DOCUMENT RESUME

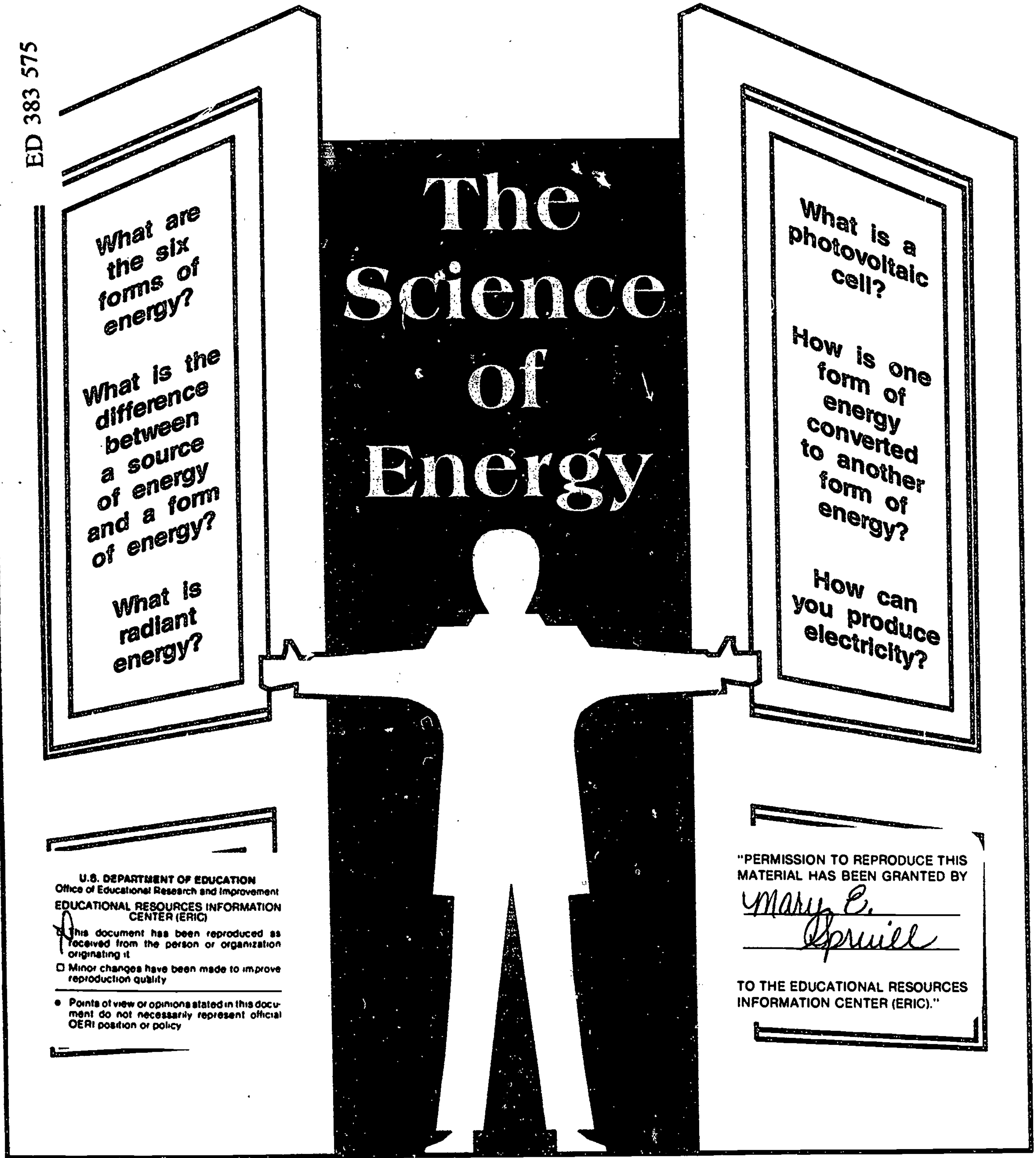
ED 383 575 SE 056 545

TITLE Science of Energy. Elementary Version.
INSTITUTION National Energy Education Development Project, Reston, VA.
PUB DATE [94]
NOTE 44p.
AVAILABLE FROM NEED Project, #414, 1920 Association Drive, Reston, VA 22091.
PUB TYPE Guides - Classroom Use - Teaching Guides (For Teacher) (052)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Demonstrations (Science); Elementary Education; *Energy; Energy Education; Experiments; *Science Activities; *Science Education; Units of Study; Worksheets
IDENTIFIERS *Energy Conversion

ABSTRACT

This unit of study for elementary students focuses on energy uses, energy sources, energy forms, and energy conversion. The unit is designed to take five 45-minute class sessions. In the first class session, the teacher conducts several energy conversion experiments. In subsequent sessions, students are divided into seven groups and each is assigned an energy conversion experiment and a station. Students learn how their experiment converts one type of energy into one or more other types of energy. Students at each station present their experiment to other groups of students rotating through the stations. The final session involves students working together to answer questions related to the unit. Teaching materials are provided for each class session and include vocabulary words, teacher demonstration instructions, worksheets, study sheets, an energy test, and instructions for station experiments. (LZ)



The Science of Energy

Elementary Version

A publication of the National Energy Education Development Project

The Science of Energy

Contents

The Science of Energy

Teacher's Guide

How to Use the Science of Energy Kit

The Science of Energy Kit has been designed to take five class sessions of 45 minutes. In the first class session, the teacher divides the students into seven groups and conducts several energy conversion experiments. In the subsequent sessions, students teach themselves and others about energy conversions.

During the first 15 minutes of the second class session, the teacher reviews concepts from the previous day and explains the format of instruction for the next three days. The student groups are given their energy conversion experiments and accompanying materials for their station. Students learn how their experiment(s) converts one type of energy into one or more other types of energy. Next, they prepare and rehearse a presentation they will give when students tour their station.

In the third class session, the seven groups are divided into A and B teams. The A teams present their experiments to the B teams that are rotating through the other six stations.

During the fourth class session, the A teams tour the other stations while the B teams serve as the presenters for their stations.

In the fifth and final class session, the original seven groups of students work together to answer questions related to the Science of Energy unit. During the last 20 minutes of the session, the teacher allows the seven groups to share their answers to the questions and then brings the unit to a close.

Objectives

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

- List and explain five things that energy enables us to do.
- Differentiate between sources of energy and forms of energy.
- Identify what forms of energy the nation's top ten energy sources provide.
- Describe the six forms of energy and give an example of each.
- Explain how one form of energy is converted to other forms of energy.
- Trace the energy conversion flow of any system back to nuclear energy.
- Explain how 16 energy conversion experiments work.

The Science of Energy is sponsored in part by Mobil Oil Corporation and Omniglow Corporation.

Getting Ready

1. Unpack the Science of Energy Kit and assemble eight sets of experiments by looking at the labels attached to the experiments. One set of experiments will be marked TD for Teacher Demonstration, and the other seven sets will be marked Station 1-7. If a label falls off an experiment, check with the teacher demonstration instructions or student station instructions to identify where it belongs.

2. Duplicate one set of instructions for each of the seven stations. Or, duplicate enough copies so that each student can have his/her own set of station instructions.

3. Duplicate enough copies of the Forms of Energy sheet, the Science of Energy Study Sheet, and the Science of Energy Test to distribute to each student.

4. Divide the class into seven groups that you feel will work well together. Make sure you have at least one strong science student per group.

5. Divide each of the seven groups into two teams. One half of the group will be the A Team and the other half will be the B Team.

6. Determine how to organize students into seven stations in the classroom. Student groups requiring hot water (stations 1, 4, and 5) should be positioned close to a source of hot water. **Teacher should dispense hot water to students.**

7. Read the Teacher Demonstration materials and become familiar with experiments to be performed for the class.

8. Read the Energy Conversion Station instructions for each of the seven stations and be prepared to answer student questions.

Science of Energy Test Answers

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

Class Session One

- Divide students into their seven groups.
- Distribute the Forms of Energy sheet to each student.

Part I

***Teacher demonstration**—ten minutes*

Explain to students that they will be starting a five-day unit called The Science of Energy. The students' grades will be based on how well their group performs rather than individual scores. Group grades will be determined by five factors. The first four factors are worth 50 percent of the grade, and the last factor is worth 50 percent.

- Their ability to work as a team to answer questions and solve problems during the teacher demonstration.
- 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 correctly answer multiple choice and essay questions from the unit exam.

Vocabulary Words

Listed below are terms in the Science of Energy that students should know before 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.

Absorb	Contract	Enable	Kinetic Energy
Activate	Conventional	Endothermic	Magnet
Activation Energy	Convert	Energy	Magnetic Field
Alternate	Conversion	Energy Flow	Magnetic North
Alternating Current	Convex	Exothermic	Mass
Ampule	Current	Expand	Mechanical Energy
Catalyst	Data	Fission	Meter
Chemical	Efficient	Friction	Molecule
Chemical Compound	Efficiency	Fossil Fuel	Molecular
Chemical Energy	Electrical Energy	Fusion	Nonrenewable
Chemical Reaction	Electricity	Generate	Nuclear Energy
Collision	Electron	Generator	Photosynthesis

Compress	Electrode	Kilowatt	Photovoltaic
Conduct	Electromagnet	Kilowatt-hour	Photovoltaic Cell
Potential Energy	Rebound	Retain	Transformation
Prediction	Renewable	Stationary	Transfer
Pulley	Repel	Thermal Energy	Turbine
Reaction	Retention	Titanium	Vacuum
Radiant Energy	Silicon	Transform	Velocity

Presentation

"Before we start talking about the various types of energy and energy sources, I would like to begin a simple experiment. Here I have two containers of sand. One container is filled about one-third of the way, and the other is filled to the top. I would like someone to stick a thermometer into each container of sand and tell me the temperature in centigrade of each container. Let's record those temperature readings on the board. Now, please put the tops on the containers and shake the containers vigorously for 30 seconds. After 30 seconds, pass the container to the next person in your row. I would like everyone in the class to shake both containers. Make sure you shake the containers as briskly as you can. After the last two students in the class have shaken the containers, they should record the temperatures of the sand. **[Give the thermometers to the last two students in the class.]** We will use this data later."

