Properties of Water

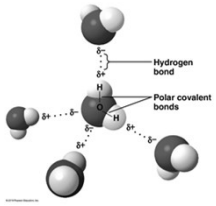
Chapter 2b

You Must Know

- The importance of hydrogen bonding to the properties of water.
- Four unique properties of water and how each contributes to life on Earth.
- How to interpret the pH scale.
- How changes in pH can alter biological systems.
- The importance of buffers in biological systems.

Water is a Polar Molecule

- Unequal sharing of e- between O and H
- **Hydrogen bond**: slightly negative O attracted to slightly positive H of nearby molecule
- H_2O can form up to 4 bonds



Four Emergent Properties of Water

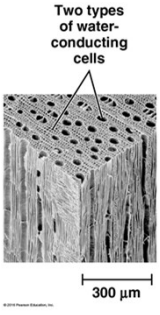
1. Cohesive Behavior

Cohesion = H-bonding between like molecules

- **Surface Tension** = measure of how difficult it is to break or stretch surface of liquid

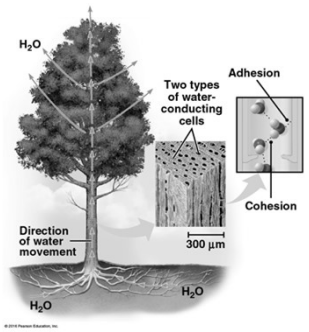
Adhesion = bonding between unlike molecules

- Adhesion of H_2O to vessel walls counters ↓ pull of gravity



Transpiration = movement of H_2O up plants

H_2O clings to each other by **cohesion**; cling to xylem tubes by **adhesion**



BIOFLIX: WATER TRANSPORT IN PLANTS

2. Moderation of Temperature

Thermal energy (heat) = Total amount of KE in system

Temperature = measure intensity of heat due to average KE of molecules

Which has higher temp?

More heat?

Water = **High specific heat**

- Change temp less when absorbs/loses heat
- Large bodies of water absorb and store more heat → warmer coastal areas
- Create stable marine/land environment
- Humans ~65% H_2O → stable temp, resist temp. change

Evaporative Cooling

- Water has high heat of vaporization
- Molecules with greatest KE leave as gas
- Stable temp in lakes & ponds
- Cool plants
- Human sweat

3. Expansion Upon Freezing

Insulation by ice – less dense, floating ice insulates liquid H_2O below

- Life exists under frozen surface (ponds, lakes, oceans)
- Ice = solid habitat (polar bears)

4. Water = Solvent of Life

- **Solution** = liquid, homogeneous mixture of 2+ substances
- **Solvent** = dissolving agent (liquid)
- **Solute** = dissolved substance
- **Water = versatile solvent**

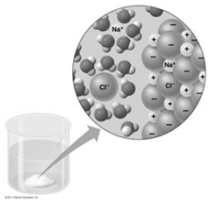
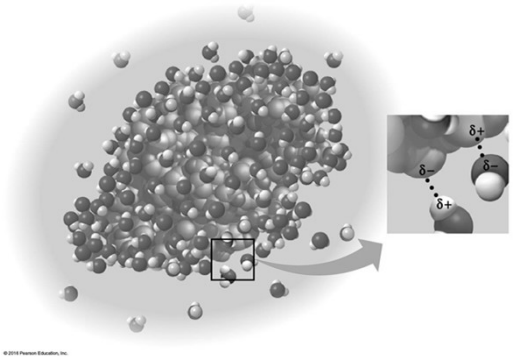


Figure 2.22 A water-soluble protein



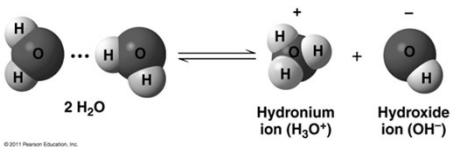
4. Solvent of life

- "like dissolves like"

Hydrophilic	Hydrophobic
Affinity for H_2O	Repel H_2O
Polar, ions	Non-polar
Cellulose, sugar, salt	Oils, lipids
Blood	Cell membrane

Water Chemistry

Acids and Bases



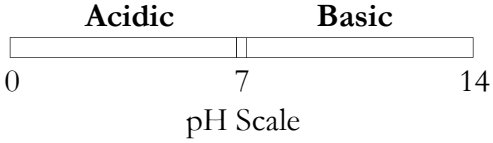
$H_2O \rightleftharpoons H^+ + OH^-$

(gains proton) $H^+ + H_2O \rightarrow \mathbf{H_3O^+}$ (hydronium ion)

