General Chemistry

Ch. 10

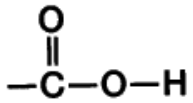
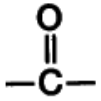
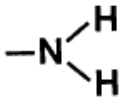
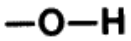
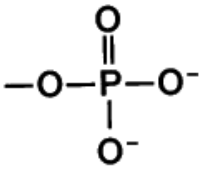
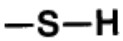
Essentials of Organic Chemistry

- Most biological important molecules are composed of organic compounds.
- These are mostly produced by biological systems.
- Organic molecules contain carbon-hydrogen bonds and often include oxygen.
  - Furthermore they sometimes contain nitrogen, sulfur, and phosphorus
  - These elements are held together by covalent bonds.
- Organic molecules have three components:
  - *3 C's (Carbon-Hydrogen bonds, Covalent Bonds, Complex Chains)*
  - Molecules made up of carbon-hydrogen bonds
  - Molecules contain mostly covalent bonds
  - Molecules can be complex as they form chains

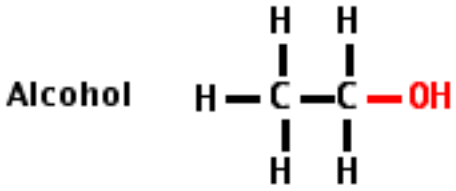
Essentials of Organic Chemistry

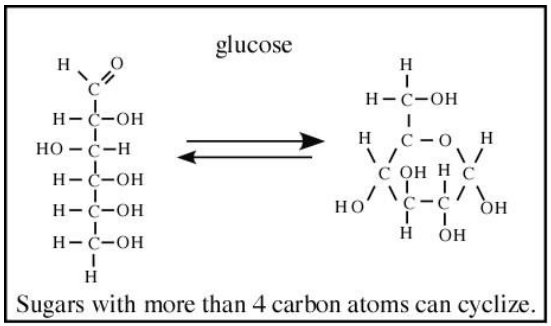
- Carbon is a key element in organic molecules.
  - Carbon can form 4 covalent bonds (forming either single or double covalent bonds).
  - Carbon forms a carbon backbone of biomolecules of various complexity.
- Organic molecules include four major classes:
  - Carbohydrates
  - Lipids
  - Proteins
  - Nucleic acids
- Complex molecules can be understood through their reactive groups *(called functional groups)*
- Functional groups are a specific configuration of atoms commonly attached to the carbon skeletons of organic molecules and usually involved in chemical reactions.

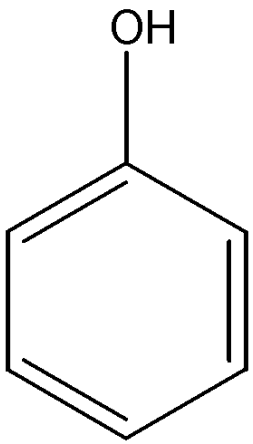
Important Functional Groups of Organic Chemistry

Functional Group	**Structural Formula**
Carboxylic acid, -COOH	
Carbonyl group, -C=O	
Amino group, $-NH_2$	
Hydroxyl group, -OH	
Phosphate group, $-PO_4$	
Sulfhydryl group, -SH	

Hydroxyl Group, -OH



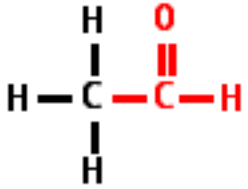




- A alcohol has an –OH group attached to a hydrocarbon chain.
- A sugar or carbohydrate has multiple –OH groups present.
- A phenol has an –OH group attached to an aromatic ring.

