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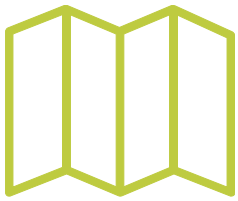

Lesson 3.2

“A Continental Puzzle”

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Lesson Overview

Students are introduced to the Investigation Question: *What evidence do we have of past plate motion?* To answer this question, students read, annotate, and discuss the article "A Continental Puzzle." This article introduces Alfred Wegener and his theory of continental drift, which ultimately lead to the theory of plate tectonics. At the end of the lesson, students share their annotations and discuss challenging words from the article. For homework, students read a second article about another historic scientist, Nicholas Steno, who developed the idea that older rock layers formed under younger ones. The purpose of this lesson is to help students understand how fossil and rock formation evidence supports the theory that plates have been moving for billions of years.

Anchor Phenomenon: Fossils of the *Mesosaurus*, an extinct reptile whose population once lived all together, are found in two locations that are separated by thousands of kilometers of ocean.
Investigative Phenomenon: The edges of the continents and landforms match, as if they had once fit together like puzzle pieces.

Students learn:

- Alfred Wegener developed a theory of continental movement in part by analyzing the locations of fossils found across the globe.
- Theories are explanations for observable phenomena.
- Science theories are based on a body of evidence developed over time.
- A hypothesis is used by scientists as an idea that may contribute important new knowledge for the evaluation of a scientific theory.

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Lesson at a Glance

ACTIVITY

1 **Warm-Up** (5 min)
Students reflect on what they learned about the evidence scientists use to understand the rate of plate motion.

WARM-UP

2 **The Value of Fossil Evidence** (10 min)
Students are introduced to the Investigation Question, and they consider how understanding current plate motion might help to explain past plate motion.

TEACHER-LED DISCUSSION

3 **Active Reading: "A Continental Puzzle"** (20 min)
Students read and annotate an article about how Alfred Wegener developed the theory of plate tectonics. They focus on identifying challenging or unfamiliar words or phrases as they read. This activity provides an opportunity for an On-the-Fly Assessment of students' ability to engage with scientific texts and identify challenging or unfamiliar words.

READING

4 **Discussing Annotations** (10 min)
Students select interesting or unanswered questions from the reading they would like to share. Students then discuss challenging words they identified when they read. Students' annotations provide an opportunity for an On-the-Fly Assessment of students' annotation skills, reading comprehension, and content understanding.

STUDENT-TO-STUDENT DISCUSSION

5 **Homework**
Students use the Sorting Tool to become familiar with the time scale of major events that have occurred on Earth and read a second article in which they learn about the seventeenth-century scientist, Nicholas Steno, who first developed one of the fundamental principles of geography and Earth's history: that older rock layers are layered beneath newer rock layers.

HOMEWORK

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Materials & Preparation

Materials

For the Class

- Annotation Tracker*

For Each Student

- optional: printed copy of the "A Continental Puzzle" article*
- optional: printed copy of the "Steno and the Shark" article*
- optional: *Plate Motion* Investigation Notebook, pages 80–84*

Digital Tools

- "A Continental Puzzle" article in the Amplify Library
- "Steno and the Shark" article in the Amplify Library
- *Plate Motion* Sorting Tool activity: Earth's History

*teacher provided

Preparation

Before the Day of the Lesson

1. **Print a copy of the Annotation Tracker for each class.** A PDF of the Annotation Tracker is in Digital Resources. Read the Annotation Tracker Instructions and view the Example Annotation Trackers in Digital Resources for more information.
2. **Make sure the Active Reading Guidelines are still posted on the wall.**
3. **Read the article "A Continental Puzzle" in the Amplify Library.** This article is also located in Digital Resources. Familiarizing yourself with the entire article will help you support students as they add questions and comments to the article during class and facilitate a conversation about the article at the end of class.

VOCABULARY

- analyze
- claim
- convergent
- cross section
- divergent
- earthquake
- evidence
- mantle
- mid-ocean ridge
- outer layer
- pattern
- plate
- plate boundary
- rate
- trench
- volcanic activity

UNPLUGGED?

Digital Devices Not Required

This lesson can be taught without devices. If students do not have devices, print copies of the "A Continental Puzzle" article and

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4. **Prepare to model Active Reading.** You can use the think-aloud script that is provided in Activity 3, or you can modify the script, modeling in a way that makes the most sense for your students. In the modeling script provided, we chose to focus on identifying challenging words and phrases. This target for modeling was chosen because it is a strategy that is especially important when reading science texts.
5. **Familiarize yourself with the article "Steno and the Shark" in the Amplify Library.** This article is also located in Digital Resources. Students will be reading this article for homework.
6. **Prepare for On-the-Fly Assessments.** There are two On-the-Fly Assessments included in this lesson. Activity 3 provides an opportunity to informally assess students' ability to engage with scientific texts and identify challenging words. In Activity 4, students' annotations provide an additional opportunity for informal assessment. Press the hummingbird icon and then select the ON-THE-FLY ASSESSMENT for details about what to look for and how you can use the information to maximize learning by all students.
7. **Familiarize yourself with the Earth's History in the *Plate Motion* Sorting Tool.** Students will use the Sorting Tool for homework. There is information about expected student responses in the Possible Responses tab associated with that activity.

Immediately Before the Lesson

1. **Write the Investigation Question on the board:** "What evidence do we have of past plate motion?"
2. **Have on hand the following materials:**
   - Annotation Tracker
   - optional: digital devices
   - optional: printed copies of the "A Continental Puzzle" article
   - optional: printed copies of the "Steno and the Shark" article
   - optional: *Plate Motion* Investigation Notebook, pages 80–84

Between-Class Prep

1. **Locate a new Annotation Tracker for your next class.**
2. **Erase digital annotations.** Erase the digital annotations you made in the article in the Amplify Library before modeling for the next class.

Investigation Notebook pages for this lesson. (PDFs of both can be found in Digital Resources.)

If students do not have access to Amplify Science at home, make time in class to complete the Sorting Tool activity and provide them with copies of page 84 from the Investigation Notebook and copies of the "Steno and the Shark" article. Make time in class after students read the article to complete questions 2 and 3 of the homework.

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At the End of the Day

1. **Print a copy of the Annotation Summary Sheet for each class.** A PDF of the Annotation Summary Sheet is in Digital Resources.
    - **Use the Annotation Trackers to review students' submitted articles.** If you have time to review students' submitted articles and annotations, continue to fill out each Annotation Tracker to identify questions, alternate conceptions, and exemplary annotations.
    - **Use the Annotation Summary Sheets to analyze students' annotations.** The Annotation Summary Sheet is intended to help you identify trends in student thinking, recurring questions students have about the text, and other issues that you might want to address. Use your Annotation Trackers to fill out the Annotation Summary Sheets.
    - **Collect exemplary annotations and recurring alternate conceptions to share with the class.** Exemplary annotations and recurring alternate conceptions can be shared in the subsequent lesson. Identify examples of student annotations that are thought provoking, exemplify the Active Reading approach, and/or target key science ideas.

DIGITAL RESOURCES

Steno and the Shark

Printable Article: "Steno and the Shark"

A Continental Puzzle

Printable Article: "A Continental Puzzle"

Annotation Tracker Instructions

Annotation Tracker

Annotation Summary Sheet

Example Annotation Trackers and Summary Sheet

Plate Motion Investigation Notebook, pages 80–84

Plate Motion Glossary

Plate Motion Multi-Language Glossary

Differentiation

Embedded Supports for Diverse Learners

Multimodal learning. Active Reading is one component of a multimodal approach to learning in which students encounter concepts through reading, talking, investigating, and writing. This multimodal approach has been shown to be a highly effective strategy for learning content.

Extended teacher modeling. The Active Reading approach includes many supports embedded in each lesson. This approach to reading is based on curiosity, inquiry, and the awareness that students learn more from reading when they are active participants and when they are provided with opportunities to share their own thinking about the text. Thus, the modeling provided in this lesson is a scaffold because it sets the tone for an approach to reading that is positive, inquiry-based, and supports all types of readers. Model the types of thinking you hope that your students will adopt while reading. The suggestions in the instructional guide for what to attend to during modeling are intended to serve as a useful guide, but we also encourage you to use this think-aloud technique to model any other aspects of sophisticated reading and deeper thinking that you think will benefit your class.

