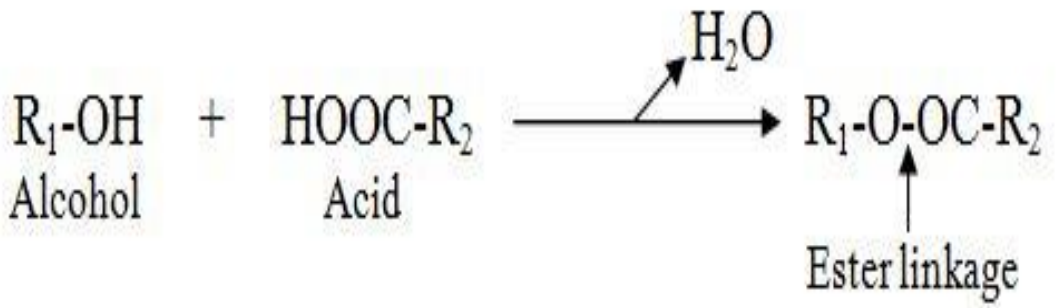
Lipids of biological importance

By

Dr. Walaa bayoumie el gazzar

- Lipids are organic substances related to fatty acids. They are water insoluble (non – polar, hydrophobic) but soluble in fat solvents as alcohols, chloroform, benzene, acetone, ethers…etc.
- Lipids are formed mainly of alcohol and fatty acids combined together by **ester linkage**.



Classification of lipids

1- Simple lipids:

- These are esters of alcohols with fatty acids. According to alcohol they are sub classified into:
- **Triacylglycerols:** these are esters of glycerol with 3 fatty acids. When fatty acid are esterified to glycerol they loose their negative charge , and hence the name neutral fats.
- **Waxes:** these are esters of monohydric alcohols higher than glycerol with one fatty acid.

2-Compound, complex or structural lipids:

- They are formed of simple lipids in addition to other substances or groups which may be phosphoric acid, carbohydrates, and proteins to give phospholipids, glycolipids, and lipoprotein, respectively.

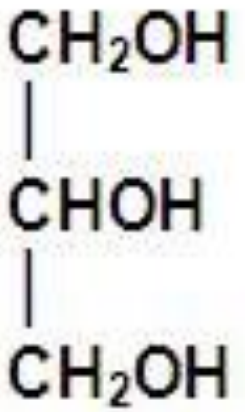
3-Derived Lipids:

- These types of lipids are derived from simple & compound lipids (obtained by the hydrolysis of the above groups).

4-Substances associated with lipids:

- These are substances present associated with lipids in nature and related to them in properties and metabolism, as fat soluble vitamins (A, D, E & K) and sterols as cholesterol and provitamins as carotenes.

Simple lipids



I. Glycerol :

- It is the simplest form of trihydric alcohol. It is commercially known as glycerin: $CH_2OH.CHOH.CH_2OH$
- The glycerol is the main component of neutral fats. Since the glycerol contains three hydroxyl groups, it has the ability to combine with three FA through an ester bond. These FA may be the same to give simple triacylglycerols (TAG) or different to give mixed triacylglycerols.
- The most common FAs which may enter in the structure of neutral fats are palmitic, stearic and/or oleic acids.

- Glycerol contains 2 primary alcohol and one secondary alcohol groups. Its carbons are numbered 1-3 from above downwards.

- It can be esterified with one, two, or three fatty acids, forming monoacylglycerol, diacylglycerol, and triacylglycerol, respectively.

II. Fatty acids

- Fatty acids are monocarboxylic acids and have the general structural formula; R-COOH. The R group represents the hydrocarbon chain.
- **General properties of FA:**
  - They are mono carboxylic acids.
  - The chain length may vary from 4 to 24 carbon atoms.
  - Natural occurring FA had an even number with few exceptions.
  - They may be saturated or unsaturated.

Classification of FA:

There are different methods for classification of FA depending on:

1- The total number of carbon atoms

a. Even chain: Most of the naturally occurring lipids contain even chain FA. They have carbon atoms 2, 4, 6 and similar series

b. Odd chain: They are present in milk and microbial cell wall. They have carbon atoms 3, 5, 7. etc.

2- Length of hydrocarbon chain:

- **Short chain FA:** with 2 to 6 carbon atoms
- **Medium chain FA:** with 8 to 14 carbon atoms.
- **Long chain FA:** with 16 to 24 carbon atoms.
- **Very long chain FA:** with more than 24 carbon atoms.

3- Nature of hydrocarbon chain:

- **Saturated FA:** without any double bond.
- **Unsaturated FA:** which may be subclassified into:

- mono-unsaturated (monoenoic or monoethenoid) containing one double bond or
- poly-unsaturated (polyenoic or polyethenoid) containing 2 or more double bonds.

