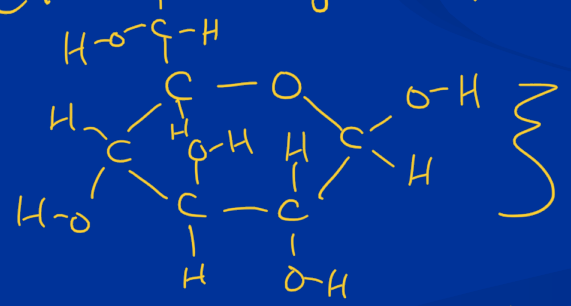
Ch. 2 Warm-Up

1. What is the difference between an atom, element and compound?
2. What are the 3 main components of an atom? What are their charges?
3. What type of bond is found in:
   - H_2O?
   - KCl? $K^{\oplus}$ $Cl^{\ominus}$ charged species → ionic bond
   - $C_6H_{12}O_6$?



covalent polar

   - N_2? :N≡N: covalent nonpolar
   - $Ba(OH)_2$?

$Ba^{+2} + 2OH^{\ominus}$ ionic bond

Ch. 2a Warm-Up

1. List 1 trace minerals found in living things and its purpose in the body.
2. What is the difference between a polar and nonpolar substance? Name an example of each.
3. What types of molecules can form hydrogen bonds? Explain.
4. Draw a possible chemical structure diagram of $C_6H_{12}O_6$.

Properties of Water

Chapter 2b

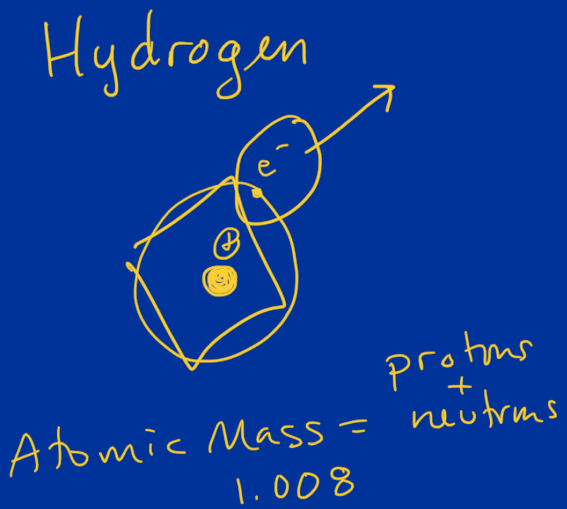
You Must Know

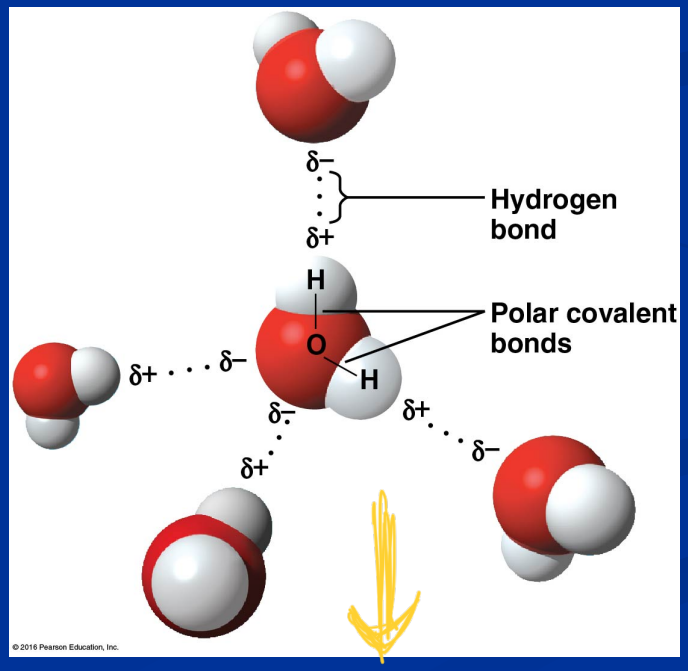
- The importance of hydrogen bonding to the properties of water.
- Four unique properties of water and how each contributes to life on Earth.
- How to interpret the pH scale. acids/bases
- How changes in pH can alter biological systems.
- The importance of buffers in biological systems.