(loses proton) $H_2O - H^+ \rightarrow \mathbf{OH^-}$ (hydroxide ion)

5. Acids and Bases

- **Acid** = increases H^+ concentration (HCl)
- **Base** = reduces H^+ concentration (NaOH)
- Most biological fluids are pH 6-8



H^+ and OH^- Ions

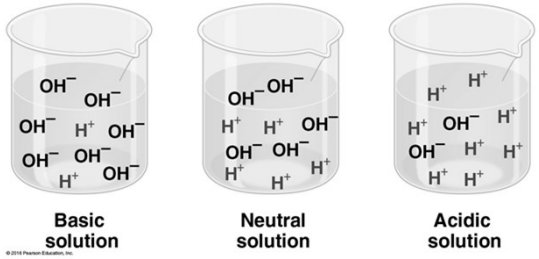
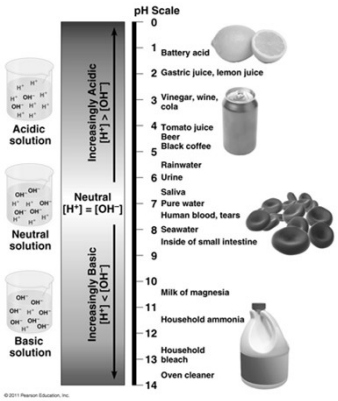


Figure 2.23 The pH scale and pH values of some aqueous solutions



Calculating pH

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

n If $[H^+] = 10^{-6}$ M, then $[OH^-] = 10^{-8}$

pH = -log $[H^+]$

1. If $[H^+] = 10^{-2}$
   - $-\log 10^{-2} = -(-2) = 2$
   - Therefore, pH = 2
2. If $[OH^-] = 10^{-10}$
   - $[H^+] = 10^{-4}$
   - $-\log 10^{-4} = -(-4) = 4$
   - Therefore, pH = 4

Buffers

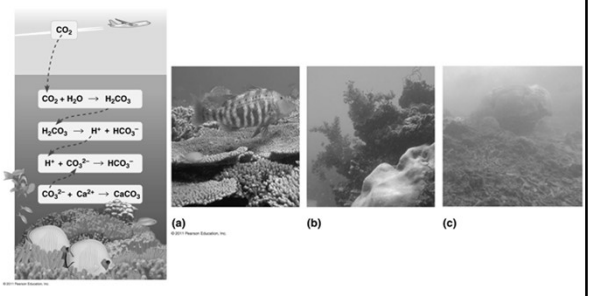
Buffers: minimize changes in concentration of H^+ and OH^- in a solution (weak acids and bases)

- Buffers keep blood at pH ~7.4
- If blood drops to 7 or up to 7.8 → death

Carbonic Acid – Bicarbonate System: important buffers in blood plasma

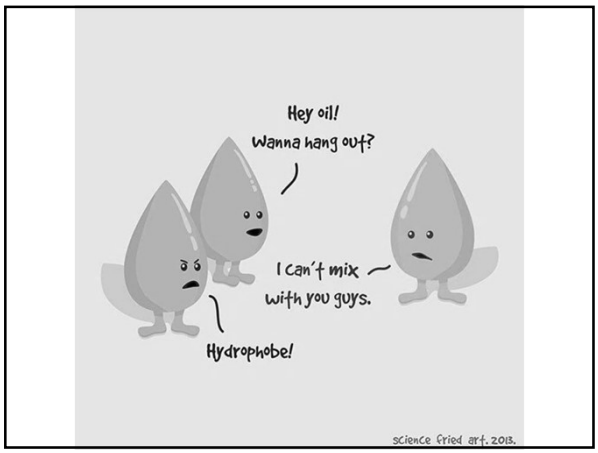
H_2CO_3 (carbonic acid) → HCO_3^- (bicarbonate) + H^+

Ocean Acidification:
Threat to Coral Reef Ecosystems



CO_2 + Seawater → Carbonic acid → Lowers ocean pH

H_2O Property	Chemical Explanation	Examples of Benefits to Life
Cohesion	•polar •H-bond •like-like	↑gravity plants, trees
Adhesion	•H-bond •unlike-unlike	plants→ xylem blood→veins
Surface Tension	•diff. in stretch •break surface •H-bond	bugs→water
Specific Heat	•Absorbs & retains E •H-bond	ocean→mod temp →protect marine life
Evaporation	•liquid→gas •KE	Cooling Homeostasis
Universal Substance	•Polarity→ionic •H-bond	Good dissolver solvent


Hey oil!
Wanna hang out?
I can't mix with you guys.
Hydrophobe!
science fried art. 2013.