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Celebrating Chemistry

Living in a Materials World

Living in a Materials World

By Lynn Hogue

Look around you. All the things you use in daily life are made of materials such as stone, wood, metal, paper, or plastic. Each of these materials is made of one or more kinds of chemicals. Since the beginning of time, people have been using the materials in their environment to make their lives easier and better.

Early humans picked up stones and used them as the first tools. Heavy, hard stones were great for pounding and smashing. Flat-edged rocks were better for scraping. Soon, humans discovered that some types of rocks, such as flint, could be sharpened into knives and arrowheads. Different types of rocks were chosen for different purposes based on their properties.

Humans started using metals about 8,000 years ago. Gold, silver, copper, iron, lead, mercury (quicksilver), and tin are all mentioned in ancient literature. The properties of metals offered many new options for making useful and beautiful objects. The first metals discovered and used were probably gold and silver because they are found in nature in their metallic form. Other metals have to be heated to high temperatures to remove them from the rock they are found in before they can be used. This process is called smelting. Copper was the first metal to be smelted. Real innovation occurred when people started mixing different metals together. Mixtures of metals are called alloys. An alloy has different properties than the individual metals used to make it. Bronze, a mixture of copper and tin, was such an important early alloy that it has an "age" named after it—the Bronze Age, of course! The properties of metals are still important to us. For example, the wiring in your home is made from copper metal because it conducts electricity well. Gold and silver metal conduct electricity better than copper but are not used because they would be too expensive to use for wiring a whole house. Gold is widely used for wiring in computers because only a small amount of it is needed.

Since our early beginnings, humans have continued to find ways to make new and better "stuff". Scientists and engineers work to make exciting new products possible. They improve the materials that products are made of by changing the mixtures of chemicals used. Sometimes, they invent brand-new materials. Here are a few examples:

- Fifty years ago, diapers were made of cloth. Today, disposable diapers contain a water-absorbing polymer that absorbs more liquid than cloth and keeps babies drier.
- If you are building an airplane, you want a strong material that is also lightweight. Aluminum is light, but too soft. It doesn't

have all the right properties. But an alloy of aluminum with a small amount of copper is both strong and light and makes a very useful aerospace material.

- You probably know that most glass is pretty fragile and breaks easily. But the deck of the Grand Canyon Skywalk is made with special 3-inch-thick laminated glass floors that allow visitors to walk out 70 feet beyond the western rim of the Grand Canyon and look down 4,000 feet below at the Colorado River. This Skywalk can withstand an 8.0 magnitude earthquake and 71 million pounds of pressure.

The discoveries that stone and metal could be made into useful products dramatically changed the lives of early humans. Today, we are at the beginning of another new age of technology that will change our lives. Nanotechnology uses very small particles to make new products. Lots of nanotech products have had an impact on our lives already, especially in sports. Michael Phelps and 25 other athletes broke world records during the last Olympic Games wearing new ultra-lightweight swimwear that uses nanotechnology. These suits don't absorb water (2% as compared to 50% for older suits). They allow the swimmer to reduce friction as they swim through water (called drag), so they can go faster.

Whether you are a professional athlete or are more casually playing school or club sports, smelly gym clothes and sports equipment are a big problem. Sports equipment and clothing are great breeding grounds for bacteria and fungi that cause bad smells and infections. Silver has been used for 100 years to kill these germs and bacteria, but incorporating it into sports equipment has been difficult. A nanotech company in State College, PA, has developed a silver nanoparticle that can combine with the cotton, plastic, or nylon material in uniforms, helmets, socks, and pads. The silver kills the bacteria and fungi, so it's good-bye to bad-smelling sports gear!

Science and technology are amazing. We enjoy the creativity and hard work of scientists every day as we play music, communicate with friends, travel, wear new fashions, cook, stay warm … or cool, recover from sickness, and do just about everything else in our lives. In so many ways, science and technology give us the power to live longer, more enjoyable lives. President Franklin D. Roosevelt once wrote, "Great power involves great responsibility." The power of science and technology gives us so much. Let's use our resources—the raw materials for everything we need and want—responsibly by recycling and reusing, purchasing less packaging and other disposable materials, and by paying attention to our personal use of water and energy. The result of our conservation efforts will be continued resources for many generations of discoveries. What can you imagine?

What Counts in Bounce

Most balls bounce. In the following activity, you will compare the bounciness of warm and cold racquetballs to see if temperature makes a difference in how well they bounce.

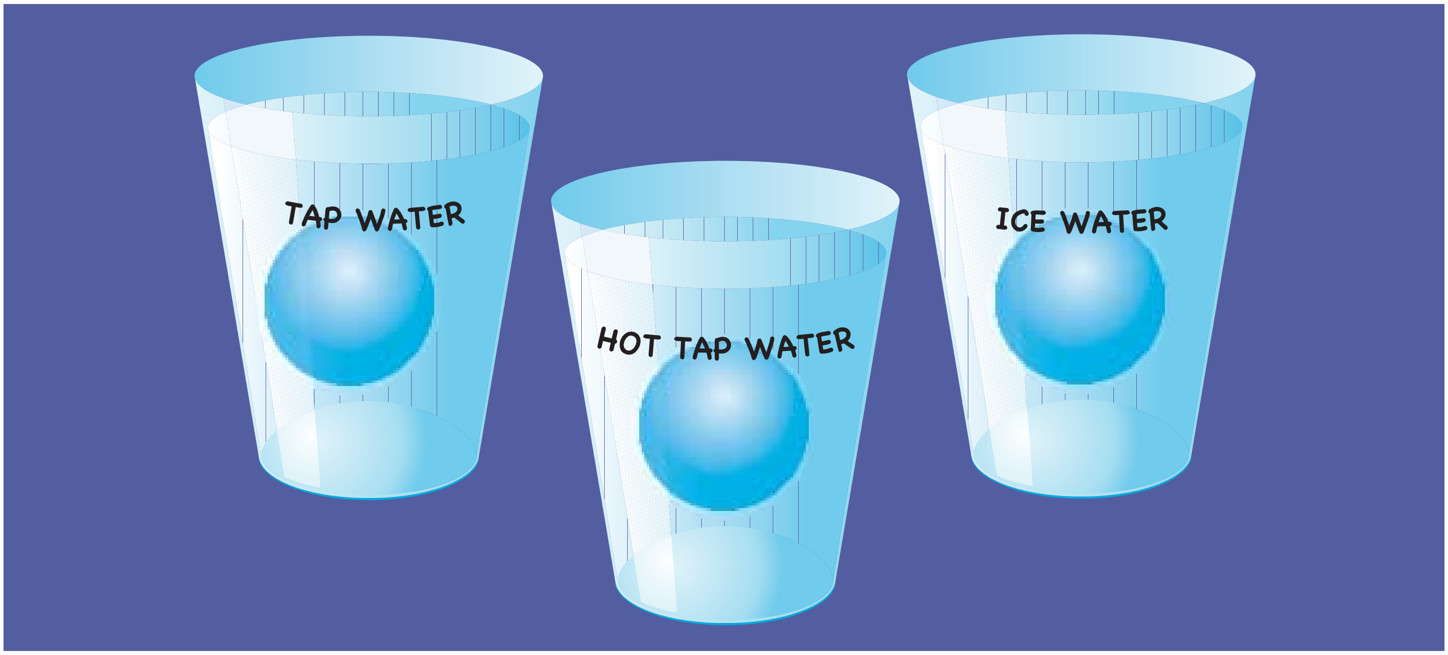
Materials

- Masking tape
- Permanent marking pen
- 3 plastic containers big enough to hold a racquetball
- Ice
- Water
- Hot tap water
- 3 racquetballs
- Timer
- Tongs
- Measuring tape or yard stick

Students who are visually challenged may press the balls in their hands to feel the difference at different temperatures.

