Processes That Changed the Earth

GRADE LEVELS:
Grades 9th – 10th

OBJECTIVES:

- Students will explore how plate-tectonic activity and sea-floor spreading create the Earth's surface

ACADEMIC CONTENT STANDARDS:

- Science: Earth Science: 9.5, 9.6, 9.7
- Science: Scientific Inquiry: 8.1

VOCABULARY/KEY WORDS:
Erosion- The process by which the surface of the earth is worn away by the action of water, glaciers, winds, waves, etc.
Geology-The science that deals with the dynamics and physical history of the earth, the rocks of which it is composed, and the physical, chemical, and biological changes that the earth has undergone or is undergoing.
Sediment-Mineral or organic matter deposited by water, air, or ice.
Tectonics- The structure and distribution of the rocks that make up the crust of the earth.
Volcano- A vent in the earth's crust through which lava, steam, ashes, etc., are expelled, either continuously or at irregular intervals.

EXTENSIONS AT COSI:
Ocean

- Visit the Erosion Table
- Visit the Wave Machine

ADDITIONAL RESOURCES:
http://www.geology.com/teacher
http://earthquake.usgs.gov/learn/animations/
http://www.pbs.org/wgbh/nova/teachers/resources/subj_06_03.html
http://adventuresinscience.edublogs.org/teacher-resources/
http://www.open2.net/sciencetechnologynature/worldaroundus/geologytooklit/rocktypes_embedded.html

SAMPLE TEST QUESTIONS:

Q. Soil is a mixture of:

A. Organic matter

B. Oxygen

C. Pieces of rocks

D. Water

E. All of the above

Q. Each layer of soil is called a:

A. Horizon

B. Litter

C. Organic Matter

D. Humus

Q. How does erosion affect topsoil?

A. Keeps it moist

B. Makes it more fertile, easier plant growth.

C. Washes it away

D. Moves the topsoil to other areas where it is needed more.

Q. Erosion is more common on _______________.

A. Level Ground

B. Steep Slopes

C. In Valleys

D. On Small Hills

Changing Earth's Surface Pre Visit Activities

Earthquake Energy

Description: Where does an earthquake get its destructive energy? Using craft supplies students will simulate an earthquake.

Materials:

- Scissors
- Ruler
- Sewing elastic, 1/2 inch (1.25 cm) wide
- Marking pen
- 12 drinking straws
- Stapler
- Masking tape

Procedure:

1. Cut a 3-foot strip of elastic.
2. Begin 6 inches from one of the ends of the elastic and use the marking pen to make 12 marks every 2 inches on the strip.
3. Put one straw underneath each mark and attach the middle of each straw to the elastic using the stapler.
4. Tape one end of the elastic strip to the top of a door's frame, so the elastic hangs down from the doorway.

5. Pull the bottom of the elastic strip down about 12 inches.
6. Twist the last straw around one half time, and then let go! What happens?

What's Going On?

Rocks inside the surface of the earth are, pulled, pushed, and moved by the motion of hot materials below the crust, the gravity of the moon and sun, as well as the earth's gravity and the rotation of the earth. Earthquakes begin when a force makes rocks break and fall apart. When you twist the bottom straw out of place, it can be compared to the strain the rocks experience below the earth's crust. When you let go of the straw, it sends a source of energy up the elastic and as it moves it twists each straw out of place. The energy moving to the top of the earth's crust, twists rocks out of place as it approaches the crust. The rocks return to their regular formation as the energy moves through the elastic strip.

Relevant Ohio Science Content Standards:
Earth & Space Sciences: 8.10
Physical Science: 3.4, 8.4, 8.5

Chocolate Lava

Description: Melt and cool fudge to learn about different kinds of lava.

Materials:

- Chocolate fudge mix and ingredients listed on box.
- Saucepan
- 2 baking dishes
- Adult as needed

Procedure:

1. Have an adult help you in the kitchen with the stove. Make the fudge mix as written on package.
2. As the fudge begins to boil, pour half of it into a baking dish.
3. Begin to stir the other half of the fudge mix for ten minutes as it begins to cool down.
4. Pour this fudge that is cooled into the second baking dish.

What's Going On?

Two types of lava flow from volcanoes, they are named from the Hawaiian language. The fudge that was put in the first pan was hot, flowed smoothly, and formed a flat surface. This is similar to the texture of pahoehoe lava. Pahoehoe (pronounced pa-hoy-hoy) lava can form lava tubes and an undersea formation called pillow lava. The other fudge that was cooled formed lumps and made a lumpy surface in the pan. This has an appearance like aa lava. Aa (pronounced Ah-Ah) lava produces sharp and twisted rocks that are difficult to walk on.

