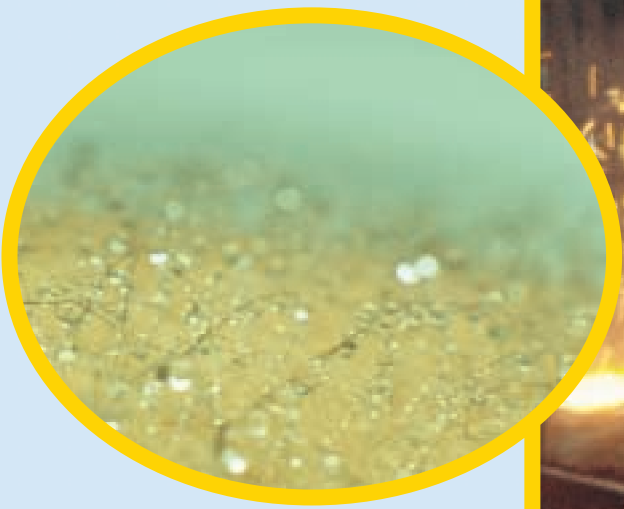
CHAPTER 6

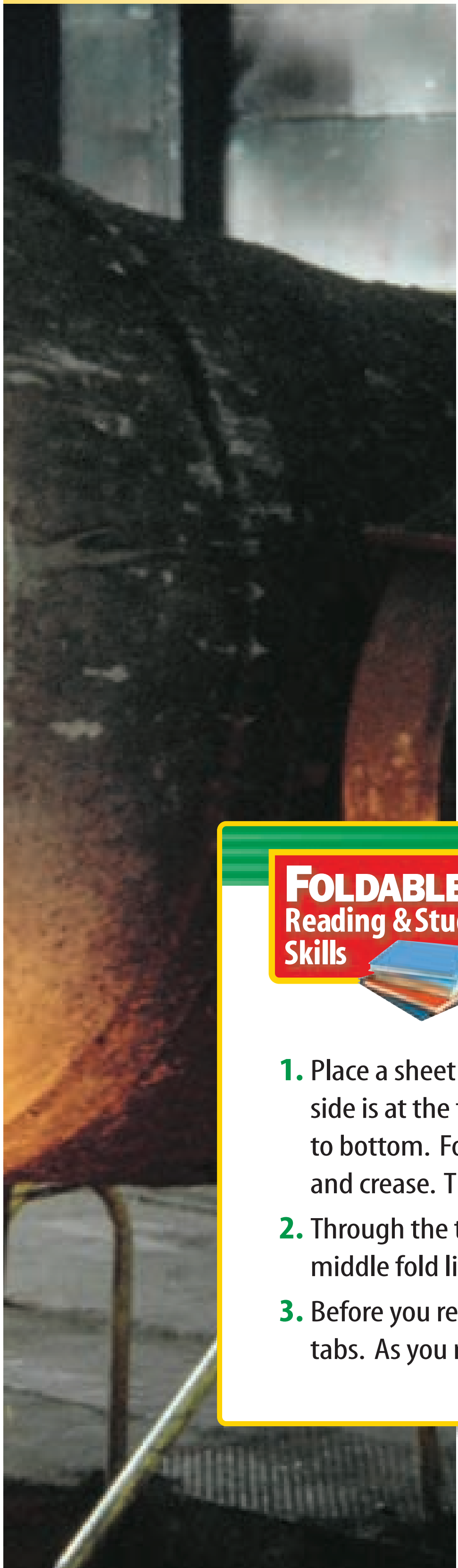
# Thermal Energy

You probably couldn't shape a piece of cold steel unless it was very thin like a wire. But if the steel is heated enough, it melts, and the liquid steel can be poured into molds, as shown in this picture. In the mold, the steel cools and again becomes a solid, this time in the desired shape. In this chapter you will learn how heat and temperature are related, and how thermal energy is transferred. You will also learn how the flow of heat can be controlled.

## What do you think?

Look at the picture below with a classmate. Discuss what this might be or what is happening. Here's a hint: *You can do this, but a dog can't.* Write your answer or your best guess in your Science Journal.





## Explore Activity

Why does hot water burn your skin but warm water does not? Molecules move faster and have more energy at a higher temperature than at a lower temperature. The energy of moving molecules is called kinetic energy. When fast-moving molecules of hot water touch your skin, they trigger nerve cells to send pain signals to your brain. Warm water molecules have less energy and cause no pain. In this activity, observe and compare other effects of fast-moving and slow-moving water molecules.

### Observe the effects of molecules at different temperatures

1. Pour 200 mL of room-temperature water into a beaker.
2. Pour 200 mL of water into a beaker and add some ice.
3. Put one drop of food coloring into each beaker.
4. Compare how quickly the food coloring causes the color of the water to change in each beaker.

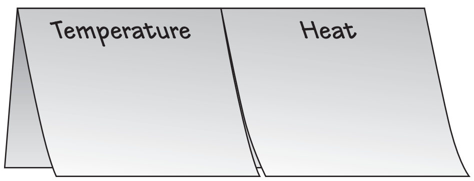
### Observe

Write a paragraph in your Science Journal describing the results of your experiment. Infer why the food coloring spread throughout the water in the two beakers at different rates.

## Before You Read

**Foldables Reading & Study Skills**

**Making a Compare and Contrast Study Fold** **Make the following Foldable to help you see how temperature and heat are similar and different.**




1. Place a sheet of paper in front of you so the long side is at the top. Fold the paper in half from top to bottom. Fold from the left side to the right side and crease. Then unfold.
2. Through the top thickness of paper, cut along the middle fold line to form two tabs. Label the tabs *Temperature* and *Heat*.
3. Before you read the chapter, write what you know about temperature and heat under the tabs. As you read the chapter, add to and correct what you have written.



CONTENTS

SECTION 1

# Temperature and Heat

## As You Read

### What You'll Learn

- **Explain** the difference between heat and temperature.
- **Define** thermal energy.
- **Explain** the meaning of specific heat.

### Vocabulary

temperature
thermal energy
heat
specific heat

### Why It's Important

If you know the difference between temperature and heat, you can understand why heat flows.

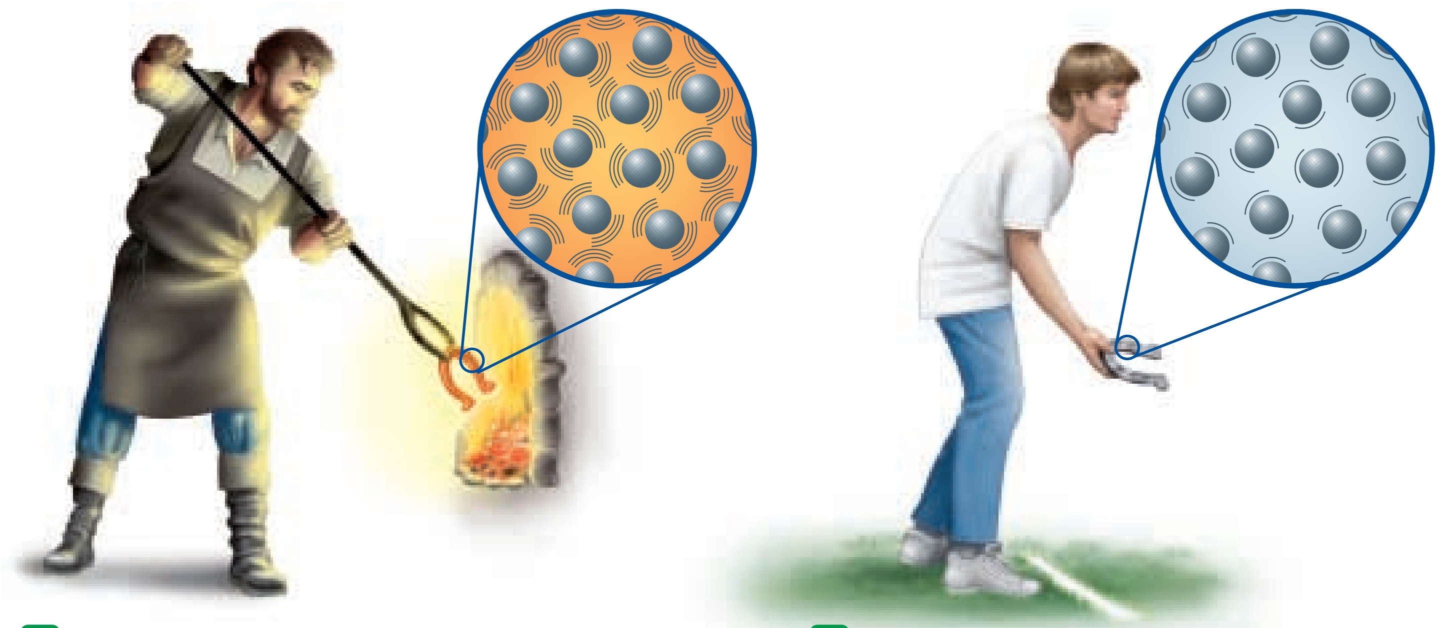
## Temperature

The words hot and cold are commonly used to describe the temperature of a material. Although the terms *hot* and *cold* are not very precise, they still are useful. Everyone understands that hot indicates high temperature and that cold indicates low temperature. But what is temperature and how is temperature related to heat?

**Matter in Motion** All matter is made of tiny particles—atoms and molecules. Molecules are made of atoms held together by chemical bonds. Atoms and molecules are so small that a speck of dust has trillions of them. However, in all materials—solids, liquids, or gases—these particles are in constant motion.

Like all objects that are moving, these moving particles have kinetic energy. The faster these particles move, the more kinetic energy they have. **Figure 1** shows how molecules are moving in hot and cool objects.

**Figure 1**
**The atoms in an object are in constant motion.**



**A** When the horseshoe is hot, the particles in it move very quickly.

**B** When the horseshoe has cooled, its particles are moving more slowly.

**Temperature** Why do some objects feel hot and others feel cold? The **temperature** of an object is related to the average kinetic energy of the atoms or molecules. The faster these particles are moving, the more kinetic energy they have, and the higher the temperature of the object is. Think about a cup of hot tea and a glass of iced tea. The temperature of the hot tea is higher because the molecules in the hot tea are moving faster than those in the iced tea. In SI units, temperature is measured in kelvins (K), and a change in temperature of one kelvin is the same as a change of one degree Celsius.

## Thermal Energy

If you let cold butter sit at room temperature for a while, it warms and becomes softer. Because the air in the room is at a higher temperature than the butter, molecules in air have more kinetic energy than butter molecules. Collisions between molecules in butter and molecules in air transfer energy from the faster-moving molecules in air to the slower-moving butter molecules. The butter molecules then move faster and the temperature of the butter increases.

Molecules in the butter can exert attractive forces on each other. Recall that Earth exerts an attractive gravitational force on a ball. When the ball is above the ground, the ball and Earth are separated, and the ball has potential energy. In the same way, atoms and molecules that exert attractive forces on each other have potential energy when they are separated. The sum of the kinetic and potential energy of all the molecules in an object is the **thermal energy** of the object. Because the kinetic energy of the butter molecules increased as it warmed, the thermal energy of the butter increased.

