

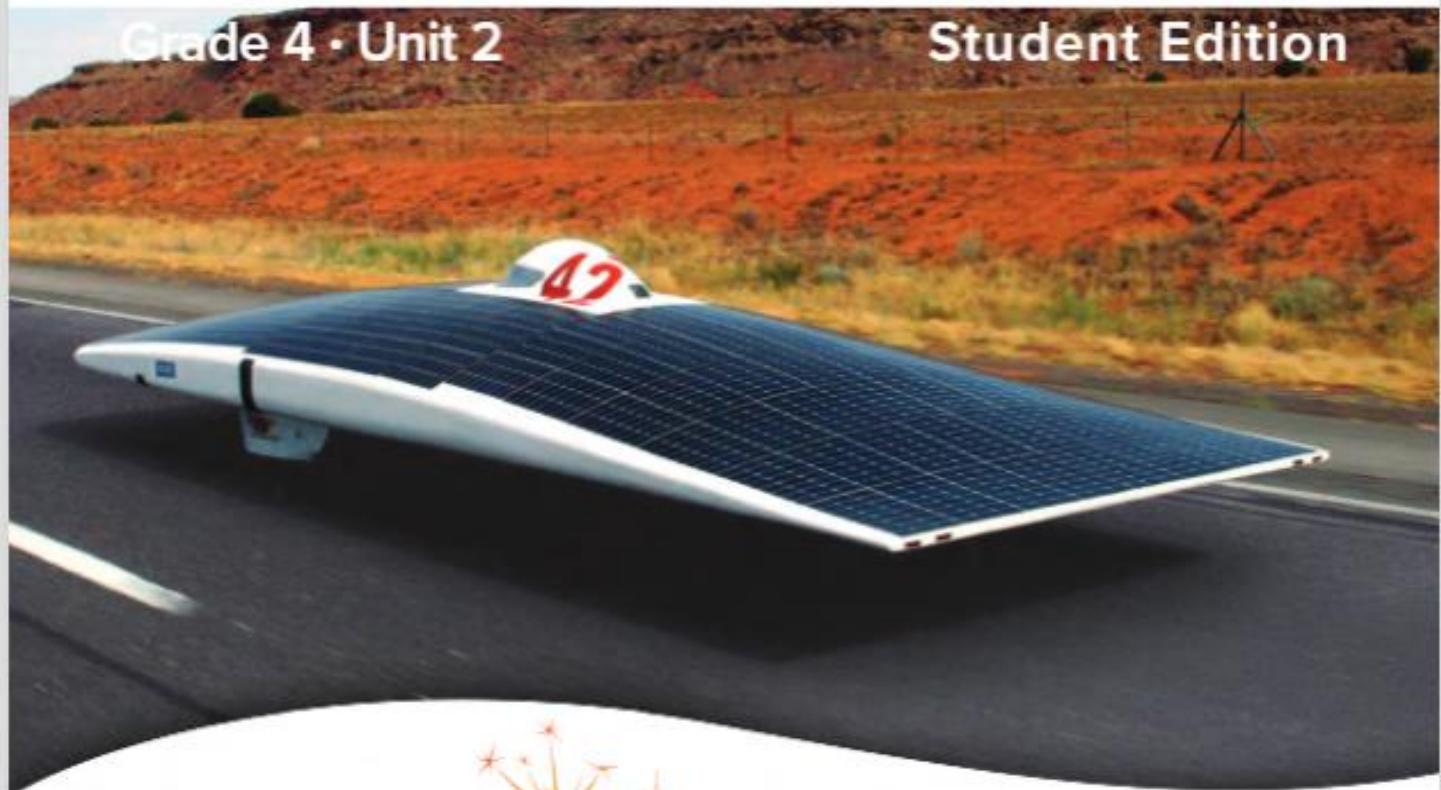


UNITED ARAB EMIRATES  
MINISTRY OF EDUCATION



Grade 4 • Unit 2

Student Edition



# Inspire Science

UAE Edition  
Grade 4  
2021-2022

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# Energy Transfer



## ENCOUNTER THE PHENOMENON

How does energy move throughout a city?

Traffic

### GO ONLINE

Check out *Traffic* to see the phenomenon in action.

### Talk About It

Look at the photo and watch the video of the city at night. Can you observe any energy transfer in the photo? What do you wonder about the phenomenon? Share your thoughts with a partner.

### Did You Know?

A TV set could be powered for a week with the energy generated by 48 people riding their bikes for 24 hours.



## STEM Module Project Launch

### Engineering Challenge

# Design a Community Warning System

Lesson 1  
Types of Energy



Lesson 2  
Sound and Light

Lesson 3  
Electricity



Lesson 4  
Heat

Energy is all around in the city. How can energy be used to alert the people that live in a city of possible hazards? You are being hired as an electrical technician. Your goal will be to design, build, and test a model that uses sound and light to notify residents of an emergency. All of the students in your classroom must be able to see and hear the alarm when you turn it on.

You will be an electrical technician!



Do you like fixing things? Electrical technicians maintain and repair the parts of a device that use electricity. Electrical technicians need to have good communication, reading, and math skills.

**MALIK**  
Photonics Engineer

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### STEM Module Project

**Plan and Complete the Engineering Challenge** Use what you learn throughout the module to build the warning system.

**LESSON 1 LAUNCH**

## Movement of Energy

Energy can move from place to place. Circle all of the boxes that are examples of energy moving from one place to another.

Thunder claps loudly.	A light bulb lights up.	A car crashes into a wall.
Ice cubes stay frozen in the freezer.	An ice cube melts in the hot sun.	An electric fan turns.
Hot water cools off.	Wood burns in a fireplace.	A book sits on a shelf.
A car horn beeps.	A baseball bat hits a ball.	A bowling ball knocks over pins.

Explain your thinking. What kinds of evidence show that energy moves from one place to another?

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You will revisit the Page Keeley Science Probe later in the lesson.

LESSON 1

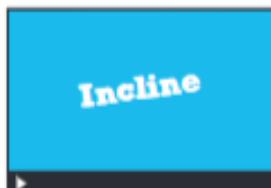
# Types of Energy



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## ENCOUNTER THE PHENOMENON

Which types of energy are used by a cable car?



### GO ONLINE

Check out *Incline* to see the phenomenon in action.

### Talk About It

Look at the photo and watch the video of the cable cars. How do you think they work? What questions do you have? Talk about your observations with a partner. Record or illustrate your thoughts below.

### Did You Know?

Most large American cities had cable cars by 1890. These cars replaced the need for horse-drawn cars by the 1920s.



## INQUIRY ACTIVITY

### Hands On

# Build an Energy-Transforming Device

You have learned that energy can be transferred and transformed. A cable car uses energy to move, but what affects how much energy is transferred or transformed? Read through the activity. Now, you will build a device that transforms energy. You will use a balloon and a plastic cup to build a pom-pom launcher.

**Make a Prediction** How can a launcher make a pom-pom travel farther?

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### Materials



safety goggles



rubber balloon



scissors



thick plastic cup with the bottom cut off



pom-poms



meterstick

### Carry Out an Investigation

**BE CAREFUL** Do not launch pom-poms at people. The rough edge of the plastic cup can be sharp. Use safety goggles.

1. Tie a knot at the open end of an uninflated balloon.
2. Cut off about 1 cm off of the other side of the balloon (the closed end).
3. Get a plastic cup with the bottom cut off. Stretch the cut end of the balloon around the wider end of the plastic cup. The knot of the balloon should be near the center of the cup.
4. Go to the area designated by your teacher for launching the pom-poms. Place a pom-pom inside the cup.
5. Point the open end of the cup away from you and others and slightly upward at a 45 degree angle.
6. Pull the tied end of the balloon downward toward you, then let go of the balloon. Observe what happens.

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7. Experiment with your device to see how you can get the pom-pom to launch the farthest.
8. Measure how far it travels each time. Record your measurements and observations in the table below.

How I Launched the Pom-Pom	Observations
<b>First Attempt:</b>	
<b>Second Attempt:</b>	
<b>Third Attempt:</b>	

## INQUIRY ACTIVITY

### Communicate Information

9. What affected the distance the pom-pom traveled?

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10. What types of energy change do you think you observed in your device?

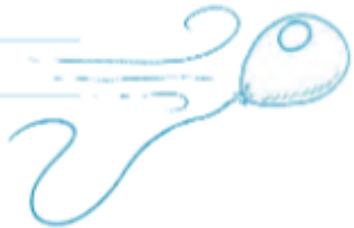
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11. Was your prediction supported by your observations? How did you make the pom-pom launch farther?

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12. Explain the evidence of energy transfer that you observed.

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## MAKE YOUR CLAIM

How does your pom-pom launcher transform energy?

Make your claim. Use your investigation.



### CLAIM

My device transforms energy by changing the balloon's stored energy to \_\_\_\_\_.

Cite evidence from the activity.

### EVIDENCE

The investigation showed that the device \_\_\_\_\_.

Discuss your reasoning as a class. Tell about your discussion.

### REASONING

The evidence supports the claim because \_\_\_\_\_.

You will revisit your claim to add more evidence later in the lesson.

## VOCABULARY

Look for these words as you read:

chemical energy  
nuclear energy  
thermal energy

# Forms of Energy

Stored energy and energy of motion can take many forms. You just investigated how the stored energy in a balloon transfers and transforms into the energy of motion of a pom-pom. Think about other ways different forms of energy affect your life as you learn about them.

Chemical energy is a type of stored energy or potential energy. **Chemical energy** is potential energy that is released when links between particles, which are tiny parts that make up a material, are broken or created. These links store energy that can be released by a chemical reaction. A chemical reaction is needed to change this stored energy into energy of motion. Burning wood and digesting food are examples of chemical reactions.

**Nuclear energy** is stored energy that is released when the links between the particles that make up matter are broken. It takes a nuclear reaction to split the particles and release this energy. For example, nuclear reactions in the Sun release nuclear energy.



### Talk About It

Discuss with a partner. Identify and label the type of energy represented by each photo on pages 12–14.

Energy that comes from the movement of charged particles is electrical energy. This energy is a type of energy of motion because it involves the motion of particles.

Some electrical energy comes from chemical energy stored in batteries. Most of it, however, comes from power plants that burn fuel to make electricity. The electrical energy is sent through wires to homes and businesses.

Light is a type of energy. Stars are visible because light energy can travel through space. The Sun is the main source of light energy on Earth. Plants use light energy to make their food. Humans rely on light energy for vitamin absorption, warmth, and light.

 **GO ONLINE** Watch the video *Energy in an Automobile* to learn more about energy transformations in a car.



1. What types of energy transfers and transformations occur when you flip a light switch at your house?

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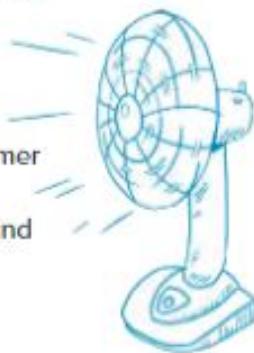
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A stove, a heater, and a match can all produce thermal energy. **Thermal energy** is the internal energy of an object due to the energy of motion of its particles. The faster these particles move, the warmer a substance gets. Thermal energy increases as the substance gets warmer.

Sound energy is a type of energy produced by vibrations of material. A vibration is a fast back-and-forth movement. When a drummer beats a drum, the drum vibrates. The vibrations of the drum make the air vibrate. Sound waves travel away in all directions. Because sound depends on the movement of the particles that make up matter, it is a type of energy of motion.



2. Classify each type of energy that you learned about as kinetic energy or potential energy. Remember that potential energy is stored and kinetic energy involves motion.

Stored Energy	Energy of Motion

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## Label the Photo: Energy in the Classroom



Read the description below. Use the numbers to label the type of energy present in the photo above.

1. **Window with Sunlight:** The radiation from the Sun is converted to heat and light in the classroom.
2. **Teacher Talking:** The teacher transforms chemical energy from food into kinetic energy and sound energy.
3. **Computer:** The computer transforms electrical energy into light, sound, and thermal energy.
4. **Students Building a Model:** The students transforms chemical energy from food into kinetic energy when they use their hands to build a model.

 **GO ONLINE** Explore what happens when different types of energy are applied to different objects in the *Energy Causes Change* simulation.

## INQUIRY ACTIVITY

## → Hands On

## Energy on the Move

You have learned about different types of energy. Now you will demonstrate energy transfers and transformations. You will collect evidence to support a claim.

**State the Claim** Look around the classroom at the different stations that are set up. How will energy move at each station?

## Materials



safety  
goggles



wind-up  
toy



pom-pom launcher



pom-poms



rubber ball



marbles

## Carry Out an Investigation

**BE CAREFUL** Be sure to launch pom-poms away from other students. Use safety goggles.

1. At the wind-up toy station, wind the toy. Then place it on the desk and observe what happens. On a separate sheet of paper, make a table and record your observations about how energy is transferred.
2. At the pom-pom launcher station, place a pom-pom inside the cup. Pull down on the bottom of the balloon, and let go to launch the pom-pom. Record your observations.
3. At the dropped ball station, drop the ball from different heights. Record your observations.
4. At the marble station, roll one marble into another. Record your observations.

## Communicate Information

5. Look back at your observations for each station. Was energy transferred or transformed? Use your observations to identify the types of energy involved at each station. Fill in the table below.

Station	Energy Transfer or Transformation?	Types of Energy
Wind-up toy		
Pom-pom launcher		
Dropped ball		
Marbles		



Use your **observations** from the investigation to explain how **energy changed** in each station.

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## COLLECT EVIDENCE

Add evidence to your claim on page 11 about how the pom-pom launcher transforms energy.



Revisit the Page Keeley Science Probe on page 5.

# Not-So-Simple Inventions

 **GO ONLINE** Explore the simulation *Energy Skate Park* to learn more about how energy changes.

Rube Goldberg was an American cartoonist popular in the 1920s. He liked to draw hilariously complicated gadgets meant to do simple tasks. These days, many schools and museums hold Rube Goldberg machine-building contests. Usually, there's a goal. A goal could be blowing out a candle in no less than 20 steps. Points are given for how many steps the device takes to complete a task. The more complicated and goofy, the more points!

## PRIMARY SOURCE



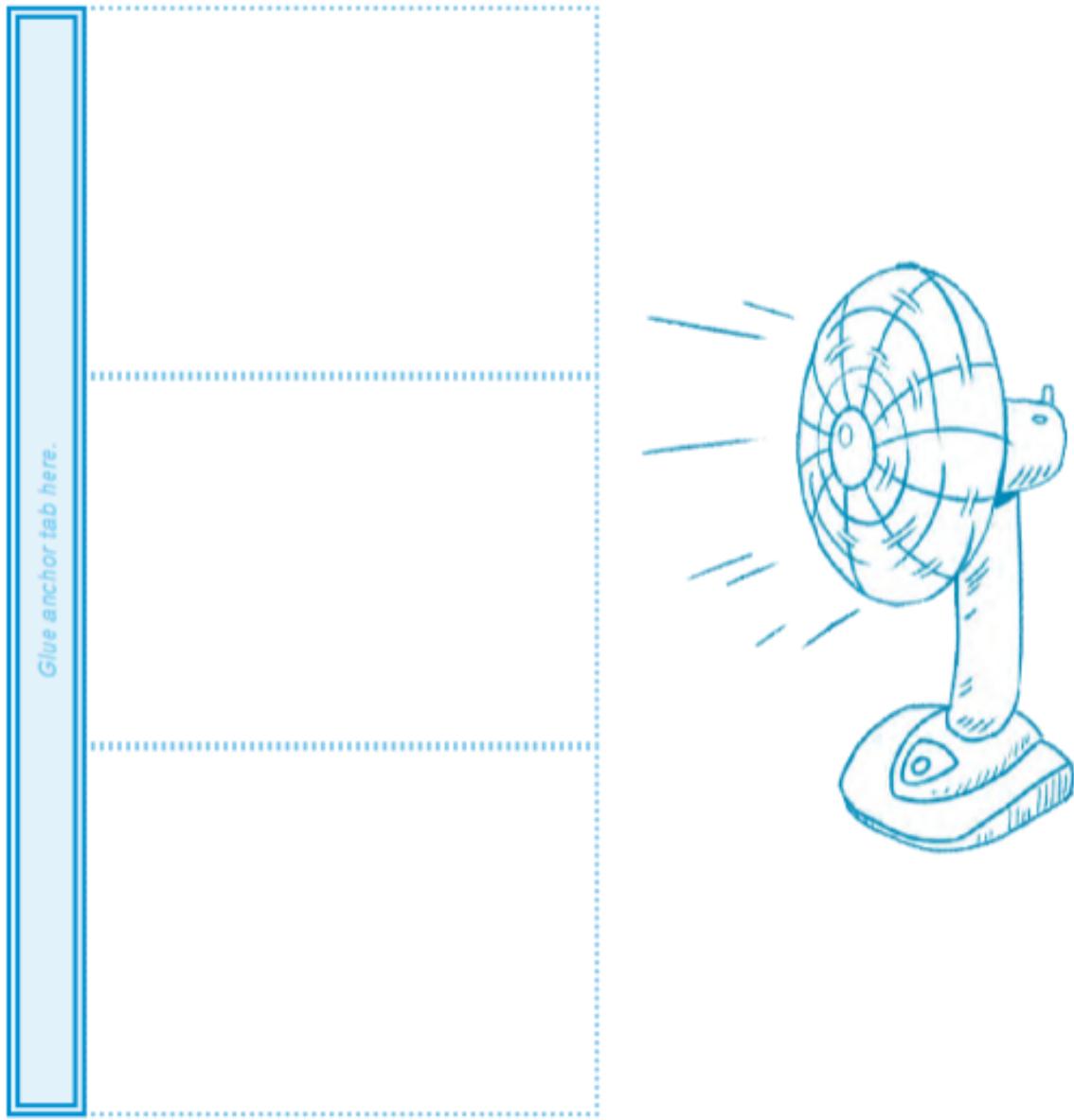
Here's an original Rube Goldberg plan for a "Self-operating Napkin"—would you like to install one in your lunchroom? (A) As you raise your spoon to your mouth, (B) it pulls a string, (C) which jerks on the ladle, (D) throwing a cracker (E) past the parrot. (F) The parrot jumps to get the cracker, (G) tipping the perch and spilling the seeds (H) into a pail. (I) The extra weight in the pail pulls a cord, (J) which flicks on a candle-lighter, (K) that sets off a rocket, (L) causing a curved knife (M) to cut the string, (N) allowing a pendulum with napkin attached to swing back and forth in front of your mouth, wiping off your chin. Now, reset for the next spoonful.

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## FOLDABLES®

Cut out the Notebook Foldable tabs given to you by your teacher. Glue the anchor tabs as shown below. Use what you have learned to describe three energy transfers that you see in the Rube Goldberg cartoon.

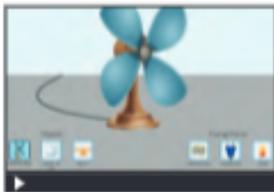


## INQUIRY ACTIVITY

### Engineering

## Energy Transfer Machine

Now, it is time to apply what you have learned to design a solution. Using Rube Goldberg's drawing as a model, you will design your own device to complete a task. Your device must include at least three energy transfers.



#### GO ONLINE

Build your Rube Goldberg machine using the *Energy Causes Change* simulation.

**Define a Problem** What problem will your device solve?

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### Design Your Solution

1. Research other Rube Goldberg drawings for ideas. You can also use the *Energy Causes Change* simulation for ideas.
2. Draw your device on a separate sheet of paper. Use labels and arrows to tell how it will work and identify the energy transfers.

### Communicate Information

3. Describe how your device will work. Be sure to identify the energy transfers and energy transformation.

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### Talk About It

How would you improve your design? Share your ideas with a partner.

## STEM Connection

# How Could You Become a Physicist?



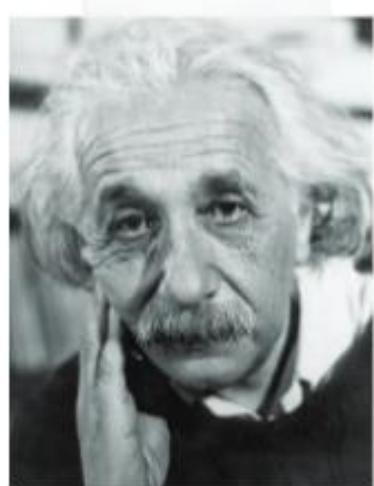
Are you curious about how the world works? Do you often find yourself asking "Why?" If so, you might have what it takes to become a physicist. **Physicists** study the nature of the universe and use math and science to explain natural phenomena. Physicists are often employed by government agencies, universities, and various industries.

If you think you might be interested in physics, there are a few things you can do right now to prepare yourself for your career. You need to take many math and science courses to become a physicist. If possible, talk to physicists. Ask about their job and how they got there. Ask for advice. If you don't know any physicists, read about them. Some famous physicists include Marie Curie, Lisa Meitner, Albert Einstein, Albert Baez, and France A. Córdova.

### It's Your Turn

What questions did you answer in this lesson about how the world works?

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Photo: © iStock/Janet G. Smith, iStockphoto, Getty Images



### Talk About It

How might the career path of a mechanical engineer be similar to that of a physicist?



## LESSON 1

## Review

## EXPLAIN THE PHENOMENON

Which types of energy are used by a cable car?

## Summarize It

Identify and explain how different types of energy are transferred and transformed by the cable car.



Revisit the Page Keeley Science Probe on page 5. Has your thinking changed? If so, explain how it has changed.

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## Three-Dimensional Thinking

1. Which best describes how energy changes in a toaster?

- A. chemical to thermal
- B. electrical to light
- C. electrical to thermal
- D. electrical to chemical

2. Dan made the following observations in his science notebook:

*The radio sitting on the table made the water in my glass move.*

What can he conclude?

- A. Some types of energy cannot transfer through water.
- B. The sound energy of the radio transferred to the water.
- C. The electrical energy of the radio transferred through the water.
- D. Only light can move through water.

3.

Energy Transformation	Example
chemical to electrical	battery powered flashlight
light to thermal	sunlight heats the sidewalk
motion to sound	

Which example best fits in the last row of the table?

- A. burning candle heats up
- B. plucked guitar string makes noise
- C. ball rolls down hill
- D. rubbing warms hands

## Extend It

Use teacher-approved websites to research a recent invention or technology. Identify and explain the types of energy transfer it uses. If possible, present a way that the technology could be improved. Present your results to the class. Use the space below to take notes and plan your presentation.

## OPEN INQUIRY

What questions do you still have about how energy is transferred?

Plan and carry out an investigation or research to find the answer to your question.



## KEEP PLANNING

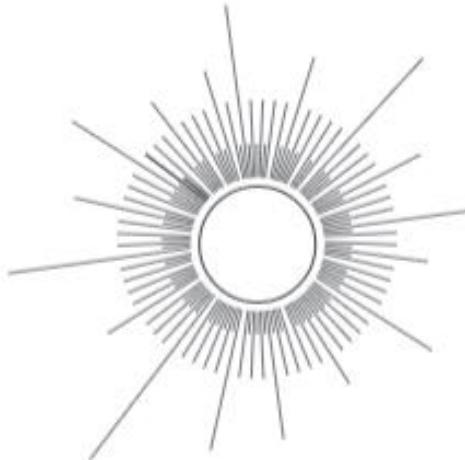
## STEM Module Project Engineering Challenge

Now that you have learned about the different types of energy, go to the Module Project to explain how the information will affect the plan for your community warning system.

