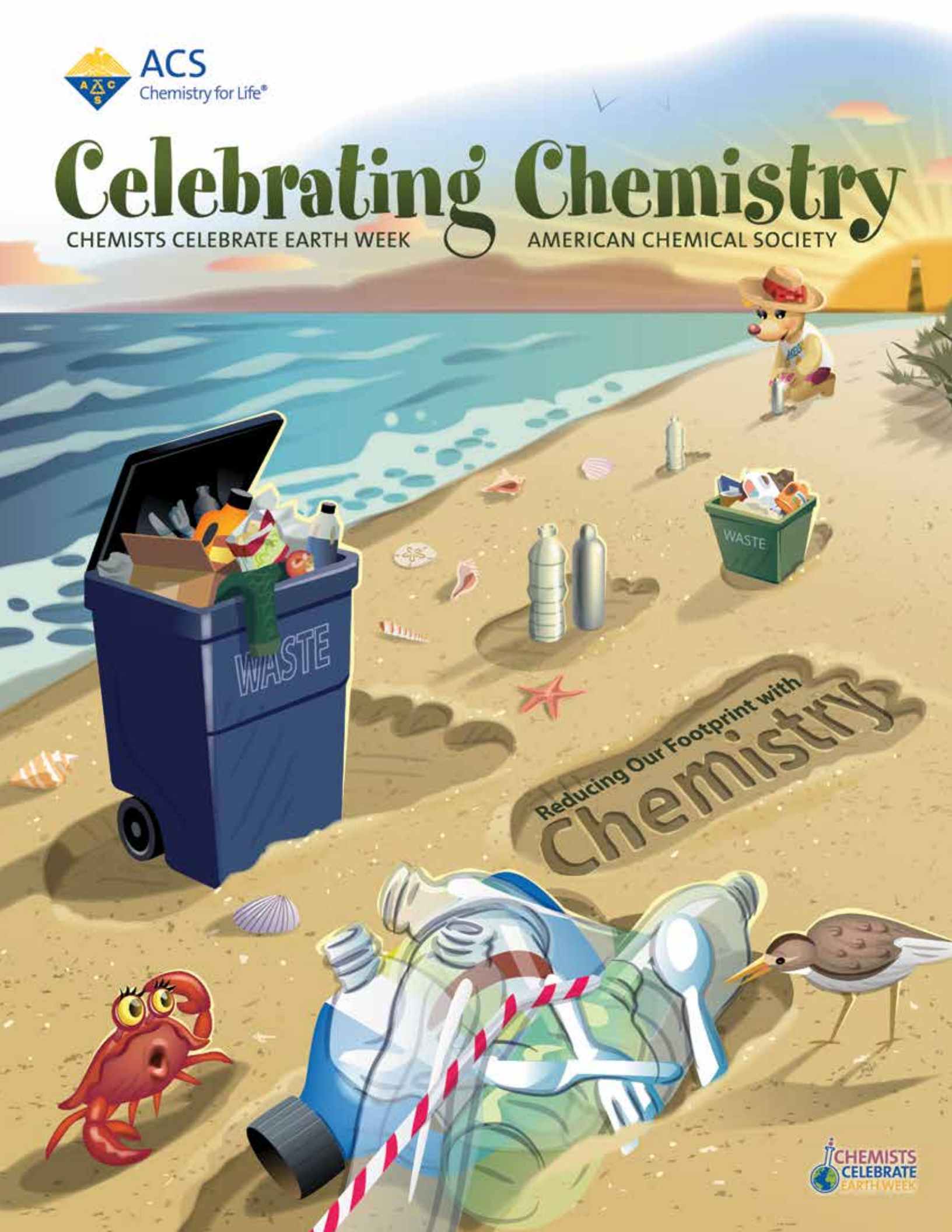
ACS
Chemistry for Life®

Celebrating Chemistry

CHEMISTS CELEBRATE EARTH WEEK

AMERICAN CHEMICAL SOCIETY



Reducing Our Footprint with CHEMISTRY

By Neal Abrams and the ACS Committee on Ethics

Have you ever looked at your footprint? Maybe you've walked through a puddle or sand on a beach, and seen the steps you've left behind. Our footprints leave a trace, and tell a story about where we've been.

But actually, we all leave more footprints than just our steps on the ground. A more important "footprint" is the size of the impact we make on the earth. That impact is our **environmental footprint,** and it includes the energy, food, water, and materials we use or leave behind. By reducing our footprint, it means we are living more **sustainably**.

You might wonder why it is important to live sustainably — and there are many reasons. It is probably best described by the expression, "Leave no trace." This means trying to make sure that the planet stays the way we found it, by not consuming or discarding anything that changes how the planet looks or behaves. To live sustainably, we need to reduce our footprint. How can we do that, and how can chemistry help us?

