WRAP-UP

To wrap-up the investigation, bring your students together for a group discussion to help them understand why and how they achieved their results. It is important to share results so that everyone has a clear picture of what happened. To help you facilitate the discussion, review the explanation in "The Why and The How" using the Group Discussion questions as a guide.

Group Discussion
Explain to students that scientists learn from each other through discussion, and they build upon the work of others to make new discoveries. Just as scientists come to conclusions based on the findings of their experiments, they will now come together as a group to share their results and make conclusions about the investigations they've conducted. Have students record their final results and the explanation in their journals.

- What did you learn about water from the string investigations?
- What did you expect your results to be?
- What surprised you?
- What other liquids would you like to test?
- What new questions do you have?

The "Why" and The "How"
The adhesive properties of water cause it to cling to the string. Wet string works better than dry string because cohesive properties also help the water move along the string. When the string is wet, water clings to both the string (adhesion) and to itself (cohesion). If the water is poured too quickly, there is not enough string for all of the water to stick to, so gravity pulls the excess water down. When we change one aspect of an experiment to see how it affects our results, this is known as a variable. In order to compare results, we only change one variable at a time for each experiement to make sure that other factors aren't affecting the outcomes.

adhesion, cohesion, and surface tension of water on a spider web

Curriculum Match-Up

- Repeat the experiment and create a graph of the time it took for water to travel along the different types of string.
- Calculate the ratio of length to speed for different strings.
- Calculate the average speed for different trials or different types of string.
- Create a graph for how long it took to get water across the room for the entire class.
- List five ways that you might observe the property of adhesion as you walk home on a rainy day.

References:
www.uark.edu/~k12info/teacher/workshops/AIMS-lessons/Water_Olympics.pdf
www.bpa.gov/Corporate/KR/ed/sold/water/k1/drip_drop.pdf

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Stick to It: Adhesion II

Learning Objectives

Students will:

1. Learn that water molecules can also stick to molecules in other materials, a property known as adhesion.
2. Develop a procedure to solve a problem.
3. Test the adhesion of water to different types of string.

Vocabulary Ventures

molecule
atom
teddy bear molecule
attraction
cohesion
adhesion

Note: This introduction is repeated from the previous lesson on adhesion.

Have you ever wondered how water sticks to a window pane when it rains? What keeps the water in a watermelon? Why does water roll off a duck's back? It has to do with a property of water known as adhesion.

Everything on the planet is made of something smaller. The smallest unit of water that can exist alone and still have the same chemical characteristics or properties is called a **molecule**. A molecule is made up of several small particles called **atoms** that are joined by a chemical **attraction**. In a water molecule, two hydrogen atoms with a positive charge are attached to an oxygen atom with a negative charge. When these atoms attach to each other, they form a shape that looks like the head of a teddy bear. The water molecule is known as the **"teddy bear molecule"**.

water droplets showing cohesion and adhesion

Water molecules are polarized like a magnet, with a positive end and a negative end. The oxygen atom in one molecule of water is attracted to the hydrogen atom in another water molecule. This attractive force causes water molecules to be drawn to one another, a property known as **cohesion**. Cohesion helps little drops of water form into a larger pool of water.

Water can also be attracted to molecules found in other materials such as glass, plants or soil. This property of water is known as adhesion.

The forces of **adhesion** between water and other materials can vary. Water may be strongly attracted to some materials and not attracted to others. For example, water is not very strongly attracted to the oils found on duck feathers, and is actually more attracted to itself. This is why water does not stick to duck feathers and instead rolls off in droplets. Stronger adhesive forces also keep water inside the tissues of the human body and in fruits and vegetables.

