Seafloor Spreading Lesson Plan
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(2-3) 90 min periods

Summary:
Seafloor spreading is the basis for the modern theory of Plate Tectonics. It is the process by which new seafloor is created as the plates are pulled apart and new material emerges in the center gap. As seafloor ages and moves outward, it often eventually collides with continents and is destroyed causing catastrophic earthquakes and volcanoes. This is the life cycle of the seafloor. Main points of this presentation are: 1) New seafloor forms at seafloor spreading centers and spreads out to both sides of the middle causing the symmetric/mirror image pattern of seafloor ages and magnetic stripes; 2) Seafloor forms at different rates in different oceans, but always has the same mirrored pattern; 3) Because seafloor spreading occurs on a sphere, the spreading center is broken up into many "ridge segments" that are connected by other features called transform faults and fracture zones; 4) Seafloor is destroyed at areas called subduction zones, where the seafloor dives underneath another plate and into the mantle; 5) The deepest places on earth (called Trenches) are associated with subduction zones and are located near the coasts of the continents (in most cases); 6) Subduction causes devastating earthquakes and explosive volcanoes, many of which are located around the coasts of the Pacific ocean and termed the "Ring of Fire"; 7) The Pacific ocean is shrinking over time due to subduction, while the Atlantic ocean is growing because it has no subduction.

Materials:
PopQuiz_SeafloorSpreadingUnit.doc (1 per student, two versions)
Lecture_SeafloorSpreading.ppt Lecture Slides (including presenters notes contained within the powerpoint)
4 Rolls of Paper Towels
Worksheet_SF_Spreading.doc (1 per student)
Internet Connection
Worksheet_SeafloorSpreadingModel.doc Instructions/Questions (1 per student)
Activity_SeafloorSpreadingModel.pdf Packet (1 per group)
Cardstock for printing 1 page per group
Tape, Scissors
DVD of "How the Earth was Made: Ring of Fire" (available on instant Netflix)
Worksheet_RingOfFire_Video.doc (1 per student)

Documents:
Activity_SeafloorSpreadingModel.pdf
Lecture_SeafloorSpreading.ppt
Lesson_Plan_SeafloorSpreading.pdf
PopQuiz_SeafloorSpreadingUnit.doc
Worksheet_SeafloorSpreadingModel.doc
Worksheet_SF_Spreading.doc

Worksheet_RingOfFire_Video.doc

Prep: Set up the paper towel spreading center so it's ready to go when the slides are done. Sandwich the loose ends of two rolls of paper towels back-to-back between two desks. Let the rolls stay on the floor so they will unravel when students pull on the loose ends. Repeat this set up adjacent to the first two desks, but offset the paper towel "ridges" so "transform faults" and "fracture zones" will form.

Lesson Plan & Instructions:

1. Warm up: Pop Quiz! This pop quiz asks students to recall the evidence for Continental Drift and the patterns observed in seafloor ages and magnetic stripes.
2. Present the first part of the Lecture Slides (annotated in detail on each slide). Have students take notes if you wish.
3. Ask for volunteers to pull on the edges of the paper towel spreading centers while the rest of the class observes. Draw arrows on the paper towel showing spreading motion and discuss the different features (ridge segments, transform faults, fracture zones) that develop. Students should draw a picture of what they see.
4. Distribute *Worksheet_SF_Spreading.doc* for students to complete (this can be completed as homework).
5. Present the second part of the Lecture Slides (annotated in detail on each slide). Have students take notes if you wish.
6. Divide students in to groups of about two to complete the *Activity_SeafloorSpreadingModel.pdf* Activity and Questions (on the *Worksheet_SeafloorSpreadingModel.doc*). Detailed images of the steps in the activity are shown below.
7. Show the video "How the Earth was Made: Ring of Fire." During the video, students should fill out *Worksheet_RingOfFire_Video.doc*. They should be allowed to use this to study for the exam. See additional notes below.

