3rd grade Winter Garden Lesson
Potato Batteries

Objective: Building on knowledge previously learned in their electricity unit, students will work in pairs to construct a potato battery capable of powering a small digital clock and small LED light bulb. Students will create a series circuit and experiment with number of potatoes needed to run the clock vs. LED. They will also experiment with other forms of potatoes (raw, mashed, whole, sliced, etc.) and other ways of connecting/creating circuits and hypothesize as to outcomes.

Materials: (amounts dependent on class size) 'How To' handout, potatoes (pre-boiled/cooled for easier insertion of nails/pennies as well as some raw/mashed for experimentation), small digital clocks (1 volt, with easy connections to + and – battery terminals), small LED bulbs (1 volt, the kind found in circuit kits with accessible + and – wires), alligator clips, clean (shiny!) pennies or copper wire, galvanized nails (meaning they are coated in zinc oxide) or zinc metal strips. ***Optional:*** voltage meter to measure battery output, lemons, oranges or other fruits/veggies for students to test, Gatorade to presoak raw potatoes in the night before lesson, other low voltage items like mini fans, other bulbs, for students to test power, different coins to use (nickels, dimes), different potato varieties to use (red/white/blue), switches from commercial "snap circuit" kits, etc.

Vocabulary: students should be familiar with following terms: current electricity, battery, electrons (negative charge), protons (positive charge), conductor, resistor, series vs. parallel circuits, open vs. closed circuits, voltage.

45 min
***break class into student pairs or triads; lesson can be done at desks.**
***lay out extra supplies/optional materials at 'stations' in classroom**
*** pass out materials to student pairs while giving lesson intro/overview**

5 min
Intro: Hold up a typical battery and ask students what it is and what it does. Point out the 2 ends positive/negative charges. Ask them what electricity is. Hold up a potato and ask students what it is and what it does. (Remember what plant family it's in? – related to tomatoes/peppers/eggplants – Nightshade or *Solanaceae* family). Potatoes are not only good for eating, you can turn them into a battery too! That's what we'll be doing today.

5-10 min
Overview: In pairs, you will create a potato battery to power a digital clock and turn on an LED light bulb. (If kids ask….What does LED stand for? ***Light Emitting Diode*** and it uses less electricity or energy than old-fashioned incandescent bulbs - show an example of each. What is a ***diode***? A diode is an electronic component with 2 terminals or electrodes. It conducts electrical current primarily in one direction. The

two electrodes are called anode and cathode. An anode is the positively charged electrode by which the electrons leave a device. A cathode is the negatively charged electrode by which electrons enter an electrical device. (*draw picture on board showing + and – sides to LED bulb, the long wire is +, the short* -).

You will use 2 types of metals in this experiment. Why use metal? **(*good conductors of electricity!)*** We will use pennies and nails. What metal are pennies made from? Copper! What about nails? Steel, but these steel nails are galvanized which means they've been coated with zinc so they won't rust rust – it's the zinc we need for this experiment. (*draw picture on board of copper penny (+) and zinc coated nail (-)*.) What do we call tiny negatively (-) charged particles? Electrons. What about positive particles (+)? Protons. You're also going to use *alligator clips* (hold one up) to connect everything together.

Now that you have the supplies you need, follow the directions on your handout to construct your own potato battery. When you've successfully turned on both a clock and an LED light with your potatoes, try experimenting on your own! Use more or less potatoes, hook things up differently, try simultaneously turning on the clock AND LED, try turning on something else, etc. You can come and get extra supplies as needed from stations we've set up in the room.

25-30 min
Experiment: Students construct batteries on their own. Monitor progess and help trouble shoot if batteries don't work. Prompt kids to brainstorm what might have gone wrong before giving answers. Have extra potatoes/supplies on hand in case something is destroyed or malfunctions! Encourage further experimentation.

