Name ______________________________ Date __________
AP Biology Mr. Collea

Part I. Water Molecule Building Activity

(Prior Knowledge)

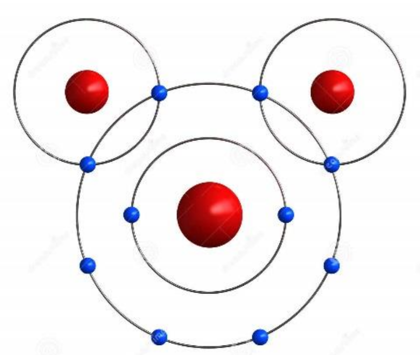


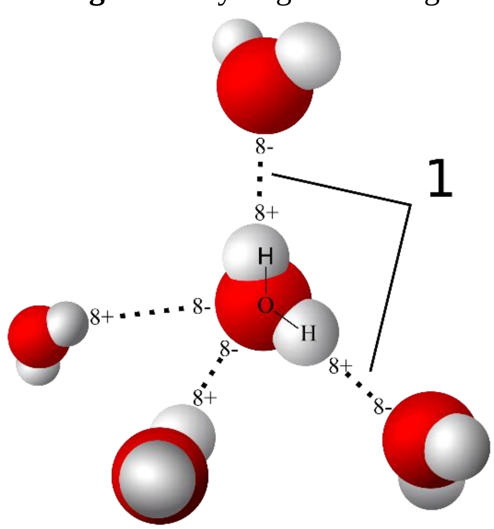
Figure 1. Molecular Structure of Water

IMAGINE TRYING TO live in a world dominated by ***dihydrogen oxide,*** *a compound that has no taste or smell and is so variable in its properties that it is generally benign but at other times swiftly lethal. Depending on its state, it can scald you or freeze you. In the presence of certain organic molecules it can form carbonic acids so nasty that they can strip the leaves from trees and eat the faces off statuary. In bulk, when agitated, it can strike with a fury that no human edifice could withstand. Even for those who have learned to live with it, it is an often murderous substance.* ***We call it water****.*

Background Information

Water is a compound essential to all living things. The average human body is 70% water by volume. Without water, cells would have difficulty maintaining their shape and chemical messengers and vital nutrients could not travel around the body. Water is the medium in which the business of life is conducted. Water is formed when one oxygen atom forms a single covalent bond with two separate hydrogen atoms. This arrangement gives oxygen the two electrons it needs to fill its outer shell and allows both hydrogen atoms to receive the single electrons they need for their outer shells. The oxygen and hydrogen atoms share electrons but they don't exactly share evenly. **(Figure 1)** Oxygen has eight protons in its nucleus and each hydrogen atom has only one. Because oxygen's nucleus has so many more protons, the pull it has on the orbiting electrons is much greater that the pull exerted by the much smaller hydrogen nuclei. As a result the electrons spend a greater amount of their time on the oxygen side of the water molecule. This creates a region of slightly negative charge on the oxygen side of water and a region of slightly positive charge on the hydrogen side of water. A molecule with an uneven distribution of charge is known as a **polar molecule**. The polar nature of water allows it to demonstrate some unique properties that will be investigated in this activity.

Figure 2: Hydrogen Bonding



Activity 1A: Hydrogen Bonding in Water

<u>Procedure</u>:

Using the Water Molecule Model Building Cut-Outs page:

1. Color the oxygen atoms of each water molecule red.
2. Indicate the relative charge of each side of the water molecules by placing pluses and minuses on the correct sides.
3. Cut out 5 of the water molecules.
4. Model a water droplet by gluing the water molecules in an arrangement similar to **Figure 2** in the space below.
5. Indicate the hydrogen bonds between each water molecule by drawing three black circles as seen in **Figure 2**.

