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# **Biochemistry**

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# Fats, oils, phospholipids, and steroids

## Biomedical Importance

The lipids are a heterogeneous group of compounds, including fats, oils, steroids, waxes, and related compounds, that are related more by their physical than by their chemical properties. They have the common property of being

- (1) Relatively **insoluble in water** and
- (2) **soluble in nonpolar solvents** such as ether and chloroform.
- (3) They are important **dietary constituents** not only because of the high energy value of fats, but also because **essential fatty acids** and **fat-soluble vitamins** and other lipophilic **micronutrients** are contained in the fat of natural foods.

## Lipids are classified as Simple or complex

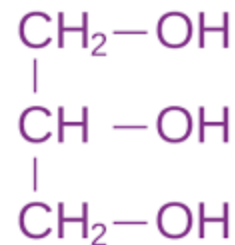
Based on the chemical nature, lipids are classified

**1. Simple lipids** include fats and waxes which are **esters of fatty acids** with various alcohols, They are subclassified

**a. Fats:** Esters of fatty acids with glycerol. **Oils** are fats in the liquid state.

**b. Waxes:** Esters of fatty acids with higher molecular weight monohydric alcohols.

glycerol



## 2. Compound Lipids

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

**a. Phospholipids, Containing Phosphoric Acid**

**b. Non-phosphorylated Lipids** such as Glycosphingolipids (carbohydrate)

## 3. Derived Lipids

They are compounds which are derived from lipids or precursors of lipids, e.g. fatty acids, steroids, prostaglandins, leukotrienes, terpenes, dolichols, etc. For details of cholesterol and steroids.

**4. Lipids Complexed** to Other Compounds Proteolipids and lipoproteins

## Fatty acids

Fatty acids are straight-chain hydrocarbons with a **terminal carboxyl group**. Fatty acids, are included in the group of derived lipids. It is the most common component of lipids in the body. They are generally found in **ester linkage** in different classes of lipids. In the human body free fatty acids are formed only during metabolism. Fatty acids are aliphatic carboxylic acids and have the general structural formula,  $R-CO-OH$ , where  $COOH$  (carboxylic group) represents the functional group. Depending on the R group (the hydrocarbon chain), the fatty acids may vary.



# Classification of Fatty Acids

## 1. Depending on Total No. of Carbon Atoms

- a. **Even chain**, having carbon atoms 2,4,6 and similar series. Most of the naturally occurring lipids contain even chain fatty acids.
- b. **Odd chain**, having carbon atoms 3, 5, 7, etc. Odd numbered fatty acids are seen in microbial cell walls. They are also present in milk.

