NATIONAL ELECTRONICS MUSEUM

Lesson Plan:

Flow of Electrons, Circuits, and Batteries

Grades 3rd-5th

NGSS Standards:
Engineering and Design

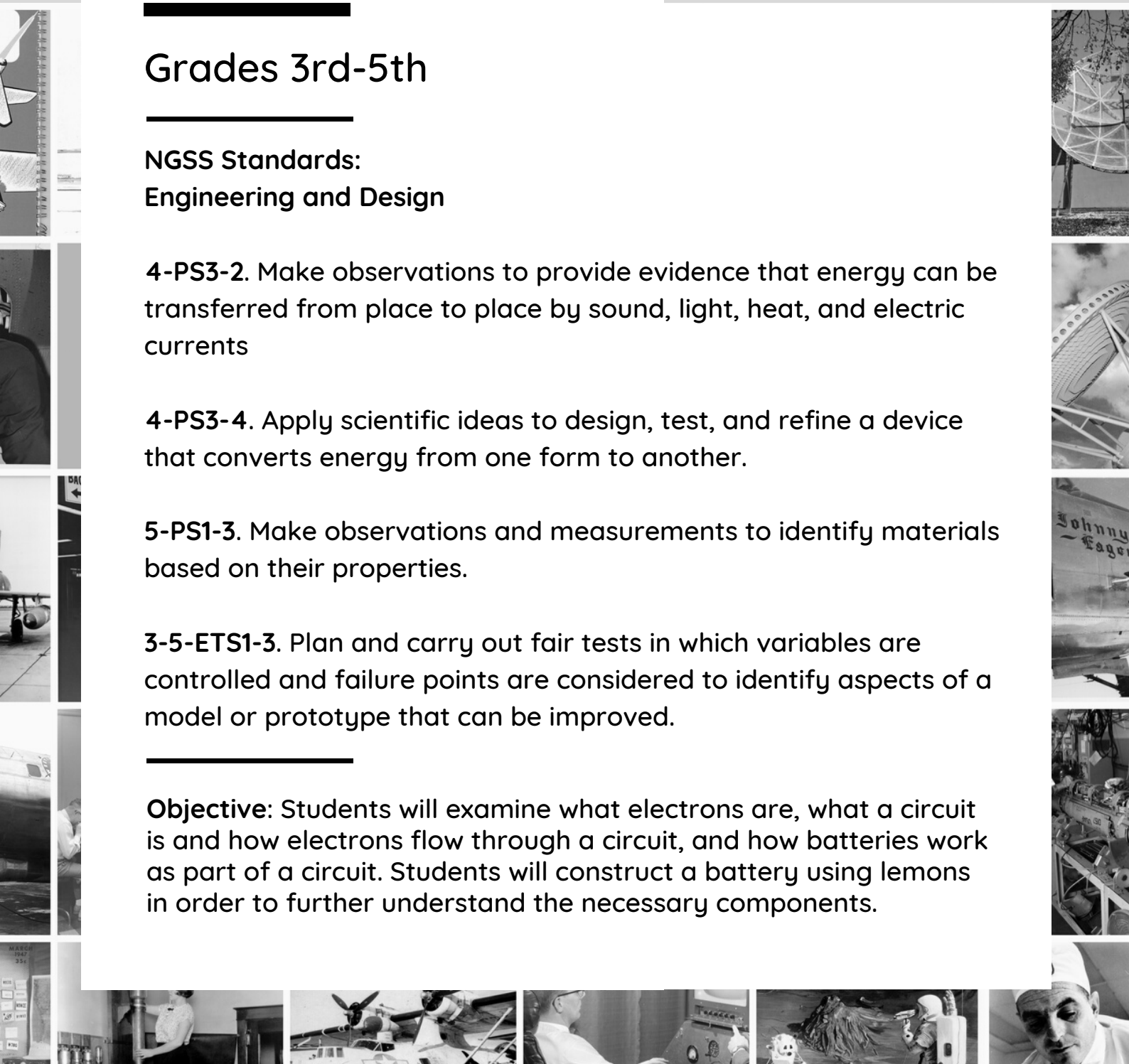
4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents

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.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Objective: Students will examine what electrons are, what a circuit is and how electrons flow through a circuit, and how batteries work as part of a circuit. Students will construct a battery using lemons in order to further understand the necessary components.



Overview

Part 1

Lesson Introduction (~15-20 minutes)

- Students will complete the reading on Part #1, the short “Introduction” paragraph and the “Parts of an Atom” reading section.
- Have students complete Quiz #1 questions

Part 2 (~15-20 minutes)

- Students will read the sections entitled “Electric Circuits” and “Introduction to Batteries”
- Student will complete Quiz #2

Lab: Lemon Battery (~30 minutes)

- Students will follow along with the video clip and/or the written instructions to conduct the lemon battery experiment.
- After students have successfully created their lemon battery, answer the reflection questions (Quiz #3)

Student Learning Goal:

- By the end of the lesson, students should be able to name and define the three particles of an atom, understand what a circuit is, and how electrons flow through the circuit, and how electrons flow through a battery.
- Be able to build and explain the parts of their lemon battery.

