

# Winds

## Reading Preview

### Key Concepts

- What causes winds?
- How do local winds and global winds differ?
- Where are the major global wind belts located?

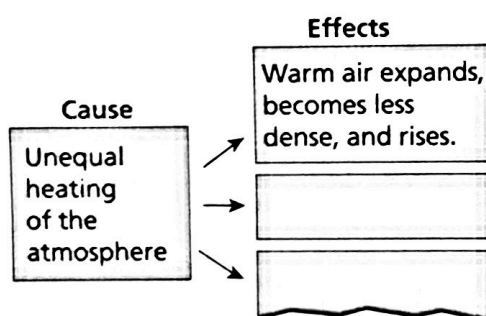
### Key Terms

- wind • anemometer
- wind-chill factor • local winds
- sea breeze • land breeze
- global winds • Coriolis effect
- latitude • jet stream



## Target Reading Skill

**Relating Cause and Effect** As you read, identify how the unequal heating of the atmosphere causes the air to move. Write the information in a graphic organizer like the one below.



A kite festival in Capetown, South Africa ►

Lab zone

## Discover Activity

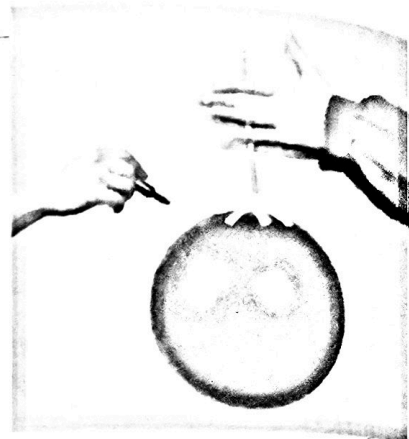
### Does the Wind Turn?

Do this activity with a partner. Let the ball represent a model of Earth and the marker represent wind.

1. Using heavy-duty tape, attach a pencil to a large smooth ball so that you can spin the ball from the top without touching it.
2. One partner should hold the pencil. Slowly turn the ball counterclockwise when seen from above.
3. While the ball is turning, the second partner should use a marker to try to draw a straight line from the "North Pole" to the "equator" of the ball. What shape does the line form?

### Think It Over

**Making Models** If cold air were moving south from Canada into the continental United States, how would its movement be affected by Earth's rotation?



Have you ever flown a kite? Start by unwinding a few meters of string with the kite downwind from you. Have a friend hold the kite high overhead. Then, as your friend releases the kite, run directly into the wind. If you're lucky, the kite will start to rise. Once the kite is stable, you can unwind your string to let the wind lift the kite high into the sky. But what exactly is the wind that lifts the kite, and what causes it to blow?



# What Is Wind?

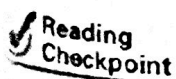
Because air is a fluid, it can move easily from place to place. Differences in air pressure cause the air to move. A **wind** is the horizontal movement of air from an area of high pressure to an area of lower pressure. **Winds are caused by differences in air pressure.**

Most differences in air pressure are caused by the unequal heating of the atmosphere. Convection currents form when an area of Earth's surface is heated by the sun's rays. Air over the heated surface expands and becomes less dense. As the air becomes less dense, its air pressure decreases. If a nearby area is not heated as much, the air above the less-heated area will be cooler and denser. The cool, dense air with a higher pressure flows underneath the warm, less dense air. This forces the warm air to rise.

**Measuring Wind** Winds are described by their direction and speed. Wind direction is determined with a wind vane. The wind swings the wind vane so that one end points into the wind. The name of a wind tells you where the wind is coming from. For example, a south wind blows from the south toward the north. A north wind blows to the south.

Wind speed can be measured with an **anemometer** (an uh MAHM uh tur). An anemometer has three or four cups mounted at the ends of spokes that spin on an axle. The force of the wind against the cups turns the axle. A meter on the axle shows the wind speed.

