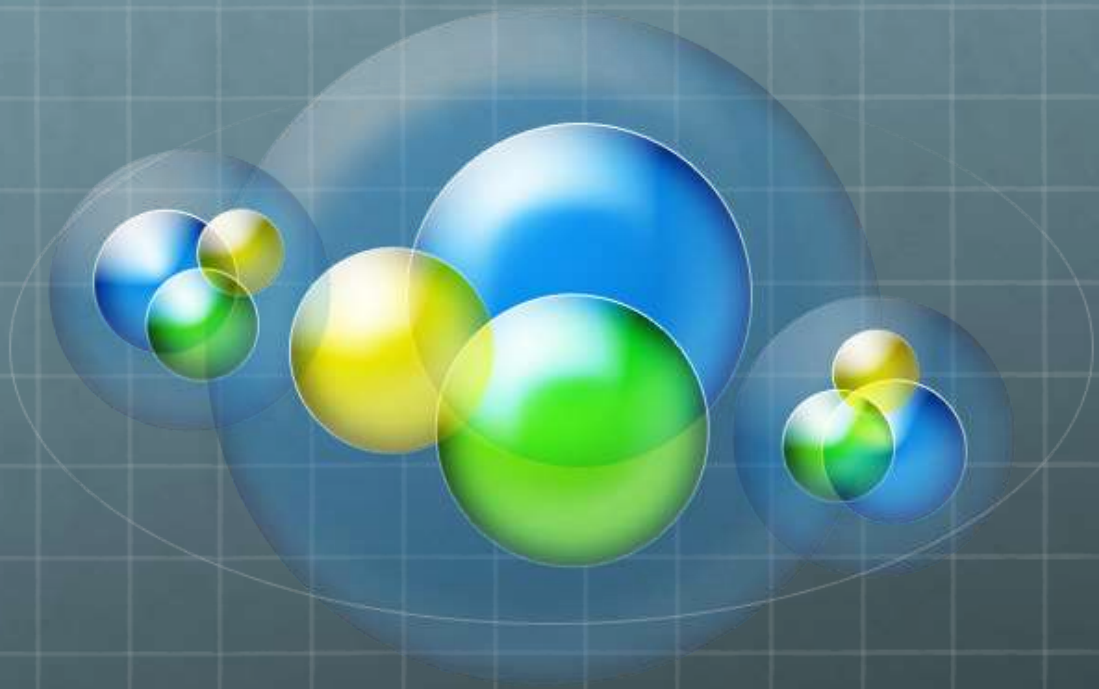


Chapter 2: Chemistry

But this is BIOLOGY!!

Don’t Panic

Basic Principles

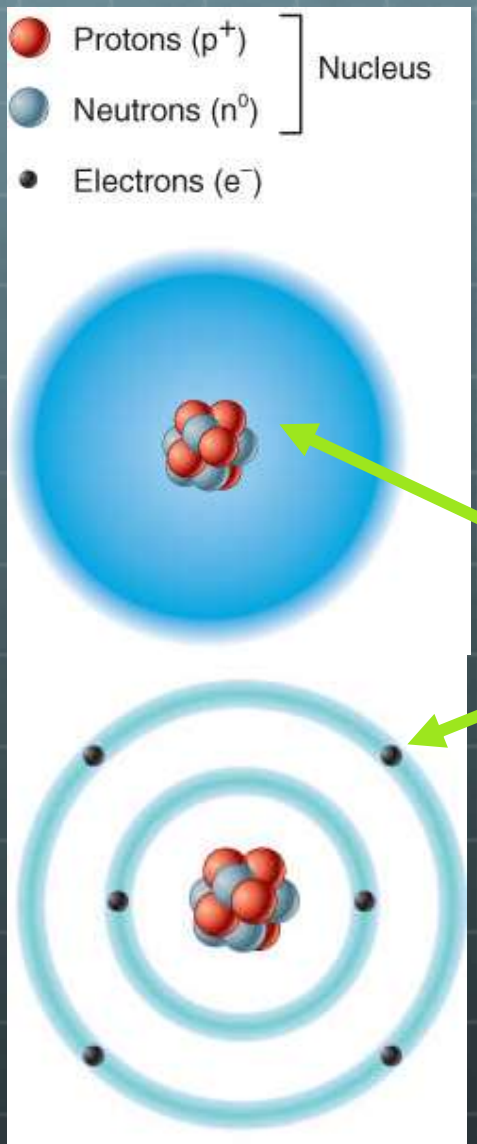
- *Chemistry* is the science of the structure and interactions of matter.

- *Matter* is anything that occupies space and has mass.
  - *Mass* is the amount of matter a substance contains
  - *weight* is the force of gravity acting on a mass.

HOW MATTER IS ORGANIZED

- Chemical Elements
  - All forms of matter are composed of *chemical elements* which are substances that cannot be split into simpler substances by ordinary chemical means.
  - Elements have abbreviations called *chemical symbols*.
    - Oxygen (O), carbon (C), hydrogen (H), and nitrogen (N) make up 96% of body weight.
    - These elements, together with calcium (Ca) and phosphorus (P) make up 98.5% of total body weight.
  - Trace elements are present in tiny amounts
    - copper, tin, selenium & zinc

Structure of Atoms



- Atoms are the smallest units of matter that retain the properties of an element
- 3 types of <u>subatomic particles</u>
  - protons, neutrons and electrons
- Nucleus: protons (p+) & neutrons (neutral charge)
- Electrons (e-) surround the nucleus as a cloud (electron shells are designated regions of the cloud)

Ions, Molecules, & Compounds

- Ions
  - an atom that gave up or gained an electron
  - written with its chemical symbol and (+) or (-)
- Molecule
  - atoms share electrons
  - written as molecular formula showing the number of atoms of each element (H_2O)

Chemical Bonds

- What are they?
- Types
  - Ionic
  - Covalent
  - Polar covalent
  - Hydrogen
- Water
- pH
- Chemical reactions