Part II

What does energy enable us to do?—10 minutes

"Energy enables us to do many things. For example, energy has the ability to make things move. Can you give me some examples of moving objects and how energy produced that motion? (i.e., car is moved by the combustion of gasoline, sailboat by the energy in the wind, a baseball by the energy given to it by a person's arm and hand, exploding gun powder enables a bullet to move at great speed.)

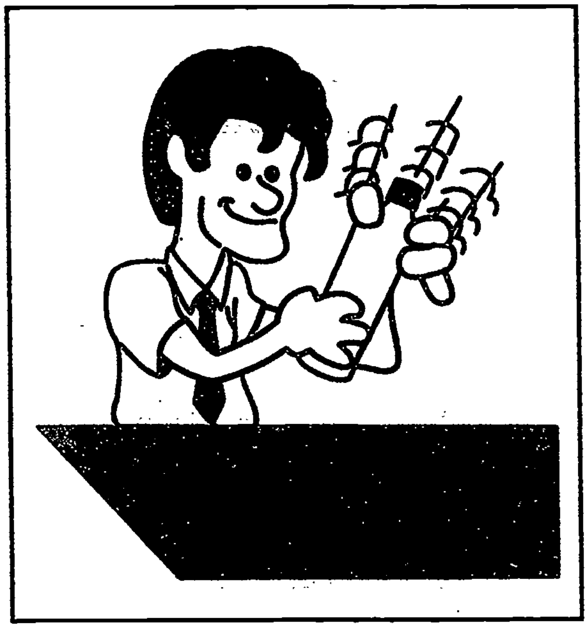
"In addition to making things move, energy also enables us to do four other major things. As a group, I want you to determine the other four major things energy enables us to do. Once your group has come to a decision, each one of you should write those four things on a piece of paper."

After one minute, ask student groups for their lists of four major things energy does for us. The list should be as follows:

1. **Motion**
2. **Heat**
3. **Light**
4. **Operate electrical equipment**
5. **Make plants grow**

"There are six types of energy that enable us to do these things. They are: mechanical, chemical, electrical, radiant, thermal, and nuclear." **[Distribute Forms of Energy sheets to each student and discuss the six forms of energy.]**

Part III
Teacher demonstration continued—5 minutes



"Now let us see what, if any, temperature change occurred in the sand as a result of all that shaking. **[Ask last student for a temperature reading of the container that is one-third full of sand—you should see about a five degree centigrade increase.]** What is the cause of the temperature change? **[Get answers.]**

"The shaking of the bottle is mechanical energy—the energy of motion. By shaking the container we gave the grains of sand kinetic energy, which caused friction between the particles, creating heat. Another example of how mechanical energy can be transformed into heat is when a moving hammer strikes a nail. Have you ever felt the head of a nail or head of a hammer after several strikes? They both feel warm. A portion of the mechanical energy in the moving hammer is transferred to thermal energy. Where do you think the rest of the mechanical energy has gone? **[Get answers.]** That's right, the energy goes into sound, the motion of the nail pushing into the wood, and the heating of the nail and the wood.

[Ask the student holding the container that is filled with sand what the temperature of the sand was after it had been shaken by the class. You should see about a two degree centigrade increase.] Why is the increase in temperature much greater for the container that was only one-third full? **[Get answers.]** Right, it is because the partially filled container has more space in it, and therefore the grains of sand collide with each other and the sides of the container with more velocity. More velocity means more kinetic energy. In the container filled with sand, the grains of sand have little space to move, therefore a lower velocity and less kinetic energy.

"Let's examine the energy flows from shaking this container of sand. Let's start with the thermal energy we produced as a result of the mechanical energy our bodies provided. Where did our bodies get the energy to shake the bottle? **[Get answers.]** That's right, from the food we ate. Of the six types of energy, what type of energy is stored in food? **[Get answers.]**

"Chemical energy is stored in food through the process of photosynthesis. Sunlight, or radiant energy, is needed to change water and carbon dioxide into plant matter.

"What type of energy was transformed to produce this radiant solar energy? **[Get answers.]** Right, the answer is nuclear energy. Inside the sun's core, atoms of hydrogen are fused together to form heavier atoms of helium. The fusion occurs because of the tremendous heat and gravitational forces inside the sun's core. The resulting atom of helium has less mass than the original four atoms of hydrogen. This missing mass is changed into energy.

"The increase in the temperature of the sand is the result of nuclear energy. In fact, all energy transformations can be traced back to nuclear energy, either fission or fusion. The energy stored in fossil fuels (coal, petroleum, natural gas) 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 lost and changed into energy.

"So, all energy transformations can be traced back to nuclear energy. I want each group to determine what percentage the six forms of energy contribute to the nation's energy needs. Look at the back of the Forms of Energy Sheet. First, determine how energy is stored in each of the ten sources of energy. Remember, if the source of energy must be burned, the energy is stored in the form of chemical energy. Next, look at the pie chart and calculate the percentage of the nation's energy needs that each form of energy provides."

NOTE: You may wish to give a brief description of the five renewable and five nonrenewable sources.

After one or two minutes ask groups for their answers.

1. Chemical (petroleum, natural gas, coal, propane, biomass)—89.3%

2. Nuclear (nuclear fission)—7.5%

3. Mechanical (wind, hydropower)—3.5%

4. Thermal (geothermal)—less than 0.3%

5. Radiant (solar)—less than 0.01%

6. Electrical (a secondary source)—0%

"As you can see, the nation's, as well as the world's, economy is based on chemical energy. This is true not only now, but for as long as man has been around. Wood, animal, and human power have always been a result of stored chemical energy.

Part IV

Activation energy—20 minutes

"Since the nation basically relies on chemical energy, we must also learn about activation energy. A pile of coal, a gallon of gasoline, or a cord of wood contains stored chemical energy. How do we activate or release that chemical energy? Once we activate it, will the release of chemical energy continue? **[Get answers.]**

"The best example of activation energy is the lighting of a match. I will strike the chemical end of the match against the smooth side of the match box. Why isn't it lighting? **[Get answers.]** Right, there isn't enough friction between the chemical side of the match and the surface of the box to provide the thermal energy to activate the reaction. Chemical reactions that give off heat energy require a push to get them going. When I slowly strike the chemical side against the rough texture of the striker nothing happens. Why? **[Get answers.]** Once again, there isn't enough friction to provide the thermal energy to activate the reaction. When I strike the match quickly against the striker, then enough thermal energy is produced by friction to activate the release of the chemical energy.

"What will happen if I strike the wooden tip of the match against the rough surface of the striker? **[Get answers.]** The friction between the wood and the striker doesn't produce enough thermal energy to activate the wooden tip of the match. Wood has a higher activation energy than the chemical compounds of sulfur on the tip of the match. **[Strike the chemical tip of the match against the striker.]** Yet, the thermal energy released by the chemicals on the tip of the match is enough to ignite the wood. Once the wood is burning, it produces enough thermal energy to keep the chemical reaction going until all the chemical energy in the wooden match is consumed.

"What provides the activation energy for gasoline inside an engine? **[Get answers.]** The electrical energy provided by a spark plug ignites the air-gasoline mixture inside the cylinder of an engine. The expanding hot gases move pistons up and down to provide the mechanical energy to move the automobile. Heating oil, propane, and natural gas require some activation energy, usually in the form of an electric starter, to get their reactions going inside a furnace. These sources of energy release their chemical energy and convert it into thermal energy to warm the house."

Class Session Two

Part V

Tracing energy flows

"I would like everyone to trace the energy flow for the following demonstration. **[Darken the room and then gently tap the hammer directly on one of the caps.]** Why didn't the cap explode? That's correct, I tapped the hammer too gently. Only a small amount of thermal energy was produced by the mechanical energy of the hammer. There was not enough thermal energy to activate the chemicals in the cap. Now I will put more mechanical energy into the hammer, producing enough thermal energy to activate the chemical reaction in the cap.

"What three forms of energy were produced as a result of the exploding cap? The first form is radiant—you can see the light when the cap explodes. The sound we hear is the second form of energy. Sound is mechanical energy and is caused by the movement of air molecules. The third form of energy is thermal energy.

"Now let's see if you can trace the energy flow of the following experiment. This flashlight **[hold up flashlight]** works by converting mechanical energy into electrical energy. Here, squeeze the handle of the flashlight. **[Hand flashlight to student and have him/her squeeze the handle several times.]**

"This flashlight is generating electricity to run the light. Here's how. The handle is hooked to a gear that spins a metal disk. **[Squeeze handle several times.]** This disk is actually a magnet. Below the disk is a thin coil of copper wire with two lead wires leading to the light bulb. The magnet spins around the wire, creating a current through the wire. The filament in the light is made of a very thin tungsten wire. When the electricity reaches the tungsten, there is a great amount of resistance. The resistance makes the tungsten very hot and causes it to emit light. If you squeeze the handle slowly, you can see the tungsten wire begin to glow. **[Squeeze handle slowly a few times.]**

"We will try it again, but this time instead of squeezing the handle slowly, we will squeeze it rapidly. **[Squeeze handle rapidly a few times.]** Notice how much brighter the light is. Why? **[Get answers.]** That's right. The more mechanical energy you put into the system, the more electrical energy you will get out. Now, starting with the light from this flashlight, I would like each group to trace the energy conversions back to nuclear energy. **[Give students two minutes to develop their list and have**

several groups report their energy conversions. Make a transparency of the Energy Transformations on page nine. Discuss the transformations with the class.]

