Name _____ Class _____ Date _____

CHAPTER 15 The Atmosphere

SECTION 1

# Characteristics of the Atmosphere

**BEFORE YOU READ**

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

- What is Earth's atmosphere made of?
- How do air pressure and temperature change as you move away from Earth's surface?
- What are the layers of the atmosphere?

**National Science Education Standards**
**ES 1h**

## What Is Earth's Atmosphere Made Of?

An **atmosphere** is a layer of gases that surrounds a planet or moon. On Earth, the atmosphere is often called just "the air." When you take a breath of air, you are breathing in atmosphere.

The air you breathe is made of many different things. Almost 80% of it is nitrogen gas. The rest is mostly oxygen, the gas we need to live. There is also water in the atmosphere. Some of it is invisible, in the form of a gas called *water vapor*. ☑

Water is also found in the atmosphere as water droplets and ice crystals, like those that make up clouds. The atmosphere also contains tiny *particles*, or solid pieces. These particles are things like dust and dirt from continents, salt from oceans, and ash from volcanoes.

**STUDY TIP**

**Define** When you come across a word you don't know, circle it. When you figure out what it means, write the word and its definition in your notebook.

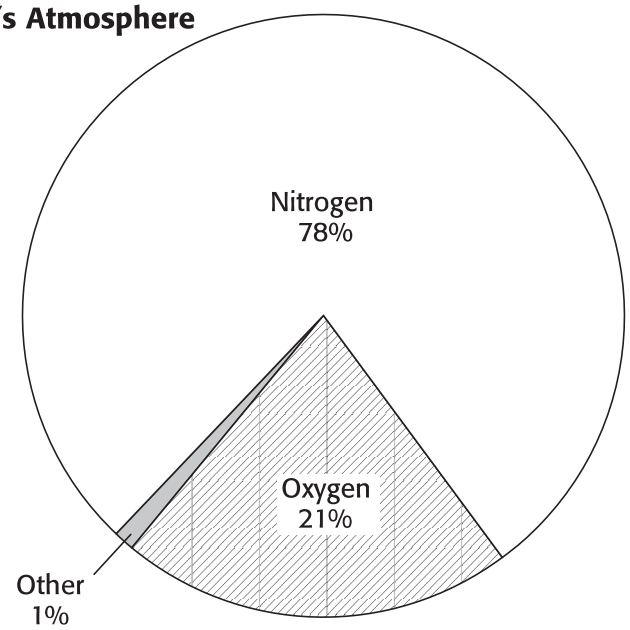
**READING CHECK**

**1. List** Which two gases make up most of Earth's atmosphere?

_____

_____

**Gases in Earth's Atmosphere**




## Math Focus

**2. Analyze Data** About what fraction of the Earth's atmosphere is NOT made of nitrogen? Give your answer as a reduced fraction.

_____

## Where Do the Gases in the Atmosphere Come From?

The gases in Earth's atmosphere come from many different sources. The table below shows some of those sources.

| Gas | Where the gas comes from |
|---|---|
| Oxygen | Plants give off oxygen as they grow. |
| Nitrogen | Nitrogen is given off when dead plants and animals decay. |
| Water vapor | Liquid water evaporates and becomes water vapor.<br>Plants give off water vapor as they grow.<br>Water vapor comes out of the Earth during volcanic eruptions. |
| Carbon dioxide | Carbon dioxide comes out of the Earth during volcanic eruptions.<br>When animals breathe, they give off carbon dioxide.<br>Carbon dioxide is given off when we burn things that were once plant or animal material. |

**TAKE A LOOK**

**3. Identify** Name two gases that volcanoes contribute to the atmosphere.

_____

_____

## Why Does Air Pressure Change with Height?

**Air pressure** is how much the air above you weighs. It is a measure of how hard air molecules push on a surface. We don't normally notice air pressure, because our bodies are used to it. ☑

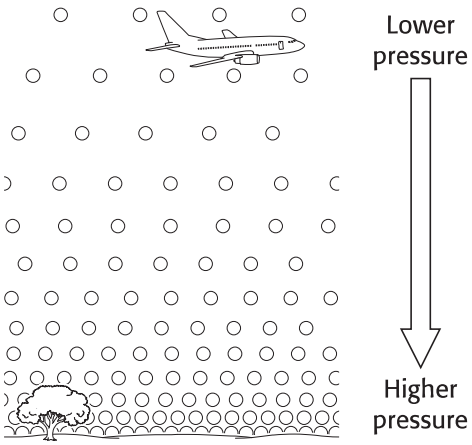
**READING CHECK**

**4. Define** Write your own definition for air pressure.

_____

_____

As you move up from the ground and out toward space, there are fewer gas molecules pressing down from above. Therefore, the air pressure drops. The higher you go, the lower the air pressure gets.




**TAKE A LOOK**

**5. Compare** How is the air pressure around the tree different from the air pressure around the plane?

_____

_____

_____

## Why Does Air Temperature Change with Height?

Like air pressure, air temperature changes as you move higher in the atmosphere. Air pressure always gets lower as you move higher, but air temperature can get higher or lower. The air can get hotter or colder. ☑

There are different layers of the atmosphere. Each layer is made of a different combination of gases. Air temperature depends on the gases in the atmosphere. Some gases absorb energy from the sun better than others. When a gas absorbs energy from the sun, the air temperature goes up.

