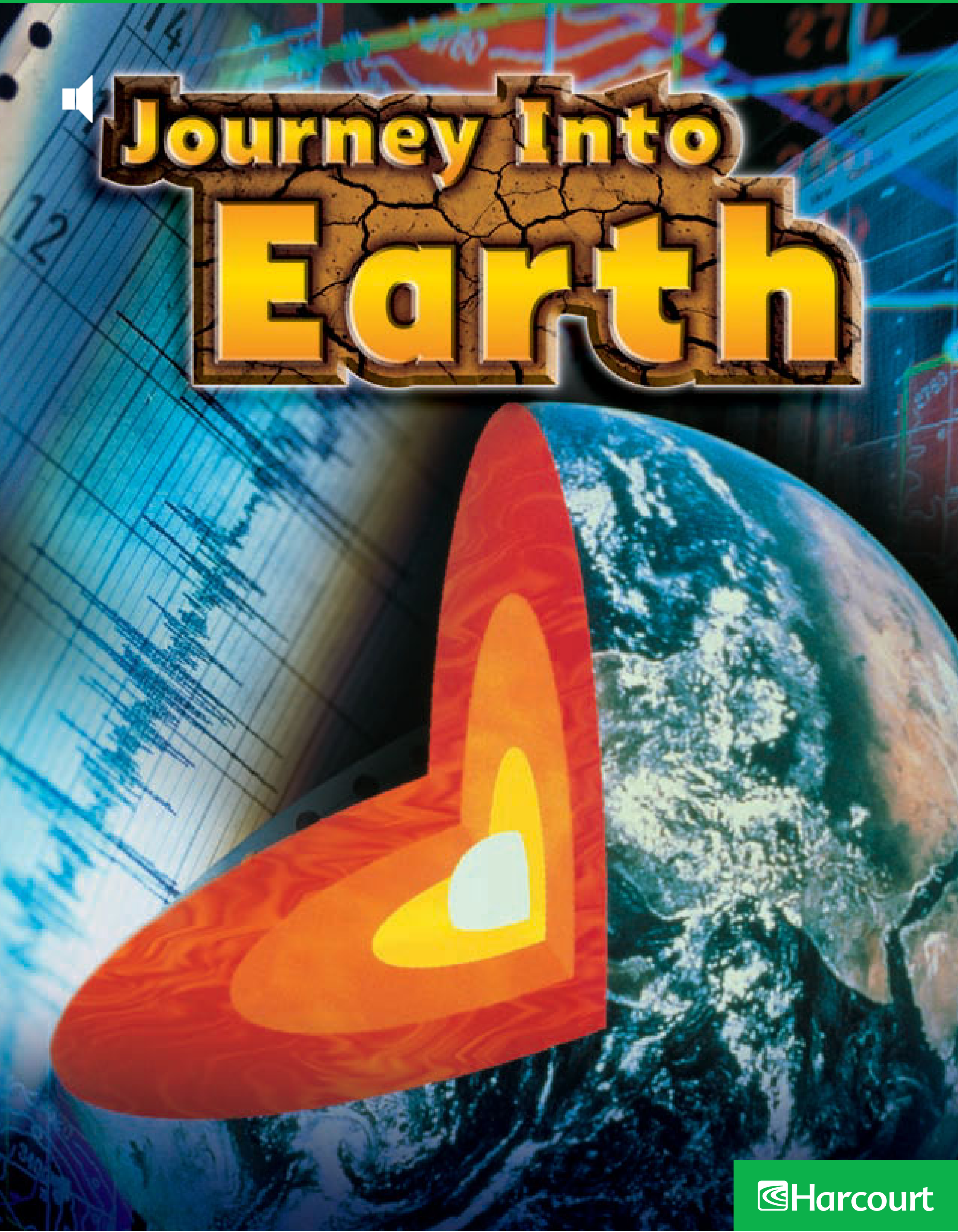
Journey Into Earth



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Journey Into Earth

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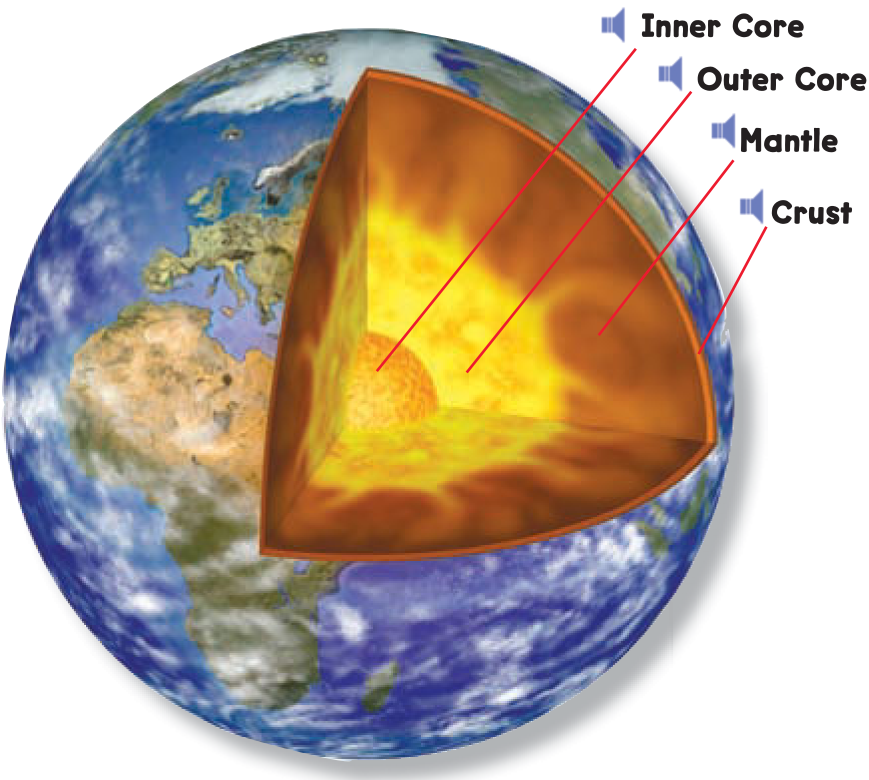
Introduction

To eat a hard-boiled egg, you first have to crack the hard, outer shell. The shell breaks into pieces that you can peel away. When you cut the shelled egg in half, you see a layer of white surrounding the yellow yolk at the center.

A hard-boiled egg makes a good model of Earth. Like an egg, Earth is made up of three main layers. Earth's three layers are the crust, the mantle, and the core. Let's find out more about Earth's layers.

Earth is made up of layers, just like a hard-boiled egg.



Making a Layered Earth