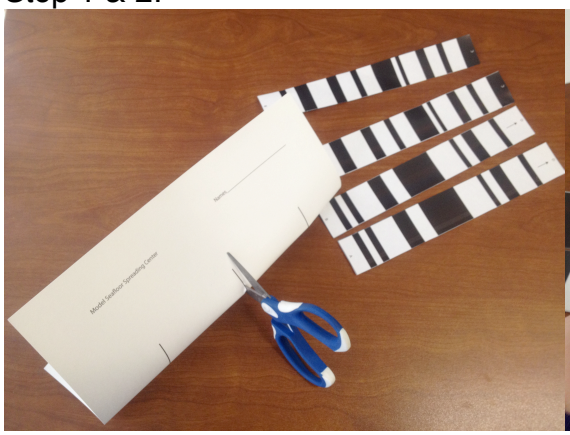
Additional Notes for "How the Earth was Made: Ring of Fire" Video
This is an excellent video for solidifying the concepts learned in this unit. However, there are a few details in the video that are out of the scope of this lesson and I recommend skipping through these parts. Below is a list of times at which I suggest stopping and starting the video in order to avoid the extraneous materials. In total, with the cuts, the video is about 30 minutes. Without the cuts, it is 45 minutes. A more advanced class will have no problem understanding the full video.

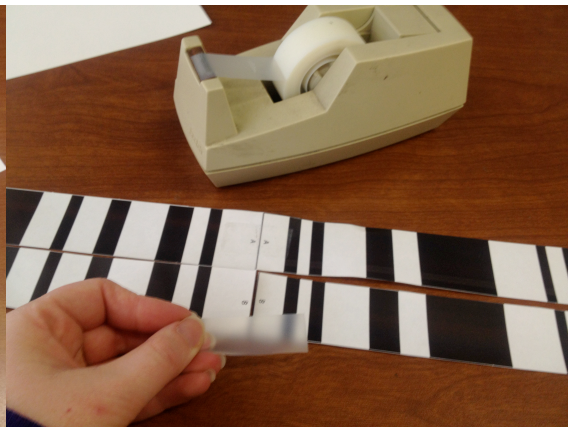
Play from beginning
stop at 11:49
start at 17:39
stop at 20:55
start at 24:45
stop at 33:33

start at 36:45
stop at 37:40
start at 38:50
Play until the end

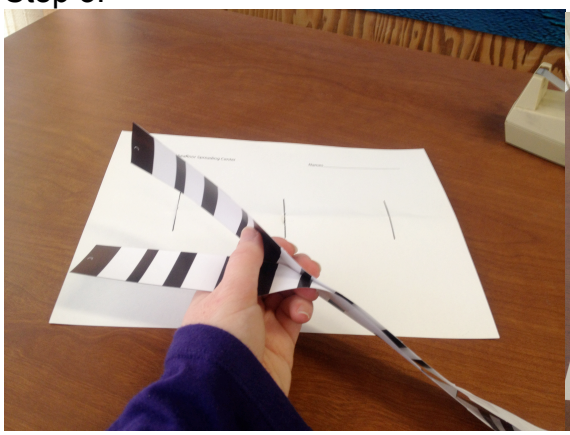
Activity Instructions (Seafloor Spreading Model)

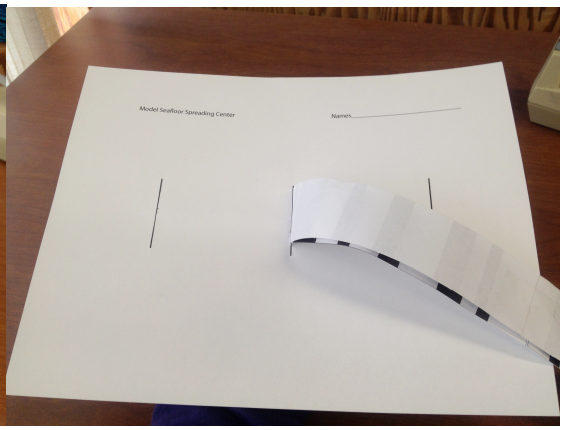
Step 1 & 2:



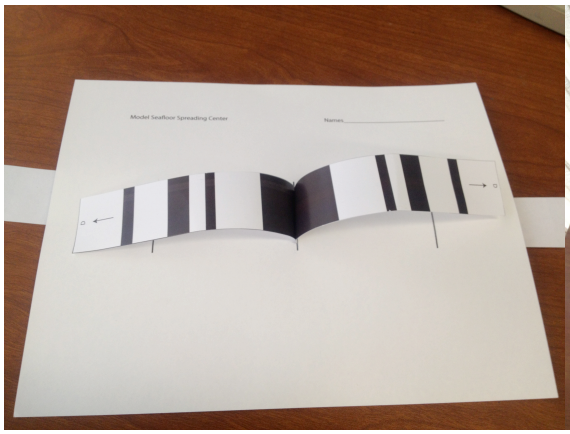


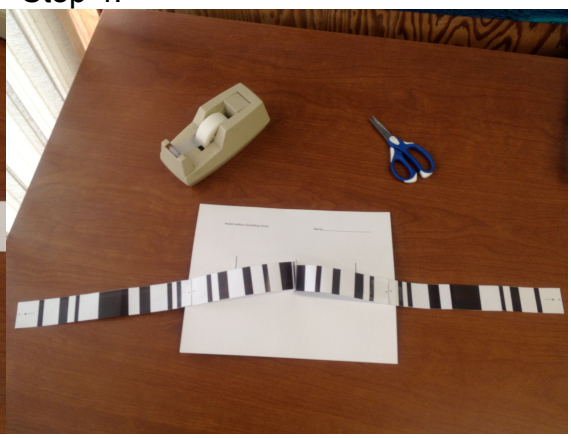
Step 3:



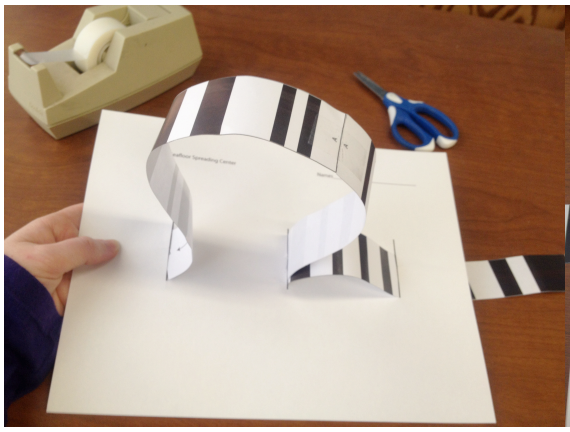


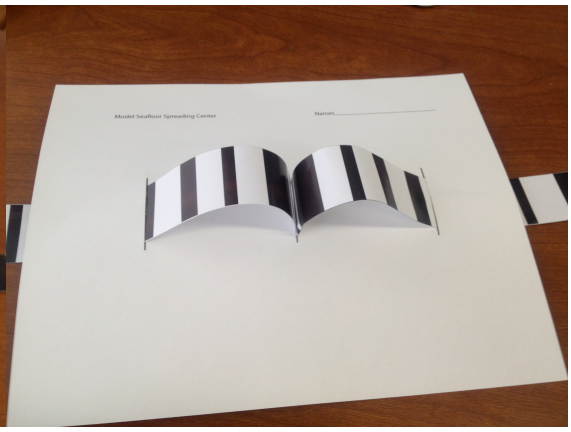
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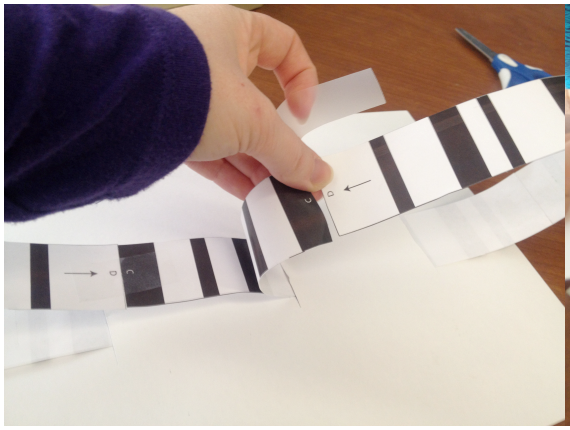


