SECONDARY SCIENCE OF ENERGY

This booklet includes hands-on experiments that students use to teach themselves and others about forms of energy and energy transformations.

SCIENCE OF ENERGY

GRADE LEVEL
8–12

SUBJECT AREAS
Science
Math
Language Arts
Public Speaking

NEED

2007

Putting Energy into Education

NEED Project PO Box 10101 Manassas, VA 20108 1-800-875-5029 www.NEED.org

Teacher Advisory Board

NEED Mission Statement

The mission of the NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

Teacher Advisory Board Vision Statement

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

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NEED

Putting Energy into Education

Correlations to National Science Standards

(Bolded standards are emphasized in the unit.)

UNIFYING CONCEPTS & PROCESSES

1. Systems, Order, and Organization

a. The goal of this standard is to think and analyze in terms of systems, which will help students keep track of mass, energy, objects, organisms, and events referred to in the content standards.

b. Science assumes that the behavior of the universe is not capricious, that nature is the same everywhere, and that it is understandable and predictable. Students can develop an understanding of order—or regularities—in systems, and by extension, the universe; then they can develop understanding of basic laws, theories, and models that explain the world.

c. Prediction is the use of knowledge to identify and explain observations, or changes, in advance. The use of mathematics, especially probability, allows for greater or lesser certainty of prediction.

d. Order—the behavior of units of matter, objects, organisms, or events in the universe—can be described statistically.

2. Evidence, Models, and Explanation

a. Evidence consists of observations and data on which to base scientific explanations. Using evidence to understand interactions allows individuals to predict changes in natural and designed systems.

3. Change, Constancy, and Measurement

a. Although most things are in the process of change, some properties of objects and processes are characterized by constancy; for example, the speed of light, the charge of an electron, and the total mass plus energy of the universe.

b. Energy can be transferred and matter can be changed. Nevertheless, when measured, the sum of energy and matter in systems, and by extension in the universe, remains the same.

c. Changes can occur in the properties of materials, position of objects, motion, and form and function of systems. Interactions within and among systems result in change. Changes in systems can be quantified and measured. Mathematics is essential for accurately measuring change.

d. Different systems of measurement are used for different purposes. An important part of measurement is knowing when to use which system.

INTERMEDIATE (GRADES 5-8) CONTENT STANDARD–A: SCIENCE AS INQUIRY

1. Abilities Necessary to do Scientific Inquiry

a. Identify questions that can be answered through scientific inquiry

b. Design and conduct a scientific investigation

c. Use appropriate tools and techniques to gather, analyze, and interpret data

d. Develop descriptions, explanations, predictions, and models using evidence

e. Think critically and logically to make the relationships between evidence and explanations

f. Recognize and analyze alternative explanations and predictions

g. Communicate scientific procedures and explanations

h. Use mathematics in all aspects of scientific inquiry

INTERMEDIATE STANDARD–B: PHYSICAL SCIENCE

2. Motions and Forces

a. The motion of an object can be described by its position, direction of motion, and speed.

b. An object not subjected to a force will continue to move at a constant speed in a straight line.

c. Applying one or more forces to a moving object will cause changes in speed or direction of the object's motion.

3. Transfer of Energy

a. Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical.

b. Energy is transferred in many ways.

c. Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature.

d. Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection).

e. Electrical circuits provide a means of transferring electrical energy.

f. In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers.

g. The sun is the major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths.

SECONDARY (GRADES 9-12) CONTENT STANDARD–A: SCIENCE AS INQUIRY

1. Abilities Necessary to do Scientific Inquiry

a. Identify questions and concepts that guide scientific investigation.

b. Design and conduct scientific investigations.

c. Use technology and mathematics to improve investigations and communications.

d. Formulate and revise scientific explanations and models using logic and evidence.

e. Recognize and analyze alternative explanations and models.

f. Communicate and defend a scientific argument.

SECONDARY STANDARD–B: PHYSICAL SCIENCE

3. Chemical Reactions

a. Chemical reactions occur all around us.

b. Chemical reactions may release or consume energy. Some reactions, such as the burning of fossil fuels, release large amounts of energy by losing heat and by emitting light.

c. Light can initiate many chemical reactions such as photosynthesis and the evolution of urban smog.

d. A large number of important reactions involve the transfer of electrons or hydrogen ions. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes such as the presence of ozone and greenhouse gases in the atmosphere, burning and processing of fossil fuels, the formation of polymers, and explosions.

e. Catalysts accelerate chemical reactions.

4. Motions and Forces

b. Gravitation is a universal force that each mass exerts on any other mass.

c. The electrical force is a universal force that exists between two charged objects.

d. Most observable forces such as those exerted by a coiled spring or friction can be traced to electric forces acting between atoms and molecules.

e. Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces.

5. Conservation of Energy and the Increase in Disorder

a. The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered.

b. All energy can be considered to be either kinetic energy—the energy of motion; potential energy—which depends on relative position; or energy contained by a field, such as electromagnetic waves.

c. Heat consists of random motion and the vibrations of atoms, molecules, and ions. The higher the temperature, the greater the atomic or molecular motion.

d. Everything tends to become less organized and less orderly over time. Thus, in all energy transfers, the overall effect is that the energy is spread out uniformly. Examples are the transfer of energy from hotter to cooler objects by conduction, radiation, or convection and the warming of our surroundings when we burn fuels.

6. Interactions of Energy and Matter

a. Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.

d. In some materials, such as metal, electrons flow easily, whereas in insulating materials such as glass, they can hardly flow at all.

SECONDARY STANDARD–C: LIFE SCIENCE

1. The Cell

a. Plants and many microorganisms use solar energy to combine molecules of carbon dioxide and water into complex, energy rich organic compounds and release oxygen to the environment. This photosynthesis provides a vital connection between the sun and the energy needs of living systems.

5. Matter, Energy, and Organization in Living Systems

b. The energy for life primarily derives from the sun. Plants capture energy by absorbing light and using it to form strong chemical bonds. The energy stored in the bonds (chemical energy) can be used as sources of energy for life processes.

c. The chemical bonds of food molecules contain energy. Energy is released when the bonds are broken and new compounds with lower energy bonds are formed.

Teacher Guide

BACKGROUND

The Science of Energy includes a teacher demonstration and six lab stations. The Secondary version for 8th-12th grade is designed to take five class sessions. Students are divided into six (or seven) groups, with each group responsible for learning and teaching the other groups the experiments in their assigned station. Instructions, guides, procedures, worksheets, and sample scripts are provided for teacher and students.

TIME

Five class periods of 45-60 minutes.

OBJECTIVES

Upon completion of the Science of Energy activity, students will be able to:

- Explain what energy enables us to do.
- Differentiate between forms and sources of energy.
- Understand how energy is stored in the major energy sources.
- Describe the main forms of energy and give examples.
- Explain energy transformations.
- Trace the energy flow of a system.

MATERIALS NEEDED

- Science of Energy Kit
- Transparencies of Masters (pp 11-15)
- One copy of Forms & Sources (pg 16) and Worksheets (pp 21, 29-30, 39, 44, 50) for each student
- One copy of the Unit Exam (pp 57-58) for each student or group, depending on how you evaluate the students
- Two copies of the Station Guides for each station (pp 17-19, 22-26, 31-37, 40-42, 45-48, 51-54)
- One laminated copy of each Station Procedure and Diagram (pp 20, 25-26, 27-28, 35-37, 43, 48, 49, 53-54, 55)

MATERIALS NOT INCLUDED IN KIT

Station One:	Cup of Hot Water	Meter Stick	
Station Two:	Vinegar	Scissors	Water
Station Three:	Tape	Overhead Projector or Flashlight	
Station Four:	Cups of Hot/Ice Water	Matches	14 - 12” pieces of Thin Metal Coat Hanger
Station Five:	Cups of Hot/Cold Water	Apple	

UNIT EXAM ANSWERS

1. b 2. b 3. d 4. a 5. b 6. b 7. d 8. d 9. d 10. b

11. An electromagnet is a device in which magnetism is produced by an electric current.

12. A windmill converts wind into electricity, as well as sound and heat.

13. A firecracker converts chemical energy into light, heat, sound, and motion.

14. Firefly: radiant energy - chemical energy - radiant energy - nuclear energy.

15. Electricity is an energy carrier that is convenient for us to use to perform many tasks.

Energy Flow: 1. sun-nuclear 2. sun-radiant 3. plant-chemical 4. child-chemical 5. flashlight-motion 6. meter-electrical 7. light-radiant

INTRODUCTION

The Science of Energy activity is designed so that the teacher introduces the activity and gives several demonstrations on Day One. On Days Two through Four, students learn their stations and present them to the other students in teams rotating through the stations and completing worksheets. On Day Five, student groups work together to answer questions about the unit and complete their science journals. *It is recommended that the students keep science journals of the unit.*

PREPARATION

- Familiarize yourself with the kit and procure the materials listed in the Materials Not Included section.
- Duplicate copies and laminate as indicated in the Materials Needed section.
- Make transparencies as indicated in the Materials Needed section.
- Divide the class into six groups. If the class is very large, you can separate Station Two into two groups: Endothermic and Exothermic.
- Divide each group into two teams, designated A & B teams.
- Organize your classroom into six stations, with the stations requiring hot water near a source.
- For Station Three, place the glow toy without the label in the sun or a bright light for a day before beginning the unit.

VOCABULARY

Listed below are terms in the Science of Energy that students should understand when using the kit. You may want to spend a day going over these terms, or have the students look up the definitions as an assignment before beginning the unit.

Kinetic Energy	Endothermic	Magnetic Field	Energy Flow	Exothermic
Mass	Mechanical Energy	Catalyst	Fission	Chemical Energy
Electrical Energy	Fusion	Nonrenewable	Nuclear Energy	Photosynthesis
Electrode	Kilowatt	Photovoltaic	Electromagnet	Kilowatt-hour
Photovoltaic Cell	Potential Energy	Renewable	Thermal Energy	Radiant Energy

Please note: In this unit, the terms heat and thermal energy are used interchangeably, as they are in the national standards. Technically, thermal energy is defined as the amount of kinetic energy in a substance and heat is defined as the movement of thermal energy. Temperature is a measure of the average amount of thermal energy in a substance.

GRADING

The students' grades are based on how well their group performs rather than on individual scores. Group grades will be determined by five factors. The first four factors are worth 85 percent of the grade, and the last factor is worth 15 percent, as listed below:

- Their individual ability to develop hypotheses, record data, and form conclusions during the student presentations.
- 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.
- Their ability to handle equipment properly and safely.
- Their ability to answer questions on the unit exam.

EXTENSIONS

- Have students prepare data tables and graphs after the presentations.
- Have students design experiments with hypotheses and procedures to conduct the Further Explorations at the end of each procedure.
- Have students write reflections on each station in their science journals.

Teacher Demonstration

MATERIALS (*NOT PROVIDED IN KIT)

2 Sand Containers
2 Thermometers
Hand Generated Flashlight
* Transparencies
* Overhead Projector

PREPARATION

- ☐ Familiarize yourself with the Teacher Demonstration materials, procedures, and script.
- ☐ Make sure you have one copy of the **Forms of Energy**, **Forms & Sources** activity and **Student Station Worksheets** for each student, two copies of the **Station Guides** for each station, and one copy of the **Unit Exam** for each group.
- ☐ Make sure you have one laminated copy of each **Station Procedure** and **Guide Diagram**.
- ☐ Make sure you have the transparencies.

PROCEDURE—DAY ONE: TEACHER DEMONSTRATION

- ☐ Use the **Thermometer** transparency to review how to read a thermometer using both Fahrenheit and Celsius scales. Use the **Fahrenheit/Celsius Conversion** transparency to review how to convert Fahrenheit to Celsius and vice versa.
- ☐ Record the temperatures of the two sand containers. Ask each student to shake the containers vigorously for 30 seconds then pass it on to another student while you are giving the introduction. *(Two jars of water can also be used.)*
- ☐ Introduce the activity using the script as a guide.
- ☐ Distribute the **Forms of Energy** sheets to the students. Explain the forms of energy, using the transparency and the script as a guide.
- ☐ When all the students have shaken the containers, have two students record the temperatures of the containers of sand again. Discuss the difference, using the script as a guide.
- ☐ Give a brief description of the ten major sources of energy and explain the terms renewable and nonrenewable. *(Use the Secondary Energy Infobooks as a reference.)*
- ☐ Place students in their groups and have them complete the **Forms and Sources** activity.

SAMPLE SCRIPT—DAY ONE: TEACHER DEMONSTRATION

Before we start talking about energy, let's begin an experiment. Here, I have two containers of sand. One is filled about a third of the way and the other is filled to the top. Let's record the temperature of the two containers in Fahrenheit and Celsius. [Have students record the temperatures on the board.] Since they have both been in the same environment, they should be the same temperature. Now, let's put the tops on tightly and begin shaking the containers. After thirty seconds, pass them to other students. I would like everyone in the class to shake both containers for thirty seconds while I continue with the introductory demonstration.

PROCEDURE— DAY TWO: TEACHER DEMONSTRATION & STUDENT PREPARATION

- ☐ Explain energy transformations and energy flows with the hand generated flashlight and the **Energy Transformations** transparency, using the script as a guide. *(Then put the flashlight at Station Six.)*
- ☐ Explain the procedure for the next three days and place students in their groups.
- ☐ Discuss lab safety using the **Lab Safety Rules** transparency.
- ☐ Distribute a set of **Station Guides** and a laminated **Station Procedure** to each group and have the students spend a few minutes reading their experiment, then answer any questions and assign students to their stations to familiarize themselves with the equipment and the procedures for their station.

- ☐ Explain to the students that they must learn their experiments well, because they can only use the **Station Procedures** in their presentations, not the guides. The guides are just to help them learn the experiments and give them the information they need.
- ☐ Have the six stations set up around the room, with the equipment in place, except for the hot water.
- ☐ Caution the students to treat the equipment carefully and to not use their supplies carelessly. The supplies must last for two days of demonstrations.
- ☐ Provide hot water to the stations that require it and monitor the students carefully as they investigate their experiments.

WHAT ENERGY HELPS US DO

What is energy? Energy helps us do many things; it is defined as the ability to do work. Energy makes things move. Can you give me some examples of moving objects and how energy moves them? (i.e., a car is moved by burning gasoline, a sailboat by the wind, a baseball by the energy in a person's arm and hand, a bullet by exploding gunpowder.) In addition to making things move, energy also helps us do other things. I want you to try to figure out four things energy helps us do. Write your ideas on a piece of paper. You have two minutes to come up with your answers. These are the five main things energy helps us do:

1. Make things move
2. Make heat
3. Make light
4. Make technology work (run electrical devices)
5. Make things grow

FORMS OF ENERGY

The energy we use is stored in different forms. [Distribute the **Forms of Energy** sheets to each student and explain the forms of energy using the transparency.] Now, let's go back to those containers of sand. Let's check the container with a little sand in it first. [Record the temperature of the container of sand. You should see a two–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 should equal a nine-degree difference in Fahrenheit.]

What do you think caused the temperature change? Shaking the container is kinetic energy—the energy of motion. By 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 heat. We transformed our motion into heat.

[Record the temperature of the full container of sand. You should see about a two degree Celsius increase.] Why is the increase in temperature greater for the container that was only one-third full? Because the partially filled container has more space in it, and the grains of sand collide with each other with more velocity. More velocity means more kinetic energy. In the container filled with sand, the grains have less space to move.

Another example of how motion can be transformed into heat is by striking a nail with a hammer. Have you ever felt the head of a nail or the head of a hammer after several strikes? They both feel warm. Some of the motion is transferred to thermal energy. Where do you think the rest of the energy has gone? The energy goes into sound, the motion of the nail pushing into the wood, and the heat of the nail and the wood.

ENERGY FLOWS

Let's explore the energy flow from shaking this container of sand. Let's start with the thermal energy, or heat, we produced as a result of the motion our bodies provided. Where did our bodies get the energy to shake the bottle? From the food we ate. How is energy stored in food? It is stored 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 glucose and oxygen in plants. Glucose is a sugar with lots of energy—chemical energy. What type of energy produced the radiant energy from the sun?

The answer is nuclear energy. Inside the sun's core, atoms of hydrogen are fused together to form atoms of helium. The fusion occurs because of the large mass and pressure causing tremendous heat and gravitational forces inside the sun's core. The resulting atoms of helium have less mass than the original atoms of hydrogen. This remaining mass is changed into energy—radiant energy.