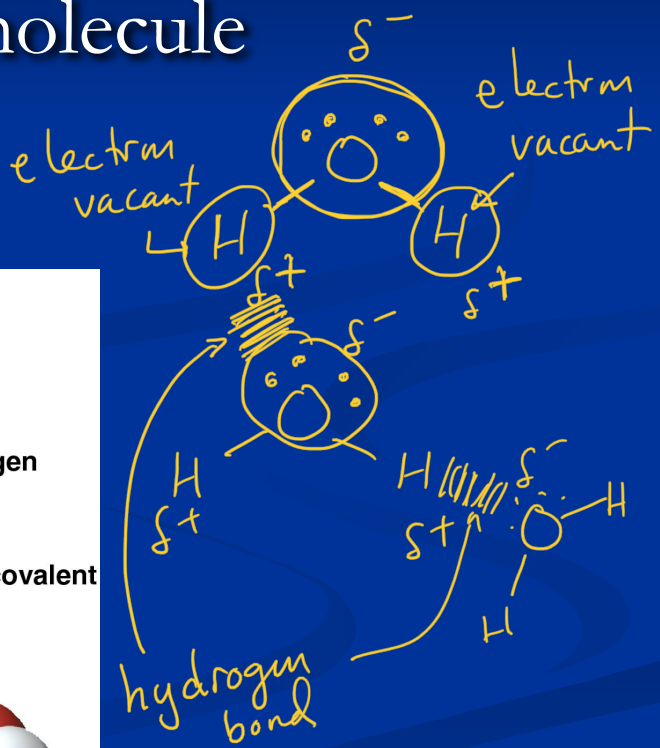
Water is a **Polar Molecule**

definition of polar covalent bond

- 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

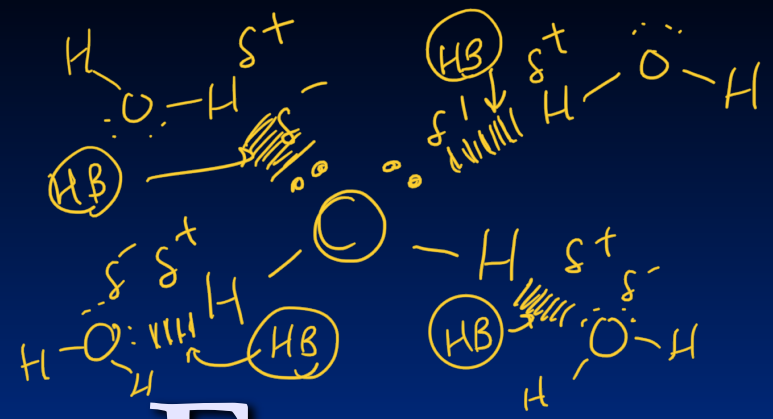




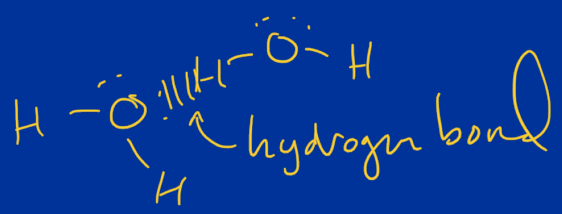


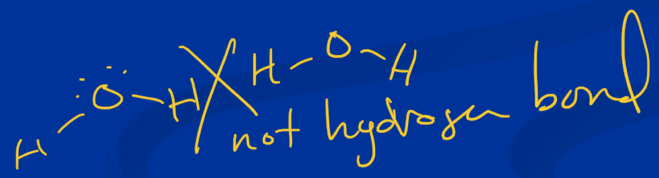
Water Molecule

form up to 4 hydrogen bonds



Four Emergent Properties of Water





	Water Vapor	Water (liquid)	Ice (solid)
# of HB / water molecule	1-3	≈ 3.6	4

1. Cohesive Behavior

water to water

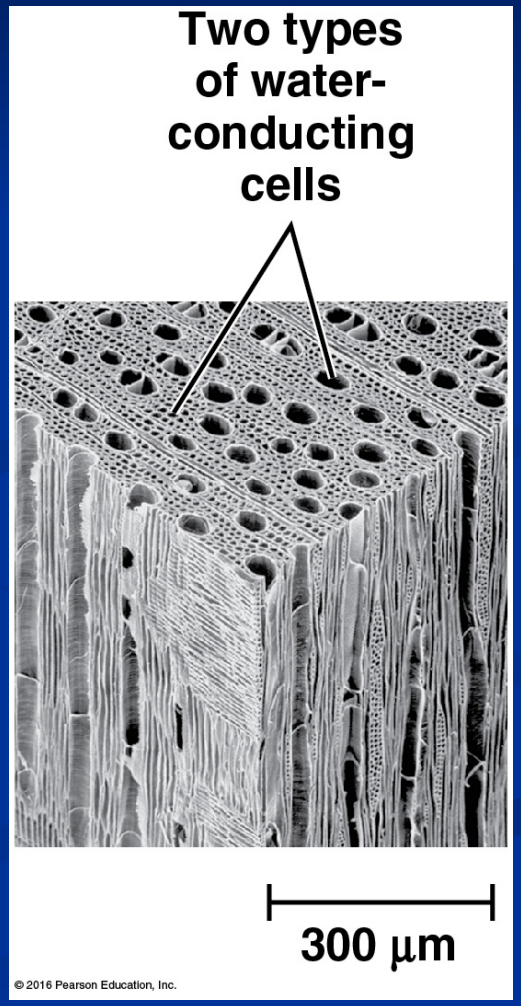
Cohesion = H-bonding between like molecules

