LIPIDS

(Part-1)

Dr. Aditi

Post Graduate Department of Zoology

Magadh University, Bodh Gaya

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Lipids

- **Lipids** (Greek: *lipos,* fat) are the fourth major group of molecules found in all cells.
- Unlike nucleic acids, proteins, and polysaccharides, lipids are not polymeric. However, they do aggregate, and it is in this state that they perform their central function as the structural matrix of biological membranes.
- Lipids exhibit greater structural variety than the other classes of biological molecules. But they are largely hydrophobic and only sparingly soluble in water.
- In general, **lipids perform three biological functions** (although certain lipids serve more than one purpose in some cells):

1. **Lipid molecules in the form of lipid bilayers are essential components of biological membranes.**
2. **Lipids containing hydrocarbon chains serve as energy stores.**
3. **Many intra- and intercellular signaling events involve lipid molecules.**

Lipids

- The **length and saturation** of a fatty acid chain **determine its physical properties**.
- **Triacylglycerols (TAGs)** and **Glycerophospholipids** contain **fatty acids esterified to glycerol**.
- **Sphingolipids** resemble glycerophospholipids but may **include large carbohydrate groups**.
- **Steroids**, **Isoprenoids**, and other lipids perform a **wide variety of functions**.
- *Lipids are substances of biological origin that are **soluble in organic solvents** such as chloroform and methanol.* Hence, they are easily separated from other biological materials by extraction into organic solvents.
- They can then be **separated chromatographically** and **identified by mass spectrometry** according to their masses and characteristic fragmentation patterns.
- Fats, oils, certain vitamins and hormones, and most non-protein membrane components are lipids.

The Properties of Fatty Acids Depend on Their Hydrocarbon Chains

- ***Fatty acids*** *are carboxylic acids with long-chain hydrocarbon side groups* (**Figure 1**).

- They usually occur in esterified form as major components of the various lipids. The more common biological fatty acids are listed in **Table I**.

- In higher plants and animals, the predominant fatty acid residues are those of the C_{16} and C_{18} species: **palmitic, oleic, linoleic**, and **stearic acids**.

- Fatty acids with <14 or >20 carbon atoms are uncommon.

- Most fatty acids have an even number of carbon atoms because they are biosynthesized by the concatenation of C_2 units.

Figure 1. The structural formulas of some C18 fatty acids. The double bonds all have the cis configuration.

