Battery Scientist: Build a Better Battery

A Middle School Lesson Plan on Battery Chemistry and Energy Storage

Duration: 45 Minutes

Students become Battery Scientists and run controlled experiments to discover which materials make the best battery. Working in teams, they build simple chemical cells, change one variable at a time (the electrolyte, then the metal pair), measure voltage with a multimeter, and combine their best cells to power an LED — mirroring how real battery scientists test new chemistries in the lab.

Students Will Be Able To:

- Explain that a battery stores chemical energy and converts it to electrical energy using two different metals (electrodes) and a conducting substance (electrolyte).
- Design and run a fair test by changing only one variable at a time and keeping all other conditions the same.
- Measure and record voltage using a multimeter and compare results across different materials.
- Use data to identify the best-performing electrode and electrolyte combination and justify their choice with evidence.
- Connect cells in series to increase voltage and power a device.
- Demonstrate professional teamwork, problem-solving, and data-driven decision-making.
- Identify the core role, responsibilities, and career outlook of a Battery Scientist.

Career Spotlight: Battery Scientist

- Role & Responsibilities**:** Battery Scientists research and test new materials for electrodes and electrolytes to make batteries that store more energy, charge faster, last longer, and are safer and cheaper. They design experiments, analyze performance data, and work with engineers to scale promising chemistries for electric vehicles, phones, and grid storage for solar and wind power.
- Education**:** A Bachelor's Degree in Chemistry, Materials Science, Chemical Engineering, or Physics is the entry point. Many research scientist roles require a Master's Degree or Ph.D. Battery lab technicians may start with an Associate's Degree.
- Experience & Training: Entry-level roles often start as lab technicians or research associates, with hands-on training in lab safety, testing equipment, and data analysis. Advanced roles require independent research experience, often through graduate school or internships.
- Salary Range**:** The median pay for chemists and materials scientists is about $95,000 per year. Entry-level pay typically starts around $67,000, and experienced scientists can earn more than $197,000. Materials scientists earn a median of about $118,000.
- Career Outlook: Employment is projected to grow about 7% from 2025–2035, much faster than average, with strong demand driven by electric vehicles and renewable energy storage.

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Materials List

- Battery Scientist Slide Deck
- Student Worksheet

Per group (5–6 groups):

- Digital multimeter (set to DC Volts, 20V range)
- 2 alligator clip leads (4 per group if building a series battery)
- 1 red LED (red LEDs need the least voltage to light)
- Safety goggles for each student
- Ice cube tray or 6 small plastic cups (one "cell" per test)
- Masking tape and marker for labeling cells
- Paper towels

Electrodes (metals) per group:

- 4 copper strips (or clean copper wire, or pre-1982 pennies)
- 3 zinc strips or galvanized (zinc-coated) nails
- 1 aluminum foil strip (folded 3–4 times for stiffness)
- 1 plain steel/iron nail (not galvanized)

Electrolytes (test substances) per group:

