Electric Excitement
4-H ELECTRIC SERIES

National 4-H Curriculum
BU-06849

Electric 2

Investigating Electricity

Project Activity Guide

Name_____

County _____

REVIEWED & RECOMMENDED
National 4-H Curriculum

Acknowledgments

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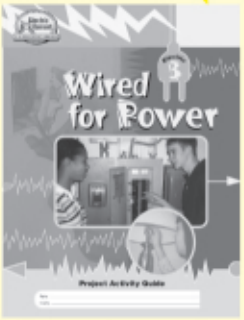
The Story of Electricity and Magnetism by Bernard Seeman, 1967, Harvey House, Inc., New York

Science Projects About Electricity and Magnets by Robert Gardner, 1994, Enslow Publishers, Inc. Springfield, NJ.

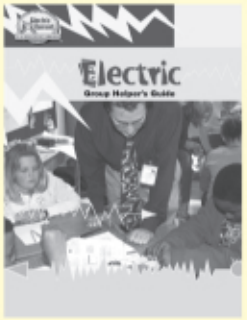
For more on Electriciy, look for these other guides in this set.

Magic of Electricity



Wired for Power

Entering Electronics



Electric Helper's Guide

Investigating Electricity

Contents

Note to the Electric Project Helper

Welcome to *Electric Excitement!* You will enjoy helping youth demystify the "magic" of electric circuits, magnetism, motors and electronics. From building burglar alarms to learning how to select stereo equipment, this curriculum contains dozens of hands-on, useful and fun projects. These activities can be used in a variety of settings such as in the classroom, with special interest clubs, after school groups or community clubs, or one-on-one.

You will be a key individual with whom young people can share the experiences outlined in this activity guide. You will provide encouragement and recognition, as they develop technical and scientific electrical literacy. In addition, these young people will learn important life skills such as creative thinking, decision making, problem solving and participating as members of a team.

Investigating Electricity is designed for youth who understand basic electric principles such as the concept of magnetism, electron flow and circuit design. It is recommended that youth have already completed the first guide in this series.

Your Role

- **Review this guide and the Electric Group Activity Guide**
- **Support the youth in his or her efforts to set goals and complete the Planning Guide and Electric Achievement Program**
- **Help select electric projects to construct, give assistance in doing the activities and answer questions**
- **Help the young person to think about why something happened the way it did**
- **Serve as a resource person to help connect the young person with the community, resource materials and others knowledgeable about electricity**

The Electric Excitement Series

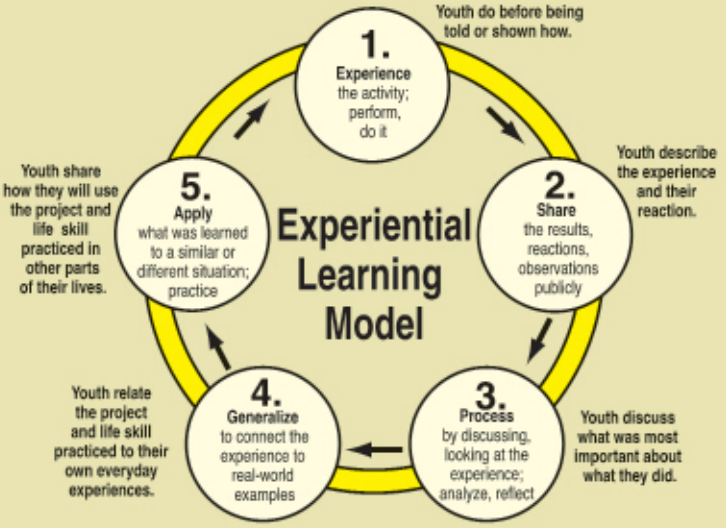
This is the second activity guide in the *Electric Excitement* Series.

Activity Guide	Level 1	Age	Grade
Magic of Electricity	1	9–11	4–5
Investigating Electricity	2	11–13	6–7
Wired for Power	3	13–16	8–9
Electronics I	4	16–18	10–12

These activity guides may be used by youth at any grade-level based on their electric skills, knowledge and expertise. A fifth activity guide, the *Electric Group Activity Guide*, provides additional group activities that can be adapted to the family, classroom or youth group. These activities strengthen understanding of electrical concepts and reinforce electrical skills.

The Experiential Learning Model

The experiential learning model is used in each activity as a means to help the young person gain the most from the experience.