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

hydrogen

Adhesion = bonding between unlike molecules

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



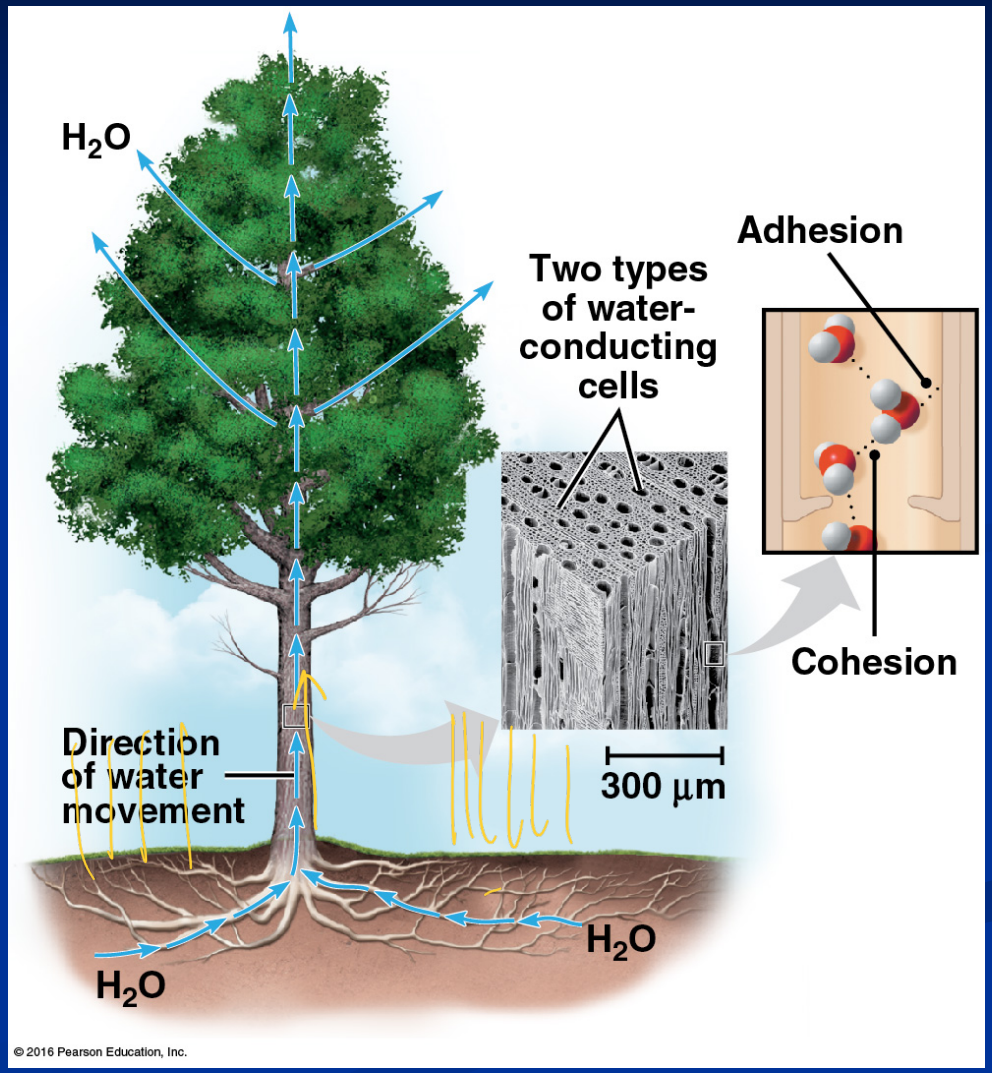
Cohesion vs. Adhesion

The attraction between two like molecules is **cohesion**.

The attraction between two unlike molecules is **adhesion**.

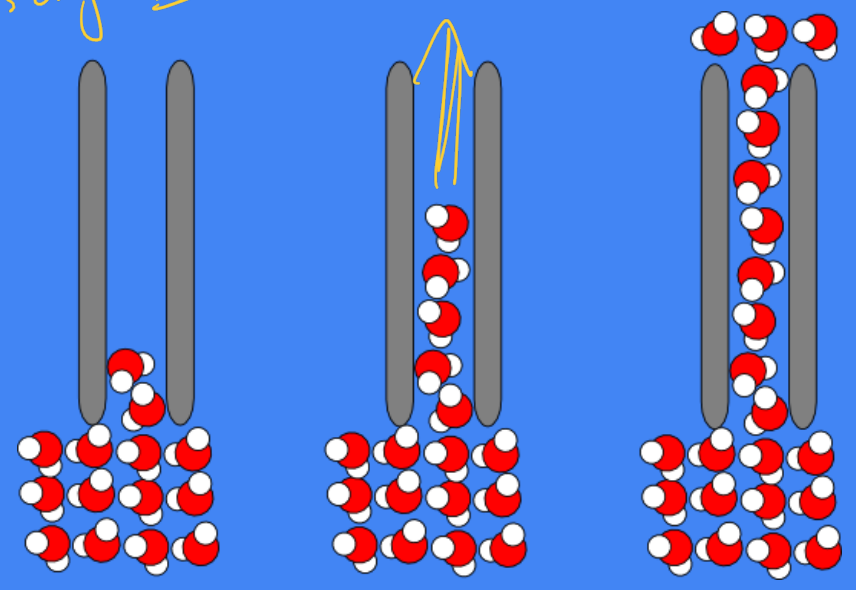
Transpiration = movement of H_2O up plants

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



Capillary Action

water molecules can pull themselves up a surface by using both cohesion and adhesion.



BIOFLIX: WATER TRANSPORT IN PLANTS

2. Moderation of Temperature

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

more mass → more heat

kinetic energy

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

KE → kinetic energy is the energy of motion

higher temperature

cup o' boiling water

lukewarm bathtub (more heat)

Which has higher temp?

More heat?

specific heat – amount of energy required to increase the temperature of one gram of a substanced by 1°C.

