SBT1102 – BIOCHEMISTRY

UNIT 1 CARBOHYDRATES

Introduction. Classification, Properties and Biological importance. Isomers, epimers, enantiomers,mutarotation, open chain and closed chain structures of glucose.

UNIT 2 AMINOACIDS AND PROTEINS

Aminoacids: classification- essential and non-essential amino acids, protein and nonprotein amino acids, Zwitter ions. Proteins: Classification- based on i) shape and solubility and ii) increasing complexity of structure. Structure of proteins: primary, secondary, tertiary and quaternary, biological significance. Concept of isoelectric point and its significance.

UNIT 3 LIPIDS

Introduction, Classification, Properties and Biological importance. Fatty acid nomenclature and structure, Lipids in cell membrane Cholesterol and Steroids, Hormones - structure and function

UNIT 4 NUCLEIC ACIDS

Introduction- Nitrogeneous bases - Purines and Pyrimidines - Nucleosides and Nucleotides -- Structure of nucleic acids - DNA, RNA: m-RNA, t-RNA, r-RNA - Biological importance of nucleic acids. 16s rRNA and its significance.

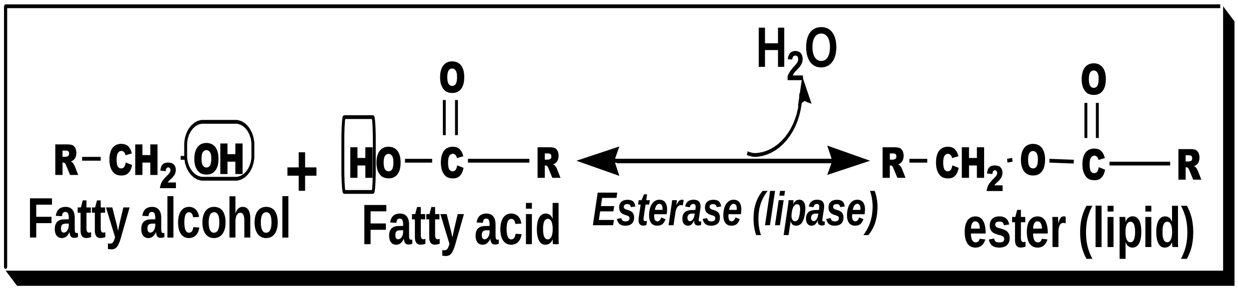
UNIT 5 VITAMINS AND MINERALS

Vitamins: fat soluble and water soluble vitamins. Minerals: Micro and Macro minerals. Biological importance of vitamin and minerals, deficiency symptoms

LIPDS

Definition

Lipids are organic compounds formed mainly from alcohol and fatty acids combined together by ester linkage.



- Lipids are insoluble in water, but soluble in fat or organic solvents (ether, chloroform, benzene, acetone).
- Lipids include fats, oils, waxes and related compounds.
- They are widely distributed in nature both in plants and in animals.

Biological Importance of Lipids

1. They are more palatable and storable to unlimited amount compared to carbohydrates.
2. They have a high-energy value (25% of body needs) and they provide more energy per gram than carbohydrates and proteins but carbohydrates are the preferable source of energy.
3. Supply the essential fatty acids that cannot be synthesized by the body.
4. Supply the body with fat-soluble vitamins (A, D, E and K).
5. They are important constituents of the nervous system.
6. Tissue fat is an essential constituent of cell membrane and nervous system. It is mainly phospholipids in nature that are not affected by starvation.

7. Stored lipids “depot fat” is stored in all human cells acts as:
   - A store of energy.
   - A pad for the internal organs to protect them from outside shocks.
   - A subcutaneous thermal insulator against loss of body heat.
8. Lipoproteins, which are complex of lipids and proteins, are important cellular constituents that present both in the cellular and subcellular membranes.
9. Cholesterol enters in membrane structure and is used for synthesis of adrenal cortical hormones, vitamin D3 and bile acids.
10. Lipids provide bases for dealing with diseases such as obesity, atherosclerosis, lipid-storage diseases, essential fatty acid deficiency, respiratory distress syndrome,

Classification of Lipids

Bloor (1943) has proposed the following classification of lipids based on their chemical composition.

I. Simple lipids or Homolipids.

These are esters of fatty acid with farious alcohols.

1. Fats and oils (triglycerides, triacylglycerols).These are esters of fatty acids with a trihydroxy alcohol, glycerol. A fat is solid at ordinary room temperature wheras an oil is liquid.

2. Waxes. These are esters of fatty acids with high molecular weight monohydroxy alcohols.

II. Compound lipids or Heterolipids.

These are esters of fatty acids with alcohol and possess additional group(s). e.g., sulfur, phosphorus, amino group, carbohydrate, or proteins beside fatty acid and alcohol.

Compound or conjugated lipids are classified into the following types according to the nature of the additional group

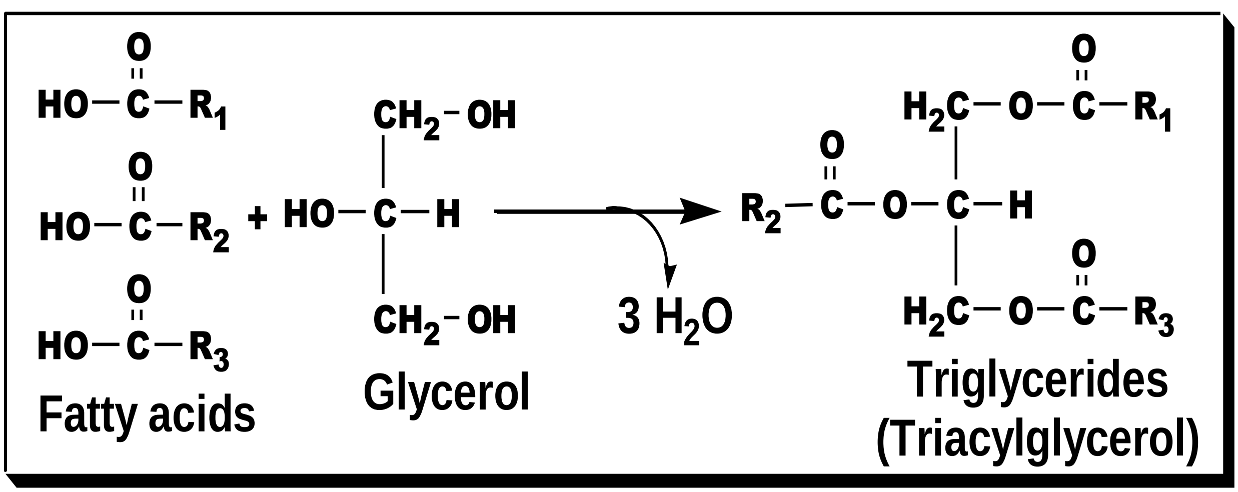
1. Phospholipids
2. Glycolipids.
3. Lipoproteins
4. Sulfolipids and amino lipids.

III. Derived lipids.

These are the substances derived from simple and compound lipids by hydrolysis. These include fatty acids, alcohols, mono- and diglycerides, steroids, terpenes and carotenoids.

Simple Lipids

- They are called neutral because they are uncharged due to absence of ionizable groups in it.
- The neutral fats are the most abundant lipids in nature. They constitute about 98% of the lipids of adipose tissue, 30% of plasma or liver lipids, less than 10% of erythrocyte lipids.
- They are esters of glycerol with various fatty acids. Since the 3 hydroxyl groups of glycerol are esterified, the neutral fats are also called “Triglycerides”.
- Esterification of glycerol with one molecule of fatty acid gives monoglyceride, and that with 2 molecules gives diglyceride.

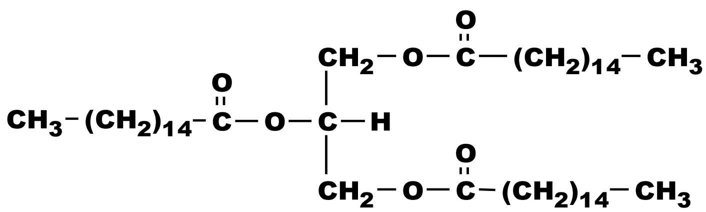


Types of triglycerides

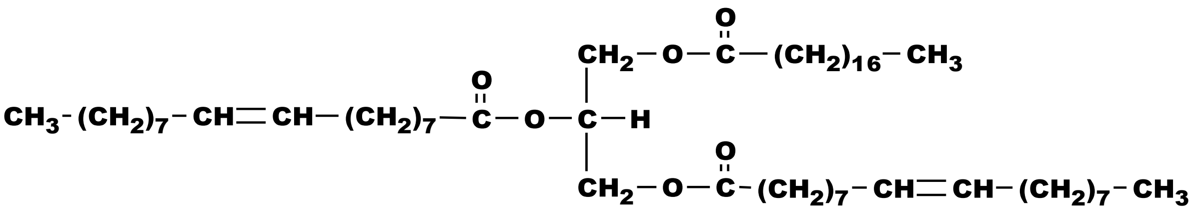
1. Simple triglycerides: If the three fatty acids connected to glycerol are of the same type the triglyceride is called simple triglyceride, e.g., tripalmitin.

2. Mixed triglycerides: if they are of different types, it is called mixed triglycerides, e.g., stearo-diolein and palmito-oleo-stearin.

