Section 1

Earth's Interior

Reading Preview

Key Concepts

- How have geologists learned about Earth's inner structure?
- What are the characteristics of Earth's crust, mantle, and core?

Key Terms

- seismic waves
- pressure
- crust
- basalt
- granite
- mantle
- lithosphere
- asthenosphere
- outer core
- inner core

Target Reading Skill

Using Prior Knowledge Before you read, look at the section headings and visuals to see what this section is about. Then write what you know about Earth's interior in a graphic organizer like the one below. As you read, write what you learn.

What You Know
1. Earth's crust is made of rock. 2.

What You Learned
1. 2.

Lab zone Discover Activity

How Do Scientists Find Out What's Inside Earth?

1. Your teacher will provide you with three closed film canisters. Each canister contains a different material. Your goal is to determine what is inside each canister—even though you can't directly observe what it contains.
2. Tape a paper label on each canister.
3. To gather evidence about what is in the canisters, you may tap, roll, shake, or weigh them. Record your observations.
4. What differences do you notice between the canisters? Apart from their appearance on the outside, are the canisters similar in any way? How did you obtain this evidence?

Think It Over

Inferring From your observations, what can you infer about the contents of the canisters? How is a canister like Earth?

Imagine watching an island grow! That's exactly what you can do on the island of Hawaii. On the south side of the island, molten material pours out of cracks in Mount Kilauea (kee loo AY uh) and flows into the ocean. As this lava flows over the land, it cools and hardens into rock.

The most recent eruptions of Mount Kilauea began in 1983. An area of cracks 7 kilometers long opened in Earth's surface. Through the cracks spurted "curtains of fire"—fountains of hot liquid rock from deep inside Earth. Since that time, the lava has covered more than 100 square kilometers of land with a layer of rock. When the lava reaches the sea, it extends the borders of the island into the Pacific Ocean.

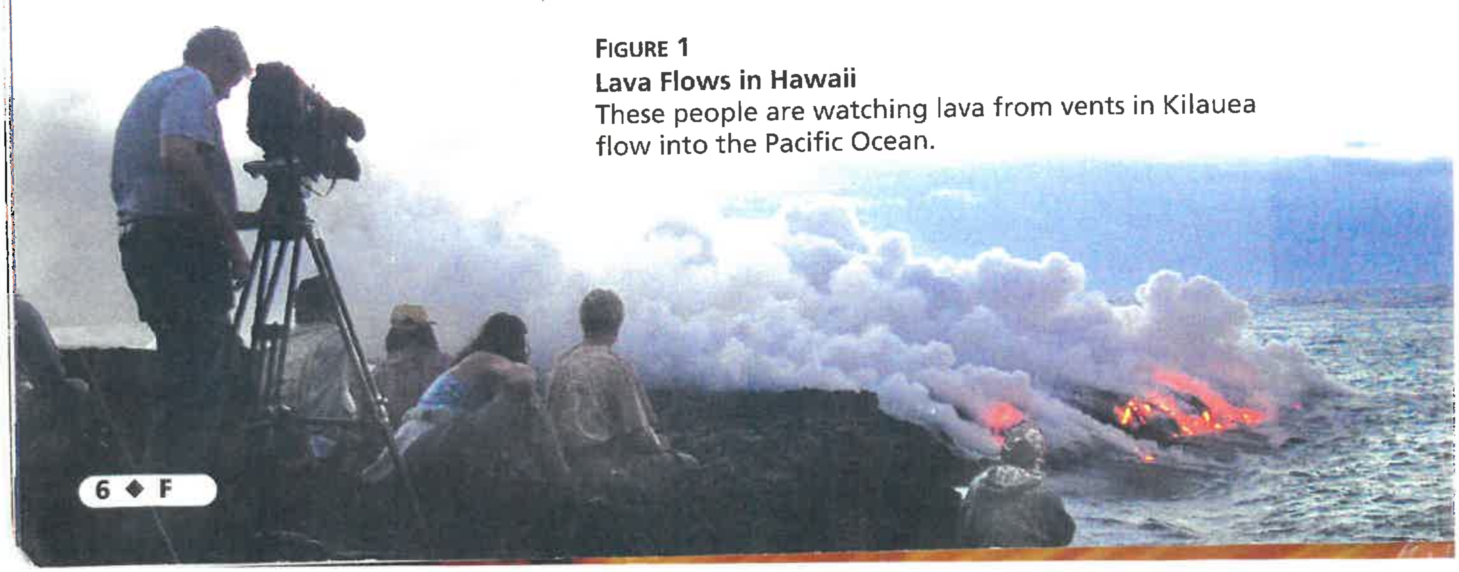

FIGURE 1
Lava Flows in Hawaii
These people are watching lava from vents in Kilauea flow into the Pacific Ocean.

