ACS
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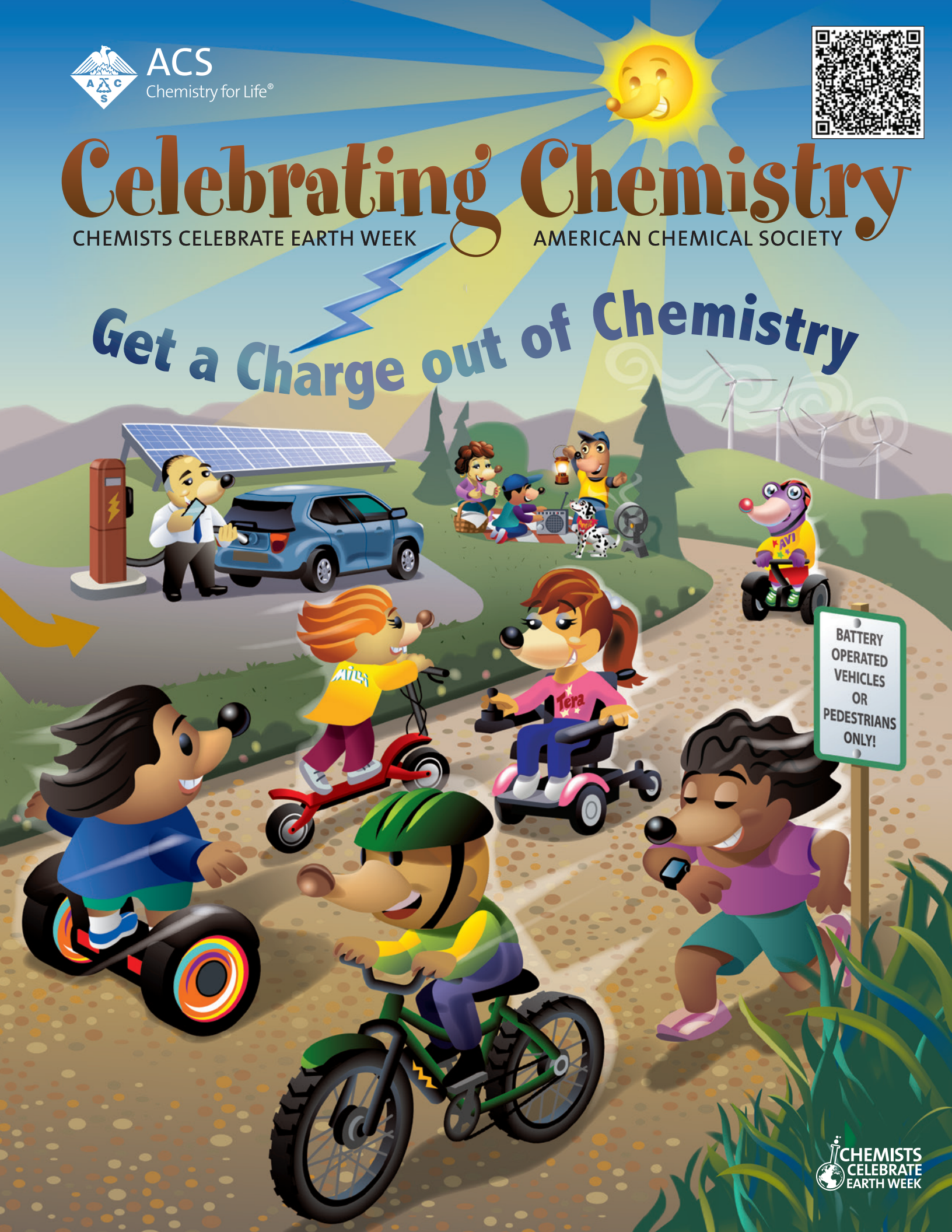
Celebrating Chemistry

CHEMISTS CELEBRATE EARTH WEEK

AMERICAN CHEMICAL SOCIETY

Get a Charge out of Chemistry



Welcome to "Get a Charge out of Chemistry"!

Did you know the world's first-ever battery was made over 2,000 years ago? Today, batteries are everywhere!

A battery is a storage device for energy. It contains chemicals that allow it to store energy in the form of **chemical energy**. This stored energy can be converted to electrical energy whenever we need it (on page 4, read about how a battery works). With this electrical energy, you can power anything … from a flashlight to a car!

The HUGE role of batteries

Alternative energy sources (like solar and wind energy) are becoming more popular, as less and less oil is available for use. Fuels like oil and coal are called **fossil fuels**. Their use pollutes the earth. *Alternative* fuel sources, however, do not pollute the earth as much. They can replace fossil fuels, with the help of batteries (more about the role of batteries on page 3).

What types of batteries do you know about?

Certain batteries can be charged and reused (discharged) many times over. These are called **rechargeable batteries**. Common examples are cell phone and laptop batteries. However, other types of batteries have to be replaced with a new one once they "die." They are called **single-use batteries** or **disposable batteries**. Old batteries of any type should be recycled (read more on page 8).

