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Celebrating Chemistry

CHEMISTS CELEBRATE EARTH WEEK

AMERICAN CHEMICAL SOCIETY

CHEMISTS CELEBRATE EARTH WEEK

TAKE NOTE: The Chemistry of PAPER

By An-Phong Le and Cary Supalo

Paper is one of the most amazing materials ever invented. It has been around for 2000 years and has been essential to the development of knowledge and technology around the world. Unfortunately, it is so commonplace and ordinary that many people hardly ever think about it!

The ability to write and record things may be the one unique trait that separates humans from the rest of the animal kingdom. Humans have recorded pictures and words on everything from cave walls to clay tablets. When paper was invented 2000 years ago in China, it was done by mashing wood from trees and spreading the resulting slurry of water and wood fibers to dry in sheets. They didn't understand the chemistry involved. They didn't know about cellulose, lignin, or chemical bonds. They also didn't know what an impact paper making would have, or how far it would spread.

Paper was far superior to anything that had ever been used for writing. It was lighter and less breakable than clay tablets, and smoother than papyrus. It was much cheaper and easier to produce than parchment. And best of all, it came from sustainable trees and plants and could be recycled again and again.

Paper helped change people and how they thought about the world, even though its use spread slowly at first. It took 500 years before it spread to Korea, and 1000 years for the Arab world to see its usefulness. And in Europe, it wasn't until the Renaissance (700 years ago) that the surge in arts and science led to paper's wide use. That use helped spread the new way of thinking known as the Enlightenment more quickly and cheaply than anything else available. The development of the printing press just made things even faster and cheaper.

The basic process of making paper hasn't changed since its invention. Paper has been made using a variety of plants as the source of fiber — including rice, yucca, bananas, mulberry, bamboo, hemp, and many other plants. Today, we make lots of paper from pine trees … but nearly any tree or plant containing fibers can be used.

No matter which plant is used, the process for making paper is very similar. Plants are harvested to obtain **fibers.** These plant fibers are made from chemical compounds called cellulose and lignin. **Cellulose** is a long **polymer** made from glucose molecule subunits (or parts). **Lignin** is a more complex polymer that helps strengthen the plant stem and aids in the transport of water from the ground up into the plant.

The plant fibers are mashed into a pulp slurry by either simple mechanical mixing or by chemical pulping. These processes add substances that help break down the slurry's structure and separate the lignin from the cellulose.

The fibers are washed with water and mixed with additives to make the resulting paper whiter or improve its texture. This mixture is spread out on screens, rolled, dried, and flattened to make paper. Different types of paper are made of nearly the same stuff, but they differ in how they are processed and treated.

In the end, we can create paper for many uses, from storing information in books, to producing notebooks, magazines, or newspapers. It can be used for packaging in corrugated boxes, paper bags, wrapping paper, and envelopes. We also use it for personal products, such as toilet paper, facial tissues, and paper towels — not to mention for currency, sandpaper, wallpaper, filter paper, and even chemical test papers like pH paper.

One last thought! It can be hard for people with disabilities to participate in science. That's exactly why the topic of paper was chosen—because, with paper, there are more opportunities to feel and hear science. We hope that you will work to include all people as you learn about the chemistry of paper through the articles and activities in this issue of *Celebrating Chemistry*. We also hope that you, and your friends, families, and classmates will participate in Chemists Celebrate Earth Week from April 21-27, 2019.

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Recycling Paper: A Success Story

By George Fisher

Did you know that nearly two-thirds of the paper consumed in the U.S. is recycled to make more paper? More than twice as much paper is now recycled than is sent to landfills. By weight, more paper is recovered for recycling from municipal solid waste streams than glass, plastic, steel and aluminum combined, according to the Environmental Protection Agency (EPA).

As you now know, paper is mostly made from wood fiber from trees, and wood fiber can be reused as much as six to seven times before it's no longer able to go through the papermaking process. It makes sense to keep reusing it. So how is recycled paper processed into new paper products?

When paper arrives at the recycling plant, it is separated into different types and grades. The separated paper is washed with soapy water to remove inks. It is strained through screens to remove staples and any glue or plastic (especially from plastic-coated paper) that may still be in the mixture. Next, the paper is put into a large tank where it is mixed with more water and chemicals to break it down. It is then chopped up and heated, which breaks it down further into strands of cellulose, a type of organic **polymer** naturally found in trees. This resulting mixture is called **pulp**, or **slurry**. This pulp is mixed with additional pulp made from wood chips to strengthen the mixture. The slurry is then spread into thin sheets and pressed using larger rollers. The paper is left to dry and then rolled up, ready to be cut into new recycled paper.