FIGURE 2
Getting Beneath the Surface
Geologists (left) examine rocks for clues about what's inside Earth. Even though caves like this one in Georgia (below) may seem deep, they reach only a relatively short distance beneath the surface.

Exploring Inside Earth

Earth's surface is constantly changing. Throughout our planet's long history, its surface has been lifted up, pushed down, bent, and broken. Thus Earth looks different today from the way it did millions of years ago.

Volcanic eruptions like those at Mount Kilauea make people wonder, What's inside Earth? Yet this question is very difficult to answer. Much as geologists would like to, they cannot dig a hole to the center of Earth. The extreme conditions in Earth's interior prevent exploration far below the surface.

The deepest mine in the world, a gold mine in South Africa, reaches a depth of 3.8 kilometers. But that mine only scratches the surface. You would have to travel more than 1,600 times that distance—over 6,000 kilometers—to reach Earth's center. **Geologists have used two main types of evidence to learn about Earth's interior: direct evidence from rock samples and indirect evidence from seismic waves.** The geologists in Figure 2 are observing rock on Earth's surface.

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Evidence From Rock Samples Rocks from inside Earth give geologists clues about Earth's structure. Geologists have drilled holes as much as 12 kilometers into Earth. The drills bring up samples of rock. From these samples, geologists can make inferences about conditions deep inside Earth, where these rocks formed. In addition, forces inside Earth sometimes blast rock to the surface from depths of more than 100 kilometers. These rocks provide more information about the interior.

Evidence From Seismic Waves Geologists cannot look inside Earth. Instead, they must rely on indirect methods of observation. Have you ever hung a heavy picture on a wall? If you have, you know that you can knock on the wall to locate the wooden beam underneath the plaster that will support the picture. When you knock on the wall, you listen carefully for a change in the sound.

To study Earth's interior, geologists also use an indirect method. But instead of knocking on walls, they use seismic waves. When earthquakes occur, they produce **seismic waves** (SYZ mik). Geologists record the seismic waves and study how they travel through Earth. The speed of seismic waves and the paths they take reveal the structure of the planet.

Using data from seismic waves, geologists have learned that Earth's interior is made up of several layers. Each layer surrounds the layers beneath it, much like the layers of an onion. In Figure 3, you can see how seismic waves travel through the layers that make up Earth.

Reading Checkpoint What causes seismic waves?

