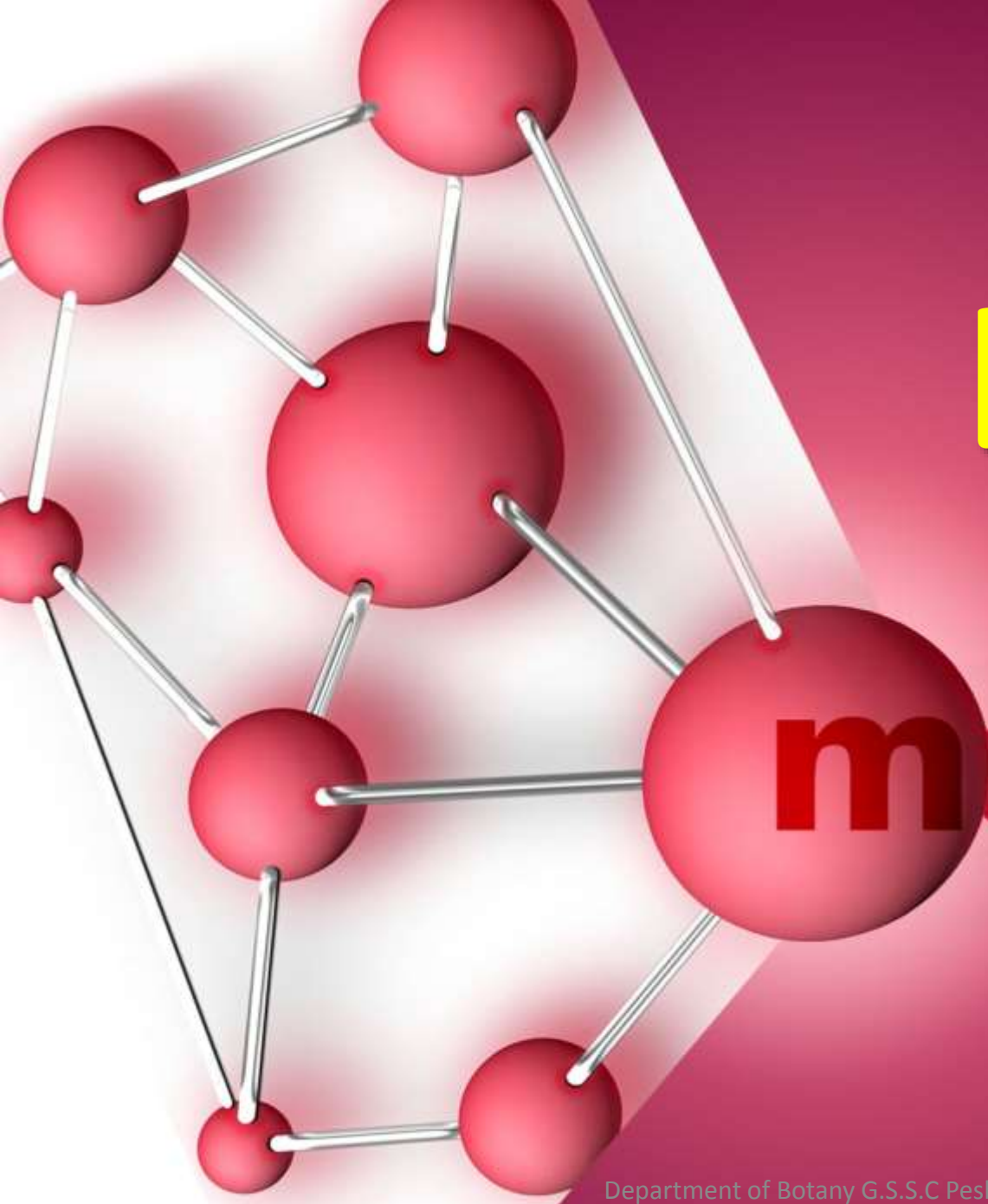
بسم الله الرحمن الرحيم



LIPIDS

molecule

ASAD KHAN
B.S Botany
3RD Semester

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LIPIDS

- Lipids are diverse group of chemicals that are fats and oily substances.
- Lipids are hydrophobic.
- These are insoluble in water.
- Lipids are in soluble in organic solvents, such as Ether, Ethanol, Acetone, Chloroform, Benzene, etc.

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Continued……

- Lipids contain Carbon, Hydrogen and Oxygen, as in Carbohydrates. But in lipids the proportion of Oxygen is much less.
- Having only two Oxygen atoms at one end of long molecule.

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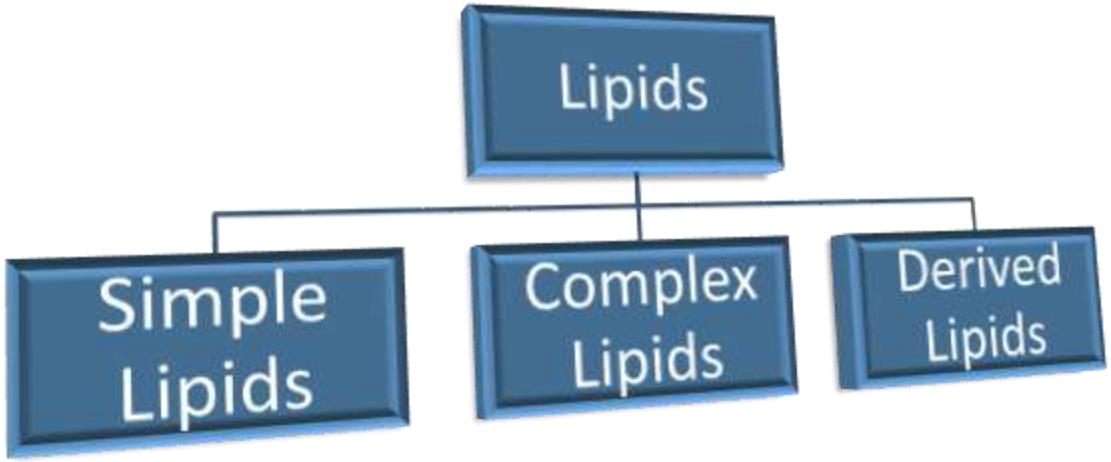
Classification of Lipids



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Simple Lipids

- Simple Lipids are esters of fatty acids with alcohols.
- Simple Lipids can be sub-divided into:

1. Fats
2. Waxes

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Fats

- Esters of fatty acids with glycerol.
- Solid at room temperature.
- Some are liquid at room temperature, and are known as oils.
- Physical state depends upon the nature of fatty acids.
- Fats are rich in saturated fatty acids.
- Oils are rich in unsaturated fatty acids.

