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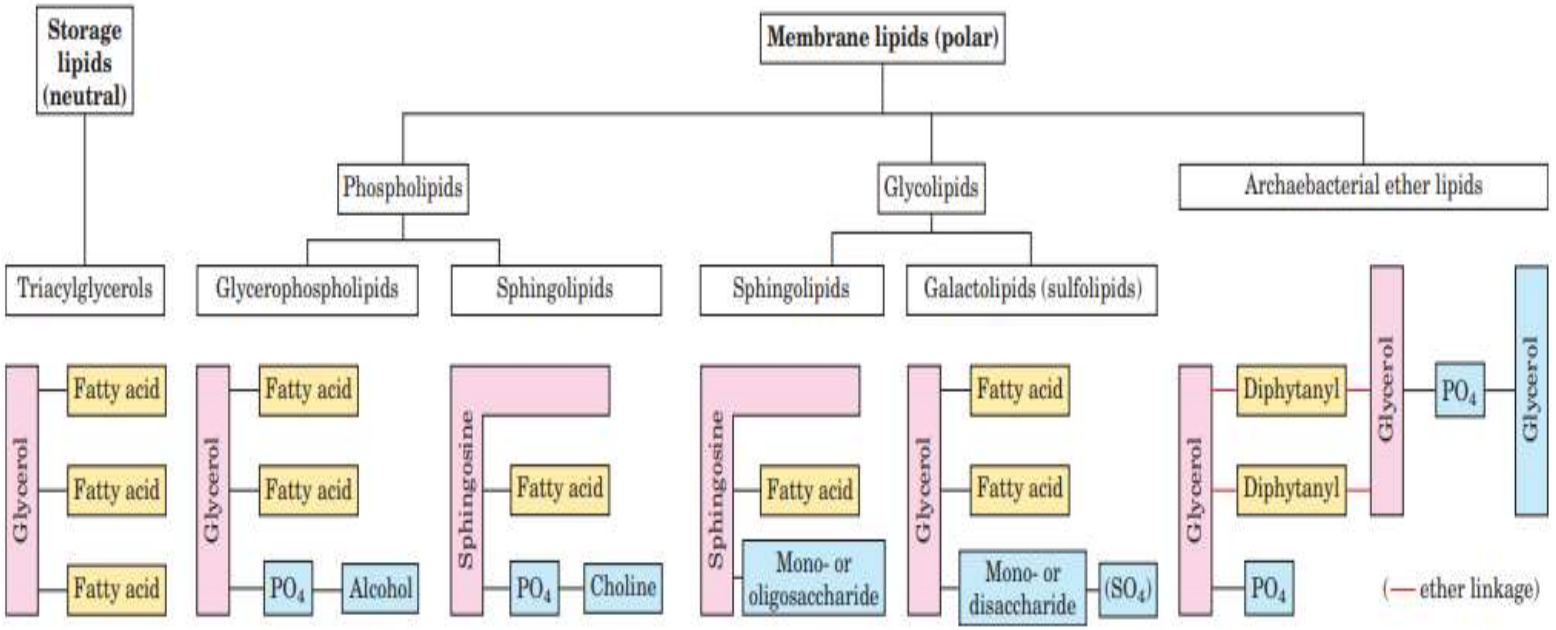
Lipids

- Lipids are organic compounds that are found in living organisms.
- They have variety of structures and functions, and soluble in organic solvents due to their hydrocarbon component.



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Fatty Acids Are Hydrocarbon Derivatives

- Fatty acids are carboxylic acids with hydrocarbon chains ranging from 4 to 36 carbons long (C4 to C36).
- In some fatty acids, this chain is unbranched and fully saturated (contains no double bonds); in others the chain contains one or more double bonds
- Fatty acids are unbranched carboxylic acids having long hydrocarbon chains
- Most of the naturally available fatty acids bears an even number of carbon atoms due to their synthesis from acetate.
- In unsaturated fatty acids, the double bonds have cis-configuration and are separated by one CH2 group.
- Thus, unsaturated fatty acids have less intermolecular interactions compared to saturated fatty acids.
- unsaturated fatty acids have lower melting points in comparison to saturated fatty acids. The melting point decreases as the number of double bonds increases.