So, the increase in the temperature of the sand is the result of nuclear energy. In fact, almost all energy transformations can be traced back to nuclear energy, either fission, fusion, or radioactive decay. The energy stored in fossil fuels (coal, petroleum, natural gas, propane) 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 a result of the radioactive decay of elements in the earth's core. The electricity produced in a nuclear power plant is a result of the splitting or 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. Now, let's figure out how energy is stored in the major energy sources we use in the United States. Look at the **Forms and Sources** sheet. Use your **Forms of Energy** sheet to determine how energy is stored in each of the sources of energy. Remember, if the source of energy must be burned, the energy is stored as chemical energy. Next, look at the chart and calculate the percentage of the nation's energy use that each form of energy provides. [You may wish to give a brief description of the five renewable and five nonrenewable sources at this time.] The answers are:

1. Chemical (petroleum, natural gas, coal, propane, biomass)	88.5%
2. Nuclear (uranium)	8.3%
3. Motion (wind, hydropower)	2.8%
4. Thermal (geothermal)	0.3%
5. Radiant (solar)	0.1%

SAMPLE SCRIPT—DAY TWO: TEACHER DEMONSTRATION—TRACING ENERGY FLOWS

Watch this demonstration. This flashlight works by converting motion into electrical energy. [Squeeze the handle of the flashlight several times.] Electricity is powering the light. Here's how. The handle is connected to a gear that spins a metal disk, which is a magnet. Above and below the disk are two thin coils of copper wire with two wires leading to a battery and LED light bulbs. The magnet spins inside the coils of wire, creating an electric current.

As I squeeze the handle, an electric current is generated that flows to the battery and begins to charge it. [Squeeze handle slowly a few times.] The light will stay on as long as the battery is charged. Now, watch as I squeeze the handle quickly. [Squeeze the handle quickly several times.] Notice how much brighter the light is. Why? The more motion energy I put into the system, the more energy is stored in the battery and the more energy there is to produce light. You will have an opportunity to examine this flashlight when you visit Station Six.

Now, starting with the light from this flashlight, I would like each of you to trace the energy transformations back to nuclear energy. [Use **Transformations** transparency to discuss the transformations.] As you can see, one form of energy can be transformed into other forms of energy quite easily. During the next three days, you will be performing experiments that demonstrate these energy transformations. I have divided you into six groups. Each group will be responsible for a different energy conversion station. Your group will be responsible for investigating how to conduct and present your energy conversion experiments. You will have the rest of this class period to look through your station's guide and practice your experiments and presentation.

Tomorrow, half of your group will present the experiments, while the other half tours the other five stations. On the following day, you will switch roles. The presenters will tour the other five stations while the other students present their stations' experiments to the touring students. Here are your **Station Guides** and **Station Procedures**. Please be careful not to break any of the equipment or needlessly use the supplies. Let's review lab safety rules. [Use **Lab Safety Rules** transparency.]

PROCEDURE—DAYS THREE AND FOUR

- ☐ Distribute one set of **Worksheets** to each student and explain that the students must complete the Hypothesis and Data sections as they rotate through the stations and the Conclusion and Conversion sections after they have completed the presentations.
- ☐ Students rotate through the stations at eight minute intervals: Group A on Day Three and Group B on Day Four.

PROCEDURE—DAY FIVE

- ☐ Have students complete their worksheets and science journals.
- ☐ Have students take the **Science of Energy Exam** either in their groups or individually. Discuss.

THERMOMETER

A thermometer measures temperature.

The temperature of a substance is the average amount of thermal energy in the substance.

Temperature can be measured using many different scales.

The scales we use most are:

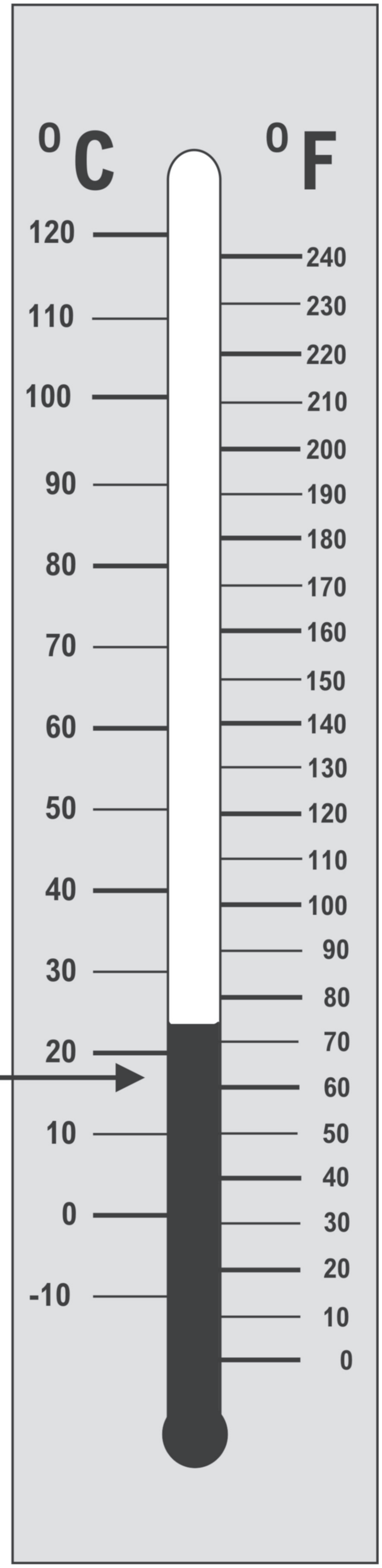
CELSIUS
The Celsius (C) scale uses the freezing point of water as $0^{o}C$ and the boiling point of water as $100^{o}C$.

FAHRENHEIT
The Fahrenheit (F) scale uses the freezing point of water as $32^{o}F$ and the boiling point of water as $212^{o}F$.

Zero ($0^{o}F$) on the Fahrenheit scale is the temperature of a mixture of equal weights of snow and salt.

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.

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 thermal energy.



FAHRENHEIT/CELSIUS CONVERSION

On the Fahrenheit scale, the freezing point of water is 32^{o} and the boiling point of water is 212^{o} - a range of 180^{o}.

On the Celsius scale, the freezing point of water is 0^{o} and the boiling point of water is 100^{o} - a range of 100^{o}.

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.

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

If C = 5 $\quad F = \left(\frac{9}{5} \times 5\right) + 32 \quad F = 9 + 32 = 41$

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.

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

If F = 50 $\quad C = \frac{5}{9} \times (50 - 32) \quad C = \frac{5}{9} \times 18 = 10$

FORMS OF ENERGY

All forms of energy fall under two categories

POTENTIAL

Potential energy is stored energy and the energy of position (gravitational).

CHEMICAL ENERGY

Chemical energy is the energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, propane and coal are examples of stored chemical energy.

NUCLEAR ENERGY

Nuclear energy is the energy stored in the nucleus of an atom. It is the energy that holds the nucleus together. The nucleus of a uranium atom is an example of nuclear energy.

STORED MECHANICAL ENERGY

Stored mechanical energy is energy stored in objects or substances by the application of a force. Compressed metal springs and stretched rubber bands are examples of stored mechanical energy.

GRAVITATIONAL ENERGY

Gravitational energy is the energy of place or position. Water held in a reservoir behind a hydropower dam is an example of potential gravitational energy. When the water in the reservoir is released to spin the turbines, it becomes motion energy.

KINETIC

Kinetic energy is motion. It is the motion of waves, electrons, atoms, molecules and substances.

RADIANT ENERGY

Radiant energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Solar energy is an example of radiant energy.

THERMAL ENERGY

Thermal energy (or heat) is the internal energy in substances. It is the vibration and movement of atoms and molecules within substances. Geothermal energy is an example of thermal energy.

MOTION

The movement of objects or substances from one place to another is motion. Wind is an example of motion energy.

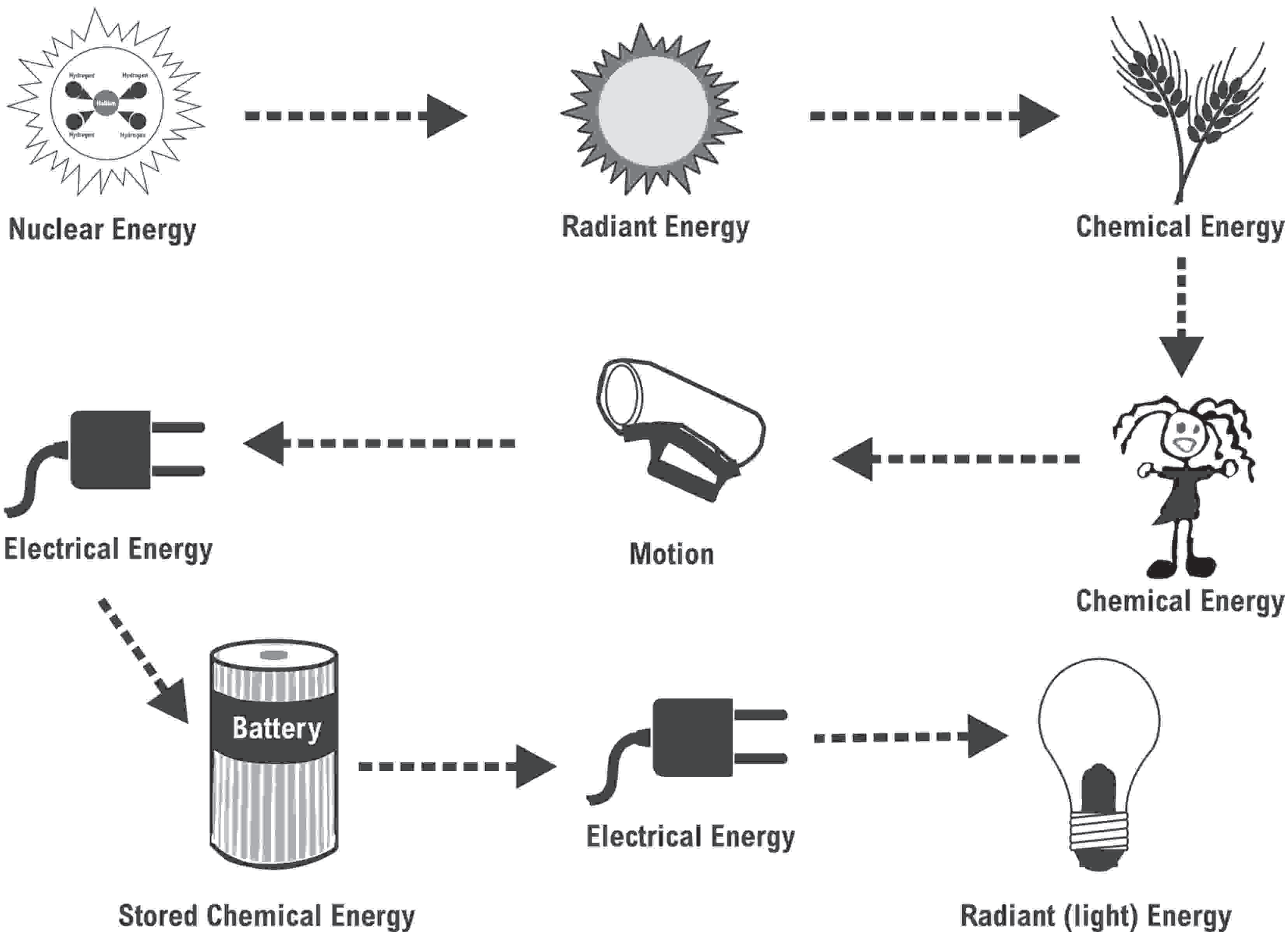
SOUND

Sound is the movement of energy through objects or substances in longitudinal (compression/rarefaction) waves.

ELECTRICAL ENERGY

Electrical energy is the movement of electrons. Lightning and electricity are examples of electrical energy.

ENERGY TRANSFORMATIONS
Hand Generated Flashlight



Lab Safety Rules

EYE SAFETY

- ☐ Always wear safety glasses when performing experiments.

FIRE SAFETY

- ☐ 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.
- ☐ Always keep long hair pulled back and secured.
- ☐ Do not heat any substance in a closed container.
- ☐ Always use the 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 the flame as soon as you are finished with the experiment and move it away from the immediate work area.

HEAT SAFETY

- ☐ 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.
- ☐ Do not use the steam generator without the assistance of your teacher.
- ☐ Remember that many objects will remain hot for a long time after the heat source is removed or turned off.

GLASS SAFETY

- ☐ 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 glass has been heated.
- ☐ Clean glass equipment carefully before packing it away.

CHEMICAL SAFETY

- ☐ 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.
- ☐ Do not pour a chemical down the laboratory drain unless instructed to do so.
- ☐ If a chemical accidentally touches your skin, immediately wash the 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.

Lightstick Safety: The solutions contained in the lightsticks 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 lightstick 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 medical emergency contact at 1-800-228-5635, ext 162.

Forms & Sources of Energy

The energy we use in the United States is mainly provided by the following sources of energy. Write the form of energy—how the energy is stored or delivered—for each of the sources on the line to the right of the source.

RENEWABLE		NONRENEWABLE	
Biomass	____________	Petroleum	____________
Hydropower	____________	Natural Gas	____________
Geothermal	____________	Coal	____________
Wind	____________	Uranium	____________
Solar	____________	Propane	____________

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

Chemical ________

Nuclear ________

Motion ________

Thermal ________

Radiant ________

Renewables ________

Nonrenewables ________

U. S. ENERGY CONSUMPTION BY SOURCE

BIOMASS *renewable* Heating, electricity, transportation	**2.9%**	**PETROLEUM** *nonrenewable* Transportation, manufacturing	**37.2%**
HYDROPOWER *renewable* Electricity	**2.7%**	**NATURAL GAS** *nonrenewable* Heating, manufacturing, electricity	**23.7%**
GEOTHERMAL *renewable* Heating, electricity	**0.3%**	**COAL** *nonrenewable* Electricity, manufacturing	**22.8%**
WIND *renewable* Electricity	**0.1%**	**URANIUM** *nonrenewable* Electricity	**8.3%**
SOLAR & OTHER *renewable* Light, heating, electricity	**0.1%**	**PROPANE** *nonrenewable* Manufacturing, heating	**1.9%**

Station One Guide: Motion

KINETIC ENERGY: THE ENERGY OF MOTION
POTENTIAL ENERGY: ENERGY OF POSITION & STORED ENERGY

MATERIALS (* NOT INCLUDED IN KIT)

1 Set of Happy/Sad Balls
1 Super Ball
1 Yo-yo
1 Toy Car
10 Balloons
Tongs
* 1 Meter Stick
* 1 Cup of Hot Water (not boiling)
* Table with hard, flat surface

PREPARATION—PART ONE: COLLISIONS

Part One Materials: Happy/sad balls, superball, hot water, meter stick, tongs, table with a hard, flat surface.

- ☐ Study the sample script to learn the experiment. Practice your presentation.
- ☐ Examine the equipment. The happy ball is the hard, bouncy ball. The sad ball is the softer ball.
- ☐ Get hot water from your teacher. **The water should be very hot, but not boiling**. Be careful! The water could easily burn you or someone else. The ball must remain in the hot water for one minute. Use the spoon or tongs to place the sad ball in the hot water and to take it out of the hot water.

PROCEDURE—PART ONE: COLLISIONS

- ☐ Have the students examine the balls while you explain motion as energy.
- ☐ Drop the balls from a height of 1 meter onto the table while you explain collisions and kinetic and potential energy.
- ☐ Use the meter stick to measure the rebound of the balls; explain how the potential energy is changed into motion, heat, and sound.
- ☐ Give the sad ball energy by placing it into the hot water, using the tongs. After one minute, remove the ball with the tongs and drop it again, measuring the rebound. Explain that the ball bounces higher when it is hot because it contains more heat energy and can't absorb as much heat energy when it is dropped.
- ☐ Drop the sad ball several times as it cools; measure the decreasing rebound as it loses energy.

SAMPLE SCRIPT—PART ONE: COLLISIONS

This script is just a sample. You don't need to say it word for word. The important thing is to get the major concepts and facts across to your audience.

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 potential energy. A rock at the top of a hill has potential energy. As it rolls down the hill, the potential energy turns into kinetic energy - the energy of motion.

Today, I'm going to talk about collisions. A collision occurs when a moving object hits another object. [Move the happy ball around the table, first slowly, then quickly. Stop it with your other hand.] When I push this ball, my hand gives it kinetic energy. The faster it goes, the more kinetic energy it has. When the ball runs into my other hand, there is a collision. If it stops completely, it loses all its kinetic energy. The energy can't 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 bounces. This means it hasn't lost all of its kinetic energy. Take a moment now to examine these three balls without dropping them. Which will bounce the highest? How high do you think they will bounce? *Record what you think will happen - your hypotheses - on your worksheet now.*

When I hold this ball above the table [Hold happy ball about one meter above table], I have given it energy by lifting it. If I drop the ball, we know it will fall because of gravity. This energy of position is its potential energy.

Let's see how high the ball will bounce when I drop it. [Drop ball several times; it should bounce back about 60-70 centimeters. Have a member of the audience measure how high it bounces.]

The ball bounced back about [65] centimeters. That means it kept about [65] percent of its energy. Where did the rest of the energy go? Part of the energy was changed into sound. Listen! [Drop the ball again.] Part of the energy was also changed into heat, or thermal energy. The ball and the table are both getting warmer every time I drop the ball, though you can't really feel the difference.

This ball is called a happy ball. Over here I have a ball that looks the same. Do you think it will bounce the same? Watch what happens when I drop it. [Drop the sad ball from about one meter. It should hardly bounce at all.] It hardly bounces. I gave it the same amount of potential energy. What happened?

