Lesson 2

Wind in the Atmosphere

ESSENTIAL QUESTION

What is wind?

By the end of this lesson, you should be able to explain how energy provided by the sun causes atmospheric movement, called wind.

Although you cannot see wind, you can see how it affects things like these kites.
1 **Predict** Check T or F to show whether you think each statement is true or false.

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<table>
<thead>
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<tbody>
<tr>
<td>T</td>
<td>F</td>
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<td></td>
<td></td>
<td>The atmosphere is often referred to as air.</td>
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<td></td>
<td></td>
<td>Wind does not have direction.</td>
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<td></td>
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<td>During the day, there is often a wind blowing toward shore from the ocean or a large lake.</td>
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<td></td>
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<td>Cold air rises and warm air sinks.</td>
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2 **Explain** If you opened the valve on this bicycle tire, what would happen to the air inside of the tire? Why do you think that would happen?

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**Active Reading**

3 **Synthesize** You can often define an unknown phrase if you know the meaning of its word parts. Use the word parts below to make an educated guess about the meanings of the phrases *local wind* and *global wind*.

<table>
<thead>
<tr>
<th>Word part</th>
<th>Meaning</th>
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<tbody>
<tr>
<td><em>wind</em></td>
<td>movement of air due to differences in air pressure</td>
</tr>
<tr>
<td><em>local</em></td>
<td>involving a particular area</td>
</tr>
<tr>
<td><em>global</em></td>
<td>involving the entire Earth</td>
</tr>
</tbody>
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**Vocabulary Terms**

- *wind*
- *Coriolis effect*
- *global wind*
- *jet stream*
- *local wind*

4 **Identify** This list contains the vocabulary terms you'll learn in this lesson. As you read, circle the definition of each term.
What causes wind?
The next time you feel the wind blowing, you can thank the sun! The sun does not warm the whole surface of the Earth in a uniform manner. This uneven heating causes the air above Earth's surface to be at different temperatures. Cold air is more dense than warmer air is. Colder, denser air sinks. When denser air sinks, it places greater pressure on the surface of Earth than warmer, less-dense air does. This results in areas of higher air pressure. Air moves from areas of higher pressure toward areas of lower pressure. The movement of air caused by differences in air pressure is called wind. The greater the differences in air pressure, the faster the air moves.

Areas of High and Low Pressure
Cold, dense air at the poles creates areas of high pressure at the poles. Warm, less-dense air at the equator forms an area of lower pressure. This pressure gradient results in global movement of air. However, instead of moving in one circle between the equator and the poles, air moves in smaller circular patterns called convection cells, shown below. As air moves from the equator, it cools and becomes more dense. At about 30°N and 30°S latitudes, a high-pressure belt results from the sinking of air. Near the poles, cold air warms as it moves away from the poles. At around 60°N and 60°S latitudes, a low-pressure belt forms as the warmed air is pushed upward.

Visualize It!
5 Identify In the white oval area on the map, draw the convection cell that was left out. Use a pencil to indicate warm air and a pen to indicate cool air.
How does Earth’s rotation affect wind?

Pressure differences cause air to move between the equator and the poles. If Earth was not rotating, winds would blow in a straight line. However, winds are deflected, or curved, due to Earth’s rotation, as shown below. The apparent curving of the path of a moving object from an otherwise straight path due to Earth’s rotation is called the Coriolis effect. This effect is most noticeable over long distances.

Because each point on Earth makes one complete rotation every day, points closer to the equator must travel farther and, therefore, faster than points closer to the poles do. When air moves from the equator toward the North Pole, it maintains its initial speed and direction. If the air travels far enough north, it will have traveled farther east than a point on the ground beneath it. As a result, the air appears to follow a curved path toward the east. Air moving from the North Pole to the equator appears to curve to the west because the air moves east more slowly than a point on the ground beneath it does. Therefore, in the Northern Hemisphere, air moving to the north curves to the east and air moving to the south curves to the west.

Winds in the Northern Hemisphere curve to the right. Winds in the Southern Hemisphere curve to the left.
What are examples of global winds?

Recall that air travels in circular patterns called convection cells that cover approximately 30° of latitude. Pressure belts at every 30° of latitude and the Coriolis effect produce patterns of calm areas and wind systems. These wind systems occur at or near Earth’s surface and are called global winds. As shown at the right, the major global wind systems are the polar easterlies (EE•ster•leez), the westerlies (WES•ter•leez), and the trade winds. Winds such as polar easterlies and westerlies are named for the direction from which they blow. Calm areas include the doldrums and the horse latitudes.

**Trade Winds**
The trade winds blow between 30° latitude and the equator in both hemispheres. The rotation of Earth causes the trade winds to curve to the west. Therefore, trade winds in the Northern Hemisphere come from the northeast, and trade winds in the Southern Hemisphere come from the southeast. These winds became known as the trade winds because sailors relied on them to sail from Europe to the Americas.

**Westerlies**
The westerlies blow between 30° and 60° latitudes in both hemispheres. The rotation of Earth causes these winds to curve to the east. Therefore, westerlies in the Northern Hemisphere come from the southwest, and westerlies in the Southern Hemisphere come from the northwest. The westerlies can carry moist air over the continental United States, producing rain and snow.

**Polar Easterlies**
The polar easterlies blow between the poles and 60° latitude in both hemispheres. The polar easterlies form as cold, sinking air moves from the poles toward 60°N and 60°S latitudes. The rotation of Earth causes these winds to curve to the west. In the Northern Hemisphere, polar easterlies can carry cold Arctic air over the majority of the United States, producing snow and freezing weather.

