Chapter 2- Essential Chemistry for Biology

I. Life on the chemical level

A. Hierarchy of Biological Organization Fig 1.3

1. **Ecosystem- all orgs in a particular area and the non-living physical components**
2. **Community- all the different species living in a particular area**
3. **Population- groups of interacting individuals of a single species**
4. **Organism- individual living thing**
5. **Organ System- group of organs performing specific function**
6. **Organ- group of tissue performing a function**
7. **Tissue-group of cells performing a function**
8. **Cell- basic unit of life**
9. **Molecule- two or more atoms chemically combined**
10. **Atom- smallest unit of an element that maintains the properties of that element**

B. All matter is made of elements.

<u>Matter</u>- anything that has mass and occupies space

1. <u>element</u>- pure substance that cannot be broken into simpler substance by ordinary chemical means (rxn w/ acids, heat, cooling, chemical rxns)

a. 92 naturally occurring elements

b. 90% of the Human Body consist of:

Element	Symbol
Carbon	C
Hydrogen	H
Nitrogen	N
Oxygen	O
Phosphorus	P
Sulfur	S

Symbol for an element comes from the Greek/Latin: Figure 2.2
Gold is Au (Aurum), Sodium is Na (Natrium)

C. Atom- smallest unit of an element that retains the property of that element

1. Atomic Structure:

Nucleus-

a. neutrons- nuclear particle with no electrical charge, and an atomic mass of "1"

b. protons- nuclear particle with a positive electrical charge, and an atomic mass of "1"

The chemical identity of an atom depends upon the number of protons in its nucleus!

Orbiting outside the nucleus (in an electron "cloud")-

c. electrons- negatively charged atomic particle

3. Atomic Number = the number of protons in an atoms nucleus

4. Atomic Mass = the number of neutrons + number of protons in an atoms nucleus

Proton = 1 Atomic Mass Unit (AMU)
Neutron = 1 AMU
Electron = 0 AMU (actually weighs 1/1837 of a proton)

Shorthand Method for writing information about Elements **C**

5. Electrons exist in energy clouds around the nucleus **Fig 2.7**

Energy level	Number of Electrons Held
#1	2
#2	8
#3	8

***The number of electrons in a electrically neutral atom equals the number of protons.**

****The number and arrangement of an atoms electrons effects its chemical reactivity.**

Valence electrons: electrons in the outer most shell (involved in chemical bonding).

D. Isotopes- have the same number of protons but a different number of electrons

Examples:

Protium Deuterium Tritium (isotopes of Hydrogen)

1. The number of neutrons will affect the stability of an atoms nucleus. Atoms with unstable nuclei can break apart and emit radiation. Elements that emit radiation are called radioactive isotopes (radioisotopes).

II. Molecules and Compounds

A. molecule- two or more atoms held together with a chemical bond

B. Compound- two or more different elements held together with a chemical bond

C. Two types of Chemical Bonds:

1. Ionic Bonds- bond between atoms with opposite electrical charges Atoms develop an electrical charge by either giving up or adding electron(s).

Atoms give up or add electrons in order to have a completely filled outer energy shell

a. ion- an atom with an electrical charge

Example: Sodium Chloride (Table Salt) Fig 2.8

2. <u>Covalent Bonds</u>- bonds formed from the sharing of electrons
Fig 2.9

Atoms will share electrons to get a completely filled outer energy shell. Share electrons to have an "octet" (8). (Except H, He- which only can hold 2 e-)

Two Kinds:

a. <u>Non-polar covalent Bonds</u>- equal sharing of electrons

<u>Structural Formula</u>:

H - H O = O Cl-Cl

<u>Molecular Formula</u>: H_2 O_2 Cl_2
Hydrogen (Gas) Oxygen (gas)
Chlorine(gas)

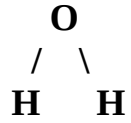
<u>A bond "-" represents a shared pair of electrons</u>.

One, two, or three pairs of electrons may be shared

(Same element on each side of a bond means equal sharing)

b. <u>Polar Covalent Bonds</u>- unequal sharing of electrons

Different elements on each side of a bond means polar bond.
Structural Formula:



O = C = O

Molecular Formula:

H_2O **CO_2**
Water **Carbon Dioxide**

D. Chemical Reactions:

$2H_2 + O_2 \rightarrow 2H_2O$

Reactants **Products**

III. Water – most abundant molecule in living things (60-70% total body weight)

A. Water has polar bonds but is also a <u>polar molecule</u>.

B. <u>Molecular polarity</u>: To determine the polarity of a molecule you must examine the bond polarity as well as the molecules shape.

(Molecular polarity has a tremendous influence on numerous factors important for life to exist.)

1. **<u>Non-polar Molecule</u>- the sum of the partial positive and partial negative charges occur at the same place in the molecule.**

2. **<u>Polar Molecule</u>- the sum of the partial positive and partial negative charges occur at different places in the molecule.**

C. <u>Hydrogen Bonds</u>- occurs when the partial negative charge of the oxygen atom on a water molecule is attracted to a partially positive charge of a hydrogen atom on a different water molecule. Fig 2.10

Has a huge influence on properties of water and on life on earth!

D. Properties of water:

1. **liquid @ room temp. most molecules w/ similar molecular mass are gases @ room temp.**

2. **good solvent (for other polar molecules and ionic compounds)**

<u>Hydrophilic</u>- (water loving) readily dissolve in water (ionic compounds) Fig 2.16

<u>Hydophobic</u>- (water fearing) do not mix with water (Non-polar compounds-fats/oils))

3. water molecules are cohesive (attracted to each other). Why?

4. liquid water temperature raises and lowers slowly.
Calorie- amount of heat needed to raise 1 g of water 1 degree Celsius
Important in maintaining homeostasis

5. High heat of vaporization- allows for evaporative cooling

6. Frozen water is less dense than liquid water Fig 2.15

IV. Acids/Bases/pH

A. pH = - log [H^+]

[ ] means "concentration of" (in this case H^+ ions)

pH Scale- runs from 0-14 Fig 2.17

1. pH 7 is neutral

2. pH < 7 is acidic

3. pH > 7 is basic (alkaline)

B. Acids- produce H^+ in solution.
[H^+] > [OH^-]

C. Bases- produce OH^- in solution.
[H^+] < [OH^-]

D. <u>Buffers</u>- molecules that in solution absorb or produce H^+ or OH^- in order to resist changes in pH.

There are many Biologically important buffers:

Bicarbonate Buffer in blood- Keeps blood @ 7.4 pH

If blood pH is too low or too high? You are DEAD!