Time Needed to Conduct Investigation
This investigation has four parts.
Organize and set up materials: 10 minutes
Introduce the lesson: 5 minutes
Conduct the investigation: 25 minutes
Student journaling/group reflection: 10 minutes
Total estimated time: 50 minutes

Investigation: Walking the Tightrope

Materials

For groups of three or four
Student journals and writing tools

Part 1:
- ½ liter water bottle with tap water
- Plastic tablecloths
- Two 16 oz plastic cups (label one cup 'A' and the other cup 'B')
- Scissors
- White cotton string
- Measuring tape
- Masking tape
- Sponges

Part 2:
- Additional white cotton string

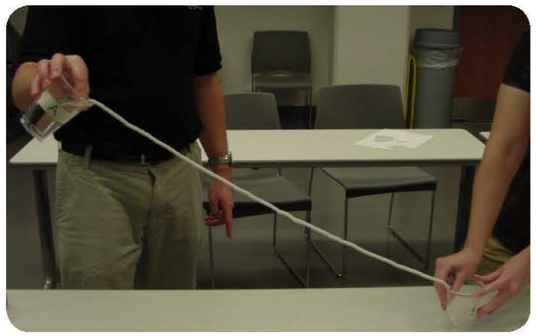
Part 3:
- Fishing line
- Thick clothesline
- Twine
- Thread
- Yarn
- Wax-coated string

Part 4:
- Long lengths of white cotton string

Part 1
Water on a String

GET READY!

In this investigation, your students will discover that the adhesive and cohesive properties of water enable it to travel on a string. Place plastic tablecloths on the surfaces where students will be working. Review any relevant concepts/ vocabulary from previous investigations.



set-up for water on a string

PROCEDURE

1. Explain to students that their task is to try to get the water from cup "A" to cup "B" while keeping them 60 cm apart.
2. Only materials provided may be used. Hands and mouths cannot be used.
3. Students should measure 60 cm using the measuring tape.
4. Next, have students mark this distance on the table with masking tape.
5. Students should cut 70 cm of cotton string to use in the experiment.
6. Fill Cup A ¾ full of water.

Let students experiment with different methods of transporting the water, but don't immediately provide the solution. Instead, ask questions that will help get students on the right track. Invite students to discuss their methods, observations and results with their partner.

TIP
Wet the string first to get the water from one cup to another.

How it Works!
One person grasps the cup containing the water and uses his index finger to hold one end of the string inside the cup submerged in the water. A partner grasps the empty cup and uses her index finger to hold the other end of the string inside the cup while keeping the string taut. Next, lift the cup containing the water above the level of the empty cup and slowly tilt the cup so that the water begins to flow from the cup and onto the string. Remind students to keep the cups 60 cm apart!

OBSERVE

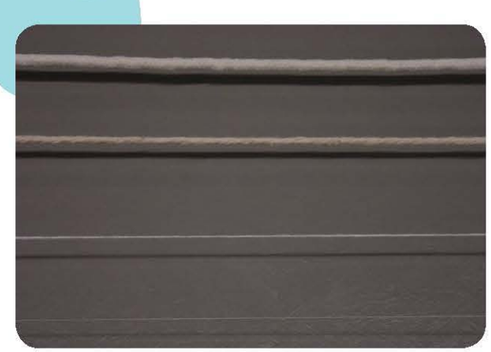
Invite the students to make the following observations:
- How did you come up with the method that you are testing?
- How is the water behaving on the string?
- What techniques are working/not working?
- Does the speed at which the water is being poured have an effect? Why?
- Why do you think some water sticks to the string while some falls to the table?
- Which works better: wet string or dry string? Why?
- How many tries did it take for the water to travel from one cup to the other?

water drop traveling on a blade of grass

Part 2
A String of Strings

Invite students to repeat the procedure from Part 1, experimenting with different lengths and types of string such as thread, yarn, twine, waxy string and fishing line.

Ask students to record the following observations:
- How does the experiment work when using a longer string?
- How does the water behave on different types of materials? Why?
- Which material transports the water the fastest? The slowest?



twine, yarn, kite string, and fishing line

Part 3
One String or Two?

Invite students to experiment with two strings instead of one to create a water bridge. Ask students to discuss the following observations with their partner or group:
- How did your results change with two strings versus one?
- Did the water move faster or slower? Why?

Part 4
Going the Distance

Invite students to see if they can transport water across the entire room using the string of their choice. Ask students to make the following observations:
- How far can you get the water to travel?
- Which material works best for a long distance?
- How long did it take for the water to travel across the room on the string?
- How much water can you transport from one cup to the other?