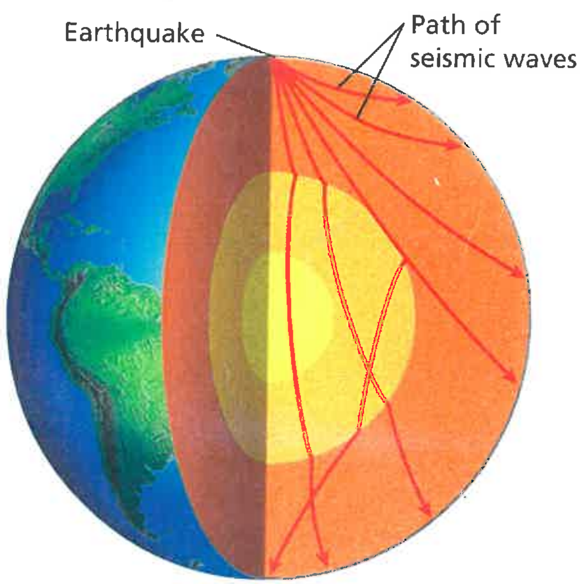
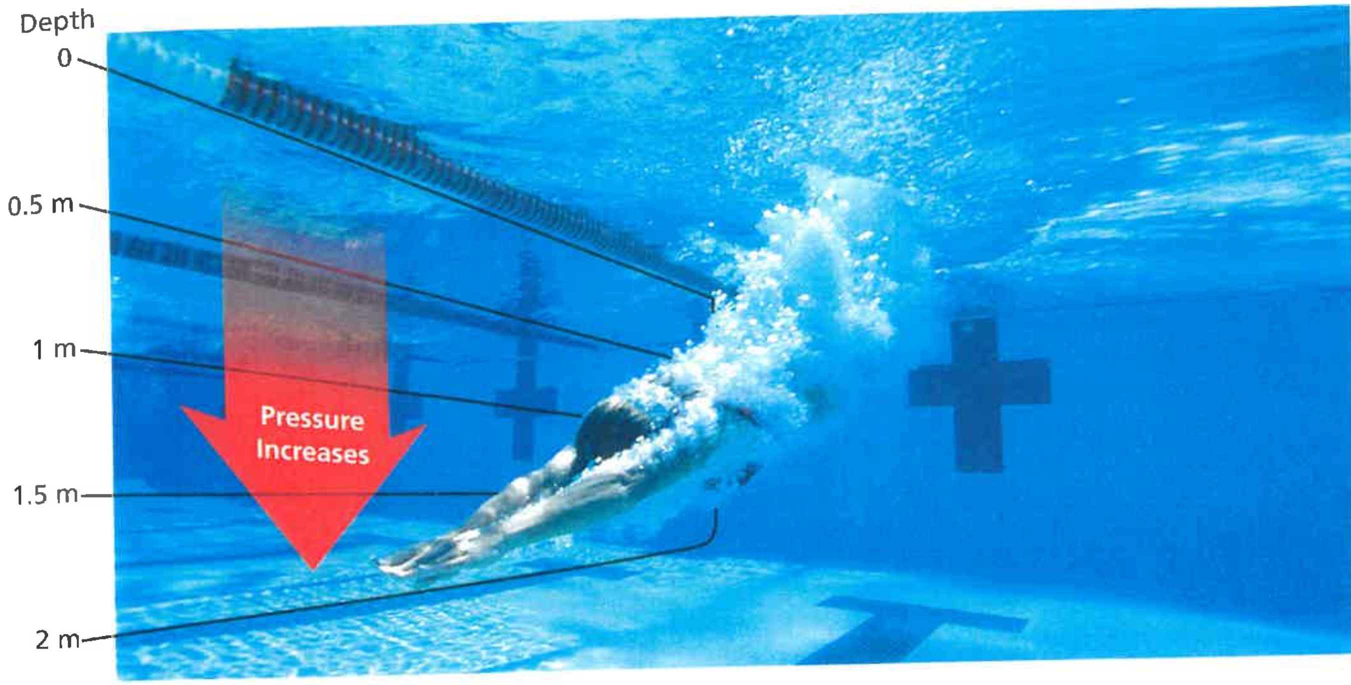


FIGURE 3
Seismic Waves
Scientists infer Earth's inner structure by recording and studying how seismic waves travel through Earth.



A Journey to the Center of Earth

The three main layers of Earth are the crust, the mantle, and the core. These layers vary greatly in size, composition, temperature, and pressure. If you could travel through these layers to the center of Earth, what would your trip be like? To begin, you will need a vehicle that can travel through solid rock. The vehicle will carry scientific instruments to record changes in temperature and pressure as you descend.

Temperature As you start to tunnel beneath the surface, the surrounding rock is cool. Then at about 20 meters down, your instruments report that the rock is getting warmer. For every 40 meters that you descend from that point, the temperature rises 1 Celsius degree. This rapid rise in temperature continues for several tens of kilometers. After that, the temperature increases more slowly, but steadily. The high temperatures inside Earth are the result of heat left over from the formation of the planet. In addition, radioactive substances inside Earth release energy. This further heats the interior.

Pressure During your journey to the center of Earth, your instruments record an increase in pressure in the surrounding rock. **Pressure** results from a force pressing on an area. Because of the weight of the rock above, pressure inside Earth increases as you go deeper. The deeper you go, the greater the pressure. Pressure inside Earth increases much as it does in the swimming pool in Figure 4.

