UNIT F PHYSICAL SCIENCE

Exploring Energy and Forces

UNIT EXPERIMENT

Evaporation

Evaporation occurs when a liquid becomes a gas. While you study this unit, you can conduct a long-term experiment to find out how evaporation is related to heat. Here are some questions to think about. When water evaporates from a dish, does it gain heat or lose heat? Do liquids other than water act the same way? Plan and conduct an experiment to find answers to these or other questions you may have about evaporation and heat. See pages x–xii for help in designing your experiment.

CHAPTER 1

Energy

Energy is all around you. It is in sunlight, moving water, gasoline, and batteries. It can move and change from one form to another. Without energy, plants could not grow, animals could not move, and machines could not operate.

Vocabulary Preview

- energy
- potential energy
- kinetic energy
- electricity
- fossil fuel
- vibrate
- circuit

Fast Fact

The Earth is struck by lightning 100 times every second. Most lightning strikes do not cause any damage, but sometimes they start fires. About 75,000 forest fires are started every year by lightning.

Fast Fact

It takes a ray of sunlight 8 minutes to travel from the sun to Earth. It would take a car going 60 miles per hour about 170 years to travel the same distance.

Fast Fact

Animals get their energy from the food they eat. Racehorses can run as fast as 43 miles per hour. But ostriches can run even faster—up to 45 miles per hour.

Running Speeds	
Human	22 mph
African elephant	25 mph
Cat	30 mph
Alligator	35 mph
Pronghorn antelope	55 mph
Cheetah	62 mph

LESSON 1

How Is Energy Stored?

In this lesson, you can . . .

INVESTIGATE how energy can be stored.

LEARN ABOUT the different ways stored energy can be used.

LINK to math, writing, health, and technology.

This hurricane lamp burns oil to produce light energy.

INVESTIGATE

Twisting Up Energy

Activity Purpose You use energy to do lots of things every day. It takes energy to brush your teeth, walk to the bus stop, play kickball, or jump rope.

In this investigation, you will **hypothesize** what happens to the energy you use to twist two clothespins held together by a rubber band.

Materials

- safety goggles
- 1 rubber band
- 2 clothespins

Activity Procedure

CAUTION

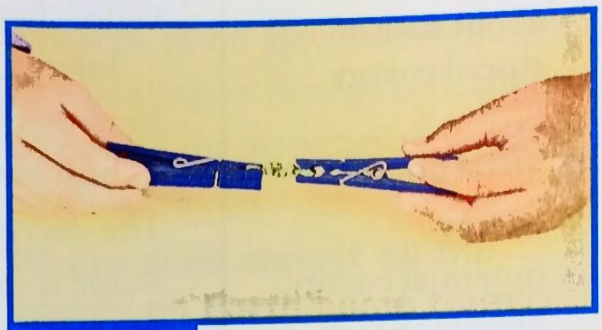
1. **CAUTION Put on safety goggles to protect your eyes in case a clothespin pops loose.**
2. Attach the rubber band to each clothespin. Work with a partner to twist the rubber band between the clothespins. (Picture A)

3. When you have finished, the rubber band should be twisted and curled up. (Picture B)

4. Holding the clothespins tightly, lay them on the table and **hypothesize** what will happen to them when you let them go. **Communicate** your hypothesis to your partner.

5. **Observe** what happens to the clothespins when you let them go. Then do the investigation again, this time twisting the pins more tightly than you did before. **Compare** what the clothespins did the first time with what they did the second time.

Picture A



Picture B

Draw Conclusions

1. Describe what happened each time you put the clothespins on the table and let go of them. How did your hypothesis compare to the actual results?

2. Where did the energy to move the clothespins come from?

3. **Scientists at Work** Scientists **conduct simple experiments** to learn more about how things work. What did you learn about energy and twisted rubber bands from your investigation?

Investigate Further **Observe** what happens to a third clothespin that you twist around the other two with a second rubber band.

Process Skill Tip

When you **hypothesize** before **conducting an experiment**, you are explaining what you think will happen. Then you can plan other experiments to explore your results further.

LEARN ABOUT

What Energy Is

FIND OUT

- about different forms of energy
- how energy can be stored
- about uses of stored energy

VOCABULARY

energy
potential energy
kinetic energy
electricity
fossil fuel

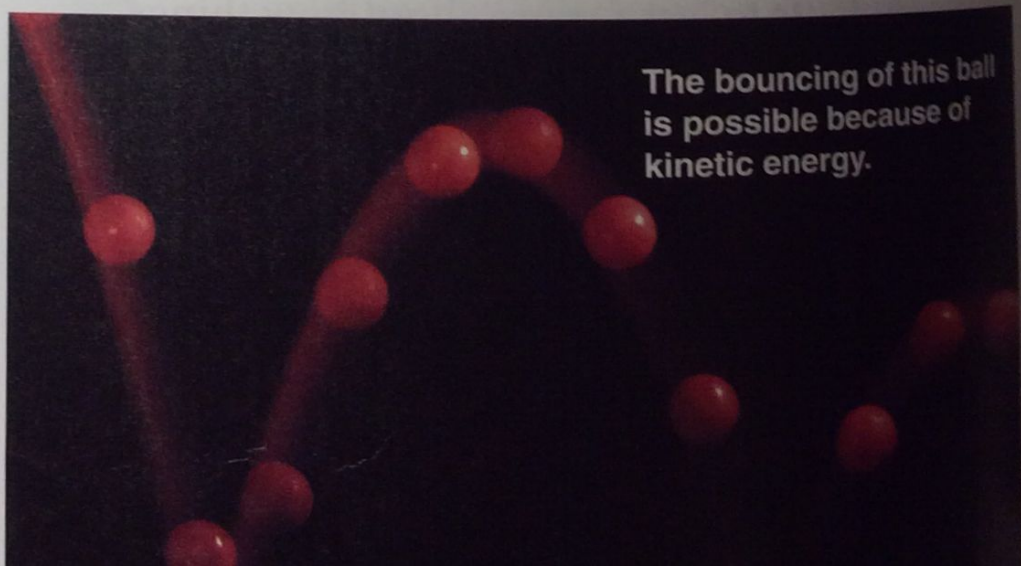
Energy to Live and Move

Think about what happens when you are riding your bike. How are you able to pump the pedals or stop? These actions use energy. **Energy** is the ability to cause change. Energy allows movement in the world.

Energy comes from many places, including the sun, food that you eat, gas that allows cars to run, and oil to heat your home. But all objects can have energy. The energy an object has because of where it is or its shape is called **potential** (poh•TEN•shul) **energy**. For example, a rock on top of a hill has potential energy. If the rock is pushed, that energy is released as the rock rolls down the hill.

Potential energy can change into kinetic energy. **Kinetic** (kih•NET•ik) **energy** is the energy of motion. Any moving object has kinetic energy. The rock rolling down the hill has kinetic energy. A bigger rock would have greater kinetic energy. The heavier a moving object is, the more kinetic energy it has.

✓ **What is energy?**



The bouncing of this ball is possible because of kinetic energy.

Sources of Energy

Almost all energy on Earth comes from the sun. The food we eat, the gas we put in our cars, even the electricity that lights our homes can all be traced back to the sun's energy.

Light and heat are forms of energy that come directly from the sun. Plants need energy from sunlight to make food. Heat from the sun warms everything on Earth.