DR. ANNIKA SINGH MBT 2002

Chhatrapati Shahu Ji Maharaj University, Kanpur
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Some Naturally Occurring Fatty Acids: Structure, Properties, and Nomenclature

Carbon skeleton	Structure*	Systematic name†	Common name (derivation)	Melting point (°C)	Solubility at 30 °C (mg/g solvent)	
					Water	Benzene
12:0	$CH_3(CH_2)_{10}COOH$	*n*-Dodecanoic acid	Lauric acid (Latin *laurus*, "laurel plant")	44.2	0.063	2,600
14:0	$CH_3(CH_2)_{12}COOH$	*n*-Tetradecanoic acid	Myristic acid (Latin *Myristica*, nutmeg genus)	53.9	0.024	874
16:0	$CH_3(CH_2)_{14}COOH$	*n*-Hexadecanoic acid	Palmitic acid (Latin *palma*, "palm tree")	63.1	0.0083	348
18:0	$CH_3(CH_2)_{16}COOH$	*n*-Octadecanoic acid	Stearic acid (Greek *stear*, "hard fat")	69.6	0.0034	124
20:0	$CH_3(CH_2)_{18}COOH$	*n*-Eicosanoic acid	Arachidic acid (Latin *Arachis*, legume genus)	76.5		
24:0	$CH_3(CH_2)_{22}COOH$	*n*-Tetracosanoic acid	Lignoceric acid (Latin *lignum*, "wood" + *cera*, "wax")	86.0		
16:1(Δ^9)	$CH_3(CH_2)_5CH{=}CH(CH_2)_7COOH$	*cis*-9-Hexadecenoic acid	Palmitoleic acid	1–0.5		
18:1(Δ^9)	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	*cis*-9-Octadecenoic acid	Oleic acid (Latin *oleum*, "oil")	13.4		
18:2($\Delta^{9,12}$)	$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$	*cis*-,*cis*-9,12-Octadecadienoic acid	Linoleic acid (Greek *linon*, "flax")	1–5		
18:3($\Delta^{9,12,15}$)	$CH_3CH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$	*cis*-,*cis*-,*cis*-9,12,15-Octadecatrienoic acid	α-Linolenic acid	−11		
20:4($\Delta^{5,8,11,14}$)	$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_3COOH$	*cis*-,*cis*-,*cis*-,*cis*-5,8,11,14-Icosatetraenoic acid	Arachidonic acid	−49.5		

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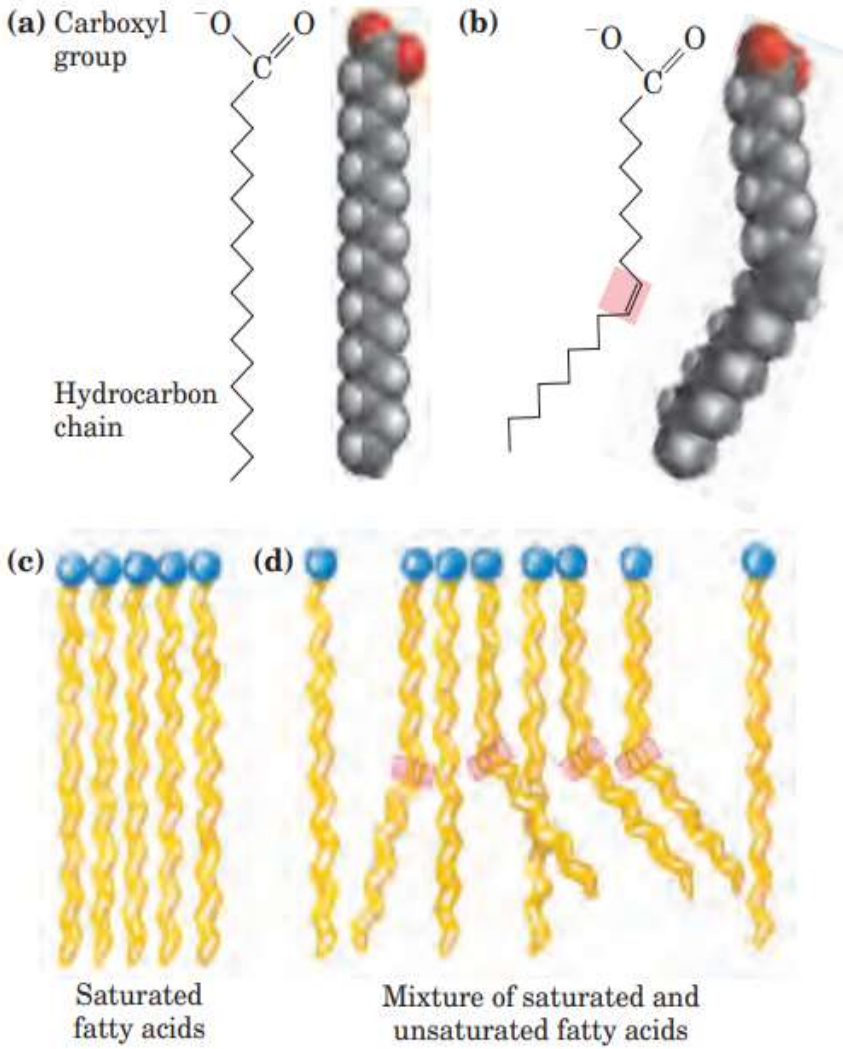
Saturated and Unsaturated fatty acids