Processes that Changed the Earth Post Visit Activities

Earthquake-Proof Buildings

Objective: Students will explore different materials, shapes and design options that affect the durability of a building.

Materials:

For the class:

- Computers with Internet access (optional but very helpful)

To build the tabletop earthquake generator, you will need the following:

- A 1-inch × 10-foot piece of #40 PVC plastic pipe, which will be cut into two 24-inch pipes and two 30-inch pipes
- Four 1-inch #40 PVC 90o degree elbows
- Two ½ inch x 36 inch dowels wooden dowels
- One piece of plywood .25 × 24 × 24 inches
- Four eyebolts, .25 × 2.5 inches with .25 inch nuts
- Four hex bolts, .25 × 1 inch, with .25 inch nuts
- Four rubber bands, #64
- One saw
- One drill with .25-inch drill bit
- Hot glue

To conduct the earthquake experiments, students will need the following:

- Styrofoam packing blocks
- Wood blocks
- Spongy foam
- Cardboard
- Scissors (for cutting the foam board or cardboard)
- Shallow box or pan
- Marbles
- Wood dowels or pencils
- Large sponge
- Sand (optional)
- Teflon cooking sheets (optional)

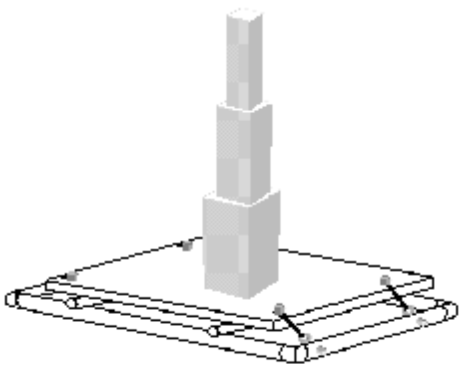
Note: Use either foam or cardboard for the lightweight blocks.

For each student:

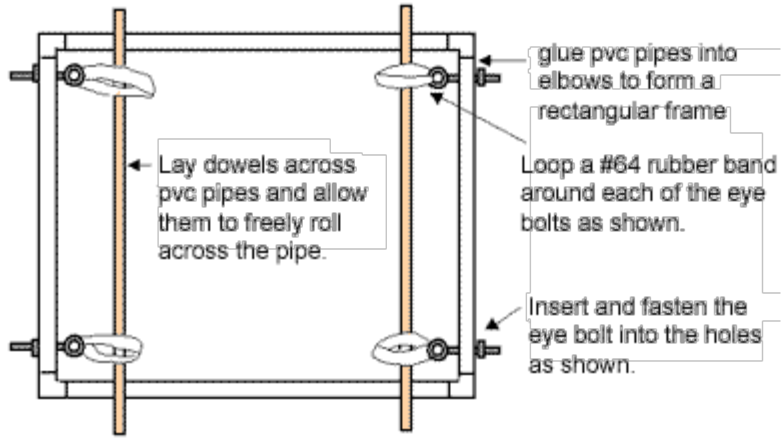
- Pencil
- Paper

Procedures:

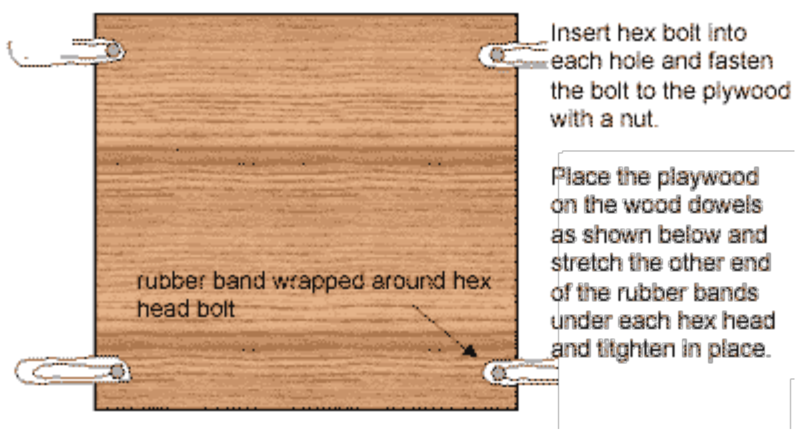
Before conducting the experiments, you must build the tabletop earthquake generator. (Materials for the generator can be found at your local hardware store or a large home supply center.) Consider asking a few interested students to help build the generator, which is shown below with a sample test structure.



