The Science of Water

Nancy Moreno, PhD,
and Barbara Tharp, MS.

Center for
Educational Outreach

Baylor College of Medicine

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The Science of Water

Complete instructions for conducting activities in this slide set, including materials needed, setup instructions, student sheets (in English and in Spanish), answer keys and extensions, can be found in *The Science of Water Teacher's Guide*, which is available free-of-charge at: http://www.bioedonline.org/lessons-and-more/teacher-guides/water/.

Introduction

This slide set is designed for use with *The Science of Water Teacher's Guide,* which contains lessons that enable students to explore water, behavior of molecules, the water cycle, how we use water, that living things are made mostly of water, how water is taken in and released from the body, what a one part per million solution is, separation techniques, and non-point source water pollution. *The Science of Water Teacher's Guide* may be used alone or with the following integrated educational components.

- *Mystery of the Muddled Marsh* (student storybook)
- *Explorations* (student magazine)

- *The Reading Link* (language arts supplement)
- *The Math Link* (mathematics activities supplement)

Activities are organized into the following science areas.

- Physical Science (hydrogen bond, polarity, solutions, mixtures, dissolving substances, properties of water, water cycle, precipitation, evaporation)
- Life Science (uses of water, water in food and in the body)
- Environmental Science and Health (serial dilution, chromatography, separations, pollution, point-source pollution)

Reference

Moreno, N., and Tharp, B. (2011) *The Science of Water Teacher's Guide*. Baylor College of Medicine: Houston. ISBN: 978-1-888997-61-3

Image Reference

Key Words

lesson, life science, physical science, environmental science, health, water, water molecule, three states of water, properties of water, polarity, water cycle, hydrologic cycle, precipitation, condensation, transpiration, evaporation, ground water, ocean, lake, river, kidney, excretion, dehydrate, dehydration, chromatography, eutrification, pollution, water supply, fertilizer, conservation, preserving, preserve, dehydration, dehydrating, part per million, ppm, concentration, dissolve, solution, contaminant, non-point pollution, mining, oil, oil spill, water supply, water source, water supplies, ground water, pesticide, algae, green algae, hay infusion,

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Why Is Water Important?

1. Write down reasons why water is important in your science lab journal or notebook.
2. What are four of the most important aspects of water for health?
3. Complete your pre-assessment.

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Why Is Water Important? (pre-assessment)

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Background

Human beings are about 67% water. In fact, every living organism, whether composed of one cell or many millions of cells, contains water. Water is needed to transport nutrients and oxygen throughout living organisms and to carry out waste. Water also is vital for cooking, cleaning, growing crops, raising animals, transportation, production of electricity and manufacturing. Without water we would not only be unhealthy, we would not be alive.

Procedure

1.Ask students, *Why is water important?* Have students devise and write down reasons why water is important in their science lab journals/notebooks. Tell students they may add to their lists as they complete the unit.

2. Explain to students that they will complete a pre-assessment to see what they already know about water.

3.Have students complete the pre-assessments individually; then collect and save the sheets. You should have students refer back to their pre-assessment answers at the conclusion of this unit to make any corrections based on the knowledge gained in the unit. This can be used as one component of the post-assessment activity (see Variations, PDF).

Reference

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Image Reference

Photo courtesy of the CDC\Amanda Mills.

Key words

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Properties of Water

- Water drops are made up of individual water molecules.
- When joined together, water travels as
  - liquid water in oceans,
  - water vapor in the atmosphere,
  - water and ice on the land, and
  - underground water.

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Properties of Water – Physical Science Basics

More than 70% of Earth’s surface is covered by water, with about 96.5% of it in the global oceans. This amazing substance is essential for all life on our planet and helps maintain Earth’s climate. Water has several unique properties that distinguish it from most other substances.

Water has both a high boiling point (100° C; 212° F) and a low freezing point (0° C; 32° F). Consequently, it can be found naturally as a solid (ice or snow), a liquid (liquid water) and a gas (steam or water vapor), at any given time on our planet.

Liquid water changes temperature very slowly. This characteristic helps animals to maintain their body temperatures. It also keeps large areas of water from warming or cooling rapidly, thereby helping to regulate Earth’s climate.

Liquid water is an excellent solvent. This property makes water valuable to living organisms. All of the thousands of chemical processes inside cells take place in water. Water also carries dissolved nutrients throughout the bodies of living organisms and transports wastes. Unfortunately, the same characteristics make liquid water easy to pollute, because so many different chemicals can be dissolved in it.

Molecules in liquid water are attracted to one another and, as a result, “stick” very closely together. This properly explains water’s ability to form rounded droplets and to rise within a thin, hollow tube. This characteristic is important for plants, which conduct water and nutrients through very narrow tubes extending from the roots to the branches and leaves.

Liquid water expands when it becomes a solid (ice). Most substances take up less space when they are transformed from a liquid to a solid. Water, on the other hand, actually takes up more space as a solid because the molecules in ice crystals are farther apart than those in liquid water. Since it is less dense, ice floats on top of liquid water.

Water is colorless and allows light to shine through it. Plants can grow underwater because water is transparent to the wavelengths of light needed for photosynthesis.

Most of these properties are related to the structure of the water molecule, which consists of two hydrogen atoms and one oxygen atom. The oxygen atom and the hydrogen atoms share electrons, but the electrons are not shared equally. The electrons are pulled toward the oxygen side of the molecule, which ends up with a slight negative charge. Correspondingly, the hydrogen side of the molecule ends up with a slight positive charge. This separation of positive and negative charges (polarity) causes each water molecule to act like a tiny magnet, capable of clinging to other water molecules and to any other electrically charged particle or surface.

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Image Reference

Composite image courtesy of NASA Earth Observatory.

Key words

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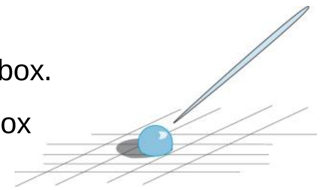
What Makes Water Special?

1. Make equal-sized drops from “Liquid 1”on a sheet of paper.
2. In the column labeled “Liquid 1,” draw a drop from the top in the first box.
3. Draw the drop from the side in the box underneath the first.



4. Write three words to describe the drop.
5. Split a drop with a toothpick and draw it in the third box.
6. Join two drops together. Draw what you see in the next box.
7. Push two drops together. Mix food coloring into the new drop and draw it in the next box.

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What Makes Water Special? – Physical Science

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Background

Water molecules are attracted to each other because, in many ways, they act like tiny magnets. Each molecule in liquid water has a positive end and a negative end. The forces of attraction between these opposite charges bring the molecules together very tightly. Attraction among molecules of the same kind is called cohesion.

The forces of attraction among the molecules in most liquids are not as strong as those that occur among water molecules. The “stickiness” of water accounts for much of its behavior, including the formation of rounded droplets and its ability to creep upward inside a narrow tube (capillary action).

In this activity, students discover some of the unique qualities of water and compare and contrast water with another liquid (mineral or salad oil) that behaves differently.

Procedure

Session 1: Examining Liquid 1

1.Demonstrate the use of a pipet (or dropper) by placing several drops of Liquid 1 (water) on an overhead projector or under a document projector.

2.Ask students to describe the drops being projected. Explain that they will be examining drops of two different liquids at their own working areas.

3.Have the Materials Managers collect the supplies from a central location. Each student should prepare a working surface by placing the wax paper over the graph paper.

4.Have the students practice making equal-sized drops of Liquid 1, sharing the dropper and using the graph paper as an approximate guide to size. Students should examine the drops with their hand lenses.

5.Ask the students to draw a drop from the side and top on their student sheets, and to describe the drop using at least three descriptive words.