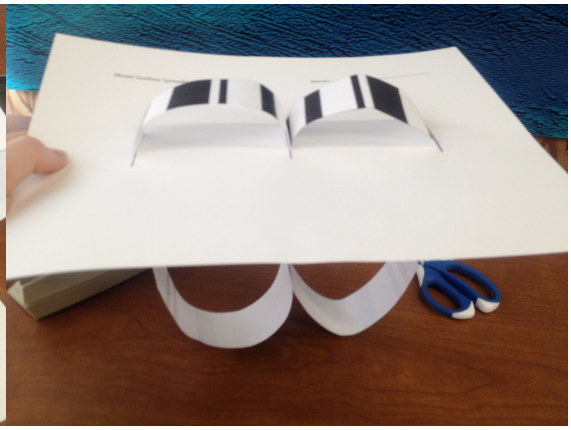


Step 5:

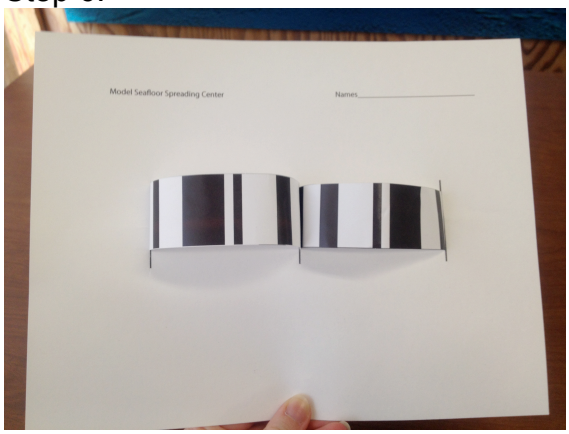



Model Seafloor Spreading Center
Names





Step 6:


Model Seafloor Spreading Center
Names

Seafloor Spreading Unit Pop Quiz! **Name_____Key_____**
Ver. 1
To get credit, make sure you read the question carefully and answer the question asked. Answer the following questions in complete sentences.

1. What are THREE main pieces of evidence that support Continental Drift?

1) The fit/shape of the continents.
2) Common land plant and animal fossils among now separated continents.
3) Matching mountain chains bridging now separated continents.
4) Glacial markings on continents that are no longer in cold climates.

2. What is the PATTERN seen in the magnetic stripes on the seafloor?

The pattern observed is a symmetric (or mirror-image or reflection) pattern.

3. What is the PATTERN seen in the ages of the seafloor? Within the pattern, where is the seafloor OLDEST and where is it YOUNGEST?

The pattern observed is a symmetric (or mirror-image or reflection) pattern.
The youngest seafloor defines the symmetry axis and oldest seafloor is furthest away from the axis.

4. What is the MAIN REASON that scientists did not believe Wegener's idea of Continental Drift?

Scientists could not come up with a reasonable force that would be large enough to move the massive continents.

Seafloor Spreading Unit Pop Quiz! **Name_____**
Ver. 2
To get credit, make sure you read the question carefully and answer the question asked. Answer the following questions in complete sentences.

1. What is the PATTERN seen in the magnetic stripes on the seafloor?

2. What are THREE main pieces of evidence that support Continental Drift?

3. What is the MAIN REASON that scientists did not believe Wegener's idea of Continental Drift?

4. What is the PATTERN seen in the ages of the seafloor? Within the pattern, where is the seafloor OLDEST and where is it YOUNGEST?

