# Section 13.3

## Objectives

- **Identify** the conditions required for tropical cyclones to form.
- **Describe** the life cycle of a tropical cyclone.
- **Recognize** the dangers of hurricanes.

## Review Vocabulary

**Coriolis effect:** caused by Earth's rotation, moving particles, such as air, are deflected to the right north of the equator, and to the left south of the equator

## New Vocabulary

tropical cyclone
eye
eyewall
Saffir-Simpson hurricane scale
storm surge

# Tropical Storms

**MAIN Idea** **Normally peaceful, tropical oceans are capable of producing one of Earth's most violent weather systems—the tropical cyclone.**

**Real-World Reading Link** If you try mixing cake batter in a shallow bowl, you might find that a low speed works well, but a high speed creates a big mess. Tropical cyclones form from processes similar to other storm systems, but their high winds can bring devastation to locations in their path.

## Overview of Tropical Cyclones

During summer and fall, the tropics experience conditions ideal for the formation of large, rotating, low-pressure tropical storms called **tropical cyclones.** In different parts of the world, the largest of these storms are known as hurricanes, typhoons, and cyclones.

**Cyclone location** Favorable conditions for cyclone formation exist in all tropical oceans except the South Atlantic Ocean and the Pacific Ocean off the west coast of South America. The water in these areas is somewhat cooler and these areas contain regions of nearly permanently stable air. As a consequence, tropical cyclones do not normally occur in these areas. They do occur in the large expanse of warm waters in the western Pacific Ocean where they are known as typhoons. To people living near the Indian Ocean, they are known as cyclones. In the North Atlantic Ocean, the Caribbean Sea, the Gulf of Mexico, and along the western coast of Mexico, the strongest of these storms are called hurricanes. **Figure 13.12** shows where cyclones generally form.

Concepts In Motion

**Interactive Figure** To see an animation of tropical cyclones, visit glencoe.com.

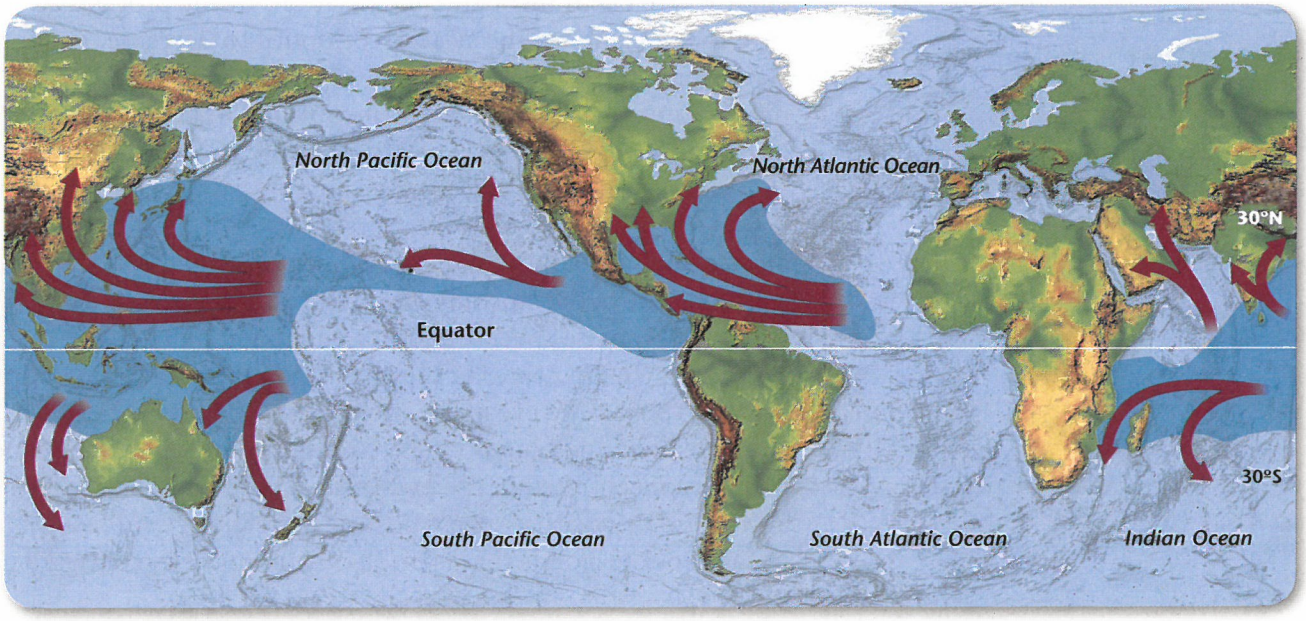



**Figure 13.12** Tropical cyclones are common in all of Earth's tropical oceans except in the relatively cool waters of both the South Pacific and South Atlantic Oceans.

