Explore Electrolytes

Batteries are made with the same essential parts—two electrodes and an electrolyte. In this activity participants compare the brightness of a bulb when connected to a battery made with saltwater and another battery made with Gatorade as the electrolyte. The label on a bottle of Gatorade, says that it contains electrolytes. Can these work in a make-it-yourself battery?

Question to Investigate

- Which is a better electrolyte for a make-it-yourself battery, Gatorade® or saltwater?

Science Content

- A battery is made of 2 electrodes and an electrolyte.
- The electrodes are made of two different metals.
    - The copper nail is the positive (+) electrode, called the **cathode**.
    - The zinc nail is the negative (-) electrode, called the **anode**.
- Electrolytes have two roles in a battery.
    - Block electrons from moving from the anode to the cathode within a battery. This way electrons at the anode, must travel through a device to get to the cathode.
    - Support chemical reactions at the anode and cathode that allow electrons to move.

Materials

- 200 copper nails
- 2000 zinc nails
- 8 ice cube trays
- 6 food service trays
- 12 wires with alligator clips at both ends
- Small light emitting diode (LED), 5 mm bulb, any color (2.0V - 2.8V)
- 2 containers of table salt, 26 oz size
- 48 bottles of Gatorade, 20 oz size, any flavor or color
- Tap water in two-liter size water bottle
- Bowl
- Medicine cup, 30 mL
- Plastic beaker, 150 mL
- Masking tape
- Copper tape, 1-inch width
- Scissors or 1-inch hole punch

Safety Requirements

- LED bulbs have sharp ends. Use caution when handling them.
- Warn children that alligator clips can pinch skin and hurt. Demonstrate careful use of them.

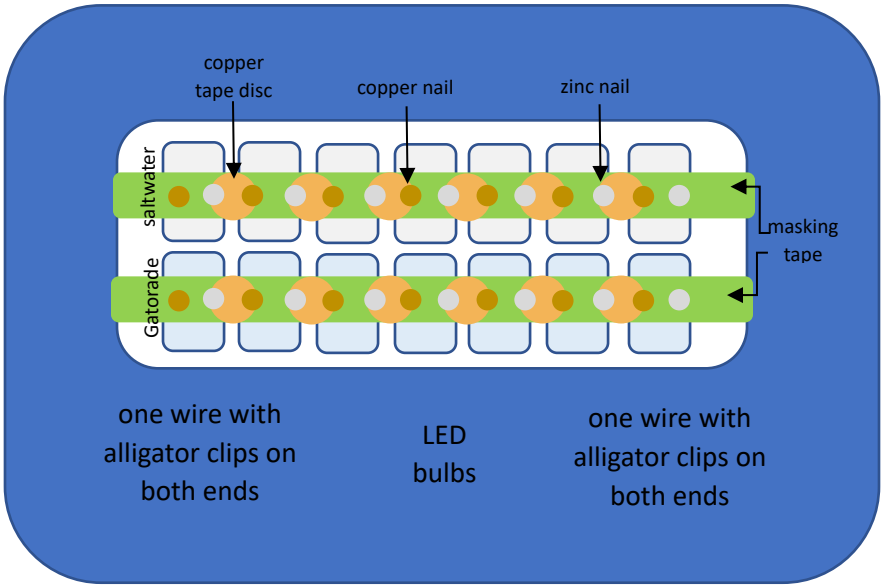
Preparation

Prior to the activity

1. Use the hole punch to cut copper tape discs that are 1-inch in diameter. If you do not have a hole punch, cut approximately 1-inch squares with scissors.
2. Label 2 two-liter bottles *saltwater* and 2 other two-liter bottles *used saltwater and Gatorade*.

Prepare on site

1. Make a saltwater solution by adding 200 mL (approximately 300 grams) of salt to 1L of water in the bottle labeled *saltwater*.
2. Close the lid, hold it securely, and shake the bottle until the salt dissolves.
3. Fill a beaker with approximately 140 mL of saltwater and then evenly distribute the liquid into the 7 wells along one row of the ice tray.
4. Pour approximately 20 mL of Gatorade into each of the wells on the other side of the ice tray.
5. Cut a piece of masking tape long enough to cover the ice tray lengthwise. Tape it over the wells containing saltwater and tuck the ends under the lip of the ice tray. Do the same for the other row.



6. Peel the paper backing off a copper disc and arrange it so that it is centered over the wall between two wells. Continue peeling and sticking until all 12 copper discs are placed as shown in the diagram.

7. Push copper and zinc nails into the masking tape, and copper tape. There will be one copper and one zinc nail in each well.
8. Arrange 6 food service trays along the front of each of two tables so that they are within easy reach of participants. Place items on each tray as indicated in the diagram on the previous page.

