Lipid Chemistry

Definition

- Lipids are organic compounds containing C, H, O and are:
 - insoluble in water
 - but <u>soluble</u> in <u>fat solvents</u> (non polar solvents) as <u>alcohol, ether, benzene</u> <u>and chloroform</u>.

Definition (cont.,)

- The lipids are a heterogeneous group of compounds, including:
 - <u>fats, oils, steroids, waxes</u>, and related compounds, which are related more by their physical than by their chemical properties.

BIOMEDICAL IMPORTANCE

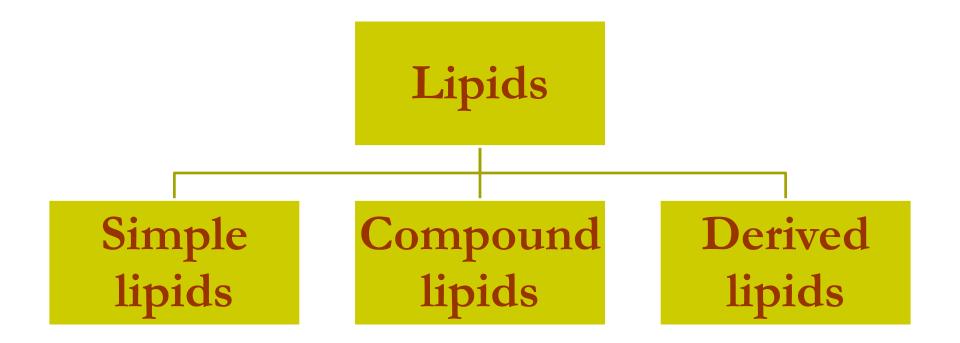
- They are important dietary constituents due to high energy value, fat-soluble vitamins and the essential fatty acids contained in the fat of natural foods.
- Fat is stored in adipose tissue, where it also serves as a <u>THERMAL INSULATOR</u> in the subcutaneous tissues and around certain organs.

BIOMEDICAL IMPORTANCE (cont.,)

 LIPOPROTEINS are important, occurring both in the <u>cell membrane</u> and in the <u>mitochondria</u>, and serving also as the means of transporting lipids in the blood.

BIOMEDICAL IMPORTANCE (cont.,)

- Lipid biochemistry is necessary in understanding many important biomedical areas, eg.,:
 - <u>obesity</u>,
 - diabetes mellitus,
 - <u>atherosclerosis</u>,
 - and the role of various polyunsaturated fatty acids in nutrition and health.



LIPIDS ARE CLASSIFIED AS SIMPLE OR COMPLEX

- Simple Lipids:
 - A- Triglycerides (Neutral fat): esters of fatty acids with glycerol.
 - B- Waxes: esters of fatty acids with <u>long chain</u> <u>alcohol</u> (higher than glycerol) higher molecular weight alcohols.

CH2OH

CHOH

ĊH₂OH

Glycerol

Glycerol: Trihydric alcohol =
 3 carbon atoms + 3 (OH) groups

FATTY ACIDS ARE ALIPHATIC CARBOXYLIC ACIDS

- Fatty acids are carboxylic acids with <u>hydrocarbon straight chains</u> ranging from 4 to 36 carbons long (<u>EVEN number</u>).
- They are two types:
 - SATURATED (no double bonds)
 - UNSATURATED (one or more double bonds).

Saturated Fatty acids (no double bonds)

Short chain FA -10 carbon atoms Liquid, volatile Long chain FA 12-24 carbon atoms Solid, non volatile

Short chain FA

(4-10 carbon atoms)

Liquid, volatile

Butyric acid* (4 C) CH3 - (CH2)2 - COOH

Caproic acid* (6 C) CH3 - (CH2)4 - COOH

* In certain fats in small amounts (especially butter). An end product of carbohydrate fermentation by rumen organisms

Caprylic acid (8 C) CH3 - (CH2)6 - COOH

• Capric acid (10 C) CH3 - (CH2)8 - COOH

Long chain FA (12-24 carbon atoms) <u>Solid, non volatile</u>

Palmitic acid* (16 C) CH3 - (CH2)14 – COOH

 Stearic acid* (18 C) CH3 - (CH2)16 - COOH
 * Common in human and all animal and plant fats

Essintial Fatty Acids

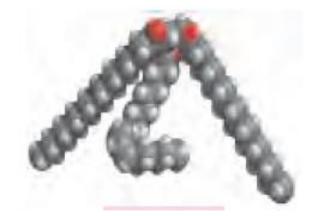
- Are fatty acids not synthesized in our bodies and should be supplied in diet.
- Linoleic acid, Linolenic acid and arachidonic acid are essential FA.
- Arachidonic acid is a precursor of important group of lipids known as prostglandins.