Practicing the 3 Rs

You may have heard of the environmental "3 Rs" — **reduce, reuse, and recycle**. These are three ways that we can help protect the earth and save resources. We may not think about these ideas every day, but they are important things to do if we want to take better care of our earth. The planet that we live on has limited resources like food, water, minerals, land, and forests. We may run out of these resources if more people keep using more resources and creating more garbage. The result causes harm to the Earth we live on.

When we choose to **reduce**, we use less of something … and that leaves more for others to share. To **reuse** means we are using the same thing many times instead of just once. If we **recycle**, we send things like paper or soda cans to a factory so that they can be re-made and used again. By practicing the 3 Rs, we are helping make resources last longer and be available for others, while we're also producing less garbage. These are good things to do, because we will cause less harm to our earth and keep our land, water, and air clean.

It can be hard to know whether doing a certain action is good or bad, but understanding **ethics** can help. Ethics is a way of thinking about the effects of our actions on ourselves, other people, and the world. It helps us decide which actions will lead to good things — such as helping, sharing, and caring for others and our earth. Let's take some time to pay attention to how we use things every day. Are we reducing, reusing, and recycling? If not, how can we do better? Remember, we want to take care of our world today and make sure that people have enough resources later!

Chemistry helps reduce our footprint

Chemistry is the science of studying the material (also called matter) that makes up everything in the universe. Some chemists study materials that exist naturally, and some chemists make new materials based on those that exist already. A chemist who develops sustainable materials is trying to reduce our footprint on the planet through clever new solutions.

For example, chemists have developed materials like water bottles and cups that are made from wood, corn, or other plants. This makes them **biodegradable,** and the products naturally disintegrate, going back to the earth where they are recycled into the soil and become nutrients for plants. **Plastics** that aren't biodegradable are usually made from fossil fuels, which are materials that were formed from the carbon that existed in plants and animals that lived millions of years ago. Because we have a limited amount of fossil fuels available, we say they are not sustainable. In addition, when we're done using these products, they go into a landfill where they stay for a long, long time … which is another problem.

Traveling from one place to another can also give us a large footprint, but chemists are working on solving that problem, too. Instead of using gasoline-powered cars, newer electric-powered cars are becoming more popular. The electricity is stored in advanced high-capacity batteries, developed by chemists. In fact, three scientists won the 2019 Nobel Prize in Chemistry for their work in developing the lithium-ion battery we find in today's cars, phones, and other electronics.

Chemistry is even helping you reduce your footprint in your own home. New, low-energy LED light bulbs were developed by chemists. These bulbs have replaced older, inefficient incandescent lights, which had a very large energy footprint. Chemistry has even helped develop modern building materials that result in much smaller footprints for the buildings we live in. For example, using modern forms of insulation decreases the energy needed to heat or cool our homes.

Even the things we throw away can be treated in a way that reduces our footprint. You've probably heard about ways to recycle paper, plastic, and metal so it doesn't go into a landfill. What about other things, like electronics? In this issue, you'll learn how we can decrease our footprint by properly recycling things like old cell phones, computers, and printers. The more of these items we recycle, the less materials like gold and copper have to be mined and processed, which leaves more of them for use in the future.

In this issue of *Celebrating Chemistry*, you'll explore ways all of us can reduce our footprint by making simple choices about the foods we eat, waste we create, and energy we use. The most important thing to remember is that we are each responsible for our own individual footprint, and making that footprint as small as possible!

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

Shrink Your Footprint with Shrinky Dinks!

By Susan Hershberger

Safety Suggestions

- ✓ Safety glasses suggested
- ✓ Caution: hot materials!
- ✓ Thoroughly wash hands after this activity
- ✓ Work with an adult. This activity involves heating polystyrene plastic in a HOT regular oven or toaster oven.

Note: Follow Milli's Safety Tips found on page 5 of this issue of *Celebrating Chemistry*.

Introduction

Some plastic food containers and lids can take the heat. They come out of the dishwasher clean and ready for the next use. Other kinds of plastic containers bend or shrink when they get too hot. That makes them not-so-reusable as food containers. Let's see if we can find another way to reuse these types of plastics, in a way that is fun and interesting!

Materials

- "Clamshell" plastic packaging marked with recycle code #6 or "PS" (polystyrene), or commercial "Shrinky Dinks"
- Oven or toaster oven able to heat to 325–350 °F (about 165–175 °C)
- Permanent markers
- Aluminum foil
- Oven mitt
- Optional: Colored pencils, sandpaper, hole punch, string
- Scissors
- Metal tray or cookie sheet
- Spatula
- Graph paper

