Name _____ Class _____ Date _____

CHAPTER 16 Understanding Weather

SECTION 1

Water in the Air

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What is weather?
- How does water in the air affect the weather?

National Science Education Standards

ES 1f, 1i

What Is Weather?

Knowing about the weather is important in our daily lives. Your plans to go outside can change if it rains. Being prepared for extreme weather conditions, such as hurricanes and tornadoes, can even save your life.

Weather is the condition of the atmosphere at a certain time and place. Weather depends a lot on the amount of water in the air. Therefore, to understand weather, you need to understand the water cycle. ☑

STUDY TIP

Outline Before you read, make an outline of this section using the questions in bold. As you read, fill in the main ideas of the chapter in your outline.

READING CHECK

1. Define Write your own definition for *weather*.

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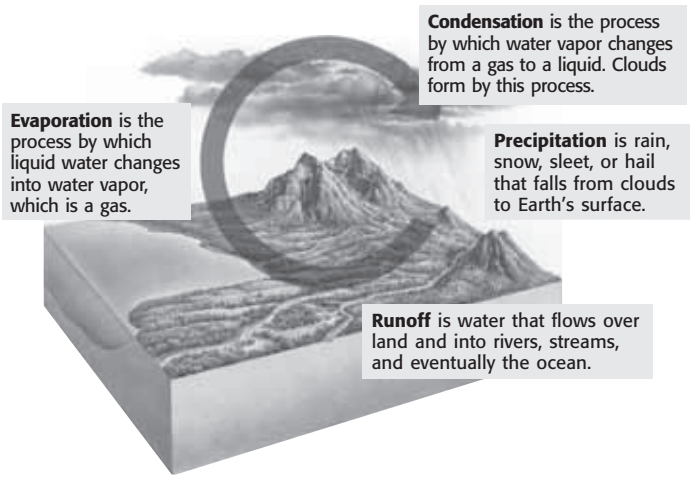
THE WATER CYCLE

The movement of water between the atmosphere, the land, and the oceans is called the *water cycle*. The sun is the main source of energy for the water cycle. The sun's energy heats Earth's surface. This causes liquid water to *evaporate*, or change into water vapor (a gas). When the water vapor cools, it may change back into a liquid and form clouds. This is called **condensation**. The liquid water may fall as rain, snow, sleet, or hail on the land.



STANDARDS CHECK

ES 1i Clouds, formed by the condensation of water vapor, affect weather and climate.

Word Help: affect
to change; to act upon

2. Identify By what process do clouds form?

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What Is Humidity?

Water vapor makes up only a small fraction of the mass of the atmosphere. However, this small amount of water vapor has an important effect on weather and climate.

When the sun's energy heats up Earth's surface, water in oceans and water bodies evaporates. The amount of water vapor in the air is called **humidity**. Warmer air can hold more water vapor than cooler air can. ☑

READING CHECK

3. Identify How does air temperature affect how much water vapor the air can hold?

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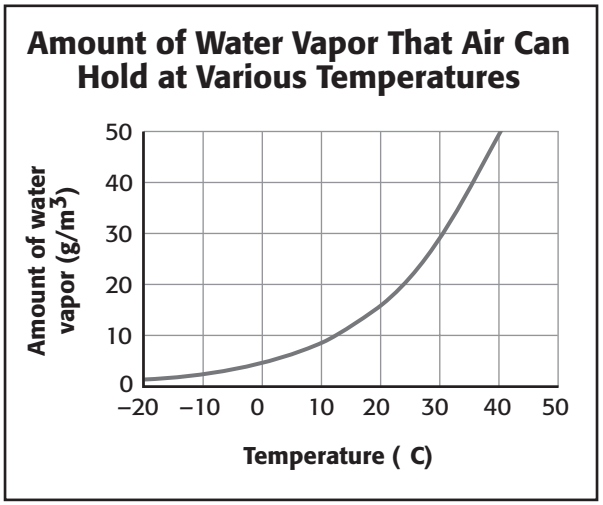

Math Focus

4. Read a Graph How much water vapor can air at 30°C hold?

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RELATIVE HUMIDITY

Scientists often describe the amount of water in the air using relative humidity. **Relative humidity** is the ratio of the amount of water vapor in the air to the greatest amount the air can hold.