"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 using more than one dozen energy conversion experiments that demonstrate these energy transformations.

"I have divided you into seven groups. Each group will be responsible for a different energy conversion station. Your group will be responsible for learning how to conduct and present your energy conversion experiment(s). I will give you the rest of this class period to look through your station's write-up and practice your experiment and presentation. Half of your group will present your station's experiment(s) tomorrow, while the other half rotates through the other six energy conversion stations. On the following day, you will switch roles. The presenters will rotate through the six stations while the other students present their station's experiment(s) to the touring students.

"I am going to give each of you a Science of Energy Study Sheet that will help you prepare for the Science of Energy test your group will be taking at the end of the unit. You should take this Study Sheet with you to each of the stations. During the next three days, you should answer the questions on the Study Sheet. All questions should be completed by the day of the test. Here are your Study Sheets and your Science of Energy Experiments. Please be careful not to break any of the equipment or needlessly use the supplies. Part of your grade will be based on how well your group works together to prepare your presentation." **[Distribute Study Sheets and Science of Energy Experiments.]**

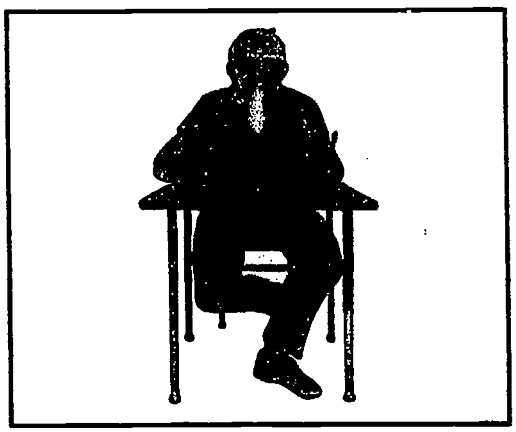
Class Session Three and Four

Students rotate through energy conversion stations. The teacher observes and grades the student groups on their performances.

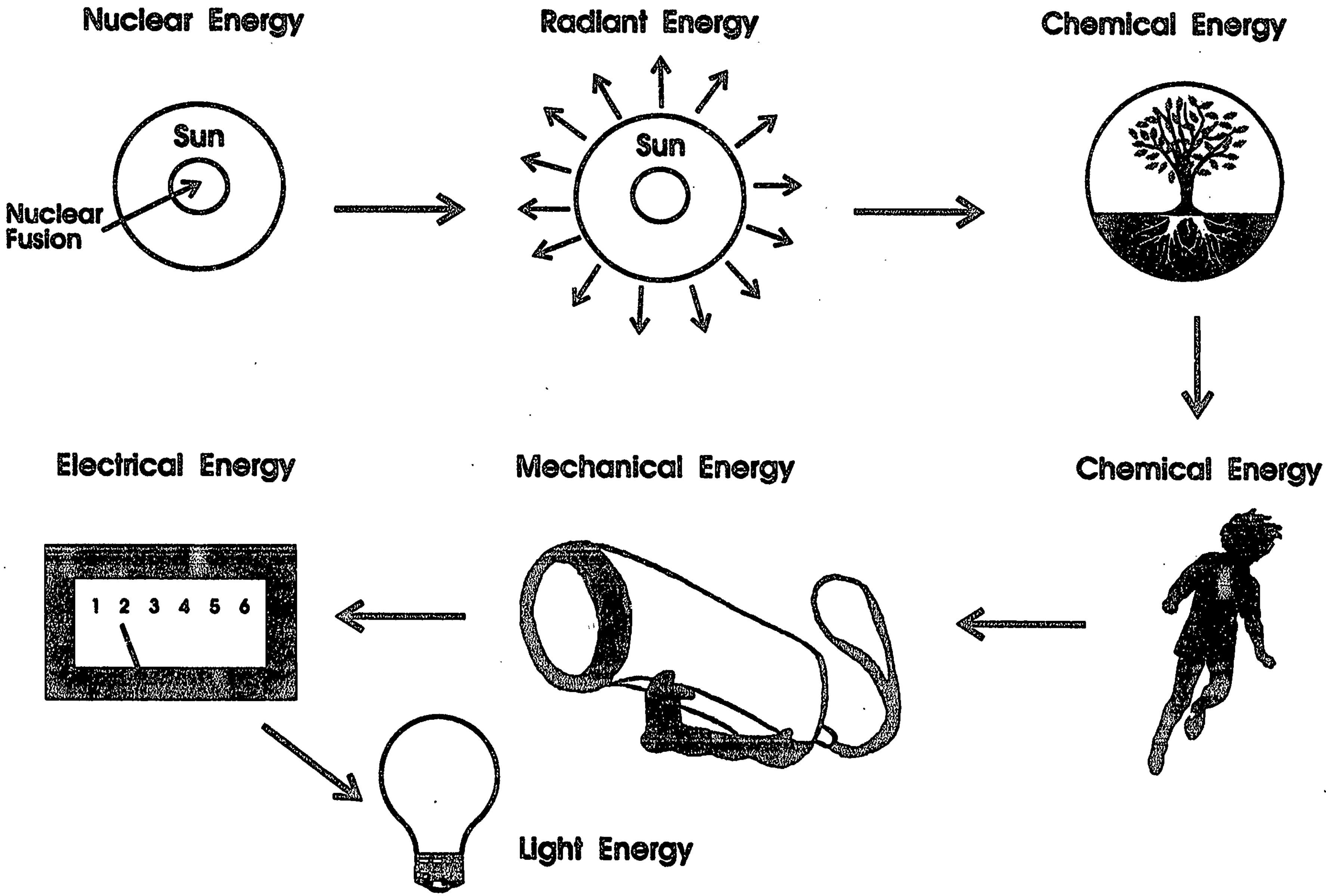
Class Session Five

Using the Science of Energy Study Sheet, student groups review the information they have learned from the teacher demonstrations and from the seven stations. The teacher may lead a discussion following this group study session.

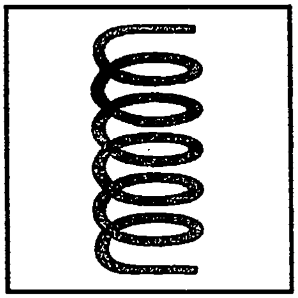
Administer the Science of Energy Test. The students should take the test by group. Following the test, the teacher should go over test questions with the class and answer questions.



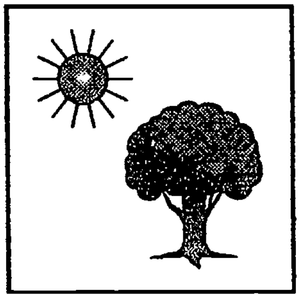
Energy Transformations



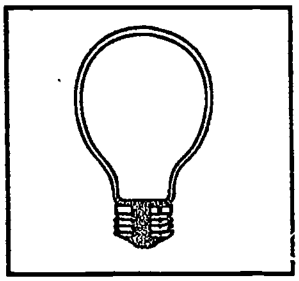
Forms of Energy



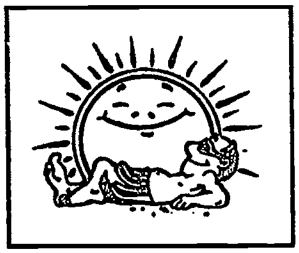
1. **Mechanical**—Mechanical energy is the energy of motion and the energy of position. An object that is moving has energy. The faster it moves, the more energy it has. The energy of motion is called kinetic energy. An object can also have energy because of its position—this is called potential energy. If an object is in a position where gravity can make it move, then it has potential energy. A rock resting at the top of a hill has potential energy. The higher it is, the more energy it has. Once the rock starts rolling down the hill, some of its potential energy becomes kinetic energy. When it reaches the bottom of the hill, all of its energy is kinetic energy. The sum of an object's kinetic and potential energy is its mechanical energy.



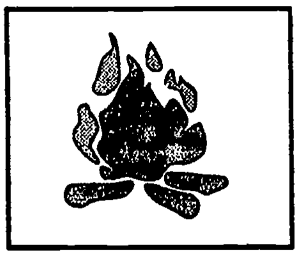
2. **Chemical**—Chemical energy is the energy that is stored in things like food, wood, and fossil fuels. It is the energy that bonds molecules together. When simple molecules bond together to make complex compounds, energy is stored in those bonds. When the compounds are changed back into simple molecules, the energy is released. For example, an acorn takes the simple molecules from the soil and turns them into a mighty oak tree. It uses energy from the sun to bond simple molecules into more complex ones to make a tree. When the wood from the tree is burned, it is changed into simple gases, and the energy is released as light and heat (radiant and thermal energy).



3. **Electrical**—Electrical energy is a special kind of kinetic (motion) energy. It's the energy of moving electrons. Lightning is a good example of electrical energy—billions of electrons travel from a cloud to the ground. Electrical energy is always produced by one of the other forms of energy. It can be produced with a battery using chemical energy or by a windmill using mechanical energy. We use electrical energy to perform lots of tasks. Electrical energy can make light, produce heat on a stove, keep our food cold, and move motors.

