science generation

DELIVERING POWER TO THE PEOPLE

SCIENCE ACTIVITIES

SUPPLEMENTARY ACTIVITIES FOR OTHER CONTENT AREAS

FOCUS WORDS

Overview

Unit 8.3

This unit introduces students to the concepts of energy, energy transformation, conservation of energy, and the generation of electricity. Focus words for the unit are transformation, generate, power, fuel, efficiency, conservation, charge, and current.

The unit begins with a conversation between three students discussing new exercise bikes and the fact that the bikes generate electricity to power digital displays. In this Reader's Theater, students write their own definition of power, refining it as they learn more. Students learn that power is a unit ratio equal to work (joules) per time.

Tracing a variety of energy systems, students discover that energy can be transformed and conserved. In session 2, students learn about the development of one of the first electrical generators. In the following session, students expand their understanding of generators as they explore how various types of electrical power plants work. Students create graphs and manipulate data about the relative power capacity of actual power plants. Students are challenged to apply facts about power plants to their everyday life and to make a stand about which types of power plants they think should be built in the U.S. Students present their findings to the class and write persuasive essays.

In the math activity, students have the opportunity to decide which type of light bulb they would recommend to their parents. An ELA and a social studies activity complete the unit. The word chart on the last page of the unit should be used as a resource for students throughout the week.

Reader's Theater

Bike Power

Setting: Hamza and Cooper are sitting in the school cafeteria discussing some new equipment they saw in P.E. class the previous period. Olivia walks up and joins them.

Hamza: I hate them.

Cooper: I think they're great! Perfect for me to work out for my triathlon.

Olivia: What are you guys arguing about?

Hamza: Those stupid exercise bikes they just put in the gym.

Olivia: So Hamza, you're not into cardio fitness?

Hamza: P.E. is for sports! What does fitness have to do with it?

Cooper: Well, I think it has everything to do with it. The bikes are there to get more students into shape. Not everyone is into sports like you are.

Olivia: I haven't seen this equipment yet. Is it new?

Cooper: Yeah, Coach Thompson said they were supposed to come in at the beginning of the year, but since she wanted the kind that doesn't plug in, they took longer to get here from the factory, I guess.

Hamza: Wait, they have to plug in somehow. They need some way to get **current**. Didn't you see that they have a digital readout and a place to **charge** your phone? That's the only cool thing about them!

Cooper: That's just it! The **power** it takes to light the display comes from spinning the pedals around.

Olivia: You mean there's a **generator** inside the bike that turns motion into electricity?

Cooper: Right.

Hamza: That's ridiculous. You can't create electricity just by spinning something around.

Olivia: I have one word to say to you, Hamza...

Hamza: Yeah?

Olivia: Windmill.

Hamza: Oh, yeah.

Cooper: She so got you, dude.

Hamza: But a windmill is huge! Bike pedals can't do what windmills do.

Olivia: True. Bike pedals can **charge** your phone and light up the display, but wind turbines can put out a megawatt. That's enough to **power** 500 houses!

Hamza: Mega what?

Cooper: Watt. Not what.

Hamza: What?

Olivia and Cooper: WATT!

Cooper: You know what a watt is. Ms. Q went over that last week.

Hamza: Oh, *watt*! Like with light bulbs. Why didn't you just say so? I remember that from when we made **generators** in science class. That was kind of fun.

Olivia: Right, and remember how Ms. Q wouldn't tell us why we needed that cardboard tube from the toilet paper rolls?

Cooper: Hamza didn't listen and brought a full roll to school! *(They laugh.)*

Hamza: I forgot about that part. I did get a lot of weird looks on the way to school that day.

Olivia: ANYWAY, so windmills have a bigger version of **generators** that **transform** kinetic wind energy to electrical energy.

Cooper: That's like the **transformation** from the kinetic energy of pedaling to electrical energy on those COOL bikes that Hamza hates.

Hamza: Okay, I guess I don't *hate* them... In fact, maybe if we sat on those bikes in all our classes instead of sitting at desks that we could supply **power** to the whole school.

Olivia: Hmmm.... Very cool idea, but do you really think we could sustain that long term? Seems like we'd get tired.

Cooper: We'd definitely have to **fuel** up with a good breakfast and the occasional energy bar. But I'm trying to picture myself learning algebra on a bike. I don't know if I could concentrate.

Teacher Directions, Session 1

pages 2-6

Reader's Theater

Choose three students to read the parts of Hamza, Cooper, and Olivia in the Reader's Theater. The dialogue appears on pages 2 and 3. The Reader's Theater is an informal introduction to the concepts of power and energy. The students discuss exercise bikes that are in the school's gym.

Prior to reading, explain to students that they will be introduced to new vocabulary terms and ideas that may not be familiar. Reassure them that this is okay. The reading is meant to introduce the ideas, not explain them completely.

Consider previewing the images before reading. Ask students what they think the two pictures represent and whether the pictures provide clues about what they will read. Students may not be familiar with exercise bike displays or simple generators. Ask them where else there are generators (on a car). Ask what function they serve on a car (to generate or produce electricity to recharge the battery).

When Olivia tells Hamza that windmills generate electricity from spinning, you may want to pause to discuss this with students. If there is a nearby windmill farm, it may be helpful to refer to it during the reading. Also ask students if they have seen lights on a bicycle that are lit up by a small wheel that spins on the bike wheel. (Bike light generators aren't so common anymore!)

It may help students to consistently use the verb "generate" when discussing how electricity is produced.

Reader's Theater

Bike Power

Hamza: *(more excited)* But think of all the energy we would **conserve**! Plus, if we got solar cells and windmills on the roof we'd be like *Rockin' Renewable Middle School* baby!

Olivia: Fun ideas, Ham, but I say we reduce our use of electricity instead of going crazy with all that stuff. We can start with light bulbs.

Hamza: Booooring!

Cooper: No, it's true. We already have the technology to make more light using less electricity. They're called energy-**efficient** lights. They cost more, but they last longer and use less **power**. Hamza, you might even be able to light one up with the watts you create pedaling one of those COOL new bikes in P.E.

Hamza: Not so cool.

Olivia and Cooper: Cool!

Hamza: Okay. Maybe a little cool.

In the Reader's Theater, Cooper says, "The **power** it takes to light the display comes from spinning the pedals around."

TURN AND TALK

In this situation, what does **power** mean? Come up with a tentative definition and write it below as Version 1.

Definition of **power**:

Version 1: ______________________________

____

Version 2: ______________________________

____

Version 3: ______________________________

____

Version 4: ______________________________

____

Reader's Theater, continued

You may wish to interrupt the reading to discuss some of the terms.

Students may not understand the word transformation. Point out that in this context, it refers to changing from one type of energy to another.

Students can infer the meaning of sustain from the sentence (maintain or keep up). Synonyms include maintain, support, bear, endure, and uphold.

"Power" appears multiple times and is the focus of the rest of the Reader's Theater. Ask students for an informal definition and to use it in a sentence. However, don't give a formal, scientific definition at this time.

If the reading was interrupted by clarifying terms, choose three other students to reread the passage without interruptions.

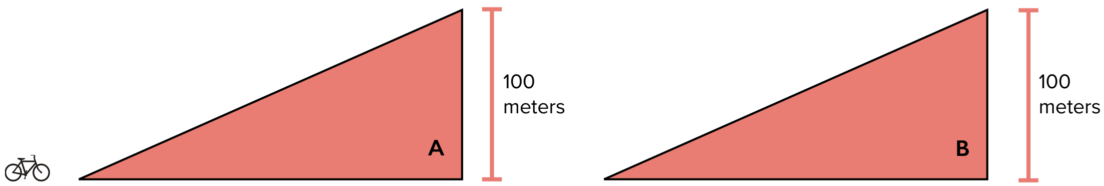
Read the sentence prompt ("In the Reader's Theater…") aloud and the Turn and Talk and the question itself. ELL students may not know the word "tentative." Ask students what it means to say, "I told my friend, 'I think I can go to dinner with you on Friday. Let's make a tentative plan to meet at 7 o'clock.' "

Tell students that they are not expected to have a scientific definition of power, but to write what they think it means. The idea is that as they learn more, they will revise their definition of power, with a total of four versions.

Give students 30 seconds to discuss the definition of power with their partner or group and 2 minutes to write their definition. If you wish, call on some students to share their definitions.

More About Power

Biking Uphill



Look at the diagrams above of two identical hills and a bicycle.

If you pedaled the bike up Hill A and then later up Hill B, which time did you do more work?

Neither, of course! It's the exact same task each time.

Okay, here is where things get a little weird:

Let's say you rode up Hill A in 1 minute and Hill B in 2 minutes. Which time did you do more work?

- ☐ Hill A in 1 minute is more work.
- ☐ Hill B in 2 minutes is more work.
- ☐ Both situations are the same amount of work.

It's still the same amount of work. Really! Yes, it was probably much more difficult to pedal up Hill A in one minute than it was to pedal up Hill B in 2 minutes. But that doesn't matter when you're measuring work.

Huh?

You are probably thinking: "But why is it more exhausting to pedal up a hill fast?"

Hmmm... You're on to something here. The 1-minute climb up the hill and the 2-minute climb up the hill were indeed different situations. But how?

TURN AND TALK

Which takes more **power** to pedal up?

- ☐ Hill A in 1 minute takes more **power**.
- ☐ Hill B in 2 minutes takes more **power**.
- ☐ Both situations use the same **power**.

It definitely took more **power** to pedal up Hill A in 1 minute. Go back to your tentative definition of **power** on the previous page and revise it. (Write your updated definition as Version 2.)

