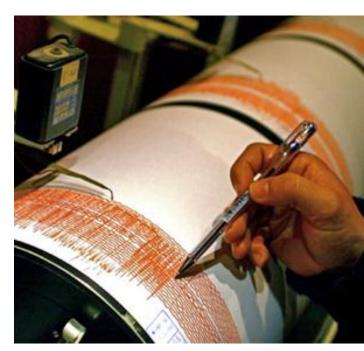
I. What are Earthquakes?

A. There is more to earthquakes than just the shaking of the ground. An entire branch of Earth science, called **seismology**, is devoted to the study of earthquakes.

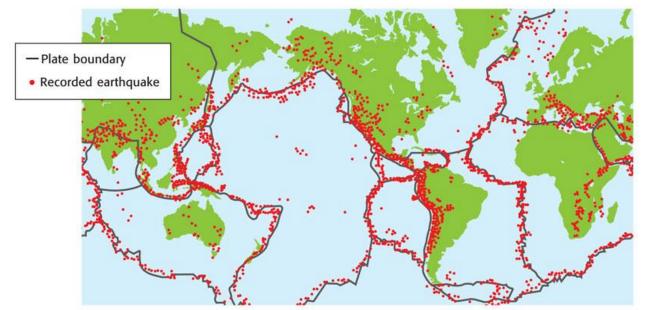
B. Earthquakes are complex, and they present many questions for **seismologists**, the scientists who study earthquakes.



http://Photo by: cdn0.cosmosmagazine.com

II. Where do Earthquakes Occur?

- A. Most earthquakes take place near the edges of tectonic plates.
- B. Tectonic plates move in different directions and at different speeds. As a result, numerous features called faults exist in the Earth's crust.
- C. A **fault** is a break in the Earth's crust along which blocks of the crust slide relative to one another.
- D. Earthquakes occur along faults because of this sliding.

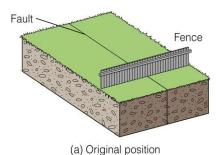


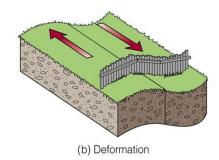
III. What Causes Earthquakes?

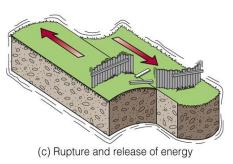
- A. As tectonic plates move, stress increases along faults near the plates' edges. In response to this stress, rock in the plates deforms.
- B. **Deformation** is the change in the shape of rock in response to the stress of bending, tilting, and breaking of the Earth's crust.
- C. Rock deforms in a plastic manner, like a piece of molded clay, or in an elastic manner, like a rubber band.
- D. Plastic deformation does not lead to earthquakes. Elastic deformation does. Like a rubber band, rock can be stretched only so far before it breaks.

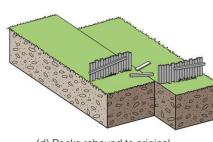
III. What Causes Earthquakes?

- E. **Elastic rebound** is the sudden return of elastically deformed rock to its undeformed shape. Elastic rebound occurs when more stress is applied to rock than the rock can withstand.
- F. During elastic rebound, energy is released. Some of this energy travels as seismic waves, which cause an earthquake.









