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What Makes Water Special?

The Science of Water: Activity 2

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What Makes Water Special?

This activity's objectives are aligned with the National Science Education Standards, specifically to standards related to Science as Inquiry and Physical Science. "What Makes Water Special?" uses guided inquiry to examine some of the unique physical properties of two mystery liquids. Students will explore the properties of each liquid, make and record observations, compare and contrast each liquid's properties, and draw conclusions based on their investigations.

Concepts

- Water is a unique liquid.
- Many of water's unique properties are caused by polarity of the water molecule.

Reference

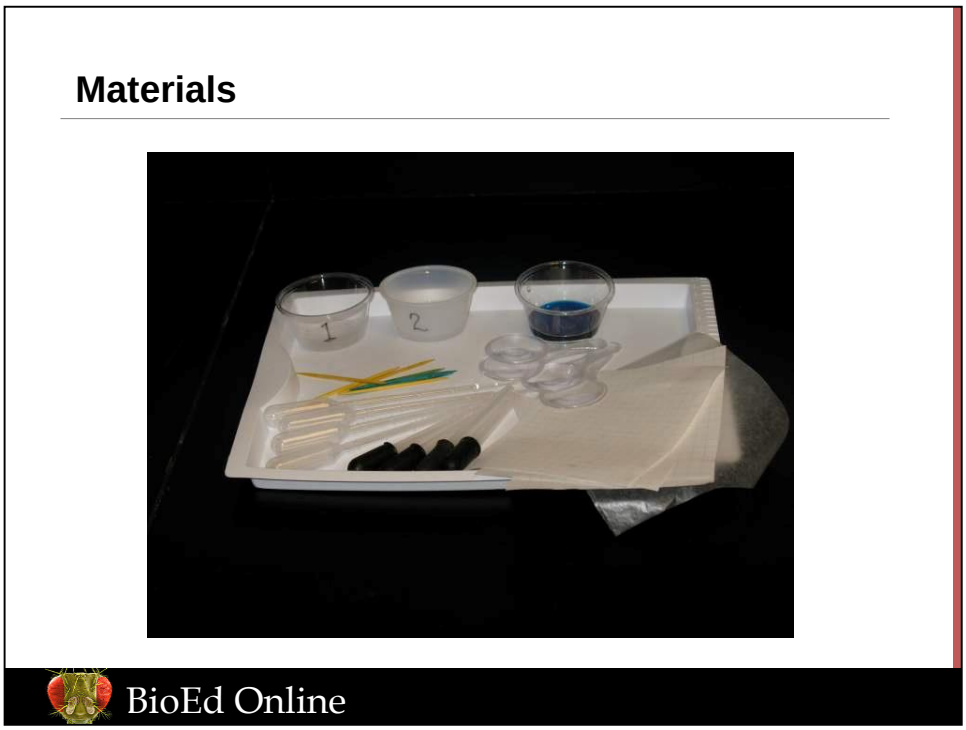
Moreno N., and B. Tharp. (2011). *The Science of Water Teacher's Guide.* Third edition. Baylor College of Medicine. ISBN: 978-1-888997-61-3. Development of this student activity was supported, in part, by grant numbers R25 ES06932 and R2510698 from the National Institute of Environmental Health Sciences of the National Institutes of Health to Baylor College of Medicine.

Image Reference

Photo © Martin Waugh. Used with permission. http://www.liquidsculpture.com/fine_art/water-drop-photo.htm?title=ExplodingBowler1

Key Words
lesson, experiment, water, water drops, water quality, water molecule, oil, cohesion, oil, polarity,

What Makes Water Special? © Baylor College of Medicine.



Materials

The following materials, for groups of four, should be placed on a tray in a central location for collection by the each group's Materials Manager.

Teacher Materials

•Bottle of food coloring (match marker color listed below to color selected)

•Marker

•Mineral oil or baby oil

•Water

Materials per Student Group

•Small labeled portion cup containing Mystery Liquid 1 (water)

•Small labeled portion cup containing Mystery Liquid 2 (mineral oil or baby oil)

•8 eye droppers or pipettes (one pipette each for four Liquid 1's and four Liquid 2's, so there is no cross-contamination)

•8 toothpicks (four for liquid 1 and four for liquid 2, so there is no cross-contamination)

•4 hand lenses or magnifiers

•4 sheets of cm graph paper

•4 sheets of wax paper to cover graph paper (Do not substitute plastic wrap.)

