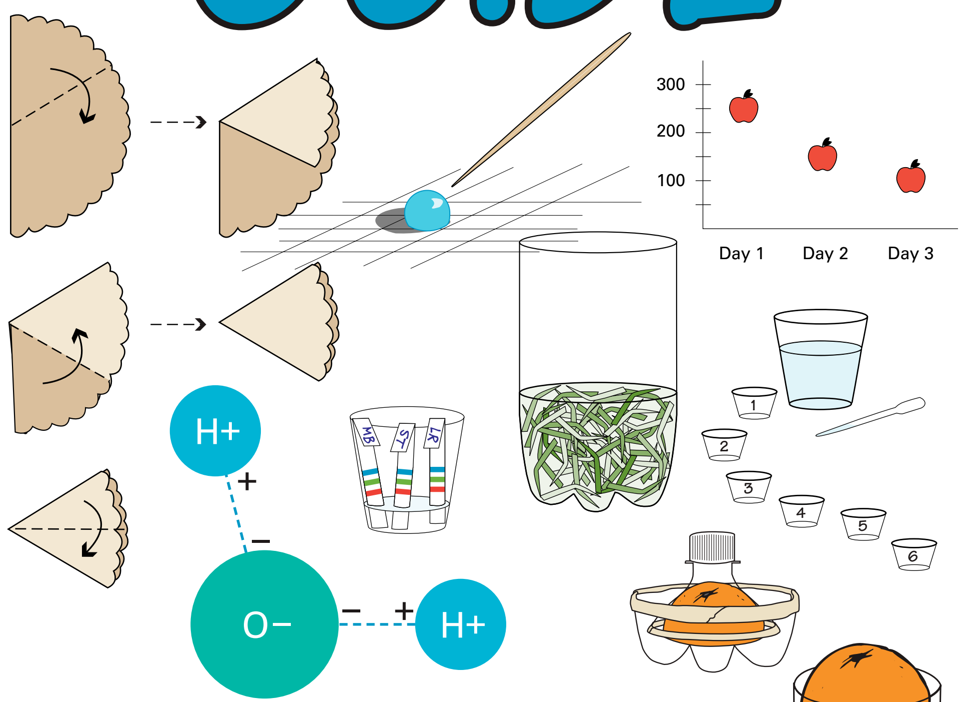
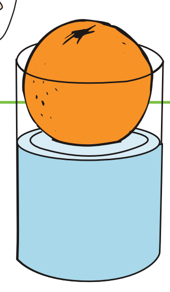
THE SCIENCE OF
Water

TEACHER'S GUIDE





Written by
Nancy P. Moreno Ph.D.
Barbara Z. Tharp, M.S.
Judith Dresden, M.S.

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Baylor College *of* Medicine

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BioEd[SM]

Teacher Resources from the
Center for Educational Outreach at
Baylor College of Medicine

Third edition. First edition published 1997.
Printed in the United States of America

ISBN: 978-1-888997-61-3

BioEd℠

Teacher Resources from the Center for Educational Outreach at Baylor College of Medicine.

Development of this unit was supported, in part, by grant numbers R25 ES06932 and R25 ES010698 from the National Institute of Environmental Health Sciences (NIEHS) of the National Institutes of Health (NIH). The opinions, findings and conclusions expressed in this publication are solely those of the authors and do not necessarily reflect the official views of Baylor College of Medicine, NIEHS or NIH.

Authors: Nancy P. Moreno, Ph.D., Barbara Z. Tharp, M.S., and Judith H. Dresden, M.S.
Editors: James P. Denk, M.A., and Paula H. Cutler, B.S.
Designer: Martha S. Young, B.F.A.

ACKNOWLEDGMENTS

The Science of Water educational materials, first developed as part of the My Health My World® project at Baylor College of Medicine, have benefited from the vision and expertise of scientists and educators representing a wide range of specialties. Our heartfelt appreciation goes to Michael Lieberman, M.D., Ph.D., William A. Thomson, Ph.D., and Carlos Vallbona, M.D., who have lent their support and expertise to the project.

Special acknowledgment is due to our original partners in this project, the Texas Medical Association and the American Physiological Society (APS). We especially thank Marsha Lakes Matyas, Ph.D., of APS, for her direction of field test activities and ongoing collaboration.

Several colleagues provided valuable assistance during the development of this guide. In particular, we would like to thank Cassius Bordelon, Ph.D.; Zenaido Camacho, Ph.D.; Ronald Sass, Ph.D.; Saundra Saunders, M.A.; Linda Thomson, M.A.; Cathey Whitener, M.S.; Ellison Wittels, M.D.; and Rosa Maria Ynfante, B.S.

Special thanks go to the National Institute of Environmental Health Sciences, Allen Dearry, Ph.D., Frederick Tyson, Ph.D., and Liam O'Fallon for their support of the My Health My World project and the related Environment as a Context for Opportunities in Schools (ECOS) project.

We are especially grateful to the many classroom teachers in Washington, D.C., and Houston and Austin, Texas, who participated in the field tests of these materials and provided invaluable feedback.

BCM
Baylor College *of* Medicine

Center for Educational Outreach
Baylor College of Medicine
One Baylor Plaza, BCM411
Houston, Texas 77030
713-798-8200 | 800-798-8244 | edoutreach@bcm.edu
www.bcm.edu/edoutreach | www.bioedonline.org | www.k8science.org

SOURCE URLS

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Contents

THE SCIENCE OF WATER

The Science of Water Teacher's Guide may be used alone. It also is integrated with the following Water unit components.

- *Mystery of the Muddled Marsh* (illustrated adventure story)
- *Explorations* (in class or take home magazine)
- *The Reading Link* (black-line masters for reading and language arts connections)
- *The Math Link* (black-line masters for mathematics connections)

TEACHER RESOURCES

Downloadable lessons and supplemental materials in PDF format, annotated slide sets for classroom use, streaming video lesson demonstrations, and other useful resources are available free at K8 Science (www.k8science.org).

WHERE DO I BEGIN?

The Science of Water Teacher's Guide may be used as a stand-alone set of science lessons. However, the other unit components are designed to be used with the guide to introduce and reinforce important concepts for students. To begin The Science of Water unit, some teachers prefer to generate interest by reading part or all of the student story. Others use the cover of the mini-magazine as a way to build student enthusiasm and introduce the unit. Still others begin with the preassessment lesson in the guide.

If this is your first unit, you may want to use the Sequence Guide on the following page to integrate three of the Water unit components into your schedule. When teaching for 45 to 60 minutes daily, most teachers will complete the unit with their students in two to three weeks. If you use the unit every other day or once per week, it will take from three to nine weeks to complete, depending on the amount of time you spend on each session.

The Science of Water Teacher's Guide provides background information for you, the teacher, at the beginning of each activity. In addition, a listing of required materials, estimates of time needed to conduct activities, and links to other components of the unit are given as aids for planning. Questioning strategies, follow-up activities and appropriate treatments for student-generated data also are provided. Student pages are provided in English and in Spanish. The first and final activities in the teacher's guide are appropriate for assessing student mastery of concepts.

ABOUT THIS UNIT

The Science of Water's exciting activities, explorations and adventures provide students, teachers and parents with science teaching materials integrated across the curriculum. Prepared by teams of educators, scientists and health specialists, each unit focuses on a different physical and life science theme. The inquiry-based, discovery-oriented approach of the materials is aligned with National Science Education Standards and National Health Education Standards.

The integrated components of the Water unit help students understand important science, health and environmental concepts related to water.

- ***The Science of Water Teacher's Guide*** provides inquiry-based lessons that entice students to discover concepts in science, mathematics and health through hands-on activities.
- ***Mystery of the Muddled Marsh***, the student storybook, presents an engaging mystery adventure (about cousins Riff and Rosie) in an illustrated format that also teaches science and health concepts.
- ***Explorations*** is colorful magazine, full of activities, information and fun things for children and adults to try in class or at home.
- ***The Reading Link*** provides language arts activities related to the story.
- ***The Math Link*** extends each unit by connecting the story and hands-on science activities to mathematics skill-building and critical thinking exercises.

The Science of Water unit offers flexibility and versatility, and is adaptable to a variety of grade levels and teaching and learning styles.

USING THE UNIT AT THE K-1 LEVEL

The Science of Water unit easily can be adapted for use with younger students. To begin, introduce students to the main characters in the storybook, *Mystery of the Muddled Marsh*. Then read the beginning of the story to students. Demonstrate the activity in the back of the storybook and help students do the paper-folding activity themselves.

Each story session should cover only about five pages of the book, accompanied by science concepts. The *Explorations* mini-magazine also is an appropriate teaching tool. With very young children, it may be more fitting to conduct some of the activities as teacher demonstrations, unless you have several helpers to assist with the hands-on activities.

Sequence Guide

The Science of Water unit components can be used together in many ways. If you have never used integrated materials before, the chart below may help you coordinate the activities with the Water unit's student storybook, *Mystery of the Muddled Marsh*, and the *Explorations* magazine. Similar information is provided in the "Unit Links" section of each activity in this book.

Additional classroom materials for the Water unit, including *The Math Link* and *The Reading Link* (pdf format), annotated slide sets for classroom use, streaming video lesson demonstrations, and other useful resources are available free at K8 Science (www.k8science.org).

The Science of Water activities are designed to be conducted by students working in collaborative groups. Assign the following roles to group members.