Outline

1. Part 1: **Introduction**
    a. Reading on Parts of an Atom
    b. Quiz #1
2. Part 2: **Electric Circuits**
    a. Electric Circuits Reading
    b. Introduction to Batteries Reading
    c. Quiz #2
3. Lab: **Build a Lemon Battery**
    a. Lab
        i. Video “Lemon Light”
        ii. Materials
        iii. Prepare your Materials
        iv. Instructions
    b. Quiz #3
4. Glossary

Flow of Electrons, Circuits, and Batteries

Part I

Introduction

Think about all of the electronic devices you have. Video games, a tablet, a cell phone, computer, etc. The reason all of these amazing and fun devices work, is due to **electricity**. We can define electricity as a form of energy resulting from the flow of charged particles. But how does this flow of electric charge light up LED lights and power all of our electronic devices? To begin to understand, we have to take a look at atoms.

Parts of an Atom

An **atom** is the basic building block of matter. Anything that has mass, meaning anything that takes up space, is made up of atoms. Atoms are made up of smaller particles, called subatomic particles. There are three types of subatomic particles are: protons, neutrons and electrons. **Protons** have a positive charge (+), **neutrons** are neutral, meaning they don't have a charge, and **electrons** have a negative charge (-). Protons and neutrons are packed together in the center nucleus of the atom, while the electrons orbit, or circle around the nucleus.

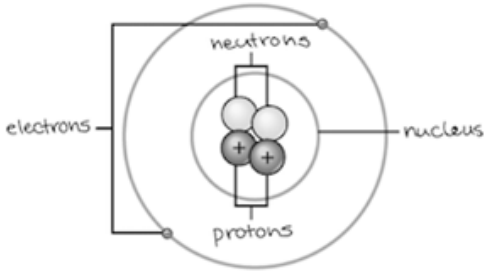


Image credit: modified from OpenStax CNX Biology

The electrons float around the outer orbit of the atom. With enough force, electrons can escape the orbit and become **free electrons**. This means they can be shared with or transferred to another atom. And free electrons allow charges to move or flow, which is what electricity is all about!

When we are talking about **electric current**, we are talking about the continuous flow of electrons in an electric circuit.

In the next section, you will find out what a circuit is, and how electricity flows through a circuit.

Flow of Electrons, Circuits, and Batteries

Quiz #1

Directions: Use the reading above to answer the following questions.

1. The building block of all matter is called an _____.
2. What are the three smaller parts, or subatomic particles of an atom?
3. What is the negatively charged particle that orbits the nucleus of the atom?
    a. Proton
    b. Neutral
    c. Electron
    d. Neutron
4. The continuous flow of electrons in an electric circuit is called _____ _____.

Answer Key:
1. Atom
2. Protons, Neutrons, Electrons
3. C
4. Electric Current

Part II

Electric Circuits

What is a circuit? A **circuit** is a closed loop or path around which **electric current** can flow. An **electric current** is a flow of negatively charged particles called electrons, that flow throughout all parts of the circuit following the path of the conductive wires. To know more about conductors and insulators, visit our Insulators and Conductors lesson plan page!

Electric circuits can be simple or complex, but all circuits have three main parts: **1)** wires that carry the current through the circuit, **2)** a lightbulb, motor or any other device that uses electricity do work, **3)** and a power source, such as a battery. In addition, most circuits have a switch that turns the power on and off.

In order for a circuit to work it has to be a closed loop, meaning all of the part of the circuit are connected. When all of the parts are connected, the **electric current** can flow, and the lightbulb will light up, for example. If there is a break in the circuit, or the switch is off, electric current will not flow through the circuit.