(d) Rocks rebound to original undeformed shape

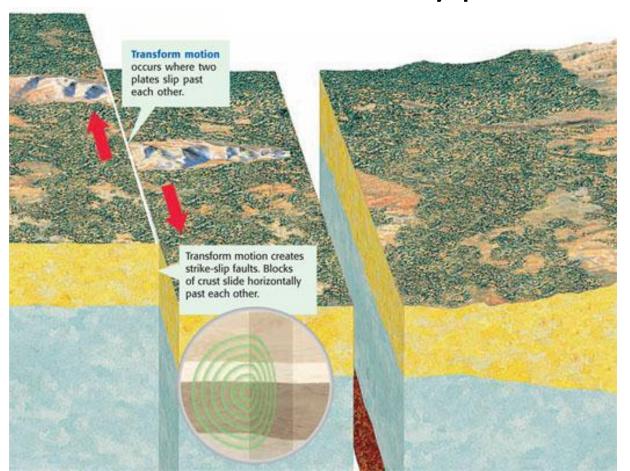
2006 Brooks/Cole - Thomson

A. A specific type of plate motion takes place at different tectonic plate boundaries.

B. Each type of motion creates a particular kind of fault that can produce earthquakes.

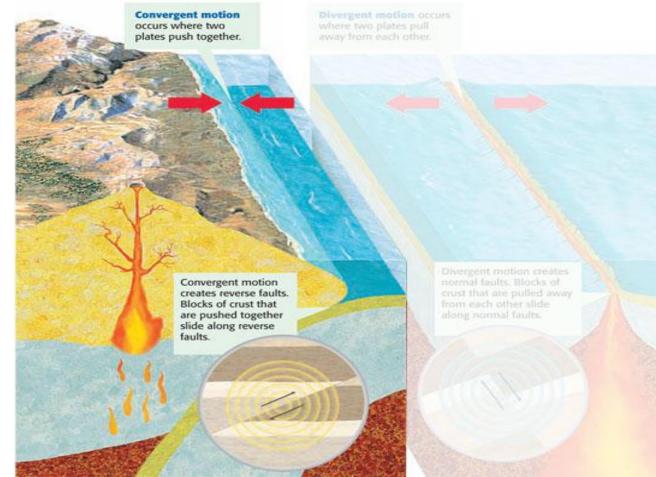
Table 1 Plate Motion and Fault Types		
Plate motion	Major fault type	
Transform	strike-slip fault	
Convergent	reverse fault	
Divergent	normal fault	

C. **Transform motion** occurs where two plates slip past each other, creating strike-slip faults. Blocks of crust slide horizontally past each other.

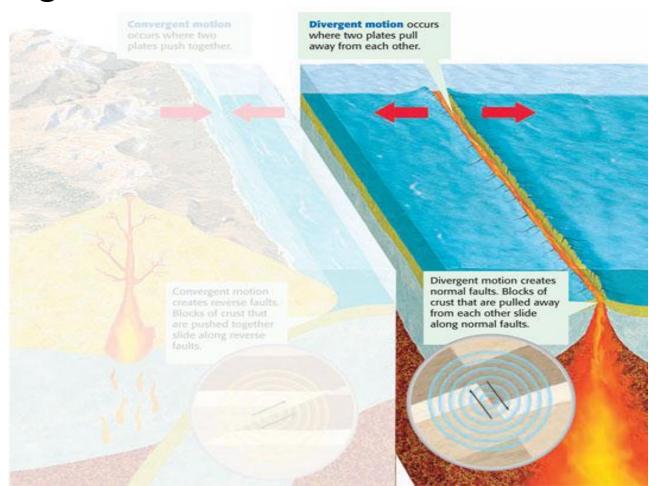


D. **Convergent motion** occurs where two plates push together, creating reverse faults. Blocks of crust that are pushed together slide along

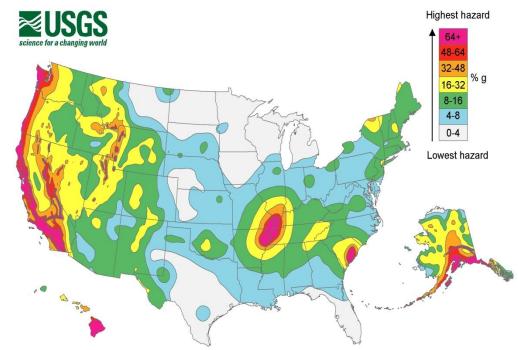
reverse faults.



E. **Divergent motion** occurs where two plates pull away from each other, creating normal faults. Blocks of crust that are pulled away from each other slide along normal faults.

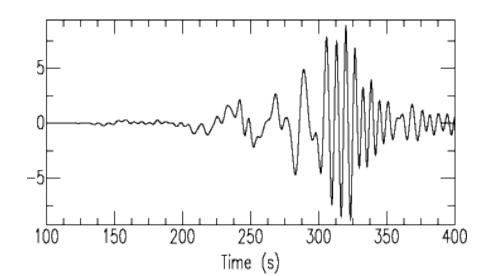


- F. **Earthquake Zones** Most earthquakes happen in the earthquake zones along tectonic plate boundaries. Earthquake zones are places where a large number of faults are located.
- G. Not all faults are located at tectonic plate boundaries. Sometimes, earthquakes happen along faults in the middle of tectonic plates.



