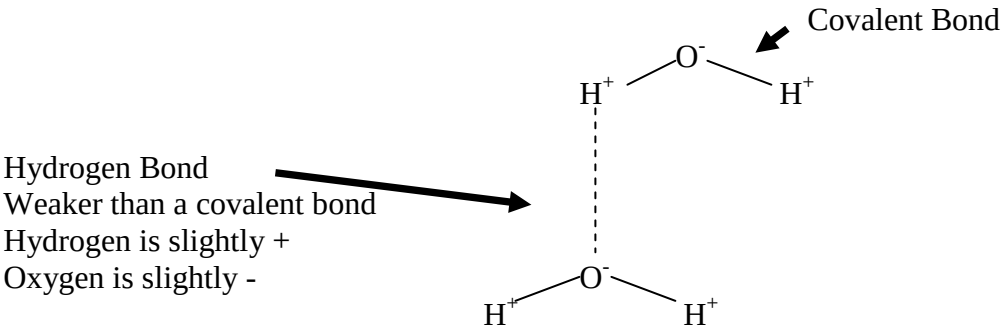
Explanation of Chemistry
The Properties of Water Lab

Water is unique; it does not follow the predicted trends that many other chemical compounds follow. The polarity and hydrogen bonding allow for interesting properties that make life possible.
This polarity and subsequent hydrogen bonding allows for the properties of water such as high boiling point, high heat of vaporization, high specific heat, high heat of fusion, low vapor pressure, ice floating, and high cohesive forces.
Water is composed of two hydrogen atoms covalently bonded to one oxygen atom. Water molecules are attracted to one another through much weaker bonds called hydrogen bonds, where the hydrogen of one water molecule forms a weak bond (the hydrogen bond) with the oxygen of another water molecule.



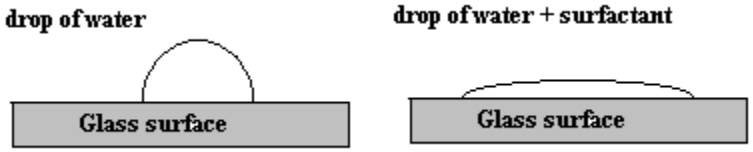
These are good sources of information about water:
http://www.physicalgeography.net/fundamentals/8a.html
http://ga.water.usgs.gov/edu/waterproperties.html Has an online quiz
http://en.wikipedia.org/wiki/Water_(molecule)
http://www.edinformatics.com/math_science/water_ice.htm
http://www.johnkyrk.com/H2O.html Great animations
http://www.biology.arizona.edu/biochemistry/tutorials/chemistry/page3.html
http://www.youtube.com/watch?v=TdMIsCF_7p0&NR=1 slow motion video that demonstrates the adhesion, cohesion, and surface tension properties of water. REALLY COOL!

Station 1-Water expands as it freezes, and becomes less dense. In liquid water, as molecules slip and slide past each other, hydrogen bonds form, break, and reform. By the time water has cooled to 4°C, the energy in the molecules is so low that the molecules are very close together, and each water molecule forms additional hydrogen bonds. At this temperature water reaches its maximum density, making it denser than water at room temperature. However, between the temperature of 4°C and 0°C the molecules line up in a crystalline lattice, which is an open hexagonal shape so as to achieve the maximum distance between the electron-rich oxygen atoms (like charges repel one another). The water molecules are held rigidly apart, unlike the molecules in liquid water. This means more empty space between the molecules and it occupies more space, and is subsequently less dense. Recall that density is defined as mass per unit volume.

Station 2 part 1-Water has a high surface tension. In other words, water is cohesive, adhesive, and elastic, and tends to aggregate in drops rather than spread over a surface as a thin film. This phenomenon also causes water to stick to the sides of vertical structures despite gravity's downward pull. Water's high surface tension allows for the formation of water droplets and waves, allows plants to move water (and dissolved nutrients) from their roots to their leaves, and the movement of blood through tiny vessels in the bodies of some animals. Pidwirny, M. (2006). "Physical Properties of Water". *Fundamentals of Physical Geography, 2nd Edition*. December 30, 2008. http://www.physicalgeography.net/fundamentals/8a.html Surface tension is the result of the strong cohesive forces of water.

