KEY CONCEPT

16.3 Most clouds form as air rises and cools.

BEFORE, you learned

- Water vapor circulates from Earth to the atmosphere
- Warm air is less dense than cool air and tends to rise

NOW, you will learn

- How water in the atmosphere changes
- How clouds form
- About the types of clouds

VOCABULARY

evaporation p. 552
condensation p. 552
precipitation p. 553
humidity p. 554
saturation p. 554
relative humidity p. 554
dew point p. 554

EXPLORE Condensation

How does condensation occur?

PROCEDURE

1. Observe the air as a classmate breathes out.
2. Observe a mirror as a classmate breathes onto it.

MATERIALS

hand mirror

WHAT DO YOU THINK?

- What changes did you observe on the mirror?
- Why could you see water on the mirror but not in the air when your classmate breathed out?

Temperature affects water in the air.

Water is always in the atmosphere. You may see water in solid form, such as falling snow. Water may also be present as liquid water droplets. Even if you can't see any water, it is still part of the air as water vapor, an invisible gas. When temperatures change, water changes its form.

- **Evaporation** is the process by which a liquid changes into a gas. For water to evaporate, it needs extra energy.
- **Condensation** is the process by which a gas, such as water vapor, changes into a liquid. Condensation occurs when moist air cools.

The picture on the left shows the processes of evaporation and condensation at work. Water in a teakettle absorbs heat. It gets enough energy to evaporate into water vapor. The invisible water vapor rises and escapes from the kettle. When the vapor hits the cooler air outside the kettle, it cools and condenses into tiny but visible water droplets.

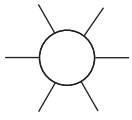
Water in the Air

Vast amounts of Earth's water are recycled. The oceans hold most of the water. Water is also stored in lakes, rivers, and ice sheets; in plants; and underground. Energy from sunlight causes molecules to evaporate from the surface of a body of water. These molecules become part of the air in the form of water vapor.

As air rises in the atmosphere, it cools. The loss of heat causes water vapor to condense into tiny water droplets or ice crystals. If the droplets or crystals grow and become heavy enough, they fall as rain, snow, sleet, or hail. Any type of liquid or solid water that falls to Earth's surface is called **precipitation.** Earth's water goes through a never-ending cycle of evaporation, condensation, and precipitation.

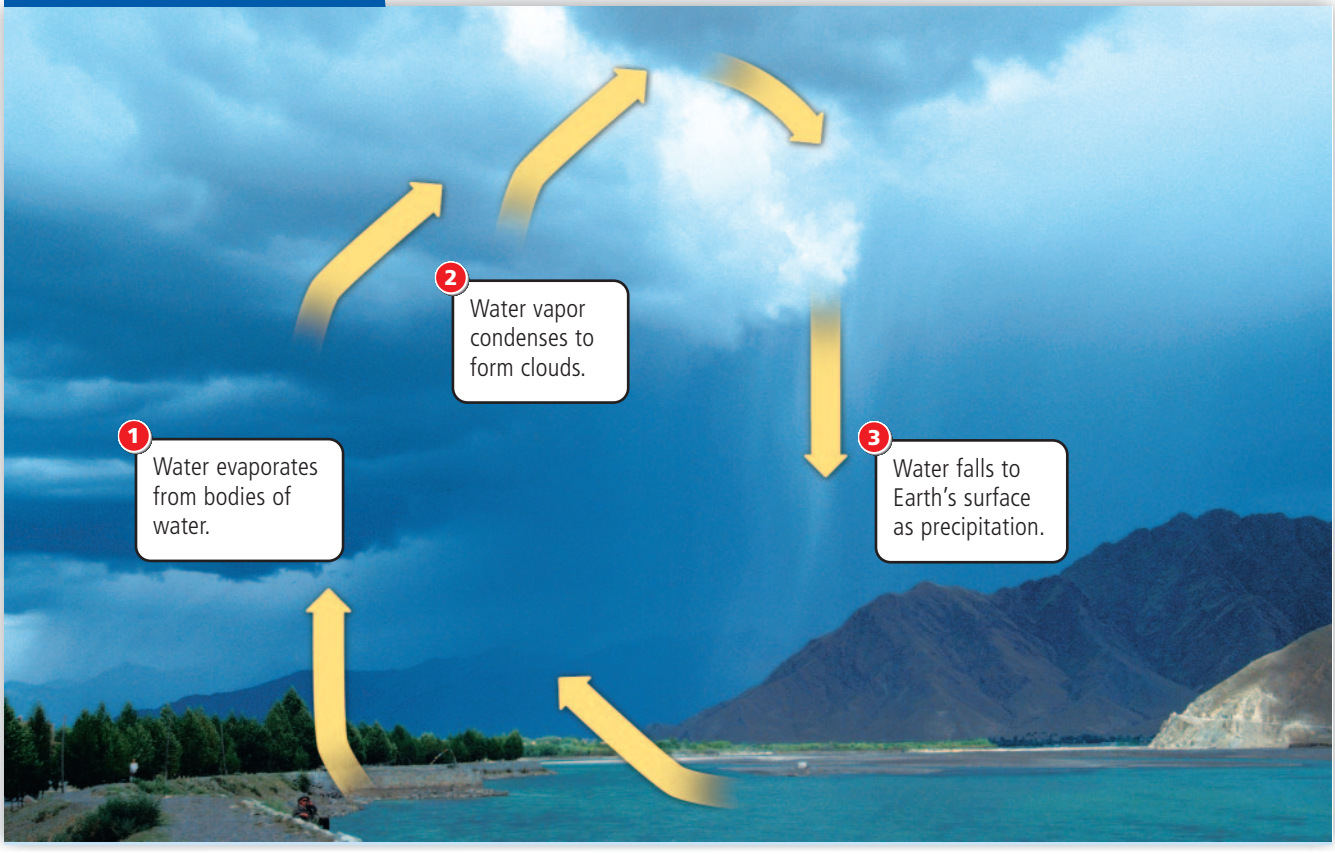
Water vapor can also condense on solid surfaces. Have you ever gotten your shoes wet while walking on grass in the early morning? The grass was covered with dew, which is water that has condensed on cool surfaces at night. If the temperature is cold enough, water vapor can change directly into a covering of ice, called frost.

