TOPIC
4.2

What are tectonic plates and how is their movement linked to geological processes?

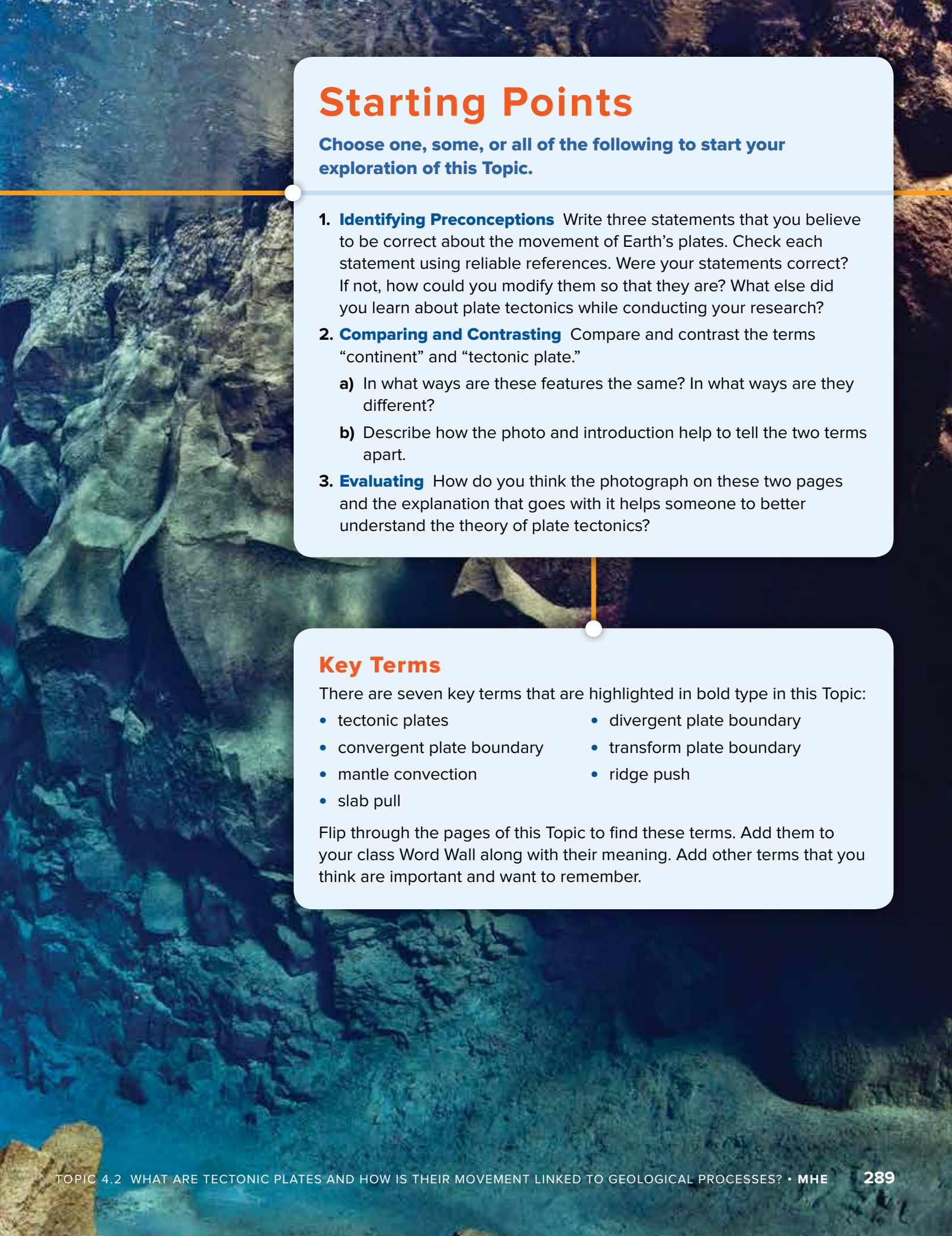
Key Concepts

- Earth's surface is made of huge rocky plates.
- Tectonic plates move relative to each other, causing certain geologic activities.
- Mantle convection contributes to tectonic plate movement.

