Guide for Reading

Focus on this question as you read.

- *What is the origin and movement of local winds and global winds?*

ACTIVITY

DISCOVERING

The Density of Water

Is cold water denser than hot water? Try this activity to find out.

1. Fill a deep pan three-fourths full of cold water.

2. Fill a small bottle with hot (not boiling) water. Add a few drops of food coloring to the hot water.

3. Hold your finger over the opening of the bottle. Carefully place the bottle on its side in the pan of cold water. Make sure the bottle is completely under water.

4. Take your finger away from the opening of the bottle. Observe what happens.

What happened when you removed your finger? What does this tell you about the density of hot water and cold water?

- What do you think would happen if you put hot water in the pan and cold water in the bottle? Try it and find out.

1–3 Winds

Have you ever flown a kite at the beach? A beach is a good place to fly a kite because of the winds that usually blow near the shore. What causes these winds to blow? When air is heated, its density decreases. The warm air rises and produces an area of low pressure. Cooler, denser air, which produces an area of high pressure, moves in underneath the rising warm air. So air moves from an area of high pressure to an area of lower pressure. **Winds** are formed by this movement of air from one place to another.

There are two general types of winds: local winds and global winds. Local winds are the type you are most familiar with. They blow from any direction and usually cover short distances. Global winds blow from a specific direction and almost always cover longer distances than local winds. **Both local winds and global winds are caused by differences in air pressure due to unequal heating of the atmosphere.**

Local Winds

During the day, the air over a land area is often warmer than the air over a nearby lake or sea. The air is warmer because the land heats up faster than the water. As the warm air over the land rises, the cooler air over the sea moves inland to take its place.

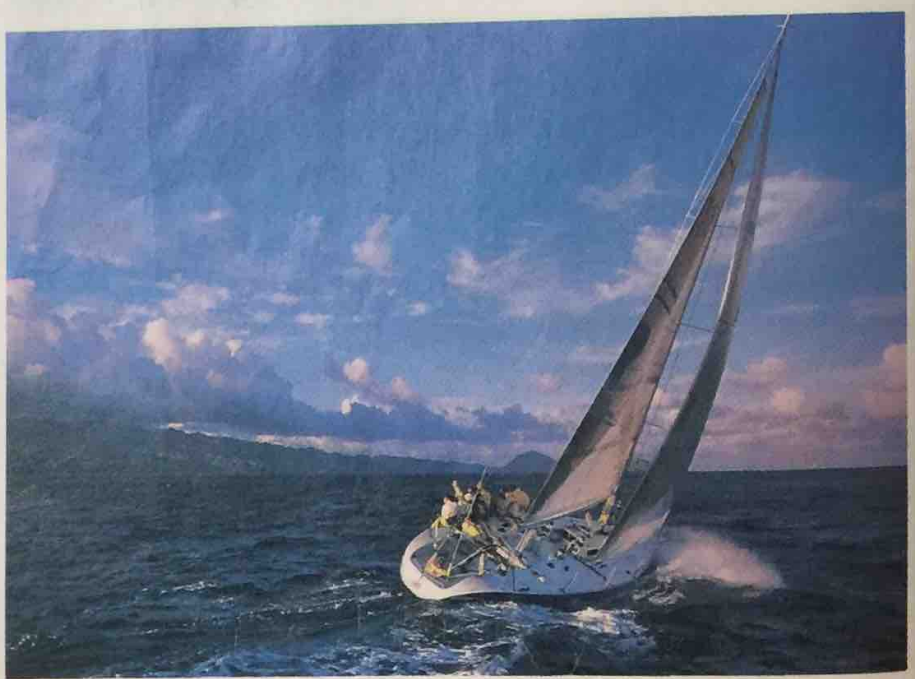


Figure 1–13 *Wind is air in motion. The force of the wind enables the crew of this racing yacht to enjoy an exciting ride.*

