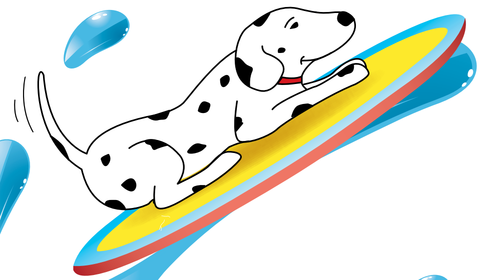
Celebrating Chemistry

"Streaming Chemistry"

CHEMISTS CELEBRATE EARTH DAY • APRIL 22

AMERICAN CHEMICAL SOCIETY



Water is a very important part of our environment. It is found covering nearly three-quarters of the Earth's surface. It is fun to splash in and it is also needed for life. In fact, we can survive much longer without food than without water to drink. Every living thing needs water. Without it, plants and trees will not grow; fish, clams, dolphins and other aquatic life will have nowhere to live; and animals like otters who find their food in the water will have nothing to eat.

And did you know that when we drink water, there are some nutrients and minerals dissolved in the water? Fluoride is commonly added to drinking water in the United States to help prevent cavities from forming in our teeth. Plants "drink" water as well by absorbing it through their roots. Minerals and other nutrients enter the plant with the water. When we eat plants, some of these same nutrients give us energy to run, play and think.

The three forms of water are solid, liquid and gas. Did you guess right? Solid water is frozen and known as ice. When water is boiled, or the sun heats the surface of a body of water, its molecules can absorb enough energy to evaporate into the air—that is, to become a gas called water vapor.

Up in Earth's atmosphere, water vapor cools and collects into clouds. When enough clusters of cloud particles stick together, they tumble back down to Earth as rain, snow, hail, or sleet. This process of water evaporating, condensing and falling to Earth is the water cycle.

Water on the Earth can flow above the ground in a stream or river. It can run underground, too. And water can also be frozen into large glaciers. Whichever form it is in, it can be a powerful force, changing the shape of the land as it erodes mountains and carves valleys.

We cannot survive on Earth without water—so we must all do our part to take care of it. People use the fresh water of lakes and rivers for drinking, washing, cooking and growing food.

Did you know that most of the world's population does not have direct access to clean water? We are very lucky to live in a country where clean water is "streaming" from our faucets. It is up to us to be responsible users of the water available on Earth.

In this edition of *Celebrating Chemistry*, you will learn how you can help the environment by conserving the water that you use at home and reminding others to do the same. Many American Chemical Society local sections will be organizing "Adopt-A-Stream" and other events around the country.

Visit **www.acs.org/earthday** to find out what they have planned.

Milli's Safety Tips Safety First!

ALWAYS

- Perform the activities with adult supervision.
- Read and follow all directions for the activity.
- Read all warning labels on all materials being used.
- Wear eye protection, specifically splash and impact-resistant 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, nose, and eyes!

NEVER experiment on your own!

For more detailed information on safety go to www.acs.org/education and click on "Safety Guidelines".

Testing Water's Skin

Water is a very important chemical! It covers about three-fourths of the Earth's surface and makes up about two-thirds of your body's weight. Every living thing needs water to survive. One of the special things about water is that it tends to stick to itself. This property is called cohesion. When water sticks to something else, it is called adhesion. Because water sticks so strongly to itself, it tends to bead up on slick surfaces like a car's hood or windshield. Water also forms a "skin" on its outer surface. This "skin" is strong enough to support a water bug, and it is flexible enough to bend around the edge of a water drop.

