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# Earthquake!

GREAT STORY & COOL FACTS



# Earthquake!



## GREAT STORY & COOL FACTS

### Introduction

Welcome to Half and Half books, a great combination of story and facts! You might want to read this book on your own. However, the section with real facts is a little more difficult to read than the story. You might find it helpful to read the facts section with your parent, or someone else, who can help you with the more difficult words. Your parent may also be able to answer any questions you have about the facts—or at least help you find more information!

# Earthquake!

With special thanks to Malcolm Barker, author of *Three Fearful Days: San Francisco Memoirs of the 1906 Earthquake & Fire*, for his review and suggestions on the fiction portion of this book (Shaken to the Ground).

With special thanks to Eric Geist, Research Geophysicist, at the U.S. Geological Survey for his review and recommendations on the nonfiction portion of this book.

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# EARTHQUAKE!

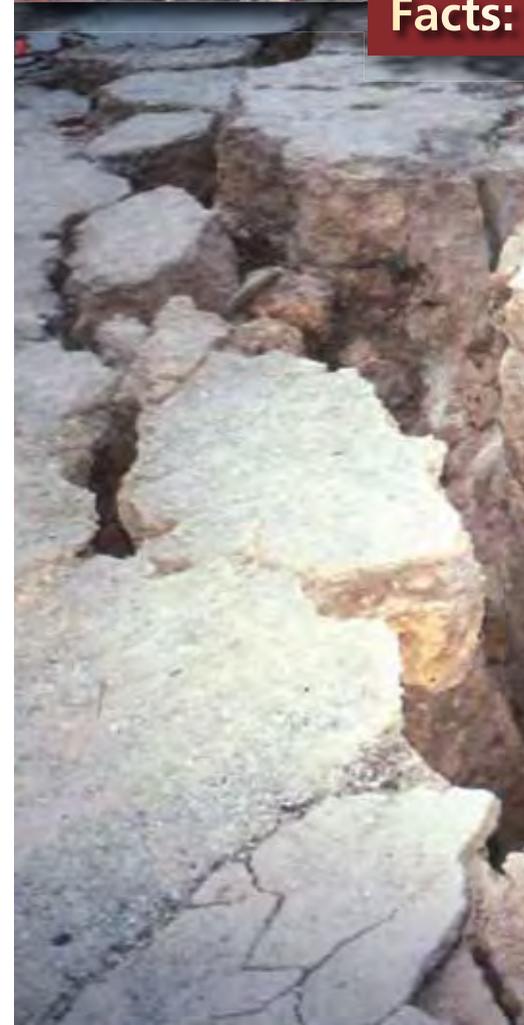


## Story: Shaken to the Ground 2

A New Start	2
Disaster	7
The Most Terrible Day	12
Camp	17
Making a Difference	23

## Facts: About Earthquakes 26

Why the San Francisco Earthquake Was So Terrible	26
Life in the Camps	30
Understanding Earthquakes	32
How Plates Fit Together	34
How Earthquakes Happen	36
The Magnitude of Earthquakes	38
Some Effects of Earthquakes	40
Other Famous Earthquakes	42
Make a Model	44
Building Better Buildings	46
Predicting Earthquakes	48
Be Prepared	49
During and After an Earthquake	50
An Earthquake Quiz	52



# SHAKEN TO THE GROUND

STORY BY FRAN HODGKINS  
ILLUSTRATED BY JUDITH HUNT

## A NEW START

Louis leaned over the ship's rail and gazed excitedly at the skyline. "San Francisco at last!" he said.

Dr. George Cabot grinned at his son and put his arm around his wife. "It's a wonderful sight after all these weeks at sea," the doctor said.

"I must say, it doesn't look like a frontier town at all," said Mrs. Cabot. "I'll have to write to Mrs. Emerson and tell her she's mistaken."

Dr. Cabot chuckled. "After all, frontier towns don't often have large hospitals that hire doctors from Massachusetts."

As the ship drew near the dock, Louis said to himself, "I hope San Francisco will be exciting!" He tried to take in all the activity on the pier. Voices spoke English, French, Spanish, Chinese, and other languages he could only guess at. Longshoremen unloaded the ship. Quickly they littered the dock with cargo of all sizes and shapes. Louis carried a small suitcase, while his father carried his medical satchel. Everything else they owned was inside trunks and crates that were somewhere among the jumble on the pier.

A tall, dark-haired young man held a sign that read "Dr. Cabot." Louis's father stopped and said, "I'm Dr. Cabot."



“Sir, what a pleasure to meet you. My name is Thomas Winter. I’m here to take you to the hotel where you’ll be staying until your house is ready.” The young fellow smiled. Louis instantly liked him. His father shook Thomas’s hand and made introductions. “This is my wife and our son, Louis.”

“Welcome to San Francisco,” Thomas said as he took the suitcase and led the family to a car. “I’ll come back and get your trunks after I drop you off.”

“Would you like to sit up front, Louis?” Dr. Cabot asked. Louis nodded, and his parents settled into the back seat.

“What’s that?” Louis asked, pointing at a large building. “That’s the Ferry Building,” Thomas said. “You can catch a boat there to Oakland and Berkeley.” Thomas grinned. “They’ve got a fine big university over there at Berkeley,” he said.

“Does it have a medical school?” Dr. Cabot asked. “I’d like my son to follow in my footsteps one day.”

Louis sighed softly. Although he was proud of his father, Louis did not want to be a doctor himself. While Thomas and Dr. Cabot chatted, Louis studied the many buildings that lined Market Street. It truly was hard to believe that the city was so new. It had everything a city needed. Banks, as stately as any bank in Boston, stood along the cobblestone street. People bustled in and out of the entrances of offices and shops. Carriages, cars, and trolleys shared the streets, and people on foot and on bicycles dodged among them. Thomas explained, "Underground cables pull the trolleys up the hills, which are too steep for horses. That's why we call them cable cars. We've had to be quite creative when it comes to solving the challenges involved with building around here."

Holding on to her hat, Mrs. Cabot said, "Is it true, Thomas, that the city is only about sixty years old?"

"Yes'm," he said. "At first, it was just a little place called Yerba Buena. Then after gold was discovered, the city grew like a weed. Today more than 400,000 people call San Francisco home."

They soon arrived at the Palace Hotel. Thomas handed the suitcase to a bellhop and declined the tip that Dr. Cabot offered. "My uncle started the hospital," he said. "When he said you were coming, I offered to pick you up. It gave me a chance to show off my city. You'll find that San Francisco is a special place."

