Name: _____ Date: _____

Lesson 3.1: Considering Rates of Plate Movement

As you determined in the previous lesson, there is a divergent plate boundary between the South American Plate and African Plate. This means that these plates, and the continents on top of these plates, are moving away from each other. This divergent plate motion explains why the fossil remains of *Mesosaurus* that were once together are now found on continents thousands of kilometers apart. But how did this plate movement happen: suddenly or slowly? How is it even possible to figure out how fast the enormous plates that make up Earth's outer layer can travel over time? In this lesson, you will learn how geologists study plate motion and how they calculate the rate of plate movement.

Unit Question

- Why are fossils of species that once lived together found in different locations on Earth now?

Chapter 3 Question

- How did the *Mesosaurus* fossils on the South American Plate and African Plate get so far apart?

Vocabulary

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

Digital Tools

- *Plate Motion* Simulation
- Optional *Plate Motion* Data Tool activity: Plate Distance vs. Time

Lesson 3.1

Plate Motion Claims

Claim 1: The South American Plate and African Plate moved apart suddenly.

Claim 2: The South American Plate and African Plate moved apart gradually.

25

Lesson 3.1

Plate Movement Map

26

Lesson 3.1

Key Concept

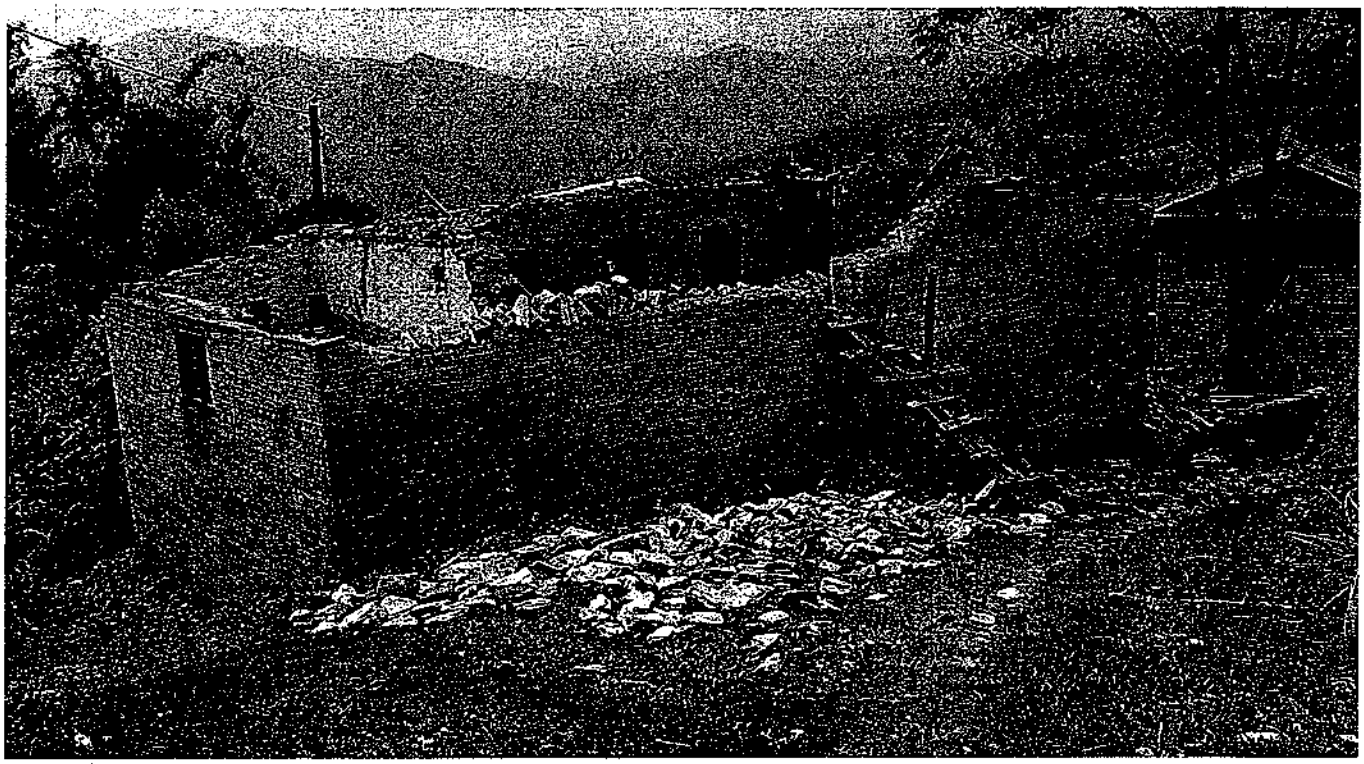
Earth's plates travel at a rate too slow to be experienced by humans.

27

Name: _____ Date: _____

Warm-Up

The building in this photo was damaged during an earthquake.



Can we feel plate movement when there isn't an earthquake?

_____

_____

How far do you think a plate can move in one day?

_____

_____

How far do you think a plate can move in one year?

_____

_____

Video Transcript: Plate Motion and GPS

Geologists use GPS, or Global Positioning System, to track the motion of Earth's plates.

You might be familiar with GPS because smart phones and many cars have built in GPS receivers.

They can work with mapping applications to show you where you are at any time so you might never be lost again.

GPS requires two parts.

A receiver on Earth and satellites in space that send radio signals to the receiver.

Once your receiver gets signals from at least three different satellites, it can accurately calculate your position on Earth.

And if your receiver moves, the GPS system can measure the exact speed and distance you've traveled.

This kind of accuracy makes GPS really useful for geologists who study plate motion.

Plates only move a few centimeters per year, which is very hard to see.

But using GPS, they can easily measure how much the plates are moving.

Geologists can install permanent GPS stations into rock on the Earth's surface to track how much the plates move over time.

This GPS station is not in the same spot it was a year ago.

But we can only tell because the GPS receiver was able to measure the tiny amount of movement that happened.

Plates move such a small distance each year that's it's not really visible to our eyes.

But as the GPS receivers continue to move, geologists can measure these very tiny movements over time.

The readings can measure exactly how fast the plates are moving and in what direction.

So even though we can't observe plates moving with our eyes, geologists can study them using accurate and reliable GPS data.

Name: _____ Date: _____

Observing How Plates Move

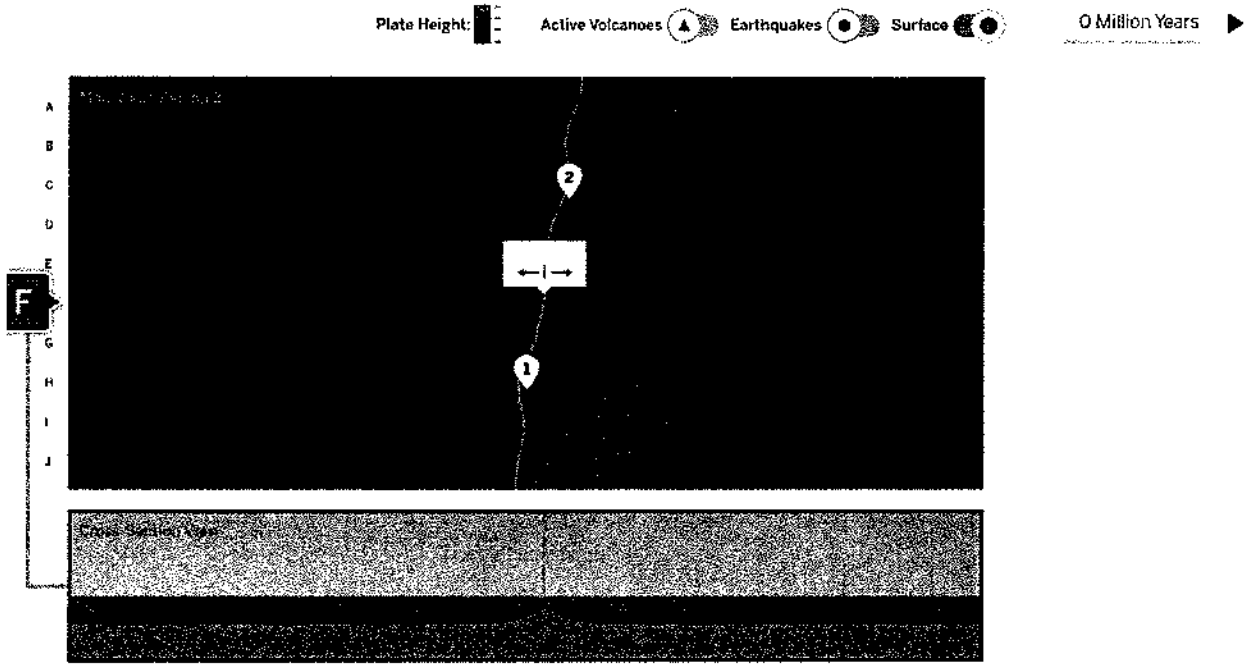
How slowly do plates move? Use the Sim to measure how far plates move from each other over time and use your measurements to calculate the rate of plate motion.