Pfeiffer, J.W., & Jones, J.E., "Reference Guide to Handbooks and Annuals" © 1983 John Wiley & Sons, Inc. Reprinted with permission of John Wiley & Sons, Inc.

The five steps in this learning model encourage the young person to try to do the activity before being told or shown how. The activity is the experience part of the cycle. Use the questions listed in the *Making Connections* section of each activity to encourage the young person to think about what he or she has learned from the experience. The reflect and application questions ask the youth to **share** what they did; **process** what was most important about the experience; **generalize** the life skill and electric skill practiced to their own lives; and think through how they could **apply** the life skill or science process skill to a new situation.

To fulfill the experiential learning process, you must complete all the steps, including the review questions in *Making Connections*. The experiential model enhances learning and adjusts to a wide variety of learning styles.

Evaluating the Experience

1. By asking the questions under *Making Connections* you can evaluate your youth's understanding of the key concepts and life skills practiced in each activity. Listening to and encouraging consideration of each question results in conclusions and opportunities for further application. In addition, the *Success Indicator* shown in the introduction of each activity will help you evaluate the experience.
2. In the *Electric Group Activity Guide* you will find an assessment sheet, *Evaluating the Impact*. Use this sheet to help you evaluate your youths understanding of electricity and circuits as he or she completes these activities.
3. Youth and volunteer helper assessments of the Electric Excitement series can be found on page 35, *Electric Group Activity Guide*.

How This Book Works

In order for you to get the most from each of the activities, take a few minutes and review why each section of the activities has been included. Each activity in the Electric Excitement series is designed to help you learn something about electricity as you practice a life skill you can use every day.

The Activities
Invite a family member or a friend to work with you on these activities and projects. These projects can even be done with your classmates or in a special interest club, after-school group or community club. Sometimes it is more fun and interesting to explore new things together. Here is a quick look at the various sections found in each activity.

Skills
Each activity lists electric skills, science process skills and life skills that you will learn and use. You will practice these types of skills when you answer the questions and discuss each activity with your electric helper.

Success Indicators
Can you do what these say, and can you do it more than once? If so, you have mastered this skill. If you have trouble with this skill, just keep practicing until you can.

Tools
These are the materials you'll need to complete the activity. By organizing and planning for each activity you'll be practicing an important skill.

Power Up
This is the "do" part of the activity. You will usually get to share part of what you do with others.

Closing the Circuit
Here is an extra activity which will help you understand or practice what you have learned in each activity.

Making Connections
This is where you and your helper get together to see what you have learned about electricity. You will use these questions to help you discuss what you learned, what you did, what was important about what you did, what it meant to you and how you could use what you learned in the future. The *Making Connections* questions are found at the end of each chapter. Check the box after talking over each question with your helper.

Light Bulb Icon
Here you will find tips to help you complete the activity or general information about electricity.

Brain Boosters
These are more challenging activities for you to do. They will help you expand your knowledge and skills to other areas. Each time you successfully complete one of these, record it on your achievement program page and have your helper initial and date it.

Safety Icon
These are helpful hints to keep yourself safe when working with electricity. The activities in this guide are designed to be safe, but remember you are dealing with electricity, which can be dangerous.

Kite Icon
Check the kite for interesting facts and trivia about the magic world of electricity.

Glossary Words
All definitions for the words listed here are found in the glossary on page 34.

Web Connection
Here you will find web sites that you can visit to learn more about magnets and electricity.

Journal
Use a journal to record your answers to *Making Connections* found at the end of each chapter.

My Project Helper _____

Phone # _____

E-mail address _____

Your Project Helper

Your electric project helper is an important part of your overall experience in the electric project. The choice of a helper is yours. This person may be your project leader or advisor, troop leader, teacher, family member, neighbor, friend or anyone who has the interest to work with you to complete the electric achievement program for this guide. Involve your helper as you set your goals, discuss the questions following each activity and sometimes work together on an activity.

Investigating Electricity
Planning Guide

My Plans

- Select an electric project helper
- Complete all four steps of the *Investigating Electricity* Planning Guide
- Do at least seven activities each year
- Take part in at least two leadership experiences each year

My Name _____

My Project Helper _____

Helper's Phone Number _____ E-mail Address _____

1 My Electric Project Goals

I plan to complete my *Investigating Electricity* activity book by _____.