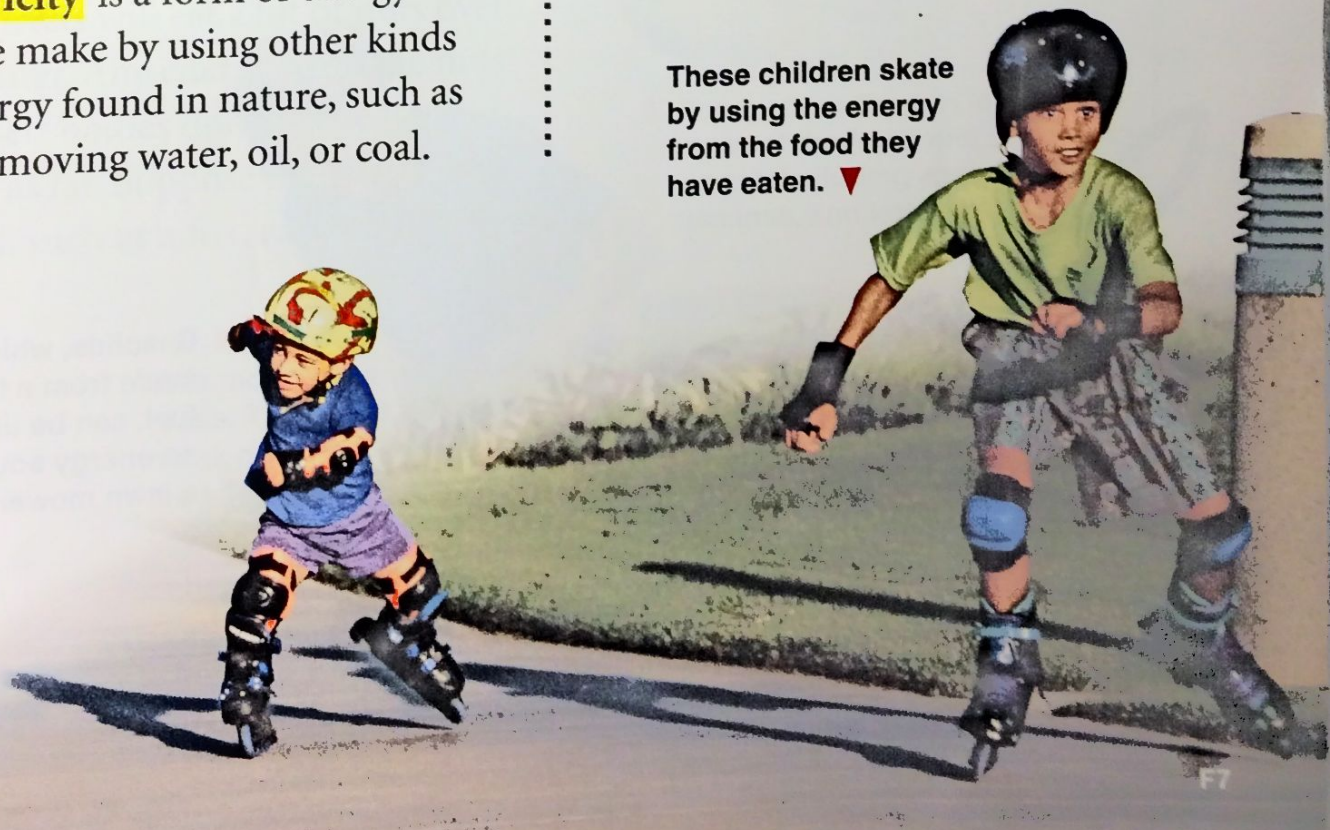
What kinds of energy come indirectly from the sun? The food we eat is one example. Food contains the energy we use to power our bodies. Another example is fuels. Fuels, such as coal and oil, contain huge amounts of energy.

Fuels can release energy that can be changed into electricity. **Electricity** is a form of energy that people make by using other kinds of energy found in nature, such as wind, moving water, oil, or coal. Energy that comes into our homes as electricity can be used to light lamps, run computers, or cook popcorn.

Wind and moving water can also be used in other ways. Wind can be used to keep a hang glider or a kite up in the air. Moving water can be used to carry logs downstream to a sawmill.

People can use other kinds of energy to open cans, print newspapers, or lift steel beams to build a skyscraper. Energy is needed for almost all the activities that make up our lives.

✓ **Where does almost all the energy on Earth come from?**



These children skate by using the energy from the food they have eaten. ▼

Stored Energy

At all times, the sun's rays are striking about half of Earth's surface. Plants use the energy in sunlight to make food, which they then use to grow and reproduce. Animals eat the plants to get the energy stored in the plant tissues. Then the animals use this energy to run, climb, hunt, and stay warm. So, organisms use a lot of the energy just by the things they do every day to stay alive. The energy that they don't use is stored in their bodies as potential energy.

People can use the potential energy of plants and animals. You use potential energy when you eat a hamburger or ride the school bus. Fuel and food are both forms of potential energy that people use.

Fuel Have you ever seen a fire burning? What was used to make the fire? Chances are, it was wood. Wood comes from trees. Like other plants, trees store energy from the sun. When wood burns, this stored energy is released as heat. The heat warms you as you sit near the fire.

All living organisms store energy. When they die, their bodies are slowly buried by soil and rocks. Over millions of years, some of this material may be pressed together until it turns into fuel, like oil or coal. This kind of fuel is called **fossil fuel**. Gasoline and heating oil are made from fossil fuels.

To release the energy stored in fossil fuels, the fuels must be burned. Burning releases heat that can be changed into other types of energy.

◀ **Gasoline, which is made from a fossil fuel, can be used as an energy source for a lawn mower engine.**

Food Just before winter, when it begins to get colder outside, do you notice anything different about the squirrels in your neighborhood? Watch them closely. You will soon see that they are collecting nuts, berries, and other bits of food. They hide some of the food and eat it later in the winter when food is hard to find.

Food is one way energy from the sun can be stored. Leaves, stems, roots, and fruits are structures in which plants store energy.

When an animal eats a plant, it gets the energy stored inside the plant and uses it to keep warm and move around. Squirrels get the energy they need to keep warm during the long, cold winter months by eating the food they collected in the fall.

Squirrels will eat a lot of nuts over the winter. Any energy from the nuts that their bodies don't use will be stored as fat. Suppose that another animal, such as a fox, eats a squirrel. The fox gets the energy stored in the squirrel's body. So while acorns are food for squirrels, squirrels are food for foxes.

✓ **Where does the energy in food and fuels come from?**

▲ **Energy from the sun is stored in many of the fruits and vegetables we eat, including apples, broccoli, bananas, and lettuce.**

This mountain goat is eating grass. The goat's body will break down the grass to release the energy stored inside. ►