This ball isn't broken. It's a sad ball. It's made of a different kind of rubber. [Happy ball is neoprene rubber and the sad ball is polynorbornene rubber.] It loses almost all of its energy when it collides. Listen! [Drop the ball again.] More of the sad ball's energy changes into sound than the happy ball's. More of the sad ball's energy changes into heat, too.

Feel both of the balls. Do they feel different? [Let everyone squeeze both balls.] Does the happy ball seem a little harder than the sad ball? The rubber molecules [polymers] inside each ball are quite different. The sad ball's molecules are loosely arranged inside like a tangled ball of strings. At room temperature, they move and rub together when there is a collision. The kinetic energy turns into heat as the molecules rub each other as a result of friction. The happy ball's molecules are more tightly arranged and do not move as easily during a collision, so more of its kinetic energy is returned as kinetic energy in its bounce.

I'm going to put the sad ball into hot water. [Carefully drop the sad ball into the cup of hot water.] While the sad ball is getting hot, let's measure the rebound of the super ball. [Hold super ball one meter above table.]

I'm going to take the sad ball out of the hot water now. The ball has absorbed heat energy from the hot water. What difference do you think that will make? Will it bounce higher or not at all? *Record your hypothesis––what you think will happen when I drop the ball.* [Carefully remove the ball with the tongs. Do not hold it in your hand. Drop the ball from one meter using tongs. It should bounce about 30 centimeters.]

Look at that! The ball bounces higher. The sad ball has absorbed heat from the water; its molecules have expanded. When the ball collides with the table, the molecules inside the ball can't move around as easily as when they are cooler. The sad ball is able to retain more of its kinetic energy and bounce higher. Less energy is turned into sound and heat in the collision. [The ball will be cool enough to pick up now using your hands. Drop the ball several more times.] As the ball cools down, the molecules inside return to their more flexible state and more of the energy is changed into heat when it hits the table. The cooler it gets, the less it bounces.

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

PREPARATION—PART TWO: STORED MECHANICAL ENERGY

Materials: Toy car, balloons, yo-yo.

- ☐ Study the procedure and sample script to learn the experiment. Practice your presentation.
- ☐ Examine the equipment.

PROCEDURE—PART TWO: STORED MECHANICAL ENERGY

- ☐ Demonstrate storing energy in the toy car while explaining how the energy is stored in the spring and how the potential energy turns into motion, heat, and sound.
- ☐ Demonstrate storing energy in a balloon while explaining how the energy is stored in the compressed air and stretched rubber, and how the potential energy turns into motion, heat, and sound.
- ☐ Demonstrate storing energy in a yo-yo while explaining how energy is stored in a spinning object and how the potential energy turns into motion and heat.

SAMPLE SCRIPT—PART TWO: STORED MECHANICAL ENERGY

This script is just a sample. You don't need to say it word for word. The important thing is to get the major concepts and facts across to your audience.

Toy Car: As I demonstrated with the balls, holding an object in the air gives it potential energy. This isn't the only way you can store potential energy, though. Watch this. [Push down on the car and hold it down.] This car has a spring in it. When I push down on the car, I'm storing my energy in the spring. [Let go of car.] When I let go of the car, the car starts to move. The stored mechanical energy in the spring changes to motion. Why does the car stop after a while? The car stops because of friction. Friction changes some of the motion into heat.

Balloon: Can anyone tell me how to store energy in this balloon? [Hold up balloon and get answers from audience.] If I blow up this balloon, I'm using my kinetic energy to stretch the rubber, just like I used my energy to compress the spring in the car. [Blow up balloon.]

That energy is stored in stretched rubber and compressed air instead of a compressed spring. Where will the energy go if I let go of this balloon? [Get answers from audience, then let go of balloon.] The stored mechanical energy is converted into motion, heat, and sound.

Yo-yo: If I let go of this yo-yo, how far back up the string do you think it will come? *Record your hypothesis on your worksheet.* [Let go of the yo-yo. If the yo-yo *sleeps*, twist the yo-yo to tighten the string around the center spool. The yo-yo should come about 60 percent of the way back up the string.] The yo-yo only came about [60] percent of the way. Why didn't it come back to my hand? Friction between the string and the yo-yo changed _some of the motion energy into heat energy.

Can anybody tell me where the energy is stored that makes the yo-yo come back up after I let it go? [Get answers from audience.] 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 motion and how we can store mechanical energy and change it into other forms of energy. Do you have any questions?

STATION ONE PROCEDURE

POTENTIAL ENERGY: ENERGY OF POSITION OR PLACE & STORED MECHANICAL ENERGY
KINETIC ENERGY: MOVEMENT OF ATOMS, MOLECULES, SUBSTANCES, & OBJECTS
MOTION: MOVEMENT OF SUBSTANCES & OBJECTS FROM ONE PLACE TO ANOTHER

PROCEDURE—PART ONE: COLLISIONS

After explaining each procedure, allow students time to record their hypotheses.

- ☐ Have the students examine the balls while you explain motion as energy.
- ☐ Drop the balls from a height of 1 meter while you explain collisions, kinetic energy, and potential energy.
- ☐ Use the meter stick to measure the rebound of the balls. Explain how the potential energy is changed into motion, heat, and sound.
- ☐ Give the sad ball energy by placing it into the hot water, using the tongs. After one minute, remove the ball with the tongs and drop it again, measuring the rebound. Explain why the ball bounces higher when it is hot; it contains more thermal energy and can't absorb as much energy when it is dropped.
- ☐ Drop the sad ball several times as it cools, measuring the decreasing rebound as it loses energy.

PROCEDURE—PART TWO: STORED MECHANICAL ENERGY

After explaining each procedure, allow students time to record their hypotheses.

- ☐ Demonstrate storing energy in the toy car while explaining how the energy is stored in the spring and how the potential energy turns into motion, heat, and sound.
- ☐ Demonstrate storing energy in a balloon, while explaining how the energy is stored in the compressed air and stretched rubber, as well as how the potential energy turns into motion, heat, and sound.
- ☐ Demonstrate storing energy in a yo-yo while explaining how energy is stored in a spinning object and how the potential energy turns into motion and heat.

FURTHER EXPLORATIONS

- ☐ Test a variety of different balls, such as a hollow ball (ping pong ball), marble, golf ball, baseball.
- ☐ Test the balls on a variety of surfaces, such as carpeting, glass table, metal table.
- ☐ Test the balls changing the temperature of the collision surface.
- ☐ Test the happy/sad balls after freezing them overnight.
- ☐ Test the distance the happy/sad balls travel on an inclined surface. Vary the temperature of the balls to determine if temperature makes a difference.
- ☐ Test to determine if placing the balls in bright light makes a difference.

STATION ONE WORKSHEET

PURPOSES: To explore potential and kinetic energy during collisions.

To explore stored mechanical energy in toys.

QUESTIONS: Which ball will bounce the highest?

How high will each ball bounce?

What affect will heating the ball have on a ball's bounce?

How can we store energy in toys?

HYPOTHESES:

PROCEDURE: Examine the three balls.

Drop the balls from a height of 1 m and measure how high they bounce.

Add thermal energy to a ball and measure how high it bounces.

Observe how energy is stored in toy cars, balloons, and yo-yos.

DATA:

CONCLUSIONS:

CONVERSION: A ball dropped from a height of one meter converts ____________________ energy into ____________________, ____________________ and ___________________ as it collides with a table.

Station Two Guide: Chemical & Thermal Energy

EXOTHERMIC REACTIONS: REACTIONS THAT PRODUCE HEAT
ENDOTHERMIC REACTIONS: REACTIONS THAT REQUIRE HEAT

MATERIALS (* NOT INCLUDED IN KIT)

ENDOTHERMIC
* 1 Bottle of Vinegar
1 Container of Baking Soda
4 Empty Plastic Bags
1 Thermometer
1 Measuring Cup
2 Display Sheets

EXOTHERMIC
8 Handwarmers
1 Sealed Bag of Iron Oxide
1 Container of Calcium Chloride
2 Empty Plastic Bags
* Scissors
* Water

PREPARATION—PART ONE: ENDOTHERMIC REACTIONS

Materials: Vinegar, baking soda, bags, thermometer, measuring cup, display sheet.

- ☐ Study the procedure and sample script to learn the experiment.
- ☐ Examine the equipment.
- ☐ Practice your presentation.

PROCEDURE—PART ONE: ENDOTHERMIC REACTIONS

- ☐ Explain that you are going to mix two substances together to make a third substance. This is an endothermic reaction - it requires heat energy to make the third substance, converting heat into stored chemical energy. Use Display Sheet to explain the reaction.
- ☐ Pour 5 ml (milliliters) of vinegar into an empty plastic bag and have the students feel the vinegar to note the temperature.
- ☐ Record the temperature of the vinegar. Leave the thermometer in the bag.
- ☐ Carefully pour 5 cm^3 (cubic centimeters) of baking soda into the bag. Be careful - the chemical reaction will foam to the top of the bag.
- ☐ Wait 30 seconds and record the temperature again.
- ☐ Remove the thermometer from the bag and carefully zip it.
- ☐ Have the students feel the bag again.

SAMPLE SCRIPT—PART ONE: ENDOTHERMIC REACTIONS

This script is just a sample. You don't need to say it word for word. The important thing is to get the major concepts and facts across to your audience.

At this station, you'll be learning about stored chemical energy and chemical reactions. Chemical reactions occur when you mix two chemicals together to form another chemical. All chemical reactions involve heat. Some give off heat and some use heat. An exothermic reaction gives off heat. *Exo* means *out* and *thermal* means *heat*. Exothermic - the heat goes out. An endothermic reaction uses heat. *Endo* means *in* and *thermal* means *heat*. So, endothermic - the heat goes in. Today, you'll be seeing both kinds of reactions. And, since the easiest way to measure heat is by its temperature, we'll use a thermometer to show the changes in heat.

This first experiment is an endothermic reaction - it uses heat. I'm going to mix vinegar and baking soda together to make other chemicals (water, carbon dioxide, and sodium acetate). *Record your hypothesis––what you think will happen––on your worksheet.*

First, I'll add the vinegar and measure the temperature of it. [Pour 5 ml of vinegar into an empty plastic bag. Hold the bag at the top and tilt it so that all the vinegar is in one corner. Make sure the bulb of the thermometer is in the solution. Record the temperature of the vinegar in Celsius and Fahrenheit scales. Let everyone touch the bag.] *Record the data on your worksheets.*

Everyone touch the bag so you'll know what the temperature feels like. Now I'm going to add the baking soda. You'll be able to see a reaction taking place. [Leave the thermometer in the bag. Pour in 5 cm^3 of baking soda. Be careful—the reaction will foam very high.] Now, watch the temperature on the thermometer. [The temperature should drop four to five degrees Celsius in 30 seconds. Let everyone touch the bag again.] The temperature is now [XX] degrees Celsius. *Record this data.* Now touch the bag and tell me how it feels. Can you feel the difference in temperature?

It feels colder because the reaction we just saw uses heat energy. It's an endothermic reaction. The heat is now stored in the bonds of the new chemical that was formed. The reaction took heat from the mixture and transformed it into stored chemical energy. [Take the thermometer out of the bag. Zip up the bag and put it aside with the vinegar and baking soda solution.]

[Show Display Sheet.] The top equation shows the reaction of vinegar and baking soda. The reaction takes the thermal energy it needs from the surrounding environment, which is why the bag feels colder.

PREPARATION—PART TWO: EXOTHERMIC REACTIONS

Materials: Sealed bag of iron oxide, handwarmers, container of calcium chloride, plastic bags, scissors, water, thermometer, display sheet.

- ☐ Study the sample script to learn the experiment.
- ☐ Examine the equipment.
- ☐ Practice your presentation.
- ☐ The sealed bag of iron oxide contains old filings from the handwarmers. This is called the *old packet*. A few minutes before your first presentation, cut open a new packet and pour it into an empty plastic bag. Keep the bag open so that oxygen and water in the air can react with the iron. This is called the *new packet*.

PROCEDURE—PART TWO: EXOTHERMIC REACTIONS

Handwarmers

- ☐ Explain that you are going to let oxygen and water in the air come into contact with pieces of iron to produce a third chemical, iron oxide. The reaction is exothermic—it produces heat. Most reactions are exothermic. Use the Display Sheet to explain the reaction.
- ☐ Show students the package that held the iron filings.
- ☐ Let students feel the new packet to note the temperature.
- ☐ Seal the new packet to prevent oxygen and water from entering the bag.
- ☐ Let students feel the old packet and note the temperature.
- ☐ After performing the second part of the demonstration—driveway ice—let students feel the new packet that you sealed noting the temperature drop after the bag was sealed and no oxygen could enter to keep the reaction going.

Driveway Ice

- ☐ Explain that calcium chloride is used to melt ice on sidewalks and driveways. When calcium chloride comes into contact with water, a chemical reaction takes place that produces heat. [Use the Display Sheet to explain the reaction.]
- ☐ Pour 5 ml of water into a plastic bag. Record the temperature using the thermometer.
- ☐ Pour 2 cm^3 of calcium chloride into water.
- ☐ Record the temperature.
- ☐ Seal the bag and put it aside.

SAMPLE SCRIPT—PART TWO: EXOTHERMIC REACTIONS

Most reactions don't absorb heat like vinegar and baking soda. Most chemical reactions give off heat—they're exothermic. Let's watch a reaction that produces heat.

A few minutes ago I opened this handwarmer. It is filled with iron filings. [Show audience the package the hand warmer came in.] Why do you think it was sealed in plastic? [Get answers from audience.] The plastic keeps oxygen and water from reaching the iron. I put the iron filings into this plastic bag and left it open so that oxygen and water could get to it. [Hold up new packet.] The oxygen in the air is reacting with the iron to form a new chemical, iron oxide, or rust. The water is a catalyst. *Record your hypothesis - what you think will happen - before I go on.*

Feel this packet. [Let everyone feel the new packet. It should feel warm.] It feels warm. When oxygen comes into contact with iron in the presence of water, the chemical reaction produces rust and heat. You can see that most of the iron filings are still black. [Show Display Sheet.] They will slowly turn to rust as long as we let oxygen reach them in the presence of water. Now, I'm going to seal the bag. No oxygen will be able to get to the iron filings. The reaction should slow down and eventually stop. At the end of the presentation, we'll feel the bag again to see if the temperature has changed.

Here is a packet of filings that has been open for several weeks. [Hold up old packet. Let everyone observe and feel it.] As you can see, all the iron has turned to rust. No more heat is being produced. Why do you think the handwarmer has a lot of iron filings instead of one chunk of iron? [Get answers from audience.] Because more iron can come into contact with oxygen when it is in small pieces.

Let me demonstrate another reaction. This container contains calcium chloride—it is a common chemical used to melt ice on sidewalks and driveways. When calcium chloride comes into contact with ice or water, it dissolves and the calcium chloride molecules dissociate into calcium and chloride ions. Some of the water molecules dissociate into hydrogen and hydroxide ions. The calcium ions bond with hydroxide ions to form calcium hydroxide, or lime. The hydrogen ions bond with chloride ions to form hydrochloric acid. The hydrochloric acid solution is very weak. [Use the Display Sheet to explain the reaction.] *Record your hypothesis––what you think will happen when I mix the calcium chloride with water.*

Let's put 5 ml of water into this plastic bag and record the temperature on your worksheet. Now, let's put 2 cm^3 of calcium chloride in the water. Since this is an exothermic reaction, will the temperature of the water increase or decrease? [Get answers.] That's right. Since exothermic reactions give off heat, the temperature of the solution should increase. [Record temperature.] *Record the temperature of the mixture on your worksheet.*

Feel the bag of iron filings that I sealed a few minutes ago. [Pass the new packet around.] The iron filings are cooler, aren't they? Sealing the bag kept oxygen from coming into contact with the iron. The chemical reaction stopped. No more heat is being produced.

Do you have any questions?

ENDOTHERMIC REACTIONS

VINEGAR & BAKING SODA

Vinegar + Baking Soda + Heat → Water + Carbon Dioxide + Sodium Acetate

$CH_3COOH + NaHCO_3 + Heat \rightarrow H_2O + CO_2 + NaCH_3COO$

IONIC REACTION

CH_3COO^- (acetate) + H^+ (hydrogen) + Na^+ (sodium) + HCO_3^- (bicarbonate) → $H_2O + CO_2 + NaCH_3COO$

EXOTHERMIC REACTIONS

IRON FILINGS & OXYGEN & WATER

Iron + Oxygen + H_2O → Iron Oxide (rust) + H_2O + Heat

$4\ Fe + 3\ O_2 + H_2O \rightarrow 2\ Fe_2O_3 + H_2O$ + Heat

CALCIUM CHLORIDE & WATER

$CaCl_2 \rightarrow Ca^{+2} + 2\ Cl^-$

$2\ H_2O \rightarrow 2\ H^+ + 2\ (OH)^-$

$CaCl_2 + 2\ H_2O \rightarrow Ca(OH)_2 + 2\ HCl$ + Heat

Calcium Chloride + Water → Calcium Hydroxide (lime) + Hydrochloric Acid + Heat

STATION TWO PROCEDURE 1

THERMAL ENERGY: KINETIC ENERGY OF ATOMS & MOLECULES AS THEY VIBRATE & MOVE
CHEMICAL ENERGY: POTENTIAL ENERGY STORED IN THE BONDS OF MOLECULES
ENDOTHERMIC: A REACTION THAT REQUIRES OR ABSORBS HEAT
EXOTHERMIC: A REACTION THAT PRODUCES HEAT

PROCEDURE—PART ONE: ENDOTHERMIC REACTIONS

After explaining each procedure, allow students time to record their hypotheses.