2 Leadership Experiences

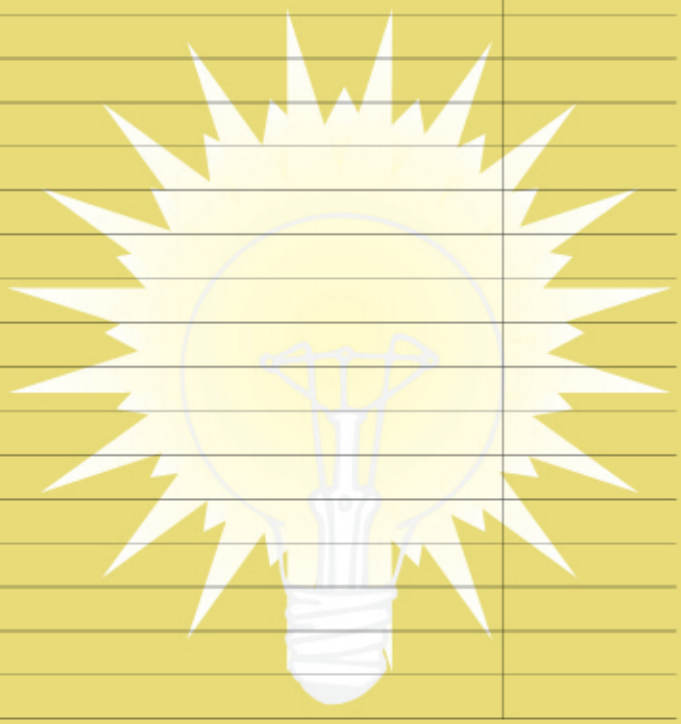
Participate in at least two of these experiences each year. Put a check mark by the ones you plan to do.

Experience	Plan To Do	Date Completed
Give an electric demonstration		
Teach someone something about electricity		
Encourage a friend to be a part of the electric project		
Attend an electric workshop		
Give a speech on an electric subject		
Tour an electric facility		
Exhibit an electric project		
My own activities:		

3 Electric Project Highlights

List and record the date every time you do and learn something exciting in *Investigating Electricity.*

	Date



4 Electric Project Review

Once you have completed what you planned, arrange to talk with your helper about what you have learned. You will want to have your planning guide, achievement program and the *Making Connections* section of this guide up-to-date.

Investigating Electricity

Achievement Program

Guidelines

- Do at least three Required Activities and four Optional Activities (Brain Boosters) this year and check them off.
- Have your electric helper date and initial this log as you complete the activities

Required Activities			Optional Activities (Brain Boosters)			
Activity Name	**Date Completed**	**Helper's Initials**	**Page/No.**		**Date Completed**	**Helper's Initials**
Get It Together						
Going Back and Forth						
The Electric Detective's Most Important Tool						
Investigating Ohm's Law						
To Flow or Not to Flow						
Decoding Circuit Diagrams						
Case of the Series Circuit						
Case of the Parallel Circuit						
Circuit Sense						
The Off and On Case						
The Case of the Switching Circuit						
Stronger Connections						
Stop the Crime						

Electric Excitement
4-H ELECTRIC SERIES

Investigating Electricity

Achievement Program Certificate

I certify that _____

has successfully completed the requirements of Electric Excitement: *Investigating Electricity*

Helper's Signature _____

Date _____

Get It Together

Activity:	*Gather materials for Investigating Electricity activities*
Life Skill:	*Solving Problems—Devising a plan of action and evaluating information*
Electric Skill:	*Becoming familiar with electrical equipment*
Science Process Skill:	*Making decisions*
Success Indicator:	*Acquires all materials needed*
National Science Standard:	*Tools help scientists make better observations, measurements and equipment for investigations*

Pencil

Before you can dig deeper into the science of electricity, you must gather the tools needed for investigation. You probably already have some of the things you will need, but not all of them. In this activity you will get organized by taking inventory of what you have and deciding what you need. Once you know what you need, you can decide on the best place to get it.

Power Up

This table lists the materials you will need for the activities in this book. For each item, indicate in the table whether or not you already have it, where you will buy it if necessary and how much it will cost. You may want to call, visit several stores, or check catalogs (many are on the Web!), to see who has the best price on an item.