Chemical Bonds

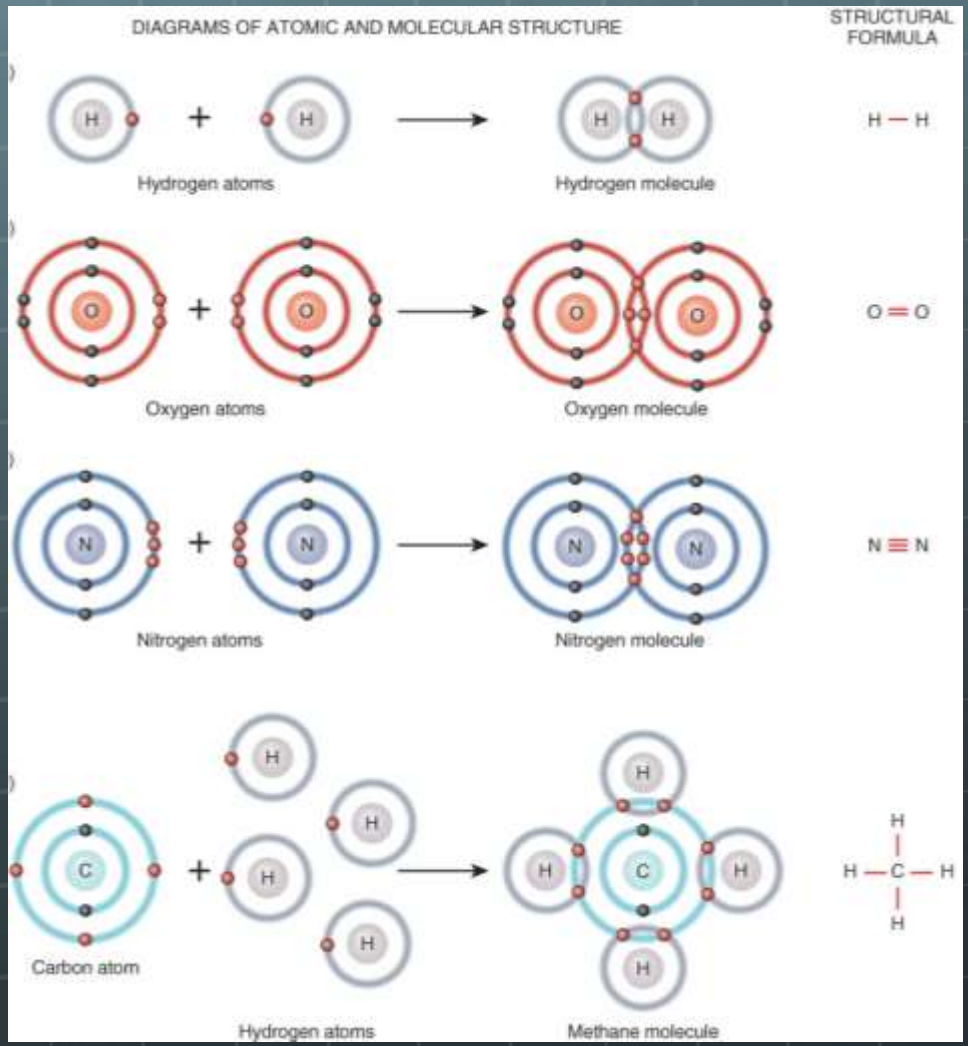
- The atoms of a molecule are held together by forces of attraction called *chemical bonds*.
- The likelihood that an atom will form a chemical bond with another atom depends on the number of electrons in its outermost shell, also called the *valence* shell.

Ionic Bonds

- When an atom loses or gains a valence electron, ions are formed
- Positively and negatively charged ions are attracted to one another.
- Cations are positively charged ions that have given up one or more electrons (they are electron donors).
- Anions are negatively charged ions that have picked up one or more electrons that another atom has lost (they are electron acceptors).

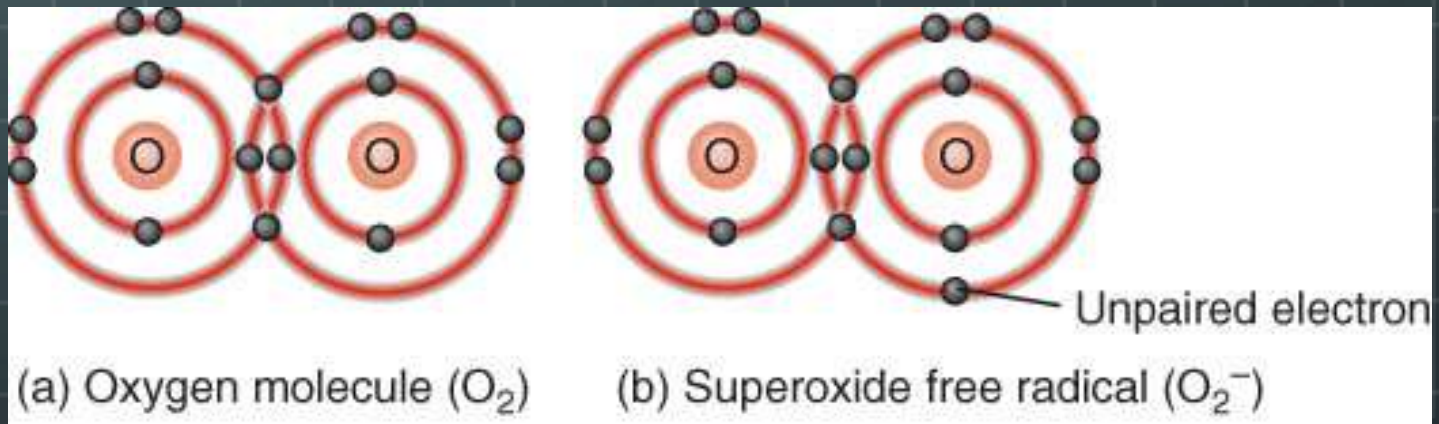
Covalent Bonds

- Atoms share electrons to form covalent bonds
- *Non-polar covalent bonds* share electrons equally
- *Polar covalent bonds* share electrons unequally between the atoms involved



