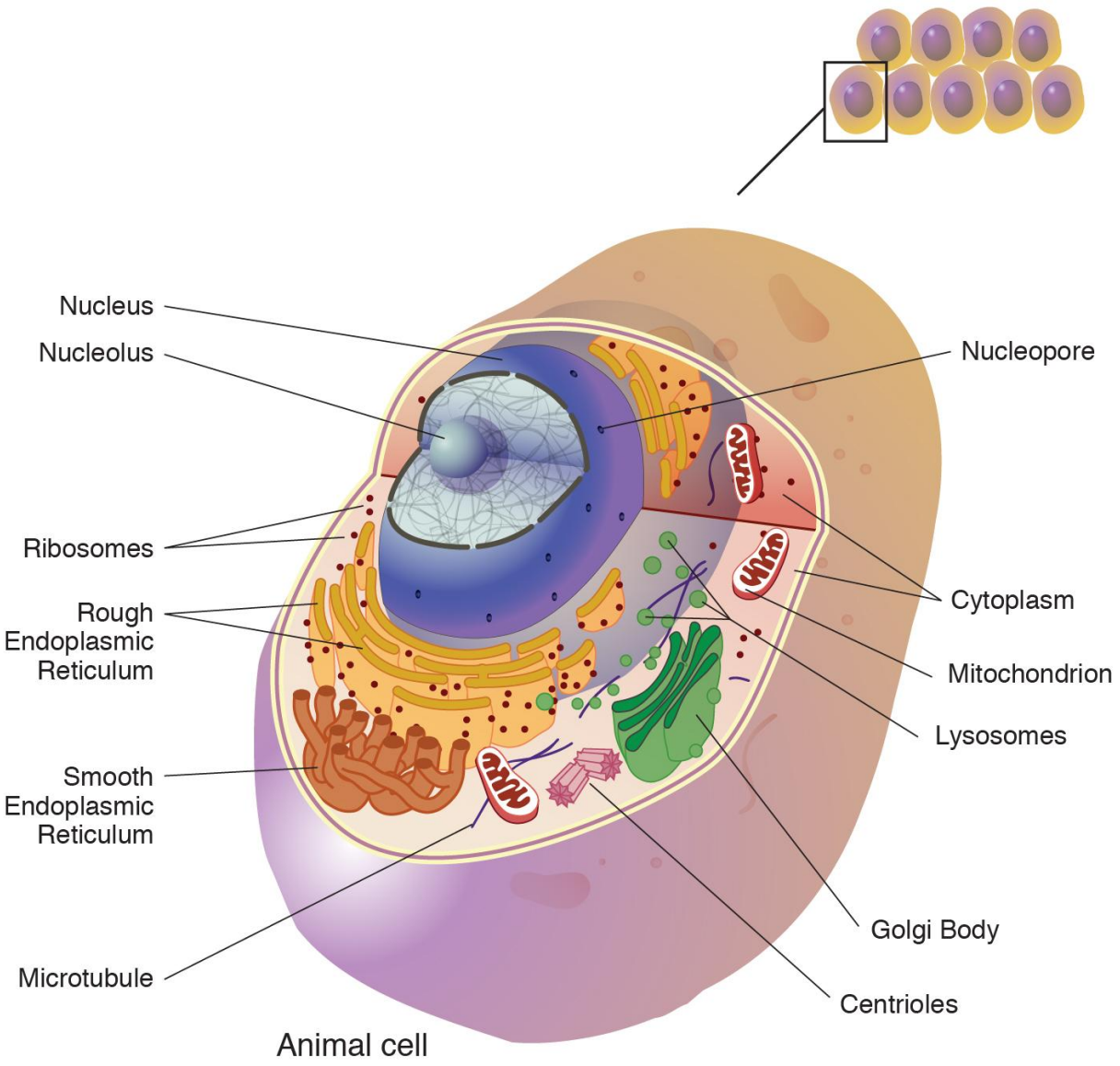
Lipídeos e Membranas Biológicas

Nelson, DL & Cox, MM. Lehninger Principles of Biochemistry, 6th Ed.

Voet, D, Voet, J e Pratt J. Fundamentals of Biochemistry

Marzzoco A e Torres BB. Bioquímica Básica, 4ª edição

Voet, D & Voet, J. Biochemistry, 3rd ed.



https://www.genome.gov/genetics-glossary/Cell

Modelo do Mosaico Fluido

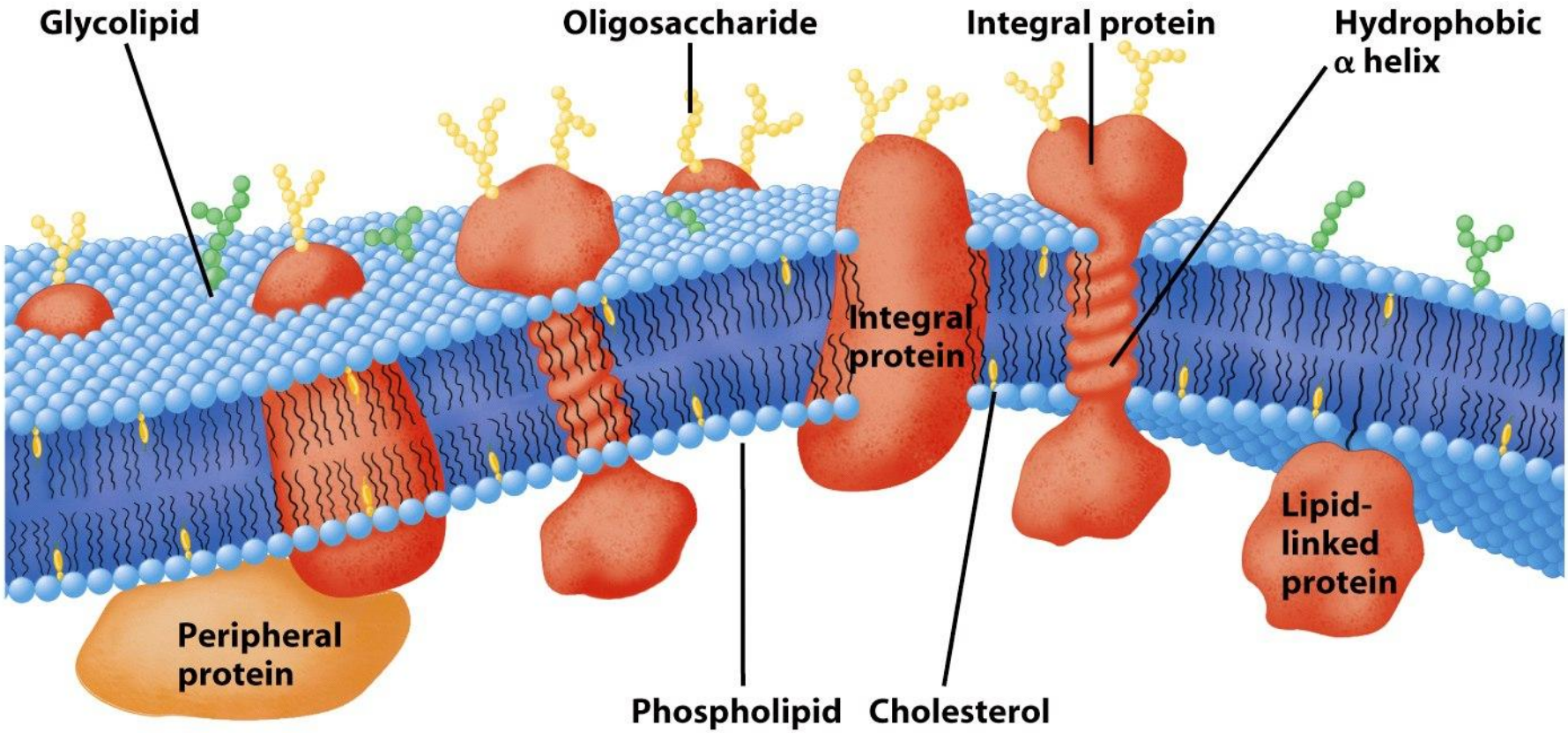


Figure 9-26 Fundamentals of Biochemistry, 2/e

Estrutura supramolecular
Dinâmica
Permeabilidade seletiva

Ácidos Graxos

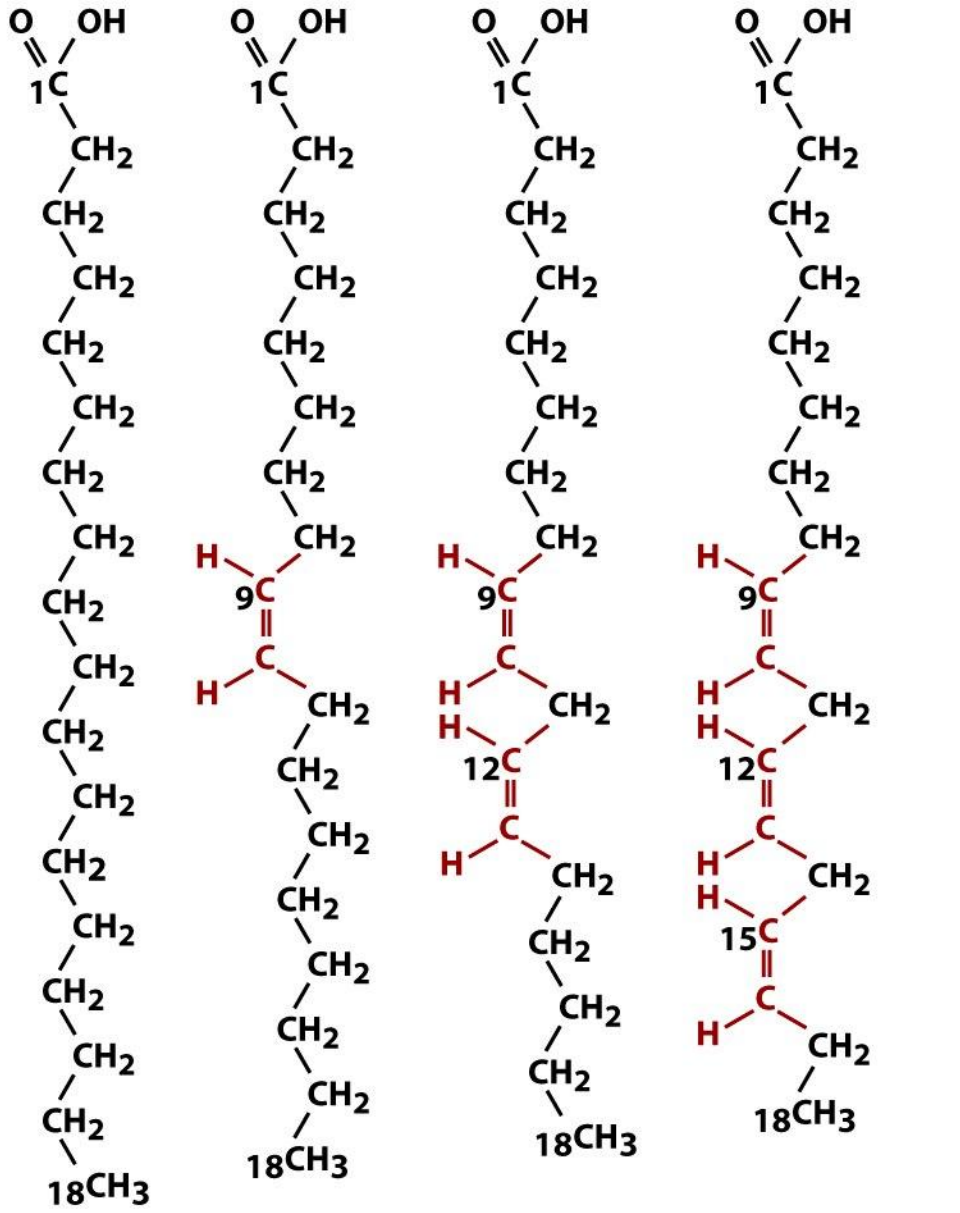
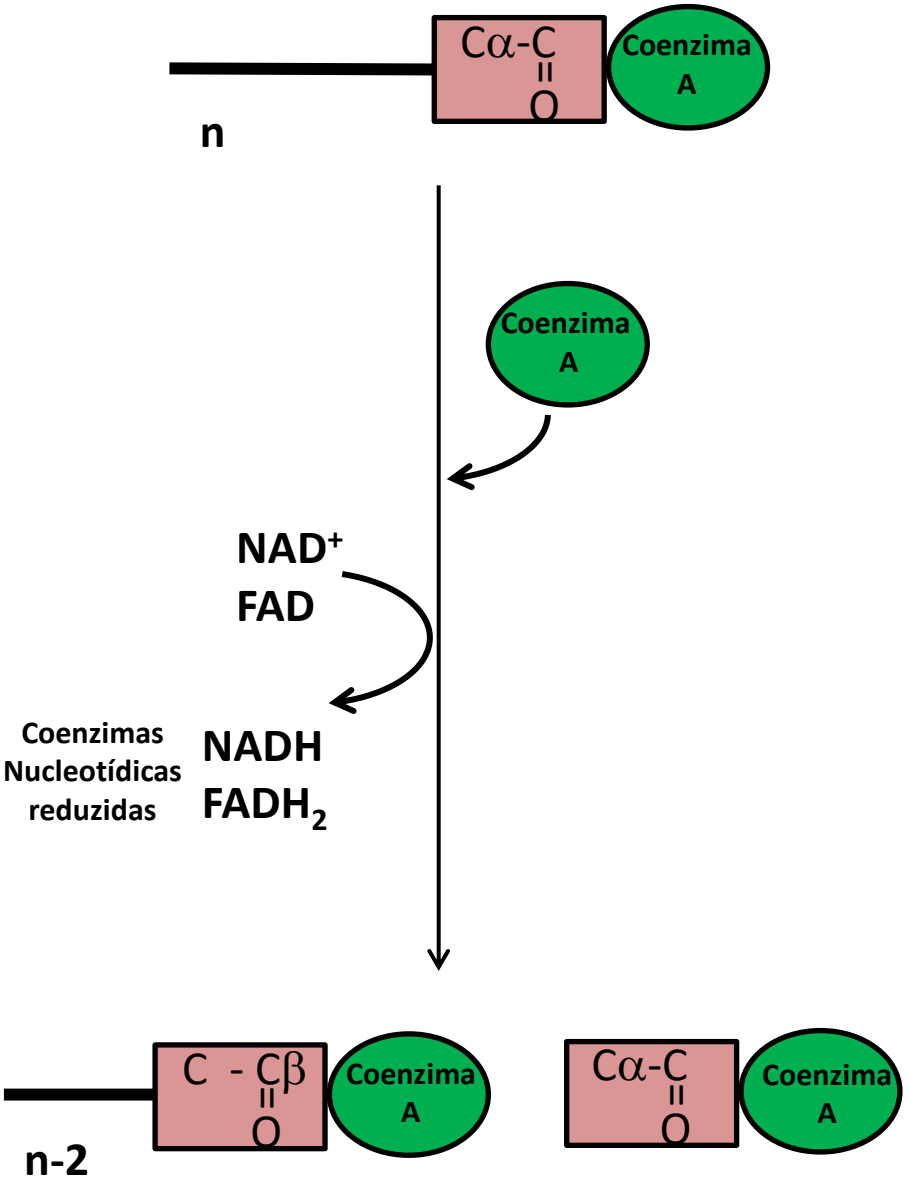
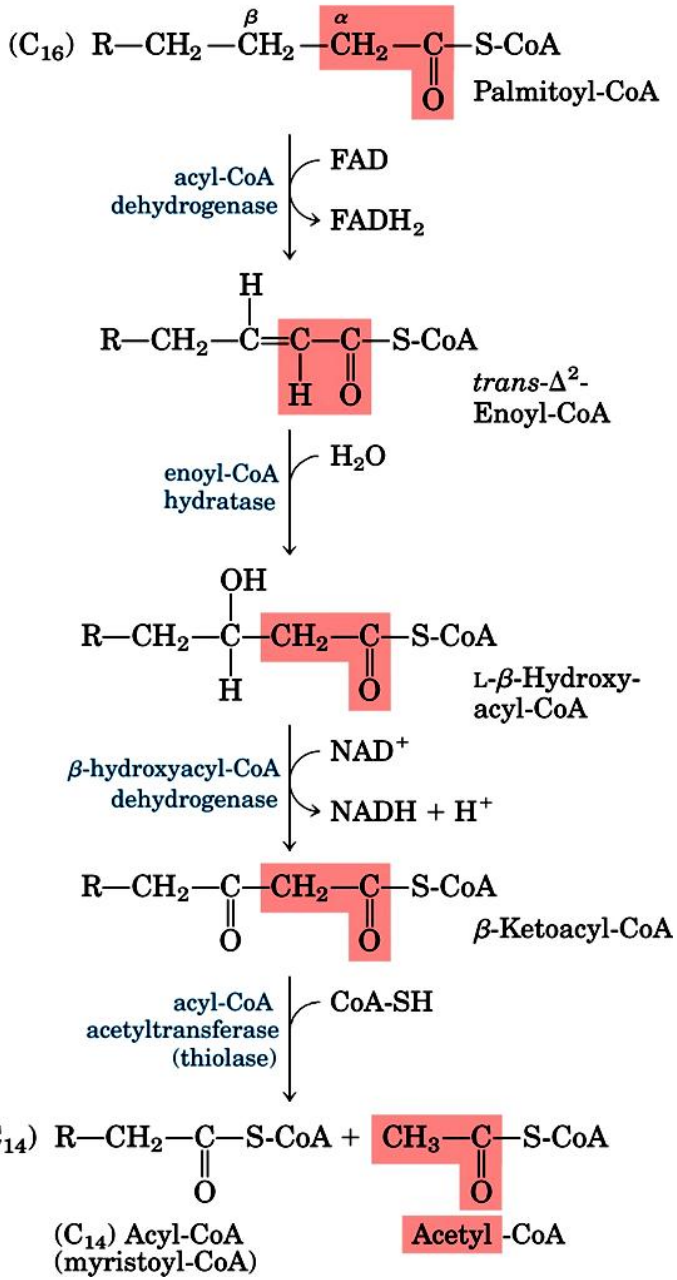


Figure 9-1 Fundamentals of Biochemistry, 2/e

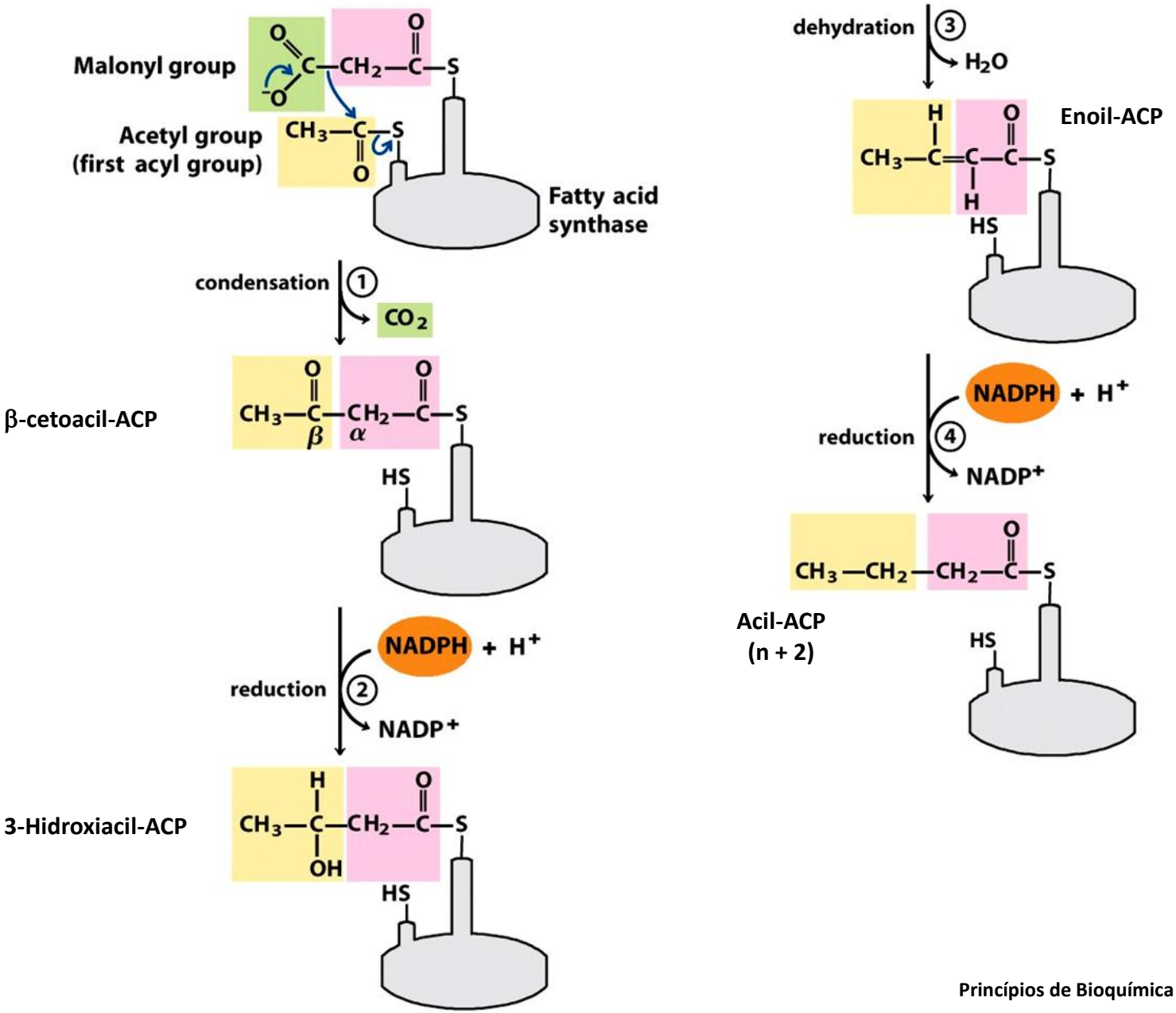
β Oxidação de Ácidos Graxos (Espiral de Lynen)