- ☐ Explain that you are going to mix two substances together to make a third substance.
- ☐ This is an endothermic reaction: it requires heat energy to make the third substance, converting heat into stored chemical energy.
- ☐ Pour 5 ml (milliliters) of vinegar into an empty plastic bag and have the students feel the vinegar to note the temperature. Place the thermometer in the bag.
- ☐ Record the temperature of the vinegar. Leave the thermometer in the bag.
- ☐ Carefully pour 5 cm^3 (cubic centimeters) of baking soda into the bag. Be careful—the chemical reaction will foam to the top of the bag.
- ☐ Wait 30 seconds and record the temperature again.
- ☐ Remove the thermometer from the bag and carefully zip the bag.
- ☐ Have the students feel the bag again.

FURTHER EXPLORATIONS

- ☐ Test a variety of liquids instead of vinegar, such as different fruit juices, soda, and tea, making sure to control other variables.
- ☐ Test by varying the amount of vinegar.
- ☐ Test by varying the amount of baking soda.
- ☐ Test by cooling and heating the vinegar.

STATION TWO PROCEDURE 2

THERMAL ENERGY:	**KINETIC ENERGY OF ATOMS & MOLECULES AS THEY VIBRATE & MOVE**
CHEMICAL ENERGY:	**POTENTIAL ENERGY STORED IN THE BONDS OF MOLECULES**
ENDOTHERMIC:	**A REACTION THAT REQUIRES OR ABSORBS HEAT**
EXOTHERMIC:	**A REACTION THAT PRODUCES HEAT**

PROCEDURE—PART TWO: EXOTHERMIC REACTIONS

After explaining each procedure, allow students time to record their hypotheses.

Handwarmers

- ☐ Explain that you are going to let oxygen and water in the air come into contact with pieces of iron to produce a third substance, iron oxide. The reaction is exothermic: it produces heat. Some of the stored chemical energy in the oxygen and iron is transformed into heat when the iron oxide is formed. Most chemical reactions are exothermic.
- ☐ Show the students the package that held the iron filings.
- ☐ Let the students feel the new packet to note the temperature as the chemical reaction is taking place.
- ☐ Seal the new packet to prevent oxygen and water from entering the bag.
- ☐ Let students feel the old packet and note its temperature.
- ☐ After performing the second part of the demonstration—driveway ice—let the students feel the new packet that you sealed noting the temperature drop after the bag was sealed and no oxygen could enter to keep the reaction going.

Driveway Ice

- ☐ Explain that calcium chloride is used to melt ice on sidewalks and driveways. When calcium chloride comes into contact with water, a chemical reaction occurs. Some of the stored chemical energy in the calcium chloride and the water molecules is converted into heat during the reaction.
- ☐ Pour 5 ml of water into a plastic bag. Record the temperature using the thermometer.
- ☐ Pour 2 cm^3 of calcium chloride into the water. Record the temperature again.

FURTHER EXPLORATIONS

- ☐ Test by heating and cooling the iron filings.
- ☐ Test the reaction of iron filings to carbon dioxide by breathing into a bag.
- ☐ Test by varying the temperature of the water with the calcium chloride.
- ☐ Test by using salt (sodium chloride) instead of calcium chloride.

STATION TWO WORKSHEET 1

PURPOSES: To explore stored chemical energy and thermal energy.
To explore endothermic reactions.

QUESTION: What happens when you mix vinegar and baking soda?

HYPOTHESiS:

PROCEDURE: Record the temperature of a bag of vinegar, then add baking soda.
Record the temperature of the mixture.

DATA:

CONCLUSION:

STATION TWO WORKSHEET 2

PURPOSES: To explore stored chemical energy and thermal energy.

To explore exothermic reactions.

QUESTIONS: What happens when you expose iron to oxygen in the presence of water?

What happens when you mix driveway ice (calcium chloride) with water?

HYPOTHESES:

PROCEDURE: Observe the temperature of iron filings exposed to oxygen in the presence of water.

Observe the temperature of iron filings not exposed to oxygen in the presence of water.

Record the temperature of a bag of water, then add calcium chloride.

Record the temperature of the solution.

DATA:

CONCLUSIONS:

CONVERSION: A handwarmer converts ____________________ energy to _____________________ energy.

Station Three Guide: Radiant Energy

TRANSFORMING RADIANT ENERGY INTO MOTION, HEAT, AND ELECTRICITY
STORING RADIANT ENERGY

MATERIALS (* NOT INCLUDED IN KIT)

1 Radiometer	3 Display Sheets	1 Fan	1 Motor	
1 Solar Panel	2 Thermometers	2 Glow Toys	* Tape	*1 Overhead Projector or Flashlight

PREPARATION—PART ONE: RADIOMETER

Materials: Radiometer, display sheet, overhead projector or flashlight

- ☐ Study the procedure and sample script to learn the experiment.
- ☐ Examine the equipment.
- ☐ Practice your presentation.
- ☐ This presentation works best if it is done near a window with strong sunlight. If using sunlight is a problem, use an overhead projector or strong flashlight as a light source.

PROCEDURE—PART ONE: RADIOMETER

- ☐ Explain that a radiometer is a device that can transform light into heat, then into motion.
- ☐ Hold the radiometer upside down so that the students can see the vanes, then turn it upright and place in bright light. Observe the speed with which the vanes turn.
- ☐ Move the radiometer closer to and farther from the light; observe the change in the speed of the vanes.
- ☐ Using the display sheet, explain how the light is transformed into heat, then motion.

SAMPLE SCRIPT—PART ONE: RADIOMETER

This script is just a sample. You don't need to say it word for word. The important thing is to get the major concepts and facts across to your audience.

Do you know that light can make things move? Today I'm going to show you how to change light into heat and then into motion—radiant energy into thermal energy into mechanical energy.

This is a radiometer [rā′-dē-ŏ′-mĕt-ĕr]. [Hold the radiometer upside down so that the audience can see the vanes.] There is very little air inside this bulb—it is almost a vacuum. The black and white vanes are hanging on a needle. There is nothing else inside the bulb. [Turn the radiometer over and place in bright light. Move the radiometer closer to and farther from the light to show the change in speed of the vanes spinning.]

When I put the radiometer in the light, the vanes begin to turn. The brighter the light, the faster they spin. How is the light making the vanes turn? You know that black objects get hotter than white objects in the sun. That's why most people wear white in the summer. Black objects absorb most of the radiant energy that strikes them, reflecting only a little. White objects reflect most of the radiant energy that strikes them and absorb only a little.

When I put the radiometer in light, the vanes absorb the light energy as heat. The air molecules inside the bulb bounce off the vanes with more energy. If both sides of the vanes were the same color, the vanes would never move. But the vanes aren't the same color on both sides. The black side 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. [Hold up Display Sheet and explain.] This is a picture of the radiometer from the top. When the air molecules hit the black sides of the vanes, they bounce with more force than when they hit the white sides, because the black sides transfer more energy to them. Since there is more force exerted on the black side than the white, the vanes begin to turn. Light is changed into heat, then into motion—radiant energy into thermal energy into mechanical energy. Do you have any questions about the radiometer?

PREPARATION—PART TWO: SOLAR PANEL

Materials: Solar panel, motor, fan, bright light source, display sheet.

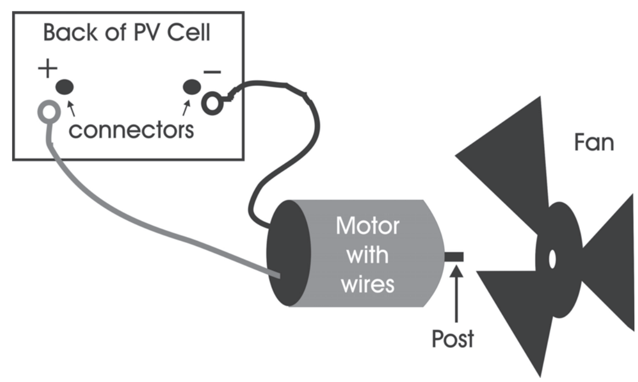
- ☐ Study the procedure and sample script to learn the experiment.
- ☐ Examine the equipment.
- ☐ Practice your presentation.
- ☐ Place the solar panel near your source of light, but NOT directly facing it.

PROCEDURE—PART TWO: SOLAR PANEL

- ☐ Explain that photovoltaic cells convert radiant energy directly into electricity and point out the individual cells in the solar panel. Explain how a PV cell works using display sheet.
- ☐ Explain that the motor converts electricity into motion.
- ☐ Demonstrate that the amount of electricity produced by the panel changes when part of the panel is covered or held at different angles by observing the speed of the fan.

SOLAR PANEL ASSEMBLY AND CONNECTION INSTRUCTIONS

- ☐ 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 the nuts.
- ☐ Attach the fan to the post on the opposite end of the motor.
- ☐ Expose the PV cell to a very strong light source (bright sunlight or an overhead projector) and the motor will spin the fan. If you reverse the connector wires, the fan will spin in the opposite direction.
- ☐ If the fan does not spin, remove the motor leads from the PV cell and touch them to the ends of a C battery to "jumpstart" the motor, then try again.



- ☐ Change the amount of light or angle of the light hitting the PV cell and the rate of spin will change.

SAMPLE SCRIPT—PART TWO: SOLAR PANEL

Let's investigate how we can use light to make electricity and motion. We will be converting radiant energy into electrical energy, then into motion. I'm sure you've all seen solar calculators or solar toys that use light to produce electricity. Most of the electricity we use today comes from the sunlight stored in fossil fuels such as coal. Changing light directly into electricity with a solar panel is clean and simple, but it is very expensive. Solar power costs about four times as much as coal or nuclear power because of the cost of the equipment.

This is a solar panel. [Point out solar panel and individual PV cells.] It 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 the 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. Let's look at how a PV cell is made and how it produces electricity.

Step 1 Pure silicon is used to form very thin wafers. [Display diagram of Photovoltaic Cell.] In some of these wafers, a small amount of the element phosphorous is added. In the other wafers, a small amount of the element boron is added. The phosphorous gives its wafer an excess of free electrons; therefore, this wafer will have a negative character. This wafer is called the n-layer. The n-layer is not a charged wafer—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 about. The boron gives its wafer a positive character because it has a tendency to attract electrons. This layer also has an equal number of protons and electrons—it has a positive character but not a positive charge. This wafer is called the p-layer.

Step 2 When the two wafers are placed together, the free electrons from the n-layer are attracted to the p-layer. An interesting thing happens at the moment of contact between the two wafers—free electrons from the n-layer flow into the p-layer for a split second, then form a barrier to prevent more electrons from moving from one layer to the other. This contact point and barrier is called the p-n junction.

Once the layers have been joined, there is a negative charge in the p-layer section of the junction and a positive charge in the n-layer section of the junction. This imbalance in the charge of the two layers at the p-n junction produces an electric field between the p-layer and the n-layer.

Step 3 If the PV cell is placed in the sun, photons of light energy 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-layer and are repelled by the negative charge in the p-layer.

Step 4 We can attach a wire from the p-layer to the n-layer. As the free electrons are pushed into the n-layer, they repel each other. The wire provides a path for the electrons to flow away from each other. This flow of electrons is an electric current that we can measure with an ammeter.

This motor converts electrical energy into a spinning motion, which you can see with the fan. The amount of electrical energy depends on the number of cells in the panel. What do you think will happen if I cover half of the panel? Record your hypothesis on your worksheet. [Cover half of panel with your hand.] Observe the speed of the fan. When I cover half the cells, the amount of electrical energy drops and the fan slows down.

If I change the angle of the panel toward the light, I can also change how much electricity is produced. [Angle the panel toward and away from the light.] More electricity is produced if the light is shining directly on the PV cells. That is because more light energy is striking the cells.

PV cells aren't very efficient. They convert only about 10 percent of the light energy that strikes into electricity. The rest is changed into heat or reflected off the surface. Scientists are working on ways to make PV cells more efficient. Now you know a way to convert light directly into electricity. Do you have any questions?

PREPARATION—PART THREE: LIGHT TO HEAT

Materials: Two thermometers, tape, cardboard.

- ☐ Using a sunny window or an overhead projector for a light source, tape one thermometer on a piece of cardboard facing the light and one on the other side facing away.
- ☐ Study the procedure and sample script to learn the experiment.
- ☐ Practice your presentation.

PROCEDURE—PART THREE: LIGHT TO HEAT

- ☐ Demonstrate how one thermometer has been facing the light and one has not.
- ☐ Record the temperatures of the two thermometers.

SAMPLE SCRIPT—PART THREE: LIGHT TO HEAT

You've probably heard the expression, "It was a 100 degrees in the shade." Why do people say that? Even when the air temperature is the same, it feels hotter when you're in the sun than when you're in the shade. The sun's radiant energy striking your body makes you feel hotter. In the shade, you only feel the heat from the air molecules striking your body.

[Show the two thermometers.] I have taped one thermometer facing the light and one facing away from the light. Which one do you think will show a higher reading? *Record your hypothesis on your worksheet.* Let's record the temperature of the two thermometers on your worksheet. The thermometer facing the light has a higher temperature because the sun's radiant energy is being transformed into thermal energy. On hot sunny days, stay in the shade.

PREPARATION—PART FOUR: STORING LIGHT

Materials: Glow toy in pouch with green label, glow toy placed in sun, display sheet.

- ☐ Study the procedure and sample script to learn the experiment.
- ☐ Examine the equipment.
- ☐ Practice your presentation.
- ☐ Make sure the glow toy in the pouch with the green label is not exposed to the sun or other light source.
- ☐ Expose the other glow toy to bright sunlight or another light source for a while before the presentations begin.

PROCEDURE—PART FOUR: STORING LIGHT

- ☐ Explain that glow toys are made of plastic mixed with zinc sulfide - a phosphorescent material that can store radiant energy.
- ☐ Place glow toy that has been exposed to light into its pouch. Have students peek into the pouch to see the glowing toy - the stored radiant energy.
- ☐ Have students peek into the pouch with the green label. Explain that the glow toy has not been exposed to the light, so it has no energy stored in it and does not glow.

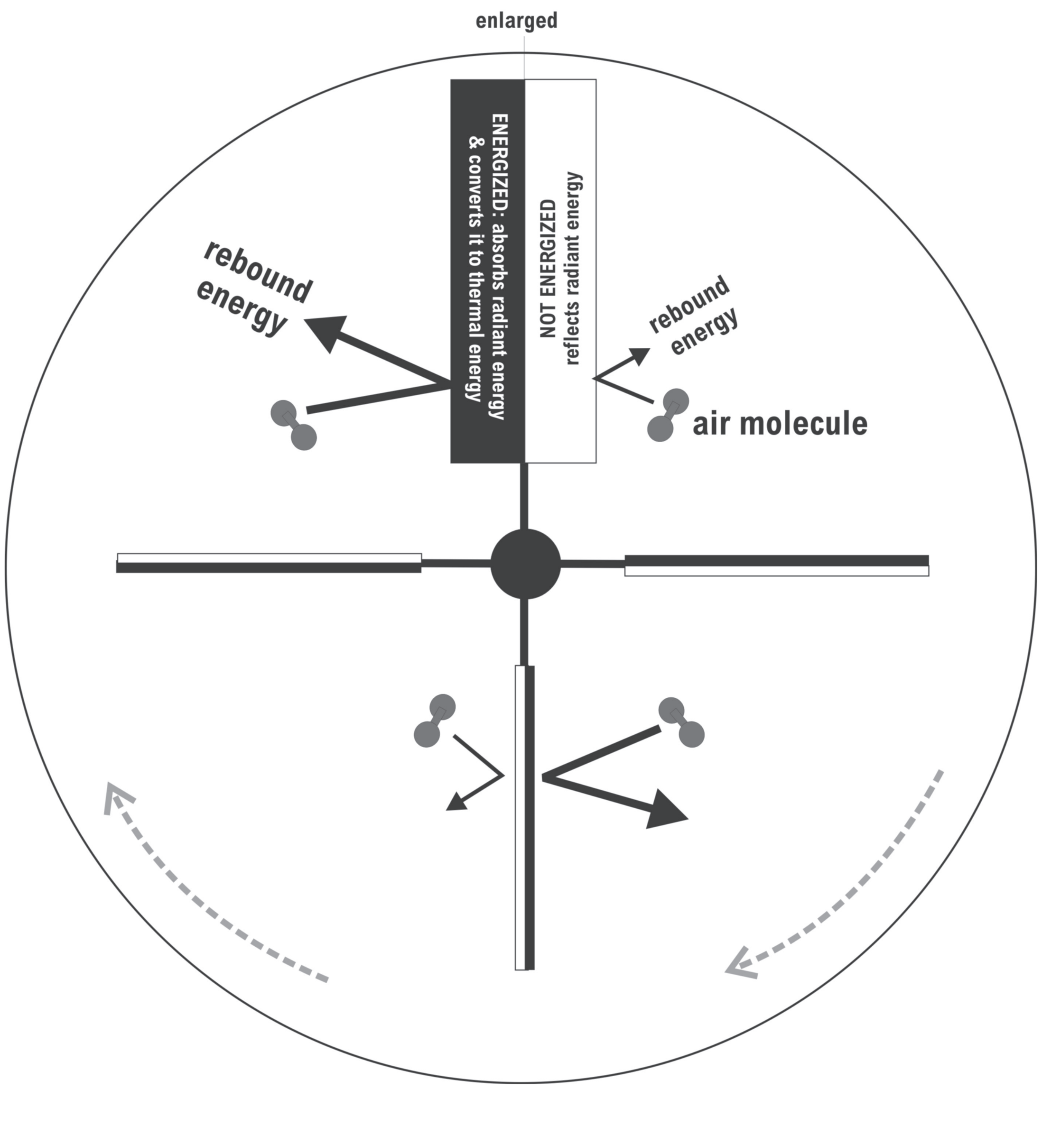
SAMPLE SCRIPT—PART FOUR: STORING LIGHT

I'm sure you have seen glow toys. We know they produce radiant energy because we can see them in a dark room. Where does the radiant energy come from? [Get answers.] The radiant energy comes from the light that was absorbed by the toys earlier and stored.

