Chapter 4
Heat

Have you ever seen a hot air balloon float high above Earth's surface? What about a hang glider or a soaring bird of prey like a hawk? Each of these objects—a hot air balloon, a hang glider, and a hawk—take advantage of heat to "fly." In this chapter, you will learn about heat and temperature and how they affect natural events and human activities.

Key Questions

1. ***What is the difference between heat and temperature?***
2. ***Why does an ice cube melt in your hand?***
3. ***Does the Sun help a hawk to fly?***

4.1 What Is Heat?

What happens to an ice cube when you hold it in your hand? The ice melts because heat flows from your hand to the ice cube. We've all experienced the effects of heat, but what exactly *is* heat?

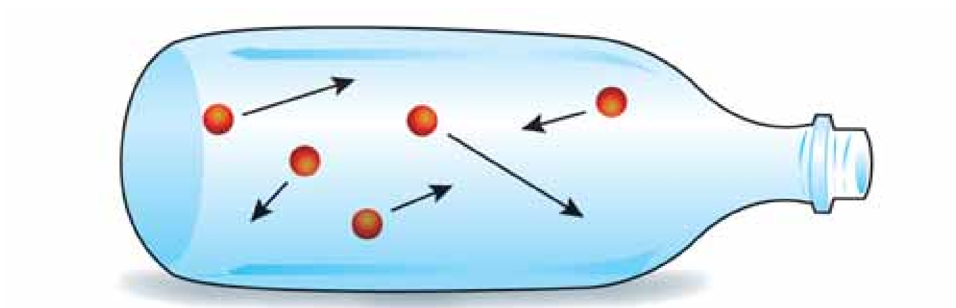
Atoms and molecules

Particles of matter move constantly

Matter is made of tiny particles called *atoms* that are too small to see with your eyes or even with a magnifying glass (Figure 4.1). In most matter, atoms occur in a group called a **molecule**. Atoms and molecules move constantly. The molecules of the water you drink and the air you breathe are moving. Molecules in an ice cube are moving. All of the atoms of your body are moving constantly, too—even when you are asleep!

Kinetic energy

Imagine what it would be like to live in an atom-sized world. If you were suddenly shrunk to the size of an atom, you would be pushed and shoved by all the atoms and molecules around you. Watch out! Atoms and molecules whiz by at amazingly fast speeds! The constant motion of atoms is a form of energy. The energy of motion is called **kinetic energy**. Faster atoms have more kinetic energy than slower atoms.



Imagine atoms were big enough to see. In this diagram, arrow length shows atom speeds. Which atoms have the most kinetic energy?

VOCABULARY

molecule - a group of atoms.

kinetic energy - energy of motion.

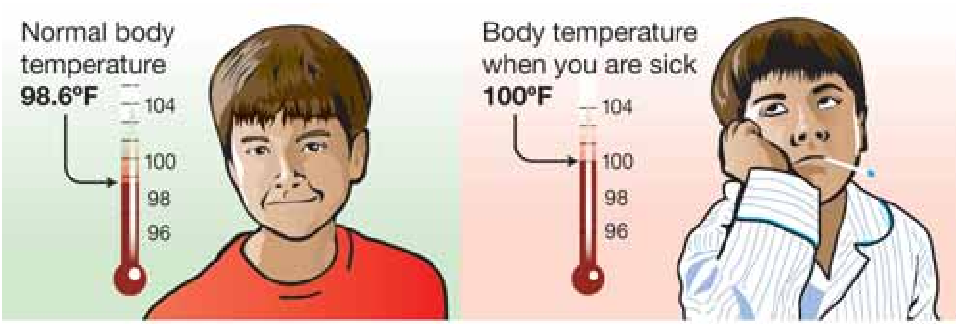
Figure 4.1: *The thickness of a sheet of aluminum foil is about 200,000 atoms across. Important note: Atoms are too small to see with your eyes or a magnifying glass!*

Heat and temperature

What is heat? **Heat** is a form of energy caused by the motion of atoms and molecules.* Heat is the sum of the kinetic energy of each atom in a sample. This means that a bucket of hot water has more heat energy than a cup of hot water. The bucket contains more hot water molecules than the cup. More molecules means more motion and more heat energy.

What is temperature? Temperature is related to heat, but it isn't the same thing. **Temperature** is a measure of the *average* speed of atoms in a sample. The average speed of the atoms in a hot object is fast. The average speed in a cold object is slow (Figure 4.2).

What is your temperature? Sometimes when you are sick, your forehead feels very warm and a thermometer might show a temperature of 100°F or more. The normal temperature for the human body is 98.6°F. A thermometer measures the average kinetic energy of the atoms in your body.



The average speed of atoms in your body is higher when you are sick.

* *Footnote: This definition of heat was adapted to be appropriate for the level and content of this text.*

VOCABULARY

heat - a form of energy caused by the motion of atoms and molecules.

temperature - a measure of the average speed of a sample containing lots of atoms.