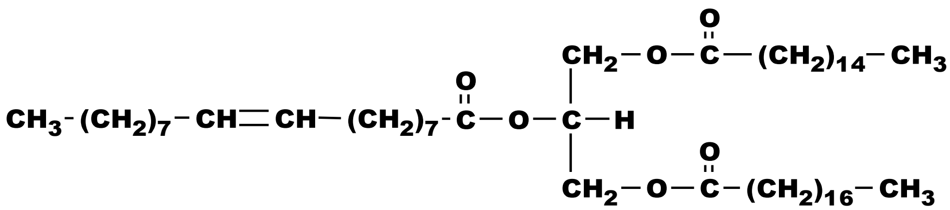
- Natural fats are mixtures of mixed triglycerides with a small amount of simple triglycerides.



Tripalmitin
(simple triacylglycerol)



1-Stearo-2,3-diolein
(mixed triacylglycerol)



1-palmito-2-oleo-3-stearin
(mixed triacylglycerol)

- The common fatty acids in animal fats are palmitic, stearic and oleic acids.

- The main difference between fats and oils is for oils being liquid at room temperature, whereas, fats are solids.

- This is mainly due to presence of larger percentage of unsaturated fatty acids in oils than fats that has mostly saturated fatty acids.

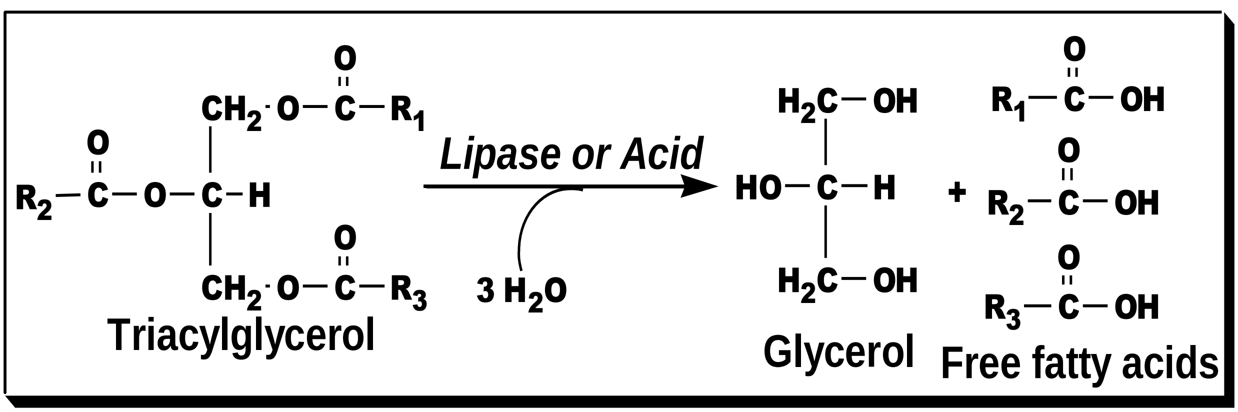
Physical properties of fat and oils

1. Freshly prepared fats and oils are colorless, odorless and tasteless.Any color, or taste is due to association with other foreign substances, e.g., the yellow color of body fat or milk fat is due to carotene pigments(cow milk).
2. Fats have specific gravity less than 1 and, therefore, they float on water.
3. Fats are insoluble in water, but soluble in organic solvents as ether and benzene.
4. Melting points of fats are usually low, but higher than the solidification point,

Chemical Properties of fats and oils

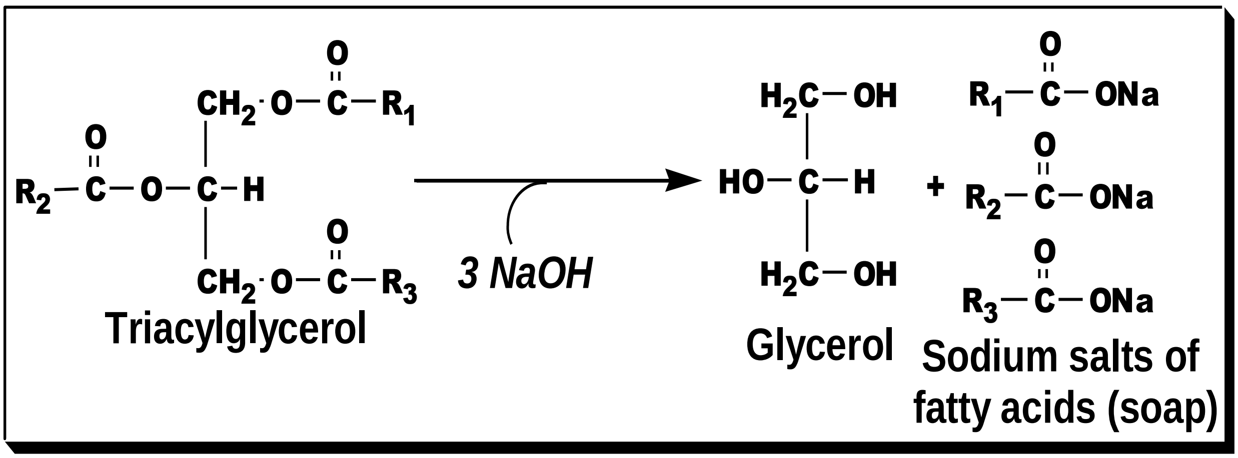
1. Hydrolysis:

- They are hydrolyzed into their constituents (fatty acids and glycerol) by the action of super heated steam, acid, alkali or enzyme (e.g., lipase of pancreas).
- During their enzymatic and acid hydrolysis glycerol and free fatty acids are produced.



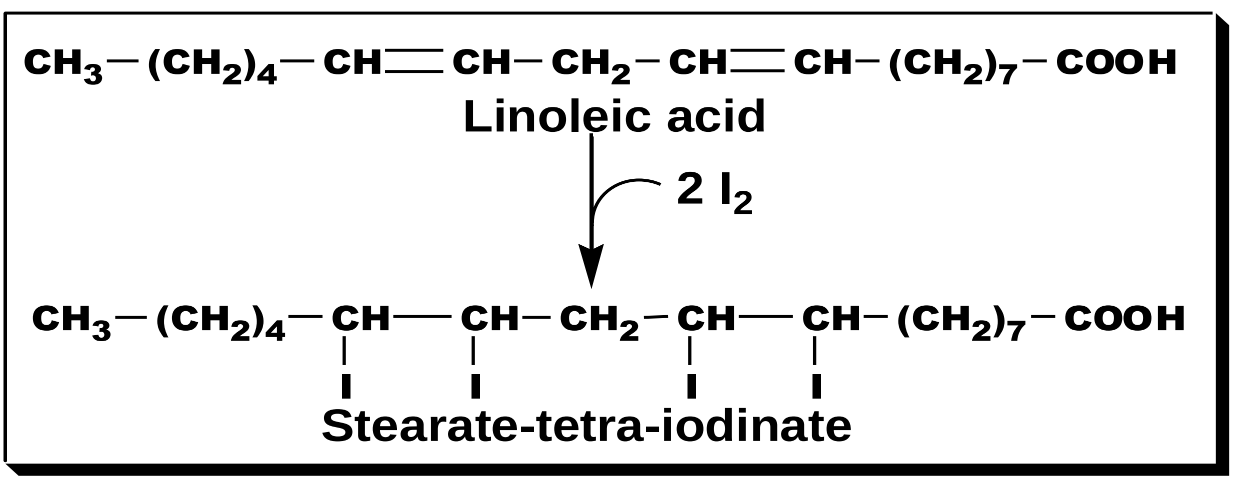
2. **Saponification**.

Alkaline hydrolysis produces glycerol and salts of fatty acids (soaps). Soaps cause emulsification of oily material this help easy washing of the fatty materials



3. **Halogenation**

- Neutral fats containing unsaturated fatty acids have the ability of adding halogens (e.g., iodine or iodination) at the double bonds.
- It is a very important property to determine the degree of unsaturation of the fat or oil that determines its biological value



4. **Hydrogenation or hardening of oils**:

- It is a type of addition reactions accepting hydrogen at the double bonds of unsaturated fatty acids.
- The hydrogenation is done under high pressure of hydrogen and is catalyzed by finely divided nickel or copper and heat.
- It is the base of hardening of oils (margarine manufacturing), e.g., change of oleic acid of fats (liquid) into stearic acid (solid).

5. Oxidation(Rancidty)

- This toxic reaction of triglycerides leads to unpleasant odour or taste of oils and fats developing after oxidation by oxygen of air, bacteria, or moisture.
- Also this is the base of the drying oils after exposure to atmospheric oxygen. Example is linseed oil, which is used in paints and varnishes manufacturing

Rancidity

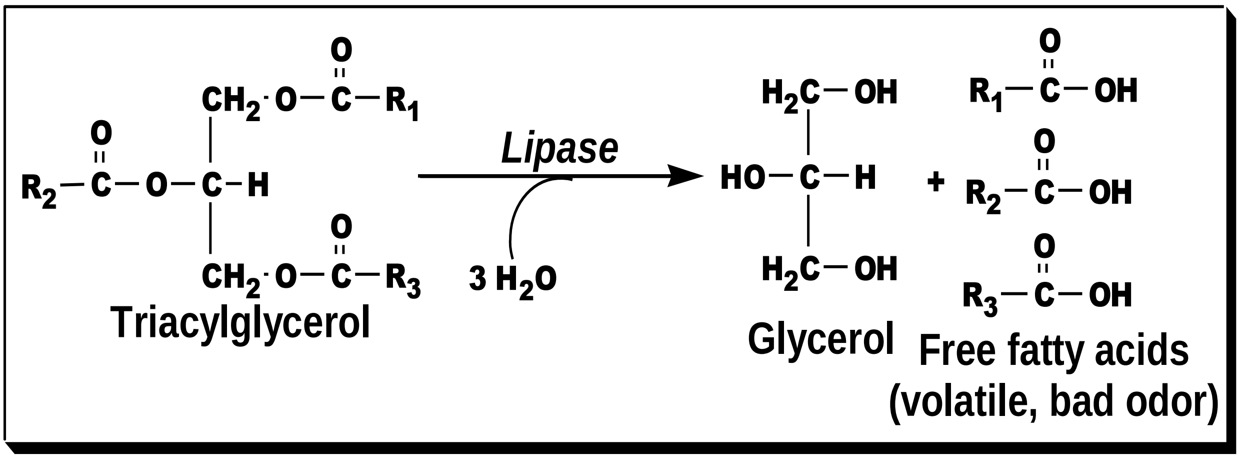
- It is a physico-chemical change in the natural properties of the fat leading to the development of unpleasant odor or taste or abnormal color particularly on aging after exposure to atmospheric oxygen, light, moisture, bacterial or fungal contamination and/or heat.
- Saturated fats resist rancidity more than unsaturated fats that have unsaturated double bonds.