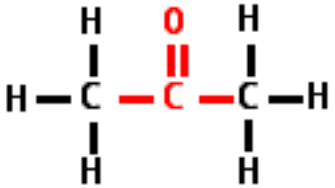
Carbonyl Group, -C=O

Aldehyde



Acetaldehyde

Ketone

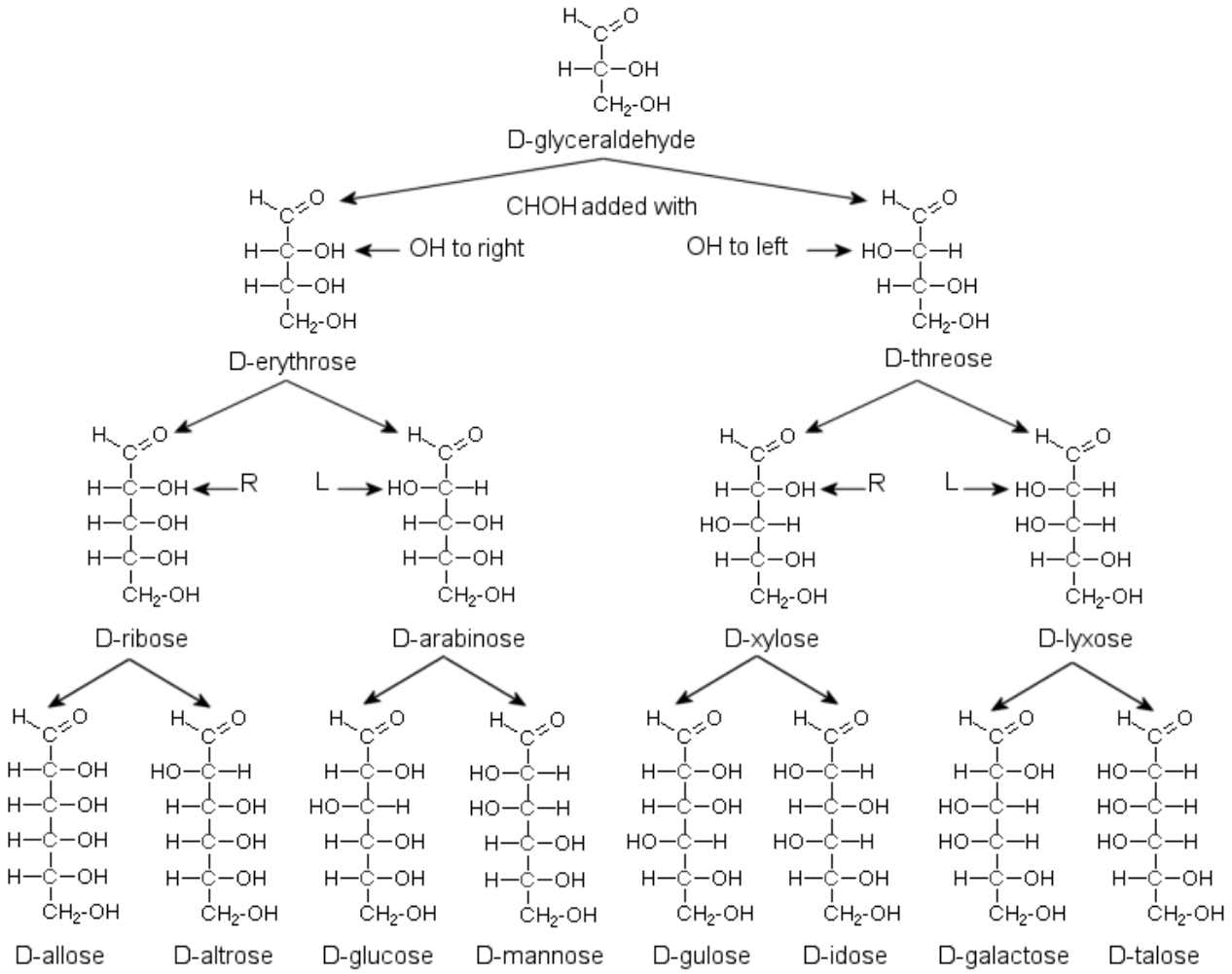


Acetone

- This is a functional group with a carbon atom double bonded to oxygen. It is one of the most important and reactive groups in cells.
- An aldehyde has a carbonyl group at the end of a carbon skeleton.
- A ketone has a carbonyl group in the interior of the molecule.
- If discussing monosachharides:
  - A sugar with an aldehyde is called an aldose.
  - A sugar with a ketone is called a ketose.
- The –C=O group is usually soluble in water, especially if the hydrocarbon group attached is small.