6.Next, ask the students to try to split one drop into smaller drops using a toothpick. They should draw the results on their sheets.

7.Have the students push two drops together and discover what happens. Have them draw the new drop that forms when the two smaller drops come in contact.

8.After forming the new larger drop, students should dip their toothpicks into a drop of food coloring and mix it into the new drop. Have students draw the drop again and color it appropriately.

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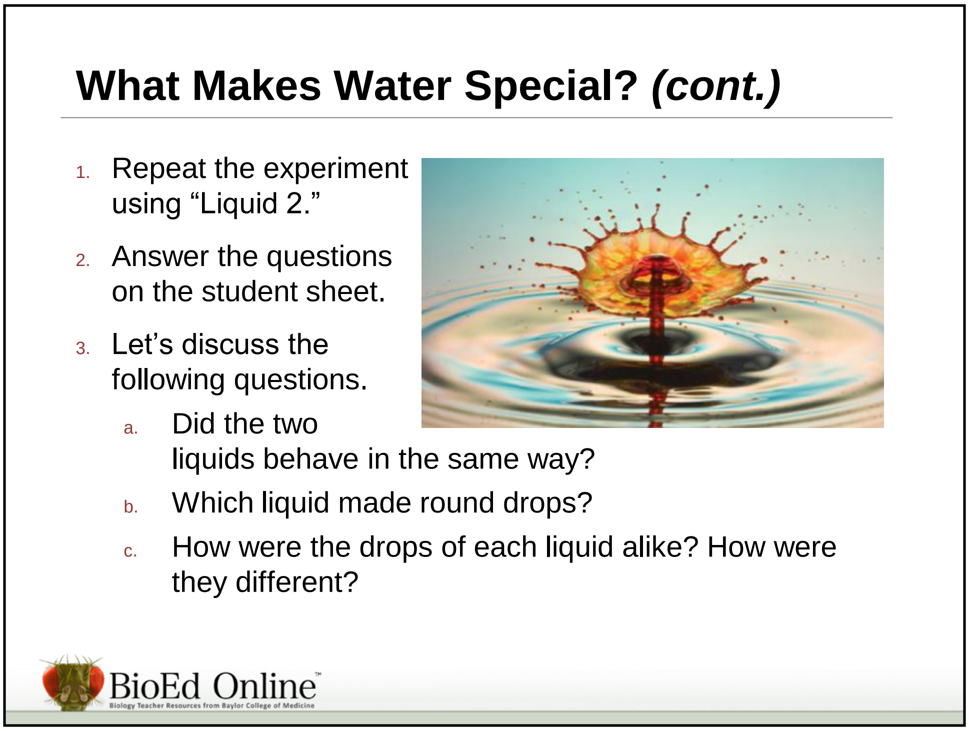

What Makes Water Special? *(cont.)*

Procedure

Session 2: Examining Liquid 2

1.Have students repeat the preceding exploration using Liquid 2 (oil) and record their results in the second column on their worksheets.

2.Afterwards, have the students answer the comparison questions at the bottom of the student page. Discuss student observations as a class. Ask, *Did the two liquids behave in the same way? OR ask, Which liquid made round drops? How were the drops of each liquid alike? How were they different?*

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What Dissolves in Water?

1. Have you ever mixed or stirred something into a glass of water?
2. How do you know when a substance is dissolved?

3. On your student sheet, predict what will happen when each of the substances listed is mixed with water.
4. Measure 100 mL of water into each of six cups.
5. Measure one teaspoon of one substance into one of the cups of water. Stir until there is no change in the mixture. Repeat with each substance in a separate cup of water.
6. Record your observations on your student sheet.

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What Dissolves in Water? – Physical Science

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Background

One of the most important properties of liquid water is its ability to dissolve many different substances. The same forces of attraction among molecules that account for the "stickiness" of water also act as tiny magnets that pull certain types of molecules (such as table salt) apart or allow some substances (alcohol, for example) to mix uniformly with water. In general, molecules that have a positive end and a negative end, or that can separate into components with positive and negative charges, will dissolve in water. Molecules without these characteristics, such as oils, will not dissolve in water.

The uniform mixture that results when one substance (such as table salt) is dissolved completely in another (such as water) is called a solution. Many common items are solutions. Household vinegar, for example, is a solution of acetic acid in water.

The reactions that take place inside living cells depend on the presence of water. Likewise, organisms require water outside of cells to transport nutrients and other substances from place to place, and to carry waste products away. In our daily lives, we take advantage of water's abilities to dissolve and remove unwanted substances by using it for cleaning and rinsing.

Procedure

1.Distribute a copy of the student page to each group. Have Materials Managers pick up materials for their groups.

2.Show the students a clear glass of water. Ask, *Have you ever mixed or stirred something into a glass of water? What happened? Do you think that everything can mix with water?* Tell students that they will observe what happens when they mix different things with water.

3.Before student groups begin, have them predict what will happen when they mix each substance with water. You may want to give groups time to discuss criteria for deciding if something has "dissolved." For example, a substance could be considered dissolved if the water is transparent, not cloudy, after the mixture has been stirred.

4.Have students measure approximately 100 mL of water into each of the six cups. Guide the groups as they conduct their tests, one substance at a time, in separate cups. For each test, ask students to observe the substance. Ask, *Is it a liquid or a solid?* Next, have students measure about one teaspoon of the substance into one of the cups of water and stir until there is no change in the mixture. Finally, they should note what happened and record their observations.

5.When students have completed their investigations, discuss their observations. Project a transparent copy of the "Disappearing Act—My Observations" sheet or draw a similar table on the board, and call on each group to share its observations for one of the substances. Expect the following results.

Salt. Will dissolve (disappear), leaving a clear solution.

Sugar: Will dissolve (disappear), leaving a clear solution.

Flour. Will not dissolve; the mixture will be cloudy, because the large flour particles will remain suspended in the water (example of a colloid).

Oil. Will not dissolve; the oil will float on top of the water because the oil is less dense, and because the oil molecules will not mix with the water molecules.

Food coloring. Will dissolve; the resulting transparent liquid will be colored.

Coffee. Part of the coffee will dissolve in the water, coloring it brown; the remainder of the coffee (woody parts of the coffee bean) will not dissolve or disperse through the liquid and will float.

6.Conclude with a discussion of the students' observations. Ask, *Which things disappeared into the water when you stirred? Do you think that they (salt or sugar) are still there? How could you figure this out?* Ask about the other substances.

7.Extend the discussion to include students' ideas about how water's role as a "dissolver" is useful in daily life. Have students think about things that remain in water after it is used for cleaning, rinsing, etc. Ask, *How this might contribute to water pollution?* Also ask, *How many substances did you dissolve in (or add to) water today?*