Other types of batteries include lead-acid batteries in gasoline powered cars; alkaline batteries in remote controls, flashlights, and smoke detectors; lithium or lithium-ion batteries in cellphones, hearing aids, electric vehicles (EVs), wheelchairs, etc.

About the cover:

The picture on the cover shows at least 11 gadgets that run on batteries. Can you find them all? Read on to confirm. (See page 9 for an activity to find items that function on batteries around your home.)

In the background, you will see a:

- Battery-operated pedestal fan (moles on a picnic);
- Radio (being set up on the blanket);
- Lantern (handheld);
- Battery-powered EV (which is plugged in for charging); and
- Mobile phone (being held by the mole charging the EV)

In the foreground, on the hiking path for pedestrians and battery-operated vehicles, you will see:

- Tera on her battery-operated wheelchair enjoying the warm day;
- Avi riding his safe Segway ride and soaking up the sun;
- Milli riding her e-scooter with the wind in her hair;
- A mole on his hoverboard having a ball;
- Other moles pedaling their e-bikes and appreciating the easy ride; and
- A mole runner with a smart watch, checking the number of steps as they workout.

You might also notice:

- Wind-powered turbines to harness wind energy; and
- Solar panels to harvest sun's energy.

Batteries today are vital to our lives. But they also pose many challenges. Scientists are making batteries lighter and better, and also building batteries that pollute less with high-energy storage capacity. Obtaining the raw materials to make batteries is expensive and polluting (read more on page 11). Scientists are making many such improvements that can help refine the batteries of tomorrow.

Batteries are everywhere and they make our lives easier. They give you instant power … no matter where you are! Find out how they work and other cool stuff about batteries in this issue. (Fancy making your own? See page 5!) Go ahead and get a "charge" out of chemistry!

Batteries Save the Sun's Energy!

By Neal Abrams

What's the connection between batteries and Earth Week? When we use batteries instead of nonrenewable power sources (like coal, oil, and natural gas), we help protect our planet!

A battery is a container to store *chemical* energy. When we need it, this energy can be changed into *electrical* power. Batteries are helping us move away from fuels that pollute to **renewable energy** sources — like sunlight*, wind, and moving water.

Fossil fuels release energy as they burn. They were formed over millions of years from dead plants and animals buried deep inside the earth. Over time, temperature and pressure changed them into various types of material with stored energy. Right now, burning these fuels is the main way we generate energy to heat our homes, power our cars, and nearly everything else.

Saying no to fossil fuels, and yes to cleaner sources!

There are only limited amounts of fossil fuels left on earth. When we have used them all up, they'll be gone forever—which is why we call them *nonrenewable*. Another problem is that they pollute the environment as we burn them for energy.

The good news is that *renewable* energy sources, like the sun and the wind, will always be around. They are much cleaner than fossil fuels, because when we use them for energy, they don't pollute the environment as much. But what do we do when the sun isn't shining, or when the wind isn't blowing?

The answer is … *batteries*! When the sun is shining, its energy can charge a battery. Similarly, when the wind is blowing, wind turbines can charge a battery. Batteries can store this energy like a bank stores money. Electricity is "deposited" (or charged) and "withdrawn" (or discharged) from batteries whenever it is needed.

Think of a house with solar panels and a battery system. On sunny days, the solar panels charge the batteries and supply electricity to the house. During cloudy days or at night, the solar panels don't produce electricity. However, we can switch to the battery with stored energy as the source of electricity for the house. The bigger the battery, the more power it can store. It would be ideal to have a battery system large enough to power a home for several days.

To make the change from using fossil fuels for energy to solar energy (and other cleaner sources), batteries are important. Today, many homeowners cannot afford to have solar panels and a battery backup for using clean energy. This is often because of the high cost for the panels and large batteries needed.

This is why engineers are working on solutions to allow entire neighborhoods, and even cities, to be powered by batteries. Scientists are working on building safer, cheaper, and better batteries for all of us. Would you like to one day own a battery-powered home?