VOCABULARY
Add a description wheel for *precipitation* to your notebook.



CHECK YOUR READING Summarize the way water moves in the water cycle. For each part of the cycle, specify whether water exists as a gas, liquid, or solid.

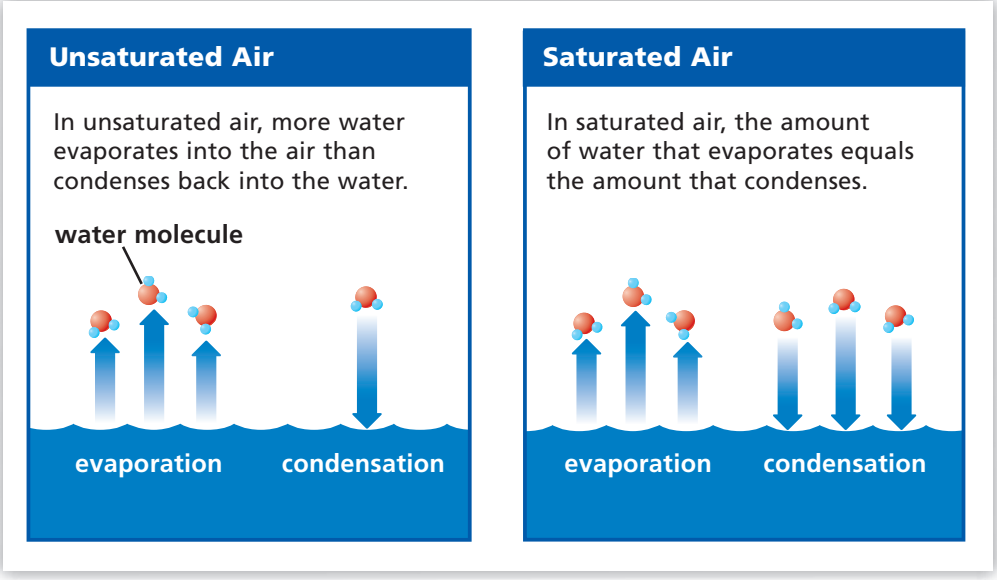
Water Cycle



Humidity and Relative Humidity

On a warm summer day, evaporation of moisture from your skin can help you feel comfortable. However, a lot of water vapor in the air can cause less moisture to evaporate from your skin. With less evaporation, the air will seem hotter and damper. **Humidity** is the amount of water vapor in air. Humidity varies from place to place and from time to time.

The illustration shows how humidity increases in a sealed container. As water molecules evaporate into the air, some start to condense and return to the water. For a while the air gains water vapor because more water evaporates than condenses. But eventually the air reaches **saturation,** a condition in which the rates of evaporation and condensation are equal. Any additional water that evaporates is balanced by water that condenses.



