SECTION 1

Inside the Earth

If you tried to dig to the center of the Earth, what do you think you would find? Would the Earth be solid or hollow? Would it be made of the same material throughout?

Actually, the Earth is made of several layers. Each layer is made of different materials that have different properties. Scientists think about physical layers in two ways—by their chemical composition and by their physical properties.

What You Will Learn

- Identify the layers of the Earth by their chemical composition.
- Identify the layers of the Earth by their physical properties.
- Describe a tectonic plate.
- Explain how scientists know about the structure of Earth's interior.

Vocabulary

crust
mantle
core
lithosphere
asthenosphere
mesosphere
tectonic plate

READING STRATEGY

Reading Organizer As you read this section, create an outline of the section. Use the headings from the section in your outline.

The Composition of the Earth

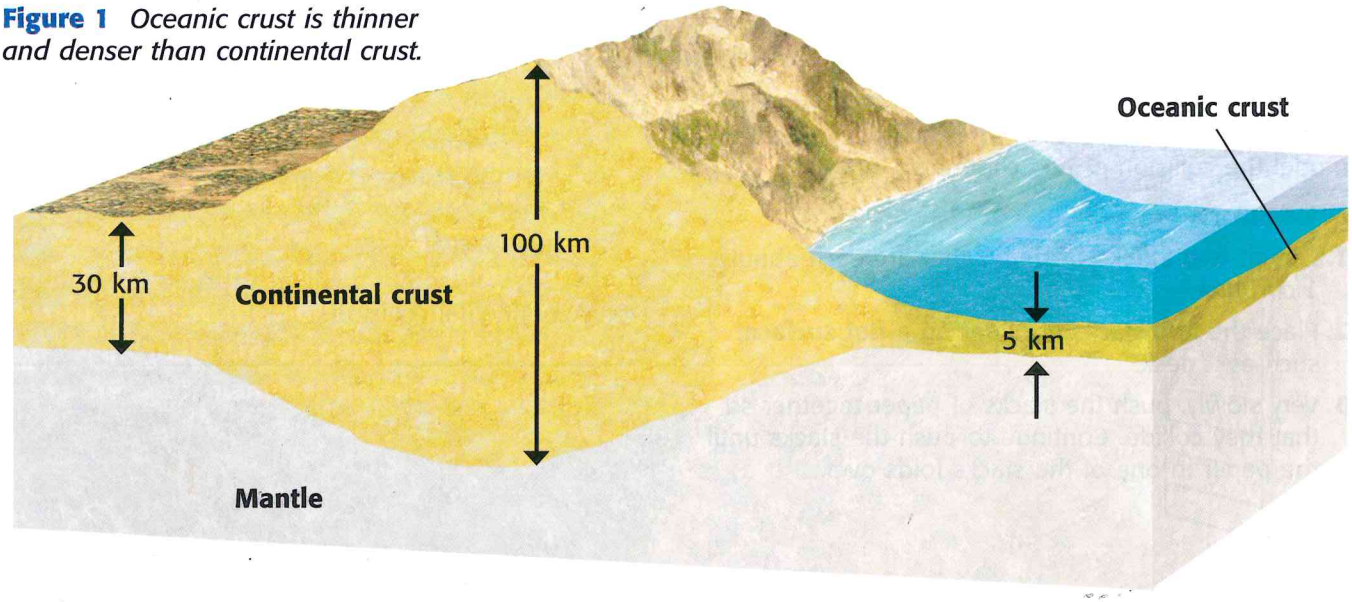
The Earth is divided into three layers—the crust, the mantle, and the core—based on the compounds that make up each layer. A *compound* is a substance composed of two or more elements. The less dense compounds make up the crust and mantle, and the densest compounds make up the core. The layers form because heavier elements are pulled toward the center of the Earth by gravity, and elements of lesser mass are found farther from the center.

The Crust

The outermost layer of the Earth is the **crust.** The crust is 5 to 100 km thick. It is the thinnest layer of the Earth.

As **Figure 1** shows, there are two types of crust—continental and oceanic. Both continental crust and oceanic crust are made mainly of the elements oxygen, silicon, and aluminum. However, the denser oceanic crust has almost twice as much iron, calcium, and magnesium, which form minerals that are denser than those in the continental crust.

