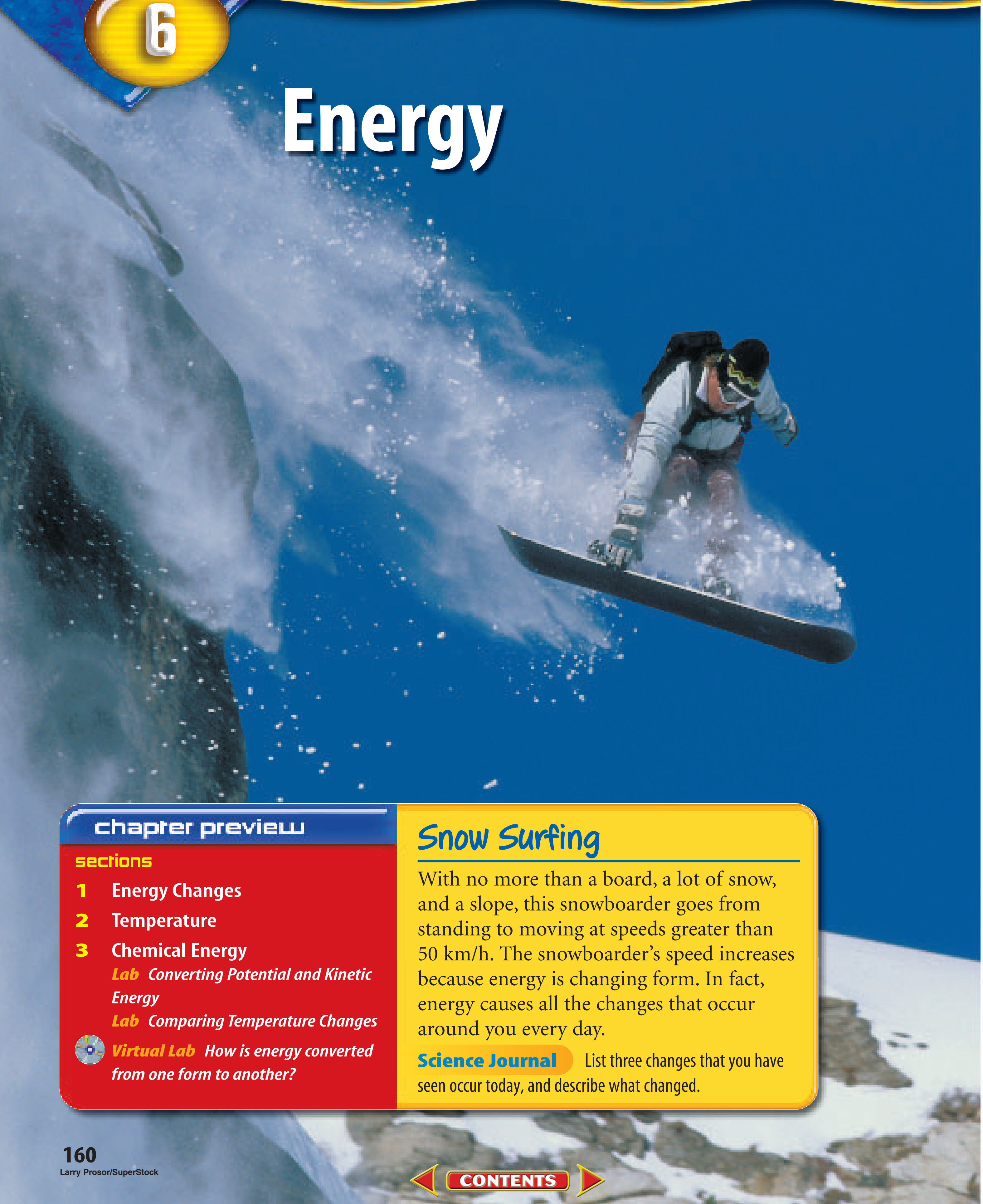
chapter 6

Energy



chapter preview

sections

1 Energy Changes
2 Temperature
3 Chemical Energy

Lab *Converting Potential and Kinetic Energy*
Lab *Comparing Temperature Changes*
Virtual Lab *How is energy converted from one form to another?*

Snow Surfing

With no more than a board, a lot of snow, and a slope, this snowboarder goes from standing to moving at speeds greater than 50 km/h. The snowboarder's speed increases because energy is changing form. In fact, energy causes all the changes that occur around you every day.

Science Journal List three changes that you have seen occur today, and describe what changed.

Español

Start-Up Activities

Launch LAB

Forms of Energy

Think of all the things you do every day such as walking to class, riding to school, switching on a light, cooking food, playing music, or stopping your bike. All of the actions of your daily life involve energy and changing energy from one form to another. What forms can energy take? In what ways can energy change from one form to another?

1. Place a beaker filled with water on a hotplate and bring the water to a boil.
2. Switch on a flashlight.
3. Rub a pencil back and forth between your palms as fast as you can.
4. Drop a baseball from a height of 2 m into a layer of clay.
5. **Think Critically** During each step of this lab, you converted one form of energy into another form. Write a paragraph in your Science Journal listing the changes that took place and why they occurred.

Science Online

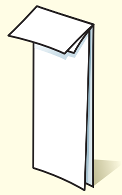
Preview this chapter's content and activities at red.msscience.com

FOLDABLES™ Study Organizer

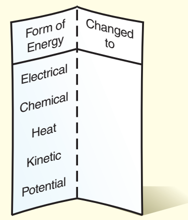
Energy Make the following Foldable to help you understand the different ways energy can be transformed.

STEP 1 **Fold** a sheet of paper in half lengthwise.

STEP 2 **Fold** paper down 2.5 cm from the top. (Hint: From the tip of your index finger to your middle knuckle is about 2.5 cm.)



STEP 3 **Open and draw** lines along the 2.5 cm fold. Label as shown.



Cause and Effect As you read the chapter, write answers to what each form of energy can be changed to under the *Changed To* heading on your Foldable. On the back of your Foldable describe what caused each form of energy to change and explain the effects of the change.

Larry Prosor/SuperStock

section 1

Energy Changes

Kennan Ward/The Stock Market/CORBIS

as you read

What You'll Learn

- **Explain** what energy is.
- **Describe** the forms energy takes.
- **Compare and contrast** potential energy and kinetic energy.

Why It's Important

Energy causes all the changes that take place around you.

Review Vocabulary
speed: the distance traveled per second by an object

New Vocabulary
- energy
- kinetic energy
- potential energy
- law of conservation of energy

Energy

Energy is a term you probably use every day. You might say that eating a plate of spaghetti gives you energy, or that a gymnast has a lot of energy. Do you realize that a burning fire, a bouncing ball, and a tank of gasoline also have energy?

What is energy? The word *energy* comes from the ancient Greek word *energos,* which means "active." You probably have used the word *energy* in the same way. When you say you have a lot of energy, what does this mean? **Energy** is the ability to cause change. For example, energy can change the temperature of a pot of water, or it can change the direction and speed of a baseball. The energy in a thunderstorm, like the one shown in **Figure 1,** produces lightning that lights up the sky and thunder that can rattle windows. Energy can change the arrangement of atoms in molecules and cause chemical reactions to occur. You use energy when you change the speed of a bicycle by pedaling faster or when you put on the brakes.

Reading Check *What does energy do?*

Figure 1 Lightning causes dramatic change as it lights up the sky.

Forms of Energy

If you ask your friends what comes to mind when they think of energy, you probably will get many different answers. Some might mention candy bars or food. Others might think of the energy needed to run a car. Energy does come in different forms from a variety of sources. Food provides energy in the form of chemical energy. Your body converts chemical energy in the food you eat into the energy it needs to move, think, and grow. Nuclear power plants use nuclear energy contained in the center or nucleus of the atom to produce electricity. What other forms of energy can you think of?

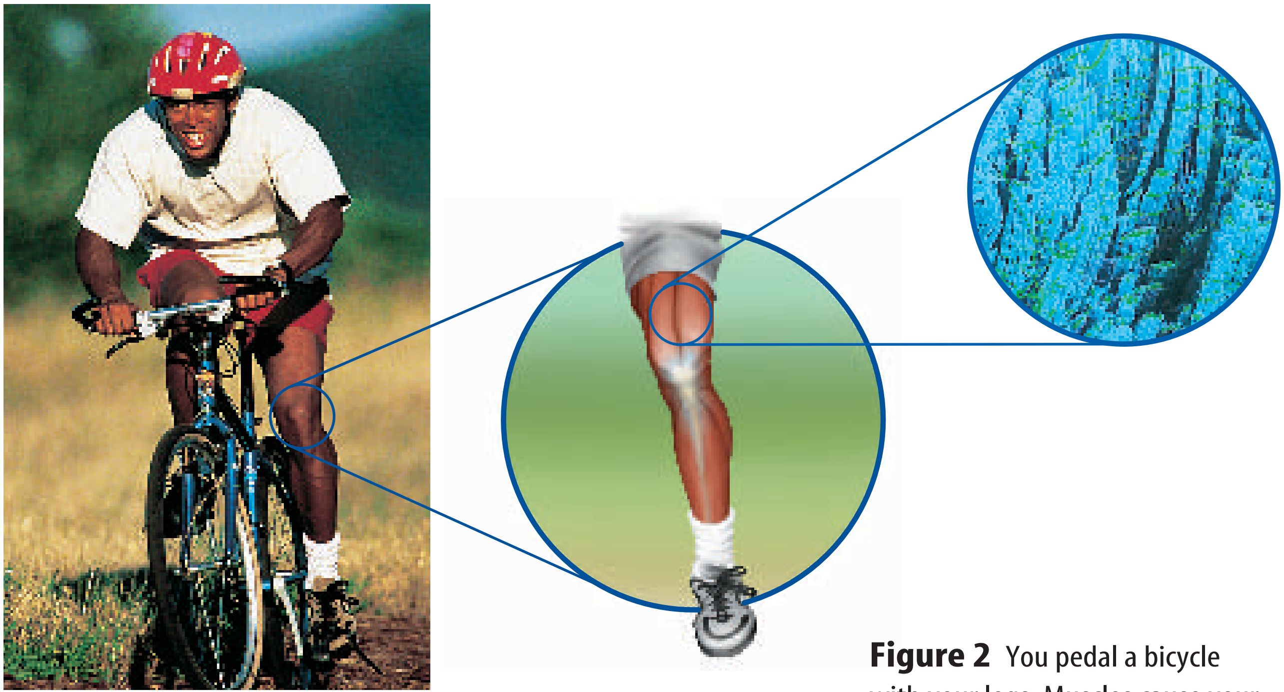


Figure 2 You pedal a bicycle with your legs. Muscles cause your leg to move by contracting. Your muscles are made of these microscopic fibers. They cause your muscles to contract by becoming shorter when certain chemical reactions release chemical energy.

Energy Transformations Energy is stored in the chemical compounds in your muscles. When you push down on a bicycle pedal, chemical energy is used to make your legs move.

An energy transformation occurs if energy changes from one form to another. Energy transformations go on all around you and inside of you all the time. The chemical energy stored in your muscles changes to energy of motion, as you can see in **Figure 2.** When a car sits in sunlight all day, the energy in sunlight changes to heat energy that warms the inside of the car. The energy you use to stretch and move a rubber band also changes into heat energy that raises the temperature of the rubber band.