Glow toys are made of plastic to which a phosphorescent chemical—usually zinc sulfide—has been added. I have two glow toys for my demonstration. One glow toy has been left in the light and the other one has been kept in this pouch with the green label away from the light. I am going to place the toy that has been left in the light into its pouch. What do you think will happen? *Record your hypothesis on your worksheet.* Now peek into the first pouch. What do you see? [Get answers.] The toy is glowing, isn't it? What do you see when you look into the pouch with the green label? The toy is not glowing.

Since light couldn't strike the glow toy in this pouch [hold up pouch with green label], it couldn't absorb any radiant energy. The other toy absorbed radiant energy when it was left in the light. The radiant energy excited the molecules in the phosphorescent material—the zinc sulfide—and stored it as electrical potential energy. Photons of light hit electrons in the zinc sulfide, causing them to jump to a higher energy level or shell. When the electrons returned to the lower shell, they emitted energy as photons of light, causing the toy to glow. There are many naturally occurring phosphorescent materials; some organisms such as fireflies even contain them. The difference between luminescence and phosphorescence is that luminescent materials cease to glow as soon as the radiant energy is removed, whereas phosphorescent materials continue to glow, sometimes for a long time. [Show Display Sheet.] Do you have any questions?

TOP VIEW OF RADIOMETER



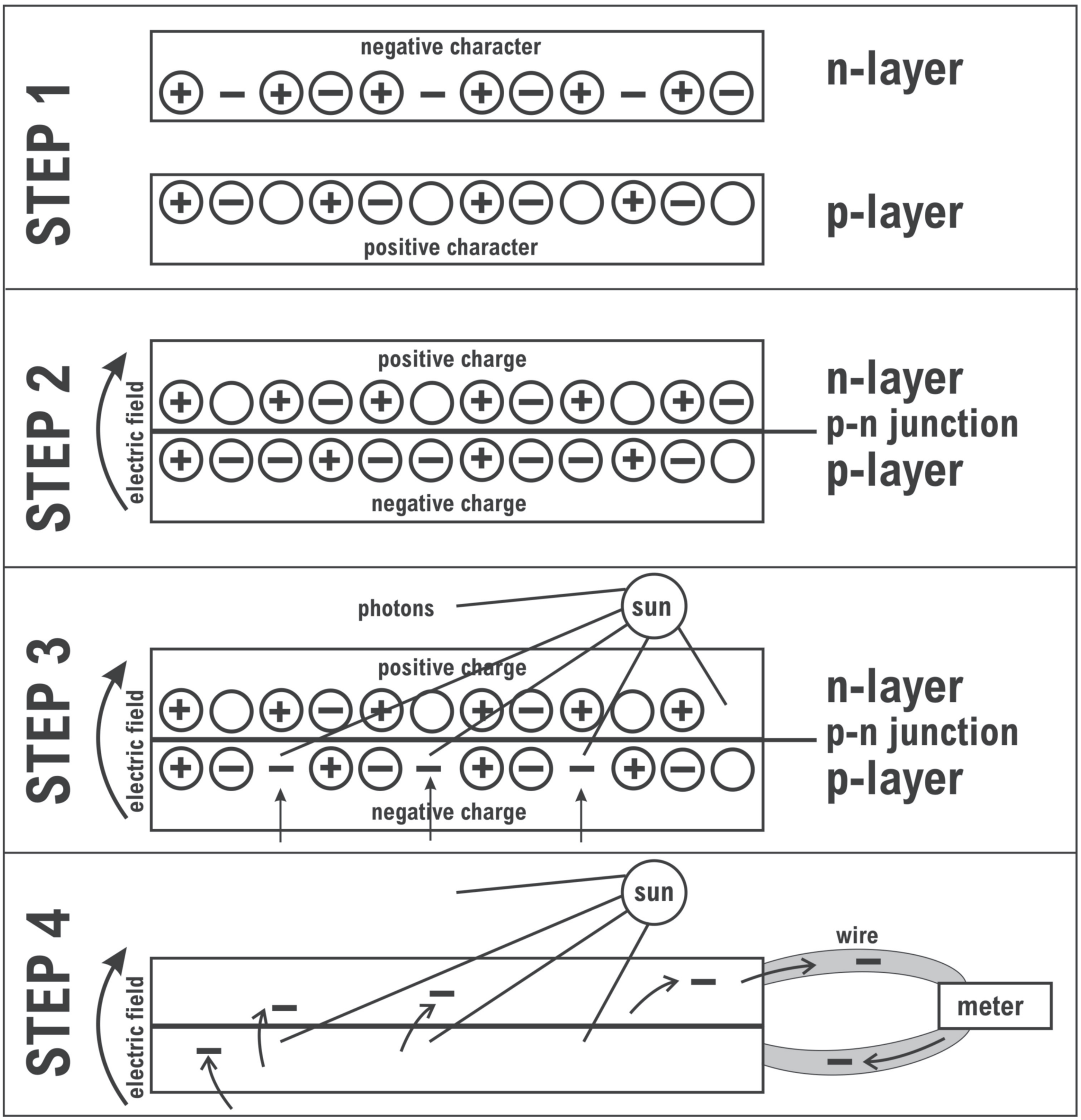
PHOTOVOLTAIC CELL

⊕ proton

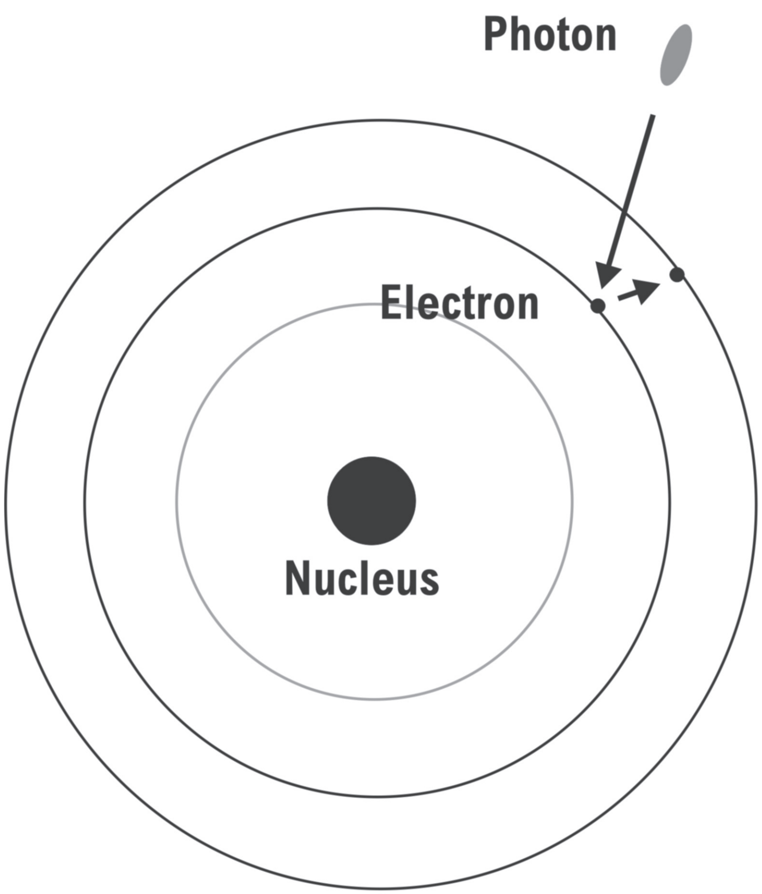
⊖ tightly-held electron

– free electron

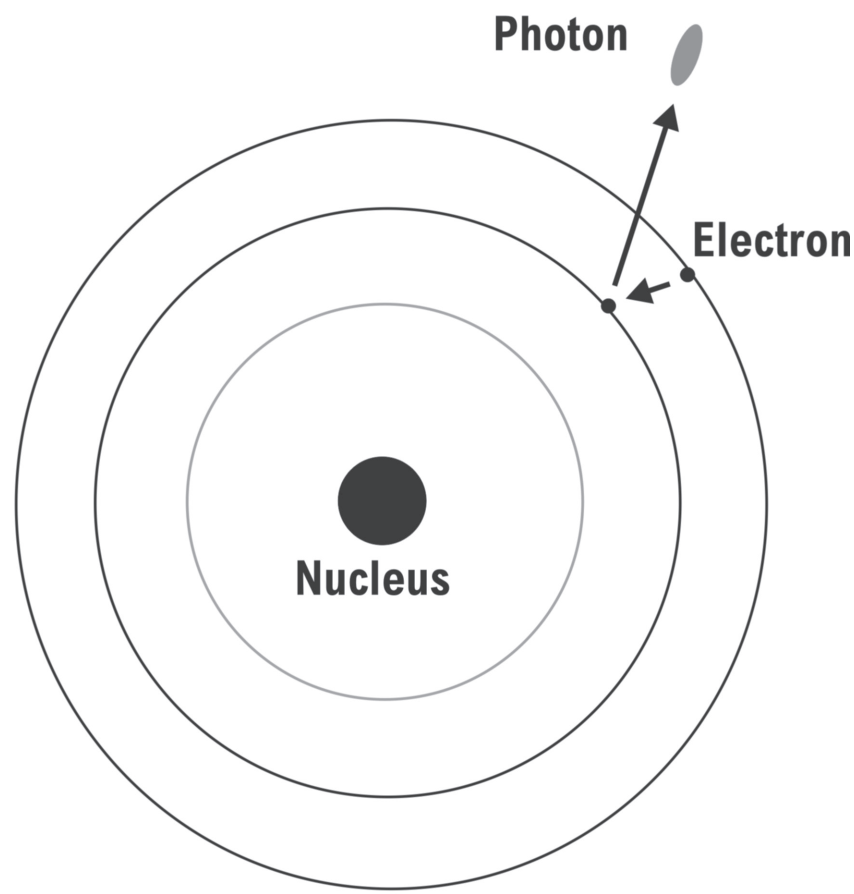
○ location that can accept an electron



GLOW TOY



Storing Radiant Energy
as Electrical Potential Energy



Emitting
Radiant Energy

STATION THREE PROCEDURE

RADIANT ENERGY: ELECTROMAGNETIC ENERGY THAT TRAVELS IN TRANSVERSE WAVES
ELECTRICAL ENERGY: THE MOVEMENT OF ELECTRONS
POTENTIAL ENERGY: ENERGY OF POSITION & STORED ENERGY

PROCEDURE—PART ONE: RADIOMETER: LIGHT TO HEAT TO MOTION

After explaining each procedure, allow students time to record their hypotheses.

- ☐ Explain that a radiometer is a device that can transform light into heat, then into motion.
- ☐ Hold the radiometer upside down so the students can see the vanes, then turn it upright and place in bright light. Observe the speed with which the vanes turn.
- ☐ Move the radiometer closer to and farther from light source. Observe the change in speed of the vanes.
- ☐ Use the display sheet to explain how the light is transformed into heat, then motion.

PROCEDURE—PART TWO: PV CELLS: LIGHT TO ELECTRICITY

- ☐ Explain that photovoltaic cells convert radiant energy directly into electricity and point out the individual cells in the solar panel.
- ☐ Explain that the motor converts electricity into motion.
- ☐ Demonstrate that the amount of electricity produced when part of the cells are covered or the panel is held at different angles to the light by observing the speed of the disc.

PROCEDURE—PART THREE: THERMOMETERS: LIGHT TO HEAT

- ☐ Tape two thermometers on opposite sides of a piece of cardboard and place the cardboard so that one thermometer is in a bright light and one in the shade.
- ☐ Demonstrate how one thermometer has been facing the light and one has not.
- ☐ Record the temperatures of the two thermometers.

PROCEDURE—PART FOUR: GLOW TOYS: STORING RADIANT ENERGY

- ☐ Explain that glow toys are made of a plastic to which a phosphorescent material—zinc sulfide —has been added. Phosphorescent material can store radiant energy as electrical potential energy.
- ☐ Place the glow toy that has been exposed to light into its pouch. Have the students peek into the pouch to observe the toy.
- ☐ Have students peek into the pouch with the green label, explaining that the glow toy has not been exposed to light.

FURTHER EXPLORATIONS

- ☐ Test to determine the effect of temperature on a glow toy by placing it in hot and cold water.
- ☐ Test to determine the different effects of sunlight and artificial light on the glow toy, the radiometer, and the PV cell.
- ☐ Test to determine the effect of a heat lamp on the glow toy, radiometer, and PV cell.
- ☐ Test to determine the absorption and reflection of different colors of paper with the thermometers.
- ☐ Research the scientific process of phosphorescence as demonstrated by the glow toys.

STATION THREE WORKSHEET

PURPOSES: To transform light into motion, heat, and electricity.

To store radiant energy.

QUESTIONS: How does a radiometer work?

How does a PV cell produce electricity?

Will an object in the sun be hotter than an object in the shade?

How is radiant energy stored in a glow toy?

HYPOTHESES:

PROCEDURE: Observe the radiometer and record your observations.

Observe the solar panel, motor, and disc, then record your observations.

Record the temperatures of one thermometer placed in direct light and one placed in the shade and compare.

Observe one glow toy that has been placed in direct light and one that has not and record your observations.

DATA:

CONCLUSIONS:

CONVERSIONS: A radiometer converts ____________________ energy to

_____________________ and ____________________ energy.

A PV cell converts ____________________ energy to __________________ energy.

Station Four Guide: Thermal Energy & Motion

TRANSFORMING THERMAL ENERGY INTO MOTION
TRANSFORMING MOTION INTO THERMAL ENERGY

MATERIALS (* NOT INCLUDED IN KIT)

1 Live Wire
1 Bi-Metal Bar
* Cup of Hot Water
* Thin Metal Coat Hangers
1 Candle
Rubber Bands
Tongs
* Cup of Ice Water
* Matches

PREPARATION—PART ONE: THE LIVE WIRE

Materials: Live wire, cup of hot water, tongs or spoon.

- ☐ Study the procedure and sample script to learn the experiment.
- ☐ Examine the equipment.
- ☐ Practice your presentation.
- ☐ Have your teacher provide you with a cup of very hot water. It should be very hot, but not boiling. Handle the hot water very carefully. It could burn you or your audience. Always use tongs when placing the live wire into and taking it out of the water.
- ☐ Place the live wire into the hot water for a moment before each presentation so that the wire is in its original shape when the presentation begins.

PROCEDURE—PART ONE: THE LIVE WIRE

- ☐ Explain that a live wire is made of nickel and titanium—a combination that can be treated with heat so that it remembers its original shape when it is heated again.
- ☐ Show the live wire in its original U shape, then twist it into different shapes.
- ☐ Using the tongs, CAREFULLY dip the live wire into the hot water, then remove it. **WARNING:** Do not let anyone put his/her face near the cup; the water can splash out when the wire is put into the cup.
- ☐ Show that the live wire has returned to its original shape.
- ☐ Explain some of the uses for metals that can "remember" their original shapes.

SAMPLE SCRIPT—PART ONE: THE LIVE WIRE

This script is just a sample. You don't need to say it word for word. The important thing is to get the major concepts and facts across to your audience.

Let's explore how a metal with a memory can be a power source. I will change heat into motion. This is called a Nitinol [nī-tĭn-ŏl] wire. Nitinol is made of nickel and titanium that has been treated in a heat process so that 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. It is used, for example, to control the temperature of greenhouses. If the temperature inside gets too hot, a Nitinol spring opens a door to let in air.