Figure 1 *Oceanic crust is thinner and denser than continental crust.*



The Mantle

The layer of the Earth between the crust and the core is the **mantle.** The mantle is much thicker than the crust and contains most of the Earth's mass.

No one has ever visited the mantle. The crust is too thick to drill through to reach the mantle. Scientists must draw conclusions about the composition and other physical properties of the mantle from observations made on the Earth's surface. In some places, mantle rock pushes to the surface, which allows scientists to study the rock directly.

As you can see in **Figure 2,** another place scientists look for clues about the mantle is the ocean floor. Magma from the mantle flows out of active volcanoes on the ocean floor. These underwater volcanoes have given scientists many clues about the composition of the mantle. Because the mantle has more magnesium and less aluminum and silicon than the crust does, the mantle is denser than the crust.

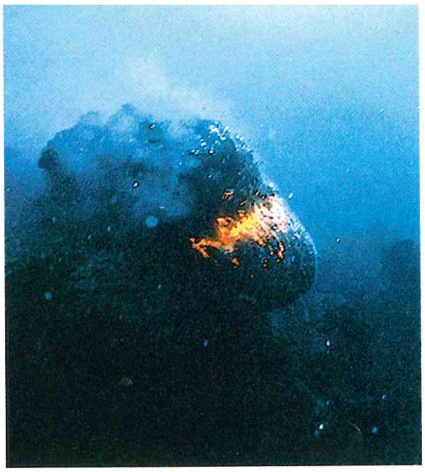


Figure 2 *Volcanic vents on the ocean floor, such as this vent off the coast of Hawaii, allow magma to rise up through the crust from the mantle.*

The Core

The layer of the Earth that extends from below the mantle to the center of the Earth is the **core.** Scientists think that the Earth's core is made mostly of iron and contains smaller amounts of nickel but almost no oxygen, silicon, aluminum, or magnesium. As shown in **Figure 3,** the core makes up roughly one-third of the Earth's mass.

crust the thin and solid outermost layer of the Earth above the mantle

mantle the layer of rock between the Earth's crust and core

core the central part of the Earth below the mantle

Reading Check **Briefly describe the layers that make up the Earth.** (*See the Appendix for answers to Reading Checks.*)