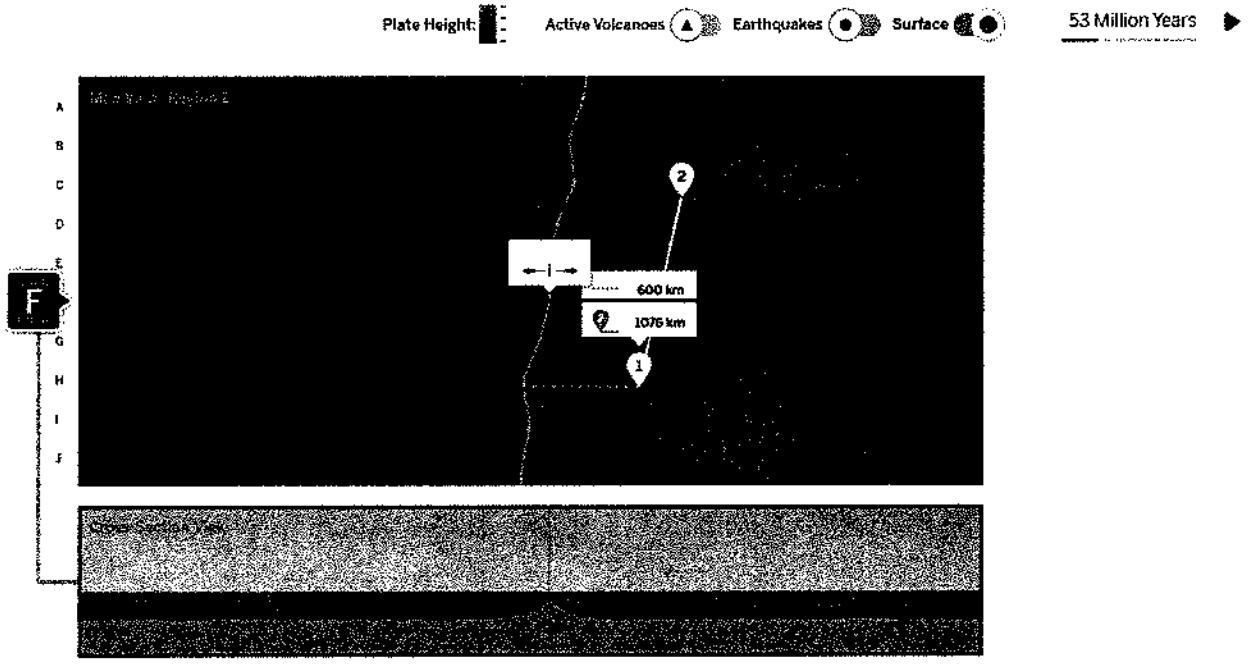
1. Open the *Plate Motion* Sim.
2. Go to Region 2 of the Sim.
3. Add a GPS marker to each plate as close as possible to each other and to the plate boundary.
4. Press SET BOUNDARY and select Divergent as the plate boundary type. Then press RUN.
5. During the run, press Pause approximately every 50 million years. Record the time in the first column of the table below. Observe the distance between the two pins by pressing on either pin and reading the distance to the other and then record that number in the Distance column. You can press the Reset button in the top right corner to replay the Sim.
6. Calculate the rate for each pair of distances and times by dividing the distance by the time. Record those numbers in the Rate column.

Fill out the data table below, using evidence from the Sim.

Time (millions of years)	Distance (km)	Rate (km per million years)

Lesson 3.1 Diverging boundaries





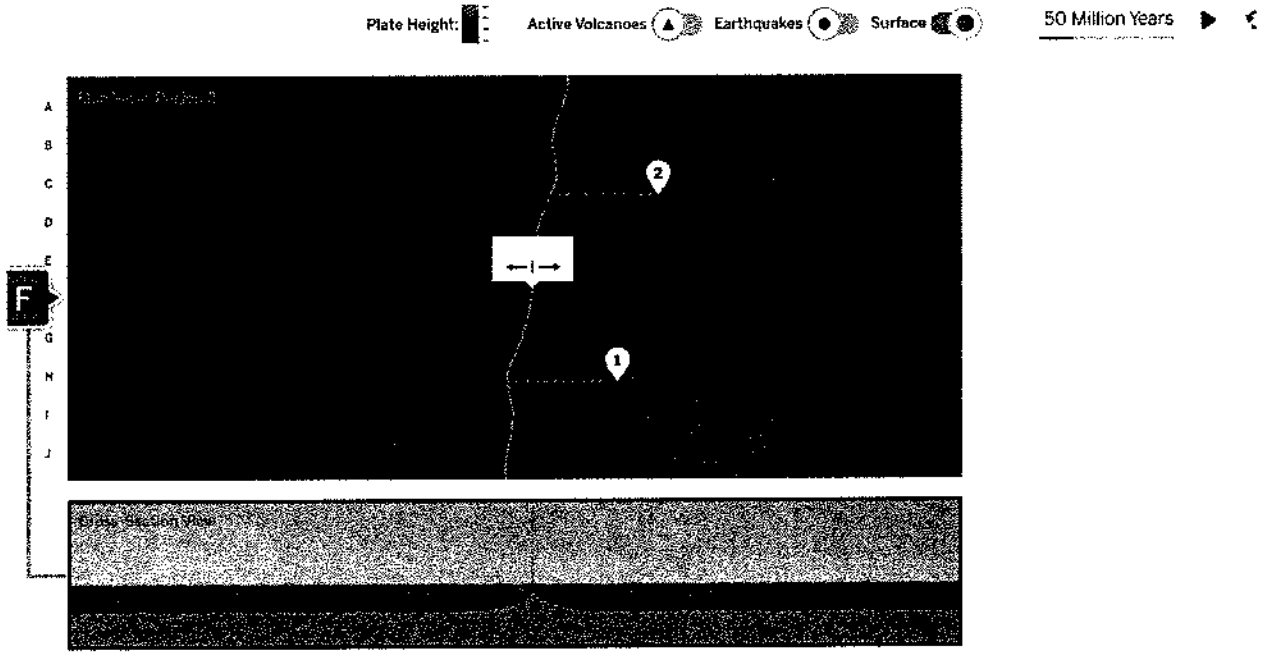


Plate Height:
Active Volcanoes
Earthquakes
Surface
50 Million Years
A
B
C
D
E
F
G
H
I
J
2
1
Cross Section View

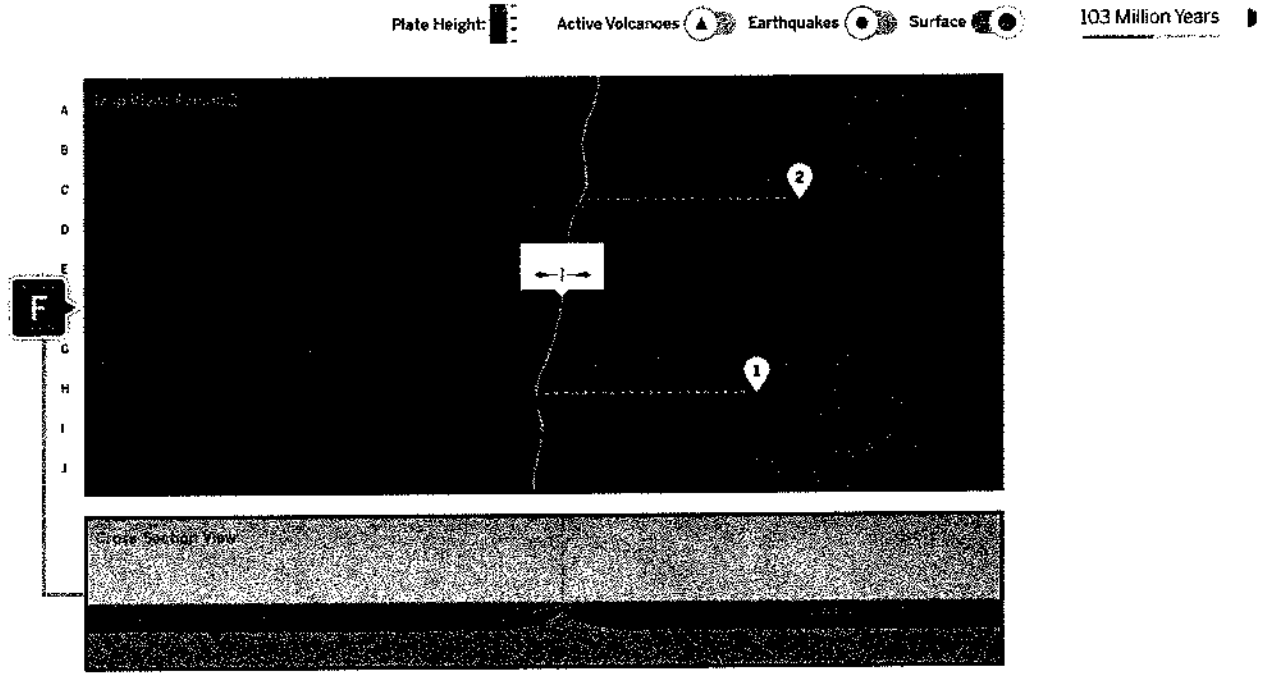


Plate Height:
Active Volcanoes
Earthquakes
Surface
103 Million Years
A
B
C
D
E
F
G
H
I
J
2
1
Cross Section View