As his parents checked in, Louis investigated a display in the lobby. Titled "The Safest Hotel in California," the display featured a tiny model of the hotel. To his amazement, Louis read that California experienced earthquakes, mighty movements of the ground. However, the Palace Hotel was built with two-foot-thick, iron-reinforced walls. "No earthquake could destroy the Palace," the display boasted.

His father called, "Come now, Louis. Let's have our dinner." He left the display and followed his parents to the dining room.

Later, washed up and in his nightclothes, Louis lay in bed. Thinking about how interesting his new city was, he drifted off to sleep.

## DISASTER

When Louis awoke, it was still dark. He kept thinking about seeing this new city. Unable to sleep, he dressed quietly and then sat in an armchair, staring out the window at the dark. His parents snored softly in their bed.

Suddenly the chair shook. The two beds danced across the floor, waking his parents. "What the dickens!" exclaimed Dr. Cabot. Mrs. Cabot's eyes were wide with fright. The overhead lamp swung wildly. Louis clung to the chair as it shimmied across the floor and struck the wall.

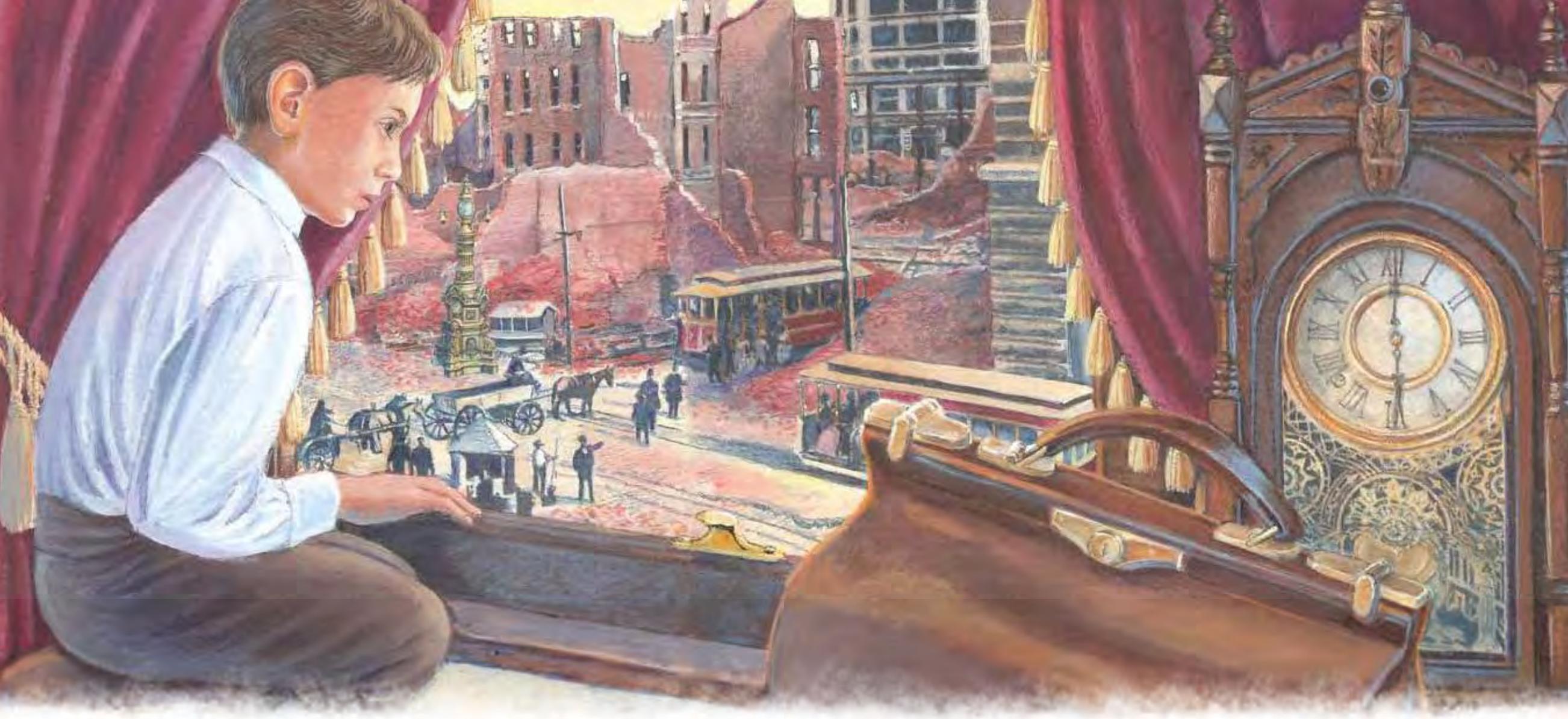
Over the next minute, the earthquake shook the city. Streets lurched up and down. Water and gas pipes snapped. Bricks and cobblestones flew. Chimneys disintegrated. Windows shattered. In kitchens, stoves fell, and burning coal and logs skittered over wood floors. Small fires sprang up everywhere.

Once the quake ended, the family dressed quickly and hurried downstairs. In the lobby, the manager told guests, "You're perfectly safe, ladies and gentlemen. The Palace Hotel is earthquake-proof."

"What about fire?" someone asked.