Materials

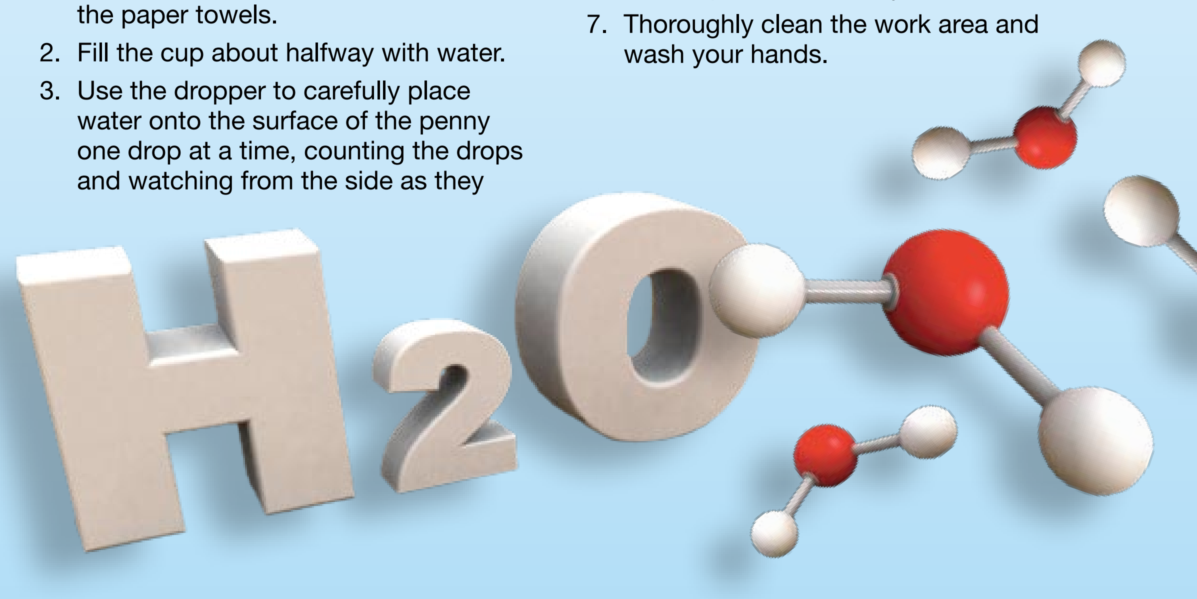
- **2 Paper towels**
- **Penny**
- **Small disposable paper cup (3 oz.)**
- **Water**
- **Dropper**
- **Liquid dish detergent**
- **Food coloring (optional)**

ADAPTATION *To see the water's surface more clearly, you can add a drop of food coloring to the water. You may also want to use a magnifying glass and a flashlight.*

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 used in this activity.*

Procedure

1. Place a clean, dry penny flat on one of the paper towels.
2. Fill the cup about halfway with water.
3. Use the dropper to carefully place water onto the surface of the penny one drop at a time, counting the drops and watching from the side as they are added. Add the drops close to the center of the penny and hold the tip of the dropper just above the penny. How many drops of water fit onto the penny before the water runs over the edge and onto the paper towel? Write down your answer and draw a picture of what you saw.
4. Dry the penny completely with the other paper towel and then place it onto a dry spot on your first paper towel.
5. Add five drops of liquid dish detergent to the cup containing the water and mix it slowly with the dropper.
6. Try dropping soapy water onto the top surface of the penny as before. How many drops can you add before the water runs over the edge onto the paper towel? Write down your answer and draw a picture of what you saw.
7. Thoroughly clean the work area and wash your hands.

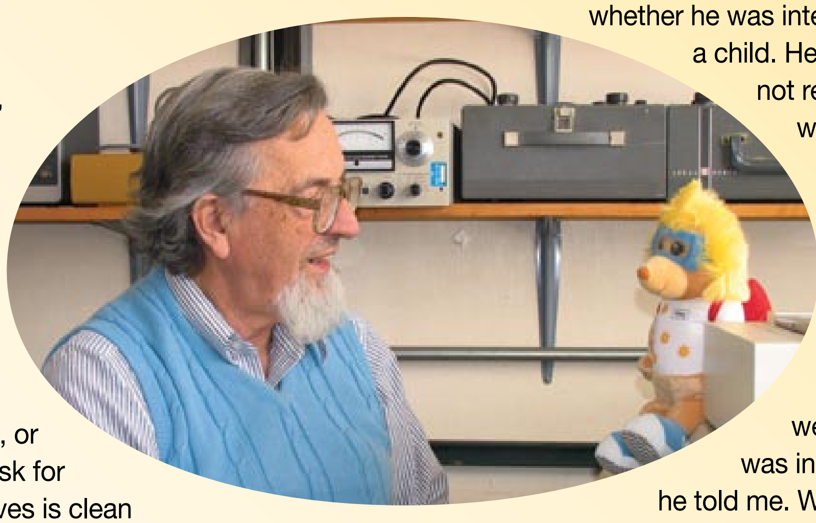


The Adventures of Meg A. Mole Future Chemist

Meg interviews Dr. William "Will" B. White

PROFILE:

Dr. Will White's job is all about water—water purity, drinking water, and things that contaminate, or pollute water! He works at the Materials Research Institute at Pennsylvania State University. One program with which he works focuses on water in caves! Water in caves can come to the surface as big springs, which are often used as sources for drinking water. Dr. White puts on heavy boots, coveralls, gloves and a hard hat to visit a cave. There he collects samples of water and analyzes it, or tests it, in his laboratory. The water in caves is at risk for contamination, so making sure the water in the caves is clean and safe is a very important job!



