Lipids: Membrane Structure

- Role of lipids
- Fatty acid structure and nomenclature
- Types of membrane lipids
- Structure of membrane
- Membrane fluidity





Role of lipids

- Energy
- Energy Storage
- Hormones
- Vitamins
- Digestion
- Insulation
- Membrane structure: Hydrophobic properties

Lipids





Fatty acid nomenclature

Number of carbons	Number of double bonds	Common name	Systematic name	Formula
12	0	Laurate	n-Dodecanoate	CH ₂ (CH ₂) ₁₀ COO ⁻
14	0	Myristate	n-Tetradecanoate	CH,(CH,),,COO-
16	0	Palmitate	<i>n</i> -Hexadecanoate	CH, (CH,), COO-
18	0	Stearate	n-Octadecanoate	CH, (CH,), COO-
20	0	Arachidate	n-Eicosanoate	CH,(CH,),,,COO-
22	0	Behenate	n-Docosanoate	CH, (CH,), 000-
24	0	Lignocerate	<i>n</i> -Tetracosanoate	CH,(CH,),,,COO-
16	1	Palmitoleate	<i>cis</i> - Δ^9 -Hexadecenoate	CH, (CH,),CH=CH(CH,),COO-
18	1	Oleate	cis - Δ^9 -Octadecenoate	CH, (CH,),CH=CH(CH,),COO-
18	2	Linoleate	<i>cis, cis</i> -∆ ⁹ , ∆ ¹² - Octadecadienoate	$CH_3^{\prime}(CH_2)_4^{\prime}(CH=CHCH_2)_2^{\prime}(CH)_6COO^-$
18	3	Linolenate	all- <i>cis</i> - Δ^9 , Δ^{12} , Δ^{15} - Octadecatrienoate	$CH_3CH_2(CH=CHCH_2)_3(CH_2)_6COO^-$
20	4	Arachidonate	all- <i>cis</i> ∆ ⁵ ,∆ ⁸ ,∆ ¹¹ , -∆ ¹⁴ Eicosatetraenoate	$CH_3(CH_2)_4(CH=CHCH_2)_4(CH_2)_2COO^-$

TABLE 12.1 Some naturally occurring fatty acids in animals

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Fatty acid Structure

- Long hydrocarbon chains
- Various lengths
- Saturated Fatty acids
- No double bond



Unsaturated Fatty acids

- One or more double bonds
- Cis: *cis*-Δ⁹, double bond between 9 and 10 carbon
- Trans: trans- Δ², double bond between 2 and 3 carbon
- ω-3 counting from the distal end.



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Types of membrane lipids

- Phospholipids
- Glycolipids
- Cholesterol

Phospholipids

- Glycerol backbone
- 2 fatty acids usually one saturated and one unsaturated
- C-3 carbon has phosphoric acid group



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Types of phospholipids



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Sphingomyelin: amino alcohol



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Glycolipids: sugar containing lipids

- Cerbroside
- Gangliosides: branched chain of sugars
- Extracellular side of membrane
- receptors



Cholesterol H₃C CH₃ **CH**₃ ĊH₃ **CH**₃ HO **Cholesterol**

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Structure of membrane

- Membrane bilayer
- Lipids are amphipathic: hydrophillic and hydrophobic
- Contains phospholipids, glycolipids, cholesterol, and proteins
- Membranes are asymmetric
- Membranes are fluid
- Proteins mediate most functions



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Membrane bilayer



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Lipid bilayers

- Nanometers to millimeters in thickness, usually 6-10 nm
- Self assembly: entropy
- Impermeable to ions and most polar molecules to form boundaries
- Create a charge difference



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Membrane proteins

- Protein ratio in membranes can vary from 1:4 to 4:1 depending on function
- Integral proteins
- Peripheral proteins



Membrane fluidity

- Phospholipids can diffuse laterally
- Rotations from one face to the other is very slow



Control of membrane fluidity

TABLE 12.3	The melting temperature of phosphatidylcholine containing different pa	airs
	of identical fatty acid chains	

	Number of double bonds	FATTY ACID			
Number of carbons		Common name	Systematic name	7 _m (°C)	
22	0	Behenate	n-Docosanote	75	
18	0	Stearate	n-Octadecanoate	58	
16	0	Palmitate	n-Hexadecanoate	41	
14	0	Myristate	n-Tetradecanoate	24	
18	1	Oleate	$cis-\Delta^9$ -Octadecenoate	-22	

Table 12-3 Biochemistry, Sixth Edition



- Processes require some fluidity
- T_m = melting temperature depends on length of fatty acid chain
- Double bonds increase fluidity
- Cholesterol inserts into bilayers and disrupts interactions; moderates fluidity

Fatty acid composition

- Bacteria can vary number of double bonds to regulate fluidity
- Eukaryotic cells (and bacteria) can change fatty acid composition with ratio of saturated to unsaturated fatty acids and chain length

	Percent weight of total fatty acid content						
	Chilling-resistant species			Chilling-sensitive species			
Major fatty acids ^a	Cauliflower bud	Turnip root	Pea shoot	Bean shoot	Sweet potato	Maize shoot	
Palmitic (16:0)	21.3	19.0	12.8	24.0	24.9	28.3	
Stearic (18:0)	1.9	1.1	2.9	2.2	2.6	1.6	
Oleic (18:0)	7.0	12.2	3.1	3.8	0.6	4.6	
Linoleic (18:2)	16.4	20.6	61.9	43.6	50.8	54.6	
Linolenic (18:3)	49.4	44.9	13.2	24.3	10.6	6.8	
Ratio of unsaturated to :	saturated						
fatty acids	3.2	3.9	3.8	2.8	1.7	2.1	

^a Shown in parentheses are the number of carbon atoms in the fatty acid chain and the number of double bonds. *Source*: After Lyons et al. 1964.