**Unit Essential Question:** How have natural processes and human activities created the ecosystems we see today?

**Introduction**

In the Lift-Off task, students were introduced to Biosphere 2 and began to generate questions about how well-functioning ecosystems/biospheres work. In this task, students begin to examine ecosystems from a macro perspective: based on plate motions, what geographic features are present in different ecosystems? Students engage with this question by thinking about a real case in scientific history. In the early 1900s, a meteorologist named Alfred Wegener developed a theory: in looking at the shape of the continents, he proposed that the continents had once formed a single landmass and have since drifted apart. At the time, no one accepted his idea, but since then, much more evidence has been collected that suggests that Wegener was most likely correct. In this task, students embark on this journey on their own, making sense of the phenomenon of continent movement by collecting an abundance of data to provide evidence of plate movement over time. By the end of this task, students will be able to write a CER report agreeing or disagreeing with Wegener’s theory. This will then inform their culminating project by helping them identify geographic features within their arena based on the continental location they choose.

**Alignment Table**

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| --- | --- | --- | --- |
| **Performance Expectations** | **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| **MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.** [Clarification Statement:  Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).] [Assessment Boundary: Paleomagnetic anomalies in oceanic and continental crust are not assessed.] | **Analyzing and Interpreting Data**   * Analyze and interpret data to provide evidence for phenomena. | **ESS2.B: Plate Tectonics and Large-Scale System Interactions**  * Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth’s plates have moved great distances, collided, and spread apart. | **Patterns**   * Patterns in rates of change and other numerical relationships can provide information about natural systems. |
| **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. | | | |
| **Supplementary Crosscutting Concepts**   * Systems and System Models   + Systems may interact with other systems; they may have sub-systems and be a part of a larger complex system. | | | |
| **Equity and Groupwork**   * Contribute information to a class-wide model by playing an assigned role. * Discuss how continents are arranged and collaborate on a visual model. | | | |
| **Language**   * Annotate a drawing. * Orally present evidence of plate motions. * Record evidence from oral presentations. * Construct an explanation about continental drift. * Use the Stronger Clearer protocol to strengthen an explanation. | | | |

**Learning Goals**

This learning task introduces students to the concept of past plate motions and highlights the skills of analyzing and interpreting data to provide evidence. More specifically, the purpose is to:

* Engage prior knowledge of continent arrangement based on observation skills.
* Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures.
* Explain plate movement, using evidence collected to justify a claim.
* Participate in the Stronger Clearer protocol to strengthen an explanation.
* Apply knowledge of how geologic features have developed in order to design their own “imitation” environment.

**Content Background for Teachers**

 Earth’s outer layer, the crust, is divided into a set of large moving plates. These are called tectonic plates. Mounting evidence from satellites in the 1960s suggested that these tectonic plates are actually moving at a very slow rate. This is because of convection currents in the layer below the crust, known as the mantle. Hot mantle rock rises from the core and moves along under the crust until it grows cool and heavy and sinks down again. This causes the plates to move and can result in tectonic events along the plate boundaries, such as earthquakes and volcanoes.

The focus of this task is not on current plate motions, however, but rather on evidence for the larger past plate motions as a whole. The idea that plates have been moving is not a new one. In 1920, Alfred Wegener took a look at the shape of the continental plates and suggested that they may once have been connected in one landmass—a concept known as Pangaea. While unaccepted at the time, this idea is now accepted in light of many different sources of evidence that have been collected.

In looking at the evidence, one can see that mountain ranges on different continents line up, such as those on the coasts of Africa and South America. Similarly, European coal fields match up with coal fields in North America. Furthermore, fossils and rocks found on different continents provide evidence that the continents were once joined together in a single landmass. In the resource cards provided, students will see examples of similar fossils and types of rock found across different continents. For more information on these pieces of evidence, reference the resource cards associated with this task.

