FOOD CHEMISTRY

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BIOCHEMISTRY

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LIPIDS

LIPIDS

Lipid Classification (7 groups):

- Fatty Acids
- Acylglycerols
- Glycerophospholipids
- Sphingolipids
- Sterols
- Prenol lipids
- Saccharolipids

1.Fatty acids

- A fatty acid consists of a **hydrocarbon chain** and a terminal **carboxylic acid group**.
- This arrangement confers the molecule with a **polar, hydrophilic end**, and a **nonpolar, hydrophobic end** that is **insoluble in water**.
- The fatty acid structure is one of the most fundamental categories of biological lipids, and is commonly used as a **building block** of more structurally complex lipids.
- The carbon chain, typically between 4 to 24 carbons long, may be **saturated or unsaturated**. A saturated fatty acid has all of the carbon atoms in its chain saturated with hydrogen atoms with general formula $CH_3(CH_2)_nCOOH$ where n is an **even number**.
- Mono-unsaturated fatty acids have one double bond in their structure while polyunsaturated fatty acids have two or more double bonds.
- The double bonds in polyunsaturated fatty acids are generally separated by at least one methylene group.
- Where a double bond exists, there is the possibility of either a **cis** or **trans** geometric isomerism, which significantly affects the molecule's molecular configuration.
- Cis-double bonds cause the fatty acid chain to bend, an effect that is more pronounced when more double bonds are there in a chain. This in turn plays an important role in the structure and function of cell membranes.
- Most **naturally occurring** fatty acids are of the **cis** configuration, although the **trans** form does exist in some **natural and partially hydrogenated** fats and oils.
- **Shorter the chain** of fatty acids **lower is the melting temperature** than those with longer chains.
- **Unsaturated fatty acids have lower melting temperatures** than saturated fatty acids of same chain length.

2. Glycerolipids

• Glycerolipids are composed mainly of **mono-, di- and tri-substituted glycerols**, the most well-known being the fatty acid esters of glycerol (**triacylglycerols**), also known as triglycerides or fats. In these compounds, **all three hydroxyl groups of glycerol are esterified**, usually by different fatty acids (Mixed Lipids).

• They **function** as a **food store**, these lipids comprise the bulk of **storage fat** in animal tissue and oil seeds.

• Triglycerides or fats may be either **solid** or **liquid** at room temperature, depending on their structure and coposition.

• "**Oils**" is usually used to refer to fats that are liquids at normal room temperature, while "**fats**" is usually used to refer to fats that are solids at normal room temperature. "**Lipids**" is used to refer to both liquid and solid fats, along with other related substances.