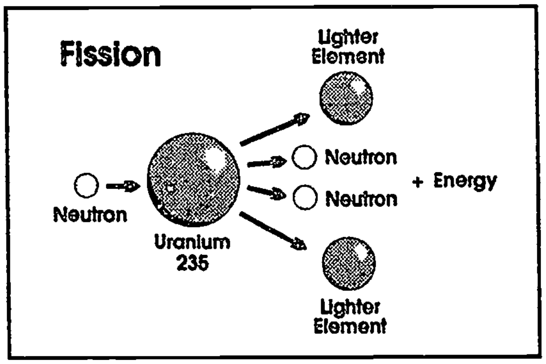


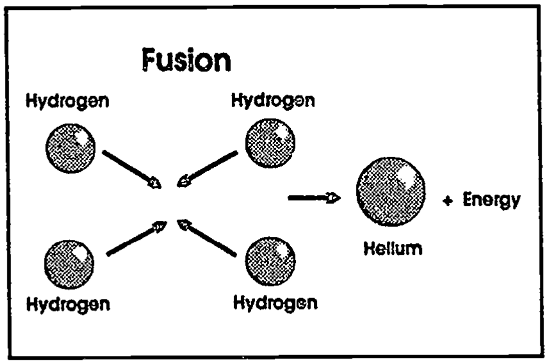
4. **Radiant**—Radiant energy is energy that travels in waves. The most familiar kind of radiant energy is light energy. We can see it and use it all the time. But light isn't the only form of radiant energy. Radio and television waves are also forms of radiant energy, but they are less powerful than light. X-rays and gamma rays are more powerful than light waves—they can pass through skin, bones, and concrete.



5. **Thermal**—Thermal, or heat energy, is a special kind of kinetic (motion) energy. It is the energy of moving or vibrating molecules. The faster the molecules in an object move or vibrate, the hotter the object becomes. The hotter an object is, the more thermal energy it has. Thermal energy always travels from hot objects to colder objects, never from cold to hot. For example, when you put an ice cube into a hot drink, the ice cube doesn't cool the liquid; instead, some of the heat from the liquid warms the ice cube.

6. **Nuclear**—Nuclear energy is the energy locked in the nucleus of the atom. This energy can be released in two ways, fission and fusion. Fission is the process of splitting atoms to make simpler atoms. When atoms are split, energy is released. Nuclear power plants produce energy by splitting uranium atoms. Energy can also be produced by fusing, or combining, simple atoms into heavier atoms. In the sun's core, simple hydrogen atoms combine to form helium, a heavier atom, and energy is produced in the process.

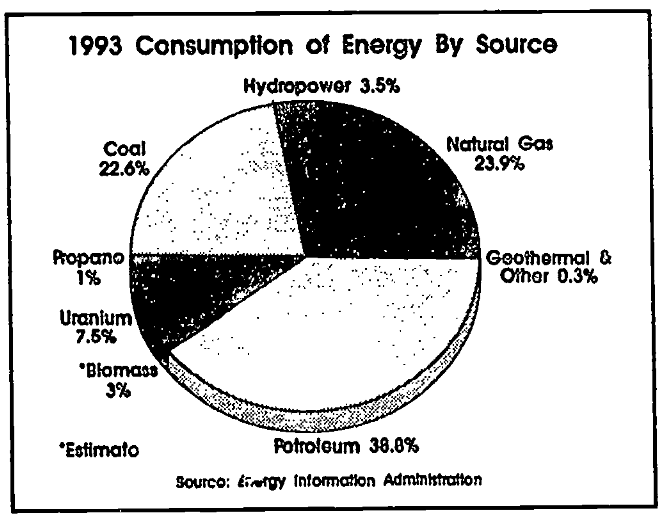




The six forms of energy are provided by the following sources of energy: List how energy is stored (mechanical, chemical, electrical, radiant, thermal, or nuclear) in each of the following sources of energy:

Nonrenewable	Renewable
Petroleum ______________	Wind ______________
Coal ______________	Solar ______________
Natural Gas ______________	Biomass ______________
Propane ______________	Hydropower ______________
Nuclear Energy ______________	Geothermal ______________

Looking at the pie chart below, calculate what percentage of the nation's energy is provided by the six forms of energy.



U.S. Energy Consumption by Form

1. Mechanical ______________%
2. Chemical ______________%
3. Electrical ______________%
4. Radiant ______________%
5. Thermal ______________%
6. Nuclear ______________%

Science of Energy Study Sheet

1. List the six forms of energy and give an example of each one. (*Teacher demonstration*)

2. Trace the energy flow of a child riding a bicycle back to the source of all the earth's energy. (*Teacher demonstration*)

3. A bottle of Nitroglycerin will explode if you drop it only a few feet. What does this tell you about the activation energy of Nitroglycerin? (*Teacher demonstration*)

4. Why does a ball dropped from a height of one meter only bounce 60 centimeters? (*Station One*)

5. Explain the difference between exothermic and endothermic reactions. Are most reactions exothermic or endothermic? (*Station Two*)

—OVER—

6. A radiometer converts radiant energy into what kind of energy? What does a PV cell do? (*Station Three*)

7. How does bending a piece of metal produce thermal energy? (*Station Four*)

8. Trace the energy flow of a battery-operated fan. (*Station Five*)

9. Why is no electricity produced when two identical pieces of metal are pushed into a piece of fruit? (*Station Six*)

10. How does the number of coils of wire affect the amount of electricity produced by an electromagnet? (*Station Seven*)

The Science of Energy Test

Group Name:____________________________

Choose the letter of the response that best answers the question (two points per question).

_______ **1.** Which is NOT a form of energy?
a. thermal b. petroleum c. mechanical d. chemical

_______ **2.** How many forms of energy are there?
a. 1 b. 6 c. 10 d. unlimited

_______ **3.** Where do all energy flows begin?
a. electrical b. chemical c. radiant d. nuclear

_______ **4.** What is another name for the energy of motion and position?
a. chemical b. electrical c. nuclear d. mechanical

_______ **5.** Plants turn light energy into what form of energy?
a. electrical b. chemical c. mechanical

_______ **6.** An endothermic reaction:
a. gives off light b. takes in heat c. gives off heat

_______ **7.** Radiant, or light, energy can be turned into:
a. electrical energy
b. mechanical energy
c. thermal energy
d. all three

_______ **8.** Electrical energy can be made from:
a. mechanical energy
b. chemical energy
c. radiant energy
d. all three

_______ **9.** Our bodies use the chemical energy in food to make:
a. mechanical energy
b. thermal energy
c. both

_______ **10.** An object held in the air has what kind of energy?
a. kinetic energy
b. potential energy
c. chemical energy

—OVER—

Please answer the following questions thoroughly (five points per question).

11. Trace the energy flow from a child jumping rope back to the energy from the sun.

12. If you drop a rock from the roof of your house, what happens to the potential energy in the rock?

The Science of Energy

Station One

What You Need

Collisions

1 Set of Happy/Sad Balls	*1 Meter Stick
1 Super Ball	*1 Pair of Tongs or Spoon
*1 Cup of Hot Water (not boiling)	(*= not included in kit)

Storing Mechanical Energy

1 Toy Car	Balloons	1 Yo-yo

Presentation

This script is just a sample. You don't need to say it word for word. Knowing the facts is the important thing. The instructions are in bold type **[like this]**. Study this guide and write down the important facts. Practice your presentation several times using the equipment. If you don't understand something, ask your teacher. Remember—science can be fun. If you have a good time, your audience will, too.

Collisions

Equipment

Ask your teacher to pour a cup of hot water for you. The water should be very hot, but not boiling. *Be careful!* The water could easily burn you or someone else.

You will need a table with a hard, flat surface. Put the happy/sad balls on the table. The happy ball is the hard, bouncy ball. The sad ball is the soft ball. Know which one is which when you start your presentation.

Sample Script

"Mechanical energy is the energy of motion and position. When an object is moving, it has kinetic energy. When an object is held so that gravity can move it, we say it has potential energy.

"Today I'm going to talk about collisions. A collision is when a moving object hits another object. An object that is moving has energy—kinetic energy. **[Move the happy ball around the table, first slow, then fast. Stop it with your other hand.]** When I push this ball, my hand gives it kinetic energy. The faster it goes, the more energy it has. When the ball runs into my other hand, it has a collision. If it stops completely, it loses all its kinetic energy. But energy can't just disappear. Where did it go? **[Get answers from audience.]**

"The kinetic energy was 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. Let me show you.

"When I hold this ball above the table **[Hold happy ball about one meter above table]**, I'm giving it energy. If I drop the ball, we know it will fall, because of the force of gravity. This energy is called potential energy. How high do you think the ball will bounce when I drop it? **[Get answers from audience.]** Let's see. **[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? **[Get answers from audience.]** 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 hotter every time I drop the ball, though you can't really feel the difference. Have you ever felt a nail after you've hit it with a hammer a few times? It can get really hot.

"This ball is called a happy ball. Over here I have a ball the looks just the same, but watch what happens when I drop it. **[Drop the sad ball from about one meter. It should hardly bounce at all.]** It barely bounces at all. I gave it the same amount of energy. What happened? **[Get answers from audience.]**

"This ball isn't broken. It's a sad ball. It's made of a different kind of rubber. It loses almost all of its energy when it collides. Listen! **[Drop the ball again.]** More of its energy changes into sound. More of its energy changes into heat, too. Feel both of the balls. Do they feel different? **[Let everyone squeeze both balls.]** The happy ball is harder than the sad ball.

"I'm going to put the sad ball into hot water. **[Carefully drop sad ball into cup of water.]** We'll get back to it in a minute.