Old newspapers also get recycled to make new newsprint. Thirty percent of the recycled fiber from newsprint is used to create paper for newspapers. However, recycled newspaper is also used to make cereal boxes, egg cartons, pencil barrels, grocery bags, cellulose insulation, tissue paper, and many other products. Paper fiber from newspaper can be recycled only four times, because each trip through the pulping process gradually breaks down the wood fibers. This is why some amount of brand-new fiber is always required to create new newsprint.

White recycled paper comes from copy paper, printer paper, and paper we recycle from our homes. Cardboard boxes from grocery stores and retail stores also get recycled to make new boxes.

Earth Day is a celebration of how we can keep our environment healthy by practicing habits that are sustainable. Paper is a very useful product that we use in many parts of our lives. And best of all, it turns out to be very recyclable and sustainable. Our recycling may not be perfect, and we can always do more. But it is definitely a good bit of success for all of us to celebrate!

__George Fisher, Ph.D.__ is a Professor of Chemistry at Barry University in Miami, Florida.

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.

NEVER eat or drink while conducting an experiment, and be careful to keep all of the materials away from your mouth, nose, and eyes!

NEVER experiment on your own!

Let's Recycle Paper

By Regina Malczewski

Introduction

People have been making paper for over 2000 years using wood, other plant materials, or rags. Making wood-based paper from scratch is difficult, so we will skip the complicated steps by making recycled paper. By tearing or cutting up newspaper, softening it in water, and then re-positioning and squeezing the slurry to remove water, a new network of fibers can be made into recycled paper.

Safety Suggestions

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

Materials

- Flat table with area to work
- Clean newspaper (other papers can be used, but newspaper is easiest), cut or torn into shreds that are 11 in x 1 in or smaller (about 28 cm x 2.5 cm) — three newspaper-size pages is a good amount to start with.
- 1 gallon of water (3.8 L)
- Measuring cups, 1/3 cup (79 mL) and 1 cup (0.24 L)
- A bowl for soaking paper
- Rubber spatula
- A simple picture frame, at least as big as the piece of new paper you hope to make. If you don't have a picture frame, you can use an embroidery hoop instead.
- A large metal or plastic pan several inches (7 or 8 cm) deep in which your picture frame will fit.
- Window insect screen. You may be able to get scraps at a hardware store that fixes screens. Fiberglass window screen works best.
- Stapler and staples
- A regular blender (one that holds 6 cups, or 1.5 L, works well)
- Absorbent cloth towels (the surface of the towels will give your paper an interesting texture)
- An electric iron or hair dryer (if you want your paper to dry faster)
- Optional: Depending on how large a piece of paper you wish to make, you may want a bowl to put multiple batches of pulp in. You can also add food coloring or bits of leaves or flowers.

Procedures

Prepare the slurry

1. Place the cut/torn paper in enough warm water that it is completely covered, and then allow it to sit for 15-30 minutes.
2. Pour about 2 cups (about 0.5 L) water into the blender and add about 1/3 cup of packed, soaked paper that has been drained.
3. Start the blender with a short 10-second burst on a "blend" setting.
4. Blend for no longer than 30 seconds until all the paper is broken down. (It will look like watery oatmeal.) NOTE: You can mash up the paper by hand, but it takes a lot more work. (If you want to add food coloring or pieces of flowers, do so now.)
5. You may wish to repeat the above steps until you have more pulp, to make sure there is enough to cover your frame. If so, put each batch into the extra bowl until you have enough pulp.

Prepare the screen

6. Staple the screen to cover the opening on your frame. If using an embroidery hoop, wedge the screen between the inner and outer hoops.
7. Put water into your pan to cover the bottom and set the frame with screen inside.

Make your paper!

8. Pour the pulp slurry from the blender or bowl onto the frame. Spread out the pulp evenly over the frame surface by jiggling the frame, or by using a spatula or your hand. The layer should not be thick — just enough so there are no gaps.
9. Add pulp until you cover the surface to match the size paper you want.
10. Lift the frame out of the water and press the pulp gently with the spatula to help remove the water.
11. Place a towel over the frame covering the pulp. Press on the towel to remove more water from the pulp.
12. Turn the towel and frame upside down and place them, towel-side down, on a table.
13. Use the second towel to remove more water through the back of the frame if you need to.
14. Carefully lift the frame, leaving the new paper on the towel.
15. Reposition the second towel so that it is flat and on top of the paper.
16. Use an iron or hair dryer on the top (second) towel to help dry the new paper between the towels. OR, you can allow the paper to air-dry (which takes longer). Ironing helps transfer the texture of the towels to the paper. Have an adult help with this step!
17. Carefully peel away the second towel, and then turn over the bottom (remaining) towel to peel it away from the paper. Keep it flat until it is completely dry.

There are several other ways to make paper. Please see the reference section on the back page for other options. You may like to try multiple methods and compare the results!

How does it work? Where's the chemistry?

