IMHOTEP'S LEGACY ACADEMY

9.4 Making a Battery

Grade 9 Activity Plan

Reviews and Updates

9.4 Making a Battery

Objectives:

1. To introduce basic concepts of electric current.
2. To distinguish between conductors and insulators and know their basic characteristics.
3. To understand how a battery works.

Key words/concepts: cell, battery, conductors, insulators, electromotive force, potential difference, voltage, current, electricity, electrochemical series, electrochemical cell, electrode, electrolyte, series connection, parallel connection.

Curriculum outcomes: 109-14, 209-3, 308-16, 308-17.

Take-home product: battery made from lemon.

Segment	Details
African Proverb and Cultural Relevance (5mins)	"It takes all sorts to make a world" -Nigeria
Pre-test (10mins)	Ask probing questions on students' knowledge of batteries and encourage them to list devices that are powered by batteries.
Background (10mins)	Discuss the two main types of batteries (Wet and Dry Cells).
Activities (45mins)	1. Demonstrate the flow of current using AA batteries 2. Build simple cells using zinc and copper electrodes in a weak acid solution (vinegar) and testing the strength of the simple cell. 3. Measure the conductivity of the simple cell using a diluted electrolyte. 4. Make batteries from fruits and vegetables.
Follow-up (10mins)	Allow students fill in any remaining spaces in their data table. Encourage them to ask questions about anything they did not understand. Review the important terms so they feel confident when you ask them the questions in the post-test.
Post-test (10mins)	Question and Answer segment based on experiments and findings.

Possible interpretation of proverb: Learn to appreciate diversity in life and be accommodating to new concepts, ideas and cultures because every human being cannot be the same. In this activity, one will observe that a battery is made up of various components.

This short video has a very interesting demo. It is suggested that the students see it.
http://www.youtube.com/watch?v=9_LLj4_3ZRA
This could also be helpful
http://www.youtube.com/watch?v=AY9qcDCFeVI

Cultural Relevance

Elijah McCoy, was born on May 2, 1844, he attended public school until the age of 15. His parents were able to save enough money to send Elijah to school in Edinburgh, Scotland to learn mechanical engineering in 1859/1860. Elijah returned to Canada after the Civil War was over, living with his family for about a year before moving to Ypsilanti Michigan.

The management of the Michigan Central Railroad could not imagine that a Negro could be an engineer, but did hire him as a train fireman/oilman. He had to stoke the boiler and lubricate the steam cylinders and sliding parts of the train.

One of the problems of hot, high pressure steam is that it is murderously corrosive of most metals, and a thin film of lubrication is required to protect and seal the steam cylinders and pistons.

In 1872 Elijah patented (U.S. Patents 129,843, which was issued on July 12, 1872) his first invention: a self-regulating lubricator that utilized the steam pressure in the cylinders to operate the valve.

Within ten years, his device was so successful that buyers of steam trains and steam engines used in mines and factories would ask if the lubrication systems were the "Real McCoy".

In 1882 Elijah moved to Detroit, Michigan. He performed consulting work for local firms and worked on his own inventions.

Over the course of his life he was granted fifty-two patents, most of which were for improvements in steam engines, although he did patent a folding ironing board and self propelled lawn sprinkler.

In 1916 he patented what he described as his greatest invention, the "graphite lubricator", which used powdered graphite suspended in oil to lubricate cylinders of "super heater" train engines.

He finally established his own company in 1920 - the Elijah McCoy Manufacturing Company. Elijah used up his money trying to perfect his inventions. He was broke and alone when he was admitted to Eliose Infirmary in 1928. He died a year later.

Whatever the reason, we still know that when we want the best, we ask for the "Real McCoy".

BACKGROUND INFORMATION

Car batteries have plates of lead and lead dioxide, with sulphuric acid between them. There are usually six cells together to make a 12 volt battery. This battery is heavy and full of acid but can produce huge electric currents for long periods of time. It works well even if it is very cold, it does not foul up and can be recharged. Recharging means that the chemical reactions which occur while the battery is in use (both plates change to lead sulphate as the car battery drives a current) can be reversed by passing a reverse electric current, from the car's generator, through the battery.

The original "dry" batteries have a damp paste of ammonium chloride (a salt, this time) between a zinc plate, usually the battery container, and a carbon rod. (Carbon conducts electricity, so can be used instead of a metal.) A paste is a lot more convenient than a liquid for portable batteries.

While there are many different types of batteries, the basic concept by which they function remains the same. When a device is connected to a battery, a reaction occurs that produces electrical energy. This is known as an **electrochemical reaction**.

