



# Lipid Chemistry

# Lipid:

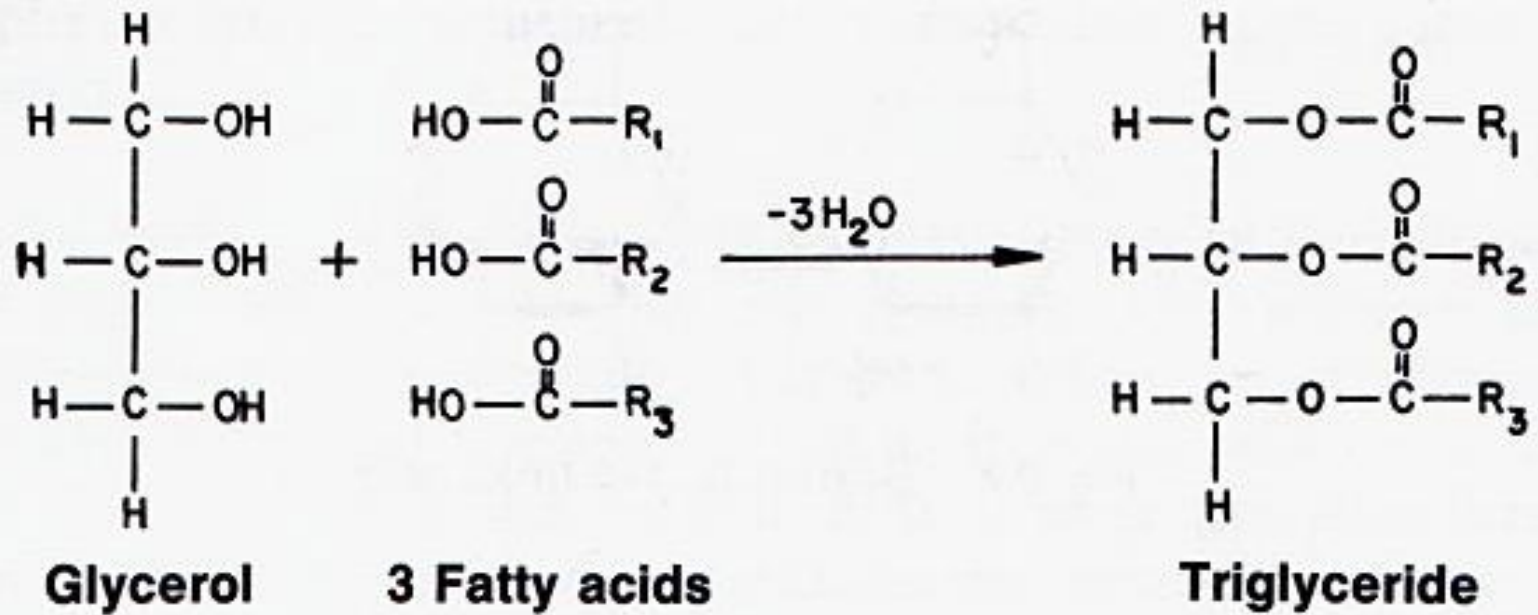
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**Def:** They are organic compounds composed of oxygen, hydrogen, carbon, and may contain nitrogen and phosphate.

- They are formed mainly from alcohol and fatty acids bound together by ester linkage.
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# Lipid:

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# Lipid:

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- Insoluble in water.
  - Soluble in fat (non-polar) solvents as alcohol, chloroform, ether, benzene.
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# Biological importance of lipids:

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1- One of the three main food stuffs:

- Palatable in taste.
- Provide high energy value than carbohydrates and protein (they supply over half of energy used in basal metabolism *although carbohydrates are the preferable rapid metabolisable source of energy*):

**N.B.** : Energy k Cal /g (*Human oxidation*)

*Carbohydrates* = 4.10k Cal /g

*Fat* = 9.30k Cal /g

*Protein* = 4.10k Cal /g

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# Biological importance of lipids:

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- Provide essential fatty acids.
  - Provide fat soluble vitamins (E, D, A, K).
  - Provide milk with its fat content.
  - Compound lipids are important for brain activities.
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# Biological importance of lipids:

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2- Inside the body lipids divided into two forms:

□ Tissue fat:

- Found in cell membrane and nervous system (neurolemma).
  - Mainly phospholipids.
  - Not affected by starvation.
  - Act as electrical insulator: allow rapid propagation of depolarization waves along myelinated nerves (the fat content of nerve tissue is high).
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# Biological importance of lipids:

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- Depot fat:
    - Stored form of fat inside the body.
    - Found in cytoplasm of adipose tissue cells.
    - Mainly consists of triglycerides.
    - Affected by starvation.
    - Act as:
      - 1- store of energy.
      - 2- Pads of internal organs.
      - 3- Thermal insulator in S.C tissues against loss of body heat (brown adipose tissue).
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# Biological importance of lipids:

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3- Form several biologically active biomolecules:

□ e.g., prostaglandins

Steroids form a major group of hormones secreted from adrenal glands and gonads. They are important in maintenance of the metabolic homeostasis and regulation of sexual functions.

