Chem 191: Biochemistry
Lecture 8 – Lipids

I. Introduction

A. They are defined in terms of their physical properties instead of their structure
   1. Lipids are biological molecules that are insoluble in water, but are soluble in non-polar solvents.
   2. They are oily, greasy, waxy substances

B. Lipids are very energy rich, even richer than carbohydrates.
   1. This is because they are highly reduced molecules.

C. Some are used for energy storage (fats)
   1. They have a higher energy content than carbohydrates.

D. They are used to make biological membranes

II. Classification of Lipids

A. **Saponifiable** *versus* **Non-saponifiable** lipids
   1. Saponification is the base hydrolysis of ester bonds
   2. Saponifiable lipids include
      a. Triglycerides (fats)
      b. Waxes
      c. Phospholipids (membrane lipids)
      d. Sphingolipids (neuromembrane lipids)
   3. Non-saponifiable lipids include
      a. Steroids and prostaglandins

B. Another classification is **simple** *versus* **complex**
   1. Simple lipids contain just two types of components: fatty acids and alcohols.
   2. Complex lipids contain more than two types of components: other components in addition to the fatty acids and alcohols.

III. Fatty acids

A. Fatty acids are derived from saponifiable lipids

B. Structure
   1. Long, non-polar, hydrocarbon side chain plus polar head group
      a. The polar head group is a carboxylic acid.
         i. At physiological *pH* (≈7), the carboxylic acid is in its charge carboxylate form.

C. Micelles
   1. Salts of fatty acids are called soaps and form micelles in aqueous (water is solvent) solutions
      a. These spherical structures allow the charged head-groups to be in contact with water while at the same time removing the non-polar tails from contact with water.

Fig18.5 - Micelle Structure

D. Characteristics of common fatty acids:

1. Usually straight chain carboxylic acids with no branching.
2. Then length of the aliphatic chain is from between 10 and 20 carbons
3. They usually have and even number of carbon atoms.
4. Fatty acids can be saturated (alkanes) or unsaturated (alkenes); apart from doubles bonds and the carboxyl group, there are rarely any other functional groups present.

E. Unsaturated usually contain *cis* double bonds
   1. This causes them to have higher boiling and melting points

Fig18.6 - Saturated *vs* Unsaturated Fatty acids

      a. This is because the *cis* double bonds reduces the amount of surface area that the hydrocarbon tails contact one another, which in turn lowers the dispersion (vander Waals) interactions which are holding them together.

