Activity Overview

Students build a paper model to illustrate sea-floor spreading. Through a thought experiment, students learn how crust is created and destroyed at divergent plate boundaries. Students look at a world plate tectonic map to explore the different types of plate boundaries. They then describe the plate tectonic setting of their own community. Content reading defines the three types of plate boundaries and the different features that are commonly associated with each boundary type

Preparation and Materials Needed

Part A: Observing Plate Motions and Plate Interactions
This part of the investigation requires quite a lot of preparation. You will need to familiarize yourself with how the material is to be prepared, in order to help the students as they do the preparation. You might make up a set of instructions for the students, or have them read the material here. Some of the groups will be more adept at setting up this investigation than others. It might be useful to encourage the groups to help each other as needed.

Materials

- Three wooden dowels, 3/4 inch or 1 inch in diameter and about 12 inches long
- Two pieces of 2 x 4 lumber, each about 12 inches long
- A length of fan-fold computer paper, about four feet long, cut in half lengthwise to make two long pieces, each about 6 inches wide
- Scotch tape
- Straightedge ruler
- Marker pens
- Stapler

To set up the experiment:

(1) Lay the two long strips of paper side by side.
(2) With the ruler and marker pens, draw identical sets of “magnetic stripes” across the strips of paper, alternating between white and black stripes. The stripes could be anywhere from one cm to three or four cm wide. Vary the widths of the stripes. Number each set of stripes with identical numbers.
(3) Tape the high-number end of each strip to one of the dowels. Roll up the strip tightly onto the dowel, the way a window shade is rolled up.
(4) Set the rolls back-to-back on a tabletop. Make sure that the loose ends of each of the paper strips come out upward from between the dowels. See the upper diagram on page 77 of the Student Book. Holding the dowels loosely together, pull out about twelve inches of each strip. Keep the stripe numbers matched up as they come off the dowels.

(5) Lay one of the pieces of 2× 4 lumber on the table, parallel to the dowels and about six inches away from it. Staple the loose end of the paper strip to the upper edge of the pieces of 2× 4 lumber. With the marker pen, label the piece of 2× 4 lumber "continent."

(6) Lay the third dowel on the table parallel to the other dowels and about nine inches away from them, on the side opposite the continent. Lay the other piece of 2 x 4 lumber next to the dowel, on the side away from the other two dowels. Label it subduction zone. See the lower diagram on page 77 of the Student Book.

(7) Run the loose end of the other paper strip over the third dowel and under the piece of 2 × 4 lumber labeled "subduction zone." See the lower diagram on page 77 of the Student Book.

The idea is for the students in the group to cooperate in pulling the two strips of paper off the dowels at exactly the same rate, so that the "magnetic stripes" are "produced" (i.e., appear as they come off the dowels) in matched pairs.

Part C: Plate Boundaries on World Maps

Make photocopies of the world map found on page 68 of the Student Book so students don't have to flip back and forth through the book. Make a copy of the **Blackline Master** of the world map.

Part D: The Plate Tectonic Setting of Your Community

Have a copy of the map *This Dynamic Planet* (USGS) for each student group.

Materials

- 3 wooden dowels: 3/4 inch or 1 inch in diameter and about 12 inches long
- 2 pieces of 2× 4 lumber: approximately 12 inches long
- A length of fan-fold computer paper, about four feet long, cut in half lengthwise to make two long pieces, each about 6 inches wide
- Scotch tape
- Straightedge ruler
- Marker pens
- Stapler
- Blank world map
- Markers or colored pencils of two different colors
- Map of *This Dynamic Planet* (USGS)*

*Visit the *EarthComm* web site to find out how to order the map or how to download an Acrobat™ Reader file (pdf) of this map.

Think about It

This is simply an opinion question. Ask students to list as many reasons as possible. Responses will tell you whether or not students understand why plate tectonics makes the geosphere dynamic (the most active plate boundary is at the leading edge of a plate).

This is a question that you may want to revisit after the students have completed the activity, to see if they have changed their answer.

Assessment Tool

Think about It Evaluation Sheet
The **Think about It Evaluation Sheet** will help students to understand and internalize basic expectations for the warm-up activity. **Think about It** is intended to reveal student conceptions about the phenomena or processes explored in the activity. It is not intended to produce closure, so any assessment of student responses should not be driven by a concern for correctness.

Investigate

Part A: Observing Plate Motions and Plate Interactions

2. **a**) A mid-ocean spreading ridge.

   b) The part of an ocean basin between a spreading ridge and a "passive" continental margin, i.e., a continental margin without consumption of oceanic lithosphere by ocean–continent subduction.

   c) It gets longer.

   d) It stays the same.

