

# SCIENCE FAIR CENTRAL

## Maker Corner Activity



## LEMON POWERED

Grades 6-12

# MAKE. CREATE. EXPLORE.

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**Energy can't be created or destroyed, although it can change form and be transferred.**

## Overview

**Energy is something that we all depend on.**

Over time, the amount of energy we use and the way in which we use it has certainly changed. However, what has not changed is The Law of Conservation of Energy. Energy can't be created or destroyed, although it can change form and be transferred from one object to another.<sup>1</sup>

In this activity, students will learn how batteries work by transforming chemical energy into electrical energy using electrolytes and electrodes. Students will apply their understanding of how these chemical cells work, by creating their own battery using lemons to help convert stored chemical energy into electric energy that can then light an LED bulb.

**This activity focuses on** the “Creating or Prototyping” and the “Refining or Improving” stages of the Engineering Design Cycle. Students will create a battery which incorporates the electrolyte, lemons, to power an LED light. Students will be testing a variety of possible electrodes with the lemon and determining which combinations will work.

This activity focuses on the **Creating or Prototyping** and **Refining or Improving** stages of the Engineering Design Cycle.

### Engineering Design Cycle

- Defining the Problem
- Designing Solutions
- **Creating or Prototyping**
- **Refining or Improving**
- Communicating Results

## Objectives

**Students will be able to:**

- **Identify** how batteries provide energy to power an object or device
- **Apply** that understanding to the structure of batteries
- **Create** a battery using lemons that is able to power an LED light



# How do batteries conserve energy instead of using it?

## Materials

- (1) Set Quiz Trade Cards for the Class
- (1) Process Journal for Each Group
- (1) LED 5 mm Bulb Light Per Group
- (1) package Copper Coupling
- (1) package Galvanized nails
- (1) package Copper Nails
- (1) package Zinc Plated Nails
- (1) package Black Phosphate Nails
- (1) package Stainless Nails
- (1) package Plastic Anchors
- (1) package Brass Plated Cup Hooks
- (1) roll Copper Wire
- 2 small parts Storage Container Tray (1 per group)
- (1) Wire Cutter
- Flip Top Box (1 per group)
- Sharpie Marker (1 per group)
- Ruler (1 per group)
- Lemons (Minimum of 4 per group)
- Alligator Clips (Optional and available for students in the class storage container)

## Have you ever wondered . . .

### How does a battery work?

It all comes down to chemistry! Batteries store chemical energy that is transformed into electrical energy to power devices. Batteries have 3 main parts to them. 2 materials with opposite charges called electrodes, and an electrolyte. When the electrodes with opposite charges are placed in the electrolyte, a chemical reaction takes place. The electrolyte allows the electrical charge to flow between the electrodes. If the electrodes of the battery are connected to a device like a light bulb, the electrical energy can continue flowing and power the light bulb.<sup>2</sup>

### Can we create electrical energy from batteries in an eco-friendly way?

Have you ever stopped to think about what happens when the battery in your remote stops working and you throw it away? 250,000 pounds of batteries are thrown away every year in the United States causing toxic chemicals that are found inside of them to leak into the environment. These harmful chemicals find their way into groundwater and into the air. As you build your battery, without the use of harmful chemicals, think about if there are other clean energy sources that could be transformed into electricity.<sup>3</sup>

**What other materials could be used to create a more eco-friendly energy conservation system?**



# Make connections!

This section captures how this activity connects to different parts of our lives and frames the reason for learning.

## How does this connect to students?

Without using batteries as an energy source, you would not be able to use cell phones, TV remotes, toys and other portable devices. You also rely on food as an energy source for your body. What if you could combine these 2 ideas? By creating a battery out of a fruit, you can generate energy in an eco-friendly way that prevents the harmful chemicals in traditional batteries from getting into the environment!