Types of Rancidity:

1. Hydrolytic rancidity
2. Oxidative rancidity
3. Ketonic rancidity

1. Hydrolytic rancidity:

- It results from slight hydrolysis of the fat by lipase from bacterial contamination leading to the liberation of free fatty acids and glycerol at high temperature and moisture.
- Volatile short-chain fatty acids have unpleasant odor.



2. Oxidative Rancidity:

- It is oxidation of fat or oil catalyzed by exposure to oxygen, light and/or heat producing peroxide derivatives which on decomposition give substances, e.g., peroxides, aldehydes, ketones and dicarboxylic acids that are toxic and have bad odor.
- This occurs due to oxidative addition of oxygen at the unsaturated double bond of unsaturated fatty acid of oils.

3. Ketonic Rancidity:

- It is due to the contamination with certain fungi such as *Asperigillus niger* on fats such as coconut oil.
- Ketones, fatty aldehydes, short chain fatty acids and fatty alcohols are formed.
- Moisture accelerates ketonic rancidity.

1. Iodine number (or value):

- Definition: It is the number of grams of iodine absorbed by 100 grams of fat or oil.
- Uses:It is a measure for the degree of unsaturation of the fat, as a natural property for it.

2. Saponification number (or value):

- Definition: It is the number of milligrams of KOH required to completely saponify one gram of fat.
- Uses: Since each carboxyl group of a fatty acid reacts with one mole of KOH during saponification, therefore, the amount of alkali needed to saponify certain weight of fat depends upon the number of fatty acids present per weight.
- Thus, fats containing short-chain acids will have more carboxyl groups per gram than long chain fatty acids and consume more alkali, i.e., will have higher saponification number.

3. Acids Number (or value):

- Definition: It is the number of milligrams of KOH required to neutralize the free fatty acids present in one gram of fat.
- Uses: It is used for detection of hydrolytic rancidity because it measures the amount of free fatty acids present.

4. Reichert- Meissl Number (or value):

- Definition: It is the number of milliliters of 0.1 N KOH required to neutralize the water-soluble fatty acids distilled from 5 grams of fat. Short-chain fatty acid (less than 10 carbons) is distillated by steam.
- Uses: This studies the natural composition of the fat and is used for detection of fat adulteration.

- Butter that has high percentage of short-chain fatty acids has highest Reichert-Meissl number compared to margarine.

5. Acetyl Number (or value):

- Definition: It is number of milligrams of KOH needed to neutralize the acetic acid liberated from hydrolysis of 1 gram of acetylated fat (hydroxy fat reacted with acetic anhydride).
- Uses: The natural or rancid fat that contains fatty acids with free hydroxyl groups are converted into acetylated fat by reaction with acetic anhydride.
- Thus, acetyl number is a measure of number of hydroxyl groups present. It is used for studying the natural properties of the fat and to detect adulteration and rancidity.

Waxes

Waxes are solid simple lipids containing a monohydric alcohol (with a higher molecular weight than glycerol) esterified to long-chain fatty acids. Examples of these alcohols are palmitoyl alcohol, cholesterol, vitamin A or D.

Properties of waxes

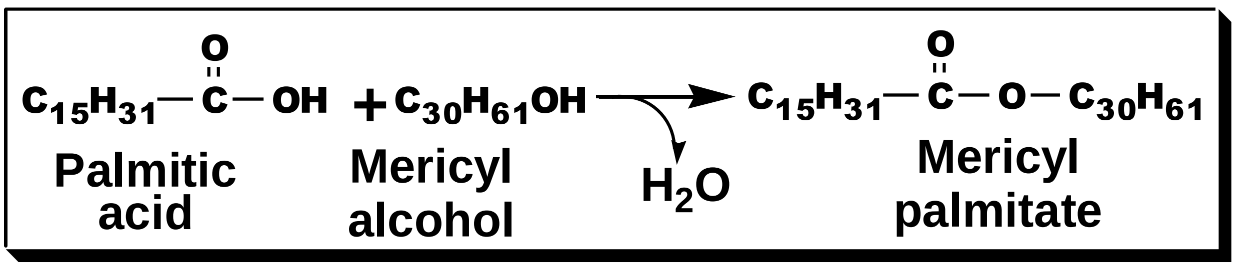
- Waxes are insoluble in water, but soluble in fat solvents and are negative for acrolein test. (**Acrolein test** is used to detect the presence of glycerol or fat. When fat is treated strongly in the presence of a dehydrating agent like potassium bisulphate ($KHSO_4$), the glycerol portion of the molecule is dehydrated to form an unsaturated aldehyde, **acrolein** that has a pungent irritating odour.)
- Waxes are not easily hydrolyzed as the fats and are indigestible by lipases and are very resistant to rancidity.
- Thus they are of no nutritional value.

Type of Waxes

Waxes are widely distributed in nature such as the secretion of certain insects as bees-wax, protective coatings of the skins and furs of animals and leaves and fruits of plants. They are classified into true-waxes and wax-like compounds as follows:

1.True waxes

Bees-wax is secreted by the honeybees that use it to form the combs. It is a mixture of waxes with the chief constituent is mericyl palmitate.



2.Wax-like compounds

- Cholesterol esters: Lanolin (or wool fat) is prepared from the wool-associated skin glands and is secreted by sebaceous glands of the skin.
- It is very complex mixture, contains both free and esterified cholesterol, e.g., cholesterol-palmitate and other sterols.

Compound Lipids

They are lipids that contain additional substances, e.g., sulfur, phosphorus, amino group, carbohydrate, or proteins beside fatty acid and alcohol.

Compound or conjugated lipids are classified into the following types according to the nature of the additional group:

1. Phospholipids
2. Glycolipids.

3. Lipoproteins
4. Sulfolipids and amino lipids.

1.Phospholipids

Phospholipids or phosphatides are compound lipids, which contain phosphoric acid group in their structure.

Importance:

1. They are present in large amounts in the liver and brain as well as blood. Every animal and plant cell contains phospholipids.
2. The membranes bounding cells and subcellular organelles are composed mainly of phospholipids. Thus, the transfer of substances through these membranes is controlled by properties of phospholipids.
3. They are important components of the lipoprotein coat essential for secretion and transport of plasma lipoprotein complexes. Thus, they are lipotropic agents that prevent fatty liver.
4. Myelin sheath of nerves is rich with phospholipids.
5. Important in digestion and absorption of neutral lipids and excretion of cholesterol in the bile.
6. Important function in blood clotting and platelet aggregation.
7. They provide lung alveoli with surfactants that prevent its irreversible collapse.
8. Important role in signal transduction across the cell membrane.
9. Phospholipase A2 in snake venom hydrolyses membrane phospholipids into hemolytic lysolecithin or lysocephalin.
10. They are source of polyunsaturated fatty acids for synthesis of eicosanoids.

Sources: They are found in all cells (plant and animal), milk and egg-yolk in the form of lecithins.

Structure: phospholipids are composed of:

1. Fatty acids (a saturated and an unsaturated fatty acid).
2. Nitrogenous base (choline, serine, threonine, or ethanolamine).
3. Phosphoric acid.
4. Fatty alcohols (glycerol, inositol or sphingosine).

Classification of Phospholipids

They are classified into 2 groups according to the type of the alcohol present into two types:

A-Glycerophospholipids: They are regarded as derivatives of phosphatidic acids that are the simplest type of phospholipids and include:

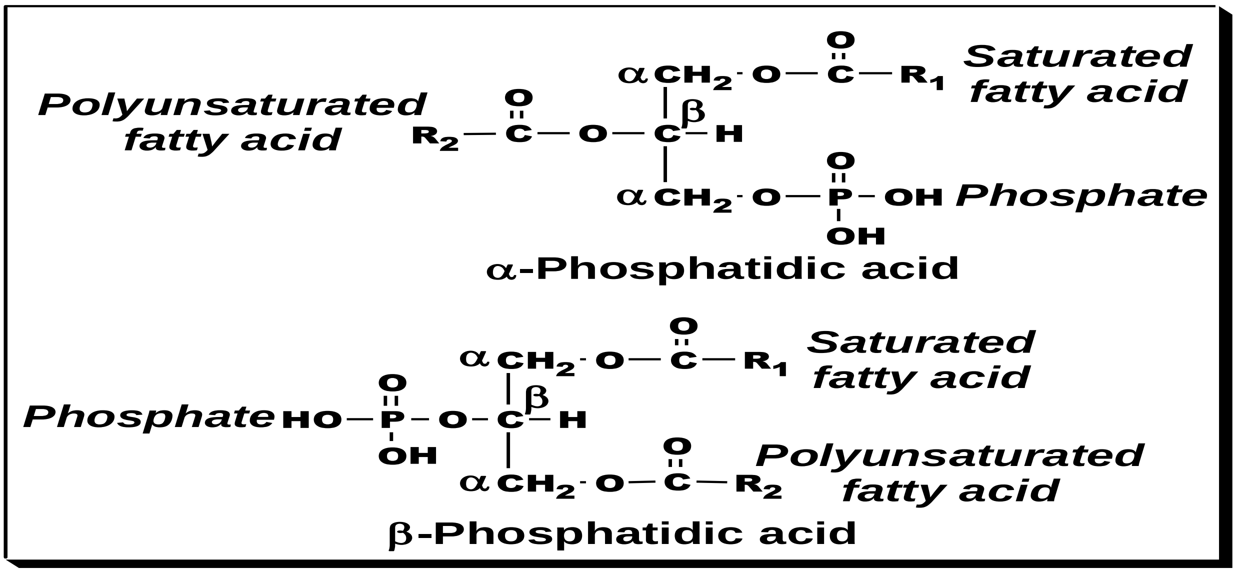
1. Phosphatidic acids.
2. Lecithins
3. Cephalins.
4. Plasmalogens.
5. Inositides.
6. Cardiolipin.