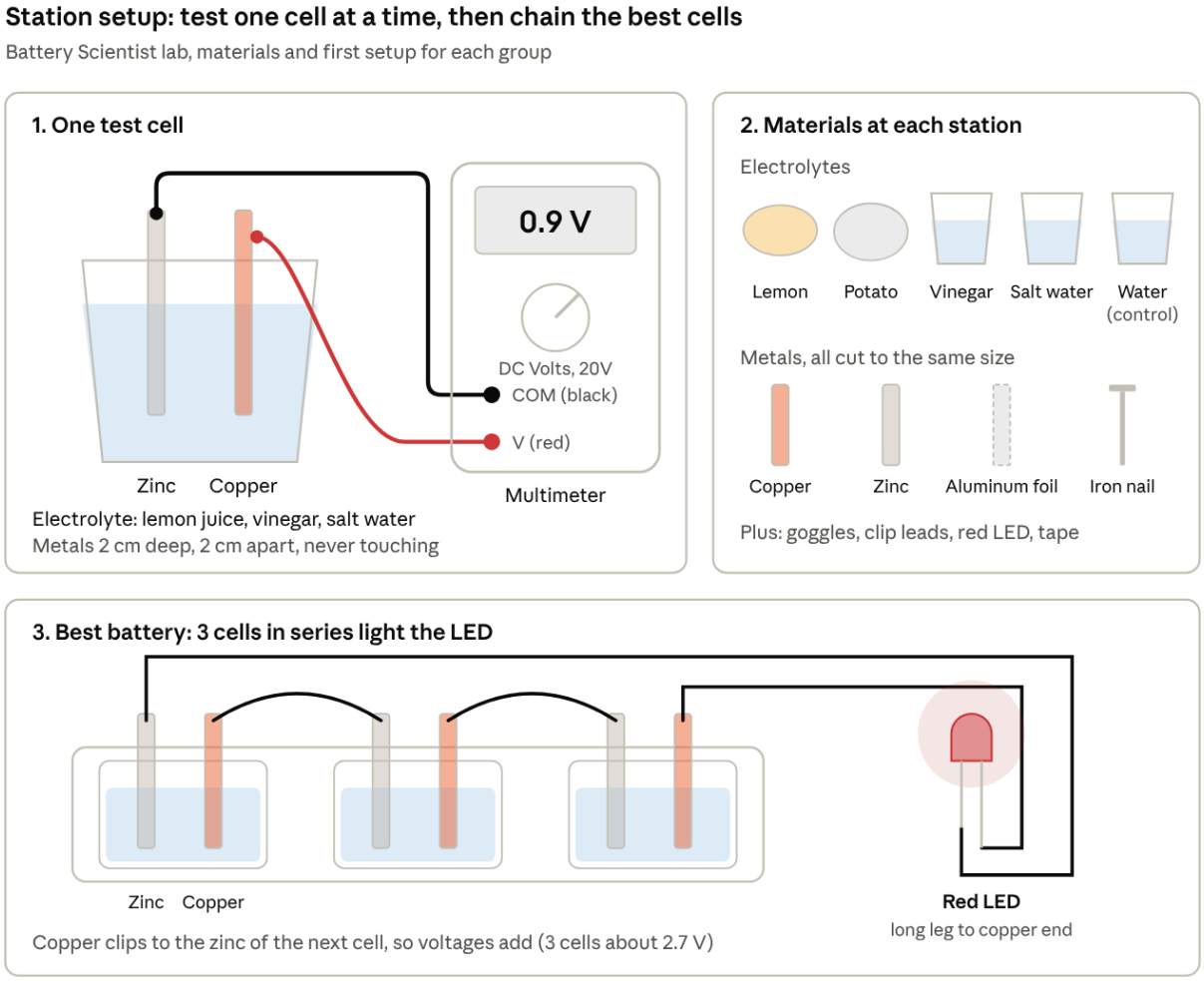
- 1 lemon (or ¼ cup lemon juice)
- 1 small potato (or ½ potato)
- ¼ cup white vinegar
- ¼ cup saltwater (1 tablespoon salt dissolved in 1 cup water)
- ¼ cup distilled or tap water (the **control**)
- Optional: apple, orange juice, sports drink, baking soda solution

Safety Notes:

- Goggles on during all testing. Lemon juice and vinegar sting eyes.
- Do not eat or drink any test materials. Metal ions from the electrodes make them unsafe to consume.
- Metal strip edges can be sharp. Handle by the sides.
- Never open, cut, or test the inside of real batteries. Only use the materials provided.
- Wash hands at the end of the lesson.

Station SetUp

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Facilitator Prep (night before)

- Cut metal strips to the same size (about 1 cm × 5 cm) so tests are fair. Lightly sand copper and zinc with sandpaper or steel wool to remove oxidation — shiny metal gives stronger readings.
- Mix the saltwater. Pour liquids into labeled bottles or cups for easy pickup.
- Cut potatoes in half. Roll lemons firmly on the table to release juice before class.
- Test one lemon cell yourself: copper + zinc in a lemon should read about 0.8–1.0 V. This confirms your multimeters and materials work.
- Set up a materials station for each group. Cells and metals can be rinsed, dried, and reused between classes.

