Introduction to WATER

Overview: The Molecule That Supports All of Life

- Water is the biological medium on Earth
- All living organisms require water more than any other substance
- Most cells are surrounded by water, and cells themselves are about 70-95% water
- The abundance of water is the main reason the Earth is habitable

Four of water's properties that facilitate an environment for life:

- Cohesive behavior
- Ability to moderate temperature
- Expansion upon freezing
- Versatility as a solvent

The polarity of water molecules results in hydrogen bonding

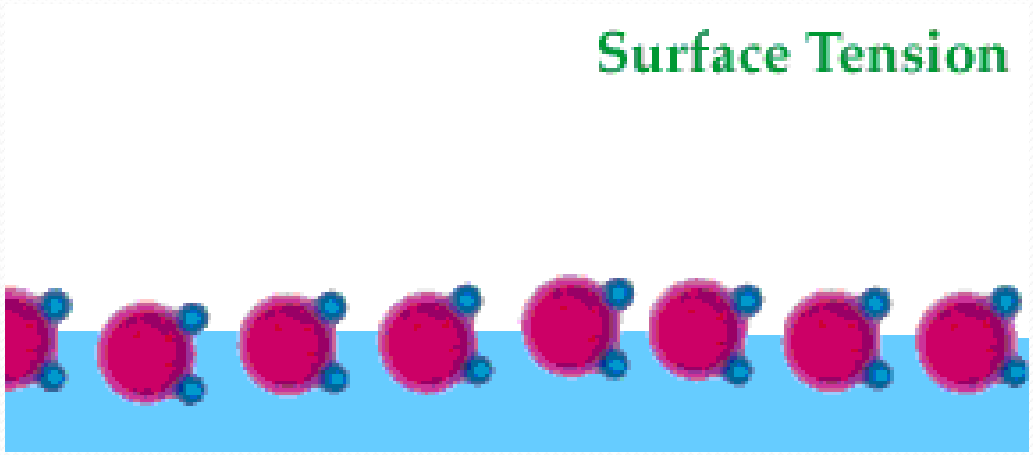
- The water molecule is a polar molecule: The opposite ends have opposite charges
- Polarity allows water molecules to form hydrogen bonds with each other

