Lipids

Lipids are a class of biological molecules defined by low solubility in water and high solubility in nonpolar solvents. As molecules that are largely hydrocarbon in nature, lipids represent highly reduced forms of carbon and, upon oxidation in metabolism, yield large amounts of energy. Lipids are thus the molecules of choice for metabolic energy storage.

$RCOOH + R'OH \longrightarrow RCOOR'$ Ester (neutral compound)

Classification

By structure:

1. Simple: fats, oils, waxes, steroids.

2. Complex: phospholipids, spingolipids, glygolipids.

3. They derivatives: hormones, fat-solubility vitamins.

On the basis of whether they undergo hydrolysis reactions in alkaline solution:

1. Saponifiable lipids can be hydrolyzed under alkaline conditions to yield salts of fatty acids
2. Nonsaponifiable lipids do not undergo hydrolysis reactions in alkaline solution.

   Biological functions

   • The most important role of lipids is as a fuel. Thus fat is the most concentrated form in which potential energy can be stored. • Since fat is a bad conductor of heat, it provides excellent insulation. • Fat may also provide padding to protect the internal organs. • Lipoproteins are constituents of cell walls. • One more important function of dietary lipids is that of supplying the so-called essential fatty acids.

Fatty acids

– are saponifiable lipid building blocks.

Fatty acids are naturally occurring carboxylic acids with an unbranched carbon chain and an even number of carbon atoms. The pathway by which

fatty acids are biosynthesized they almost always contain an even number of carbon atoms. Longchain fatty acids (12 to 26 carbon atoms) are found

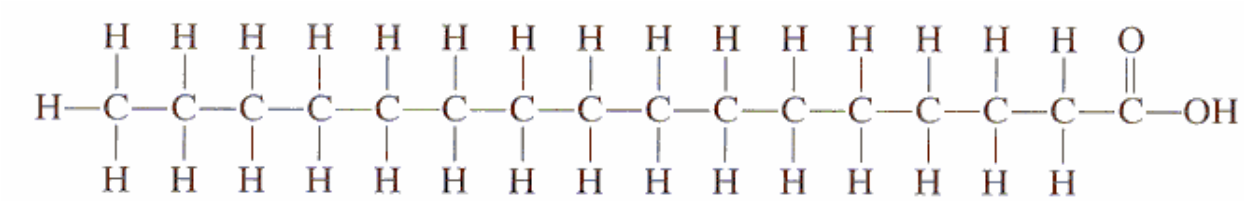
in meats and fish; medium-chain fatty acids (6 to 10 carbon atoms) and short-chain fatty acids (fewer than 6 carbon atoms) occur primarily in dairy products.

There are saturated and unsaturated Fatty acids.

Saturated fatty acid

• Fatty acid chains that contain only carbon-carbon single bonds are referred to as **saturated.**

• Palmitic acid:



Hexadecanoic acid (palmitic acid)

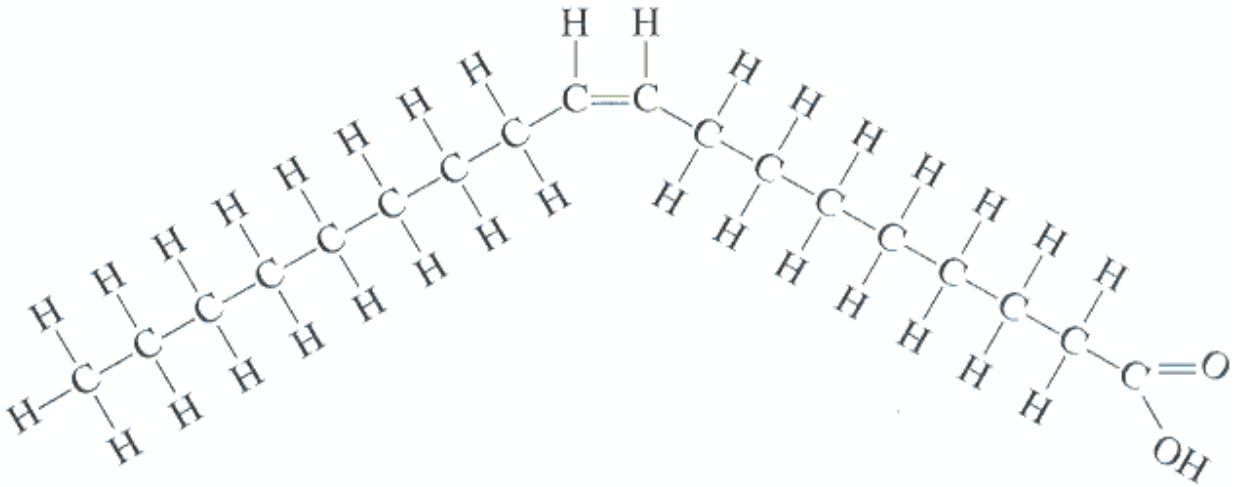


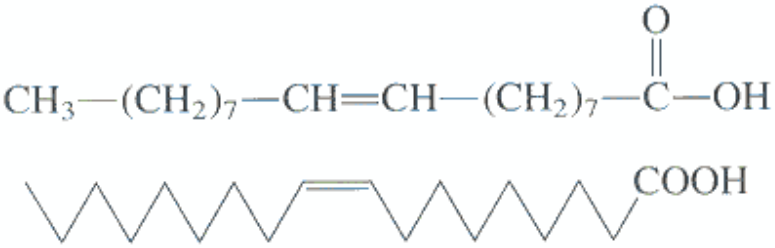
Unsaturated fatty acid

• Those molecules that contain one or more double bonds are said to be **unsaturated.**