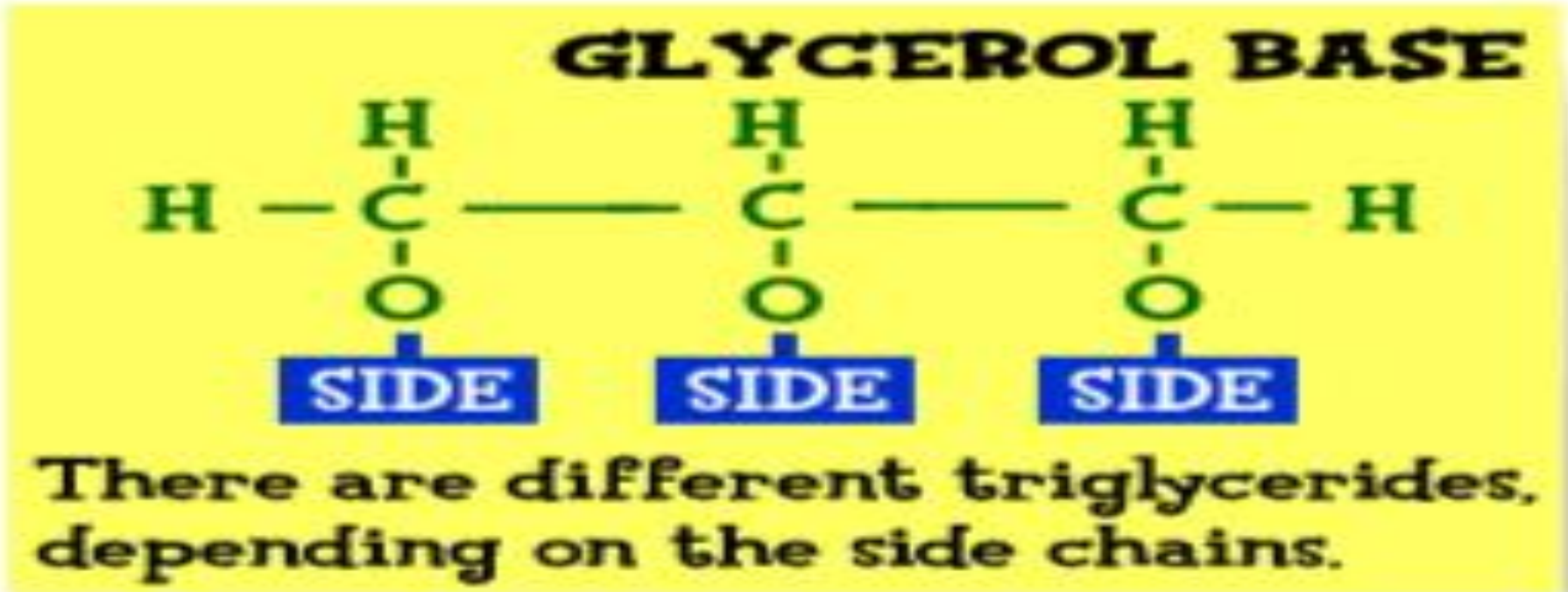


Fig 4.2 Triacylglycerols

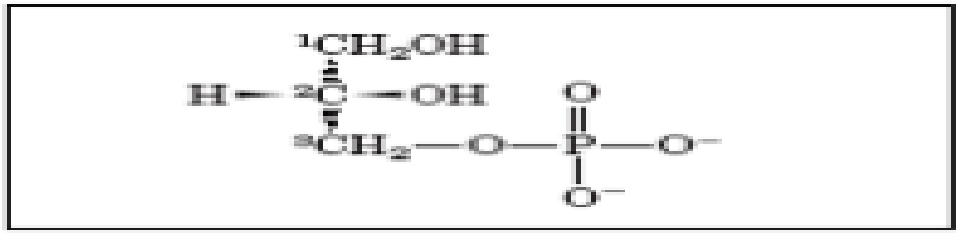
3.Glycerophospholipids

• Glycerophospholipids, also referred to as **phospholipids,** are key components of the **lipid bilayer of cells**, as well as being involved in **metabolism** and **cell signaling**.

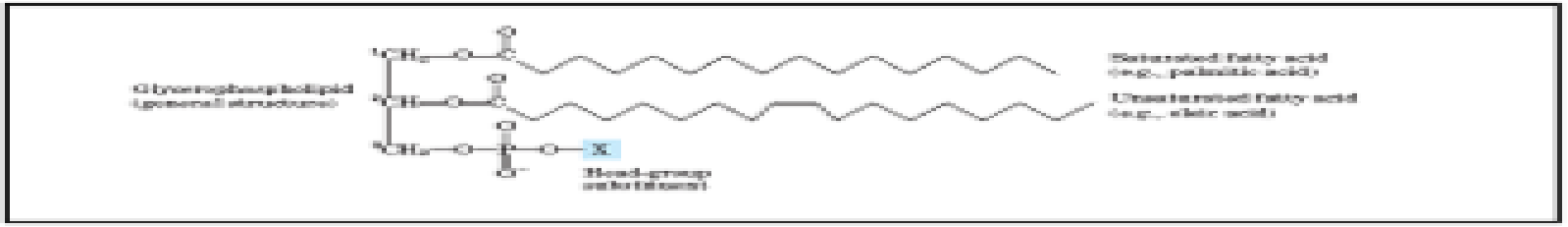
• **Neural tissue** (including the brain) contains relatively high amounts of **glycerophospholipids**, and alterations in their composition has been implicated in various **neurological disorders**.

• Examples of glycerophospholipids found in **biological membranes** are **phosphatidylcholine** (also known as PC, or lecithin), **phosphatidylethanolamine** (PE) and **phosphatidylserine** (PS).

• **Plasmalogens** are also a type of glycerolipids that contain a **fatty alcohol** at C-1 of Sn glycerol with double bond instead of a fatty acid.