"We have our own water supplies, stored in tanks right





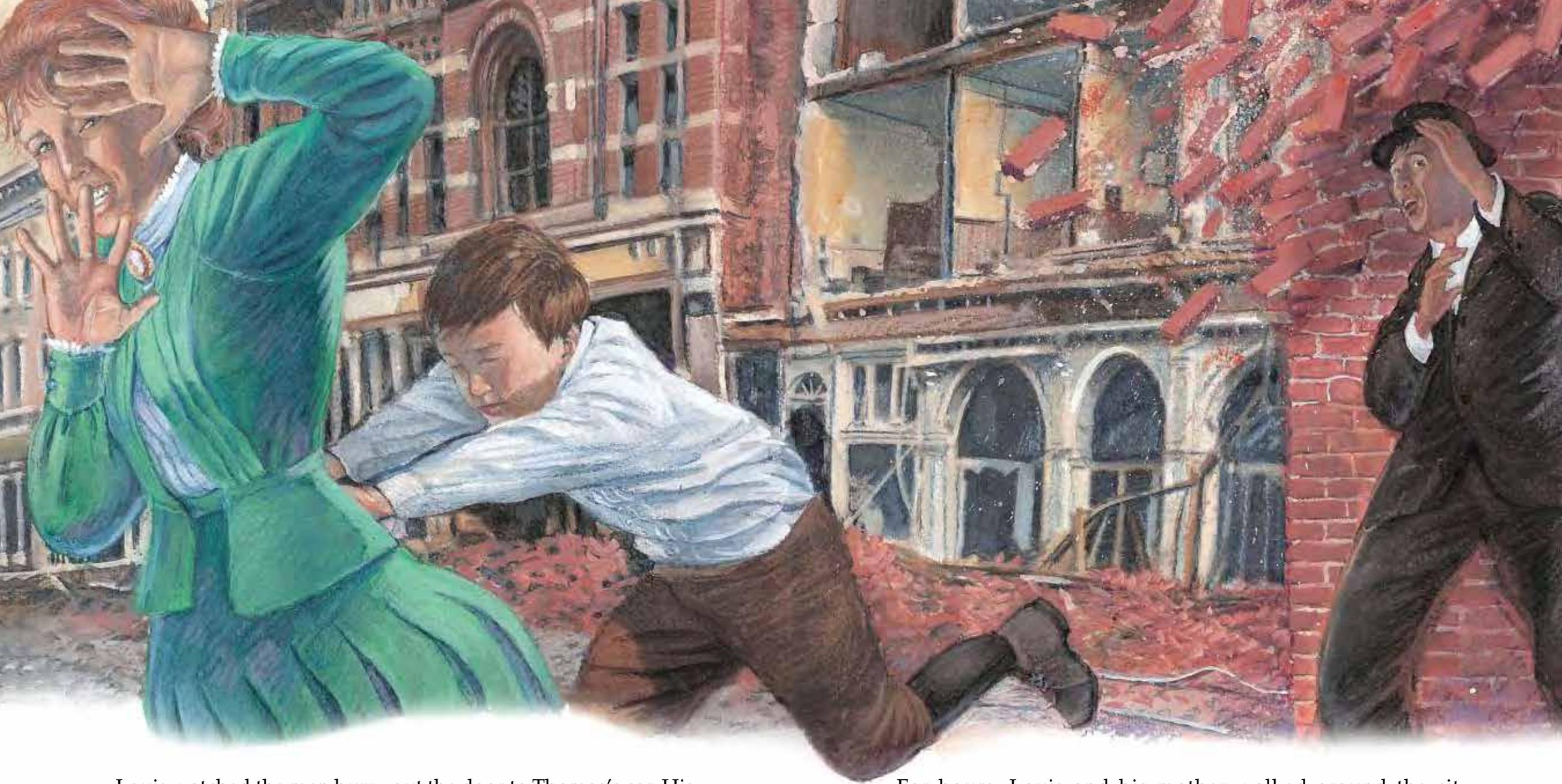
here at the hotel. Should anything occur, it will be dealt with swiftly and effectively,” the manager said. People murmured to each other, reassured.

Dr. Cabot turned to his family. “I need to go. I’m sure there are people who need my help. Louis, get my bag, please.”

Louis took the stairs two at a time to their hotel room. Day was just dawning, and the view out the window stopped him in his tracks. The beautiful city he had seen the night before lay in ruins.

Dozens of the buildings he had admired on their ride to the hotel had been reduced to huge piles of rubble. He tore himself away from the window, picked up his father’s medical bag, and hurried back downstairs.

Thomas was there, talking with his parents. His face was drawn with worry. “Thank you, son,” his father said, taking the bag. He looked into Louis’s eyes gravely. “I may be gone for a while, son. Take care of your mother.”



Louis watched the men hurry out the door to Thomas's car. His mother joined him and put her arm around his shoulders. "Well, Louis, let's see where we might be of help."

Together they left the hotel. Because bricks and other debris covered the sidewalks, they walked in the street. The silence was eerie. Louis's mother reached out and took his hand, as much to comfort herself as to reassure him.

For hours, Louis and his mother walked around the city, offering what help they could to wounded and frightened citizens. Around noon, they began heading back toward the Palace Hotel for some food and rest. Suddenly Louis heard a faint groan that slowly grew louder.

He glanced up to see the top of the wall toppling toward them. "Look out!" he cried and pushed his mother toward the other side

of the street. Behind them, the groan became a roar as the wall fell. It sent up a storm of dirt and brick dust.

Coughing, Louis covered his eyes with his left hand and gripped his mother's arm with the other. After a few moments, he opened his eyes. His mother stood next to him, frightened but unhurt. Her clothes had been tinted dark maroon by the brick dust.

"Help me!" cried a man's voice. "Help!"

## THE MOST TERRIBLE DAY

Through the clearing dust, Louis saw a man lying in the street. He had leaped out of the way just in time to avoid being crushed by the falling wall. "My arm!" the man gasped. "The pain!" His face was greenish.

"It's broken," Louis said.