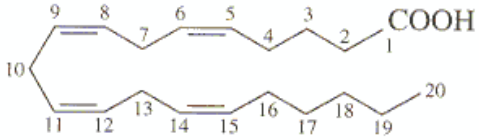
• There are mono- and polyunsaturated fatty acids.

Oleic acid:

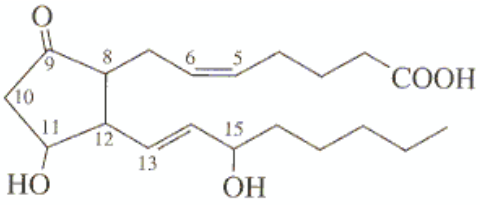




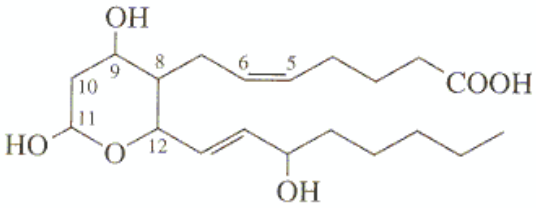
Prostaglandins are derivative of fatty polyunsaturated acids



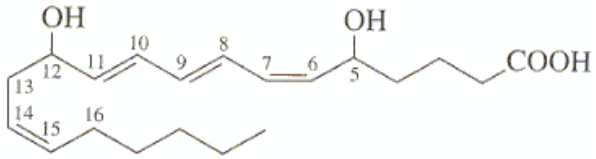
(a) Arachidonic acid



(b) Prostaglandin E_2



(c) Thromboxane B_2

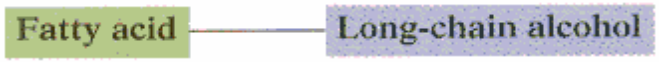


(d) Leukotriene B_4

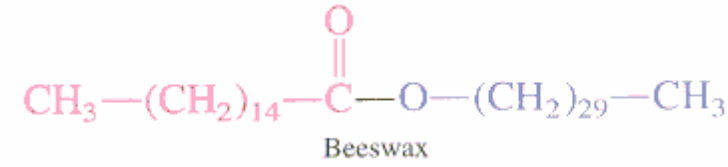
Waxes

A **wax** is a monoester formed from the reaction of a long-chain monohydroxy alcohol with a fatty acid molecule.

The block diagram



Example



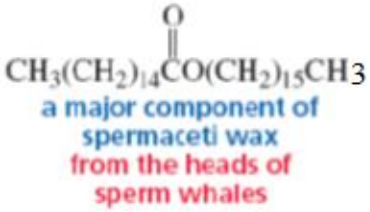
Biological role: They serve as protective coatings on leaves, stems, and fruit of plants and the skin and fur of animals.