FIGURE 4
Pressure and Depth
The deeper this swimmer goes, the greater the pressure from the surrounding water.
Comparing and Contrasting *How is the water in the swimming pool similar to Earth's interior? How is it different?*

The Crust

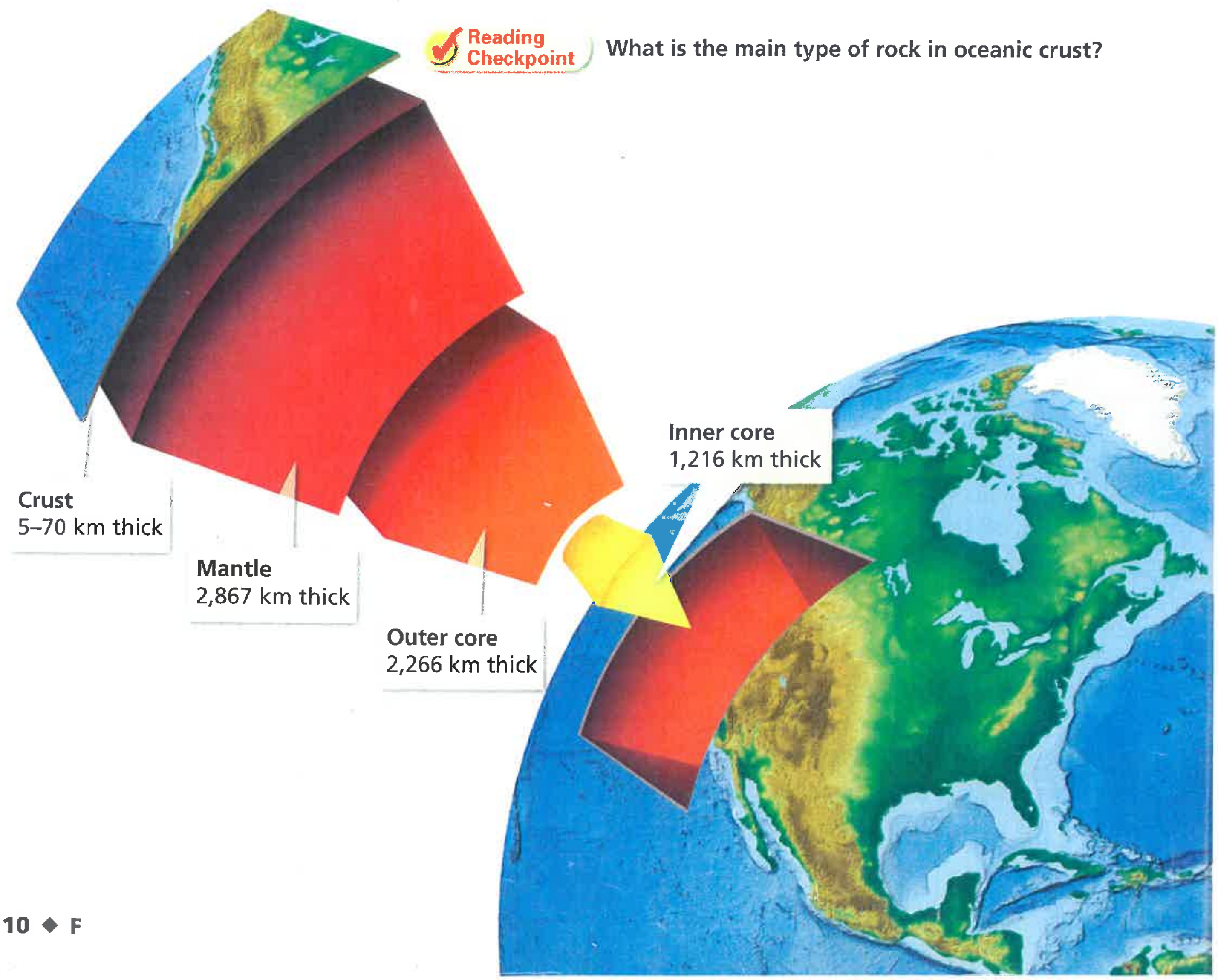
Your journey to the center of Earth begins in the crust. The **crust** is the layer of rock that forms Earth's outer skin. **The crust is a layer of solid rock that includes both dry land and the ocean floor.** On the crust you find rocks and mountains. The crust also includes the soil and water that cover large parts of Earth's surface.