## How does this connect to careers?

**Agricultural Engineers**—Agricultural Engineers apply technology to farming as they determine which products can best be used to produce fuel and improve efficiency in environmentally friendly ways.<sup>4</sup>

**Electrical Engineers**—Electrical Engineers design and create ways of using electrical power in a variety of equipment, buildings, products and homes.<sup>5</sup>

**Farmers**—Farmers produce crops and livestock to create clothing materials, energy sources, and of course the food needs of our population.<sup>6</sup>

**Soil & Plant Scientists**—Soil & Plant Scientists study the health of the soil and how the quality of the soil impacts the plants and crops grown there.<sup>7</sup>

## How does this connect to our world?

We take for granted the electricity produced by batteries and the electricity we use in our day to days lives. 1 in 5 people around the world, still do not have any form of electricity. Even more people around the world don't have safe, clean or environmentally friendly energy options for cooking. While creating your lemon powered battery, that will convert chemical energy into electrical energy, think about how this energy source would be good for the environment and significantly improve the quality of life for people.<sup>8</sup>



# Blueprint for Discovery

## Prior to the activity

- Print or post digitally a Process Journal for each group
- Print and cut out “Quiz, Quiz, Trade Cards” (if possible, laminate cards for durability)
- Fill 2 Storage Containers with nails and other items made of various materials listed in the materials above (items should be labeled so students can easily make selections)
  - Make “toolbox” for each group in the Flip Top Boxes containing:
    - Pre-cut wires each box should contain 5 wires approximately 8 inches long
    - Alligator Clips if Available
    - 4 Lemons
    - Sharpie Marker
    - 1 LED light
    - Ruler
- Place tray on top of “toolbox” for each group

**1. Ask the students to share with a partner** about the items they currently use or have used in the past that rely on batteries as a power source.

**2. Invite students to share** with the class how their lives would be different without batteries?

**3. Show students the picture of [batteries](#)** and ask them if they know what happens to them after they are no longer working. The intention is to lead the discussion to the idea that batteries are a form of pollution. They are often thrown away after they stop working and can lead to toxic chemicals being added into the environment.

**4. Show students the following [video](#)** as an introduction to the possibilities of how batteries will be used in the future and be eco-friendlier. This should get them excited about the activity they are about to participate in.

**5. Then ask for any volunteers** in the class to share what they know about how batteries actually provide power.

**6. Show students the picture of the solar panels and explain:**

*“Solar panels convert the sun’s energy into electrical energy that the homeowners can use. Just like solar panels convert energy from one form to another, batteries work in the same way but convert chemical energy into electrical energy. Today’s goal is to create a battery that changes chemical energy into electrical energy that will be able to power an LED light.”*

**7. Divide the students into teams of 3 or 4.**



**8. Pass out the *Process Journal*** to each team or direct them to where it has been made available online so students can review it together. The Process Journal contains detailed instructions for creating their battery, a diagram for setting up the battery, as well as the basics of batteries. The Process Journal provides them with scaffolds that will allow them to create their lemon powered battery.

**9. When it seems that the students have had enough time** reviewing the journal as a team, provide students with an overview of the activity. You will want to address the toolboxes you have given them, as well as the materials found in the 2 storage containers that they will be able to select materials for their test rounds from.

**10. Students can begin to work as a team** through the “Process Journal” as they experiment to create a battery. Periodically announce to the students how much time they have left to work on building their batteries.

**Teacher Notes:**

- The copper coupling attached to the long LED wire with the galvanized nail attached to the short LED wire should light the LED due to opposite charges.
- The teacher can address a variety of reasons why other combinations would not work. For example, the plastic anchor is not a conductor or “plated” materials are not necessarily a solid metal with the necessary charge

**11. Save approximately 15 minutes** at the end for students to engage in a game of “Quiz, Quiz, Trade” as a fun way to review how batteries work, the environmental impact, and key components of a battery.