MATERIAL PLANNING TABLE

ITEM	ACTIVITY USED	AMOUNT NEEDED	ALREADY HAVE?	WHERE YOU FOUND IT	COST
D-cell battery	2, 3, 5, 7, 8, 9, 10, 11	4			
Volt-Ohm meter	3, 5, 7, 8, 9	1			
Good light bulb	3	1			
Burned out light bulb	3	1			
Pencil lead for mechanical pencil	5	1			
Compass	2	1			
Aluminum foil	5, 10	1 box			
22 or 24 gauge insulated copper wire	2, 7, 8, 9, 10, 12	25 feet			
Glass jar or drinking glass	5	1			
Piece of cardboard	5, 11	2 pieces			
Copper wire	5	1 piece			
Plastic item	5	1			
Flashlight bulbs (1.5 Volts)	2, 7, 8, 9, 10, 11	2			
Light bulb holder	2, 7, 8, 9, 10, 11	2			
Battery holders for single D-cell battery	2, 7, 8, 9, 10, 11	2			
Pencil	1, 6	1			
Wire strippers	2, 7, 8	1			
Plastic bottle with adjustable nozzle	4	1			
Screw driver	7, 8	1			
Hammer	10	1			
Tin snips or strong scissors	10	1			
Clean tin can lid	10	1			
Brass paper fasteners	11	6			
Soldering iron and solder*	12	1			
Sponge*	12	1			
Needle nose pliers	12	1			
Switch	7, 8, 9	1			

* See Light Bulb Icon for more information

Closing the Circuit

Go and visit the cereal isle of a grocery store with your helper. Look at all of the different types, sizes and brands of cereals you could buy. How can you decide which cereal to purchase? List the questions you need to ask yourself when deciding on a cereal to buy:

Examples:

What type of cereal do I like to eat?

How much money do I have to spend?

Questions:

_____

_____

_____

_____

_____

_____

_____

Were you able to eliminate cereals by asking these questions? Did asking questions make it easier to decide what type, size and brand of cereal to purchase?

Soldering

Three of the items on your list are for **soldering** — a process used to make strong connections in electrical circuits. These items are relatively expensive. If you plan to continue your study of electricity and complete Electric 4, *Entering Electronics*, you will need to learn to solder and you should purchase these items. If you do not plan to study electronics, you may skip these purchases.

Brain Boosters

1. Think about the decisions you make everyday. What time do I get up? What will I wear today? What shall I have for breakfast? What homework assignment should I do first? Some of these decisions are easy to make and some are much harder. Discuss with your helper how you make decisions everyday. Discuss how people set priorities when making a decision between several options.

2. Select something you would like to purchase in the near future and do some comparison shopping. Discuss with a parent or your electric helper the answer to the following questions: • Is there more than one brand name for the item you want? • Is one brand more expensive than another? • Which brand do you like best and why? • Is the item available at more than one store? • If so, what is the difference in price of the item in the different stores?

In 1827, a German scientist, named George S. Ohm, wrote a book that stated that an electric current has to push against the **resistance** *of the conductor. This was such an unusual idea that many scientists at the time refused to believe it — they thought Ohm was crazy! Ohm made so many enemies because of his new ideas that he had to leave his home. Today, everyone accepts Ohm's ideas because there is resistance to current. This resistance can be measured in units that are called* ***Ohms****!*

Glossary Words

- **Ohm**
- **Resistance**
- **Solder**

Activity 2

Going Back and Forth

Activity:	***Learn about alternating and direct current***
Life Skill:	***Acquiring/Evaluating Information—Obtaining information***
Electric Skill:	***Identifying alternating and direct current circuits***
Science Process Skill:	***Experimenting and comparing***
Success Indicator:	***Understands the difference between direct and alternating current***
National Science Standard:	***Electrical circuits require a complete loop through which an electrical current can pass***

Tools ***Compass, 3 feet of insulated 22 or 24 gauge copper wire, light bulb, light bulb holder, D-cell battery, wire strippers***

When you flip a computer switch, you expect the computer to start working. When you push the button on a flashlight, you expect the light to turn on. Each time you flip a switch or plug in an appliance you are completing an electrical circuit. The electric current moves through the circuit and accomplishes the desired task. However, there are two different types of electrical current at work here. The computer uses **alternating current (AC)** and the flashlight uses **direct current (DC)**. In this activity you will learn about these two types of electrical current.