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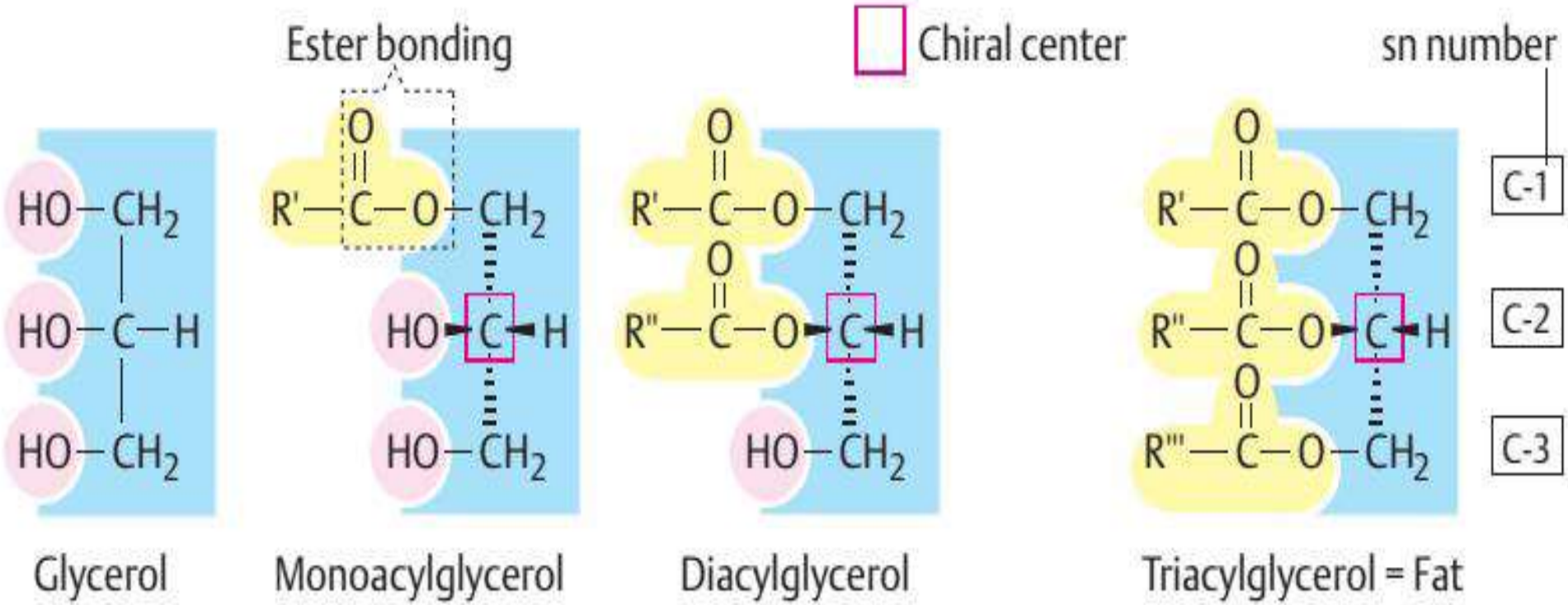
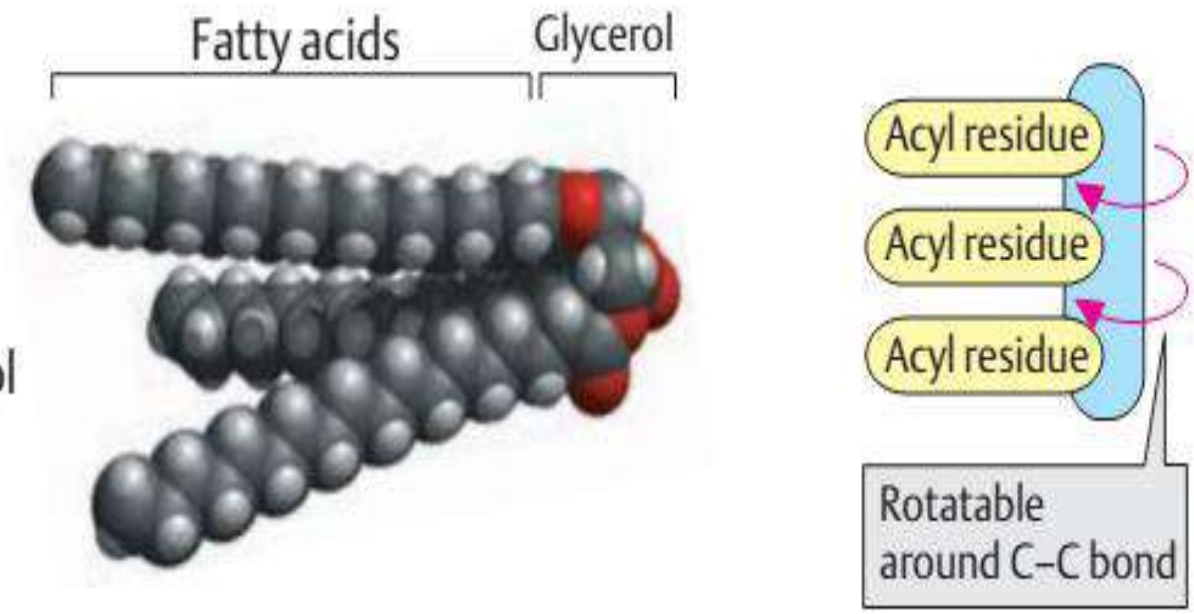


Van der Waals model of tristearylglycerol



Foods High in Fat

Fatty meats and fish

Cheese

Butter

Avocado

Nuts and seeds

Chocolate

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Waxes

- They are esters of higher fatty acids with higher mono hydroxy aliphatic alcohols(e.g. Cetyl alcohol)
- Have very long straight chain of 60-100 carbon Atoms
- They can take up water without getting dissolved in it.
- Used as bases for the preparation of cosmetics, ointments, polishes, lubricants and candles.
- In nature, they are found on the surface of plants and insects.

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EXAMPLES OF WAXES

ANIMAL WAXES

Beeswax

Chinese wax

Lanolin (wool wax)

Shellac wax

VEGETABLE WAXES

Bayberry wax

Carnauba wax

Castor wax

Jojoba oil

Soy wax

PETROLEUM WAXES

Paraffin wax

Microcrystalline wax

Petroleum jelly

MINERAL WAXES

Ceresin waxes

Montan wax

Ozocerite

Peat waxes

SYNTHETIC WAXES

Polyethylene waxes

Chemically modified waxes

Substituted amide waxes

Polymerised α-olefins

Fatty acids

- Fatty acids are carboxylic acids with hydrocarbon side chain.
- The are the simplest form of lipids.

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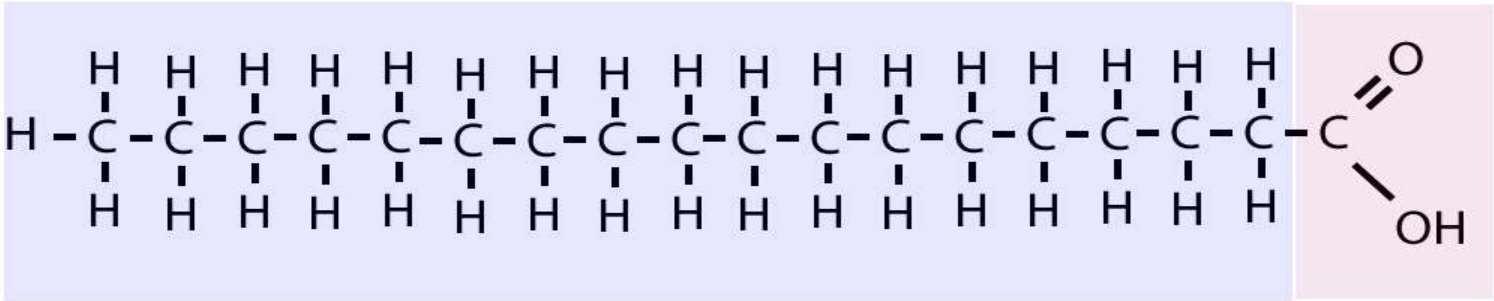
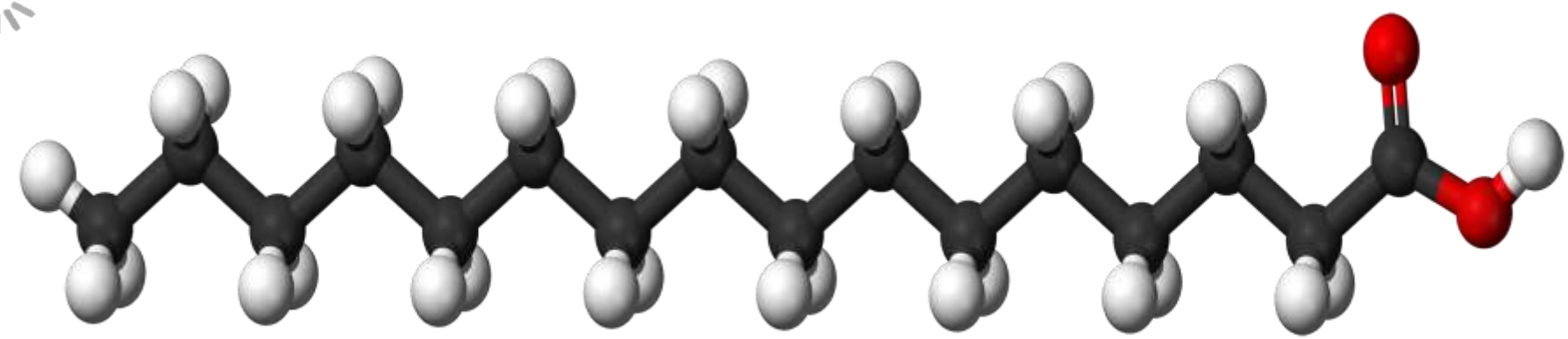
Essential features of a fatty acid



long hydrocarbon chain

carboxylic acid group



Occurrence of Fatty acid

- Majorly occur in esterified form as major constituents of various lipids.
- They are also present as free (unesterified) fatty acids.
- Fatty acids of animal origin are much more simpler in structure in contrast to those of plant origin.