B-Sphingophospholipids: They contain sphingosine as an alcohol and are named Sphingomyelins.

A.Glycerophospholipids

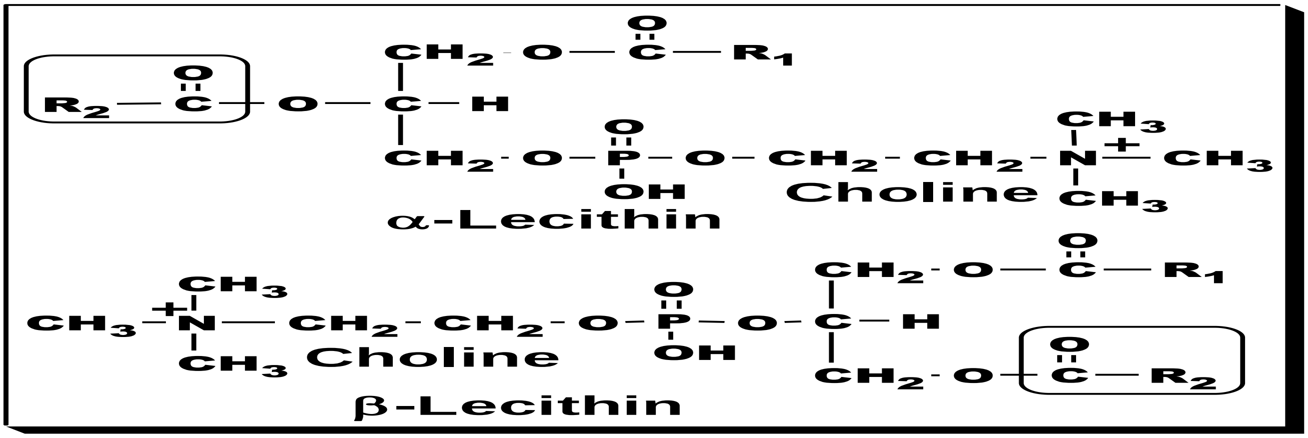
1. Phosphatidic acids:

They are metabolic intermediates in synthesis of triglycerides and glycerophospholipids in the body and may have function as a second messenger. They exist in two forms according to the position of the phosphate



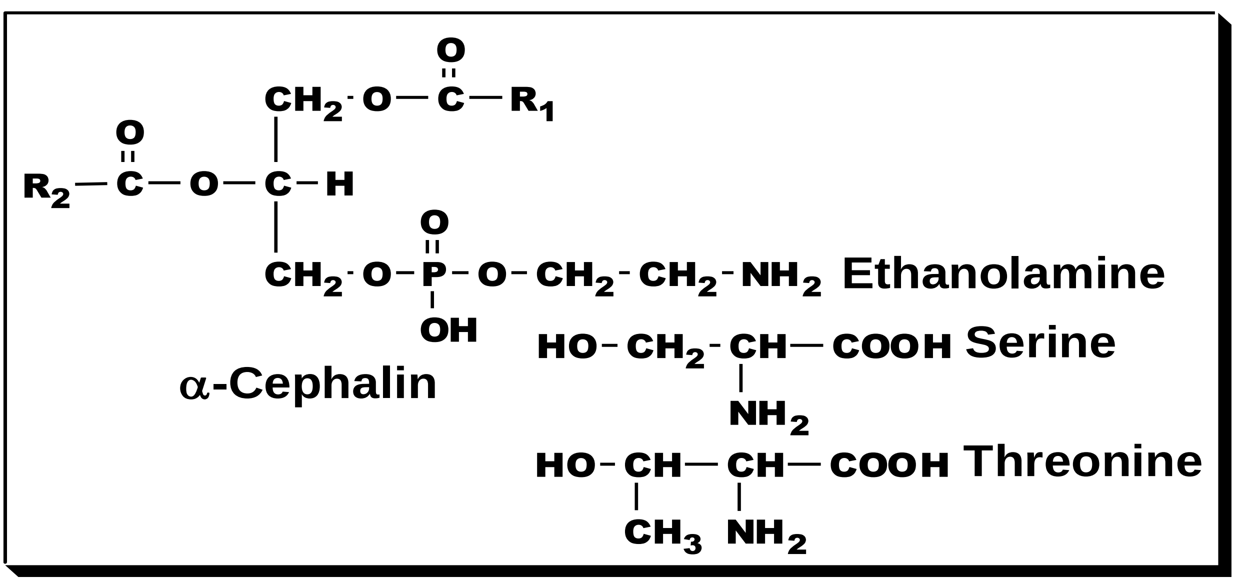
2. Lecithins:

- Lecithins are glycerophospholipids that contain choline as a base beside phosphatidic acid. They exist in 2 forms α- and β-lecithins. Lecithins are a common cell constituent obtained from brain (α-type), egg yolk (β-type), or liver (both types). Lecithins are important in the metabolism of fat by the liver.
- Structure: Glycerol is connected at C2 or C3 with a polyunsaturated fatty acid, at C1 with a saturated fatty acid, at C3 or C2 by phosphate to which the choline base is connected. The common fatty acids in lecithins are stearic, palmitic, oleic, linoleic, linolenic, clupandonic or arachidonic acids.



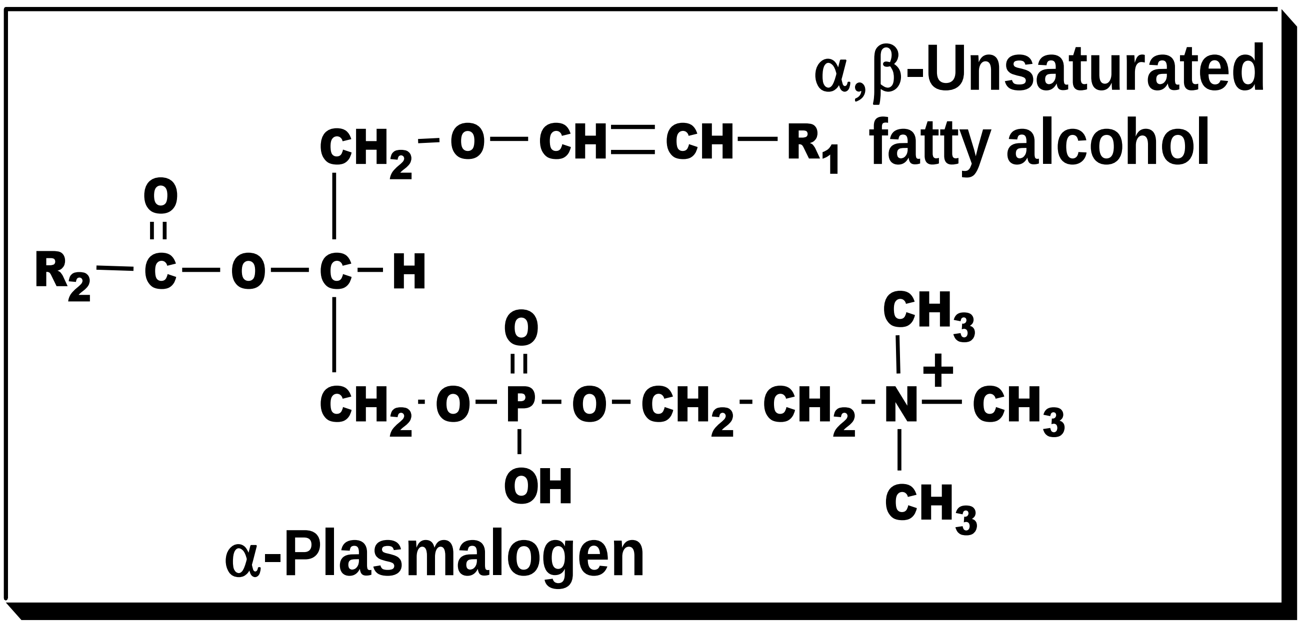
3.Cephalins (or Kephalins):

- They are phosphatidyl-ethanolamine or serine. Cephalins occur in association with lecithins in tissues and are isolated from the brain (Kephale = head).
- Structure: Cephalins resemble lecithins in structure except that choline is replaced by ethanolamine, serine or threonine amino acids.