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Student-to-student discussion for making sense of the reading. The partner sharing and discussion following the independent reading provides students with an opportunity to deepen their understanding through purposeful conversation with their peers. Through discussion, students have a chance to both share and expand on their understanding.

Potential Challenges in This Lesson

Reading-focused lesson. This lesson requires students to actively engage with the text, both through reading and through annotation. You may recommend that some students work in pairs, annotating their own articles as they read aloud. Alternatively, you could ask students to form small groups and work together during the first read. Finally, you might support students by having them read with you or another adult. As an alternative to students reading the entire article and discussing their annotations after they've finished, consider chunking the article (by section, for example) and giving students an opportunity to discuss their ideas and annotations after reading each section.

Specific Differentiation Strategies for English Learners

More practice identifying challenging words or phrases during reading. Just as they did in Lesson 2.2, in Activity 3 of this lesson students practice identifying and asking questions about challenging words and phrases from the reading. Focusing on unfamiliar words, or familiar words used in unfamiliar ways or new contexts, can help all students build their vocabulary and bolster their reading comprehension. This practice can be especially supportive for English learners. This is because idioms and words with multiple meanings often pose unique comprehension challenges for students whose primary language is not English. Taking additional time to demonstrate how even familiar words can take on new meanings depending on their context can help cultivate an environment in which English learners feel comfortable asking questions about words that might be perceived as familiar or easy. Setting this precedent helps students learn not to pass over words that they might have heard before and to pay careful attention to how words are used in context.

Specific Differentiation Strategies for Students Who Need More Support

Creating a positive environment by setting attainable goals. Establishing expectations for Active Reading and building enthusiasm and excitement around this practice might take time. You might find that many students disengage during independent reading time. These students might feel overwhelmed by the length of the articles or the cognitive load involved in having to read an entire article and record questions and connections about it. For this reason, students might resist reading because they feel that they cannot be successful. Or, students might make a strong effort to read and annotate but run out of time before they are able to finish the first few paragraphs of the article. It is important that students who struggle or who are intimidated by reading have a strategy for feeling successful as they read, even if they do not finish the entire article. Assure them that the goal is to think of at least one question they have about the article as they annotate. They can focus on a single paragraph or a visual representation and do not need to read the entire article during class.

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Specific Differentiation Strategies for Students Who Need More Challenge

Asking deeper questions and making broader connections. Students who need more challenge should be encouraged to push themselves to ask deeper questions and make broader connections while they read. Active Reading is a very sophisticated way to read, and many advanced learners who haven't used this practice before are surprised and pleased to see how much more they get out of reading when they take the time to slow down and interact with the text in this way. You can also ask students who need more challenge to record the three most important things they learned from the article after reading or to record what ideas and questions they have about evidence of ancient plate motion that weren't addressed in the article.

Standards

Key

Practices Disciplinary Core Ideas Crosscutting Concepts

3-D Statement

Students ask questions and obtain and evaluate information as they actively read "A Continental Puzzle," an article about how Alfred Wegener used patterns in fossil evidence to develop his theory of continental drift (patterns). For homework, students read "Steno and the Shark" to learn about the geologic timescale that can be interpreted from layers of rock (scale, proportion, and quantity).

Next Generation Science Standards (NGSS)

NGSS Practices

- **Practice 1:** Asking Questions and Defining Problems
- **Practice 8:** Obtaining, Evaluating, and Communicating Information

NGSS Disciplinary Core Ideas

- **ESS1.C: The History of Planet Earth**:
  - The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1- 4)
- **ESS2.A: Earth's Materials and Systems**:
  - The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2)

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- **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. (MS-ESS2-3)

NGSS Crosscutting Concepts

- Patterns
- Cause and Effect
- Scale, Proportion, and Quantity

Common Core State Standards for English Language Arts (CCSS-ELA)

- **CCSS.ELA-LITERACY.CCRA.L.4:** Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized references materials, as appropriate
- **CCSS.ELA-LITERACY.CCRA.L.6:** Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when encountering an unknown term important to comprehension or expression.
- **CCSS.ELA-LITERACY.CCRA.SL.1:** Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
- **CCSS.ELA-LITERACY.RST.6-8.1:** Cite specific textual evidence to support analysis of science and technical texts.
- **CCSS.ELA-LITERACY.RST.6-8.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics
- **CCSS.ELA-LITERACY.WHST.6-8.9:** Draw evidence from informational texts to support analysis, reflection, and research

Common Core State Standards for Mathematics (CCSS-Math)

CCSS-Math Practices

- **CCSS.MATH.PRACTICE.MP1:** Make sense of problems and persevere in solving them.
- **CCSS.MATH.PRACTICE.MP2:** Reason abstractly and quantitatively.
- **CCSS.MATH.PRACTICE.MP5:** Use appropriate tools strategically.
- **CCSS.MATH.PRACTICE.MP7:** Look for and make use of structure.

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CCSS-Math Content

- **CCSS.MATH.CONTENT.6.RP.2:** Understand the concept of a unit rate a/b associated with a ratio a: b with b ≠ 0 (b not equal to zero), and use rate language in the context of a ratio relationship

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1 WARM-UP
Warm-Up

Warm-Up

5 MIN

Students reflect on what they have learned about the evidence scientists use to understand the rate of plate motion.

Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 81 in the Investigation Notebook. Allow a few minutes for students to individually respond to the Warm-Up.

Possible Responses

1. Answers may vary, but Earthquakes, Volcanic activity, and GPS measurements are all appropriate answers.
2. Because Earth's plates move at a very slow rate. It will take a long time—millions of years—for the continents to travel to different locations.

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2 TEACHER-LED DISCUSSION
The Value of Fossil Evidence

The Value of Fossil Evidence

10 MIN

Lead a brief discussion that connects the work students have done so far to the new Investigation Question.

Instructional Guide

1. Debrief the Warm-Up and review the evidence that supports current plate motion. Ask one or two students to share their responses to the Warm-Up. Using the posted key concepts, remind students that Chapter 1 was about understanding Earth's outer layer, Chapter 2 was about what is underneath the plates and how plates move, and Lesson 3.1 introduced the idea of using GPS measurements to determine the current rate of plate motion.

We know that plates are moving slowly now. What evidence do we have to show that the plates moved this way in the past?

2. Introduce the new Investigation Question. Refer to the question on the board, and read (or have a student read) it aloud: *What evidence do we have of past plate motion?*

3. Prompt students to discuss their ideas about *past* plate motion with a partner. Let students know that they will be reading about past plate motion today. Point out that plate motion is an important part of understanding Earth's history—and is a process that happened in the past that continues today. Allow 2–3 minutes for students to share their ideas about the importance of understanding past plate motion with a partner. Ask them to use the questions on the student screen or on page 82 in the Investigation Notebook, to guide their discussions.

In this lesson, you are going to read about a scientist who investigated past plate motion. How do you think information about past plate motion might help you understand the mystery of the *Mesosaurus* fossils?

4. Provide a rationale for why the Museum of West Namibia wants to learn about what happened to Earth's plates in the past. Have several students share the ideas they discussed with their partners. Explain that this information will be helpful to Dr. Moraga and the other curators as they plan their museum exhibit because understanding past plate motion will help them provide a complete explanation of how the *Mesosaurus* fossils got separated.

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Active Reading: "A Continental Puzzle"

20 MIN

Students read and annotate the article "A Continental Puzzle."

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Instructional Guide

1. Point out the Investigation Question on the board. Remind students that answering this question will help them explain the location of ancient fossils found on separate continents.

2. Project the article "A Continental Puzzle" from the Amplify Library, or project the printed article using a document camera.

Today you will read an article about Alfred Wegener, a scientist who lived around 100 years ago, and the work he did that led modern scientists to be able to explain what happens to the plates and mantle at plate boundaries. Wegener also used fossils in his work, so reading this article will help you to better understand our own *Mesosaurus* mystery.

3. Model Active Reading. As you model, emphasize the importance of identifying challenging words or phrases. As you model, you can use the following script, or you can model your own thinking.

- **Begin by reading the title of the article aloud.**

The title suggests that there is some sort of puzzle with the continents. I know the word *puzzle* can be a bunch of pieces that fit together, and it can also be a mystery. I wonder what *puzzle* means in this case or if it maybe has a different meaning here. What is a continental puzzle? I am going to highlight this word and record my thinking about it.