Unlike water molecules in the interior of the liquid, which are bonded equally in all directions, water molecules at the surface are drawn to each other in fewer directions (horizontally and various angles downward) because air molecules lie above the water surface. With fewer total bonds, each surface water molecule bonds more strongly with those water molecules that surround it to the sides and below, almost forming a "skin" on the water surface.
http://www.kids.union.edu/pepperRun.htm

Station 2 part 2-Detergents contain surfactants (**s**urface **act**ing age**nts**) which reduce the surface tension of water by adsorption at the liquid-gas, liquid-solid, or liquid-liquid interfaces, which means that the presence of the surfactant in the water allows a film of gas molecules to adhere to the surface of the water thereby reducing the interfacial tension causing the droplet to spread out. A **detergent** is a material intended to assist cleaning.
http://en.wikipedia.org/wiki/Surfactant
A surfactant is briefly defined as a material that can greatly reduce the surface tension of water when used in very low concentrations.
http://www.chemistry.co.nz/surfactants.htm



Station 3-Adhesion and cohesion- **Adhesion** is the tendency of certain **dissimilar molecules** to cling together due to attractive forces. http://en.wikipedia.org/wiki/Adhesion
Cohesion (chemistry): the intermolecular attraction between **like-molecules**.
http://en.wikipedia.org/wiki/Cohesive

The water adheres to the glass stirring rod because the charges of the water and the glass attract each other. Cohesion (relates back to hydrogen bonding) of the water molecules keep it on the stirring rod. Water does not adhere to the plastic because the charges on the water molecules and the plastic do not attract each other.

Station 4 part 1-Adhesion, cohesion, and surface tension (see station 2 part 1 and station 3). The water adheres to the dime and the cohesion of the water molecules and the strong surface tension keep them bound together. At some point, the force of gravity on the water bulging over the sides is greater than the cohesive and surface tension forces.

Station 4 part 2-The detergent acts as a surfactant and lowers the surface tension of the water (see station 2 part 2)

Station 5-Adhesion, cohesion, and surface tension (see above). Alcohol has lower adhesion, cohesion and surface tension than water.

Station 6-Water molecules are polar; they have an electron rich end (partially negative) and an electron poor end (partially positive). When you rub a balloon on a paper towel (or your hair) you give the balloon a static charge (in this case, a negative charge). When the balloon is brought close to the water stream, the water is polarized by the presence of the electric field from the balloon, attracting the partially positive ends of the water molecules thereby bending the water stream.

Station 7-Water molecules adhere to the paper, and the cohesive forces keep the column of water together. The water should move until the adhesive and cohesive forces are equal to the force of gravity. This is an example of capillary action.

Station 8-The adhesive forces of water and glass are strong, the adhesive forces of water and plastic are not as strong, so you see a meniscus in the glass cylinder but not one in the plastic cylinder. Compare the alcohol to the water. Does alcohol have strong adhesive forces to glass or alcohol? If a meniscus forms, the answer is yes.

Station 9-The high surface tension of water allows the pepper to float randomly on the surface. The addition of detergent disrupts the surface tension where the detergent is placed and the water molecules and pepper on top move to the sides. This is similar to what happens when a rope being pulled on both ends equally is suddenly cut in the middle. Here is one explanation: http://drholly.typepad.com/ask_me_a_chemistry_questi/2006/01/pepper_and_soap.html

Station 10-The pH of pure water is 7 because when water ionizes, the concentration of the hydronium ion (H_3O^+) is equal to the concentration of the hydroxide ion (OH^-). If the concentration of H_3O^+ is greater than the concentration of OH^-, the solution is acidic (pH lower than 7). If the concentration of OH^- is greater than the concentration of H^+, then the solution is basic (pH greater than 7).

Most of the water we drink is close to a pH of 7, depending upon the materials naturally found in it, therefore, all of the drinking water tested should be around 7. If the pH is higher or lower, something in the water is causing it to be more acidic or basic. The other liquids will have different pH values. http://ga.water.usgs.gov/edu/phdiagram.html

Station 11- Capillary action occurs because water is sticky -- water molecules stick to each other (cohesion) and to other substances (adhesion), such as glass, cloth, organic tissues, and soil.

Plants and trees could not thrive without capillary action. Plants put down roots into the soil which are capable of carrying water from the soil up into the plant. Water, which contains dissolved nutrients, moves into the roots and up the plant tissue. As a water molecule begins climbing, it pulls a nearby water molecule with it, and so on.

Think of the tiniest blood vessels in your body -- your capillaries. Your blood is mostly water, and capillary action assists the pumping action of your heart to help keep blood moving in your blood vessels.
http://dwb4.unl.edu/Chem/CHEM869A/CHEM869ALinks/ga.water.usgs.gov/edu/capillaryaction.html

Water climbs up a thin glass tube because of the strong hydrogen-bonding interactions between the water and the oxygens (and terminal hydrogens) at the surface of the glass (SiO_2; surface oxygens are typically bonded to hydrogen). The energetic gain from the new intermolecular interactions must be balanced against gravity, which attempts to pull the liquid back down. Therefore, the narrower the tube, the higher the liquid will climb, because a narrow column of liquid weighs less than a thick one. http://www.madsci.org/posts/archives/1998-02/887637827.Ch.r.html

Water will not move between the two slides rubber banded together because there is not enough space between them. Water will move up the slides separated with the toothpick, however, the side without the toothpick has the best movement. Capillary action occurs best in small spaces and the side with the toothpick has a larger space.