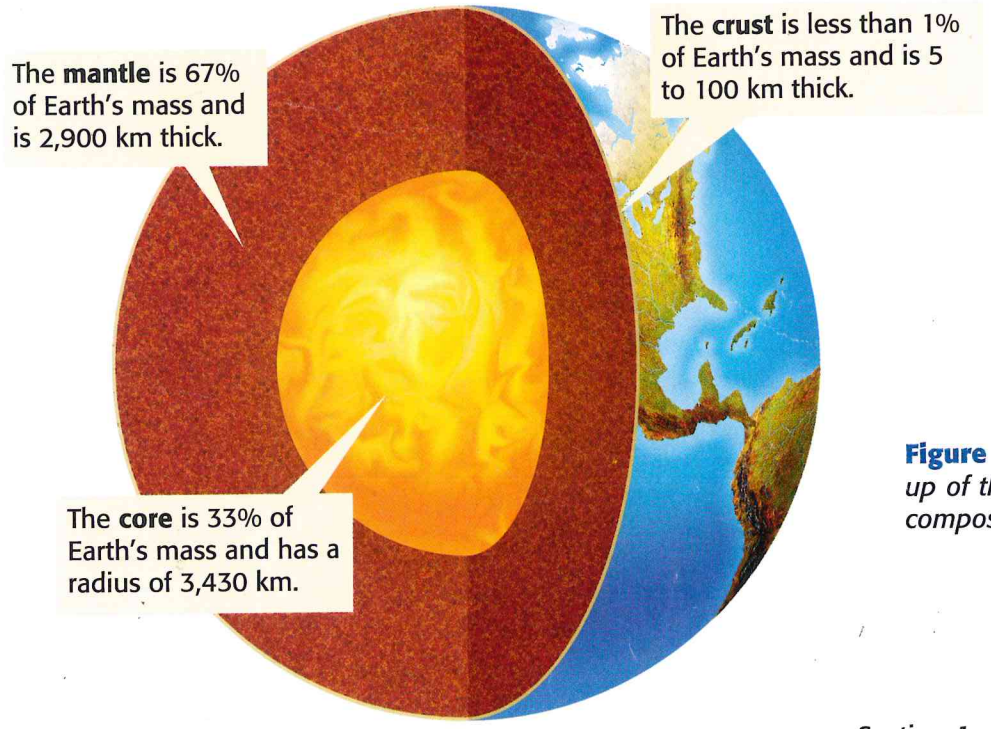


Figure 3 *The Earth is made up of three layers based on the composition of each layer.*

The Physical Structure of the Earth

Another way to look at the Earth is to examine the physical properties of its layers. The Earth is divided into five physical layers—the lithosphere, asthenosphere, mesosphere, outer core, and inner core. As shown in the figure below, each layer has its own set of physical properties.

Reading Check What are the five physical layers of the Earth?

