Section 4
The Air We Breathe

Key Concept Air is an important natural resource that is affected by human activities.

What You Will Learn
- Air pollution is caused by human activities, such as burning fossil fuels, and by natural events, such as volcanic eruptions.
- Air pollution has short-term and long-term effects on human health.

Why It Matters
Air pollution can affect your health, but you can help prevent air pollution by making certain choices.

In December 1952, one of London's "pea-soup" fogs settled on the city. But this was no ordinary fog—it was thick with coal smoke and air pollution. It burned people's lungs. The sky grew so dark that people could not see far in front of their faces. When the fog lifted four days later, thousands of people were dead!

Air Pollution
London's killer fog shocked the world and caused major changes in England's air-pollution laws. Although this event is an extreme example, air pollution is common in many parts of the world. But what is air pollution? **Air pollution** is the contamination of the atmosphere by the introduction of pollutants from human and natural sources. Air pollutants are classified according to their source as either primary pollutants or secondary pollutants.

Primary Pollutants
Pollutants that are put directly into the air by human or natural activity are *primary pollutants.* Primary pollutants from natural sources include dust, sea salt, volcanic gases and ash, smoke from forest fires, and pollen. Primary pollutants from human sources include carbon monoxide, dust, smoke, and chemicals from paint and other substances. In urban areas, vehicle exhaust is a common source of primary pollutants. Examples of primary pollutants are shown in **Figure 1.**
Figure 1 Examples of Primary Pollutants

Industrial emissions

Vehicle exhaust

Volcanic ash

Secondary Pollutants

Pollutants that form when primary pollutants react with other primary pollutants or with naturally occurring substances, such as water vapor, are *secondary pollutants.* Ozone and smog are examples of secondary pollutants. Ozone forms when sunlight reacts with vehicle exhaust and air, as shown in **Figure 2.** You may have heard of "Ozone Action Day" warnings in your community. When such a warning is issued, people are discouraged from outdoor physical activity because ozone can damage their lungs. In the stratosphere, ozone forms a protective layer that absorbs harmful radiation from the sun. Near Earth's surface, however, ozone is a dangerous pollutant that negatively affects the health of organisms.

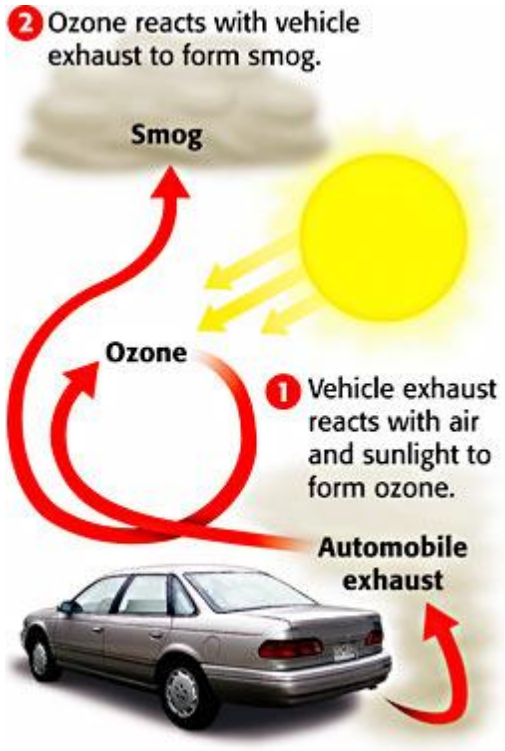


Figure 2 Smog forms when sunlight reacts with ozone and vehicle exhaust.

The Formation of Smog

Smog forms when ozone and vehicle exhaust react with sunlight, as shown in **Figure 2.** Local geography and weather patterns can also contribute to smog formation. Los Angeles, shown in **Figure 3,** is bordered by mountains that restrict the flow of wind and trap pollutants. Although pollution controls have reduced levels of smog in Los Angeles, smog remains a problem for Los Angeles and other large cities.