Procedure

1. Look for the triangle-shaped recycle symbol on your plastic item. The number 6 and letters PS mean that the plastic item is made of polystyrene, which is the type of plastic that works for this activity. **IMPORTANT: other types of plastic will not work for this activity, and may be dangerous.**
2. Cut the side off the plastic clamshell, leaving a flat area to draw a favorite design. Be careful: the edges of the cut plastic may be sharp.
3. Draw an outline of a shoe footprint on the plastic using permanent markers. Make it 3-4" (about 7.5–10 cm) long.
4. Cut around your footprint design. If you'd like to hang your design later, use a hole punch to make a hole near the edge of the plastic. Make the hole large, as it will shrink as well.
5. Place your footprint design on the graph paper grid and count the number of squares covered by the plastic. Just count the squares that are totally covered. Record the number of squares. Notice the thickness of the plastic. Estimate: how many pieces of paper thick is it?
6. Cover the surface of your cookie sheet with aluminum foil. The aluminum foil protects your cookie sheet from the permanent marker. Place your footprint design marker-side-up to prevent sticking.
7. Have your adult partner use an oven mitt to put the tray into an oven preheated to 325–350 °F for 2–5 minutes, or until the plastic stops shrinking.
8. If the oven has a window, watch the shrinking process. The plastic will curl and then flatten.
9. Have your adult partner use an oven mitt to remove the tray from the oven (both are very hot!). If the plastic needs help getting flat, press it with a spatula while still hot. Then use the spatula to move the plastic to a flat surface, such as a piece of paper on a countertop. Allow the plastic to cool completely.
10. Once it's cool enough to touch safely, place your footprint design on the graph paper grid. How many squares does your plastic cover now? Record the number of squares. How much did your plastic shrink? What happened to the thickness of the plastic film?

What did you observe?

	Before heating	After heating
Number of squares		
Thickness of plastic		

Describe any other changes:

How does it work?

Polystyrene and other plastic **polymers** are very big **molecules** that are made up of thousands of carbon and hydrogen **atoms** arranged in long chains. Certain polymers have special properties, like very high melting points. This is because the large number of atoms and the long shape of the molecules make it difficult for polymers to melt or evaporate when heated.

Some polymers soften and can be stretched when heated. The plastic food container you used was made by heating and stretching plastic into a mold. Once cooled, it kept that stretched shape. When you heated the plastic in the oven, it returned to its original, unstretched shape. Stretching the plastic means less plastic is used to make plastic food containers. Over all, this process is good for the environment because it uses less carbon. However, recycling programs in many locations do not recycle #6 plastic.

You might think that you reduced the amount of plastic by shrinking your footprint. But actually, you did not. The *amount* of matter stayed the same, and you only changed the *size* of the plastic. It is even better if you reuse the plastic to design something useful, because otherwise, it might simply be trash. Think of other shrinking designs you could make that could be useful. Maybe you could design crafts like holiday ornaments, keychains, or zipper pulls!

For more fun, you can sand one side of the surface of another piece of plastic and draw on the rough plastic film with colored pencils. Making decorative and useful items from waste is a fun way to reduce your environmental footprint!

Susan Hershberger, Ph.D. *is Director of the Center for Chemistry Education at Miami University in Oxford, Ohio.*

Listen Up!

The Life Cycle of a Cell Phone

By Faith Yarberry

A **life cycle** is the series of stages something passes through during its lifetime. We also use the term for things that are *not* living, like cell phones.

The life cycle for anything you buy includes getting the materials from the earth, making the parts, delivering the product from the factory to the store (and later to you), your use of the product, and how you get rid of it when you have finished using it.

Being friendly to your environment means thinking about everything that goes into the things that you use, and finding what you can do to limit their impact on the environment.

For example, let's look at cell phones and ways we can change how we use them to be better friends to the Earth.

The reason this is important is that there's a lot of carbon dioxide (CO_2) that is generated and released into the air during the different steps in a cell phone's life cycle. CO_2 is a **greenhouse gas** that scientists have found to cause **climate change**. In fact, up to 91 kg of CO_2 (a little more than 200 pounds) is released for every single cell phone!

Cell phones are roughly 45% plastic (made from carbon **compounds**), 35% metal, and 20% glass and ceramic. Almost half of the CO_2 (43%) created or used during a cell phone's life cycle happens during the raw material phase, caused by the machines used to discover, extract, and refine petroleum needed to make the plastics. These machines use a large amount of energy, usually gasoline or diesel fuel, which releases CO_2.

The other parts of the cell phone life cycle that cause CO_2 emissions include:

- **Manufacturing** — About one-third (34%) is caused by factories that use large amounts of electricity, most of which is generated using fossil fuels like coal and natural gas.
- **Distribution** — The next 9% is used by the trucks that deliver the phones to stores, mostly from burning diesel and gasoline.
- **Usage** — 11% is generated to produce the electricity used to recharge the cell batteries many times.
- **Disposal/resell/recycle** — About 1%.

Silver - 0.34 g/phone

Copper - 15 g/phone

Aluminum - 25 g/phone

Gold - 0.034 g/phone

If you throw your cell phone away or leave it in a drawer at home, and buy a second cell phone, then that new phone will result in another 91 kg of CO_2. Recycling or reusing the first cell phone will reduce the amount of material taken from the earth.

Nearly 1.5 billion cell phones are bought annually, but barely 10% are recycled. That means 1.4 billion phones are thrown away or left forgotten in drawers at home. By not recycling, we make 72 billion kg of CO_2 that is given off into the air. That is about the same weight as 2 million full semi trucks.