CHAT:

When I first went to visit Dr. White I could not wait to see the caves! I was so excited to go inside one... I'd never done that before. I'm glad they had Meg A. Mole-sized boots! I told Dr. White I've always loved chemistry and asked him whether he was interested in it as a child. He said he could not remember a time when he wasn't interested in science. "I was collecting rocks and keeping notes on the weather when I was in grade school", he told me. When I asked him what made him decide to go into science, he replied, "I never really thought of doing anything else." He sounds just like me!

MEG INVESTIGATES:

One question I really wanted to ask was, "Where are these caves you study?" Dr. White gets to collect water samples in Appalachian Mountain caves of Pennsylvania all the way south to Alabama. He told me there are many caves people can visit where they can see water dripping or a pool of underground water, or even rock formations called stalactites and stalagmites—and those are formed by dripping water, too! He studies all these things. One of the neat things Dr. White points out is that "water science is hidden in the background. But a child drinking a glass of fresh, clean water is benefiting from the research of water scientists in many countries over many years."

What Did You Observe?

Number of Drops of **Water** on a Penny	Number of Drops of **Soapy Water** on a Penny	Draw a Picture of Water on a Penny	Draw a Picture of Soapy Water on a Penny

To read more about my visit with Dr. White visit www.acs.org/kids

PERSONAL PROFILE: DR. WILLIAM B. WHITE

What is your favorite food?
Ice cream—Penn State's Dairy Science Department makes the best!

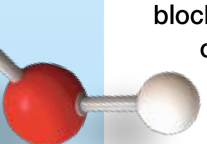
What are your favorite colors?
Blue sky and green grass!

When is your birthday?
January 5th.

Can you tell me a little bit about your family?
My wife is a civil engineer. We have a daughter, two older grandsons, and a very young granddaughter. One grandson studies science; the other is a musician.

Where's the Chemistry?

Because water sticks to itself so well, it will easily form very large drops. In a drop, all the water molecules are close together, and they can touch several other molecules at the same time. Each of the water molecules is surrounded on the top, bottom, left, and right by other water molecules. When detergent is added to the water, the drop falls apart. The detergent molecules stick to the water molecules, and they block the water molecules from sticking to each other. As more detergent is added to the water, the water molecules have a harder time sticking to one another. Since the water molecules cannot stick to each other as well, they cannot form large drops, so soapy water forms small drops, and very soapy water will not form drops at all.



