What Makes Water Special?

from *The Science of Water Teacher's Guide* and for *Mystery of the Muddled Marsh*

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The activities described in this book are intended for school-age children under direct supervision of adults. The authors and Baylor College of Medicine cannot be responsible for any accidents or injuries that may result from conduct of the activities, from not specifically following directions, or from ignoring cautions contained in the text.

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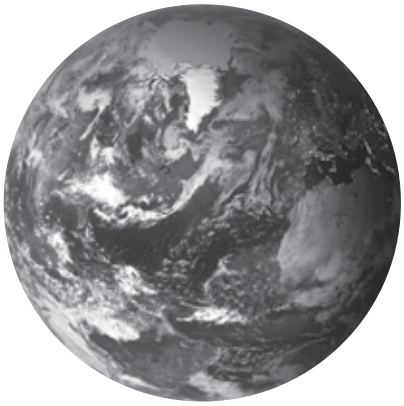
Properties of Water

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 *Taraxacum officinale* by Böhringer Friedrich, Wikimedia Creative Commons 2.5.

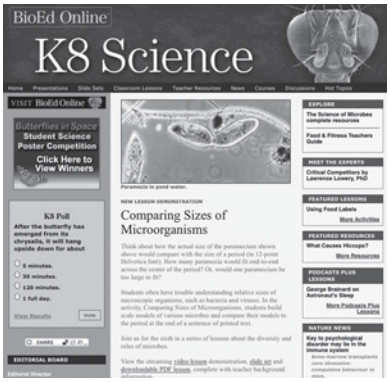
- **Liquid water expands when it becomes a solid (ice).** Most substances take up less space when they are transformed from a liquid to a solid. Water, on the other hand, actually takes up more space as a solid because the molecules in ice crystals are farther apart than those in liquid water. Since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

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.

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

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).

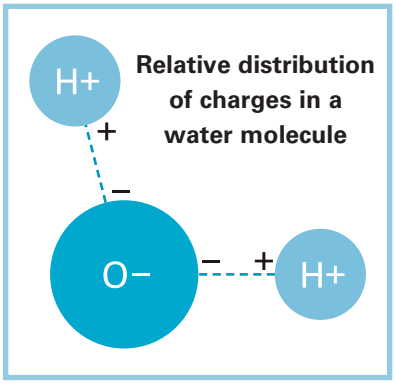
Each team will use one color of food coloring. Each team also will need a crayon, colored pencil or colored marker that matches the food coloring used.

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.

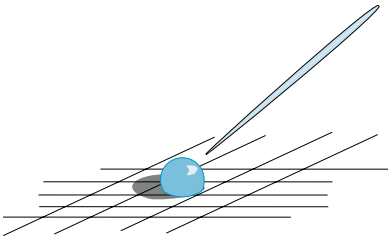
3. Have the Materials Managers collect the supplies from a central location. Each student should prepare a working surface by placing the wax paper over the graph paper.
4. Have the students practice making equal-sized drops of Liquid 1, sharing the dropper and using the graph paper as an approximate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

	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? _____

_____