Lesson 2

Energy Transfer in the Atmosphere

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

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

Vocabulary

radiation p. 418

conduction p. 421

convection p. 421

stability p. 422

temperature inversion p. 423

Multilingual eGlossary

What's really there?

Mirages are created as light passes through layers of air that have different temperatures. How does energy create the reflections? What other effects does energy have on the atmosphere?

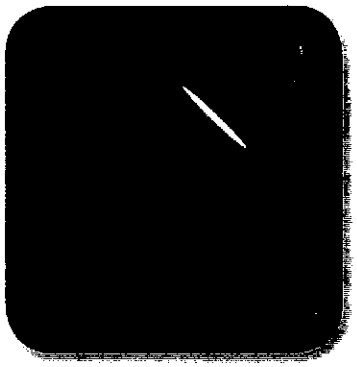
Launch Lab

15 minutes

What happens to air as it warms?

Light energy from the Sun is converted to thermal energy on Earth. Thermal energy powers the weather systems that impact your everyday life.

1. Read and complete a lab safety form.
2. Turn on a **lamp** with an incandescent lightbulb.
3. Place your hands under the light near the lightbulb. What do you feel?
4. Dust your hands with **powder.**
5. Place your hands below the lightbulb and clap them together once.
6. Observe what happens to the particles.



Think About This

1. How might the energy in step 3 move from the lightbulb to your hand?
2. How did the particles move when you clapped your hands?
3. **Key Concept** How did particle motion show you how the air was moving?

ACADEMIC VOCABULARY

process
(noun) an ordered series of actions

Energy from the Sun

The Sun's energy travels 148 million km to Earth in only 8 minutes. How does the Sun's energy get to Earth? It 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

The majority of sunlight is visible light. Recall that visible light is light that you can see. The atmosphere is like a window to visible light, allowing it to pass through. At Earth's surface it is converted to thermal energy, commonly called heat.

Near-Visible Wavelengths

The wavelengths of ultraviolet (UV) light and infrared radiation (IR) are just beyond the range of visibility to human eyes. UV light has short wavelengths and can break chemical bonds. Excess exposure to UV light will burn human skin and can cause skin cancer. Infrared radiation (IR) has longer wavelengths than visible light. You can sense IR as thermal energy or warmth. Earth absorbs energy from the Sun and then radiates it into the atmosphere as IR.

Reading Check Contrast visible light and ultraviolet light.

Energy on Earth

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

Absorption

Study **Figure 8.** Gases and particles in the atmosphere absorb about 20 percent of incoming solar radiation. Oxygen, ozone, and water vapor all absorb incoming ultraviolet light. Water and carbon dioxide in the troposphere absorb 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

Bright surfaces, especially clouds, reflect incoming radiation. Study **Figure 8** again. Clouds and other small particles in the air reflect about 25 percent of the Sun's radiation. Some radiation travels to Earth's surface and is then reflected by land and sea surfaces. Snow-covered, icy, or rocky surfaces are especially reflective. As shown in **Figure 8,** this accounts for about 5 percent of incoming radiation. In all, about 30 percent of incoming radiation is reflected into space. This means that, along with the 20 percent of incoming radiation that is absorbed in the atmosphere, Earth's surface only receives and absorbs about 50 percent of incoming solar radiation.