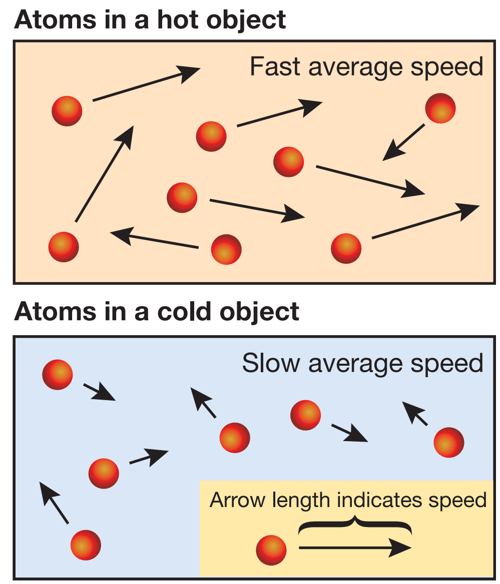


Figure 4.2: *The average speed of atoms in a hot object is fast. The average speed of atoms in a cold object is slow.*

Summary of heat and temperature

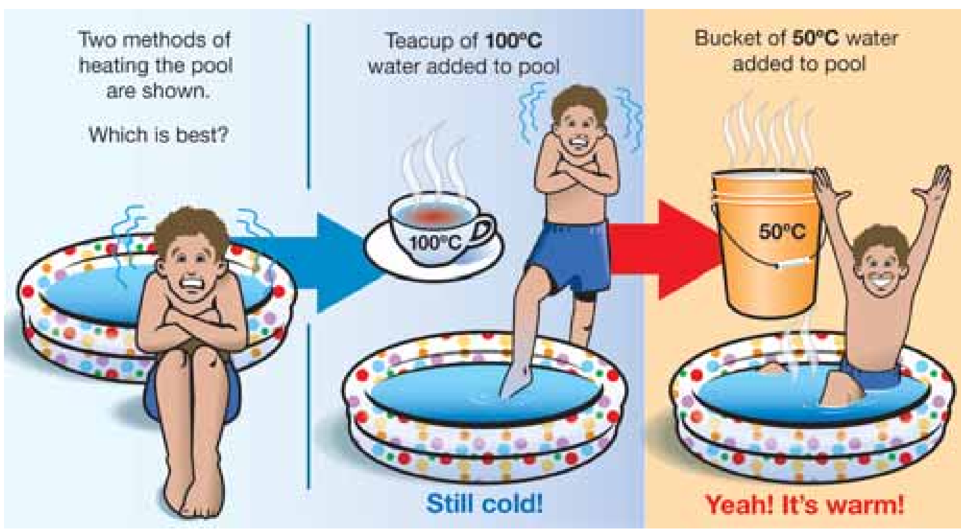
An example If you wanted to warm up a swimming pool of water you need heat energy. Here are two methods for warming the water. Which method is the best?

- Warm the water with a teacup of water at 100°C, or
- Warm the water with a bucket of water at 50°C

The water in the teacup has a higher temperature, but there are fewer molecules than in the bucket of water. This means that the teacup water has less heat energy than the water in the bucket.

Even though the teacup has a higher temperature, the bucket is a better choice for warming the pool water because it contains more total heat energy!

The best method for warming the water in the pool is to add the bucket of water at 50°C.



SOLVE IT!

When two equal volumes of water are mixed, the final temperature of the mixture is halfway between the two original temperatures.

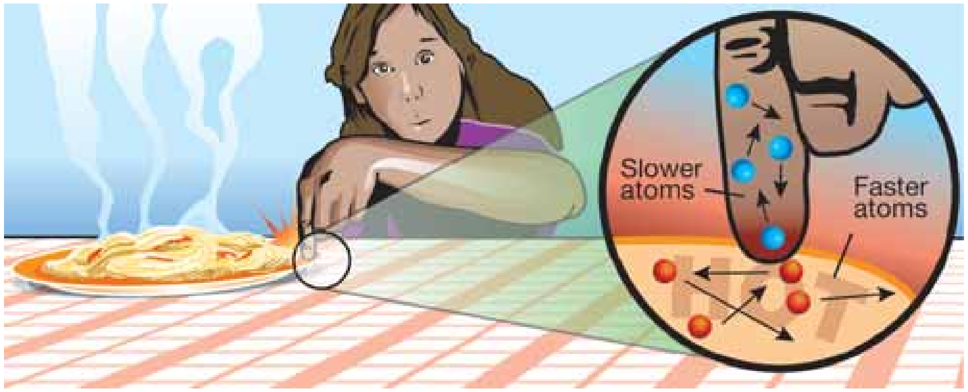
This is because molecules collide and exchange energy. Fast molecules slow down while the slow ones speed up. Eventually, all the molecules are going at about the same speed.

Use this information to solve this problem:

A cup of water at 20°C is mixed with a second cup of 80°C water. Both cups have the same amount of water. What will the temperature of the final mixture be?

Heat is a form of energy

From warmer to cooler objects Heat, as a form of energy, can be transferred from one object to another. Heat moves from warmer to cooler objects. For example, if Michelle accidentally touches a hot dinner plate, heat from the plate moves to her cooler finger. Fast-moving atoms of the plate push against the slower atoms of her finger. As a result, the nerves in her finger send a warning message to her brain. Her brain sends a message to the hand to pull away from the plate as quickly as possible. If Michelle didn't remove her finger from the plate, she might get burned!



Fortunately, the hot dinner plate will not stay too hot forever. Eventually, as heat from the plate transfers to the cooler air around it, the plate cools down to the temperature of the room.

Usable energy and heat Michelle will eat the spaghetti on her plate to get energy to do her homework. Some of that energy will be used by Michelle to do her homework. Some of that energy will become heat and Michelle cannot get back the lost heat. To get more energy, she needs to eat more food!

MY JOURNAL

1. Place an ice cube in a plastic sandwich bag and seal the bag tightly. What happens to the ice cube when you let it sit on the table (in the bag)?