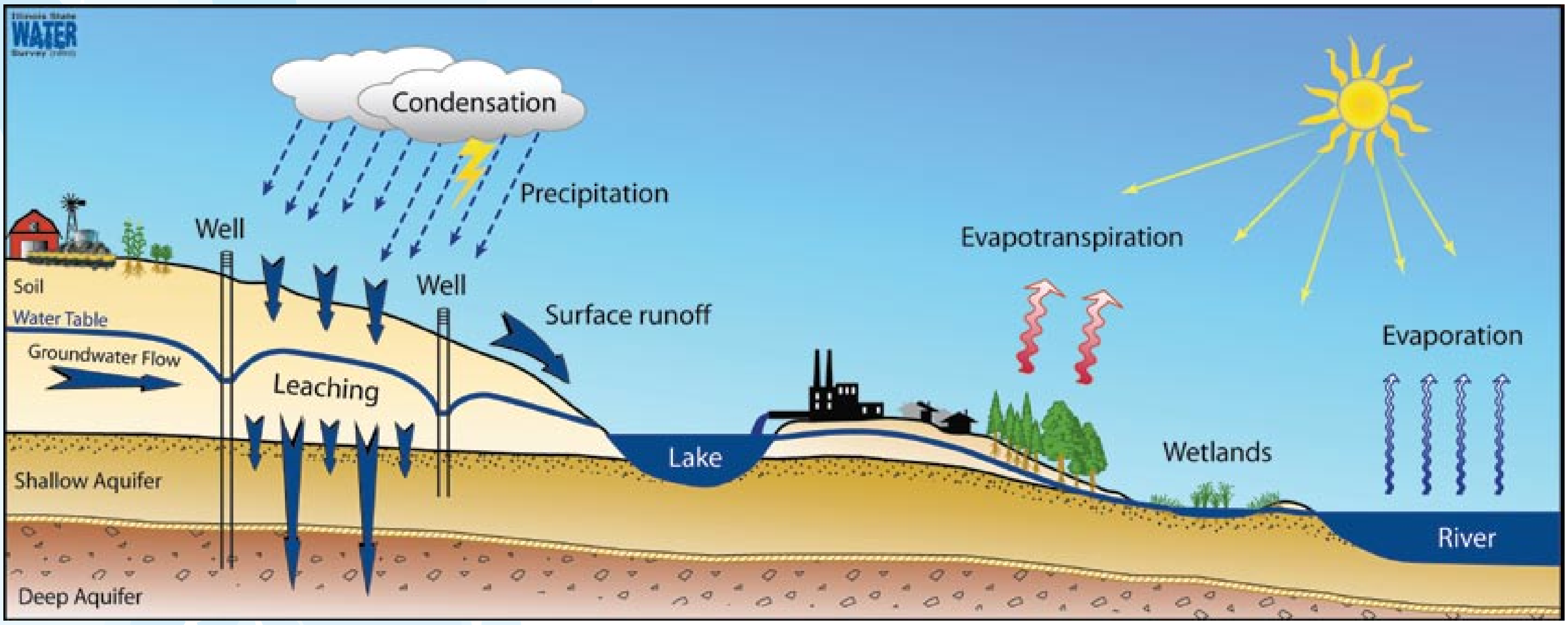


Illustration courtesy of Illinois State Water Survey, www.sws.uiuc.edu.

The Water Cycle

The world's water moves between sea, air and land. As it moves, it often changes from one state—solid, liquid, or gas—to another.

Evaporation: **water from the oceans and the ground heats up and rises into the air as vapor.**

Transpiration: **the evaporation of water from plants (also known as evapotranspiration).**

Winds **carry the warm, damp air up over higher ground.**

Condensation: **the water vapor cools and forms clouds.**

Raindrops **form inside the clouds.**

Precipitation: **the water falls back down as rain, sleet, hail, or snow.**

Percolation: **the movement of water through soil and rocks as ground water.**

Rivers **then carry the water back into the ocean and the cycle begins again.**

Leaching: **process by which soluble materials in the soil are washed into a lower layer of soil or are dissolved and carried away by water.**

Make a Water Cycle Wristband

SAFETY! *Be sure to follow Milli's Safety Tips and do this activity with an adult!*

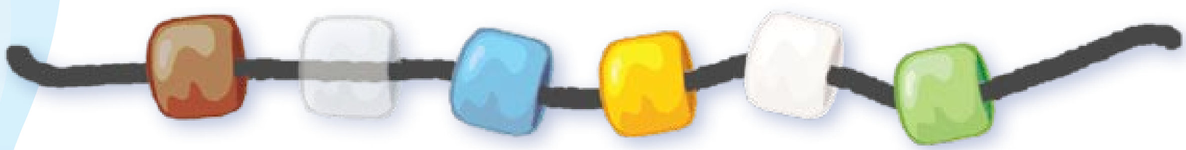
All of the water on Earth is part of a never-ending cycle called the water cycle. Water evaporates (becomes gas) from the surface of the Earth, condenses in the atmosphere as clouds, falls to Earth as precipitation and then evaporates again, starting the whole process over.

Materials

- **String, yarn, cord, or ribbon**
- **6 Plastic beads, different colors, listed below**

Procedure

1. Thread the colored beads on the string in an order you choose.
2. Place the string around your wrist and tie it (an adult may be able to help you make a slip knot so the bracelet may be easily taken on and off).
3. Rotate the beads around your wrist and explain their meaning to your friends and family.
4. Thoroughly clean the work area and wash your hands.



COLOR	REPRESENTS	MEANING
yellow	solar energy	energy from the sun
clear (no color)	evaporation	the process through which the sun heats up liquid water, which changes into water vapor (a gas) that rises into the atmosphere
green	transpiration	evaporation of water from plants
white	condensation	tiny droplets of water formed when water vapor in the air cools (we see condensed water vapor as clouds)
blue	precipitation	water that falls from the clouds as snow, rain, sleet, or hail
brown	percolation	movement of groundwater below Earth's surface

Streaming Chemistry

WORD SEARCH

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

ADHESION
ALUM
CHEMISTRY
COHESION
CONDENSATION
EVAPORATION
HYDROGEN
OXYGEN
PRECIPITATION
PURIFICATION
SEDIMENTATION
STREAM
TRANSPIRATION
TREATMENT
WATER

Answers can be found on page 8.

MORE WORDS TO KNOW

Water is called the "universal solvent" because it dissolves more substances than any other liquid. This means that wherever water goes, either through the ground or through our bodies, it carries along valuable chemicals, minerals, and nutrients. Like everything else in the world, water is a chemical. Its formula is H_2O, which means it is made up of two hydrogen atoms and one oxygen atom.

Water cycle describes the existence and movement of water on, in, and above the Earth.

Groundwater water that seeps into the ground and becomes a source of drinking water.

Water vapor water in the form of a gas; water in this form condenses to form clouds.

Surface water water found on the surface of the Earth, including rivers, streams, lakes, ponds and oceans.