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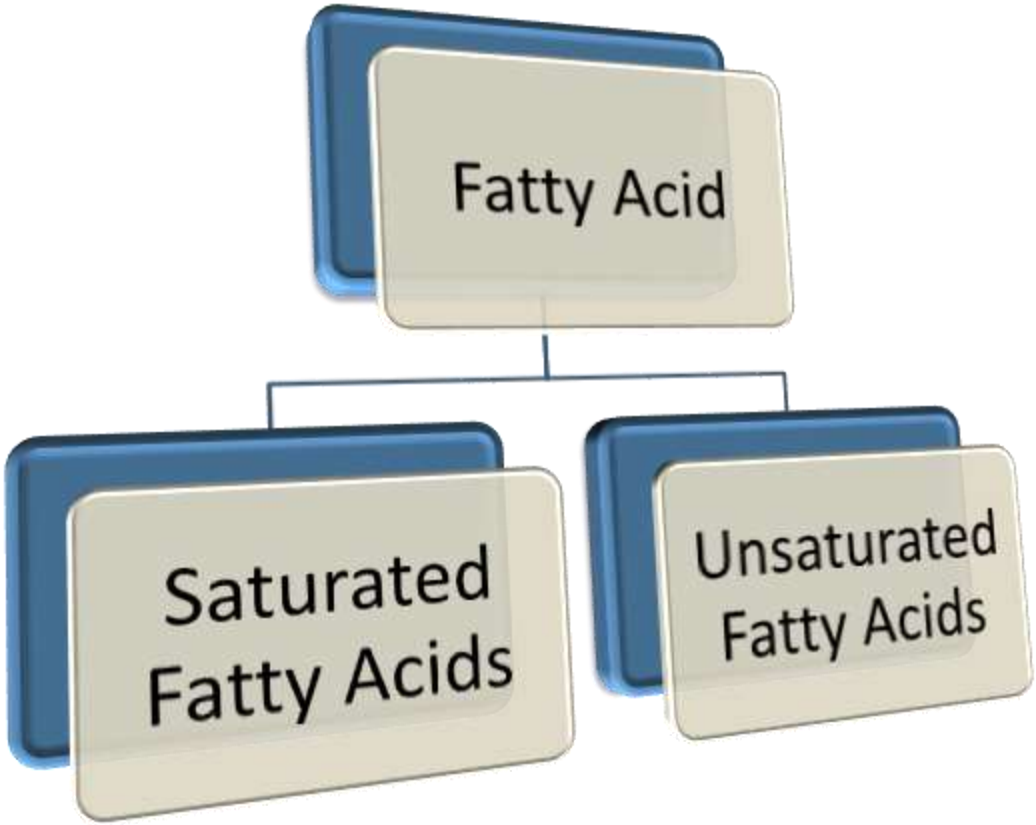
Classification of Fatty Acids



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Saturated Fatty Acids

- Contain only single C–C bonds
- Closely packed
- Strong attractions between chains
- High melting points
- Solids at room temperature

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Unsaturated Fatty Acids

- Contain one or more double C=C bonds
- Nonlinear chains do not allow molecules to pack closely
- Few interactions between chains
- Low melting points
- Liquids at room temperature

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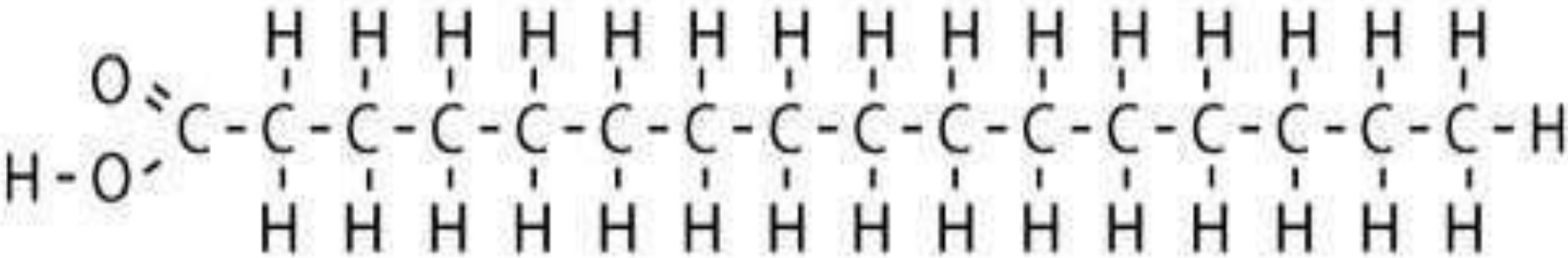
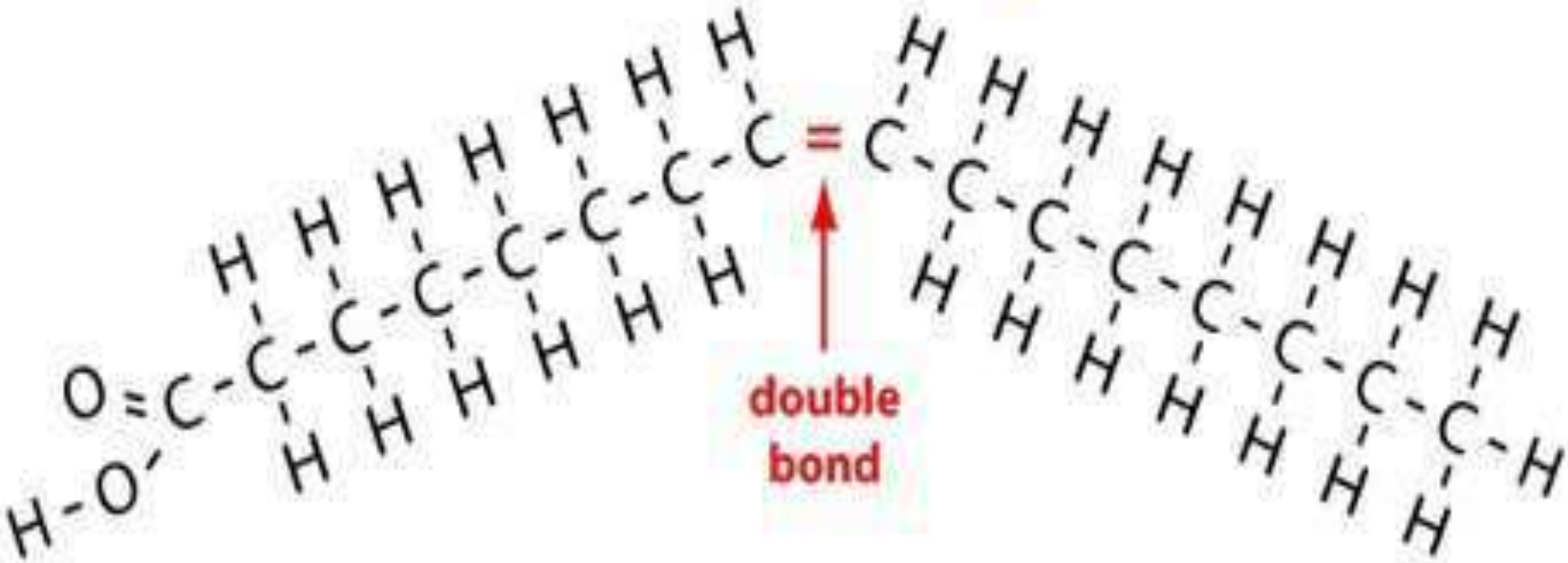
saturated fatty acid



unsaturated fatty acid



Examples of Saturated Fatty Acids

No. of C atoms	Common name	Scientific name	Formula
2	Acetic acid	Ethanoic acid	CH_3COOH
4	Butyric acid	Butanoic acid	$CH_3(CH_2)_2COOH$
6	Caproic acid	Hexanoic acid	$CH_3(CH_2)_4COOH$
8	Caprylic acid	Octanoic acid	$CH_3(CH_2)_6COOH$
10	Capric acid	Decanoic acid	$CH_3(CH_2)_8COOH$
12	Lauric acid	Dodecanoic acid	$CH_3(CH_2)_{10}COOH$
14	Myristic acid	Tetradecanoic acid	$CH_3(CH_2)_{12}COOH$

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Examples of Unsaturated Fatty Acids

Name of Fatty Acids	Structures	Sources
Palmitoleic Acid	$CH_3(CH_2)_5CH=CH(CH_2)_7COOH$	Sardine Oil
Oleic Acid	$CH_3(CH_2)_7CH=CH(CH_2)_7COOH$	Olive Oil, Peanut Oil, Linseed Oil
Linoleic Acid	$CH_3(CH_2)_4CH=CHCH_2CH=CH(CH_2)_7COOH$	Olive Oil, Peanut Oil, Linseed Oil, Soybean Oil
ϒ-linolenic Acid	$CH_3(CH_2)_4CH=CHCH_2CH=CHCH_2CH=CH(CH_2)_4COOH$	Linseed Oil
Erucic Acid	$CH_3(CH_2)_7CH=CH(CH_2)_{11}COOH$	Rapeseed Oil
Arachidonic Acid	$CH_3(CH_2)_4CH=CHCH_2CH=CHCH_2CH=CHCH_2CH=CH(CH_2)_3COOH$	Peanut Oil
Parinaric Acid	$CH_3CH_2CH=CHCH=CHCH=CH(CH_2)_7COOH$	Plant lipids

Triacylglycerols

- Storage of fatty acids in organisms is largely in the form of TAG or fats.
- These substances are tri-esters of fatty acids and glycerol.
- Also known as Neutral Fat and Triglyceride.
- Mono- and Diacylglycerol, wherein one or two fatty acids are esterified with glycerol, are also found in the tissues
- Naturally occurring fats and oils are mixtures of triglycerides.