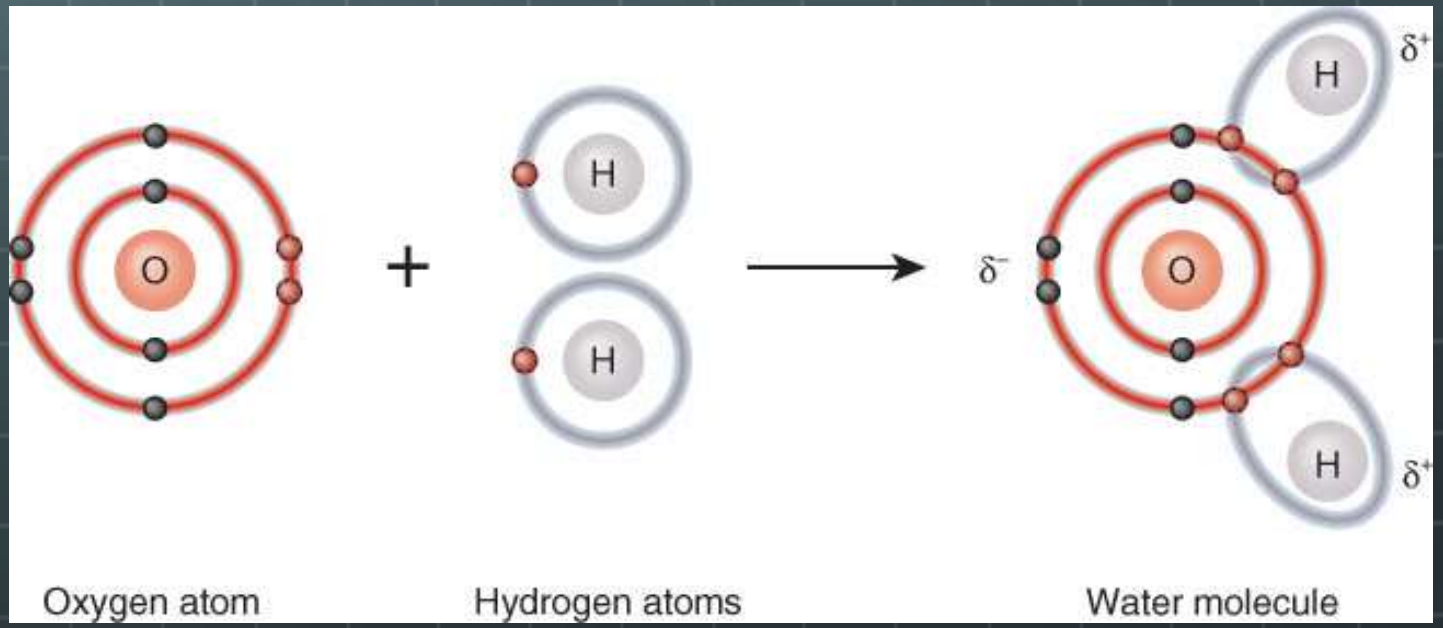
Have you ever wondered what a free radical is?

- A *free radical* is an electrically charged atom or group of atoms with an unpaired electron in its outermost shell.
- Unstable and highly reactive BUT can become stable by
  - giving up an electron OR
  - taking an electron from another molecule (example: breaking apart important body molecules)
- Antioxidants are substances that inactivate oxygen-derived free radicals



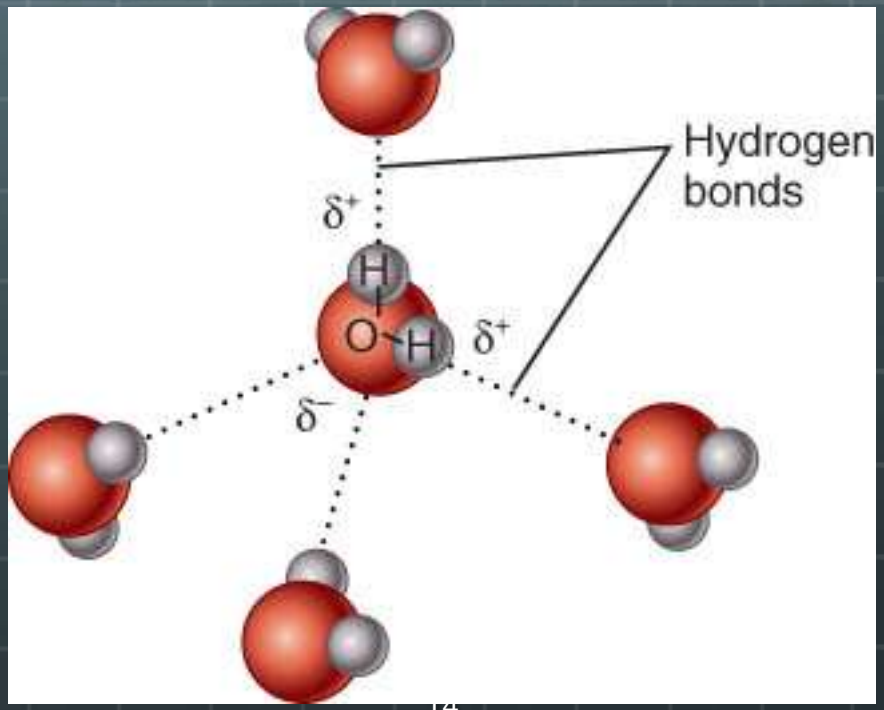
Classic Polar Covalent Bond

- In a water molecule, oxygen attracts the hydrogen electrons more strongly
  - Oxygen has greater electronegativity as indicated by the negative Greek delta sign.