There are two steps to calculating relative humidity. First, divide the amount of water in a volume of air by the maximum amount of water that volume of air can hold. Then, multiply by 100 to get a percentage. For example, 1 m^3 of air at 25°C can hold up to about 23 g of water vapor. If air at 25°C in a certain place contains only 18 g/m^3 of water vapor, then the relative humidity is:

$$\frac{18\ g/m^3}{23\ g/m^3} \times 100 = 78\%\ \text{relative humidity}$$

Math Focus

5. Calculate What is the relative humidity of 25°C air that contains 10 g/m^3 of water vapor? Show your work.

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FACTORS AFFECTING RELATIVE HUMIDITY

Temperature and humidity can affect relative humidity. As humidity increases, relative humidity increases if the temperature stays the same. Relative humidity decreases as temperature rises and increases as temperature drops if the humidity stays the same.

Critical Thinking

6. Compare How is relative humidity different from humidity?

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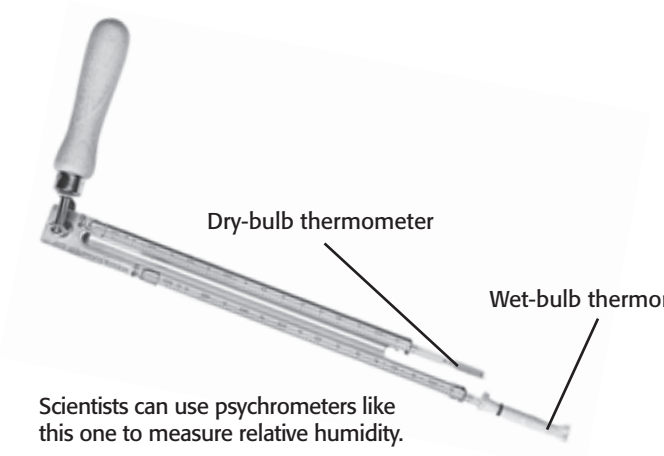
MEASURING RELATIVE HUMIDITY

Scientists measure relative humidity using special tools. One of these tools is called a *psychrometer*. A psychrometer contains two thermometers. The bulb of one thermometer is covered with a wet cloth. This is called a *wet-bulb thermometer*. The other thermometer bulb is dry. This thermometer is a *dry-bulb thermometer*.

You are probably most familiar with dry-bulb thermometers. Wet-bulb thermometers work differently than dry-bulb thermometers. As air passes through the cloth on a wet-bulb thermometer, some of the water in the cloth evaporates. As the water evaporates, the cloth cools. The wet-bulb thermometer shows the temperature of the cloth.

If humidity is low, the water evaporates more quickly. Therefore, the temperature reading on the wet-bulb thermometer is much lower than the reading on the dry-bulb thermometer. If the humidity is high, less water evaporates. Therefore, the temperature changes very little.



Scientists can use psychrometers like this one to measure relative humidity.

TAKE A LOOK

7. Identify What are two parts of a psychrometer?

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The difference in temperature readings between the dry-bulb and wet-bulb thermometers is a measure of the relative humidity. The larger the difference between the readings, the lower the relative humidity.

USING A RELATIVE-HUMIDITY TABLE

Scientists use tables like the one below to determine relative humidity. Use the table to work through the following example.

The dry-bulb thermometer on a psychrometer reads 10°C. The wet-bulb thermometer reads 7°C. Therefore, the difference between the thermometer readings is 3°C. In the first column of the table, find the row head for 10°C, the dry-bulb reading. Then, find the column head for 3°C, the difference between the readings. Find the place where the row and column meet. The number in the table at this point is 66, so the relative humidity is 66%.

Relative Humidity (%)

Dry-bulb reading (°C)	Difference between wet-bulb reading and dry-bulb reading (°C)							
	1	2	3	4	5	6	7	8
0	81	64	46	29	13			
2	84	68	52	37	22	7		
4	85	71	57	43	29	16		
6	86	73	60	48	35	24	11	
8	87	75	63	51	40	29	19	8
10	88	77	66	55	44	34	24	15
12	59	78	68	58	48	39	29	21
14	90	79	70	60	51	42	34	26
16	90	81	71	63	54	46	38	30
18	91	82	73	65	57	49	41	34
20	91	83	74	66	59	51	44	37

TAKE A LOOK

8. Apply Concepts The dry-bulb reading on a psychrometer is 8°C. The wet-bulb reading is 7°C. What is the relative humidity?

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What Is Dew Point?

What happens when relative humidity reaches 100%? At this point, the air is *saturated* with water vapor. The temperature at which this happens is the *dew point*. At temperatures below the dew point, liquid water droplets can form from the water vapor in the air. ☑

Condensation happens when air is saturated with water vapor. Air can become saturated if water evaporates and enters the air as water vapor. Air can also become saturated when it cools below its dew point.