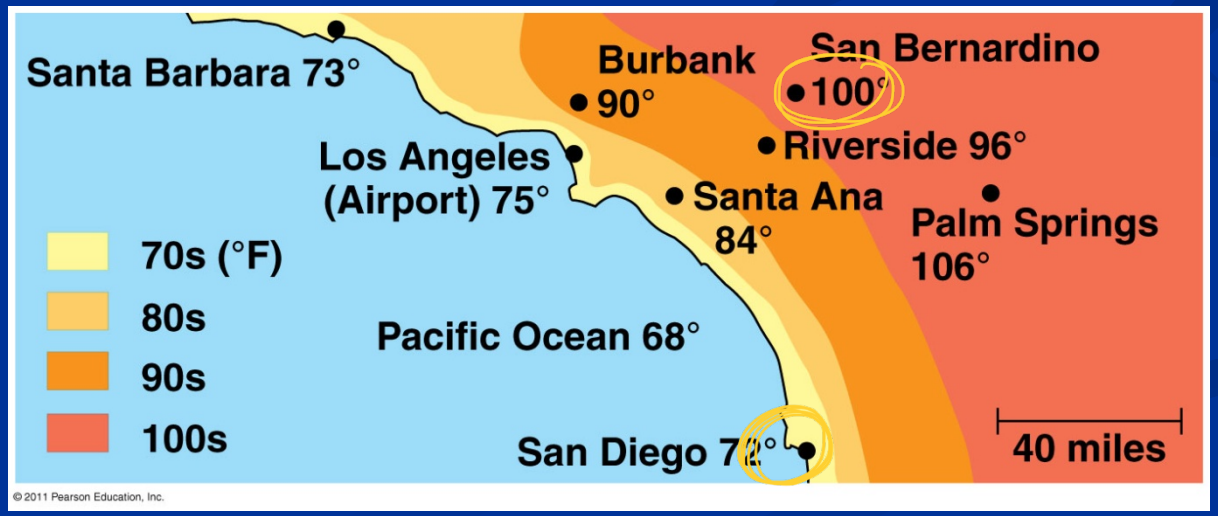
Water = **High specific heat**

- Change temp less when absorbs/loses heat

specific heat of H_2O: 4.184

- 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

water serves as a temperature buffer.



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Evaporative Cooling

Energy is released upon evaporating sweat off the skin

- 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

water molecules spaced out more

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

Ice → 4 HB less dense

water liquid ≈ 3.6 HB

- 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**

salt + water → salt water

solute solvent solution

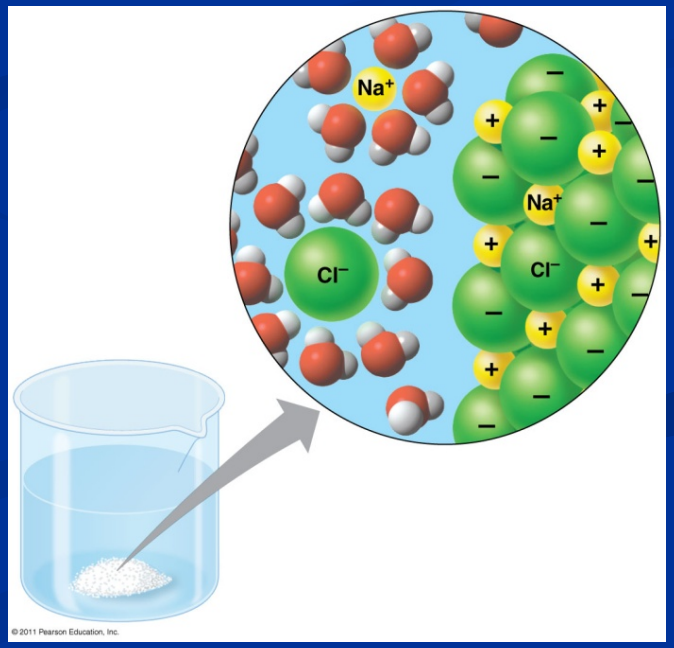
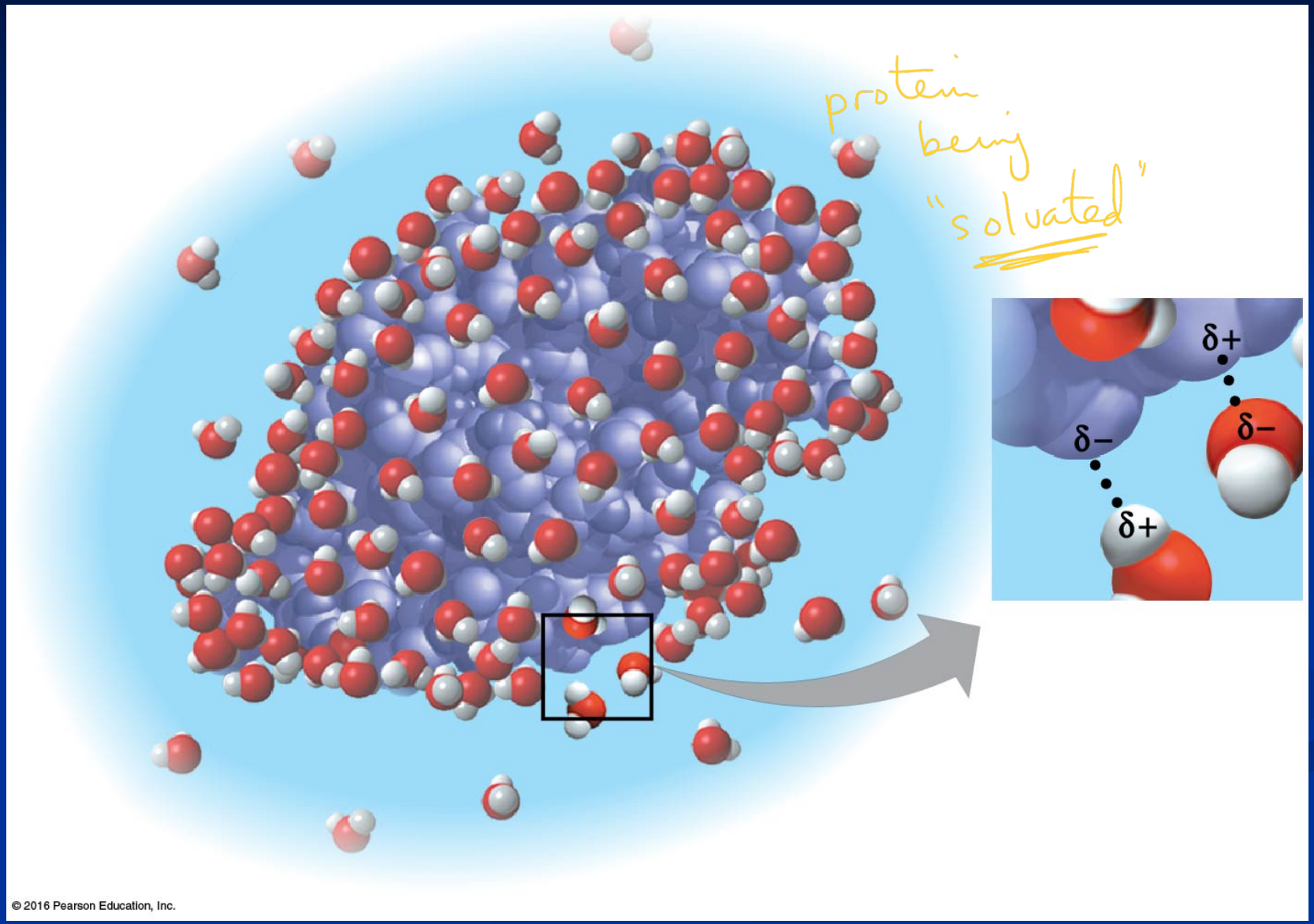


