These majestic, snow-capped mountains in Annapurna, Nepal look rugged and indestructible, but in geologic terms, they are in their infancy. As they erode over the next few hundred million years, their sharp jagged peaks will become smooth. They will begin to resemble more mature mountains, like those found in the eastern United States. In this chapter, you’ll learn how the movement of plates formed these mountains and about other Earth forces that shape mountains. You also will study layers of the Earth’s interior.

**What do you think?**

**Science Journal** Look at the picture below with a classmate. Discuss what this might be or what is happening. Here’s a hint: During earthquakes rocks can grind and scrape. Write your answer or best guess in your Science Journal.
Geologists know many things about the interior of Earth even though its center is over 6,000 km deep. Use modeling clay to make a model of Earth’s interior.

**Model Earth’s interior**

1. Obtain four pieces of clay that are different colors.
2. Roll one piece of clay into a ball. This clay represents the inner core.
3. Wrap another piece of clay around the first ball of clay, making an even bigger ball. This clay represents the outer core.
4. Repeat step 3 with the third piece of clay, which represents Earth’s mantle. Wrap your model with a thin layer of the fourth piece of clay to represent the crust.
5. Use a plastic knife to cut the ball of clay in half.

**Observe**

In your Science Journal, make a sketch of your model and label each of Earth’s layers.

---

**Before You Read**

**Making a Cause and Effect Study Fold** Make the following Foldable to help you understand the cause and effect relationship of Earth’s interior and surface.

1. Stack two sheets of paper in front of you so the short side of both sheets is at the top.
2. Slide the top sheet up so about four centimeters of the bottom sheet show.
3. Fold both sheets top to bottom to form four tabs and staple along the top fold. Turn the Foldable so the staples are at the bottom.
4. Label each flap Inner Core, Outer Core, Mantle, and Crust. Draw in the layers as shown.
5. As you read the chapter, write about each layer under the tabs.
Earth’s Moving Plates

Clues to Earth’s Interior

If someone gives you a wrapped present, how could you figure out what was in it? You might hold it, shake it gently, or weigh it. You’d look for clues that could help you identify the contents of the box. Even though you can’t see what’s inside the package, these types of clues can help you figure out what it might be. Because you can’t see what’s inside, the observations you make are known as indirect observations.

Geologists do the same thing when they try to learn about Earth’s interior. Although the best way to find out what’s inside Earth might be to dig a tunnel to its center, that isn’t possible. The deepest mines in the world only scratch Earth’s surface. A tunnel would need to be more than 6,000 km deep to reach the center, so geologists must use indirect observations to gather clues about what Earth’s interior is made of and how it is structured. This indirect evidence includes information learned by studying earthquakes and rocks that are exposed at Earth’s surface.

Waves

When you throw a rock into a calm puddle or pond, you observe waves like those shown in Figure 1. Waves are disturbances that carry energy through matter or space. When a rock hits water, waves carry some of the rock’s kinetic energy, or energy of motion, away from where it hit the water. When an earthquake occurs, as shown in Figure 2, energy is carried through objects by waves. The speed of these waves depends on the density and nature of the material they are traveling through. For example, a wave travels faster in solid rock than it does in a liquid. By studying the speed of these waves and the paths they take, geologists uncover clues as to how the planet is put together. In fact, these waves, called seismic waves, speed up in some areas, slow down in other areas, and can be bent or stopped.
Rock Clues Another clue to what’s inside Earth comes in the form of certain rocks found in different places on Earth’s surface. These rocks are made of material similar to what is thought to exist deep inside Earth. The rocks formed far below the surface. Forces inside Earth pushed them closer to the surface, where they eventually were exposed by erosion. The seismic clues and the rock clues suggest that Earth is made up of layers of different kinds of materials.

Earth’s Layers

Based on evidence from earthquake waves and exposed rocks, scientists have produced a model of Earth’s interior. The model shows that Earth’s interior has at least four distinct layers—the inner core, the outer core, the mantle, and the crust. Earth’s structure is similar in some ways to the structure of a peach, shown in Figure 3. A peach has a thin skin covering the thick, juicy part that you eat. Under that is a large pit that surrounds a seed.

Inner Core The pit and seed are similar to Earth’s core. Earth’s core is divided into two distinct parts—one that is liquid and one that is solid. The innermost layer of Earth’s interior is the solid inner core. This part of the core is dense and composed mostly of solid iron. When seismic waves produced by earthquakes reach this layer they speed up, indicating that the inner core is solid.

