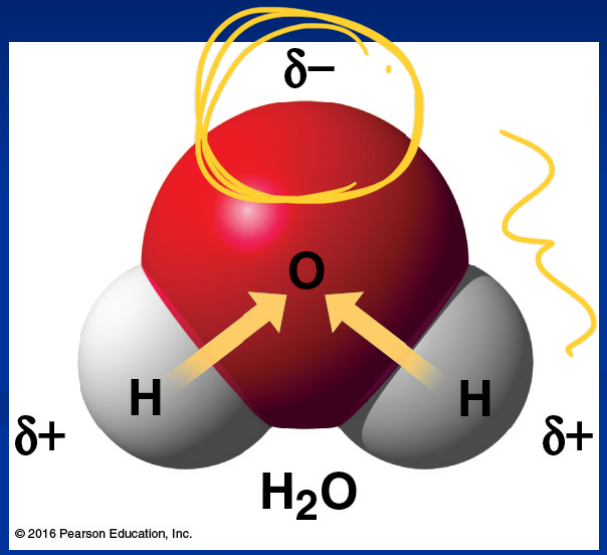
III. Chemical Bonds

Covalent bond is a bond where two atoms share valence electrons

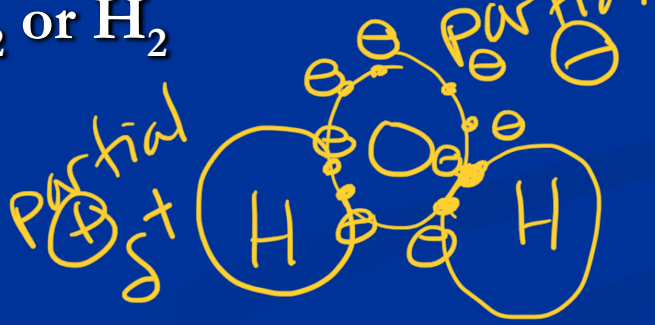
Strongest Bonds:

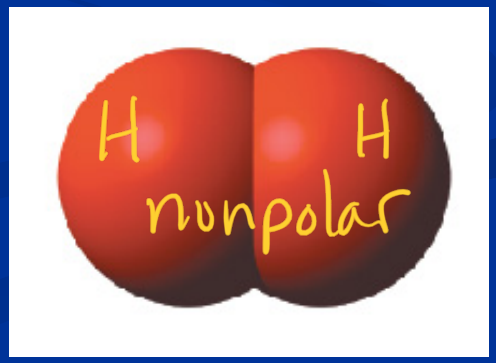
1. Covalent: sharing of e-
   - Polar: covalent bond between atoms that differ in *electronegativity*
     - Eg. H_20



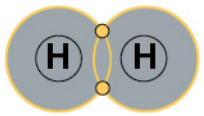
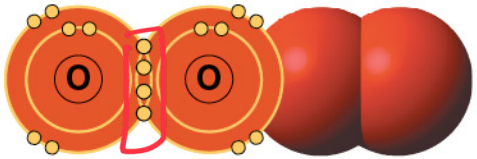
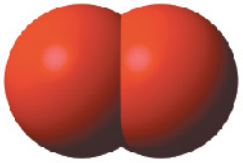
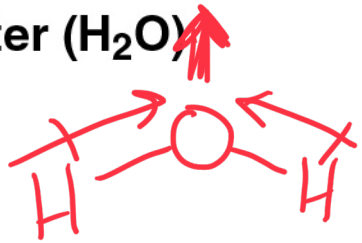
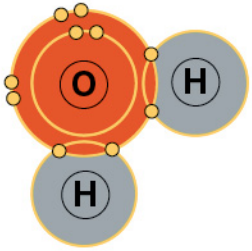
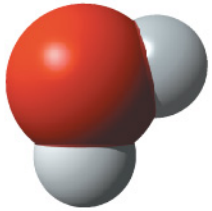
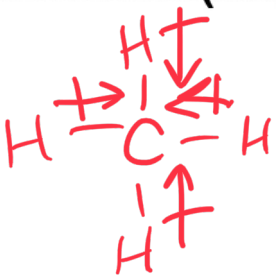
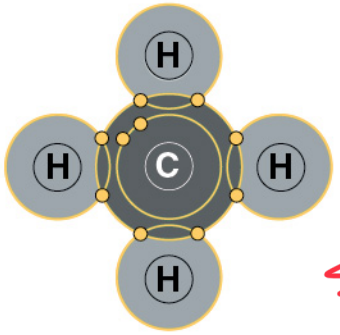
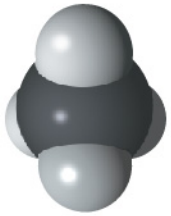
valence electrons → outer shell electrons
reactive electrons