- **Branched FA:** e.g. isovaleric acid
- **Hydroxy FA:** e.g. cerebronic acid (brain lipid)

- ***The most common fatty acids in nature are long chain and straight chain with an even number of carbon atoms.***

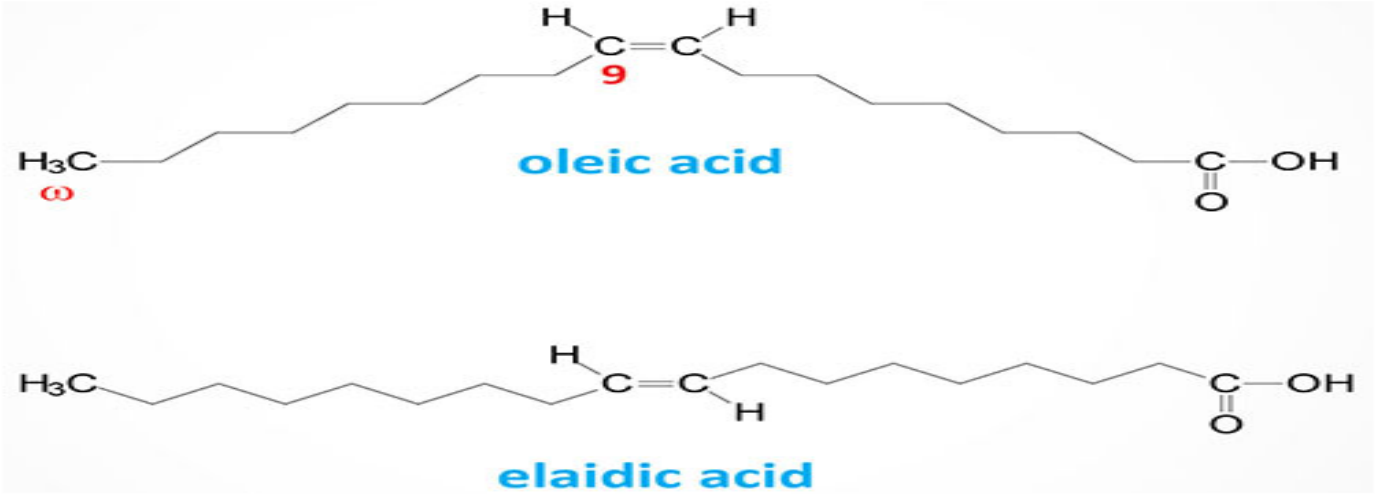
Saturated fatty acids

- They have the general formula **CH_3. (CH_2) n. COOH**.
- These contain no double bonds. All fatty acids containing an even number of carbon atoms from **C4 to C24** occur in natural fats and oils, ***the most common being palmitic and stearic acids.*** Short and medium chain fatty acids are uncommon except in milk fat and butter.

A. Even Chain, saturated FA:	**Carbon atoms No.**	**Chemical nature**	**Occurrence**
Acetic	2	Saturated, small chain	Vinegar
Butyric	4	Saturated, small chain	Butter
Caproic	6	Saturated, small chain	Butter
Capric	10	Saturated, small chain	Coconut
Lauric	12	Saturated, small chain	Coconut
Myristic	14	Saturated, small chain	Coconut
Palmitic	16	Saturated , long chain	Body fat
Stearic	18	Saturated , long chain	Body fat
Arachidic	20	Saturated , long chain	Peanut

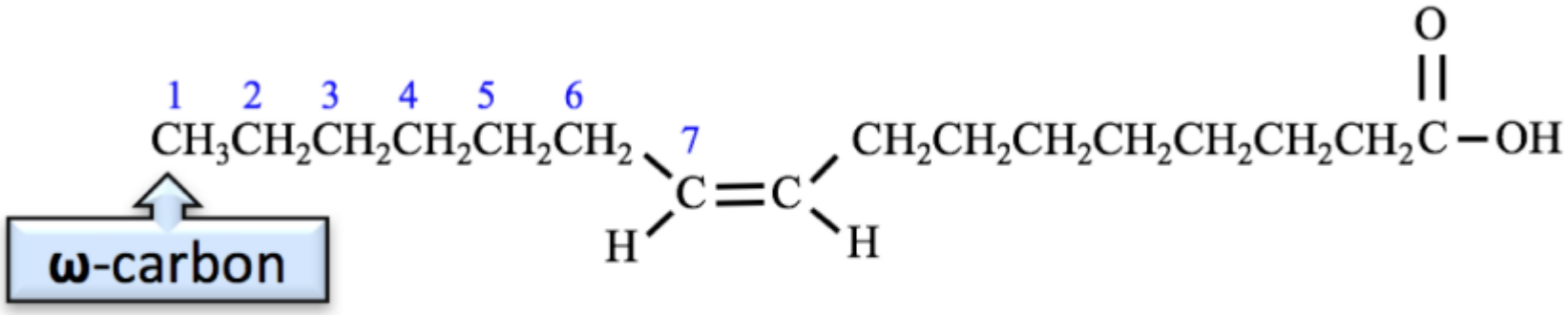
Unsaturated fatty acids

- Naturally occuring unsaturated FA contain **Cis** double bonds. This makes them bend 120° at the double bond and lowers their melting temperature.