**READING CHECK**

**6. Compare** How are the changes in air temperature with height different from changes in air pressure with height?

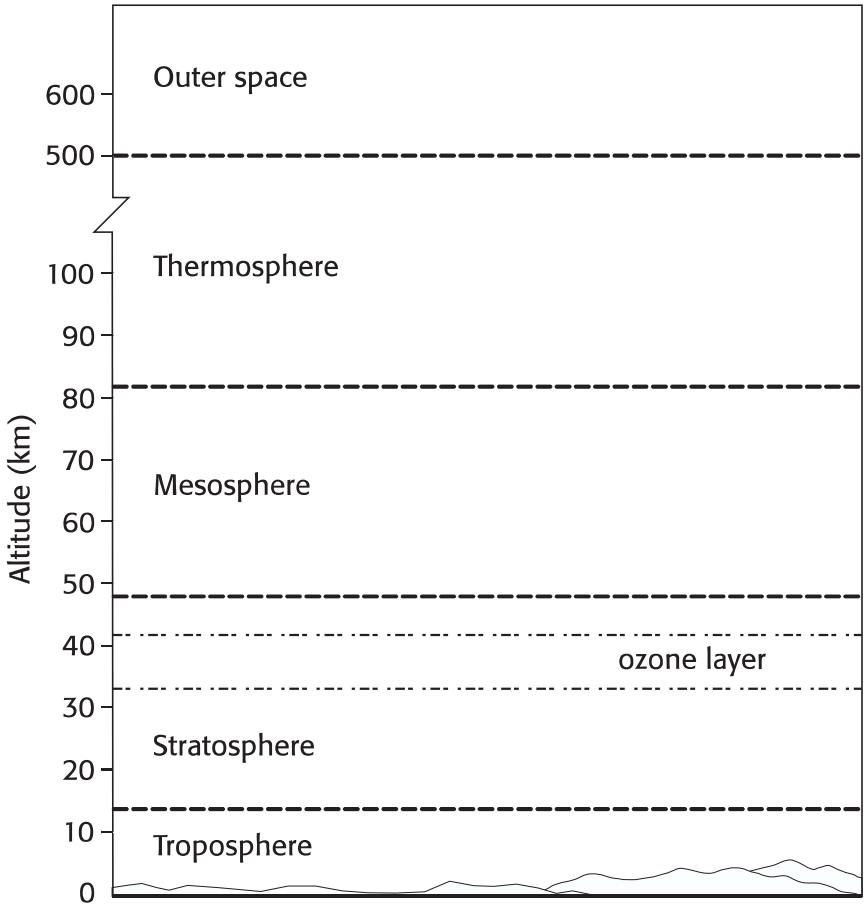
_____

_____

_____

## What Are the Layers of the Atmosphere?

There are four main layers of the atmosphere: troposphere, stratosphere, mesosphere, and thermosphere. You cannot actually see these different layers. The divisions between the layers are based on how each layer's temperature changes with height.




**Say It**

**Make Up a Memory Trick**
In groups of two or three, make up a sentence to help you remember the order of the layers of the atmosphere. The words in the sentence should start with T, S, M, and T. For example, "Tacos Sound Mighty Tasty." A sentence like this is called a *mnemonic*.

**TAKE A LOOK**

**7. Identify** At what altitude does the mesosphere end and the thermosphere begin?

_____

## Critical Thinking

**8. Explain** Why is the troposphere important to people?

_____

_____

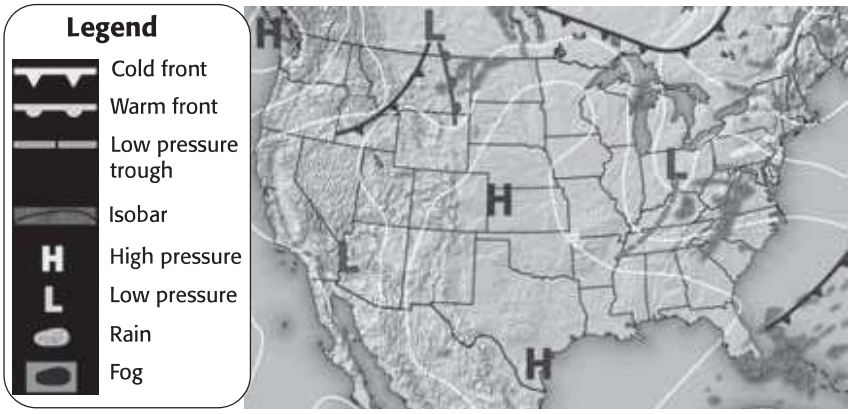
_____

_____

## THE TROPOSPHERE

The **troposphere** is the layer of the atmosphere that we live in. It is where most of the water vapor, carbon dioxide, pollution, and living things on Earth exist. Weather conditions such as wind and rain all take place in the troposphere.

The troposphere is also the densest layer of the atmosphere. This is because the troposphere is at the bottom with all the other layers pushing down from above. Almost 90% of the gases in the atmosphere are in the troposphere. As you move higher into the troposphere (say, to the top of a mountain), both air temperature and air pressure decrease.




