SUCCESS
ACADEMY
EDUCATION
INSTITUTE

# Earth and Space Science: Unit 1

# Earth's Changing Landscape: Lessons

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## Lesson 1: A Strange Discovery

**Lesson Objective: Scholars know that scientists investigate new or unexplained phenomena using several methods, such as experimentation, research, and modeling. They work to build a large body of evidence before drawing conclusions.  Materials Needed**

- For each group: **fossil discovery map**, sheet of chart paper, chart markers

**Prep**

- Intellectual Prep:
  - Review the **Lystrosaurusâ€" Facts and Pictures** webpage.

**What are scholars doing in this lesson?**

- Scholars receive a map with information about some interesting fossil discoveries. It doesn't seem to make any sense, as it shows that fossils from an animal that couldn't swim or fly were found on different continents! They brainstorm possible causes of this perplexing data.

**Do Now**

- Follow the **Do Now plan**.

**Launch**

- Explain to scholars that fifth grade science will begin with a real-life science puzzle! A series of discoveries from underground just doesn't seem to add up, and in this unit, scholars will be tasked with attempting to unravel a real science mystery, just like scientists did!
    - Tell scholars that fossils from a land-dwelling prehistoric species, Lystrosaurus, were found on several continents. The locations are thousands of miles apart and separated by entire oceans!

**Activity**

- Scholars study the map showing the approximate locations where Lystrosaurus **fossils** are found.
    - Scholars brainstorm and chart:
        - Prior knowledge about rock layers, fossils, or geography that they think may be relevant
        - Possible explanations for this strange phenomenon
    - Scholars record the hypothesis they think is the strongest/most likely to be true in their lab notebooks.
- As scholars are working, circulate and gather informal data on their prior knowledge and ability to use evidence to support an explanation.

**Discourse  Debrief activity:**

- Show an image of the map from the activity. Ask:
    - What do you already know about fossils and rock layers?
    - What information might help us to solve our Lystrosaurus mystery?
- Ask: What possible explanations did your groups come up with?
    - Share out from each group.
    - Create a class chart. (This chart should be left up throughout the unit, and ideas should be added/eliminated as they surface or are disproven!)

**Introduce the Essential Question:**

- Ask: How is it possible that Lystrosaurus fossils were found on three continents?
    - Explain to scholars that they will embark on a unit-long journey to find the answer to this question!
    - Note: You should not be explicit about the Lystrosaurus's being extinct. Scholars may bring it up because they infer that this was a dinosaur; however, do not confirm or deny this, because scholars will discover this definitively in a later lesson.

**Make broader connections:**

- Ask: As a scientist, how would you approach solving this problem? Why?
    - Lead a discussion about how scientists approach unexplainable phenomena and new problems, asking scholars to recall their prior knowledge.

**Accountability (Lab Notebook)**

- Study scholars' Lab Notebooks. Look for misconceptions in their explanations, and make a plan to circle back with scholars throughout the unit to see if they have been corrected.

**Scoring** Award points as follows:

- Score scholars on a 1–4 scale (below expectations through exceeding expectations) based on classwork. Do not penalize scholars for initial misconceptions about contentâ€" rate them on effort and writing.
    - Look for the following when scoring scholar responses:
        - A clear claim that answers the question
        - Specific evidence collected from the activity or their prior knowledge that supports the claim
        - Justification/reasoning that ties the evidence to the claim
        - High effort shown in writing, with complete sentences and proper grammar/ punctuation seen throughout the response

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# Lesson 2: Digging into Earth

**Adapted from the Edible Rock Classroom Activity by NASA**

**Lesson Objective: Scholars know that studying Earth's rock strata is important because fossils in the rock strata help us understand the types of organisms that lived in the past and therefore what the potential environment was like. It helps us understand how Earth and its features formed over time and to predict its future. Materials Needed**

- For each group: half of each of several types of candy bar, plastic bag

**Prep**

- Materials Prep:
    - Cut candy bars in half and place each into a plastic bag.

- Intellectual Prep:
    - Review reading material:
        - **Berkeley Websiteâ€”The Birth of Geology**
        - **Earth Observatory Websiteâ€”William Smith**

**What are scholars doing in this lesson?**

- Scholars observe cross-sections of candy bars that represent various locations on Earth.

**Do Now**

- Follow the **Do Now plan**.

**Launch**

- Explain to scholars:
    - Before we can solve the mystery of the Lystrosaurus fossils, we need to gather some foundational information. Ask:
        - How do fossils even get into the ground?
        - How do rock layers form, and how long does that take?
        - Do the rocks below Earth's surface hold other clues to the past?
- Explain that Earth's history can be investigated by studying the rock underneath the planet's surface. (Do not give anything away yet, though!)

**Activity**

- Scholars examine the structure and components of each candy bar that represents different locations on Earth.
    - Scholars diagram and record their observations and inferences of how these candy bars may have been constructed in their Lab Notebooks.
- As scholars are working, circulate and note those who make a clear connection between the layers on their candy to Earth's rock strata. Be sure these scholars share during the discourse.

[**Materials Management Tip:** Have an empty container for scholars to use to dispose of candy.]

[**Tip:** Make each candy bar represent a different specific city, and show scholars those cities before launching into the activity.]

**Discourse  Debrief activity:**

- Ask: What observations did you make about the cross-sections of your candy bars?
    - When scholars explain the layered structure of some of the candy bars, introduce the terms **rock layer** and **strata** using visuals.
- Ask: Compare the “rock layers” from the different locations. What are the similarities and differences? What does this tell us?
- Ask: What other components did you find in the “rock layers” of each location?
- Ask: Based on your observations, what can be learned by studying Earth’s rock strata? Why is this important?
- Show an example of a scholar diagram from a Lab Notebook.
    - Have scholars point out qualities of excellent Lab Notebook work as a way to introduce classwork expectations.

**Make connections to the Essential Question:**

- Ask: How can we use the information we uncovered today to help us understand more about the Lystrosaurus fossils?
- Ask: Does what you learned today change your hypothesis from yesterday? Why or why not?

**Accountability (Exit Ticket)**

1. Identify and explain one reason why it is important to study rock strata. [3]

One reason it is important to study rock strata is because it helps us understand the types of animals that lived in the past. During today’s investigation, we compared the nuts in the caramel layer of the Snickers bar to fossils. By studying the fossils in rock layers, we can identify not only the animals that lived in the past but also the types of environments that existed during those times.

**Scoring**  Award points as follows:

1. Award one point for each of the following:
    - A claim that identifies one reason why it is important to study rock strata
    - One piece of evidence that explains why studying rock strata is important using information from class discussion
    - Justification/reasoning that explains their evidence

Note: Do not penalize scholars for initial misconceptions about content. Instead, rate them on effort and writing.

# Lesson 3: The Rock Cycle

**Lesson Objective: Scholars know that Earth's geosphere is made up of several types of rock and is constantly changing. The rock slowly, continually changes over timeâ€" the processes that create these changes are collectively known as the rock cycle.  Materials Needed**

- For the teacher: **Rock Cycle Simulation station and printable signs**

**Prep**

- Materials Prep:
    - Place the **Rock Cycle Simulation station signs** around the classroom (use slide 1 as a "map" for correct placement). Ensure there are clear, safe paths to walk from one station to another.
    - Determine how you will divide the class into five groups for the simulation and where each group will start.
- Intellectual Prep:
    - **The Rock Cycle**

**What are scholars doing in this lesson?**

- Scholars go through a simulation in which they play the part of some of Earth's rocks to better understand Earth's geosphere.

**Do Now**

- Follow the **Do Now plan**.

**Launch**

- Explain to scholars:
    - Yesterday you saw that areas around the world have a variety of rock layers. Where do all these different types of rock come from and how do they get there?
    - Explain that the Earth's rock layers are collectively known as its **geosphere**. The geosphere is just one of Earth's "spheres"... Can scholars think of any others?
        - Introduce and define the terms **atmosphere**, **hydrosphere**, and **biosphere**.
    - Perhaps uncovering more information will help us to solve the mystery of the Lystrosaurus fossils that became trapped in the middle of the rock strata…or at least get us one step closer!

**Activity**

- Scholars move to assigned starting positions.
    - Scholars read the sign at their station and follow the directions, traveling from one station to another to create a simulated “rock cycle.”
    - Scholars track their progress as they go, recording each step of the cycle in their Lab Notebooks.
- As scholars are working, circulate and ask:
    - What are you learning about the rock cycle?
    - How do rocks form on Earth?

[**Tip:** Ensure that scholars are moving safely around the room.]

