S.T.E.M. Engineering & Technology

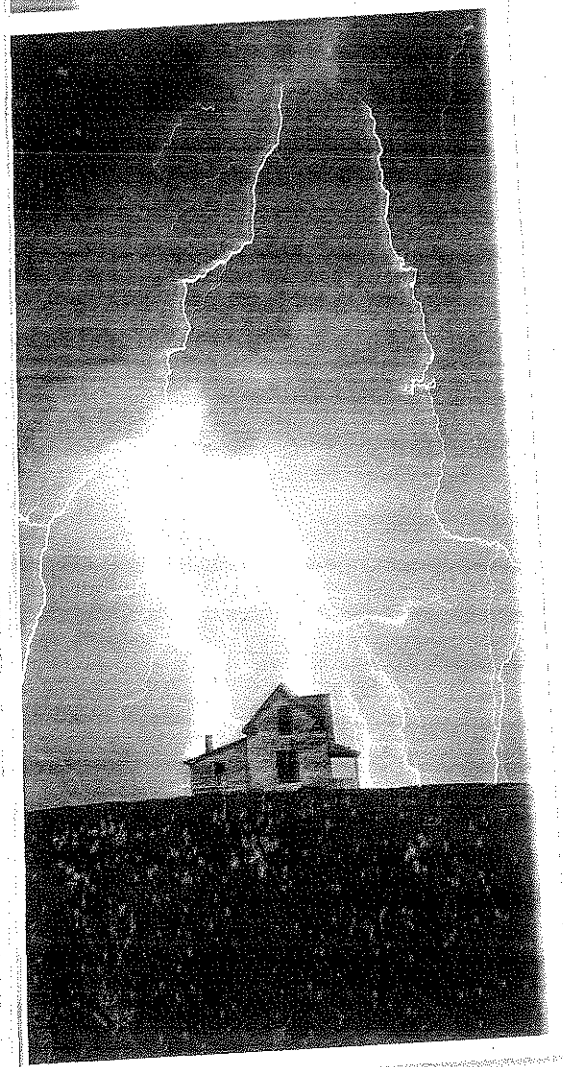
Evaluating Technological Systems

Skills

- ✓ Identify inputs
- ✓ Identify outputs
- ✓ Identify system processes
- Evaluate system feedback
- Apply system controls
- ✓ Communicate results

Objectives

- Analyze weather forecasting as a system.
- Identify the inputs and outputs of a forecasting system.
- Interpret weather data to generate a weather map.



Using Data in Systems

A system is a group of interacting parts that work together to do a job. Technological systems process inputs and generate outputs. An input is any matter, energy, or information that goes into a system. Outputs are matter, energy, or information that come out of the system. When you use a computer, the data set that is entered is the input. The computer delivers your output on the monitor or the printer.

Weather Data Go Into a System

What do you do if you have an outdoor activity planned tomorrow? You probably check the weather forecast to help you decide what to wear. Meteorologists are scientists who use data from different sources to find out what is happening in the atmosphere. Weather data are the input. The data set is processed by computers that perform complex calculations to generate weather models. Weather forecast systems combine 72 hours of data from weather stations, weather balloons, radar, aircraft, and weather satellites to show what is happening in Earth's atmosphere now and to predict what will happen in the future.

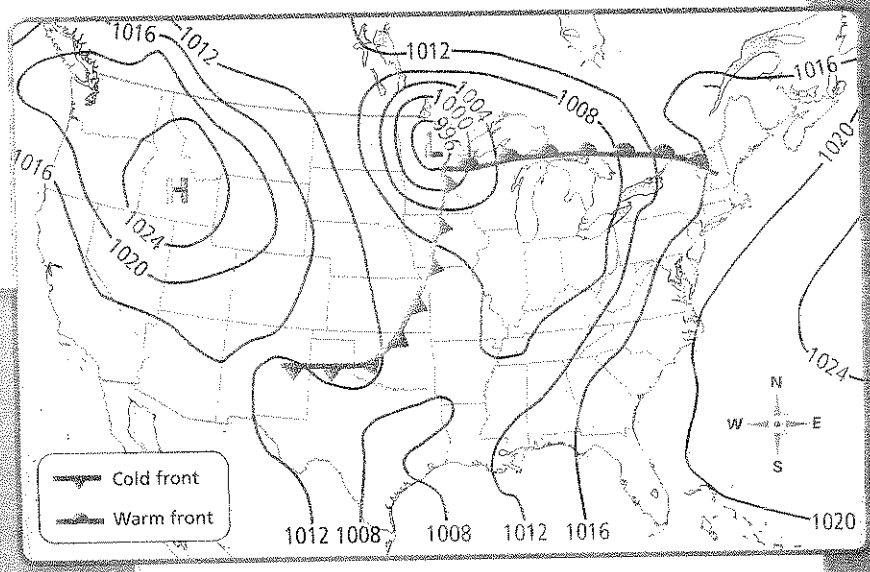
1 **Explain** How is a television weather forecast part of a technological system?

The atmosphere is a system that can have dramatic outputs. Those outputs are inputs into a weather forecasting system.

Forecast Data Come Out of the System

Weather maps are one type of output from a weather forecasting system. On a weather map you can find information about atmospheric pressure, and about the direction and temperature of moving air. The numbered lines on a weather map are called *isobars*. Isobars connect areas that have the same atmospheric pressure. Isobars center around areas of high and low pressure. An area of high pressure (H) indicates a place where cool, dense air is falling. An area of low pressure (L) indicates a place where warm, less dense air is rising. Pressure differences cause air to move. The leading edge of a cool air mass is called a *cold front*. The leading edge of a warm air mass is called a *warm front*. On a weather map, blue lines with triangles show cold fronts and red lines with half circles show warm fronts.

The direction of the triangles or half circles on a map shows which way a front is moving. Wind direction is described in terms of the direction from which the wind is blowing. A west wind is blowing from west to east.