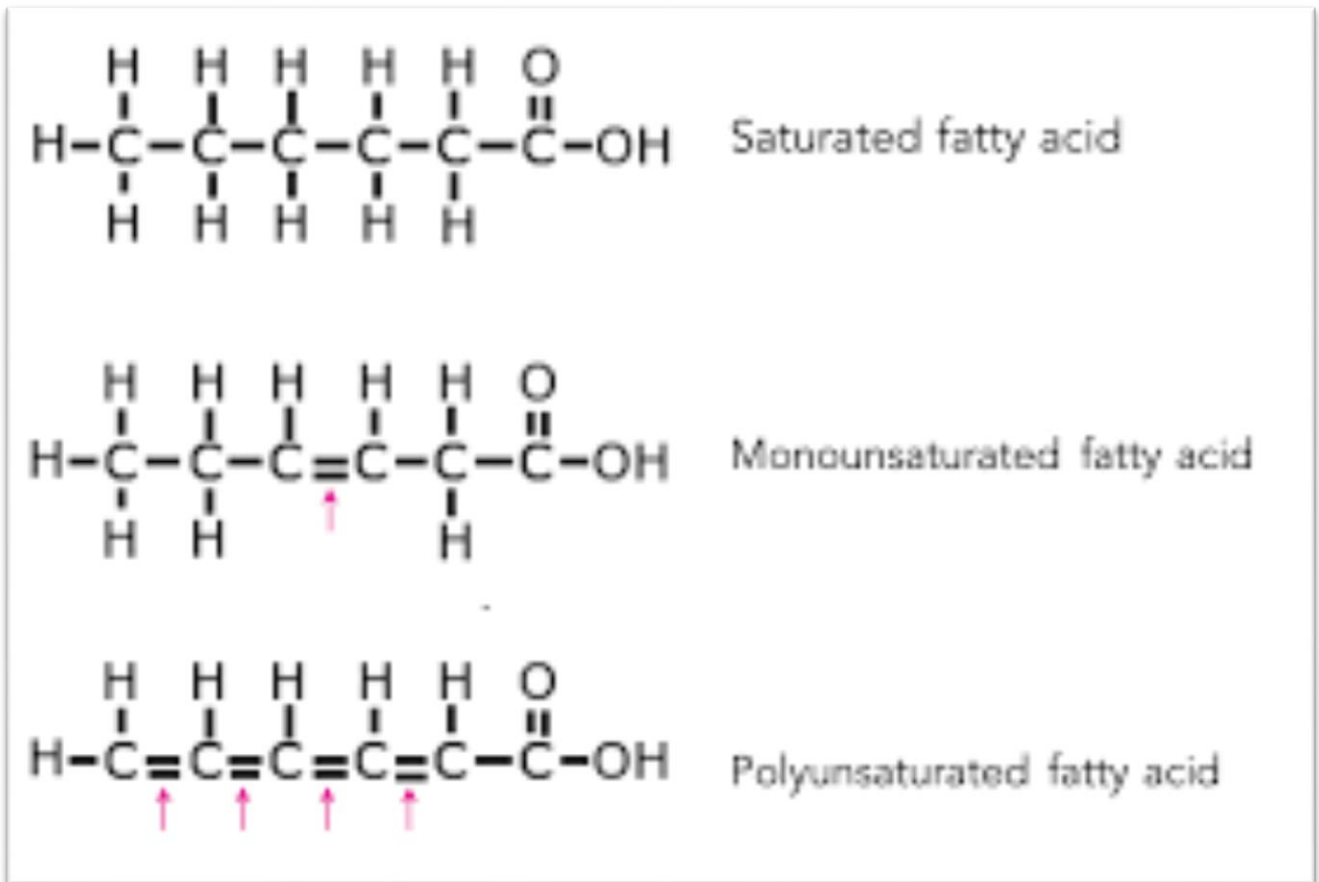
## 2. Depending on Length of Hydrocarbon Chain

- a. Short chain with 2 to 6 carbon atoms
- b. Medium chain with 8 to 14 carbon atoms
- c. Long chain with 16 and above, usually up to 24 carbon atoms

### 3. Depending on Nature of Hydrocarbon Chain

a. Saturated fatty acids

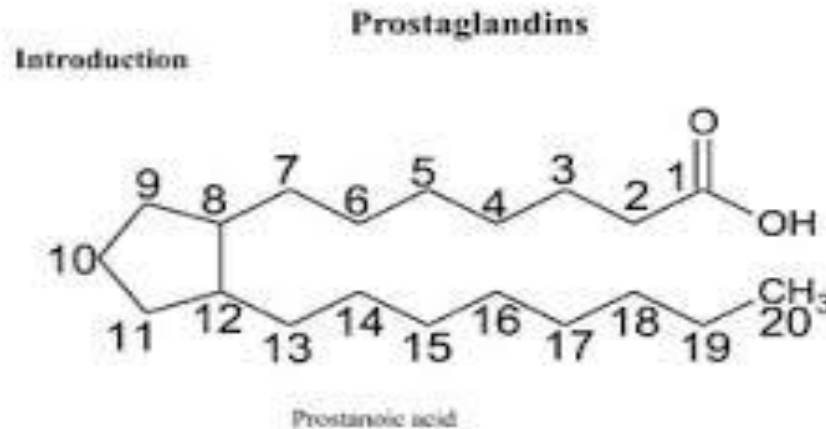
b. Unsaturated which may be subclassified into **Mono-unsaturated** (mono-enoic) having single double bond or **polyunsaturated** (poly-enoic) with 2 or more double bonds.



