DEPARTMENT OF BIOTECHNOLOGY

LIPIDS & IT's CLASSIFICATION.

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INTRODUCTION

- The word lipid is derived from a Greek word "lipos" which means Fat.
- Biological lipids are a chemically diverse group of organic compounds which are insoluble in water.
- They are soluble in non-polar solvents such as- ether, chloroform, or benzene.
- Lipids are hydrophobic in nature due to the predominance of hydrocarbon chains.(-CH_2-CH_2-CH_2-) in their structures.

- Unlike the proteins, nucleic acids, and polysaccharides, lipids are not polymer.
- They are the chief storage form of energy, they provide 6-fold as much energy as an equivalent mass of glycogen.
- Fat and oils are the principle stored forms of energy in many organism.
- Lipids participate in oxidative phosphorylation.

- neutral lipids upon hydrolysis yield glycerol and fatty acids
- Many lipid molecules are amphipathic.
- In aqueous environment lipid molecules associate by non-covalent interactions to form supramolecular structures such as monolayers, micelles, bilayers and vesicles.

DEFINITION

Lipids may be regarded as organic substances relatively insoluble in water, soluble in organic solvents, potentially related to fatty acids and utilized by the living cells.

FUNCTIONS OF LIPIDS

- They serve as a storage form of metabolic fuel.

  (fatty acid, Triacyglycerol).
- they serve as a transport form of metabolic fuel.(free fatty acid, triglyceride and cholesterol ester)
- They provide the structural components of membranes(phospholipids, glycolipids, galactolipids, sphingolipids)

- they have protective functions in bacteria, plants, insects, and vertebrates, serving as a part of the outer coating between the body of the organism and the environment.
- It serve as pigment(carotene), hormones(vitamin A & D), signaling molecules(eicosanoids, phosphatidylinositol, steroid hormone) cofactors(vitamin E, K and lipid quinones) detergent(bile salt).

CLASSIFICATION OF LIPIDS

CLASSIFICATION BASED ON THEIR CHEMICAL COMPOSITION

A. Simple lipids or **Homolipids.** These are esters of fatty acid with various alcohols.

B. Compound lipids or **Heterolipids.** These are esters of fatty acids with alcohol and possess additional group(s) also.

C. Derived lipids. These are the substances derived from simple and compound lipids by hydrolysis.

SIMPLE LIPIDS

Chapter Outline

Simple Lipids

The simple lipids include fats, oils, and waxes. These simple lipids are derivatives of lipid-like substances call fatty acids.

Fatty acids are long-chain carboxylic acids *(generally greater than about 12 carbons)* that have no solubility in water.

The hydrophilic -COOH group is referred to as a polar head and the hydrophobic hydrocarbon portion is referred to as a nonpolar tail.

COMPOUND LIPIDS

II. Compound lipids

- They are fatty acids esterified with alcohol; but in addition they contain other groups.
- Depending on these extra groups, they are sub-classified as:

a. **Phospholipids containing phosphoric acid.**

b. **Nonphosphorylated lipids.**

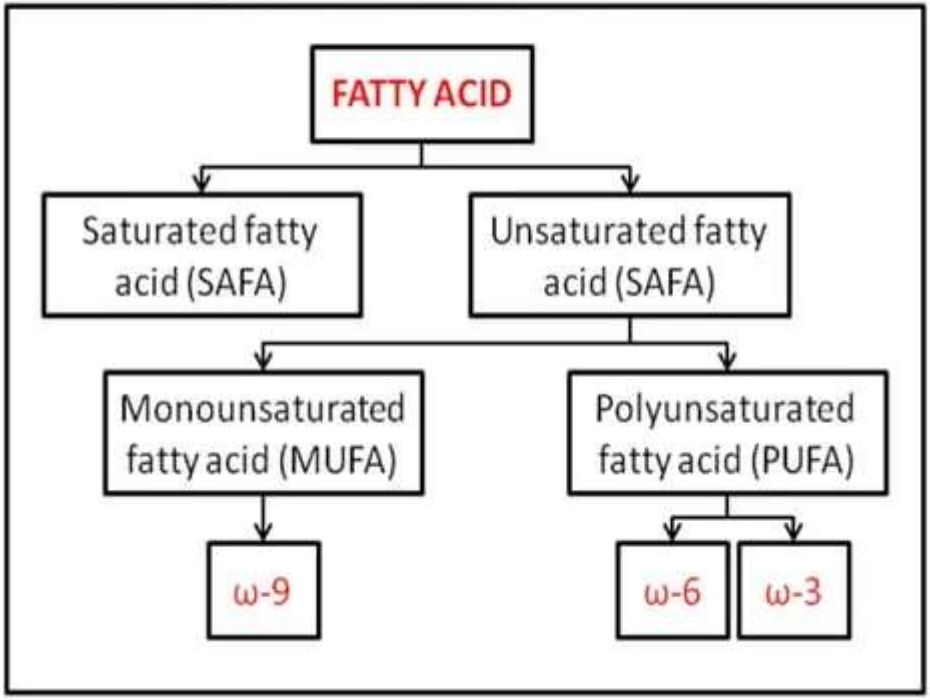
DERIVED LIPIDS

- Derived lipids are the substances derived from simple and compound lipids by hydrolysis.
- These includes fatty acids, alcohols, monoglycerides and diglycerides, steroids, carotenoids.

FATTY ACIDS

- Fatty acids are the simplest form of lipids.
- These are monocarboxylic, straight, unbranched hydrocarbon chains containing even number of carbon atoms (betweeen 4-36)
- Fatty acids are also known as acyl group when it is a part of ester.
- Fatty acids are amphipathic in nature.
- The fatty acids may be free or esterified with glycerol to form triglycerides.

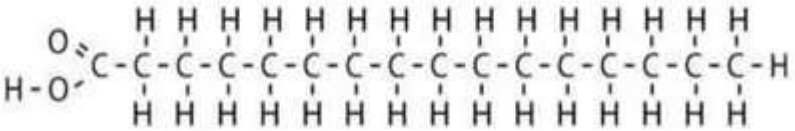
TYPES OF FATTY ACID



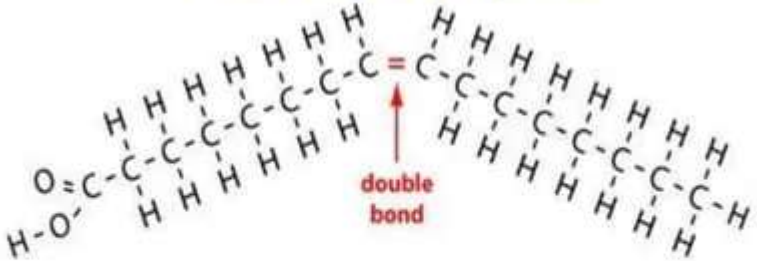
SATURATED FATTY ACID

- Saturated fatty acids have no double bonds in the chain or contain single chain.
- Their general formula is CH_3-(CH_2)n-COOH, where n specifies the number of methylene groups between the methyl and carboxyl carbons.
- They have higher melting points
- They are solid at room temperature.
- Examples- lauric, myristic, palmitic acid etc.

saturated fatty acid



unsaturated fatty acid



UNSATURATED FATTY ACID

- These fatty acid contain one or more double bonds along the length of the hydrocarbon chain.
- They are liquid at room temperature.
- Have low melting point.
- The commonly used system for designating the position of double bond in unsaturated fatty acid is the delta(Δ) numbering system.
- Example- linoleic acid, oleic acid, palmitoleic acid.
- In the naturally occurring unsaturated fatty acid the double bond are in cis configuration and trans fatty acid are produced by fermentation in the rumen of dairy animals and are obtained from dairy products and meat.

TYPES OF UNSATURATED FATTY ACID (BASED UPON THE NO. OF DOUBLE BOND PRESENT)

Monounsaturated fatty acid :-

- They contain only one double bond per fatty acid.
- The double bond is between C-9 and C-10(Δ^9)

Polyunsaturated fatty acid or PUFAs:-

- They contain two or more double bonds along the length of the hydrocarbon chains.
- PUFAs are also known as essential fatty acid.
- Examples- linoleic and linolenic acid

Saturated Fat

meats, butter, dairy products

solid at room temperature

increase levels of **"bad"** cholesterol (low-density lipoprotein)

low-density lipoprotein **clogs arteries**

Unsaturated Fat

vegetable oils

liquid at room temperature

increase levels of **"good"** cholesterol (high-density lipoprotein)

high-density lipoprotein, or HDL, "grabs" LDL and escorts it to the liver where **LDL is broken down and eventually removed from the body**

