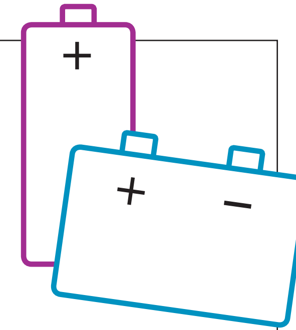


BATTERIES OF YESTERDAY AND TODAY

Give your students a “jolt” with a fun innovation challenge inspired by Alessandro Volta’s original battery!

Objective

Students will explore the oxidation/reduction chemical reaction firsthand and design an engineering solution for a real-world problem.

NGSS Standards

HS. Chemical Reactions
HS-PS1 Matter and Its Interactions
HS-ETS1-2 Engineering Design

Materials

Session 1

- The Power of Batteries reading passage
- Build a Battery activity sheet

To build a voltaic pile:

- Pennies minted prior to 1982
- Nickels
- Scissors
- Thick paper towels
- Pickle juice
- Plastic clamps
- Auto-ranging voltmeter with 200 mV DV measurement capabilities

Session 2

- Engineering Innovative Materials lesson and Drive Progress activity sheet (**bit.ly/2ytc6t1**)

Session 3

- Innovators of Tomorrow Contest entry forms
- Contest Entry Planner

Session 1: 75 minutes

1 **Kick off** the lesson with a discussion. What kinds of technology make a cell phone portable? Welcome all responses and narrow focus on the cell phone’s battery. What kinds of engineering innovations and advanced manufacturing techniques might have taken place to create a battery that is compact, lightweight, and long-lasting enough to carry around in your pocket? What are some of the other places batteries are used? Think large and small.

2 **Distribute** The Power of Batteries reading passage and Build a Battery activity sheet. Have students read the passage and complete the questions on the activity sheet.

3 **Supply** groups of students with the materials required to create their own voltaic pile. Troubleshoot as needed.

4 **Wrap up** with a discussion. What are some of the limitations of the voltaic pile? What are some of the obvious reasons it isn’t a suitable choice for powering a cell phone or using in place of a car’s battery? Prompt for ideas like: *requiring human intervention to keep the electrolyte moistened, voltage, doesn’t recharge itself, size, shape, etc.* Ask students to consider how the needs and constraints of a design problem are important to solve for when engineering and how these same needs and constraints can be used to drive innovation forward.

Session 2: 75 minutes

1 **Ask** students to recall the reading passage from the first session. Once the battery had been invented, other innovators began to wonder about how basic battery principles could be built and improved upon. Have your students examine some of the ways scientists are innovating new materials and power sources.

2 **Download** and deliver the Engineering Innovative Materials lesson.

3 Have students **complete** the accompanying Drive Progress activity sheet and consider some of the real-world constraints associated with innovation.

Session 3: 60–120 minutes

1 **Encourage** students to see themselves in the role of inventor and innovator. What kind of advanced manufacturing solution could they develop to address a real-world problem?

2 **Distribute** the Innovators of Tomorrow Contest entry forms and Contest Entry Planner. Support students as they create and submit their entries.

MORE LESSONS AND ACTIVITIES

For more innovation inspiration, introduce students to an invention designed to rid the world’s oceans of plastic (**bit.ly/2SZ7XXx**) and robotics technology that allows humans and robots to work together in new ways (**bit.ly/331urvn**).

Name ________________________________

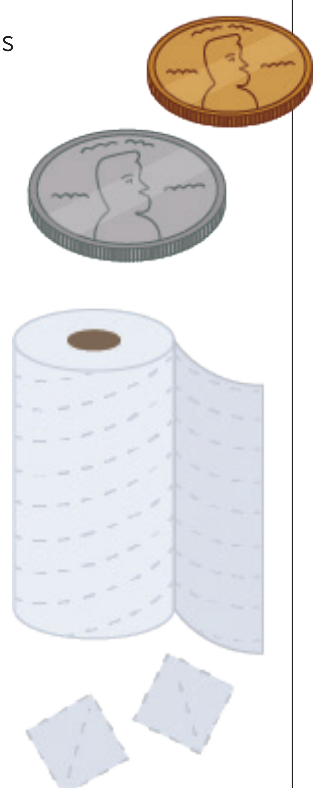
BUILD A BATTERY

Read The Power of Batteries passage and answer the questions below on a separate sheet. Then, work in groups to build a simple battery of your own.

Respond to the reading

1. **Choose three of the bolded terms** in the passage. Use plain language to explain their meaning.
2. In your opinion, **what was the most important innovation** in batteries? Explain your thinking.

Build and test



3. Assemble your materials and follow the steps below. **Materials:** four pennies (minted prior to 1982), four nickels, paper towel, pickle juice, plastic clamp, scissors, voltmeter.

   a) **Cut** paper towel into squares roughly the size of a penny and dip in brine (paper towel should be damp, not dripping).

   b) **Create** one voltaic cell by stacking a nickel, a layer of brine-soaked paper towel, and a penny. Clamp your cell and use the voltmeter to measure its voltage.

   c) **Unclamp** and continue adding cells to your pile following the towel-nickel-towel-penny-towel-nickel pattern. Re-clamp and test with the voltmeter as you add more cells.

   d) **What are your findings?** Roughly how much voltage does each cell contribute to your battery? About how many cells would it take to send current to a 19-volt laptop?