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**LESSON 2 LAUNCH**

## Energy from Sunlight



Two friends were arguing about energy from the Sun. They each had a different idea about using the Sun's energy. Here is what they said:

Violet: The Sun's energy is only useful when the Sun is shining. When there is no sunlight, you can't use the Sun's energy.

Liam: The Sun's energy can be captured and used later. The Sun does not have to be shining in order to use the Sun's energy.

Who do you agree with the most? \_\_\_\_\_

Explain why you agree.

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You will revisit the Page Keeley Science Probe later in the lesson.

# Sound and Light

Copyright © Macmillan/McGraw-Hill Education. Daniel Demirjian. Photography by Vittorio Scattolon.

## ENCOUNTER THE PHENOMENON

What types of energy do fireworks have?



### GO ONLINE

Check out *Fireworks* to see the phenomenon in action.

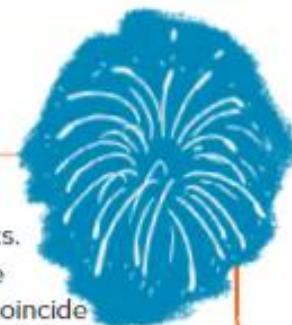
### Talk About It

Look at the photo and watch the video of the fireworks. What questions do you have about the phenomenon? Talk about them with a partner. Record or illustrate your observations below.

### Did You Know?

In the 17th century, tissue paper rolled around a trail of gunpowder was used to light fireworks.

Today, pyrotechnicians or other specialists use computers to set off fireworks often timed to coincide with music.



## INQUIRY ACTIVITY

### Hands On

### Make Sound

What causes the sounds we hear around us? Discover what is needed to make a sound and how to make it louder.

**Make a Prediction** What will happen to the sound that a rubber band makes when you change the amount of force that is used to pluck the rubber band?

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### Carry Out an Investigation

**BE CAREFUL** Wear safety goggles. Rubber bands, a sharpened pencil, and paper clips can cause eye injury if not handled properly.

1. Use the scissors to cut the rubber band so you have one long piece of rubber band. Tie one end of the rubber band to the center of the paper clip.
2. Use the pencil to poke a small hole in the bottom of the paper cup. Make sure the hole is large enough to fit the rubber band through.
3. Thread the rubber band through the hole in the paper cup so that the paper clip is inside the cup. Use masking tape on each end of the paper clip to hold it in place inside the cup.
4. Place the cup upside down on a desk or table. Place the ruler upright against the cup. Use masking tape to tape the ruler to the cup in two places.
5. Stretch the rubber band a few centimeters above the ruler. Tape it in place at the top of the ruler.

### Materials



safety goggles



sharpened pencil



paper cup



paper clip



scissors



rubber band



plastic ruler



masking tape

6. Hold the cup in place with one hand, and then pluck the rubber band with your other hand. Watch the rubber band, and listen to the sound it makes. Record your observations in the table.
7. Now use a lesser amount and a greater amount of force to pluck the rubber band. Observe how the rubber band moves and sounds. Record your observations in the table.

Strength of Pluck	Observations
First pluck	
Second pluck (less force than first)	
Third pluck (more force than first)	

### Communicate Information

8. Use your observations from the activity to form an explanation about how you think your device made sound.

### Talk About It

What other activities can you think of that involves the transfer of sound? How do you think sound travels? Share your ideas with a partner.

## VOCABULARY

Look for these words as you read:

longitudinal wave

medium

solar cell

sound wave

vibration

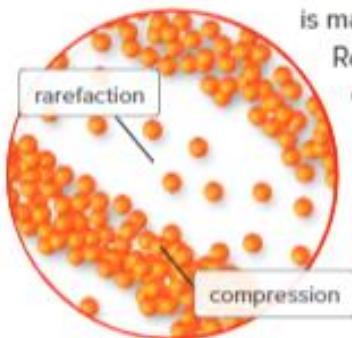
# Sound Energy

If you drop a book on the floor, you hear a sound. Some of the falling book's energy of motion has changed to sound. Sound is a type of kinetic energy. It is produced by moving particles of a material. Air is made of particles, or tiny parts, that transmit sound.

When you plucked the rubber band in the Inquiry Activity, *Make Sound*, it moved back-and-forth quickly. This back and forth motion is called a **vibration**. The vibration produced sound. All sounds begin with vibration.

The vibrating parts of the rubber band bumped into air particles. Those particles bumped into other air particles. The rubber band's vibrations pushed air particles closer together, and then those same particles were pushed out. A wave that transfers energy through a material and spreads outwards in all directions from a vibration is a **sound wave**. A sound wave is made of a series of compressions and rarefactions.

Regions of air that have many particles are called compressions. Regions of air that have fewer particles are called rarefactions.



 **GO ONLINE** Watch the video *Sound and Light Energy* to learn about how sound and light transfer energy.



A ringing bell sends sound waves in all directions.

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The substance through which waves travel is called the **medium** (plural *media*). Media can be solids, liquids, or gases. Sound travels fastest through solids and slowest through gases. The particles carry the energy, and their collisions are how sound energy travels. In a solid, the particles are close together, so they quickly collide. In a gas, the particles are far apart. Collisions are less frequent. Sound cannot travel in places with no particles of material, such as outer space.

When sound waves pass through a medium, the medium is not permanently moved, but energy moves through the medium and is transferred.

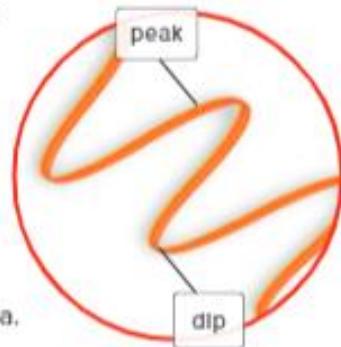
### **Talk About It**

Explain to a classmate how sound travels through different media.

Sound waves vibrate the medium in the same direction that the energy moves. Sound moves in **longitudinal waves**. Think about how a coiled toy moves when you push it together and pull it apart. Sound waves move in the same way. Sound waves can also be shown as a series of peaks and dips.

When sound hits an object, the object starts vibrating. The object is moved by the energy of the waves. Have you ever heard windows rattle from an airplane or other loud sounds?

Use evidence to show that energy is transferred by sound.



# Light Energy

If you stand outside on a sunny day, you can feel the warmth of sunlight on your face. This is evidence that light transfers energy.

For thousands of years, people have used the Sun's rays for warmth, to heat water, to dry food like fruits and grains, and for many other purposes.

Today, people use many different devices to harvest the energy of the Sun, or solar energy. For example, **solar cells** are devices that use light from the Sun to produce electricity.

Solar cells are also called photovoltaic cells. The word part *photo* refers to "light," and  *voltaic* refers to "electricity." These cells can be used to power something as small as a calculator or as large as an airplane.

Although light is a wave of energy, it also consists of particles. Light travels as tiny particles of energy. It can travel with or without a medium. Nothing travels faster than light in a vacuum. Light moves slowly in media like air and glass.

 **GO ONLINE** Explore the sound and light tabs in the simulation *Energy Transfer Through Matter* to see how sound and light move through air and cause change.

Solar radiation has powered life on Earth for billions of years.



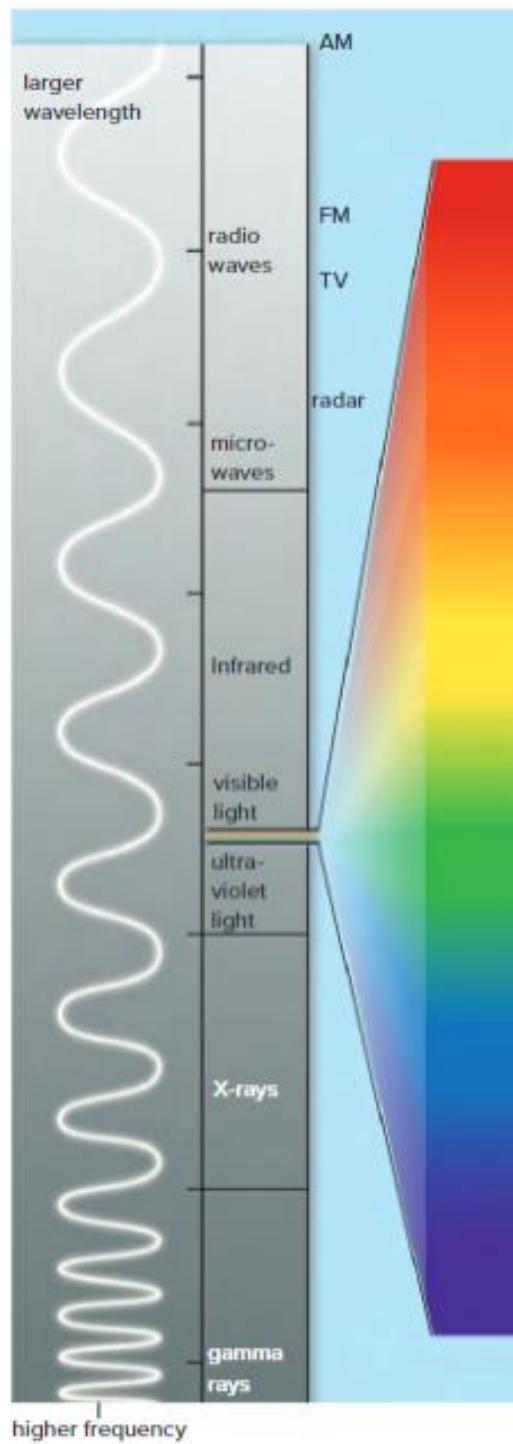
## The Electromagnetic Spectrum

The Sun's rays are also referred to as solar radiation. Light is a form of electromagnetic radiation. The different forms of radiation all together are known as the *electromagnetic spectrum*. The light that we see is just a tiny part of the electromagnetic spectrum.

Most of the radiation from the Sun is infrared, visible, and ultraviolet light. But solar flares can give off all forms of electromagnetic radiation when they erupt! Similar to fireworks, solar flares represent a sudden release of energy.

Recall that potential energy is stored energy. Fireworks store their potential energy in chemicals. When the firework goes off, energy is released as heat, light, and sound.

What evidence could you use to show that energy is transferred by light?



## INQUIRY ACTIVITY

### Hands On

## A Bright Idea

Think how light energy has been used in the past. How do we know that light transfers energy? In this activity, you will explore how light affects the temperature of a cup of water.

**Make a Prediction** What effect will the Sun have on the temperature of water? Make a prediction.

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### Carry Out an Investigation

1. Set the plastic cups side by side. Use the marker to indicate the halfway point on both cups.
2. Place one plastic cup on the construction paper in a sunny spot. Use the beaker to fill the cup with water to the line. Place a thermometer inside cup.
3. Repeat step 2, but this time place the cup in the shade.
4. Read the temperature of the water in each cup every 5 minutes for 30 minutes. Record your measurements in the table below.

Time	Temperature of Water in Sunlight	Temperature of Water in Shade
Start		
5 minutes		
10 minutes		
15 minutes		
20 minutes		
25 minutes		
30 minutes		

### Materials



2 identical cups



marker



2 sheets of black construction paper



beaker of cold water



2 thermometers

## Communicate Information

5. What patterns did you notice in the data you collected?

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6. Write an outline of how you would conduct an investigation to find out the purpose of the black construction paper in this investigation.

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How do your **observations** show that **light transfers energy**?

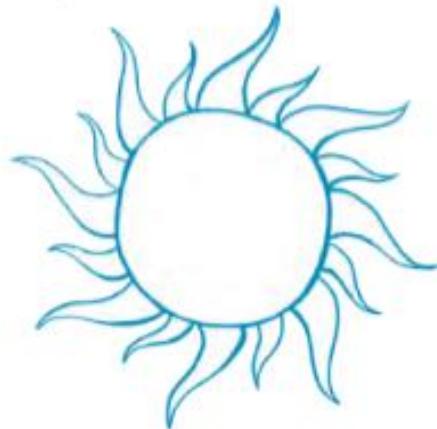
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## Talk About It

How could you use a model to show energy transfer in a system?

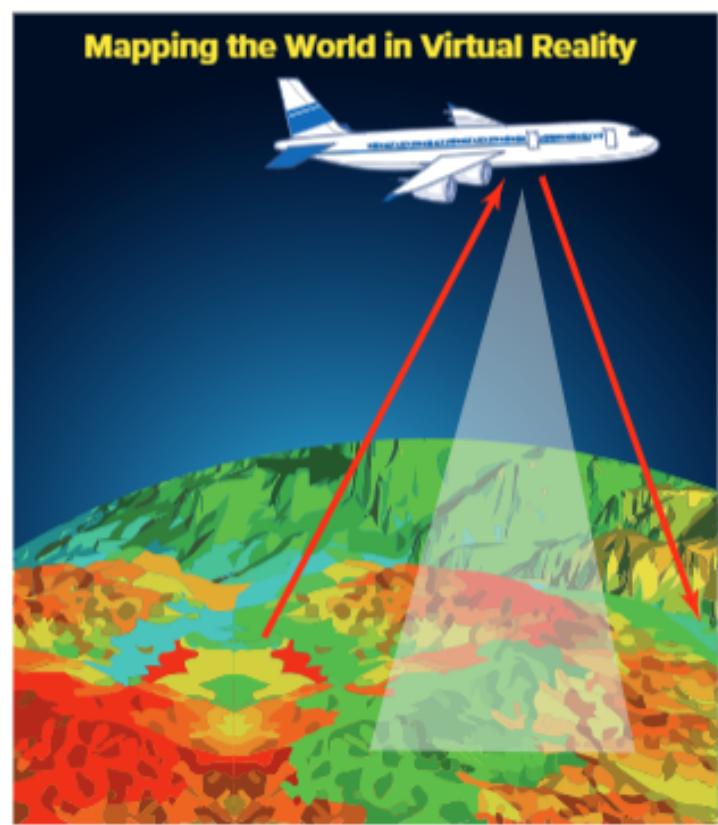


# LiDAR

## Mapping the World in Virtual Reality

“LiDAR” is a combination of the words “light” and “radar.” It works like this: A pulse of light is aimed at, say, a tree. The light hits the tree, then bounces back the way it came. The amount of time it took for the light to travel round-trip is recorded (or “detected”) by a computer. Using this information, you can calculate how far away the tree is from where you started—its range.

Scientists started using a primitive kind of LiDAR in the 1930s. They were looking for tiny particles in the atmosphere. Their method was super low-tech. “They just took big flashlights and pointed them up into the sky,” says Dr. Gene Roe, managing editor of *LiDAR News*. Then in 1960, the ruby laser was invented. “That was one of the most important inventions in the history of man,” says Roe. “Lasers can cut steel. They can read bar codes at the grocery store.” And they changed what you could do with LiDAR, big time. How does any of this actually make a map?



Laser light is very different from the light from a flashlight. It has a narrow beam that can travel great distances without getting wider or weaker. Today's high-tech LiDAR doesn't just tell you how far away the tree is. It tells you how far away every leaf and branch is.

### Talk About It

Argue from evidence how laser technology has changed from 1930 to modern days. Discuss with a partner.

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"We take those billions of points and turn them into images that represent three-dimensional models of the Earth," says Jason Stoker, a physical scientist with the United States Geological Survey (USGS). He's working on mapping the entire United States using LiDAR. LiDAR equipment can be mounted on a tripod on the ground or on a satellite in space. But mostly the USGS mounts it on airplanes and flies it around. "Some of its pulses go through holes in the forest canopy so we can see the ground below the trees. Some laser pulses bounce back off the trees, so we can study what the forests look like in 3-D." LiDAR even works in clear water and the dark of night. "The more pulses that get through, the better your map will be," says Roe.

**1. How do scientists use LiDAR technology to map the United States?**

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The old way of making maps (after drawing) was with photography. But photography works only in the daytime. And it gives only two-dimensional images of our planet. A physical 2-D hiking map would show you only how to get from the trailhead to the lake five miles away. It wouldn't show you that the lake lies at the top of a 2,000-foot hill.

A 3-D map shows you the topography of the trail—all its ups and downs. The USGS has been making topographical maps for 125 years. But landslides, earthquakes, floods, volcanic eruptions, and erosion all change the surface of Earth. Remapping the old way was too expensive and difficult to be done very often. So, the maps were often inaccurate.

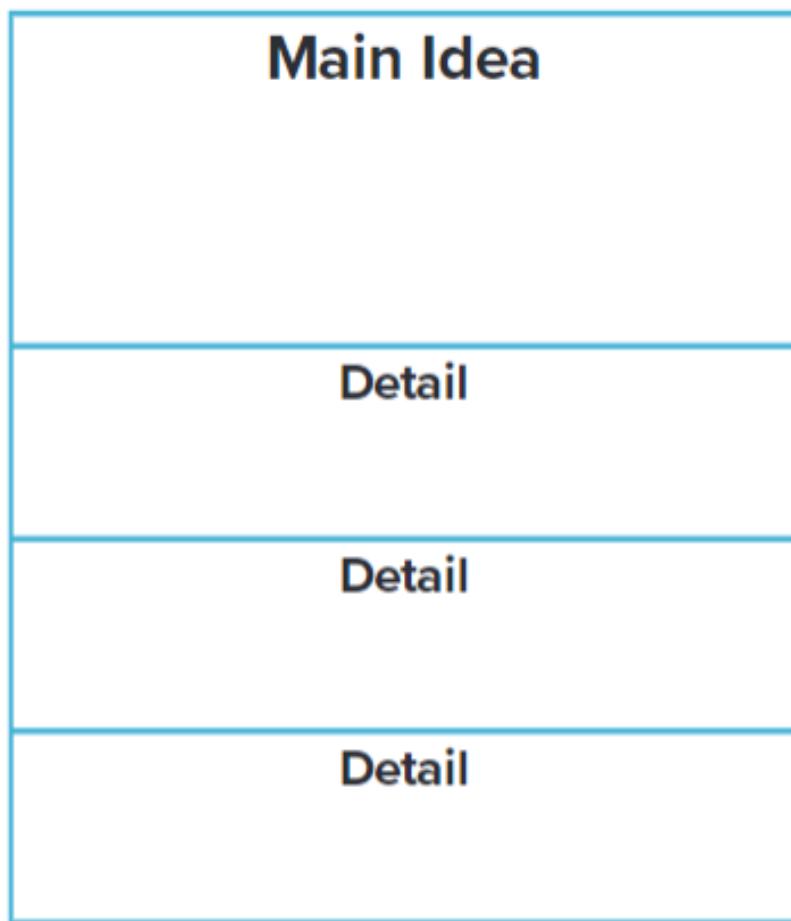
### **Talk About It**

Compare and contrast a 2-D hiking map with a 3-D map.

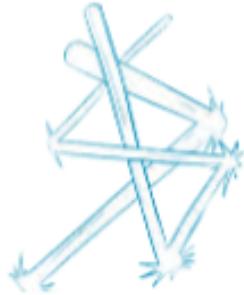


2. **WRITING Connection** Research other uses of lasers by going online to teacher-approved websites or by finding books about lasers at your local library. Write an expository essay about one of the uses of lasers.

Use the graphic organizer below to plan your essay.



To start your essay, write a sentence that states your topic (the use of lasers you chose to write about).



Now write your essay. Use a separate piece of paper. Start with your topic sentence, then include facts and details that support your main idea. Complete your essay with a conclusion.

## STEM Connection

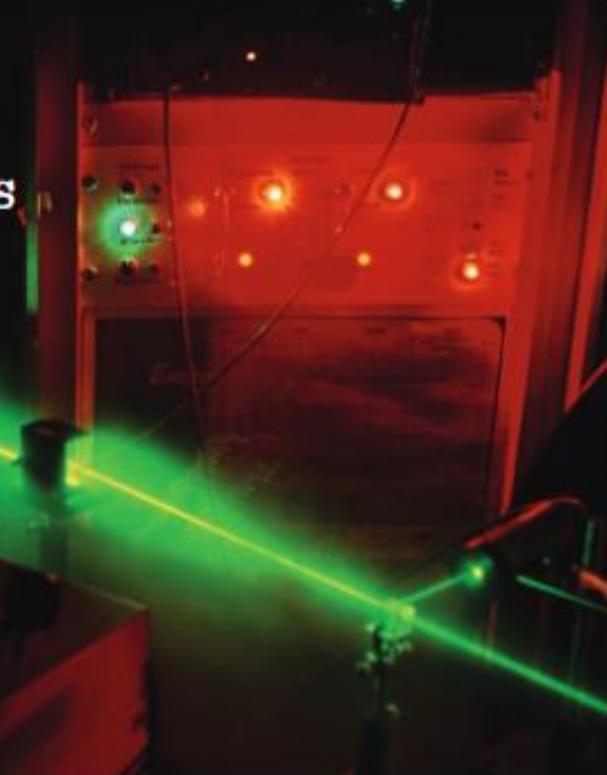
# What Does a Photonics Engineer Do?



Do you like testing new gadgets? If you do, then you might want to become a photonics engineer. **Photonics engineers** design and test devices that use light energy to solve problems. For example, photonics engineers designed and tested LiDAR devices. They design laser tools that can remove tooth decay, whiten teeth, or be used in surgeries.

Photonics engineers also design fiber-optic devices that are used for communications. These devices are used to transmit information around the world. Some photonics engineers work on developing new, energy-efficient lights, such as LED lights. These lights last longer and use less energy than other types of lighting. Some photonics engineers even design laser light shows for entertainment.

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## It's Your Turn

How could a photonics engineer help you design a community warning system for a city? Share your ideas with a partner.



## LESSON 2

## Review

## EXPLAIN THE PHENOMENON

What types of energy do fireworks have?

### Summarize It

Identify and explain the energy transfers and transformations in fireworks.



Return to the Page Keeley Science Probe on page 25. Has your thinking changed? If so, explain how it has changed.

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## Three-Dimensional Thinking

1. Compare and contrast sound energy and light energy.

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2. Sound energy is a type of \_\_\_\_\_

- A. stored energy
- B. infrared energy
- C. energy of motion
- D. none of the above

3. How can light energy solve real-life problems?

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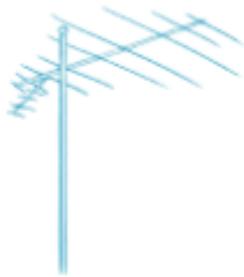
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## Extend It

Throughout the lesson, you have learned about important ways that sound and light transfer energy. These energy transfers can also be used to help people communicate around the world. Research fiber optics. Write a report explaining how you use fiber optics. How would you communicate and get information without fiber optics?



## KEEP PLANNING

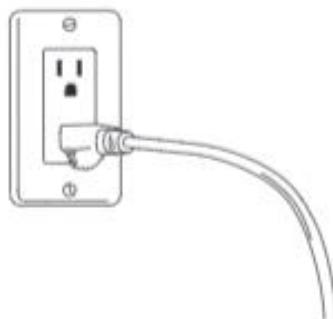
## STEM Module Project Engineering Challenge



Now that you have learned about sound and light, go to your module project to explain how you will use the information in your community warning system.

**LESSON 3 LAUNCH**

## Energy Transfer and Electric Current



Four friends were talking about energy transfer and electric current. They each had different ideas of how a windmill and an electric toy car might transfer energy. This is what they said:

Jack: I think energy from a moving object can be transferred by electric current.

Jumon: I think energy from electric current can be transferred to a moving object.