4. Knowledge of lipid biochemistry is necessary in understanding many important biomedical areas e.g. obesity, diabetes mellitus, atherosclerosis and role of polyunsaturated fatty acids in nutrition and health.

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# Biological importance of lipids:

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5. Lipoproteins combinations of fat and protein serve as the means of transporting lipids in the blood.
- They are important cellular constituents, occurring both in the cell membrane and in the mitochondria within the cytoplasm.
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# Classification of lipids:

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## 1- Simple lipids:

- esters of fatty acids and alcohol.
  - Classified according to the type of alcohol to:-
  - Triglycerides (neutral fat ) (Triacylglycerol):
    - Esters of fatty acids and glycerol.
  - Waxes:
    - Esters of fatty acids with long chain monohydric alcohol.
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# Classification of lipids:

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## **2- Compound lipids:**

- Contain a group other than fatty acids and alcohol.
    - Phospholipids: contains phosphorous.
    - Sulpholipids: contains sulphur.
    - Glycolipids: contains carbohydrates.
    - Lipoprotein: contains protein.
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# Classification of lipids:

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## 3- Derived lipids:

- Substance derived from simple or compound lipids on hydrolysis.
- As: fatty acids and alcohol.

## 4- Steroids:

- as: bile salts and sterol.

## 5- Miscellaneous lipids:

- Substance which is associated with lipids as fat soluble vitamins and hydrocarbons.
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# Glycerol

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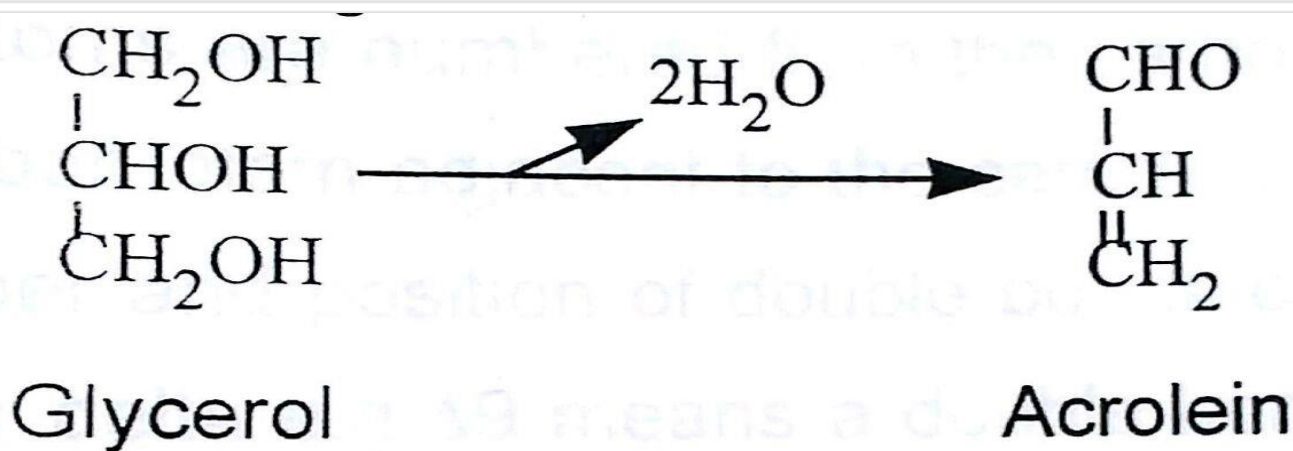
- Popular name **glycerin**
  - Trihydric alcohol (contain three hydroxyl group).
  - **Properties:**
    - Sweet in taste.
    - Soluble in water and alcohol.
  - Can be synthesized in the body from glucose and converted to glucose.
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# Glycerol

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## □ Acrolin test:

- On boiling with sulfuric acid form black substance with pungent odor (Acrolin) by withdrawal of two molecules of water from glycerol.