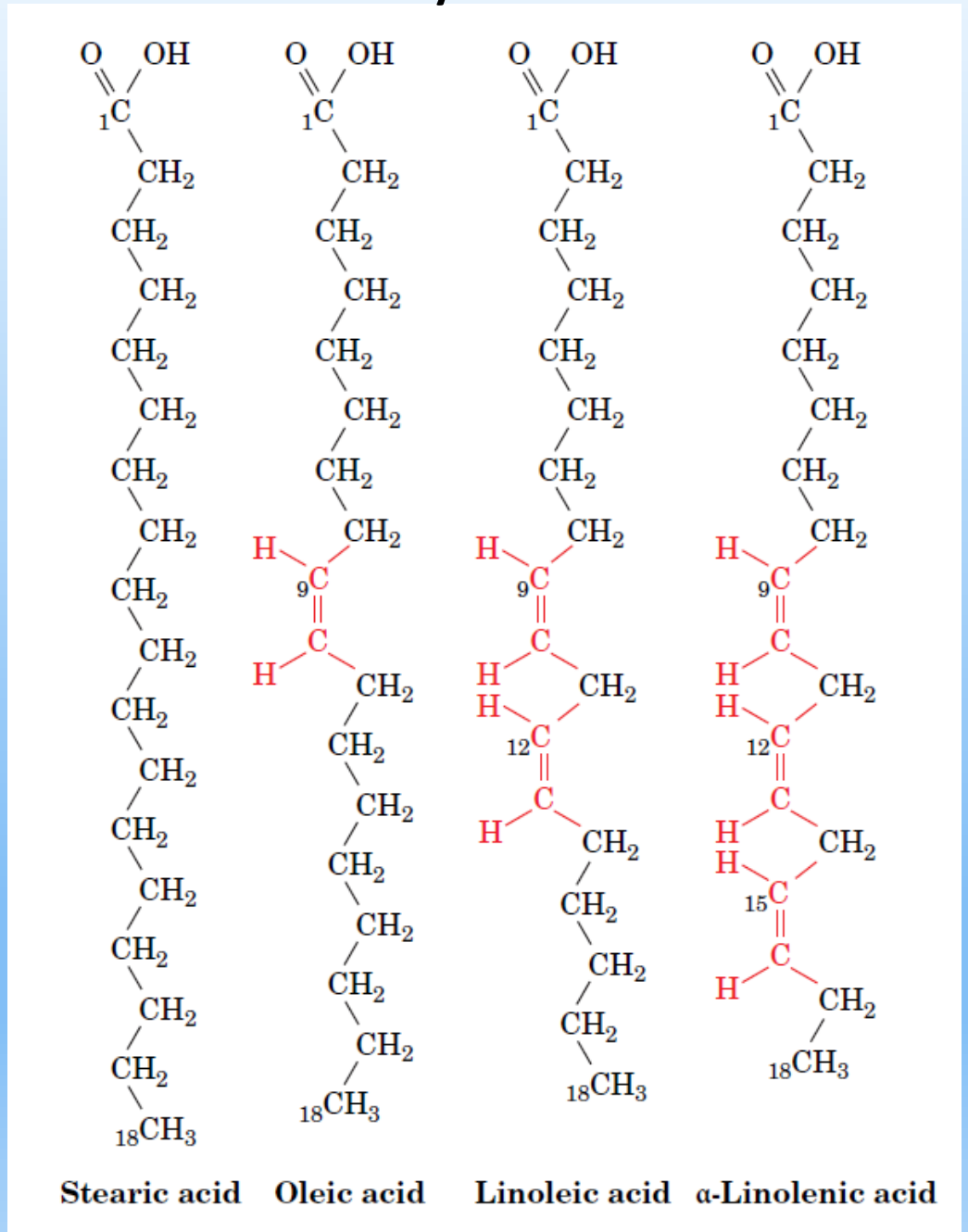
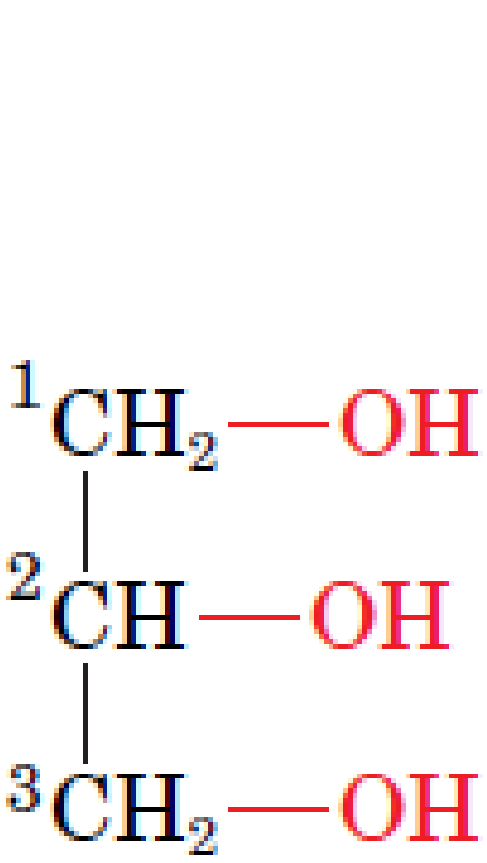