•Small portion cup containing diluted food coloring (see Setup)

•Crayons, colored pencils, or markers (use the same color as food coloring)

•Paper towels

Materials per Student

•Copy of "Do Your Liquids Behave?" page

Setup

1.Cut a sheet of centimeter graph paper into fourths and cut wax paper to cover the graph paper for each student.

2.Label small portion cups number 1 (for Liquid 1—**water**), and number 2 (for Liquid 2—**mineral or baby oil**).

3.Pour about 20 mL of Liquid 1 (water) into each of 6 cups (adjust number of cups as needed for students to share) and repeat for Liquid 2 (oil). Be sure to conceal the identity of both liquids before the investigation.

4.Place 120 mL of water into a plastic drinking cup or beaker and add six drops of food coloring. Divide this water into 6 small portion cups (adjust for your number of students/groups).

5.Use either wooden toothpicks that have been soaked in water, or stained wooden toothpicks (do not have to be soaked). Plastic toothpicks often will have a static charge and are not suitable for this activity.

6.Place all materials on a tray (except Liquid 2) in a central location to be picked up by each group's Materials Manager.

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Image Reference

Photo by JP Denk © Baylor College of Medicine.

Key Words
materials needed, materials list,

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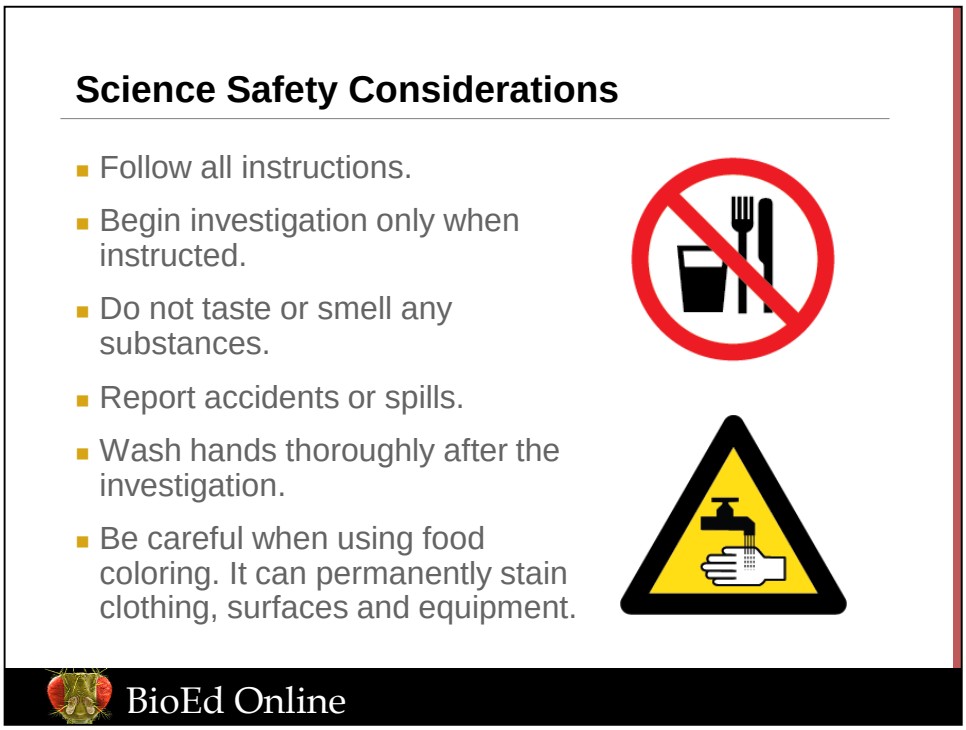


Science Safety Considerations

Students always must think about safety when conducting science investigations. This slide may be used to review safety with your class prior to beginning the activity.

Safety first!

•Always school district and school science laboratory safety guidelines.

•Have a clear understanding of the investigation in advance.

•Practice any investigation with which you are not familiar before conducting it with the class.

•Make sure appropriate safety equipment, such as safety goggles, is available.

•Continually monitor the area where the investigation is being conducted.

Safety note: Tell students to be extra cautious when using food

coloring, as it can stain surfaces, equipment, clothes and skin.