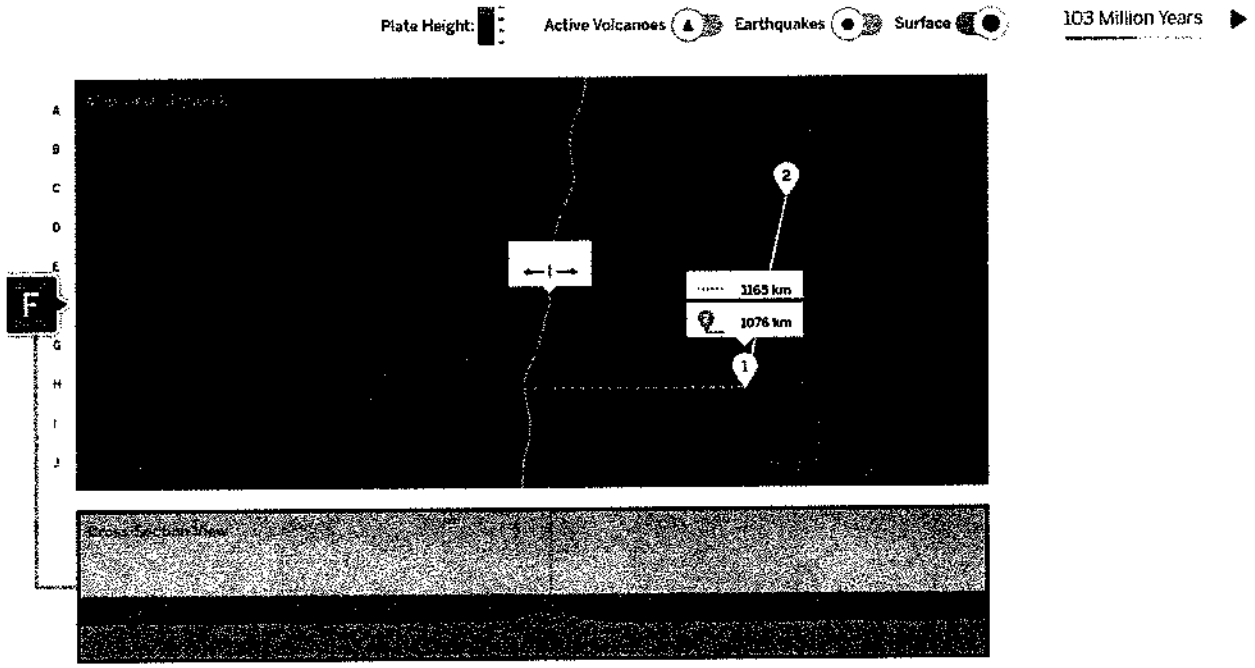


Plate Height:
Active Volcanoes
Earthquakes
Surface
103 Million Years
A
B
C
D
E
F
G
H
I
J
2
1
1165 km
1076 km

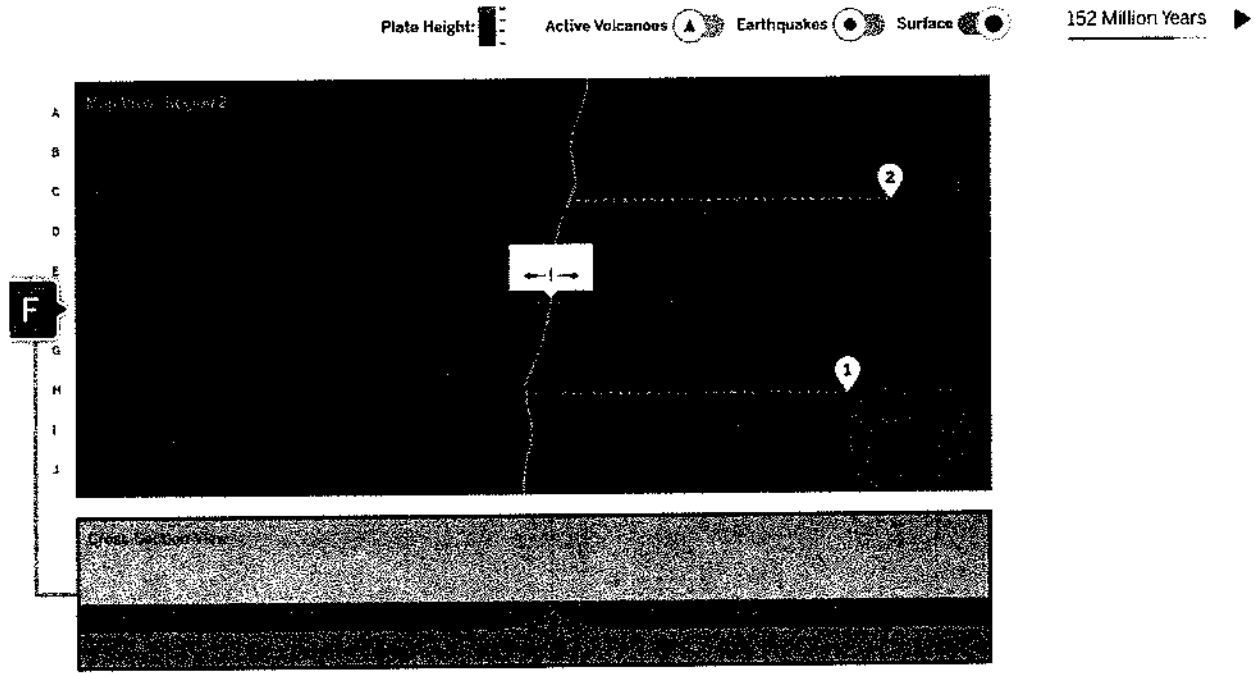


Plate Height:
Active Volcanoes
Earthquakes
Surface
152 Million Years
A
B
C
D
E
F
G
H
I
J
2
1

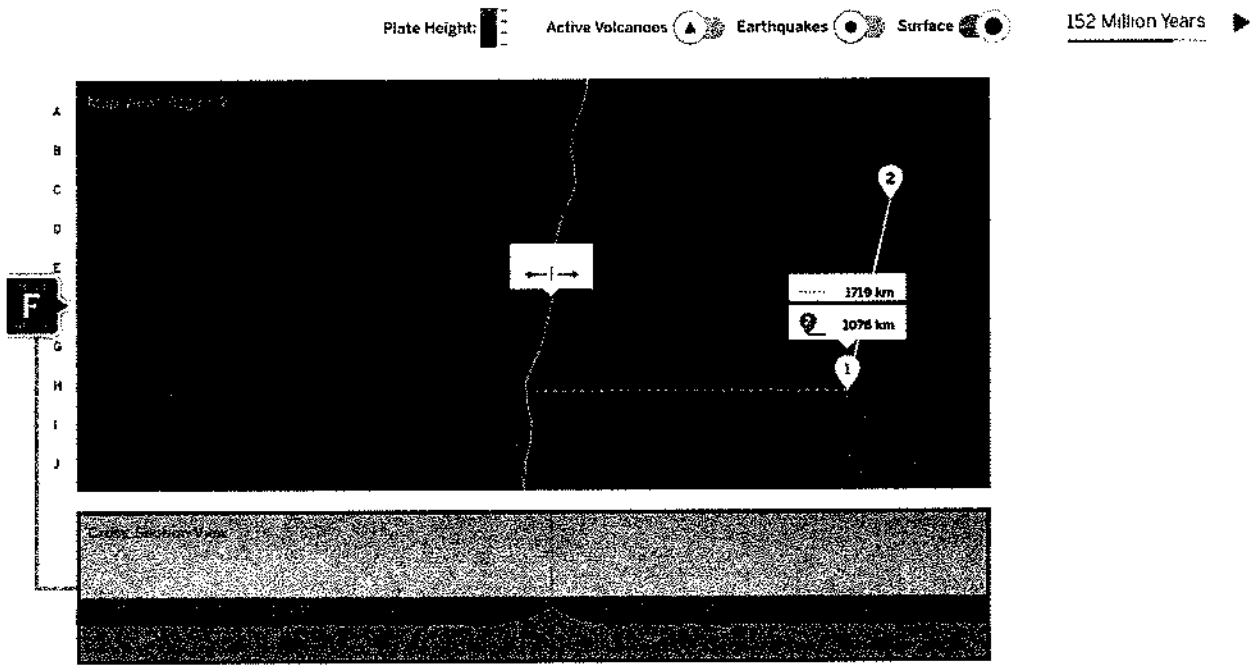


Plate Height:
Active Volcanoes
Earthquakes
Surface
152 Million Years
A
B
C
D
E
F
G
H
I
J
2
1719 km
1076 km
1