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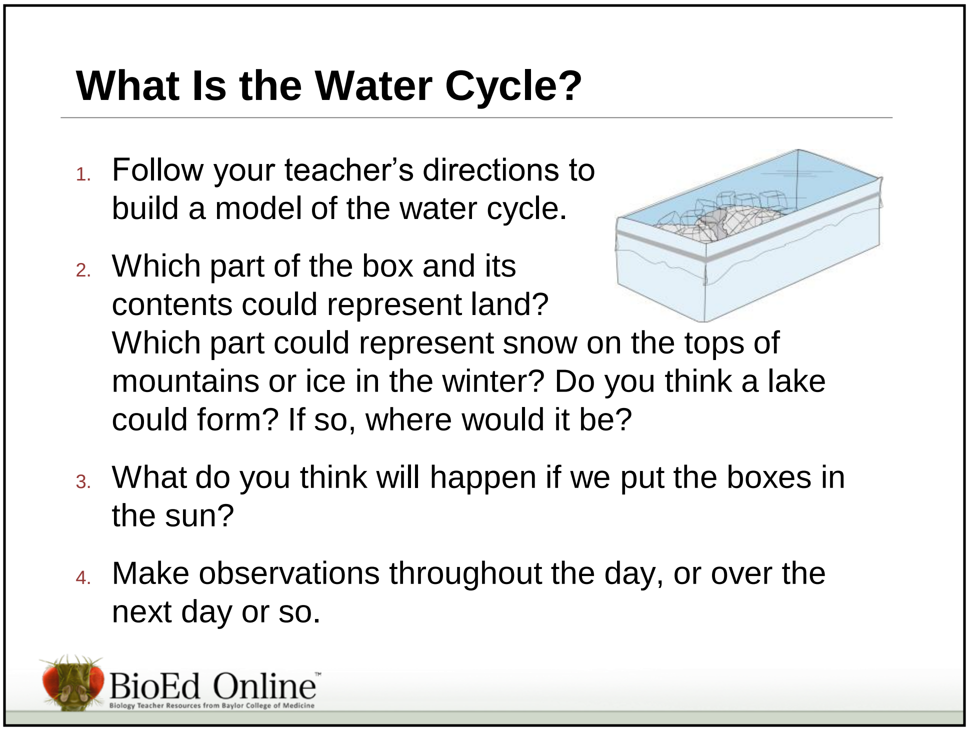

What Is the Water Cycle? – Physical Science

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Background

Water is one of the few substances that can be found in all three states—solid, liquid and gas—at any given time somewhere on Earth. For example, snow and ice always are present at the poles, as well as on the tops of high mountains. Liquid water is abundant in many places on Earth, including lakes, rivers, oceans and underground. Water vapor, the gas phase of water, usually makes up a small component of the air around us (up to 5%), and can be observed as steam when liquid water is heated.

When talking about this important resource, we usually think of liquid water. However, if water were not continuously cycling among its three states, the world's stores of freshwater quickly would become depleted or too polluted to use.

Fortunately, our supply of freshwater continually is collected, purified and redistributed as part of the water cycle. Also known as the hydrologic cycle, this continuous process replenishes our water sources through precipitation (rain, mist, snow and sleet, for example). Some water from precipitation soaks into the ground. The rest runs off into streams, lakes and the oceans. Heat from the sun causes water to evaporate from the land and from bodies of water. Water vapor collects in the atmosphere until there is too much for the air to hold in clouds, leading once again to rain or snow.

This activity allows students to explore properties of water that are important to the water cycle.

Procedure

Session 1: Making the model

1.Have each group line the inside of its box by pressing a single sheet of aluminum foil along the bottom and up the sides of the box.

2.Direct groups to take turns measuring out two cups of sand and placing it in a pile at one end of their boxes.

3.Have each group smooth the sand to create a hill at one end of the box, gradually sloping it toward the other end. This will form the “land” in the model.

4.Have each group place 20 ice cubes on top of the “land” in the box. The ice cubes will represent “snow” and “ice” in the model.

5.Help the groups cover each box with a sheet of clear plastic wrap and secure it with a large rubber band. (If using plastic storage boxes, cover them securely.)

6.Discuss the models with the class. Ask, *Which part of the box and its contents could represent land? Which part could represent snow on the tops of mountains or ice in the winter? Do you think a lake could form? If so, where would it be?*

7.Ask students, *What do you think will happen if we put the boxes in the sun?* Have each student fold a sheet of drawing paper in half. Then direct students to use one-half of the sheet to draw a “side view” of what they think the box will look like at the end of the day. Place the boxes in a sunny window or a under a lamp with an incandescent (not fluorescent) light bulb. If possible, have the students observe their boxes at intervals throughout the day. Otherwise, have them observe the boxes within the next day or so.

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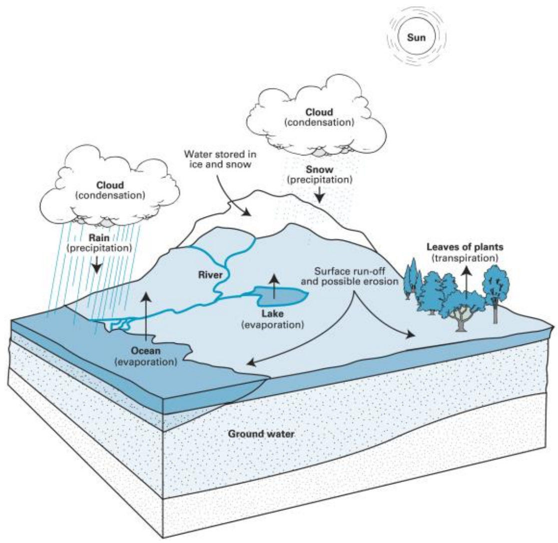
The Water Cycle

- What would happen to the water on our planet if the recycling of water through the atmosphere suddenly stopped?
- What does this teach us about using water wisely?



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The Water Cycle

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Session 2: Looking at results

1.Have the students observe their boxes without removing the covers. Ask them to note the changes that have occurred inside the boxes. Ask, *What happened to the ice cubes? What else is different about the inside of the box?* In most cases, at least a few drops of water will have condensed on the inside of the covering. Ask, *Where did the drops of water come from?*

2. Help students understand that all three states of water have been present in their shoeboxes. Review the different states in which water can be found—ice or snow (solid), liquid water and water vapor. Breathe on a mirror or piece of glass to show students how water vapor condenses on a surface, OR boil a small container of water, so that students may observe the cloud of steam. Hold a glass or mirror above the steam.

3.Let the students remove the covers from their boxes. Ask them to observe the surface of the sand. Ask, *Has the surface of the sand changed? In what ways?*

4.Talk about where the water in the box has gone. Where was all of the water in the box when we started? Where is the water now? If students have not noticed that the surface of the sand is wet, point out that some of the water has run into the bottom of the box to make a "lake," and some has soaked into the sand. Help students understand that the same processes take place outside when it rains and snows.

5.Have students draw a side view of the box on the remaining half of their folded sheet of drawing paper. Discuss the outcomes they observed and compare their findings with their predictions.

6.Challenge students to think about what would happen if other substances (for example, chemicals, oils, etc.) also were present on or in the sand.

7.Give each student a copy of "The Water Cycle" page, or project an overhead transparency of the page. Have students identify the forms in which water is present in the diagram (for example, snow on mountaintops is a solid form of water, and water evaporating from the ocean represents water in a gas phase). Direct very young students to place a sticker everywhere on the page where they can find some form of water.

Note

Water also cycles through living organisms. Transpiration is the loss of water from parts of plants. Water evaporates through tiny pores in leaves and stems. This process creates a pressure change that draws water and nutrients up from the roots into other parts of the plant.

While evaporation from the oceans is the primary vehicle for driving the surface-to-atmosphere portion of the water cycle, transpiration also is significant. For example, a cornfield 1 acre in size can transpire as much as 4,000 gallons of water every day.

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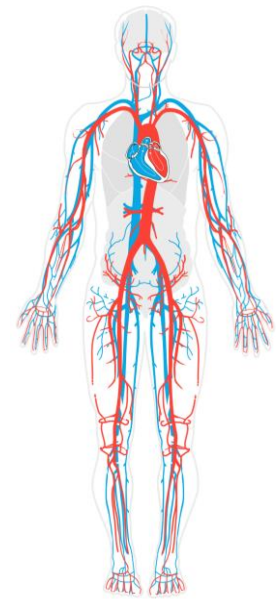
Water in Our Bodies

- Water is inside every cell.
- Water carries nutrients and oxygen to every cell in our bodies.
- Water also is used to carry waste products away from cells.
- Every living organism relies on water for life.