Batteries

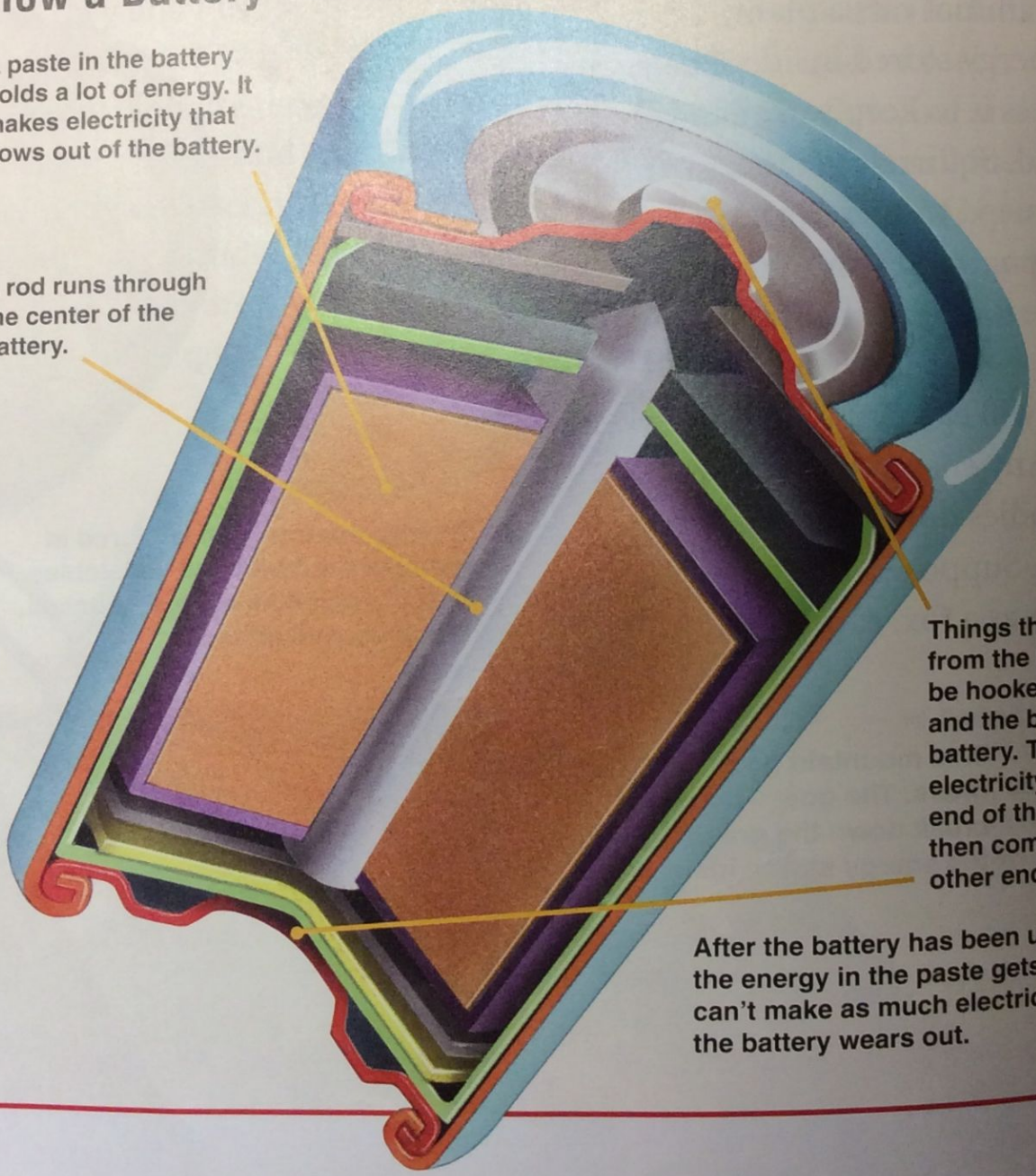
In nature, energy is stored in the form of food and fuel. But people can store energy too. You can store energy in a battery.

Batteries come in many shapes and sizes. Some are so small that they have to be handled with tweezers. Others are bigger than a suitcase—and a whole lot heavier. You probably use batteries that look like cylinders, or tubes.

Companies that make batteries charge them. To do this, the batteries are filled with chemicals that contain energy. Batteries change the energy in the chemicals into the electricity needed to make many things work.

THE INSIDE STORY

How a Battery Works



▲ Flashlights use the energy from batteries to make light.

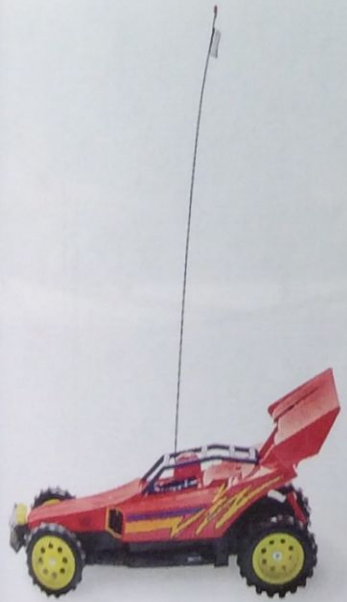
▲ You can tell that the battery in your calculator is out of energy when you can't see numbers on the screen anymore.

▲ Batteries in this stereo supply the energy needed to play the radio or the cassette inside.

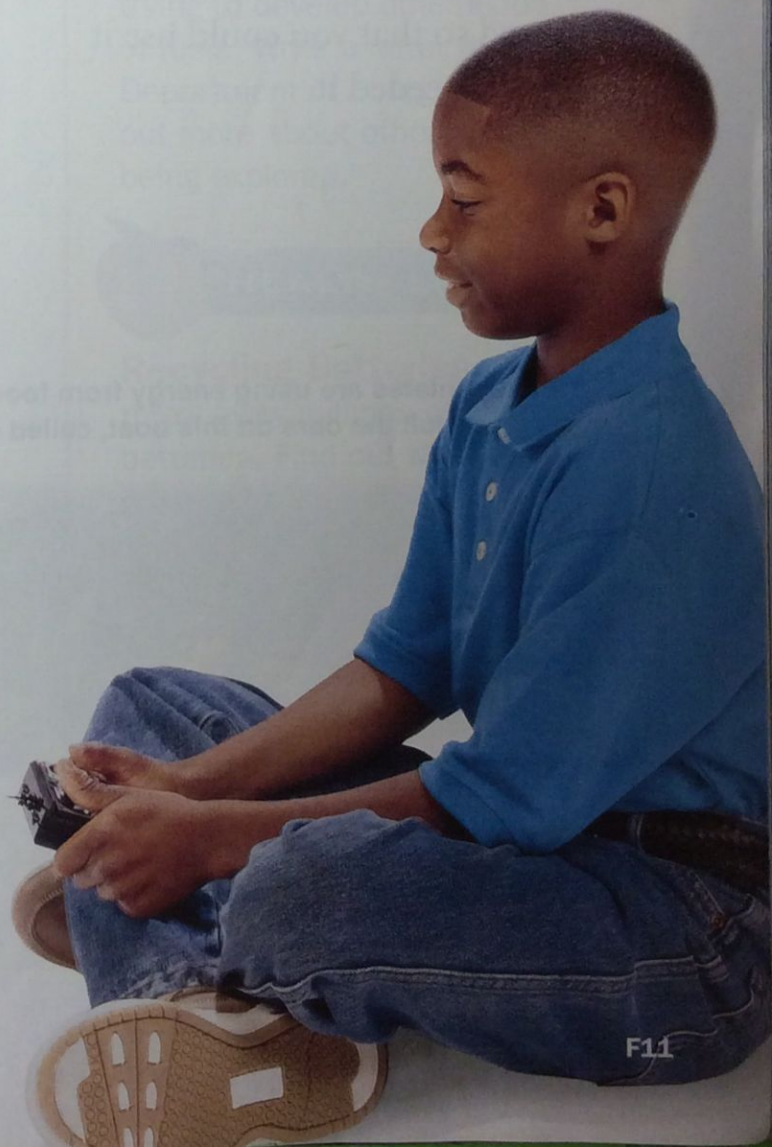
The stereo that you use to play music probably takes many big batteries. These batteries supply the stereo with the electricity it needs to play the music. Do you wear a wristwatch? Chances are, there is a small, flat battery inside. That battery provides the electricity needed for the hands to turn or the digital numbers to change on the face of the watch.

As batteries are used, the energy inside is used up. Some batteries can be recharged, or refilled with energy. Others cannot be recharged and must be recycled or thrown away.

✓ How are batteries charged?



The remote-control device for this toy gets its energy from batteries inside the control box. ►



How Stored Energy Can Be Used

You have just learned that energy can be stored as food or fuel. You also saw that energy can be stored in batteries. People store energy so they can use it when they need it. During the day, you might feel warm and be able to see objects clearly. But on a dark, cold night, you need energy to supply heat and light to your home.

Think about what you and your family did last night after supper. Maybe you had the radio on as you all played a game. The energy to play the music came from energy that was produced so that you could use it when you needed it.

Look at the picture of the women rowing in the boat below. Their muscles need energy to be able to pull the oars and move the boat forward. To get this energy, they eat foods such as sandwiches, spaghetti, and fruit. All this food originally got its energy from sunlight.

Fuel is a form of stored energy that people depend on a great deal. We either burn it to release the energy inside or use it to make electricity, which is another form of energy that can be used to make all sorts of things work. Fuel gives us energy to heat our homes, to cook our food, and to drive our cars.