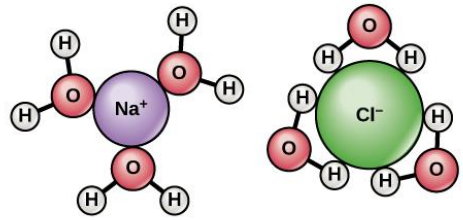
Model of a Water Droplet

Part II. Properties of Water

Activity 1: Disassociation of Salt in Water

The polarity of water enables it to dissolve many things including ionic compounds such as sodium chloride or table salt (NaCl). Water dissolves sodium chloride by causing the sodium (Na+) and Chlorine (Cl-) ions to pull away or disassociate from one another. The water molecules form a **hydration sphere** around each ion (**Figure 3**). The negative side of the water molecule will orientate toward the positive sodium ions and the positive side of the water molecule will orientate toward the negative chlorine ions.
If the water evaporates, the sodium and chlorine ions will come together again to form salt crystals.

Figure 3: Hydration Sphere



<u>Procedure</u>:

Using the Water Molecule Model Building Cut-Outs page:

1. **1.** Model a hydration sphere by cutting out and gluing the sodium (NA+) and chlorine (Cl-) ions and six water molecules water molecules in an arrangement similar to **Figure 3** in the space below.

Disassociation of Salt in Water

Activity 2: "Universal" Solvent

Contrary to the last activity, water is not a universal solvent, as it is unable to dissolve **nonpolar** molecules such as lipids/oils and some proteins thus making them very difficult to enter cells. The polarity of water is also critical to the structure of cell membranes, which are composed of phospholipids and proteins and will be discussed in more detail in Chapter 8.

Materials:

water ethanol 50 mL beaker pipets US penny safety goggles

SAFETY

Ethanol is flammable. Keep away from sources of heat. Do not ingest!

Procedure:

1. Fill a 50 mL beaker with 20 mL of water.
   Fill a second 50 mL beaker with the same amount of ethanol.
2. Place a pinch of salt into the beaker of water and carefully swirl it around to see if it dissolves.
   Does it dissolve **YES** or **NO**? Record your results in the data table below.
3. Repeat step 2, except place the salt into the 50 mL beaker containing ethanol and record your results in the data table below.
4. Clean up your work area.

Table 1. Dissolving Results

Dissolving Results	
Water	Ethanol

In what liquid(s) does the salt a dissolve and why?

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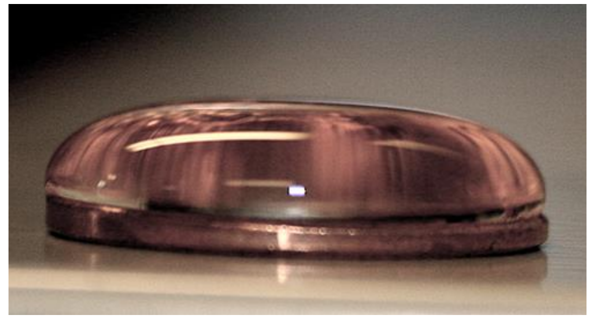
Activity 3: Adhesion, Cohesion and Surface Tension



Adhesion is the ability of water to stick to others substances. For example, water can stick to the side of a swimming pool. *Cohesion* is the ability of water molecules to stick to themselves (H-bonds). Cohesion causes the surface of the water to have tension and tests can be done to measure the relative tension of different aqueous solutions. In this portion of the lab, you will examine these three properties and later apply them to the concept of capillary action.

1. Obtain two pennies, 2 pipettes, a beaker of distilled water and a beaker of ethanol.
2. Use your pipette to drop water onto a penny, one drop at a time. Count how many drops you can add before any water spills over the edge. Record the number of drops in the data table below.
3. Repeat this 2 more times and find the average number of drops of water a penny will hold. Be sure to completely dry your penny between each trial.
4. Repeat steps 2 and 3 with ethanol.
5. Clean up your work area.