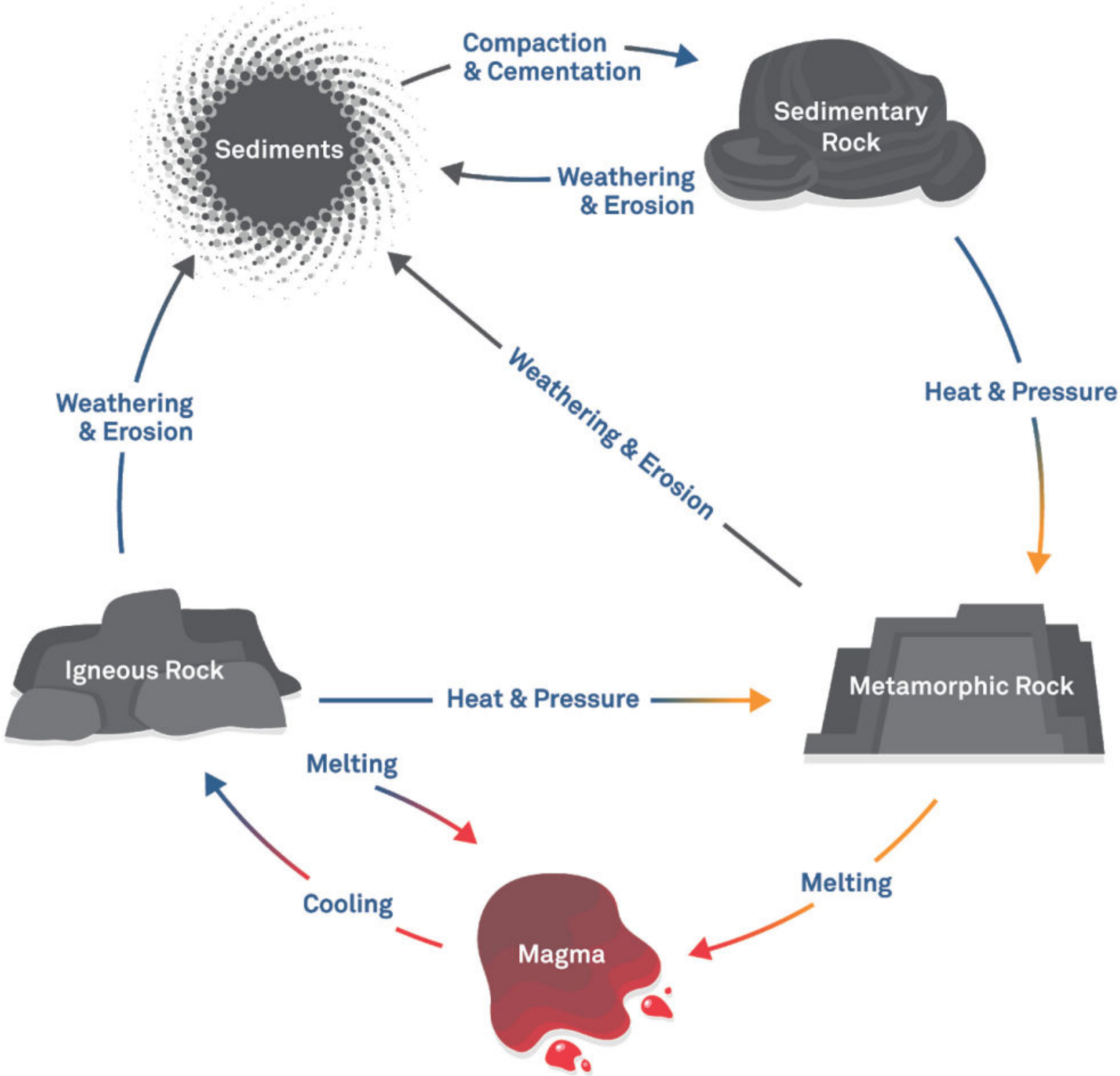
**Discourse  Debrief activity:**

- Show the map of the room on slide 1 in the PowerPoint.
    - Have one group share the path they took around the room. Trace their steps on the board.
    - Have a second group share. In a different color, trace their steps, overlaying them over the first group’s path. Ask: What do you notice about the path each group took?
    - Define **igneous rock**, **metamorphic rock**, **sedimentary rock**, and **magma**.
- Explain that the rock that makes up Earth’s geosphere is slowly changing over time and that this rock is part of a set of processes collectively known as the **rock cycle**.
    - Show slide 13 to give scholars a visual model of the rock cycle. Allow scholars to discuss their takeaways and ask questions.
    - Ask: What other “cycles” have you learned about in science? What is a cycle?
- Ask scholars to identify the point in the rock cycle when a dead organism might become trapped in Earth’s geosphere.

**Make connections to the Essential Question:**

- Ask: How can our takeaways from this lesson be applied to help us understand the odd placement of the Lystrosaurus fossils?
- Ask: What questions do you still have? What more do we need to learn to help us solve this puzzle?

**Accountability (Exit Ticket)**  The diagram below shows a visual model of the rock cycle.




1. Use the diagram to explain how it is possible for igneous rock to change into sedimentary rock over time. [2]

First, the igneous rock can be subjected to weathering and erosion. This means that pieces of the rock can break off over time, forming small particles called sediment. Then, over time the sediment is compacted (due to pressure) and cemented, forming sedimentary rock.

**Scoring** Award points as follows:

1. Award one point for each of the following:

    - An accurate description of the processes of weathering and erosion
    - An accurate description of the processes of compaction and cementation

# Lesson 4: Reading Rock Layers

**Lesson Objective: Scholars can explain that the Law of Superposition states that undisturbed horizontal sedimentary rock layers include the oldest layer at the bottom and that each higher layer is younger than the layers below it. Geologists can approximate a geological time line by determining the relative age of rock layers by studying their order in addition to any disruptions like faults, intrusions, or extrusions of igneous rocks. Materials Needed**

- For each group: **pictures of rock strata**, clear jars, takeout containers or beakers, variety of colored sand, cups, marker, tape, scissors, toothpicks, craft sticks, cardstock

**Prep**

- Materials Prep:
    - Prepare cups of sand in various colors and deli trays for each group.
    - Create folders for each lab group with copies of each rock strata picture. Print these pictures or share them digitally.
- Intellectual Prep:
    - **Law of Superposition video**

**What are scholars doing in this lesson?**

- Scholars learn more about how large groups of rock layers form by creating their own rock layers modeling real pictures. They sketch a drawing of the rock layer they want to create and then build it using sand!

**Do Now**

- Follow the **Do Now plan**.

**Launch**

- Explain to scholars that while they have learned about the process that forms individual rock layers, they have not yet studied a large sample of rock strata to determine how it was created.
    - The Lystrosaurus fossils were several layers undergroundâ€” what might that tell scientists about them? (Do not share the answer yet!)

**Activity**

- Scholars try to re-create the rock layers in the images provided by building their own sand-art rock layers.
    - Scholars sketch simplified diagrams of each rock layer scene in their Lab Notebooks, labeling any important or unusual features.
    - Scholars record notes on how they built their models in their Lab Notebooks.

[**Materials Management Tip:** Leave ample time for cleanup, as scholars will need extra time to ensure their tables are wiped down after this investigation.]

**Discourse  Debrief activity:**

- Display samples of scholar work. Ask:
    - How did you recreate each rock layer scene using the sand?
    - Which layer did you put down first? Why?
    - What does that tell us about the order that real rock layers must form in?
        - Introduce the terms **law of superposition** and **relative dating** when scholars describe them.
- Display the images that contain faulting and an intrusion. Ask:
    - How do you think these features formed? (Introduce the terms **fault**, **intrusion**, and **extrusion**.)
        - Based on what you have learned about the rock cycle, what kind of rock do you think rock strata and intrusions/extrusions are likely made of? Why?
- Show the picture below and model an interactive think-aloud for looking at a rock layer diagram and determining relative age. Ask yourself:

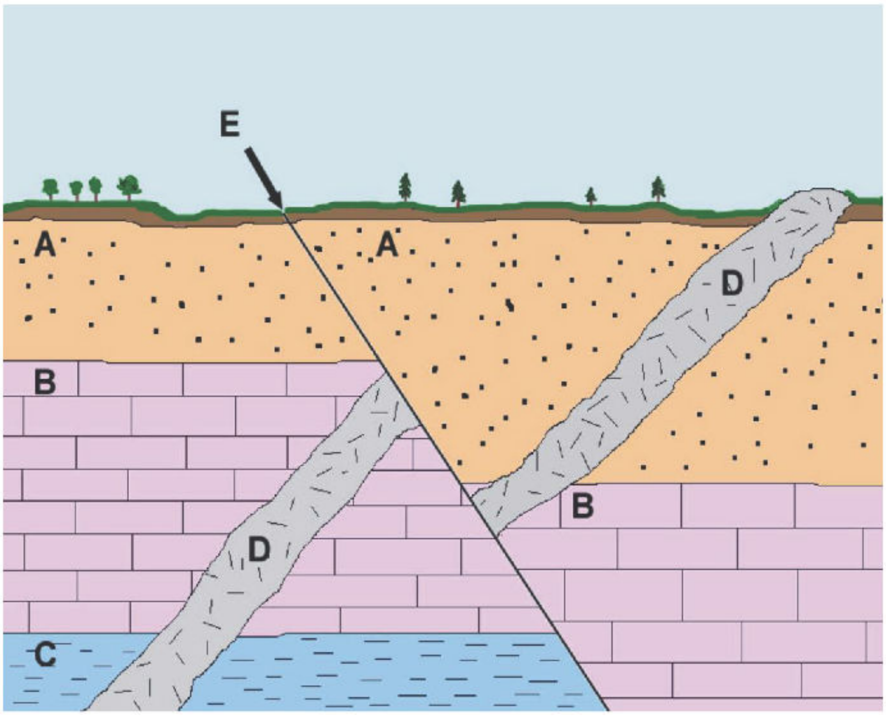



Image credit: Kurt Rosenkrantz © 2009 CK-12 Foundation CC BY-SA 3.0

- Which is the oldest? Youngest? How do we know?
- What is layer D?