F. Longer chain lengths also increase the melting point.
   1. Again, this increases the surface area for contact.

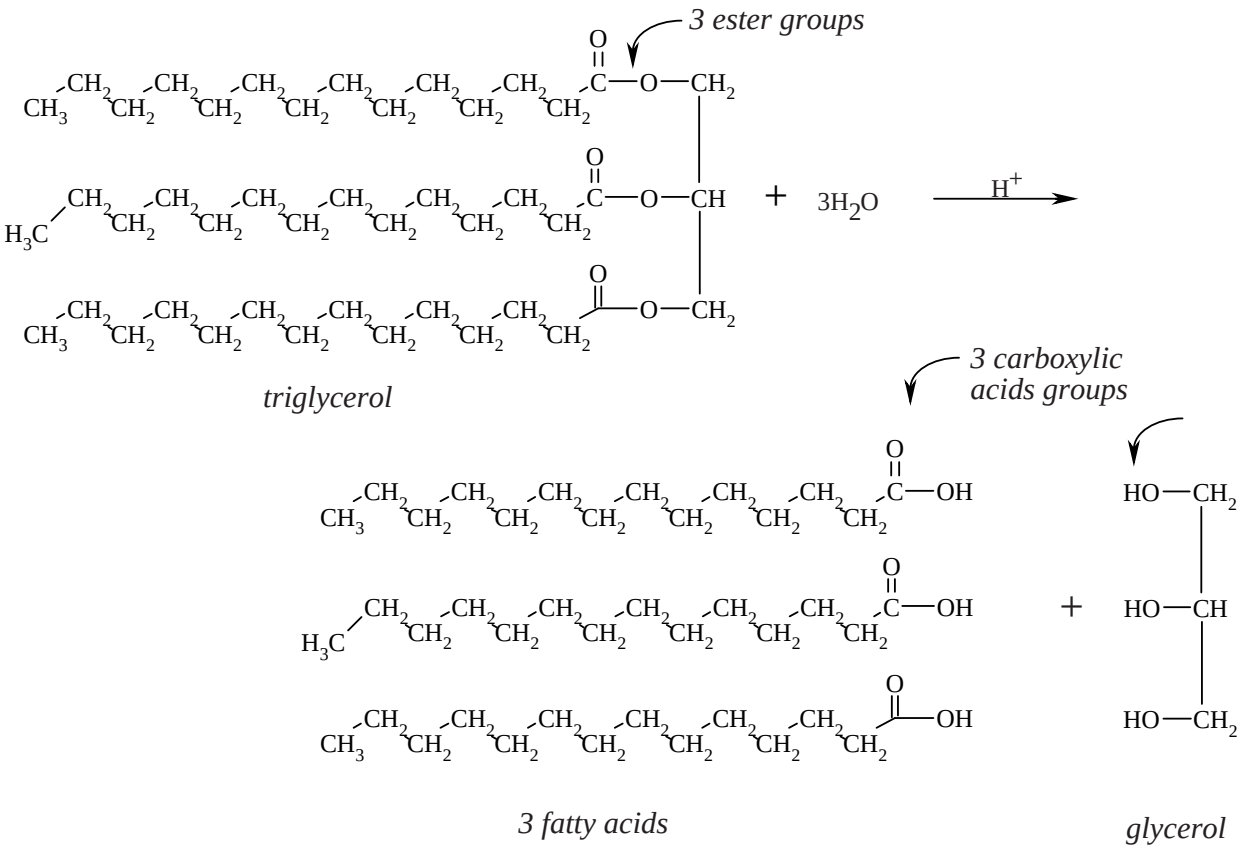
II. Structure of Fats and Oils

A. Chemically, fats and oils are very similar
   1. They both are composed of 1 glycerol molecule and three fatty acids
      a. The glycerol molecule contains three hydroxyl groups.
      b. Each hydroxyl group forms and ester with a fatty acid.
   2. Called triglycerides or triglycerols.

Fig 18.7 - Comparison of animal and plant fats/oils

III. Chemical properties of Fats and Oils

A. Hydrolysis
   1. Acid catalyzed hydrolysis of esters



2. Lipase catalyzed hydrolysis
    a. Lipases are enzymes that catalyze the hydrolysis of fatty acid esters in living cells

B. Saponification
1. Base hydrolysis and the formation of soaps
2. Saponification and be thought of as the combination of two reactions:
    a. Base catalyzed hydrolysis of the ester bond to produce and alcohol and a carboxylic acid.
    b. Subsequent titration of the carboxylic acid with the base to form the salt of the acid and water.

C. Hydrogenation
1. Commercially important (using Ni catalyst
2. Partial hydrogenation converts plant oils to semisolids

IV. Waxes

A. Esters formed with long-chain (30 C's for beeswax) primary alcohols
1. Protective coatings for plants and animals

V. Phosphoglycerides

A. Also called phospholipids
1. Alcohols used
    a. Choline

b. Ethanolamine
c. Serine

B. Lecithin is phosphotidylcholine
1. Used as an emulsifyer

C. Cephalins
1. Ehanolamine and Serine
2. Abundant in brain tissue

VI. Sphingolipids

A. Sphingomyelin uses choline
B. Glycolipids use d-galactoside
C. Inherited diseases
1. Tay-Sachs Glycolipid
2. Gaucher's Glycolipid
3. Niemann-Pick Sphingomyelins

VII. Biological Membranes

A. Cell Structure
1. Prokaryotes *vs* Eukaryotes

B. Membrane Structure
1. Mosaic model
2. Lipid bilayer

VIII. Steroids

A. Cholesterol
1. Sterol ring structure

B. Bile Salts
1. Contain cholesterol and sodium glycocholate
2. Gall Stones are precipitated cholesterol

IX. Steroid Hormones

1. Adrenocorticoid Hormones
a. glucocorticoids
b. mineral corticoids
2. Glucocorticoids
a. Cortisol
i. Increases glucose and glycogen levels
b. Synthetic coricoids include cortisone and prednisolone
i. Antiinmflamatory
3. Mineral corticoids
a. Aldosterone
i. Regulates Na^+ and Cl^- levels
1. And consequently the water balance

B. Sex Hormones
1. Testosterone
a. Methandostenolone

2. Estradiol
    a. Estrone
    b. Progesterone

X. Prostaglandins

A. Derived from arachidonic acid
    1. 5,8,11,14 Δ 20:4
B. Reguate menstruation
C. Prevent conception
D. Stimulate blood clotting
E. Lead to imflammation and fever
F. Aspiring inhibits prostaglandin synthesis