Chemistry Honors – Lesson 3
Molecular Biology/Biochemistry

Noncovalent Interactions

In Biology, the way molecules interact are determined by weak interactions that result in unique 3D structures and function. These weak interactions consists of several types of intermolecular forces and bonds we discussed previously.

A. Hydrogen bonding

Hydrogen bonding is a specific, unusually strong form of dipole-dipole interaction, which may be either intra- or intermolecular. When hydrogen is bound to a highly electronegative atom, the hydrogen atoms carries little of the electrons. The hydrogen becomes positively charged and interacts with partially negative regions. Substances with hydrogen bonding usually have high boiling points.

B. Ionic bonds

When two atoms with large differences in electronegativity react, there is a transfer of electrons from the less electronegative atom to the more electronegative atom. The atom that loses electrons becomes a positively charged ion, or cation, and the atom that gains electrons becomes a negatively charged ion, or anion. The positive and negatives charges become a force of attraction between the anion and cation called ionic bond.

C. Van der Waals/Dispersion

The bonding electrons in covalent bonds may appear to be equally shared between two atoms, but at any one moment in time they will be located randomly throughout the orbital. This results in temporary short lived dipoles. These dipoles interact with the electron clouds of other atoms, inducing more dipole formation. This force is very weak.

D. Random coil

Molecules can sometimes be made up of long chains. These chains contain bonds where atoms are free to rotate. The molecule twists upon itself and is only limited by the act no atom can occupy the same space. The 3D configuration of this randomly twisting chain is called **random coil**.

E. Hydrophobic interactions

A hydrophobic interaction is an interaction between molecules or part of molecules that are insoluble in water. These molecules that are poorly soluble in water tend to be repulsed by water. In response to this repulsion, these molecules gather and associate.

Macromolecules

A typical cell contains many different kinds of molecules. Of these molecules, some of the largest and most important are called **macromolecules**. These macromolecules are of three major groups: **proteins, nucleic acids and lipids**. The properties of these macromolecules are essential for living cells.

A. Proteins

A protein is a **polymer** (a larger molecule made up of many repeating smaller molecules) consisting of several amino acids. Each amino acid can be thought of as a single carbon atom to which there is attached one carboxyl group (CO_2H), one amino group (NH_2) and a side chain denoted R (see figure 1). A chain of amino acids (**primary structure**) can then in turn fold upon itself (**secondary structure**) to form more complex folds (**tertiary structure) (**see figure 2).

B. Nucleic acids

A nucleic acid is a polymer consisting of **nucleotides**. Each nucleotide contains a five carbon sugar, a purine/pyrimidine base, and a phosphate group (See figure 3). Watson and Crick found that DNA was made of these nucleic acids formed as a **double-stranded helix** held together by hydrogen bonding.

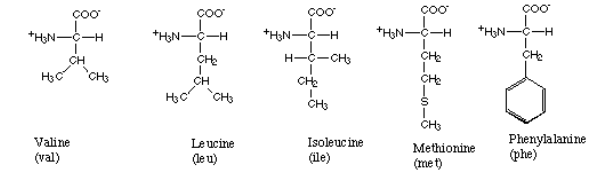
C. Lipids

Unlike proteins and nucleic acids, lipids are not polymers. They are small molecules that have a strong tendency to associate due to hydrophobicity. Lipids are usually characterized by a water loving "head" connected to a nonpolar water fearing "tail" (see figure 4). The nonpolar tail associates to drive away the water where the van der Waals interaction of the tails keep the grouping stable.

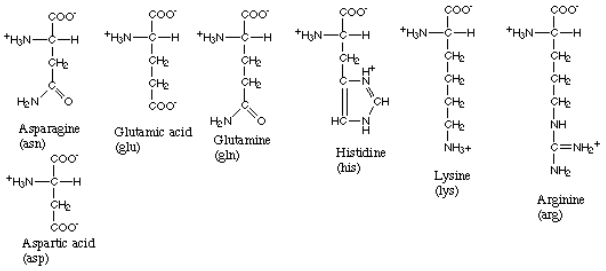
The Cell

If we take apart a living cell, we can see that the parts are made up the elements and bonds we have discussed in class. In order to have a living organism, we first need to separate it from the environment. Since lipids are hydrophobic, they help form a **lipid bilayer** or a membrane to distinguish the inside of the cell from the outside (see figure 5). However, a living cell is more than just a sac, but require working components on the inside. Amino acids from the food we eat get used to make protein in the cell of our body. These amino acids join and make a polymer that folds due to hydrogen bonding and van der Waals to give us the machinery inside the cell. However, what tells the machine how to operate? That's where we have the **nucleus** or the "brain" of the cell. The nucleus is made up of **chromosomes**, which are essentially tightly wound DNA (see figure 6). DNA as we know are made up of nucleic acids.

