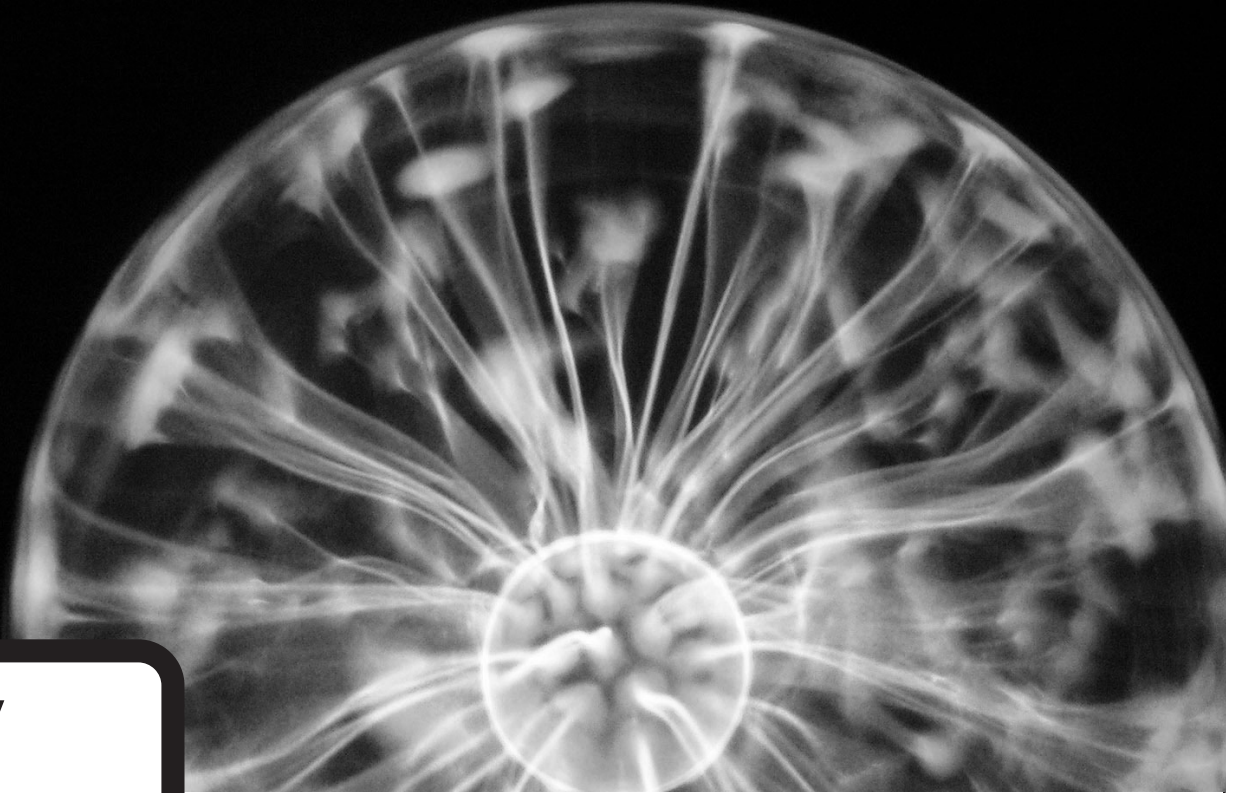


# Intermediate Science of Energy

Hands-on experiments and background information that allow students to explore the different forms of energy and how they are transformed. Students master forms of energy and their transformations, and then teach others what they have learned and how it can be visualized in the world around them.



## Grade Level:



Intermediate

## Subject Areas:



Science



Math



Language Arts



Public Speaking



National Energy Education Development Project



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## NEED Mission Statement

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## Teacher Advisory Board

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

## Energy Data Used in NEED Materials

NEED believes in providing teachers and students with the most recently reported, available, and accurate energy data. Most statistics and data contained within this guide are derived from the U.S. Energy Information Administration. Data is compiled and updated annually where available. Where annual updates are not available, the most current, complete data year available at the time of updates is accessed and printed in NEED materials. To further research energy data, visit the EIA website at [www.eia.gov](http://www.eia.gov).



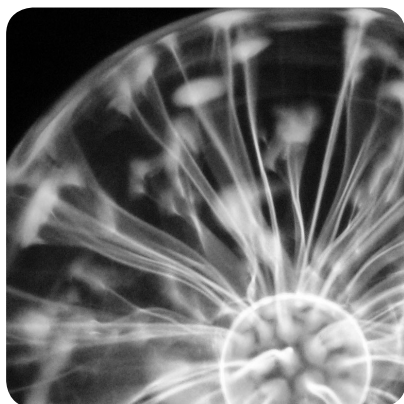
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# Intermediate Science of Energy

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## Intermediate Science of Energy Kit

- |   |   |                               |                                    |
|---|---|-------------------------------|------------------------------------|
| ▪ 1 Intermediate Science of Energy Guide (Grades 5-8) | ▪ 1 Container of baking soda                          | ▪ 3 15 mL Measuring cups      | ▪ 3 Thermometers (metal)           |
| ▪ 1 9-Volt Battery                                    | ▪ 1 Container of calcium chloride                     | ▪ 1 Measuring tape            | ▪ 4 Student thermometers (plastic) |
| ▪ 2 Sets of alligator clips                           | ▪ 2 Containers of sand (one full, one partially full) | ▪ 1 DC microammeter           | ▪ 1 Tin wire                       |
| ▪ 10 Balloons   | ▪ 1 Sealed plastic bag of iron oxide                  | ▪ 3 Motors (one disassembled) | ▪ 2 Tongs                          |
| ▪ 1 Battery holder                                    | ▪ 2 Thick copper wires                                | ▪ 1 Hand generated flashlight | ▪ 1 Toy car                        |
| ▪ 1 Bi-metal bar                                      | ▪ 1 Thin copper wire                                  | ▪ 6 Plastic bags              | ▪ 2 Live wires (nitinol)           |
| ▪ 1 Empty bottle (for vinegar)                        | ▪ 1 D Battery   | ▪ 1 Radiometer                | ▪ 1 Yo-yo                          |
| ▪ 1 Candle  | ▪ 16 Hand warmers                                     | ▪ 30 Rubber bands             | ▪ 2 Large nails                    |
| ▪ 1 Coated copper wire                                | ▪ 8 Glow sticks                                       | ▪ 1 Set of happy/sad spheres  | ▪ 2 Small nails                    |
| ▪ 1 Compass   |   | ▪ 1 Solar panel kit           |                                    |
|   |   | ▪ 1 Superball                 |                                    |





# Standards Correlation Information

[www.NEED.org/curriculumcorrelations](http://www.NEED.org/curriculumcorrelations)

## Next Generation Science Standards


- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's curriculum correlations website.

## Common Core State Standards

- This guide has been correlated to the Common Core State Standards in both language arts and mathematics. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED curriculum correlations website.

## Individual State Science Standards

- This guide has been correlated to each state's individual science standards. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED website.



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## Curriculum Correlations

NEED has correlated their materials to the Disciplinary Core Ideas of the Next Generation Science Standards. NEED has also correlated all of their materials to The Common Core State Standards for English/Language Arts and Mathematics. All materials are also correlated to each state's individual science standards. Most files are in Excel format. NEED recommends downloading the file to your computer for use. Save resources, don't print!

- [Navigating the NGSS? We have What You NEED!](#)
- [NEED alignment to the Next Generation Science Standards](#)
- [Common Core State Standards for English and Language Arts](#)
- [Common Core Standards for Mathematics](#)
- [Alabama](#)
- [Alaska](#)
- [Arizona](#)
- [Arkansas](#)
- [California](#)



NEED is adding new energy workshops all the time. Want to





# Materials

Station	Materials in Kit	Additional Materials Needed
<i>Teacher Demo</i>	<ul style="list-style-type: none"> <li>▪ 2 Containers of sand</li> <li>▪ Thermometers</li> <li>▪ Hand generated flashlight</li> </ul>	<ul style="list-style-type: none"> <li>▪ Safety glasses</li> </ul>
<i>Station One</i>	<ul style="list-style-type: none"> <li>▪ Set of happy/sad spheres</li> <li>▪ Superball</li> <li>▪ Yo-yo</li> <li>▪ Toy car</li> <li>▪ Balloons</li> <li>▪ Tongs</li> <li>▪ Measuring tape</li> </ul>	<ul style="list-style-type: none"> <li>▪ Cup of hot water</li> <li>▪ Meter stick (optional)</li> <li>▪ Safety glasses</li> </ul>
<i>Station Two</i>	<ul style="list-style-type: none"> <li>▪ Container of baking soda</li> <li>▪ Empty plastic bags</li> <li>▪ Thermometer (metal)</li> <li>▪ 15 mL Measuring cups</li> <li>▪ Hand warmers</li> <li>▪ Sealed plastic bag of iron oxide</li> <li>▪ Container of calcium chloride</li> <li>▪ Empty bottle for vinegar</li> </ul>	<ul style="list-style-type: none"> <li>▪ Scissors</li> <li>▪ Vinegar</li> <li>▪ Water</li> <li>▪ Safety glasses</li> </ul>
<i>Station Three</i>	<ul style="list-style-type: none"> <li>▪ Radiometer</li> <li>▪ Thermometers (plastic)</li> <li>▪ Solar panel with motor and fan blade</li> </ul>	<ul style="list-style-type: none"> <li>▪ Ruler</li> <li>▪ Light source (bright sunlight, clamp light with halogen or incandescent bulb)</li> <li>▪ Protractor</li> <li>▪ C Battery</li> <li>▪ Safety glasses</li> </ul>
<i>Station Four</i>	<ul style="list-style-type: none"> <li>▪ Live wire</li> <li>▪ Bi-metal bar</li> <li>▪ Candle</li> <li>▪ Rubber bands</li> <li>▪ Tongs</li> </ul>	<ul style="list-style-type: none"> <li>▪ Cup of hot water</li> <li>▪ Cup of ice water</li> <li>▪ Cup of room temperature water</li> <li>▪ Matches</li> <li>▪ 4 Pieces of metal hanger (approximately 8 inches each)</li> <li>▪ Safety glasses</li> </ul>
<i>Station Five</i>	<ul style="list-style-type: none"> <li>▪ Glow sticks</li> <li>▪ Small nail</li> <li>▪ Large nail</li> <li>▪ Thin copper wires</li> <li>▪ Thick copper wires</li> <li>▪ Tin wire</li> <li>▪ DC microammeter</li> <li>▪ Alligator clips</li> <li>▪ Thermometer (pulled from teacher demo box)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Cup of ice water</li> <li>▪ Cup of hot water</li> <li>▪ Apple</li> <li>▪ Metric ruler</li> <li>▪ Black permanent marker</li> <li>▪ Safety glasses</li> </ul>
<i>Station Six</i>	<ul style="list-style-type: none"> <li>▪ Hand generated flashlight (use from Teacher Demo)</li> <li>▪ Coated wire (heavy gauge)</li> <li>▪ Motors (1 disassembled)</li> <li>▪ 9-volt Battery</li> <li>▪ D Battery</li> <li>▪ Compass</li> <li>▪ Alligator clips</li> <li>▪ Battery holder</li> <li>▪ Large nail</li> </ul>	<ul style="list-style-type: none"> <li>▪ Tape</li> <li>▪ Safety glasses</li> </ul>

**Intermediate Science of Energy kits and additional consumable materials are available for purchase by calling 1-800-875-5029 or visit [www.NEED.org](http://www.NEED.org) for more information.**



# Teacher Guide

## Important Safety Notes

- All students should wear safety glasses while at any *Intermediate Science of Energy* station.
- This kit contains latex balloons and rubber bands. Check to see if any of your students have latex allergies. If they do, the items should be removed from their stations.
- Station One, Four, and Five require hot water. Review with students safe procedures for handling hot water. Hot water should be no hotter than 60°C (140°F).
- The live wire in Station Four may spring out of the cup. Students should not peer directly over the demonstration, and should handle the live wire with tongs. Giving the students a clear glass or beaker to use in this demonstration may keep them from wanting to look directly over the cup.
- Review procedure for open flame with students, as Station Four requires the use of flame.
- Thermometers in this kit do not contain mercury. These thermometers are made with alcohol spirits and are safe for classroom use. Should they break during the course of this unit, you can dispose of the thermometer and parts as you would anything else in your classroom.
- If the thermometers are placed in a substance that is too hot, the thermometer may break.
- Hand out the *Lab Safety Rules* and review with students prior to any investigation.

## Background

The *Intermediate Science of Energy* unit includes a teacher demonstration and six lab stations. Students are divided into six groups (or more, if needed), with each group responsible for learning and teaching the other groups about the experiments in their assigned station. Instructions, guides, masters, and explanatory articles are provided for the teacher and students. Throughout this unit, students are encouraged to record their thinking in science notebooks.

## Time

*Intermediate Science of Energy* is designed to take as few as six class sessions of 45-60 minutes each. Teachers may choose to expand the time if their schedules allow.

### Possible 6 Day Schedule

DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
Introduction to Energy and Teacher Demonstration	Energy Transformations	Station Investigations and Plan Presentations	Present and Rotate	Present and Rotate	Energy Sources

### Possible Extended Schedule

DAY 1	DAY 2	DAYS 3-4	DAYS 5-7	DAY 8	DAYS 9+
Introduction to Energy and Teacher Demonstration	Energy Transformations	Station Investigations and Plan Presentations	Present and Rotate	Energy Sources	Science of Energy Extensions

Depending on time available and/or your class size, the number of groups and rotations can be increased by separating Stations Two and Three. Station Two can be separated into endothermic and exothermic processes, while Station Three can isolate the solar panel on its own, and Station Five can be split into two parts.

## Unit Preparation

- Familiarize yourself with the equipment in the kit and procure the materials listed in the Additional Materials Needed section of the chart on page 5. Remove any materials not needed as the kit boxes may contain items used in the other *Science of Energy* units.

## Student Reporting Forms and Science Notebooks

In this unit, students may use the reporting forms provided or science notebooks to record their questions, hypotheses, data, observations, and conclusions as they work through each station. Choose the format depending on the needs of your students. If you choose to use the reporting forms, make copies of each station's reporting form for each student. These reporting forms can be found on pages 26-42. If you have chosen to use science notebooks with your class, sample template pages are provided on pages 24-25 for students to work through the stations. Make enough copies of this template so that students have enough room to record their work at each of the six stations. Also provide the station guides at each station so that students can draw their own versions of tables and charts.

It should be noted that not every station or part of each station emphasizes the identification of variables and composition of a hypothesis. This is due to the design of the activities within that station or part of the station. However, these components can easily be added at the teacher's discretion.

**Note:** For more information about energy, see the *Intermediate Energy Infobook* available for download from [www.NEED.org](http://www.NEED.org).

## Vocabulary

Listed below are terms used in this *Intermediate Science of Energy* unit. Students will encounter these terms while going through each station. A glossary can be found on page 100.

absorb	conversion	energy level	gravitational	molecular	release
alternating current	convert	energy	potential energy	molecule	renewable
ampule	current	transformation	heat*	motion energy	repel
atom	direct current	ester	hypothesis	nickel	retention
attract	elastic energy	exothermic	iron oxide	nonrenewable	silicon
Celsius	electrical energy	expand	kilowatt-hour	nuclear energy	temperature
chemical energy	electricity	Fahrenheit	kinetic energy	photovoltaic cell	thermal energy*
chemical reaction	electrode	fission	Law of	potential energy	titanium
collision	electrolyte	friction	Conservation of	prediction	transform
compress	electromagnet	fusion	Energy	radiant energy	transformation
conduct	endothermic	generator	magnetic field	reaction	turbine
contract	energy		mass	rebound	vacuum

*\*PLEASE NOTE: In this unit, the terms thermal energy and heat may be used to mean the same thing; however, technically, they are not the same thing. Thermal energy is the sum of the energy of the molecules making up a substance - kinetic and potential. When this thermal energy is transferred from one place or object to another, it is called heat.*

## Activity One: Teacher Demonstration

### Objectives

- Students will be able to define energy and list examples of the work it enables us to do.
- Students will be able to differentiate between kinetic and potential energy.
- Students will be able to list the forms of energy, providing examples of items that store or use each form.
- Students will be able to explain simple energy transformations.

### Materials

- 2 Containers of sand (one container is completely full and one container is approximately one-third full)
- 2 Thermometers
- Safety glasses
- Teacher Demonstration: What Was Happening?*, page 22
- Thermometer master*, page 43
- Fahrenheit/Celsius Conversion master*, page 44
- Forms of Energy master*, page 45

### Preparation

- Make copies of the *Forms of Energy* master for each student, or prepare a copy to project for the class.

**NOTE:** For this activity, a more dramatic difference in temperature will be seen if temperatures are measured in degrees Fahrenheit instead of degrees Celsius. Choose the temperature scale that works best for your needs and for demonstration purposes.

### Procedure

1. Open the containers of sand and place them on a table to stabilize temperature.
2. Use the *Thermometer* master to review how to read a thermometer, if necessary. Depending on your grade level and standards, explain how to convert Fahrenheit to Celsius or Celsius to Fahrenheit using the *Fahrenheit/Celsius Conversion* master.
3. Place one thermometer in each container. Compare the temperature reading of the two thermometers and record the results. Students should record the results independently or you can record it on the board.
4. Ask students, "If we shake both of these containers, what will happen to the temperature of the sand in each container? Explain your thinking." Students should record a hypothesis. Instruct students to create a table like the one on the following page, or draw it on the board.

### Vocabulary

- Celsius
- convert
- energy
- Fahrenheit
- friction
- motion energy
- thermal energy

5. Place the lids on each container tightly.
6. Explain and model the shaking of the containers of sand. Each student should shake both containers at least ten times at the same time, one in his/her right hand and one in his/her left hand, then pass the containers to the next student. Or as a class you may discuss and use a different set-up to minimize variables.
7. While students are shaking the containers, ask them what they think they already know about energy. You may want to record their responses. Give the example that energy makes things move. Ask students to name a moving object and what moves it. Energy is moving the object. For example, a car is moved by burning gasoline, a sailboat by the wind, and a baseball by the energy in a person's arm and hand. Explain that there are five main things energy helps us do: make things move, make heat, make light, make technology work (run electrical devices), and make things grow. Have students record these energy uses in their science notebooks and come up with examples of each.
8. Review the forms of energy and their definitions using the *Forms of Energy* master.
9. When all of the students have shaken the containers, open the containers and place a thermometer in each. Have two students read the thermometers and record the results on the board. Everyone should record results in their science notebooks using a table like the one below. Discuss the difference and why students think the temperatures changed the way they did.
10. Review the results of the sand investigation. Ask the class if anyone made a correct prediction about the temperature change. Ask students what may have caused the results. Use the *Teacher Demonstration: What Was Happening?* article to explain to students what was really happening in the containers.

	1/3 FULL		FULL	
	°C	°F	°C	°F
Starting Temperature				
Ending Temperature				
Change in Temperature				

## Activity Two: Introduction to Energy Transformations

### Objective

- Students will be able to explain simple energy transformations.

### Materials

- Hand generated flashlight
- *Teacher Demonstration: What is Happening?*, page 22
- *Forms of Energy* master, page 45

### Procedure

1. Review the forms of energy using the *Forms of Energy* master. Give another demonstration of energy transformations using the hand generated flashlight. Use the *Teacher Demonstration: What Was Happening?* article to explain how the flashlight is working. Discuss with students the Law of Conservation of Energy, which states that energy cannot be created or destroyed, it can only change form or be transferred.
2. Ask the students to list or draw out energy transformations of common items in their lives.

### Extension

- To reinforce vocabulary focusing on energy transformations, use the activity *Forms of Energy in the Round* found on page 17.

### Vocabulary

- Law of Conservation of Energy
- transformation

## Activity Three: Station Investigations

### Objectives

- Students will be able to explain simple energy transformations.
- Students will be able to list the forms of energy and give examples.

### Materials

- Station materials (see page 5)
- *Lab Safety Rules* master, page 46
- Safety glasses
- Copies of *Station Guides* and *What Was Happening?* articles for each station (see pages below)
- Student reporting forms for each station (see pages below) or science notebooks

### Vocabulary

See Individual Station Guides

	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5	STATION 6
Station Guide	57-59	62-64	67-70	73-75	78-80	83-84
What Was Happening?	60-61	65-66	71-72	76-77	81-82	85-86
Reporting Form	26-27	28-29	30-32	33-36	37-39	40-42

### Preparation

- Review the rotation scheme suggestions provided on the following page. Decide which one works best for your students and room layout, or modify to meet your needs.
- Divide the class into six groups. If your class is large, you can separate Station Two, Station Three, and Station Five into two groups.
- Organize your classroom into stations, with stations requiring warmer tap water (~40°C) to hot water (~50°C) near a faucet or water source. Station Three should be located near an electrical outlet.
- Make several copies of each station guide to remain at each station. Students will not remove or write on these, unless otherwise directed.
- Make copies of each *What Was Happening?* article for each student at the station. Do not pass these out until students are done with their initial investigation.
- Answer keys for the station investigations are provided on pages 18-19. These answer keys are simply provided as a reference. Students may reflect upon data and observations that are not suggested within the answers, but still accurate based on their use of the materials. It is suggested that teachers have a good familiarity with the stations for this reason.
- When conducting radiant energy transformation activities, it is suggested that teachers attempt to use incandescent bulbs as available. Newer bulbs, like LEDs, will not produce enough thermal energy in a short time to produce the desired experimental results. Traditional incandescent, or energy saving halogen incandescent bulbs, are your best bet. However, a halogen incandescent bulb will not work as well with the PV cell in this station. The light from the halogen bulbs is of a slightly different wavelength. This wavelength of light will still operate the PV cell, but the cell itself may need to be held very closely to the bulb. Use caution in this case, so as to not melt the plastic. Sunlight and traditional incandescent bulbs will provide the best results for these activities.

### Procedure

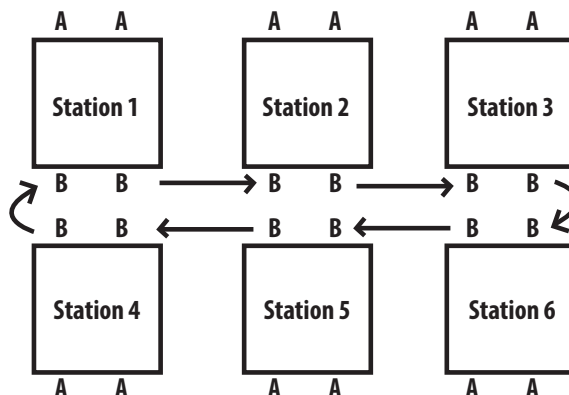
1. Explain to students that over the next few days they will be investigating energy transformations in a variety of different systems. Each group will be assigned a station. Everyone in the group is responsible for learning how to conduct and present the energy transformations taking place at their station. The first day everyone will focus on learning and becoming an expert at their station. Once all groups have learned their stations they will split up. Half of the group will stay at the station to present the energy transformations while the others rotate through the stations. The next day everyone will switch roles.
2. Review the *Lab Safety Rules* with the class.
3. Assign students to their groups. Give them the appropriate station guides. Students should read through the guides. Give the groups their materials and let them start investigating. Remind students that they should be recording observations and data.



- Students work in groups to learn their assigned stations. Students should be recording data and observations, identifying the energy transformations, and explaining how and why the energy transformations occurred in their conclusions.
- When students have finished their investigations, give them the *What Was Happening?* article that goes with their station. Students should read the article and compare what they read to what they thought was going on. Without erasing their own conclusions, students should answer the station conclusions found at the very end of each station guide.

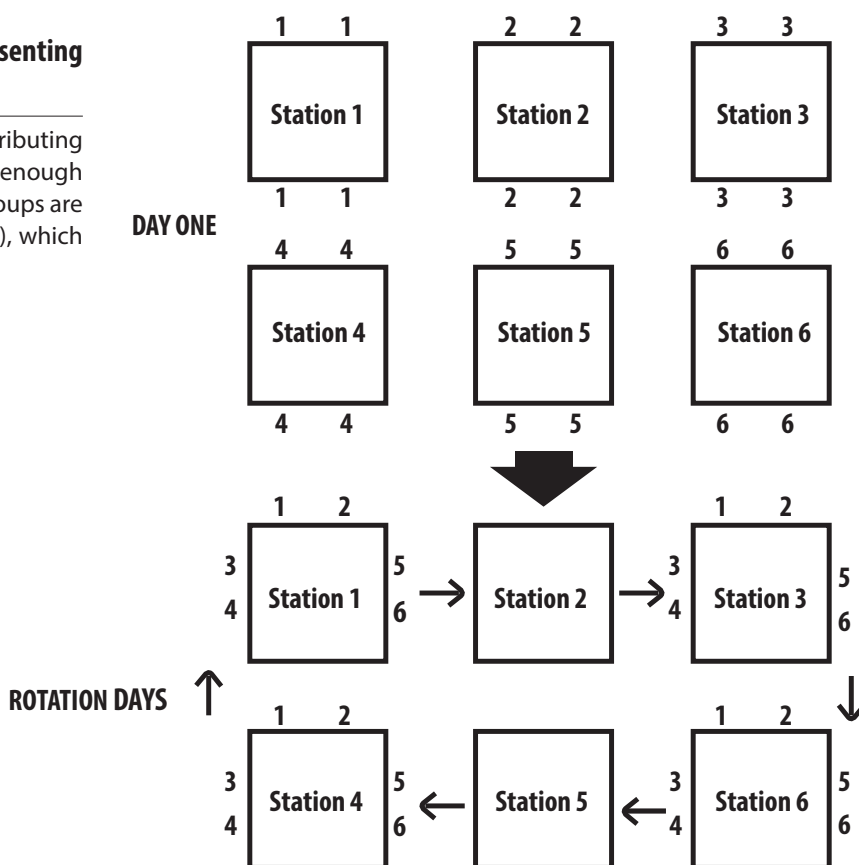
### Rotation Scheme A/B (more time, students presenting in working pairs)

Students are assigned in groups of four; two of these students are “A” students, and two are “B” students. All four learn their stations well enough to guide the rest of the class. On the first set of rotations, the A students remain with their stations while the B students rotate. On the second set, the B students remain with their stations while the A students rotate.