Making pulp with the blender is easy compared to what's needed at a paper plant to get pulp from wood. A complicated polymer called lignin binds the cellulose wood fibers together, and it takes special chemicals and lots of grinding, chopping, and beating to get a "mush" like the kind you can make in this exercise. Companies that make paper add other chemicals like bleach (to whiten the paper) or starch (to make it less absorbent, so that ink does not blur or spread when you write on it). The fibers stick together to create a mat of paper. This is because weak bonds form between the molecules of cellulose fiber, and the long fibers get tangled with one another. Because the fibers re-stick together so well, used paper becomes like new again. The cycle doesn't continue forever, though. If the fibers become too short, the new paper is very weak and tears easily. Even so, one piece of paper can be recycled six or seven times!

What do you see?

Write a short paragraph describing your paper and how it compares to other types of paper you have seen.

Regina Malczewski, Ph.D. *is a retired Senior Research Specialist from the Dow Chemical Company in Midland, Michigan.*

TEAR IT UP!

By Janet A. Asper

Introduction

Have you ever wondered how chemists know so much about atoms and molecules? They are so small that we can't easily see them directly … but that doesn't mean we can't learn about them! What scientists do is make observations about what we can easily see, and make assumptions about what is happening at the atomic level.

In this activity you will have a chance to do that very thing! We will test different types of paper by tearing them, and then see if we can learn anything about their molecular structure.

Safety Suggestions

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

Materials

- 1 newspaper
- 1 piece of copier or printer paper
- 1 piece of construction paper
- 1 page from a magazine (ask before tearing up a magazine!)

Procedures

1. Take one page from the newspaper and attempt it tear it along its short side.
2. Next, try to tear the same piece of paper along its long side.
3. Repeat these steps with each of the other types of paper.
4. Try to tear them again with your eyes closed. Describe any difference in what you feel when the paper is torn in different directions. Feel the difference in the torn edges and describe them. Listen to the sound made when you tear the paper and describe what you hear.
5. If you cannot tell any difference in each edge by simple tearing, cut a strip of paper about 1 in x 2 in (about 2.5 cm x 5 cm) and wet it with water. Allow the paper to dry on a flat, smooth surface. As the paper dries, it will curl up. The direction that it curls up is based on how its molecules are arranged.
6. Repeat these steps with the other pieces of paper and classify each as hard or easy to tear, and smooth or rough torn edges.

Observations

Kind of Paper	Easier or harder to tear?	Torn edge smooth or rough?	Difference in tearing sound?
Magazine paper			
Long edge			
Short edge			
Newspaper			
Long edge			
Short edge			
Copier paper			
Long edge			
Short edge			
Construction paper			
Long edge			
Short edge			

Questions

1. Paper is made of long chain polymer molecules. Based on your observations, in which direction do you think the polymers are lined up in each type of paper?
2. How does the direction in which you think the polymers line up change how the paper tears?
3. How does the difference in the arrangement of the molecules affect the sound of tearing paper?