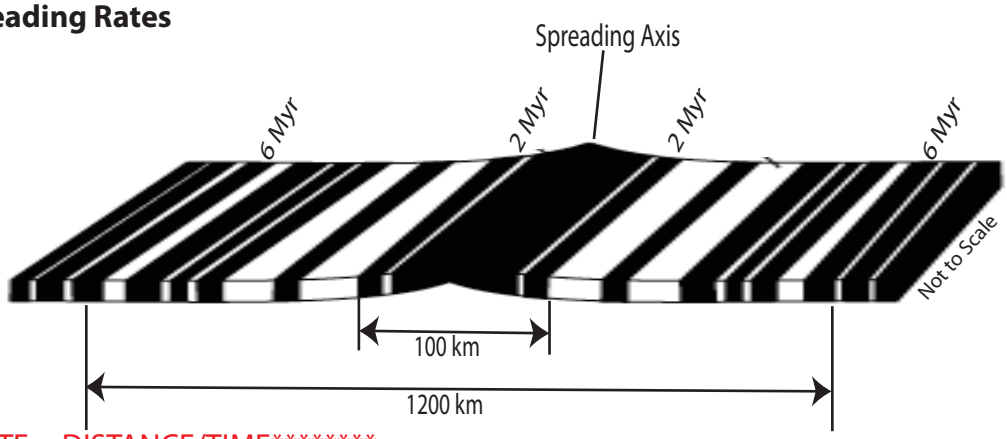
Seafloor Spreading Worktsheet

Page 1

Name_____

Period_____

Part A: Spreading Rates



********RATE = DISTANCE/TIME********

To calculate the Full Spreading Rate (FSR) of a spreading center, you must figure out how much new seafloor was created on each side of the spreading center in how many years. For example, if 200 km of seafloor was created on each side (400 km total) in 10 Million years, the FSR is 40 km/Myr (400km ÷ 10Myr). Using the diagram above, answer the following questions:

1) What is the average FSR during the most recent 2 Myr?

50 km/Myr (100 km divided by 2 Myr)

2) What is the average FSR during the most recent 6 Myr?

200 km/Myr (1200 km divided by 6 Myr)

3) Has the spreading rate changed at all in the past 6 Myr? How do you know?

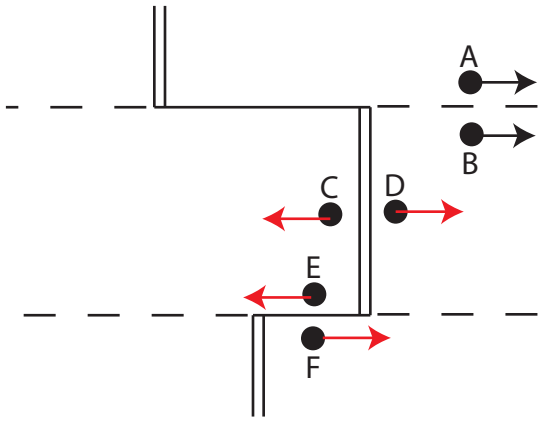
Yes, the spreading rate has changed over time. We know this because at 6 Ma the average spreading rate was 200 km/Myr, but for the last 2 Myr the average rate is 50 km/Myr. (extra credit: the average spreading rate between 2-6 Myr was 275 km/Myr (unrealisticcally high value obtained by [1200 km-100 km]/[6Myr-2Myr])).

4) Was the spreading rate fast, intermediate, or slow 6 Myr ago? 200 km/Myr is FAST

Part B: Spreading Center Features

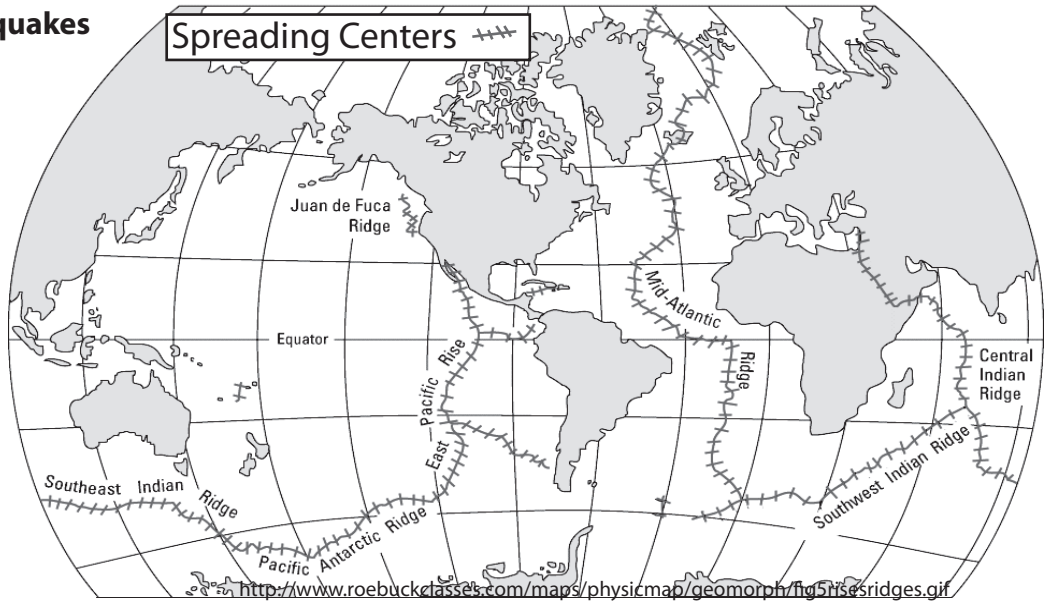
1) Draw arrows on each dot showing which way it will move as the seafloor spreads:

2) Below, circle the type of plate feature each pair of dots is associated with:

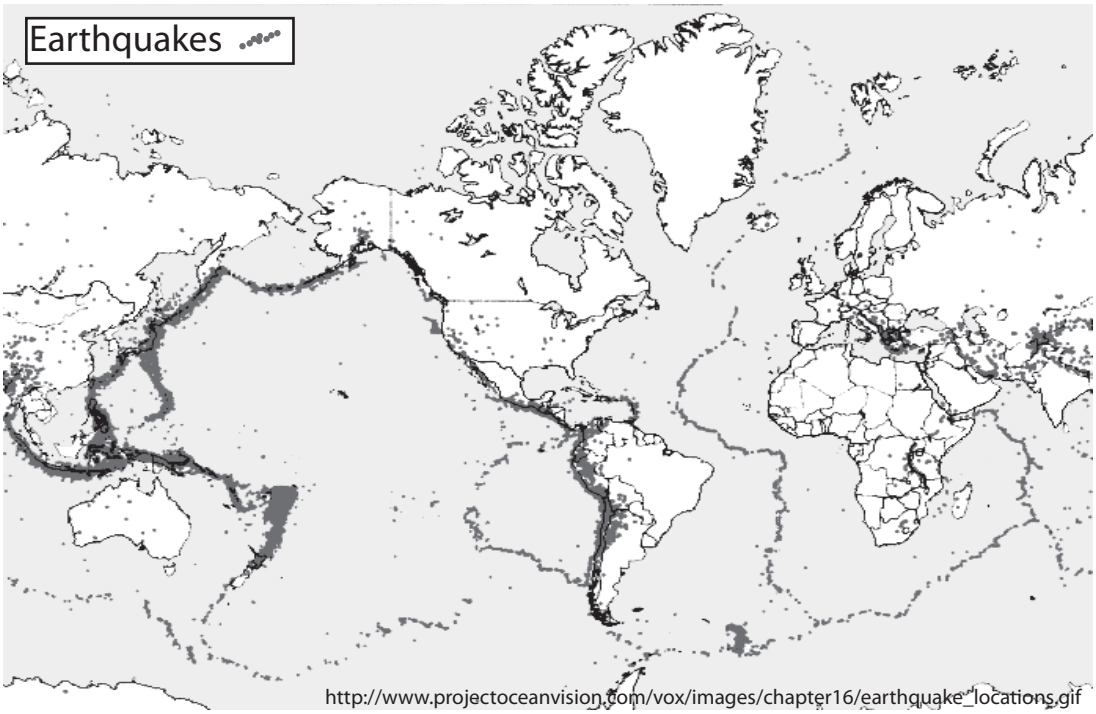


A, B	C, D	E, F
Ridge Segment	(Ridge Segment)	Ridge Segment
Transform Fault	Transform Fault	(Transform Fault)
(Fracture Zone)	Fracture Zone	Fracture Zone

Part C: Earthquakes at Spreading Centers



http://www.roebuckclasses.com/maps/physicmap/geomorph/fig5rises_ridges.gif



http://www.projectoceanvision.com/vox/images/chapter16/earthquake_locations.gif

The two maps above show the locations of all spreading centers (top) and locations of global earthquakes (bottom). Hint: It may help to color the spreading centers and earthquake with a color so they stand out.

