Section 8.3

1 FOCUS

Section Objectives

8.8 **Identify** the major hazards associated with earthquakes.

8.9 **Describe** how earthquake damage can be reduced.

Reading Focus

Build Vocabulary L2

Paraphrase Ask students to write the vocabulary words on a sheet of paper. Instruct students to write a definition, in their own words, for each term as they encounter the term while going through the chapter. After writing their own definition, they should also write a complete sentence with the term.

Reading Strategy L2

Sample answers:
a. how seismic vibrations can cause damage
b. Damage depends on the building design, intensity and length of time of the vibrations, and the material that the building was constructed on.
c. dangers associated with earthquakes
d. These include tsunamis, landslides, and fire.

2 INSTRUCT

Causes of Earthquake Damage

Reading Strategy L2

Invite a structural engineer to speak to the class about the construction of earthquake-safe buildings. Have students ask about specific regulations for building codes in your area.
Interpersonal

8.3 Earthquake Hazards

Reading Focus

Key Concepts

- What are the major hazards produced by earthquakes?
- How can earthquake damage be reduced?

Vocabulary

- liquefaction
- tsunami
- seismic gap

Reading Strategy

Monitoring Your Understanding Preview the Key Concepts, topic headings, vocabulary, and figures in this section. List two things you expect to learn. After reading, state what you learned about each item you listed.

What I Expect To Learn	What I Learned
a. ___?___	b. ___?___
c. ___?___	d. ___?___

The Prince William Sound earthquake that struck Alaska in 1964 was the most violent earthquake to jar North America in the 20th century. The earthquake was felt throughout Alaska. It had a moment magnitude of 9.2 and lasted 3 to 4 minutes. The quake left 131 people dead and thousands homeless. The state's economy was also badly damaged because the quake affected major ports and towns.

Causes of Earthquake Damage

An earthquake as powerful as the 1964 Alaska earthquake can cause catastrophic damage. But even less powerful earthquakes also pose serious hazards. **Earthquake-related hazards include seismic shaking, liquefaction, landslides and mudflows, and tsunamis.**

A

Figure 9 Earthquake Damage
A A magnitude-7.6 earthquake in northern Pakistan in 2005 destroyed mountain villages and killed more than 70,000 people.
B During a 1985 earthquake in Mexico, the soil beneath this toppled building liquified.
C A landslide triggered by an earthquake in 2001 buried this neighborhood in El Salvador.

Customize for Inclusion Students

Gifted When we consider how many earthquakes there are in one year, the number of earthquakes that cause terrible damage is actually very small. The amount of damage an earthquake causes depends on many conditions. For example, if a building is well constructed and built on solid ground, it may survive an earthquake. Most injuries and deaths during earthquakes are because of poor construction or substandard building sites. Another serious problem is not knowing how to respond to an earthquake. When people panic and rush out of buildings there is a danger of being trampled, suffocated, or injured by falling debris. Go to the Red Cross website at http://www.redcross.org/services/disaster and read about earthquake safety.

Seismic Shaking The ground vibrations caused by seismic waves, called seismic shaking, are the most obvious earthquake hazard. Seismic waves interact to jolt and twist structures. Buildings made of unreinforced brick may collapse. Wood-frame buildings may remain intact, but still can be jolted off their foundations.

Seismic shaking is generally strongest close to an epicenter. Yet strong seismic shaking can occur in areas of loose soil or filled land relatively far from an epicenter. The filled soil magnifies the effects of seismic waves. Structures in such areas can experience severe damage.

Liquefaction Where soil and rock are saturated with water, earthquakes can cause a process called **liquefaction.** When liquefaction occurs, what had been stable soil suddenly turns into liquid. The liquid cannot support buildings or other structures. Buildings and bridges may settle and collapse. Underground storage tanks and sewer lines may float toward the surface.

