The NASA SCI Files™
The Case of the
Shaky Quake

Segment 2

After investigating various leads, the tree house detectives think that an explosion caused the tremor felt in the tree house. However, they don't want to jump to conclusions too quickly and feel that more research is needed. After researching plate tectonics, the detectives decide that they need to learn more about faults, and they ask Jacob and R.J. to contact the United States Geological Survey (USGS) office for information on faults and plate boundaries. Meanwhile, back at home, the rest of the detectives set off for Tidewater Community College in Virginia Beach, Virginia, where Mr. Michael Lyle shows them how earthquakes are recorded. They also meet Dr. D who demonstrates how to make their very own seismometer.

Objectives

The students will

• explain how earthquakes occur.

• identify three types of faults.

• identify three types of plate boundaries.

• understand folklore and legends of earthquakes.

• build a model of a seismometer.

Vocabulary

convergent boundary—in plate tectonics, the boundary between two plates that are converging or moving toward each other

divergent boundary—in plate tectonics, the boundary between two plates that are diverging or spreading apart

fault—a large break in rocks, from several meters to many kilometers long, where rocks not only crack but also move along either side of the break

inertia-- tendency of objects to remain in motion or stay at rest unless acted upon by an unbalanced force

intraplate earthquake—earthquake located in the interior of a plate

normal fault—a pull-apart (tension) fracture in rocks, where rocks that are above the fault surface drop downward in relation to rocks that are below the fault surface

reverse fault—a compression fracture in rocks, where rocks that are above the fault surface are forced up over rocks that are below the fault surface

strike-slip fault—a break in rocks where rocks on either side of the fault move past each other (instead of above or below each other)

transform boundary—in plate tectonics, a boundary between two plates that are sliding past one another

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich the existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 2 of *The Case of the Shaky Quake*, discuss the previous segment to review the problem and what the tree house detectives have learned thus far. Download a copy of the Problem Board from the NASA SCI Files™ web site and have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 1 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have been dispelled during Segment 1. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Focus Questions–Print the questions from the web site ahead of time for students to copy into their science journals. Encourage students to take notes during the program to answer the questions. An icon will appear when the answer is near.
5. What's Up? Questions–Questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. These questions can be printed from the web site ahead of time for students to copy into their science journals.

View Segment 2 of the Video

For optimal educational benefit, view *The Case of the Shaky Quake* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the

Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Have students work in small groups or as a class to discuss and list what new information they have learned about the layers of the Earth, fossils, and plate movement. Organize the information and determine if any of the students' questions from Segment 1 were answered.
4. Decide what additional information is needed for the tree house detectives to determine what caused the tremor. Have students conduct independent research or provide students with information as needed. Visit the NASA SCI Files™ web site for an additional list of resources for both students and educators.
5. Choose activities from the educator guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
6. If time did not permit you to begin the web activity at the conclusion of Segment 1, refer to number 6 under "After Viewing" on page 15 and begin the Problem-Based Learning activity on the NASA SCI Files™ web site. If the web activity was begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, Problem-Based Learning activity:

   Research Rack - books, internet sites, and research tools

   Problem-Solving Tools - tools and strategies to help guide the problem-solving process

   Dr. D's Lab - interactive activities and simulations

   Media Zone - interviews with experts from this segment

   - listing of Ask-An-Expert sites and biographies of experts featured in the broadcast
7. Have students write in their journals what they have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon as suggested on the PBL Facilitator Prompting Questions instructional tool found in the educator's area of the web site.
8. Continue to assess the students' learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools that can be found on the web site. Visit the Research Rack in the tree house, the online PBL investigation main menu section "Problem-Solving Tools," and the "Tools" section of the educator's area for more assessment ideas and tools.

Careers

metallurgical engineer
gemologist
soil engineer

Resources

Books

Kerhet, Peg: *Earthquake Terror.* Sea Star Books, 1998, ISBN 0613068114.

Lassieur, Allison: *Earthquakes*. Capstone Books, 2001, ISBN 0763805869.

Sattler, Helen Rodney: *Our Patchwork Planet*. Lothrop, Lee, and Shepary Books, 1995, ISBN 0688093124.

Video

Earth Revealed. The Annenberg/CPB Collection, 1992, ISBN 155464437.