More About Power

Students are asked to consider the work and power required to pedal a bike up two identical hills. The first question asks which hill requires more work. (In this scenario, the rider took 1 minute to climb the first hill and 2 minutes to climb the second). The second question asks which hill required the most power.

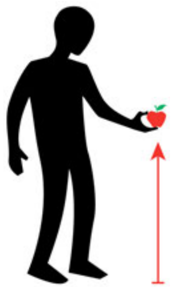
You may wish to review what students learned in Unit 8.2 about force and work. You could do this before reading this page, or prior to answering the first question. Review the fact that when a student pushes against a door, force is involved. The standard unit of measurement of force is a newton. On an object that weighs 1 kilogram, gravity exerts a force of about 9.8 newtons. In physics, work is defined as force times a distance traveled. When a student pushes against a door, if the door doesn't open, there is no work being done, only a force against the door. But if the door opens, there is work. Work must include some movement.

Give students a moment to answer the first multiple-choice question (about work) before reading on to the provided answer.

Have students talk to their partner and agree on an answer for the second multiple-choice question (about power.) Read the final paragraph that reveals that more power was used on the first hill. Now instruct students to apply what they learned about power and to write a second definition of power on page 3 next to "Version 2." You can ask students to share their second version of their definitions. If any definition includes a reference to time, tell the class that this definition is on the right track; it is a good tentative definition.

More About Power

Crunching the Numbers



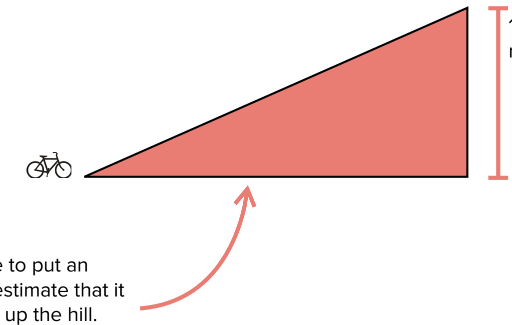
Let's recap.

It's the same amount of work to pedal up each hill, but it takes more **power** to pedal up the hill faster.

You might remember that work is measured by newton-meters, or joules. One joule is the amount of work it takes to raise something that weighs one newton a distance of one meter. What's something that weighs about a newton? Let's say an apple.

one joule, or

1 J



100 meters

ten thousand joules, or

10,000 J

Based on the idea that it takes 1 joule to put an apple on a shelf, let's make a rough estimate that it takes 10,000 joules to pedal the bike up the hill.

Now, let's think again about your 1-minute climb up Hill A and your 2-minute climb up Hill B:

FAST climb up Hill A: $\dfrac{\text{10,000 joules}}{\text{60 seconds}}$

SLOW climb up Hill B: $\dfrac{\text{10,000 joules}}{\text{120 seconds}}$

WAIT!

TURN AND TALK

Before you do the math, THINK! Which one is going to be the larger number? Will this number match the situation that you think takes more **power**?

Go back to your tentative definition of **power** on page 3 and revise it. (Write your updated definition as Version 3.)

More About Power, continued

Students are first reminded the unit of measure for work is a joule. The amount of work to ride up the hill is estimated in context of the work of lifting an apple on to a shelf. The estimate is 10,000 joules.

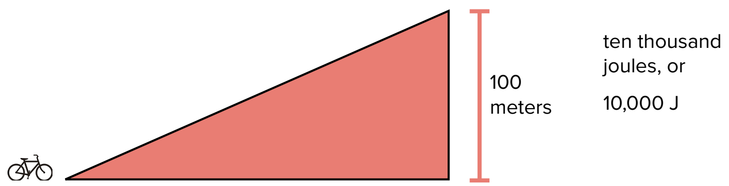
Students are then asked to think about the work involved for both hill-climbing situations. The ratio of work to time is discussed. The ratio is first written using the word "to" and then as a fraction. Ask students to recall what a rate that has 1 in the denominator is called. (unit rate) Ratio, rate, and unit rate are generally 6th and 7th grade concepts so they should be understood in this context.

Emphasize that by dividing numerator by denominator the answers will have a 1 in the denominator, so the unit rates can be compared. The goal is to determine which is greatest. Before calculating the unit rate, ask students to estimate their answers and choose which number will be greater. Page 6 presents the answers to the calculations.

Finally, students are asked to write a third definition of power. Some students will realize that the unit rates are the power used to climb the hills.

More About Power

Conclusions



FAST climb: $\frac{\text{10,000 joules}}{\text{60 seconds}}$ SLOW climb: $\frac{\text{10,000 joules}}{\text{120 seconds}}$

$10000 \div 60 = 166.67$

$10000 \div 120 = 83.33$

These two numbers tell you a lot! They describe the **power** of the slow climb and the **power** of the fast climb. **Power** describes how quickly work is getting done.

So, when you pedaled up the hill slowly, you did 10,000 joules of work with a **power** rating of 83.33. When you pedaled up the hill quickly, you did 10,000 joules of work with a **power** rating of 166.67. But what is the unit for measuring **power**? *Watt!*

Reread this section of the Reader's Theater.

Olivia: Bike pedals can **charge** your phone and light up the display, but wind turbines can put out a megawatt. That's enough to **power** 500 houses!

Hamza: Mega what?

Cooper: *Watt*. Not what.

Hamza: What?

Olivia and Cooper: WATT!

Cooper: You know what a watt is. Ms. Q went over that last week.

Hamza: Oh, *watt*! Like with light bulbs. Why didn't you just say so?

Watts are used to describe the amount of **power**. If you pedal up a hill faster, it takes more watts. If a light bulb uses electricity faster, it takes more watts. The engine of a car might use 100 kilowatts (100,000 watts). And the wind turbine that Olivia mentioned is not using watts, but rather supplying watts to homes. A megawatt is one million watts.

Go back one more time to your definition of **power** that you wrote several pages back. Revise it one more time as Version 4, and make sure your definition works with this equation:

$$\textbf{Power} = \frac{\textbf{Work}}{\textbf{Time}}$$

More About Power, continued

The calculations to determine which climb required the greatest power are shown at the top of this page. The two resulting unit rates can be compared because both have 1 in the denominator.

10,000 joules / 60 seconds or 166.67 joules / 1 second is greater than 10,000 joules / 120 seconds or 83.33 joules / 1 second. Therefore it takes twice as much power to ascend the first hill.

Consider reading this page with the entire class. Pause to clarify any questions. Reiterate that a watt is a unit of measure of power, and that watt is a unit rate (1 watt = 1 joule per 1 second).

Before reading the final paragraph, ask students if they know how many watts are in a typical light bulb. This wattage will provide a point of reference for the definition and size of the units. Consider asking how many typical light bulbs a windmill that generates 1,000,000 watts could light up.

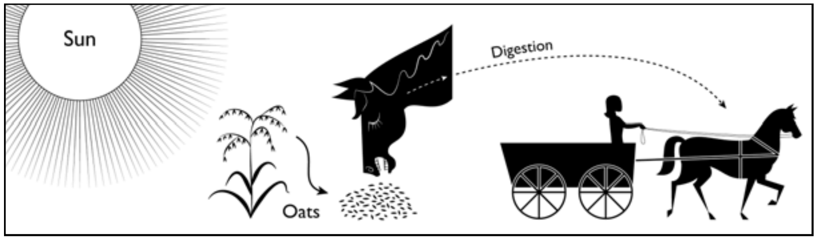
At the end of the page, students are asked to define power for a final time. As before, students will write their response on page 3. It is helpful if, when reading the definition of power, the fraction bar is read as "divided by." So the definition is "power equals work divided by time."

Speaking Scientifically

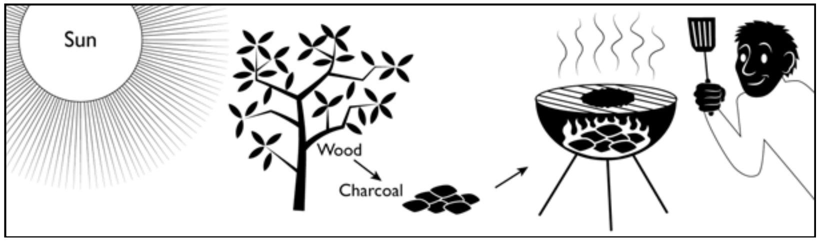
"Generating" electricity? Really? You decide...

Energy can be **transformed** from one type into another, but it can't be made from nothing. And it can't disappear. This idea is called "**conservation** of energy." But **conservation** of energy is different from "**conserving** energy" – a phrase we use a lot to refer to using energy without wasting it.

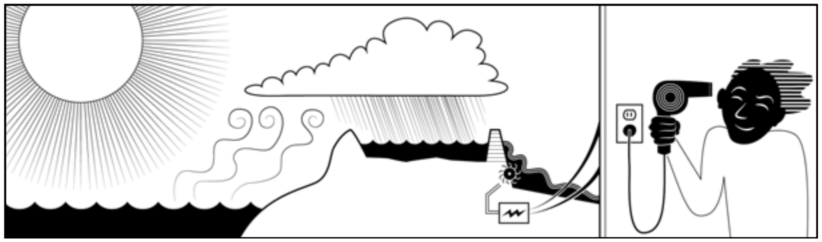
To get used to the idea of **conservation** of energy, try tracing energy as it moves through a system.



Write a caption to describe the flow of energy through this system:



Write a caption to describe the flow of energy through this system:



Write a caption to describe the flow of energy through this system:

Teacher Directions, Session 2

pages 7-10

Speaking Scientifically

Students are introduced to the concept of conservation of energy. Energy cannot be made from nothing. It can't be destroyed, but it can be transferred.

