Section 13.2

Objectives

- **Explain** why some thunderstorms are more severe than others.
- **Recognize** the dangers of severe weather, including lightning, hail, and high winds.
- **Describe** how tornadoes form.

Review Vocabulary

air mass: large body of air that takes on the characteristics of the area over which it forms

New Vocabulary

supercell
downburst
tornado
Fujita tornado intensity scale

Severe Weather

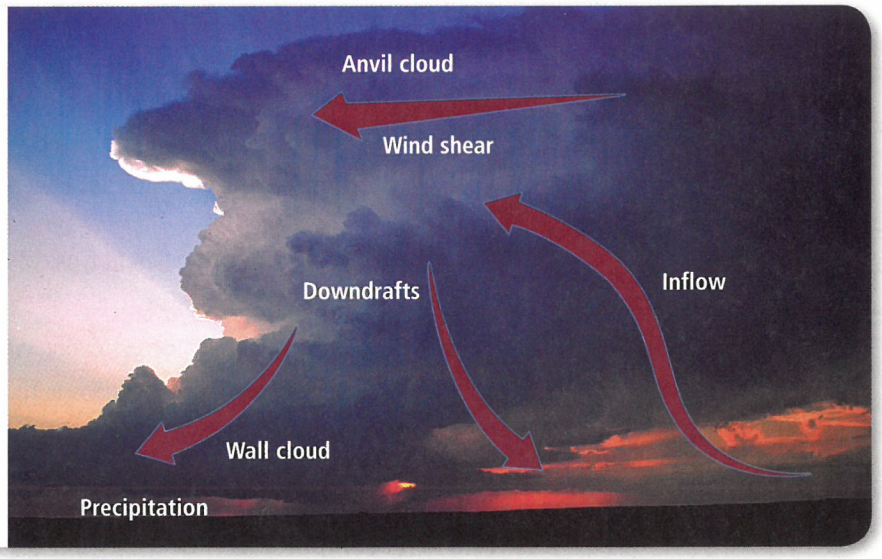
MAIN Idea **All thunderstorms produce wind, rain, and lightning, which can have dangerous and damaging effects under certain circumstances.**

Real-World Reading Link Sliding down a park slide might seem mild and safe compared to a roller coaster's wild and chaotic ride. Similarly, while a gentle rain is appreciated by many, the same weather processes can create thunderstorms on a massive atmospheric scale, resulting in disaster.

Weather Cells

All thunderstorms are not created equal. Some die out within minutes, while others flash and thunder throughout the night. What makes one thunderstorm more severe than another? The increasing instability of the air intensifies the strength of a storm's updrafts and downdrafts, which makes the storm severe.

Supercells Severe thunderstorms can produce some of the most violent weather conditions on Earth. They can develop into self-sustaining, extremely powerful storms called **supercells.** Supercells are characterized by intense, rotating updrafts taking 10 to 20 minutes to reach the top of the cloud. These furious storms can last for several hours and can have updrafts as strong as 240 km/h. It is not uncommon for a supercell to spawn long-lived tornadoes. **Figure 13.7** shows an illustration of a supercell. Notice the anvil-shaped cumulonimbus clouds associated with severe storms. The tops of the supercells are chopped off by wind shear. Of the estimated 100,000 thunderstorms that occur each year in the United States, only about 10 percent are considered to be severe, and fewer still reach supercell proportions.



■ **Figure 13.7** An anvil-shaped cumulonimbus cloud is characteristic of many severe thunderstorms. The most severe thunderstorms are called supercells.