Power Up

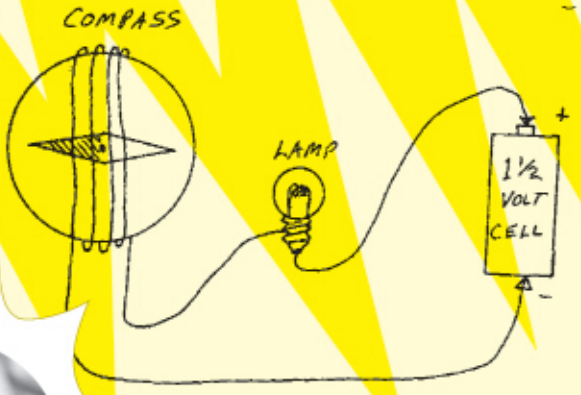
In this activity you will demonstrate alternating and direct current by building a galvanometer and using it in a circuit that includes a light bulb (Refer to *The Magic of Electricity,* Activity 11).

Wrap several (10 to 20) turns of small wire around a magnetic compass. To make a complete circuit:

- Connect one of the wires from the galvanometer to a D-cell battery
- Connect another wire from the other side of the D-cell battery to one side of the light bulb
- Connect the other side of the light bulb to the other wire from the galvanometer

The circuit will be easier to handle if you use a battery holder for the battery and a light bulb holder for the light bulb. Once you finish your circuit, you will see that the needle of the compass will turn one direction and then stop. The electric current is moving in only one direction. This is called direct current.

If you reverse the two wires that are connected to the battery, the needle of the compass will turn and point in the other direction. This shows a change in the direction of the current. If you switch the D-cell connection back and forth quickly, you are making an alternating current.



Closing the Circuit

A transformer converts electric energy to magnetic energy and then back to electric energy at a different **voltage**. A transformer may be used to increase or decrease voltage. Very small transformers are found inside plugs used for cordless telephones and video games. Transformers are also found inside remote controlled equipment such as TVs, garage door openers and thermostat controls for furnaces. Very large transformers are found in electric power substations. Your home gets its power from a power transformer located near your home.

Count and record the number of small transformers used in your home. Locate the power transformer that serves your home. Most power transformers are mounted overhead on poles, but some are on the ground and have underground wiring.

Transformer Location	How many in your home?	Indoors or Outdoors?
Ex. *telephone*	*4 telephones*	*indoors*

Glossary Words

- **Alternating current**
- **Direct current**
- **Hertz**
- **Transformer**
- **Voltage**

In the 1880's, a German scientist, Heinrich Hertz, was experimenting with electromagnetism. Hertz was using a wireless transmitter, an early type of telegraph, which sparked whenever ultraviolet light was shone on the transmitter. This was the first step toward the photoelectric devices that we use today, such as the doors that open like magic at the grocery store and other buildings!

Direct and Alternating Current

The electricity coming from a battery is called direct current. Direct current electricity always flows in the same direction.

The electricity that comes from an electrical generating plant, which is the same electricity that is available at the receptacle in the wall of your home, is different from the electricity in a battery. The electricity from the generating plant flows in one direction and then in the other direction; it is called alternating current. The alternating current used in the United States changes direction, back and forth, 60 times per second (called 60-cycle or 60-**Hertz** electricity). Electricity in much of the world is 50-Hertz. That is one reason why an electrical appliance built to work with electricity generated in America will not always work with electricity generated in another country.

Why use AC current instead of DC?

AC electricity has a major advantage over DC electricity. To move large amounts of DC electricity a few miles requires very large wires. AC electricity can move large amounts of electricity several miles on relatively small wires (which you see on electric poles) by using **transformers** to increase the voltage.

Brain Boosters

Make a list of the things in your house that use direct current. Make another list of things in your house that use alternating current. Describe to your helper how you determined if an item used direct or alternating current.

Author: Wayne Newhart, Tipmont REMC

Activity 3

The Electric Detective's Most Important Tool

Activity:	*Use a Volt-Ohm meter*
Life Skill:	*Acquiring/Evaluating Information—Obtaining information and analyzing data*
Electric Skill:	*Using a Volt-Ohm meter*
Science Process Skill:	*Gathering data*
Success Indicator:	*Reads Volt-Ohm meter correctly*
National Science Standard:	*Tools help scientists make better observations, measurements and equipment for investigations*

Volt-Ohm meter, battery (or batteries) for the meter, two D-cell batteries

Some of the tools used to study electricity are Volt-Ohm meters, galvanometers, circuit diagrams and circuit components. Meters, such as the Volt-Ohm meter and the galvanometer, help to measure what is going on in a circuit. Circuit diagrams help us to figure out how to put the pieces of the circuit together, and circuit components actually do the work of conducting the electricity (and more). In addition to good observation skills, every electric detective needs to know how to use these different tools. In this activity you will test your skill using a Volt-Ohm meter.