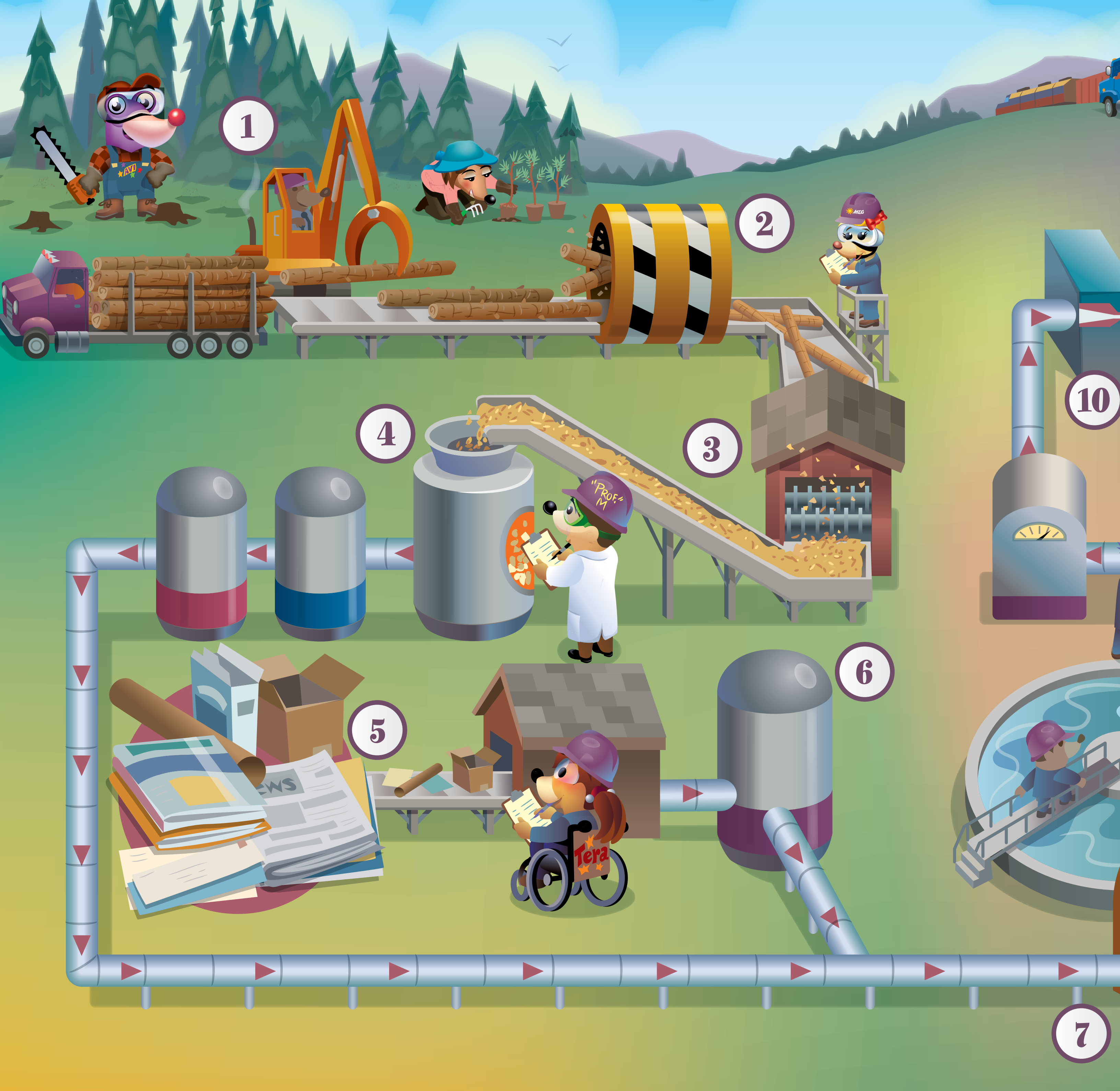
How does it work? Where's the chemistry?

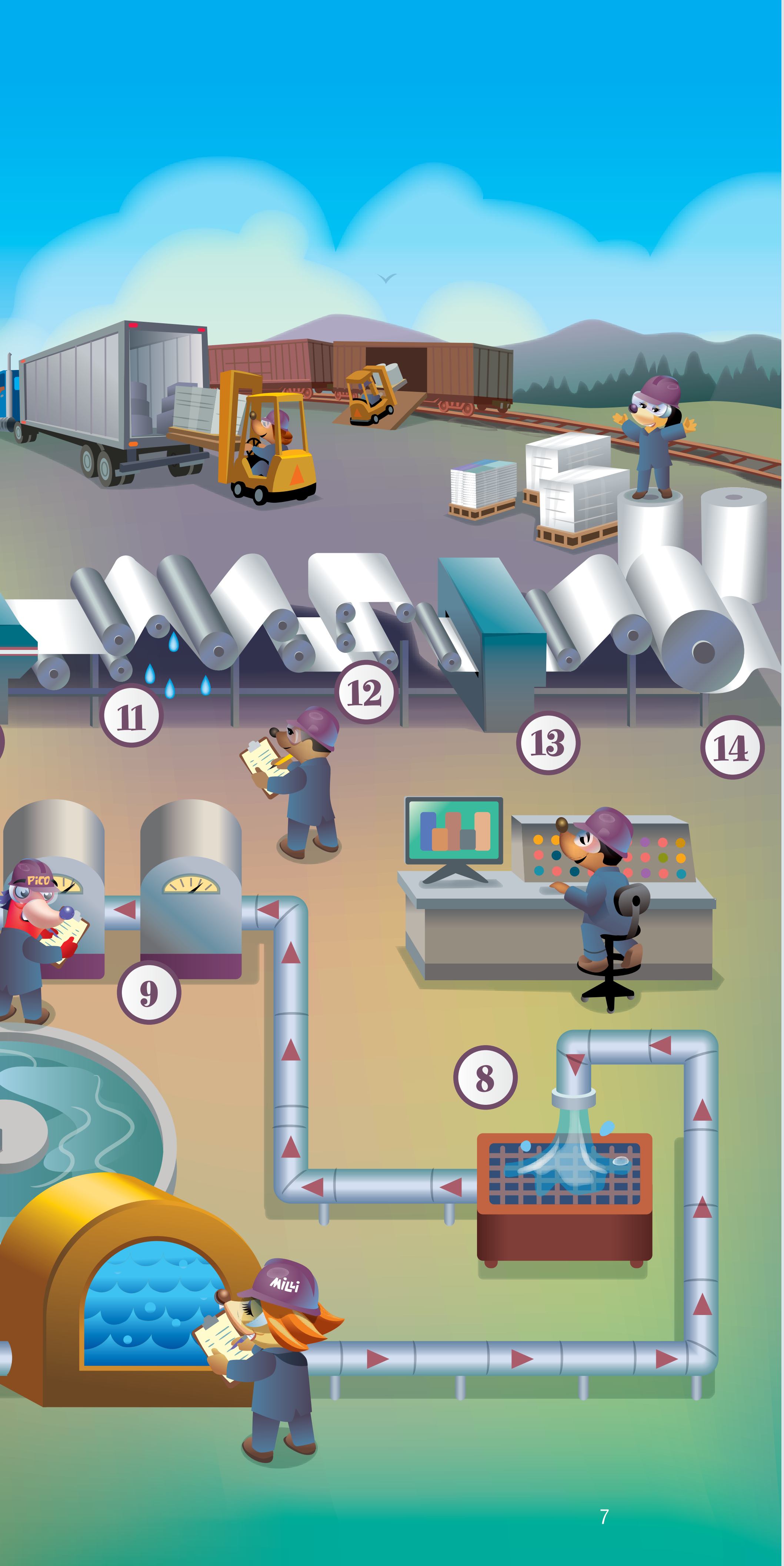
You already know how paper pulp is made from wood, and that it is actually fibers made up of long chains of cellulose. But did you know that the orientation of the paper fibers themselves give different types of paper different properties?