READING TiP

Relative means "considered in comparison with something else."

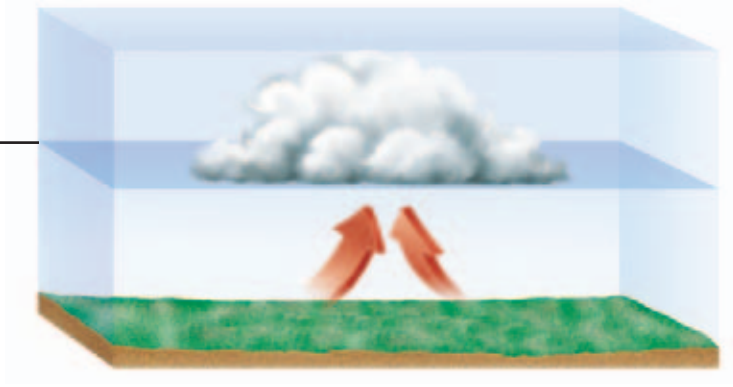
The amount of water vapor in air at saturation depends on the temperature of the air. The warmer air is, the more water vapor it takes to saturate it. Scientists use this principle to describe the humidity of air in two different ways: relative humidity and dew point.

Relative humidity compares the amount of water vapor in air with the maximum amount of water vapor that can be present at that temperature. For example, air with 50 percent relative humidity has half the amount of water needed for saturation. If the amount of water vapor in air stays the same, relative humidity will decrease as the air heats up and increase as the air cools.

Dew point is the temperature at which air with a given amount of water vapor will reach saturation. For example, air with a dew point of 26°C (79°F) will become saturated if it cools to 26°C. The higher the dew point of air, the more water vapor the air contains.

Water vapor condenses and forms clouds.

Clouds are made of condensed water vapor. As warm air rises in the atmosphere, it cools. When the air cools to its dew point—the temperature at which air reaches saturation—water vapor condenses into tiny droplets or ice crystals. These droplets and crystals are so light that they either float as clouds on rising air or fall very slowly.



Rising warm air can produce clouds. Water vapor begins to condense when the air cools to its dew point.

Recall how dew condenses on grass. Water must condense on something solid. There are no large solid surfaces in the air. However, the air is filled with tiny particles such as dust, smoke, and salt from the ocean. Water vapor condenses on these particles.

INVESTIGATE Condensation

How does a cloud form?

SKILL FOCUS
Observing

MATERIALS
- clear 1-liter plastic bottle with cap
- water at room temperature
- tablespoon
- matches

TIME
10 minutes

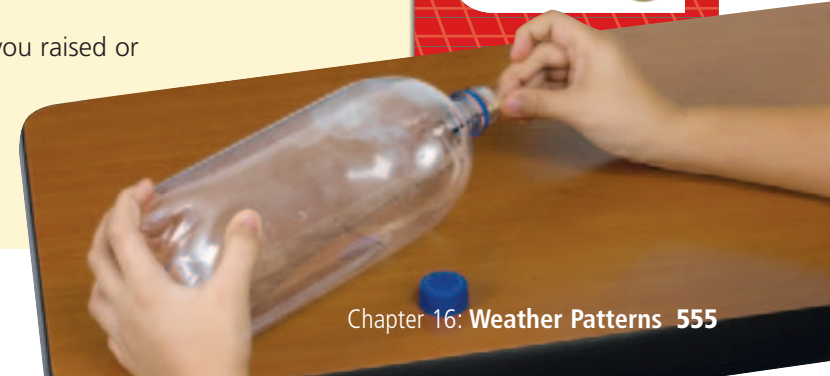
PROCEDURE

1. Add a spoonful of water to the bottle to increase the humidity inside it.
2. Lay the bottle on its side. Light a match, blow it out, and then stick the match into the bottle for a few seconds to let smoke flow in. Replace the cap.
3. Squeeze the bottle quickly and then release it. Observe what happens when the bottle is allowed to expand.

WHAT DO YOU THINK?

- What happened to the water vapor inside the bottle when you squeezed the bottle and then let it expand?
- How did the smoke affect what happened to the water vapor?

CHALLENGE How would the cloud change if you raised or lowered the temperature inside the bottle?



RESOURCE CENTER
CLASSZONE.COM
Observe different types of clouds.