During these and other types of energy transformations, the total amount of energy stays the same. Energy is never lost or gained—it only changes form.

Using Energy Transformations Since the earliest times, humans have used different forms of energy. When humans first learned to make fires, they used the chemical energy in wood and other fuels to cook, stay warm, and light their way in the dark. Today, a gas stove, like the one in **Figure 3,** transforms the chemical energy in natural gas to heat energy that boils water and cooks food. An electric current that flows in a wire carries electrical energy that can be used in many ways. A hair dryer converts electrical energy into heat energy. A lightbulb converts electrical energy into heat and light energy when you flip on a switch.

Figure 3 As natural gas burns in a gas stove, it gives off energy that heats the water.

Kinetic Energy

One soccer ball is sitting on the ground and another is rolling toward the net. How does the energy of the moving ball compare to the one at rest? A moving ball certainly has the ability to cause change. For example, a moving bowling ball shown in **Figure 4** causes the bowling pins to fall. A moving ball has energy due to its motion. The energy an object has due to its motion is called **kinetic** (kih NE tihk) **energy.** A football thrown by a quarterback has kinetic energy. A sky diver or a leaf falling toward Earth also has kinetic energy.

INTEGRATE Life Science

Food Is Chemical Energy You transform energy every time you eat and digest food. The food you eat contains chemical energy. This energy changes into forms that keep your body warm and move your muscles. The amount of chemical energy contained in food is measured in Calories. Check some food labels to see how many Calories your food contains.

Mass, Speed, and Kinetic Energy Although moving objects have kinetic energy, not all moving objects have the same amount of kinetic energy. What determines the amount of kinetic energy in a moving object? The amount of kinetic energy an object has depends on the mass and speed of the object, as shown in **Figure 5.** Imagine a small rock and a large boulder rolling down a hillside at the same speed. Which would have more kinetic energy? Think about the damage the rock and the boulder could do if they hit something at the bottom of the hill. The large boulder could cause more damage, so it has more kinetic energy. Even though the rock and the boulder were moving at the same speed, the boulder had more kinetic energy than the rock because it had more mass.

Kinetic energy also depends on speed. The faster a bowling ball moves, the more pins it can knock down. When more pins are knocked down, a greater change has occured. So the faster the bowling ball moves, the more kinetic energy it has. Kinetic energy increases as speed increases.

Figure 4 Any moving object has energy because it can cause change.
Identify *a change that the bowling ball is causing.*

NATIONAL GEOGRAPHIC

VISUALIZING KINETIC ENERGY

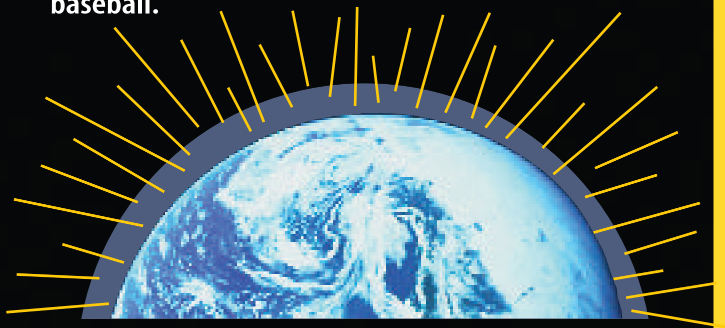
Figure 5

The amount of kinetic energy of a moving object depends on the mass and the speed of the object. For example, the fastest measured speed a baseball has been thrown is about 45 m/s. The kinetic energy of a baseball traveling at that speed is about 150 J.

▲ There is evidence that a meteorite 10 km in diameter collided with Earth about 65 million years ago and might have caused the extinction of dinosaurs. The meteorite may have been moving 400 times faster than the baseball and would have a tremendous amount of kinetic energy due to its enormous mass and high speed—about a trillion trillion joules.

▼ A 600-kg race car, traveling at about 50 m/s, has about 5,000 times the kinetic energy of the baseball.

▼ Earth's atmosphere is continually bombarded by particles called cosmic rays, which are mainly high-speed protons. The mass of a proton is about a 100 trillion trillion times smaller than the mass of the baseball. Yet, some of these particles travel so fast, they have nearly the same kinetic energy as the baseball.



◀ A sprinter with a mass of about 55 kg and running at 9 m/s has kinetic energy about 15 times greater than the baseball.

Figure 6 Kinetic energy is transferred from domino to domino by tapping the first one in line.

Transferring Kinetic Energy Kinetic energy can be transferred from one object to another when they collide. Think about the transfer of energy during bowling. Even if the bowling ball does not touch all of the pins, it still can knock them all down with one roll. The bowling ball transfers kinetic energy to a few pins. These pins move and bump into other pins, transferring the kinetic energy to the remaining pins and knocking them down.

A transfer of kinetic energy also takes place when dominoes fall. You need to give only the first domino in the row a bit of kinetic energy by lightly tapping it to make it fall against the next domino. As the first domino falls into the next one, its kinetic energy is transferred to the second domino, as shown in **Figure 6.** This transfer of kinetic energy continues from domino to domino until the last one falls and hits the table. Then, the last domino's kinetic energy is transferred to the table.

Potential Energy

Suppose the ski lift in **Figure 7** takes a skier to the top of a hill. The skier has no kinetic energy when she is standing at the top of the hill. But as she skis down and moves faster, her kinetic energy increases. Where does this kinetic energy come from? Gravity pulls the skier down the hill. If the skier were standing at the bottom of the hill, gravity would not start her moving, as it does when she is at the top of the hill. When the skier's position is at the top of the hill, she has a form of energy called potential energy. **Potential energy** is energy that is stored because of an object's position. By using the ski lift to take her to the top of the hill, the skier increased her potential energy by changing her position.

Figure 7 Potential and kinetic energy change as the skier moves up and down the slope.
Explain *how the skier's energy changes as she moves from the top of the hill to the bottom.*

Paul Avis/Liaison Agency/Getty Images

Increasing Potential Energy When you raise an object above its original position, it has the potential to fall. If it does fall, it has kinetic energy. To raise an object, you have to transfer energy to the object. The ski lift uses energy when it takes a skier up a hill and transfers some of that energy to the skier. This energy becomes stored as potential energy in the skier. As the skier goes down the hill, the potential energy she had at the top of the hill is converted to kinetic energy.

If the skier were lifted higher, her potential energy would increase. The higher an object is lifted above Earth, the greater its potential energy.

Converting Potential and Kinetic Energy

When a skier skis down a hill, potential energy is transformed to kinetic energy. Kinetic energy also can be transformed into potential energy. Suppose you throw a ball straight up into the air. The muscles in your body cause the ball to move upward when it leaves your hand. Because it is moving, the ball has kinetic energy. Look at **Figure 8.** As the ball gets higher and higher, its potential energy is increasing. At the same time, the ball is slowing down and its kinetic energy is decreasing.

What happens when the ball reaches its highest point? The ball comes to a stop for an instant before it starts to fall downward again. At its highest point, the ball has no more kinetic energy. All the kinetic energy the ball had when it left your hand has been converted to potential energy, and the ball will go no higher. As the ball falls downward, its potential energy is converted back into kinetic energy. If you catch the ball at the same height above the ground as when you threw it upward, its kinetic energy will be the same as when it left your hand.

Mini LAB

Comparing Kinetic Energy and Height

Procedure:

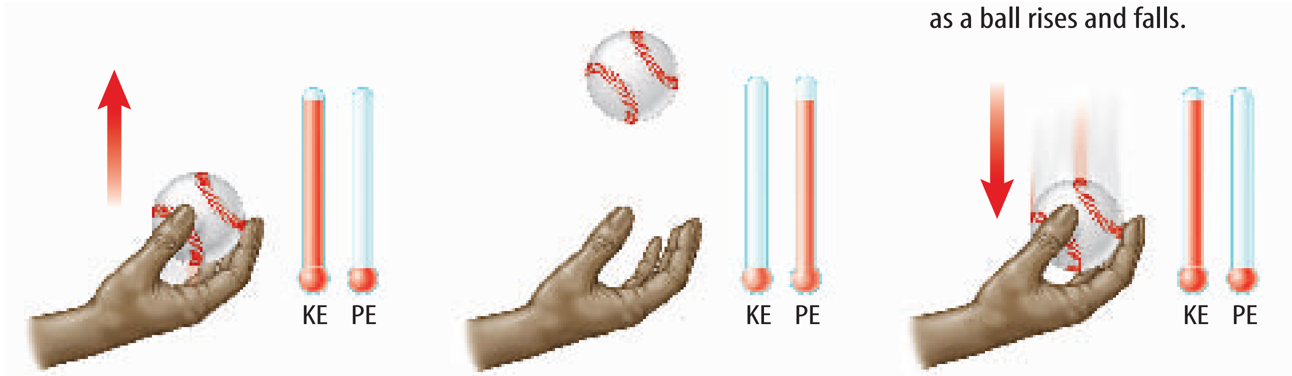
1. Lay a 3-cm-thick layer of smooth modeling **clay** on a piece of **cardboard.** Place the cardboard on the floor.
2. Drop an object such as a **baseball, golf ball,** or **orange** into the clay from a height of 10 cm. Measure and record the depth of the hole made by the object.
3. Repeat step 2 from a height of 50 cm and 1 m.

Analysis

1. How does the depth of the hole depend on the height of the ball?
2. How does the kinetic energy of the falling ball depend on the distance it fell?

Try at Home

Figure 8 Energy is transformed as a ball rises and falls.



As the ball leaves the person's hand, it is moving the fastest and has maximum kinetic energy.

As the ball moves upward, it slows down as its kinetic energy is transformed into potential energy.

As the ball moves downward, it speeds up as its potential energy is transformed into kinetic energy.

Energy Changes in Falling Water

Energy Changes in Falling Water You might have stood close to a large waterfall and heard the roar of the water. Just like a ball falling to the ground, the potential energy that the water has at the top of the falls is transformed into kinetic energy as the water falls downward.

The kinetic energy of falling water can be used to generate electricity. As shown in **Figure 9,** water backs up behind a dam on a river, forming a lake or reservoir. The water near the top of the dam then falls downward. The kinetic energy of the moving water spins generators, which produce electricity. The potential energy of the water behind the dam is transformed into electrical energy.

Reading Check *The potential energy of falling water is transformed into what form of energy?*

Science Online

Topic: Earth's Crust
Visit red.msscience.com for Weblinks to information about faults in the crust of Earth and the energy transformations that take place in them.

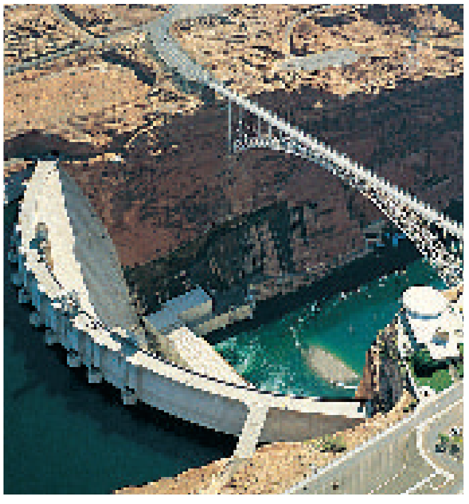
Activity Describe the energy transformations that occur when there is movement along the faults.