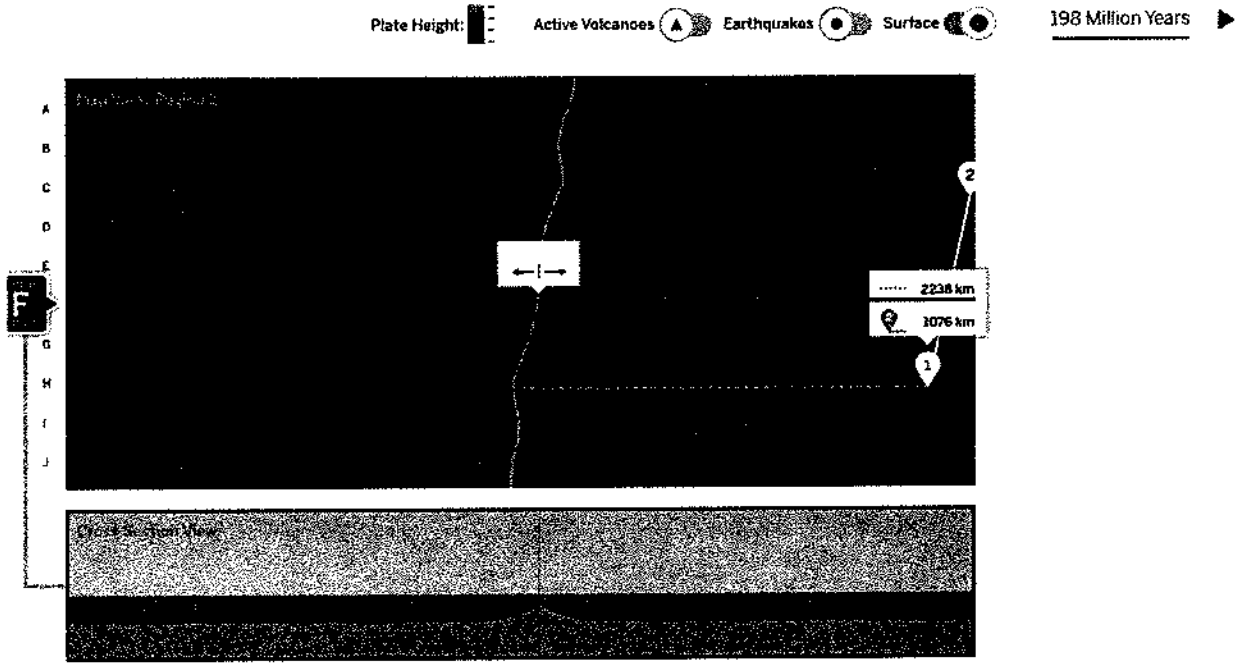


Plate Height:
Active Volcanoes
Earthquakes
Surface
198 Million Years
A
B
C
D
E
F
G
H
I
J
2
2238 km
1076 km
1

Name: _____ Date: _____

Word Relationships

Geologists think about "slow" and "fast" plate motion in special ways because plate motion happens so slowly. Use the ~~Word Relationships Cards~~ word bank to create sentences that answer both of these questions:

What does "moving slow" mean to a geologist?

Why do you think it is difficult to tell that the plate beneath you is moving right now?

- Use at least two different words from the wordbank ~~Word Relationships Cards~~ in each sentence. ~~In your group of four, take turns as both the speaker and the listener.~~
- ~~Your group~~ You may use the same word more than once. You do not need to use all the vocabulary words.
- There are many different ways to answer these questions, and you will need to create more than one sentence in order to express your ideas completely

Word Bank

mantle	outer layer	pattern
plate	plate boundary	rate

Name: _____ Date: _____

Homework: Ideas About the Separation of the *Mesosaurus* Fossils

The Museum of West Namibia wants to know if the *Mesosaurus* fossils were separated in one or a series of quick, huge movements, or if the separation was the result of slow and steady movement.

Given what you learned today, which of the claims below seems best supported? Why? What questions do you still have? Write your response to these questions below, using words from the Word Bank.

Claim 1: The South American Plate and African Plate moved apart **suddenly.**

Claim 2: The South American Plate and African Plate moved apart **gradually.**

Word Bank

mantle	outer layer	pattern
plate	plate boundary	rate

Name: _____ Date: _____

Lesson 3.2: "A Continental Puzzle"

It can be overwhelming to think about the massive changes that have happened on Earth over millions and billions of years. In this lesson, you will read an article about a curious scientist named Alfred Wegener, who thought he was just studying climate but ended up with a lot of evidence about plate motion. Once you have read this article, you will be able to apply this understanding to the *Mesosaurus* fossils and use evidence to better explain how the fossils got so far apart.

Unit Question

- Why are fossils of species that once lived together found in different locations on Earth now?

Chapter 3 Question

- How did the *Mesosaurus* fossils on the South American Plate and African Plate get so far apart?

Key Concepts

- Earth's plates travel at a rate too slow to be experienced by humans.

Vocabulary

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

Digital Tools

- *Plate Motion* Sorting Tool activity: Earth's History

Lesson 3.2

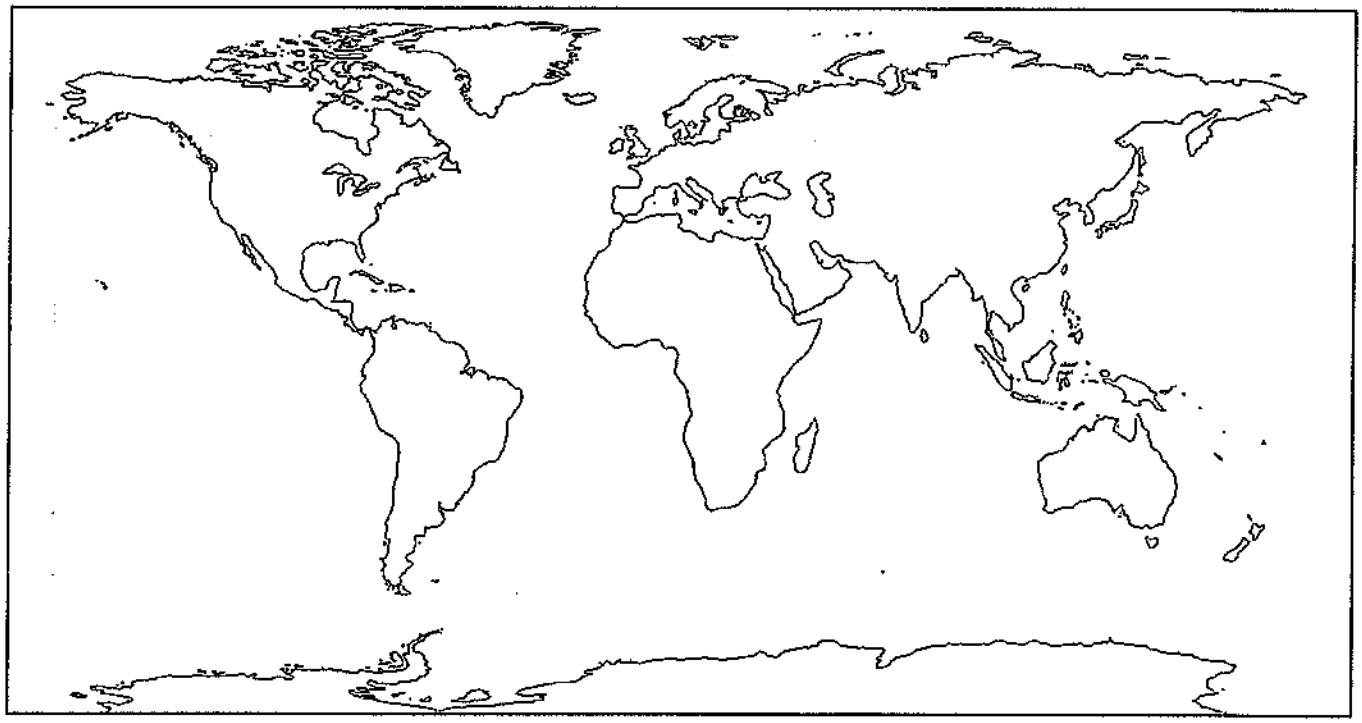
Refer back to the *Active Reading Guidelines* & the *Discussing Annotation* hashtag slides from Lesson 2.2

Name: _____ Date: _____

Warm-Up

Earth's plates are constantly moving. What evidence do scientists use to support this claim?
Hint: You may choose more than one answer.

- ☐ earthquakes
- ☐ volcanic activity
- ☐ GPS measurements
- ☐ They watch the plates move with their eyes.



If Earth's plates are constantly moving, why don't we need to update the locations of continents on world maps (such as the one above) all the time?

_____

_____

_____

_____

Name: _____ Date: _____

The Value of Fossil Evidence

What evidence do we have of past plate motion?

Discuss the following questions with your partner.

1. How can understanding how plates move today help explain how plates moved in the past?
2. How could knowing about past plate motion help explain how the *Mesosaurus* fossils got separated?

Name: _____ Date: _____

Reading "A Continental Puzzle"

1. Read and annotate the article "A Continental Puzzle."
2. Choose and mark annotations to discuss with your partner. Once you have discussed these annotations, mark them as discussed.
3. Now, choose and mark a question or connection, either one you already discussed or a different one you still want to discuss with the class.
4. Answer the reflection question below.

Rate how successful you were at using Active Reading skills by responding to the following statement:

As I read, I paid attention to my own understanding and recorded my thoughts and questions.

- ☐ Never
- ☐ Almost never
- ☐ Sometimes
- ☐ Frequently/often
- ☐ All the time

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.

