Water Olympics 9/13/07

DRAFT

Activity Description

Discusses surface tension and how it applies to the outside world with three demonstrations

Take Home Message

The molecules of water make a very strong bond together called a hydrogen bond. The bond is so strong that organisms and small objects can float on the water surface. Water molecules can also cling to other materials.

Massachusetts Frameworks

Physical Science

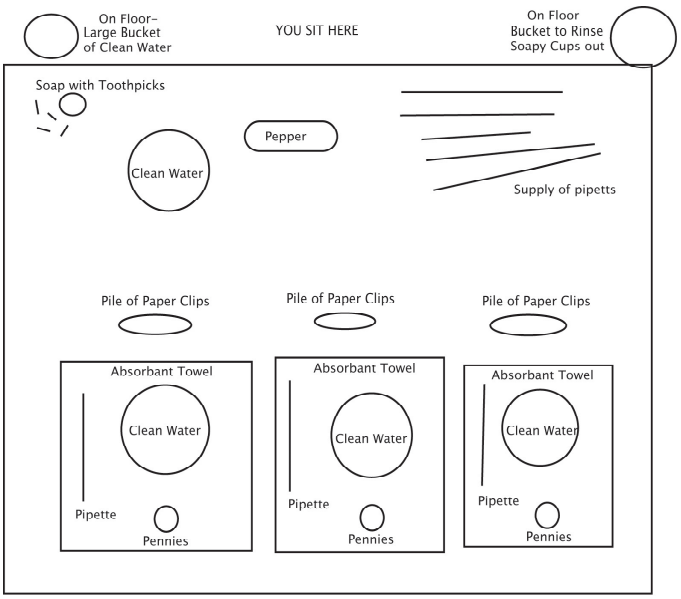
Properties of Matter #2

Supplies

- Pennies
- Pipettes
- Dry paperclips
- Small clear plastic cups: short wide ones work best.
- Fork
- Dishwashing soap (in a contact lens case or other small container and toothpick
- Spice (cinnamon, pepper)
- Sponge
- Pitcher of water
- Towels, one large to cover table, and one small one for each workstation
- Prizes (coin gum)

Set-Up

First lay out a towel on the table. Set up for each student: cup 1/2 filled with water on the small towel. Place one pipette next to each cup along with a penny and stack of paper clips. Place the signs where the kids can see them, "Caution scientists at work, don't move the table". Have a similar setup for yourself, so you can demonstrate. Have a few forks available, also set up the pepper trick (cup of water, packet of pepper, toothpick with dap of soap (from a contact lens case or film canister)



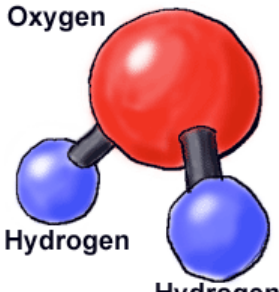
Background Science and Vocabulary

Starting with the Basics: Molecules and Polarity

Water is a **molecule** that is made up of one oxygen and two hydrogen atoms, as described by its chemical name, H_2O. In chemistry each type of molecule has a different configuration, and some have parts that carry a positive or negative charge. The configuration of the water molecule is such that it is polar: positively charged on the hydrogen side and negatively charged on the oxygen side. The polarity of water is one of the most important properties.

One reason polarity is important is because water can bond to other polar molecules; hence water is often called the universal solvent. A good example of this is the addition of sugar to water. Because sugar is also a polar molecule, the positive end of the water joins to the negative end of sugar and vice versa. Oil and water do not mix because oil is non-polar and therefore doesn't have a positive or negative side.

Salt is an example of an exception to this. Salt is a non-polar molecule, yet water can dissolve it. Salt dissolves in water because it breaks down into ions in solution. It becomes Na^+ and Cl^- ions that the water molecules attach to. Water, like other liquids, can also dissolve gases. An increase in pressure allows gasses to more easily dissolve in water and an increase in temperature causes a decrease in the ability to dissolve gases. This is why soda manufactures put the bottles under pressure to ensure the carbon dioxide gas does not escape and the gas remains dissolved in the soda.



Adhesion, Cohesion, Surface Tension, and the Capillary Effect

Two of the unique properties of water are caused by its polarity. Water molecules are attracted to each other; this is called **cohesion**. When water molecules bond to themselves, the bond is called a **hydrogen bond**. Although this bond is not as strong as a covalent bond, it provides stronger attractions between molecules than most polar bonds. Hydrogen bonds are responsible for surface tension as well as the high specific heat of water. The cohesion of molecules of water that allows it to support paper clips or water striders is called surface tension. The polarity of water also makes it stick to other types of substances. This is called **adhesion**. These properties are the reason plants can get water and blood can travel through the body. When water appears to be climbing a paper towel or a string that is at an angle with the ground it is because the water is attracted to the substance as well as itself. The water molecules will continue to "climb" until they are overcome by the force of gravity.