Figure 3 Smog levels in Los Angeles can vary dramatically. During summer, a layer of warm air can trap smog near the ground. However, in the winter, a storm can quickly clear the air.

Standards Check How does the burning of gasoline by cars contribute to air pollution?

Human-Caused Air Pollution

Human-caused air pollution comes from many sources. A major source of air pollution

today is transportation. Cars contribute about 10% to 20% of the human-caused air pollution in the United States. However, pollution controls and cleaner gasoline have reduced air pollution from automobiles.

Industrial Air Pollution

Many industrial plants and electric power plants burn fossil fuels, such as coal, to produce energy. Burning some kinds of coal without pollution controls can release large amounts of air pollutants. Some industries also produce chemicals that can pollute the air. Oil refineries, chemical manufacturing plants, and other industries are all potential sources of air pollution.

Standards Check How does burning of fuels to produce energy affect air quality?

Indoor Air Pollution

Sometimes, the air inside a building can be more polluted than the air outside. Some sources of indoor air pollution are shown in **Figure 4.** *Ventilation,* or the mixing of indoor air with outdoor air, can lower indoor air pollution. Another way to lower indoor air pollution is to limit the use of chemical solvents and cleaners.

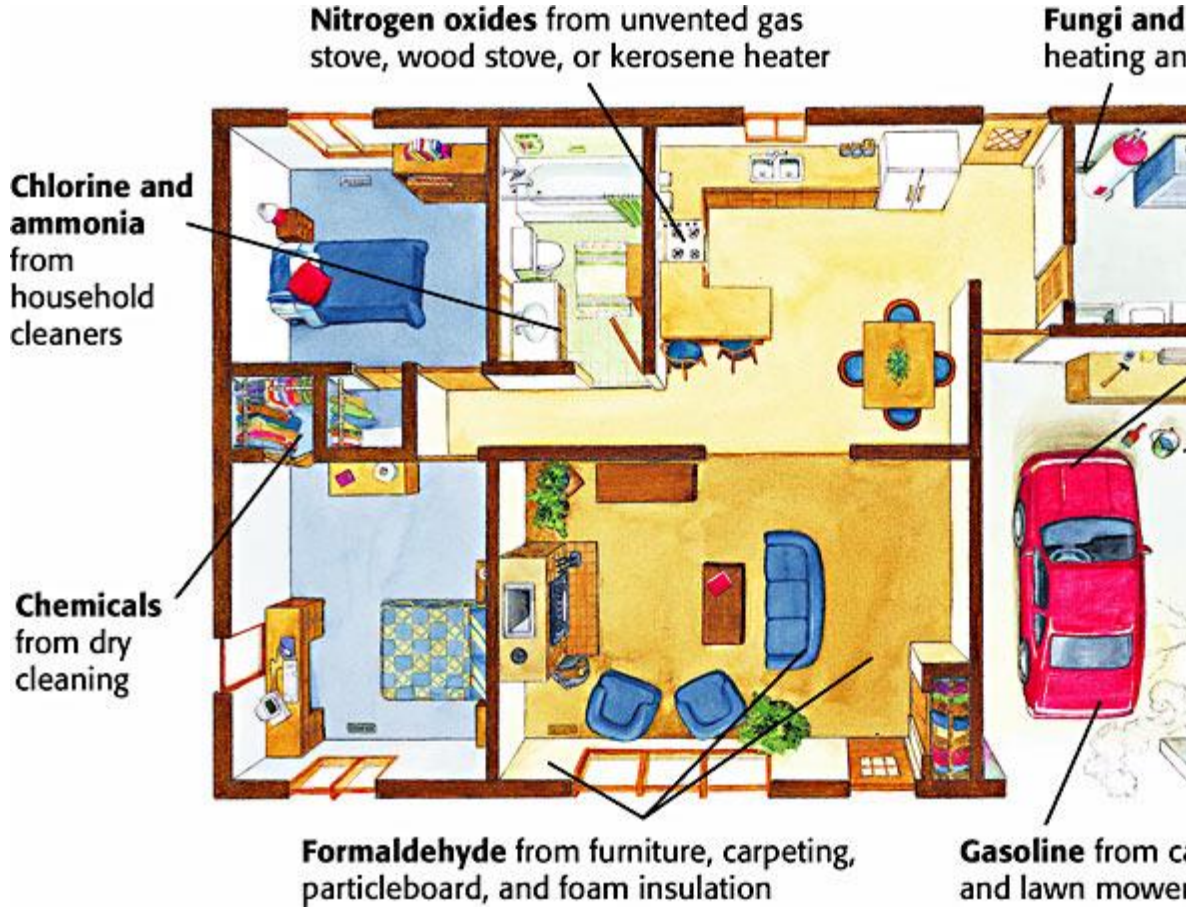


Figure 4 Indoor air pollution can come from many sources.

Acid Precipitation

Precipitation such as rain, sleet, or snow that contains acids from air pollution is called **acid precipitation.** When fossil fuels are burned, they can release sulfur dioxide and nitrogen oxide into the atmosphere. When these pollutants combine with water in the atmosphere, they form sulfuric acid and nitric acid. Precipitation is naturally acidic, but sulfuric acid and nitric acid can make precipitation so acidic that it can

negatively affect the environment. In most areas of the world, pollution controls have helped lower acid precipitation.

Standards Check What causes acid precipitation?

Acid Precipitation and Plants