   - Nonpolar: e- shared equally
     - Eg. O_2 or H_2





δ lowercase Delta Δ (partial)

Name and Molecular Formula	Electron Distribution Diagram	Structural Formula	Space-Filling Model
(a) Hydrogen (H_2)		nonpolar H—H	
(b) Oxygen (O_2) same element		nonpolar O=O	
(c) Water (H_2O)	 	Oxygen is more electronegative O—H H Polar	
(d) Methane (CH_4)	 	nonpolar H H—C—H H symmetrical	

III. Chemical Bonds

Strongest Bonds:

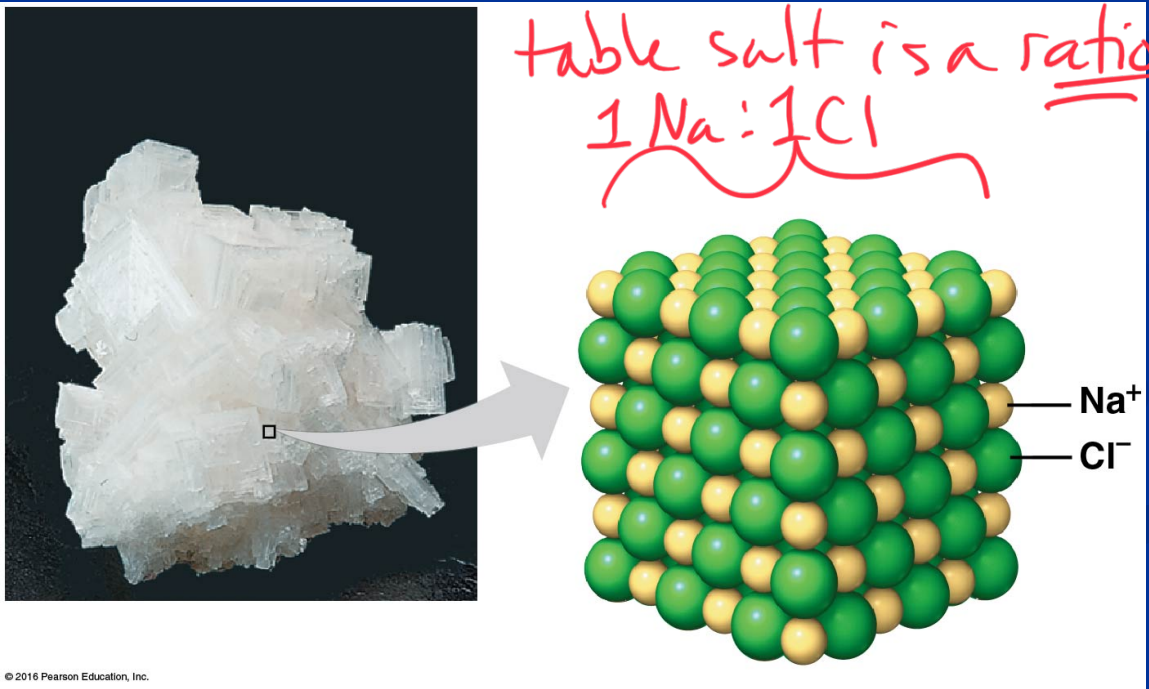
Ionic → non covalent → not covalent
not electron sharing

2. **Ionic:** 2 ions (+/-) bond (givers/takers)
   - Na^+Cl^-
   - Affected by environment (eg. water)