Characteristics of Clouds

If you watch the sky over a period of time, you will probably observe clouds that do not look alike. Clouds have different characteristics because they form under different conditions. The shapes and sizes of clouds are mainly determined by air movement. For example, puffy clouds form in air that rises sharply or moves straight up and down. Flat, smooth clouds covering large areas form in air that rises gradually.

Location affects the composition of clouds. Since the troposphere gets colder with altitude, clouds that form at high altitudes are made of tiny ice crystals. Closer to Earth's surface, clouds are made of water droplets or a mixture of ice crystals and water droplets.

CHECK YOUR READING How are clouds that form at high altitudes different from clouds that form close to Earth's surface?

COMBINATION NOTES
Record information about the three main cloud types.

In the illustration on page 557, notice that some cloud names share word parts. That is because clouds are classified and named according to their altitudes, the ways they form, and their general characteristics. The three main types of clouds are cirrus, cumulus, and stratus. These names come from Latin words that suggest the clouds' appearances.

- ***Cirrus*** (SEER-uhs) means "curl of hair." Cirrus clouds appear feathery or wispy.
- ***Cumulus*** (KYOOM-yuh-luhs) means "heap" or "pile." Cumulus-type clouds can grow to be very tall.
- ***Stratus*** (STRAT-uhs) means "spread out." Stratus-type clouds form in flat layers.

Word parts are used to tell more about clouds. For example, names of clouds that produce precipitation contain the word part *nimbo-* or *nimbus*. Names of clouds that form at a medium altitude have the prefix *alto-*.