Conservation of Energy

Following the trail of energy as it is transformed can be a challenge. Sometimes it might seem that energy disappears or is lost. But that's not the case. In 1840, James Joule demonstrated the law of conservation of energy. According to the **law of conservation of energy,** energy cannot be created or destroyed. It only can be transformed from one form into another, so the total amount of energy in the universe never changes. The only change is in the form that energy appears in.

Kinetic energy can be converted into heat energy when two objects rub against each other. As a book slides across a table, it will slow down and eventually stop. The book's kinetic energy isn't lost. It is converted into heat energy as the book rubs against the surface of the table.

Figure 9 The potential energy of water can be transformed into electrical energy.
Explain *how a dam changes the potential energy of the water behind it.*



The potential energy of water behind the dam is converted to kinetic energy as the water falls through pipes.

The kinetic energy of the moving water spins generators like these that produce electricity.

A moving soccer player has kinetic energy.

Kinetic energy from the player's moving leg is transferred to the ball.

When the ball rolls, its kinetic energy is transformed by friction into heat as the ball rubs against the grass.

Figure 10 Energy can take different forms, but it can never be created or destroyed.

Following the Energy Trail The flow of energy as a soccer ball is kicked is shown in **Figure 10.** Chemical energy in the soccer player's leg muscles is converted into kinetic energy when she swings her leg. When the ball is kicked, this kinetic energy is transferred to the ball. After the ball rolls for a while, it comes to a stop. The kinetic energy of the ball seems to have disappeared, but it hasn't. As the ball rolled, its kinetic energy was transformed into heat energy as the ball rubbed against the grass.

section 1 review

Summary

Energy

- Energy is the ability to cause change.
- Energy has different forms such as chemical energy, nuclear energy, heat energy, and electrical energy.
- Energy can be transformed from one form into another.

Kinetic and Potential Energy

- Kinetic energy is the energy due to the motion of an object and increases as the object's mass or speed increases.
- Potential energy is stored energy due to an object's position and increases as the object's height above Earth increases.

Law of Conservation of Energy

- The law of conservation of energy states that energy cannot be created or destroyed, but only transformed from one form into another.

Self Check

1. **Describe** the energy transformations that occur when a light bulb is turned on.
2. **Explain** how the total energy changes when a falling rock hits the ground.
3. **Infer** on which part of a roller coaster a roller coaster car has the greatest potential energy.
4. **Determine** which has the greater kinetic energy if both are traveling at the same speed—a fully-loaded truck or a motorcycle.
5. **Think Critically** When a ball is thrown upward, how does the height reached by the ble ball depend on its initial speed?

Applying Skills

6. **Diagram** the energy transformations that occur when you eat breakfast, walk to the bus stop, and ride the bus to school.

Science Online red.msscience.com/self_check_quiz

section 2

Temperature

as you read

What You'll Learn

- **Distinguish** between temperature and heat.
- **Identify** important uses of heat.
- **Explain** how heat moves.

Why It's Important

The flow of heat warms Earth, produces weather, cooks your food, and warms and cools your home.

Review Vocabulary

molecule: a particle formed when two or more atoms bond together

New Vocabulary

- temperature
- heat
- conduction
- convection
- radiation

Temperature

What's today's temperature? If you looked at a thermometer, listened to a weather report on the radio, or saw a weather map on television, you probably used the air temperature to help you decide what to wear. Some days are so hot you don't need a jacket. Others are so cold you want to bundle up.

Hot and *cold* are words used in everyday language to describe temperature. However, they are not scientific words because they mean different things to different people. A summer day that seems hot to one person might seem just right to another. If you grew up in Texas but moved to Minnesota, you might find the winters unbearably cold. Have you ever complained that a classroom was too cold when other students insisted that it was too warm?

Temperature and Kinetic Energy What is temperature? Remember that any material or object is made up of atoms or molecules. These particles are moving constantly, even if the object appears to be perfectly still. Every object you can think of—your hand, the pencil on your desk, or even the desktop—contains particles that are in constant motion. In solids, liquids, and gases particles do not move in a single direction. Instead they move in all directions. In a gas, particles are far apart and can move, as shown in **Figure 11.** In liquids, atoms are close together and can't move as far as in a gas. In solids, particles are bound more tightly together than in a liquid. Instead of moving freely as shown in **Figure 11,** atoms or molecules in a solid vibrate back and forth. The motion of particles in all directions in solids, liquids, and gases is called random motion. Because the particles are moving, they have kinetic energy. The faster the particles are moving, the more kinetic energy they have.

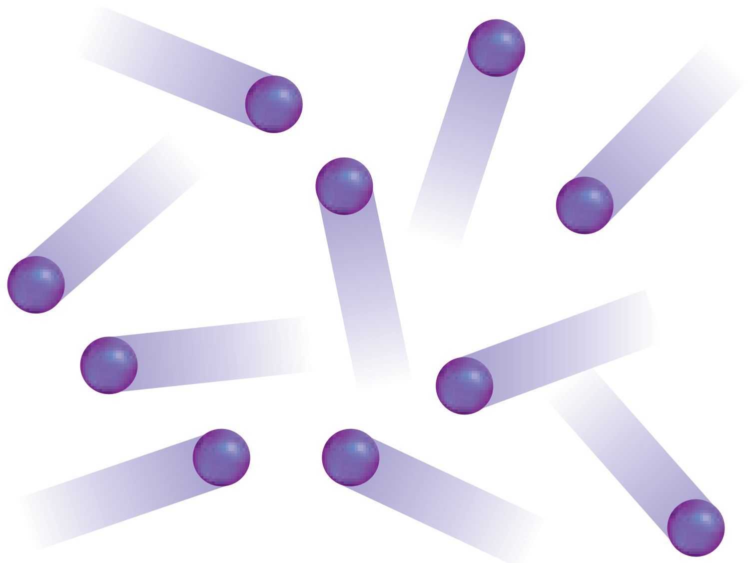


Figure 11 In gases, atoms or molecules are free to move in all directions.

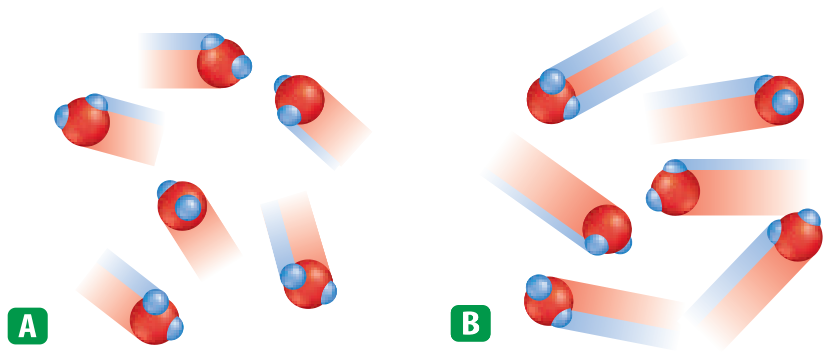


Figure 12 Temperature depends on the average kinetic energy of the atoms or molecules. **A** The gas molecules move slower on average at a lower temperature. **B** Gas molecules move faster on average at a higher temperature.

Temperature is a measure of the average kinetic energy of the particles in an object. When an object's temperature is higher, its atoms or molecules have more kinetic energy. **Figure 12** shows gas molecules at two temperatures. At the higher temperature, the molecules are moving faster and have more kinetic energy.

Applying Science

Can you be fooled by temperature?

On a cold, wintry morning, you may have heard a local meteorologist caution you to "Bundle up, because the wind chill index is minus 20 degrees." While wind cannot lower the temperature of the outside air, it can make your body lose heat faster, and make you feel as if the temperature were lower.

Wind Chill Index

Temperature (°C)	Wind Speed (km/h)							
	10	20	30	40	50	60	70	80
20	18°C	16°C	14°C	13°C	13°C	12°C	12°C	12°C
12	9°C	5°C	3°C	1°C	0°C	0°C	−1°C	−1°C
0	−4°C	−10°C	−14°C	−17°C	−18°C	−19°C	−20°C	−21°C
−20	−26°C	−36°C	−43°C	−47°C	−49°C	−51°C	−52°C	−53°C
−36	−44°C	−57°C	−65°C	−71°C	−74°C	−77°C	−78°C	−79°C

Identifying the Problem

A wind chill index of –29°C presents little danger to you if you are properly dressed. Below this temperature, however, your skin can become frostbitten within minutes. Use the table to find wind chill values for conditions that present the greatest dangers.

Solving the Problem

1. Assuming you live in an area where wind speeds in the winter rarely reach 50 km/h, at which air temperature should you be certain to take extra precautions?
2. What happens to the wind chill index as wind speeds get higher and temperatures get lower?

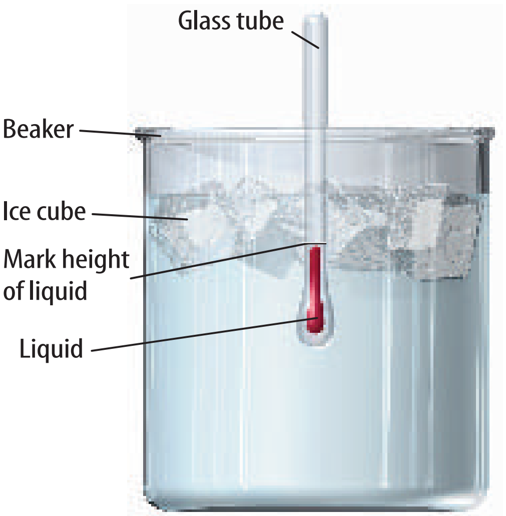
Measuring Temperature

Some people might say that the water in a swimming pool feels warm, although others might say it feels cool. Because the temperature of the water feels different to different people, you cannot describe or measure temperature accurately by how it feels. Remember that temperature is related to the kinetic energy of all the atoms in an object. You might think that to measure temperature, you must measure the kinetic energy of the atoms. But atoms are so small that even a tiny piece of material consists of trillions and trillions of atoms. Because they are so small and objects contain so many of them, it is impossible to measure the kinetic energy of all the individual atoms. However, a practical way to measure temperature is to use a thermometer, as shown in **Figure 13.**

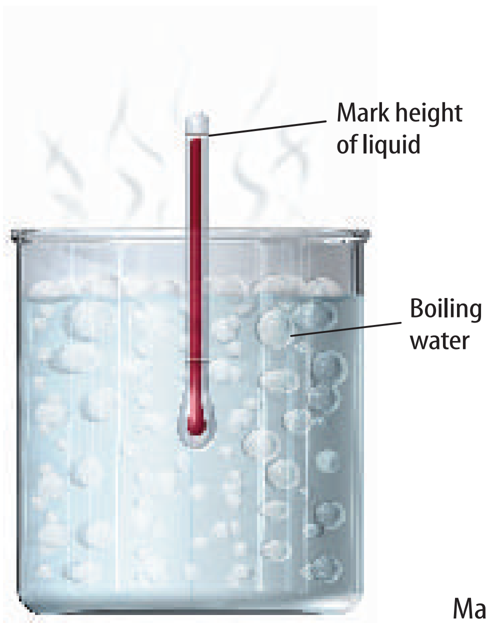
Reading Check ***Why can't the kinetic energy of all the atoms in an object be measured?***

The Fahrenheit Scale One temperature scale you might be familiar with is the Fahrenheit (FAYR un hite) scale. On the Fahrenheit scale, the freezing point of water is given the temperature 32°F, and the boiling point is 212°F. The space between the boiling point and the freezing point is divided into 180 equal degrees. The Fahrenheit scale currently is used mainly in the United States.