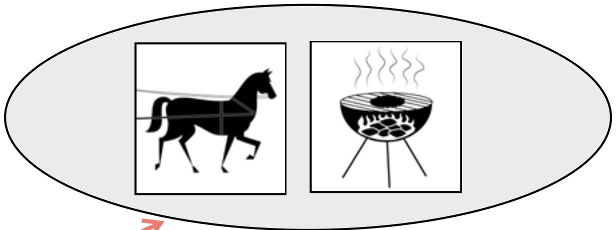
Three images are presented where energy is used: a horse pulls a wagon, charcoal cooks a burger, and a hair dryer is on full blast. For each image, students are asked to "trace" (or follow) the transfer of energy and describe the transfer of energy as a caption for the image.

In the whole class setting, briefly discuss what the first image portrays. If students don't know where to begin, consider completing the caption for the first image together. It may help to ask students to follow the transfer of energy backwards. You may wish to instruct students to use arrows to indicate how the energy is transferred. This activity could be done individually, in pairs, or in groups.

Here are a few possible answers.

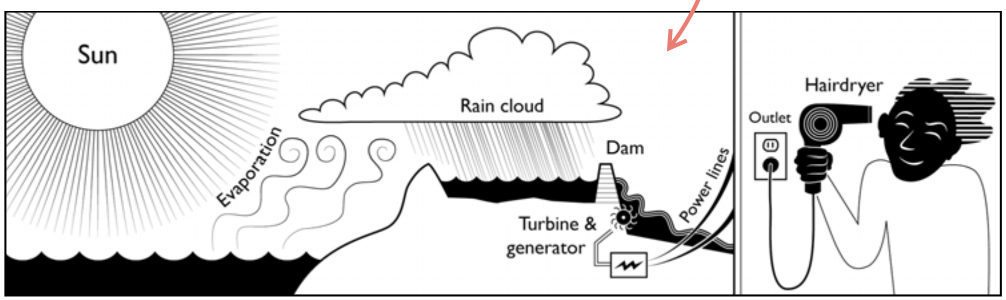
- The leaves of the plant turn energy from the sun plus carbon dioxide into sugars and oxygen using photosynthesis. The horse eats plants and gains energy. The horse then performs work when it pulls the wagon.
- Sun's energy → photosynthesis makes the tree grow → tree is burned in pit with little oxygen → charcoal is burned → meat is cooked on the grill.
- The sun's energy causes water to evaporate from oceans and lakes. Next the water cycle causes rain to fall. A lake fills up. Water flows from the lake through a power plant. Electricity flows through power lines and into a house. A boy plugs in his hair dryer and the dryer heats up and blows air.

Speaking Scientifically



A very important part of these two systems is that the charcoal and the oats both have stored energy in their chemistry (**fuel**). The horse **transforms** that chemical energy into kinetic energy by digesting the oats. In the second example, the cook **transforms** the chemical energy into thermal energy by setting the coal on fire.

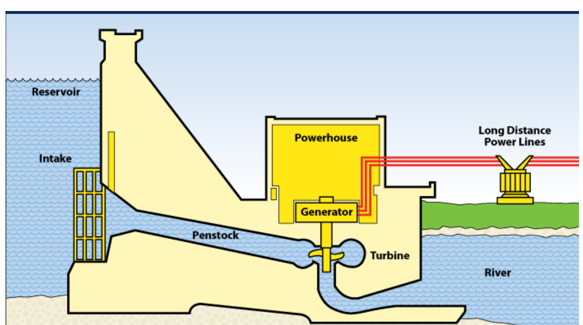
Let's take a closer look at the hair dryer system. How does this person's hair dryer get the energy to dry their hair?



TURN AND TALK

In the system to the right, the dam's powerhouse **transforms** the kinetic energy of the rushing water into electrical energy. How does this happen?

Locate the **generator** and the turbine in the diagram. Describe the flow of energy in this system.



Source: Tennessee Valley Authority.

Speaking Scientifically, continued

Read the text and emphasize that both the charcoal for the grill and oats for the horse are fuels; they are stored chemical energy. The horse's digestive system transforms chemical energy into kinetic energy and burning the charcoal transforms chemical energy into thermal energy.

Students are next asked to describe the flow of energy in a hydroelectric power plant. Before students turn to talk about this prompt, it will help to determine what prior knowledge students have about dams, power plants, and turbines. If they have a fair idea of how they work, don't provide any further clues. If students have little prior knowledge, consider asking: "There are turbines in power plants in dams. Turbines in dams are deep inside. But you have probably seen a turbine. Where would that be?" (Answer: on a jet plane or a turbo-charged car engine.) Ask how turbines create power (they rotate rapidly). Then ask how that power is turned into electricity. Ask students to look at the diagram to offer the answer (the turbine rotates the generator and the generator produces electricity).

Give students 1 minute to discuss the prompt with partners, or in groups, and 2 minutes more to write a response. Then ask students to share their responses with the class. Discuss the merits of the various responses.

Students should recognize the steps: water falling rotates a turbine, the turbine turns a generator, the generator produces electricity, and electricity flows along power lines. In subsequent activities students will be asked to include descriptions of the type of energy transformed. Here a simpler explanation is fine.

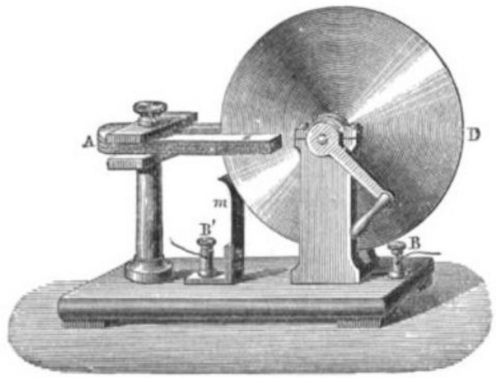
Sample response: Water sits in a lake behind a dam. Then the water rushes from the lake through the dam and down to a river. Inside the dam the rushing water flows through a turbine. The energy from the falling water spins the turbine. The turbine then turns a generator and the generators produce electricity. The electricity flows through a power station and then onto high voltage power lines to another power station inside a city. From there, the electricity flows through more power lines and into houses.

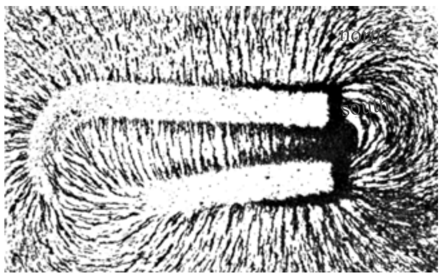
Speaking Scientifically

Michael Faraday (1791–1867)

What are the basics about generators?

Take a look at the **generator** below. It is called the Faraday Disk. It was one of the first examples of a machine using a magnetic field to **generate** electricity. Michael Faraday first constructed it by mounting a magnet on a stand. The magnets were shaped so the spinning disk could fit between the north and south poles of the magnet. While this contraption seems pretty simple, it can actually turn motion into electricity!





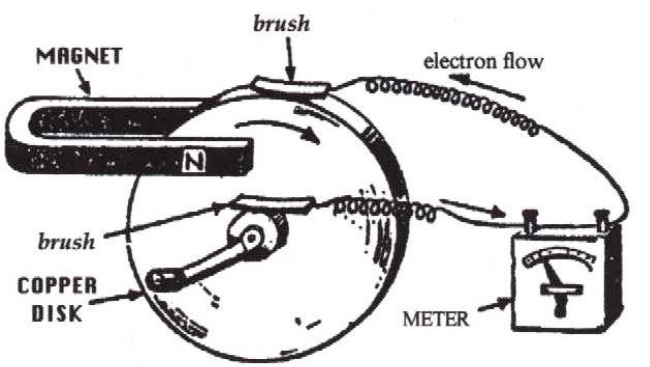
U-shaped magnets with the poles close together create stronger magnetic fields.

Here is another illustration of the same type of machine. The crank shown in this illustration is for spinning the disk to create the flow of electric **current** that can travel away from the **generator** to **power** other things, like the meter shown. **Generators** like this one use magnetic forces to make electrons move.

TURN AND TALK

Trace the energy flow in the illustration.

Discuss how a similar system might light up the display on a stationary bicycle.



Speaking Scientifically, continued

This page introduces how generators work. Having just considered huge hydroelectric power plants, students now turn to the first generator built by Michael Faraday.

Read the first caption with the whole class and ask students if they see any similarities between the generator at the dam and this one. Something is spinning and both make electricity. Ask what differences they notice. This one spins by hand, not by a turbine, and it is a lot smaller! Point out to students that this is an old drawing and the letters probably had labels. Ask students if they can guess what A, B, D, and m stood for. A is the magnet, B is a post to hold the electrical wire, and D is a spinning disk. If they have read ahead, they will realize that m probably is a brush.

Next discuss the picture of the magnet. Ask what the black wavy lines are (metal shavings that are lining up along the magnetic fields).

Point out that the third drawing is an early generator, but it shows only the working parts. To ensure students look carefully at the drawing, ask them what the “N” on the magnet represents. Then ask them what might be on the other side of the magnet that they can’t see.

Read the Turn and Talk. It may be best to first spend a minute or two only on the first prompt: Trace the energy flow in the second illustration of the Faraday disk. Students could respond in writing or verbally.