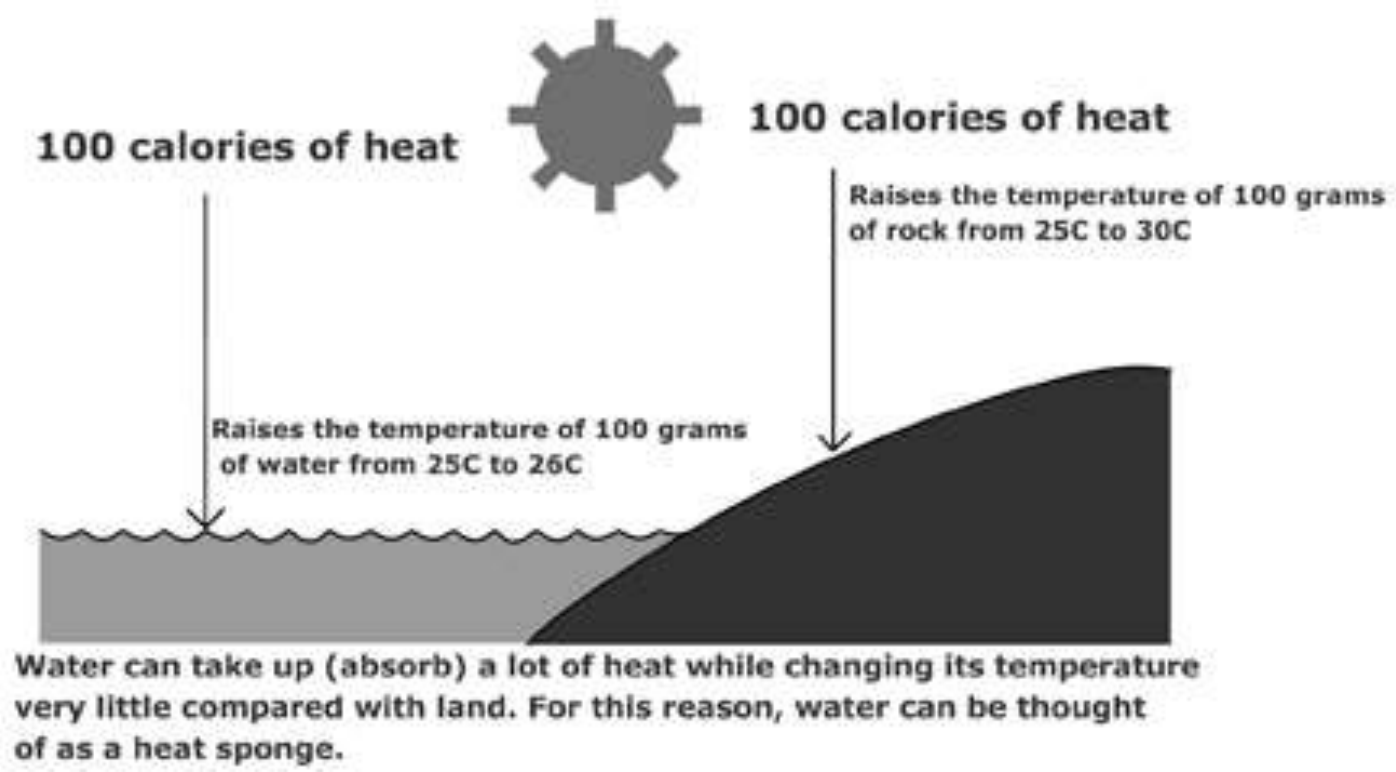
Hydrogen Bonds

- Approximately 5% as strong as covalent bonds
- Large 3-D molecules are often held together by a large number of hydrogen bonds.
- *Water* is the most important and abundant inorganic compound in all living systems.
- An important property of water is its polarity.



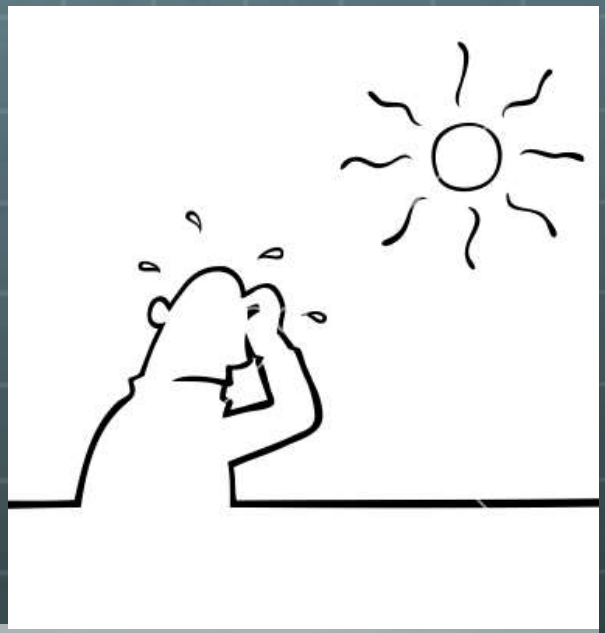
Properties of Water

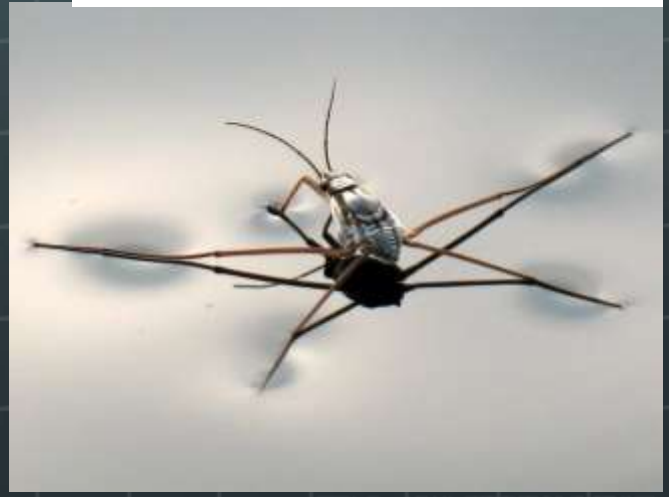
- Water has a high heat capacity.



Properties of Water

- Heat of *vaporization* is also high
  - amount of heat needed to change from liquid to gas
- Has high surface tension
  - Can affect respiratory function





Properties of Water

- Water is a major part of mucus and other lubricating fluids.
- It is found wherever friction needs to be reduced or eliminated

Water in Chemical Reactions

- Hydrolysis breaks large molecules down into simpler ones by adding a molecule of water.