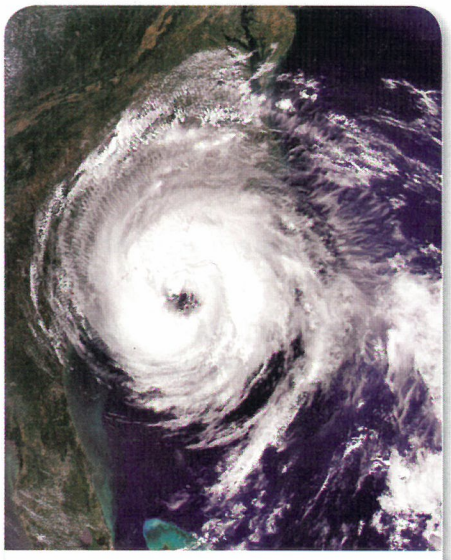


**Figure 13.13** The characteristic rotating nature of cyclonic storms is evident in this tropical depression that formed over the Atlantic Ocean.

**Cyclone formation** Tropical cyclones require two basic conditions to form: an abundant supply of warm ocean water and some sort of mechanism to lift warm air and keep it rising. Tropical cyclones thrive on the tremendous amount of energy in warm, tropical oceans. As water evaporates from the ocean surface, latent heat is stored in water vapor. This latent heat is later released when the air rises and the water vapor condenses.

The air usually rises because of some sort of existing weather disturbance moving across the tropics. Many disturbances originate along the equator. Others are the result of weak, low-pressure systems called tropical waves. Tropical disturbances are common during the summer and early fall. Regardless of their origin, only a small percentage of tropical disturbances develop into cyclones. There are three stages in the development of a full tropical cyclone.

**Reading Check** **Infer** what is produced when water vapor condenses.

**Formative stage** The first indications of a building tropical cyclone is a moving tropical disturbance. Less-dense, moist air is lifted, triggering rainfall and air circulation. As these disturbances produce more precipitation, more latent heat is released. In addition, the rising air creates an area of low pressure at the ocean surface. As more warm, dense air moves toward the low-pressure center to replace the air that has risen, the Coriolis effect causes the moving air to turn counterclockwise in the northern hemisphere. This produces the cyclonic (counterclockwise) rotation of a tropical cyclone, as shown in **Figure 13.13.** When a disturbance over a tropical ocean acquires a cyclonic circulation around a center of low pressure, it has reached the developmental stage and is known as a tropical depression, as illustrated in **Figure 13.14.**

**Mature stage** As the moving air approaches the center of the growing storm, it rises, rotates, and increases in speed as more energy is released through condensation. In the process, air pressure in the center of the system continues to decrease. As long as warm air is fed into the system at the surface and removed in the upper atmosphere, the storm will continue to build and the winds of rotation will increase as the air pressure drops.

When wind speeds around the low-pressure center of a tropical depression exceed 65 km/h, the system is called a tropical storm. If air pressure continues to fall and winds around the center reach at least 120 km/h, the storm is officially classified as a cyclone. Once winds reach these speeds, another phenomenon occurs—the development of a calm center of the storm called the **eye,** shown in **Figure 13.14.** The eye of the cyclone is a span of 30 to 60 km of calm weather and blue sky. The strongest winds in a hurricane are usually concentrated in the **eyewall**—a tall band of strong winds and dense clouds that surrounds the eye. The eyewall is visible because of the clouds that form there and mark the outward edge of the eye.