How did Earth become layered? Scientists believe that when the planet formed about 4.6 billion years ago, it was a fiery ball covered by molten (liquid) rock. Heavy materials, such as nickel and iron, sank to the center of the liquid Earth just as stones sink in a bowl of water. Lighter materials such as silicon and oxygen rose toward the surface. As Earth cooled, the hot liquid at the surface became a hard, solid crust. Eventually, this crust broke into pieces like the cracked shell of an egg.

The result of all of this separating and cooling was a layered planet, with each layer having its own composition and own properties.

The Core

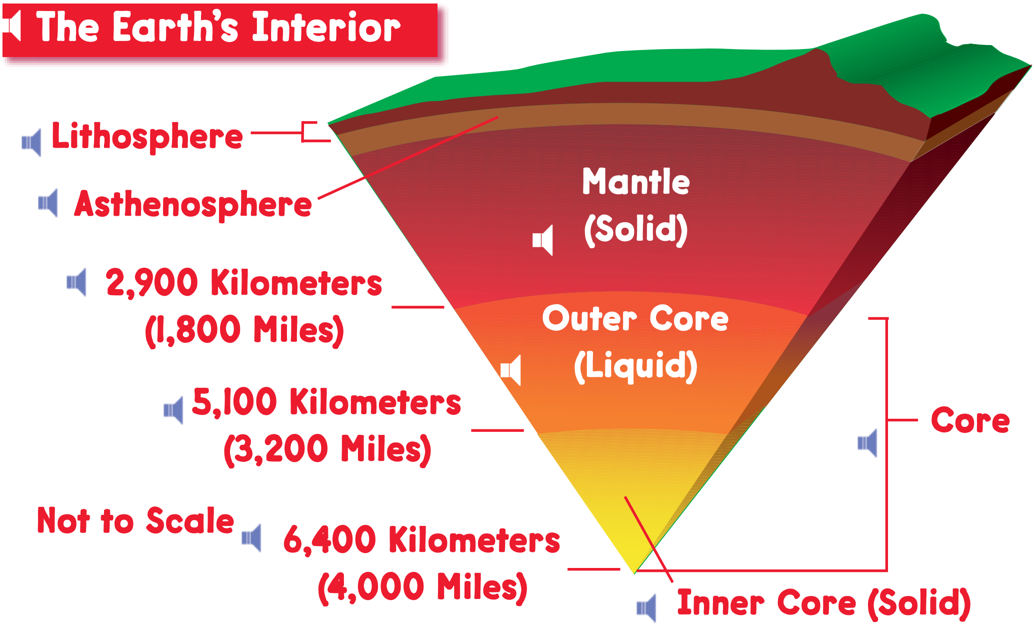
The Earth's core consists of two parts: an inner core and an outer core. These two parts are made up of the heavy metals that sank while Earth was forming. The inner core consists mostly of iron and is a solid ball. It's surrounded by the outer core, a melted layer of nickel and iron.

