Experiments to Explore Electricity
Teacher's Guide

Note to Instructor
The activities and experiments in this booklet build on each other to develop a student's understanding of electricity and electrical safety. Solutions to the puzzles and answers to the questions in the booklet can be found on page 15.

Divide your class into groups of students who will work together to do all the experiments. Each group will need these materials:

- 1.2 volt light bulb
- E-10 light bulb base
- D-cell battery
- about 8 feet of 18-22 gauge, insulated wire
- 3″ × 3″ piece of cardboard
- large paper clip
- 3 brass fasteners
- 1 lemon
- 4-inch iron nail
- 1 penny
- 1 nickel
- masking tape
- steel wool, a piece of plastic or plastic lid, a penny, a paper clip, a rubber eraser, yarn, a piece of glass or small drinking glass

An adult will need to strip the insulation from both ends of all the wires for the students. Note that in the Short Circuit experiment (page 11), insulation must also be stripped in the middle of the wires. To do the Wet-Cell Battery experiment (page 12), you may need to borrow a multimeter from the custodian, an electrician, or a parent. Multimeters, bulbs, bases, batteries, and wire can be purchased at electronics retailers. Be sure the light bulbs and bases match.

Safety First!
Supervise students while doing the electricity experiments. The teacher or another adult should be responsible for stripping insulation from wires. Explain to the children that electricity can be dangerous if it is not handled correctly, and emphasize the information in the Safety Tips on pages 5, 7, 8, and 11.

Page 2: What Is Electricity?
Objective: To introduce the subject of electricity and help students understand that it originates with the movement of electrons from atom to atom.

Background/Discussion: All matter is composed of atoms. The nucleus, or center of the atom, contains positively charged particles called protons and neutral particles called neutrons. Electrons, which carry a negative charge, orbit the atom's nucleus. An object carries an electric charge if its atoms contain an unequal number of protons and electrons. When electricity flows through a wire, free electrons bump from one atom to the next. The movement of many electrons in the same direction is called an electric *current*. In a complete circuit, the current can flow around in a circle and back to the source.

Static electricity is created when two objects are rubbed together. A charge of static electricity builds up until it jumps between objects with a little spark.

Page 3: How Do We Use Electricity?
Objective: To help students become more aware of how electricity serves them.

Background/Discussion: Divide the class into three or four groups to brainstorm 50 ways electricity helps in their activities. Have each group devise a skit to show what life was like before electricity.

Page 4: Where Does Electricity Come From?
Objective: To teach students how electricity travels from the power plant to where it is used.

Background/Discussion: Electricity is produced in generating or power plants in machines called generators. Turbines run the generators. In coal, gas, and nuclear power plants, these fuels are used to generate steam, which drives the turbines. In hydroelectric stations, moving water drives the turbines. The turbines turn magnets that are surrounded by heavy copper coils inside the generator. The spinning magnets stimulate the electrons in the copper to move, generating electricity.

Power plant generators push out electricity at 25,000 volts or more (too powerful to use in the home). Transformers boost this voltage up to 400,000 volts, so the electricity can travel long distances along transmission lines. At high voltage, less energy is lost through resistance in the cables. As it nears its destination, electricity is stepped down with transformers, first at substations and then on power poles, until it is just 110 to 240 volts. This voltage is safe to use in factories, stores, schools, and homes, but it is still powerful enough to seriously injure or kill someone.

Page 5: Find the Power Words
Objective: To introduce vocabulary specific to electricity and the electric distribution system.

Background/Discussion: Explain to the students that electrical substations and transformers are in their neighborhoods. Signs on these facilities warn of high voltage and the need to stay away; explain that these signs must be obeyed. Emphasize to students that they could be seriously injured or even die if they come into contact with power lines.

(The key to the word search is on page 15 of the booklet.)

Page 6: Complete a Circuit
Objective: To demonstrate to students that electricity travels in a circuit.

Background/Discussion: Electricity is produced in a power plant and is then sent over wires to industries, factories, and homes where it is used. It then flows back to the power plant, completing the circuit.

Page 7: Make a Simple Switch
Objective: To help students understand how an electric switch works.

Background/Discussion: Ask students what happens when they enter a room and turn on a light switch. (Explain that when a light switch is turned on, a circuit is completed, so that an electric current can flow to the light bulb.) Reiterate the safety tip, to never experiment with electricity from wall outlets.

Pages 8-9: Identifying Conductors and Insulators
Objective: To help students recognize that some materials allow electricity to flow through them more easily than others, and to reinforce that their bodies can conduct electricity, so they should stay away from it!

