

Climate Change

CALIFORNIA Standards Focus

S 6.4.e Students know differences in pressure, heat, air movement, and humidity result in changes in weather.

How might human activities be affecting the temperature of Earth's atmosphere?

How have human activities affected the ozone layer?

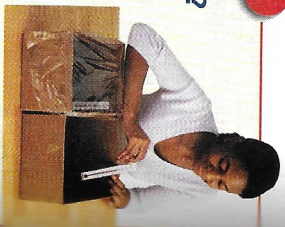
Key Terms

- ice age
- global warming
- greenhouse gas
- ozone hole
- chlorofluorocarbon

Lab Zone Standards Warm-Up

What Is the Greenhouse Effect?

1. Cut two pieces of black construction paper to fit the bottoms of two shoe boxes. Place a thermometer in each box. Record the temperatures on the thermometers. Cover one box with plastic wrap.
2. Place the boxes together where sunlight or a light bulb can shine on them equally. Make sure the thermometers are shaded by the sides of the boxes.
3. Wait 15 minutes and read the thermometers again. Record the temperatures.
4. Think It Over **Inferring** How can you explain any temperature difference between the two boxes?



The amount of energy transferred from the sun to Earth remains nearly constant over time. As a result, Earth's climates tend to be fairly stable for thousands of years. However, climates have gradually changed throughout Earth's history. Over millions of years, warm periods have alternated with cold periods known as **ice ages**. During an ice age, huge sheets of ice called glaciers cover large parts of Earth's surface.

In the past two million years there have been many major ice ages. Each one lasted 100,000 years or longer. Long, warmer periods occurred between the ice ages. Some scientists think that we are now in a warm period between ice ages.

The last ice age ended only about 10,500 years ago. Ice sheets covered much of northern Europe and North America, reaching as far south as present-day Iowa and Nebraska. In some places, the ice was more than 3 kilometers thick. So much water was frozen in the ice sheets that the average sea level was much lower than it is today. When the ice sheets melted, the rising oceans flooded coastal areas. Inland, the Great Lakes and many smaller bodies of water formed.

Video Field Trip

Discovery Channel School
Climate and Climate Change

Global Warming

Most past changes in world climates were caused by natural factors, such as volcanic activity and the motion of the continents. But recently scientists have observed climate changes that may be the result of human activities. For example, over the last 120 years, the average temperature of the troposphere has risen by about 0.7 Celsius degree. This gradual increase in the temperature of Earth's atmosphere is called **global warming**.

The Greenhouse Hypothesis Recall that gases in Earth's atmosphere hold in heat from the sun, keeping the atmosphere at a comfortable temperature for living things. Recall that the process by which gases in Earth's atmosphere trap this energy is called the greenhouse effect. Look at the greenhouse in Figure 22. Notice that sunlight does not heat the air in the greenhouse directly. Instead, sunlight first heats the soil, benches, and pots. Then infrared radiation from these surfaces heats the air in the greenhouse. The greenhouse effect in Earth's atmosphere is similar in some ways.

Gases in the atmosphere that trap energy are called **greenhouse gases**. Carbon dioxide, water vapor, and methane are some of the greenhouse gases. Many scientists have hypothesized that human activities that add greenhouse gases to the atmosphere are warming Earth's atmosphere.



Figure 22

Greenhouse Effect Sunlight enters a greenhouse is absorbed. The interior of the greenhouse radiates back or heat. Much of the heat is trapped and held inside the greenhouse, warming it. **Applying Concepts** What gases in Earth's atmosphere can trap like a greenhouse?

Infrared radiation cannot pass through the greenhouse roof.



FIGURE 23

Ice Core Samples

These scientists are taking an ice core from the glacier that covers Antarctica. Data from ice cores enable scientists to measure changing levels of carbon dioxide in the atmosphere.

Changing Levels of Carbon Dioxide Scientists think

that an increase in carbon dioxide is a major factor in global warming. Until the late 1800s, the level of carbon dioxide in the atmosphere remained about the same. How did scientists determine this? They measured the amount of carbon dioxide in air bubbles trapped in Antarctic ice. They obtained these samples of ancient air from ice cores, as shown in Figure 23. The glacier that covers Antarctica formed over millions of years. Gas bubbles in the ice cores provide samples of air from the time the ice formed.

Is global warming caused by human activities, or does it have a natural cause? Scientists have done a great deal of research to try to answer this question.

Since the late 1800s, the level of carbon dioxide in the atmosphere has increased steadily. Most scientists think that this change is a result of increased human activities. For example, the burning of wood, coal, oil, and natural gas adds carbon dioxide to the air. During the last 100 years, these activities have increased greatly in many different countries. Some scientists predict that the level of carbon dioxide could double by the year 2100. If that happens, then global temperature could rise by 1.5 to 4.5 Celsius degrees.