The packing of fatty acids into stable aggregates. The extent of packing depends on the degree of saturation. (a) Two representations of the fully saturated acid stearic acid (stearate at pH 7) in its usual extended conformation. Each line segment of the zigzag represents a single bond between adjacent carbons. (b) The cis double bond (shaded) in oleic acid (oleate) does not permit rotation and introduces a rigid bend in the hydrocarbon tail. All other bonds in the chain are free to rotate. (c) Fully saturated fatty acids in the extended form pack into nearly crystalline arrays, stabilized by many hydrophobic interactions. (d) The presence of one or more cis double bonds interferes with this tight packing and results in less stable aggregates

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Saturated and Unsaturated fatty acids

- Melting points are also strongly influenced by the length and degree of unsaturation of the hydrocarbon chain. At room temperature (25^0C), the saturated fatty acids from 12:0 to 24:0 have a waxy consistency, whereas unsaturated fatty acids of these lengths are oily liquids.
- This difference in melting points is due to different degrees of packing of the fatty acid molecules.
- In the fully saturated compounds, free rotation around each carbon–carbon bond gives the hydrocarbon chain great flexibility; the most stable conformation is the fully extended form, in which the steric hindrance of neighboring atoms is minimized.
- These molecules can pack together tightly in nearly crystalline arrays, with atoms all along their lengths in van der Waals contact with the atoms of neighboring molecules.
- In unsaturated fatty acids, a cis double bond forces a kink in the hydrocarbon chain.
- Fatty acids with one or several such kinks takes less thermal energy to disorder these poorly ordered arrays of unsaturated fatty acids, they have markedly lower melting points than saturated fatty acids of the same chain length

DR. ANNIKA SINGH MBT 2022

Chhatrapati Shahu Ji Maharaj University, Kanpur
Uttar Pradesh State University

Waxes

- Waxes are esters of long chain carboxylic acids with long chain alcohols.
- For example, beeswax contains a 26 carbon carboxylic acid and a 30 carbon alcohol component, while carnauba wax has a 32 carbon carboxylic acid component and a 34 carbon alcohol component.
- The latter is an example for a hard wax, and is widely used as a car wax and in floor polishes
- Waxes are also common in living organisms.
- Biological waxes find a variety of applications in the pharmaceutical, cosmetic, and other industries. Lanolin (from lamb's wool), beeswax
- Biological waxes is found on the surfaces of some leaves, where it serves as protectant against parasites and minimizes the evaporation of water.
- the feathers of birds are coated with wax to make them water repellent

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Triacylglycerols Are Fatty Acid Esters of Glycerol

- The simplest lipids constructed from fatty acids are the triacylglycerols, also referred to as triglycerides, fats, or neutral fats.
- Triacylglycerols are composed of three fatty acids each in ester linkage with a single glycerol
- Simple triacylglycerols of 16:0, 18:0, and 18:1, for example, are tristearin, tripalmitin, and triolein, respectively
- triacylglycerols are nonpolar, hydrophobic molecules, essentially insoluble in water.
- Lipids have lower specific gravities than water, which explains why mixtures of oil and water have two phases
- Adipocytes and germinating seeds contain lipases, enzymes that catalyze the hydrolysis of stored triacylglycerols, releasing fatty acids for export to sites where they are required as fuel

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Fats and Oils

- The solid or semisolid triglycerides at room temperature are called fats, while the liquid is called oil.
- Fats are generally obtained from animals, while oils come from plant products. In fats, saturated fatty acid is usually involved in the formation of ester with glycerol, whereas in oils, unsaturated fatty acid is involved.
- In case of fats, the saturated fatty acid chain can pack closely together causing them to be solids at room temperature. In case of oil, the unsaturated fatty acid chain can not pack tightly together, and therefore, that leads to usually have low melting points.
- Polyunsaturated fats and oils are prone to undergo oxidation by O2 via radical reaction.
- The allylic H is the one that is easily removed because the resulting radical is resonance stabilized by the unpleasant taste bonds. The oxidation reaction and smell associated with sour milk and rancid butter.

Triacylglycerols
(general structure)

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