- Pass out 1 card to each student with the question on the front and answer on the back.
- Students will move around the room pairing up with someone.
- Student #1 asks the question to student #2, waits for a response and then clarifies using the answer provided on the back.
- Student #2 asks the question to student # 1, waits for a response and then clarifies using the answer on the back.
- The students trade question cards and move onto another classmate repeating the process.

*Depending on the number of students in the class, it is not going to be a problem if some students have 2 cards or some cards need to be copied twice so there are enough for each student in the class.*





# Take Action

**Want to find out about battery recycling programs?** Check out The Home Depot's battery stewardship program!

<https://corporate.homedepot.com/newsroom/battery-recycling-one-million-pounds>

**Learn More about biofuels as an eco-friendly energy source.**

<http://biofuel.org.uk/biofuels-for-kids.html>

**Learn how to create an oven that is powered by solar energy** instead of electricity or gas. You'll even be able to make s'mores using it!

<https://climatekids.nasa.gov/smares/>

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## National Standards

### Science

#### Next Generation Science Standards

##### MS-ETS1-4

Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

##### HS-PS3-1 Energy

Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

##### HS-PS3-3 Energy

Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

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### Technology Education

#### Next Generation Science Standards and International Technology and Engineering Educators Association

**Students will develop an understanding of Technology and Society.** This includes learning about:

- The cultural, social, economic, and political effects of technology.
- The effects of technology on the environment.
- The role of society in the development and use of technology.
- The influence of technology on history.

**Students will develop an understanding of the Designed World.** This includes selecting and using:

- Agricultural and related biotechnologies.
  - Energy and power technologies.
  - Manufacturing technologies.
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## Mathematical Practice

### Common Core

**CCSS.Math.Practice.MP1** Make sense of problems and persevere in solving them.

**CCSS.Math.Practice.MP5** Use appropriate tools strategically.

**CCSS.Math.Practice.MP7** Look for and make use of structure.

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## Works Cited

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8. International Institute for Environment and Development. Improving people's access to sustainable energy. October 26, 2012.  
<https://www.iied.org/improving-people-s-access-sustainable-energy>





# Lemon Powered Process Journal

Name of Team Members: \_\_\_\_\_

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## 1. Getting Started—Assign a Job or Role for Each Member of The Team

Job Title	Description	Team Member Selected
<b>Materials Manager</b>	Collects and returns materials as your group needs them and when you are finished with them	
<b>Measurer</b>	Determines the correct location to write the labels on your lemons and measures how far into the lemon the materials should be placed	
<b>Recorder</b>	Records notes in the journal that can be shared with all members of the group	
<b>Labeler</b>	Uses the Sharpie to label the lemons correctly with number and letters according to the diagram	

2. **Listen and observe** as your teacher explains what materials you can find in the 2 storage containers that are set up around the room. Using The Battery Basics & Diagram, what do you think the role (or purpose) of the materials your teacher just described will be in the battery you build?

<b>Role of the Materials We Select:</b>	
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3. The **Materials Manager** should open your toolbox, spread the materials out on your work space and discuss with your group mates what you think the role (or purpose) of the wire and lemons will be. What will they do in the battery? Again—use the Battery Basics & Diagram to help.

<b>Lemon Role:</b>	
<b>Wire Role:</b>	

4. Using your Sharpie Marker, the **Labeler** should label each lemon #1, #2, #3, and #4 according to their location in the tray.



5. Then the **Labeler** will write an A and B in Sharpie Marker on each lemon so the letters match with the diagram above. The **Measurer** want to make sure your A and B are about an inch apart (or more!) so your materials don't touch each other inside of the lemon.

6. Now it's time to think about how you are going to get your battery working. After seeing the choices of materials your teacher is providing, what combinations would you like to try in your battery? The **Recorder** should include them in the chart below.