2 Analysis How would you describe the wind direction behind the warm and cold fronts shown on the map?

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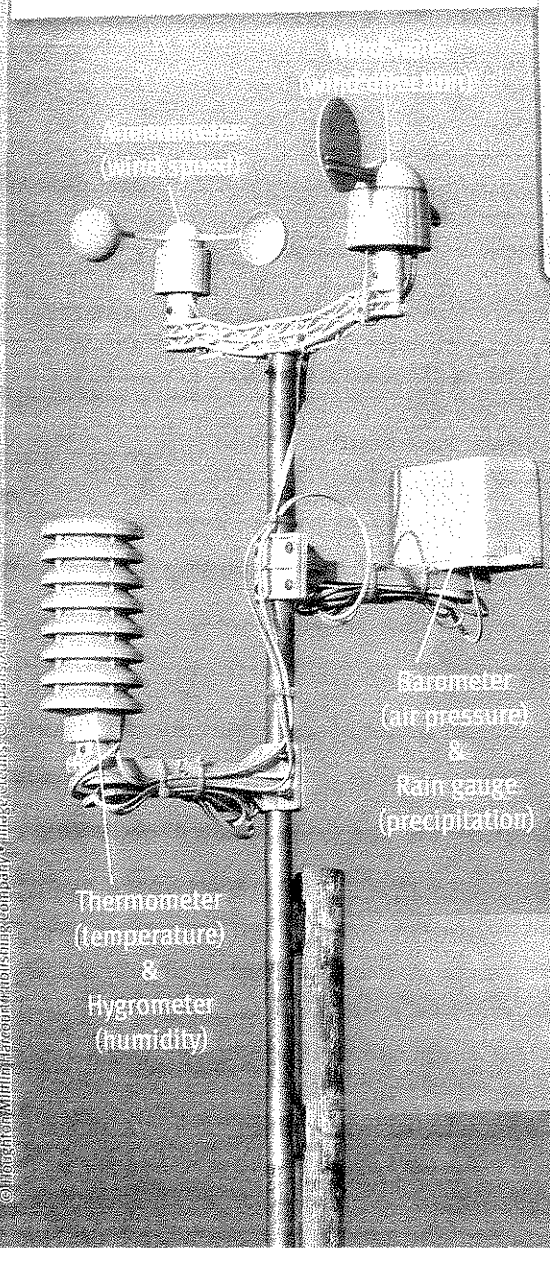


Weather instruments constantly measure conditions in the atmosphere and deliver data.

You Try It!

Now it's your turn to use weather data to make a forecast.

You Try It!

Now it's your turn to become part of the weather forecasting system. The table and map on these pages show some weather data for several cities in the United States. You will use those data to analyze weather and make predictions.

1 Identify Inputs

Which information in the table will you use to determine where the high and low pressure areas may be located?

City	Barometric pressure (mbar)	Wind direction	Temperature (°F)
Atlanta	1009	S	63
Chicago	1012	W	36
Cleveland	1006	S	35
Denver	1021	S	34
New York	990	S	58
Billings	1012	SW	28
Spokane	1009	SW	27
Los Angeles	1009	W	68
Dallas	1012	NW	50
Memphis	1012	NW	45
Orlando	1006	S	78
Raleigh	998	S	60

2 Identify Outputs

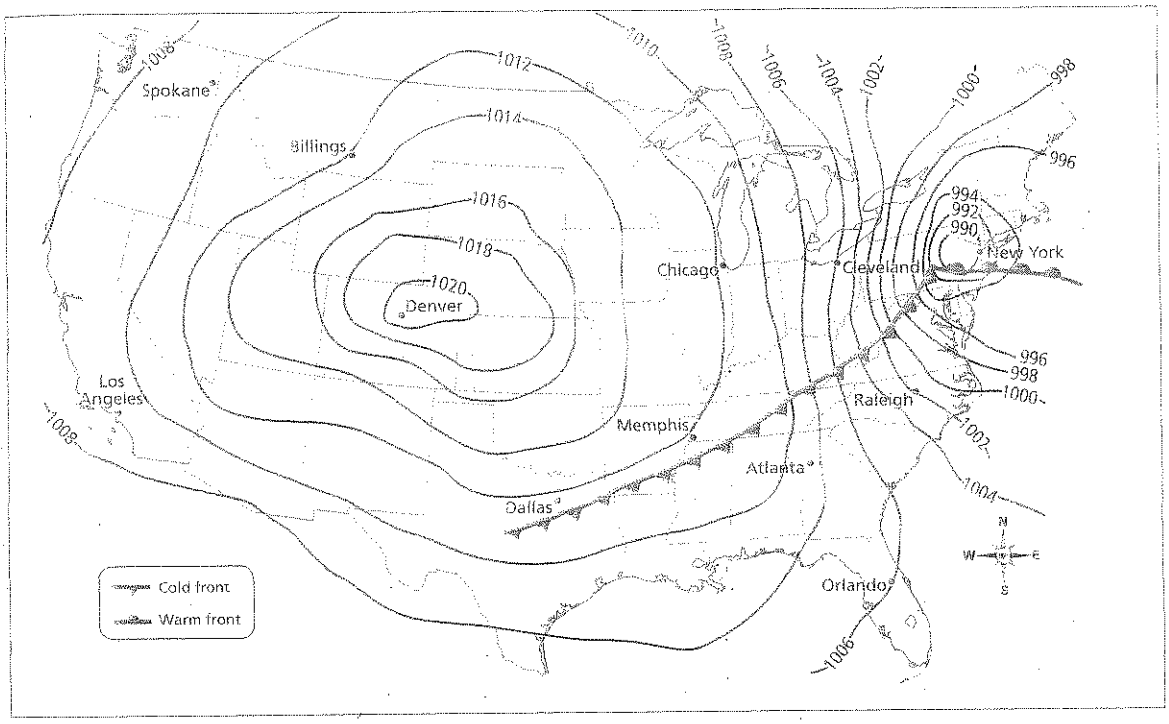
What outputs from weather stations are included on a weather map?

3 Identify System Processes

How will you process the information in the table and on the map to make predictions? Describe how you will use the inputs to develop an output.

4 Communicate Results

Use data from the table and the map to answer the questions below.



A According to the data in the table, where are the centers of the high and low pressure systems at this time? Mark them on the map using an H or an L.

B Add the temperature listed in the table for each city to the map.

C Imagine that you are a meteorologist in Atlanta and this is the current map. What temperature change would you predict over the next few hours, and why?

D What pressure change would you predict for Denver over the next few days, and why?

Water, Water

How does the water cycle affect weather?

Weather is the short-term state of the atmosphere, including temperature, humidity, precipitation, air pressure, wind, and visibility. These elements are affected by the energy received from the sun and the amount of water in the air. To understand what influences weather, then, you need to understand the water cycle.

The *water cycle* is the continuous movement of water between the atmosphere, the land, the oceans, and living things. In the water cycle, shown to the right, water is constantly being recycled between liquid, solid, and gaseous states. The water cycle involves the processes of evaporation, condensation, and precipitation.

Evaporation occurs when liquid water changes into water vapor, which is a gas. Condensation occurs when water vapor cools and changes from a gas to a liquid. A change in the amount of water vapor in the air affects humidity. Clouds and fog form through condensation of water vapor, so condensation also affects visibility. Precipitation occurs when rain, snow, sleet, or hail falls from the clouds onto Earth's surface.

Active Reading

5 **List** Name at least 5 elements of weather.

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Visualize It!

6 **Summarize** Describe how the water cycle influences weather by completing the sentences on the picture.