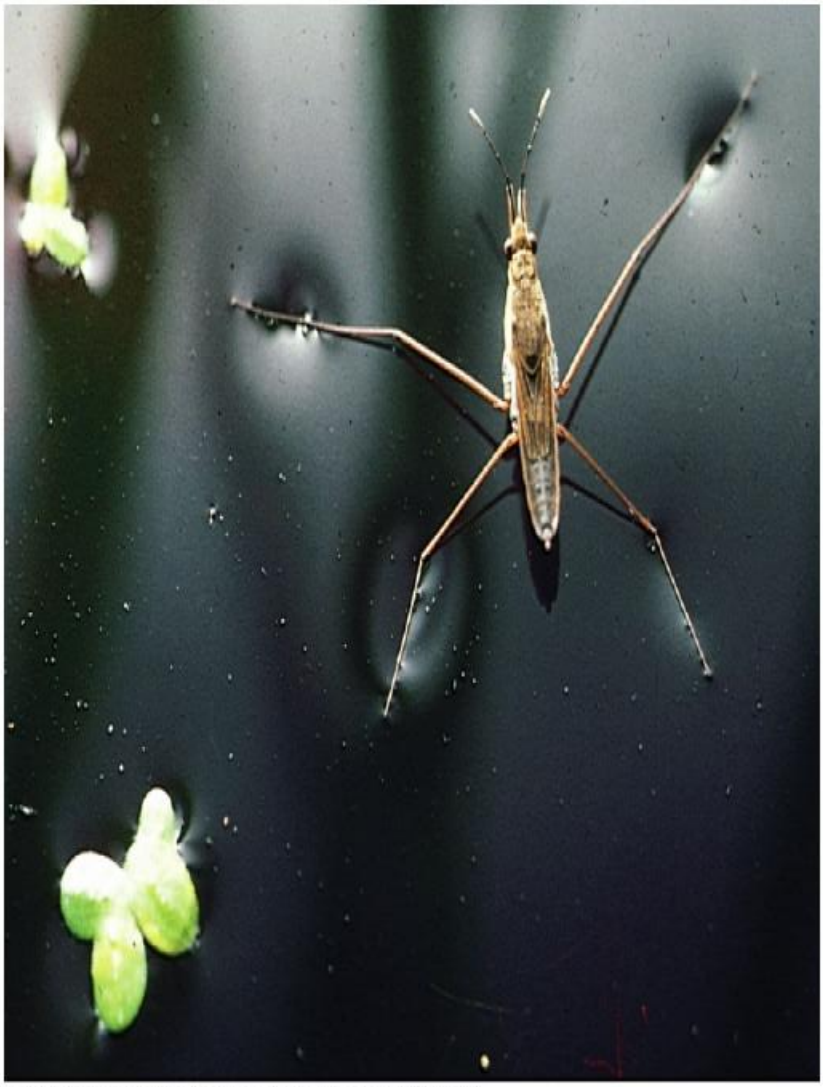
Cohesion

a physical property of a substance, caused by the intermolecular attraction between like-molecules within a body or substance that acts to unite them.

- In other words: Water is attracted to Water.
- Collectively, hydrogen bonds hold water molecules together, a phenomenon called cohesion
- Cohesion helps the transport of water against gravity in plants

- ***Surface tension*** is the name we give to the cohesion of water molecules at the surface of a body of water.
- Surface tension is a measure of how hard it is to break the surface of a liquid





Adhesion

Adhesion: the tendency of certain dissimilar molecules to cling together.

Adhesion of water to plant cell walls also helps to counter gravity

- The oxygen end of water has a negative charge and the hydrogen end has a positive charge. The hydrogen's of one water molecule are attracted to the oxygen from other water molecules.
- This attractive force is what gives water its cohesive and adhesive properties.

Moderation of Temperature

- Water absorbs heat from warmer air and releases stored heat to cooler air
- Water can absorb or release a large amount of heat with only a slight change in its own temperature

Water's High Specific Heat

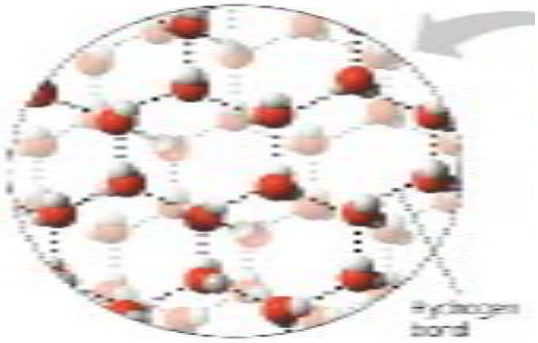
- The specific heat of a substance is the amount of heat that must be absorbed or lost for 1 gram of that substance to change its temperature by 1°C
- Water's high specific heat (4186°)minimizes temperature fluctuations to within limits that permit life
  - Heat is absorbed when hydrogen bonds break
  - Heat is released when hydrogen bonds form

Evaporative Cooling

- Evaporation is transformation of a substance from liquid to gas
- As a liquid evaporates, its remaining surface cools, a process called evaporative cooling
- Evaporative cooling of water helps stabilize temperatures in organisms and bodies of water

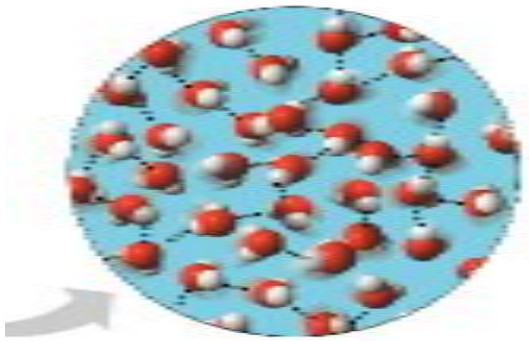
Insulation of Bodies of Water

- Ice floats in liquid water because hydrogen bonds in ice are more "ordered," making ice less dense
- If ice sank, all bodies of water would eventually freeze solid, making life impossible on Earth



ICE

Hydrogen bonds are stable.