TABLE -1 The Common Biological Fatty Acids

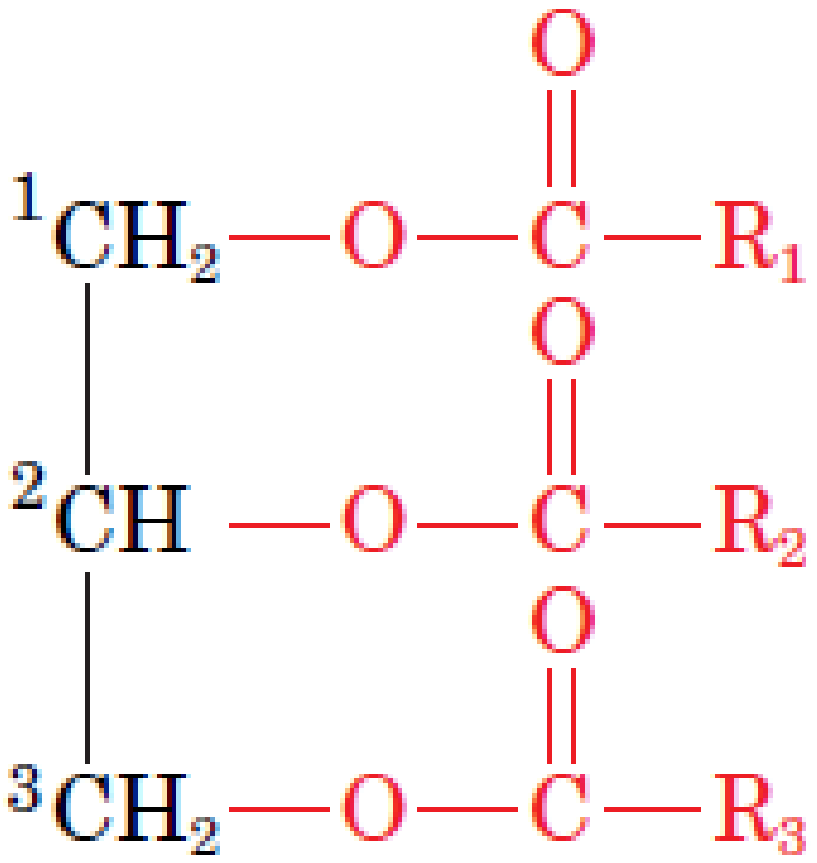
Symbol[a]	Common Name	Systematic Name	Structure	mp (°C)
Saturated fatty acids				
12:0	Lauric acid	Dodecanoic acid	$CH_3(CH_2)_{10}COOH$	44.2
14:0	Myristic acid	Tetradecanoic acid	$CH_3(CH_2)_{12}COOH$	53.9
16:0	Palmitic acid	Hexadecanoic acid	$CH_3(CH_2)_{14}COOH$	63.1
18:0	Stearic acid	Octadecanoic acid	$CH_3(CH_2)_{16}COOH$	69.6
20:0	Arachidic acid	Eicosanoic acid	$CH_3(CH_2)_{18}COOH$	77
22:0	Behenic acid	Docosanoic acid	$CH_3(CH_2)_{20}COOH$	81.5
24:0	Lignoceric acid	Tetracosanoic acid	$CH_3(CH_2)_{22}COOH$	88
Unsaturated fatty acids (all double bonds are cis)				
16:1*n*–7	Palmitoleic acid	9-Hexadecanoic acid	$CH_3(CH_2)_5CH{=}CH(CH_2)_7COOH$	−0.5
18:1*n*–9	Oleic acid	9-Octadecanoic acid	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	12
18:2*n*–6	Linoleic acid	9,12-Octadecadienoic acid	$CH_3(CH_2)_4(CH{=}CHCH_2)_2(CH_2)_6COOH$	−5
18:3*n*–3	α-Linolenic acid	9,12,15-Octadecatrienoic acid	$CH_3CH_2(CH{=}CHCH_2)_3(CH_2)_6COOH$	−11
18:3*n*–6	γ-Linolenic acid	6,9,12-Octadecatrienoic acid	$CH_3(CH_2)_4(CH{=}CHCH_2)_3(CH_2)_3COOH$	−11
20:4*n*–6	Arachidonic acid	5,8,11,14-Eicosatetraenoic acid	$CH_3(CH_2)_4(CH{=}CHCH_2)_4(CH_2)_2COOH$	−49.5
20:5*n*–3	EPA	5,8,11,14,17-Eicosapentaenoic acid	$CH_3CH_2(CH{=}CHCH_2)_5(CH_2)_2COOH$	−54
22:6*n*–3	DHA	4,7,10,13,16,19-Docosohexenoic acid	$CH_3CH_2(CH{=}CHCH_2)_6CH_2COOH$	−44
24:1*n*–9	Nervonic acid	15-Tetracosenoic acid	$CH_3(CH_2)_7CH{=}CH(CH_2)_{13}COOH$	39

[a]Number of carbon atoms: Number of double bonds. For unsaturated fatty acids, the quantity " *n–x* " indicates the position of the last double bond in the fatty acid, where *n* is its number of C atoms, and *x* is the position of the last double-bonded C atom counting from the methyl-terminal (ω) end.