Conditions in the inner core are extreme compared to those at the surface. At about 5,000°C, the inner core is the hottest part of Earth. Also, because of the weight of the surrounding rock, the core is under tremendous pressure. Pressure, or the force pushing on an area, increases the deeper you go beneath Earth’s surface. Pressure increases because more material is pushing toward Earth’s center as a result of gravity. The inner core, at the center of Earth, experiences the greatest amount of pressure.

Figure 2
As seismic waves travel across Earth’s surface, the ground shakes and damage occurs.

Figure 3
The structure of Earth can be compared to a peach. If the part of Earth that you live on is like the skin of the peach, what does that tell you about this layer of Earth?
The outer core lies above the inner core and is thought to be composed mostly of molten metal. The outer core stops one type of seismic wave and slows down another. Because of this, scientists have concluded that the outer core is a liquid. The location of the outer core is similar to the location of the pit in the peach model. Even the wrinkled surface of the pit resembles the uneven nature of the boundary between Earth’s outer core and its mantle as indicated by seismic studies.

**Reading Check** What peach layer is similar to the outer core?

**Mantle** The layer in Earth’s interior above the outer core is the mantle. In the peach model, the mantle would be the juicy part of the peach that you would eat. The mantle is the largest layer of Earth’s interior. Even though it’s solid, the mantle flows slowly, similar to putty.

**Crust** Earth’s outermost layer is the crust. In the model of the peach, this layer would be the fuzzy skin of the peach. Earth’s crust is thin when compared to the other layers, though its thickness does vary. It is thinnest under the oceans and thickest through the continents. All features on Earth’s surface are part of the crust.
Earth’s Structure

Although Earth’s structure can be divided into four basic layers, it also can be divided into other layers based on physical properties that change with depth beneath the surface. Figure 4 shows the structure of Earth and describes some of the properties of its layers. Density, temperature, and pressure are properties that are lowest in the crust and greatest in the inner core.

![Distribution of Earth’s Mass]

The mantle makes up the majority of Earth’s mass.

![Temperature Versus Depth]

Increasing temperature vs. increasing depth

![Pressure Versus Depth]

Increasing pressure vs. increasing depth

The mantle makes up 67% of Earth’s mass. The outer core makes up 30%, the inner core makes up 2.5%, and the crust makes up 0.5%.
Earth’s Plates

Although the crust is separated from the mantle, the uppermost, rigid layer of the mantle moves as if it were part of Earth’s crust. The rigid, upper part of Earth’s mantle and the crust is called the lithosphere. It is broken into about 30 sections or plates that move around on the plasticlike asthenosphere, which also is part of the mantle. Earth’s major plates vary greatly in size and shape, as shown in Figure 5.

Reading Check  What parts of Earth make up the lithosphere?

The movements of the plates are fairly slow, often taking more than a year to creep a few centimeters. This means that they have not always looked the way they do in Figure 5. The plates have not always been their current size and shape, and continents have moved great distances. Antarctica, which now covers the south pole, was once near the equator, and North America was once connected to Africa and Europe.

Lasers and satellites are used to measure the small plate movements, which can add up to great distances over time. If a plate is found to move at 2 centimeters per year on average, how far will it move in 1,000 years? What about in 10 million years?
Plate Boundaries

The places where the edges of different plates meet are called plate boundaries. The constant movement of plates creates forces that affect Earth's surface at the boundaries of the plates. At some boundaries, these forces are large enough to cause mountains to form. Other boundaries form huge rift valleys with active volcanoes. At a third type of boundary, huge faults form. **Faults** are large fractures in rocks along which movement occurs. The movement can cause earthquakes. **Figure 6** shows the different plate motions.

**Plates That Move Apart** Plates move apart as a result of pulling forces that act in opposite directions on each plate. This pulling force is called tension. **Figure 7** shows what happens as tension continues to pull two plates apart.

One important result of plates separating is the formation of new lithosphere. New lithosphere forms in gaps where the plates pull apart. As tension continues along these boundaries, new gaps form and are filled in by magma that is pushed up from the mantle. Over time, the magma in the gaps cools to become new lithosphere. This process of plate separation and lithosphere formation takes place under the oceans at places called mid-ocean ridges. As new lithosphere moves away from the mid-ocean ridges, it cools and becomes denser.

**Figure 6** Earth's plates can collide, move away from each other, or slide past each other.

**Science Online**

**Data Update** Visit the Glencoe Science Web site at **tx.science.glencoe.com** for recent news or magazine articles about Earth's plates and the different boundaries that they form. Communicate to your class what you learn.