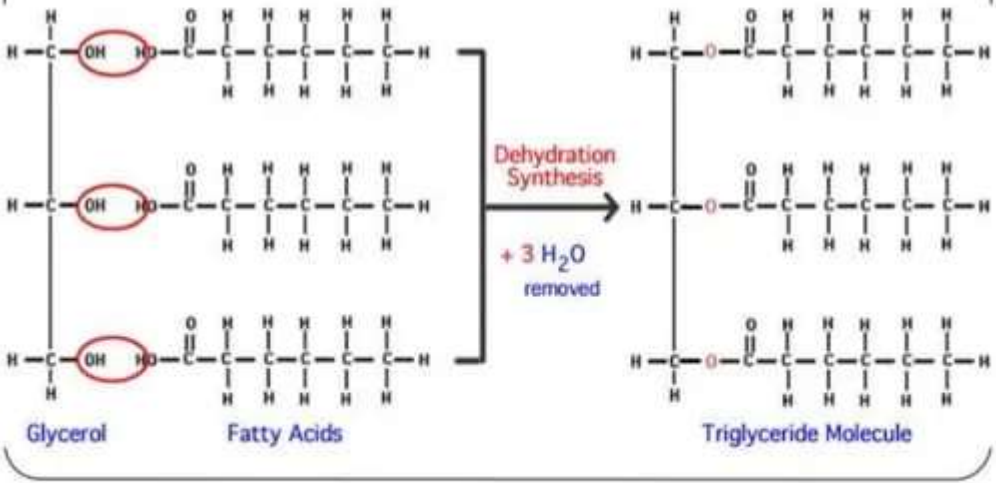
TRIACYLGLYCEROL

- Triacylglycerol(triglycerides/fats/neutral fats) are triesters of fatty acids and glycerol.
- They are composed of three fatty acids and a glycerol molecules.
- Triacylglycerols are of two types-

a) Simple- these contains single type of fatty acids.

b) Mixed- contains two or more different kind of fatty acid.

- Triacylglycerol are esters of glycerol with fatty acids



- Triacylglycerols are nonpolar, hydrophobic in nature and a major form of stored lipids.
- These molecules contain fatty acids of various length and they be saturated or unsaturated.
- They can be distinguished as fat and oil on the basis of physical state at room temperature.

REACTIVITIES

- **Saponification :-**

Fats when boiled with alkali(NaOH, KOH) or hydrolysis with alkali forms soap and are called saponification.

- **Rancidity:-**

The fats turns rancid when exposed to air. it is unsuitable for human consumption.

Esterification:-

Carboxyl group of fatty acid is esterified when reacts with alcohol, resulting in an ester.

Hydrogenation:-

Double bonds on unsaturated fatty acids

Can be oxidised or hydrogen can be added to them in the presence of a catalyst(nickel, platinum).

FUNCTIONS OF TRIACYLGLYCEROLS

I. Triacylglycerols provide stored energy
II. It also provides insulation.
III. Partial hydrogenation of cooking oils produces trans Fatty acids.

PHOSPHOLIPIDS

- A phospholipids is an amphipathic molecule constructed from four components: fatty acids, phosphate, alcohol and glycerol or sphingosine.
- Also called as phosphatides, contains a phosphorous atom.
- The phospholipids are very important structural components of all cell membranes including those of the cell organelles.
- Lecithin may also play an important role in transport of ion across the membranes.

- Phospholipids are of different kinds but all of them contain a glyceryl residue to which are attached in ester linkage two long chain fatty acid and a phosphorylated component.
- Sometimes phospholipid grouped under ‘polar lipid’ because they are readily soluble in polar solvents such as ethanol.
- Phospholipids can be broken down to their residue by the enzyme phosphatidases which hydrolyse their fatty acids and phosphoric acid ester bonds specifically.

DEPENDING UPON THE TYPE OF PHOSPHORYLATED COMPONENT OF THE PHOSPHOLIPIDS, CLASSIFIED AS:-

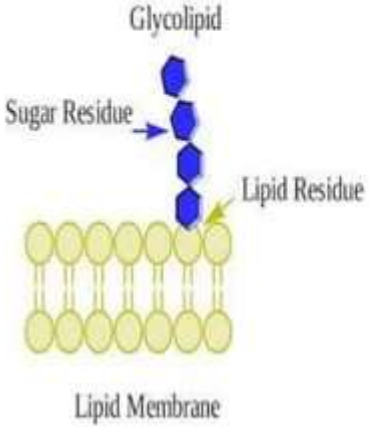
- Phosphatidyl choline(lecithin)- this phospholipid has nitrogen containing choline in its phosphorylated component.
- Phosphatidyl lethanolamine(cephalin)- the phosphorylated component contains ethanolamine.
- Phosphatidyl linositol- this phospholipid contains hexahydric alcohol called inositol in its phosphorylated component.