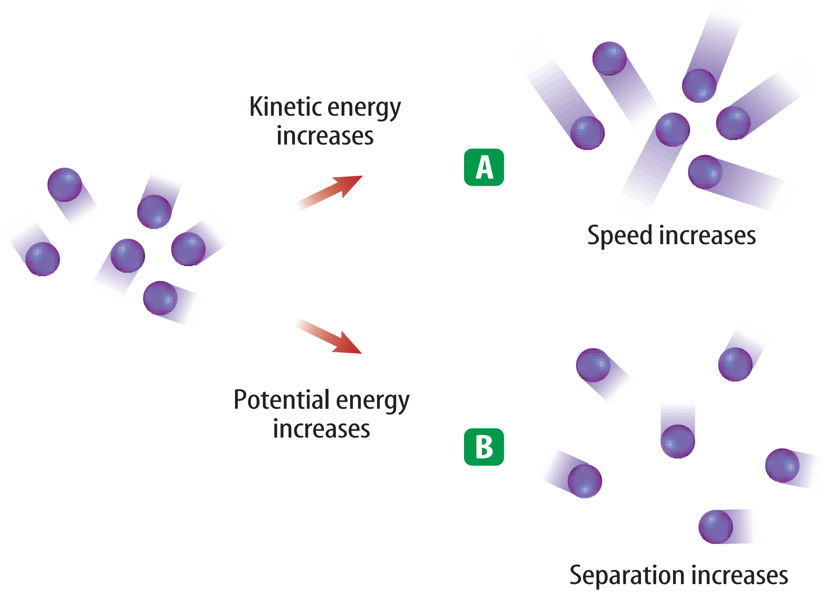



**Figure 2**
**The thermal energy of a substance is the sum of the kinetic and potential energy of its molecules. A The kinetic energy increases as the molecules move faster. B The potential energy increases as the molecules move farther apart.**

**SCIENCE Online**

**Research** Visit the Glencoe Science Web site at **science.glencoe.com** for information about how weather satellites use thermal energy. Communicate to your class what you learn.

CLICK HERE

**Thermal Energy and Temperature** Thermal energy and temperature are related. When the temperature of an object increases, the average kinetic energy of the molecules in the object increases. Because thermal energy is the total kinetic and potential energy of all the molecules in an object, the thermal energy of the object increases when the average kinetic energy of its molecules increases. Therefore, the thermal energy of an object increases as its temperature increases.

**Thermal Energy and Mass** Suppose you have a glass and a beaker of water that are at the same temperature. The beaker contains twice as much water as the glass. The water in both containers is at the same temperature, so the average kinetic energy of the water molecules is the same in both containers. But there are twice as many water molecules in the beaker as there are in the glass. So the total kinetic energy of all the molecules is twice as large for the water in the beaker. As a result, even though they are at the same temperature, the water in the beaker has twice as much thermal energy as the water in the glass does. If the temperature doesn't change, the thermal energy in an object increases if the mass of the object increases.

## Heat

Can you tell if someone has been sitting in your chair? Perhaps you've noticed that your chair feels warm, and maybe you concluded that someone has been sitting in it recently. The chair feels warmer because thermal energy from the person's body flowed to the chair and increased its temperature.

**Heat** is thermal energy that flows from something at a higher temperature to something at a lower temperature. Heat is a form of energy, so it is measured in joules—the same units that energy is measured in. Heat always flows from warmer to cooler materials. How did the ice cream in **Figure 3** become cold? Heat flowed from the warmer liquid ingredients to the cooler ice-and-salt mixture. The liquid ingredients lost enough thermal energy to become cold enough to form solid ice cream. Meanwhile, the ice-and-salt solution gained thermal energy, causing some of the ice to melt.

**Reading Check** *How are heat and thermal energy related?*


**Figure 3**
**Heat flows from the warmer ingredients inside the container to the ice-and-salt mixture.**

## Specific Heat

If you are at the beach in the summertime, you might notice that the ocean seems much cooler than the air or sand. Even though energy from the Sun is falling on the air, sand, and water at the same rate, the temperature of the water has changed less than the temperature of the air or sand has.

As a substance absorbs heat, its temperature change depends on the nature of the substance, as well as the amount of heat that is added. For example, compared to 1 kg of sand, the amount of heat that is needed to raise the temperature of 1 kg of water by 1°C is about six times greater. So the ocean water at the beach would have to absorb six times as much heat as the sand to be at the same temperature. The amount of heat that is needed to raise the temperature of 1 kg of some material by 1°C or 1 K is called the **specific heat** of the material. Specific heat is measured in joules per kilogram kelvin [J/(kg K)]. **Table 1** shows the specific heats of some familiar materials.

**Table 1 Specific Heat of Some Common Materials**

| Substance | Specific Heat [J/(kg K)] |
|---|---|
| Water | 4,184 |
| Wood | 1,760 |
| Carbon (graphite) | 710 |
| Glass | 664 |
| Iron | 450 |

**Water as a Coolant** Compared with the other common materials in **Table 1,** water has the highest specific heat, as shown in **Figure 4.** Because water can absorb heat without a large change in temperature, it is useful as a coolant. A coolant is a subtance that is used to absorb heat. For example, water is used as the coolant in the cooling systems of automobile engines. As long as the water temperature is lower than the engine temperature, heat will flow from the engine to the water. Compared to other materials, water can absorb more heat from the engine before its temperature rises. Because it takes water longer to heat up compared with other materials, it also takes water longer to cool down.

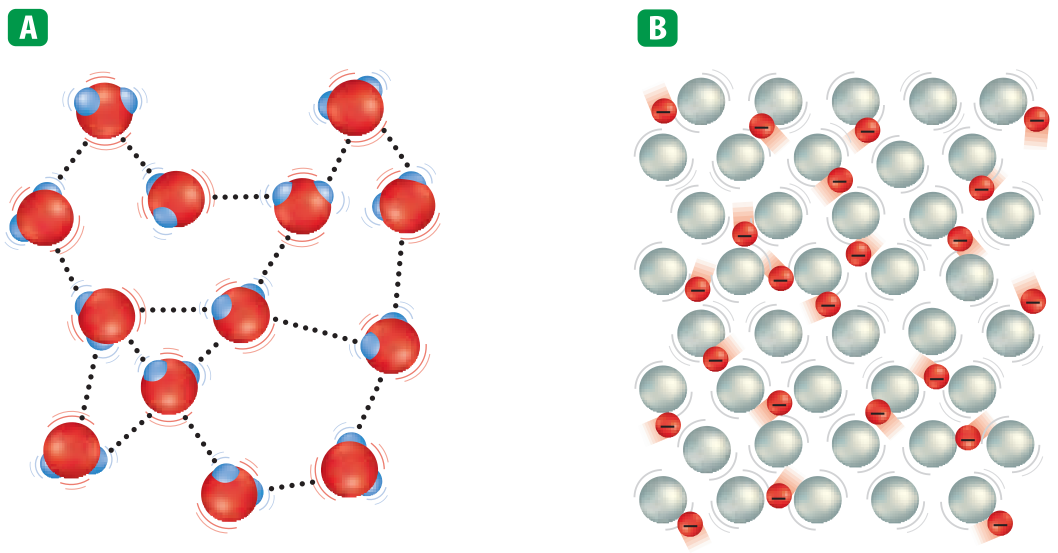



**Figure 4**
The specific heat of water is high because water molecules form strong bonds with each other.
**A** When heat is added, some of the added heat has to break some of these bonds before the molecules can start moving faster.
**B** In metals, electrons can move freely. When heat is added, no strong bonds have to be broken before the electrons can start moving faster.

**Chemistry INTEGRATION**

While Karen was blow-drying her hair, she noticed that her silver earring had become uncomfortably hot. If her earring was about the same mass as her earlobe, infer which of the two had the higher specific heat. Assuming a human earlobe is composed largely of water, find data from **Table 1** to support your inference and record it in your Science Journal.

## Calculating Changes in Thermal Energy

The thermal energy of an object changes when heat flows into or out of it. The change in thermal energy is related to the mass of the object, its specific heat, and its change in temperature in this way:

Change in thermal energy = mass × change in temperature × specific heat

The change in temperature is calculated by subtracting the initial temperature from the final temperature in this way:

Change in temperature = $T_{final} - T_{initial}$

If $Q$ is the change in thermal energy, $m$ is the mass, and $C$ is the specific heat, then the change in thermal energy can be calculated from this formula:

$$Q = m \times (T_{final} - T_{initial}) \times C$$

## Math Skills Activity

### Calculating Changes in Thermal Energy

**Example Problem**

The temperature of a 32-g silver spoon increases from 20°C to 60°C. If silver has a specific heat of 235 J/(kg K) what is the change in the thermal energy of the spoon?

**Solution**

1. *This is what you know:* mass of spoon, $m = 32\text{ g} = 0.032\text{ kg}$; specific heat of silver, $C = 235\text{ J/(kg K)}$; initial temperature, $T_{initial} = 20°\text{C}$; final temperature, $T_{final} = 60°\text{C}$
2. *This is what you want to find:* change in thermal energy, $Q$
3. *This is the equation you need to use:* $Q = m \times (T_{final} - T_{initial}) \times C$
4. *Solve the equation for Q:* $Q = 0.032\text{ kg} \times (60°\text{C} - 20°\text{C}) \times 235\text{ J/(kg K)}$; $Q = 301\text{ J}$

*Check your answer by dividing it by the change in temperature then by the specific heat of silver. Did you get the original mass of the spoon?*

**Practice Problem**

1. A 45-kg brass sculpture gains 203,000 J of thermal energy as its temperature increases from 28°C to 40°C. What is the specific heat of brass?

For more help, refer to the Math Skill Handbook.

## Thermal Energy and Temperature Changes

When the temperature of an object changes, the amount of thermal energy it contains changes also. When heat flows into an object its temperature usually increases. So $T_{final}$ is greater than $T_{initial}$ and the change in temperature is a positive number. According to the formula for the change in thermal energy, if the change in temperature is a positive number, then $Q$ is a positive number. Therefore, when the temperature increases, heat flows into an object, and $Q$ is positive.

In the same way, when heat flows out of an object its temperature usually decreases. Then the temperature of an object decreases, the change in temperature is a negative number, and $Q$ is also negative.

**Measuring Specific Heat** The specific heat can be measured using a device called a calorimeter, shown in **Figure 5.** To do this, the mass of the water in the calorimeter and its temperature are measured. Then a sample of a material of known mass is heated and its temperature measured. The heated sample is then placed in the calorimeter. Heat flows from the sample to the water until they both reach the same temperature. Then the increase in thermal energy of the water can be calculated. This is equal to the thermal energy lost by the sample. Because the mass of the sample, its change in temperature, and change in thermal energy are known, the sample's specific heat can be calculated.

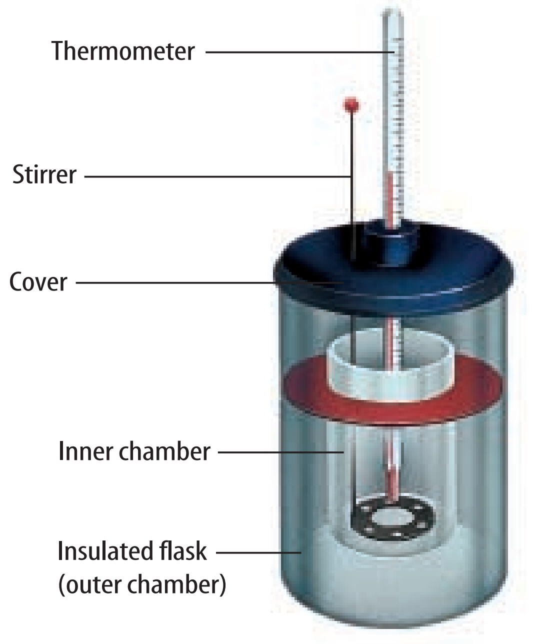



**Figure 5**
**A calorimeter can be used to measure the specific heat of materials. The sample is placed in the inner chamber.**

## Section 1 Assessment

1. Explain the difference between heat and temperature.
2. What is thermal energy and what causes it to change?
3. How is heat transferred between two objects?
4. What is specific heat?
5. **Think Critically** Using your knowledge of heat, explain what happens when you heat a pan of soup on the stove, and then put some of the leftover warm soup in the refrigerator.

### Skill Builder Activities

6. **Interpreting Data** Equal amounts of iron, water, and glass with the same initial temperature were placed in an oven and heated briefly. Use the data in **Table 1** to match each final temperature with the appropriate material: 51.5°C, 25°C, and 66°C. **For more help, refer to the Science Skill Handbook.**
7. **Solving One-Step Equations** Calculate the change in thermal energy of 30 g of wood that cools from 100°C to 30°C. **For more help, refer to the Math Skill Handbook.**

SECTION

# 2 Transferring Thermal Energy

## As You Read

**What You'll Learn**

- **Compare and contrast** thermal energy transfer by conduction, convection, and radiation.
- **Compare and contrast** conductors and insulators.
- **Explain** how insulation affects the transfer of energy.