**Wind-Chill Factor** On a warm day, a cool breeze can be refreshing. But during the winter, the same breeze can make you feel uncomfortably cold. The wind blowing over your skin removes body heat. The stronger the wind, the colder you feel. The increased cooling a wind can cause is called the **wind-chill factor**. Thus a weather report may say, "The temperature outside is 20 degrees Fahrenheit. But with a wind speed of 30 miles per hour, the wind-chill factor makes it feel like 1 degree above zero."



Toward what direction does a west wind blow?

FIGURE 6

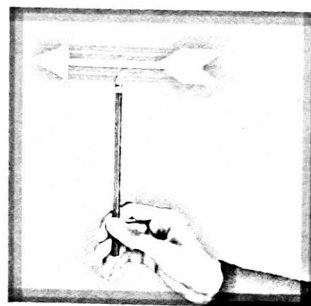
## Wind Direction and Speed

The wind vane on the left points in the direction the wind is blowing from. The anemometer on the right measures wind speed. The cups catch the wind, turning faster when the wind blows faster.

## Lab zone Try This Activity

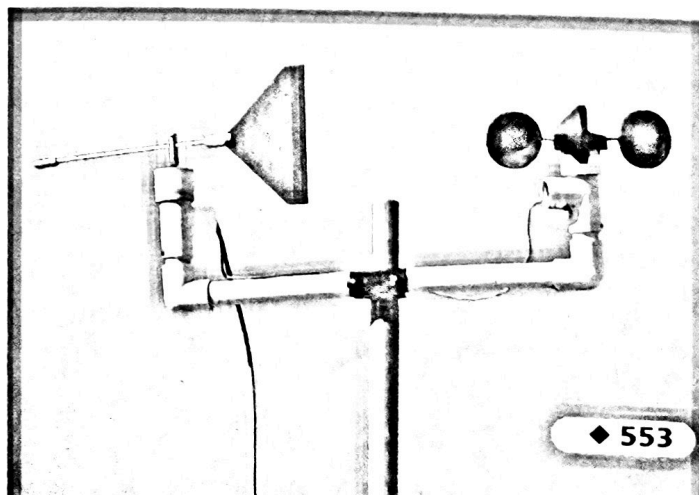
### Build a Wind Vane

1. Use scissors to cut out a pointer and a slightly larger tail fin from construction paper.
2. Make a slit 1 cm deep in each end of a soda straw.
3. Slide the pointer and tail fin into place on the straw, securing them with small pieces of tape.



4. Hold the straw on your finger to find the point at which it balances.
5. Carefully push a pin through the balance point and into the eraser of a pencil. Make sure the wind vane can spin freely.

**Observing** How can you use your wind vane to tell the direction of the wind?



## Local Winds

Have you ever noticed a breeze at the beach on a hot summer day? Even if there is no wind inland, there may be a cool breeze blowing in from the water. This breeze is an example of a local wind. **Local winds** are winds that blow over short distances. **Local winds are caused by the unequal heating of Earth's surface within a small area.** Local winds form only when large-scale winds are weak.

**Sea Breeze** Unequal heating often occurs along the shore of a large body of water. It takes more energy to warm up a body of water than it does to warm up an equal area of land. As the sun heats Earth's surface during the day, the land warms up faster than the water. As a result, the air over the land becomes warmer than the air over the water. The warm air expands and rises, creating a low-pressure area. Cool air blows inland from over the water and moves underneath the warm air, causing a sea breeze. A **sea breeze** or a **lake breeze** is a local wind that blows from an ocean or lake. Figure 7 shows a sea breeze.

**Land Breeze** At night, the process is reversed. Land cools more quickly than water, so the air over the land becomes cooler than the air over the water. As the warmer air over the water expands and rises, cooler air from the land moves beneath it. The flow of air from land to a body of water is called a **land breeze**.