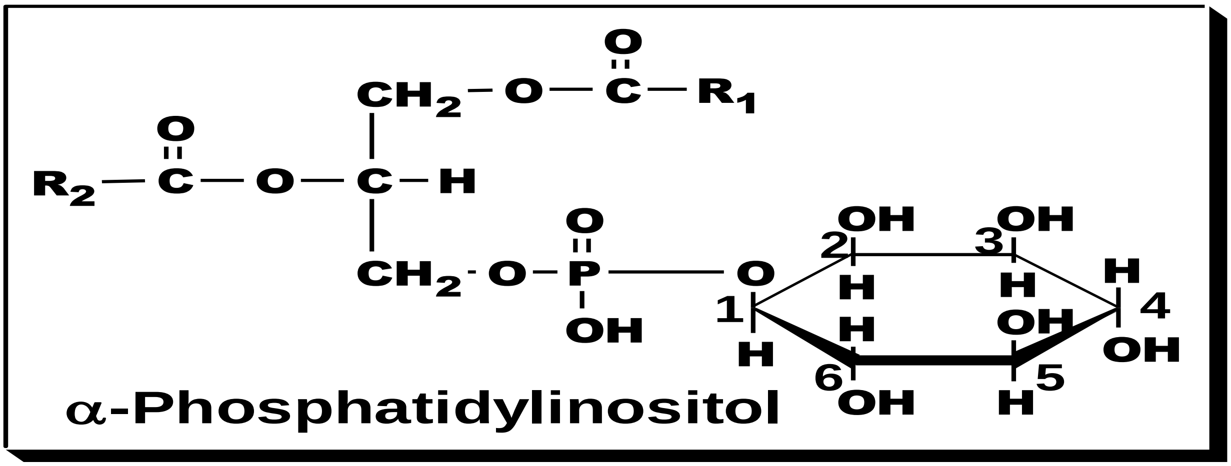
4. Plasmalogens:

- Plasmalogens are found in the cell membrane phospholipids fraction of brain and muscle (10% of it is plasmalogens), liver, semen and eggs.
- Structure: Plasmalogens resemble lecithins and cephalins in structure but differ in the presence of α,β-unsaturated fatty alcohol rather than a fatty acid at C1 of the glycerol connected by ether bond.
- At C2 there is an unsaturated long-chain fatty acid, however, it may be a very short-chain fatty acid



5. Inositides:

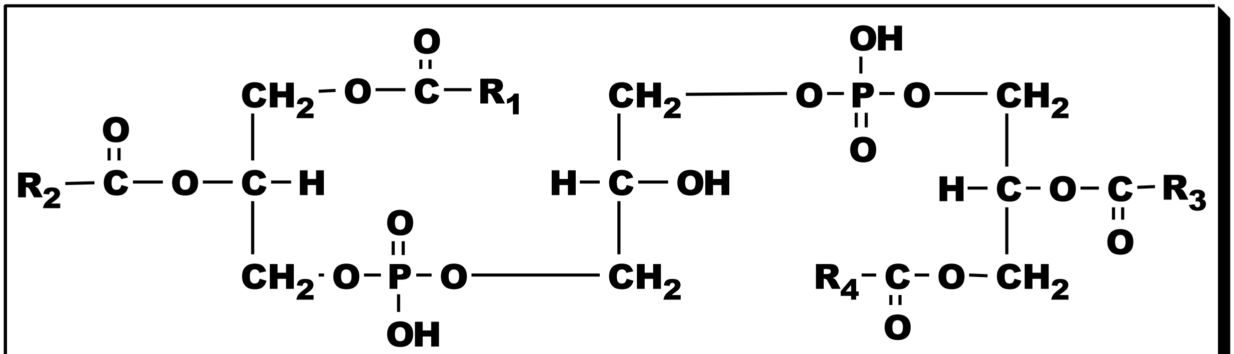
They are similar to lecithins or cephalins but they have the cyclic sugar alcohol, inositol as the base. They are formed of glycerol, one saturated fatty acid, one unsaturated fatty acid, phosphoric acid and inositol



- Source: Brain, tissues. Etc.,
- Function
- Phosphatidyl inositol is a major component of cell membrane phospholipids particularly at the inner leaflet of it.
- They play a major role as second messengers during signal transduction for certain hormone..
- On hydrolysis by phospholipase C, phosphatidyl-inositol-4,5-diphosphate produces diacyl-glycerol and inositol-triphosphate both act to liberate calcium from its intracellular stores to mediate the hormone effects.

6. Cardiolipins:

- They are diphosphatidyl-glycerol. They are found in the inner membrane of mitochondria initially isolated from heart muscle (cardio). It is formed of 3 molecules of glycerol, 4 fatty acids and 2 phosphate groups.
- Function: Used in serological diagnosis of autoimmunity diseases.

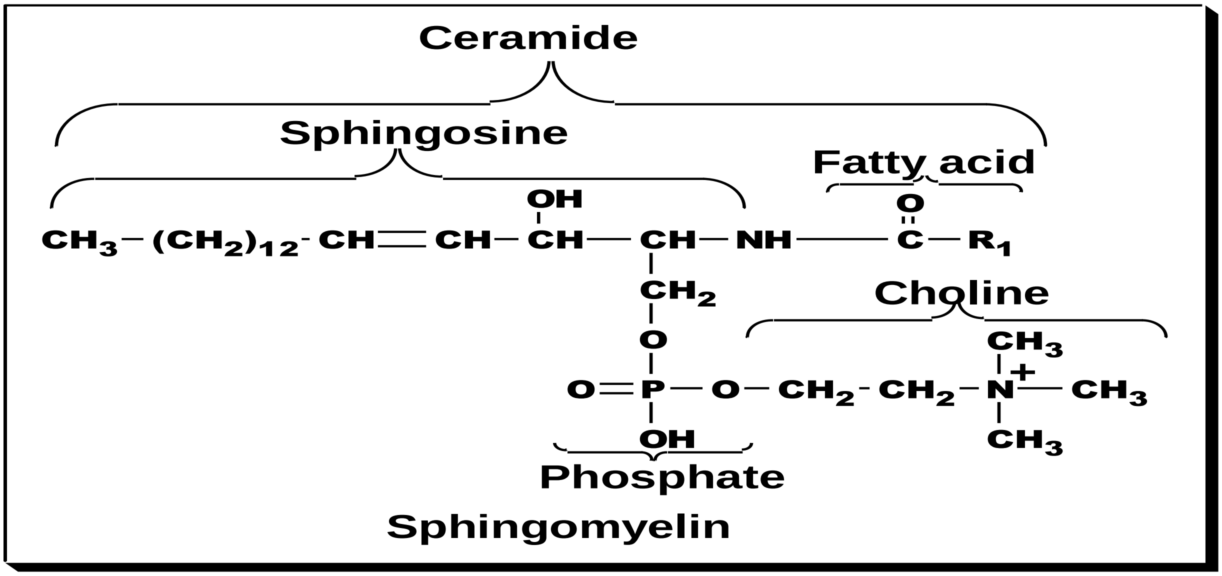


Cardiolipin

B.Sphingophospholipids

1. Sphingomyelins

- Sphingomyelins are found in large amounts in brain and nerves and in smaller amounts in lung, spleen, kidney, liver and blood.
- Structure: Sphingomyelins differ from lecithins and cephalins in that they contain sphingosine as the alcohol instead of glycerol, they contain two nitrogenous bases: sphingosine itself and choline.
- Thus, sphingomyelins contain sphingosine base, one long-chain fatty acid, choline and phosphoric acid.
- To the amino group of sphingosine the fatty acid is attached by an amide linkage.
- Ceramide This part of sphingomyelin in which the amino group of sphingosine is attached to the fatty acid by an amide linkage.
- Ceramides have been found in the free state in the spleen, liver and red cells.



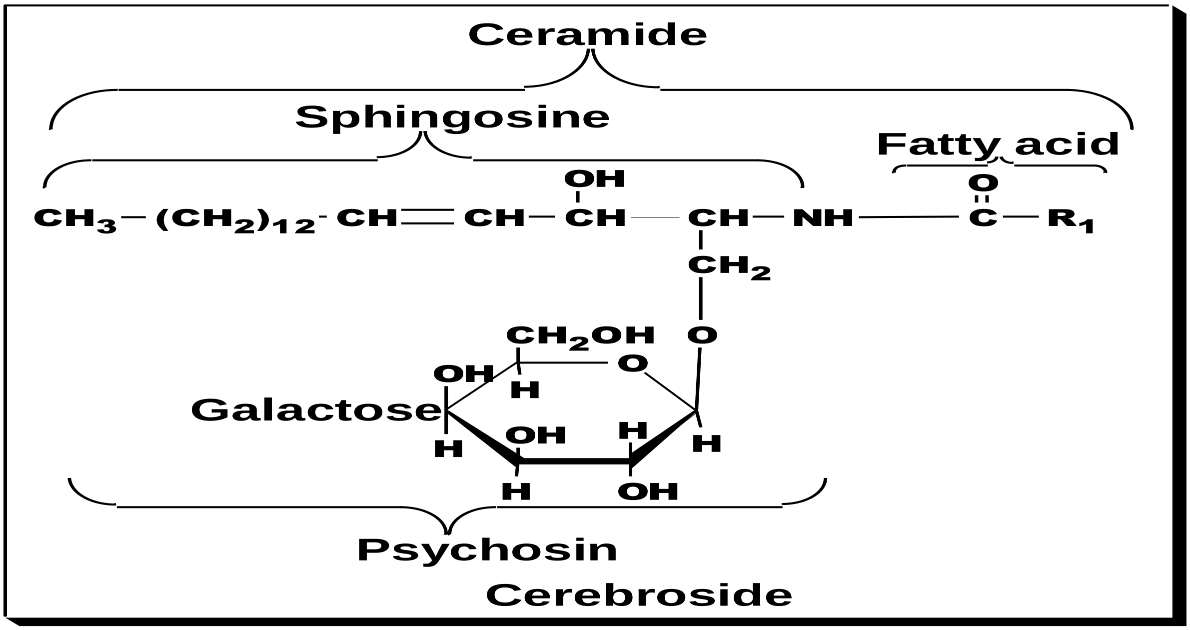
2. **Glycolipids**

- They are lipids that contain carbohydrate residues with sphingosine as the alcohol and a very long-chain fatty acid (24 carbon series).
- They are present in cerebral tissue, therefore are called cerebrosides
- Classification: According to the number and nature of the carbohydrate residue(s) present in the glycolipids the following are

1. Cerebrosides. They have one galactose molecule (galactosides).
2. Sulfatides. They are cerebrosides with sulfate on the sugar (sulfated cerebrosides).
3. Gangliosides. They have several sugar and sugaramine residues.