### Rotation Scheme Jigsaw (less time, students presenting individually)

Students are assigned to each of the six stations, distributing them as equally as possible, to learn their stations well enough to guide the rest of the class. On rotation days, new groups are formed, one from each station (groups of six students), which then rotate through the stations.



**\*IMPORTANT NOTE:** Regardless of the rotation scheme selected, the order of rotations will not matter or affect student learning, as all stations are independent of each other.

## Activity Four: Presentation Planning

---

### Objectives

---

- Students will be able to explain simple energy transformations.
- Students will be able to list the forms of energy, providing examples of items that store or use each form.

### Materials

---

- Station materials
- Station Guides* and *What Was Happening?* articles
- Station Presentation Planning Guide*, page 23

### Procedure

---

1. Students should reflect and discuss what they learned in their station investigations. All students will need to understand what was happening at their station and be able to explain it to their peers during station rotations.
2. Using their written responses, the *What was Happening?* article, and *Station Presentation Planning Guide*, students should decide how they will demonstrate and explain their station to their peers.
3. Students should practice presenting their station. Let students know how much time they will have to present their stations so they can practice in that time frame.

## Activity Five: Station Rotations

---

### Objectives

---

- Students will be able to explain simple energy transformations.
- Students will be able to list the forms of energy, providing examples of items that store or use each form.

### Materials

---

- Station materials
- Station Guides*
- Safety glasses

### Preparation

---

- Set out a fresh apple at Station Five.
- Make sure each station has an adequate amount of consumable supplies.
- Have a supply of ice and hot water ready.

### Procedure

---

1. Put students into new groups based on the rotational scheme you've selected. Follow the scheme instructions on page 10.
2. Students will rotate through stations for as many days as needed for all groups to observe the stations. Everyone will have a chance to present, and everyone will rotate through the other stations.
3. Depending on the amount of time in your class period, set a time limit for station rotations. Give students a two minute warning and one minute warning before having groups rotate.

## Activity Six: Energy Flows

### Background

Nuclear energy produced the radiant energy from the sun. Inside the sun's core, isotopes of hydrogen are fused together to form atoms of helium. Fusion occurs because of the tremendous heat and gravitational forces inside the sun's core. The resulting atom of helium has less mass than the original atoms of hydrogen. This missing mass is changed into energy—radiant energy.

Accordingly, the increase in the temperature of the sand used in the teacher demonstration is the result of nuclear energy. In fact all energy transformations can be traced back to nuclear energy: fission, fusion, or radioactive decay. The energy stored in fossil fuels is a result of sunlight from millions of years ago. Wind, hydropower, and biomass energy are also a result of the sun's radiant energy. Geothermal energy is due to pressure, heat, and radioactive decay of elements in the Earth's core. The electricity produced in a nuclear power plant is the result of the splitting (fission) of heavy uranium atoms into lighter atoms. When fission occurs, mass is changed into energy. *All energy transformations can be traced back to nuclear energy.* Albert Einstein understood that energy is required to make mass, and that if mass disappears energy is released. Einstein explained the relationship between energy (E) and mass (m) as  $E=mc^2$  (where "c" is the speed of light).

If you trace the energy flow from the thermal energy in a bending hanger it will eventually lead back to the sun. You put motion from the muscles in your hands and arms into the hanger. Your muscles got their energy from the chemical energy in the food you ate. The plants you ate transformed radiant energy from the sun into the chemical energy. The sun gets its energy from nuclear fusion. So the energy flow from the sun to the hanger is: nuclear energy, to radiant energy, to chemical energy, to motion energy, to thermal energy.

### Objectives

- Students will be able to list the forms of energy, providing examples of items that store or use each form.
- Students will be able to explain simple energy transformations.
- Students will be able to trace the energy flow of a common item back to the sun.

### Materials

- Hand generated flashlight
- Energy Flow Cards*, pages 87-89
- Energy Transformations* master, page 47

### Preparation

- Make enough copies of the *Energy Flow Cards* so that each student or group has a set.
- Cut out each of the cards and fold on the dotted lines. Assemble groupings of the cards so that each group will have a full set.

### Procedure

1. Review the stations and transformations observed briefly with the class.
2. Revisit the flashlight from Activity Two and ask a student to make it light. Ask students if they can trace the transformation of that flashlight further than simply motion to light. Ask them if they can trace the transformation or energy flow the whole way back to the sun. Jot down or record their answers on the board.
3. Project the *Energy Transformations* master and discuss student answers. Ask students to try to trace the flow of energy from a different station item, for example, the metal hanger in Station 4. Highlight information from the teacher background information above, if necessary.

### A Note About Your Hand Generated Flashlight

This flashlight stores energy using a NiMH (Nickel Metal Hydride) rechargeable battery. This battery will hold a charge for approximately two hours. For demonstration purposes, teachers may wish to "drain" the charge on the battery by turning on the flashlight and allowing it to remain lit for some time, in order to show the flashlight starting from zero to generate light. If the light is mostly drained and faint, students will immediately be able to see the light brightening as they shake and add energy. From this point, however, it may take extended amounts of shaking to fully recharge the battery and to emit a bright light. Refer to the charging instructions on the box for more information regarding recharging the battery.

4. Distribute the shuffled set of cards to students or groups of students. Explain to students that energy flows exist in all items. Some of those flows include living items – like a food chain, for example. Some can be even longer and include living and non-living items. Ask students to put the cards in the correct order of their energy flow starting with the sun. Observe students, helping them to organize if needed.
5. Redistribute the cards so that each group has tried each of the sets of cards.

### Extension

- Regroup the cards so that two or more sets are in one stack with only one sun. Distribute to the students and have them form a human chain, putting their cards in order of the energy flow. Students can hold hands or pieces of string. Some students may have to connect to more than one other student.

## Activity Seven: Energy Sources

### Objective

- Students will be able to describe how energy is stored in the major energy sources.

### Materials

- *Forms and Sources of Energy* activity sheet, page 48
- *How Wind is Formed* master, page 49
- *Harnessing the Wind to Generate Electricity* master, page 50
- *Wind Energy Flow* master, page 51
- *How Coal Was Formed* master, page 52
- *Burning Fossil Fuels to Generate Electricity* master, page 53
- *Energy Flow Cards*, pages 87-89
- *Cool Coal Story* (optional), pages 54-56

### Preparation

- Make enough copies of the *Forms and Sources of Energy* sheet so each student has a copy.
- Prepare copies of the masters for projection and discussion.
- Make copies of the *Energy Flow Cards* so that each student or group has a set. The cards are numbered so it is easy to see which cards belong to the set. Cut out the cards and assemble into stacks by sets.

### Procedure

1. Distribute the forms and sources activity sheet to students.
2. Give a brief description of the ten major sources of energy and explain the terms renewable and nonrenewable. (Use the *Intermediate Energy Infobook* as a reference. Infobooks can be downloaded from [www.NEED.org](http://www.NEED.org).)
3. Have students complete the *Forms and Sources of Energy* activity.
4. Discuss the answers to the activity. Answers are listed on page 20.
5. Ask students if they think they could trace the energy flow the whole way from an energy source back to the sun.
6. Project the *How Wind is Formed* and *Harnessing the Wind to Generate Electricity* masters. Discuss with students how the wind is formed and how a wind turbine can generate energy in the form of electricity. Ask students how much of our energy comes from wind?
7. Project the *Wind Energy Flow* master. Ask students to go through and label each part of this energy flow with the forms of energy present. Discuss the answers as a class.
8. Project the *How Coal Was Formed* master and *Burning Fossil Fuels to Generate Electricity* master. Discuss the differences between a wind turbine and a thermal energy plant for generating electricity.
9. Ask students to draw out an energy flow for coal like they did previously for wind.
10. Distribute the *Energy Flow Cards* to the class.

11. Direct students to add or create new cards to incorporate a source or sources of energy. Have them trade with other groups so that those groups can re-order the cards.

## Extensions

- Read *A Cool Coal Story* with students (pages 55-56). Give the class props or allow them to create props to act out the energy flow in the story.
- Have students write their own story about a different source of energy to mimic *A Cool Coal Story*. Have them act out their flow story with props.
- For more information on energy sources, energy consumption, and energy conservation, use the *Intermediate Energy Infobook* and *Intermediate Energy Infobook Activities* available for free download at [www.NEED.org](http://www.NEED.org).

## Unit Extensions

- Reinforce vocabulary and concepts with the *Forms of Energy Fun* activities found on pages 93-95. Answers can be found on page 20.
- Invite other classes of all ages to rotate through the stations and have your class teach others about energy transformations.

## Unit Assessment and Evaluation

There are multiple options for evaluating student learning in this unit:

- Evaluate students on their group work including: their ability to work as a team to learn the material and prepare their experiment; their ability to teach students from other teams about their experiment; and their ability to handle equipment properly and safely. Devise a rubric and share it with the class.
- Assess students' reporting forms or science notebooks for developing science process skills and their understanding of the concepts covered at each station. A sample rubric is provided below.
- Have students create an *Intermediate Science of Energy Brochure* using the rubric on page 90.
- Use the *Intermediate Science of Energy Assessment* on pages 91-92. Answers can be found on page 21.

## Student Reporting Form or Science Notebook Rubric

This is a sample rubric that can be used with student reporting forms or science notebooks. You may choose to only assess one area at a time, or look at an investigation as a whole. It is suggested that you share this rubric with students and discuss the different components ahead of time.

	SCIENTIFIC CONCEPTS	SCIENTIFIC INQUIRY	DATA/OBSERVATIONS	CONCLUSIONS
4	Written explanations illustrate accurate and thorough understanding of scientific concepts.	The student independently conducts investigations and designs and carries out his or her own investigations.	Comprehensive data is collected and thorough observations are made. Diagrams, charts, tables, and graphs are used appropriately. Data and observations are presented clearly and neatly with appropriate labels.	The student clearly communicates what was learned and uses strong evidence to support reasoning. The conclusion includes application to real life situations.
3	Written explanations illustrate an accurate understanding of most scientific concepts.	The student follows procedures accurately to conduct given investigations, begins to design his or her own investigations.	Necessary data is collected. Observations are recorded. Diagrams, charts, tables, and graphs are used appropriately most of the time. Data is presented clearly.	The student communicates what was learned and uses some evidence to support reasoning.
2	Written explanations illustrate a limited understanding of scientific concepts.	The student may not conduct an investigation completely, parts of the inquiry process are missing.	Some data is collected. The student may lean more heavily on observations. Diagrams, charts, tables, and graphs may be used inappropriately or have some missing information.	The student communicates what was learned but is missing evidence to support reasoning.
1	Written explanations illustrate an inaccurate understanding of scientific concepts.	The student needs significant support to conduct an investigation.	Data and/or observations are missing or inaccurate.	The conclusion is missing or inaccurate.





# Science of Energy BINGO Instructions

## Get Ready

Duplicate as many *Science of Energy Bingo* sheets (found on page 96) as needed for each person in your group. In addition, decide now if you want to give the winner of your game a prize and what the prize will be.

## Get Set

Pass out one *Science of Energy Bingo* sheet to each member of the group.

## Go

### PART ONE: FILLING IN THE BINGO SHEETS

Give the group the following instructions to create bingo cards:

- This bingo activity is very similar to regular bingo. However, there are a few things you'll need to know to play this game. First, please take a minute to look at your bingo sheet and read the 16 statements at the top of the page. Shortly, you'll be going around the room trying to find 16 people about whom the statements are true so you can write their names in one of the 16 boxes.
- When I give you the signal, you'll get up and ask a person if a statement at the top of your bingo sheet is true for them. If the person gives what you believe is a correct response, write the person's name in the corresponding box on the lower part of the page. For example, if you ask a person question "D" and he or she gives you what you think is a correct response, then go ahead and write the person's name in box D. A correct response is important because later on, if you get bingo, that person will be asked to answer the question correctly in front of the group. If he or she can't answer the question correctly, then you lose bingo. So, if someone gives you an incorrect answer, ask someone else! Don't use your name for one of the boxes or use the same person's name twice.
- Try to fill all 16 boxes in the next 20 minutes. This will increase your chances of winning. After the 20 minutes are up, please sit down and I will begin asking players to stand up and give their names. Are there any questions? You'll now have 20 minutes. Go!
- During the next 20 minutes, move around the room to assist the players. Every five minutes or so tell the players how many minutes are remaining in the game. Give the players a warning when just a minute or two remains. When the 20 minutes are up, stop the players and ask them to be seated.

### PART TWO: PLAYING BINGO

Give the class the following instructions to play the game:

- When I point to you, please stand up and in a LOUD and CLEAR voice give us your name. Now, if anyone has the name of the person I call on, put a big "X" in the box with that person's name. When you get four names in a row—across, down, or diagonally—shout "Bingo!" Then I'll ask you to come up front to verify your results.
- Let's start off with you (point to a player in the group). Please stand and give us your name. (Player gives name. Let's say the player's name was "Joe.") Okay, players, if any of you have Joe's name in one of your boxes, go ahead and put an "X" through that box.
- When the first player shouts "Bingo," ask him (or her) to come to the front of the room. Ask him to give his name. Then ask him to tell the group how his bingo run was made, e.g., down from A to M, across from E to H, and so on.

*Science of Energy Bingo* is a great icebreaker for a NEED workshop or conference. As a classroom activity, it also makes a great introduction to an energy unit.

## Preparation

▪ 5 minutes

## Time

▪ 45 minutes

**Bingos are available on several different topics. Check out these resources for more bingo options! All are available for free download at [www.NEED.org](http://www.NEED.org).**

- Biomass Bingo—*Energy Stories and More*
- Change a Light Bingo—*Energy Conservation Contract*
- Coal Bingo—*Coal guides*
- Energy Bingo—*Energy Games and Icebreakers*
- Energy Efficiency Bingo—*Monitoring and Mentoring and Learning and Conserving*
- Hydropower Bingo—*Hydropower guides*
- Hydrogen Bingo—*H<sub>2</sub> Educate*
- Nuclear Energy Bingo—*Nuclear guides*
- Oil and Natural Gas Bingo—*Oil and Natural Gas guides*
- Solar Bingo—*Solar guides*
- Transportation Bingo—*Transportation guides*
- Wind Energy Bingo—*Wind guides*

■Now you need to verify the bingo winner's results. Ask the bingo winner to call out the first person's name on his bingo run. That player then stands and the bingo winner asks him the question which he previously answered during the 20-minute session. For example, if the statement was "can name two renewable sources of energy," the player must now name two sources. If he can answer the question correctly, the bingo winner calls out the next person's name on his bingo run. However, if he does not answer the question correctly, the bingo winner does not have bingo after all and must sit down with the rest of the players. You should continue to point to players until another person yells "Bingo."

## SCIENCE OF ENERGY BINGO

## ANSWERS

- |   |  |  |   |
|---|--|--|---|
| A. Knows what type of reaction releases thermal energy                                | B. Knows the form of energy that comes from the sun                      | C. Knows one way to store energy       | D. Knows the form in which our bodies store energy            |
| E. Knows the force responsible for the attraction between the Earth and nearby masses | F. Knows why rubbing your hands together makes them warm                 | G. Can name a form of kinetic energy   | H. Has visited a thermal power plant                          |
| I. Knows where most energy on Earth originates  | J. Knows what type of reaction absorbs thermal energy                    | K. Has used a radiant clothes dryer    | L. Knows what form of energy is stored in most energy sources |
| M. Knows how an electric generator works  | N. Knows what device turns energy from the sun directly into electricity | O. Can name a form of potential energy | P. Knows what energy can be transformed into                  |

<b>A</b> exothermic	<b>B</b> radiant	<b>C</b> battery, chemical, in a spring, etc.	<b>D</b> chemical
<b>E</b> gravity	<b>F</b> motion energy is transformed into thermal energy through friction	<b>G</b> radiant, thermal, motion (kinetic), sound, electrical	<b>H</b> Anyone who has visited a nuclear, coal, natural gas power plant has visited a thermal power plant
<b>I</b> the sun	<b>J</b> endothermic	<b>K</b> Anyone who has hung wet clothes on a line outside has used a radiant clothes dryer	<b>L</b> chemical
<b>M</b> Coils of wire surround a magnet. The magnet(s) rotate inside the wire, inducing electric current in the wire. The coils can also rotate inside magnets.	<b>N</b> photovoltaic cell, PV cell	<b>O</b> chemical, nuclear, elastic, gravitational	<b>P</b> any other form of energy



# Forms of Energy in the Round Instructions

## Get Ready

- Copy one set of the *Forms of Energy in the Round Cards* on pages 97-99 on card stock and cut into individual cards.
- Have a class set of the *Intermediate Energy Infobooks* available for quick reference.

## Get Set

- Distribute one card to each student. If you have cards left over, give some students two cards so that all of the cards are distributed.
- Have the students look at their bolded words at the top of the cards. Give them five minutes to review the information about their words using the *Intermediate Energy Infobooks*.

## Go

- Choose a student to begin and give the following instructions:
  - Read the question on your card. The student with the correct answer will stand up and read the bolded answer, "I have \_\_\_\_."
  - That student will then read the question on his/her card, and the round will continue until the first student stands up and answers a question, signaling the end of the round.
- If there is a disagreement about the correct answer, have the students listen to the question carefully looking for key words (forms versus sources, for example) and discuss until a consensus is reached about the correct answer.

## ANSWER KEY

### STARTING WITH CHEMICAL ENERGY'S CLUE:

NUCLEAR FUSION

POTENTIAL ENERGY

CONDUCTOR

RADIANT ENERGY

LAW OF CONSERVATION OF ENERGY

MOTION

PHOTOSYNTHESIS

EXOTHERMIC REACTION

ELECTRICAL ENERGY

CHEMICAL CHANGE

THERMAL ENERGY

ENERGY

PHOTOVOLTAIC CELL

KINETIC ENERGY

INERTIA

ELASTIC ENERGY

GRAVITY

NUCLEAR FISSION

NUCLEAR ENERGY

INSULATOR

CONVECTION

GENERATOR

SOUND

REFLECTION

FRICTION

PHYSICAL CHANGE

ENDOTHERMIC REACTION

VISIBLE LIGHT

CONDUCTION

CHEMICAL ENERGY

***Forms of Energy in the Round*** is a quick, entertaining game to reinforce information about energy sources, forms of energy, and general energy information from the *Intermediate Energy Infobook*.

## Preparation

- 10 minutes

## Time

- 20–30 minutes

## Alternative Instructions

- Give each student or pair a set of cards.
- Students will put the cards in order, taping or arranging each card so that the answer is directly under the question.
- Have students connect the cards to fit in a circle or have them arrange them in a column.

**"In the Rounds" are available on several different topics. Check out these resources for more fun "In the Round" examples! All are available for free download at [www.NEED.org](http://www.NEED.org).**

- Coal in the Round—*Exploring Coal*
- Conservation in the Round—*Monitoring and Mentoring, Learning and Conserving*
- Hydrogen in the Round—*H<sub>2</sub> Educate*
- Oil and Natural Gas Industry in the Round—*Fossil Fuels to Products, Exploring Natural Oil and Gas*
- Uranium in the Round—*Nuclear guides*
- Solar Energy in the Round—*Energy from the Sun*
- Transportation Fuels in the Round—*Transportation guides*



# Station Investigation Answer Keys

## Station One

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### Parts One and Two

The bouncing spheres demonstrated how gravitational potential energy (GPE) is transformed into kinetic energy, and then back into GPE when the sphere rebounds off of the table. Not all of the kinetic energy is transformed back into GPE, as demonstrated by the decrease in the height of the bounce. Some of the energy is dissipated to the air and surface as sound and thermal energy. Hot water added thermal energy to the spheres, which caused them to bounce higher. Students' answers will vary when discussing the real world applications.

### Part Three

The toy car and balloon transform elastic energy into motion energy, and some sound and thermal energy. The yo-yo transforms gravitational potential energy into motion energy.

## Station Two

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### Part One

The temperature of the vinegar decreased when baking soda was added. The chemicals absorbed some thermal energy when they reacted. The transformation observed was chemical energy to thermal energy.

### Part Two

The temperature of the water increased when calcium chloride was added. The chemicals released some thermal energy when they reacted. The chemical energy was transformed into thermal energy.

### Part Three

When iron is exposed to oxygen, it reacts with the oxygen to form rust, and thermal energy is released. The chemical energy in the oxygen is transformed to thermal energy.

## Station Three

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### Part One

Direct sunlight causes the temperature of an object to increase because it absorbs the energy. Radiant energy is transformed into thermal energy, as evidenced by the increase in temperature.

### Part Two

The vanes in the radiometer absorb the light that reaches them. The black sides of the vanes absorb more thermal energy than the white sides, and they get warmer. The increased thermal energy of the black vanes is transferred to the air molecules next to the black vanes and the molecules start to move faster, pushing on the black sides of the vanes. This causes the radiometer to rotate in a direction away from the light on the black side and toward the light on the white side. Radiant energy is transformed into thermal energy, and thermal energy is transformed into motion energy.

### Part Three

Tilting the solar panel away from the light source caused the motor to spin slower, indicating that less electrical energy was being produced by the solar panel. The solar panel transforms radiant energy into electrical energy and the motor of the fan transforms electrical energy into motion energy.

## Station Four

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### Part One

Bending the hanger causes the atoms in the metal to rub against each other, creating more friction and subsequently heating up. The motion energy of the metal is transformed into thermal energy.

### Part Two

Stretching a rubber band causes it to release thermal energy as its molecules are stressed and stretched, and it feels warmer. Relaxing the rubber band causes it to absorb thermal energy as the molecules relieve their stress and come back together, and it feels cooler. Motion energy is transformed into thermal energy.

### Part Three

The thermal energy of the hot water was transferred to the live wire, and it moved back into its original, straight shape. The thermal energy was transformed into motion energy.

### Part Four

The thermal energy from the burning candle caused the bi-metal bar to bend. The bending is caused by uneven expansion of the two metals in the bar when they are heated. Because stainless steel always expands more than nickel, the bi-metal bar will always bend away from the stainless steel side and toward the nickel side. Thermal energy is transformed into motion energy.

## Station Five

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### Part One

When the glow stick was heated by the warm water, it glowed brighter, indicating that the chemical reaction inside the glow stick was progressing at a faster rate. When placed in the ice water, the glow stick became dimmer, indicating that the chemical reaction was slowing down. The chemical energy inside the glow stick is transformed into radiant energy.

### Part Two

When the wires were inserted deeper into the apple, more surface area of metal was exposed to the interior of the apple, allowing the chemical reaction to progress more rapidly. The amount of electric current indicated by the meter increased. Thicker wires make more material available to react with the compounds in the apple, and the reaction increases to produce greater amounts of electrical energy. In general, the higher the concentration of material, and the greater the surface area of the substance, the faster the chemical reaction will occur. Chemical energy was being transformed into electrical energy.

## Station Six

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### Part One

When electric current flows through a wire, it generates a magnetic field. This will cause the needle of a compass to move when they are brought near to each other. The magnetic field of the wire and the magnetic field of the compass needle align. The chemical energy in the battery is transformed into electrical energy. The electrical energy in the wire is then transformed into motion energy in the compass needle.

### Part Two

A hand generated flashlight and motor work based on the same concept – the interaction between motion energy and electrical energy. The flashlight uses motion energy to generate electrical energy inside, and then further by transforming the electrical energy into radiant energy in the light bulb inside the flashlight. A motor uses electrical energy to generate motion energy, which can then be used to do other things, like turning a fan or operating a machine. A generator and a motor have the same parts but perform the opposite transformation: motion to electricity, or electricity to motion.





# Answer Keys

## Forms and Sources of Energy, page 48

### NONRENEWABLE

Petroleum - chemical  
Coal - chemical  
Natural Gas - chemical  
Uranium - nuclear  
Propane - chemical

### RENEWABLE

Biomass - chemical  
Hydropower - motion  
Wind - motion  
Solar - radiant  
Geothermal - thermal

▪Chemical - 86.5%, Nuclear - 8.6%, Motion - 4.2%, Radiant - 0.4%, Thermal - 0.2%

▪Nonrenewables - 90.2%, Renewables - 9.7%

## Energy Crossword, page 93

### ACROSS

1. kinetic
4. endothermic
6. chemical
9. react
11. photovoltaic
12. light
13. nuclear
14. solar

### DOWN

2. potential
3. energy
5. elastic
7. thermal
8. exothermic
10. electricity

## Energy Scramble, page 94

ELECTRICITY, HEAT, MOTION, LIGHT, GROW, ENERGY

## Energy Transformations, page 94

1. radiant to electrical
2. chemical to electrical
3. chemical to motion
4. motion to electrical
5. chemical to thermal
6. chemical to radiant
7. chemical to electrical and radiant

8. radiant to thermal and motion
9. chemical to thermal and radiant
10. nuclear to radiant and thermal
11. chemical to motion and radiant
12. chemical to motion and thermal
13. chemical to motion and thermal and sound
14. chemical to radiant and thermal and sound

## Energy Flow, page 95

- Radiant (Light) Energy - 8
- Chemical Energy (Grains) - 3
- Radiant Energy - 2
- Chemical Energy (Girl) - 4

- Motion Energy - 5
- Nuclear Energy - 1
- Electrical Energy - 7
- Electrical Energy (Battery) - 6



# Answer Keys

## Intermediate Science of Energy Assessment, pages 91-92

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1. The ball will not return to the original height because some of the energy will be transformed into other energy forms such as thermal and sound energy.
2. **Examples:**
  - Compressing a spring and letting it go
  - Rock sitting on a hill, rolls down the hill
  - Air in a balloon, letting it go and it flies
3. It is exothermic because it is a reaction that produces heat. Chemical energy is transformed to thermal energy.
4. Radiant energy is changed into thermal energy in the bulb, which is absorbed or reflected, exciting air molecules and creating motion.
5. Radiant energy is changed to electrical energy.
6. Both items change thermal energy to motion.
7. The rate of the chemical reaction increases with heat added and decreases with heat being removed. Chemical energy is changed to radiant energy.
8. Chemical energy is changed to electrical energy. The size, type, and depth of metal affect the transformation of energy.
9. Shaking the flashlight moves the magnet through a coil of copper wire that flows to the capacitor or battery where it is stored as electricity. This electricity powers the light.
10. The sun's nuclear energy transforms to radiant energy, to chemical energy in plants, to chemical energy in people, which then transforms into motion energy to pedal the bike.