Finally, let's look at the effect of recycling on some of the metals taken from the earth to make a cell phone. To the left are some of the metals used in a cell phone, and the amount of each.

If we *recycled* the 1.5 billion cell phones bought each year, what could we save from being taken out of the earth?

- 47.6 million grams of gold (worth $123 billion)
- 476 million grams of silver (about the same weight as 680 cars)
- 21 billion grams of copper (the same amount of copper as 750 Statues of Liberty)
- 35 billion grams of aluminum (about the same weight as 7,800 elephants)

Now *that* is a lot of metal!

What you can do

Before you consider recycling your cell phone, you should first think about reusing it until it no longer works and can't be repaired. At that point, you can recycle it, rather than just putting it in the garbage. Recycling your cell phone will reduce your carbon footprint by reducing the amount of CO_2 that is generated and released into the air. Recycling will also reduce the amount of metals that must be removed from the earth to make new cell phones.

Now that you see what recycling cell phones can do for the planet, consider starting a cell phone recycling campaign. The environment needs you, so stop talking … and listen to it!

Faith Yarberry, Ph.D. *is a Lecturer II at the University of Central Arkansas, in Conway, Arkansas.*

Taking a Bite out of Food Wastage

By Gina Malczewski

One of the biggest challenges the world faces is feeding its people. One of every nine of us goes to bed hungry every night now, and this problem will get worse as the global population gets bigger. By 2050, we will need to grow 1.6 times the amount of food grown today.

But we *can* do something about this! **Food wastage** is the total amount of food that gets lost or goes bad before we get it. It also includes food wasted when we throw leftovers away, or let food spoil. Every year, wastage accounts for about one-third of all the food grown around the world, and this translates into some really big losses: 75 million dollars lost, 66 trillion gallons of water "down the drain," and 3.7 billion tons of unnecessary greenhouse gases added to the air. Yikes!

Reducing food wastage starts with picking crops at the right time, and getting them to their final destinations efficiently. Grocery stores can help by selling "imperfect" food at a lower price rather than throwing it away, or donating what they can't sell.

Chemists and other scientists are working on processes and technology for reducing food waste. By adding small living things (called microbes), we can convert some food waste to basic chemical building blocks like proteins, fats, and sugars. These can be turned into other products like carpeting, furniture, and clothing. Food waste can also be used to make bio-based fuels, which can reduce our transportation footprint.

And each of us can help, too — by shopping for just what we need, storing it correctly, and using what we buy. We need to worry less about "use-by" dates — these are actually the last dates when food is at its best. The U.S. Department of Agriculture says most foods are safe to eat even after the use-by date, as long as they don't smell or look funny. What we can't eat or donate should be fed to animals or put into compost piles.

And there's more you can do! Here are some ideas:

- Grow some of your food in your own garden
- Donate any extra food from your garden to the local food pantry
- Eat plant-based diets, which have smaller footprints than eating meat or fish
- Save, label, and date your leftovers … and use them!
- Store leftovers in the refrigerator or freezer, with the oldest in front
- Eat older things first
- Adjust what you buy based on what gets eaten

Everyone should work on eating well, so that we can all win the war on wastage!

Gina Malczewski, Ph.D. *is a retired biochemist who worked at Dow Corning Corporation in Midland, Michigan.*

Milli's Safety Tips Safety First!

ALWAYS:

- Work with an adult.
- Read and follow all directions for the activity.
- Read all warning labels on all materials being used.
- Use all materials carefully, following the directions given.
- Follow safety warnings or precautions, such as wearing gloves or tying back long hair.
- Be sure to clean up and dispose of materials properly when you are finished with an activity.
- Wash your hands well after every activity.

Find the Footprint of Your Favorite Snacks!

By Susan Hershberger

Introduction

In this activity, you'll think about the amount of energy and resources needed to make your favorite snack food and get it to you fresh, delicious, and undamaged.

What is your favorite snack? Select one to start:

- ☐ Cookies
- ☐ Granola bar
- ☐ Bag of chips
- ☐ Chilled soft drink
- ☐ Beef jerky
- ☐ Fruit smoothie
- ☐ Freshly popped popcorn
- ☐ Fresh apple
- ☐ Mini-carrots and dip
- ☐ Fruit drink
- ☐ Cheese and crackers
- ☐ Ice cream
- ☐ Other: _____

_____

Procedure

Find out how "earth-friendly" your snack is by answering the following questions. You may have to do some research! The more points a snack earns, the larger its carbon footprint … and the worse it is for the environment.

What do you observe?

Repeat the exercise above for a few more snacks. Which snacks have the smallest footprint? Which snacks have the biggest footprint?

Snack	Total Points

How does it work?

Reducing our environmental footprint is important. But it's about more than just making cleaner factories or more efficient cars. It also has to do with the personal choices we make. The snacks we choose (and the packaging they come in) make a difference. The amount of energy used to make, transport, and dispose of the snack also makes a difference. Even though the choices we make are small, the combined effect of all of us making good choices is huge!