Curricular Competencies

- Collaboratively plan an investigation to answer a question.
- Demonstrate an understanding and appreciation of evidence.
- Seek patterns and connections in data from secondary sources
- Transfer and apply learning to new situations.

If you want to visit western Europe, the quickest way is to fly by plane from Canada's east coast. But what if you were in a contest to get from North America to Europe in the least amount of time? The diver in the photo isn't in a contest, but the trip from one continent to the other takes the diver only a few seconds! This feat isn't quite so astonishing when you know something about where this photo was taken. The Thingvellir region of Iceland is an area of sea floor spreading. In this place, the North American plate and the Eurasian plate are slowly moving apart. The rocky features on each side of the diver are those tectonic plates.



Starting Points

Choose one, some, or all of the following to start your exploration of this Topic.

1. **Identifying Preconceptions** Write three statements that you believe to be correct about the movement of Earth's plates. Check each statement using reliable references. Were your statements correct? If not, how could you modify them so that they are? What else did you learn about plate tectonics while conducting your research?
2. **Comparing and Contrasting** Compare and contrast the terms "continent" and "tectonic plate."
   - **a)** In what ways are these features the same? In what ways are they different?
   - **b)** Describe how the photo and introduction help to tell the two terms apart.
3. **Evaluating** How do you think the photograph on these two pages and the explanation that goes with it helps someone to better understand the theory of plate tectonics?

Key Terms

There are seven key terms that are highlighted in bold type in this Topic:

- tectonic plates
- convergent plate boundary
- mantle convection
- slab pull
- divergent plate boundary
- transform plate boundary
- ridge push

Flip through the pages of this Topic to find these terms. Add them to your class Word Wall along with their meaning. Add other terms that you think are important and want to remember.

CONCEPT 1

Earth's surface is made of huge rocky plates.

Activity

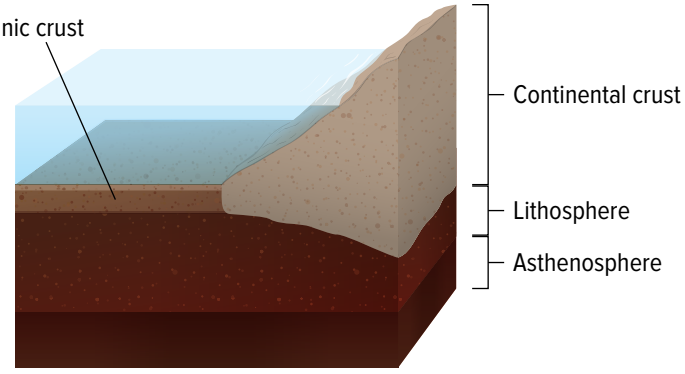
Structural Zones of Earth's Interior

Have you heard of the lithosphere and asthenosphere? What do you think they are? Explain your answer.

As shown in Figure 4.9, Earth's *lithosphere* is the outer layer of solid rock that is composed of crust and part of the upper mantle. According to the theory of plate tectonics, the lithosphere consists of very large slabs of rocky material, called **tectonic plates**. Some tectonic plates, such as the Pacific plate and the Juan de Fuca plate, are made up of only oceanic crust. Most tectonic plates, such as the North American plate, are made up of both oceanic crust and continental crust.

tectonic plates parts of the crust and uppermost mantle that move over Earth's surface

Tectonic plates move slowly and float on a layer called the *asthenosphere*. Material that makes up the asthenosphere is so hot that it behaves like a plastic material, making this layer much less rigid than the lithosphere. The asthenosphere flows like toothpaste or melted tar. This enables Earth's plates to move because the hotter, plastic mantle material beneath them can flow. The interactions between lithosphere and asthenosphere help to explain plate tectonics.



Oceanic crust is made mostly of basalt. It is denser than continental crust. Oceanic crust can be between 5 km and 8 km thick.

Continental crust is made mostly of granite. It is less dense than oceanic crust. Continental crust can be between 10 km and 70 km thick.

Figure 4.9 Earth's lithosphere consists of tectonic plates. **What is the key role of the asthenosphere in the theory of plate tectonics?**

Before you leave this page . . .

1. Tectonic plates are composed of which parts of Earth's layers?
2. What are two types of tectonic plates? Describe two features of each.