Figure 2.22 A water-soluble protein



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4. Solvent of life

Polar → hydrophilic
water – loving

Nonpolar → hydrophobic
water - fearing

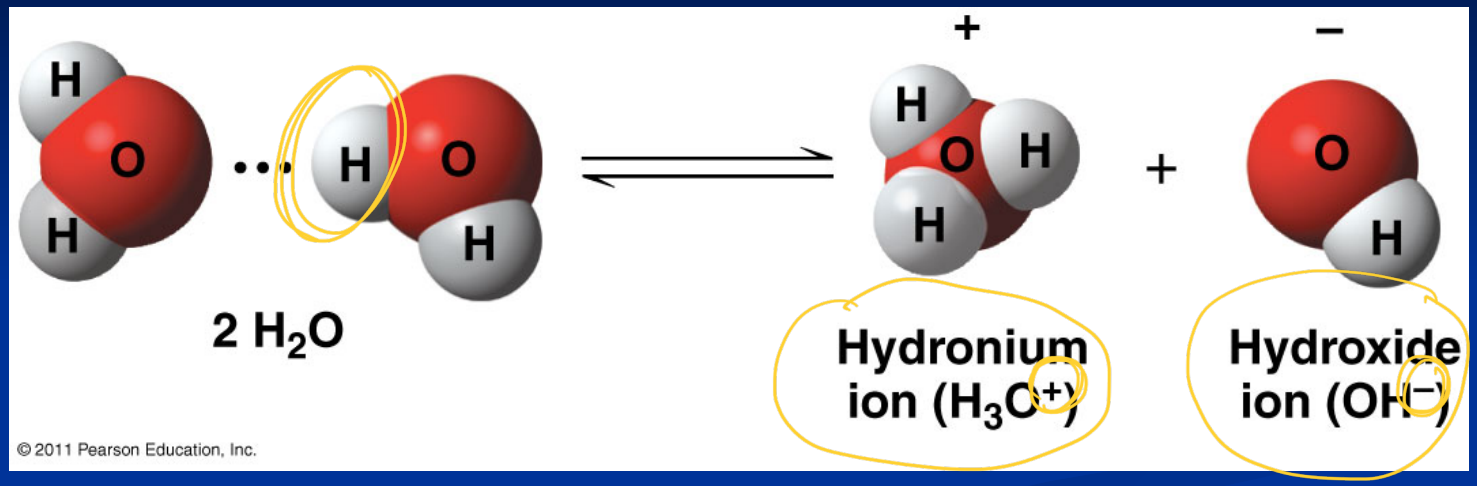
"oil and water don't mix"

- "like dissolves like"

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

Water Chemistry

Acids and Bases



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

acid → extra H^+

(gains proton) $H^+ + H_2O \rightarrow$ **H_3O^+** (hydronium ion)

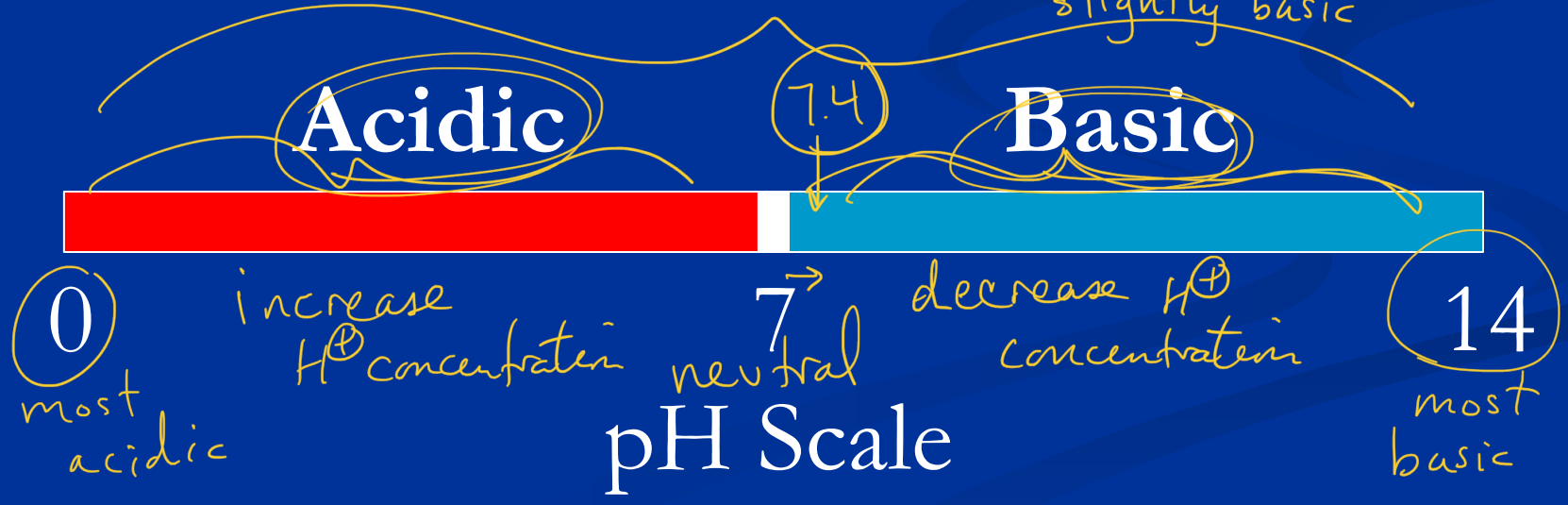
(loses proton) $H_2O - H^+ \rightarrow$ **OH^-** (hydroxide ion)