2. Sketch a "before" and "after" picture in your journal. Record the time it took for the ice cube to melt.

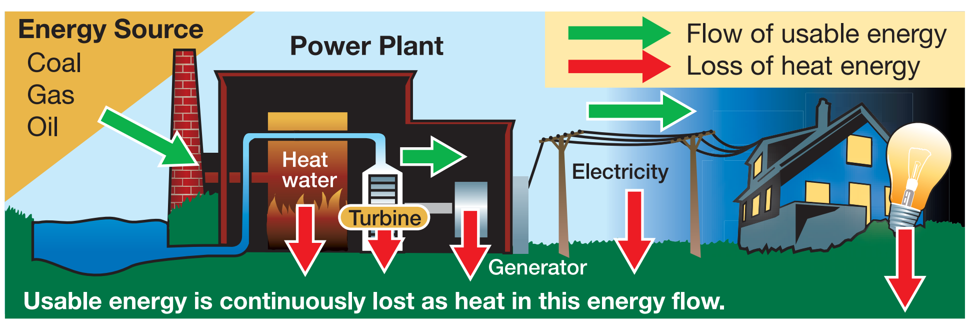
3. What could you have done to shorten the melting time? List all possibilities.

Energy flow and heat loss

Heat and light bulbs The source of energy for a light bulb is electricity. A light bulb produces energy in the form of light. The light bulb might feel hot to the touch after it has been lit for awhile. This is because only 2% of the energy produced by a regular (or incandescent) light bulb is light energy and 98% of the energy produced is heat energy. Only a small amount of the energy produced by the bulb is useful for brightening a room (Figure 4.3).

Heat and cars The source of energy for a car is gasoline. For most cars, about 20% of the gasoline burned by the engine is used to move the car. Eighty percent of the energy from the gasoline is given off as heat energy (Figure 4.4).

Heat and fuels Like a light bulb or a car, a power plant loses some of the energy it produces as heat. A **power plant** is a place where electricity is generated. Fossil fuels like coal, oil, and natural gas are common sources of energy for power plants. The first step of producing electricity involves burning the fossil fuels to boil water. The resulting steam turns a turbine. The *turbine* converts the energy from the steam into energy that turns a generator. The generator then converts this kinetic energy into electricity. The electricity is carried to your house by wires. Some heat is lost at each step in the process of converting fuel energy into useful electricity.



VOCABULARY

power plant - a place where electricity is generated.

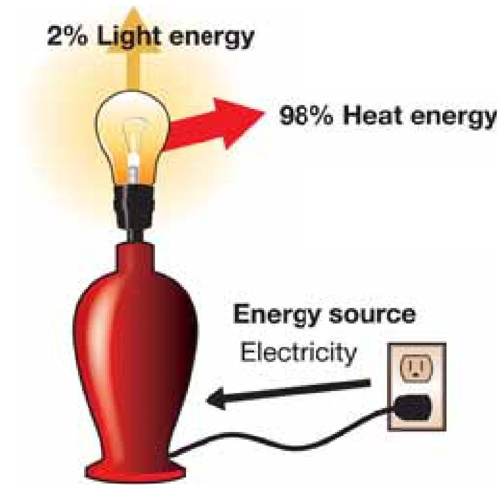


Figure 4.3: *Most of the energy used by a light bulb becomes heat energy.*

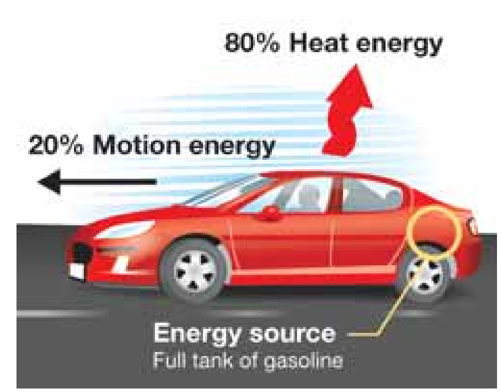


Figure 4.4: *Most of the energy from gasoline becomes heat energy.*

4.1 Section Review

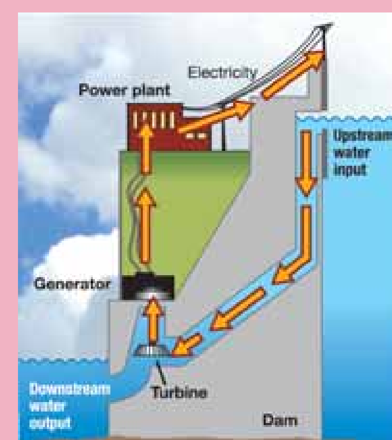
1. What are atoms and molecules?
2. Relate the amount of kinetic energy to the speed of atoms.
3. Fill in the blank. Faster atoms have _____ (more/less) kinetic energy than slower atoms.
4. Figure 4.5 lists the speeds of students running in a gymnasium. Find the average speed of the students by adding the speeds and dividing by five. If the group of students represents a group of atoms, what does their average speed represent?
5. What is the difference between heat and temperature?
6. Will 1 liter of hot water have more or less heat energy than 2 liters of hot water? Explain your answer.
7. In which direction is heat transferred—from warm to cool or from cool to warm?
8. You mix 100 milliliters of 10°C water and 100 milliliters of 90°C water. What is the final temperature of the mixture?
9. What kind of energy is used to keep a light bulb lit?
10. Name three fossil fuels that are used as the source of energy at many power plants.
11. Describe the process by which electricity is made at a power plant that uses fossil fuels.
12. In a light bulb, car, and power plant, what type of energy is lost?
13. Research the answers to the following questions using your school library or the Internet. In terms of energy produced:
    a. What is the main difference between an incandescent light bulb and a compact fluorescent light bulb?
    b. What is the main difference between gasoline-powered and electric hybrid cars?

Student	Speed (cm/s)
Alice	100 cm/s
Bernard	150 cm/s
Chloe	50 cm/s
Dev	75 cm/s
Eduardo	125 cm/s
AVERAGE (sum of five speeds ÷ 5)	

Figure 4.5: *The speeds of five students running in a gymnasium.*

CHALLENGE

Compare and contrast this hydroelectric power plant with a fossil fuel burning power plant.