- **Highlight "Puzzle."** Press ADD NOTE and type, "What does puzzle mean here?"
- **Read the first paragraph aloud.**

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This paragraph is interesting! I think it is saying that the ideas we have today about how plates move—the ideas we are learning about in class—were doubted less than 100 years ago. I want to make a note of that. If I write a question about this, I can remember it and answer the question later.

- **Highlight a section of the paragraph.** Press ADD NOTE and type, "Why did scientists doubt Wegener's ideas during his lifetime?"
- **Continue to make annotations.** If useful, add notes about vocabulary, questions, or connections.

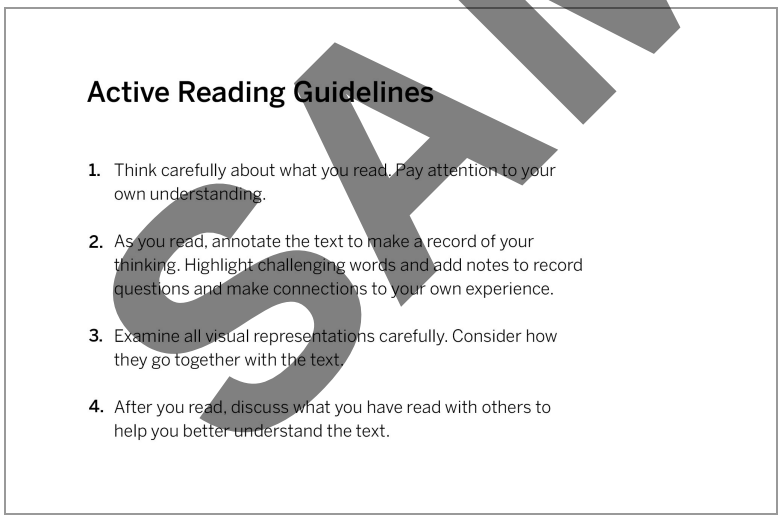
4. Remind students of how to identify a challenging word or phrase.

Remember to identify challenging words or phrases as you read. As a reminder, a challenging word or phrase can be something that is completely unfamiliar, such as a word or phrase that you have never seen before. Alternatively, it can be a word that you have seen or heard before, but you are not sure of its exact meaning.

Lastly, a challenging word can be one that you are familiar with but is being used in a different context. The word might have a meaning other than the one you are familiar with.

Emphasize that students are likely to select different words as challenging or unfamiliar. There are no right answers.

5. Project and review Active Reading Guidelines. Point out that these guidelines are also posted in the classroom and on page 83 in the Investigation Notebook. Briefly discuss each guideline, emphasizing that you would like students to focus on identifying and asking questions about challenging words or phrases as they read.



Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

6. Instruct students to open "A Continental Puzzle." Students can open the article using the link on their screens or from Digital Resources.

7. Prompt students to read and annotate. Circulate as students read, using the Annotation Tracker to record annotations that you would like to invite students to share during the class discussion in Activity 4.

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8. On-the-Fly Assessment: Progress with Identifying Challenging Words and Phrases. For further suggestions on how to support students as they annotate, press the hummingbird icon and select ON-THE-FLY ASSESSMENT 9.

Embedded Formative Assessment

ON-THE-FLY ASSESSMENT 9: Progress with Identifying Challenging Words and Phrases

Look for: This reading activity is an opportunity to check students' progress with identifying challenging or unfamiliar words and phrases—a process modeled in Lesson 2.2. As in all reading lessons in which students annotate, students should feel free to annotate in unique ways that are helpful to each individual student's learning and personal style. Look for students to be actively engaged in the reading and annotation process. Students may make a wide range of annotations that reflect their varying levels of science understanding. This variation is fine. You can review annotations, gauging students' attention to new or unfamiliar vocabulary, by asking yourself the following questions: *Do students seem to be strategically highlighting challenging or unfamiliar words as they read? Are students taking time to think critically about what the word or phrase might mean in this context? Are they adding annotations that reflect what they already know, initial ideas, or questions they have about the words and phrases they highlight?*

Now what? This reading experience is intended to give students the space to practice Active Reading strategies, including identifying unfamiliar or challenging words and phrases. However, some students may need support in developing this type of awareness as they read. Consider periodically sharing words that multiple students have identified as problematic or unfamiliar. Provide positive, encouraging feedback about these choices. For example, you might note how a word that students identified as familiar in other contexts is used in an unfamiliar or interesting way in this article. You can also offer general prompts to support deeper engagement by pointing out specific words or phrases and asking students to record their ideas about what the words mean. You might also notice that while some students need encouragement to identify a few words or phrases, other students might begin to quickly highlight a large number of words without stopping to look for clues about what the words or phrases might mean or to record their initial ideas. If this is the case, you can invite these students to record annotations each time they highlight a word or phrase, challenging them to think deeply and critically about what the word or phrase might mean in this context.

Teacher Support

Instructional Suggestion

Providing More Support: Helping Students with the Concept of a Continent
Some students may need more support understanding what a continent is, and how continents are related to plates. If you think that your students could benefit from more time with these ideas before reading "A Continental Puzzle," you may want to take time to work with the Sim and with maps of Earth that have been included in this unit to discuss these ideas. Students should know that the continents are the thicker parts of the plates that rise above sea level.

Rationale

Pedagogical Goals: Understanding the Nature of Science
The article, "A Continental Puzzle," further develops students' understanding of the nature of science as a discipline and the ways in which scientific knowledge develops over time. It provides an opportunity for students to experience the

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understanding that Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena, which is one of the eight understandings about the nature of science called out by NGSS. The article illustrates the idea that theories are explanations for observable phenomena based on a body of evidence that developed over time, and that a hypothesis is used by scientists as an idea that may contribute important new knowledge for the evaluation of a scientific theory.

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Discussing Annotations

10 MIN

Students share their questions and ideas about the article "A Continental Puzzle."

Instructional Guide

1. Project and review Discussing Annotations. Explain that students will review their annotations and choose a question, connection, or challenging word that is interesting to them and that they would like to share with a partner. Explain that in order to edit an annotation as one to share, students press EDIT and type "#share."

Discussing Annotations

#share	Carefully choose an interesting annotation (comment, question, connection, vocabulary word) you'd like to share with your partner and add #share to this annotation.
#discussed	Add #discussed to your annotation if you feel that you and your partner have resolved a question OR if your discussion gave you a deeper understanding about something in the article.
#present	Add #present to your annotation to mark any unresolved questions or ideas you would like to present to the class.

2. Ask students to choose and tag annotations they want to discuss.

3. Prompt partners to discuss annotations. Circulate as partners discuss, using the Annotation Tracker and listening for questions and connections that you would like to share during class discussion. Ask students to change the tags in their shared annotations to "#discussed" if they feel that their partner discussions gave them a deeper understanding of the annotation they made or if they answered their tagged questions.

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4. Prompt partners to prepare for class discussion. Ask partners to choose an interesting or unanswered question, a connection, or a challenging word or phrase that they would like to share with the class. Explain that these can be the same annotations they shared with their partners if the questions are still unresolved. Ask students to tag the annotations they would like to share with the class by pressing EDIT and writing "#present."

5. Facilitate a brief class discussion about annotations. Invite students to share their tagged questions, connections, or challenging words. Encourage students to respond to one another and to look back at the article to answer their peers' questions.

6. Highlight exemplary or noteworthy annotations; focus on the strategy of identifying challenging or unfamiliar words and phrases.

- Refer to your Annotation Tracker and invite students with annotations that you noted to share them with the class.
- Provide specific, positive feedback as students share, noting when annotations show evidence of Active Reading. Examples might include annotations that make a connection to science ideas, annotations that use vocabulary from the unit, or instances in which students were able to answer their own questions.
- If you noticed a good example of a word or phrase identified by one or more students, ask a student to share this example. Help the class reflect on how identifying these words and phrases supports them in a deeper understanding of the science text.

7. Refer back to the Investigation Question. Read, or have a student read, the Investigation Question introduced at the beginning of this lesson: *What evidence do we have of past plate motion?*

What did you learn from the article about plate motion in the past?
[Earth's outer layer is made of slow-moving plates, which have been moving for billions of years. The continents are parts of these moving plates. As a result of plate motion, the continents have moved great distances from where they were billions of years ago.]

What evidence do we have to support that the plates moved great distances over billions of years?
[The edges of the continents fit together like puzzle pieces. This indicates that the continents once were together and broke apart. There are identical landforms, similar rock formations, and similar fossils that also indicate the continents were once together.]