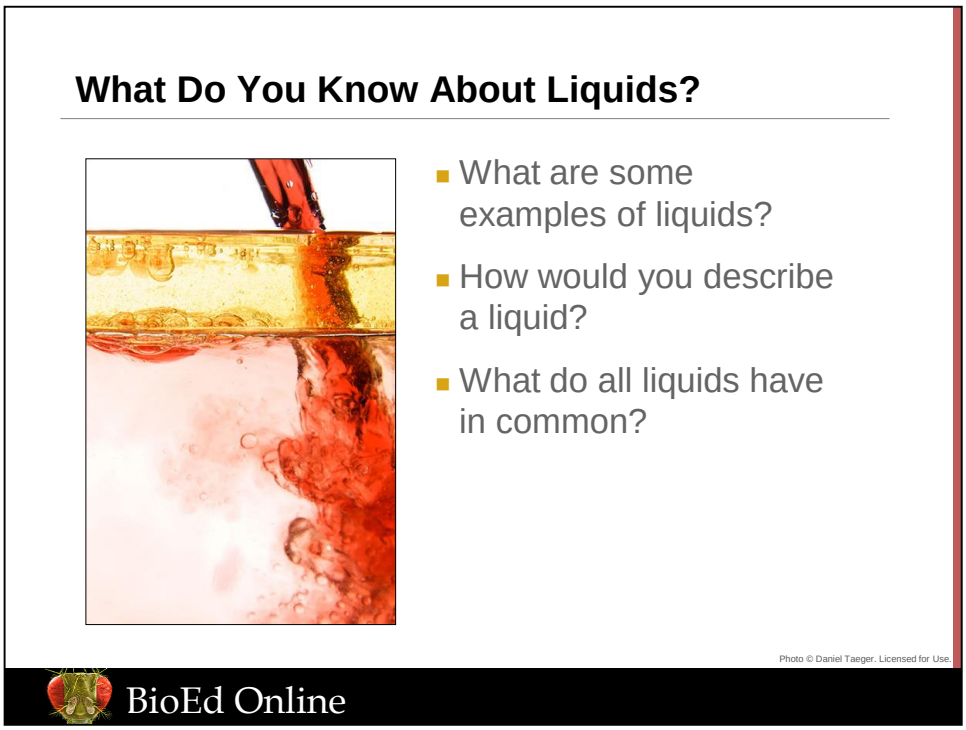
References

1.Dean R., M. Dean, and L. Motz. (2003). *Safety in the Elementary Science Classroom*. National Science Teachers Association.

2.Moreno N., B. Tharp, and J. Dresden. (2011). *The Science of Water Teacher´s Guide.* Third edition. Baylor College of Medicine. ISBN: 978-1-888997-61-3. Development of this student activity was supported, in part, by grant numbers R25 ES06932 and R2510698 from the National Institute of Environmental Health Sciences of the National Institutes of Health to Baylor College of Medicine.

Key Words

science, classroom, safety, lab, laboratory, rules, safety signs,



What Do You Know About Liquids?

When starting a new activity, it is always a good idea to focus students' attention. Begin this activity by engaging students in a discussion about different liquids, and ask them to record the names of at least five liquids.

Next ask, "*How would you describe each of the liquids you named,* and *what do all of these liquids have in common*?" Descriptions of liquids may include color, viscosity or thickness (how easily the liquid flows), transparency, etc. Explain that the physical properties or observable characteristics of liquids include the following.

Liquids...

•are bounded by the shape of a container.

•are not easily compressed.

•allow solids to pass through easily (one can pass an object, such as a spoon, through a liquid).

•have definite volume (can be measured).

•will change to a gas when enough heat is applied.

•will change to a solid when enough heat is removed.