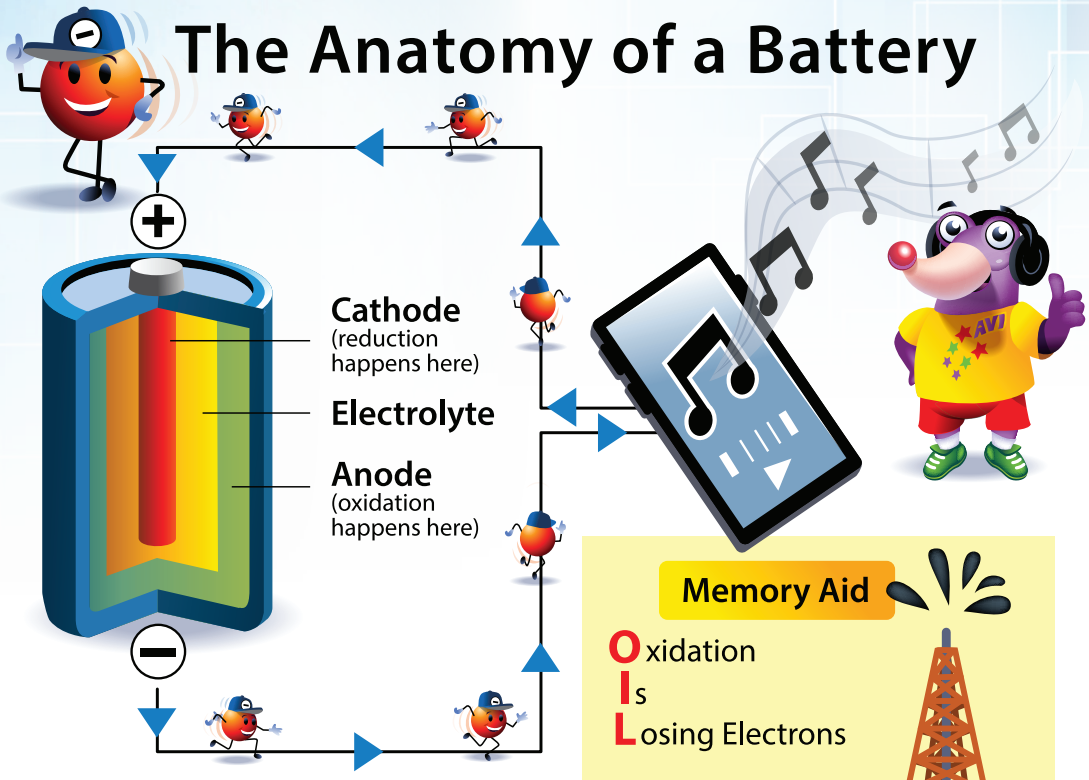
*The sun's lifetime is so long that its energy will practically never run out.

Neal Abrams *is Associate Professor of Chemistry at the SUNY College of Environmental Science and Forestry in Syracuse, New York.*

Milli's Safety Tips: Safety First!

- Ask an adult for permission to do the activity and for help when necessary.
- Read and follow all directions and safety recommendations before starting the activity.
- Wear appropriate personal protective equipment (safety glasses, at a minimum), including during preparation and clean up.
- Tie back long hair and secure loose clothing, such as long sleeves and drawstrings.
- Do not eat or drink food when conducting the activity.
- Clean up and dispose of materials properly when you are finished with the activity.
- Thoroughly wash hands after conducting the activity.

The Anatomy of a Battery



We place batteries inside remote controls, toys (like the ones that light up or make sounds), wireless keyboards and mouses, wall clocks, and smoke detectors. Let's take a look inside a single-use alkaline battery you might have at home.

By Tracy P. Hamilton

What is a battery?

A battery is a storage device for energy. It stores chemical energy and converts it into electrical energy whenever you need it.

Parts of a battery

Look closely at the cylinder-shaped battery in the picture. It has two ends: one has a part that sticks out on its top. Next to it, you can see a little plus (+) sign. This is the *positive* end of the battery, or **cathode**. The completely flat end of the battery has a minus (–) sign next to it. This is the *negative* end of a battery, or **anode**. Depending on the battery type, there is also a liquid, solid, or paste/gel, called an **electrolyte**. The electrolyte separates the cathode and the anode.

How does a battery work?

Everything around us is made of the smallest, basic building blocks called **atoms**. They make up everything from the chair you sit on, to your favorite book, to your own body! Atoms are extremely small. Even the dot over one "i" on this page is made of millions and millions of atoms.

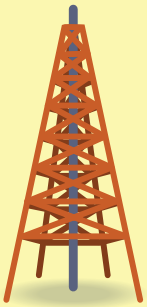
Atoms have **electrons**, which are extremely tiny, negatively-charged particles. Batteries work by making these electrons move from one part of the battery to another. Batteries are made up of two parts. One part, the anode, "holds on" to its electrons very loosely. The other part is the cathode, and it has a strong pull on the electrons and holds them tightly.

Electricity is generated when electrons move from the anode (– end) to the cathode (+ end). The electrons don't start moving until you pop the battery into a device and turn it on. Now the electrons can move from the anode to the cathode through your device. When electricity is flowing, the cathode gains the same number of electrons that the anode loses. This happens through two different types of chemical reactions. The reaction when the cathode gains electrons is called **reduction**. The reaction when the anode loses electrons is called **oxidation**.