"While the sad ball is getting hot, let's play with this super ball for a minute. **[Hold super ball one meter above table.]** How high do you think it will bounce? **[Have each member of the audience make a guess, then drop ball several times. Compare results with happy ball.]**

"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? **[Get answers from audience. Carefully remove ball with spoon or tongs. Drop ball from one meter. It should bounce about 30 centimeters.]** Look at that! The ball bounces higher. Since the ball has absorbed heat energy from the water, it can't absorb much more heat energy from the collision. The ball retains more of its energy and bounces higher. **[Drop the ball several more times.]** As the ball cools down, it loses its heat energy and more of the energy can be changed into heat when it hits the table. The cooler it gets, the less it bounces.

"These balls show us how mechanical energy is changed into sound and heat."

Storing Mechanical Energy

Toy Car

"As you saw 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 car and hold it down.]** This car has a spring in it. When I push down on the car, I'm storing energy in the spring. **[Let go of car.]** When I let go of the car, the car starts to move. The potential energy stored in the spring changes to kinetic energy. Why does the car stop after a while? **[Get answers from audience.]** That's right! The car stops because of friction. Friction changes some of the mechanical energy into heat energy."

Balloons

"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 energy to stretch the rubber, just like I used my energy to compress the spring in the car. **[Blow up balloon.]** Now the energy is stored in 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 potential energy is converted into kinetic energy and sound."

Yo-yo

"If I let go of this yo-yo, how far back up the string do you think it will come? **[Have each member of the audience make a guess. Let go of the yo-yo. You might need to give it a slight tug to get it to start back up the string. It 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? **[Get answers from audience.]** Friction changed 40 percent of the energy into heat. 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 a spinning object, sometimes called a flywheel.

"This station has been about mechanical energy, both potential and kinetic, and how we can change it into other forms of energy. Thanks for listening. Do you have any questions?"

The Science of Energy

Station Two

What You Need

Endothermic Reactions

1 Bottle of Vinegar
1 Thermometer
1 Container of Baking Soda
*1 Spoon
3 Empty Plastic Bags

Exothermic Reactions

4 Hand Warmers
*Scissors
1 Sealed Bag of Iron Oxide
(* = not included in the kit)
1 Empty Plastic Bag

Rubber Bands

1 Rubber Band for Each Student

Presentation

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Endothermic/Exothermic Reactions

Equipment

The sealed bag in the kit contains old filings from the hand warmers. This is the "old packet." A few minutes before your first presentation, cut open a new packet and pour it into the empty plastic bag. Keep the bag open so that the oxygen in the air can react with the black powder. This is called the "new packet." Place all the equipment on the table.

Sample Script

"Hi! At this station, I'm going to teach you about chemical reactions. Chemical reactions are mixing two chemicals 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, of course, means heat. So, endothermic—the heat goes in.

"Today I'm going to show you 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.

Endothermic Reaction

"The first experiment is an endothermic reaction—it uses heat. I'm going to mix vinegar and baking soda together to make another chemical. First, I'll add the vinegar and check the temperature of it. **[Pour about an ounce 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. Take the temperature of the vinegar. It should be about room temperature. Let everyone touch the bag.]** It is XX degrees. 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 about a teaspoonful 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 Centigrade in 30 seconds. Let everyone touch the bag again.]** The temperature has dropped about four to five degrees. Now touch the bag and tell me how it feels. Do you feel the difference?

"It feels colder because the reaction we just saw uses energy. It's an endothermic reaction. The heat went into the reaction. The reaction took heat from the bag, the thermometer, and our hands. When heat energy is taken from your hand, it will feel colder." **[Take thermometer out of bag. Zip up bag and put to the side with the vinegar and baking soda.]**

Exothermic Reaction

"Most reactions don't use heat like the vinegar and baking soda. More than 90 percent of all chemical reactions give off heat—they're exothermic. Now I'll show you a reaction that gives off heat.

"A few minutes ago I opened this hand warmer. It was 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 any air from reaching the iron. I put the iron filings in this plastic bag and left it open so that oxygen 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. Iron oxide is called rust.

"Feel this packet. **[Let everyone feel new packet. It should feel warm.]** It feels warm. When oxygen comes into contact with iron, it makes rust and heat. You can see that most of the iron filings are still black. They will slowly turn to rust as long as we let oxygen reach them.

"Here is a packet of filings that has been opened for several weeks. **[Hold up old packet. Let everyone feel it.]** As you can see, all the iron has turned to rust. No more heat is being produced.

"Why do you think the hand warmer has a lot of iron filings instead of one chunk of iron? **[Get answers from audience.]** Right. Because more iron can come in contact with the oxygen when it is in small pieces.

"What do you think will happen if I close the bag now? The reaction will slow down, then stop.

"This is an example of an exothermic reaction that gives off heat. Do you have any questions about endothermic or exothermic reactions?"

Rubber Bands

"Now let's do an experiment that gives off and takes in energy without a chemical reaction. **[Give everyone a rubber band.]** Hold the rubber band between your thumbs and index fingers like this. **[Show them how to hold rubber bands.]** Put the rubber band on your forehead so that both sides are touching your skin. Stretch the rubber band to twice its length a few times. Do you feel anything as the rubber band stretches across your skin? **[Get answers from audience. Their skin should feel warm.]** Now, concentrate on how the rubber band feels as it returns to its original size. Do you feel anything? **[Get answers from audience. Their skin should feel cool.]**

"The rubber band should feel warm when you stretch it and cool when it is contracting. When you stretch the rubber band, you put stress on the molecules and they give off heat energy. When the rubber band contracts, the stress is removed and the molecules absorb heat.

"Today I showed you how chemical reactions involve heat and how heat can be produced without a chemical reaction. Thank you for listening. Do you have any questions?"

The Science of Energy

Station Three

What You Need

	The Radiometer	
1 Radiometer	1 Display Sheet	1 Overhead Projector
	The Solar Panel	
1 PV Meter	1 Solar Panel	1 Overhead Projector
	Radiant to Thermal Energy	
2 Thermometers	*Tape	(*=not included in kit)

Presentation

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The Radiometer

Equipment

This presentation works best if it is done near a window with a lot of sunlight. If you can't do that, put the radiometer on an overhead projector.

Sample Script

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

"This is a radiometer. **[Hold 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.]**

"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? **[Get answers from audience.]**

"You all know that black objects get hotter than white objects in the sun. That's why most people wear white in the summer. A black object absorbs most of the radiant energy that strikes it, and reflects a little. A white object reflects most of the radiant energy that strikes it, and absorbs only a little.

"When I put this radiometer in a strong light, the vanes inside begin to heat up. The light energy is changed into heat energy. 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 white side of the vanes, they push a little. When the molecules hit the black side of the vanes, they push a lot. Since there is more of a push on one side than the other, the vanes begin to turn. The more light energy that reaches the radiometer, the more heat energy is produced, and the faster the vanes spin.

"Light is changed into heat into motion. Radiant energy to thermal energy into mechanical energy. Do you have any questions about the radiometer?"

The Solar Panel

Equipment

Connect the clip from the positive (+) side of the meter to the positive (+) side of the solar panel. Connect the negative (-) side of the meter to the negative (-) side of the solar panel.

Place the meter where the audience can easily see the dial. You need a strong source of light, but DO NOT point the solar panel directly at the sun.

Sample Script

"Now I'm going to show you how we can use light to make electricity. We will be converting radiant energy into electrical energy. I'm sure you've all seen solar calculators or solar toys that convert light in this way.

"Most of the electricity we use comes from the sunlight stored in fossil fuels such as coal. Changing light directly into electricity is one of the cleanest and simplest ways of making power, but it is very expensive. With the technology we have today, solar power costs four times as much as coal or nuclear power.

"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 can make electricity from light.

"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 in such a way that they make an electric current. It happens instantly and silently. There are no moving parts to wear out.

"This meter can measure the amount of electricity produced by the solar panel. The amount of electricity produced depends on the number of cells in the panel. **[Cover half of panel with your hand.]** Watch the meter! When I cover half of the cells, the amount of electricity produced drops by half.

"If I change the angle of the panel in relation to the light, I can also change how much electricity is produced. **[Angle the panel toward and away from the light.]** More power is produced if the light is shining directly on the PV cells. That is because more light energy is striking the cells. Some large panels have motors so they can follow the sun across the sky.

"PV cells aren't very efficient. Only about 10 percent of the light energy that strikes them is converted into electricity. The rest is changed into heat or reflected off the surface. Scientists are working on ways to make PV cells more efficient.

"So now you know how to convert light into electricity. Thanks for listening. Do you have any questions?"