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Image Reference

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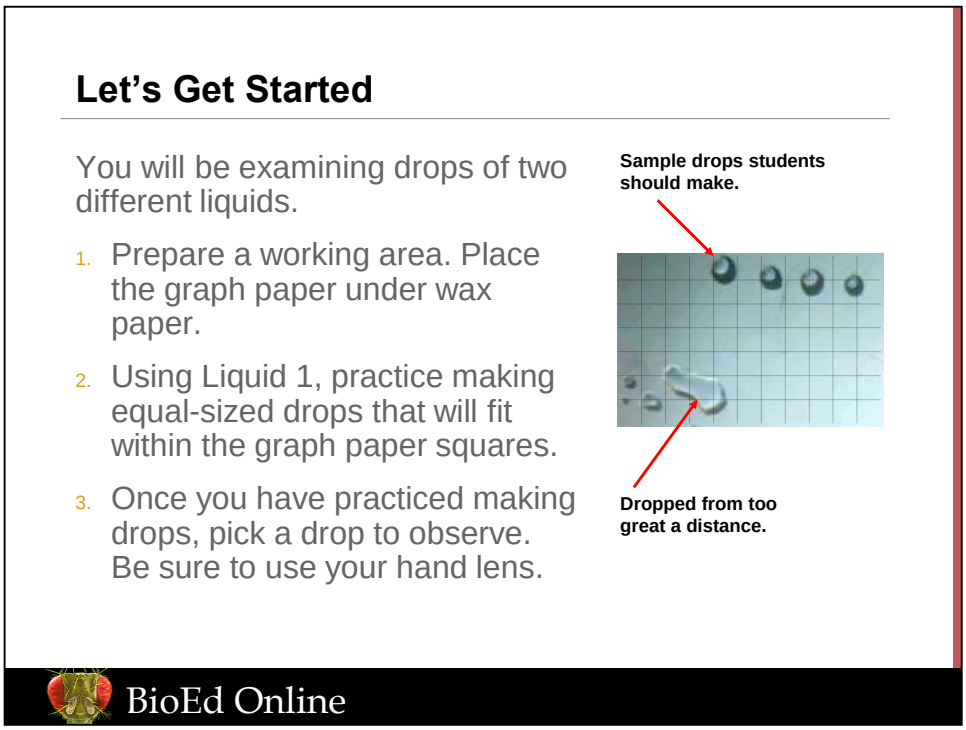
Key Words
lesson, assessment, water, liquid,



Let's Get Started

Students will investigate the appearance and feel of the two mystery liquids. Do not tell the students what the liquids are until the end of the activity.

Before beginning this activity, demonstrate the proper user of an eyedropper. This can be accomplished by using an overhead projector. Begin by placing drops of Liquid 1 on the glass surface of the overhead projector to demonstrate proper use of the eye dropper. Ask students to describe the drops. They might say that the drops are round, clear, shiny, etc.

1. Explain to students that they will be observing several physical properties of two liquids. Physical properties include how the liquid looks, feels, smells, tastes, sounds or acts, as well as the boiling point, melting point, and more.

2. Instruct students to prepare their working areas by removing anything

that could be damaged by liquids.

3. Have Material Managers collect supplies for each group from a central location.

4. Tell students that they are to use a clean dropper and toothpick for investigation of each liquid.

5. Ask each student to place the graph paper beneath a piece of wax paper before they begin to make practice drops from Liquid 1 and Liquid 2.

6. Have students explore the properties of each liquid by following the directions outlined on the student worksheet.

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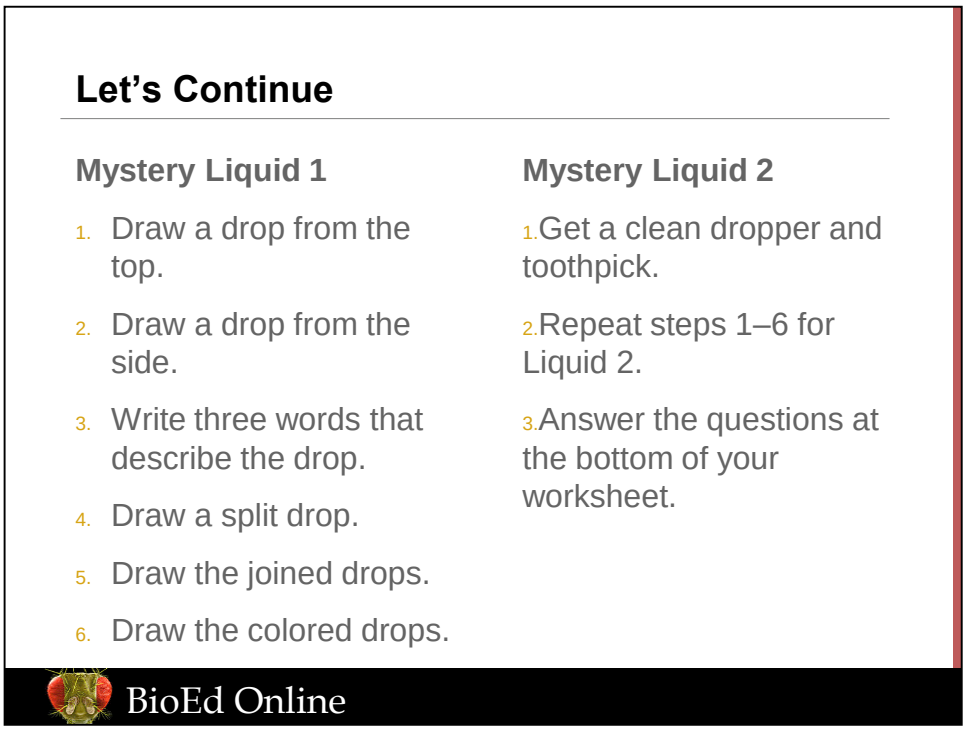