Strong Winds

Recall that rain-cooled downdrafts descend to Earth's surface during a thunderstorm and spread out as they reach the ground. Sometimes, instead of dispersing that downward energy over a large area underneath the storm, the energy becomes concentrated in a local area. The resulting winds are exceptionally strong, with speeds of more than 160 km/h. Violent downdrafts that are concentrated in a local area are called **downbursts.**

Based on the size of the area they affect, downbursts are classified as either macrobursts or microbursts. Macrobursts can cause a path of destruction up to 5 km wide. They have wind speeds of more than 200 km/h and can last up to 30 minutes. Smaller in size, though deadlier in force, microbursts affect areas of less than 3 km but can have winds exceeding 250 km/h. Despite lasting fewer than 10 minutes on average, a microburst is especially deadly because its small size makes it extremely difficult to predict and detect. **Figure 13.8** shows a microburst.

■ **Figure 13.8** A microburst, such as this one in Kansas, can be as destructive as a tornado.

Hail

Each year in the United States, almost one billion dollars in damage is caused by hail—precipitation in the form of balls or lumps of ice. Hail can do tremendous damage to crops, vehicles, and rooftops, particularly in the central United States where hail occurs most frequently. Hail is most common during the spring growing season. **Figure 13.9** shows some conditions associated with hail.

Hail forms because of two characteristics common to thunderstorms. First, water droplets enter the parts of a cumulonimbus cloud where the temperature is below freezing. When these supercooled water droplets encounter ice pellets, the water droplets freeze on contact and cause the ice pellets to grow larger. The second characteristic that allows hail to form is an abundance of strong updrafts and downdrafts existing side by side within a cloud. The growing ice pellets are caught alternately in the updrafts and downdrafts, so that they constantly encounter more supercooled water droplets. The ice pellets keep growing until they are too heavy for even the strongest updrafts to keep aloft, and they finally fall to Earth as hail.

■ **Figure 13.9** This hail storm in Sydney, Australia, caused slippery conditions for the traffic as well as damage to property.

Tornadoes

In some parts of the world, the most feared form of severe weather is the tornado. A **tornado** is a violent, whirling column of air in contact with the ground. When a tornado does not reach the ground, it is called a funnel cloud. Tornadoes are often associated with supercells—the most severe thunderstorms. The air in a tornado is made visible by dust and debris drawn into the swirling column, sometimes called the vortex, or by the condensation of water vapor into a visible cloud.

Reading Check **Define** the term *tornado.*

Development of tornadoes A tornado forms when wind speed and direction change suddenly with height, a phenomenon associated with wind shear. Current thinking suggests that tornadoes form when small pockets of cooler air are given a horizontal, rolling-pin type of rotation near Earth's surface, as shown in **Figure 13.10.** If this rotation occurs close enough to the thunderstorm's updrafts, the twisting column of wind can be tilted from a horizontal to a vertical position. As updrafts stretch the column, the rotation is accelerated. Air is removed from the center of the column, which in turn lowers the air pressure in the center. The extreme pressure gradient between the center and the outer portion of the tornado produces the violent winds associated with tornadoes. Although tornadoes rarely exceed 200 m in diameter and usually last only a few minutes, they can be extremely destructive. A tornado is classified according to its destructive force.