Test Round 1	Material A:	Material B:
Test Round 2	Material A:	Material B:
Test Round 3	Material A:	Material B:
Test Round 4	Material A:	Material B:

7. The **Materials Manager** should collect from the teacher 4 of your determined Test Round 1 Material A and 4 of your determined Test Round 1 Material B.

8. Take the Test Round 1 Material A and push them into the lemons (about an inch deep) in each spot **labeled with an A.**

9. Take the Test Round 1 Material B and and push them into the lemons (about an inch deep) in each spot **labeled with an B.**

10. Now it's time to connect the lemons, using the wires from your toolbox, so the electricity can travel and light the LED!

11. Starting with lemon #1- wrap the wire around Material B and connect to the next lemon by wrapping it around Material A on lemon #2.

12. Now onto lemon #2 - wrap the wire around Material B on lemon #2 and attach it Material A on lemon #3.

13. Wrap the wire around Material B on lemon #4 and attach it to Material A on lemon #1.



14. Wrap the wire around Material B on lemon #3 and attach it to the longer wire on the LED.
15. Wrap the wire around Material A on lemon #4 and attach it to the short wire on the LED.
16. WHAT HAPPENS????!!!! Record your observations in your data table!
17. If it didn't light the LED, before giving up on it, try 1 more step that might do the trick! **Undo the wires attached to the LED only. REVERSE THE LED** so the short and long connection are now being attached to opposite materials. Material A on Lemon # 4 should now be attached to the long wire of the LED. Material B on lemon # 4 should now be attached to the short wire of the LED.
18. What HAPPENS? Any change? Record your observations in your data table.
19. The **Materials Manager** Should return any Materials that will not be used again in another test round.

Round	Material A	Material B	LED Light Up? (YES or NO)	Reversed LED Connection Light Up? (YES or NO)
1				
2				
3				
4				

20. Repeat Steps #7-#19. Only this time you are using Test Round 2 materials.
21. When you are finished Follow Steps #7-19 for Test Rounds 3 & 4 also.

**As you work through Rounds 1-4, make sure you allow all members of the group an opportunity to connect and disconnect wires!**