- Phosphatidyl glycerol- this has glycerol in its phosphorylated component.
- Diphosphatidylglycerol(cardiolipin)- it consist of two glycerol residues with their usual esterified fatty acid chains. Both these residues in turn are linked to a common glycerol molecule which is phosphorylated on both of its side.

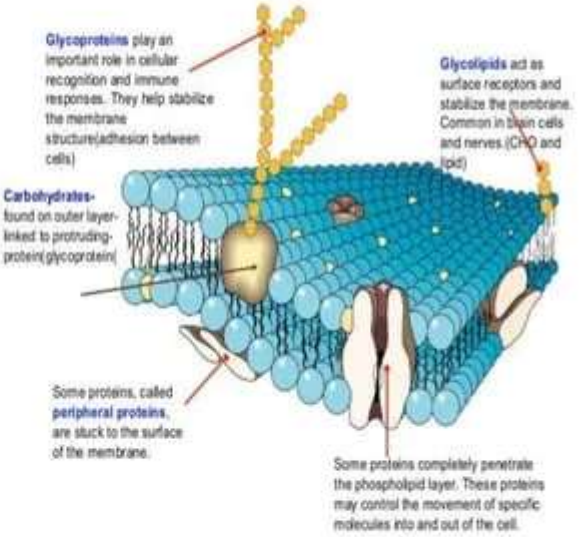
GLYCOLIPIDS

I. OVERVIEW

- Glycolipids are molecules that contain both carbohydrate and lipid components. Like the phospholipid sphingomyelin, glycolipids are derivatives of ceramides in which a long-chain fatty acid is attached to the amino alcohol sphingosine. They are, therefore, more precisely called glycosphingolipids. Like the phospholipids, glycosphingolipids are essential components of all membranes in the body, but they are found in greatest amounts in nerve tissue. They are located in the outer leaflet of the plasma membrane, where they interact with the extracellular environment. As such, they play a role in the regulation of cellular interactions (for example, adhesion and recognition), growth, and development.



Membrane Structure



Types of Glycolipid

1. **Cerebrosides**-Cerebroside (from cerebro=brain) are glycolipids that are found primarily in the brain and peripheral (other areas of the body) nervous tissue.

Function:

Provide protective coating to each nerve and act as insulator.

Types of Lipid

2. Gangliosides- These glycolipids (glycosphingolipids) are neutral (uncharged). The gangliosides are acidic in pH and they are the more complex of the glycolipids.

Type of Lipid

3. Sulfoglycosphingolipids-These cerebrosides are also called sulfatides, They are simply cerebrosides with a sulfate residue on the sugar portion of glycolipid.

Ocurrance:

this particular lipid is found primarily in the medulated nerve fibres.

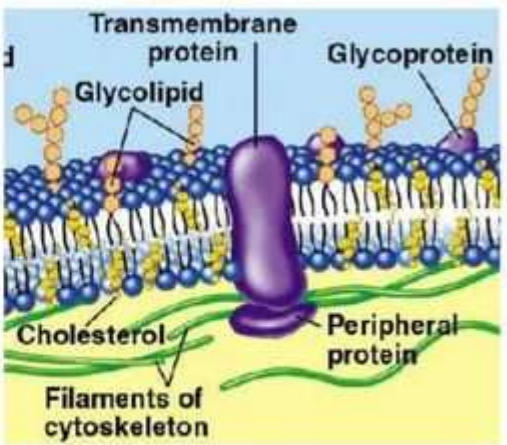
Functions of Glycolipid

- The glycolipids are an essential part of cell membranes.
- Glycolipids also help determine the blood group of an individual.
- Glycolipids act as receptors at the surface of the red blood cell.
- some viruses, bacteria (eg., cholera) use glycolipids on their cell surface as well. This helps the immune system destroy and clear the pathogen from the body.