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Water in Our Bodies – Life Science Basics

Every living organism, whether it consists of one cell or billions, relies on water for the transport of nutrients and, in most cases, oxygen. Water also is used to carry waste products away from cells. Even the countless reactions that happen inside cells must take place in water. Organisms consisting of one to just a few cells interact directly with their environments. In such organisms, obtaining raw materials and eliminating wastes are relatively simple processes, because each cell is in contact with the outside (usually water-containing) environment. More complex organisms, however, must find ways to maintain a constant internal fluid environment. They also must provide cells with the materials they need and remove waste products.

In vertebrate animals, nutrients, gases and wastes are carried throughout the body by the circulatory system—which consists of a heart and numerous blood vessels. Water is a significant component of blood and also is the base for the solutions that surround cells throughout the body. In fact, about 50% of the water in the body of a complex animal is found in fluids outside of cells.

Vertebrates take in water and food through the mouth. Materials reach the stomach, where food is mixed and broken up. Food exits the stomach as a soupy mixture, which passes into the small intestine, where most digestion and absorption of nutrients occurs. Most food molecules must be broken down into smaller components before they can be absorbed into the body. These and other nutrients, like salts and minerals, pass through the cells that form the walls of the small intestine into the bloodstream. Water is essential to transport nutrients released during digestion. Materials that have passed through the small intestine enter the large intestine, where much of the water used during the digestive process is reabsorbed.

The removal of wastes from cells also depends on water. Cells release waste products into the blood, which carries them to the kidneys, organs located near the lower back that remove potentially toxic materials from the blood. The kidneys use very little water in this process. Waste materials are concentrated as urine, which is stored in the bladder until being eliminated. The kidneys also control the relative amounts of water retained within the body and/or released in urine.

Note

Water loss always is a threat to the survival of living organisms. Water can be lost by evaporation from surfaces involved in breathing (inside the lungs, for example), by evaporation from other surfaces (such as through perspiration), and by elimination (both in urine and in feces). Water that is lost must be replaced. Additional water can come from food, from drinking liquids and as a byproduct of energy-releasing reactions inside cells.

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lesson, life science, health, water, transpiration, evaporation, body, cells, kidney, excretion, dehydrate, dehydration, chromatography,

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How Do We Use Water?

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How Do We Use Water? – Life Science

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Background

Water is essential for life, and each of us uses water in many ways. For example, each person needs to have about eight cups of water each day to stay healthy. The water we need can come from liquids we drink and the foods we eat. We also use water to wash dishes and food items, to remove microorganisms that can cause illnesses. We prevent other kinds of diseases when we use water for bathing and for brushing teeth.

However, many daily uses of water are non-essential. We use water to wash our cars or driveways, because they look better when they are clean. We sprinkle our flower gardens and lawns with water, even though we don't use those plants for food. In addition, we often use more water than necessary to carry out essential tasks. Examples include leaving the water running while brushing teeth, taking long showers or filling the bathtub to the brim before bathing.

This activity will make students aware of the ways they use water each day. Each student will keep a personal Water Use Journal for 24 hours. If desired, students can keep journals over the course of the entire unit, saving all of their worksheets and observations, writings, drawings, magazine clippings, etc., related to water and human health. Such a journal is useful for review and reinforcement. It also can serve as an assessment tool during and at the end of the unit.

Reference

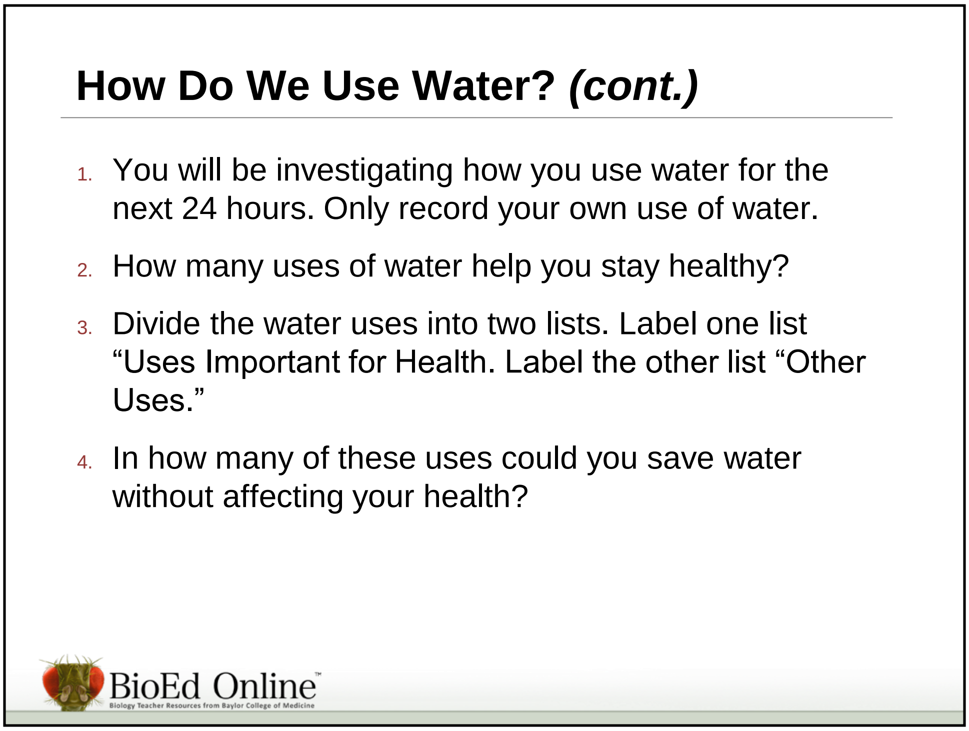
Moreno, N., Tharp, B., and Dresden, J. (2011) *The Science of Water Teacher's Guide*. Baylor College of Medicine: Houston. ISBN: 978-1-888997-61-3.

Image Reference

Key words

lesson, life science, health, water, transpiration, evaporation, body, cells, kidney, excretion, dehydrate, dehydration, chromatography,

The Science of Water Teacher's Guide © Baylor College of Medicine was developed with support from the National Institute of Environmental Health Sciences of the National Institutes of Health, grant numbers R25 ES06932 and R25 ES010698.



How Do We Use Water? *(cont.)*

Note

- Each person needs 8–10 cups (2.5 quarts) of water each day for health.
- Americans each use about 183 gallons of water each day for cooking, washing, flushing and watering.
- Most home water use is in the bathroom.
- 4,000 gallons of water are needed to produce one bushel of corn.
- It takes 1,400 gallons of water to produce a meal of a hamburger, French fries and a soft drink.
- 39,000 gallons of water are required to produce an automobile.

Source: U.S. Environmental Protection Agency, Office of Water.

Procedure

Day 1: How do you use water?

1.Open a short discussion by asking students to list ways that people use water every day. Some uses might include: washing, drinking, cooking, watering plants, etc.

2. Pass out one copy of the “Water Use Journal” sheet to each student. Explain that students will be investigating how they use water for the Have students take their sheets home. Specify the period of time during which they should record their water use (for example, from the moment they leave the classroom until the moment they return; from the time they arrive home until the time they leave home in the morning; etc.).

Day 2: What are essential uses of water?

1.Divide classes of older students into groups of 3 to 4. Have each group discuss and compile a list of the uses of water that they reported in their journals. With younger students, conduct this session as a full class activity. Ask each student to contribute one of the uses of water that he or she recorded. List the uses on the board.

2.Ask, *How many uses of water on your list (or on the list on the board) help you stay healthy*? Have each group divide the water uses on its list into two categories: “Uses Important for Health,” and “Other Uses.” With younger students, create the same categories and lists on the board.

3.Have each group share its list of uses with the rest of the class. Encourage discussion of the students’ ideas. Now, present each group with a new challenge. Ask, *In how many of these uses could you save water without affecting your health?* Have each group revisit its list and create a new list of “Ideas for Saving Water.” Let each group share its ideas.