base → less H^+

5. Acids and Bases

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

physiological pH ≈ 7.4
slightly basic



pH Scale

H^+ and OH^- Ions

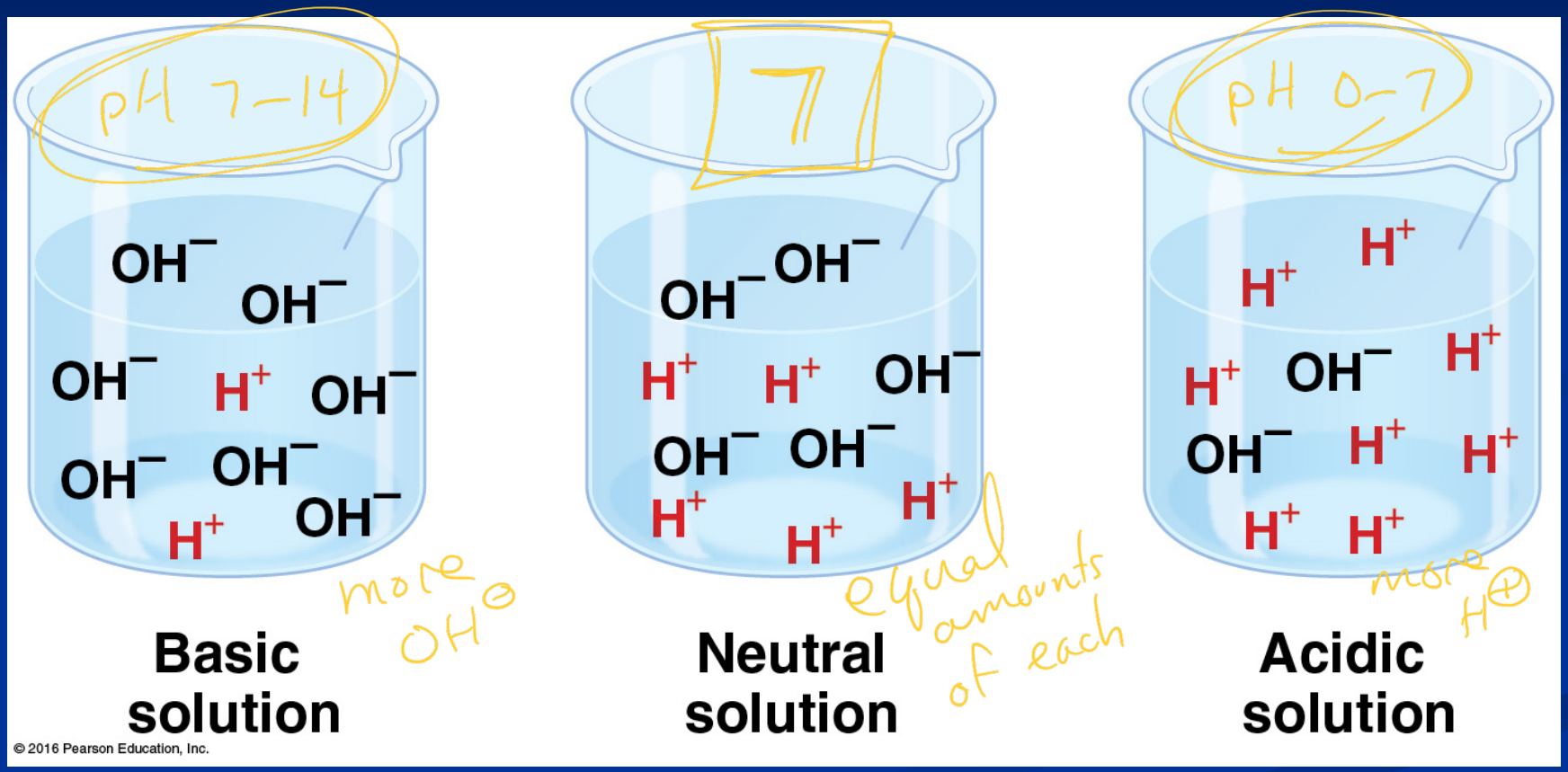


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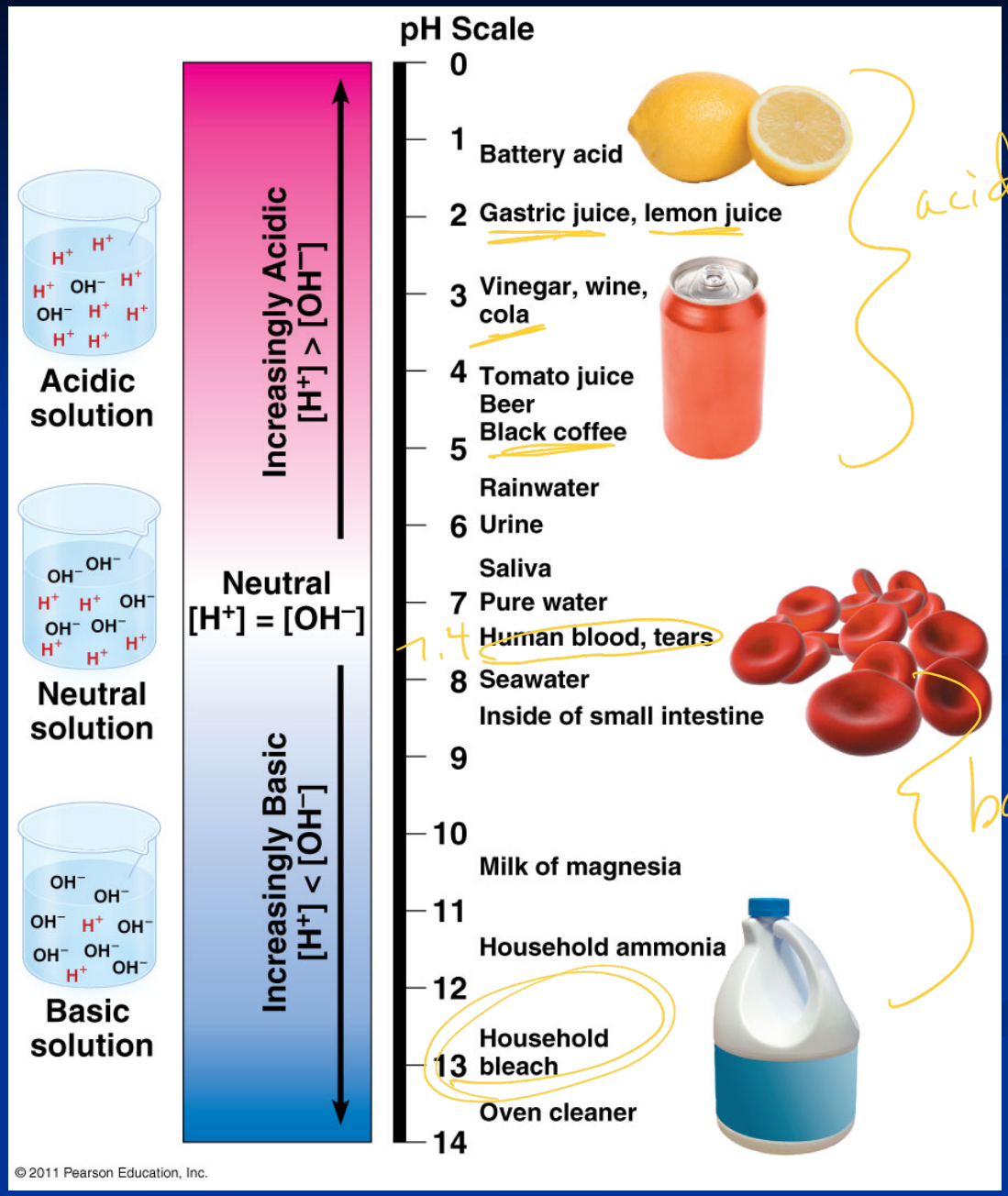