# Teacher Demonstration: What Was Happening?

## Containers of Sand, pages 7-8

The energy we use is stored in different forms. Energy does not disappear, it just changes forms. This is the Law of Conservation of Energy. This law states that energy is neither created nor destroyed.

There are two containers of sand, one filled about one-third of the way and the other filled to the top. Since they have been in the same environment, they should be the same temperature.

After each student has shaken the containers, the temperature was recorded. You should have seen a two to five degree Celsius increase with the third-full one, less with the full one. The difference will be more apparent on the Fahrenheit scale since the increments are smaller on the Fahrenheit scale. A five-degree difference in Celsius equals a nine-degree difference in Fahrenheit.

Shaking the container, we moved the grains of sand, causing them to collide with each other. They rubbed against each other, causing friction between the particles and producing thermal energy (heat). We transformed motion energy into thermal energy (heat).

The increase in temperature was greater for the container that was only one-third full, because the partially full container has more space in it for the sand to move around. The grains of sand collide with each other with greater velocity. More velocity means more kinetic energy (motion). In the container filled with sand, the grains of sand have little space to move.

## Energy Transformations, page 8

The energy transformation from shaking these containers of sand originated from our sun.

Let's start with the thermal energy, or heat, we produced as a result of the motion our bodies provided. Our bodies got the energy to shake the bottle from the food we ate. The energy was stored in the food as chemical energy in the bonds of the molecules. Chemical energy is stored in food through photosynthesis. Sunlight, or radiant energy, changes water and carbon dioxide into the glucose and oxygen in plants. Glucose is a sugar with lots of energy—chemical energy.

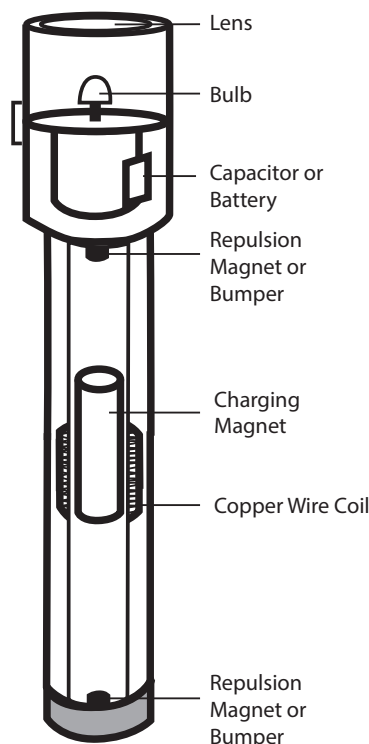
Additionally, some amount of energy was transferred to each container by our hands. The full container has less of a temperature increase because the energy transferred was spread out over a greater amount of sand. The less full container has less sand, and thus the energy transformation was higher, resulting in a higher temperature.

## Hand Generated Flashlight, pages 8, 12

A hand generated flashlight works by converting motion into electrical energy. Electricity is powering the light and charging the capacitor or battery to use when not shaking.

Inside of the flashlight is a stationary coil of wire. There is also one magnet that passes through the coil of wire when the flashlight is gently shaken. This magnet is called the "charging" magnet. At each end of the inner housing is sometimes an additional magnet. These magnets are oriented to repel the charging magnet so it moves smoothly through the coil of wire. This is called a magnetic repulsion recoil system. There may also be rubber bumpers, rather than magnets, that cause the central magnet to recoil.

As the flashlight is shaken, electricity is generated as the charging magnet passes back and forth through the coil of wire. The electricity is stored in a capacitor or battery. When the flashlight is turned on, the capacitor or battery delivers electricity to a light emitting diode (LED). The light will stay on as long as the capacitor or battery is charged.



In a hand generated flashlight, motion energy is transformed into electrical energy and radiant energy.



# Station # \_\_\_\_\_ Presentation Planning Guide

PRESENTATION ELEMENTS	WHO IS RESPONSIBLE?
Present the question.	
Demonstration: What will you do?	
Ask the group to identify the energy transformations.	
Explain what was happening at your station.	

This image shows a full page of blank graph paper. The grid consists of thin, light gray horizontal and vertical lines that intersect to form small squares across the entire surface. There are no margins, text, or other markings on the paper.



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This image shows a full page of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page, providing a template for handwriting practice or general note-taking. There are no margins, text, or other markings on the page.

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# Station One Reporting Form

## PART ONE: SPHERES

Independent Variables (IV): \_\_\_\_\_

Dependent Variables (DV): \_\_\_\_\_

Constants: \_\_\_\_\_

🌟Hypothesis: \_\_\_\_\_

### Data and Observations:

	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE
SUPERBALL				
BLACK SPHERE 1				
BLACK SPHERE 2				
OBSERVATIONS				

## PART TWO: SPHERES IN HOT WATER

Independent Variables (IV): \_\_\_\_\_

Dependent Variables (DV): \_\_\_\_\_

Constants: \_\_\_\_\_

🌟Hypothesis: \_\_\_\_\_

### Data and Observations:

HOT WATER				
	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE
BLACK SPHERE 1				
BLACK SPHERE 2				
SUPERBALL				
OBSERVATIONS				

**PART ONE AND TWO CONCLUSIONS: SPHERES**

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**Energy Transformation(s)**

**PART THREE: TOYS**

 **Hypothesis:** \_\_\_\_\_

\_\_\_\_\_

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TOY	ENERGY TRANSFORMATION

**PART THREE CONCLUSION: TOYS**

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**Energy Transformation(s)**

**STATION ONE CONCLUSIONS**

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**QUESTIONS FOR FURTHER INVESTIGATION**

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# Station Two Reporting Form

## PART ONE: BAKING SODA AND VINEGAR

Data and Observations:

	TEMPERATURE	OBSERVATIONS
VINEGAR		
VINEGAR AND BAKING SODA		

### PART ONE CONCLUSION: BAKING SODA AND VINEGAR

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Energy Transformation(s)

## PART TWO: CALCIUM CHLORIDE AND WATER

Data and Observations:

	TEMPERATURE	OBSERVATIONS
WATER		
WATER AND CALCIUM CHLORIDE		

### PART TWO CONCLUSION: CALCIUM CHLORIDE AND WATER

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Energy Transformation(s)

PART THREE: HAND WARMERS

	TEMPERATURE			OBSERVATIONS
	INITIAL	AFTER 3 MINUTES	3 MINUTES AFTER SEALING	
NEW PACKET				
OLD PACKET				

PART THREE CONCLUSION: HAND WARMERS

\_\_\_\_\_

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Energy Transformation(s)

STATION TWO CONCLUSIONS

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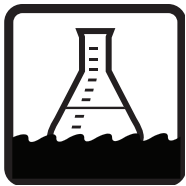
QUESTIONS FOR FURTHER INVESTIGATION

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# Station Three Reporting Form

## PART ONE: SUNLIGHT AND SHADE

Independent Variables (IV): \_\_\_\_\_

Dependent Variables (DV): \_\_\_\_\_

Constants: \_\_\_\_\_

Hypothesis: \_\_\_\_\_

### Data and Observations:

	STARTING TEMPERA- TURE	5 MINUTES TEMPERATURE	10 MINUTES TEMPERATURE	15 MINUTES TEMPERATURE	OVERALL CHANGE IN TEMPERATURE
THERMOMETER IN SUN OR DIRECT LIGHT					
THERMOMETER IN THE SHADE OR OUT OF DIRECT LIGHT					

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AMOUNT OF LIGHT	RADIOMETER OBSERVATIONS

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PART THREE: SOLAR PANEL

Independent Variable (IV):

Dependent Variable (DV):

Constants:

Hypothesis:

Data and Observations:

PV CELL DEGREES FROM VERTICAL	OBSERVATIONS
0°	

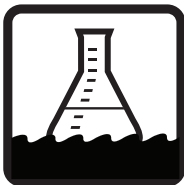
PART THREE CONCLUSION: SOLAR PANEL

Energy Transformation(s)

STATION THREE CONCLUSIONS

QUESTIONS FOR FURTHER INVESTIGATION





# Station Four Reporting Form

## PART ONE: THE HANGER

### HANGER OBSERVATIONS

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### PART ONE CONCLUSION: THE HANGER

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### Energy Transformation(s)

## PART TWO: THE RUBBER BAND

### RUBBER BAND OBSERVATIONS

#### STRETCHED

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#### CONTRACTED

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### PART TWO CONCLUSION: THE RUBBER BAND

Energy Transformation(s)

### PART THREE: THE LIVE WIRE

Independent Variable (IV):

Dependent Variable (DV):

Constants:

Hypothesis:

#### Data and Observations:

WATER	SHAPE BEFORE	SHAPE AFTER
ICE WATER 0		
HOT WATER 0		
ROOM TEMPERATURE WATER 0		

### PART THREE CONCLUSION: THE LIVE WIRE

Energy Transformation(s)

## PART FOUR: THE BI-METAL BAR

### BI-METAL BAR DIAGRAM



### COMPARE DIAGRAM AND ACTUAL BAR

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### BI-METAL BAR AND CANDLE DIAGRAM

#### OBSERVATIONS

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### BI-METAL BAR AND ICE WATER DIAGRAM

#### OBSERVATIONS

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#### PART FOUR CONCLUSION: THE BI-METAL BAR

Energy Transformation(s)

#### STATION FOUR CONCLUSIONS

#### QUESTIONS FOR FURTHER INVESTIGATION



# Station Five Reporting Form

## PART ONE: GLOW STICKS

Independent Variables (IV): \_\_\_\_\_

Dependent Variables (DV): \_\_\_\_\_

Constants: \_\_\_\_\_

Hypothesis: \_\_\_\_\_

### GLOW STICK DIAGRAM

### HOW IT WORKS

### Data and Observations:

	OBSERVATIONS	BRIGHTNESS RANK
GLOW STICK IN COLD H <sub>2</sub> O		
GLOW STICK IN HOT H <sub>2</sub> O		
GLOW STICK AT ROOM TEMPERATURE		

### PART ONE CONCLUSION: GLOW STICKS

Energy Transformation(s)

PART TWO: THE APPLE BATTERY

Independent Variables (IV):

Dependent Variables (DV):

Constants:

Hypothesis:

APPLE BATTERY DIAGRAM

OBSERVATIONS

DATA TABLE 1

	LARGE ZINC NAIL AND THICK COPPER WIRE	LARGE ZINC NAIL AND THIN COPPER WIRE	SMALL ZINC NAIL AND THIN COPPER WIRE
1 cm			
2 cm			
3 cm			
4 cm			
METALS TOUCHING			

DATA TABLE 2

COMBINATION OF METALS	MICROAMMETER READING
2 COPPER WIRES	

**PART TWO CONCLUSION: THE APPLE BATTERY**

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**Energy Transformation(s)**

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**STATION FIVE CONCLUSIONS**

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**QUESTIONS FOR FURTHER INVESTIGATION**

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# Station Six Reporting Form

## PART ONE: BATTERY AND COMPASS

### OBSERVATIONS

#### HEAVY-GAUGE WIRE PARALLEL TO COMPASS NEEDLE

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#### HEAVY-GAUGE WIRE PERPENDICULAR TO COMPASS NEEDLE

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#### HEAVY-GAUGE WIRE WITH ELECTRIC CURRENT PARALLEL TO COMPASS NEEDLE

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#### HEAVY-GAUGE WIRE WITH ELECTRIC CURRENT PERPENDICULAR TO COMPASS NEEDLE

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### PART ONE CONCLUSION: BATTERY AND COMPASS

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#### Energy Transformation(s)



**PART TWO: HAND GENERATED FLASHLIGHT AND MOTORS**

**HAND GENERATED FLASHLIGHT DIAGRAM**

**HOW IT WORKS AND OBSERVATIONS**

**DISASSEMBLED MOTOR DIAGRAM**

**ASSEMBLED MOTOR DIAGRAM**

**OBSERVATIONS**

**PART TWO CONCLUSION: HAND GENERATED FLASHLIGHT AND MOTORS**

**Energy Transformation(s)**

### STATION SIX CONCLUSIONS

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### QUESTIONS FOR FURTHER INVESTIGATION

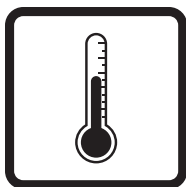
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# Thermometer

A thermometer measures temperature. The temperature of a substance is a measure of the average amount of kinetic energy in the substance.

This thermometer is a long, glass tube filled with colored alcohol. Alcohol is used in many thermometers because it expands in direct proportion to the increase in kinetic energy or temperature.

Temperature can be measured using many different scales.

The scales we use most are:

## ▪ Celsius

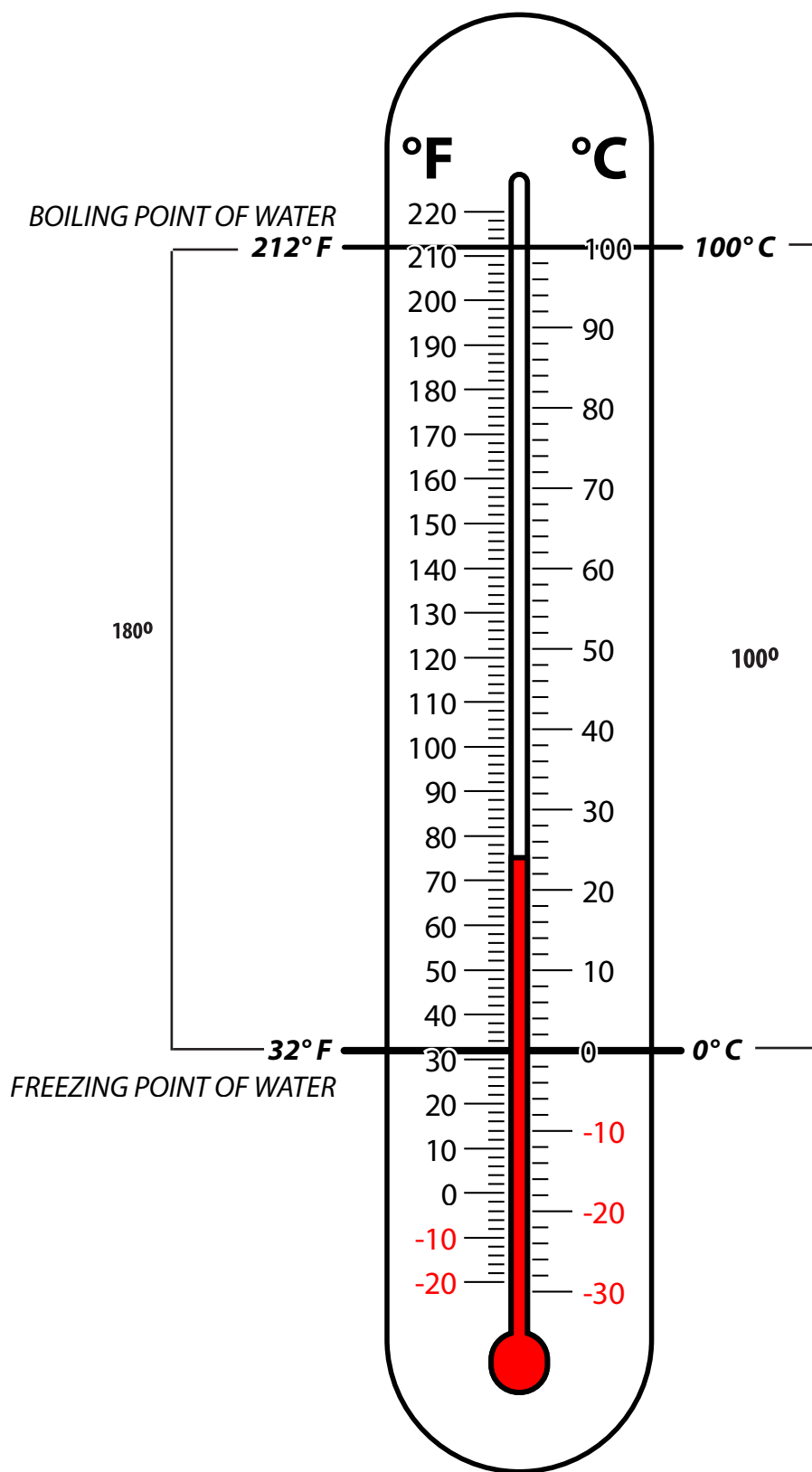
The **Celsius (C)** scale uses the freezing point of water as  $0^{\circ}\text{C}$  and the boiling point of water as  $100^{\circ}\text{C}$ .

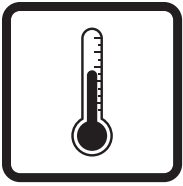
## ▪ Fahrenheit

The **Fahrenheit (F)** scale uses the freezing point of water as  $32^{\circ}\text{F}$  and the boiling point of water as  $212^{\circ}\text{F}$ .

In the United States, we usually use the Fahrenheit scale in our daily lives, and the Celsius scale for scientific work. People in most countries use the Celsius scale in their daily lives as well as for scientific work.

Notice the numerical difference between the freezing and boiling points of water are different on the two scales. The difference on the Celsius scale is 100, while the difference on the Fahrenheit scale is 180. There are more increments on the Fahrenheit scale because it shows less of an energy change with each degree.





# Fahrenheit/Celsius Conversion

On the Fahrenheit scale, the freezing point of water is 32° and the boiling point of water is 212°.

On the Celsius scale, the freezing point of water is 0° and the boiling point of water is 100°.

To convert from Celsius to Fahrenheit, multiply the C number by  $\frac{180}{100}$  or  $\frac{9}{5}$ , then add 32, as shown in the formula below.

$$F = (C \times \frac{9}{5}) + 32$$

$$\text{If } C = 5$$

$$F = (5 \times \frac{9}{5}) + 32$$

$$F = 9 + 32$$

$$F = 41$$

To convert from Fahrenheit to Celsius, subtract 32 from the F number, then multiply by  $\frac{100}{180}$  or  $\frac{5}{9}$  as shown in the formula below.

$$C = (F - 32) \times \frac{5}{9}$$

$$\text{If } F = 50$$

$$C = (50 - 32) \times \frac{5}{9}$$

$$C = 18 \times \frac{5}{9}$$

$$C = 10$$



# Forms of Energy

**All forms of energy fall under two categories:**



## POTENTIAL

Stored energy and the energy of position (gravitational).

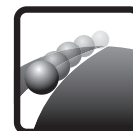


**CHEMICAL ENERGY** is the energy stored in the bonds between atoms in molecules. Gasoline and a piece of pizza are examples.

**NUCLEAR ENERGY** is the energy stored in the nucleus or center of an atom – the energy that holds the nucleus together. The energy in the nucleus of a plutonium atom is an example.

**ELASTIC ENERGY** is energy stored in objects by the application of force. Compressed springs and stretched rubber bands are examples.

**GRAVITATIONAL POTENTIAL ENERGY** is the energy of place or position. A child at the top of a slide is an example.



## KINETIC

The motion of waves, electrons, atoms, molecules, and substances.



**RADIANT ENERGY** is electromagnetic energy that travels in transverse waves. Light and x-rays are examples.

**THERMAL ENERGY** or heat is the internal energy in substances – the vibration or movement of atoms and molecules in substances. The heat from a fire is an example.

**MOTION ENERGY** is the energy of the movement of a substance from one place to another. Wind and moving water are examples.

**SOUND ENERGY** is the movement of energy through substances in longitudinal waves. Echoes and music are examples.

**ELECTRICAL ENERGY** is the movement of electrons. Lightning and electricity are examples.



# Lab Safety Rules

## Eye Safety

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- Always wear safety glasses when performing experiments.

## Fire Safety

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- Do not heat any substance or piece of equipment unless specifically instructed to do so.
- Be careful of loose clothing. Do not reach across or over a flame.
- Keep long hair pulled back and secured.
- Do not heat any substance in a closed container.
- Always use tongs or protective gloves when handling hot objects. Do not touch hot objects with your hands.
- Keep all lab equipment, chemicals, papers, and personal effects away from the flame.
- Extinguish any flame as soon as you are finished with the experiment and move it away from the immediate work area.

## Heat Safety

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- Always use tongs or protective gloves when handling hot objects and substances.
- Keep hot objects away from the edge of the lab table, in a place where no one will accidentally come into contact with them.
- Remember that many objects will remain hot for a long time after the heat source is removed or turned off.

## Glass Safety

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- Never use a piece of glass equipment that appears cracked or broken.
- Handle glass equipment carefully. If a piece of glassware breaks, do not attempt to clean it up yourself. Inform your teacher.
- Glass equipment can become very hot. Use tongs if glassware has been heated.
- Clean glass equipment carefully before packing it away.

## Chemical Safety

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- Do not smell, touch, or taste chemicals unless instructed to do so.
- Keep chemical containers closed except when using them.
- Do not mix chemicals without specific instructions.
- Do not shake or heat chemicals without specific instructions.
- Dispose of used chemicals as instructed. Do not pour chemicals back into containers without specific instructions to do so from your teacher.
- If a chemical accidentally touches your skin, immediately wash the affected area with water and inform your teacher.

**MSDS Safety Sheets** are included for all chemicals in the kits as well as the products of all chemical reactions.

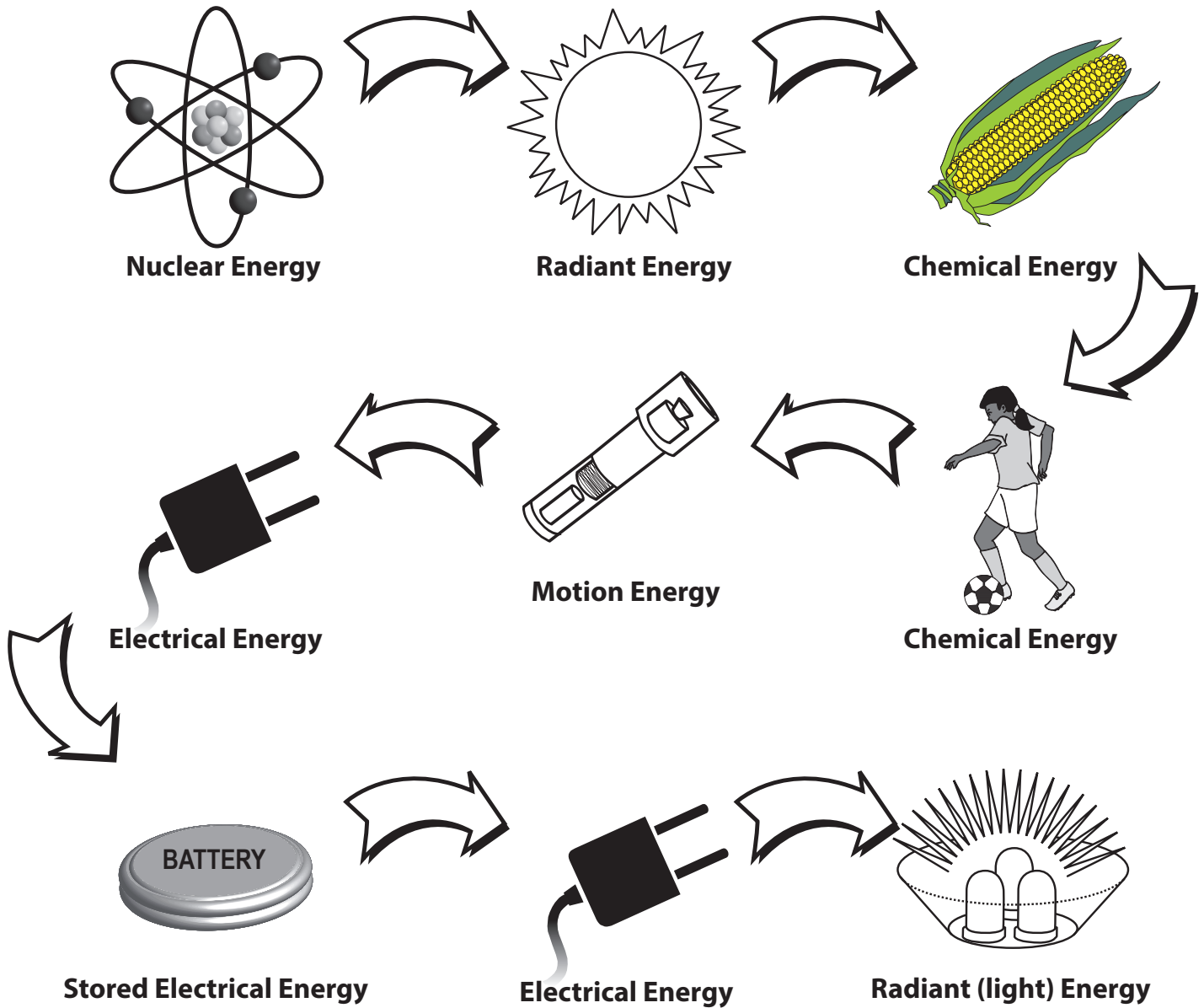
**Glow Stick Safety:** The solutions contained in the glow sticks are non-toxic and will not cause injury to the skin or eyes. Eye contact may cause temporary discomfort similar to that produced by soaps or shampoos. Should a glow stick rupture, rinse the affected area thoroughly with water, then repeat the process. The solutions can soften or mar paint and varnish, and can stain fabric. If you have any concerns about possible allergic reactions or sensitivities, please speak with Omniglow's customer service at 1-866-783-3799.