Procedure

1. Using the marking pen and a strip of masking tape, label one of the containers *Ice water*, label the second one *Tap water*, and the third one *Hot tap water.*
2. Fill the container labeled *Ice water* halfway with tap water. Next add ice so that the container is ¾ full of ice and water.
3. Fill the container labeled *Tap water* with tap water until it is about ¾ full.
4. Have an adult partner fill the container labeled *Hot tap water* with hot tap water until it is about ¾ full.
5. Place one racquetball in each container and let it sit for at least 2 minutes. Use a timer to keep track of the time.
6. Meanwhile, have your adult partner hold a measuring stick or tape with the zero end resting on the floor.
7. Use tongs to remove the ball from the *Tap water* container.
8. Hold the ball at the top of measuring stick above a hard surface and drop the ball next to the measuring stick or tape. Measure how high the ball bounced. You may have to drop the ball more than once to get this measurement.
9. Record your result in the "What Did You Observe?" table. Place the ball back into its container.
10. Repeat Steps 7–9 for the balls placed in the *Tap water* and *Hot tap water* containers, respectively.
11. Thoroughly clean the work area and wash your hands.



What Did You Observe?

Ball temperature	Height (centimeters/inches)
Tap water	
Ice water	
Hot tap water	

Analyze your results

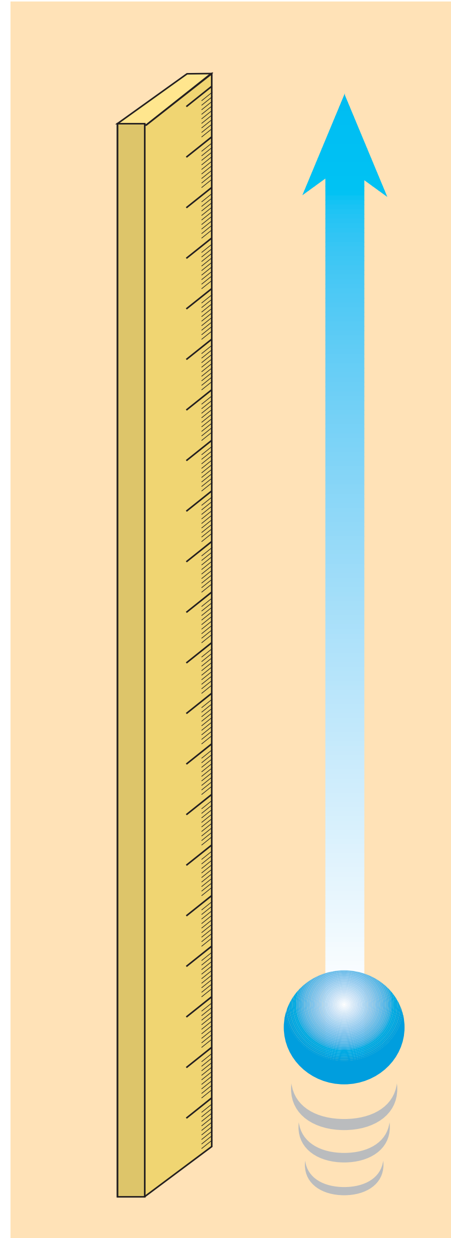
Make a claim about how temperature affects the height a racquetball bounces.

Try this...

Test how temperature affects golf balls.

Where's the chemistry?

Balls bounce because most of them are made from some type of polymer, like rubber. The type of polymer used in a ball will determine how high, or low, a ball will bounce. The rubber polymers found in racquetballs are long, stringy, and closely coiled to each other. It is that coiled shape that gives a ball its ability to spring into the air. When the temperature of a ball is cooled, the polymer loses its coiled shape and becomes straighter and less springy. Warm up a ball, and its polymers become even more coiled than they are at room temperature.



Milli's Safety Tips Safety First!

ALWAYS:

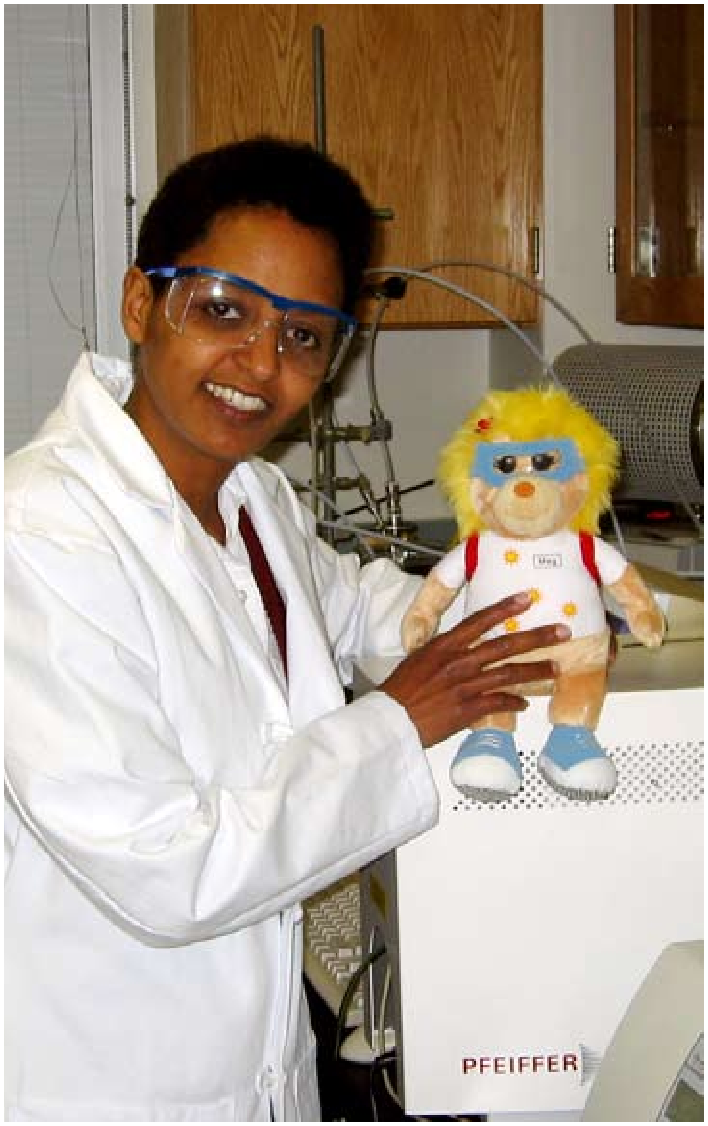
- Work with an adult.
- Read and follow all directions for the activity.
- Read all warning labels on all materials being used.
- Wear eye protection, specifically goggles.
- Follow safety warnings or precautions, such as wearing gloves, or tying back long hair.
- Use all materials carefully, following the directions given.
- 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 used away from your mouth, your nose, and your eyes!