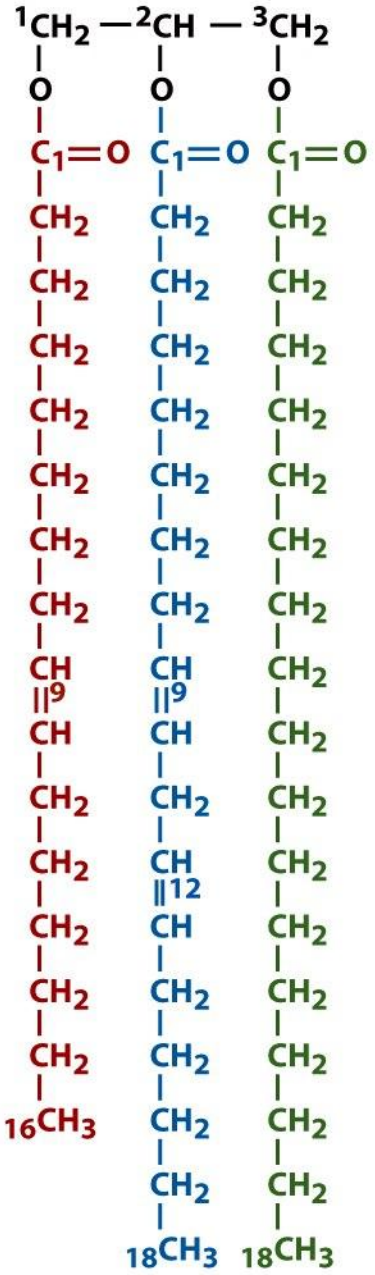


Princípios de Bioquímica de Lehninger

Sintese de Ácidos Graxos



Princípios de Bioquímica de Lehninger



1-Palmitoleoyl-2-linoleoyl-3-stearoyl-glycerol

Triacilglicerol

Unnumbered figure pg 236b Fundamentals of Biochemistry, 2/e

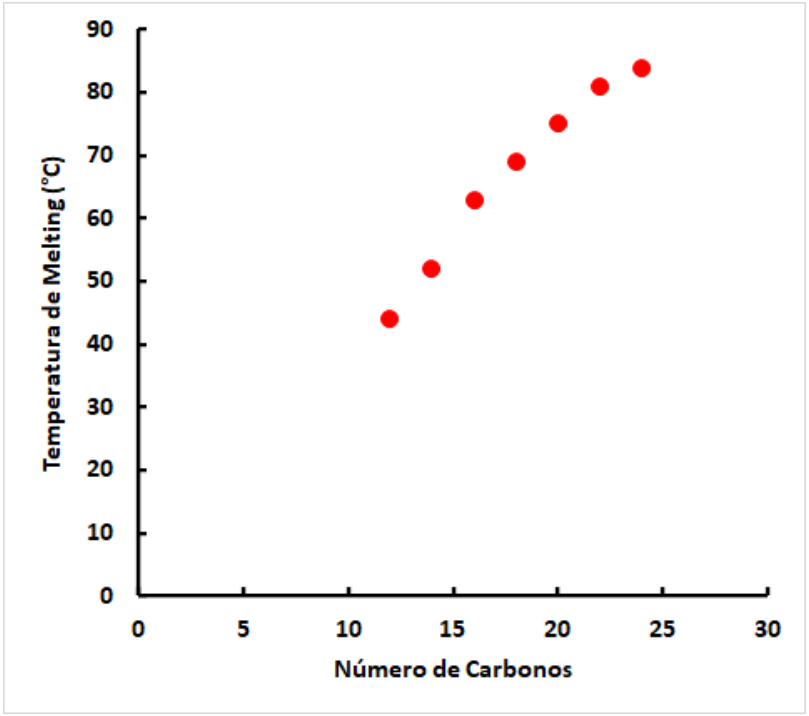
Table 9-1 The Common Biological Fatty Acids

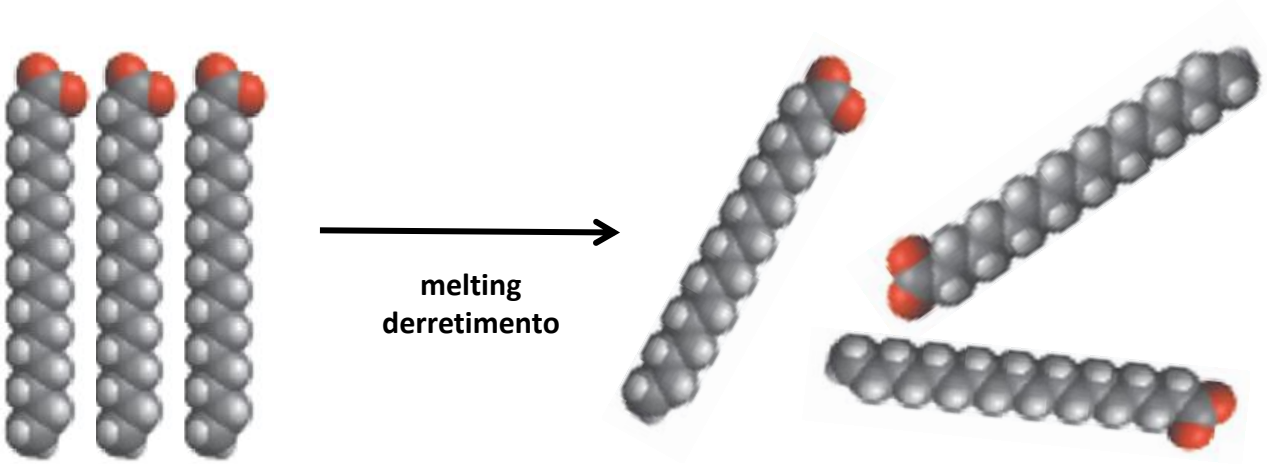
Symbol[a]	Common Name	Systematic Name	Structure	mp (°C)
Saturated fatty acids				
12:0	Lauric acid	Dodecanoic acid	$CH_3(CH_2)_{10}COOH$	44.2
14:0	Myristic acid	Tetradecanoic acid	$CH_3(CH_2)_{12}COOH$	52
16:0	Palmitic acid	Hexadecanoic acid	$CH_3(CH_2)_{14}COOH$	63.1
18:0	Stearic acid	Octadecanoic acid	$CH_3(CH_2)_{16}COOH$	69.1
20:0	Arachidic acid	Eicosanoic acid	$CH_3(CH_2)_{18}COOH$	75.4
22:0	Behenic acid	Docosanoic acid	$CH_3(CH_2)_{20}COOH$	81
24:0	Lignoceric acid	Tetracosanoic acid	$CH_3(CH_2)_{22}COOH$	84.2
Unsaturated fatty acids (all double bonds are cis)				
16:1*n*−7	Palmitoleic acid	9-Hexadecenoic acid	$CH_3(CH_2)_5CH{=}CH(CH_2)_7COOH$	−0.5
18:1*n*−9	Oleic acid	9-Octadecenoic acid	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	13.2
18:2*n*−6	Linoleic acid	9,12-Octadecadienoic acid	$CH_3(CH_2)_4(CH{=}CHCH_2)_2(CH_2)_6COOH$	−9
18:3*n*−3	α-Linolenic acid	9,12,15-Octadecatrienoic acid	$CH_3CH_2(CH{=}CHCH_2)_3(CH_2)_6COOH$	−17
18:3*n*−6	γ-Linolenic acid	6,9,12-Octadecatrienoic acid	$CH_3(CH_2)_4(CH{=}CHCH_2)_3(CH_2)_3COOH$	
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	$CH_3CH_2(CH{=}CHCH_2)_6CH_2COOH$	
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.

Source: Dawson, R.M.C., Elliott, D.C., Elliott, W.H., and Jones, K.M., *Data for Biochemical Research* (3rd ed.), Chapter 8, Clarendon Press (1986).

Table 9-1 Fundamentals of Biochemistry, 2/e





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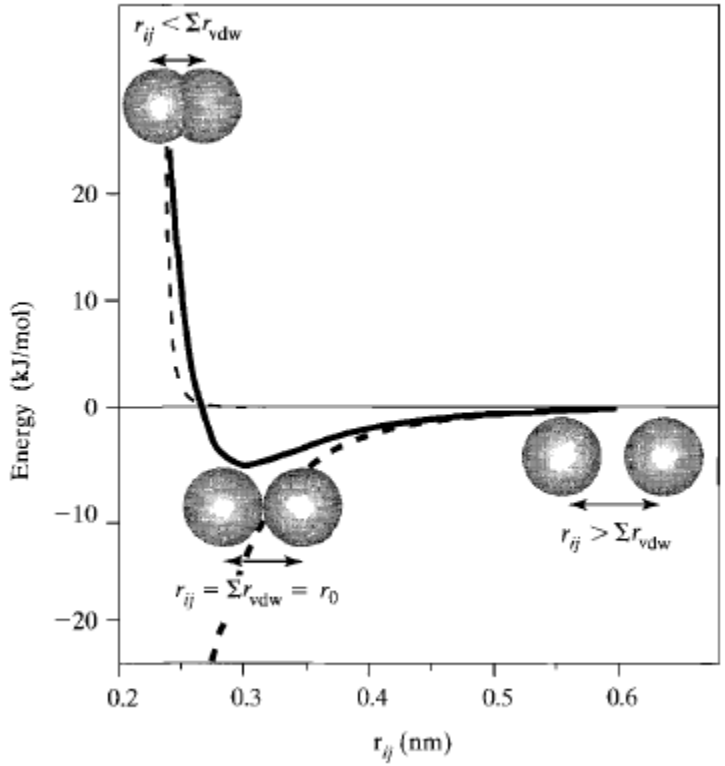
repulsão

atração



$$V_{HB} = \frac{C}{r^{12}} - \frac{D}{r^6}$$

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Table 1.1 Relationship of Noncovalent Interactions to the Distance Separating the Interacting Molecules, r

Type of Interaction	Distance Relationship
Charge-charge	$1/r$
Charge-dipole	$1/r^2$
Dipole-dipole	$1/r^3$
Charge-induced dipole	$1/r^4$
Dispersion	$1/r^6$
Repulsion	$1/r^{12}$

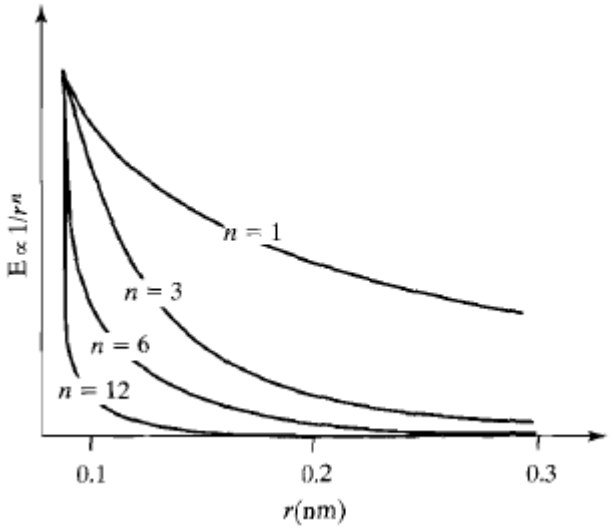
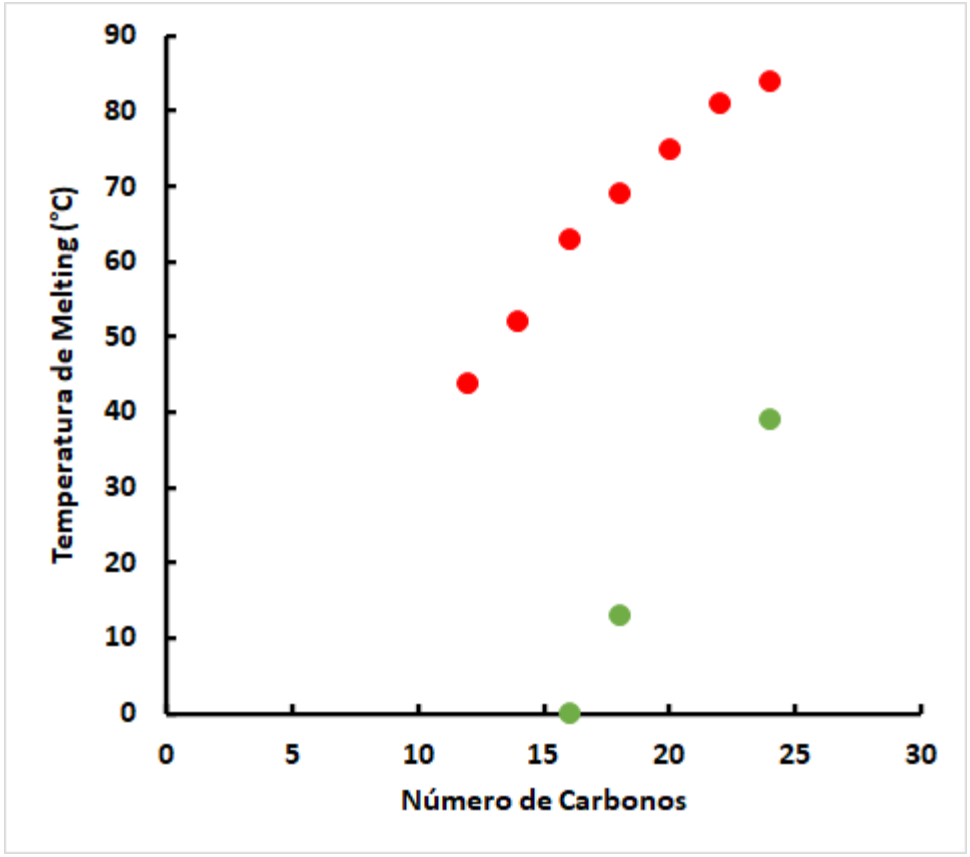


Table 2.1 Noncovalent Interactions Between Molecules

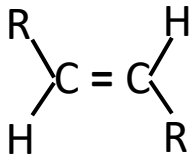
Type of Interaction	Equation[a]	Order of Magnitude[b] (kJ/mol)
Ion-ion (Charge-Charge)	$E = \frac{Z_1 Z_2 e^2}{Dr}$	60
Ion-dipole	$E = \frac{Z_1 e \mu_2 \theta}{Dr^2}$	−8 to +8
Dipole-dipole	$E = \frac{\mu_1 \mu_2 \theta'}{Dr^3} - \frac{3(\mu_1 r\theta'')(\mu_2 r\theta'')}{Dr^5}$	−2 to +2
Ion-induced dipole	$E = \frac{Z_1 e^2 \alpha_2}{2D^2 r^4}$	0.2
Dispersion[c]	$E = \frac{3h\nu_0 \alpha^2}{4r^6}$	0 to 40

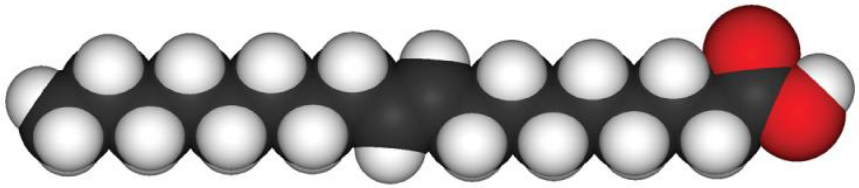
Principles of Physical Biochemistry
van Holde, Johnson e Ho



Saturados

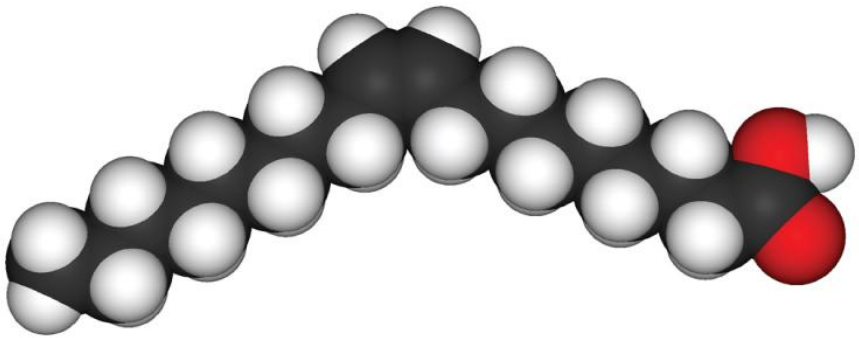
Insaturados





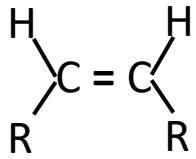
Eliadic acid

Trans



Oleic acid

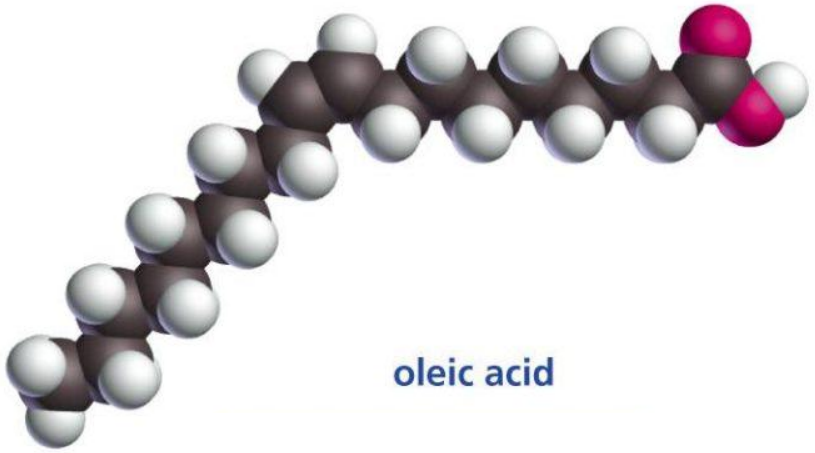
Cis



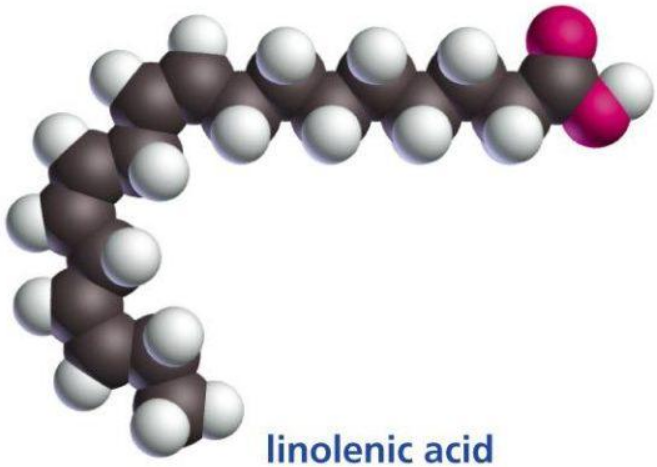
https://commons.wikimedia.org/wiki/File:Figure_02_03_05.jpg

