Build a Battery Workshop: Voltaic Pile

Participants construct a voltaic pile high enough to light jumbo red LED bulb! The experience will give participants an idea how battery inventor, Alessandro Volta, felt as he worked on this important discovery back in 1780. Can participants beat his dev score of 1.1 **volts**?

Question to Investigate

- How many cells does it take to light a red, white, or blue LED bulb?

Science Content

- A battery is made of 2 electrodes and an electrolyte.
- The electrodes are made of two different metals.
    - The copper washer is the cathode and has a positive charge.
    - The zinc washer is the anode has a negative charge.
- The longer leg of the LED must be on the copper cathode and the shorter end must be on the zinc anode so that the bulb will light.
- Batteries store energy within chemical bonds and release it as electrical energy.

Materials

- Copper washers, ¾ inch outer diameter and suitable for use with ¼ inch screws
- Zinc washers, ¾ inch outer diameter and suitable for use with ¼ inch screws
- Thin copper wire, bare
- Wire cutters
- 3/4-inch hole punch
- 5/16-inch hole punch
- Paper
- Vinegar, two 32-ounce bottles
- Light emitting diode (LED), 10 mm bulb, any color
- Acrylic stands with plastic posts that are ¼ inch in diameter
- 4 short clear plastic cups per station
- Plastic tweezers
- Assortment of 5 mm and 10 mm LED bulbs in different colors
- Adafruit noods (LED noodles), 130 mm
- Bowl
- Small plastic beaker, 90 mL size
- Water
- Digital voltmeter

Safety Requirements

- LED bulbs have sharp ends. Use caution when handling them.

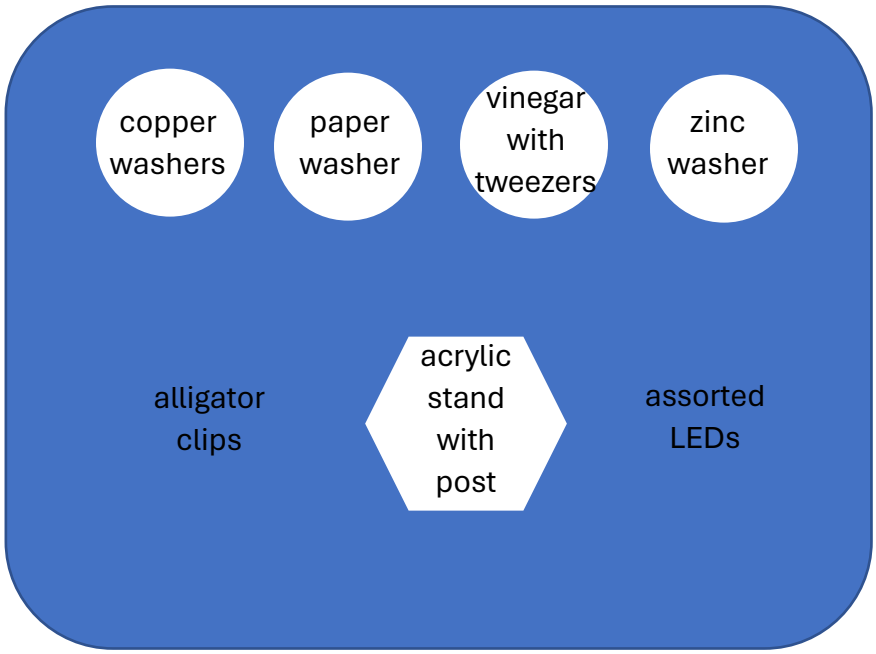
Preparation

Prior to the activity

1. Use the hole punches to make paper washers the same size as the metal washers.
2. Label each set of 4 clear plastic cups, zinc, paper, vinegar, and copper.
3. Cut 8 pieces of wire about 6 inches long. Assemble each acrylic stand and coil the wire around the post at the base of the acrylic stand.

