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?

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.

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.

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

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.

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.
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.

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.

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READING CHECK

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

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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?
**SECTION 1** Characteristics of the Atmosphere *continued*

**Critical Thinking**

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

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**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.

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**TAKE A LOOK**

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

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**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.

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**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 $-93^\circ C$. 

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Interactive Textbook 282 The Atmosphere
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. ✓

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.

<table>
<thead>
<tr>
<th>Layer</th>
<th>How temperature and pressure change as you move higher</th>
<th>Important features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Troposphere</td>
<td>temperature decreases pressure decreases</td>
<td></td>
</tr>
<tr>
<td>Stratosphere</td>
<td></td>
<td>gases are arranged in layers contains the ozone layer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>has the lowest temperatures</td>
</tr>
<tr>
<td>Thermosphere</td>
<td>temperature increases pressure decreases</td>
<td></td>
</tr>
</tbody>
</table>

**TAKE A LOOK**

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

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.

**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.

**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.

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

3. List Name two ways that air gets heated.

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.

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

1. Light energy from the sun passes through the atmosphere and is absorbed by clouds and by Earth’s surface.
2. Clouds and Earth’s surface radiate the energy back out as heat energy.

**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.

**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.

**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.
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.

<table>
<thead>
<tr>
<th>Type of energy transfer</th>
<th>How energy is transferred</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Energy travels as electromagnetic waves.</td>
</tr>
<tr>
<td>Conduction</td>
<td></td>
</tr>
</tbody>
</table>

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.
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?

**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.

**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.

**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.

**READING CHECK**

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

**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.

<table>
<thead>
<tr>
<th>Wind belt</th>
<th>Location (latitude)</th>
<th>Toward the equator or toward the poles?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade winds</td>
<td>0° to 30°</td>
<td>toward the equator</td>
</tr>
<tr>
<td>Westerlies</td>
<td>30° to 60°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60° to 90°</td>
<td></td>
</tr>
</tbody>
</table>

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.
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.

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**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.

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?

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

**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.

### 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.
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.

![Convection Cell](image)

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?

4. **Apply Concepts**  Would there be winds if Earth’s surface were the same temperature everywhere? Explain your answer.
What Is Air Pollution?

Air pollution is the addition of harmful substances to the atmosphere. An air pollutant is anything in the air that can damage the environment or make people or other organisms sick. Some air pollution comes from natural sources. Other forms of air pollution are caused by things people do.

There are two kinds of air pollutants: primary pollutants and secondary pollutants. Primary pollutants are pollutants that are put directly into the air. Dust, sea salt, volcanic ash, and pollen are primary pollutants that come from natural sources. Chemicals from paint and other materials and vehicle exhaust are primary pollutants that come from human activities.

Secondary pollutants form when primary pollutants react with each other or with other substances in the air. Ozone is an example of a secondary pollutant. It forms on sunny days when chemicals from burning gasoline react with each other and with the air. Ozone damages human lungs and can harm other living things as well.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Primary pollutant or secondary pollutant?</th>
<th>Natural or caused by people?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car exhaust</td>
<td>primary</td>
<td>human-caused</td>
</tr>
<tr>
<td>Dust</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ozone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paint chemicals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pollen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sea salt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volcanic ash</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SECTION 4  Air Pollution continued

TAKE A LOOK
3. Identify What is the primary pollutant in this figure?

What Is Smog?
On a hot, still, sunny day, yellowish brown air can cover a city. This is called smog. Smog forms when ozone mixes with other pollutants. During summer in cities such as Los Angeles, a layer of warm air can trap smog near the ground. In the winter, a storm can clear the air.

Exhaust
Ozone
Smog
Sun

1. Vehicles such as cars give off exhaust.
2. Exhaust reacts with the air and with sunlight to form ozone.
3. Ozone mixes with other pollutants to form smog.

What Is Smog?
On a hot, still, sunny day, yellowish brown air can cover a city. This is called smog. Smog forms when ozone mixes with other pollutants. During summer in cities such as Los Angeles, a layer of warm air can trap smog near the ground. In the winter, a storm can clear the air.

How Do Humans Cause Air Pollution?
Many of our daily activities cause air pollution. The main source of human-caused air pollution in the United States is motor vehicles. Cars, motorcycles, trucks, buses, trains, and planes all give off exhaust. Exhaust is a gas that contains pollutants that create ozone and smog.

Factories and power plants that burn coal, oil, and gas also give off pollutants. Businesses that use chemicals, such as dry cleaners and auto body shops, can add to air pollution.

READING CHECK
4. Identify What is the main source of human-caused air pollution in the United States?
What Causes Air Pollution Indoors?

Sometimes the air inside a building can be more polluted than the air outside. There is no wind to blow pollutants away and no rain to wash them out of the air indoors. Therefore, they can build up inside. It is important to air out buildings by opening the windows or using fans that bring fresh air in from outside.