✓ **Why is stored energy useful?**

These athletes are using energy from food they have eaten to pull the oars on this boat, called a racing shell. ▼

Summary

Energy is the ability to cause change. All living things need energy to survive. Tools and machines need energy to operate. Energy comes mainly from the sun and can be found in many different forms. It can be stored and used later when it is needed. Food and fuel are both forms of stored energy. Electricity is a form of energy that is made by using other forms of energy.

Review

1. What is the main source of energy on Earth?
2. What are fossil fuels?
3. Why are batteries useful?
4. **Critical Thinking** What would the world be like if the sun did not shine?
5. **Test Prep** Which of the following is not a source of energy?

   A wind C engine
   B moving water D coal

LINKS

MATH LINK

Multiply Whole Numbers Scientists estimate that the sun produces about 4 million metric tons of energy every second. About how many metric tons does it produce each minute?

WRITING LINK

Persuasive Writing—Business Letter Fossil fuels are still commonly used in the United States. Scientists are trying to develop other kinds of fuels. Write a letter to the Department of Energy to find out more about other fuels being explored.

HEALTH LINK

Recycling Batteries People throw away millions of used batteries. Find out what recycling centers do with old batteries.

TECHNOLOGY LINK

To learn more about energy from the sun, watch Solar Float on the **Harcourt Science Newsroom Video** in your classroom video library.

CNN Turner Learning

LESSON 2

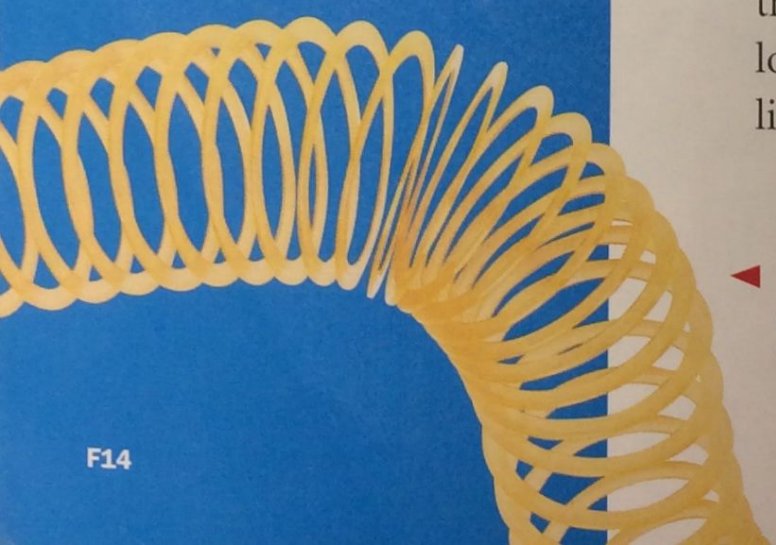
How Does Energy Move?

In this lesson, you can . . .

INVESTIGATE how energy moves as waves.

LEARN ABOUT how warm objects can become cold and how cold objects can become warm.

LINK to math, writing, social studies, and technology.



INVESTIGATE

Waves of Energy

Activity Purpose Energy can move through the air, through water, through wires—even through our bodies! One way energy moves is as waves.

In this investigation, you will **use models** to show two of the ways energy can move.

Materials

- rope about 6 feet long
- coiled spring toy

Activity Procedure

1. Do this investigation with a partner. Hold one end of the rope while your partner holds the other. Stand so that the rope hangs loosely between you.
2. While your partner holds his or her end of the rope still, move your end of the rope gently up and down. Now move the rope faster. **Compare** what the rope looked like before with what it looks like now. (Picture A)

◀ **This coiled spring toy can be used to show one way energy can move.**

3. Now take the coiled spring toy and place it on a table or on the floor. Hold one end, and have your partner hold the other. (Picture B)

4. Ask your partner to hold the end still as you quickly push your end of the toy in about 4 inches. Now push and pull the end backward and forward. **Observe** what happens to the coils.

5. Draw and label a diagram explaining what happened to the rope when you moved one end. Make another diagram showing what happened to the coiled spring toy when you pushed one end in.

Picture A

Picture B

Draw Conclusions

1. What happened to the rope when you moved one end up and down? How did it move? What happened when you moved it faster?
2. What happened when you pushed your end of the coiled spring toy toward your partner? What happened when you moved it back and forth?
3. **Scientists at Work** When things in nature can't be seen, scientists **use models** to see how they work. They then **communicate** what they learn. How did your diagram help you to communicate what you learned about how energy moves as waves?

Process Skill Tip

Using models is a good way to learn more about things that you can't see. Carefully drawn and labeled diagrams can then be used to **communicate** what you learned.

LEARN ABOUT

Energy Can Move as Waves

FIND OUT

- how energy can move as waves
- how energy can move as electricity

VOCABULARY

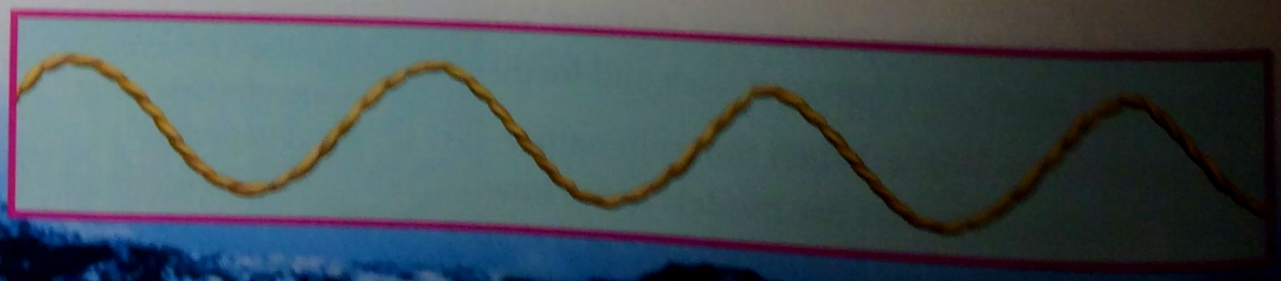
vibrate
circuit

Kinds of Waves

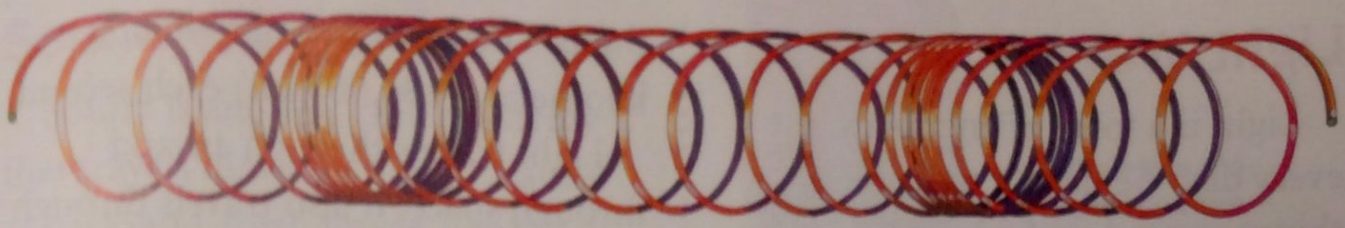
Have you ever seen a painting of the ocean? How did the artist draw the waves? Most of the waves we see every day look like curvy lines. If you were to draw a wave, it would probably start low, go up high, and then come back down low again. It would keep going like this over and over again.

Wind moving over water makes waves on the surface. Sometimes the waves are small, but at other times they are big enough to toss a boat about. You may even have made your own waves in the bathtub as you moved around. Waves in water are the easiest waves to see.

Look at the diagram below of a wave. If you wanted to measure the wave, what would you do? You might look at how high and how low each curve went. Or you might measure the distance from the top of one curve to the top of the next curve.



One kind of wave, like the one you made with the rope, moves up and down.



▲ The kind of wave you make with a coiled spring toy moves back and forth.

But what about the other kind of wave you made in the investigation? You don't see this kind of wave every day. It moves back and forth instead of up and down.

Look at the diagram above. It shows the kind of wave you made by using a coiled spring toy. If you look closely, you'll notice that some parts of the spring are very close together and others are spread out.

