Earth's Atmosphere

Energy Transfer in the Atmosphere

Before You Read

What do you think? Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.

Before	Statement	After
	3. All the energy from the Sun reaches Earth's surface.	
	4. Earth emits energy back into the atmosphere.	

Read to Learn

Energy from the Sun

The Sun's energy reaches Earth through the process of radiation. **Radiation** *is the transfer of energy by electromagnetic waves*. Ninety-nine percent of the radiant energy from the Sun consists of visible light, ultraviolet light, and infrared radiation.

Visible Light

Most sunlight is visible light. Visible light is light that you can see. Visible light passes through Earth's atmosphere. At Earth's surface, the Sun's energy is converted to thermal energy, commonly called heat.

Near-Visible Wavelengths

Ultraviolet (UV) light and infrared radiation (IR) are two other forms of radiant energy from the Sun. The wavelengths of UV and IR are just beyond the range of visibility to human eyes. UV light has short wavelengths and can break chemical bonds. A large dose of UV light will burn human skin and can cause skin cancer. Infrared radiation (IR) has longer wavelengths than visible light. You can feel IR as thermal energy or warmth. Earth absorbs energy from the Sun, and then it is radiated back as IR.

Key Concepts

- How does energy transfer from the Sun to Earth and to the atmosphere?
- How are air circulation patterns within the atmosphere created?

Study Coach

K-W-L Fold a sheet of paper to form three columns. In the first column, write what you already know about energy transfer. In the second column, write what you want to know. In the third column, write what you have learned from reading this lesson.

Reading Check

1. Contrast What is the difference between visible light and ultraviolet light?

Energy on Earth

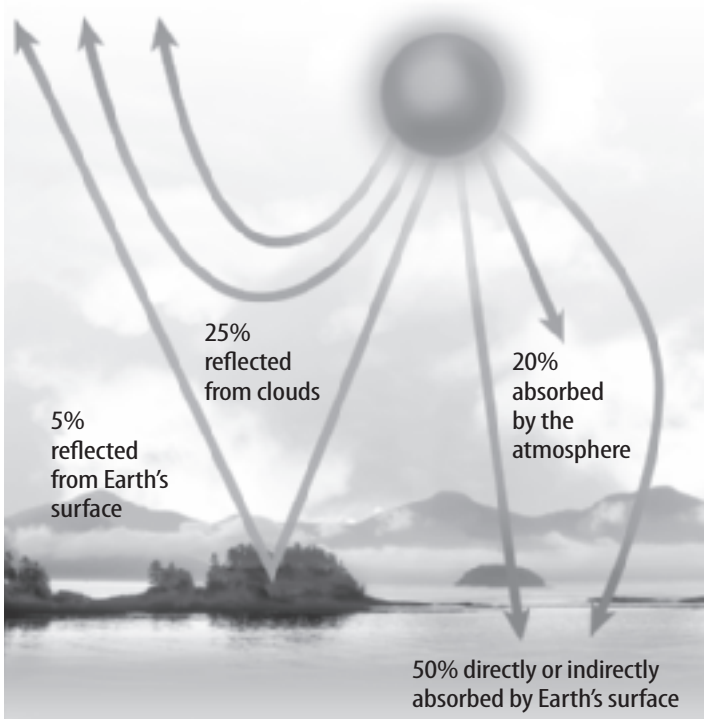
As the Sun's energy passes through the atmosphere, some of it is absorbed, or taken in, by gases and particles. Some of it is reflected back into space. As a result, not all of the energy coming from the Sun reaches Earth's surface.

Absorption

Look at the figure below. Gases and particles in the atmosphere absorb about 20 percent of incoming solar radiation. Oxygen, ozone, and water vapor all absorb ultraviolet light. Water and carbon dioxide in the troposphere aborb some infrared radiation from the Sun. Earth's atmosphere does not absorb visible light. Visible light must be converted to infrared radiation before it can be absorbed.

Reflection

Look again at the figure below. Bright surfaces, especially clouds, reflect radiation as it enters the atmosphere. Clouds and other small particles in the air reflect about 25 percent of the Sun's radiation. Some of the radiation travels to Earth's surface. There, land and sea surfaces reflect it back. About 30 percent of all radiation that enters the atmosphere reflects back into space. If 30 percent of the incoming radiation reflects back into space and the atmosphere absorbs 20 percent, only about 50 percent of incoming solar radiation reaches Earth. Earth's surface then absorbs it.



SCIENCE USE V. COMMON USE

reflect

Science Use to return light, heat, sound, and so on, after it strikes a surface

Common Use to think quietly and calmly

Think it Over

2. Express What is the total percentage of radiation that is reflected by Earth's atmosphere?

Visual Check

3. Identify What percent of incoming radiation is absorbed by gases and particles in the atmosphere? (Circle the correct answer.)

a. 20 percent

b. 25 percent

c. 50 percent

Radiation Balance

The Sun's radiation warms Earth. So why doesn't Earth get hotter and hotter? Over time, there is a balance between the amount of radiation that comes in from the Sun and the amount of radiation that leaves Earth.