4.Display the “Ideas for Saving Water” in a central place in the classroom. If desired, have each group create a colorful poster illustrating one of its ideas.

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How Much Water Is in a Fruit?

1. Predict the amount of water contained in one orange.
2. Measure the volume of an orange by submerging a whole orange in a glass of water.

3. Squeeze the juice out of an orange. Save the remainders of the orange.
4. Measure the amount of juice obtained.
5. How can the remaining material be measured?

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How Much Water Is in a Fruit? – Life Science

Complete instructions for conducting activities in this slide set, including materials needed, setup instructions, student sheets (in English and in Spanish), answer keys and extensions, can be found in *The Science of Water Teacher's Guide*, which is available free-of-charge at: http://www.bioedonline.org/lessons-and-more/teacher-guides/water/.

Background

The cells and tissues that make up living organisms are mostly water. For example, water comprises about 90% of the weight of a tomato, 80% of the weight of an earthworm, 70% of the weight of a tree, and 70% of the weight of a human body.

In this activity, students will investigate the amounts of water in two different fruits and use measures of weight and volume. The activity also introduces students to the concept of drying (or removing water) as a means of preserving foods. Drying can be traced back to ancient times, and was an important method of food preservation used by American Indians and early settlers in North America. When foods are dried, most of the moisture is removed. Drying makes many grains, meats and vegetables much less suitable environments for the growth and reproduction of molds, bacteria and insects.

Dehydration also makes foods lighter, and easier to store and transport. Other methods for preserving food that involve dehydration include smoking—which is faster and more effective because the absorbed smoke is toxic to many microorganisms—and salting, which draws moisture out of the food items.

Procedure

Session 1: How much liquid does an orange have?

1.While holding a bag of oranges in front of the class, ask, *How much water do you think is in this bag?* Lead a class discussion about the amount of water in an orange. Ask the students to predict the amount of water contained in one orange. Make sure they equate orange juice with water.

2.Show the students how to measure the volume of an orange by observing and measuring "how much space it takes up." Fill a prepared beaker with 800 mL of water. Record the number of mL in the beaker on the board. Then place an orange into the water. Hold it down gently, so that the whole orange is submerged. Ask, *Did the water level go up or down? How much? Why?* To help students understand the concepts of displacement and volume, talk about what happens to the water when someone gets into a bathtub.

3.On the board, subtract the original volume of water in the container from the volume in the container after the orange was added. Calculate and record the difference. Ask, *What does the difference represent?* (A standard juice orange will displace about 140–150 mL and will yield 40–50 mL of squeezed juice.)

4.Have each group measure the volume of an orange by submergence, as you demonstrated. Ask the students to suggest ways to measure the amount of juice inside their oranges.

5.Show the students how to squeeze the juice out of an orange. Have them cut their oranges in half using serrated plastic knives. Use the top and bottom portions of soft drink bottles as "juicers," purchased plastic juicers, or let students devise their own ways to squeeze out the juice. Have each group squeeze the juice out of one orange. Make sure the students save the remainders of their oranges.

6. Have each group measure the amount of juice obtained by pouring it into a 250-mL beaker. Ask*, How can the remaining material be measured?* If students suggest weighing, have them consider the conversions necessary to equate the weight information with their earlier measurement in mL. Have students place the remaining orange pieces without juice into the beaker prepared with of 800 mL water and read the new volume. Ask, *Has the amount of water displaced changed? Why? What was the volume of the entire orange? What is the volume of the remaining "stuff"? What fraction of the orange was water?* Have students record the values they obtained on the "How Much Juice Is in an Orange" observations sheet.

Reference

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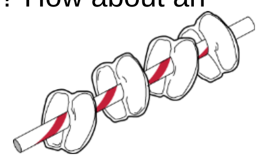
How Much Water Is in a Fruit? *(cont.)*

1. Do you think other foods contain water? How about an apple? How could we find out?
2. Each group: Weigh your apple and record the value.



3. Cut your apple into vertical slices. Skewer the slices along a straw.
4. Let the apple sit in a warm place for 3–5 days.
5. Weigh the sliced apple daily and record the results in grams. Make a graph of daily weights.
6. On the last day, record the weight of the apple and subtract it from the starting weight. How much water did the apple contain?

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How Much Water Is in a Fruit? *(cont.)*

Session 2: How much liquid does an apple have?

1.Ask the class, *Do you think other foods contain water? How about an apple?* Encourage the students to predict whether apples and other fruits and vegetables contain water. Ask, *How could we find out? Could we squeeze an apple?*

2.Give each group of students an apple and a plastic serrated knife. Direct the students to weigh their apples, record the values and cut their apples into slices vertically (about 1/2 cm in thickness). Have students place the slices between two sheets of paper towel, or skewer the slices along a straw. Then let the apples sit in a warm place for 3–5 days. (The amount of time will vary depending on the temperature; see next step.)

3.Have students weigh their sliced apples every day and record the weights (or mass) in grams. When the slices no longer show an appreciable change in weight from one day to the next, they have dried as much as will be possible. Have older students make a graph of the daily weights of their apple slices. Ask, *What does the graph tell us about the weight of the apple?*

4. Have students in each group subtract the final weight of the slices from the starting weight of the apple. The difference will be the weight of the water lost from the apple during the experiment.

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How Much Water Do Humans Need?

1. How much water enters the body in food and liquid during a typical day?
2. What happens to the water in our bodies? Where does it go?
3. What would happen if no water entered the body?

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How Much Water Do Human Need? – Life Science

Complete instructions for conducting activities in this slide set, including materials needed, setup instructions, student sheets (in English and in Spanish), answer keys and extensions, can be found in *The Science of Water Teacher's Guide*, which is available free-of-charge at: http://www.bioedonline.org/lessons-and-more/teacher-guides/water/.

Background

Water is a unique substance upon which all life depends. It is essential both inside cells—where it provides the medium in which all chemical reactions take place—and outside cells, where it is necessary for the transport of nutrients and other materials, and for the removal of wastes.

On land, plants and animals must conserve water within their bodies. Animals lose water through evaporation from lung surfaces and the outer body surface, and through elimination in feces and excretion in urine. The water that is lost must be replaced.

Most land animals are adapted to minimize water loss through excretion and elimination. Our kidneys, for example, are extremely efficient in their use of water. While approximately 170 liters of water are cycled through a human's kidneys each day, almost all of this water is reabsorbed. Water used during the digestion of food also is reabsorbed by the body. This process occurs in the large intestine.

The threat of water loss is especially significant for animals living in dry environments. Most of these animals have evolved special strategies to conserve water. Kangaroo rats living in deserts, for example, hardly ever drink water. They obtain almost all of the water they need from the chemical breakdown of the grains they eat. To reduce water loss, the rats are inactive during the hottest parts of the day, produce very dry feces, and release extremely concentrated urine.

An average human doing light work in a temperate climate loses nearly 6 pints (3 liters) of water daily. This water must be replaced to keep the body functioning optimally.

Healthy human beings show the effects of water deprivation (dehydration) after about three days. Death is likely when the body loses about 20% of its total volume of water. This equals approximately 2.75 gallons (22 pints, or 10.5 liters) in a medium-sized adult. On the other hand, as long as water is available, it is possible to survive for up to two months without food (and lose up to half of the body's weight).

Procedure

1.Using the 2,000-mL handled beaker, measure or have students in each group measure 3,000 mL of water into a large dishpan (or tub). This is the amount of water that enters the body in food and liquid during a typical day.

2.Ask students, *What happens to the water in our bodies? Where does it go?* Have students take turns moving the following quantities of water from the tub into the milk jug. Students should use a funnel when pouring water into the jug.