Water flowing from a high point to a low point provides the energy to turn the turbine.

4.2 How Does Heat Move?

Ice cream will melt when it comes in contact with warm air molecules. How does this happen? This section describes how heat is transferred.

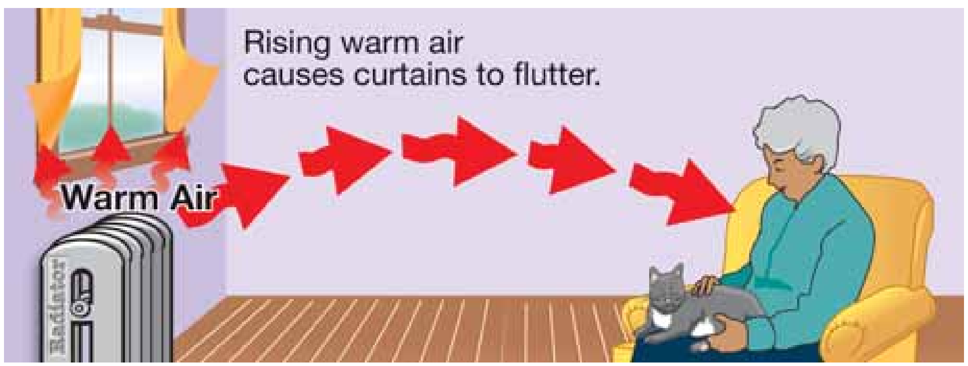
VOCABULARY

convection - transfer of heat through the motion of liquids and gases.

Heat transfer by convection

What is convection? **Convection** is the transfer of heat through the motion of gases and liquids such as air and water. Warm air tends to rise and cold air tends to sink. Convection occurs naturally in Earth's atmosphere. Convection also occurs in homes. To understand convection, let's think of how a room gets heated.

Convection is used to heat rooms A radiator is a device used to heat a room. Heat from a radiator warms nearby air atoms. The warmed atoms move quickly and carry heat energy as they rise above the radiator. A curtain above the radiator flutters as fast-moving atoms collide with it. Eventually, heat from the radiator and convection of the air make the room comfortably warm.



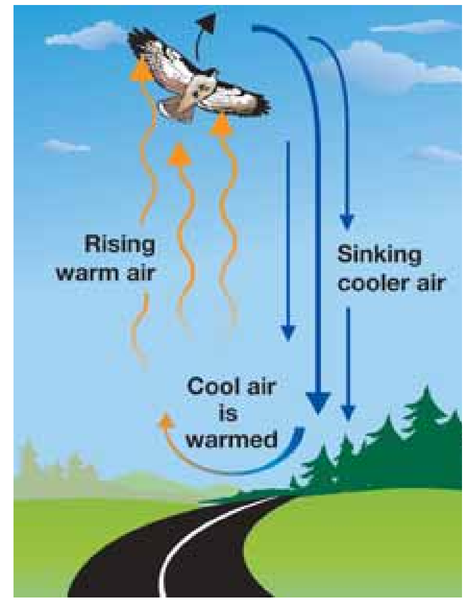


Figure 4.6: *Hawks use convection to soar. They are lifted higher in the sky by rising warm air.*

Convection is used to fly Air near Earth's surface gets warm and rises. Hawks make use of convection to soar in the sky. Rising warm air provides lift so that hawks can soar. Eventually, the rising warm air cools down and sinks back to the ground where it may get reheated.

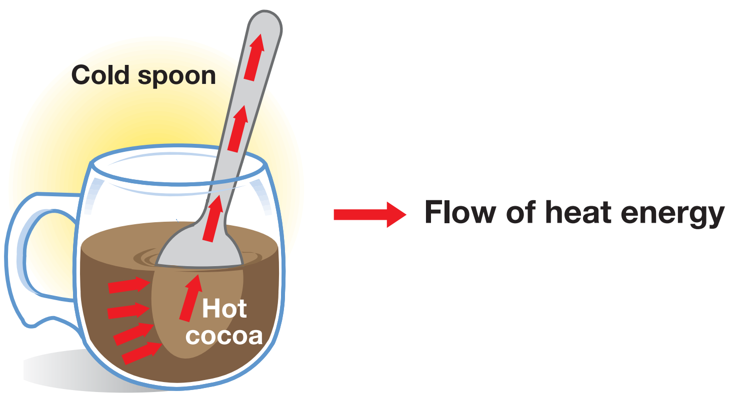
Heat transfer by conduction

What is conduction?

Conduction is the transfer of heat by the direct contact of atoms and molecules in solids. Heat is transferred from atom to atom by direct contact. If you hold an ice cube in your hand, warmer hand atoms will transfer heat by conduction to the cooler ice cube atoms.

Example of heat transfer by conduction

Unlike the atoms in liquids and gases, the atoms in solids are anchored in place. They can wiggle and push each other, but they do not move freely. If you place a cold spoon into a mug of hot cocoa, you may notice that the handle of the spoon becomes warm. If solid atoms can't move freely, how does the *handle* of a spoon resting in a mug of hot cocoa get warm? Imagine the spoon handle as a long line of atoms. At first, all of the atoms are moving at similar speeds. You know this because the whole handle is at the same temperature. Soon the part of the handle closest to the surface of the cocoa heats up. This means that the handle's atoms close to the surface of the cocoa are now wiggling and pushing at a higher speed. As these atoms push other atoms further along the handle, these more distant atoms speed up in turn. In a similar fashion, the atoms are sped up all along the handle. Transferring heat this way is an example of conduction.



VOCABULARY

conduction - transfer of heat by direct contact of atoms and molecules.