**Academic Vocabulary**

* Continent
* Plate
* Fossil
* Climate
* Glacier
* Pangea

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

5.5 Days

* Engage: 0.5 period
* Explore: 2 periods
* Explain: 1 period
* Elaborate: 1 period
* Evaluate and Reflection: 1 period

**Materials**

* Unit 1, Task 1 Student Version

Explore

* Continent Pieces: Two continent pieces per group (enlarge, print, cut, and laminate)
  + <https://pubs.usgs.gov/imap/2800/>
  + Suggested Groupings:
    - South America and Africa
    - South America and North America
    - North America and Europe/Asia
    - North America and Africa
    - Europe/Asia and Africa
    - Antarctica and Australia
    - Antarctica and Africa
* Envelope of Evidence Cards (1 per group): Look at the list below for the relevant evidence cards for each pair of continents. Cut them into continent pieces, label the backs with the type of evidence, laminate, and put into an envelope. *Note: Evidence cards must be in color for students to see evidence.*
  + South America and Africa: Mountain Ranges, Rock, Glacial Deposits, Fossils
  + South America and North America: Coal, Fossils
  + North America and Europe/Asia: Mountain Ranges, Coal, Rock, Fossils
  + North America and Africa: Mountain Ranges, Fossils
  + Europe/Asia and Africa: Mountain Ranges, Fossils
  + Antarctica and Australia: Glacial Deposits, Fossils
  + Antarctica and Africa: Glacial Deposits, Fossils

Explain

* Projector and Speaker (for video)

Evaluate

* Project Organizer Handout

**Instructions**

**Engage**

1. Introduce Task 1: In the Lift-Off task, we looked at an artificial environment. 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: However, your arena should be designed to be built on real land in a real location, so you will have to take into account the large geologic features that might be there. To get a full understanding of your arena location, today we will explore geologic features around the world and how they were made.
   * Now pass out their Task 1 student guide.
3. Students begin this task by using their prior knowledge to make a prediction about where continents may have been located hundreds of millions of years ago. Students should draw arrows directly on the map in their student guide. They then explain why they drew what they drew. This activity can be done in pairs.
   * Share out a few different possibilities that students come up with. There are no right answers. Most students will reference the borders and shapes of continents as their reasoning for their prediction.

**Explore**

1. In the early 1900s, a meteorologist named Alfred Wegener also thought about this question and suggested that the continents were once joined together, but moved over time to where they are today. In this activity, students will analyze various pieces of evidence to decide if they agree or disagree with Wegener’s idea.

* This gives students practice at **Analyzing and Interpreting Data** to provide evidence of the phenomenon of continental drift.

1. Assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Facilitator, Materials Manager, Harmonizer, and Reporter.
   * Ask Facilitator to read the directions and to make sure everyone understands the task.
   * Ask the Materials Manager to gather the 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 the group is prepared for the presentation.
2. Assign each group two continent pieces and distribute the enlarged continent pieces and the envelopes of relevant evidence cards (as laid out in the materials section above).

* Ask students to examine the evidence cards provided for their two assigned continents.
  + Walk around and listen to the kind of evidence students are discussing.
  + Try not to provide too much guidance - let the group decide what information they will use to make sense of the two continent pieces they are working with.
* Students should fill out the data collection table in their student guide in order to record and organize the evidence they have to justify the placement of their continent pieces.
* Once students have had time to collect their own data, remind them that they need to prepare to present their information out to the class.
* In this activity, students are beginning to explore these ideas through the lens of **Systems and System Models** by considering the smaller sub-system of two continents, which they will then apply to the larger continental system in a class-wide discussion.