Watershed the land area that drains water to a particular stream, river, or lake. For example, the part of a mountain range whose streams drain into a river below would be that river's watershed.

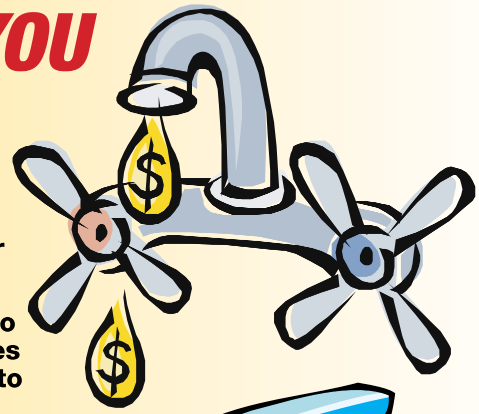
Hydrologist scientist who studies the movement, distribution, and quality of water throughout the Earth, working within the fields of either earth or environmental science, physical geography, or civil and environmental engineering.

Water recycling the reuse of treated wastewater for purposes other than drinking, such as irrigation and manufacturing.

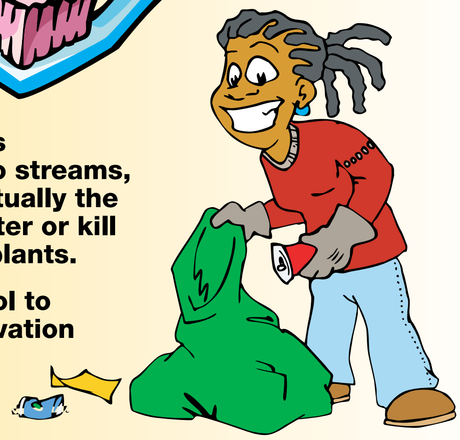
Freshwater the water from rain, hail, and snow that flows in streams and rivers and is not salty.

Water table the highest point at which groundwater is found in any terrain.

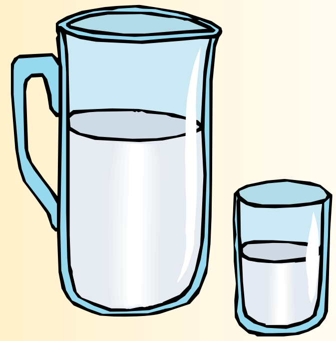
THINGS *YOU* CAN DO:



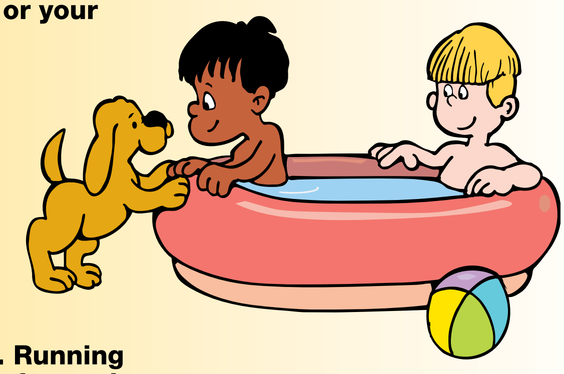
- ☐ **Turn the water off while brushing your teeth.**
- ☐ **Limit your shower to less than 10 minutes or your bath water to less than 6 inches (15 cm) deep.**



- ☐ **Never litter or dump anything, such as paint, pesticides, or motor oil, into storm drains or sewers. This pollution can flow into streams, rivers, bays and eventually the ocean and pollute water or kill aquatic animals and plants.**
- ☐ **Encourage your school to adopt a water conservation program.**
- ☐ **Keep a container of drinking water in the refrigerator instead of letting the faucet run until the water cools down. Running the faucet wastes 3 to 7 gallons (11 to 26 liters) of water per minute.**



- ☐ **Recycle your wading pool water by using it to water your garden.**
- ☐ **Collect rainwater to water indoor plants or your garden.**
- ☐ **Organize a cleanup day at a river or beach in your area.**



- ☐ **Don't use the sprinklers just to cool off or for play. Running through water from a hose or sprinkler is fun, but wastes gallons of water.**
- ☐ **Be conscious of the clothes you put in the laundry. Are they actually dirty and do they need washing?**

- ☐ **Tell your friends and neighbors and ask your parents to help out. Set a good example and see how many ways you can think of to help planet Earth.**

Clean Water: Streaming into Your Life with the Help of Chemistry

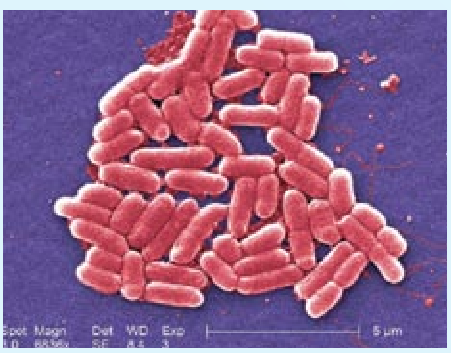
Every day all the clean water you need comes streaming through the faucets of your home, on demand. You can rely on water to be a refreshing drink on a hot summer day or a warm bath on a wintry night; it can be added to your backyard pool for swimming, or your parents can boil it to cook your favorite pasta. Clean water from the tap is so useful and reliable that we forget to be amazed that it's always there for us, fresh and abundant.