- Did the intrusion occur before or after rock layer A formed?

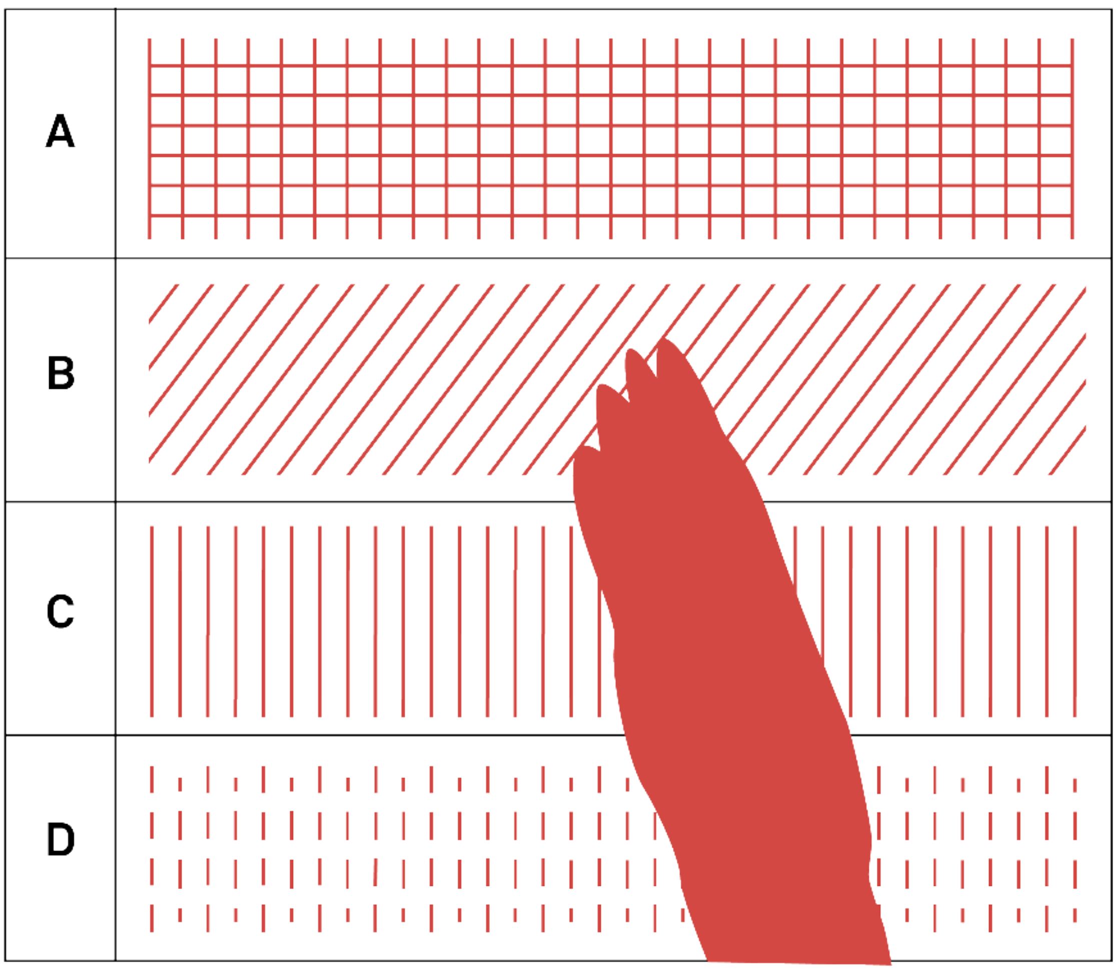
**Make connections to the Essential Question:**

- Ask: How could we apply our new knowledge of the law of superposition to help solve the Lystrosaurus mystery? (Scholars should conclude that you could check the location of the fossils to find their relative age. This would help you to determine when the organisms lived/ died on the land.)

**Accountability (Exit Ticket)**

1. Use the layer template below to create a diagram of the rock layers. Use the symbols provided to create your diagram. Some symbols may not be used. Be sure to include the intrusion. [4]

Exemplar:



**Scoring** Award points as follows:

1. Award one point for each of the following:

    - Rock layers are correctly ordered (oldest layer on the bottom and youngest on the top)
    - Rock layers are correctly drawn using the symbols from the key
    - Intrusion starts at the bottom
    - Intrusion stops halfway through the shale layer (regardless of whether the shale layer is correctly placed)

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# Lesson 5: Finding Fossils

**Lesson Objective: Scholars understand how the fossil record can be used to determine the relative age of rock formations and how lands may have been connected in the past. Index fossils are widely distributed (found in many different areas) and represent a type of organism that existed only briefly (usually found in one rock layer)â€" they can be used to match and date rock layers from different parts of the world. Materials Needed**

- For the teacher: one **Carolina Biological Fossil Kit** per group of scholars
- For each group: five deli containers with preburied fossils and colored sand, toothpicks

**Prep**

- Materials Prep:
    - Create a rock layer set for each group:
        - Fill five deli containers with different-colored sand and number them according to the outline below.
        - Add the following “fossils” to each container as follows:
            - Container 1 (blue sand): Dinosaur Tooth, Clam Shell
            - Container 2 (green sand): Horse Tooth, Scallop Shell
            - Container 3 (orange sand): Ammonite (either type), Brachiopod (either type)
            - Container 4 (yellow sand): Trilobite (either type), Nautiloid
            - Container 5 (red sand): Trilobite (either type), Fern
- Intellectual Prep:
    - **How to Fossilize...Yourself video**

**What are scholars doing in this lesson?**

- Scholars excavate mixed-up rock layers to identify fossils and help put the rock layers back in order using the law of superposition.

**Do Now**

- Follow the **Do Now plan**.

**Launch**

- The law of superposition will be key to solving the mystery of the Lystrosaurus, so today your new understandings will be put to the test!
- Show the **"Fabulous Fossil: A Week in Science" video** (2 minutes, 37 seconds). Discuss:
    - Why are fossils important?
    - What do fossils tell us about the past?
- Explain to scholars that today they will put their knowledge to the test. They will imagine that a local museum just opened a new fossil exhibit. Unfortunately, when putting together the rock strata, a few employees mixed up the "rock layers" they were supposed to install!
    - How can we use the "fossils" in the exhibit hall's rock layers to put the layers back in order based on the law of superposition?

**Activity**

- Scholars "excavate."
    - First they dig into each rock layer by sifting through each container to find fossils.
    - Then they identify each fossil using the kit's enclosed key and find its approximate age.
    - Finally, they determine how they can use the information to place the layers back in the correct order. (Scholars should stack the deli trays according to the law of superposition.)
- As scholars are working, circulate and coach those who are struggling to identify their fossils.
- Scholars record their work in their Lab Notebooks.

[**Materials Management Tip:** Leave ample time for cleanup, as scholars will need extra time to ensure their tables are wiped down after this investigation.]