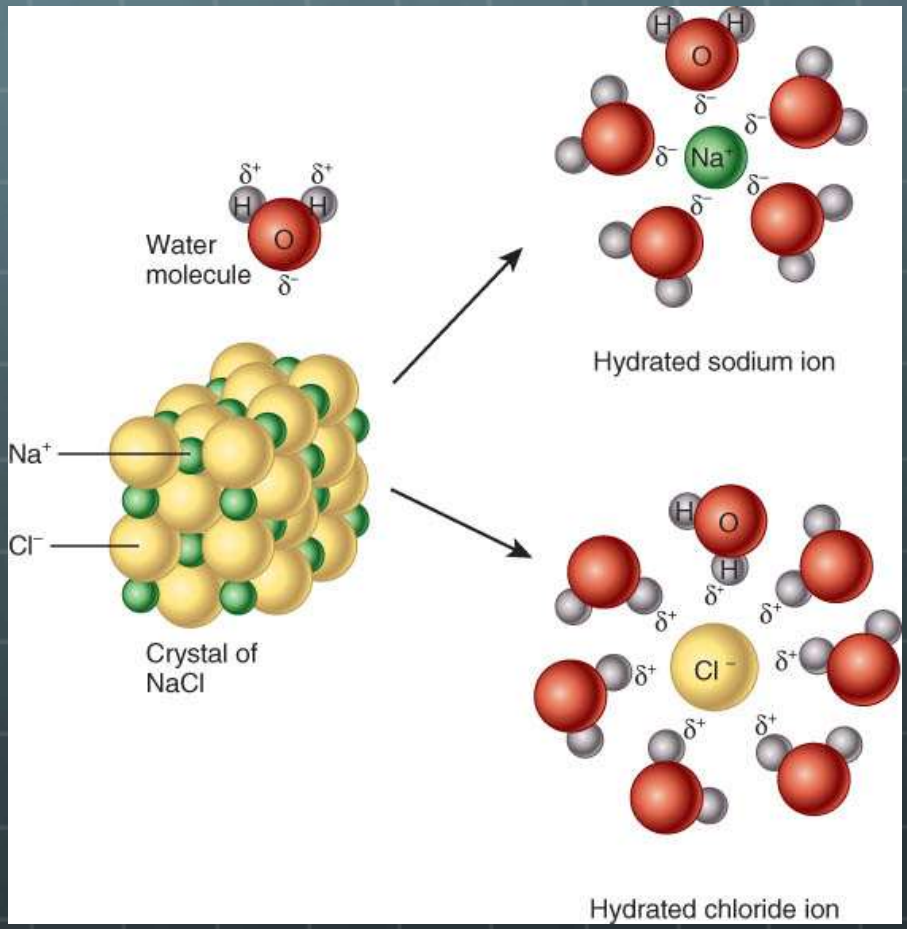
- Dehydration synthesis occurs when two simple molecules join together, eliminating a molecule of water in the process.

Water as a solvent

- In a solution: the *solvent* dissolves the *solute*.
  - Some examples
- Substances that dissolve in water are hydrophilic, while substances that do not are hydrophobic.