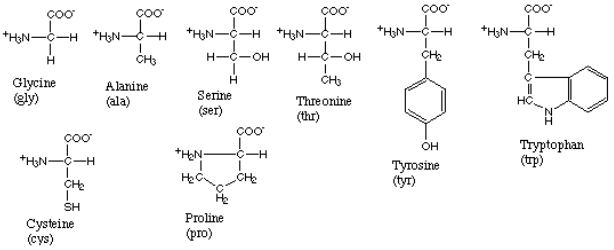
Amino acids with hydrophobic side groups

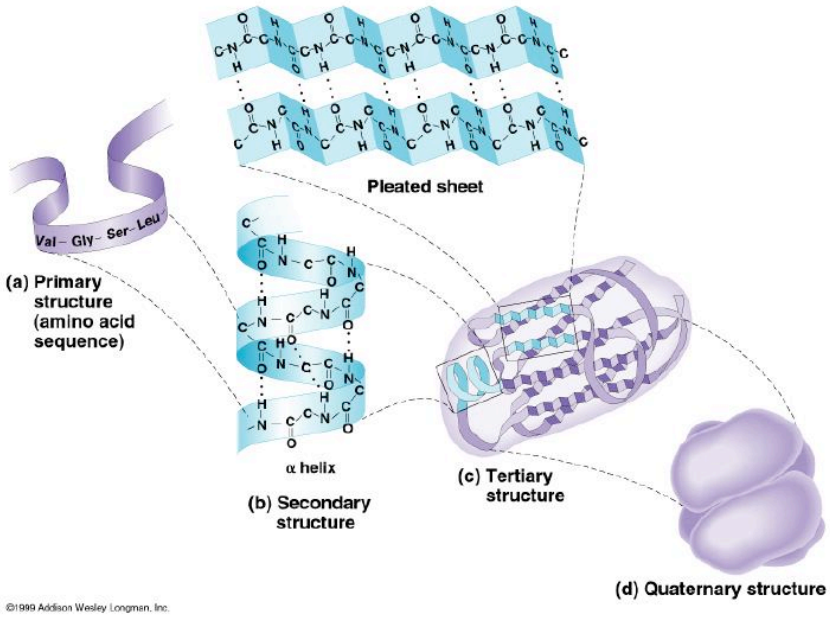


Amino acids with hydrophilic side groups



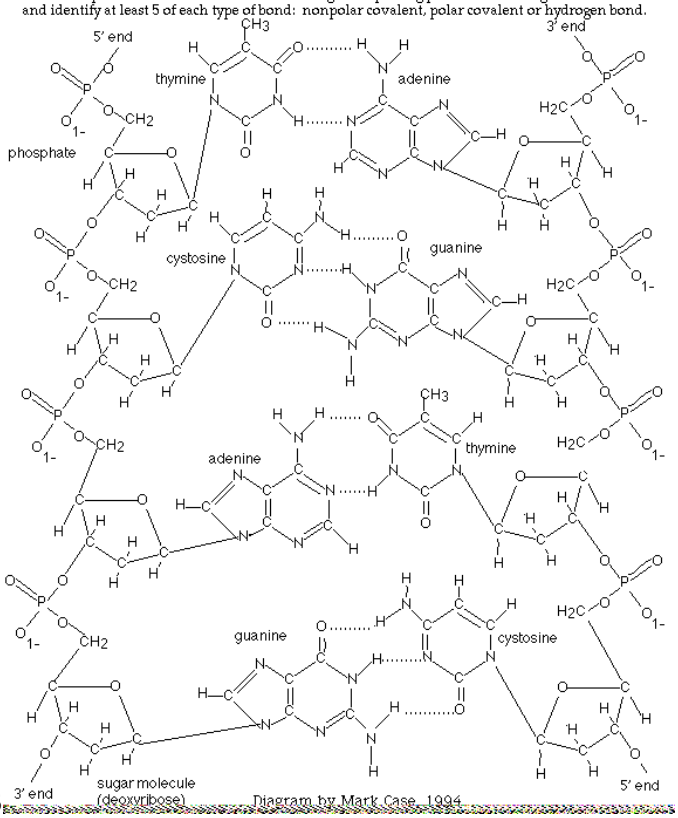
Amino acids that are in between





BONDING IN DNA WORKSHEET

DNA (deoxyribonucleic acid) is the main information-bearing molecule in the cell. Below is a portion of a DNA molecule, showing the repeating pattern of bonding units. Label and identify at least 5 of each type of bond: nonpolar covalent, polar covalent or hydrogen bond.