Neutral Fats

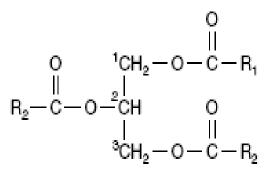
Triglycerides - Triacylglycerols

- Are Fatty Acid Esters of Glycerol
- Triacylglycerols are composed of three fatty acids each in ester linkage with a single glycerol









Lehninger, 4th ed., 2005, Ch 10

Physical properties of Triglycerides

- Insoluble in water
- Soluble in fat solvents
- Colorless, odorless, tasteless
- At room temperature (RT) they are:
 - Liquid oil (rich in unsaturated FA)
 - Solid fat (rich in saturated FA)



Triacylglycerols Provide Stored Energy and Insulation

- In vertebrates, specialized cells called adipocytes, or fat cells, store large amounts of triacylglycerols.
- They are also <u>stored as oils in the seeds of</u> <u>many types of plants.</u>





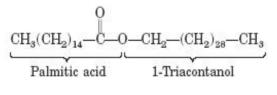
- Humans have fat tissue (composed primarily of adipocytes) under the skin, in the abdominal cavity, and in the mammary glands.
- In some animals, triacylglycerols stored under the skin serve not only as energy stores but as insulation against low temperatures.



Waxes

- They are esters of long-chain (C14 to C36) saturated and unsaturated fatty acids with long-chain (C16 to C30) alcohols.
- Their melting points (60 to 100 °C) are generally higher than those of triacylglycerols.
- They are more solid and not easily hydrolyzed.

Lehninger, 4th ed., 2005, Ch 10





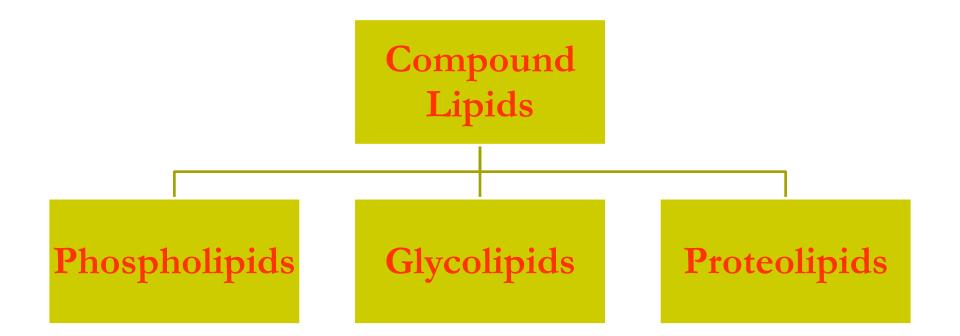


(b)

FIGURE 10-5 Biological wax. (a) Triacontanoylpalmitate, the major component of beeswax, is an ester of palmitic acid with the alcohol triacontanol. (b) A honeycomb, constructed of beeswax, is firm at 25 °C and completely impervious to water. The term "wax" originates in the Old English weax, meaning "the material of the honeycomb."

Compound Lipids

- It is more complicated than simple lipids as it contains:
 - FAs
 - alcohol
 - Prothetic group

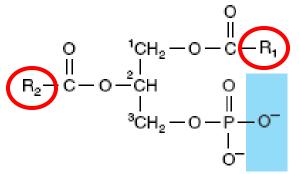


Phospholipids

- Are lipids (multiple compounds) containing:
 - FAs
 - alcohol
 - Phosphoric acid
 - Nitrogen containing bases

Phospholipids are the main lipid constituents of membranes

- Phospholipids may be regarded as derivatives of phosphatidic acid in which the phosphate is esterified with the -OH of a suitable alcohol.
 - Phosphatidic acid is the precursor of all phospholipids containing glycerol.
 - Hydrolysis = glycerol + Sat. FA
 + Unsat. FA + phosphoric acid

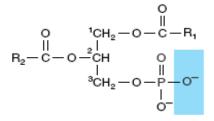


Phosphatidic acid

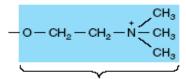
Lecithins

(Phosphatidylcholines Occur in Cell Membranes)

- Is present in large amounts in liver and brain.
- Represents a large proportion of the body's store of choline.
 - Choline is important in nervous transmission, as acetylcholine.
- Hydrolysis = glycerol + Sat. FA
 + Unsat. FA + phosphoric acid
 + choline base







Choline

Cobra venom is rich in lecithinase enzyme.

