Power Up:
Exploring Electrochemistry with Lithium

This STEM activity was designed for the LiTHIUMLEARNS HIRED Grant program.

Power Up — Exploring Electrochemistry with Lithium (4th and 5th grades)

Students will explore the basics of electrochemistry by building a simple Galvanic cell using copper and zinc electrodes, a salt bridge, and lemon juice or vinegar as the electrolyte. They'll use a multimeter to measure the voltage produced and relate their findings to how lithium powers batteries in everyday life.

Arkansas Science Standards Alignment:

- **4-PS3-2**: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
- **4-PS3-4**: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
- **5-PS1-3**: Make observations and measurements to identify materials based on their properties.
- **5-PS1-4**: Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

Materials (per group):

- 1 small **plastic or glass cup**
- **Lemon juice** or **white vinegar** (electrolyte)
- **Copper strip** (penny cleaned with sandpaper or copper wire)
- **Zinc strip** (galvanized nail or zinc-coated washer)
- **Paper towel** or coffee filter strip (salt bridge)
- **Salt water** (1 tsp salt in ½ cup warm water)
- 2 **alligator clips** and wires
- **Multimeter** (digital, to measure voltage)

Intro:

- Begin with a question: "What powers your tablet, flashlight, or robot?"
- Introduce **batteries** as tools that **turn chemicals into electricity**.
- Show images or a video of a **lithium-ion battery** and explain lithium's special role in powering devices.

Procedure:

- Build a Galvanic Cell:
  - Fill cup halfway with lemon juice or vinegar.
  - Insert copper and zinc electrodes on opposite sides.
  - Dip a paper towel in salt water and drape one end in the lemon juice, connecting the other end to a second cup (if doing a more advanced version) or leave one end in solution to act as a salt bridge.

- Attach alligator clips to each electrode, and then connect to the multimeter.
- Record the voltage reading.

Discussion:

- What happened? The chemical reaction between metals and the acid (electrolyte) produced electricity!
- Define the parts:
  - **Electrode** = metal strip
  - **Electrolyte** = lemon juice
  - **Salt bridge** = helps ions move to complete the circuit
  - **Voltage** = energy available to do work

Power Up: Exploring Electrochemistry with Lithium (Middle School)

Students will explore the basics of **electrochemistry** by building a **simple Galvanic cell** using **copper and zinc electrodes**, a **salt bridge**, and **lemon juice or vinegar** as the electrolyte. They'll use a multimeter to measure the voltage produced and relate their findings to how **lithium powers batteries** in everyday life.

Arkansas Science Standards Alignment (6th, 7th, and 8th grades):

- *MS-PS1-2*: Analyze and interpret data on the properties of substances before and after interactions.
- *MS-PS3-3*: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes energy transfer.
- *MS-ESS3-1*: Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral resources are the result of past and current geoscience processes.

Materials (per group):

- 2 beakers or clear plastic cups
- **Copper electrode** (copper wire or strip)
- **Zinc electrode** (galvanized nail or zinc strip)
- **Lemon juice** or **vinegar** (electrolyte)
- **Salt bridge**: strip of paper towel soaked in salt water
- **Multimeter** (set to voltage)
- 2 alligator clip wires
- Ruler (optional, for measuring distance between electrodes)
- Safety goggles and gloves
- Printed diagrams of Galvanic cells and lithium-ion batteries (for instruction)

Introduction:

- Ask: *"What powers your phone, laptop, or electric car?"*
- Explain: **Lithium-ion batteries** store and release energy using a chemical reaction between two materials (electrodes) and an electrolyte.
- Show a simple animation or diagram of a **lithium-ion battery** and compare it to the Galvanic cell students will build.
- Briefly introduce the role of **lithium**, an element that gives up electrons easily. Connect to **Arkansas's Smackover Formation**, a lithium-rich brine area.
- Break down the reaction at a simplified level:
    - **Zinc loses electrons** (oxidation)
    - **Copper gains electrons** (reduction)

    - The **electrolyte** allows ions to move, and the **salt bridge** keeps the charge balanced.
- Define basic terms: redox, electron flow, electrode, voltage.

Procedure:

- **Build a Galvanic Cell**:
  - Fill a beaker with **lemon juice** or **vinegar**.
  - Insert **copper** and **zinc electrodes** on opposite sides.
  - Connect with a **salt bridge** (paper towel soaked in salt water).
  - Attach alligator clips to each electrode and connect to **multimeter**.
  - Record the **voltage** (should be between 0.6V–1.1V depending on conditions).
  - Optionally, test multiple configurations or additional lemons/cells in series.

Data Collection:

- Students sketch the setup and label:
    - Oxidation and reduction reactions
    - Electron flow direction
    - Ion movement
- Record the voltage

Discussion

- Compare: How is this like a **lithium battery**?
- Ask: What affects the amount of electricity generated?

Power Up: Exploring Electrochemistry with Lithium (High School)

Students will explore the basics of **electrochemistry** by building a **simple Galvanic cell** using **copper and zinc electrodes**, a **salt bridge**, and **lemon juice or vinegar** as the electrolyte. They'll use a multimeter to measure the voltage produced and relate their findings to how **lithium powers batteries** in everyday life.

Arkansas Science Standards Alignment (High School):

- **C.1.PS1.3**: Plan and conduct investigations to compare the properties of ionic and covalent compounds.
- **C.2.PS3.3**: Design, build, and refine a device that works within given constraints to convert one form of energy into another.
- **C.1.PS1.6**: Design a procedure for separating the components of a mixture based on physical and chemical properties.
- **EVS.6.ESS3.3**: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- **EVS.2.ESS3.1**: Analyze geoscience data to explain the uneven distribution of Earth's mineral resources (e.g., lithium).

Materials (per group):

- 2 beakers (100–250 mL)
- Zinc strip (or galvanized nail)
- Copper strip (or clean penny)
- Lemon juice or vinegar (electrolyte)
- Salt bridge (paper towel or filter paper soaked in salt solution)
- Multimeter (set to DC voltage)
- Alligator clip wires
- Lab notebook or worksheet
- Optional: potassium nitrate for a true salt bridge

Intro:

- Ask: "How do lithium-ion batteries work? Why are they so important today?"
- Show a short video or infographic explaining how lithium-ion batteries use **redox reactions** to power devices.
- Introduce Arkansas's **Smackover Formation**, a major source of lithium-rich brine, and discuss **Direct Lithium Extraction** (DLE) as a more sustainable alternative to open-pit mining.

Procedure:

- **Build a Galvanic Cell**
  - Fill two beakers with lemon juice or vinegar.
  - Place a **zinc electrode** in one and a **copper electrode** in the other.
  - Connect the two beakers using a **salt bridge** (soaked salt water paper towel or actual salt bridge).
  - Use alligator clips to connect electrodes to a **multimeter**.
  - Measure and record the **voltage** (expect ~0.9–1.1V).

Data Collection:

- Students sketch the setup and label:
  - Oxidation and reduction reactions
  - Electron flow direction
  - Ion movement
- Record the voltage

Discussion:

- Identify:
  - Anode: Zinc (oxidation occurs)
  - Cathode: Copper (reduction occurs)
- Discuss electrode potentials and how they generate voltage.
- Students analyze similarities/differences between their Galvanic cell and a lithium-ion battery.