The original shape of our wire looks like this. [Hold up wire - it should be in the shape of a U.] I can bend this wire into any kind of shape I want. Watch! [Bend the wire into another shape, but don't tie it into a knot.] What do you think will happen if I place the wire into hot water? *Record your hypothesis on your worksheet.*

If I heat this wire to give it thermal energy, it should return to its original shape. [Carefully lower the wire into the cup of hot water and remove it with the tongs. The wire should return to its U shape.] The heat in the water made the wire return to its original shape. The thermal energy was transformed into motion. Do you have any questions?

PREPARATION—PART TWO: THE WIRE HEATER

Materials: Several 12-inch pieces of thin metal coat hangers

- ☐ Study the procedure and sample script to learn the experiment.
- ☐ Practice your presentation.

PROCEDURE—PART TWO: THE WIRE HEATER

- ☐ Explain to the students that you will use motion to produce heat.
- ☐ Bend the piece of metal back and forth five times at the center. [Do not bend the metal more than eight times—it might break or become hot enough to burn someone.]
- ☐ Allow students to touch the hanger at the bend to feel the heat produced.

SAMPLE SCRIPT— PART TWO: THE WIRE HEATER

Now, let's do the opposite of what we did with the live wire. Let's change motion into heat, or thermal energy. Here I have a piece of a metal hanger. I'm going to use my motion energy to bend the metal a few times. What do you think will happen when I bend this piece of metal back and forth? *Record your hypothesis on your worksheet.* [Bend the hanger back and forth five times at the center. Let the audience feel it at the bend. CAUTION: Bending the hanger more than eight times might break the metal or make it too hot to touch—you might burn someone.]

Carefully touch the spot where the metal was bending. What do you feel? It's hot, isn't it? When I bend the wire, the molecules of metal at the bend move faster. The motion creates friction, which produces heat. Let's trace the energy flow from the heat in this metal back to the sun. I put motion from the muscles in my hands and arms into the wire. My muscles get their energy from the stored chemical energy in the food I eat. The plants I eat transform radiant energy from the sun into the stored chemical energy and the sun gets its energy from nuclear fusion. So the energy flow from the sun is nuclear energy to radiant energy to stored chemical energy to motion to thermal energy.

You've probably converted motion into heat lots of times on cold days. Try this. Put your hands on your face to feel how much heat they have. Now, rub your hands together for ten seconds and put them back on your face. Do they feel warmer? They should. You have just converted motion into heat. Do you have any questions?

PREPARATION—PART THREE: THE BI-METAL BAR

Materials: Bi-metal bar, candle, matches, cup of ice water

- ☐ Study the procedure and sample script to learn the experiment.
- ☐ Practice your presentation.
- ☐ CAUTION: Place candle in the middle of the table, away from you and your audience. Get matches from your teacher and CAREFULLY light your candle or have your teacher light it for you. Be careful to keep your clothes and your audience away from the candle during your presentation.

PROCEDURE—PART THREE: THE BI-METAL BAR

- ☐ Explain that when objects are heated—given more energy—they expand.
- ☐ Show students the bi-metal bar and explain that it is made of two metals—nickel and stainless steel—that expand at different rates when they are heated. [The coefficient of linear expansion of a material is the change in length of the material per unit length that accompanies a change in temperature of one degree Celsius. The coefficient of linear expansion of nickel is 13 ($10^{-6}/^{o}C$) and the coefficient of linear expansion of stainless steel is 17.3 ($10^{-6}/^{o}C$).]
- ☐ Carefully hold the bi-metal bar in the top of the candle flame so that both sides of the bar are in the flame. When the blade begins to bend, remove it. DO NOT touch the bar: it will be very hot and could burn you or your audience.
- ☐ Place the bar into the cup of ice water for a moment and show students how the bar bends the opposite way. Explain that the metals also contract at different rates when heat is removed.

SAMPLE SCRIPT—PART THREE: THE BI-METAL BAR

When substances and objects are heated, they expand. I'm sure you've all seen the spaces between sections of sidewalk. They are designed that way so that the concrete can expand on hot, sunny days without cracking.

Sometimes in the summer, it's hard to open doors. The metal or wood in the doors has expanded. Heat energy has made the molecules in the concrete and doors move faster, and they have expanded. Heat energy has produced motion. All objects expand when they are heated, but they don't 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 when it is heated.

Solids don't expand as much as gases and liquids because their molecules can't move freely. It's sometimes hard to see them expand. Here I have a bi-metal bar to show you 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. What do you think will happen if I heat the bar? *Record your hypothesis on your worksheet.*

[Carefully hold bar in the candle flame so that both sides of the metal are in the flame. Remove it AS SOON AS YOU SEE IT BEND.] The stainless steel in the bar expands more than the nickel so that when it is heated, the bar bends. The stainless steel side is the outside of the curve. What do you think will happen if I take heat energy away from the bar? *Record your hypothesis on your worksheet.* [Place bar in ice water until it bends the other way, then remove it.] The bar bends the other way. The stainless steel side also contracts faster when energy is taken away, so it is now on the inside of the curve.

The coefficient of expansion of a material is the change in length or area of the material per unit length or unit area that accompanies a change in temperature of one degree Celsius. The coefficient of linear expansion of nickel is 13 ($10^{-6}/^{o}C$) and the coefficient of linear expansion of stainless steel is 17.3 ($10^{-6}/^{o}C$).

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. You've just seen how thermal energy can be changed into kinetic energy—heat into motion. Do you have any questions?

PREPARATION—PART FOUR: RUBBER BANDS

Materials: One rubber band for each student

- ☐ Study the procedure and sample script to learn the experiment.
- ☐ Practice your presentation.

PROCEDURE—PART FOUR: RUBBER BANDS

Give the students rubber bands and demonstrate how to hold them with their index fingers inside the ends of the rubber bands and their thumbs on the outside, pinching them firmly. Demonstrate how to stretch the rubber band to twice its length, then place it with both sides flat against your forehead. Have audience members stretch the rubber bands to twice their original length, place them on their foreheads, and allow them to contract, concentrating on the temperature of the bands as they contract.

Explain that the energy used to stretch the rubber bands produces heat, so the bands should feel warm when they are stretched and cool as they contract.

SAMPLE SCRIPT—PART FOUR: RUBBER BANDS

Now let's do an experiment that both gives off energy and takes in energy. [Give everyone a rubber band. Show how to hold them.] Quickly stretch the rubber band to twice its length, then place it on your forehead and allow it to return to its original length. Try it several times. Do you feel anything as the rubber band contracts? Concentrate on how the rubber band feels as it returns to its original size. Do you feel a change in temperature?

The rubber band should feel warm when it is stretched and cool when it contracts. When you stretch the rubber band, you put stress on the molecules, and they give off heat. When the rubber band contracts, the stress is removed and the molecules absorb heat. Do you have any questions?

STATION FOUR PROCEDURE

THERMAL ENERGY: KINETIC ENERGY OF ATOMS & MOLECULES AS THEY VIBRATE & MOVE
KINETIC ENERGY: MOVEMENT OF ATOMS, MOLECULES, SUBSTANCES & OBJECTS
MOTION: MOVEMENT OF SUBSTANCES & OBJECTS FROM ONE PLACE TO ANOTHER

PROCEDURE—PART ONE: LIVE WIRE: HEAT TO MOTION

After explaining each procedure, allow students time to record their hypotheses.

- ☐ Explain that a live wire is made of metal that remembers its original shape when heated.
- ☐ Show the live wire in its original U shape, then twist it into different shapes.
- ☐ Using the tongs, CAREFULLY dip the live wire into hot water, then remove it and show that the live wire has returned to its original shape.
- ☐ Explain some of the uses for metals that can remember their original shape.

PROCEDURE—PART TWO: WIRE HEATER: MOTION TO HEAT

- ☐ Bend the piece of metal back and forth FIVE TIMES ONLY at the center.
- ☐ Allow students to touch the hanger at the bend to feel the heat produced.

PROCEDURE—PART THREE: BI-METAL BAR: HEAT TO MOTION

- ☐ Show students the bi-metal bar and explain that it is made of two metals that expand at different rates when they are heated.
- ☐ Hold the bi-metal bar in the flame so that both sides of the bar are in the flame until it begins to bend, then remove it. DO NOT TOUCH the bar; it will be very hot and could burn you or your audience.
- ☐ Place the bar into the ice water and show how the bar bends the opposite way, explaining that the metals also contract at different rates when cooled.

PROCEDURE—PART FOUR: RUBBER BANDS

- ☐ Give each audience member a rubber band and show how to hold them.
- ☐ Demonstrate how to stretch the rubber band, place it on the forehead and allow it to contract, concentrating on the temperature as the band contracts.
- ☐ Explain that the bands should feel warmer when they are stretched and cooler as they contract.

FURTHER EXPLORATIONS

- ☐ Test to determine the effect of putting the live wire in a bright light.
- ☐ Test to determine the effect of placing the live wire in ice water.
- ☐ Test to determine the effect of placing the bi-metal bar in very hot water, in a bright light, and under a heat lamp.
- ☐ Test to determine the effect of bending materials other than rigid metals, such as plastic straws, cardboard, wood, and rolled aluminum foil.
- ☐ Conduct research to determine how a thermostat and thermocouple work.

STATION FOUR WORKSHEET

PURPOSES: To transform heat into motion.

To transform motion into heat.

QUESTIONS: What does a live wire do?

What happens when you bend a piece of metal back and forth?

Why does a bi-metal bar bend when it is heated?

What happens when rubber bands stretch and contract?

HYPOTHESES:

PROCEDURE: Observe the live wire and record your observations.

Observe the piece of metal after it is bent and record your observations.

Observe the bi-metal bar as it is heated and cooled and record your observations.

Stretch and contract a rubber band against your forehead and record your observations.

DATA:

CONCLUSIONS:

CONVERSIONS: The bi-metal bar converts ________________ energy into ________________ energy.

The live wire converts __________________ energy into __________________ energy.

The rubber band converts ________________ energy into ________________ energy.

Bending the metal converts ________________ energy into _______________ energy.

Station Five Guide: Chemical Energy

TRANSFORMING CHEMICAL ENERGY INTO RADIANT ENERGY
TRANSFORMING CHEMICAL ENERGY INTO ELECTRICAL ENERGY

MATERIALS (* NOT INCLUDED IN KIT)

8 Lightsticks
1 Small Zinc Nail
1 Tin Wire
*1 Cup of Hot Water (not boiling)
1 Large Zinc Nail
1 Thin Copper Wire
1 Display Sheet
* 1 Cup of Cold Water
1 Thick Copper Wire
1 Meter
Alligator Clips
* 1 Apple

PREPARATION—PART ONE: LIGHTSTICKS

Materials: Lightsticks, cups of cold and hot water

- ☐ Study the procedure and sample script to learn the experiment.
- ☐ Practice your presentation.
- ☐ CAUTION: Get a cup of hot water from your teacher. Be very careful with the water and place it so that you don't burn yourself or a member of your audience. You might need to get a new cup of hot water before each presentation.
- ☐ Take two lightsticks out of their packages, but do not break them until you begin your first presentation.

PROCEDURE—PART ONE: LIGHTSTICKS

- ☐ Show your audience a lightstick, pointing out the glass ampule inside. Explain that there are two chemicals (hydrogen peroxide and an ester) inside the lightstick and the ampule.
- ☐ Bend the lightstick until the ampule inside breaks, then shake the lightstick. Only break a lightstick for the first presentation; for the other presentations, show the audience the unbroken lightstick, then use the broken one. You may need to use another lightstick if the first one becomes dim.
- ☐ Explain how the chemicals are reacting to produce light.
- ☐ Place the lightstick in the cold water, then in the hot water and point out how the intensity of light changes with the temperature.

SAMPLE SCRIPT—PART ONE: LIGHTSTICKS

This script is just a sample. You don't need to say it word for word. The important thing is to get the major concepts and facts across to your audience.

At this station, you will see chemical energy changed into light energy. [Hold up a lightstick so that the audience can see it. Point out the glass ampule inside.] This is called a lightstick. You've probably all seen them in toy stores, especially at Halloween. The lightstick is filled with a substance called an ester. An ester is an organic compound that is formed by a reaction between an alcohol and an acid. Inside the lightstick you can see a glass container, or ampule. This ampule contains hydrogen peroxide, a liquid used to clean cuts. Right now the two chemicals can't touch each other. What do you think will happen when I bend the lightstick and break the ampule inside? [Bend the lightstick until you hear the glass snap, then shake it for a few seconds to mix the chemicals.] [Note: ONLY break a lightstick for the first group. For the other groups, show them the unbroken lightstick and then use the broken one. If the lightstick becomes too dim before your presentations are over, you can break another one.]

The lightstick is producing light—radiant energy. When I broke the glass, the hydrogen peroxide and ester reacted to form different chemical compounds. The new compounds don't need as much energy to hold their molecules together, so they release the extra energy as light. Only a few chemical reactions emit light—most emit heat. The fluorescent dye in the lightstick absorbs the light and becomes energized. When the dye gives up the extra energy and returns to its normal state, it emits the light it absorbed and that is the light we see.

You've probably seen lightsticks of different colors. They have different fluorescent dyes in them. The reaction between the hydrogen peroxide and the ester is the same.

What do you think will happen if I put the lightstick in cold water? *Record your hypothesis on your worksheet.* [Drop lightstick into the cold water.] The lightstick isn't as bright. Do you think the lightstick will get brighter if I put it into hot water? *Record your hypothesis on your worksheet.* [Take the lightstick out of the cold water and carefully drop it into the hot water. After a few seconds, remove it.] It really glows when it's hot.

How does heat change the brightness of the lightstick? Some of the heat energy from the hot water is absorbed by the chemicals in the lightstick. The added energy makes the chemicals react faster and produce more light. The cold water takes some of the heat energy from the lightstick, so the reaction slows down. The lightstick will glow for about two hours at room temperature, but only for about 30 minutes in the hot water. It might glow for six hours in the cold water.

CHEMILUMINESCENCE

The lightstick is made of a flexible plastic tube containing a thin-walled glass tube. Inside the glass tube is a solution of hydrogen peroxide, H_2O_2. Outside the glass tube is a solution containing a phenyl oxalate ester and a fluorescent dye. When the lightstick is bent, the thin-walled glass tube breaks and its contents mix with the solution outside. Then, the H_2O_2 reacts with the phenyl oxalate ester. During the reaction, an intermediate forms that transfers energy to the dye molecules. The energized dye molecules release this energy as visible light. The process in which energy from a chemical reaction is released directly as radiant energy or visible light is called chemiluminescence.

If we add heat, the lightstick will glow brighter, but for a shorter time. If we take away heat, it will glow for a long time, but not as brightly. Either way, the same total amount of light will be produced. The lightstick is a good example of changing chemical energy into light energy.

PREPARATION—PART TWO: THE APPLE BATTERY

- ☐ Study the procedure and sample script to learn the experiment.
- ☐ Examine the equipment.
- ☐ Practice your presentation.
- ☐ Place the meter on table so that the audience can see its face. The meter will indicate when there is an electric current produced.

PROCEDURE—PART TWO: THE APPLE BATTERY

- ☐ Explain that you will be using the chemical energy in an apple to make electricity.
- ☐ Insert the large zinc nail and the thick copper wire into the apple about one centimeter, making sure the ends don't touch each other. Attach the clip with the green label to the zinc nail; the other clip to the copper wire. Attach the clips to the leads of the meter. Point out that the meter is showing an electric current in the wire.
- ☐ Using the Display Sheet, explain to the audience how the acid in the apple reacts with metals to free electrons and produce an electric current.
- ☐ Push the nail and wire farther into the apple and point out the meter reading.
- ☐ Pull the copper wire out part way, then reverse the arrangement, observing the meter.
- ☐ Push the nail and wire into the apple so that the ends are touching. Point out that there is no current and explain a short circuit.
- ☐ Insert the thin copper wire into the apple and compare the current of the copper wires with the nail.
- ☐ Attach the two copper wires to the meter and explain why there is no current.
- ☐ Insert the tin wire into the apple, along with the copper and zinc, making sure none of the ends touch. Explore the different combinations of metals.

SAMPLE SCRIPT—PART TWO: THE APPLE BATTERY

This script is just a sample. You don't need to say it word for word. The important thing is to get the major concepts and facts across to your audience.

I'm going to use the chemical energy in the apple to make electricity. Chemicals are everywhere. Take this apple, for example. [Hold up apple.] It has malic acid that can be used to make a battery. I have a zinc nail and a piece of copper wire. I'm going to push them into the apple. [Insert large nail and thick copper wire about 1 cm into the apple, making sure the ends don't touch. Attach clip with green label to the zinc nail and the other clip to the copper wire.] Now I'm going to attach them to this meter, which measures electric current. What do you think will happen? *Record your hypothesis.* [Attach the clips to the meter.]