1. Cerebrosides:

- Occurrence: They occur in myelin sheath of nerves and white matter of the brain tissues and cellular membranes. They are important for nerve conductance.
- Structure: They contain sugar, usually β-galactose and may be glucose or lactose, sphingosine and fatty acid, but no phosphoric acid**.**

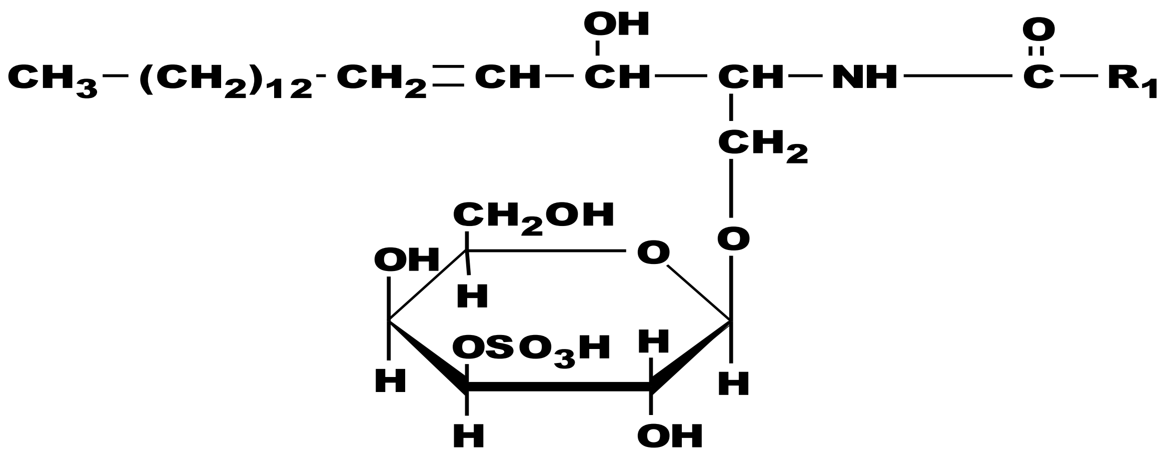


- Types: According to the type of fatty acid and carbohydrate present, there are 4 different types of cerebrosides isolated from the white matter of cerebrum and in myelin sheaths of nerves. Rabbit cerebrosides contain stearic acid.

1. Kerasin contains lignoceric acid (24 carbons) and galactose.
2. Cerebron (Phrenosin) contains cerebronic acid (2-hydroxylignoceric acid) and galactose.
3. Nervon contains nervonic acid (unsaturated lignoceric acid at C15) and galactose.
4. Oxynervon contains oxynervonic acid (2-hydroxynervonic acid) and galactose.

2. Sulfatides:

- They are sulfate esters of kerasin or phrenosin in which the sulfate group is usually attached to the –OH group of C3 or C6 of galactose. Sulfatides are usually present in the brain, liver, muscles and testes.



Sulfatides (sulfated cerebroside)

3. Gangliosides

- They are more complex glycolipids that occur in the gray matter of the brain, ganglion cells, and RBCs. They transfer biogenic amines across the cell membrane and act as a cell membrane receptor.
- Gangliosides contain sialic acid (N-acetylneuraminic acid), ceramide (sphingosine + fatty acid of 18-24 carbon atom length), 3 molecules of hexoses (1 glucose + 2 galactose) and hexosamine. The most simple type of it the monosialoganglioside,. It works as a receptor for cholera toxin in the human intestine.

Ceramide-Glucose-Galactose-N-acetylgalactosamine-Galactose

Sialic acid

Monosialoganglioside

3. Lipoproteins

- Lipoproteins are lipids combined with proteins in the tissues. The lipid component is phospholipid, cholesterol or triglycerides. The holding bonds are secondary bonds.

1. Structural lipoproteins: These are widely distributed in tissues being present in cellular and subcellular membranes. In lung tissues acting as a surfactant in a complex of a protein and lecithin. In the eye, rhodopsin of rods is a lipoprotein complex.

2. Transport lipoproteins: These are the forms present in blood plasma. They are composed of a protein called apolipoprotein and different types of lipids. (Cholesterol, cholesterol esters, phospholipids and triglycerides). As the lipid content increases, the density of plasma lipoproteins decreases

Plasma lipoproteins

a) <u>Chylomicrons</u>:

They have the largest diameter and the least density. They contain 1-2% protein only and 98-99% fat. The main lipid fraction is triglycerides absorbed from the intestine and they contain small amounts of the absorbed cholesterol and phospholipids.

b) <u>Very low-density lipoproteins (VLDL) or pre-β-lipoproteins</u>:

Their diameter is smaller than chylomicrons. They contain about 7-10% protein and 90-93% lipid. The lipid content is mainly triglycerides formed in the liver. They contain phospholipid and cholesterol more than chylomicrons.

c) <u>Low-density lipoproteins (LDL) or β-lipoproteins</u>:

They contain 10-20% proteins in the form of apolipoprotein B. Their lipid content varies from 80-90%. They contain about 60% of total blood cholesterol and 40% of total blood phospholipids. As their percentage increases, the liability to atherosclerosis increases.

d) High-density lipoproteins (HDL) or α-Lipoproteins:

They contain 35-55% proteins in the form of apolipoprotein A. They contain 45-65% lipids formed of cholesterol (40% of total blood content) and phospholipids (60% of total blood content). They act as cholesterol scavengers, as their percentage increases, the liability to atherosclerosis decreases. They are higher in females than in males. Due to their high protein content they possess the highest density.

Derived lipids

These are the substances derived from simple and compound lipids by hydrolysis. These include fatty acids, alcohols, mono- and diglycerides, steroids, terpenes and carotenoids.

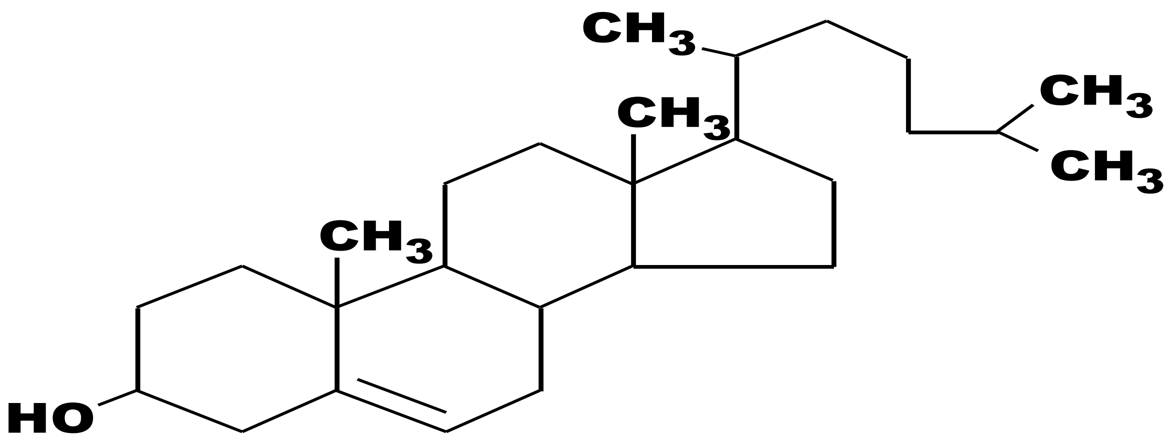
Cholesterol

- Importance: It is the most important sterol in animal tissues as free alcohol or in an esterified form (with linoleic, oleic, palmitic acids or other fatty acids).
- Steroid hormones, bile salts and vitamin D are derivatives from it.
- Tissues contain different amounts of it that serve a structural and metabolic role, e.g., adrenal cortex content is 10%, whereas, brain is 2%, others 0.2-0.3%.
- Source: It is synthesized in the body from acetyl-CoA (1gm/day, cholesterol does not exist in plants) and is also taken in the diet (0.3 gm/day as in, butter, milk, egg yolk, brain, meat and animal fat).

Physical propeties

- It has a hydroxyl group on C3, a double bond between C5 and C6, 8 asymmetric carbon atoms and a side chain of 8 carbon atoms.
- It is found in all animal cells, corpus luteum and adrenal cortex, human brain (17% of the solids).

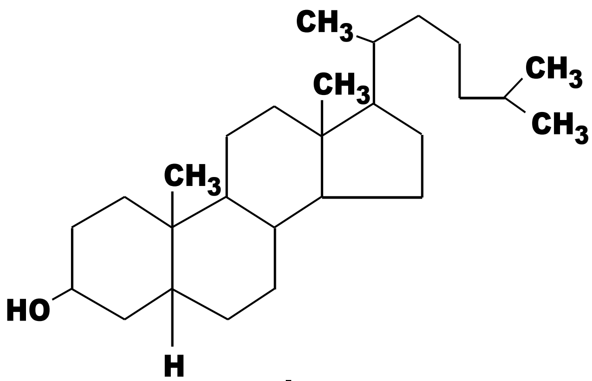
- In the blood (the total cholesterol amounts about 200 mg/dL of which 2/3 is esterified, chiefly to unsaturated fatty acids while the remainder occurs as the free cholesterol.