If you could journey to the center of the Earth, you probably would not have much fun. For one thing, you would have to travel far to reach the center of Earth —about 6,380 kilometers (4,000 mi)! That's almost twice the distance from Washington, D.C., to Phoenix, Arizona.

The core itself measures about 7,000 kilometers (4,300 mi) across its diameter. It is so large, the planet Mars could actually fit inside of it.

Another reason the core would be a bad place to visit is its temperature. The core is so hot, temperatures there can reach between 5,000 degrees Celsius (9,000°F) and 7,000 degrees Celsius (12,600°F). That's about 25 times hotter than your kitchen oven's highest temperature! Because the temperature is so hot, you might wonder why the inner core is not melted like the outer core. The inner core is under tremendous pressure from all the other layers pushing down on it. And if you traveled to Earth's center, your body would be under 3 million times more pressure than it is right now. This pressure keeps Earth's center solid.

The Earth's Interior

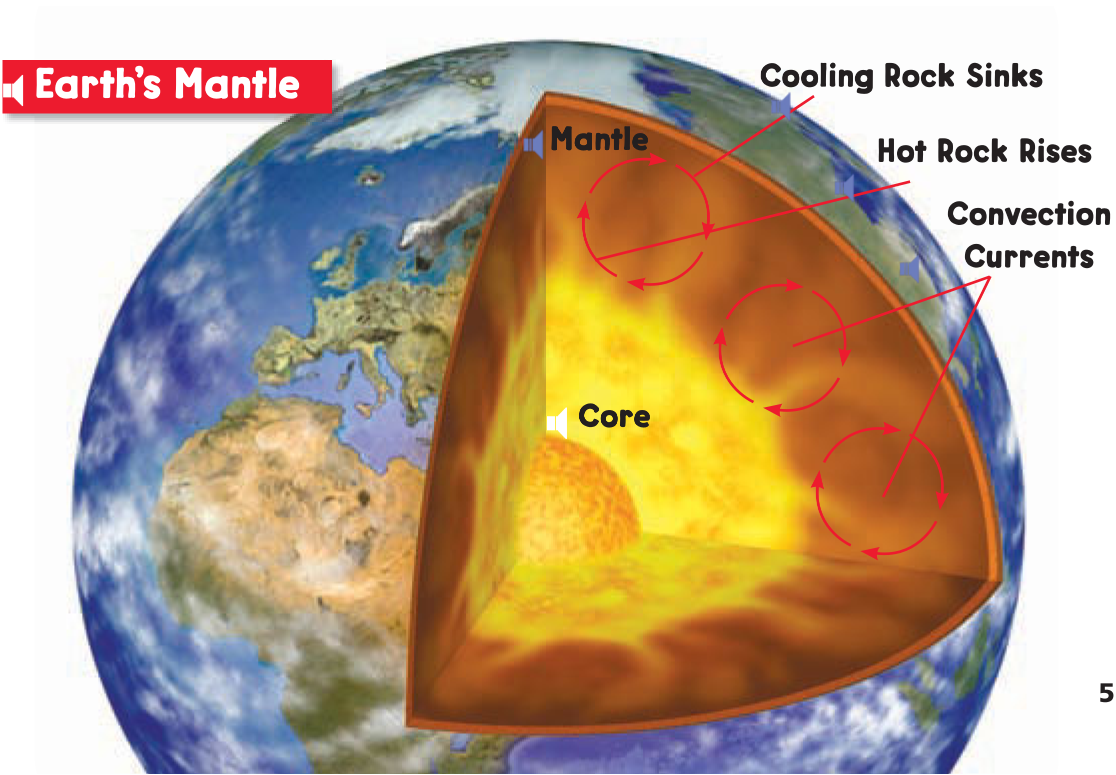


The Mantle

Between the core and the crust is the mantle. The mantle is about 2,900 kilometers (1,800 mi) thick. Scientists believe that olivine, a mineral rich in iron and magnesium, makes up most of the mantle. This layer is not as rich in iron as the core, but it does contain more iron and magnesium than the crust above it.