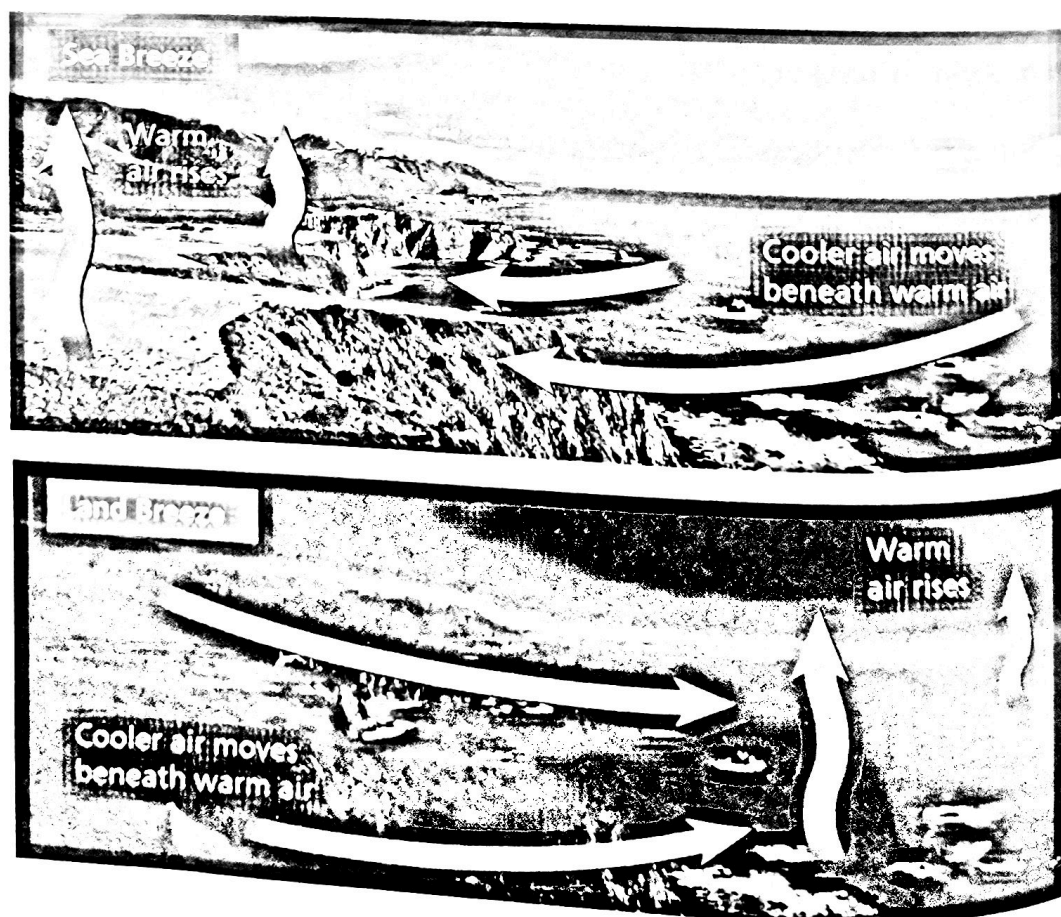


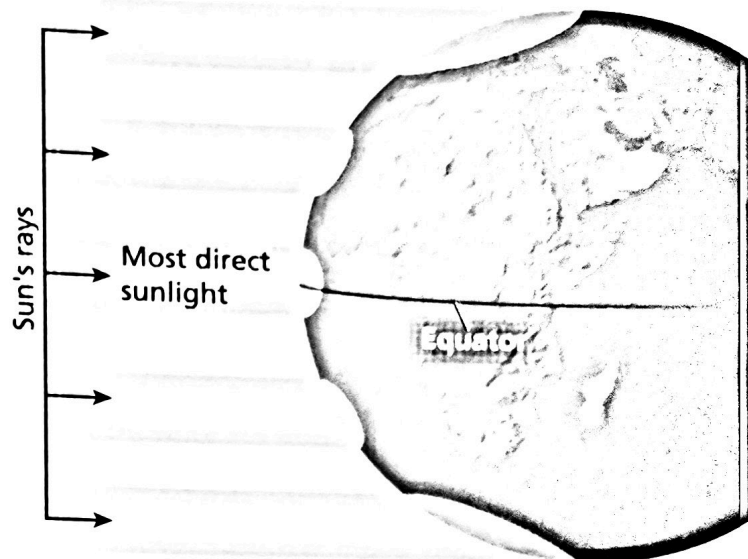
FIGURE 7

### Local Winds

During the day, cool air moves from the sea to the land, creating a sea breeze. At night, cooler air moves from the land to the sea. **Forming Operational Definitions** What type of breeze occurs at night?

## Global Winds

Global winds are winds that blow steadily from specific directions over long distances. Like local winds, global winds are created by the unequal heating of Earth's surface. But unlike local winds, global winds occur over a large area. Recall how the sun's radiation strikes Earth. In the middle of the day near the equator, the sun is almost directly overhead. The direct rays from the sun heat Earth's surface intensely. Near the poles, the sun's rays strike Earth's surface at a lower angle. The sun's energy is spread out over a larger area, so it heats the surface less. As a result, temperatures near the poles are much lower than they are near the equator.



**Global Convection Currents** How do global winds develop? Temperature differences between the equator and the poles produce giant convection currents in the atmosphere. Warm air rises at the equator, and cold air sinks at the poles. Therefore air pressure tends to be lower near the equator and greater near the