NEVER experiment on your own!

For more detailed information on safety, go to www.acs.org/education/policies/safety.

The Adventures of Meg A. Mole, Future Chemist



In autumn of 2011 of the International Year of Chemistry, I decided to learn more about the work of material chemists. One chemist I visited was Dr. Sossina M. Haile. I got to travel all the way to Pasadena, California! Dr. Haile is a professor at the California Institute of Technology.

Dr. Haile told me that she tries to find ways to make renewable energy more affordable. She also spends her time as a professor, guiding her students on which experiments to try and also teaching them how to use special equipment. Her research will improve things like batteries and fuel cells! I am very familiar with batteries since I use them for my TV remotes and portable radio! Fuel cells take chemical energy from a fuel and make it into electric energy by a chemical reaction. Fuel cells have been tested to power spacecrafts, boats, cars, and even submarines!

I wanted to know more about what Dr. Haile liked most about her job. She told me she likes being able to decide how she spends her days. She enjoys being able to pick the problems she wants to work on. So what does Dr. Haile think is the best thing about being a scientist? She says that she "loves being able to discover new things. To be the very first person to know something is fantastic… and then to be able to use it to solve an important world problem is even better!" Dr. Haile said she chose a career in science and engineering because she was good at math and wanted to spend her life inventing solutions to problems that the world faces.

In the future, a lot of the work Dr. Haile's research team does can apply to many lives, even children. She said she thinks we all know that we can't use oil and coal indefinitely. By helping the world transition to renewable energy, she hopes to make sure that the next generation will have a healthy planet.

With scientists like Dr. Haile working so hard to help develop these new technologies, the future is looking bright!

To read more about my visit with Dr. Haile, please visit my web pages at www.acs.org/kids.

TELL ME ABOUT YOUR FAMILY: I was originally born in Ethiopia. My family moved to the United States as political refugees. I've spent most of my life in the United States. My early childhood experiences have given me an appreciation for the comforts and freedoms of life here.

Spaghetti Strength

Can you think of an example of a polymer that is a strong building material? Yes you can! Wood is a naturally occurring polymer found in the lumber used to build the frame of a home or in the plywood placed on the outside part of the frame. One of the reasons why it is strong is because of the strength of its chemical bonds. Imagine standing side-by-side in a line with your friends. Each of your arms is hooked so that you are sturdily linked to each other. Your linked arms are like the wood's chemical bonds. Chemical bonds may be broken by a force, like someone pulling really hard on one side of the line with your friends. If the force is strong enough, the bonds will break. Strong chemical bonds are important for building materials, like lumber, because it has to be sturdy enough to hold the weight of a home or building. Scientists test how much force is required to break a sample of material to make sure that it is safe and strong enough to use for building. In this activity, you will see how scientists examine building materials by testing the strength of spaghetti and how the number of strands affects its strength.

Materials

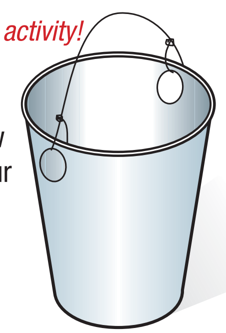
- Small paper cup (4 oz.)
- String
- Pencil
- Raw spaghetti
- Other uncooked pasta (one thinner and one thicker than spaghetti, e.g., angel hair and fettuccini)
- Masking tape
- Metric ruler
- Pennies

NOTE:
To more closely mimic the layers within a piece of plywood, it is suggested that the pasta strands be dipped in water and stuck together by running the thumb and index finger over the length of the water-dipped pasta until they stick to one another. Pasta prepared this way will need to dry overnight before conducting the activity.
If done in a large group, smaller groups can be given one type of pasta each and may be asked to share data.

ADAPTATION *The cup can be suspended using a pipe cleaner as the handle instead of string. Larger coins or identical steel washers could be used instead of pennies.*

SAFETY! *Be sure to follow Milli's Safety Tips and do this activity with an adult!*
Do not eat or drink any of the materials in this activity!

Procedure



1. Make a "penny bucket" from the paper cup and string. First use the pencil to carefully poke a hole in the side of the cup, just below the rim. Poke a second hole directly across from the first one. Your adult partner may help you make the holes.
2. Tie one end of the string to each hole to make a handle for your penny bucket as shown, and set it aside.
3. Place one piece of spaghetti on the table and use the ruler to measure so that 12 centimeters of spaghetti hang off the edge of the table.
4. Tape the spaghetti in place.
5. Place a small piece of masking tape on the end of the spaghetti that hangs off the table by folding the tape in half over the end.
6. Hang the empty penny bucket on the spaghetti up against the tape.
7. GENTLY place pennies one at a time into the penny bucket.
8. Continue to add pennies until the spaghetti breaks.
9. Record the number of pennies in the "What Did You Observe?" table.
10. Repeat steps 3 through 9 for two, three, and four strands of spaghetti. When you tape the ends, make sure the spaghetti strands are touching one another.
11. Repeat steps 3 through 10 for thinner and thicker pasta.
12. Throw away the empty penny bucket and broken spaghetti pieces. Return the pennies to their owner. Thoroughly clean the work area and wash your hands.

Try this...

Graph the data for this experiment, with the number of strands of pasta on the x-axis and the number of pennies on the y-axis.

Try putting the pasta strands at different distances from the edge of the table.

What Did You Observe?

Number of strands of pasta	Number of pennies held before breaking		
	Regular spaghetti	Thin pasta	Thick pasta
1			
2			
3			
4			

Which number of strands was the first to break? ____________ the last? ____

Which type of pasta held the most pennies overall? __________ ____

Why do you think this is so? ____________________________ ____

Where's the chemistry?

Spaghetti is a type of polymer called a carbohydrate. Its bonds are strong; however, it could only support a certain number of pennies. When there was too much strain on the spaghetti strands, it caused the chemical bonds to break. There is strength in having several strands of spaghetti stuck together. This allows more pennies to be supported.

The Adventures of Meg A. Mole, Future Chemist

My trip this quarter in honor of the International Year of Chemistry 2011 was to meet Dr. Dawn Mason. She is a group leader at Eastman Chemical Company in Kingsport, Tennessee! Tennessee is one of my favorite places to visit because I love the mountains!

Dr. Mason told me she spends most of her time working in the laboratory and on a computer. In her job, she and her colleagues test how new compounds would perform in products, and they look at how well things stick together. That sounded neat, and I could not wait to hear more! Next, she showed me one of the experiments she was working on. They were testing glue to see how well it would stick to cereal boxes. That is definitely important in keeping your food safe! Another thing she showed me was how they were working with labels to see how they would stick to things like paper and metal and how temperature affects how well it would stick. This reminded me of the stickers I got for National Chemistry Week. I bet there is a chemist somewhere testing those, too, before they go to the ACS store!