If you wanted to measure this wave, what would you do? You could look at the distance between one bunched-up part and the next.

Energy often moves. Light is one kind of energy that moves from the sun to Earth. Sound is another kind of energy that moves. It travels from our mouths to the ears of people when we speak.

Some forms of energy, including light and sound, move through the air as waves. Light moves as up-and-down waves, like the rope wave. Sound moves as back-and-forth waves, like the coiled spring toy waves.

✓ **How is a rope wave different from a coiled spring toy wave?**

This sailboat is being tossed about by ocean waves. ▼

Light Waves

Light is a form of energy we use every day. We need it to see the things around us. Light comes from many different sources. The sun is the most important. Other light sources, such as lamps and candles, provide light when the sun doesn't give us light.

Light has something in common with water waves. When you throw a pebble into a pond, ripples move away from the spot where the pebble hit. In the same way, light waves move away from a light source. Light, like water, moves in up-and-down waves. Light waves travel until they come to an object. When the waves strike the object, some bounce off it so that we can see the object.

You cannot see light waves. Light waves move too fast for you to see them. They move about 300,000 kilometers (186,000 mi) each second.

Light travels through air and through space. It also travels through clear materials such as glass and water. You know this because you can see fish in an aquarium. Light doesn't travel through most objects, though. A shadow is made whenever an object, like your body, stops the path of light waves. When you stand outside on a sunny day, light waves from the sun hit your body, but they can't move through you to the ground behind you. Your body blocks the light, and a shadow forms.

✓ **How does light travel?**

Lights placed all along this runway give off light waves, allowing pilots to see the runway and to land the plane safely—even at night.

Sound Waves

Sound is another kind of energy that travels in waves. Sound travels as back-and-forth waves, like the coiled spring toy in the investigation.

Think of different sounds you hear every day—the voice of a friend, the jingle of a bell, the slamming of a door, the buzz of an insect, a song on the radio. Even though these sounds seem different, they all travel the same way.

Think about the sound from a bell. When you ring a bell, the clapper inside hits the sides of the bell. The sides then start to **vibrate**, or move back and forth very quickly. This makes the air around the bell vibrate too. Waves of vibrating air move away from the bell in all directions. When these waves reach your ears, your brain hears the bell ring.

When this old-fashioned fire alarm rings, sound waves are sent out in all directions, warning people of the danger.

Have you ever been in a storm with lightning and thunder? As the storm was coming toward you, you probably saw the lightning before you heard the thunder. But the lightning and the thunder began at the same time. You saw the lightning first because light waves travel much faster than sound waves.

✓ **How does sound travel?**

Instruments made with wood, strings, and metal can be used to make beautiful sounds that we hear as music.

Energy Can Move as Electricity

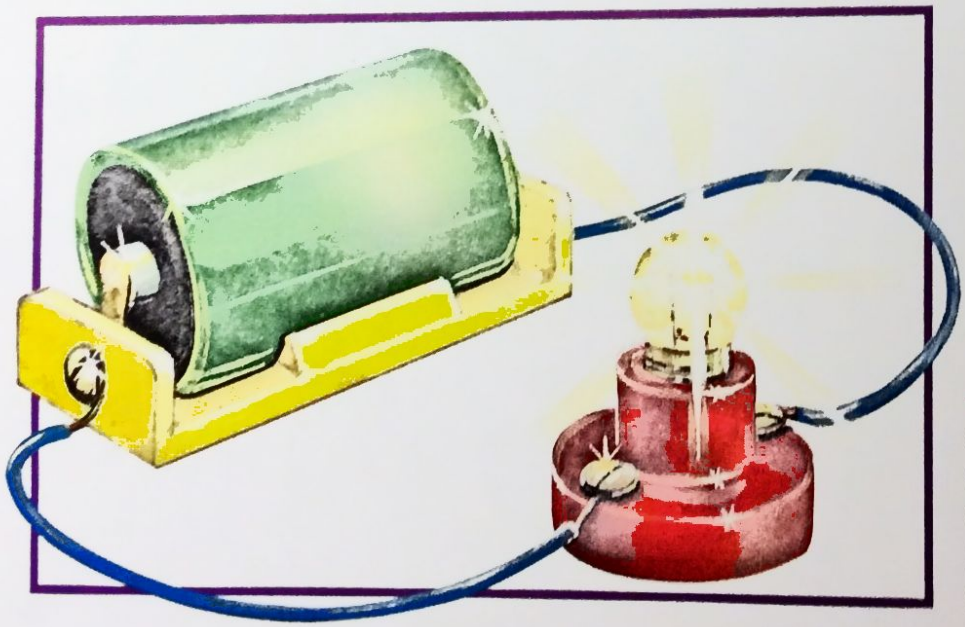
Light and sound are both forms of energy, and both travel in waves. Another way energy can travel is as electricity.

In the last lesson you learned that batteries can store energy so that it can be used later. The kind of energy that batteries produce is called electricity. Electricity is also produced by energy companies and sent to your home. You can use this electricity by plugging something into a wall socket.

Electricity can be used to do many things. This is because electricity can easily be changed to other forms of energy. It can be used to start a car engine, to light a lamp, to turn the blades of a fan, or to make your favorite toy move.

▲ Energy, in the form of electricity, moves out of batteries and turns the blades of this fan.

Have you ever made a bulb light by using a battery and some wires? The bulb lights because energy moves as electricity from the battery, through the wires, to the bulb, and back to the battery. When the bulb lights, electric energy is changed to light energy. The path the electricity follows from the battery, through the bulb, and back again is called a **circuit**.



◀ In a circuit, energy moves from the battery, through the wires, to the bulb, and then back to the battery.

Electricity can change form to make things move or turn. The battery in a hand-held fan supplies electricity to a little motor in the fan that turns the blades of the fan.

✓ **What is a circuit?**

Summary

Energy can move in many ways. Light energy moves as up-and-down waves. Sound energy moves as back-and-forth waves. Electricity is a form of energy that can move from a battery to other objects.

Review

1. What are two kinds of waves?
2. What do all sounds have in common?
3. How does electricity move to light the light bulbs in a room?
4. **Critical Thinking** What types of energy can be produced by a battery? Why is this energy important?
5. **Test Prep** What sort of energy moves by waves?
   - A electricity
   - B sound
   - C batteries
   - D lightning

LINKS

MATH LINK

Solve a Problem About 30 parts of every 100 parts of the energy coming to Earth from the sun reflect back into space when it hits the Earth's atmosphere. What part reaches the Earth's surface?

WRITING LINK

Narrative Writing—Description On the oceans there are different kinds of waves. Some you can see. Others you can't. Write a description for your teacher about an ocean and all the waves you might see or feel.

SOCIAL STUDIES LINK

Ringing the Bell Research the role of the bell tower in ancient times. Why was the bell located in the middle of town? Who was in charge of ringing it? How was it used to send out information?

TECHNOLOGY LINK

Learn more about sound waves and music by investigating *Waves of Music* on **Harcourt Science Explorations CD-ROM.**

LESSON 3

How Can Energy Be Changed?

In this lesson, you can . . .

INVESTIGATE how energy flows from a battery to light a bulb.

LEARN ABOUT how some forms of energy can be changed into other forms.

LINK to math, writing, and technology.

◀ the sun

INVESTIGATE

Lighting a Bulb

Activity Purpose Have you ever put batteries in a flashlight the wrong way? What happened? In order for the bulb to light up, the batteries need to be connected to the bulb in a certain way.

In this investigation you will **experiment** with a battery, a bulb, and wires.