**Sliding Plates** When plates slide along each other, earthquakes commonly occur. Earthquakes are the result of energy that builds up at these boundaries and then is released suddenly.

**Separating Plates** When plates move apart, new crust forms to fill in the gap between the plates. This new crust is less dense than the surrounding cooler crust, which often causes a high ridge to form.

**Colliding Plates** When plates collide, the tremendous force causes mountains like the Andes in South America to form.
When two continental plates pull apart, rift valleys may form. If spreading continues and the growing rift reaches a coastline, seawater floods in. Beneath the waves, molten rock, or magma, oozes from the weakened and fractured valley floor. In time, the gap between the two continental slabs may widen into a full-fledged ocean. The four steps associated with this process are shown here. Africa’s Great Rift Valley, which cuts across the eastern side of Africa for 5,600 km (right), represents the second of these four steps. If rifting processes continue in the Great Rift Valley, East Africa eventually will part from the mainland.

Rising magma forces the crust upward, causing numerous cracks in the rigid crust.

As the crust is pulled apart, large slabs of rock sink, generating a rift zone.

Further spreading generates a narrow sea or lake.

Eventually, an expansive ocean basin and ridge system are created.
**Plates That Collide** When plates move toward each other, they collide, causing several different things to occur. As you can see in Figure 8, the outcome depends on the density of the two plates involved. The crust that forms the ocean floors, called oceanic crust, is more dense than the continental crust, which forms continents.

If two continental plates collide, they have a similar density so the collision causes the crust to pile up. When rock converges like this, the force is called compression. Compression causes the rock layers on both plates to crumple and fold. Imagine laying a piece of fabric flat on your desk. If you push the edges of the cloth toward each other, the fabric will crumple and fold over on itself. A similar process occurs when plates crash into each other, causing mountains to form.

Flat rock layers are pushed up into folds. Sometimes the folding is so severe that rock layers bend completely over on themselves, turning upside down. As rock layers are folded and faulted, they pile up and form mountains. The tallest mountains in the world, the Himalaya in Asia, are still rising as two continental plates collide.

**Plate Subduction** When an oceanic plate collides with another oceanic plate or a continental plate, the more dense one plunges underneath the other, forming a deep trench. When one plate sinks underneath another plate, it’s called subduction. When a plate subducts, it sinks into the mantle. In this way, Earth’s crust does not continue to grow larger. As new crust material is generated at a rift, older crustal material subducts into the mantle.

---

**TRY AT HOME**

**Mini LAB**

**Modeling Tension and Compression**

**Procedure**
1. Obtain two bars of taffy.
2. Hold one bar of taffy between your hands and push your hands together.
3. Record your observations in your Science Journal.
4. Hold the other bar of taffy between your hands and pull gently on both ends.
5. Record your observations in your Science Journal.

**Analysis**
1. On which bar of taffy did you apply tension? Compression?
2. Explain how this applies to plate boundaries.

**Figure 8** There are three types of convergent plate boundaries.

---

**Oceanic-oceanic collisions** The collision of two oceanic plates causes subduction, which forms a deep ocean trench where the plates meet. Erupting lava forms islands near the trench.

**Continental-oceanic collisions** When a continental plate collides with an oceanic plate, the more dense oceanic plate slides underneath the continental plate, forming volcanoes.

**Continental-continental collisions** Two continental plates have similar densities. As a result, they buckle and fold when they collide, piling up into high mountain ranges, such as the Himalaya.
Plates That Slide Past

In addition to moving toward and away from one another, plates also can slide past one another. For example, one plate might be moving north while the plate next to it is moving south. The boundary where these plates meet is called a transform boundary. When a force pushes something in two different directions, it’s called shearing. Shearing causes the area between the plates to form faults and experience many earthquakes. Figure 9 shows part of the San Andreas Fault near Taft, California, which is an example of the features that form along a transform boundary.

Why do plates move?

As you can see, Earth’s plates are large. To move something so massive requires a tremendous amount of energy. Where does the energy that drives plate movement come from? The reason plates move is complex, and geologists still are trying to understand it fully. So far, scientists have come up with several possible explanations about what is happening inside Earth to cause plate movement. Most of these theories suggest that gravity is the driving force behind it. However, gravity pulls things toward the center of Earth, and plates move sideways across the globe. How does gravity make something move across the surface of Earth?