Ⓐ Evaporation affects weather by _____

_____

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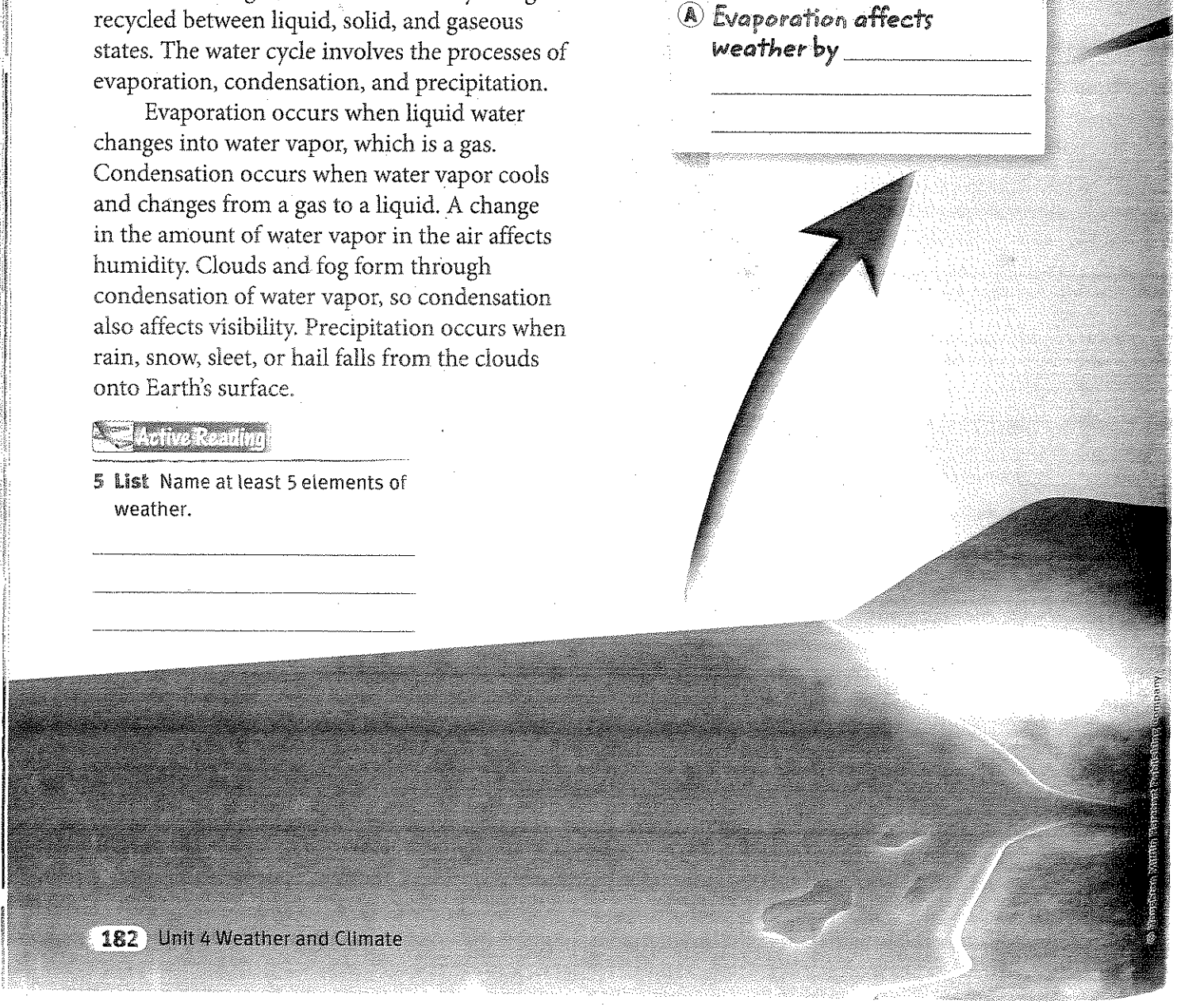

Everywhere . . .

Ⓑ Condensation affects weather by _____

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Ⓒ Precipitation affects weather by _____

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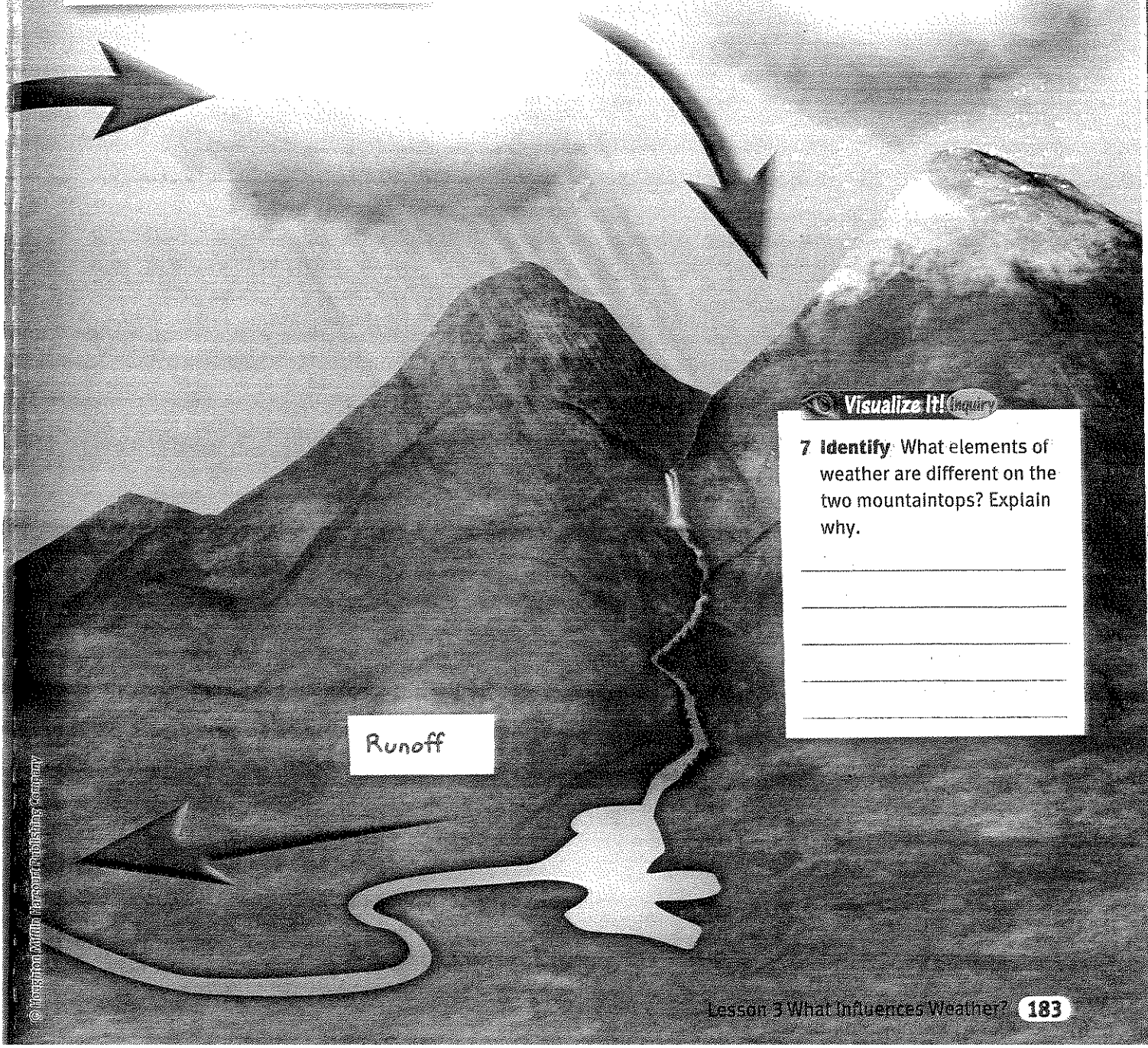

Visualize It! (Inquiry)

7 **Identify** What elements of weather are different on the two mountaintops? Explain why.

