

KEY CONCEPT

17.3

Vertical air motion can cause severe storms.

◀ BEFORE, you learned

- Fronts produce changes in weather
- Rising moist air can produce clouds and precipitation

▶ NOW, you will learn

- How thunderstorms develop
- About the effects of thunderstorms
- About tornadoes and their effects

VOCABULARY

thunderstorm p. 588
tornado p. 591

EXPLORE Lightning

Does miniature lightning cause thunder?

PROCEDURE

- 1 Use a thumbtack to attach the eraser to the center of a piece of foil.
- 2 Rub the foam tray quickly back and forth several times on the wool. Set the tray down.
- 3 Using the eraser as a handle, pick up the foil and set it onto the tray. Slowly move your finger close to the foil.

MATERIALS

- thumbtack
- eraser
- aluminum foil
- plastic foam tray
- wool fabric



WHAT DO YOU THINK?

What happened when you touched the foil?

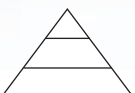
Thunderstorms form from rising moist air.

If you have ever shuffled your shoes on a carpet, you may have felt a small shock when you touched a doorknob. Electrical charges collected on your body and then jumped to the doorknob in a spark of electricity.

In a similar way, electrical charges build up near the tops and bottoms of clouds as pellets of ice move up and down through the clouds. Suddenly, a charge sparks from one part of a cloud to another or between a cloud and the ground. The spark of electricity, called lightning, causes a bright flash of light. The air around the lightning is briefly heated to a temperature hotter than the surface of the Sun. This fast heating produces a sharp wave of air that travels away from the lightning. When the wave reaches you, you hear it as a crack of thunder. A **thunderstorm** is a storm with lightning and thunder.

VOCABULARY

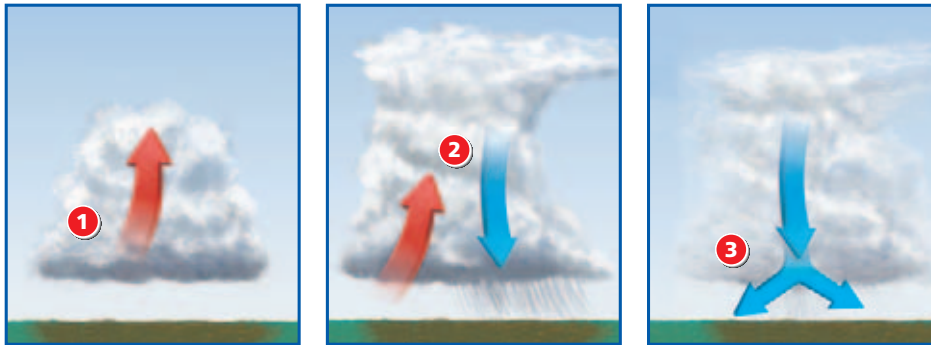
Put new terms into a word triangle diagram.



Is thunder a cause or an effect of lightning?

Formation of Thunderstorms

Thunderstorms get their energy from humid air. When warm, humid air near the ground moves vertically into cooler air above, the rising air, or updraft, can build a thunderstorm quickly.



- 1 Rising humid air forms a cumulus cloud. The water vapor releases energy when it condenses into cloud droplets. This energy increases the air motion. The cloud continues building up into the tall cumulonimbus cloud of a thunderstorm.
- 2 Ice particles form in the low temperatures near the top of the cloud. As the ice particles grow large, they begin to fall and pull cold air down with them. This strong downdraft brings heavy rain or hail—the most severe stage of a thunderstorm.
- 3 The downdraft can spread out and block more warm air from moving upward into the cloud. The storm slows down and ends.

Thunderstorms can form at a cold front or within an air mass. At a cold front, air can be forced upward quickly. Within an air mass, uneven heating can produce convection and thunderstorms. In some regions, the conditions that produce thunderstorms occur almost daily during part of the year. In Florida, for example, the wet land and air warm up during a long summer day. Then, as you see in the diagram, cool sea breezes blow in from both coasts of the peninsula at once. The two sea breezes together push the warm, humid air over the land upward quickly. Thunderstorms form in the rising air.

In contrast, the summer air along the coast of California is usually too dry to produce thunderstorms. The air over the land heats up, and a sea breeze forms, but there is not enough moisture in the rising warm air to form clouds and precipitation.



INVESTIGATE Updrafts

How do updrafts form?