Figure 2.23 The pH scale and pH values of some aqueous solutions



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

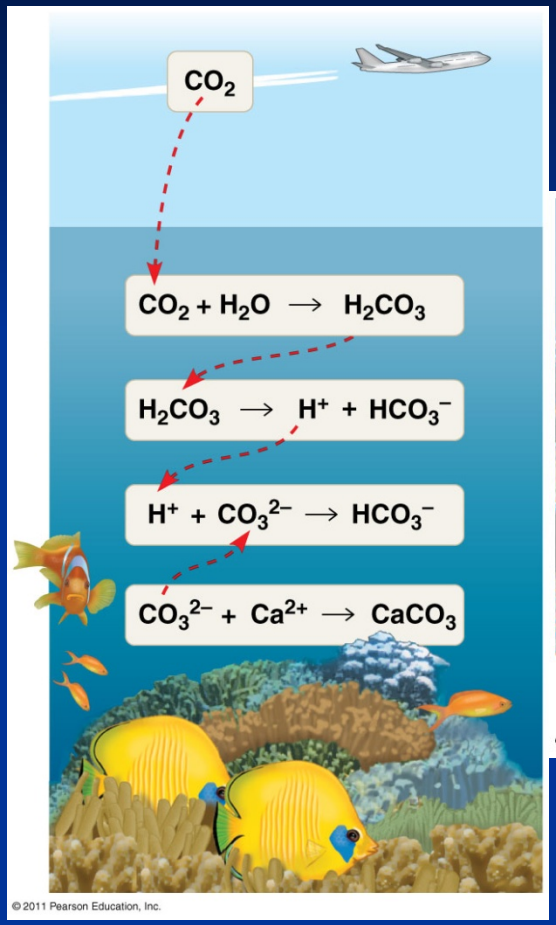
Buffers: minimize changes in concentration of H^+ and OH^- in a solution (weak acids and bases)