Name: _____ Date: _____

Homework: Rereading "A Continental Puzzle"

Scientists pay attention to patterns they observe in the natural world. A pattern can often provide evidence and help explain how something works, or why something has happened. In "A Continental Puzzle," you read about Alfred Wegener. Wegener made a claim that continents used to fit together, but have moved apart from each other.

Reread the section titled "Evidence of Change on Earth's Surface" in "A Continental Puzzle" and pay close attention to the patterns that Wegener used as evidence for his claim. As you read, annotate information about patterns and then answer the questions below.

1. What patterns did Wegener use as evidence for his claim?

2. What do you think a scientist should do if they discover an interesting pattern in the world that no one else has described, but they cannot explain what is causing the pattern?

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.

Name: _____ Date: _____

Lesson 3.3: Reconstructing Gondwanaland

In this lesson, you will interpret the evidence scientists use to understand past plate motion. To accomplish this, you will return to the article about Alfred Wegener. After closely rereading part of the article, you will complete an activity that challenges you to think about evidence of past plate motion the way Wegener did.

Unit Question

- Why are fossils of species that once lived together found in different locations on Earth now?

Chapter 3 Question

- How did the *Mesosaurus* fossils on the South American Plate and African Plate get so far apart?

Key Concepts

- Earth's plates travel at a rate too slow to be experienced by humans.

Vocabulary

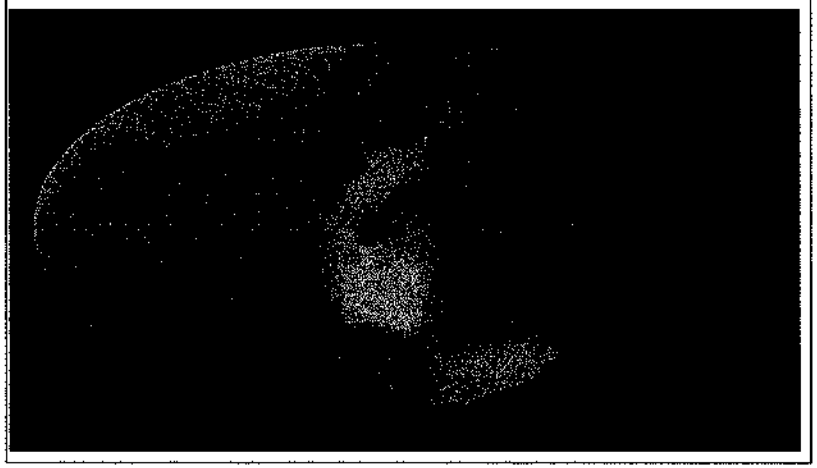
- analyze
- claim
- convergent
- cross section
- divergent
- earthquake
- evidence
- mantle
- mid-ocean ridge
- outer layer
- pattern
- plate
- plate boundary
- rate
- scientific argument
- trench
- volcanic activity

Digital Tools

- *Plate Motion* Sorting Tool activity: Plate Motion Predictions

Lesson 3.3

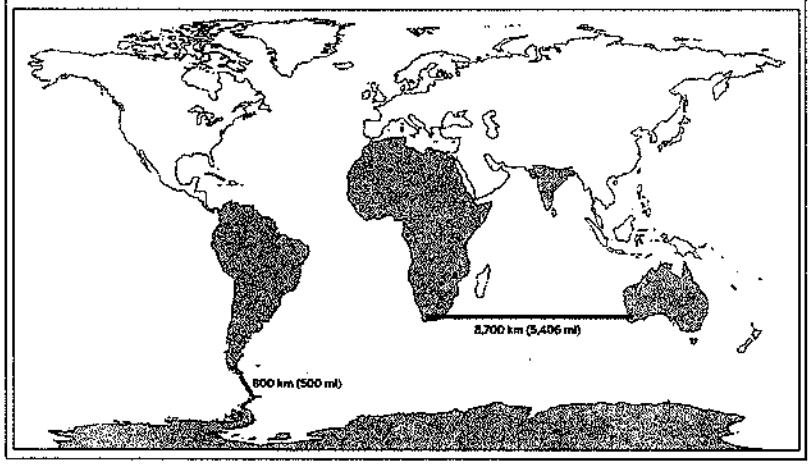
Map of Pangea



29

Lesson 3.3

World Map: Today



30

Lesson 3.3

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?

31

Lesson 3.3

Discussion Question 2

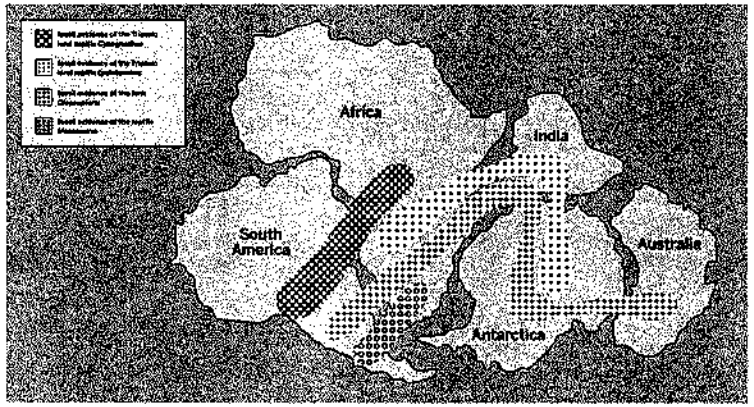
After cutting away the hard, solid rock that makes up the ocean floor, what was your strategy for putting the landmasses of Gondwanaland back together, as they were 200 million years ago?

32

Discussion Question 3

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

Map of Gondwanaland 200 Million Years Ago



Key Concept

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

Name: _____ Date: _____

Warm-Up

Use the Plate Motion Predictions Worksheet (Next Page)
~~Open the Sorting Tool activity~~: Plate Motion Predictions and follow the instructions below. You'll be revising this response for homework.

When your model is complete, press HAND IN. If you worked with a partner, write their name here:

_____

Goal: Show where you think South America and Africa will be located 50 years from now and 50 million years from now.

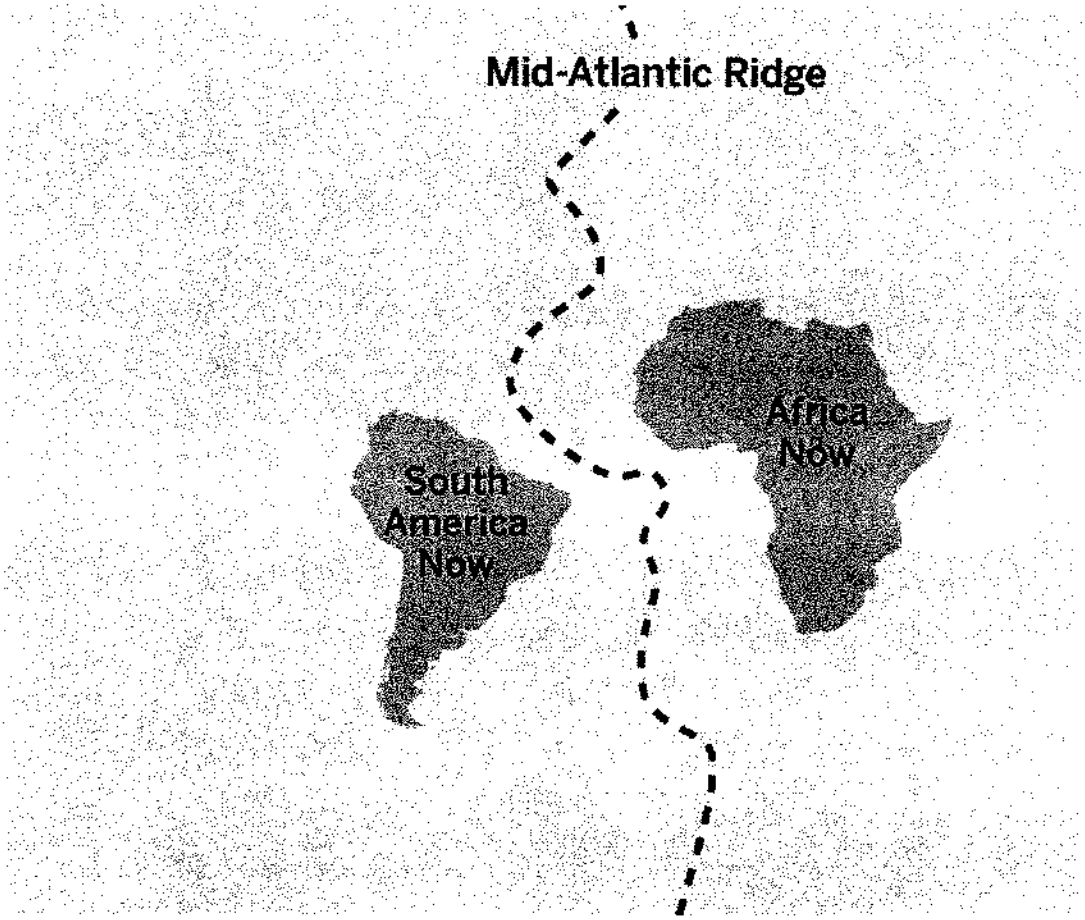
Do: CUT & PASTE

- ~~Place~~ the continents labeled "50 Years Later" and "50 Million Years Later" to indicate where you think they will be located at those times.