Background/Discussion: See if students can identify the commonalities among the objects in the page 9 experiment that proved to be conductors (the steel wool, penny, and paper clip). Were the objects similar shapes? Sizes? Materials? Students should be able to recognize that all three of these objects are made of some kind of metal. Why is it helpful to know that metal is a conductor? (Because you can be extra careful around metal objects and make sure to keep them out of electricity's path. For example, you should keep aluminum ladders away from power lines.)

Pages 10-11: Short Circuits and Fuses
Objective: To teach students the function of fuses and circuit breakers, what a short circuit is, and how to respond to one.

Background/Discussion: After doing the puzzle on page 10 and the short circuit experiment on page 11, ask the children what happens in their homes when the power in part of the house goes off. Stress that an adult should take care of the problem. A power outage could be a result of the overloading of a circuit or a short circuit. A short may result in large, uncontrolled current flow, which might cause overheating of wiring or cause protective devices such as fuses or circuit breakers to operate.

Safety tip for the experiment: Explain that the short circuit wire will get hot. Students should not hold the bare wire with their fingers. Tell them to hold the short circuit wire in place by grasping the insulation.

Here is more background on how to respond to a blown fuse or tripped circuit breaker: If a fuse is blown, the fuse window appears discolored, and the metal strip running across the inside of the window is broken. Circuits protected by circuit breakers can be identified by the handle of the tripped circuit breaker being in the tripped or OFF position. If there is a blown fuse or a tripped circuit breaker, an adult should disconnect all lights and appliances on the circuit with the blown fuse or tripped circuit breaker, and then replace the blown fuse or turn on the tripped circuit breaker. If the fuse blows or the circuit breaker trips with all of the appliances unplugged from the circuit, the short is in the circuit wiring itself and the wiring must be repaired or replaced. If the circuit is good, the adult will reconnect each light and appliance on that circuit, one at a time, to discover which one is faulty or overloading the circuit.

Page 12: Make a Wet-Cell Battery
Objective: To show students that electricity can be created through a chemical reaction.

Background/Discussion: The battery you create changes chemical energy into electrical energy. There is a chemical reaction between the metals in the coins and the lemon juice. The acid in the lemon juice makes extra electrons collect on one coin. The electrons flow through the lemon when the multimeter completes the circuit. A single lemon usually produces only about 7/10ths of a volt of electricity—not even enough to run a digital watch!

Page 13: Build an Electromagnet
Objective: To teach students how an electromagnet works.

Background/Discussion: Have students test the power of the electromagnet depending on how many times the wire is wrapped around it. The students will determine that the more times the wire is wrapped around, the stronger the magnetic force. Explain that when the wires are attached to the battery posts the nail becomes magnetized. The students will see that by running electric current through a wire, they can create a magnetic field.

Pages 14-15: What Have You Learned? and Puzzle Solutions
Objective: The quiz on page 14 reviews the key science and safety tips in this booklet. Students can use page 15 to self-correct this quiz and their other work in this booklet.

Back Cover: Home Safety Checklist
Objective: To encourage students to involve their families in identifying and correcting home electrical hazards.

Background/Discussion: Have the students in their groups add other potential indoor and outdoor electrical safety hazards to their list. The groups can then combine their lists to make one master checklist that students can use at home. Invite students to report to the class about the hazards they found and their families' efforts to correct them.

Glossary

Atom—A tiny bit of matter containing protons, electrons, and neutrons.
Charge—The gain and loss of electrons.
Circuit—A closed loop of conductors that allows current to flow from the power source and back.
Circuit breaker—A circuit protector that snaps to "off" when the circuit it protects gets overloaded.
Conductor—A substance through which electrical charges can easily flow.
Current—The flow of an electrical charge through a conductor.
Distribution lines—Wires bringing electricity to your neighborhood.
Electron—Negatively charged particle that orbits around the nucleus of an atom.
Electromagnet—A piece of iron that becomes a strong magnet when an electric current is passing through wire coiled around it.
Fuel—Things that are burned to provide heat or power. Coal, wood, natural gas, and oil are fuels.
Fuse—Part of an electric circuit that melts and breaks the circuit if the current becomes dangerously strong.
Generator—A device for producing electrical current by moving a coil of wire in a magnetic field.
Insulator—A material through which electric charges cannot move.
Neutron—Electrically neutral particle located in an atom's nucleus.
Nucleus—The central core of an atom consisting of protons and neutrons.
Power plant or generating plan—A place where electricity is produced.
Proton—A positively charged particle in the nucleus of an atom.
Substation—A place where the voltage is changed.
Switch—A device that closes or opens a circuit, thereby allowing or preventing current flow.
Transformer—A device that changes the voltage of electricity. This allows electricity to be transmitted over long distances at high voltages, but safely used at a lower voltage.
Turbine—A device in which a wheel is made to turn by the force of water, steam, or air.
Voltage—The pressure behind the flow of electrons in a circuit. The force of an electric current.