Plant communities have adapted over long periods of time to the natural acidity of the soil in which they grow. Acid precipitation can cause the acidity of soil to increase. This process, called *acidification,* changes the balance of a soil's chemistry in several ways. When the acidity of soil increases, some nutrients are dissolved. Nutrients that plants need for growth may get washed away by rainwater. Increased acidity also causes aluminum and other toxic metals to be released. Some of these toxic metals are absorbed by the roots of plants.

The Effects of Acid Precipitation on Forests

Forest ecology is complex. Scientists are still trying to fully understand the long-term effects of acid precipitation on groups of plants and their habitats. In some areas of the world, however, acid precipitation has damaged large areas of forest. The effects of acid precipitation are most noticeable in Eastern Europe, as shown in **Figure 5.** Forests in the northeastern United States and in eastern Canada have also been affected by acid precipitation.

Figure 5 This forest in Poland was damaged by acid precipitation.

Acid Precipitation and Aquatic Ecosystems

Aquatic organisms have adapted to live in water that has a particular range of acidity. If acid precipitation increases the acidity of a lake or stream, aquatic plants, fish, and other aquatic organisms may die. The effects of acid precipitation on lakes and rivers are worst in the spring, when the acidic snow that built up in the winter melts and acidic water flows into lakes and rivers. A rapid change in a body of water's acidity is called *acid shock.* Acid shock can cause large numbers of fish to die. Acid shock can also affect the delicate eggs of fish and amphibians.

To reduce the effects of acid precipitation on aquatic ecosystems, some communities spray powdered lime on acidified lakes in the spring. Lime, a base, neutralizes the acid in the water. Unfortunately, lime cannot be spread to offset all acid damage to lakes.

Standards Check What effects can the burning of fossil fuels have on aquatic ecosystems?

The Ozone Hole

In 1985, scientists reported an alarming discovery about Earth's protective ozone layer. Over Antarctica, the ozone layer was thinning, particularly during the spring. This change was also noted over the Arctic Ocean. Chemicals called *CFCs* were causing ozone to break down into oxygen, which does not block the sun's harmful ultraviolet (UV) rays. The thinning of the ozone layer makes an ozone hole, shown in **Figure 6.** The ozone hole allows more UV radiation to reach Earth's surface. UV radiation is dangerous to organisms because it damages genes and can cause skin cancer.