**Thermometer Safety:** Thermometers included for use in this kit contain alcohol spirits and are safe for classroom use. They do not contain mercury.



# Energy Transformations

## Hand Generated Flashlight





# Forms and Sources of Energy

In the United States we use a variety of resources to meet our energy needs. Use the information below to analyze how each energy source is stored and delivered.

- 1 Using the information from the *Forms of Energy* chart, and the graphic below, determine how energy is stored or delivered in each of the sources of energy. Remember, if the source of energy must be burned, the energy is stored as chemical energy.

## NONRENEWABLE

Petroleum \_\_\_\_\_  
Coal \_\_\_\_\_  
Natural Gas \_\_\_\_\_  
Uranium \_\_\_\_\_  
Propane \_\_\_\_\_

## RENEWABLE

Biomass \_\_\_\_\_  
Hydropower \_\_\_\_\_  
Wind \_\_\_\_\_  
Solar \_\_\_\_\_  
Geothermal \_\_\_\_\_

- 2 Look at the U.S. Energy Consumption by Source graphic below and calculate the percentage of the nation's energy use that each form of energy provides.

What percentage of the nation's energy is provided by each form of energy?








Chemical \_\_\_\_\_  
Nuclear \_\_\_\_\_  
Motion \_\_\_\_\_  
Radiant \_\_\_\_\_  
Thermal \_\_\_\_\_

What percentage of the nation's energy is provided by nonrenewables? \_\_\_\_\_

by renewables? \_\_\_\_\_






## U.S. Energy Consumption by Source, 2015

### NONRENEWABLE

	<b>PETROLEUM</b> 36.6%  *	<i>Uses: transportation, manufacturing - includes propane</i>
	<b>NATURAL GAS</b> 29.0%  *	<i>Uses: heating, manufacturing, electricity - includes propane</i>
	<b>COAL</b> 16.0%	<i>Uses: electricity, manufacturing</i>
	<b>URANIUM</b> 8.6%	<i>Uses: electricity</i>
	<b>PROPANE</b>	<i>Uses: heating, manufacturing</i>

\*Propane consumption is included in petroleum and natural gas totals.

### RENEWABLE

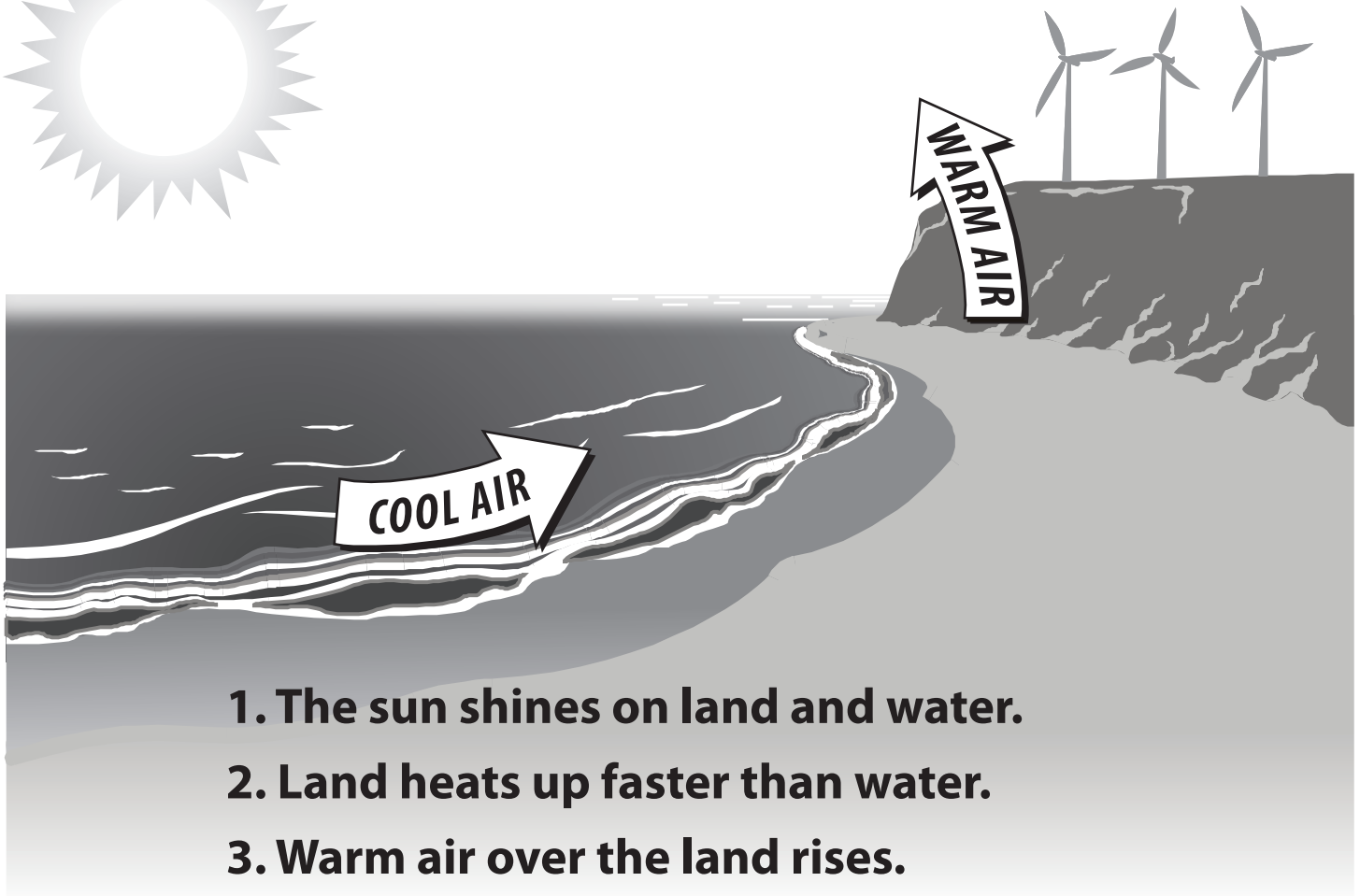
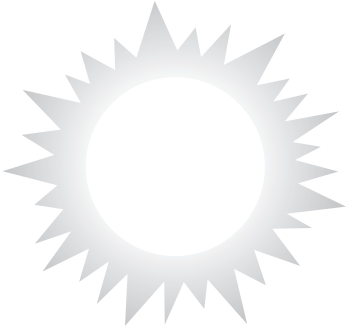
	<b>BIOMASS</b> 4.9%	<i>Uses: heating, electricity, transportation</i>
	<b>HYDROPOWER</b> 2.4%	<i>Uses: electricity</i>
	<b>WIND</b> 1.8%	<i>Uses: electricity</i>
	<b>SOLAR</b> 0.4%	<i>Uses: heating, electricity</i>
	<b>GEOTHERMAL</b> 0.2%	<i>Uses: heating, electricity</i>

\*\*Total does not add up to 100% due to independent rounding.  
Data: Energy Information Administration





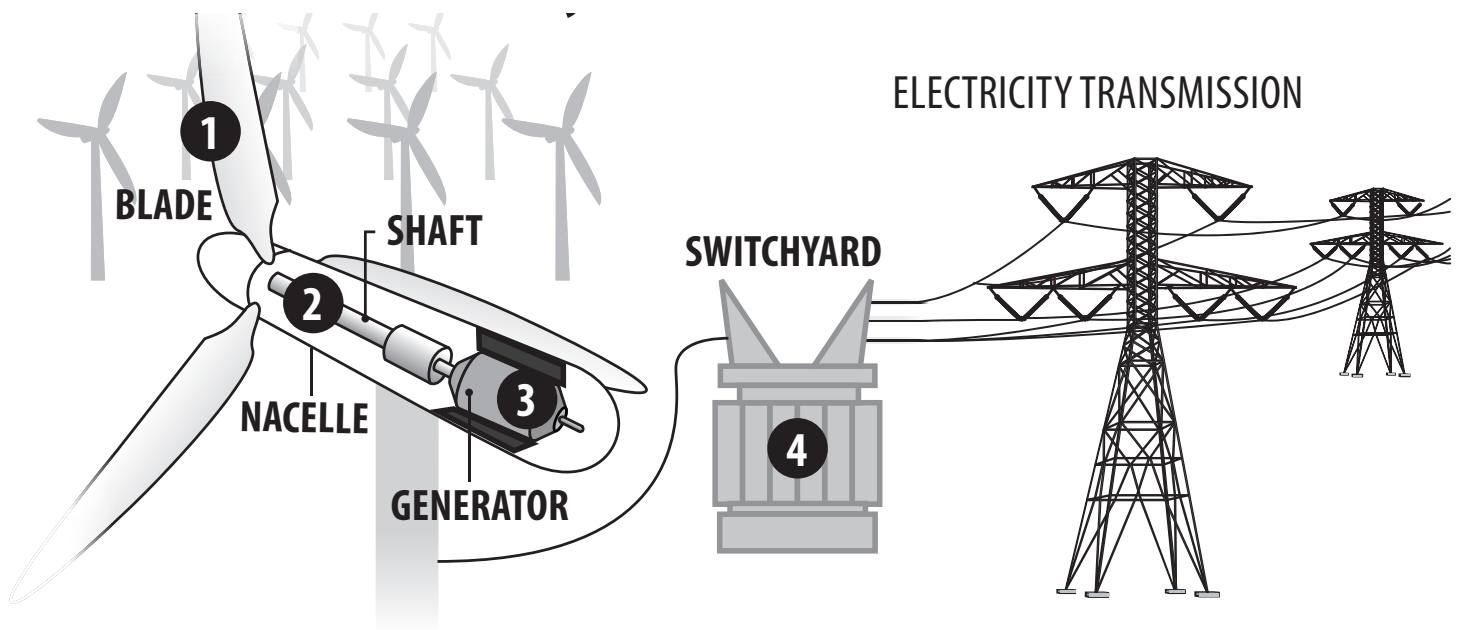
## How Wind is Formed



1. The sun shines on land and water.
2. Land heats up faster than water.
3. Warm air over the land rises.
4. Cool air over the water moves in.



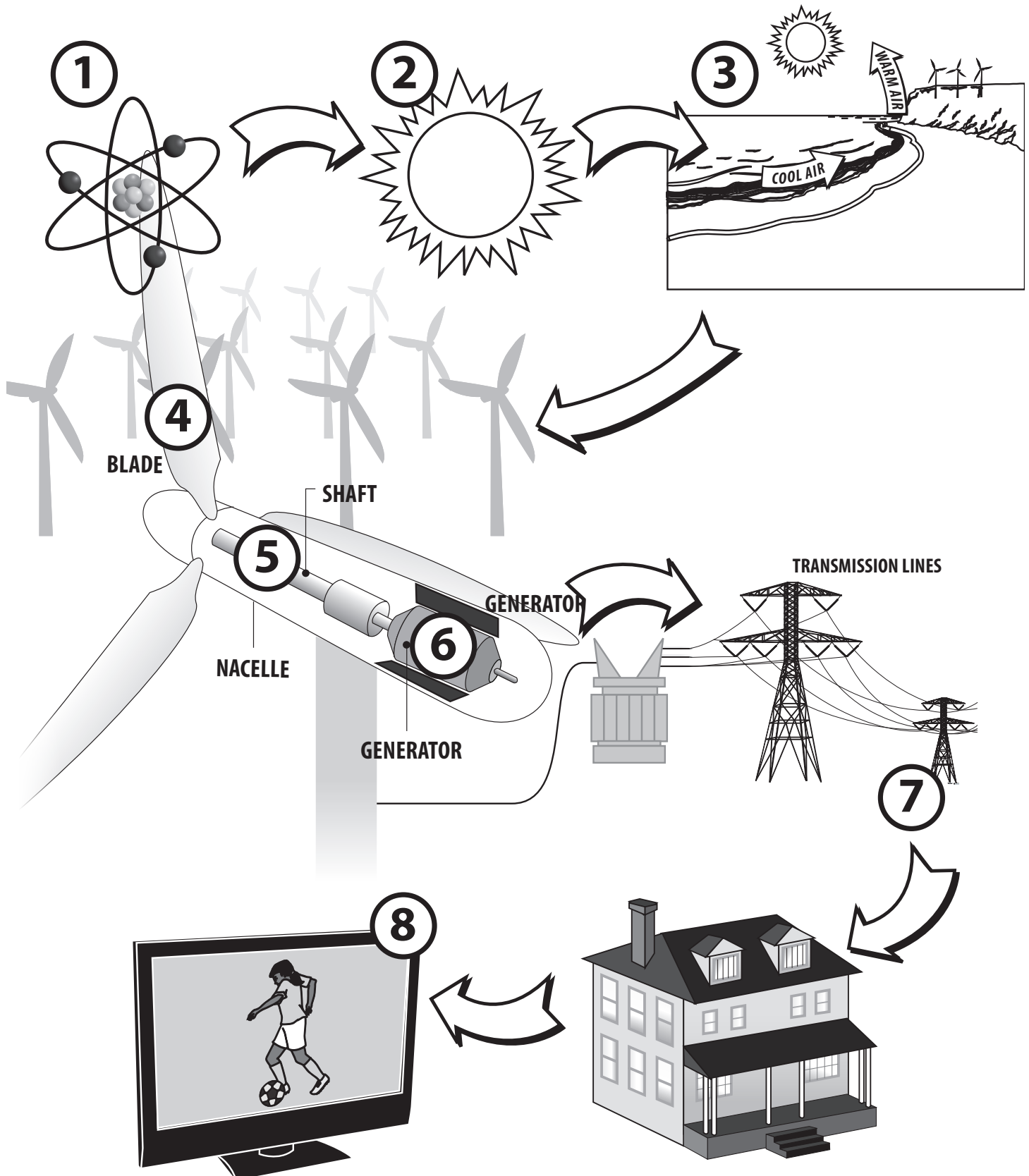
# Harnessing the Wind to Generate Electricity

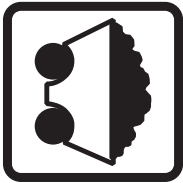


1. Wind turns the blades of the turbine.
2. The blades spin a shaft inside the nacelle.
3. Inside the generator, the shaft spins coils of copper wire inside a ring of magnets. This creates an electric field, producing electricity.
4. Electricity is sent to a switchyard, where a transformer increases the voltage, allowing it to travel through the electric grid.

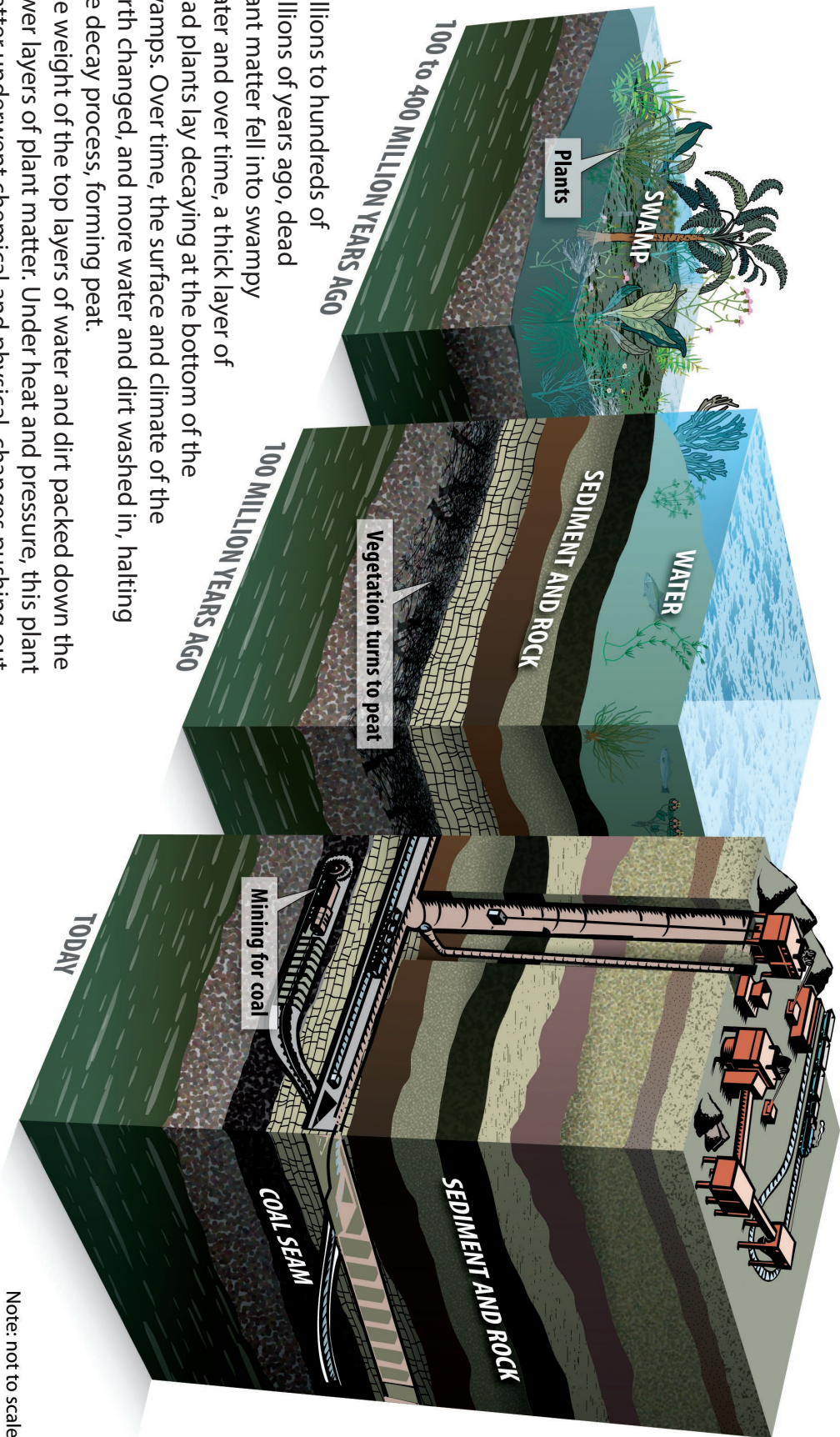


# Wind Energy Flow



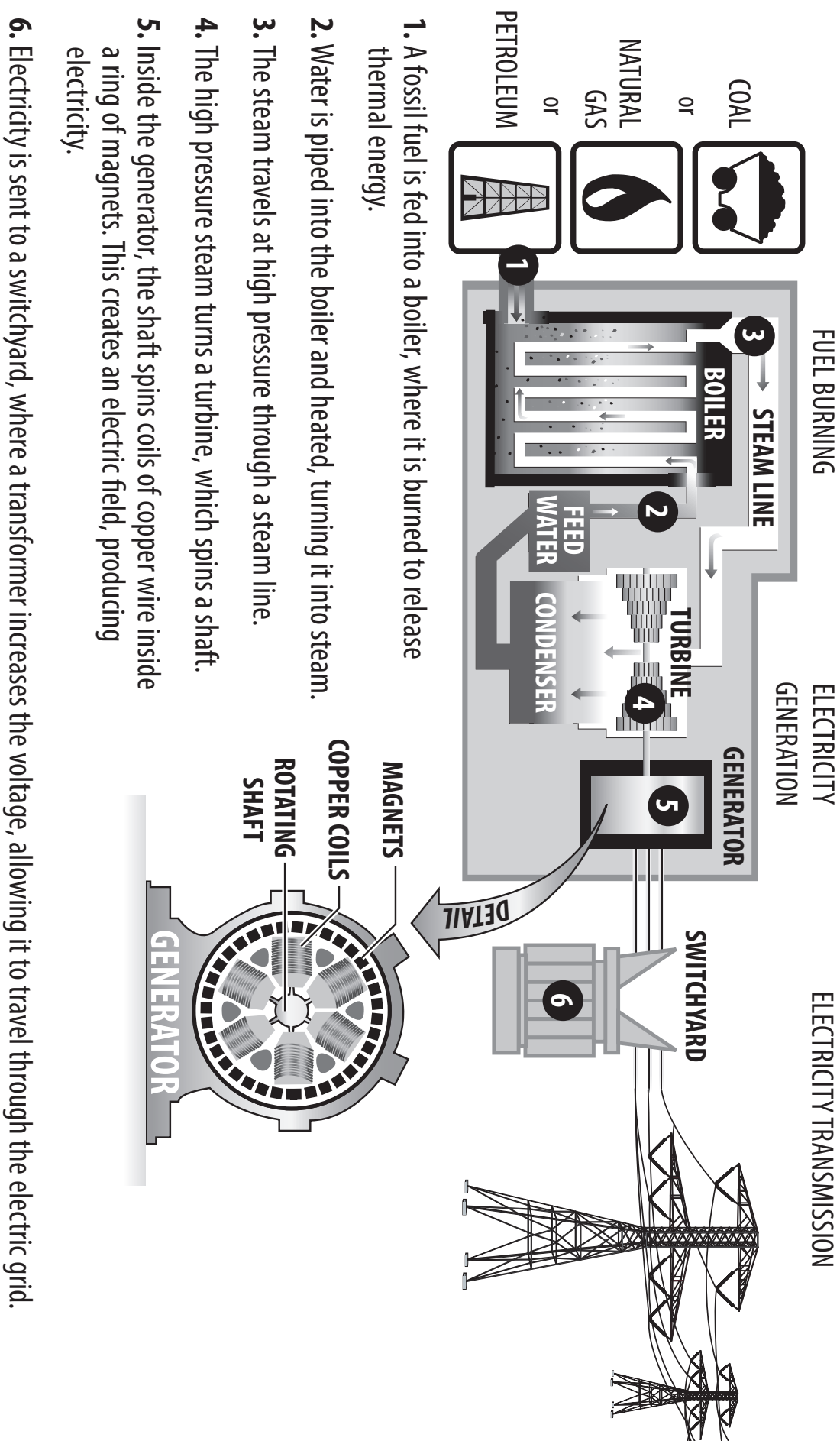


# How Coal Was Formed





# Burning Fossil Fuels to Generate Electricity







# A Cool Coal Story

Students will demonstrate the flow of energy to produce electricity using props. Depending on the audience, signs with the different forms of energy can be used by the students to identify the energy transformations. This activity can also be used to demonstrate other energy flows, like biodiesel, ethanol, natural gas, etc.

<b>Sun</b>	Nuclear fusion—produces energy
Prop & Action	Yellow ball
<b>Radiant Energy</b>	Nuclear energy in the sun is transformed to radiant energy and travels through space to Earth. Radiant energy travels in WAVES.
Prop & Action	Long pieces of yellow ribbon, several students wave in the air
<b>Chemical Energy</b>	Radiant energy is absorbed by green plants and through photosynthesis converts radiant energy to chemical energy.
Prop & Action	Green plants or silk plants, students bring up from floor
<b>Stored Chemical Energy</b>	Green plants die and are compressed under extreme pressure over a LONG period of time and become COAL. Chemical energy is stored in the coal.
Prop & Action	Green plants or silk plants, students step on leaves
<b>Coal</b>	Coal is mined and taken to a power plant. (Additional details may be added if desired.)
Prop & Action	Pieces of coal OR wads of black construction paper, students pick up coal from ground
<b>Thermal Energy</b>	Coal is burned in the furnace. Stored chemical energy produces thermal energy.
Prop & Action	Empty box, coal is put into "furnace" box
<b>Thermal Energy</b>	The thermal energy heats the water. Water becomes steam.
Prop & Action	Hot pot or bottled water, student lifts up hot pot
<b>Steam</b>	Steam travels down pipes (plastic tubing) to the turbine.
Prop & Action	Plastic hose or tubing, connect tube to hot pot used above
<b>Motion/Mechanical Energy</b>	Steam causes the turbine blades to spin.
Prop & Action	Student arms, student stands with arms outstretched and bent upwards at the elbow, student spins as steam touches them
<b>Electrical Energy</b>	The turbine is connected to the generator causing the magnets to spin around the copper coils producing electrical energy.
Prop & Action	Bar magnets, copper ribbons, three students hold bar magnets, one student is 'wrapped' in copper colored ribbon or wire, students with magnets 'spin' around copper wire
<b>Electrical Energy</b>	Electrical energy travels down the power lines to our homes.
Prop & Action	Twisted rope, start with twisted rope then pull away the smaller pieces to designate the low voltage lines that come into our homes
<b>Electrical Energy</b>	Electrical energy powers our homes.
Prop & Action	'Magic' light bulb, and extension cord, student pulls chain on light bulb or switches it on
<b>Variations</b>	<i>Other energy flows can be demonstrated, substituting other sources for the coal (corn to ethanol; soybeans to biodiesel; decomposing garbage to methane, etc.)</i>



## A Cool Coal Story

A long, long time ago before even the dinosaurs roamed the Earth, the sun shone in the sky and giant plants grew in swampy forests. Like all living things, these plants died.

And more plants grew and died. This happened over and over for millions of years—plants grew and died and fell into the swamp.

The plants on the bottom got squished—really, really squished. After millions of years of being really squished those plants turned into COAL.

Now the coal is buried in the ground. Big machines—giant bulldozers and steam shovels—dig it up.