The land, water, plants, and other organisms absorb solar radiation that reaches Earth's surface. After absorbing radiation, Earth reradiates, or bounces, it back into the outer atmosphere. The radiation from Earth is mostly in the form of infrared radiation (IR). The amount of radiation Earth receives from the Sun is the same amount Earth radiates back up into the atmosphere. Earth absorbs the Sun's energy and radiates it away until a balance is achieved.

Reading Check

4. Cause and Effect Why doesn't Earth get hotter as it continues to receive radiation from the Sun?

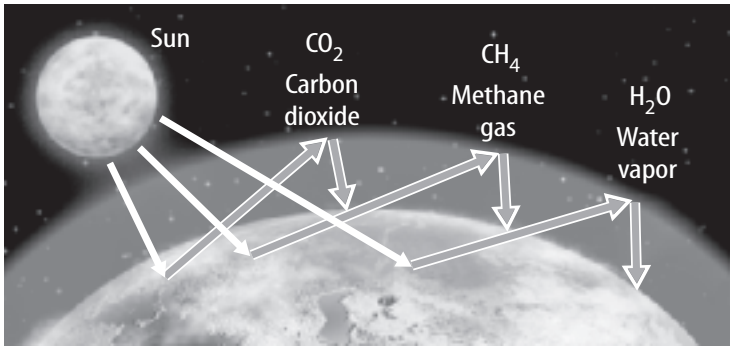
The Greenhouse Effect

The figure below shows how light passes through the glass of a greenhouse. The glass converts the light to infrared energy. The glass also stops the IR from escaping and it warms the greenhouse.

Some of the gases in Earth's atmosphere act like the glass of a greenhouse. These gases are called greenhouse gases. The gases let sunlight pass through, but they stop IR energy from escaping. When gases in Earth's atmosphere direct radiation back toward Earth's surface, this warms Earth's atmosphere more than normal. This is known as the greenhouse effect. The gases that trap IR best are water vapor (H_2O), carbon dioxide (CO_2), and methane (CH_4).

Reading Check

5. Describe What causes the greenhouse effect?

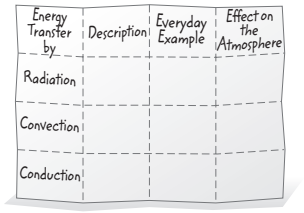


Visual Check

6. Name three of Earth's greenhouse gases.

FOLDABLES®

Make a four-column, four-row table. Use it to organize information about thermal energy transfer.



Key Concept Check

7. Identify How does energy transfer from the Sun to Earth and the atmosphere?

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Visual Check

8. Explain What happens to water when heat energy is absorbed? (Circle the correct answer.)

a. Ice melts.

b. Liquid water freezes.

c. Water vapor condenses.

Thermal Energy Transfer

Recall that there are three types of thermal energy transfer—radiation, conduction, and convection. All three types of transfer occur in the atmosphere. Radiation is the process that transfers energy from the Sun to Earth.

Conduction

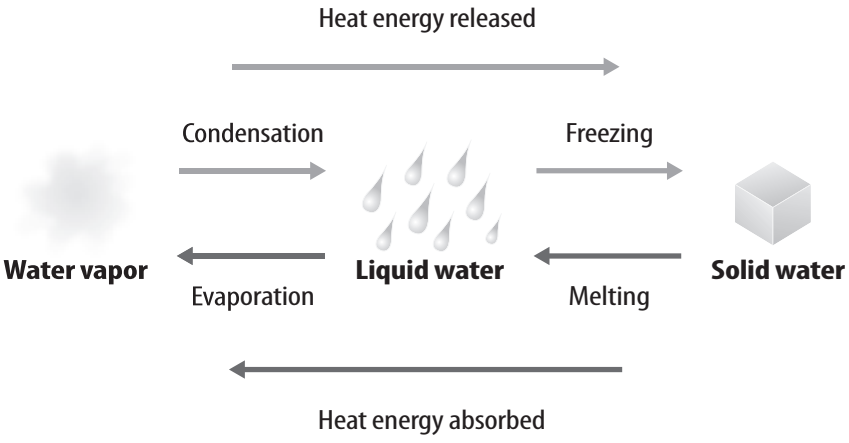
Thermal energy always moves from an object with a higher temperature to an object with a lower temperature. **Conduction** *is the transfer of thermal energy by collisions between particles of matter*. Particles must be close enough to touch to transfer energy by conduction. If you touched a pot of boiling water, thermal energy from the pot would move to your hand by conduction. Conduction occurs where the atmosphere touches Earth.