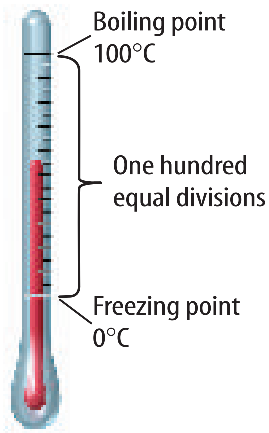
Figure 13 This thermometer uses the height of a liquid in a tube to measure temperature. The liquid height changes with temperature because the liquid expands as its temperature increases. The thermometer is calibrated by marking the liquid height at two known temperatures.



The height of the liquid is marked when the thermometer is placed in water at 0°C.



The height of the liquid is marked when the thermometer is placed in boiling water at 100°C.



Make a temperature scale by dividing the distance between the two marks into equal degrees.

The Celsius Scale Another temperature scale that is used more widely throughout the world is the Celsius (SEL see us) scale. On the Celsius temperature scale, the freezing point of water is given the temperature 0°C and the boiling point is given the temperature 100°C. Because there are only 100 Celsius degrees between the boiling and freezing points of water, a temperature change of one Celsius degree is bigger than a change of one Fahrenheit degree.

Heat

On a warm, sunny day when you tilt your head back, you can feel the warmth of the Sun on your face. On a chilly day, putting your cold hands near an open fire warms them up. In both cases, you could feel heat from the Sun and from the fire making you warmer. What is heat?

Look at **Figure 14.** Suppose you pick up a tall glass of iced tea. If you hold the glass for a while, the drink warms up. Your hand is at a higher temperature than the tea, so the atoms and molecules in your hand have a higher kinetic energy than the ones in the iced tea. Kinetic energy from the moving atoms and molecules in your hand is transferred by collisions to the atoms and molecules in the tea.

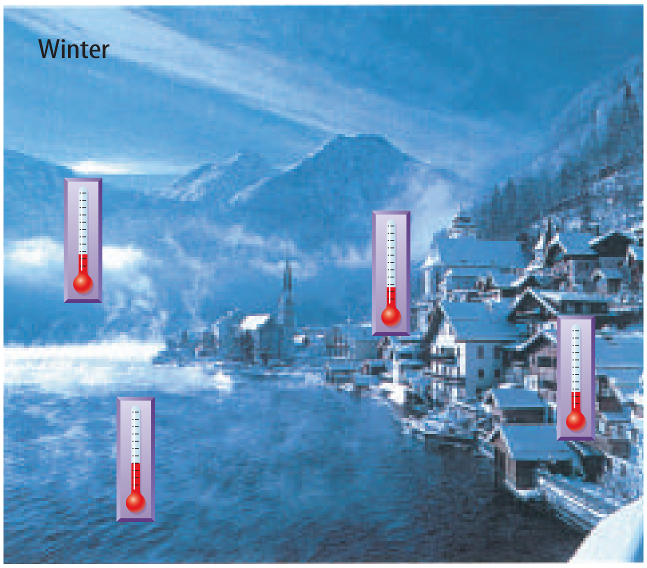
A transfer of energy from one object to another due to a difference in temperature is called **heat.** Heat flows from warmer objects to cooler ones. In the example just given, heat flows out of your hand and into the glass of iced tea. As you hold the glass, the temperature of the tea increases and the temperature of your skin touching the glass decreases. Heat will stop flowing from your hand to the glass of tea when the temperatures of your hand and the glass are the same.

Figure 14 Heat flows from your hand to the glass of iced tea, making your hand feel cold.
Explain *why people wear gloves in cold weather.*

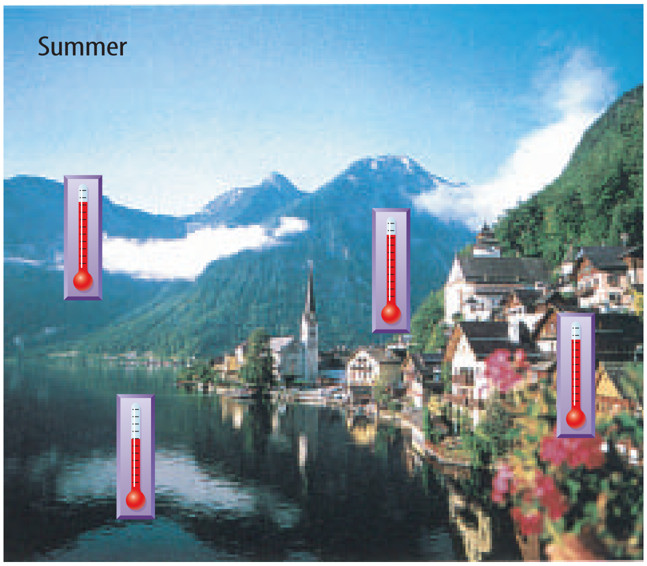
Heat and Temperature

How much does the temperature of something increase when heat is transferred to it? It depends on two things. One is the amount of material in the object. The other is the kinds of atoms the material is made of. For example, compared to other materials, water is an unusual substance in that it must absorb a large amount of heat before its temperature rises by one degree. Water often is used as a coolant. The purpose of the water in a car's radiator is to carry a large amount of heat away from the engine and keep the engine from being damaged by overheating, as shown in **Figure 15.**

Figure 15 This car's engine overheated because its cooling system didn't carry enough heat from the engine.



During the winter, the lake is warmer than the surrounding land.



During the summer, the lake is cooler than the surrounding land.

Figure 16 Water can absorb and lose a great deal of heat without changing temperature much.

INTEGRATE History

The Caloric Theory At one time heat was thought to be a fluid, called caloric. A warm object contained more caloric than a cold object. Benjamin Thompson in the late eighteenth century noticed that tremendous amounts of heat were generated during the boring of the holes in cannons. He concluded the amount of heat depended only on the work done by the drill. James Joule later showed that other forms of energy could be converted into heat. Research how the work of Thompson and Joule disproved the caloric theory of heat.

Lakes and Air Temperature How does the temperature of water in a lake compare to the temperature of the surrounding air on a hot summer day? How do these temperatures compare at night when the air has cooled off? You might have noticed that the water is cooler than the air during the day and warmer than the air at night. This is because it takes longer for a large body of water to warm up or cool down than it does for the surrounding air and land to change temperature. Even from season to season, a large body of water can change temperature less than the surrounding land, as shown in **Figure 16.**

Heat on the Move

A transfer of energy occurs if there is a temperature difference between two areas in contact. Heat is transferred from warm places to cooler ones. This transfer can take place in three ways—radiation, conduction, and convection. Conduction transfers heat mainly through solids and liquids. Convection transfers heat through liquids and gases. Radiation can transfer energy through space.

Conduction Have you ever picked up a metal spoon that was in a pot of boiling water and dropped it because the spoon had become hot? The spoon handle became hot because of conduction. **Conduction** (kun DUK shun) is the transfer of energy by collisions between the atoms and molecules in a material.

As the part of the spoon in the boiling water became warmer, its atoms and molecules moved faster. These particles then collided with slower-moving particles in the spoon. In these collisions, kinetic energy was transferred from the faster-moving to the slower-moving particles farther up the spoon's handle.

Bumping Along Even though conduction is a transfer of kinetic energy from particle to particle, in a solid, the particles involved don't travel from one place to another. As shown in **Figure 17,** they simply move back and forth in place, bumping into each other and transferring energy from faster-moving particles to slower-moving ones. Conduction usually occurs in solids.

Reading Check *How is energy transferred by conduction?*

Conductors It's dinnertime and the hamburgers are frozen solid. This is one time when you want to transfer heat rapidly. You could put a frozen hamburger on a metal tray to speed up the thawing process. Materials through which it is easy to transfer energy are thermal conductors. Most metals are good conductors of heat. Metals such as gold, silver, and copper are the best thermal conductors. Copper is widely available and less expensive than gold or silver. Some cooking pans are made of steel but have copper bottoms. A copper bottom conducts heat more evenly. It helps spread heat across the bottom surface of the pan to prevent hot spots from forming. This allows food to cook evenly.

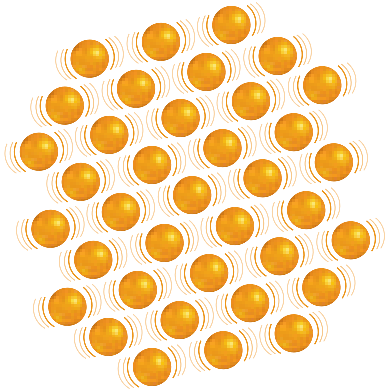
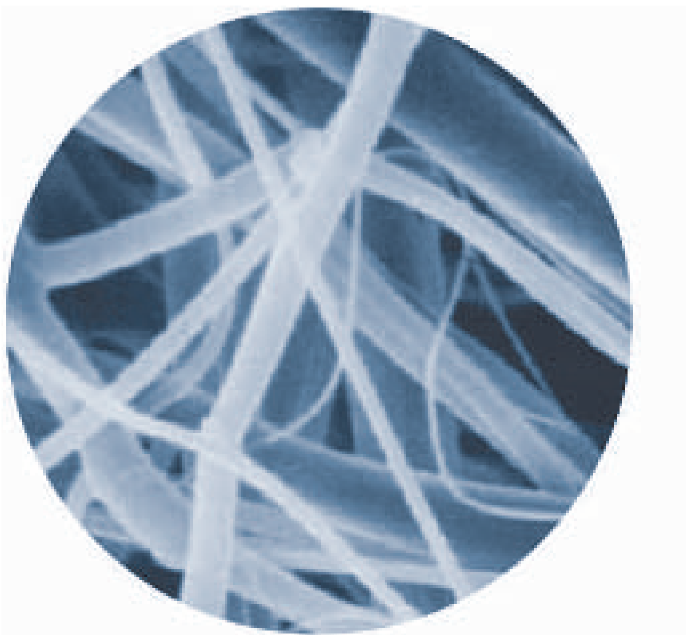


Figure 17 In a solid, particles collide with each other as they vibrate back and forth.

Insulators Some materials are poor conductors of heat. These materials can be used as thermal insulators. When you are cold, for example, you can put on a sweater or a jacket or add another blanket to your bed. You are keeping yourself warm by adding insulation. The clothes and the blanket are poor conductors of heat. In fact, they make it more difficult for heat to escape from your body. By trapping your body heat around you, you feel warmer.