5 min
Possible Wrap-up Questions for discussion or for use during experimentation:

- Why do you think the LED light needed more potatoes than the clock to work? Do different potatoes (red vs. white vs. blue) work differently?
- Is the potato making electricity or is something else going on? What do you think is happening inside the potato when the battery is working?
- What other fruits/vegetables do you think might also make good batteries?
- How many potatoes do you think we'd need to power the lights in this classroom? In this school? In this town??
- How do potatoes power your body with energy?? (possibly end lesson with potato chip snack ;-)

Optional Expansion Activities:

Article for students to read/discuss after lesson:
http://www.bbc.com/future/story/20131112-potato-power-to-light-the-world

Potato Power: the spuds that could light the world

With a simple trick, the humble spud can be made into a battery, so could potato powered homes catch on? *By Jonathan Kalan 11/12/13*

http://www.bbc.com/future/story/20131112-potato-power-to-light-the-world

Mashed, boiled, baked or fried? You probably have a preference for your potatoes. Haim Rabinowitch, however, likes his spuds “hacked”.

For the past few years, researcher Rabinowitch and colleagues have been pushing the idea of “potato power” to deliver energy to people cut off from electricity grids. Hook up a spud to a couple of cheap metal plates, wires and LED bulbs, they argue, and it could provide lighting to remote towns and villages around the world.

They’ve also discovered a simple but ingenious trick to make potatoes particularly good at producing energy. **“**A single potato can power enough LED lamps for a room for 40 days,” claims Rabinowitch, who is based at the Hebrew University of Jerusalem.

The idea may seem absurd, yet it is rooted in sound science. Still, Rabinowitch and his team have discovered that actually launching potato power in the real world is much more complex than it first appears.

While Rabinowitch and team have found a way to make potatoes produce more power than usual, the basic principles are taught in high school science classes, to demonstrate how batteries work.

To make a battery from organic material, all you need is two metals – an anode, which is the negative electrode, such as zinc, and a cathode, the positively charged electrode, such as copper. The acid inside the potato forms a chemical reaction with the zinc and copper, and when the electrons flow from one material to another, energy is released.

This was discovered by Luigi Galvani in 1780 when he connected two metals to the legs of a frog, causing its muscles to twitch. But you can put many materials between these two electrodes to get the same effect. Alexander Volta, around the time of Galvani, used saltwater-soaked paper. Others have made “earth batteries” using two metal plates and a pile of dirt, or a bucket of water.

Potato Battery Instructions

To run a digital clock…

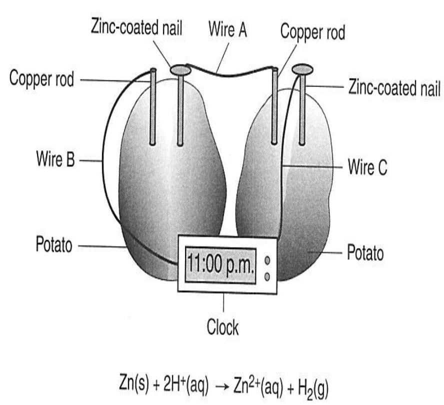
1. Take 2 boiled potatoes. In each potato, insert a copper penny (+) and zinc-coated nail (-) almost all the way into the potato, about ¼" apart. *Make sure the penny and nail do not touch each other!*

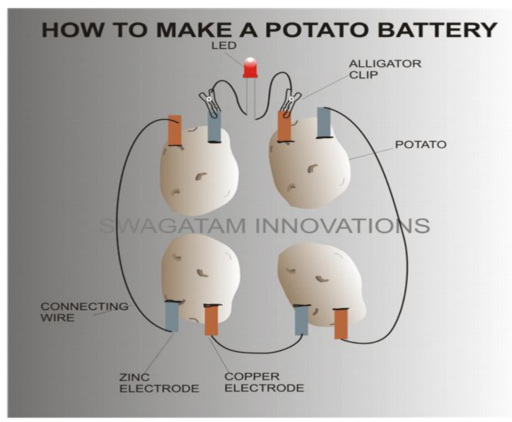
2. Take one alligator clip and connect the penny in potato 1 to the nail in potato 2 by clipping onto each so you connect (+) to (-).