Convection

As molecules of air close to Earth's surface heat, they spread apart, and air becomes less dense. Less-dense air rises and transfers thermal energy to higher altitudes. *The transfer of thermal energy by the movement of matter from one place to another is called* **convection.** Convection occurs in the atmosphere when conduction heats air close to Earth's surface.

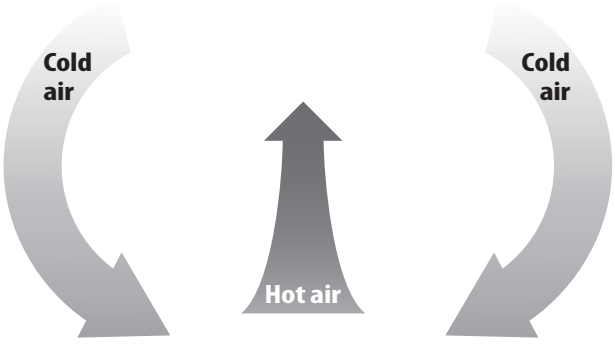
Latent Heat

More than 70 percent of Earth's surface is covered by water. Water is the only substance that can exist as a solid, a liquid, and a gas within Earth's temperature ranges. Latent heat is the heat energy released or absorbed during the phase changes of water. When water changes from one phase to another, latent heat is exchanged also, as shown in the figure below. Like other forms of heat transfer, latent heat energy is transferred from Earth's surface to the atmosphere.



Circulating Air

You've already read that energy transfers through the atmosphere by convection. On a hot day, air that is heated becomes less dense. This creates a pressure difference. Cool, denser air pushes the warm air out of the way. The more-dense air replaces the warm air, as shown in the figure below. The warm air is often pushed upward. Warmer, rising air always comes with cooler, sinking air.



Air constantly moves in the atmosphere. For example, wind flowing into a mountain range rises and flows over the mountains. After the air reaches the top, it sinks on the other side. This up-and-down motion sets up an atmospheric condition called a mountain wave. The rising air within mountain waves can create saucer-shaped, or lenticular (len TIH kyuh lur), clouds. Circulating air affects weather and climates around the world.

Stability

When you stand outside in the wind, your body forces some of the air to move above you. The same is true for plants, hills, cars, and buildings. Conduction and convection also cause air to move upward. **Stability** *describes whether circulating air motions will be strong or weak*. When air is unstable, circulating motions are strong. When air is stable, circulating motions are weak.

Unstable Air and Thunderstorms Unstable conditions often occur on warm, sunny afternoons. During unstable conditions, air near the ground is much warmer than air at higher altitudes. As warm air rapidly rises, it cools in the atmosphere. Large, tall clouds form. Latent heat released as water vapor changes from a gas to a liquid, adds to the instability, and produces a thunderstorm.

Visual Check

9. Describe what is happening in the figure.

Key Concept Check

10. Explain How are air circulation patterns within the atmosphere created?

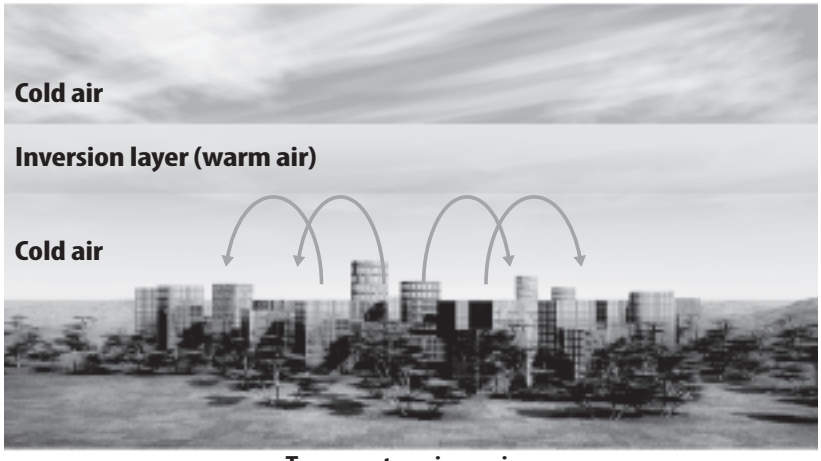
Reading Check

11. Contrast How are circulating air motions different in stable and unstable air?

Stable Air and Temperature Inversions Sometimes, air near the ground is nearly the same temperature as air at higher altitudes. When this happens, the air is stable, and circulating motions are weak. A temperature inversion can take place under these conditions. *A* **temperature inversion** *occurs in the troposphere when temperature increases as altitude increases*.

The first figure below shows normal temperature conditions. The second figure shows a temperature inversion. During a temperature inversion, a layer of cooler air close to Earth is trapped by a layer of warm air above it. Temperature inversions prevent air from mixing. This can trap pollution in the air close to Earth's surface.

Normal conditions



Temperature inversion

Visual Check

12. Contrast How do conditions during a temperature inversion differ from normal conditions?