**Vocabulary**

conduction
convection
radiation
insulator

**Why It's Important**

Understanding how thermal energy is transferred can help you use energy more efficiently.

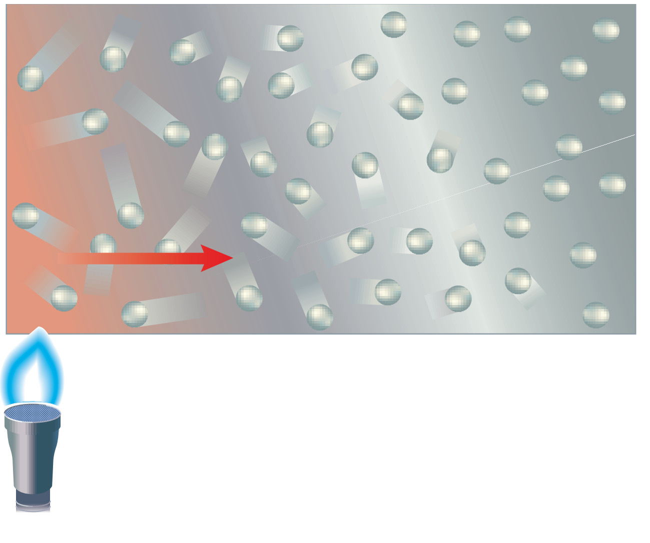


**Figure 6**
**Conduction transfers heat from the hotter part of the material to the cooler part.**

## Conduction

Thermal energy travels as heat from a material at a higher temperature to a material at a lower temperature. When you pick up a handful of snow to make a snowball, thermal energy from your hand is transferred to the snow, causing the snow to begin melting and your hand to get a little colder. When you come back indoors, the opposite happens if you hold a cup of hot chocolate. The thermal energy from the cup moves to your hand, making it warmer and the cup cooler. Direct contact is one way heat can travel from one place to another. The transfer of thermal energy through matter by the direct contact of particles is called **conduction.** Conduction occurs because all matter is made of atoms and molecules that are in constant motion.

**Transfer by Collisions** Think about what happens when you grasp a handful of snow. The slower-moving molecules in the snow come into contact with the faster-moving molecules in your warm hand. These particles then collide with one another, and some of the kinetic energy from the faster-moving particles is transferred to the slower-moving particles. This causes the slower-moving particles to speed up and the faster-moving particles to slow down. As the collisions continue, thermal energy gets transferred from your bare hand to the snow. As a result, your hand gets colder and the snow melts.

Heat can be transferred by conduction from one material to another or through one material. What happens to a metal ladle that's used to stir a pot of simmering soup? The hot soup transfers thermal energy to the part of the ladle sitting in the soup. At first, this end of the ladle is hotter than the rest. Eventually, however, the entire ladle becomes hot. Heat was transferred from the soup to the ladle—from one material to another—and through the length of the ladle—through one material. **Figure 6** shows how heat is transferred by conduction.

**Heat Conductors** Although conduction can occur in solids, liquids, and gases, solids usually conduct heat much more effectively. The particles in a solid are usually much closer together than they are in liquids and gases, so they collide with one another more often. The loosely held electrons in a metal make them especially good heat conductors. In a metal, electrons can move easily, and they readily transfer kinetic energy to other nearby particles. Silver, copper, and aluminum are among the best heat conductors. Wood, plastic, glass, and fiberglass are poor conductors of heat. Why do you think most cooking pots are made of metal, but the handles usually are not?

## Convection

One way liquids and gases differ from solids is that they can flow. Any material that flows is a fluid. The ability to flow allows fluids to transfer heat in another way—convection. **Convection** is the transfer of energy in a fluid by the movement of the heated particles. In conduction, heated particles collide with each other and transfer their energy. In convection, however, the more energetic fluid particles move from one location to another, and carry their energy along with them.

As the particles move faster, they tend to be farther apart. In other words, the fluid expands as its temperature increases. Recall that density is the mass of a material divided by its volume. When a fluid expands, its volume increases, but its mass doesn't change. As a result, its density decreases. The same is true for parts of a fluid that have been heated. The density of the warmer fluid, therefore, is less than that of the surrounding cooler fluid.

**Heat Transfer by Currents** How does convection occur? Look at the lamp shown in **Figure 7.** Some of these lamps contain oil and alcohol. When the oil is cool, its density is greater than the alcohol, and it sits at the bottom of the lamp. When the two liquids are heated, the oil becomes less dense than the alcohol. Because it is less dense than the alcohol, it rises to the top of the lamp. As it rises, it loses heat by conduction to the cooler fluid around it. When the oil reaches the top of the lamp, it has become cool enough that it is denser than the alcohol, and it sinks. This rising-and-sinking action is a convection current. Convection currents transfer heat from warmer to cooler parts of the fluid. In a convection current, both conduction and convection transfer thermal energy.

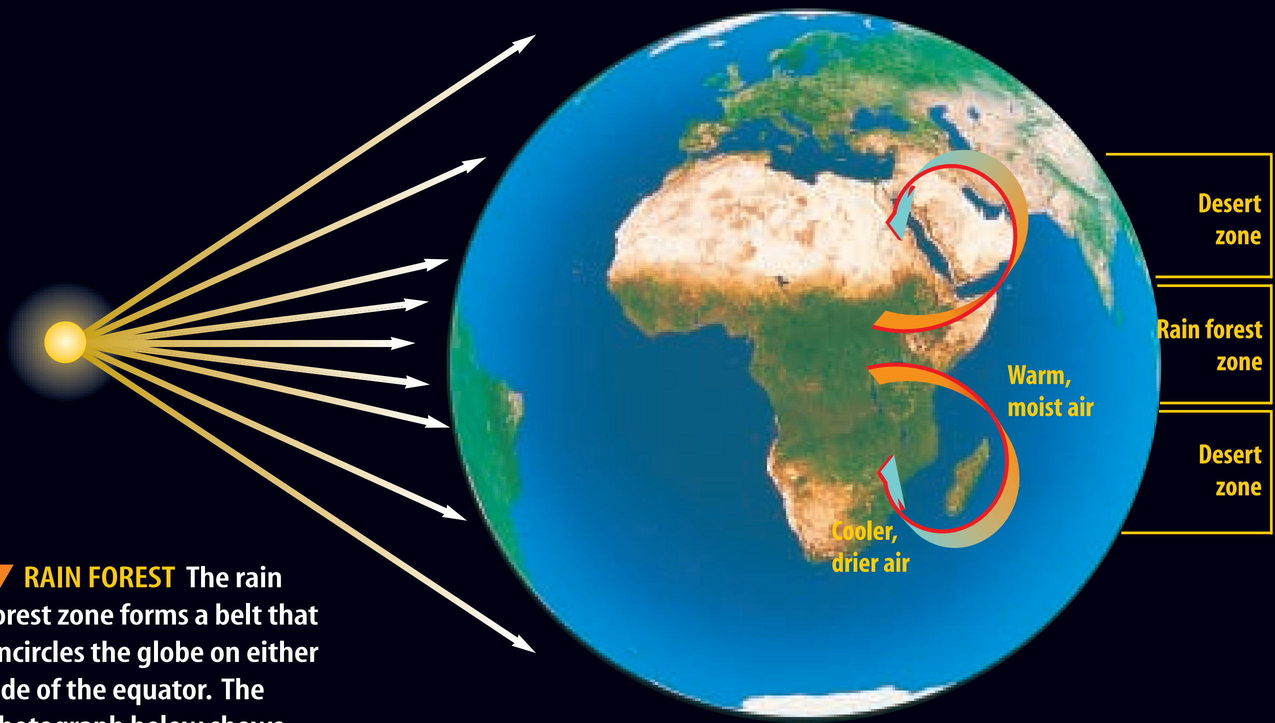
**Reading Check** *How are conduction and convection different?*

**Figure 7**
**The heat from the light at the bottom of the lamp causes one fluid to expand more than the other. This creates convection currents in the lamp.**

# VISUALIZING CONVECTION CURRENTS

## Figure 8

When the Sun beats down on the equator, warm, moist air begins to rise. As it rises, the air cools and loses its moisture as rain that sustains rain forests near the equator. Convection currents carry the now dry air farther north and south. Some of this dry air descends at the tropics, where it creates a zone of deserts.




▼ RAIN FOREST The rain forest zone forms a belt that encircles the globe on either side of the equator. The photograph below shows a rain forest near the Congo River in central Africa.

▲ DESERT Like many of the great desert regions of the world, the Sahara, in northern Africa, is largely a result of atmospheric convection currents. Here, a group of nomads gather near a dried-up river in Mali.

**Desert and Rain Forests** Earth's atmosphere is made of various gases and is a fluid. The atmosphere is warmer at the equator than it is at the north and south poles. Also, the atmosphere is warmer at Earth's surface than it is at higher altitudes. These temperature differences create convection currents that carry heat to cooler regions. **Figure 8** shows how these convection currents create rain forests and deserts over different regions of Earth's surface.

## Radiation

Earth gets heat from the Sun, but how does that heat travel through space? Almost no matter exists in the space between Earth and the Sun, so heat cannot be transferred by conduction or convection. Instead, the Sun's heat reaches Earth by radiation.

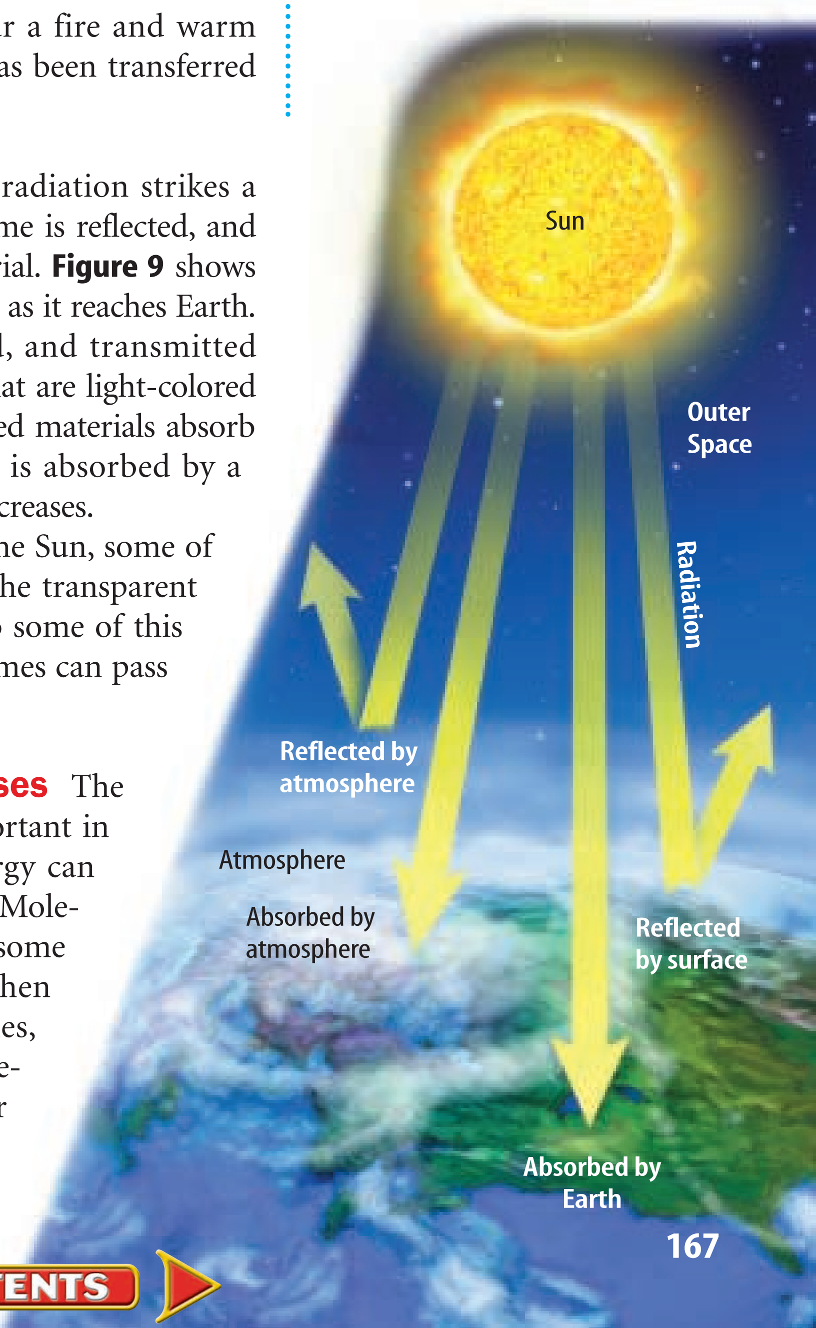
**Radiation** is the transfer of energy by electromagnetic waves. These waves can travel through space even when no matter is present. Energy that is transferred by radiation often is called radiant energy. When you stand near a fire and warm your hands, much of the warmth you feel has been transferred from the fire to your hands by radiation.