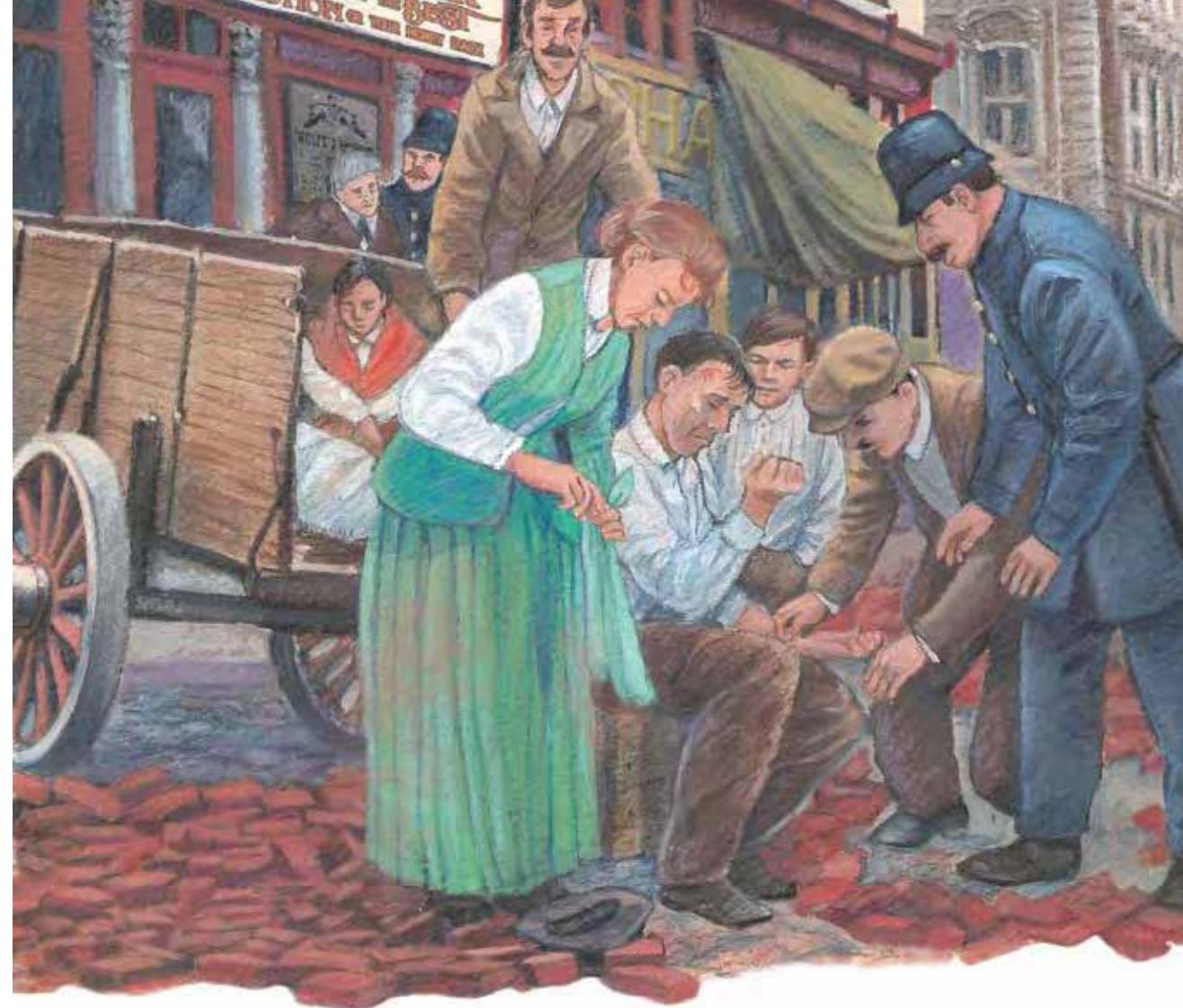
"We need to splint it and get you to the hospital," Mrs. Cabot said. Louis dug through the rubble until he found a piece of wood about a foot and a half long. Meanwhile, Mrs. Cabot tore her jacket into strips.

"This is going to hurt," she warned the man.

He nodded and bit his lip. Louis held the arm straight as his mother tied it securely to the wooden splint. Color drained from the man's face as they worked but gradually came back. "That helps. Thank you."

Just then, a police officer came around the corner and rushed up to help. "Come with me, sir," he said. "I'll get you to the hospital." The officer turned to the Cabots. "Where are you folks headed?" When he heard they were headed back to the Palace Hotel, he shook his head. "Sorry, ma'am, but the Palace Hotel is on fire, and there is no chance of saving it."

"Oh, no! Everything we had was at the hotel," exclaimed

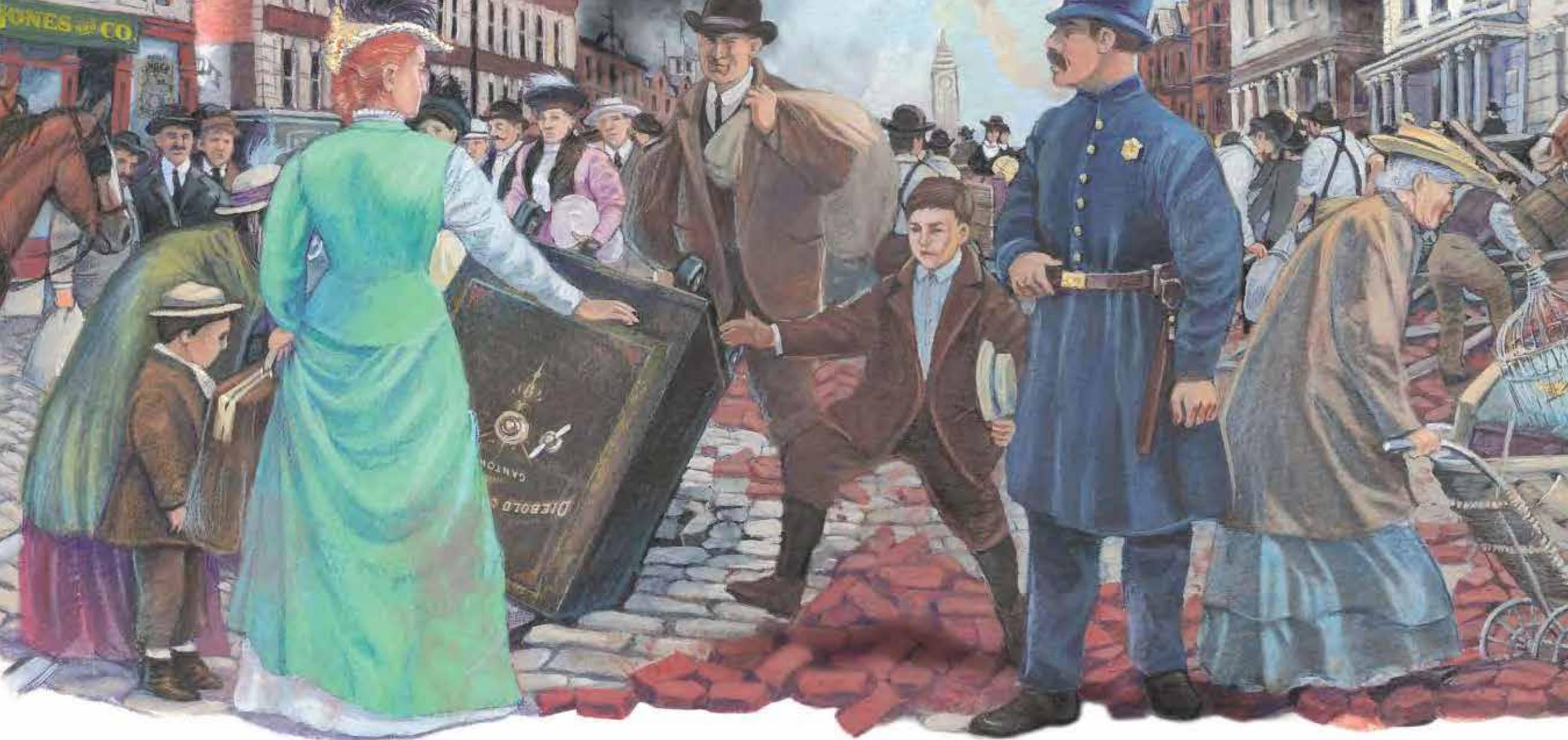


Mrs. Cabot. "We arrived last night and don't know anyone. Could I follow you to the hospital? My husband is a doctor there."