- 150 mL - Water eliminated by the intestines
- 600 mL - Water lost as vapor during breathing
- 1,500 mL - Water eliminated as urine

• 750 mL - Water lost as perspiration

3.Ask the students to record the amount of water left in the first container. (It all will be gone!) Ask, *What would happen if no water entered the body?*

4.Ask students to identify different ways the body's water supply could be replenished. Have each group create plans or strategies to replace the 3,000 mL of water needed by the body each day to survive. Note that about half of the water we need can come from food, and that about 300 mL of water per day is produced inside the body, as energy is released from food. Have students share their ideas with the rest of the class.

Reference

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Image Reference

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Key words

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Water Pollution and Health

- Water carries visible and invisible components, and is home to many sea creatures. Oil, when spilled in ocean or river water, can travel very far by water currents, affecting animals and objects it touches.
- The patch of oil shown in the image is entering a loop current, which circulates around the Gulf of Mexico before bending around Florida and up the Atlantic coast.

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Water Pollution and Health – Environmental Science and Health Basics

All the water on Earth ultimately forms a single, immense system. Oceans, wetlands, streams, lakes and underground water supplies all are linked through drainage patterns in watersheds and through the endless cycling of water on our planet. Because water sources are connected, pollutants travel from part of one ecosystem to another. Eventually, the contaminants can affect very distant ecosystems and populations. Water pollutants can be divided into several major categories, all of which impact human health and well-being.

•Nutrients. These can come from chemical sources (fertilizers or detergents) or can be biological in origin (sewage or manure). Nutrients usually are carried into water sources by rainwater. They cause excessive growth of water plants and algae, which can clog navigable waterways and consume oxygen (needed by other organisms such as fish) when they decompose. These changes cause the decline of important lakes and wetlands, and can affect the quality of drinking water. In groundwater, fertilizers can make water from wells unsafe to drink.

•Soil and sand from plowed fields, construction sites, logging sites, urban lands and areas being strip-mined. These sediments make lakes, wetlands and streams more shallow, limiting the use of waterways for transportation and decreasing the quality of wildlife habitats. Washed-off soil also can be a source of excess nutrients.

•Disease-causing organisms. Bacteria, viruses and single-celled parasites can enter water supplies from inadequately treated sewage, storm water drainage, septic systems, livestock pens, and boats that dump human wastes. These organisms cause diseases such as dysentery and typhoid, and skin and respiratory illnesses.

•Metals (such as mercury and lead) and toxic chemicals (such as those found in pesticides, herbicides, cleaning solvents, plastics and petroleum derivatives). These substances can be poisonous to humans and wildlife. Metals and many manufactured chemicals persist in the environment. They build up in the bodies of fish and other animals, and can find their way into groundwater, making it unsafe to drink.

•Heat. Warm water discharged from power plants (where water is used for cooling) can drastically alter aquatic ecosystems. Changes in water temperature can affect the quantity of oxygen in the water and can make some organisms more susceptible to disease, parasites and toxic chemicals.

Most sources of water pollution are spread over large areas. Water from rain and irrigation collects pollutants as it washes over the land or sinks into the soil. This type of pollution, which is not attributable to a single location, generally is called non-point source pollution. It is much more difficult to monitor and to control than point source pollution—which is discharged at a single place (such as from a factory or waste treatment plant, or a chemical spill).

Reference

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Image Reference

Photo courtesy of NASA Earth Observatory.

Key words

lesson, environmental science, health, water, water cycle, precipitation, transpiration, evaporation, ground water, ocean, lake, river, chromatography, eutrification, pollution, water supply, fertilizer, conservation, preserving, preserve, dehydration, dehydrating, part per million, ppm, concentration, dissolve, solution, contaminant, non-point pollution, mining, oil, oil spill, water supply, water source, ground water, pesticide, algae, green algae, hay infusion,

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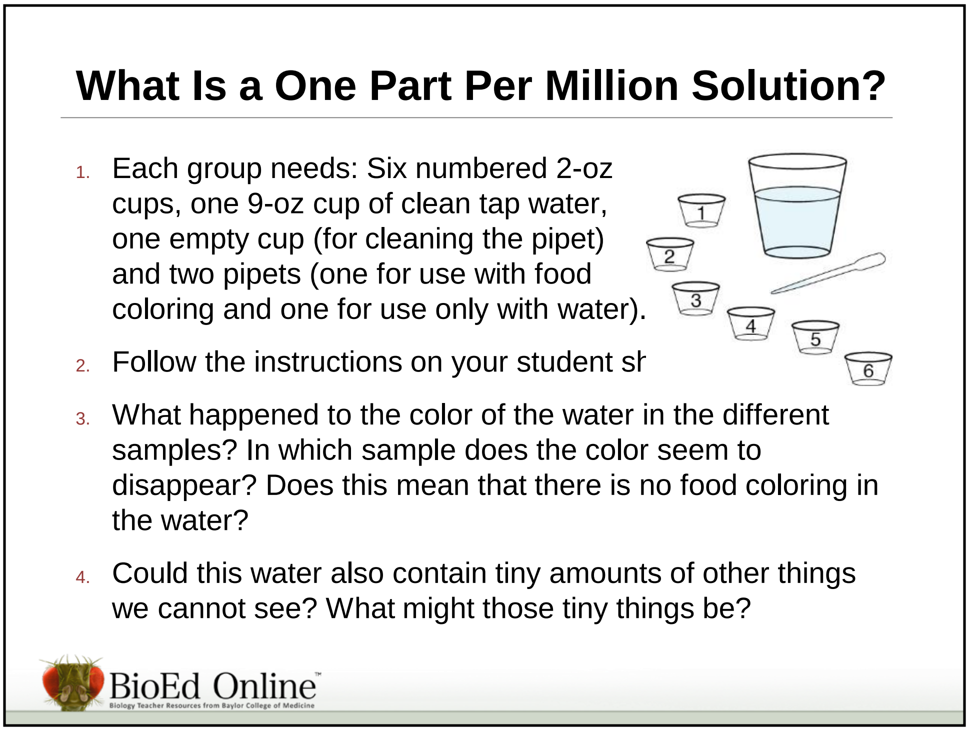

What Is a One Part Per Million Solution? – Environmental Science and Health

Complete instructions for conducting activities in this slide set, including materials needed, setup instructions, student sheets (in English and in Spanish), answer keys and extensions, can be found in *The Science of Water Teacher's Guide*, which is available free-of-charge at: http://www.bioedonline.org/lessons-and-more/teacher-guides/water/.

Background

Water that looks clean and clear still may contain many different types of chemical and biological materials. In fact, even water from crystal clear wilderness sources, or "natural spring water" sold in stores contains dissolved minerals and other substances. Most of these are harmless—especially in tiny quantities.

However, some types of water contaminants are harmful to human health, even in very small amounts. The concentration of many of these substances usually is measured in parts per million, or even in parts per billion. The Environmental Protection Agency (EPA) sets limits for the amounts of potentially harmful chemicals in drinking water sources.

In the following exercise, students create a solution that contains a concentration of one part per million of commercial food coloring.

Procedure

1.Make sure that each group has six numbered 2-oz cups (or a tray), one 9-oz cup of clean tap water, one empty cup (for cleaning the pipet) and two pipets (one for use with food coloring and one for use only with water).

2.Following the instructions on the “What Does One in a Million Look Like?” student sheet, have students place 1 drop of food coloring into “Cup 1.” (OR put one drop of food coloring into the cup for each group.) Have students use a clean pipet to add 9 drops of water to the cup. Ask, *How many colored drops did you add to the cup? How many drops are in the cup all together?*

3.Instruct students to collect 1 drop of the mixture in Cup 1 and place it into Cup 2. Next, have them use a clean pipet to add 9 drops of water to Cup 2. Students may need to rinse their pipets with tap water and squirt the excess into the empty cup. Each group should repeat the procedure, using 1 drop from the previous cup until all 6 cups are filled.