PROCEDURE

- 1 Set up the cardboard, the cups, the container, and the cool water as shown in the photograph. Wait for the water to become still.
- 2 Use the eyedropper to place 2–3 drops of coloring at the bottom of the water.
- 3 Slide a cup of hot water (about 70°C) beneath the food coloring.

WHAT DO YOU THINK?

In what ways was the motion of the water like the air in a thunderstorm?

CHALLENGE How could you observe updrafts in air?



SKILL FOCUS Inferring



MATERIALS

- 4 cardboard squares
- 5 foam cups
- clear container
- cool water
- food coloring
- eyedropper
- hot tap water

TIME
20 minutes



Effects of Thunderstorms

A thunderstorm may provide cool rain at the end of a hot, dry spell. The rain can provide water for crops and restore lakes and streams. However, thunderstorms are often dangerous.

Flash floods can be strong enough to wash away people, cars, and even houses. One thunderstorm can produce millions of liters of rain. If a thunderstorm dumps all its rain in one place, or if a series of thunderstorms dump rain onto the same area, the water can cover the ground or make rivers overflow their banks.

Winds from a thunderstorm can be very strong. They can blow in bursts that exceed 270 kilometers per hour (170 mi/hr). Thunderstorm winds once knocked down a stretch of forest in Canada that was about 16 kilometers (10 mi) wide and 80 kilometers (50 mi) long. Thunderstorms can also produce sudden, dangerous bursts of air that move downward and spread out.

Hail causes nearly \$1 billion in damage to property and crops in the United States every year. Hail can wipe out entire fields of a valuable crop in a few minutes. Large hailstones can damage roofs and kill livestock.

Lightning can kill or seriously injure any person it hits. It can damage power lines and other equipment. Lightning can also spark dangerous forest fires.



SAFETY TIPS

THUNDERSTORMS

- Stay alert when storms are predicted or dark, tall clouds are visible.
- If you hear thunder, seek shelter immediately and stay there for 30 minutes after the last thunder ends.
- Avoid bodies of water, lone trees, flagpoles, and metal objects.
- Stay away from the telephone, electrical appliances, and pipes.
- If flash floods are expected, move away from low ground.
- Do not try to cross flowing water, even if it looks shallow.



CHECK YOUR READING

In what ways are thunderstorms dangerous? Did any surprise you?

Tornadoes form in severe thunderstorms.

Under some conditions, the up-and-down air motion that produces tall clouds, lightning, and hail may produce a tornado. A **tornado** is a violently rotating column of air stretching from a cloud to the ground. A tornado moves along the ground in a winding path underneath the cloud. The column may even rise off the ground and then come down in a different place.

You cannot see air moving. A tornado may become visible when water droplets appear below the cloud in the center of the rotating column. A tornado may lift dust and debris from the ground, so the bottom of the column becomes visible, as you see in the photographs below. Water droplets and debris may make a tornado look like an upright column or a twisted rope.