Blankets and clothes help keep you warm because they are made of materials that contain many air spaces, as shown in **Figure 18.** Air is a good insulator, so materials that contain air are also good insulators. For example, building insulation is made from materials that contain air spaces. Materials made of plastics also are often good insulators. If you put a plastic spoon in boiling water, it takes a long time for it to get hot. Many cooking pans have plastic handles that won't melt instead of metal ones. These handles remain at a comfortable temperature while the pans are used for cooking. Other examples of insulators include wood, rubber, and ceramic materials such as tiles.

Figure 18 Under high magnification, this insulating material is seen to contain many air spaces. **Explain** *how increasing the number of air spaces in a material affects the movement of heat.*



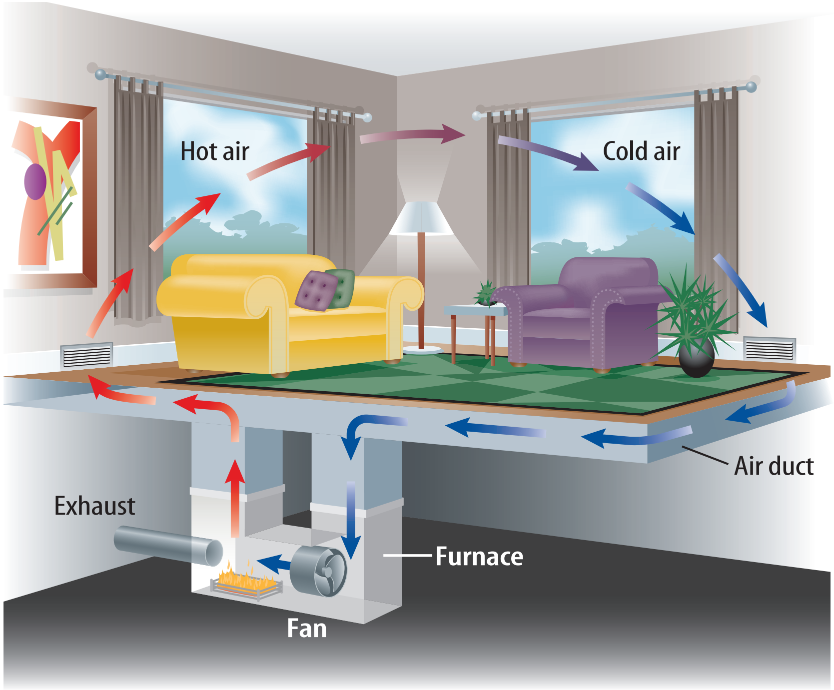


Figure 19 The furnace's fan helps circulate hot air through your home. Warmer air particles move upward while cooler air particles move downward.
Explain *why the hot air ducts are placed near the floor.*

Feeling the Heat Think about getting into a car that has been closed up on a sunny day. Do you prefer a car that has fabric-covered or vinyl-covered seats? Even though the masses of the seats are similar and the temperatures of the surroundings are the same, the vinyl material feels hotter on your skin than the fabric does. How hot something feels also is affected by how fast heat flows, as well as the actual temperature. Vinyl is a better conductor than fabric, so heat flows to your skin more rapidly from the vinyl than from the fabric. As a result, the vinyl feels hotter than the fabric does.

Convection Heat also can be transferred by particles that do not stay in one place but rather move from one place to another. **Convection** (kun VEK shun) transfers heat when particles move between objects or areas that differ in temperature. This type of transfer is most common in gases and liquids. As temperature increases, particles move around more quickly, and the distance between particles increases. This causes density to decrease as temperature increases. Cooler, denser material then forces the warmer, less dense material to move upward.

Some homes are heated by convection. Look at **Figure 19.** Air is warmed in the furnace. The warm, less dense air is then forced up through the air duct by the furnace fan. The warm air gets pushed up through the room by the cooler air around it. As the warm air cools, it becomes more dense. Cool, dense air sinks and is then pulled into the return air duct by the furnace fan to be warmed again and recirculated.

Mini LAB

Comparing Energy Content

Procedure
1. Pour equal amounts of **hot, cold, and room-temperature water** into each of three **transparent, labeled containers.**
2. Measure and record the temperature of the water in each container.
3. Use a **dropper** to gently put a drop of **food coloring** in the center of each container.
4. After 2 min, observe each container.

Analysis
1. Based on the speed at which the food coloring spreads through the water, rank the containers from fastest to slowest.
2. Infer how water temperature affected the movement of the food coloring.
3. In which container do the water particles have the most kinetic energy?

Examples of Convection Eagles and hawks float effortlessly high in the air. Sometimes a bird can stay in the air without flapping its wings because it is held up by a thermal.

As shown in **Figure 20,** a thermal is a column of warm air that is forced up as cold air around it sinks. It is a convection current in the air.

Convection also occurs in liquids. In a pot of boiling water, the warmer, less dense water is forced up as the cooler, denser water sinks. Convection currents on a larger scale are formed in oceans by cold water flowing from the poles and warm water flowing from tropical regions.

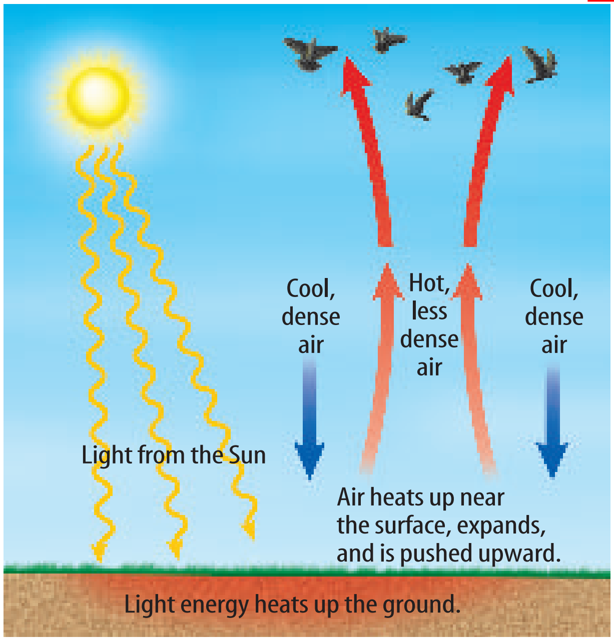


Figure 20 Thermals form when hot, thin air rises up through cooler, denser air.

Radiation The transfer of energy by waves is **radiation** (ray dee AY shun). These waves can be visible light waves or types of waves that you cannot see. When these waves strike an object, their energy can be absorbed and the object's temperature rises. Radiation can travel through air and even through a vacuum.

The Sun transfers energy to Earth through radiation. You take advantage of radiation when you warm yourself by a fire. Heat is transferred by radiation from the fire and you become warmer. You also can use radiation to cook food. A microwave oven cooks food by using microwave radiation to transfer energy to the food.

section 2 review

Summary

Temperature

- The particles that make up an object are in constant random motion.
- The temperature of an object is a measure of the average kinetic energy of the particles in the object.

Heat

- Heat is a transfer of energy from one object to another due to a difference in temperature.
- Heat always flows from a higher temperature to a lower temperature.
- Heat can be transferred by conduction, convection, and radiation.
- Insulators are materials that are poor conductors of heat.

Self Check

1. **List** three ways that heat is transferred and give an example for each.
2. **Describe** the condition that must exist for transfer of heat to occur.
3. **Identify** the type of energy transfer that can take place with little or no matter present. Explain.
4. **Think Critically** Popcorn can be cooked in a hot-air popper, in a microwave oven, or in a pan on the stove. Identify how energy is transferred in each method.

Applying Math

5. **Convert Temperature** To change a temperature from Fahrenheit to Celsius, subtract 32 from the Fahrenheit temperature then multiply by 5/9. If the temperature is 77°F, what is the Celsius temperature?

section 3

Chemical Energy

as you read

What You'll Learn

- **Determine** how chemical energy is transformed.
- **Explain** how reaction rates are changed.

Why It's Important

Chemical energy makes it possible for your body to move, grow, and stay warm.

Review Vocabulary

chemical bonds: the forces holding atoms together in a molecule

New Vocabulary

- endothermic reaction
- exothermic reaction
- catalyst

Chemical Reactions and Energy

On a hot summer night, you might have seen fireflies glowing, like those in **Figure 21.** Did you ever wonder how they make their eerie, blinking light? If you have seen light sticks, which glow for a short period of time, you have observed the same process that causes the fireflies' glow. Energy in the form of light is released when a chemical reaction takes place inside the light stick. A burner on a gas stove releases heat and light energy because of a chemical reaction taking place. You might not realize it, but every day you make use of the energy released by many chemical reactions.

What is a chemical reaction? In a chemical reaction, compounds are broken down or new compounds are formed. Sometimes both processes occur. Some chemical reactions occur when atoms or molecules come together. New compounds are formed when atoms and molecules combine and bonds form between them. A compound is broken down when the bonds between the atoms that make up the compound are broken. These atoms are then available to recombine to form new compounds.

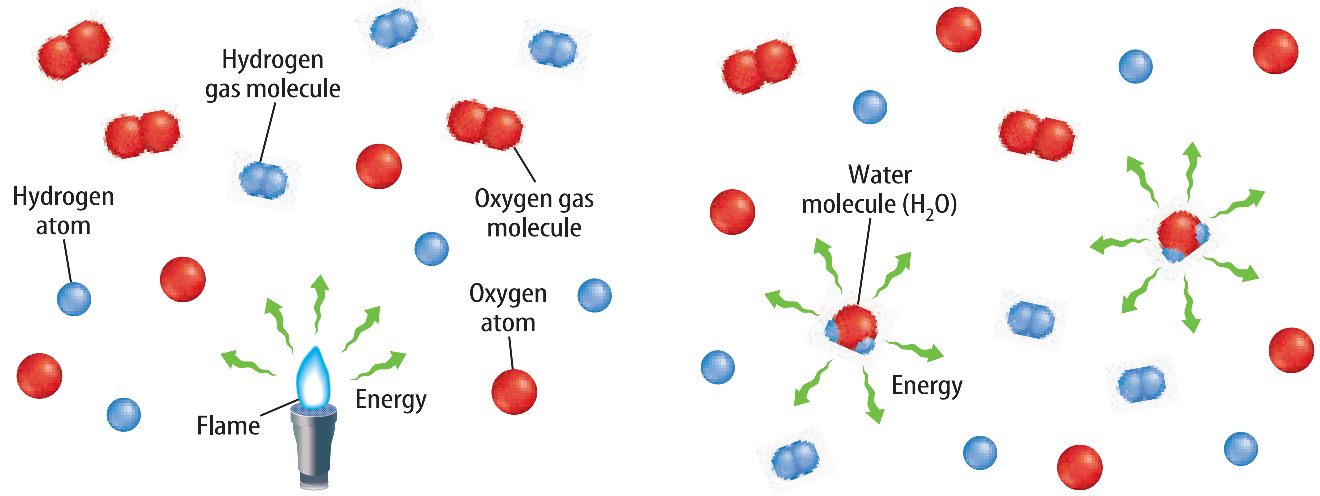
When a fire burns, a chemical reaction occurs. Bonds between the atoms in some of the compounds that make up the wood are broken. These atoms then combine with atoms in the air and form new compounds. As these new compounds are formed, heat and light are given off.

Figure 21 Chemical reactions can release light energy.

A chemical reaction inside a firefly's body releases light.

