SECTION 2

Atmospheric Heating

You are lying in a park. Your eyes are closed, and you feel the warmth of the sun on your face. You may have done this before, but have you ever stopped to think that it takes a little more than eight minutes for the energy that warms your face to travel from a star that is 149,000,000 km away?

READING WARM-UP

Objectives

- Describe what happens to solar energy that reaches Earth.
- Summarize the processes of radiation, conduction, and convection.
- Explain the relationship between the greenhouse effect and global warming.

Terms to Learn

radiation
thermal conduction
convection
global warming
greenhouse effect

READING STRATEGY

Reading Organizer As you read this section, make a table comparing radiation, conduction, and convection.

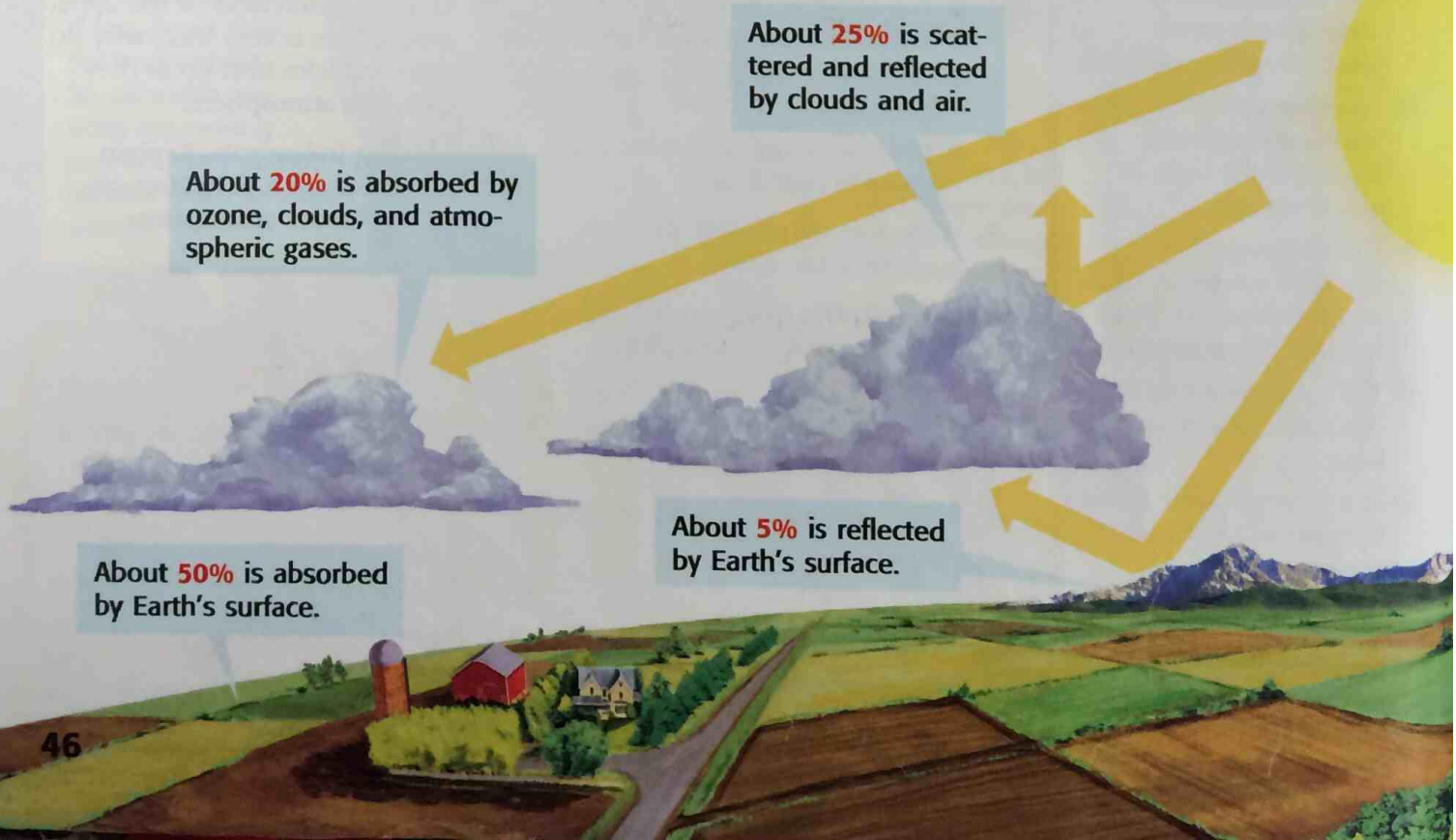
Energy in the Atmosphere

In the scenario above, your face was warmed by energy from the sun. Earth and its atmosphere are also warmed by energy from the sun. In this section, you will find out what happens to solar energy as it enters the atmosphere.

