Lipids

Introduction:

Lipids are a class of hydrocarbon-containing organic compounds. Lipids are soluble in nonpolar solvents (such as ether and chloroform) and are relatively insoluble in water.

Functions of lipids:

1- Lipids are a good source of energy for the body (9kcal/gm).

2- Lipids are major structural components of membranes, e.g., phospholipids, glycolipids and sterols.

3- Cholesterol, a sterol, is a precursor of many steroid hormones and is also an important component of plasma membrane.

4- Lipid helps in absorption of fat soluble vitamins

(A,D,E and K), it acts as a solvent for the transport of fat soluble vitamins.

5- Bile acids derived from cholesterol act as an emulsifying agent and help the digestion and absorption of lipids.

- **Classification of lipids:**

Lipids can be classified into:

1- Simple lipids.

a2- Compound lipids.

3- Derived lipids.

1-Simple lipids:

These are esters of fatty acids (F.A) with different alcohols.Simple lipids are classified into two types, depending on the type of alcohols:

A- Neutral lipids.

B- Waxes.

A-Neutral lipids:

Neutral lipids:

Esters of fatty acid with glycerol are called (glyceride).

Condensation

Glycerol + 3fatty acids ----------→ triglyceride (fat) + water

Glycerol:-

Is a simple polyol compound,it has three hydroxyl groups. The glycerol backbone is central to all lipids known as triglycerides , glycrophospholipids & glycroglycolipids.

- **Fatty acids:-**

Fatty acids are long chain mono carboxylic acid. Fatty acids have hydrophilic (COOH) and hydrophobic (hydrocarbon chain) groups in the structure. Fatty acids serve as a major fuel for most cells and they are precursors of all other classes of lipid.

- Individual fatty acids can range in length from **4 to 22** carbons,

-Fatty acids may be **saturated,** which means that each carbon has a single bond to another carbon and 2 hydrogen atoms.

Table 7.1. Major Saturated fatty acids and their sources

S. No.	Name of fatty acids	Structure	Source
1.	Butyric acid	$CH_3(CH_2)_2COOH$	Butter
2.	Caproic acid	$CH_3(CH_2)_4COOH$	Butter, palm oil, coconut oil
3.	Caprylic acid	$CH_3(CH_2)_6COOH$	Palm oil, coconut oil
4.	Capric acid	$CH_3(CH_2)_8COOH$	Palm oil, coconut oil
5.	Lauric acid	$CH_3(CH_2)_{10}COOH$	Plants of lauraceae, coconut oil, palm oil.
6.	Myristic acid	$CH_3(CH_2)_{12}COOH$	Seed fats of mace, butter, coconut oil
7.	Palmitic acid	$CH_3(CH_2)_{14}COOH$	Plant fats, palm oil, peanut oil.
8.	Stearic acid	$CH_3(CH_2)_{16}COOH$	Plant and animal fats
9.	Arachidic acid	$CH_3(CH_2)_{18}COOH$	Peanut oil
10.	Behenic acid	$CH_3(CH_2)_{20}COOH$	Plant lipids
11.	Lignoceric acid	$CH_3(CH_2)_{22}COOH$	Plant lipids
12.	Cerotic acid	$CH_3(CH_2)_{24}COOH$	Beewax, wool

-fatty acids may be **unsaturated,** which means that a carbon has two bonds to the adjacent carbon, called a double bond, and a single bond to another carbon and a hydrogen atom.

-A monounsaturated fat has **1 double bond.**

- A polyunsaturated fat has **2 or more double bonds** in the carbon chain.

Unsaturated Fatty Acids

Common Name	Systematic Name	Formula	Common source
	A. Monoethenoic Acids		
Oleic	Cis 9-octadecenoic	$C_{17}H_{33}COOH$	plant and animal fats
Elaidic	Trans 9-Octadecenoic	$C_{17}H_{33}COOH$	animal fats
	B. Diethenoic Acids		
Linoleic	9,12-Octadecadienoic	$C_{17}H_{31}COOH$	peanut, linseed, and cottonseed oils
	C. Triethenoid Acids		
Linolenic	9,12,15-Octadecatrienoic	$C_{17}H_{29}COOH$	linseed and other seed oils
Eleostearic	9,11,13-Octadecatrienoic	$C_{17}H_{29}COOH$	peanut seed fats
	D. Tetraethenoid Acids		
Moroctic	4,8,12,15-Octadecatetraenoic	$C_{17}H_{27}COOH$	fish oils
Arachidonic	5,8,11,14 Eicosatetraenoic	$C_{19}H_{31}COOH$	traces in animal fats

The melting point and hardness of the fatty acid is affected by:

- The length of the carbon chain.
- The degree of unsaturation.
- As chain length increases, melting point increases. As the degree of
- unsaturation increases, the melting point decreases.