The water that arrives in your bathtub or shower may have started out in a flowing river, in a quiet lake, or deep under the ground, filling cracks in rocks and the tiny spaces between sand grains. Whether your water comes from above or below Earth's surface, every day water is pumped to water treatment plants to be cleaned and changed in ways that are better for our health before being piped to your home. Chemistry plays a starring role in the cleanup.

Dr. Harriette Chick figured out how best to use chlorine to destroy germs in water.

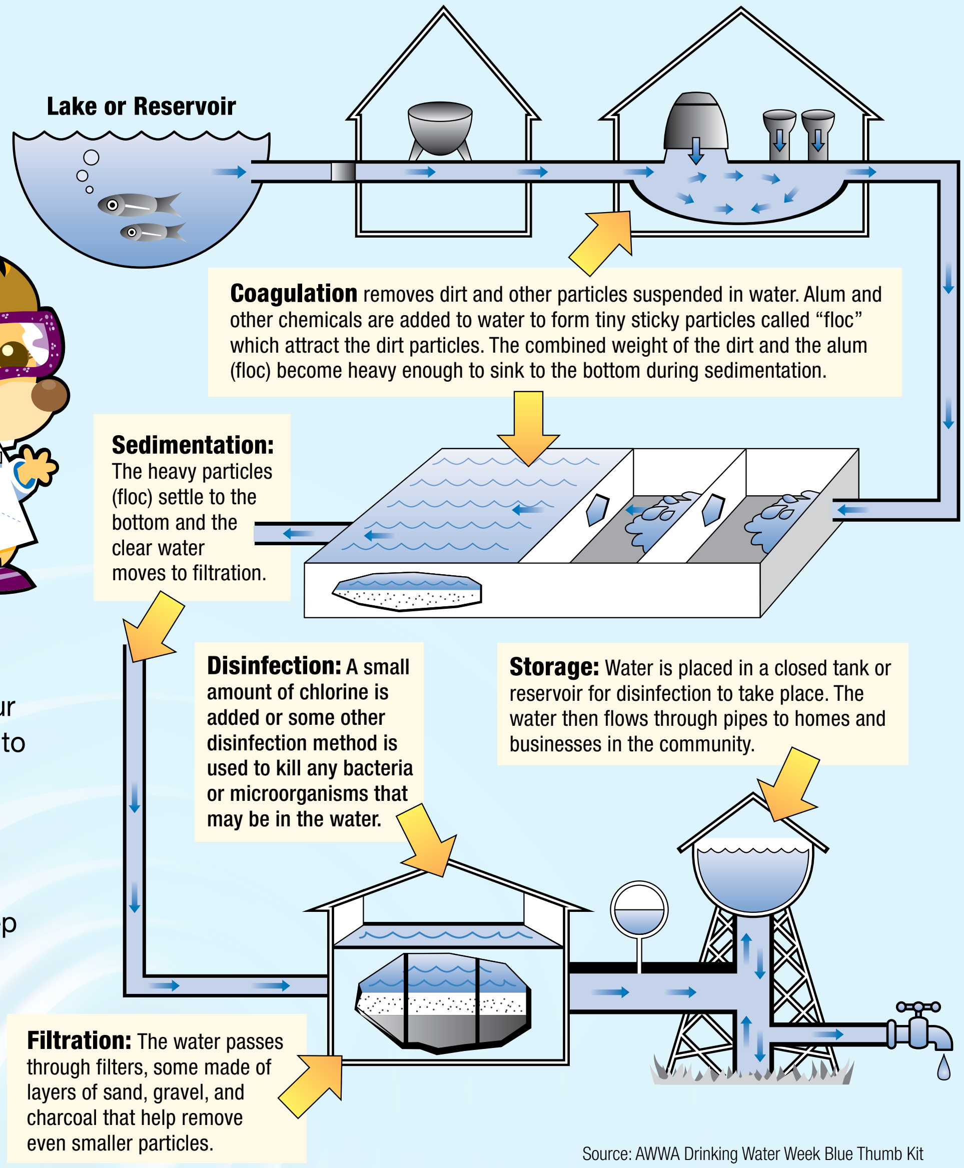
"Cleaning" water

The first step in water treatment is removing dirt and other particles from water. A chemical known as alum may be added to a tank of muddy river water that has lots of small solid particles in it. Alum (aluminum sulfate) makes particles stick together to form clumps. This is called *coagulation* (see the diagram). As the clumps become heavy they sink to the bottom of the water tank, leaving clear water above (the *sedimentation* step in the diagram). Water also may be passed through sand, which acts like a screen, holding back dirt and letting clear water stream through (the *filtration* step in the diagram).