**Radiant Energy and Matter** When radiation strikes a material, some of the energy is absorbed, some is reflected, and some may be transmitted through the material. **Figure 9** shows what happens to radiant energy from the Sun as it reaches Earth. The amount of energy absorbed, reflected, and transmitted depends on the type of material. Materials that are light-colored reflect more radiant energy, while dark-colored materials absorb more radiant energy. When radiant energy is absorbed by a material, the thermal energy of the material increases.

For example, when a car sits outside in the Sun, some of the radiation from the Sun passes through the transparent car windows. Materials inside the car absorb some of this radiation and become hot. Radiation sometimes can pass through solids and liquids, as well as gases.

**Radiation in Solids, Liquids, and Gases** The transfer of energy by radiation is most important in gases. In a solid, liquid or gas, radiant energy can travel through the space between molecules. Molecules can absorb this radiation and re-emit some of the energy they absorbed. This energy then travels through the space between molecules, and is absorbed and re-emitted by other molecules. Because molecules are much farther apart in gases than in solids or liquids, radiation usually passes more easily through gases than through solids or liquids.

**Figure 9**
**Not all of the Sun's radiation reaches Earth. Some of it is reflected by the atmosphere. Some of the radiation that does reach the surface is also reflected.**






CONTENTS

TRY AT HOME **Mini LAB**

### Observing Heat Transfer by Radiation

**Procedure**

1. On a sunny day, go outside and place the back of your hand in **direct sunlight** for two min.
2. Go inside and find a **window exposed to direct sunlight.**
3. Place the back of your hand in the sunlight that has passed through the window for two min.

**Analysis**

1. Explain how heat was transferred from the Sun to your skin when you were outside.
2. Compare how warm your skin felt inside and outside.
3. Was thermal energy transferred through the glass in the window? Explain.

## Controlling Heat Flow

You might not realize it, but you probably do a number of things every day to control the flow of heat. For example, when its cold outside, you put on a coat or a jacket before you leave your home. When you reach into an oven to pull out a hot dish, you might put a thick, cloth mitten over your hand to keep from being burned. In both cases, you used various materials to help control the flow of heat. Your jacket kept you from getting cold by reducing the flow of heat from your body to the surrounding air. And the oven mitten kept your hand from being burned by reducing the flow of heat from the hot dish.

As shown in **Figure 10,** almost all living things have special features that help them control the flow of heat. For example, the antarctic fur seal's thick coat and the emperor penguin's thick layer of blubber help keep them from losing heat. This helps them survive in a climate in which the temperature is often below freezing. In the desert, however, the scaly skin of the desert spiny lizard has just the opposite effect. It reflects the Sun's rays and keeps the animal from becoming too hot. An animal's color also can play a role in keeping it warm or cool. The black feathers on the penguin's back, for example, allow it to absorb as much radiant energy as possible. Can you think of any other animals that have special adaptations for cold or hot climates?

**Reading Check** *What are two animal adaptations that control the flow of heat?*

**Figure 10**
Animals have different features that help them control heat flow.

**A** The antarctic fur seal grows a coat that can be as much as 10 cm thick.

**B** The emperor penguin has a thick layer of blubber and thick, closely grown feathers, which help reduce the loss of body heat.

**C** The scaly skin of the desert spiny lizard reflects the rays of the Sun. This prevents it from losing water by evaporation in an environment where water is scarce.

**Figure 11**
**The tiny pockets of air in fleece make it a good insulator. They help prevent the jogger's body heat from escaping.**

## Insulators

A material that doesn't allow heat to flow through it easily is called an **insulator.** A material that is a good conductor of heat, such as a metal, is a poor insulator. Materials such as wood, plastic, and fiberglass are good insulators and, therefore, are poor conductors of heat.

Gases, such as air, are usually much better insulators than solids or liquids. Some types of insulators contain many pockets of trapped air. These air pockets conduct heat poorly and also keep convection currents from forming. Fleece jackets, like the one shown in **Figure 11,** work in the same way. When you put the jacket on, the fibers in the fleece trap air and hold this air next to you. This air slows down the flow of your body heat to the colder air outside the jacket. Gradually, the air trapped by the fleece is warmed by your body heat, and underneath the jacket you are wrapped in a blanket of warm air.

**✔ Reading Check** ***Why does trapped air make a material like fleece a good insulator?***

**Insulating Buildings** Insulation, or materials that are insulators, helps keep warm air from flowing out of buildings in cold weather and from flowing into buildings in warm weather. Building insulation is usually made of some fluffy material, such as fiberglass, that contains pockets of trapped air. The insulation is packed into a building's outer walls and attic, where it reduces the flow of heat between the building and the surrounding air.

Insulation helps furnaces and air conditioners work more effectively, saving energy. In the United States, about 55 percent of the energy used in homes is used for heating and cooling.

## Mini LAB

### Comparing Thermal Conductors

**Procedure**

1. Obtain a **plastic spoon,** a **metal spoon,** and a **wooden spoon** with similar lengths.
2. Stick a small **plastic bead** to the handle of each spoon with a dab of **butter or wax.** Each bead should be the same distance from the tip of the spoon.
3. Stand the spoons in a beaker, with the beads hanging over the edge of the beaker.
4. Carefully pour about 5 cm of boiling water in the beaker holding the spoons.

**Analysis**

1. In what order did the beads fall from the spoons?
2. Describe how heat was transferred from the water to the beads.
3. Rank the spoons in their ability to conduct heat.

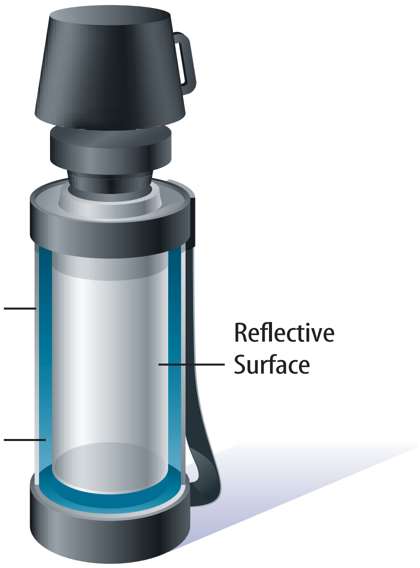



**Figure 12**
**The vacuum layer of the thermos bottle is a very poor conductor of heat.**

**Using Insulators** You might have used a thermos bottle, like the one in **Figure 12,** to carry hot soup or iced tea. The vacuum layer in the thermos helps keep your soup hot by reducing the heat flow due to conduction, convection, and radiation. Thermos bottles don't use a thick layer of material to reduce heat flow, instead they use nothing. A thermos bottle has two glass layers with a vacuum between the layers. The vacuum between the two layers contains almost no matter, and so prevents heat transfer either by conduction or by convection.

To reduce heat transfer by radiation, the inside and outside glass surface of a thermos bottle is coated with aluminum to make each surface highly reflective. This causes the electromagnetic waves that carry heat energy by radiation to be reflected at each surface. The inner coating prevents electromagnetic waves from leaving the bottle, and the outer coating prevents them from entering the bottle.

Think about the things you do to stay warm or cool. Sitting under a shady umbrella reduces the heat energy transferred to you by radiation. Also, wearing light-colored or dark-colored clothing changes the amount of heat you absorb due to radiation. To change the amount of heat transferred by convection, you can open and close windows. Putting on a sweater reduces the heat transferred from your body by conduction and convection. In what other ways do you control the flow of heat?

## Section 2 Assessment

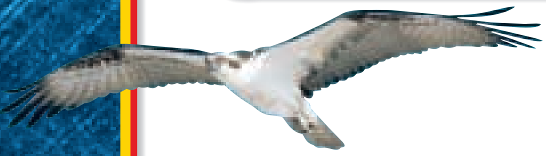
1. Describe the three ways thermal energy can be transferred.
2. Why are materials that are good conductors of heat also poor insulators?
3. How is heat transfer by radiation different from conduction and convection?
4. How could insulating a home save money?
5. **Think Critically** Several days after a snowfall, the roofs of some houses on a street have almost no snow on them, while the roofs of other houses are still snow-covered. Which houses are better insulated? Explain.

### Skill Builder Activities

6. **Testing a Hypothesis** Design an experiment to find out which material makes the best insulation: plastic foam pellets, shredded newspaper, or crumpled plastic bags. Remember to state your hypothesis and indicate what factors must be held constant. **For more help, refer to the Science Skill Handbook.**
7. **Concept Mapping** Make a concept map showing the three types of thermal energy transfer and ways you can control the flow of heat in each type. **For more help, refer to the Science Skill Handbook.**

Activity

# Convection in Gases and Liquids



A hawk gliding through the sky will rarely flap its wings. Hawks and some other birds conserve energy by gliding on columns of warm air rising up from the ground. These convection currents form when gases or liquids are heated unevenly, and the warmer, less dense fluid is forced upward. In this activity, you will create and observe your own convection currents.

## What You'll Investigate

How can convection currents be modeled and observed?

## Materials

burner or hot plate
water
candle
500-mL beaker
black pepper

## Safety Precautions

**WARNING:** *Use care when working with hot materials. Remember that hot and cold glass appear the same.*

## Goals

- **Model** the formation of convection currents in water.
- **Observe** convection currents formed in water.
- **Observe** convection currents formed in air.

## Procedure

1. Pour about 450 mL of water into a 500-mL beaker.
2. Use a balance to measure 1 g of black pepper.
3. Sprinkle the pepper into the beaker of water.
4. Let the pepper settle to the bottom of the beaker.
5. Heat the bottom of the beaker using the burner or by placing it on the hotplate.
6. **Observe** how the particles of pepper move as the water is heated, and make a drawing showing their motion in your Science Journal.
7. Turn off the hot plate or burner. Light the candle and let it burn for a few minutes.
8. Blow out the candle, and observe the motion of the smoke.
9. Make a drawing of the movement of the smoke in your Science Journal.

## Conclude and Apply

1. **Describe** how the particles of pepper moved as the water became hotter.
2. How is the motion of the pepper particles related to the motion of the water?
3. **Explain** how a convection current formed in the beaker.
4. **Explain** why the motion of the pepper changed when the heat was turned off.
5. **Predict** how the pepper would move if the water were heated from the top.
6. **Describe** how the smoke particles moved when the candle was blown out.
7. **Explain** why the smoke moved as it did.

## Communicating Your Data

**Compare** your conclusions with other students in your class. **For more help, refer to the Science Skill Handbook.**

SECTION

# 3 Using Heat

**As You Read**

***What* You'll Learn**

- **Compare and Contrast** three types of conventional heating systems.
- **Distinguish** between passive and active solar heating systems.
- **Describe** how internal combustion engines work.
- **Explain** how a heat mover can transfer thermal energy in a direction opposite to that of its natural movement.