Memory Aid

Oxidation
Is
Losing Electrons

Reduction
Is
Gaining Electrons



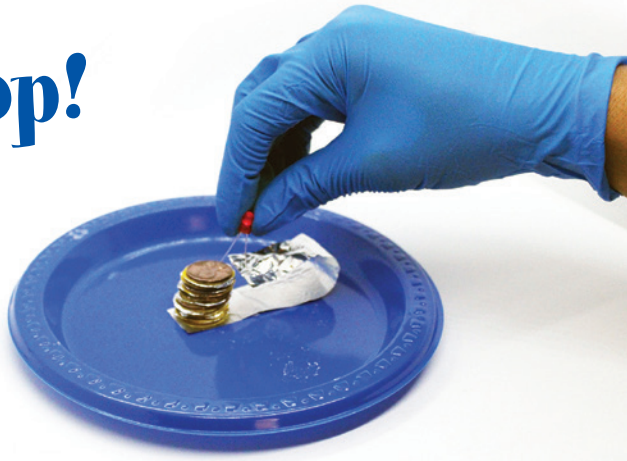
Why do batteries "die"?

A battery works when the original chemicals inside it are still new and unused. When electricity starts flowing, these chemicals react with each other to become different chemicals. Once the original chemicals are all used up, the battery is dead. If you could reverse the reaction or add more of the original chemicals, you may be able to keep the reaction going.

A chemical reaction is a bit like building a little house with Legos. Once you have used up all your Lego pieces, the (re)action stops. If you want to build something new, you have two choices. You could choose to take the house apart and reuse the Legos, which is kind of how rechargeable batteries work. Or you could decide to buy more Legos, which is kind of like replacing dead batteries with new ones. Just like you would reuse your Legos to make something else, be sure to **recycle** your dead batteries. See page 8 to find out how.

Tracy P. Hamilton *is a retired associate professor who taught at the University of Alabama at Birmingham.*

Build-A-Battery Workshop!



By Sherri C. Rukes

Introduction

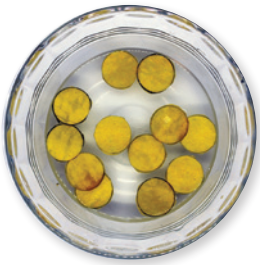
In this activity, you can build a simple battery with enough power to light a small red lightbulb (or a buzzer/fan)! You'll feel the joy of building your own battery, just like Alessandro Volta did when he discovered batteries in 1780!

Question to Investigate

How can you light a bulb (or sound a buzzer) with pennies and foil?

Materials

- 12 pennies
- Aluminum foil
- 12 zinc washers, ¾" wide (about 2 cm) (optional)
- Construction paper, 6" x 12" inch (about 15 x 30 cm), any color
- Small red LED bulb (search online for "5 mm red LED bulbs")
- Optional buzzer in place of the light (search online for "hobby buzzer/motor" or "buzzer for circuit")
- 2 Tbsp (30 mL) of household vinegar, colorless
- 2 tsp table salt
- 5 mL (teaspoon) measure
- 15 mL (tablespoon) measure
- Plate, lid, or small tray
- Tap water
- Small bowl
- Scissors
- Spoon
- Forceps (tweezers)



Safety Suggestions

- ✓ Safety goggles required
- ✓ Thoroughly wash hands after this activity
- ✓ Use forceps (tweezer) to remove items from vinegar solution
- ✓ Ask your adult partner to cut the aluminum strip

Notes:

- Zinc washers work best. But aluminum foil also works fine (like in the pictures).
- For making additional cells, you will need extra pennies, foil, and construction paper. This is especially the case for using a buzzer or fan instead of a small red lightbulb.
- Have an adult tear a strip aluminum foil about 4 inches (or 10 cm) wide.

Procedure

I. Prepare the night before

1. Pour 2 Tbsp of vinegar into a small bowl. Add the pennies, cover them, and let soak overnight to clean them.
2. In the morning, remove the pennies from the vinegar using forceps and rinse them with water.
3. Lay them on a paper towel to dry and rinse the bowl.

II. Prepare the pieces of your battery

1. Ask your adult partner to cut one rectangular strip of aluminum foil that is ¾" (2 cm) wide and 6" (15 cm) long.
2. Use a pencil to trace a penny on the construction paper 12 times.
3. Use scissors to cut out 12 disks from the construction paper. If you're using foil instead of zinc washers, you can layer the paper over the foil and cut out both together.
4. Add 2 Tbsp room-temperature water and 2 Tbsp of salt to the bowl. Gently stir with a spoon until the salt dissolves.
5. Place the construction paper disks in the saltwater to soak for about 1 minute. Then, remove and place them on a tray or plate.

III. Build your battery

1. Place the strip of aluminum foil on the plate so that one end is at the center of the plate.
2. Place one moist construction paper disk on top of the foil. Place a penny over it. This stack of foil-paper-penny is called one **cell**.
3. Stack more foil-paper-penny cells on top of the first one. The setup must end with a penny resting on the very top. Your battery will have 12 cells (see pictures below).

IV. Test your battery

1. The LED bulb has one long and one short "leg." Position the long leg touching the penny on top of the stack. Place the shorter leg touches the loose end of the foil. You can bend the legs of the LED bulb to do this. Does the LED light up? If not, try the "Troubleshooting tips" box below.
2. Can you light up the bulb using fewer cells? Try it! What is the fewest number of cells you need to use to light up your bulb? What would you do to make the bulb glow brighter?