This outer rind of rock is much thinner than the layer that lies beneath it. In fact, you can think of Earth's crust as being similar to the paper-thin skin of an onion. The crust is thickest under high mountains and thinnest beneath the ocean. In most places, the crust is between 5 and 40 kilometers thick. But it can be up to 70 kilometers thick beneath mountains.

The crust beneath the ocean is called oceanic crust. Oceanic crust consists mostly of rocks such as basalt. **Basalt** (buh SAWLT) is dark rock with a fine texture. Continental crust, the crust that forms the continents, consists mainly of rocks such as granite. **Granite** is a rock that usually is a light color and has a coarse texture.

Reading Checkpoint **What is the main type of rock in oceanic crust?**

FIGURE 5
Earth's Interior
Earth's interior is divided into layers: the crust, mantle, outer core, and inner core.
Interpreting Diagrams *Which of Earth's layers is the thickest?*



The Mantle

Your journey downward continues. About 40 kilometers beneath the surface, you cross a boundary. Below the boundary is the solid material of the **mantle,** a layer of hot rock. **Earth's mantle is made up of rock that is very hot, but solid. Scientists divide the mantle into layers based on the physical characteristics of those layers. Overall, the mantle is nearly 3,000 kilometers thick.**

The Lithosphere The uppermost part of the mantle is very similar to the crust. The uppermost part of the mantle and the crust together form a rigid layer called the **lithosphere** (LITH uh sfeer). In Greek, *lithos* means "stone." As you can see in Figure 6, the lithosphere averages about 100 kilometers thick.

The Asthenosphere Below the lithosphere, your vehicle encounters material that is hotter and under increasing pressure. As a result, the part of the mantle just beneath the lithosphere is less rigid than the rock above. Like road tar softened by the heat of the sun, this part of the mantle is somewhat soft—it can bend like plastic. This soft layer is called the **asthenosphere** (as THEN uh sfeer). In Greek, *asthenes* means "weak." Although the asthenosphere is softer than the rest of the mantle, it's still solid. If you kicked it, you would stub your toe.

The Lower Mantle Beneath the asthenosphere, the mantle is solid. This solid material extends all the way to Earth's core.

Reading Checkpoint What is the asthenosphere?

Lab zone Skills Activity

Creating Data Tables

Imagine that you are in a super-strong vehicle that is tunneling deep into Earth's interior. You stop several times on your trip to collect data. Copy the data table. For each depth, identify the layer and what that layer is made of. Then complete the table.

Data Table

Depth	Name of Layer	What Layer Is Made Of
20 km		
150 km		
2,000 km		
4,000 km		
6,000 km		