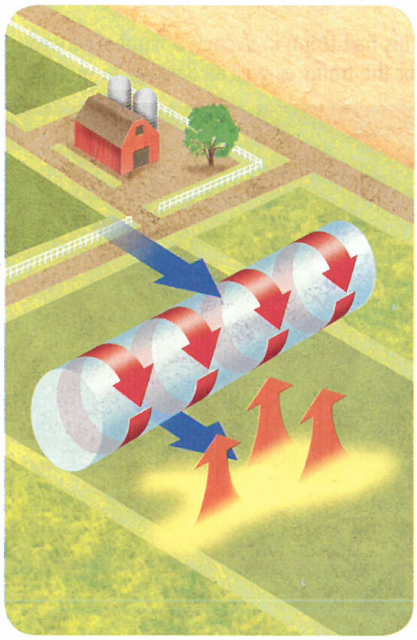
VOCABULARY

ACADEMIC VOCABULARY

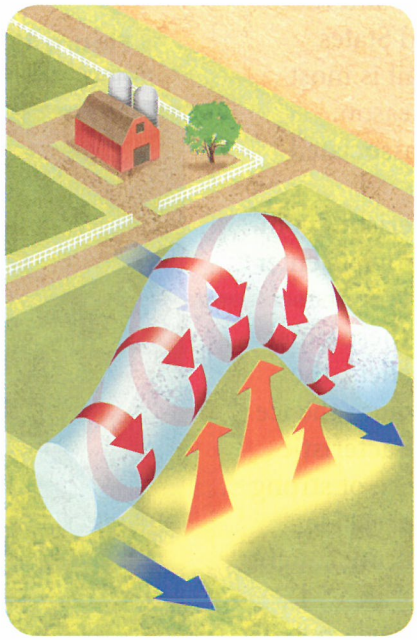
Phenomenon
an object or aspect known through the senses rather than by thought or intuition
Students observing the phenomenon realized later that the powerful wind was a microburst.

Concepts In Motion
Interactive Figure To see an animation of tornado formation, visit glencoe.com.

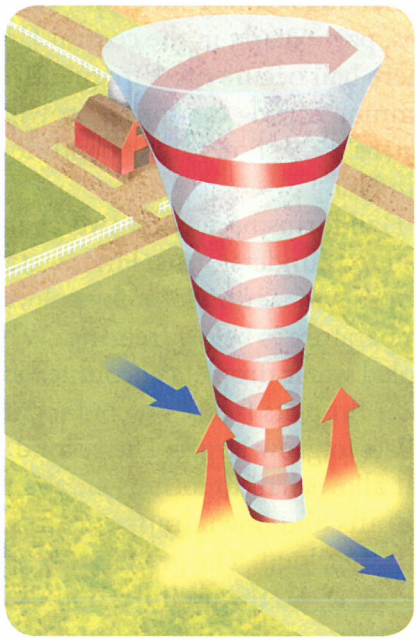
Figure 13.10 Tornado formation is associated with changes in wind speed and direction.
Infer *what would cause the updrafts.*



A change in wind direction and speed creates a horizontal rotation in the lower atmosphere.



Strong updrafts tilt the rotating air from a horizontal to a vertical position.



A tornado forms within the rotating winds.

Table 13.1 Fujita Tornado Intensity Scale

Concepts In Motion
Interactive Table To explore more about the Fujita tornado intensity scale, visit glencoe.com.

Fujita scale tornadoes	Weak (F0 and F1) 80 percent of all tornadoes Path: up to 4 km Duration: 1–10 min Wind speed: 70–180 km/h	Strong (F2 and F3) 19 percent of all tornadoes Path: 24 km + Duration: 20 min + Wind speed: 181–332 km/h	Violent (F4 and F5) 1 percent of all tornadoes Path: 80 km + Duration: 1 h + Wind speed: 333–512+ km/h
Photo of tornado			

Tornado classification Tornadoes vary greatly in size and intensity. The **Fujita tornado intensity scale,** which ranks tornadoes according to their path of destruction, wind speed, and duration, is used to classify tornadoes. The Fujita scale was named for Japanese tornado researcher Dr. Theodore Fujita. The scale ranges from F0, which is characterized by winds of up to 118 km/h, to the incredibly violent F5, which can pack winds of more than 500 km/h. Most tornadoes do not exceed the F1 category. In fact, only about 1 percent reach F4 or F5. Those that do, however, can lift entire buildings from their foundations and toss automobiles and trucks around like toys. The Fujita scale is shown in **Table 13.1.**

Tornado distribution While tornadoes can occur at any time and at any place, there are some times and locations where they are more likely to form. Most tornadoes—especially violent ones—form in the spring during the late afternoon and evening, when the temperature contrasts between polar air and tropical air are the greatest. Large temperature contrasts occur most frequently in the central United States, where cold continental polar air collides with maritime tropical air moving northward from the Gulf of Mexico. These large temperature contrasts often spark the development of supercells, which are each capable of producing several strong tornadoes. More than 700 tornadoes touch down each year in the United States. Many of these occur in a region called "Tornado Alley," which extends from northern Texas through Oklahoma, Kansas, and Missouri.