- **Principal Investigator:** Asks others to help, asks questions
- **Materials Manager:** Collects materials, helps the Principal Investigator
- **Recorder:** Writes or draws results, tells teacher when the group is done
- **Safety Scientist:** Follows the safety rules, directs clean-up

ACTIVITY	CONCEPTS	CLASS PERIODS TO COMPLETE	LINKS TO OTHER COMPONENTS OF UNIT	
			Mystery of the Muddled Marsh	*Explorations*
Why Is Water Important?	There is much to learn about water.	1		
What Makes Water Special?	Water molecules have special properties.	2	Story, pp. 1–4; Activity, pp. 32–33	Falling Water, p. 3
What Dissolves in Water?	Some substances dissolve in water.	1	Story, pp. 4–9	The Great Dissolver, p. 4
What Is the Water Cycle?	Water circulates among three states (solid, liquid, gas) in the water cycle.	2	Story, pp. 10–13; Science box, p. 3	What Am I? p. 5
How Do We Use Water?	Water has many uses important for health.	2	Story, pp. 13–17; Science box, p. 7	Cover activity; Not Such a New Issue, p. 5
How Much Water Is in a Fruit?	Water is in all foods.	1 or 2	Story, pp. 18–22	Water in Your Body, p. 8
How Much Water Do Humans Need?	Our bodies take in and release water.	1	Story, pp. 23–25; Science boxes, pp. 5 and 14	Intestine puzzle, p. 4
What Is a One Part Per Million Solution?	Tiny amounts of substances can be dissolved in water without being visible.	1	Story, pp. 26–31	Let's Talk About Water and Health, pp. 2–3
How Can We Find Out What Is in Water?	Many different substances can be dissolved in water at the same time.	1	Science boxes, pp. 17 and 24	Riff and Rosie Talk to Ms. Linda Holman, p. 7
Can Nutrients in Water Cause Harm?	Non-point source pollution is a threat to water resources.	3	Science boxes, pp. 10 and 21	We Can Make a Difference! p. 6
Why Is Water So Important?	Summary and Post-assessment activity.	1	Science boxes, pp. 3, 5 and 7	Cover; Tips for Healthy Living, p. 3

Materials

You will need the following materials and consumable supplies to teach this unit to 24 students working in six cooperative groups. See Setup sections within each activity for alternatives or specifics.

ACTIVITY 1 (p. 1)
Colored markers, pencils or pens

ACTIVITY 2 (p. 6)
48 colored toothpicks (see SETUP)
24 cups, 9-oz clear plastic (12 for oil, 12 for water)
24 hand lenses (or magnifiers)
24 pipets or droppers
12 sheets of cm graph paper, cut in half (8-1/2 in. x 5-1/2 in.)
6 bottles of food coloring (one color per group)
6 sets of two crayons, colored pencils or markers (one color per set to match food coloring)
Bottle of clear oil (baby, cooking, or mineral)
Roll of paper towel
Roll of wax paper
Water

ACTIVITY 3 (p. 10)
36 cups, 9-oz clear plastic
36 cups, 2-oz plastic, or bottle caps
36 spoons or coffee stirrers
6 beakers, 100–250 mL cap
6 tsp of clear oil (cooking, mineral or baby)
6 tsp of diluted food coloring
6 tsp of flour
6 tsp of ground coffee (not instant)
6 tsp of salt
6 tsp of sugar
Water

ACTIVITY 4 (p. 14)
120 ice cubes (approx.)
24 sheets of drawing paper
12 cups of sand
6 measuring cups, 8-oz size
6 rubber bands (large, 7 in. x 1/8 in.)
6 shoeboxes (see SETUP)
Lamp with incandescent bulb if sunny window is not available
Roll of aluminum foil
Roll of plastic wrap

ACTIVITY 5 (p. 20)
No consumable supplies needed.

ACTIVITY 6 (p. 24)
4,800 mL water (800 mL in each of 6 containers)
24 hand lenses (or magnifiers)
6 apples
6 beakers, 1,000 mL (or clear plastic cups marked in mL)
6 beakers, 250 mL (or clear plastic cups marked in mL)
6 juicers (see SETUP to make your own)
6 jumbo plastic straws or 12 sheets of paper towel
6 oranges
6 plastic, serrated knives
Equal arm balance (1 per group if possible)
Interlocking 1-cm/1-g cubes (150 cubes, weight for balance)

ACTIVITY 7 (p. 29)
18,000 mL water (3,000 mL in each of 6 containers)
6 beakers, 1,000 mL cap (or clear plastic cups marked in mL)
6 plastic dishpans, 15 qt size, or tub with capacity of 3 liters
6 plastic funnels, 2 3/4 in.
6 plastic milk jugs, gal size
Plastic beaker with handle, 2,000-mL capacity

ACTIVITY 8 (p. 32)
250 mL of water
36 cups, 2-oz plastic, or chemical tray (see SETUP)
12 cups or beakers, 9-oz clear plastic
12 pipets or droppers
6 bottles of blue or red food coloring

ACTIVITY 9 (p. 36)
12 round white coffee filters
6 beakers, 250 mL (or clear plastic cups marked in mL)
12 metric rulers
12 pairs of scissors
Clear plastic cup, 9 oz
Food coloring: blue, green and red
Water

ACTIVITY 10 (p. 38)
3 clear soft drink bottles, 2 liter
Aquarium bottom, 1-1/2 gal size
Aquarium lid, 1-1/2 gal size
Gal of spring water (see SETUP)
Hay, 2-oz pkg (or dried grass)
Small container of fish food
Small container of liquid fertilizer

ACTIVITY 11 (p. 43)
24 sheets of drawing paper (or 6 large sheets of butcher paper)
Colored markers, pencils, pens, paints or crayons

Why Is Water Important?

1

Pre-assessment

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.

Photo © Brand X Pictures

SETUP

Have students work individually to complete the pre-assessment.

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 below).

VARIATIONS

Refer to Activity 11 instructions and have students prepare drawings and write about (depending on grade level) four of the most important aspects of water for health as a pre-assessment. Then, revisit the drawings at the end of the unit and have students expand their previous drawings or make new drawings to express what they have learned.

CONCEPTS

Allows teacher to estimate prior knowledge and misconceptions of students related to the role of water in their world.

OVERVIEW

Pre-assessment designed to use with students before beginning the unit. Can be revisited as part of Post-assessment.

SCIENCE, HEALTH & MATH SKILLS

- Asking questions
- Communicating

TIME

Preparation: 5 minutes
Class: 30–45 minutes

MATERIALS

Each student will need:

- Colored markers, pencils or pens
- Copy of "What Do You Know About Water?" page

IMAGE CITATIONS

Source URLs are available at the front of this guide.

PRE-ASSESSMENT ANSWER KEY

1.	c	6.	b
2.	a	7.	c
3.	b	8.	d
4.	d	9.	a
5.	a	10.	b

What Do You Know About Water?

Name ____

Please circle the letter beside the correct answer to each question below.

1. What makes water special?
   a. Dinosaurs drank it.
   b. It is clear.
   c. All living things need it.
   d. It evaporates.

2. Why are water drops round?
   a. Water likes to stick together.
   b. Water is slippery.
   c. Water is the same as oil.
   d. Water is wet.

3. Which of these is made mostly of water?
   a. Brick
   b. Orange
   c. Peanut
   d. Sweater

4. Which of these substances will dissolve in water?
   a. Wood
   b. Sand
   c. Flour
   d. Sugar

5. You might use which one of the following methods to investigate a mystery liquid?
   a. Chromatography
   b. Point source pollution
   c. Condensation
   d. Dissolving

6. What happens if too much fertilizer gets into a pond?
   a. Nothing
   b. Fish get sick.
   c. Fish get too big.
   d. The pond floods.

7. Where is most water absorbed into the rest of the body?
   a. Mouth
   b. Small intestine
   c. Large intestine
   d. Stomach

8. How much water should a person drink in one day?
   a. 2 glasses
   b. 4 glasses
   c. 6 glasses
   d. 8 glasses

9. Which of the following can cause water pollution?
   a. Lawn chemicals
   b. Groundwater
   c. Carbon dioxide
   d. Native plants

10. Which process is part of the water cycle?
   a. Sedimentation
   b. Condensation
   c. Transportation
   d. Aviation

¿Quanto sabes de agua?

Nombre ____

Haz un círculo alrededor de la letra de la respuesta correcta.

1. ¿Porque es especial el agua?
   a. Lo bebieron los dinosaurios.
   b. Es transparente.
   c. Todos los seres vivientes lo necesitan.
   d. Se evapora.

2. ¿Porque son redondas las gotas de agua?
   a. Les gusta estar pegadas unas a las otras.
   b. Son resbalosas.
   c. Son idénticas al aceite.
   d. Son húmedas.

3. ¿Cual de los siguientes se compone principalmente de agua?
   a. Un ladrillo
   b. Una naranja
   c. Un cacahuate
   d. Un sueter

4. ¿Cual de los siguientes puede disolverse en el agua?
   a. Madera
   b. Arena
   c. Harina
   d. Azúcar

5. ¿Que método podrías usar para investigar un líquido desconocido?
   a. La cromatografía
   b. La contaminación
   c. La condensación
   d. La disolución

6. ¿Que pasa si demasiados fertilizantes se disuelvan en un estanque?
   a. Nada.
   b. Los peces se enferman.
   c. Los peces crecen mucho.
   d. El estanque se inunde.