https://fireinabottle.net/lets-talk-about-fat/

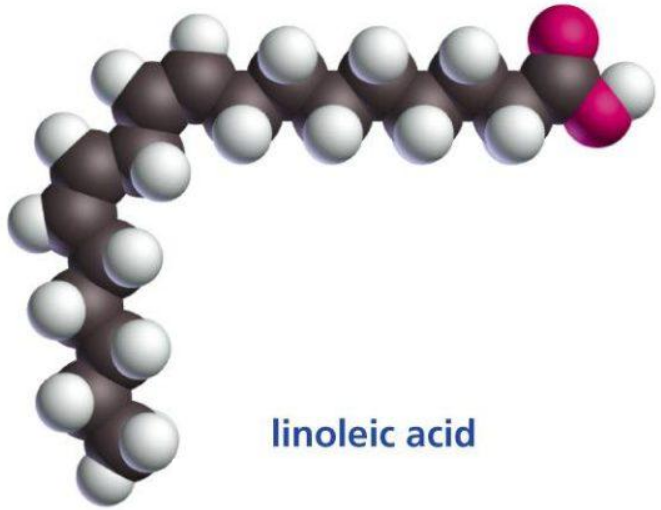
stearic acid



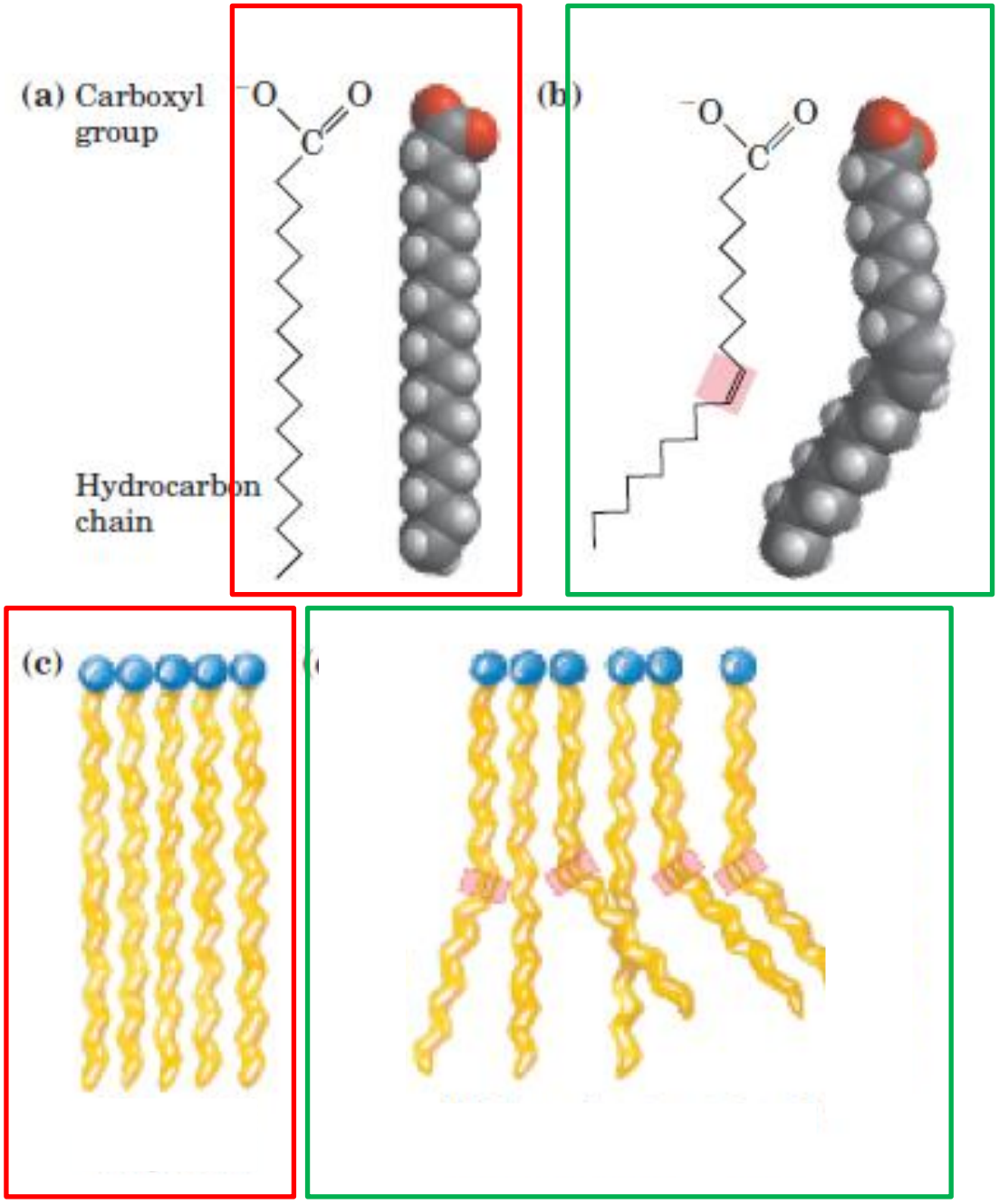
oleic acid



linolenic acid



linoleic acid



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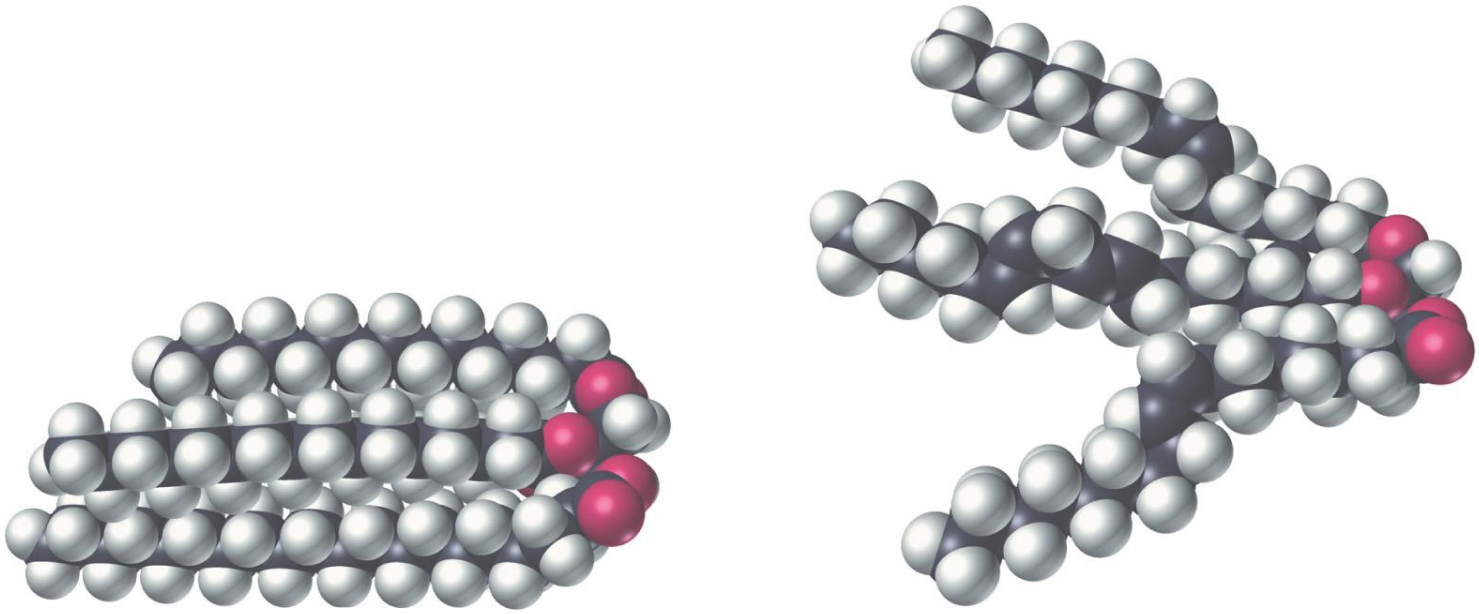
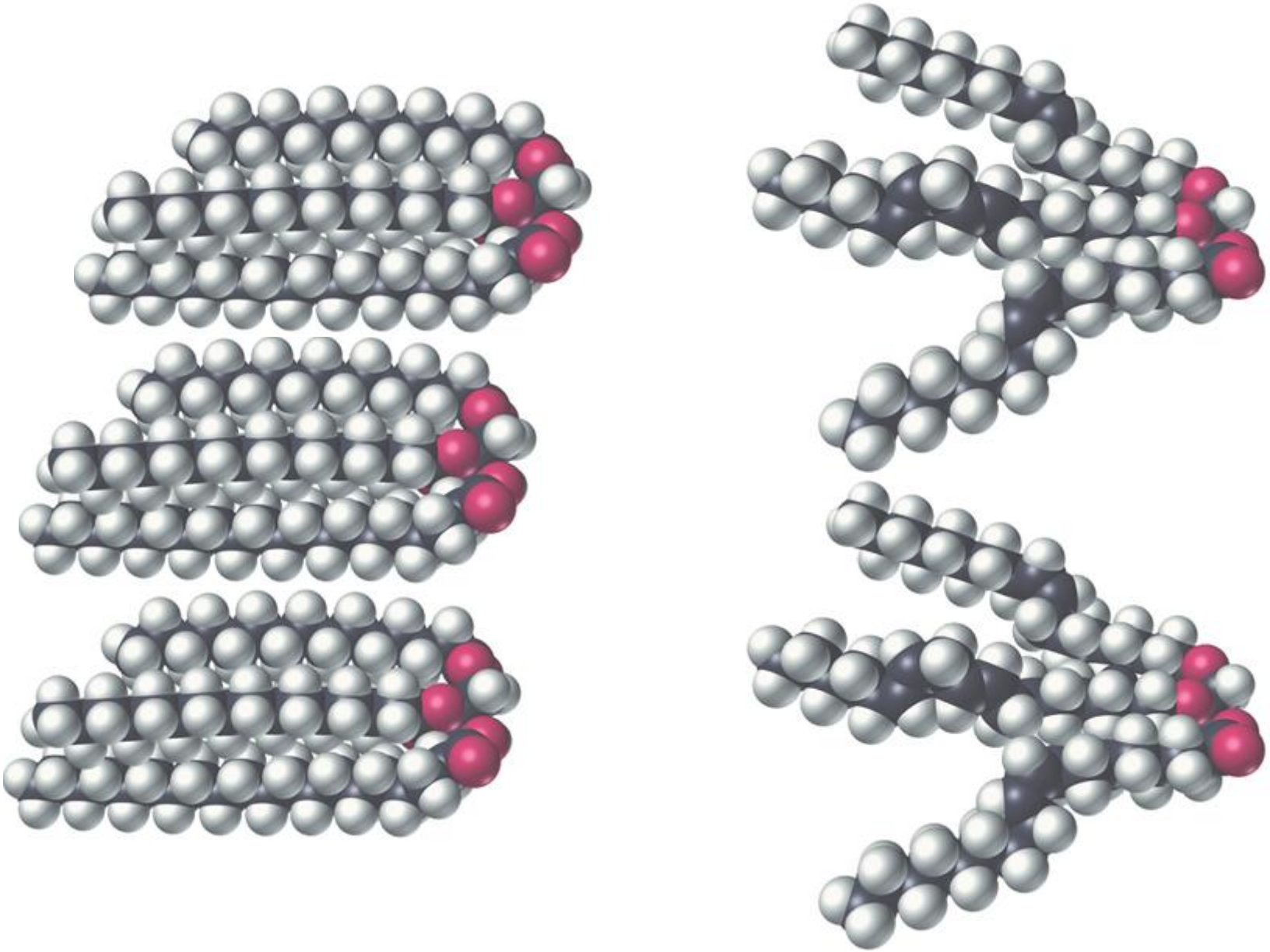
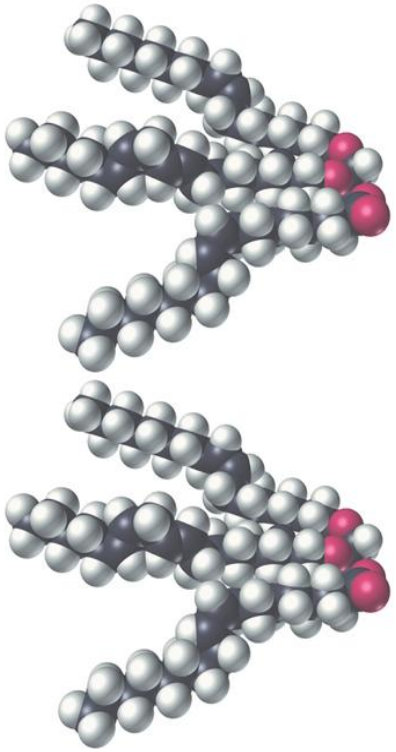
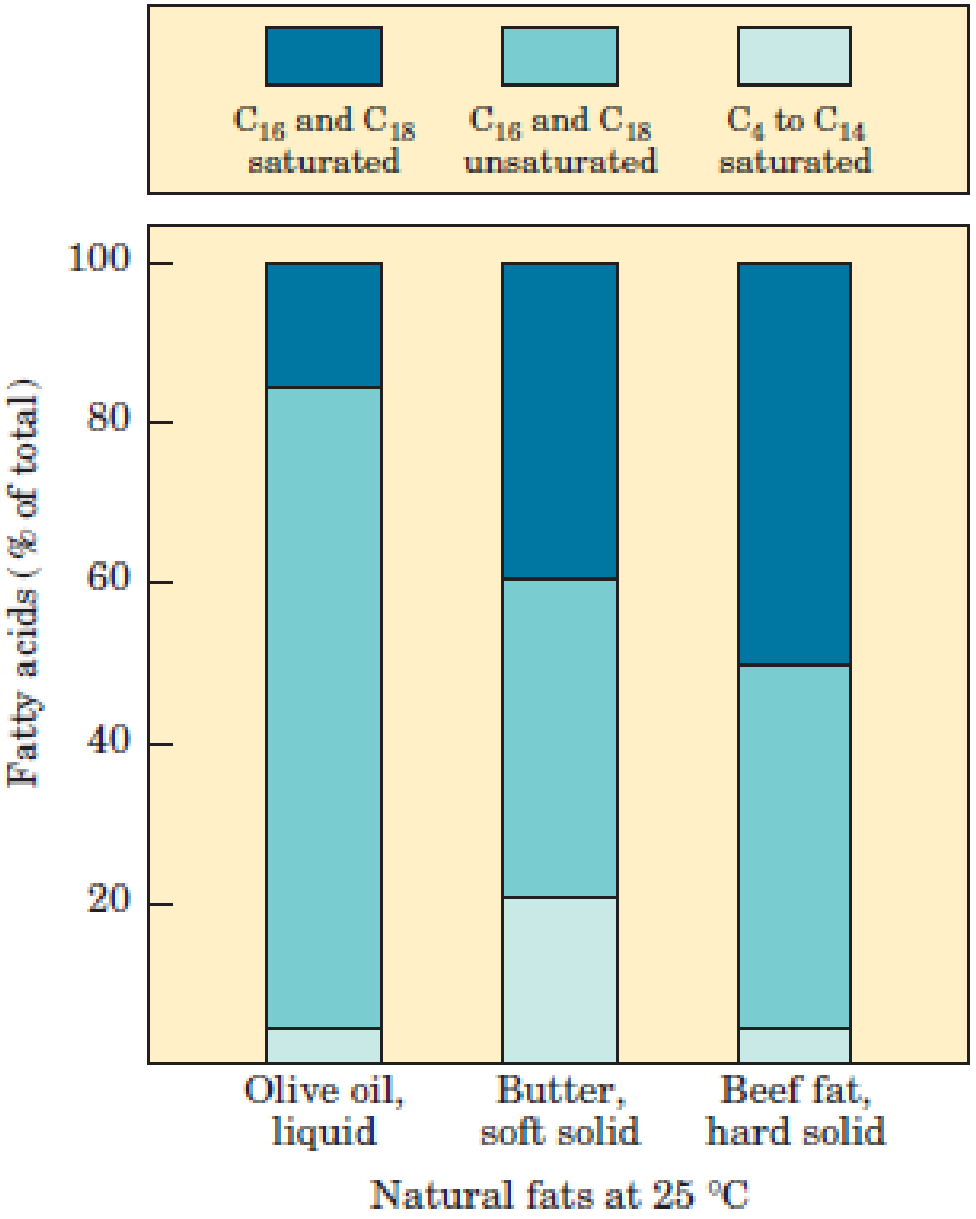
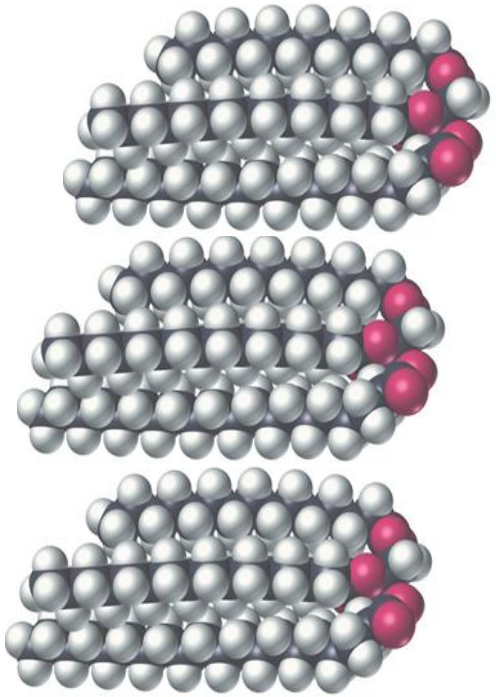




Fluidez em uma mesma temperatura







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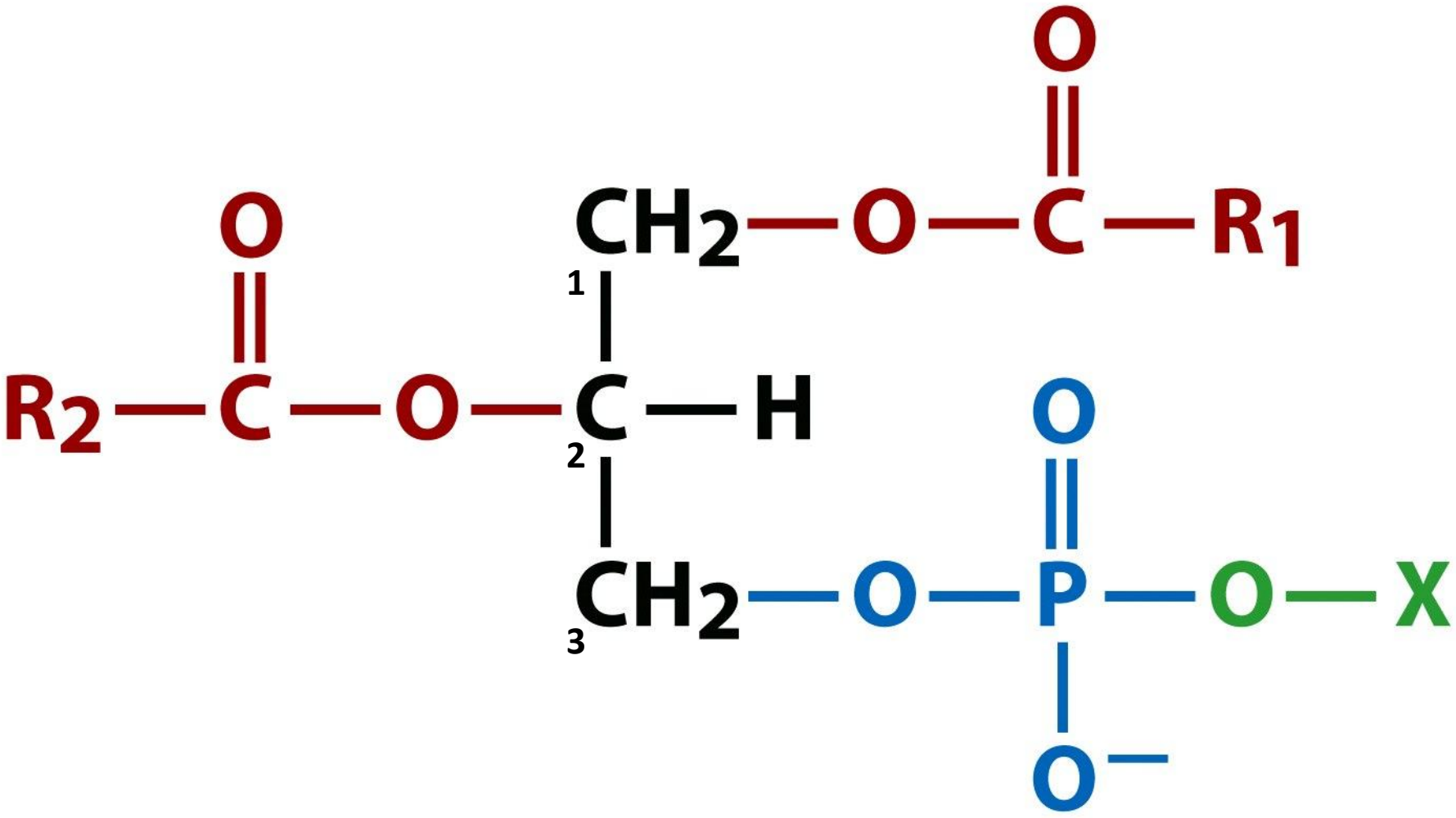