Troubleshooting tips:

- Squeeze out excess liquid from the battery stack and let it rest for about an hour or two.
- Double check that all foil-paper-penny cells are correctly ordered in your battery.
- Do not squeeze the cells together when trying to light the bulb. It works better if they are a little loose.

How does it work?

Your completed battery works because electrons flow between the anode (aluminum foil/zinc washer) and cathode (penny) through the bulb (it lights up). All atoms contain electrons. Some atoms (like the copper in the penny here) "hold onto" their electrons more tightly than some other atoms (like aluminum/zinc in the foil/washer). When the LED bulb is connected to the setup, it allows the loosely-held electrons from the aluminum/zinc anode to flow through the bulb to the penny cathode.

Two different chemical reactions take place to convert chemical energy to electrical energy or electricity. The type of chemical reaction happening at the penny is called *reduction* (when electrons are *gained*). The one happening at the zinc washer is called *oxidation* (which is the name for the *loss* of electrons). One cannot happen without the other. That's how batteries work!

Sherri C. Rukes *is a chemistry teacher at Libertyville High School in Libertyville, Illinois.*


SUNNY DAY!
EV charge station
Solar Car move up 2 extra spaces!
EV, Solar, and Hybrid cars jump 2 extra spaces!
EV move ahead 3 spaces!
Oops! Gas Car falls in river and loses 1 turn.
SWAMP MONSTER
All cars lose a turn to the Swamp Monster.
EV, Solar, and Hybrid cars jump 2 extra spaces!
EV charge station
Mountain Pass Shortcut
EV move 3 extra spaces!
EV and Solar Car take this path for not using fossil fuels.
Gas station
Gas Car move one extra space!
THE CAR RACE GAME
What You'll Need
1. Six-sided die (or a digital simulator)
2. The game board on this page
3. Scissors to cut out the play pieces.
START
FINISH
1 more space to win!!
EV and Solar Car move ahead 3 spaces!
EV
NANO
GAS
MILLI

How to Play

1. 2-4 players can play this game.
2. Choose your car and cut out the play pieces in the dashed boxes below.
3. Each player rolls the die, and the player who rolls the highest number goes first. The player to the right follows next.
4. When players roll the die, they move forward the number of spaces shows on the die.
5. When you land on a space, perform the action(s) indicated on it.
6. The first one to reach FINISH wins.

Playing Pieces - Cut outs

Recycle That Battery!

By David S. Heroux

Look around, and you might notice that people use batteries every day in cars, smart watches, hearing aids, cellphones, and more! Batteries can allow us to use renewable energy sources and reduce pollution.

Most modern batteries, like those used in cell phones and electric cars, are reusable (or rechargeable). They can be charged and used over and over until they wear out and no longer work. When that happens, we need to recycle them. Recycling is a process for changing old, worn-out things into new, reusable parts or devices. Almost all batteries are recyclable, either entirely or in part.

Lead-acid batteries

Cars that run on gasoline have the oldest type of rechargeable batteries, called **lead-acid batteries**. They are used for starting the car and operating the lights, radio, and other accessories. Lead-acid batteries provide energy, but they are also big and bulky, and have a limited life span. Fortunately, lead-acid batteries are fairly easy to recycle. Many stores that sell new batteries will take used ones in exchange.

Lead-acid batteries have heavy plastic containers that hold lead and lead compounds, surrounded by acid. To recycle these batteries, the acid must be neutralized, and then the whole battery is crushed up. Crushed parts are put in water: plastic parts float up and lead parts sink. Plastic parts are first separated, and then recycled into new battery containers. The lead parts can be melted and recycled into new batteries. Over 99% of lead-acid batteries today are recycled, and new batteries are made from 60-80% recycled lead and plastic.

Alkaline batteries

Most common household devices, such as remote controls, flashlights, and radios, run on **alkaline batteries**. This type of battery is often not rechargeable and can only be used once. Certain parts of alkaline batteries are recyclable—but currently, less than half are.

Inside alkaline batteries are zinc (Zn) and manganese (Mn), two types of metal that can be recycled. The casing is made of steel, which can be recycled multiple times. First, the batteries are cut up and crushed. Then, after an electric current is used to separate the parts, the Zn and Mn can be recycled into new batteries. Some companies are trying to make plant fertilizers from them.

Lithium-ion batteries

Cellphones, bicycles, hearing aids, and electric cars all use **lithium-ion batteries** (or LIBs, for short). These can be charged again and again. They can be made in various shapes and sizes and can be quite powerful.

LIBs can also be recycled, but only about 5% are. This may be because LIBs are harder to recycle. They contain parts that are made of different metals including lithium (Li), cobalt (Co), and nickel (Ni). Some of these parts can be dangerous to people, and they need to be handled with caution. Currently the biggest challenge is finding a cost-effective method to recycle them.