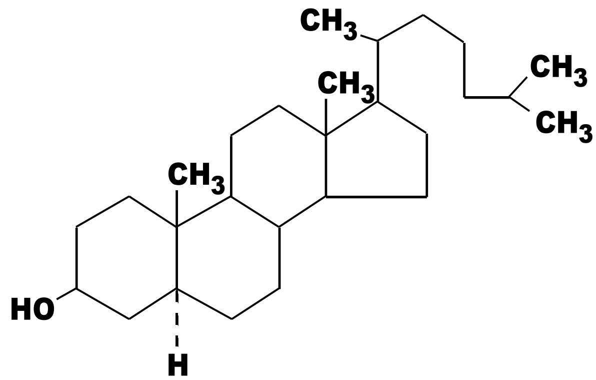
Cholesterol

Chemical properties

- Intestinal bacteria reduce cholesterol into coprosterol and dihydrocholesterol.
- It is also oxidized into 7-Dehydrocholesterol and further unsaturated cholesterol with a second double bond between C7 and C8. When the skin is irradiated with ultraviolet light 7-dehydrocholesterol is converted to vitamin D3. This explains the value of sun light in preventing rickets.

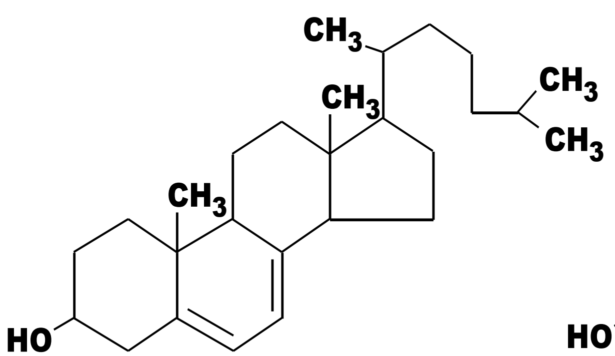


Coprosterol, in feces

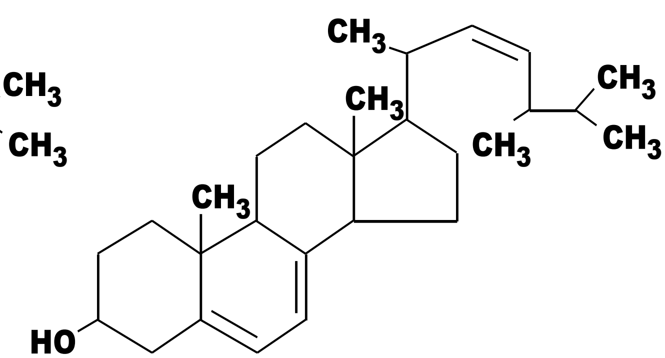


Dihydrocholesterol, in blood and other tissues

- Ergosterol differs from 7-dehydrocholesterol in the side chain.
- Ergosterol is converted to vitamin D2 by irradiation with UV Ergosterol and 7-dehydrocholesterol are called Pro-vitamins D or precursors of vitamin D.
- It was first isolated from ergot, a fungus then from yeast. Ergosterol is less stable than cholesterol (because of having 3 double bonds).



7-dehydrocholesterol



Ergosterol

TERPENES

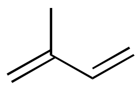
Terpenes are a large and diverse class of organic compounds, produced by a variety of plants, particularly conifers, though also by some insects such as termites or swallowtail butterflies, which emit **terpenes** from their osmeteria (defensive organ).

Terpenes and terpenoids are the most important constituents in essential oils

These hydrocarbons and their oxygenated derivatives have lesser than 40 carbon atoms.

The simplest terpenes are called monoterpenes with formula $C_{10}H_{16}$ those with the formula $C_{15}H_{24}$ are called as sesquiterpenes, with C20H32 as diterpenes and with $C_{30}H_{48}$ as triterpenes. Terpenes with 40 carbon atoms (or tetraterpenes) include compounds called carotenoids

Terpenes are built from C_5 isoprene units



isoprene

(2-methyl-1,3-butadiene)

Terpenes are the building blocks for a number of molecules such as Phytol tail on chlorophyll, Ubiquinone tail, Gibberellins, Cytokinin and Steroids

Membrane Lipids

- Phospholipids are made up of a glycerol backbone with a hydrophilic head region containing a phosphate group and a hydrophobic tail region containing a saturated fatty acid and an unsaturated fatty acid.
- The fact that it has both types of fatty acids ensures the cell membrane is fluid.
- Cholesterol is interspersed throughout the cell membrane to add rigidity to it.
- It also allows the cell membrane to stay fluid over a wider range of temperatures.

- Various proteins are associated with the cell membrane.

1. Integral Proteins (trans-membrane proteins) span the width of the cell membrane and create channels through which charged molecules or large molecules can pass through.
2. Peripheral Proteins are found on the surface of the cell membrane and are primarily used in cell to cell signaling with surface carbohydrate chains or linking with the cytoskeleton for support.

- The cytoskeleton is attached to the cell membrane for added stability, since membrane proteins and phospholipids can shift places in the membrane.