Ida: I agree with Jack and Jumon. Energy can be transferred either way.

Mayumi: I think energy is not transferred by electric current or moving objects.

Who do you agree with the most? \_\_\_\_\_

Explain why you agree.

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You will revisit the Page Keeley Science Probe later in the lesson.

LESSON 3

# Electricity



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## ENCOUNTER THE PHENOMENON

How do the overhead wires make the trolley move?

Trolley

### GO ONLINE

Check out *Trolley* to see the phenomenon in action.

Circle the parts of the trolley that help it move. What do you wonder about the trolley? What do you observe? Discuss with a partner. Record or illustrate your thoughts below.

### Did You Know?

One out of every ten people in the country use public transportation, such as the trolley, every day.



## INQUIRY ACTIVITY

### Hands On

### Make It Work

How do electrical devices work? The trolley in the lesson phenomenon photo was connected to wires. In this activity, you will use a wire, a battery, and a lightbulb to make the bulb light up.

**Make a Prediction** How can you arrange the materials to make the lightbulb work?

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#### Materials



mini lightbulb



wire with clips



D-cell battery

### Carry Out an Investigation

1. Use the materials provided to make the lightbulb light as many ways as possible.
2. Draw a diagram of each test you make. Identify if the lightbulb worked or not.

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## Communicate Information

3. How did you get the lightbulb to light? Do your results support your prediction?

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4. What do you think electrical devices need in order to work?

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5. Use your observations as evidence to explain how energy has been transferred from place to place.

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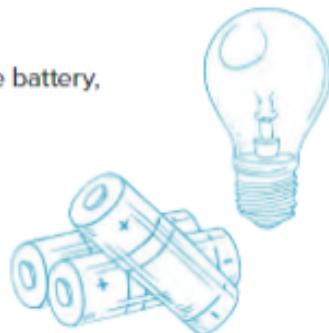
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### Talk About It

Do the lights in your classroom work in the same way that the battery, wire, and lightbulb worked? Explain your answer to a partner.



## VOCABULARY

Look for these words as you read:

circuit

conductor

electric current

insulator

resistor

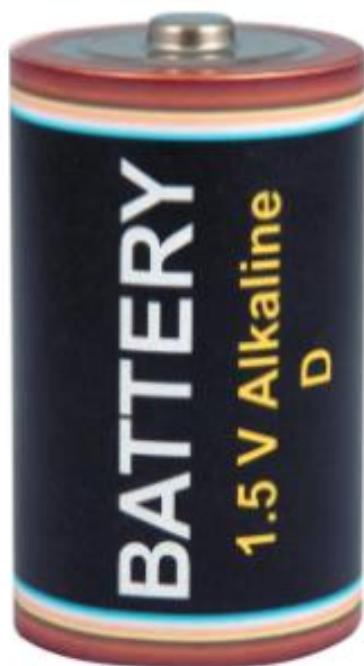
# Electric Current

When you are in the dark, a flashlight is useful. A flow of electric charge lights the bulb. **Electric current** is the flow of electricity through a conductor.

A **conductor** is a material through which electricity flows easily. In contrast, an **insulator** is a material that slows or stops the flow of energy, such as electricity or sound.

As you saw in the Inquiry Activity, *Make it Work*, a **circuit** is a path through which electric current can flow. Often this path consists of wires. Circuits must also have a device to move electrically charged particles along. These devices, called voltage sources, increase the number of charged particles flowing in a circuit. Batteries are a voltage source.

A switch is a device that can open or close the path in a circuit. When the switch is closed, the electric current can flow around and around through the circuit. When the switch is open, the current cannot flow.



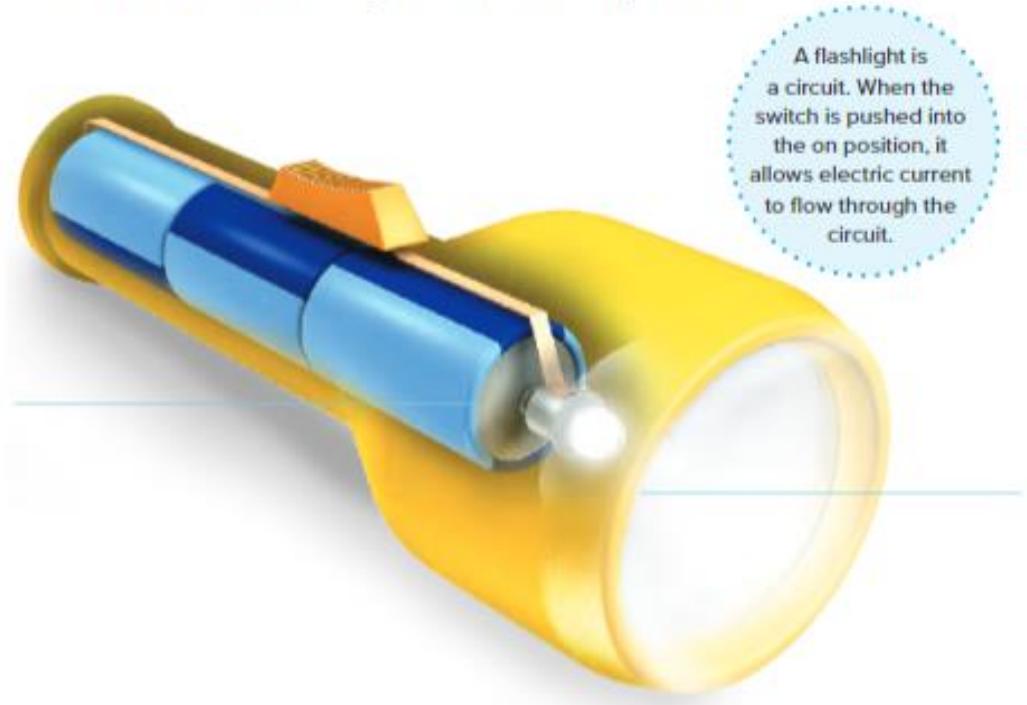
**GO ONLINE** Watch the video *Uses of Electricity* to see different ways that electricity is used every day.

The chemicals inside a battery store energy.

An object in an electrical circuit that resists the flow of energy is called a **resistor**. Electrically charged particles lose energy when flowing through a resistor. This energy is transformed into other forms of energy, such as motion, light, or heat. A lightbulb is an example of a resistor.

### Label a Diagram

Label the resistor and the voltage source on the diagram below.



What happens to energy in a resistor?

# Read a Circuit Diagram

Your home has a collection of electric circuits hidden in the walls.

When you plug in a device that uses electricity, you are making the device part of the circuit.

A circuit diagram uses symbols to show parts of an electric circuit.

The key below shows the symbols used in circuit diagrams.

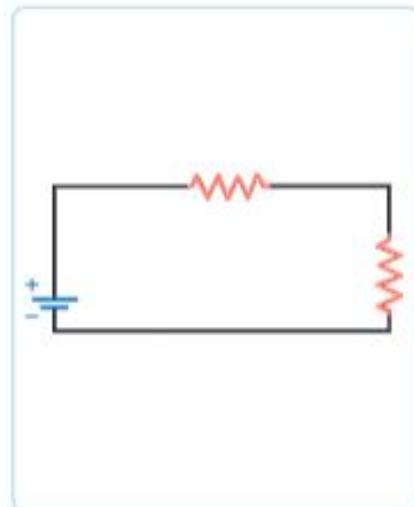
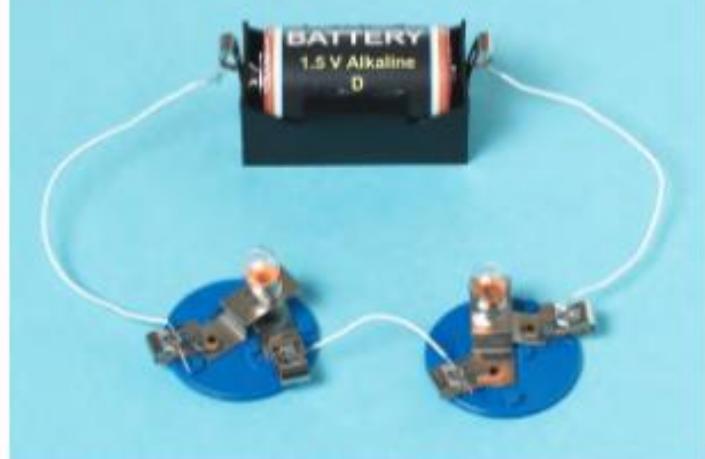
## Label a Diagram: Electric Circuits

Circuit A has been drawn for you. Use the key to complete the circuit diagram for Circuit B.

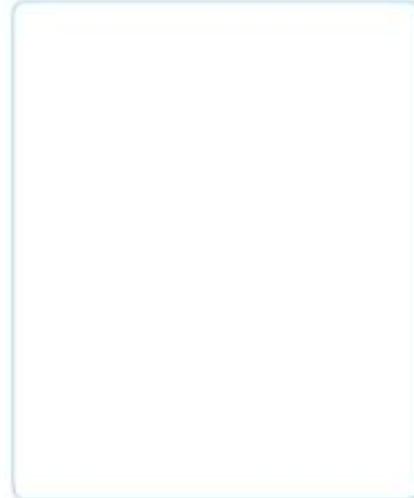
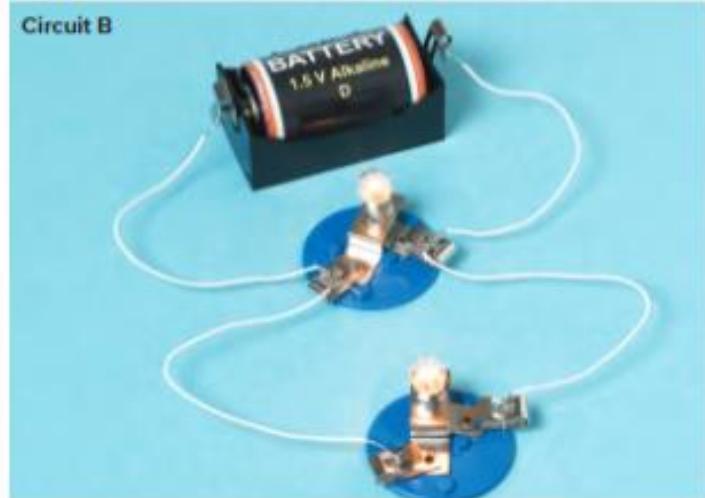
### KEY

- wire
- resistor
- voltage source

Circuit A



Circuit B



## INQUIRY ACTIVITY

### Hands On

## Build Different Circuits

How does electricity flow through different types of circuits?

You just saw diagrams of two different types of circuits.

Now, you will build them and observe the brightness of the lightbulbs in each type of circuit.

**Make a Prediction** What will happen if you remove a lightbulb from a socket in each circuit?

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### Materials



10 wires



4 D-cell batteries



4 battery holders



6 mini lightbulbs



6 lightbulb holders

### Carry Out an Investigation

1. Use the diagrams on the previous page to construct each of the circuits.
2. **Record Data** Observe the brightness of the bulbs in each circuit. Record your observations in the tables.
3. Take one lightbulb from its socket in each circuit. Record your observations in the table. Then return the lightbulbs to the sockets.
4. Add another socket and lightbulb to each circuit. Observe.
5. Add an additional battery to each circuit. Record your observations in the table.

Data Table: Circuit A

	Observations
<b>Brightness</b>	
<b>Remove one lightbulb</b>	
<b>Add another lightbulb</b>	
<b>Add another battery</b>	

## INQUIRY ACTIVITY

Data Table: Circuit B

	Observations
<b>Brightness</b>	
<b>Remove one lightbulb</b>	
<b>Add another lightbulb</b>	
<b>Add another battery</b>	

### Communicate Information

6. With three lightbulbs in each circuit, how did the brightness of the bulbs compare in Circuit A and Circuit B?

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7. Did the results of your investigation support your prediction? Explain.

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8. If you bought a set of decoration lights, which type of circuit would you want the lights to be arranged in? Explain.

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### Talk About It

Discuss with a partner. How do you know that energy was transferred by electric current?

# Types of Circuits

In the investigation that you just completed, Circuit A was a series circuit. A series circuit has only one conductive path. In this type of circuit, the resistance increases with each resistor added. Electric charges travel through all of the resistors, one after another. As resistors are added, the energy each resistor receives is decreased. If one lightbulb in a series circuit goes out, the others will go out too because the path of the circuit is broken.

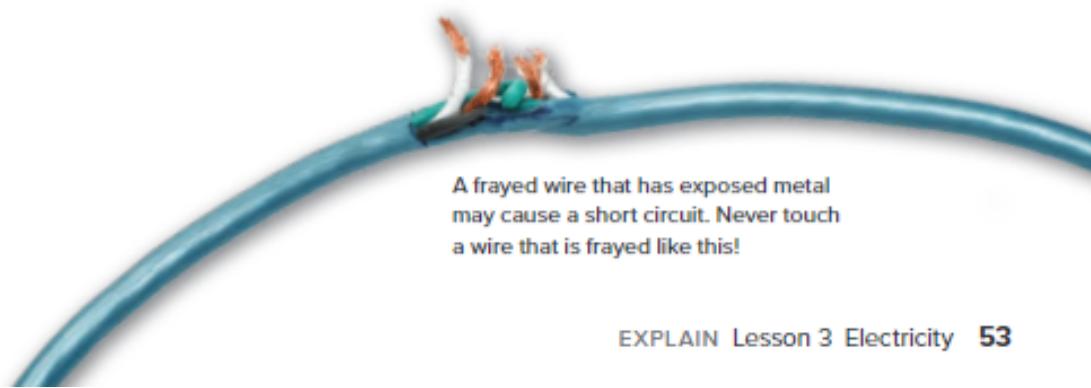
Circuit B was a parallel circuit. Circuits in your home are parallel. A parallel circuit has more than one conductive path. The overall resistance in the circuit is smaller, so more current will flow. Electric charge flows through all paths at the same time in a parallel circuit. If one path is broken, the current flows through the remaining paths.

A short circuit is a path that has little or no resistance that connects two ends of an electrical source. Short circuits cause currents large enough to damage appliances or start fires. Frayed wires can cause short circuits.

## Make It Work: Revisit



Use your **observations** from the Inquiry Activity, *Make It Work*, to create a model that shows how **electric current** is transferred in a circuit to get the lightbulb to work. Label the diagram.



A frayed wire that has exposed metal may cause a short circuit. Never touch a wire that is frayed like this!



## CLOSE READING

### Inspect

**Read** the passage *Electromagnets and Generators*. Underline the text that tells about the simplest form of an electromagnet.

### Find Evidence

**Reread** the third paragraph. Highlight text evidence that tells you how electromagnets and electric motors work to make a wheel spin.

### Notes

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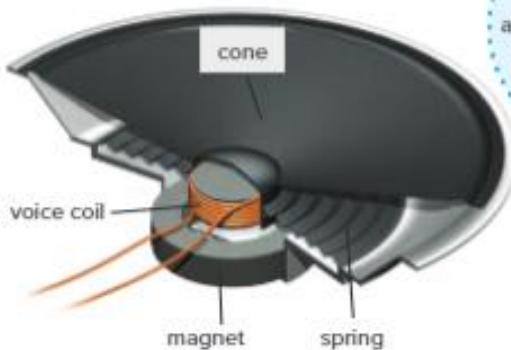
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## Electromagnets and Generators

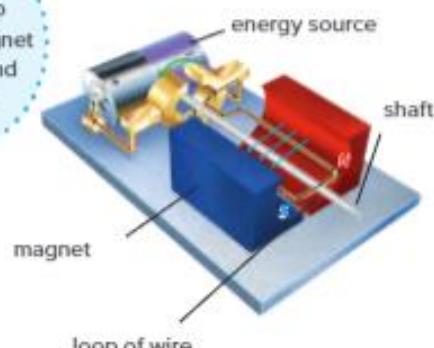
Electricity and magnetism are related. When charged particles move, they form magnetic fields, which means we can use electric current to make magnets. An electromagnet is an electric circuit that produces a magnetic field.

The most uncomplicated electromagnet is a straight wire. A magnetic field circles the wire when current is flowing through the wire. The more current, the stronger the magnetic field. You can also increase the magnetic field by looping the wire or adding an iron core.

Electromagnets must be part of a circuit in order to work. This means that they can be turned on and off with a switch. The ability to turn them on and off makes electromagnets useful in many devices. Voice coils are electromagnets that are used in audio speakers. The coil uses the magnets to make vibrations, which produces sound waves in the air. Electric motors also use electromagnets. Simple electric motors have a power source that produces electric current that runs through the wire loop, making it an electromagnet. They have a magnet that pushes and pulls on the electromagnet, causing the loop and shaft to spin. The shaft is usually attached to a gear or wheel.



The voice coil vibrates next to a permanent magnet to produce sound in a speaker.



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A motor uses electricity and magnetism to produce motion. Motion and magnetism can also be used to produce electricity. If you turn the axle of a motor by hand, you are rotating a wire coil in a magnetic field. This produces electric current in the wire. Using the motor to produce electricity instead of motion makes it a generator. Power plants use very large generators to produce electricity. That electricity travels through power lines to the electrical circuits in homes and businesses. Like batteries, generators are a voltage source.

How are the energy transformations in electric motors and generators related?

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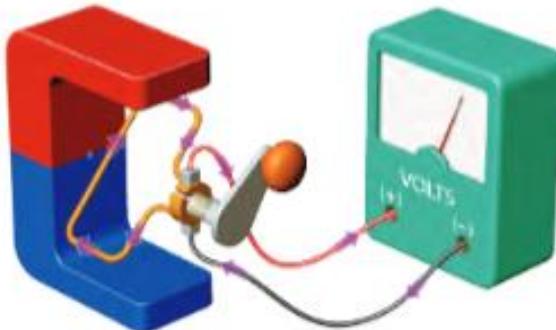
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A simple generator has a metal coil in a magnetic field. As the coil rotates, a magnetic field is produced.



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Power plants must use some other form of energy to cause the motion that spins the coil in a generator.



**REVISIT** Revisit the Page Keeley Science Probe on page 43.



## Make Connections

### Talk About It

Talk with a partner about how electric motors and generators are related.

**GO ONLINE** Watch the video *How a Generator Works* to learn how energy of motion is transformed into electrical energy.

## Notes

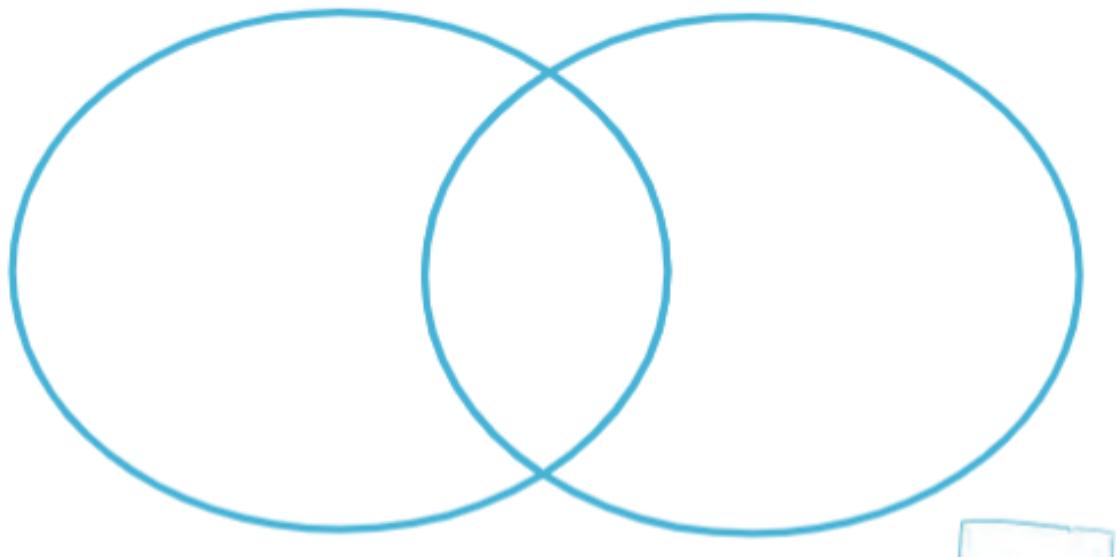
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**WRITING Connection** Read the Investigator article *Engineering with Electrifying Outcomes* to learn how electric eels use their bodies as a voltage source. Use the compare and contrast graphic organizer below to compare the electrocytes of an electric eel to batteries.



Write a paragraph explaining how electrocytes are like batteries. Explain how engineers are using what they know about electric eels to help people.



### STEM Connection

## What Does an Electrician Do?



The next time you flip on a light switch or turn on a computer, thank an electrician! Electricians are responsible for safely wiring buildings. These wires allow electricity to flow to all areas of a house or other building. Lights, computers, televisions, and many other devices run on this electricity. Electricians also repair or replace faulty wiring, transformers, circuits, fixtures, and breakers. This is critical when preventing house fires due to other electrical problems.

Electricians use many different tools to do their job. They must be able to read blueprints and other diagrams to properly install wiring. They also inspect existing electrical equipment and identify problems.

### Talk About It

How would an electrician help you design a community warning system that uses sound and light to alert the residents of a city?



### It's Your Turn

Think like an electrician. What will you use as the voltage source in your Module Project?



## LESSON 3

## Review

## EXPLAIN THE PHENOMENON

How do the overhead wires make the trolley move?

## Summarize It

Explain how the overhead wires make the trolley move.



Revisit the Page Keely Science Probe on page 43. Has your thinking changed? If so, explain how it has changed.



## Three-Dimensional Thinking

1. What role does a switch play in a circuit?

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2. What happens to the brightness of bulbs each time another is added in a series circuit? In a parallel circuit?

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3. A(n) \_\_\_\_\_ is a material that slows or stops the flow of energy.

- A. conductor
- B. insulator
- C. battery
- D. flashlight

## Extend It

Think about all of the different ways that you use batteries. You learned that batteries are a voltage source. You also learned about a new type of biobattery in the Investigator article *Engineering with Electrifying Outcomes*. Conduct research to find out how batteries work. Find out about other new types of batteries and their advantages and disadvantages. Make a news report to communicate your findings. Use the space below to take notes and plan your news report.



## KEEP PLANNING

## STEM Module Project



Now that you have learned how electric currents can transfer energy, go to your Module Project to explain how the information will affect your community warning system design.

## LESSON 4 LAUNCH

## Where Does the Energy Go?



Four friends are drinking hot chocolate from mugs. They each have different ideas about the hot chocolate and energy. This is what they said:

Alexis: The hot chocolate will stay hot as long as it is in the mug.

Kenny: The hot chocolate will lose energy to the air.

Olivia: The hot chocolate will keep losing energy until the mug and the hot chocolate are the same temperature as the air.

Michael: The hot chocolate will stop losing heat energy when both the mug and the hot chocolate are the same temperature.

Whom do you agree with the most? \_\_\_\_\_

Explain why you agree.

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You will revisit the Page Keeley Science Probe later in the lesson.

LESSON 4

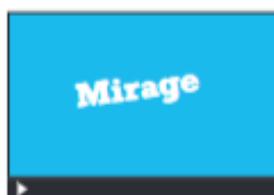
# Heat



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## ENCOUNTER THE PHENOMENON

How does energy from the Sun heat the road?