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

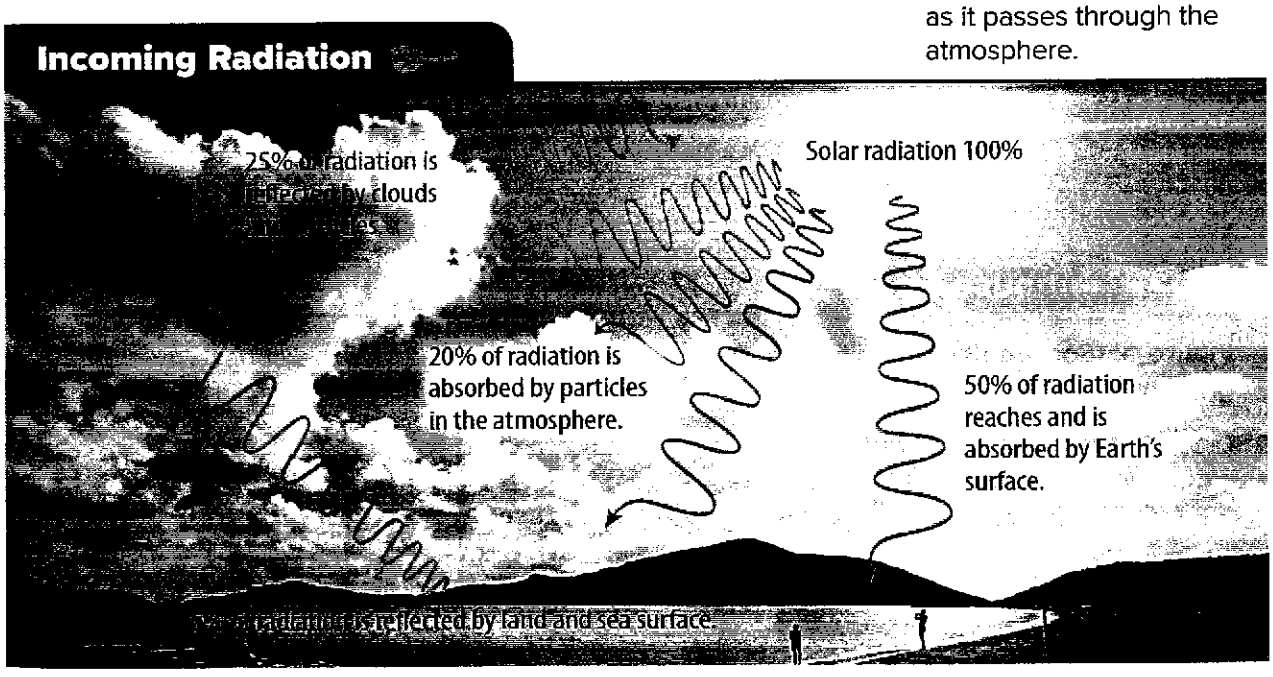
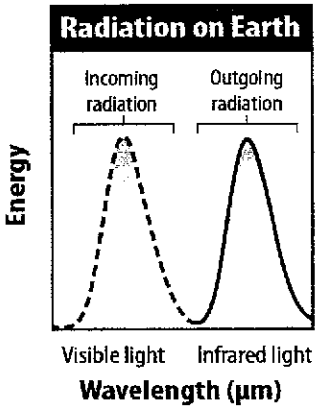


Figure 8 Some of the energy from the Sun is reflected or absorbed as it passes through the atmosphere.

Visual Check What percent of incoming radiation is absorbed by gases and particles in the atmosphere?

Hutchings Photography/Digital Light Source
Eric James/Alamy



▲ **Figure 9** The amount of solar energy absorbed by Earth and its atmosphere is equal to the amount of energy Earth radiates back into space.

Radiation Balance

The Sun's radiation heats Earth. So, why doesn't Earth get hotter and hotter as it continues to receive radiation from the Sun? There is a balance between the amount of incoming radiation from the Sun and the amount of outgoing radiation from Earth.

The land, water, plants, and other organisms absorb solar radiation that reaches Earth's surface. The radiation absorbed by Earth is then re-radiated, or bounced back, into the atmosphere. Most of the energy radiated from Earth is infrared radiation, which heats the atmosphere. **Figure 9** shows that the amount of radiation Earth receives from the Sun is the same as the amount Earth radiates into the outer atmosphere. Earth absorbs the Sun's energy and then radiates that energy away until a balance is achieved.

The Greenhouse Effect

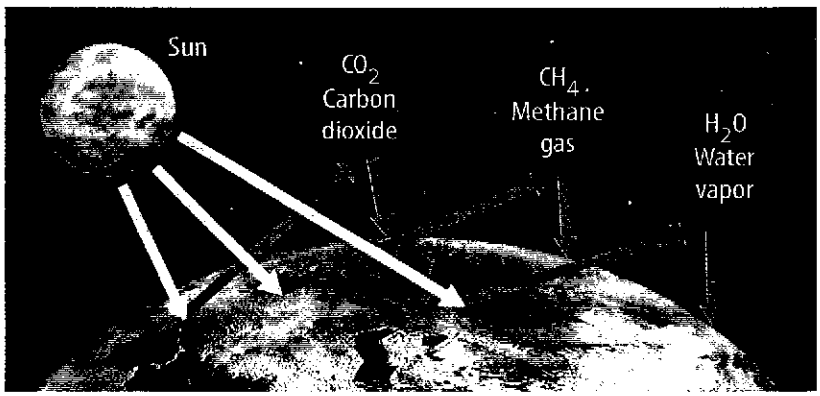
As shown in **Figure 10,** the glass of a greenhouse allows light to pass through, where it is converted to infrared energy. The glass prevents the IR from escaping and it warms the greenhouse. Some of the gases in the atmosphere, called greenhouse gases, act like the glass of a greenhouse. They allow sunlight to pass through, but they prevent some of Earth's IR energy from escaping. Greenhouse gases in Earth's atmosphere trap IR and direct it back to Earth's surface. This causes an additional buildup of thermal energy at Earth's surface. The gases that trap IR best are water vapor (H_2O), carbon dioxide (CO_2), and methane (CH_4).