Ask students to press NEXT to continue this activity.

8. Prompt students to review their annotations on their digital devices and submit their annotated articles. On each student's screen, the article "A Continental Puzzle" and the annotations each student made in the Amplify Library should be visible. Students should answer the reflection question and then submit their articles and reflection question responses by pressing HAND IN.

9. On-the-Fly Assessment: Insight from Students' Annotations. For further suggestions on how to review students' annotations, press the hummingbird icon and then select ON-THE-FLY ASSESSMENT 10.

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10. Point out the homework assignment to students (Activity 5 or page 84 in the Investigation Notebook). Explain that for homework, students will complete a Sorting Tool activity where they place major events in Earth's history on a timeline and read a second article about another scientist, Nicholas Steno, who lived long ago and who also studied fossils. His work helped the scientific community to better understand Earth's history, just as Wegener's work did.

Embedded Formative Assessment

ON-THE-FLY ASSESSMENT 10: Insight from Students' Annotations

Look for: Review submitted student annotations after class. You can use these annotations to assess students' annotation skills, reading comprehension, and content understanding. Use the Annotation Tracker and Annotation Tracker Instructions for guidance.

Now what? See the Annotation Tracker Instructions for suggestions on how to further support students.

Teacher Support

Rationale

Science Reading: Value of Sharing Student Annotations
Much of students' success with Active Reading comes from teacher modeling and encouragement to engage with the approach, expanding on skills and techniques. Offering examples of interesting student annotations is one way to support Active Reading as a classroom norm. Sharing annotations also provides students with new ways to think about the activity itself.

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Homework

Students sort events on a timeline of Earth's history and find out about how scientists study layers of rock to learn more about geologic history by reading the "Steno and the Shark" article.

Instructional Guide

1. If needed, make additional time to explain the homework. If students do not have access to Amplify Science at home, make time in class to complete the Sorting Tool and provide them with copies of page 84 from the Investigation Notebook and printed copies of the "Steno and the Shark" article. If students do not have access to Amplify Science at home, you will also need to make time in class to complete questions 2 and 3 after students read the article.

Teacher Support

Rationale

Pedagogical Goals: Purpose of the Sorting Tool and Reading "Steno and the Shark" Article
Scientists use the geologic time scale to analyze and interpret their data and communicate their explanations about Earth's past. The presence of fossils in rock layers can provide information about the relative ages of the layers, helping scientists understand the history of landforms. Students often have a difficult time understanding the scale of Earth's history and how events that occurred millions of years in the past are related. The homework in Lesson 3.2 provides students with an opportunity to use more familiar concepts, such as plants and animals, to understand a small subset of geologic time increments. They sort major events on a timeline using the Sorting Tool to get a sense of when these major events occurred. They then read the article, "Steno and the Shark," to understand how rock layers reflect the geologic time scale and extend their understanding of the types of evidence supporting theories related to the history of Earth.

Assessment

Assessment Opportunity: Student Understanding of Rock Strata and Geologic Time
This activity can be used to assess students' understanding of the idea that examining rock strata can provide information about the geological time scale as well as evidence of the relative age of fossils found within different strata. Look for whether students are able to describe that the rocks making up parts of Earth's surface are formed in layers, with the older layers beneath the newer layers, and therefore older fossils are found in lower layers. If many students do not seem to understand these ideas, you might take some time to return with the class to the illustration at the end of the article that shows layers of rock, and help students talk through what the illustration is showing. Ask students to

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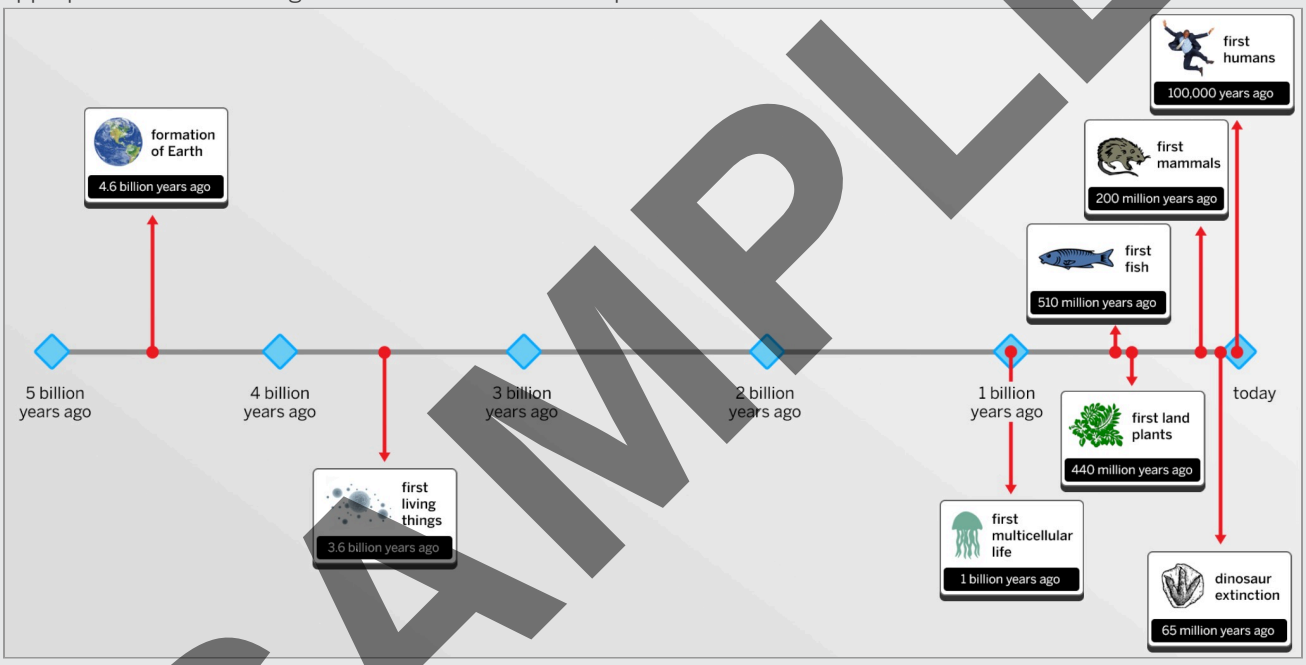
point out which rock layers are older and to explain how they know. Then ask students how newer layers were added; if needed, help students search in the article to find this information. Help students construct the understanding that new layers of rock can be added on top of older layers when sand or mud falls on top of rock and then hardens into new rock, and that this is why newer layers of rock are on top of older ones.

Possible Responses

Part 1: Students should use the time points given for each of the images in the toolbar to place the images on the appropriate locations along the timeline. The correct response is shown below.



Part 2:

1. The rock layer that the fossil can be found in provides information about the relative date of the event. Rock layers that are older are found below younger rock layers. Fossils found in rock layers closer to the surface are from more recent time periods than fossils found in rock layers below.
2. Cambrian Period
3. Answers will vary.

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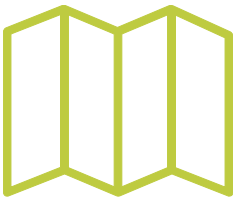

Lesson 3.3

Reconstructing Gondwanaland

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Lesson Overview

Students reread part of the article "A Continental Puzzle" in order to more fully understand how the theory of plate tectonics developed and the convergence of evidence that supported it. Next, they use puzzle pieces representing the modern-day plates to create a model of the ancient supercontinent Gondwanaland. The puzzle pieces also include information about a few important fossil discoveries. Students use the notes they took as they read to aid them in constructing this model. This lesson helps students to synthesize their thinking about how slowly plates travel over vast periods of time, and how fossil evidence supports scientists' understanding of this process.

Anchor Phenomenon: Fossils of the *Mesosaurus*, an extinct reptile whose population once lived all together, are found in two locations that are separated by thousands of kilometers of ocean.
Investigative Phenomenon: The edges of the continents and landforms match, as if they had once fit together like puzzle pieces.

Students learn:

- It takes a long time for Earth's plates to travel great distances.
- In Earth's ancient past, the continents were connected into supercontinents, including Gondwanaland.

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Lesson at a Glance

ACTIVITY

1 **Warm-Up** (5 min)
Students use their understanding about the rate of plate motion to predict how much the continents will move in the future.

WARM-UP

2 **Rereading "A Continental Puzzle"** (15 min)
Students reread part of the article to consider the rate of plate motion over millions of years.