As the pulp moves through the paper-making machine, the cellulose fibers line up in the direction that the paper is moving. That arrangement of fibers is called the "grain direction" or "machine direction." This grain direction is important because paper is easier to fold and cut along grain direction. If you tear a sheet of paper, it will tear straighter along the grain. Tearing across the grain is harder, and will make a rough edge. By comparing your observations, you can make an assumption about how the molecules in paper are arranged!

__Janet A. Asper, Ph.D.__ is a Professor of Chemistry at University of Mary Washington in Fredericksburg, Virginia.

The Paper Making Process





By An-Phong Le

Match the numbered steps in the paper making process to their names and descriptions below!

- ◯ **Bleaching:** Adding bleaches to whiten the pulp.
- (12) **Calendering:** Squeezing the paper between one or more sets of rollers to bring the paper to its finished thickness.
- ◯ **Chipping:** Breaking logs into small wood chips by pressing logs against a large spinning blade with sharp teeth.
- ◯ **Coating:** Adding coatings, pigments, and additives to the paper surface to achieve certain properties.
- ◯ **De-inking:** Removing adhesives, ink, and other impurities from the pulp of recycled paper.
- ◯ **Debarking:** Removing bark by rotating the log while pressing it against spinning chains or blades.
- ◯ **Finishing:** Cutting the paper rolls into sheets or smaller rolls for use.
- ◯ **Harvesting:** Collecting wood from sustainably managed forests.
- ◯ **Pressing:** Squeezing and heating the fiber mat to remove more water, forming a long, continuous sheet of paper. The paper is pressed against felt rollers to help with water removal.
- ◯ **Pulping:** Grinding wood chips into fibers, and removing lignin by heating a mixture of these fibers with water and other chemicals.
- ◯ **Recycling:** Collecting used paper and reducing it to pulp to separate the fibers that can be added to new pulp.
- ◯ **Rolling:** Squirting the pulp through the headbox to create a continuous mat of fibers.
- ◯ **Spraying:** Spraying the mixture of fibers and water onto a wire mesh to remove undesirable materials.
- ◯ **Washing:** Rinsing the pulp fibers with water.

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Paper or Plastic?

By Regina Malczewski

Every day we experience our own small environmental decisions, like when the clerk at the grocery store asks us if we prefer "paper or plastic" for our carry out bag. Which is the best choice? Some communities have passed laws restricting the use of one or both of them. But which one is best for the environment?

The word **plastic** is used for all kinds of materials that are man-made (or synthetic). Most of them are made from natural resources like crude oil and natural gas, which are unfortunately non-renewable. We only have a certain amount of oil and gas … and when we use it up, it is gone forever.

Paper, on the other hand, is made from trees, which are renewable. We can always plant new trees, and they just need enough time to grow. But it takes a lot of trees to make paper. For example, it takes three tons of wood chips to make one ton of wood pulp. Making paper also takes a lot of water and energy, which can lead to water and air pollution.

It is cheaper to make bags out of plastic than paper, and they are also more water resistant. But we consume billions of them each year and they are not biodegradable. That means if they go in the trash, they don't break down easily. If they aren't properly disposed of, they can affect animals, either when the animal gets tangled up in the plastic, or eats it by mistake. About 10% of litter washed up on our ocean shores are plastic bags.

Paper and plastic, although very different, do have things in common. Both are made of polymers — long chains of repeating subunits (or parts). Paper is made of one kind of natural polymer (cellulose) whose subunits are simple sugars. Different plastics each have their own types of man-made polymers, with subunits like styrene or propylene. Both paper and plastic can be molded, but plastics can be used in many more ways. Both can be written on, but plastic needs special inks.