Weather happens in the troposphere. A weather map shows what the troposphere is like in different places.

## TAKE A LOOK

**9. Analyze** What does the map tell you about the air temperature in the troposphere?

_____

_____

## THE STRATOSPHERE

As you go up from the ground, the temperature decreases. At an altitude of about 15 km, however, it starts to increase. This marks the beginning of the **stratosphere**. *Strato* means "layer." The gases in the stratosphere are layered. They do not mix as they do in the troposphere.

The main reason the temperature increases in the stratosphere is because of a gas called *ozone*. Ozone absorbs energy from the sun, making the temperature of the atmosphere increase. The ozone layer is important for life on Earth because it absorbs harmful ultraviolet energy. ☑

**READING CHECK**

**10. Explain** Why is ozone in the stratosphere important for living things?

_____

_____

## THE MESOSPHERE

Above the ozone layer, at an altitude of about 50 km, the temperature begins to drop again. This marks the bottom of the **mesosphere**. The temperature keeps decreasing all the way up to 80 km. The temperatures in the mesosphere can be as low as −93°C.

## THE THERMOSPHERE

The **thermosphere** is the uppermost layer of the atmosphere. In the thermosphere, temperatures begin to rise again. The thermosphere gets its name from its extremely high temperatures, which can be above 1,000°C. *Therm* means "heat." The temperatures in the thermosphere are so high because it contains a lot of oxygen and nitrogen, which absorb energy from the sun. ☑

**READING CHECK**

**11. Explain** Why is the thermosphere called the thermosphere?

_____

_____

_____

## THE IONOSPHERE—ANOTHER LAYER

The troposphere, stratosphere, mesosphere, and thermosphere are the four main layers of the atmosphere. However, scientists also sometimes study a region called the ionosphere. The *ionosphere* contains the uppermost part of the mesosphere and the lower part of the thermosphere. It is made of nitrogen and oxygen *ions*, or electrically charged particles.

The ionosphere is where auroras occur. *Auroras* are curtains and ribbons of shimmering colored lights. They form when charged particles from the sun collide with the ions in the ionosphere. The ionosphere is important to us because it can reflect radio waves. An AM radio wave can travel all the way around the Earth by bouncing off the ionosphere.

| Layer | How temperature and pressure change as you move higher | Important features |
|---|---|---|
| Troposhere | temperature decreases<br>pressure decreases | |
| Stratosphere | | gases are arranged in layers<br>contains the ozone layer |
| | | has the lowest temperatures |
| Thermosphere | temperature increases<br>pressure decreases | |

**TAKE A LOOK**

**12. Identify** Use the information from the text to fill in the table.

Name _____ Class _____ Date _____

# Section 1 Review

**NSES** ES 1h

## SECTION VOCABULARY

| | |
|---|---|
| **air pressure** the measure of the force with which air molecules push on a surface | **stratosphere** the layer of the atmosphere that is above the troposphere and in which temperature increases as altitude increases |
| **atmosphere** a mixture of gases that surrounds a planet or moon | **thermosphere** the uppermost layer of the atmosphere, in which temperature increases as altitude increases |
| **mesosphere** the layer of the atmosphere between the stratosphere and the thermosphere and in which temperature decreases as altitude increases | **troposphere** the lowest layer of the atmosphere, in which temperature decreases at a constant rate as altitude increases |

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

_____

_____

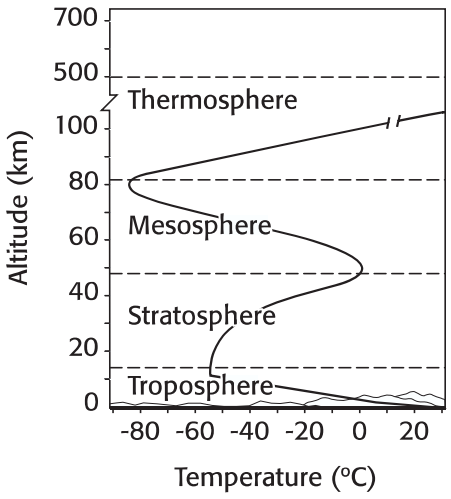
2. **Explain** Why does air temperature change as you move up from the Earth's surface?

_____

_____

_____

3. **Make a Graph** The graph below shows how the temperature changes as you move up through the atmosphere. On the graph, draw a curve showing how the pressure changes.




4. **Identify Relationships** How does the sun affect air temperatures?

_____

_____

Name _____ Class _____ Date _____

CHAPTER 15 The Atmosphere

SECTION 2

# Atmospheric Heating

**BEFORE YOU READ**

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

- How does energy travel from the sun to Earth?
- What are the differences between radiation, conduction, and convection?
- Why is Earth's atmosphere so warm?