- **Glycerides:-**

There are three general acylglycerols occur,

1- **Monoglyceride:-** consist of **one**, **fatty acid** esterified to glycerol.

2- **Diglyceride:-** consist of, **two**, **fatty acids** esterified to glycerol.

Monoglyceride and diglyceride are metabolic intermediates; they are normally present in small amounts.

3-Triglycerides

Depending on their fatty acid compositions, **Triglyceride** mixtures are referred to as **fats** or **oils**.

Fats:-

which are **solid** at room temperature, contain a large proportion of **saturated fatty acids**.

- **Oils:-**are **liquid** at room temperature; contain a large proportion of **unsaturated fatty .**

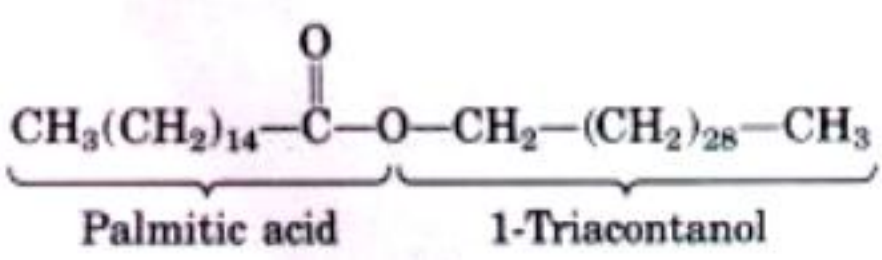
Waxes:

Waxes are esters of **long-chain fatty acid** (having 16 to 36 carbon atoms) **and a long chain monohydroxy alcohols** (having 16 to 30 carbon atoms). Their melting points (60 to 100 °C) are generally higher than those of triglycerides. Waxes are solid at room temperature, owing to their molecular weight.

Waxes also serve a range of other functions in nature, related to their properties and their firm consistency. Water repellent ,the shiny leaves of holly, poison ivy, and many tropical plants are coated with a layer of waxes, which protects against parasites and prevents excessive evaporation of water.

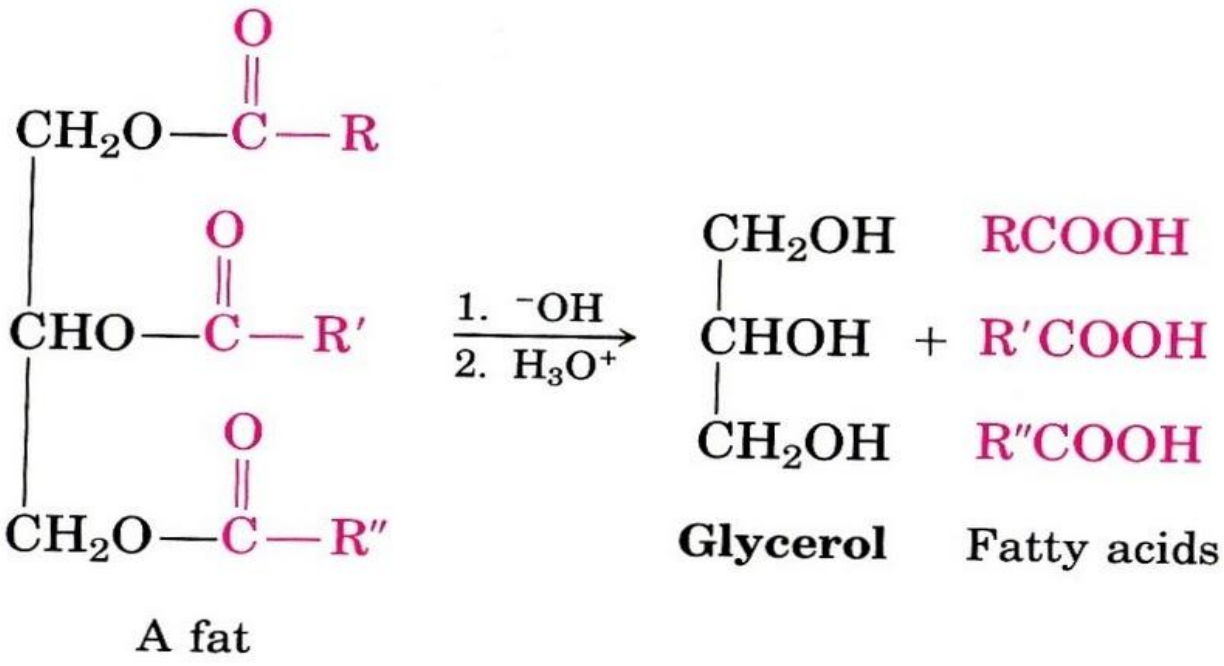
Beeswax, carnauba wax (from a Brazilian palm tree), are widely used in the manufacture of lotions, ointments, and polishes.