**Discourse  Debrief activity:**

- Ask: How did you use the fossils to determine the age of each rock layer?
- Ask: Because containers 4 and 5 both contained trilobites, how were you able to determine which container was older?
- Ask: Introduce the term **fossil record** and the concept of **index fossils**. Have a discussion about the importance of index fossils to scientists.
- Show the image below. Ask:

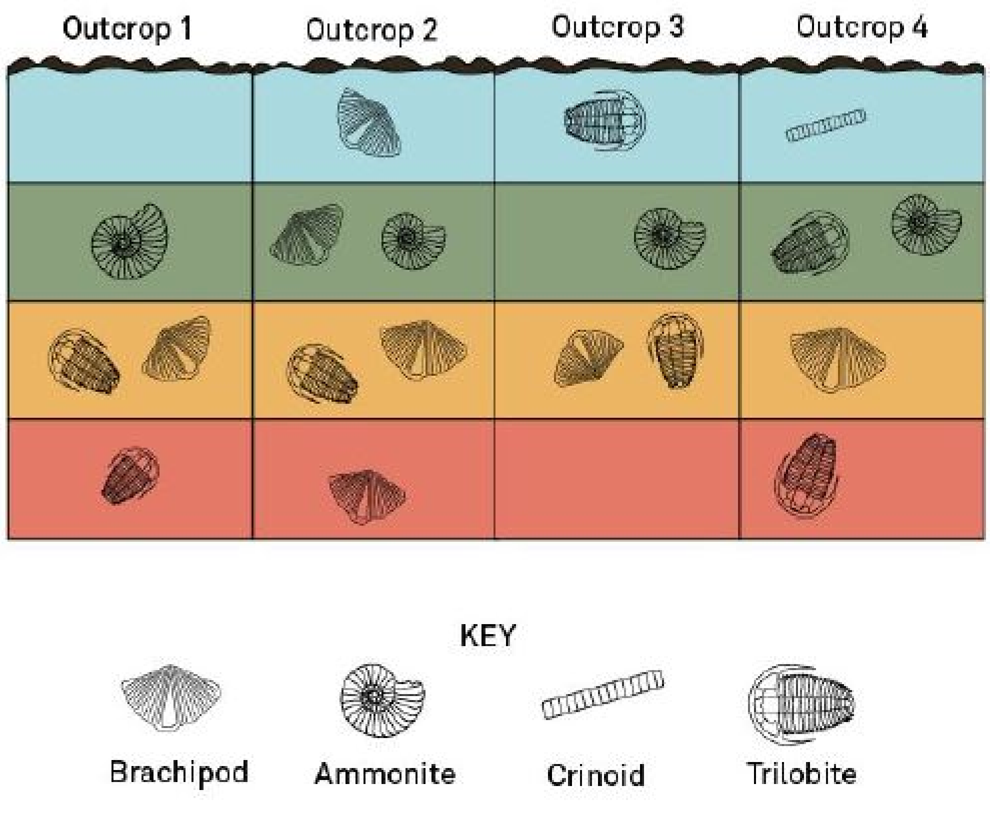
- What can you infer about the rock layers based on the labels and color-coding in this diagram?
- Which of the fossil(s) would make the best index fossils? How do you know?
- Why does the same fossil sometimes appear in several different layers?

**Make connections to the Essential Question:**

- Ask: Why do you think some fossils appear and/or disappear in the rock layers over time?
    - What does that make you think about the Lystrosaurus? (If scholars guess that the Lystrosaurus is now extinct, confirm that this is true!)

**Accountability (Exit Ticket)**

1. Based on the image below, which fossil would make the best index fossil? Include evidence and reasoning. [3]




Index fossils are used to date rock layers and should be widespread and specific to a particular time period. Ammonite would make the best index fossil. In the picture, ammonite is found in only one rock layer (second layer from the top) and in all four outcrops, whereas the other three fossils are either found in more than one rock layer and/or not found in all outcrops. Ammonite is the only fossil that fits these requirements.

**Scoring** Award points as follows:

1. Award one point for each of the following:

    - A claim that identifies ammonite as the best index fossil
    - One piece of evidence that explains that ammonite is only found in the second layer from the top and is found in all four sites
    - Justification/reasoning that explains how index fossils are widespread (found in multiple sites) and specific to a certain time period, allowing us to date that layer

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# Lesson 6: The Geologic Timescale

**Lesson Objective: Scholars understand that Earth's geologic timescale is divided into different eras classified by major events and developments in Earth's history. Scholars distinguish the following characteristics between the Precambrian time, Paleozoic, Mesozoic, and Cenozoic eras: The Precambrian timeâ€" Earth is mostly volcanic but begins to solidify; bacteria and other unicellular life develop; and first multicellular life forms appear near the end of the eon. The Paleozoic eraâ€" an explosion of new forms of multicellular life; ocean life such as fish and sharks; early land plants; and reptiles and amphibians appear. The Mesozoic eraâ€" early mammals, birds, and flowering plants appear; dinosaurs appear and then become extinct. The Cenozoic eraâ€" large mammals, modern birds, horses, and most of all the animals we see today appear, and the first humans appear. Materials Needed**

- For each group: chart paper, computers

**Prep**

- Intellectual Prep:
    - **Ted-Ed's Four Ways to Understand the Earth's Age video**

**What are scholars doing in this lesson?**

- Scholars learn about Earth's long history by researching different eras.

**Do Now**

- Follow the **Do Now plan**.

**Launch**

- Scholars create a personal time line in their Lab Notebooks to identify the most significant events in their life. Have scholars share and discuss:
    - What are some of the events on your personal time line?
    - Why did you choose those events?
    - Is there a logical way of grouping these events into different stages of your life? (For example, learning to walk or speak and attending your first day care may fall into the "toddler" or "early childhood" stage.)

- Explain:
    - Similar to our own personal time lines, Earth's "lifetime" (estimated at 4.6 billion years!) is divided into major time periods. We will learn about four of these time periods today: the **Precambrian time**, the **Paleozoic era**, the **Mesozoic era**, and the **Cenozoic era**.
        - Because this time line is so long, scientists speak about these time periods using the units MYA (millions of years ago) and BYA (billions of years ago)!
    - Each "stage" in Earth's history is characterized by the emergence of key life-forms and major events.

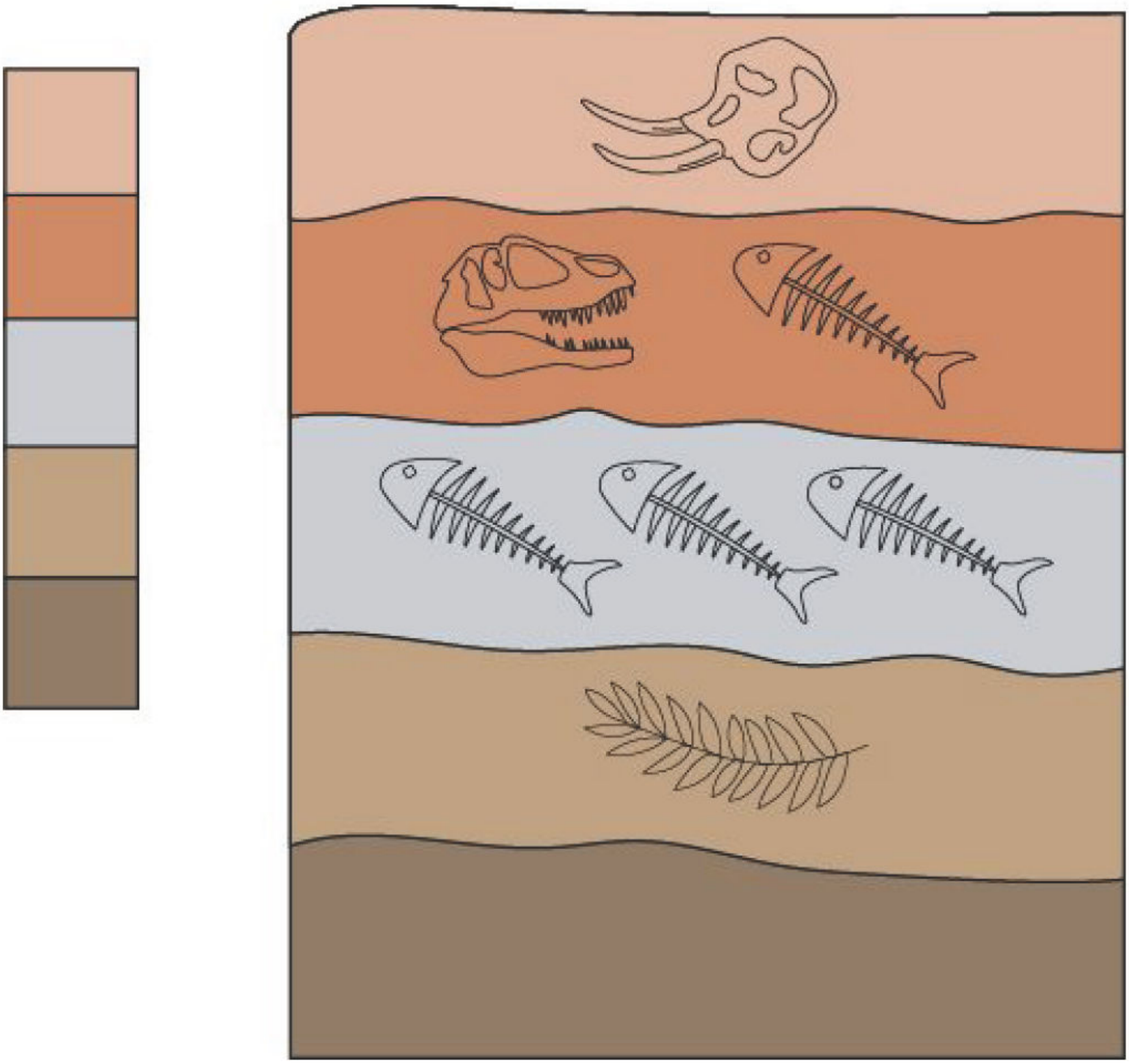
**Activity**

- Scholars conduct research online to identify some of the key characteristics of each era and record notes in their Lab Notebooks.
    - Before scholars begin working, model how to appropriately conduct research online and how to identify a reputable source of information.
    - As a group, scholars create one chart highlighting their most important observations about each era. Notes may include information regarding the Earth's climate, landscape, life-forms, and the approximate time line of each era.
    - As scholars work, circulate and take note of groups whose charts can serve as models during the discourse.