Onsite activity		
Step	**Details**	**Ask participants**
Review the key parts of a battery	• Batteries are made with the same essential parts—two electrodes and an electrolyte. • There are two batteries in this ice cube tray. Each long row is one battery. Each little container inside each row is one cell of the battery.	• Where are the electrodes? • What are the electrodes made of? • Where are the electrolytes? • What are the electrolytes made of? • How many cells are in each battery?
Introduce the question to investigate	• Which is a better electrolyte for a make-it-yourself battery, Gatorade® or saltwater? • Let's try it!	• Which battery would you like to test first?
Test the battery in one row	**Direct participants to:** • Connect one end of an alligator clip to the copper cathode on either the saltwater or Gatorade battery. • Connect one end of another alligator clip to the zinc anode at the end (or start) of the same row. • Close the circuit by adding an LED! Connect the longer leg of the LED to the copper cathode and the short leg to the zinc anode.	• Does the bulb light? • Does it matter which way you turn the LED bulb? • Do all the colors of bulbs light up? • What happens if you remove an electrode? • Does it matter which one you remove? • What happens if you use fewer than 7 cells?
Trace the path of the electrons through the battery.	• Trace the path of the flow of electrons from the zinc anode through the short leg of the LED into the bulb, out the long leg of the LED and to the cathode.	

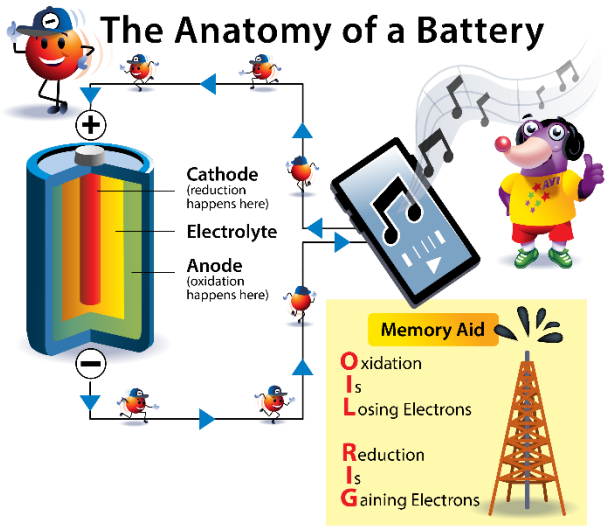
	• Point out that each cell is connected to another by a circle made of copper tape. When the circuit is closed, electrons move through the copper tape from one cell to the next. • Batteries store energy in chemical bonds and when the circuit is closed chemical reactions convert the chemical energy into electrical energy. This is how batteries can provide the electricity needed to make phones, toys, and game controllers work.	
Connect and test the other battery in a similar way	**Direct participants to:** • Connect one end of an alligator clip to the copper cathode on either the saltwater or Gatorade battery. • Connect one end of another alligator clip to the zinc anode at the end (or start) of the same row. • Close the circuit by adding an LED! Connect the longer leg of the LED to the copper cathode and the short leg to the zinc anode.	• Does the bulb light? • Does it matter which way you turn the LED bulb? • Do all the colors of bulbs light up? • What happens if you remove an electrode? • What happens if you use fewer than 7 cells?
Re-ask the question to investigate	• Explain that salts, such as table salt, or the different salts in Gatorade react with the electrodes providing electrons ready to move. The saltwater is saltier than the ocean and would not be good for our bodies. However, it is good at helping electrons flow. • Connecting each battery to a device like a bulb, closes the circuit so that electrons move, and *moving electrons is electricity*.	• Which is a better electrolyte for a make-it-yourself battery, Gatorade® or saltwater? • How do you know?

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 liquid 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 cathode and anode can never touch.

In your make-it-yourself battery, you tried two different liquids to see which one was the better electrolyte. The bulb lit when you used both saltwater and Gatorade, or a similar drink containing "electrolytes." While the salts in these drinks are meant to restore electrolytes that your body loses when you exercise and sweat, they also work well enough to make a low-voltage battery.

Good electrolytes do two things. One is that they block electricity from flowing between the cathode and anode. This forces the extra electrons at the anode to move through your device to get to the cathode. The second thing that good electrolytes do is help the chemical reactions happen at the anode and cathode. If you'd like to test other liquids in your battery, try substances that contain salts, like Epsom salt, or drinks that say that they contain electrolytes. You may also try acidic substances, such as lemon juice or vinegar. Gatorade contains citric acid for a pleasant sour taste and salts. This combination makes it, and other sports drinks good electrolytes for a make-it-yourself battery.