"I wouldn't advise that, ma'am. Fires are breaking out all over the city. There is a chance the entire city is going to burn to the ground. I'd strongly advise you two to head over to the waterfront and catch one of the ferries out of town to someplace safe. I'll get word to your husband if you'd like."

"But how will he know where we are?"

"I heard that they're setting up a refugee camp in Berkeley," the officer said.



“Then we shall go there. Can you please get word to Dr. Edward Cabot at the hospital, and let him know where we are?”

The officer repeated the name and tipped his hat. “Yes, ma’am, I’ll take this gentleman to see him right now. Best be getting along now.”

Although he was frightened, Louis did not let it show. He looked at his mother’s calm face and realized that she too was hiding her fear. He could tell by the tight lines around her mouth. He took her hand and she smiled at him.

Dozens of people joined them as they traveled along Market Street. People picked their way over cracks in the street and around spots flooded by broken water mains. Snapped by the quake, power poles dangled by their electric lines.

They paused and surveyed the wreckage of a bank. Its huge safe had fallen through the floor and lay on its side in a deep hole. Several police officers stood on guard. “Move along, move along!” shouted one of the officers. “Nothing to see here!”



As they walked, the sky grew dark with ash. Fires burned throughout the city. No one knew it then, but gradually the fires would combine into one terrible raging firestorm. More than five hundred city blocks would be destroyed over the next four days.

The Cabots finally reached the Ferry Building. Crowds of people waited to board a boat and flee the city. Louis spied a sign that said Berkeley, and they joined the line of passengers. Soon after they boarded the ferry, it cast off from the dock.

## CAMP

Like Louis and his mother, the other ferry passengers stood silently as they watched the fires burning throughout the city.

As they watched, Louis thought about the destruction. He could see that some buildings were standing almost intact. Most, though, had fallen. "How were they different?" he wondered. They all looked the same from the outside, but clearly something important

# Why the San Francisco **Earthquake** Was So Terrible

The San Francisco earthquake of 1906 was one of the strongest earthquakes Americans have ever experienced. Why was it so terrible?

Wednesday 5:00 AM  
San Francisco awakes

5:13 AM  
Earthquake!

Much of the city was still asleep when the huge quake struck early on April 18, 1906. The main temblor only lasted about one minute, but the ground continued to shudder from aftershocks.

9:00 AM  
Fires break out

Many buildings crumbled to the ground. Fires broke out all around the city and eventually joined to create one huge inferno that lasted for four days. Over 225,000 people were left homeless and 3,000 died, making this one of the worst natural disasters in the history of the United States.



Many parts of the city were built on former marshes that had been filled in with sand and other debris. This “made land” was very unstable and turned to mush during the earthquake—something called *liquefaction*. The soft, soggy ground could no longer support the buildings and many of them simply collapsed.

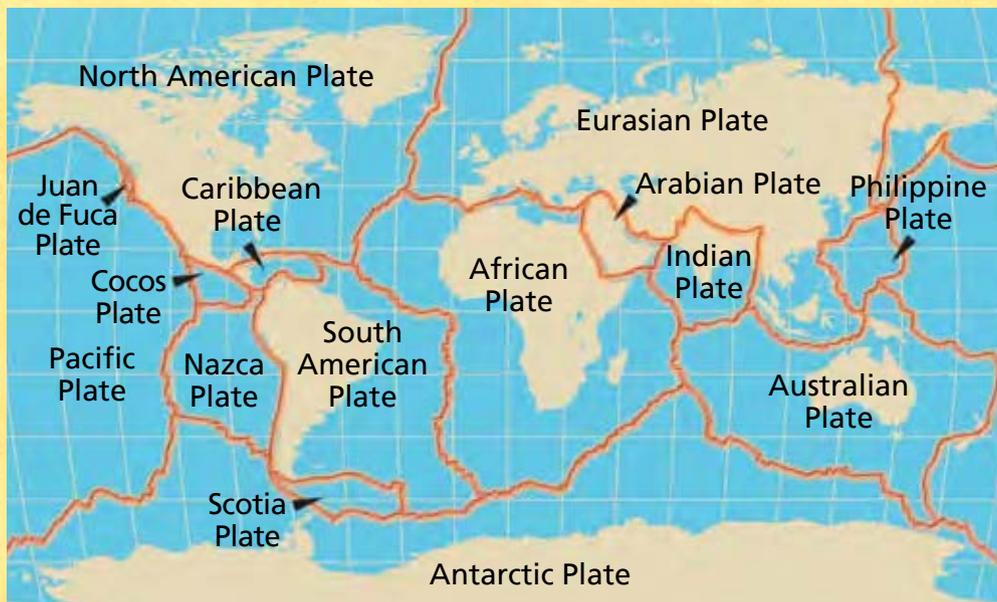


The shifting of the earth during the quake caused underground pipes to rupture. Some of those pipes carried natural gas, a highly flammable fuel. The leaking gas caused fires. Other broken pipes were water mains—and when the mains broke, that meant that firefighters had no water to use to fight the fires. Unchecked, the fires spread quickly.