ionic bond is not as strong as a covalent

NaCl
table salt

NaCl
↓
$Na^{\oplus}$ $Cl^{\ominus}$



Covalent
bond ↓ strength
ionic

water
1 oxygen
and
2 H

Weaker Bonds: Hydrogen bonds

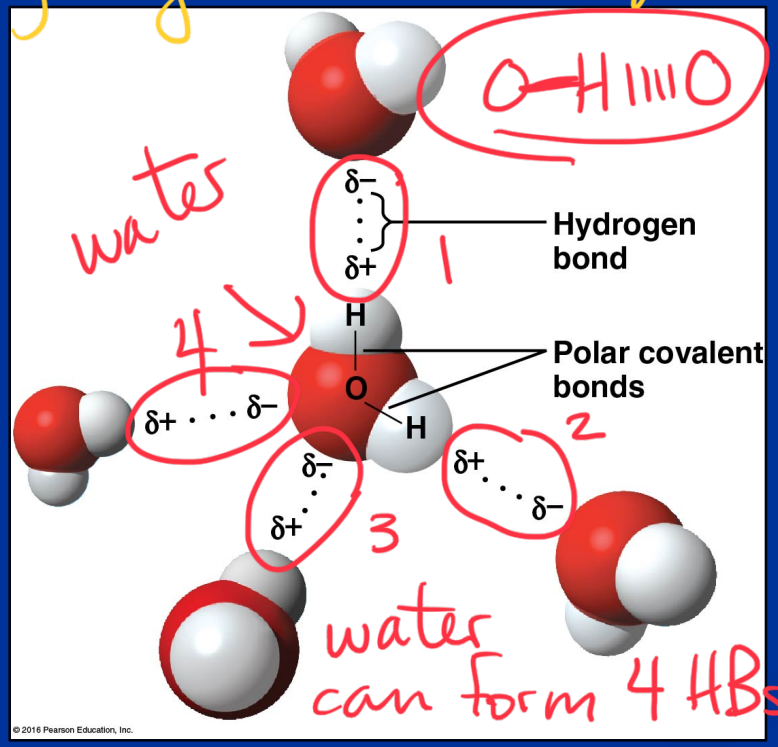
important to living processes

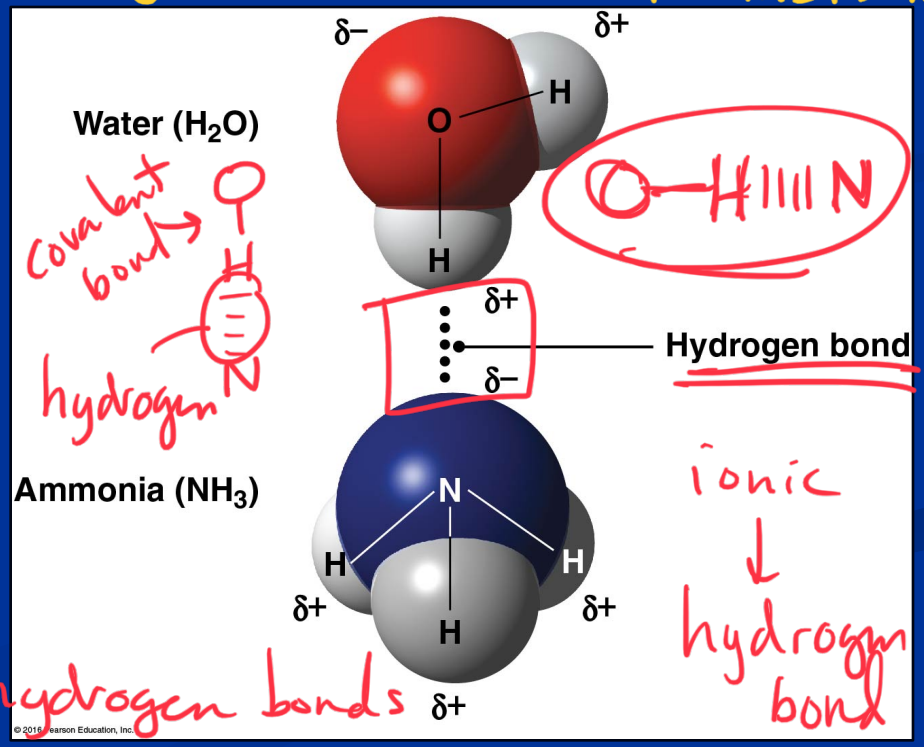
3. **Hydrogen:** H of ***polar covalent*** molecule bonds to electronegative atom of ***other polar covalent*** molecules

protein folding + formation of membranes

proton

Hydrogen bond – unequal sharing of an H





adhesion / cohesion through surface area

Weaker Bonds:

4. Van der Waals Interactions: slight, fleeting attractions between atoms and molecules close together

very weak

- Weakest bond
- Eg. gecko toe hairs + wall surface

strength is due to numbers.