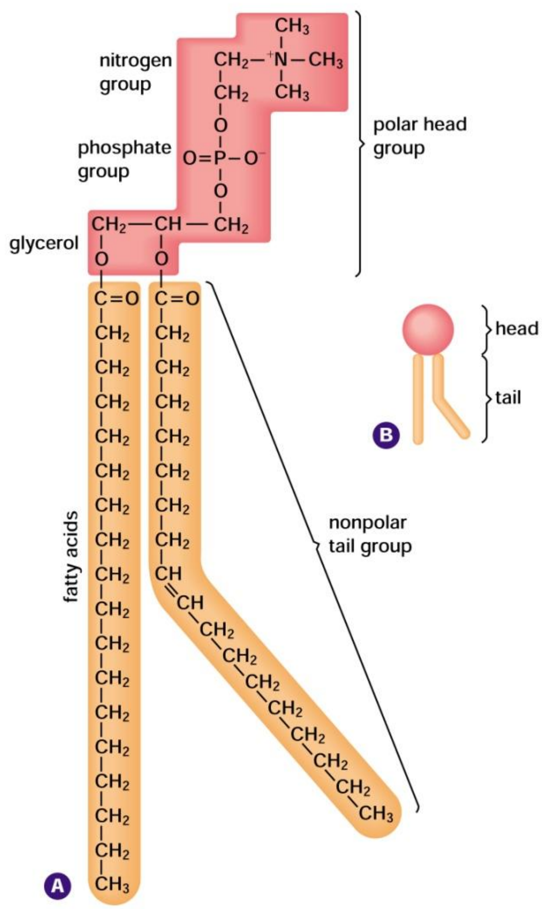


Fig. Head and tail region of phospholipid

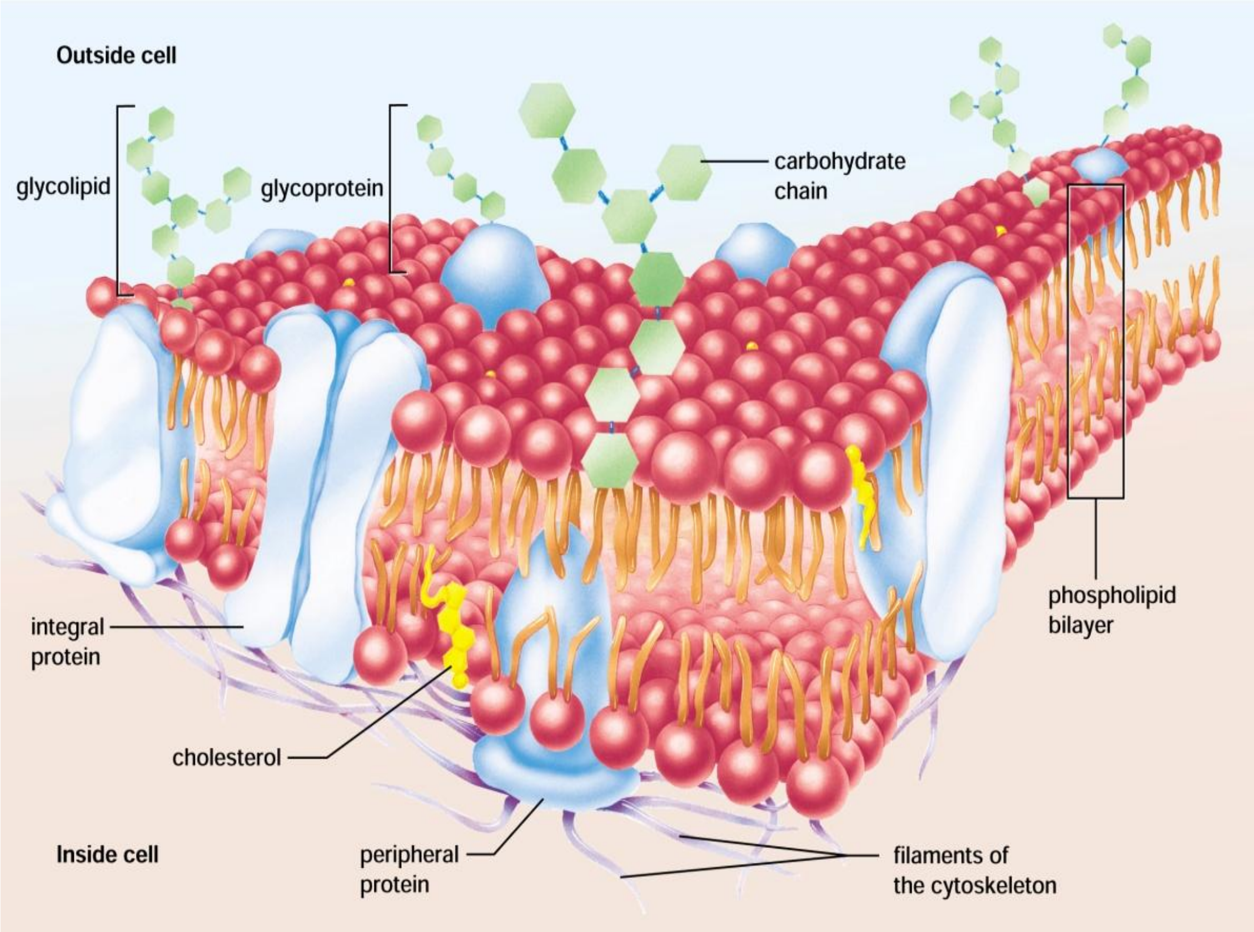


Fig.Lipid bilayer

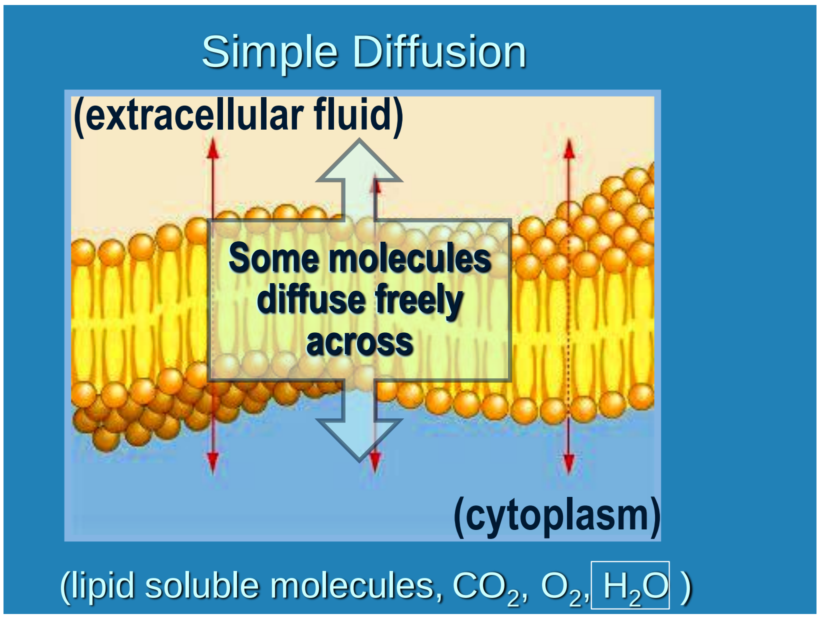
Lipid membrane has four main functions:

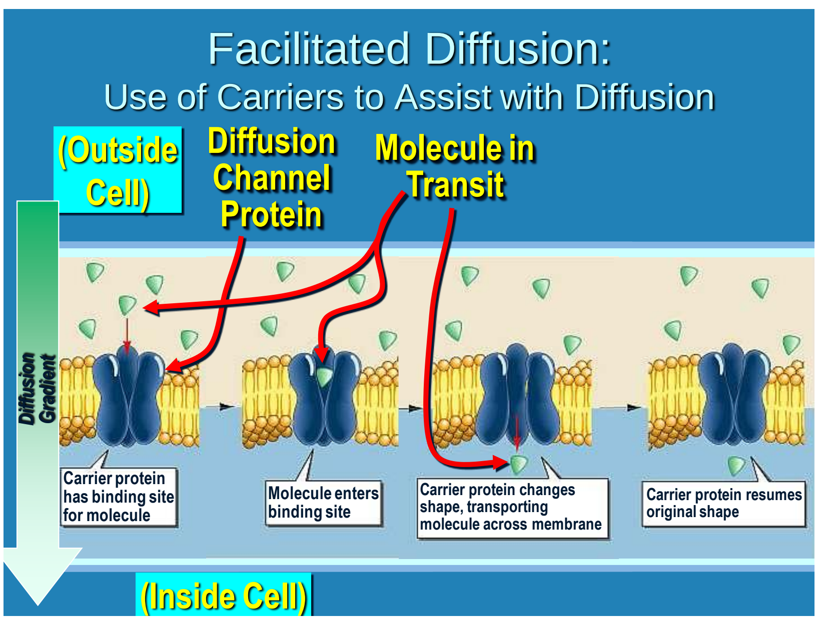
1. Allow the transport of raw materials into the cell
2. Allow the transport of manufactured products and wastes out of the cell
3. Prevent the entry of unwanted material into the cell
4. Prevent the leakage of essential matter out of the cell

Transport Processes

- Movement of substances across the cell membrane
- Passive transport
  - Substances move from [high]→[low]

  - No energy input required
  - Simple Diffusion, Facilitated Diffusion, Osmosis
- Active transport
  - Substances move from [low]→[high]
  - Requires energy input
  - Protein carriers, Endocytosis, Exocytosis





Steroid Hormones

Steroid hormones are derived from cholesterol and differ only in the ring structure and side chains attached to it.

Types of steroid hormones

- Glucocorticoids - cortisol is the major representative in most mammals
- Mineralocorticoids - aldosterone being most prominent
- Androgens such as testosterone
- Estrogens including estradiol and estrone
- Progestogens (also known a progestins) such as progesterone

Functions of Steroid Hormones

Steroid hormones play important roles in:

1. carbohydrate regulation (glucocorticoids)
2. mineral balance (mineralocorticoids)
3. reproductive functions (gonadal steroids)

Steroids also play roles in inflammatory responses, stress responses, bone metabolism, cardiovascular fitness, behavior etc.,

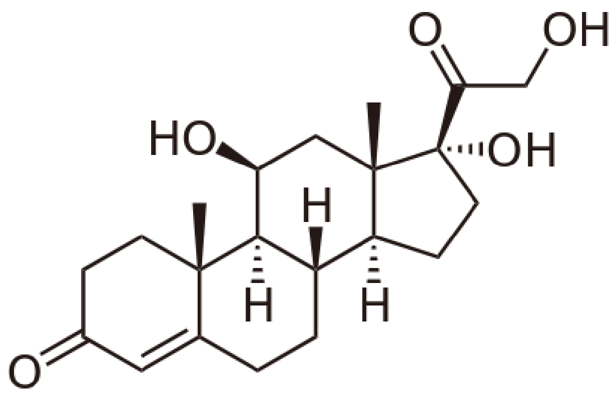
Steroid hormone synthesis

All steroid hormones are derived from cholesterol. A series of enzymatic steps in the mitochondria and endoplasmic reticulum of steroidogenic tissues convert cholesterol into all of the other steroid hormones and intermediates.

Glucocorticoids

The name glucocorticoid is composed from its role in regulation of glucose metabolism The primary glucocorticoid in humans is cortisol and produced in adrenal cortex.

Functions - promote gluconeogenesis; favor breakdown of fat and protein (fuel mobilization); anti-inflammatory

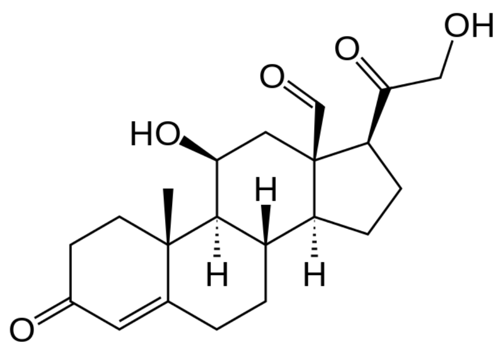


cortisol

Mineralocorticoids

Steroid hormones that affect electrolyte balance. The primary human mineralocorticoid, aldosteron and produced in adrenal cortex.

Functions - maintains blood volume and blood pressure by increasing sodium reabsorption by kidney



Aldosteron

Gonadal steroids

Androgens

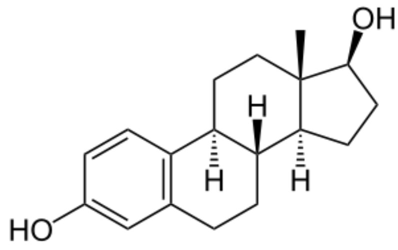
Produced in testes primarily but weak androgens in adrenal cortex.

Functions - Development of male secondary sex characteristics and prevents bone resorption

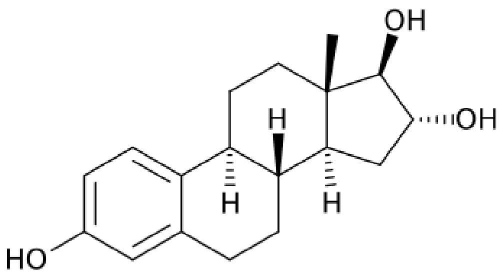
Estrogen

Produced in ovaries primarily but also in adipose cells of males and females

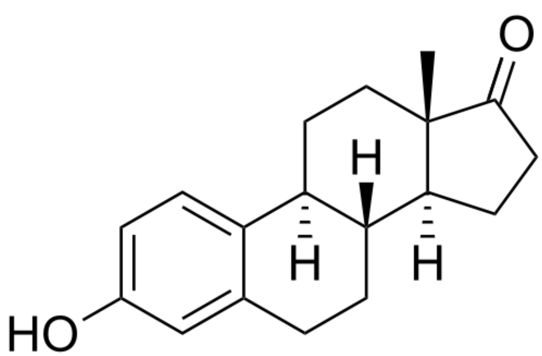
Functions - Development of female secondary sex characteristics; prevents bone resorption



Estradiol (E2)



Estriol (E3)



Estrone (E1)