In the laboratory, Dr. Mason told me it is very important to wear safety glasses, gloves, and lab coats. Sometimes, they use other protective equipment, such as face shields. They definitely make sure they are being safe! Some of the other things I saw on my visit were hot polymer coming out of a tube, a machine pulling tape to see how well it sticks, and even a reactor making something new!

Dr. Mason told me she was interested in science growing up because she liked the subjects in school and they challenged her mind. She thinks the best thing about being a scientist is that you are always learning something new. Getting to work with great people is what she likes best about her job.

As we were leaving the laboratory, I asked her where she thought a child would come in contact with her work. She looked at me with a big smile and said, "Diapers and cereal boxes!" Her work definitely impacts a lot of children!

Meg Interviews Dr. Dawn Mason.

To read more about my visit with Dr. Mason, please visit my web pages at www.acs.org/kids.

FAVORITE HOBBIES: Gardening, exercising, and reading.

Recycling: San Francisco Style!

By Lynn Hogue

What if you could do something good for nature and the environment? What if this “something” took very little effort? What if all your school friends were doing it … would you do it too? Kids all over San Francisco are doing something every day that’s making a world of difference. Through a city-wide school recycling program, these kids are reducing the garbage from their school that goes to landfills by up to 90%! They are the first kids in the nation to participate in a widespread recycling program of this type.

If the school garbage isn’t going into a landfill, what happens to it? Every school in San Francisco (along with all the residents and businesses) recycle and compost most of their garbage. Special bins are placed in the school cafeteria—green bins for food scraps and dirty paper; blue bins for recyclable materials like hard plastics, metal, and glass; and black bins for everything else. When they are done eating, kids separate their trash into the proper bins. Older students in orange aprons supervise the sorting and help younger ones get waste into the correct bin.

So what happens to the stuff in each bin? The contents of the green bin go to a special center to be composted. Composting just means that the stuff in the bin rots and decomposes (breaks down) into material that makes soil much better for growing plants. This compost is sold to area farmers, especially organic farmers who use a lot of compost. If a school has their own garden, they can get the compost back for free.

The contents of the blue bin go to a recycling center to be separated and then sold to companies that will turn the material into new products. The properties of the materials, such as whether they sink or float or if they can be picked up by magnets, determine how they are separated. Only the garbage in the black bin has to go to the landfill.

San Francisco’s strong recycling program is only a first step in protecting the environment. Tamar Hurwitz, Environmental Education Manager for San Francisco, wants people to be aware of all the stuff we use and the materials used to make those things. Tamar says, “Everything we use comes from something originally found in nature. It’s important to think about where materials come from and the impact that has on nature and our health. Today everyone has a role in changing things for the better. We can explore the world of plants to provide us with substitutes to chemicals that are made from petroleum or oil. Examples include biodeisel fuel made from leftover French Fry grease, compostable plastics made from corn, and even skin lotion made from coconuts. Plant-based chemistry offers us a great opportunity for being smarter about how we make things!”

San Francisco is a great example of a community that is making a difference and helping the environment and the planet. Currently, the people of San Francisco are keeping 77% of their garbage out of landfills. Their goal is to have zero waste by 2020. If they can do it, we all can. Just remember these four essential R’s: reduce, reuse, recycle, and rot!

Visit www.sfenvironmentkids.org for lots of information about recycling and composting. There is even a teacher’s lounge with activities that can be used in the classroom.

Plastics, Bioplastics, and Recycling

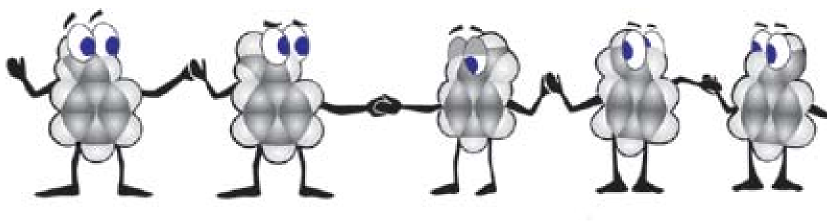
By Ronald P. D'Amelia

Usually a time in history is known by the kinds of materials its people use to manage the world they live in. We had the Stone Age and Iron Age, and now we have the Plastic Age. Plastics make up much of our automobile parts, building materials, packaging materials, bottles, personal items, and many other useful things. Except for our food, air, and water, almost every ordinary thing we come into contact with each day contains some sort of plastic material.

The word *plastic* comes from the Greek *plastikos*, for a material that can be molded or shaped. One of the advantages plastic has over other materials is its durability. A great disadvantage to its durability is that plastic is not environmentally friendly. It tends to remain in landfills for a long, long, time, without decomposing.

Basic Chemistry of Plastics

Probably no group of human-made materials is more important to our modern way of life than plastics. All plastics are made of polymers. *Poly* means *many* and *mer* means *parts* or *segments.* Polymers make up most of our natural and



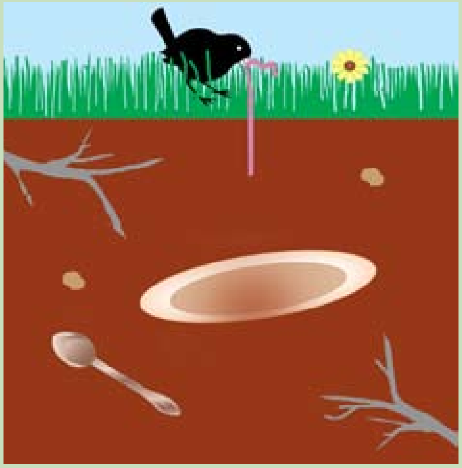
synthetic world. Even we (humans) are made of polymers—natural polymers make up our hair, muscles, organs, and DNA! Examples of natural polymers are cotton, silk, and wool. Examples of synthetic polymers are milk containers (made of polyethylene), nylon ropes (made of nylon polymer), drinking cups (made of polystyrene), and many other plastic materials.

Polymers are made up of repeating units that form a long chain-like structure. The repeating units are called *monomers*, meaning *one*. There are many, many monomers that make up a single polymer molecule. The process of linking the monomers together is called polymerization. Since polymers are very long and straight, like spaghetti, they can bend and twist and get all tangled up. They can even stick to each other! Polymers as plastics are better than metal because they are lightweight, cheap, easy to form in shapes, and hard to break; they last a long time; and some are recyclable.

PLA: The Biodegradable Plastic

By Ronald P. D'Amelia

Polylactic acid (PLA) is used in plastics, and is renewable, and biodegradable. PLA is made from corn starch, which is converted to sugar and then into lactic acid (monomers). The lactic acid monomers are joined together to form polylactic acid, a clear, stiff, and glossy product. Common products that contain PLA are food packaging, disposable tableware, and diapers. They are also used for many medical applications, including sutures for closing wounds and drug delivery devices.