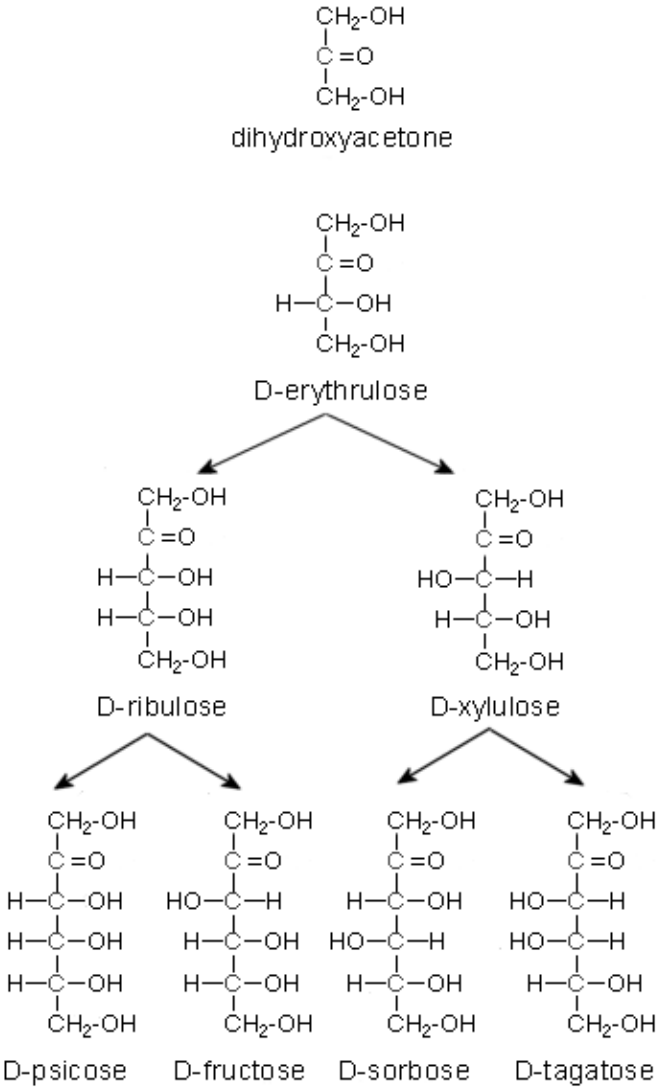
Monosaccharide Terminology and Classification

- This diagram shows the relationship between all the 3, 4, 5 and 6 carbon sugars based on D-Glyceraldehyde



Monosaccharide Terminology and Classification

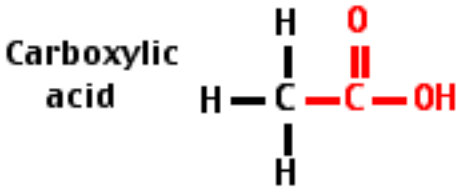
- This diagram shows the relationship between all the 3, 4, and 5 carbon sugars based on Dihydroxyacetone, a ketone.
  - Note: reduction of D-sorbose yields a non-cariogenic sugar alcohol called sorbitol. Similarly, xylitol (another common non-cariogenic sugar alcohol, is derived from the aldopentose xylose).



Naming Monosaccharides

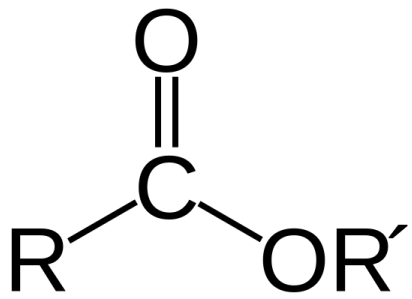
- Monosaccharides, either aldoses or ketoses, are often given more detailed generic names to describe both the important functional groups and the total number of carbon atoms
  - Aldotetroses – aldose with 4 carbons
  - Ketotetroses – ketose with 4 carbons
  - Aldopentoses – aldose with 5 carbons (such as ribose)
  - Aldohexoses – aldose with 6 carbons (such as glucose and galactose
  - Ketohexoses – ketose with 6 carbons such as fructose
- Sometimes the ketone-containing monosaccharides are named by inserting the letters –ul- into the generic terms
  - Tetrulose, pentulose, hexulose