How It Works (Teacher Background): A battery cell needs three parts: two *different* metals (electrodes) and an electrolyte that lets charged particles (ions) move between them. One metal gives up electrons more easily than the other. That difference pushes electrons

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through the wire as an electric current. The **metal pair mostly sets the voltage**, and the **electrolyte affects how easily charge moves** (how much current flows). Students will discover both ideas by testing one variable at a time - exactly how battery scientists screen new materials.

Metal Pair (In lemon or vinegar)	Approximate Voltage
Copper + Zinc	0.8 - 1.0 V
Copper + Aluminum	0.4 - 0.7 V
Copper + Iron/Steel	0.3 - 0.7 V
Copper +Copper (same metal)	About 0 V

Readings vary with freshness, strip size, and how deep the metals are inserted. Use this table to check that groups are on track, not as the "right answers."

Longer-Term Option: If you have a second class period, students can research real battery chemistries (lithium-ion, sodium-ion, iron-air, saltwater batteries) and connect their findings to how scientists are searching for cheaper, safer, and more eco-friendly materials.

1. Opening: What makes a Battery work? (5 Minutes)

Step	Teacher Script	Teacher Notes
1. Introduce the Role	*"Today, you are Battery Scientists. Solar panels only make power when the sun shines, and wind turbines only when the wind blows. Battery scientists search for better materials to store that energy so we can use it anytime. Your job is to test different materials and find the best recipe for a battery."*	**Goal**: Hook students with a real-world role and connect to the Solar Installer and Energy Services lessons. Show the occupational video clip for Battery Scientist / Materials Scientist careers if available.
2. Essential Questions	*"Before we start: What do you think is inside a battery that makes electricity?* ***Turn & Talk:** If you had to build a battery from things in your kitchen, what would you try, and why?"*	**Facilitation:** Lead a 2–3 minute discussion. Elicit ideas like metals, acids, liquids, and "juice." Introduce the three parts of every battery: **two different metals (electrodes)** and an **electrolyte** between them. Explain that today they will change one part at a time to see what

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		matters most — just like a real battery lab.

2. Hands-On Activity: Battery Materials Lab (30 Minutes)

Objective: Students test different electrolytes and metal pairs, measure the voltage each combination produces, and use their data to build the best-performing battery — mirroring how real Battery Scientists screen new materials.

Step	Teacher Script	Teacher Notes
1. Setup & Materials Check	*"Each team has a multimeter, clip leads, metal strips, and several test substances. Put on your goggles. The multimeter is your most important tool today — it tells you the voltage, or how hard the battery is pushing electricity. Battery scientists never guess; they measure."*	**Demonstrate:** Set the multimeter to DC Volts (20V). Red probe touches one metal, black probe touches the other. A negative number just means the probes are reversed — swap them. **Fair Test Rules:** Same size strips, same depth (about 2 cm into the substance), strips about 2 cm apart and never touching. Hold probes steady for 5 seconds before reading.
2.Test 1: Which Electrolyte Works Best?	*"In Test 1, you will keep the metals the same — copper and zinc — and change only the electrolyte. Test lemon, potato, vinegar, saltwater, and plain water. Record the voltage for each in Table A. Before you start, write a prediction: which one will be best?"*	**Variable Focus:** Ask, "What is the one thing you are changing? What are you keeping the same?" Plain water is the **control** — it shows what happens with almost no electrolyte. Rinse and dry the metals between tests so one substance doesn't contaminate the next. **Expect:** Most electrolytes give similar voltages (about 0.8–1.0 V). Plain water is much lower or unsteady.