Example: Myricylpalmitate (Bees wax): It is an ester of **palmitic acid** with the alcohol **Myricyl .**



Hydrolysis of triacylglycerol:

Ester bonds of triacylglycerols can be hydrolyzed by acid, base, or lipase enzyme to obtain fatty acids and glycerol.



A fat

2. Compound Lipids:-

These are esters of fatty acid with alcohol containing additional (prosthetic) groups. These are sub classified according to the type of prosthetic group present in the lipid:

1- Phospholipids

2- Glycolipids

3- Lipoproteins

1-Phospholipids:

Lipids contain fatty acids, alcohol, and phosphoric acid residue as additional groups. They often have nitrogen containing base and other substituent's.

Phospholipids may be classified on the basis of the type of alcohol present in them as:

a- Glycerophospholipids.

b- Sphingophospholipids.

A- Glycerophospholipids:

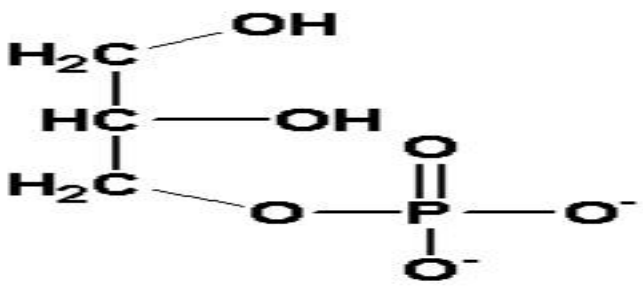
Glycerophospholipids, also called phosphoglycerides , are lipids in which two fatty acids are attached in ester linkage to the first and second carbons of glycerol, and a highly polar or charged group is attached through a phosphodiester linkage to the third carbon.

Glycerophospholipids are the most abundant phospholipid molecules found in cell membranes.

The simplest glycerophospholipid, phosphatidic acid, is the precursor for all other glycerophospholipid. Phosphatidic acid is composed of glycerol-3-phosphate that is esterified with two molecules of fatty acids at C-1 and C-2.

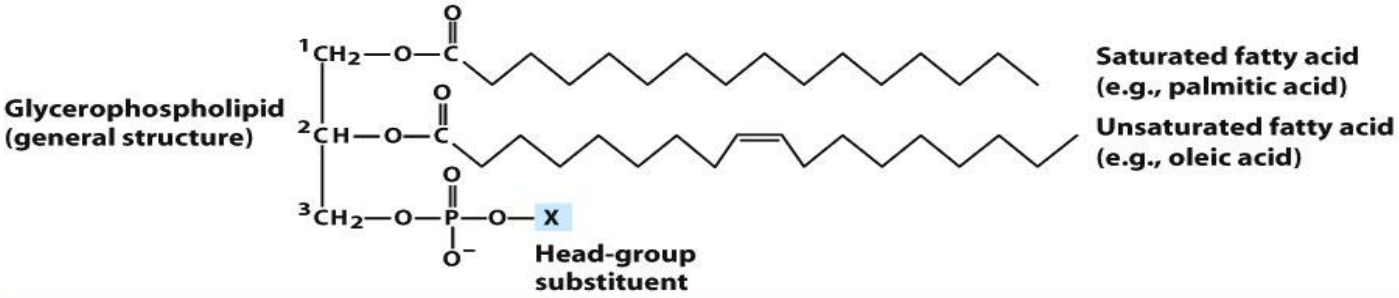
Glycerophospholipid are classified according to which alcohol becomes esterifies to the phosphate group.