Create a diagram

4. Now that you have seen it in action, **draw a diagram** of a voltaic pile powering an electronic device of your choice. Use the images and the information in the reading passage to help you. Be sure to:

   a) Label the following: voltaic pile, one voltaic cell, electrolyte, cathode, anode, wire, electronic device, positive terminal, negative terminal.

   b) Use arrows to demonstrate the flow of electrons.

READING PASSAGE

The Power of Batteries

Learn the fascinating history and science behind this groundbreaking electrical invention.

Batteries power so many things in your everyday life that you probably don't think twice about them. Around 1800, an Italian physicist and chemist named Alessandro Volta created a simple battery called the voltaic pile, but before then there was no such thing as portable electricity. In his experiments, Volta found that stacked disks of copper and zinc, separated by cloth or paper soaked in a salty solution, would produce a small amount of electrical energy (see diagram on next page). The energy was the result of a chemical reaction known as **oxidation reduction**, or **redox** for short.

IN THE CHEMISTRY LAB

If you connect the positive and negative terminals of a voltaic cell with a wire, the zinc begins to lose its electrons in a process called oxidation. They then move toward the copper in a process called reduction (you can remember this as: Because electrons are negative, they reduce positive charge).

Oxidation reduction is an **exothermic reaction**, meaning that energy is released as the reaction occurs. Volta's discovery meant that **potential chemical energy** could be "stored" in a battery and used in the form of electrical energy whenever the time was right. The more voltaic cells that were stacked, the greater the voltage.

MODERN INNOVATORS

The invention of the battery made power supply portable, but the practical applications of the voltaic cell were very limited. Enter the innovators who continued to improve the battery by engineering and experimenting with new materials, creating batteries that were more reliable, more powerful, easier to use, and longer-lasting. Notable advances in battery science include:

The Daniell Cell: the first practical source of portable power that provided a longer and more reliable current than Volta's. Example application: telegraphy.

Lead-Acid Battery: the first battery that could be recharged. Example application: car battery.

The Dreaded Dead Battery

How annoying is it when your cell phone battery dies? With any battery, eventually the anode has no more electrons to supply, and the battery will die or go flat. **Some batteries, like the one in your phone, are designed to be rechargeable**. The same electrochemical processes that allowed the battery to supply power are reversed using an external power supply (such as plugging a cell phone into its charger). The reverse flow of electrons restores the battery's power-giving abilities.

continued

Zinc-Carbon Battery: the first dry-cell battery. Unlike wet cells, the zinc-carbon battery would not spill and did not have to be kept upright. Example application: flashlight.

Alkaline Battery: achieved better energy density (could store more energy per unit of volume) than its predecessors. Example application: television remote.

Lithium-Ion Battery: significant advancements in energy density and the ability to recharge more than a thousand times. Example application: cell phone.

In the future, you may be using batteries that are paper-thin and have the ability to recharge hundreds of thousands of times. As with any innovation process, though, there will be setbacks along the way. Batteries have their share of problems, including both safety and environmental concerns. A battery that has significant energy density, for instance, will cause a dangerous explosion if its cathode and anode accidentally come into contact. Over their history, batteries have been manufactured using heavy metals such as mercury and lead along with other components. They must be recycled responsibly because they pose a threat to humans and the natural environment.

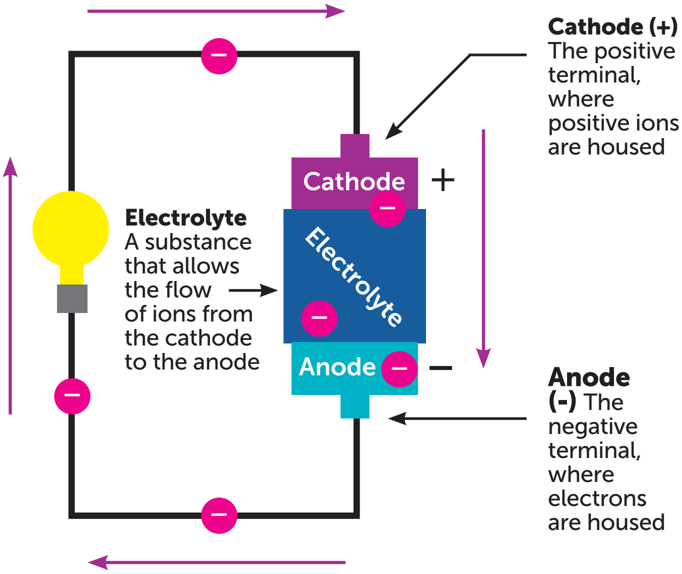
Are you the next innovator? How could you make a battery that is more environmentally friendly? A battery that holds a charge longer that is lighter, smaller, safer, or stronger?

What's a frog got to do with it? Do a quick online search to find out how the very curious behavior of a dead frog inspired Volta's battery experiments.

Or what about a battery that could recharge an infinite number of times? Challenge yourself to come up with the next great idea!

The Anatomy of a Battery

A battery you bought at the store last week and the earliest versions of batteries have the same three components in common. Check out the diagram below: When a wire closes the circuit or connects the cathode and the anode, electrons: a) move into the wire from the anode, b) power a device, and c) continue on their way back to the cathode.



Voltaic Pile

The voltaic pile is made up of individual cells that are stacked to increase the amount of voltage.