Tip:

- The gray continents shown on the map indicate the current locations of South America and Africa.

Plate Motion Predictions (Warm Up)



South America
50 Million Years Later

Africa
50 Million Years Later

South America
50 Years Later

Africa
50 Years Later

Name: _____ Date: _____

Rereading "A Continental Puzzle"

By rereading a portion of the article "A Continental Puzzle," you will be able to answer the Investigation Question: *What evidence do we have of past plate motion?*

Read and annotate the first three paragraphs in the "Evidence of Change on Earth's Surface" section. Highlight or annotate any important information you find and then answer the questions below.

How did Wegener use the shapes of the continents as evidence that the continents had moved?

_____

_____

_____

How did Wegener use the similar mountain ranges and areas made of certain types of rock found in Africa and South America as evidence that these two continents were once connected?

_____

_____

_____

How did Wegener use fossils as evidence that continents had moved?

_____

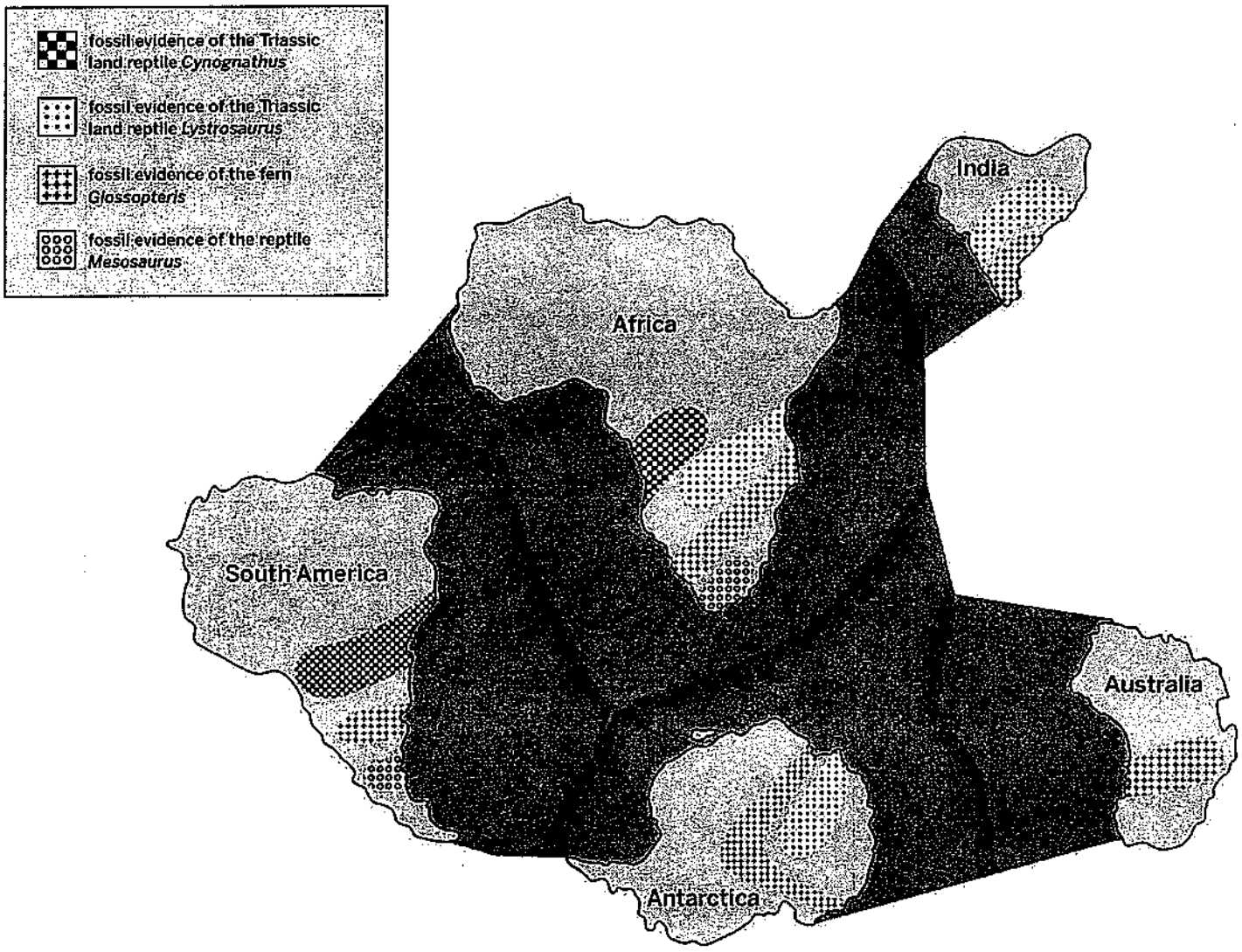
_____

_____

Name: _____ Date: _____

Reconstructing Gondwanaland

Part 1: Map of Gondwanaland Today



Discussion Questions

- 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?

Name: _____ Date: _____

Reconstructing Gondwanaland (continued)

Part 2: Reconstructing Gondwanaland

Instructions found on next page

1. Gather the map, a glue stick, and a blank sheet of paper.
2. Cut away and discard the white space on your map.
3. Cut the plates apart along the plate boundaries. These boundaries are found in the middle of the oceans.
4. Cut away the ocean floor. This hard, solid rock formed between the landmasses over the last 200 million years.
5. Use the fossil evidence and the shapes of the landmasses to reconstruct Gondwanaland as it was 200 million years ago.
6. Glue your Gondwanaland to the blank sheet of paper.

Discussion Questions

- Why did you cut away the hard, solid rock on the ocean floor that formed between the landmasses over the last 200 million years?
- 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?
- How did your knowledge of plate motion help you complete the Gondwanaland puzzle?

Gondwanaland Puzzle

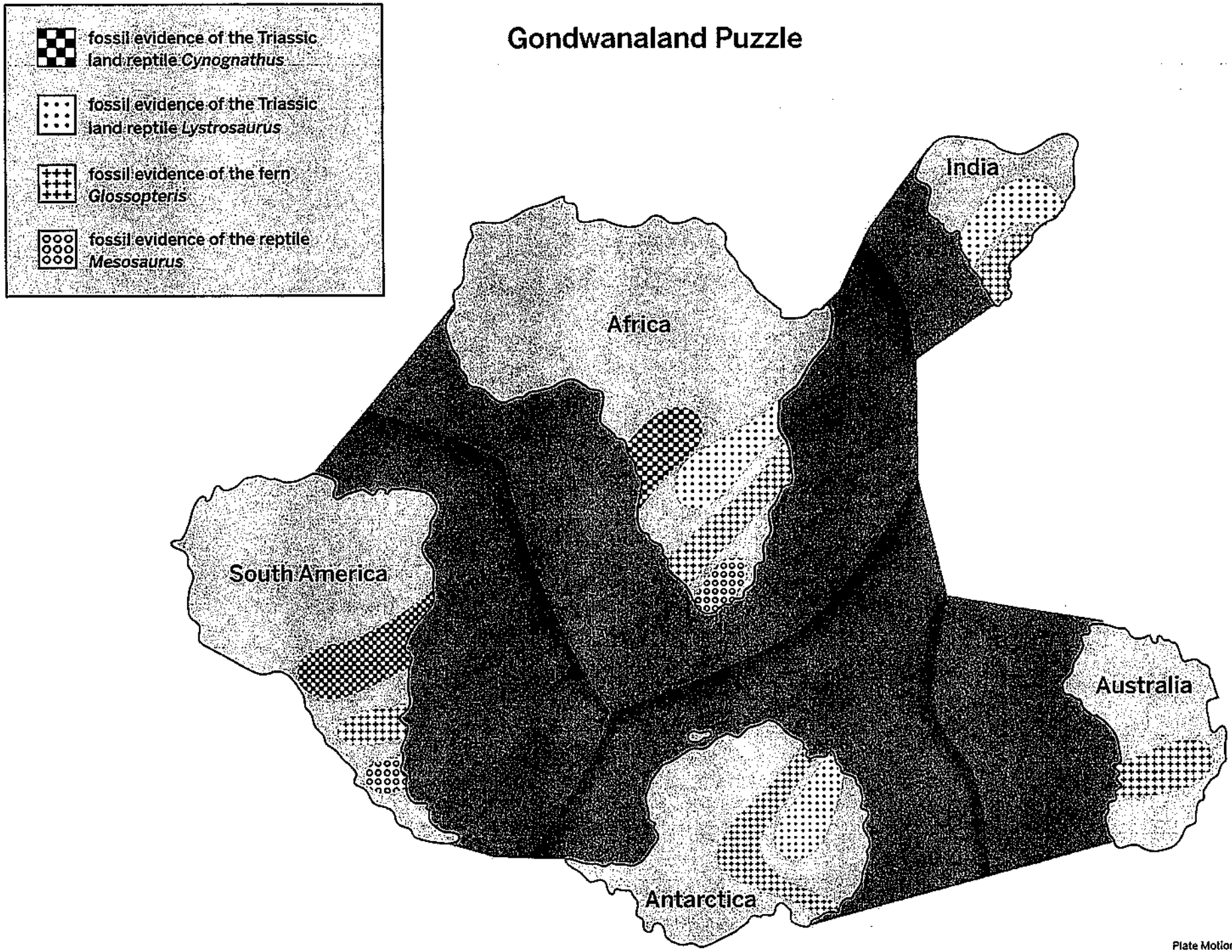


Plate Motion—Lesson 3.