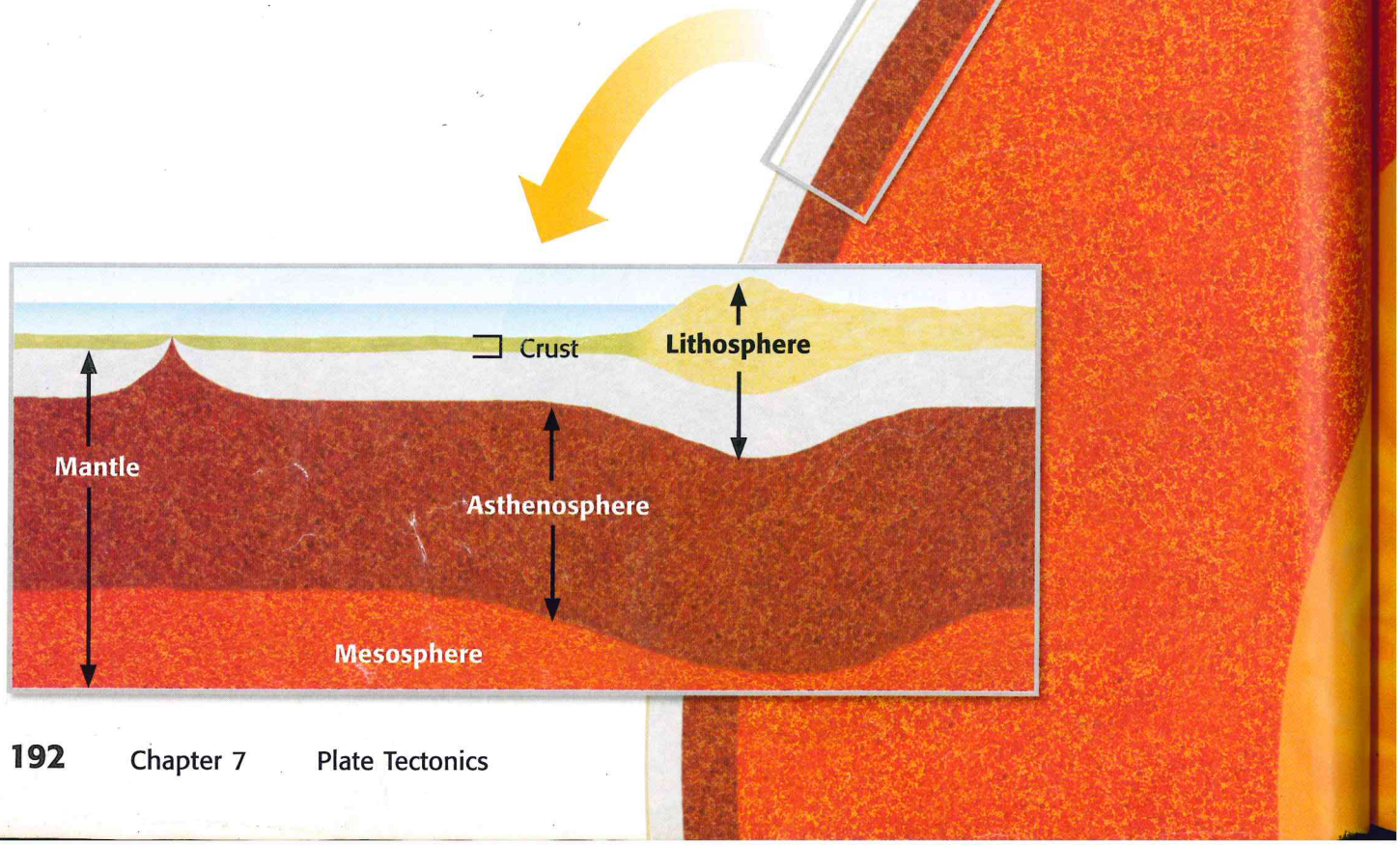
MATH PRACTICE

Using Models

Imagine that you are building a model of the Earth that will have a radius of 1 m. You find out that the average radius of the Earth is 6,380 km and that the thickness of the lithosphere is about 150 km. What percentage of the Earth's radius is the lithosphere? How thick (in centimeters) would you make the lithosphere in your model?

Lithosphere The outermost, rigid layer of the Earth is the **lithosphere.** The lithosphere is made of two parts—the crust and the rigid upper part of the mantle. The lithosphere is divided into pieces called *tectonic plates.*

Asthenosphere The **asthenosphere** is a plastic layer of the mantle on which pieces of the lithosphere move. The asthenosphere is made of solid rock that flows very slowly.

