

## TOPIC

# Water is a Universal Solvent

## OUR WORLD, OUR RESPONSIBILITY

- 6.1** The student will demonstrate an understanding of scientific and engineering practices by
- a. asking questions and defining problems
    - ask questions to determine relationships between independent and dependent variables
    - develop hypotheses and identify independent and dependent variables
    - offer simple solutions to design problems
  - b. planning and carrying out investigations
    - independently and collaboratively plan and conduct observational and experimental investigations; identify variables, constants, and controls where appropriate, and include the safe use of chemicals and equipment
    - evaluate the accuracy of various methods for collecting data
    - take metric measurements using appropriate tools
    - use tools and materials to design and/or build a device to solve a specific problem
  - c. interpreting, analyzing, and evaluating data
    - compare and contrast data collected by different groups and discuss similarities and differences in findings
    - use data to evaluate and refine design solutions
  - d. constructing and critiquing conclusions and explanations
    - construct explanations that includes qualitative or quantitative relationships between variables
    - construct scientific explanations based on valid and reliable evidence obtained from sources (including the students' own investigations)
    - generate and compare multiple solutions to problems based on how well they meet the criteria and constraints
  - e. developing and using models
    - use, develop, and revise models to predict and explain phenomena
    - evaluate limitations of models
- 6.6** The student will investigate and understand that water has unique physical properties and has a role in the natural and human-made environment. Key ideas include (a) water is referred to as the universal solvent; (b) water has specific properties; and (f) water is important for agriculture, power generation, and public health.
- 6.8** The student will investigate and understand that land and water have roles in watershed systems. Key ideas include (d) natural processes, human activities, and biotic and abiotic factors influence the health of a watershed system.

## BACKGROUND INFORMATION

A solvent is a liquid able to dissolve other substances. A solute is a substance dissolved in a solvent. Water can dissolve a variety of different substances, which is why it is such a good solvent. Because it can dissolve more substances (solutes) than any other liquid, it is called the universal solvent.

Water's chemical composition and physical attributes

make it an excellent solvent. Water molecules have a polar arrangement of the oxygen and hydrogen atoms—one side (hydrogen) has a positive electrical charge and the other side (oxygen) has a negative charge. This allows the water molecule to become attracted to many different types of other molecules. Water can become so heavily attracted to a different molecule, like salt (NaCl), that it can disrupt the attractive forces that hold the sodium and chloride in the

salt molecule together and, thus, dissolve it.

Because water can dissolve a variety of substances, it can become dirty in our environment and requires treatment before people can use it. Luckily nature does a good job of naturally cleaning water. However, this process does not happen fast enough to meet the demands of the community. Therefore, the community relies on wastewater and drinking

water treatment plants to remove items mixed with and dissolved in water.

In this lesson, students will learn that water is a universal solvent, build a wetland model to show how nature naturally cleans water and learn about the organizations that help speed up the water treatment process.

## MATERIALS

### Part 1: Universal Solvent

- 1 bottle of distilled water
- 1 bottle of rubbing alcohol
- 1 bottle of cooking oil
- 1 bottle of club soda
- 1 container of salt (per student group)
- 1 measuring teaspoon (per student group)
- 4 coffee stirrers (per student group)
- 4 clear plastic cups or beakers (per student group)

### Part 2: Natural Sponge

- 1 clear plastic cup or bowl (per student group)

- 1 roll of tape (per student group)
- 2 paper towels (per student group)
- 1 pitcher or 16 oz. measuring cup filled with water (per student group)
- 5 sandwich or snack size Ziplock bags (per student group)
- 2 spoons or sand shovels for digging (per student group)
- Access to nature

### For each student:

- Handout: Soak It Up

## VOCABULARY

Solvent, solute, universal solvent, molecule, wetland

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## STUDENT/TEACHER ACTIONS

### LESSON LESSON SET-UP:

#### Part 1 Prep:

- Identify student groups, the number of groups and who will be in each group. This will allow students to be more hands-on with each activity.
- Prepare four clear plastic cups/beakers for each group, each with 50mL of the following substances: distilled water, rubbing alcohol, club soda and cooking oil. Make sure each substance is labeled.
- Provide each group with salt (they'll need to measure 1 teaspoon for each substance).
- Provide each group a teaspoon for measuring and a coffee stirrer for mixing.