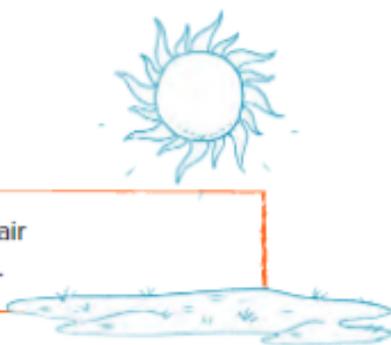
### GO ONLINE

Check out *Mirage* to see the phenomenon in action.

Look at the photo and watch the video of a mirage. How do you know that the road is hot? What do you observe? What do you wonder about the mirage? Talk about your ideas with a partner. Record or illustrate your observations below.

### Did You Know?

When light passes through cool air to warm air an optical illusion known as a mirage occurs.



## INQUIRY ACTIVITY

### Hands On

## Particles on the Move

How does thermal energy move? You just saw the Sun heating the road. Now you will investigate the movement of thermal energy in water.

Think about how a cup of hot water differs from a cup of cold water. How do these differences relate to the motion of the particles in the two cups?

**Make a Prediction** What will happen when you add food coloring to a cup of cold water? A cup of hot water?

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### Carry Out an Investigation

1. Use a marker to label a plastic cup "cold." Fill the cup with cold water. Add an ice cube to the cup.
2. Label the other plastic cup "hot." Fill the cup with hot tap water.
3. Place both of the cups on a white sheet of paper. Let the two cups sit for approximately one minute so the water can settle.
4. Add one drop of red food coloring to the right side of each cup. Add one drop of blue food coloring to the left side of each cup.
5. Observe the cups for five minutes. Record your observations.
6. Check your cups again after ten minutes and after one hour. Describe what you see in each of the cups.

### Materials

	2 clear plastic cups
	cold water
	hot tap water
	permanent marker
	sheet of white paper
	blue food coloring
	red food coloring
	ice cube

Cup	Time	Observations
Cold water	5 minutes	
	10 minutes	
	1 hour	
Hot water	5 minutes	
	10 minutes	
	1 hour	

## INQUIRY ACTIVITY

### Communicate Information

7. In which cup did the particles move the fastest? How do you know?

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8. Did the results support your prediction? Explain your answer.

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9. What improvements could you make to this investigation?

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## MAKE YOUR CLAIM

How do particles move in liquid as you change the temperature?

Make your claim. Use your investigation.



### CLAIM

As I increase the water's temperature, the particles move \_\_\_\_\_.

Cite evidence from the activity.

### EVIDENCE

The investigation showed that \_\_\_\_\_.

Discuss your reasoning as a class. Tell about your discussion.

### REASONING

The evidence supports the claim because \_\_\_\_\_.

You will revisit your claim to add more evidence later in the lesson.

## VOCABULARY

Look for these words as you read:

conduction

convection

heat

radiation

## Heat

In the Inquiry Activity, *Particles on the Move*, you used food coloring to compare the motion of particles in hot and cold water. Thermal energy depends on the motion of particles in a material. The hot and cold water had different amounts of thermal energy. That is why the food coloring moved at different rates.

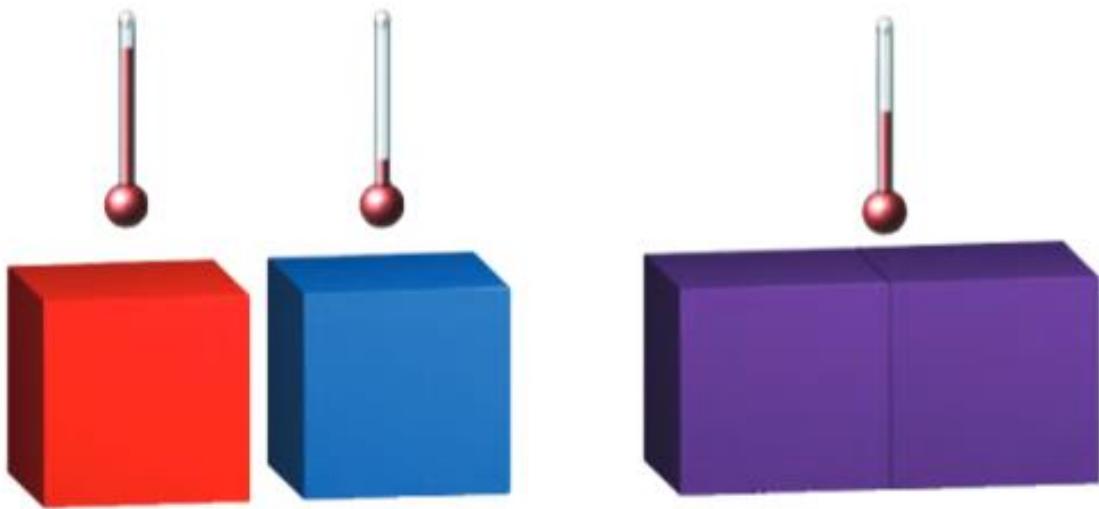
**Heat** is movement of energy from a warmer object to a cooler object. If the particles are moving at different rates, thermal energy is transferred.



A lizard can warm itself by sitting in sunlight. Heat flows from sunlight into the lizard. It also flows from the rock into the lizard.

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Toni Karoni, Author & Photography/Masterfile/Alamy Stock Photo

Thermal energy moves from a substance with a higher temperature to a substance with a lower temperature. Temperature is a measure of the average energy of motion of the particles in an object. All of the particles in an object are vibrating with kinetic energy. Objects with a higher kinetic energy are vibrating faster. Objects with a lower temperature have particles that do not vibrate as much. When a hot object touches a cold object, their particles bump into each other. When this happens, the particles from the hot object pass on some of their energy to the particles in the cold object. The cold object becomes warmer and the hot object loses heat.



When the two blocks are pushed together, energy will flow from the hot block to the cooler block.

When the two blocks reach the same temperature, thermal energy will stop flowing between the two blocks.

1. What is the difference between thermal energy and heat?

# Thermal Energy Transfers

Thermal energy transfer happens in three different ways:

**Conduction** The particles that make up matter are always vibrating. **Conduction** is the transfer of energy between two solid objects that are touching.

Conduction can also occur within the same object. The material itself does not move. The vibrations spread from a warmer object or part of an object to a cooler object or part of an object. On a summer day, when your cool feet touch the hot sand, your feet become warmer through conduction.

**Convection** Inside a pot of heating water, thermal energy spreads as warm and cool parts of the water move around. **Convection** is the transfer of energy in moving gases or liquids, such as the warm air rising above a heater. Convection is caused by cool parts sinking and pushing warmer parts up into the liquid or gas. As the warm and cool parts move, they cause rotating currents. The currents spread thermal energy throughout the material.

**Radiation** Earth's surface is warmed by radiation from the Sun. **Radiation** is the energy that comes from a source in the form of waves or particles. As the waves travel from their source, they carry energy from one place to another. Unlike with conduction and convection, radiation does not need a material to transfer energy. Hot objects radiate heat.

## Label a Diagram: How Thermal Energy Moves

Use what you learned about conduction, convection, and radiation to label each process on the diagram below.



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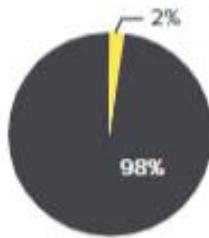
# Producing Thermal Energy

Like all energy, thermal energy cannot be created or destroyed. It can be released as energy changes occur. If you rub your hands together very fast, you can feel them get warmer. Friction between your hands changes the energy of motion into thermal energy.

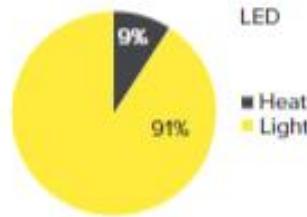
Sometimes the heat produced by friction can cause problems. When the parts of a machine rub together, friction between the parts produces thermal energy. The machine has less energy to do work because the machine has changed some of its energy to thermal energy.

Mixing and burning are other ways to produce thermal energy. Some of the energy in a chemical reaction may be given off as heat. In a campfire, chemical energy stored in wood is released as heat when logs burn.

Lightbulbs also release heat as they converts energy into light. Incandescent lightbulbs get very hot because most of the energy is transformed into heat, which makes them much more inefficient compared to LED lamps. LED lamps waste very little energy in the form of heat. They can produce the same amount of brightness as a incandescent lightbulb, but with less energy. LEDs can even last up to 20 years!



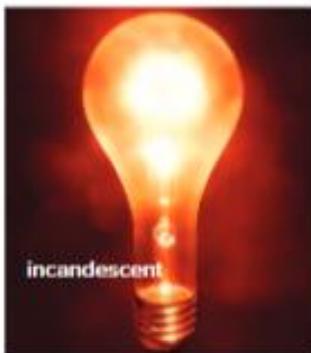
Incandescent  
■ Heat  
■ Light



LED  
■ Heat  
■ Light



Friction between the match head and the surface produces enough heat to light the match.



How would using LED lightbulbs help save energy?



Revisit the Page Keeley Science Probe on page 61.

## INQUIRY ACTIVITY

### Simulation

# Energy Transfer Through Matter

You have used the *Energy Transfer Through Matter* simulation to explore how sound and light move. Now you will explore how thermal energy moves.



#### GO ONLINE

Explore the heat tab of the *Energy Transfer Through Matter* simulation to see how energy moves in the process of conduction.

**State the Claim** What happens to particles when you increase the flame under a metal pan?

### Carry Out an Investigation

1. Use the slider to set the flame height to low. Check the box to show the kinetic energy of the particles in red. Observe the particles. Record your observations in the table.
2. Use the slider to set the flame height to medium. Record your observations.
3. Use the slider to set the flame height to high. Record your observations.

**GO ONLINE** Use the Personal Tutor *Conduction, Convection, and Radiation* to learn more about how energy moves from place to place.



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	Movement of particles
Flame height: low	
Flame height: medium	
Flame height: high	

### Communicate Information



On a separate sheet of paper, **draw and label** the **flow of energy** as it moved through the solid when it was heated. Was your claim supported?



### COLLECT EVIDENCE

Use what you learned about the movement of thermal energy as evidence to support your claim about particle motion on page 67.

# Thermal Conductivity

Thermal energy travels at different speeds. Thermal energy is carried by radiation through empty space at the speed of light. Convection currents travel slower. Conduction is usually slower than both radiation and convection. In conduction, thermal energy must travel through all of the particles of matter.

The ability of a material to transfer heat is called thermal conductivity.

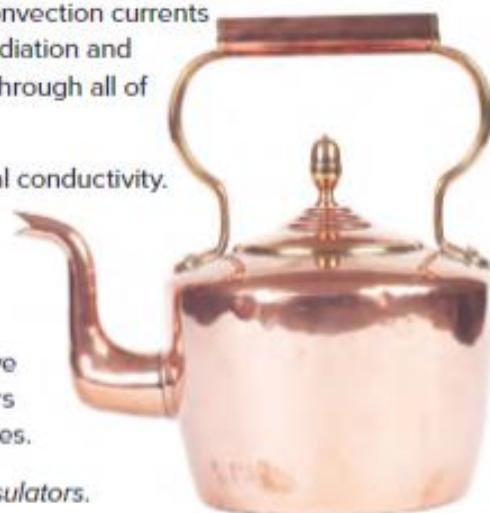
Materials that conduct heat easily are good thermal conductors. Most metals are thermal conductors.

Thermal conductivity usually increases with density.

Density is the amount of matter in an object. When particles in a material are closer together, heat can move more quickly through them. Solids are better conductors than liquids, and liquids are better conductors than gases.

Materials that conduct heat poorly are called thermal insulators.

Air, for example, is a thermal insulator. Most winter coats are puffy because they contain pockets of air that prevent heat from moving away from your body.



This copper pot is a good thermal conductor.

Thermal Conductivity	
Material	How Many Times Better Than Air It Conducts Heat
Oak wood	6
Water	23
Brick	25
Glass	42
Stainless steel	534
Aluminum	8,300
Copper	15,300
Silver	16,300

Use evidence to explain which material from the table above is the best thermal conductor.

## STEM Connection

# A Day in the Life of a Thermal Engineer



As a **thermal engineer**, I use what I know about thermal energy transfer. I use this information to design heating and cooling systems. I also use what I know about conductors and insulators. I help to make sure buildings are well insulated and energy efficient.

For example, I have studied this building and labeled the different temperatures I detected. These observations can show where heat is being lost from this building. Using the data collected, I can make adjustments to the heating system and insulation. This helps reduce the amount of thermal energy transfer that occurs. This also helps reduce the energy needed to keep this building warm in the winter and cool in the summer.

### It's Your Turn

Think like a thermal engineer. What material or materials from the table on the previous page would you use as insulation? Can you think of a material that would work even better?

Thermal engineers design heating and cooling systems for buildings.



This diagram shows the temperatures in different areas of the house.

### Talk About It

How might an electrical engineer and a thermal engineer work together?



## LESSON 4

## Review

## EXPLAIN THE PHENOMENON

How does energy from the Sun heat the road?

## Summarize It

Explain how energy from the Sun is transferred to the road.

# REVISIT

 PAGE KEELEY  
SCIENCE  
PROBES

Revisit the Page Keeley Science Probe on page 61. Has your thinking changed? If so, explain how it has changed.

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## Three-Dimensional Thinking

1. Tell about an experience you have had involving conduction, convection, or radiation.

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2. When you rub your hands together quickly, what energy transfers are involved?

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3. Name three materials that are good conductors. Explain your reasoning.

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4. Give an example of a good insulator. Explain your reasoning.

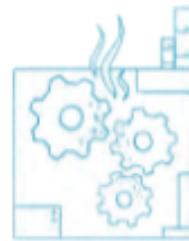
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## Extend It

**WRITING Connection** Heat has many uses, but it can also be an unwanted waste product. Heat caused by friction can cause machines to wear down. It can also lower the efficiency of machines. Identify a problem caused by waste heat and communicate a plan to solve it.



## KEEP PLANNING

## STEM Module Project Engineering Challenge



Now that you have learned about how thermal energy moves, go to your Module Project to explain how the information will help you design your community warning system.



## STEM Module Project

### Engineering Challenge

# Design a Community Warning System

You have been hired as an electrical technician. Using what you have learned throughout this module, you will design a community warning system to alert residents of possible danger. Your goal is to design, build, and test a model that uses a circuit to transmit both a light and sound message. The students in your class will serve as the residents of the city. The light and sound from the alarm must be able to be seen and heard from a distance of 50 feet (length of a basketball court). The alarm should be able to be triggered manually.



### Planning after Lesson 1

Apply what you have learned about different types of energy to your project planning.

How does knowing about different types of energy affect your design of a community warning system?

Record Information  
to help you plan your model  
after each lesson.



**MALIK**  
Photonic Engineer



## STEM Module Project

### Engineering Challenge

#### Planning after Lesson 2

Apply what you have learned about sound and light energy to your project planning.

How will you use your knowledge about sound and light energy to help design your community warning system?



#### Planning after Lesson 3

Apply what you have learned about electricity to your project planning.

Explain how you will use electrical energy to construct your community warning system.

## Planning after Lesson 4

Apply what you have learned about heat to your project planning.

How will your understanding of heat affect your design of a community warning system?

## Research the Problem

Research ideas for community warning systems that could be used in your project. Find out what is used at the county, city, and state levels by going online to teacher-approved websites, or by finding books about warning systems at your local library.

Source	Information to Use in My Project

## Sketch Your Model

Draw and label your ideas for possible design features. Use a separate piece of paper. Make sure to specify the initial and final forms of energy on your sketch. Identify the device that will transform energy.





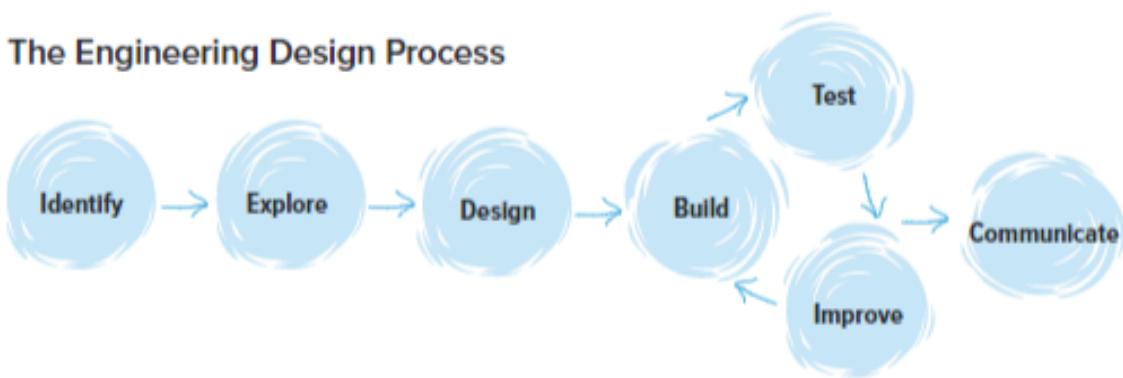
## STEM Module Project

### Engineering Challenge

## Design a Community Warning System

Look back at the planning you did after each lesson. Use that information to complete your final module project.

## The Engineering Design Process



## Build Your Model

1. Define the materials needed to build and test your model. List the materials to the right.
2. Use your project planning to build your model.
3. Write clear steps to test your model.
4. Your warning system must include the use of sound and light.
5. Your warning system must be able to alert all of the students in your classroom using both sound and light. Everyone must be able to see and hear the alarm.
6. You must design the circuit so that the lightbulb, the buzzer, or both are on. You will switch the lightbulb and buzzer on and off.

## Materials

### Procedure:

## Test Your Model

Build and test your model. Record your observations and results on a separate piece of paper. Use a data table if you need to.



You are using  
the Engineering Design  
Process!





## STEM Module Project

### Engineering Challenge

## Communicate Your Results

Share the plan for your model and your results with another group. Compare how well each of your models met the criteria of alerting all the students in your classroom using both sound and light. Communicate your findings below.



## MODULE WRAP-UP

### REVISIT THE PHENOMENON

Using what you learned in this module, identify and explain the types of energy transfer that occur in a city.



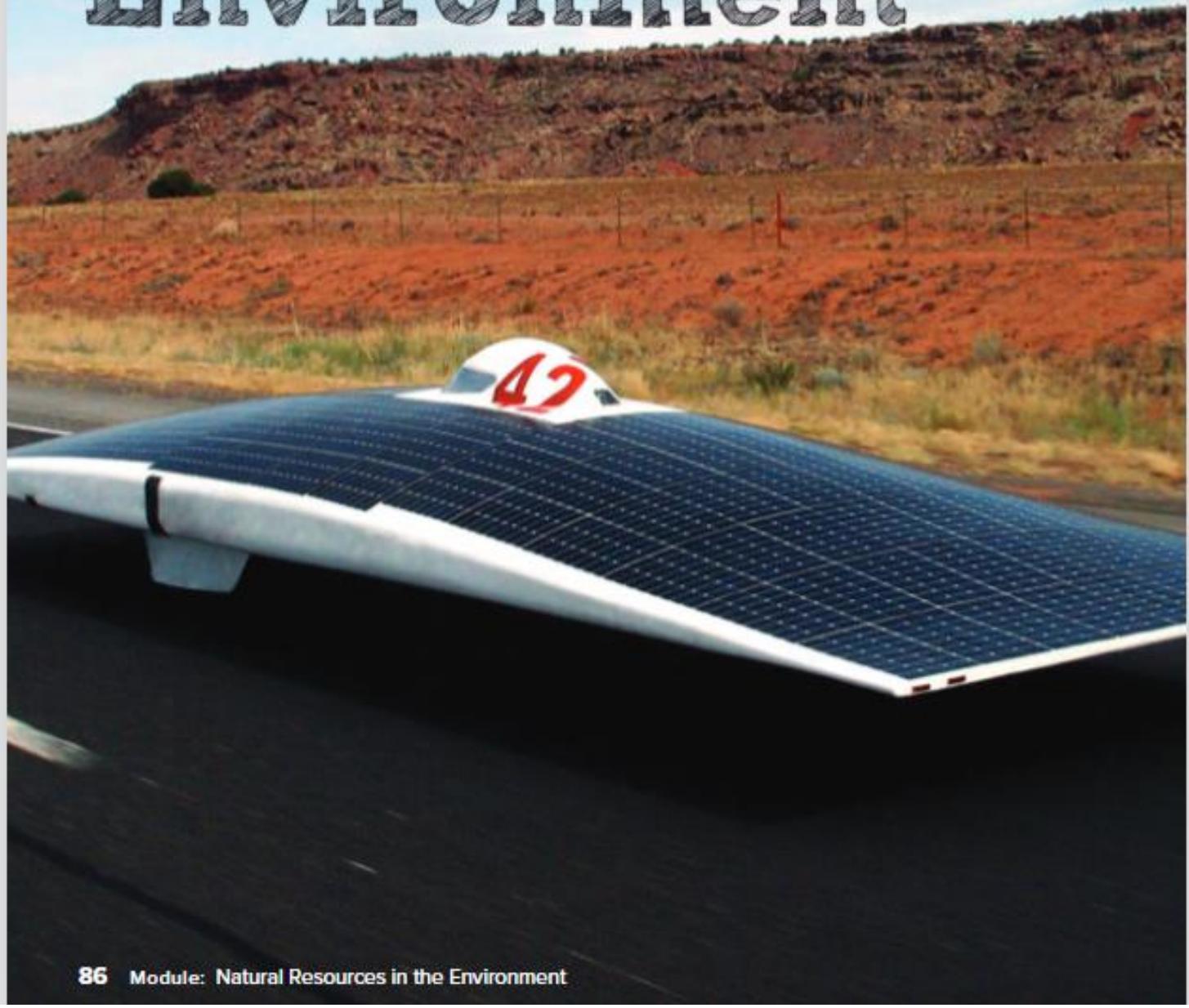
Revisit your project if you need to gather more evidence.

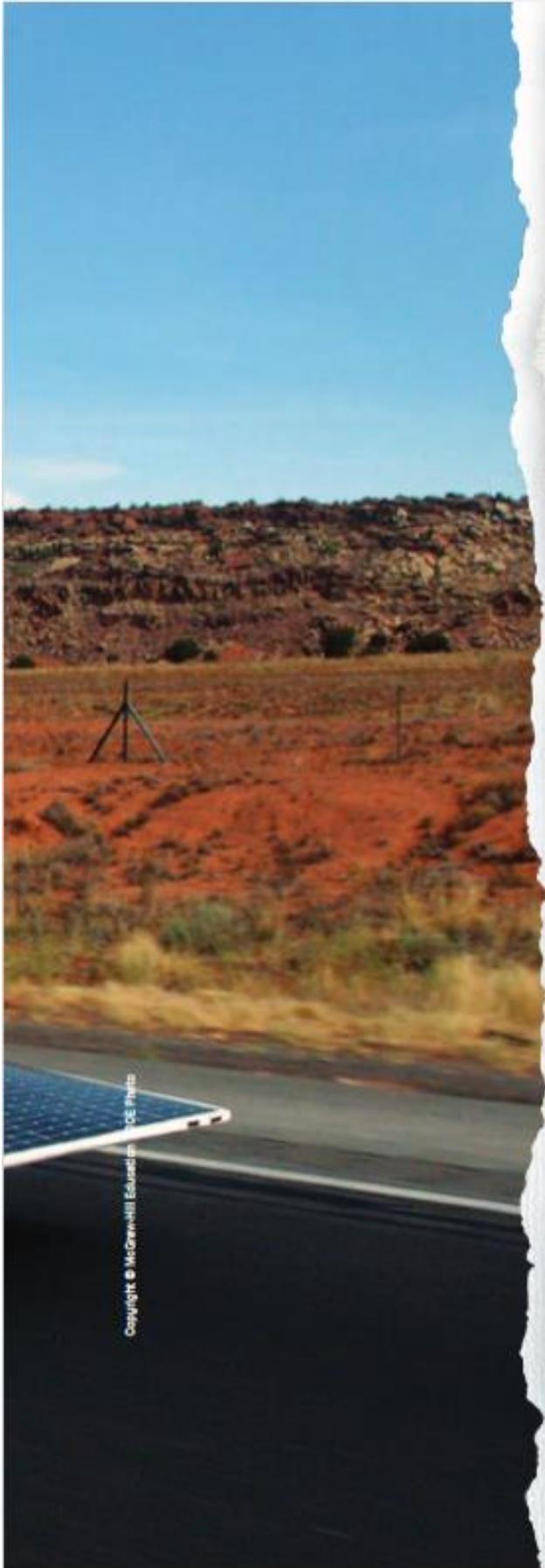


Have your ideas changed? Explain your answer.