READING

3 **Reconstructing Gondwanaland** (25 min)
Students use physical materials to reconstruct an ancient supercontinent, based on evidence and their knowledge of plate motion. The teacher uses this opportunity as an On-the-Fly Assessment of students' understanding that maps of ancient land masses reveal how Earth's plates have moved.

HANDS-ON

4 **Homework**
Students revise their Warm-Up responses based on the new understandings they constructed during the lesson.

HOMEWORK

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Materials & Preparation

Materials

For the Classroom Wall

- key concept: *It takes a long time for Earth's plates to travel great distances.*

For the Class

- masking tape*

For Each Pair of Students

- 1 copy of the Gondwanaland Puzzle student sheet*
- 1 blank sheet of 8.5" x 11" paper*
- 1 pair of scissors*
- 1 glue stick*

For Each Student

- optional: printed copy of the "A Continental Puzzle" article*
- optional: *Plate Motion* Investigation Notebook, pages 85–90*

Digital Tools

- *Plate Motion* Sorting Tool activity: Plate Motion Predictions
- "A Continental Puzzle" in the Amplify Library

*teacher provided

Preparation

Before the Day of the Lesson

1. **Gather the following item for the classroom wall:**
    - key concept: *It takes a long time for Earth's plates to travel great distances.*

VOCABULARY

- analyze
- claim
- convergent
- cross section
- divergent
- earthquake
- evidence
- mantle
- mid-ocean ridge
- outer layer
- pattern
- plate
- plate boundary
- rate
- scientific argument
- trench
- volcanic activity

UNPLUGGED?

Digital Devices Optional (with Modifications)

Students can complete most of the lesson without the use of digital devices. If students do not have

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2. **Choose student annotations to share.** Use your completed Annotation Trackers and Annotation Summary Sheets from Lesson 3.2 to identify one or two exemplary annotations to share. You may also wish to identify any alternate conceptions, revealed in students' annotations, that you would like to discuss.
Students will likely have alternate conceptions about how to explain why fossils are sometimes found in unlikely locations, such as the tropical plant fossils that have been found in Antarctica. Students may think that the climate was different at the seemingly unlikely location in the past rather than thinking that the continent traveled from a different location due to plate motion. Discussing alternate conceptions will prepare students for the second read in this lesson.
3. **Familiarize yourself with the *Plate Motion* Sorting Tool activity: Plate Motion Predictions in this lesson.** Practice the activity and refer to Apps in This Unit under Teacher References at the unit level for more information.
4. **Make copies of the Gondwanaland Puzzle copymaster.** Locate the copymaster in Digital Resources. Print out the Gondwanaland Puzzle copymaster and make enough copies for each pair of students to receive one copy.
5. **Prepare for the hands-on activity.**
    - **Make a plan for distributing materials for the hands-on activity.** Determine how you will distribute the Gondwanaland Puzzle student sheets, pairs of scissors, glue sticks, and blank sheets of paper to students.
    - **Decide if you want to allow more time.** The hands-on activity is very engaging and students enjoy discussing the evidence and working with the puzzle. You may wish to give students additional class time to participate in this activity, so they can more fully engage in both the problem-solving and the peer discussion involved in the activity.
6. **Prepare for On-the-Fly Assessments.** Activity 3 provides an opportunity to assess students' understanding that maps of ancient land masses reveal how Earth's plates have moved. Press the hummingbird icon and then select ON-THE-FLY ASSESSMENT 11 for details about what to look for and how you can use the information to maximize learning by all students.
7. **Review the optional Hands-On Flextension: Modeling Plate Boundaries and decide if you will teach it after this lesson.** The Flextension lesson guide and Flextension copymaster are available in Digital Resources.

devices, project the Sorting Tool during the Warm-Up and complete it as a class. Print copies of the Investigation Notebook pages for this lesson. (A PDF can be found in Digital Resources.)

If students do not have access to Amplify Science at home, adjust your schedule to make time to complete the Sorting Tool activity in class.

DIGITAL RESOURCES

A Continental Puzzle

Printable Article: "A Continental Puzzle"

Gondwanaland Puzzle copymaster

Plate Motion Investigation Notebook, pages 85–90

Hands-On Flextension lesson guide: Modeling Plate Boundaries

Hands-On Flextension copymaster: Modeling Plate Boundaries

Plate Motion Glossary

Plate Motion Multi-Language Glossary

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Immediately Before the Lesson

1. **Make sure the Investigation Question is still written on the board:** "What evidence do we have of past plate motion?"
2. **Have on hand the following materials:**
    - digital devices
    - Gondwanaland Puzzle student sheets
    - blank sheets of 8.5" x 11" paper
    - pairs of scissors
    - glue sticks
    - optional: printed copies of the "A Continental Puzzle" article
    - optional: *Plate Motion* Investigation Notebook, pages 85–90

Between-Class Prep

1. **Gather the next class's annotations.** If you chose annotations to share that were specific to the next class, make sure you have these annotations on hand.
2. **Gather materials for the next class.** Gather Gondwanaland Puzzle student sheets, blank sheets of paper, pairs of scissors, and glue sticks for the next class.

At the End of the Day

1. **Post the key concept on the classroom wall:**
    - *It takes a long time for Earth's plates to travel great distances.*

Differentiation

Embedded Supports for Diverse Learners

Multiple modalities with the same topic. In the previous lesson, students read the article "A Continental Puzzle" to learn about evidence of past plate motion. Today, they reread part of the article, then use the text to consider evidence of past plate motion in order to construct a paper model of the supercontinent Gondwanaland. Engaging with the same ideas through different modalities provides students multiple opportunities to make sense of complex concepts and provides access points for different types of learners.

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Potential Challenges in This Lesson

Partner work. Student-to-student discussion and cooperation during the hands-on activity is central to this lesson, so you may want to consider which student partners will work best with each other to promote learning and a feeling of safety and inclusion.

Specific Differentiation Strategies for English Learners

Extra discussion time after reading. Some English learners would be supported by having more time to discuss after reading. This is especially true for this lesson, since after reading students are focusing on interpreting a visual representation of the arrangement of continents today and creating a visual representation of the arrangement millions of years ago. It would be helpful to some English learners to take additional time to discuss the way Wegener used the shapes of the continents and the presence of similar fossils on different continents to develop his hypothesis. Taking time to discuss the Map of Gondwanaland Today and making a connection to the article will support students in interpreting the map.

Specific Differentiation Strategies for Students Who Need More Support

Providing more time. If your students need more time to make sense of the activities in this lesson, consider teaching this lesson over the span of two class periods. Building in more time to process and reflect can help some students better understand what they are being asked to do and can also provide time for you to check in more closely with those students.

More focus on making connections between physical models and scientific phenomena. Students are asked to use a simplified paper model (the Gondwanaland Puzzle) to support their understanding of ancient plate movement. You may wish to create more opportunities for explicitly reflecting on what is represented by the different aspects of the model, as well as its limitations.

Specific Differentiation Strategies for Students Who Need More Challenge

Additional research on fossil evidence. In addition to locations where *Mesosaurus* fossils have been found, the Gondwanaland Puzzle student sheet shows locations where fossils of the Triassic reptiles, *Cynognathus* and *Lystrosaurus*, and the fern *Glossopteris* have been found. Students who need more challenge can do research on *Cynognathus*, *Lystrosaurus*, or *Glossopteris*. Some topics you might consider encouraging students to research are the approximate dates that these species existed on Earth, the characteristics of the species that can be learned about from their fossils, or how these organisms might have ended up on different continents.

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Standards

Key
Practices Disciplinary Core Ideas Crosscutting Concepts

3-D Statement

Students obtain information about how fossil evidence supports scientists' understanding of past plate motion (patterns) by rereading "A Continental Puzzle" in order to construct a paper model of the ancient supercontinent Gondwanaland, using puzzle pieces representing the modern-day plates.