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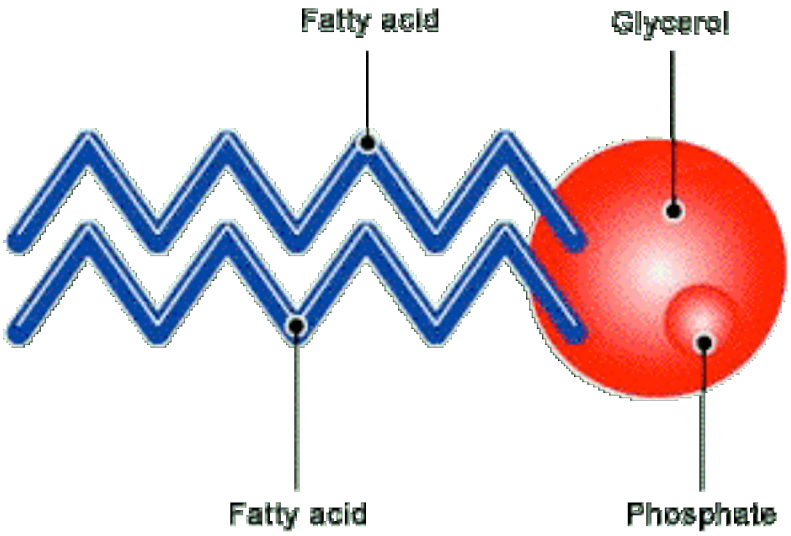

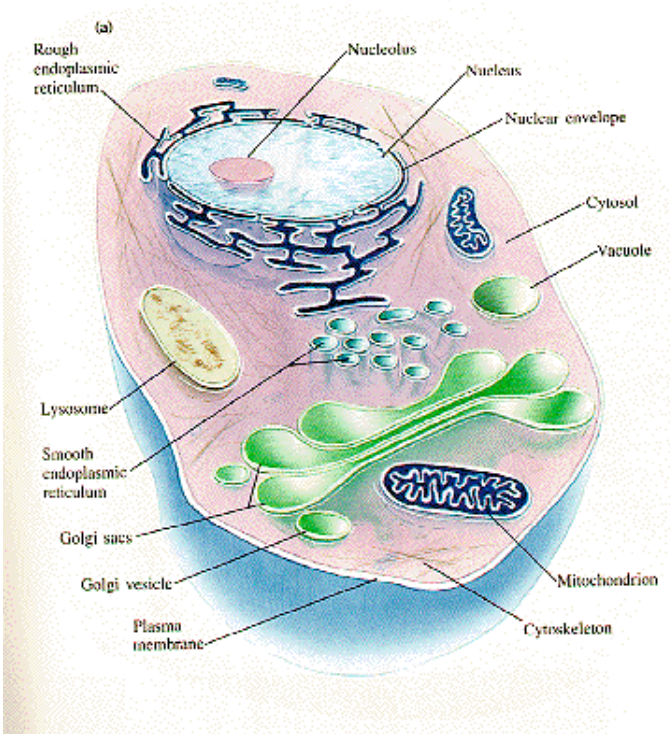

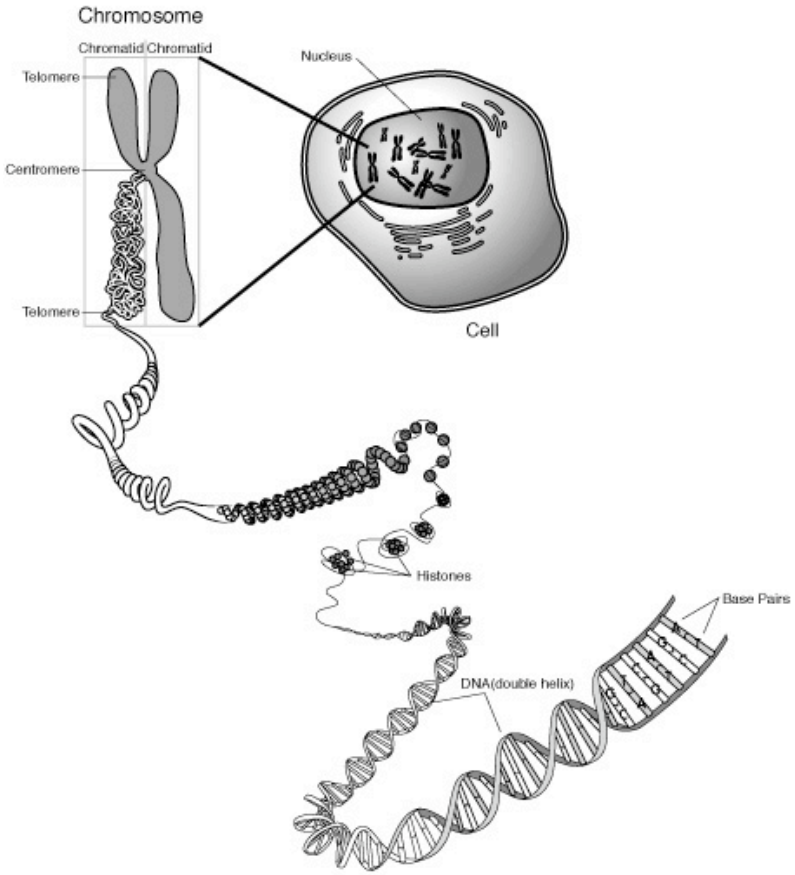

http://www.accessexcellence.org/AB/GG/chromosome.html