One theory that could explain plate movement is convection of the mantle. Convection in all materials is driven by differences in density. In the mantle, density differences are caused by uneven heating, which results in a cycling of material, as shown in Figure 10. The theory suggests that the plates move as part of this circulation of mantle material.
1. How is the speed of earthquake waves used by scientists to provide information about Earth’s interior?
2. Name the three types of plate movements and give examples of where they occur.
3. Which layer of Earth’s interior is the largest?
4. List the layers of Earth’s interior in order of least to greatest density.
5. Think Critically How can slab-pull and ridge-push contribute to the movement of a plate at the same time?

Skill Builder Activities

6. Comparing and Contrasting Compare and contrast the following pairs of terms: inner core, outer core; ridge-push, slab-pull. For more help, refer to the Science Skill Handbook.
7. Using Graphics Software Use the graphics capabilities of a computer to produce illustrations of plate movement at the three types of plate boundaries. For more help, refer to the Technology Skill Handbook.
You have learned that Earth’s surface is separated into plates that move apart, move together, or slide past each other. In this activity, you will observe a process that is thought to cause this plate movement.

**What You’ll Investigate**

What process inside Earth provides the energy for plate motion?

**Materials**

- 1-L beaker (2)
- rubber band
- food coloring
- water (warm and cold)
- aluminum foil
- pencil
- 2-cm paper squares (3)
- small, clear-plastic cup

**Goals**

- **Observe** movement of solid plates on a liquid.
- **Identify** the cause of plate movement on Earth’s surface.

**Safety Precautions**

Handle the warm water with care. Water from the tap should be warm enough.

**Procedure**

1. Fill one of the 1-L beakers with cold water.
2. Fill the small cup with warm water.
3. Add four drops of food coloring to the cup of warm water and cover the top with aluminum foil. Secure the aluminum foil with a rubber band. No air should be underneath the foil.
4. Carefully place the cup of colored, warm water in the bottom of the second 1-L beaker.
5. Carefully pour the cold water from the first 1-L beaker into the second 1-L beaker. Take care not to disturb the cup of colored water.
6. Place the pieces of paper on the surface of the water in the second 1-L beaker.
7. Use a long pencil to make two small holes in the aluminum foil covering the cup.
8. Observe what happens to the contents of the cup and to the pieces of paper. Record your observations in your Science Journal.

**Conclude and Apply**

1. What happened to the colored, warm water originally located in the cup?
2. What effect, if any, does the warm water have on the positions of the floating paper?
3. How is what happens to the warm water similar to processes that occur inside Earth? How is it different?
4. After observing the pieces of paper floating on the cold water, explain what features on Earth’s surface they are similar to.

**Communicating Your Data**

Compare your conclusions with those of other students in your class. For more help, refer to the Science Skill Handbook.
Building Mountains

One popular vacation that people enjoy is a trip to the mountains. Mountains tower over the surrounding land, often providing spectacular views from their summit or from surrounding areas. The highest mountain peak in the world is Mount Everest in the Himalaya in Tibet. Its elevation is more than 8,800 m above sea level. In the United States, the highest mountains reach an elevation of more than 6,000 m. There are four main types of mountains—fault-block, folded, upwarped, and volcanic. Each type forms in a different way and can produce mountains that vary greatly in size.

Age of a Mountain As you can see in Figure 11, mountains can be rugged with high, snowcapped peaks, or they can be rounded and forested with gentle valleys and babbling streams. The ruggedness of a mountain chain depends largely on whether or not it is still forming. Mountains like the Himalaya are currently forming at a rate of several centimeters per year, while much older mountains like the Ouachita Mountains in Arkansas stopped forming millions of years ago and are now being eroded by geological processes.

As You Read

What You’ll Learn
- Describe how Earth’s mountains form and erode.
- Compare types of mountains.
- Identify the forces that shape Earth’s mountains.

Vocabulary
- fault-block mountain
- folded mountain
- upwarped mountain
- volcanic mountain
- isostasy

Why It’s Important
Forces inside Earth that cause Earth’s plates to move around also are responsible for forming Earth’s mountains.

Figure 11
A Mountains can be high and rugged like the mountains of the Himalaya, or B they can be large, gently rolling hills like the Ouachita Mountains in Arkansas. What determines how rugged and high a mountain chain is?
Fault-Block Mountains

The first mountains you’ll study are fault-block mountains. Some examples are the Sierra Nevada in California and the Teton Range in Wyoming. Recall that pulling forces that occur at the boundaries of plates moving apart, work to create surface features such as rift valleys and faults. Fault-block mountains also form from pulling forces. 