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How do air masses affect weather?

Active Reading

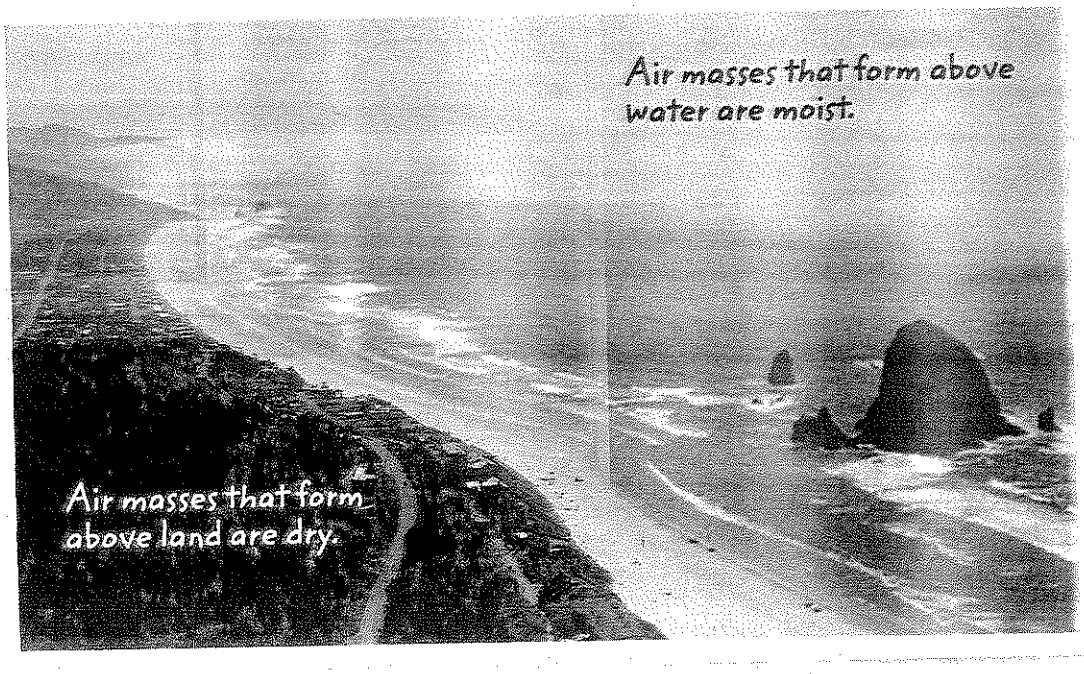
8 Identify As you read, underline how air masses form.

You have probably experienced the effects of air masses—one day is hot and humid, and the next day is cool and pleasant. The weather changes when a new air mass moves into your area. An **air mass** is a large volume of air in which temperature and moisture content are nearly the same throughout. An air mass forms when the air over a large region of Earth stays in one area for many days. The air gradually takes on the temperature and humidity of the land or water below it. When an air mass moves, it can bring these characteristics to new locations. Air masses can change temperature and humidity as they move to a new area.

Where do fronts form?

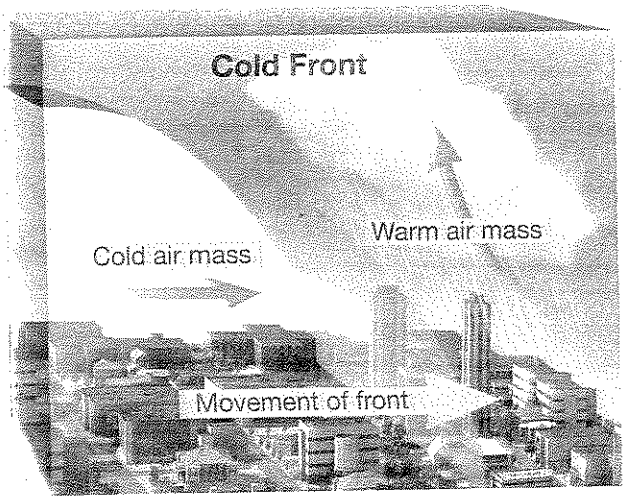
When two air masses meet, density differences usually keep them from mixing. A cool air mass is more dense than a warm air mass. A boundary, called a **front**, forms between the air masses. For a front to form, one air mass must run into another air mass. The kind of front that forms depends on how these air masses move relative to each other, and on their relative temperature and moisture content. Fronts result in a change in weather as they pass. They usually affect weather in the middle latitudes of Earth. Fronts do not often occur near the equator because air masses there do not have big temperature differences.

The boundary between air masses, or front, cannot be seen, but is shown here to illustrate how air masses can take on the characteristics of the surface below them.



Cold Fronts Form Where Cold Air Moves under Warm Air

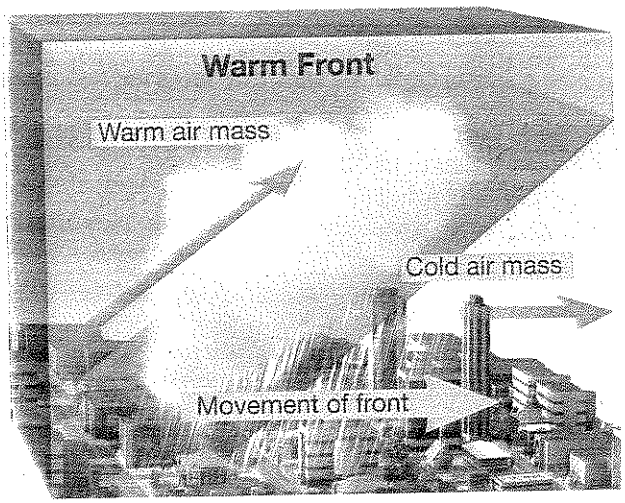
Warm air is less dense than cold air is. So, a cold air mass that is moving can quickly push up a warm air mass. If the warm air is moist, clouds will form. Storms that form along a cold front are usually short-lived but can move quickly and bring heavy rain or snow. Cooler weather follows a cold front.



9 **Apply** If you hear that a cold front is headed for your area, what type of weather might you expect?