**Vocabulary**

solar energy
solar collector
heat engine
internal combustion engine
heat mover

***Why* It's Important**

Heat is used to heat homes and operate vehicles.

## Heating Systems

Almost everywhere in the United States air temperatures at some time become cold enough that a source of heat is needed. As a result, most homes and public buildings contain some type of heating system. No one heating system is best in all conditions. The best heating system for any home or building depends on the local climate and how the building is constructed.

All heating systems require some source of energy. In the simplest and oldest heating system, wood or coal is burned in a stove. The heat that is produced by the burning fuel is transferred from the stove to the surrounding air by conduction, convection, and radiation. One disadvantage of this system is that heat transfer from the room in which the stove is located to other rooms in the building can be slow.

**Forced-Air Systems** The most common type of heating system in use today is the forced-air system, shown in **Figure 13.** In this system, fuel is burned in a furnace and heats a volume of air. A fan then blows the warm air through a series of large pipes called ducts. The ducts lead to openings called vents in each room. Cool air returns to the furnace through additional vents, where it is reheated.

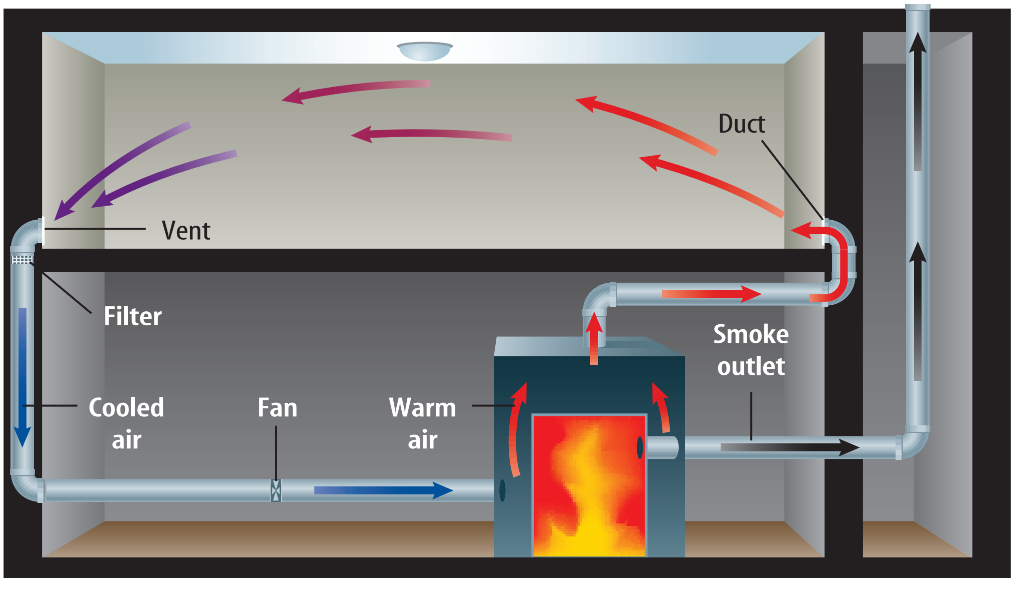



**Figure 13**
**In forced-air systems, air heated by the furnace gets blown through ducts that usually lead to every room.**

**Radiator Systems** Before forced-air systems were widely used, many homes and buildings were heated by a system of radiators. A radiator is a closed metal container that contains hot water or steam. The thermal energy contained in the hot water or steam is transferred to the air surrounding the radiator by conduction. This warm air then moves through the room by convection.

In a radiator heating system fuel is burned in a central furnace and heats a tank of water. A system of pipes carries the hot water to radiators that are located in the rooms of the building. Usually each room has one radiator, although large rooms may have several. When the water cools, pipes take it back down to the water tank, where it is reheated. In some radiator systems water is heated to produce steam that flows to the radiators. As the steam cools, it condenses into water and flows back to the tank.

You might have seen some electric radiators like the one in **Figure 14** that are not connected to a central furnace. These radiators contain metal coils that are heated when an electric current passes through them. The hot coils then transfer thermal energy to the room, mainly by radiation. This type of radiator often is used to provide heat in rooms that do not receive enough heat from the central heating system.

**Figure 14**
**Electric radiators like this one convert electric energy to thermal energy.**

**Reading Check** *What are two ways that heat is transferred from a radiator?*

**Electric Heating Systems** An electric heating system has no central furnace as forced-air and radiator systems do. Instead, it uses electrically heated coils placed in ceilings and floors to heat the surrounding air by conduction. Convection then distributes the heated air through the room. Electric heating systems are not as widely used as forced-air systems. In many areas, electric heating systems cost more to use. However, the walls and floors of some buildings might not be thick enough to include the pipes and ducts that forced-air and radiator systems require. Then an electric heating system might be the only practical way to provide heat.

Electric heating systems may seem to be a pollution-free way to provide heat. However, most power plants that produce electric energy burn fossil fuels, producing various pollutants. Also, it is much more efficient to burn fuels to produce heat rather than generate electricity. As a result, less fuel is burned to heat a house using a conventional furnace.

## Solar Heating

Radiant energy from the Sun can make a greenhouse warm. The windows of the greenhouse allow the Sun's radiant energy to be transferred inside the greenhouse where materials absorb the radiant energy and become warmer. As they become warmer, the greenhouse heats up. The windows now keep the thermal energy from being transferred to the air outside, so the greenhouse stays warm.

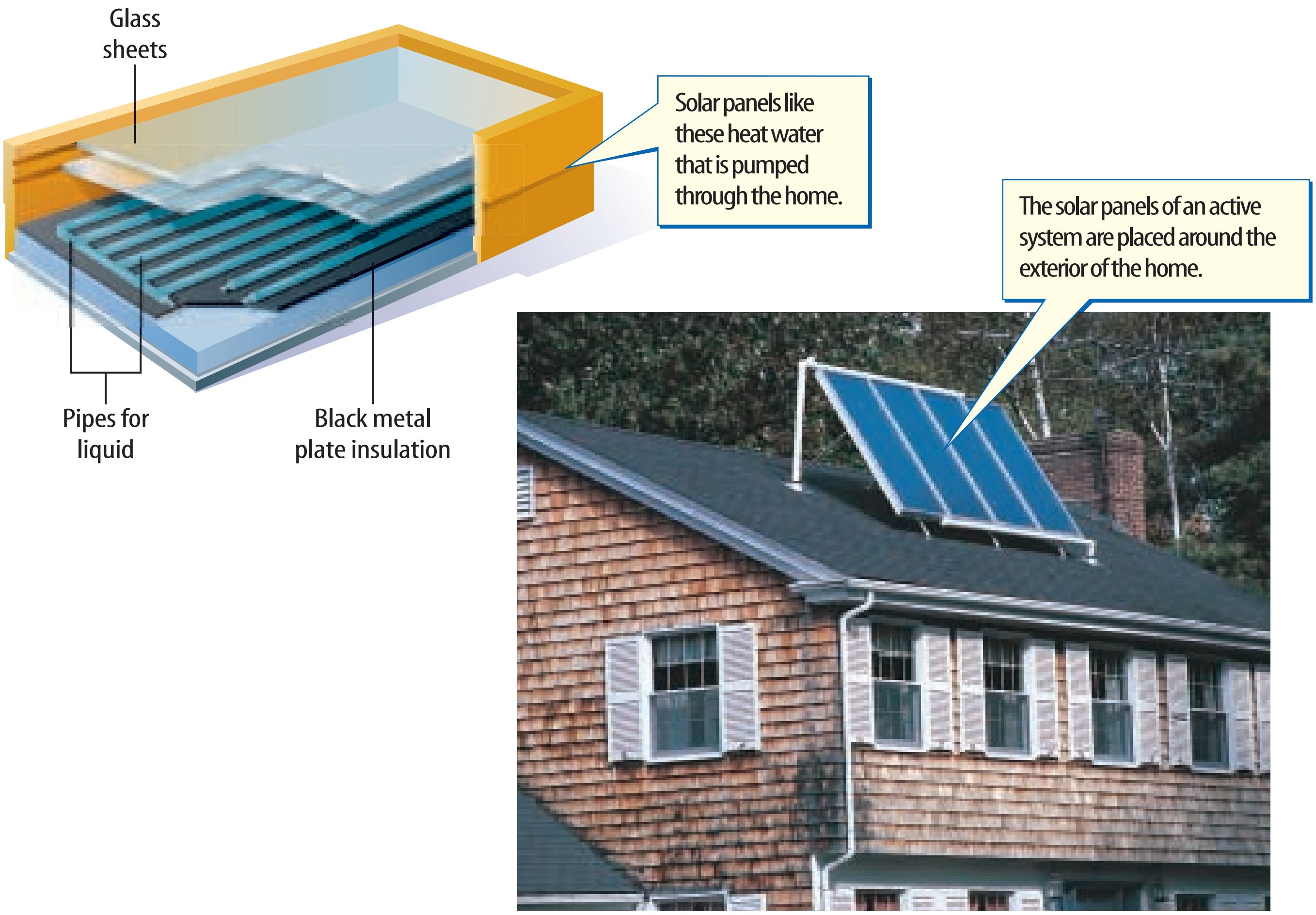
The energy from the Sun is called **solar energy.** Solar energy is not only free, it is also available in a seemingly endless supply. Just as solar energy can heat a greenhouse, it also can be used to help heat homes and buildings.

### Passive Solar Heating

Two types of solar heating systems—passive and active—are available. In passive solar heating systems, solar energy heats rooms inside a building, but no mechanical devices are used to move heat from one area to another. Just as in a greenhouse, materials such as water or concrete inside a building absorb radiant energy from the Sun during the day and heat up. At night when the building begins to cool, the thermal energy absorbed by these materials helps keep the room warm.

**Figure 15** shows a room in a house that uses passive solar heating. The south side of buildings usually receives the most solar energy. Homes that are heated by passive solar systems often have a wall of windows on the south side of the house. Walls of windows receive the maximum amount of sunlight possible during the day. The other walls are heavily insulated and have no windows to help reduce the loss of heat.

**Figure 15**
**Passive solar heating systems make use of many materials' ability to hold heat.** *In what climates would these systems work well?*




**Active Solar Heating** Active solar heating systems use devices called **solar collectors** that absorb radiant energy from the Sun. The collectors usually are installed on the roof or south side of a building where exposure to the Sun is greatest. Radiant energy from the Sun heats air or water in the solar collectors. This hot air or water is then circulated through the house.

**Figure 16** shows a home with one type of active solar collector. The metal plate absorbs radiant energy from the Sun. The glass sheets reduce energy loss due to convection and conduction. Water-filled pipes are located just below the metal plate. The absorbed radiant energy heats the water in the pipes. A pump circulates the warm water to radiators in the rooms of the house. The cooled water is pumped back to the collector to be reheated. Some systems have large, insulated tanks for storing heated water. The water can then be used as needed to provide heat. Some homes use active solar heating to provide hot water for cleaning and bathing.

If your were asked to design a building, what kind of heating system would you install? How would the climate of your area affect the choice you make? What other factors would you need to consider?

**Figure 16**
**In an active solar heating system, solar energy is absorbed and can be used to heat different rooms in the house.**

CLICK HERE

SCIENCE Online

**Data Update** Visit the Glencoe Science Web site at **science.glencoe.com** for information about improvements in solar heating designs.

**Earth Science INTEGRATION**

Hurricanes are severe tropical storms that form over the ocean in regions of low pressure. Because hurricanes use heat from warm air to produce strong winds, they are sometimes called nature's heat engines. Research hurricanes and draw a diagram showing how they behave like a heat engine.