Layers of honeycomb in a beehive

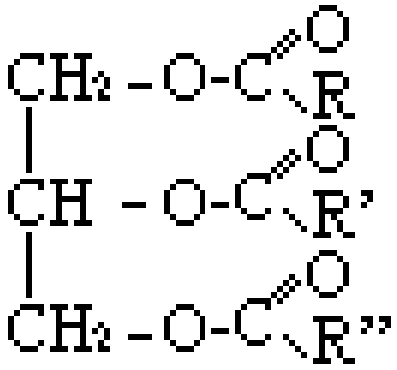




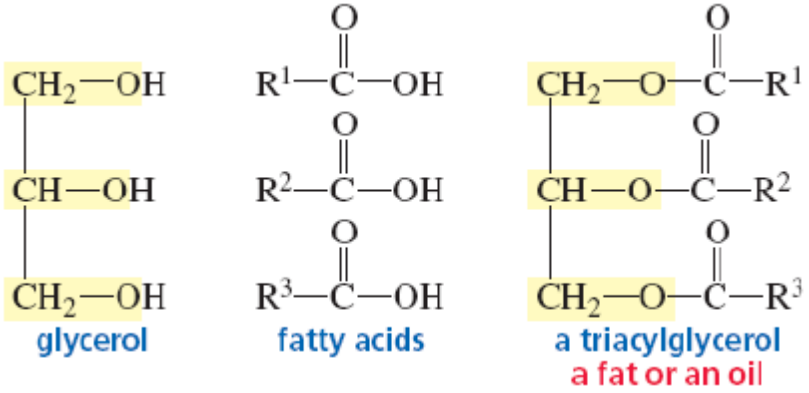


Oils and fats

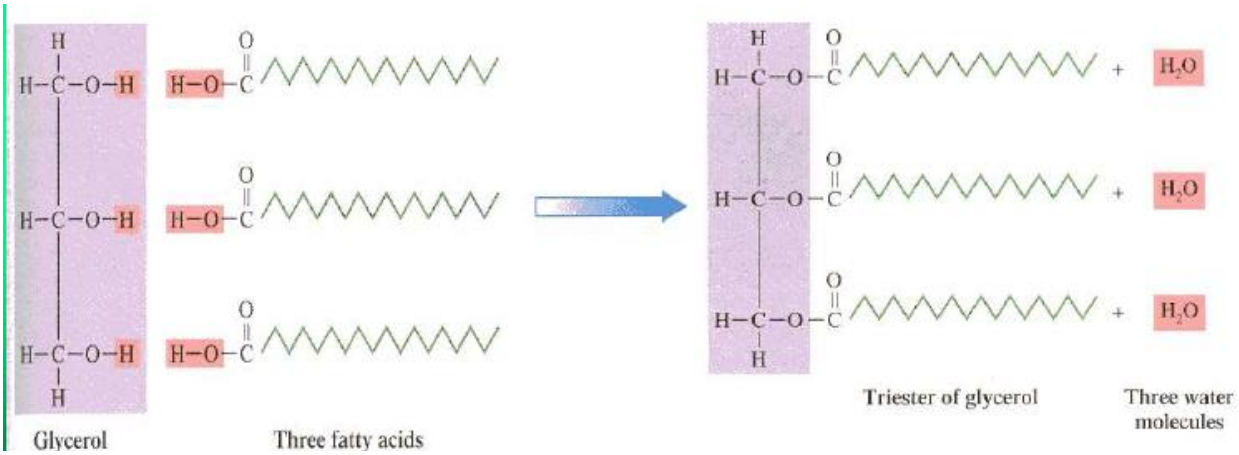
• Fatty acid esters of the trihydric alcohol – glycerol are called acylglycerol or glicerides; “neutral fat”.



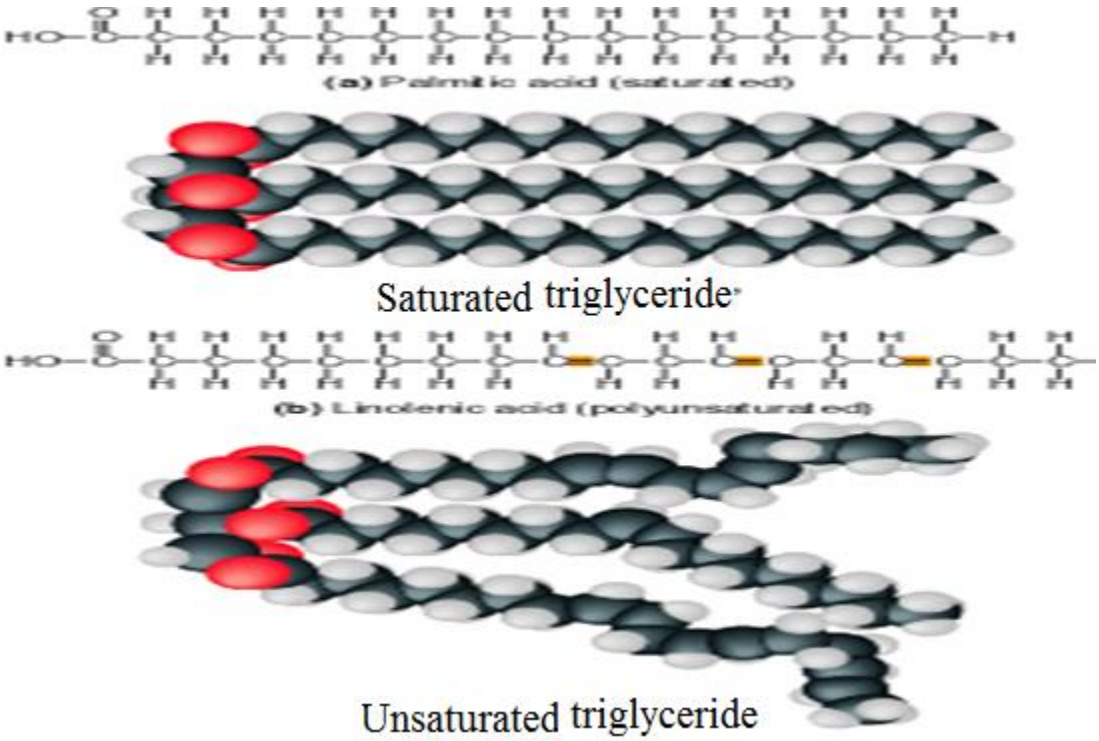
Reaction formation of triacylglicerols



Reaction formation of triacylglycerol.