7. ¿Donde se absorbe la mayoría del agua en el cuerpo humano?
   a. La boca
   b. El intestino delgado
   c. El intestino grueso
   d. El estómago

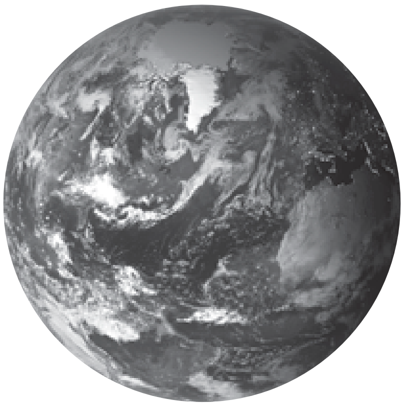
8. ¿Que cantidad de agua debe tomarse en un día?
   a. Dos vasos de agua
   b. Cuatro vasos de agua
   c. Seis vasos de agua
   d. Ocho vasos de agua

9. ¿Cual de los siguientes contribuye a la contaminación del agua?
   a. Productos químicos para el jardín
   b. El agua bajo la tierra
   c. El dióxido de carbono
   d. Las plantas nativas

10. ¿Cual proceso es parte del ciclo hidrológico?
    a. Sedimentación
    b. Condensación
    c. Transportación
    d. Aviación

Properties of Water

Physical Science Basics



In the water (hydrologic) cycle, individual water molecules travel as liquid water in the oceans, water vapor in the atmosphere, water and ice on the land, and underground water.

Source: NASA Earth Observatory.

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.

Water droplets on *Taraxacum officinale*, the common dandelion.

Composite image of Earth by Reto Stöckli, NASA Earth Observatory. Photo of *Tarasacum officinale* by Böhringer Friedrich, Wikimedia Creative Commons 2.5.

- **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.

Ice, liquid water and clouds at Lake Yellowstone, Teton County, Wyoming.

- **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.

Photo of Lake Yellowstone by J. Schmidt, National Park Service.

TEACHER RESOURCES

Downloadable activities in PDF format, annotated slide sets for classroom use, streaming video lesson demonstrations, and other resources are available free at www.k8science.org or www.bioedonline.org/.

2 What Makes Water Special?

Physical Science

CONCEPTS

- Polarity of the water molecule is responsible for the unique properties of water.

OVERVIEW

Students explore and compare some of the physical properties of water and oil.

SCIENCE, HEALTH & MATH SKILLS

- Predicting
- Making and recording observations
- Drawing conclusions

TIME

Preparation: 10 minutes
Class: One or two 30-minute sessions

MATERIALS

- Cup containing a small amount of water
- Cup containing a small amount of clear cooking oil (or mineral or baby oil)
- 2 pipets (or droppers)
- 4 toothpicks
- Food coloring (a few drops)
- Paper towel
- Overhead or document projector

Each student will need:

- Sheet of cm graph paper (approx. 8 1/2 in. x 5 1/2 in.)
- Sheet of wax paper to cover graph paper
- Hand lens (or magnifier)
- Crayon, colored pencil or marker to match the food coloring used
- Copy of "Do Your Liquids Behave?" page

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.

Unit Links

Mystery of the Muddled Marsh
Story, pp. 1–4; Activity, pp. 32–33

Explorations
Falling Water, p. 3

SETUP

This activity can be done in one or two class periods. Students should work in teams of two to share materials. Colored wooden toothpicks work best for this activity. If you prefer plain, wooden toothpicks, soak them in a glass of water for an hour or so before using them. (Dry, unvarnished toothpicks will absorb the water droplets.) Do not substitute plastic wrap for wax paper in this activity, as static charge on the sheets of plastic wrap may affect the behavior of the water drops. Resealable plastic bags may be substituted for the wax paper.

Cut the cm graph paper sheets in half.

Pour a small amount of water (Liquid 1) into 12 cups. Pour a small amount of clear cooking oil (or mineral or baby oil) into 12 cups (Liquid 2).

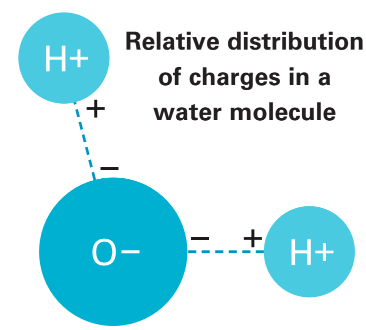
Each team will use one color of food coloring. Each team also will need a crayon, colored pencil or colored marker that matches the food coloring used.

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.

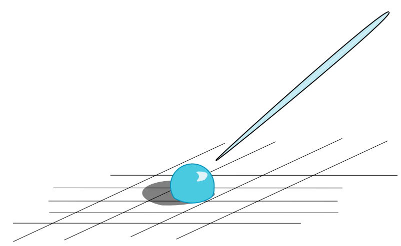
3. Have the Materials Managers collect the supplies from a central location. Each student should prepare a working surface by placing the wax paper over the graph paper.
4. Have the students practice making equal-sized drops of Liquid 1, sharing the dropper and using the graph paper as an approximate 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.



Relative distribution of charges in a water molecule

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?*



Students observe and compare the characteristics of drops of water and oil.

VARIATIONS

- Challenge students to use their toothpicks to push water drops (size of their choice) as quickly as possible from the top of the wax paper to the bottom. Ask, *What size drop moves fastest? Is there anything besides size that affects how fast a drop can be pushed?*
- Encourage students to consider other variables. For instance, what happens when they mix Liquid 1 and Liquid 2 together? What happens if food coloring is added to the mixture?
- Have students add a drop of liquid soap or detergent to a drop of water and observe what happens. (The soap decreases the attraction among water molecules, thereby causing the drop to spread out.)
- Make paper boats (see *Mystery of the Muddled Marsh*, pages 32–33). Use the activity as part of a mathematics lesson or a further exploration of the properties of waters.

Do Your Liquids Behave?

	Liquid 1	Liquid 2
Draw a drop from the top.		
Draw a drop from the side.		
Write three words that describe the drop.	______ ______ ______	______ ______ ______
Draw a split drop.		
Draw the joined drops.		
Draw the colored drops.		

In what ways were the drops the same? ______________________________

____

In what ways were the drops different? ______________________________

____

¿Como se comportan los líquidos?

2

	Líquido 1	Líquido 2
Dibuja una gota vista desde arriba.		
Dibuja una gota vista desde un lado.		
Escribe tres palabras que describan una gota.	______ ______ ______	______ ______ ______
Dibuja la gota partida.		
Dibuja las gotas unidas.		
Dibuja las gotas con colorante.		

¿En que se parecen las gotas? ____________________

____

¿En que se diferencian las gotas? ____________________

____

3 What Dissolves in Water?

Physical Science

CONCEPTS

- Some liquids and solids will dissolve in water.
- Substances dissolved in water sometimes are invisible.

OVERVIEW

Students investigate whether several common substances are soluble in water.

SCIENCE, HEALTH & MATH SKILLS

- Predicting
- Making and recording observations
- Measuring
- Drawing conclusions

TIME

Preparation: 10 minutes
Class: 30 minutes

MATERIALS

Each group will need:

- 6 cups, 9-oz clear plastic
- 6 cups, 2-oz clear plastic (or bottle caps)
- 6 spoons (or coffee stirrers)
- Beaker, 100–250 mL
- Tsp each of salt, sugar, flour, oil (clear), diluted food coloring and ground coffee (not instant)
- Water
- Copy of "Disappearing Act—My Observations" page

When one substance becomes dissolved in another, the atoms or molecules of each substance are mixed evenly together.

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.

Unit Links

Mystery of the Muddled Marsh
Story, pp. 4–9

Explorations
The Great Dissolver, p. 4

SETUP

Before beginning, prepare a dilute solution of food coloring by adding several drops of any color to a glass of water. This will be one of the substances tested in this activity.

Set all the materials in a central area. Students should work in groups of four.

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 "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?*

VARIATIONS

- Create filtering cups by punching holes in the bottoms of disposable cups. Line the cups with coffee filters or paper towels. Have the student groups pour the contents of each cup used for the activity through the filtering cups and report the results.

Substances like alcohol that dissolve easily in water are called hydrophilic, from the Greek words *hydro-* (water) and *-philos* (loving).

COLLOIDS

When fine particles are dispersed throughout another substance, the mixture is called a colloid. The particles in a colloid usually are greater in size than those in a solution. The easiest way to tell a colloid from a true solution is to shine a light through the mixture. The beam of light will pass through a solution (such as salt mixed in water) without any visible effect. But when light is shone through a colloid (such as a mixture of flour and water), the beam's path will be illuminated clearly.

There are different kinds of colloids. A sol is a solid dispersed in a liquid. An aerosol is a solid or liquid in a gas (fog is an aerosol). An emulsion is small globules of one liquid in a second liquid, and a foam is gas bubbles in a liquid or a solid.

Disappearing Act — My Observations

Substance	What do you think will happen?		Describe what happened.
Salt		→	
Sugar		→	
Flour		→	
Oil		→	
Food Coloring		→	
Coffee		→	

Acto de desaparición—Mis observaciones

3

Sustancia	¿Qué piensas que va a pasar?		Escribe lo que pasó.
Sal		→	
Azucar		→	
Harina		→	
Aceite		→	
Colorante		→	
Café		→	

What Is the Water Cycle?

4

Physical Science

CONCEPTS

- Water can be found naturally as a solid, a liquid and a gas on Earth.
- Water circulates among these three states in the water cycle.