1. Conduct a presentation for all groups to share their analysis about their assigned continents. The purpose of these presentations is for students to engage in an authentic scientific process in which they learn about evidence from other groups. In doing so, they are able to identify **patterns** across different groups of evidence to form a more cohesive picture of continental drift on Earth. This also continues their exploration of the crosscutting concept of **Systems and System Models**, as student groups situate their own two continents within the larger continental system.
   * Project a map of the world to set context: <https://pubs.usgs.gov/imap/2800/>
   * Ask each group to come to the front of the room and:
     + Explain whether they think the continents were once in a different location than they are now, citing all relevant evidence that justifies their claim.
     + Tape their two continent pieces to the board to illustrate how they think the two continents might have been arranged in the past.
   * Ask each new group to add their continent pieces to the first group’s pieces and share their evidence that justifies their choice.
     + Ask each group follow-up questions about their evidence when connections are not explicit. For example, “You said there are coal deposits on both continents. How is that evidence of movement? Can you point it out on your continent pieces?”
     + Students may want to bring up their evidence card cut-outs so they can reference the evidence as needed.
   * As students listen, they should be documenting other groups’ evidence in the chart on their student guide. This will be used to write their CER report in the next section.
     + You may want to model this type of note-taking using one pattern of evidence. For example, in the first row, you might write: “Group 1 found that there were mountain ranges on the east side of \_\_\_\_ and the west side of \_\_\_\_\_.”
   * Here is a suggested sequence for having groups present
     + South America and Africa
     + South America and North America
     + North America and Europe/Asia
     + North America and Africa
     + Europe/Asia and Africa
     + Antarctica and Australia
     + Antarctica and Africa
2. After each group has completed their presentation, conduct a whole group discussion of whether the class thinks the continents have moved over time and what type of evidence was the most convincing.
   * Possible sentence stems to provide are: “I think the continents have moved over time because…” and “The most convincing type of evidence is \_\_\_\_ because…”
   * Students can then draw a complete class model of all the continents in their student guide. This practice continues to highlight the crosscutting concept of **Systems and System Models** by allowing students to take individual components and bring them together within one whole Earth system.

Sample Student Evidence Chart

|  |  |
| --- | --- |
| **Type of Evidence** | **Specific Examples** |
| Mountain Ranges | * + The lower tip of Africa and the eastern side of South America both have mountain ranges.   + The eastern side of North America and the northwestern tip of Africa both have mountain ranges.   + The northeastern side of North America and the western side of Europe/Asia both have mountain ranges.   + The southeastern side of Europe/Asia and the northwestern tip of Africa both have mountain ranges. |
| Coal Distribution | * Lots of coal deposits are found in both the top of South America and the bottom of North America. * Lots of coal deposits are found in both North America and Europe/Asia. |
| Types of Rock | * Large deposits of Archian Rock are found in both North America and South America. * Large deposits of Archian Rock are found in both South America and Africa. There are also other matching rock types between these two continents. * Large deposits of Archian Rock are found in both North America and Europe/Asia. There are also other matching rock types between these two continents. |
| Distribution of Glacier Deposits | * Glacial deposits are found in the tip of Africa and all of Antarctica. * Glacial deposits are found in the bottom half of Australia and all of Antarctica. * Glacial deposits are found in both southern tips of Africa and South America. |
| Distribution of Fossils | * The Kannemeyerid fossil is found in both North America and Europe/Asia. * The Kannemeyerid fossil is found in both North America and South America. * The Kannemeyerid fossil is found in both North America and Africa. * The Kannemeyerid fossil is found in both Africa and Europe/Asia. * The Kannemeyerid, Mesosaurus, Glossopteris fossil are found in both South America and Africa. * The Labyrinthodont and Lystrosaurus fossil is found in Africa and Antarctica. * The Labyrinthodont fossil is found in Australia and Antarctica. |

**Explain**

1. At the beginning of the Explore, students were introduced to Alfred Wegener’s theory. In this section, students will agree or disagree with his theory, using the evidence from the Explore.
2. Project the following video about Alfred Wegener’s theory on the board: <https://www.youtube.com/watch?v=RgJZ0ySEKYg>
   * Stop the video at 4:40.
   * Have students answer the discussion questions in pairs, which help them to process the ideas in the video and prepare to construct their explanation.
   * Debrief as a class. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See “How To Use This Curriculum” for more details).
3. Students then individually construct an explanation agreeing or disagreeing with Wegener’s theory and answering the following question: Based on your data analysis, do you think the continents have always been arranged the way they are today or do you think the continents have moved over time?
   * They should use the evidence chart from the *Explore* to help them. This allows students explicit practice in the skill of **Constructing Explanations** as they use evidence to support a claim.
   * Optional scaffold: Write a claim together as a class and brainstorm an example of a piece of evidence from student presentations that could be used to support the claim.