Basic Structure: Glycerol and Triacylglycerol (TAG)

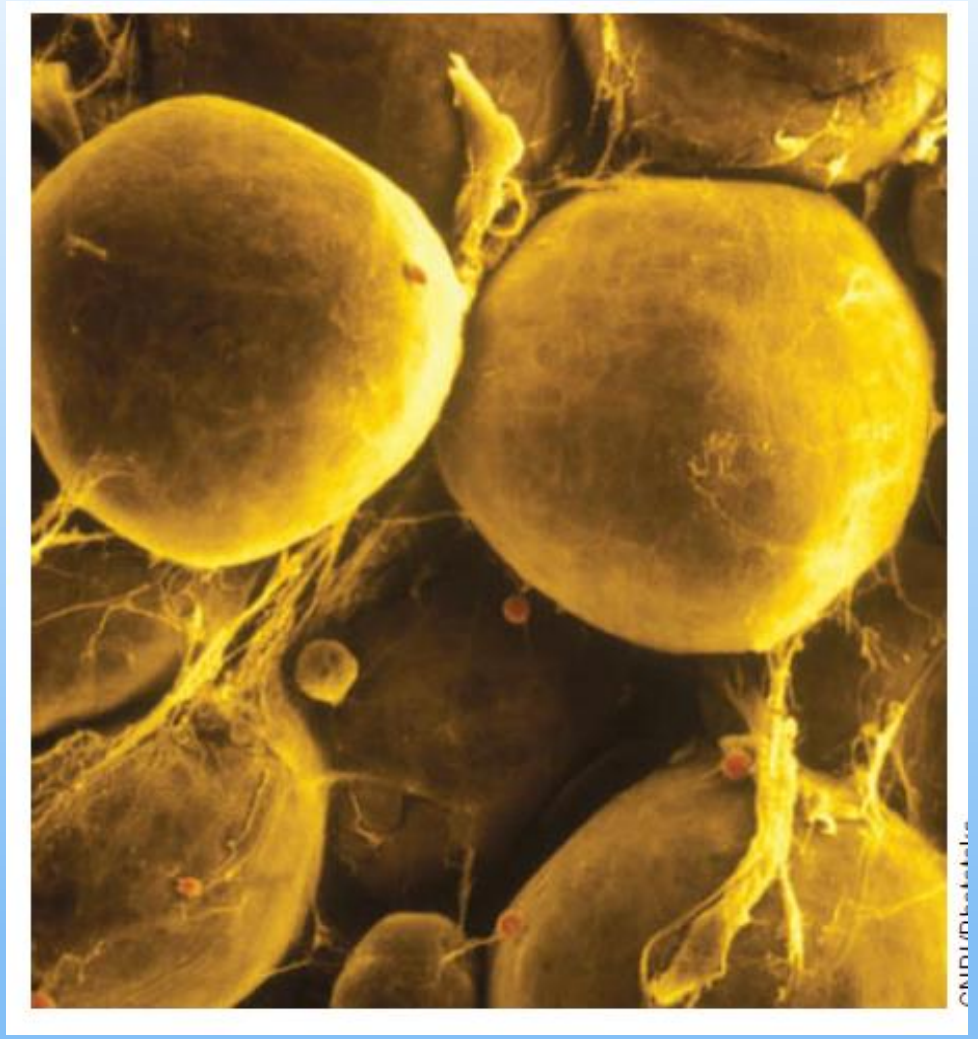


Glycerol



Triacylglycerol

Site of lipid storage in adipose tissue



Scanning Electron Micrograph of Adipocytes: Each adipocyte contains a fat globule that occupies nearly the entire cell and stores TAGs

Reference Book

- Fundamentals of Biochemistry, Life at the Molecular Level, Voet & Voet