Materials

- masking tape
- D-cell battery
- 2 pieces of insulated electrical wire
- miniature light bulb

Activity Procedure

1. Use a piece of masking tape to tape the battery to your desk. This way, it won't roll around. (Picture A)
2. As your partner holds the light bulb a few inches away from the battery, use the wires to connect the ends of the battery with the base of the bulb. (Picture B)

3. Now switch the wires. Do you **observe** any changes?

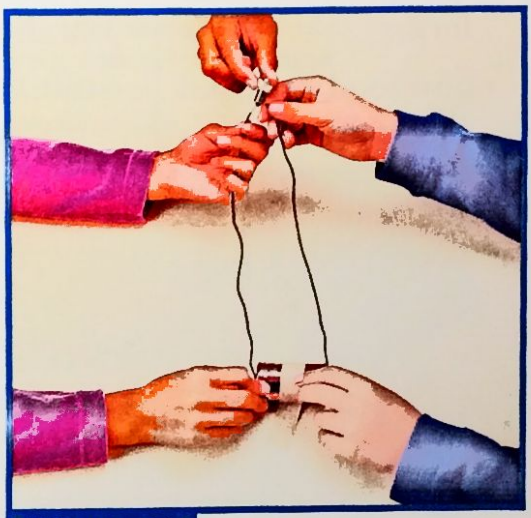
4. Try to make the bulb light by touching the wires to the glass part of the bulb. Can you make it light?

5. Can you make the bulb light by touching the wires to the sides of the battery?

Picture A

Draw Conclusions

1. What happened when you connected the ends of the battery to the base of the light bulb by using the wires?
2. What happened when you switched the wires?
3. Could you make the bulb light by touching the wires to the glass part of the bulb? Did the bulb light when you touched the wires to the sides of the battery?
4. **Scientists at Work** Scientists know that the results of experiments don't often turn out exactly the same every time. This can be caused by differences in materials or differences in procedure. How could you change the materials in this investigation to see if the results would change?



Picture B

Investigate Further **Plan and conduct a simple investigation** to find out if you can make the bulb light by using something other than wires to connect the battery and the bulb. **Control variables** by using the same battery and bulb for each trial.

Process Skill Tip

When you **experiment** with materials to see how they interact, you can figure out how to make them do something, like light a bulb. By experimenting, you can see the evidence that helps you **draw conclusions** about how things work.

LEARN ABOUT

Energy Can Change Forms

FIND OUT

- how energy from sunlight can be changed into other forms
- how food, fuel, and electricity can produce motion and heat

From Sunlight to Electricity

Sunlight brings us light and heat every day. We need light to see and heat to keep us warm. But sunlight cannot run our washing machines or play our radios. To do those things, we need electricity.

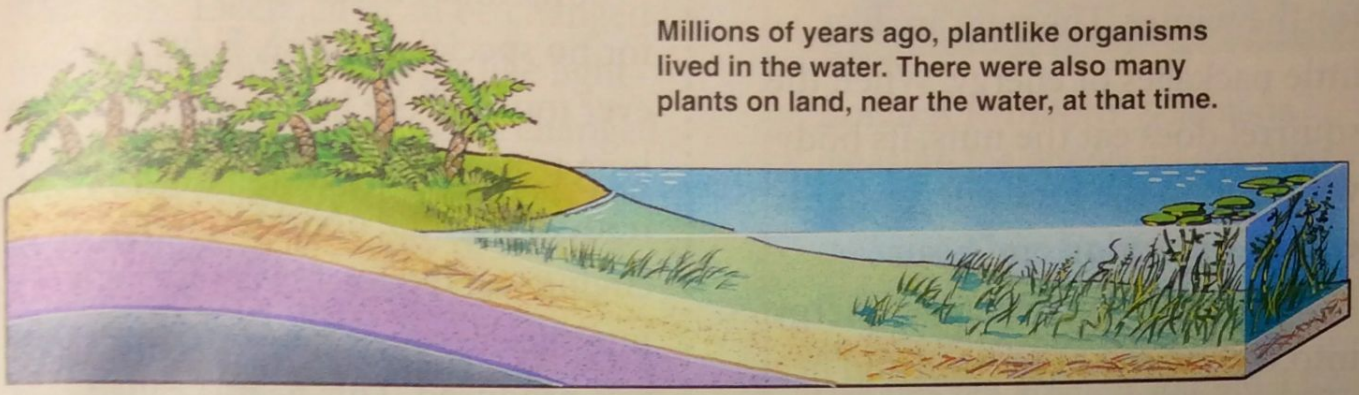
Electricity is a form of energy we use every day. You have probably already used electricity several times today. Electricity comes from many different sources, but almost all of them can be traced back to energy from the sun.

You may remember that plants can make their own food by using the energy from sunlight. When animals eat the plants, they convert, or change, the energy into energy they can use. When wood burns, the energy stored in the wood changes into thermal energy. These are just some of the ways that energy can be changed from one form to another.

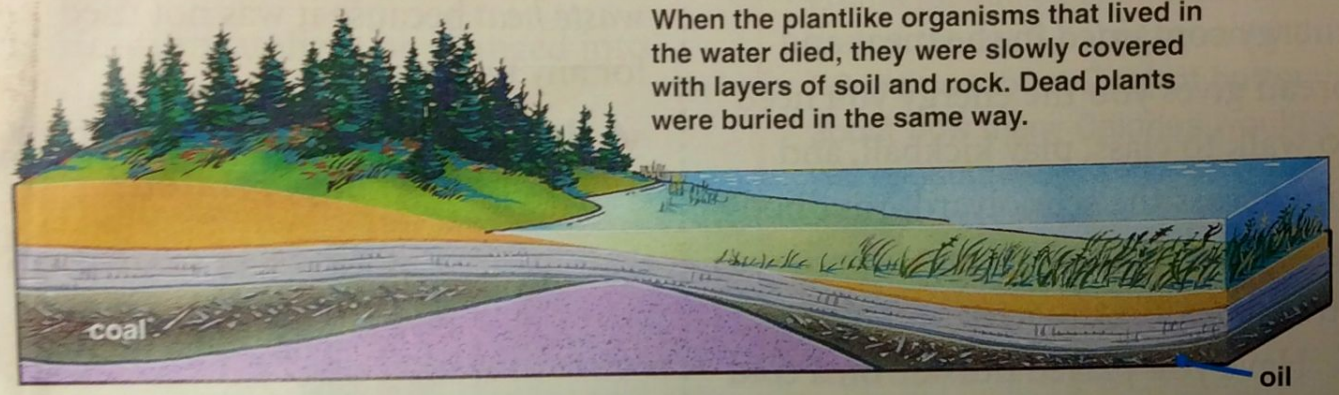
✓ **Where did the energy in oil come from?**

Electricity is carried through wires to places where it is needed, like our homes. There, we change it into heat, light, motion, or other forms of energy. ▼