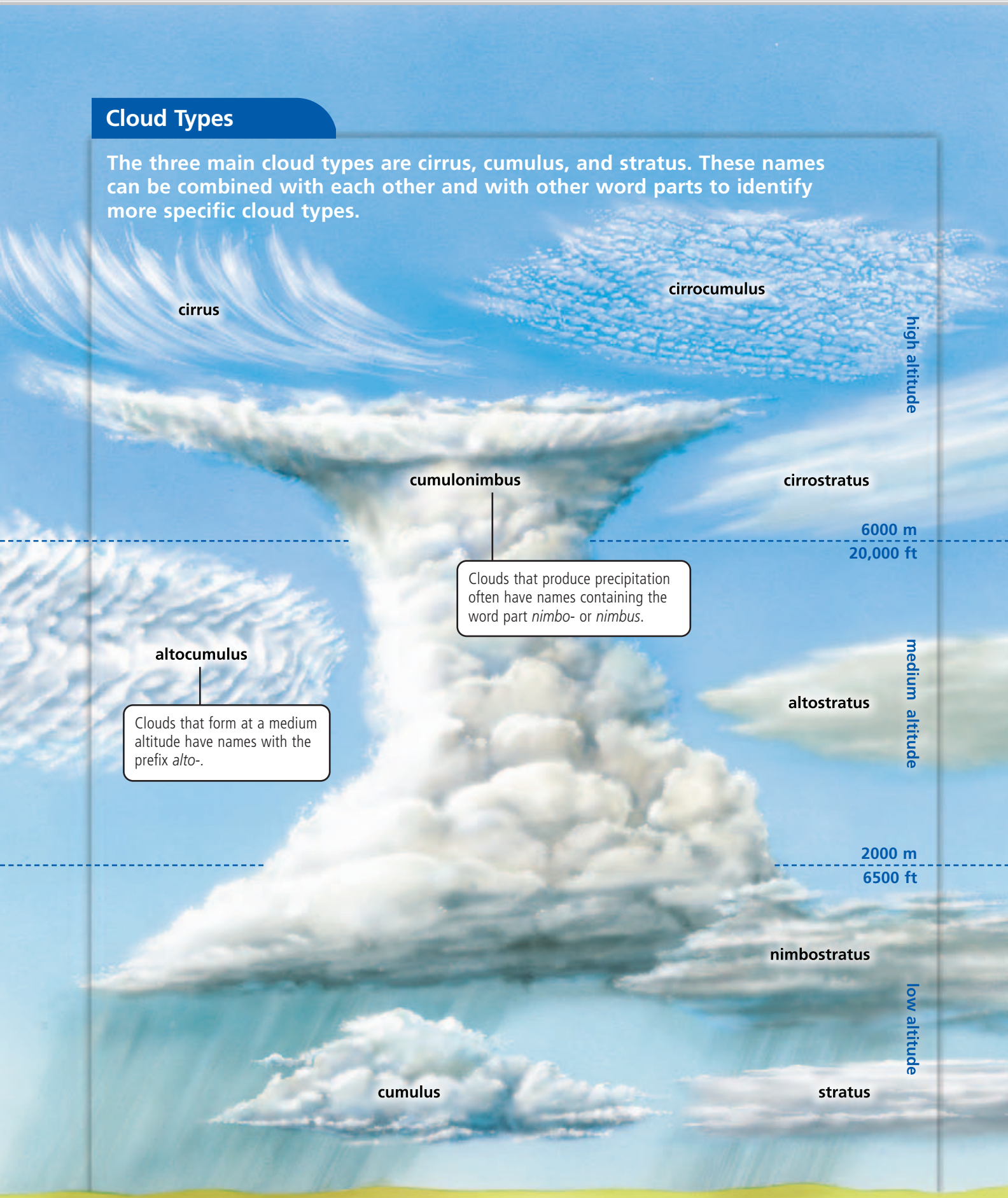

cirrus clouds

Cirrus Clouds

Cirrus clouds form in very cold air at high altitudes. Made of ice crystals, they have a wispy or feathery appearance. Strong winds often blow streamers or "tails" off cirrus clouds. These features show the direction of the wind in the upper troposphere. You will usually see cirrus clouds in fair weather. However, they can be a sign that a storm is approaching.

Cloud Types

The three main cloud types are cirrus, cumulus, and stratus. These names can be combined with each other and with other word parts to identify more specific cloud types.



READING VISUALS Which cloud names are combinations of names of two main cloud types?

READING TiP

As you read each description of a main cloud type, look back at the visual on page 557. Notice the different clouds that have the main cloud type as part of their names.

Cumulus Clouds

cumulus clouds

Cumulus clouds are puffy white clouds with darker bases. They look like cotton balls floating in the sky. There are several varieties of cumulus clouds. Usually they appear in the daytime in fair weather, when warm air rises and its water vapor condenses. Cooler air sinks along the sides of the clouds, keeping cumulus clouds separate from one another.

cumulonimbus clouds

If cumulus clouds keep growing taller, they can produce showers. The precipitation usually lasts less than half an hour because there are spaces between the clouds. The tallest clouds are cumulonimbus clouds, or thunderheads. These clouds produce thunderstorms that drop heavy rainfall. A cumulonimbus cloud can tower 18 kilometers (11 mi) above Earth's surface. By comparison, jet planes usually fly at about 10 kilometers (6 mi). Strong high-altitude winds often cause the top of the cloud to jut out sharply.

CHECK YOUR READING How are cumulonimbus clouds different from other cumulus clouds?

Stratus Clouds

stratus clouds

Have you ever noticed on some days that the whole sky looks gray? You were looking at stratus clouds. They form in layers when air cools over a large area without rising or when the air is gently lifted. Stratus clouds are smooth because they form without strong air movement.

Some low stratus clouds are so dark that they completely block out the Sun. These clouds produce steady, light precipitation—unlike the brief showers that come from cumulus clouds. Stratus clouds that form at high altitudes are much thinner than low stratus clouds. You can see the Sun and the Moon through them. The ice crystals in high stratus clouds can make it seem as if there's a circle of colored light around the Sun or the Moon.

This fog formed around Castleton Tower in Utah. The land cooled overnight, causing water vapor in the air above it to condense.

Fog

Fog is a cloud that rests on the ground or a body of water. Like stratus clouds, fog has a smooth appearance. It usually forms when a surface is colder than the air above it. Water vapor in the air condenses as it cools, forming a thick mist. Fog on land tends to be heaviest at dawn, after the ground has cooled overnight. It clears as the ground is heated up by sunlight.

Fog can look beautiful rolling over hills or partly covering structures such as bridges. However, it often makes transportation dangerous by limiting visibility. In the United States close to 700 people die each year in automobile accidents that occur in dense fog.

16.3 Review

KEY CONCEPTS

1. Describe the three forms in which water is present in the atmosphere.
2. How does altitude affect the composition of clouds?
3. How are clouds classified?

CRITICAL THINKING

4. **Summarize** Describe the main characteristics of cirrus, cumulus, and stratus clouds.
5. **Draw Conclusions** Why might cumulonimbus clouds be more likely to form on sunny days than on days with little sunlight?

CHALLENGE

6. **Apply** Imagine that the sky has turned very cloudy after a hot morning. You notice that the bread in your sandwich is soggy and the towels on the towel rack won't dry. Explain why these things are happening. Use the following terms in your answer: *condensation, evaporation, relative humidity.*