**VOCABULARY**

**SCIENCE USAGE V. COMMON USAGE**

**Depression**

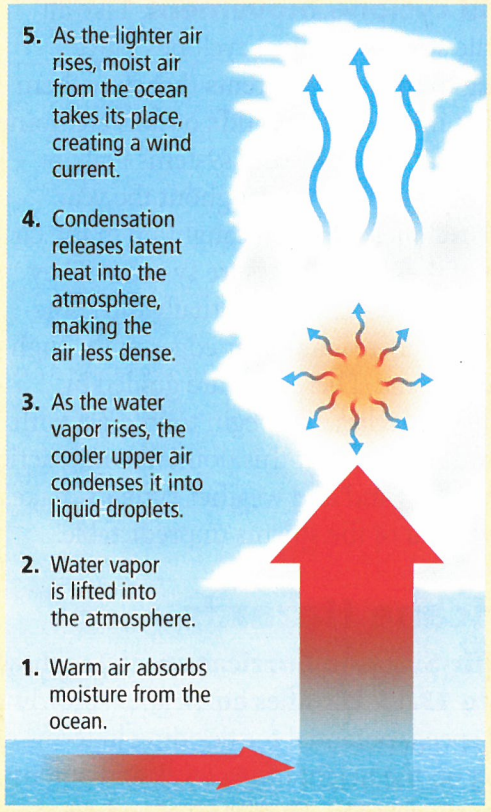
***Science usage:*** a pressing down or lowering, the low spot on a curved line

***Common usage:*** a state of feeling sad

# Visualizing Cyclone Formation

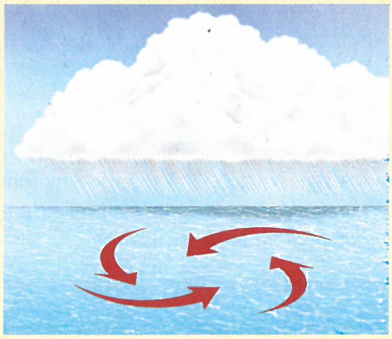
NATIONAL GEOGRAPHIC

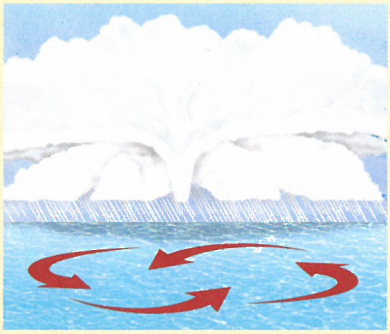
**Figure 13.14** Like most storms, cyclones begin with warm moist air rising.