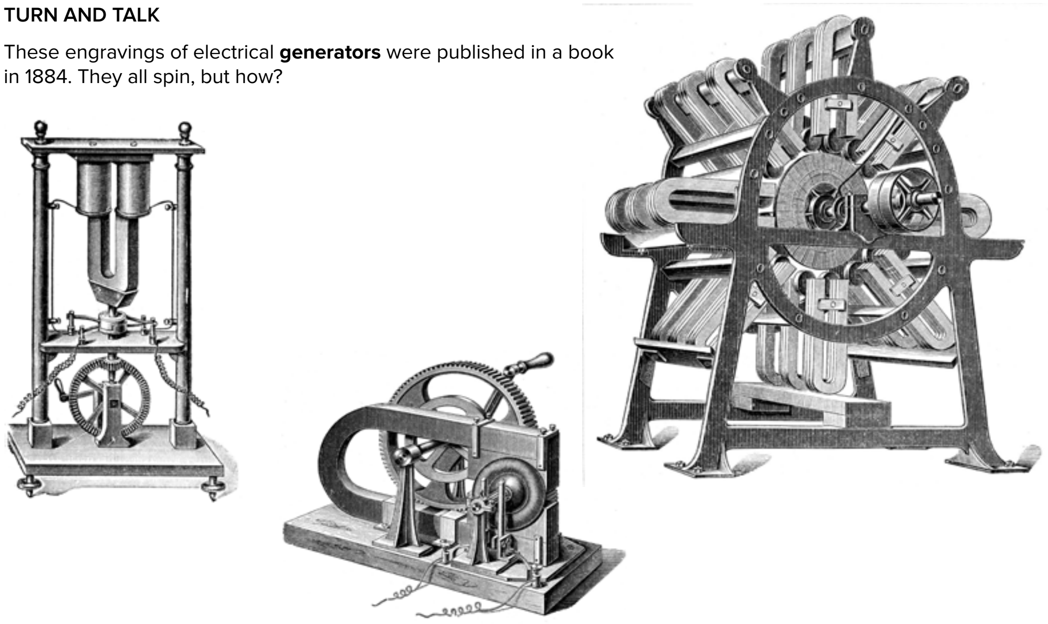
A complete answer would mention that the handle is turned using kinetic energy from a person’s arm. That kinetic energy is transformed into rotational kinetic energy by the spinning disk. The copper and the magnet work together to transform the kinetic energy into electricity. The brush near the handle picks up the electricity. The electricity moves from the brush through the meter and completes the electrical circuit by going to the other brush.

After sharing responses to the first Turn and Talk prompt, ask students how a similar system could light up a display on an exercise bike. To get started, ask them what kind of “system” they will describe (a generator). A generator could have a small wheel that rides against the rim of the bike wheel. Inside the generator, a copper disk spins around a magnet, and brushes pick up the electricity. Wires take the electricity to the display. Share responses with the class.

Speaking Scientifically

TURN AND TALK

These engravings of electrical **generators** were published in a book in 1884. They all spin, but how?

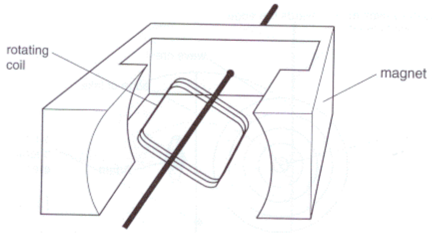


Avoiding the work of spinning by harnessing nature's kinetic energy...

Hamza's idea of providing energy to the school by pedaling the stationary bikes seems interesting, but is it practical? People have been thinking for many, many years about ways to spin magnets, disks, or copper wire coils in order to **generate** electrical energy. Some great ideas have emerged, and most of them involve turbines. Turbines are machines that make it possible for some other force (besides human energy!) to spin the parts of a **generator**. Usually turbines are fitted with something flat that's pushed by water or air and set up at an angle so that it spins. A pinwheel toy is a simple version of a turbine.

Now think about attaching the pinwheel toy to this simple **generator**. What would you need to make this work?

What you're imagining is actually a tiny windmill that **generates** electricity. Windmills are a great example of people figuring out a way to make something in nature do the work of spinning, instead of having to do it ourselves.



Speaking Scientifically, continued

The discussion about generators continues with a look at generators built about 200 years ago.

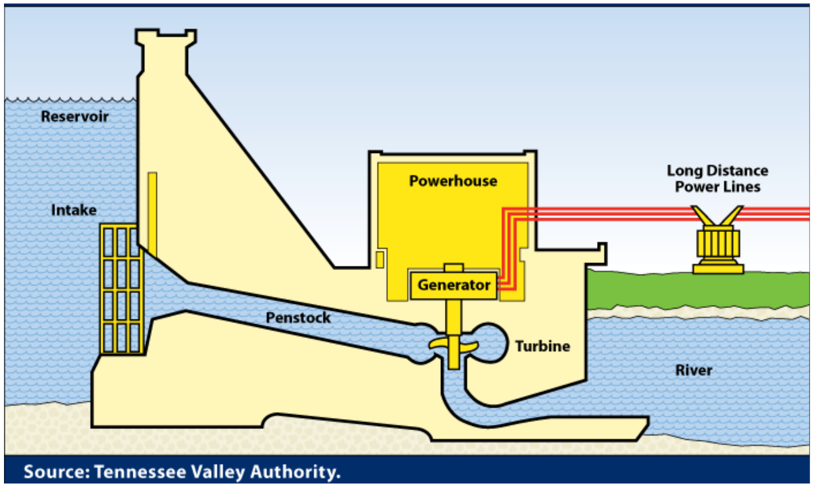
Have the whole class read the page together and ask the class what powers the three antique generators. "Do you think they make more electricity if they spin quickly or slowly?" "What would make them spin quickly?" "How large would you guess that they are?"

Ask students: "Hamza's idea of providing energy to the school by pedaling the stationary bikes seems interesting, but is it practical?" Tell students that they know how many watts a light bulb needs, so how much electricity would all the lights in a school use? What else in the school uses electricity? What is a good estimate of the total watts (or kilowatts) a school might use? Then discuss how many watts a bicyclist could create. Go back to page 6 for an estimate!

Read on and have students discuss why a pinwheel is like a turbine. Then ask how a pinwheel could be attached to the simple generator that is shown at the bottom of the page. Ask if such a system could produce much electricity. Tell students that on the next page they will see an example of a very large windmill that generates a large amount of electricity.

Spinning Turbines

Here are some ways people use nature to spin turbines:



Hydroelectric

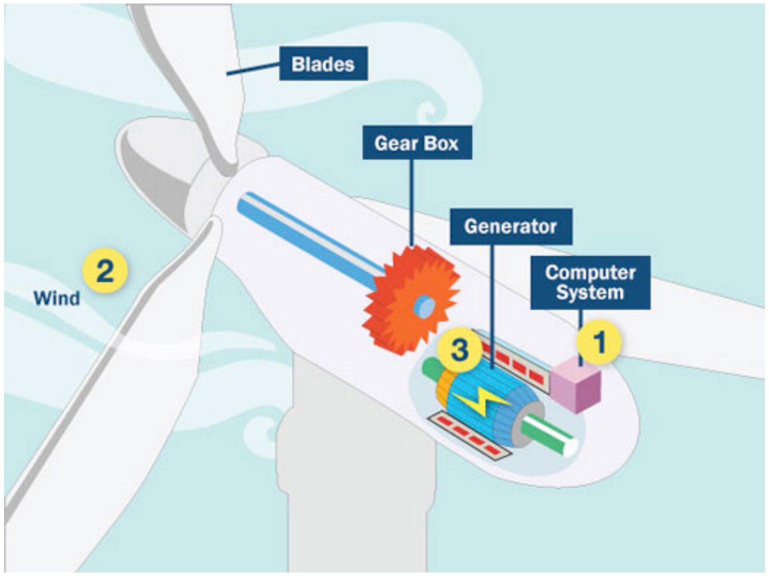
This is a diagram of a hydroelectric **power** plant. Can you see how it works? What kind of energy **transformations** are happening here?

Trace and describe the energy **transformations** with a partner.

Wind Turbine

Here is a diagram of a wind turbine. Can you see how it works? What kind of energy **transformations** are happening here?

Trace and describe the energy **transformations** with a partner.



Teacher Directions, Session 3

pages 11-13

Spinning Turbines

On page 11 are two drawings of how natural, renewable resources (falling water and blowing wind) turn turbines and produce electricity.

You may choose to have small groups or partners read and complete this page without a whole class discussion. It may help to first reiterate that "trace" means to "follow." Also challenge students to describe what type of energy is being transferred. Remind them that they know the terms kinetic energy and potential energy. Give students 5 to 10 minutes to read the prompts, discuss, and write their responses. Then ask students to share their responses with the class.

For ELL students and others, point out that the word "hydroelectric" is made from two 2 words, *hydro* and *electric*. Hydro is the ancient Greek word for water.

You may choose to have student groups or pairs continue on to page 12 where students are asked to trace the energy transformations of a third power plant – this one is a coal-fired thermal plant.

Here is one possible response to the first discussion prompt. Water sits in a dam with gravitational potential energy. Then the water rushes from the dam down to a river with a huge amount of kinetic energy. Inside the dam, the rushing water flows through a turbine and spins it. That gives the turbine rotational kinetic energy that turns a generator. From the rotational kinetic energy, generators produce electricity. The electricity flows through the power station and then onto high voltage power lines to another power station inside a city. From there it flows through more power lines and into houses.