Fault-block mountains are made of huge, tilted blocks of rock that are separated from surrounding rock by faults. When rock layers are pulled from opposite directions, large blocks slide downward, creating peaks and valleys, as shown in Figure 12.

Models of Mountain Building

If you hold a candy bar between your hands and then begin to pull it apart, cracks might form within the chocolate. Similarly, when rocks are pulled apart, faults form. Unlike rocks deep in Earth, rocks at Earth’s surface are hard and brittle. When they are pulled apart, large blocks of rock can move along the faults. The Teton Range of Wyoming formed when a block of crust was tilted as one side of the range was uplifted above the neighboring valley. As shown in Figure 13, if you travel to the Grand Teton National Park, you will see sharp, jagged peaks that are characteristic of fault-block mountains.

Now, hold a flat piece of clay between your hands and then push your hands together gently. What happens? As you push your hands together, the clay begins to bend and fold over on itself. A similar process causes rocks to fold and bend, causing folded mountains to form on Earth’s surface.
Folded Mountains  Traveling along a road that is cut into the side of the Appalachian Mountains, you can see that rock layers were folded just as the clay was when it was squeezed, or compressed. Tremendous pushing forces exerted by two of Earth’s plates moving together squeezed rock layers from opposite sides. This caused the rock layers to buckle and fold, forming folded mountains. Folded mountains are mountains formed by the folding of rock layers caused by compressive forces.

What type of force causes folded mountains to form?

The Appalachian Mountains are folded mountains that formed about 250 million to 300 million years ago. A small part of the folded Appalachians is shown in Figure 14. The compression occurred as the North American Plate and the African Plate moved together. The Appalachians are the oldest mountain range in North America, and also one of the longest. They extend from Alabama northward to Quebec, Canada. Erosion has been acting on these mountains since they were formed. As a result, the Appalachians are small compared to other mountain ranges. At one time, the Appalachian Mountains were higher than the Rocky Mountains are today.

Upwarped Mountains  The Adirondack Mountains in New York, the southern Rocky Mountains in Colorado and New Mexico, and the Black Hills in South Dakota are examples of upwarped mountains. Upwarped mountains form when forces inside Earth push up the crust. With time, sedimentary rock layers on top will erode, exposing the igneous or metamorphic rocks underneath. The igneous and metamorphic rocks can erode further to form sharp peaks and ridges.

---

**Mini LAB**

**Modeling Mountains**

**Procedure**
1. Use layers of clay to build a model of each major type of mountain.
2. For fault-block mountains, cut the layers of clay with a plastic knife to show how one block moves upward and another moves downward.
3. For folded mountains, push on the layers of clay from directly opposite directions.
4. For upwarped mountains, push a large, round object, such as a ball, upward from below, forcing the layers of clay to warp.
5. For volcanic mountains, place layer upon layer of clay to form a cone-shaped feature.

**Analysis**
1. Do any of the mountains you have modeled look similar? Explain.
2. How could you recognize the different types of mountains?

---

**Figure 14**
This roadcut in Maryland exposes folded rock layers that formed when the North American Plate and the African Plate collided.
Volcanic Mountains Occasionally, magma from inside Earth reaches the surface. When this happens, the magma is called lava. When hot, molten lava flows onto Earth’s surface, volcanic mountains can form. Over time, layer upon layer of lava piles up until a cone-shaped feature called a volcanic mountain forms. Washington’s Mount St. Helens and Mexico’s Mount Popocateptl, shown in Figure 15, are examples. Next, you will take a closer look at how volcanic mountains form.

Some volcanic mountains form when large plates of Earth’s lithosphere sink into Earth’s mantle at subduction zones. As the plates sink deeper into the mantle, they cause melting to occur. The magma produced is less dense than the surrounding rock, so it is forced slowly upward to Earth’s surface. If the magma reaches the surface, it can erupt as lava and ash. Layers of these materials can pile up over time to form volcanic mountains.

Research Visit the Glencoe Science Web site at tx.science.glencoe.com for more information on and photographs of volcanic mountains. Communicate to your class what you learn.

**Figure 15**
Volcanic mountains form when lava and ash build up in one area over time.

**Crater** This bowl-shaped part of the volcano surrounds the vent. Lava often collects here before it flows down the slope.

**Pipe** Magma flows through this nearly vertical crack in the rock called the pipe.

**Magma Chamber** Rising magma forms and fills a large pocket underneath the volcano. This pocket is called the magma chamber. In some cases, one magma chamber feeds several volcanoes.