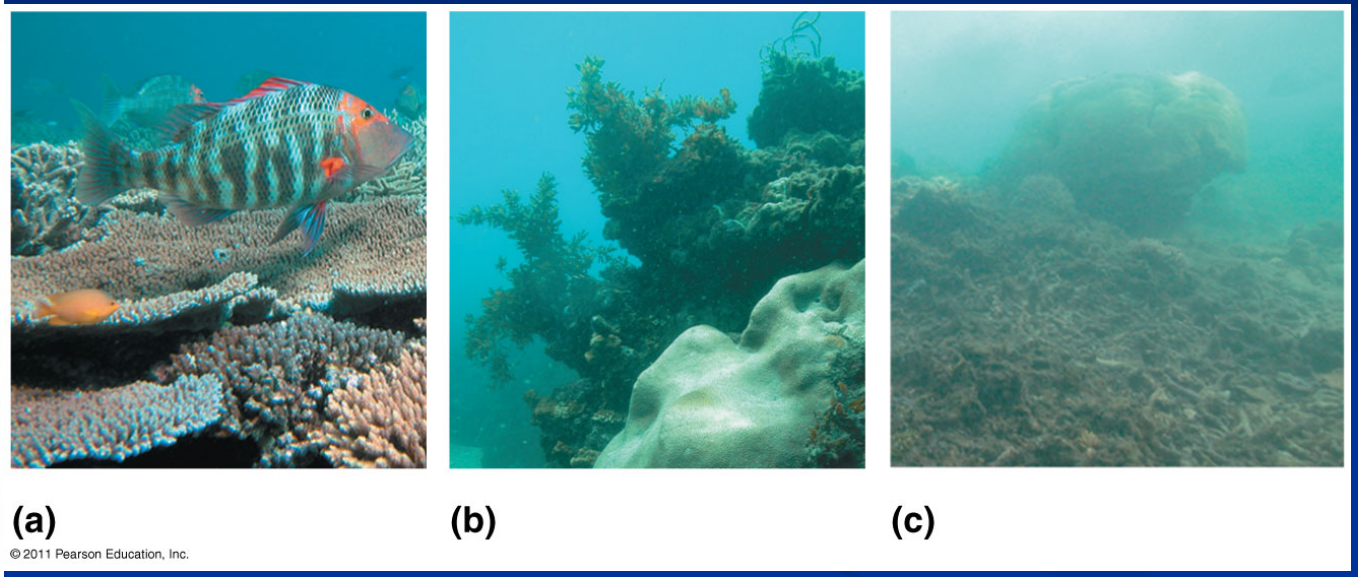
- Buffers keep blood at pH ~7.4
- If blood drops to 7 or up to 7.8 → death

Carbonic Acid – Bicarbonate System: important buffers in blood plasma

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

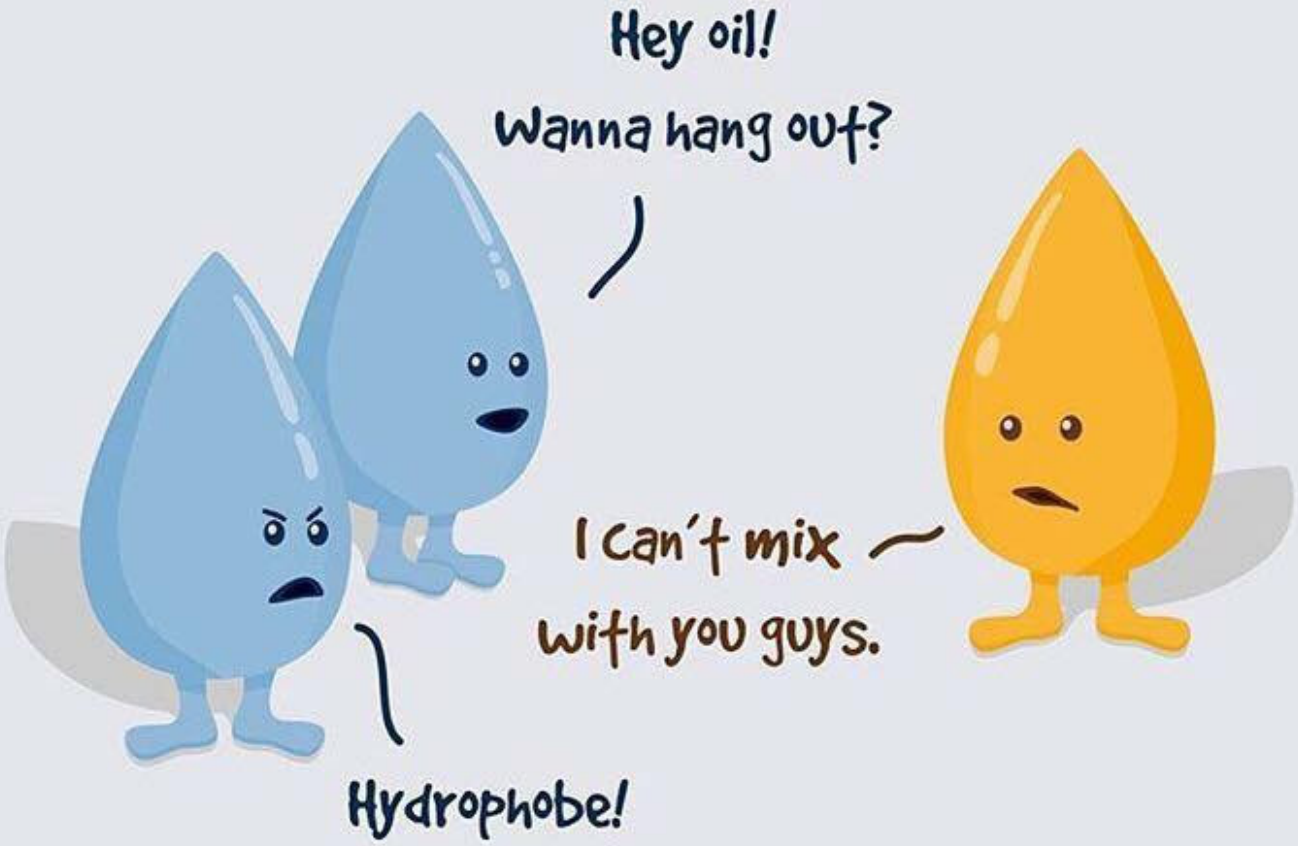
Ocean Acidification:
Threat to Coral Reef Ecosystems





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



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