The mantle isn't exactly the same all over. Just above the outer core is the lower mantle, which scientists believe to be a solid. Above this is solid rock that doesn't exactly act like a solid. This part of the mantle is called the asthenosphere.

Have you ever played with putty? It stretches, folds, and flows without breaking. It is not a rigid solid. The rock in the asthenosphere behaves like putty. It bends without breaking, and it flows like a liquid.



Above the asthenosphere is the uppermost part of the mantle. It is a solid much like the crust above it. Together, the uppermost mantle and crust form a layer called the lithosphere.

The mantle may not be as hot as the core, but it is still one hot layer. It ranges in temperature from about 870 degrees Celsius (1,600°F) at the top to 2,200 degrees Celsius (4,000°F) at the bottom. Some scientists think that the temperature differences cause some of the rock in the mantle to flow in something they call *convection currents.*

Here's how convection currents work. Deep in the mantle, hot rock rises. Near the top of the mantle, the rock cools and sinks. A cycle of heating and rising, cooling and sinking happens again and again. This cycle moves rock throughout the layer, pushing the crust around, as well. You'll learn more about this in a later section.

The Crust

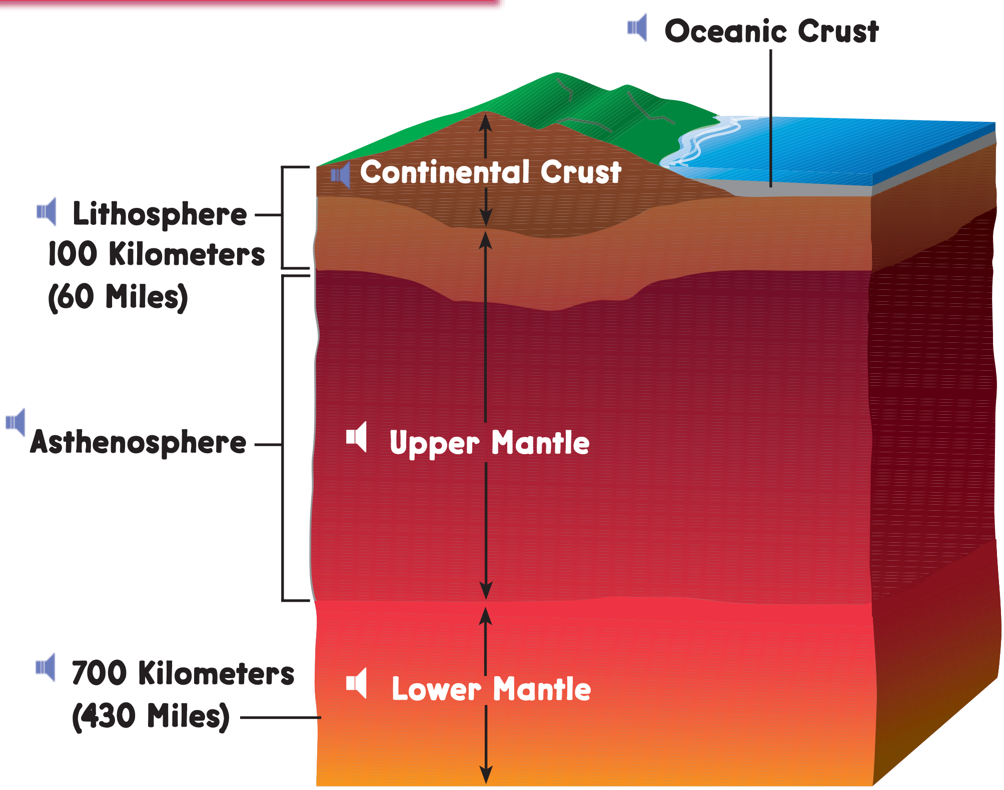
The crust is Earth's outermost layer. The crust is very thin and brittle. Its rocks can bend until they break. When rocks break, an earthquake occurs.