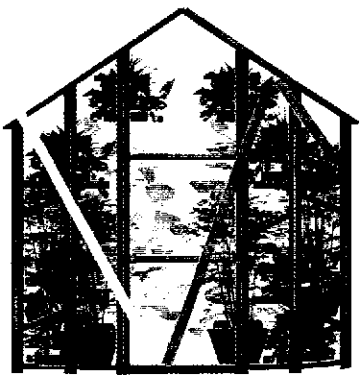
Reading Check Describe the greenhouse effect.

The Greenhouse Effect

Animation

Figure 10 Some of the outgoing radiation is directed back toward Earth's surface by greenhouse gases.





Thermal Energy Transfer

Recall that there are three types of thermal energy transfer–radiation, conduction, and convection. All three occur in the atmosphere. Recall that 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. Touching the pot of water, shown in **Figure 11,** would transfer energy from the pot to your hand. Conduction occurs where the atmosphere touches Earth.

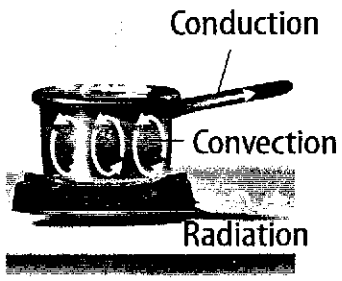
Convection

As molecules of air close to Earth's surface are heated by conduction, they spread apart, and air becomes less dense. Less dense air rises, transferring thermal energy to higher altitudes. *The transfer of thermal energy by the movement of particles within matter is called* **convection.** Convection can be seen in **Figure 11** as the boiling water circulates and steam rises.

Latent Heat

More than 70 percent of Earth's surface is covered by a highly unique substance–water! Water is the only substance that can exist as a solid, a liquid, and a gas within Earth's temperature ranges. Recall that latent heat is exchanged when water changes from one phase to another, as shown in **Figure 12.** Latent heat energy is transferred from Earth's surface to the atmosphere.

Key Concept Check How does energy transfer from the Sun to Earth and the atmosphere?



Personal Tutor

▲ **Figure 11** Energy is transferred through conduction, convection, and radiation.

WORD ORIGIN

conduction
from Latin *conducere,* means "to bring together"

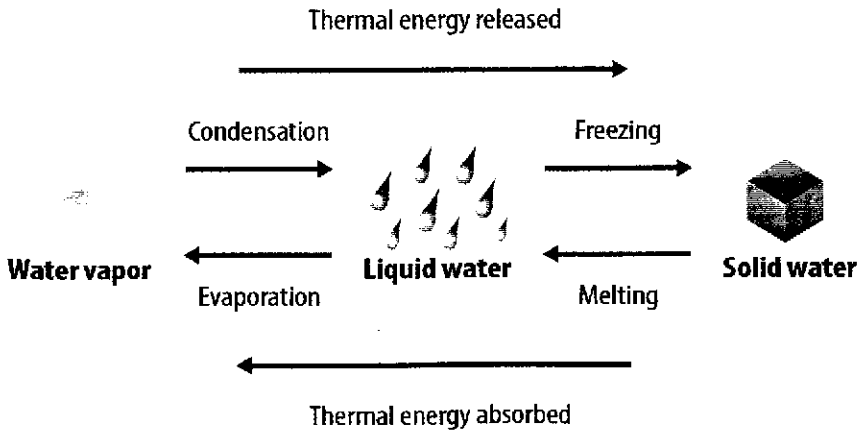


Figure 12 Water releases or absorbs thermal energy during phase changes.

FOLDABLES®

Fold a sheet of paper to make a four-column, four-row table and label as shown. Use it to record information about thermal energy transfer.

Energy Transfer by...	Description	Everyday Example	Effect on the Atmosphere
Radiation			
Convection			
Conduction			

Figure 13 Rising warm air is replaced by cooler, denser air that sinks beside it.