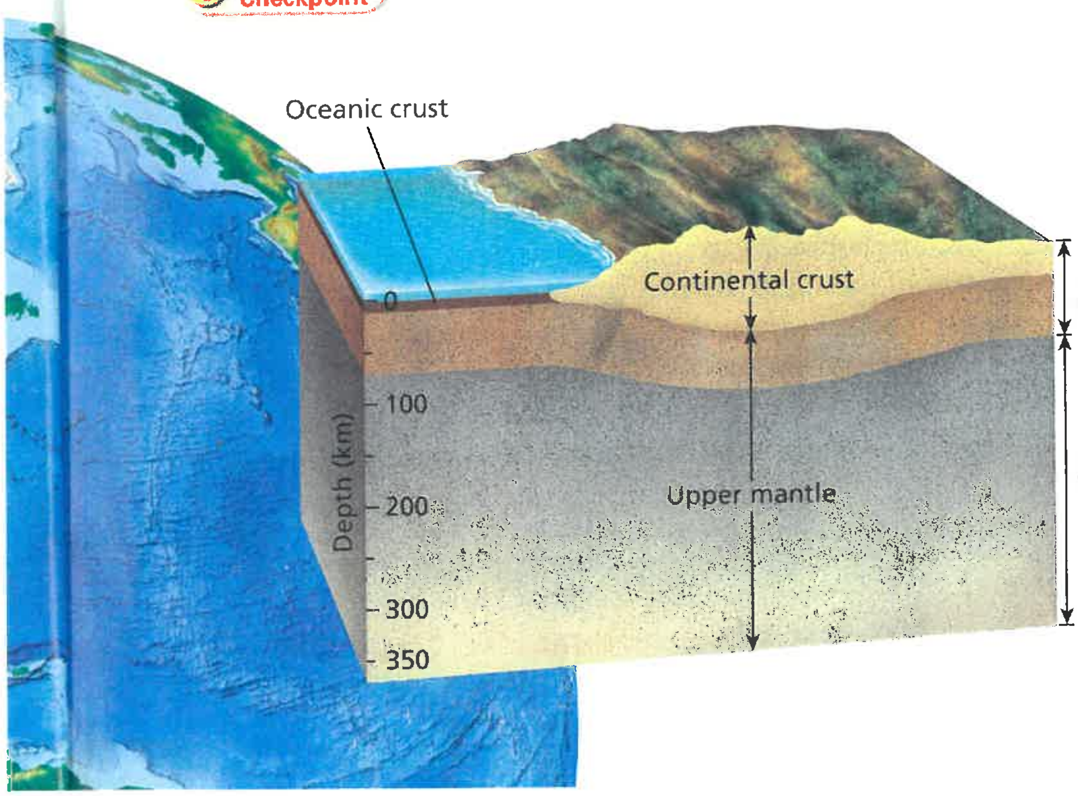


FIGURE 6
Lithosphere and Asthenosphere
The rigid lithosphere, which includes the crust, rests on the softer material of the asthenosphere.

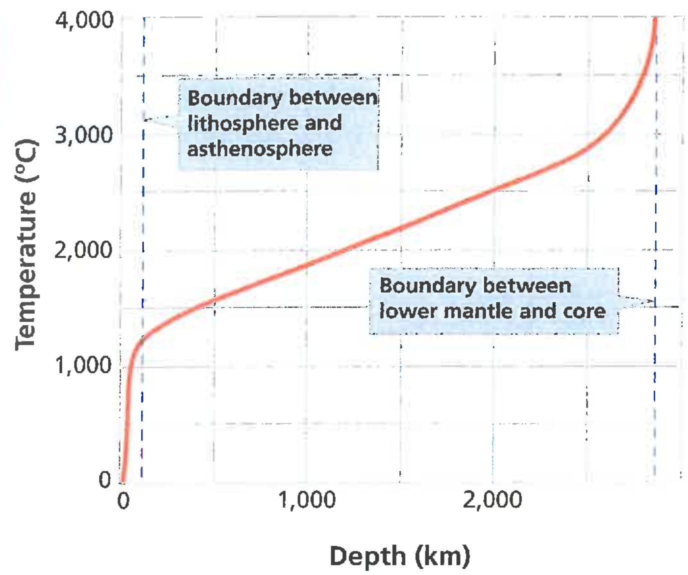
Math Analyzing Data

Temperature Inside Earth

The graph shows how temperatures change between Earth's surface and the bottom of the mantle. On this graph, the temperature at Earth's surface is 0°C. Study the graph carefully and then answer the questions.

1. **Reading Graphs** As you move from left to right on the *x*-axis, how does depth inside Earth change?
2. **Estimating** What is the temperature at the boundary between the lithosphere and the asthenosphere?
3. **Estimating** What is the temperature at the boundary between the lower mantle and the core?
4. **Interpreting Data** How does temperature change with depth in Earth's interior?

Temperature and Depth



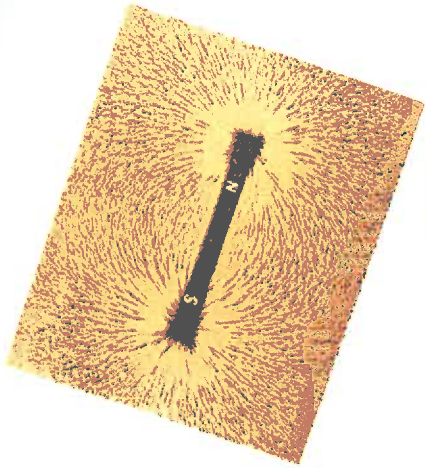
The Core

After traveling through the mantle, you reach Earth's core. **The core is made mostly of the metals iron and nickel. It consists of two parts—a liquid outer core and a solid inner core.** Together, the inner and outer core are 3,486 kilometers thick.