## How Does Energy Travel from the Sun to Earth?

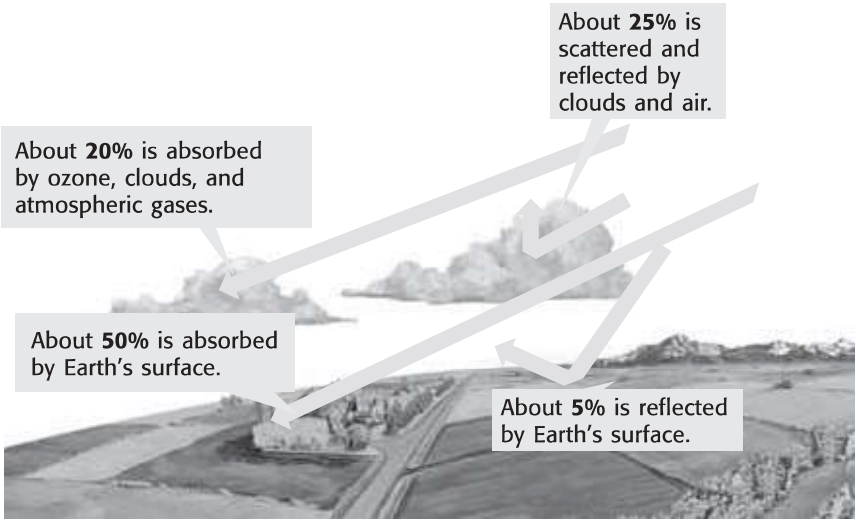
Most of the heat energy on Earth's surface comes from the sun. Energy travels from the sun to Earth by **radiation**, which means that it travels through space as waves. As solar energy (energy from the sun) is absorbed by air, water, and land, it turns into heat energy. This energy causes winds, the water cycle, ocean currents, and changes in the weather.

**STUDY TIP**

**Outline** In your notebook, write an outline of this chapter. Use the questions in bold to make your outline. As you read, fill in information about each question.

## What Happens to Radiation from the Sun?

Not all of the radiation from the sun reaches Earth's surface. Much of it gets absorbed by the atmosphere. Some of it is scattered and reflected by clouds and gases.




## TAKE A LOOK

**1. Identify** How much of the sunlight that gets to Earth is absorbed by Earth's surface?

_____

**2. Summarize** What happens to the sunlight that is not absorbed by Earth's surface?

_____

_____

_____

## How Is Heat Transferred by Contact?

Once sunlight is absorbed by Earth's surface, it is *converted*, or changed, into heat energy. Then, the heat can be transferred to other objects and moved to other places. When a warm object touches a cold object, heat moves from the warm object to the cold one. This movement of heat is called **thermal conduction**.

When you touch the sidewalk on a hot, sunny day, heat energy is conducted from the sidewalk to you. The same thing happens to air molecules in the atmosphere. When they touch the warm ground, the air molecules heat up. ☑

**READING CHECK**

**3. List** Name two ways that air gets heated.

_____

_____

## How Is Heat Energy Transferred by Motion?

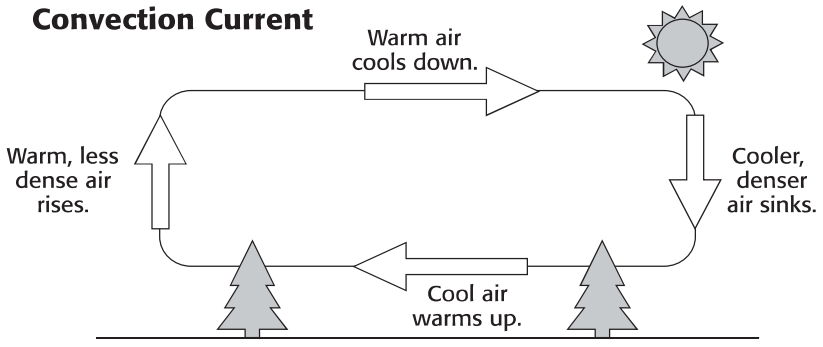
If you have ever watched a pot of water boil, you have seen convection. During **convection**, warm material, such as air or water, carries heat from one place to another.

When you turn on the stove under a pot of water, the water closest to the pot heats up. As the water heats up, its density decreases. The warm water near the pot is not as dense as the cool water near the air. Therefore, the cool water sinks while the warm water rises.

As it rises, the warm water begins to cool. When it cools, its density increases. It becomes denser than the layer below, so it sinks back to the bottom of the pot. This forms a circular movement called a *convection current*.

Convection currents also move heat through the atmosphere. In fact, most heat energy in the atmosphere is transferred by convection. Air close to the ground is heated by conduction from the ground. It becomes less dense than the cooler air above it. The warmer air rises while the cooler air sinks. The ground warms up the cooler air by conduction, and the warm air rises again.

**Convection Current**




## Critical Thinking

**4. Apply Concepts** Before the water in the pot can heat up, the pot itself must heat up. Does the pot heat up by conduction, convection, or radiation? Explain your answer.