Table 2 Major Earthquakes

Year	Location	Magnitude†
*1906	San Francisco, California	7.8
1923	Tokyo, Japan	7.9
1960	Southern Chile	9.5
*1964	Alaska	9.2
*1971	San Fernando, California	6.5
1985	Mexico City	8.1
*1989	Loma Prieta, California	6.9
*1994	Northridge, California	6.7
1999	Izmit, Turkey	7.4
1999	Chi Chi, Taiwan	7.6
2004	Indian Ocean near Indonesia	9.3

* U.S. earthquakes

† Widely differing magnitudes have been estimated for some earthquakes. When available, moment magnitudes are used.

Landslides and Mudflows Earthquakes can trigger different types of mass movement. These destructive events can quickly bury entire towns under millions of tons of debris.

Earthquakes often cause loose rock and soil on slopes to move. The result is a landslide. Most landslides occur on steep slopes where sediment is loose or where the rocks are highly fractured.

In areas where the water content of soil is high, an earthquake can start a mudflow. During a mudflow, a mixture of soil and water slides rapidly downhill.

Reading Checkpoint *What is liquefaction?*

B

C

Causes of Earthquake Damage

Build Science Skills L2

Using Models Students should create a model of a house on a small hill using sand, potting soil, and thin wire netting. The model should be no more than 30 cm high. Then, students will shake their model in such a way that mimics an earthquake. They will then observe what happens to the hill and the buildings placed on it. Ask: **What happens to the buildings on the slope?** *(Answers will vary but students should see that the buildings slid down the slope.)* **What impact could water have on the model earthquake?** *(The damage would probably be worse if the hillside was saturated with water.)*
Kinesthetic

Use Community Resources L2

Instruct students to ask their village or city officials about local tsunamis, landslides, or fires that resulted from an earthquake. Some sources to contact might be fire departments, city halls, and newspaper or media archives. Ask them to brainstorm appropriate questions and ask the official they hope to interview.

Build Reading Literacy L1

Refer to **p. 474D** in **Chapter 17,** which provides guidelines for monitoring your understanding.

Monitor Your Understanding Display a world map with the names of major cities. Help students find the locations where the earthquakes listed in Table 2 occurred. Then ask students whether the earthquake's location is in any of the earthquake zones on the map on page 231. *(Most are in the circum-Pacific belt. Armenia—1988; Iran—1990; and Izmit, Turkey—1999 are in the Mediterranean-Asian belt. The Charleston, SC, earthquake of 1886 is not in any of the zones described in the text.)*

Facts and Figures

American Earthquake Hazards Where in the United States do the largest earthquakes occur? It is not California. Transform faults, like the San Andreas, cannot have the most powerful earthquakes. If the entire San Andreas fault ruptured at the level of its 1906 quake, the resulting earthquake would only have a magnitude of about 8.3. However, both Alaska and the Pacific Northwest, which are both over subduction zones, have had earthquakes with magnitudes greater than 9. The 1964 Alaska earthquake was the largest recorded quake in the United States with a magnitude of 9.2. A quake of at least magnitude 9 also occurred beneath Oregon and Washington in 1700. If an earthquake of that magnitude occurs again, Seattle and Portland could be devastated.

Answer to . . .

Reading Checkpoint *the earthquake hazard in which soil that is saturated with water suddenly changes to liquid mud, collapsing any structures built on the soil*

Section 8.3 (continued)

Tsunamis

Build Science Skills L2

Observing Have pairs of students investigate recent or historically significant tsunamis. (They may use library resources or conduct a Web search.) After students have had time to obtain information, have them compare their findings with another group.
Interpersonal, Verbal

Build Reading Literacy L1

Refer to **p. 334D** in **Chapter 12** for guidelines on outlining content.