poles. This difference in pressure causes winds at Earth's surface to blow from the poles toward the equator. Higher in the atmosphere, however, air flows away from the equator toward the poles. Those air movements produce global winds.

FIGURE 8

### Angle of Sun's Rays

Near the equator, energy from the sun strikes Earth almost directly. Near the poles, the same amount of energy is spread out over a larger area.

**The Coriolis Effect** If Earth did not rotate, global winds would blow in a straight line from the poles toward the equator. Because Earth is rotating, however, global winds do not follow a straight path. As the winds blow, Earth rotates from west to east underneath them, making it seem as if the winds have curved. The way Earth's rotation makes winds curve is called the **Coriolis effect** (kawr ee OH lis).

Because of the Coriolis effect, global winds in the Northern Hemisphere gradually turn toward the right. As Figure 9 shows, a wind blowing toward the south gradually turns toward the southwest. In the Southern Hemisphere, winds curve toward the left.

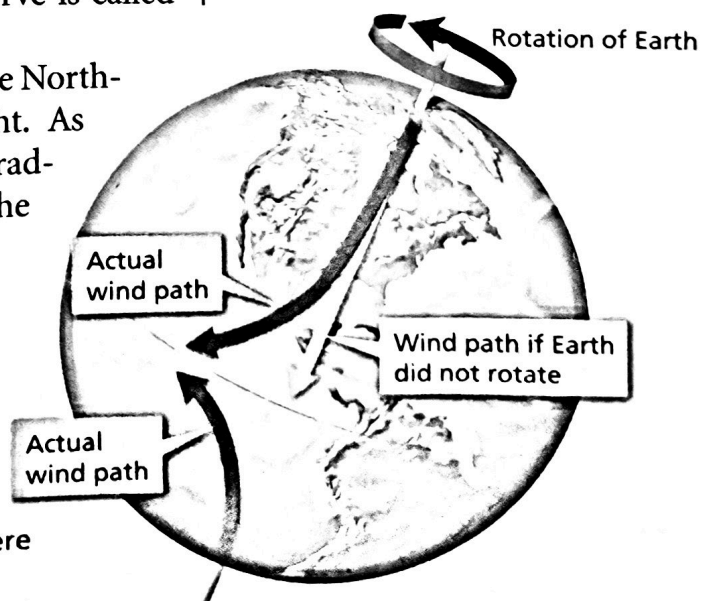


**Which way do winds turn in the Southern Hemisphere?**

FIGURE 9

### Coriolis Effect

As Earth rotates, the Coriolis effect turns winds in the Northern Hemisphere toward the right.