OVERVIEW

Students create a simple model of the water cycle.

SCIENCE, HEALTH & MATH SKILLS

- Predicting
- Making and recording observations
- Measuring
- Drawing conclusions

TIME

Preparation: 10 minutes
Class: 30 minutes to set up; 30 minutes to observe and draw conclusions

MATERIALS

Each group will need:

- 20 ice cubes
- 2 cups of sand
- Shoebox (see SETUP for alternative)
- Aluminum foil (to line the bottom and sides of the shoebox)
- Plastic wrap (to cover the top of the shoebox)
- Large rubber band, about 7 in. x 1/8 in. (to secure the plastic wrap)
- Measuring cup, 8 oz
- Lamp with incandescent bulb if sunny window is not available
- Copy of "The Water Cycle" page

Each student will need:

- Sheet of drawing paper

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.

Unit Links

Mystery of the Muddled Marsh
Story, pp. 10–13;
Science box, p. 3

Explorations
What Am I?, p. 5

SETUP

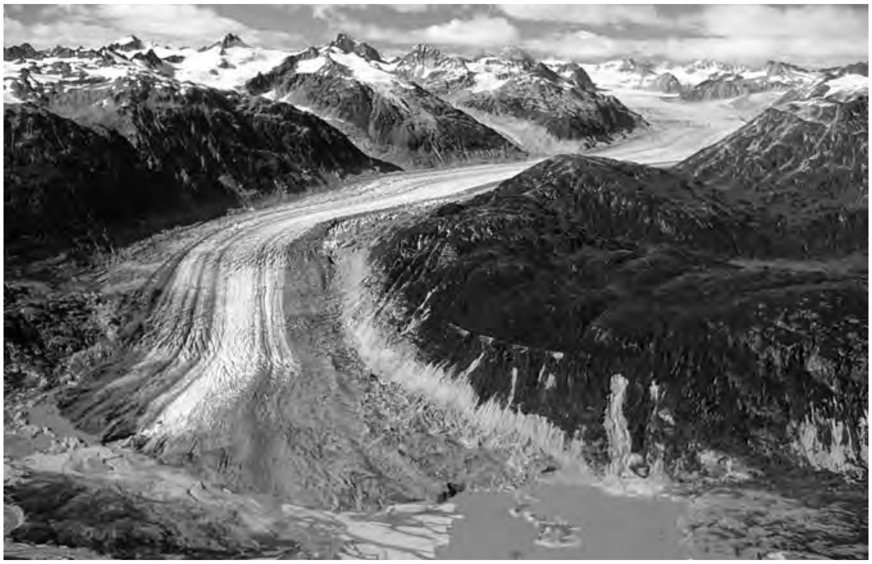
Place a container of sand in a central area, so that groups may measure out the quantities they need. As an alternative to shoeboxes, aluminum foil and plastic wrap, students may use plastic boxes with clear covers.

Have students work in groups of four.

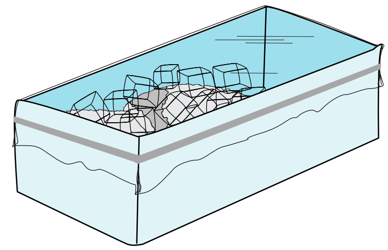
PROCEDURE

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



Aerial photo of the retreating Tanaina Glacier and the recently re-formed Summit Lake in Alaska. The lake is dammed by sediment and an ice-cored moraine left by the retreat of the glacier.



Students create a model of the water cycle by placing ice cubes over a mound of sand within a closed container.

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.
8. 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.

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. *What happened to the ice cubes? What else is*

Continued

TRANSPIRATION

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.

Photo of Tanaina Glacier by William R. Reckert, U.S. Geological Survey.

Most snowflakes are hexagon-shaped. This six-sided arrangement actually reflects the arrangement of water molecules inside the crystals of snow. Each snowflake contains approximately 10^{16}, or 10,000,000,000,000,000 water molecules! (See "How Can We Find Out What Is in Water?" p. 37).

QUESTIONS FOR STUDENTS TO THINK ABOUT

- 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?
- When water evaporates, any substances that had been dissolved in the water are left behind. What eventually happens to manufactured chemicals that have been mixed into water? How could this be avoided?

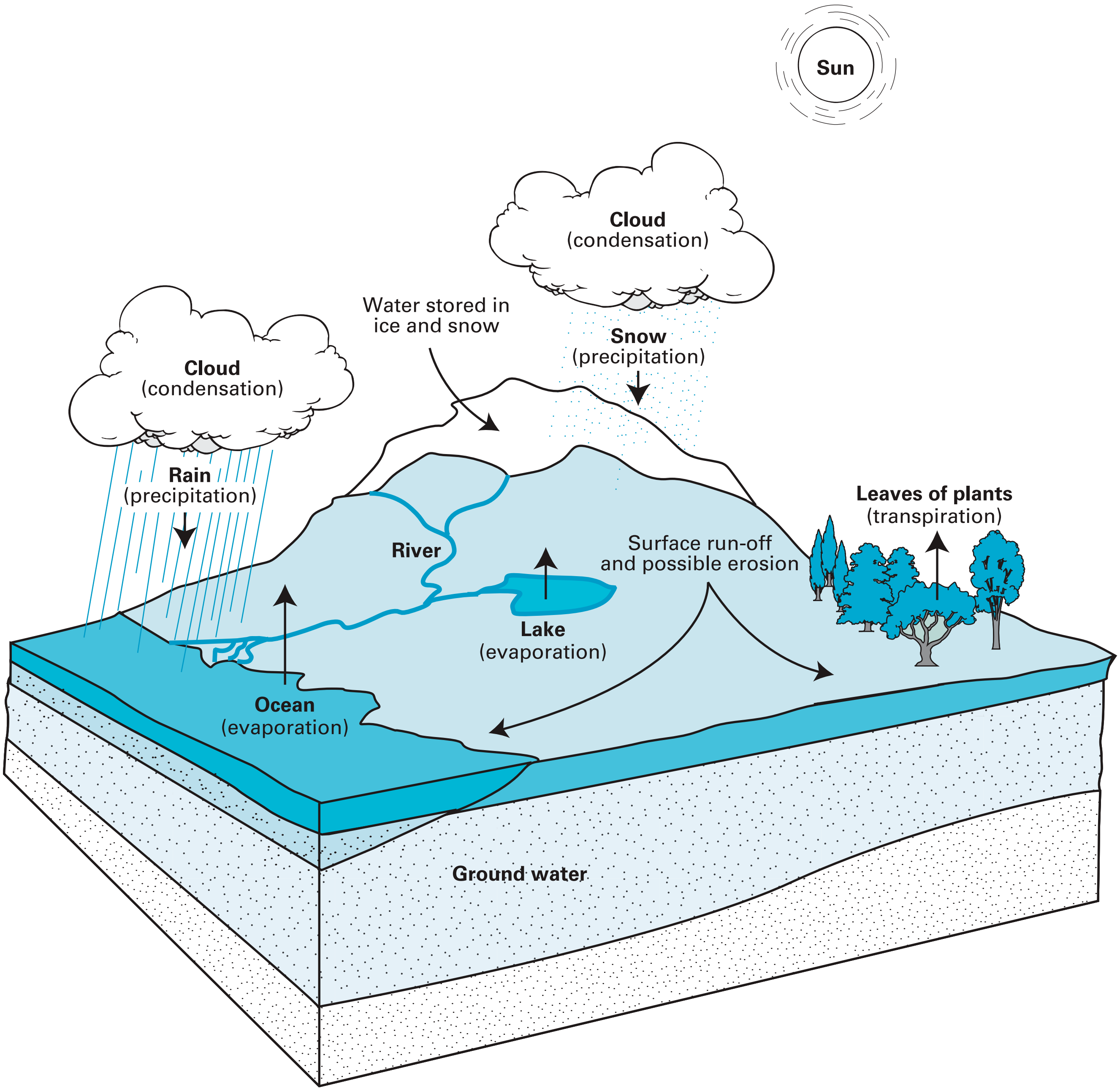
different about the inside of the box? In most cases, at least a few drops of water will have condensed on the inside of the covering. Ask, *Where did the drops of water come from?*

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.

