Ministry of Higher Education and Scientific Research
AL-Mustaqbal University College of Science
Department of medical biotechnology

Biochemistry

Lecture 6

Lipids

By

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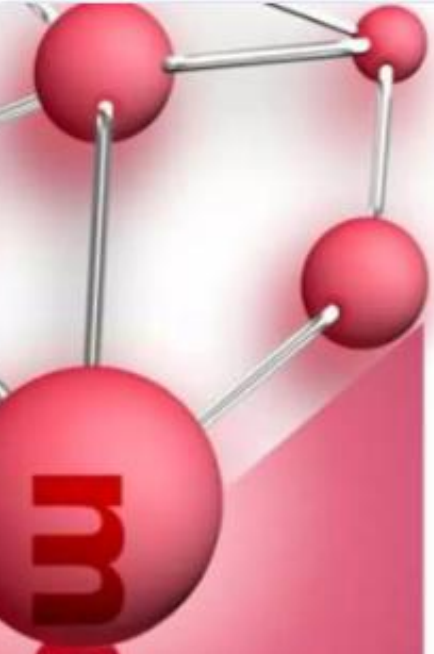
LIPIDS

molecule

ASAD KHAN
B.S Botany
3RD Semester

Introduction

- Definition of lipids: family of biochemicals that are **soluble in organic solvents** but not in water
  - Most lipids are fatty acids or ester of fatty acid
  - Soluble in non-polar solvents (petroleum ether, benzene, chloroform)
- Functions
  - Energy storage
  - Structure of cell membranes
  - Thermal blanket and cushion
  - Precursors of hormones (steroids and prostaglandins) etc



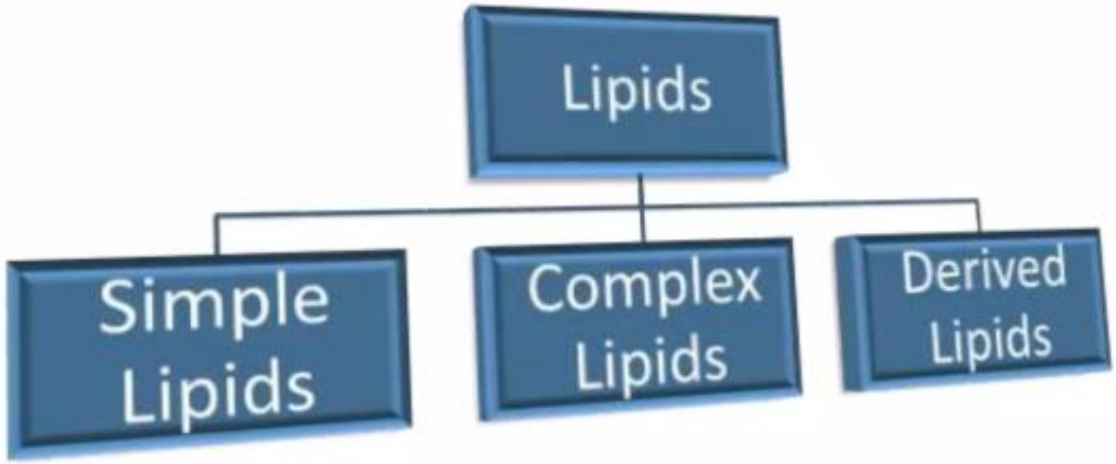
LIPIDS

- 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.

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.

Classification of Lipids

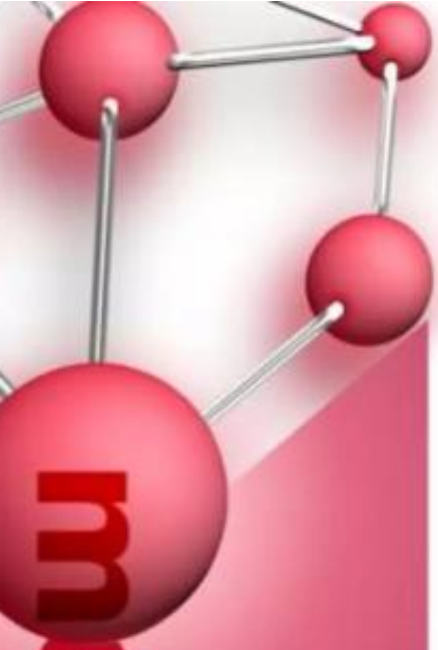


molecule

Simple Lipids

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

1. Fats
2. Waxes



Fats

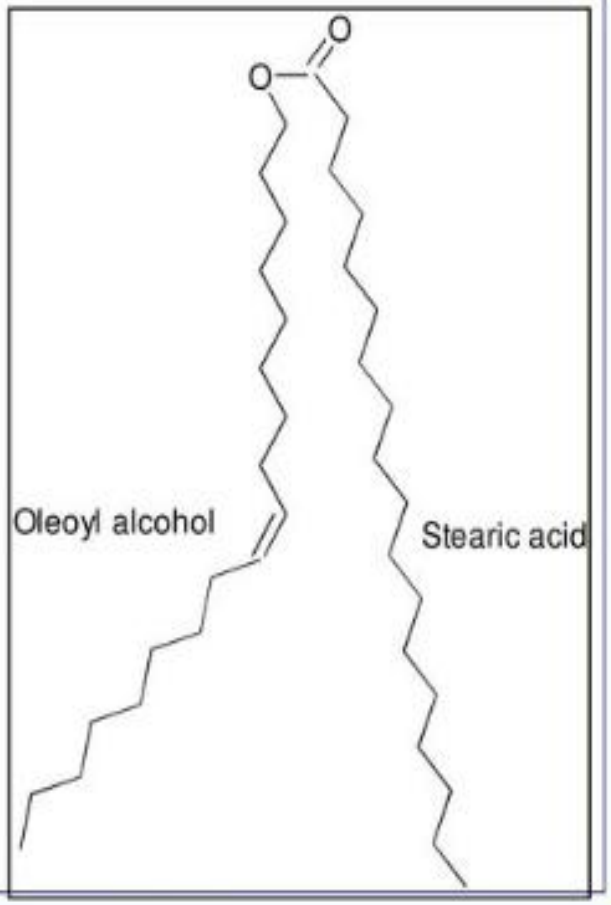
- Esters of fatty acids with glycerol.
- Solid at room temperature.
- Some are liquid at room temperature, and are known as oils.
- Physical state depends upon the nature of fatty acids.
- Fats are rich in saturated fatty acids.
- Oils are rich in unsaturated fatty acids.