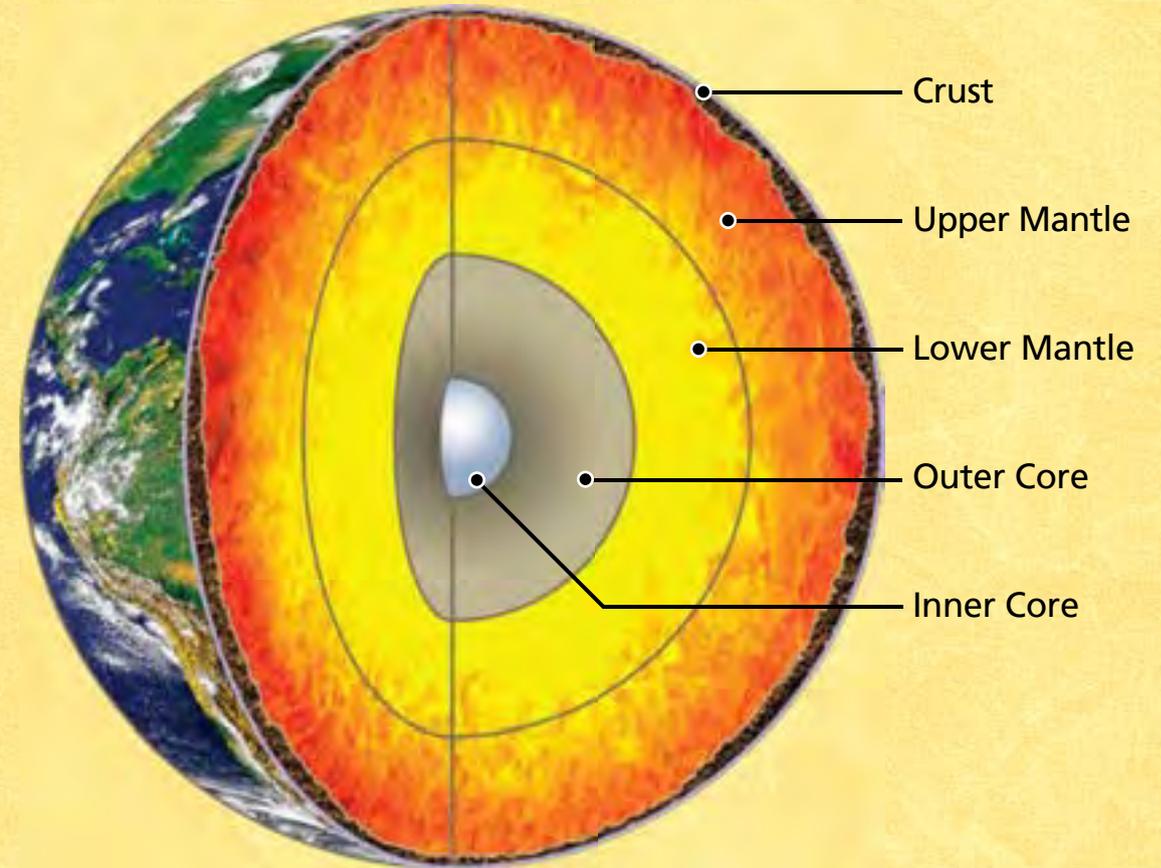
Imagine a total disruption of your everyday life: Your house is too dangerous to live in, so you sleep on the sidewalk or in the front yard. You can't go inside to cook, so your parents grill on the street. There is no running water, so you can't get a drink, wash, or use the toilet. These were the experiences of many families after the 1906 earthquake.

# Understanding EARTHQUAKES

To understand why earthquakes like the one in San Francisco happen, we first must examine the ground beneath our feet.



Wherever you stand, whether on a tall mountain or a sandy beach, the Earth's surface seems steady and solid. However, it is not one solid piece. It is actually made up of many pieces—pieces that are so huge that we aren't aware of their existence as we go about our day. The pieces are bigger than states, countries, even continents. They're called *tectonic plates*. They fit together and cover the entire surface of the earth—even the parts that are underwater.



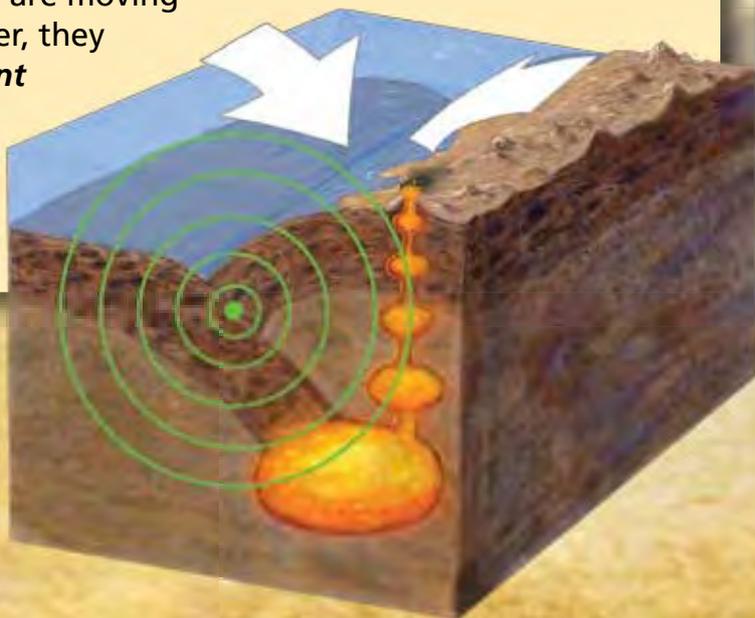
These plates are composed of the crust and the upper part of the Earth's mantle. The plates float on the lower mantle, which completely surrounds the planet's dense, hot core.

Because the lower mantle is extremely hot, it is always moving. And as the lower mantle moves, it drags the plates along with it.

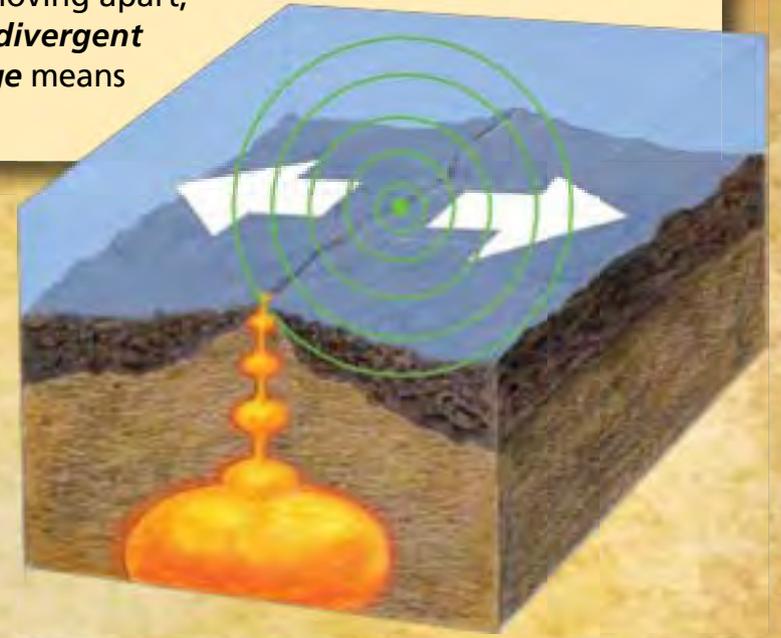
# How Plates Fit Together

Scientists call the places where two plates meet a *plate boundary*. *Boundary* is another word for "edge." Three main kinds of plate boundaries exist: convergent, divergent, and transform. A lot of geologic activity takes place at plate boundaries. As one plate collides with another, they may both wrinkle into mountains. One may be forced under the other. Volcanoes and earthquakes occur most often at or near plate boundaries.