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# Natural Resources in the Environment





## ENCOUNTER THE PHENOMENON

How does the car get its energy to move?

Powered by  
the Sun

 **GO ONLINE**

Check out *Powered by the Sun* to see the phenomenon in action.

 **Talk About It**

Look at the photo and watch the video of a solar-powered car. What do you observe? Talk about your ideas with a partner.

**Did You Know?**

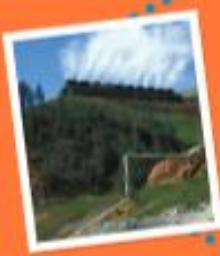
In 1984, a completely solar-powered car was developed. Now, solar-powered cars are believed to be the cars of the future!



## STEM Module Project Launch

### Engineering Challenge

Lesson 1  
Energy from  
Non-renewable  
Resources



Lesson 2  
Energy from  
Renewable  
Resources



Lesson 3  
Impact of  
Energy Use



Lesson 4  
Design  
Energy  
Solutions

## Build a Solar Oven

How can we use energy from the Sun? You are being hired as a solar energy engineer. At the end of this module, you will build a solar oven to heat water. Your goal will be to design and test a solar oven that can raise the temperature of 100 mL of water by at least 5° Celsius in less than 30 minutes.

You will be a solar energy engineer and build a solar oven at the end of the module.



Do you like drawing, being outside, and using computers? Solar energy engineers use computers to create and test their designs. They apply their knowledge of natural resources to plan, design, and install solar panels to produce electricity.

**ANTONIO**  
Robotics Engineer



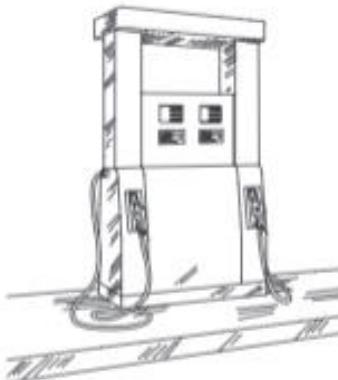
### STEM Module Project

**Plan and Complete the Engineering Challenge** Use what you learn throughout the module to build your solar oven.

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John A. Martinez/U.S. Coast Guard photo by Petty Officer 2nd Class Michael Hickey/stock/Corbis Images  
Hector Cordero/Corbis Images/Corbis Images

## LESSON 1 LAUNCH

## Energy from Natural Resources



Four friends were talking about nonrenewable energy resources such as natural gas, coal, and oil. They each had different ideas about these energy resources. This is what they said:

Jake: Coal and oil can harm the environment. Natural gas is natural, so it doesn't harm the environment.

Kim: Oil can harm the environment because it can get into water. Coal and natural gas don't harm the environment.

Alisha: Coal, oil, and natural gas are all safe for the environment because they are natural resources.

Lucas: Coal, oil, and natural gas can all harm the environment.

Whom do you agree with most? \_\_\_\_\_

Explain why you agree.

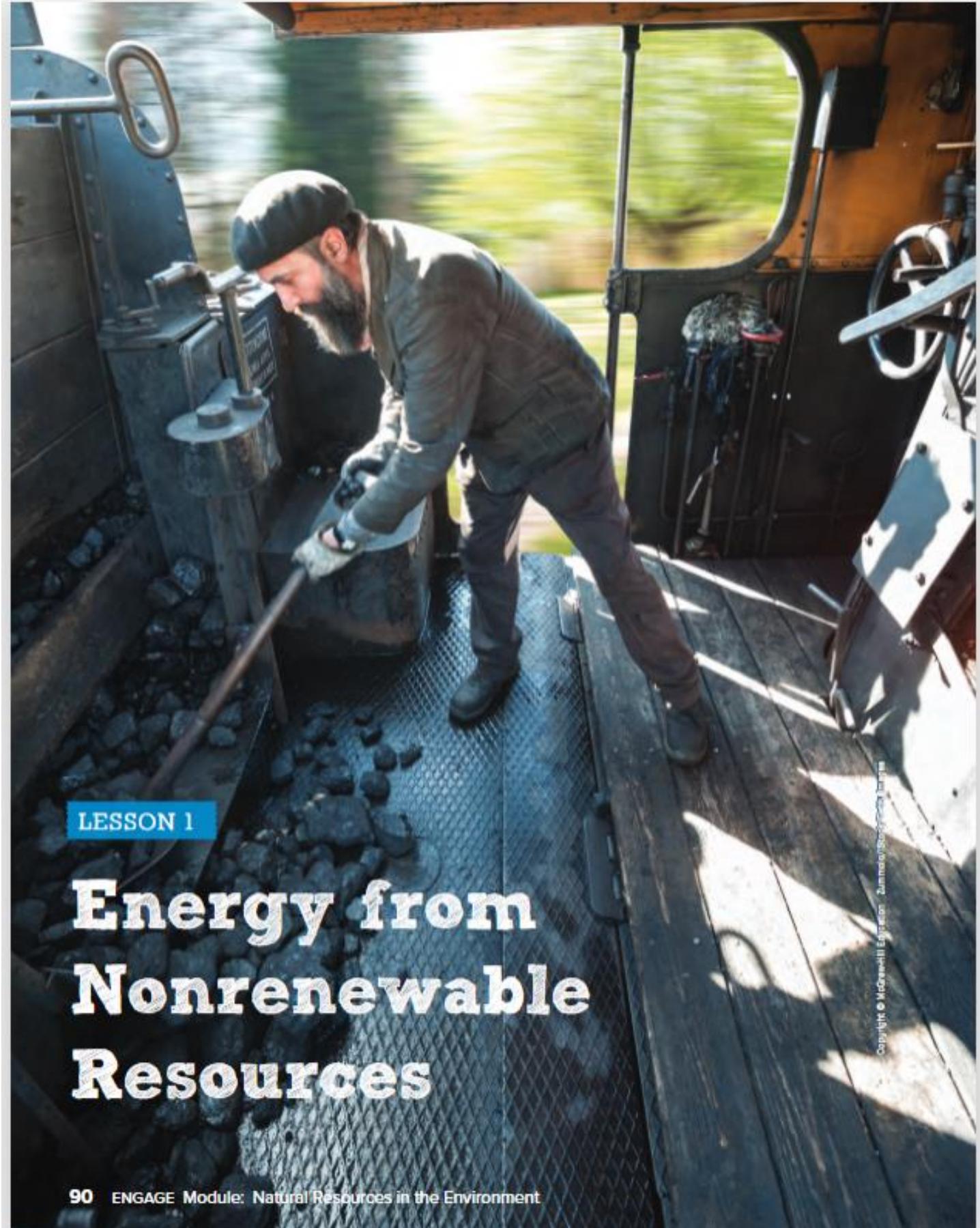
  

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You will revisit the Page Keeley Science Probe later in the lesson.

A color photograph showing a man with a beard and a cap, wearing a dark jacket and pants, shoveling dark-colored coal from a metal bin into the firebox of a steam train engine. He is using a long-handled shovel. The train's interior is visible, including a circular window showing green trees outside. The floor of the engine is covered in coal. The image has a slightly blurred background, suggesting motion.

LESSON 1

# Energy from Nonrenewable Resources

# ENCOUNTER

## THE PHENOMENON

What is burning inside the locomotive?



GO ONLINE

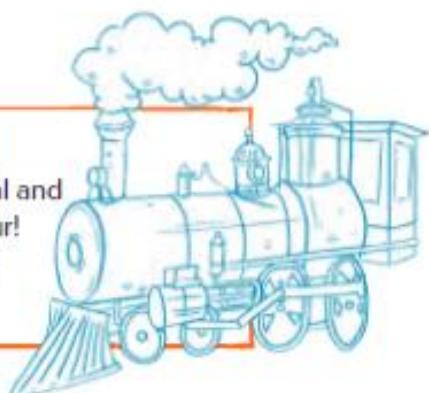
Check out *Locomotive* to see the phenomenon in action.

 **Talk About It**

Look at the photo and watch the video of a steam locomotive. What do you observe? Discuss your thoughts with a partner. Record questions or illustrate your observations below.

### Did You Know?

The locomotive known as Big Boy consumed up to 9,979 kilograms (22,000 pounds) of coal and 45,425 liters (12,000 gallons) of water per hour! That's how much water the average family of four uses in a month!



## INQUIRY ACTIVITY

### Hands On

## Limited Resources

Vehicles like the locomotive use energy to function. What would happen if there was no more gasoline for cars? Many of the resources are limited. Energy, such as coal, oil, and natural gas take millions of years to be replaced. Investigate what happens when we use limited resources.

**Make a Prediction** What happens to nonrenewable resources as we use them over time? What happens if we use those resources more quickly?

### Carry Out an Investigation

1. Decide which partner will be the excavator and who will be the recorder.
2. Remove only the number of beads indicated on data table 1.
3. Calculate the number of “renewable” and “nonrenewable” beads that are left inside the bag. Record number on data table 1.
4. Return only the “renewable” beads back into the bag after each trial. Place the “nonrenewable” beads in the bowl.
5. Repeat steps 3–4 until you have run out of “nonrenewable” beads. Use a separate piece of paper if you need to extend your data table.
6. Return all beads to the bag and repeat steps 3–5 for data table 2.

### Materials



90 black beads (non-renewable)



10 white beads (renewable)



small bowl



small brown paper bag



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**Data Table 1: Constant Rate of Consumption**

Resources	10 Years	20 Years	30 Years	40 Years	50 Years	60 Years	70 Years	80 Years	90 Years	100 Years
Resources removed	10	10	10	10	10	10	10	10	10	10
Nonrenewable inside bag										
Renewable inside bag										

**Data Table 2: Increased Rate of Consumption**

Resources	10 Years	20 Years	30 Years	40 Years	50 Years	60 Years	70 Years	80 Years	90 Years	100 Years
Resources removed	10	15	20	25	30	35	40	45	50	55
Nonrenewable inside bag										
Renewable inside bag										

7. Why do you think the beads were put inside a paper bag?

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### Communicate Information

8. Do the results support your prediction? Explain.

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### **Talk About It**

What could contribute to the decreased or increased use of limited resources?

## VOCABULARY

Look for these words as you read:

fossil fuel

natural resource

nonrenewable resource



# Nonrenewable Resources

A **natural resource** is something that is found in nature and is valuable to humans. Natural resources can be living or nonliving and include air, water, sunlight, soil, rocks, minerals, plants, and animals. They are classified into two major groups: renewable and nonrenewable.

In the Inquiry Activity, *Limited Resources*, you modeled the use of a nonrenewable resource. **Nonrenewable resources** are natural materials or sources of energy that are useful to people and cannot be replaced easily. They take millions of years to form.

Metals, such as copper, are nonrenewable resources that people mine from beneath Earth's surface. Metals are used for building and manufacturing. They are found in our homes, computers, cars, and appliances.

Many of the fuels we use are also nonrenewable. Some of the electricity we use comes from nuclear energy. Uranium is not burned. Instead, it goes through a nuclear reaction to release energy. Uranium is a metal found in rocks all over the world.

### 1. What makes a natural resource nonrenewable?

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About one-third of the electricity used in the United States is produced by burning coal.

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(c) Miami Rekaen/Culture Creative (p) / iStock Photo.

## Fossil Fuels

A larger portion of the energy humans use comes from burning fossil fuels. A **fossil fuel** is a source of energy made from the remains of ancient, once-living things. Coal, oil, and natural gas are examples of fossil fuels.

Coal, the most plentiful fossil fuel, is found between rock layers. Coal is used mainly to generate electricity. Coal was once used to power the steam engines in locomotives and steamboats.

Crude oil is a thick, black substance that is also called petroleum. People drill into rocks to find oil and pump it to the surface. Oil can be used to produce electricity. It can be turned into gasoline and other types of fuel.

Natural gas can be found where oil is found. It is pumped out of the ground from wells and stored. Natural gas can provide energy for cooking and heating our homes.

2. Underline in the text how we use each type of fossil fuel.

New technologies are being developed for finding and using more old energy sources. However, some believe that the use of fossil fuels and nuclear power may damage the environment. Researchers are also exploring new energy sources. They consider what it costs to obtain and use it, its effect on the environment, and if it is renewable or not.

3. Highlight in the text why there are concerns about using fossil fuels.

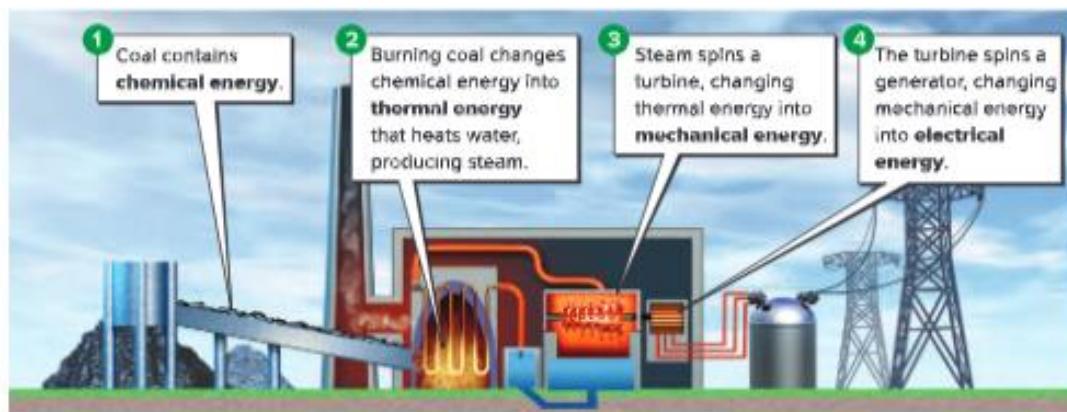


**GO ONLINE** Watch the video *Using Nonrenewable Resources* to see some examples of nonrenewable resources and how they are used.

## Read a Diagram: Power Plant

Circle the nonrenewable resource used to produce electrical energy in the diagram below.

**GO ONLINE** Explore *The Energy Sequence* to learn more about how coal is used to generate electricity.





Research to **obtain more information** about where we get our fuel supply. **Evaluate and communicate** how technology **affects** the supplies of **nonrenewable resources**.

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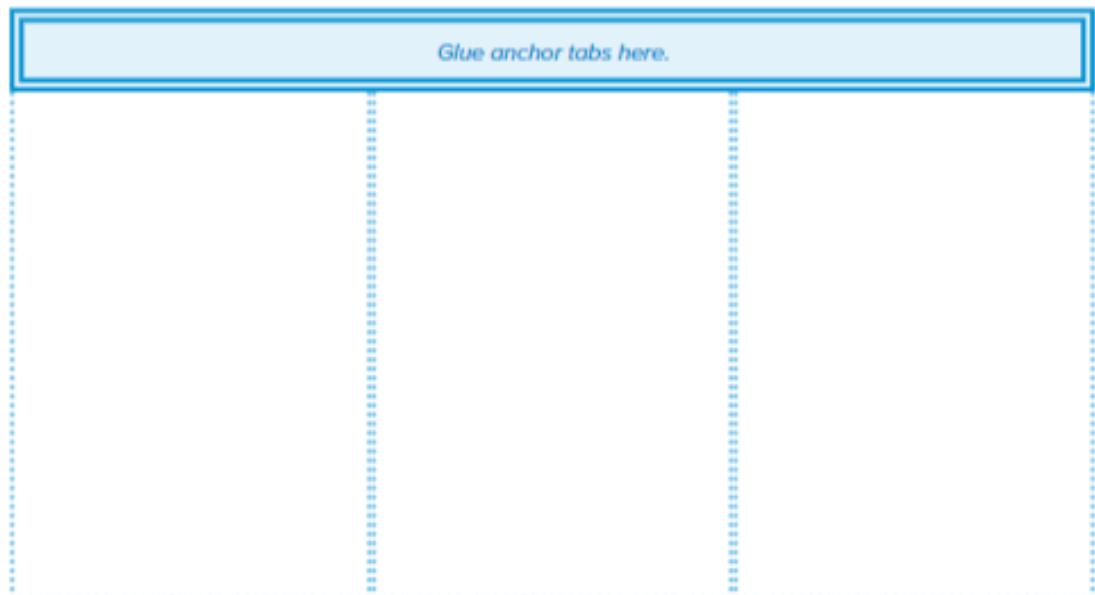
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## FOLDABLES®

Cut out the Notebook Foldables® tabs given to you by your teacher. Glue the anchor tabs as shown below. Summarize what you have learned about three nonrenewable resources, and draw examples of each.



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# Energy Changes

Energy is found in many forms. There is energy in light, heat, electricity, and in food. We cannot make energy, but we can change it from one form to another. When we eat, we change the energy that was stored in food into the energy of movement—like when you run. A car engine changes most of the chemical energy stored in gasoline into energy of motion. A microwave oven turns electrical energy into heat.

Sometimes energy is stored. Batteries store chemical energy. If we connect a battery to a circuit, electricity flows through the wires. Wind-up toys store energy in a spring when you turn the crank. The stored energy, or potential energy, in the spring changes into energy of motion when the toy is released.

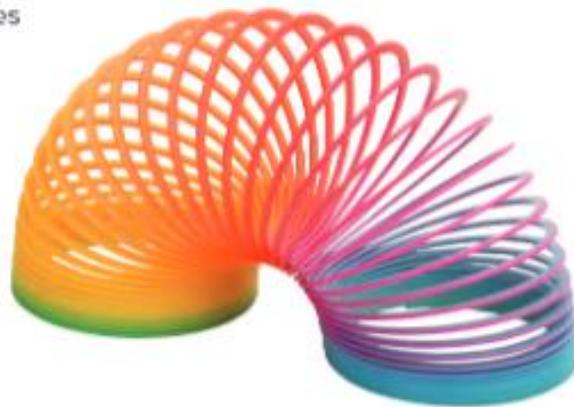
1. Underline the sentence in the first paragraph that shows what happens to the chemical energy in a car.
2. How is the energy transformation in a lightbulb similar to starting a campfire?

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## Talk About It

Discuss with a partner. What other energy changes have you experienced today?



## INQUIRY ACTIVITY

### Data Analysis

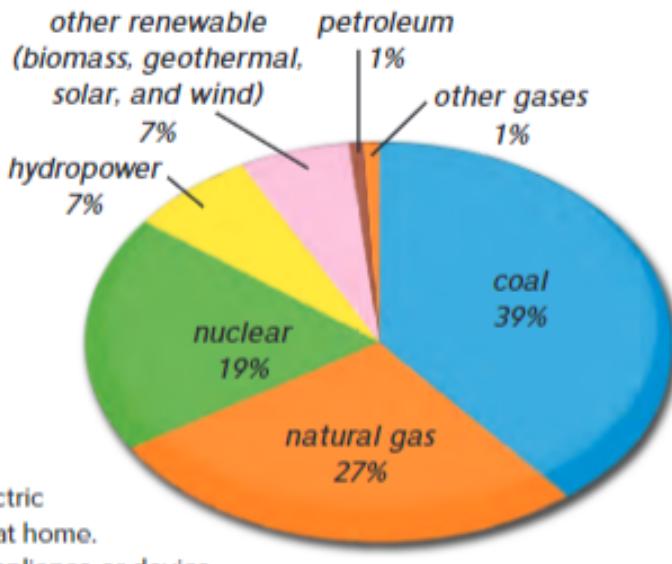
## Energy Usage Investigation

People use energy in the form of electricity every day.

Power lines connect your home to a power plant that generates electricity. Much of this energy is produced from nonrenewable resources, as shown in the graph. How much does it cost to run our electronic devices? Research to obtain information on how much it costs to operate 4–5 common household appliances or devices.

**Make a Prediction** Identify 4–5 electric appliances or devices that are used at home.

Based on how often you use each appliance or device, make a prediction about how much each appliance costs to operate daily.



Sources of Electricity

### Carry Out an Investigation

1. Use teacher-approved websites to research the amount of electricity used to power each device.
2. Find out how long each device is used on a typical day.
3. **MATH Connection** Use the formula below to convert to kWh. Show your work on a separate piece of paper. Complete the data table.

$$\text{kWh} = \frac{(\text{Watt rating}) \times (\text{total minutes used}/60)}{1000}$$



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Electric Appliance or Device	Watt Rating (W)	Time Used (minutes per day)	kWh Used per Day	Cost of Use Per Day: _____ per kWh
<b>Total</b>				

4. Rank each appliance or device in order of their cost of use per day from highest to lowest.

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### Communicate Information

5. How could you reduce energy cost and usage at home?  
Explain the advantages and disadvantages of your solution.

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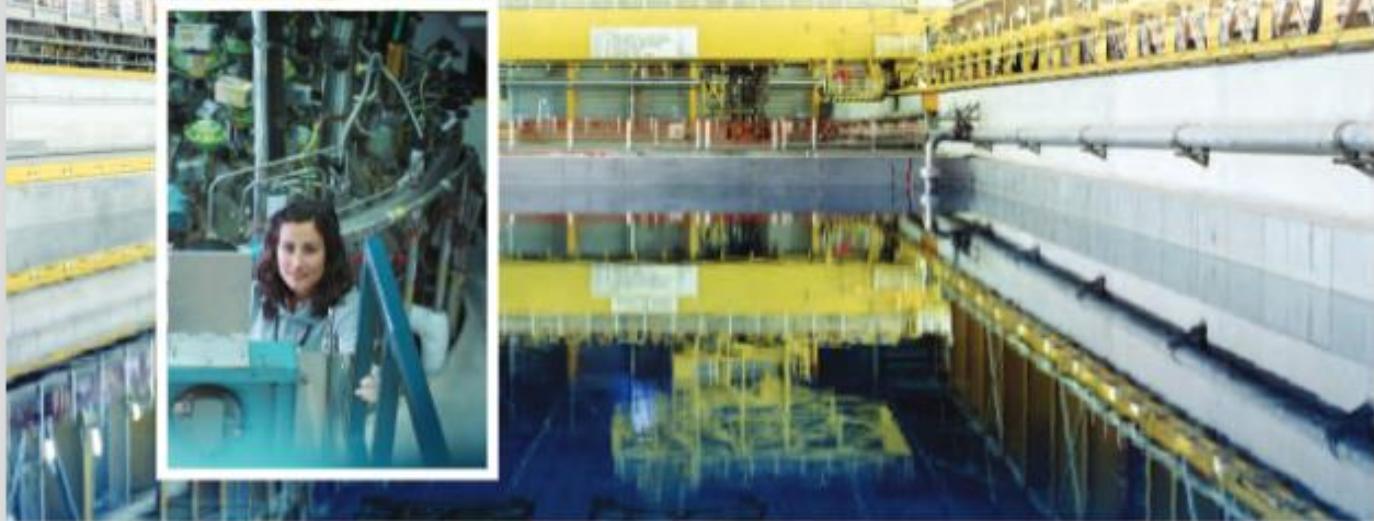
### Talk About It

Did the results support your prediction? What other factors might affect how much energy your family uses?