[**Tip:** Consider preselecting two or three websites where scholars can complete their research.]

**Discourse  Debrief activity:**

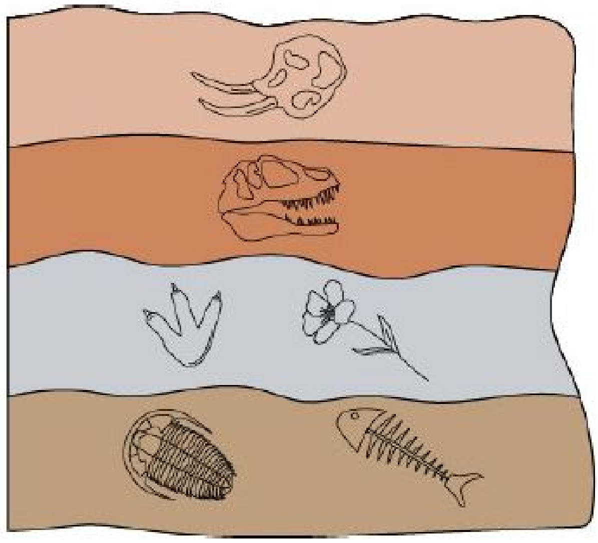
- Display one or two groups' charts. Discuss the questions below and create one class reference chart to record the major features of each time period.
    - What observations did you make about each era? What facts did you learn?
    - What are the similarities and differences between the eras?
    - What do you think "defines" each time period?
    - What do you think might have happened between the eras that caused differences in the fossils found in the rock layers of each era?
- Show the image below. Ask: Based on the fossils in each layer, are there any layers from the Precambrian time? Paleozoic era? Mesozoic era? Cenozoic era? How do you know?



**Make connections to the Essential Question:**

- Tell scholars that Lystrosaurus fossils have been dated to between 200 MYA and 300 MYA. Ask:
    - Based on this data, what major time period did the Lystrosaurus live in?
    - How do you think scientists determined the age of the Lystrosaurus fossils when they were first discovered?

**Accountability (Exit Ticket)** The diagram below depicts four rock strata and the fossils found within them.



| | |
|---|---|
| A | Fossil: Mammoth |
| B | Fossil: Dinosaur Skeleton |
| C | Fossil: Dinosaur Track & Flowering Plant |
| D | Fossil: Tribolite & Fish |

1. Based on the fossils found in each layer, identify and record the era in Earth's history that it corresponds to. Then, identify at least two defining characteristics of that era. Note that more than one layer may be from the same era. [8]

| Layer | Era | Defining Characteristics of the Era |
|---|---|---|
| A | cenozoic | large mammals appear, the first humans appear |
| B | mesozoic | the rise and fall of dinosaurs, flowering plants appear |
| C | mesozoic | the rise and fall of dinosaurs, flowering plants appear |
| D | paleozoic | fish appear, reptiles appear |

**Scoring** Award points as follows:

1. Award one point for each of the following per row, for a total of up to eight points:
    - Each correctly identified era
    - Providing at least two accurate defining characteristics for each era identified

# Lesson 7: Putting the Puzzle Together: The Theory of Continental Drift

**Lesson Objective: Scholars know that the theory of continental drift states that all continents were once joined together in a single landmass (known as Pangaea) and have since very slowly drifted apart. Alfred Wegener supported this hypothesis with evidence from land features, fossils, and climates, but his ideas were rejected by the scientific community because he could not explain *how* the continents moved apart.**

**Materials Needed**

- For the teacher: laminator (optional)
- For the group: two **world maps**, two **Wegener's Evidence document**, two sets of **Wegener's Puzzling Evidence** materials, colored pencils, scissors

**Prep**

- Materials Prep:
    - Print (and, optionally, cut out in advance and/or laminate) the landmass pieces for each group.

[**Materials Management Tip:** Consider laminating and cutting out one set of landmass pieces for each group or partnership in advance so multiple classes can reuse them.]

- Intellectual Prep:
    - **National Geographic Resource Library on Plate Tectonics**

**What are scholars doing in this lesson?**

- Scholars study Alfred Wegener's evidence and use a 3D interactive Earth website to determine the cause of his findings that reveal the theory of continental drift.

**Do Now**

- Follow the **Do Now plan**.

**Launch**

- Show a map of the world.
- Explain that in 1915, Alfred Wegener, a German scientist, published a book with some interesting evidence. This evidence might be just what we need!

- Present the investigation:
  - Study Wegener's evidence alongside the world map and continent cutouts to see if you can determine the cause of his strange findings! Maybe we can even connect these findings to the mysterious Lystrosaurus!
    - If scholars do not know what a continent is, be sure to give a brief explanation before they begin working.

**Activity**

- Scholars follow the directions in their Lab Notebooks to identify the fossils on each landmass/ continent, color-code them, and try to determine how they could have ended up where they are now.
  - Do not give away that the landmass cutouts should be formed into a supercontinent. Allow scholars to discuss the evidence and reach that conclusion.
- As scholars are working, circulate and have them explain their ideas and supporting evidence.
- Scholars record their predictions about the cause(s) of the evidence Wegener found in their Lab Notebooks.

[**Tip:** If scholars need more time, find a reasonable stopping point to have a discourse and allow them to share their findings so far. Then allow them to continue working the next day.]

**Discourse  Debrief activity:**

- Ask: What evidence did Wegener find?
  - What do you think caused these phenomena?
  - Allow several scholars to share their ideas. When a scholar says that the continents must have moved or fit together like puzzle pieces, define "supercontinent" and **Pangaea**. (If no scholars suggest this, share with them that Wegener came to the conclusion that the continents must have been in one large mass at some point in Earth's history.)
- Explain that Wegener used all his evidence to support what is referred to as the **theory of continental drift**. Display **this** image and discuss:
  - Is there enough evidence to support Wegener's claim?
  - What are the strong parts of his claim?
  - What are the weaknesses?
    - If scholars have difficulty coming up with weaknesses, be prepared to share the following: Wegener claimed that the continents moved by plowing through the oceans, but scientists knew this was unlikely, because the continental land is not thick and dense enough to push through the heavy oceans.

**Make connections to the Essential Question:**

- Ask: If true, how would this help us understand the strange locations that Lystrosaurus fossils have been found in?

**Make broader connections:**

- Debate whether the class should accept or reject Wegener's hypothesis. After allowing scholars to debate, explain:
    - Wegener's hypothesis was rejected at first. People didn't think it was possible for entire continents to move, and Wegener couldn't explain how that could have happened.
    - About 50 years later, other scientists found evidence to convince the scientific community that there was a mechanism for a previous supercontinent to break apart.
- Show the **"Continental Driftâ€" Pangaea" video** on YouTube (1 minute and 32 seconds).
- Explain to scholars that continental drift is still occurring today, and we don't notice it because the continents only move a couple of centimeters per year!

[**Tip:** As an extension or on a day when you have extra time, allow scholars a few minutes to explore this **interactive Pangaea map**.]

**Accountability (Exit Ticket)**

1. Choose one piece of evidence from class today and explain how it supports the theory of continental drift. [3]

One piece of evidence that supports the Theory of Continental Drift is the discovery of fossils of the same land organism on different continents. In class, we learned that Wegener found evidence of reptile fossils across different continents, which would seem impossible because these reptiles could not swim across the entirety of an ocean. These reptiles must have been separated when the supercontinent, Pangaea, broke up and the continents drifted away from each other.

2. Why was Wegener's theory not generally accepted in the scientific community? [1]

Wegener's theory was not generally accepted in the scientific community at first because although he had evidence of his theory, he could not explain how the continents moved away from each other.

