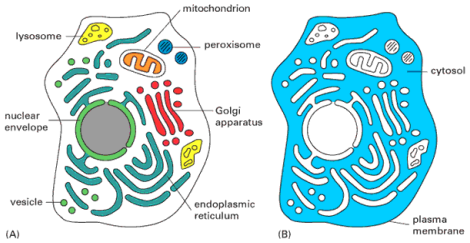
Chapter 2.4

Water—The Elixir of Life!

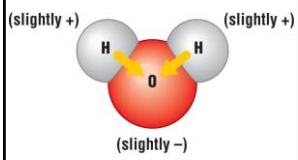
Why are we studying water?

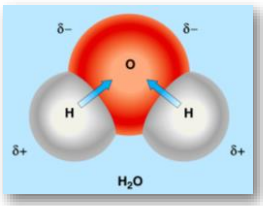
- All life occurs in water
  - inside & outside the cell



Chemistry of water

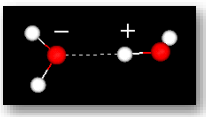
- Water is polar molecule
  - remember polar covalent bonds
  - + & – poles

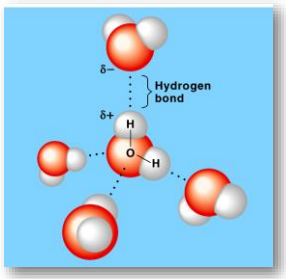




Chemistry of water

- H_2O molecules form H bonds with each other
  - + attracted to –
  - creates a sticky molecule



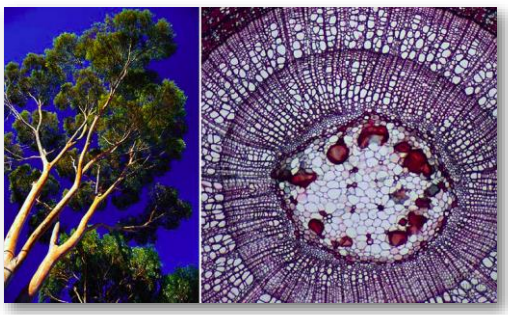


Cohesion

- H bonding between H_2O creates cohesion
  - water is "sticky"
  - surface tension
  - drinking straw
    - can you suck sugar up a straw?

How does H_2O get to top of tree?

- Transpiration (much, much later)

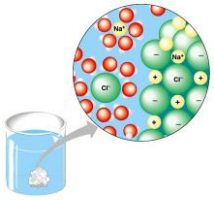


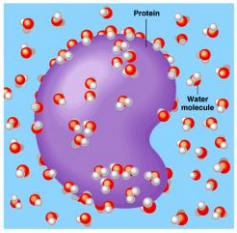
Adhesion

- H_2O molecules form H bonds with other substances
  - capillary action
  - meniscus
  - water climbs up fiber
    - ex. paper towel

Water is the solvent of life

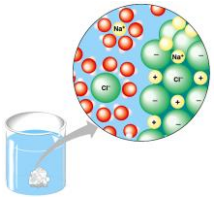
- H_2O is a good solvent due to its polarity
  - polar H_2O molecules surround + & – ions
  - solvents dissolve solutes creating aqueous solutions

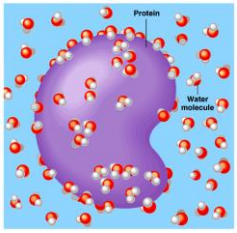




Hydrophilic

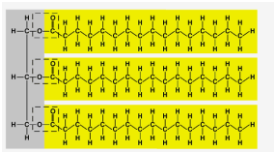
- Hydrophilic
  - substances have affinity for H_2O
  - polar or non-polar?
  - ionic





Hydrophobic

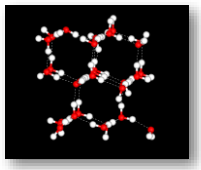
- Hydrophobic
  - substances do not have affinity for H_2O
  - polar or non-polar?
  - non-ionic

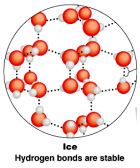


fat (triglycerol)