1) What do you notice about the spreading center and earthquake locations?

The earthquakes trace the seafloor spreading centers.

2) Where do you notice other earthquakes that aren't on spreading centers?

Other earthquakes are seen nearer to the continents (not in the middle of the ocean basins), like on the east coast of Asia or the west coast of South America. These earthquakes are not on spreading centers.

3) What do you think causes these "non-spreading center" earthquakes?

These "non-spreading center" earthquakes are caused by the destruction of the seafloor at the oceanic plate dives beneath the adjacent plate in a process called subduction.

Seafloor Spreading Center Activity **Name ____KEY_____**

Keywords:
Seafloor Spreading
Ridge Segment
Subduction

Materials:
Seafloor Strips Handout
Cardstock Handout
Scissors, Tape

Review Questions: What is the Pacific Ring of Fire? What causes it?
An area of active volcanoes and earthquakes that surrounds the coasts of the Pacific Ocean. It is caused by subduction.

Instructions:

1. Cut out the 4 strips of seafloor from seafloor strips handout. Tape the letters A together and the letters B together so you have two long strips that have the same striped pattern.
2. Cut 2-inch slits along the three lines printed on the cardstock.
3. Hold the two strips of seafloor so the letters C are lined up with the pattern facing inwards, and feed the ends with the letters C into the center slit of the cardstock until only about 2 inches remain above the cardstock.
4. Slowly pull the two strips of seafloor horizontally in opposite directions toward the arrows. Stop and answer the first three questions.
5. Now feed the ends of the strips with the letter D into the two side slits. Tape the letter D to the letter C so you have two loops of seafloor.
6. Slowly pull the two strips of seafloor in opposite directions, the same way you did before. As you pull, push the edges of the seafloor back down into the outside slits. Stop and answer the remaining questions.

Questions:

1. What happens to the seafloor as you continue to pull on the strips in step 4?
The seafloor gets wider and keeps spreading.

2. What happens to the oldest seafloor in Step 4?
The oldest seafloor continues to spreading farther apart.

3. Step 4 is an example of which ocean on Earth?
Atlantic Ocean

4. What happens to the oldest seafloor in Step 6?
It is destroyed as it dives back into the Earth (subduction).

5. Step 6 is an example of which ocean on Earth?
Pacific Ocean

6. Would you expect more earthquakes to occur for the setup in Step 4 or Step 6? How do you know?
More earthquakes would occur for Step 6 because the plates are subducting. There is more contact between plates.

7. Will the Atlantic Ocean grow or shrink over time?
Grow

8. Eventually, what will happen to the Pacific ocean?
It will Shrink over time and eventually disappear.

Ring of Fire Video Question Sheet **Name ___KEY_____**

Instructions: Answer the following questions as you watch the "Ring of Fire" video. Take additional notes on the back, especially if we stop the video to discuss something.

Questions:

1. What continents are circled by the Ring of Fire?
South America, North America, Eastern Asia, (New Zealand, Alaska)

2. What is a Stratovolcano?
A tall, pointy volcano with violent explosive eruptions.

3. Why does thick lava make explosive volcanoes?
Gas bubbles are trapped in thick lava and as the lava rises, the bubbles expand and cause explosions.
4. How does water get below the volcanoes in the Ring of Fire?
Water is trapped in the oceanic crust and dragged into the Earth by subduction. It is carried into the Earth along with the oceanic plate.
5. What two main natural hazards surround the Ring of Fire?
Earthquakes and Volcanoes.

6. What happens when water and hot rock mix deep underground?
The water causes the rock to melt and form magma.

7. What was the biggest earthquake in North America?
Alaska 1964

8. Draw or describe the side-view of earthquake depth locations.
Earthquakes are shallower towards the trench and get deeper moving inland.

9. What are the deepest areas on the planet called and where are they?
The deepest areas are called Trenches or Subduction Trenches, and they occur away from the middle of the oceans.
10. What will happen to Hawaii and parts of California in the future?
Since they are part of the Pacific plate, Hawaii and parts of California will move north/northeast and eventually be subducted.
11. Draw a picture of a seafloor spreading center and a subduction zone connected by an oceanic plate.