_____

_____

_____

_____

## TAKE A LOOK

**5. Describe** What happens to warm air as it moves through the atmosphere?

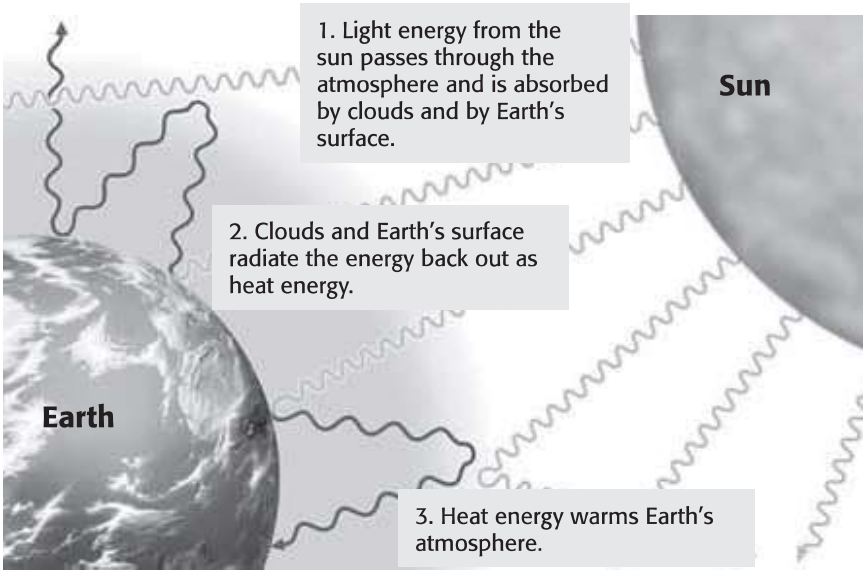
_____

## How Does the Earth Stay Warm?

A gardener who needs to keep plants warm uses a glass building called a greenhouse. Light travels through the glass into the building, and the air and plants inside absorb the energy. The energy is converted to heat, which cannot travel back through the glass as easily as light came in. Much of the heat energy stays trapped within the greenhouse, keeping the air inside warmer than the air outside.

Earth's atmosphere acts like the glass walls of a greenhouse. Sunlight travels through the atmosphere easily, but heat does not. Gases in the atmosphere, such as water vapor and carbon dioxide, absorb heat energy coming from Earth. Then, they radiate it back to Earth's surface. This is known as the **greenhouse effect**. ☑

**The Greenhouse Effect**




**READING CHECK**

**6. List** Name two gases in Earth's atmosphere that absorb heat.

_____

_____

**TAKE A LOOK**

**7. Identify** On the drawing, label the light coming from the sun with an **L**. Label the heat energy that is trapped by Earth's atmosphere with an **H**.

## What Is Global Warming?

Many scientists are worried that Earth has been getting warmer over the past hundred years. This increase in temperatures all over the world is called **global warming**.

Scientists think that human activities may be causing global warming. When we burn fossil fuels, we release greenhouse gases, such as carbon dioxide, into the atmosphere. Because greenhouse gases trap heat in the atmosphere, adding more of them can make Earth even warmer. Global warming can have a strong effect on weather and climate.

**Say It**

**Predict** How might global warming affect your community? What can you do to slow global warming? In groups of two or three, discuss how global warming might affect your lives.

Name _____ Class _____ Date _____

# Section 2 Review

## SECTION VOCABULARY

**convection** the transfer of thermal energy by the circulation or movement of a liquid or gas

**global warming** a gradual increase in average global temperature

**greenhouse effect** the warming of the surface and lower atmosphere of Earth that occurs when water vapor, carbon dioxide, and other gases absorb and reradiate thermal energy

**radiation** the transfer of energy as electromagnetic waves

**thermal conduction** the transfer of energy as heat through a material

1. **Apply Concepts** A person is camping outside. The person toasts a marshmallow by holding it above the flames of the fire. Does the marshmallow cook because of convection, conduction, or radiation? Explain your answer.

_____

_____

2. **Compare** Fill in the table below to name and describe the three ways energy is transferred in Earth's atmosphere.

| Type of energy transfer | How energy is transferred |
|---|---|
| | Energy travels as electromagnetic waves. |
| | |
| Conduction | |

3. **Explain** How does most of the heat in Earth's atmosphere move from place to place?

_____

_____

4. **Identify Relationships** Explain how global warming and the greenhouse effect are related.

_____

_____

_____

Name _____ Class _____ Date _____

CHAPTER 15 The Atmosphere

SECTION 3

# Global Winds and Local Winds

**BEFORE YOU READ**

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

- What causes wind?
- What is the Coriolis effect?
- What are the major global wind systems on Earth?

**National Science Education Standards**

ES 1j

## What Causes Wind?

**Wind** is moving air caused by differences in air pressure. Air moves from areas of high pressure to areas of low pressure. The greater the pressure difference, the faster the air moves, and the stronger the wind blows. ☑

You can see how air moves if you blow up a balloon and then let it go. The air inside the balloon is at a higher pressure than the air around the balloon. If you open the end of the balloon, air will rush out.

**STUDY TIP**

**Underline** Each heading in this section is a question. Underline the answer to each question when you find it in the text.

**READING CHECK**

**1. Define** What is wind?

_____

_____

**TAKE A LOOK**

**2. Identify** On the drawing, label the high-pressure area with an **H** and the low-pressure area with an **L**.

## What Causes Differences in Air Pressure?

Most differences in air pressure are caused by differences in air temperature. Temperature differences happen because some parts of Earth get more energy from the sun than others. For example, the sun shines more directly on the equator than on the poles. As a result, the air is warmer near the equator. ☑

The warm air near the equator is not as dense as the cool air near the poles. Because it is less dense, the air at the equator rises, forming areas of low pressure. The cold air near the poles sinks, forming areas of high pressure. The air moves in large circular patterns called *convection cells*. The drawing on the next page shows these convection cells.