London dispersion forces

Good to know

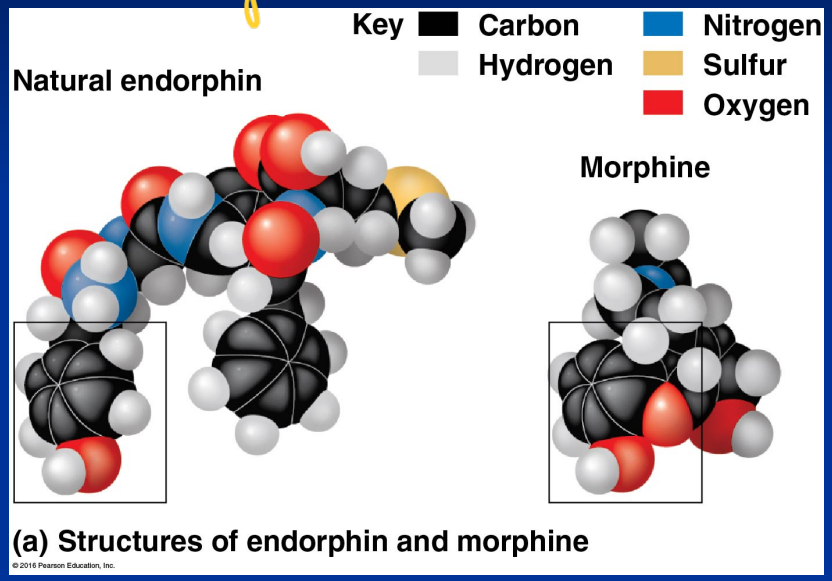
Bonds

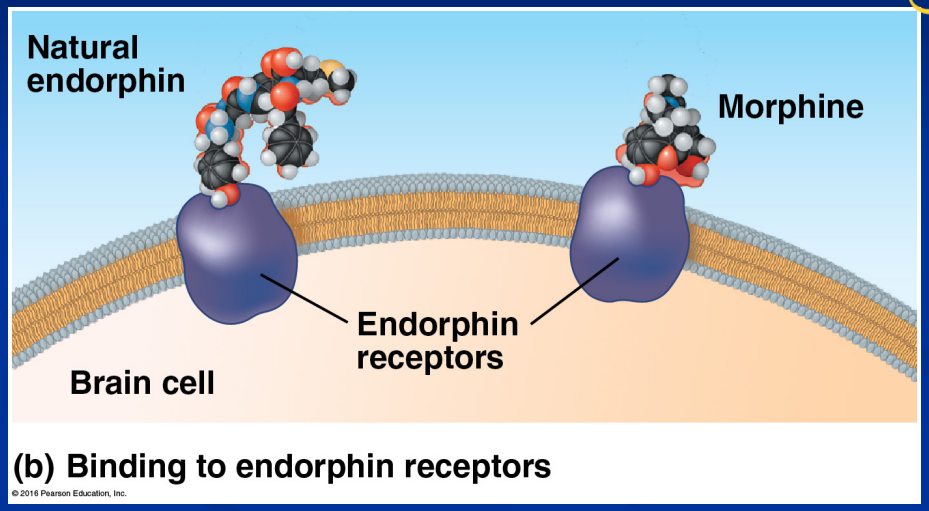
Covalent	Ionic	Hydrogen
All important to life		
Form cell's molecules macromolecules	Quick reactions/ responses	H bonds to other electronegative atoms
Strong bond	Weaker bond (esp. in H_2O)	Even weaker
Made and broken by chemical reactions		

strength

A molecule's STRUCTURE (SHAPE) affects a molecule's FUNCTION

The shape of a molecule determines its functionality





- **Similar shapes = mimic**
  - morphine, heroin, opiates mimic endorphin (euphoria, relieve pain)

Chemical Reactions

- **Reactants** → **Products** finish
  - Eg. $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + O_2$
- Some reactions are reversible:
  - Eg. $3H_2 + N_2 \rightleftharpoons 2NH_3$ Does not mean the reaction stops
- **Chemical equilibrium**: point at which forward and reverse reactions offset one another exactly
  - Reactions still occurring, but **no net change** in concentrations of reactants/products

Properties of Water

Chapter 2b

You Must Know

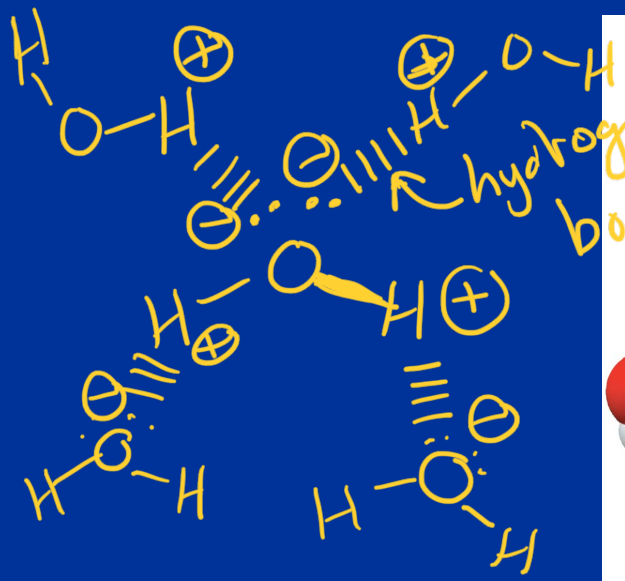
- The importance of hydrogen bonding to the properties of water.
- Four unique properties of water and how each contributes to life on Earth.
- How to interpret the pH scale.
- How changes in pH can alter biological systems.
- The importance of buffers in biological systems.