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.

Waxes

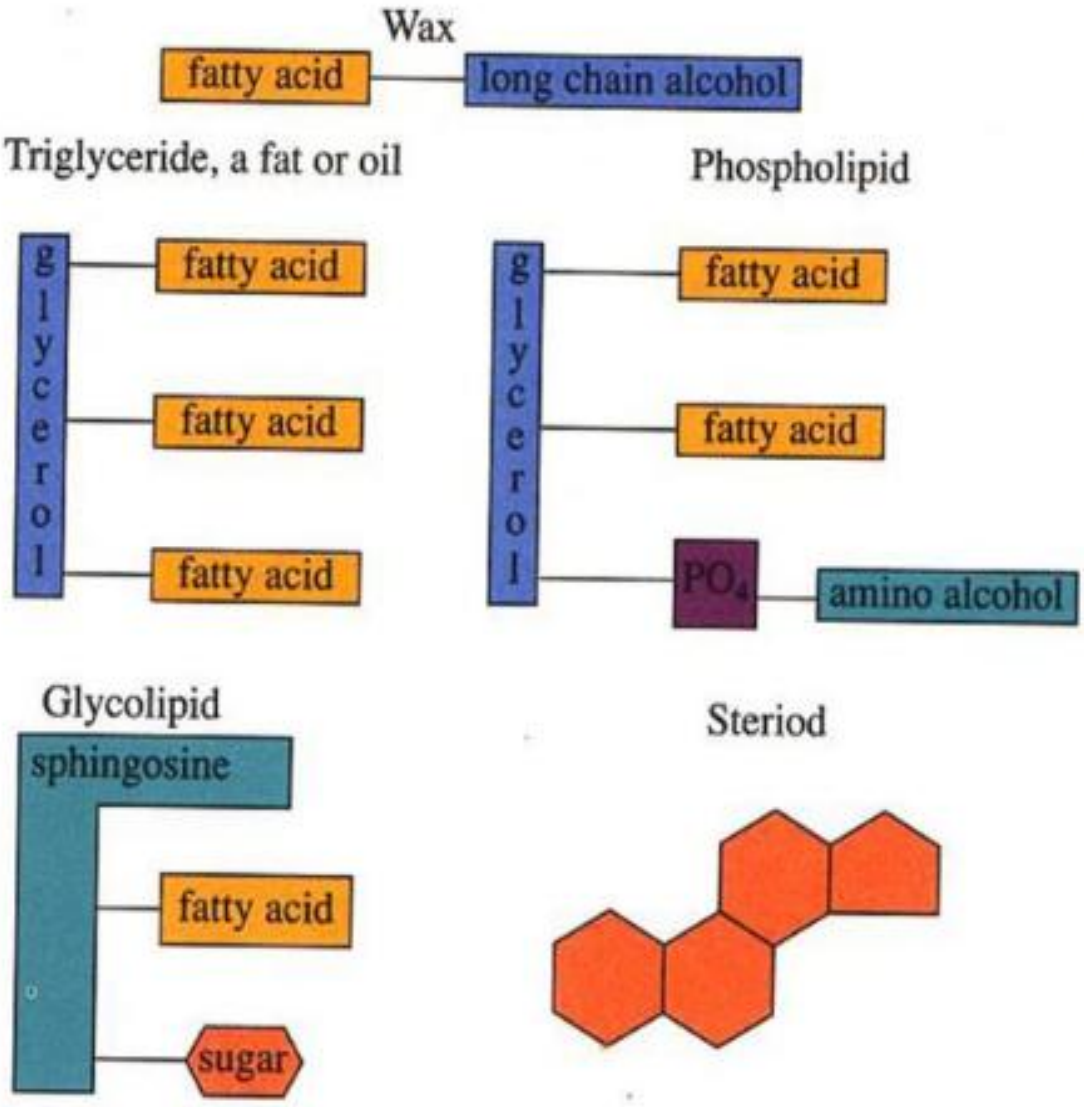
- Esters of long chain fatty acids
  - (C14-36) with long chain
  - (C16-30) alcohols
  - High melting points (60-100°C)
- Energy storage
  (Plankton, 浮游生物)
- Water repellant
  (birds and plants)

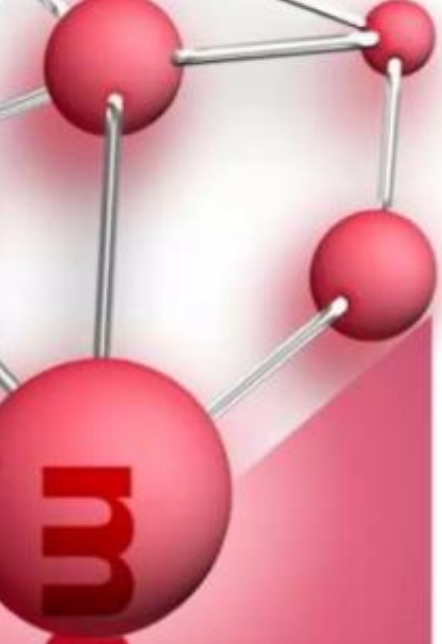


Classification of Lipids

- Waxes: fatty acid + a long-chain alcohol
- Triglycerides (fats & oils): glycerol + 3 fatty acids
- Phospholipids: glycerol + 2 fatty acids + phosphate + amino alcohol
- Glycolipids: glycerol or spinogosine + fatty acid + monosaccharide
- Steroids: 3 cyclohexanes + 1 cyclopentane fused together