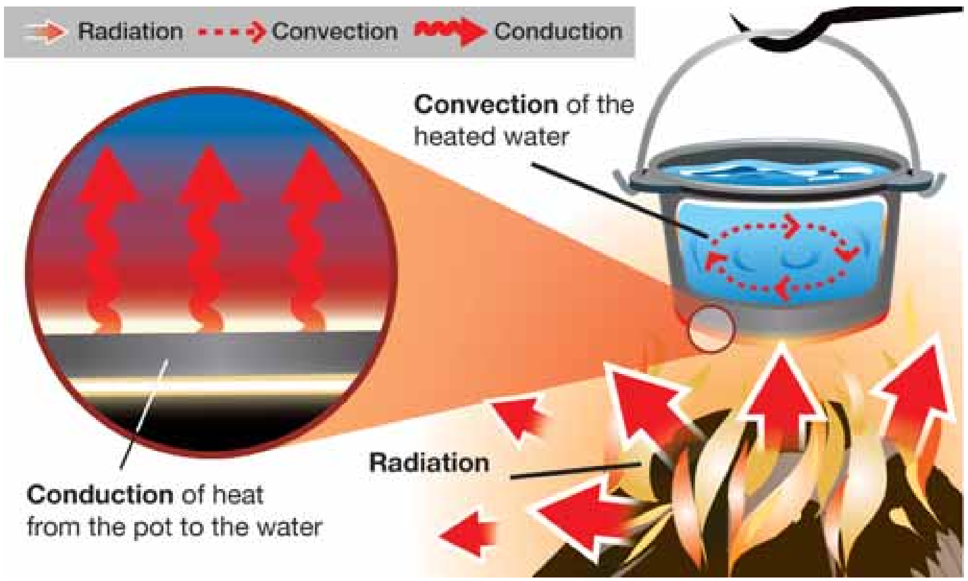
MY JOURNAL

Where is conduction in your house? Walk through your house. In each room, observe whether or not there are objects that are involved in conduction. Based on your observations, make a list of as many examples of heat transfer by conduction as you can. Remember, heat transfer by conduction works in solids, because direct contact of atoms and molecules must occur.

Heat transfer by radiation

What is radiation? The warmth of the Sun on your face feels good on a cool day. The heat from the Sun is necessary for life to exist on Earth (Figure 4.7). This heat is not transferred to Earth by conduction or convection. Instead, the Sun's heat reaches Earth by a heat transfer process called radiation. **Radiation** is heat transfer through empty space. Heat transfer by radiation occurs without direct contact or movement of atoms.

Summary of convection, conduction, and radiation All three forms of heat transfer are often working at the same time to transfer energy from warmer objects to cooler objects. A pot of water being heated by a campfire is warmed through the process of conduction, convection, and radiation!



VOCABULARY

radiation - heat transfer that involves energy waves and no direct contact or movement by atoms.

Figure 4.7: *The Sun's heat is the product of nuclear reactions between atoms in the Sun. The Sun's heat reaches Earth by radiation.*

4.2 Section Review

1. Why does an ice cube melt in your hand?
2. State the type of heat transfer that is occurring in each situation:
   a. Warm air rises.
   b. You feel the heat on your feet as you walk barefoot across a driveway in the summertime.
   c. You feel the warmth of the Sun on your face.
3. A hawk gets some help while flying by using convection currents (air currents created by rising warm air). How is the Sun involved in creating convection currents?
4. How would heat transfer occur in the following substances or objects?
   a. The atmosphere
   b. A metal rod
   c. Water in a pot
   d. An empty pot on a hot stove
   e. The air inside a hot-air balloon
5. You mom is cooking a pot of spaghetti on the stove. You observe that the spaghetti moves all around the pot even though she isn't stirring. What makes the spaghetti move?
6. How is radiation different from heat transfer by convection and conduction?
7. A thermostat controls the switches on a furnace or air conditioner by sensing room temperature. Explain, using conduction, convection, and radiation, where you would place the thermostat in your classroom. Consider windows, outside and inside walls, and the locations of heating and cooling ducts.

Another type of power plant

You have probably heard of nuclear power plants. These power plants produce heat using radioactivity. When unstable atoms undergo radioactive decay, they also happen to produce heat. This heat can be used to heat water. As with power plants that use fossil fuels, nuclear power plants work by using the steam from heated water to turn a turbine. The turbine converts the energy from the steam into energy that turns a generator. The generator then converts this kinetic energy into electricity.


A nuclear power plant

4.3 Earth's Heat Energy

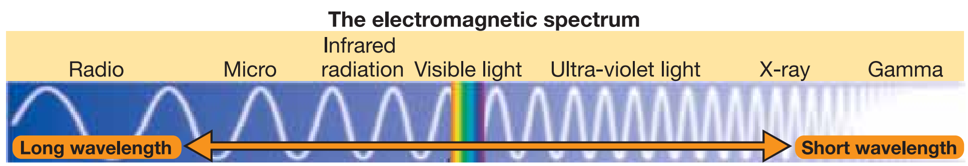
Heat energy is necessary for life on Earth to exist. Even in the coldest parts of Antarctica, heat energy due to the motion of molecules can be found. Do you know where most of Earth's heat energy comes from?

Where does Earth's heat come from?

Surface heat energy

Most of Earth's surface heat energy comes from the Sun, and a little comes from volcanoes and geysers. About 5 million tons of the Sun's mass is converted to energy every second through nuclear reactions. This energy leaves the Sun as radiant energy that is mostly visible light, but also includes infrared radiation (heat) and ultraviolet light. Visible and ultraviolet light, and infrared radiation are part of the *electromagnetic spectrum*.