#### Part 2 Prep:

- Tape a layer of paper towel over the opening of a clear plastic cup or bowl for each group. Make sure the entire opening is covered and the paper towel is securely taped to the cup or bowl.
- Write the following wetland layers on the outside of 5 different Ziplock bags: gravel, soil, roots, vegetation, dirt. Each group will get a set of 5 labeled bags.

### TEACHER LESSON INTRODUCTION:

- Share with students that a solvent is a liquid able to dissolve other substances.
- Share with students that a solute is a substance dissolved in a solvent.
- Ask the students to share some examples of a solvent and a solute... or something that dissolves in a liquid.
- A lot of the examples might list water as the solvent. If this is the case, point this out but don't explain why just yet.

### TEACHER ACTIVITY INSTRUCTION:

#### Part 1: Universal Solvent

- Share that each group has the same amount of four different solvents in the cups/beakers before them.
- Share that they have 50 mL of distilled water, cooking oil, rubbing alcohol and club soda.

- Tell the students they are going to add the same amount of salt to each substance. Salt will serve as the solute in this experiment.
  - Ask the students to predict which solvent will absorb the most and least amount of solute. Have them note their hypothesis on their “Soak it up” handout.
  - Have the students pour 1 teaspoon of salt into each solvent.
  - Have the students stir each mixture for 10-30 seconds.
  - Share the results:
    - Students will find that water is the best solvent, and heavier liquids like cooking oil are the worst.
    - Some salt will dissolve in alcohol, but since the polarity of alcohol is not as strong as water, it is not as good a solvent.
    - Club soda will likely dissolve more than alcohol because it contains water.
  - Have the students record their results on their “Soak it up” handout and check to see if their hypothesis was correct.
  - Explain to students that water’s chemical composition and physical attributes make it an excellent solvent.
  - Point out the number of examples students shared in the introduction that involved water as the solvent.
  - Share that water molecules have a polar arrangement of hydrogen and oxygen molecules. Draw on the board the arrangement of water molecules:
    - One side (hydrogen) has a positive electrical charge
    - The other side (oxygen) has a negative charge.
  - Share that this arrangement allows the water molecule to become attracted to many different types of other molecules. Water can become so heavily attracted to a different molecule, like salt (NaCl), that it can disrupt the attractive forces that hold the sodium and chloride in the salt molecule together and, thus, dissolve it.
  - Share that water can dissolve a variety of different substances, which is why it is such a good solvent. But because it can dissolve more substances than any other liquid, it is called the universal solvent.
  - Water’s ability to dissolve substances can have many benefits. Ask students to share some of the benefits they can think of.
  - In general, wherever water goes, either through the ground or through our bodies, it takes along valuable chemicals, minerals and nutrients.
  - Now ask students to think of some challenges that may be created by water’s ability to dissolve substances.
  - Share that we rely on water to survive. But water in our natural environment can easily get dirty because it dissolves and mixes with substances like salt, sand, dirt, chemicals and more.
    - This requires water to be treated before it is used by the community.
- Part 2: Natural Sponge*
- Share that nature is amazing because it helps naturally remove some of the solutes from water. The layers of soil work together to naturally soak up and clean water.
  - Share that one place to see this process happen is in wetlands.
  - Ask students if they know what a wetland is or if they have ever seen a wetland.
  - Share that a wetland is an area of land where the water level remains near or above the ground’s surface for most of the year. Marshes and swamps are examples of wetlands. You can find a lot of them in places like Florida.
  - Optional: pull up a few photos of wetlands and show to the class.
  - Share that a wetland is made up of many layers. Review the layers of a wetland and have them label accordingly on their “Soak it up” handout.
  - Share with the students that the many different layers help filter water as it passes through.
  - Share that the groups are going to build a model of a wetland to show how this works.
  - Share that the students are going to collect layers to build their wetland model outside.
  - Tell students that when you go outside, they need to collect a small amount of the following items and place in their labeled bags. Remind students of the model size and that they do not need a lot of each item.
    - Dirt: Collect soil, sand, dirt to mix with water (may need a spoon/shovel)
    - Gravel: Collect rocks, pebbles, gravel
    - Soil: Collect soil, sand, dirt (may need a spoon/shovel)
    - Roots: Collect sticks to represent roots (don’t want students to pull up nice plants)
    - Vegetation: Collect grass to represent plants
  - Return to the classroom and have students assemble their wetland model by arranging the layers in this way:
    - Place a layer of “Gravel” on top of the cup/bowl covered with paper towels.
    - Place another layer of paper towels on top of gravel. Tape to secure to cup/bowl.
    - Place a layer of “Soil” on top of paper towels.
    - Place a layer of “Roots” on top of soil.
    - Place a layer of “Vegetation” on top of roots.
  - Once all layers are in place, mix the collected items for “Dirt” in the cup or pitcher of water until it looks muddy and dirty.
  - Once it is mixed, ask the students to observe the dirty water.