Glycerolphospholipids contain both a polar and non polar end and therefore are amphipathic.



Glycerol-3-phosphate (Gly3P)

Examples on glycerophospholipids:



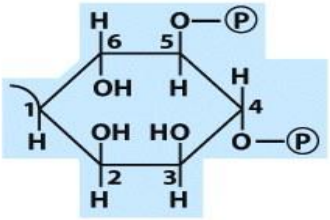
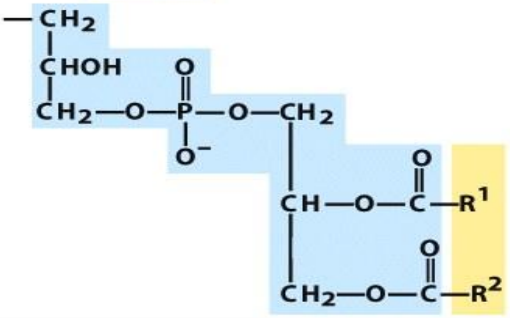
Name of glycerophospholipid	Name of X	Formula of X	Net charge (at pH 7)
Phosphatidic acid	—	—H	−1
Phosphatidylethanolamine	Ethanolamine	$-CH_2-CH_2-\overset{+}{N}H_3$	0
Phosphatidylcholine	Choline	$-CH_2-CH_2-\overset{+}{N}(CH_3)_3$	0
Phosphatidylserine	Serine	$-CH_2-\underset{COO^-}{CH}-\overset{+}{N}H_3$	−1
Phosphatidylglycerol	Glycerol	$-CH_2-\underset{OH}{CH}-CH_2-OH$	−1
Phosphatidylinositol 4,5-bisphosphate	*myo*-Inositol 4,5-bisphosphate		−4
Cardiolipin	Phosphatidyl-glycerol		−2

Figure 10-9
Lehninger Principles of Biochemistry, Fifth Edition

Phosphotidyl cholin (Lecithin):

These are glycerophospholipids containing glycerol, fatty acids,cholin. These are most abundant phospholipids of the cell membrane having both structural and metabolic functions. They occur in the liver, brain and in plasma as part of the lipoproteins. Lecithin contains both a polar head and non polar tails therefore are amphipathic.

Phosphatidyl ethanol amine (Cephalin):

Cephalin differs from lecithin in that the nitrogen base ethanol amine is present instead of cholin. Cephalin is also found in bio membranes and possesses amphipathic properties.

Phosphatidyl inositol:

The phosphatidic acid is esterified to inositol at C-3. Phosphatidyl inositol bisphosphate (PIP_2) is present in cell membranes. This compound plays a vital role in the medication of hormone action on cell membranes.

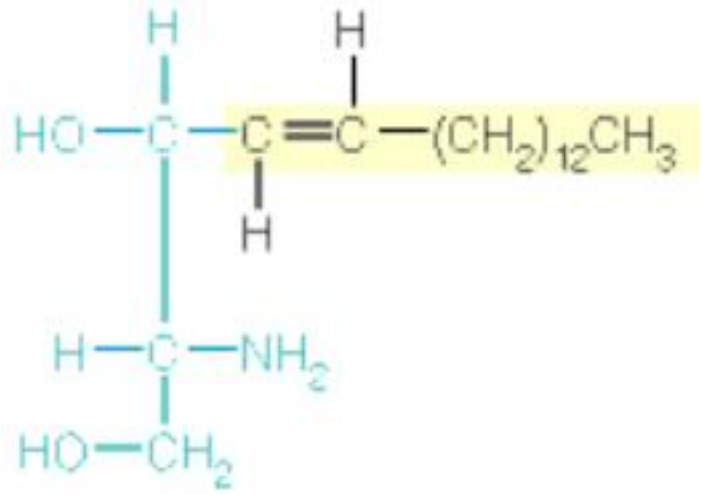
Phosphatidyl Serine:

The phosphatidic acid is esterified to serin at C-3.

b- Sphingophospholipids:

Phospholipids derived from alcohol sphingosine instead of glycerol are called sphingophospholipids.

Sphingophospholipids are amphipathic, having a polar head group and non polar fatty acid tails, and are structural components of cell membrane.