Membrane Carbohydrates

- Attached to proteins (glycoproteins) or lipids (glycolipids)

- Play a key role in cell-cell recognition
  - ability of a cell to distinguish neighboring cells from another
  - important in organ & tissue development
  - basis for rejection of foreign cells by immune system

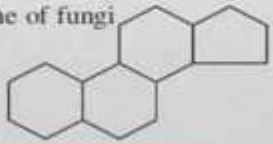


http://faculty.southwest.tn.edu/rbarkett/GB1-osmosis.htm

STEROLS

- Sterol
  - also known as steroid alcohols
  - occur naturally in **plants, animals, and fungi, with the most familiar type of animal sterol being cholesterol**
  - TYPES:
    - Phytosterols – plant sterol (campesterol, sitosterol, and stigmasterol)
      - blocks cholesterol absorption sites in the human intestine, thus helping to reduce cholesterol in humans
    - Zoosterol – animal sterol (cholesterol)
    - Ergosterol – sterol present in the cell membrane of fungi

STEROL




STEROL
HO

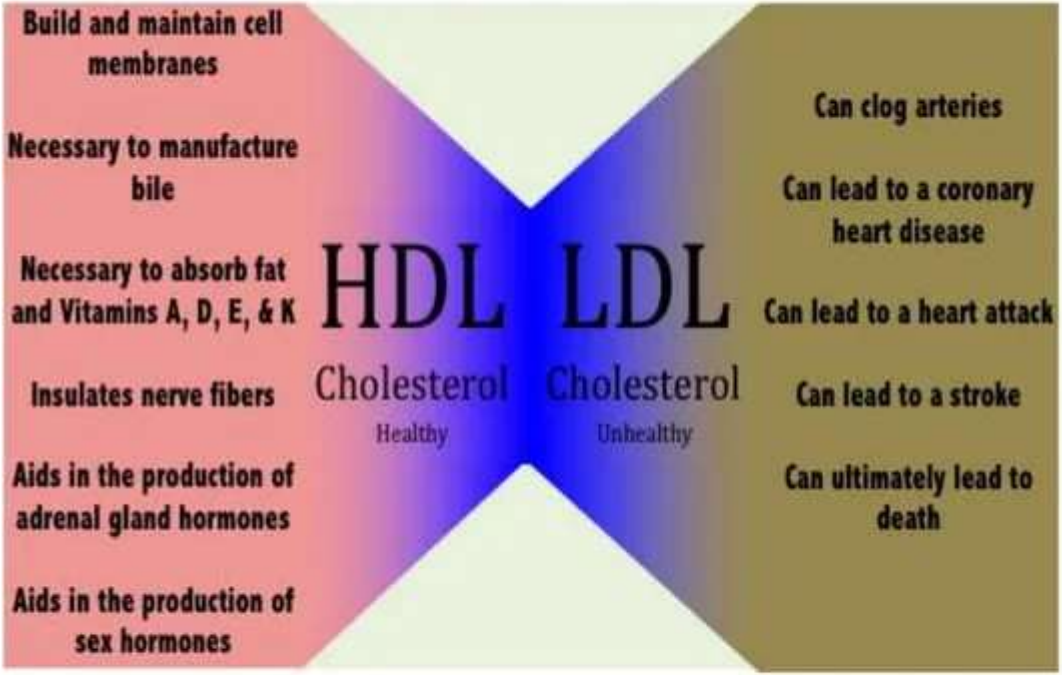
STRUCTURE

- It is a subgroup of steroids with a hydroxyl group at the 3- position of the A- ring. And the hydroxyl group is polar, and rest of the aliphatic chain is non-polar.
- They are amphipathic lipid synthesized from acetyl-coenzyme A via the HMG-CoA reductase pathway.
- The overall molecule is quite flat

ROLE OF STEROLS

- Cholestrol forms part of the cellular membrane in animals and serve as secondary messenger in developmental signaling.
- Cortisol act as signaling compound in cellular communication and general metabolism.
- It is common component of human skin oils.

- Sterols functions as a precursor to fat soluble vitamins and steroid hormones.
- cholesterol is vital to cell membrane.


Build and maintain cell membranes
Necessary to manufacture bile
Necessary to absorb fat and Vitamins A, D, E, & K
Insulates nerve fibers
Aids in the production of adrenal gland hormones
Aids in the production of sex hormones
HDL
LDL
Cholesterol
Healthy
Cholesterol
Unhealthy
Can clog arteries
Can lead to a coronary heart disease
Can lead to a heart attack
Can lead to a stroke
Can ultimately lead to death

REFERENCES

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- S.C.RASTOGI, 2003, OUTLINES OF BIOCHEMISTRY. PAGE NO-53-59.

Thank you