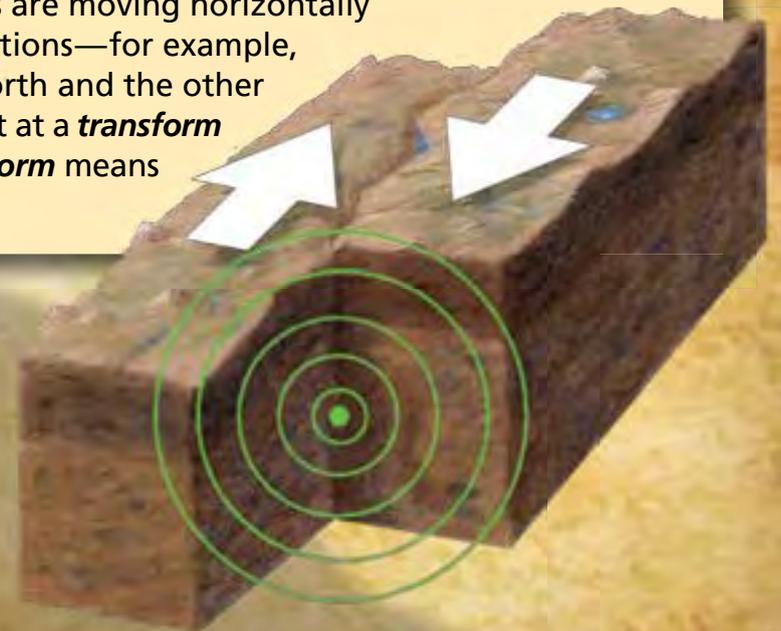
When two plates are moving toward each other, they form a **convergent boundary**. **Converge** means move together.



When they are moving apart, they make up a **divergent boundary**. **Diverge** means move apart.



When the plates are moving horizontally in different directions—for example, one is moving north and the other south—they meet at a **transform boundary**. **Transform** means change.



# How Earthquakes Happen

The plates of the Earth move about as fast as your fingernails grow. However, sometimes the plates get “stuck” and don’t move at all for a period of time. Pressure builds. Then suddenly they move very quickly.

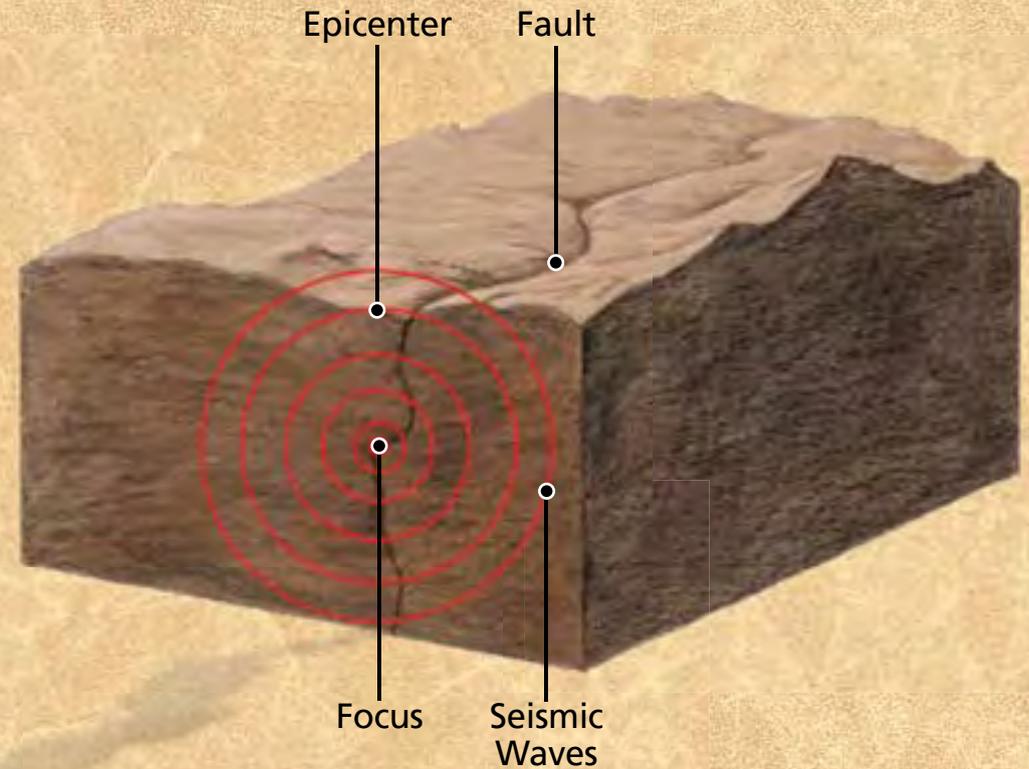


San Andreas Fault, Carrizo Plain, California.



Imagine pulling off a rainboot: you pull and you pull, and suddenly the boot flies off your foot. There’s a lot of energy released when that boot finally comes off—sometimes enough energy to send you toppling backward!

The same thing happens after plates have been grinding against each other for many years. At some point, the energy is released in a sudden, explosive event: an earthquake.



The point where an earthquake begins is called its *focus*. The focus of an earthquake may be near the surface, or it may be as deep as 400 miles underground. The point on the Earth’s surface directly over the focus is called the *epicenter*.



The energy of an earthquake travels out from the focus in the form of *seismic* (sīz’ mik) waves. The seismic waves of an earthquake release great amounts of energy in a short amount of time—usually in less than a minute. After an earthquake, lesser quakes called *aftershocks* are common.

# The Magnitude of EARTHQUAKES

*Magnitude* is the way that scientists measure the amount of energy released by an earthquake.

The magnitude scale for earthquakes is based on mathematical formulas called *logarithms*. On the magnitude scale, each whole number reflects 10 times the intensity and 31 times the energy of the previous number. Therefore, a quake of 6.0 is actually 10 times more intense and releases 31 times the energy of a quake of 5.0.

The San Francisco earthquake of 1906 is estimated to have had a magnitude of 7.8.