Inside a battery are a **cathode**, which connects to the positive terminal, and an **anode**, which connects to the negative terminal. These components, more generally known as **electrodes**, occupy most of the space in a battery and are the place where the chemical reactions occur. A **separator** creates a barrier between the cathode and anode, preventing the electrodes from touching while allowing electrical charge to flow freely between them. The medium that allows the electric charge to flow between the cathode and anode is known as the **electrolyte**. Finally, the **collector** conducts the charge to the outside of the battery and through the load.
When a load completes the circuit between the two terminals, the battery produces electricity through a series of electromagnetic reactions between the anode, cathode and electrolyte. The anode experiences an **oxidation reaction** in which two or more **ions** (electrically charged atoms or molecules) from the electrolyte combine with the anode, producing a compound and releasing one or more electrons. At the same time, the cathode goes through a **reduction reaction** in which the cathode substance, ions and free electrons also combine to form compounds. The reaction in the anode creates electrons, and the reaction in the cathode absorbs them. The net product is electricity. The battery will continue to produce electricity until one or both of the electrodes run out of the substance necessary for the reactions to occur.

Alkaline battery: This chemistry is also common in AA, C and D dry cell batteries. The cathode is composed of a manganese dioxide mixture, while the anode is a zinc powder. It gets its name from the potassium hydroxide electrolyte, which is an alkaline substance.

Activity 1: Testing AA Batteries

Suggested format: make students form groups of two.

Purpose: to understand current flow in a simple circuit.

Items	**Quantity (for mentor and 10 students)**
Alligator Clips	12 (small size)
LED	6 bulbs
AA Batteries	12
Lead Connectors	12

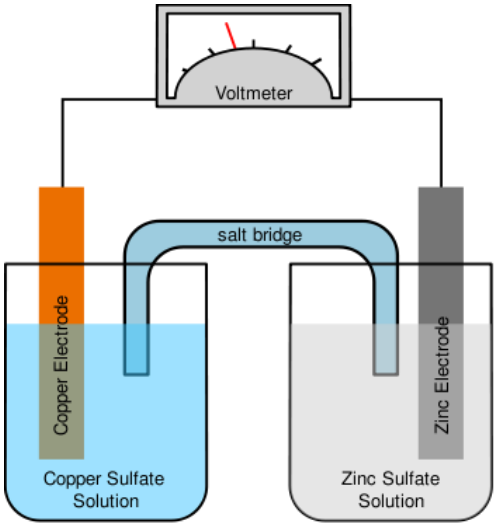
Procedure:

1. Attach one lead connector to the right side of the LED
2. Attach another lead connector to the left side of the LED.
3. Place the loose end of the lead connector from the right side of the LED to one terminal of the AA battery.
4. Place the loose end of the other lead connector from the left side of the LED to the other terminal of the AA battery.
5. Let students try experiment with two batteries connected in series and monitor the outcomes (LED becomes brighter).
6. Measure and record the voltage and current of each variation.

Current flows only in one direction; if the LED does not light up check to make sure the wires are connected to the correct terminals.

Activity 2: Building a Battery With Vinegar.

This image serves as a representation of the activities. The copper and zinc electrodes are the same as the experiment. However, the solution is not copper or zinc sulfate but rather vinegar. The salt bridge is replaced by a copper-zinc connector.



Suggested format: mentor should perform activity and encourage students to actively participate.

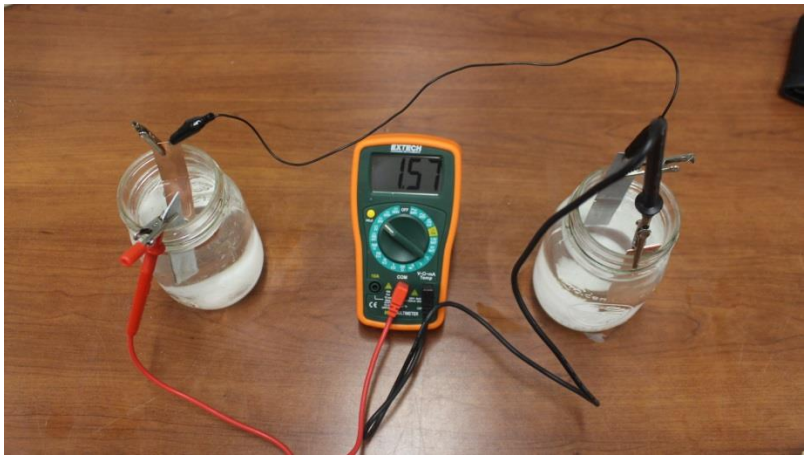
Purpose: to understand how a battery works and know the functions if different parts of a battery.