Name: _____ Date: _____

Homework: Revising Your Predictions

Look Back at Warm Up:

~~Open the Sorting Tool activity~~: Plate Motion Predictions and revise your response, if needed. By recreating (CUT & PASTE)

When your model is complete, press HAND IN. If you worked with a partner, write their name here:

_____

Goal: Show where you think South America and Africa will be located 50 years from now and 50 million years from now.

Do:

- Place the continents labeled "50 Years Later" and "50 Million Years Later" to indicate where you think they will be located at those times.

Tip:

- The gray continents shown on the map indicate the current locations of South America and Africa.

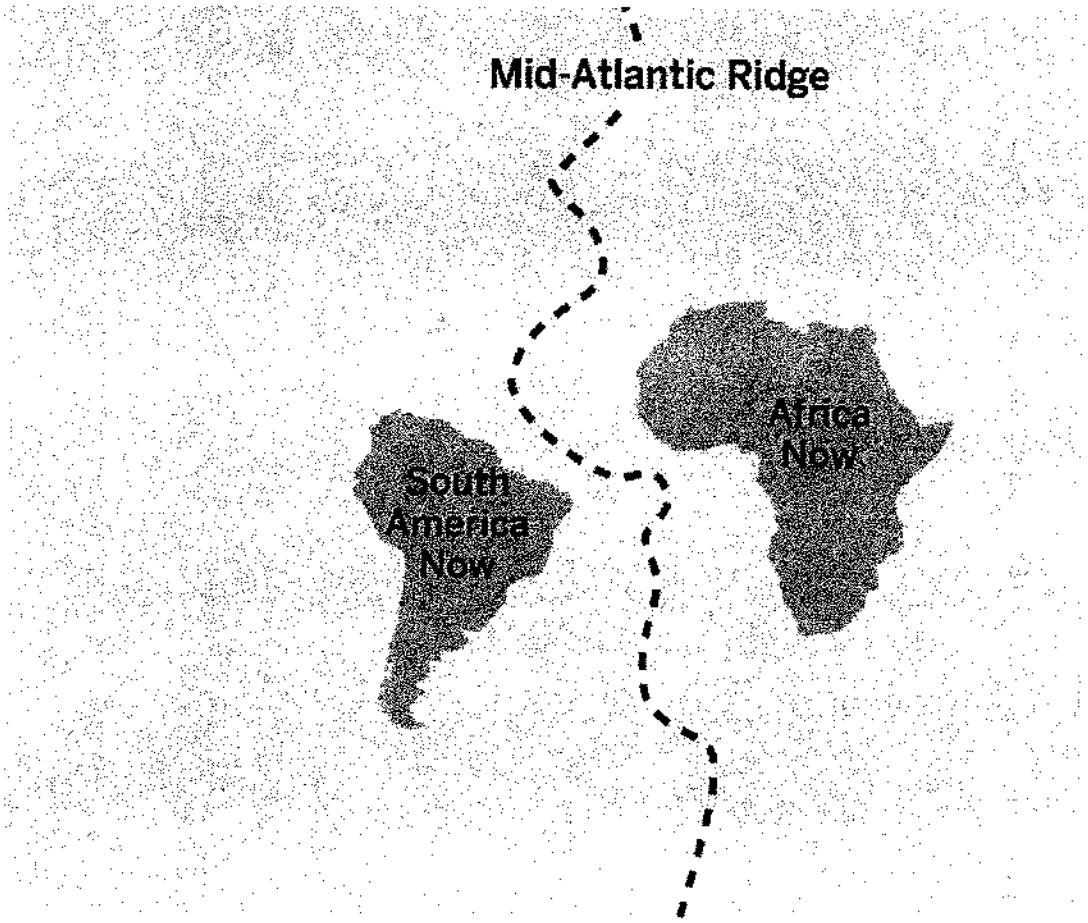
How is your revised response different from your Warm-Up response? Why did you make these changes?

_____

_____

_____

Plate Motion Predictions — REVISED –



South America
50 Million Years Later

Africa
50 Million Years Later

South America
50 Years Later

Africa
50 Years Later

Name: _____ Date: _____

Modeling Plate Boundaries

Part 1: Planning and Creating a Divergent Plate Boundary Model

Answer questions 1 and 2 to make a plan for your divergent boundary model.

1. What are you planning to show in your model?

_____

_____

2. What are you not planning to show in your model?

_____

_____

~~Examine the~~ Use any materials available, then answer the question below. When you have completed your explanation, ~~have one partner~~ gather the materials you need and begin building your model.

3. What materials will you use to show the different parts of your model? Explain why you chose each material.

_____

_____

_____

_____

Share your model: After creating your model, practice explaining how it works with your partner. You will be showing another group how your model works. In your explanation, include what your model shows well and does not show well about plate movement and plate boundaries. Be sure to use the words listed in the Word Bank below in your explanation.

Take a picture and submit on google classroom.

Word Bank

divergent	earthquake	mantle	mid-ocean ridge
plate	plate boundary	rate	volcanic activity

Name: _____ Date: _____

Modeling Plate Boundaries (continued)

Part 2: Planning and Creating a Convergent Plate Boundary Model

Answer questions 1 and 2 to make a plan for your convergent boundary model.

1. What are you planning to show in your model?

_____

_____

2. What are you not planning to show in your model?

_____

_____

Consider the materials available, then answer the question below. When you have completed your explanation, ~~have one partner~~ gather the materials you need and begin building your model.

3. What materials will you use to show the different parts of your model? Explain why you chose each material.

_____

_____

_____

_____

Share your model: After creating your model, practice explaining how it works with your partner. You will be showing another group how your model works. In your explanation, include what your model shows well and does not show well about plate movement and plate boundaries. Be sure to use the words listed in the Word Bank below in your explanation.

Word Bank Take a picture and submit on google classroom.

convergent	earthquake	mantle	plate
plate boundary	rate	trench	volcanic activity

Name: _____ Date: _____

Modeling Plate Boundaries (continued)

Part 3: Critiquing Your Models

Divergent Boundary Model

1. How did your model show a divergent boundary well?

2. What are some characteristics of plate boundaries that your model did not show accurately? Is there anything that you planned on showing that you could not?

Name: _____ Date: _____

Modeling Plate Boundaries (continued)

Part 3: Critiquing Your Models (continued)

Convergent Boundary Model

3. How did your model show a convergent boundary well?

4. What are some characteristics of plate boundaries that your model did not show accurately? Is there anything that you planned on showing that you could not?

Name: _____ Date: _____

Lesson 3.4: Writing About *Mesosaurus*

It's almost time! Dr. Moraga needs to know how the *Mesosaurus* fossils got so far apart from each other, and by the end of this lesson, you'll be ready to explain that to him. In the meantime, you and your fellow student geologists will review the evidence and discuss how it can be used to make the most convincing scientific argument to Dr. Moraga and his team at the Museum of West Namibia.

Unit Question

- Why are fossils of species that once lived together found in different locations on Earth now?

Chapter 3 Question

- How did the *Mesosaurus* fossils on the South American Plate and African Plate get so far apart?

Key Concepts

- Earth's plates travel at a rate too slow to be experienced by humans.
- 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
- reasoning
- scientific argument
- trench
- volcanic activity

Digital Tools

- *Plate Motion* Simulation

Lesson 3.4

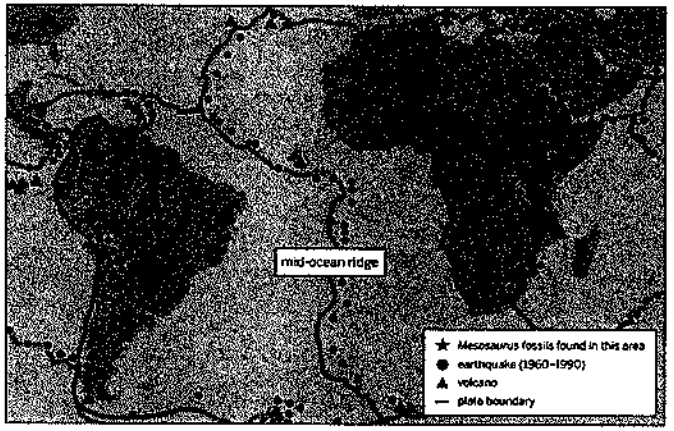
Plate Motion Claims

Claim 1: The South American Plate and African Plate moved apart suddenly.

Claim 2: The South American Plate and African Plate moved apart gradually.

Lesson 3.4

Plate Boundary Evidence Map



Lesson 3.4

Reasoning Tool

How does the evidence support or refute the claim?