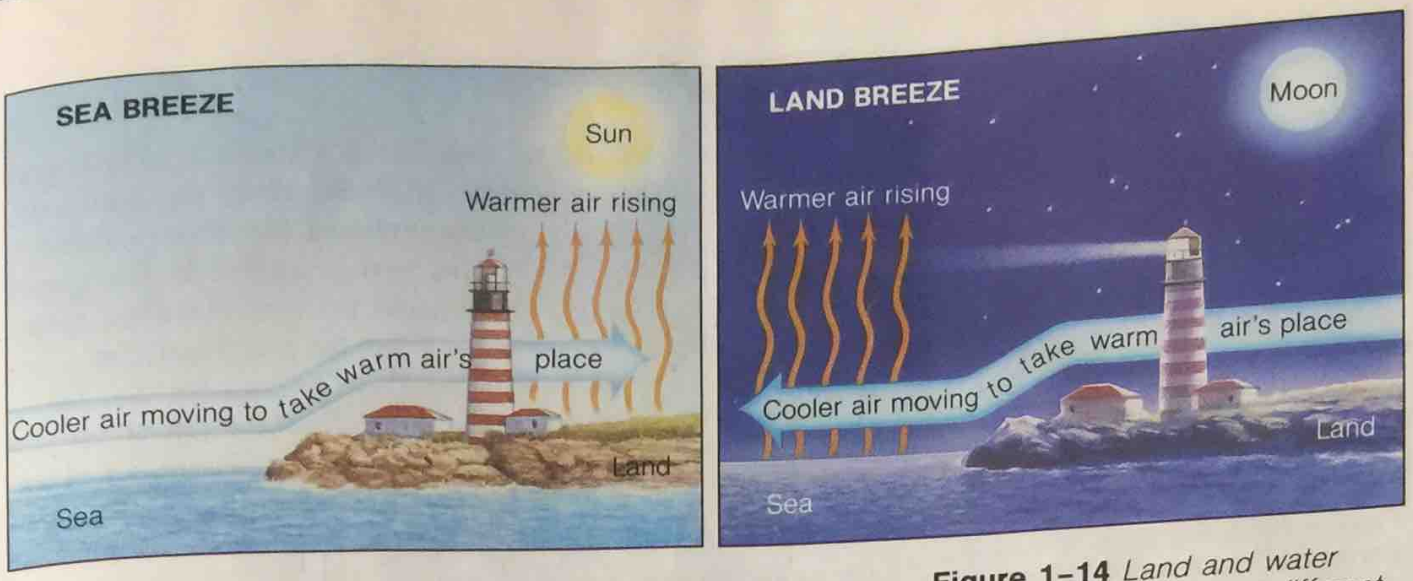


Figure 1–14 *Land and water absorb and lose heat at different rates, causing a sea breeze during the day and a land breeze during the night. Which heats up faster: land or water?*

This flow of air from the sea to the land is called a **sea breeze.** If you have ever spent a summer's day at the beach, you have probably felt a sea breeze.

During the night, the land cools off faster than the water. The air over the sea is now warmer than the air over the land. This warm air over the sea rises. The cooler air over the land moves to replace the rising warm air over the sea. A flow of air from the land to the sea, called a **land breeze,** is formed. If you have stayed at the beach after sunset, then you are probably familiar with a land breeze, too. A land breeze is also called an off-shore breeze.

The name of a wind tells you from which direction the wind is blowing. A land breeze blows from the land to the sea. A sea breeze blows from the sea to the land. Most local winds that you are familiar with are named according to the direction from which they are blowing. For example, a northwest wind blows from northwest to southeast. From what direction does a southwest wind come? In what direction is it blowing?

A major land and sea breeze is called a monsoon (mahn-SOON). A monsoon is a seasonal wind. (The word monsoon is derived from an Arabic word that means season.) During part of the year, a monsoon blows from the land to the ocean. During the rest of the year, it blows from the ocean to the land. When a monsoon blows from the ocean to the land, it brings in warm, moist air. This results in a rainy season with warm temperatures and huge amounts of rain. The rainy season is important to many countries because it supplies the water needed for farming. Monsoon winds are very common in Asia.

ACTIVITY

DISCOVERING

Heating Land and Water

Obtain the following materials: two beakers, sand, water, a thermometer, a watch or clock, and a bright light bulb (or a sunny window). Using these materials, design an experiment to answer these questions.

1. Which heats up faster: land or water?

2. Which one cools down faster?

3. Which one holds heat longer?

■ Based on the results of your experiment, explain why land and sea breezes occur.