The machines load the coal onto trains and barges to take it to the power plant.

Inside the power plant there is a giant tub of water with a big furnace in the middle. The coal is put into the big furnace and burned.

The smoke from the fire is cleaned with big scrub brushes before it goes up the smokestack and into the air.

Inside the furnace it gets really hot. So hot, the water in the tub boils and turns into steam. The oven is called a boiler because it boils the water and turns it into steam.

That steam comes roaring through a big pipe and turns a giant pinwheel, called a turbine.

The middle of the pinwheel has coils of wire wrapped around it. On the blades of the pinwheel are big magnets. When the magnets spin around the wire, it makes electricity. That is amazing!

Now, we can't go down to the power plant to buy a bag of electricity. So, the electricity comes to us.

A wire from the turbine runs out of the power plant and up a tall, tall pole. The electricity flows up the wire to the top of the pole. It flows through high-power lines from pole to pole until it gets to our town.

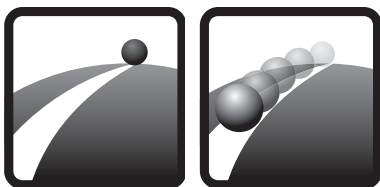
Then it flows into lots of small wires to our houses. Inside our houses—hidden in the walls—are lots of wires. They go to all the switches and all the outlets all over our house and the electricity flows through them.

When we flip on a light switch, the electricity flows into the light bulb and makes light.

When we plug a radio into an outlet, we get music. The electricity flows through the cord to make it work. Electricity runs our washers and dryers, TVs, and video games.

Lots of the electricity in our country is made by burning coal. The energy in the coal came from the sun.





# Station One Guide

## POTENTIAL AND KINETIC ENERGY

### Part One: Spheres

#### Questions

- What forms of energy are demonstrated when you bounce a ball?
- What energy transformation(s) occur?

#### Hypothesis

Read the questions above and the procedure below. Write a hypothesis to address the questions. Identify the variables to help you write the hypothesis.

Independent Variable(s) \_\_\_\_\_

Dependent Variable(s) \_\_\_\_\_

Constants \_\_\_\_\_

#### Materials

- Measuring tape or meter stick
- Safety glasses
- 1 Set of happy/sad spheres
- Hard surface  
(to drop spheres on)
- Superball

#### Vocabulary

- absorb
- collision
- gravitational potential energy
- kinetic energy
- potential energy
- rebound
- thermal energy

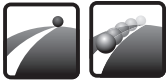
#### Procedure

1. Drop the superball onto a hard surface from a height of one meter.
2. Record how high the superball rebounds and any other observations.
3. Repeat steps 1-2 two more times for a total of three trials and calculate the average.
4. Drop one black sphere onto a hard surface from a height of one meter.
5. Record how high the sphere rebounds and any other observations.
6. Repeat steps 4-5 two more times for a total of three trials and calculate the average. Place the sphere aside on a piece of scrap paper labeled "sphere 1."
7. Drop the second black sphere onto the hard surface, also from a height of one meter.
8. Record how high the sphere rebounds and any other observations.
9. Repeat steps 7-8 for a total of three trials and calculate the average. Place the sphere aside on a piece of scrap paper labeled "sphere 2."

#### Data

Table 1

	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE
SUPERBALL				
BLACK SPHERE 1				
BLACK SPHERE 2				



## Station One Guide | *POTENTIAL AND KINETIC ENERGY*

### Part Two: Spheres in Hot Water

#### Question

▪How does a change in temperature affect the energy transformations in bouncing spheres?

#### Hypothesis

Read the question above and the procedure below. Write a hypothesis to address the question. Identify the variables to help you write the hypothesis.

Independent Variable(s) \_\_\_\_\_

Dependent Variable(s) \_\_\_\_\_

Constants \_\_\_\_\_

#### Materials

- Measuring tape or meter stick
- 1 Set of happy/sad spheres
- Hard surface (to drop spheres on)
- Superball
- Safety glasses
- Tongs
- Cup of hot water

#### Vocabulary

- absorb
- collision
- gravitational potential energy
- kinetic energy
- potential energy
- rebound
- thermal energy

#### Procedure

1. Place sphere 1 into the cup of hot water and let it sit in the hot water for two minutes.
2. Using the tongs, remove sphere 1 and place sphere 2 into the cup of hot water.
3. Drop sphere 1 onto a hard surface from a height of one meter, and record the results. Repeat for a total of three trials.
4. Set sphere 1 aside and remove sphere 2 from the hot water using the tongs. Put the superball into the hot water.
5. Drop sphere 2 onto the hard surface from a height of one meter, and record the results. Repeat for a total of three trials.
6. Set sphere 2 aside and remove the superball from the hot water using the tongs.
7. Drop the superball onto the hard surface from a height of one meter, and record the results. Repeat for a total of three trials.

#### Data

Table 2

HOT WATER				
	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE
BLACK SPHERE 1				
BLACK SPHERE 2				
SUPERBALL				

#### Part One and Two Conclusions

What forms of energy were demonstrated and what transformations occurred? Was there a change in results after the spheres had been placed in hot water? How was energy transferred when hot water entered the system? Explain what happened and why you think it happened using data to support your reasoning. What real world applications can you think of where energy transfers occur in the same manner?



## Station One Guide | *POTENTIAL AND KINETIC ENERGY*

### Part Three: Toys

#### Caution

This activity uses a balloon made of latex. If you have a latex allergy you should not handle the balloon.

#### Questions

- What forms of energy are demonstrated?
- What energy transformations occur in each toy?

#### Hypothesis

Read the questions above and the procedure below. Write a hypothesis to address the question. How do you think each toy transforms energy?

#### Materials

- Toy car
- Balloon (see Caution above)
- Yo-yo
- Safety glasses

#### Vocabulary

- compress
- contract
- elastic energy
- friction
- kinetic energy
- Law of Conservation of Energy
- motion energy
- potential energy
- transformation

#### Procedure

1. Investigate each toy. Make each toy move over some distance and observe the movement closely.
2. Record the energy transformation that you observe in each of the three toys.

#### Data

TOY	ENERGY TRANSFORMATION

#### \*\* Part Three Conclusion

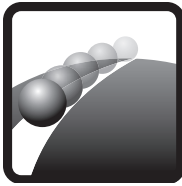
Describe the forms of energy you observed and what transformations occurred?

#### \*\* Station One Conclusions

Read the *Station One: What Was Happening?* article. Using your conclusions from each part of this station, summarize the energy transformations you observed. How do your findings compare to the explanations in the *Station One: What Was Happening?* article? Cite specific textual evidence in your summary.

#### Questions for Further Investigation

- When might you use the information you learned from this station?
- What new questions do you have? Brainstorm new investigation questions for this station.



# Station One: What Was Happening?

## POTENTIAL AND KINETIC ENERGY

### Spheres

When an object is moving, it has kinetic energy. When an object is still, but is in a position so that gravity can move it, it has gravitational potential energy (GPE). A rock at the top of a hill has potential energy. As it rolls down the hill, the GPE turns into kinetic energy—the energy of motion.

A collision occurs when a moving object hits another object. When you push a sphere, your hand gives it kinetic energy. The faster it goes, the more kinetic energy it has. When the sphere runs into your other hand, there is a collision. If it stops completely, it loses all its kinetic energy. The Law of Conservation of Energy says that energy is neither created or destroyed. The energy cannot just disappear. Where does it go?

The kinetic energy is converted into other kinds of energy – like sound and heat. Usually, when there is a collision, an object doesn't stop completely. It rebounds. This means it has not lost all of its kinetic energy. The sphere will continue bouncing until it no longer has any kinetic energy.

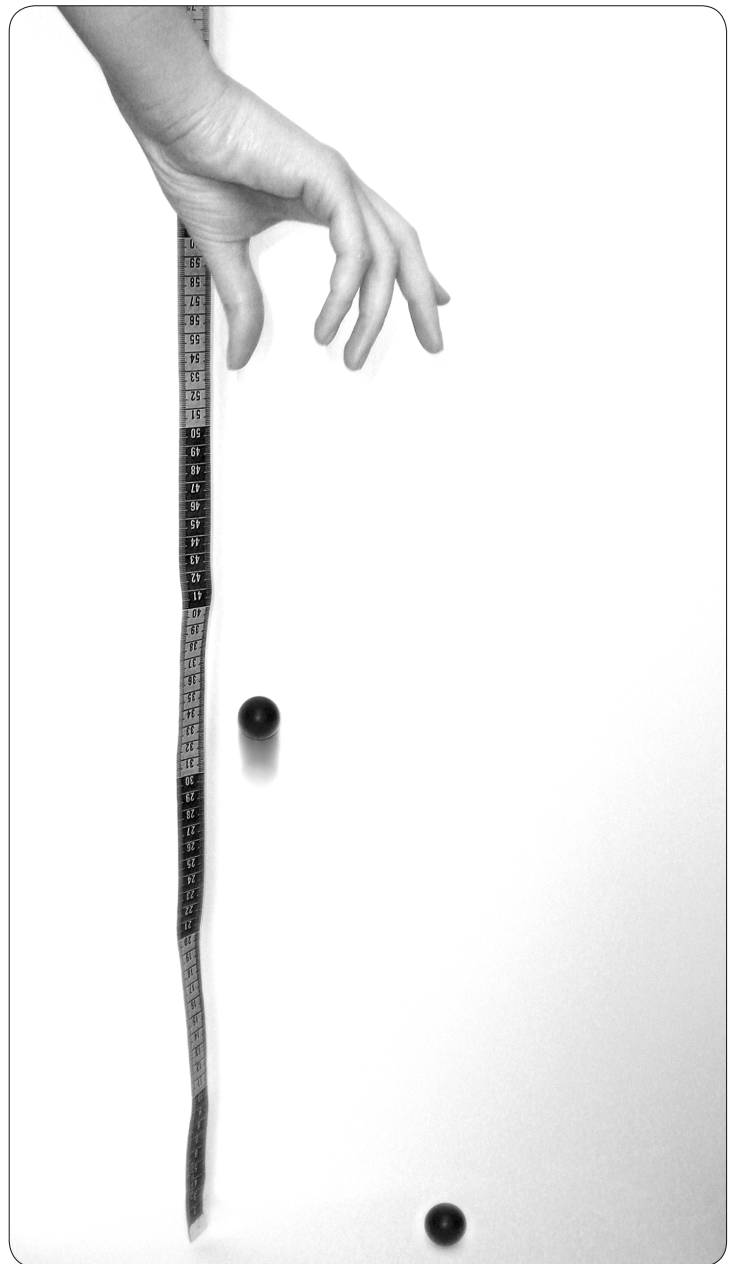
When you held the sphere above the table you gave it GPE. If you drop the sphere, you know it will fall because of the force of gravity. This energy of position is its GPE. One of the black spheres you dropped bounced back about 65 centimeters (cm); this is the "happy sphere." That means it kept about 65 percent of its energy. Where did the rest of the energy go? When the sphere hit the table, could you hear the collision? Part of the energy was changed into sound. Part of the energy was also changed into heat, or thermal energy. The sphere and the table are both getting hotter every time you drop the sphere, even though you cannot really feel the difference.

The other sphere you tested also had the same amount of GPE at the beginning, but it hardly bounced; this is the sad sphere. What happened?

This "sad sphere" is not broken. It is made of a different kind of rubber than the "happy sphere". (The happy sphere is neoprene rubber and the sad sphere is polynorborene rubber.) Almost all of the kinetic energy changes into other forms of energy. Most of the sphere's kinetic energy changes into sound and heat. Feel both of the spheres. Do they feel different? Does the happy sphere seem harder than the sad sphere? The sad sphere is softer, so its shape can change more easily and it can absorb more energy in a collision than a happy sphere. How does the superball compare?

When you put the sad sphere into hot water the sphere absorbed thermal energy from the hot water. The sad sphere bounced higher than when it was cool. Since the sphere has absorbed thermal energy from the water, it cannot absorb much more thermal energy from the collision. The sphere retains more of its kinetic energy and bounces higher. As the sphere cools down, it loses its thermal energy and more of the GPE can be changed into heat when it hits the table. The cooler it is before dropping, the less it bounces.

These experiments show us how potential energy is changed into motion and how motion is changed into sound and heat.



The happy sphere (left) keeps more of its energy, allowing it to rebound higher than the sad sphere (right). More of the energy in the sad sphere is transferred into heat and sound.

## Toys

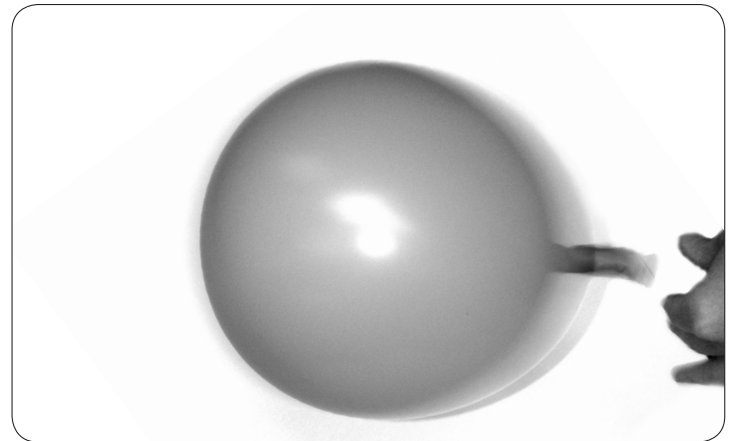
### ▪ Toy Car

As demonstrated with the spheres, holding an object in the air gives it potential energy; however, this is not the only way you can store potential energy. The car has a spring in it. When you push down on the car and pull it backward, you transfer your kinetic energy by compressing the spring. Your kinetic energy is now stored in the form of elastic energy. When the car is released, the car starts to move. The elastic energy in the spring changes to motion. Why does the car eventually stop? The car stops because of friction. Friction changes some of the motion into thermal energy and sound.



### ▪ Balloon

When you blow up a balloon, you are using your kinetic energy to stretch the rubber, storing it as elastic energy. Just as you used your energy to compress the spring in the car, energy is stored in stretched rubber and compressed air. Where did the energy go when you let go of the balloon? The elastic energy was converted into motion, thermal, and sound energy. The balloon moves in a specific direction when you let go of it. The air in the balloon comes out of the opening. Due to Newton's Third Law of Motion, the balloon will move in the exact opposite direction from the air forced out.



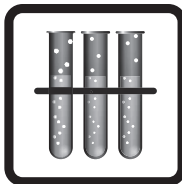
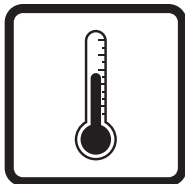
### ▪ Yo-yo

When you let go of the yo-yo, how far back up the string did it come? The yo-yo only came a little over half way. Why did it not come back to your hand? Friction between the string and the yo-yo changed some of the motion energy into thermal energy.

Where is the energy stored that makes the yo-yo come back up after you let it go? The energy is stored in the yo-yo. Potential energy can be stored in many spinning objects, which sometimes are called flywheels.

These demonstrations have explored potential and kinetic energy, and how we can change energy from one form to another.





# Station Two Guide

## ENDOTHERMIC AND EXOTHERMIC PROCESSES

### Part One: Baking Soda and Vinegar

#### Questions

- How is the temperature of vinegar affected when it is combined with baking soda?
- What energy transformation(s) occur?

#### Materials

- Baking soda
- Safety glasses
- Measuring cups
- Plastic bags
- Thermometer
- Vinegar

#### Vocabulary

- absorb
- chemical energy
- chemical reaction
- endothermic
- exothermic
- thermal energy

#### Procedure

Note: Milliliter (mL) is a liquid measurement and cubic centimeter (cm<sup>3</sup>) is a dry measurement. 1 mL = 1 cm<sup>3</sup>.

- Pour 10 mL of vinegar into an empty plastic bag.
- Feel the bag. Observe and record how the temperature feels.
- Place the thermometer in the bag. Make sure the bulb of the thermometer is submerged in the vinegar. Record the temperature of the vinegar. Leave the thermometer in the bag.
- Carefully pour 10 cm<sup>3</sup> of baking soda into the bag and gently mix. (Be careful, the chemical reaction will cause foam to fill the bag.)
- Wait 30 seconds and record the temperature again.
- Remove the thermometer from the bag and carefully zip the bag.
- Feel the bag again and note how the temperature change feels. Record observations.

#### Data

DATA TABLE	TEMPERATURE	OBSERVATIONS
VINEGAR		
VINEGAR AND BAKING SODA		

#### \*\* Part One Conclusion

How was the temperature of the vinegar affected when combined with baking soda? What forms of energy were demonstrated and what transformations occurred? Use appropriate vocabulary in your answer.



## Station Two Guide | *ENDOTHERMIC AND EXOTHERMIC PROCESSES*

### Part Two: Calcium Chloride and Water

#### Questions

- How is the temperature of water affected when combined with calcium chloride?
- What energy transformation(s) occur?

#### Materials

- Calcium chloride
- Measuring cup
- Safety glasses
- Plastic bags
- Thermometer
- Water

#### Vocabulary

- chemical energy
- chemical reaction
- endothermic
- exothermic
- release
- thermal energy

#### Procedure

*Note: Milliliter (mL) is a liquid measurement and cubic centimeter (cm<sup>3</sup>) is a dry measurement. 1 mL = 1 cm<sup>3</sup>.*

1. Pour 10 mL of water into an empty plastic bag. Feel the bag. Observe and record how the temperature feels.
2. Place the thermometer in the bag. Make sure the bulb of the thermometer is submerged in the water. Record the temperature of the water. Leave the thermometer in the bag.
3. Carefully pour 4 cm<sup>3</sup> of calcium chloride into the water and gently mix.
4. Wait 30 seconds and record the temperature again.
5. Remove the thermometer from the bag and carefully zip the bag.
6. Feel the bag again and note how the temperature change feels. Record your observations.

#### Data

	TEMPERATURE	OBSERVATIONS
WATER		
WATER AND CALCIUM CHLORIDE		

#### Part Two Conclusion

How was the temperature of the water affected when combined with calcium chloride? What forms of energy were demonstrated and what transformations occurred. Use appropriate vocabulary in your answer.





## Station Two Guide | *ENDOTHERMIC AND EXOTHERMIC PROCESSES*

### Part Three: Hand Warmers

#### Questions

- How are iron filings (tiny pieces) affected when exposed to oxygen?
- What energy transformation(s) occur?

#### Materials

- Safety glasses
- Hand warmer (iron filings)
- Plastic bags
- Scissors
- Thermometer
- Sealed plastic bag of iron oxide (old packet)

#### Vocabulary

- chemical energy
- chemical reaction
- endothermic
- exothermic
- iron oxide
- release
- thermal energy

#### Procedure

1. Remove a hand warmer from the plastic wrap. Cut open the cloth hand warmer packet.
2. Pour the contents of the hand warmer into an empty plastic bag. This will be called the "new packet." Record the temperature of this new packet immediately, and leave the bag open for three minutes.
3. Observe the sealed bag of old iron filings. This will be called the "old packet." Touch the bag and observe how the temperature feels. Put a thermometer in the bag and record the temperature and observations about the old packet.
4. After 3 minutes, feel the new packet and note how the temperature feels. Put a thermometer in the bag and record the temperature. Record your observations. Record the temperature and your observations about the old packet.
5. Seal both the old packet and the new packet to prevent oxygen from entering the bags and set aside.
6. After three minutes, feel and measure the temperature of the new packet and old packet. Are there any changes to the temperatures? Record your observations.

\*Do not discard the old packet. You will use this packet during the presentations.

#### Data

	TEMPERATURE			OBSERVATIONS
	INITIAL	AFTER 3 MINUTES	3 MINUTES AFTER SEALING	
NEW PACKET				
OLD PACKET				

#### Part Three Conclusion

Explain what happens to iron when it is exposed to oxygen. Use vocabulary to explain your answer and describe what energy transformations took place.

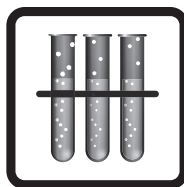
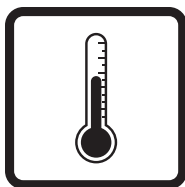
#### Station Two Conclusions

Read the *Station Two: What Was Happening?* article. Using your conclusions from each part of this station, summarize the energy transformations you observed. How do your findings compare to the explanations in the *Station Two: What Was Happening?* article? Cite specific textual evidence in your summary.

#### Questions for Further Investigation

- When might you use the information you learned from this station?
- What new questions do you have? Brainstorm new investigation questions for this station.





## Station Two: What Was Happening?

### ENDOTHERMIC AND EXOTHERMIC PROCESSES

#### Baking Soda and Vinegar

Many of the items we use every day can be classified as chemicals. Chemicals undergo changes regularly. We call these changes chemical processes. Some chemical processes are chemical reactions and some are not. Chemical reactions occur when you mix two chemicals together to form one or more new chemicals. All chemical processes involve thermal energy. Some release heat and some absorb heat.

An endothermic process absorbs heat. *Endo-* means in and *thermal* means heat. Endothermic—the thermal energy goes in. An exothermic process releases heat. *Exo-* means out and *thermal* means heat. Exothermic—the thermal energy goes out. In Station Two you saw both types of processes.

Mixing baking soda and vinegar is an endothermic process—it absorbed thermal energy. Combining vinegar and baking soda together made other chemicals: water, carbon dioxide, and sodium acetate. Therefore, it is a chemical reaction.

When you added baking soda to the vinegar you were able to visually see a reaction taking place. The temperature of the liquid also dropped, which you could tell by feeling the bag, and from your thermometer reading.

Thermal energy always moves from a warmer object to a colder object. You can feel the thermal energy move away from your hand into the chemical reaction of baking soda and vinegar.

The mixture felt colder because the reaction absorbed thermal energy. It was an endothermic reaction. The thermal energy that was in each substance individually was stored in the bonds of the new chemical that was formed. The reaction took thermal energy from the mixture and transformed it into stored chemical energy.

Most spontaneous chemical reactions do not absorb thermal energy like the vinegar and baking soda. Most chemical reactions release thermal energy—they are exothermic. The second and third part of Station Two were examples of exothermic processes.

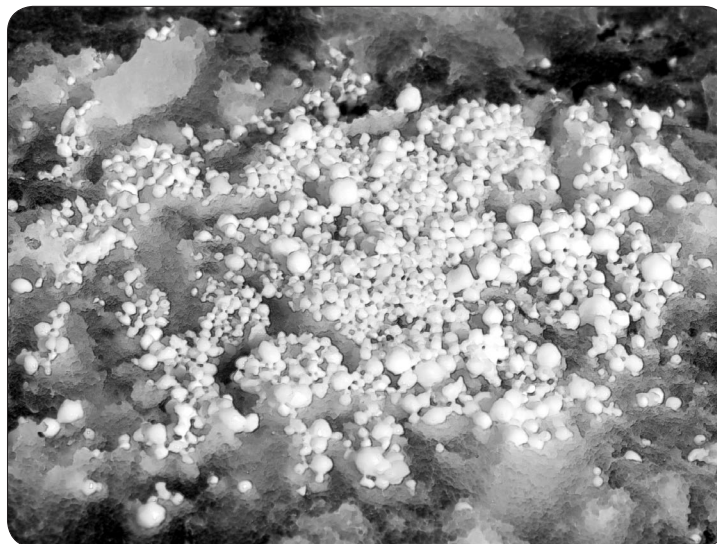
#### Calcium Chloride and Water

When calcium chloride came into contact with water, it dissolved into a solution. In this investigation you witnessed an exothermic process. Even though dissolving  $\text{CaCl}_2$  is a physical change and not a chemical change, it still releases thermal energy. You observed the temperature increase on the thermometer and could feel the difference, which also let you know thermal energy was being released.

A common use for calcium chloride is driveway ice melt. You can buy driveway ice melt at your local hardware store to melt the ice on your driveway and sidewalks during the winter.



An endothermic reaction occurred when you combined vinegar and baking soda.



Calcium chloride (the small, round spheres) is commonly used to melt ice on driveways and sidewalks.

## Hand Warmers

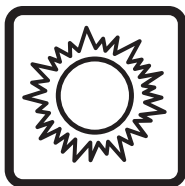
Hand warmers are filled with a mixture that includes iron filings. They are sealed in plastic to keep air from reaching the iron. The old packet had been open for several weeks. When the iron filings were left in an open plastic bag, oxygen and water vapor in the air were able to come in contact with the surface area of the filings. The oxygen and water in the air reacted with the iron to form a new chemical, iron oxide, or rust. As you could see, all the iron had turned to rust. No more heat was being produced in the chemical process.

The new packet you opened felt warm. When oxygen came into contact with iron in the presence of water vapor, it made rust and heat. You could see that most of the iron filings were still black. They slowly turned to rust as long as we let oxygen reach them. When you sealed the bag, oxygen was not allowed to reach the iron filings. The reaction should have slowed down and stopped.

Why do you think the hand warmer has a lot of iron filings instead of one large piece of iron? Using iron filings in place of larger pieces increases the surface area of exposed iron, allowing more oxygen to come in contact with it, which gives off more thermal energy. It speeds up the reaction because of the increase in surface area. Large pieces of iron react more slowly and release heat more slowly.



When exposed to oxygen and water vapor, iron filings will turn into iron oxide.



# Station Three Guide

## RADIANT ENERGY TRANSFORMATIONS

### Part One: Sunlight and Shade

#### Caution

Keep the thermometers 15–30 centimeters away from the light source to avoid melting the plastic.

#### Questions

- How does direct light affect the temperature of an object?
- What energy transformation(s) occur?

#### Hypothesis

Read the questions above and the procedure below. Write a hypothesis to address the questions. Identify the variables to help you write the hypothesis.