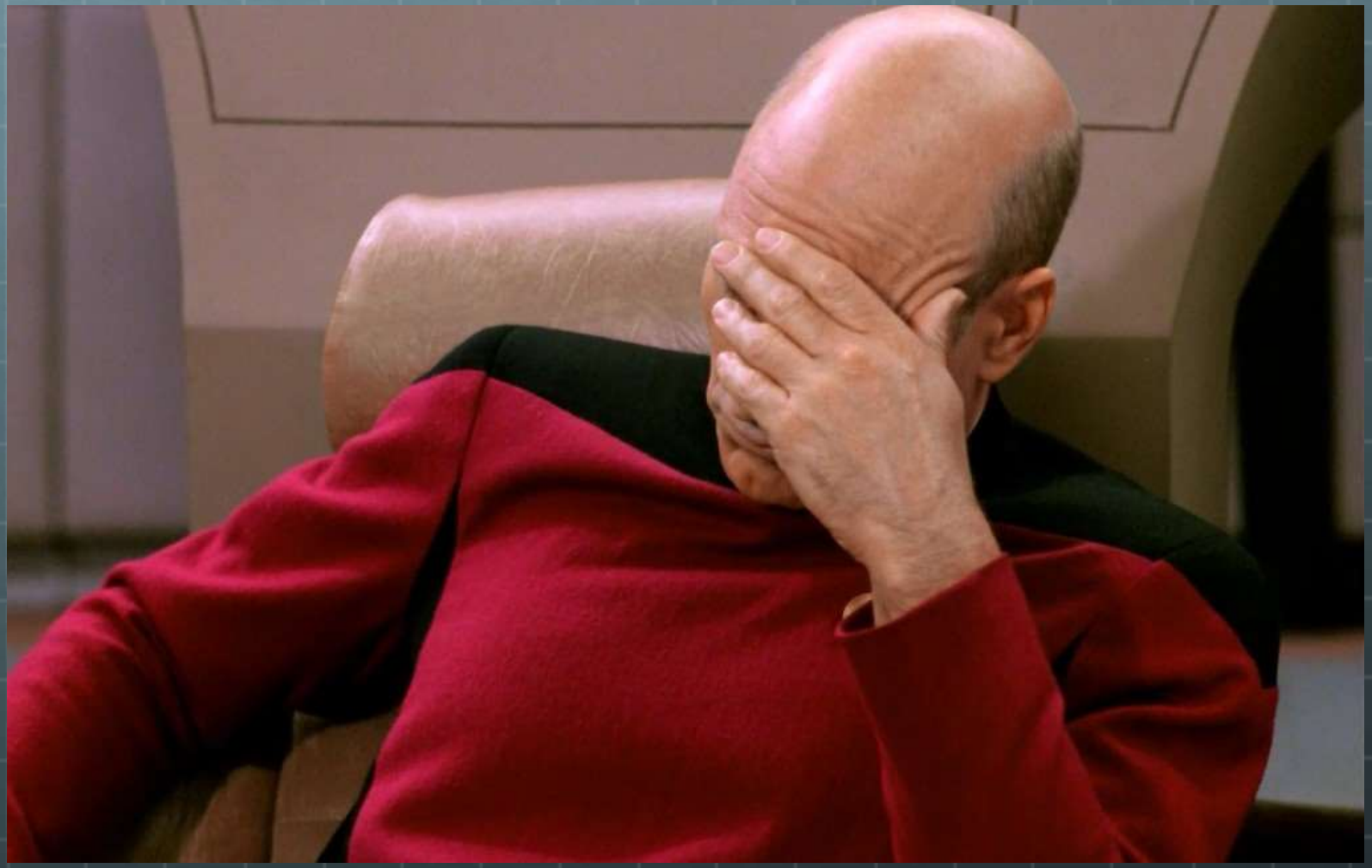
Water as a Solvent

- Most versatile solvent known
  - polar covalent bonds allow it to interact with many molecules
- Water dissolves or suspends many substances