Outline Have students read the section. Then have students use the headings as major divisions in an outline. Allow students to refer to their outlines when answering the questions in Section 8.3 Assessment.
Visual

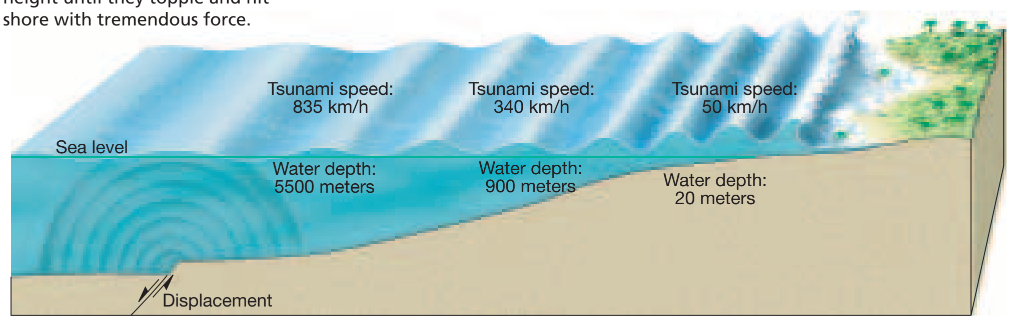
Figure 10 Indian Ocean Tsunami, 2004 A surge of water rushes inland as a tsunami strikes the coast of Thailand. On average, only one or two destructive tsunamis occur worldwide every year. Only about one tsunami in every 10 years causes major damage and loss of life.

Tsunamis A **tsunami** is a wave formed when the ocean floor shifts suddenly during an earthquake. For example, in 2004 a magnitude-9.3 earthquake west of the island of Sumatra in the Indian Ocean produced devastating tsunamis. Without warning, the huge waves struck coastal areas of Indonesia, Sri Lanka, Thailand, and several other countries, killing nearly 300,000 people.

How do these giant waves form? A tsunami can occur when an earthquake pushes up a slab of ocean floor along a fault. An underwater landslide or volcanic eruption can also trigger a tsunami. Once formed, a tsunami resembles the ripples created when you drop a pebble in a pond. Surprisingly, a tsunami on the open ocean is usually less than 1 meter high. This wave races across the ocean at hundreds of kilometers per hour. However, as the wave enters shallower water near shore, the wave slows down and water begins to pile up. As you can see in Figure 11, a tsunami can strike the shore as a huge wave that sweeps inland causing great destruction. Tsunamis range from a few meters to more than 30 meters high.

A tsunami warning system alerts people in coastal areas around the Pacific Ocean. After the deadly 2004 tsunami, a similar system was planned for the Indian and Atlantic oceans. Scientists use devices that measure wave height to detect a tsunami. Tsunami warnings allow sufficient time to evacuate all but the area closest to the epicenter.

Figure 11 How a Tsunami Forms Movement of the ocean floor causes a tsunami. The speed of a tsunami is related to the ocean depth. As waves slow down in shallow water, they can grow in height until they topple and hit shore with tremendous force.



Facts and Figures

Tsunami Dispersion Something very dangerous happens when a tsunami travels across the ocean. It breaks up into several different waves, a process called *dispersion*. This occurs because the waves of different wavelengths travel at different speeds. Students may be most familiar with dispersion from the way that different colors of light (which also have different wavelengths) refract differently through a prism, causing the colors to separate. Tsunami waves with longer periods travel faster and arrive first. However, this means that the tsunami hazard is not over after the first wave hits. In fact, the largest and most destructive waves often arrive after the first wave hits.

Reducing Earthquake Damage

Earthquake damage depends on several factors. Two important factors are the strength and duration of seismic shaking and the materials and design of structures. **Earthquake damage and loss of life can be reduced by determining the earthquake risk for an area, building earthquake-resistant structures, and following earthquake safety precautions.**