Carboxylic Group, -COOH



Acetic acid

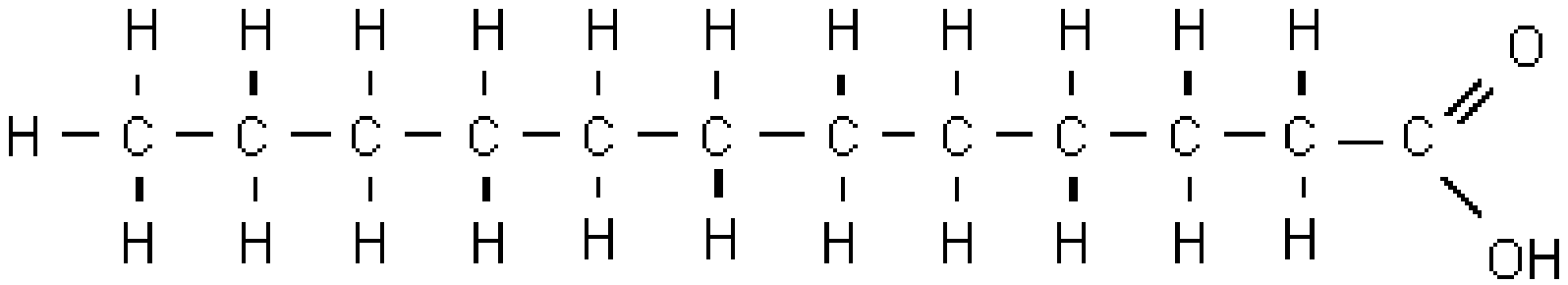
- Compounds containing this group are weak acids, as the hydrogen tends to dissociate in solution yielding $–COO^-$
- Carboxylic groups are present in amino acids and fatty acids.
- Esters are similar, but the O is attached to C instead of H. They are fragrant and flavorful (such as in flowers and fruits).



Ester

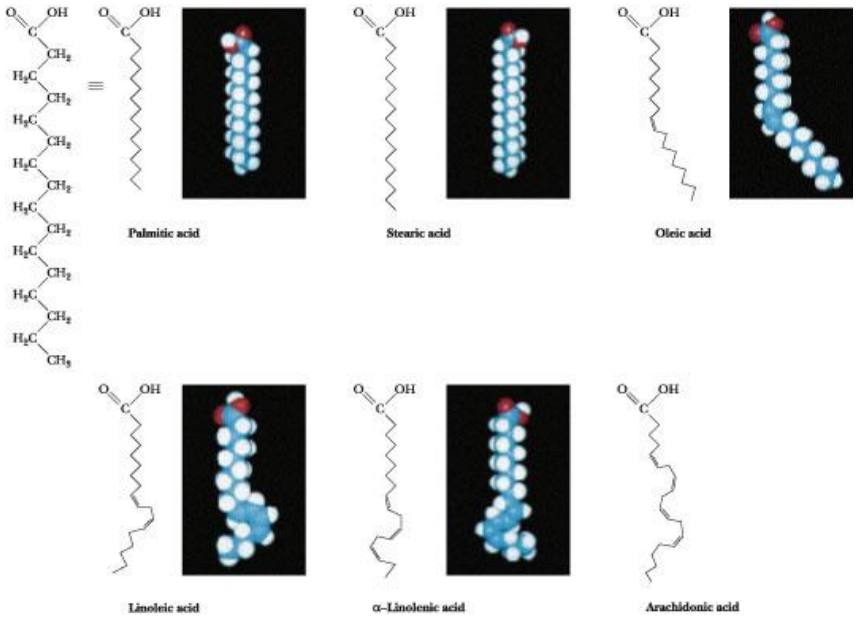
Fatty Acids

- Composed of a long hydrocarbon chain (or "tail"). Typically have 10-20 (but sometimes more) carbons.
- Fatty acids have a terminal (-COOH) carboxyl group (or "head").
- These are mostly nonpolar covalent bonds, so they are not soluble in water



Fatty Acid Classification

- Fatty acids are either Saturated or Unsaturated
  - Saturated means that they have all carbon-carbon single covalent bonds (also these carbons are saturated with hydrogen).
  - Unsaturated indicates that they have a double covalent bond between one or more pair of carbons (and these are not saturated with hydrogen)

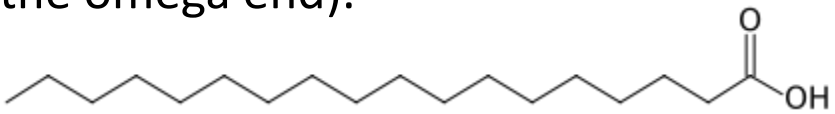


Fatty Acid Nomenclature

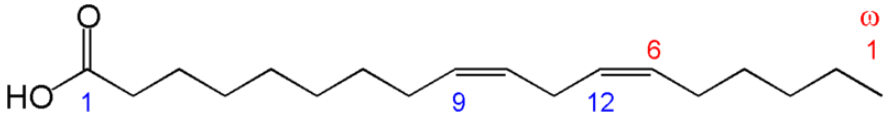
- Fatty acids can be named and described in four ways. These are:
  - Systemic name
    - Indicates number of carbons.
    - Examples) - Octadecanoic acid - 18 carbons saturated fatty acid, 9,12-Octadecanoic acid , 9,12,15-Octadecanoic acid
  - Common name
    - Memorization (mostly this is how you will see them).
      - For the examples above
        - » Octadecanoic acid is Stearic acid , 9,12-Octadecanoic acid is Linolenic acid (or LA), 9,12,15-Octadecanoic acid is alpha-Linolenic acid (α-Linolenic acid or ALA)
  - Symbol
    - Number of carbons is followed by a colon which is followed by the number of double covalent bonds
      - For the examples above
        - » 18:0, 18:2, 18:3
  - Structure
    - Includes the tail, carbon-hydrogen bonds, and carboxyl group
      - See next slide for examples

Fatty Acid Nomenclature (cont.)