CONCEPT 2

Tectonic plates move relative to each other, causing certain geologic activities.

Activity

Modelling Plate Movements

Use your hands and the information in **Table 4.1** to model three ways plates can move. Place your hands side-by-side, touching and palms down, parallel to the floor. Move your hands apart to simulate plate movement along a mid-ocean ridge. Now place your hands parallel to the floor with palms down and fingertips touching. Force one hand down under the other to show what can happen when two plates move toward each other. Finally, place your hands, palms down, parallel to the floor with your index fingers touching and parallel to each other. Slide your hands back and forth against each other to simulate plate motion along a transform plate boundary.

Tectonic plates move in different directions and at different rates relative to one another. Plates interact with each other at their edges, or *plate boundaries*. Because we compare the motion of one plate with the plates around it, we refer to the "relative motion" of two plates at a plate boundary. When two plates separate and create new oceanic crust, a **divergent plate boundary** forms. When two tectonic plates collide, they form a **convergent plate boundary**. A **transform plate boundary** forms when two plates slide horizontally past each other. These three types of plate boundaries are shown in **Table 4.1** on the next page, with examples of geological features associated with each type.

divergent plate boundary where two tectonic plates move apart

convergent plate boundary where two tectonic plates collide

transform plate boundary where two tectonic plates slide past each other horizontally

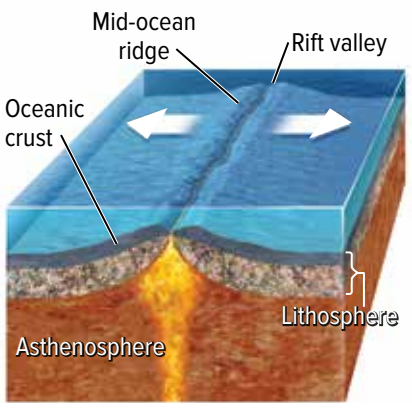
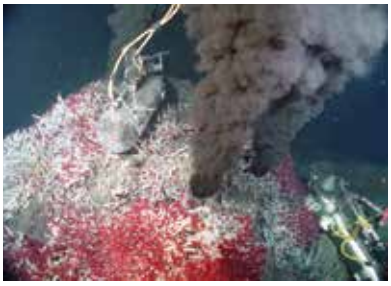
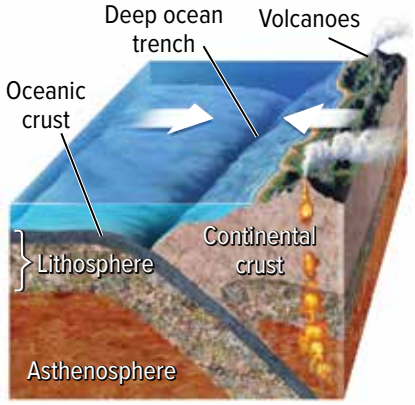
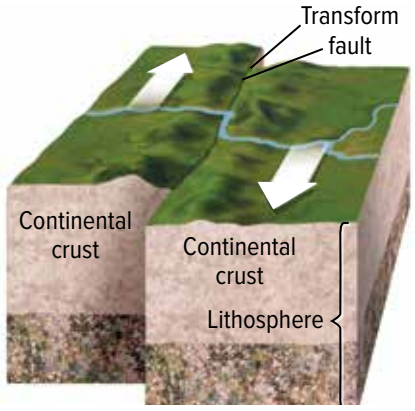
Extending the Connections

Plate Boundaries Around British Columbia

Draw a map to identify the relative positions and movement of the tectonic plates and their boundaries that lie near B.C. Identify all transform, convergent, and divergent plate boundaries, as well as the Juan de Fuca Ridge. What is a geologic fault? What faults lay along the west coast of Canada? What are the Mendocino Triple Junction and Cascadia Subduction Zone? Add these to your map.