**Scoring** Award points as follows:

1. Award one point for each of the following:
    - A claim that identifies a piece of evidence that supports the theory of continental drift (e.g., mountain ranges from different continents line up, fossils of organisms that cannot swim were found on different continents, continents fit together like puzzle pieces)
    - One piece of evidence from the activity and/or discussion
    - Justification/reasoning that explains how the evidence identified explains the theory of continental drift

2. Award one point for an explanation that identifies that Wegener did not provide a mechanism to explain his theory or explains that often it takes a large body of evidence from repeated experiments or extensive research over time to convince the general public of a new theory.

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# Lesson 8: Introducing Plate Tectonics (Two Days)

**Lesson Objective: Scholars can explain how Earth's structure allows for the movement of tectonic plates, supporting the theory of continental drift. Convection in Earth's mantle allows for the tectonic plates in Earth's crust to move. Tectonic plates move and interact with each other in three distinct ways: convergent boundary, divergent boundary, and transform boundary.**
**Materials Needed**

- Day One:
  - For each scholar: **USGS "Inside the Earth" web page**, **Everything You Need to Know About Planet Earth" Video**, computer
- Day Two:
  - For the teacher: hot plate, small opaque pot, milk, cocoa powder, oven mitt
  - For each group: hot plate, glass 500 mL beaker, diluted rheoscopic fluid (**SDS**), food coloring (optional), 2 oven mitts

**Prep**

- Materials Prep:
  - Day One:
    - Share the **Everything You Need to Know About Planet Earth" video** link with scholars.
  - Day Two:
    - Using the directions on the bottle, dilute the rheoscopic fluid and separate the mixture for each group. You may add food coloring to the rheoscopic fluid.
- Intellectual Prep:
  - **National Geographic Resource Library on Plate Tectonics**
  - **Plate Tectonics Video**

**What are scholars doing in this lesson?**

- Scholars investigate Earth's structure by taking notes on various readings and videos. They begin to hypothesize how Earth's layers may play a role in continental drift. On day two, scholars develop a model that represents the processes occurring in the mantle that allow tectonic plates to move and support the theory of continental drift.

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# Day One

### Do Now

- Follow the **Do Now plan**.

### Launch

- Show the **Journey to the Center of the Earth trailer video** (first minute only). Discuss:
    - Could we travel to the center of the Earth?
    - What do you think we would find there if we did?
        - What do you think is beneath Earth's rock layers? What clues do we have?
            - Have you ever seen something emerge from underground onto Earth's surface? What was it? (Guide scholars to discuss volcanoes.)
            - Studying Earth's layers will help you to understand the mechanism that drives continental drift, which will then help us to understand how the Lystrosaurus fossils made it to their current locations!
- Ask: How does the structure of the Earth support the theory of continental drift?

### Activity

- Scholars read the information on the "**Inside the Earth**" web page.
    - Scholars take notes in their Lab Notebooks.
    - Note: This reading includes information on specific parts of the mantle (asthenosphere and lithosphere) that help give scholars more background information on the concept but need not be memorized.

[**Tip:** Provide scholars with a structure or template for note-taking.]

- Scholars watch the **"Everything You Need to Know About Planet Earth" video** (from 3:10 to 4:32).
    - Scholars take notes in their Lab Notebooks.
- As scholars are working, circulate to make sure they are taking detailed notes.

[**Classroom Management Tip:** Check in with scholars who do not normally share during the discourse and press them to explain their thinking.]

**Discourse Debrief activity:**

- Ask: What did you learn about Earth's composition?
  - Define **crust**, **mantle**, and **core**.

**Make broader connections:**

- Ask: How might the Earth's layers relate to continental drift?

**Make connections to the Essential Question:**

- Ask: How might Earth's layers help us understand the strange locations that Lystrosaurus fossils have been found in?

**Accountability (Lab Notebook)**

- Study scholars' Lab Notebooks. Look for misconceptions in their work and make a plan to circle back with scholars who need additional support on day two.

**Scoring** Award points as follows:

- Score scholars on a 1–4 scale (below expectations through exceeding expectations) based on classwork. Do not penalize scholars for misconceptions about contentâ€" rate them on effort and writing.
  - Look for the following when scoring scholar responses:
    - Descriptive notes on each of Earth's layers
    - Labeled diagrams of Earth's layers
    - Overall high effort shown in writing, with complete sentences and proper grammar/punctuation seen throughout

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# Day Two

**Do Now**

- Follow the **Do Now plan**.

**Launch**

- On a hot plate, heat milk in an opaque pot and tap some cocoa powder on top. Use a document camera or overhead projector for this demo. Discuss:
  - What observations can you make about the cocoa powder?
  - How can we relate this demo to the structure of the Earth?

  - What does each part represent?

- Explain:
  - The milk is like the mantle, and the heating plate represents the extremely hot core.
  - In the demo, scholars saw what happens to continents on the surface but not what happens inside the Earth.

- Present the lab:
  - You will create a model to see the processes that are occurring in the mantle to move the plates of the Earth. This will help to explain how Pangaea was able to separate.

**Activity**

- Scholars heat the rheoscopic fluid with a hot plate.
  - As scholars adjust the temperature, they will examine how temperature changes affect the motion of the fluid.
  - Scholars will record their observations in their Lab Notebooks.

- As scholars are working, circulate and press them to explain how the heating of the fluid can serve as a model to explain the theory of continental drift.

**Discourse  Debrief activity:**

- Ask: What were you modeling in the lab?
  - What did the rheoscopic fluid represent? What about the cocoa powder?

- Ask: What observations did you make about the motion of the fluid?
  - When scholars accurately describe the motion, introduce **convection**. Explain that “cells” form because of temperature differences. Show the **“Plate Tectonics” video** (1 minute and 13 seconds) to help scholars visualize the motion of Earth’s mantle that acts as the mechanism for pushing and pulling Earth’s plates.

**Make connections to the Essential Question:**

- Ask: How could the convection in Earth’s mantle cause continental drift? How does this connect to the locations in which Lystrosaurus fossils were found?

**Make broader connections:**

- Introduce **plate tectonics**. Discuss:
  - How do plate tectonics help support the theory of continental drift?

- Show the image below (full-size image **here**). Ask:
    - What happens if the edges of two tectonic plates collide? Separate? Scrape past each other? (Introduce **convergent**, **divergent**, and **transform plate boundaries**.)