Let's Continue

Review the worksheet, step by step. After instructions are given, this activity can be conducted step-by-step with younger students, along with the teacher. Older students can complete the investigation independently. With younger students and/or depending on time allowed, you may want to investigate only one liquid during each session. Remind students that they must follow the worksheet to make the observations.

Mystery Liquid 1

1.Each student should select a drop to observe with a hand lens. Have students draw the drop from the top and side and describe the drop using three words on their student sheets.

2.Next, ask the students to try to split the drop into smaller drops using a toothpick. They should draw the results on the student sheet.

3.Now, have the students try to move the smaller drops together and discover what happens.

4. Have them draw the new drop that is formed when the smaller drops come in contact with one another.

5.After forming the new larger drop, students should dip their toothpick into a drop of food coloring and mix it into the new drop. When adding food coloring, students should touch the tip of the toothpick into the food coloring. Students should allow some of the food coloring to flow onto the toothpick and then place the toothpick into the liquid. Remind students that food coloring can stain clothes, materials and skin.

6.Have students draw the drop again and color it appropriately.

7.After students have completed their investigations of Liquid 1, instruct Materials Managers to collect Liquid 2 for their groups.

Mystery Liquid 2

1.Instruct students to get a clean toothpick and dropper.

2.Have students repeat steps 1–6 for Liquid 2.

3.Once students have completed step 6 for Liquid 2, have them complete the "Compare and Contrast" portion of the worksheet.

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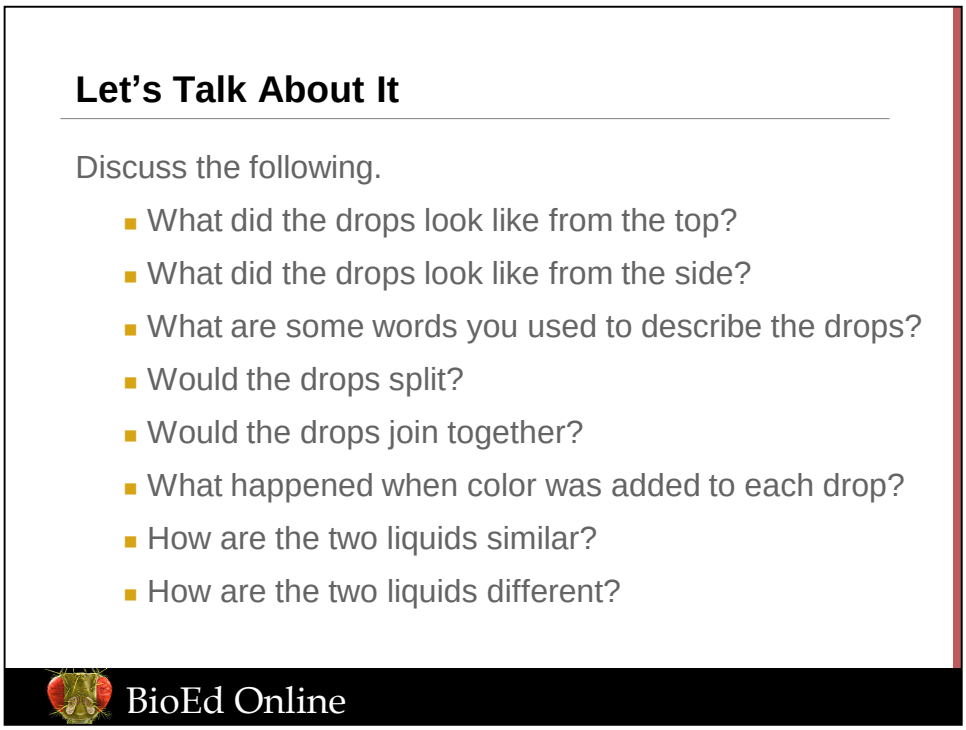

Let's Talk About It

This activity affords students an opportunity to learn about liquids, in general, and to begin to build understanding of some basic physical science concepts, such as polarity of molecules and cohesion (forces of attraction among molecules of a given substance). In addition, the activity provides practice in making and recording observations using drawings and words.