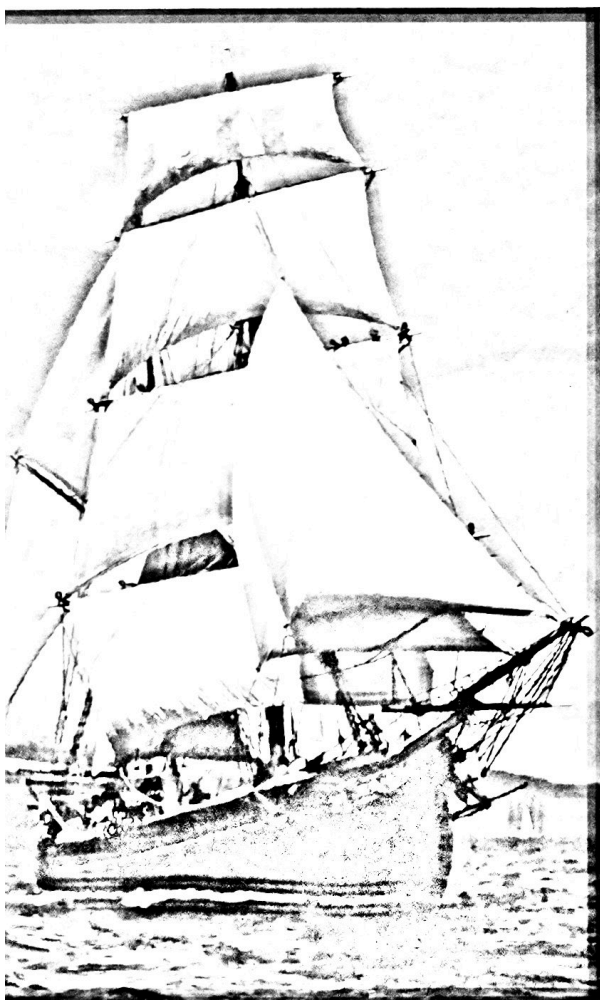




**FIGURE 10**

**Ocean Sailing**

Sailing ships relied on global winds to speed their journeys to various ports around the world. Applying Concepts *How much effect do you think the prevailing winds have on shipping today?*



## Global Wind Belts

The Coriolis effect and other factors combine to produce a pattern of calm areas and wind belts around Earth, as shown in Figure 11. The calm areas include the doldrums and the horse latitudes. The major global wind belts are the trade winds, the polar easterlies, and the prevailing westerlies.

**Doldrums** Near the equator, the sun heats the surface strongly. Warm air rises steadily, creating an area of low pressure. Cool air moves into the area, but is warmed rapidly and rises before it moves very far. There is very little horizontal motion, so the winds near the equator are very weak. Regions near the equator with little or no wind are called the doldrums.

**Horse Latitudes** Warm air that rises at the equator divides and flows both north and south. **Latitude** is distance from the equator, measured in degrees. At about 30° north and south latitudes, the air stops moving toward the poles and sinks. In each of these regions, another belt of calm air forms. Hundreds of years ago, sailors becalmed in these waters ran out of food and water for their horses and had to throw the horses overboard. Because of this, the latitudes 30° north and south of the equator came to be called the horse latitudes.

**Trade Winds** When the cold air over the horse latitudes sinks, it produces a region of high pressure. This high pressure causes surface winds to blow both toward the equator and away from it. The winds that blow toward the equator are turned west by the Coriolis effect. As a result, winds in the Northern Hemisphere between 30° north latitude and the equator generally blow from the northeast. In the Southern Hemisphere between 30° south latitude and the equator, the winds blow from the southeast. For hundreds of years, sailors relied on these winds to move ships carrying valuable cargoes from Europe to the West Indies and South America. As a result, these steady easterly winds are called the trade winds.