An example of E. coli bacteria that can be destroyed by chlorine disinfection. Some strains of E. coli are harmful to humans.

Photo credit: Janice Haney Carr
CDC Public Health Image Library
http://phil.cdc.gov/Phil/details.asp



Source: AWWA Drinking Water Week Blue Thumb Kit

Solving the microscopic problems

Just because water looks clean doesn't mean it is safe to drink. Once water is cleared of dirt, it's time to get rid of the problems so small that we can't see them without the help of a microscope—the germs that can make us sick. Untreated water can cause life-threatening diseases in people and animals alike. About 100 years ago, scientists found that by adding small amounts of the chemical chlorine to water they could destroy most germs. The process of destroying germs is called *disinfection*.

In 1908, British scientist Dr. Harriette Chick found a way to calculate how long to keep chlorine in contact with water to make it as germ-free as possible. That same year, Jersey City, New Jersey became the first city in the United States to disinfect water using chlorine. The results were remarkable—people stopped getting sick from drinking water, and soon cities around the country were disinfecting their water with chlorine.

Most experts agree that providing safe water is one of the most important ways to keep people healthy. It works so well that most of us take our clean water for granted. So, the next time you go to the faucet to fill your sports bottle, think about the path taken by the clean water streaming into the bottle… and the essential role played by chemistry in getting it there.

Avogadro's Bubbly Adventure

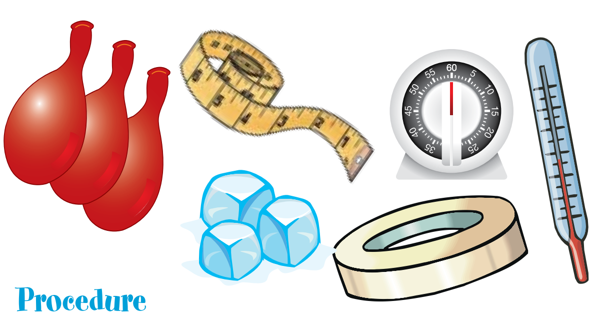
Small amounts of gases are soluble, or dissolve, in water. Two of these gases are oxygen and carbon dioxide. For example, carbon dioxide gas is what gives soft drinks their "fizz". And fish use oxygen dissolved in water for their body chemistry, much like humans do. When there is not enough oxygen dissolved in the water, fish can "suffocate".

In this activity you will study the solubility of gas in water at different temperatures to see whether temperature changes this property.

Materials

- **3 small (20 oz. or less) unopened plastic bottles of carbonated water (if a soft drink will be used, sugarless and colorless will make less mess)**
- **3 medium-sized balloons**
- **3 containers to hold water, large enough for the plastic bottle to be mostly surrounded by water**
- **Masking tape**
- **Marking pen**
- **Thermometer with a scale from 0°C (32°F) to at least 50°C (122°F)**
- **Ice cubes**
- **Water at room temperature**
- **Hot tap water**
- **Clock or timer**
- **Flexible tape measure (metric)**
- ***Optional:* graph paper**

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! Be very careful with the hot water in this experiment, and be sure to wear your safety goggles.*



Procedure

1. Stretch each of the 3 balloons at least 10 times each. Your adult partner can also inflate each balloon the same amount several times.
2. Place one balloon over the cap of each bottle. Use your fingers to stretch the neck of the balloon, and be sure that the lip of the balloon is past the bottom of the cap.
3. Tape all the way around the bottom edge of the balloon on the bottle to make a tight seal.
4. Label the three containers with tape and the marking pen as follows: "ice water", "room temperature water", and "hot water".
5. Add one bottle with balloon to each labeled container.
6. Fill the "ice water", "room temperature water", and "hot water" containers with water of the labeled temperature. Make sure the bottle is submerged at least three-fourths of the way. The hot water should be at least 40°C (104°F). *Do not use boiling water and use caution when handling hot water.*
7. Let the bottles sit in the water for 5 minutes. Gently swirl each bottle in its water bath several times during this period. This mixing ensures an equal temperature of liquid in the bottle.
8. At the end of the 5 minutes, measure and record the temperature of each water bath in the "What Did You Observe?" section.
9. For each bottle, carefully grasp the cap through the balloon and unscrew it just until the cap seal snaps. This action will release the gas while keeping the balloon tightly taped.
10. Grasp one bottle around the neck, invert 4 times, and return it to its water bath. Repeat with the other two bottles.
11. Record your observations about what happens to each balloon in the "What Did You Observe?" section.
12. Use the tape measure to determine the circumference (the distance around) of the balloon at its widest point. Record the measurement in centimeters in the "What Did You Observe?" section.
13. Carry the bottle/balloon systems to a sink and carefully remove the balloons from the bottles. Pour the contents of the balloons and bottles into the sink. Pour out the water baths as well. Thoroughly clean the work area and wash your hands.