Susan Hershberger, Ph.D. *is Director of the Center for Chemistry Education at Miami University in Oxford, Ohio.*

Question	If "yes," add these points	Energy and Ingredient Use
Is the snack in a package that can be washed and reused?	+ 1	• Small • Energy and materials to make, water and soap to wash and reuse
Is the snack in a package that is disposable?	+ 5	• Large • Energy and materials needed to make it, collect it as trash, and take it to the landfill
Is the snack in a package that is recyclable?	+ 3	• Medium to Large • Energy and materials to needed to make, collect, and recycle the material
If the package can be recycled, do you throw it in the trash instead?	+ 2	• Medium to Large • A recyclable package that does not get recycled has the same footprint as a disposable package
Is the snack in a package that is compostable?	+ 1	• Small • Some energy and materials to make the package, and a small amount of energy to compost it
Is the snack or ingredients shipped to you by truck or train?	+ 3	• Medium • Energy costs for transportation
Is the snack or ingredients shipped to you by plane or boat?	+ 5	• Large • Energy costs for transportation
Is the snack or ingredients made in a factory?	+ 4	• Medium to Large • Energy is needed to run production and packaging factories
Is the snack or ingredients made at home?	+ 2	• Small to Medium • Energy for light, heat, and refrigeration at home, plus ingredients to make the snack
Does a farmer grow the snack or ingredients on a farm?	+ 2	• Small to Medium • Farmers use water and energy to grow food
Did you grow the snack or ingredients in your garden?	+ 1	• Small • You still need water, seeds, and some energy
Is water part of the snack?	+ 1	• Small, but not zero • Tap water is purified and distributed, which uses some energy
Does the snack need to be kept cold as it travels from the factory to the store, and in your home?	+3	• Medium • Refrigeration requires electrical energy
Are there other energy or ingredient costs for your snack?	+1–5	• Small to Large • Meat or cheese snacks require much more energy to produce than vegetables
TOTAL NUMBER OF POINTS =		

Insulation Keeps Us Warm

By Alex Madonik

Do you prefer warm or cool weather? Or are you more like Goldilocks, and like your weather 'just right'?

When it gets too hot or too cold outside, it's time to find someplace more comfortable. Our houses are designed to keep heat in when it's cold outside, and to keep heat out when it's too hot. Heat is a form of energy, and it always transfers from a hotter place to a cooler place. This continuous transfer of heat is why it takes extra energy to keep a refrigerator cold, or to warm your house when it's chilly outside. All that extra energy increases your environmental footprint.

We can save energy and stay more comfortable if we slow down heat transfer. The first step is to close windows and doors, because air carries heat with it. If it's hot outside, and your window or wall feels warm, that means heat is still getting through. Any solid material can be a heat "conductor." Metals are good at conducting heat, similar to how they conduct electricity.

To stop heat transfer, we need an insulator. The best insulator is a vacuum — in fact, that's how a thermos works, by wrapping its contents inside a double wall, with the air in the middle removed. Having a vacuum is best, but air itself can also be a good insulator. We use insulating materials that trap air so it can't move. Filling the hollow spaces in the walls of a building with a good **insulation** is a great way to keep the temperature inside 'just right.'

Heat is conducted through hollow walls much faster than when the wall space is filled with insulation. The more insulation, the better. This difference in the heat transfer rate is called the "R-factor." The higher the R-factor of a wall or window, the slower heat passes through it. A single pane of glass has an R-factor of 0.9. Feel the glass on a window when it's cold outside, to know that an R-factor of 0.9 doesn't do much to keep heat indoors. Heat will easily move out of a building into the cold outdoors. That doesn't do much to keep houses comfortable. It's better to have windows with *two* panes of glass, with a little space for air in between them, which improves the R-factor to 2. Triple-pane glass is even better! Most new buildings must have R30–R60 insulation in ceilings, R15–R21 in walls, and R13–R30 in floors. The amount and type of insulation you have in your home depends on where you live and what the weather is like.

Insulation can be improved by adding a layer of aluminum foil backing. This aluminum foil is bright and shiny, and can reflect heat radiation and keep it from passing through the insulation. This improves the R-factor.

Newer houses and apartment buildings are built with very good amounts of insulation. For older homes, that may not be true. One of the best things you can do for an older home is to add or upgrade the amount of insulation. Methods and materials for insulating homes are constantly improving. Perhaps one day you will discover a renewable insulation that is even more economical, safe, and efficient… and make everyone's footprint smaller!

Alex Madonik, Ph.D. *is a Chemistry Instructor at Peralta Community College in Oakland, California.*

Be Cool ... with Insulation!

By Alex Madonik

An insulated water bottle like the one shown here can keep your drink cool for hours!

Introduction

On a hot day, there's nothing better than a cold drink. You might not want to drink it all at once. If you leave the cold drink out in the hot sun, it won't stay cold for long. How can you keep your drink cool for the longest amount of time? Insulate!