Glycerophospholipid

Figure 9-3b Fundamentals of Biochemistry, 2/e

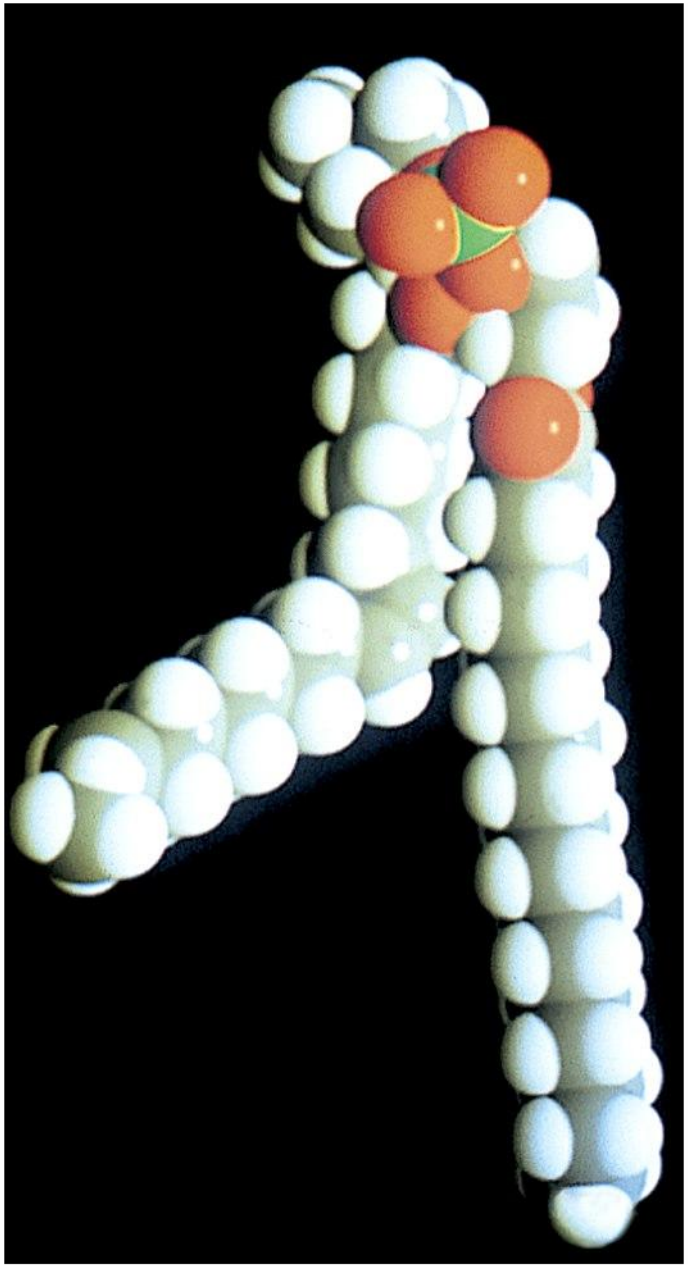


Figure 9-4b Fundamentals of Biochemistry, 2/e

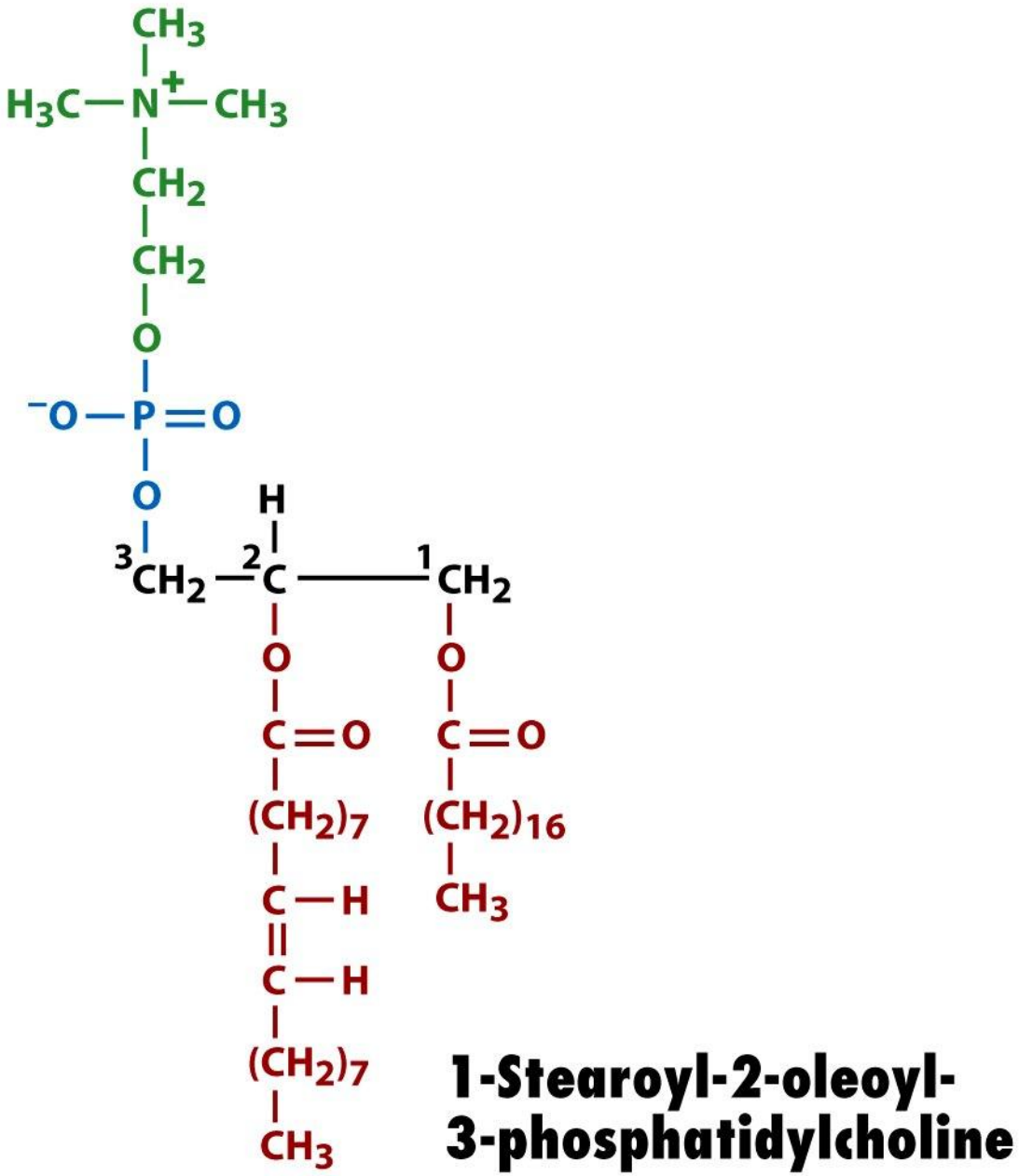
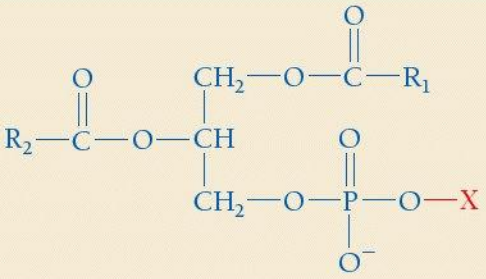
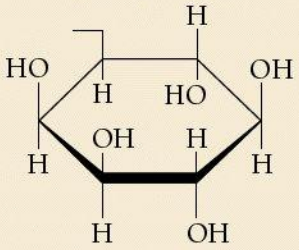
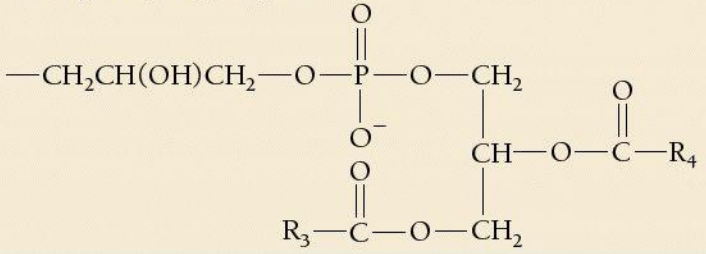


Figure 9-4a Fundamentals of Biochemistry, 2/e

Table 9-2 The Common Classes of Glycerophospholipids



Name of X—OH	Formula of −X	Name of Phospholipid
Water	—H	Phosphatidic acid
Ethanolamine	$-CH_2CH_2NH_3^+$	Phosphatidylethanolamine
Choline	$-CH_2CH_2N(CH_3)_3^+$	Phosphatidylcholine (lecithin)
Serine	$-CH_2CH(NH_3^+)COO^-$	Phosphatidylserine
myo-Inositol		Phosphatidylinositol
Glycerol	$-CH_2CH(OH)CH_2OH$	Phosphatidylglycerol
Phosphatidylglycerol		Diphosphatidylglycerol (cardiolipin)

Esfingofosfolipídeo

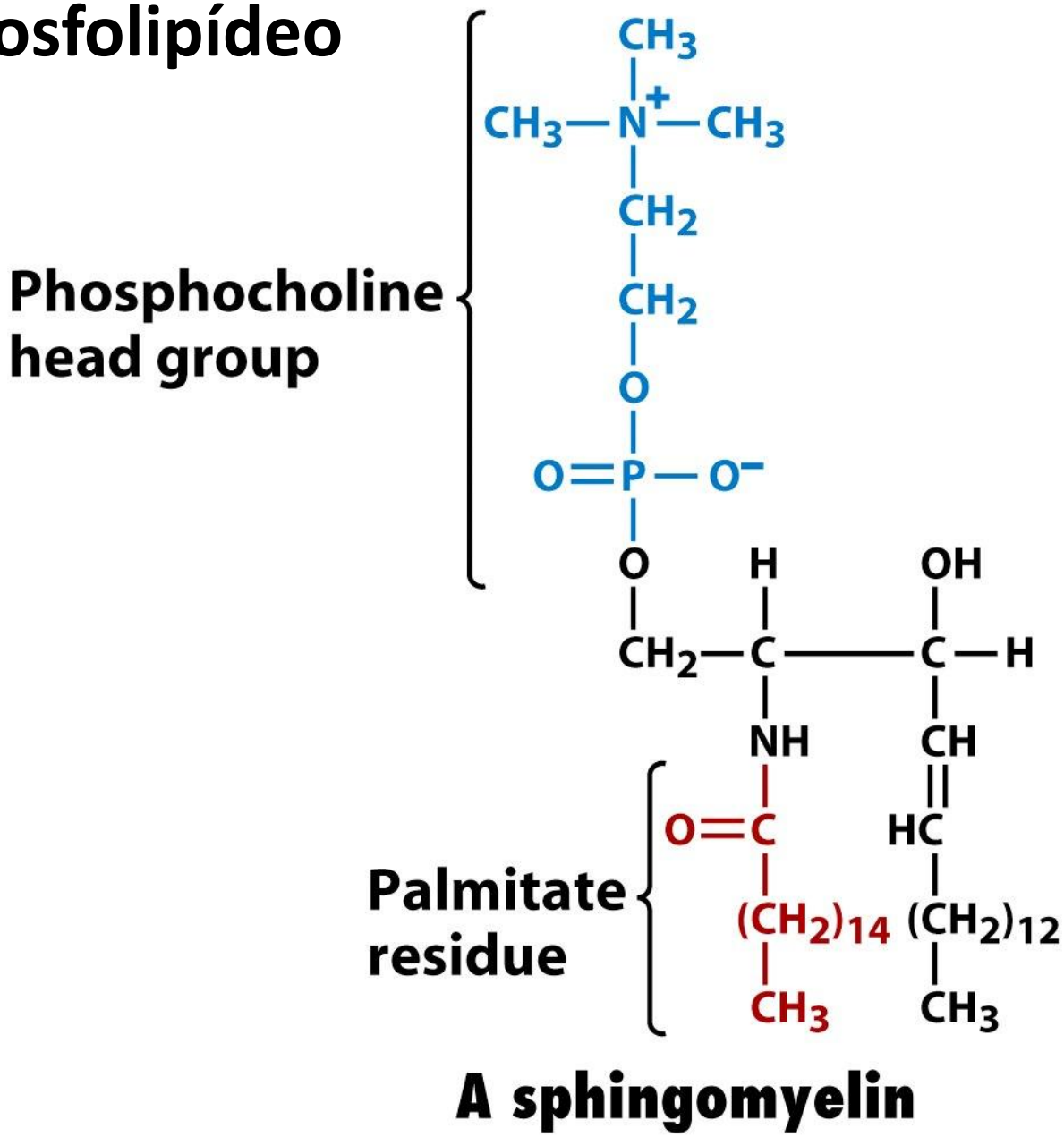


Figure 9-7a Fundamentals of Biochemistry, 2/e

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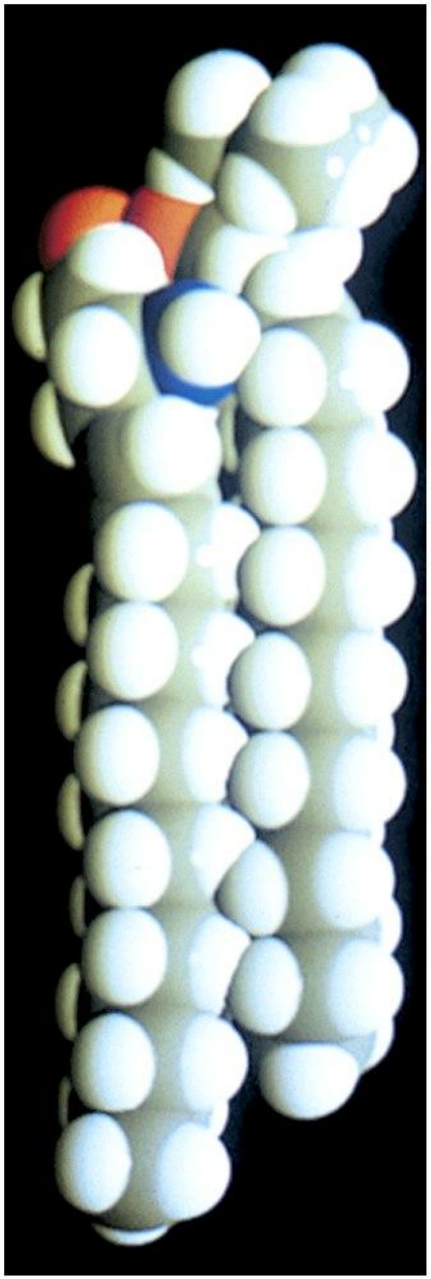

Figure 9-7b Fundamentals of Biochemistry, 2/e

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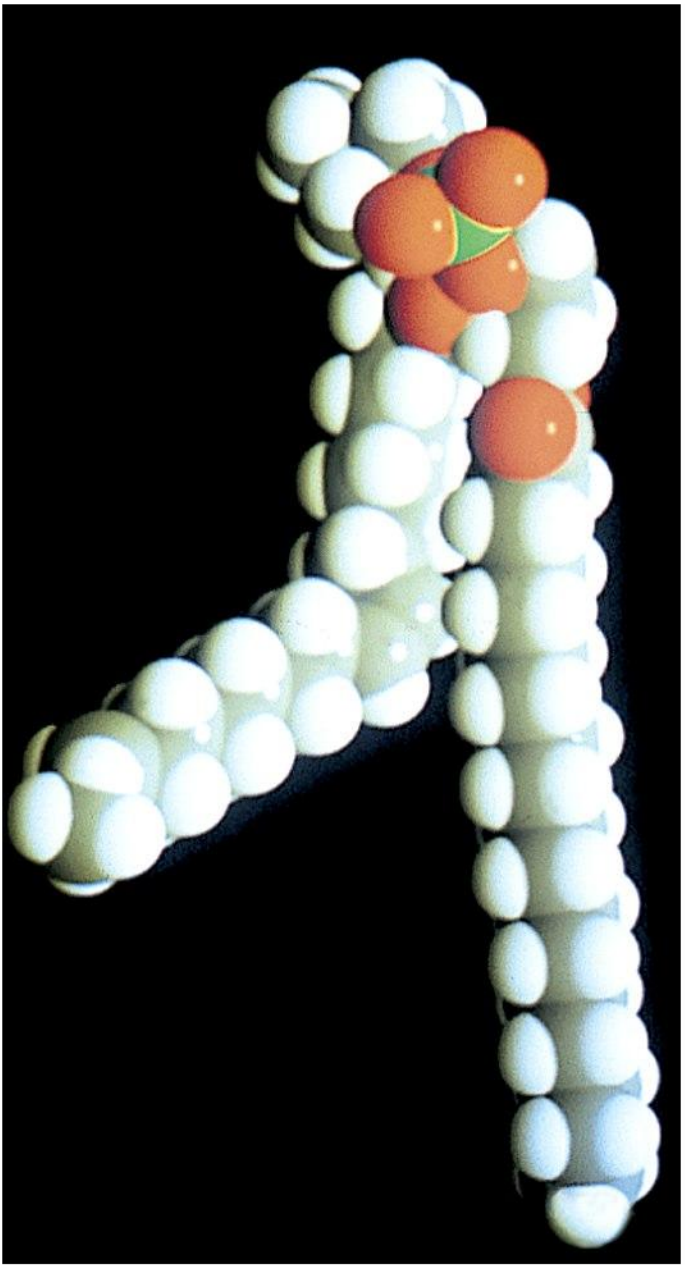

Figure 9-4b Fundamentals of Biochemistry, 2/e

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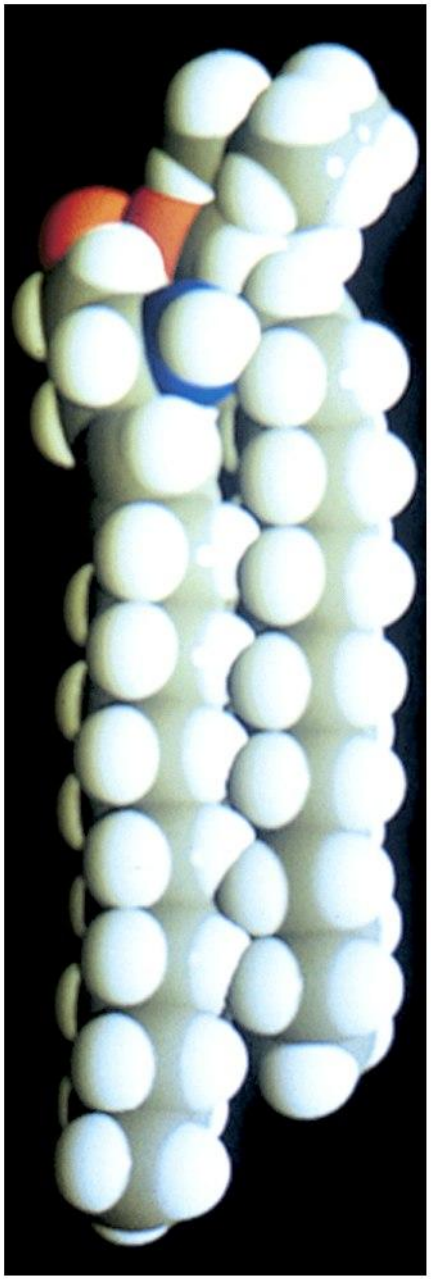