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Function of Triglycerides (Fat)

- Major lipid in the body and diet
- Stored fat provides about 60% of the body's resting

  energy needs – compactly!
- Insulation and protection
- Carrier of fat-soluble compounds
- Sensory qualities – flavor and texture

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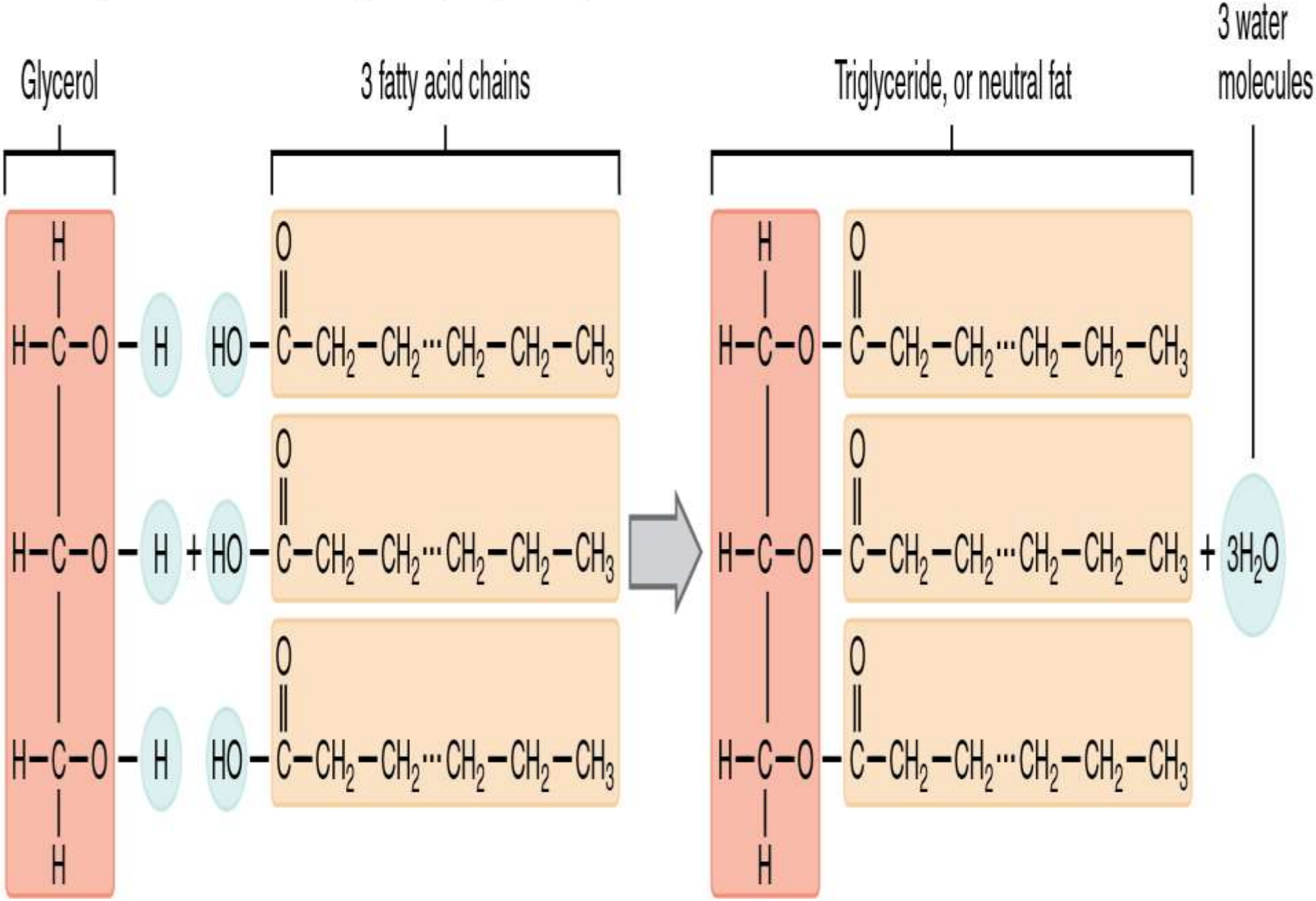
Three fatty acid chains are bound to glycerol by dehydration synthesis.



Complex Lipids

- Contain some non-lipid substances in addition to fatty acids and alcohol.
- Non-lipids include proteins, carbohydrates, phosphate, sulphate, nitrogen etc.

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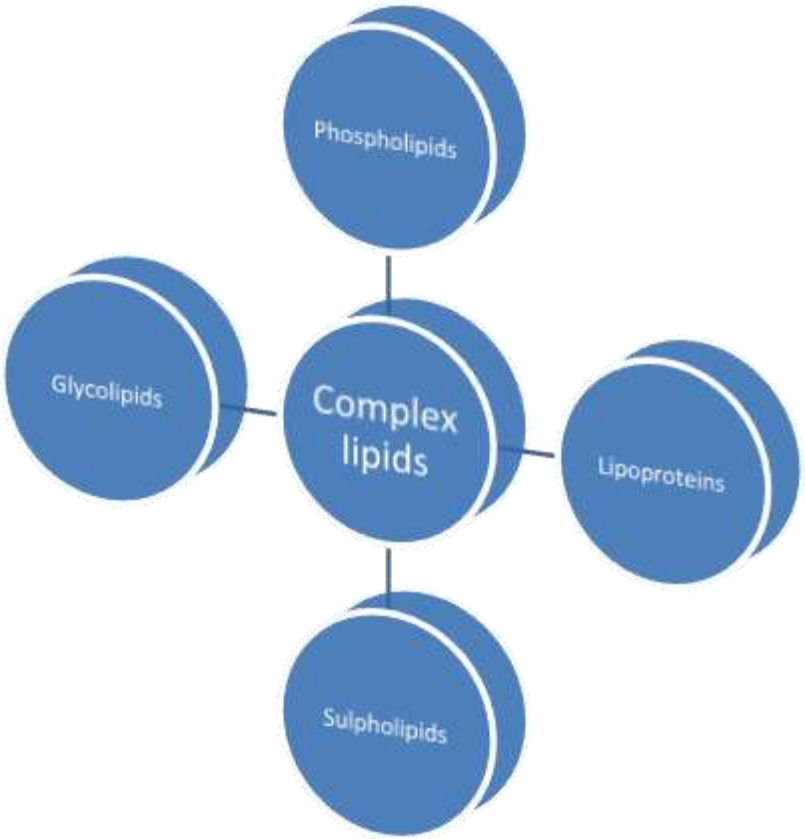
Classification Of Complex Lipids



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Phospholipids

- Made up of fatty acids, an alcohol, phosphoric acid and a nitrogenous base.
- Some examples are lecithin, cephalin and sphingomyelin

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Functions

- Component of cell membrane –**both structural and regulatory functions.**
- Phospholipids in mitochondria–lecithin, cephalin and cardiolipin–maintain ETC
- Absorption of fat
- Transport of lipids
- Arachidonic acid –serves as a precursor of various eicosanoids
- Cephalin–Blood clotting