3. Now take a different alligator clip and connect the zinc nail (-) in potato 1 to the black wire (-) of the digital clock. This time you connect (-) to (-).

4. Take another different alligator clip and connect the copper penny (+) in potato 2 to the red wire (+) of the digital clock. You connect (+) to (+).

5. What happens? What kind of circuit did you just make? (series or parallel?)





To turn on an LED light bulb…

1. Disconnect the clock from your potatoes. Instead, clip the connecting wire from the zinc nail (-) in potato 1 to the ***short wire*** (-) of the LED bulb.

2. Now clip the connecting wire from the copper penny (+) in potato 2 to the ***long wire*** (+) of the LED bulb. What happens?

3. Figure out how to add a 3rd potato to your circuit and try connecting the LED bulb again. Now what happens?

4. Add a 4th potato and try the experiment again. What happens when you add more potatoes to your circuit?

Now YOU Experiment! There are more supplies at different stations in the classroom. Find what you need/want and see what else you can do with your potato battery! ***Design your own*** experiment or test out some on the back of this page…

Try some of these experiments or come up with your OWN ideas!

1. Will using a different state of potato affect how well the battery works? (mashed, raw, Gatorade-soaked)

2. Will a different color/variety of potato like red/white/blue potatoes affect how well the battery works?

3. What happens when you switch the wire connections and clip (+) to (+) and (-) to (-) between the potatoes? Or you switch the connections to the clock/LED and instead connect (+) to (-)?

4. Can you make a battery out of just one large potato?
   Can you make a battery by cutting one potato into smaller pieces?

5. Can you create a parallel circuit with your potato battery? Can you make your potato battery run BOTH the clock and the LED *at the same time?!*

6. Use a multimeter tester to measure the voltage coming from your potato battery when you use 2 potatoes vs. 3 potatoes vs. 4 potatoes. Is there a difference? Compare your potato battery's voltage to a commercial battery's voltage.

7. What happens when you try inserting/connecting *different metals* in the potato battery like a quarter, nickel, dime instead of pennies and nails?

8. Can you make a battery using different fruits/veggies instead of potatoes?

9. Try to run something else with your battery – can you get a sound chip to make a noise? Can you get a small fan to turn on?

10. Try connecting an on/off switch to your series circuit to demonstrate how an open and closed circuit works. Why are switches important?

3rd grade electricity unit vocabulary

all material made of **atoms**
atoms are made of 3 parts: **protons, electrons, neutrons**
positive, negative, neutral (no) charges
rotate around nucleus of atom

current electricity = the flow of atoms through a conductor; used to power things; flows through wires; follows a path called a circuit; electricity flows from the negative side of a battery to the positive side
resistor = sth that uses some of the electricity in a circuit such as a light bulb/motor/speaker
open circuit vs. closed circuit/switches
open circuit = does not allow electrons to flow/turns things off
closed circuit = allows smooth flow of elections/turns things on
series circuit vs. parallel circuit
series = electricity can follow only one path
parallel = electricity has more than one path to follow
static electricity = when electrons jump from one atom to another
conductor = material which allows the easy flow of electrons
battery = supplies the energy in an electric circuit to power a resistor
voltage = the force or pressure of electricity
Electrolyte = a substance containing ions that can conduct electricity
Gatorade = a commercial drink containing electrolytes (sodium/sugar) to help your body rehydrate faster if you have lost water and salt (sweating a lot!) sodium helps conduct electrons

http://www.kidzworld.com/article/4726-how-potato-batteries-work

How the Potato Clock works

A potato battery is an **electrochemical battery**, otherwise known as an electrochemical cell. An electrochemical cell is a cell in which chemical energy is converted to electric energy by a spontaneous electron transfer. In the case of the potato, the zinc in the nail reacts with the copper wire. The potato acts as a sort of buffer between the **zinc ions** and the **copper ions**. The zinc and copper ions would still react if they touched within the potato but they would only **generate heat**. Since the potato keeps them apart, the electron transfer has to take place over the copper wires of the circuit, which channels the energy into the clock. Presto! You have potato power.