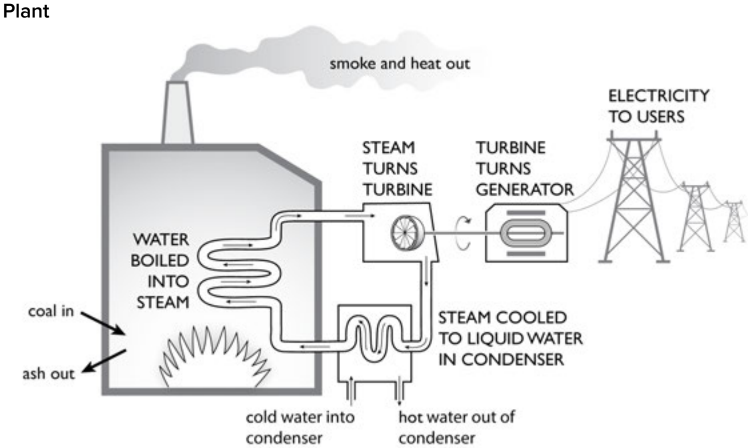
For the wind turbine, a student may answer: The potential energy of air is all around us. When the wind blows, the air has kinetic energy. That energy turns the blades of the windmill. The blades have rotational energy that turns the shaft of the gear box (it is blue). Then, the shaft turns then gears. The gears work like the gears on a bike or car and make the generator spin quickly. Next the generators take the rotational kinetic energy and make electricity. The electricity is controlled by the computer and runs on wires down the support post of the wind turbine.

Thermal Power Plants

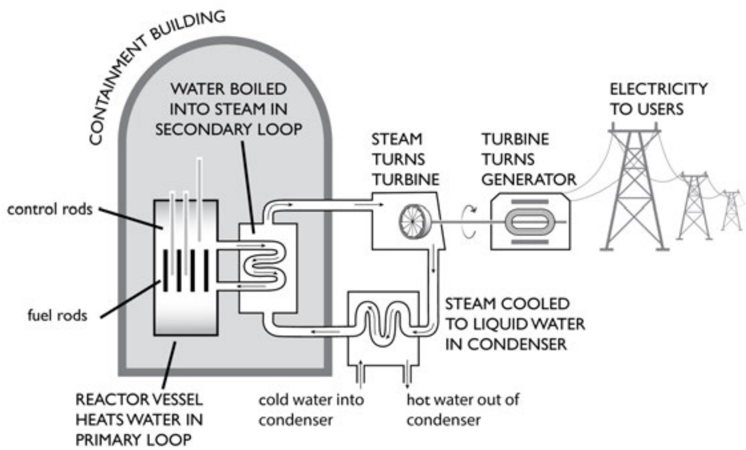
Below are diagrams of thermal **power** plants. Can you see how they work? What kind of energy **transformations** are happening? Can you explain how steam plays a role in these systems?

With a partner, trace and describe the energy **transformations** in the coal-fired **power** plant and the nuclear **power** plant. What is the same? What is different?

Coal-Fired Power Plant



Nuclear Power Plant



The system in the coal-fired thermal **power** plant burns coal to heat water. The boiling water creates steam that spins turbines. There are also thermal **power** plants that heat water using other methods than burning coal. A nuclear **power** plant uses uranium that has been made into nuclear **fuel**. Other common methods in the United States are burning natural gas, burning oil, burning trash, and sometimes even burning the gases given off at landfills.

Thermal Power Plants

Students continue to examine the flow of energy in power plants. This power plant is a coal-fired thermal plant. As on page 11, it may be best to read the prompt as a whole class and then encourage pairs or groups to describe how energy is transferred within the system. Perhaps remind students about the picture of the person using charcoal to grill dinner. Charcoal is similar to coal; they are both plant-based fuels. Allow 3 to 5 minutes for students to discuss and write about energy transformations. Students could use arrows to signify the transformations.

A possible response is:

Coal is made from plants and trees pressed over millions of years. The chemical energy of coal is turned into thermal energy when it is burned. The thermal energy heats up water and turns it to steam. The steam has kinetic energy as it rushes over the blades of the turbine. The turbine has rotational kinetic energy as it turns. The turbine turns a generator. The rotational kinetic energy produces electricity. As with other power plants, electricity is carried to wherever it is needed by power lines.

Encourage students to share their answers and discuss for a few minutes with the whole class.

Other Electricity Methods

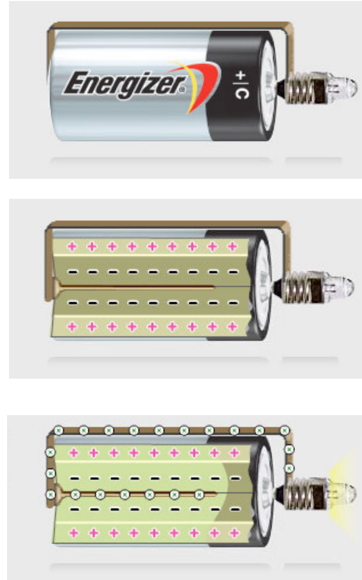
Most of the electricity we use comes from spinning turbines, but not all of it!

Consider Batteries:

A chemical reaction inside of a battery starts when you complete the circuit with a wire or with a device like a flashlight or battery-**powered** toy.

In batteries we put certain chemicals close enough to each other to react, but also keep them separate from each other so the reaction is controlled.

The battery contains a collector that looks like a tiny rod that picks up the electric **current** and carries it out along an external circuit.

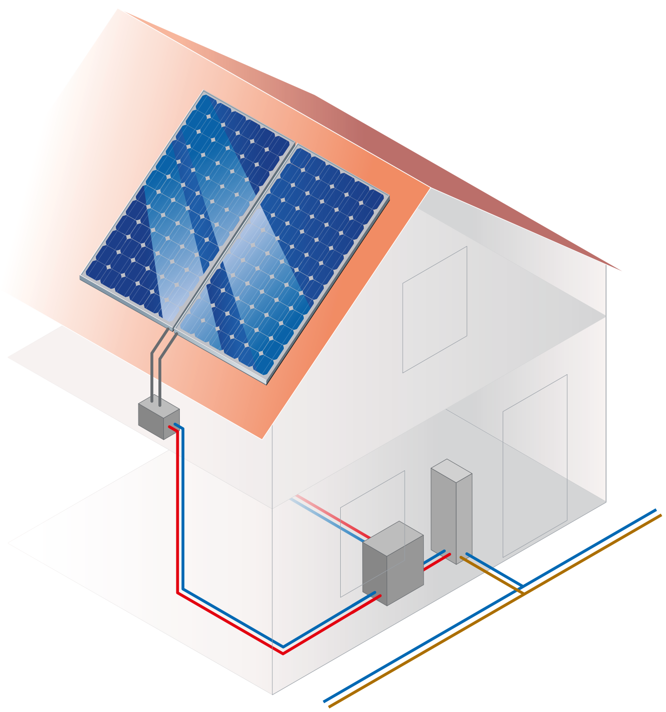


Consider Solar Cells:

Solar cells don't use spinning turbines, either.

In solar panels, light energy is transferred to some of the electrons, freeing them to move.

That electricity can quickly be made available for all of the electrical appliances within a home. In fact, if a house with solar cells **generates** more electricity than it uses, the electricity can move out to the national grid so other homes can use it.



Other Electricity Methods

Continue to read page 13 with your whole class after finishing page 12.

After reading the section on batteries ask for a volunteer to explain what is going on in the images. The pink pluses indicate chemicals with positive electrical charges and the black negative signs indicate negative charges. The circles with a green dot symbolize electricity flowing from the battery, around the wire on the outside of the battery, and illuminating the light.

Students may be interested in what chemicals are in batteries. Common batteries like the "C" battery shown have alkaline manganese dioxide. Car batteries use lead and sulfuric acid. Cell phones and laptops use nickel and cadmium. You may wish to point out that all used batteries must be recycled as the chemicals are toxic.

Most students are familiar with solar panels that capture sunlight and convert it into electricity. The text states that excess "electricity can move out to the national grid." You may need to clarify that the "national grid" is all the connected power lines in the United States. Of course, excess electricity can also be stored in batteries. In fact, for any house that is "off the grid," with no connection to power lines, batteries must be used to store electricity from solar panels. For students interested in learning more, there are many sources online. This link below is from the US Department of Energy. It involves a bit of reading, but is thorough.

http://www.eia.gov/kids/energy.cfm?page=solar_home-basics

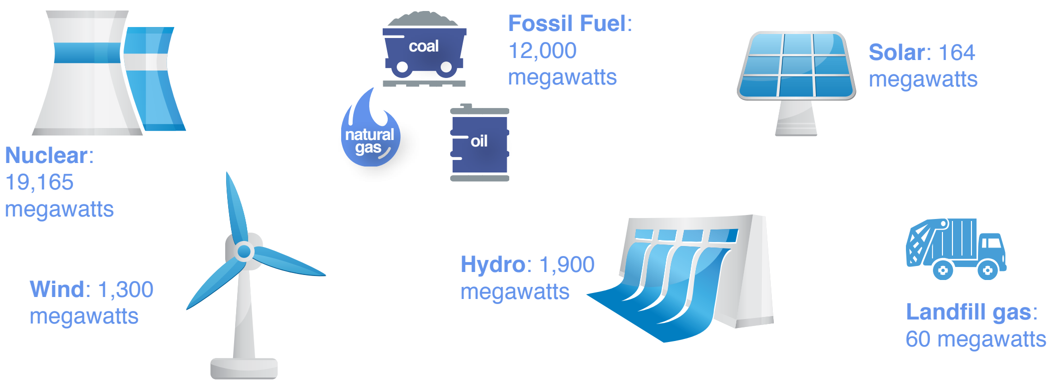
Energy Discussion Groups

Let's take a closer look at one American city's electricity supply.