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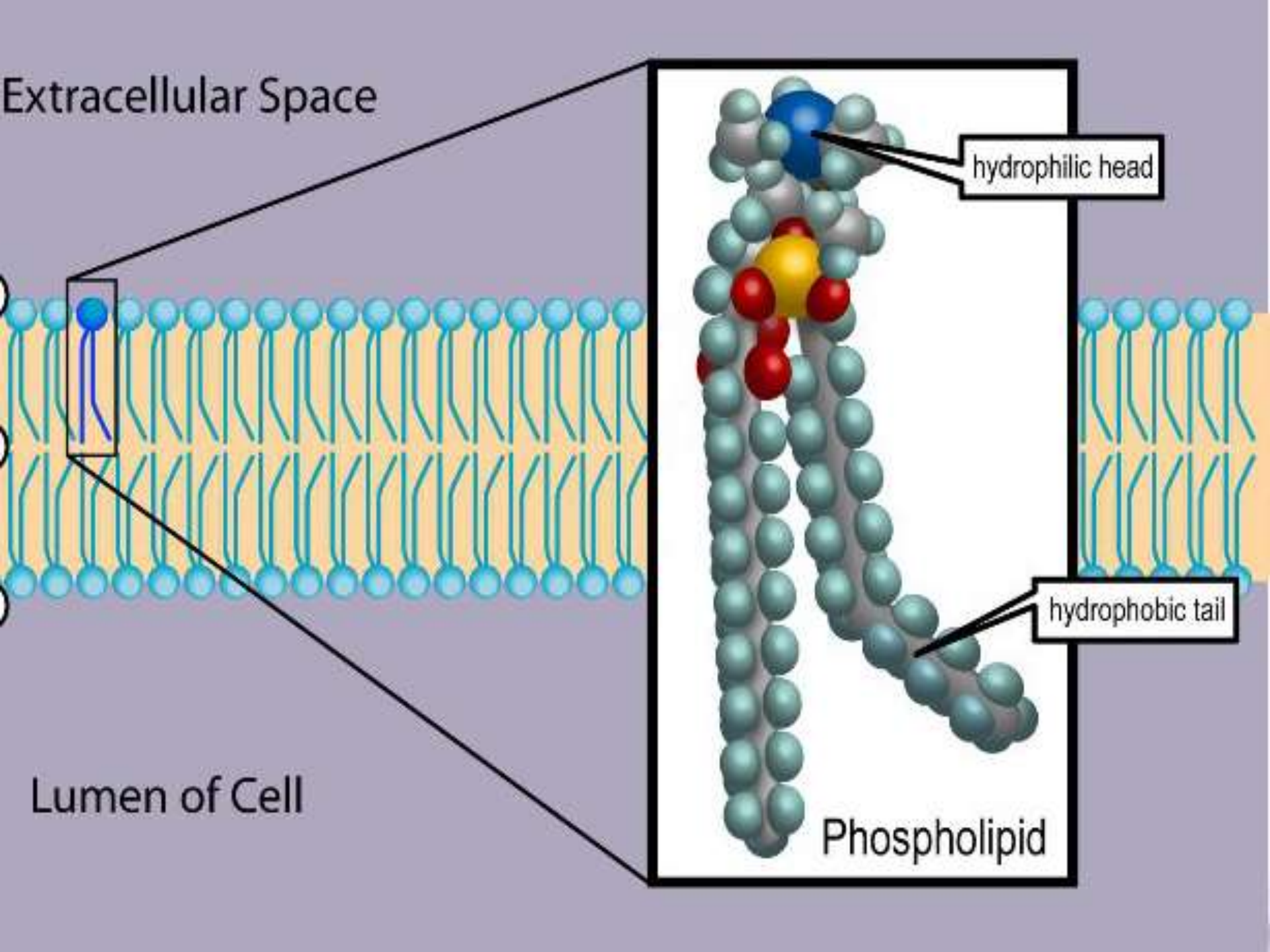
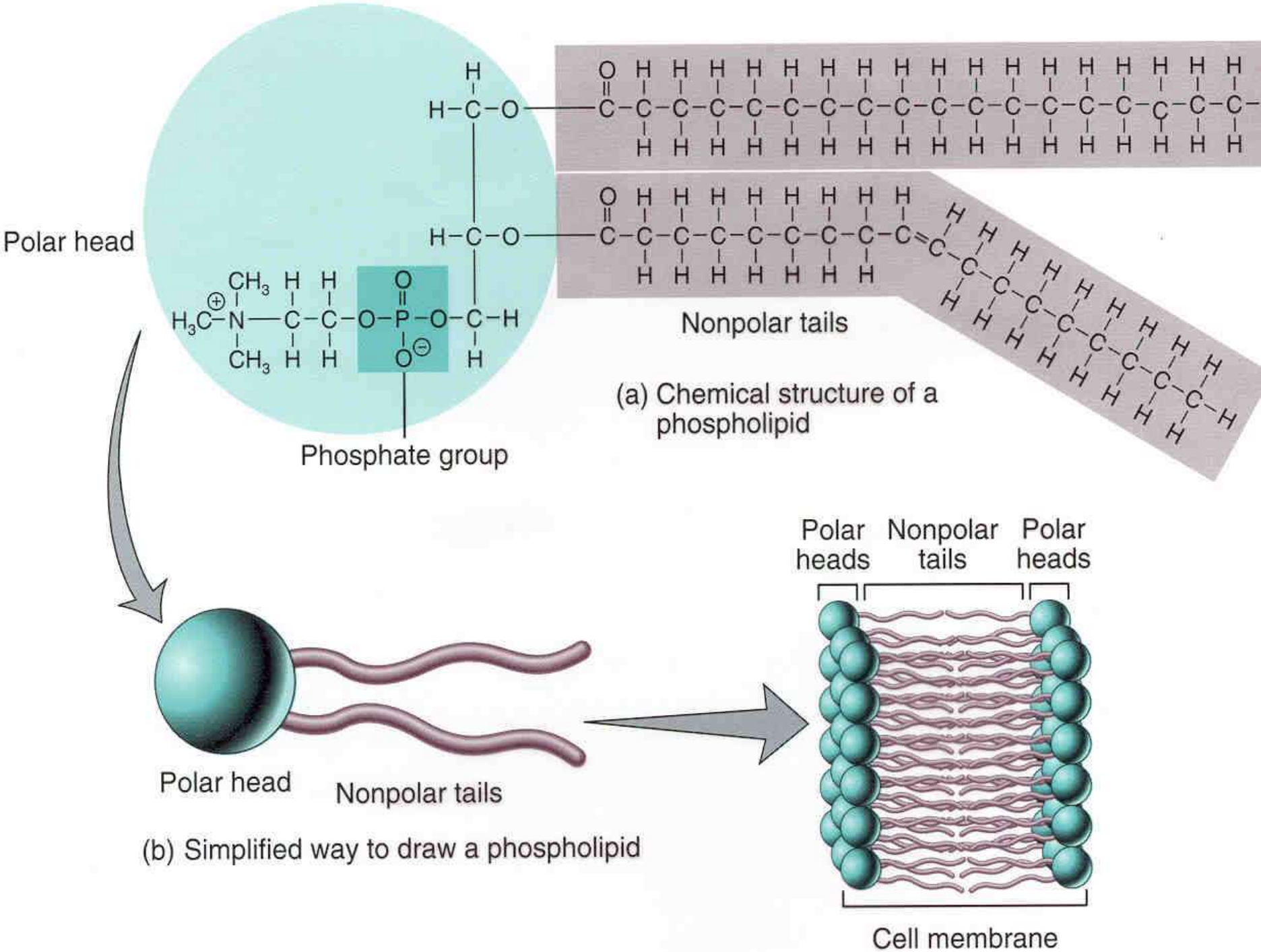
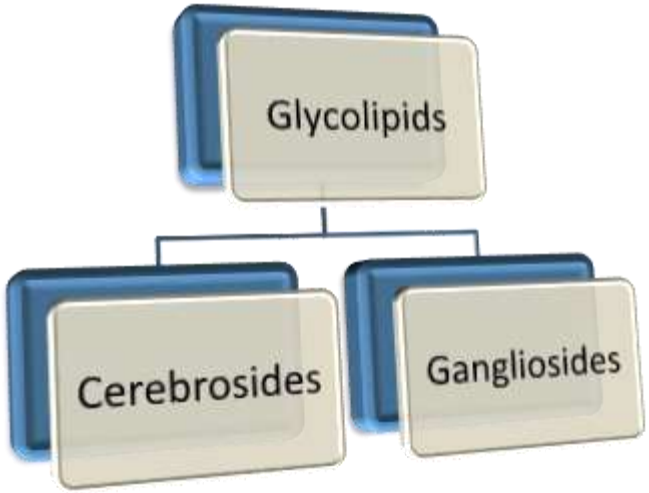

Extracellular Space
hydrophilic head
hydrophobic tail
Lumen of Cell
Phospholipid


Polar head
Phosphate group
Nonpolar tails
(a) Chemical structure of a phospholipid
Polar head
Nonpolar tails
(b) Simplified way to draw a phospholipid
Polar heads
Nonpolar tails
Polar heads
Cell membrane

Glycolipids

- Made up of a fatty acid, an alcohol and some carbohydrates.



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Cerebrosides

- Cerebrosides are made up of:

1. A fatty acid
2. Sphingosine (an amino alcohol)
3. A carbohydrate (galactose).

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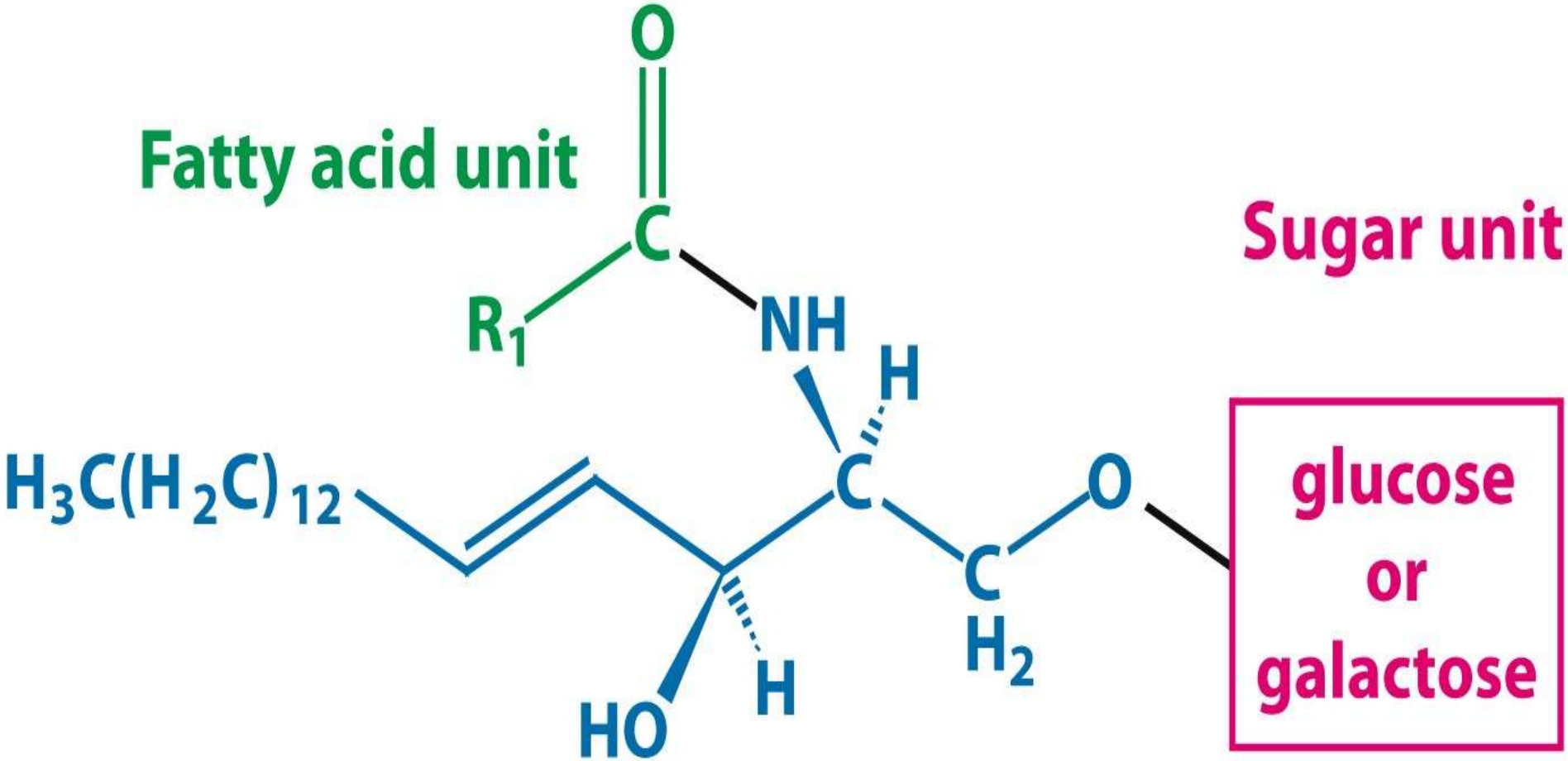

Cerebroside
(a glycolipid)

Unnumbered 12 p350a
***Biochemistry*, Seventh Edition**
© 2012 W. H. Freeman and Company

Gangliosides

- **Gangliosides are made up of:**

1. A fatty acid
2. Sphingosine
3. N-acetyl-neuraminic acid
4. Some hexoses

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Natural Glycolipids

Ceramide

Ganglioside: GM3

Ganglioside: GM1

M. Corti et al. Curr. Op. Coll. Int. Sci. 12 (2007) 148–154.

Lipoproteins

- May be considered to be conjugated proteins or compound lipids.
- Made up of some lipids combined with some specific proteins.
- Lipids includes triglycerides, phospholipids, cholesterol and fatty acids.
- These are soluble in water because of their protein content.
- These are the form in which lipids are transported in circulation.

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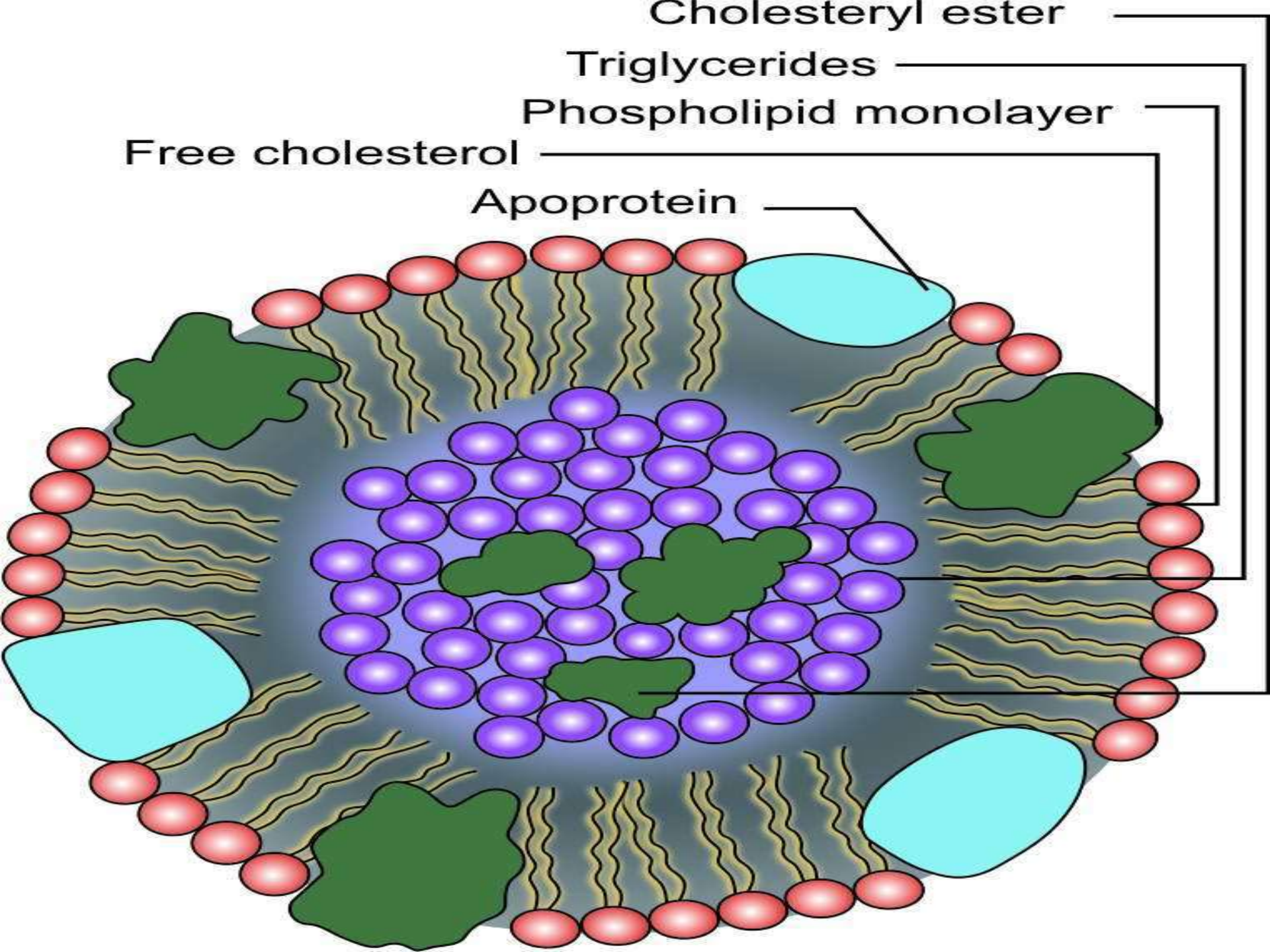
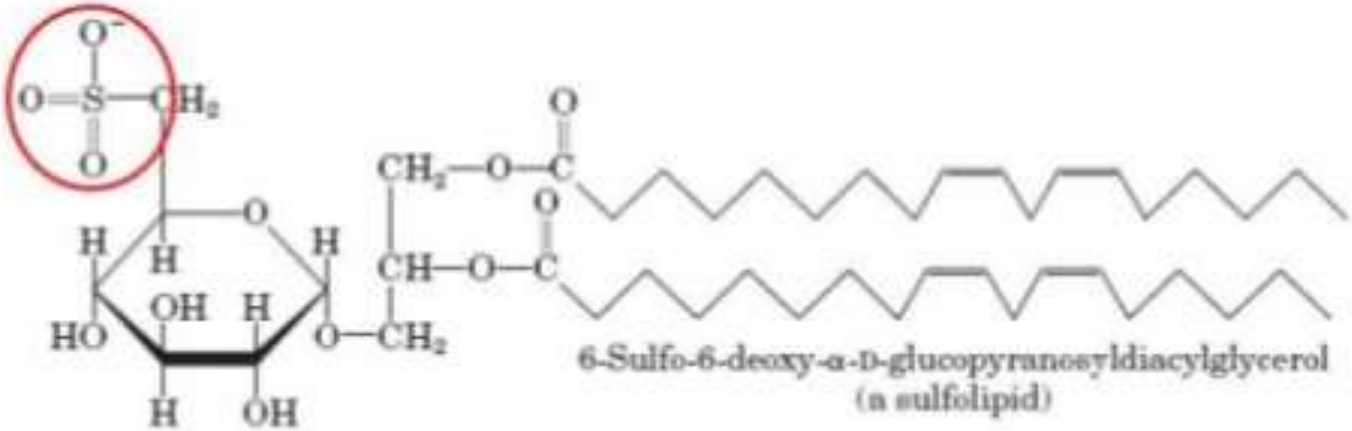

Cholesteryl ester
Triglycerides
Phospholipid monolayer
Free cholesterol
Apoprotein

Sulfolipids



Sulfolipids have a sulfonated glucose residue joined to a diacylglycerol in glycosidic linkage. They also exist predominantly in chloroplast

Derived Lipids

- These compounds which obtained on hydrolysis of simple and compound lipids.
- Possessing properties of lipids.
- Examples are fatty acids, higher alcohols, sterols, steroids, hydrocarbons etc.