Never try to measure a voltage unless the meter dial is set for voltage. If you try to read a voltage with your meter set to read resistance (Ω) it will damage your meter! Set the meter on voltage DC if you are reading the voltage of a battery or voltage AC if you are reading voltage from a wall socket.

Power Up

Obtain an analog or digital **Volt-Ohm meter** (see *Light bulb*). When you get new equipment, it is always a good idea to read the manual instructions on proper usage.

You may need to install a battery, or it may have come with one already installed. Some meters require that you connect the red lead wire to the positive terminal on the meter, and the black lead wire to the negative terminal. Now you are ready to take some readings with your meter and fill in the data table.

1. Using the meter by itself, set the meter to read direct current (DC). Notice what the meter output shows when you touch the ends of the red and black lead to each other, and when they are separated. Record these meter readings in the table.
2. Next, change the Volt-Ohm meter to read alternating current (AC). Again, record the meter readings when the ends of the red and black leads are touching and when they are separated.
3. To measure **electrical resistance**, change the meter to read **Ohms** (Ω). Record the resistance values when the ends of the two leads are touching and when they are separated.

Check your manual to see if your meter can measure **electrical continuity**. If it can, change the setting to measure continuity Record the meter readings when the ends of the two leads are touching and when they are separated.

WARNING: The meter cannot measure resistance when voltage is present in a circuit, so you must disconnect the battery from the circuit before you use your Volt-Ohm meter to read an electrical resistance. The meter can be harmed if resistance is read while voltage is present.

VOLT-OHM DATA

Meter Setting	*Leads Touching*	*Leads Separated*
Direct Current (DC)		
Alternating Current (AC)		
Resistance (Ohms)		
Continuity		

Glossary Words

- **Analog**
- **Digital**
- **Electrical resistance**
- **Electrical continuity**
- **Ohm**
- **Volt**
- **Voltage**
- **Volt-Ohm meter**

Closing the Circuit

Use your Volt-Ohm meter to read the voltage in a D-cell battery and record what you see. What setting did you need to put the meter on? Does it matter which battery terminal the red lead attaches to? Put two batteries together end-to-end (like they go together in a flashlight) and read the voltage of the two. What did the Volt-Ohm meter read?

Analog or Digital Meter?

As its name implies, a Volt-Ohm meter is a device to measure the **voltage** (both AC and DC) and resistance in electrical components to help understand what is happening in an electrical circuit. If your meter has a needle that moves from one side of a scale to the other it is an **analog** meter. A **digital** meter has a number read out.

The meter cannot measure resistance when voltage is present in a circuit, so you must disconnect the battery from the circuit before you use your Volt-Ohm meter to read an electrical resistance. The continuity check on a meter lets you see if a circuit has a break in it somewhere. A broken wire can act just like an open switch. If the continuity checks, there is not a break in the circuit. If the continuity does not check, then the circuit is open. The circuit may be open because a switch is open, but it may be open because a wire is broken or a connection is bad! If a meter has a continuity check built in, it will generally buzz or light an indicator light if the circuit is good.

Electricians often check for continuity in circuits that aren't working. If you have a light bulb that you know is burned out, check it for continuity or use your meter to read the resistance across the light bulb. To do this, touch one lead on the side of the screw part of the bulb, and another lead on the end of the light bulb that sticks out (just like the way you made connections in book one to get the "broken flashlight" to work!) Try the same test with a good light bulb. Are the readings different? Explain what you discovered to your helper.

Brain Boosters

In the space provided sketch a simple circuit showing a light bulb, battery, switch and wire; then answer the questions.

What provides the energy for the circuit?

What is the electrical load?

What do the wires do?

How do the electrons travel through the circuit?

Why do you put a switch in a circuit?

Simple Circuit

Alessandro Volta, an 18th century Italian scientist, believed that electricity had something to do with the interaction of two different metals. In his efforts to prove his theory, Volta became the first person to produce a continuous electric current. The unit by which electric pressure is measured is called the "Volt" in honor of Alessandro Volta.