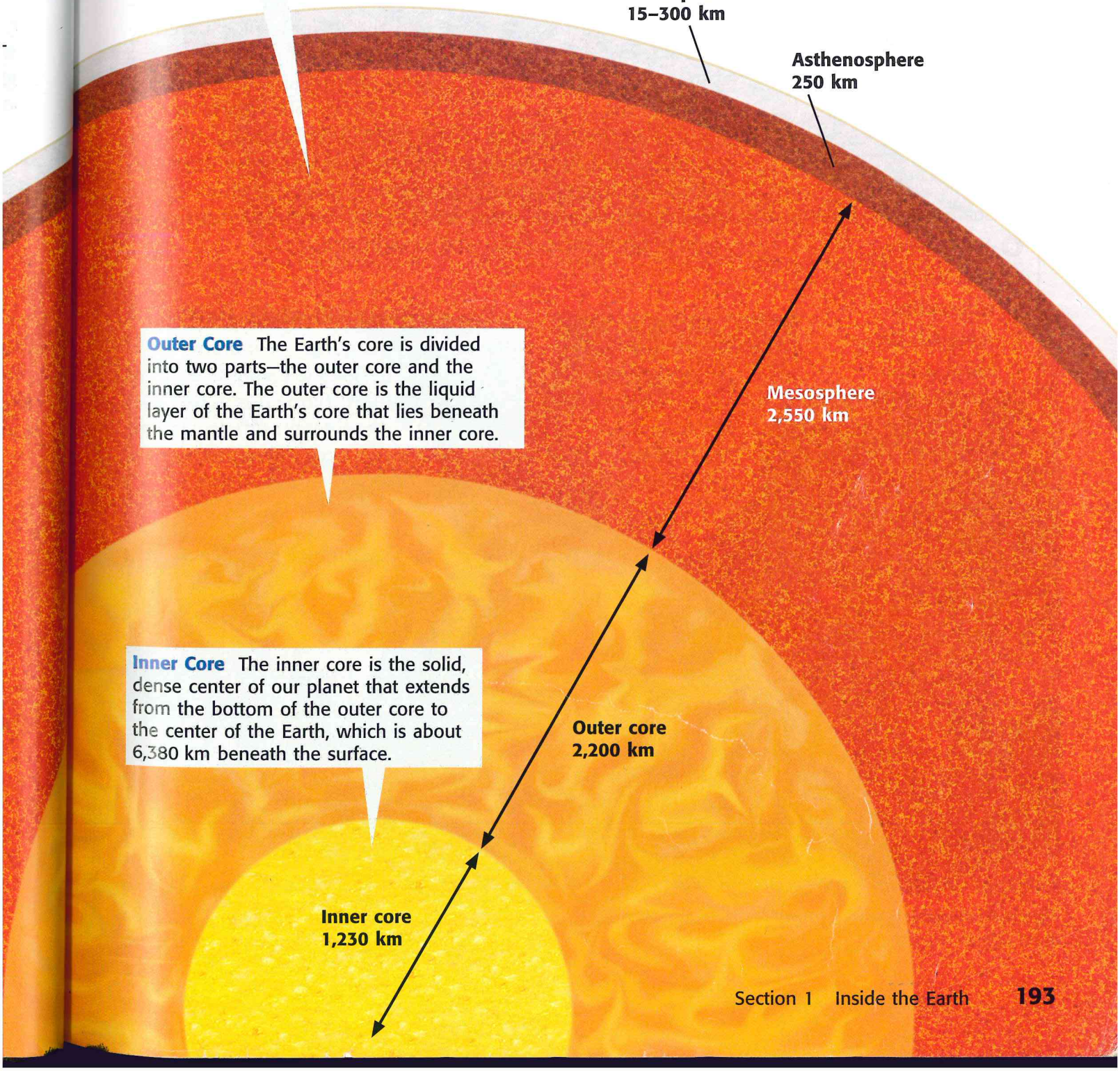


lithosphere the solid, outer layer of the Earth that consists of the crust and the rigid upper part of the mantle

asthenosphere the soft layer of the mantle on which the tectonic plates move

mesosphere the strong, lower part of the mantle between the asthenosphere and the outer core

Mesosphere Beneath the asthenosphere is the strong, lower part of the mantle called the **mesosphere.** The mesosphere extends from the bottom of the asthenosphere to the Earth's core.



Outer Core The Earth's core is divided into two parts—the outer core and the inner core. The outer core is the liquid layer of the Earth's core that lies beneath the mantle and surrounds the inner core.

Inner Core The inner core is the solid, dense center of our planet that extends from the bottom of the outer core to the center of the Earth, which is about 6,380 km beneath the surface.

Tectonic Plates

tectonic plate a block of lithosphere that consists of the crust and the rigid, outermost part of the mantle

Pieces of the lithosphere that move around on top of the asthenosphere are called **tectonic plates**. But what exactly does a tectonic plate look like? How big are tectonic plates? How and why do they move around? To answer these questions, begin by thinking of the lithosphere as a giant jigsaw puzzle.

A Giant Jigsaw Puzzle

All of the tectonic plates have names, some of which you may already know. Some of the major tectonic plates are named on the map in **Figure 4.** Notice that each tectonic plate fits together with the tectonic plates that surround it. The lithosphere is like a jigsaw puzzle, and the tectonic plates are like the pieces of a jigsaw puzzle.

Notice that not all tectonic plates are the same. For example, compare the size of the South American plate with that of the Cocos plate. Tectonic plates differ in other ways, too. For example, the South American plate has an entire continent on it and has oceanic crust, but the Cocos plate has only oceanic crust. Some tectonic plates, such as the South American plate, include both continental and oceanic crust.

Major Tectonic Plates

1. Pacific plate
2. North American plate
3. Cocos plate
4. Nazca plate
5. South American plate
6. African plate
7. Eurasian plate
8. Indian plate
9. Australian plate
10. Antarctic plate