Independent Variable(s) \_\_\_\_\_

Dependent Variable(s) \_\_\_\_\_

Constants \_\_\_\_\_

#### Materials

- 2 Thermometers
- Sunlight (or other light source that uses an incandescent bulb)
- Safety glasses

#### Vocabulary

- absorb
- radiant energy
- thermal energy

#### Procedure

1. Place one thermometer in direct sunlight or 15-30 cm from a light source.
2. Place a second thermometer in the shade or out of direct light.
3. Record the starting temperature of each thermometer.
4. Record the temperature of each thermometer every five minutes. Continue working on the other parts of Station Three while time passes.
5. Graph your data in a double line graph.

#### Data

	STARTING TEMPERATURE	5 MINUTES TEMPERATURE	10 MINUTES TEMPERATURE	15 MINUTES TEMPERATURE	OVERALL CHANGE IN TEMPERATURE
THERMOMETER IN SUN OR DIRECT LIGHT					
THERMOMETER IN THE SHADE OR OUT OF DIRECT LIGHT					

#### **\*\* Part One Conclusion**

Explain how direct sunlight affects the temperature of an object. What energy transformation(s) occurred? Cite the evidence to support your reasoning.



## Station Three Guide | *RADIANT ENERGY TRANSFORMATIONS*

### Part Two: Radiometer

#### Questions

- How does light affect a radiometer?
- What energy transformation(s) occur?

#### Materials

- Radiometer
- Light source (bright sunlight, clamp light, flashlight, sun, etc.)
- Ruler
- Safety glasses

#### Vocabulary

- absorb
- expand
- molecule
- motion energy
- radiant energy
- thermal energy
- vacuum

#### Procedure

1. Observe the radiometer. Draw a diagram of the radiometer, labeling the black and white sides of the vanes.
2. Place the radiometer in a bright light. Observe the direction that the vanes move. Add arrows to your diagram to show the direction of vane movement.
3. Vary the amount of light the radiometer receives by moving the radiometer. Record how you changed the light and how the radiometer responded in the table below.
4. Find ways to partially and completely shield the radiometer from the light. Record your observations in the table.

#### Data

AMOUNT OF LIGHT	RADIOMETER OBSERVATIONS

#### **Part Two Conclusion**

Explain how light affects a radiometer. Explain the energy transformation(s) that occurred.



## Station Three Guide | *RADIANT ENERGY TRANSFORMATIONS*

### Part Three: Solar Panel

#### Questions

- How does the angle of the light affect the amount of electricity produced by a solar panel?
- What energy transformation(s) occur?

#### Hypothesis

Read the questions above and the procedure below. Write a hypothesis to address the questions. Identify the variables to help you write the hypothesis.

Independent Variable(s) \_\_\_\_\_

Dependent Variable(s) \_\_\_\_\_

Constants \_\_\_\_\_

#### Materials

- Solar panel with motor and fan blade
- Artificial light source
- Protractor
- Ruler
- C Battery
- Safety glasses

#### Vocabulary

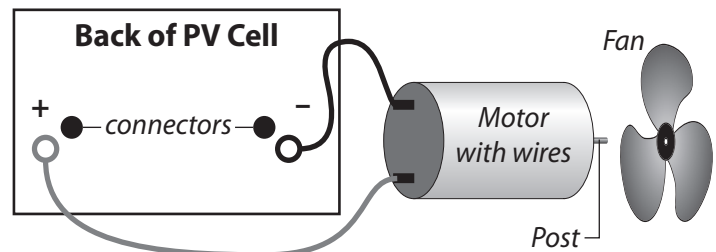
- absorb
- electrical energy
- motion energy
- photovoltaic cell
- radiant energy
- silicon

#### Solar Panel Assembly and Connection Instructions

1. Attach the wires from the motor to the connectors on the back of the PV cell by removing the nuts from the connectors, sliding the motor wires onto the posts and replacing and tightening the nuts as shown in Diagram 1.
2. Attach the fan to the post on the opposite end of the motor.
3. If nothing happens, remove the motor leads from the solar panel and touch them to the ends of a C battery to "jumpstart" the motor, then try again.\*

\*NOTE: You may need to hold the panel very close to the lamp if working with a halogen incandescent bulb. Use caution and check to be sure the plastic is not melting.

Diagram 1



#### Procedure

1. Set up the light source, PV cell, and protractor as shown in Diagram 2. The PV cell is placed in a position vertical to the table.
2. Record in the table how the fan blades are moving.
3. Tilt the PV cell back in 15 degree increments away from vertical. Record observations in the table below.

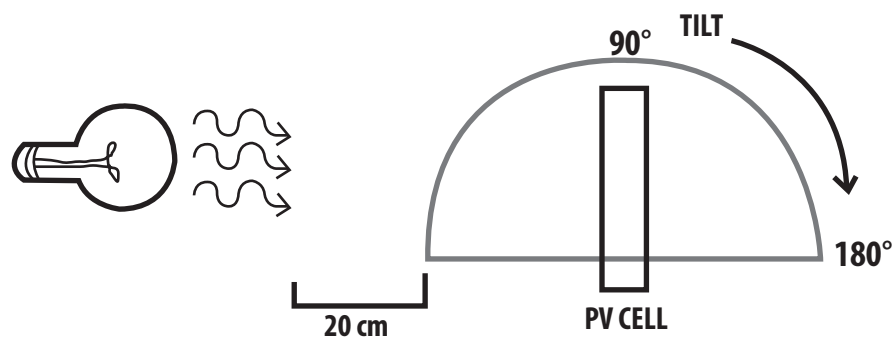
#### Data

PV CELL DEGREES FROM VERTICAL	OBSERVATIONS
0°	



## Station Three Guide | *RADIANT ENERGY TRANSFORMATIONS*

Diagram 2 LIGHT SOURCE



### \*\* Part Three Conclusion

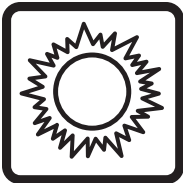
Explain how changing the angle of the solar panel affected electricity production. Describe the energy transformation(s). Use evidence from your observations to support your conclusions.

### \*\*Station Three Conclusions

Read the *Station Three: What Was Happening?* article. Using your conclusions from each part of this station, summarize the energy transformations you observed. How do your findings compare to the explanations in the *Station Three: What Was Happening?* article? Cite specific textual evidence in your summary.

### ? Questions for Further Investigation

- When might you use the information you learned from this station?
- What new questions do you have? Brainstorm new investigation questions for this station.



# Station Three: What Was Happening?

## RADIANT ENERGY TRANSFORMATIONS

### Sunlight and Shade: Radiant Energy into Heat

You may have heard the expression, "It was 100 degrees cooler in the shade." Why do people say that? Even when the air temperature is the same, it feels hotter when you are in the sun than when you are in the shade. When you are in the sun, the sun's radiant energy is absorbed by your body and turned into thermal energy, making you feel hotter. In the shade, you only feel the thermal energy from the air molecules striking your body.

The thermometer facing the light has a higher temperature because the sun's radiant energy is being transformed into thermal energy.



Sitting in the shade protects you from directly absorbing the sun's radiant energy, keeping you cooler.

### Radiometer: Radiant Energy into Motion

Did you realize that light can make things move? In the radiometer investigation, you saw light change into heat, then into motion—radiant energy into thermal energy into motion.

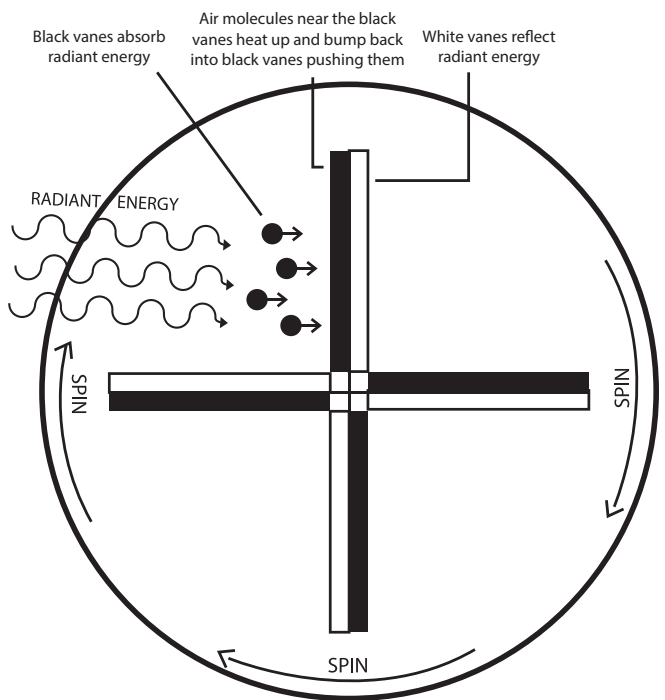
The radiometer has very little air inside the bulb; it is almost a vacuum. The black and white vanes are balancing on a needle. There is nothing else inside the bulb.

When you put the radiometer in the light, the vanes begin to turn. How is the light making the vanes turn? Black objects get hotter than white objects in the sun. That is why people wear light colored clothes in the summer. A black object absorbs most of the radiant energy that strikes it and reflects only a little. A white object reflects most of the radiant energy that strikes it and absorbs only a little.

When you put the radiometer in the light, the vanes absorb sunlight. The radiant energy is changed into thermal energy. The black side of the vane is absorbing more energy than the white side. When the air molecules hit the black side, they bounce back with more energy than when they hit the white side. The brighter the light, the faster the vanes turn. If both sides of the vanes were the same color, the vanes would never move because the air molecules would be bouncing off the vanes with the same amount of force.

To the right is a picture of the radiometer from the top. When the air molecules hit the white sides of the vanes, they push a little. The air molecules nearer to the black sides of the vanes get warmer. When air molecules heat up, they move faster. They will push harder than the air molecules on the white sides of the vanes. Since there is more of a push on one side than the other, the vanes begin to turn. The more radiant energy that reaches the radiometer, the more thermal energy is produced, and the faster the vanes spin. Radiant energy is changed into thermal energy, which causes motion.

### Top View of Radiometer





## Solar Panel: Radiant Energy into Electricity

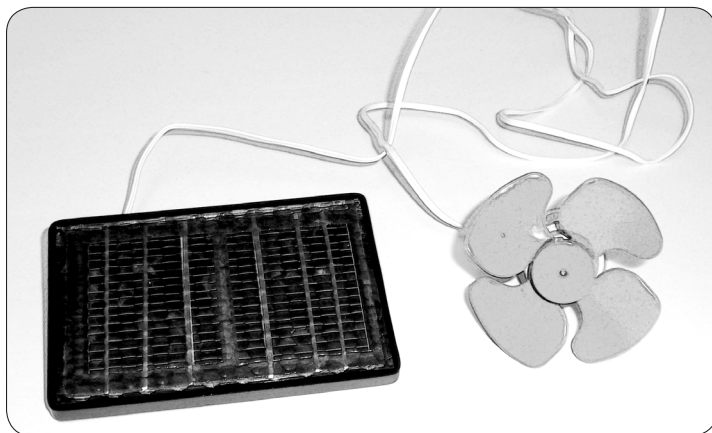
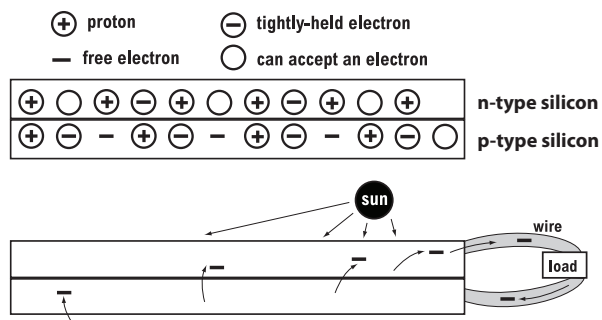
You have probably seen solar calculators or solar toys that use light to produce electricity. In this investigation you saw radiant energy converted into electrical energy, then into motion energy.

A solar panel is made of lots of photovoltaic cells, or PV cells, connected together. *Photo* means light and *volt* is a measure of electricity. PV cells are made of silicon, the same substance that is in sand. When light strikes PV cells, the electrons in the cells move, producing an electric current. It happens instantly and silently. There are no moving parts to wear out.

The motor converts electrical energy into a spinning motion, which you saw with the fan. The amount of electrical energy depends on the number of cells in the panel.

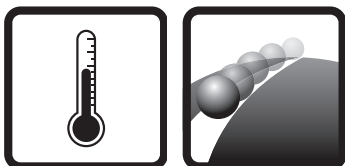
When you changed the angle of the panel toward the light, you also changed how much electricity was produced. This changed the speed of the fan. More electricity is produced if the light is shining directly on the PV cells, because more radiant energy is striking the cells.

### Photovoltaic Cell



A solar panel transforms light into electricity, which powers the motor.





# Station Four Guide

## THERMAL ENERGY AND MOTION ENERGY

### Part One: The Hanger

#### Questions

- How does bending the hanger affect its temperature?
- What energy transformation(s) occur?

#### Materials

- Piece of thin metal hanger
- Safety glasses

#### Vocabulary

- friction
- molecule
- motion energy
- thermal energy

#### Procedure

1. Feel and note the temperature of the metal hanger.
2. Bend the metal back and forth 5 times at the center.
3. Feel the metal with your finger. What do you notice? Record your observations.

#### \*\* Part One Conclusion

Explain how bending the hanger affects the temperature of the metal.

What energy transformation(s) occurred?

### Part Two: The Rubber Band

#### Cautions

- Safety glasses should be worn for this exploration.
- Rubber bands can be made from latex. If you have a latex allergy, do not handle the rubber bands.

#### Questions

- How does stretching and releasing the rubber band affect its temperature?
- What energy transformation(s) occur?

#### Materials

- 1 Large rubber band
- Safety glasses

#### Vocabulary

- contract
- expand
- thermal energy

#### Procedure

1. Hold the rubber band firmly with your index fingers inside the ends of the rubber band and your thumbs on the outside.
2. Place the rubber band flat on your forehead. Quickly stretch the rubber band to twice its original length. Repeat three times. What did you notice? Record your observations.
3. Holding the rubber band away from your forehead, stretch the rubber band twice its original length. Place the rubber band against your forehead, then let it contract slowly. Repeat three times. What did you notice? Record your observations.



#### \*\* Part Two Conclusion

Explain how stretching and releasing the rubber band affected its temperature. What energy transformation(s) occurred?



## Station Four Guide | *THERMAL ENERGY AND MOTION ENERGY*

### Part Three: The Live Wire

#### Caution

Handle the hot water very carefully. Always use the tongs when placing the live wire into or removing the live wire from the hot water. Do not look directly over the cup. NEVER place the live wire into a flame.

#### Questions

- How does temperature affect the live wire?
- What energy transformation(s) occur?

#### Hypothesis

Read the questions above and the procedure below. Write a hypothesis to address the questions. Identify the variables to help you write the hypothesis.

Independent Variable(s) \_\_\_\_\_

Dependent Variable(s) \_\_\_\_\_

Constants \_\_\_\_\_

#### Materials

- Live wire
- Cup of hot water
- Cup of ice water
- Cup of room temperature water
- Tongs
- Safety glasses

#### Vocabulary

- absorb
- thermal energy

#### Procedure

1. Twist the wire into a shape, but do not tie it in a knot. Draw the shape of the live wire in the data table.
2. Using the tongs, CAREFULLY dip the live wire into the ice water, wait 30 seconds and remove it. Draw the shape of the live wire in the data table.
3. Repeat steps 1 and 2 for room temperature and hot water.

#### Data

WATER	SHAPE BEFORE	SHAPE AFTER
ICE WATER 0 _____		
HOT WATER 0 _____		
ROOM TEMPERATURE WATER 0 _____		

#### \*\* Part Three Conclusion

Explain how temperature affected the live wire. Explain the energy transformation(s) that occurred.



## Station Four Guide | *THERMAL ENERGY AND MOTION ENERGY*

### Part Four: The Bi-Metal Bar

#### Caution

Follow safety procedures for using an open flame source.

#### Questions

- How does temperature affect the bi-metal bar?
- What energy transformation(s) occur?

#### Materials

- Bi-metal bar
- Candle
- Matches
- Safety glasses
- Cup of ice water

#### Vocabulary

- absorb
- expand
- contract
- molecules
- thermal energy

#### Procedure

Diagram 1

**Bi-Metal Bar**



1. Compare diagram 1 of a bi-metal bar to the actual bi-metal bar. Record your observations.
2. Carefully hold the bi-metal bar sideways in the top of the candle flame so that both sides of the bar are in the flame.
3. Remove the bi-metal bar from the flame. **DO NOT TOUCH THE BAR.** Place the bi-metal bar into the cup of ice water for 30 seconds.
4. Record and illustrate your observations for steps 2 and 3.

#### **\*\* Part Four Conclusion**

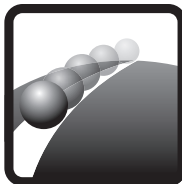
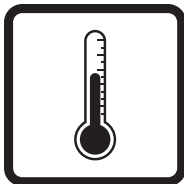
Explain how temperature affected the bi-metal bar. Why did the bi-metal bar bend only in one direction? Explain the energy transformation(s) that occurred.

#### **\*\* Station Four Conclusions**

Read the *Station Four: What Was Happening?* article. Using your conclusions from each part of this station, summarize the energy transformations you observed. How do your findings compare to the explanations in the *Station Four: What Was Happening?* article? Cite specific textual evidence in your summary.

#### Questions for Further Investigation

- When might you use the information you learned from this station?
- What new questions do you have? Brainstorm new investigation questions for this station.



## Station Four: What Was Happening?

### *THERMAL ENERGY AND MOTION ENERGY*

#### The Hanger

You used your own kinetic energy to bend a piece of the metal hanger a few times. What happened when you did this? When you bent the hanger, the molecules of the metal at the bend moved faster. The motion created friction, which in turn produced thermal energy. When you felt the hanger, you should have felt it was warmer than when you started.

You've probably converted motion into thermal energy lots of times on cold days. Try this. Put your hands on your face to note the warmth of your hands. Next, rub your hands together for about ten seconds and put them back on your face. They should feel warmer. You have just converted motion into thermal energy.

#### The Rubber Band

This experiment demonstrated an energy transformation that both released and absorbed energy.

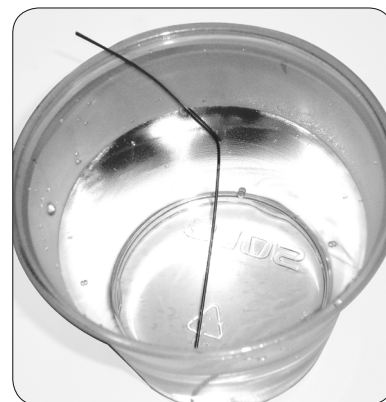
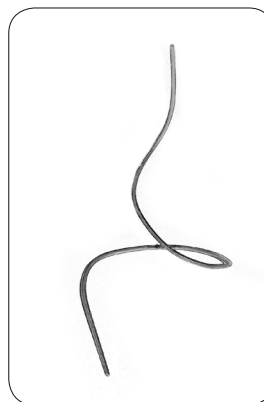
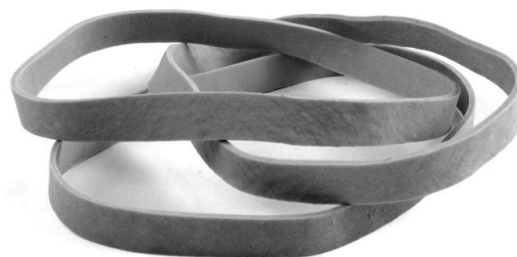
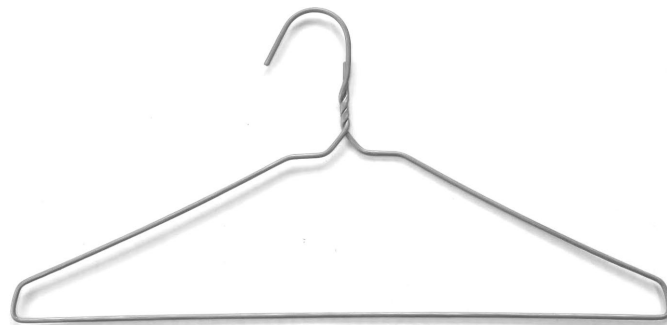
When you quickly stretched the rubber band to twice its length and placed it against your forehead, or when you let it contract, did you feel a change in temperature? The rubber band should have felt warm when it was stretched and cool when it contracted.

When you stretched the rubber band, you put stress on the interactions between the molecules and released heat because their bonds break. When the rubber band contracted, the stress was removed and the molecules absorbed heat, because their bonds reformed.

#### The Live Wire

What happened with the live wire? When you put the live wire in the hot water, it quickly returned to its straight shape. However, when you put it into room-temperature or cold water, the wire did not move. Why is this? The "live wire" is a nitinol (nī-tīn-ōl) wire, made of nickel and titanium. Nitinol is a special kind of metal because it has a "memory." Most metals stay in whatever shape you put them in, but nitinol is different. Nitinol "remembers" its original shape when it is heated. The energy from the hot water is transferred to the atoms in the wire, giving it the energy to move back to its original shape. The room temperature water was the same temperature as the wire, so no energy was transferred, and the cold water actually pulled thermal energy out of the wire. Neither the room temperature water, nor the cold water transferred energy into the live wire allowing it to move back into its original shape. Thermal energy from the hot water was transformed into motion in the wire.

Nitinol has many practical uses. It is used in space to move robot arms. It can also be used to control the temperature of greenhouses. If the temperature gets too hot, a nitinol spring opens a door to let in air. Orthodontists use it in braces that straighten teeth. When your mouth heats the wire, it causes the wire to want to move back to its original shape.



**Left:** The nitinol wire is bent and twisted before being placed in hot water.

**Right:** Thermal energy is transformed into motion as the nitinol wire is placed in hot water, causing it to return to its original shape.

## The Bi-Metal Bar

When substances and objects are heated, they expand. You may have noticed the spaces between sections of sidewalk. They are designed that way so that the concrete can expand on hot, sunny days without cracking.

Bridges are built with expansion joints that allow the metal and the concrete in the bridge to expand and contract according to temperature, without breaking.

All objects expand when they are heated, but they do not expand at the same rate. Gases and liquids expand very quickly when they are heated. Their molecules can move about freely. A thermometer works because the liquid inside expands and contracts according to temperature.

Solids do not expand as much as gases and liquids because their molecules cannot move freely. It is sometimes hard to see them expand. The bi-metal bar is a good example of how metals expand when heated. This bar is made of two metals – one side is nickel, the other side is stainless steel. These metals expand at different rates.

When you placed the bar in the flame, it bent. The stainless steel in the bar expands more quickly than the nickel, so when it is heated, the bar bends. The stainless steel side is the outside of the curve.

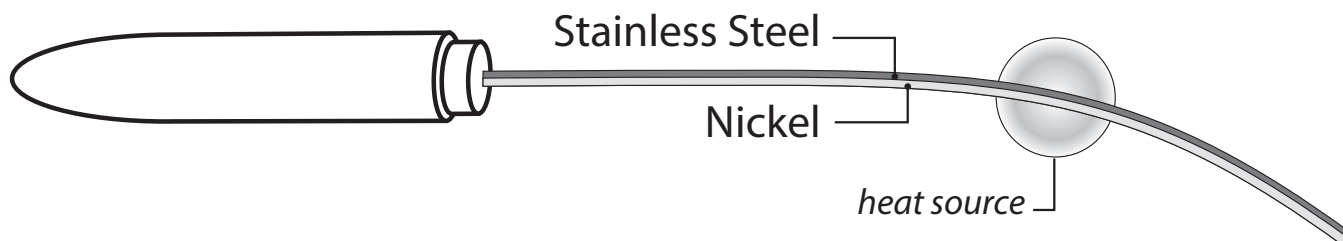
When placed in the cup of ice water, the bar bent back the other way to its original shape. If you left the bar in the ice water long enough the bar would bend in the other direction. The stainless steel side also contracts faster when energy is taken away, so it is now on the inside of the curve.

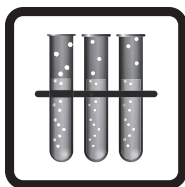


Bi-metal strips like this are very useful. They are used in thermostats on furnaces and air conditioners to control the temperature. When the temperature in a room reaches a certain temperature, the bi-metal strip will bend enough to close a circuit and turn on the furnace or air conditioner. Bi-metal strips are also used in holiday lights that twinkle. When the metal gets hot it causes the strip to bend and stops the flow of electricity (breaks the circuit), which turns the light off. As the strip cools it bends back allowing electricity to flow again, completing the circuit and turning the light on.

### Why the Bi-Metal Bar Bends

Metals expand at different rates when heated, causing the bi-metal bar to bend when placed over the flame.





# Station Five Guide

## CHEMICAL ENERGY

### Part One: Glow Sticks

#### Caution

Hot water for this station should be less than 85 degrees Celcius to prevent the glow sticks from leaking.

#### Questions

- How does the temperature affect the rate of the chemical reaction in a glow stick?
- What energy transformation(s) occur?

#### Hypothesis

Read the questions above and the procedure below. Write a hypothesis to address the questions. Identify the variables to help you write the hypothesis.

Independent Variable(s) \_\_\_\_\_

Dependent Variable(s) \_\_\_\_\_

Constants \_\_\_\_\_

#### Materials

- 3 Glow sticks of the same color
- 1 Cup of hot water
- 1 Cup of ice water
- Safety glasses

#### Vocabulary

- chemical reaction
- molecules
- radiant energy
- thermal energy

#### Procedure

1. Look at an unbroken glow stick. Notice the container inside the glow stick. Draw a diagram of a glow stick, label the parts, and describe how the glow stick works.
2. Put hot water and ice water in two separate cups.
3. Bend the three glow sticks until the containers inside break.
4. Starting at the same time, place one glow stick in the ice water, one in the hot water, and leave one out of the water at room temperature for 2-3 minutes.
5. Take the glow sticks out of the water and compare their brightness to the glow stick that has not been in the water. Record your observations.