Radiation from the Sun



When the Sun's radiation arrives at Earth, it is reflected or absorbed by the atmosphere or the surface (Figure 4.8). For example, our sky looks blue and our Sun seems yellow because blue visible light is scattered by the atmosphere more than yellow light. *(Safety note: Never look at the Sun. Its radiation can harm your eyes.)* Fortunately, ozone in our atmosphere absorbs most of the ultraviolet light which can cause sunburns and skin cancer.

Internal heat energy

The Earth's internal heat energy mostly comes from its *core* (Figure 4.9). Much of this heat energy is left over from when Earth first formed. Some of the core's heat energy comes from the breakdown of radioactive atoms. Radioactive atoms are unstable and undergo changes that produce heat and other products.

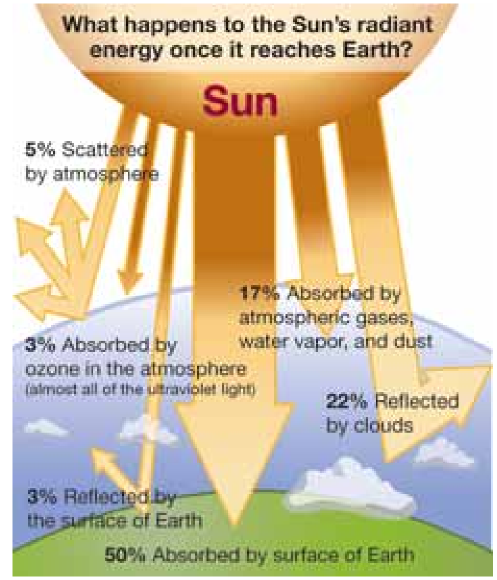


Figure 4.8: *The Sun's radiant energy at Earth's surface.*

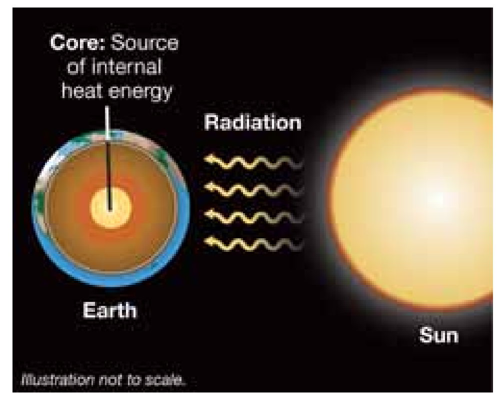


Figure 4.9: *Most of Earth's internal heat comes from the core. Most of Earth's surface heat comes from the Sun's radiation.*

4.3 Section Review

1. How much of the Sun's mass is converted to energy every second?
2. From where and in what form does Earth get most of its surface energy?
3. How much of the Sun's radiant energy is absorbed by Earth's surface?
4. How much of the Sun's radiant energy is reflected by clouds or scattered by the atmosphere?
5. List two other sources of heat energy at Earth's surface.
6. Some of the radiation that reaches Earth's surface from the Sun is *ultraviolet* radiation. This type of radiation causes skin cancer. Look at Figure 4.8. Why is Earth's ozone layer so important?
7. From where does Earth get most of its internal energy?
8. Why is Earth's core so hot? List two reasons.
9. The electromagnetic spectrum is the range of energy waves called electromagnetic waves. Name the type of electromagnetic waves:
   a. that we can see.
   b. that are the main component of solar radiation.
10. What is a volcano? What is a geyser? Define these terms in your own words, using knowledge you already have. These features provide some energy at Earth's surface, but where do they get their source of heat energy?
    (Note: You will learn more about the heat source for volcanoes and geysers in chapter 10).

SOLVE IT!

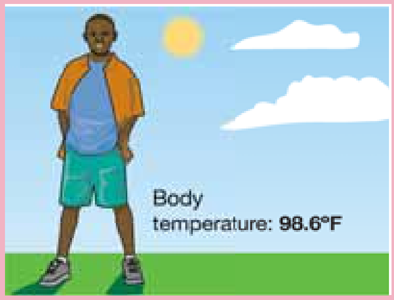
Make a graph of the information in Figure 4.8. What kind of graph should you make? Make your graph easy to read and understand.

CHALLENGE

Like Earth, you produce internal heat and you also get heat from outside sources. Following are some questions about heat and how you stay warm. Use your school library or the Internet to find the answers to these questions.

(1) Your body is 98.6°F most of the time. How does it stay so warm?

(2) What sources of energy do you use to stay warm indoors? What sources of energy do you use to stay warm outdoors?



GEOLOGY CONNECTION

Earth's Energy

Remember the last time you dipped your foot into a bathtub of hot water? Or how good it feels to take a hot shower on a cold rainy day? The hot water we use every day has to be heated by a system. Your home probably has a hot water heater to heat water. However, there are places on Earth, like Iceland, that use Earth's plumbing and heating system to get hot water. Parts of this system are geysers and hot springs. The source of heat is *geothermal energy*—heat that comes from inside our planet.

At Earth's core, temperatures can reach 4982°C (9,000°F). Heat from the core travels to the next layer of rock, the mantle. Mantle rock that melts becomes magma. Magma, lighter than the surrounding rock, travels upward carrying heat. This upward movement and transfer of heat through a fluid is called convection. Convection moves heat away from its source at a lower, hotter area to a higher, cooler area.

Magma that reaches the Earth's surface is lava, but most magma stays below the surface. That underground magma heats nearby water and rocks.

Hot springs and geysers are created by surface water that seeps into the ground and finally reaches those hot rocks. When that heated water rises by convection back to the surface, hot springs and geysers are created.

Hot water from Earth

Rocks are hotter the deeper they are inside Earth. In areas where there is no volcanic activity, those hot rocks heat the hot springs. In areas with volcanic activity, the hot springs are heated by magma. Extremely hot magma can cause the water in a hot spring to boil.