Radiation: Energy Transfer by Waves

The Earth receives energy from the sun by radiation. **Radiation** is the transfer of energy as electromagnetic waves. Although the sun radiates a huge amount of energy, Earth receives only about two-billionths of this energy. But this small fraction of energy is enough to drive the weather cycle and make Earth habitable. **Figure 1** shows what happens to solar energy once it enters the atmosphere.

Figure 1 *Energy from the sun is absorbed by the atmosphere, land, and water and is changed into thermal energy.*



Conduction: Energy Transfer by Contact

If you have ever touched something hot, you have experienced the process of conduction. **Thermal conduction** is the transfer of thermal energy through a material. Thermal energy is always transferred from warm to cold areas. When air molecules come into direct contact with the warm surface of Earth, thermal energy is transferred to the atmosphere.

Convection: Energy Transfer by Circulation

If you have ever watched a pot of water boil, you have observed convection. **Convection** is the transfer of thermal energy by the circulation or movement of a liquid or gas. Most thermal energy in the atmosphere is transferred by convection. For example, as air is heated, it becomes less dense and rises. Cool air is denser, so it sinks. As the cool air sinks, it pushes the warm air up. The cool air is eventually heated by the Earth's surface and begins to rise again. This cycle of warm air rising and cool air sinking causes a circular movement of air, called a *convection current,* as shown in **Figure 2.**

Reading Check **How do differences in air density cause convection currents?** (*See the Appendix for answers to Reading Checks.*)

radiation the transfer of energy as electromagnetic waves

thermal conduction the transfer of energy as heat through a material

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

Figure 2 *The processes of radiation, thermal conduction, and convection heat Earth and its atmosphere.*