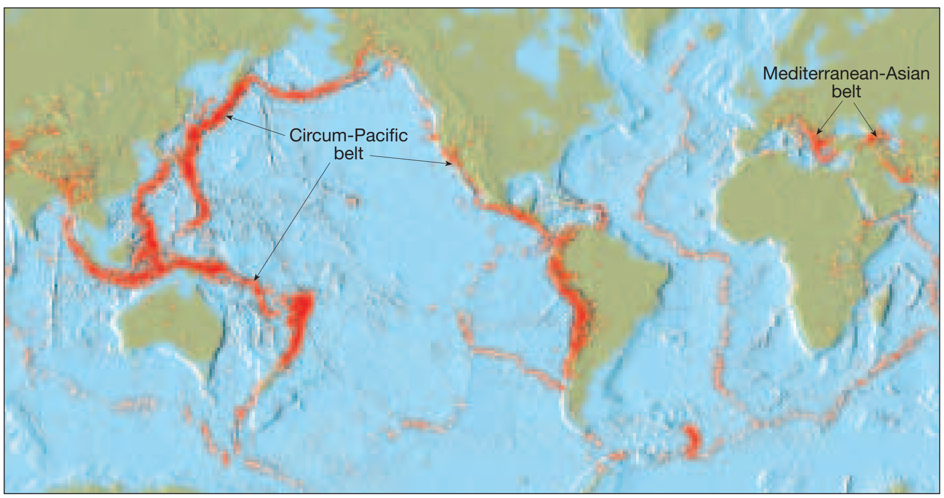
Assessing Earthquake Risk How can people reduce damage from earthquakes? First, it is important to know the risk of earthquakes in a region. As you can see in Figure 12, the distribution of earthquakes forms a pattern. Scientists have found that earthquakes are most frequent along the boundaries of Earth's tectonic plates.

Scientists use several methods to determine earthquake risk. They study historical records of earthquakes. They use devices to measure uplift, subsidence, and strain in the rocks near active faults. They also study "seismic gaps." A **seismic gap** is an area along a fault where there has not been any earthquake activity for a long period of time. Scientists hypothesize that the buildup of strain along a seismic gap will eventually lead to an earthquake. Considering all these data, scientists are studying ways to estimate the probability that an earthquake will occur in an area within the next 30 to 100 years.

Scientists also look for warning signs that an earthquake is about to strike. In addition to monitoring fault movements, they measure water levels and pressure in wells, radon gas emissions, and small changes in the electromagnetic properties of rocks. But efforts at short-term prediction of earthquakes have not yet been successful.

Reading Checkpoint *What is a seismic gap?*

Figure 12 The map shows the distribution of the 14,229 earthquakes with magnitudes equal to or greater than 5 from 1980 to 1990. **Observing** ***Where do you find most of the earthquakes—in the interiors of the continents or at the edges?***



Reducing Earthquake Damage

Build Science Skills

Reading Maps Ask students to describe the overall pattern of earthquakes that they see on the map in Figure 12. Tell them that the major belt of earthquakes around the Pacific Ocean is called the "Ring of Fire" because it is also an area where many volcanoes form. Point out that the east–west belt of earthquakes stretching across southern Europe and Asia corresponds with an area of mountain building. Explain that earthquakes are common in these areas because there are many active faults. The faults form in areas where tectonic plates come together or pull apart. Tell students that they will learn more about this process in Chapter 9.
Visual

Integrate Biology

L2

Can Animals Predict Earthquakes? There is much speculation as to the ability of animals to predict earthquakes. Documented cases have shown snakes and bees rapidly leaving their homes, dogs barking excessively, and other erratic behavior in domesticated and wild animals prior to major earthquakes. The US Geological Survey, however, is more skeptical. They acknowledge the abundance of cases of reported behavioral changes prior to an earthquake but there aren't enough reproducible connections to conclusively state that animals are predicting the earthquakes. Have students research specific cases of odd animal behavior prior to earthquakes and present their findings in a newspaper article.
Verbal

Customize for English Language Learners

Earthquakes happen most frequently in certain areas of the world. These areas are called earthquake belts. The rim or edge of the Pacific Ocean is the largest of these belts. Another belt stretches from China to Southeast Asia to Africa and Europe. A third earthquake belt lies under the Atlantic Ocean. With a partner, look at a map of the world. Identify the areas where there are earthquake belts. List on a piece of paper the names of the oceans or land masses where you think there are earthquake belts.

Answer to . . .

Figure 12 *mostly along the edges of continents*

Reading Checkpoint *part of a fault where no earthquakes have occured for a long time*

Section 8.3 (continued)

3 ASSESS

Evaluate Understanding

L2

Have students work in groups to develop a short public service announcement on the other dangers facing areas that have experienced an earthquake.