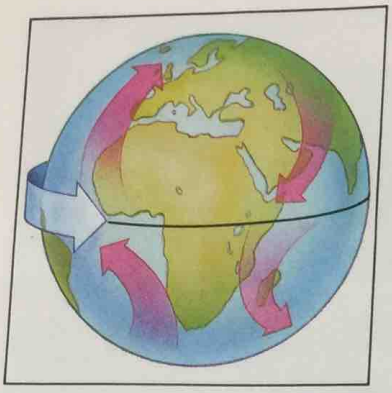


Figure 1–15 *Because of the Earth's rotation, winds appear to curve to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. What is the name for this shift in wind direction?*

Global Winds

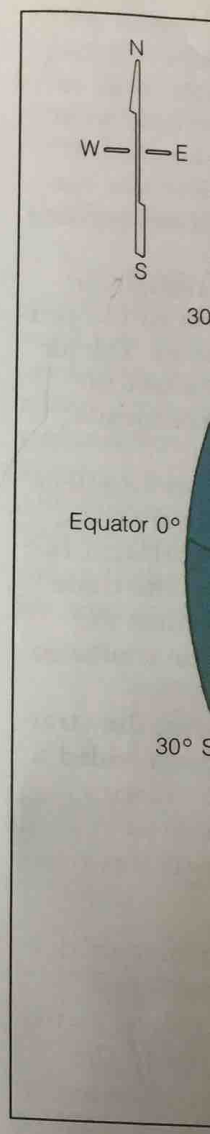
Unequal heating of the Earth's surface also forms large global wind systems. In areas near the equator, the sun is almost directly overhead for most of the year. The direct rays of the sun heat the Earth's surface rapidly. The polar regions receive slanting rays from the sun. The slanting rays do not heat the Earth's surface as rapidly as the direct rays do. So temperatures near the poles are lower than those near the equator. At the equator, the warm air rises and moves toward the poles. At the poles, the cooler air sinks and moves toward the equator. This movement produces a global pattern of air circulation.

Global winds do not move directly from north to south or from south to north as you might expect. Because the Earth rotates, or spins on its axis, from west to east, the paths of the winds shift in relation to the Earth's surface. All winds in the Northern Hemisphere curve to the right as they move. In the Southern Hemisphere, winds curve to the left. This shift in wind direction is called the **Coriolis effect.**

The Coriolis effect is the apparent shift in the path of any fluid or object moving above the surface of the Earth due to the rotation of the Earth. For example, suppose you are in an airplane flying south from Seattle, Washington, to San Jose, California. If the pilot does not adjust for the Coriolis effect, the airplane will land west of the point for which it is headed. In other words, an invisible force seems to be pushing the airplane west. You might wind up in the Pacific Ocean!

The diagram in Figure 1–16 shows the Earth's global wind systems. Refer to it often as you read the description of each global wind system. Remember, wind systems describe an overall pattern of air movement. At any particular time or place, local conditions may influence and change the pattern.

DOLDRUMS At the equator (0° latitude), surface winds are quite calm. These winds are called the doldrums (DOHL-druhmz). A belt of air around the equator receives much of the sun's radiant energy. The warm, rising air produces a low-pressure area that extends many kilometers north and south of the equator. Cooler, high-pressure air would normally flow into such an area, creating winds. But the