#### Data

GLOW STICK	OBSERVATION	BRIGHTNESS RANK
GLOW STICK IN COLD H <sub>2</sub> O		
GLOW STICK IN HOT H <sub>2</sub> O		
GLOW STICK AT ROOM TEMPERATURE		

#### \*\* Part One Conclusion

Explain how temperature affected the rate of the chemical reaction in the glow stick. Describe the energy transformation(s) that occurred.



## Station Five Guide | *CHEMICAL ENERGY*

### Part Two: The Apple Battery

#### Questions

- How do the diameter of the metal pieces, depth of the metal pieces, and metal combination affect the electric current produced by an apple battery?
- What energy transformation(s) occur?

#### Hypothesis

Read the questions above and the procedure below. Write a hypothesis to address the questions. Identify the variables to help you write the hypothesis.

Independent Variables \_\_\_\_\_

Dependent Variables \_\_\_\_\_

Constants \_\_\_\_\_

#### Materials

- Small nail
- Large nail
- Tin wire
- Thick copper wire
- Thin copper wire
- DC microammeter
- Ruler
- Apple
- 2 Alligator clips
- Permanent marker
- Safety glasses

#### Vocabulary

- chemical energy
- conduct
- direct current
- electricity
- electrode

#### Procedure

1. Use the ruler and permanent marker to make marks at 1 cm, 2 cm, 3 cm, and 4 cm on each nail and wire.
2. Insert the large nail and thick copper wire into the apple 1 cm. Make sure the ends do not touch each other.
3. Attach the end of one alligator clip to the positive (red) terminal of the microammeter, and the other end of the clip to the thick copper wire.
4. Attach one end of the second alligator clip to the negative (black) terminal of the microammeter, and the other end of the clip to the nail.
5. Reverse the arrangement of the alligator clips, observe what happens on the microammeter.
6. Draw a diagram of the apple battery and record your observations.
7. Push the nail and wire into the apple in one-centimeter increments, up to four centimeters. Record the microammeter readings in Data Table 1.
8. Push the nail and wire into the apple so that the ends are touching. Record the microammeter reading in Data Table 1.
9. Remove the thick copper wire and replace it with the thin copper wire, inserting it into the apple. Reattach the alligator clips and repeat steps 7 and 8.
10. Remove the large nail and replace it with the small nail, inserting it into the apple. Reattach the alligator clips and repeat steps 7 and 8.
11. Push the two copper wires into the apple and attach the wires to the microammeter. Record the microammeter reading in Data Table 2.
12. Experiment with other combinations of metals and record your readings in Data Table 2.



## Station Five Guide | *CHEMICAL ENERGY*

### Data

DATA TABLE 1

	LARGE NAIL AND THICK COPPER WIRE	LARGE NAIL AND THIN COPPER WIRE	SMALL NAIL AND THIN COPPER WIRE
1 cm			
2 cm			
3 cm			
4 cm			
METALS TOUCHING			

DATA TABLE 2

COMBINATION OF METALS	MICROMETER READING
2 COPPER WIRES	

### \*\* Part Two Conclusion

Explain how the depth, diameter, and combinations of wires affected the electrical output of the apple battery. Use data to support your answer. Describe the energy transformation(s) that occurred.

### \*\* Station Five Conclusions

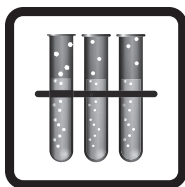
Read the *Station Five: What Was Happening?* article. Using your conclusions from each part of the station, summarize the energy transformations you observed. How do your findings compare to the explanations in *Station Five: What Was Happening?* article? Cite specific textual evidence in your summary.

### Questions for Further Investigation

When might you use the information you learned from this station?

What new questions do you have? Brainstorm new investigation questions for this station.





# Station Five: What Was Happening?

## CHEMICAL ENERGY

### Glow Sticks

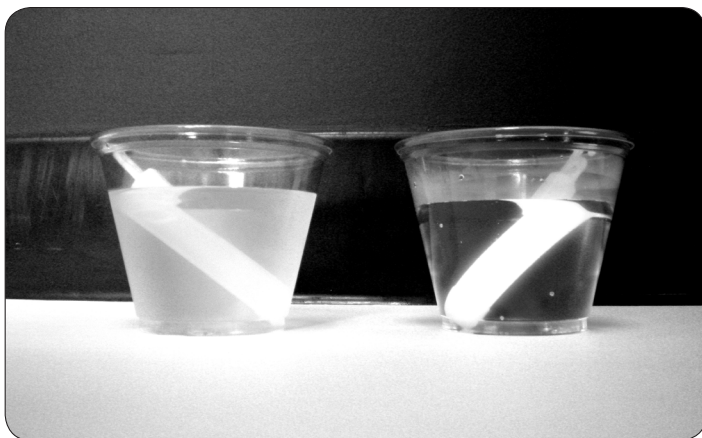
At this station, chemical energy was transformed into radiant energy. The glow sticks are filled with an ester, a chemical compound, and a fluorescent dye. Inside the glow stick you can see a little glass container, called an ampule. The ampule holds hydrogen peroxide, a liquid often used to clean cuts. Before you break the ampule the two chemicals cannot touch each other.

When you broke the ampule, the chemicals mixed together and formed new chemicals. These chemicals do not need as much energy to hold their molecules together, so they release that extra energy as light.

When you put the glow stick in cold water, the glow stick wasn't as bright. The cold water absorbed some of the thermal energy from the glow stick, so the reaction slowed down.

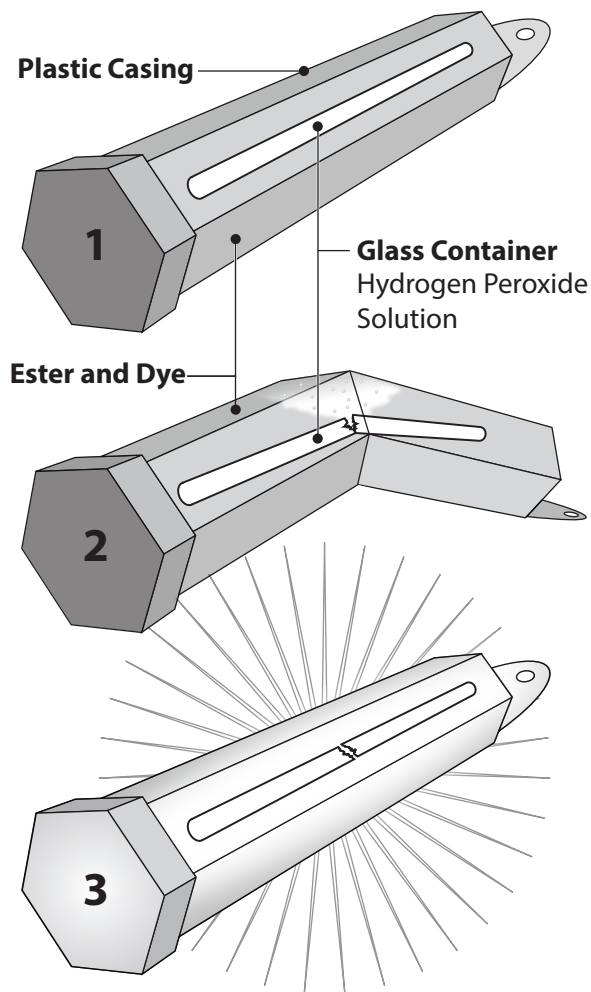
When placed in hot water, the chemicals in the glow stick absorbed the thermal energy from the hot water. The added energy made the chemicals react faster and produce more light. At room temperature, the glow stick will glow for about two hours, in hot water about 30 minutes, and in ice water it might glow for six hours.

If we add thermal energy, the glow stick will glow brighter, but for a shorter time. If we take away thermal energy, it will glow for a long time, but not as brightly. Either way, the same total amount of light will be produced. The glow stick is a good example of changing chemical energy into radiant energy. The temperature of the glow sticks will affect the rate of the chemical reaction and the intensity of the light.



The glow stick in the hot water (right) glows brighter than the glow stick in the cold water (left) because the higher temperature increases the speed of the chemical reaction.

### How a Glow Stick Works



1. The glow stick is filled with a chemical compound called an ester and dye. Inside, a small glass container is filled with hydrogen peroxide.
2. When the glow stick is bent and the container is broken, the chemicals from the ampule and the glow stick mix, causing a chemical reaction.
3. During the chemical reaction, energy is released as light.

## The Apple Battery

In the apple battery investigation you used the chemical energy in the apple to make electricity. You used the malic acid in the apple to make a battery. Nails are often made of steel and coated in zinc and other metals to keep them from rusting and corroding. When you pushed the nail and a piece of copper wire into the apple and attached them to the microammeter you saw the needle move. This shows that there is an electric current moving through the circuit.

As you observed the microammeter, you saw that the needle moved to the right to indicate an electric current. When you put the nail (zinc) and copper into the apple, they both reacted with the acid, but they did not react the same way. The different reactions created an imbalance in electrical charge. The electrons flowed from the nail through the meter to the copper wire and then back through the apple to the nail. This flow of electrons registered on the microammeter. Chemical energy was converted to electrical energy. Because the microammeter moved to the right it showed that the charge was flowing. This is the way all batteries work. There are two metals and an electrolyte (a non-metal conductor) in batteries, and the electric charge flows from one metal to the other, converting chemical energy into electrical energy.

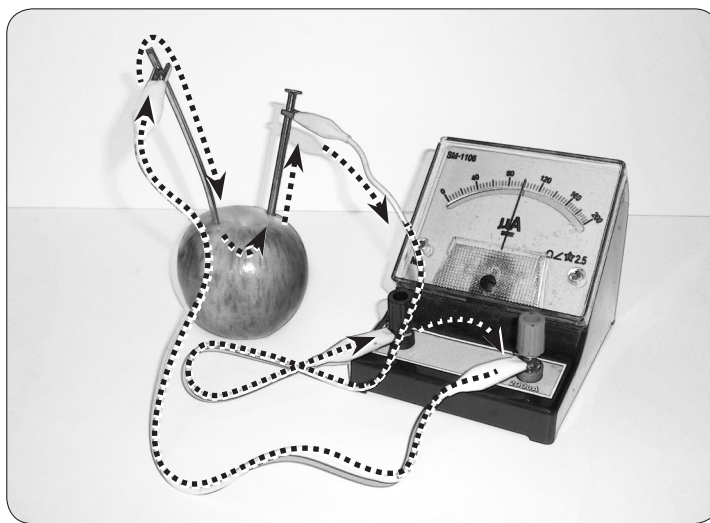
The further you pushed the nail and copper wire into the apple, the greater the flow of electrons. There was more electric current because there was more metal to react with the acid, and more electrons were free to move. Direct current (DC) electricity is movement of electrons in one direction only.

When you reversed the arrangement of the clips, the electrons then flowed in the opposite direction. This was seen on the microammeter. The needle should have moved to the left when reversed, below zero. If the meter had more space to the left of zero, it would have read a negative measurement that was similar to the value prior to switching the arrangement of the clips.

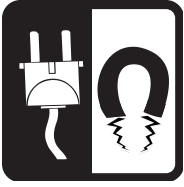
The next step was to push both metals into the apple so they were touching each other. No current was flowing through the meter. This does not mean there was not any electric current. It just means the electrons were flowing straight from one metal to the other. Electrons always take the easiest path. This is called a short circuit because the electrons are taking the shortest path.

Next, you added a thin copper wire into the apple, so we could compare the current. The thick wire produced more current because it has more surface area to come in contact with the acid and react to transfer electrons.

When you attached the two copper wires to the microammeter, there should not have been any current. Both copper wires are electron acceptors. There is no electron donor. If you attached both zinc nails to the microammeter, there was no current produced in this case either. Both nails are electron donors. There is no electron acceptor. The combination of metals determines which metal will be the electron donor and which will be the electron acceptor.



Zinc on the nail and copper react with the acid in the apple to produce an electric current. The arrows show the path of the electrons.



# Station Six Guide

## ELECTRICAL ENERGY

### Part One: Battery and Compass

#### ⚠ Caution

Use only recommended types of batteries for each part.

The battery, when attached in the holder, can become hot over time. Remove the battery from the holder when finished.

#### ❓ Questions

- How does an electric current affect the needle of a compass?
- What energy transformation(s) occur?

#### 📄 Materials

- Heavy-gauge coated wire (thick wire with no clips)
- D Battery
- D Battery holder
- Compass
- Safety glasses

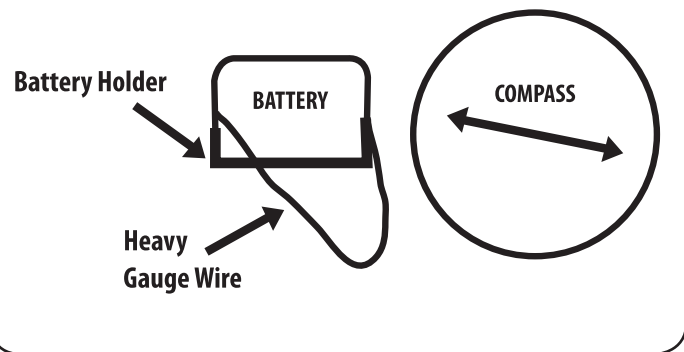
#### 🗉 Vocabulary

- attract
- conduct
- direct current
- electricity
- electromagnet
- magnetic field
- repel
- parallel
- perpendicular

#### ✓ Procedure

1. Place the compass on the table and wait for the needle to stop moving.
2. Hold the heavy-gauge wire over the compass needle parallel to the compass needle. Observe how the needle moves and record your observation.
3. Rotate the wire perpendicular to the compass needle. Observe how the needle moves and record your observation.
4. Put the battery in the battery holder. Clip one end of the wire into each end of the battery holder. See Diagram 1.
5. Move the wire over the compass repeating steps 2 and 3. Be sure to use caution as the battery and any metal attached to it will become hot.
6. Move the compass over the top of the wire. Do you notice anything different? Remove the battery from the clip immediately after finishing.

Diagram 1



#### \*\* Part One Conclusion

Explain how an electric current affects the needle of a compass. Describe the energy transformation(s) that occurred.



## Station Six Guide | *ELECTRICAL ENERGY*

### Part Two: Hand Generated Flashlight and Motors

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#### ? Questions

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- How does a motor compare to a hand generated flashlight?
- What energy transformation(s) occur?

#### 📄 Materials

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- Hand generated flashlight
- 2 Motors (1 disassembled)
- 1 9-volt Battery
- D Battery
- Alligator clips
- Masking tape
- Safety glasses

#### 🗉 Vocabulary

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- chemical energy
- conduct
- direct current
- electricity
- electromagnet
- motion energy

#### ✓ Procedure

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1. Observe the hand generated flashlight. Notice the magnets and coils of copper wire.
2. Draw the hand generated flashlight. Label the magnets, copper wire, and light bulb.
3. Shake the flashlight several times. Observe and record how the flashlight works and what happens.
4. Look at the disassembled motor. Draw and label the parts of the disassembled motor. Label the magnets and wire.
5. Pull the center section out. Draw and label the center of the motor. Record your observations.
6. Fold a piece of tape like a flag onto the shaft of the assembled motor and put an X on one side.
7. Connect the assembled motor to the 9-volt battery with the alligator clips. Record your observations.
8. Connect the alligator clips to the opposite terminals of the battery. Observe and illustrate your observations. (Hint: Notice the direction of the spinning motor shaft by watching the X on the flag.)
9. Connect the assembled motor to the D battery with the alligator clips. Record your observations.

#### \*\* Part Two Conclusion

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Compare a hand generated flashlight and motor. Describe their similarities and differences. Describe the energy transformation(s) that occurred.

#### \*\* Station Six Conclusions

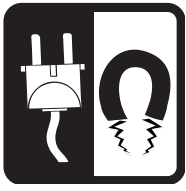
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Read the *Station Six: What Was Happening?* article. Using your conclusions from each part of this station, summarize the energy transformations you observed. How do your findings compare to the explanations in the *Station Six: What Was Happening?* article? Cite specific textual evidence in your summary.

#### ? Questions for Further Investigation

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- How do a hand generated flashlight and power plant compare?
- When might you use the information you learned from this station?
- What new questions do you have? Brainstorm new investigation questions for this station.



# Station Six: What Was Happening?

## ELECTRICAL ENERGY

### Battery and Compass

Using a battery, a piece of copper wire, and a compass, you were able to convert electrical energy into motion. When you clipped the ends of the wire to the ends of the battery holder there was an electric current produced, creating a magnetic field. When you placed the wire and battery over the compass, the magnetic field caused the needle to move.

You should have seen the needle of the compass start moving. What do you think caused this to happen? The electric current flowed through the wire and turned the wire into an electromagnet. The needle in the compass is also a magnet, pointing to north. What happens when two magnets are placed together? Either they attract or repel each other, right? That is what was happening here.

When you picked up the compass and moved it over the wire, what was the result? The needle moved in the opposite direction. This is because the magnetic field around the wire is like a circle magnet—one side is the north pole of the magnet and the other side is the south pole.

In this investigation we used electrical energy from a battery to move the needle of a compass. We changed chemical energy to electrical energy to motion energy. The chemical energy in the battery is converted to electric current that flows in one direction through the wire forming an electromagnet with a north and south pole. This type of current is called “direct current” or DC because it flows in one direction.

### Motors and Batteries

In this station we had two tiny electric motors. Lots of little toys have motors like these. They make the toys move. They convert electrical energy into motion energy. Inside the disassembled motor, you can see a coil of wire on the shaft with small magnets around the coil.

Remember that in the compass demonstration we learned that when electricity flows through a coil of wire, it produces a magnetic field around the wire. The wire will act like a magnet. When you bring the same ends of two magnets together—north and north or south and south—they repel each other—they push each other away. Inside the motor, the magnets push away from the magnetic field in the coil of wire. This turns the shaft of the motor, converting electrical energy into motion. Toy motors get their electrical energy from batteries that make electrical energy from the chemical energy stored in them.

What happened when you connected the wires from the motor to the 9-volt battery? Electrical energy from the battery flowed through the coil of wire in the motor. The coil of wire became a magnet—an electromagnet. As you saw, the shaft began to spin. The tape was attached so you could see the shaft turning. Did you notice the direction in which the shaft was turning?



Electric current flows through the wire, turning it into an electromagnet. The magnetic field around the wire interacts with the needle in the compass, causing it to move.





## Motors and Generators

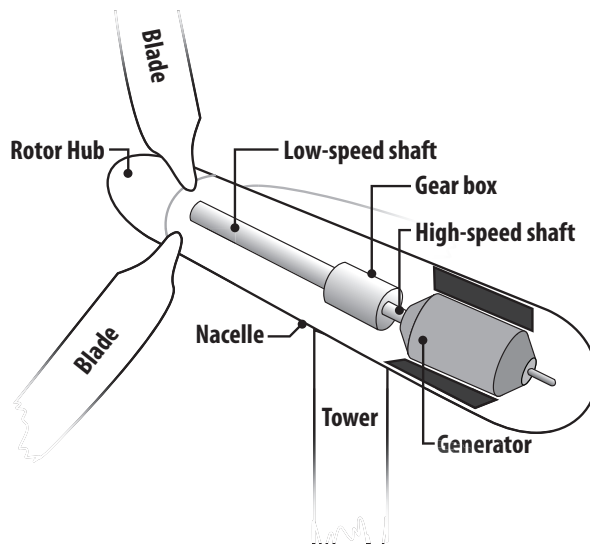
You started part two of this station by looking at a hand generated flashlight. It uses a person's kinetic energy to produce electricity to light the bulb. Inside there is a coil of wire and magnets. When you used your energy to shake the flashlight the magnet passed through the coil of wire. Moving the magnet through the coil of wire produced electricity, which was stored in the capacitor or battery. When you turned the flashlight on, electricity flowed from the capacitor or battery to the bulb.

Power plants use the same concept to produce electricity. Many energy sources are used to spin turbines that rotate coils of copper wire inside magnets to generate electricity. The picture below shows a diagram of a coal power plant. Coal is burned to superheat water into very high temperature, and high pressure steam spins the turbine. Wind turbines use the force of the wind, and hydropower plants use the force of falling water to turn turbine blades.

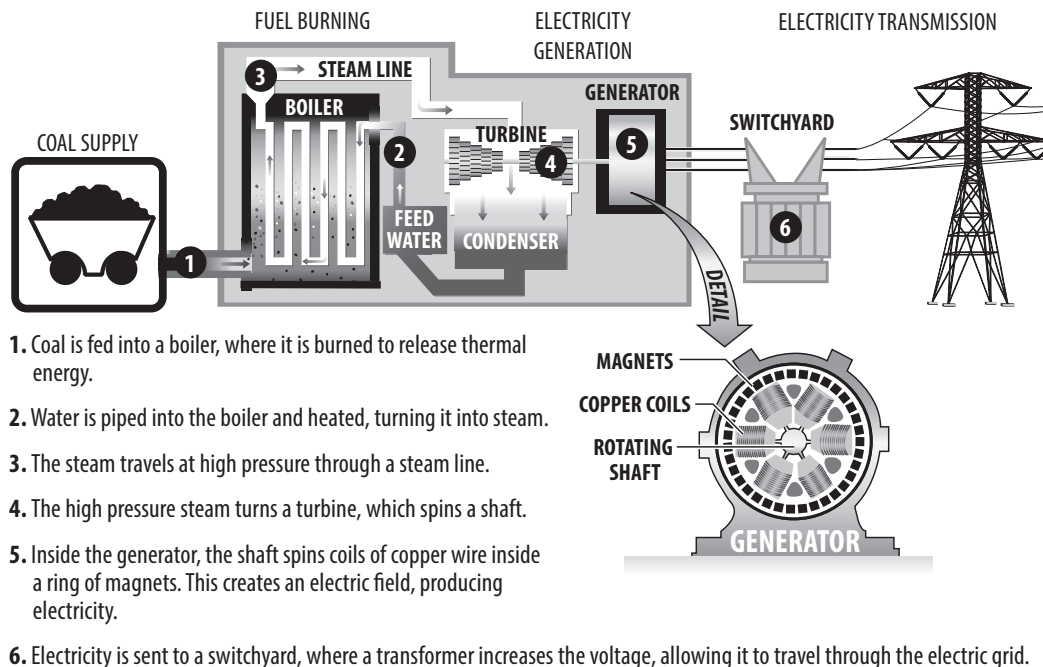
The turbine in a power plant turns the shaft with the copper wire coil inside the magnets. Electric current is induced as electrons move through the wires. The type of current produced by a power plant generator is alternating current, or AC, which moves in alternating directions. Because the generator has a rotating coil, the electrons flow in one direction and then alternate directions as the coil turns. AC power is more desirable in a power plant because it can provide more power and can be transported a long distance without losing strength. Also, the strength, or voltage, of AC current can be made stronger or weaker using transformers. Transformers reduce the voltage along a power line before it comes into a home. When we charge our laptops or other electronic devices that require DC power, we use an adaptor that converts the AC power from the electrical outlet to DC power going into the device.

Electricity is a secondary source of energy; it does not exist by itself. Electricity generation begins with chemical energy, motion energy, nuclear energy, or radiant energy.

### Energy Transformations in a Wind Turbine: Motion to Electrical Energy



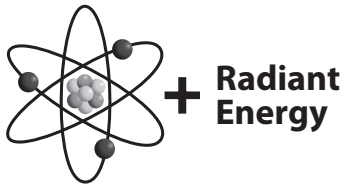
### Energy Transformations Inside a Coal Power Plant: Chemical to Thermal to Motion to Electrical Energy





# Energy Flow Cards

1



**Sun**

**Through the process of fusion, I convert nuclear energy into radiant energy.**

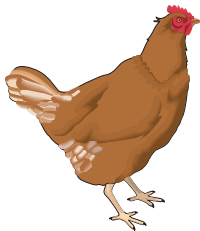
1



**Green Plant**

**Through the process of photosynthesis, I convert radiant energy into chemical energy and store it in my cells.**

1



**Chicken**

**I store energy from food in my cells and turn some of it into other forms of energy.**

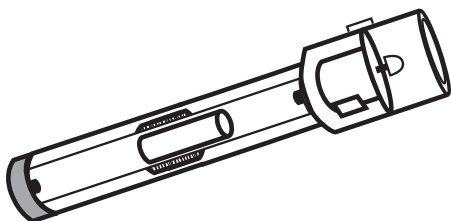
1



**Human Being**

**I store chemical energy from food in my cells and turn some of it into other forms of energy.**

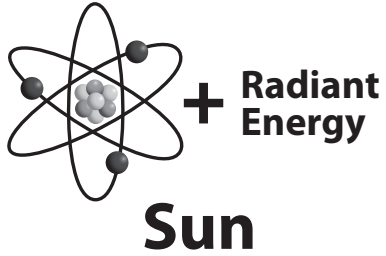
1



**Flashlight**

**I convert motion energy into electrical energy and electrical energy into light when I'm shaken.**

2



**Through the process of fusion, I convert nuclear energy into radiant energy.**

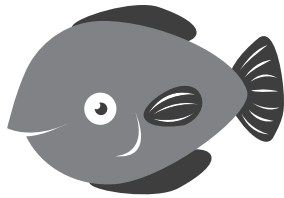
2



**Green Plant**

**Through the process of photosynthesis, I convert radiant energy into chemical energy and store it in my cells.**

2



**Fish**

**I store chemical energy from food in my cells and turn some of it into other forms of energy.**

2

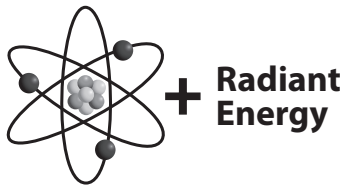


**Bear**

**I store chemical energy from food in my cells and turn some of it into other forms of energy.**



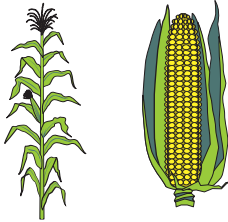
3



**Sun**

**Through the process of fusion, I convert nuclear energy into radiant energy.**

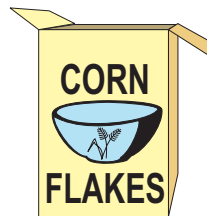
3



**Green Plant**

**Through the process of photosynthesis, I convert radiant energy into chemical energy and store it in my cells.**

3



**Cereal**

**I have chemical energy stored in my cells.**

3



**Human Being**

**I store chemical energy from food in my cells and turn some of it into other forms of energy.**

3



**Rubber Band**

**I store elastic energy when I am stretched and when I'm let go, I release thermal and motion energy.**



# Intermediate Science of Energy Brochure

New students have moved to your school. They have not learned about energy transformations. Your assignment is to help them by developing an energy transformation brochure. At least five energy transformations must be addressed. Three of these may be examples from the *Intermediate Science of Energy* unit. At least two must be transformations not experimented with in class.

