Stickin' Together: Surface Tension, Cohension, and Adhesion

FRAMEWORK

I. Scientific and Engineering Practices
II. Cross-Cutting Concepts
III. Physical Sciences

SKILLS/OBJECTIVES

- Exploring water's ability to "stick" to itself and other materials; seeing what amazing properties this produces; connecting these facts to everyday observations like water's meniscus, the ability for objects to float on water, dew drops forming on plants, and the movement of water from root to stem in plants.

MATERIALS

- Water (1 gallon?)
- 2 test tubes
- 15-20 Pipettes
- 15-20 pennies
- 20 small Dixie cups
- 5 larger glasses
- Roll of paper towels
- 15-20 paper clips
- Soap
- Oil, ethanol (1/2 gallon each?)
- Food dye

NOTES

- The capillary action activity should be re-visited at the end of the lessons to examine its progress
- The first activity should be done as a large group, but the rest can be in smaller groups (3-5) kids with a club member.
- These activities should be accessible to all age groups

BACKGROUND

- Water is all around us and is necessary for every kind of life on this planet. Most of your body is made of water, and so is most of the planet!
- There are some really special and cool things about water that make it unique.
- It is actually really sticky stuff, even though it doesn't feel that way. It is able to "grab" onto itself better than a lot of other material. When it sticks to itself, water becomes very strong and able to hold things. Have you ever seen a bug walking on the water?
- The key idea here is that water "sticks" to things, especially itself, by grabbing and holding on which can lead to incredible strength and the ability to work against other forces.

Activity # 1	**Hydrogen Bonding**
Materials	None
Worksheet	None

- This is to provide an introduction to the idea of hydrogen bonding.
- Have each of the kids be an individual molecule of water (or if they don't understand that, maybe a "part" or "piece" of water?).
- Water likes to hang out with friends, so **everyone should try to hold hands (feet?) with as many people as they can at once!**
- In water, this kind of holding hands and feet is called a *Hydrogen Bond.*
- Now everyone is going to be a different kind of liquid, like ethanol or oil. These liquids don't like hanging out with other people as much, so **everyone can only hold hands with one other person and put the other hand behind their backs.**
- Which of these liquids, water or ethanol/oil, is stronger? If we were to throw a stuffed animal on top of you, which group would prevent it from hitting the ground?
- **Water is stronger because it likes to stick together!**

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Activity #2	**Capillary Action Paper Towel Race!**
Materials	• 2 test tubes • 1 small Dixie cup filled with water • 1 small Dixie cup filled with oil • 2 empty Dixie cups • 2 pieces of twisted paper towel • Food dye

Worksheet	None

- This activity shows how water may adhere to other surfaces to work against the force of gravity. This same principle, water's ability to stick to non-water surfaces, is responsible for concave appearance of water's meniscus. Mercury, on the other hand, has little adhesive properties, so the liquid in a thermometer, for example, forms a convex meniscus. Similarly, adhesion allows water to flow up small-diameter tubes, the root-shoot system in plants.
- *This should be done as a group in front of the whole class*
- **Pour water into one test tube and oil into another**
    - The top of the liquid, where liquid meets the air, is called *the meniscus*. It looks different for different liquids.
    - **-Examine the meniscus of the water and compare it to that of the oil.** What does it look like? How are they different?
        - The liquid with greater adhesive properties will climb higher up on the side of the test tube
- **Pour water into one cup and oil into another**
- **Add food dye color of the kids' choice to the cup full of water and of oil**
- **so it is easier to see.**
- **Kids twist a piece of paper towel until in looks like a string. They then place one end of the paper towel in the full cup of water and one end in the empty glass. Do the same for the cup of oil.**
- **Examine progress at end of class.**
- They should observe that the water can travel up the paper towel and into the empty cup faster/more than the oil.
- Have you seen this before? How does this relate to how plants get water from the ground?

Activity # 2	**Droplet**
Materials	o Pipettes o Cup of water o Pennies o Other liquids
Worksheet	None

- This activity looks at the ability of water to form sizable droplets due to cohesion. When the droplet gets too large, the pressure inside it overwhelms the weaker forces of cohesion acting on the surface, so the droplet bursts.
- **Kids use pipettes to drop water onto pennies**
- **If there is extra time, they could try to do the same with oil or ethanol**
- **Before they begin, ask how many drops of water they think a penny can hold.**
- **How large can they get the water droplet before it bursts? Which coin can hold the largest droplet? What happens when the coin is already wet? Are**

there other factors that affect how large the droplet can get? Would you say the cohesive forces are strong?

- Make sure they compare this to their daily observations about water droplets on plants etc.

Activity # 3	**Surface Tension**
Materials	o 1 glass filled with water o Paperclip o Paper towel o Soap
Worksheet	None

- This activity examines surface tension by using this force to float a paperclip on the surface of water and seeing what kinds of things break surface tension.
- **Have kids put a paperclip in the glass of water and see that it just sinks to bottom. Why couldn't it float? Why can little water bugs float on top of the water and not this paperclip?**
- **Remove the paper clip and dry it**
- **Have kids tear off a small piece of dry paper towel to place underneath the paperclip. Put both towel and paperclip in the glass of water.** The water will soak the paper towel, sinking it (you may want to push the paper towel down with your finger), leaving the dry paperclip to float on the surface of the water. **What was different this time? Did the paperclip weigh any less?**
- **Have kids put a drop of soap onto/near the paperclip and watch as the paperclip sinks. What happened here? What is important to maintain surface tension?**
- **Kids may then try this activity in the other liquids.**
- The paperclip did not sink the second time because it did not disturb the water's surface tension; the paper towel did that job for it. The soap breaks the surface tension and the paperclip sinks.

<u>Appendix of Info for Us Grown-Ups</u>

- Water has such high surface tension, cohesive, and adhesive properties because of its ability to form H-bonds. In bulk water, each water molecule can form 4 H-bonds. When adhering to other surfaces, dispersive forces allow water to make weak bonds with other materials; this causes capillary action and the formation of a meniscus etc. Other kinds of liquids aren't typically able to make as many H-bonds; ethanol for example, has a lower surface tension/cohesive abilities
- Surface tension and cohesion are essentially different words for the same property of water: its ability to make H-bonds. Adhesion has a different underlying mechanism

CONCLUSIONS

Water likes to grab onto itself and others, so it can hold weight, make droplet shapes, and travel up little tubes. These features are necessary for some of the things we see every day!

Whenever a water droplet sticks to your window, or you water a plant, think of all the different forces going on in there!