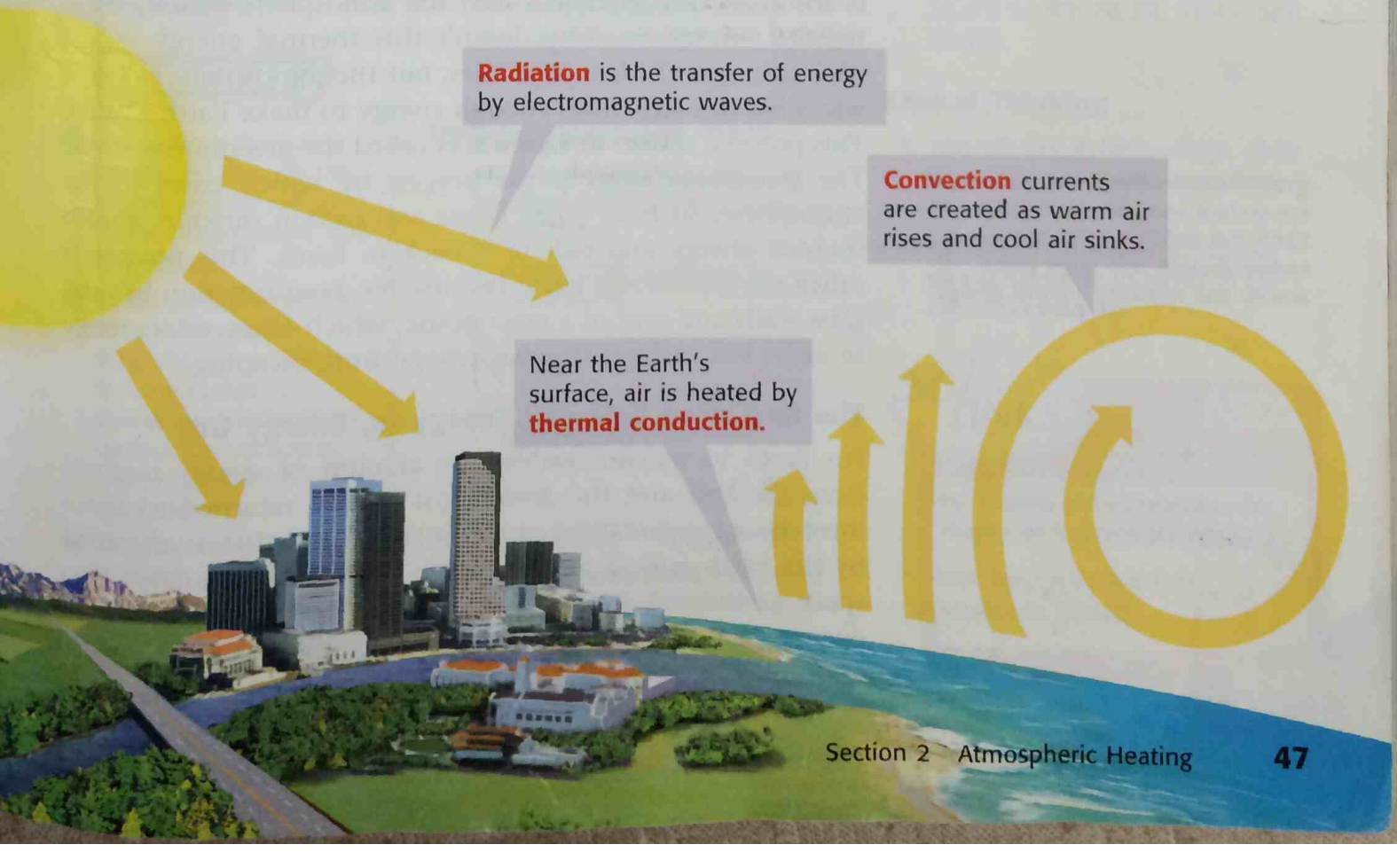
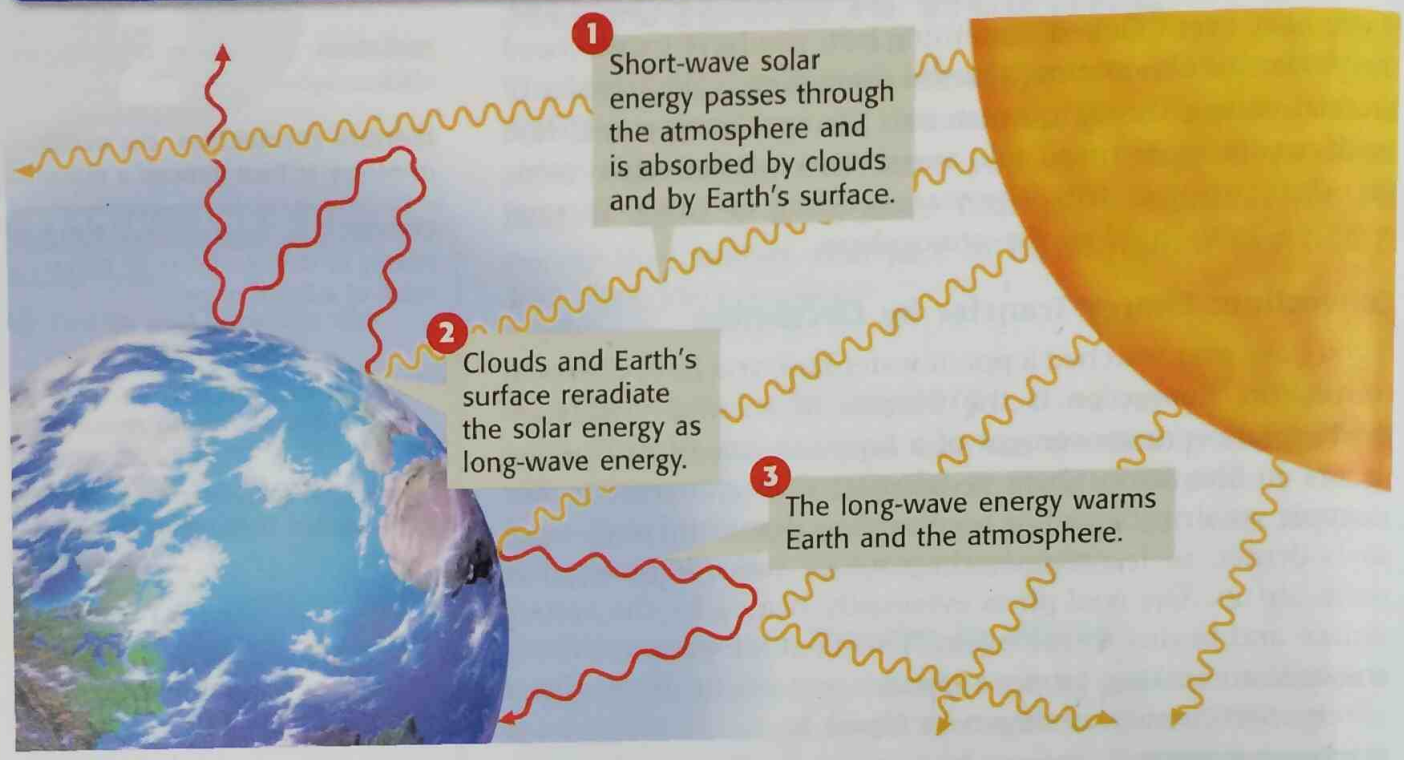