**Prevailing Westerlies** In the mid-latitudes, between 30° and 60° north and south, winds that blow toward the poles are turned toward the east by the Coriolis effect. Because they blow from the west to the east, they are called prevailing westerlies. The prevailing westerlies blow generally from the southwest in north latitudes and from the northwest in south latitudes. The prevailing westerlies play an important part in the weather of the United States.

FIGURE 11

## Global Winds

A series of wind belts circles Earth. Between the wind belts are calm areas where air is rising or falling. Interpreting Diagrams Which global wind belt would a sailor choose to sail from eastern Canada to Europe?

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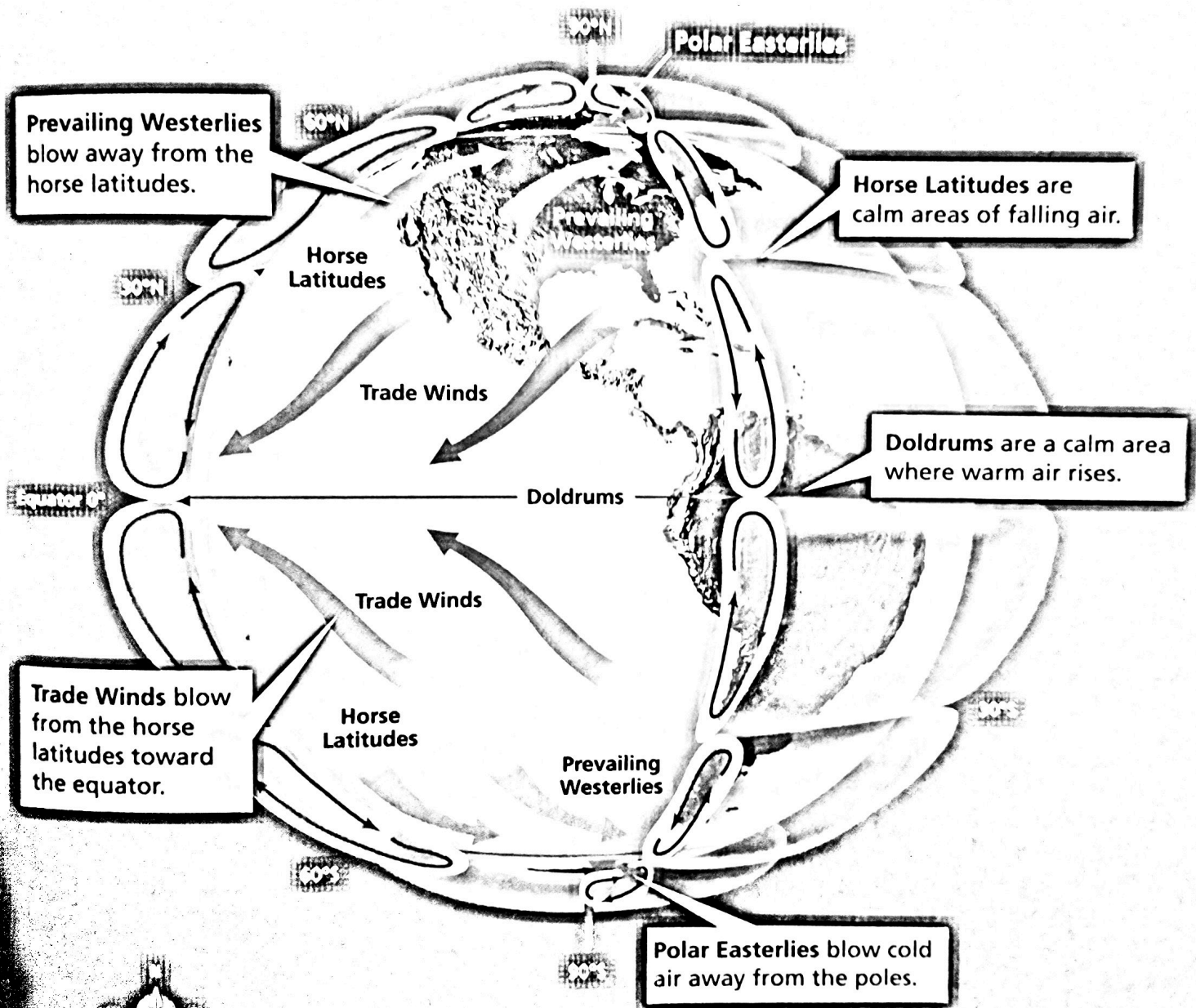
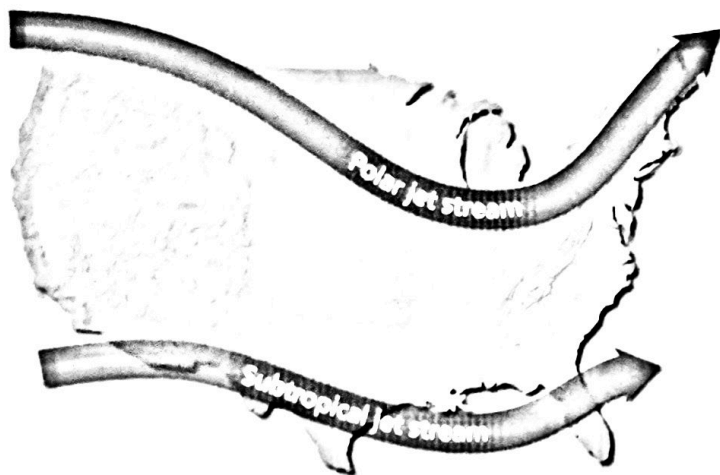