Family of Lipids



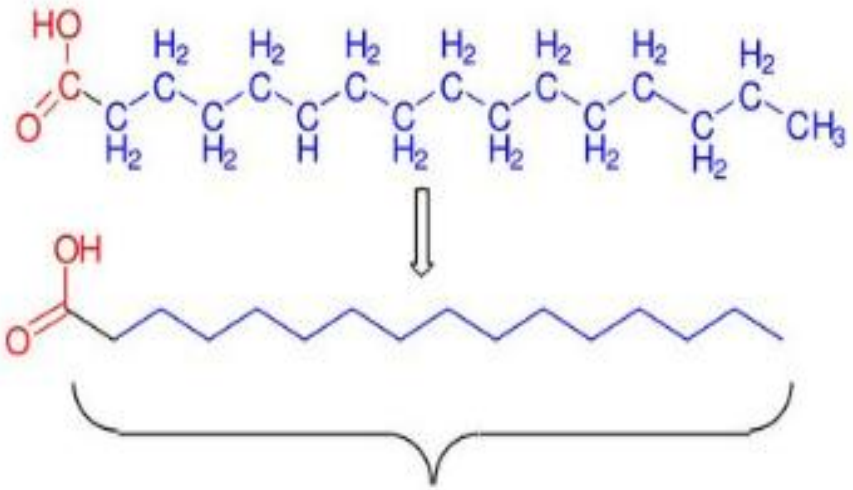


Fatty acids

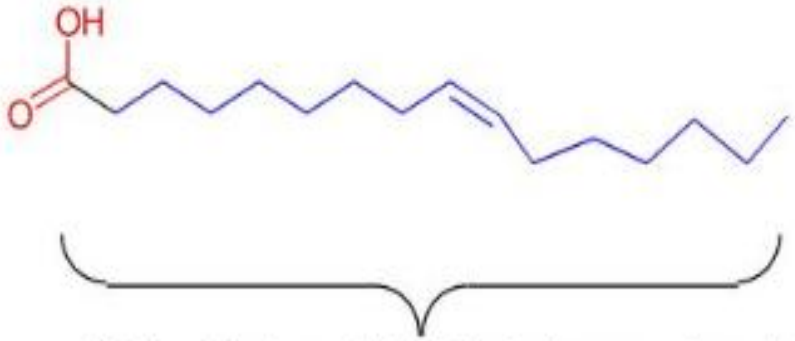
- Fatty acids are carboxylic acids with hydrocarbon side chain.
- The are the simplest form of lipids.

Fatty Acids

Fatty acids = carboxyl group + a long hydrocarbon chain



16:0 =Palmitic Acid=Hexadecanoic acid



18:1 =Oleic acid=9-Octadecenoic acid

Saturated fatty acids are single bonds in all carbon-carbon bonds;
Unstaurated fatty acids contain one or more double bonds in hydrocarbon chains;

