Biology 2420 - Chemistry Chapters 2 (Revised Fall 06)

Chapter 2 - **Chemical principles**
This chapter will be covered very quickly and without a whole lot of detail. The purpose of this topic is to give you a broad background for further discussions, particularly that of metabolism (Chapter 8). If you have had chemistry, this will be basic. If you have not, then this will probably be a review of material you learned a long time ago in high school.

Basic building blocks (look at figure 2.1 pg 26 – For a diagram of an atom and its 3 parts.)

1. **Atom –** smallest units of matter
2. **Element –** unique type of atoms, distinguished by its structure of protons neutrons and electrons. See table 2.1 pg. 28 for examples of elements found in living things
3. **Molecule –** a distinct chemical substance that results from the combination of two or more atoms. This can be the same or different elements.
4. **Compound –** when a molecule is a combination of 2 or more different elements in a certain ratio, (formula) it is called a compound.

Chemical bonds are formed when two or more atoms share, donate, or accept electrons. See pages 29 –32 for examples of atoms, electron shell structure and formation of bonds.

1. **Ionic bonds –** these bonds form when an atom loses an electron becoming + charged (ion) and another atom gains and electron becoming –charged (ion). The atoms are bound by the attraction of the different + and – charges. NaCl is good example.
2. **Covalent bonds** form when atoms share electrons. Organic compounds like sugars, fats, proteins, are molecules with covalent bonds. See pg. 35 for methane and other example.

When some compounds such as NaCl are dissolved in water, the atoms (actually ions) separate and are evenly distributed throughout the water in what is called a solution. Pg. 32

1. **Solution –** a mixture of solute and solvent like salt in water. In living cells the solvent is water. See pg 31 for a diagram of water
2. **Hydrogen bonds** form with water, here there is a weak attraction between the hydrogen and oxygen atoms in neighboring molecules.
3. Water molecules have a slightly + charged region and a slightly – charged region, giving them a **polar** characteristics and thus water is a great solvent (pg. 31)
4. An **acid** is compound that gives up H+ ions when dissolved in water
5. A is a **base** compound that gives up OH- ions when dissolved in water
6. **The pH scale** describes how acidic or basic a solution is: measure the concentration of H+ or OH- ions (see page 37 for ph scale)
7. **Buffers** are weak acids that help stabilize changes in ph in a solution
   They are usually organic compounds (molecules with carbon as core atomic material, also contain oxygen, hydrogen)
8. **Oxidation chemical reactions**: when a chemical donates electrons (loses electron) in a reaction, the chemical is said to be oxidized
9. **Reduction reactions**: when a chemical receives-accepts electrons in a chemical reaction, the chemical is said to be reduced.
10. **Oxidation –reduction** reactions often occur together and are referred to as "Redox" reactions (Insight 2.2, pg. 33)
    a. This redox principle is very important in understanding the metabolism reactions that occur in living cells

b. **Catabolism** reactions are reactions that result in the breakdown of organic molecules to release energy (energy is harvested to drive the functions of all the cells) Decomposition reactions
c. **Anabolism** reactions are reactions that require energy and build up or combine simple chemical units to form larger compounds (starches are formed from simpler sugar molecules) Synthesis reactions.
(See page 34, for example of "exchange reaction" –
$HCl + NaOH = NaCl + HOH$

11. Role of **Enzymes** as Catalysts of reactions in living organisms
Increase the rate of chemical reactions, yet are not changed and can be reused over and over, specific kinds of cellular proteins

Biochemistry – Science of the chemical compounds of living systems

Carbon compounds are the basic building blocks of living systems. Carbon can form 4 covalent bonds.

C-C (carbon to carbon)
C-C-C-C (carbon in chains)
Carbon in ring forms (see page 35)
C-H (Carbon to Hydrogen)
C-N (Carbon to Nitrogen)
C-O (Carbon to Oxygen) (even double bonded $C=O_2$)

Functional groups and classes of organic molecules (page 38, Table 2.3)

1. Hydroxyl
2. Carboxyl
3. Amino
4. Ester
5. Sulfhydryl
6. Carbonyl
   a. Terminal=Aldehydes
   b. Internal=Ketones
7. Phosphate, $R\text{-}PO_4$

Macromolecules – are made of smaller building blocks. Smaller units are combined together by dehydration synthesis (condensation type reaction) There are four types of these macromolecules we need to know to understand biochemistry of microorganisms.

1. **Carbohydrates –** sugars and polysaccharides (see pg. 40 ,41, and 42)
   a. Made of simple sugars (monosaccharides) like glucose
   b. Disaccharides are double sugars – 2 monosaccharide units
   Sucrose is a disaccharide of glucose and galactose
   c. Polysaccharide – is a compound of many repeating monosaccharide units such as starch or cellulose
2. **Lipids –** fats, phospholipids, and waxes (see pg. 43 and 44)
   a. Most are triglycerides – subunits are glycerol and fatty acids
   b. Lids include triglycerides, phospholipids, steroids, and waxes
   c. Phospholipids and sterols are vital structural components of cell membranes

3. **Proteins –** macromolecules consisting of repeating subunits (amino acids) See page 44, table 2.5, and also page 45 for diagrams of amino acids.
   a. Amino acids are linked together with **peptide bonds**
   b. **Polypeptides** are chains of amino acids, tremendous variety possible because there are 20+ different amino acids (do the math)
   c. Proteins are very complex polypeptides. Some may have several different polypeptide chains bound together by hydrogen bonds into very specific shapes. The final shape of the protein determines its cellular function
      i. **Enzymes** are proteins that act as catalysts to control cellular reactions (metabolism)
      ii. Structural proteins meet the structural needs of a cell.
   d. Note the importance of the primary, secondary, tertiary, and quartenary structure of a protein. Shape determines function. Loss or alteration of shape is called denaturation and loss of function.

4. **Nucleic acids –** these vital compounds are made of 3 parts: nitrogenous base, 5-carbon sugar, and a phosphate
   a. **DNA –** deoxyribonucleic acid, contains coded genetic information
   b. **RNA –** ribonucleic acid, carries out the operations of the genetic information: such as directing protein synthesis
   c. **Be able to compare DNA and RNA (build a chart on the board)**
   d. **ATP**, adenosine triphosphate, (used for energy in driving cellular processes) nicotinamide adenosine dinucleotide (**NAD, FAD, and related carriers**)- when oxidized and reduced acts as carrier of electrons

Cells - Where the chemicals come together and allow life.

1. Life is cellular. All living systems are composed of cells (single cellular life to multicellular living forms)
2. The combination of all the interrelated chemicals bring about the condition we call “Living”
3. Cells are primarily observed as spheres, cubes. Cylinders, even polygons of protoplasm encased in a membrane. They have DNA as chromosomal material and ribosomes for protein synthesis.
   a. Prokaryotes – no true nucleus, Bacteria and Archae
   b. Eukaryotes – true nucleus and membrane bound organelles such as the mitochondria - Protozoans, Fungi, Plants and animals
4. Processes that define life:
   a. Growth
   b. Reproduction and inheritance patterns
   c. Metabolism (catabolism and anabolism)
   d. Movement and/or response to stimuli
   e. Cell support and protection – storage mechanisms
   f. Transport of materials in and out of cells

What about Viruses? Prions? Viroids?

REMEMBER THIS IS A SELF STUDY CHAPTER. IT WILL BE ON TEST ONE. COME AND SEE ME IF YOU HAVE TROUBLE. CHECK THE URL BELOW FOR ADDITIONAL ON LINE SUPPORT ON BASIC CHEMISTRY.

http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookTOC.html