Figure 9-7b Fundamentals of Biochemistry, 2/e

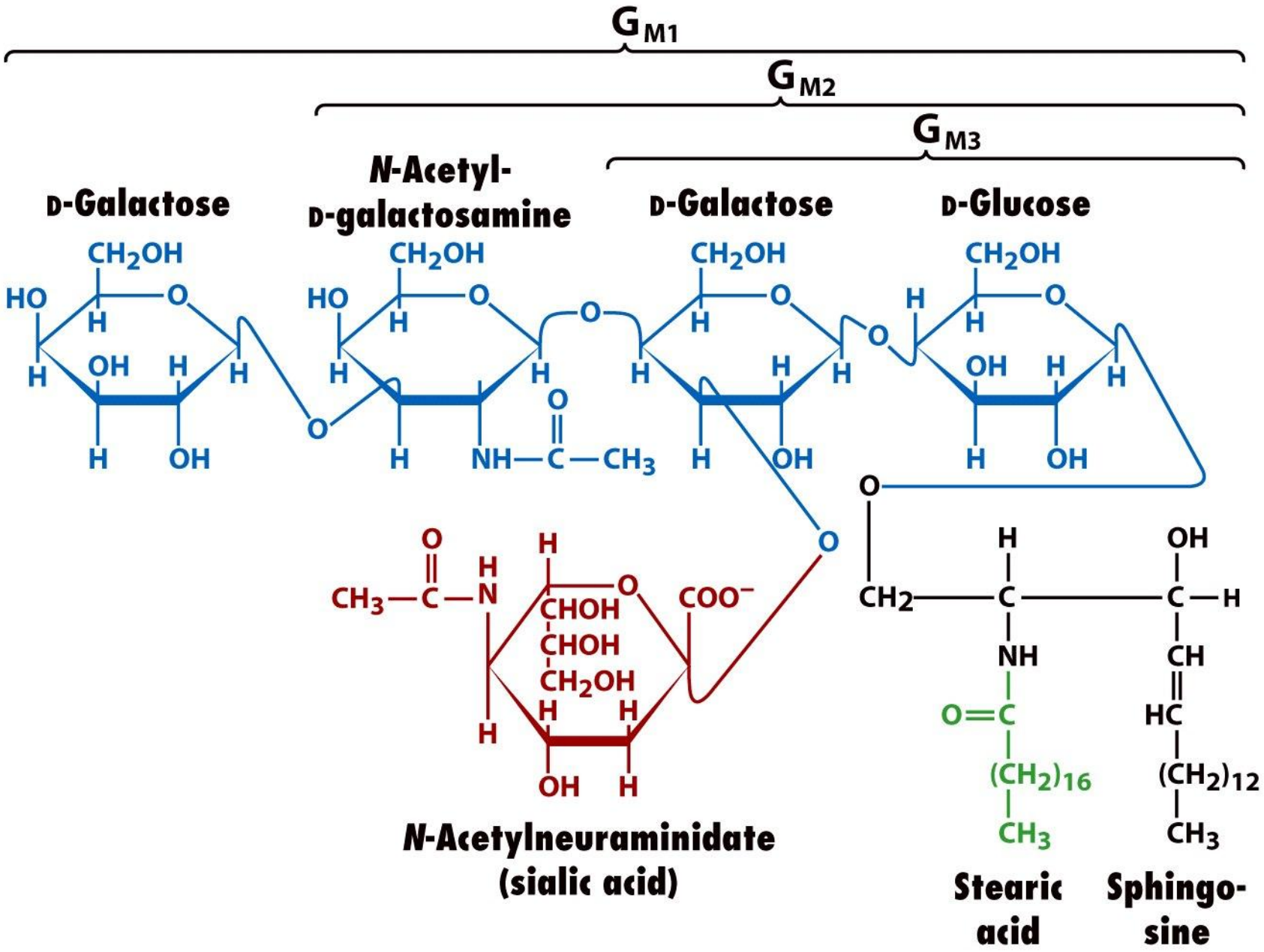

Figure 9-9a Fundamentals of Biochemistry, 2/e

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glicoesfingolipídeo

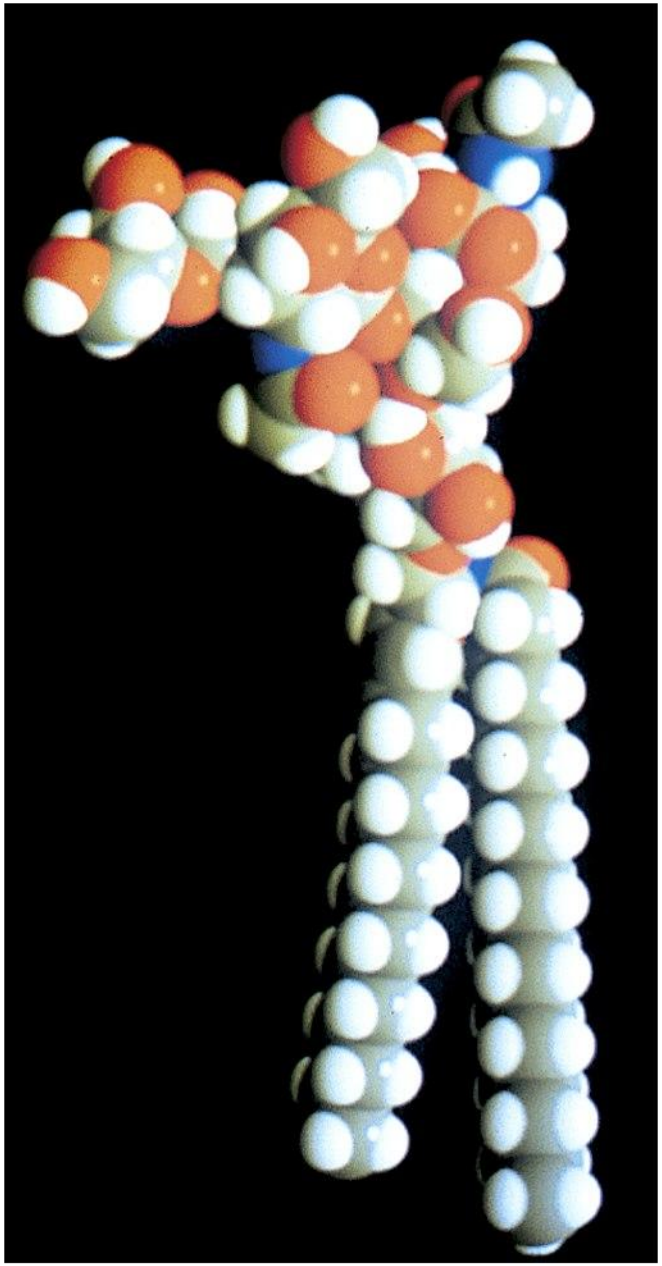

Figure 9-9b Fundamentals of Biochemistry, 2/e

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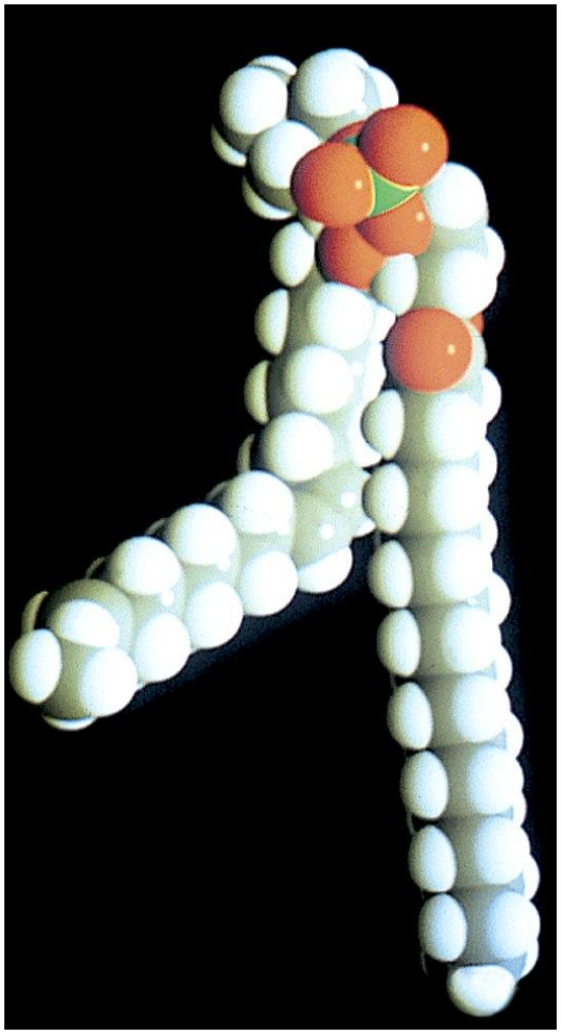

Figure 9-4b Fundamentals of Biochemistry, 2/e

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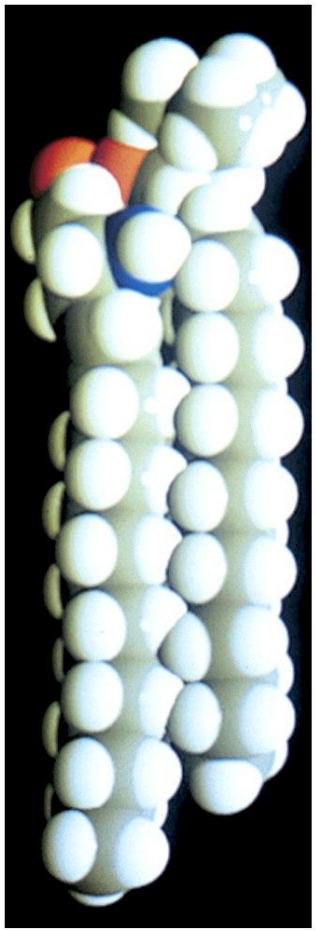

Figure 9-7b Fundamentals of Biochemistry, 2/e

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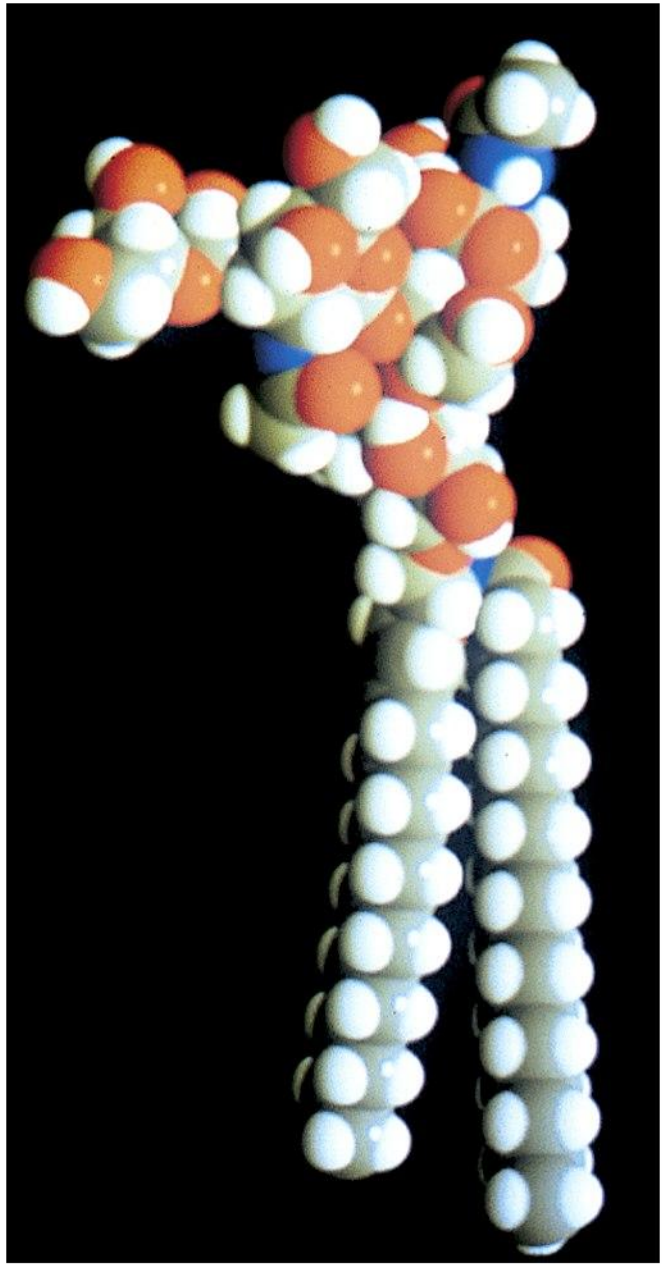
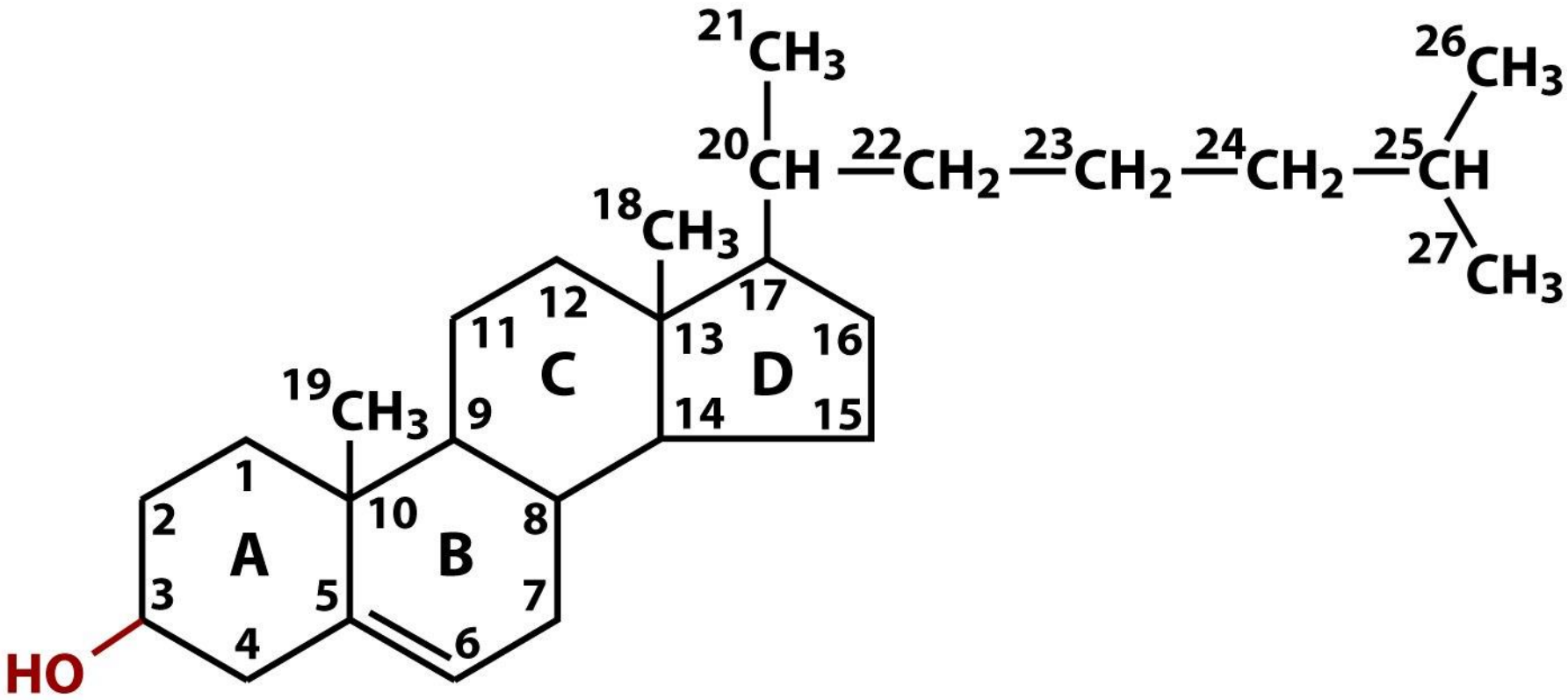


Figure 9-9b Fundamentals of Biochemistry, 2/e



Cholesterol

Figure 9-10a Fundamentals of Biochemistry, 2/e

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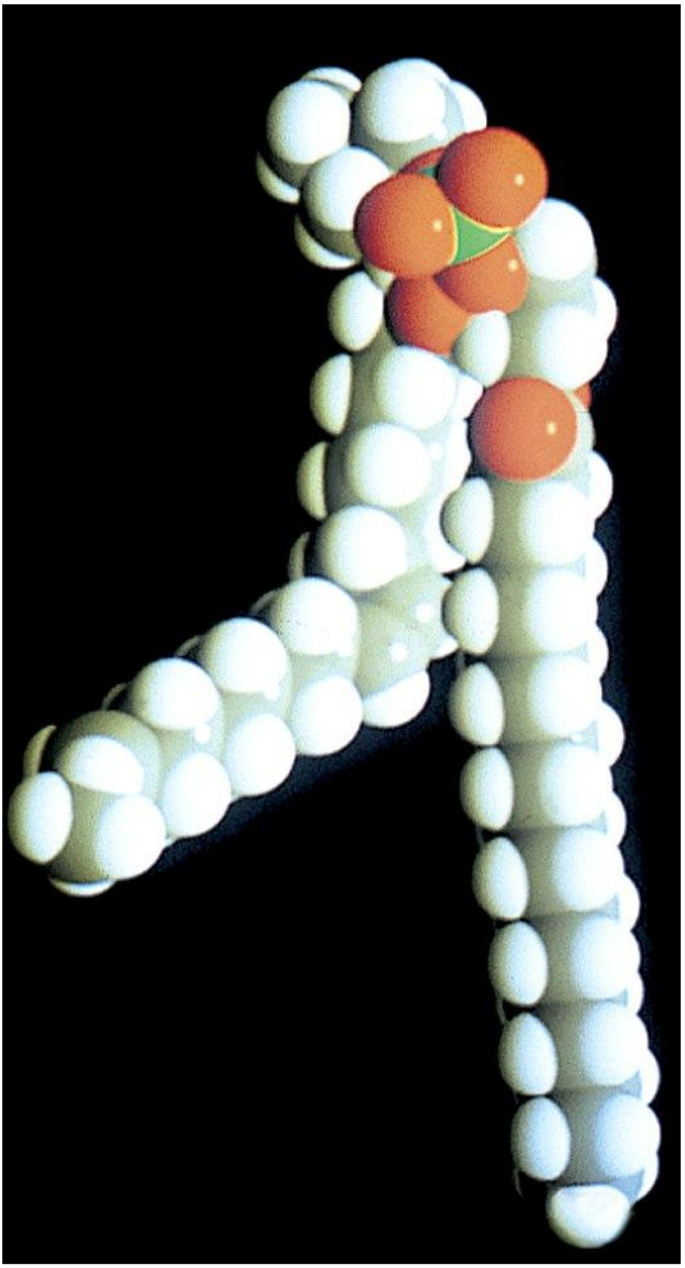
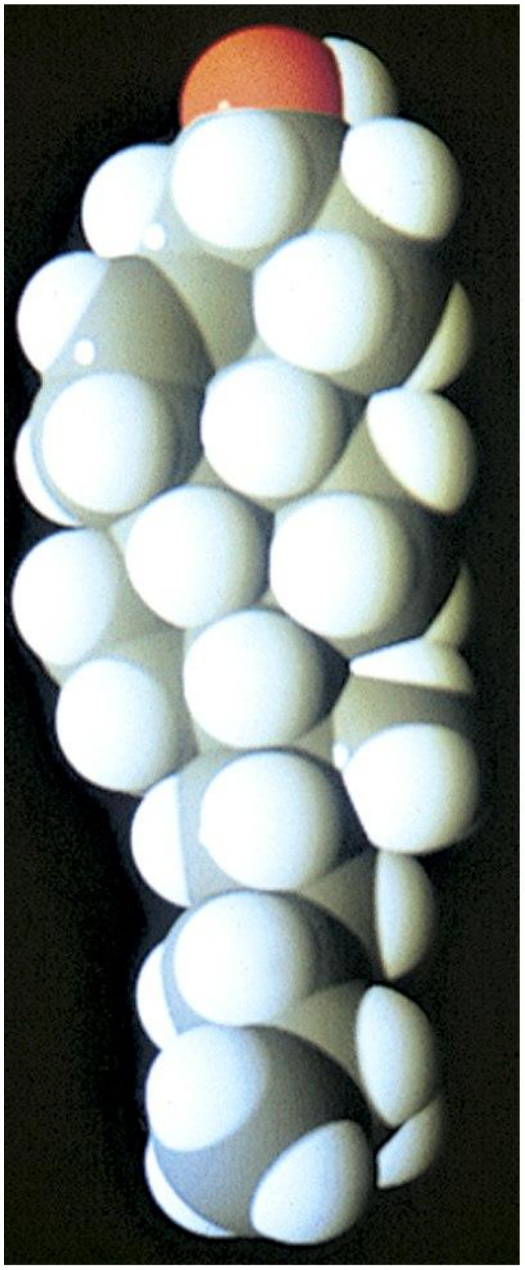


Figure 9-4b Fundamentals of Biochemistry, 2/e

colesterol



igure 9-10b Fundamentals of Biochemistry, 2/e

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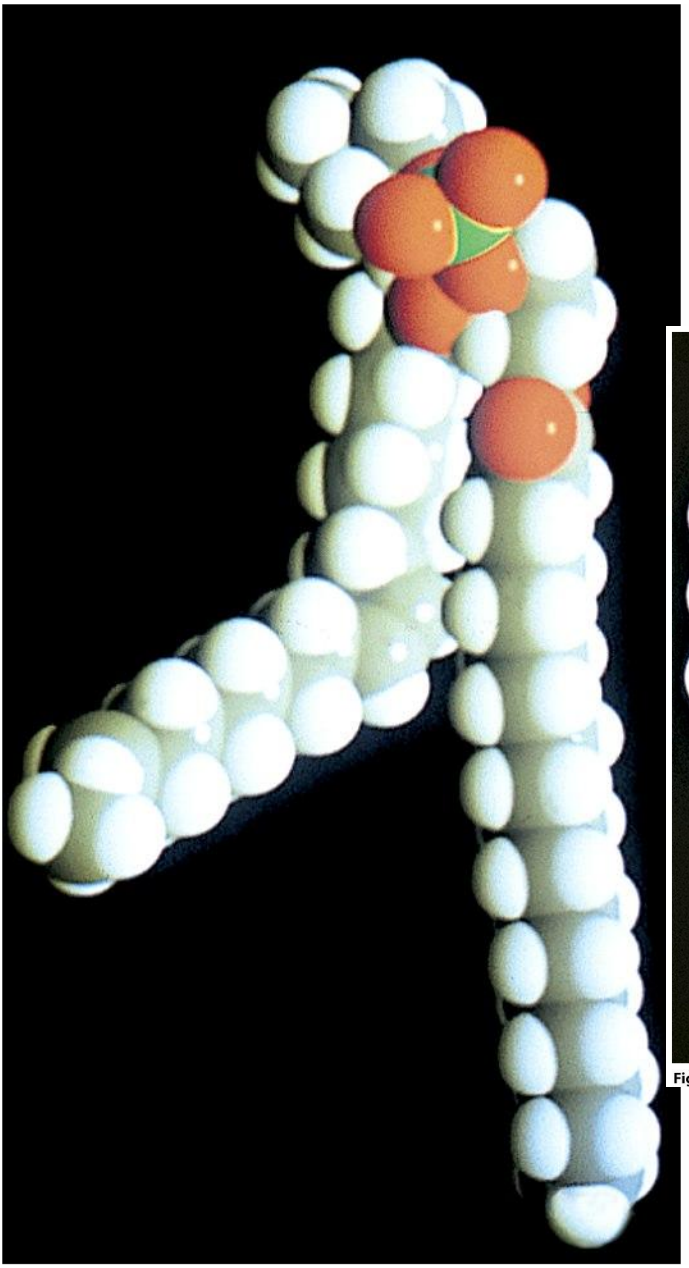


Figure 9-4b Fundamentals of Biochemistry, 2/e

colesterol

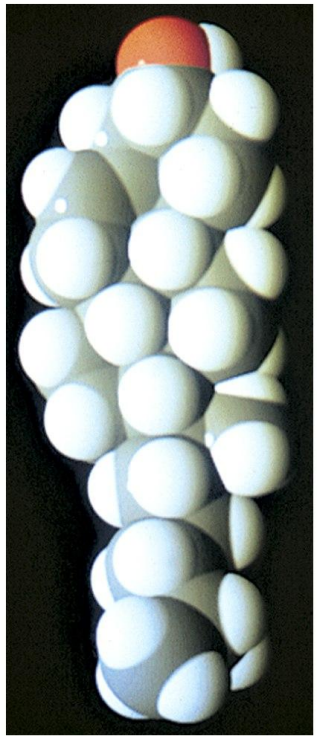
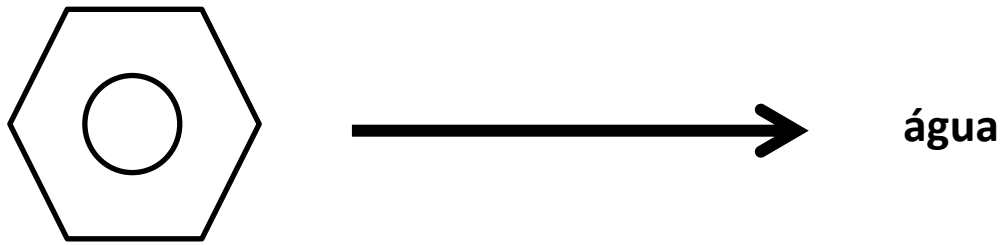


Figure 9-10b Fundamentals of Biochemistry, 2/e

Recordando o Efeito Hidrofóbico...