Each point of greenish light in this picture is a firefly.

CONTENTS



The added energy from the flame causes the bonds to break in the oxygen gas and hydrogen gas.

When the new bonds form between hydrogen and oxygen to produce water particles, energy is released.

Figure 22 Oxygen and hydrogen gas will not react unless energy is added.

Chemical Bonds Energy is stored in the bonds between the atoms in a compound. The stored energy in the chemical bonds is a form of potential energy called chemical energy.

The chemical energy stored in oil, gas, and coal is an important source of energy that is used every day. The chemical energy stored in food provides a source of energy for your body. The muscles in your body transform some of this chemical energy into kinetic energy and heat when they move. List some of the other sources of chemical energy you used today.

Energy in Reactions

In every chemical reaction, transformations in energy occur. To break bonds, energy must be added. The reverse is also true. When bonds form, energy is released. Often energy must be added before the reaction can begin. For example, energy is needed to start the reaction between hydrogen and oxygen to form water. Look at **Figure 22.** When a lighted match is placed in a mixture of hydrogen gas and oxygen gas, the mixture will explode and water will form. The energy to begin the reaction comes from the heat supplied by the flame. As the reaction occurs, bonds form between hydrogen and oxygen atoms, and water molecules form. The energy released as the bonds form results in the explosion.

After the hydrogen and oxygen atoms are bound together to form a water molecule, it is difficult to split them apart. Energy—usually supplied by electricity, heat, or light—is required to break the chemical bonds.

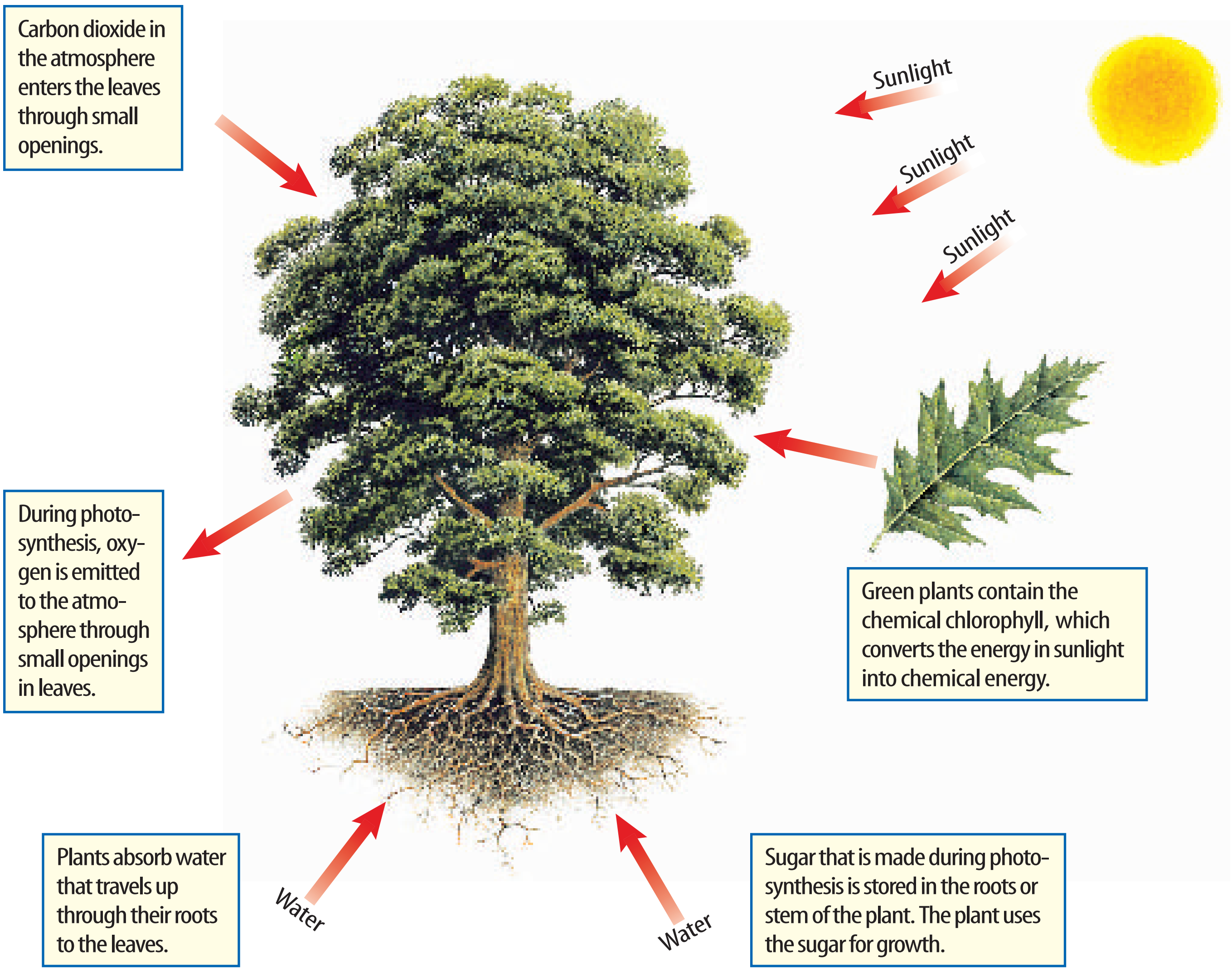
Reading Check *What is required to break chemical bonds?*

Energy-Absorbing Reactions Some chemical reactions absorb energy. A chemical reaction that absorbs heat energy is called an **endothermic** (en duh THUR mihk) **reaction.** Endothermic chemical reactions often occur in the preparation of food. Thermal energy is absorbed by the food as it cooks. For example, in baking some kinds of cookies, an endothermic reaction produces a gas that puffs up the cookies.

INTEGRATE Life Science

Photosynthesis Chemical reactions occur when sunlight strikes the leaves of green plants. These chemical reactions convert the energy in sunlight into chemical energy contained in a type of sugar. Oxygen also is produced by these chemical reactions. This process, shown in **Figure 23,** is called photosynthesis. When the plant is deprived of sunlight, the reactions stop. Photosynthesis is probably the most important endothermic process on Earth. Plants provide you, and almost all other living things, with food and oxygen through photosynthesis.

Figure 23 In photosynthesis, plants absorb light energy and make oxygen and sugar from water and carbon dioxide.



Energy-Releasing Reactions Endothermic chemical reactions are usually important because of the compounds the reactions produce. Other reactions are important because they release energy. **Exothermic** (ek soh THUR mihk) **reactions** are chemical reactions that release heat energy. A chemical hand warmer releases heat when an exothermic reaction takes place inside the hand warmer. When a substance burns, atoms in the substance combine with oxygen atoms in the air. An exothermic reaction occurs, and energy in the form of heat and light is released. The exothermic reaction that occurs when a material burns by combining with oxygen is called combustion. Burning oil, coal, and gas produces much of the energy needed to heat homes and schools.

Reading Check *What are chemical reactions that give off heat energy called?*

Rate of Reaction Chemical reactions can occur at different rates. They occur very fast when fireworks explode. However, if you leave tools or a skateboard outside for a long time, you might notice the metal parts slowly becoming rusty, as shown in **Figure 24.** Rusting is a chemical reaction that occurs when a metal combines with oxygen. In a similar way, when silver is exposed to air, it tarnishes. These chemical reactions, however, occur much more slowly than the burning of a candle's wick or a fireworks explosion.

In your body an enormous number of chemical reactions are occurring every second. The rates of these reactions are carefully controlled by your body to enable it to function properly.

Science Online

Topic: Deep Sea Vents

Visit red.msscience.com for Web links to information about the heat released at deep-sea vents.

Activity Make a travel brochure for visiting deep-sea vents. Include what is released by the vents, what organisms live near the vents, and the temperature of the vent fluids.

This photo shows a wrench before it rusts.

This photo shows a wrench after it rusts.

Figure 24 Rust is a chemical compound formed when iron and oxygen combine.

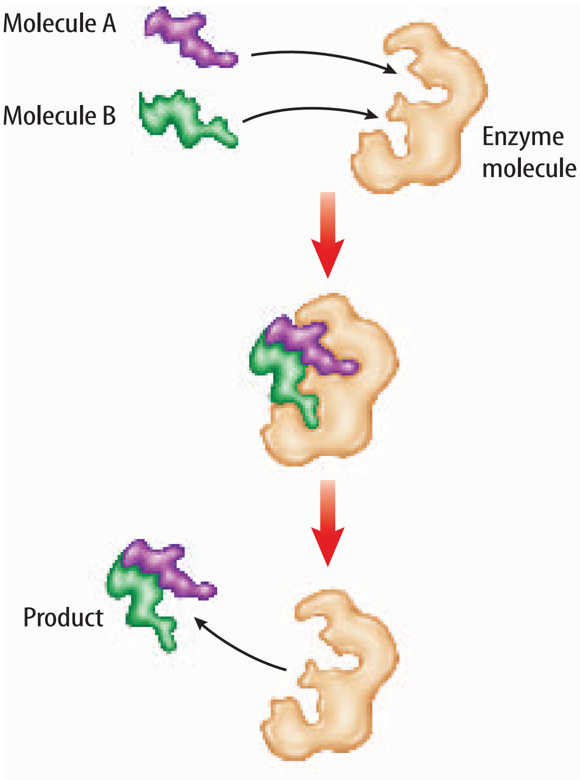


Figure 25 An enzyme makes a chemical reaction go faster by bringing certain molecules together. Only the molecules that have the right shape to fit on the surface of the enzyme will react.

Changing the Rate of Reaction Two ways to change the rate of a chemical reaction are changing the temperature and adding a type of compound called a catalyst. For example, if you pour cake batter into a pan and leave it on a table for several hours, nothing seems to happen. However, if you put the pan in a hot oven, the cake batter becomes a cake. Raising the temperature of the cake batter in the hot oven causes substances in the batter to react more quickly.

A **catalyst** (KA tuh list) is a substance that changes the rate of a chemical reaction without any permanent change to its own structure. Many cell processes in your body are controlled by the presence of catalysts, called enzymes, as shown in **Figure 25.** Enzymes are found throughout your body and are important for growth, respiration, and digestion. When you chew a piece of bread, glands in your mouth produce saliva that contains an enzyme. The enzyme in saliva acts as a catalyst to help break down starches in food into smaller molecules.

Many other chemical reactions depend on catalysts to help them go faster. The production of vegetable shortening, synthetic rubber, and high-octane gasoline are all chemical processes that occur with the help of catalysts.

section 3 review

Summary

Chemical Reactions

- In a chemical reaction compounds can be broken apart and new compounds can form.
- Chemical energy is a form of potential energy stored in the chemical bonds between atoms.

Energy in Chemical Reactions

- Energy must be supplied to start some chemical reactions.
- Reactions that absorb heat energy are endothermic reactions.
- Reactions that release heat energy are exothermic reactions.
- The rate of a reaction can be changed by changing the temperature or using a catalyst.

Self Check

1. **Explain** how chemical energy is produced.
2. **Explain** what happens to bonds when new compounds are formed in a chemical reaction.
3. **Explain** how a catalyst speeds up a reaction.
4. **Describe** how photosynthesis transforms radiant energy from sunlight into chemical energy.
5. **Think Critically** Gasoline can react explosively with oxygen in air. Why doesn't the gasoline in a car's gas tank explode when the gas cap is removed?

