What is biochemistry?

- Advanced organic chemistry?
- Cell biology?
- Molecular biology?
- The most fun and interesting subject in science (personal bias)?
- The study of life on a molecular level. Or, the formal term of bios = life meaning biochemistry is the science concerned with the chemistry of various molecules that occurs in living cells


Two out of three farmers approve of genetically engineered produce.

- Biochemistry encompasses large areas of cell biology, molecular biology, and molecular genetics
- Biochemistry is essential to all of the life sciences (biomedical and plant sciences) All advanced degrees require that biochemistry is one of the first courses
- This class will be taught not - as an advanced organic but as an encompassing science that should help tie several of your classes together

Course Description

This course is an introduction to the chemistry of biological molecules and macromolecules.

- We will study the structure and properties of the four major classes of biomacromolecules:
  - nucleic acids, proteins, carbohydrates and lipids, and their functional impact on the cell and on the organism.
- We will study enzyme kinetics and metabolism and how they relate to different cellular pathways, including the production of energy and macromolecules.
- Throughout the semester we will take these broad ideas and study them in the context of human health and disease pathology.

Simply put, we will be studying the four macro-biomolecules - proteins, DNA/RNA, lipids and carbohydrates, and when possible, put them into a biomedical context

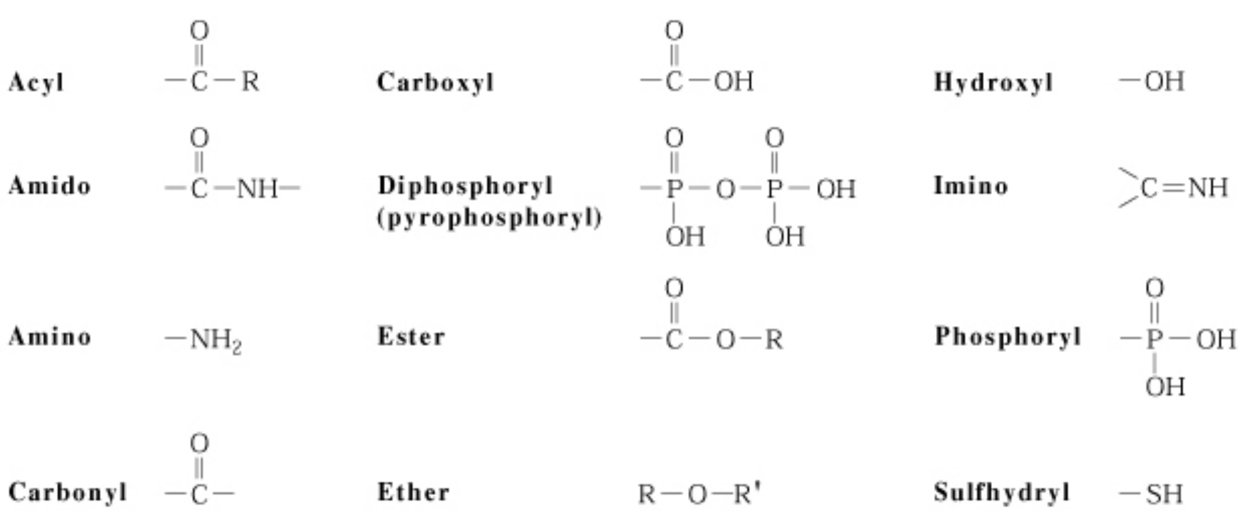
What are YOUR expectations of this class?

– Ask yourself why you need this course

… and now the fun begins…

Functional Groups - One of the reasons why organic chemistry is a prerequisite for the class

Just for review – recognize each of the following.



Disulfide

Thioester

Anhydride (2 carboxylic acids)

Guanidino

Imidizole

Macromolecular Biomolecules

Complex, large biomolecules – the big four

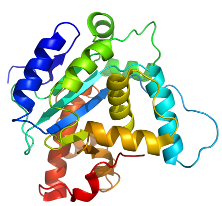
- Proteins, Carbohydrates, Nucleotides, lipids

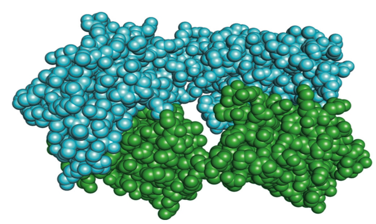
✓ Macromolecules and their building blocks have a "sense" or directionality
✓ Macromolecules are informational
✓ Biomolecules have characteristic three-dimensional architecture
✓ Weak forces maintain biological structure and determine biomolecular interactions