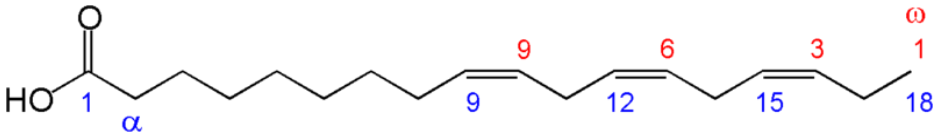
- Structure
  - Every bend indicates a C with 1, 2 or 3 H bonded with it.
  - Sometimes indicates carbon numbers
    - There are two sets (one from the carboxyl end and the other from what is referred to as the omega end).
      - Stearic acid



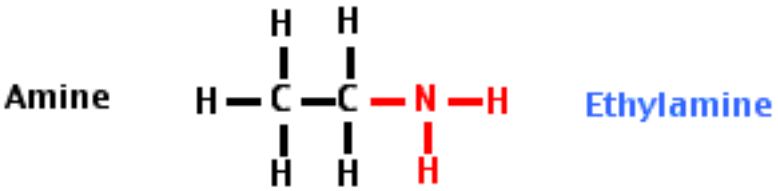
    - For Unsaturated fatty acids
      - Linoleic acid



      - α-Linolenic acid



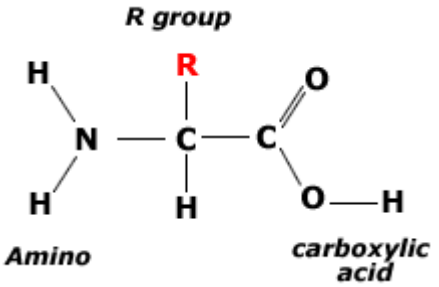
Amino Group, -NH_2

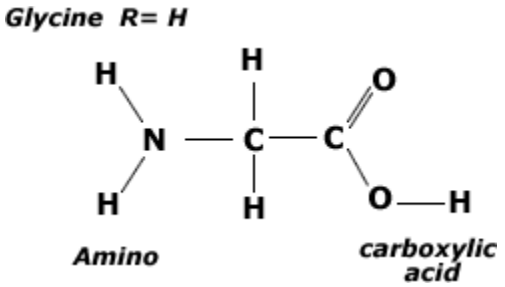


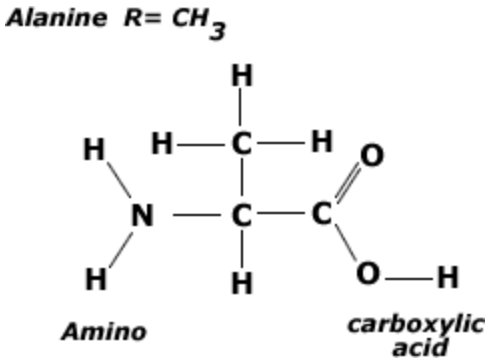
- Compounds containing this group are called amines.
- Amines can act as bases, accepting a proton (due to N's electronegativity).
- In cells, it tends to be – NH_3^+