Optional Sentence Stems to Provide:

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| --- | --- |
| **Do you agree or disagree with Wegener’s theory?** | I agree/disagree with Wegener’s theory…  Evidence from many different sources suggests that… |
| **What evidence do you have to support your position?** | There are many different sources of evidence, such as…  First, we can see …  One piece of evidence is…  Similarly, \_\_\_\_\_\_ evidence shows that…  For example…  This is also shown in the case of…  Lastly, \_\_\_\_\_ evidence suggests that…  All of these pieces of evidence show that…  Because of \_\_\_\_\_\_, this suggests…  This is possible because… |

Sample Explanation

|  |  |
| --- | --- |
| **Do you agree or disagree with Wegener’s theory?** | I agree with Wegener’s theory. Evidence from many different sources suggests that continents have not always been arranged the way they are today, but have actually moved over time. |
| **What evidence do you have to support your position?** | First, we can see from matching mountain ranges along continents like North America and Europe/Asia that certain continents were once connected. This is also shown through the common types of rock and glacial deposits we see between continents. For example, we see similar glacial deposits on the southern tip of Africa as well as the western end of Australia, implying these areas were once connected. Similarly, Archian rocks can be found in both eastern South America and western Africa, implying a previous connection there. Fossil evidence also suggests that continents were once connected. For example, the Labyrinthodont fossil is found in both Antarctica and Australia. Lastly, coal deposits, are found in both North America and Europe/Asia areas, suggesting that that continents may have once been in similar locations. All of these pieces of evidence show that continents may have once been connected in one larger continent, called Pangaea, but have since moved because of plate motions. |

**Elaborate**

1. Students will now participate in a language routine known as *Stronger Clearer*. This activity gives students the opportunity to share their ideas, gather feedback, and revise their explanations. This protocol is especially useful since their explanation required the cognitively challenging task of integrating many pieces of evidence.
2. Students will share with three different partners, allowing them to discuss feedback and record any notes each time. Once complete, students should be given time to individually revise their explanations based on their discussions. A protocol is provided in their student guide.
3. This revised explanation can be a good option for formative assessment. Collect student work to identify trends in students’ ability to use evidence to support an explanation. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.
4. 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: evidence of past plate motions and the geologic features present in certain areas of the world.
   * 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.
   * **Systems and Systems Models**: These could be phrases such as, “is a part of” “connects to,” “interacts with,” “is made up of,” “works together with,” 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. Usually, we recommend that students independently complete their project organizer. However, at this point, it is important that the group make a decision about WHERE the arena will be located. Students should work with their group to fill out 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 creating an arena that mimics an environment they may see on Earth. Their prompt is as follows: Over the course of this task, you gathered evidence of how past plate motions have led to some geologic features you see on Earth. As a group, decide on a location for your arena that would have the geologic features you want. Then individually,
   * Draw a map showing your arena location on Earth as well as any relevant surrounding continents, making captions that answer the questions below:
     + On what continent would your arena be located? Why are you locating it there?
     + What features would you find (mountain ranges, types of rock, glaciers, etc.)?
     + How can you use plate motions to explain these features?

**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 make a hypothesis about how continents may have once been connected. Look back at your hypothesis: after collecting all the evidence today, how would you change or add to your hypothesis? Use evidence from the task to justify your changes or additions and record below.
* In this task, we focused on the crosscutting concepts of **Patterns**: Patterns can be used to identify cause and effect relationships and provide information about natural systems, and **Systems and System Models**: Models can be used to represent systems and their interactions within and between systems. Where did you see examples of **Patterns** and **Systems and System Models** in this task?
* Now that you have learned more about the evidence for past plate motions, 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.

1. 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.