## Using Heat to Do Work

Thermal energy not only keeps you warm, it also is the form of energy that enables cars and other vehicles to operate. For example, a car's engine converts the chemical energy in gasoline to thermal energy by a process called combustion. During combustion, a fuel such as gasoline combines with oxygen and produces heat and light. The thermal energy that is produced is then converted into mechanical energy. An engine that converts thermal energy into mechanical energy is called a **heat engine.**

**Internal Combustion Engines** A heat engine, like those usually used in cars, is called an **internal combustion engine** because fuel is burned inside the engine in chambers, or cylinders. Automobile engines usually have four, six, or eight cylinders. The more cylinders an engine has, the more power it can produce. Each cylinder contains a piston, which can move up and down. **Figure 17** shows how the motion of pistons is transmitted to the wheels of a car. Each piston is connected to a metal shaft called the crankshaft. The up-and-down motion of the pistons causes the crankshaft to spin. The motion of the crankshaft is transmitted through the transmission and the differential to the tires of the car. As the tires turn, rolling friction between the tires and the road causes the car to move.

Each up-and-down movement of the piston is called a stroke. In a gasoline or diesel engine there are four different strokes, so these engines are called four-stroke engines. A sequence of the four strokes is called a cycle. When the engine is running, many cycles are repeated for each piston every second. **Figure 18** shows the four-stroke cycle in an automobile engine.

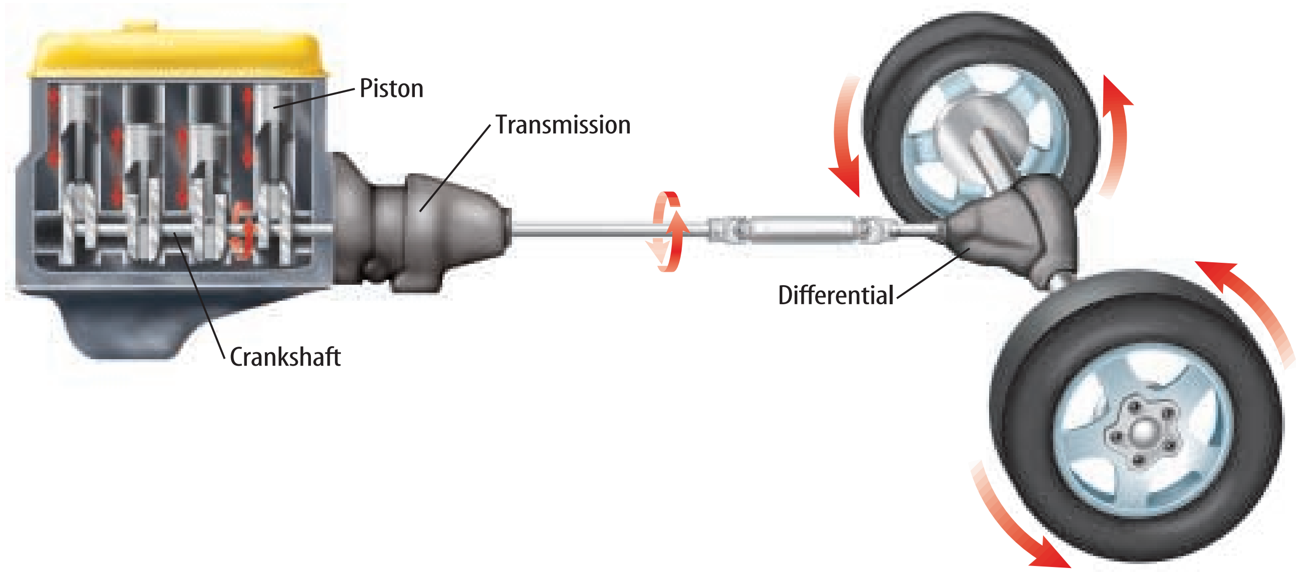
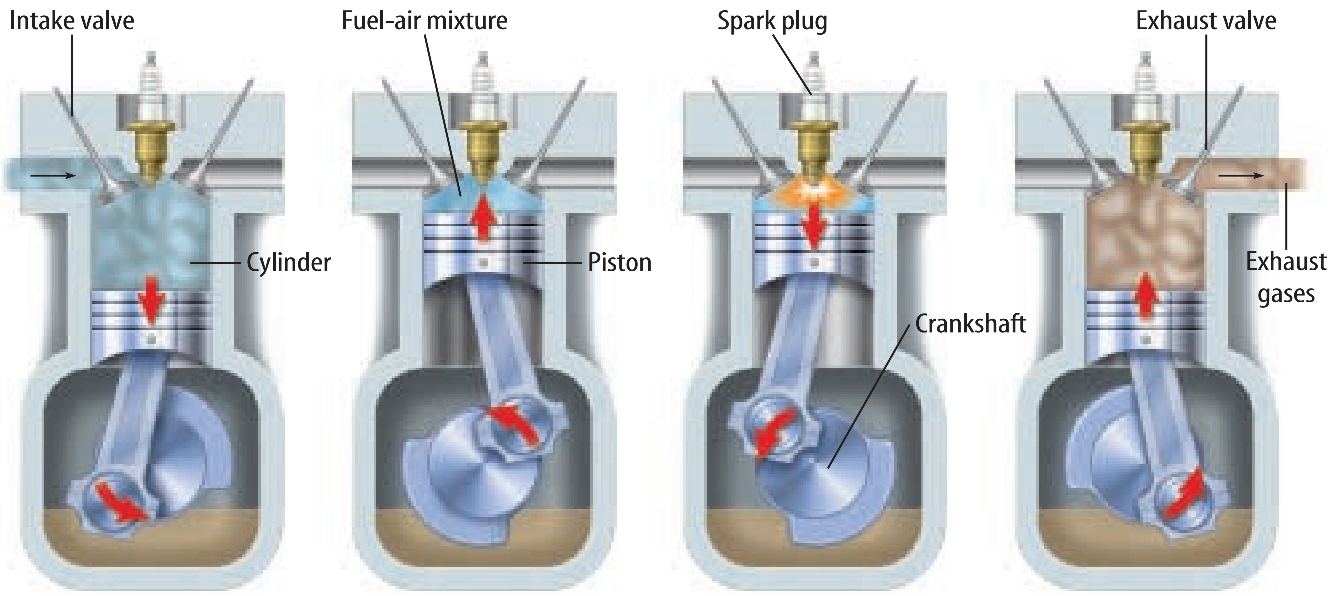



**Figure 17**
**Fuel in the cylinders burns and pushes the pistons downward. A system of gears then translates the up and down motion of the pistons into motions that can turn the wheels.**




**A Intake stroke** The intake valve opens as the piston moves downward, drawing a mixture of gasoline and air into the cylinder.

**B Compression stroke** The intake valve closes as the piston moves upward, compressing the fuel-air mixture.

**C Power stroke** The spark from a spark plug ignites the fuel-air mixture. As the mixture burns, hot gases expand, pushing the piston down.

**D Exhaust stroke** As the piston moves up, the exhaust valve opens, and the waste gases from burning the fuel-air mixture are pushed out of the cylinder.

**Figure 18** Automobile engines are usually four-stroke engines. Each four-stroke cycle converts thermal energy to mechanical energy.

**Why are engines hot?** If you've opened the hood of a car after it has been driven, you know the engine is too hot to touch. In an internal combustion engine, only part of the thermal energy that is produced by the burning fuel is converted into mechanical energy. Some of the thermal energy from the burning fuel has made the engine and other car parts hotter. So much heat is transferred to the engine that a cooling system is needed to keep the engine from becoming too hot to run properly. Gasoline automobile engines convert only about 26 percent of the chemical energy in the fuel to mechanical energy.

## Heat Movers

How can the inside of a refrigerator stay cold? Heat should flow from the warmer room into the refrigerator until the room and refrigerator are at the same temperature. Instead, a refrigerator moves thermal energy out of the refrigerator into the warmer room. Heat can be made to flow from the cool refrigerator to the warm room only if work is done. The energy to do the work comes from the electricity that powers the refrigerator. A refrigerator is an example of a heat mover. A **heat mover** is a device that removes thermal energy from one location and transfers it to another location at a different temperature.

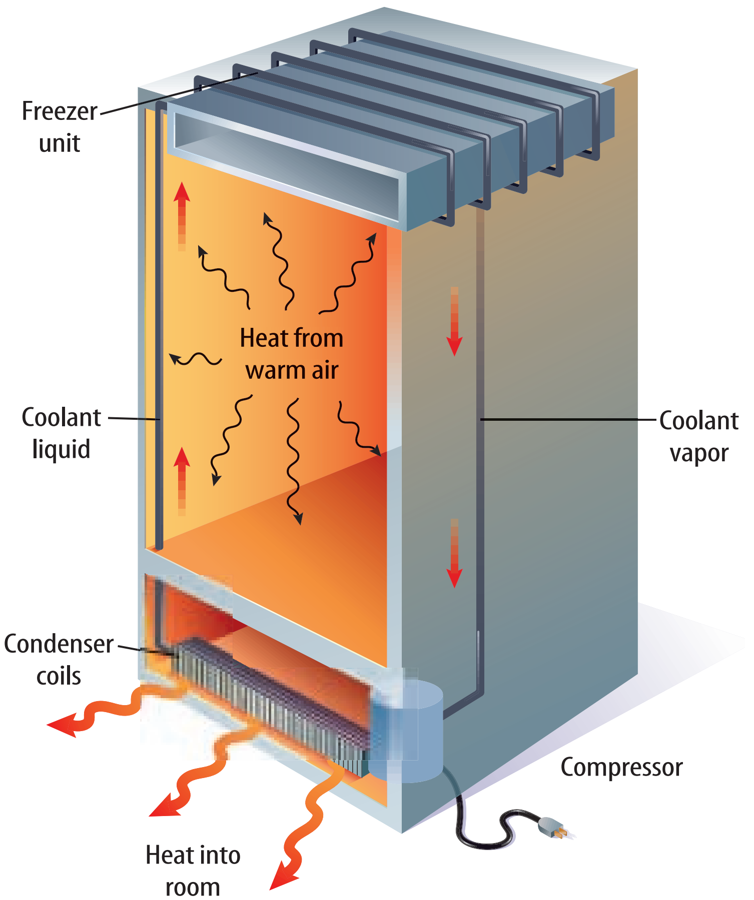



**Figure 19**
**In refrigeration systems, the coolant that flows through the pipes absorbs heat from the food that is stored inside. It then condenses and releases the heat into the room.**

**Refrigerators** A refrigerator contains a coolant that is pumped through pipes on the inside and outside of the refrigerator. The coolant is a special substance that evaporates at a low temperature. **Figure 19** shows how a refrigerator operates. Liquid coolant is pumped through a device where it changes into a gas. When the coolant changes to a gas, it cools. The cold gas is pumped through pipes inside the refrigerator, where it absorbs thermal energy. As a result, the inside of the refrigerator cools.

The gas then is pumped to a compressor that does work by compressing the gas. This makes the gas warmer than the temperature of the room. The warm gas is pumped through the condenser coils. Because the gas is warmer than the room, thermal energy flows from the gas to the room. Some of this heat is the thermal energy that the coolant gas absorbed from the inside of the refrigerator. As the gas gives off heat, it cools and changes to a liquid. The liquid coolant then is changed back to a gas, and the cycle is repeated.

**Reading Check** *What happens to a coolant when it is compressed?*

**Air Conditioners and Heat Pumps** An air conditioner is another type of heat mover. It operates like a refrigerator, except that warm air from the room is forced to pass over tubes containing the coolant. The warm air is cooled and is forced back into the room. The thermal energy that is absorbed by the coolant is transferred to the air outdoors. Refrigerators and air conditioners are heat engines working in reverse—they use mechanical energy supplied by the compressor motor to move thermal energy from cooler to warmer areas.

A heat pump is a two-way heat mover. In warm weather, it operates as an air conditioner. In cold weather, a heat pump operates like an air conditioner in reverse. The coolant gas is cooled and is pumped through pipes outside the house. There, the coolant absorbs heat from the outside air. The coolant is then compressed and pumped back inside the house, where it releases heat.

Life Science INTEGRATION

**The Human Coolant** After exercising on a warm day, you might feel hot and be drenched with sweat. But if you were to take your temperature, you would probably find that it's close to your normal body temperature of 37°C. How does your body stay cool in hot weather?