Warm Fronts Form Where Warm Air Moves over Cold Air

A warm front forms when a warm air mass follows a retreating cold air mass. The warm air rises over the cold air, and its moisture condenses into clouds. Warm fronts often bring drizzly rain and are followed by warm, clear weather.

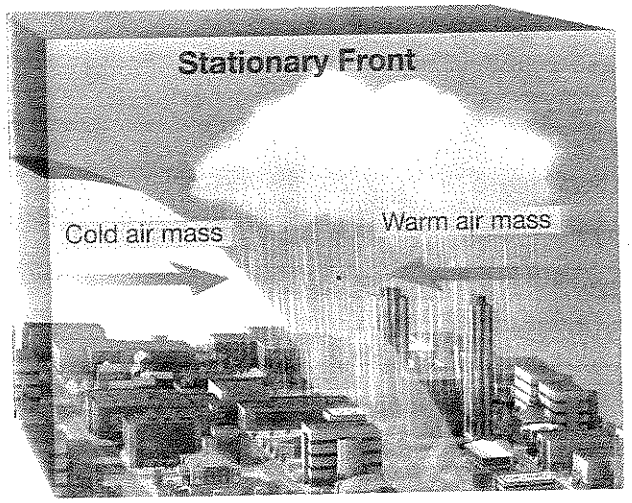


10 **Identify** The rainy weather at the edge of a warm front is a result of

- ☐ the cold air mass that is leaving.
- ☐ the warm air rising over the cold air.
- ☐ the warm air mass following the front.

Stationary Fronts Form Where Cold and Warm Air Stop Moving

In a stationary front, there is not enough wind for either the cold air mass or the warm air mass to keep moving. So, the two air masses remain in one place. A stationary front can cause many days of unchanging weather, usually clear.



11 **Infer** When could a stationary front become a warm or cold front? *Inquiry*

What are pressure systems, and how do they interact?

Areas of different air pressure cause changes in the weather. In a *high-pressure system*, air sinks slowly down. As the air nears the ground, it spreads out toward areas of lower pressure. Most high-pressure systems are large and change slowly. When a high-pressure system stays in one location for a long time, an air mass may form. The air mass can be warm or cold, humid or dry.

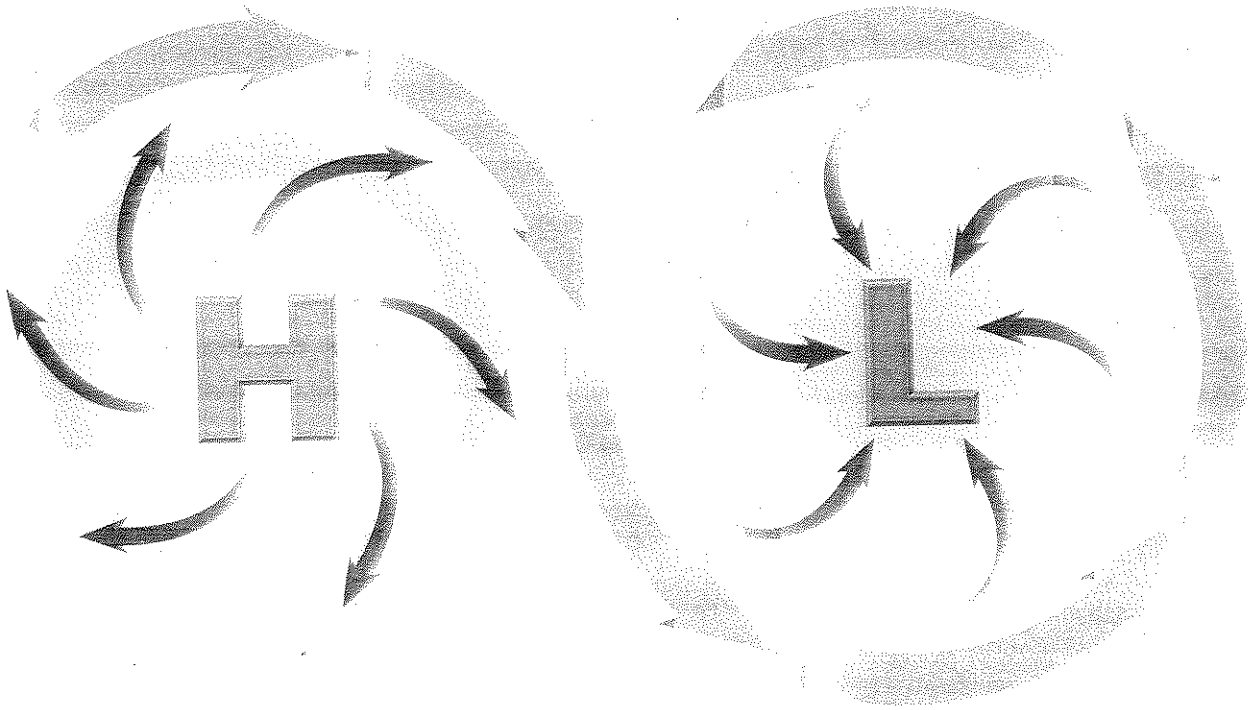
In a *low-pressure system*, air rises and so has a lower air pressure than the areas around it. As the air in the center of a low-pressure system rises, the air cools.

The diagram below shows how a high-pressure system can form a low-pressure system. Surface air, shown by the black arrows, moves out and away from high-pressure centers. Air above the surface sinks and warms. The green arrows show how air swirls from a high-pressure system into a low-pressure system. In a low-pressure system, the air rises and cools.

Visualize It!

12 Identify Choose the correct answer for each of the pressure systems shown below.

A high-pressure system can spiral into a low-pressure system, as illustrated by the green arrows below. In the Northern Hemisphere, air circles in the directions shown.



(A) In a high-pressure system, air

- ☐ rises and cools.
- ☐ sinks and warms.

(B) In a low-pressure system, air

- ☐ rises and cools.
- ☐ sinks and warms.

Windy Weather

How do global wind patterns affect local weather?