Proteins Structure

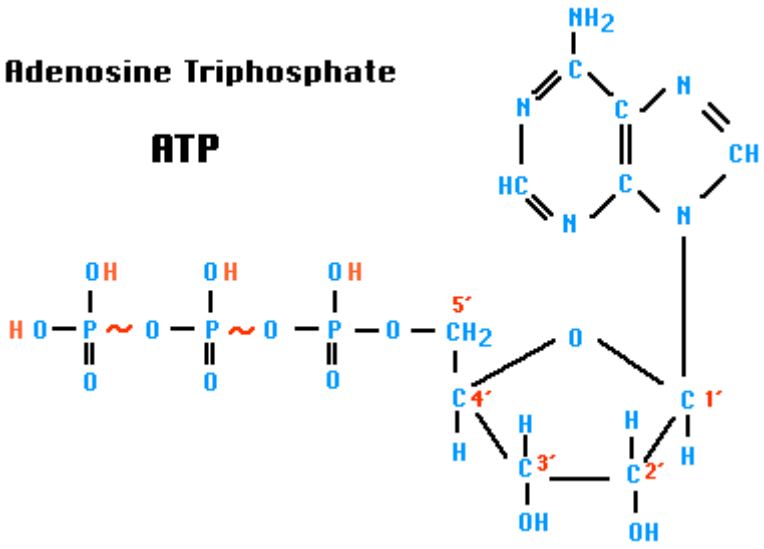
- Proteins consist of long chains of amino acids linked together by peptide bonds.
  - –Amino acids consist of five components
    - A central carbon atom
    - A hydrogen atom
    - An amino group (-NH2)
    - A carboxyl group (-COOH)
    - A variable group (known as an R group or a side chain)







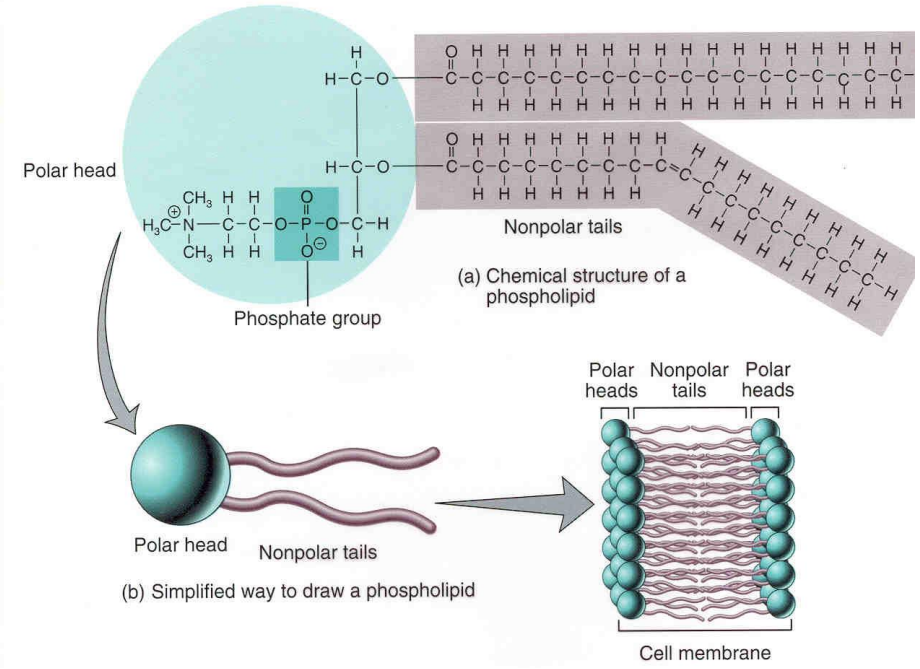
Phosphate Group, -PO_4



- Acts as an acid, because the oxygens lose H+ in solution.
- The dissociation leaves this group with a negative charge.
- This group is important in ATP and the transfer of energy between organic molecules.

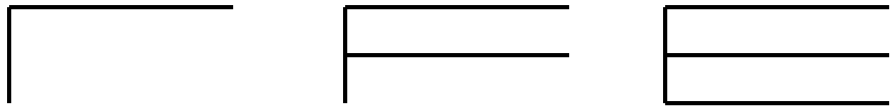
Glycerophospholipids
(Phospholipids)

- A phospholipid is a diglyceride that has a phosphate group esterfied to a glycerol backbone
- Phospholipids form an essential parts of a cell membrane and membrane bound vesicles within the cell
- The nature of the fatty acids contained in the phospholipids can greatly affect the chemical and physical properties

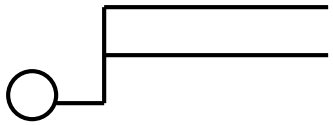


Shorthand for Mono, Di, and Triglycerides and Phospholipds

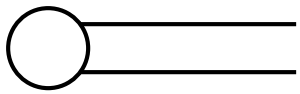
- Glycerides are often referred to as Neutral Fats
  - They can be written in shorthand as below



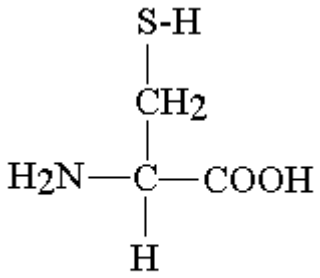
- Phospholipids are diglycerides with a polar phosphate containing group added
  - These can be written in shorthand as below