L-Glycerol 3--phosphate



Amphiphilic

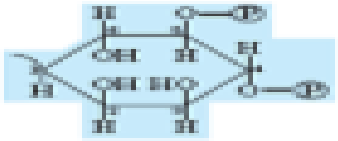
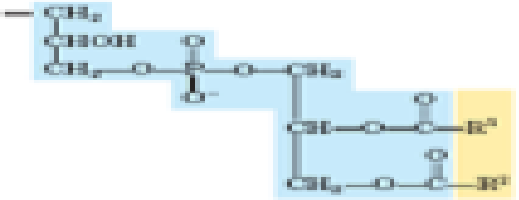
Name of glycerophospholipid	Name of X	Formula of X	Net charge (at pH 7)
Phosphatidic acid	—	—H	−1
Phosphatidylethanolamine	Ethanolamine	$-CH_2-CH_2-\overset{+}{N}H_3$	0
Phosphatidylcholine	Choline	$-CH_2-CH_2-\overset{+}{N}(CH_3)_3$	0
Phosphatidylserine	Serine	$-CH_2-\underset{COO^-}{CH}-\overset{+}{N}H_3$	−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

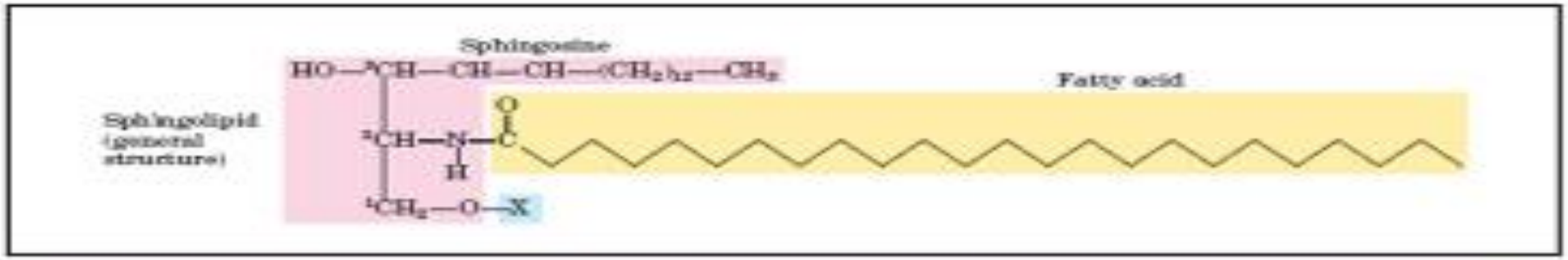
Fig 4.3 Glycerophospholipids

4.Sphingolipids

- Sphingolipids are a complex family of compounds that share a common structural feature, **a sphingoid base backbone** that is synthesized de novo from the amino acid **serine** and a long-chain fatty acyl CoA, then converted into ceramides, phosphosphingolipids, glycosphingolipids and other compounds.

- The major sphingoid base of mammals is commonly referred to as **sphingosine**.

- **Ceramides** (N-acylsphingoid bases) are a major subclass of sphingoid base derivatives with an amide-linked fatty acid. The fatty acids are typically saturated or mono-unsaturated with chain lengths from 16 to 26 carbon atoms.



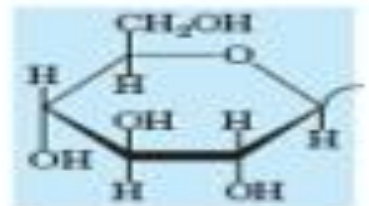
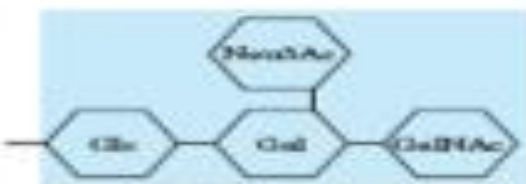
Name of sphingolipid	Name of X	Formula of X
Ceramide	—	—H
Sphingomyelin	Phosphocholine	
Neutral glycolipids Glucosylcerebroside	Glucose	
Lactosylceramide (a globoside)	Di-, tri-, or tetrasaccharide	
Ganglioside GM2	Complex oligosaccharide	

Fig 4.4 Sphingolipids

5. Sterols

- Sterol lipids, such as **cholesterol** and its derivatives, are an important component of **membrane lipids**, along with the glycerophospholipids and sphingomyelins.

- The steroids, all derived from the same fused four-ring core structure, have different biological roles as **hormones** and **signaling molecules**.

- The eighteen-carbon(C18) steroids include the **estrogen** family whereas the C19 steroids comprise the **androgens** such as testosterone and androsterone. The C21 subclass includes the **progestogens** as well as the **glucocorticoids** and **mineralocorticoids**. The secosteroids, comprising various forms of vitamin D, are characterized by cleavage of the B ring of the core structure.