**Vent** As magma flows up the pipe, it reaches the surface at an opening called the vent. Side vents often branch off of the main pipe.

**Magma** The hot, molten mixture of rock material and gases is called magma.
Underwater Volcanic Mountains  You know that volcanic mountains form on land, but did you know that these mountains also form on the ocean floor? Underwater eruptions can produce mountains beneath the sea. Eventually, if enough lava is erupted, these mountains grow above sea level. For example, Hawaii, shown in Figure 16A, is the peak of a huge volcanic mountain that extends above the surface of the water of the Pacific Ocean. Figure 16B illustrates how the Hawaiian Islands formed.

Volcanic mountains like the Hawaiian Islands are different from the volcanic mountains that form where one plate subducts beneath another. The Hawaiian Islands formed from material that came from near the boundary between Earth’s core and mantle. Hot rock travels through the mantle as a plume and melts to form a hot spot in Earth’s crust. As plates travel over the hot spot, a series of volcanoes, as seen in Hawaii, forms. Magma from subduction volcanoes forms much closer to Earth’s surface. Hot spot volcanoes also are much larger and have more gently sloping sides than subduction volcanoes.

What type of mountains make up the Hawaiian Islands?

Figure 16
The Hawaiian Islands are a series of volcanic mountains that have been built upward from the seafloor.

Mauna Kea, shown here, forms part of the island of Hawaii.

Hawaii began to form as lava erupted onto the ocean floor. Over time, the mountain grew so large that it rose above sea level.
About 20,000 years ago, much of North America was covered by a large glacial ice sheet. How do you think an ice sheet can affect Earth’s crust? What do you think happens when the ice melts?

Identifying the Problem

More than 100 years ago, people living in areas that once had been covered by glaciers noticed that features such as old beaches had been tilted. The beaches had a higher elevation in some places and a lower elevation in others. How do you think old beaches could be tilted?

Solving the Problem

1. The weight of glaciers pushes down Earth’s crust. What do you think happens after the glacier melts?

2. How could rising crust cause beaches to be tilted? Do you think the crust would rise the same amount everywhere? Explain.
Adjusting to Gravity  Similar to the wooden blocks, if mountains continue to grow larger, they will sink even farther into the mantle. Once mountains stop forming, erosion lowers the mountains and the crust rises again because weight has been removed. If the process continues, the once-thick crust under the mountains will be reduced to the thickness of the crust where no mountains exist.

Icebergs behave in much the same way, as shown in Figure 17. The iceberg is largest when it first breaks off of a glacier. As the iceberg floats, it melts and starts to lose mass. This causes the iceberg to rise in the water. Eventually, the iceberg will be much smaller and will not extend as deeply into the water. How is this similar to what happens to mountains?

Figure 17
Isostasy makes Earth's crust behave in a similar way to these icebergs. As an iceberg melts and becomes smaller, ice from below the water's surface is forced up.

Section 2 Assessment

1. What are the four main types of mountains found on Earth?
2. If compression were exerted on rock layers, what type of mountains would form?
3. Describe how fault-block mountains form.
4. How does a volcano form?
5. Think Critically  Put the Appalachian, Himalaya, and Rocky Mountains in order from youngest to oldest knowing that the Himalaya are most rugged and the Appalachians are the least rugged.

Skill Builder Activities

6. Concept Mapping  Make a chain of events concept map that describes how folded mountains form. For more help, refer to the Science Skill Handbook.
7. Using a Word Processor  On a computer, prepare a table with descriptions of how the four different types of mountains form. Be sure to show any similarities and differences in their formation. For more help, refer to the Technology Skill Handbook.
**Goals**
- **Observe** the results of isostasy.
- **Predict** what will happen to floating objects when mass is removed or added.

**Possible Materials**
- 5-cm × 5-cm × 3-cm wooden blocks (3)
- 10-cm × 35-cm × 15-cm clear-plastic storage box or other bin
- water
- permanent marker
- ruler

**Safety Precautions**

**Data Source**

**SCIENCE Online** You can learn more about isostasy and the related concept of buoyancy by visiting the Glencoe Science Web site at tx.science.glencoe.com.
**Planning the Model**

1. **Decide** what object(s) you will float in the water initially. How will you remove mass from that object? How will you add mass?
2. What will you observe as the mass changes. How will you record the effects of adding or removing mass?
3. How much water will you use? What problems might you encounter if you have too much or too little water?
4. Will you make any additional measurements or record any other data?
5. **List** all the steps that you plan to do in this activity. Are the steps in a logical order?