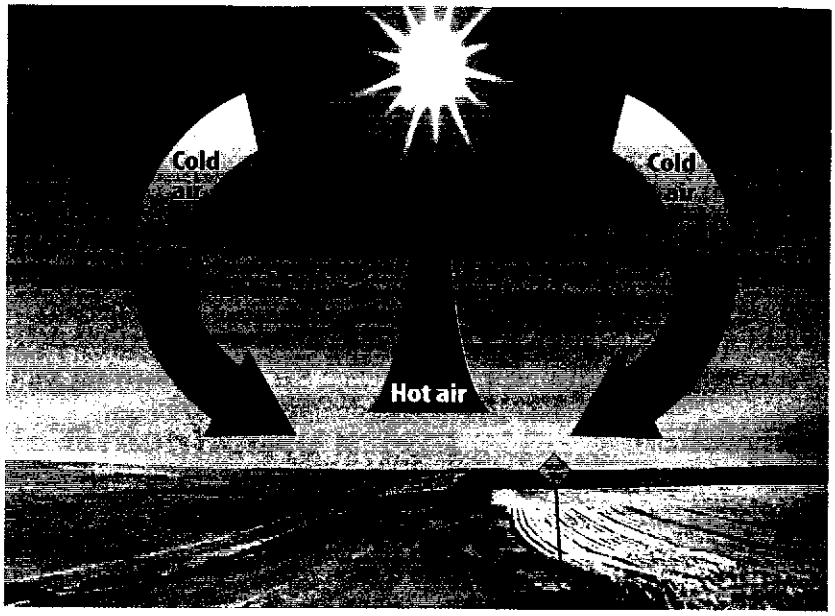
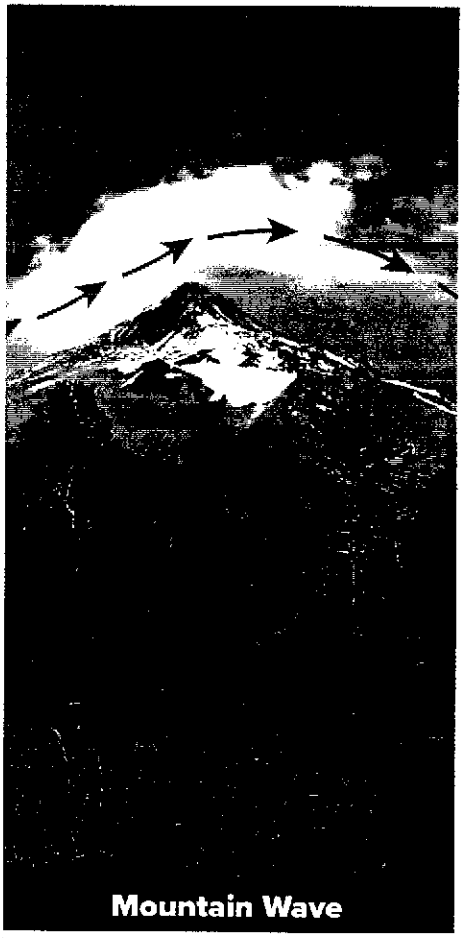


Figure 14 Lens-shaped lenticular clouds form when air rises with a mountain wave. ▼


Mountain Wave

Circulating Air

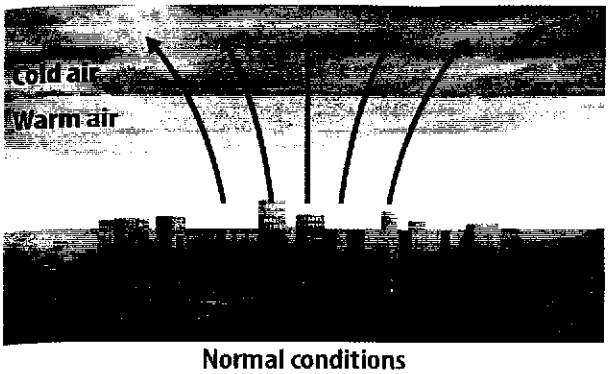
You've read that energy is transferred through the atmosphere by convection. On a hot day, air that is heated becomes less dense. This creates a pressure difference. Cool, denser air pushes the warm air out of the way. The warm air is replaced by the more dense air, as shown in **Figure 13.** The warm air is often pushed upward. Warmer, rising air is always accompanied by cooler, sinking air.

Air is constantly moving. For example, wind flowing into a mountain range rises and flows over it. After reaching the top, the air sinks. This up-and-down motion sets up an atmospheric phenomenon called a mountain wave. The upward moving air within mountain waves creates lenticular (len TIH kyuh lur) clouds, shown in **Figure 14.** Circulating air affects weather and climate around the world.