Biodegradable plastics like PLA are good for the environment because they break down or decompose by heat, water, compost material, and carbon dioxide (CO_2). PLAs are not perfect for the environment; however, it is a good start for creating more environmentally friendly plastics. Eventually, chemists will develop biodegradable plastics that will look and function like traditional plastic material without the harmful effects to the environment.

See the *ChemMatters* podcasts Plastics-Go-Green for more exciting information on how scientists are developing more environmentally friendly plastics.

Making Recycled Paper

Did you ever wonder where paper comes from? Paper is usually made from trees. To make paper, wood from trees is ground into very small fibers called wood pulp. The wood pulp is then washed with water and pressed into paper sheets. Every year, people in the United States use more than 750 pounds of paper each! To produce that much paper, a 100-foot-tall tree would have to be cut down for each person. Luckily, much of the paper used in the United States today is recycled. To recycle your own paper, follow the simple steps below.

Materials

- Newspaper
- Blunt-end scissors
- Ruler
- Bowl
- Measuring cup
- Water
- Blender or food processor (optional with adult supervision)
- Disposable plastic fork
- 2 square pieces of nylon screen (1 foot or 30 centimeters on each side)
- Plastic needlework frame (6 inches or 15 centimeters)
- Rolling pin
- Hair dryer (optional)

Procedure

1. Cut a piece of newspaper that is 30 centimeters (12 inches) wide and 40 centimeters (15 inches) long.
2. Rip the paper into small pieces that are about 1 centimeter (½ inch) square, and place the pieces into a bowl.
3. Add a ½ cup of water to the bowl and set it aside for 2 days. (Alternatively, you can add the water and paper to a blender or food processor. An adult must complete all steps involving the blender or food processor! After the lid has been fastened securely onto the appliance, the water mixture should be blended on medium speed for 5 minutes. Skip to Step 5.)
4. Using a plastic fork, mix the paper with the water until the paper disintegrates into pulp.
5. Stretch one piece of the nylon screen into the needlework frame.
6. Using the plastic fork, strain the pulp and drop it onto the nylon screen in the needle work frame. Then spread the pulp evenly across the surface of the screen.
7. Carefully remove the nylon screen from the frame and place it pulp-side up onto a pile of newspaper.
8. Place the second piece of nylon screen over the pulp, so that you make a sandwich with screen on top and bottom and the pulp in the middle.
9. Use the rolling pin to squeeze all of the water out of the pulp by rolling it over the top of the nylon screens.
10. Without removing the screens, move your newly formed paper to a dry spot, and allow it to dry overnight. (Alternatively, you can dry the paper using a hair dryer. An adult must perform this step.)
11. Remove the paper from the nylon screens.
12. Pour the liquids down the drain, recycle any unused paper, and throw everything else in the trash. Thoroughly clean your work area, and wash your hands.

Try this...

Make a second batch of recycled paper adding in a few pieces of colored paper, yarn, or string to the newspaper. You can also add small pieces of leaves or grass to change the texture of the paper.

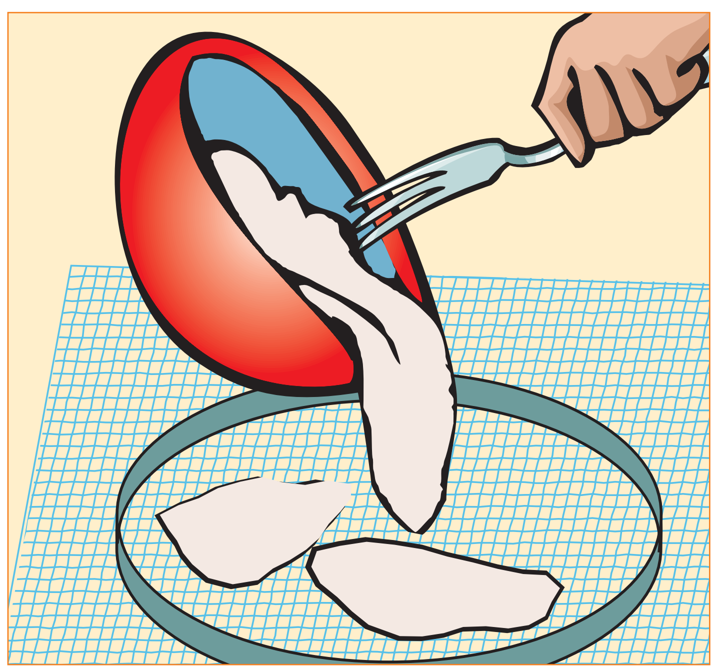
What Did You Observe?

What does your paper look like?

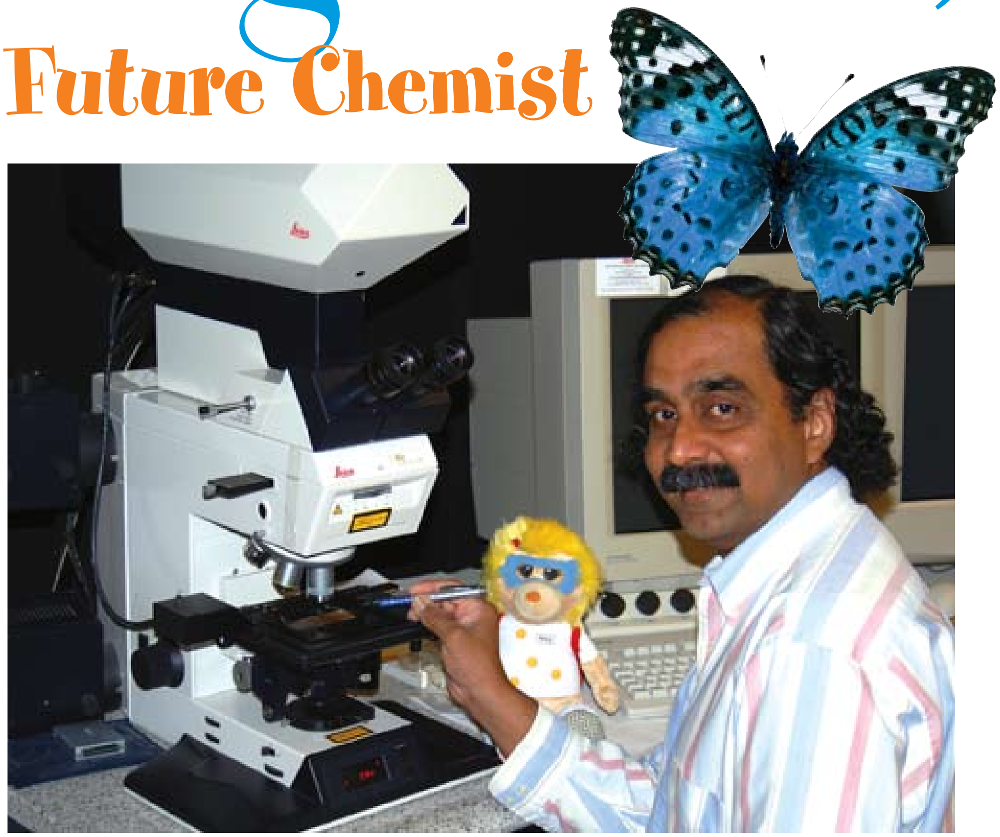
Why do you think it looks like it does?