Classification of Fatty Acids

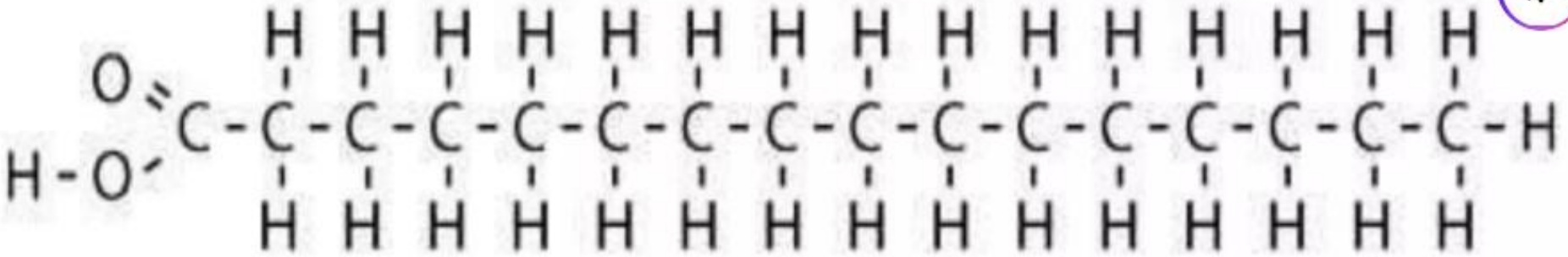
Saturated Fatty Acids

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

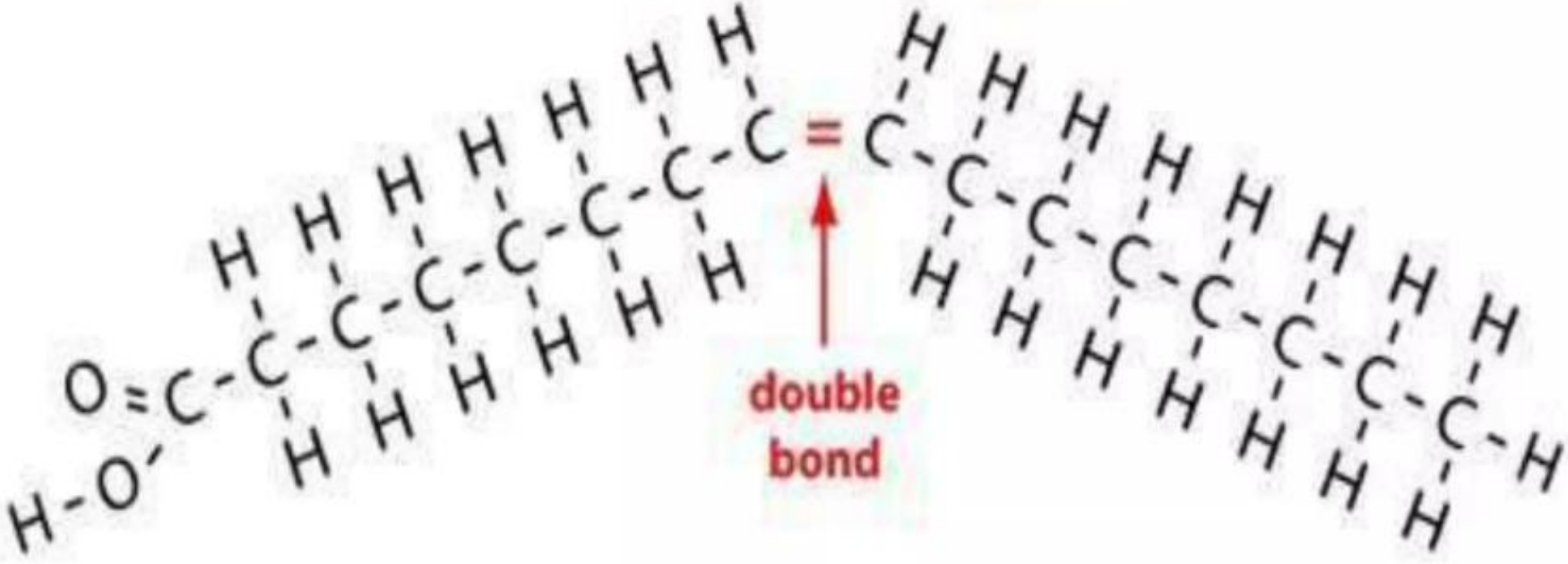
Unsaturated Fatty Acids

- 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

saturated fatty acid

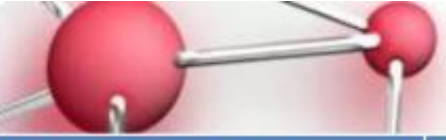


unsaturated fatty acid



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	$CH_3(CH_2)_{12}COOH$



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.

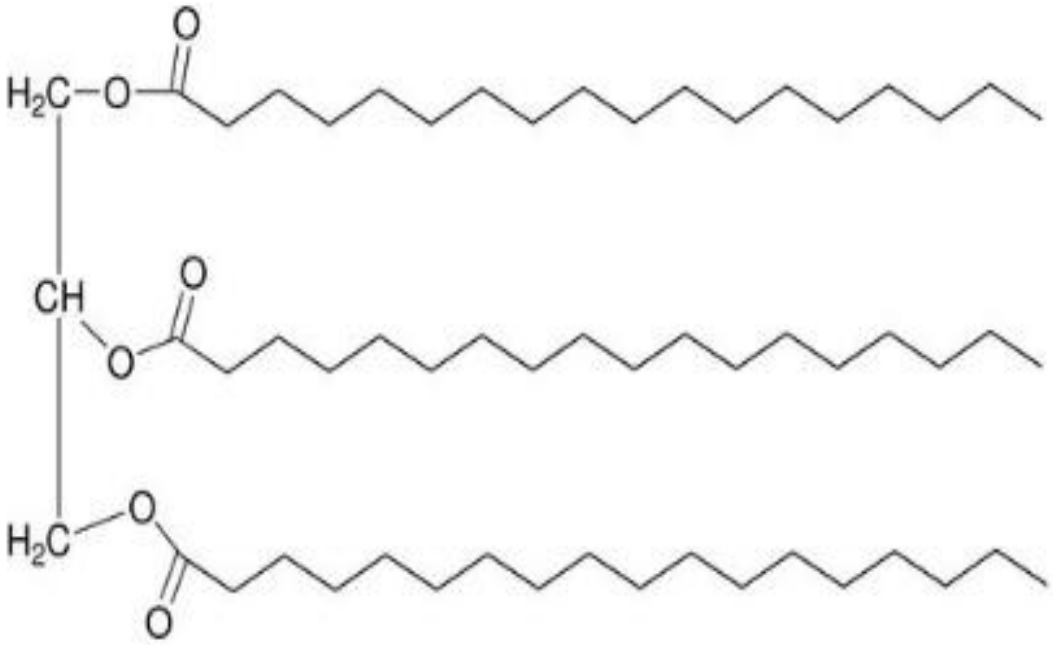
Function of Triglycerides (Fat)

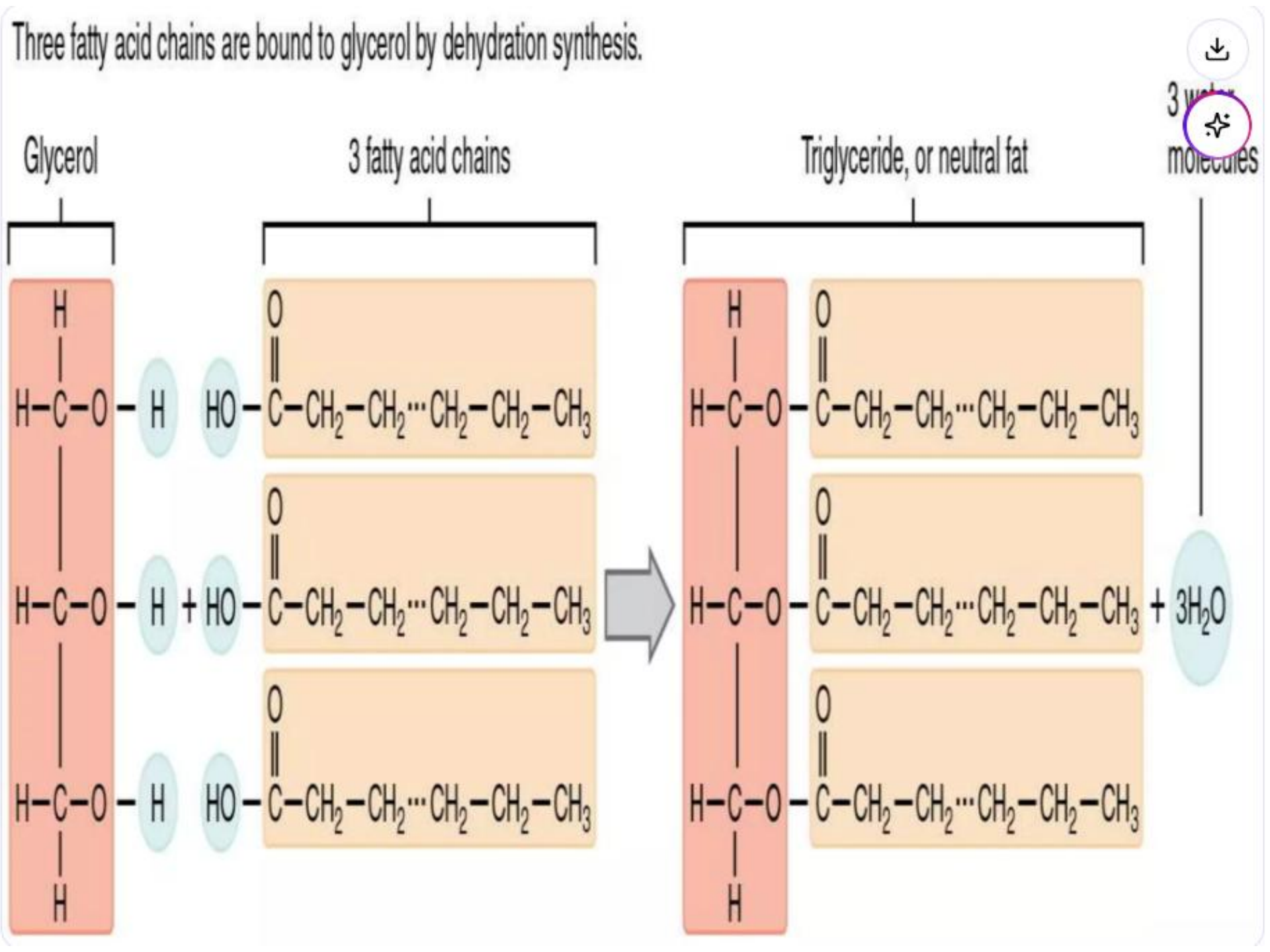
- Major lipid in the body and diet
- Stored fat provides about 60% of the body's resting