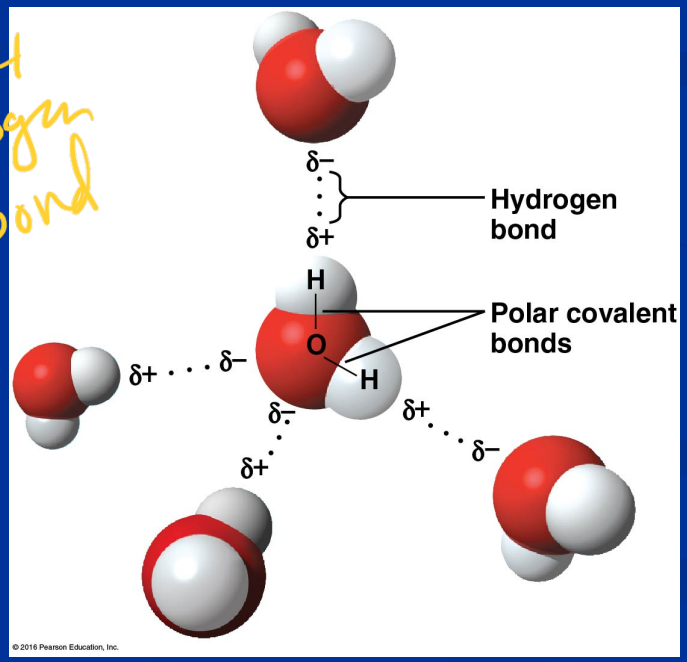
Water is a Polar Molecule

polar covalent

- 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

unequal → polar
sharing → covalent





Four Emergent Properties of Water

4 HBs

add temperature →

break hydrogen bonds

3 HBs ↓ add temp

Boil into vapor 1-2 HB

water, on average, has 3.4 hydrogen bonds

# Hydrogen Bonds	1-2	3	4
	vapor (Gas)	water (liquid)	ice (solid)

1. Cohesive Behavior

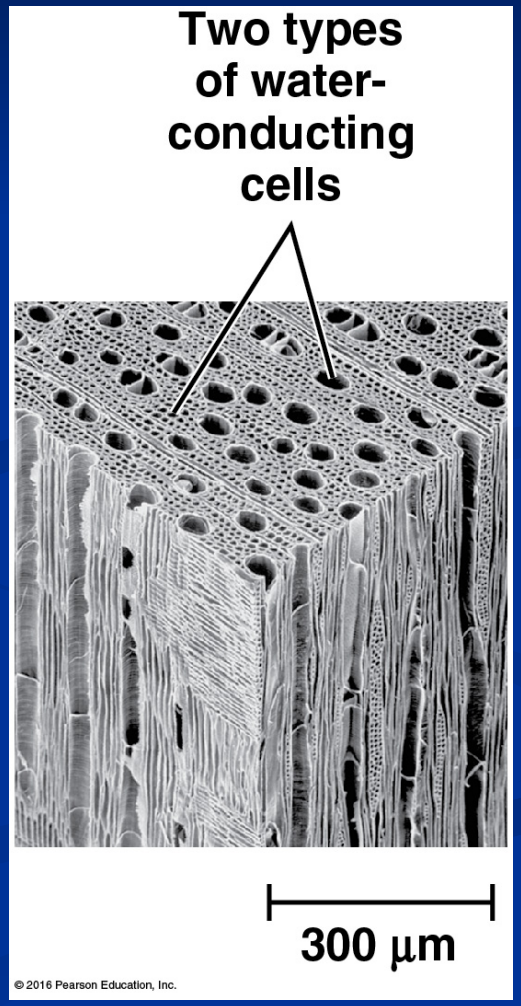
water sticking to water

Cohesion = H-bonding between like molecules

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