Your body uses evaporation to keep its internal temperature constant. When a liquid changes to a gas, energy is absorbed from the liquid's surroundings. As you exercise, your body generates sweat from tiny glands within your skin. As the sweat evaporates, it carries away heat, making you cooler, as shown in **Figure 20.** The thermal energy that is lost by your body becomes part of the thermal energy of your evaporated sweat.

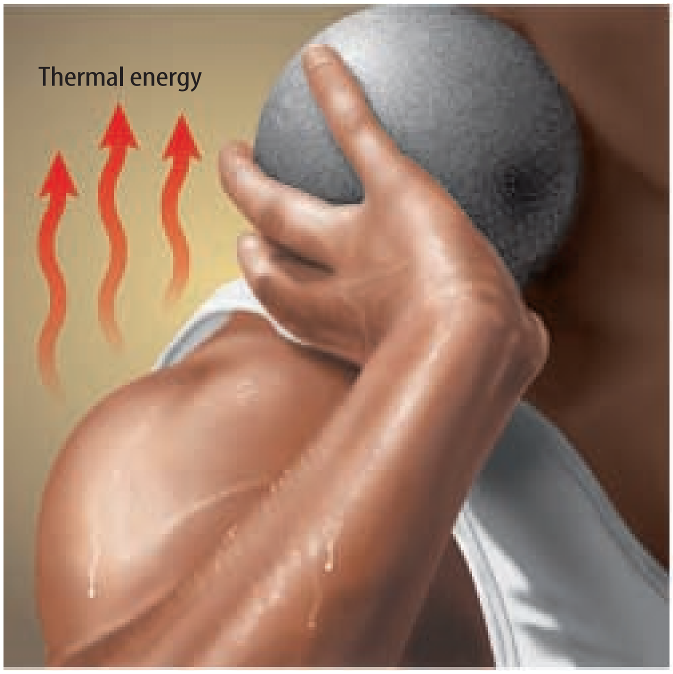



**Figure 20**
**As perspiration evaporates from your skin, it carries heat away, cooling your body.**

**Why do humid days feel hotter?** To most people humid days feel warmer than drier days, even when the temperature is the same. On humid days, more water vapor is in the air around you. Because there is more water vapor in the air, your sweat doesn't evaporate as quickly. As a result, your body loses heat more slowly. Many animals can't sweat like humans do. Dogs, for example, sweat on the pads of their feet rather than over all their skin. Instead, to cool off a dog breathes rapidly, or pants, with its tongue hanging out. Panting forces air through the nose and mouth, causing moisture to evaporate. This helps carry away the excess heat.

## Section 3 Assessment

1. Compare and contrast electrical, radiator, and forced-air heating systems.
2. Compare and contrast active and passive solar heating systems.
3. Describe how internal combustion engines work.
4. What is a heat mover?
5. **Think Critically** How does a heat mover absorb heat from cold air?

### Skill Builder Activities

6. **Making and Using Tables** In a table, organize information about heating systems. **For more help, refer to the Science Skill Handbook.**
7. **Communicating** Only a small part of the chemical energy of gasoline is used to move your car. In your Science Journal, describe ways to improve an engine's efficiency. **For more help, refer to the Science Skill Handbook.**

# Activity

## Conduction in Gases

Does smog occur where you live? If so, you may have experienced a temperature inversion. Usually the Sun warms the ground, and the air above it. When the air near the ground is warmer than the air above, convection occurs. This convection also carries smoke and other gases emitted by cars, chimneys, and smokestacks upward into the atmosphere. If the air near the ground is colder than the air above, convection does not occur. Then smoke and other pollutants can be trapped near the ground, sometimes forming smog. In this activity you will use a temperature inversion to investigate the conduction of heat in air.

### What You'll Investigate

How is heat transferred by conduction in gases?

### Goals

- **Measure** temperature changes in air near a heat source.
- **Observe** conduction of heat in air.

### Materials

Thermometers (3)
2 foam cups
400-mL beakers (2)
burner or hot plate
paring knife
thermal mitts (2)

### Safety Precautions

**WARNING:** *Use care when handling hot water. Pour hot water using both hands.*

## Procedure

1. Using the paring knife, carefully cut the bottom from one foam cup.
2. Use a pencil or pen to poke holes about 2 cm from the top and bottom of each foam cup.
3. Turn both cups upside down, and poke the ends of the thermometers through the upper holes and lower holes, so both thermometers are supported horizontally. The bulb end of both thermometers should extend into the middle of the bottomless cup.
4. Heat about 350 mL of water to about 80°C in one of the beakers.
5. Place an empty 400-mL beaker on top of the bottomless cup. Record the temperature of the two thermometers in your data table.
6. Add about 100 mL of hot water to the empty beaker. After one minute, record the temperatures of the thermometers in a data table like the one shown here.
7. Continue to record the temperatures every minute for 10 min. Add hot water as needed to keep the temperature of the water at about 80°C.

**Air Temperatures in Foam Cup**

| Time (min) | Upper Thermometer (°C) | Lower Thermometer (°C) |
|---|---|---|
| 0 | | |
| 1 | | |
| 2 | | |
| 3 | | |

## Conclude and Apply

1. **Explain** whether convection can occur in the foam cup if it's being heated from the top.
2. **Describe** how heat was transferred through the air in the foam cup.
3. **Graph** the temperatures measured by the upper and lower thermometers, with time on the horizontal axis.
4. **Explain** why the temperature of the two thermometers changed differently.

# Science Stats

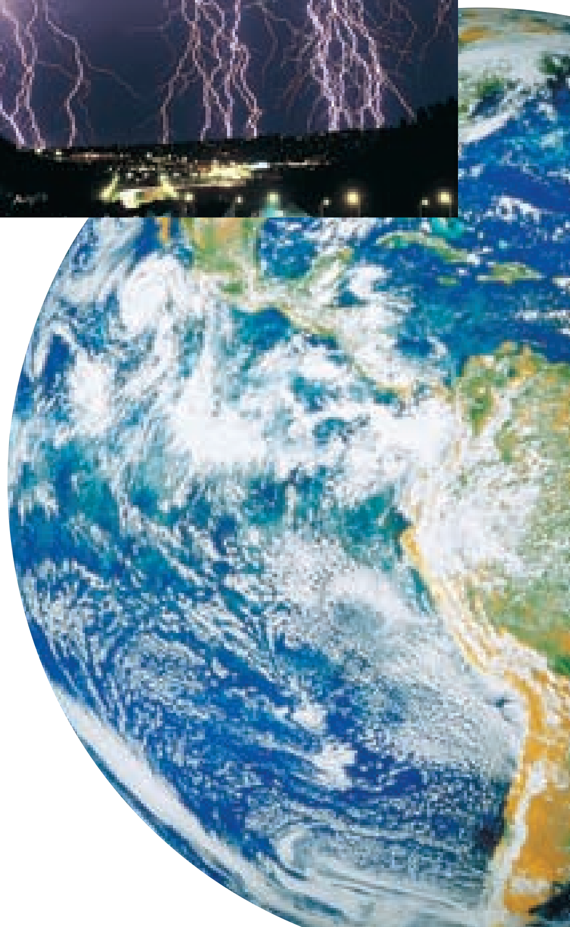
## Surprising Thermal Energy

Did you know...

**. . . The average amount of solar energy** that reaches the United States each year is about 600 times greater than the nation's annual energy demands.

**. . . Energy travels from the Sun** to Earth at the speed of light—299,274 km/s. This is fast enough to travel around Earth's equator almost eight times in a second.

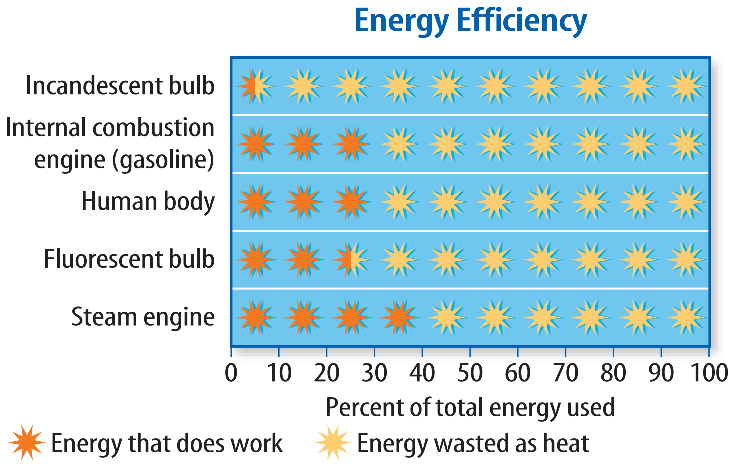
**. . . A lightning bolt heats the air** in its path to temperatures of about 25,000°C. That's about 4 times hotter than the average temperature on the surface of the Sun.



**. . . Without energy from the Sun,** Earth's average temperature would be −240°C. Earth would be like the side of the Moon that never sees the Sun. There could be no life at such frigid temperatures. The lowest recorded temperature on Earth is −89°C.

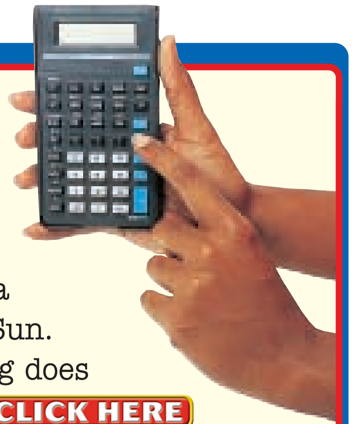
## Connecting To Math

**. . . More than 70 percent of the energy used by the average home is for temperature control.** This includes your refrigerator, heating, air-conditioning, and hot-water heater.




**. . . When a space shuttle reenters** Earth's atmosphere at more than 28,000 km/h, its outer surface is heated by friction to nearly 1,650°C. This temperature is high enough to melt steel.

## Do the Math



1. The highest recorded temperature on Earth is 58°C and the lowest is −89°C. What is the range between the highest and lowest recorded temperatures?
2. What is the average temperature of the surface of the Sun? Draw a bar graph comparing the temperature of a lightning bolt to the temperature of the surface of the Sun.
3. The Sun is almost 150 million km from Earth. How long does it take solar energy to reach Earth?

CLICK HERE

### Go Further

Use the library and the Glencoe Science Web site at **science.glencoe.com** to research how much energy is used in the United States. How much of the energy used comes from the Sun?

# Chapter 6 Study Guide

## Reviewing Main Ideas

### Section 1 Temperature and Heat

1. The temperature of a material is a measure of the average kinetic energy of the molecules in the material.
2. Heat is thermal energy that flows from a higher to a lower temperature. *How is heat flowing in the photo at the right?*

3. The thermal energy of an object is the total kinetic and potential energy of the molecules in the object.
4. The specific heat is the amount of heat needed to raise the temperature of 1 kg of a substance by 1 K.