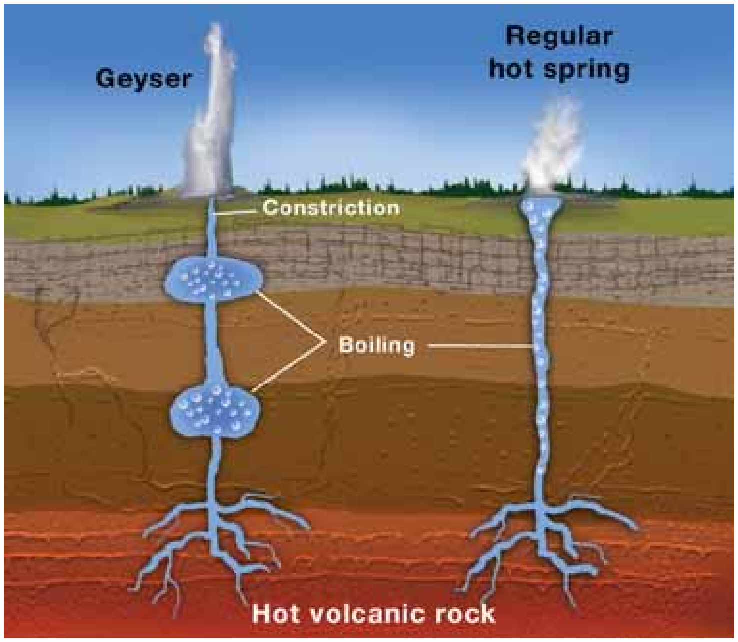
Water temperatures in hot springs vary. Usually the water is warmer than body temperature—37°C (98.6°F)—which makes it feel hot to the skin. In hot springs with high temperatures, the water is usually clear because the water is too hot for algae or bacteria grow. However, this water may not be safe to drink because of the minerals dissolved in it.

Things come to a boil

Geyser is an Icelandic word meaning "roarer." A geyser is a type of hot spring that shoots water and steam into the air. The roaring sound comes from the eruption of the water and steam. As it does with a hot spring, water seeps into the ground until it reaches hot rocks. Most geysers are located in areas of volcanic activity. One big difference between a hot spring and a geyser is constriction, which is a narrowed area of plumbing that causes pressure to build.

Far below Earth's surface, geysers fill with water. Near the top of the geyser, a constricted area forms a seal and pressure is created. Pressure also differentiates a hot spring from a geyser. Cooler water sitting in the area pushes down on the hot reservoir of water. Under increased pressure, the reservoir below heats up even more. As the temperature rises, the reservoir starts to boil.

The building pressure of the boiling water causes an eruption. Water and steam is forced out of the geyser to the surface through an opening called a vent. Pressure is released—and, naturally, the process begins again.



Old Faithful

There are four big locations for geysers on the planet: Iceland (where they got their name), Yellowstone National Park in Wyoming, North Island in New Zealand, and Kamchatka Peninsula in Russia. Old Faithful in Yellowstone is one of the world's famous geysers. Just about every 35 to 120 minutes, it shoots water 100 to 200 feet into the air. Yellowstone is located over a hot spot in the planet's mantle and this makes it one of the richest locations for geysers—nearly 500 of them in all.

Importance of geothermal energy

Hot springs and geysers are more than rare natural attractions. They also can be sources of energy. In the 1970s, Iceland started to use its hot springs and geysers to provide energy for power, heat, and hot water. Today, Iceland uses geothermal energy to provide heat to nearly 87 percent of its homes. In Northern California, geothermal geyser fields have been used for nearly 40 years and produce electricity for San Francisco. Earth's energy can provide a safe, low-cost, and environmentally sound source of power.

Questions:

1. What is geothermal energy?
2. What is the difference between a hot spring and a geyser?
3. Why is "geyser" a good term for Old Faithful?

CHAPTER ACTIVITY Energy at the Surface of Earth

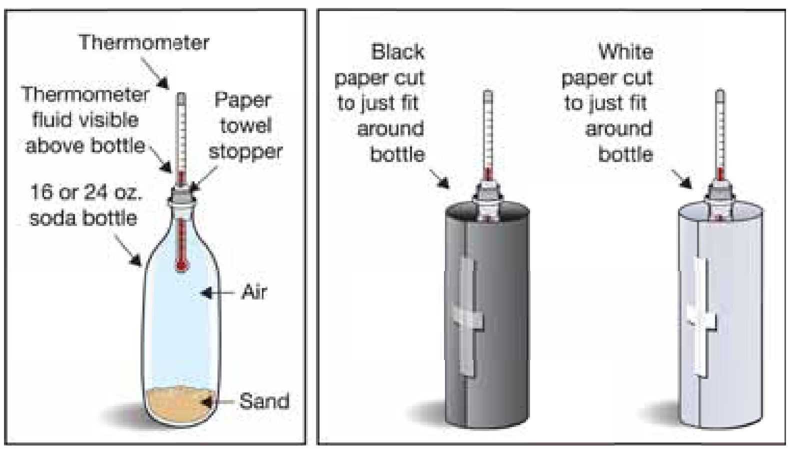
In this activity you will model radiation of heat energy from the Sun to Earth.

Materials

- Two 16- or 24-ounce soda bottles with some sand for stability
- Two digital thermometers and paper towels
- Light source
- Black paper and white paper
- Stopwatch (or use the CPO Science timer)
- Tape, pencil, and a metric ruler

What you will do

1. Pour a handful of sand into each of the soda bottles. The sand steadies the empty bottle by adding a little weight.
2. Wrap a strip of paper towel around the thermometers at the zero degree mark. Insert a thermometer into each bottle so that it snugly fits into the neck.