V. How Do Earthquake Waves Travel?

- A. Waves of energy that travel through the Earth away from an earthquake are called seismic waves.
- B. Seismic waves that travel along the Earth's surface are called surface waves.



V. How Do Earthquake Waves Travel?

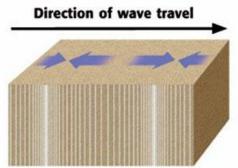
- C. Seismic waves that travel through Earth's interior are called body waves. There are two types of body waves: P waves and S waves.
- D. **P waves** are seismic waves that cause particles of rock to move in a back-and-forth direction.
- E. **S waves** are seismic waves that cause particles of rock to move in a side-to-side direction.



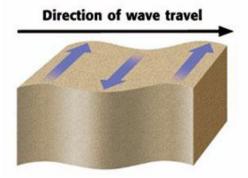
Primary Waves; Secondary Waves; Surface Waves

P waves move rock back and forth, which squeezes and stretches the rock, as they travel through the rock.

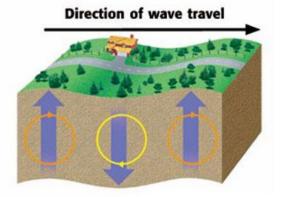
Direction of wave travel



S waves shear rock side to side as they travel through the rock.

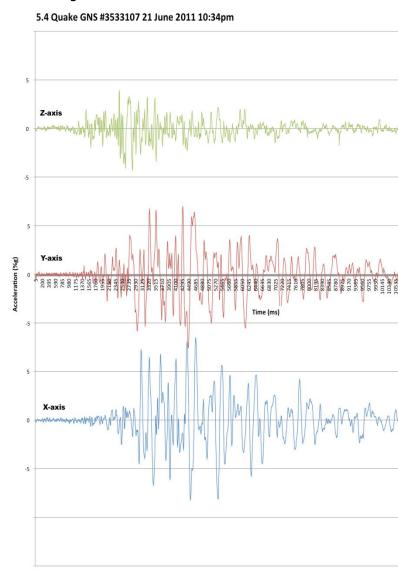


Surface waves move the ground much like ocean waves move water particles.



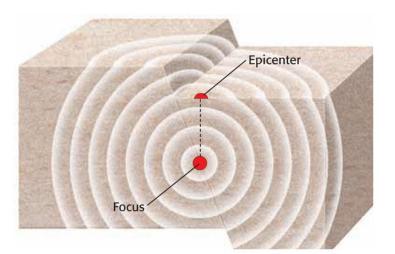
VI. Locating Earthquakes

- A. Scientists use seismographs to study earthquakes.
- B. A **seismograph** is an instrument that records vibrations in the ground and determines the location and strength of an earthquake.
- C. When earthquake waves reach a seismograph, it creates a **seismogram**, a tracing of the earthquake's motion.



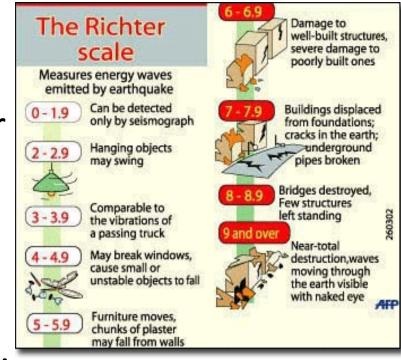
VI. Locating Earthquakes

- D. **Determining Time and Location of Earthquakes**Seismograms are used to find an earthquake's epicenter.
- E. An **epicenter** is the point on the Earth's surface directly above an earthquake's starting point.
- F. A **focus** is the point inside the Earth where an earthquake begins.
- G. An earthquake's epicenter is on the Earth's surface directly above the earthquake's focus.