Every year, more and more bikes, cars, trucks, and even planes are using LIBs. Scientists and engineers are working to find better ways to recycle and reuse these batteries, and at the same time, reduce waste. Some scientists are even developing robots to separate the parts and make recycling easier and safer.

Perhaps, one day, you will be a scientist or engineer who helps develop a safer and less expensive way to recycle batteries and all their parts!

David S. Heroux *is the Leavy Family Professor of Chemistry at Saint Michael's College in Colchester, Vermont.*

On the Hunt … for Batteries!

By Weslene Tallmadge

Introduction

This is an indoor scavenger hunt that you can do alone or with a friend. Read a clue from the list below. Think about what each item might be. Then look for it until you find it. How many items can you find in 10 minutes?

Hint: It will be an item that uses batteries as its energy source.

Question to Investigate

Which items in your home use batteries?

Materials

- a timer
- a piece of paper, pen, or cell phone for each player
- a printed copy (or picture) of the clues on this page for each player

Procedure

1. Set the timer for 10 minutes.
2. Find as many items as you can that use batteries. If you can't find an item, guess!
3. Provide evidence of each item found/guessed by writing the name of the item next to each clue, OR take a photo of each item exactly where you found it. Ask your adult partner to tell you if the item uses rechargeable or single-use batteries. You will note down an "R" next to the items that contain rechargeable batteries or an "SU" next to those that use single-use batteries.
4. When 10 minutes are up, check the answer key on this page, and give yourself 1 point for each item you found/guessed correctly based on the answer.
5. Add an extra point for each item that contains rechargeable batteries, rather than disposable batteries.

Safety Suggestions

- ✓ Adult supervision and assistance required.
- ✓ Do not remove batteries from any items.
- ✓ Put the items back where you found them.

Battery Hunt Clues!

1. Although I can usually fit in just one hand, I am all you need to write to your grandma, watch videos, play games, and take pictures at a birthday party.
2. You can scribble on me and not get into trouble, and you might use me for some homework assignments, too.
3. I keep track of time, even when the power is out.
4. I can change the channel for you without you having to get up.
5. Do not burn your toast, or you may hear from me (loudly).
6. If you like to play games, get a grip on me!
7. You may wish you could always use me in math class.
8. Hold me tight when it's dark at night. I shine bright.
9. You are never too old to play. I might be your favorite gift.
10. I can be loud or quiet. You connect me to an electronic device to dance or sing along.

Ask an adult if any of the items you found use rechargeable batteries, and you make a note.

Bonus items: Look around to find more items that use batteries but aren't on the list.

1. _____
2. _____

Answer Key

1. Cell phone (R)
2. Tablet/laptop computer (R)/(R)
3. Alarm clock/watch (can be a smart watch or regular watch) (SU)/(R)
4. TV remote (SU)
5. Smoke detector (SU)
6. Wireless/mobile game controller (SU)/(SU)
7. Calculator (SU)
8. Flashlight/battery-powered lamp (SU)/(R)
9. Any toy that runs on batteries (SU)
10. Bluetooth speakers/earphones/headphones (R)/(R)/(R)

Bonus answer: Some other items you might find include: remote controls for a fan, space heater, light, or car key, solar lights, robot vacuum cleaners, wheelchairs, electronic scales, battery-operated toothbrushes or shavers, wireless doorbells, security cameras, thermometers, watches, clocks, musical devices such as keyboards, two-way radios, hearing aids, cars, e-bikes, and garage door openers.

Where's the chemistry?

Since their invention, batteries have played a greater and greater role in our daily lives. We rely on batteries to store energy, and then provide that energy when and where we want to use it. Using batteries can decrease how much we use fossil fuels, help us be more mobile, and make our devices do more for us.

Weslene Tallmadge *is a Professor at Gannon University in Erie, Pennsylvania.*

The Adventures of Meg A. Mole, Future Chemist

Mr. Jeff Michalski

In honor of this year's Chemists Celebrate Earth Week theme, "Get a Charge out of Chemistry," I traveled to Midland, Michigan. There I met with Jeff Michalski, who used to be the president and chief operating officer (CEO) of XALT Energy & Freudenberg Battery Power Systems. Mr. Michalski worked at this company for over 20 years.

I asked Mr. Michalski to tell me a little more about his role. He shared, "I led a team of highly specialized experts to make battery systems" for powering buses and ships, and even race cars.

"How exactly do they do it?" I asked. He explained that his team members "mix the metals that create the chemical reaction which stores and discharges electricity. They also make the cells and perform all the safety and quality tests." Additionally, he explained that the room where all this happens needs to be extremely dry and clean. Mr. Michalski also told me that people who work in that room need to wear outfits that look like spacesuits!