Next Generation Science Standards (NGSS)

NGSS Practices

- **Practice 2:** Developing and Using Models
- **Practice 4:** Analyzing and Interpreting Data
- **Practice 6:** Constructing Explanations and Designing Solutions
- **Practice 8:** Obtaining, Evaluating, and Communicating Information

NGSS Disciplinary Core Ideas

- **ESS2.A: Earth's Materials and Systems**:
  - The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2)
- **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. (MS-ESS2-3)

NGSS Crosscutting Concepts

- Cause and Effect
- Patterns
- Scale, Proportion, and Quantity

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Common Core State Standards for English Language Arts (CCSS-ELA)

- **CCSS.ELA-LITERACY.CCRA.L.4:** Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized references materials, as appropriate
- **CCSS.ELA-LITERACY.CCRA.SL.1:** Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
- **CCSS.ELA-LITERACY.RST.6-8.1:** Cite specific textual evidence to support analysis of science and technical texts.
- **CCSS.ELA-LITERACY.RST.6-8.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics
- **CCSS.ELA-LITERACY.RST.6-8.7:** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
- **CCSS.ELA-LITERACY.WHST.6-8.2.D:** Use precise language and domain-specific vocabulary to inform about or explain the topic.
- **CCSS.ELA-LITERACY.WHST.6-8.9:** Draw evidence from informational texts to support analysis, reflection, and research

Common Core State Standards for Mathematics (CCSS-Math)

CCSS-Math Practices

- **CCSS.MATH.PRACTICE.MP1:** Make sense of problems and persevere in solving them.
- **CCSS.MATH.PRACTICE.MP2:** Reason abstractly and quantitatively.
- **CCSS.MATH.PRACTICE.MP4:** Model with mathematics.
- **CCSS.MATH.PRACTICE.MP5:** Use appropriate tools strategically.
- **CCSS.MATH.PRACTICE.MP7:** Look for and make use of structure.

CCSS-Math Content

- **CCSS.MATH.CONTENT.6.RP.2:** Understand the concept of a unit rate a/b associated with a ratio a: b with b ≠ 0 (b not equal to zero), and use rate language in the context of a ratio relationship

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1 WARM-UP
Warm-Up

Warm-Up

5 MIN

Students consider how far continents move in 50 years versus how far they move in 50 million years.

Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 86 in the Investigation Notebook. Allow a few minutes for students to individually respond to the Warm-Up.

Possible Responses

***Plate Motion* Sorting Tool: Plate Motion Predictions**

Responses will vary for the Warm-Up (students will revise their responses for homework). The continents labeled "50 Years Later" should be in approximately the same place as the continents labeled "Now." The continents labeled "50 Million Years Later" should be a few centimeters (as shown in the Sorting Tool) farther away from the mid-ocean ridge. After 50 million years, both South America and Africa should be farther apart from each other, and farther from the plate boundary.

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2 READING
Rereading "A Continental Puzzle"

Rereading "A Continental Puzzle"

15 MIN

Students reread part of the article "A Continental Puzzle" to consider how much time it takes plates to travel great distances.

Instructional Guide

1. Introduce the theory of plate tectonics.

Remember in the previous lesson you read about Alfred Wegener. He used the shape of continents and fossils as evidence for his hypothesis that the continents moved apart. This evidence and evidence gathered from other scientists eventually led to the "theory of plate tectonics." Since it is a theory, it may sound like scientists are not sure about it, but a scientific theory is an idea that has a lot of evidence that many scientists have gathered over a long time.

2. Remind students of the Investigation Question. Refer to the board to remind students of the Investigation Question presented in the previous lesson: *What evidence do we have of past plate motion?*

Today we will continue to use what we know about plate motion to make claims about how plates move over time. In the Warm-Up activity, you thought about how Earth's plates will travel in the future, using your understanding of how the plates move today. We will also use evidence to think about how plates moved in the past, just as Alfred Wegener did.

3. Introduce purpose of rereading an excerpt from "A Continental Puzzle." Explain that students will reread an excerpt from the article in order to look for additional information that helps them answer the Investigation Question. Students should underline or highlight information that helps them understand how plates moved in the past.

4. Share selected annotations from the previous lesson. Share exemplary annotations that demonstrate thoughtfulness or creativity. You may also want to review and discuss any alternate conceptions that were revealed in students' annotations.

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5. Point out the Guiding Questions that are on the student screen or on page 87 in the Investigation Notebook Collapse the instructional guide and project the student screen, or have students turn to page 87 in the Investigation Notebook. Explain to students that as they read, they should focus on finding information that will help them answer the Guiding Questions. Point out that these questions all relate to the Investigation Question *What evidence do we have of past plate motion?* Review the questions as needed.

6. Direct students to reread the article excerpt. Provide approximately 10 minutes for students to read, circulating to assist as needed. Remind students to highlight important sentences or phrases that help them to answer the three Guiding Questions.

7. Lead a whole-class discussion about information students found in the article. Use the Guiding Questions to prompt discussion and summarize the following lines of evidence that Wegener used to construct his scientific argument:

- The edges of the continents match like puzzle pieces.
- Some identical landforms are found on more than one continent (for example, Africa and South America) as if they had once been connected.
- Similar fossils, rock formations, and mountain ranges are found on different continents.

Possible Responses

1. The continents looked like they fit together like puzzle pieces. Wegener used this as evidence that they had once been together but had somehow moved apart over time.
2. Africa and South America have mountain ranges and rocks that are very similar. When you put the two continents together so that they fit, these similar mountain ranges and rocks line up and fit together. This is evidence that these two continents were once connected.
3. Fossils that were from the same time and population have been found on continents that are far apart. Since these organisms once lived near each other, fossils can be used as evidence that the continents were once together but moved far apart.

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3 HANDS-ON
Reconstructing Gondwanaland

Reconstructing Gondwanaland

25 MIN

Students use evidence to reconstruct the supercontinent Gondwanaland, as it was 200 million years ago.

Instructional Guide

1. Project Map of Pangea and remind students about the supercontinent. Remind students that this map is the same as the one from the article and they read the section about Pangea in the previous lesson. Review with students that Alfred Wegener's work led him not only to explain that continents could and did move, but also led him to offer an amazing claim—that at one time, all the continents were once connected, as shown in this image.

Map of Pangea

The supercontinent Wegener proposed was called Pangea. Using Wegener's original work, geologists have since used evidence to confirm that the supercontinent Pangea existed about 300 million years ago. Since then, the continents have continued to move.

2. Set context for the hands-on activity. Explain that students will be using physical materials to reconstruct another supercontinent called Gondwanaland, which was one of two big sections that made up the larger supercontinent Pangea.

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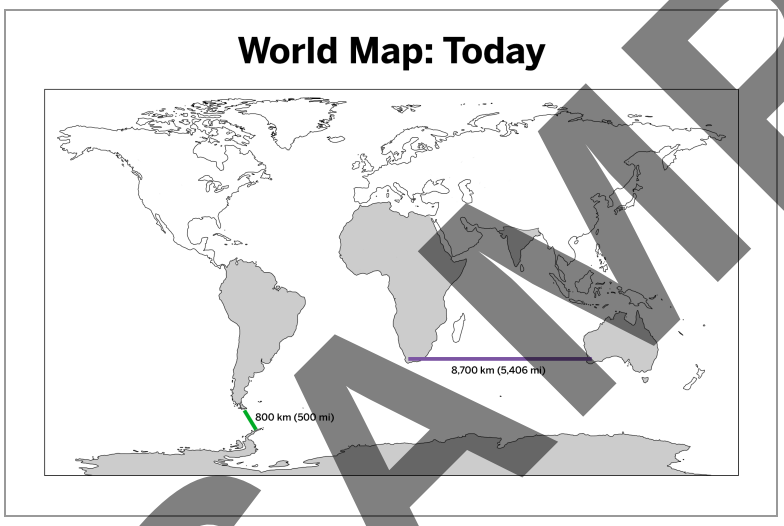
From the article you read, you know that there is compelling evidence that continents have not always been in the same locations as they are today. You read about the different types of evidence Wegener used to explain that the continents had once been connected and then slowly separated as they traveled great distances over very long periods of time.

Today you will use similar evidence to figure out the positions of the continents as they were when they were joined together as the supercontinent Gondwanaland. Around 200 million years ago, Pangea separated into two large sections. One of these sections, Gondwanaland, included the land that we now know as India, Antarctica, Australia, Africa, and South America.

3. Project World Map: Today to highlight the current locations of the Gondwanaland landmasses. Explain that this map shows where the landmasses that used to make up Gondwanaland are today. These landmasses are shown in gray on the map. Explain that the word *landmasses* includes continents, such as South America and Africa, and sections of continents, such as India. Point out that the southern tip of South America and the Antarctic Peninsula are about 800 km apart, and the distance between Cape Town in Africa and Perth in Australia is about 8,700 km.