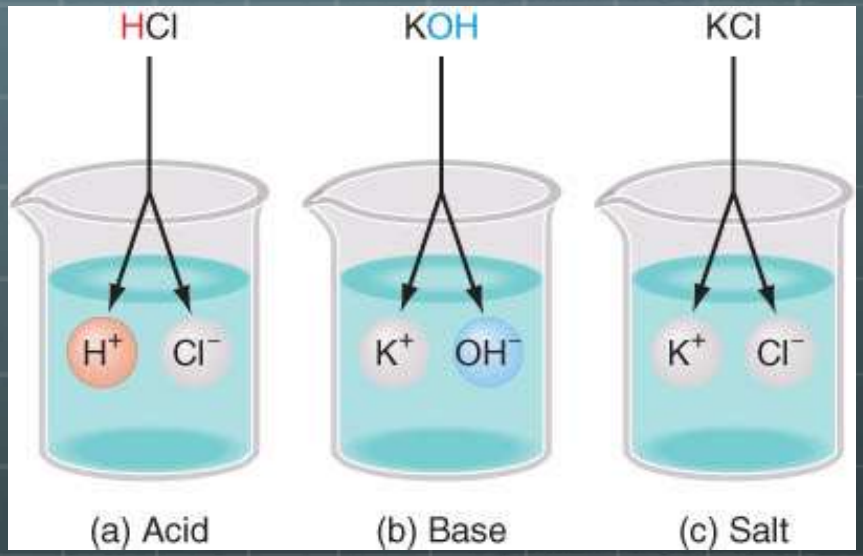
Check in Time…

On to: pH

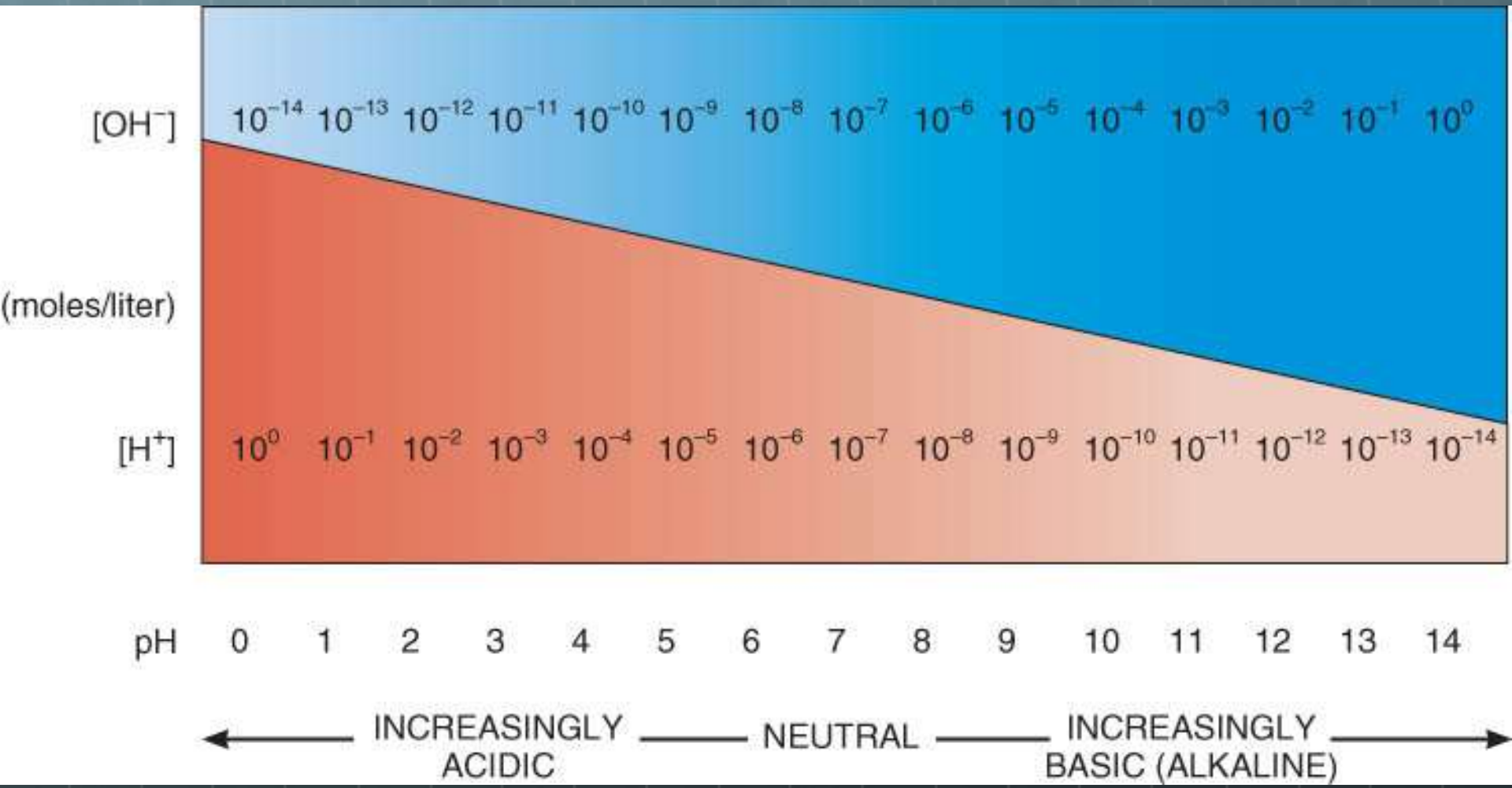


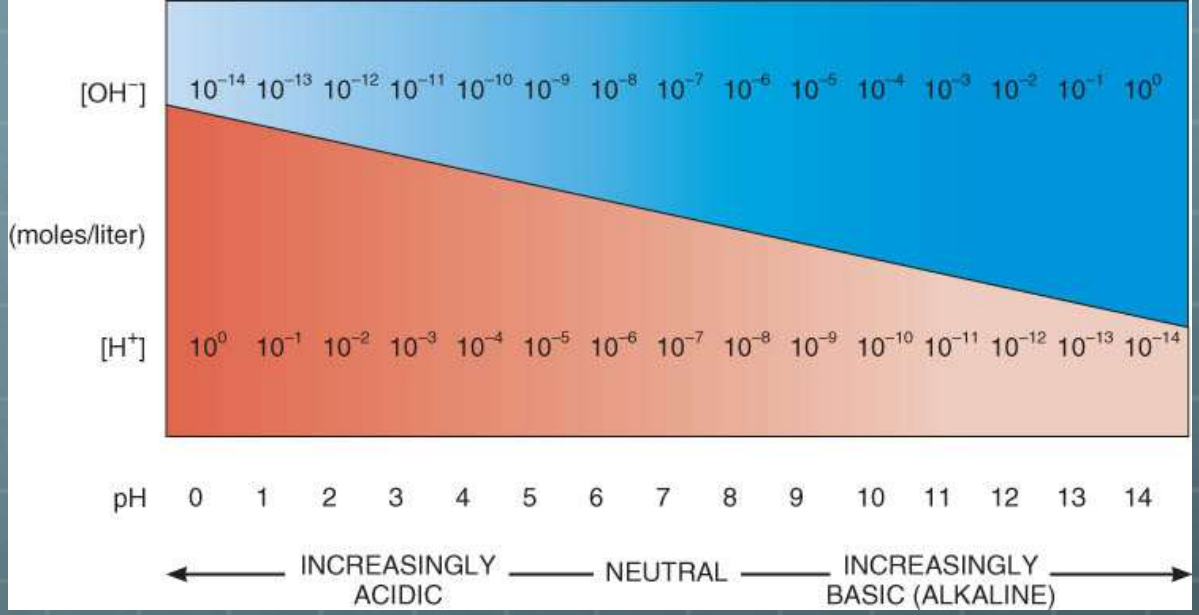
Acids and bases

- ***Electrolytes* – substances that release ions in water**
  - ***Acids* – electrolytes that release H (hydrogen) ions**
  - ***Bases* – electrolytes that release ions that combine with H ions. Often dissociate into OH- (hydroxide ion)**
  - ***Salt* – electrolytes that releases ions that are neither H or OH**
- ***pH***
  - **Concentration of H ions in solution**
  - **Ranges from 0-14**