As you observe the meter, you can see that the needle has moved to the right to indicate an electric current. The question is why. When I put the zinc and copper into the apple, they both react with the acid, but they don't react the same way. The different reactions create an imbalance in electrical charge. The charge flows from the zinc-covered nail through the meter to the copper wire and then back to the nail through the apple. This flow of electrical charge registers on the meter. Chemical energy is converted to electrical energy. *Record your observations on your worksheet.*

Electrons carry a charge from the zinc nail through the wires and the meter to the copper wire. Look at the direction the needle on the meter is pointing. It shows that the charge is flowing from the zinc to the copper. This is the way all batteries work. There are two metals and acids in batteries, and the electric charge flows from one metal to the other, converting chemical energy into electrical energy.

What do you think will happen if I push the zinc and copper all the way into the apple? [Push both in about 4 cm, making sure the ends don't touch.] Look at the meter. There is more electric current because there is more metal to react with the acid and more electrons free to move. *Record your observations on your worksheet.*

What do you think will happen if only one metal is pushed in all the way? [Pull the zinc nail out most of the way.] The current drops, doesn't it? There isn't as much zinc to give up electrons. Let's try the opposite way, pushing in the zinc and pulling out the copper. Same result, right? Even if there's a lot of zinc to give up electrons, there isn't a lot of current because there isn't a lot of copper to accept the electrons. *Record your observations on your worksheet.*

This time I'm going to push both metals into the apple so that they're touching each other. What do you think will happen? [Push copper wire and nail in so the ends touch inside the apple.] No current is flowing through the meter. Does this mean there is no electric current? No, it just means the electrons are 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. *Record your observations on your worksheet.*

Let's try something else. I'm going to put this thin copper wire into the apple, too, so that we can compare the current. Which wire do you think will produce more current? [Put both wires and nail into the apple about 4 cm so the ends aren't touching. Measure the current using the thick wire, then the thin wire.] First, let's measure the current of the thick copper wire. Now let's measure the thin wire. The thick wire produces more current, because it has more surface area to come in contact with the acid. *Record your observations on your worksheet.*

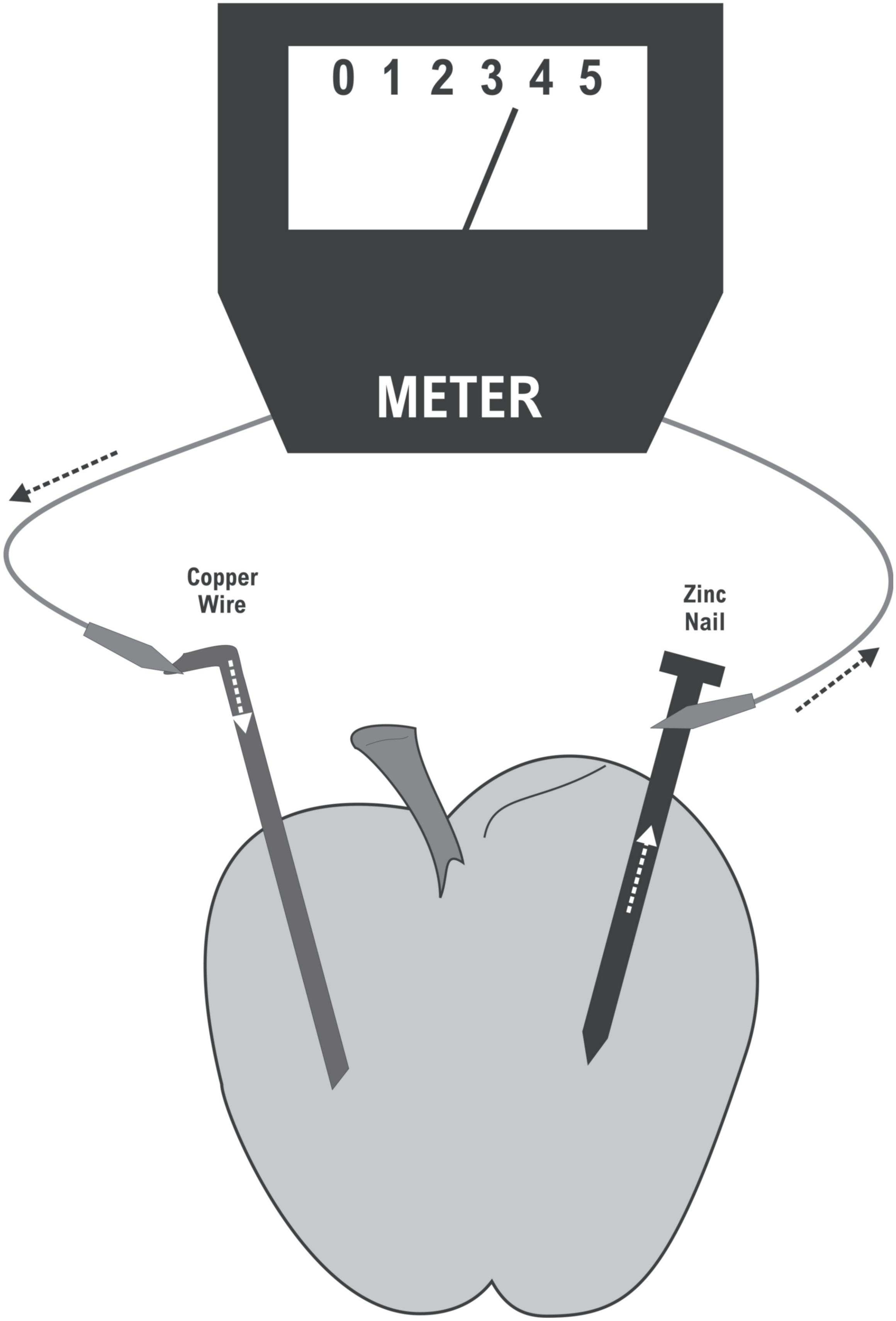
What do you think will happen if I attach the two copper wires to the meter? [Attach copper wires to the meter.] There shouldn't be any current, should there? Both copper wires are electron acceptors. There is no electron donor. Let's attach both zinc nails to the meter and see what happens. [Attach both zinc nails to meter.] There is no current produced in this case either. Both nails are electron donors. There is no electron acceptor. There are no moving electrons. *Record your observations on your worksheet.*

Now let's try a new metal—tin. Let's place all three metals into the apple to see if tin will be an electron donor or acceptor. [Insert the large zinc nail, the thick copper wire, and the tin wire into the apple, making sure the ends don't touch.] Observe the meter. When I attach the tin and the copper into a circuit, you can see that tin is an electron donor. *Record your observations on your worksheet.*

When I use the zinc nail and the tin, watch what happens. The needle on the meter moves the other way. That's because the tin has now become the electron acceptor. The combination of metals determines which metal will be the electron donor and which will be the electron acceptor.

We have explored several ways an apple battery can convert chemical energy into electrical energy. Do you have any questions?

APPLE BATTERY



STATION FIVE PROCEDURE

CHEMICAL ENERGY: POTENTIAL ENERGY STORED IN THE BONDS OF MOLECULES
RADIANT ENERGY: ELECTROMAGNETIC ENERGY THAT TRAVELS IN TRANSVERSE WAVES
ELECTRICAL ENERGY: THE MOVEMENT OF ELECTRONS

PROCEDURE—PART ONE: LIGHTSTICK: CHEMICAL TO RADIANT

After explaining each procedure, allow students time to record their hypotheses.

- ☐ Point out the ampule inside the lightstick and explain the two chemicals (hydrogen peroxide and an ester).
- ☐ Bend the lightstick until the ampule breaks, then shake it, and explain how the two chemicals are reacting to produce light.
- ☐ Place the lightstick in cold water, then in hot water using the tongs and point out how the intensity of light changes with the temperature.

PROCEDURE—PART TWO: APPLE BATTERY: CHEMICAL TO ELECTRICAL

- ☐ Explain that you will be using the chemical energy in an apple to make electrical energy.
- ☐ Insert large zinc nail and thick copper wire into the apple about 1 cm. Attach the clip with the green label to the zinc nail and the other clip to the copper wire. Attach the clips to the meter. Point out that the meter is showing an electric current in the wire.
- ☐ Use the Display Sheet to explain what is taking place.
- ☐ Push the nail and wire 4 cm into the apple and point out the meter reading.
- ☐ Pull the copper wire out part way, then reverse the arrangement, observing the meter.
- ☐ Push the nail and wire into the apple so that the ends are touching. Point out that there is no current and explain a short circuit.
- ☐ Insert the thin copper wire and compare the meter readings of the two copper wires.
- ☐ Attach the two copper wires to the meter and explain why there is no current.
- ☐ Insert the tin wire into the apple, along with the copper and zinc, making sure none of the ends touch. Explore the different combinations of metals and explain.

FURTHER EXPLORATIONS

- ☐ Test to determine how long a lightstick will glow in hot water. In cold water. Graph the relationship between the temperature of the water and the length of time the lightstick glows.
- ☐ Test to determine the effect of using different kinds or colors of apples.
- ☐ Test to determine the effect of the degree of ripeness of a fruit.
- ☐ Test to determine the effect of using different fruits, such as a banana, with the electrodes at the ends.
- ☐ Test to determine the effect of using different liquids instead of an apple, such as soda, milk, vinegar, tea, salt water, and detergent.
- ☐ Test to determine the effect of using other substances such as meat or mud.
- ☐ Test to determine the effect of using other metals, such as aluminum or steel, as the electrodes.
- ☐ Conduct research to determine the chemical reaction taking place in the lightstick.
- ☐ Conduct research to determine how the concentration of ions in fruits affects conductivity.

STATION FIVE WORKSHEET

PURPOSES: To transform chemical energy into radiant energy.

To transform chemical energy into electrical energy.

QUESTIONS: How does a lightstick produce radiant energy?

How does an apple battery change chemical energy into electrical energy?

What happens when the copper wire and the nail touch inside the apple?

HYPOTHESES:

PROCEDURE: Observe the lightstick in hot and cold water and record your observations.

Observe the apple battery with different metals. Record your observations.

DATA:

CONCLUSIONS:

CONVERSIONS: A battery converts ____________________ energy into ___________________ energy.

A lightstick converts ____________________ energy into __________________ energy.

Station Six Guide: Electrical Energy

TRANSFORMING ELECTRICITY INTO MOTION
TRANSFORMING MOTION INTO ELECTRICITY AND LIGHT

MATERIALS (* NOT INCLUDED IN KIT)

1 Hand Generated Flashlight
1 Covered Wire
2 Motors (1 disassembled)
2 Display Sheets
1 9-volt Battery
* Tape
Alligator Clips
1 Compass

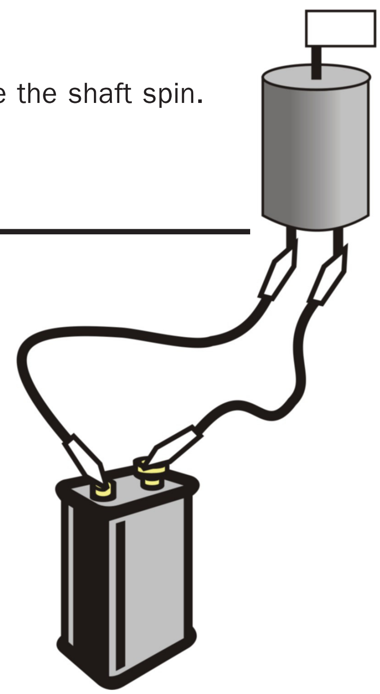
PREPARATION—PART ONE: MOTORS & BATTERIES

Materials: Hand generated flashlight, 9-volt battery, 2 motors (1 disassembled), alligator clips

- ☐ Study the procedure and sample script to learn the experiment.
- ☐ Examine the equipment.
- ☐ Place a piece of tape on the motor shaft like a flag so that it is easier to see the shaft spin.
- ☐ Practice your presentation.

PROCEDURE—PART ONE: MOTORS & BATTERIES

- ☐ Show the hand generated flashlight; point out the coils of wire and the magnet. Explain that spinning a magnet inside the coils of wire produces an electric current, charging a battery that lights the bulb.
- ☐ Show the disassembled motor; point out the coils of wire and magnet.
- ☐ Connect the motor to the 9-volt battery with the alligator clips; explain that the chemical energy in the battery is producing electrical energy, making the shaft of the motor turn. Disconnect the clips from the 9-volt battery.
- ☐ Touch the alligator clips to the opposite terminals of the 9-volt battery. Observe the direction of the spinning motor shaft.
- ☐ Do not try this with other batteries without permission from your teacher.



SAMPLE SCRIPT—PART ONE: MOTORS & BATTERIES

This script is just a sample. You don't need to say it word for word. The important thing is to get the major concepts and facts across to your audience.

This is a hand generated flashlight. It uses a person's motion to produce electricity that charges a battery to light the bulb. Inside there are a magnet and two coils of copper wire. [Show the audience the flashlight, pointing out the coils of wire and magnet.] When I use my energy to squeeze the handle, the magnet spins. The spinning magnet inside the coils of wire produces an electric current that flows to a battery, then to the bulb. I'm using the motion of my hand to generate electricity. The more kinetic energy I use, the brighter the bulb glows. [Show how the bulb is brighter when you squeeze the handle quickly.]

Power plants use this same concept to produce electricity. Many energy sources are used to spin giant turbines that rotate coils of copper wire inside magnets to produce electricity. In most power plants, coal is burned to heat water to make steam to spin the turbines. Windmills use the motion energy in the wind to spin the turbines. Hydropower plants use the force of falling water. [Use Display of Power Plant.]

Here I have two tiny electric motors. Lots of little toys have motors like these. They make the toys move; they produce motion. Let's look inside one of these motors. [Hold up motor that has been taken apart. Point out the coils of wire and magnet.] Inside the motor, you can see a coil of wire on this shaft with small magnets around the coil, like in the flashlight. 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. You have electrical energy producing motion. Toy motors get their electrical energy from batteries that make electrical energy from the chemical energy stored in them.

What do you think will happen if I connect the wires from the motor to the 9-volt battery. *Record your hypothesis on your worksheet.* [Connect the motor to the 9-volt battery with the alligator clips.] Electrical energy from the battery will flow through the coil of wire in the motor. The coil of wire will become a magnet—an electromagnet. As you can see the shaft begins to spin. Observe the direction in which the shaft is spinning. If I switch the alligator clips to the opposite ends of the battery, what do you think will happen? *Record your hypothesis on your worksheet.* [Switch the clips to the opposite terminals of the 9-volt battery.] The motor reverses direction. The current flows from one end of the battery to the other and determines the direction of the spin of the motor shaft.

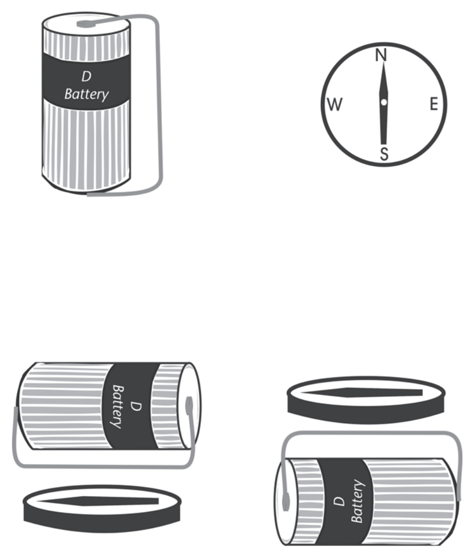
PREPARATION—PART TWO: COMPASS

Materials: Heavy-gauge coated wire, D battery, compass.

- ☐ Study the procedure and sample script to learn the experiment.
- ☐ Examine the equipment.
- ☐ Practice your presentation.

PROCEDURE—PART TWO: COMPASS

- ☐ Bend the wire into the shape of an open-sided rectangle as shown in the diagram.
- ☐ Attach one end of the wire to each terminal of the battery. The battery and wire can get hot over time, so be careful.
- ☐ Explain how the needle of the compass is a magnet pointing north.
- ☐ Place the wire over the compass so that the wire is on top of the needle going in the same direction. Observe the needle of the compass.
- ☐ Explain that the electric current in the wire makes it act like a magnet.
- ☐ Move the compass over the wire. Observe the needle moving in the opposite direction.
- ☐ Explain the action of the needle as a result of the action of two magnets.