Web Sites

Earthquakes
This site is packed with information on earthquakes. Learn what to do during a quake, read a map to discover earthquake prone areas, discover ancient legends that were used to explain quakes, and much more. Presented in a kid friendly environment.
http://www.fema.gov/kids/quake.htm

Earthquake Legends
This site is full of legends and folklore about how earthquakes are explained by various cultures.
http://www.fema.gov/kids/eqlegnd.htm

Life Along the Fault Line
This cool site contains real video clips of experts in the field of geology. It contains activities, links, and a place to share your story. It also has past webcasts that can be viewed.
http://www.exploratorium.edu/faultline/index.html

Plate Tectonics: The Cause of Earthquakes
A good discussion about how plate tectonics and earthquakes go hand in hand. Information is also available about the three types of plate boundaries.
http://www.seismo.unr.edu/ftp/pub/louie/class/100/plate-tectonics.html

How Stuff Works: How Earthquakes Work
Learn more about the dynamics of earthquakes and find many links to other sites.
http://www.howstuffworks.com/earthquake.html

USGS: Earthquake Hazards Program

The USGS site has so many resources to use that it would be impossible to list them. You can view current earthquake activity, news, and even request earthquake notification via e-mail.
http://neic.usgs.gov/

Activities and Worksheets

In the Guide

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Learn how earthquakes are created along fault lines. 32

It's Not My Fault!
Create cardboard models of three types of faults. 33

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Make edible models of three types of plate boundaries. 34

Folklore and Legends
Read and research legends and how various cultures explain the trembling Earth. 35

Got Quakes?
Build your own seismometer. 36

Answer Key
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On the Web

Plates On a Globe
Create a model of the lithospheric plates by using a tennis ball.

Modeled to a Fault
Create 3-dimensional paper models of three types of faults.

Breaking Loose

Problem

To explain how earthquakes occur

Materials

small wooden block
rubber band
2 pieces of sandpaper
tack
science journal

Procedure

1. Securely tape one piece of sandpaper in place on a flat surface.
2. Wrap the other piece of sandpaper around the small block of wood and secure it with tape.
3. On the top of the small block of wood, attach a rubber band with a tack. See Diagram 1.
4. Lay the block of wood, sandpaper side down, on top of the sandpaper attached to the table. See diagram 2.
5. Very slowly begin to pull on the block with the rubber band. Notice that the force of your pulling builds up in the rubber band.
6. Continue to pull until the block moves. Record your observations in your science journal.

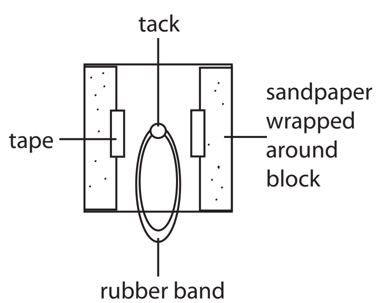


Diagram 1

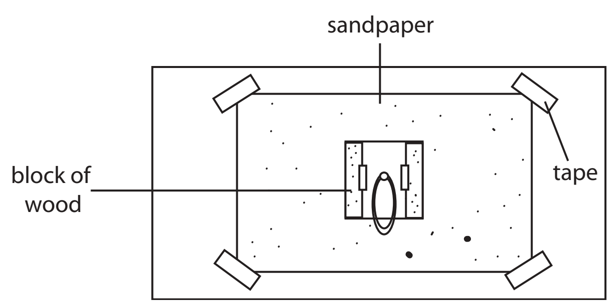


Diagram 2

Conclusion

1. What happened when you continued to pull on the rubber band? Why?
2. Explain how this simulation relates to earthquakes.
3. Use the Internet, books, and other resources to research the elastic rebound theory and create a report for the class.

It's Not My Fault!

Problem

To identify three types of faults

Materials

Inclined Plane

wooden plank or sturdy piece of cardboard
stack of books
protractor
2 paperback books tied together with string
spring scale

Procedure

1. On the cardboard, use a metric ruler to draw two rectangles that each measure 16 cm X 9 cm.
2. Cut out the two rectangles.
3. Use the ruler to divide each rectangle into three equal lengthwise parts. See diagram 1.
4. Label one rectangle, "Rectangle A" and label the parts 1, 2, and 3. Color each part a different color.
5. Repeat with the second rectangle, labeling it "Rectangle B."
6. On Rectangle A, measure 2 cm from the upper left corner and mark.
7. Measure 2 cm from the bottom right corner and mark.
8. Draw a diagonal line between the two marks. See diagram 2.
9. Using scissors, cut along the diagonal line and set aside.
10. On Rectangle B, measure to find the lengthwise middle of the rectangle on the top and bottom.
11. Draw a line between the two marks and cut along the line. See diagram 3.
12. Position Rectangle A in front of you and push against each side so that the right side drops down below the left side to demonstrate a normal fault.
13. Reposition Rectangle A in front of you and push against each side so that the right side pushes above the left side. This demonstrates a reverse fault.
14. Position Rectangle B in front of you and slide the left side past the right side to demonstrate a strike-slip fault.
15. In your science journal, write a description of each fault. In your group or as a class, reach a consensus for a definition of each fault.
16. Research the term "hanging wall" and determine which wall would be the hanging wall in a normal and reverse fault.