4. Introduce the Map of Gondwanaland Today. Collapse the instructional guide and project the student screen, or have students turn to page 88 in the Investigation Notebook. Explain that this map shows only the landmasses that made up Gondwanaland; students will receive a printed copy of this map in a moment.

5. Prompt students to make initial observations of the Map of Gondwanaland Today and its key. Have students turn and talk to a partner about their initial observations of this map and key. Invite students to share what they notice with the class. Point out that the patterned areas on the landmasses show the distributions of different fossils. Wegener used this fossil evidence to construct his scientific argument. Use the key to point out that this evidence includes the *Mesosaurus* fossils they have been investigating.

6. Call attention to the mid-ocean ridge landforms on the map to identify the plate boundaries.

Where are mid-ocean ridges found? What do mid-ocean ridges tell us about plate motion?

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Students should identify that these landforms are found at divergent plate boundaries, where plates move apart.

7. Prompt partners to discuss past plate motion. Encourage students to refer to the discussion questions on their screens.

The presence of mid-ocean ridges tells us that there are divergent plate boundaries at the places where the plates meet. This means that the plates, and the landmasses that are parts of those plates, have been moving apart slowly over time. As they move apart, rock from the mantle is added to the edges of both plates.

If you were to go back in time, to 200 million years ago, what do you think the location of these landmasses would be? Would there be more ocean floor between the continents or less? Why? Explain your initial thinking to your partner.

Ask students to press NEXT (or to turn to page 89 in their Investigation Notebooks) to continue this activity.

8. Introduce the Gondwanaland Puzzle activity. Explain that students will use evidence on the Map of Gondwanaland Today to put the pieces of Gondwanaland back together again, as they were 200 million years ago.

- **Review the instructions.** Collapse the instructional guide and project the student screen, or have students refer to page 89 in the Investigation Notebook.
- **Distribute materials for the hands-on activity.** Distribute one Gondwanaland Puzzle student sheet, one pair of scissors, one glue stick, and one blank sheet of paper to each pair of students.

9. Prompt students to complete the first four steps of the instructions. Circulate and help students as they cut the plates apart and then cut off the hard, solid rock that makes up the ocean floor.

10. Facilitate brief partner and whole-class discussions about Discussion Question 1.

- When it looks like most students have completed Steps 1–4, project Discussion Question 1.

Discussion Question 1

Why did you cut away the hard, solid rock on the ocean floor that formed between the landmasses over the last 200 million years?

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- Have students share their ideas with their partners and the class. Use students' responses to point out that this rock did not exist 200 million years ago! It formed at the divergent plate boundaries as the plates moved apart from each other and rock from the mantle was added to the edges of the plates. Students needed to remove that rock by cutting it out in order to put Gondwanaland back together as it was 200 million years ago.

11. Instruct students to assemble the Gondwanaland Puzzle and discuss the remaining discussion questions.
Circulate and assist students, as needed.

- After several more minutes, project Discussion Question 2.

Discussion Question 2

After cutting away the hard, solid rock that makes up the ocean floor, what was your strategy for putting the landmasses of Gondwanaland back together, as they were 200 million years ago?

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- Ask students to read and discuss this question with their partners; they will discuss this as a class in a few minutes.
- After partners discuss, encourage students to begin gluing their Gondwanaland supercontinent together on the blank sheet of paper.
- After students have glued their Gondwanaland on a sheet of paper, project Discussion Question 3.

Discussion Question 3

How did your knowledge of plate motion help you complete the Gondwanaland puzzle?

- Ask partners to discuss this question. Let them know that they will discuss this as a class in a few minutes.

12. Lead a brief whole-class discussion about Discussion Questions 2 and 3.

- Invite students to share their responses to Discussion Question 2 with the class. (*What was your strategy for putting the landmasses of Gondwanaland back together?*)
- Use students' responses to point out that the fossil evidence on the landmasses and the way the continents fit together (what Wegener called the "puzzle fit") are two lines of evidence that may have been particularly relevant to completing this task.
- Encourage students to share their reflections from the activity and Discussion Question 3. (*How did your knowledge of plate motion help you complete the Gondwanaland puzzle?*) As it comes up in conversation, note that the fossil evidence and the fit of the continents (after cutting away the ocean floor) were the most useful pieces of evidence to understand how the landmasses were once together 200 million years ago.
- Ask students to recall why the ocean floor wasn't included in their reconstructions of Gondwanaland. Note that the ocean floor was not there 200 million years ago and formed as rock from the mantle was added to the edges of the plates as the plates slowly moved away from each other.

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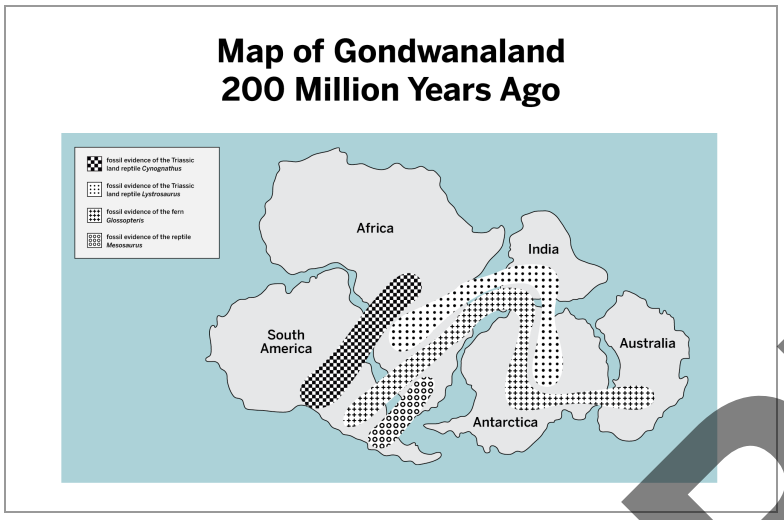
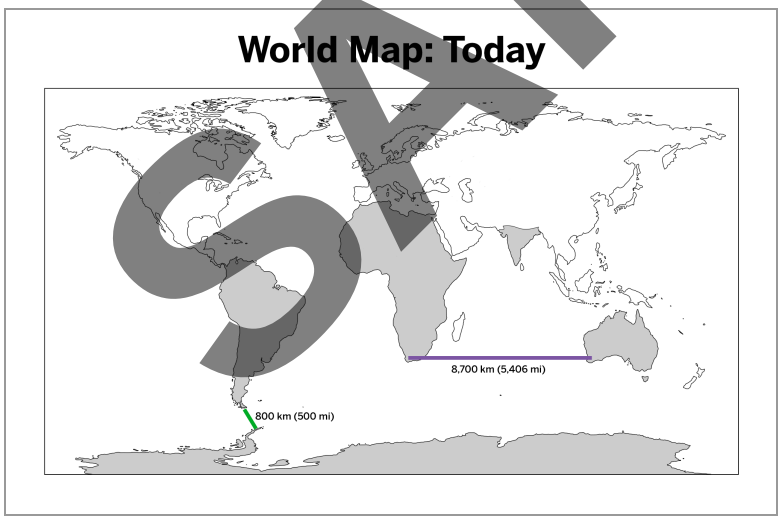
13. Project Gondwanaland (200 Million Years Ago). Invite students to compare and contrast their completed Gondwanaland Puzzles to this map.



This is how scientists think these landmasses were arranged when they were parts of Gondwanaland. This is based on a lot of evidence, including the evidence you considered.

14. Project World Map: Today again and reflect on the positions of the landmasses today. Remind students that this map highlights where the landmasses that made up Gondwanaland are today. Use the information on the map to remind students that the landmasses that made up Gondwanaland are very far apart now.



Today, the landmasses that made up Gondwanaland are separated by hundreds or thousands of kilometers, but we know from the evidence we worked with in this activity that 200 million years ago, these landmasses were much closer together. As we know, plates move at a very slow rate, so it took many millions of years for the landmasses to get as far apart as they are today.

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15. Project and introduce the key concept. Read, or ask a student to read, the key concept aloud: *It takes a long time for Earth's plates to travel great distances.*

Key Concept

It takes a long time for Earth's plates to travel great distances.

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16. Return to Investigation Question. Refer to the Investigation Question written on the board. Make a connection between the Investigation Question and the key concept that was just introduced. Ask students what evidence we have to support this new key concept and how this relates to past plate motion. [The shapes of the continents and the landforms that appeared on them tell us that they may have once been connected. The edges of the continents matched like puzzle pieces. Some identical landforms appeared on more than one continent as if they had once been connected. Similar fossils, rock formations, and mountain ranges are found on different continents. GPS data tells us that currently the plates are moving very slowly, so maybe they have been doing so for a very long time.]