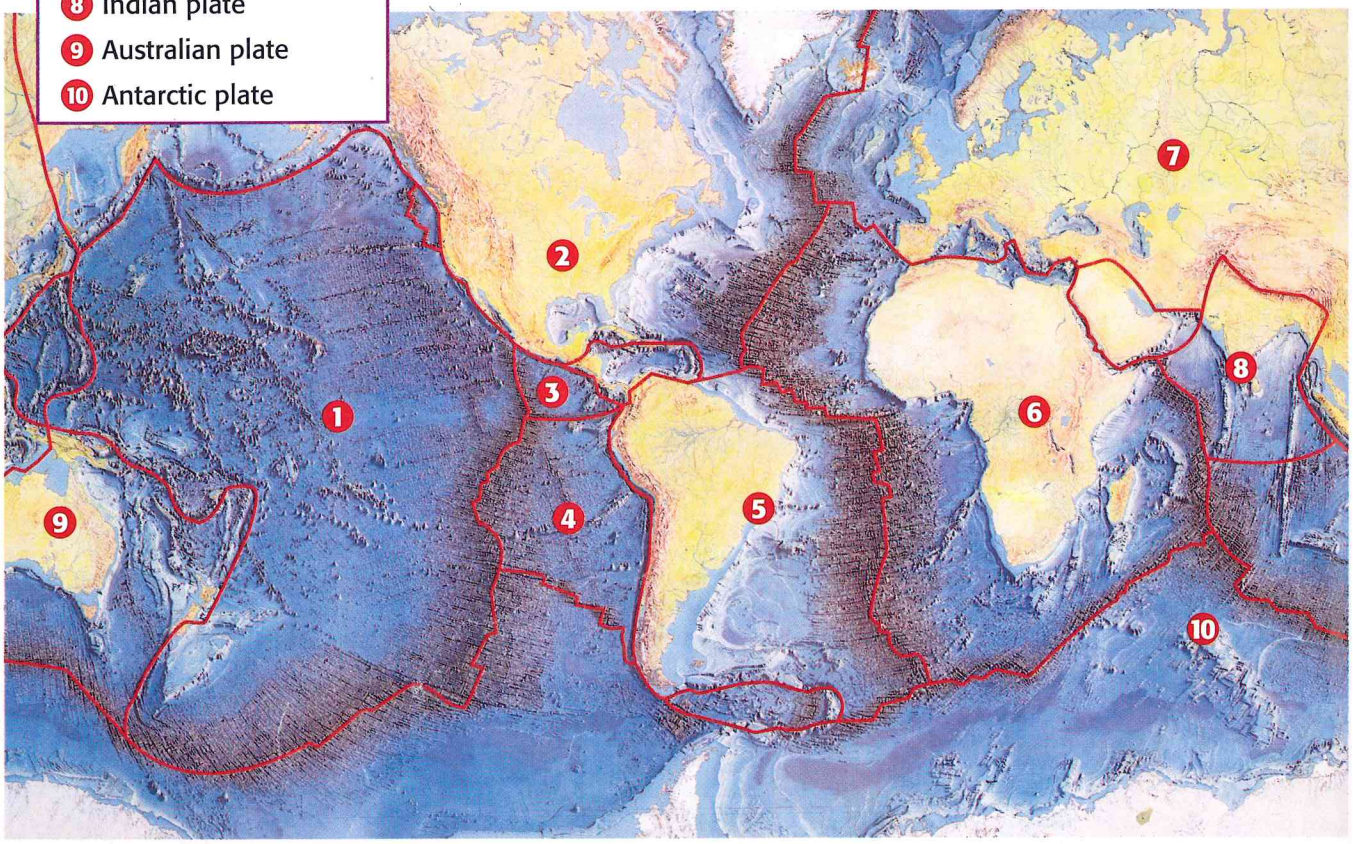
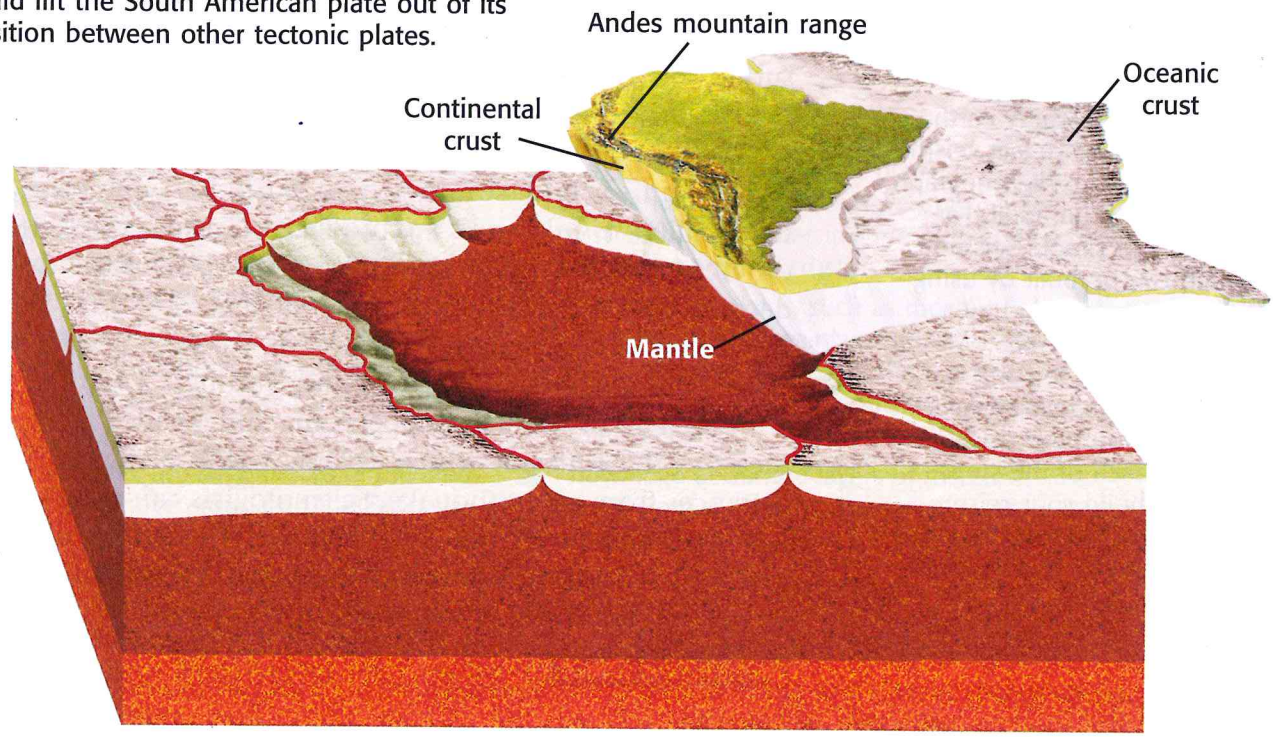