## Prostaglandins

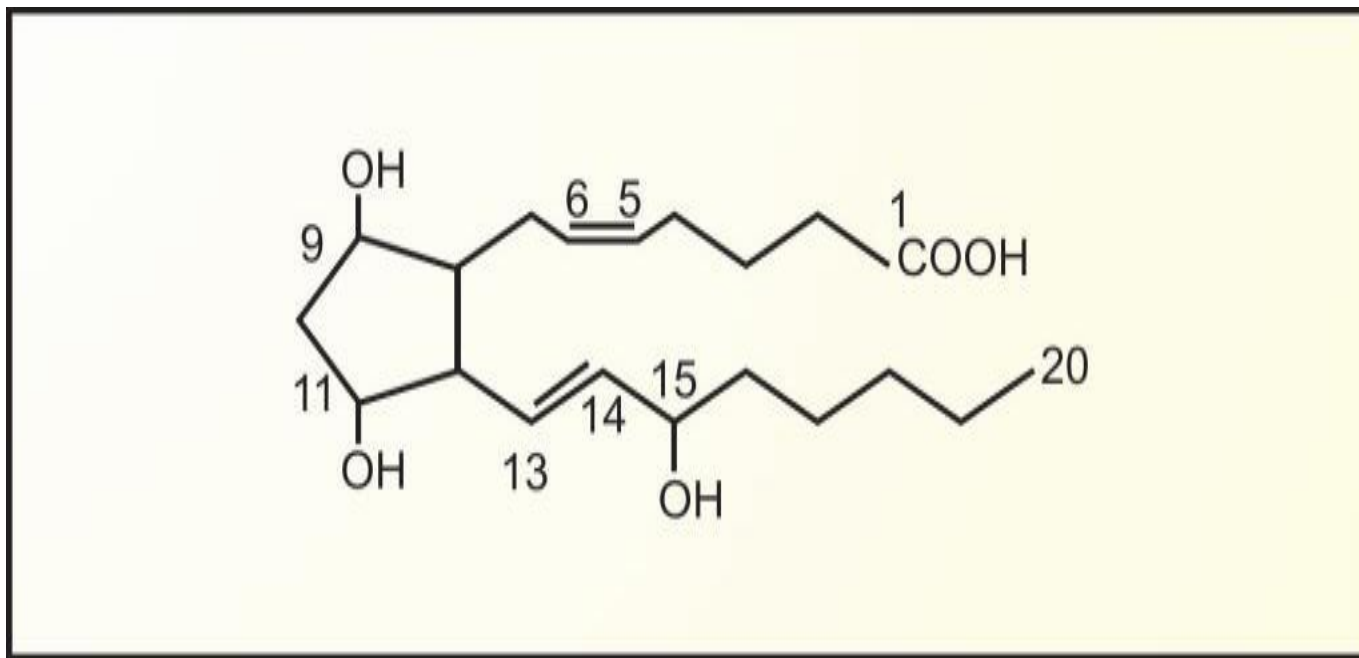
Prostaglandins (PGs) were originally isolated from **prostate tissue** and hence the name. But they are present in almost all tissues. They are the most potent biologically active substances; as low as one nanogram/ml of PG will cause smooth muscle contraction.

**Chemical Structure** All prostaglandins are considered to be derived from the (20 C) cyclic saturated fatty acid, The five carbon ring is saturated. All naturally occurring PGs have an alpha oriented OH group at C15.