Connect to Investigation 4-D on pages 296–297

Table 4.1 Interactions of Earth's Tectonic Plates

Plate Boundary	Relative Motion	Example
Divergent Plate Boundary When two plates separate and create new oceanic crust, a divergent plate boundary forms. This process occurs where the sea floor spreads along a mid-ocean ridge, as shown to the right. This process can also occur in the middle of continents and is referred to as a continental rifting.		 The Endeavour hydrothermal vents, created as the Juan de Fuca plate moves away from the Pacific plate.
Convergent Plate Boundary When two tectonic plates collide, they form a convergent plate boundary. When they collide, the denser crust eventually goes below the less-dense crust. This process is called *subduction*. Subduction causes deep sea trenches to form. Volcanoes and mountains, such as Mount Garibaldi and Mount Meager, form at these boundaries and earthquakes are common.		 Mount Garibaldi was created as a result of the Juan de Fuca plate subducting under the North American plate.
Transform Plate Boundary This boundary was first identified by a Canadian geologist named John Tuzo Wilson. A transform plate boundary forms when two plates slide horizontally past each other. The Queen Charlotte Fault results from movement along a transform plate boundary. Earthquakes are very common at these boundaries.		 In October 2012, an earthquake with a magnitude of 7.7 originated from movement along the Queen Charlotte Fault.

Before you leave this page . . .

1. What is subduction? When and why does it occur?
2. Describe the geological processes that occur at a divergent boundary. Relate it to what you learned about sea floor spreading.

CONCEPT 3

Mantle convection contributes to tectonic plate movement.

Activity

Modelling Heat Transfer

Convection is a process in which a warm fluid (liquid or gas) moves from one place to another, carrying heat with it. The fluid moves because of differences in density. The arrows show the direction of fluid movement.

- Where is the warmer and cooler water?
- Why does cooler water sink and warmer water rise?
- How could a process like this occur in the mantle, and how could it affect tectonic plates?

The movement of tectonic plates is measured using satellites, lasers, and other technologies. For example, the Global Positioning System (GPS) uses small radio receivers to record signals from several satellites that orbit Earth. These GPS receivers are placed at sites on land. By placing receivers on different tectonic plates, scientists can measure how fast the plates are moving and monitor the positions of the plates over time. Plates move at a rate of 1 to 15 cm per year. The map in **Figure 4.10** shows the relative movements of the plates along the major plate boundaries.