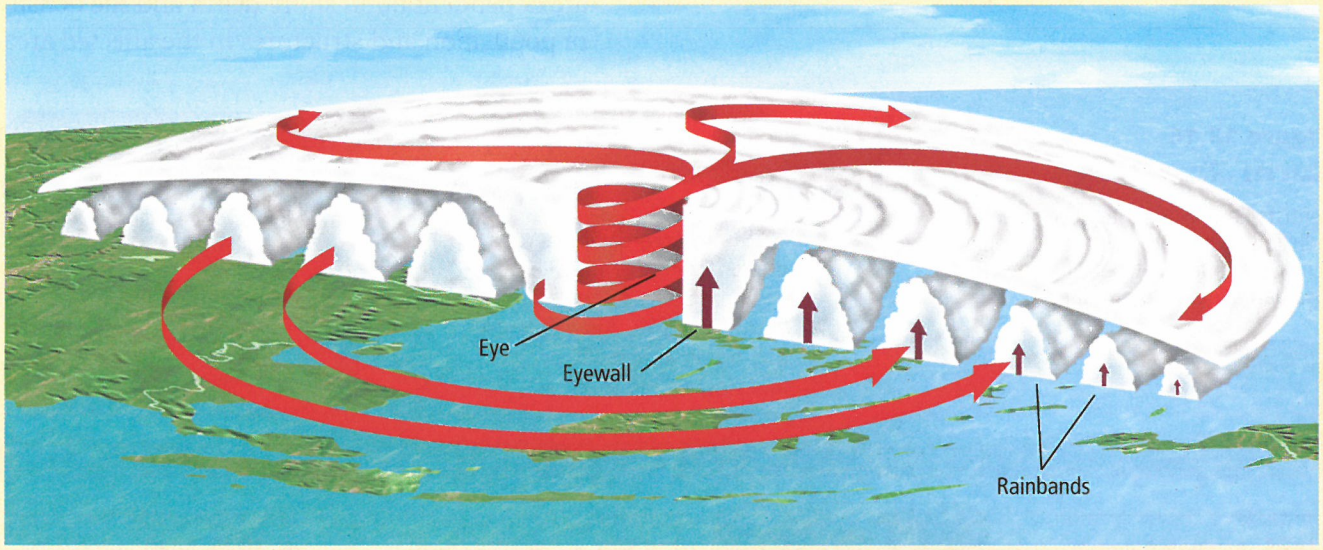

Moving air starts to spin as a result of the Coriolis effect.

**Tropical Depression** The first indications of a building storm are a tropical depression with good circulation, thunderstorms, and sustained winds of 37–62 km/h.





**Tropical Storm** As winds increase to speeds of 63–117 km/h, strong thunderstorms develop and become well defined. They are now tropical storms.




**Cyclone** With sustained winds of 118 km/h, an intense tropical weather system with well-defined circulation becomes a cyclone, also called a typhoon or hurricane.

Concepts In Motion To explore more about cyclone formation, visit glencoe.com.

Earth Science Online

### Saffir-Simpson Hurricane Scale

| Category | Winds (km/h) | Change in sea level | Damage |
|---|---|---|---|
| 5 | >250 | >5.5 m | catastrophic |
| 4 | 210–249 | 4.0–5.5 m | extreme |
| 3 | 178–209 | 2.8–3.7 m | extensive |
| 2 | 154–177 | 1.8–2.5 m | moderate |
| 1 | 119–153 | 1.2–1.5 m | minimal |

**Figure 13.15** The Saffir-Simpson hurricane scale classifies hurricanes according to wind speed, potential for flooding, and potential for property damage.

**Dissipation stage** A cyclone will last until it can no longer produce enough energy to sustain itself. This usually happens when the storm has moved either over land or over colder water. During its life cycle, a cyclone can undergo several fluctuations in intensity as it interacts with other atmospheric systems.

**Tropical cyclone movement** Like all large-scale storms, tropical cyclones move according to the wind currents that steer them. Recall that many of the world's oceans are home to subtropical high-pressure systems that are present to some extent throughout the year. Tropical cyclones are often caught up in the circulation of these high-pressure systems. They move steadily west, then eventually turn poleward when they reach the far edges of the high-pressure systems. There they are guided by prevailing westerlies and begin to interact with midlatitude systems. At this point, the interaction of the various wind and weather systems makes the movement of the storms unpredictable.

## Hurricane Hazards

The **Saffir-Simpson hurricane scale,** as shown in **Figure 13.15,** classifies hurricanes according to wind speed, potential for flooding in terms of the effect on the height of sea level, and potential for property damage. The sea level and damage are dependent upon shore depth and the density of population and structures in the affected area.

**Figure 13.16**

### Storm Tracking

Scientists have worked to develop weather prediction technology to protect people against the different types of storms that cause damage and loss of life.

**1888** A three-day blizzard dumps 125 cm of snow on the northeast United States, creating 17-m snowdrifts burying houses and trains, killing 400 people, and sinking 200 ships.

1850 — 1900 — 1925

**1861** An English newspaper publishes the first daily weather forecasts based on countrywide data that is compiled via the recently invented telegraph.

**1900** A Category 4 hurricane hits Texas. Five-m waves sweep over Galveston Island, killing more than 8000 people and washing away half the homes on the island.

**1925** An F5 tornado rips through Missouri, Illinois, and Indiana covering 352 km in three hours.

**Damage** Hurricanes can cause extensive damage, particularly along coastal areas, which tend to be where human populations are the most dense. Evidence of storm damage is documented in **Figure 13.16** by a photo from a hurricane that hit Galveston, Texas, in 1900.

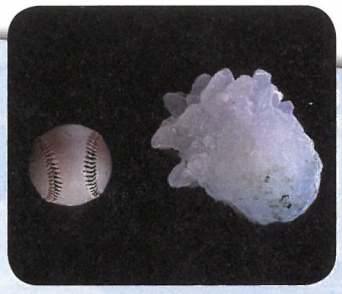
**Winds** Much of the damage caused by hurricanes is associated with violent winds. The strongest winds in a hurricane are usually located at the eyewall. Outside of the eyewall, winds taper off as distance from the center increases, although winds of more than 60 km/h can extend as far as 400 km from the center of a hurricane.