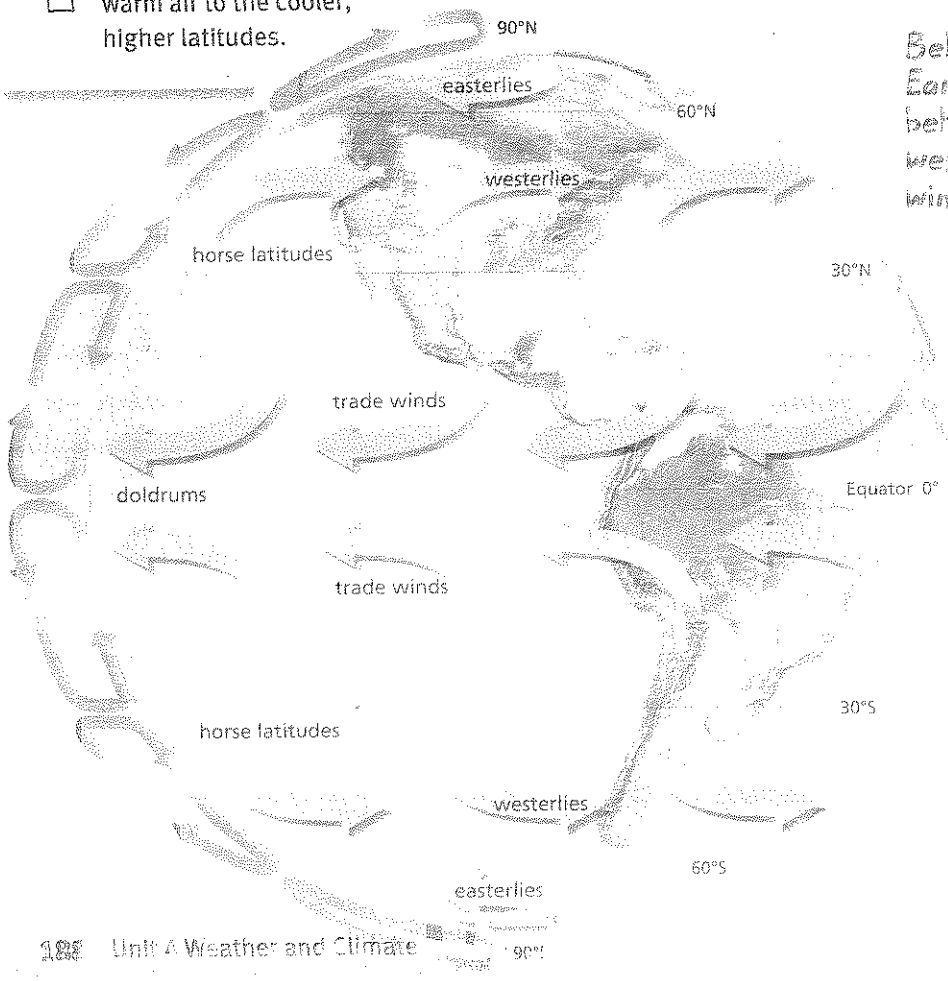
Winds are caused by unequal heating of Earth's surface—which causes air pressure differences—and can occur on a global or on a local scale. On a local scale, air-pressure differences affect both wind speed and wind direction at a location. On a global level, there is an overall movement of surface air from the poles toward the equator. The heated air at the equator rises and forms a low-pressure belt. Cold air near the poles sinks and creates high-pressure centers. Because air moves from areas of high pressure to areas of low pressure, it moves from the poles to the equator. At high altitudes, the warmed air circles back toward the poles.

Temperature and pressure differences on Earth's surface also create regional wind belts. Winds in these belts curve to the east or the west as they blow, due to Earth's rotation. This curving of winds is called the *Coriolis effect* (kawr•ee•OH•lis eff•EKT). Winds would flow in straight lines if Earth did not rotate. Winds bring air masses of different temperatures and moisture content to a region.

Visualize It!

14 Apply Trade winds bring

- ☐ cool air to the warmer equatorial regions.
- ☐ warm air to the cooler, higher latitudes.



Belts of global winds circle Earth. The winds in these belts curve to the east or west. Between the global wind belts are calm areas.

How do jet streams affect weather?

Long-distance winds that travel above global winds for thousands of kilometers are called **jet streams**. Air moves in jet streams with speeds that are at least 92 kilometers per hour and are often greater than 180 kilometers per hour. Like global and local winds, jet streams form because Earth's surface is heated unevenly. They flow in a wavy pattern from west to east.

Each hemisphere usually has two main jet streams, a polar jet stream and a subtropical jet stream. The polar jet streams flow closer to the poles in summer than in winter. Jet streams can affect temperatures. For example, a polar jet stream can pull cold air down from Canada into the United States and pull warm air up toward Canada. Jet streams also affect precipitation patterns. Strong storms tend to form along jet streams. Scientists must know where a jet stream is flowing to make accurate weather predictions.

Active Reading **15 Identify** What are two ways jet streams affect weather?

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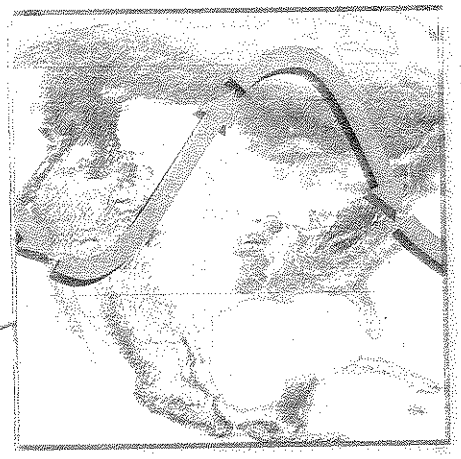
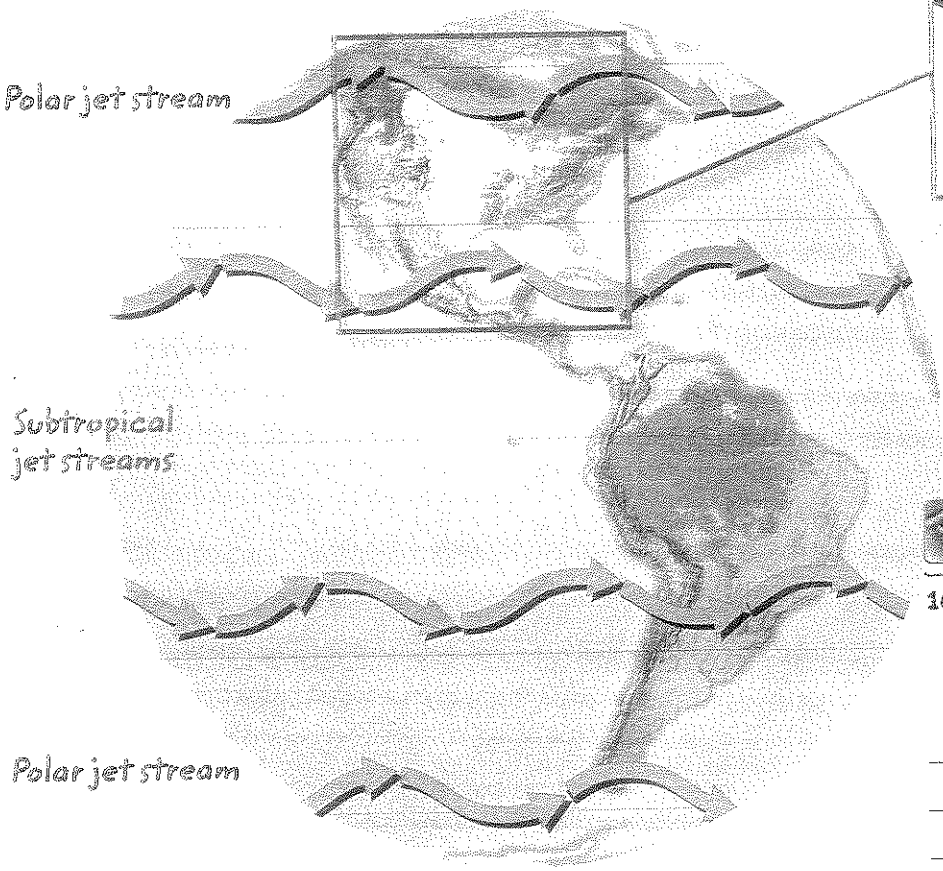
In winter months, the polar jet stream flows across much of the United States.