Safety Suggestions

- ✓ Safety glasses suggested
- ✓ Do not eat or drink any of the materials used in this activity
- ✓ Thoroughly wash hands after this activity

Note: Follow Milli's Safety Tips found on page 5 of this issue of *Celebrating Chemistry*.

Materials

- Insulation materials to test: old socks, bubble wrap, coffee filters, flexible plastic foam, or any other material you want to test
- Ice cubes
- Small, clear plastic cups (at least 3)
- Reusable plastic containers with snap-lids, big enough to hold the small plastic cups with insulation around them (at least 3)
- Clock or timer
- Optional: kitchen scale that reads to +/- 1 gram

Procedure

1. Arrange each clear plastic cup in a "nest" of insulation in the reusable plastic container. As a control, place one cup in a container with no insulation around it.
2. Put one or two ice cubes in each cup. If possible, weigh them to make sure that each cup starts with the same weight of ice, more or less.
3. Every 30 minutes, check the ice in each cup to see how much has melted. If you have a scale, use a spoon to remove each ice sample and weigh it, then return it to the cup and put the cover back on the container. If you don't have a scale, just observe the ice samples every 30 minutes and note the changes as they melt.

What do these observations mean?

Which insulation worked best at keeping the ice frozen? Compare the sample that melted the most to the sample that melted the least. How much longer did the well-insulated ice cubes last compared to the ones with no extra insulation? What do you think makes one kind of insulation work better than another?

How does it work?

Heat always transfers from hot to cold. In this case, the heat comes from the surroundings of the cup, which are much warmer than the ice. The ice melts when it absorbs heat from the surroundings. To prevent heat transfer, we place a barrier between the cup and the air. If the barrier slows down the transfer of heat, it is an insulator. Some materials do a better job slowing the transfer of heat than others. What piece of clothing do you own that is made with a good insulator? Hint: This item keeps part of your body feeling warm when it is cold outside.

What did you observe?

	Weight of ice (in grams)					
Type of Insulation	**At start of activity**	**After 30 minutes**	**After 60 minutes**	**After 90 minutes**	**After 120 minutes**	**After 150 minutes**
None						

Alex Madonik, Ph.D. *is a Chemistry Instructor at Peralta Community College in Oakland, California.*

The Adventures of Meg A. Mole, Future Chemist

Mary Draves

Chief Sustainability Officer and V.P. of Environmental Health & Safety

In honor of this year's Chemists Celebrate Earth Week (CCEW) theme, "Reducing Our Footprint with Chemistry," I traveled to Midland, Michigan, to meet with Mary Draves, Chief Sustainability Officer and Vice President of Environmental Health and Safety at Dow.

I could not wait to learn what Ms. Draves and her team did at work each and every day! She explained, "Our team protects the health and safety of all of Dow's employees and makes sure we are positive environmental protectors. Our team also is responsible for setting the standard for sustainability at the company. We work to achieve ambitious goals that focus on global challenges like recycling and climate change."

I told her I had learned how important it is to reduce our footprint. She was very excited to tell me more. She said, "My colleagues' and my knowledge and expertise are the most important tools we have. Our team also uses a wide range of technologies, including robots and advanced computers, to improve safety and better understand the life cycle of products our customers use."

So where is her work done? "Currently I do most of my work from home while we are all doing our part to prevent the spread of COVID-19. When I am at my workplace, I am primarily in an office setting, but I do go to our manufacturing plants and lots of different locations around the globe," she told me. I then asked Ms. Draves what she enjoyed most about her work. "My role directly impacts major problems that the world has to solve. Dow's products are making a tremendous difference in solving the challenges of plastic waste, climate change, and safer chemistry," she said.

When she was growing up, Ms. Draves was very interested in science. She told me about the fun she had outdoors as a child. "We had a living laboratory in our backyard, as we spent a lot of time in nature and on our grandparents' farm," she said. "Along with my brothers, sisters, and cousins, we learned about agriculture, mechanics, biology, and chemistry."

Ms. Draves added that children can come into contact with her work every day. She said, "Dow makes products that you use every day, including cell phones, sports equipment, and clothing. As we create new products that lessen the impact to our world, we all benefit." I am so thankful for all the work Ms. Draves and her team do to help the environment, and look forward to visiting again!

Word Search

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

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

CHEMISTRY
ETHICS
FOOTPRINT
GREENHOUSE GAS
LIFE CYCLE
PLASTIC
POLYMER
RECYCLE
REDUCE
REUSE

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

Fun Facts

- **Accomplishment you are proud of:**
  Becoming a mom and watching our children follow their passions!
- **Favorite movies:**
  I am a big "Transformers" and "Fast and Furious" fan!
- **Favorite food:**
  I love crackers with butter and blueberries (when I can pick them myself!)
- **About your family:**
  My husband Todd and I have two children who are in college — Melissa, who is 20, and David, who is 18.