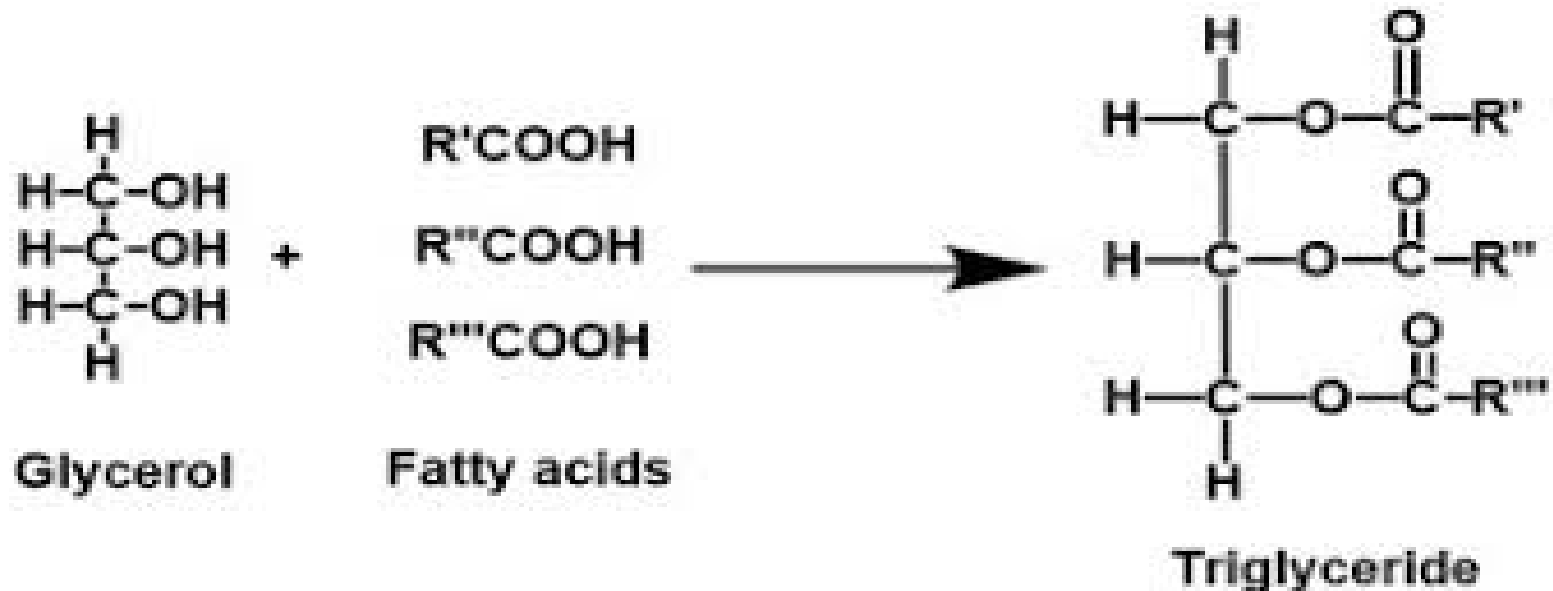


**Classification of Prostaglandins:** According to the attachment of different substituent groups to the ring, PGs are named with capital letters such as A, B, E, F and I. In the same series, depending on number of double bonds on the side chains they are denoted by a subscript after the capital letter, *e.g.* PGE<sub>1</sub>, PGE<sub>2</sub>, PGE<sub>3</sub>, etc. Series 2 have 2 double bonds at 13–14 (trans) and 5–6 (cis). Structure of PGF<sub>2</sub> is shown in Figure below:



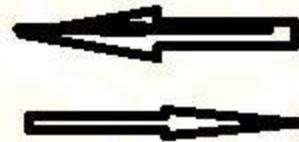
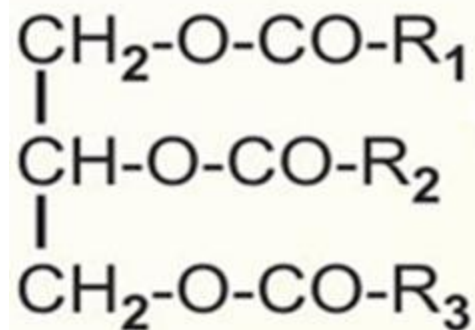
## Triglycerides

Most of the fatty acids in the body are **components** of triglyceride and are stored in the depots (adipose tissue) as fat. Adipose cells convert fatty acids into triglyceride by esterification with glycerol-3-phosphate, compounds that arises from glucose metabolism, cells must contain glucose for triglyceride formation. glucose is absent during periods of fasting, starvation, or uncontrolled diabetes mellitus, and in these condition, hydrolysis of triglycerides, and withdrawal of their fatty acids from the depots predominate

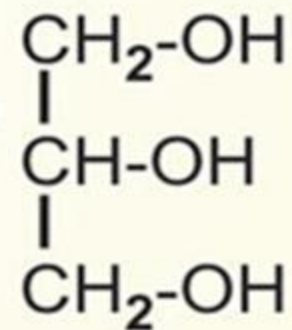


Excess carbohydrate ingested during a meal may be stored temporarily as triglycerides after conversion of glucose to fatty acids. The hormone insulin promotes the synthesis of triglycerides by adipose cells, whereas its deficiency accelerated triglyceride hydrolysis. The first step in the catabolism of triglycerides begins with their hydrolysis. The fatty acids appear in the plasma as **nonesterified** (free) fatty acids bounded to albumin as a carrier.