Radiant to Thermal Energy

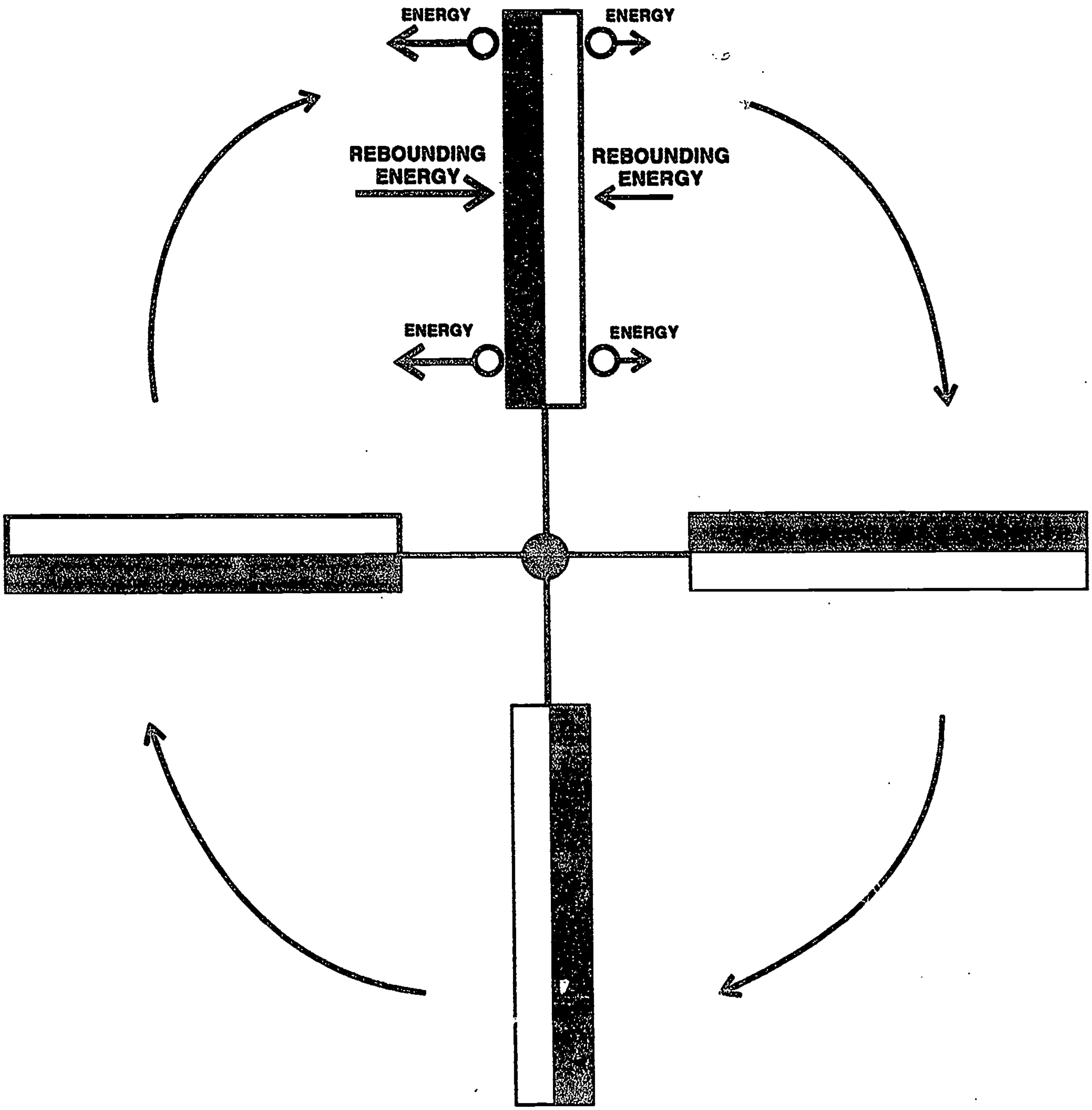
Equipment

On a sunny window or a wall near an overhead projector, tape one thermometer facing toward the light source and one facing away.

Sample Script

"You've probably heard the expression, "It was a 100 degrees in the shade." Why do people say that? **[Get answers from audience.]** That's right! Even when the air temperature is the same, it feels hotter when you're standing in the sun than when you're standing in the shade. The sun's radiant energy makes you feel hotter. In the shade, you only feel the heat from the air molecules striking your body. **[Show the two thermometers.]** A little while ago, I taped one thermometer facing the light, and one facing away from the light. Which one do you think will show a higher temperature? Let's look. The thermometer facing the light reads a higher temperature, because the radiant energy is being converted into thermal energy.

"So, on hot summer days, stay in the shade. Thanks for listening."



Top-view of Radiometer

The Science of Energy

Station Four

What You Need

The Thermobile

1 Thermobile	1 Live Wire	*1 Foam Coffee Cup
*1 Cup of Hot Water	*1 Pair of Tongs	(* = not included in kit)

The Wire Heater

1 Metal Coat Hanger (cut in several pieces) (= not included in kit)

The Jumping Disc

1 Jumping Disc for Each Student 1 Flat Piece of Metal

Presentation

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The Thermobile

Equipment

Place equipment on table.

Ask your teacher to pour a cup of hot water for you. It should be very hot but not boiling. Be careful when using the water. It could easily burn you or one of the audience members.

Sample Script

"Welcome to Station Four. I'm going to show you how a metal with a memory can be a power source. I will change heat into motion, or thermal energy into mechanical energy.

"This is called a thermobile. **[Hold up thermobile.]** As you can see, it's just a pair of pulley wheels and a curved wire. The wire is made out of Nitinol, which is a mixture of nickel and titanium.

"Nitinol is a special kind of metal. 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. Nitinol is used in space to move robot arms. It is also used to control the temperature of greenhouses. If the temperature gets too hot, a Nitinol spring opens a door to let in air.

"Here is another piece of Nitinol wire. Its original shape 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 in a knot.]** Now, if I heat this wire, it should remember its original shape. I'll drop it into this cup of hot water. **[Drop wire into hot water and remove it with a spoon or tongs. Be careful! The wire should have returned to its U shape.]** The heat energy in the water made the wire return to its original shape.

"Now, let's use the memory of nitinol to make mechanical energy. The wire in this thermobile was originally straight. Let's see what happens when we give it some energy. **[Place half of the small wheel in hot water. Make sure the water doesn't touch the plastic, just the wheel. If the thermobile doesn't start spinning, give the big wheel a little push. If it still doesn't spin, the water isn't hot enough. You may need to replace the hot water after every demonstration.]**

"I'm going to put this little wheel in hot water. The little wheel is made of brass; the big one is plastic. The brass wheel will absorb the heat from the water and pass it on to the wire. The Nitinol wire will absorb the heat energy and begin to straighten out into its original shape. As the wire travels around the plastic wheel, it loses the heat to the air. As the wire loses heat, it stops remembering its original shape and goes back to a loop. Since the part of the wire in contact with the brass wheel is absorbing heat all the time, it keeps trying to straighten out and pushes the whole loop along.

"It's an interesting machine—but is the energy from the wheel free? No, because we need energy to heat the water. Do you have any questions about the Nitinol wire or the thermobile?"

The Wire Heater

Sample Script

"Now I'm going to do just the opposite of what we did with the thermobile. I'm going to change motion into heat—mechanical energy into thermal energy.

"Here I have a piece of a metal hanger. I'm going to use mechanical energy to bend the metal a few times. Now watch! **[Bend the hanger back and forth about six or seven times at the center. Let the audience feel it. Caution: bending the hanger more than eight times may make the metal 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 mechanical energy from the muscles in my hands and arms into the wire. My muscles get their energy from the chemical energy in the food I eat. The plants I eat change the light energy from the sun into 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 chemical energy to mechanical energy to thermal energy.

"You've probably converted mechanical energy into thermal energy lots of times on cold days. Try this. Put your hands on your face to feel how much heat they have now. Next, rub your hands together for about ten seconds and put them back on your face. Do they feel warmer? They should. You have just converted mechanical energy into thermal energy."

The Jumping Disc

Sample Script

"Now we're going to change mechanical energy into heat energy and back into mechanical energy. These are jumping discs. **[Hand one disc to each member of the group.]** They're made of two different metals that react to heat at different temperatures. Let's take the discs and click them back and forth about ten times so that they will absorb heat from our hands and from the mechanical energy we're putting into them. Once they're warm, click them so that the logo is curved out and put them on this cool piece of metal. *Stand back from the table.* **[Make sure everyone is back from the table so that a flying disc doesn't hit anyone in the eye.]** What do you think is going to happen? **[Get answers from the audience. The discs should jump within a few seconds.]**

"Why do you think the discs jumped? **[Get answers from audience.]** At room temperature, the discs stayed in their original position. We added heat and mechanical energy to them to get them to stay in the clicked-in position. When we put them on this cool piece of metal, the heat from the discs flowed into the piece of metal and into the air. Once the discs lost the heat energy, they used the mechanical energy to return to their original position.

"The jumping discs show how we can change mechanical energy into heat energy and back into mechanical energy. Thanks for listening. Do you have any questions?"

Note: *The Jumping Disc works best at temperatures between 72 and 78 degrees. Below 70 degrees it might be hard to get the disc to stay in the clicked-in position. Above 80 degrees, the disc might take a long time to jump. If your disc doesn't jump or is too slow, don't think it's broken or worn out. Try again. You might try cooling the piece of metal piece a little or warming the disc a little more in your hands.*

The Science of Energy

Station Five

What You Need

Omniglow Lightsticks

Omniglow Lightsticks	*1 Pair of Tongs or Spoon	*1 Cup of Cold Water
*1 Cup of Hot Water (not boiling)		(* = not included in kit)

Electric Motors

2 Motors	1 9-Volt Battery With Holder	1 Disassembled Motor

Presentation

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Omniglow Lightsticks

Equipment

You'll need a table, one cup of cold water, and one cup of hot water. Ask your teacher to pour the hot water for you and be very careful with it, so you don't burn yourself or a member of the audience. Take two lightsticks out of their packages, but don't break them until you begin your first presentation.

Sample Script

"At this station, you will see how chemical energy can be changed into light energy. **[Hold up lightstick so that 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 hydrogen peroxide, a liquid used to clean cuts and bleach hair. Inside the lightstick you can see a little glass container. This container holds another chemical called an ester. Right now the two chemicals can't touch each other. But watch what happens when I bend the lightstick and break the glass container 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 the broken one. You can tell them you broke the lightstick a few minutes ago. If the broken lightstick becomes too dim before your presentations are over, you might have to break another one.*

"The lightstick is producing light—radiant energy. Why? **[Get answers from audience.]** When I broke the glass, the two chemicals mixed together and formed new chemicals. These chemicals don't need as much energy to hold their molecules together, so they give up that extra energy in the form of light.