I asked Mr. Michalski what he enjoyed most about working with batteries. He answered that he loved how hard his team worked to create technology to make the world cleaner. "Being a scientist who pioneers such a change," he said, "can be very difficult, but also very rewarding." When I asked him if any of us might one day be impacted directly by his work, he exclaimed, "Of course! If you are ever on a bus that has a very quiet, smooth, and powerful ride, it might be powered by our batteries!"

I asked Mr. Michalski what he was like as a child. He said, "I was always interested in science when I was growing up. I was always interested in how things worked, and [how] science attempts to explain how the world around us functions. Chemistry experiments reminded me of performing magic tricks!" Mr. Michalski also added, "I was excited to be a part of something that was not only interesting, but also something that is so important and useful to humankind…. My favorite subjects were chemistry and math, which led to my decision to become a chemical engineer."

Fun Facts

- **Favorite pastime/hobby:** I enjoy playing video games and travelling. Through my work, I have had the chance to live on three continents, learn a new language (German), and visit over 40 different countries. Getting to know different cultures is an amazing learning experience.
- **About your family:** My wife was born in Poland, my daughter was born in Germany, and my dog and I were born in the United States. We have great respect for the different cultures of the world and enjoy learning about them and trying to understand the differences.

Are Batteries Battering the Environment?

By Sara M. Delgado Rivera

You may have seen homes with pathway or garden lights that turn on at night. Did you know these lights are powered by solar energy? But how do they work at night, when the sun isn't around to shine on them? The answer is rechargeable batteries (like the ones in cell phones and tablets). These can be charged and used many times over!

Energy coming from the sun is converted into usable electrical energy by solar panels. Batteries store this energy, which can then light up a house's pathways even when the sun is nowhere to be seen.

Batteries allow us to store and use ecofriendly sources of energy (such as solar and wind energy), where and when we need them. Cars and even houses can run on the sun's energy by using such batteries. Unlike fossil fuels, we will never run out of renewable sources of energy. The sun, wind, and moving water are examples of renewable energy sources.

There are several types of rechargeable batteries. The most popular is the lithium-ion battery (LIB). They are popular because they can store large amounts of electricity in small sizes. They can also be charged quickly, and are lightweight and easy to maintain! But where does Li come from?

Li is found in Li-rich salt lakes in the Andes mountain range in South America. It is also found in Li-rich rocks in Australia. Recently, on the border between Oregon and Nevada in the U.S., a large deposit of Li was discovered. This is currently the largest known deposit in the world.

What are the challenges?

Li by itself isn't stable, and is dangerous to handle. A lot of processing is required to separate Li from its natural sources. This includes mining, drilling, evaporation, filtration, purification, and more.

All the processes for Li separation require large amounts of energy and millions of gallons of water. These processes also pollute the air, water, and soil around the mining area. This pollution can cause harm to (or loss of) plant and animal life. It also affects local communities and peoples' lives by causing serious health issues. Strict environmental laws are needed to protect our environment and people from the hazards of mining Li (and other types of resources).

Li is a nonrenewable resource, just like fossil fuels. Currently, most rechargeable batteries depend on Li in order to work. But it's not good to depend on any resource that has a limited supply. Because of this, scientists are looking for other battery solutions that don't rely on Li. Scientists and researchers are also trying to find processes for mining Li that pollute the environment less.

Batteries are currently the biggest hope for changing our dependence on fossil fuels. Recycling Li-based batteries properly can lower the need for mining new Li. Let's be mindful of the challenges that come with batteries, and plan for a more practical, safer, and greener tomorrow!

Sara M. Delgado Rivera *is a Chemistry Professor at the University of Puerto Rico at Rio Piedras.*

Word Search

Try to find the words listed below – they can be horizontal, vertical or diagonal, and read forward or backward!

E	J	P	E	R	E	N	E	W	A	B	L	E	G	L	M
L	C	E	C	A	E	H	B	A	T	T	E	R	I	E	S
E	A	O	C	P	H	C	R	M	L	A	I	S	Y	F	D
C	T	F	P	O	B	A	H	E	R	E	N	G	B	A	I
T	H	O	O	D	F	A	N	A	G	Y	R	O	P	U	S
R	O	X	U	S	A	R	K	G	R	E	H	E	D	T	P
O	D	I	X	T	S	R	I	D	N	G	Y	N	S	E	O
L	E	D	A	C	F	I	H	E	A	V	E	T	G	P	S
Y	I	A	T	O	M	S	L	A	N	G	E	A	N	O	A
T	O	T	K	I	E	A	R	F	C	D	E	S	B	L	B
E	S	I	H	C	C	M	E	N	U	O	L	Y	I	L	L
Z	T	O	L	I	B	E	C	R	A	E	I	Y	V	U	E
C	E	N	M	I	U	F	Y	C	T	I	L	N	D	T	I
H	R	E	M	R	N	M	C	P	E	M	D	S	O	I	A
M	H	E	P	A	S	O	L	A	R	N	H	Y	L	O	L
C	X	R	V	I	S	K	E	L	E	C	T	R	O	N	S

ANODE
ATOMS
BATTERIES
CATHODE
CHEMICAL ENERGY
DISPOSABLE
ECOFRIENDLY
ELECTROLYTE
ELECTRONS
FOSSIL FUELS
LITHIUM
LIB
OXIDATION
POLLUTION
RECHARGEABLE
RECYCLE
RENEWABLE
SOLAR

For answers to the word search, please visit **www.acs.org/celebratingchemistry**.