Assessment Tool

Investigate Notebook Entry-Checklist
Refer students to the **Investigate Notebook Entry-Checklist** to remind them of the criteria against which they will be assessed. The checklist also provides a quick guide for student self-assessment and provides you with an opportunity to quickly score student work.

3. **a**) As in **2 c**), it gets longer.
   b) It gets shorter.
   c) The spreading ridge arrives at the subduction zone.

4. **a**) It would last as long as the given arrangement stays the same.
   b) The spreading ridge goes down the subduction zone, never to be seen again, and creation of new oceanic lithosphere ceases. This may seem strange to the students, if they are thinking in terms of mantle convection driving the motions of the plates. In the next activity, **Activity 3**, they will gain some insight into this. If the movement in the convection cell is driven by the lithospheric plates, rather than the other way around, then there is no problem with the disappearance of the spreading ridge.
   c) It would become narrower, as the continent moved closer to the subduction zone.
   d) A new subduction zone would form in the ocean between the spreading ridge and the continent. This would happen fairly close to the continent, where the oceanic lithosphere is coldest and therefore most dense.

Part B: How Transform Faults Are Formed

Encourage the students to run this thought experiment carefully in their own minds, by using their powers of mental visualization. Some people are better at that than others. Those who have trouble doing that can be encouraged to use the diagram on page 78 as a guide.

1. **a**) A fracture would form in the wax. The break would run across the pan, approximately perpendicular to the direction of spreading. The spectacular result in the actual experiment was that the break had the same characteristics as real spreading ridges: short segments of "spreading ridge" oriented perpendicular to the direction of motion were connected by short segments parallel to the direction of motion. These latter segments operated in exactly the same way as real transform faults. This is shown in the diagram on page 78.
   b) As the two plates of wax move apart, hot liquid wax would well up in the gap between the edges of the diverging plates, and new solid plate material would form, just as in a real-life spreading ridge.

2. a) Answers will vary.
   b) The experiment suggests that the pattern of transform faults along spreading ridges developed at the same time that the spreading ridge formed. Thereafter, as explained in the **Digging Deeper** reading section, the pattern would stay the same for an indefinitely long time.

Part C: Plate Boundaries on World Maps

Circulate about the class as students begin work on this activity. Students may work alone or in small groups. Group work reduces the number of questions you will have to answer; as students discuss questions within the group, they often solve the problems themselves.

Refer to the map on page 68. Because of its small size, this map has fewer arrows to show plate motion than the USGS map *This Dynamic Planet*. You might want to use the USGS map for the beginning of this activity.

1. a) Examples of colliding plates include: South American Plate and Nazca Plate; Indo-Australian Plate and Eurasian Plate.
   b) Two examples of plates moving apart include the African Plate and South American Plate, the Pacific Plate and the Nazca Plate, and the North American Plate and the Eurasian Plate.
   c) Two examples of plates sliding past one another are the North American Plate and the Pacific Plate, and the Eurasian Plate and the African Plate.

2. Students should produce a map.

Part D: The Plate-Tectonic Setting of Your Community

This question brings the students back to the community context of *EarthComm*. Encourage students to investigate the earthquake activity, volcanic activity, and types of landforms in their region. The western United States has all three features associated with plate boundaries. The eastern United States has a geological region (the Appalachian Mountains) that developed during the collision of the North American Plate with the African Plate 200 million years ago. Earthquakes sometimes occur along the faults that developed during this collision. Although the region is no longer experiencing convergence and continent–continent collision, stresses that continue to develop within the plate, for obscure reasons, are usually relieved at such zones of weakness, causing minor continued movement along the faults.

Reflecting on the Activity and the Challenge

Use this opportunity to direct the students back to the **Chapter Challenge**. Students have explored how various lines of evidence support plate tectonics. Earthquakes, volcanoes, and landforms are three types of observable evidence that do so. Encourage students to make the connection between evidence and scientific theory. A theory must be supported by evidence.

Digging Deeper

Assign the reading for homework. The questions in **Check Your Understanding** (page 85) can be assigned for homework.

Assessment Opportunity

A vocabulary sheet or pop quiz on the types of plate boundaries will help to reinforce their importance. A sample quiz is shown below.

Write a brief definition for each of the following terms and give an example of where you might find each:

a) Divergent plate boundary
(A plate boundary where two plates move away from one another. These can be found along the mid-ocean ridges and rift valleys.)

b) Convergent plate boundary
(A plate boundary where two plates move toward each other. There are three types: continent–continent, ocean–ocean, and ocean–continent.)

c) Transform plate boundary
(A plate boundary where two plates slide parallel to one another. They form transform faults, such as the San Andreas Fault in California and also along the mid-ocean ridges.)