**Storm surge** Strong winds moving onshore in coastal areas are partly responsible for the largest hurricane threat—storm surges. A **storm surge** occurs when hurricane-force winds drive a mound of ocean water toward coastal areas where it washes over the land. Storm surges can sometimes reach 6 m above normal sea level, as shown in **Figure 13.17.** When this occurs during high tide, the surge can cause enormous damage. In the northern hemisphere, a storm surge occurs primarily on the right side of a storm relative to the direction of its forward motion. That is where the strongest onshore winds occur. This is due to the counterclockwise rotation of the storm.

Hurricanes produce great amounts of rain because of their continuous uptake of warm, moist ocean water. Thus, floods from intense rainfall are an additional hurricane hazard, particularly if the storm moves over mountainous areas, where orographic lifting enhances the upward motion of air and the resulting condensation of water vapor.

**Figure 13.17** Storm surges can sometimes reach 6 m above normal sea level and cause enormous damage.

NATIONAL GEOGRAPHIC To read about increasingly strong hurricanes and the science behind them, go to the National Geographic Expedition on page 910.



**1949** Lightning sparks a wildfire in Helena National Forest, Montana, that claims the lives of 13 firefighters and destroys 20 km² of land in five days.

**1970** Large hailstones, more than 13 cm in diameter, fell on Coffeyville, Kansas.

**2005** The Atlantic hurricane season unleashes the most hurricanes and Category 5 storms in history.

1950 1975 2000

**1960** The U.S. government launches TIROS, the first weather satellite.

**1990** The United States deploys its first operational Doppler radar system after more than 30 years of research.

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Interactive Time Line To learn more about these discoveries and others, visit glencoe.com. Earth Science Online


**Figure 13.18** This residential area has been engulfed in debris left behind from the flood waters of Hurricane Katrina. Most of the deaths associated with a hurricane come from flooding, not high winds.

**CAREERS IN EARTH SCIENCE**

**Hurricane Hunter** A hurricane hunter flies an instrument-laden airplane into a hurricane to measure wind speed and gather weather data on the features of a hurricane. To learn more about Earth science careers, visit glencoe.com.

**Hurricane advisories and safety** The National Hurricane Center, which is responsible for tracking and forecasting the intensity and motion of tropical cyclones in the western hemisphere, issues a hurricane warning at least 24 hours before a hurricane is predicted to strike. The center also issues regular advisories that indicate a storm's position, strength, and movement. Using this information, people can then track a storm on a hurricane-tracking chart, such as the one you will use in the Internet GeoLab at the end of this chapter. Awareness, combined with proper safety precautions, has greatly reduced death tolls associated with hurricanes in recent years. **Figure 13.18** shows debris and destruction left by hurricane flooding; loss of life can be prevented by evacuating residents before the storm hits.

## Section 13.3 Assessment

### Section Summary

- Cyclones rotate counterclockwise in the northern hemisphere.
- Cyclones are also known as hurricanes and typhoons.
- Cyclones go through the same stages of formation and dissipation as other storms.
- Cyclones are moved by various wind systems after they form.
- The most dangerous part of a tropical cyclone is the storm surge.
- Hurricane alerts are given at least 24 hours before the hurricane arrives.

### Understand Main Ideas

1. MAIN Idea **Identify** the three main stages of a tropical cyclone.
2. **Describe** the changing wind systems that guide a tropical cyclone as it moves from the tropics to the midlatitudes.
3. **Identify** two conditions that must exist for a tropical cyclone to form.
4. **Explain** what causes a cyclone to dissipate.

### Think Critically

5. **Analyze** Imagine that you live on the eastern coast of the United States and are advised that the center of a hurricane is moving inland 70 km north of your location. Would a storm surge be a major problem in your area? Why or why not?
6. **Compare** the Saffir-Simpson scale with the Fujita scale. How are they different? Why?

### MATH in Earth Science

7. Determine the average wind speed for each hurricane category shown in **Figure 13.15**.



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