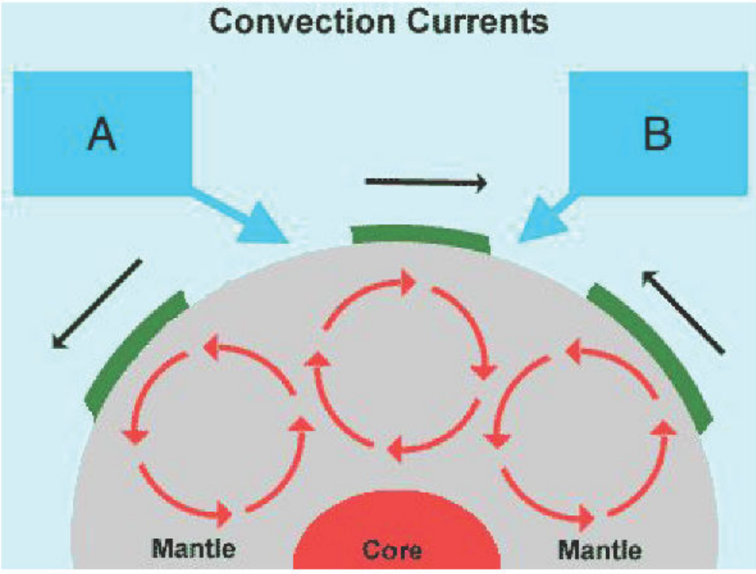


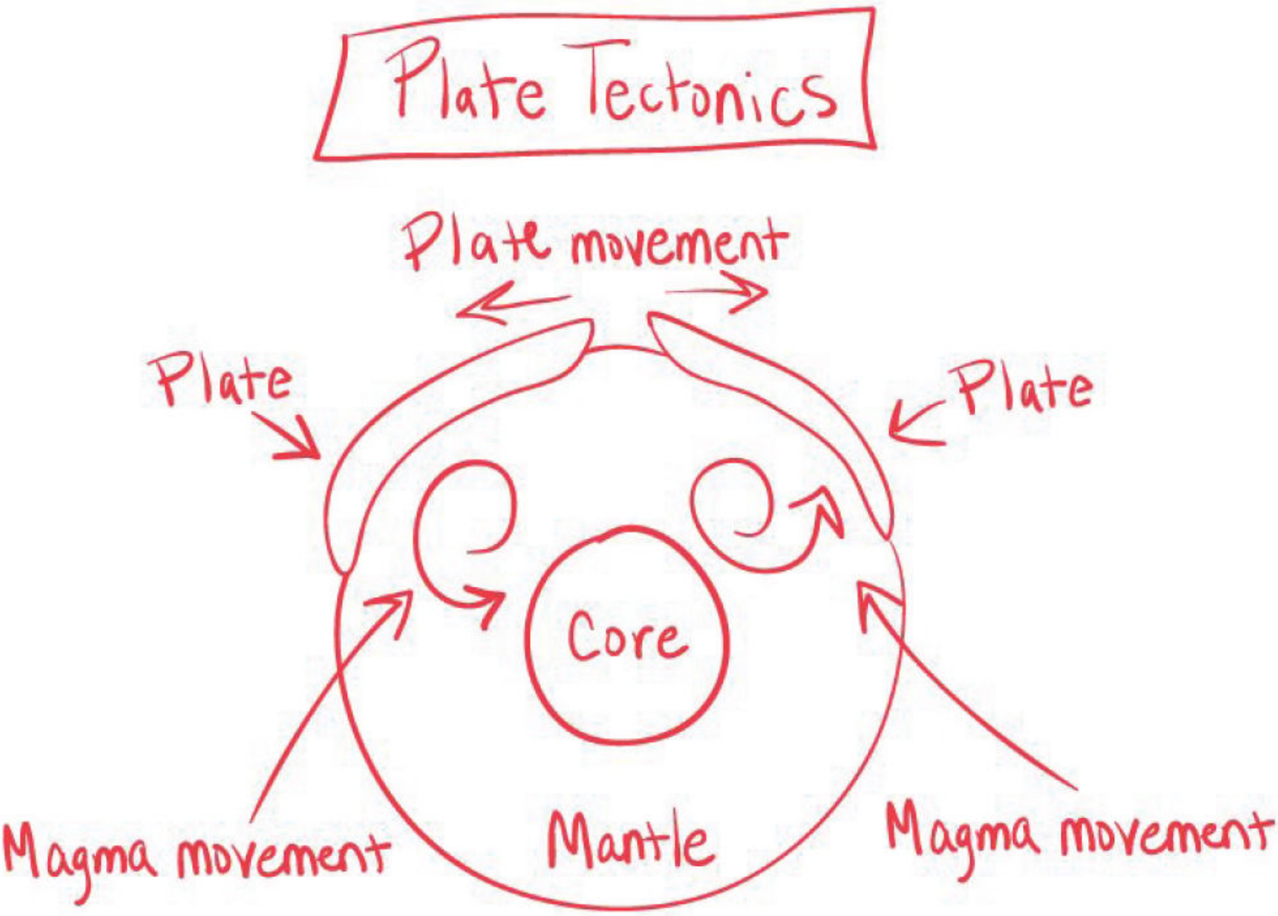

Image credit: Ewalde1 via Wikimedia Commons CC-BY-SA-3.0

- Note: The image above makes it appear that only land masses are on tectonic plates. Ensure that you show scholars supplemental visuals to help them see both oceanic and continental crust and explain that oceanic crust tends to be thinner and weaker. **This** image may provide strong support.

**Accountability (Exit Ticket)**

1. Draw a diagram to show how plate tectonics works. Be sure to include: core, mantle, plates, and arrows showing magma movement and plate movement. [4]

Exemplar:




2. How does the theory of plate tectonics add support to Wegener's theory of continental drift? Include evidence from class and reasoning. [3]

Plate tectonics helps to explain the missing part of Wegener's theory of continental drift: how the Earth's plates actually move. Wegener's Theory was not strong because it could not explain *how* the plates moved, but by studying plate tectonics, we can provide more evidence for Wegener's theory. In science, the theory with the most evidence is the best supported, so with the new knowledge that plates move due to the convection currents in the mantle, the theory is stronger.

**Scoring** Award points as follows:

1. Award one point for each of the following:

    - Accurate labeling of mantle, core, and crust (plates) that make up Earth's structure (up to two points, award partial credit for one inaccuracy)
    - Accurate drawing of magma movement in the mantle
    - Accurate labeling of plate movement

2. Award one point for each of the following:

    - A claim that identifies that plate tectonics describes the mechanism or "how" of the movement of the continents
    - One piece of evidence from the investigation or discussion
    - Justification/reasoning that explains how evidence relates to the motion of the plates

# Lesson 9: Seafloor Spreading

**Lesson Objective: Scholars can explain how seafloor spreading lends further evidence to the theory of continental drift. The seafloor spreads apart along both sides of a mid-ocean ridge creating a new crust. As a result, the sections of ocean floor move like conveyor belts, carrying the continents along with them. Subduction occurs when thick continental crust and thinner oceanic crust meet and the ocean floor sinks back into the mantle at deep-ocean trenches.**
**Materials Needed**

- For the teacher: scissors, cardstock, paper
- For each group: **seafloor spreading base handout**, tape, scissors, 2 seafloor strips, computer/device

**Prep**

- Materials Prep:
    - Print copies of the seafloor spreading base handout on cardstock. (Or you may choose to cut out the slits in the middle of each base in advance.)
    - Create two “seafloor strips” for each group from paper. (Strips should be long and just under 8 cm wideâ€” these should fit through the slits in the base once they are cut. You can see an image of an assembled model in the Activity section below.)
- Intellectual Prep:
    - **National Geographic Resource Library on Plate Tectonics**
    - **Seafloor Spreading Slideshow**

**What are scholars doing in this lesson?**

- Scholars further investigate plate tectonics by watching a video on seafloor spreading and using a model to explain how the continents were able to drift apart so far.

**Do Now**

- Follow the **Do Now plan**.

**Launch**

- Display a world map that shows the Earth’s tectonic plates and their boundaries. Point to a **plate boundary** in the ocean and discuss:
    - Based on your knowledge from the previous lesson, what do you think is happening at this plate boundary?
- Ask: There isn’t really any empty space on this map! It looks as if tectonic plates could bump into one another and move back and forth a bit, but there isn’t any space for a plate to make

significant movement across the planet. So how do you think the continents were able to move so far?

- Explain that scientists have explored the oceans and looked at underwater landscapes to help them find answers. And they have found mountains, trenches, and ridges, all underwater! Introduce the term mid-ocean ridge.

**Activity**

- Scholars watch **"Sea Floor Spreading" by Science Channel** video (1 minute and 13 seconds).
- Scholars create a seafloor spreading model, referencing the image below (which is also in their Lab Notebooks).
    - Cut three slits in the base as indicated by the dotted lines. Label the slits "A" and "B" at either end.
    - Cut out the plate strips and place them back to back. Tape them together at one end.
    - Thread the two strips up through the center slit and then curve them, gently feeding one down through each of the slits at either end of the base.

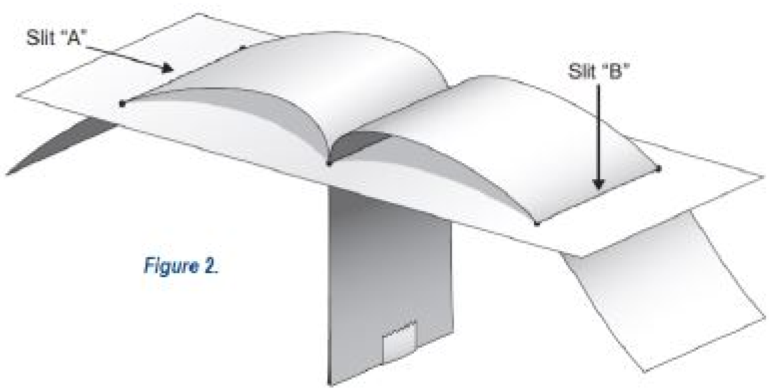



Image credit: Reprinted with permission. Joides Resolution International Ocean Discovery Program

- To use the model, scholars should work together to hold the base steady while pushing the taped end of the paper strips upward. This simulates the upward movement or magma that leads to the formation of new oceanic crust.
- Scholars complete analysis questions in their Lab Notebooks using the video and models they just created to help them answer the questions.
- As scholars are working, circulate and press them to think about what each part of the model represents and how it relates to what they know about Earth's structure and the theory of continental drift.

**Discourse Debrief activity:**

- Ask: What is **seafloor spreading**?
    - How does seafloor spreading provide evidence for the theory of continental drift?

**Make connections to the Essential Question:**

- Ask: How did seafloor spreading contribute to the Lystrosaurus fossils' being found in their current locations?

**Make broader connections:**

- Ask: What do you think our ocean floors will look like far in the future? Why?
- Ask: How does seafloor spreading occur without the world as a whole expanding?
    - Define **subduction**.

**Accountability (Exit Ticket)**

1. How does seafloor spreading support Wegener's theory of continental drift? Explain your reasoning. [3]

Seafloor spreading supports Wegener's theory of continental drift by explaining how the continents were able to move far apart. In class, we learned that as new crust is formed at mid-ocean ridges, old crust is pushed away from the ridge, making the ocean floors move like conveyor belts. As a result, the plates are pushed and pulled, carrying along the continents as they move.