2. Follow the instructions below to assemble the tabletop earthquake generator.
   a. Cut the PVC pipe into two 24-inch pipes and two 30-inch pipes.
   b. Drill a .25-inch hole 2 inches away from each end of both 24-inch PVC pipes.
   c. Glue the PVC pipes together to form a rectangular frame.



   d. Insert and fasten the eyebolts into the holes.
   e. Loop a rubber band around each of the eyebolts.
   f. Lay the dowels or pencils across the PVC pipe and allow them to roll freely across the pipe.
   g. Drill four .25-inch holes at each corner of the board. The holes should be 2 inches away from the edge of each of the four corners.
   h. Insert a hex bolt into each hole. Fasten the bolt to the plywood with a nut.



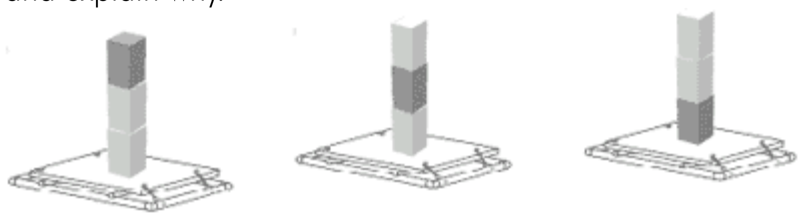
   i. Place the plywood on the wood dowels or pencils. Stretch the other end of the rubber bands under each hex head. Tighten the pieces into place.

3. Discuss with the class the different variables that need to be considered when constructing a building durable enough to survive a catastrophic earthquake. Help students understand that the following factors contribute to the durability of a structure:
    - Distribution of weight
    - Variation in shape
    - Variation in height
    - Variation in foundation material
4. Explain to students that they will be constructing their own miniature buildings to test these four factors. Before they begin, have students do some initial research on earthquakes and earthquake engineering. Encourage them to look for information regarding the four factors that contribute to the durability of a structure. They could begin their research in class and continue as a homework assignment. The Web sites below offer a good starting point for their research:
   MCEER—Multidisciplinary Center for Earthquake Engineering Research
   Earthquake Engineering Research, University of California, Berkeley
5. The next day, divide the class into four groups. Explain that each group will build different structures and then see how durable each is by placing it on the earthquake generator and simulating an earthquake by shaking the generator. Each group will be testing one of the variables discussed above. Before conducting the experiment, each group should make a prediction of which structure has the best chances of surviving an earthquake. Students will record their predictions, observations, and conclusions on the Classroom Activity Sheet: Earthquake Data.

6. Listed below are the variables that will be tested and the steps the groups will follow:

   Experimental Group 1: How does the distribution of weight within a structure affect its stability during an earthquake?

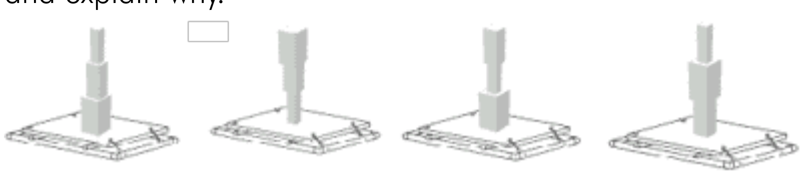
   a. Students in this group will make two rectangular, solid blocks with dimensions approximating 15 × 15 × 20 centimeters from light materials such as Styrofoam, cardboard, or foam board. The third block should be made of a heavier material, such as wood. The wood block, placed at different positions during each trial, is the dark-colored block in the drawings below.
   b. Predict which structure has the best chance of withstanding an earthquake and explain why.

   c. Place each structure on the earthquake generator and simulate an earthquake by shaking the generator.
   d. Observe which structure was the most durable and withstood the earthquake.
   e. Write your conclusion and revise your original explanation if you *disproved* your prediction.

   Experimental Group 2: How does variation in shape and placement of objects within a structure affect its stability during an earthquake?

   a. Students in this group will use three different rectangular, solid blocks made from the *same* material (either Styrofoam, foam board, or cardboard). Make one block 15 × 15 × 20 centimeters, one block 10 × 10 × 20 centimeters, and one block 5 × 5 × 20 centimeters. In each trial, the blocks will be stacked in a different order, as shown in the diagrams below.
   b. Predict which structure has the best chance of withstanding an earthquake and explain why.

   c. Place each structure on the earthquake generator and simulate an earthquake by shaking the generator.
   d. Observe which structure was durable enough to withstand the earthquake.