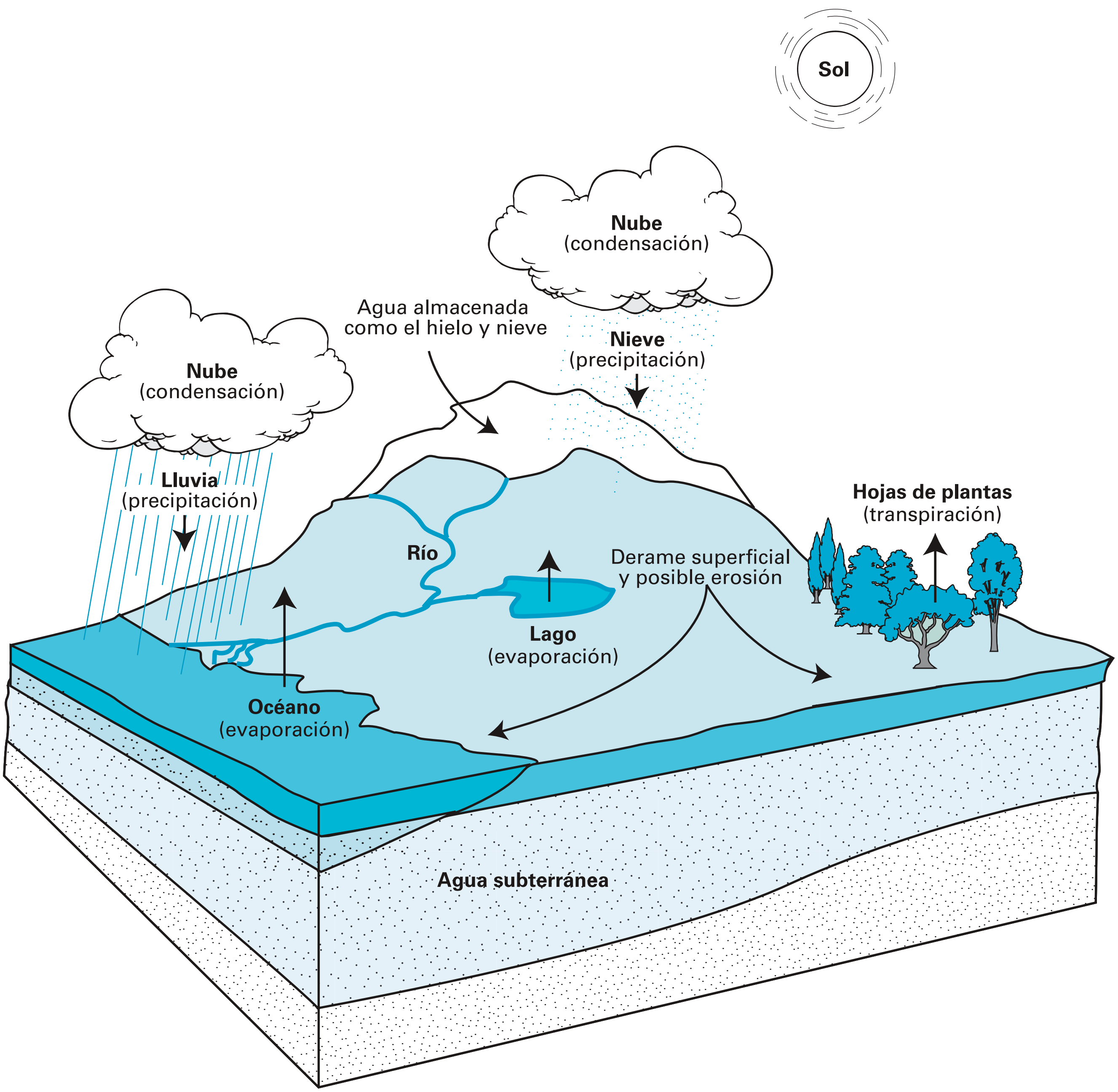
VARIATIONS

- Have students design experiments to learn what happens to chemicals in soil by placing drops of food coloring on the sand in the shoeboxes before adding the ice cubes. Ask students to note where the colors end up in the system.
- A limited version of this activity can be conducted using plastic resealable bags. Add small amounts of sand and ice to each bag, then tape the bags to a window.
- Provide an opportunity for students to observe water transport within plants. Place a stalk of celery in a container of water with a few drops of food coloring. The colored water will travel up through the water-conducting tissue in the stalk into the leaves.

The Water Cycle



El ciclo del agua

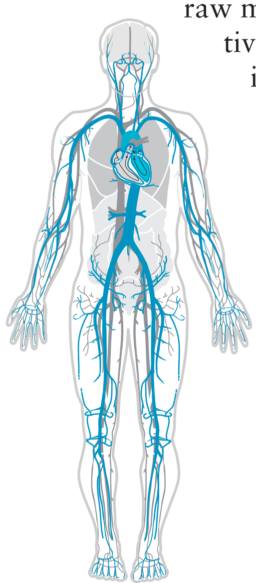


Water in Our Bodies

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.

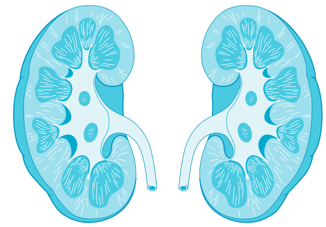


Human circulatory system

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.

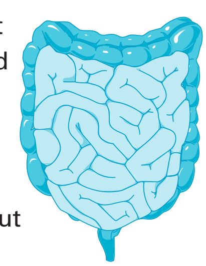
Vertebrates take in water and food through the mouth. Materials reach the stomach, where food is mixed and broken up. Food exits the stomach as a soupy mixture, which passes into the small intestine, where most digestion and absorption of nutrients occurs. Most food molecules must be broken down into 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.



The kidneys filter more than 170 liters of liquid each day. Imagine how many glasses of water this represents!

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.



The small intestine of an adult human is about 23 feet long and about an inch in diameter.

The large intestine is about 5 feet long and about 3 inches in diameter.

5 How Do We Use Water?

Life Science

CONCEPTS

- We use water in many ways each day.
- Some ways in which we use water are not essential for life.

OVERVIEW

Students keep a personal Water Use Journal for a day to become aware of the ways in which they use water.

SCIENCE, HEALTH & MATH SKILLS

- Making and recording observations
- Collecting data
- Drawing conclusions

TIME

Preparation: 10 minutes
Class: 30 minutes to set up; two 30-minute sessions on successive days

MATERIALS

Each student will need:

- Copy of "Water Use Journal" page

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.

Unit Links

Mystery of the Muddled Marsh
Story, pp. 13–17;
Science box, p. 7

Explorations
Cover activity; Not Such a New Issue, p. 5

SETUP

This activity will take place over at least two class periods. On Day 1, students will take their journal sheets home to record their uses of water. Classroom activities on Day 2 may be conducted with the whole class or with students in smaller groups.

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 next 24 hours. Stress that each student should record only his or her own uses of water.

TYPICAL AMOUNTS OF WATER USED IN AMERICAN HOMES

AMOUNT	ACTIVITY
2 gallons	Brush teeth
2 gallons	Run faucet until water is cold
2–7 gallons	Flush toilet
12–20 gallons	Run dishwasher
50 gallons	Run clothes washer
25–50 gallons	Take a 10 minute shower
25–50 gallons	Fill bathtub
50 gallons	Run garden hose for 5 minutes

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

3. 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.

WATER USE FACTS

- 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.

Water Use Journal

Name ________________________________

Day of Observations ________________________

These are the ways I used water.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________
11. ____________________
12. ____________________
13. ____________________
14. ____________________
15. ____________________
16. ____________________
17. ____________________
18. ____________________
19. ____________________
20. ____________________

Diario de uso de agua

5

Nombre ______________________________

Fecha de las observaciones ______________________________

Usé el agua para:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________
11. ______________________________
12. ______________________________
13. ______________________________
14. ______________________________
15. ______________________________
16. ______________________________
17. ______________________________
18. ______________________________
19. ______________________________
20. ______________________________

6 How Much Water Is in a Fruit?

Life Science

CONCEPTS

- Water is a major component of most foods.

OVERVIEW

Students investigate the amount of water in an orange and an apple.

SCIENCE, HEALTH & MATH SKILLS

- Making and recording observations
- Weighing
- Measuring volume
- Estimating
- Predicting

TIME

Preparation: 10 minutes
Class: two 30-minute sessions

MATERIALS

- Equal arm balance (1 per group if possible)
- Interlocking 1-cm/1-g cubes (weight for balance)

Each group will need:

- Beaker, 1,000-mL (or clear plastic cup calibrated in milliliters)
- Beaker, 250-mL (or clear cup calibrated in mL)
- Drinking straw (or 2 sheets of paper towel)
- Hand lenses (magnifiers)
- Juicer (see SETUP)
- Plastic serrated knife
- Apple
- Orange
- Water
- Copy of "How Much Juice Is in an Orange" page

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.

> **Unit Links**
>
> ***Mystery of the Muddled Marsh***
> Story, pp. 18–22
>
> ***Explorations***
> Water in Your Body, p. 8

SETUP

You will need a juicer for each group of students. If commercial juicers are not available, make your own by combining the top and bottom pieces of a 2-liter soft drink bottle (see sidebar, p. 25).

This activity will take at least two periods and may be extended to three. It should be conducted with groups of four students.

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.

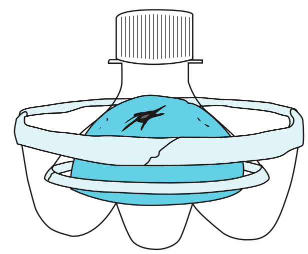
3. On the board, subtract the original volume of water in the container from the volume in the container after the orange was added. Calculate and record the difference. Ask, *What does the difference represent?* (A standard juice orange will displace about 140–150 mL and will yield 40–50 mL of squeezed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

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 (see illustration, right). 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

Continued

The ancient Greek scientist, Archimedes, was the first to note that a submerged object displaces an amount of water equal to its own volume.



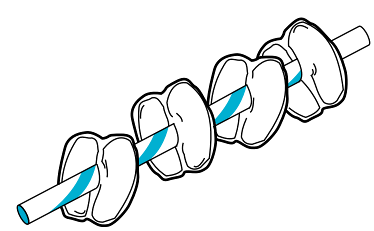
Juicer made from top and bottom parts of a 2-liter plastic soft drink bottle.

Safety note: Cover sharp edges with masking tape.

WHAT IS VOLUME?