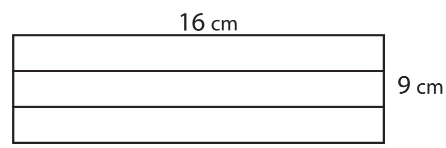


Diagram 1

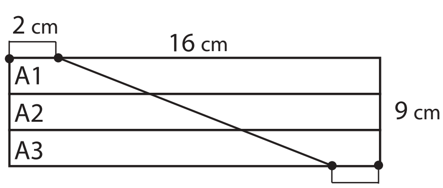


Diagram 2

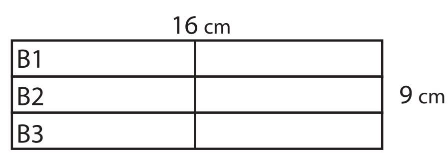


Diagram 3

Conclusions

1. How might each of these faults be created?
2. Are there faults in your local area? How do you know?

Extensions

1. Research what landforms are created by each of these faults.

Shaky Quake Cake

Problem To identify three types of plate boundaries

Teacher Note: To demonstrate three types of plate boundaries, you will need three cakes. This activity can be done as a class demonstration, or each group can have a cake to demonstrate one of the plate boundaries.

Materials

- 6 foil pans (30 cm X 40 cm)
- cake batter for 3 cakes (prepared)
- scissors
- 3 pieces of aluminum foil 10 cm X 40 cm
- cooking oil spray
- paper plates
- forks
- napkins

Procedure

1. Starting just underneath the reinforced rim 10 cm from corners, cut one foil pan diagonally from side to side. Leave the rim intact to help hold the pan in position during baking. See diagram 1.
2. To reinforce the cut pan, cover the outside with the aluminum foil.
3. Place the foil-reinforced pan inside the uncut pan.
4. Spray liberally with cooking oil.
5. Pour prepared cake batter into the pan. NOTE: To create a layering effect to represent the layering of rocks and soil, use different colored cake batter for each layer. Add nuts, to represent rocks in the soil, coconut to represent plant roots, and so on.
6. To make the second cake, repeat steps 1-5 but cut the pan across the center of the pan. See diagram 2.
7. To make the third cake, repeat step 6. Once you have cut the pan across the center, slightly overlap the edges in the middle so that they will slide together.
8. Bake according to the package or recipe directions.
9. Allow the cakes to completely cool.
10. If desired, after the cakes have cooled, use different colors of a stiff icing to add roads, streams, hills, and other details to the landscapes of the cakes. The cakes can also be topped with models of animals, cars, trees, trucks, buildings, and so on.
11. Carefully remove the cakes from the outer uncut pans. Loosen the aluminum foil from the edges but do not remove from the bottom of the pan.
12. Finish cutting the rims so that the pans are no longer connected. Be careful not to fracture the cakes in the process.
13. Use the cake that has the pan cut diagonally to demonstrate a transform boundary. You and a partner should firmly grasp the pan at each end. One will slowly move half the pan to the left while the other moves the other side of the pan slowly to the right. Make sure you keep the cake and pan as level as possible.
14. Discuss what happened to the "Earth" as you applied pressure to each side.
15. To demonstrate a divergent plate boundary, use one of the other cakes and firmly grasp each end. Gently and slowly pull outward on the pan and cake without twisting until the cake begins to fracture.
16. Discuss what happened to the "Earth" as it was pulled apart.
17. To demonstrate a convergent plate boundary, firmly grasp one end of the pan and have your partner grasp the other end. Gently and slowly push toward each other with steady pressure. The cake should buckle in the middle.
18. Discuss what happened to the "Earth" as it was pushed together.
19. Answer the conclusion questions and then enjoy the shaky quake cake.