Prepare on-site

1. Half-fill a bowl with water for used zinc washers.
2. Half-fill the copper cup with copper washers.
3. Add paper washers to their labeled cup.
4. Use a small beaker to add 30 mL of vinegar to its labeled cup.
5. Lean the tweezers in the vinegar.
6. Half-fill the zinc cup with zinc washers.
7. Arrange the cups and other items on the tray as indicated in the diagram.
8. Arrange 4 trays along the front of each table. Each tray indicates one station.



Onsite activity		
Step	**Details**	**Ask participants**
Introduce the activity	• Tell participants that they will build a battery using metal washers and paper dipped in vinegar. Their task is to find out which bulb will light first, the red, white, or blue one.	• If this battery works, what do you expect to happen to the LED bulb.
Have participants make one cell of the battery	• Instruct participants to place the copper washer on the acrylic stand first. • Then show them how to place a paper washer in the vinegar cup, use the tweezers to push it down and remove it, and then place it over the post on the acrylic stand. • Finally, have them stack a zinc washer on top. • Explain that this "electrolyte sandwich" is one cell of the battery.	
Try to light a bulb	• Show participants how to use a bulb to close the circuit by making an LED "do the splits." Touch the end of the wire under the copper washer to the longer leg of the LED. While placing the shorter leg on the zinc washer. • Use a digital multimeter to demonstrate that some voltage is being produced, just not enough to light the bulb.	• Can one cell light a blub? *(No.)*
Add a two more cells to the voltaic pile	• Tell participants to follow the pattern as they stack two more cells on top of the voltaic pile. • Then have them test the bulb as you demonstrated.	• Can three cells light a bulb? *(The red light will be dim.)*

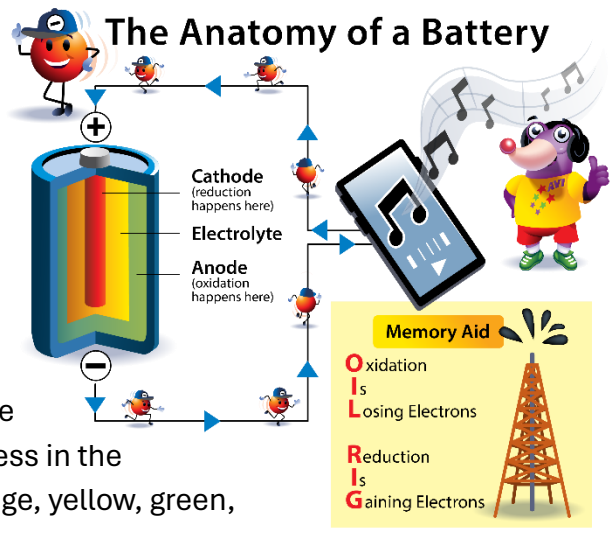
Continue to build the pile and test the bulbs	• Have participants continue to stack additional cells and test bulbs until they are ready to stop. • Those who make tall stacks can add their names, and number of cells, to the leaderboard.	• What do you notice about the brightness of the bulb with each additional cell? • Which color bulb requires the fewest number of cells to light? • Which color bulb requires the greatest number of cells to light?

Chemistry Details

All batteries contain key parts that make them work—two electrodes and an electrolyte. The electrodes cannot be made of the same metal. They must be made of one metal that gives up electrons easily and another metal that accepts electrons easily.

Zinc gives up electrons. This type of chemical reaction is called **oxidation** and this process is why the zinc end of your battery has a negative charge. The electrode that gives up electrons is called the **anode**.

At the copper electrode, protons from the acids or salts in the drink accept the electrons and react to form hydrogen gas. This type of chemical reaction is called **reduction** and this process gives the copper end of your battery a positive charge. This makes the copper electrode the **cathode**.



If you look closely at a battery that powers a toy, flashlight, or remote, you will likely see a small "+" sign written near one end. This tells you where the cathode is. The anode is at the other end of the battery as well as all along the round inside wall of the battery.

The red bulb requires the least amount of voltage to light, so is a good color to test first. The blue requires the most voltage. The colors progress in the same order as the colors of a rainbow. Red, orange, yellow, green, blue, purple.