### Section 2 Transferring Thermal Energy

1. Thermal energy is transferred by conduction, convection, and radiation.
2. Conduction and convection can occur only when matter is present.
3. Heat can flow easily through materials that are conductors. Heat flows more slowly through insulators. *What materials below are conductors, and which are insulators?*

### Section 3 Using Heat

1. Conventional heating systems use air, hot water, and steam to transfer thermal energy through a building.
2. A solar heating system converts radiant energy from the Sun to thermal energy. Active solar systems use solar collectors to absorb the thermal radiant energy.
3. Heat engines convert thermal energy produced by burning fuel into mechanical energy. In an internal combustion engine, fuel is burned inside the engine in cylinders.
4. Heat movers, like refrigerators and air conditioners, move thermal energy from one place and release it somewhere else.
5. Sweating helps humans cool their bodies through evaporation. *Why is this person shivering after getting out of a pool, even though it is a warm day?*

**FOLDABLES Reading & Study Skills**

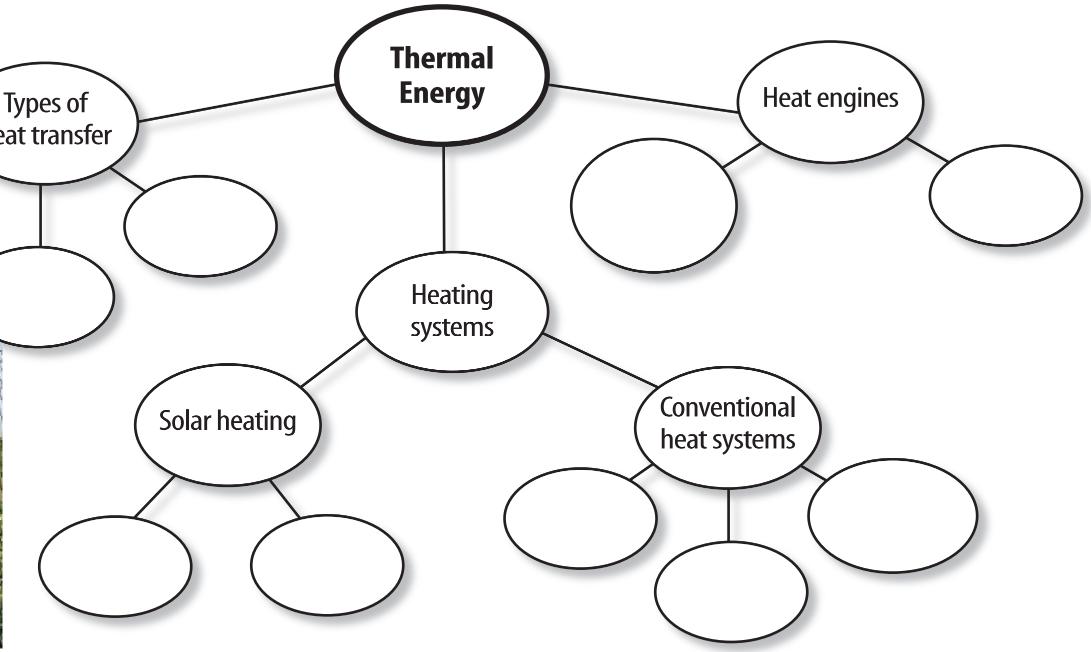
**After You Read**

Use what you learned and write how temperature and heat are related but different on the front of your Foldable.

# Chapter 6 Study Guide

## Visualizing Main Ideas

*Complete the following concept map of thermal energy transfer.*




## Vocabulary Review

### Vocabulary Words

**a.** conduction
**b.** convection
**c.** heat
**d.** heat engine
**e.** heat mover
**f.** insulator
**g.** internal combustion engine
**h.** radiation
**i.** specific heat
**j.** solar collector
**k.** solar energy
**l.** temperature
**m.** thermal energy

### Using Vocabulary

*Using the vocabulary words, change the incorrect terms to make the sentences read correctly.*

**1.** A heat mover is a device that converts thermal energy into mechanical energy.

**2.** Solar energy is energy that is transferred from warmer to cooler materials.

**3.** A heat engine is a device that absorbs the Sun's radiant energy.

**4.** The energy required to raise the temperature of 1 kg of a material 1 K is a material's thermal energy.

**5.** Heat is a measure of the average kinetic energy of the particles in a material.

**6.** Convection is energy transfer by electromagnetic waves.

THE PRINCETON REVIEW **Study Tip**

Make a plan. Before you start your homework, write out a checklist of what you need to do for each subject. As you finish each item, check it off.

# Chapter 6 Assessment

## Checking Concepts

*Choose the word or phrase that best answers the question.*

**1.** Which is NOT a method of heat transfer?
**A)** conduction **C)** radiation
**B)** specific heat **D)** convection

**2.** In which of the following devices is fuel burned inside chambers called cylinders?
**A)** internal combustion engines
**B)** radiators
**C)** heat pumps
**D)** air conditioners

**3.** During which phase of a four-stroke engine are waste gases removed?
**A)** power stroke
**B)** intake stroke
**C)** compression stroke
**D)** exhaust stroke

**4.** Which material is a poor insulator of heat?
**A)** iron **C)** air
**B)** feathers **D)** plastic

**5.** Which of the following devices is an example of a heat mover?
**A)** solar panel
**B)** refrigerator
**C)** internal combustion engine
**D)** diesel engine

**6.** Which term describes the measure of the average kinetic energy of the particles in an object?
**A)** potential energy **C)** temperature
**B)** thermal energy **D)** specific heat

**7.** Which of these is NOT used to calculate change in thermal energy?
**A)** volume
**B)** temperature change
**C)** specific heat
**D)** mass

**8.** Which of these does NOT require the presence of particles of matter?
**A)** radiation **C)** convection
**B)** conduction **D)** combustion

**9.** Which of the following is the name for thermal energy that is transferred only from a higher temperature to a lower temperature?
**A)** potential energy **C)** heat
**B)** kinetic energy **D)** solar energy

**10.** Which device changes thermal energy into mechanical energy?
**A)** conductor **C)** solar collector
**B)** refrigerator **D)** heat engine

## Thinking Critically

**11.** On a hot day a friend suggests that you can make your kitchen cooler by leavng the refrigerator door open. Explain whether leaving the refrigerator door open would or would not cause the air temperature in the kitchen to decrease.

**12.** A copper bowl and a silver bowl of equal mass were heated from 27°C to 100°C. Which required more heat? Explain.

| Specific Heat [J/(kg K)] | |
|---|---|
| Copper | 385 |
| Silver | 235 |

**13.** Explain whether or not the following statement is true: If the thermal energy of an object increases, the temperature of the object must also increase.

**14.** Which has the greater amount of thermal energy, one liter of water at 50°C or two liters of water at 50°C? Explain.

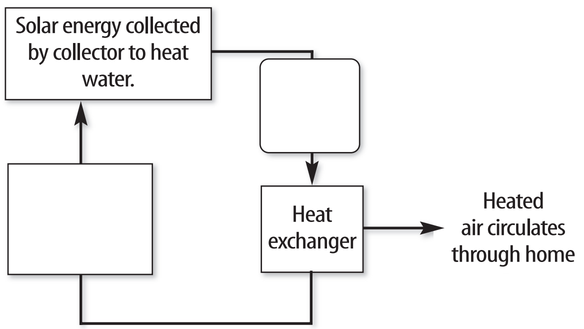
**15.** Suppose a beaker of water is heated from the top. Will heat transfer by convection occur in the water? Explain.

## Developing Skills

**16. Classifying** Order the events that occur in the removal of heat from an object by a refrigerator. Show the complete cycle, from the placing of a warm object in the refrigerator to the changes in the coolant.

**17. Recognizing Cause and Effect** Describe what might happen if the following occur in an internal combustion engine, and indicate the engine stroke that will be affected: exhaust valve stuck closed, bad spark plug, and intake valve will not close.

**18. Concept Mapping** Complete the following events chain to show how an active solar heating system works.




## Performance Assessment

**19. Making Observations and Inferences** Identify the building materials that are used in or on the walls, ceilings, or attic space in your home and school. Which ones are good heat insulators?

### Technology

Go to the Glencoe Science Web site at **science.glencoe.com** or use the **Glencoe Science CD-ROM** for additional chapter assessment.

CLICK HERE

## THE PRINCETON REVIEW Test Practice

Pierre's science class did an experiment involving heat. The setup for the experiment is shown in the diagram below. Pierre took temperature readings every 2 min for 20 min. For the first 10 min, the light was turned on. For the last 10 min, the light was turned off.

*Study the diagram and answer the following questions.*

**1.** What is probably being measured in the setup in the diagram?

**A)** the rate at which electricity affects the temperature of soil and water

**B)** the rate at which soil and water evaporate

**C)** the rate at which soil and water absorb heat energy

**D)** the effect of light on plant growth in soil and water

**2.** How could Pierre improve his experiment?

**F)** by putting soil in both containers

**G)** by taking temperature readings every 5 min

**H)** by using more or less water

**J)** by moving the lamp so that it heats both beakers equally

## Reading Comprehension

*Read the passage. Then read each question that follows the passage. Decide which is the best answer to each question.*

# Bouncing Back

Have you ever noticed that the balls you use for different sports bounce differently? If you played baseball with a tennis ball, the ball would probably fly way out into the outfield without much effort when you hit it with your bat. In contrast, if you used a baseball in a tennis match, the ball probably would not bounce high enough for your opponent to hit it very well. The difference in the way balls bounce depends upon the materials that make up the balls and the way in which the balls are constructed.

A ball drops to the floor as a result of gravity. As the ball drops, it gathers speed. When the ball hits the floor, the energy that it has gained goes into deforming the ball, changing it from its round shape. As the ball changes shape, the molecules within it stretch farther apart in some places and squeeze closer together in other places. The strength of the bonds between molecules determines how much they stretch apart and squeeze together. This depends on the chemical composition of the materials in the ball.

Most balls are made of rubber. Rubber is elastic, which means that it returns to its original shape after it's been deformed. Rubber is made of molecules called polymers that are long chains. Normally these chains are coiled up, but when the rubber is stretched, the chains straighten out. Then when the stretching force is removed, the chains coil up again. How high a ball bounces depends on the type of polymer molecules the rubber is made of. Bouncing balls sometimes feel warm because some of the ball's kinetic energy is converted into thermal energy.

**Test-Taking Tip** Make a list of the important details in the passage.


**The force applied by a bat caused the shape of a baseball to change.**

**1.** According to information in the passage, it is probably accurate to conclude that _____.

**A)** all rubber balls bounce the same, no matter what they are made of

**B)** the way rubber balls bounce depends upon the polymers that they are made of

**C)** baseballs are better for playing tennis than tennis balls are for playing baseball

**D)** the higher a ball bounces, the more thermal energy is produced

**2.** In the context of this passage, the word elastic means _____.

**F)** able to retain its shape

**G)** inflexible

**H)** tightly linked

**J)** deformed

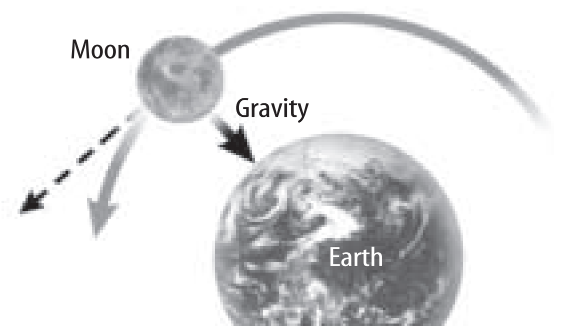
## Reasoning and Skills

*Read each question and choose the best answer.*

**1.** Latifah wanted to figure out which race car had the most kinetic energy during a competition. She researched the different race cars to find out their masses. Her experiment could be improved by _____.

**A)** writing down a list of observations during the competition
**B)** finding out the velocity of each race car during the competition
**C)** weighing the cars after the competition
**D)** researching motorcycles

**Test-Taking Tip** Consider how mass and velocity affect an object's kinetic energy.




Centripetal Force

**2.** Which kind of scientist would most likely use this picture?

**F)** botanist
**G)** physicist
**H)** chemist
**J)** zoologist

**Test-Taking Tip** Consider the type of information presented by the picture.

**Training record**

| End of Month | Maximum Speed (km/h) |
|---|---|
| 1 | 7.0 |
| 2 | 7.5 |
| 3 | 8.0 |
| 4 | ? |

**3.** These data were collected while an athlete trained for a marathon. If the trend continues, what will be the maximum speed of the athlete at the end of the fourth month?

**A)** 6.5 km/h
**B)** 8.0 km/h
**C)** 9.0 km/h
**D)** 8.5 km/h

**Test-Taking Tip** Carefully consider the information in both the chart and the question in order to identify the trend.

*Consider this question carefully before writing your answer on a separate sheet of paper.*

**4.** Explain the similarities and differences between simple and complex machines. Give some examples of simple and complex machines you see or use everyday.

**Test-Taking Tip** Recall examples of simple and complex machines from everyday life.