Lemon Batteries Revised
5th Grade
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References:

- Modified from WOW lemon lesson found at:
  [http://www.wow.osu.edu/Electricity/lemon.htm](http://www.wow.osu.edu/Electricity/lemon.htm)

Other Lemon Battery sites:

  This site identifies some of the difficulties with lemon batteries.

- [http://pbskids.org/zoom/activities/sci/lemonbattery.html](http://pbskids.org/zoom/activities/sci/lemonbattery.html)

Benchmarks:

SLC 9: Provide examples of transformation and/or conservation of matter and energy in simple physical systems.

CPS Benchmark: Students will explore the transformation of energy within living and physical systems.

Objectives:

Students will identify chemical energy in food and batteries as potential or stored energy. Students will be able to trace the origin on various forms of energy to the sun.

Materials:

Per Group:

- One lemon per student (or have half the class use another fruit, like limes)
- One plastic knife
- One steel paper clip or steel nail
- One penny, brass nail, or copper nail
- 8” pieces of copper wire per group with alligator clips
- one diode
- one modified calculator

Per Class:

- Battery
- Solar powered calculator
- paper towels and a source of water for clean-up

**Calculator:** A low wattage calculator or clock with a digital display is needed. The battery should be removed, and wires soldered to the contact points for the battery. WOW has one such calculator that can be borrowed.
Initial Demonstration:

Ask students what they mean when they say they have energy. They should get to something along the lines of “being able to do something.” Explain that in science, energy is the “ability to do work.” Ask the students what kind of energy a battery produces (electricity). Write this on the board. Ask them where the electricity comes from. (Chemicals inside) Write “chemical energy” on the board. Ask them which kind of energy can be stored. (Chemical). What is another name for stored energy? (Potential energy). Attach the wires from the light bulb to either end of the battery and show that it lights up. Ask the students what form of energy is being produced. If they say light but not heat, ask someone to touch the light bulb. It should be warm but not too hot to touch.

Target Observations:

- Energy is stored in batteries.
- This energy can be converted to electricity, which can be converted to heat and light.

Target Model:

- Chemicals store energy that can be converted to electricity or motion of people (kinetic).

Procedure:

Ask the students where we get our energy from. (Food). Do they think they could get electricity from food such as a lemon? (Remind them that their brains conduct electricity all the time). Show them the lemons and ask them how they could show that electricity was flowing through the lemon. (They could use a light bulb). Try sticking the light bulb into the lemon. (Use the plastic knife to cut through the rind if necessary).

This might be a good point to give the students each a lemon. They need to roll the lemons, squeeze them, and perhaps pound them on the table to loosen the pulp. However, if you tell them to pound the lemons, they will break them open. The experiment still works, but it gets pretty messy. I told them if they were making noise with the lemon, I would take it away.

The light bulb does not light up. Explain that electricity involves moving electrons, and electrons “like” certain metals better than others. So if they put two different kinds of metal in the lemon and attach the light bulb to them, it should light up. Ask students what they think will affect how well the battery works. They may suggest the size of the nail, how clean it is, how big the lemon is, or what fruit is used.
Discuss the variety of materials available for use: Zinc works better than steel. Paperclips have zinc coating, but are thinner than nails. Pennies are not pure copper, and neither are the copper plated nails. But the solid brass nails are smaller than the pennies. Each group should select either paper clips or steel nails for one electrode, and pennies, copper plated nails, or brass nails for the second electrode.

Use a plastic knife to cut a place for the penny in each lemon if necessary. Remind the students that the electrons flow because of the difference between the metals. Ask them if the battery will work if they attach a penny to a penny. (No) Have each student attach one end of an alligator clip to their own penny or copper/brass nail. If the class is capable, have them figure out how to connect all of the lemons together so that each wire is attached to one type of each electrode. Alternatively, tell the students to take the other end of the wire (the one attached to their penny) and attach it to the paperclip or steel nail of the person to their right. (Use the figure above as a guide). Check to make sure the circle is complete for each group, and then have them disconnect one and only one wire. They should take an additional wire and attach it where the last one was disconnected. Now there should be two free wires, one attached to a penny, one attached to a paper clip. The diode should be inserted with the positive end to the penny, and the negative end to the paperclip. This probably won’t light up if there are 4 lemons in a group, maybe with 5, and probably with 6. If this works, have them try the calculator. Have the students see how few lemons they can use and still get the calculator to work. (You may get it to work briefly with 3 lemons).

Can the chemical energy in the lemon be turned into electrical energy? Which kind of energy is being used? Which kind is being stored? Into what kind of energy is the electrical energy being transformed? Ask the class to present their findings and discuss which electrodes, if any, worked best. If you compared the size of lemons, did this make a difference? What about the type of fruit used?
**Target Revised Model:**

- Chemical energy in batteries and in food can be transformed into electrical energy.

**Procedure:**

Take one of the groups and attach a Christmas tree light. It probably will not light up. Explain that there is not enough current. See if you can get it to light if you use more lemons. See if moving the electrodes closer together makes the light bulb light better.

Have students present their results to the class answering the following questions. What made the calculator work best? What made the light bulb work? What method is the most efficient way to transform energy? How do you know? (The brighter the bulb, the more energy you are getting out).

**Target Revised Model:**

- Energy Transformations are the most efficient when we get the most out of the same materials or input.

**Procedure:**

Ask where the lemon got its energy from. (The lemon tree or the sun). Explain that most forms of energy on the earth can be traced back to the sun. Show the students the solar powered calculator. Have a student cover up the solar strip to illustrate how the light powers the calculator. (This is a form of technology that allows us to power our world without harmful chemicals, SLC 4) Use an example of a wind mill. Wind mills produce electricity; the wind comes from air heated by the sun:

\[
\text{Sun} \rightarrow \text{Wind} \rightarrow \text{Windmill} \rightarrow \text{Electricity}
\]

Have students complete the sheet “Trace it to the Sun”.

Have students list as many forms of energy as they can. Have them separate the list into “Stored energy” and “Energy being Used”. Help them to use scientific words for the various forms of energy: kinetic energy=motion, radiant energy=light, thermal energy=heat, etc.

**Target Revised Model:**

- Almost all energy on Earth can be traced back to the sun

**Summary:**

There are many forms of energy. One form of energy can be converted into another, such as when the chemical energy of a battery makes a toy car move. Almost all energy on the Earth originally came from the Sun.
Trace it to the sun!

1) The motion of a flag flapping in the wind is kinetic energy, trace this back to the sun.

Sun( ) --> ______________ --> Flag (Kinetic)

2) Jamar is a fast runner. He had oatmeal for breakfast. Trace his kinetic energy back to the sun.

Sun( ) --> ______________ --> Jamar (Kinetic)

3) Shaquille’s family is having a bar-be-que. They are cooking chicken over hot coals (charcoal is made from wood). Trace the thermal energy of the fire back to the sun.

Sun( ) --> ______________ --> charcoal( ) --> fire( )

4) Gasoline in a car is a fossil fuel. Fossil fuels come from plants and animals that have been decomposing underground for millions of years. Trace the kinetic energy of the car back to the sun!
Sun( ) --> ___________ --> ___________ --> car (kinetic)