Structure of thiacylglycerol



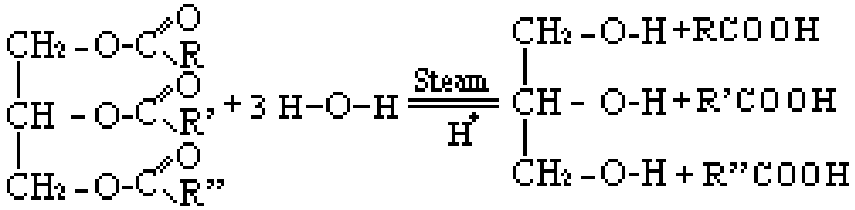
Characterization of fats

1. **Acid number:** It is the number of milligrams of potassium hydroxide required to neutralize the free fatty acids in 1g of the oil or fat.
2. **Saponification number:** it is number of milligrams of the oil or fat.
3. **Iodine number:** it is the number of grams of iodine that combine with 100 g of oil or fat. It is a measure of the degree of unsaturation of a fat or oil; a high iodine number indicates a high degree of unsaturation of the fatty acids of the fat.

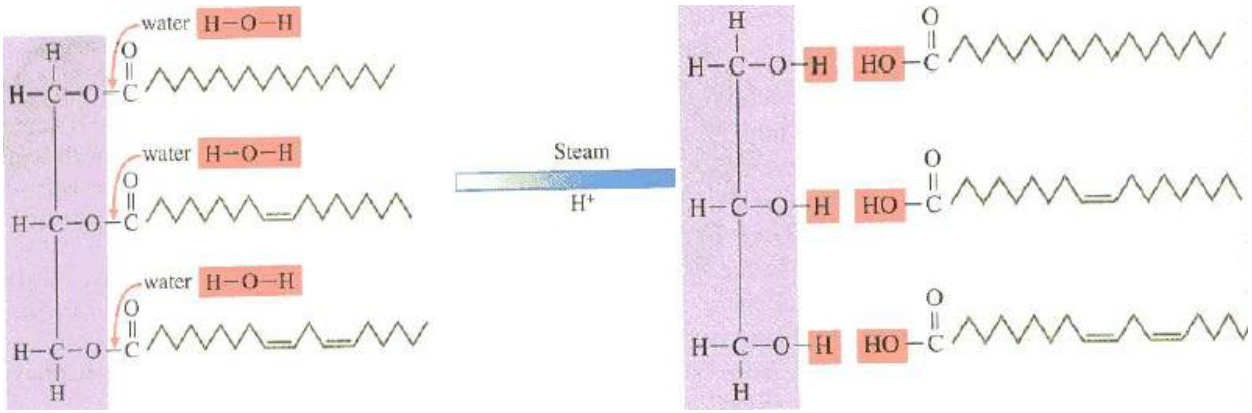
Chemical properties

• **Hydrolysis.** There is acetic, basic and enzyme's hydrolysis.

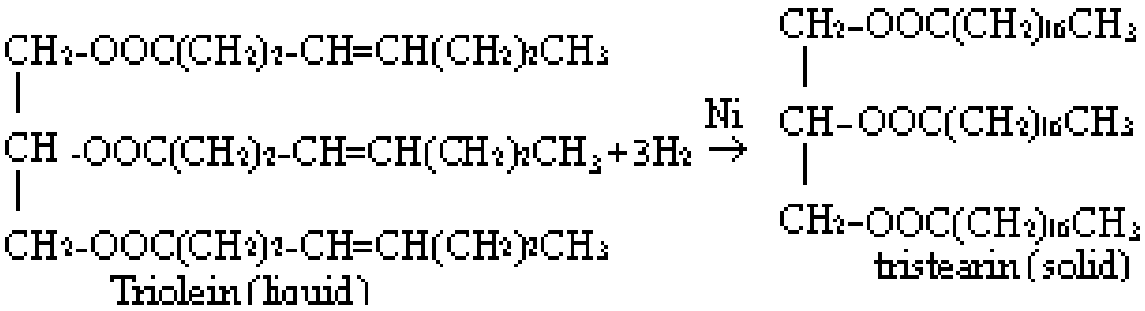
Acidic and enzyme:



Saponification –basic hydrolysis



Hydrogenation



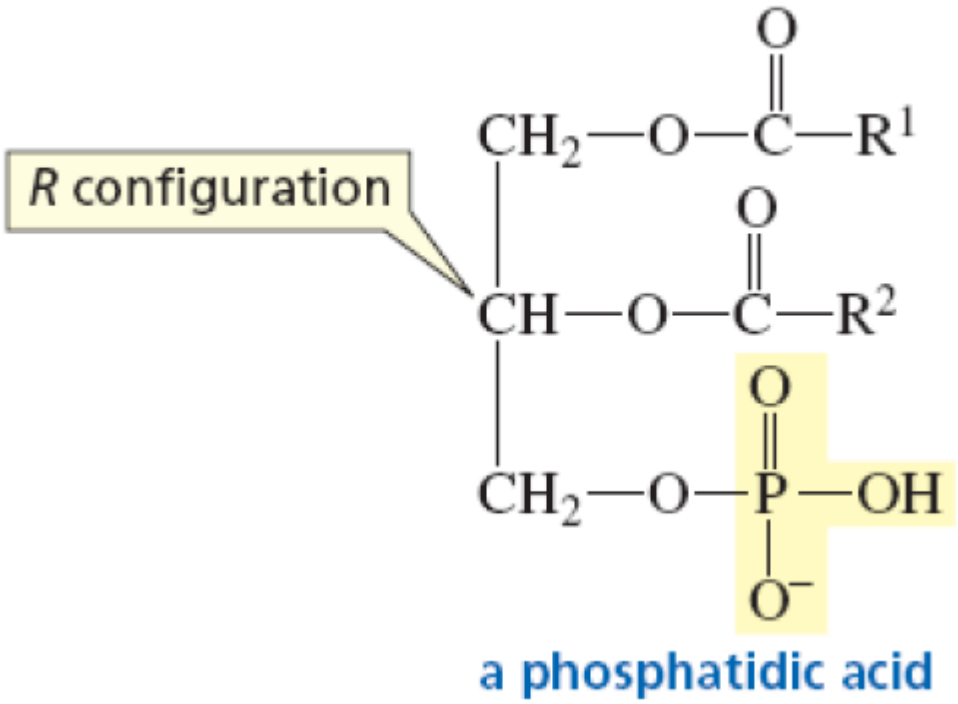
Phospholipides

• **Phosphoacylglycerols** are triesters of glycerol in which two -OH groups are esterified with fatty acids and one the third is esterified with phosphofic acid, which in turn is esterified to an alcohol.