VII. Measuring Earthquake Strength and Intensity

- A. The Richter Magnitude Scale
 Throughout much of the 20th
 century, seismologists used a
 scale created by Charles Richter
 to measure the strength of
 earthquakes.
- B. Earthquake Ground Motion A measure of the strength of an earthquake is called magnitude. The Richter scale measures the ground motion from an earthquake and adjusts for distance to find its strength.



VII. Measuring Earthquake Strength and Intensity

- C. Modified Mercalli Intensity
 Scale A measure of the degree to which an earthquake is felt by people and the damage it caused is called intensity.
- D. Currently, seismologists use the Modified Mercalli Intensity Scale to measure earthquake intensity. This is a numerical scale that uses Roman numerals from I to XII to describe earthquake intensity levels.

Modified Mercalli Scale

- Not felt.
- II. Felt by persons at rest, on upper floors, or favorably placed.
- III. Felt indoors. Vibration like passing of light trucks.
- IV. Vibration like passing of heavy trucks.
- V. Felt outdoors. Small unstable objects displaced or upset.
- VI. Felt by all. Furniture moved. Weak plaster/masonry cracks.
- VII. Difficult to stand. Damage to masonry and chimneys.
- VIII. Partial collapse of masonry. Frame houses moved.
 - Masonry seriously damaged or destroyed.
 - X. Many buildings and bridges destroyed.
 - XI. Rails bent greatly. Pipelines severely damaged.
- XII. Damage nearly total.

VII. Measuring Earthquake Strength and Intensity

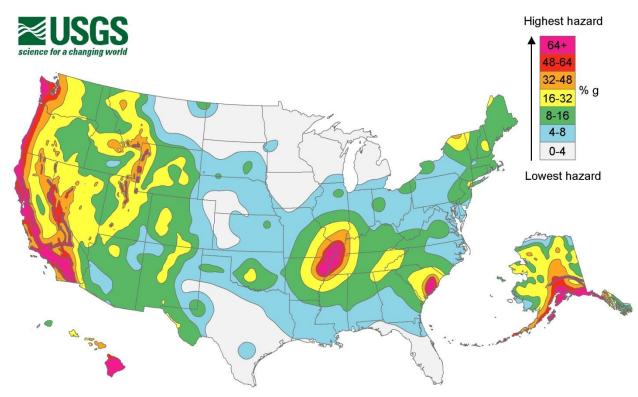
- E. In the Modified Mercalli Intensity Scale, an intensity of I describes an earthquake that is not felt by most people. An intensity level of XII indicates total damage of an area.
- F. Because the effects of an earthquake vary based on location, any earthquake will have more than one intensity value. Intensity values usually are higher near the epicenter.

Modified Mercalli Scale

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VIII. Earthquake Hazard

- A. Earthquake hazard is a measurement of how likely an area is to have damaging earthquakes in the future.
- B. An area's earthquake-hazard level is determined by past and present seismic activity.
- C. The greater the seismic activity, the higher the earthquake-hazard level.



IX. Earthquake Forecasting

- A. Forecasting when and where earthquakes will occur and their strength is difficult.
- B. By studying areas of seismic activity, seismologists have discovered some patterns in earthquakes that allow them to make some general predictions.

C. **Strength and Frequency** Earthquakes vary in strength. The strength of earthquakes is related to how often

they occur.

Table	1 Worldwide Earthquake Frequence	y
(Based	on Observations Since 1900)	

Descriptor	Magnitude	Average number annually
Great	8.0 and higher	1
Major	7.0-7.9	18
Strong	6.0-6.9	120
Moderate	5.0-5.9	800
Light	4.0-4.9	about 6,200
Minor	3.0-3.9	about 49,000
Very minor	2.0-2.9	about 365,000