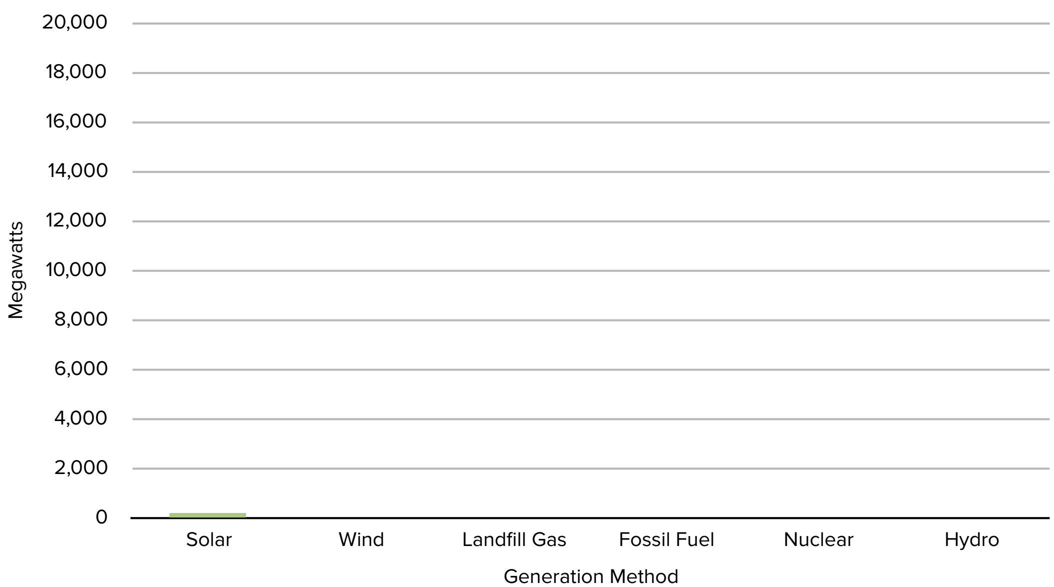
Baltimore, Maryland

A company called Baltimore Gas and Electric (BGE) is in charge of supplying electricity to the people of Baltimore. BGE is owned by a larger company called Exelon.

Exelon is a very important supplier of electricity all over the United States. In a report Exelon published in 2012, the company shared many important facts about how much electricity it **generates** and its methods of electricity generation.



Note the amount of **power** supplied by Exelon's various methods of **generating** electricity above. To get a sense of how the quantities compare to each other, transfer the data above to the graph below. The first one has been done for you.



Teacher Directions, Session 4

pages 14-15

Energy Discussion Groups

Consider reading the instructions for pages 14-15 as a whole class and then have students work in pairs or groups to complete the activity on each page.

The goal of the activity on page 14 is for students to understand the different types of power plants that produce electricity and the relative amount of power that is generated by a power company from different sources.

Read the two paragraphs and discuss points that students may not be aware of. BGE, like all power companies, does 3 things: they own power plants that produce electricity, they sell electricity to homes and businesses in a large geographical area, and they connect their electrical lines to the national grid, so they can sell power to other power companies, too.

Review the icons and the number of megawatts generated by each power plant. Discuss why coal and oil are "fossil" fuels. (Coal and oil are fossils and plants of animals from millions of years ago.) You may wish to ask why these icons are used for this type of power plant. (The can-like icons for nuclear power symbolize the huge towers used to cool the steam back to water. They actually don't hold the nuclear material or the turbines.)

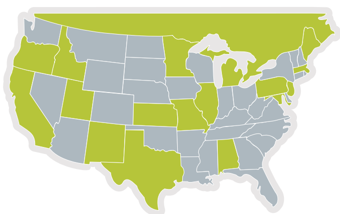
Help students put these numbers in perspective by asking if they recall how many homes can be served by 1 megawatt of power. Refer students to page 2 if they don't remember that 1 megawatt can serve 500 homes. (Of course industry and businesses use considerable more electricity that a house.) You may wish to challenge students who finish early to determine how many homes each type of power source could serve.

Students create a bar graph using data from the icons. The first bar is drawn. It shows the number of megawatts generated by solar power. Have a pair of students share their bar graphs with the class.

Energy Discussion Groups

Look over the list below that the Exelon company provided in its 2012 report. With a partner, look for patterns to determine which facilities **generate** more electricity and which facilities **generate** less. Do you see trends? Which types of facilities are the most powerful?

Generation Facilities



ALABAMA

- Gas: Hillabee (Combined Cycle), 740 MW

CALIFORNIA

- Hydro: Malacha *(Ownership Interest Only)*, 16 MW
- Solar: SEGS *(Ownership Interest Only)*, 8 MW

IDAHO

- Wind: Idaho Wind, 4 Projects, 128 MW

ILLINOIS

- Nuclear: Braidwood, Unit 1 - 1,190 MW; Unit 2 - 1,157 MW
- Nuclear: Byron, Unit 1 - 1,174 MW; Unit 2 - 1,150 MW
- Nuclear: Clinton, Unit 1 - 1,067 MW
- Nuclear: Dresden, Unit 2 - 880 MW; Unit 3 - 873 MW
- Nuclear: LaSalle, Unit 1 - 1,154 MW; Unit 2 - 1,162 MW
- Nuclear: Quad Cities, Unit 1 - 903 MW; Unit 2 - 937 MW
- Gas: SE Chicago, 296 MW
- Solar: Exelon City Solar, 10 MW
- Wind: Illinois Wind, 1 Project, 8 MW

KANSAS

- Wind: Kansas Wind, 2 Projects, 116.5 MW

MARYLAND

- Hydro: Conowingo, 572 MW
- Gas/Oil: Perryman,199 MW, Oil; 147.6 MW
- Gas: Gould Street, 97 MW
- Gas/Oil: Riverside, 74 MW, Gas; 115 MW, Gas/Oil; 39 MW, Oil
- Gas: Westport, 115.8 MW
- Gas: Notch Cliff, 100.7 MW
- Oil: Philadelphia Road, 60.9 MW
- Wind: Maryland Wind, 70 MW, 1 Project

MASSACHUSETTS

- Gas/Oil: Mystic, 1,406 MW, Gas (8-9 Combined Cycle); 8 MW, Oil (Jet); 560MW, Gas/Oil (7)
- Oil: Framingham, 31 MW
- Gas: Fore River (Combined Cycle), 688 MW
- Oil: New Boston, 16 MW
- Oil: West Medway, 119 MW

MAINE

- Oil: Wyman *(Ownership Interest Only)*, 36 MW

MICHIGAN

- Wind: Michigan Wind, 5 Projects, 352 MW

MINNESOTA

- Wind: Minnesota Wind, 9 Projects, 78 MW

MISSOURI

- Wind: Missouri Wind, 4 Projects, 163 MW

NEW JERSEY

- Nuclear: Oyster Creek, Unit 1 - 625 MW

NEW MEXICO

- Wind: New Mexico Wind, 1 Project, 27 MW

OREGON

- Wind: Oregon Wind, 4 Projects, 75 MW

PENNSYLVANIA

- Nuclear: Limerick, Unit 1 - 1,158 MW; Unit 2 - 1,153 MW
- Nuclear: Peach Bottom, Unit 2 - 1,148 MW; Unit 3 - 1,151 MW
- Nuclear: Three Mile Island, Unit 1 - 837 MW
- Oil: Falls, 51 MW
- LFG: Fairless Hills, 60 MW
- LFG: Pennsbury, 6 MW
- Oil: Croydon, 391 MW
- Oil: Delaware, 59 MW
- Oil: Richmond, 96 MW

PENNSYLVANIA

- Oil: Schuylkill, 33 MW
- Oil: Southwark, 52 MW
- Oil: Chester, 39 MW
- Oil: Eddystone, 760 MW, Oil/Gas; 60 MW
- Hydro: Muddy Run, 1,070 MW
- Hydro: Safe Harbor *(Ownership Interest Only)*, 277.7 MW
- Waste Coal: Colver, 25.5 MW
- Oil: Conemaugh *(Ownership Interest Only)*, 532.7 MW, Coal; 3.1 MW
- Oil: Keystone *(Ownership Interest Only)*, 716.2 MW, Coal; 4.3 MW
- Gas: Handsome Lake, 267.5 MW

TEXAS

- Gas: Mountain Creek, 805 MW
- Gas: Wolf Hollow (Combined Cycle), 705 MW
- Gas: LaPorte, 152 MW
- Gas: Colorado Bend (Combined Cycle), 50 MW
- Gas: Quail Run (Combined Cycle), 550 MW
- Gas: Handley, 1,265 MW
- Wind: Texas Wind, 282 MW, 13 Projects

UTAH

- Waste Coal: Sunnyside, 25.5 MW
- Gas: West Valley, 200 MW

CANADA

- Gas: Grande Prairie, 93 MW

Energy Discussion Groups, continued

Page 15 is a Turn and Talk exercise that can be done by groups or pairs of students. The table lists the number of megawatts produced by a selection of actual power plants in the U.S. and Canada. The location and type of plant is listed.

The goal of the activity is for students to appreciate the relative size of the different types of plants. Students are asked to look for trends. It may help to explain that trends mean patterns. Is there a pattern in the size of different plants? For example, are most of solar plants small?

Help students understand the table before they work on their own.