Figure 3 The Greenhouse Effect



The Greenhouse Effect and Life on Earth

As you have learned, about 70% of the radiation that enters Earth's atmosphere is absorbed by clouds and by the Earth's surface. This energy is converted into thermal energy that warms the planet. In other words, short-wave visible light is absorbed and reradiated into the atmosphere as long-wave thermal energy. So, why doesn't this thermal energy escape back into space? Most of it does, but the atmosphere is like a warm blanket that traps enough energy to make Earth livable. This process, shown in **Figure 3,** is called the greenhouse effect. The **greenhouse effect** is the process by which gases in the atmosphere, such as water vapor and carbon dioxide, absorb thermal energy and radiate it back to Earth. This process is called the greenhouse effect because the gases function like the glass walls and roof of a greenhouse, which allow solar energy to enter but prevent thermal energy from escaping.

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

The Radiation Balance: Energy In, Energy Out

For Earth to remain livable, the amount of energy received from the sun and the amount of energy returned to space must be approximately equal. Solar energy that is absorbed by the Earth and its atmosphere is eventually reradiated into space as thermal energy. Every day, the Earth receives more energy from the sun. The balance between incoming energy and outgoing energy is known as the *radiation balance.*

Greenhouse Gases and Global Warming

Many scientists have become concerned about data that show that average global temperatures have increased in the past 100 years. Such an increase in average global temperatures is called **global warming.** Some scientists have hypothesized that an increase of greenhouse gases in the atmosphere may be the cause of this warming trend. Greenhouse gases are gases that absorb thermal energy in the atmosphere.

global warming a gradual increase in average global temperature

Human activity, such as the burning of fossil fuels and deforestation, may be increasing levels of greenhouse gases, such as carbon dioxide, in the atmosphere. If this hypothesis is correct, increasing levels of greenhouse gases may cause average global temperatures to continue to rise. If global warming continues, global climate patterns could be disrupted. Plants and animals that are adapted to live in specific climates would be affected. However, climate models are extremely complex, and scientists continue to debate whether the global warming trend is the result of an increase in greenhouse gases.

Reading Check What is a greenhouse gas?

SECTION Review

Summary

- Energy from the sun is transferred through the atmosphere by radiation, thermal conduction, and convection.
- Radiation is energy transfer by electromagnetic waves. Thermal conduction is energy transfer by direct contact. Convection is energy transfer by circulation.
- The greenhouse effect is Earth's natural heating process. Increasing levels of greenhouse gases could cause global warming.

Using Key Terms

1. Use each of the following terms in a separate sentence: *thermal conduction, radiation, convection, greenhouse effect,* and *global warming.*

Understanding Key Ideas

2. Which of the following is the best example of thermal conduction?
   - **a.** a light bulb warming a lampshade
   - **b.** an egg cooking in a frying pan
   - **c.** water boiling in a pot
   - **d.** gases circulating in the atmosphere
3. Describe three ways that energy is transferred in the atmosphere.
4. What is the difference between the greenhouse effect and global warming?
5. What is the radiation balance?

Math Skills

6. Find the average of the following temperatures: 73.2°F, 71.1°F, 54.6°F, 65.5°F, 78.2°F, 81.9°F, and 82.1°F.

Critical Thinking

7. **Identifying Relationships** How does the process of convection rely on radiation?
8. **Applying Concepts** Describe global warming in terms of the radiation balance.

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