Where's the chemistry?

Plants use the energy of the sun to make all sorts of chemicals like sugars and complex carbohydrates. One of these complex carbohydrates is called cellulose. Cellulose is tough and indigestible. It is the main ingredient in wood pulp. Plants use cellulose to make their limbs and trunks strong and stiff. Without it, they would not be able to stand. Cellulose can be made into many different products like paper, cardboard, rayon fabric, and insulation. By recycling paper, we cut down on the amount of waste in our landfills, save trees, and conserve energy.



The Adventures of Meg A. Mole, Future Chemist



In autumn of 2011 of the International Year of Chemistry, I decided to learn more about the work of materials chemists. My trip brought me to Atlanta, Georgia, where I met Dr. Mohan Srinivasarao. Dr. Srinivasarao is a materials chemist and professor at the Georgia Institute of Technology.

So, what does Dr. Srinivasarao do in his laboratory? He explained to me that they work on how light interacts with polymeric materials and liquid crystals. They also work on the color of butterfly wing scales. The scales are the parts of the wing that have all of the pretty colors. They also look at beetle exocuticles, which are the part of the outer shell that makes it strong and gives it its color. He says that they "mostly use light microscopes to see and understand how differents chemicals, like in computer screens, behave."

Dr. Srinivasarao really enjoys that he gets to communicate with people about what he knows. He is very proud of being a professor. He really enjoys getting to teach people things and also likes to tell stories about famous scientists. So, what does he think is the best thing about being a scientist? He told me it was definitely "trying to figure things out for yourself, and it is amazing when you actually figure it out!"

So, why did Dr. Srinivasarao go into a career in chemistry? His favorite subjects in school were chemistry and physics. He also told me that since he was 9 years old, he has been very interested in light. He also used to build small airplanes that take off vertically. He was very interested in knowing why some things happened and why other things did not.

So, how does his work with materials impact kids? He explained that laptop computer screens have liquid crystals in them and that he and his group study how liquid crystals work and react in different situations. They also work on polymers. He told me that the shirt I had on and children's clothing are made of polymers too!

To read more about my visit with Dr. Srinivasarao, please visit my web pages at www.acs.org/kids.

Personal Profile

FAVORITE FOOD: Very spicy Indian and Thai food.

FAVORITE HOBBY: Watching and playing tennis as much as possible.

Nano What?

By Robert De Groot

Think small. Think really, really small—smaller than anything you've seen through a magnifying glass or a microscope at school. Think atoms and molecules, and now you're there. You're down at the nanoscale. Working at the nanoscale, scientists are creating new tools, products, and technologies. Nanotechnology will help solve some of the world's biggest challenges.

How small is a nanometer? There are one billion (1,000,000,000) nanometers (nm) in one meter. This is a hard concept to understand. Here are some other ways to think about the size of a nanometer.

- A sheet of notebook paper is about 100,000 nm thick.
- If you are blond, your hair is probably about 15,000 to 50,000 nm in diameter.
- If you have black hair, its diameter is between 50,000 and 180,000 nm.
- A large raindrop is 2,500,000 nm in diameter.
- Fingernails grow 1 nanometer in a second.

Nanoscientists try to discover new things about substances that are roughly 1 to 100 nm in size. Nanotechnology is the way these discoveries are put to work.

Why is the nanoscale so special? Materials can have very different properties at the nanoscale. Some materials are better at conducting electricity or heat, and others are stronger.

For example, nanoscale tubes of carbon (1/100,000 the diameter of a human hair) are incredibly strong. They are already being used to make bicycles, baseball bats, and some car parts. Carbon nanotubes also conduct both heat and electricity better than any metal. They can be used to protect airplanes from lightning strikes and to cool computer circuits.

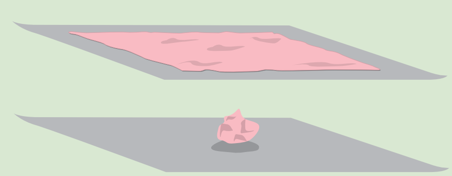
Nanoscale materials are all around us, in smoke from fire, volcanic ash, and even sea spray! Nanoscale gold was used in stained glass and ceramics as far back as the year 1100. It took nearly another 900 years before machines were developed to see, manipulate, and control substances at the nanoscale. Today, many of our nation's most creative scientists and engineers are finding new ways to use nanotechnology to improve our world. There are many possibilities—even you may make an exciting new discovery!

Try this!

Nanoscale materials have far larger surface areas than similar volumes of larger-scale materials. This means that more surface is available for interactions with other materials around them.

To demonstrate the importance of surface area, chew a piece of gum and then divide the piece into two balls. Put one of the balls on a piece of wax paper. Take the other ball of gum and stretch it into as thin of a sheet as possible. The surface, or area visible on the outside, is much greater for the stretched-out gum than the remaining ball of gum. The stretched-out gum is likely to dry out and become brittle faster than the other ball because of more contact at the surface with the air around it.

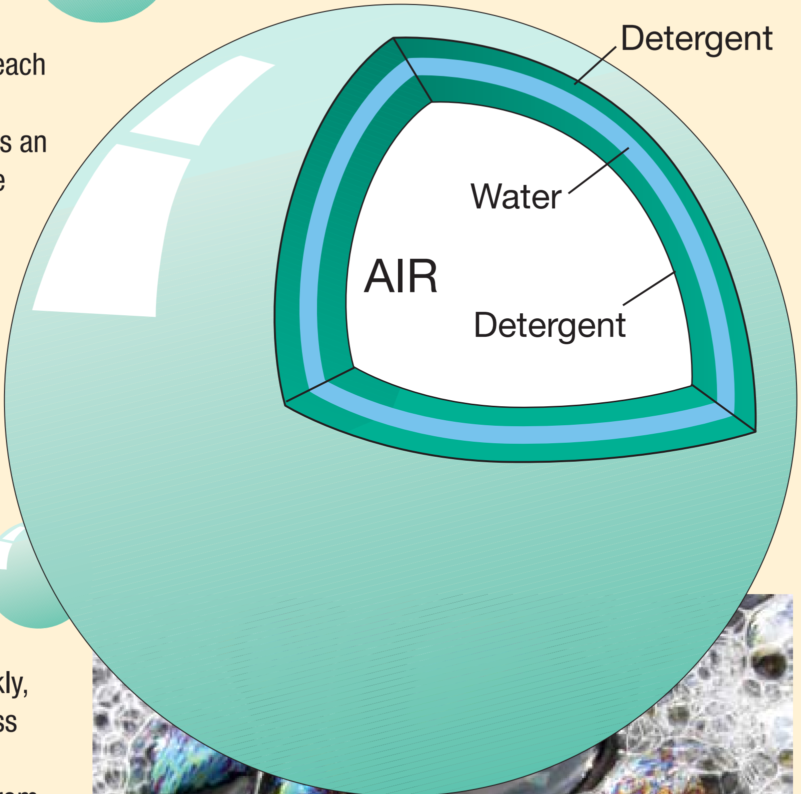
This article and the activity are an adaptation of material found in the publication *Nanotechnology: Big Things from a Tiny World* (www.nano.gov), which was federally funded by the National Nanotechnology Coordination Office (a multi-agency consortium of the National Science Foundation, National Institutes of Health, U.S. Department of Energy, and the U.S. Food and Drug Administration).