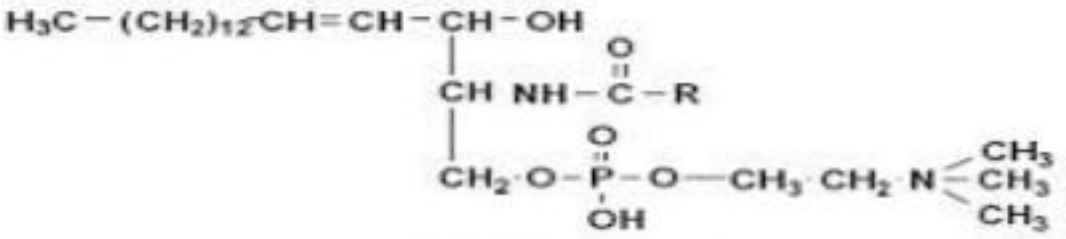


Sphingosine = D-4-sphinganine

Sphingomyelins:

Sphingomyelins are phospholipids which contain sphingosine , one molecule of fatty acid, phosphoric acid and cholin.

Sphingo myelin is found in most animal cell membranes. They are found in abundance in the myelin sheath that surrounds and insulates cells of the central nervous system.



Sphingomyelin

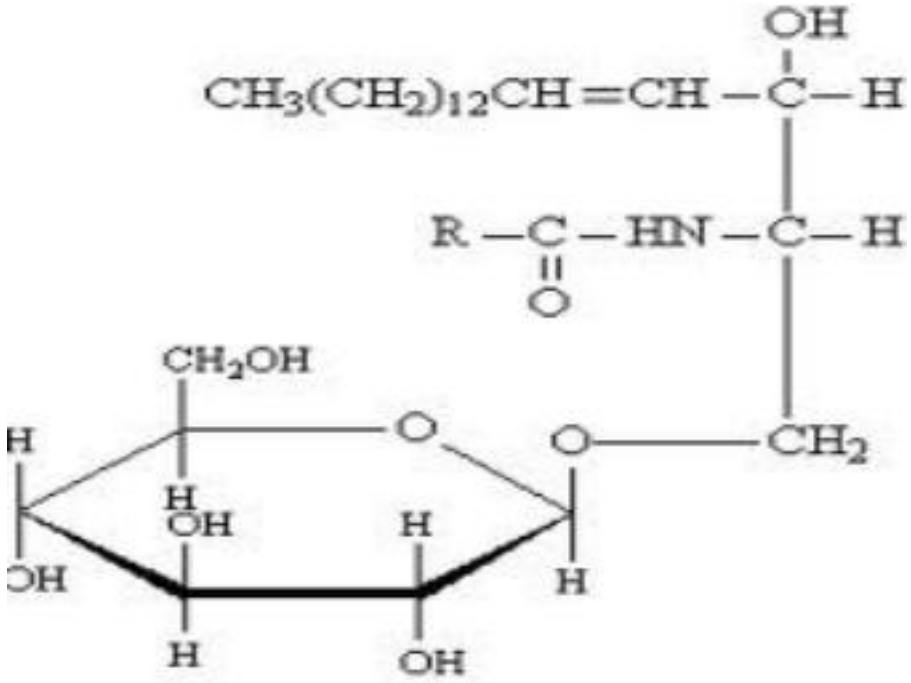
2-Glycolipids:

Glycolipids are molecules that contain carbohydrate and lipid. All glycolipids are derivatives of ceramides in which a long chain fatty acid is attached to the amino alcohol sphingosine. They are, therefore called glycosphingolipids.

Glycosphingolipids are essential components of all membranes in the body, but they are found in greatest amounts in nerve tissue.

The simplest glycosphingolipids are the cerebrosides.

Cerebrosides are cereamide monosaccharide that contain either a galactose (galactocerebroside- the most common cerebroside found in membranes of brain cells), or glucose (glucocerebroside found in the membranes of macrophages {cells that protect the body ingesting and destroying foreign microorganisms})



Glucocerebroside

Derived lipids:

Sterols:

Sterols are a class of steroids. Sterols are structural lipids present in the membranes of most cells. Cholesterol is the major sterol in animal tissues.

Cholesterol is amphipathic, with a polar head the OH group at C-3 and a non polar, the steroid nucleus and hydrocarbon side chain at C-17.

Most of the cholesterol in the body exist as a cholesterol ester, with a fatty acid attached the OH at C-3.

Cholesterol is a major structural constituent of the cell membranes and plasma lipoproteins. Cholesterol is a precursor in the biosynthesis of all steroid hormones (likeTestosterone), vitamin D and bile salts.