- Two systems are used for numbering of carbon atoms and denoting the position of double bonds in fatty acids:

➢ ***(1) Delta (Δ) numbering, or C-numbering, and Greek lettering system***, in which carbon atoms are numbered from the carboxyl group, which is given the number I. The carbon atom adjacent to the carboxyl group is C-2, and is also known as the α-carbon. The next carbon is C-3 and is also known as the β-carbon. The position of the double bonds is shown by the Greek letter **Δ** (delta), e.g. Δ^9 indicates a double bond between carbons 9 and 10 such as in palmitoleic acid.



palmitoleic acid (an *omega-7* fatty acid)

- ***(2) Omega (ω) numbering system,*** in which the methyl carbon ***at*** the end of the hydrocarbon chain is known as the **ω**1 carbon (omega 1 carbon). From the nutritional point of view, it is better to indicate the position of the double bond as related to the o-carbon rather than the carboxyl carbon.

- In this way palmitoleic acid is **ω** 7, oleic acid is **ω**9, linoleic and arachidonic acids are **ω** 6, and α-lino1enic and timnodonic acids are **ω**3.

***Palmitoleic (unsaturated palmtic acid)**: 16:1:w7

$$CH_3-(CH_2)_5-\underset{10}{CH}=\underset{9}{CH}-(CH_2)_7-COOH$$

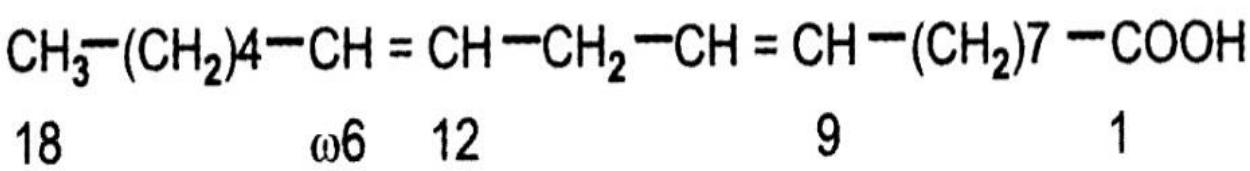
***Oleic (unsaturated stearic):** 18:1:w9

$$CH_3-(CH_2)_7-\underset{10}{CH}=\underset{9}{CH}-(CH_2)_7-COOH$$

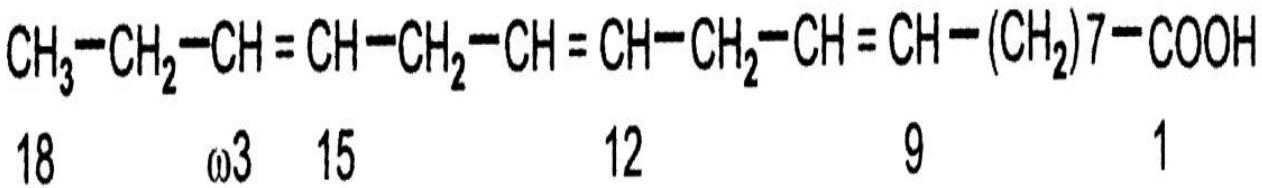
***Nervonic (unsaturated lignoceric):** 24:1:w9

$$CH_3-(CH_2)_7-\underset{16}{CH}=\underset{15}{CH}-(CH_2)_{13}-COOH$$

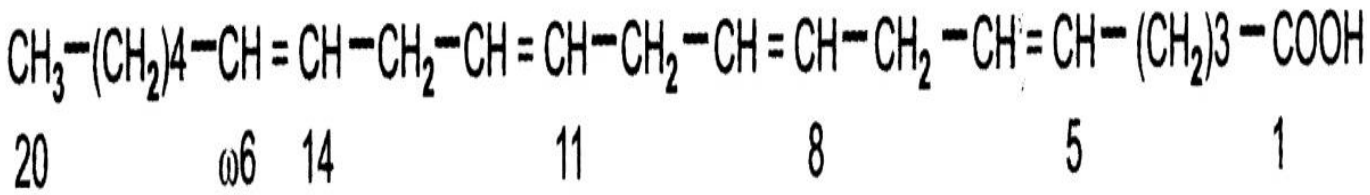
Linoleic (C_{18}) Δ9, 12 **(two double bonds)** (ω6 family)



Linolenic (C_{18}) Δ9, 12, 15 **(three double bonds)** (ω3 family)



Arachidonic (C_{20}) Δ5, 8, 11, 14 **(four double bonds)** (ω6 family)



- Linoleic, (ω6), linolenic (ω3) are called essential fatty acids (EFA), they cannot be synthesized by the body and must be taken in diet.

- Arachidonic acid is not one of the essential fatty acids. However it does become essential if there is a deficiency in linoleic acid or if there is an inability to convert linoleic acid to arachidonic acid which is required by most mammals.