7. After students have completed their experiments, have students come back together and share their results. Then assign the Take-Home Activity Sheet: Create Your Own Earthquake-Proof Building. Based on the results of the four experiments, ask each student to construct a tower with three stackable rectangles that would have the best chance of surviving an earthquake. Then have students write a paragraph explaining why their structure is earthquake proof.
8. During the next class period, have students share their “ideal building” concepts. If time permits, select a couple of “ideal” structures and test them out on the earthquake generator. Can the structures withstand the simulated earthquake?

POSSIBLE INTERACTIVE QUESTIONS:

1. Review the four variables that contribute to the durability of a building: distribution of weight, variation in shape, variation in height, and the type of material used for the foundation. Discuss what is needed to create earthquake-proof buildings. For example, what would happen if a building was constructed properly but was built on a sandy foundation? What issues do builders face when constructing very tall buildings?
2. There have been many severe earthquakes in the 20th century. The 1985 earthquake in Mexico City and the earthquake in Kobe, Japan, in the late 1990s are two examples. Using the Internet or library resources, find out about a serious earthquake. What caused the most damage? What strategies could be implemented so that the damage is not as great the next time?
3. Based on what you have learned about earthquake-proof buildings, in what kind of building would you like to be during an earthquake? Describe its features and why you think it would be safe.
4. One of the largest freestanding domed structures on Earth is the Hagia Sophia in Istanbul, Turkey. It has survived all magnitudes of earthquakes for nearly 1,500 years. Using the Internet or library for research, do a structural analysis of the Hagia Sophia. Then report on some of the theories proposed about why this structure appears to be earthquake proof.
5. Discuss some of the structural features that are being incorporated into modern buildings to help them withstand earthquakes registering on the high end of the Richter scale. Use your library or the Internet to find resources to assist you in your research.

6. Following are three different approaches for preparing for future earthquakes. Discuss the value of each approach. Is one better than the others? Would you be more likely to invest in one approach over the others? Or do you think that all three should be implemented simultaneously? Give evidence to support your ideas.
    - Support and encourage engineers to design better buildings that have a greater chance of withstanding an earthquake.
    - Support and encourage engineers and scientists to learn more about earthquakes, enabling them to better predict when they will take place. This increased knowledge will help people be more prepared when the earthquake does hit.
    - Support public information campaigns that educate people about the safest places to build homes and discourage them from building in areas at the greatest risk for earthquakes.

COSI Center of Science and Industry

Mid-Ocean Ridge Spreading

Objective: The model is designed to help students understand the movement of the oceanic plates at the mid-ocean ridge. The foam board represents the oceanic lithosphere. Each strip represents 5 million years of extension at the ridge. As the blocks are pushed sideways, new magma is generated at the ridge and moves upward. The colors of the foam indicate periods of normal and reversed polarity. In the real world Earth, the time periods of normal (shaded) and reversed polarity would not be of equal duration (one million years in this simulation) and thus the widths of the stripes would vary. The student activity will allow students to create their own model of the mid-ocean ridge in order to simulate seafloor spreading.

Materials:
Demonstration Model:
Shoe Box w/lid Foam Core Board
Closed Cell Foam (camping pad type) X-acto Knife
Permanent Markers Masking Tape
Rubber Cement
Student Activity:
Copy of "Mid-Ocean Ridge" Model
Scissors
Glue or tape
Colored Pencils

Instructions:
Assembly
1. Cut two pieces of foam core board (10 cm x 30 cm).
2. Cut two pieces of closed cell foam (10 cm x 20 cm). Glue to the ends of the foam core board.
3. Cut 12 strips of closed cell foam (2 cm x 10 cm). Color 6 strips with red permanent marker. Glue to the foam core board alternating colors.
4. Score the foam board with an X-acto knife between each piece of closed cell foam. Place masking tape on the back side of the foam board. This will allow the board to bend at each strip.
5. Cut an opening in the top of the shoe box (4.5 cm x 11 cm).
6. Label the box and the foam pieces.
Student Activity:
1. Have students cut out the stripped pattern (Section A) around the outside edge and through the center so that they have two separate pieces.
2. Place the pieces together so that the printed sides are facing each other.
3. Tape or glue the end where it is marked.
4. Fold each side along the bold lines so that you can read the pattern.
5. Cut a slit in the center of the mid-ocean ridge base where marked.
6. Insert the stripped pieces "Section A" through the slit in the base. The printed sides should be facing inwards.
7. Open the stripped pieces so that you can see the Oceanic Lithosphere on either side of the slit. Pull the pieces slowly in the direction of the arrows.