Getting from Here to There

By Neal Abrams

If you really want to reduce your footprint, you need to look at how you get from one place to another. Whether it is walking, cycling, driving, or flying, each form of transportation has its own energy footprint, based on how much it affects our environment. In the United States, transportation accounts for 28% of all energy use. Most of that energy comes from sources like oil and gas, which are not sustainable and have a very large footprint on the earth.

What are some ways you can reduce your transportation footprint? One way is to use your own body to get you places. Consider walking, bicycling, or even using a scooter to get places. Sometimes you need to get somewhere very far or uphill from where you are, but don't want or need to get a lot of exercise along the way. In that case, you might want to consider an electric bike, which uses lithium-ion batteries to store energy and power a very efficient motor.

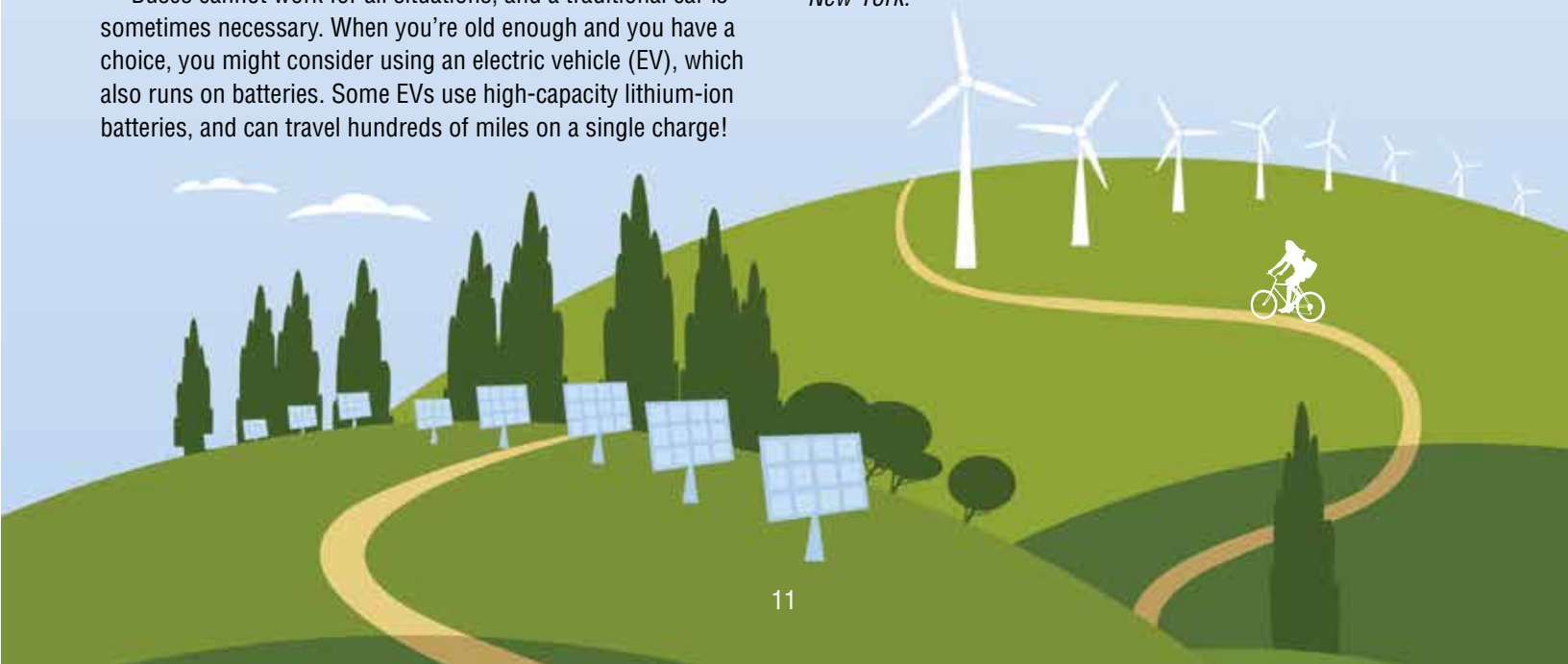
When adults do need to travel in a vehicle, taking a bus can be better for their energy footprint than driving a car. Some modern buses are powered by a special fuel called biodiesel, which is made from **renewable resources**, like vegetable oil and even algae! Even if you can't ride on a "biobus," a traditional bus is still a better choice than a car. Why? Because a bus full of people has a smaller footprint than if all of those people were driving their own cars.

Buses cannot work for all situations, and a traditional car is sometimes necessary. When you're old enough and you have a choice, you might consider using an electric vehicle (EV), which also runs on batteries. Some EVs use high-capacity lithium-ion batteries, and can travel hundreds of miles on a single charge! While these vehicles do not burn any gas, they do require electricity, which is traditionally made in high-footprint power plants that burn coal or gas. Another way to produce electricity is by using renewable energy sources like solar panels or wind turbines. Even if your family does not own these technologies, your parents or guardians can ask if your power company can deliver energy that comes from renewable resources.