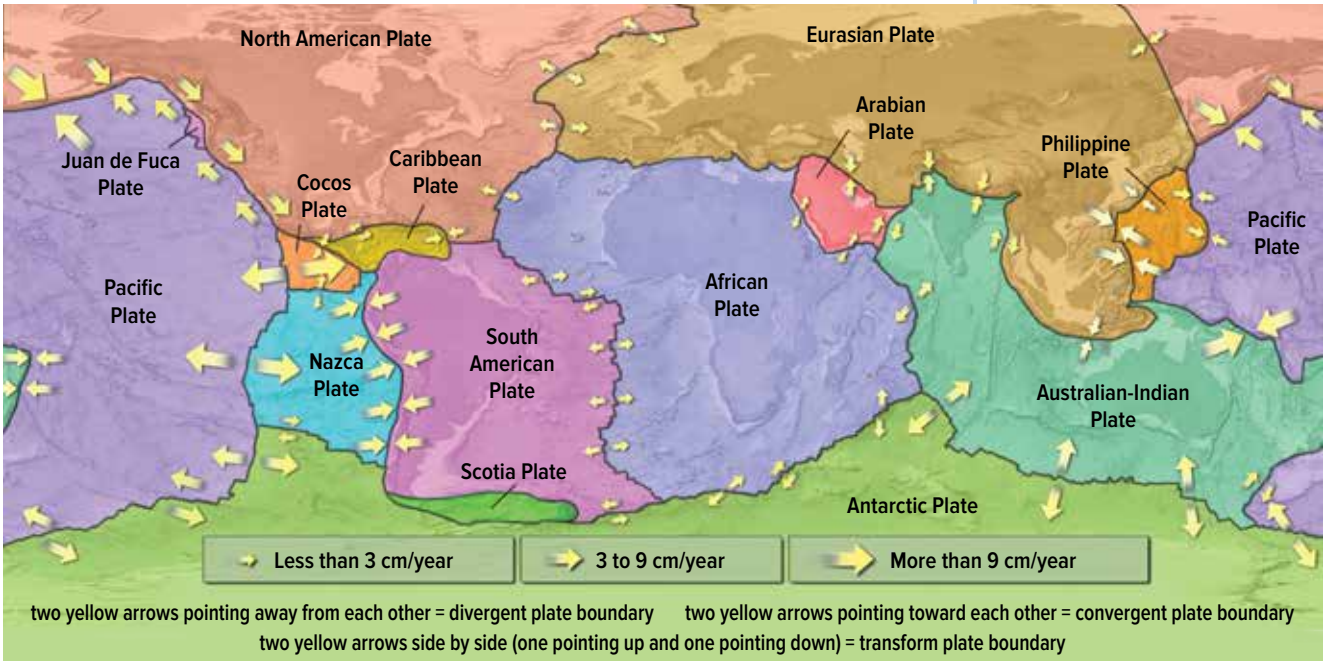


Figure 4.10 Arrows show whether the plate boundary is divergent, convergent, or transform. Wider arrows show faster movement than narrower arrows.

Mantle Convection

mantle convection current in the mantle where cooler, denser material sinks and warmer, less dense material rises

ridge push new material pushes older material aside, causing tectonic plates to move apart

slab pull pulling of a tectonic plate due to gravity and subduction

Recall that Earth's mantle is made of partially melted material. Energy from radioactive decay of some elements in Earth's interior and from Earth's core heats up parts of the mantle. Warmer, less dense material rises and cooler, denser material sinks. This causes very large *convection currents* within the mantle. As the mantle material moves, it drags the tectonic plates above with it. Figure 4.11 shows how **mantle convection** is thought to occur.

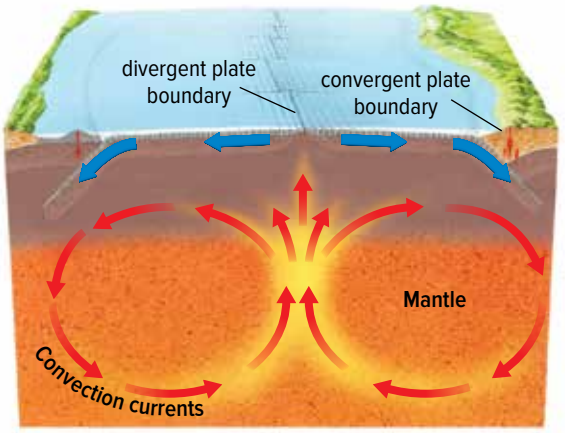


Figure 4.11 Convection currents are thought to drive tectonic plate motion. **Analyzing** Describe how mantle convection helps transfer heat between Earth's interior and exterior.

Scientists think there are several processes that determine how mantle convection affects the movement of tectonic plates. Two important processes are **ridge push** and **slab pull** (Figure 4.12).

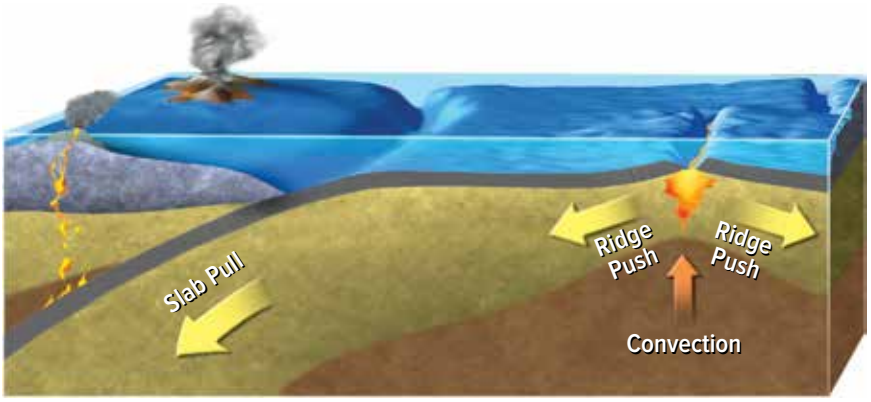


Figure 4.12 Ridge push and slab pull are thought to move tectonic plates. **Identify a convergent plate boundary and a divergent plate boundary in the illustration.**

Slab Pull
As the leading edge of a subducting plate sinks, it pulls the rest of the plate with it at convergent plate boundaries. Gravity and convection assist this movement.