After students have had an opportunity to complete their observations, review each question on the student recording page, "Do Your Liquids Behave?" and discuss students' responses as a class. When conducting a class discussion, expect a variety of answers and observations, and use questions to encourage students' thinking.

In general, students will discover that drops of Liquid 1 (water) are rounded and dome-shaped (hemispherical) and that drops of Liquid 2 (oil) can have various shapes and are a flattened when viewed from the side. Keep in mind that the two liquids used in this activity represent two different types of molecules. Water molecules are polar, which means that one end of the molecule has a partial negative charge and the other end has a partial positive charge. This makes water molecules act like minuscule magnets that want to stick together. Oil molecules, on the other hand, are essentially neutral and are attracted less strongly to one another than what happens with water molecules. As a result of these fundamental differences, drops of the two liquids will behave differently. Through observation and discussion, students will be able to uncover these

differences for themselves. Students also might observe that both liquids have many similar characteristics. Possible student answers include the following.

What did the drops look like from the top?

Liquid 1 - circular, round, shiny, clear, transparent, convex, colorless, transparent, able to flow, etc.

Liquid 2 - circular, round, concave, reflective, colorless, transparent, able to flow, etc.

What did the drops look like from the side?

Liquid 1 - round, high, domed, convex, colorless, transparent, able to flow, etc.

Liquid 2 - flat, spread out, caved-in, transparent, able to flow, etc.

What are some words you used to describe the drops?

Liquid 1 - clear, domed, plump, shiny, half a hemisphere, colorless, transparent, able to flow, etc.

Liquid 2 - clear, flat, thick, transparent, colorless, able to flow, etc.

Individual drops of Liquid 1 (water) will be attracted to one another and will coalesce to form larger drops—all with similar, rounded shapes. This force is called cohesion and creates surface tension at the boundary of the drop or a larger body of water. Drops of Liquid 2 (oil) will not join together in this fashion. Instead, oil drops will form larger smears of oil on the wax paper. When students try to split the drops, they will find that it is difficult to force water drops to divide into smaller drops, but that once the separation is accomplished, several smaller, identically shaped droplets will form. The oil drops will not separate into coherent droplets. Discuss the following questions with your students. Possible answers include the following.

Would the drops split?

Liquid 1 - It was difficult to split but once it did; it was very distinct. The smaller drops are shaped liked the original larger drop.

Liquid 2 - It smeared and did not form two different drops.

Would the drops join together?

Liquid 1 - It reformed easily. It has the same shape it had to begin with.

Liquid 2 - No, the liquid smeared.

Ask why this happened. Students should understand that the attraction among molecules of the same kind is called cohesion. Without this property, liquids do not hold their shape.

When added to the drops, food coloring, which usually is water-based, will disperse readily throughout drops of Liquid 1 (water), but will not mix with Liquid 2 (oil). This happens because the water molecules and water soluble dye in the food coloring are attracted strongly to one another. When combined with oil, the polar molecules are attracted more strongly to one another than they are to the oil molecules, which essentially are crowded out.

Discuss the following question with your students.

Possible answers include the following.

What happened when color was added to each?

Liquid 1 - The color dissolved into the drop evenly.

Liquid 2 - The colored drop floated on top of Liquid 2. The colored liquid remained separate from the liquid in the drop.

Compare and Contrast

Students might observe that both liquids have many similar characteristics such as being colorless, transparent, are able to flow, etc. But Liquid 1 tends to maintain a domed shape on the wax paper, while Liquid 2 is tends to spread out and take on a much flatter shape. The colored water dissolved in Liquid 1 but remained separated in Liquid 2.