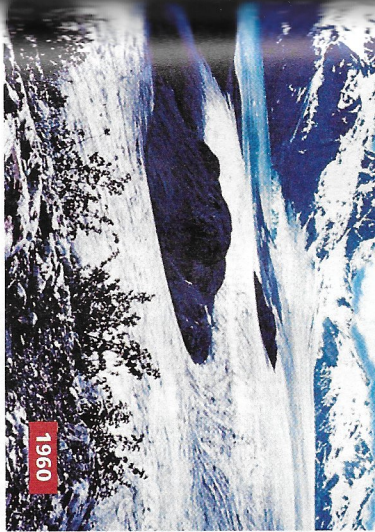
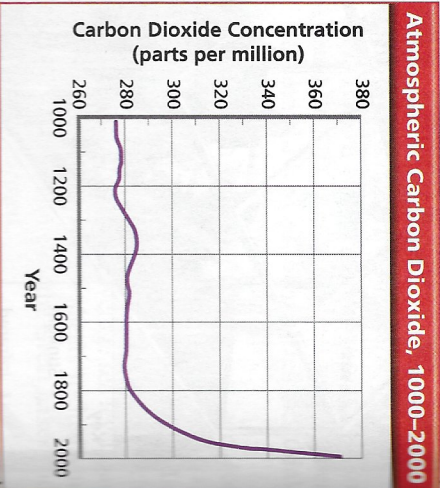
Math Analyzing Data

Math: Algebra and Functions 6.2.0

Carbon Dioxide Levels

The graph shows estimated carbon dioxide levels in the atmosphere over the last 1,000 years.

- Reading Graphs** What variable is shown on the x-axis of the graph? On the y-axis?
- Interpreting Data** What pattern do you see in these data? How would you explain this pattern?
- Interpreting Data** How much did carbon dioxide levels increase between 1800 and 1900? Between 1900 and 2000?
- Predicting** Given the trend in carbon dioxide levels between 1900 and 2000, predict the level of carbon dioxide in the atmosphere in 2100. If your prediction is correct, what might be the result?



Climate Variation Hypothesis Not all scientists agree

about the causes of global warming. Some scientists think that the 0.7 Celsius degree rise in global temperatures over the past 120 years may be due in part to natural variations in climate.

Satellite measurements have shown that the amount of energy the sun produces increases and decreases slightly from year to year. Even such minor changes in solar energy could be causing periods of warmer and cooler climates. Climate change could be a result of changes in both carbon dioxide levels and the amount of solar energy.

Possible Effects Global warming could have some positive effects. Farmers in some areas that are now cool could plant two crops a year instead of one. Places that are too cold for farming today could become farmland. However, many effects of global warming are likely to be less positive. Higher temperatures would cause water to evaporate from exposed soil, such as plowed farmland. Dry soil blows away easily. Thus, some fertile fields might become “dust bowls.”

A rise in temperatures of even a few degrees will warm up water in the oceans. Some scientists think warmer ocean water would increase the strength of hurricanes.

As the water warms, it would expand, raising sea level around the world. The melting of glaciers and polar ice caps could also increase sea level. Sea level has already risen by 10 to 20 centimeters over the last 100 years, and could rise another 25 to 80 centimeters by the year 2100. Even such a small rise in sea level would flood low-lying coastal areas.

Reading Checkpoint What are three possible effects of global warming?

Figure 24

Melting Glaciers

The photos show the glacier in Alaska. The left was taken in 1960, and the right, taken in the large amount of time that has taken place. **Devil Hypotheses** What do you think is responsible for the changes shown in the photos?

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It's Your Skin!


Compare how well sunscreens block out ultraviolet rays.

1. Close the blinds or curtains in the room. Place one square of sun-sensitive paper inside each of three plastic sandwich bags.
2. Place three drops of one sunscreen on the outside of one bag. Spread the sunscreen as evenly as possible. Label this bag with the SPF number of the sunscreen.
3. On another bag, repeat Step 2 using a sunscreen with a different SPF. Wash your hands after spreading the sunscreen. Leave the third bag untreated as a control.
4. Place the bags outside in direct sunlight. Bring them back inside after 3 minutes or after one of the squares turns completely white.

Drawing Conclusions Did both of the sunscreens block ultraviolet radiation? Was one better than the other? Explain.

Ozone Depletion

Another global change in the atmosphere involves the ozone layer. Ozone in the stratosphere filters out much of the harmful ultraviolet radiation from the sun, as shown in Figure 25.