## STEM Connection

# A Day in the Life of a Nuclear Engineer



Do you like making predictions?

As a **nuclear engineer**, I monitor the supply of uranium and use computer models to predict how much electricity is produced. I get to work at a nuclear power plant that delivers electricity to many homes and businesses.

We use uranium as fuel. Energy is stored in the center of the uranium particles. Uranium particles are split apart in the nuclear reactor to release stored energy. The energy released is in the form of heat. Remember the steam engine in a locomotive? Coal was used as fuel to boil water and power the engine to make the train move. In the nuclear power plant, uranium is used to heat water to turn turbines and produce electricity.

### Talk About It

Compare a nuclear power plant and a steam engine locomotive. Discuss with a partner.



### It's Your Turn

Research to find out the energy source used by a local power plant. Communicate your findings on a separate piece of paper.

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(Photo: Tony Barnard/Corbis/Getty Images)

# Fuel Economy

Think back to the Inquiry Activity, *Energy Usage Investigation* and the data you collected. Vehicles, lightbulbs, and appliances can have different energy efficiencies. For example, an energy-efficient lightbulb or appliance uses relatively little electricity to power it compared to traditional lightbulbs and appliances.



A fuel-efficient vehicle travels longer on a smaller amount of gas. This saves the user money and helps to conserve resources. In the United States, we measure the amount of gasoline that a car uses in miles per gallon (mpg).

Think of your dream car. What features are most important to you? Research an electric, a hybrid, and a gasoline-powered car. Use the table below to collect your data:

Car	Brand and Make	Price of Vehicle	Miles Per Gallon (MPG)	Tank Size (gallons)	Cost to Fill Tank or Recharge	Annual Fuel Cost
Electric						
Hybrid						
Gasoline						

## Communicate Information

1. **MATH Connection** Which car is most efficient if you consider annual fuel costs?
  

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2. **ENVIRONMENTAL Connection** What are the advantages and disadvantages of using the most efficient car?
  

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## Talk About It

Research the kind of energy that your family uses for transportation. Share your findings with a partner.



## LESSON 1

## Review

## EXPLAIN THE PHENOMENON

What is burning inside the locomotive?

### Summarize It

Explain how we get energy from nonrenewable resources.

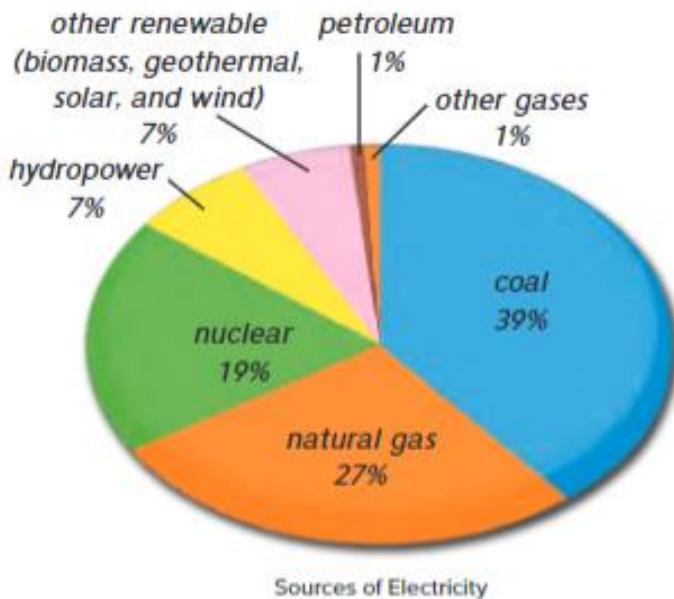


Revisit the Page Keeley Science Probe on page 89. Has your thinking changed? If so, explain how it has changed.

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### Three-Dimensional Thinking



1. Based on the "Sources of Electricity" pie graph, what is the total percentage of nonrenewable resources that are used to generate electricity?
  - A. 86%
  - B. 100%
  - C. 67%
  - D. 15%
2. If a new natural resource was discovered, what information would you need to know to be able to classify it as a nonrenewable or renewable resource?

### Extend It

Many people travel to their place of work. Some people travel with their coworkers. Others travel to their workplace using their own cars or other forms of transportation. Combine information from two different sources to describe where humans get their fuel supply for transportation.

Propose a way that people could save on energy usage and transportation costs. Include reasons why people should consider using less energy.

Write a speech, create a flyer, or make a poster. List the key points you want to make.

## OPEN INQUIRY

What questions do you still have about the use of nonrenewable resources?

Plan and carry out an investigation or research to find the answer to your question.



## KEEP PLANNING

## STEM Module Project



Now that you have identified and learned about the uses of nonrenewable resources, go to your Module Project to explain how the information will affect your plan for your solar oven.

## LESSON 2 LAUNCH

## Renewable Resources

Some energy resources can be used over again without being depleted, or used up. These are called renewable energy resources. Draw a circle around any box that contains a renewable energy resource.

Oil	Wood	Wind
Sun	Water	Coal
Natural Gas	Living Things	Heat from Inside Earth
Corn	Fossil Fuels	Gasoline

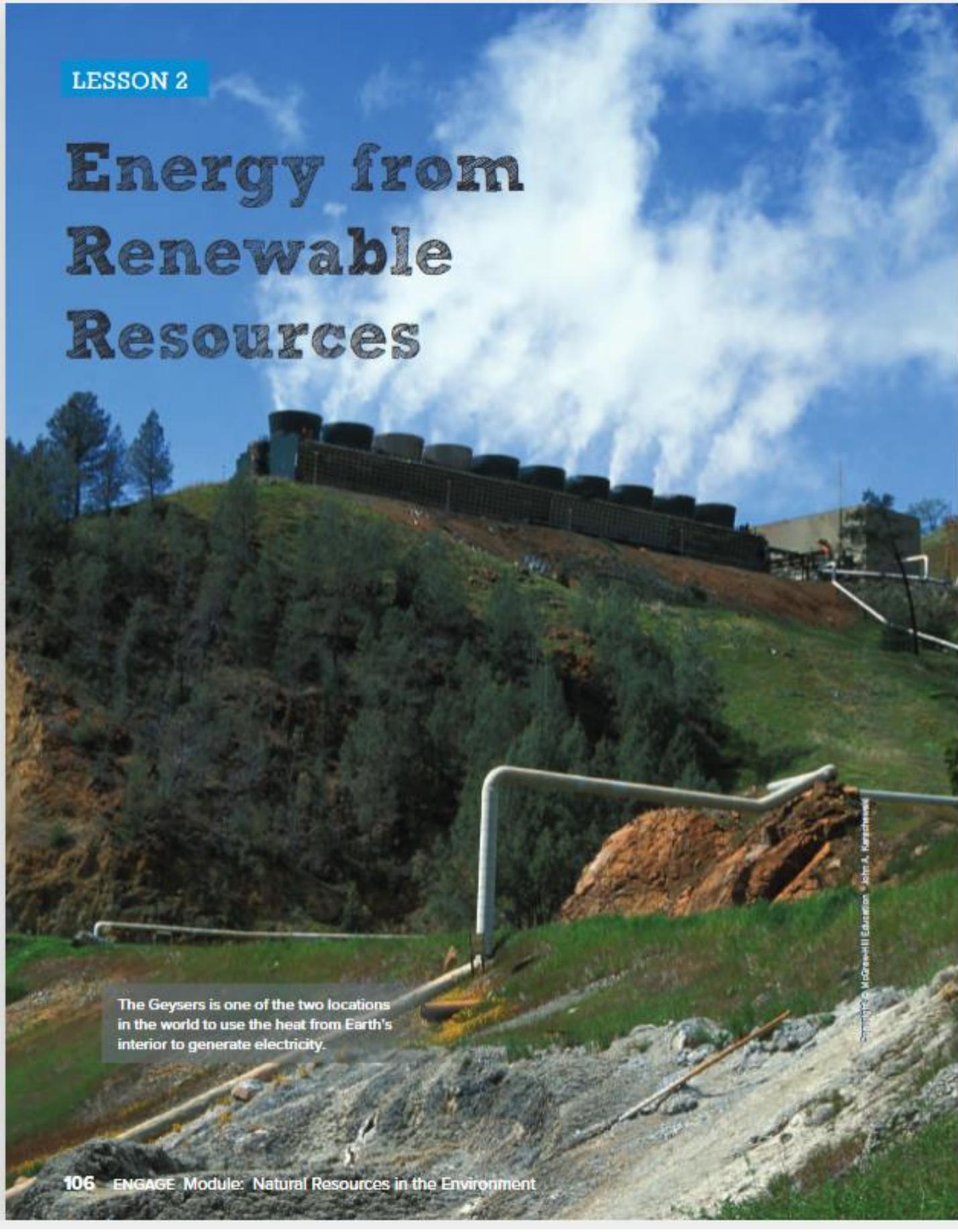
Explain your thinking. How did you decide if something is a renewable energy resource?

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You will revisit the Page Keeley Science Probe later in the lesson.

LESSON 2

# Energy from Renewable Resources



The Geysers is one of the two locations in the world to use the heat from Earth's interior to generate electricity.

# ENCOUNTER

## THE PHENOMENON

How can Earth's thermal energy be used?



GO ONLINE

Check out *Eruption* to see the phenomenon in action.

 **Talk About It**

Look at the photo and watch the video of a geothermal power plant. What questions do you have about the phenomenon? Talk about them with a partner. Record your questions below.

## Did You Know?

The Geysers is the largest geothermal field in the world!



## INQUIRY ACTIVITY

### Hands On

## Renewable Resources

Unlike the nuclear power plants seen in Lesson 1, geothermal power plants use the heat from Earth as energy. Energy resources such as geothermal, solar, hydroelectric, and wind are naturally replenished. Think about the Inquiry Activity, *Limited Resources*, in Lesson 1. This time you will investigate what happens when you focus on using renewable sources as a larger part of your energy supply.

**Make a Prediction** How does the supply of renewable resources change over time?

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### Materials



80 black beads  
(non-renewable)



20 white beads  
(renewable)



20 red beads



small bowl



small brown paper bag



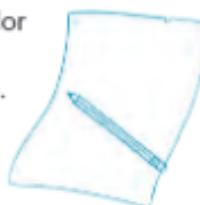
plastic cup

### Carry Out an Investigation

1. Decide who will be the engineer and who will be the recorder. Switch roles after each time period. Place the 20 white beads, 20 red beads, and 20 of the black beads into the paper bag. Close the bag and gently shake to mix the beads.
2. Look at the data table. Have the engineer pull five beads from the bag for the first time period. Place the beads on the table.
3. Have the recorder write the number of each color of bead removed from the bag in the “Number of colored beads pulled” column.
4. On a separate sheet of paper, calculate the number of beads of each color left in the bag. Record these amounts in the “Remaining” column. Then place the white beads into the bowl.
5. Count the number of black beads on the table. Use the black beads in the cup to double the number of black beads. Skip this step if no black beads were pulled.
6. On your separate sheet of paper, calculate how many beads of each color will be in the bag after resources are replenished. Use the rules at the bottom of the data table. Record your answer in the “Replenish” column. Return the red and black beads to the paper bag.
7. Repeat steps 2-6 for the remaining time periods. Pay attention to the number of beads removed for each time period.



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## Data Table

Resources		10 Years		20 Years		30 Years		40 Years		50 Years	
Remove from bag		5		10		15		20		25	
	Starting amount	Number of colored beads pulled	Remaining	Replenish	Number of colored beads pulled	Remaining	Replenish	Number of colored beads pulled	Remaining	Replenish	Number of colored beads pulled
White beads	20										
Red beads	20										
Black beads	20										

To replenish white beads, use what is in the "Remaining" column and add zero.

To replenish red beads, use what is in the "Remaining" column and add the amount in the "Number of colored beads pulled" column.

To replenish black beads, use what is in the "Remaining" column and add twice the amount in the "Number of colored beads pulled" column.

## Communicate Information

8. How did the outcome of this activity differ from the *Limited Resources* activity in Lesson 1?

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9. Describe what happened to the black beads over time.

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### Talk About It

Compare the three colors of beads. What type of resource does each bead represent? Explain. Discuss with a partner.

## VOCABULARY

Look for these words as you read:

alternative energy source

biofuel

geothermal energy

hydroelectricity

renewable resource

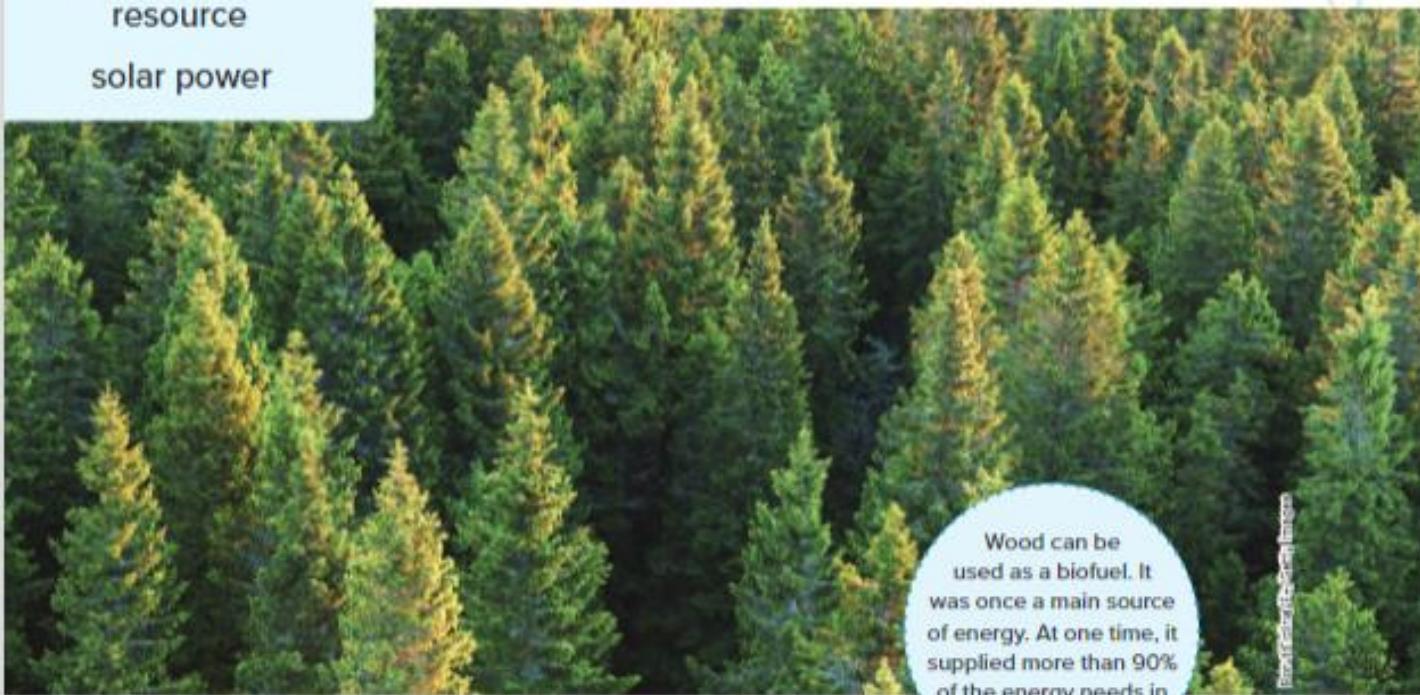
solar power

# Renewable Resources

Think about how you were able to replace renewable resources in the Inquiry Activity, *Renewable Resources*. Researchers are trying to find ways to use renewable resources. A **renewable resource** is a material that is replaced quickly in nature. Water, wind, sunlight, plants, and animals are examples of renewable resources.

An **alternative energy source** is a source of energy other than burning of a fossil fuel. Plants, animals, sunlight, geothermal energy, moving water, and wind are all examples of alternative energy sources.

 **GO ONLINE** Watch the video *Using Renewable Resources* to see some examples and uses of renewable resources.



## Biomass

Wood, crops, and animal waste are part of what we know as biomass. Burning biomass transforms the stored energy into thermal energy, gas or fuel. A type of fuel made from biomass, or living or formerly living material, is called **biofuel**. Iowa, Georgia, Mississippi, North Carolina, and North Dakota lead the United States in biomass production.

Underline the evidence in the text that shows stored energy can be transformed into thermal energy.

Wood can be used as a biofuel. It was once a main source of energy. At one time, it supplied more than 90% of the energy needs in the United States.

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## Solar Energy

Energy that comes from the Sun is called solar energy. Solar energy heats water and land. **Solar power** is power obtained from solar energy to generate electricity using solar cells. The use of solar power continues to grow in the United States, where people can even use solar panels to power their own homes.

## Geothermal Energy

Energy obtained from Earth's interior is called **geothermal energy**. In some places, water that lies deep inside Earth is heated. This hot water is used to do work or produce electricity. Sometimes the heated water makes its way to Earth's surface as pools of hot water (hot springs) or jets of hot water and steam (geysers). Geysers can be harnessed and used to heat dwellings. They can also be converted to electricity in a power plant. Currently, geothermal energy is mostly produced in the western states of the United States.

The thermal energy that is responsible for hot springs and geysers can be used to produce electricity.



Corn can be made into a biofuel.



**Combine and evaluate information** to explain which **renewable resource** would have the greatest **impact** in your community.

# Hydropower

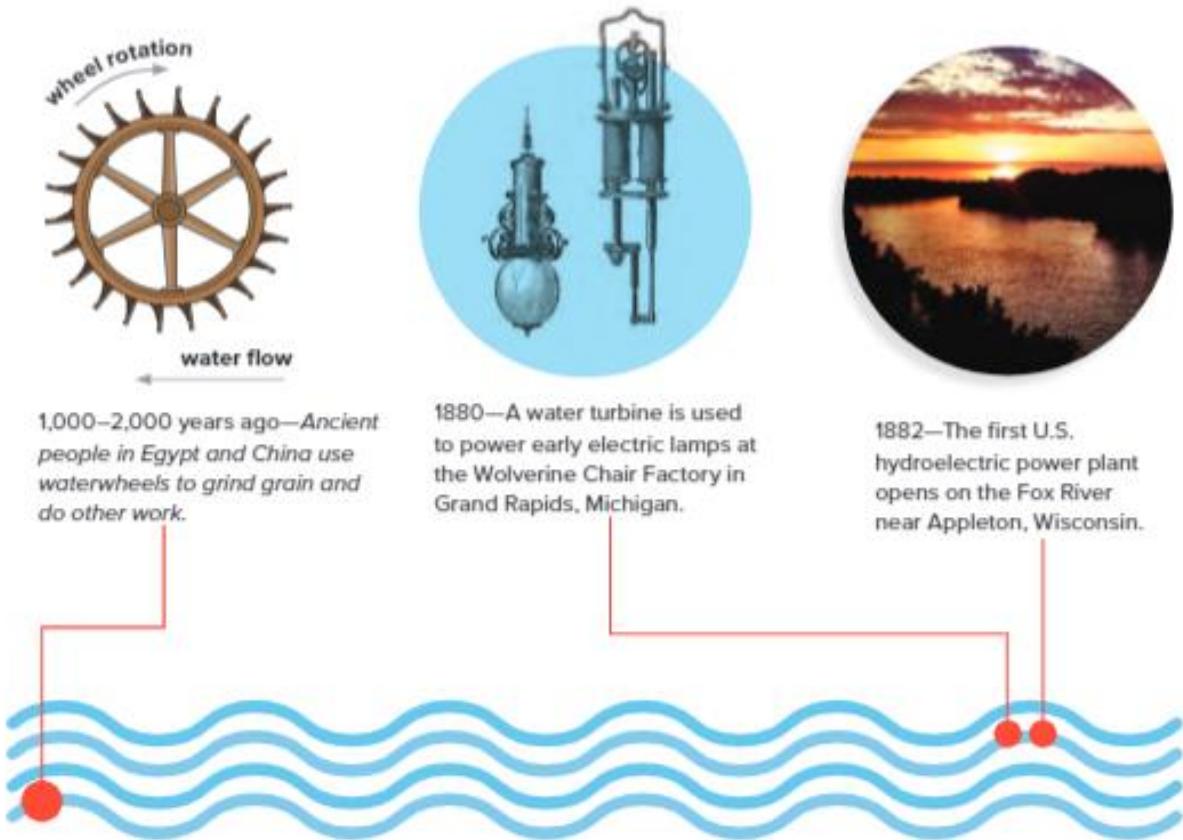
Water is another renewable energy source and an alternative energy source. Hydropower is energy that comes from moving water. Moving water is a valuable source of energy because it is readily available, plentiful, and easy to find. Many cities are located near bodies of water, which makes this type of energy very accessible. The state of Washington produces 30 percent of the nation's hydropower.

Hydropower is one of the oldest types of energy harnessed by humans. For many years, people have used moving water to help them do things such as travel and generate energy. Ancient people used this form of energy to turn wheels to grind grains. Before creating water-powered mills to grind grain into flour, people used hand tools for this task.



Grand Coulee dam in Washington State is the largest source of hydroelectric power in the United States.

## History of Hydropower



## Hydroelectricity

In the late 1800s, people used moving water to generate electricity. Electricity produced by waterpower is called **hydroelectricity**.

The water that produces this type of electricity is obtained from rivers, tides, and ocean waves. This water has kinetic energy, or energy from motion.

Like most electricity, hydroelectricity comes from a power plant. One that uses the kinetic energy of moving water is called a hydroelectric power plant. These plants are built near rivers or other water sources.

What type of energy change occurs at a hydroelectric power plant?

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 **GO ONLINE** Explore Renewable Energy for more information about geothermal and hydroelectric energy.



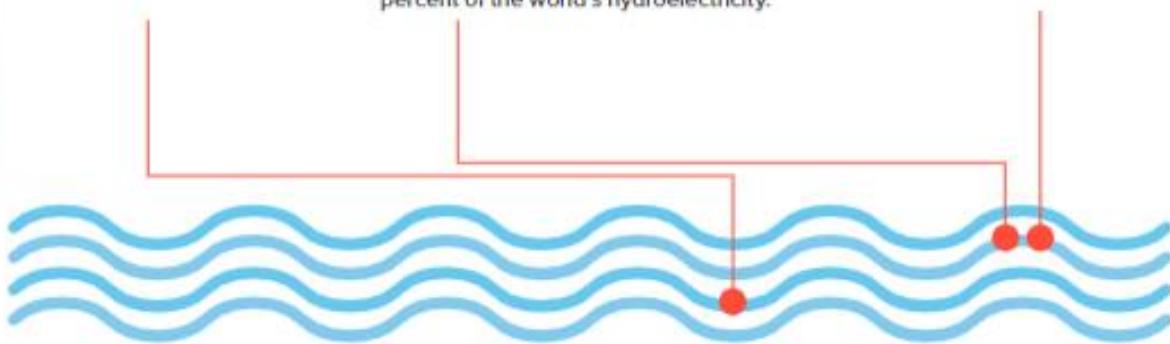
1949—Hydropower provides almost one-third of the United States with electricity.