**When you are finished, clean up according to your teacher's directions!**



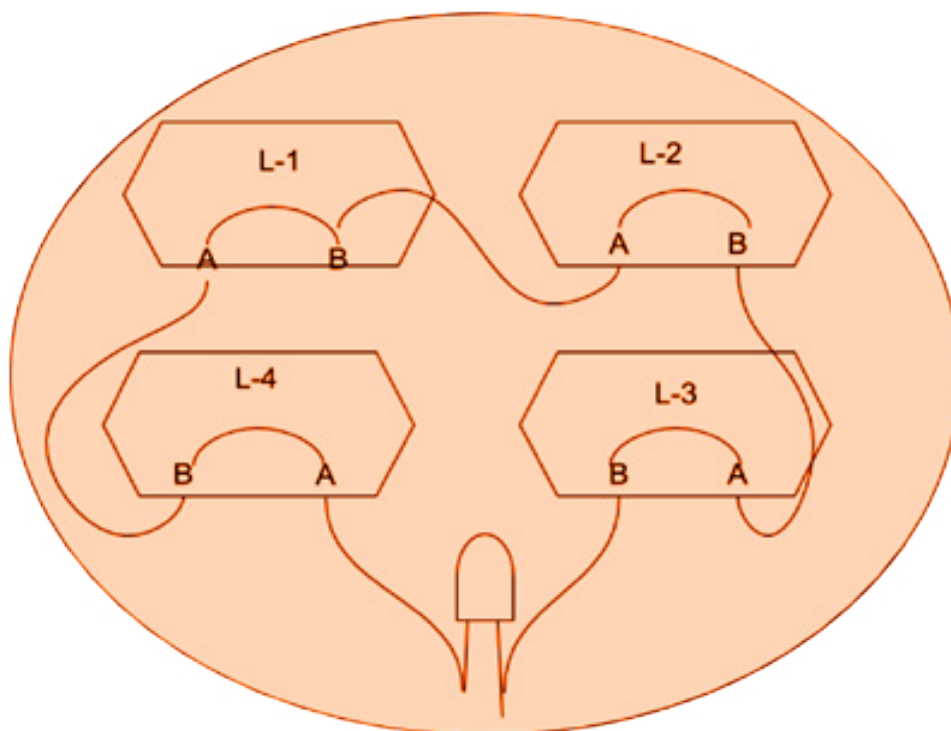
# Reflection

- Why do you think some combinations of Materials A & B were able to power the LED while others were not?
- Agricultural engineers, farmers, plant scientists and soil scientists all have a role in the process of creating crops that can be used in batteries like the one you built today? What would you like to see changed or improved about your lemons that could have made your lemon battery better?
- What are the benefits of using batteries like the one you built today instead of only using the traditional batteries you buy in the store?

# Battery Basics & Design Diagram

## Some Battery Basics: It all comes down to chemistry!

- Batteries store chemical energy that is transformed into electrical energy to power devices. Batteries have 3 main parts to them.
- 2 materials with opposite charges called electrodes, and an electrolyte.
- When the electrodes with opposite charges are placed in the electrolyte, a chemical reaction takes place.
- The electrolyte allows the electrical charge to flow between the electrodes.
- If the electrodes of the battery are connected to a device like a light bulb, the electrical energy can continue flowing and power the light bulb.



# Quiz

**Question:** What does an electrode do in a battery?

**Answer:** An electrode allows the electrical current to travel in a battery.

**Question:** The 2 electrodes in a battery must be \_\_\_\_\_?

**Answer:** Opposite charges (positive and negative)

**Question:** What makes galvanized nails special?

**Answer:** They are coated in zinc.

**Question:** What is an electrode?

**Answer:** An electrode is a conductor with either a positive or negative electrical charge.

**Question:** What is a conductor?

**Answer:** A conductor is a material that lets an electrical charge travel through it.

**Question:** In the battery you built, what were 2 electrodes that worked?

**Answer:** 2 Electrodes that worked were materials made of zinc and copper.

**Question:** What is a problem you can think of using batteries?

**Answer:** If a battery is not rechargeable, it gets thrown away after only 1 use.

**Question:** What happens when batteries you buy are thrown away.

**Answer:** They can leak toxic chemicals into the environment.

**Question:** What is a battery?

**Answer:** A battery changes chemical energy into electrical energy that can be used to power something.

**Question:** In the battery you just built, what was the electrolyte?

**Answer:** The lemon with juice in it was the electrolyte.

**Question:** What type of energy do batteries convert?

**Answer:** Batteries convert or change chemical energy.

**Question:** What type of energy do batteries release that can be used to power a device?

**Answer:** Batteries release electrical energy.



**Question: What are the main parts of a battery? Hint: there are 2**      **Question: How many electrodes are needed in a battery?**

**Answer:** The 2 main parts of a battery are the electrolyte and electrodes.      **Answer:** 2 Electrodes are needed in a battery.

**Question: How many electrolytes are needed in a battery?**      **Question: Why is an electrolyte needed in a battery?**

**Answer:** Only 1 electrolyte is needed in a battery.      **Answer:** Electrolytes are needed in batteries because they allow the electrical charge to flow between the 2 electrodes

**Question: What is something you use regularly that uses a battery?**      **Question: Why are batteries useful?**

**Answer:** Only 1 electrolyte is needed in a battery.      **Answer:** Batteries provide portable electricity.

**Question: Why didn't the battery you made work with the plastic anchor?**      **Question: What other foods can you think of that would work in a battery?**

**Answer:** Plastic is not a conductor and it didn't have a charge.      **Answer:** Potatoes and limes would also work.

**Question:**      **Question:**

**Answer:**      **Answer:**

**Question:**      **Question:**

**Answer:**      **Answer:**