MW means megawatt. Students can ignore all the information within any parentheses (they indicate who owns the plant). Review a location with more than 1 plant. For example the first listing under Massachusetts is Mystic. There are 3 plants at Mystic: Gas/Oil 1,406 MW; Oil 8 MW; and Gas/Oil 560 MW.

There are 8 types of power plants in the list: gas, hydro, solar, wind, nuclear, gas/oil combined, LFG (landfill gas), and waste coal.

It may be best to divide the class into 7 groups. Each group would compile data on one type of power plant. (The 7th group would be responsible for both LFG and waste coal.) Each group should list all of the power plants of their type from greatest number of megawatts to least. They could then easily find the highest and lowest number of megawatts, the median, mean, and mode (if any). Groups could then compare the data with the entire class and discuss any trends.

Alternatively, groups of 3 or 4 could compile lists of the largest and smallest plants and report their findings to the class.

At the end of the presentations, discuss the relative size of the different types of power plants. The data on the table shows that the nuclear plants are the largest, followed by some gas plants. Solar plants and wind generate the least megawatts on average. Mention, however, that the table does not list some of the large hydroelectric power facilities in the U.S. In Washington state, the Grand Coulee dam has four power plants that total 6,800 megawatts – that is the largest power plant in the U.S. And the Hoover dam in Nevada generates 2,080 MW. The Agua Caliente (means hot water!) solar plant in California produces 250 MW.

Session 5

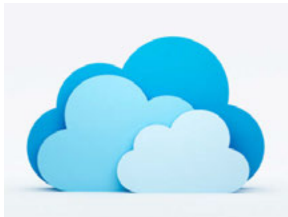
transformation • generate • power • fuel • efficiency • conservation • charge • current

Electricity Generation

The United States has had a difficult time developing a long-term energy policy because three different factors compete for top priority. Today you'll be considering which you think should be the top priority:

ENERGY SUPPLY SECURITY

An advocate of this priority might say, "We use electricity to run our businesses, to **charge** our phones, to do our banking, to run our medical equipment, and to run our law enforcement and military operations. Without a reliable way to **generate** electricity, life as we know it in our country would not exist. We must do whatever it takes to supply the U.S. with all the electricity we use."



ENVIRONMENT AND CLIMATE

An advocate of this priority might say, "We must minimize the environmental impacts of the supply, distribution, and use of energy. The evidence is clear that burning fossil **fuels** is affecting the climate. Many people suffer asthma and other medical conditions due to dirty methods of **generating** electricity. Solar and wind energy might be more expensive in the short term, but they are well worth our investment in the long term."

ECONOMICS AND JOB CREATION

An advocate of this priority might say, "If we spend a lot of money on expensive ways to **generate** electricity, taxes will have to go up even more and people won't be able to afford to buy goods and services. As a result, our country will not have a healthy economy and businesses won't be able to give people jobs."

Think about it. Which do you believe should be the top priority?

Once you've determined your priority, the next step is to decide on a form of electricity generation that you think we should increase in the U.S.

Also, think about a form of energy you think we should decrease. To develop a thoughtful position, you may use:

1. scientific information;
2. personal beliefs and values;
3. personal experience (what you know from the way you use electricity); and
4. information from the pro/con chart on the next page.

Teacher Directions, Session 5

pages 16-19

Electricity Generation

Session 5 should be read as a whole class before students begin working on the project. The reading will take 10 – 20 minutes depending on how much discussion you feel necessary during the reading.

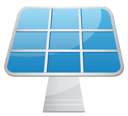
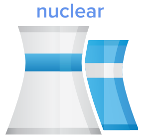
Students are asked to consider three conflicting goals of America's energy policy and to decide which of the three goals they support. Personalize each of the three goals to help students choose. Point out that these are real issues that Americans are considering every day when they try to decide which type of power plants to build. Review any terms that students may not understand.

Next review the prompt at the bottom of the page. Have students jot done their priorities in order.

Electricity Generation

Pro/Con Chart

This chart lists some pros and cons about various methods of **generating** electricity.

	Pro	Con
solar 	• no greenhouse gases • unlimited supply • decentralization (can be produced locally instead of at one large plant)	• can't charge after the sun sets • expensive • panels take a lot of space
wind 	• no greenhouse gases • unlimited supply • decentralization	• wind not constant • noisy • turbines sometimes don't fit in with the natural landscape
landfill gas 	• reduces gas emissions from landfills (like methane) • uses waste for something helpful • using gas for **power** prevents it from going into soil	• increased recycling would reduce **fuel** supply • plant must relocate when gas is used • requires large volumes of landfill
fossil fuel 	• can **generate** a huge amount of electricity • cheap and abundant (especially coal) • **fuel** can be transported to the **power** plant easily	• pollution and greenhouse gases • extraction of **fuel** causes environmental damage • while abundant now, the supply won't last forever
nuclear 	• no greenhouse gases • the price of the **fuel** (like uranium) is more stable than fossil **fuels** • plant can run for long periods of time without interruption	• nuclear waste is dangerous and hard to store • accidents are extremely dangerous • nuclear plants use lots of water to cool the reactors, which can be an environmental problem
hydro 	• no greenhouse gases • dams last a long time • cheaper to maintain than thermal plants	• can flood large areas of land, displacing many people • dams change river ecosystems • if water supplies are low, hydro plants are affected

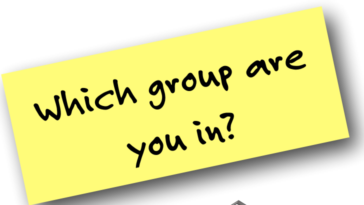
Electricity Generation, continued

Page 17 lists reasons to build and not to build six different types of power plants. It is recommend that the chart be read as a whole class. Many of the factors students will understand readily. Others will require a brief explanation. You many need to explain that a greenhouse gas is a gas whose presence in the Earth's upper atmosphere causes temperatures to increase; examples are methane and carbon dioxide.

As the chart is read, encourage students to consider whether the factors match the student's top priority. For example if the priority is to Environment and Climate, a student may want clean solar power plants. Students could circle the type of power that they would choose to build and put an X through those that they wouldn't want to build at all.

Electricity Generation

Make some notes to summarize your personal position about the top priority here:

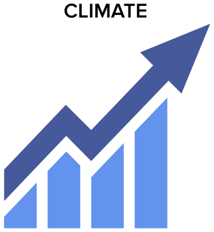


Now your teacher is going to place you in groups with people who agree with you regarding the priority for our national energy policy. But they may or may not agree with you regarding which forms of electricity generation to increase and which to decrease. Discuss your point of view with the group and together come up with a unified idea of how you think the U.S. should **generate** electricity.

Write bullet points listing the main ideas of what your group agreed on. Be ready to present your group's position to the class. Take notes in the other two boxes (next page) while other groups present. Think of ways to respectfully challenge their positions.


ENERGY SUPPLY SECURITY


ENVIRONMENT AND CLIMATE


ECONOMICS AND JOB CREATION

Our team agrees that...

Electricity Generation, continued

In the first box, students are instructed to write which priority they support and why. Review the instructions and allow 3 to 5 minutes for students to write their response.

Next read the two paragraphs with the entire class. Ask students which of the 3 priorities they chose and group the class by priority. You may wish to limit the number in each group to 4 or 5 (and thus have more than 1 group for priorities chosen by many students). Go over norms for group discussion.

Emphasize that a complete report will have supporting reasons for every statement, (for example, we chose to build solar plants because they pollute the least and we do not care about the high cost). Each group must summarize what they agree on and each group member should write down the same notes. Groups then present their position. You may encourage students in the audience to ask questions and raise objections. Rather than making presentations, the groups could engage in a three-way debate. In this case, establish rules and procedures about how and when each group will talk and respond.

Electricity Generation

Notes from another group's presentation:

☐  ☐  ☐ 

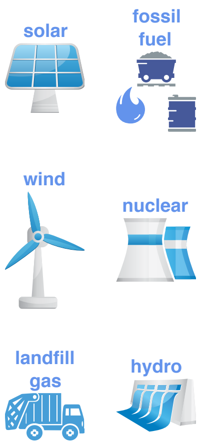
Notes from another group's presentation:

☐  ☐  ☐ 

Writing With and Without Bias

Using the pro/con chart on page 17, select one method of electricity generation to write about. The challenge of this activity is to write about the method in three different ways.

Select one:



Write a description of the technology you selected that conveys a bias *toward* using that technology.

Write a description of the technology you selected that conveys a bias *against* using that technology.

Write a description of the technology that is balanced and emphasizes facts and scientific thinking.

Teacher Directions, Supplementary Activities

pages 20-22

ELA Activity

This ELA activity is an opportunity for students to write two biased or propaganda paragraphs and a third balanced and factual description of the power plant of their choice.

Read the instructions as a whole class. Offer an explanation about what a biased paragraph is. Use the sentence starters below if necessary. Allow students 5 – 10 minutes to write on their own. If you wish, ask students to exchange papers for peer editing before they write a final draft. Have some students read their response. Allow students to state what they liked about each writing sample and to offer one positive suggestion for improvement.

Students begin by choosing a technology that generates electricity. They may want to choose the same one as they chose to defend from pages 16-18 (if that activity was already completed).

In the first paragraph, instruct students to describe their technology in the most glowing terms. Mention all the positive aspects of the technology. Write about the benefits but not about the negative factors. Students can exaggerate their position. If students need a sentence starter suggest: “From now on, America should only build ____ power stations because these have many benefits. They include...”