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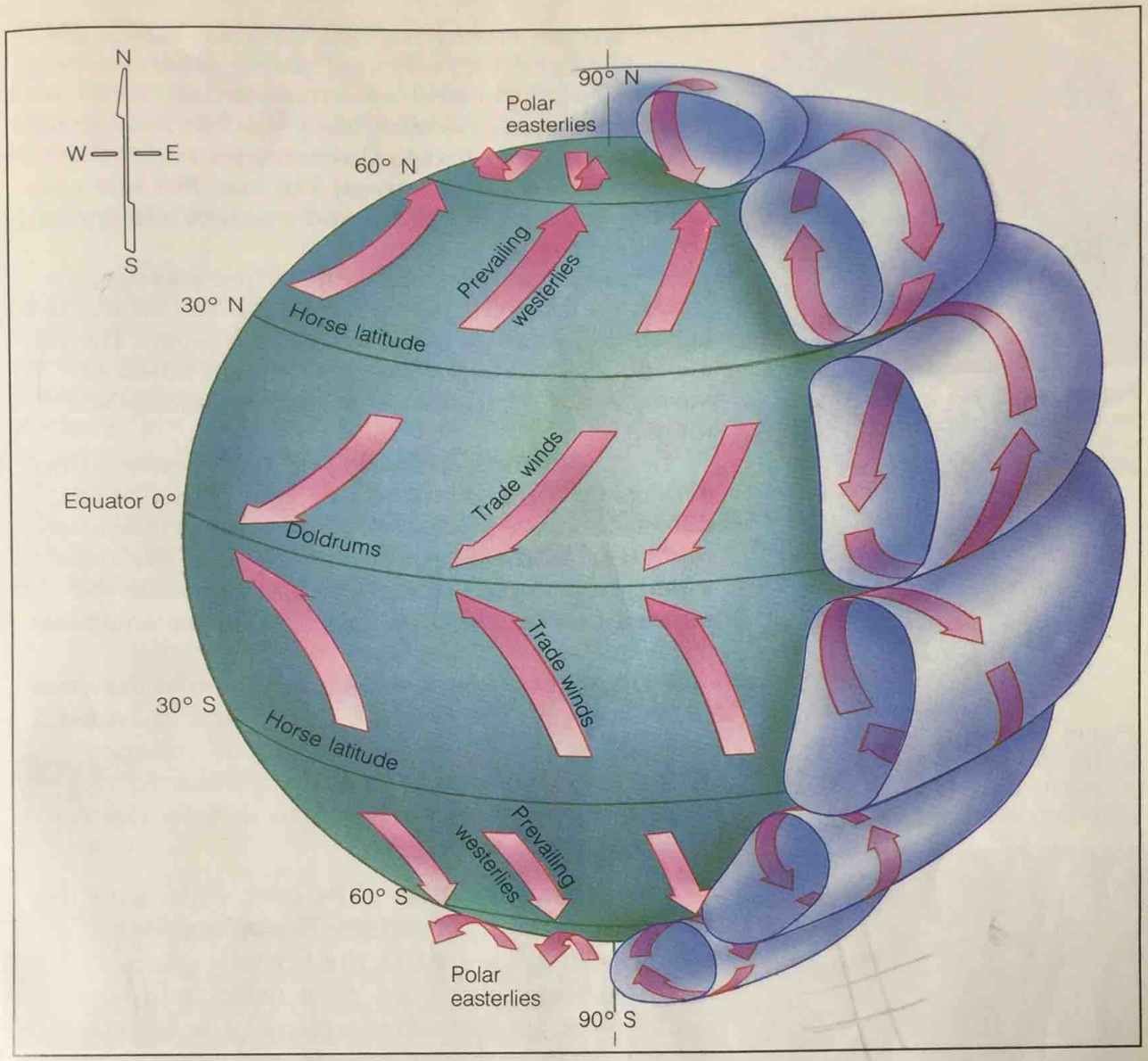

cooler air is warmed so rapidly near the equator that the winds which form cannot move into the low-pressure area. As a result, any winds that do form are weak. The doldrums can be a problem for sailing ships. Because there may be no winds, or weak winds at best, sailing ships can be stuck in the doldrums for many days. Have you ever heard people refer to themselves as being "in the doldrums"? What did they mean?

Figure 1–16 *Global wind patterns are caused by the unequal heating of the Earth's surface and by the rotation of the Earth. Warm air rises, cold air sinks, and the Coriolis effect causes the winds to curve. What are the three major global winds?*

TRADE WINDS About 30° north and south of the equator, the warm air rising from the equator cools and begins to sink. Here, the sky is usually clear.

Figure 1–17 *The overall movement of global wind systems can be seen in the pattern of the Earth's cloud cover.*

Figure 1–18 *Unlike the trade winds, the prevailing westerlies are strong winds. Where are the prevailing westerlies located?*

There are few clouds and little rainfall. Winds are calm. Hundreds of years ago, sailing ships traveling to the New World were sometimes unable to move for days or weeks because there was too little wind. Sailors sometimes had to throw horses overboard when the horses' food supply ran out. For this reason the latitudes 30° north and south of the equator are called the horse latitudes.

At the horse latitudes, some of the sinking air travels back toward the equator. The rest of the sinking air continues to move toward the poles. The air moving back toward the equator forms a belt of warm, steady winds. These winds are called trade winds.

In the Northern Hemisphere, the Coriolis effect deflects the trade winds to the right. These winds, called the northeast trades, blow from northeast to southwest. In the Southern Hemisphere, the trade winds are deflected to the left. They become the southeast trades. In what direction do the southeast trades blow?

Early sailors used the trade winds when they traveled to the New World. The trade winds provided a busy sailing route between Europe and America. Today, airplane pilots use the trade winds to increase speed and save fuel when they fly this route from east to west.

PREVAILING WESTERLIES The cool, sinking air that continues to move toward the North and South poles is also influenced by the Coriolis effect. In the Northern Hemisphere, the air is deflected to the right. In the Southern Hemisphere, it is deflected to the left. So in both hemispheres, the winds appear to travel from west to east. These winds are called the prevailing westerlies. (Remember, winds are named according to the direction from which they blow.) As you can see from Figure 1–16, the prevailing westerlies are located in a belt from 40° to 60° latitude in both hemispheres. Unlike the trade winds, the prevailing westerlies are often particularly strong winds.