**READING CHECK**

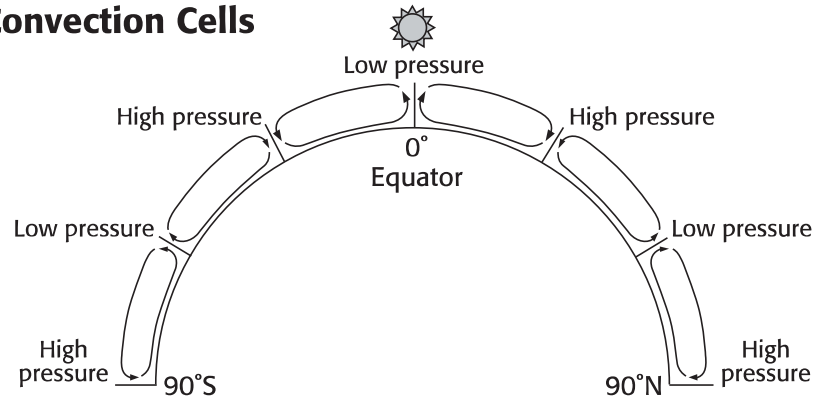
**3. Explain** Why isn't all the air on Earth at the same temperature?

_____

_____

_____

### Convection Cells




**TAKE A LOOK**

**4. Describe** Is air rising or sinking in areas of high pressure?

_____

## What Are the Major Global Wind Systems?

*Global winds* are large-scale wind systems. There are three pairs of major global wind systems, or wind belts: trade winds, westerlies, and polar easterlies. ☑

**READING CHECK**

**5. Identify** What are the three main global wind belts?

_____

_____

_____

**Trade winds** are wind belts that blow from 30° latitude almost to the equator. They curve to the west as they blow toward the equator. **Westerlies** are wind belts that are found between 30° and 60° latitude. The westerlies blow toward the poles from west to east. Most of the United States is located in the belt of westerly winds. These winds can carry moist air over the United States, producing rain and snow.

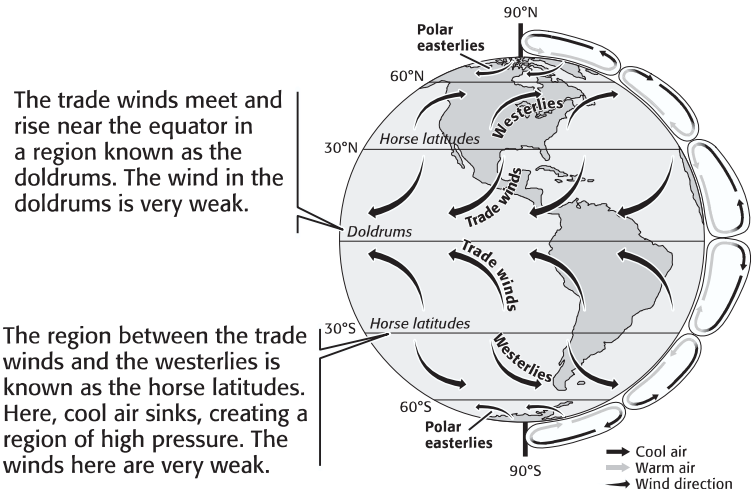
**Polar easterlies** are wind belts that extend from the poles to 60° latitude. They form as cold, sinking air moves away from the poles. In the Northern Hemisphere, polar easterlies can carry cold arctic air over the United States. This can produce snow and freezing weather.

**TAKE A LOOK**

**6. Describe** Fill in the blanks in the table.

| Wind belt | Location (latitude) | Toward the equator or toward the poles? |
|---|---|---|
| Trade winds | 0° to 30° | toward the equator |
| Westerlies | | |
| | 60° to 90° | |

The figure on the next page shows the locations of these different wind belts. Notice that the winds do not move in straight lines. The paths of the wind belts are controlled by convection cells and by the Earth's rotation.




The trade winds meet and rise near the equator in a region known as the doldrums. The wind in the doldrums is very weak.

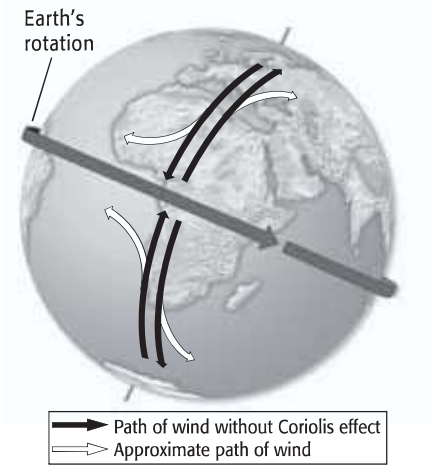
The region between the trade winds and the westerlies is known as the horse latitudes. Here, cool air sinks, creating a region of high pressure. The winds here are very weak.