17. On-the-Fly Assessment: Interpreting Maps of Ancient Land Masses. For suggestions on how to support students in interpreting maps of ancient land masses, press the hummingbird icon and then select ON-THE-FLY ASSESSMENT 11.

18. Collect the materials from the hands-on activity.

19. Point out the homework assignment to students (Activity 4 or page 90 in the Investigation Notebook). If students do not have access to Amplify Science at home, adjust your schedule to make time to complete the Sorting Tool activity in class. Explain that students will revise their Warm-Up responses and make note of how their thinking has changed over the course of this lesson.

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Embedded Formative Assessment

ON-THE-FLY ASSESSMENT 11: Interpreting Maps of Ancient Land Masses

Look for: This activity is an opportunity to assess students' ability to interpret maps and their understanding that maps of ancient land masses reveal how Earth's plates have moved. During the discussion of the investigation question, students should refer to the map of Gondwanaland 200 Million Years Ago to explain how Earth's plates have moved. Listen for students to mention that they were able to reconstruct Gondwanaland because the shape of the continents are like puzzle pieces that fit together, showing that they were once together but have now moved apart. Students should also use fossil and rock evidence to show that the continents were once close together and then moved far apart.

Now what? If students are unable to use the map of Gondwanaland to explain how Earth's plates have moved, print the map of Gondwanaland and have students use it to construct how the land masses look today using a modern day map as a reference. As students move the pieces, point out that in moving the pieces to their current locations, students are moving the continents according to GPS data on how the plates are currently moving. Point out that there is evidence of similar fossils and rock formations found on different continents, which shows that they were once close together.

Teacher Support

Rationale

Data and Visual Representations: Maps of Gondwanaland
Some students may notice that the large island of Madagascar (currently located in the Indian Ocean off the coast of Africa) is missing from the maps of Gondwanaland used in this activity. The fossil evidence from Madagascar does support Wegener's theory of continental drift and modern theories of plate movement, as well. However, since the Gondwanaland Puzzle activity is intended to convey information about how scientists have learned to track large-scale plate movement by following fossil patterns mostly across larger landmasses, we chose to focus only on the larger landmasses that made up Gondwanaland. This is why the maps do not show islands. If students point this out, congratulate them on their observation and explain that the map has been simplified, but is still accurate in its depiction of the fossil evidence.

Instructional Suggestion

Student Thinking: Floating Continents
Just as students can maintain the alternate conception that Earth's plates float on a sea of hot, liquid magma, they may also think that the continents float across the ocean to travel to new locations on Earth. This notion may be reinforced in this activity because students are moving continents around as if they are disconnected from Earth's plates. If you notice students referring to continents moving around independent of plates or floating on ocean water, be sure to remind them that a continent is not a detached entity, but rather, a part of a larger plate. Use the classroom wall to reinforce the key concepts related to Earth's outer layer being made of moving plates made of hard, solid rock.

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Possible Responses

Answers will vary. The purpose of this discussion is for students to express their initial ideas. Students should know that (because of plate motion) the landmasses would have been in different locations. They may also be able to explain that, because ocean floor is being created at divergent plate boundaries, there would have been less ocean floor between the continents 200 million years ago than there is today.

Discussion Questions

1. I cut away the rock on the ocean floor because this rock was added to the plates as the plates moved apart from each other. Two hundred million years ago, this rock on the ocean floor between the landmasses had not yet formed.
2. I arranged the landmasses so that the coastlines fit together with no gaps. I also made regions with the same fossils touch. If these regions have the same fossils (like the *Mesosaurus*), that means they were once connected.
3. I know that at divergent plate boundaries, plates move away from each other. Rock from the mantle is added to the edges of the plates. This is what happened with Gondwanaland. As the plates moved apart, rock from the mantle was added to the edges of the plates. This formed the oceans that now separate the landmasses. I also know that even though plates move very slowly, over millions of years, they can move great distances.

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Homework

Students revise their Warm-Up predictions of future plate motion based on their new understandings of past plate motion.

Instructional Guide

1. If needed, make additional time to explain homework. If students do not have access to Amplify Science at home, adjust your schedule to make time to complete the Sorting Tool activity in class.

Possible Responses

***Plate Motion* Sorting Tool: Plate Motion Predictions**

The continents labeled "50 Years Later" should be in approximately the same place as the continents labeled "Now." The continents labeled "50 Million Years Later" should be a few centimeters (as shown in the Sorting Tool) farther away from the mid-ocean ridge. After 50 million years, both South America and Africa should be farther apart from each other, and farther from the plate boundary. A possible proficient response is shown below.

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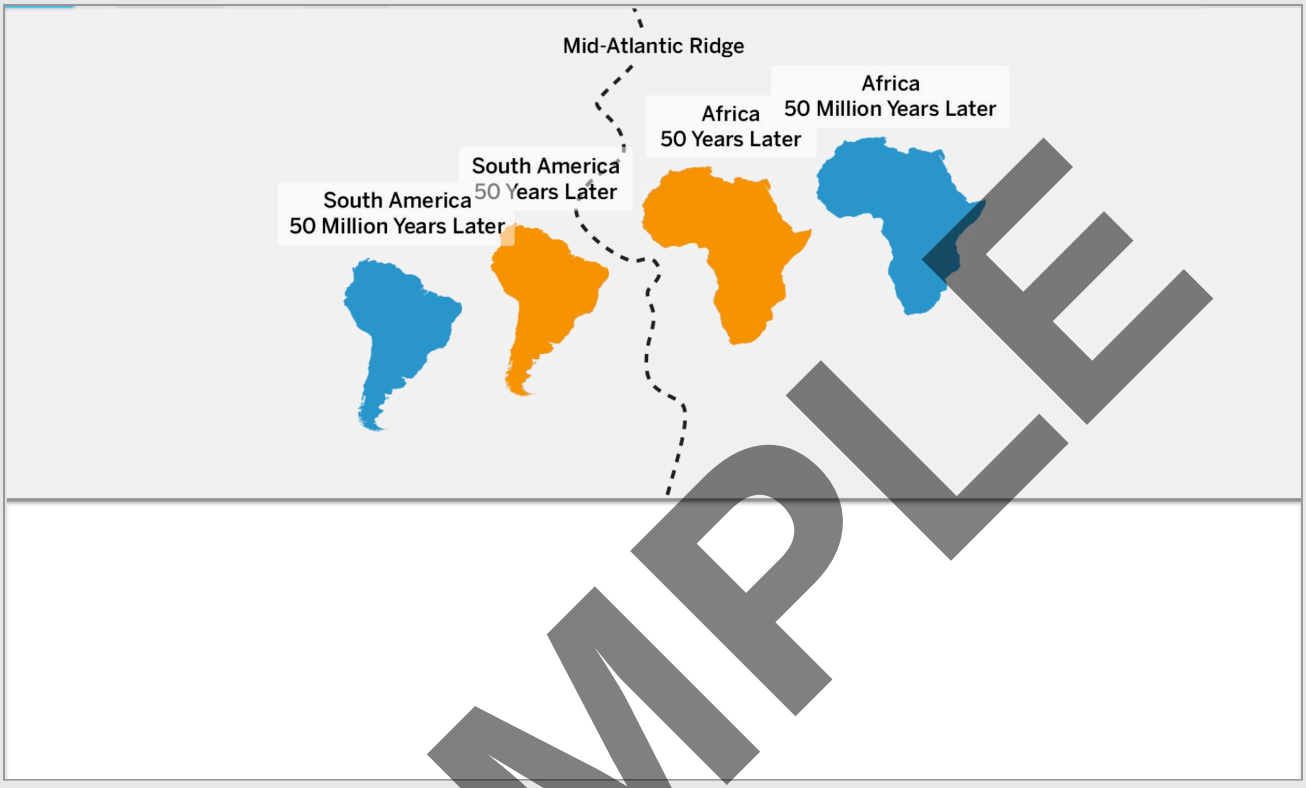

How is your revised response different from your Warm-Up response? Why did you make these changes?
Answers will vary. Example:
I placed the continents labeled "50 Years Later" almost exactly where the continents are today because continents don't move very much in only 50 years. In my Warm-Up response, I showed the continents moving too far for such a short amount of time.

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