Figure 4 *Tectonic plates fit together like the pieces of a giant jigsaw puzzle.*

Figure 5 **The South American Plate**

This image shows what you might see if you could lift the South American plate out of its position between other tectonic plates.



A Tectonic Plate Close-Up

What would a tectonic plate look like if you could lift it out of its place? **Figure 5** shows what the South American plate might look like if you could. Notice that this tectonic plate not only consists of the upper part of the mantle but also consists of both oceanic crust and continental crust. The thickest part of the South American plate is the continental crust. The thinnest part of this plate is in the mid-Atlantic Ocean.

Like Ice Cubes in a Bowl of Punch

Think about ice cubes floating in a bowl of punch. If there are enough cubes, they will cover the surface of the punch and bump into one another. Parts of the ice cubes are below the surface of the punch and displace the punch. Large pieces of ice displace more punch than small pieces of ice. Tectonic plates "float" on the asthenosphere in a similar way. The plates cover the surface of the asthenosphere, and they touch one another and move around. The lithosphere displaces the asthenosphere. Thick tectonic plates, such as those made of continental crust, displace more asthenosphere than do thin plates, such as those made of oceanic lithosphere.

Reading Check **Why do tectonic plates made of continental lithosphere displace more asthenosphere than tectonic plates made of oceanic lithosphere do?**

Quick Lab

Tectonic Ice Cubes

1. Take the bottom half of a clear, **2 L soda bottle** that has been cut in half. Make sure that the label has been removed.
2. Fill the bottle with **water** to about 1 cm below the top edge of the bottle.
3. Get **three pieces of irregularly shaped ice** that are small, medium, and large.
4. Float the ice in the water, and note how much of each piece is below the surface of the water.
5. Do all pieces of ice float mostly below the surface? Which piece is mostly below the surface? Why?