Words to Know

Alkaline batteries – usually single-use batteries. They have an alkaline electrolyte in them instead of an acid.

Anode – the negative end of a battery, marked with a minus (–) sign.

Atoms – the smallest building blocks of all matter. Everything is made of atoms!

Cathode – the positive end of a battery, marked with a plus (+) sign.

Chemical energy – the energy stored in the chemical bonds of compounds.

Disposable (single-use) batteries – batteries that can be used only once and cannot be recharged with the help of electricity. They must be replaced by a new battery for the device to work.

Electrolyte – a powder, gel, paste, or liquid that separates the anode and the cathode that allows electrons to move from the anode to the cathode through a device.

Electrons – part of every atom. They are extremely tiny and are negatively charged.

Fossil fuels – were formed over millions of years from buried plants and animals, and are available only in limited amounts. They have stored energy. They are also called nonrenewable energy sources.

Lead-acid batteries – rechargeable batteries that contain lead compounds in their anodes and cathodes. They use an acid for the electrolyte and are often used in automobiles.

Lithium-ion batteries (LIB) – rechargeable batteries made with lithium metal; used in EVs, mobile phones, wheelchairs, wireless headsets, etc..

Oxidation – the chemical reaction happening at the cathode, where the cathode loses electrons.

Rechargeable batteries – batteries that can be charged and used again, over and over for a long time (like those in cell phones).

Recycle – to make new usable parts or items from old, used, or worn-out things.

Reduction – the chemical reaction happening at the anode, where the anode gains electrons.

Renewable energy – the energy sources in nature that never run out. They last pretty much forever (like the sun's energy).

About *Celebrating Chemistry*

Celebrating Chemistry is a publication of the ACS Office of Science Outreach in conjunction with the Committee on Community Activities (CCA). The Office of Science Outreach is part of the ACS Division of Education. Chemists Celebrate Earth Week (CCEW) edition of *Celebrating Chemistry* is published annually and is available free of charge online or in print through your local CCEW Coordinator. Visit **www.acs.org/ccew** to learn more.

About the American Chemical Society

The American Chemical Society (ACS) is one of the world's largest scientific organizations. ACS members are chemists, chemical engineers, and other professionals who work in chemistry or chemistry-related jobs. The ACS has over 151,000 members in more than 140 countries around the world. Members of the ACS share ideas with each other and learn about important discoveries in chemistry during scientific meetings held several times a year, through the ACS website, and through the many peer-reviewed scientific journals the ACS publishes. ACS members carry out many programs that help the public learn about chemistry. One of these programs is Chemists Celebrate Earth Week, held annually during the week of Earth Day on April 22. ACS members celebrate by holding events in schools, shopping malls, science museums, libraries, and even virtually online! Activities at these events include carrying out chemistry investigations and participating in contests and games. If you would like more information about these programs, please contact us at **outreach@acs.org**.

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The activities described in this publication are intended for children under the direct supervision of adults. The American Chemical Society cannot be responsible for any accidents or injuries that may result from conducting the activities without proper supervision, from not specifically following directions, or from ignoring the cautions contained in the text.

REFERENCES

https://samcotech.com/what-is-lithium-extraction-and-how-does-it-work/

Harper, G., Sommerville, R., Kendrick, E. et al. Recycling lithium-ion batteries from electric vehicles. Nature 575, 75–86 (2019). https://doi.org/10.1038/s41586-019-1682-5

https://www.continentalbattery.com/blog/how-it-works-the-step-by-step-of-lead-acid-battery-recycling#:~:text=The%20plastic%20is%20washed%20and,and%20formed%20into%20plastic%20pellets.&text=The%20metal%20pieces%20make%20their,lead%20and%20are%20siphoned%20off.

https://resource.co/article/what-happens-when-batteries-are-recycled#:~:text=The%20manganese%20oxide%20inside%20alkaline,used%20to%20make%20new%20batteries.

https://www.energy.gov/sites/default/files/2022-03/ES_Consumer-Guide-to-BatteryRecycling.pdf

https://www.batteriesplus.com/blog/power/battery-chemistries

https://www.electrical4u.com/alkaline-batteries/

https://www.engoplanet.com/single-post/the-benefits-of-using-batteries-for-backup-power-and-emergency-preparedness#:~:text=The%20benefits%20of%20using%20batteries%20for%20backup%20power%20and%20emergency%20preparedness,-With%20unpredictable%20weather&text=Convenience%3A%20Unlike%20generators%2C%20batteries%20are,convenient%20option%20for%20emergency%20preparedness.

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