Liquid Water

Hydrogen bonds constantly break and reform

The Universal Solvent

- Water is often called the universal solvent due to the fact that many substances can dissolve in water.

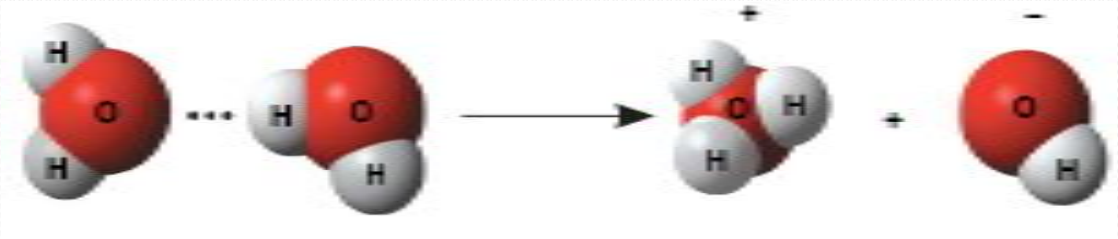
- **It has the ability to dissolve both bases and acids**

The Solvent of Life

- A solution is a liquid that is a homogeneous mixture of substances
- A solvent is the dissolving agent of a solution
- The solute is the substance that is dissolved
- Water is a versatile solvent due to its polarity

Dissociation of water leads to acidic and basic conditions

- A hydrogen atom in a hydrogen bond between two water molecules can shift from one to the other:
  - The hydrogen atom leaves its electron behind and is transferred as a proton, or hydrogen ion (H+)
  - The molecule with the extra proton is now a hydronium ion (H_3O^+)
  - The molecule that lost the proton is now a hydroxide ion (OH^-)



Hydronium H_30

Hydroxide (OH-)

- The process can be described in a simplified way as the separation of a water molecule into a hydrogen ion (H^+) and a hydroxide ion (OH^-)
- Though statistically rare, the dissociation of water molecules has a great effect on organisms
- Changes in concentrations of H^+ and OH^- can drastically affect the chemistry of a cell