Items	**Quantity (for mentor only)**
Alligator Clips	9
Vinegar	600mL
Copper electrodes	8
Zinc electrodes	8
Multimeter	1
LED	6
Lead connectors	2
Small glass jars	4

Procedure:

1. Fill two glass jars with 100 ml of vinegar.

2. Connect the circuit as shown in the figures below. Connect the negative (black) wire from the multi-meter to a copper electrode and the positive wire from the multi-meter to a zinc electrode.
3. Place a zinc and copper electrode to connect the two jars as shown in the figure below. Insert the copper electrode connected to the negative terminal of the multi-meter into the vinegar solution.
4. Insert the zinc electrode connected to the positive terminal of the multi-meter into the vinegar solution as shown in the figure. Ensure that there are **two different electrodes** in each glass jar.
5. Measure and record the voltage and current from the multi-meter.
6. Remove the multi-meter and replace with an LED
7. As long as you record an adequate voltage, the LED should light up



Note: connect more jars in series in order to increase potential difference.

Activity 3: Effects of Changing the Electrolyte and Electrodes

Purpose: to explore the effects of changing the concentration of the electrolyte on the output of the cell.

Items	**Quantity (for mentor only)**
Alligator Clips	9
Vinegar	450mL
Water	150mL
Copper electrodes	8
Zinc electrodes	8
Multimeter	1
LED	6
Lead connectors	2
Small glass jars	4

This is the same as Activity 2 except the variable manipulated is the electrolyte; the vinegar is diluted.

Make a solution containing 25% vinegar, 75% water (3:1 ratio).

Procedure:

1. Turn the multi-meter off.
2. Remove the LED from the Circuit and replace with the multi-meter.
3. Remove the electrodes connected to the multi-meter from the Glass Jars and place them in front of you (Be sure not to dislodge any of the connections).
4. **Discard** the vinegar and replace with **dilute** vinegar.
5. **Wipe down** the Electrodes with paper towel
6. Place the Electrodes back into the solution.
7. Turn the multi-meter on.
8. Measure and record the voltage and current through the voltmeter.
9. Replace the voltmeter with an LED.
10. Observe the brightness compared to Activity 2.

If possible, obtain two **dissimilar** electrodes (other than copper and zinc) and redo Activity 3.

Activity 4: Making Batteries from Fruits and Vegetables

Suggested format: this should be a group activity. All participants should be involved including mentor.
Follow this link for more ideas:
http://pbskids.org/zoom/activities/sci/lemonbattery.html

Purpose: to understand that the juice in some fruits are electrolytic.

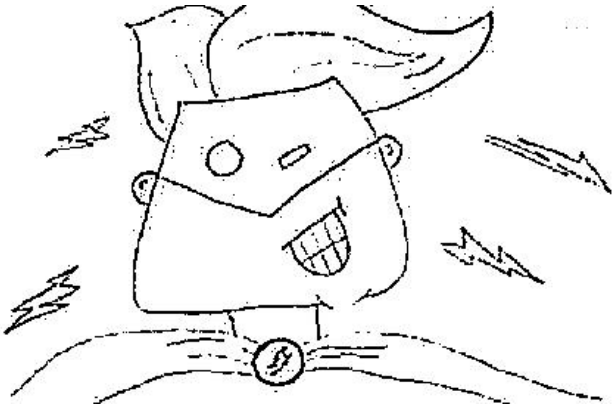
Items	**Quantity (for mentor and 10 students)**
Alligator Clips	12 (small size)
LED	1
Pennies	10
Lead Connectors	12
Lemons	10
Paper clips	10

Procedure:

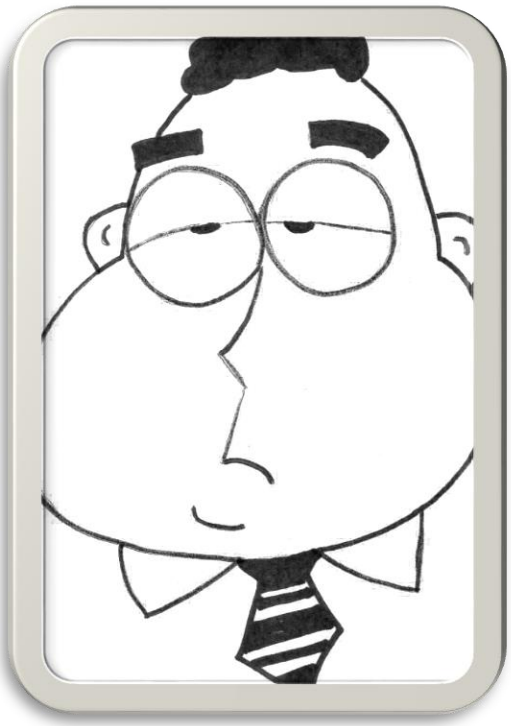
1. Attach one of the paperclips to a wire.
2. Attach a penny to a second wire.
3. Attach a penny to one end of the third wire and a paper clip to the other end.
4. Squeeze lemons to 'pop' the pulp inside of the; do not squeeze too hard in order not to squash it.
5. With a knife/blade, make two small cuts about an inch apart.
6. Insert the paper clip that is attached to the wire and the penny into one of the cuts until you get to the juicy part of the lemon.
7. Insert the penny into a hole in the other lemon.
8. Insert the other paper clip into the second hole of the lemon with the penny.
9. Now insert the remaining penny into the last cut.
10. Measure the potential difference between the terminals and attempt using the setup to power a LED.