Visualize It!

16 Infer How does the polar jet stream influence the weather on the southern tip of South America?

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Ocean Effects

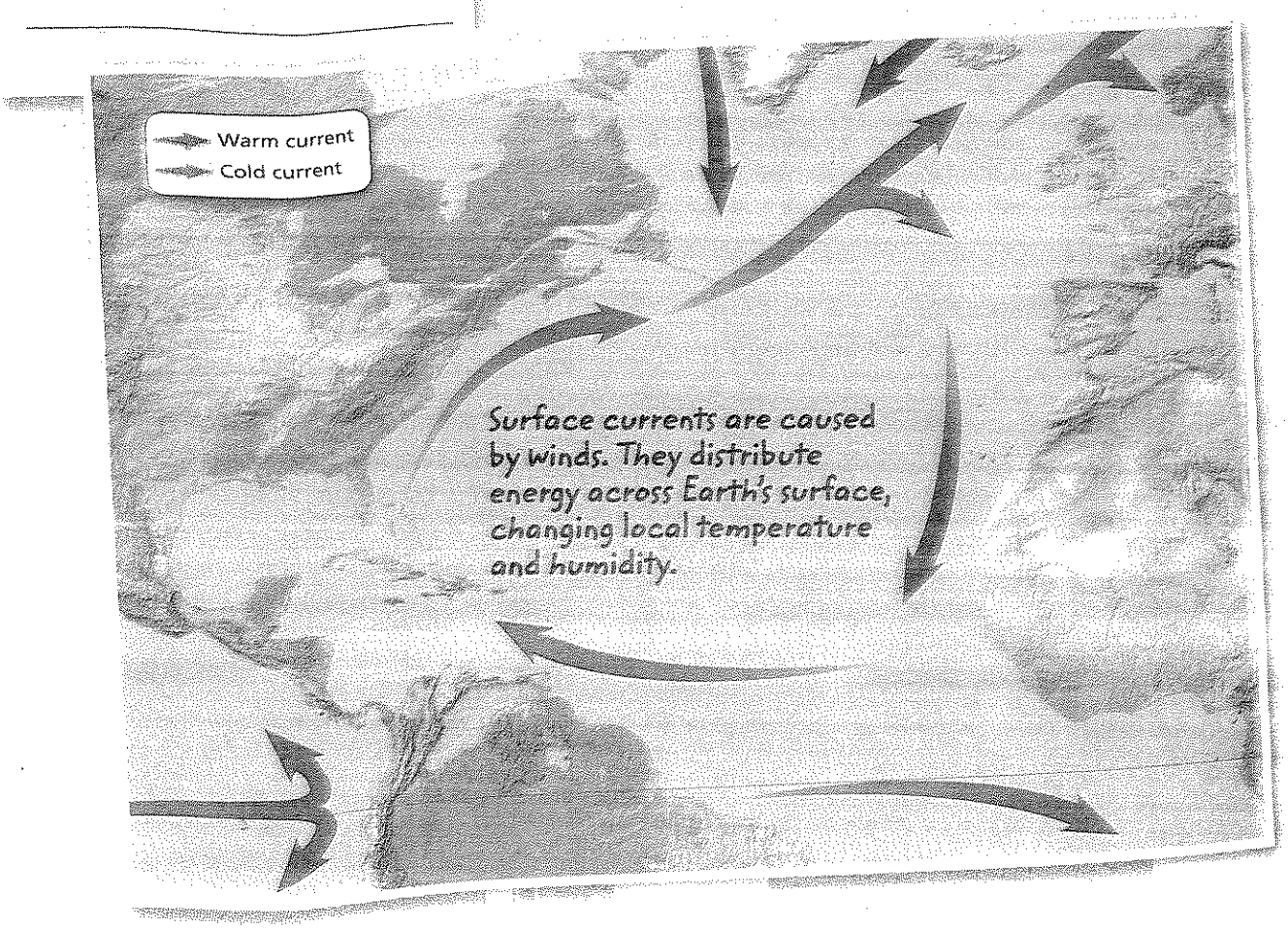
How do ocean currents influence weather?

The same global winds that blow across the surface of Earth also push water across Earth's oceans, causing surface currents. Different winds cause currents to flow in different directions. The flow of surface currents moves energy as heat from one part of Earth to another. As the map below shows, both warm-water and cold-water currents flow from one ocean to another. Water near the equator carries energy from the sun to other parts of the ocean. The energy from the warm currents is transferred to colder water or to the atmosphere, changing local temperatures and humidity.

Oceans also have an effect on weather in the form of hurricanes and monsoons. Warm ocean water fuels hurricanes. Monsoons are winds that change direction with the seasons. During summer, the land becomes much warmer than the sea in some areas of the world. Moist wind flows inland, often bringing heavy rains.

Visualize It!

17 Summarize Describe how ocean currents help make temperatures at different places on Earth's surface more similar than they would be if there were no currents.



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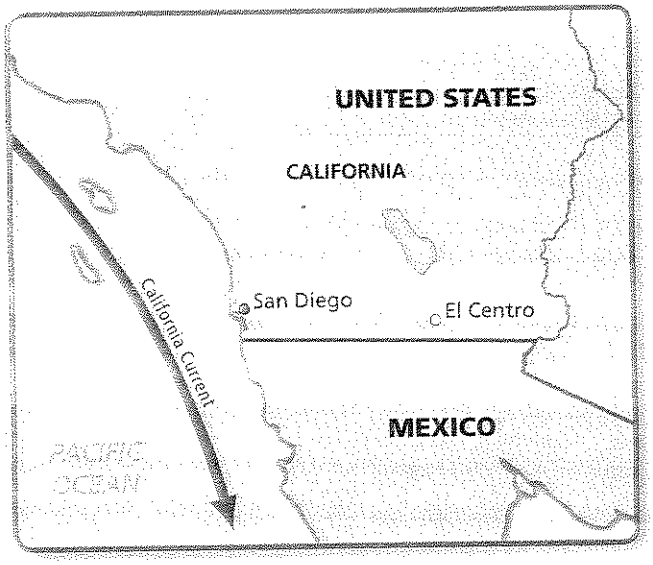
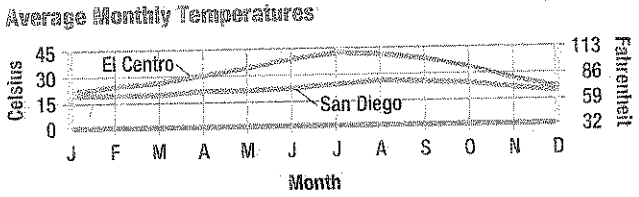
As currents flow, they warm or cool the atmosphere above, affecting local temperatures. The California current is a cold-water current that keeps the average summer high temperatures of coastal cities such as San Diego around 26 °C (78 °F). Cities that lie inland at the same latitude have warmer averages. The graph below shows average monthly temperatures for San Diego and El Centro, California.