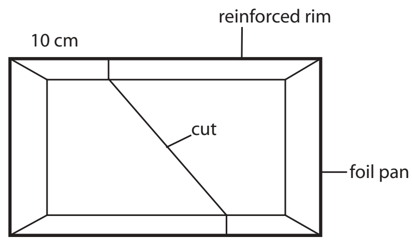


Diagram 1

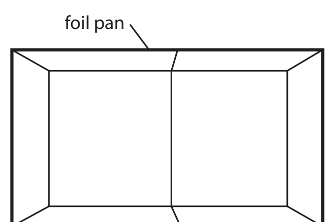


Diagram 2

Conclusion

1. Define the three types of plate boundaries and describe how each is created.
2. How were the three types of boundaries similar?
3. What happened to the cake after the pushing or pulling stopped?

Folklore and Legends

Background

Different cultures around the world have attempted to explain earthquakes in various ways. Below are a few legends about what makes the ground shake.

India

The Earth is held up by four elephants that stand on the back of a turtle. The turtle is balanced on top of a cobra. When any of these animals move, the Earth trembles and shakes.

Mexico

El Diablo, the devil, makes giant rips in the Earth from the inside. He and his devilish friends use the cracks when they want to come and stir up trouble on Earth.

Native American

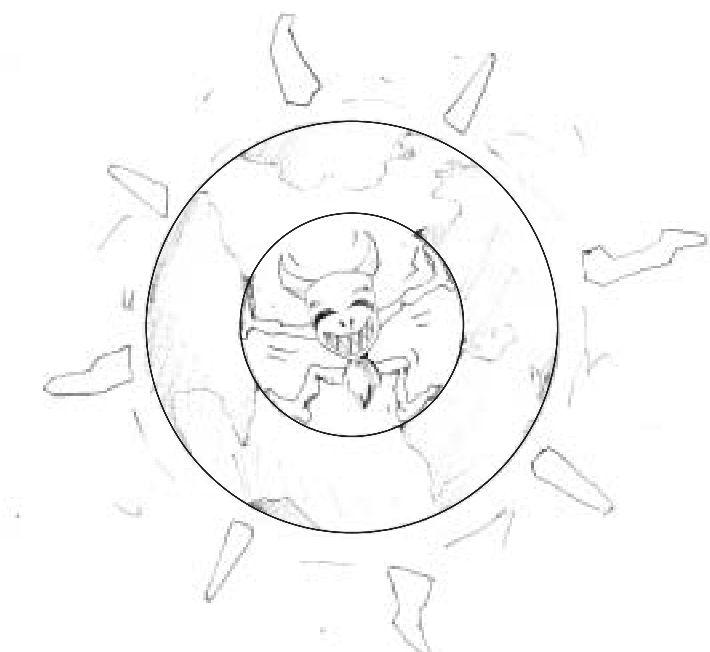
Once a Chickasaw chief was in love with a Choctaw princess. He was young and handsome, but he had a twisted foot, so his people called him Reelfoot. When the princess's father refused to give Reelfoot his daughter's hand, the chief and his friends kidnapped her and began to celebrate their marriage. The Great Spirit was angry and stomped his foot. The shock caused the Mississippi River to overflow its banks and drown the entire wedding party. (Reelfoot Lake, on the Tennessee side of the Mississippi River, was formed as a result of the New Madrid earthquake of 1812.)

Procedure

After reading the above legends, conduct research using the Internet, books, or other resources to learn about other legends from around the world. Create a skit, poster, written or oral report, or some other way to introduce the legend to the class.

Extension

Create a legend of your own, and illustrate it.



El Diablo Shaking the Earth

Got Quakes?

Problem

To build a model of a seismometer to record the movements in the Earth

Materials

two strings 10 cm long each
one string 30 cm long
paper cup with plastic lid
weights (marbles or washers)
metric ruler
2 pencils
science journal
stopwatch
3 strips of paper, 10 cm x 28 cm
cereal box
scissors
glue