READING TIP

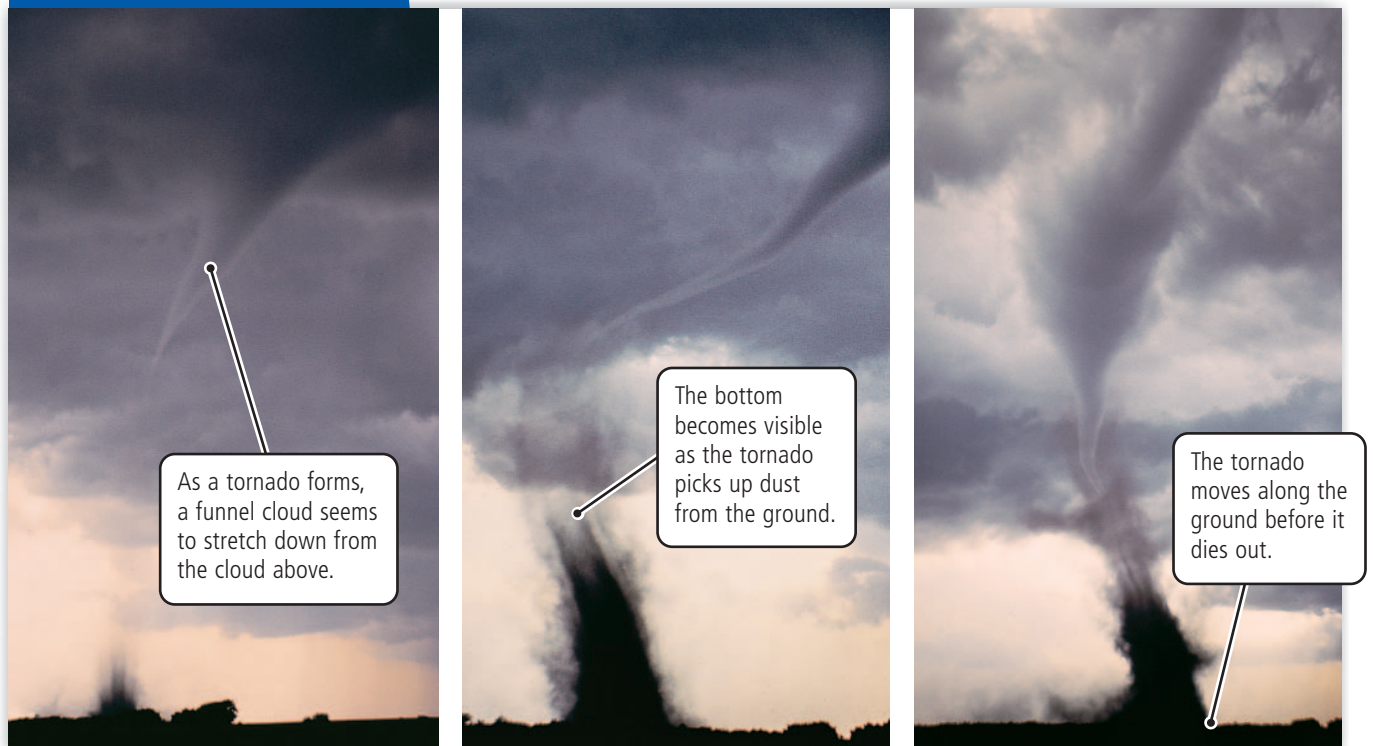
A spinning column of air is not called a tornado unless it touches the ground. If it touches water instead, it is called a waterspout.

CHECK YOUR READING

What makes a tornado become visible?

More tornadoes occur in North America than anywhere else in the world. Warm, humid air masses move north from the Gulf of Mexico to the central plains of the United States. There, the warm air masses often meet cold, dense air and form thunderstorms. In the spring, the winds in this region often produce the conditions that form tornadoes. A thunderstorm may form a series of tornadoes or even a group of tornadoes all at once.

Tornado Formation





Effects of Tornadoes

The powerful winds of a tornado can cause damage as the bottom of the tornado moves along the ground. Tornado winds can also pick up and slam dirt and small objects into buildings or anything else in the tornado's path.

The most common tornadoes are small and last only a few minutes. Their winds may be strong enough to break branches off trees, damage chimneys, and tear highway billboards. A typical path along the ground may be 100 meters (300 ft) wide and 1.5 kilometers (1 mi) long.

Larger tornadoes are less common but have stronger winds and last longer. About 20 percent of tornadoes are strong enough to knock over large trees, lift cars off the ground, and tear the roofs off houses. Very few—about 1 percent of all

tornadoes—are violent enough to lift or completely demolish sturdy buildings. These huge tornadoes may last more than two hours. You can find more details about tornadoes in the Appendix.

Paths of Tornadoes

A tornado moves along with its thunderstorm. It travels at the same pace and weaves a path that is impossible to predict. A tornado may appear suddenly and then disappear before anyone has time to report it. However, the conditions that form tornadoes may persist, so citizens' reports are still useful. The National Weather Service issues a tornado watch when the weather conditions might produce tornadoes. A tornado warning is issued when a tornado has been detected.

SAFETY TIPS

TORNADOES

- Listen for tornado warnings when severe weather is predicted.
- If you are in a car or mobile home, get out and go into a sturdy building or a ditch or depression.
- Go to the basement if possible.
- Avoid windows and open areas.
- Protect your head and neck.

17.3 Review

KEY CONCEPTS

1. What conditions produce thunderstorms?
2. How can rain from thunderstorms become dangerous?
3. How do tornadoes cause damage?

CRITICAL THINKING

4. **Compare** What do hail and tornadoes have in common?
Hint: Think about how each forms.
5. **Synthesize** Which type of front is most likely to produce thunderstorms and tornadoes? Explain why.

CHALLENGE

6. **Compare and Contrast**
If you saw the photograph above in a newspaper, what details would tell you that the damage was due to a tornado and not a hurricane?