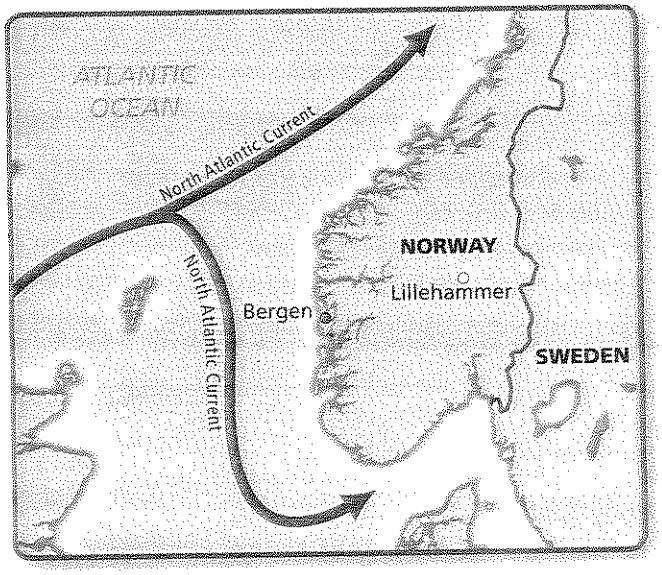


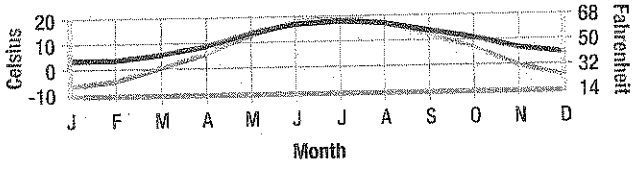
Visualize It!

18 Explain Why are temperatures in San Diego, California, usually cooler than they are in El Centro, California?



Source: weather.com





Source: worldweather.org

Warm Ocean Currents Raise Coastal Air Temperatures

In areas where warm ocean currents flow, coastal cities have warmer winter temperatures than inland cities at similar latitudes. For example, temperatures vary considerably from the coastal regions to the inland areas of Norway due to the warmth of the North Atlantic Current. Coastal cities such as Bergen have relatively mild winters. Inland cities such as Lillehammer have colder winters but temperatures similar to the coastal cities in summer.

Visualize It!

19 Identify Circle the city that is represented by each color in the graph.

Lillehammer/Bergen

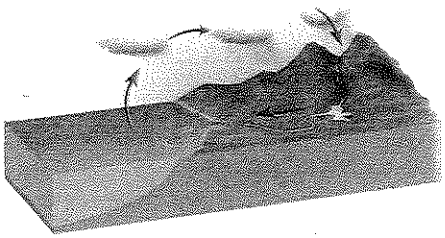
Lillehammer/Bergen

Visual Summary

To complete this summary, circle the correct word. Then, use the key below to check your answers. You can use this page to review the main concepts of the lesson.

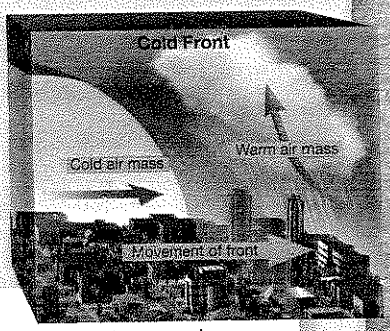
Influences of Weather

Understanding the water cycle is key to understanding weather.



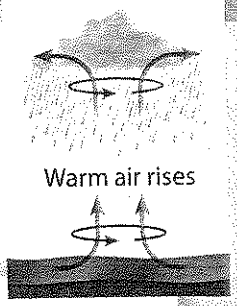
20 Weather is affected by the amount of oxygen / water in the air.

A front forms where two air masses meet.



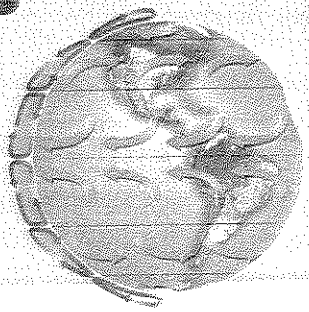
21 When a warm air mass and a cool air mass meet, the warm / cool air mass usually moves upward.

Low-pressure systems bring stormy weather, and high-pressure systems bring dry, clear weather.



22 In a low-pressure system, air moves upward / downward.

Pressure differences from the uneven heating of Earth's surface cause predictable patterns of wind.



23 Global wind patterns occur as, due to temperature differences, air rises / sinks at the poles and rises / sinks at the equator.

Global ocean surface currents can have warming or cooling effects on the air masses above them.

24 Warm currents have a warming / cooling effect on the air masses above them.

Answers: 20 water; 21 warm; 22 upward; 23 sinks; rises; 24 warming

25 **Synthesize** How do air masses cause weather changes?

Lesson Review

Vocabulary

For each pair of terms, explain how the meanings of the terms differ.

1 *front* and *air mass*

2 *high-pressure system* and *low-pressure system*

3 *jet streams* and *global wind belts*

Key Concepts

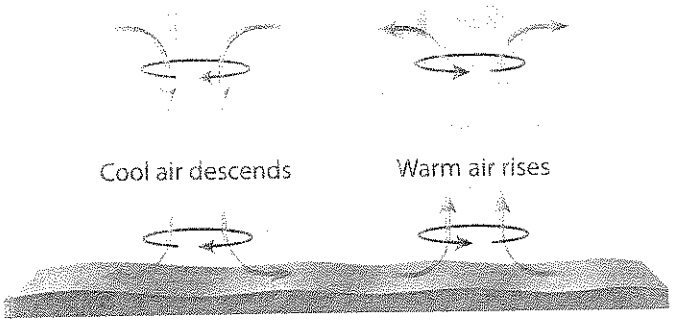
4 **Apply** If the weather becomes stormy for a short time and then becomes colder, which type of front has most likely passed?

5 **Describe** Explain how an ocean current can affect the temperature and the amount of moisture of the air mass above the current and above nearby coastlines.

6 **Synthesize** How does the water cycle affect weather?

Critical Thinking

Use the diagram below to answer the following question.



7 **Interpret** How does the movement of air affect the type of weather that forms from high-pressure and low-pressure systems?

8 **Explain** How does the polar jet stream affect temperature and precipitation in North America?

9 **Describe** Explain how changes in weather are caused by the interaction of air masses.