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

Triglycerols (triglycerides)

- Triglycerols consist of a glycerol esterified with three fatty acids
- If all fatty acid chains are the same, the molecule is called triacylglycerol (e.g., tristearin)

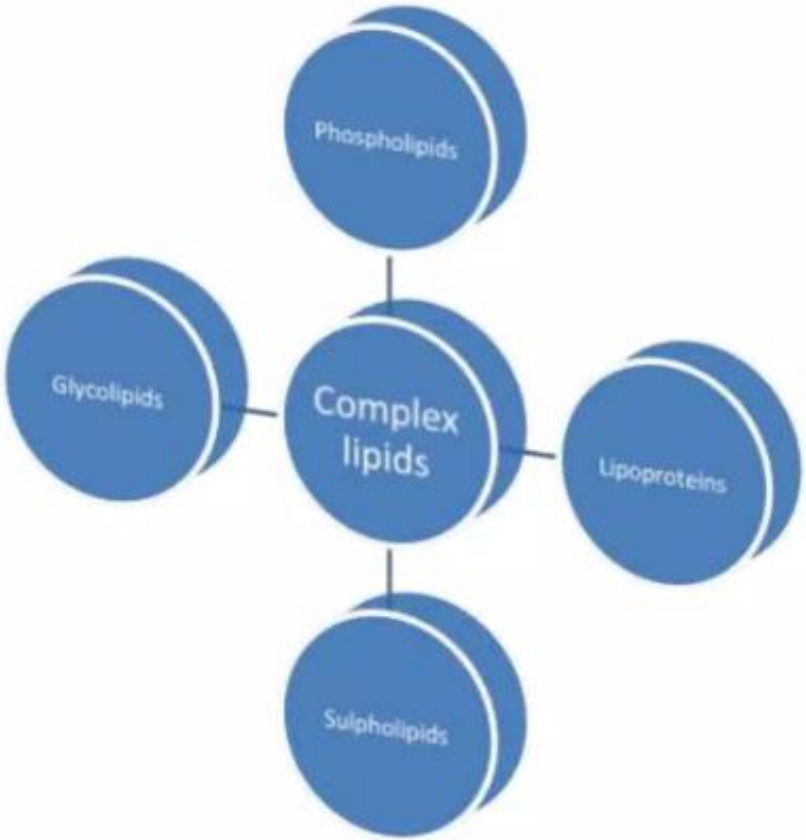


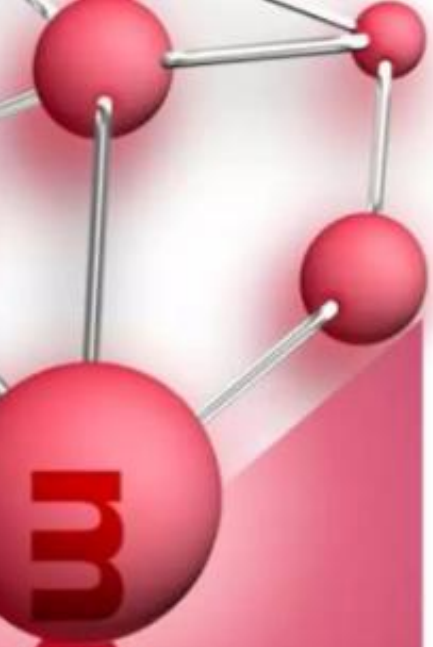

Three fatty acid chains are bound to glycerol by dehydration synthesis.
Glycerol
3 fatty acid chains
Triglyceride, or neutral fat
3 water molecules
+ 3H2O

Complex Lipids

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

Classification Of Complex Lipids





Phospholipids

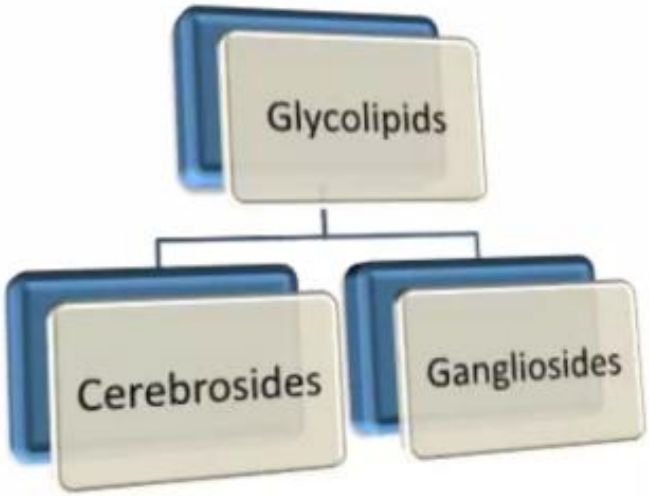
- Made up of fatty acids, an alcohol, phosphoric acid and a nitrogenous base.
- Some examples are lecithin, cephalin and sphingomyelin