Structure and Function

The shape and role of a biomolecule is largely determined by many ***weak forces***

- Shape of molecules, interaction between molecules, binding of small molecules





Inter-Intra molecular forces

- Covalent bonds hold atoms together so that molecules are formed
- Weak forces profoundly influence the structures and behaviors of all biological molecules
- Weak forces create interactions that are constantly forming and breaking under physiological conditions
- Energies of weak forces range from 0.4 to 30 kJ/mol
- Weak forces include:
  - van der Waals interactions
  - Hydrogen bonds
  - Ionic interactions
  - Hydrophobic interactions

Noncovalent Bonds

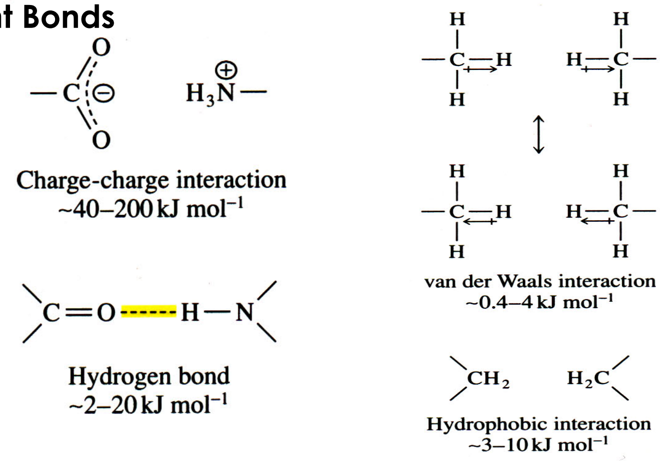
Ionic

H-bond

van der Waals

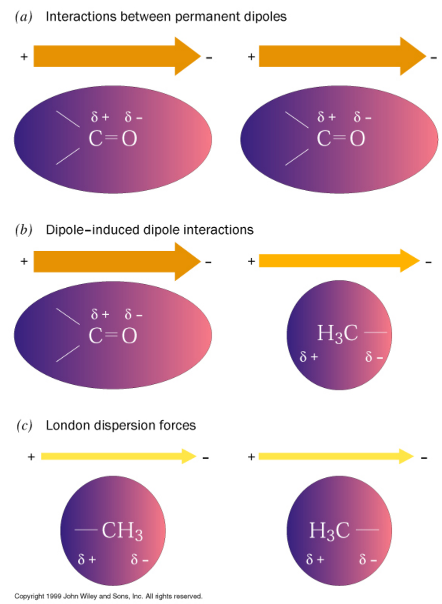
Hydrophobic

Ionic>H-bond, hydrophobic>van der Waals



The major noncovalent interactions in cells are electrostatic (ionic), hydrophobic, hydrogen bonds, and van der Waals. London forces are minimal unless tight association occurs

Most covalent bonds are 8 to 10 times stronger yet the overall shape and effectiveness of large molecules are due to the much weaker non-covalent bonds.

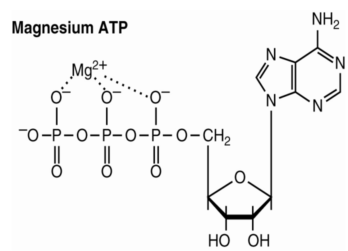


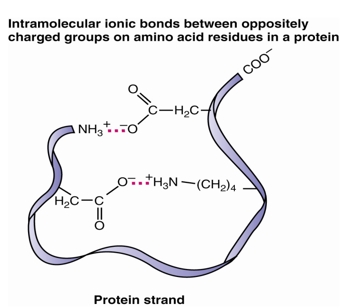
Ionic Bonds

Ionic Bonds AKA salt bridges... Simple magnetic attraction between

- **Carboxy and amino groups, metals…**

- **The force of attraction (F) depends on distance and relative shielding**
- ***Water and salts weaken bond***
- **Strongest single noncovalent bond**





Ionic bonds contribute to the stability of proteins

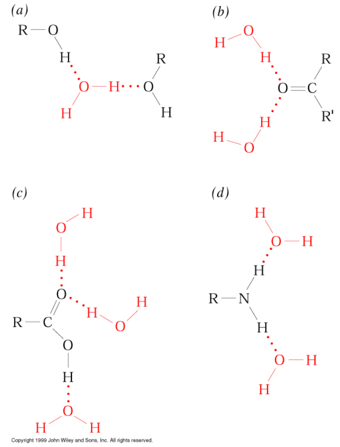
Hydrogen Bonds

H Bonds result from the interactions of strong covalent bonds between hydrogen and a highly electronegative atom (N and O)

Strongest bonds are when the arraignment is linear.