SCHOOL to HOME

Build a Seismograph

Seismographs are instruments that seismologists, scientists who study earthquakes, use to detect seismic waves. Research seismograph designs with an adult. For example, a simple seismograph can be built by using a weight suspended by a spring next to a ruler. With an adult, attempt to construct a home seismograph based on a design you have selected. Outline each of the steps used to build your seismograph, and present the written outline to your teacher.

ACTIVITY

Mapping the Earth's Interior

How do scientists know things about the deepest parts of the Earth, where no one has ever been? Scientists have never even drilled through the crust, which is only a thin skin on the surface of the Earth. So, how do we know so much about the mantle and the core?

Would you be surprised to know that some of the answers come from earthquakes? When an earthquake happens, vibrations called *seismic waves* are produced. Seismic waves travel at different speeds through the Earth. Their speed depends on the density and composition of material that they pass through. For example, a seismic wave traveling through a solid will go faster than a seismic wave traveling through a liquid.

When an earthquake happens, machines called *seismographs* measure the times at which seismic waves arrive at different distances from an earthquake. Seismologists can then use these distances and travel times to calculate the density and thickness of each physical layer of the Earth. **Figure 6** shows how seismic waves travel through the Earth.

Reading Check **What are some properties of seismic waves?**

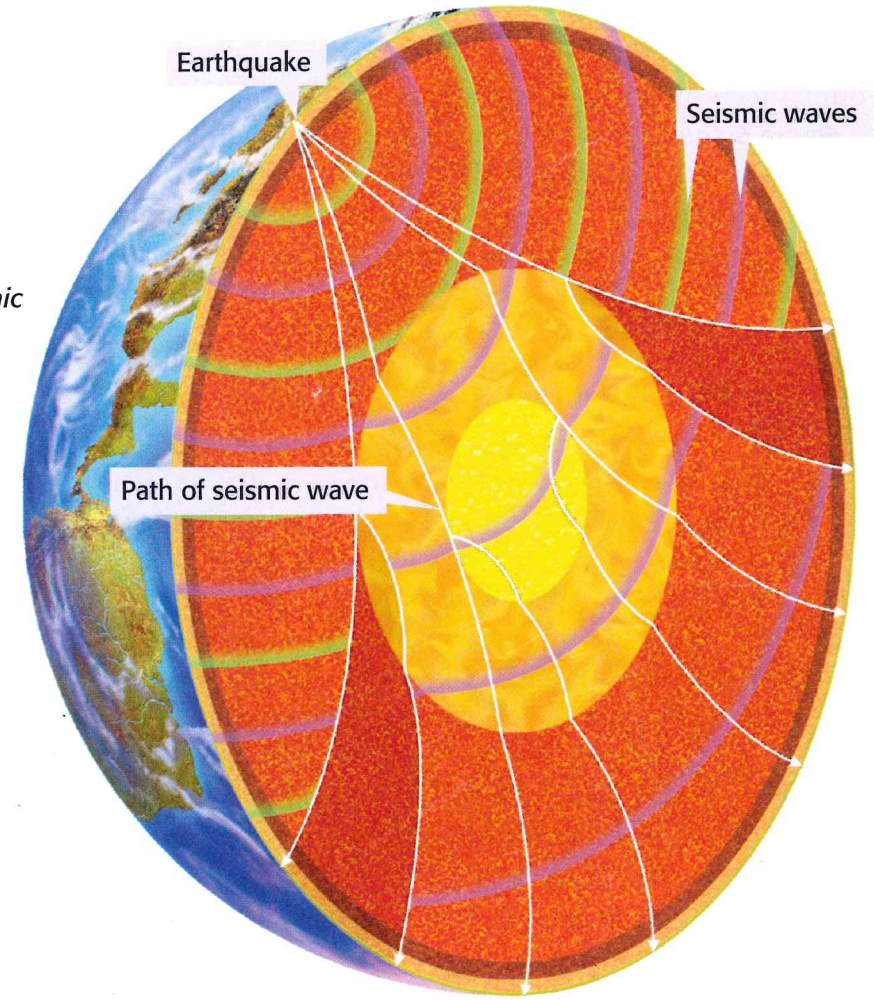


Figure 6 *By measuring changes in the speed of seismic waves that travel through Earth's interior, seismologists have learned that the Earth is made of different layers.*