**Sources of Indoor Air Pollution**

- **Chlorine and ammonia** from household cleaners
- **Nitrogen oxides** from unvented gas stove, wood stove, or kerosene heater
- **Fungi and bacteria** from dirty heating and air conditioning ducts
- **Carbon monoxide** from faulty furnace and car left running
- **Solvents** from paint strippers and thinners
- **Formaldehyde** from furniture, carpeting, particleboard, and foam insulation
- **Chemicals** from dry cleaning
- **Gasoline** from car and lawn mower

What Is Acid Precipitation?

**Acid precipitation** is rain, sleet, or snow that contains acids from air pollution. When we burn fossil fuels, such as coal, pollutants such as sulfur dioxide are released into the air. These pollutants combine with water in the atmosphere to form acids.

Acid precipitation can kill or damage plants, damage soil, and poison water. When acid rain flows into lakes, it can kill fish and other aquatic life.

**Diagram:**

1. People burn coal for energy.
2. Acid rain falls in the lake.
3. Fish die.

**Reading Check**

5. Explain Why can air pollution indoors be worse than air pollution outdoors?

**Take a Look**

6. Identify Name two sources of indoor air pollution shown here that may be in your own home.

7. Sequence Complete the graphic organizer to show how burning coal can cause fish to die.
What Is the Ozone Hole?

Close to the ground, ozone is a pollutant formed by human activities. However, high in the stratosphere, ozone is an important gas that forms naturally. The ozone layer absorbs harmful ultraviolet (UV) radiation from the sun. Ultraviolet radiation can harm living things. For example, it can cause skin cancer in humans.

In the 1980s, scientists noticed that the ozone layer over the poles was getting thinner. This hole in the ozone layer was being caused by chemicals called CFCs, which destroy ozone. CFCs were being used in air conditioners and chemical sprays. Many CFCs are now banned. However, CFCs can remain in the atmosphere for 60 to 120 years. Therefore, the ozone layer may slowly recover, but it will take a long time.

Ozone in the statosphere
Forms naturally
Not a pollutant

Ozone near the ground
harmful to living things

How Does Air Pollution Affect Human Health?

Air pollution can cause many health problems. Some are short-term problems. They happen quickly and go away when the air pollution clears up or the person moves to a cleaner location. Others are long-term health problems. They develop over long periods of time and are not cured easily. The table below lists some of the effects of air pollution on human health.

<table>
<thead>
<tr>
<th>Long-term effects</th>
<th>Short-term effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emphysema (a lung disease)</td>
<td>Headache</td>
</tr>
<tr>
<td>Lung cancer</td>
<td>Nausea and vomiting</td>
</tr>
<tr>
<td>Asthma</td>
<td>Eye, nose, and throat irritation</td>
</tr>
<tr>
<td>Permanent lung damage</td>
<td>Coughing</td>
</tr>
<tr>
<td>Heart disease</td>
<td>Difficulty breathing</td>
</tr>
<tr>
<td>Skin cancer</td>
<td>Upper respiratory infections</td>
</tr>
<tr>
<td>Worsening of emphysema</td>
<td>Asthma attacks</td>
</tr>
<tr>
<td></td>
<td>Worsening of emphysema</td>
</tr>
</tbody>
</table>

8. Explain How is the ozone layer helpful to humans?

9. Compare Fill in the chart to show the differences between ozone in the atmosphere and ozone near the ground.

10. Compare What is the difference between short-term effects and long-term effects of air pollution?
What Can We Do About Air Pollution?

Air pollution in the United States is not as bad now as it was 30 years ago. People today are much more aware of how they can cause or reduce air pollution. Air pollution can be reduced by new laws, by technology, and by people changing their lifestyles.

The United States government and the governments of other countries have passed laws to control air pollution. These laws limit the amount of pollution that sources such as cars and factories are allowed to release. For example, factories and power plants now have scrubbers on smokestacks. A scrubber is a tool that helps remove pollutants from smoke before it leaves the smokestack.

Many cars are more efficient now than they used to be, so they produce less pollution. Individuals can do a lot on their own to reduce air pollution, as well. For example, we can walk or bike instead of driving.

Critical Thinking

11. Analyze Processes
Electric cars don't give off any exhaust. They don't cause pollution in the cities where they are driven. However, driving them can cause pollution in other places. How? (Hint: Where does most electricity come from?)

In Copenhagen, Denmark, companies lend bicycles for anyone to use for free. The program helps reduce automobile traffic and air pollution.
Section 4 Review

SECTION VOCABULARY

<table>
<thead>
<tr>
<th>acid precipitation</th>
<th>air pollution</th>
</tr>
</thead>
<tbody>
<tr>
<td>rain, sleet, or snow that contains a high concentration of acids</td>
<td>the contamination of the atmosphere by the introduction of pollutants from human and natural sources</td>
</tr>
</tbody>
</table>

1. **Identify Relationships** How are fossil fuels related to air pollution and acid precipitation?

2. **Compare** Complete the table below to compare different pollutants.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Source</th>
<th>Negative effects</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFCs</td>
<td></td>
<td></td>
<td>banning CFCs</td>
</tr>
<tr>
<td>Ozone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>burning of fossil fuels</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. **Infer** Name three things, other than humans, that can be harmed by air pollution.

4. **Explain** Why is the hole in the ozone layer dangerous?