Reteach

L1

Ask students to use the diagram in Figure 11 to explain how tsunamis are generated and how they move to shore.

Connecting Concepts

If there were some way to measure the amount of energy stored in rocks, this might lead to the prediction of earthquakes. If scientists could observe and measure the buildup of stress within rocks, they might be able to determine the amount of stress the rocks could withstand before the energy needed to be released. This could provide an estimate of time for an earthquake.

Address Misconceptions

L2

Many students may have heard that the safest place in a house during an earthquake is in a doorway. Challenge this misconception by pointing out that modern doorways are no stronger than other sections of a house and usually have doors that could swing and injure someone. Encourage students to come up with another plan for earthquake safety. This should involve ducking under a sturdy table or desk and staying clear of objects that could tip over, such as file cabinets and bookcases.

Go Online NSTA SCILINKS

Download a worksheet on predicting earthquakes for students to complete, and find additional teacher support from NSTA SciLinks.

Figure 13 Strong, diagonal beams called cross-braces have been installed in this building to improve the structure's ability to withstand seismic waves.

Go Online SCILINKS NSTA

For: Links on predicting earthquakes
Visit: www.SciLinks.org
Web Code: cjn-3082

Seismic-Safe Design Many cities in earthquake-prone regions have building codes that set standards for earthquake-resistant structures. Steel frames can be reinforced with cross-braces. Buildings can be mounted on large rubber and steel pads, called base-isolators, which absorb the energy of seismic waves. Wood-frame homes can be reinforced and bolted to their foundations. People can "retrofit" or reinforce older buildings to make them more earthquake resistant.

Utility lines must also be protected. To prevent fires or explosions in gas mains, flexible pipes and automatic shut-off valves can be installed. Flexible joints in water mains can prevent loss of water pressure needed to fight fires. Much of the damage after the 1906 San Francisco earthquake resulted from fires. The fires could not be put out because water mains had broken.

Earthquake Safety Knowing what to do during an earthquake can reduce your risk of injury. The basic rule is to "drop, cover, and hold." Indoors, crouch beneath a sturdy table or desk and hold onto it. If no desk or table is nearby, crouch against an inner wall away from the outside of a building. Cover your head and neck with your arms. Avoid windows, mirrors, and furniture that might topple.

If you are outdoors when an earthquake strikes, move to an open area. Avoid vehicles, power lines, trees, and buildings. Sit down to avoid being thrown down. The danger does not end once an earthquake has stopped because an aftershock could cause weakened structures to collapse.

Section 8.3 Assessment

Reviewing Concepts

1. Describe five hazards caused by earthquakes.
2. Explain how earthquake-related damage can be reduced.
3. What is a tsunami?
4. What is a seismic gap?

Critical Thinking

5. **Making Judgments** A builder in Alaska has a choice of two sites for a building: one is on filled land next to the ocean, and the other is inland on solid ground. Both sites are the same distance from an active fault. Which site should the builder choose? Explain.
6. **Predicting** In an earthquake-prone area, it has been many years since the last earthquake along a fault. Should residents be concerned about a future earthquake? Explain.

Connecting Concepts

Earthquakes In Section 8.1, you learned about the elastic energy stored in rocks before an earthquake and the elastic rebound hypothesis. How could this information be used to try to predict earthquakes?

Section 8.3 Assessment

1. Seismic shaking, liquefaction, landslides, mudflows, tsunamis
2. Ways of reducing earthquake damage include determining the level of earthquake risk for the area, constructing earthquake-safe buildings, and taking steps for earthquake safety.
3. A tsunami is a seismic sea wave created by an underwater earthquake or a landslide under the ocean floor generated by an earthquake.
4. A seismic gap is an area along a fault that has not had any earthquake activity for a long period of time.
5. The builder should choose the inland site on solid ground. If an earthquake occurred, the other site would be in danger from tsunamis and liquefaction.
6. Yes. Stress may have been building up along the fault, making an earthquake more likely.