Ridge Push
Rising material spreads out as it reaches the upper mantle. This causes the lithosphere to lift and push tectonic plates apart at divergent plate boundaries.

Before you leave this page . . .

1. Describe mantle convection.
2. Describe how slab pull and ridge push each contribute to plate movement.

Check Your Understanding of **Topic 4.2**

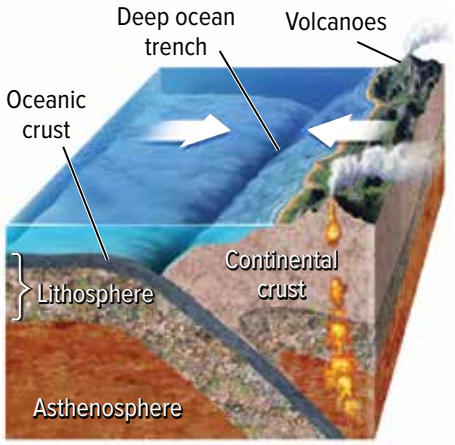
QP Questioning and Predicting PC Planning and Conducting PA Processing and Analyzing E Evaluating
AI Applying and Innovating C Communicating

Understanding Key Ideas

1. Use your current understanding of the theory of plate tectonics to explain the shapes and positions of the continents. PA E

2. What is the relationship between the following two terms: "divergent boundary" and "sea floor spreading"? PA

3. Use the following diagram to answer the questions below. C PA



   a) What is represented in the diagram? Explain how you know.
   b) Write a caption for the diagram.
   c) Describe how the deep ocean trench and the volcanoes are forming.

4. Draw a sketch that represents a transform boundary. Make sure to label the boundary and the components of your diagram. Explain why Earth's crust is neither destroyed nor created at such a boundary. PA C

5. Some people say that the theory of plate tectonics is the modern version of the continental drift hypothesis. Do you agree or disagree with this statement? Provide at least two reasons that support your opinion. C E

Connecting Ideas

6. When scientists cannot study an event directly, they often use a model to represent it.
   a) Describe two advantages of using a model.
   b) Describe two disadvantages of using a model.
   c) Describe one topic in earth science where using a model is useful. Explain why you think a model is useful in that situation. PA AI

7. Draw a diagram comparing convection in a pot of water with convection in Earth's mantle. Relate the process to how scientists think tectonic plates move. C

Making New Connections

8. Through the use of space probes, scientists have discovered that some moons, planets, and dwarf planets of our solar system have geologic processes similar to those of Earth. For example, Jupiter's moon Io has volcanoes, and there is evidence of tectonic activity on Pluto, which is nearly 6 billion km from the Sun. What questions do you have about these kinds of discoveries? List at least four questions. Then choose one and suggest your own ideas for possible answers. QP AI

INVESTIGATION
4-D

GUIDED INQUIRY

Skills and Strategies

- Planning and Conducting
- Processing and Analyzing
- Evaluating
- Communicating

Comparing Plate Boundaries with Geologic Features and Processes

According to the theory of plate tectonics, rocky plates move across Earth's surface and interact at plate boundaries. In this investigation, you will analyze maps to identify examples of geological processes at convergent, divergent, and transform plate boundaries. (These boundaries appear on the map below.)

Question

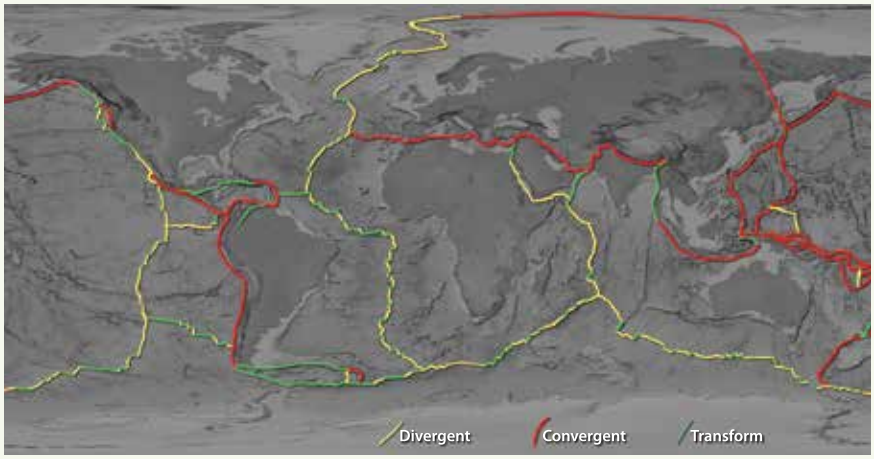
What geologic processes and features are associated with each type of plate boundary?