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3. Test 2: Which metal pair works best?	*"Now switch roles. Keep the electrolyte the same and use the one that worked best in Test 1.* *Then change only the metals. Test copper + zinc, copper + aluminum, copper + iron nail, and copper + copper.* *Record your results in Table B."*	**Key Discovery:** The metal pair changes the voltage much more than the electrolyte does. Copper + copper should read about 0 V — ask, "Why do you think two of the same metal makes no electricity?" (A battery needs two metals that "want" electrons differently.) **Real-World Link:** This is why scientists study lithium, sodium, and zinc — each metal changes what a battery can do.
4. Analyze your Data	*"Look at Tables A and B together.* *What is your team's best battery recipe: which electrolyte and which metal pair? What evidence supports your choice?"*	**Assessment:** Circulate and check that students justify their choice with numbers, not opinions. Push groups to notice patterns: "Which changed the voltage more: switching the metals or switching the electrolyte?"
5. Build the Battery	*"One cell doesn't make enough voltage to light an LED — it needs about 1.8–2 volts. Use your best recipe to build 2, 3, or 4 cells in the ice cube tray. Connect them in a chain: the copper of one cell clips to the zinc of the next. Measure the total voltage, then connect the LED. How many cells does it take?"*	**Series Circuit:** Voltages add in series (3 cells × about 0.9 V = about 2.7 V). The LED's long leg connects to the copper end; the short leg connects to the zinc end. If it doesn't light, flip the LED and check that no metals are touching. Dim the lights for a better view. **Challenge:** The team that lights the LED with the fewest cells wins. **Differentiation:** Advanced groups can compare their measured total to their predicted total and explain the difference.

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3. Closing & Review: Career Spotlight (10 Minutes)

Step	Teacher Script	Teacher Notes
1. Data Review & Discussion	*"What was your best battery recipe? Did changing the metals or changing the electrolyte make a bigger difference? Why do you think plain water and copper + copper didn't work well?"*	Collect each group's best voltage on the board and compare. Lead a discussion on the two big ideas: **the metal pair sets the voltage** and **the electrolyte lets charge move between the metals**. Connect to real batteries: lithium-ion batteries use lithium compounds as electrodes and a special liquid or gel as the electrolyte.
2. Career Profile Wrap Up	*"You've practiced the core skills of a Battery Scientist — designing fair tests, changing one variable at a time, measuring carefully, and using data to find the best materials. Battery scientists are working right now to make batteries that store more solar and wind energy, cost less, and use materials that are safer for the planet."*	Wrap-Up: Review the career profile. Ask students what surprised them most and how their experiment reflects real lab work. Connect to local examples — electric buses, phone batteries, and battery storage for the power grid.

Extension: Design a Green Battery

Challenge students to sketch a design for an eco-friendly battery that could store energy from solar panels or wind turbines. Their design should name the electrode and electrolyte materials they would use (based on today's data), explain why those materials are safer or more sustainable, and describe how the battery would be used. Groups present their designs and explain how their battery would help build a greener energy future.

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Battery Materials Challenge

Student Worksheet

Name: _____ Date: _____
Group Members: _____

Scenario:

You are a Battery Scientist. A clean-energy company wants a low-cost battery made from common, eco-friendly materials to store energy from small solar panels. Your job is to test different electrolytes and metal pairs, measure the voltage each one produces, and recommend the best battery recipe — just like a real battery research lab.

Part 1: Career Spotlight – Battery Scientist

You will use the information below to answer the final analysis questions.

Detail	Description
Role & Responsibilities	Research and test new materials for batteries so they store more energy, charge faster, last longer, and are safer and cheaper. Design experiments, analyze data, and work with engineers on batteries for electric vehicles, phones, and solar and wind energy storage.
Education	Bachelor's Degree in Chemistry, Materials Science, Chemical Engineering, or Physics. Many research roles require a Master's Degree or Ph.D.
Experience & Training	Many start as lab technicians or research associates, with training in lab safety, testing equipment, and data analysis.
Career Outlook	Estimated 7% growth from 2025–2035, much faster than average, driven by electric vehicles and renewable energy storage.

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Salary Range	Median pay is about $95,000 per year. Entry-level pay starts around $67,000; experienced scientists can earn more than $197,000.

Part 2: Hands-On Challenge Procedure

Materials Check:

- Multimeter and 2–4 alligator clip leads
- Ice cube tray or small cups, masking tape, marker
- Metals: copper, zinc (or galvanized nail), aluminum foil strip, iron nail
- Electrolytes: lemon, potato, vinegar, saltwater, plain water
- Red LED
- Safety goggles

A. Procedure

Before you begin: Safety First

- Put on your safety goggles and keep them on until cleanup is finished.
- Do not eat, drink, or taste any test materials, even the lemon or potato.
- Handle metal strips by the sides. The edges can be sharp.
- If juice or vinegar gets in your eyes, tell your teacher right away and rinse with water.