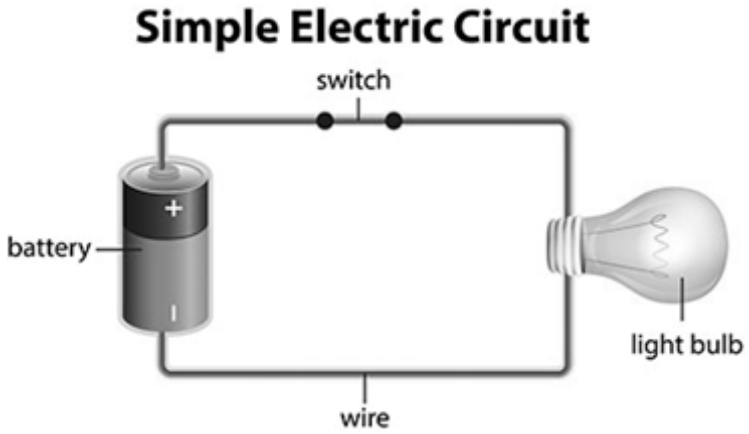
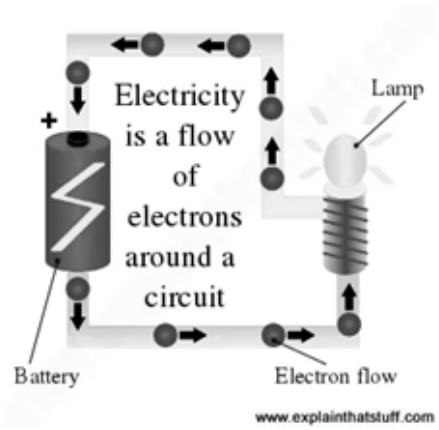


Image Source:
https://accessdl.state.al.us/AventaCourses/access_courses/physci_ua_v16/08_unit/08-06/08-06_learn.htm

Part II, continued

When we talk about current flowing through a circuit, we are talking about the electrons flowing through a circuit. As electrons move around the circuit, they are carrying electrical charge with them.



But what does an electric circuit have to do with batteries? In short, the battery is the power source that pushes the electrons around circuit and that is why the lightbulb glows.

Read on to find out how batteries work!

Introduction to Batteries

In order to have a circuit that works, we need a power source, and a common energy source is a battery. A **battery** is a device that converts chemical energy into electrical energy.

Inside a battery there are two pieces of metal in a paste. A paste is a partially moist mixture of chemicals

In a battery, there is a negative (-) end and a positive (+) end. Another name for the ends of batteries are **terminals**. Electrons flows through a battery from the negative (-) end and it returns to the positive (+) end.

When the terminals of the battery are connected to the circuit, it is the chemical reaction in the electrolyte of the battery that causes the electrons to flow.

Part II, continued

Introduction to Batteries, continued

If we think back to our circuit, we have conductive wires, a lightbulb, and a battery. To make a complete circuit, the electricity has to leave one end of the power source and the return to the opposite end, to make a complete, unbroken loop.

The diagram below shows how electrons flow through a basic circuit. The negative terminal or end of the battery will push the negative electrons along the wire. Electrons flow from the negative terminal of the battery, through the lightbulb, and back around to the positive terminal.

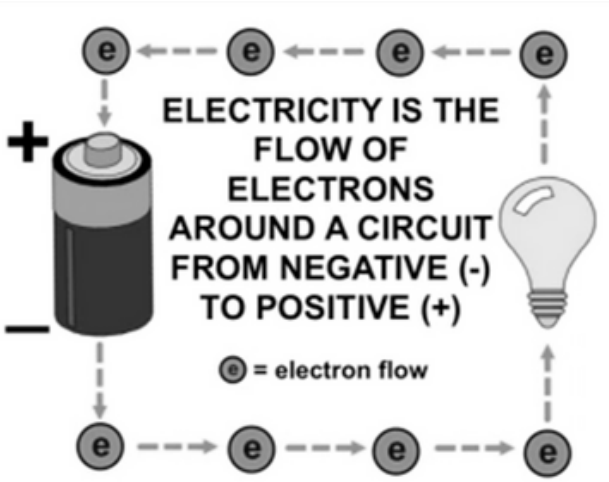


Image Source: https://docireport.org/2013/08/17/electricity-simplified/

Once again, this flow of electrons around the circuit causes the lightbulb to glow. When the battery is being used, it is converting its stored chemical energy into electrical energy. When a battery is part of a circuit, it can give electric power to flashlights, video games, cell phones, and other electronic devices.

Quiz #2

1. Name the three most important elements of a circuit.
2. Electricity moves only in a _____ loop.
   a. Open
   b. Circuit
   c. Square
   d. Closed
3. A battery is a device that converts _____ energy into _____ energy.
4. Electrons flow from the _____ terminal of the battery, through the circuit, to the _____ terminal of the battery.

Answer Key:
1) Wire, lightbulb or device that uses electricity to "do work", and a power source such as a battery
2) D.
3) chemical, electrical
4) negative, positive

Lab: Build a Battery

At the end of this lab you will be able to:

1) Construct a lemon battery,
2) Demonstrate how a lemon battery can light an LED,
3) Sketch a lemon battery circuit to show a friend and
4) Explain to your friend how the lemon battery works.

Click here to watch the “Lemon Light” video demonstration. If you are unable to view the video, you can follow the full instructions below.

Materials

If you don’t have these materials at home, many can be found online!