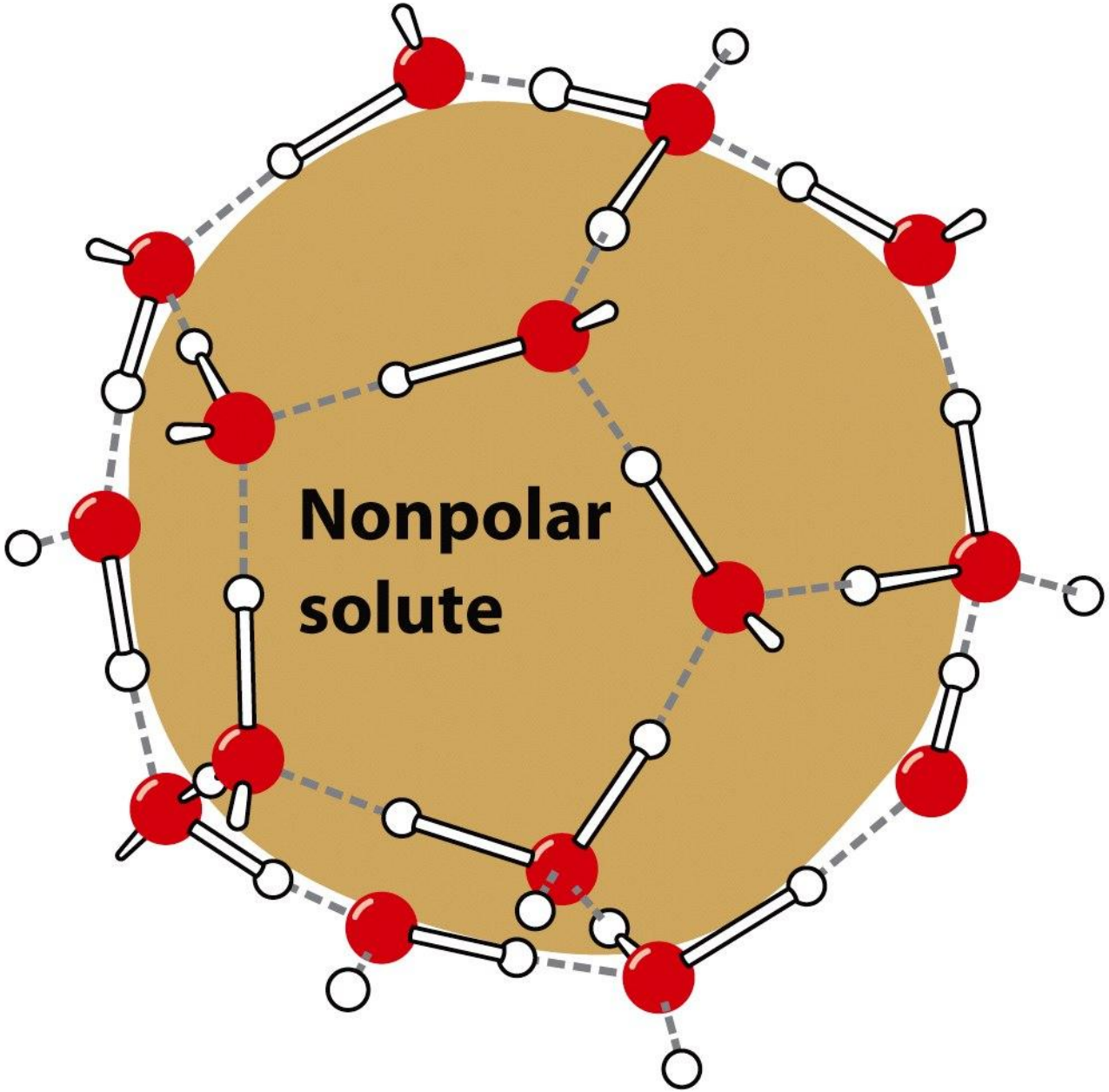


Figure 2-8 Fundamentals of Biochemistry, 2/e

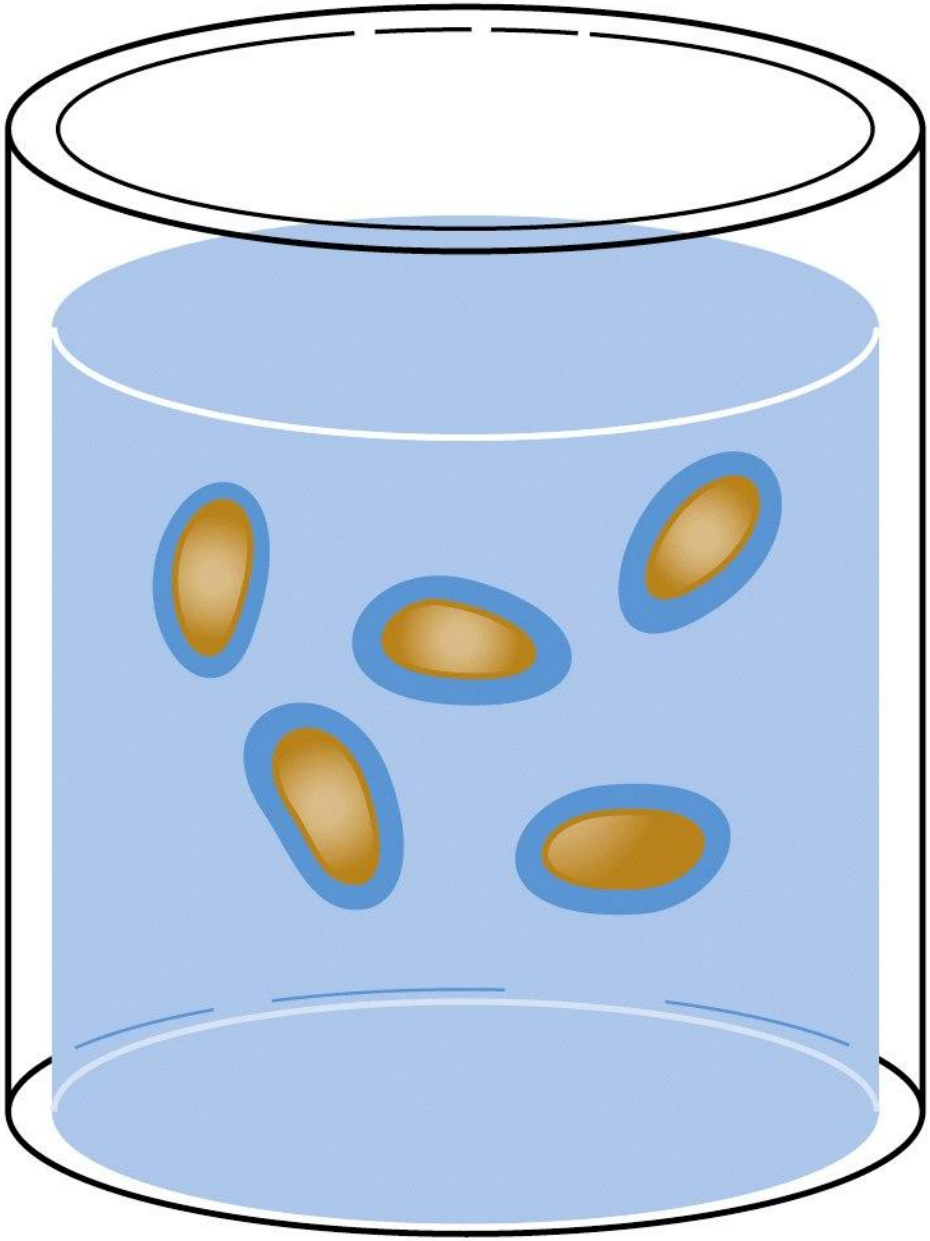
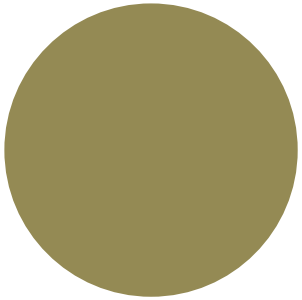


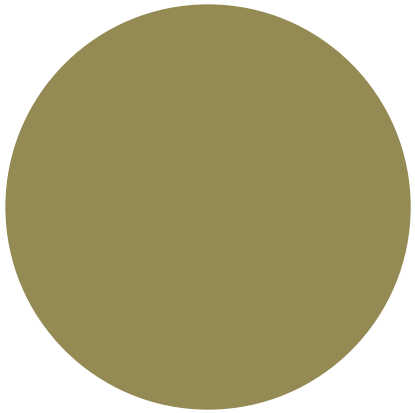
Figure 2-9a Fundamentals of Biochemistry, 2/e

Considere uma esfera...



1 mL (1 cm^3)
$V=(4/3)\pi r^3$
R=1,33 cm
$A = 4\pi r^2$
A=22,2 cm^2

Considere que duas esferas se combinem...



2 mL (2 cm^3)
$V=(4/3)\pi r^3$
R=1,67 cm
$A = 4\pi r^2$
A=35,0 cm^2

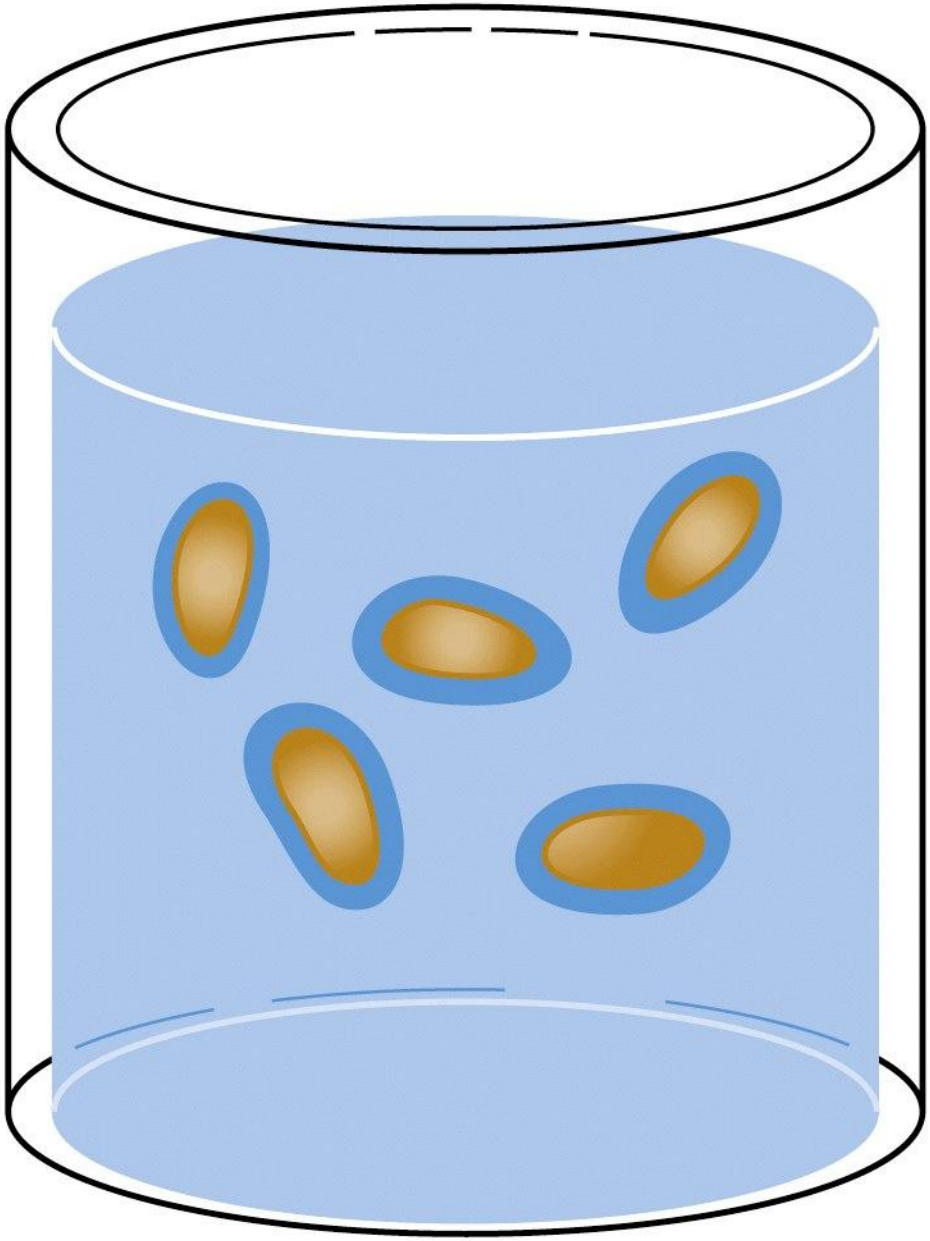


Figure 2-9a Fundamentals of Biochemistry, 2/e

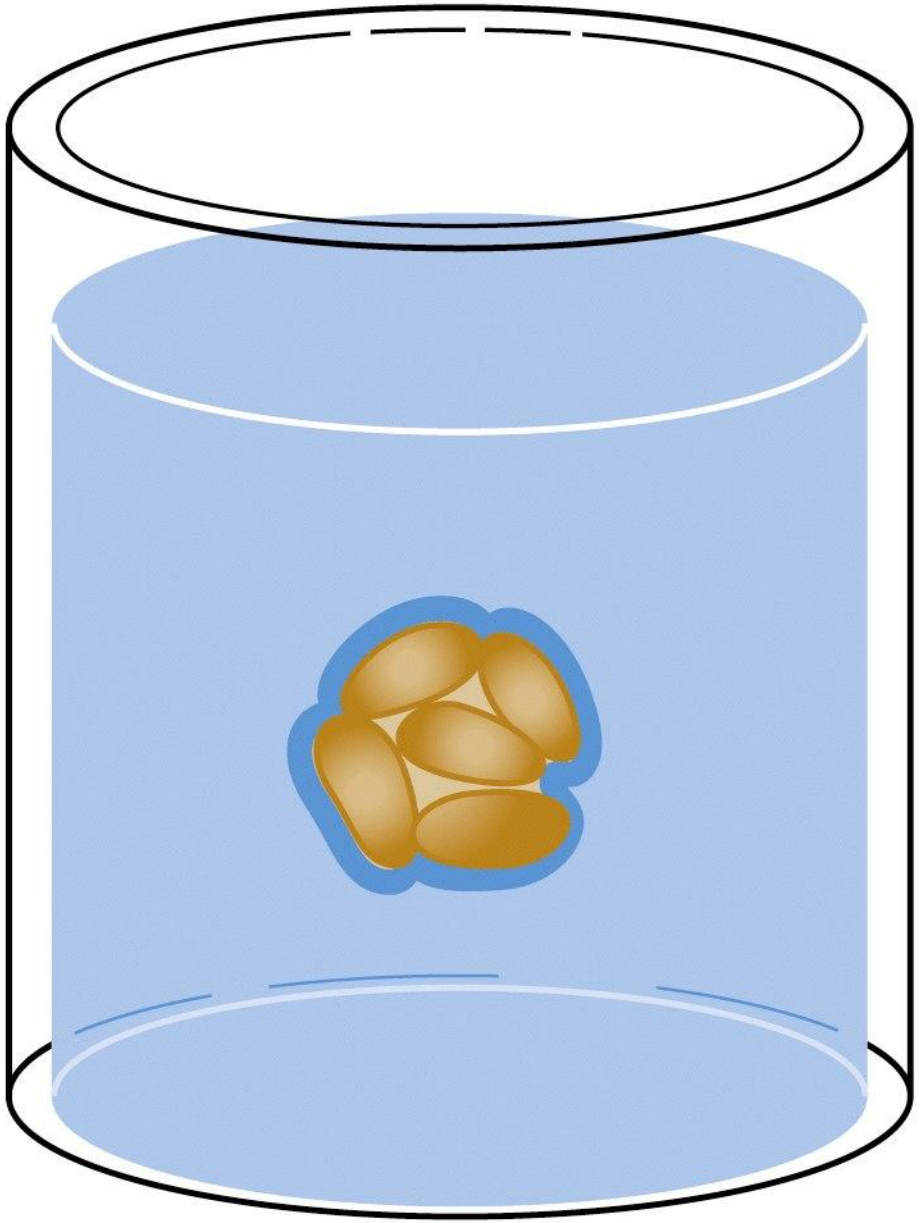


Figure 2-9b Fundamentals of Biochemistry, 2/e

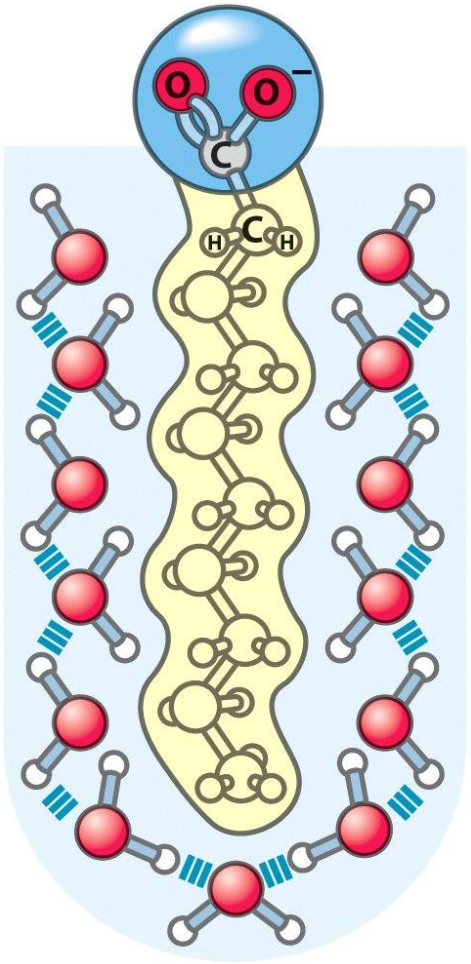
Oil and water separation by molecular dynamics simulation

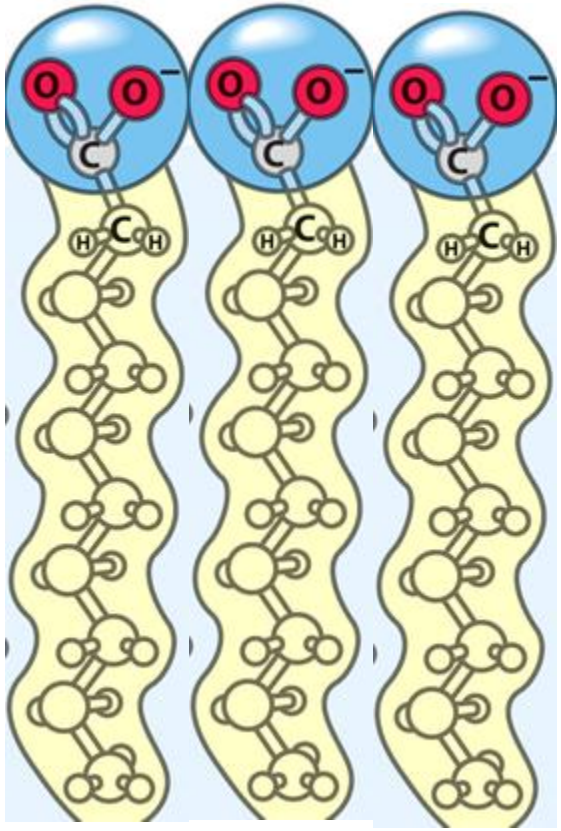
https://www.youtube.com/watch?v=xcMSHy3CqXA

Molecular dynamics simulation of oil (pentane, C_5H_{12}) and water separation at 300 K temperature and 1 atm.

O Efeito Hidrofóbico e Lipídeos em Solução...