3. Practice fitting a piece of black paper around one of the bottles so that the bottle is completely surrounded, but with no overlap. Mark the paper with a pencil, and cut the paper as necessary so that there is no overlap.
4. Tape the black paper to the bottle. Wrap the paper snugly around the bottle, and tape it in place.
5. Repeat steps 3 and 4 for the other bottle, substituting the white paper for the black paper.
6. Place each bottle 10 cm away from the light source.
7. Record the initial temperature of the bottles in Table 1.
8. Turn on the light source and record temperatures in both bottles every minute for 10 minutes in the table.
9. Graph your data. Use the time as the x-axis data and the temperature as the y-axis data.
10. Make a legend to indicate the curves for the black bottle and white bottle. Don't forget to label your axes, to use units, and to title your graph.

Table 1: Radiation data

	Temperature at each minute (°C)										
	0	1	2	3	4	5	6	7	8	9	10
Black bottle											
White bottle											

Applying your knowledge

a. What form of heat transfer occurs between the light source and the bottles?

b. Which of the bottles reached a higher temperature?

c. What was the difference in the final temperatures of the two bottles?

d. Which bottle absorbed more energy from the light source? How do you know this?

e. Describe what happened to the energy from the light source when it reached the black bottle and the white bottle. Think about how the two bottles each absorbed and reflected radiation.

f. Based on your results, what types of surfaces on Earth would absorb more radiation from the Sun? What is the light source modeling in the Earth-Sun system?

Vocabulary

Select the correct term to complete the sentences.

heat	molecules	kinetic energy
convection	temperature	power plant
radiation	conduction	

Section 4.1

1. A place that produces electricity is called a _____.
2. The normal _____ for the human body is 98.6°F.
3. Atoms occur in groups called _____.
4. _____ is the energy of motion.
5. Twenty five grams of hot water has more _____ energy than fifteen grams of hot water.

Section 4.2

6. _____ is heat transfer through empty space.
7. The transfer of heat by the direct contact of atoms and molecules is called _____.
8. _____ is the transfer of heat through the motion of gases and liquids.

Concepts

Section 4.1

1. Use the terms in the box below to answer these questions.
   a. Two hydrogen atoms and one oxygen atom make one water ______.
   b. ______ move constantly, make up matter, and are too small to see with your eyes or a magnifying glass.

atom(s)	molecule(s)	power plant(s)

2. Which of the following would be an example of kinetic energy?
   a. Energy stored in the muscles of a cat
   b. Energy from the wind
   c. Energy in a battery
3. An iceberg has more heat in it than a cup of boiling water. Explain why this is true based on what you understand about heat energy.
4. Give an example of heat moving from a warmer object to a cooler object.
5. For a hot air balloon to work, the air molecules inside the balloon must be heated. Explain how these molecules behave when they are heated. Use your new vocabulary to explain.
6. Give an example of energy being lost as heat.

Section 4.2

7. Saucepans are made of metal so they heat up quickly. This takes advantage of the process of:
   a. radiation
   b. convection
   c. conduction
8. Birds use this type of heat transfer to lift them in the air.
   a. radiation
   b. convection
   c. conduction
9. The transfer of heat energy through space from the Sun comes in the form of:
   a. radiation
   b. convection
   c. conduction

Section 4.3

10. From where and in what form does Earth get most of its surface energy?
11. From where does Earth get its internal energy?
12. What is the main type of electromagnetic radiation that makes up the solar radiation that reaches Earth?
13. **Challenge question:** The solar energy that reaches Earth does so in such a way that some places on Earth are cooler or warmer than others. Why do you think this happens?

Math and Writing Skills

Section 4.1

1. The normal human body temperature in Fahrenheit is 98.6°F. What is the normal human body temperature in Celsius. Use this conversion formula to help you:

$$T_{°F} = (\tfrac{9}{5} \times T_{°C}) + 32 \qquad T_{°C} = \tfrac{5}{9}(T_{°F} - 32)$$

$T_{°F}$ = Temperature in °F $\quad$ $T_{°C}$ = Temperature in °C

2. A cup of water at 5°C is mixed with a cup of water at 25°C. Both cups have the same amount of water. What will the temperature of the final mixture be?
3. The final temperature of a mixture is 60°C and the volume of the mixture is 200 milliliters. To make the mixture, a 100-milliliter sample of water at 30°C water was used. What was the temperature and volume of the other sample of water that was used to make the mixture?
4. What would the temperature in Celsius be if you mixed 50 milliliters of water at 32°F with 50 milliliters of water at 0°C? Explain your answer.

Section 4.2

5. The Sun is 151,000,000 kilometers from Earth. Light travels at approximately 300,000 kilometers per second. How many seconds does it take for the Sun's light to get to Earth? How many minutes does it take?
6. Sunscreen protects your skin from the Sun's energy. Research how sunscreens work and write up your findings in a paragraph.

Section 4.3

7. What percentage of Earth's diameter does the core take up, given that it provides most of the internal energy for Earth? The radius of Earth is 6,371 kilometers. The diameter of the core is 2,462 kilometers.
8. Ultraviolet light is one kind of radiation that reaches Earth's surface. What other kinds of radiation reach Earth's surface? What form is most common?

Chapter Project—Exploring Radiation

1. Use a digital thermometer to record air temperatures near the surface in different areas of your school. Examples include the parking lot, a sidewalk, and a grassy field. What does your data this tell you about the amount of solar radiation that is absorbed in and around your school by different types of surfaces? Present your data as a poster.
2. Solar radiation includes visible light, ultraviolet light, and infrared radiation. Research these types of radiation. Make a poster to present your findings. Use these questions to guide your research: (1) How much of each kind of radiation reaches Earth? (2) Which form of radiation has the highest energy? The lowest energy? (3) What is the relationship between white light and colors of light?