Adhesion = hydrogen bonding between unlike molecules

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



Cohesion vs. Adhesion

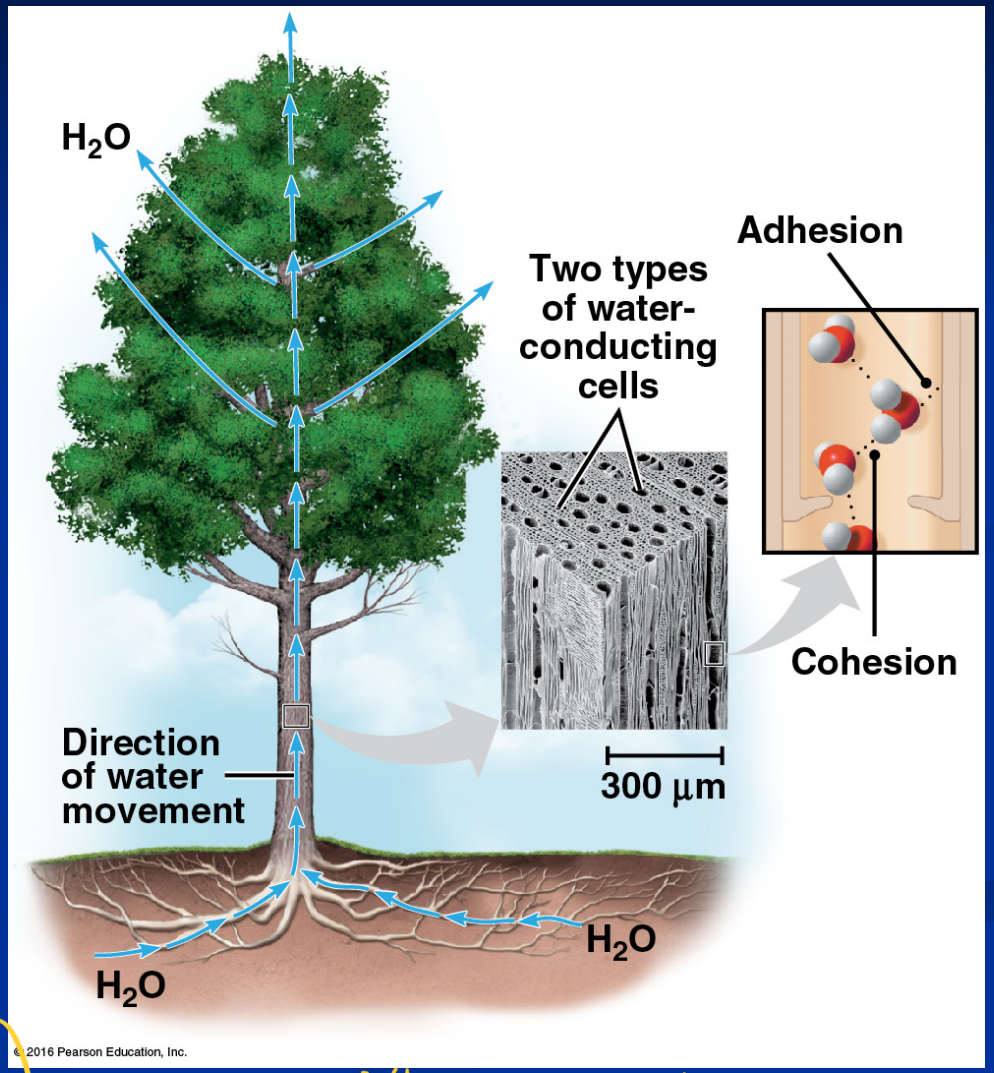
Please know!

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

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

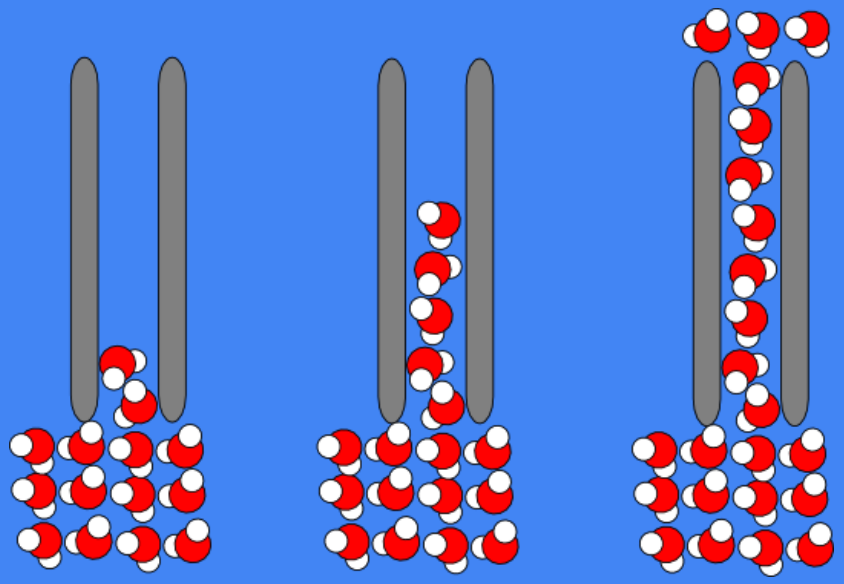
Transpiration = movement of H_2O up plants

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



water can "crawl" upwards through cohesion (water binding to water) and adhesion (water binding to a surface) → capillary action.