The majority of the grade will be on content; however, it is expected that you will use correct grammar, spelling, and punctuation. Graphics (i.e., pictures, drawings, diagrams, etc.) are to be incorporated. All aspects of the brochure must follow copyright guidelines.

BROCHURE	3	2	1	0
<b>Content</b>	At least five energy transformations are correctly identified and explained. At least two are examples that are not included in the <i>Intermediate Science of Energy</i> unit.	Three to four energy transformations are correctly identified and explained.	One or two transformations are correctly identified and explained.	No energy transformations are correctly described.
<b>Graphics</b>		Graphics are incorporated that enhance understanding of transformations.	Graphics are incorporated, but do not help with the understanding of energy transformations.	No graphics are incorporated.
<b>Mechanics</b>		There are no errors in grammar, spelling, or punctuation.	There are fewer than five errors in grammar, spelling, or punctuation.	There are five or more errors in grammar, spelling, or punctuation.
<b>Copyright</b>		No copyright violations are present. Sources are cited properly.	No copyright violations are present; however, not all sources are cited properly.	Copyright violations are present.
<b>Total</b>	<b>/9 Points</b>			



# Intermediate Science of Energy Assessment

Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. When you drop a basketball from eye level, the ball will not return to its original height. Explain the energy transformations that cause this to happen.

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2. Give an example of potential energy transforming into kinetic energy.

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3. When iron rusts, is an endothermic or an exothermic process taking place? What energy transformation causes this process?

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4. Describe the energy transformations that are taking place in a radiometer.

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5. Describe the energy transformations that occur with a PV cell?

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6. Compare and/or contrast the energy transformation in a bi-metal bar and a nitinol wire.

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7. How does temperature affect the rate at which the chemical reaction occurs in a glow stick? What energy transformations occur during this reaction?

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8. What energy transformation(s) occur in an apple battery? What variables affect the transformation(s).

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9. How does a hand generated flashlight transform motion into light?

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10. Starting with the sun, trace the energy flow needed to ride a bike.

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# Forms of Energy Fun

## Energy Crossword

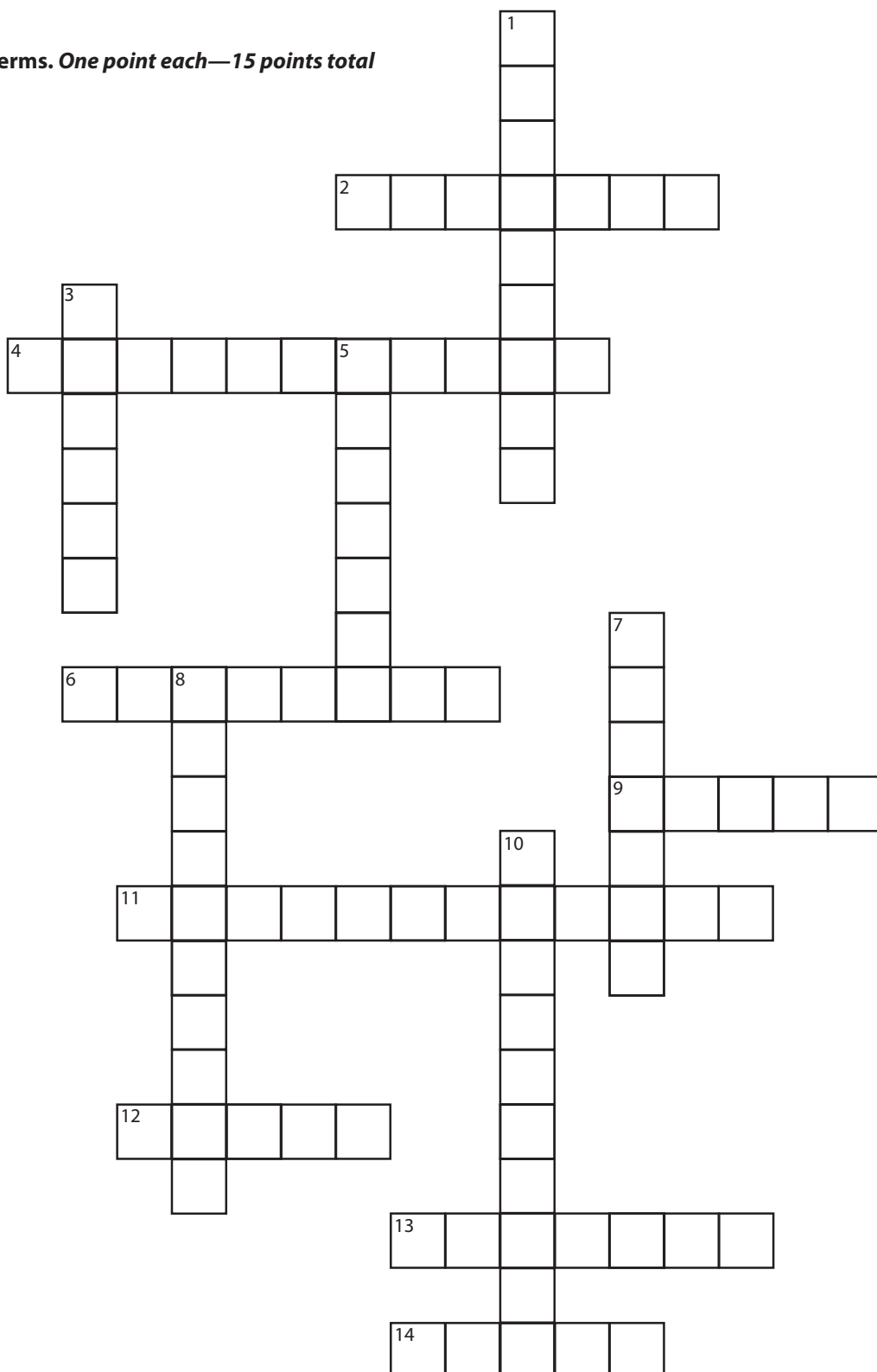
Fill in the boxes with forms of energy terms. *One point each—15 points total*

### Across ►

- 2. The energy of moving things
- 4. A chemical reaction that absorbs heat
- 6. The energy stored in the bonds of molecules
- 9. Chemicals \_\_\_\_\_ to produce energy
- 11. A cell that converts solar energy to electricity
- 12. Radiant energy
- 13. Energy locked in the nucleus of an atom
- 14. From the sun

### Down ▼

- 1. Energy of position
- 3. The ability to do work
- 5. \_\_\_\_\_ energy has the potential to move after stretching
- 7. Heat
- 8. Chemical reaction that releases heat
- 10. Energy of moving electrons



# Energy Scramble

Unscramble the five words that describe what energy does, then use the letters with the dots underneath to figure out the mystery word.

Y L I T E C R E C I T

A H T E

T O O M I N

H I L T G

R W O G

Mystery Word

# Energy Transformations

Fill in the blanks to show the energy transformations made by each object. One point for each blank—38 points total

1. PV Cell

\_\_\_\_\_ energy to \_\_\_\_\_ energy
2. Battery

\_\_\_\_\_ energy to \_\_\_\_\_ energy
3. Bicycle

\_\_\_\_\_ energy to \_\_\_\_\_ energy
4. Wind Turbine

\_\_\_\_\_ energy to \_\_\_\_\_ energy
5. Hand Warmer

\_\_\_\_\_ energy to \_\_\_\_\_ energy
6. Glow Stick

\_\_\_\_\_ energy to \_\_\_\_\_ energy
7. Flashlight

\_\_\_\_\_ energy to \_\_\_\_\_ and \_\_\_\_\_ energy
8. Radiometer

\_\_\_\_\_ energy to \_\_\_\_\_ and \_\_\_\_\_ energy
9. BBQ Grill

\_\_\_\_\_ energy to \_\_\_\_\_ and \_\_\_\_\_ energy
10. Sun

\_\_\_\_\_ energy to \_\_\_\_\_ and \_\_\_\_\_ energy
11. Firefly

\_\_\_\_\_ energy to \_\_\_\_\_ and \_\_\_\_\_ energy
12. Athlete

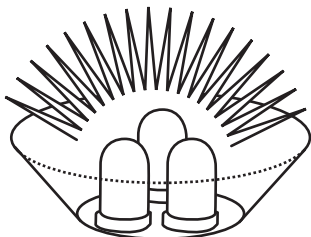
\_\_\_\_\_ energy to \_\_\_\_\_ and \_\_\_\_\_ energy
13. Car Engine

\_\_\_\_\_ energy to \_\_\_\_\_ and \_\_\_\_\_ and \_\_\_\_\_ energy
14. Firecracker

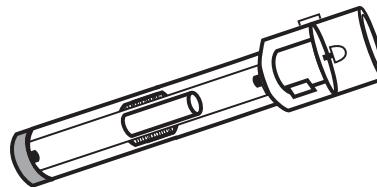
\_\_\_\_\_ energy to \_\_\_\_\_ and \_\_\_\_\_ and \_\_\_\_\_ energy

# Energy Flow

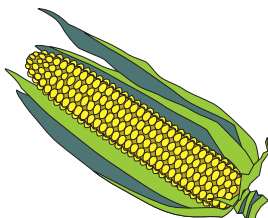
Unscramble the energy flow so that the forms of energy are in the proper order. Number the pictures from 1 to 8 on the lines to the right of the pictures, with number one as the beginning of the flow.



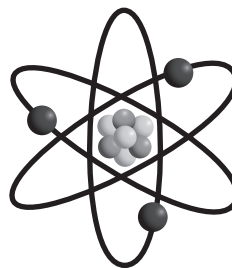
Radiant (light) Energy \_\_\_\_\_



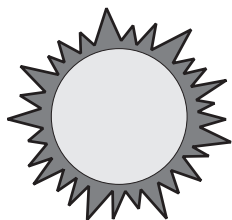
Motion Energy \_\_\_\_\_



Chemical Energy \_\_\_\_\_



Nuclear Energy \_\_\_\_\_



Radiant Energy \_\_\_\_\_



Electrical Energy \_\_\_\_\_



Chemical Energy \_\_\_\_\_



Electrical Energy \_\_\_\_\_



- |   |   |   |   |
|---|---|---|---|
| A | B | C | D |
| E | F | G | H |
| I | J | K | L |
| M | N | O | P |





# Forms of Energy in the Round Cards

<p><b>I have chemical energy.</b></p> <p>Who has the process where very small nuclei are combined into large nuclei?</p>	<p><b>I have the Law of Conservation of Energy.</b></p> <p>Who has the movement of objects or substances from one place to another?</p>
<p><b>I have nuclear fusion.</b></p> <p>Who has stored energy?</p>	<p><b>I have motion.</b></p> <p>Who has the process by which plants convert radiant energy into chemical energy?</p>
<p><b>I have potential energy.</b></p> <p>Who has a material that moves thermal or electrical energy well?</p>	<p><b>I have photosynthesis.</b></p> <p>Who has a chemical process that releases thermal (heat) energy?</p>
<p><b>I have conductor.</b></p> <p>Who has the form of energy that includes visible light?</p>	<p><b>I have exothermic process.</b></p> <p>Who has the form of energy that is the movement of electrons?</p>
<p><b>I have radiant energy.</b></p> <p>Who has the concept that energy is neither created nor destroyed?</p>	<p><b>I have electrical energy.</b></p> <p>Who has the change where one or more substances become one or more new substances?</p>

<p><b>I have chemical change.</b></p> <p>Who has the form of energy commonly referred to as heat?</p>	<p><b>I have inertia.</b></p> <p>Who has energy that is stored in objects when stretched or compressed?</p>
<p><b>I have thermal energy.</b></p> <p>Who has the ability to cause change or do work?</p>	<p><b>I have elastic energy.</b></p> <p>Who has the force of attraction between any two objects?</p>
<p><b>I have energy.</b></p> <p>Who has a device that converts radiant energy into electrical energy?</p>	<p><b>I have gravity.</b></p> <p>Who has the process of splitting large nuclei to release energy?</p>
<p><b>I have photovoltaic cell.</b></p> <p>Who has the energy of moving things?</p>	<p><b>I have nuclear fission.</b></p> <p>Who has the form of energy that is stored in the nucleus of an atom?</p>
<p><b>I have kinetic energy.</b></p> <p>Who has what must be overcome to change the speed or direction of an object?</p>	<p><b>I have nuclear energy.</b></p> <p>Who has a material that does not transfer thermal or electrical energy well?</p>

<p><b>I have insulator.</b></p> <p>Who has the process by which thermal energy is transferred by moving through a gas or liquid?</p>	<p><b>I have friction.</b></p> <p>Who has a change where no new substance is formed?</p>
<p><b>I have convection.</b></p> <p>Who has a device that converts motion into electrical energy?</p>	<p><b>I have physical change.</b></p> <p>Who has a chemical process that absorbs thermal (heat) energy?</p>
<p><b>I have generator.</b></p> <p>Who has the movement of energy through substances in longitudinal waves?</p>	<p><b>I have endothermic process.</b></p> <p>Who has the portion of radiant energy that lets us see?</p>
<p><b>I have sound.</b></p> <p>Who has radiant energy bouncing off an object?</p>	<p><b>I have visible light.</b></p> <p>Who has the process by which thermal energy is transferred between objects that are touching?</p>
<p><b>I have reflection.</b></p> <p>Who has a force that opposes motion?</p>	<p><b>I have conduction.</b></p> <p>Who has the form of energy stored in the bonds between atoms and molecules?</p>



# Glossary

<b>absorb</b>	the ability of a substance or material to take in another substance or energy, like a sponge taking in water
<b>alternating current (AC)</b>	electricity in which the electrons change direction at regular intervals; used to move energy from one place to another, usually through a wire; the electricity used in homes to operate lights, televisions, and other household devices
<b>ampule</b>	a glass container, usually holding a liquid
<b>atom</b>	the smallest part of all matter
<b>attract</b>	to draw in or stick to
<b>Celsius</b>	temperature scale in which the freezing point of water is 0° and the boiling point of water is 100°
<b>chemical energy</b>	the energy stored in substances; the energy held in the atomic bonds that hold atoms to each other
<b>chemical reaction</b>	a change or process in which new substances are formed
<b>collision</b>	when two objects hit each other and transfer energy
<b>compress</b>	to press or squeeze together
<b>conduct</b>	to transfer energy from one place to another
<b>contract</b>	to shorten the length of an object
<b>conversion</b>	to change from one thing to another
<b>convert</b>	to alter the physical or chemical properties of a substance
<b>current</b>	the flow of energy from one place to another
<b>direct current (DC)</b>	the flow of electricity through a conductor, in which electric charges move in only one direction
<b>elastic energy</b>	energy stored in an object when force is applied, when stretched or compressed
<b>electrical energy</b>	the energy of moving electrons; a secondary source of energy
<b>electricity</b>	the energy of moving electrons
<b>electrode</b>	the positive or negative terminal of a battery or of another electrical device
<b>electrolyte</b>	a chemical compound that dissolves to conduct electricity
<b>electromagnet</b>	a magnet created by the flow of electrons through a conductor or wire
<b>endothermic</b>	a change where energy is absorbed; this is usually felt as a loss of heat from the surroundings or the feeling of cold
<b>energy</b>	the ability to do work or make change
<b>energy level</b>	area where electrons can be found; describes the probable amount of energy in an atom
<b>energy transformation</b>	the process of energy moving from one place or object to another
<b>ester</b>	a chemical compound made from an alcohol and an acid
<b>exothermic</b>	a change where energy is released; this is usually felt as heat
<b>expand</b>	to increase the size of an object
<b>Fahrenheit</b>	temperature scale commonly used in the U.S. in which the freezing point of water is 32° and the boiling point is 212°
<b>fission</b>	a nuclear reaction that breaks apart an atom
<b>friction</b>	a force that opposes motion
<b>fusion</b>	a nuclear reaction that combines two atoms together to make another larger atom
<b>generator</b>	a device that changes motion energy into electricity
<b>gravitational potential energy</b>	energy of place or position

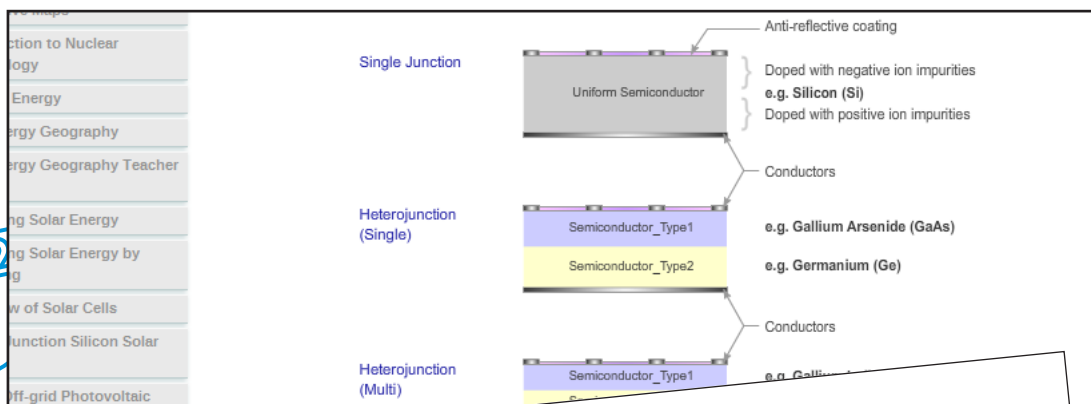
<b>heat</b>	energy that flows from one object to another by virtue of a difference in temperature
<b>hypothesis</b>	an educated guess that answers a scientific problem or question
<b>iron oxide</b>	a chemical compound composed of iron and oxygen, commonly called rust
<b>kilowatt-hour</b>	a unit of measure that is equal to 1,000 watts of power for one hour, commonly used to measure amounts of electrical energy
<b>kinetic energy</b>	the energy of motion
<b>Law of Conservation of Energy</b>	states that energy cannot be created or destroyed, it can only change form or be transferred
<b>magnetic field</b>	the region of magnetic force around a magnet
<b>mass</b>	the amount of matter in an object
<b>molecular</b>	a description of the smallest parts of matter
<b>molecule</b>	composed of two or more atoms that are chemically bonded to each other and act as a single particle; the smallest part of a substance that has all of the properties of that substance
<b>motion energy</b>	the movement of a substance from one place to another
<b>nickel</b>	a metal that is silver in color and bendable (ductile)
<b>nonrenewable resource</b>	a natural resource that cannot be replaced or would take millions of years to replace; nonrenewable energy resources are petroleum, natural gas, coal, propane, and uranium
<b>nuclear energy</b>	the energy contained in the in the nucleus of an atom; used commonly in reactors to produce heat, which can then be used to generate electricity
<b>photovoltaic cell</b>	a device composed of silicon and other substances used to generate electricity from sunlight
<b>potential energy</b>	energy that is stored in an object based upon its position
<b>prediction</b>	a thoughtful guess about the future
<b>radiant energy</b>	electromagnetic energy that travels in waves such as light, x-rays, and microwaves
<b>reaction</b>	a response that is produced by the action of another object or force
<b>rebound</b>	to spring back or the motion of an object after it hits another object
<b>release</b>	to allow something to move or flow freely
<b>renewable resource</b>	a natural resource that can be easily replaced over a short period of time; renewable energy resources are wind, geothermal, solar, hydropower, and biomass
<b>repel</b>	a force that pushes away other objects
<b>retention</b>	to hold onto something
<b>silicon</b>	a non-metallic element; number 14 on the periodic table of elements
<b>temperature</b>	the measure of the average kinetic energy of particles in a substance
<b>thermal energy</b>	the sum of energy of the molecules making up a substance; for this unit, it is used to mean heat
<b>titanium</b>	a silvery-gray, metallic element that is lightweight and strong; number 81 on the periodic table of elements
<b>transform</b>	to change the structure, shape, or composition of a substance
<b>transformation</b>	the act of changing the structure, shape, or composition of an object
<b>turbine</b>	a rotary engine that can be caused to turn by the force of electricity, wind, water, or other forces
<b>vacuum</b>	the absence of matter in a given area; empty space



## Looking For More Resources?

Our supplemental materials page contains PowerPoints, animations, and other great resources to compliment what you are teaching!

This page is available at [www.NEED.org/educators](http://www.NEED.org/educators).



## SOLAR AT A GLANCE

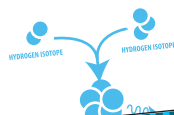


### WHAT IS SOLAR?

Solar energy is radiant energy that is produced by the sun. Every day the sun radiates, or sends out, an enormous amount of energy. The sun radiates more energy in one second than people have used since the beginning of time!

### NUCLEAR FUSION

The process of fusion most commonly involves hydrogen isotopes combining to form a helium atom with a transformation of matter. This matter is emitted as radiant energy.



### PHOTOVOLTAIC CELLS

Photovoltaic comes from the words photo meaning "light" and volta, a measurement of electricity. Sometimes photovoltaic cells are called PV cells or solar cells for short. These are the four steps that show how a PV cell is made and how it produces electricity.

1. A slab (or wafer) of pure silicon is used to make a PV cell. The top of the slab is very thinly diffused with an "n" dopant such as phosphorus. On the base of the slab a small amount of a "p" dopant, typically boron, is diffused. The boron side of the slab is 1,000 times thicker than the phosphorus side. The phosphorus has one more electron in its outer shell than silicon, and the boron has one less. These dopants help create the electric field that motivates the energetic electrons out of the cell created when light strikes the PV cell. The phosphorus gives the wafer of silicon an excess of free electrons; it has a negative character. This is called then-type silicon (n = negative). The n-type silicon is not charged—it has an equal number of protons and electrons—but some of the electrons are not held tightly to the atoms. They are free to move to different locations within the layers. The boron gives the base of the silicon a positive character, because it has a tendency to attract electrons. The base of the silicon is called p-type silicon (p = positive). The p-type silicon has an equal number of protons and electrons; it has a positive character but not a positive charge.

2. A location that can accept an electron.

3. If the PV cell is placed in the sun, photons of light strike the electrons in the p-n junction and energize them, knocking them free of their atoms. These electrons are attracted to the positive charge in the n-type silicon and repelled by the negative charge in the p-type silicon. Most photon-electron collisions actually occur in the silicon base.

4. A conducting wire connects the p-type silicon to an electrical load, such as a light or battery, and then back to the n-type silicon, forming a complete circuit. As the free electrons are pushed into the n-type silicon they repel each other because they are of like charge. The wire provides a path for the electrons to move away from each other. This flow of electrons is an electric current that travels through the circuit from the n-type to the p-type silicon. In addition to the semi-conducting materials, solar cells consist of a top metallic grid or other electrical contact to collect electrons from the semi-conductor and

Where the n-type silicon and p-type silicon meet, free electrons from the n-layer flow into the p-layer.

When the n-type silicon and p-type silicon meet, free electrons from the n-layer flow into the p-layer.

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### TOP SOLAR STATES



## ENERGY FACTS

### WORLD RANKING OF ENERGY PRODUCTION

Canada ranks fifth in the world in total energy production, fifth in annual petroleum production, third in natural gas production, second in uranium production, and fifth in electricity produced by hydropower.



### WORLD RANKING OF ENERGY CONSUMPTION



# Intermediate Science of Energy Evaluation Form

State: \_\_\_\_\_ Grade Level: \_\_\_\_\_ Number of Students: \_\_\_\_\_

- |  |                              |                             |
|--|------------------------------|-----------------------------|
| 1. Did you conduct the entire unit?                              | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 2. Were the instructions clear and easy to follow?               | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 3. Did the activities meet your academic objectives?             | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 4. Were the activities age appropriate?                          | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 5. Were the allotted times sufficient to conduct the activities? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 6. Were the activities easy to use?                              | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 7. Was the preparation required acceptable for the activities?   | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 8. Were the students interested and motivated?                   | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 9. Was the energy knowledge content age appropriate?             | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 10. Would you teach this unit again?                             | <input type="checkbox"/> Yes | <input type="checkbox"/> No |

*Please explain any 'no' statement below*

How would you rate the unit overall? ☐ excellent ☐ good ☐ fair ☐ poor

How would your students rate the unit overall? ☐ excellent ☐ good ☐ fair ☐ poor

What would make the unit more useful to you?

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Other Comments:

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Please fax or mail to: **The NEED Project**

8408 Kao Circle  
Manassas, VA 20110  
FAX: 1-800-847-1820



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