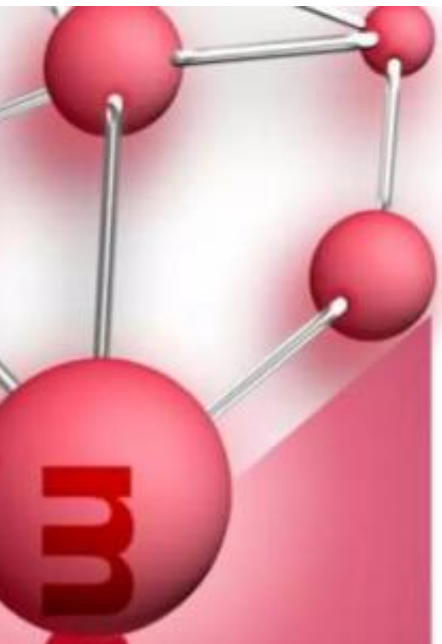
Functions

- 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

Glycolipids

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

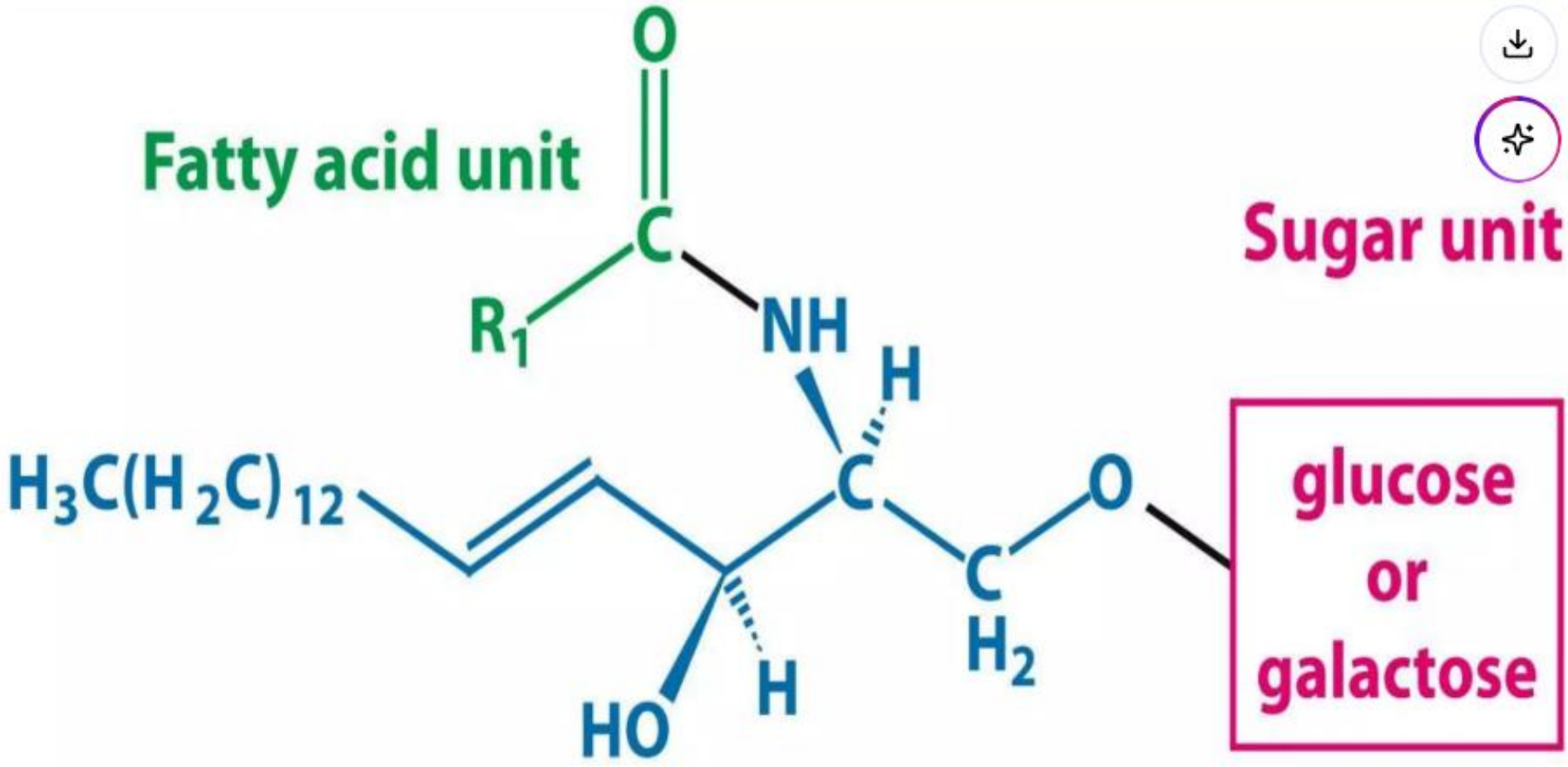




Cerebrosides

- Cerebrosides are made up of:

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



Sugar unit

Cerebroside
(a glycolipid)