Triacylglycerol



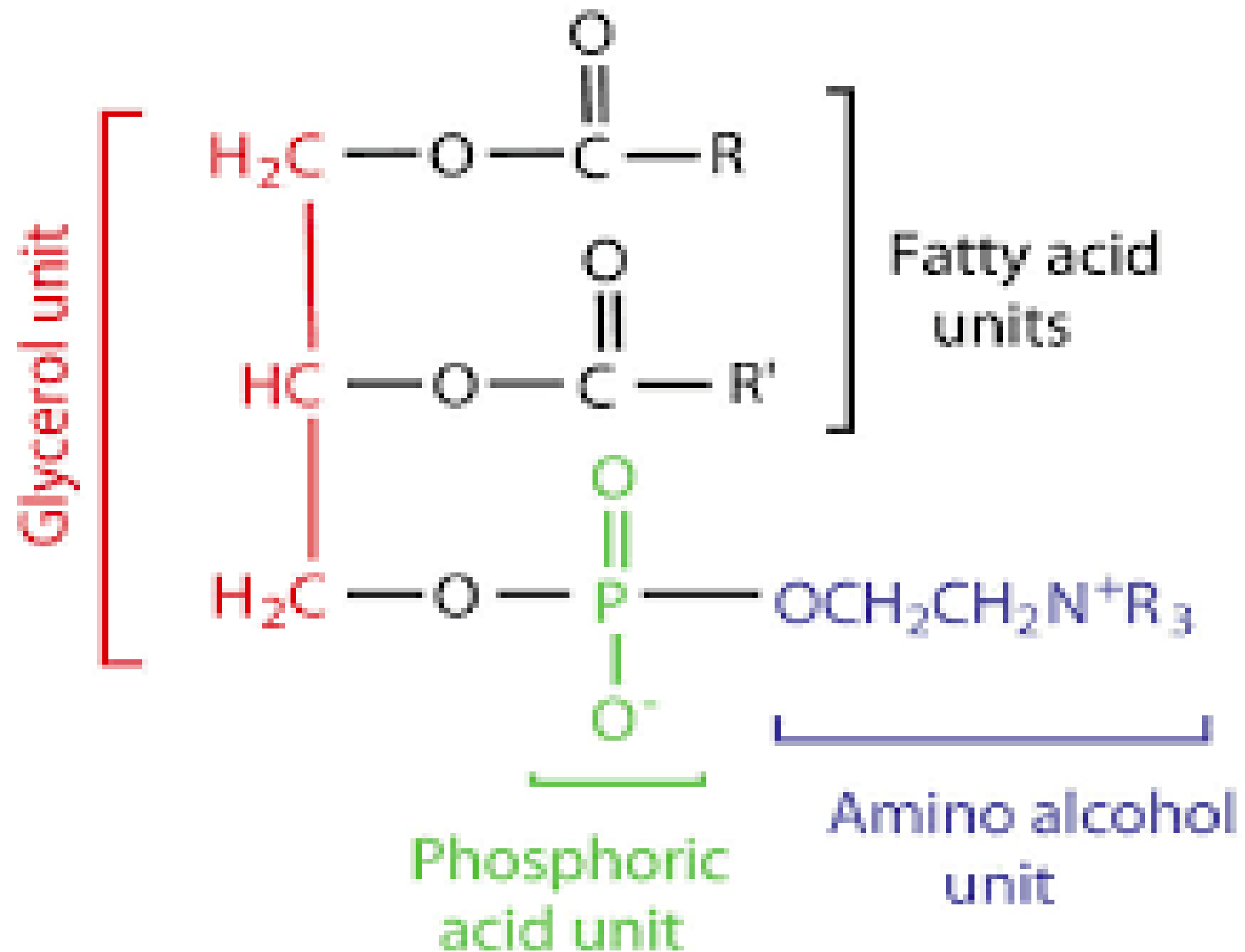
glycerol

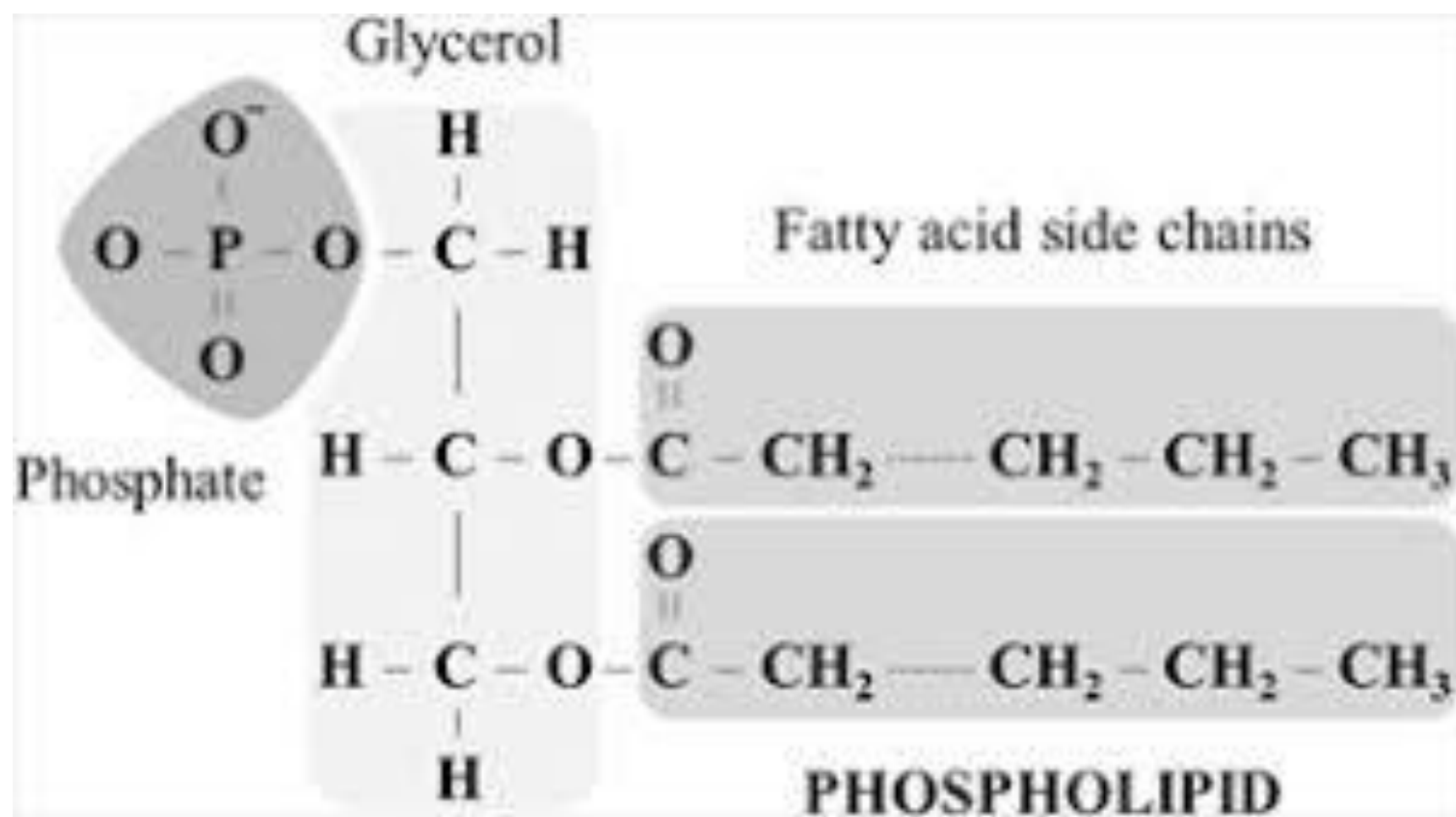


## Phospholipids

The principal phospholipids are composed of triglyceride esterified with phosphoric acid, which in turn, is bound as an ester to a nitrogen containing base (**choline, ethanolamine**) or to **serine**, and **inositol** are some times collectively referred to as **cephalins**. Phospholipids are essential compounds of cell membrane because of their ability align themselves between water and lipids phase. Phosphoethanolamine, a constituent of blood platelets, is a necessary participant in the clotting process. Phospholipids in lipoproteins also supply the fatty acids necessary for the esterification of cholesterol. The phospholipids play a role in

