

17.1

Structure of Earth

Earth is nearly spherical, 12 800 km around at the equator. These facts were known more than 2000 years ago. However, it was only in the last 100 years that some understanding was reached about the internal structure of our planet. Today, we know that Earth is made up of layers (Figure 1).

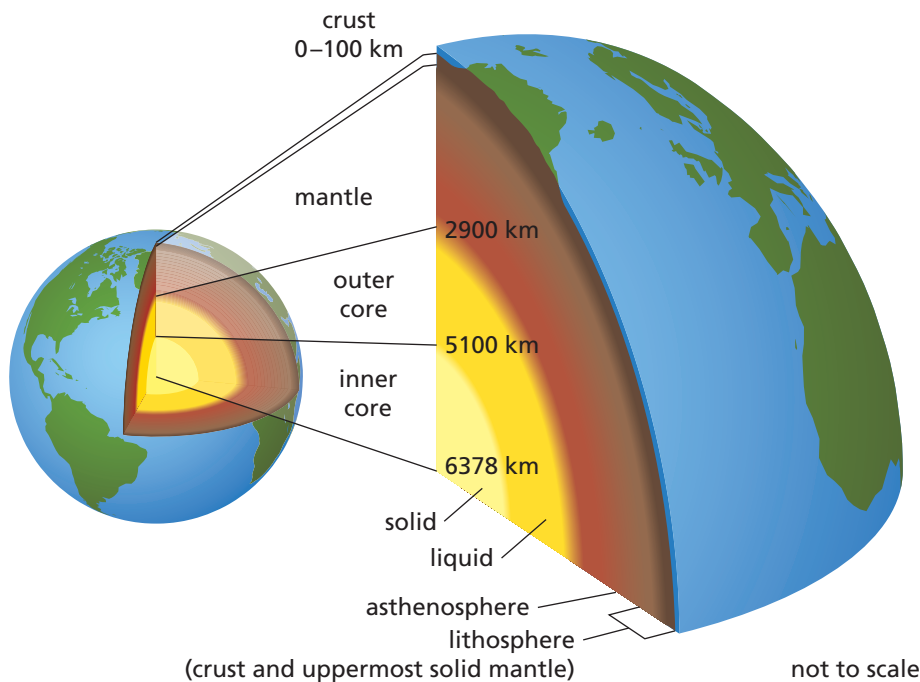


Figure 1 Each layer of Earth contains a different mix of materials and has distinct physical properties.

Earth's outermost layer is the **crust**, the rigid rock of the continents and ocean floors. The ocean floor crust is only 5–7 km thick, but is more dense than the continental sections. It is generally high in magnesium, calcium, and iron, but lower in silicon. The crust in the continents is 30–100 km thick, is less dense than the sea floor crust, and contains more silicon.

Under the crust lies the **mantle**, nearly 3000 km thick. There are three layers within the mantle that we will discuss. First, just beneath the crust is the solid outer mantle. Together with the crust, this layer forms the rigid **lithosphere**. Beneath the lithosphere is the **asthenosphere**. It is so hot and has so much pressure on it from the lithosphere above that it behaves like a viscous fluid, or soft plastic, even though it is solid mantle. Beneath that is a dense inner layer of lower mantle.

The **core** is the nearly spherical centre of Earth. It has a radius of about 3500 km with two distinct layers. The **outer core** consists of liquid iron and nickel, while the **inner core** is mostly very dense solid iron.

LEARNING TIP

Previewing gives you a quick glimpse into the content of the chapter. Skim Chapter 17 to note the headings, words in bold, and the graphics. What information is new to you? What topics do you need to pay attention to?

Did You KNOW?

Deepest Hole

In 1970, scientists began drilling a research well on Russia's Kola Peninsula, near the Arctic Ocean. Their goal was to sample the rock from as deep within Earth as possible. When they stopped drilling in 1994, the borehole was over 12 km deep. The temperature of the rock at the bottom was more than 180 °C, part of the reason they could not drill deeper. The surprising things they found along the way changed our understanding of Earth's crust.

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TRY THIS: Can a Solid Act Like a Fluid?

Skills Focus: analyzing, communicating, creating models, observing

The material in the lower mantle of Earth is a solid, but behaves like a fluid in some ways. This is because of the intense heat and pressure far beneath the surface. In this activity, you will observe a change in a substance's properties when under pressure.

Materials: 250 g creamed honey, wax paper, board, dinner knife



Push gradually, using proper body mechanics.

1. Cool the unopened container of honey to just below room temperature.
2. Remove the honey from the container in one big chunk by running the dinner knife around the edge of the container.
3. Place the honey on a 30 cm² sheet of wax paper. Observe the state of the honey and record your observations.
4. Place another sheet of wax paper over the honey and use a board to press down on the honey until it begins to squish.
5. Uncover the honey and record your observations again.
6. Tilt the wax paper under the honey and observe whether the honey will flow.
 - A. Before pressing, does the honey hold its shape? Does it provide resistance when you press gently on it? Is the honey a solid or a fluid?
 - B. After pressing, would you describe the honey as a solid or a fluid? Explain.