Capillary Action



BIOFLIX: WATER TRANSPORT IN PLANTS

2. Moderation of Temperature

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

KE → kinetic energy – energy of movement

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

average movement

more energy

Which has higher temp?

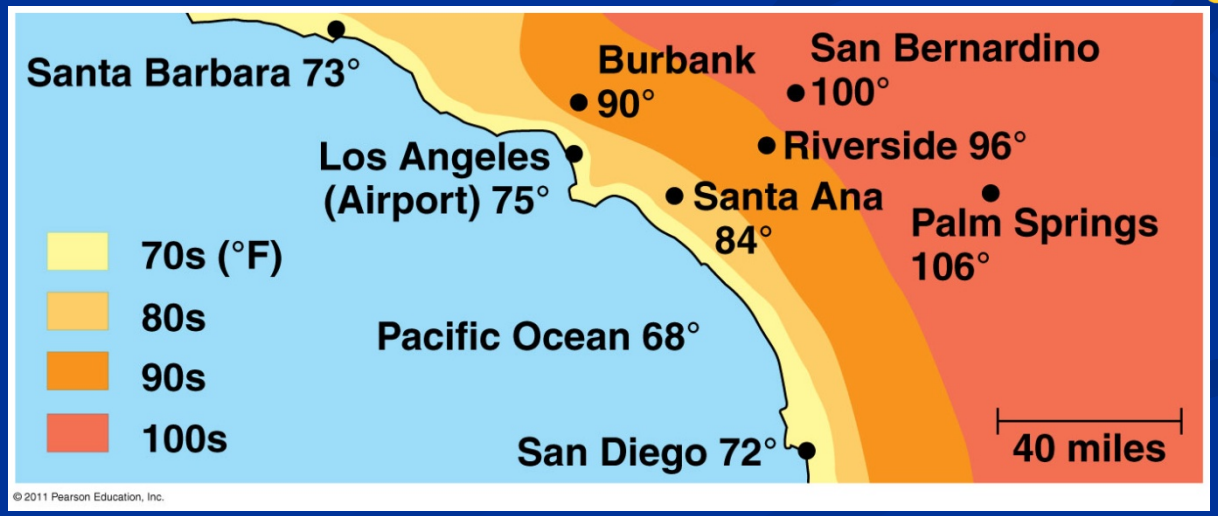
More heat?

Water = **High specific heat** 4.184 J

- 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

1 calorie → amount of energy required to raise the temperature of 1 gram of water by 1°C.

water can absorb and release energy



Evaporative Cooling

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

sweat

heat from our bodies warm the sweat and causes it to evaporate

heat is transferred from our body to the sweat.