Unnumbered 12 p350a
Biochemistry, Seventh Edition

Gangliosides

- **Gangliosides are made up of:**

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

Natural Glycolipids

Ceramide

Ganglioside: GM3

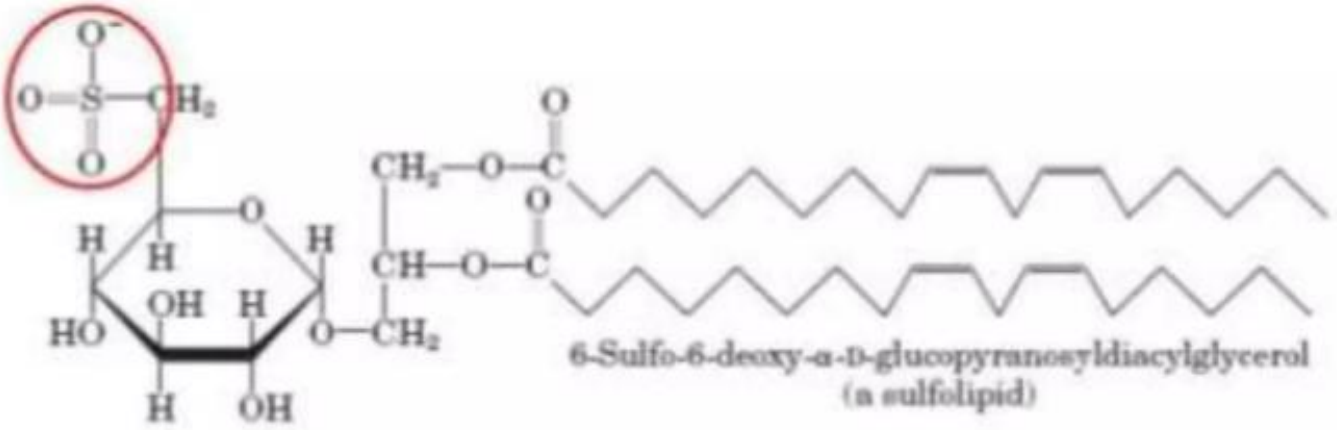
Ganglioside: GM1

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.

Sulfolipids



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

Derived Lipids

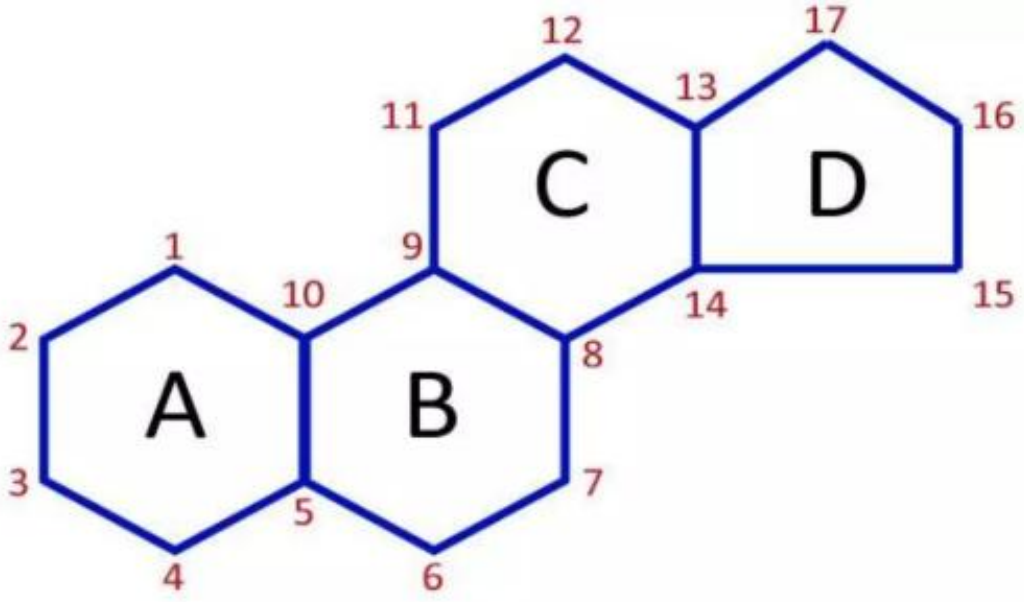
- These compounds which obtained on hydrolysis of simple and compound lipids.
- Possessing properties of lipids.
- Examples are fatty acids, higher alcohols, sterols, steroids, hydrocarbons etc.

Steroids

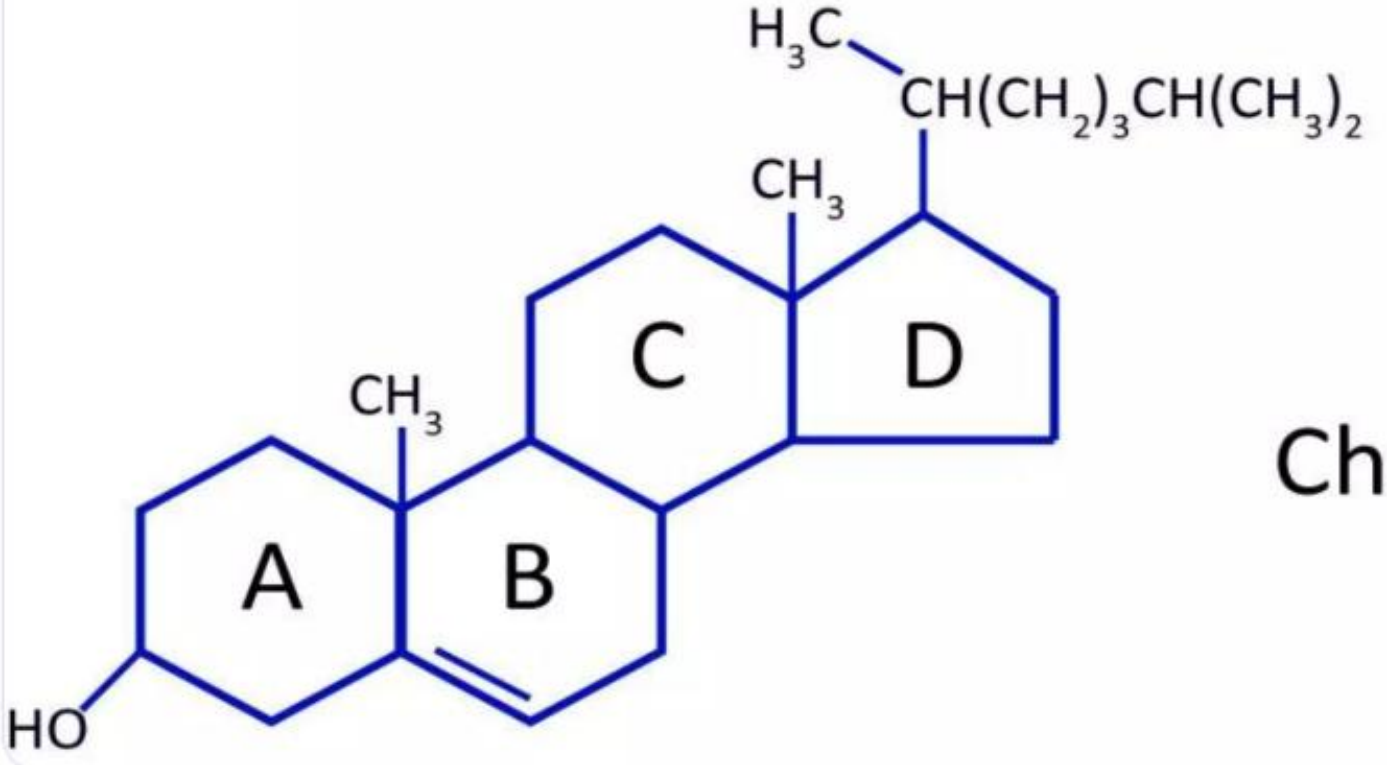
- **Steroids** are lipids containing a steroid nucleus (core structure).
- The **steroid nucleus** is a fused ring system consisting of three cyclohexane rings and one cyclopentane ring.
- The rings are designated A, B, C and D.
- Attachment of different groups to the core steroid structure leads to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