There are even some high-speed trains that are both very fast and have a very low footprint because they use the power of magnetism. These trains levitate above the track using opposing forces of magnets, which is how they get their name "maglev." Advances made by chemists and chemistry have helped develop these exciting technologies.

The last and probably simplest way to shrink one's transportation footprint is to work or learn remotely. In fact, a lot of us are doing this by using new technologies. Being able to do this means we don't have to use any transportation energy to get to school or work. There is not one solution for everyone in every situation, but the next time you need to go somewhere, try thinking about how you can reduce your own footprint!

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



Words to Know

Atom – the smallest part of an element that has the characteristics of the element.

Biodegradable – capable of being decomposed by bacteria or other living organisms.

Chemistry – the science of studying the materials that make up everything in the universe, and the changes that can happen to the material.

Climate change – a change in the average temperature and weather conditions of a region over a long period of time.

Compound – a pure material that combines two or more elements in a specific, stable form.

Environmental footprint – the effect that a person, community, or nation has on the ecosystems of earth.

Ethics – a way of thinking about the effects of our actions on ourselves, other people, and the world that helps us decide which actions will lead to good and fair things such as helping, sharing, and caring for others and our planet.

Food wastage – the food that gets lost or goes bad before we get it, plus the food that's wasted when we throw leftovers away or let food spoil.

Greenhouse gas – any gas that absorbs the sun's infrared energy and traps heat within the earth's atmosphere. Water, CO_2, and methane are the most important examples. The amount of CO_2 and methane in the atmosphere is increasing rapidly.

Insulation – materials that slow down the transfer of heat.

Life cycle – the series of stages something passes through during its existence, including the resources needed to manufacture a product, the resources it consumes during use, and what happens when we're done with it.

Molecule – the smallest unit of a chemical compound.

Plastic – human-made material that can be formed into a useful shape. Most plastics are polymers made from petroleum, but other options include biodegradable plastics made from plants or even milk.

Polymer – long-chain molecules built from smaller subunits ("monomers") that are the building blocks of life (including starch, cellulose, proteins, and even DNA). Synthetic polymers are usually made from petroleum, but can also be made from plants.

Recycling – the process of sending things like paper or soda cans to a factory so that they can be re-made and used again.

Reducing – using less of something and that leaves more for others to share.

Renewable resource – a resource (like plants, sunlight, water, or wind) that is naturally replaced as we use it. Nonrenewable resources take thousands of years to form (like stone, oil, or gases) that people use faster than it can form.

Reusing – using the same thing many times, instead of just once.

Sustainably – living in a way that doesn't use up our planet's natural resources, and leaves more for the future.

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. The 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 152,000 members in more than 130 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'd like more information about these programs, please contact us at **outreach@acs.org**.

PRODUCTION TEAM

Allison Tau, Editor
Eric Stewart, Copyeditor
Michael Tinnesand, Copyeditor
Rhonda Saunders, Designer
Jim Starr, Illustrator
Beatriz Hernandez, Translator

TECHNICAL AND SAFETY REVIEW TEAM

Lynn Hogue, Consultant
Bettyann Howson, Safety Reviewer
Ashley Neybert, Accessibility Reviewer
Sara Delgado-Rivera, Translation Reviewer

CCEW 2021 THEME TEAM

Rick Rogers, CCEW Chair
Neal Abrams, 2020 Chair
Susan Hershberger
David Katz
Alex Madonik
Regina Malczewski
JaimeLee Rizzo
Alexsa Silva
Faith Yarberry

DIVISION OF EDUCATION

LaTrease Garrison, Executive Vice President
Lily L. Raines, Manager, Science Outreach
Allison Tau, Program Specialist, Science Outreach

ACKNOWLEDGMENTS

The articles and activities used in this publication were written by theme team members of the ACS Committee on Community Activities (CCA) under the leadership of **Holly Davis**. Meg A. Mole's interview was written by **Kara KasaKaitas**. Lastly, ACS would like to acknowledge editorial contributions from the **ACS Committee on Ethics**.

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://www.bbc.com/future/article/20161017-your-old-phone-is-full-of-precious-metals
www.youtube.com/watch?v=4lfhtIr2gmE — (video about the Life Cycle of Mobile Phones)
http://www.fao.org/nr/sustainability/food-loss-and-waste/en/
https://www.mercycorps.org/blog/quick-facts-global-hunger
https://www.matrec.com/en/news-free/made-in-food-waste
http://www.auburn.edu/~cgs0013/ETK/SaveThePenguinsETK.pdf
https://research.engr.utexas.edu/igertsustainablegrids/images/stories/docs/group%20project%20lesson%20plan%20final.pdf
https://www.teachengineering.org/activities/view/uoh_insulation_activity1
https://www.eia.gov/energyexplained/use-of-energy/transportation.php

Division of Education, Office of Science Outreach • 1155 Sixteenth Street NW, Washington, DC 20036
800-227-5558 • outreach@acs.org • www.acs.org/outreach

Want to learn more about Dr. B. Green and the other moles? Check out www.acs.org/moles.