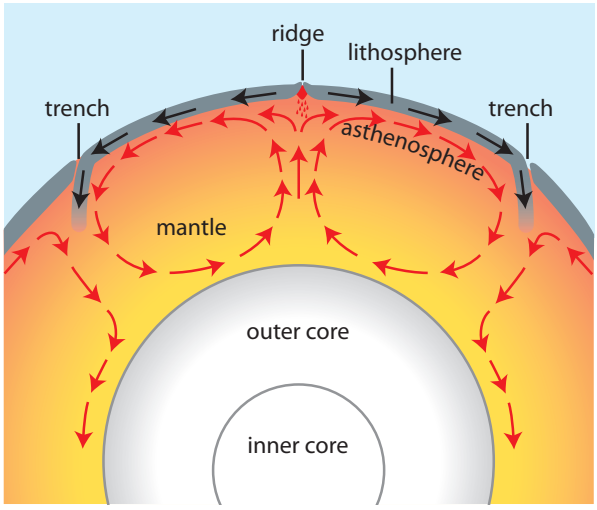
14 What Makes the Plates Move?

MODELING

CONVINCING EVIDENCE SHOWS that Earth's lithospheric plates are constantly moving. There are two main forces that drives plate motion: gravity and convection.



Red arrows represent the movement of the mantle due to convection. Black arrows represent the movement of the plates due to gravity.

The primary force is gravity. **Gravity** is a force that pulls objects towards each other. At divergent plate boundaries, the volcanic landforms that make up mid-ocean ridges rise to around 2,000 m above the sea floor. This height causes plates on either side of the ridge to move down the slope, away from the mid-ocean ridge due to gravity.

When an oceanic plate collides with another plate at a convergent plate boundary, one sinks into the mantle to form a trench. As the edge of the oceanic plate subducts the other plate, gravity pulls the rest of the plate down with it. The whole plate is pulled toward Earth's center. Scientists call this downward movement of the plate due to gravity *slab pull*. The movement of the plates due to slab pull is represented by black arrows in the diagram above.

Another force that acts on plates is thermal energy from Earth's hot interior. You learned that the core is the hottest layer of Earth. It is hotter than the mantle and so transfers thermal energy to the mantle. **Thermal energy** is the internal energy of a substance due to the movement of particles within the substance.

Scientists think that this transfer of thermal energy from core to mantle causes convection in the mantle. **Convection** is the transfer of thermal energy by the movement of matter of different temperatures. Convection in the mantle, shown in red arrows in the diagram above, is a driver of plate movement. While we often think about convection occurring in liquids, like boiling water, convection can also occur in solids, like Earth's mantle.

In this activity, you will investigate how both convection and gravity work by using models. The models will help you learn about how temperature differences can cause substances, like mantle material, to move and how gravity affects the movement of Earth's plates.

GUIDING QUESTION

What drives plate motion?

MATERIALS

For the class

- supply of warm water
- supply of cold water

For each group of four students

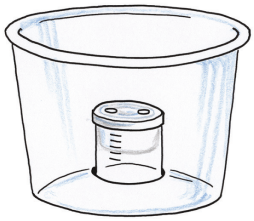
- 2 plastic cups (9-ounce)
- 1 plastic syringe
- 1 plastic cup with circular depression
- 1 small vial with 2-holed cap
- 1 bottle of red food coloring
- 20 paper clips
- 3 textbooks
- paper towels and/or a sponge

PROCEDURE

Part A: Investigating Convection

1. Fill two 9-ounce plastic cups, one with warm water and the other with cold water.
2. Snap the small vial (cap-side up) into the base of the plastic cup that has a circular depression, as shown at right.

Capped Vial in Cup



3. Gently remove the cap, and place 1 drop of food coloring into the bottom of the vial. Carefully and firmly re-cap the vial with the 2-holed cap.
4. Use the syringe to carefully fill the vial with about 5 mL of warm water. Gently tap the vial to remove any air bubbles.
5. Cover the holes in the 2-holed cap with your fingers, and have one person in your group slowly add cold water to the setup until it is almost full.
6. Remove your fingers, and observe what happens from both the side and the top.
7. Record your observations as Trial 1 in your science notebook. Draw a labeled picture, and use arrows to sketch the movement of the colored water.
8. After a few minutes, carefully remove the vial from the cup. Describe the contents of the vial in your science notebook.
9. Empty and rinse the vial, the cap, and the cup.
10. Repeat Steps 3–9, but this time use *cold* water in Step 4 and *warm* water in Step 5. Record your observations as Trial 2. Draw a labeled picture, and use arrows to sketch the movement of the colored water.
11. Respond to Analysis items 1 and 2 in your notebook.

Part B: Investigating Gravity

12. To make a model lithospheric plate, each member of your group will link five paper clips together.
13. Link your four chains together to make one long chain of 20 paper clips. This is your model lithospheric plate.
14. Place your paper clip chain on the top of your desk in a straight line perpendicular to the edge of the desk. The end of the chain should be touching the edge of the desk.
15. Gently push one paper clip from the chain over the edge of the table. Observe what happens.

16. Repeat Step 15 until the entire chain is pulled over the edge. In your notebook, describe what you observed.
    - How many paper clips did you push over the edge before the entire chain was pulled to the floor?
    - What caused the rest of the paper clip chain to be pulled over the edge?
17. Separate all of the paper clips, except for a chain of three paper clips.
18. Make a ramp using your three textbooks by stacking two on the table, and leaning the third against the stack.
19. Place the paper clip chain at the top of the ramp so that the chain points down the ramp.
20. Release the paper clip chain. Record your observations in your notebook. What caused the paper clip chain to be pulled down the ramp?
21. Separate all of the paper clips, and return them to your supply bin.
22. Respond to Analysis items 3–6 in your notebook.

ANALYSIS

1. Use your observations from Part A to answer the following questions:
    a. Did both trials result in the movement of water? Why or why not?
    b. What do you think is necessary for convection to happen?
2. Imagine that hotter material is lying beneath an area of cooler material deep in Earth's mantle. What do you predict will happen? Be as specific as you can, and explain your reasoning.
3. What do scientists believe causes plates to move? Explain your ideas using your observations from Part A and Part B.

4. What evidence do we have that the lithospheric plates that make up Earth's surface have moved? Include at least three different types of evidence, and for each,

   - describe what the evidence is.
   - describe where the evidence was found.
   - explain how the evidence supports the idea that the plates have moved.

   Hint: Revisit your learning from the last three activities. What evidence have you learned about that supports the theory of plate tectonics?

5. Lithospheric plates move at a rate of around 5 cm per year. If we were able to place a barrel of nuclear waste in a trench, how far will it have moved in kilometers in 250,000 years (by the time the nuclear waste is no longer hazardous)?

   Hint: There are 100 cm in 1 m, and 1,000 m in 1 km.

6. **Reflection:** Geologists may never be able to observe directly what is happening inside Earth's mantle to drive plate motion. Why might they never be able to observe the mantle directly?