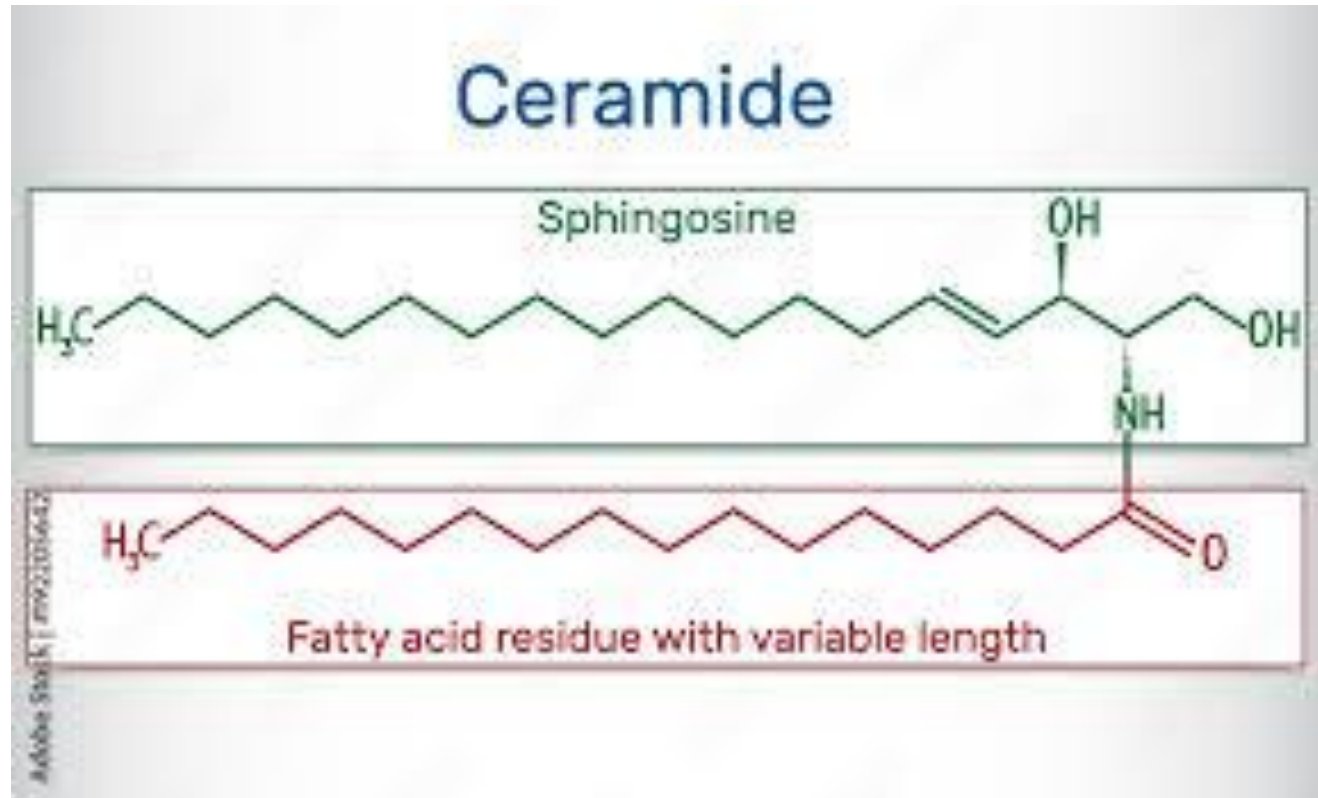
- **mitochondrial metabolism,**
- **blood coagulation, and**
- **lipid transport as part of lipoproteins, and**
- **are important structural components of membranes**