4 Lemons
4 Galvanized Nails
4 Copper Wires
1 LED (Light Emitting Diode)
5 Alligator Clip Leads: to connect the lemon batteries
Wire Cutters: to cut the copper wire to length
Pliers: to bend the wire
Sandpaper (if needed)

Prepare Your Materials

Lemon Electrolyte: Lemons are filled with citric acid which makes a great electrolyte; however, the acid is captured in the tiny segments within the lemon so firmly roll the lemons on the table to break up the segments releasing the acid within the lemon. Don't press too hard and break the skin of the lemon!

Galvanized Nails, Anode Electrodes: These are nails made of iron or steel. In the video, you will see the nails were lightly sanded to remove any excess dirt or dust.

Copper Wires, Cathode Electrodes: You are going to cut the copper wire into four, 3-inch pieces and bend one end so it is easier to attach your alligator clips. Sand your pieces of copper wire to remove the outer coating

LED: Did you notice in Fig. 7 one lead of the LED is longer than the other? LED's allow current to flow in one direction. The + (positive) connection is the longer lead and the – (negative) connection is the shorter lead.

Instructions

1. Insert a nail into each lemon without poking all the way through.
2. Insert a copper wire into each lemon without poking all the way through and be sure the wire doesn't touch the nail inside the lemon. Space the wire and nail about 1-2 inches apart.
3. Arrange the lemons in a row and have it so there is a copper to zinc pattern, as you can see in the image below.
4. Connect a set of test leads between each lemon. You will have a wire on each end, one connected to the copper wire, the other connected to the zinc nail. In the center are three more wires with alligator clips, with one clip on the nail and the other on the copper wire.
5. Connect a test lead from last nail to the short lead of the LED.
6. Connect a test lead from the copper wire at the other end of your battery to the long lead of the LED.
7. Your LED should now light up.

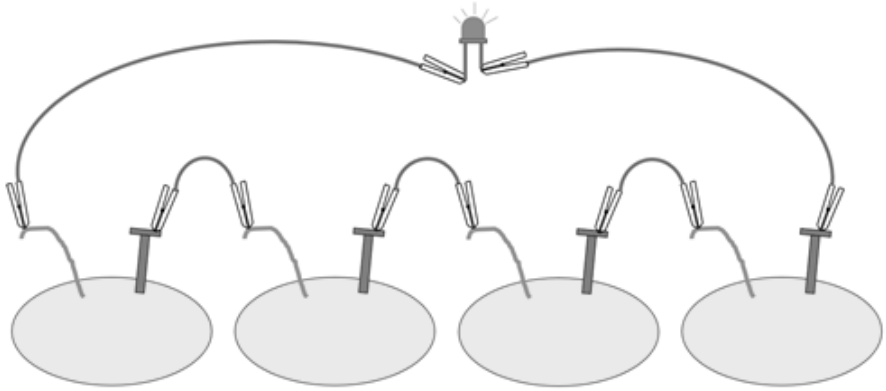
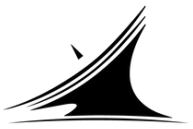


Fig. 8

If your LED doesn't light, try the following:

- Make sure the long lead of the LED's is connected to last copper wire of your lemon battery.
- Be sure none of the nails are touching the copper wires in the lemons.
- You may need to add another lemon cell to your lemon battery.
- Your electrodes might not be making good contact with your electrolyte, do the following for each cell:
  - Disconnect the connections to the cell
  - Remove the copper wire
  - Wiggle the Nail to break any segments preventing the electrolyte from reaching both electrodes.
  - Return the copper wire to the same hole it was in before you removed it.
  - Reconnect the test leads.



Quiz #3

Directions:
After completing your lemon battery, answer the following questions.

1. To make your lemon battery, you needed to have wires, and LED bulb, and the lemons interacting with the zinc and copper materials are the power source. Does this mean that you made a complete circuit? Why or why not?
2. Batteries require two electrodes, or metals, and an electrolyte to work. What are the two electrodes and the electrolyte in your lemon battery experiment?
3. What happened when you connected the alligator clips to the LED bulb?
4. Do you think other fruits or vegetables will work in place of the lemons? Try some out and record your results below. Why do you think some things work and others don't?

Answer Key:
1) Yes, it has the three necessary parts of a complete circuit
2) copper & zinc are the electrodes, the lemon juice is the electrolyte
3) the LED should light up

Glossary

Atom- the basic building block for all matter.

Battery- a device that converts stored chemical energy into electrical energy.

Circuit- The complete path through which electric current can flow.

Current- The movement of electrons along a conductor in a circuit.

Electrical Conductivity- how well a material accommodates the transport of electric charge.

Electrode- A conductor that moves electricity.

Electrolyte- a chemical medium that allows charged ions to flow. An electrolyte can be a liquid, gel, or a solid substance.

Electron- negatively charged particles of an atom that travel around the nucleus of the atom.

Neutron- particles in the nucleus of an atom that have no charge.

Proton- particles in the nucleus of an atom that have a positive charge.