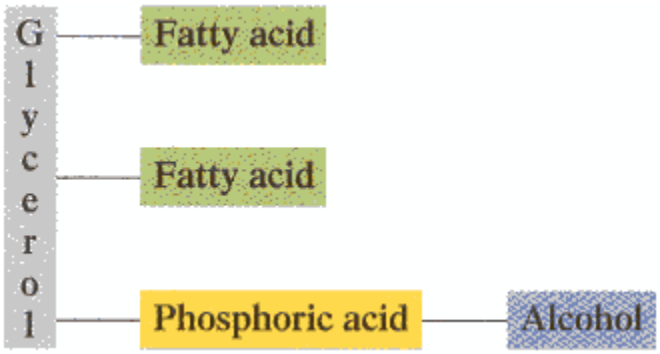
a)Phosphatidylethanolamines

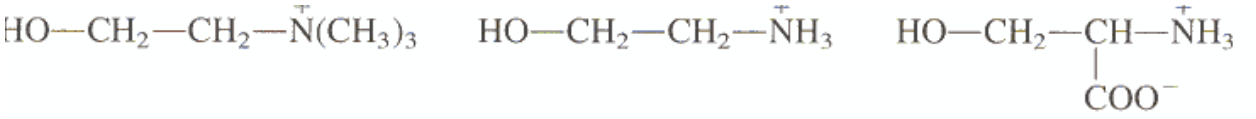
b)Phosphatidylcholines

c)Phosphatidylserines



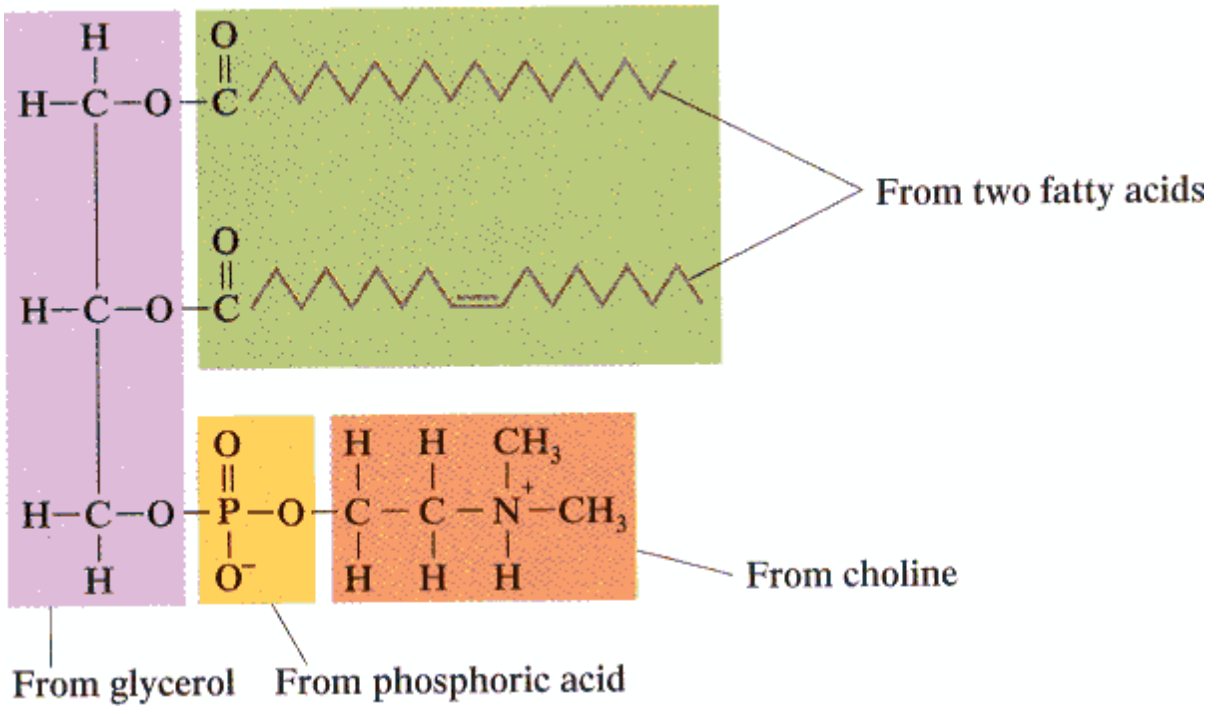
Phosphoacylglycerols



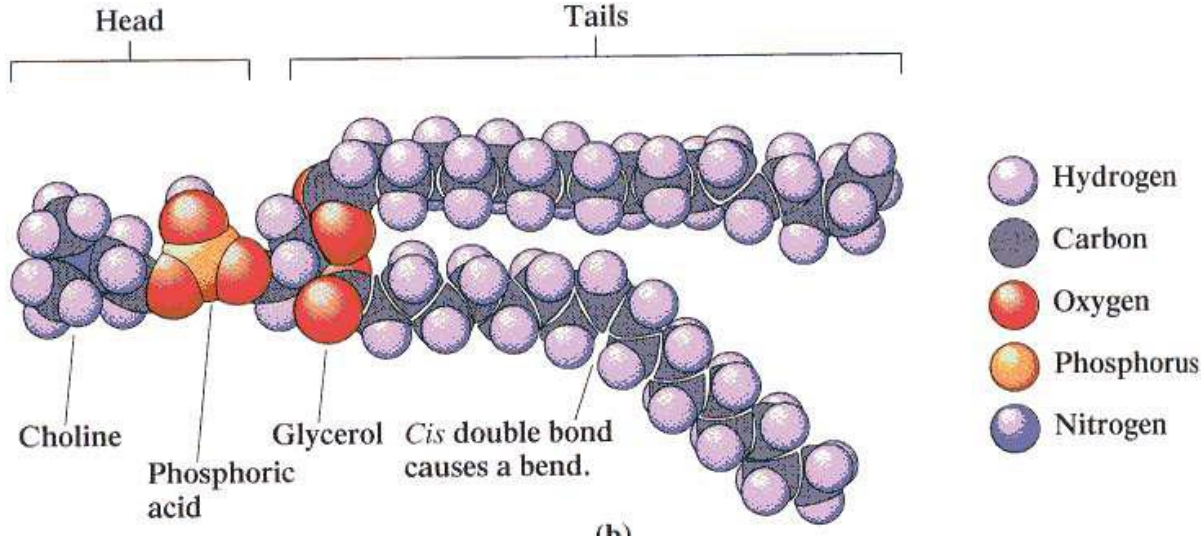


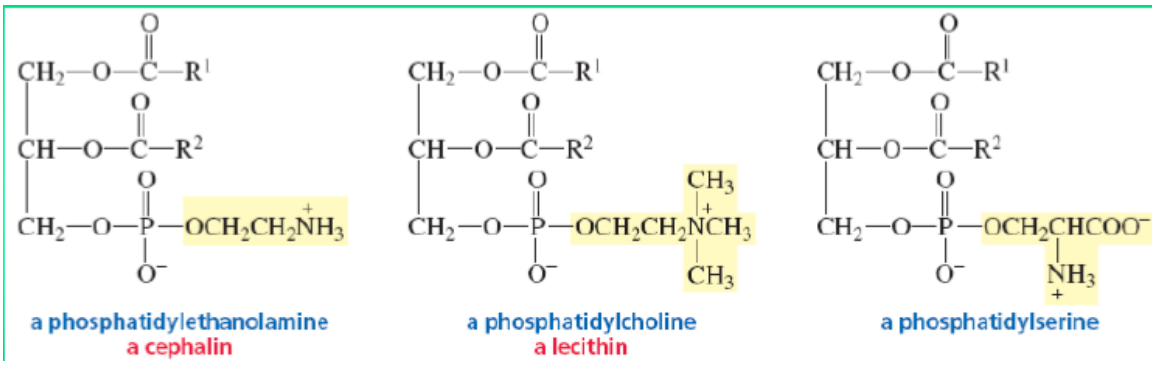