Ácido Graxo

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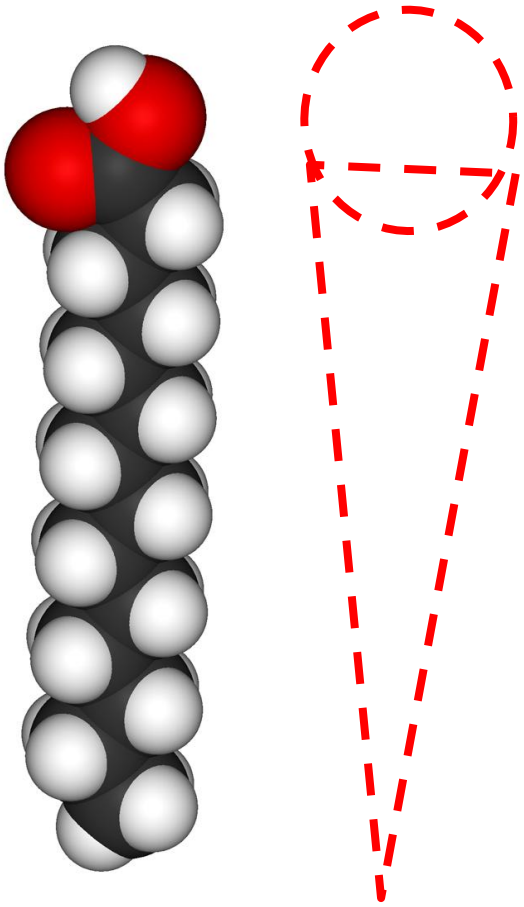


Superfície aproximada

Figure 9-13a Fundamentals of Biochemistry, 2/e

Micela

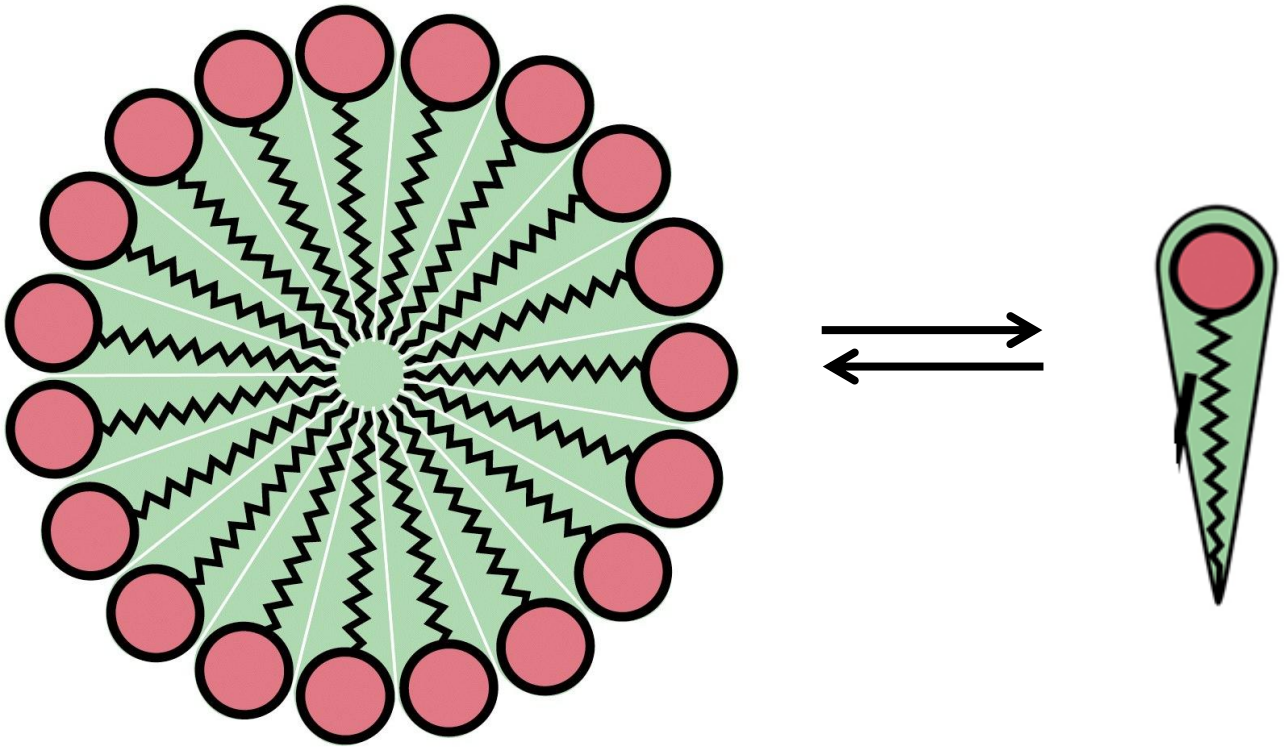
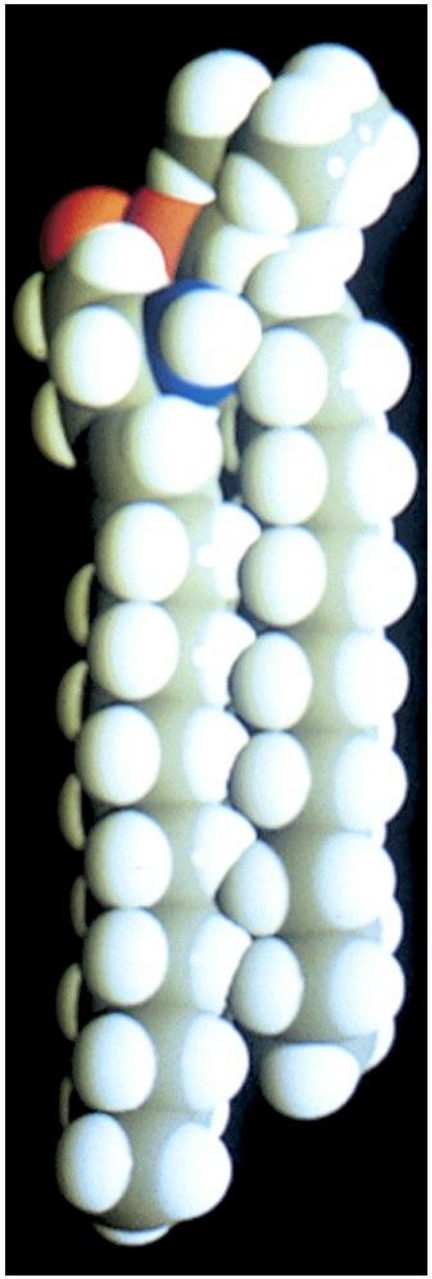


Figure 9-13b Fundamentals of Biochemistry, 2/e

esfingofosfolipídeo



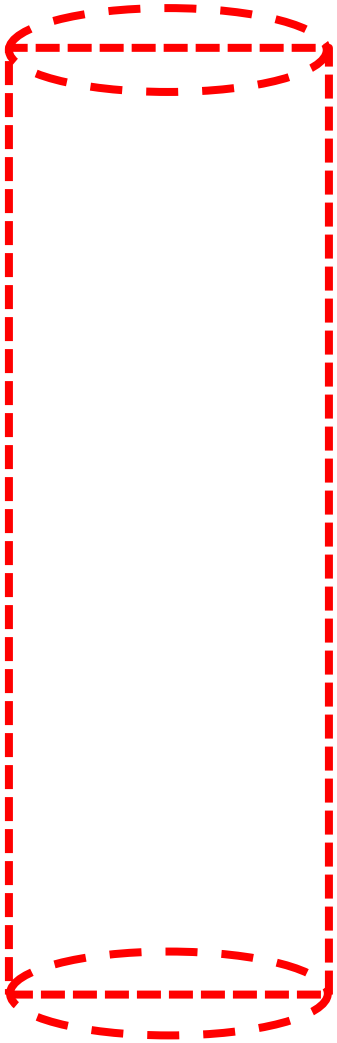
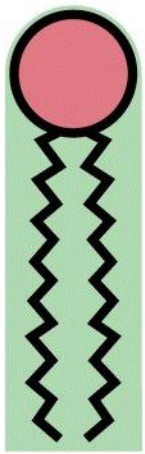


Figure 9-7b Fundamentals of Biochemistry, 2/e



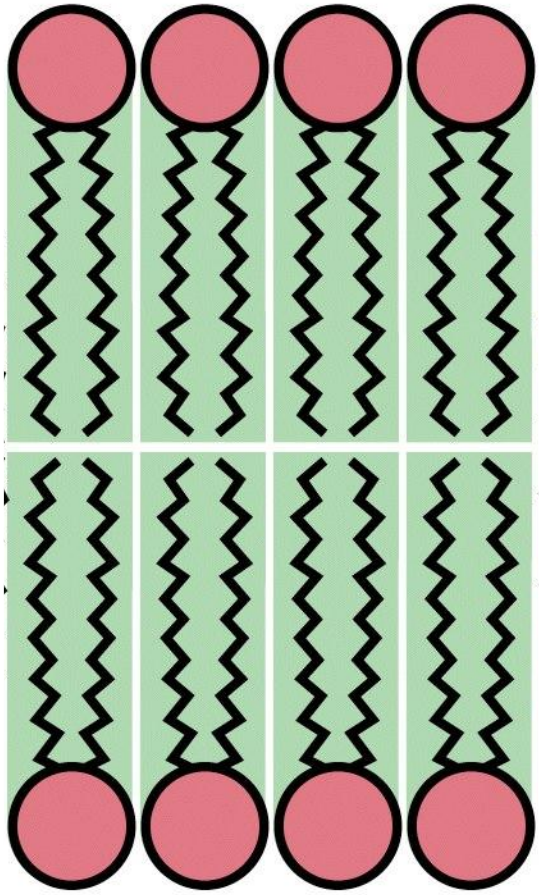


Figure 9-14 Fundamentals of Biochemistry, 2/e

esfingofosfolipídeo

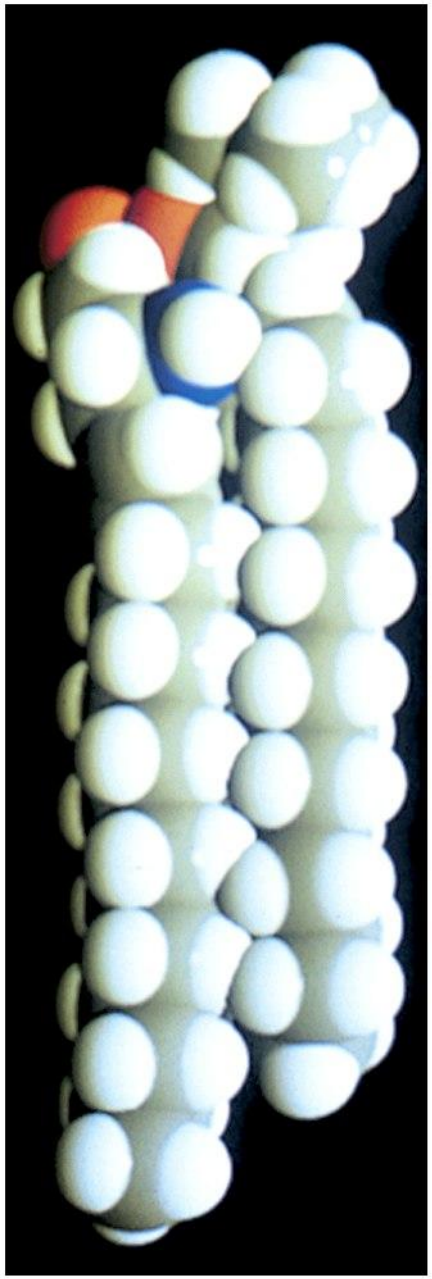
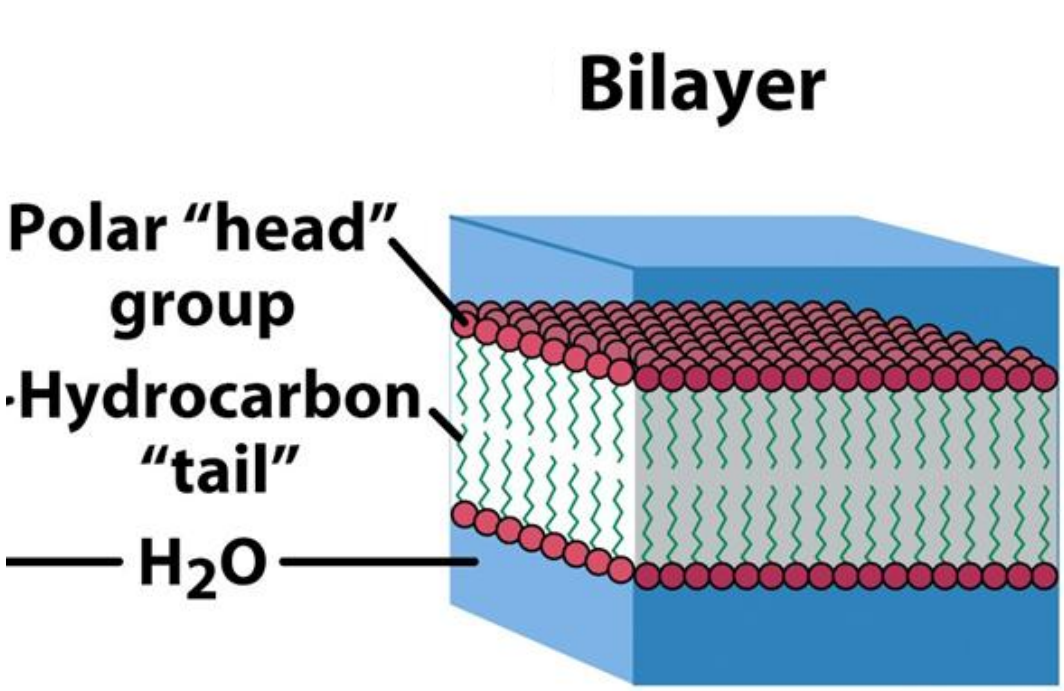


Figure 9-7b Fundamentals of Biochemistry, 2/e

Bicamada



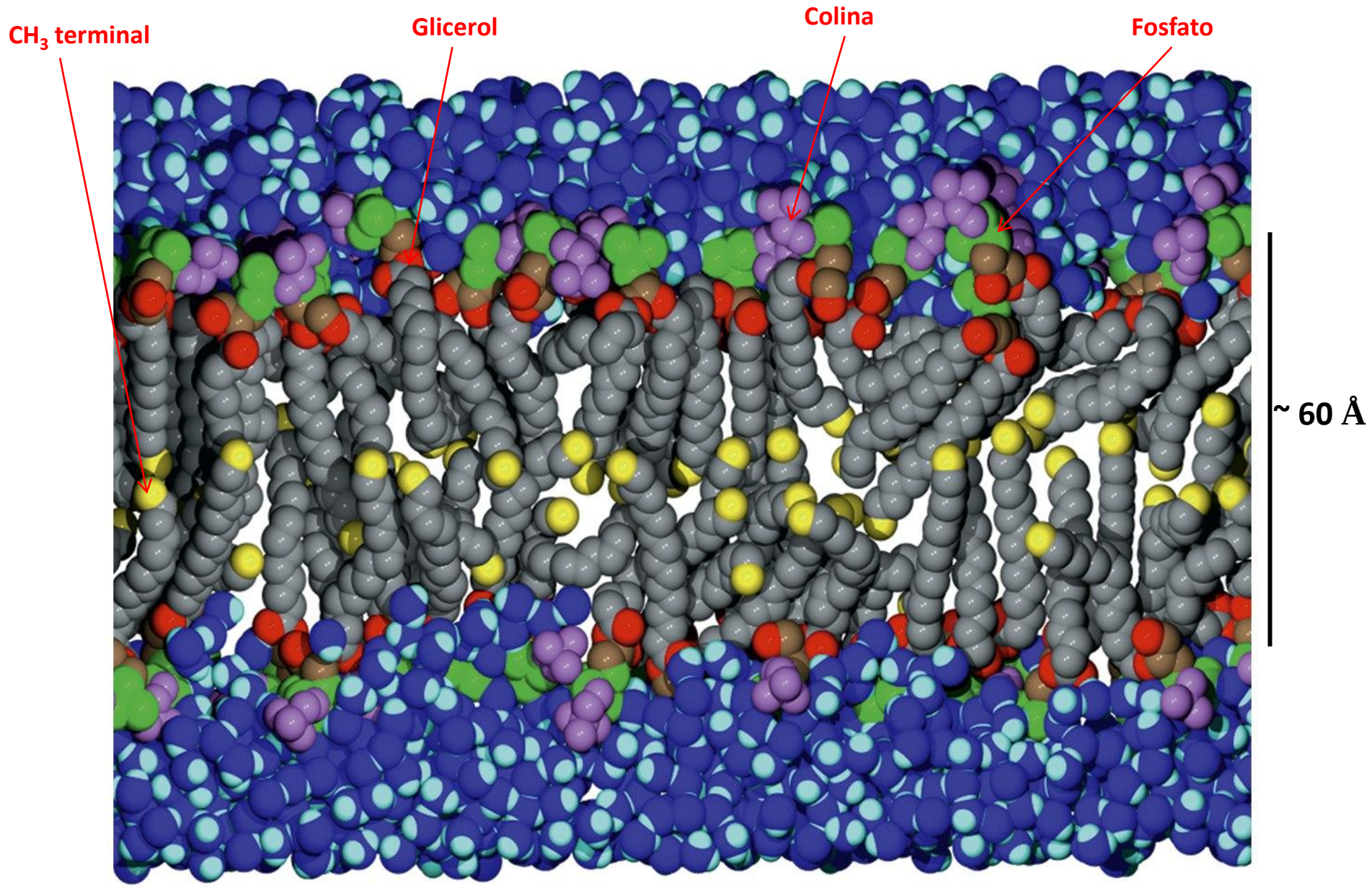


Figure 9-17 Fundamentals of Biochemistry, 2/e

Permeabilidade da bicamada lipídica

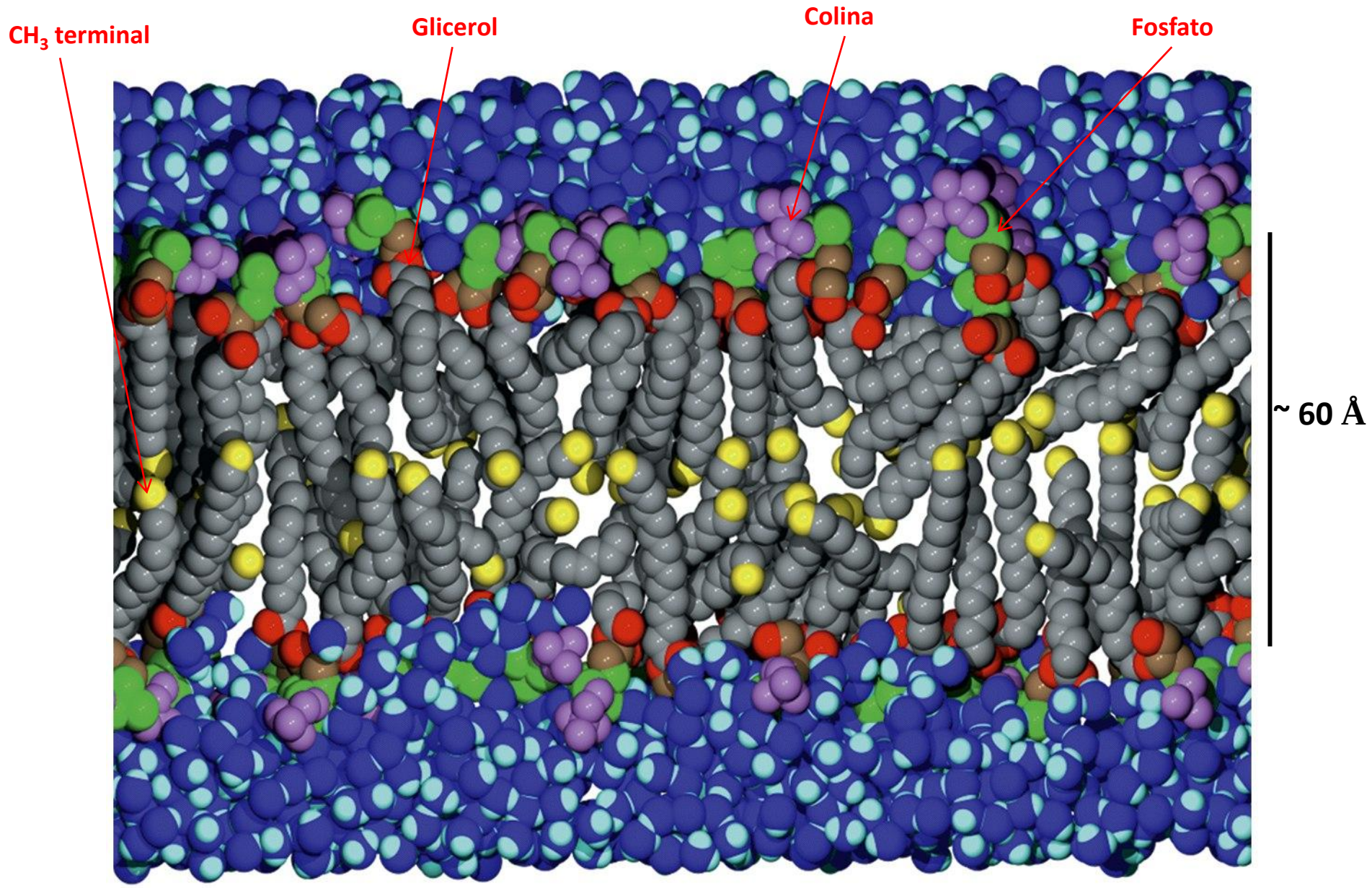


Figure 9-17 Fundamentals of Biochemistry, 2/e

Permeabilidade da bicamada lipídica

Água

https://www.youtube.com/watch?v=ePGqRaQiBfc

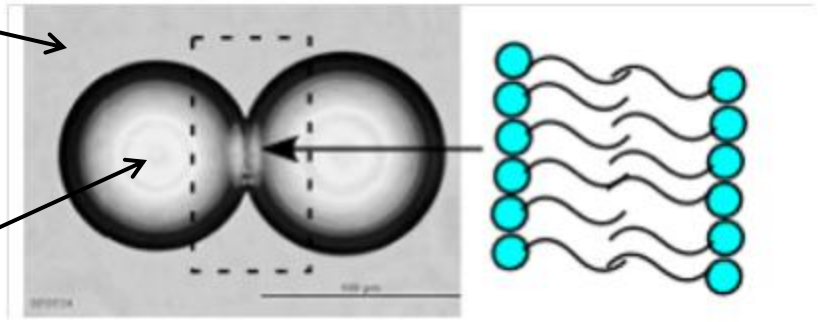
Permeabilidade da bicamada lipídica

Propriedades físico-químicas dos fosfolipídeos

Esquema de uma bicamada na interface entre gotas - BIG

Meio com monoglicerídeos dissolvidos em solvente apolar

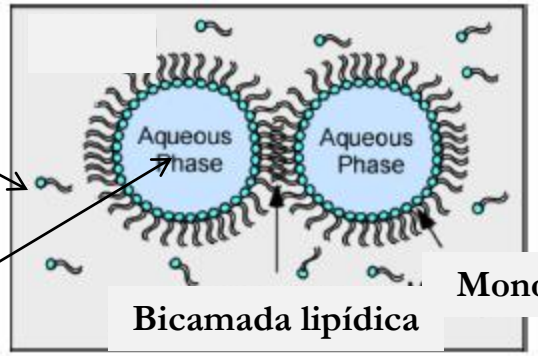
gota de água envolvida por uma monocamada de monoglicerídeos