Ask students if they discovered the identity of each liquid as they worked through the investigation, and why they identified the liquids as they did. Explain that Liquid 1 is water and Liquid 2 is oil. Water molecules are attracted to each other like tiny magnets. This attraction causes the water drops to be cohesive or tightly stuck together and form droplets. Forces of attraction among molecules in most liquids, like Liquid 2 (oil) are not as strong as in water molecules.

Help students understand that liquid water is an excellent solvent, which is valuable to organisms for transport of nutrients and waste products in cells and tissue, But this characteristic also allows water to become polluted easily. Many other liquids, like oil, do not act as solvents as readily as water.

Discuss other types of similar-looking or acting liquids.

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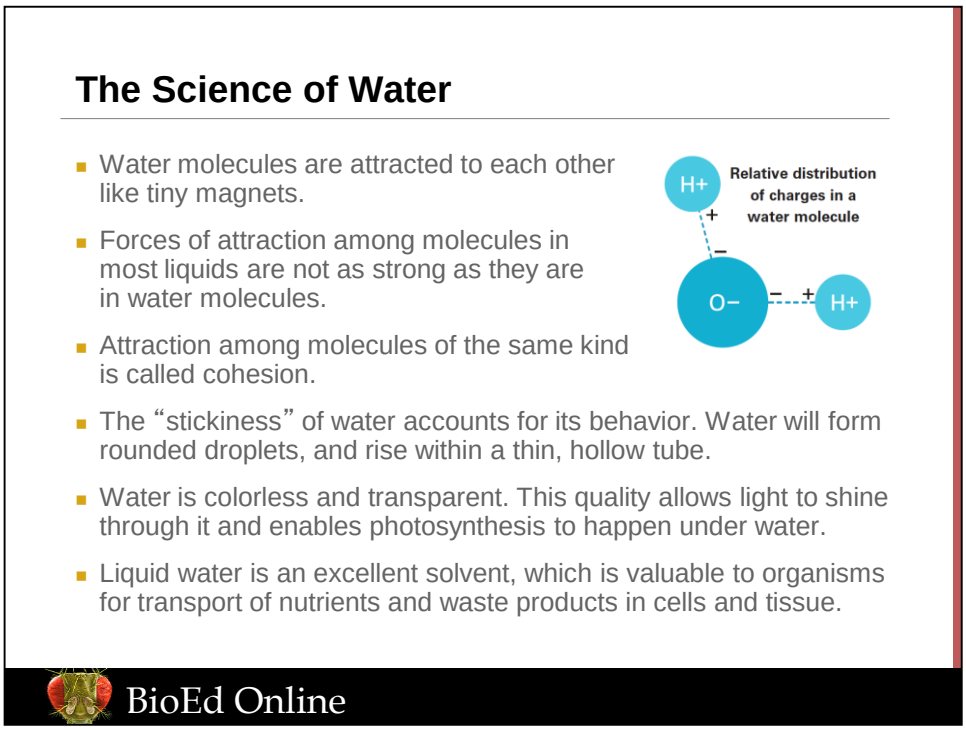
Key Words
lesson, water, liquid, properties of water,



The Science of Water

Most properties of water are related to the structure of the water molecule. Each water molecule consists of two hydrogen atoms and one oxygen atom. As with all molecules of this type, the oxygen atom and the hydrogen atoms share electrons. However, the electrons are not shared equally. They 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. Each molecule in liquid water, therefore, has a positive end and a negative end. This separation of positive and negative charges (polarity) makes each water molecule act like a tiny magnet, capable of clinging to other water molecules and to any other particle or surface that is electrically charged (adhesion). The forces of attraction between the opposite charges hold the molecules together quite tightly.

In this activity, students learned about the following properties of water.

- **Molecules in liquid water are attracted to one another.** This characteristic accounts for water's ability to form rounded

droplets and for the difficulty students' observed in splitting water drops. Surface tension is a term describing the cohesion of water molecules at the surface of a body of water.

- **Liquid water is an excellent solvent of many substances.** This makes water particularly 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 to transport wastes. Unfortunately, the same characteristics make liquid water easy to pollute, because so many different chemicals can be dissolved in it.

- **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.

- **Not all liquids behave in the same way as water.** Oil, which is not made of polar molecules, does not show the same properties of mutual attraction that can be observed with water.