Bubble-ology (bə-bəl-ˈä-lə-jē)
The study of bubbles

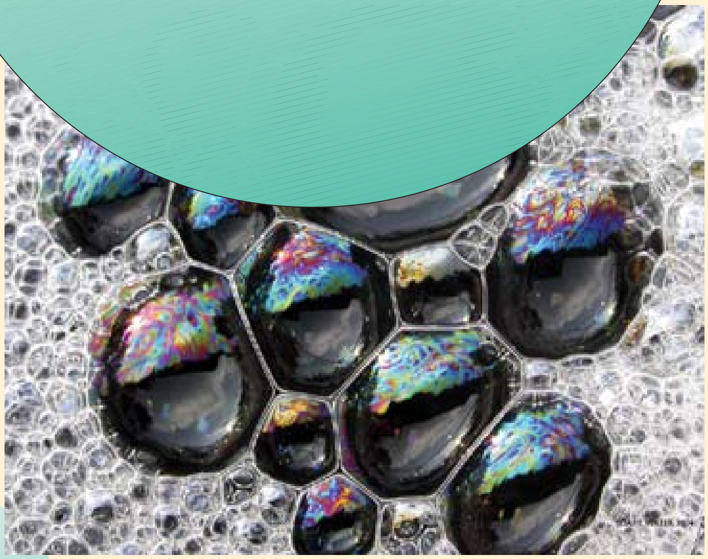
A lot can be learned from a bubble! Bubbles can teach us about life, light, and strength.

The wall of a bubble has three parts. There is an outer wall made of soap or detergent, a center wall made of water, and an inner wall that is also made of soap or detergent. The inside of the bubble is filled with air. This structure of the bubble's wall is very similar to that of membranes found in living creatures like us.



Did you ever wonder how the food you eat gets from inside your stomach to inside your muscles? To get to your muscles, the food must first be digested. Then it must pass through a set of membranes into your blood. The nutrients then circulate through your arteries to your muscles, where they pass through another set of membranes into your muscles.

The next time that you blow bubbles, look for a cluster of them, and watch closely. If they don't pop too quickly, you will see that the air from the smaller bubbles will pass through the bubble wall into a larger bubble on the other side. This is very similar to the way that oxygen passes from your lungs through a membrane and into your blood stream. The larger bubbles are sturdier, because their walls are not curved as much as the walls of smaller bubbles.

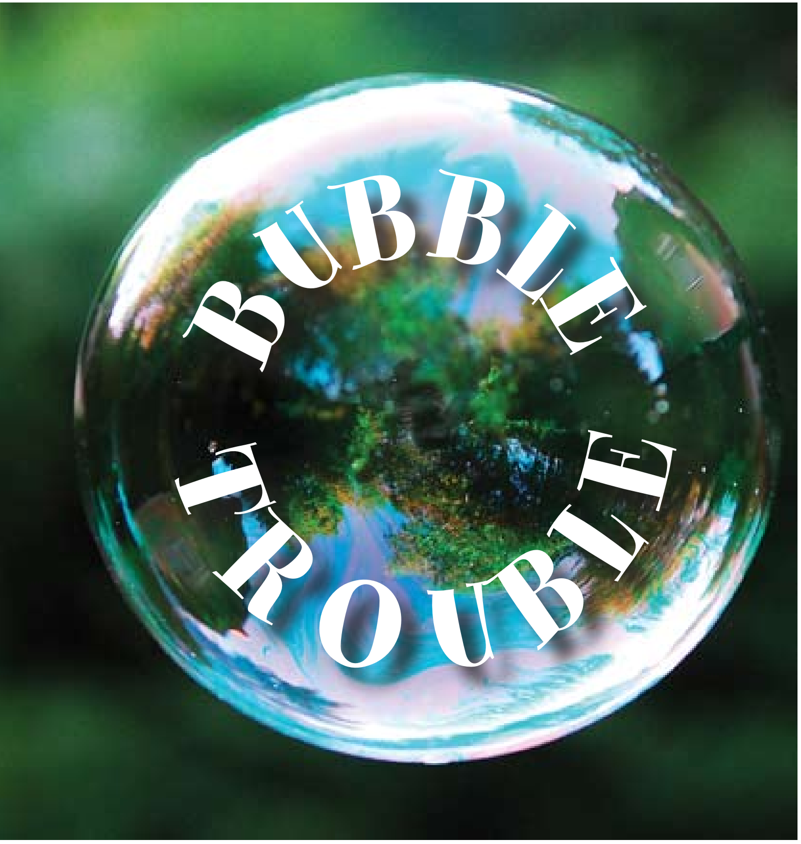


Bubbles can also teach us about light. The light from the sun is made up of many different colors. Mixed together, they look white. However, it is possible to separate the different colors of light from each other with a prism. Small drops of water or ice crystals can work like a prism. You have seen this for yourself, if you have ever seen a rainbow.

The wall of a bubble can work the same way. That is why bubbles are iridescent. When light hits a bubble, it may look blue, or it may look red. The colors seem to dance around on the surface. The colors that we see depend upon the thickness of the wall of the bubble and how much it is bent. As water evaporates from the bubble, the bubble's wall becomes thinner, and the colors change. Also, as the wind blows a bubble around, its wall bends, changing the color.

Bubbles can also teach us how to make things stronger. Bubbles are usually very fragile. They can easily pop. But if we add sugar to the bubble solution, the bubbles are much sturdier. They will last for two or three times as long. This is because the sugar strengthens the wall of the bubble. The sugar dissolves in the water layer of the bubble's wall and takes the place of some of the water. Since the sugar does not evaporate as quickly as the water, the bubbles last longer. In addition, the sugar molecules are very large and stiff compared to water molecules. Like a large board nailed to the wall of a house, the sugar molecules brace the wall of the bubble to make it stronger.

Bubbles are pretty incredible, but who knew? The observations that people have made about them have led to many questions and interesting answers that help explain the world around us.



An important quality of soap is how well it suds or bubbles and how long the suds last. Suds help spread out the soap so it can work to clean greasy dirt. Sometimes other chemicals change a material's properties. In this activity, you will measure the amount of bubbles that you can make with a detergent and see if adding something to it affects its sudsiness.