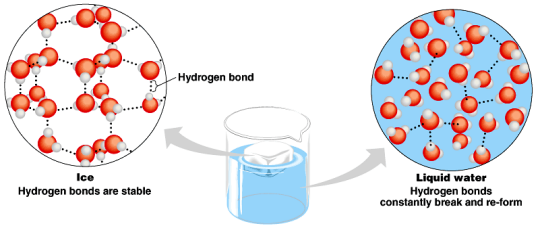
The special case of ice

- Most (all?) substances are more dense when they are solid
- But not water…
- Ice floats!
  - H bonds form a crystal with loose structure





Ice floats



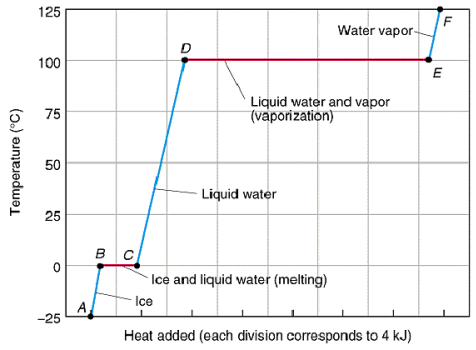
Why is "ice floats" important?

- Oceans & lakes don't freeze solid
  - if ice sank…
    - eventually all ponds, lakes & even ocean would freeze solid
    - during summer, only upper few inches would thaw
  - surface ice insulates water below
    - allowing life to survive the winter
  - seasonal turnover of lakes
    - cycling nutrients

Specific heat

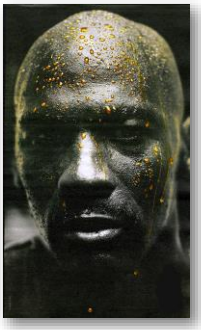
- H_2O has high specific heat
  - due to H bonding
- H_2O resists changes in temperature
  - takes a lot to heat it up
  - takes a lot to cool it down
- H_2O moderates temperatures on Earth

Heating curve for 1.00 mol of ice at -25°C



Evaporative cooling

- Organisms rely on heat of vaporization to remove heat



Water forms ions

- Hydrogen ion (H^+) splits off from water to leave a hydroxide ion (^-OH)

$$H_2O \rightarrow H^+ + {}^-OH$$

- If concentration of 2 ions is equal, water is neutral
- If $[H^+] > [^-OH]$, water is acidic
- If $[^-OH] > [H^+]$, water is basic
- pH scale = how acidic or basic a solution is

pH Scale

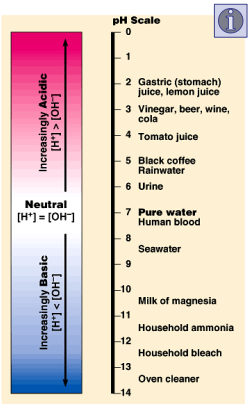
- In pure water only 1 water molecule in every 554 million is dissociated.
  - very small amount of ions
  - $[H^+]$ and $[OH^-]$ is 10^{-7}M

$$[H^+]\,[OH^-] = 10^{-14}$$

- pH scale is based on this equation

pH Scale

- In neutral solution $[H^+] = 10^{-7} \rightarrow pH = 7$
- Values for pH ***decline*** as $[H^+]$ ***increase***
- Acids
  - adding acid increases $[H^+]$
- Bases
  - adding base increases $[OH^-]$

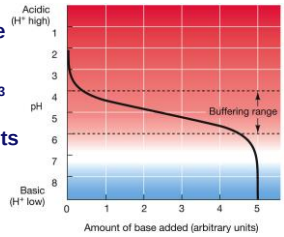


pH & Biology

- pH of a neutral solution = 7
- Acidic solutions = pH < 7
  Basic solutions = pH > 7
- Most biological fluids have pH 6 – 8
  - pH values in human stomach can reach 2
- Each pH unit represents a 10-fold difference in H^+ & OH^- concentrations.
  - small change in pH actually indicates a substantial change in $[H^+]$ & $[OH^-]$

Buffers

- Resist pH change
- Is a solution of weak acid and its corresponding base
- ex. $HCO_3^- + H^+ \rightarrow H_2CO_3$
- Staying in the buffering range limits pH swings



Importance of Water

- Water is a polar molecule
- The special properties of water make life on Earth possible
- The chemical behavior of water governs how organisms function