- Then have the students slowly pour the dirty water over their model. Have them observe the water that drains through the layers.
- The water that ends up in the cup/bowl will be a lot cleaner than the water in the pitcher/cup.
- Share that this model shows how nature naturally cleans water. Nature helps remove some solutes from water, the universal solvent. This process happens every day in the environment.
- However, the community uses and needs water at a fast rate. This means we can't rely on nature to naturally clean the solutes from our water fast enough for our use.
- Ask the students if they know of any organizations that help speed up this process.
- Share the following about your local community:
  - Fairfax Water – This company manages the water treatment plant. They pull water from local water sources and clean it to get it ready for community use.
  - Virginia American Water – This company is responsible for distributing clean water

from Fairfax Water to the local community. They manage the infrastructure (pipes and valves) that carries water to places like homes, schools, and businesses.

- AlexRenew – This company manages the wastewater treatment plant. They clean water after it has been used in homes, schools and businesses. Once cleaned, water is returned to local water sources.

#### **TEACHER ACTIVITY CONCLUSION:**

- Share that today students learned that water is a universal solvent, which means it can absorb more solutes than any other substance.
- Share that they learned how this can be a positive thing, but also a challenging thing for our lives and our community.
- Remind students that water is naturally cleaned every day in the environment. But the community is fortunate to have organizations that speed up the process of cleaning water to meet the community's needs.

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## **ASSESSMENT**

### **QUESTIONS**

- What is a solute?
- What is a solvent?
- Why is water considered a universal solvent?
- What is a wetland?
- How does nature naturally clean water?
- What organizations help clean and distribute water for community use?

### **JOURNAL/WRITING PROMPT**

- In your own words, describe what happens to salt when added to each solvent. Use illustrations to enhance your explanation.
- In your own words, describe how water is naturally cleaned in the environment. Use illustrations to enhance your explanation.

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## **EXTENSIONS AND CONNECTIONS**

- Have students try different amounts of the solutes in water and vary the temperature. Have students predict and record the outcomes.
- Have students graph all results for Part 1.
- Invite a guest speaker from a local water treatment/distribution facility in to talk about the process of cleaning water.
- Have students research wetlands and bring in photos of a wetland they discovered in their research.

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## **STRATEGIES FOR DIFFERENTIATION**

- Use a variety of solvents and solutes for Part 1.
- Have supplies for the wetland model available in the classroom and only have students assemble models instead of collecting supplies.