- Other examples of sterols are the **bile salt** and their conjugates, which in mammals are oxidized derivatives of cholesterol and are **synthesized in the liver**

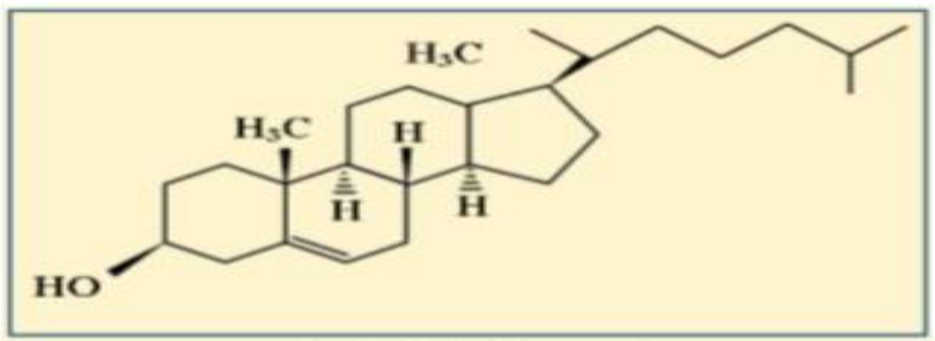


Fig 4.5 Cholesterol

6.Prenol lipids

• Prenol, or 3-methyl-2-buten-1-ol, is a **natural alcohol**. It is one of the most simple **terpenes**.

• Prenol lipids are synthesized from the 5-carbon precursors isopentenyl diphosphate and dimethylallyl diphosphate that are produced mainly via the mevalonic acid (MVA) pathway.

• The simple **isoprenoids** (linear alcohols, diphosphates, etc.) are formed by the successive addition of C5 units, and are classified according to number of these terpene units.

• Structures containing **greater than 40 carbons** are known as **polyterpenes**.

• **Carotenoids** are important simple **isoprenoids** that function as **antioxidants** and as **precursors of vitamin A**.

• Another biologically important class of molecules is exemplified by the **quinones and hydroquinones**, which contain an **isoprenoid tail** attached to a quinonoid core of non-isoprenoid origin.

• **Vitamin E** and **vitamin K**, as well as the **ubiquinones**, are examples of this class.

7. Saccharolipids

• Saccharolipids describe compounds in which **fatty acids** are linked directly to a **sugar backbone**, forming structures that are compatible with **membrane bilayers**.

• In the saccharolipids, a **monosaccharide** substitutes for the **glycerol backbone** present in glycerolipids and glycerophospholipids.

• The most familiar saccharolipids are the **acylated glucosamine** precursors of the Lipid A component of the lipopolysaccharides in **Gram-negative bacteria**

Common Fatty Acids

Chemical Names and Descriptions of some Common Fatty Acids				
Common Name	Carbon Atoms	Double Bonds	Scientific Name	Sources
Butyric acid	4	0	butanoic acid	butterfat
Caproic Acid	6	0	hexanoic acid	butterfat
Caprylic Acid	8	0	octanoic acid	coconut oil
Capric Acid	10	0	decanoic acid	coconut oil
Lauric Acid	12	0	dodecanoic acid	coconut oil
Myristic Acid	14	0	tetradecanoic acid	palm kernel oil
Palmitic Acid	16	0	hexadecanoic acid	palm oil
Palmitoleic Acid	16	1	9-hexadecenoic acid	animal fats
Stearic Acid	18	0	octadecanoic acid	animal fats
Oleic Acid	18	1	9-octadecenoic acid	olive oil
Vaccenic Acid	18	1	11-octadecenoic acid	butterfat
Linoleic Acid	18	2	9,12-octadecadienoic acid	grape seed oil
Alpha-Linolenic Acid (ALA)	18	3	9,12,15-octadecatrienoic acid	flaxseed (linseed) oil
Gamma-Linolenic Acid (GLA)	18	3	6,9,12-octadecatrienoic acid	borage oil
Arachidic Acid	20	0	eicosanoic acid	peanut oil, fish oil
Arachidonic Acid (AA)	20	4	5,8,11,14-eicosatetraenoic acid	liver fats
EPA	20	5	5,8,11,14,17-eicosapentaenoic acid	fish oil