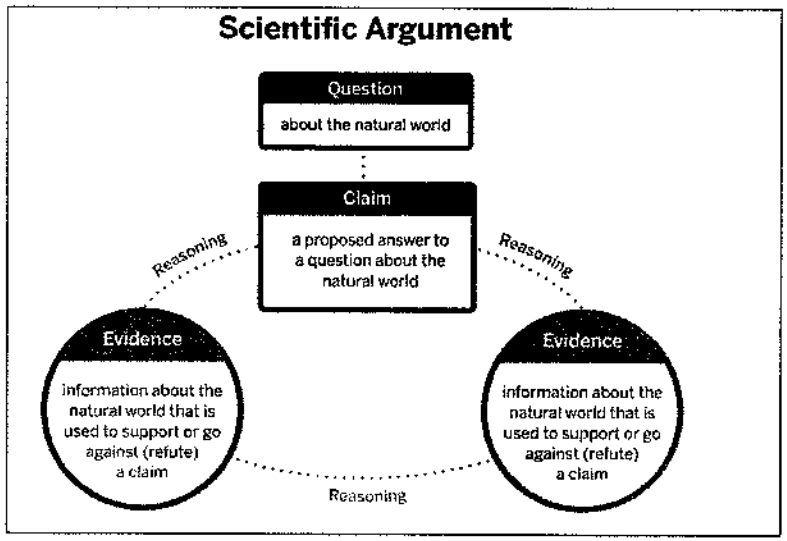
Evidence	This matters because . . . (How does this evidence support or refute the claim?) →	Therefore, . . . (claim)

Lesson 3.4

A scientific argument . . .

- **begins with a question.**
- **has a claim that proposes an answer to the question.**
- **has evidence that supports the claim.**
- **clearly explains how the evidence supports the claim (reasoning).**

Lesson 3.4


Scientific Argument
Question
about the natural world
Claim
a proposed answer to a question about the natural world
Reasoning
Reasoning
Evidence
information about the natural world that is used to support or go against (refute) a claim
Evidence
information about the natural world that is used to support or go against (refute) a claim
Reasoning

Name: _____ Date: _____

Warm-Up

Use the fossil function in the Sim to re-create what happened to the *Mesosaurus* fossils over time.

1. Open the Sim.
2. Select Region 3. Use the Add Rock tool to set up the land as it was when the *Mesosaurus* was alive.
3. Drag and drop fossils onto the land.
4. Add GPS markers near two fossils, one on each side of the plate boundary.
5. Press SET BOUNDARY and select the plate boundary type.
6. Press RUN and observe what happens to the fossils.
7. How far apart are the fossils after 200 million years? Is this what happened to the *Mesosaurus* fossils? If not, press BUILD and try setting up the landscape differently.
8. After you have re-created what happened to the *Mesosaurus* fossils in the Sim, describe what happened to the fossils below.

_____

_____

_____

Be prepared to discuss the following questions with a partner.

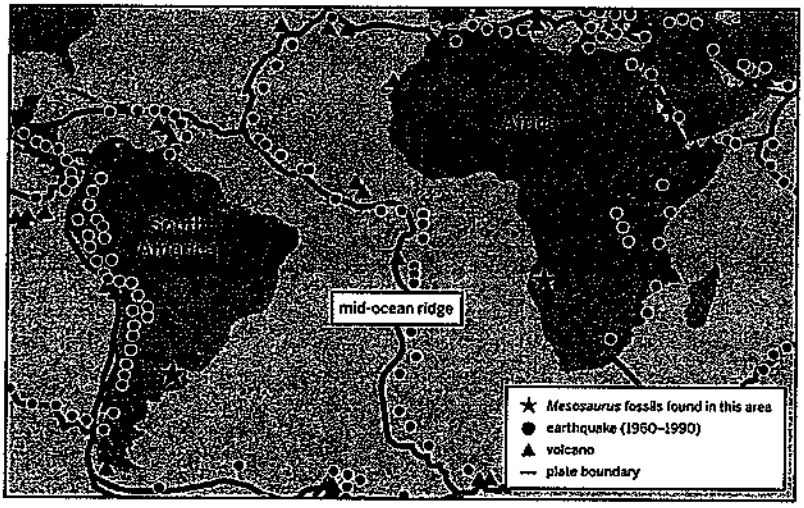
Discussion Questions

- What happened to the fossils over time in the Sim?
- How is this similar to what you know about *Mesosaurus* fossils? How is this different from what you know about *Mesosaurus* fossils?
- What can you observe about how Earth's surface changed over time?

Name: _____ Date: _____

Examining Evidence About Plate Motion

Read the evidence cards below. Then, record any notes you think will help you better understand the evidence and help you prepare to write your final argument.



Evidence Card A

Earthquakes occur in a pattern along the plate boundary between the South American Plate and African Plate.

Evidence Card B

A mid-ocean ridge landform is found along the plate boundary between the South American Plate and African Plate.

Evidence Card C

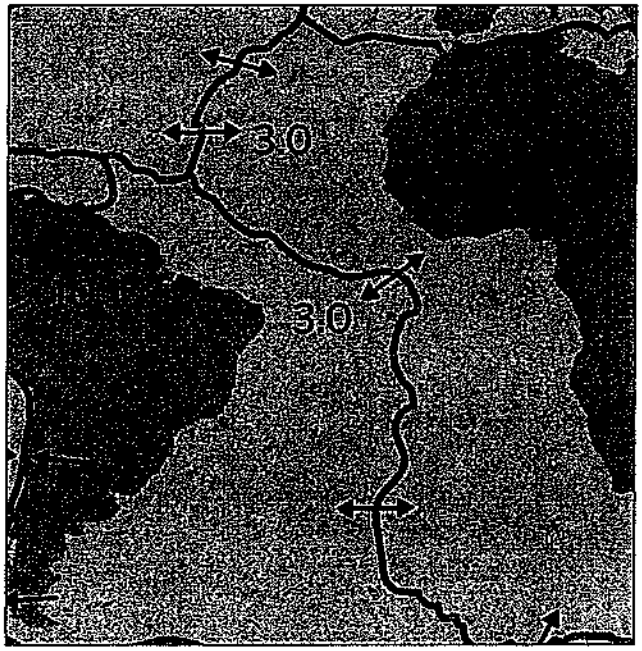
Volcanic activity happens in a pattern along the plate boundary between the South American Plate and African Plate.

Notes about this evidence:

Name: _____ Date: _____

Examining Evidence About Plate Motion (continued)

Read the additional evidence card below. Then, record any notes you think will help you better understand the evidence and help you prepare to write your final argument.



Evidence Card D

The continents of South America and Africa, where *Mesosaurus* fossils are located, are currently about 4,000 km apart and separated by the Atlantic Ocean. GPS measurements show that the South American Plate and African Plate are currently spreading apart from each other at a rate of 3.0 cm per year.

Notes about this evidence:

Name: _____ Date: _____

Reasoning About Plate Motion

With your group, use the Reasoning Tool to connect each piece of evidence to the claim you think is strongest.

Question: How did the *Mesosaurus* fossils on the South American Plate and African Plate get so far apart?

Claim 1: The South American Plate and African Plate moved apart **suddenly**.

Claim 2: The South American Plate and African Plate moved apart **gradually**.

Evidence	**This matters because . . .**	**Therefore, . . .** (claim)
A. Earthquakes occur in a pattern along the plate boundary between the South American Plate and African Plate.		
B. A mid-ocean ridge landform is found along the plate boundary between the South American Plate and African Plate.		
C. Volcanic activity happens in a pattern along the plate boundary between the South American Plate and African Plate.		
D. The continents of South America and Africa, where *Mesosaurus* fossils are located, are currently about 4,000 km apart and separated by the Atlantic Ocean. GPS measurements show that the South American Plate and African Plate are currently spreading apart from each other at a rate of 3.0 cm per year.		

Name: _____ Date: _____

Homework: Advising the Museum of West Namibia

Use the notes you recorded about the evidence and the work you did with your group using the Reasoning Tool to help you write a message to Dr. Moraga about the *Mesosaurus'* history. You may wish to use some of the vocabulary words listed in the Word Bank below to help you write.

Question: How did the *Mesosaurus* fossils on the South American Plate and African Plate get so far apart?

Claim 1: The South American Plate and African Plate moved apart **suddenly.**

Claim 2: The South American Plate and African Plate moved apart **gradually.**

Word Bank

plate	plate boundary	rate
convergent	divergent	pattern

Write a message to Dr. Bayard Moraga explaining how the Museum of West Namibia's exhibit should tell the story of the *Mesosaurus.*

First, state your claim about how the *Mesosaurus* fossils got separated. Then, use evidence to support your claim. For each piece of evidence you use, explain how the evidence supports your claim.

Name: _____ Date: _____

Homework: Check Your Understanding

This is a chance to reflect on your learning so far. This is not a test. Be open and truthful when you respond to the questions below.

Scientists investigate in order to figure things out. Are you getting closer to figuring out why the fossils of *Mesosaurus* that once lived together are found in different locations on Earth now?

1. I understand what Earth's outer layer is made of underneath the water and soil on the surface. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

2. I understand what happened with the plates and the mantle between South America and Africa. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

3. I understand what happens with the plates and the mantle when two plates move toward each other. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____