## Quake Magnitude Scale



2.0 – 4.9      5.0 – 5.9      6.0 – 6.9      7.0 – 7.9      8.0+

- A quake that registers less than 2.0 on the magnitude scale is called a microquake and would probably not be felt by humans.
- Quakes between 2.0 and 4.9 might be felt but would probably not cause much damage.
- Quakes between 5.0 and 5.9 are considered “moderate” and could cause damage to poorly constructed buildings.
- Quakes between 6.0 and 6.9 are likely to be felt by everyone in the area and can be destructive.
- Quakes between 7.0 and 7.9 are considered to be major earthquakes and can cause serious damage over large areas.
- Quakes of 8.0 and above are considered “great” earthquakes, and their damage can be devastating.

# Some Effects of Earthquakes

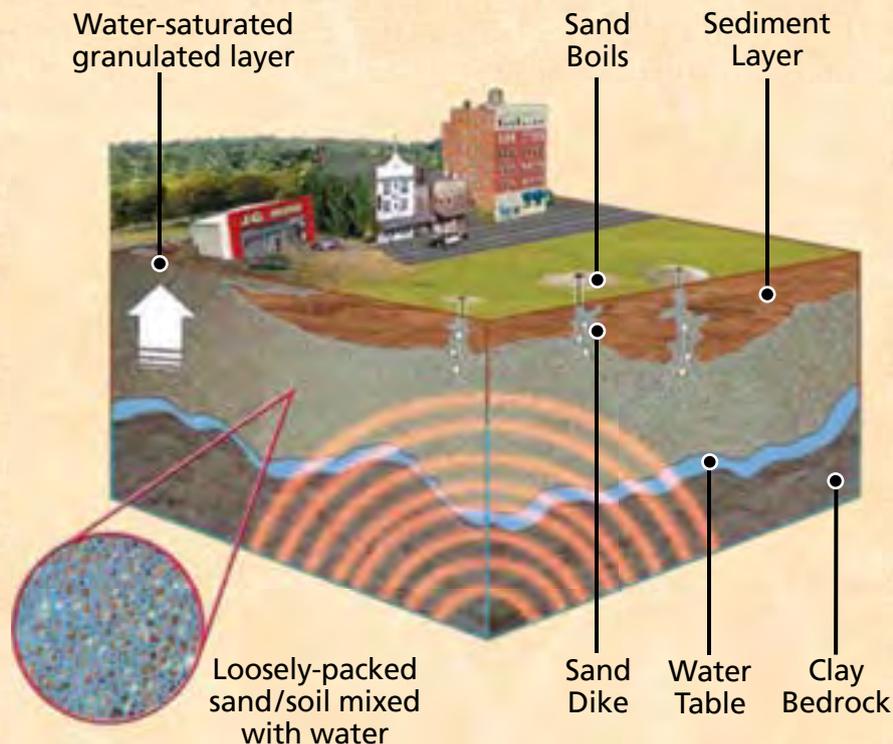
The effects of an earthquake vary widely, depending on the magnitude.

During a small earthquake, the shaking may just feel like a big truck is driving by. In a moderate earthquake, windows may shatter and pictures might fall off walls. In a large earthquake, walls, chimneys, and brick buildings may fall. Major earthquakes can cause large cracks to appear in the ground and often cause major damage to poorly constructed buildings.



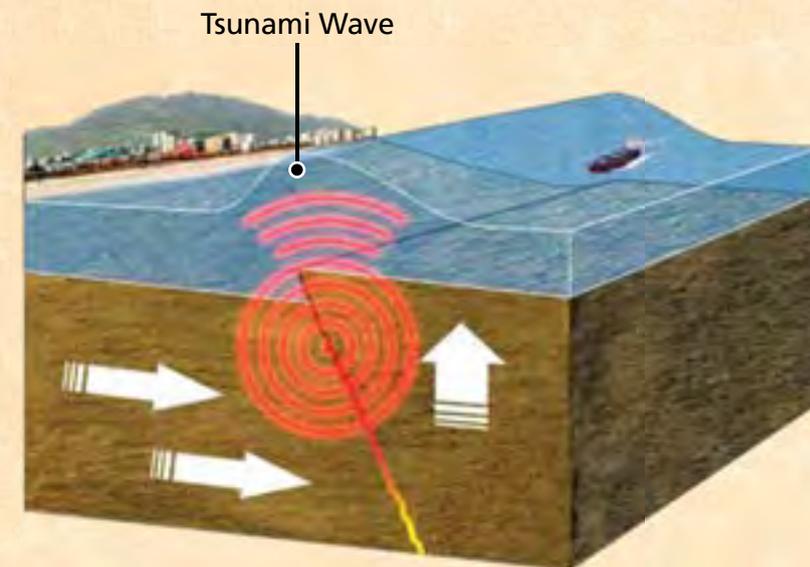
Liquefaction is responsible for much of the damage sustained in the Marina district of San Francisco during the Loma Prieta earthquake of 1989. That earthquake had a magnitude between 6.9 and 7.1.

## Liquefaction



Sometimes a building will collapse due to liquefaction, which occurs when the loosely-packed, wet soil underneath it is shaken so hard that it takes on a pudding-like or liquid-like consistency. When the ground turns soft, it can't support the buildings, and the buildings sink.

During the 1906 earthquake, liquefaction caused a four-story hotel to sink so deep that only the fourth floor remained above ground!



Tsunamis are another deadly effect of earthquakes. These huge waves occur when an undersea earthquake lifts up part of the sea bed. The movement creates a huge wave which can travel for thousands of miles. When it approaches the shore, the tsunami gets higher, reaching as much as 30 meters (100 feet) into the air.

# Make a Model to Simulate an Earthquake



How do you study something that you can't predict? Scientists who study earthquakes and engineers who design earthquake-resistant structures use models. They create "model" earthquakes by using a device called a shake plate. The shake plate simulates the multi-directional movement the Earth experiences during a quake.

## You can build your own model shake plate.

What you need:

A shallow pan, like a cookie sheet

Enough marbles to cover the cookie sheet

A sheet of cardboard

A model structure to test

1. Place the marbles in a single layer on the cookie sheet.
2. Put the cardboard on top of the marbles.
3. Build a structure to test on top of the marbles.
4. Shake the pan from side to side. What happens to your structure?

Experiment with different materials and ways of building your structures to see what works best—for example, marshmallows stacked on top of each other and marshmallows stacked but attached with toothpicks.