2006—The United States, China, Canada, and Brazil are named the top countries for hydroelectricity production, together producing 44 percent of the world's hydroelectricity.



2008—The Aguçadoura Wave Park in Portugal becomes the world's first "farm" for capturing ocean wave energy.



# Wind Energy

Wind is a renewable resource and an alternative energy source.

Wind is formed as the Sun heats Earth unevenly. This causes some of the atmosphere to have areas with warm air and other areas with cooler air. Wind is formed as warm air rises and cooler air sinks.

Windmills harness the motion of the wind to generate electricity.

Windmills called wind turbines change wind's kinetic energy into electric energy. How? The blades are connected to a shaft that is connected to a generator. As the wind moves the blades, the generator converts the power of the wind to electricity.

Thirty-nine states currently have operating wind turbines. Mountaintops, shorelines, open plains, and valleys are good places for windmills. Wind towers are tall since winds are stronger at higher altitudes above the ground. Wind power generates 32 percent of the total electricity produced in the United States.

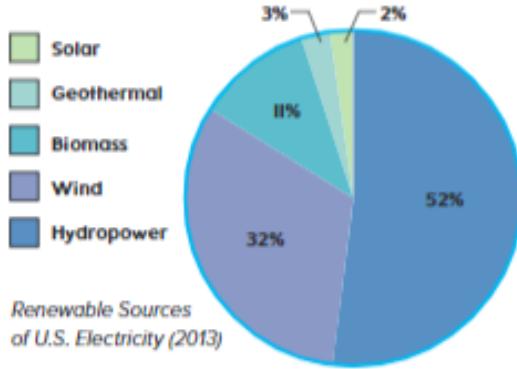
What does a wind turbine do?

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Wind turbines are made up of a tower, usually three blades, and a generator.



Hydropower and wind power are the most widely used renewable sources of electricity in the United States.

Copyright © McGraw-Hill Education. Image Source: Getty Images

## MAKE YOUR CLAIM

Which renewable resource is widely-used to generate electricity in the United States?

**Make your claim. Use your investigation.**



### CLAIM

\_\_\_\_\_ is the renewable resource that is widely-used to generate electricity in the United States.

**Cite evidence from the activity.**

### EVIDENCE

My research showed that \_\_\_\_\_.

**Discuss your reasoning as a class. Tell about your discussion.**

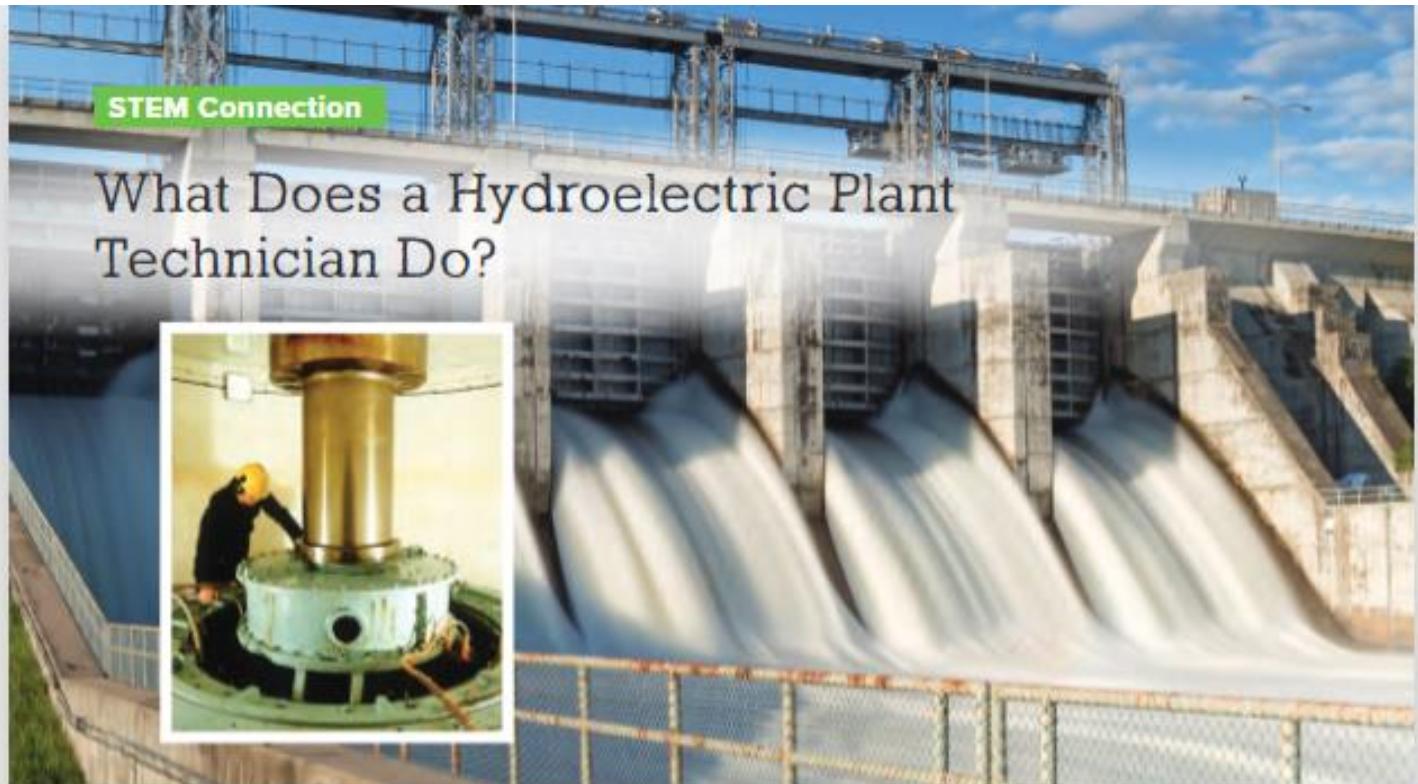
### REASONING

The evidence supports the claim because \_\_\_\_\_.

 You will revisit your claim to add more evidence later in the lesson.

## STEM Connection

# What Does a Hydroelectric Plant Technician Do?



Are you good at noticing small details? If you are, then you might want to become a hydroelectric plant technician.

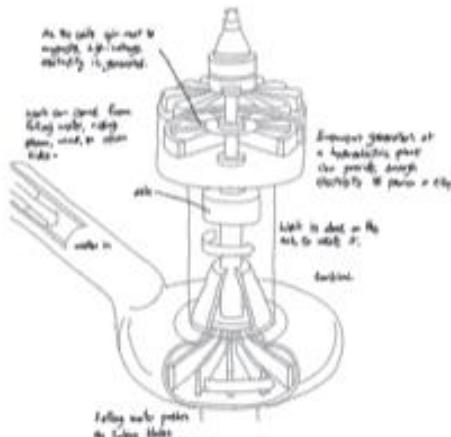
**Hydroelectric plant technicians** have to be very observant and detail-oriented. They work at power plants where electricity is generated using the movement of water. Technicians use computers to control the flow of water moving through a turbine. The drawing on the right shows how a turbine generates electricity.

### It's Your Turn

Think like a hydroelectric plant technician. Complete the activity on the next page to learn about the different energy demands in different parts of the nation.

### COLLECT EVIDENCE

Add evidence to your claim on page 115 about the type of renewable energy that is mostly used in the United States.



### Talk About It

Read the Investigator article *Underground Heat*, and use other resources to learn more about renewable energy. What information did you find interesting during your research? Share your findings with a partner.

## INQUIRY ACTIVITY

### Research

## Compare Energy Usage

Think about how we generate electricity. The electrical energy that people use can be measured in kilowatts per hour of electricity. Do all cities use the same amount?

**Ask a Question** Look at the data table. What question will your research answer?

### Carry Out an Investigation

1. Research the populations of the cities listed in the data table below.
2. Use teacher-approved online resources to investigate your question. Think of the factors that could contribute to the differences in energy usage among states.

City	Electricity Consumed in a Year per Person (kWh)	Population	Total Energy Consumed
Kansas City, MO			
Virginia Beach, VA			
Atlanta, GA			
San Francisco, CA			

### Communicate Information

3. Write a speech, draw a poster, create a flyer, or use media to present your findings to the class.



## LESSON 2

## Review

## EXPLAIN THE PHENOMENON

How can Earth's thermal energy be used?

### Summarize It

Look at the photo of the geothermal power plant. How can we use renewable energy to our advantage?

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### REVISIT



Revisit the Page Keeley Science Probe on page 105.



## Three-Dimensional Thinking

1. \_\_\_\_\_ is a useful material that is replaced quickly in nature.
  - A. An alternative energy source
  - B. A renewable resource
  - C. A nonrenewable resource
  - D. Coal
2. Wood is a renewable resource. What factors could cause wood to become scarce?

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3. What conditions would determine if hydropower or wind power should be used in your community?

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4. What weather conditions would affect hydropower plants?

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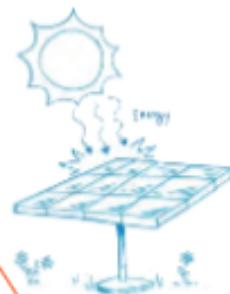
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## Extend It

Make a presentation that explains why people should use a certain type of renewable energy. Use the space below to plan your presentation. Present your research.

Listen to your classmates' presentations. Take notes below.



## KEEP PLANNING

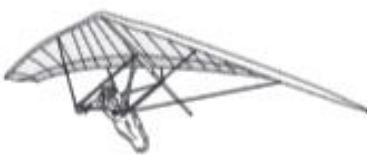
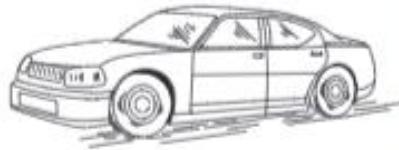
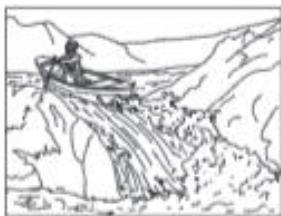
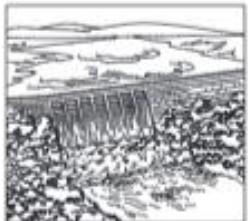
## STEM Module Project Engineering Challenge



Now that you have identified and know the uses of renewable resources, go to your Module Project to explain how the information will affect your plan for your solar oven.

### LESSON 3 LAUNCH

## Energy from Water and Air

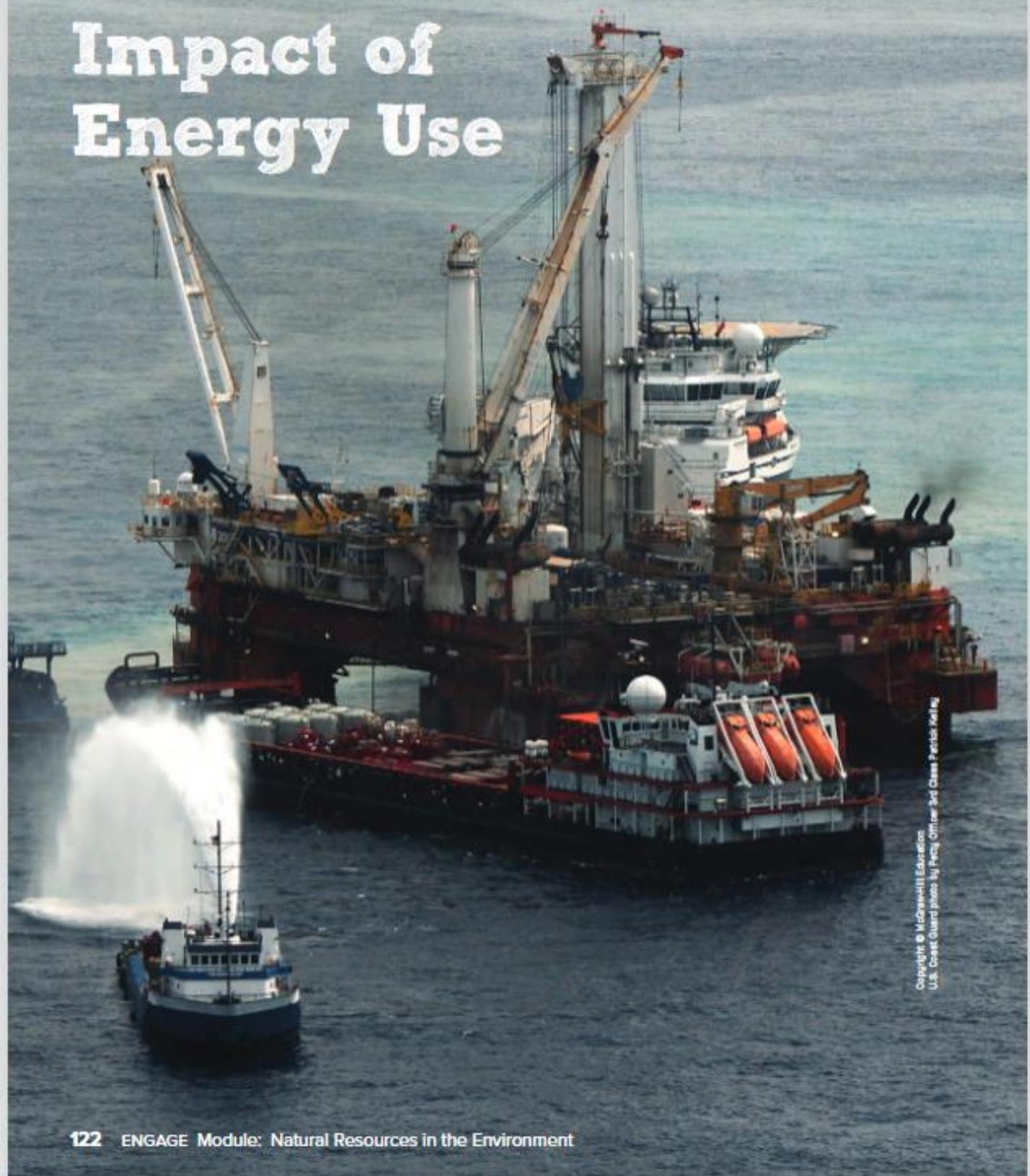


The energy from moving water and air can do many things.

Draw a circle around any of the pictures that show how we use the energy from moving water and moving air.

Explain your thinking.

# Impact of Energy Use



## ENCOUNTER THE PHENOMENON

What impact does the oil rig have on the ocean?



 GO ONLINE

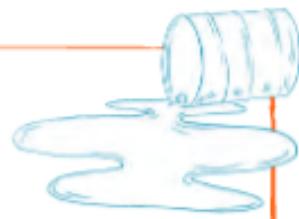
Check out *Oil Rig* to see the phenomenon in action.

### Talk About It

Look at the photo and watch the video of an off-shore oil rig. What do you observe? Talk about your thoughts with a partner. Record your questions or illustrate your observations below.

### Did You Know?

The largest oil spill in United States history occurred in 2010 in the Gulf of Mexico, where over 130 million gallons of oil were spilled into the ocean.



## INQUIRY ACTIVITY

### Hands On

## Oil Spill Cleanup

As you saw in the oil spill photo, sometimes accidents happen when obtaining and using resources. You will model an oil spill in an environment. Think about how the oil would affect the environment and the organisms in it. Your job will be to find a way to clean up as much oil as possible from the habitat.

**Make a Prediction** What materials are more effective in cleaning up an oil spill?

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Now you will develop a plan to test your prediction.

### Carry Out an Investigation

**BE CAREFUL** Do not eat or drink any of the materials. Wear safety goggles.

1. Fill the pan with water to the depth of 1 to 2 cm.
2. Your teacher will add an "oil spill" to your ecosystem.
3. Dip the bird feather into the oily water. Place on a paper towel.
4. Using the materials available, come up with a plan to clean up your oil spill. Use your prediction to guide your plan. Outline your plan here, and share it with your teacher before you begin.

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### Materials



safety  
goggle



aluminum  
pan with  
water



ruler



dark olive  
oil



bird  
feather



paper  
towels



dish  
detergent



plastic  
spoon



cotton  
balls



pieces of  
sponge



chenille  
stems

5. Follow your plan to test the different materials and cleaning methods.
6. **Record Data** Record the results of the different cleaning methods that you tested.

## Communicate Information

7. What materials worked best to remove the oil from the model habitat? Explain your answer.



 **Talk About It**

What are some improvements that you could make to this investigation?  
Discuss with a partner.



## INQUIRY ACTIVITY

8. Think of how difficult it was to clean up the habitat. Observe your feather from step 3. Plan and carry out an investigation on how to effectively clean the feather. Use what you observed when you cleaned the habitat.

### Plan

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### Results

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### Conclusion

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9. **ENVIRONMENTAL Connection** How do you think an oil spill affects wildlife in a habitat?

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**Evaluate** the information that you have **obtained** in this investigation. What variables can **affect** the **design solution** to an oil spill cleanup in the real world?

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## MAKE YOUR CLAIM

How does obtaining and using energy resources affect the environment?

**Make your claim. Use your investigation.**



### CLAIM

Obtaining and using oil can cause \_\_\_\_\_.

**Cite evidence from the activity.**

### EVIDENCE

The investigation showed that \_\_\_\_\_.

**Discuss your reasoning as a class. Tell about your discussion.**

### REASONING

The evidence supports the claim because \_\_\_\_\_.

You will revisit your claim to add more evidence later in the lesson.

## VOCABULARY

Look for these words as you read:  
conservation  
pollution

# Effects of Obtaining and Using Energy Resources

All organisms in an environment need clean air, water, and soil to survive. Obtaining and using some of our energy resources can have negative impacts on the environment.

## Pollution

Think back to the Inquiry Activity, *Oil Spill Cleanup*, and recall how an oil spill can have harmful effects on the environment.

**Pollution** is any harmful substance that affects Earth's land, air, or water. Burning fossil fuels releases particles that are one of the main causes of air pollution. Air pollution can cause breathing problems and eye irritation. Obtaining fossil fuels can also cause water pollution, as in 2010 when an oil rig in the Gulf of Mexico exploded.

Unlike fossil fuels, nuclear power plants do not pollute the atmosphere unless an accident occurs. However, accidents have occurred. The accidental release of radioactive material can pollute the air and cause cancer in living things. Also, the waste from nuclear power plants can remain radioactive for many years. These waste products must be stored.

Solar, geothermal, hydroelectric, and wind power do not cause air or water pollution. Burning biofuels, however, does cause air pollution.



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## Talk About It

What types of pollution can occur when humans obtain and use energy sources? Discuss with a small group.

## Habitat Loss

People work in coal mines or use giant shovels to dig away layers of rock and soil to obtain coal. People must drill into rocks to obtain oil and natural gas. These activities affect the land. Trees, plants, and topsoil are often removed to get to coal. Mining also creates pollution and destroys habitats. A habitat is a place where living things or organisms live.

The use of some renewable resources also can result in habitat loss or destruction. Dams are built on rivers to harness hydroelectric power. These dams can affect the animals that live in the water by changing their habitat. Some types of fish need to migrate up rivers to reproduce. Dams and other hydroelectric plant structures block the natural migration of certain fish.

Wind turbines can affect the habitat of birds. Birds can get hurt or killed when they fly into the blades of wind turbines.

### Read a Photo: Strip Mining

1. What has been cleared away in this strip mining operation?

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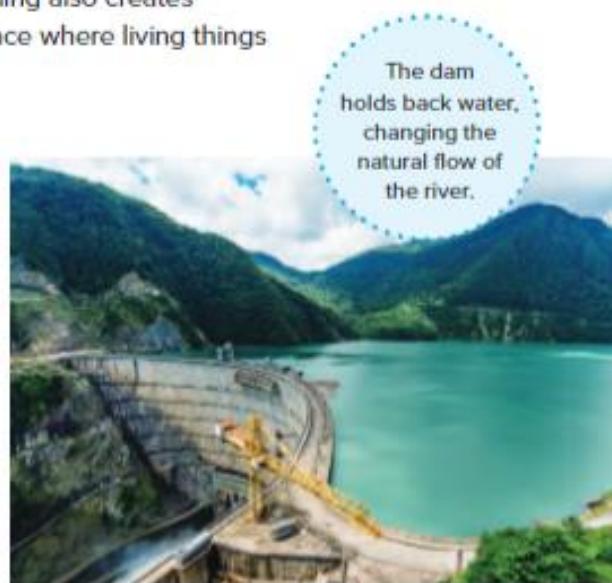
2. **ENVIRONMENTAL Connection**

How does burning fossil fuels affect the environment?

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## REVISIT



Revisit the Page Keeley Science Probe on page 121.

**GO ONLINE** Watch the video *Energy Use and the Environment* to see how energy use can affect habitats.

A teal circular button with the word "CLOSE" in white, bold, sans-serif capital letters. The button has a dashed border and a small white handle on the left side.

## READING

## Inspect

### Read the passage

*Pittsburgh's Transformation.*  
Underline the text that tells  
about how much steel was  
made in Pittsburgh in the  
1900's.

## Find Evidence

**Reread the text.**

Highlight the text that describes what Pittsburgh was like and how it changed.

## Notes



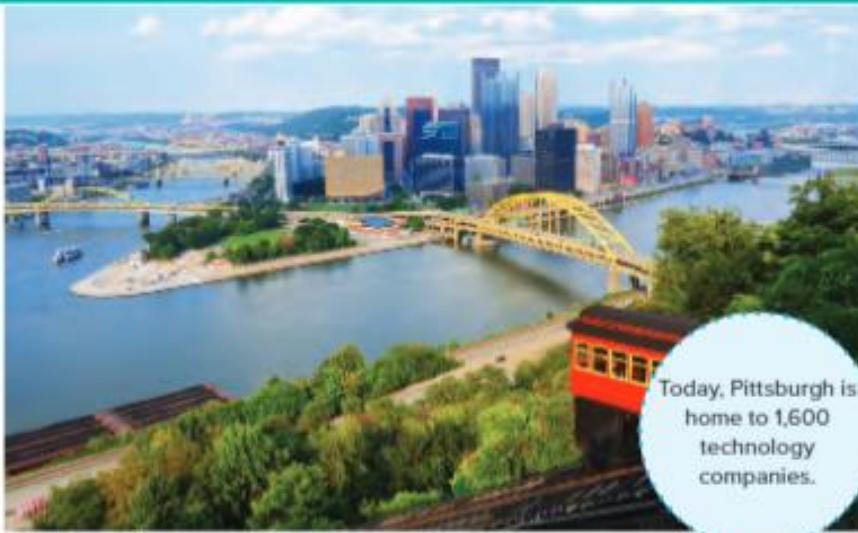
Coal and iron are needed to make steel. Both ingredients are mined from the ground.

## Pittsburgh's Transformation

The steel industry was one of the strongest economies in post-war America. Around the early 1900s, Pittsburgh produced between one-third to half of the country's steel. Industrial plants known as steel mills produced steel but also released thick clouds of soot. This black, powdery substance covered the city. This forced the city to keep the streetlights on even during the day. Soot also blackened houses and caused the city's rivers to look like open sewers or sludge. Workers enjoyed the high wages, so the pollution was tolerated.

During the 1970s, the city's steel industry started to slow down. Higher costs, increased competition, and lower demand for steel caused high unemployment and a decline in population. City leaders took action. They invested in state-run programs to attract new talent and new industries.