Choline Ethanolamine Serine

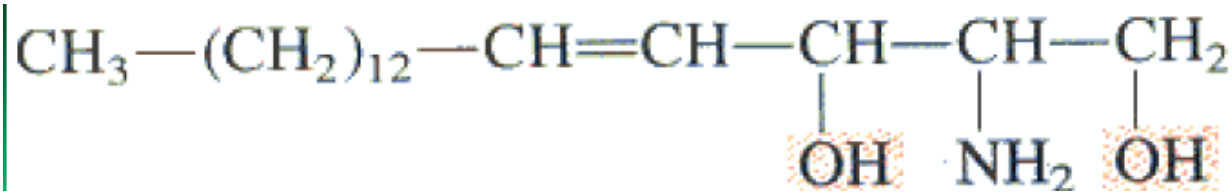
Phosphatylcholine



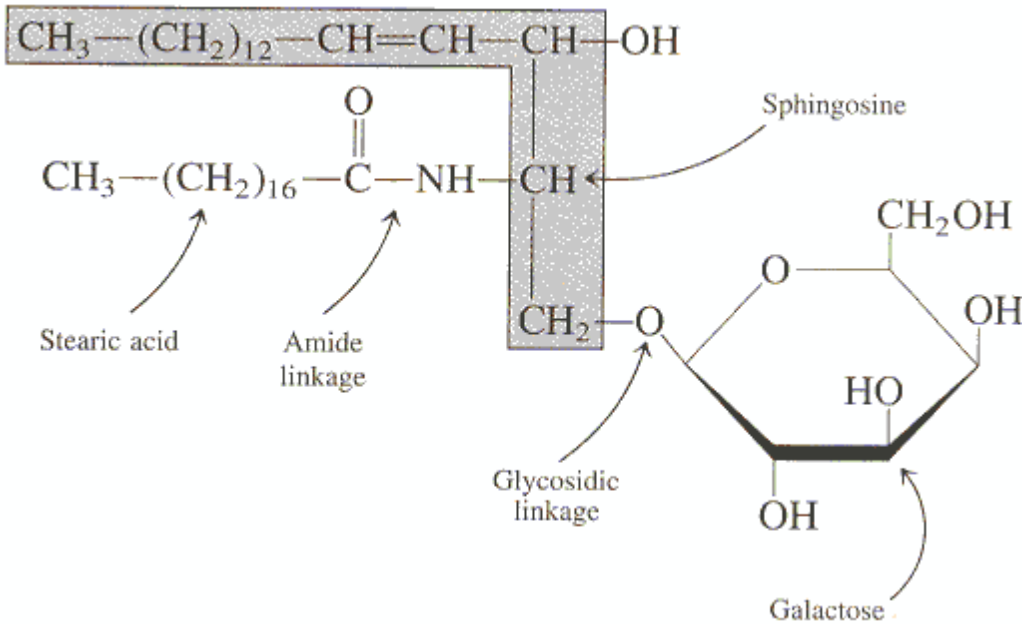
Phosphatylcholine, structure of moleculea




a phosphatidylethanolamine
a cephalin
a phosphatidylcholine
a lecithin
a phosphatidylserine