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Steroids

- **Steroids** are lipids containing a steroid nucleus (core structure).
- The **steroid nucleus** is a fused ring system consisting of three cyclohexane rings and one cyclopentane ring.
- The rings are designated A, B, C and D.
- Attachment of different groups to the core steroid structure leads to a wide variety of steroid compounds, including cholesterol, bile salts and steroid hormones.

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Continued……

- They are involved with regulating metabolic processes/activities in the body because many forms of them are Hormones.
- Testosterone, Estrogen, and progesterone are all examples of Steroid Hormones.
- Cholesterol is the most common Steroid.
- It is the building block for other Steroid Hormones and also function in cell membrane structure.

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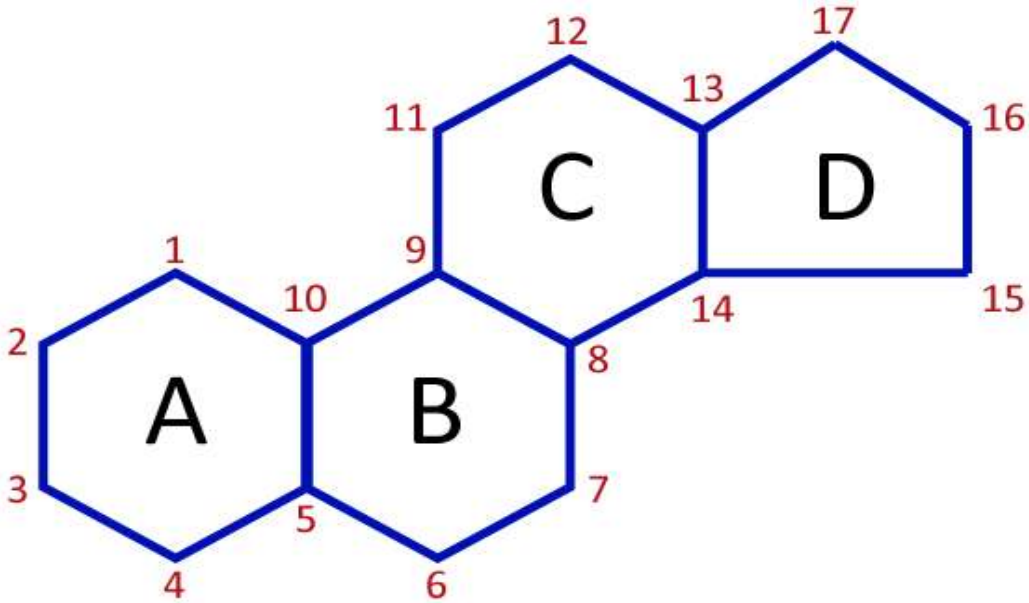
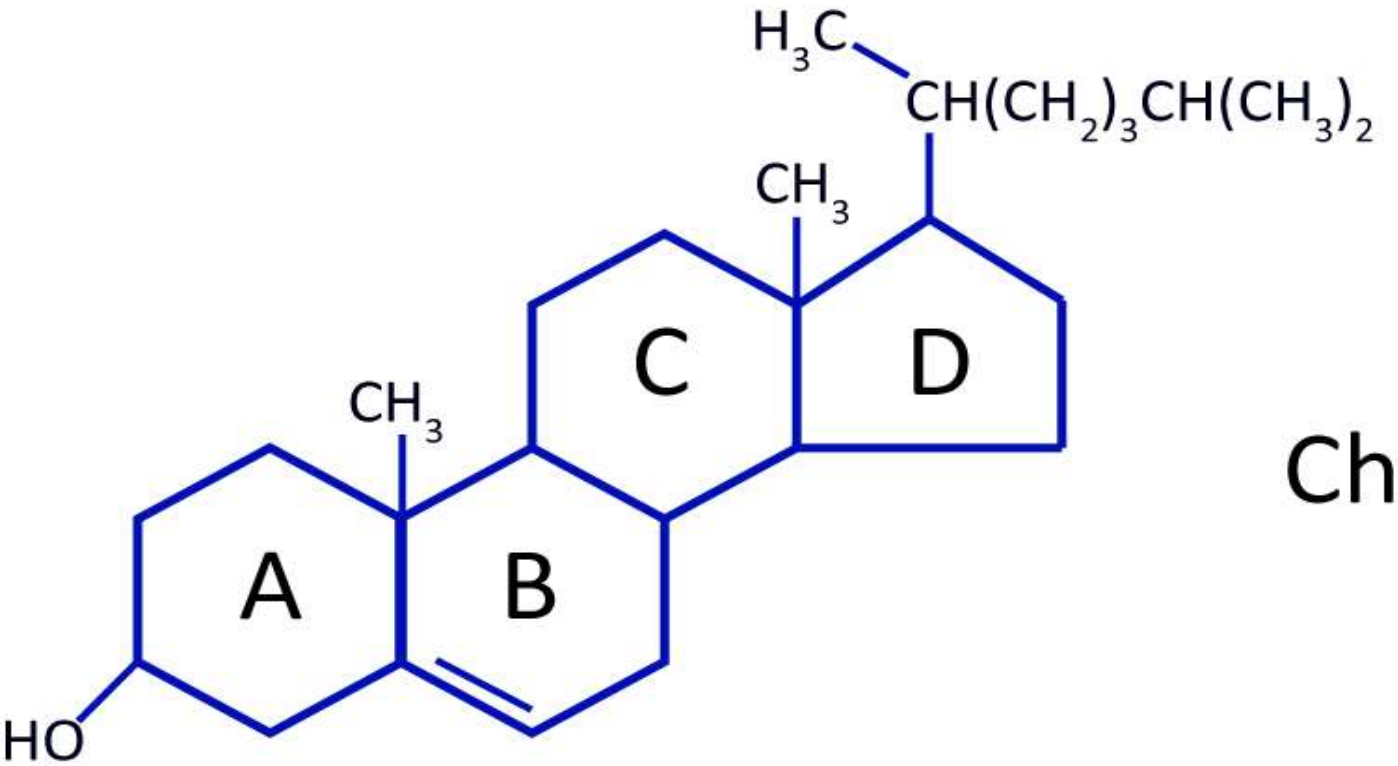
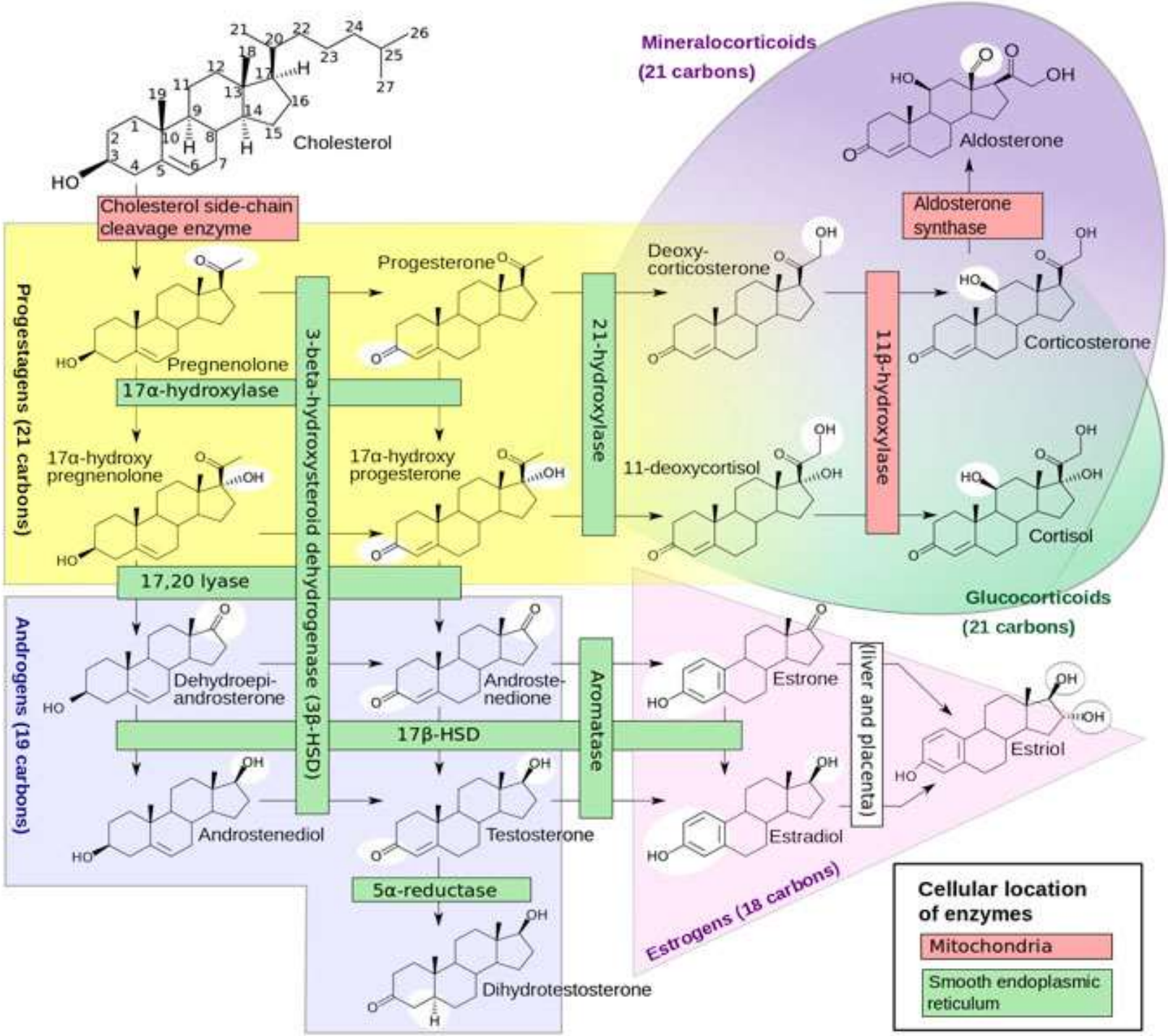


