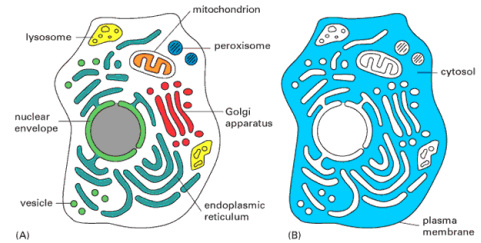


## Chapter 2.4 Water—The Elixir of Life!



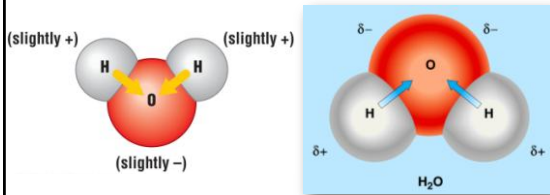
### Why are we studying water?

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



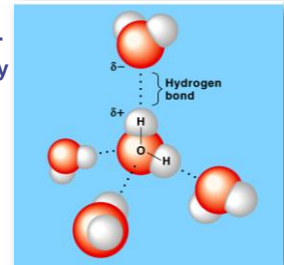
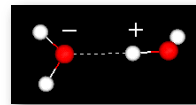
### Chemistry of water

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



### Chemistry of water

- H<sub>2</sub>O molecules form H bonds with each other
  - ◆ + attracted to -
  - ◆ creates a sticky molecule



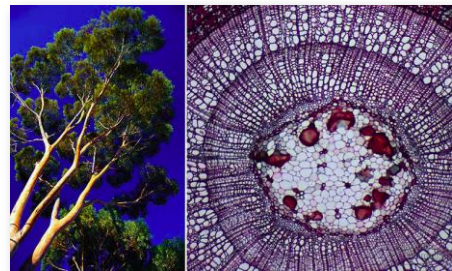
### Cohesion

- H bonding between H<sub>2</sub>O creates cohesion
  - ◆ water is “sticky”
  - ◆ surface tension
  - ◆ drinking straw
    - can you suck sugar up a straw?



### How does H<sub>2</sub>O get to top of tree?

- Transpiration (much, much later)

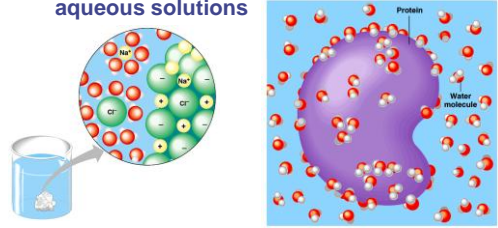


### Adhesion

- H<sub>2</sub>O molecules form H bonds with other substances
  - ◆ capillary action
  - ◆ meniscus
  - ◆ water climbs up fiber
    - ex. paper towel

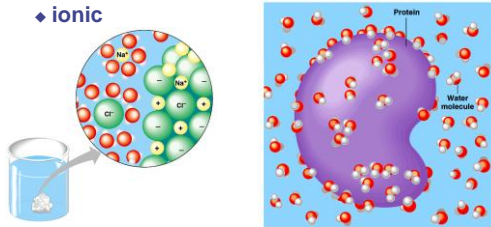
### Water is the solvent of life

- H<sub>2</sub>O is a good solvent due to its polarity
  - ◆ polar H<sub>2</sub>O molecules surround + & - ions
  - ◆ solvents dissolve solutes creating aqueous solutions



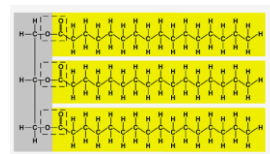
### Hydrophilic

- Hydrophilic
  - ◆ substances have affinity for H<sub>2</sub>O
  - ◆ polar or non-polar?
  - ◆ ionic



### Hydrophobic

- Hydrophobic
  - ◆ substances do not have affinity for H<sub>2</sub>O
  - ◆ polar or non-polar?
  - ◆ non-ionic

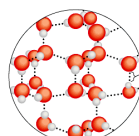
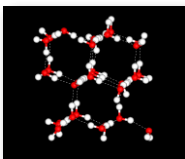


fat (triglycerol)



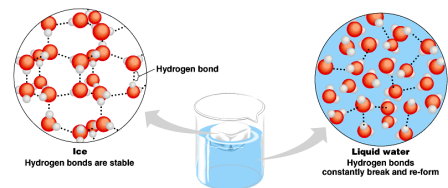
### The special case of ice

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



Ice  
Hydrogen bonds are stable

### Ice floats



Ice  
Hydrogen bonds are stable

Liquid water  
Hydrogen bonds constantly break and re-form

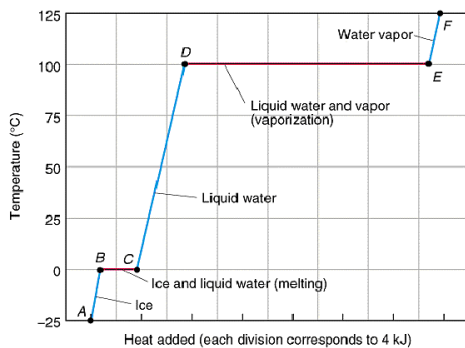
### Why is "ice floats" important?

- 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

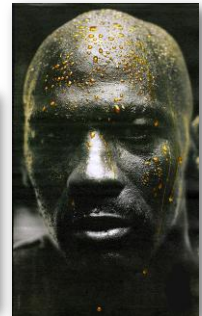
- H<sub>2</sub>O has high specific heat
  - ◆ due to H bonding
- H<sub>2</sub>O resists changes in temperature
  - ◆ takes a lot to heat it up
  - ◆ takes a lot to cool it down
- H<sub>2</sub>O moderates temperatures on Earth

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<sup>+</sup>) splits off from water to leave a hydroxide ion (OH<sup>-</sup>)



- If concentration of 2 ions is equal, water is **neutral**
- If [H<sup>+</sup>] > [OH<sup>-</sup>], water is **acidic**
- If [OH<sup>-</sup>] > [H<sup>+</sup>], 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<sup>+</sup>] or [OH<sup>-</sup>] is 10<sup>-7</sup>M

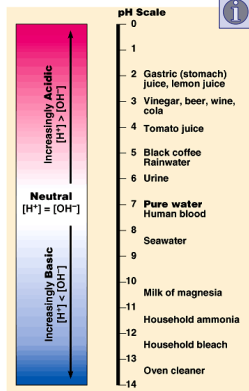
$$[\text{H}^+][\text{OH}^-] = 10^{-14}$$

- 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  $[OH^-]$

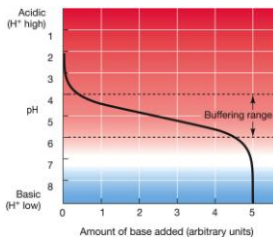


### pH & Biology

- 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