Materials

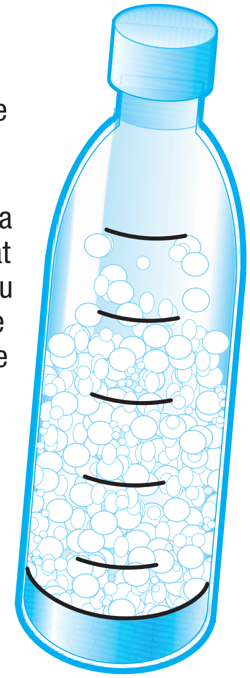
- 3 disposable, clear, plastic bottles with caps (20-ounce soda bottles work well; the bottles should be the same size and shape)
- Ruler
- Permanent marker
- Distilled water
- Food coloring (optional)
- Measuring spoons
- Liquid dishwashing detergent
- Epsom salt
- Clock or timer with second hand

SUGGESTIONS:
A few drops of food coloring can be added to the water to make it easier to see. You can also use a magnifying glass to see things more clearly, and you can use a funnel to help you pour the water into the bottles.

SAFETY!

Be sure to follow Milli's Safety Tips and do this activity with an adult! Do not drink any of the water samples in this activity.

Procedure



1. Use the ruler to measure 2 centimeters up from the bottom of one of the bottles, and make a mark with the permanent marker.
2. Using the mark as your guide, draw a line all the way around the bottle that is 2 centimeters from the bottom. You may need to make a few more guide marks with the ruler to make the line straight. This line will be your water line.
3. Using the ruler again, measure up from the water line that you just made, and mark every 1 centimeter until you get to the top of the bottle. Number the marks as you make them starting with 1 for the first mark above the water line.
4. Repeat Steps 1–3 for the other two bottles.
5. Using the marker, label the side of one of the bottles *Water,* the side of another one *Water + Detergent*, and the side of the last one *Water + Detergent + Salt*.
6. Carefully add water to each of the bottles, stopping at the water line. If you add too much water, just pour some out and try again.
7. Add one-quarter (¼) teaspoon of dishwashing detergent to the bottles labeled *Water + Detergent* and *Water + Detergent + Salt.*
8. Add one-quarter (¼) teaspoon of Epsom salt to the bottle labeled *Water + Detergent + Salt.*
9. Tightly cap each of the bottles, and shake each one for 5 seconds.
10. Write down how many centimeters (or inches) of bubbles you observed in each of the bottles in the "What Did You Observe?" table below.

What Did You Observe?

Bottle contents	Height of suds (centimeters)
Water	
Water + Detergent	
Water + Detergent + Epsom salt	

11. Wash your hands and thoroughly clean the work area. Pour the liquids down the drain, and recycle the bottles.

Analyze your results

Does adding Epsom salt affect the detergent's ability to make suds? How?

Try this...

What if you add a different type of salt? Would the result be similar? Try the experiment again using table salt in place of the Epsom salt to see what happens! Make a claim about the effect a salt has on a detergent's ability to make suds.

Where's the chemistry?

Epsom salt is a chemical called magnesium sulfate. When magnesium sulfate is added to soapy water, the magnesium combines with the soap. This combination is actually a new substance that doesn't dissolve well in water. The common name for this substance is soap scum. Since it can't dissolve in water, the soap in the soap scum can't get back into the water to make bubbles.

When people complain about "hard" water reducing the bubbling and sudsiness of their soap, it is often magnesium and calcium in the water that are causing the problem. Detergent works better than soap in hard water because magnesium and calcium do not bond to detergent in the same way as they do with soap.

The Adventures of Meg A. Mole, Future Chemist

I enjoyed my trip to Atlanta, Georgia, so much, I decided to stay another day and meet another fantastic materials chemist! On day two of my visit to the Georgia Institute of Technology, I was introduced to Dr. Elsa Reichmanis.

I met Dr. Reichmanis many years ago at an ACS National Meeting. It was in the fall of 2003 and she was President of the American Chemical Society! I was so glad that I finally got a chance to learn all about her career as a chemist. Dr. Reichmanis says that she "designs and develops new plastics that can be used for computers and other electronic technologies." She does most of her work in a laboratory. She uses chemicals in her work, so I'm glad I had my goggles and lab coat on; she also wore gloves. It was a lot of fun to watch her work with plastics!

Dr. Reichmanis really enjoys discovering new things and being able to make something new that people can find useful. Her favorite thing about her job is that she gets to interact with students and help them grow and develop into professionals. It's amazing how anyone who uses a computer can come into contact with her work! She explained that work she has done has helped in the manufacture of electronic devices, so a child could come into an aspect of her work whenever they use a computer.

So, what made her interested in a career in chemistry? Dr. Reichmanis told me that her favorite subjects in school were math and science. She said she was always interested in chemistry because she had a great high school teacher.

To read more about my visit with Dr. Reichmanis, please visit my web pages at www.acs.org/kids.

Personal Profile

FAVORITE FOOD: Chocolate.

ABOUT YOUR FAMILY: I'm married and have four children.

Celebrating Chemistry

is a publication of the ACS Department of Volunteer Support in conjunction with the Committee on Community Activities. The Department Volunteer Support is part of the ACS Division of Membership and Scientific Advancement. Four editions of *Celebrating Chemistry* will be available for the 2011 celebration of the International Year of Chemistry (www.acs.org/outreach).

International Year of CHEMISTRY 2011

What is the American Chemical Society?

The American Chemical Society (ACS) is the largest scientific organization in the the world. ACS members are mostly chemists, chemical engineers, and other professionals who work in chemistry or chemistry-related jobs. The ACS has more than 163,000 members. Most ACS members live in the United States, but others live in different countries around the world. Members of the ACS share ideas with each other and learn about important discoveries in chemistry during meetings that the ACS holds around the United States several times a year, through the use of the ACS website, and through the 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 Day, held annually on April 22. Another of these programs is National Chemistry Week, held annually the fourth week of October. 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!

Words to Know

Biodegradable – capable of being broken down by living things such as microorganisms.

Compost – a mixture of decayed organic matter used for fertilizing land.

Durability – the ability to exist for a long time while maintaining the original properties.

Landfill – a large area where trash is disposed of by burying it under layers of earth.

Mixture – a portion of matter consisting of two or more components that together are regarded as a new component.

Plastic – a special kind of polymer material that can be made into various sizes and shapes by different processes such as heating, chemical condensation, and casting.

Polymer – a natural or synthetic chemical compound or mixture of compounds formed by polymerization and consisting essentially of repeating structural units.

Properties – qualities belonging to a material.

Recycle – to process (as paper, glass, or cans) in order to regain material for future use.

Synthetic – human-made as opposed to being made by a naturally occurring process.

PRODUCTION TEAM

Alvin Collins, Editor
Kelley Carpenter, Copyeditor
Neal Clodfelter, Clodfelter Design, Layout and Design
Jim Starr, Illustrations
Chris Morse, Puzzle Design

TECHNICAL AND SAFETY REVIEW TEAM

Michael Tinnesand, Scientific Adviser
Ingrid Montes, Chair, International Year of Chemistry 2011 Theme Team
Lynn Hogue, Chair, Committee on Community Activities

INTERNATIONAL YEAR OF CHEMISTRY — MATERIALS THEME TEAM

Lynn Hogue, Chair
Ronald D'Amelia
Robert DeGroot

DIVISION OF MEMBERSHIP AND SCIENTIFIC ADVANCEMENT

Denise Creech, Director
John Katz, Director, Member Communities
LaTrease Garrison, Assistant Director, Member Communities

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