"Now, let's try something else. What do you think will happen if I put the lightstick in cold water? **[Get answers from audience. Drop lightstick in cold water.]** Let's see. The lightstick isn't as bright, is it? Do you think the lightstick will get brighter if I put it in hot water? Let's see. **[Take lightstick out of cold water and carefully drop it in the hot water. After a few seconds, remove it with the spoon or tongs.]** It really glows when it's hot, doesn't it? How does heat change the brightness of the lightstick? **[Get answers from audience.]**

"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 an hour at room temperature, but only for about 20 minutes in the hot water. It might glow for six hours if we leave it in the cold water.

"Every lightstick has the same amount of chemicals and the same amount of energy. If we add heat, they will glow brighter, but for a shorter time. If we take away heat, they will glow for a long time, but not as bright. The lightstick is a good example of changing chemical energy into light energy."

Electric Motors

"Here we have tiny electric motors. Lots of little toys have motors like these. They make things move—they produce mechanical energy. Let's take a look inside one of these motors. **[Hold up motor that has been taken apart. Point out the parts as you talk about them.]** Inside the motor, you can see a coil of wire on this shaft. Small magnets are around the coil.

"When electricity is sent through the wire, it produces a magnetic field. The wire will act just like a magnet. Do you know what happens when you bring the north ends of two magnets together? **[Get answers from audience.]** That's right, they repel each other—they push each other away. The same thing happens when you bring the south ends of two magnets together.

"Inside the motor, the magnets push away from the magnetic field in the coil of wire. This turns the shaft of the motor. So, you have electrical energy making mechanical energy. Where do these little motors in toys get their electrical energy? **[Get answers from audience.]** From batteries. The batteries make electrical energy from the chemical energy stored in them.

Let's connect the wires from this battery to this motor. **[Connect the wires to one of the motors.]** As you can see, the shaft begins to spin. If we left this battery connected for a long time, what do you think would happen? **[Get answers from audience.]** The motor would slow down and then stop, because the battery would run out of energy. All of the chemical energy in the battery would be changed into electrical energy and then into motion.

"Now let's see if we can make this second motor spin without using a battery. Let's connect one motor to the other. **[Connect the clips from one motor to the clips on the other motor—it doesn't matter which way. Then spin the gear of the first motor as fast as you can with your fingers.]** I'm using my mechanical energy to spin the gear on this motor. When I spin the gear, the coil of wire inside spins around. The magnets and the spinning coil produce an electric current that turns the second motor. I'm using mechanical energy to make electrical energy to make mechanical energy.

"Watch the speed of the second motor. Is it going as fast as I'm spinning the first motor? No, the second motor spins slower. Why? Well, some of the energy is lost to friction, which turns into heat energy.

"Thanks for listening. Do you have any questions?"

Station Six

What You Need

The Electrochemical Cell

2 Zinc-plated Nails	1 Thin Copper Wire	1 Electrochemical Meter
*1 Apple	1 Thick Copper Wire	1 Display Sheet
(* = not included in kit)		

Presentation

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The Electrochemical Cell

Equipment

Put the meter on the table so that everyone can see it. If the needle on the meter gets stuck, gently tap the face of the meter. Have the zinc nails, copper wires, and the apple nearby.

Sample Script

"Welcome to my power plant. I'm going to make electricity for you today. Most of the electricity we use today is made using turbines to turn coils of wire around magnets, like we show at Station Five. Coal-fired plants use the chemical energy stored in the coal to make steam to turn the turbines. Nuclear plants use the nuclear energy stored in atoms to make steam. Hydro plants and wind farms use the mechanical energy from falling water and spinning blades to turn turbines.

"I'm going to use chemical energy to make electricity without a turbine. Chemicals are everywhere. Everything is made up of chemicals. Take this apple, for example. **[Hold up apple.]** Can anybody tell me what kind of acid is in this apple? **[Get answers from audience.]** Tannic acid. I'm going to use the acid in this apple to show how a battery works.

"Here I have a zinc nail and a piece of copper wire. I'm going to push each of them into the apple a little bit. **[Insert nail and thick wire about one centimeter into apple, making sure they don't touch. Attach clip with the green label to zinc nail and the other clip to wire.]** Now I'm going to attach them to this meter, which measures electricity. As you can see, I've produced 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 copper gives off electrons—it is an electron donor. The zinc nail has room for more electrons—it is an electron acceptor. **[Explain diagram.]** So electrons from the copper wire flow through the wires and the meter to the zinc nail. Look at the direction the needle on the meter is pointing. It shows that electrons are flowing from the copper to the zinc.

"What do you think will happen if I push the zinc and copper all the way into the apple? **[Get answers from audience. Push both in about four centimeters, making sure they don't touch.]** Let's see. There is more electricity, because there is more zinc and copper in the acid—more electrons are freed.

"What will happen if only one is pushed in all the way? **[Get answers. Pull copper most of the way out.]** Let's try it and see. The current drops, doesn't it? There isn't as much copper to give up electrons. Let's try the opposite way, pushing in the copper and pulling out the zinc. Same result, right? Even if there's a lot of copper to give up electrons, there won't be a lot of current unless there's a lot of zinc to accept them.

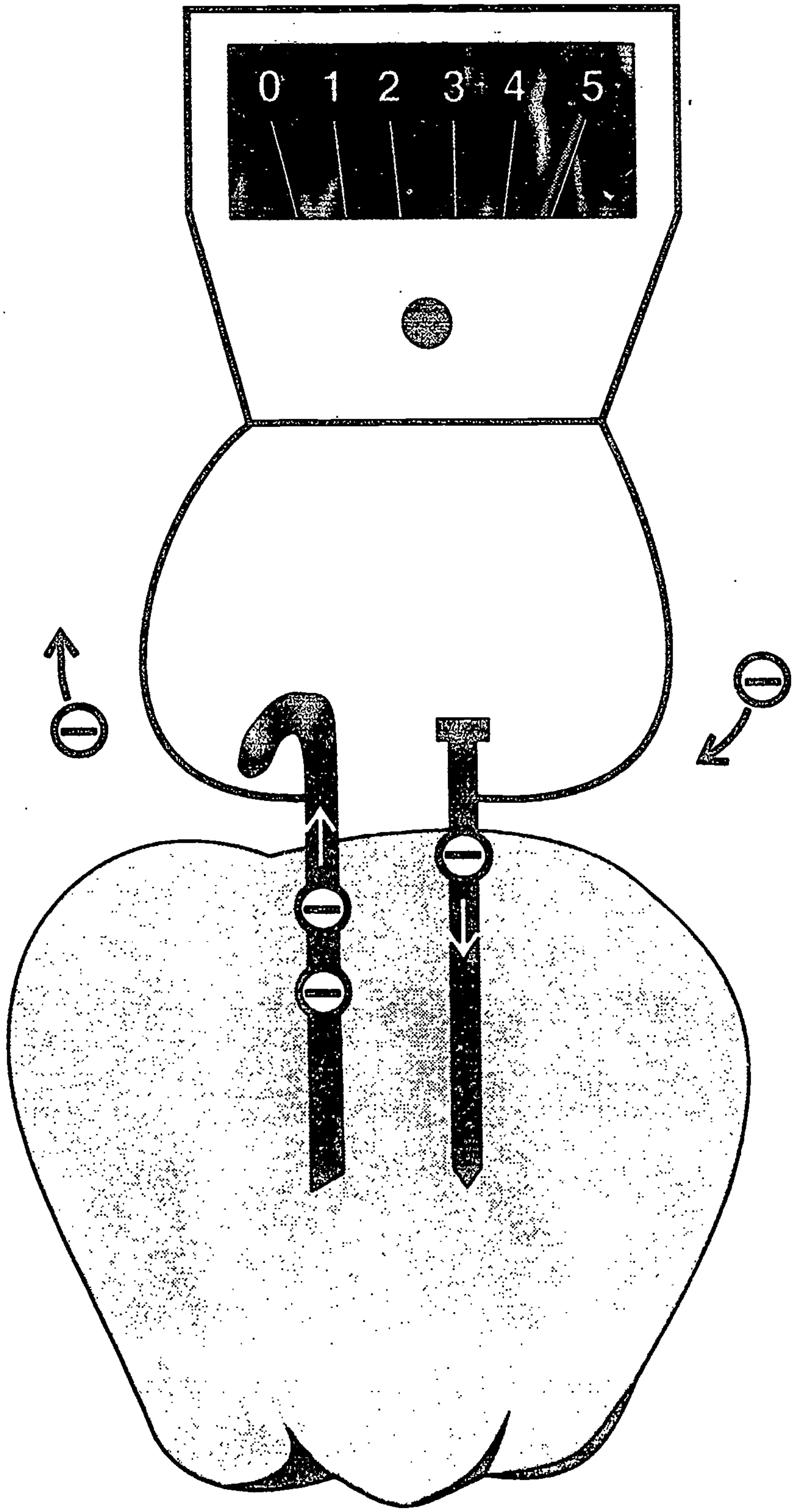
"Let's try something else. I'm going to put this thin copper wire into the apple, too, so we can compare the current. Which wire do you think will produce more current? **[Get answers. Put both wires and nail into apple about four centimeters so they aren't touching each other. Measure the current using 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 to come in contact with the acid.

"What do you think will happen if I put two zinc nails in the apple? **[Get answers. Remove copper wires and put both nails into apple.]** Let's try it and see. There shouldn't be any current, should there?

"Now let's try two different metals again. This time I'm going to push them into the apple so they're touching each other. What do you think will happen? **[Get answers. Push copper wire and nail in so the ends touch inside the apple.]** No current is flowing through the meter. Does that mean I didn't produce any electricity? 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 because the electricity is taking the shortest path.