Effects of changes in pH

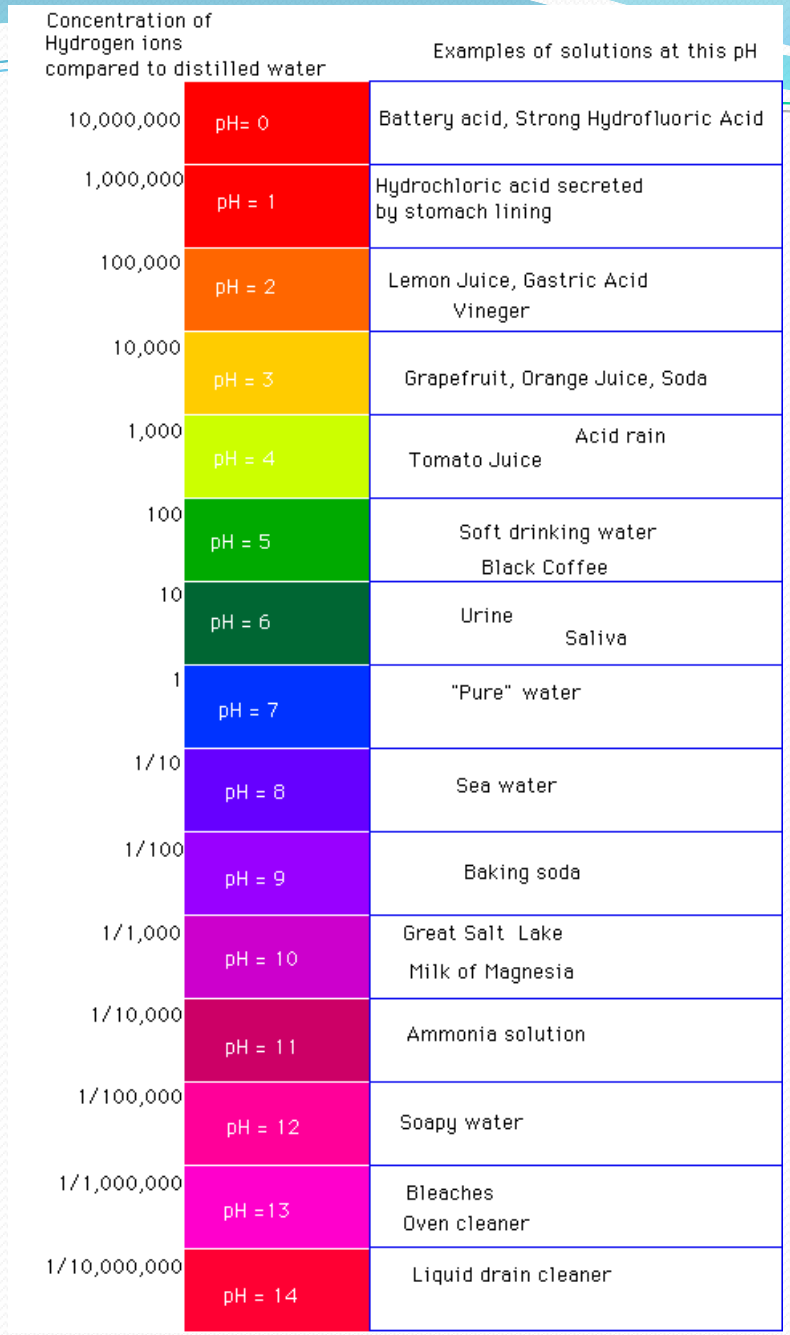
- Concentrations of H+ and OH- are equal in pure water
- Adding certain solutes, called acids and bases, modifies the concentrations of H+ and OH-
- Biologists use something called the pH scale to describe how acidic or basic (the opposite of acidic) a solution is

Acids and Bases

- An acid is any substance that increases the H+ concentration of a solution
- A base is any substance that reduces the H+ concentration of a solution

pH Scale

- The pH of a solution is determined by the relative concentration of hydrogen ions
- Acidic solutions have pH values less than 7
- Basic solutions have pH values greater than 7
- Most biological fluids have pH values in the range of 6 to 8


Concentration of Hydrogen ions compared to distilled water
Examples of solutions at this pH
10,000,000
pH= 0
Battery acid, Strong Hydrofluoric Acid
1,000,000
pH = 1
Hydrochloric acid secreted by stomach lining
100,000
pH = 2
Lemon Juice, Gastric Acid
Vineger
10,000
pH = 3
Grapefruit, Orange Juice, Soda
1,000
pH = 4
Acid rain
Tomato Juice
100
pH = 5
Soft drinking water
Black Coffee
10
pH = 6
Urine
Saliva
1
pH = 7
"Pure" water
1/10
pH = 8
Sea water
1/100
pH = 9
Baking soda
1/1,000
pH = 10
Great Salt Lake
Milk of Magnesia
1/10,000
pH = 11
Ammonia solution
1/100,000
pH = 12
Soapy water
1/1,000,000
pH =13
Bleaches
Oven cleaner
1/10,000,000
pH = 14
Liquid drain cleaner

Buffers

- The internal pH of most living cells must remain close to pH 7
- Buffers are substances that minimize changes in concentrations of H+ and OH- in a solution
- Most buffers consist of an acid-base pair that reversibly combines with H+