FIGURE 12

### Jet Streams

The jet streams are high-speed bands of winds occurring at the top of the troposphere. By traveling east in a jet stream, pilots can save time and fuel.



**Polar Easterlies** Cold air near the poles sinks and flows back toward lower latitudes. The Coriolis effect shifts these polar winds to the west, producing the polar easterlies. The polar easterlies meet the prevailing westerlies at about 60° north and 60° south latitudes, along a region called the polar front. The mixing of warm and cold air along the polar front has a major effect on weather in the United States.

**Jet Streams** About 10 kilometers above Earth's surface are bands of high-speed winds called **jet streams**. These winds are hundreds of kilometers wide but only a few kilometers deep. Jet streams generally blow from west to east at speeds of 200 to 400 kilometers per hour, as shown in Figure 12. As jet streams travel around Earth, they wander north and south along a wavy path.



What are the jet streams?

## Section 3 Assessment

### Target Reading Skill

**Relating Cause and Effect** Refer to your graphic organizer about the effects of unequal heating to help you answer Question 1 below.

#### Reviewing Key Concepts

1.
  - a. **Defining** What is wind?
  - b. **Relating Cause and Effect** How is wind related to air temperature and air pressure?
  - c. **Applying Concepts** It's fairly warm but windy outside. Use the concept of wind-chill factor to explain why it may be a good idea to wear a jacket.
2.
  - a. **Defining** What are local winds?
  - b. **Summarizing** What causes local winds?
  - c. **Comparing and Contrasting** Compare the conditions that cause a sea breeze with those that cause a land breeze.
3.
  - a. **Identifying** Name the three major global wind belts.
  - b. **Describing** Briefly describe the three major global wind belts and where they are located.
  - c. **Interpreting Diagrams** Use Figure 9 and Figure 11 to describe how the Coriolis effect influences the direction of the trade winds in the Northern Hemisphere. Does it have the same effect in the Southern Hemisphere? Explain.

### Writing in Science

**Explanation** Imagine that you are a hot-air balloonist. You want to fly your balloon across the continental United States. To achieve the fastest time, would it make more sense to fly east-to-west or west-to-east? Explain how the prevailing winds influenced your decision.