# Glycerol

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- It is an alcohol in glycerphospholipids and triglycerides.
  - Glycerol reacts with nitric acid producing Trinitroglycerin which is used as explosive.
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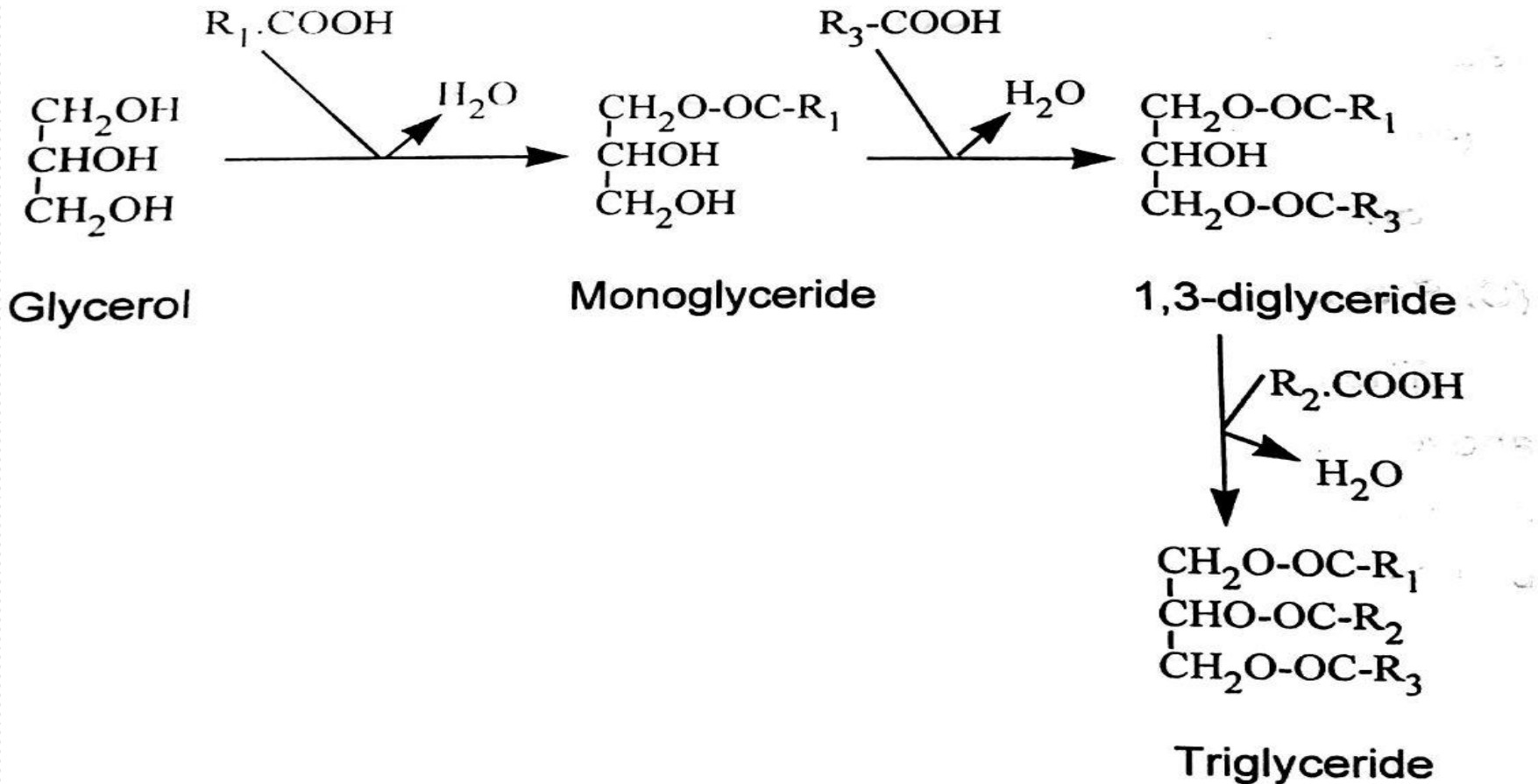
# Glycerol

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## Esterification with fatty acids:

- Glycerol combined with fatty acids by ester linkage forming:
    - Monoglycerides: glycerol + one fatty acid
    - Diglycerides: glycerol + two fatty acids.
    - Triglycerides: glycerol + three fatty acids.
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# Glycerol



# Clinical uses of glycerol:

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1. Enter in all cosmetic preparations.
  2. Nitroglycerin: vasodilator specially for coronary arteries so used in treatment of angina pectoris.
  3. Used in treatment of glaucoma (increased intraocular pressure) as glycerol has the ability to dehydrate tissues from its water.
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# Fatty acids

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- ❑ Monocarboxylic acids: have one COOH group.
  - ❑ General formula (RCOOH) where R stands for alkyl radical composed of Carbon and Hydrogen atoms.
  - ❑ Aliphatic: not branched.
  - ❑ Mainly found as esters with alcohol forming triglycerides.
  - ❑ Present as free fatty acids in plasma.
  - ❑ Fatty acids that occur in natural fats usually contain an even number of carbon atoms and of straight chain which may be saturated or unsaturated.
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# Classification of fatty acids