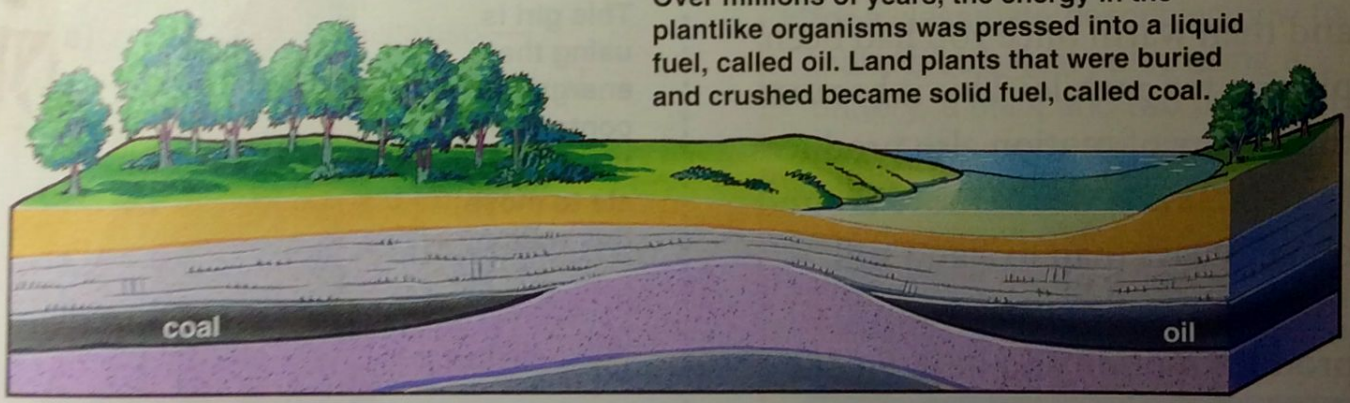
The Formation of Fossil Fuels



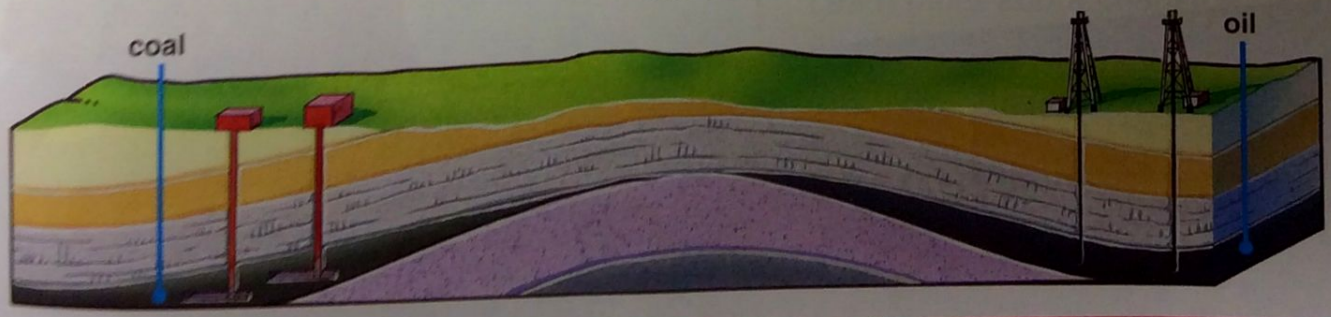
Millions of years ago, plantlike organisms lived in the water. There were also many plants on land, near the water, at that time.



When the plantlike organisms that lived in the water died, they were slowly covered with layers of soil and rock. Dead plants were buried in the same way.



Over millions of years, the energy in the plantlike organisms was pressed into a liquid fuel, called oil. Land plants that were buried and crushed became solid fuel, called coal.



Today, people pump up oil and mine coal from beneath the ground. Then the oil and coal are converted to electricity.

Energy Into Motion and Heat

Recall that squirrels collect nuts for the winter. The nuts are like little packages of energy. When the squirrel does eat the nuts, its body will convert the food energy to the energy of motion and heat.

All animals convert food energy into the energy of motion and heat. When you eat a turkey sandwich, the energy contained in the meat and bread gives you the energy you need to walk to class, play kickball, and run across the schoolyard. Your body also uses the food energy to produce thermal energy to keep you warm.

Have you played outside on a cold day? Were you cold when you started and then warm once you had been playing for a while? This is because the energy of motion also produces heat. So it is better to move around on cold days than to stand still.

Machines also use energy to produce motion and heat. Fuel is the energy source. A car or boat engine uses fuel to produce motion. Furnaces use fuel to warm air or water.

Sometimes machines produce heat for no special purpose. Have you ever touched the hood of a car after a long trip? If you did, you would have noticed that the hood felt hot. As the engine worked to convert fuel energy into the energy of motion, heat was produced. This heat is called *waste heat* because it was not used for any purpose.

✔ **How are the energy of motion and heat energy related?**

This girl is using the energy contained in the food she ate to move this wagon. ►

Summary

Energy can change forms. Sunlight can be changed into food, fuel, or electricity. Electricity can be changed into other kinds of energy, like light energy. Food and fuel can be changed into motion and heat by animals and by machines. The energy of motion often produces waste heat.

Lesson Review

1. How can sunlight be changed into electricity?
2. Where do you get the energy to climb stairs?
3. **Critical Thinking** If all fossil fuels disappeared tomorrow, could you still watch TV? Explain your answer.
4. **Test Prep** A car engine feels hot after a long ride because —
   - A it contains a lot of electrical energy
   - B the sun heats the engine
   - C the energy of motion produces waste heat
   - D the battery keeps it warm

LINKS

MATH LINK

Solve a Problem Scientists measure the energy we get from the food we eat in units called Calories. A gram of fat provides about 9 Calories. Bread, pasta, and meat provide about 4 Calories per gram. If you ate 112 grams (about 4 oz) of meat on 84 grams (about 3 oz) of bread with 56 grams (about 2 oz) of butter, about how many Calories would you consume?

WRITING LINK

Narrative Writing—Description Write a paragraph for a classmate describing how to make a bulb light up by using a battery, a bulb, and two pieces of wire. Then exchange paragraphs with a partner. Mark any places in the paragraph that you didn't understand. Rewrite your paragraph to make it clearer.

TECHNOLOGY LINK

GO ONLINE

Learn more about changing electricity to light by visiting the Smithsonian Institution Internet site.

www.si.edu/harcourt/science

Smithsonian Institution®

SOLAR POWER

An Airplane That Soars on Sunlight

Most airplanes use fuel to run their engines. *Pathfinder* is not most airplanes; it is a solar-powered airplane. It runs on sunshine. *Pathfinder* is very lightweight and can fly higher than any other propeller-driven plane. The scientists who built *Pathfinder* think that solar-powered planes can do many of the same jobs that satellites do.

A Flimsy Flying Wing

Pathfinder is made of thin plastic film stretched over a skeleton of plastic and Styrofoam. It weighs only about 455 kilograms (1,000 lb)—about as much as five big men. *Pathfinder* doesn't look like an ordinary plane. It has one wing that's 40 meters (about 130 ft) long. The top surface of this long wing is covered with solar cells that turn sunlight into electricity. The electricity runs motors that turn *Pathfinder's* eight propellers.

Pathfinder doesn't go very fast—only about 28 kilometers per hour (17 mph). Most kids can pedal a bike that fast! But it can go almost 42 kilometers (25 mi) high.

Pathfinder can't carry passengers. It doesn't even have a pilot. The plane is controlled by radio signals sent from the ground. So what good is a big, slow plastic airplane high in the sky? It can do some of the same jobs that satellites

do. *Pathfinder* can take pictures while it is flying. The pictures can be used to keep track of hurricanes and to help predict the weather, just like satellites do. It can carry instruments that help scientists learn about pollution, and it can relay signals for radios and cellular telephones.

What Happens When the Sun Goes Down?

Pathfinder can fly only when the sun is shining. It has to land at night. But engineers at AeroVironment are working on a new solar-powered plane with batteries that can store energy during the day. Energy from the batteries will keep the propellers spinning during the night. The new plane is called *Helios*, from the Greek word that means "sun." *Helios* could stay in the air for a long time. By using sunlight during the day and batteries at night, *Helios* could fly for six months without landing.

Where Else Could It Fly?

Pathfinder flies where the atmosphere is very thin. The atmosphere on other planets is thin, too. Scientists at NASA—the National Aeronautics and Space Administration—think a plane like *Pathfinder* could be used to explore other worlds. NASA hopes to have a small, lightweight solar-powered plane flying on Mars in 2003.

THINK ABOUT IT

1. Satellites use solar power in outer space. Have you seen any machines that use solar power on Earth?
2. What are some advantages and disadvantages of using sunlight for energy?

CAREERS

ENERGY MANAGER

What They Do

Energy managers help people decide on the best way to use energy in homes, offices, and factories. They make suggestions about what kinds of lights to use, when to turn air conditioning or heating on and off, and what kind of machines are the most efficient.

Education and Training An energy manager needs a college degree. He or she must know about different kinds of lighting, heating systems, and other machines that use energy. Energy managers also need to know about electricity and accounting.

GO ONLINE

WEB LINK
For Science and Technology updates, visit the Harcourt Internet site.
www.harcourtschool.com

PEOPLE IN SCIENCE

Steven Chu

PHYSICIST

When Steven Chu was growing up in Garden City, New York, he wasn't crazy about school. "Learning seemed like work. I wanted it to be an adventure," he says. So he began asking questions that made learning fun—questions like "Why does that happen?"