References:

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2.National Science Foundation. (2005). The Chemistry of Water. http://www.nsf.gov/news/special_reports/water/index_low.jsp?id=properties

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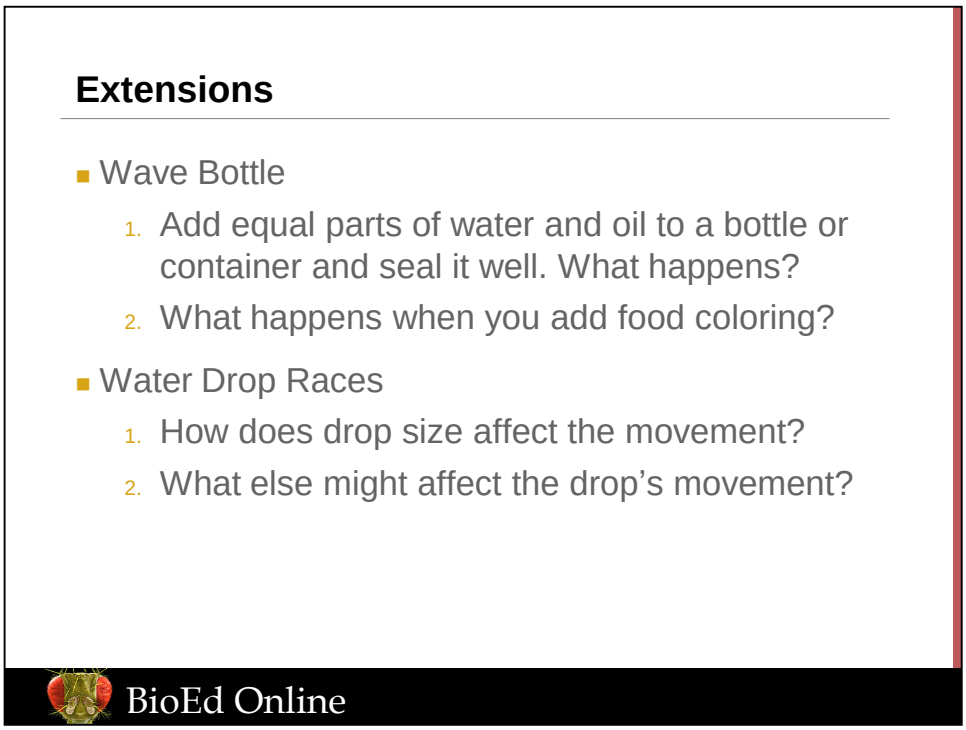

Investigating the Behavior of Water: Extensions

These are some ideas you can use to further your students' inquiry into the behavior of liquids, particularly water and oil.

Wave Bottle

Create a wave inside a bottle. Add equal parts of water and oil to a bottle or container that can be tightly sealed. Have students investigate what happens when you add the two liquids together. Ask students, *What happens when you shake up the bottle?* Next, add some food coloring. Ask, *Where does the food coloring go? Why?*

Answers

Oil and water do not mix. Water molecules are attracted strongly to one another, and will exclude the oil, which forms a separate layer. The oil layer will float above the water because it is less dense. When you shake the bottle, the oil is temporarily dispersed through the water, but the two liquids will eventually separate again. When you add a drop of food coloring, the water-based and less dense coloring sinks below the oil and mixes with the water underneath. The resulting bottle looks similar to a lava lamp.

Water Drop Races

Use your toothpicks to push water drops along the wax paper (or tilt the

wax paper up and have the drops run down it) as quickly as possible. Ask students, *What size of drop moves the fastest? What else affects how quickly the drop can be pushed?*

Answers

Smaller drops move faster than larger drops. The surface on which the drop sits also can affect how fast it moves. Wax paper is neutral, so the drops are not attracted strongly to the surface. On the other hand, plastic wrap may slow down the water drops due to static charges, that attract and hold the polar molecules in water.

References:

1. Moreno N., B. Tharp, and J. Dresden. (2011). *The Science of Water Teacher's Guide.* Third edition. Baylor College of Medicine. ISBN: 978-1-888997-61-3. Development of this student activity was supported, in part, by grant numbers R25 ES06932 and R2510698 from the National Institute of Environmental Health Sciences of the National Institutes of Health to Baylor College of Medicine.
2. National Science Foundation. (2005). The Chemistry of Water. http://www.nsf.gov/news/special_reports/water/index_low.jsp?id=properties

Key Words

lesson, extension, water, liquid, properties of water, water drop, oil,