Steroid skeleton



Cholesterol


Cholesterol
Cholesterol side-chain cleavage enzyme
Mineralocorticoids
(21 carbons)
Aldosterone
Aldosterone synthase
Progestagens (21 carbons)
Pregnenolone
Progesterone
Deoxy-corticosterone
Corticosterone
17α-hydroxylase
3-beta-hydroxysteroid dehydrogenase (3β-HSD)
21-hydroxylase
11β-hydroxylase
17α-hydroxy pregnenolone
17α-hydroxy progesterone
11-deoxycortisol
Cortisol
17,20 lyase
Glucocorticoids
(21 carbons)
Androgens (19 carbons)
Dehydroepi-androsterone
Androste-nedione
Aromatase
Estrone
(liver and placenta)
Estriol
17β-HSD
Androstenediol
Testosterone
Estradiol
5α-reductase
Dihydrotestosterone
Estrogens (18 carbons)
Cellular location of enzymes
Mitochondria
Smooth endoplasmic reticulum

Chemical reactions of lipids

- Lipids can undergo:
- **Hydrolysis:** The ester bonds of lipids can be hydrolysed by specific enzymes.
- **Saponification:** Hydrolysis of triglycerides by alkalis is known as saponification. It results in the formation of alkali salts of fatty acids (soaps).
- **Hydrogenation:** Double bonds of unsaturated fatty acids can be hydrogenated in the presence of catalysts e.g. nickel

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Continued…….

- **Iodination:** Iodine can also reduce the double bonds of unsaturated fatty acids.

- **Oxidation:** Unsaturated fatty acids can react with atmospheric oxygen to form:

❖ **Fatty acid peroxides**

❖ **Fatty acids epoxides**

❖ **Fatty acid aldehydes**

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Functions of Lipids

- Storage form of energy.
- Important dietary components because of their high energy value and also because of the fat soluble vitamins and the essential fatty acids contained in the fat of natural foods.
- Structural components of cell membranes
- Serve as thermal insulators in the subcutaneous tissues and around certain organs.
- Non-polar lipids act as electrical insulators, allowing rapid propagation of depolarization waves along myelinated nerves.

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Continued……

- Provide shape and contour to the body
- Act as metabolic regulators
- Combinations of lipid and protein (lipoproteins) are important cellular constituents, occurring both in the cell membrane and in the mitochondria, and serving also as the means of transporting lipids in the blood.

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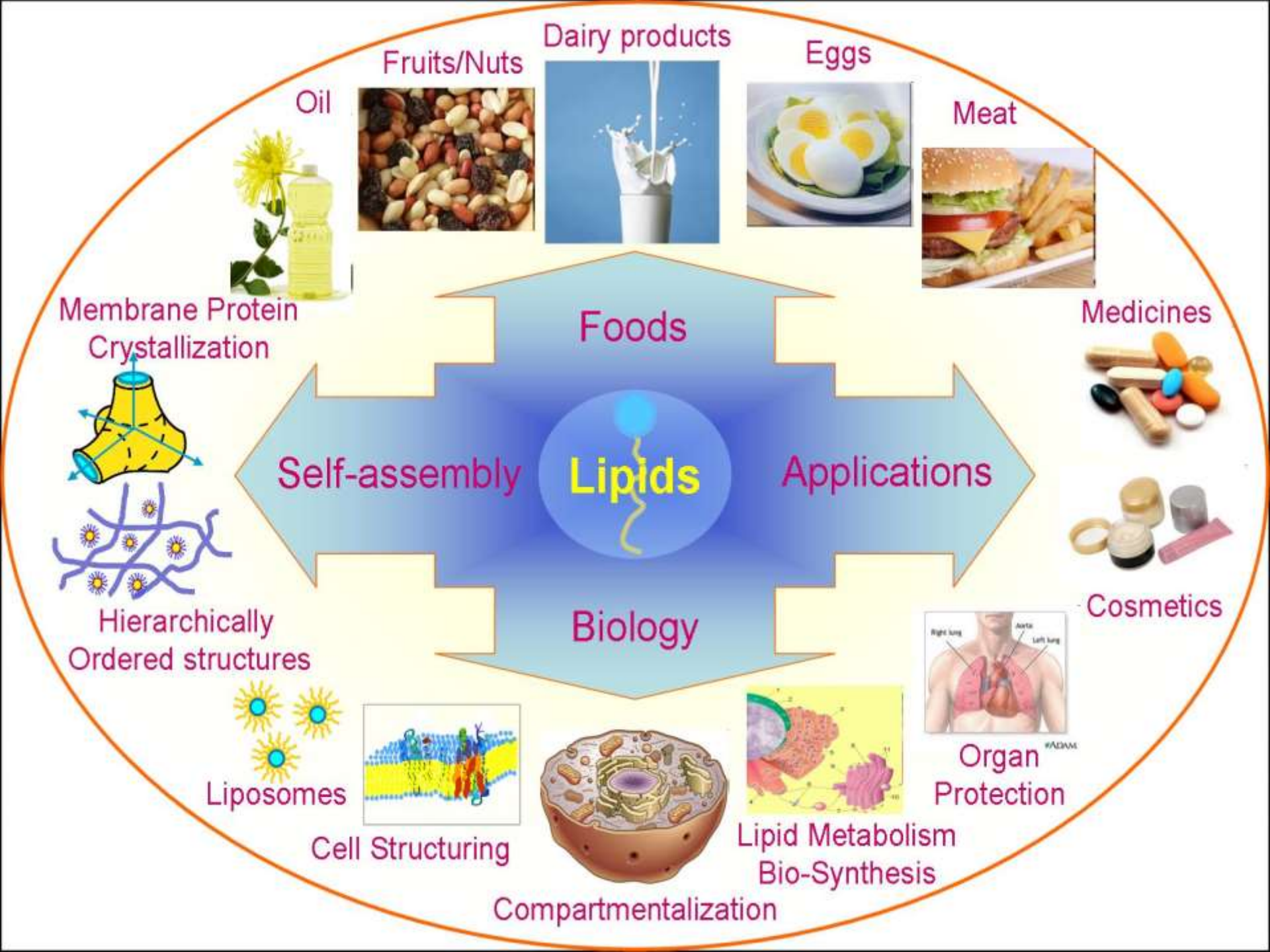
Roles of Lipids

- Energy storage (fatty acids, triacylglycerols)
- Structural elements (phospholipids, cholesterol)
- Hormones (sex hormones e.g. Estrogen)
- Enzyme cofactors (coenzyme A)
- Electron carriers (coenzyme Q, plastpquinone)
- Light-absorbing pigments (carotenoids)
- Hydrophobic anchors (dolichols)
- Emulsifying agents (bile salts)
- Intracellular messengers (phosphatidyl inositol)


Dairy products
Fruits/Nuts
Eggs
Oil
Meat
Foods
Membrane Protein Crystallization
Medicines
Self-assembly
Lipids
Applications
Cosmetics
Hierarchically Ordered structures
Biology
Liposomes
Cell Structuring
Organ Protection
Lipid Metabolism Bio-Synthesis
Compartmentalization

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  By: Tanveer Ahmad Malik

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The End

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