The decision about "paper or plastic" should be based on which properties you need for the bag, and also on their long-term effect on the environment. So another answer to the question might be, "none of the above." Instead, you can use recyclable bags that you take to the store every time you visit. By reusing the same sturdy bag many times, we reduce the overall impact on the environment.

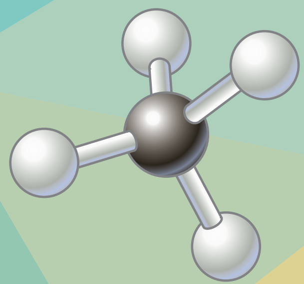
Another alternative is to come up with new choices. New materials called **bioplastics** have been created using more natural materials. They can be composted, but they are also strong and cheap like traditional plastic bags.

Chemistry gives us many choices. The choice between paper and plastic should be made after thinking about what you need, how much waste will be made, and the impact on the environment. In the future, there may be even more kinds of bags to choose from, made in ways we can't yet imagine!

Regina Malczewski, Ph.D. *is a retired Senior Research Specialist from the Dow Chemical Company in Midland, Michigan.*

Make Your Own Paper Molecule

By Ressano Machado



Tips for Folding Your Molecule

- Solid lines are 'mountain' folds, where the sides fold away from you, like getting a top-down view of a mountain. The solid line should be on top of the mountain ridge.
- Dashed lines are 'valley' folds, where the sides fold toward you, like getting a view of a valley with the dashed line at the bottom of the valley.

Procedure

1. Cut along the outside solid line of the paper model cutout.
2. Start by making the 'valley' folds. Secure each fold with a small piece of tape.
3. Make each of the 'mountain' folds.
4. Fold into a four-sided pyramid and secure with tape.

Questions

In the model, where is the carbon atom? Where are the hydrogen atoms?

What does this model tell us about the shape of the molecule?

How does the shape of the paper model compare to the sketch of the model you made at the beginning of this activity?

When designing a large, complex building like a shopping mall, an architect may build a small model to help people imagine what the building will look like once completed. Three-dimensional (3D) models are useful because they help people understand things better than written words or drawings can do alone. These models are not perfect representations, but they can help people understand the different sizes of rooms and how they are arranged inside the building. Models may even help people notice details, such as the placement of windows, skylights, or doors that they might not have realized otherwise.

Chemists use models, too — but instead of representing big things on a small scale, models in chemistry help us see and feel the super-small world of **atoms** and **molecules**. Molecular models show the number and type of atoms needed to build one molecule, and how the atoms are arranged. While most are not perfect scale-models of molecules, they can help people understand something special about molecules that can only be understood by holding a model in their hands.

In this activity, you will make a paper model of a methane molecule by cutting out and folding the diagram below. Compared to actual molecules, which are too small to be seen, this paper model is enormous!