What Did You Observe?

1. On another paper, draw a picture of each balloon after you cracked the cap seal and inverted the bottle 4 times.
2. What happened to the amount of gas found in the balloon as the temperature increased?
3. What conclusion can you draw from this observation?

Optional: You can graph this data, placing temperature on the X-axis and circumference on the Y-axis. Work with your adult partner to figure out the proper range and increments for each axis, and then plot the data points.

	Water Temperature	Balloon Circumference
Ice water		
Room temperature		
Warm water		

Where's the Chemistry?

Soft drink bottles contain carbon dioxide under pressure. When you open the cap, carbon dioxide gas enters the balloon. The amount that remains in the soft drink depends on the temperature of the water in the soft drink—the amount of gas that is in the balloon shows how much gas has left the soft drink. This means that the more gas that is in the balloon, the less the gas found in the liquid at that temperature.

In our environment, dissolved gases are very important to animals that live in water. As water warms, such as on a hot day or in an area where hot water is released into a river or lake, the amount of oxygen that stays in water decreases—it is released due to the higher temperatures. Researchers who study global warming are concerned about this effect, too.

And closer to home, this is why you often see thermometers and bubbling aerators in home fish tanks—to monitor the temperature and make sure the water contains enough oxygen for the fish to stay healthy. Look at warm tap water when you pour it into a clear glass. You will be able to observe small bubbles as the dissolved gases leave the water.

Wondering About Water

What if water did not have all of its special properties? In what ways would the world be different? Think about how strange the world would be if water were different. Write a poem or a story about a world where water doesn't work like we expect.

Think about these things:

What if water adhered strongly to many substances?

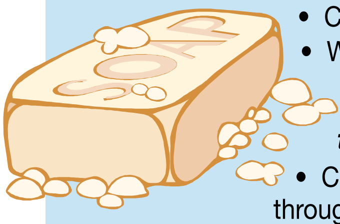
- How well would windshield wipers work?
- How easily could you dry off after a swim?
- What would happen when it rained?

What if water was not very cohesive, and did not stick to itself easily?

- Could you pour a glass of water?
- How big would puddles be?
- Could plants survive?

What if water did not dissolve things?

- Could you make a glass of sweetened tea?
- Could you wash with soap?
- Would ocean water be salty?



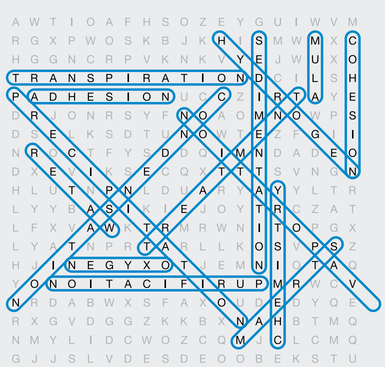
What if ice sank rather than floated in water?

- Could aquatic plants and animals live through a cold winter?
- How long would you have to wait to go ice-skating in the winter?
- Would there be liquid water to drink in a cold winter?

What if water did not have cohesion and adhesion?

- Would water bugs sink?
- Could we drip drops from an eyedropper?
- Would we need to use detergent to make bubbles in water?

Solution for Streaming Chemistry Word Search **on page 5.**



The Earth Day edition of *Celebrating Chemistry*

is published annually and is available free of charge through your local Chemists Celebrate Earth Day Coordinator and the American Chemical Society (ACS). Chemists Celebrate Earth Day is a combined effort among the Office of Community Activities, the Committee on Community Activities, and several ACS Technical Divisions. Please visit www.acs.org/earthday to learn more.

What is 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 more than 160,000 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 22nd. Another of these programs is National Chemistry Week, held annually the fourth week in October. ACS members celebrate by holding events in schools, shopping malls, libraries, science museums, and even train stations! Activities at these events include carrying out chemistry investigations and participating in contests and games. If you would like more information about these programs, please contact us!

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