READING CHECK

9. Explain What happens when the temperature of air is below its dew point?

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AN EVERYDAY EXAMPLE

You have probably seen air become saturated because of a temperature decrease. For example, when you add ice cubes to a glass of juice, the temperatures of the juice and the glass decrease. The glass absorbs heat from the air, so the temperature of the air near the glass decreases. When the air's temperature drops below its dew point, water vapor condenses on the glass. The condensed water forms droplets on the glass.

The glass absorbs heat from the air. The air cools to below its dew point. Water vapor condenses onto the side of the glass.

How Do Clouds Form?

A **cloud** is a group of millions of tiny water droplets or ice crystals. Clouds form as air rises and cools. When air cools below the dew point, water droplets or ice crystals form. Water droplets form when water condenses above 0°C. Ice crystals form when water condenses below 0°C.

DIFFERENT KINDS OF CLOUDS

Scientists classify clouds by shape and altitude. The three main cloud shapes are stratus clouds, cumulus clouds, and cirrus clouds. The three altitude groups are low clouds, middle clouds, and high clouds. The figure on the next page shows these different cloud types. ☑

Critical Thinking

10. Apply Concepts People who wear glasses may notice that their glasses fog up when they come indoors on a cold day. Why does this happen?

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TAKE A LOOK

11. Describe Where did the liquid water on the outside of the glass come from?

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READING CHECK

12. Explain How are clouds classified?

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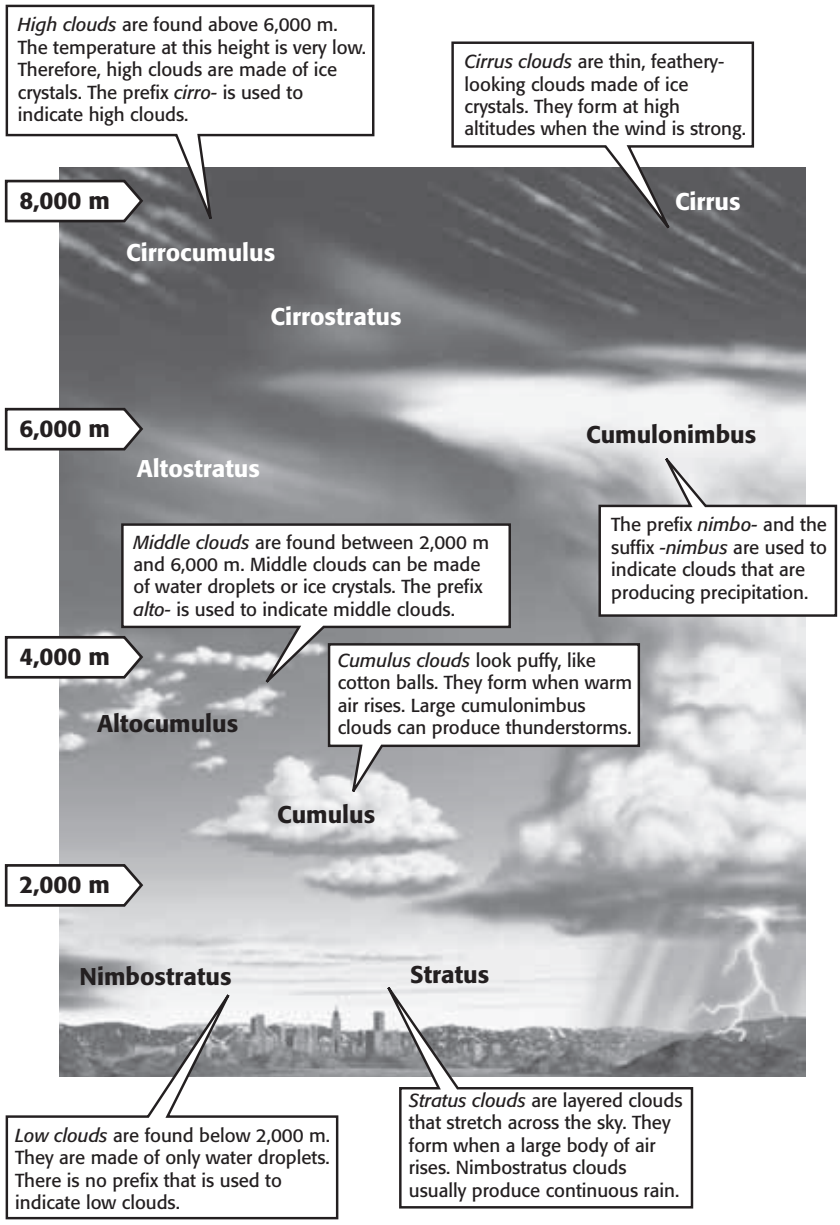
Say It

Observe and Describe Look at the clouds every day for a week. Each day, write down the weather and what the clouds looked like. At the end of the week, share your observations with a small group. How was the weather related to the kinds of clouds you saw each day?