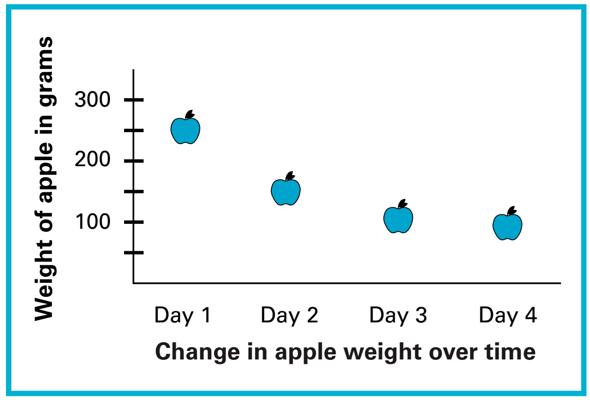
Volume is a measure of three-dimensional space that is occupied by an object or a substance.

The capacity of a container refers to the volume of material that the container can hold.



Students use a plastic straw as a skewer for apple slices.

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.

QUESTIONS FOR STUDENTS TO THINK ABOUT

In this activity, water is measured in two ways: by volume and by weight.

- Which of these two measures is used most commonly for liquids? Why do you think so?
- Can you find a way to convert a measure of volume to a measure of weight, or vice versa?

VARIATIONS

- Students also may want to compare weight (mass) differences between raisins and grapes, dehydrated potatoes slices (packaged potato casserole mixes) and fresh potato slices, banana chips and fresh slices of banana, beef jerky and strips of raw beef, or dried peas and fresh peas.
- Approximately 70%, or 7/10, of the human body consists of water. Have students use the following formula to calculate approximately how much of their own weight is water.

---

1. Your weight × 7 =
2. Value from Step 1 ÷ 10 = approximate amount of water in body.

OR

1. Count out the number of snap-together math cubes equal to your weight (i.e., 45 lb = 45 cubes).
2. Separate the cubes into 10 equal groups.
3. Place 7 groups in one set and 3 in another.
4. The largest set represents the portion of your body that is water.

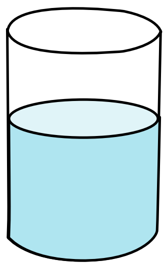
- Have students estimate the volume of water in their bodies (1 lb of water represents approximately 2 cups).

How Much Juice Is in an Orange?

6

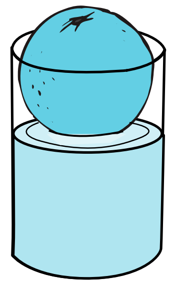
We usually measure liquids in milliliters. We also can use milliliters to measure how much space something takes up (volume).

1



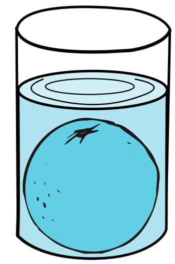
Fill a container with 800 mL of water.

2



Carefully place an orange in the container. Did the water go up or down?

3



Now, push the orange under the water and hold it there. What happened to the water?

How many milliliters are in the container now? ____________ mL

What was the change, in milliliters, from figure 1 to figure 3? ____________ mL

ESTIMATE
How much of the orange is juice? Write your estimate in milliliters. ____________ mL

DO
Squeeze the juice from the orange and measure it. How many milliliters of juice did you get? ____________ mL

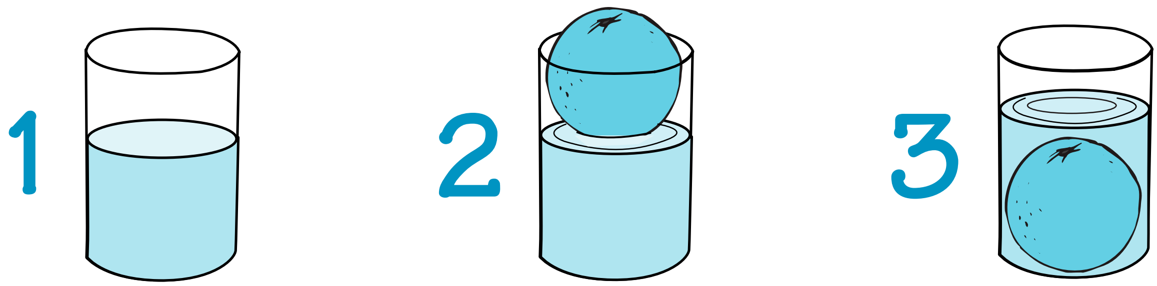
COMPARE
Compare your original estimate with the actual amount of juice you measured. Did you estimate more or less juice than the amount you found? ________________ What is the difference? ____________ mL

What is left of the orange? ____

Measure the leftover pieces of orange by putting them into the container of water and recording the change in volume. How many milliliters did the water level go up? ____________ mL

¿Cuánto jugo tiene una naranja?

Generalmente medimos los líquidos en mililitros. También podemos usar mililitros para medir el espacio ocupado por un objeto (el volumen).



Llena un envase con 800 mL de agua.

Con mucho cuidado, mete una naranja en el envase. ¿Subío o bajó el nivel del agua?

Ahora, empuja la naranja hacia abajo del agua y detenla allí. ¿Quele pasó al nivel del agua?

¿Cuantos mililitros hay en el envase? ____________ mL

¿Cuantos mililitros cambió el nivel del agua de figura 1 a figura 3? ____________ mL

ESTIMAR
¿Qué tanto de la naranja es jugo? Escribe tu estimación en mililitros. ____________ mL

HACER
Exprime todo el jugo que puedas de la naranja. ¿Cuantos mililitros de jugo obtuviste? ____________ mL

COMPARAR
Compara tu estimación con la cantidad de jugo que obtuviste. ¿Hubo más o menos jugo de lo que estimaste? ________________ ¿Cuanto es la diferencia? ____________ mL

¿Qué quedó de la naranja? ____

Ahora, puedes medir el volumen de los pedazos restantes de la naranja. Sumérjelos todos en el envase con agua y observa el cambio en el nivel del agua. ¿Cuantos mililitros subió el nivel del agua? ____________ mL

How Much Water Do Humans Need?

7

Life Science

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).

Unit Links

Mystery of the Muddled Marsh
Story, pp. 23–25; Science boxes, pp. 5 and 14

Explorations
Intestine puzzle, p. 4

SETUP

Ask students to bring clean, empty one-gallon milk or juice jugs from home. Each group of students will need one jug.

Use beakers or graduated cylinders, or make your own (or have students make their own) by calibrating clear plastic cups ahead of time.

Continued

CONCEPTS

- Water is essential for survival.
- Under normal conditions, our bodies take in and release balanced amounts of water.

OVERVIEW

Students learn about the amounts of water lost through a variety of normal, daily activities.

SCIENCE, HEALTH & MATH SKILLS

- Making and recording observations
- Calculating values based on observations
- Measuring

TIME

Preparation: 10 minutes
Class: 45 minutes

MATERIALS

- Beaker with handle, or a pitcher, 2,000-mL

Each group will need:

- Beaker, 1,000-mL cap (or clear plastic cup marked in mL)
- Dishpan, 15-qt (or tub with a minimum capacity of 3 liters)
- Funnel, plastic, 2 3/4-in.
- Plastic milk jug, gal size
- Water, about 3 liters

People who are exercising vigorously lose much more water than people who are not. Someone doing hard work in the sun can lose as much as 20 pints of water. The greatest daily loss ever recorded was 50 pints in a single day!

WATER LOSS

- 150 mL lost by elimination from the digestive system (feces)
- 1,500 mL lost in urine
- 600 mL lost by evaporation during breathing
- 750 mL lost as sweat

REPLACEMENT

- 1,500 mL replaced from liquid water
- 1,200 mL replaced from food
- 300 mL replaced from the release of water molecules during the chemical breakdown of food (respiration)

Place materials in a central location for Materials Managers to collect. Conduct this activity in groups of four students.

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.

VARIATIONS

- Students can explore the volume of water filtered by the kidneys by calculating the number of 2-liter bottles of water that would be processed each day. (The kidneys process approximately 170 liters of water each day.)
- This activity also can be conducted as a demonstration by the teacher, using premeasured and colored amounts of water to represent water loss through urine (yellow), perspiration (clear), feces (brown) and breathing (blue).
- Desert organisms have had to adopt special strategies to save water. Have students use resources in the library or on the Internet to investigate some of the unique characteristics of desert dwellers.
- Aquatic organisms (plants and animals that live in water) have another problem: too much water. Have students research strategies used by aquatic organisms to survive while submerged.

Water Pollution and Health

Environment 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).

A large patch of oil visible near the site of the *Deepwater Horizon* rig collapse and oil spill on May 17, 2010. A long ribbon of oil stretches far to the southeast, entering the loop current, a stream of fast moving water that circulates around the Gulf of Mexico before bending around Florida and up the Atlantic coast.

Source: NASA Earth Observatory.

Satellite image courtesy of NASA Earth Observatory.

WATERSHEDS

An area of land that catches rain and snow and drains into a marsh, river, lake, groundwater or other body of water is called a watershed. Watersheds come in all sizes, and they form based on water drainage patterns. Within watersheds, water always flows downhill—so any activity that changes characteristics of water upstream will affect water quality downstream. Homes, farms, cities, fields and forests all can be part of the same watershed.

8 What Is a One Part Per Million Solution?

Environment and Health

CONCEPTS

- Substances dissolved in water can be present in very tiny amounts that are not visible to the eye.

OVERVIEW

Students make a solution of food coloring with a concentration of one part per million.