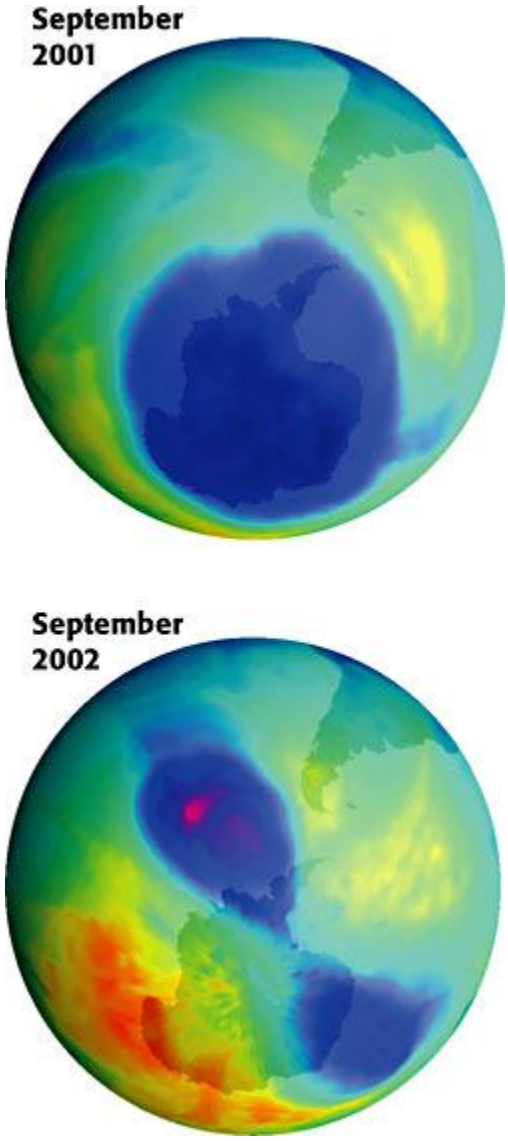


Figure 6 Polar weather conditions cause the size of the ozone hole (shown in blue) to vary.

Cooperation to Reduce the Ozone Hole

In 1987, a group of representatives from several nations met in Canada and agreed to take action to prevent the destruction of the ozone layer. Agreements were made to reduce and eventually ban CFC use, and CFC alternatives were quickly developed. As a result, many people consider ozone protection an environmental success story. The battle to protect the ozone layer is not over, however. CFC molecules can remain active in the stratosphere for 60 to 120 years. So, CFCs released 30 years ago are still

destroying ozone today. Thus, the ozone layer will take many years to completely recover.

Air Pollution and Human Health

Daily exposure to small amounts of air pollution can cause serious health problems. Children and elderly people are especially vulnerable to the effects of air pollution. So are people who have asthma, allergies, lung problems, and heart problems. **Table 1** shows some of the effects of air pollution on the human body. The short-term effects of air pollution are immediately noticeable. Coughing, headaches, and increases in asthma-related problems are only a few short-term effects. The long-term effects of air pollution, such as lung cancer, are more dangerous. Long-term effects may not be noticed until many years after an individual has been exposed to pollutants.

Table 1 Effects of Air Pollution on Human Health

Short-term effects	headache; nausea; irritation of eyes, nose, and throat; coughing; upper respiratory infections; worsening of asthma and emphysema
Long-term effects	emphysema; lung cancer; permanent lung damage; heart disease

Cleaning Up Air Pollution

Much progress has been made in reducing air pollution. For example, in the United States, the Clean Air Act was passed by Congress in 1970 and was strengthened in 1990. The Clean Air Act is a law that gives the Environmental Protection Agency (EPA) the authority to control the amount of air pollutants that can be released from any source, such as cars and factories. The EPA also checks air quality. If air quality worsens, the EPA can set stricter standards.

Controlling Air Pollution from Industry

The Clean Air Act requires many industries to use pollution-control devices such as scrubbers. A *scrubber* is a device that is used to remove some pollutants before they are released by smokestacks. Scrubbers in coal-burning power plants remove particles such as ash from the smoke. Other industrial plants, such as the power plant shown in **Figure 7,** focus on burning fuel more efficiently so that fewer pollutants are released.