POLAR EASTERLIES In both hemispheres, the westerlies start rising and cooling between 50° and 60° latitude as they approach the poles (90° latitude). Here they meet extremely cold air flowing toward the equator from the poles. This band of cold air is deflected west by the Coriolis effect. As a result, the

winds appear to travel from east to west and are called the polar easterlies. The polar easterlies are cold but weak winds. In the United States, many changes in the weather are caused by the polar easterlies.

Jet Streams

For centuries, people have been aware of the global winds you have just read about. But it was not until the 1940s that another global wind was discovered. This wind is a narrow belt of strong, high-speed, high-pressure air called a jet stream. Jet streams flow from west to east at altitudes above 12 kilometers. Wind speeds in the jet streams can reach 180 kilometers per hour in the summer and 220 to 350 kilometers per hour in the winter. Airplane pilots flying from west to east can use a jet stream to increase speed and save fuel.

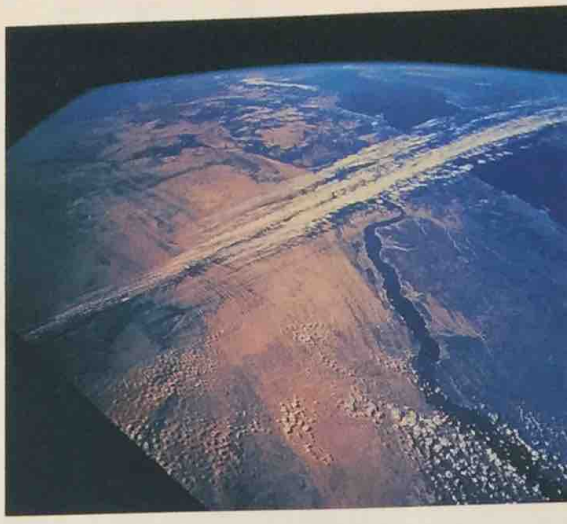

Figure 1–19 *A high-altitude jet stream moves over the Nile River Valley and the Red Sea. In which direction do jet streams flow?*

PROBLEM ?·?·? Solving

North Pole Smog Alert

No place on the surface of the Earth is farther away from industry and human development than the land above the Arctic Circle near the North Pole. Yet scientists have discovered sulfur particles in the arctic air that are identical to those found in the polluted air of some European cities. These particles are so thick that they form a blue-gray haze similar to that seen over many large cities. Using your knowledge of global wind systems, explain how air pollution has reached the Arctic. Draw a map to illustrate your explanation.

Figure 1–20 *Wind speed is related to the rate at which the cups of the anemometer revolve. What other weather instrument can you see in the photograph?*

Activity Bank
Build Your Own Anemometer, p.121

ACTIVITY DOING

Build a Wind-Speed Meter

1. Obtain a square piece of cardboard.
2. Stick a push pin into the upper left corner.
3. Hang a 3-cm strip of metal from the push pin.
4. Calibrate your wind-speed meter by holding it out the window of a moving car. The metal strip will move higher as the wind speed increases. Mark the position of the strip at different speeds.

Jet streams do not flow around the Earth in regular bands. They wander up and down as they circle the Earth. At times, they take great detours north and south. The wind speed and depth of a jet stream can change from season to season, or even from day to day.

The wandering jet streams affect the atmosphere below them. The rush of a jet stream creates waves and eddy currents, or swirling motions opposite to the flow of the main stream, in the lower atmosphere. These disturbances cause air masses in the lower atmosphere to spread out. This produces areas of low pressure. The low-pressure areas serve as the centers of local storms.

Measuring Wind

As you have been reading about local and global winds, you have probably noticed that two measurements are needed to describe wind: wind direction and wind speed. Meteorologists and weather observers use a wind vane to determine the direction of the wind on the Earth's surface. A wind vane points into the wind. An **anemometer** (an-uh-MAHM-uh-ter) is used to measure wind speed. Wind speed is usually expressed in meters per second, miles per hour, or knots. One knot is equal to 1850 meters per hour.

1–3 Section Review

1. What are the differences between local winds and global winds? How are they alike?
2. What causes winds in the Northern Hemisphere to curve to the right as they move?
3. Name the Earth's four major wind belts.
4. Describe the movements of the three major global winds in terms of unequal heating and the Coriolis effect.

Connection—*You and Your World*

5. An airplane trip from New York City to Los Angeles takes longer than the return trip from Los Angeles to New York. Explain why.