**Scoring** Award points as follows:

1. Award one point for each of the following:
    - A claim that identifies that seafloor spreading describes the mechanism or "how" of the movement of the continents or relates it to plate tectonics/convection currents
    - One piece of evidence from the investigation or discussion
    - Justification/reasoning that explains how the evidence relates to the motion of the plates

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# Lesson 10: On a Planet Far, Far Away…

**Lesson Objective: Scholars are able to use sources and their knowledge to draw conclusions and to make predictions about a scientific phenomenon in a new context. Materials Needed**

- For the teacher: scissors, laminator
- For each group: **planet Brota puzzle set**, **structure diagram**, **rock layer cross-section**, and **current map** (same document as puzzle set), tape

**Prep**

- Materials Prep:
    - Print, cut out, and compile the following for each group in a folder:
        - planet Brota puzzle pieces
        - diagram of planet Brota structure

    - rock layer cross-section from planet Brota
    - current-day map of planet Brota (use the “puzzle pieces” sheet, but keep it whole!)

[**Materials Management Tip:** Laminate all materials to reuse in each class.]

- Intellectual Prep:
    - **NASA Website - NASA Telescope Reveals Largest Batch of Earth-Size, Habitable-Zone Planets Around Single Star**

**What are scholars doing in this lesson?**

- Scholars study evidence from a new planet, planet Brota, to learn about its past and make predictions about its future.

**Do Now**

- Follow the **Do Now plan**.

**Launch**

- Explain to scholars that NASA’s Spitzer Space Telescope recently found seven Earth-size planets around a single star, three of which reside in a “habitable zone” from the star. This means that scientists have reason to believe that the temperatures on those planets are within a comfortable range for life to exist there. Additionally, scientists believe there could be liquid water present on each planet.
- Show the **“A Treasure Trove of Planets Found” video** on YouTube (1 minute and 56 seconds) and discuss:
    - What do you think these planets look like?
- Tell scholars to imagine that scientists have found some evidence from one of these planets, which we will call Brota, but they need help understanding its past and future.

**Activity**

- Scholars use the scientists’ “evidence” in their folders and the knowledge they’ve acquired in this unit to answer the questions in their Lab Notebooks.
- As scholars are working, circulate and press them to explain their thinking using clear claims, best evidence, and strong reasoning.

[**Tip:** If scholars are moving slowly, find a reasonable point to wrap up and hold a discourse to share their initial thoughts, then use a flex day to allow work to continue for a second day.]

**Discourse  Debrief activity:**

- Have scholars share their claims of how they believe planet Brota has changed throughout the last 500 million years. Discuss:
  - How does your evidence support your claim?
  - What evidence are you missing to support your claim?

**Make connections to the Essential Question:**

- Ask: Is it possible that planet Brota may have fossils like the Lystrosaurus fossils found on different continents? Why?

**Make broader connections:**

- Ask: What do you think planet Brota will look like in another 500 million years? Why?
  - Allow scholars to manipulate a set of cutouts under a document camera or overhead projector while answering this question.

**Accountability (Exit Ticket)**  Note: Allow scholars to use their Lab Notebooks during this Exit Ticket.

1. Based on the images below, which drawing do you believe best represents what planet Brota looked like 500 million years ago? Include a claim, at least two pieces of evidence, and reasoning. [4]

C

D

I believe image C best represents what planet Brota looked like 500 million years ago. During the investigation, we discovered that planet Brota had a similar internal structure to that of Earth, meaning that there are likely convection currents that push and pull the land plates on the surface apart. Using this information, we noticed correlations between the types of fossils found on the different landmasses. We connected the landmasses by aligning similar fossil types found on the coastlines of each landmass. Only one landmass had no fossil correlations with any other landmass. Similar to Earth, planet Brota likely started as a single landmass (with one landmass separate from the bigger landmass) and drifted apart due to convection currents in the mantle.

**Scoring** Award points as follows:

1. Award one point for each of the following:

    - A claim that identifies an image that best represents what planet Brota looked like 500 million years ago (can be any image as long as the scholar's evidence and reasoning support it)
    - Includes a relevant piece of evidence from class discussion, reading, or past investigations
    - Includes a second relevant piece of evidence from class discussion, reading, or past investigations
    - Justification/reasoning that explains how the evidence relates to claim

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# Lesson 11: Putting the Puzzle Together

**Lesson Objective: Scholars can explain how rock strata and fossil evidence unveil clues to Earth's history. Based on this evidence, scientists theorize that tectonic plates have moved great distances, collided, and spread apart, causing continental drift over time. Materials Needed**

- For each group: colored pencils
- For each scholar: copy of **letter**, lined paper

**Prep**

- Materials Prep:
    - Print out a copy of the letter for each scholar.

**What are scholars doing in this lesson?**

- Scholars use the knowledge they have accumulated from the unit to respond to a letter about the discovery of strange fossil evidence.

**Do Now**

- Follow the **Do Now plan**.

**Launch**

- Explain that to showcase their new expertise from the unit, scholars will be given one final challenge: to respond to a letter from another scholar, Varik, who has uncovered strange fossil evidence and is confused!
    - Read the letter aloud to scholars.
    - Explain that they will each receive a copy of the letter and that their job will be to compose a response using lined paper.
    - Provide a simple template (or two or three options) to help scholars organize and plan their responses. In total, letters should contain three to five paragraphs and may be supplemented by drawings or diagrams where appropriate.

**Activity**

- Scholars study the provided **letter**.
- Scholars plan and compose their letters.
- If time allows, scholars may color any diagrams or pictures they chose to include in their letter.
- As scholars are working, circulate and study their responses. Take note of scholars who struggle to explain major unit concepts independently and make a plan to offer them additional practice.

**Discourse  Debrief activity:**

- Share one or two scholar responses and allow the class to evaluate them and offer feedback.
    - Elicit one or two pieces of positive feedback and one or two pieces of constructive feedback for each response shared.

**Make connections to the Essential Question:**

- Revisit the unit's Essential Question one last time and allow scholars to explain: How is it possible that Lystrosaurus fossils were found on three continents?

**Accountability (Exit Ticket)**  Note: This Exit Ticket will gauge scholar mastery of the unit goals. Look out for lingering misconceptions that need to be resolved as the unit wraps up.

- In place of an Exit Ticket, score scholars' letters to Varik. Look for responses that clearly demonstrate full understanding of major unit concepts (unit goals) and the ability to synthesize information from multiple lessons throughout the unit.

Hi, Varik,

I understand why you are so confused, but there *is* a scientific explanation for the phenomenon you described!

Long ago, the continents were in different locations. All of the places you mentioned may be far apart now, but millions of years ago, they were all part of one giant landmass called Pangaea, and Glossopteris plants grew there. When the continents began to separate and move, patches of Glossopteris plants simply got separated.

I’m sure you’re wondering how it’s possible that the continents moved, since they’re so big and heavy! Basically, Earth’s crust is made of large pieces called tectonic plates. Underneath those, there is a layer of magma. The magma is constantly swirling in a cycle called convection, and that movement can shift the plates.

Over a long period of time, this can cause significant movement, and that’s exactly what happened. The continents went through something called continental drift and are now in their current locations. (Interestingly, continental drift is still happening today! It’s just such a small amount of movement that we don’t notice itâ€” only a couple of centimeters a year.)

I hope this helps to answer your question!

Sincerely,

Luis

**Scoring** Award points as follows:

1. Score scholar letters holistically on a 1–4 scale, as follows:

    - Four points: Scholar response is detailed and clear, obviously demonstrates full understanding of major unit content, and uses appropriate vocabulary terms from the unit.
    - Three points: Scholar response demonstrates understanding of major unit content, is mostly clear, and includes multiple pieces of supporting evidence.
    - Two points: Scholar response demonstrates partial understanding of unit content, but may be lacking in clarity, appropriate vocabulary, or level of detail.
    - One point: Scholar response demonstrates fundamental misconceptions of major unit content or is vague/unclear in a way that hinders the reader’s ability to diagnose their level of understanding.

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# Unit Vocabulary

**Vocabulary List**

- **geosphere**
- **atmosphere**
- **hydrosphere**
- **biosphere**
- **rock cycle**
- **igneous rock**
- **metamorphic rock**
- **sedimentary rock**
- **fossil**
- **rock layer**
- **strata**
- **intrusion**

- **extrusion**
- **relative dating**
- **index fossil**
- **fossil record**
- **Precambrian Time**
- **Paleozoic era**
- **Mesozoic era**
- **Cenozoic era**
- **crust**
- **mantle**
- **core**
- **magma**
- **law of superposition**
- **theory of continental drift**
- **theory of plate tectonics**
- **convection**
- **fault**
- **convergent boundary**
- **divergent boundary**
- **transform boundary**
- **Pangaea**
- **plate boundary**
- **seafloor spreading**
- **subduction**