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# I Chemical Classification

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1. Saturated fatty acids: (containing no double bonds)
    - Short chain fatty acids contain 2-10 carbon atoms.
      - Volatile fatty acids: (contain 2-6 carbon atoms).
      - Non volatile fatty acids: (contain 7-10 carbon atoms).
    - long chain fatty acids contain more than 10 carbons
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# I Chemical Classification

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2. Unsaturated fatty acids: (containing one or more double bonds).
    - Monounsaturated fatty acids: (contain one double bond).
    - Polyunsaturated fatty acids: (contain more than one double bond).
    - Eicosanoids: cyclic compounds derived from arachidonic acid (C<sub>20</sub> contain 4 double bonds).
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## II Nutritional classification:

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### 1- Essential fatty acids:

- Can't be synthesized inside the body so must be taken in the diet (polyunsaturated fatty acids) as enzyme system inside the body can't introduce double bond except at carbon atom number 9.
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## II Nutritional classification:

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### Importance of essential fatty acids:

1. Essential for normal growth.
  2. Form part of various membranes.
  3. Inter in the phospholipid and cholesterol ester formation.
  4. Protect the body against X rays of sun.
  5. Source of certain important materials as prostoglandins.
  6. Play a part in lipid transport and certain lipoprotein enzymes.
  7. Transfer to cholesterol.
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## **II Nutritional classification:**

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### **Deficiency of essential fatty acids:**

- 1.** Fatty liver and sterility in adults.
  - 2.** Impaired growth and dermatitis in infants.
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# II Nutritional classification:

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## 2- Non essential fatty acids:

- Can be synthesized inside the body from acetyl CoA (active acetate) which is derived from glucose oxidation so it is not necessary to be taken in the diet.
  - They include all saturated and monounsaturated fatty acids.
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# I Chemical Classification

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## 1- Saturated fatty acids: (containing no double bonds)

- General formula  $\text{CH}_3(\text{CH}_2)_n\text{COOH}$  where  $n$  stands for (total no. of carbon atoms – 2).
- Classified according to number of carbon atoms to:

A) Short chain fatty acids contain 2-10 carbon atoms.

## 1- Volatile fatty acids:

- Contain 2-6 carbon atoms.
  - Soluble in water.
  - Volatile fatty acids.
  - Liquid at room temperature.
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# I Chemical Classification

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- Acetic (C2)
  - Propionic (C3)
  - Butyric (C4)
  - Valeric (C5)
  - Caproic (C6)
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# I Chemical Classification

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## 2- Non volatile fatty acids:

- Contain 7-10 carbon atoms.
  - Insoluble in water.
  - Soluble in fat solvents.
  - Non volatile.
  - Solid at room temperature.
  - e.g:
    - Caproic (C8)
    - Caprylic (C10)
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# I Chemical Classification

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## B- Long chain fatty acids:

- Contain more than 10 carbons.
  - Insoluble in water.
  - Soluble in fat solvents.
  - Non volatile.
  - Solid at room temperature.
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# I Chemical Classification

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- Lauric (C12)
- Myristic (C14)
- Palmitic (C16)
- Stearic (C18)
- Arachidic (C20)
- Behenic (C22)
- Lignoceric (C24)

## **N.B:**

- Palmitic acid is the main end product of fatty acid synthesis in the body.
  - Palmitic and Stearic acid are most abundant in body fat.
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# Numbering of fatty acids:

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# I Chemical Classification

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## 2- Unsaturated fatty acids:

- Containing one or more double bonds.
- Classified according to number of double bonds to:

### a) Monounsaturated fatty acids (Monoenoic acids):

- Contain one double bond at carbon atom number 9.
  - Non essential fatty acids as enzyme system inside the body can introduce double bond only at carbon atom number 9.
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# I Chemical Classification

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□ Oleic: C18 : 1  $\Delta$  <sup>9</sup>

**It is the common fatty acid in the natural fat.**

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# I Chemical Classification

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## b) Polyunsaturated fatty acids (Polyenoic acids):

- Contain more than one double bond.
  - Essential fatty acids as enzyme system of the body can't introduce double bond except at carbon atom number 9 so these fatty acids must be taken in the diet.
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# I Chemical Classification

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- **Linoleic (ω6): C18 : 2 Δ<sup>9,12</sup>**
- **Linolenic (ω3): C18: 3Δ<sup>9,12,15</sup>**
- **Arachidonic (ω6): C20:4Δ<sup>5,8,11,14</sup>**
- Linoleic acid is the common fatty acid in the natural fat.
- Double bonds repeated every three carbons.

## **Source of Polyunsaturated fatty acids:**

- Fish and vegetable oils as corn, linseed, cottonseed, maize, sunflower and soybean oils.
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# Position of double bond

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□ Delta ( $\Delta$ ) system:

□ Omega ( $\omega$ ) system:

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