On to pH

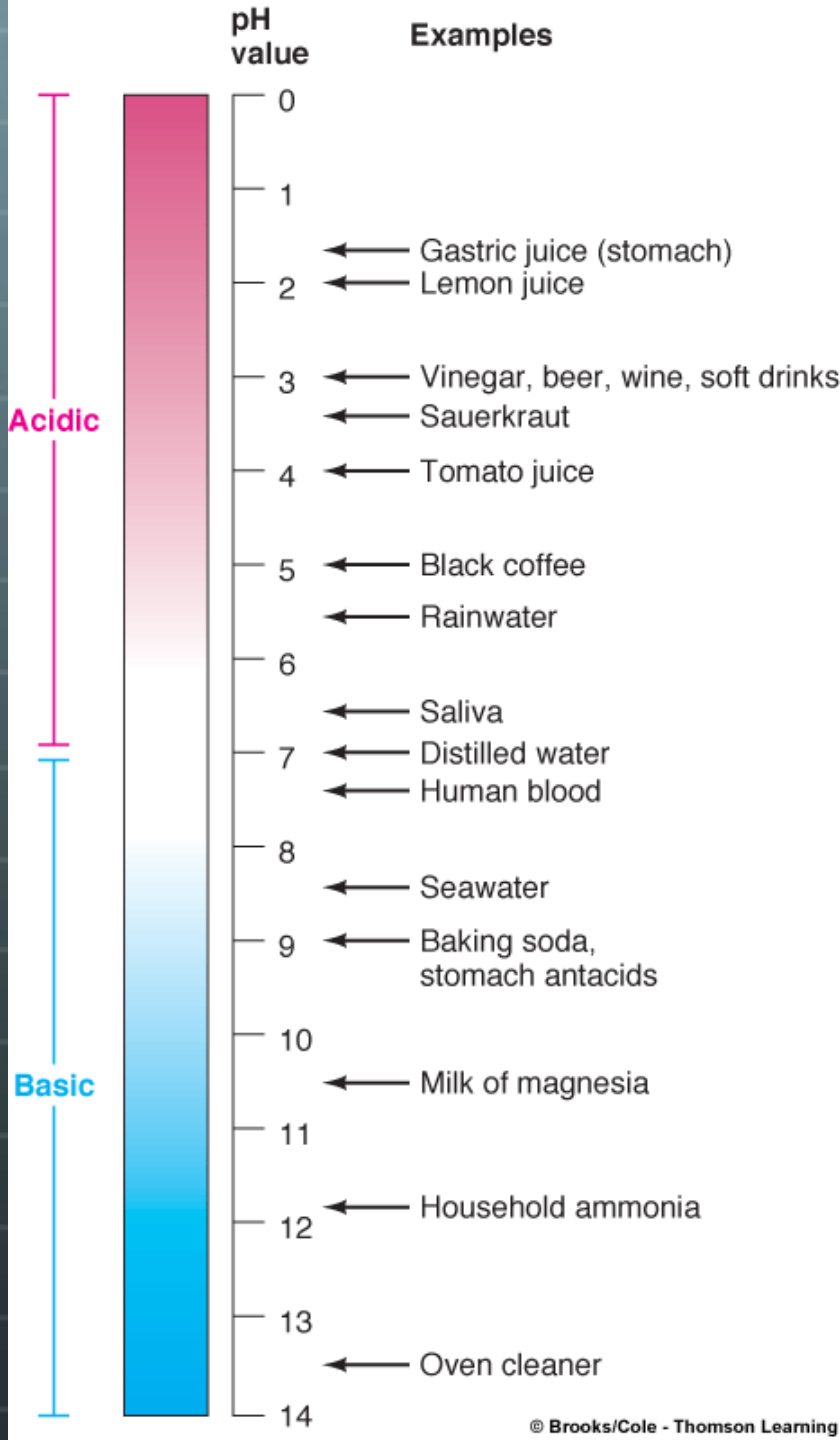

[OH⁻]
(moles/liter)
[H⁺]
10⁻¹⁴ 10⁻¹³ 10⁻¹² 10⁻¹¹ 10⁻¹⁰ 10⁻⁹ 10⁻⁸ 10⁻⁷ 10⁻⁶ 10⁻⁵ 10⁻⁴ 10⁻³ 10⁻² 10⁻¹ 10⁰
10⁰ 10⁻¹ 10⁻² 10⁻³ 10⁻⁴ 10⁻⁵ 10⁻⁶ 10⁻⁷ 10⁻⁸ 10⁻⁹ 10⁻¹⁰ 10⁻¹¹ 10⁻¹² 10⁻¹³ 10⁻¹⁴
pH 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
INCREASINGLY ACIDIC
NEUTRAL
INCREASINGLY BASIC (ALKALINE)



Concept of pH

- **pH of 7 is neutral**
  (distilled water -- concentration of OH- and H+ are equal)
- **pH below 7 is acidic ($[H^+] > [OH^-]$).**
- **pH above 7 is alkaline ($[H^+] < [OH^-]$).**
- **pH is a logarithmic scale**
  Example: a change of two or three pH units
  pH of 1 contains 10x10=100 more H+ than pH of 3

- Biochemical reactions are very sensitive to even small changes in acidity or alkalinity.
  - pH of blood is 7.35 to 7.45



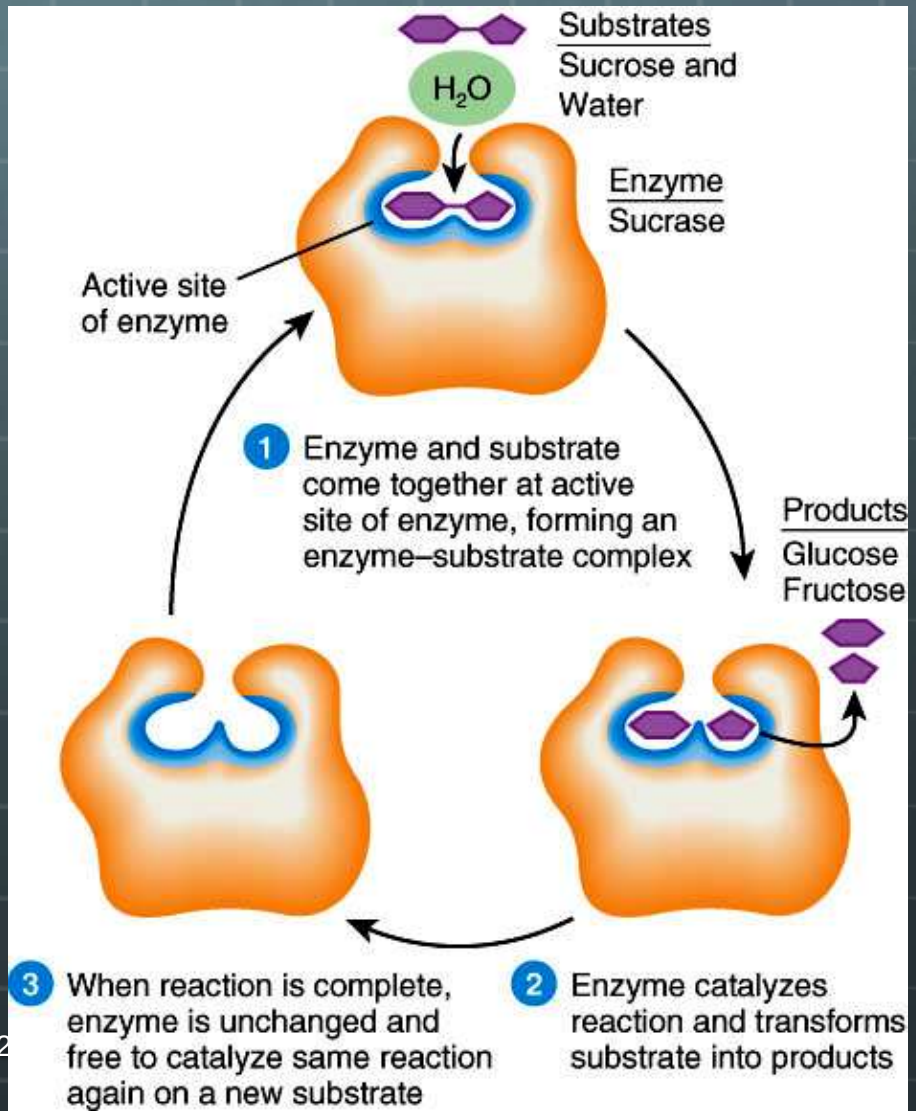
Maintaining pH: Buffer Systems

- The pH values of different parts of the body are maintained fairly constant by buffer systems
  - Example: carbonic acid-bicarbonate buffer system.

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$$

Chemical Reactions - Enzymes

- Highly specific
- Very efficient
  - speed up reaction up to 10 billion times faster
- Are unchanged after reaction occurs
- Enzymes usually end in suffix -ase
  - protease, and lipase are examples



Any questions?