"This is the way all batteries work. There are chemicals in batteries and the electrons flow from one to the other, converting chemical energy into electrical energy. Thanks for listening. Do you have any questions?"

The Electrochemical Cell



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The Science of Energy

Station Seven

What You Need

The Electromotor Force

1 EMF Meter	1 Small Coil of Wire	1 Small Magnet
1 Large Coil of Wire	1 Large Magnet	1 Display Sheet

Compass and Magnetic Field

1 Wire	1 Battery	1 Compass

Presentation

This script is just a sample. You don't need to say it word for word. Knowing the facts is the important thing. The instructions are in bold type **[like this]**. Study this guide and write down the important facts. Practice your presentation several times using the equipment. If you don't understand something, ask your teacher. Remember—science can be fun. If you have a good time, your audience will, too.

The Electromotor Force

Equipment

Place your equipment on the table. Connect the leads from the meter to the leads at the bottom of the large coil of wire—it doesn't matter which way you connect them. If the needle on the meter gets stuck, tap lightly on the face of the meter.

Sample Script

"You'll see lots of different ways to make electricity today—but I'm here to show you how the pros do it. More than 160 years ago, Michael Faraday discovered that if you move a magnet through a coil of copper wire, you produce an electric current in the wire. All of our major power plants produce electricity this way. **[Explain display sheet.]**

"Power plants use some form of energy to spin a huge turbine. The turbine rotates a magnet in a coil of copper wire to produce electricity. Lots of different kinds of energy are used to spin the turbines. In most power plants, coal is burned to make steam. Sometimes, natural gas, petroleum, or biomass is burned to make steam. Nuclear power plants split uranium atoms to heat water into steam. In all of these plants, the steam is used to spin the turbines. Hydro plants and wind farms use the energy in falling water and in the wind to spin the turbines.

"Today, I'm going to use mechanical energy to make electricity. **[Show audience the large magnet and the coil hooked to the meter.]** Here I have a coil of copper wire attached to a meter that measures electric current. And here I have a magnet. **[Place the flat side of the magnet on top of the yellow label on the coil. Move the magnet away from the coil. Do this several times.]** When I use my mechanical energy to move the magnet away from the coil, I make electricity. Watch the meter—notice to which side the needle jumps.

"Now, if I flip the magnet over, I'll reverse the magnetic field. Which way do you think the needle will jump? **[Get answers from audience. Move the magnet away from the coil as you did before.]** The needle jumps the other way, doesn't it? Notice what happens when I move the magnet toward and away from the coil. The needle alternates between the right and the left side. That means the current is alternating from one direction to the other. I'm producing an alternating current. It's called an AC current and it's the kind of electricity we use in our homes. The electricity you get from a battery is direct—or DC—current. That means it always flows in one direction. Batteries produce DC current.

"If I just rest the magnet on top of the coil, no electricity is produced. No mechanical energy is being used to make the electrical energy.

"What do you think will happen if I put the magnet on the table and move the coil? Let's try it and see. **[Get answers, then move coil away from magnet.]** It produces electricity. It doesn't matter whether we move the magnet or the coil, as long as one of them moves and the other doesn't. If I move both the magnet and the coil in the same direction at the same speed, no electricity will be produced. I'll show you. **[Place coil on magnet and move them together.]**

"Let's see what we can do that affects the amount of electricity we produce. First, let's try speed. Do you think I can produce more electricity if I move the magnet away slowly or quickly? **[Get answers.]** I'll move the magnet away slowly—let's see what the meter reads. **[Slowly move the magnet away from the coil several times, noting the reading on the meter.]** Now, let's try moving the magnet faster. **[Move magnet quickly.]** I produce more electricity when I move the magnet fast, don't I? That's because I'm putting more mechanical energy into the magnet when I move it quickly.

"Can you think of anything else that might affect the amount of electricity produced? **[Get answers.]**

How about the strength of the magnet? Here I have a smaller magnet. Let's see what happens when I move both magnets at the same speed. **[Demonstrate with both magnets several times, trying to keep your speed the same.]** The larger one produces more electricity. So a stronger magnetic field produces more electricity.

"There's one more thing that can affect the amount of electricity produced—the number of coils in the copper wire. I have two coils here, one with about twice as many coils as the other. Let's try the experiment again. **[Demonstrate using both coils.]** The larger coil produces more electricity, doesn't it?

"Today we've learned that we can make electric energy using mechanical energy to pass a magnet around a coil of copper wire. We've also learned that the strength of the magnet, the speed of the magnet, and the number of turns in the coil all affect the amount of electricity produced. Do you have any questions?"

Compass and Magnetic Field

Sample Script

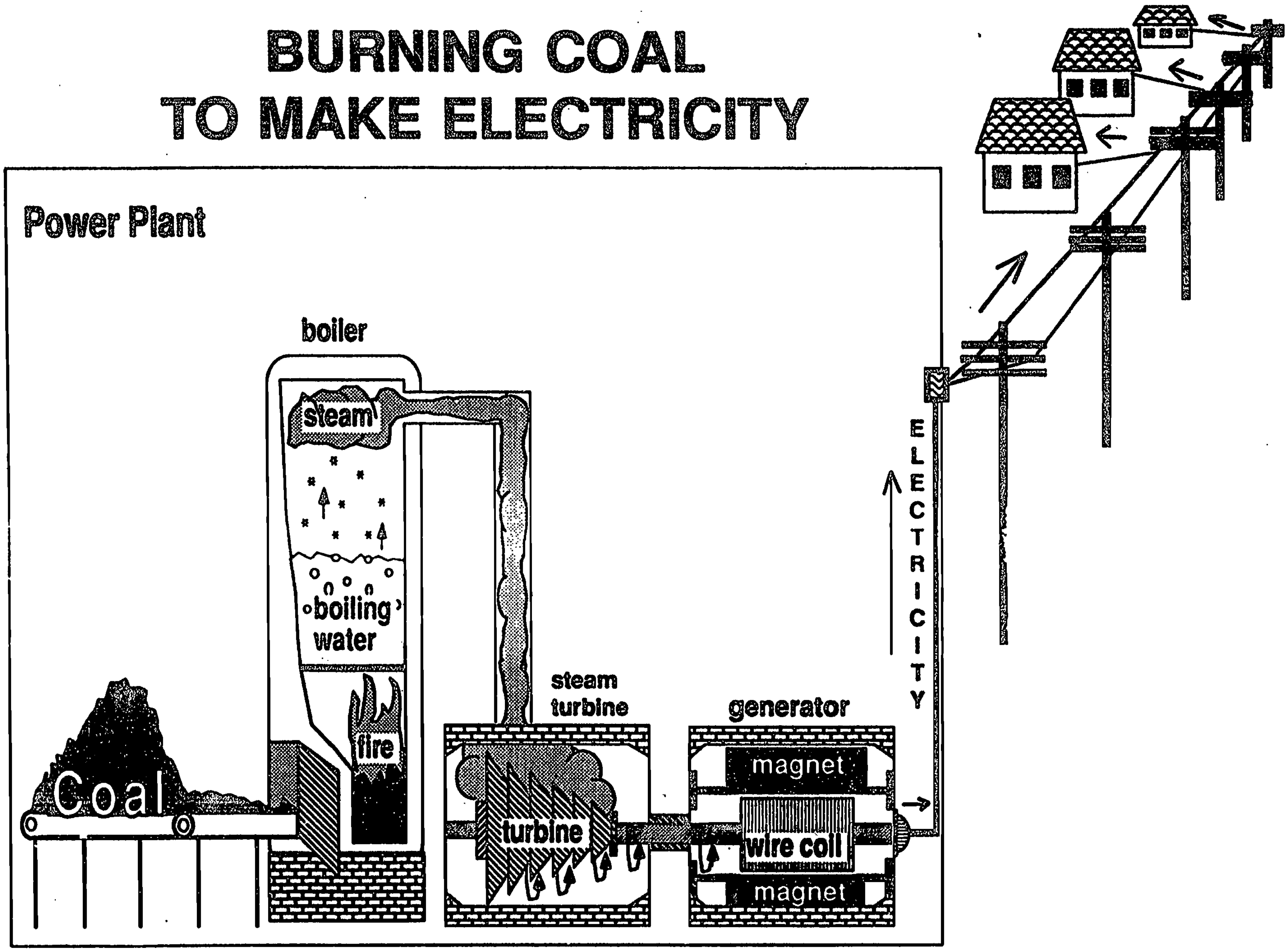
"Over here I have a battery, a wire, and a compass. With these three things, let's reverse what we just did with the magnet and coil. Let's convert electrical energy into mechanical energy. First, I'll have to make some electrical energy. I'm going to attach this wire to the battery to produce an electric current through the wire. **[Attach an end of the wire to each terminal of the battery. Then place the wire over the compass so that the wire and the needle of the compass are pointing in the same direction.]** Take a look at the compass. The needle is really a magnet that is pointing to the north—magnetic north. Now I'm going to place the wire over the compass in the same direction as the needle. Watch what happens. The needle moves. Why do you think this happens? **[Get answers from audience.]**

"The electric current in the wire is producing a magnetic field. The magnetic field makes the needle move because it is also a magnet. You know how two magnets either attract or repel each other—that's what's happening here. One of the magnets just happens to be an electromagnet.

"If I pick up the compass and hold it over the wire, what do you think will happen? **[Get answers, then move compass over the wire. The needle should move in the opposite direction.]** 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 and the other side is the south pole of the magnet.

"Here we used the electricity from the battery to move the needle of the compass. We converted electrical energy into mechanical energy. Thanks for listening. Do you have any questions?"

BURNING COAL TO MAKE ELECTRICITY



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