What were the effects last time?
* How will you use the evidence to convince the public that it is important to protect Earth from another asteroid collision?

**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 guess what asteroid collision occurred 65 million years ago. Look back at your prediction: after collecting all the evidence today, how have you added to or changed your prediction?
* In this task, we focused on the crosscutting concept of **Patterns**: Graphs, charts, and images can be used to identify patterns in data and these patterns can be used to identify cause-and-effect relationships. Where did you see examples of **Patterns** in this task?
* Now that you have learned more about the fossil record and what it tells us about asteroid collisions, 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.