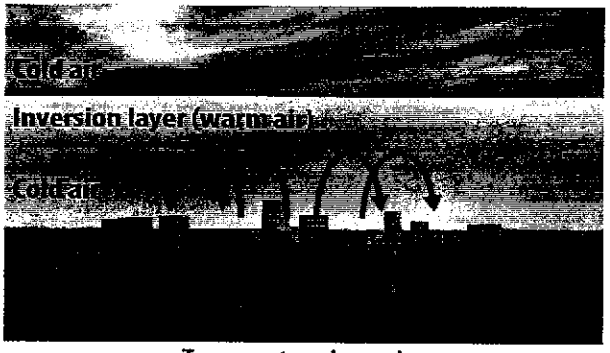
Key Concept Check How are air circulation patterns within the atmosphere created?

Stability

When you stand in the wind, your body forces some of the air to move above you. The same is true for hills 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. During stable conditions, circulating motions are weak.



Normal conditions



Temperature inversion

Figure 15 A temperature inversion occurs when cooler air is trapped beneath warmer air.

Visual Check How do conditions during a temperature inversion differ from normal conditions?

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

Reading Check Relate unstable air to the formation of thunderstorms.

Stable Air and Temperature Inversions Sometimes ground-level air is nearly the same temperature as higher-altitude air. During these conditions, the air is stable, and circulating motions are weak. A temperature inversion can occur under these conditions. *A* **temperature inversion** *occurs in the troposphere when temperature increases as altitude increases.* During a temperature inversion, a layer of cooler air is trapped by a layer of warmer air above it, as shown in **Figure 15.** Temperature inversions prevent air from mixing and can trap pollution in the air close to Earth's surface.

MiniLab

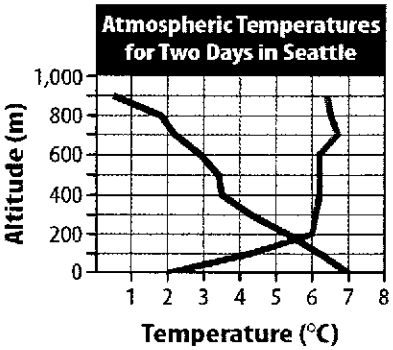
20 minutes

Can you identify a temperature inversion?

You've read that a temperature inversion is a reversal of normal temperature conditions in the troposphere. What do data from a temperature inversion look like on a graph?

Analyze and Conclude

1. **Describe** the information presented in the graph. How do the graph's lines differ?
2. **Analyze** Which graph line represents normal conditions in the troposphere? Which represents a temperature inversion? Explain your answers in your Science Journal.
3. **Key Concept** From the graph, what pattern does a temperature inversion have?

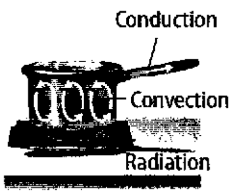


Lesson 2 Review

Online Quiz

Visual Summary

Not all radiation from the Sun reaches Earth's surface.



Thermal energy transfer in the atmosphere occurs through radiation, conduction, and convection.

Temperature inversion

Temperature inversions prevent air from mixing and can trap pollution in the air close to Earth's surface.

FOLDABLES

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think NOW?

You first read the statements below at the beginning of the chapter.

3. All of the energy from the Sun reaches Earth's surface.

4. Earth emits energy back into the atmosphere.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

1 The property of the atmosphere that describes whether circulating air motions will be strong or weak is called ________.

2 **Define** *conduction* in your own words.

3 ________ is the transfer of thermal energy by the movement of particles within matter.

Understand Key Concepts

4 Which statement is true?

A. The Sun's energy is completely blocked by Earth's atmosphere.

B. The Sun's energy passes through the atmosphere without warming it significantly.

C. The Sun's IR energy is absorbed by greenhouse gases.

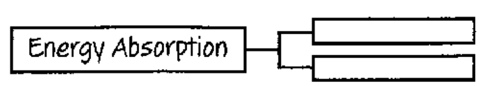
D. The Sun's energy is primarily in the UV range.

5 **Distinguish** between conduction and convection.

Interpret Graphics

6 **Explain** how greenhouses gases affect temperatures on Earth.

7 **Sequence** Copy and fill in the graphic organizer below to describe how energy from the Sun is absorbed in Earth's atmosphere.



Critical Thinking

8 **Suggest** a way to keep a parked car cool on a sunny day.

9 **Relate** temperature inversions to air stability.