Procedure

1. Using scissors cut out the two largest faces of the cereal box, leaving a 3-cm border on the top and the two sides. Along the bottom, cut all the way to the edge. See diagram 1.
2. Cut a small hole in the top face.
3. Use a hole-punch to make two holes on opposite sides of the cup.
4. Thread a 10-cm piece of string through each hole and secure each string to the cup by tying a knot in the string.
5. Bring the two strings together and tie them in a knot. See diagram 2.
6. Tie the 30-cm string to where the 10-cm strings are joined together.
7. Make a small hole in the center bottom of the cup and insert a pencil so that it protrudes approximately 1 to 2 cm.
8. Place some weights in the bottom of the cup (3-5 marbles or washers).
9. Place the lid on the cup so that the eraser end of the pencil is sticking out of the hole where a straw would normally be placed. See diagram 3.
10. Thread the 30-cm string through the hole in the top of the cereal box.
11. Tie the string around a pencil and lay the pencil flat against the top of the box. The cup should now be suspended from the cereal box. Adjust the string by wrapping it around the pencil until the pencil lead is barely touching the bottom of the box.
12. Glue the 3 strips of paper together end to end.
13. Place one end of the paper directly under the point of the pencil. The rest of the strip should be flat on the surface on the other side of the box. See diagram 4.
14. Assign each member of your group a job.
    - One student will be in charge of shaking the surface that the box is on.
    - One student will pull the paper through the box.
    - One student will lightly hold the box in place so that it doesn't tip over.
    - One student will record the time with a stopwatch.
15. After everyone is in place, begin the earthquake and time it for 10 seconds.
16. Look at your seismograph and discuss what you have recorded.

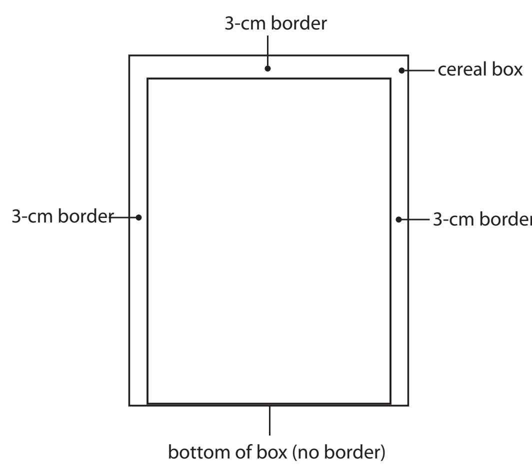


Diagram 1

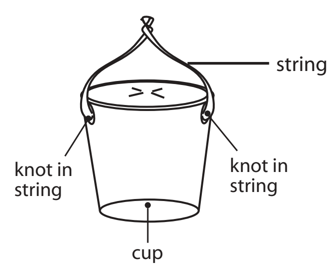


Diagram 2

Got Quakes? (continued)

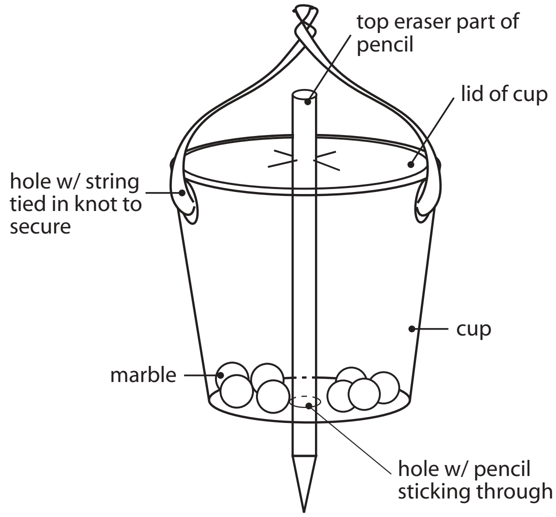


Diagram 3

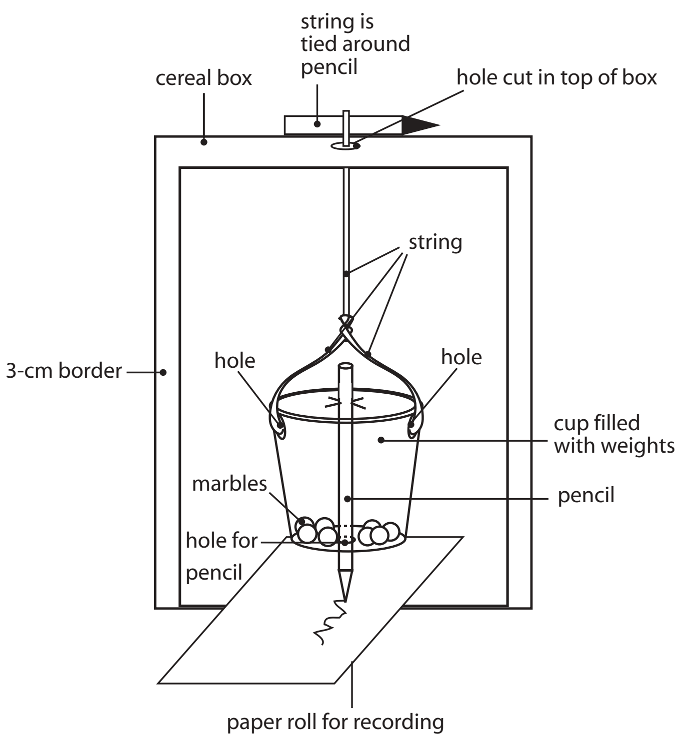


Diagram 4

Conclusion

1. Why do scientists use seismometers?
2. How can they help people that live close to boundaries that move?
3. In what other ways could you use a seismometer?