SCIENCE, HEALTH & MATH SKILLS

- Using pipets (droppers) as a measuring tool
- Observing
- Drawing conclusions

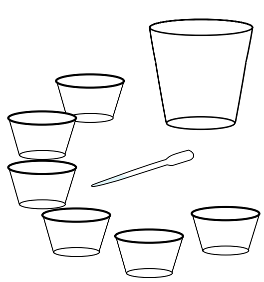
TIME

Preparation: 10 minutes
Class: 30 minutes

MATERIALS

Each group will need:

- 6 cups, 2-oz clear plastic (see SETUP)
- 2 cups, 9-oz clear plastic
- 2 pipets (or droppers)
- Small bottle (or container) of blue or red food coloring
- Water
- Copy of "What Does One in a Million Look Like?" page



Students will create a series of dilutions by successively adding one drop of solution to nine drops of water.

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.

Unit Links

Mystery of the Muddled Marsh
Story, pp. 26–31

Explorations
Let's Talk About Water and Health, pp. 2–3

SETUP

Prepare 6 small cups for each group of students, numbering each set "1" through "6" with a permanent marker.

As an alternative, use commercially available chemistry trays or cut the bottoms of plastic egg cartons in half to create trays with 6 wells.

Students should carry out this activity in groups of four. Set up a station in a central area with materials that each group will need.

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?*

VARIATIONS

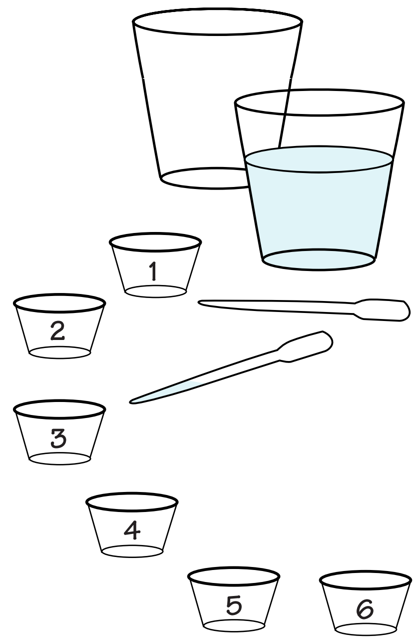
- Refer students to the "Riff and Rosie Talk to . . ." section on page 7 of this unit's *Explorations* magazine. It features a microbiologist who tests water for levels of disease-causing organisms.
- The Safe Water Drinking Act of 1974 requires the EPA to set and enforce standards of safety for drinking water in the United States. Have older students check resources in the library or on the Internet to find out which substances currently are considered hazardous by the EPA, and at what concentrations.
- Water treatment plants typically pass water through a complex filtering process to remove suspended particles and to add chlorine to kill disease-causing organisms. Water also may be sprayed into the air to help evaporate some kinds of chemicals and improve its taste and smell. Organize a class visit to your municipal water treatment plant or have a representative from the local water or health department visit your classroom.

The Safe Drinking Water Act (SDWA) was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996, and requires many actions to protect drinking water and its sources: rivers, lakes, reservoirs, springs and ground water wells. However, SDWA does not regulate private wells which serve fewer than 25 individuals.

Source: U.S. Environmental Protection Agency.

Photo by Daniel Schwen, Wikimedia Creative Commons 2.5.

8 What Does One in a Million Look Like?



1. Add one drop of food coloring and nine drops of water to Cup 1.

   How many drops of food coloring does Cup 1 hold? ____________

   What is the total number of drops in Cup 1? ____________

   The amount of food coloring in Cup 1 is: **1 drop in 10**.

2. Take one drop from Cup 1 and put it into Cup 2. Then add nine drops of water to Cup 2.

   What is the total number of drops in Cup 2? ____________

   The amount of food coloring in Cup 2 is: **1 drop in 100**.

3. Continue adding one drop from the previous cup and nine drops of water to each new cup until all six cups hold 10 drops. Then fill out the table.

   Hint: Look for a pattern in the amount of food coloring that ends up in each cup.

Cup Number	Total Drops in Cup	Amount of Food Coloring Present
1	10	1 drop in 10
2	10	1 drop in 100
3	______	1 drop in 1,000
4	______	1 drop in ____________
5	______	1 drop in ____________
6	______	1 drop in ____________

¿Que es uno en un millón?

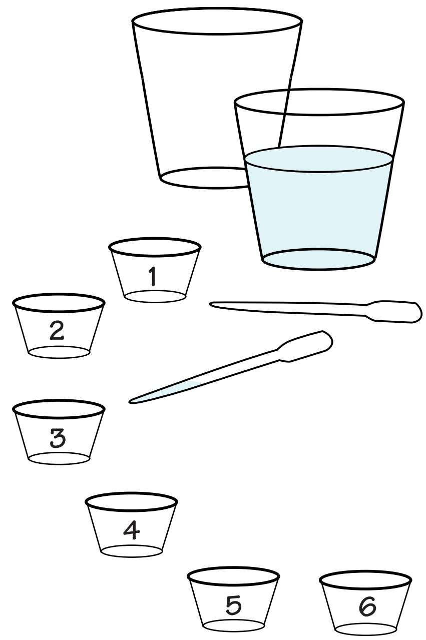
8

1. Añade una gota de colorante para alimentos y nueve gotas de agua a la Taza 1.

   ¿Cuanto es el número total de gotas en la Taza 1? ______________

   ¿Cuantas gotas tiene la Taza 1 en total? ______________

   La cantidad de colorante en la Taza 1 es: **1 gota en 10**.



2. Toma una gota de la Taza 1 y ponla en la Taza 2. Añade nueve gotas de agua.

   ¿Cuanto es el número total de gotas en la Taza 2? ______________

   La cantidad de colorante en la Taza 2 es: **1 gota en 100**.

3. Continua añadiendo 1 gota de la taza anterior y 9 gotas de agua a cada taza hasta que las seis tazas tengan 10 gotas en cada una. Ahora, completa la tabla.

   Una sugerencia: Fíjate si hay un patrón en las cantidades de colorante que están en las tazas.

Taza número	**Total de gotas en la taza**	**Cantidad de colorante presente**
1	10	1 gota en 10
2	10	1 gota en 100
3	________	1 gota en 1,000
4	________	1 gota en ______________
5	________	1 gota en ______________
6	________	1 gota en ______________

How Can We Find Out What Is in Water?

9

Environment and Health

CONCEPTS

- Many different substances can be dissolved in water at the same time.

OVERVIEW

Students use simple paper chromatography to investigate a mystery liquid.

SCIENCE, HEALTH & MATH SKILLS

- Measuring
- Predicting
- Making observations
- Drawing conclusions

TIME

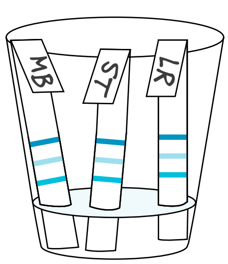
Preparation: 10 minutes
Class: 30 minutes

MATERIALS

- Cup, 9-oz clear plastic
- Red, green and blue food coloring (see SETUP)
- Water

Each group will need:

- Round basket-type coffee filters (1–2 per group)
- Beaker, 250-mL (or 9-oz clear plastic cup)
- 2 pairs of scissors
- 2 rulers
- Water



Students observe the bands of color that appear on filter paper strips.

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

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.

Unit Links

Mystery of the Muddled Marsh
Science boxes, pp. 17 and 24

Explorations
Riff and Rosie Talk to Ms. Linda Holman, p. 7

SETUP

Before beginning the activity, prepare a "mystery liquid" by adding 10–15 drops each of red, blue and green food coloring to about one cup of water.

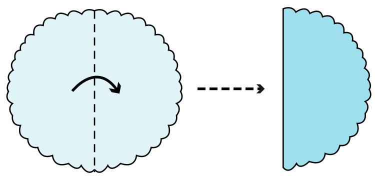
Set the materials out in a central area for the Materials Managers to pick up. Have students conduct this activity in groups of four.

PROCEDURE

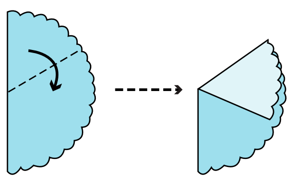
1. Show the mystery liquid to the students. Ask, *Can you tell what's in this liquid?* Explain that each student is going to be a detective and investigate the mystery liquid.
2. Students will need to prepare a test strip of filter paper. Give each group 1–2 basket-type coffee filters. Have the students 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 (see illustration, left sidebar).

How to Make a Paper Snowflake

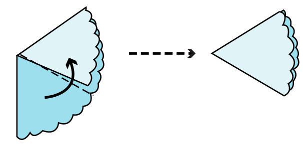
1. Fold a flattened coffee filter in half.



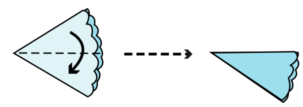
2. Fold approximately one-third of the folded filter toward the center.



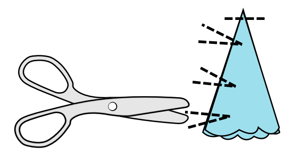
3. Fold the remaining third toward the center to create a triangular shape.



4. Fold the small triangle in half.



5. Cut a pointed tip and other designs on the solid side of the triangle.



6. Open the snowflake.

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?*

> The word "chromatography" comes from the Greek words *khroma* (color) and *graphein* (to write).