Applying Skills

6. **Draw Conclusions** Identify three processes that take place in your classroom that involve chemical reactions. Which of these reactions are exothermic?

Science Online red.msscience.com/self_check_quiz

LAB

Converting Potential and Kinetic Energy

Imagine standing at the top of a mountain ready to ski down its slope. Because of your height on the mountain, you have potential energy. As you ski down the side of the mountain, your speed and kinetic energy increase, but as you lose height, your potential energy decreases. Where does your potential energy go? Where does your kinetic energy come from?

Real-World Question

How can you measure the conversion of potential energy into kinetic energy?

Goals

- **Measure** and calculate potential energy and kinetic energy.
- **Observe** the conversion between potential energy and kinetic energy.

Materials

stiff piece of cardboard (1 m)
triple-beam balance
table-tennis ball
tennis ball
baseball
stopwatch
meterstick

Procedure

1. Copy the data table into your Science Journal.
2. Lean your cardboard against a chair.
3. **Measure** and record the height and length of the board.
4. **Measure** and record the mass of each ball.
5. Let each ball roll from the top of the board to the floor. Measure and record the time it takes for each ball to roll the length of the board.

Conclude and Apply

1. **Calculate** the potential energy of each ball at the top of the board by multiplying the mass times the height times 9.8.
2. **Calculate** the average velocity of each ball as it reaches the floor by dividing the length of the board by the time.
3. **Calculate** the average kinetic energy of each ball as it rolled down the board by multiplying the mass times the velocity squared, and dividing by 2.

Energy Factors

Type of Ball	Mass of Ball (kg)	Height of Board (m)	Length of Board (m)	Time (s)
Table-tennis ball				
Tennis ball		Do not write in this book.		
Baseball				

4. **Infer** Which ball had the greatest kinetic energy? Infer why this ball had more kinetic energy.
5. **Infer** how the table-tennis ball could have more potential energy than the baseball.
6. **Infer** the relationship between each ball's potential energy at the top of the slope and its average kinetic energy.

Communicating Your Data

Compare your data with the data collected by your classmates. **For more help, refer to the Science Skill Handbook.**

LAB

Comparing Temperature Changes

Goals
- **Measure** temperature.
- **Calculate** temperature change.
- **Infer** a material's ability to absorb heat.

Materials
—10°C to 110°C range thermometers (4)
computer probe
self-sealing freezer bags (2)
water (100 mL)
ice cubes (2 to 3)
pancake syrup (100 mL)
corn syrup
400-mL to 600-mL beakers (4)
heat-safe glass containers
spoon or stirring rod
**Alternate materials*

Safety Precautions

WARNING: *Use care when handling the heated bags and hot water. Do not taste, eat, or drink any materials used in the lab. Take care when handling glass thermometers.*

Real-World Question

How does the temperature of a substance change as it gains or loses heat? The temperatures of equal amounts of different substances change differently as they are heated or cooled. In this lab you will determine how the temperatures of two different materials change as they absorb and release heat.

Procedure

1. **Design** two data tables to record your temperature measurements of the hot- and cold-water beakers. Use the sample table to help you.
2. Pour 200 mL of hot tap water (about 90°C) into each of two large beakers.
3. Pour 200 mL of cool tap water into each of two large beakers. Add two or three ice cubes and stir until the ice melts.

KS Studios

4. Pour 100 mL of room-temperature water into one bag and 100 mL of syrup into the other bag. Tightly seal both bags.
5. **Record** the starting water temperature of each hot-water beaker. Place each bag into its own beaker of hot water.
6. **Record** the water temperature in each of the hot-water beakers every 2 minutes until the temperature does not change.
7. **Record** the starting water temperature of each cold-water beaker. If any ice cubes remain, remove them from the cold water.
8. Carefully remove the bags from the hot water and put each into its own beaker of cold water.
9. **Record** the water temperature in each of the cold-water beakers every 2 minutes until no change in temperature occurs.

Analyze Your Data

1. **Make a graph** of the water temperature of the beakers with the syrup bag in hot water and the water bag in hot water. Plot both lines on the same graph, with the temperature on the *y*-axis and the time on the *x*-axis.
2. **Make a graph** of the water temperature of the beakers with the syrup bag in cold water and the water bag in cold water. Plot the graph as in step 1.
3. **Determine** which bag warmed the fastest and which bag cooled the fastest.
4. **Determine** which bag reached the highest temperature and which bag reached the lowest temperature.

Water Temperatures—Hot Beaker

Water Bag		Syrup Bag	
Time (min)	Temp. (°C)	Time (min)	Temp. (°C)
0	Do not write in this book.	0	
2		2	
4		4	
6		6	
8		8	

Conclude and Apply

1. **Infer** which material absorbed more heat as it warmed, and which material released more heat as it cooled.
2. **Infer** Suppose you have equal amounts of syrup and water at the same temperature. Which material would require more heat to change its temperature by 1°C? Explain.

Communicating Your Data

Compare your results with the results of other students in your classroom. Explain any differences in your data or your conclusions. **For more help, refer to the Science Skill Handbook.**

Hiroshima

by Lawrence Yep

On August 6, 1945, an American B-29 bomber dropped a new weapon called the atom bomb on the Japanese city of Hiroshima. The bomb destroyed 60 percent of the city, killing between 90,000 and 140,000 people.

Everything is made up of tiny particles called atoms. They are so small they are invisible to the eye. Energy holds these parts together like glue. When the atom breaks up into its parts, the energy goes free and there is a big explosion.

Inside the bomb, one uranium atom collides with another. Those atoms both break up. Their parts smash into more atoms and split them in turn.

This is called a chain reaction. There are millions and millions of atoms inside the bomb. When they all break up, it is believed that the atom bomb will be equal to 20,000 tons of dynamite. In 1945, it is the most powerful weapon ever made….

Up until then, no single bomb has ever caused so much damage or so many deaths.

The wind mixes their dust with the dirt and debris. Then it sends everything boiling upward in a tall purple-gray column. When the top of the dust cloud spreads out, it looks like a strange, giant mushroom.

The bomb goes off 580 meters above the ground. The temperature reaches several million degrees Celsius immediately.

One mile away, the fierce heat starts fires.

Even two miles away, people are burned by the heat.

Understanding Literature

Summarize When you summarize something, you mention only the main ideas and necessary supporting details. The author of *Hiroshima* has chosen to summarize the events. He briefly explains the science behind the atom bomb. He also gives some details about the destruction after the bomb was dropped on Hiroshima, Japan. How are summaries useful?

Respond to the Reading

1. What was the author's reason for writing this piece?
2. How is the atom bomb different from other bombs?
3. **Linking Science and Writing** Write a one- or two-paragraph summary of one of the sections in this chapter.

INTEGRATE Physics Energy can be released by exothermic chemical reactions when the bonds between atoms are broken. In this excerpt from *Hiroshima*, Lawrence Yep describes the effects of the energy released in a different process—the energy released when the nuclei of atoms are split. This reaction released an enormous amount of energy that destroyed a city.

Reviewing Main Ideas

Section 1 Energy Changes

1. Energy is the ability to cause change.
2. Energy can have different forms, Energy can be transformed from one form into another.
3. Kinetic energy is the energy an object has due to its motion. Kinetic energy increases as the speed of an object increases.
4. Potential energy is stored energy that increases as an object's height increases.

Section 2 Temperature

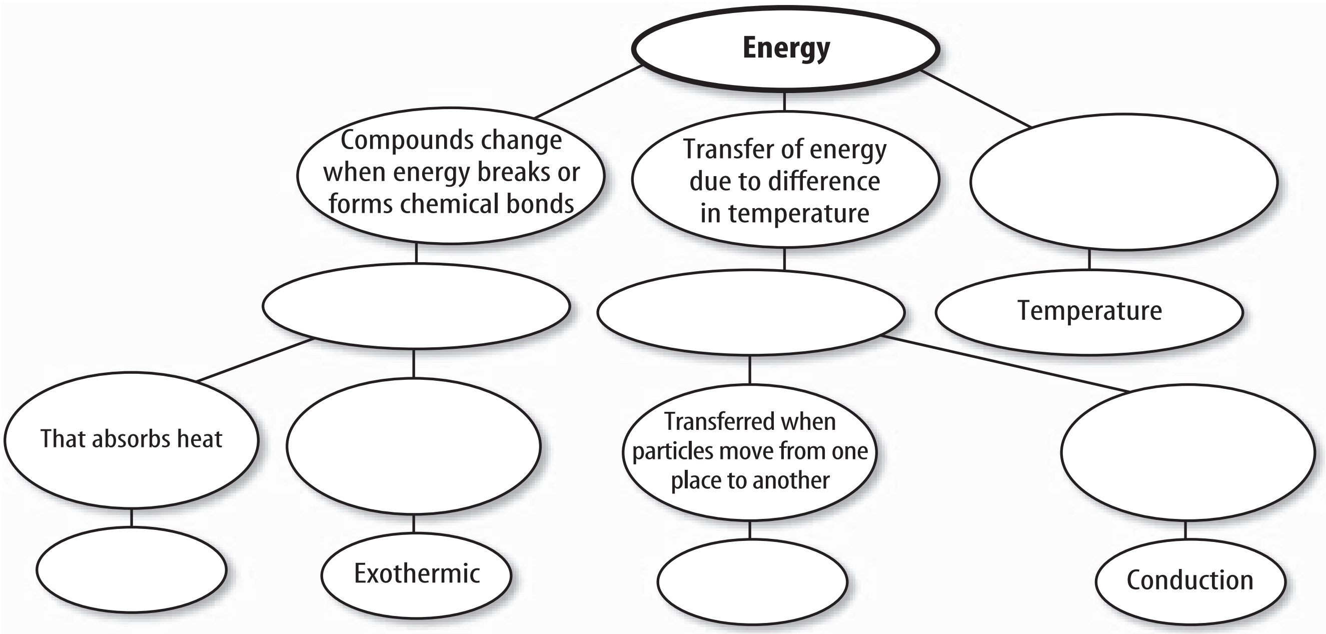
1. Temperature is a measure of the average kinetic energy of the particles in a material.
2. The movement of energy from a warmer object to a cooler one is called heat.
3. Heat can be transferred by conduction, convection, and radiation.

Section 3 Chemical Energy

1. The energy stored in chemical bonds is chemical energy.
2. Chemical reactions can release or absorb energy. Exothermic reactions are chemical reactions that release energy. Endothermic reactions absorb energy.
3. Changing the temperature and adding catalysts can change the rate of chemical reactions.

Visualizing Main Ideas

Copy and complete the following concept map on energy.



chapter 6 Review

Using Vocabulary

catalyst p. 182	heat p. 173
conduction p. 174	kinetic energy p. 164
convection p. 176	law of conservation of energy p. 168
endothermic reaction p. 180	potential energy p. 166
energy p. 162	radiation p. 177
exothermic reaction p. 181	temperature p. 171

Fill in the blanks with the correct vocabulary word or words.