Finding Out About Earth's Structure

Scientists obtain information about the structure of Earth in a variety of ways. Through direct and indirect observations, geologists build a theory about the structure of Earth. Theories are tested in experiments and updated to include new discoveries.

Direct Observations

Volcanoes provide scientists with one of the best ways to directly observe Earth's interior. Some volcanoes bring molten rock from deep within Earth's mantle. Sampling ancient and fresh lava flows allows scientists to compare the minerals in magma to other minerals in rock at or near the surface (Figure 2a). Rock samples are also collected from holes drilled into Earth for oil exploration or mining (Figure 2b).



(a)




(b)

Figure 2 (a) Sampling lava flows and (b) drilling rock samples are types of direct observation. The rock samples show light grey continental rock and grey-black rock of the ocean floor.

Indirect Observations

Scientists use observations made at the surface of Earth to make suggestions about the structures and processes underground. Sometimes measuring one thing can tell you a lot about something else:

- Measuring the magnetic field of layers of ancient lava flows gives a record of the strength and direction of Earth's magnetic field over time. This record can then be compared to measurements across the sea floor to make inferences about the age of sea floor rock.
- Measuring the local strength of gravity gives geologists clues about the density of material below the surface because denser rock increases the local gravity. 

The most important tool for investigating the interior of Earth is the study of seismic waves. If you snapped your fingers under water in the sink, you would see waves on the surface. Imagine how those waves would be different in a sink full of honey. When slabs of Earth's crust break, crack, or slip by each other, they create waves through the surrounding rock. These **seismic waves** cause the destruction associated with earthquakes, but they also tell scientists about earthquake dynamics and the structure of Earth. The speed and direction of the waves change as they travel through different types of rock, just like the waves from a finger snap are different as they travel through water or honey. You will learn more about seismic waves in Chapter 18.

Modern Mapping

Mapping techniques allow scientists to plot the locations of geologic formations such as volcanoes, mountain ranges, lava flows, fossil beds, and ancient oceans. New remote sensing technologies make mapping increasingly accurate:


- satellite and aerial photography record vast areas (Figure 3);
- global positioning system (GPS) receivers are used to track very small movements (in millimetres per year) of Earth's crust; and
- infrared and radar images are combined to illustrate features not visible from Earth's surface.



Figure 3 The Coast Mountains are too big to see completely from the surface of Earth. Scientists use satellite images like this one to study such large features.

LEARNING TIP

Check your understanding of direct and indirect observation by explaining them to a partner. Try to use examples in your explanation.

If you would like to learn more about measuring gravity, go to www.science.nelson.com 

Did You KNOW?

Seismographs

The same instrument that measures earthquake waves (a seismograph) can be used to monitor nuclear test detonations. It is impossible to test a nuclear device in secret because the explosion creates waves in Earth's crust that are easily detected all over the world. Mineral exploration also uses seismic wave studies, setting off small explosive charges to provide "mini-earthquakes" on demand. The analysis of the resulting waves helps predict where minerals can be found.

1. Name the three main layers that make up Earth. List them in order starting at the outside, and describe their relative thickness.
2. Explain Earth's layers by comparing Earth to a familiar object such as an avocado (Figure 4). How are the layers similar? How are they different?



Figure 4

3. The lithosphere is composed of the rigid crust and the uppermost layer of the mantle. How does this top layer of the mantle differ from the underlying asthenosphere? Copy the Venn diagram in Figure 5, then complete it to compare their properties.

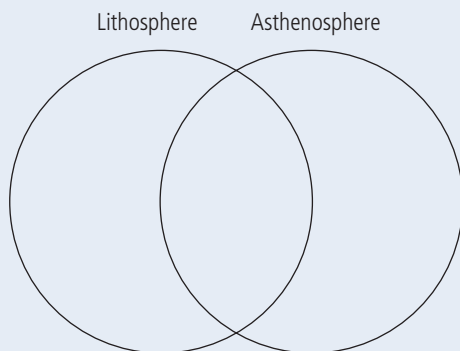


Figure 5

4. What extreme conditions cause the rock of the asthenosphere to act like a fluid?
5. What kinds of direct observation can be made about the structure of Earth?
6. How can measuring one thing provide clues about something else? Give an example.
7. Collecting lava samples is dangerous work; the rock is extremely hot and releases toxic gases. What makes these risks worthwhile?
8. By measuring the local strength of gravity, what can a scientist learn about formations on Earth?
9. Copy Table 1 and list methods scientists use to make observations about the interior of Earth. Explain one.

Table 1

Methods	Type of observation

10. Lava that solidifies on the surface cools quickly and forms small mineral crystals. Magma that solidifies underground cools slowly and forms large mineral crystals. Explain how examining rock core samples could help you infer where the rock formed.
11. No one has been able to collect samples or take direct measurements of each of Earth's layers. Why not?