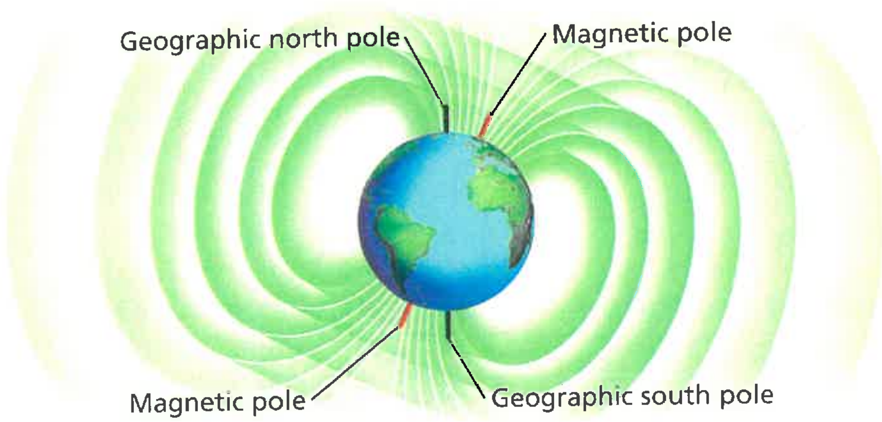
Outer Core and Inner Core The **outer core** is a layer of molten metal that surrounds the inner core. Despite enormous pressure, the outer core is liquid. The **inner core** is a dense ball of solid metal. In the inner core, extreme pressure squeezes the atoms of iron and nickel so much that they cannot spread out and become liquid.

Most of the current evidence suggests that both parts of the core are made of iron and nickel. But scientists have found data suggesting that the core also contains substances such as oxygen, sulfur, and silicon. Scientists must seek more data before they decide which of these other substances is most important.

Reading Checkpoint **What is the main difference between the outer core and the inner core?**



Bar Magnet's Magnetic Field
The pattern of iron filings was made by sprinkling them on paper placed under a bar magnet.



Earth's Magnetic Field
Like a magnet, Earth's magnetic field has north and south poles.

FIGURE 7
Earth's Magnetic Field
Just as a bar magnet is surrounded by its own magnetic field, Earth's magnetic field surrounds the planet.
Relating Cause and Effect *If you shifted the magnet beneath the paper, what would happen to the iron filings?*

The Core and Earth's Magnetic Field Scientists think that movements in the liquid outer core create Earth's magnetic field. Because Earth has a magnetic field, the planet acts like a giant bar magnet. As you can see in Figure 7, the magnetic field affects the whole Earth.

Consider an ordinary bar magnet. If you place it on a piece of paper and sprinkle iron filings on the paper, the iron filings line up with the bar's magnetic field. If you could cover the entire planet with iron filings, they would form a similar pattern. When you use a compass, the compass needle aligns with the lines of force in Earth's magnetic field.

Section 1 Assessment

Target Reading Skill Using Prior Knowledge Review your graphic organizer and revise it based on what you just learned in the section.

Reviewing Key Concepts

1. a. **Explaining** Why is it difficult to determine Earth's inner structure?
   b. **Inferring** How are seismic waves used to provide evidence about Earth's interior?
2. a. **Listing** List Earth's three main layers.
   b. **Comparing and Contrasting** What is the difference between the lithosphere and the asthenosphere? In which layer is each located?
   c. **Classifying** Classify each of the following layers as liquid, solid, or solid but able to flow slowly: lithosphere, asthenosphere, lower mantle, outer core, inner core.

Writing in Science

Narrative Write a narrative of your own imaginary journey to the center of Earth. Your narrative should describe the layers of Earth through which you travel and how temperature and pressure change beneath the surface.