**Check the Model Plans**

1. **Compare** your model plans to those of other students.
2. Make sure your teacher approves your plans before you start.

**Making the Model**

1. Fill the storage box or bin with an appropriate amount of water.
2. Start by floating the initial object you planned to use in the water. Observe and record relevant data.
3. Follow the list of steps you planned in order to obtain data for removing and adding mass. Observe your model and record all relevant data in your Science Journal.

**Analyzing and Applying Results**

1. What did your initial object look like? What level did the water rise to when your initial object was placed in the bin? How did you add and remove mass?
2. What happened to the amount of the object that was submerged and the amount sticking out of the water when mass was removed from the object?
3. What happened to the amount of the object that was submerged and the amount sticking out of the water when mass was added?
4. How can you explain your observations about how much of the object was submerged and how much was sticking out of the water? How is this similar to processes that occur in Earth?

**Communicating Your Data**

Make a poster that illustrates what you have learned about isostasy. For more help, refer to the Science Skill Handbook.
Did you know...

...Mount Monadnock is the most-often climbed mountain in the world. Located in New Hampshire, it’s climbed by about 125,000 people every year. That’s the same amount of people as the population of Topeka, Kansas. Mount Fuji, in Japan, previously claimed this honor.

...The world’s longest mountain range is underwater. The mid-ocean ridge that winds around Earth beneath the Arctic, Atlantic, and Pacific Oceans is 65,000 km long. That’s four times longer than the combined lengths of the Andes Mountains, the Rocky Mountains, and the Himalaya.

...The beautiful Appalachian Mountains are among the oldest in the world. By 250 million years ago, their formation was complete. Today, the mountains aren’t among the tallest because they have been worn down by many millions of years of erosion.
**Connecting To Math**

**In 1963, Surtsey**, a small island, formed when an underwater volcano erupted off the coast of Iceland. The 1.6-km-long island rose to the height of 183 m—about as tall as a 55-story building.

---

**...Many people live on or near mountains,** but only about 134 people live in Mountain—Mountain, North Dakota, that is.

---

**Do the Math**

1. One trail to the top of Mount Monadnock is about 3 km long. If it takes a climber 4 h to reach the top, how many kilometers does this climber hike in 1 h?

2. Draw a picture to scale that accurately represents the sizes of Mount McKinley (6,194 m), Mount Rainier (4,392 m), and Mount Everest (8,850 m).

3. If the mid-ocean ridge is four times the combined length of the Andes Mountains, the Rocky Mountains, and the Himalaya, what is the combined length of these mountain ranges?

**Go Further**

Research a mountain on tx.science.glencoe.com. Pinpoint its location on a map, and then accurately draw the mountain and the view from its top.
Section 1 Earth’s Moving Plates

1. Earth’s interior is divided into four layers, the inner core, the outer core, the mantle, and the crust. *Can you identify these layers in the diagram below?*

2. Earth’s inner and outer cores are thought to be composed mostly of iron. The outer core is thought to be liquid and the inner core is solid.

3. Plates composed of sections of Earth’s crust and rigid upper mantle move around on the plasticlike asthenosphere.

4. Earth’s plates move together, move apart, and slide past each other. *Which type of movement occurs at the San Andreas Fault in California, shown below?*

5. Evidence suggests that plates move because of various effects of gravity. Convection in Earth’s mantle, ridge-push, and slab-pull might all contribute to plate movement.

Section 2 Uplift of Earth’s Crust

1. Uplift, as a result of different processes, causes mountains to form. Faulting, folding, upwarping, and volcanic eruptions are all processes that build mountains above the surrounding land.

2. The four main types of mountains are fault-block mountains, folded mountains, upwarped mountains, and volcanic mountains. *Which type of mountain is shown in the photo below?*

3. Compression and tension affect the thickness of Earth’s crust.

4. As erosion removes material from the tops of mountains, the mass of the mountains is reduced. As a result of isostasy, the crust is then forced upward.

After You Read

To help you review the four layers of Earth’s interior, use the Foldable you made at the beginning of the chapter.
Visualizing Main Ideas

Fill in the following table comparing examples and causes of the four types of mountains.