In the 1970s, scientists noticed that the ozone layer over Antarctica was growing thinner each spring. A large area of reduced ozone, or **ozone hole**, was being created. In 2000, the ozone hole reached a record size of more than 28.5 million km²—almost the size of Africa. By 2004, the maximum size of the ozone hole decreased to about 20 million km². What created the ozone hole?  **Chemicals produced by humans have been damaging the ozone layer.**

Chlorofluorocarbons A major cause of ozone depletion is a group of compounds called **chlorofluorocarbons**, or CFCs. CFCs were used in air conditioners and refrigerators, as cleaners for electronic parts, and in aerosol sprays, such as deodorants. Most chemical compounds released into the air eventually break down. CFCs, however, can last for decades and rise all the way to the stratosphere. In the stratosphere, ultraviolet radiation breaks down the CFC molecules into atoms, including chlorine. The chlorine atoms then break ozone down into oxygen atoms.

Results of Ozone Depletion Because ozone blocks ultraviolet radiation, a decrease in ozone means an increase in the amount of ultraviolet radiation that reaches Earth's surface. Ultraviolet radiation can cause eye damage and several kinds of skin cancer.

In the late 1970s, the United States and many other countries banned most uses of CFCs in aerosol sprays. In 1990, many nations agreed to phase out the production and use of CFCs. Because ozone depletion affects the whole world, such agreements must be international to be effective. Worldwide production of the chemicals has greatly decreased. In the United States, at the current rate it will take until 2010 to completely eliminate the use of CFCs. The size of the ozone hole is expected to gradually shrink over time as these agreements take effect.

Reading Checkpoint What are CFCs?

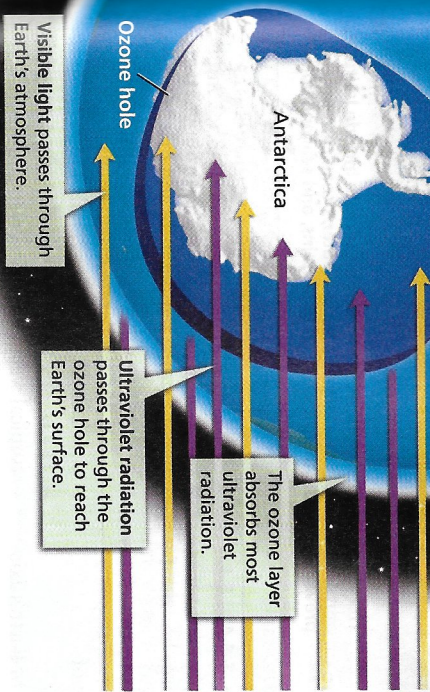
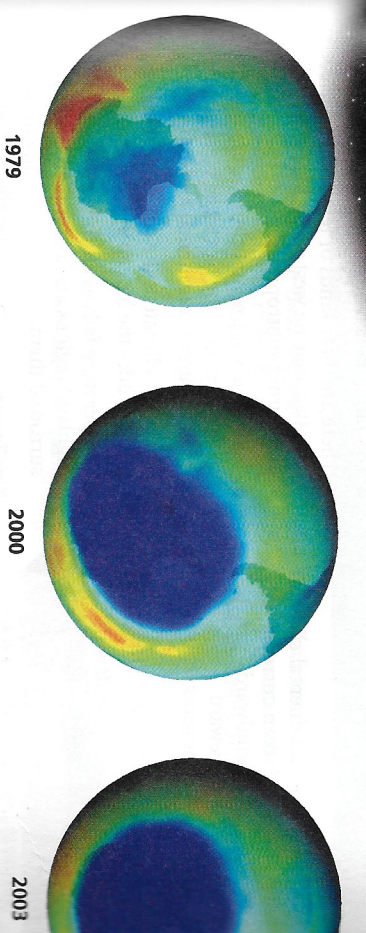


Figure 25
The Ozone Hole
The ozone layer blocks most of the ultraviolet radiation coming from the sun. Visible light passes through the ozone layer. The satellite images below show the concentration of ozone over the South Pole over the past three years. The dark area where the ozone layer is thinnest. **Observing** How has the size of the ozone hole changed over time?



Section 4 Assessment

Vocabulary Skill High-Use Academic Words
Complete the following sentence to show you understand the word *major*. Some major factors that scientists believe are affecting global warming are _____.

Reviewing Key Concepts

1. a. **Defining** What is global warming?
b. **Identifying** What human actions increase the amount of carbon dioxide in the atmosphere?
c. **Relating Cause and Effect** How do scientists think that increased carbon dioxide levels are contributing to global warming?
d. **Inferring** Much of the atmosphere of the planet Venus is made up of carbon dioxide. How do you think this influences the surface temperatures on Venus?

2. a. **Reviewing** What effect have human activities had on the ozone layer?
b. **Summarizing** Summarize the causes of depletion and the steps taken to reverse it.
c. **Relating Cause and Effect** Explain the causes of ozone depletion on human health.

Lab At-Home Activity

Sun Protection Visit a drugstore with a family. Compare the SPF (sun protection factor) of the various sunscreens for sale. Explain why it is important to protect your skin from ultraviolet radiation. Determine the best value for the money in terms of SPF for the price.