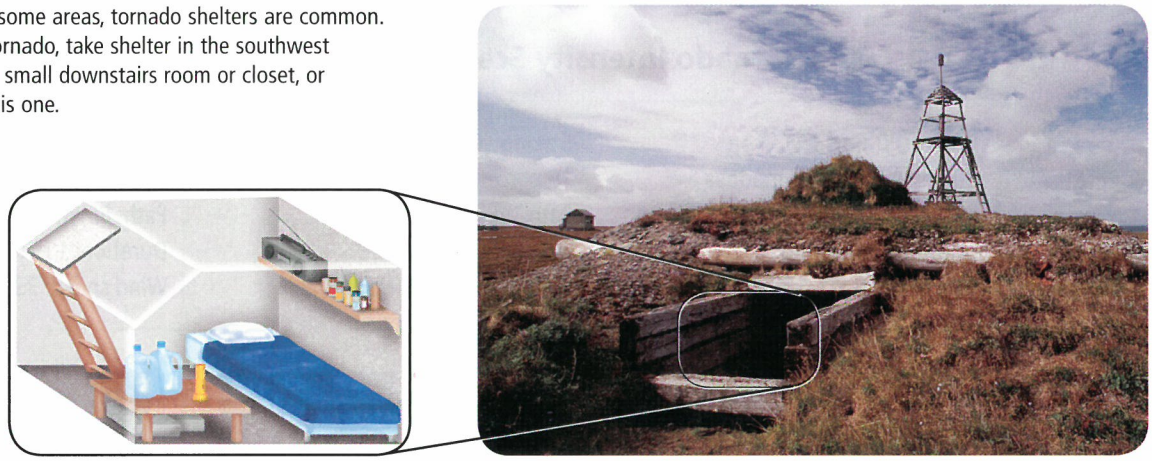


Figure 13.11 In some areas, tornado shelters are common. If you are caught in a tornado, take shelter in the southwest corner of a basement, a small downstairs room or closet, or a tornado shelter like this one.

Tornado safety In the United States, an average of 80 deaths and 1500 injuries result from tornadoes each year. In an ongoing effort to reduce tornado-related fatalities, the National Weather Service issues tornado watches and warnings before a tornado strikes. These advisories are broadcast on local radio stations when tornadoes are indicated on weather radar or spotted in the region. During a severe thunderstorm, the presence of dark, greenish skies, a towering wall of clouds, large hailstones, and a loud, roaring noise similar to that of a freight train are signs of an approaching or developing tornado.

The National Weather Service stresses that despite advanced tracking systems, some tornadoes develop very quickly. In these cases, advance warnings might not be possible. However, the threat of tornado-related injury can be substantially decreased when people seek shelter, such as the one shown in **Figure 13.11,** at the first sign of threatening skies.

Section 13.2 Assessment

Section Summary

- Intense rotating updrafts are associated with supercells.
- Downbursts are strong winds that result in damage associated with thunderstorms.
- Hail is precipitation in the form of balls or lumps of ice that accompany severe storms.
- The worst storm damage comes from a vortex of high winds that moves along the ground as a tornado.

Understand Main Ideas

1. MAIN Idea **Identify** the characteristics of a severe storm.
2. **Describe** two characteristics of thunderstorms that lead to hail formation.
3. **Explain** how some hail can become baseball sized.
4. **Compare and contrast** a macroburst and a microburst.
5. **Identify** the steps that change wind shear into a tornado.
6. **Identify** the conditions that lead to high winds, hail, and lightning.

Think Critically

7. **Explain** Why are there more tornado-producing storms in flat plains than in mountainous areas?
8. **Analyze** the data of the Fujita scale, and determine why F5 tornadoes have a longer path than F1 tornadoes.

WRITING in Earth Science

9. Design a pamphlet about tornado safety.