<table>
<thead>
<tr>
<th>Mountain Type</th>
<th>Example</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fault-block mountain</td>
<td>Teton Range</td>
<td></td>
</tr>
<tr>
<td>Folded mountain</td>
<td></td>
<td>compression</td>
</tr>
<tr>
<td>Upwarped mountain</td>
<td>Adirondack Mountains</td>
<td></td>
</tr>
<tr>
<td>Volcanic mountain</td>
<td></td>
<td>lava flows</td>
</tr>
</tbody>
</table>

Vocabulary Words

a. crust
b. fault
c. fault-block mountain
d. folded mountain
e. inner core
f. isostasy
g. lithosphere
h. mantle
i. outer core
j. plate
k. subduction
l. upwarped mountain
m. volcanic mountain

Using Vocabulary

Answer the following questions with complete sentences.

1. Which part of Earth’s core do scientists think is liquid?
2. The Sierra Nevada mountains in California are which type of mountain?
3. What type of mountains form in areas where rocks are being pushed together?
4. What process occurs when a more dense plate sinks beneath a less dense plate?
5. Which type of mountain forms when magma is forced upward and flows onto Earth’s surface?

Study Tip

Don’t just memorize definitions. Write complete sentences using new vocabulary words to be certain you understand what they mean.
Choose the word or phrase that best answers the question.

1. Which part of Earth is largest?
   A) crust  C) outer core
   B) mantle  D) inner core

2. Earth’s plates are pieces of which of the following layer of Earth?
   A) lithosphere  C) inner core
   B) asthenosphere  D) mantle

3. Which force pushes plates together?
   A) tension  C) shearing
   B) compression  D) isostasy

4. Which force occurs where Earth’s plates are moving apart?
   A) tension  C) shear
   B) compression  D) isostasy

5. Which layer of Earth is thought to be solid and composed mostly of the metal iron?
   A) crust  C) outer core
   B) mantle  D) inner core

6. Which of the following suggests that Earth’s crust floats on the upper mantle?
   A) tension  C) shear
   B) compression  D) isostasy

7. Which type of mountain forms because of compressional forces?
   A) fault-block mountains
   B) folded mountains
   C) upwarped mountains
   D) volcanic mountains

8. Which type of mountain forms because forces inside Earth push up overlying rock layers?
   A) fault-block mountains
   B) folded mountains
   C) upwarped mountains
   D) volcanic mountains

9. Which of the following causes volcanic mountains to form?
   A) forces pulling apart
   B) force of buoyancy
   C) forces pushing together
   D) forces pushing upward

10. Which type of plate movement produces deep rifts such as the mid-ocean rift?
    A) plates moving together
    B) plates moving apart
    C) plates sliding past each other
    D) plates sinking

11. Which is older, the Great Rift Valley in East Africa, or the Mid-Atlantic Ridge in the Atlantic Ocean? Explain.

12. How can you determine whether or not a mountain is still forming?

13. Seismic waves slow down when entering the asthenosphere. What does this tell you about the nature of the asthenosphere?

14. What would happen to the elevation of the island of Greenland if the ice sheet were to melt away?

15. If you wanted to know whether a certain mountain was formed by compression, what would you look for?

16. Comparing and Contrasting  Compare and contrast volcanic and folded mountains. Draw a diagram of each type of mountain. Label important features.

17. Making Models  Use layers of clay to make a model of fault-block mountains. Draw a diagram of your model.
18. **Drawing Conclusions** The speed of seismic waves suddenly increases when they go from the upper mantle into the lower mantle. What does this indicate about the comparative densities of the rock in both layers?

19. **Using Graphics Software** Use the graphics capabilities of a computer to generate a scale illustration of Earth’s interior. Include the thickness of each layer in kilometers.

20. **Recognizing Cause and Effect** What is the effect of subduction at the boundary of two plates?

21. **Poem** Write a poem in a style of your choosing about the spectacular view often associated with mountains. You may wish to write about the scene from the top of a mountain or the one you see from the bottom of the mountain looking up to its peak.

---

**Performance Assessment**

**TAKS Practice**

Germaine’s homework assignment was to do some research about Earth’s plates. In an encyclopedia, he saw a reference to the San Andreas Fault in California. The diagram he found is shown below.

**TEKS 6.6 C, TEKS 6.2 C**

Study the diagram and answer the following questions.

1. Which of the following is the most likely cause of frequent earthquake activity along the San Andreas Fault?
   - A) unusually high tides
   - B) movement of plates
   - C) increased sunspot activity
   - D) excessive oil drilling

2. According to the diagram, which statement best describes the motion of the plates on either side of the San Andreas Fault?
   - F) They are moving apart.
   - G) They are moving together.
   - H) They are sliding past each other.
   - J) They are not moving.

---

**Technology**

Go to the Glencoe Science Web site at tx.science.glencoe.com or use the Glencoe Science CD-ROM for additional chapter assessment.