Teaching Tip

Use the **Blackline Masters** of *Figures 1* and *2* (**Blackline Masters Plate Tectonics 2.1 and 2.2**) to make overheads that can then be incorporated into a lecture or discussion on divergent and convergent plate boundaries. (Labels have been removed. Add these to the overhead as part of your interactive discussion.) Visit the *EarthComm* web site to be linked to sites which contain colorful graphics that can be used to supplement the illustrations in the student text. These sites also contain images of the types of features that are typically found at these plate boundaries. Actually seeing an image of a real volcanic arc or a close-up view of a mid-ocean ridge may help students to better understand the impact that plate tectonics has on our planet.

Assessment Opportunity

Copies of **Blackline Masters Plate Tectonics 2.1 and 2.2** may be provided for students to label.

Check Your Understanding

1. Divergent boundaries (mid-ocean spreading ridges), convergent boundaries (subduction zones), and transform boundaries (transform faults).

2. Rift valleys are formed when a changed pattern of mantle convection causes doming and fracturing of existing continental lithosphere. This could happen anywhere on the continents in the future.

3. Ocean basins can grow by the creation of new oceanic lithosphere at mid-ocean spreading ridges and can shrink by consumption of oceanic lithosphere at subduction zones.

4. (1) Ocean–ocean subduction zones, where one oceanic lithospheric plate is subducted under another oceanic lithospheric plate; (2) ocean–continent subduction zones, where an oceanic lithospheric plate is subducted under a continental lithospheric plate; (3) continent–continent collision zones, where two continental lithospheric plates have collided.

5. The subducting plate bends downward as it reaches the subduction zone, to form a deep oceanic trench. This plate travels far down into the mantle, eventually to be absorbed and become part of the mantle once again. Earthquakes occur on the downgoing plate because initially the plate is stretched as it is pulled down by its own negative buoyancy. But at greater depths, as it is heated, it becomes positively buoyant and is compressed because it resists further motion. Volcanoes are produced because magma is generated by release of water from the subducting plate and rise of that water into the overlying mantle, to depress the melting point of the rocks, which causes melting.

6. The movement of plates along transform faults is always parallel to the transform fault itself. Movement of a plate down a subduction zone can be at some angle with the trend of the subduction zone that is different from 90° (this is called oblique subduction).

7. Because the continents are of lower density than the mantle, continental lithosphere is buoyant and resists being subducted. Instead, one of the plates is shoved horizontally under the other, resulting in thickening of the lithosphere and creation of high plateaus and mountains.

Teaching Tip

Use the **Blackline Masters** to make an overhead of *Figure 5*. This map can be incorporated into a discussion on transform plate boundaries. Most students are aware that earthquakes frequently occur in California, and you may point out to them that these quakes are the result of stress release along a transform plate boundary. This will introduce the idea that earthquakes occur along plate boundaries, a concept addressed in **Activity 4**.

Understanding and Applying What You Have Learned

1. Designs will probably vary in their nature and sophistication, depending on how much the students have learned so far in this chapter and how creative they are. Encourage them to go back to **Part A** of the **Investigate** section and think about how to modify the investigation to address this question.

2. **a)** Any of the mid-ocean ridges, in the Atlantic, the Pacific, or Indian Oceans

b) The East African Rift Valley

c) Tonga Trench, Aleutian Trench

d) West coast of South America; Oregon–Washington coast

e) Himalayan Mountains

f) Accept any response that corresponds to a location that is specific enough to indicate a plate interior. For example, "the state of Colorado"

g) San Andreas Fault, California

Preparing for the Chapter Challenge

Students should emphasize the role of evidence (in this case, the features and processes observed at plate boundaries) as providing evidence to support the theory of plate tectonics. The hands-on work in this activity can be captured on video, as digital photos, or drawn to illustrate the concepts and included in the final presentation.

Inquiring Further

1. Evolution of the Biosphere at Mid-Ocean Ridges

Recently, new forms of life have been discovered associated with hot water and minerals rising to the surface in rift valleys. This life does not depend upon the sun for energy, but instead upon the energy from Earth's interior. For further information, go to the *EarthComm* web site.

This inquiry allows students to connect interrelated Earth systems. They can see how the dynamic geosphere (the release of matter and energy at mid-ocean-ridge spreading centers) provides unique settings for the evolution of the biosphere (unique life forms that have evolved in this particular environment of superheated water and sulfur-rich minerals).