4.When students have made all their solutions, have them observe the color of the solution in each cup. Ask, *What happened to the color of the water in the different samples? In which sample does the color seem to disappear? Does this mean that there is no food coloring in the water?*

5.Look at the table on the “What Does One in a Million Look Like?” sheet. Be sure students notice that the concentration in Cup 6 is one part in one million. Each cup has a food coloring solution that is 10 times more diluted than the solution in the preceding cup. Ask, *Is there another way to make a mixture that has one part in 1 million?* (One way is to add 1 drop of food coloring to 999,999 drops of water! Another would be to add one drop of food coloring to a bathtub full of water—this would be an approximation.)

6.Hold up a glass of tap water. Ask, *Could this water also contain tiny amounts of other things that we can’t see? What might those tiny things be?* Possible answers could include minerals, microorganisms (germs), or chemicals. Ask, *Are all of these things necessarily harmful?* Help students understand that almost no water, except in a laboratory, is completely pure. On the other hand, point out that some pollutants can be harmful to human beings even in very tiny amounts, often measurable only in parts per million or parts per billion (for example, heavy metals like lead and mercury, pesticides and some industrial chemicals). Mention that certain city, county, state and federal agencies test drinking water for potentially harmful chemicals. Ask, *Why might this be important?*

Reference

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Image Reference

Illustration © Baylor College of Medicine\M.S. Young.

Key words

lesson, environmental science, health, water, water cycle, precipitation, transpiration, evaporation, ground water, ocean, lake, river, chromatography, eutrification, pollution, water supply, fertilizer, conservation, preserving, preserve, dehydration, dehydrating, part per million, ppm, concentration, dissolve, solution, contaminant, non-point pollution, mining, oil, oil spill, water supply, water source, ground water, pesticide, algae, green algae, hay infusion,

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How Can We Find Out What Is in Water?

- Have you ever seen a paper towel with stains from coffee or another liquid on it?
- Small amounts of many different substances can be found in water. They may not be visible when mixed with water.

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How Can We Find Out What Is in Water? – Environmental Science and Health

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Background

Small amounts of many different substances can be dissolved in water at the same time. Many of these materials are not visible or distinguishable when they are mixed together in water. In this activity, students will use a simple separation technique to detect the presence of several different food dyes in water.

The technique, called chromatography, takes advantage of the "sticky" qualities of water, which help it travel up a piece of filter paper. When this happens, the water molecules are attracted to charged regions on the paper's cellulose molecules. As water moves up the paper, it carries other molecules (such as the food coloring used here). Different molecules will move up the paper at different rates, based on their sizes and degrees of attraction to the water molecules. As a result, the different substances (food coloring dyes in this case) will form separate bands or spots on the filter paper.

Note

This activity works best if the strips are not pressed against the sides of the beaker or cup.

Procedure

1.Show the mystery liquid to the students. Ask, *Can you tell what's in this liquid?* Explain that each student is going to be a detective and investigate the mystery liquid.

2.Students will need to prepare a test strip of filter paper. Give each group 1–2 basket-type coffee filters. Have the students smooth the filters so that they lie as a flat circle. Each student should cut a strip of filter paper 2 cm wide by 10 cm long.

3.Give each group a 250-mL beaker (or 9-oz clear cup) with about 1 cm of the mystery liquid in the bottom. Tell students they will put the tips of the paper strips into the mystery liquid. Ask them to predict what might happen.

4.Have each student write his or her initials in pencil or permanent ink at the top of his or her filter paper strip. Then have students place the strips in the liquid and gently fold the top of the strips over the side of the beaker so that the strips stay upright.

5.Have the students observe their strips for 5–10 minutes. As the color begins to rise up the strips, ask, *What is happening to the mystery liquid?*

6.Once the liquid in the strips has risen to about 2 cm from the top of the beaker, have students carefully remove their strips and lay them on pieces of paper towel to dry. Instruct students to observe the colors. Ask, *How many colors are on your strips? Which colors?* Let each student report which colors appeared on his or her strip. (Usually three bands will form: blue at the top, followed by yellow or green, followed by red at the base.) Ask, *What does this* *result tell us about the mystery liquid? How many substances were mixed together to make the liquid?*

7.The strips may be preserved in a notebook or displayed in class after they are dry. Encourage students to extend their findings to other situations. Ask, *Since several different substances were mixed together in the mystery liquid, do you think that other types of liquids can be mixtures of different materials?*

Reference

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Image Reference

Key words

lesson, water, water molecule, properties of water, three states of water, water cycle, hydrologic cycle, precipitation, condensation, transpiration, evaporation, ground water, water supply, ocean, lake, river, kidneys, excretion, dehydrate, dehydration, chromatography, nutrient, pollution, fertilizer, organisms, conservation, preserving, dehydration, part per million, ppm, dissolve, solution, dilution, contaminant, non-point pollution, sewage, oil, chemicals, pesticides, overgrowth, green algae, hay infusion

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Can Nutrients in Water Cause Harm?

- Dyke Marsh, a tidal marsh on the west bank of the Potomac River south of Alexandria, Virginia, is a mixture of fresh water and salt water.

- The marsh water also is used by and affects animals living in this ecosystem. The animals which include beavers, bats, birds, foxes, muskrats, rabbits, squirrels, shrews and field mice.

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Can Nutrients in Water Cause Harm? – Environmental Science and Health

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Background

In general, two types of sources contribute to water pollution in the United States. Point sources, such as factories, sewage treatment plants, abandoned mines and oil tankers, introduce pollutants into waterways at single places. This type of pollution is not always significant in terms of volume, but it is the major point of entry for toxic chemicals into water supplies. In most cases, point sources of pollution can be identified and monitored by government agencies.

Non-point source pollution occurs across large areas of land that drain into underground and surface water sources. Pollutants are collected and deposited by water as it travels over land and through layers of soil. Major contributors to non-point source pollution include agricultural activities (which can add chemical fertilizers, pesticides, manure and soil to water), logging and other activities that leave the soil surface bare (allowing soil to be washed into waterways), urban and suburban areas (where lawn chemicals, household chemicals, motor oil and gasoline can enter water supplies), and septic systems (which can contaminate underground water supplies with disease-causing bacteria). Non-point sources of water pollution are difficult to control because they are spread over large areas, and often result from the actions of many individuals.

In the story, *Mystery of the Muddled Marsh*, which accompanies this unit, runoff from a new park development introduces soil and fertilizers into a marsh and stream ecosystem. Excess soil and fertilizers lead to murky water and overgrowth of plants, green algae and some microorganisms in the marsh, threatening the marsh animals and their habitat. Riff and Rosie (characters in the story) are able to connect development of the park to changes that they have observed in the marsh.

In this activity, students investigate, on a small scale, the changes that occur when fertilizers are added to pond water cultures.

Note

The water and plants in Dyke Marsh are not only adversely affected by contaminants already in the fresh water and salt water, but also by shoreline erosion and surface runoff.

Procedure

Session 1: Set up pond water cultures

1.Begin by asking students if they remember what happened to Marigold Marsh in the story, *Mystery of the Muddled Marsh*. Allow time for everyone to share his or her ideas. Then, tell students that they will be able to see some of the tiny plants and animals that lived in the muddled marsh while they conduct an investigation of what happens when fertilizer is added to a water ecosystem.