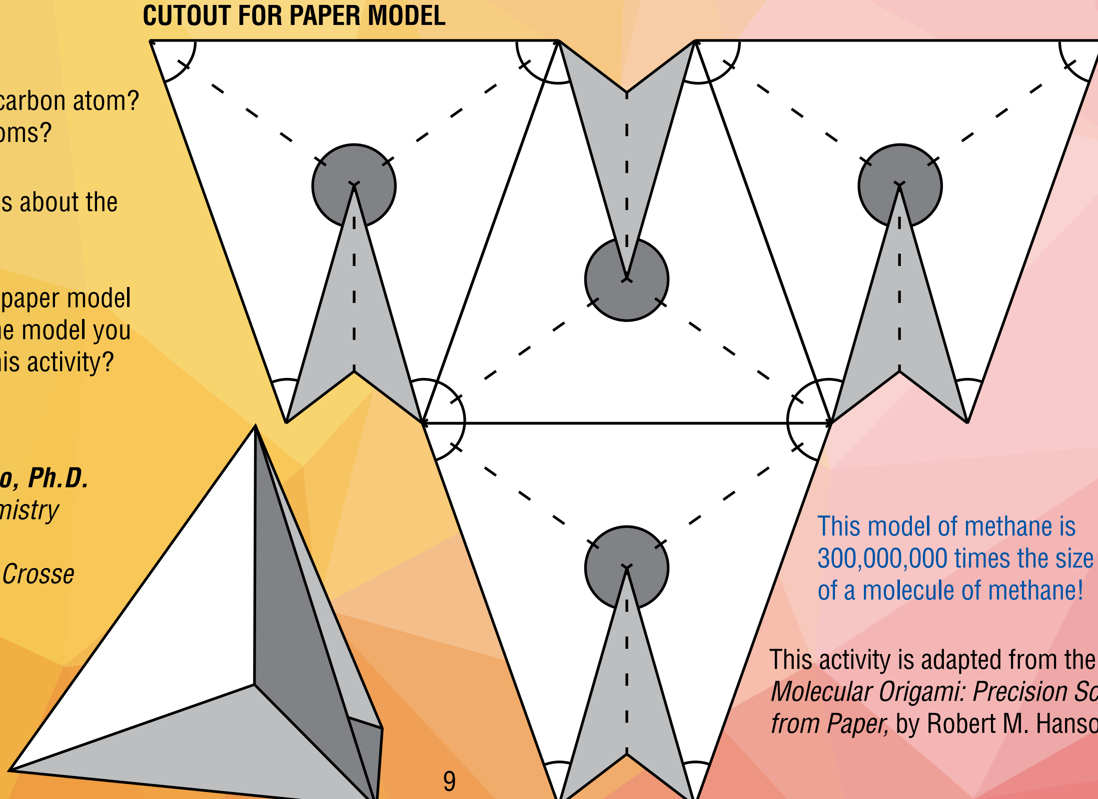
Methane - CH_4

- One carbon atom and four hydrogen atoms.
- Very flammable (catches on fire very easily)!
- Methane is delivered to homes and office buildings through underground pipes. If the stove in your home makes a flame, it uses methane.

Before you start making your model, make a sketch of what you guess a molecule of methane might look like. Remember: methane is made of one carbon atom attached to four hydrogen atoms.

Hint: There's an image of a methane molecule on this page.

CUTOUT FOR PAPER MODEL



This model of methane is 300,000,000 times the size of a molecule of methane!

This activity is adapted from the book, *Molecular Origami: Precision Scale Models from Paper,* by Robert M. Hanson.

Ressano Desouza-Machado, Ph.D. *is a Senior Lecturer of Chemistry and Biochemistry at the University of Wisconsin-La Crosse in La Crosse, Wisconsin.*

The Adventures of Meg A. Mole, Future Chemist

Dr. D. Steven Keller, Professor

In honor of this year's CCEW theme, "*Take Note: The Chemistry of Paper*," I traveled all the way to Oxford, Ohio to meet with Dr. D. Steven Keller, Professor at Miami University in the Department of Chemical, Paper, and Biomedical Engineering.

Dr. Keller explained to me that his job focuses on teaching college engineering students about paper. "I teach them where the raw materials come from, how pulp fibers are produced from wood, and how they are reformed to make all sorts of paper products used for writing, packaging, or for cleaning. I also study how the fibers in paper and nonwovens are arranged in the structure, and how the structure and chemistry affects end use properties," he explained.

Word Search

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

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

ATOM	ELEMENT	PLASTIC
BIOPLASTICS	FIBER	POLYMER
CELLULOSE	LIGNIN	PULP
ELECTRON	MOLECULE	SLURRY
	PAPER	

Touring the laboratory was the best part of my visit! As I followed him through the lab, he showed me "specially designed instruments used to study the mechanical and optical properties of paper." I was very surprised to learn one fact about his lab equipment. He said, "I use instruments that are just like those used in hospitals like CAT scanners and X-ray machines, but much smaller and at lower energies to see the organic fibers."

I asked Dr. Keller about his interest in chemistry while growing up. He shared, "I always loved science and exploring, especially the countryside and forest. I also liked putting together model cars and airplanes. Bringing together the enjoyment of building and exploring nature to study new methods of analyzing materials and solving scientific problems is exciting and rewarding. My father was a chemist and a materials scientist who encouraged my siblings and me to look carefully at the natural world around us. We always had access to books and household resources to conduct simple experiments, like changing the color of flowers with food coloring, or making desktop volcanoes." So why did he decide to go into chemistry specifically? He told me, "I decided to go into science, and especially chemistry, since it is a challenging field that is so complex, yet allows one to make new and significant discoveries every day."

"So, what is the best thing about your job?" I asked. He said, "Working with enthusiastic students, excited about learning how technology and natural resources can be used to make everyone's life much better. Being a scientist means that you are confronted by different problems each day. Some problems are easily solved, others might take years. But there is great satisfaction when you solve a problem and share the discovery with others."

Personal Profile

- **Birthday:** July 15
- **Do you have a hobby?** Well, I still make scale models, but now I use wood and metals to make scratch built ship models.
- **Can you tell me about your family?** I have a wonderful wife Kathy, a son Steven who is married to Rebecca, and two wonderful grandchildren, Allison and David (ages 5 and 1).

To Flush or Not to Flush?

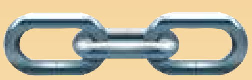
Chemistry Makes it Flushable!