Figure 7 This power plant in Florida is leading the way in cleancoal technology. The plant turns coal into a gas before it is burned, so fewer pollutants are released.

The Allowance Trading System

The Allowance Trading System is another initiative to reduce air pollution. In this program, the EPA establishes allowances for the amount of a pollutant that companies can release. A company that releases more than its allowance must pay a fine. A company that releases less than its allowance can sell some of its allowance to a company that releases more. Allowances are also available for the public to buy. So, organizations seeking to reduce air pollution can buy an allowance of 1,000 tons of sulfur dioxide. This purchase reduces the total sulfur dioxide allowances that industries can buy.

Reducing Air Pollution from Vehicles

A large percentage of air pollution in the United States comes from the vehicles we drive. To reduce air pollution from vehicles, the EPA requires car makers to meet a certain standard for vehicle exhaust. Devices such as catalytic converters remove many pollutants from exhaust and help cars meet this standard. Cleaner fuels and more-efficient engines have also helped reduce air pollution from vehicles. Car manufacturers are also making cars that run on fuels other than gasoline. Some of these cars run on hydrogen or natural gas. Hybrid cars, which are becoming more common, use gasoline and electric power to reduce emissions. Other ways to reduce air pollution are to carpool, use public transportation, or bike or walk to your destination, as shown in **Figure 8.**

Figure 8 In Copenhagen, Denmark, companies lend free bicycles in exchange for publicity. The program helps reduce air pollution and automobile traffic.

Section Summary

- Air pollution is the introduction of harmful substances into the air by humans or by natural events.
- Primary pollutants are pollutants that are put directly into the air by human or natural activity.
- Secondary pollutants are pollutants that form when primary pollutants react with other primary pollutants or with naturally occurring substances.
- Transportation, industry, and natural sources are the main sources of air pollution.
- The burning of fossil fuels may lead to air pollution and acid precipitation, which may harm human and wildlife habitats.
- Air pollution can be reduced by legislation, such as the Clean Air Act; by technology, such as scrubbers; and by changes in lifestyle.

Chapter Summary

The Big Idea

Earth's atmosphere is a mixture of gases that absorbs solar energy and enables life on Earth.

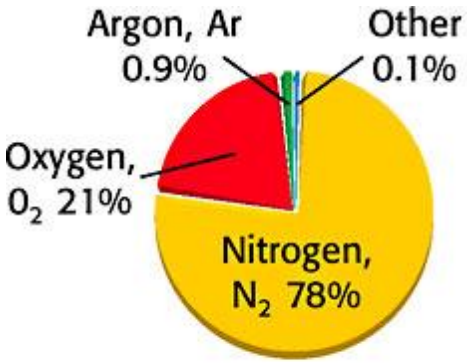
Section 1

Characteristics of the Atmosphere

Key Concept Earth's atmosphere absorbs solar energy and transports energy around Earth's surface.

- Earth's atmosphere is a mixture of gases that

surrounds Earth and absorbs solar radiation.
- Pressure and temperature in the atmosphere change as distance from Earth's surface increases.



Nitrogen is the most common gas in Earth's atmosphere.

Section 2
Atmospheric Heating

Key Concept Heat in Earth's atmosphere is transferred by radiation, conduction, and convection.

- Solar energy travels through space as radiation and passes through the atmosphere to Earth's surface.
- Energy is carried through the atmosphere by radiation, conduction, and convection.

The atmosphere transfers energy by three processes.

Section 3
Air Movement and Wind

Key Concept Global winds and local winds are produced by the uneven heating of Earth's surface.

- Uneven heating of Earth's surface by the sun causes differences in air pressure that cause wind.
- Wind patterns can be global or local and are influenced by the rotation of Earth and by geography.

Winds are part of a global air-circulation pattern.

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- Air pollution is caused by human activities, such as burning fossil fuels, and by natural events, such as volcanic eruptions.
- Air pollution has short-term and long-term

effects on human health.

Smog is a common type of air pollution.