2.Have one or two students label the three bottles “NF” (no fertilizer, or control), “N” (natural fertilizer), and “C” (chemical fertilizer). In bilingual classrooms, label the containers “SF” (sin fertilizante), “N” (fertilizante natural), and “Q” (fertilizante químico).

3.Show students the prepared (or pond) water. If possible, put a few drops of the water under a microscope for students to observe. Explain that they will be growing similar living things in the bottles. Add about 250–500 mL of the hay infusion or pond water, along with some hay/dried grass, to each bottle.

4.Set the soft drink bottles in a bright window or under bright fluorescent lights for 1–2 days to allow the culture to develop. (In conditions with low light, hay infusions will tend to develop mold and/or foul smelling bacteria within 2–3 days.) *Note.* If using pond water that already has plenty of green algae and other growth, proceed directly to the next step without resting the cultures.

Reference

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Image Reference

Photo courtesy of the U.S. National Park Service.

Key words

lesson, environmental science, health, water, water cycle, precipitation, transpiration, evaporation, ground water, ocean, lake, river, chromatography, eutrification, pollution, water supply, fertilizer, conservation, preserving, preserve, dehydration, dehydrating, part per million, ppm, concentration, dissolve, solution, contaminant, non-point pollution, mining, oil, oil spill, water supply, water source, ground water, pesticide, algae, green algae, hay infusion,

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Can Nutrients in Water Cause Harm? *(cont.)*

Eutrophication occurs when large amounts of nutrients are present in lakes, streams or the ocean.

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Can Nutrients in Water Cause Harm? *(cont.)*

Session 2: Beginning the experiments

1.Allow time for groups of students to observe the three bottles. Each student should record his or her own observations. Ask, *Do you notice any differences among the bottles? Why or why not?* Have students observe the water using a hand lens or microscope.

2.Explain to the students that they will investigate what happens when nutrients, in the form of fertilizer, are added to aquatic ecosystems. Most students will be familiar with the word “fertilizer” from the story, *Mystery of the Muddled Marsh*. Make sure that they understand that fertilizer has good applications and that it can be very important for food production.

3.Show the chemical fertilizer and fish food to the class. Help the students understand that both substances will add nutrients to the water in the bottles.

4.Ask one student to add three drops of liquid fertilizer to the bottle labeled “C,” and another student to add a large pinch of fish food to the bottle labeled “N.” Have students predict what will happen in each bottle over the course of the next week. The bottles should be kept in a bright window or under bright fluorescent lights.

Session 3: Looking at results

1.Have students observe the bottles every day and write or draw their observations on their student sheets.

2.After about a week, have students discuss their results within small groups. Have them compare the appearance of the three bottles. Ask, *Which bottle has the cloudiest water? Which bottle has the clearest water?* Students also may be able to observe differences in water color and/or the amount of organisms in their bottles. Older students may want to compare the amount of organisms in a drop of water from each bottle. In general, expect the bottles with chemical and natural fertilizers to grow more algae and other microorganisms. Given enough time, these cultures may turn brown and develop a foul smell.

3.Discuss the results with the class. Ask, *What happened when we added more nutrients to the water in the bottle? What do you think will happen if we continue to add more nutrients to the bottles?* Help the students make extensions to other situations by asking, *What can we do to reduce the amount of fertilizer that washes into lakes and streams? What would happen if no one used fertilizers at all? Can you think of ways we can use the fertilizer we need to grow food without polluting our waterways?*

Note

Eutrophication is when large amounts of nutrients are present in lakes, streams or the ocean. Algae and other microscopic organisms may grow so abundantly that they choke out other water life. The algal growth blocks sunlight. This causes underwater plants, which provide food and shelter for many animals, to die. In addition, when the algae begin to die and decompose, dissolved oxygen needed by fish and other animals is used up. This process occurs naturally over hundreds or thousands of years in some aquatic ecosystems. However, human activities accelerate eutrophication by increasing the rate at which nutrients enter bodies of water. In the image shown on the slide, eutrification has occurred in the waters of Lake Maracaibo, Venezuela.

Reference

Moreno, N., Tharp, B., and Dresden, J. (2011) *The Science of Water Teacher's Guide*. Baylor College of Medicine: Houston. ISBN: 978-1-888997-61-3.

Image Reference

Photo courtesy of Wilfredo R. Rodriguez H.

Key words

lesson, environmental science, health, water, water cycle, precipitation, transpiration, evaporation, ground water, ocean, lake, river, chromatography, eutrification, pollution, water supply, fertilizer, conservation, preserving, preserve, dehydration, dehydrating, part per million, ppm, concentration, dissolve, solution, contaminant, non-point pollution, mining, oil, oil spill, water supply, water source, ground water, pesticide, algae, green algae, hay infusion,

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Why Is Water So Important?

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Why Is Water So Important? (post-assessment)

Complete instructions for conducting activities in this slide set, including materials needed, setup instructions, student sheets (in English and in Spanish), answer keys and extensions, can be found in *The Science of Water Teacher's Guide*, which is available free-of-charge at: http://www.bioedonline.org/lessons-and-more/teacher-guides/water/.

Background

Water is essential for all life on our planet. People need water every day to keep their bodies healthy and clean, and to do many other things.

Water has many uses for individuals and the community—from brushing teeth, to washing dishes, running automobiles, growing vegetables, manufacturing paper and machinery, and generating electricity. We even use water for recreation! However, while Earth's population and the demand for water continue to grow, the planet's supply of usable fresh water remains fixed. So we must use water wisely.

Water constantly is used and reused as it is circulates through the natural water cycle.

Unfortunately, the same unique properties that make water vital for all life also make it susceptible to contamination. Nutrients, soils and sediments, chemicals, heavy metals and disease-causing organisms all can be dissolved in, or mixed with water through human activities. Pollution from these sources can harm human health and cause irreparable damage to valuable ecosystems. The best way to keep water supplies clean is through prevention.

In this activity, students will review (individually or collectively) the role of water in their lives and reach some conclusions regarding the importance of clean water to human health.

Procedure

1.For the post-assessment, lead a class discussion of water pollution and the importance of water to health. Have the students suggest different ways in which water impacts human health (both positive and negative). List their suggestions on the board or on an overhead projector.

2.Explain to students that they will be drawing (or, with older students, writing about) what they consider the most important aspects of water for health. Explain that they may consider anything they have learned over the course of the unit, and that they may include both negative and positive impacts of water and water pollution on health.

3.Have students fold a sheet of paper into fourths and draw an important health-related aspect of water in each box. Have older students also write a sentence or paragraph explaining the significance of each drawing. If students have kept journals through the entire unit, their new drawings and paragraphs can be added to the journals.

OR

Have the students work in groups. Give each group a large piece of butcher paper and let students divide it into four sections. Have groups decide on the uses of water they will depict in their “water and health murals.”

4.Display the drawings or murals around the classroom. Let each student or group share their work with the rest of the class.

5. Distribute a copy of the post-assessment to each student. Have students complete the assessment individually or within their groups.

6.Give each student his or her completed pre-assessment from Activity 1. Ask, *Did your answers to some of the questions change?* Have each student identify any question(s) that he or she answered differently on the post-assessment, and write one or two sentences explaining why he or she selected the different answer.

Reference

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Image Reference

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Key Words

lesson, life science, physical science, environmental science, health, water, water molecule, three states of water, properties of water, polarity, water cycle, hydrologic cycle, precipitation, condensation, transpiration, evaporation, ground water, ocean, lake, river, kidney, excretion, dehydrate, dehydration, chromatography, eutrification, pollution, water supply, fertilizer, conservation, preserving, preserve, dehydration, dehydrating, part per million, ppm, concentration, dissolve, solution, contaminant, non-point pollution, mining, oil, oil spill, water supply, water source, water supplies, ground water, pesticide, algae, green algae, hay infusion,

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