Step 1: Organize Your Station

1. Check that you have everything on the Materials Check list. Tell your teacher if anything is missing.
2. Use masking tape and a marker to label each cup: *Vinegar*, *Saltwater*, and *Water*.
3. Fill each cup about ¾ full with its liquid.
4. Roll the lemon firmly on the table for about 10 seconds to make it juicy inside.
5. Assign roles:
    - Setup Scientist: places the metals.
    - Meter Reader: holds the probes and reads the voltage.
    - Recorder: writes the data in the tables.
    - Materials Manager: rinses and dries the metals between tests.
6. Switch roles after Test 1.

Step 2: Set up the Multimeter

1. Turn the dial to the **DC Volts** section (marked **V** with a straight line). Choose the **20** setting.
2. Plug the black wire into the port marked **COM** and the red wire into the port marked **V**.
3. **Practice:** touch the red and black probe tips together. The screen should read about **0.00**.

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4. **Rule for the whole lab:** the **red probe always touches the copper**, and the black probe touches the other metal.
5. If a reading shows a minus sign (for example, −0.85), your probes are reversed. Swap them and read again.

Step 3: Learn the Fair Test Rules

A fair test means only **one thing changes** at a time. For every test:

- Push each metal strip about **2 cm** into the substance. Use your ruler, or mark 2 cm on each strip with a marker.
- Keep the two metals about **2 cm apart**. They must **never touch** each other, or the test won't work.
- Touch the probe tips to the **dry tops** of the metal strips, not to the liquid.
- Hold the probes steady for **5 seconds** before reading.
- If the number keeps changing, wait until it settles and record the middle value.
- Record your voltage to **two decimal places** (example: 0.87 V).

Step 4: Test 1 — Which Electrolyte Works Best?

You will change only the electrolyte. The metals stay copper + zinc every time.

1. **Predict:** Before testing, write your prediction at the top of Table A. Which electrolyte do you think will produce the most voltage, and why?
2. **Lemon:** Push the copper strip and the zinc strip into the lemon, 2 cm deep and 2 cm apart. Touch the red probe to the copper and the black probe to the zinc. Wait 5 seconds and record the voltage in Table A.
3. **Clean the metals:** Remove both strips, rinse them in the rinse cup, and dry them with a paper towel. *Why?* Leftover juice would mix with the next substance and make the test unfair.
4. **Potato:** Repeat steps 2–3 using the potato.
5. **Vinegar, Saltwater, and Water:** Stand both strips in each cup, 2 cm apart. If the strips slide or lean, tape them to opposite sides of the cup. Measure, record, then rinse and dry.
6. **Plain water is your control.** It shows what happens when there is almost no electrolyte. Compare every other result to it.
7. In the Observations column, write anything you notice, such as bubbles, a number that keeps dropping, or a metal changing color.
8. **Discuss as a group:** Which electrolyte had the highest voltage? Circle it in Table A. You will use it for Test 2.

Step 5: Test 2 — Which Metal Pair Works Best?

Now you will change only the metals. The electrolyte stays the same, using your best one from Test 1.

1. Write your chosen electrolyte on the blank line in the Table B title.
2. Set up fresh electrolyte: a clean cup of liquid, or a new spot on your lemon or potato.
3. **Copper + Zinc:** Insert both strips (2 cm deep, 2 cm apart), measure, and record in Table B.

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4. **Copper + Aluminum:** Fold the foil strip lengthwise 3–4 times so it is stiff enough to stand. Test it with the copper strip. Measure and record.
5. **Copper + Iron Nail:** Test the iron nail with the copper strip. Measure and record.
6. **Copper + Copper:** Use two copper strips (borrow one from another group if needed). Measure and record. Predict first: what do you think will happen?
7. Rinse and dry the metals between every test.
8. **Discuss as a group:** Which metal pair gave the highest voltage? Which gave the lowest? Did changing the metals make a bigger or smaller difference than changing the electrolyte in Test 1?