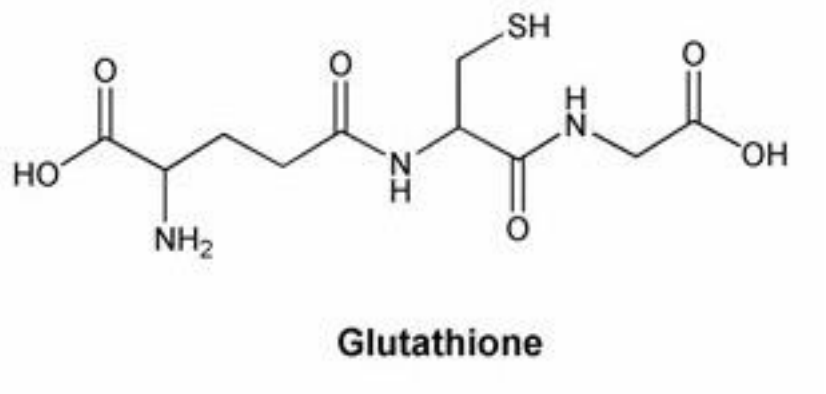
  - Or more commonly like this



Sulphydryl Group, -SH



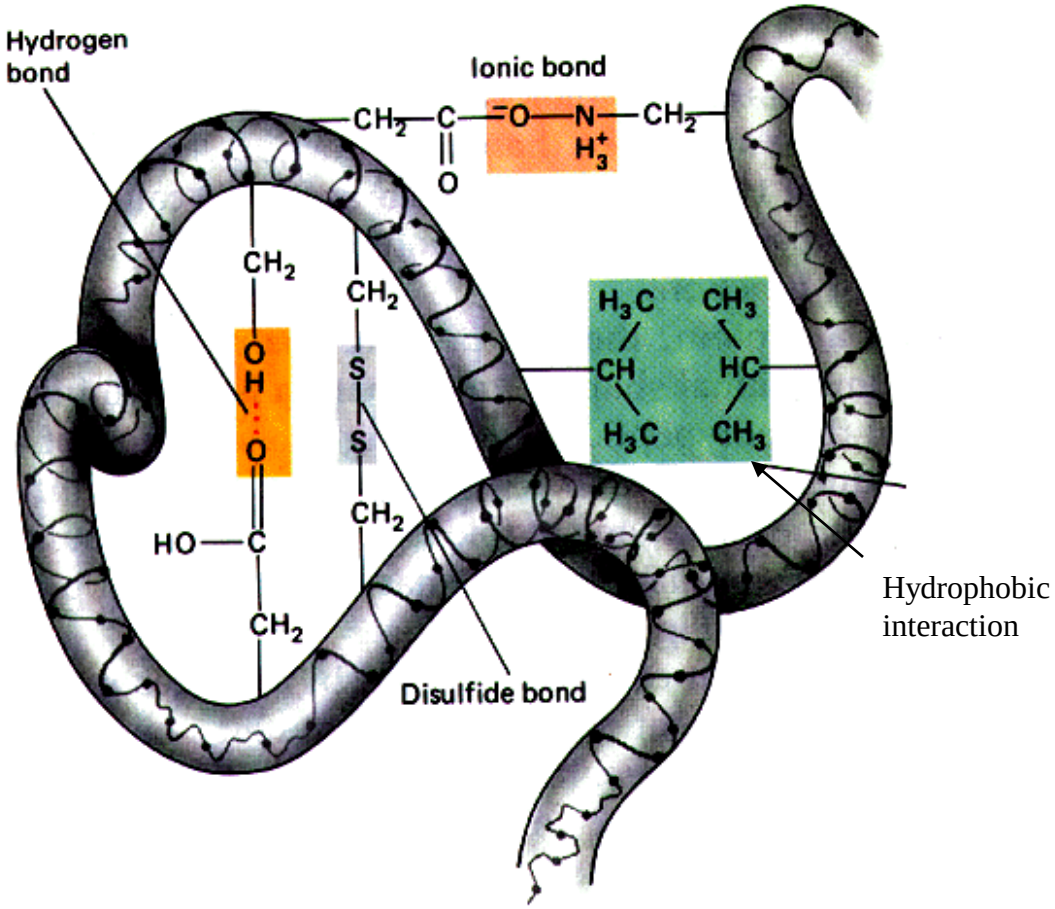
cysteine



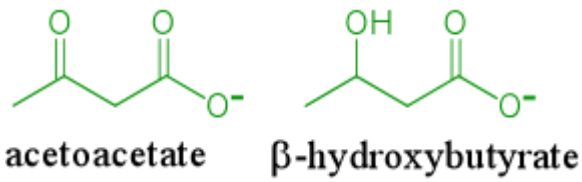
Glutathione

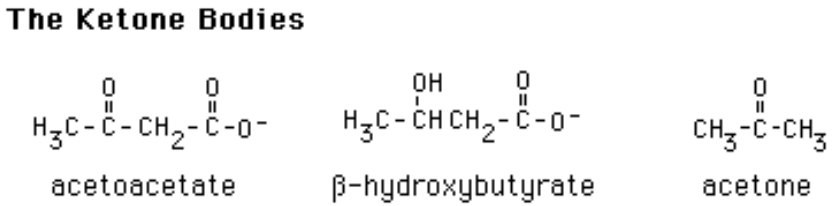
- Molecules called thiols are characteristic of this group.
- These groups interact to help stabilize the shape of proteins.
- In proteins, often two –SH become oxidized to form cross linked structures (S-S).

Protein


Hydrogen bond
Ionic bond
Disulfide bond
Hydrophobic interaction

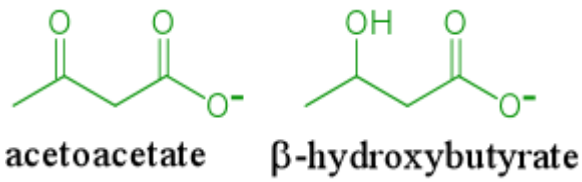
Nomenclature

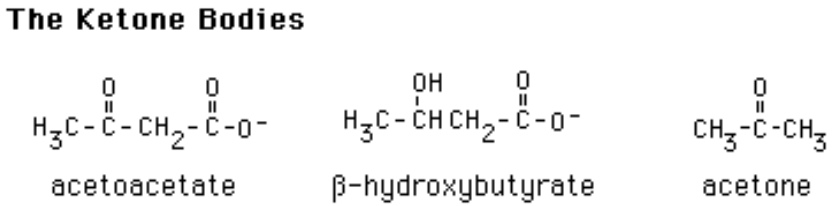




- Functional group names are often incorporated into the common name of a compound
  - –A ketone containing molecule might have a name that ends in –one
    - Ex) acetone
  - –A hydroxyl (alcohol or OH group) containing molecule might have a name that ends in –ol
    - Ex) ethanol

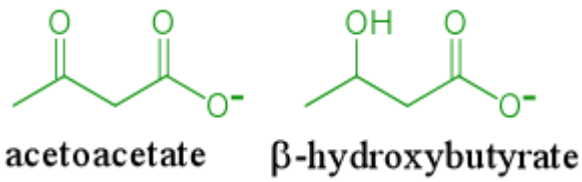
Nomenclature

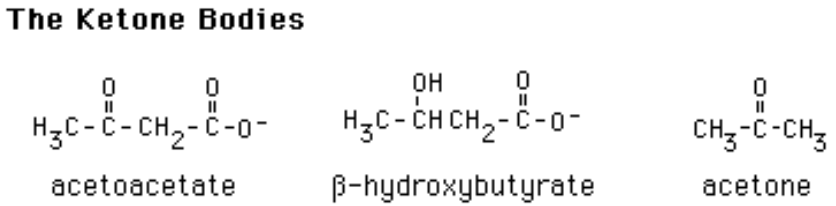




- Carbon numbering
  - Carbons in an organic molecule are numbered two ways
    - The first starts with carbon 1 which is the carbon in the most oxidized group.
    - The second involves the use of Greek letters starting with the carbon next to the most oxidized group.
    - You will not need to number these carbons, but I want you to understand the nomenclature.

Nomenclature





- Number of carbons
  - –Molecules or groups containing one, two, three, four, and five carbons plus hydrogen may contain in the name methyl-, ethyl, propionyl-, butyl-, and pentanyl respectively.
  - –If the carbon chain is branched, the prefix –iso is used. If the compound contains a double bond –ene is sometimes used .

Interactive Webpage

- http://media.pearsoncmg.com/bc/bc_campbell_biology_7/media/interactivemedia/activities/load.html?4&C

Some Simple Types of Organic Molecules and Their Functional Groups

- http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/O/Organics.html