Discussion:
The foam board represents the oceanic lithosphere. Each strip represents 5 million years of extension at the ridge. As the blocks are pushed sideways, new magma is generated at the ridge. In the real world Earth, the time periods of normal (shaded) and reversed polarity would not be of equal duration (one million years in this simulation) and thus the widths of the stripes would vary.

To demonstrate the concepts of divergent plate boundary and mid-ocean ridge spreading, insert the stripes of foam board into the hole in the top of the box. The oceanic lithosphere should be placed on the top of the box with the arrows on these pieces pointing outward. These pieces present oceanic lithosphere at a time six million years ago and contain oceanic crust (the upper layer of the lithosphere) that is 6 million years old and older. Slowly slide the two foam pieces away from each other about 2 cm. This will represent the passage of time and will demonstrate how magma pushes up through the mid-ocean ridge creating new ocean floor. As the magma emerges, the old ocean floor is pushed aside.

In the real mid-ocean, there is not an opening between the plates. At slower spreading ridges, like the northern Mid-Atlantic Ridge, the seafloor behaves like nougat or cold chocolate bars – when it gets pulled enough it cracks and breaks. The ocean crust at slow spreading ridges breaks in to ridges and valleys as the seafloor gets pulled apart. Faster spreading ridges like the northern and southern East Pacific Rise are “hotter.” This means that the ridge spreads more like hot taffy being pulled apart. More magma is present beneath the ridge and more volcanic eruptions occur.

Because the oceanic crustal layer in this new lithosphere is formed from igneous processes, it cools from a liquid. The rocks acquire a magnetic direction which is the same as the Earth’s magnetic field direction at that time. Because the Earth’s magnetic field occasionally reverses its polarity, the lithosphere created at mid-ocean ridges has stripes of normal and reversed magnetic polarity parallel to the ridge. At the mid-ocean ridge spreading axis, these changes in the direction of the Earth’s magnetic field are recorded in the magnetization of the lava. This creates a symmetrical pattern of magnetic stripes of opposite polarity on either side of the mid-ocean ridges. Continue to push the two plates away from each other at the ridge crest and reveal the new pieces of lithosphere. When you are finished, the stripes will represent the passage of time from 1 million to 5 million years. Note that the youngest rocks are in the center, along the ridge and the older rocks are farthest away from the ridge crest.

Weathering and Erosion

Objective: Students will describe how weathering and erosion change the Earth's surface.

Materials:

- 15 rough, sandstone, limestone, or shale (sedimentary) rocks.
- Three same size containers with lids (such as 32-ounce Gatorade bottles, wide mouth).
- Three clear cups or jars.
- A pen, paper, and masking tape, to label both the cans and the clear jars with A, B and C.
  (Expand this activity by using an acid such as vinegar or lemon juice to show chemical erosion)

Procedure:

1. Separate the stones into three piles of five and put each pile onto a sheet of paper.
2. Label each can and jar "A," "B," and "C," and put five rocks in each.
3. Fill can "A " half way with water and put in the stones from pile "A." Do the same with pile "B," and with pile "C." Let the stones stand in the water overnight.

4. Pass the jar around to the students. Instruct them to hold can “A” in both hands and shake it hard about 10 times each, about 1,000 shakes.

5. Remove the stones from can “A” and pour the water into jar “A”. Observe the stones and the water.

6. Using the same process, give can “B ” about 300 shakes (you may rest between shakes). Remove the stones and pour water into can “B.” Once again, observe the stones and the water.

7. Do not shake can “C.” Remove the stones and pour the water into jar “C.” Observe the stones and the water.

8. Compare the three piles of stones and the three jars of water. Ask the students: “How do the piles of stones differ?” “ Can you explain why?” “Which pile acted as a control group? Why?” “How do the jars of water differ?” “How does this show what happens to rocks and stones through the water erosion process?”

9. Let the three jars of water sit overnight. Have the class observe any differences or changes.

10. Explain that we have just learned the process of weathering. Erosion continues the work that weathering starts. It helps loosen particles and transport-weathered material. Erosion by way of waves, wind, glaciers, gravity, running water, etc., causes change in geological features. Valleys, canyons, buttes, and drakes are all examples. The main agent of erosion is running water. It probably does more to wear away the land than all the other geologic agents combined. Ice, wind, plants and animals also affect landscape.

What is going on?:

Two forces, weathering and erosion, are constantly at work wearing away the rocks that make up Earth's crust. Weathering causes rocks to fragment, crack, crumble, or break down chemically. Erosion loosens and carries away the rock debris caused by weathering. Over time these two forces, working together, can change the shape of the land.