VARIATIONS

- After conducting the activity with filter paper strips, let students fold and cut snowflakes out of coffee filters. You may wish to copy and distribute "How to Make a Paper Snowflake" (see box, above). Set the folded snowflakes in the beakers, with the tips in the mystery liquid, to color the snowflakes in rainbow patterns.

10 Can Nutrients in Water Cause Harm?

Environment and Health

CONCEPTS

- Many different kinds of organisms live in water.
- Excess nutrients will cause over-abundant growth of some organisms living in water.
- Non-point source pollution is a major threat to water supplies in the United States.

OVERVIEW

Students create pond water cultures and investigate the effects of adding chemical or natural nutrients.

SCIENCE, HEALTH & MATH SKILLS

- Measuring
- Predicting
- Observing
- Drawing conclusions

TIME

Preparation: 30 minutes
Class: Three 30-minute sessions

MATERIALS

- 3 clear, 2-liter soft drink bottles,
- Hay (or dried grass), 2 oz
- Small container of fish food
- Small container of liquid fertilizer
- Spring water, gal (or tap water without chlorine, see SETUP)

Each student will need:

- Copy of "My Marsh Observations" page

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.

Unit Links

Mystery of the Muddled Marsh
Science boxes, pp. 10 and 21

Explorations
We Can Make a Difference, p. 6

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.

SETUP

You will need to use a hay infusion kit (or pond water) to carry out this activity. Hay infusion kits may be ordered from science education supply companies. Set up your hay infusion culture in a two-liter bottle about one week before beginning the activity. Use one gallon of spring water (or let the same amount of tap water rest uncovered for 24 hours).

As an alternative to creating your own "pond water" by means of a hay infusion kit, you may use water that you or your students have collected from a pond, ditch or stream. In this case, try to find water that has bits of green algae floating in it.

You also will need three clear 2-liter plastic soft drink bottles. Cut the tops off the bottles to make cylindrical containers.

Conduct this activity as a class demonstration. Have each student record his or her own observations on the "My Marsh Observations" sheets.

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

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, shews and field mice.

Source: U.S. National Park Service.

PROCEDURE

Session 1: Set up pond water cultures

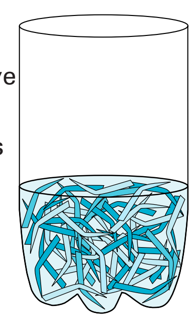
1. Begin by asking students if they remember what happened to Marigold Marsh in the story, *Mystery of the Muddled Marsh*. Allow time for everyone to share his or her ideas. Then, tell students that they will be able to see some of the tiny plants and animals that lived in the muddled marsh while they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

If possible, obtain a microscope and allow students to observe some of the minute organisms present in the pond water.

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*.



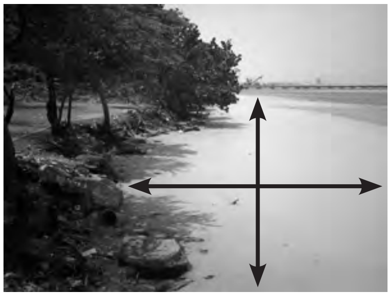
Students observe the effects of adding nutrients to a water community (see SETUP).

Continued

Photo of Dyke Marsh by MultK, Wikimedia Creative Commons 3.0.

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.



The area marked with arrows is an algal bloom in a Venezuelan lagoon. The bloom, combined with pollution, resulted in eutrophication of the water.

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.

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?*

VARIATIONS

- Visit a nearby stream, marsh, or ditch with standing water and let students collect small samples of water. Have students observe their water samples in class using hand lenses or low-power microscopes. Students should compare what they see to their observations of the water in the soft drink bottles.
- Keep one or more cultures of pond water alive in the classroom for longer periods of time by aerating the culture with a simple aquarium pump and plastic tubing inserted into the water.
- Have student groups set up their own cultures and investigate the effects of one or both kinds of fertilizers on their systems.

My Marsh Observations

Write or draw your observations in the boxes below.

Name ______________________________

Date ______________________________

NF	N	C
No fertilizer	Natural fertilizer (fish food)	Chemical fertilizer

Date ______________________________

NF	N	C
No fertilizer	Natural fertilizer (fish food)	Chemical fertilizer

Mis observaciones del pantano

Escribe o dibuja tus observaciones en los cuadros.

Nombre ______________________________

Fecha ______________________________

SF	N	Q
Sin fertilizante	**Fertilizante natural (alimento para peces)**	**Fertilizante qúimico**

Fecha ______________________________

SF	N	Q
Sin fertilizante	**Fertilizante natural (alimento para peces)**	**Fertilizante qúimico**

Why Is Water So Important?

11

Post-assessment

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.

Unit Links

Mystery of the Muddled Marsh
Science boxes, pp. 3, 5 and 7

Explorations
Cover, Tips for Healthy Living, p. 3

SETUP

Have students work individually or in groups of four.

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

Continued

CONCEPTS

- Water is a special chemical compound with unique properties.
- All life on Earth depends on water.
- Water can be polluted easily from a variety of sources.
- Everyone can help keep our water supplies safe.

OVERVIEW

Students review points covered in this unit and reach conclusions regarding the importance of water to human health.

SCIENCE, HEALTH & MATH SKILLS

- Problem solving
- Drawing conclusions

TIME

Preparation: 10 minutes
Class: 45 minutes

MATERIALS

Each group will need:

- Colored markers, pencils, pens, paints or crayons
- Drawing paper (1 sheet per student) or large sheet of butcher paper (1 per group)

Each student will need:

- Copies of completed pre-assessments
- Copy of "What Do You Know About Water?" page

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.

POST-ASSESSMENT ANSWER KEY

1.	c	6.	b
2.	a	7.	c
3.	b	8.	d
4.	d	9.	a
5.	a	10.	b

VARIATIONS

- Let students collect pictures from magazines and newspapers to use in their pictures or murals.
- Challenge students to imagine what Earth would be like if clean water quickly began to disappear. Have each student share an idea about one consequence of limited supplies of clean fresh water. Using the cooperative group concept, have the Recorder in each group write down the ideas. Then, have each group present its ideas to the rest of the class.

What Do You Know About Water?

11

Name ________________________________

Please circle the letter beside the correct answer to each question below.

1. What makes water special?
   a. Dinosaurs drank it.
   b. It is clear.
   c. All living things need it.
   d. It evaporates.

2. Why are water drops round?
   a. Water likes to stick together.
   b. Water is slippery.
   c. Water is the same as oil.
   d. Water is wet.

3. Which of these is made mostly of water?
   a. Brick
   b. Orange
   c. Peanut
   d. Sweater

4. Which of these substances will dissolve in water?
   a. Wood
   b. Sand
   c. Flour
   d. Sugar

5. You might use which one of the following methods to investigate a mystery liquid?
   a. Chromatography
   b. Point source pollution
   c. Condensation
   d. Dissolving

6. What happens if too much fertilizer gets into a pond?
   a. Nothing
   b. Fish get sick.
   c. Fish get too big.
   d. The pond floods.

7. Where is most water absorbed into the rest of the body?
   a. Mouth
   b. Small intestine
   c. Large intestine
   d. Stomach

8. How much water should a person drink in one day?
   a. 2 glasses
   b. 4 glasses
   c. 6 glasses
   d. 8 glasses

9. Which of the following can cause water pollution?
   a. Lawn chemicals
   b. Groundwater
   c. Carbon dioxide
   d. Native plants

10. Which process is part of the water cycle?
    a. Sedimentation
    b. Condensation
    c. Transportation
    d. Aviation

¿Quanto sabes de agua?

Nombre ________________________________

Haz un círculo alrededor de la letra de la respuesta correcta.

1. ¿Porque es especial el agua?
   a. Lo bebieron los dinosaurios.
   b. Es transparente.
   c. Todos los seres vivientes lo necesitan.
   d. Se evapora.

2. ¿Porque son redondas las gotas de agua?
   a. Les gusta estar pegadas unas a las otras.
   b. Son resbalosas.
   c. Son idénticas al aceite.
   d. Son húmedas.

3. ¿Cual de los siguientes se compone principalmente de agua?
   a. Un ladrillo
   b. Una naranja
   c. Un cacahuate
   d. Un sueter

4. ¿Cual de los siguientes puede disolverse en el agua?
   a. Madera
   b. Arena
   c. Harina
   d. Azúcar

5. ¿Que método podrías usar para investigar un líquido desconocido?
   a. La cromatografía
   b. La contaminación
   c. La condensación
   d. La disolución

6. ¿Que pasa si demasiados fertilizantes se disuelvan en un estanque?
   a. Nada.
   b. Los peces se enferman.
   c. Los peces crecen mucho.
   d. El estanque se inunde.

7. ¿Donde se absorbe la mayoría del agua en el cuerpo humano?
   a. La boca
   b. El intestino delgado
   c. El intestino grueso
   d. El estómago

8. ¿Que cantidad de agua debe tomarse en un día?
   a. Dos vasos de agua
   b. Cuatro vasos de agua
   c. Seis vasos de agua
   d. Ocho vasos de agua

9. ¿Cual de los siguientes contribuye a la contaminación del agua?
   a. Productos químicos para el jardín
   b. El agua bajo la tierra
   c. El dióxido de carbono
   d. Las plantas nativas

10. ¿Cual proceso es parte del ciclo hidrológico?
   a. Sedimentación
   b. Condensación
   c. Transportación
   d. Aviación

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ISBN: 978-1-888997-61-3