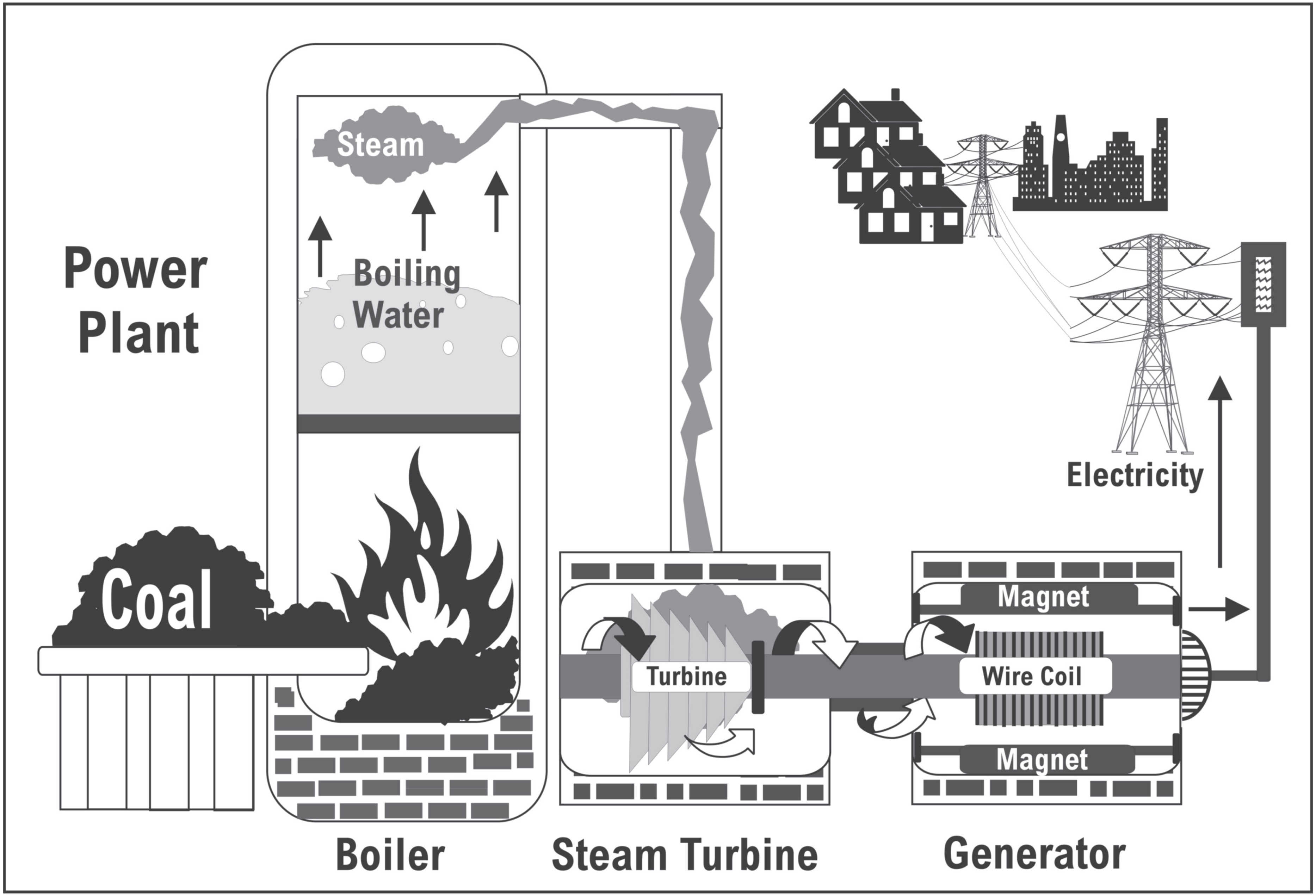
SAMPLE SCRIPT—PART TWO: COMPASS

Here I have a battery, a piece of copper wire, and a compass. With these three things, I can convert electrical energy into motion. First, I will attach the wire to the battery to produce an electric current. If I place this wire over the compass, what do you think will happen? *Record your hypothesis on your worksheet.* [Attach the wire to the battery. Then place the wire over the compass so that the wire is lying in the same direction as the needle of the compass.]

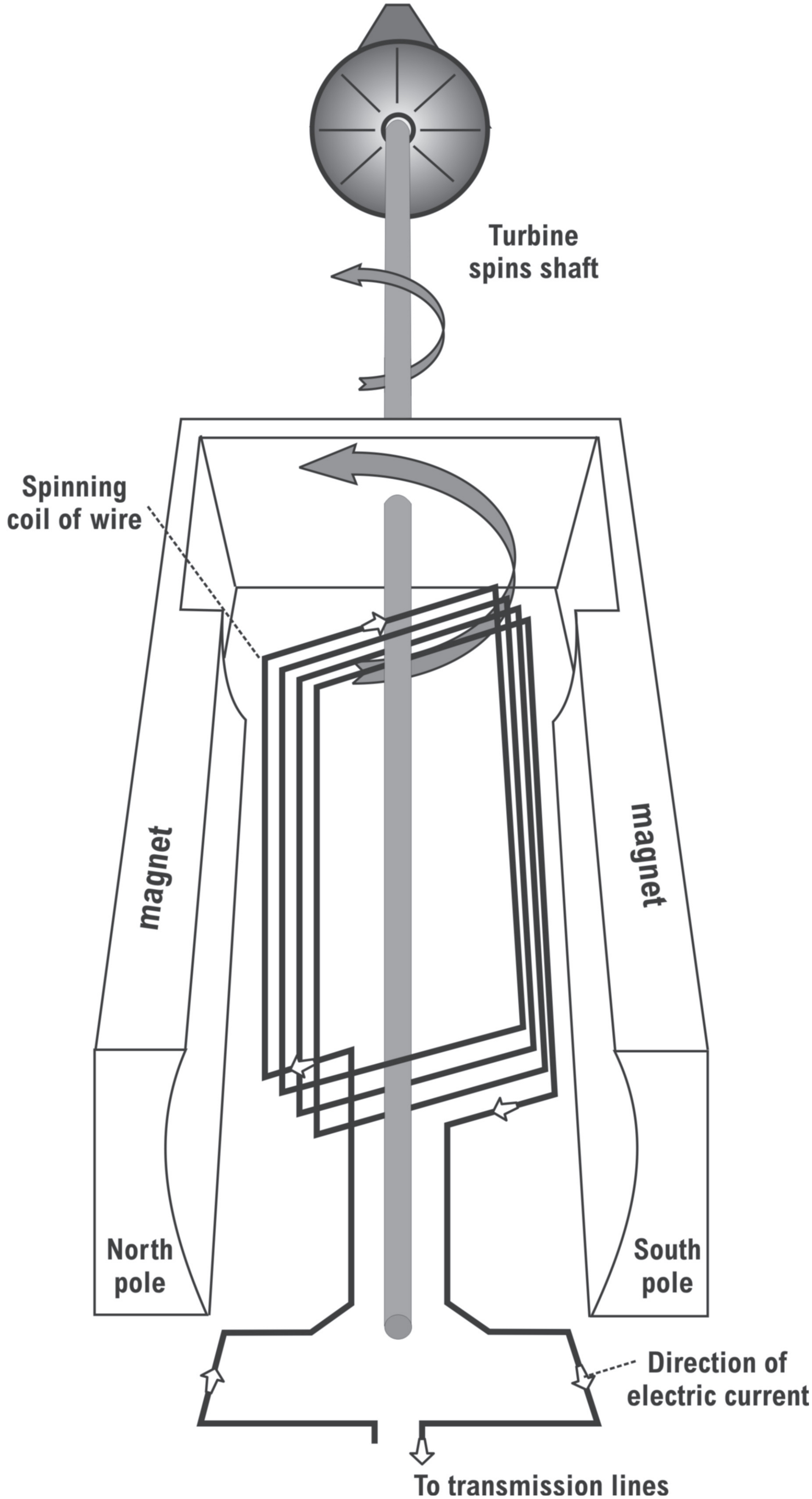
Watch the needle of the compass—it's moving. Why do you think this is happening? The electric current flowing through the wire turns the wire into an electromagnet. The needle in the compass is also a magnet, pointing to north. What happens when two magnets are placed together? Either they attract or repel each other, right? That's what is happening here.

If I pick up the compass and move it over the wire, what do you think will happen? *Record your hypothesis on your worksheet.* [Move the compass across the wire.] The needle moves 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. Here we've used electrical energy from a battery to move the needle of a compass. We've changed chemical energy to electrical energy to motion. Do you have any questions?

BURNING COAL TO MAKE ELECTRICITY



TURBINE GENERATOR



STATION SIX PROCEDURE

ELECTRICAL ENERGY: THE MOVEMENT OF ELECTRONS
CHEMICAL ENERGY: POTENTIAL ENERGY STORED IN THE BONDS OF MOLECULES
MOTION: MOVEMENT OF SUBSTANCES & OBJECTS FROM ONE PLACE TO ANOTHER

PROCEDURE—PART ONE: MOTORS & BATTERIES

After explaining each procedure, allow students time to record their hypotheses.

- ☐ Show the hand generated flashlight. Point out the coils of wire and the magnet. Explain that spinning a magnet in coils of wire produces an electric current that charges a battery that lights the bulb.
- ☐ Show the disassembled motor, pointing out the coil of wire and magnets.
- ☐ Place a piece of tape on the assembled motor shaft as a flag. Connect the motor to the 9-volt battery and explain how the chemical energy in the battery is producing electrical energy, making the shaft of the motor spin. Observe the speed and direction of the spinning shaft of the motor.
- ☐ Switch the clips to the opposite terminals of the battery. Observe the direction of the spin.

PROCEDURE—PART TWO: COMPASS

- ☐ Bend the wire into an open-sided rectangle and hold one end of the wire to each terminal of the D battery. The wire and battery can get very hot over time so be careful.
- ☐ Explain how the needle of the compass is a magnet pointing north.
- ☐ Place the wire over the compass so that the wire is on top of the needle going in the same direction. Observe the needle of the compass.
- ☐ Explain that the electric current in the wire makes it act like a magnet.
- ☐ Move the compass over the wire. Observe the needle moving in the opposite direction.
- ☐ Explain the action of the needle as a result of the action of two magnets.

FURTHER EXPLORATIONS

- ☐ Test to determine what effect the apple battery from Station Five has on the compass.
- ☐ Test to determine what effect the PV cell from Station Three has on the compass.
- ☐ Test to determine whether the apple battery will run the motor.
- ☐ Make a flow chart of the energy transformations of the no-battery flashlight.
- ☐ Research and explain Faraday's Law and its application to motors and generators.
- ☐ Make a list of the motors and generators you use on a routine basis and the impact they make on your life.

STATION SIX WORKSHEET

PURPOSES: To transform electrical energy into motion.

To transform motion into electrical energy and light.

QUESTIONS: How does a hand generated flashlight transform motion into light?

How does a motor transform electrical energy into motion?

How does an electric current affect a compass?

HYPOTHESES:

PROCEDURE: Observe the hand generated flashlight and record your observations.

Observe the motors and batteries and record your observations.

Observe the compass as affected by electric current and record your observations.

DATA:

CONCLUSIONS:

CONVERSIONS: A motor converts _________________ energy into __________________ energy.

A generator converts ________________ energy into __________________ energy.

Science of Energy Exam

_____ 1. Which is NOT a form of kinetic energy?

a. heat b. gravity c. motion d. sound

_____ 2. The movement of molecules within substances is what form of energy?

a. chemical b. thermal c. nuclear d. mechanical

_____ 3. In which form do most energy flows begin?

a. electrical b. chemical c. radiant d. nuclear

_____ 4. In which form of energy do most of the energy sources we rely on store energy?

a. chemical b. electrical c. nuclear d. radiant

_____ 5. Photosynthesis converts radiant energy into which form of energy?

a. electrical b. chemical c. thermal d. kinetic

_____ 6. An endothermic reaction...

a. emits light b. absorbs heat c. produces heat

_____ 7. Radiant energy can be converted into...

a. electrical b. motion c. thermal d. all three

_____ 8. Electrical energy can be produced from...

a. motion b. chemical c. radiant d. all three

_____ 9. Our bodies use the chemical energy stored in food to produce...

a. motion b. thermal c. electrical d. all three

_____ 10. An object held in the air has what kind of energy?

a. kinetic energy b. potential energy c. radiant energy

11. What is an electromagnet?

12. A windmill converts the movement of the wind into what form(s) of energy?

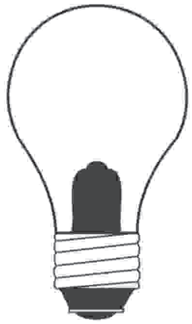
13. A firecracker converts chemical energy into what form(s) of energy?

14. Trace the energy flow of the light from a firefly back to the sun.

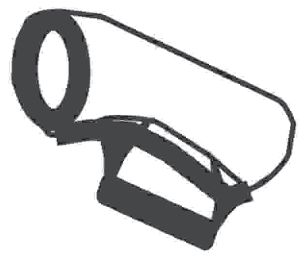
15. Why do we convert so many of the energy sources we use into electricity?

Energy Flow

Below are seven forms of energy involved in an energy flow. Your job is to unscramble the energy flow so that the forms of energy are in the proper order. Number the pictures from one to nine on the lines to the right of the pictures, with number one as the beginning of the flow.

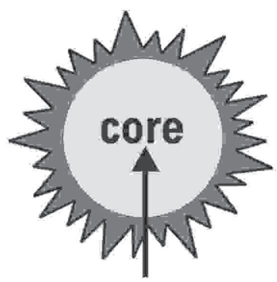


Radiant Energy ________

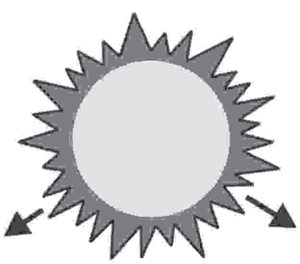


Motion ________

Chemical Energy ________



Nuclear Energy ________

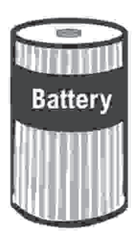


Radiant Energy ________

____

Electrical Energy ________

Chemical Energy ________



Chemical Energy ________

SECONDARY SCIENCE OF ENERGY
Evaluation Form

State: ___________ **Grade Level:** ___________ **Number of Students:** __________

1.	Did you conduct the entire activity?	Yes	No
2.	Were the instructions clear and easy to follow?	Yes	No
3.	Did the activity meet your academic objectives?	Yes	No
4.	Was the activity age appropriate?	Yes	No
5.	Were the allotted times sufficient to conduct the activity?	Yes	No
6.	Was the activity easy to use?	Yes	No
7.	Was the preparation required acceptable for the activity?	Yes	No
8.	Were the students interested and motivated?	Yes	No
9.	Was the energy knowledge content age appropriate?	Yes	No
10.	Would you use the activity again?	Yes	No

How would you rate the activity overall (excellent, good, fair, poor)?

How would your students rate the activity overall (excellent, good, fair, poor)?

What would make the activity more useful to you?

Other Comments:

Please fax or mail to:
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Manassas, VA 20108
FAX: 1-800-847-1820

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Kentucky Oil and Gas Association
Kentucky Propane Education & Research Council
Kentucky River Properties LLC
Kentucky Soybean Board
Kentucky State Fair
Keyspan
KidWind
Llano Land and Exploration
Long Island Power Authority–NY
Maine Energy Education Project
Maine Public Service Company
Marathon Oil Company
Marianas Islands Energy Office
Massachusetts Division of Energy Resources
Michigan Energy Office
Michigan Oil and Gas Producers Education Foundation
Minerals Management Service–U.S. Department of the Interior
Mississippi Development Authority–Energy Division
Nabors Alaska
Narragansett Electric–A National Grid Company
New Jersey Department of Environmental Protection
NASA Educator Resource Center–WV
National Alternative Fuels Training Center–West Virginia University
National Association of State Energy Officials
National Association of State Universities and Land Grant Colleges
National Biodiesel Board
National Fuel
National Hydrogen Association
National Hydropower Association
National Ocean Industries Association
New Jersey Department of Environmental Protection
New York Power Authority
North Carolina Department of Administration–State Energy Office
Northern Indiana Public Service Company–NIPSCO
Nebraska Public Power District
New Mexico Oil Corporation
New Mexico Landman's Association
New York State Energy Research and Development Authority
Noble Energy
Nuclear Energy Institute
Offshore Energy Center/Ocean Star/OEC Society
Offshore Technology Conference
Ohio Energy Project
Oil & Gas Rental Services
Pacific Gas and Electric Company
Petroleum Equipment Suppliers Association
Poudre School District–CO
Puerto Rico Energy Affairs Administration
RSA Engineering
Renewable Fuels Association
Roanoke Gas
Robert Gorham
Roswell Desk and Derrick Club
Roswell Geological Society
Rhode Island State Energy Office
Saudi Aramco
Schlumberger
SchoolDude.com
Sentech, Inc.
Shell Exploration and Production
Snohomish County Public Utility District–WA
Society of Petroleum Engineers
Southwest Gas
Spring Branch Independent School District–TX
Tennessee Department of Economic and Community Development
Texas Education Service Center–Region III
Toyota
TransOptions, Inc.
University of Nevada–Las Vegas
United Illuminating Company
Urban Options–MI
U.S. Environmental Protection Agency
U.S. Department of Agriculture–Biodiesel Education Program
U.S. Department of Energy
U.S. Department of Energy–Hydrogen, Fuel Cells and Infrastructure Technologies
U.S. Fuel Cell Council
Vectren Energy Delivery
Virgin Islands Energy Office
Virginia Department of Mines, Minerals and Energy
Virginia Department of Education
Virginia General Assembly
Wake County Public Schools–NC
Western Kentucky Science Alliance
W. Plack Carr Company
Xcel Energy
Yates Petroleum