Procedure

1. Plan how you will use the maps to answer the question.
2. Decide how you will communicate the results of your analyses of the maps. For example, you may find a table format to be helpful. Then, carry out your plan.

Analyze and Interpret

1. Draw a sketch of what happens at each type of plate boundary that results in geologic processes.
2. What geologic processes are not always associated with plate boundaries? What do you think causes these?

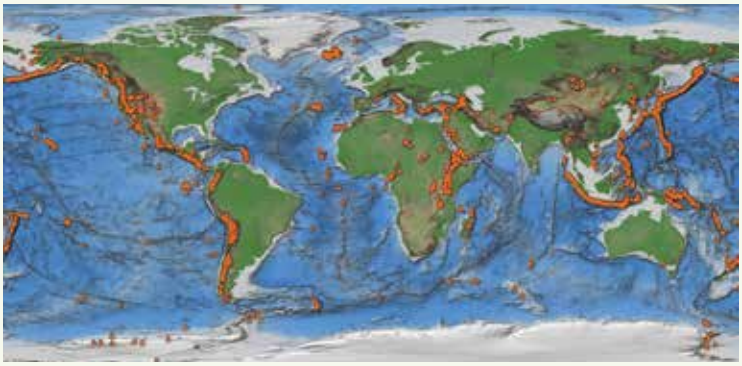


Conclude and Communicate

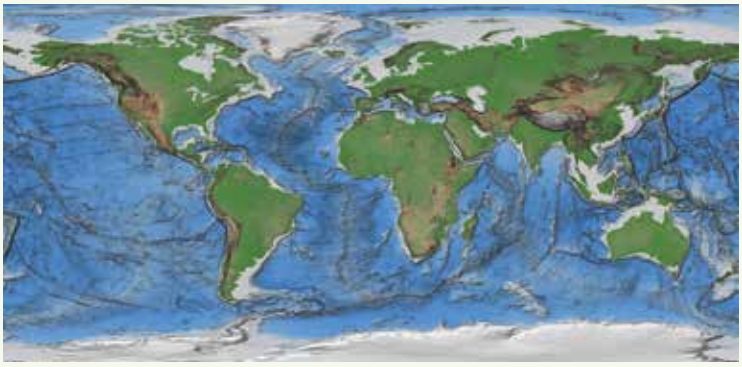
3. What geologic processes did you identify to be associated with each plate boundary?

4. In what ways were the maps a useful way of representing the information? In what ways were they not useful?

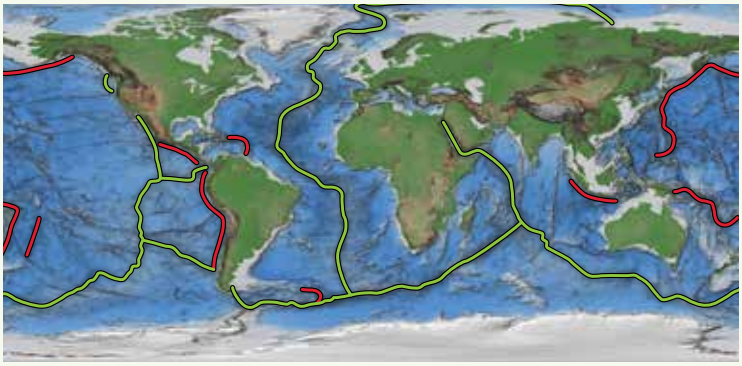
Yellow circles show where moderate to strong earthquakes have happened.



Orange triangles show the locations of active volcanoes.



High elevation is in brown, and low elevation is in green.



This map shows deep sea trenches (red) and mid-ocean ridges (green).