There are three pairs of major global wind belts on Earth: the polar easterlies, the westerlies, and the trade winds.

## Why Do Global Winds Curve?

Remember that pressure differences can cause air to move and form winds. If Earth did not rotate, these winds would blow in straight lines. However, because Earth does rotate, the winds follow curved paths. This *deflection*, or curving, of moving objects from a straight path because of Earth's rotation is called the **Coriolis effect**. ☑

As Earth rotates, places near the equator travel faster than places closer to the poles. This difference in speed causes the Coriolis effect. Wind moving from the poles to the equator is deflected to the west. Wind moving from the equator to the poles is deflected east.




The Coriolis effect causes wind and water to move along curved paths.

**STANDARDS CHECK**

**ES 1j** Global patterns of atmospheric movement influence local weather. Oceans have a major effect on climate, because water in the oceans holds a large amount of heat.

**Word Help: major**
of great importance or large scale

**7. Explain** Use the map to explain why surface winds are generally very weak near the equator.

_____

_____

_____

_____

_____

**READING CHECK**

**8. Describe** How does Earth's rotation affect the paths of global winds?

_____

_____

_____

**TAKE A LOOK**

**9. Apply Ideas** If air is moving south from California, which way will it tend to curve?

_____

## What Are Jet Streams?

The polar easterlies, prevailing westerlies, and trade winds are all winds that we feel on the ground. However, wind systems can also form at high altitude. **Jet streams** are narrow belts of very high-speed winds in the upper troposphere and lower stratosphere. They blow from west to east all the way around the Earth. ☑

Jet streams can reach speeds of 400 km/h. Pilots flying east over the United States or the Atlantic Ocean try to catch a jet stream. This wind pushes airplanes along, helping them fly faster and use less fuel. Pilots flying west try to avoid the jet streams.

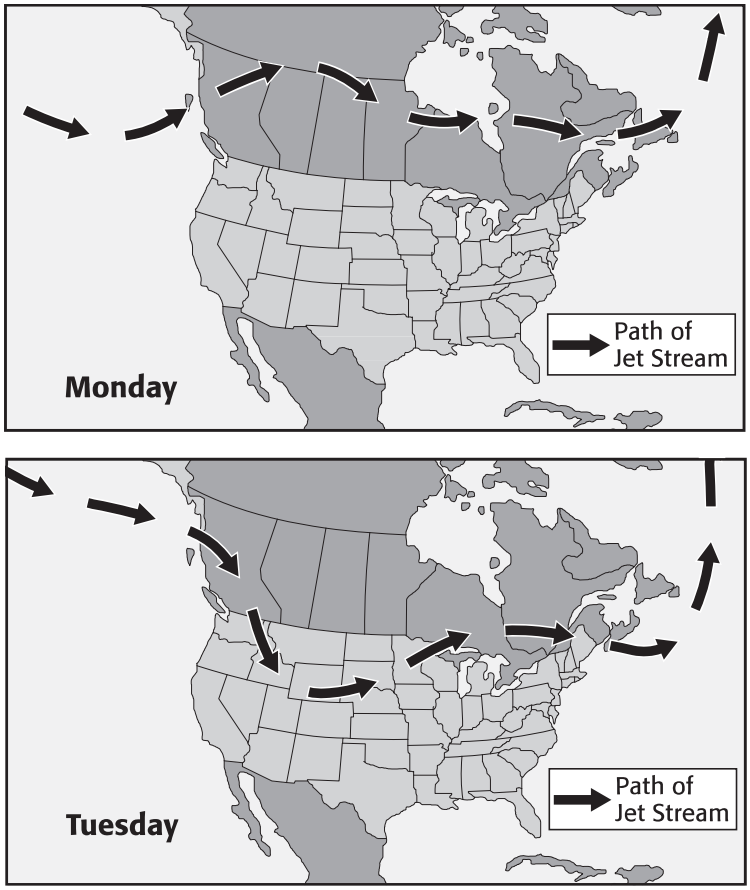
The global wind systems are always found in about the same place every day. Unlike these global wind systems, jet streams can be in different places on different days. Because jet streams can affect the movements of storms, meteorologists try to track the jet streams. They can sometimes predict the path of a storm if they know where the jet streams are.

**READING CHECK**

**10. Identify** In what two layers of the atmosphere are the jet streams found?

_____

_____




Jet streams form between hot and cold air masses. Unlike the other wind systems, jet streams are found in slightly different places every day.