Crust under the land is called the continental crust. It is made up mostly of the igneous rock, granite. Crust under the oceans is the oceanic crust. It is made up mostly of the igneous rock, basalt.

Compared to the other layers, the crust is very thin. But it is not the same thickness all over. Beneath the ocean waters, the crust is the thinnest, only about 5 kilometers (3 mi) thick. On the continents, the crust's thickness varies more. It is usually about 30 kilometers (18 mi) thick. But, it can be as thick as 100 kilometers (62 mi) beneath large mountain ranges such as the Sierra Nevada.

Compared to the mantle and core, the crust is quite cool. At the surface, it is about the same temperature as the air. At its deepest part, the crust is about 870 degrees Celsius (1,600°F). This is the temperature at which rock begins to melt.

Upper Mantle and Crust



Plates of the Lithosphere

Plate Movement

Remember how the crust cracked into pieces as it cooled? The pieces are called plates, and they move around Earth's surface. Plates actually consist of the lithosphere, which is the crust and rigid uppermost mantle combined.

Earth's plates are made of much lighter rock than the asthenosphere below. As a result, the plates float on the flowing asthenosphere, almost as toy boats float on a stream. As a stream flows, the boats get carried along by the current. In a similar way, when convection currents flow in the mantle, the plates floating on them get carried along, too. The currents move the plates (and the continents on them) together, apart, and past each other. But don't think the plates speed across Earth's surface. They move only about 10 millimeters (0.8 in.) to 130 millimeters (5 in.) each year! Even a snail can move faster than that.

Finding Out What's Down There

Needless to say, the crust is the layer that we know the most about. We live on its surface, after all! Some people have seen what's just below Earth's surface. People who explore deep underground caves have seen what it is like a few hundred feet down. Miners have also dug and traveled through tunnels below the surface. But even the deepest mine, a gold mine near Johannesburg, South Africa, reaches only 3.6 kilometers (2.2 mi) below the surface. And the deepest hole drilled goes down only 12 kilometers (7.5 mi) deep. So how do we know what lies thousands of miles inside Earth?

Working deep below Earth's surface

Scientists use two types of information to learn about Earth's interior: direct evidence and indirect evidence. Direct evidence is information that you can observe yourself. You can reach inside an open box, pull out what's inside, and look at it. What you see is direct evidence. Scientists study rock samples from volcanoes, mines, and holes that they drill. These rock samples are direct evidence of Earth's interior.