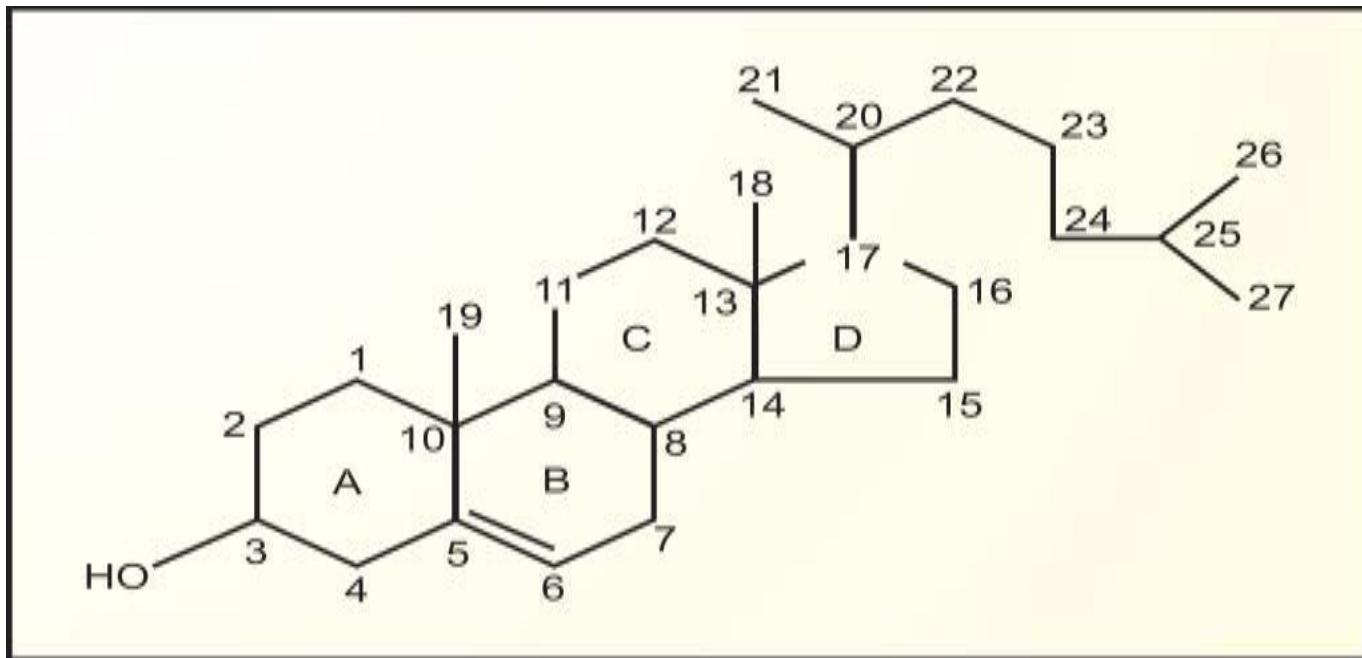
## Sphingolipids

The sphingolipids are all compounds containing the long chain, dihydroxyamino alcohol sphingosine. All the sphingolipids bind a fatty acid in amide linkage to the amino group and are also known as ceramides, because they are cerebral lipids containing an amide group



## Cholesterol

Cholesterol, the principal body sterol, is a complex alcohol formed of **four fused rings** and a **side chain**, pure cholesterol is a solid at body temperature. The major sites of synthesis of cholesterol are **liver, adrenal cortex, testis, ovaries and intestine**.





Approximately 70 % of plasma cholesterol exists in an **acyl ester** form. The esterification takes place almost exclusively in high density lipoprotein (**HDL**) complex. Most of the cholesterol in the body is synthesized from acetyl CoA, but we also ingest some when we eat meat, dairy products, or eggs ,plants do not contain cholesterol, although they do have closely related sterols.

### Formation of cholesterol esters

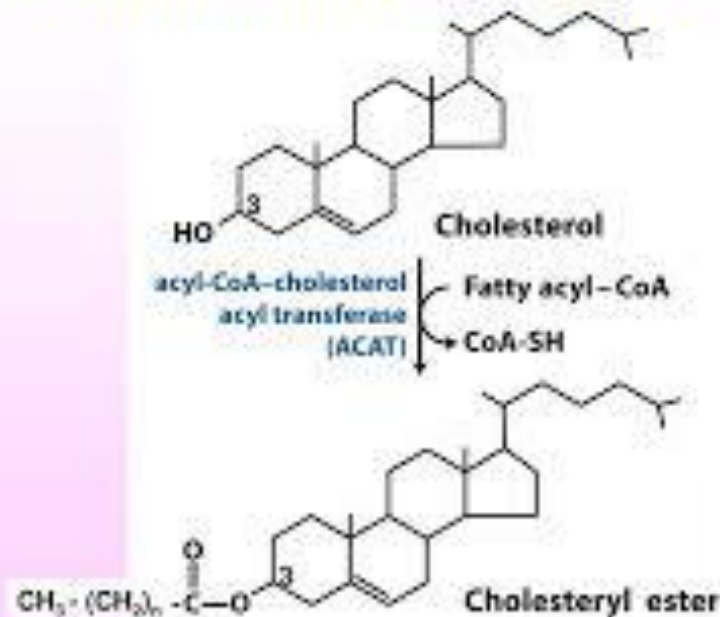


Figure 21-34  
Lehninger Principles of Biochemistry, Fifth Edition  
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**Cholesterol** is catabolized in hepatic cells by oxidation to bile acids (cholic and chenodeoxycholic acids that conjugate with glycine or taurine before secretion into bile. These bile acids and conjugates are emulsifying agents that are essential for the digestion and absorption of fats. Some of cholesterol is also secreted as such into the bile

Both the bile acids and biliary cholesterol are reabsorbed to some extent in the intestine by an enterohepatic circulation. *Thus*, the liver is the site of cholesterol disposal or degradation, as well as its major site of synthesis.

Serum cholesterol concentration can **rise** to high levels in some pathological states. An elevated cholesterol concentration has been implicated as one of several risk factors leading to coronary artery disease (**atherosclerosis** or **myocardial infarction**); *thus* the measurement of serum cholesterol is a fairly common lab.

## **Significance and Functions of Cholesterol:**

1. **Heart diseases:** The level of cholesterol in blood is related to the development of atherosclerosis. Abnormality of cholesterol metabolism may lead to cardiovascular accidents and heart attacks.
2. **Cell membranes:** Cholesterol is a component of membranes and has a modulating effect on the fluid state of the membrane.
3. **Nerve conduction:** Cholesterol is a poor conductor of electricity, and is used to insulate nerve fibers.
4. **Bile acids and bile salts:** The 24 carbon bile acids are derived from cholesterol. Bile salts are important for fat absorption.
5. **Steroid hormones:** 21 carbon glucocorticoids, 19 carbon androgens and 18 carbon estrogens are synthesized from cholesterol.
6. **Vitamin D:** It is synthesized from cholesterol

*thank you*