**TAKE A LOOK**

**11. Infer** Why would a pilot flying across North America take a different route on Tuesday than on Monday?

_____

_____

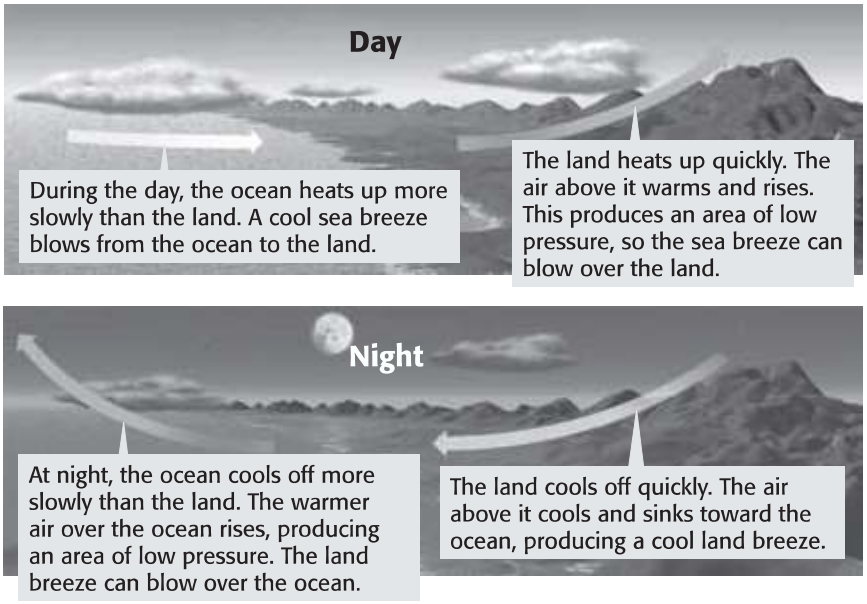
_____

_____

## What Are Local Winds?

Most of the United States is in the belt of prevailing westerly winds, which move from west to east. However, you've probably noticed that the wind in your neighborhood does not always blow from the west to the east. This is because global winds are not the only winds that blow. Local winds are also important. *Local winds* are winds that generally move over short distances and can blow from any direction.

Like the other wind systems, local winds are caused by differences in temperature. Many of these temperature differences are caused by geographic features, such as mountains and bodies of water. The figure below shows how water and mountains can affect local winds.




### MOUNTAIN BREEZES AND VALLEY BREEZES

Mountain and valley breezes are other examples of local winds caused by geography. During the day, the sun warms the air on mountain slopes. The warm air rises up the mountain slopes, producing a warm valley breeze. At night, the air on the slopes cools. The cool air moves down the slopes, producing a cool mountain breeze.

### Critical Thinking

**12. Compare** Describe one difference between global winds and local winds.

_____

_____

_____

_____

### Say It

**Share Experiences** Have you ever been in a very strong wind? In groups of two or three, discuss the strongest or worst wind you've ever been in.

### TAKE A LOOK

**13. Identify** In the figures, label the high-pressure areas with an **H** and the low-pressure areas with an **L**.

Name _____ Class _____ Date _____

# Section 3 Review

NSES ES 1j

## SECTION VOCABULARY

**Coriolis effect** the curving of the path of a moving object from an otherwise straight path due to the Earth's rotation

**jet stream** a narrow band of strong winds that blow in the upper troposphere

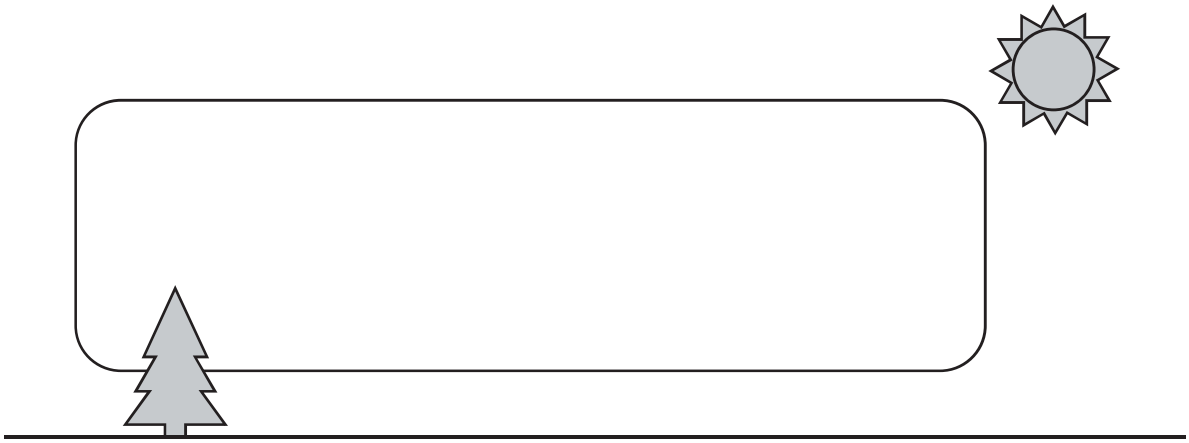
**polar easterlies** prevailing winds that blow from east to west between 60° and 90° latitude in both hemispheres

**trade winds** prevailing winds that blow from east to west from 30° latitude to the equator in both hemispheres

**westerlies** prevailing winds that blow from west to east between 30° and 60° latitude in both hemispheres

**wind** the movement of air caused by differences in air pressure

1. **Identify** The drawing below shows a convection cell. Put arrows on the cell to show which way the air is moving. Label high pressure areas with an **H** and low pressure areas with an **L**. Label cold air with a **C** and warm air with a **W**.



2. **Identify** Which global wind system blows toward the poles between 30° and 60° latitude?

_____

3. **Explain** Why does wind tend to blow down from mountains at night?

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4. **Apply Concepts** Would there be winds if Earth's surface were the same temperature everywhere? Explain your answer.

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