3. Expansion Upon Freezing

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

temperature barrier

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

Ice → 4 hydrogen bonds → less dense → ice floats

4. Water = Solvent of Life

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

Kool-Aid solvent of life

kool-aid powder → solute

water → solvent

Kool-Aid → solution

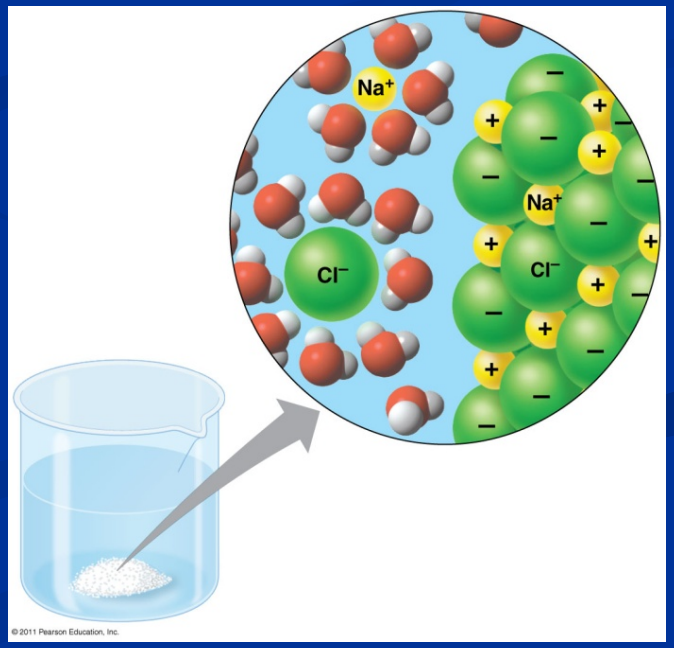
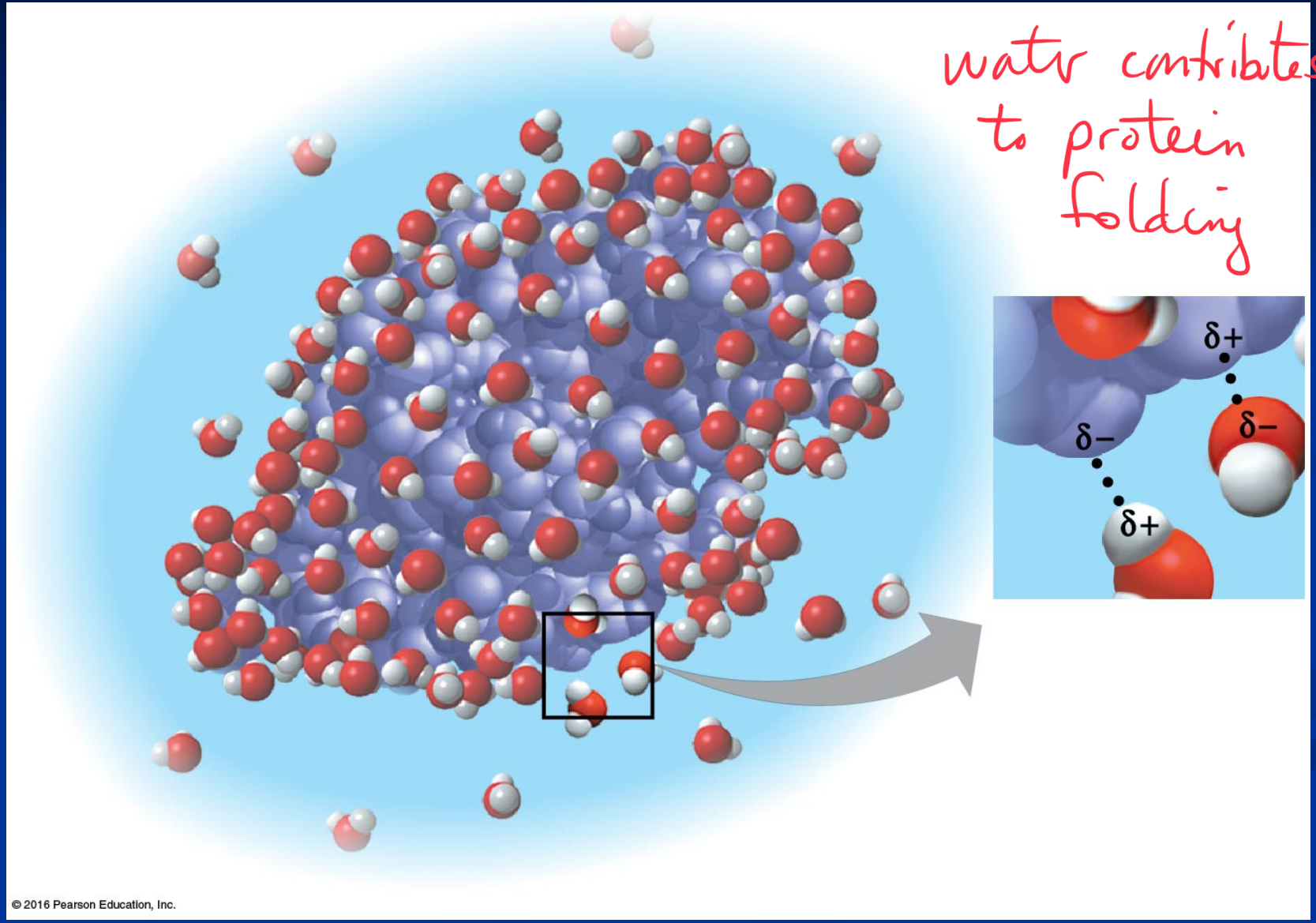


Figure 2.22 A water-soluble protein



water contributes to protein folding

4. Solvent of life

hydrophilic — water loving

hydrophobic — water fearing

- "like dissolves like"

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

dissolve in water

does not dissolve in water

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