The reason that you can form bubbles comes from the property of adhesion. When soap is added, especially a soap like glycerin which is a **hygroscopic** (water-absorbing) chemical, you can increase the distance between water molecules without breaking the surface tension. The water molecules are still attracted to themselves forming the **surface tension**, but they are also attracted to the soap and glycerin mixture allowing them to be further apart then normal.

Activity Procedure/Script

- Introduce yourself and ask for the student's names. **Ask them about surface tension and if they know what it is.** If not, than ask them if they have ever seen a bug on the surface of the water. That is a good example; the weight of the bug fails to break the surface tension and therefore stays on top.

- Explain to the students that one of water's unique features is that water molecules are strongly attracted to one another. The attraction is so strong that they form a bond between each other - the water behaves as though it was covered by a thinly stretched membrane. This phenomenon is called surface tension.

- **Tell the students that there is a special name for when the water molecules are attracted to each other, do they know what it is?**
  - Try to get them to say cohesion.
  - Explain that the water molecules are drawn so close together that they stick (or cohere) to each other.
- **Tell the students that they can see just how this works!**
  - In front of each student have a penny, a pipette and a cup of water.
  - Make sure that each student knows how to use a pipette, have them practice to make sure they have good control and can let the water out a drop at a time (some youth don't know how to work a pipette)
  - Now tell them that they have to be very considerate scientists, and be VERY careful not to wiggle the table. You'll have to remind them a few times.
  - Have the students slowly add drops of water to the penny.
- **Ask the students what they are observing as they add more water.**
  - They should be seeing that a bubble is forming on top of the penny
  - As they add more drops the bubble should start to expand until it reaches the edges of the penny and grows up.
  - After they put enough drops the bubble will break.
- **Tell the students that when the bubble breaks, that is surface tension breaking. The water molecules were cohering to each other.**
  - You can have them keep track of how many drops they can add before the surface tension breaks, and keep track of the "total score" of each team…Then at the end of the festival announce the team winner.

- **Tell the students that now they are going to do another experiment to demonstrate surface tension.**
  - In front of each student there should be a cup that is about 1/2 full with water, a stack of paper clips, and a tool to lower the paper clips. (this is just a folded out paper clip or a fork works well also to slowly lower the clip onto the water surface).
  - Show the students how they can slowly drop a paper clip into the cup and it will float on top. (The trick here is to have the paper clip be totally flat and slowly lower it onto the waters surface, if the clip bends it will break the tension, if it is flat, it will float)
  - Have the students each try it a few times. See who can get the most paper clips to float on the surface of the water. The paper clips are floating on the surface "skin" of water.

- **As the paper clips are added to the water, ask the students to observe what is happening.**
  - Make sure they see how the paper clips are coming together
  - Also they should note what the water looks like around the edge of the paper clips. They can see how each molecule is attaching to the paper clip without actually breaking the surface tension.
  - Leave the cup with the most paper clips floating. Tell them to be careful not to wiggle the table.
- **Tell the students, that you want to show them a magic trick.**

    - Sprinkle some pepper on a glass 1/2 full of clean water. Get students to tell you why the pepper floats on top of the water (your choice: surface tension, the "skin on the water", cohesion, etc).
    - Now take a toothpick and touch the end to soap.
    - You can say, "And for the magic trick, I will use soap to break the surface tension of the water"
    - Touch the soap to the water surface, and voila, the pepper shoots to the sides of the glass and then falls to the bottom.
- **Ask the students, what they think will happen if soap is added to the cup of water with the paper clips?**
    - The paper clips will sink because you have broken the surface tension and the water molecules will no longer adhere to the paper clip.
    - Let the student who had floated the most clips touch the toothpick with soap to the surface of his cup, (all the clips drop as if by magic)
- **Record the most number of paper clips a student got as well as the number of water droplets on the penny. Compare these to other groups that have come through the day.**
- **Ask the students questions about adhesion, cohesion, and surface tension.**

Clean-Up

During the festival

- After a few groups, dry the paper clips and pennies.
- Rinse out the cups, the water gets gross from kids fingers.
- Refill the cup of water about 1/2 full.
- Make sure that the cups where you added soap are well rinsed, it won't work if any soap is left.

After the festival

- Empty all the water from the cups.
- Thoroughly dry the paper clips and pennies.
- Pack everything up neatly in the box.
- The only supply that you may need to replenish is the soap in the little container, and toothpicks. you can get soap from Fred the Fish, or the Bubble Booth. A tablespoon or two should last all year.

NOTES: While surface tension a simple principal, is an excellent opportunity to talk about the amazing properties of water. You will have to emphasize that the kids need to be very careful to not shake the table. Try to pick the most level table to begin with.