1. **ENVIRONMENTAL Connection** Why was pollution tolerated in the early 1900s?



Today, Pittsburgh is home to 1,600 technology companies.

Today, Pittsburgh is known as a pioneer in new technologies that use renewable resources. The city is trying new energy solutions. The use of renewable resources, or clean energy, has attracted educational, medical, and high-tech industries. It has also cleaned up the city, produced new jobs, and promoted economic growth. The renewable energy industry has employed 13,000 professionals in Pittsburgh.

Pittsburgh is an example of how communities can continue their economic growth while still protecting the environment through innovation and new technologies.

2. What decision taken by city leaders caused Pittsburgh's transformation?

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## Make Connections

## Talk About It

What did it take to get  
Pittsburgh to change?

## Notes

 **GO ONLINE** Watch the video *Air Pollution* to learn more about the causes and effects of air pollution.

## COLLECT EVIDENCE

Revisit your claim to add evidence from the lesson.

# Conservation

Many resources are being used more quickly than nature can replace them. Some cannot be replaced at all. **Conservation** is the act of saving, protecting, or using resources wisely.

People conserve resources in many ways. Planting trees helps conserve soil. Taking shorter showers helps conserve water. The “three Rs” also guide people in conserving resources. The three Rs are *reduce, reuse, and recycle*.

## Reduce

To reduce means to lessen the amount something is used. Paper is made from material that comes from trees. People can conserve trees by writing or printing on both sides of each sheet of paper. Running many errands at once instead of taking multiple trips helps reduce the amount of fuel used. Installing low-energy lightbulbs instead of standard ones helps reduce electricity used.

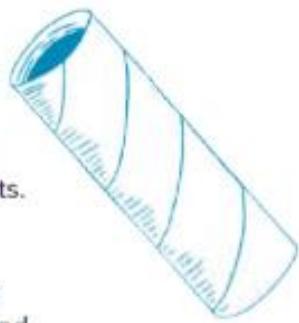


**1. Read a Diagram** Look at the diagram below. What are some ways people can conserve resources?

Guidelines for Energy Conservation	
 Turn off the lights when you leave the room.	 Turn off hot water when you aren't using it.
 Turn off electronic equipment when you aren't using it.	 Carpool or use public transportation whenever you can.
 Use water-conserving showerheads and take shorter showers.	 Turn the heat or air conditioning down when you are not home. Insulate windows and doors to prevent heat loss.

## Reuse

To reuse means to use something more than once. Cloth grocery bags are reusable. These bags replace disposable plastic or paper bags. Old T-shirts can be torn into strips and used as rags. Scrap paper can be saved and used for future art projects. Food scraps can be composted. Compost can provide nutrients for soil and plants.



## Recycle

When an item is recycled, it is made into a new product. People are encouraged to place recyclable materials, including metals, glass, and plastic, in separate bins rather than in the trash. These items are picked up and taken to a facility where they are cleaned and prepared for recycling. For example, plastic bottles can be recycled into fleece clothing. Recycling products keeps waste out of landfills and helps keep soil and water clean.

2. Give an example of how to reduce the use of resources.



## STEM Connection

# How Can I Become an Environmental Scientist?



Do you enjoy reading, being outside, and talking to people? If so, then a career in environmental science might be a good choice for you. **Environmental scientists** are scientists who use their knowledge to protect plants, animals, and human health. They understand the effects of obtaining and using different energy resources.

Environmental scientists must have good problem-solving skills. An environmental scientist might study how coal mining affects a local stream's water quality and organisms. They work to control or eliminate any threats like pollution or habitat destruction.

Environmental scientists usually find work at consulting **firms**, government agencies, and universities.



### It's Your Turn

Now you will think like an environmental scientist. Write an article telling others why it is important to make wise energy resource decisions.

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# Energy Choices

**WRITING Connection** Write a persuasive article for your local newspaper. Research where coal, oil, natural gas, solar, wind, water, and nuclear energy are derived from. Consider the positive and negative environmental effects of using each of the energy resources. Identify whether each energy resource is renewable and how human energy needs change.

Select one type of energy resource to recommend or avoid. Use the graphic organizer below to help plan your essay. Write your opinion as the main idea. Combine information from at least two sources. Use evidence as the details to support your opinion.

Write your essay on a separate piece of paper. Clearly state your opinion, and use convincing reasons to persuade the residents of your town to make wise energy resource choices. Ask your readers to take action.



**GO ONLINE** Explore the simulation *Energy Supply* to learn more about the effects of energy choices.





## LESSON 3

## Review

## EXPLAIN THE PHENOMENON

What impact does the oil rig have on the ocean?

## Summarize It

Explain how our use of energy resources affects the environment.

**REVISIT**  
PAGE KEELEY  
SCIENCE  
PROBES

Return to the Page Keeley Science Probe on page 121. Has your thinking changed? If so, explain how it has changed.

SCHOOL OF EDUCATION



## Three-Dimensional Thinking

1. Based on what you learned in this lesson, which energy resource would have the least impact on the environment?

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2. What methods could be used to reduce pollution in cities?

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3. Why is it important to conserve natural resources? How does this relate to Lesson 1?

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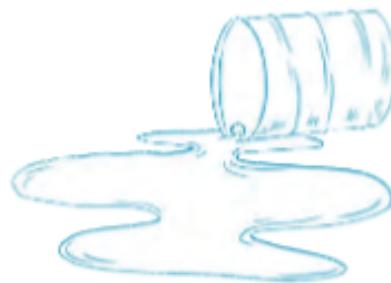
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## Extend It

Some nonrenewable energy resources are mined from the earth. That process can have negative effects on the environment. How can energy resources be mined while minimizing the negative impact on the environment? Write a proposal, draw a model, or use media to communicate your ideas on more environmentally friendly mining processes. Include information on how technology can be used to improve the mining process while reducing the negative effect on the environment.



## KEEP PLANNING

## STEM Module Project Engineering Challenge



Now that you have learned about the impact of energy use, go to your Module Project to explain how the information will affect your plan for a solar oven.

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## LESSON 4 LAUNCH

## Energy Transfer Engineering Problem

A group of students are working on an engineering project. They have to design a container that would slow down the transfer of heat. They each have different ideas about how to start the engineering process. This is what they said:

Georgie: I think we need to start by identifying all the materials and resources we can use.

Hal: I think we need to start by defining the engineering problem.

Martha: I think we need to start by building a model.

LaBron: I think we need to start by brainstorming possible solutions.

Whom do you agree with most?

Explain why you agree.

You will revisit the Page Keeley Science Probe later in the lesson.

LESSON 4

# Design Energy Solutions



These wind turbines are part of the nation's largest wind power facility.

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## ENCOUNTER THE PHENOMENON

What problem do  
the wind turbines solve?



 **GO ONLINE**

Check out *Wind Farm* to see  
the phenomenon in action.

### **Talk About It**

Look at the photo and watch the video of the wind farm. What do you observe? Talk about your ideas with a partner. Record or illustrate your observations below.

### **Did You Know?**

One wind turbine can power approximately  
500 homes!



## INQUIRY ACTIVITY

## Engineering

## Design a Windmill

You have learned that wind is an important source of renewable energy. Windmills make use of this energy. You will design a model windmill that will use wind energy to lift a weight. Your goal is to determine which windmill design will lift the weight the fastest.

**Make a Prediction** How will the number of blades used affect the speed at which the paper clip is lifted?

### Carry Out an Investigation

**BE CAREFUL** Wear safety goggles.

1. Cut the milkshake straw to about 2 cm shorter than the pencil. Put the pencil through the straw.
2. Use the template to build two windmills, each with a different number of blades. Attach the blades to the pencil with push pins.
3. Tie the paper clip to the thread. Tape the other end of the thread to the pencil, about 1 cm from the end, opposite the blades.
4. Hold the straw with the three-bladed windmill gently at the distance marked by your teacher. Hold the windmill in the air current.
5. Use the stopwatch to time how long it takes to lift the paper clip to the pencil. Record the data in the table for the three trials and calculate the average time.
6. Repeat steps 5 and 6 with the four-bladed windmill. Sketch and label your two windmills in the drawing box on the next page.



2 push pins

electric fan

## Materials



safety  
goggles



2 pencils



milkshake  
straw



masking  
tape



2 (50-cm)  
pieces of  
thread



**paper clip**



## stopwatch



2 push pins



### electric fan

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Type of pinwheel	Time to Lift Paper Clip(s) — Trial 1	Time to Lift Paper Clip(s) — Trial 2	Time to Lift Paper Clip(s) — Trial 3	Average Time to Lift Paper Clip(s)
3 blades				
4 blades				



**Design a solution** using a windmill to generate electricity. Identify the **energy transfer** in your model. Draw and label your diagram.



### Communicate Information

7. How was the energy from the fan used to raise the paper clip?

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### Talk About It

Compare and discuss your results with a classmate from another group. Do the results support your prediction? Explain.

## VOCABULARY

Look for these words as you read:

- constraint
- criteria
- design process
- prototype

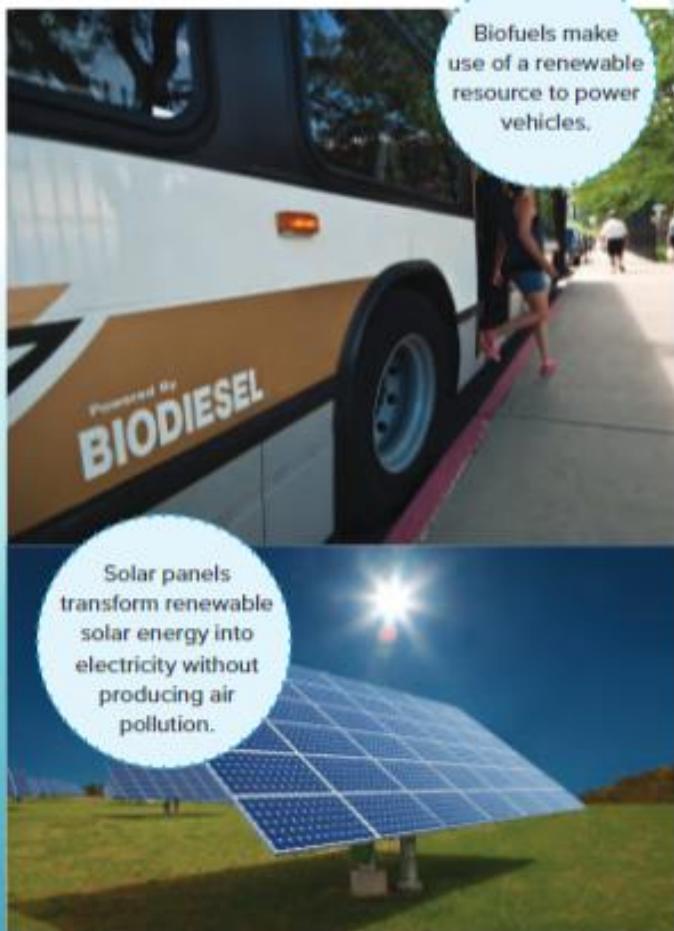
LED lightbulbs are designed to be much more energy efficient than incandescent or CFL bulbs. This means that they produce more light and less heat.

## Solve Energy Problems

In the Inquiry Activity, *Design a Windmill*, you designed a windmill to lift a paper clip. You used energy transfer to solve a design problem. Engineers use their knowledge of energy and energy transfer to solve design problems. Some problems are easy to solve. Other problems can be more challenging, such as using alternative energy to reduce the use of fossil fuels. Think about how energy transfer can be used to solve energy problems.

### Talk About It

Look at the photos below. Identify the source of energy in each photo. Discuss with a partner.



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 **GO ONLINE** Watch the video *Technology and Energy Transfer* to see examples of devices that transfer or transform energy.

## Energy Solutions

What happens to the ice in your drink on a hot summer day? It melts as your drink starts to warm up. Scientists are able to explain why the ice in your drink melts because of energy transfer. Engineers can use this information about energy transfer to help them design ways to solve the problem.



The vacuum-insulated mug was designed to keep the ice frozen and the drink cold longer.



Scientists and engineers have developed materials to slow down the transfer of energy from one object to another. Recall that a substance that slows down thermal energy transfers is called an insulator. Engineers are constantly trying to improve insulating materials. These materials can be used to keep hot things hot and cold things cold.

Design solutions involving energy transfer and transformation often involve making devices more efficient. That means minimizing energy transformations that result in waste. It might also mean minimizing the transfer of the desired types of energy. For example, energy-efficient lightbulbs produce more light and less heat. Insulation slows down the transfer of heat from inside a house to outside where it is cold during the winter. The reverse takes place in summer.

What problem does the vacuum-insulated mug solve? What scientific knowledge did engineers use to develop this solution?

# The Design Process

The engineering **design process** is a series of steps that engineers follow to come up with a solution for a problem. The process is usually thought of as a loop since engineers are constantly trying to improve technologies once they are created. The number of steps, and even the order of the process, can vary, but there are three main phases: define, develop, and optimize solutions.

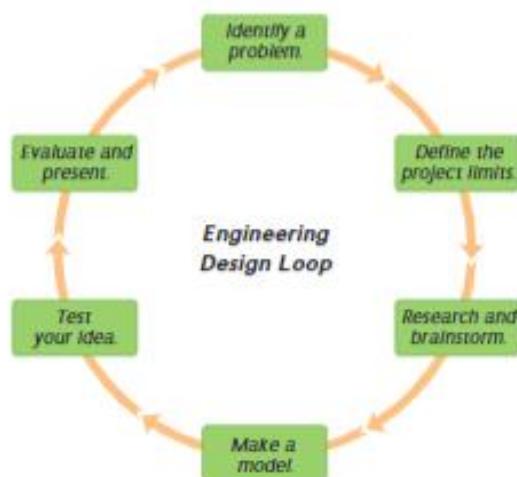
## Define Solutions

Within the define phase of the engineering design process, engineers describe the problem to which they are trying to find a solution. Engineers identify specific criteria for the design. **Criteria** are standards on which a decision may be based. The design will be tested based on these criteria. At this phase, engineers also describe possible **constraints**, or things that might limit a solution to a problem. Time, money, and materials are often constraints. They might research the effects of many different solutions. For example, engineers might need a cell phone battery to last two hours longer than current batteries. They know that making the battery larger will work, but size is a constraint so they need to think of a different solution.

## Label a Diagram: The Design Process

Identify the category that each step of the design process falls in.

1. Why is brainstorming an important part of the design process?



 **GO ONLINE** Explore the Design Process to see what happens at each step of the design process.

## Develop Solutions

The next phase of the engineering design process involves researching, brainstorming, and testing multiple solutions that might solve the problem. By exploring multiple solutions, engineers can weigh their options in terms of materials, cost, and other factors. Engineers usually work as a team to build models and test their designs. A **prototype** is an original or first model of something from which other forms are copied or developed. Engineers record data as they go so that they can make informed decisions.

## Optimize Solution

The engineering design process is continuous and focuses on improving solutions. The process involves improving successful solutions based on tests. If a solution fails, engineers can return to a previous step in the process to improve the design. Often, even a simple solution needs to be revised several times before it is reliable enough to use again and again.

2. Why should criteria and constraints be determined at the beginning of the design process?

New technology  
is constantly being  
developed to improve  
cell phones.



## STEM Connection

# What Does a Materials Engineer Do?



**Materials engineers** study the properties of different substances and use them to make new materials. They might work with metals, ceramics, or plastics.

Materials engineers use the design process to develop new materials to meet criteria. They might need to design materials for computer chips that can process more information more rapidly and still be affordable.

Some materials engineers work with other engineers to select the best materials for a particular design. They are always concerned with how the properties of the materials fit the use. If the wrong materials are selected, the design may not work well. After the materials are designed or selected, materials engineers test them.



### It's Your Turn

Now, you will think like a materials engineer as you build a solar circuit.

## INQUIRY ACTIVITY

### Hands On

### Build a Solar Circuit

Recall that solar cells collect light energy from the Sun and transform it into electricity. Solar cells are used in wristwatches and to power buildings. Think about how solar cells work.

**Make a Prediction** How will exposing the solar cell to different amounts of light affect a LED lamp?

#### Materials



solar cell with wires



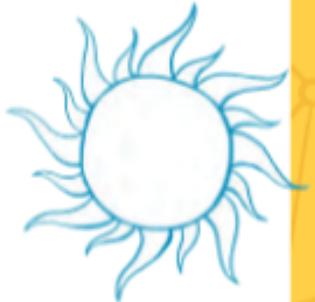
light socket with clips



LED lamp

### Carry Out an Investigation

1. Set your solar cell in a location with very bright sunlight.
2. Connect each of the lead wires from the solar cell to the light socket. Record your observations of the LED lamp in the table below.
3. Use your hand to block the light shining on the solar cell. Record your observations.



Light on Solar Cell	LED Lamp Observations
Full Sun	
Blocked Sun	

### Communicate Information

4. What do your results tell you about how to harness energy from the Sun?

### Talk About It

Compare your results with a classmate from another group. Do the results support your prediction? Explain.



## LESSON 4

## Review

## EXPLAIN THE PHENOMENON

What problem do the wind turbines solve?

## Summarize It

Explain what problem can be solved by designing and building wind turbines.

# REVISIT

 PAGE KEELEY  
SCIENCE  
PROBES

Revisit the Page Keeley Science Probe on page 139. Has your thinking changed? If so, explain how it has changed.

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## Three-Dimensional Thinking

1. Which of the choices is an example of a constraint?
  - A. The materials that are available to design the solution.
  - B. The safety of the workers.
  - C. The time needed to complete the project.
  - D. All of the above
2. How are failure points in the design process important when designing a model or prototype?

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3. Based on what you learned in the Inquiry Activity, *Build a Solar Circuit*, what was the purpose of the solar cell? Use evidence from the investigation in your explanation.

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## Extend It

## OPEN INQUIRY

Insulation can help slow the transfer of thermal energy.

It helps keep buildings warm in the winter and cold in the summer.

It can keep your drink cold or your soup hot. How else could insulation be used?

be used? Think of a problem that could be solved using a thermal insulator.

Describe the problem, criteria, and constraints. Identify a material to

use as an insulator, and draw and label your design on a separate sheet.



## KEEP PLANNING

## STEM Module Project

## Engineering Challenge



Now that you have learned about how the design process is used to develop energy solutions, go to your Module Project to explain how the information will affect your plan for your solar oven.



## STEM Module Project

### Engineering Challenge

# Build a Solar Oven

You've been hired as a solar energy engineer. Using what you have learned throughout this module, you will design and build a solar oven to heat water. Your goal will be to use sunlight to raise the temperature of 100 mL of water by at least 5°C in less than 30 minutes.



### Planning after Lesson 1

Apply what you have learned about energy from nonrenewable resources to your project planning.

What nonrenewable resources might solar energy replace in your solar oven as compared to a traditional oven?

Record Information  
to help you plan your model  
after each lesson.



ANTONIO  
Robotic Engineer



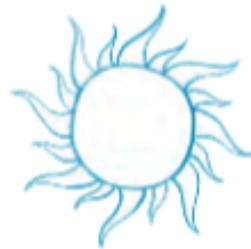
## STEM Module Project

### Engineering Challenge

#### Planning after Lesson 2

Apply what you have learned about energy from renewable resources to your project planning.

How will your understanding of solar energy affect your project planning?



#### Planning after Lesson 3

Apply what you have learned about the impact of energy use to your project planning.

What effects will using your solar oven have on the environment?

## Planning after Lesson 4

Apply what you have learned about designing energy solutions to your project planning.

What criteria about energy transfer do you need to consider to design your solar oven?

## Research the Problem

Work in groups to research solar ovens and how solar energy is used around the world. Go online to teacher-approved websites, or find books on solar energy at your local library. Combine information from at least three sources.

Source	Information to Use in My Project

## Sketch Your Model

Use a separate piece of paper to draw and label your ideas. Specify the initial and final forms of energy in your sketch. Also, identify the device that will transform the energy. Select the best solution to test.

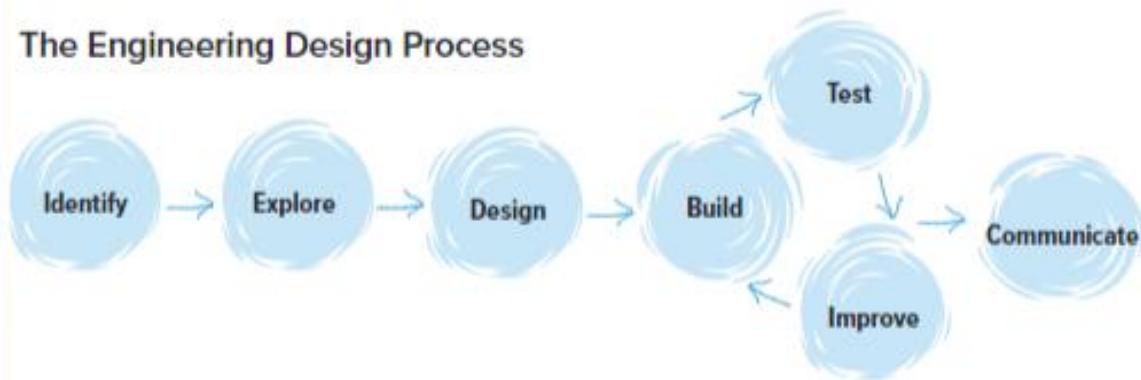




## Build a Solar Oven

Look back at the planning you did after each lesson. Use that information to complete your final module project. Work in small groups to design a solar oven.

## The Engineering Design Process



## Build Your Model

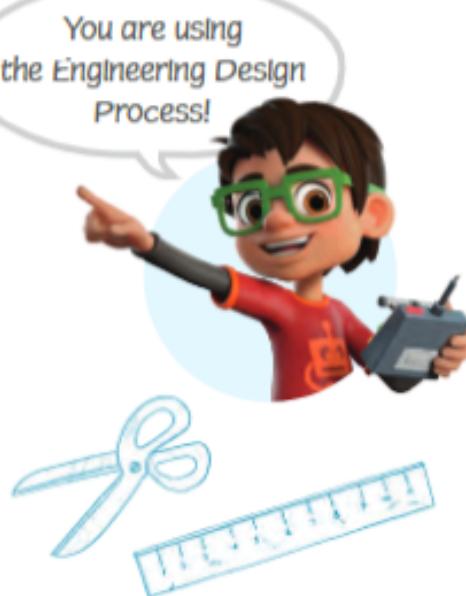
1. Your solar oven must raise the temperature of the water at least 5°C within 30 minutes.
2. Define the materials and constraints for building and testing your model. List the materials in the space provided.
3. Use your project planning notes to build your model.
4. Write clear steps to test your model.
5. Test your device. Evaluate your solution.
6. Identify any problems, and modify your procedure, materials, or design as needed to improve the solution.

## Materials

### Procedure:

## Test Your Model

Build and test your model. Record your observations and results. Use a data table if you need to.





## STEM Module Project

### Engineering Challenge

## Communicate Your Results

Share the plan for your model and your results with another group. Compare how quickly each of your solar ovens was able to heat the water  $5^{\circ}\text{C}$  above the starting temperature. Communicate your findings below.



## MODULE WRAP-UP

### REVISIT THE PHENOMENON

Using what you learned in this module, explain how the car gets its energy to move.



Revisit your project if you need to gather more evidence.



Have your ideas changed? Explain.

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