TAKE A LOOK

13. Compare How is a nimbostratus cloud different from a stratus cloud?

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What Is Precipitation?

Water in the air can return to Earth's surface through precipitation. **Precipitation** is solid or liquid water that falls to Earth's surface from clouds. There are four main kinds of precipitation: rain, snow, sleet, and hail. Rain and snow are the most common kinds of precipitation. Sleet and hail are less common. ☑

READING CHECK

14. Define What is precipitation?

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RAIN

Water droplets in clouds are very tiny. Each droplet is smaller than the period at the end of this sentence. These tiny droplets can combine with each other. As the droplets combine, they become larger. When a droplet reaches a certain size, it can fall to Earth's surface as *rain*. ☑

READING CHECK

15. Explain What happens to water droplets in clouds when they combine?

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SLEET

Sleet forms when rain falls through a layer of very cold air. If the air is cold enough, the rain freezes in the air and becomes falling ice. Sleet can make roads very slippery. When it lands on objects, sleet can coat the objects in ice.

SNOW

Snow forms when temperatures are so low that water vapor turns directly into a solid. That is, the water vapor in the cloud turns into an ice crystal without becoming a liquid first. Snow can fall as single ice crystals. In many cases, the crystals join together to form larger snowflakes. ☑

READING CHECK

16. Identify What is a snowflake?

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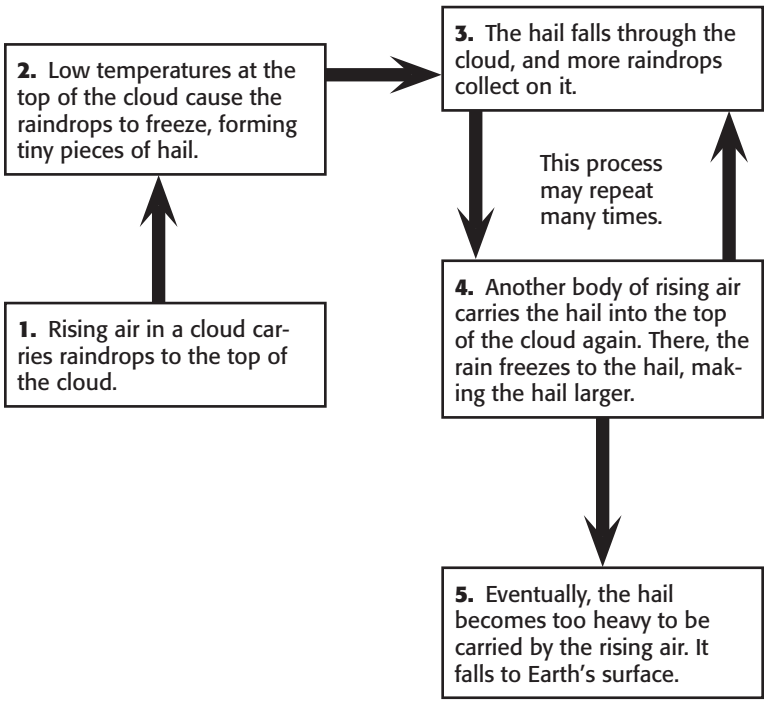
HAIL

Balls or lumps of ice that fall from clouds are called *hail*. Hail forms in cumulonimbus clouds. Hail can become very large. Hail grows larger in a cycle, as shown in the chart below.



TAKE A LOOK

17. Identify When does hail fall to the ground?

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Name _____ Class _____ Date _____

Section 1 Review

NSES ES 1f, 1i

SECTION VOCABULARY

cloud a collection of small water droplets or ice crystals suspended in the air, which forms when the air is cooled and condensation occurs

condensation the change of state from a gas to a liquid

humidity the amount of water vapor in the air

precipitation any form of water that falls to Earth's surface from the clouds

relative humidity the ratio of the amount of water vapor in the air to the amount of water vapor needed to reach saturation at a given temperature

weather the short-term state of the atmosphere, including temperature, humidity, precipitation, wind, and visibility

1. Identify Relationships How is dew point related to condensation?

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2. Identify What is the main source of energy for the water cycle?

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3. Explain How do clouds form?

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4. Compare What is the difference between sleet and snow?

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5. Apply Concepts Fill in the spaces in the table to describe different kinds of clouds.

Name	Altitude	Shape	Precipitation?
Cirrostratus	high		no
Altocumulus		puffy	
Nimbostratus			
Cumulonimbus	low to middle		