1. Energy transfer by contact is _________.
2. Energy of motion is _________.
3. The movement of energy from warm to cool objects is _________.
4. A measure of the average kinetic energy of the atoms in a substance is _________.
5. _________ is energy that is stored.
6. _________ is the transfer of energy by collisions between the particles in a material.
7. Energy transferred by waves is called _________.
8. A chemical reaction that absorbs heat energy is a(n) _________.
9. A(n) _________ is a substance that changes the rate of a chemical reaction.

Checking Concepts

Choose the word or phrase that best answers the question.

10. Which of the following correctly describes energy?
    A) can be created
    B) can be destroyed
    C) cannot change form
    D) can cause change

11. The temperature of an object is related to which of the following?
    A) heat
    B) total energy of its atoms
    C) kinetic energy of its atoms
    D) total chemical energy

12. What happens if two objects at different temperatures are touching?
    A) Heat moves from the warmer object.
    B) Heat moves from the cooler object.
    C) Heat moves to the warmer object.
    D) No energy transfer takes place.

13. Which of the following describes how the total amount of energy changes during an energy transformation?
    A) It increases.
    B) It decreases.
    C) It stays the same.
    D) It depends on the form of energy being transferred.

14. How is energy from the Sun transferred to Earth?
    A) It is transferred by conduction.
    B) It is transferred by convection.
    C) It is transferred by radiation.
    D) It is transferred by endothermic reactions.

15. When would you have the most potential energy?
    A) walking up the hill
    B) sitting at the top of the hill
    C) running up the hill
    D) sitting at the bottom of the hill

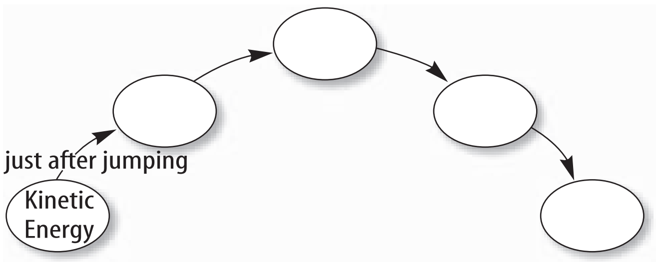
16. Which of the following chemical reactions releases heat energy?
    A) exothermic **C)** catalysts
    B) endothermic **D)** thermals

17. Heat flows easily in which material?
    A) plastic **C)** glass
    B) insulator **D)** conductor

Science Online red.msscience.com/vocabulary_puzzlemaker
CONTENTS

Thinking Critically

18. Concept Map Below is a concept map on the energy changes that occur when a person jumps upward. Copy and complete the map by indicating the type of energy—kinetic, potential, or both—the person has at each of the following stages: halfway up, the highest point, halfway down, and just before hitting the ground.



19. Explain why the air feels cooler on a windy day, than on a calm day, even though the air temperature is the same.

Use the table below to answer question 20.

Kinetic Energy of a Ball

Speed of Ball (m/s)	Kinetic Energy (J)
5	2.5
10	10.0
15	22.5
20	40.0
25	62.5
30	90.0

20. Make a Graph Using the data in the table above, graph the kinetic energy of the ball on the y-axis and the speed of the ball on the x-axis. Describe the shape of your graph. How does the kinetic energy change when the speed doubles? How does the kinetic energy change when the speed triples?

21. Determine If heat flows in only one direction, how can hot and cold liquids reach room temperature as they sit on a table?

22. Explain why the walls of houses often are filled with fiberglass insulation.

23. Determine the forms of energy involved in each of the following situations—a log burns in a fireplace, a ball is dropped, sunlight falls on the leaves of a tree.

24. Explain why a blanket is a better conductor of heat when it is wet than when it is dry.

Performance Activities

25. Design an Experiment to determine how quickly the temperature of different materials changes as they absorb radiant energy. Use the following items—three different colors of construction paper, three thermometers, and a sunny window or a heat lamp.

Applying Math

Use the table below to answer question 26.

Fahrenheit and Celsius Temperatures

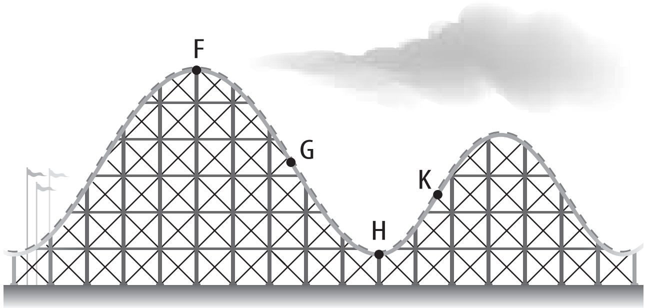
Celsius Temperature (°C)	Fahrenheit Temperature (°F)
100	212
50	122
0	32
−25	−13
−50	−58

26. Temperature Scales Graph the data in the table with the Celsius temperature on the x-axis and the Fahrenheit temperature on the y-axis. From your graph, determine the temperature that has the same value on both temperature scales.

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Use the illustration below to answer questions 1–4.



1. At which point would a roller coaster have the greatest kinetic energy?
A. point F **C.** point G
B. point H **D.** point K

2. At which point would a roller coaster have the greatest potential energy?
A. point F **C.** point G
B. point H **D.** point K

3. At which point is kinetic energy being transformed to potential energy?
A. point F **C.** point G
B. point H **D.** point K

4. At which point is the roller coaster's potential energy smallest?
A. point F **C.** point G
B. point H **D.** point K

5. What causes a metal spoon in a pot of boiling soup to become hot?
A. conduction **C.** radiation
B. convection **D.** insulation

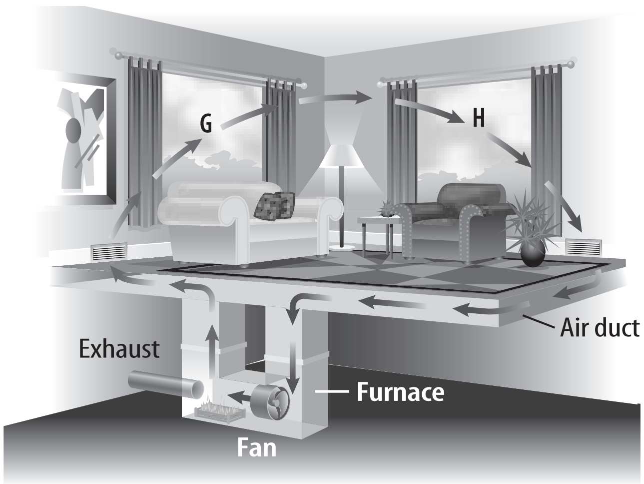
6. Which occurs as you hold a glass of ice tea?
A. Heat flows from the glass to your hand.
B. Heat flows from your hand to the glass.
C. Cold flows from the glass to your hand.
D. Cold flows from your hand to the glass.

7. Which of the following describes the energy stored in chemical bonds?
A. It is a form of potential energy.
B. It is a form of kinetic energy.
C. It is a form of heat energy.
D. It is a form of nuclear energy.

8. The kinetic energy of an object depends on which of the following?
A. its temperature
B. its speed only
C. its mass and its speed
D. how high it is above the ground

9. Which is a good conductor of heat?
A. copper **C.** wood
B. rubber **D.** air

Use the illustration below to answer questions 10 and 11.



10. What type of heat transfer is shown?
A. conduction **C.** radiation
B. convection **D.** insulation

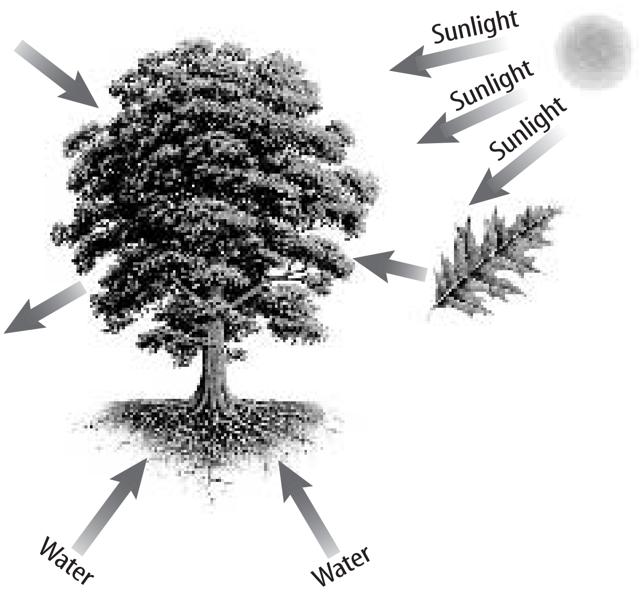
11. How does the air at point G compare to the air at point H?
A. Air at point G is warmer and denser.
B. Air at point G is warmer and less dense.
C. Air at point G is cooler and denser.
D. Air at point G is cooler and less dense.

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

12. Why are many cooking pans made of metal, but have wood handles?

Use the illustration below to answer questions 13 and 14.



13. Is photosynthesis an endothermic or exothermic reaction?

14. What kind of energy transformation occurs during photosynthesis?

15. What is the purpose of water in a car's radiator?

16. Why are catalysts important in the human body?

17. Explain the difference between exothermic and endothermic reactions.

18. How can you increase the potential energy of an object?

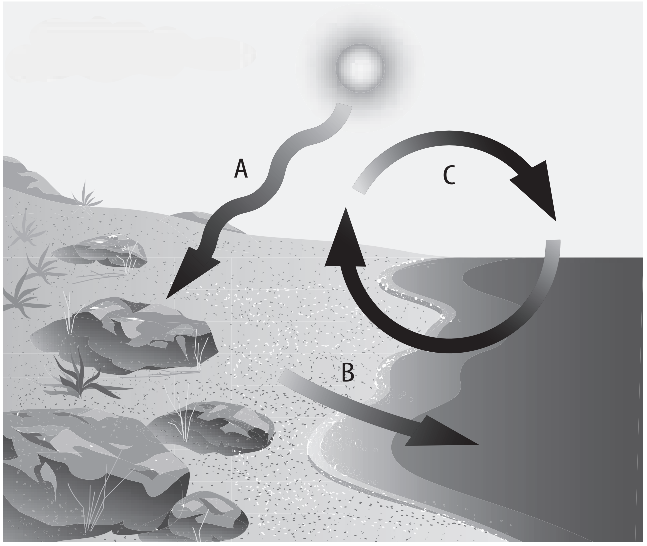
19. Compare the reaction rate of the burning of newspaper with the rusting of a metal tool. Which reaction releases energy at a faster rate?

Part 3 Open Ended

Record your answers on a sheet of paper.

20. Would you rather sit on a wooden bench or metal bench outdoors on a hot day? Explain your choice.

Use the illustration below to answer questions 21 and 22.



21. Describe how energy is being transferred at points A, B, and C.

22. How does the tĬemperature of the water in the lake compare to the temperature of the land around it on a hot summer day? Explain.

23. If heat only flows in one direction, how can frozen food thaw when placed in a refrigerator and hot foods become chilled when placed in a refrigerator?

24. People caught in cold weather with only light jackets are told to crumple up newspapers and place them inside their jackets. Why would this help?

25. Describe the energy changes that occur when falling water is used to generate electricity.