In the second paragraph, students take the opposite approach and discuss all the negative reasons supporting the idea that the same technology should not be built in America. Only negative aspects should be mentioned to make the paragraph most convincing. A possible sentence starter is: “The worst type of electrical power plant is ______. America is guaranteed to have problems if we continue to build them because….”

The third paragraph requires students to offer a factual perspective on the benefits and negative factors associated with the technology of their choice. Here students should discuss the points raised in the chart on page 18. A complete essay will include a discussion of how the power plant works.

Energy Efficiency

Energy **efficiency** is the idea that a device can do more work using less energy. For example, cars today are far more **efficient** than they were 40 years ago. They use less gasoline to go the same distance.

Use the idea of **efficiency** to help you decide which light bulb you think would be the best for your home. Be ready to provide good arguments for your choice.

	Brand and Product Name	Technology	Wattage Used	Lumens (Light Output)	Life of Bulb	Estimated Energy Cost	Purchase Price
	GE: Reveal 40	incandescent bulb; filtered glass for color enhancement	40	360	1,000 hours	$5.75/ year	$4.99 (for a four-pack)
	GE: Energy-**efficient** Soft White	general-purpose halogen bulb	29	430	.9 year (based on 3 hours a day)	$3.49/ year	$4.99 (for a two-pack)
	Eco-stay: T2*	mini-spiral fluorescent bulb	9	500	up to 9 years (10,000 hours)	$1.18/ year	$3.99
	Eco-stay: LED	semi-directional, dimmable LED bulb	7	470	25,000 hours	$0.92/ year	$9.99

See the next page for math activity directions.

Math Activity

Present the math activity to the whole class. It may be best to ask students to preview the table: "What are the pictures? What are the headings? What do you think we will be doing?" Next, before reading the data in the table, read the text at the top of the page. Students should understand that they are to determine which bulb is the most efficient and which they might buy for their home.

On one level, this activity could be "solved" by simply comparing the data in the rows. It can be argued that the bulb using the least wattage is efficient. The bulb with the highest lumens also has low wattage so it must be efficient. The LED light uses the least watts and lasts much longer, so it must be super efficient over a long time period. The LED also has the lowest estimated cost per year, so it should be the best buy.

On a second level, students can be challenged to find unit rates that compare the bulbs. A ratio of lumens per wattage can be converted into a unit rate of lumens per 1 watt. This figure is an efficiency rating. Lumens per watt for each bulb are: 9l/w for the GE Reveal; 14.8 for GE Energy efficient; 55.6 for T2, and 67.1 for the LED.

To determine which bulb to buy, the best comparison is to first determine the unit rate of purchase price per year of use and then add that figure to the energy cost per year to use it. That will give the total cost per year. Below are the figures for this calculation. Notice that both GE bulbs last an average of 1,000 hours or .9 years.

If you want your students to calculate unit rates, these further scaffolding questions may help. Ask, "How do we know that cars are more efficient now than 40 years ago?" If students do not mention miles per gallon, respond, "How would we measure the efficiency of cars using math?" "What is the fuel they use?" "How do we compare how efficiently a car uses gas?" Once miles per gallon is mentioned, contrast two cars. The Prius gets 44 miles per gallon and the Mini Cooper gets 32 mpg. Ask which is most efficient. Ask what type of ratio miles per gallon is. Refer students to pages 5 and 6 if they don't recall that it is a unit rate.

Tell students that mileage is an output for a car and gasoline is the fuel. So, miles per gallon is output per fuel use. Ask students which unit in the columns is the output of the light bulb (lumens), and which unit is similar to fuel (watts). Then ask how they would calculate a unit rate of output per fuel (use lumens/ watt).

Next discuss which bulb they would recommend. Mention that a Tesla electric car doesn't use any gas at all, but it's cost is $100,000 so it might be best to buy a Ford Escort that gets 33 mpg but only cost $15,000! Ask students how they would determine which bulb is the cheapest. You can provide a table similar to the one above for them to fill out, or simply encourage students to make their own assumptions and calculations.

This activity can be done in pairs or small groups. After 15 to 20 minutes, ask pairs or groups of students to present their answers and ask others in the class to summarize their statements.

	Approximate Cost for 1 bulb	Years the bulb will last	Purchase price per year	Energy cost per year	Total cost per year of use
GE Reveal	2.50	.9	$2.78	4.82	7.60
GE energy efficient	2.50	.9	$2.78	3.49	6.27
T2	4.00	9	$.44	1.18	1.62
LED	10.00	22.5	$.44	.92	1.38

New Power Supply for Local Middle School

Carver Middle School is in for a big **transformation** – and a lot of controversy! The school board has decided that the school will **generate** its own electricity by installing solar panels on campus. This change will allow the school to save thousands of dollars a year by using this **renewable** source of energy to **power** lights, **charge** new computer tablets, and run air conditioning during the hot months! Great idea! It will even get a special award for being a "Green School."

However, the solar panels will be built on what is **currently** a little park where kids hang out during lunch. The park also contains a small garden where the school has started to grow some of its own vegetables. Many of the students, parents, and teachers are not happy about losing this little park. They like the idea of solar panels but think that they should be installed at other schools instead of theirs.

The school board arranged a meeting and invited three community members who support the solar panels to explain the benefits to the concerned crowd. Here are excerpts from their discussions:

Community Members

 **Ms. Boswell**	"Over the next few years, students and teachers are going to rely on laptops and computer tablets for nearly all of their texts. Even tests will be given on computers. We will rely on a consistent source of energy to **power** these devices in a way that we've not had to with books, paper, and pencils. With these new solar panels, we will know that **power** will always be on. Imagine if you were in the middle of a test and your computer ran out of **power** with no way to **charge** it!
 **Mr. Barrett**	"We realize that your garden is providing some vegetables for your school's cafeteria. Growing your own food is a terrific way to help the environment because it cuts down on oil consumption when transporting food from farms to grocery stores. We hate to see this garden go to make room for these new solar panels; however, **generating** your own source of **power** will have a far greater impact on protecting the environment. This **renewable** source of energy is clean and **efficient**. We will find space for a new garden."
 **Mrs. Cartwright**	"The company that is building these solar panels brought 150 new jobs to our local economy. This means that these families are now shopping at stores that some of you own, or getting their hair cut at salons where you work. They are paying taxes that go to our schools. A project like this is not only good for the environment, it is good for the economy. We need to do our part to keep these businesses going. This is a win-win for everyone!"

For discussion:
Each community member has shared his or her perspective on why the school should build the solar panels. Match the following priorities with each of their perspectives:

ENERGY SUPPLY SECURITY

ENVIRONMENT AND CLIMATE

ECONOMICS AND JOB CREATION

Which would be the most compelling perspective to you if you were in the audience? Why?

Social Studies Activity

The social studies activity presents a situation where a school plans to erect solar panels. But the panels will be built on an existing garden and park. Three community members offer various points of view on the proposed project. Students are asked to match each speaker with 1 of 3 perspectives. The larger question is which point of view students find the most "compelling."

Consider reading this page with the entire class. Tell ELL students and others that a compelling argument is strong enough to convince you that it is right. If your mother compels you to turn off the TV, you agree to do it! Encourage students to think about their personal beliefs and also how strong each character's arguments are.

Examining the Focus Words Closely

SciGen Unit 8.3

→ Scientific or ✱ Everyday Use	Definition	Try using the word...
→ **transformation** *noun*	when studying energy, the change from one form of energy to another	*Hydroelectric dams are one place where an energy **transformation** occurs. Can you describe it?*
✱ **transform** *verb*	to make a thorough or dramatic change	*What are some organisms that **transform** during their lives? How do they change?*
→ **generate** *verb*	to produce	*Electricity can be **generated** from the energy of flowing water. What else **generates** electricity?*
✱ **generator** *noun*	a machine that converts one form of energy into another	*When might someone use a backup **generator** for electricity?*
→ **power** *noun*	work done in a certain amount of time (joules per second if the **power** is measured in watts)	*Does it take more **power** to pedal up a hill slowly or quickly? Why?*
✱ **power** *noun*	authority, control	*Who has more **power** at your school: the teachers or the principal?*
→ **fuel** *noun*	the material that is used up to produce power	***Fuels** store energy. How is food a **fuel**? How is gasoline a **fuel**?*
✱ **fuel** *verb*	to supply or provide what is needed for something to work	*How do you **fuel** up before exercising?*
→ **efficiency** *noun*	the ratio of the useful work performed by a device to the total amount of energy it uses	*How does technology improve your **efficiency** at completing schoolwork?*
✱ **efficient** *adjective*	working in a well-organized and competent way	*Are you **efficient** at getting ready for school? Explain.*
→ **conservation** *noun*	the idea that the total value of energy stays constant in a system	*Considering the **conservation** of energy, what happens to the energy that goes into a car crash?*
✱ **conserve** *verb*	to avoid wasteful use of something	*How can your family **conserve** resources to save money?*
→ **charge** *noun*	a property of matter responsible for electric and magnetic forces	*When is matter considered **charged**?*
✱ **charge** *verb*	to request an amount as a price	*Have you ever been **charged** too much for an item? What happened?*
→ **current** *noun*	the flow of electricity	*How do batteries create an electric **current**?*
✱ **currently** *adverb*	at the present time	*Name some challenges **currently** facing our government.*

Teacher Directions, Focus Words

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Examining the Focus Words Closely

The chart includes the scientific definitions that are reinforced throughout the unit. Each of these words has an arrow next to it. Additionally, there are other forms of the words or polysemous meanings that sometimes cause confusion for students. These words are marked with an asterisk.

Have students discuss the questions next to each word to help them learn these distinctions. Make sure students answer the questions using the focus word.