**Active Reading**
8 Explain If something is being carried by westerlies, what direction is it moving toward?

**Think Outside the Book Inquiry**
9 Model Winds are described according to their direction and speed. Research wind vanes and what they are used for. Design and build your own wind vane.
The Doldrums and Horse Latitudes

The trade winds of both hemispheres meet in a calm area around the equator called the doldrums (DOHL•druhmz). Very little wind blows in the doldrums because the warm, less-dense air results in an area of low pressure. The name doldrums means “dull” or “sluggish.” At about 30° latitude in both hemispheres, air stops moving and sinks. This forms calm areas called the horse latitudes. This name was given to these areas when sailing ships carried horses from Europe to the Americas. When ships were stalled in these areas, horses were sometimes thrown overboard to save water.
The Jet Streams

A flight from Seattle to Boston can be 30 min faster than a flight from Boston to Seattle. Why? Pilots can take advantage of a jet stream. **Jet streams** are narrow belts of high-speed winds that blow from west to east, between 7 km and 16 km above Earth's surface. Airplanes traveling in the same direction as a jet stream go faster than those traveling in the opposite direction of a jet stream. When an airplane is traveling “with” a jet stream, the wind is helping the airplane move forward. However, when an airplane is traveling “against” the jet stream, the wind is making it more difficult for the plane to move forward.

The two main jet streams are the polar jet stream and the subtropical (suhb•TRAHP•i•kuhl) jet stream, shown below. Each of the hemispheres experiences these jet streams. Jet streams follow boundaries between hot and cold air and can shift north and south. In the winter, as Northern Hemisphere temperatures cool, the polar jet stream moves south. This shift brings cold Arctic air to the United States. When temperatures rise in the spring, this jet stream shifts to the north.

Identify

As you read, underline the direction that the jet streams travel.

Visualize It!

Label the polar jet stream and the subtropical jet stream in the Northern Hemisphere.
Why It Matters

Desert Trades

How does some of the Sahara end up in the Americas? Global winds carry it.

Trade Wind Carriers
Trade winds can carry Saharan dust across the Atlantic Ocean to Florida and the Caribbean.

Florida Meets the Sahara
This hazy skyline in Miami is the result of a dust storm. Where did the dust come from? It all started in the Sahara.

The Sahara
The Sahara is the world’s largest hot desert. Sand and dust storms that produce skies like this are very common in this desert.

Extend

13 Explain Look at a map and explain how trade winds carry dust from the Sahara to the Caribbean.

14 Relate Investigate the winds that blow in your community. Where do they usually come from? Identify the wind system that could be involved.

15 Apply Investigate how winds played a role in distributing radioactive waste that was released after an explosion at the Chernobyl Nuclear Power Plant in Ukraine. Present your findings as a map illustration or in a poster.
What are examples of local winds?

Local geographic features, such as a body of water or a mountain, can produce temperature and pressure differences that cause local winds. Unlike global winds, local winds are the movement of air over short distances. They can blow from any direction, depending on the features of the area.

Sea and Land Breezes

Have you ever felt a cool breeze coming off the ocean or a lake? If so, you were experiencing a sea breeze. Large bodies of water take longer to warm up than land does. During the day, air above land becomes warmer than air above water. The colder, denser air over water flows toward the land and pushes the warm air on the land upward. While water takes longer to warm than land does, land cools faster than water does. At night, cooler air on land causes a higher-pressure zone over the land. So, a wind blows from the land toward the water. This type of local wind is called a land breeze.

Active Reading

16 Identify As you read, underline two examples of geographic features that contribute to the formation of local winds.

Visualize It!

17 Analyze Label the areas of high pressure and low pressure.

Sea breeze

A __________ pressure

B __________ pressure

Land breeze

C __________ pressure

D __________ pressure

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Valley and Mountain Breezes

Areas that have mountains and valleys experience local winds called mountain and valley breezes. During the day, the sun warms the air along the mountain slopes faster than the air in the valleys. This uneven heating results in areas of lower pressure near the mountain tops. This pressure difference causes a valley breeze, which flows from the valley up the slopes of the mountains. Many birds float on valley breezes to conserve energy. At nightfall, the air along the mountain slopes cools and moves down into the valley. This local wind is called a mountain breeze.

Visualize It!

18 Analyze Label the areas of high pressure and low pressure.
Wind is the movement of air from areas of higher pressure to areas of lower pressure.

19 Cool air sinks, causing an area of high/low air pressure.

Global wind systems occur on Earth.

20 High-speed wind between 7 km and 16 km above Earth's surface is a jet stream/mountain breeze.

Geographic features can produce local winds.

21 During the day, an area of high/low air pressure forms over water and a sea/land breeze occurs.

22 Explain Would there be winds if the air above Earth's surface was the same temperature everywhere? Explain your answer.
Lesson Review

Vocabulary
Fill in the blanks with the term that best completes the following sentences.

1 Another term for air movement caused by differences in air pressure is

2 Pilots often take advantage of the __________, which are high-speed winds between 7 km and 16 km above Earth’s surface.

3 The apparent curving of winds due to Earth’s rotation is the __________

Key Concepts

4 Explain How does the sun cause wind?

5 Predict If Earth did not rotate, what would happen to the global winds? Why?

6 Explain How do convection cells in Earth’s atmosphere cause high- and low-pressure belts?

8 Identify Name a latitude where each of the following occurs: polar easterlies, westerlies, and trade winds.

9 Predict How would local winds be affected if water and land absorbed and released heat at the same rate? Explain your answer.

10 Compare How is a land breeze similar to a sea breeze? How do they differ?

11 Analyze What type of local wind would you experience if you were standing in the valley? Explain your answer.

12 Infer Would the local wind change if it was nighttime? Explain.