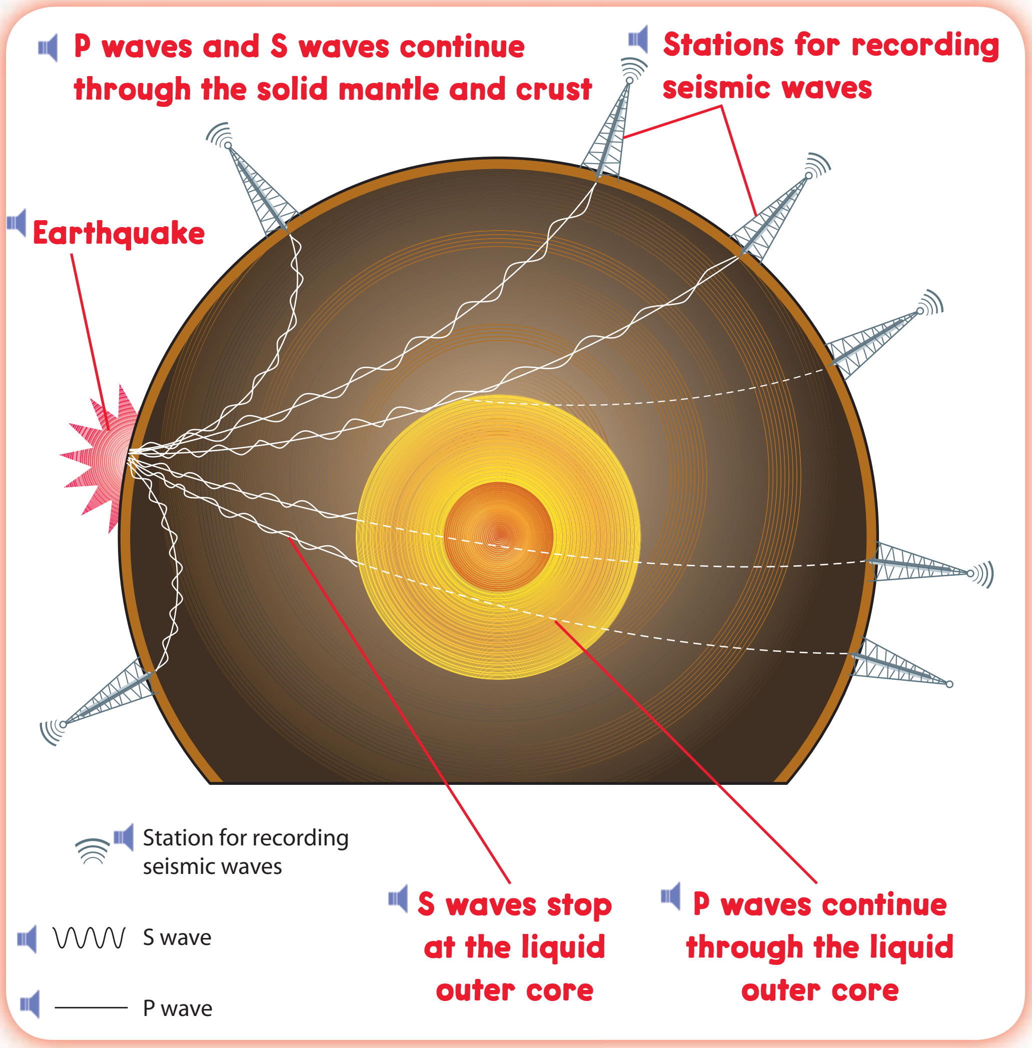
Indirect evidence is information you use to infer when you can't observe something yourself. Say you have a box taped up with something inside. You can't see what's inside, but you can shake the box and listen. You can use what you hear to infer what's inside. The sound that you hear is indirect evidence.

Much of what we know about Earth's layers comes from indirect evidence. One type of indirect evidence is found in the recordings of earthquake waves, called seismic waves. When an earthquake occurs in the lithosphere, seismic waves travel outward from the earthquake through Earth. Instruments located at stations around the world record the waves.

Two kinds of seismic waves are P waves and S waves. P waves travel through solids and liquids. S waves cannot travel through liquids.

When these seismic waves pass from one material into another material (such as from one layer into another layer), their speed and direction change. The waves either bend and pass into the new material or they get bounced back and can't pass into the new material.

If Earth were just one solid layer of the same material, seismic waves would pass right through Earth to the other side. But that isn't what happens.



After studying recorded seismic waves, scientists inferred that Earth was made up of different layers. They concluded that, because both P and S waves travel through the crust and mantle, these layers must be solid. However, only P waves pass through the core. When they reach the outer core, P waves bend and change speed, but they do continue through. S waves do not pass into the outer core. Because S waves cannot travel through liquids, scientists inferred that the outer core was liquid. When they reach the inner core, P waves change speed again. From this evidence, scientists inferred that the inner core was solid.

Will we ever be able to gather direct evidence of what's deep inside Earth? Probably not. It is very expensive to drill such large holes and dig such long tunnels. And the heat and pressure deep inside Earth would make going to the core deadly. So for now, we will have to be satisfied with gathering evidence from Earth's outermost layer.

Think and Write

1. If you use an egg as a model of Earth, what parts represent Earth's three main layers?
2. Could someone dig right through Earth's center to the other side of the planet? Explain your answer.
3. How do scientists know what's inside Earth?
4. **Expository Writing** Compare and contrast the inner core and outer core.

Hands-On Activity

Build Earth Layer by Layer Make a model of Earth's interior. Use clay of different colors to show Earth's layers. Label each layer.

School-Home Connection

Catalog Your Rocks Start a rock collection. With your family, collect rocks and use reference materials to identify them. Include granite and basalt in your collection.

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