Lecithinaze removes unsaturated FA from lecithin converting it into lysolecithin which causes lyses of RBCs then death 🛞

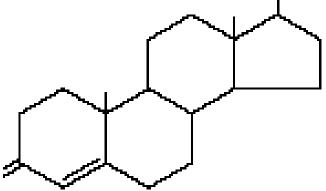




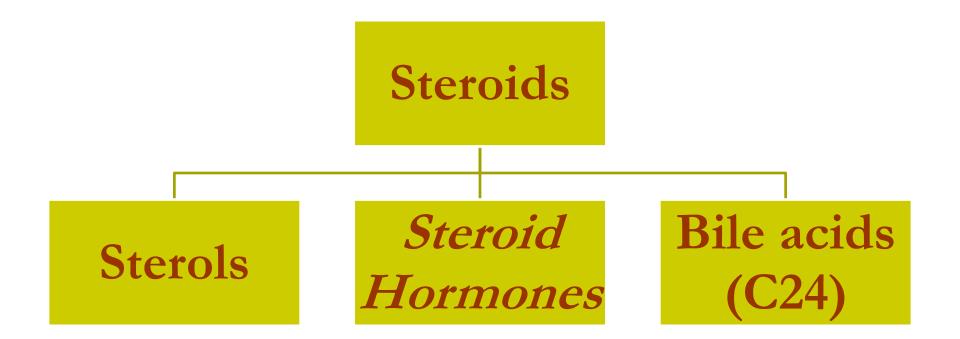


Derived Lipids Steroids

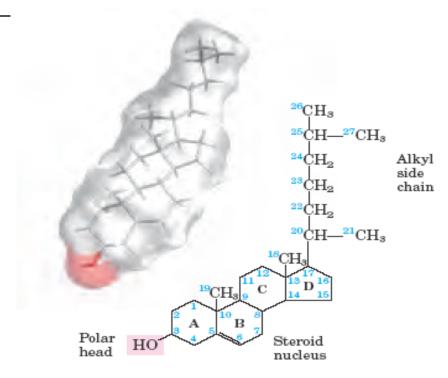
 They contain C17 steroid nucleus or Cyclo-Pentano-Perhydrophenanthrene ring (CPPP)

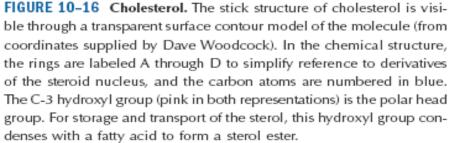


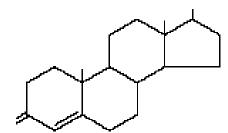
Classification of Steroids



Cholesterol







Lehninger, 4th ed., 2005, Ch 10

Importance of Cholesterol

- Formed from activated acetic acid (active acetate).
- It is the <u>PRECURSOR OF ALL</u> <u>STEROIDS</u> in animal body.
- Widely distributed in all tissues.
- Higher conc. present in nervous tissues, liver, adrenals, gonads, skin and adipose tissues.

Importance of Cholesterol (cont.,)

- Plasma conc. (100-200mg/dL)
 - (30% as free cholesterol and 70% as cholesteryl esters).
- Hypercholesterolemia → atherosclerosis

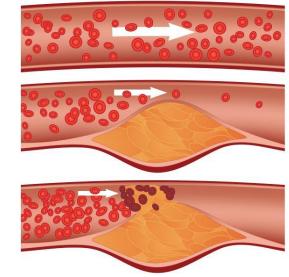


Image from: http://www.omnimedicalsearch.com/conditions-diseases/images/atherosclerosis-plaque1.jpg

Importance of Cholesterol (cont.,)

Excretion:

About 1 g of cholesterol is eliminated from the body per day.

- Bile in the form of bile salts: Cholesterol, cholesteryl esters and dihydrocholesterol.
- Large intestine: is reduced by bacteria to give coprostanol. (Lower intestine)

Importance of Cholesterol (cont.,)

- Cholesterol converted in the liver to
- 7-Dehydrocholesterol which converted to vitamin D3 <u>under skin</u> by the action of <u>UV</u> <u>rays.</u>