Note: one can increase the voltage by adding more lemons to the set up. DO NOT FORGET TO SQUEEZE THEM. Also, potatoes can be used for this experiment.

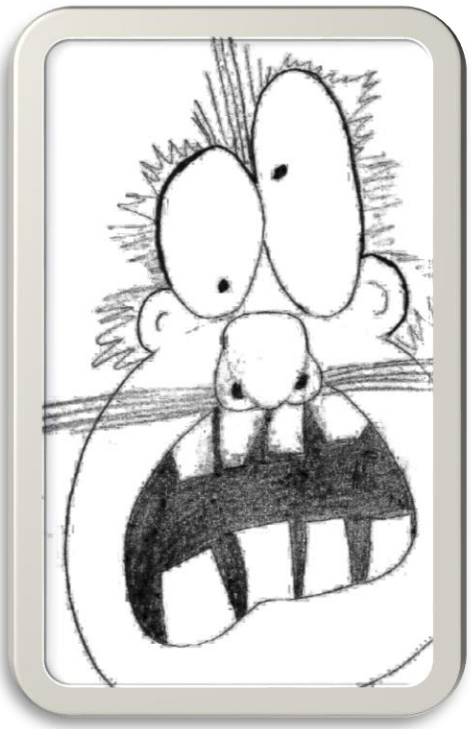
The Electric Man *by Nicholle Morrison (mentor)*



This fictional character can imaginatively create dangerous currents (shock). But realistically eels found in Amazon/South America have specialized muscle cells called electrocytes that can be "piled" together in its body (like the battery made in this activity) to create high voltage.
Electric man is even less realistic than a real life eel because water is a much greater conductor of electricity than air.



This is what someone could look like before coming in contact with electric man (or an electric eel)



And what they might look like after being in water conducting up to 10,000V generated by an electric eel

Follow this link for more information
http://www.sciencedaily.com/releases/2008/10/081002172534.htm

Data Table:

Direct students to fill out the table below as they follow through each activity. Extra rows are provided in case additional items are tested.

Vinegar is a weak acid, more formally known as acetic acid. It is typically found in stores as 4 or 5 percent acetic acid. For activities 1, 2 and 4, pure vinegar should be used. Activity 3 tests the effect of diluting the electrolyte. Since the vinegar is diluted 3 parts water to 1 part vinegar, the percent acetic acid is simply divided by 4. A 4% solution would become 1% acetic acid. A 5% solution should now be recorded as 1.25%.

Activity	**Object Tested**	**% Acetic Acid**	**Voltage** (Volts)	**Current** (Amps)
1	'AA' Battery			
	2 'AA' Batteries			
2	White LED			
	Red LED			
3	White LED			
	Red LED			
4	White LED			
	Red LED			

Post-test

Compare numbers recorded for voltage and current for experiment 2 and 3.

- Which gave the highest current?
- Did pure vinegar or dilute vinegar produce more current?
- What do you expect to happen if we use a stronger acid?

Which of the experiments gave the highest voltage?
How is this related to the brightness of the LED?
The higher the voltage, the higher the current, hence the brighter the LED.

Discuss why batteries can stand alone for long periods of time without getting discharged
No connection between the positive and negative terminal to drain power from the battery.

What do I have to do if I want to power a heavier load?
There are several correct answers:

- Use electrodes with larger surface area
- Use a more concentrated electrolyte
- Connect batteries in series

What is the effect of using different types of electrodes?
Using different electrode pairs can either reduce or increase the voltage from the battery.

What is the charge of an electron? What effect does it have on an atom?
What is the effect of using a stronger electrolyte or liquid?
What is the effect of using an electrode with a larger surface area?
Name the two electrolytes we used for the experiments?
What is the name of the instrument we used to measure the voltage and current through the circuit?
What properties do the lead connectors posses that allow current to pass through them?

Item	**Quantity (10 Students)**
AA Battery	3
LED light (White, Red, Krypton if possible)	5
Wide glass jar (baby food jar)	10
Zinc electrode	20
Copper electrode	20
Iron electrode	20
Lead connectors	20
Alligator head clips	10
Bottle of vinegar (1L) (or lemon juice)	1
Multi-meter	3