Step 6: Analyze Your Data

1. Look at Tables A and B side by side.
2. Choose your **best battery recipe:** the electrolyte with the highest voltage plus the metal pair with the highest voltage. Write it on the "Our best recipe" line above Table C.
3. Be ready to explain your choice using **numbers** from your tables, not just opinions.

Step 7: Build the Best Battery

*One cell makes about 1 volt. A red LED needs about 2 volts to light. You will connect several cells in a chain, called a **series**, to add their voltages together.*

1. **Make the cells:** Fill 4 compartments of your ice cube tray about ¾ full with your best electrolyte. If your best electrolyte was lemon, use lemon juice or small lemon pieces. Label them Cell 1, 2, 3, and 4.
2. **Add metals:** In each compartment, place one zinc strip on the left and one copper strip on the right. Keep them from touching.
3. **Measure 1 cell:** Red probe on the copper of Cell 1, black probe on the zinc of Cell 1. Record the voltage in Table C (1 cell).
4. **Connect 2 cells:** Clip a lead from the **copper of Cell 1** to the **zinc of Cell 2**. Measure the total: black probe on the zinc of Cell 1 and red probe on the copper of Cell 2. Record.
5. **Connect 3 cells:** Clip a lead from the **copper of Cell 2** to the **zinc of Cell 3**. Measure from the zinc of Cell 1 to the copper of Cell 3. Record.
6. **Test the LED:**
    - Clip a lead from the **copper end** of your chain to the LED's **long leg**.
    - Clip a lead from the **zinc end** of your chain to the LED's **short leg**.
    - Ask your teacher to dim the lights and look closely at the LED. Record Yes, Dim, or No.
7. **Not lighting?** Try these fixes in order:
    - Flip the LED's legs.
    - Check that no metals are touching inside the cells.
    - Check that every clip is firmly attached to metal.
    - Add Cell 4 and test again.
8. Record the fewest number of cells it took to light the LED. This is the group challenge!

Step 8: Make Your Recommendation

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Answer the recommendation question at the bottom of Part 2. Tell the clean-energy company your best recipe, how many cells it takes to light the LED, and the data that supports your choice.

Step 9: Clean Up

1. Remove all metals, rinse them, and dry them completely.
2. Pour liquids into the sink. Throw the lemon and potato in the trash, since they are not safe to eat after testing.
3. Turn the multimeter dial to **OFF**.
4. Wipe down your table and return all materials to the bin.
5. Wash your hands with soap and water.

B. Data Collection Table

My prediction: The best electrolyte will be: _____ because

_____

_____

Table A: Testing Electrolytes (metals stay the same: Copper + zinc)

Electrolyte	Voltage (V)	Observations
Lemon		
Potato		
Vinegar		
Saltwater		
Plain water (control)		
Your choice: _____		

Table B: Testing Metal Pairs (electrolyte stays the same: _____)

Electrolyte	Voltage (V)	Observations
Copper + Zinc		

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Copper + Aluminum		
Copper + Iron Nail		
Copper + Copper		

Table C: Building the Best Battery

Our best recipe:

Electrolyte: _____ Metal Pair_____

Number of Cells in Series	Voltage (V)	Did the LED light? (Yes/Dim/No)
1		
2		
3		
4		

As a battery scientist, what battery recipe would you recommend to the clean energy company and why?

_____

_____

_____

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Part 3: Analysis and Conclusion

Answer the following questions based on your experiment and the Career Spotlight section.

1. What are the three parts every battery cell needs? Which part did you change in Test 1, and which part did you change in Test 2?

2. According to the Career Spotlight, what is the expected employment growth for Battery Scientists (chemists and materials scientists) from 2025–2035?

3. Which made a bigger difference in voltage — changing the electrolyte or changing the metals? Use numbers from your tables as evidence.

4. Your copper + copper cell produced almost no voltage. Why do you think a battery needs two *different* metals?

5. Real Battery Scientists test many materials to find batteries that are cheaper, safer, and better for the planet. If you could test one new material next, what would it be and why? How would you keep your test fair?

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