By Janet A. Asper

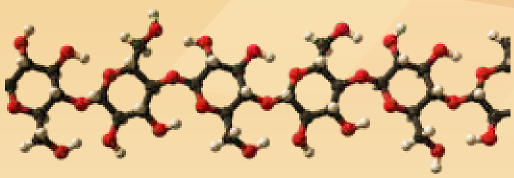
Modern toilets and sewage systems are marvels of technology. They let us dispose of all our human waste and take it away silently and cleanly. But there are limits to what kinds of things we can flush down our toilets — in fact, there are basically only two items. First is any waste that comes out of your body, and the second is toilet paper. Anything else is a problem. So, what is the difference between things you can flush compared to those you shouldn't?

As you know, paper fiber is made of long polymers called cellulose. The cellulose fibers in toilet paper are very short. When toilet paper gets wet, the water is attracted to the cellulose, causing the paper to swell and pushing the fibers apart. Add a little bit of stirring (FLUSH!), and the paper breaks up into tiny pieces that are easily carried through the pipes out of your house, to the sewers, and on to the sewage treatment plant.

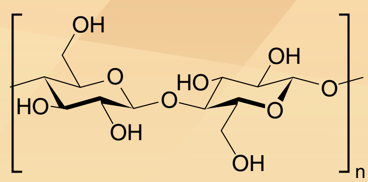
Here's a chain!



Here's a polymer. A polymer is like a chain because of it's repeating parts. A polymer is one big molecule made up of repeating smaller molecules.



Here's cellulose. Cellulose is a molecule and polymer we find in plants and use to make paper. Below is the group of atoms that repeat in a chain to make the molecule cellulose.



But what about wet wipes (also called baby wipes)? They are used to wipe the same "stuff" off of the same part of the body. Why don't we flush those? The difference is in the chemistry. Baby wipes are made of different polymer molecules, including long chains of polypropylene, polyester, and rayon that don't attract water. These fibers make the wipes really soft and strong, but they do not break down in water. The wet wipe sheets stay pretty much whole.

When you flush baby wipes, these large sheets don't move through the sewer pipes as easily, because they aren't carried by the flow of the water. Instead, they bunch up together and attract oils and fats in the wastewater. This is because one of the rules in chemistry is "like dissolves like." Although the cellulose attracts water, the polypropylene in baby wipes is made up of only carbon and hydrogen atoms — two atoms that are great at attracting fats and oils. The oils and fat stick to the baby wipes, and then the baby wipes begin to stick to each other, attracting more oil. This makes a gooey, insoluble glob called a "fatberg." The fatberg can grow and grow, clogging drains and sewer pipes. Many cities are very worried about fatbergs because they are very difficult (and disgusting) to remove.

In 2017, a 820-foot-long, 286,000-pound fatberg was removed from the sewers in London, England. Samples of it are on display at the Museum of London.

A dried section of the Whitechapel fatberg, on display at the Museum of London.
Lord Belbury

Now, do you still think it doesn't matter what you flush down your toilet?

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Words to Know

Atom: the smallest part of an element that has the characteristics of the element

Bioplastics: plastics that are made from living things, such as corn or potatoes

Cellulose: a polymer made by plants which gives them their structure

Chemical Reaction: the process of rearranging atoms between substances to make different substances

Electron: a part of the atom that has a negative charge and is attracted to protons

Element: a pure substance, such as copper, which is made from a single type of atom

Fiber: a group of cellulose molecules or lignin arranged into tiny threads

Lignin: a polymer made by woody plants that binds cellulose fibers together

Molecule: the smallest part of a compound which is made up of two or more atoms

Paper: a material made primarily from fibers of cellulose and lignin pressed together

Plastic: a polymer, usually made from petroleum, that can be rigid or flexible

Polymer: a long chain made of repeating molecules

Pulp: a mixture of fibers and water that have a dough-like consistency

Slurry: a mixture of fibers and water that behaves like a thick liquid

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.

About the American Chemical Society

The American Chemical Society (ACS) is the largest scientific organization in the world. ACS members are mostly chemists, chemical engineers, and other professionals who work in chemistry or chemistry-related jobs. The ACS has nearly 157,000 members. ACS members live in the United States and different countries around the world. Members of the ACS share ideas with each other and learn about important discoveries in chemistry during scientific meetings held around the United States several times a year, through the use of the ACS website, and through the many peer-reviewed scientific journals the ACS publishes. The members of the ACS 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 train stations! 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**.

About the International Year of the Periodic Table

The United Nations General Assembly proclaimed 2019 as the International Year of the Periodic Table of Chemical Elements (IYPT), commemorating milestones in the history of the periodic table, its development, and its importance in science, technology, and sustainable development. ACS and chemical societies around the world will be celebrating throughout the year. IYPT celebrations will include contests, technical programming, themed gifts and giveaways, public engagement campaigns, and more. Visit **www.acs.org/iypt** to learn more.

United Nations Educational, Scientific and Cultural Organization

International Year of the Periodic Table of Chemical Elements

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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.

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