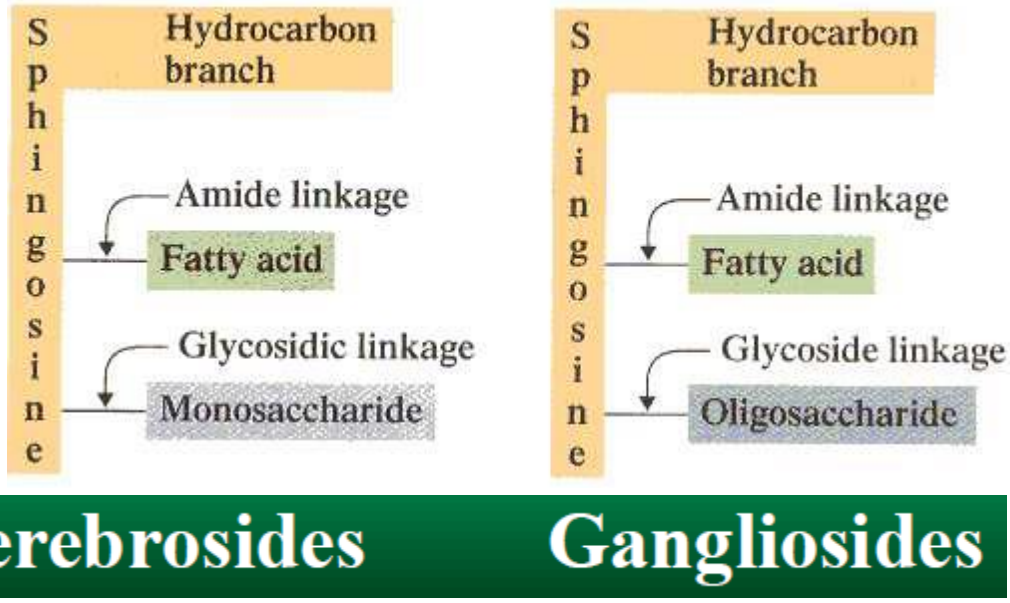


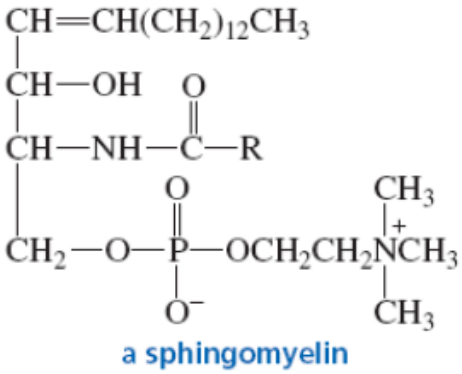
Glycolipid

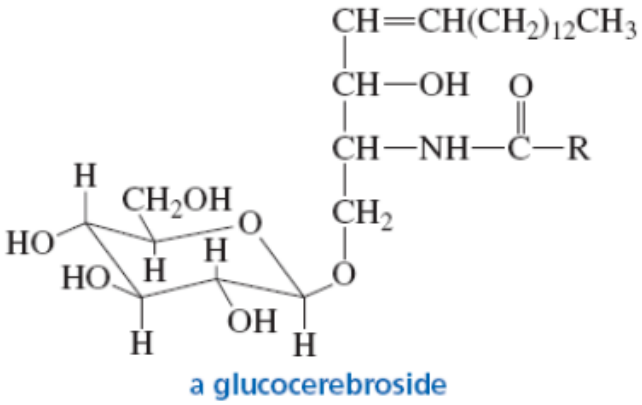

Sphingosine
Stearic acid
Amide linkage
Glycosidic linkage
Galactose

Cerebrosides, the simplest of such carbohydratecontaining lipids, usually have a glucose or galactose as the carbohydrate unit.

•**Gangliosides** contain more complex carbohydrate heads; up to seven monosaccharide units are present.







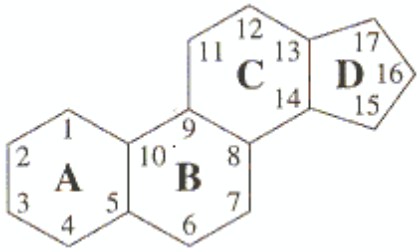
Nonsaponifiable Lipids

• **Lipids** do not undergo hydrolysis in alkaline solution.

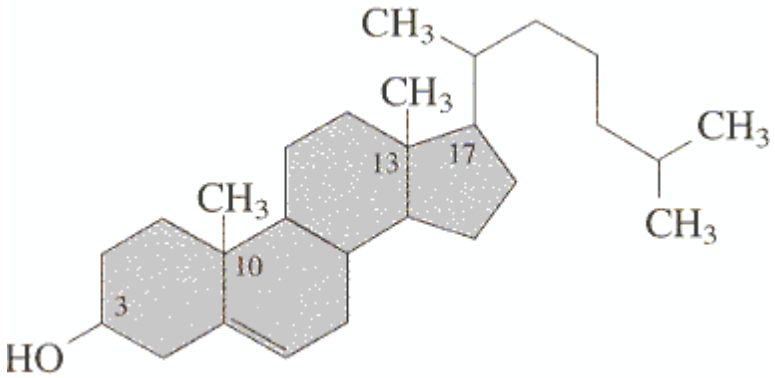
• **Nonsaponifiable** Lipids: steroids, eicosanoids, terpenes, pheromones, fat-soluble vitamins

• A **steroid** is a lipid whose structure is based on the tetracyclic (four-ring) system shown in the following examples. Three of the rings are sixmembered, while the fourth is five-membered. Steroids have many diverse roles throughout both the plant and animal kingdoms.

Pentahydrofenantrene (sterane)



Cholesterol: is the most abundant steroid in the human body.

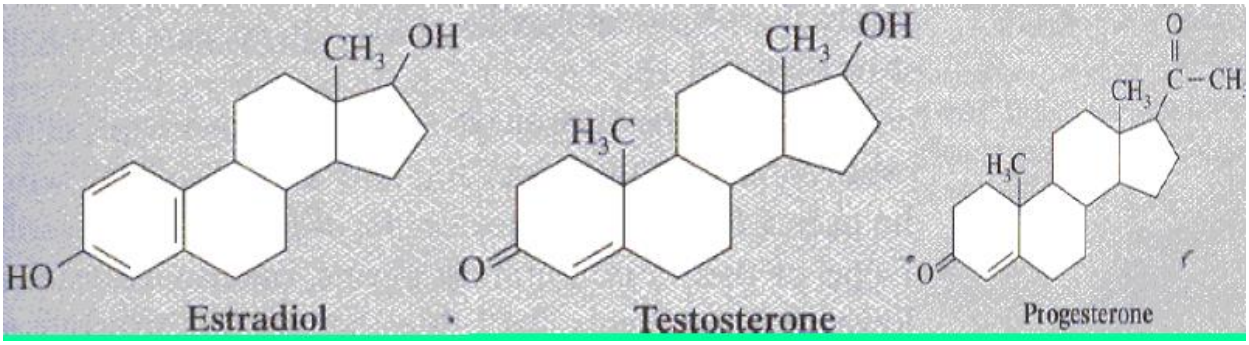


Cholesterol, an unsaturated alcohol whose structure is the most abundant animal steroid. It has been estimated that a 60 kg person has a total of about 175 g of cholesterol distributed throughout the body. Much of this cholesterol is bonded through ester links to fatty acids, but some is found as the free alcohol. Gallstones, for example, are nearly purecholesterol.

• Cholesterol serves two important functions in the body. First, it is a minor component of cell membranes, where it helps to keep the

membranes fluid. Second, it serves as the body's starting material for the synthesis of all other steroids, including the sex hormones.

Steroids hormones.



Hormones are chemical messengers produced by ductless glands.