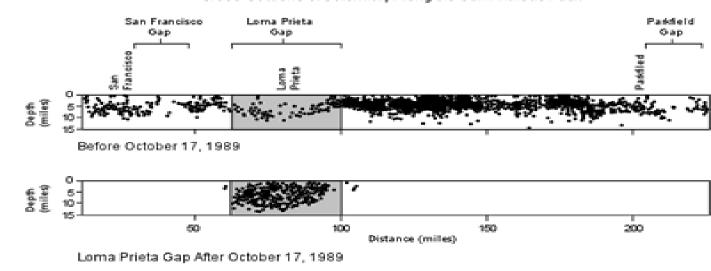
IX. Earthquake Forecasting

- D. Another method of forecasting an earthquake's strength, location, and frequency is the gap hypothesis.
- E. The gap hypothesis is based on the idea that a major earthquake is more likely to occur along the part of an active fault where no earthquakes have occurred for a certain period of time.
- F. An area along a fault where relatively few earthquakes have occurred recently but where strong earthquakes have occurred in the past is called a seismic gap.

IX. Earthquake Forecasting

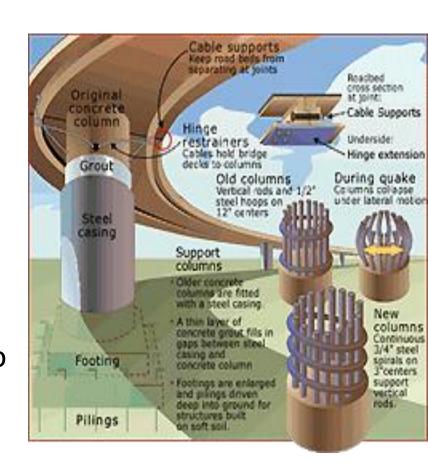
- G. **Using the Gap Hypothesis** Not all seismologists believe the gap hypothesis is an accurate method of forecasting earthquakes.
- H. But some seismologists think the gap hypothesis helped forecast the approximate location and strength of the 1989 Loma Prieta earthquake in California.

 Cross-Sections of Seismicity Along the San Andreas Fault



X. Earthquakes and Buildings

- A. Earthquakes can easily topple buildings and destroy homes. Today, older structures in seismically active places, such as California, are being made more earthquake resistant.
- B. **Retrofitting** is the name given to the process of making older structure more earthquake resistant.
- C. A common way of retrofitting an older home is to securely fasten it to its foundation.
- D. Steel is often used to strengthen buildings and homes made of brick.



X. Earthquakes and Buildings

- E. Earthquake-Resistant
 Buildings A lot has been learned from building failure during earthquakes.
- F. With this knowledge, architects and engineers use new technology to design and construct buildings and bridges to better withstand earthquakes.

Earthquake-Resistant Building Technology

The mass damper is a weight placed in the roof of a building. Motion sensors detect building movement during an earthquake and send messages to a computer. The computer then signals controls in the roof to shift the mass damper to counteract the building's movement.

The active tendon system works much like the mass damper system in the roof. Sensors notify a computer that the building is moving. Then, the computer activates devices to shift a large weight to counteract the movement.

Base isolators act as shock absorbers during an earthquake. They are made of layers of rubber and steel wrapped around a lead core. Base isolators absorb seismic waves, preventing them from traveling through the building. Steel cross braces are placed between floors. These braces counteract pressure that pushes and pulls at the side of a building during an earthquake.

Flexible pipes help prevent waterlines and gas lines from breaking. Engineers design the pipes with flexible joints so that the pipes are able to twist and bend without breaking during an earthquake. XI. Are You Prepared for an Earthquake?



- B. Place heavier objects on lower shelves so they do not fall during an earthquake.
- C. Find safe places within each room of your home and outside of your home.
- D. Make a plan with others to meet in a safe place after the earthquake is over.

XI. Are You Prepared for an Earthquake?

- E. When the Shaking Starts If you are indoors, crouch or lie face down under a table or desk.
- F. If you are outside, cover your head with your hands and lie face down away from buildings, power lines, or trees.
- G. If you are in a car on an open road, you should stop the car and remain inside.



XI. Are You Prepared for an Earthquake?

- H. **After the Shaking Stops** Try to calm down and get your bearings.
- I. Remove yourself from immediate danger, such as downed power lines, broken glass, and fire hazards.
- J. Do not enter any damaged buildings unless you are told it is safe by someone in authority.
- K. Beware that aftershocks may cause more damage.