Answer Key

Breaking Loose

1. As you continued to pull on the rubber band, the force finally overcame friction, and the block leapt forward, skipping over the rough sandpaper surface. The rubber band stored energy until it had enough to overcome the friction of the sandpaper.
2. In most places, plate motion is steady and slow as the plates slide past each other, moving only a few centimeters each year. This kind of motion is referred to as seismic creep. But in some locations where the friction between plates is great, whole sections become stuck against each other. The pressure on the sections increases and eventually this pressure is released. Though rock may seem brittle, it's actually an elastic material, capable of stretching and storing energy like a spring or rubber band and then returning that energy in a sudden rebound. A little bit more plate motion is the final trigger, and the friction between the plates is overcome. A section of the fault suddenly breaks loose, releasing all the stored elastic energy in one sudden jerk.
3. Reports will vary.

It's Not My Fault!

1. Rocks are subjected to tension from the constant movement of the plates. Tension can pull rocks apart to create a normal fault. Think of pulling a piece of clay apart. It takes a lot of effort, but eventually, the clay will snap into pieces. If it were to break into three pieces, the middle piece would fall downward. Compression forces are generated at convergent plate boundaries. Compression pushes on rocks from opposite directions and causes them to bend and fold and sometimes break. At a strike-slip fault, the rocks on either side of the fault surface are moving past each other without much upward or downward motion.
2. Answers will vary. Visit the USGS web site < http://www.usgs.gov/> for information on faults in your area.

The Shaky Quake Cake

1. A transform fault (boundary) occurs when two plates slide past each other. Transform faults occur when two plates are moving in opposite directions or in the same direction at different rates. The San Andreas Fault is a transform boundary. A divergent plate boundary is the boundary between two plates that are moving apart from one another. Divergent boundaries can occur when convection currents in the mantle cause two plates to move apart. Seafloor spreading and the Great Rift Valley in eastern Africa are examples of divergent boundaries. Convergent boundaries occur where two plates are colliding. New crust is being added at divergent boundaries, which causes the plates to move away from the fault area. This movement causes the plates to collide in other areas. There are three types of convergent boundaries. One is when the ocean floor plate collides with a less dense continental plate, creating a subduction zone and volcanoes such as those in the Andes Mountains of South America. The second type occurs when two ocean plates collide, forming deep-sea trenches and islands. This type of collision formed the islands of Japan. The third type occurs when two continental plates collide, crumpling up and forming mountain ranges such as the Himalayan Mountains. There is not a subduction zone because both plates are less dense than the material in the asthenosphere.
2. Answers will vary but should include that the Earth's forces create all three boundaries and that it is the build up of stress and pressure that causes the boundaries to move. The stresses and strains in the Earth's upper layers are induced by many causes: thermal expansion and contraction, gravitational forces, solid-earth tidal forces, specific volume changes because of mineral phase transitions, and so on. Faulting is one of the various manners of mechanical adjustment or release of such stress and strain.
3. When the pushing and pulling stopped, the cake did not snap back to its original form. Fissures, (cracks) in the Earth caused by earthquakes, usually do not close back up but in time they fill in with debris from erosion.

Got Quakes?

1. Seismometers are primarily used to record the movements of the Earth's crust. Scientists use the information obtained by a seismometer to help locate the epicenter (origin) of an earthquake. Scientists can also use the information to help predict future earthquakes and even to map the interior of our Earth. Scientists have begun to estimate the locations and likelihood of future damaging earthquakes. Sites of greatest hazard are being identified, and structures are being designed that will withstand the effects of earthquakes.
2. Seismometers can help people that live close to plate boundaries by helping scientists predict future earthquakes and to warn of earthquakes that have triggered tsunamis.
3. Answers will vary but might include that seismometers can be used to record traffic vibrations, construction blasts, sonic booms, and anything else that would make the ground vibrate.

On the Web

Plates On a Globe

1. There are approximately 10 major plates shown on the globe.
2. The plates are mostly named for the continent on which they are located.
3. Reports will vary.

Modeled to a Fault

1. Answers will vary.
2. Reports will vary.