Table 2. Drop Results

Number of Drops on a Penny		
Trial	Water	Ethanol
1		
2		
3		
Avg.		

Is there a difference in the total number of drops that can fit on a penny for each liquid? ___________

Is this difference **SIGNIFICANT**? ____

Which liquid had more cohesion? How do you know?
Give an explanation for your results in terms of hydrogen bonds.

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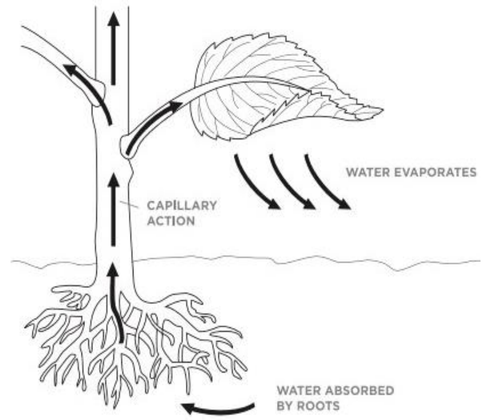
Activity 4: Capillary Action, Adhesion and Cohesion



Water has the ability to stick onto things (*adhesion*) and stick to itself (*cohesion*). These two properties together allow water to defy gravity and climb up tubes of small diameter in plants called xylem. This is called capillary action and is responsible for the transpirational pull observed in plants. You will learn what specific role water plays in photosynthesis in Ch.10.

1. Observe the white carnations in the various colored water solutions.

Use the diagram above to help you explain how these properties could be applicable to living things.

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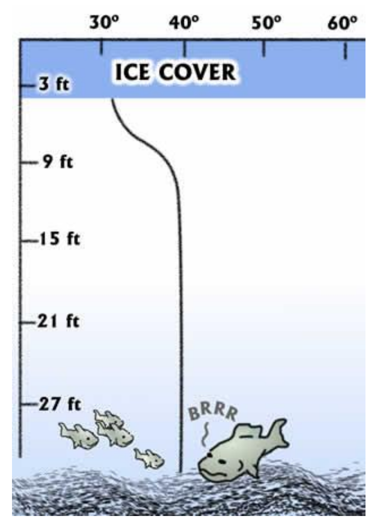
Activity 5: Water Expands Upon Freezing



<u>Density</u> is the mass of the material in a given volume. The density of most liquids increases as temperature decreases so most substances are MORE dense as solids than as liquids. The molecules of a liquid move more slowly and come close together as the Average Kinetic Energy (temperature) decreases. However, water's hydrogen bonds keep the individual water molecules "at arm's length" when freezing and water reaches it maximum density at 4^{o}C… <u>SO . . . SOLID ICE IS LESS DENSE THAN LIQUID WATER</u> which means ice floats. This unique property causes lakes to freeze from the top down which insulates bodies of water by floating ice thus protecting aquatic ecosystems by allowing living things to survive in winter when lake/pond freezes

1. Place a few ice cubes in a glass of water and *describe* and *explain* what happens.

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2. State why this property important for aquatic ecosystems like lakes and pond?

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Activity 6: Thermal Properties

Water has a **high specific heat** which means water can absorb a large amount of heat before its temperature significantly changes – this helps organisms to MAINTAIN a STABLE internal temperature.
The heat capacity of water is about four times greater that air.

1. Fill a balloon with water then hold it over a lit candle.
(Be sure to do this in the SINK)

2. Briefly *describe* and *explain* what happens.

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Discussion Questions

1. Why do living things need water?

2. What kinds of bonds can form between two adjacent water molecules?

3. How does the size of oxygen's nucleus affect the distribution of electrons in the water molecule?

4. What does it mean to be a polar molecule?

5. Give an example of water's cohesive and adhesive nature playing a role in a biological process.

6. Is water the world's greatest solvent?

7. What structures are formed when water molecules surrounds individual ions?

Water Molecule Building Activity

(Cut- Outs)