The hydrogen is “shared” by a the covalently bonded atom and another electronegative atom

You must be able to identify the donor and acceptor



Dipolar water dissociates in solution
association of dipolar water with typical biological side groups due to Hydrogen bonding

Van der Waals (dipole-induced interactions)

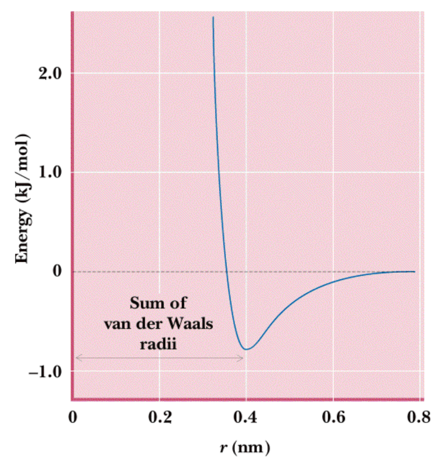
Next to london dispersion forces, these are the weakest of the nonionic bonds but are important due to the large number of van der Waal interactions in a protein

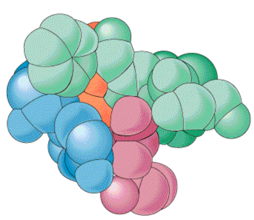
These bonds originate from very small dipole moments generated in atoms as electrons move around the nucleus

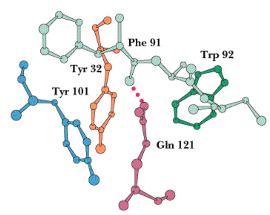
These are small ionic, dipolar interactions

The energy of the attraction is related to the distance between nuclei

The average separation between atoms or molecules is the sum of the van der Waals radii



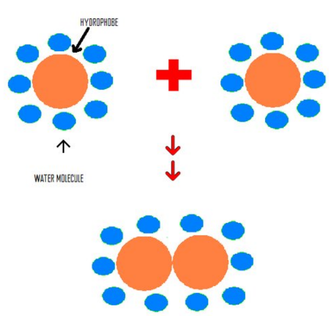




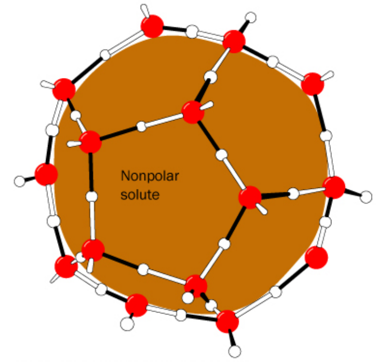
Space filling models use the van der Waal Radii to depict sizes

Hydrophobic interactions

The observation that hydrophobic compounds and particles or regions of molecules associate together avoiding contact with water



Hydrophobic interactions



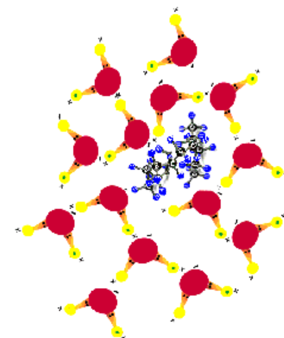
The association of relatively nonpolar molecular groups in an aqueous environment.

Driven by the order of water entropy

- The lack of interactions with apolar molecules with decreases the randomness of the order of water. (an increase in entropy)

Water forms cage-like structure around hydrocarbons forming shells of highly ordered water – Clathrate Cage

- Shell formation is due to water forming hydrogen bonds with each other
- Aggregation of hydrophobic moleculules reduces total surface area and results in less order (increase in



hydrophobic portions of the molecule permits the water max degrees of freedom (a minimization of entropy increase)

Very important in maintaining protein structure

- hydrophobic portions of proteins are solvated by "hiding" inside the molecule away from the water.

This is the driving force for the formation of ampipathic molecules forming lipid bilayers membranes and vesicles