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.



Steroid skeleton



Cholesterol

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

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**

Functions of Lipids

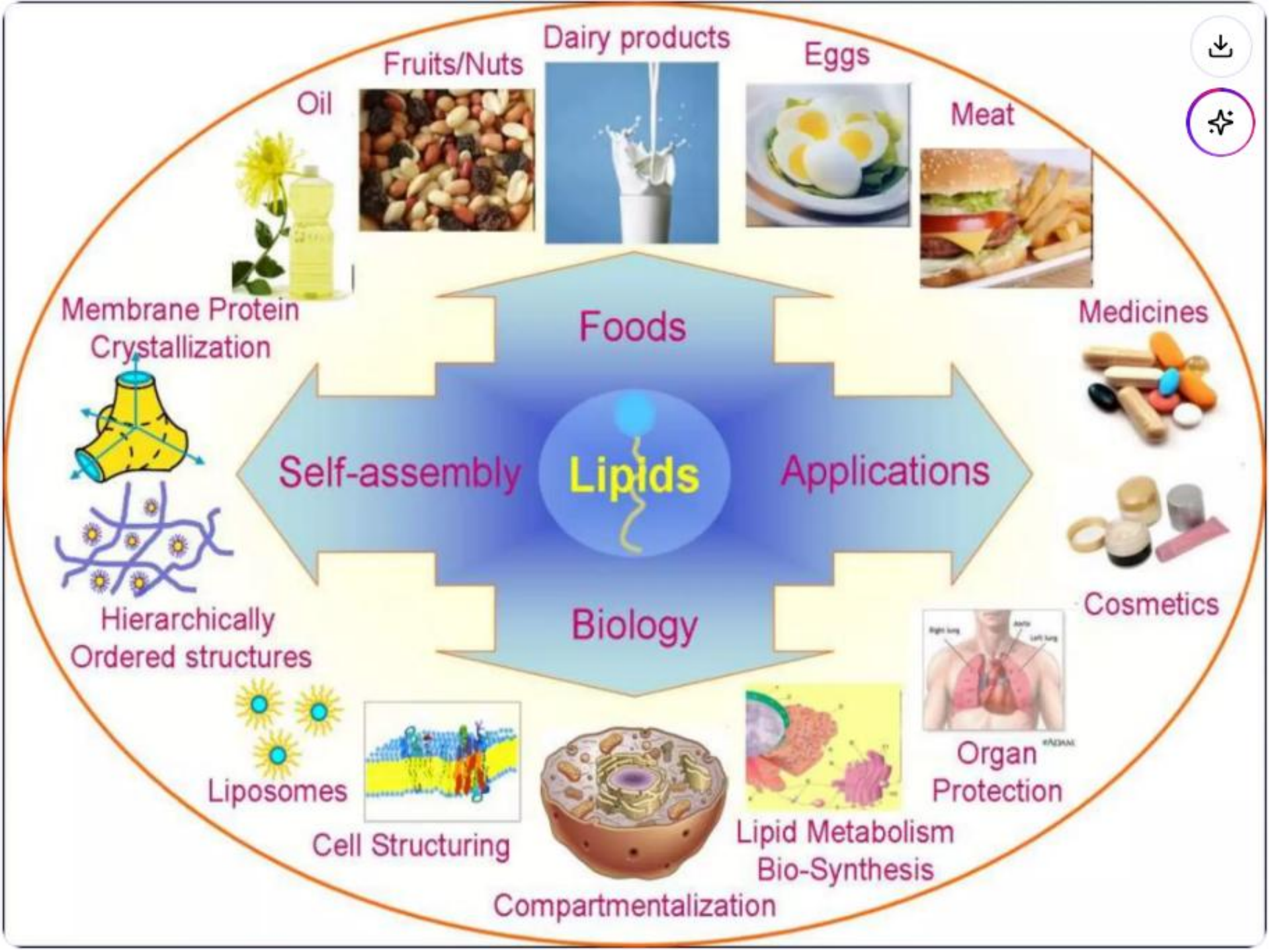
- Storage form of energy.
- Important dietary components because of their high energy value and also because of the fat soluble vitamins and the essential fatty acids contained in the fat of natural foods.
- Structural components of cell membranes
- Serve as thermal insulators in the subcutaneous tissues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

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.

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)


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

THANK YOU