Steven Chu was on his way to becoming a particle physicist—a scientist who studies atoms and the forces that hold them together or make them come apart.

In high school, Chu met a science teacher who encouraged him to keep learning about things by asking simple questions and then creating experiments that would give answers. Soon he was experimenting with chemistry sets and homemade rockets.

Chu's curiosity has led to some important questions and answers. In 1997 he received one of the most important awards in science—the Nobel Prize in physics. He won the award for thinking of a way to slow down tiny particles so other scientists can study them more carefully.

Steven Chu wants other people to know how much adventure there is in asking questions. He is a teacher at Stanford University in California. He loves working with students there. "They figure out that textbooks and professors don't know everything, and then they start to think on their own," he says. "Then I begin learning from them."

THINK ABOUT IT

1. What are you curious about? Pick a question, and try to think of some experiments that could help you find the answer.
2. Look for a story about science in a newspaper or magazine. What questions were the scientists asking?

ACTIVITIES FOR HOME OR SCHOOL

HOT ICE

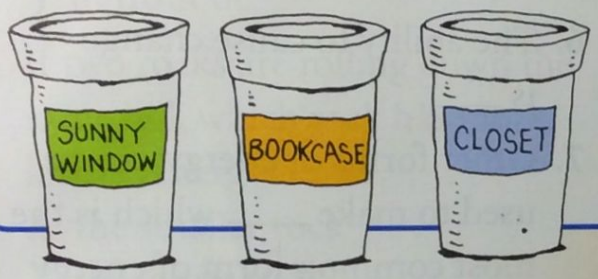
What environments make ice cubes melt fastest?

Materials

- 3 ice cubes of equal size
- 3 foam cups

Procedure

1. Place one ice cube in each cup.



2. Choose three different places to leave the cups. Predict which ice cube will melt most during a half-hour.
3. Place the cups in their locations. Thirty minutes later, get the cups and observe the ice cubes.
4. Which ice cube melted the most? Did your results support your hypothesis?

Draw Conclusions

How did heat affect your ice cubes?

BIG EARS

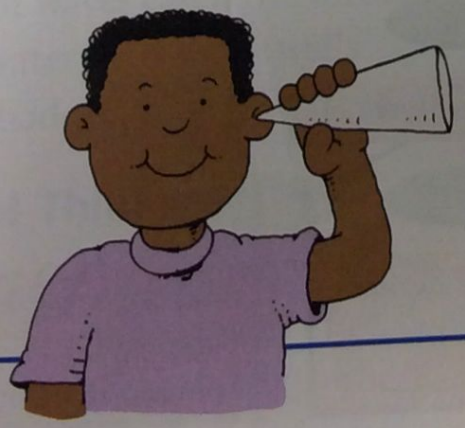
How do big ears help animals hear?

Materials

- sheet of plain paper

Procedure

1. Work with a partner for this activity. Standing about 3 meters from your partner, have him or her whisper something to you. Can you hear what he or she said?



2. Now roll your sheet of paper into a cone, and hold the small end to your ear. Have your partner whisper at the same level as before. Were you able to hear your partner better this time?

Draw Conclusions

Explain how you think the cone helped you hear the whispering better. Use the term *sound waves* in your explanation.

CHAPTER 1 Review and Test Preparation

Vocabulary Review

Use the terms below to complete the sentences 1 through 7. The page numbers in ( ) tell you where to look in the chapter if you need help.

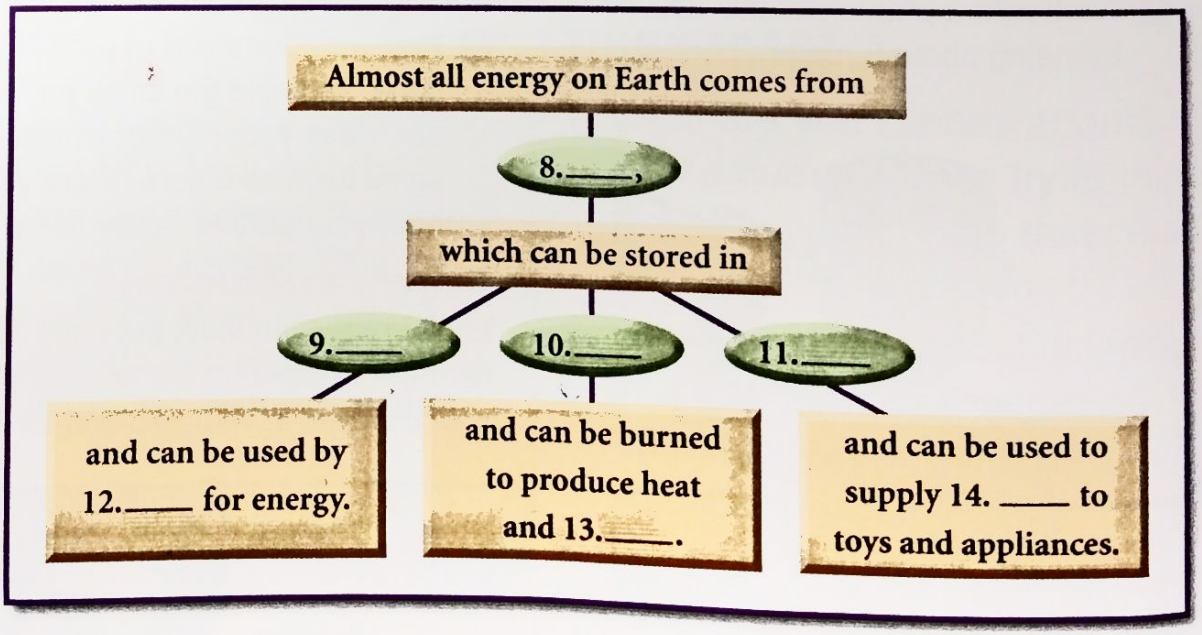
energy (F6)
potential energy (F6)
kinetic energy (F6)
electricity (F7)
fossil fuel (F8)
vibrate (F19)
circuit (F20)

1. The energy an object has because of where it is or its shape is ____.
2. A ____ is made up of a battery, a bulb, and wires.
3. When objects ____, they make sounds.
4. The energy of motion is ____.
5. A source of stored energy called ____ was made over millions of years as the bodies of dead plants and animals were pressed together.
6. The ability to cause change is ____.
7. Other forms of energy can be used to make ____, which is the most common form of energy that we use.

Connect Concepts

Use the terms in the Word Bank to complete the concept map.

motion **food** **sunlight** **batteries**
animals **fuel** **electricity**



Check Understanding

15. Almost all energy on Earth comes from —
    A batteries
    B electricity
    C the sun
    D fuel

16. Sound waves move ___ light waves.
    F slower than
    G faster than
    H at the same speed as
    J in front of

17. If two rocks are rolling down the same hill, which rock has more kinetic energy?
    A the smaller rock
    B the larger rock
    C They have the same kinetic energy.
    D They have no kinetic energy.

18. Which object has potential energy?
    F a glass on a table
    G a stretched rubber band
    H a cat in a tree
    J All of the above.

19. Light waves can move through —
    A water
    B shadows
    C walls
    D the ground

Critical Thinking

20. What forms of energy can be found in your home? How does your family use each form?

21. Why do we need to store energy?

22. Draw a diagram that shows how a fossil fuel is formed.

Process Skills Review

23. **Compare** food to fuel. How is each formed? What are they used for? Who are they used by? Present your ideas in a table.

24. Based on your **observations** of the rubber bands and clothespins, what can you **infer** about what happened to the energy you used to twist up the rubber bands?

Performance Assessment

Diagram Energy

Working with a partner, draw a diagram showing everything you know about the energy in sunlight—who uses it directly, how it moves, how it can be stored, and into what other forms of energy it can be converted.