Visão esquemática da bicamada lipídica formada na interface entre as duas gotas

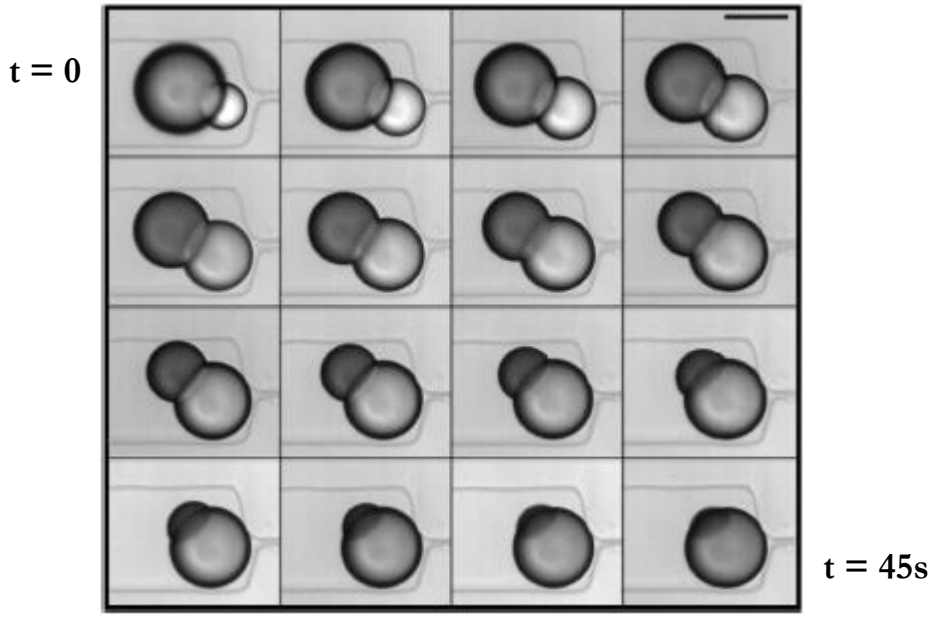
Monoglicerídeos em solvente apolar

Fase aquosa



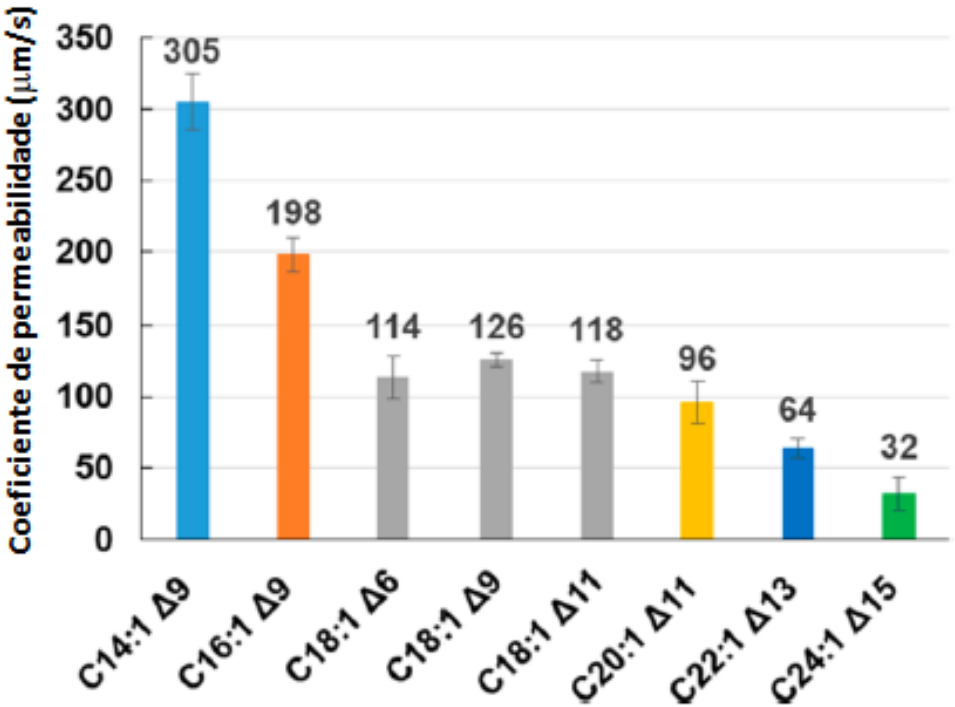
Visão esquemática das duas gotas mostradas acima

Langmuir 34, 2147-2157 (2018) e Langmuir 33, 900-912 (2017)



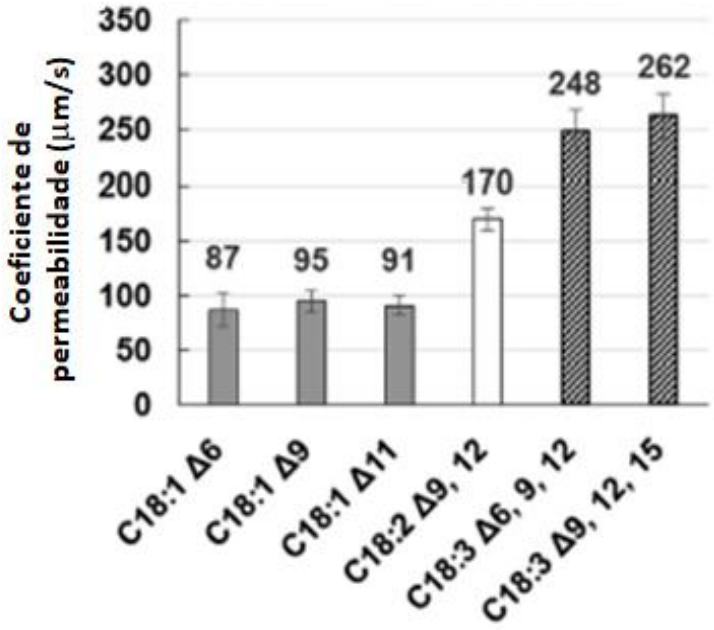
Langmuir 34, 2147-2157 (2018) e Langmuir 33, 900-912 (2017)

Espessura da bicamada lipídica



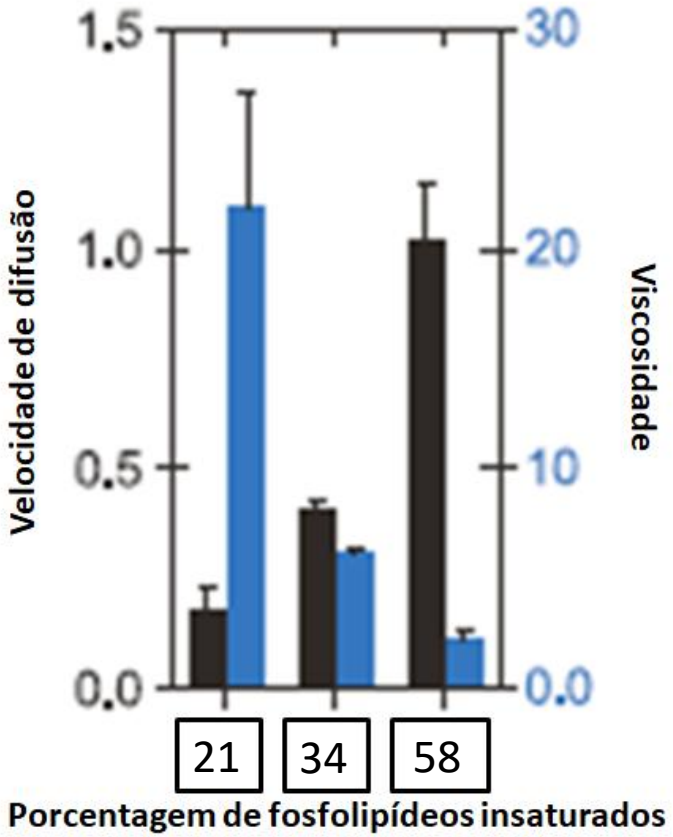
Coeficiente de permeabilidade (μm/s) de bicamadas formadas por diferentes monoglicerídeos medidas usando o modelo de BIG. Extraído de Langmuir 33, 900-912 (2017)

Fluidez (viscosidade) da bicamada lipídica

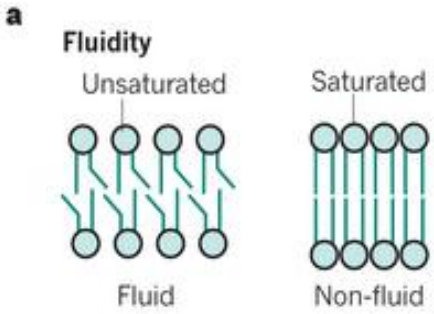


Coeficiente de permeabilidade (μm/s) de bicamadas formadas por diferentes monoglicerídeos medidas usando o modelo de BIG. Extraído de Langmuir 33, 900-912 (2017)

Fluidez (viscosidade) da bicamada lipídica



Science 362, 1186 – 1189; 2018



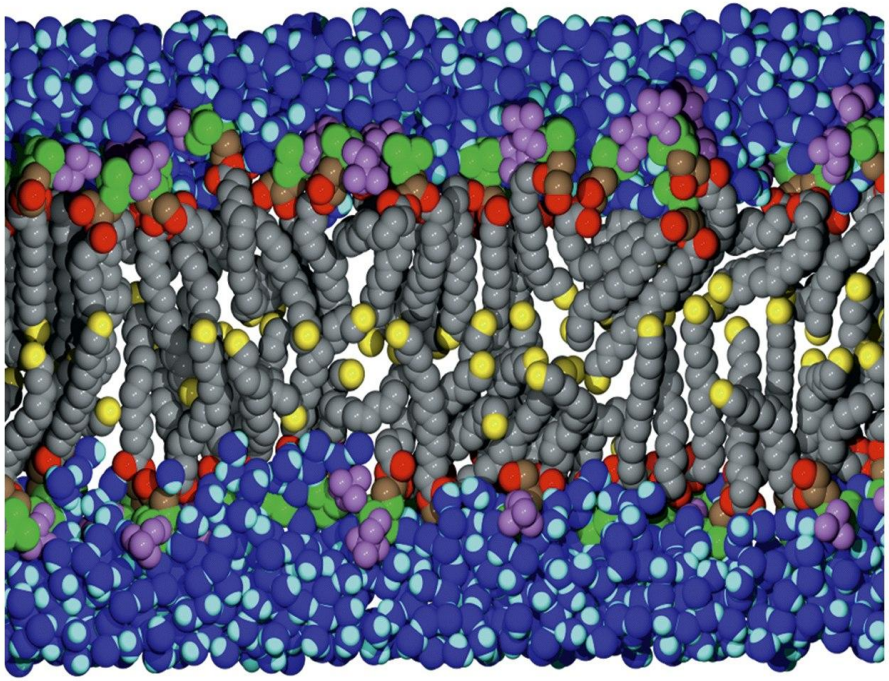


Figure 9-17 Fundamentals of Biochemistry, 2/e

Desordenado

Ordenado

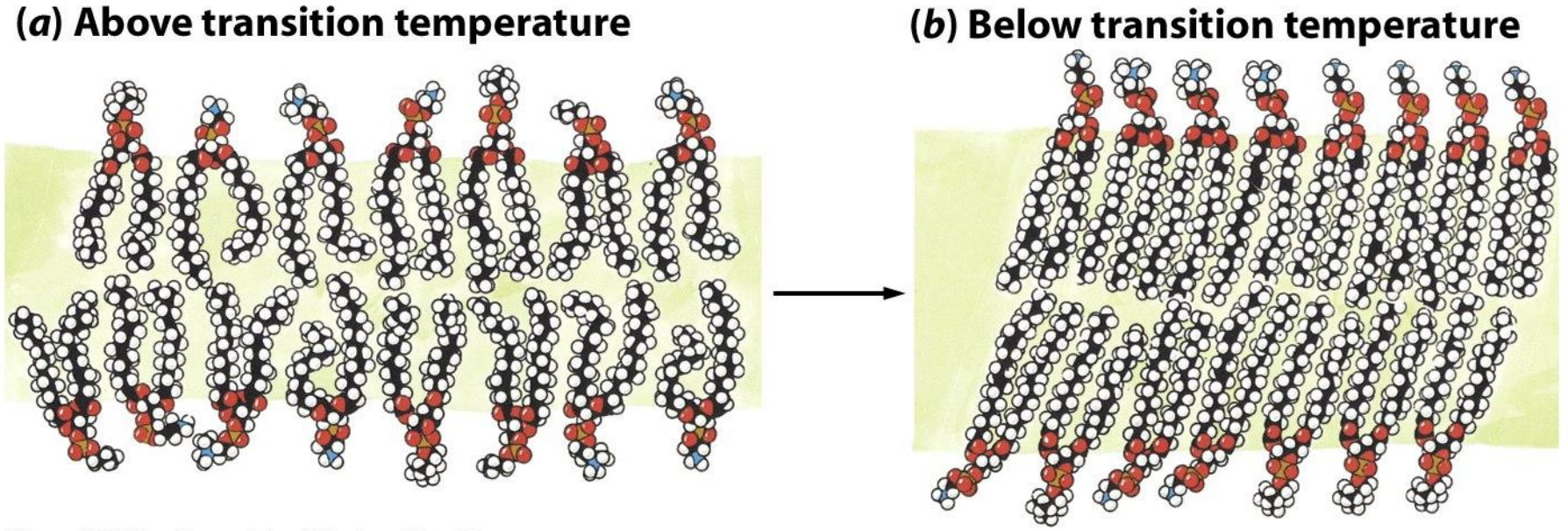


Figure 9-18 Fundamentals of Biochemistry, 2/e

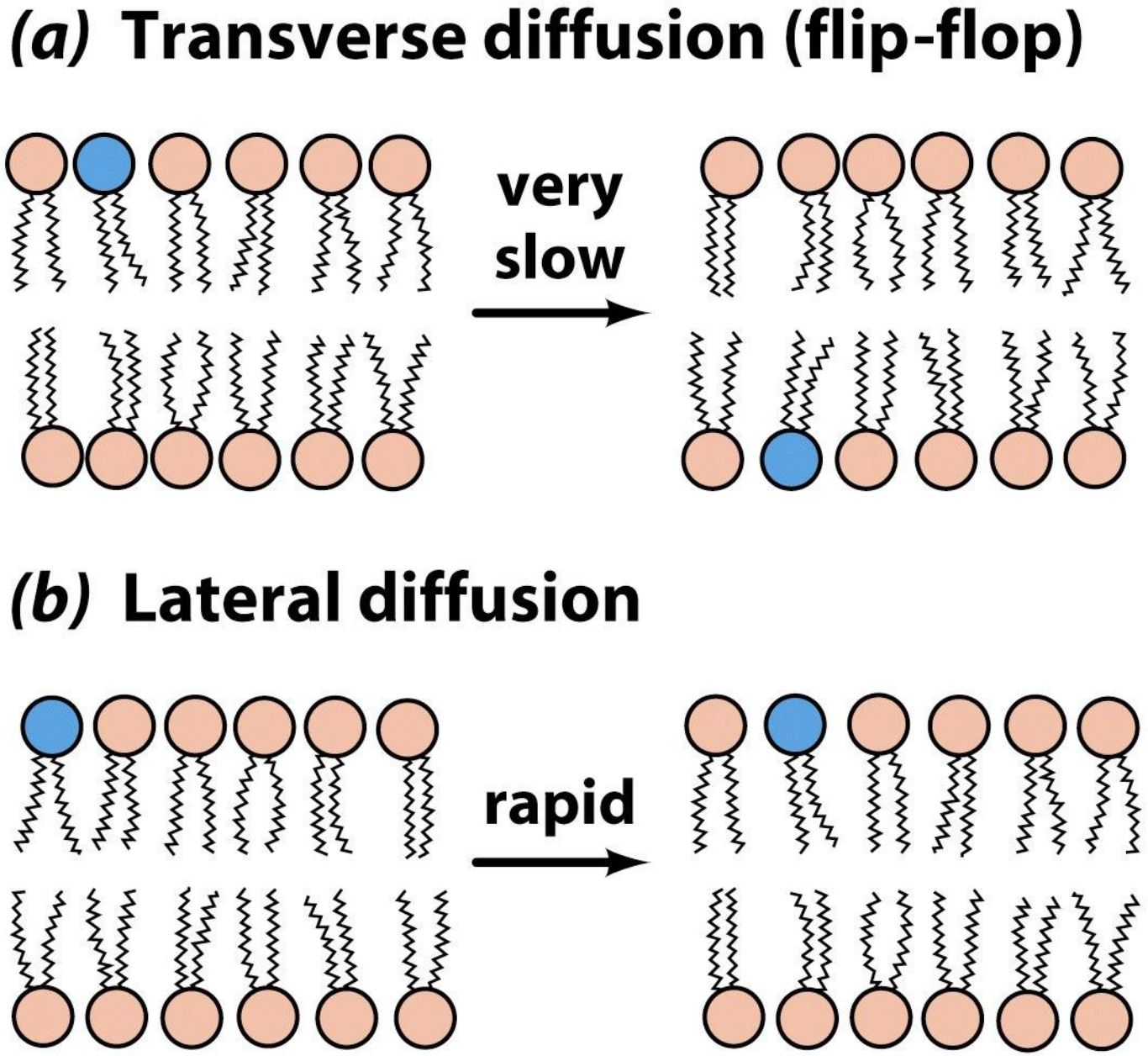


Figure 9-16 Fundamentals of Biochemistry, 2/e

glicerofosfolipídeo

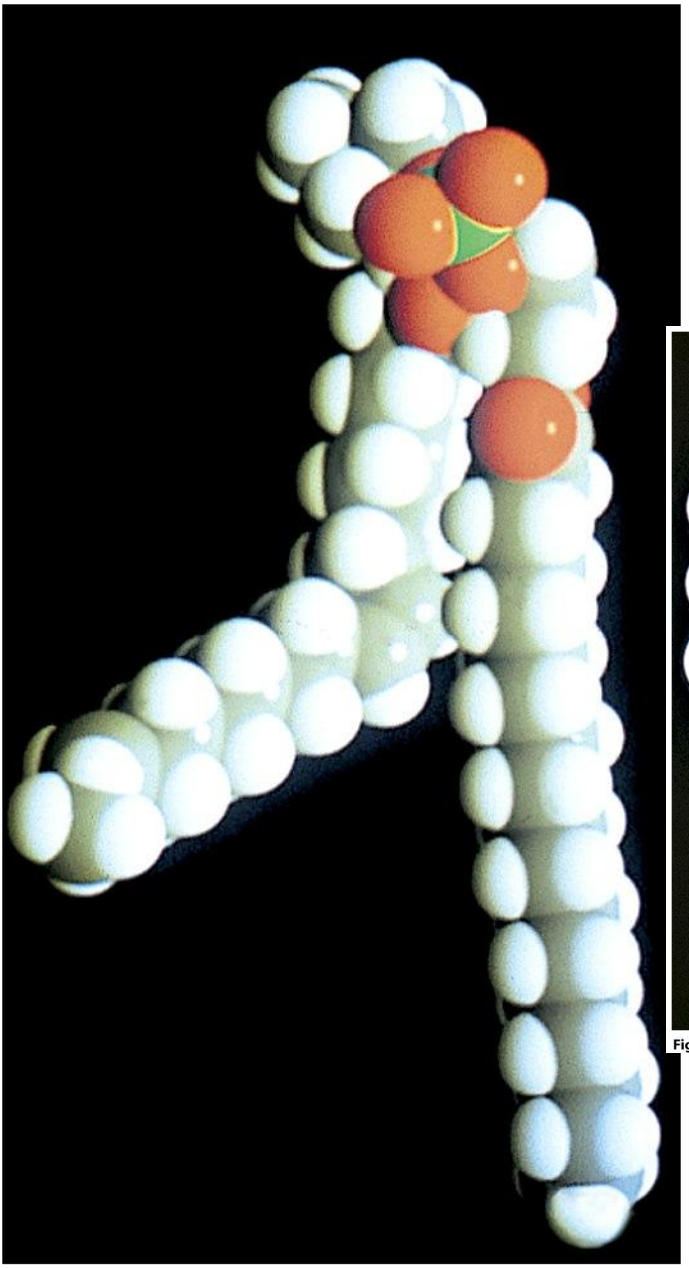


Figure 9-4b Fundamentals of Biochemistry, 2/e

colesterol

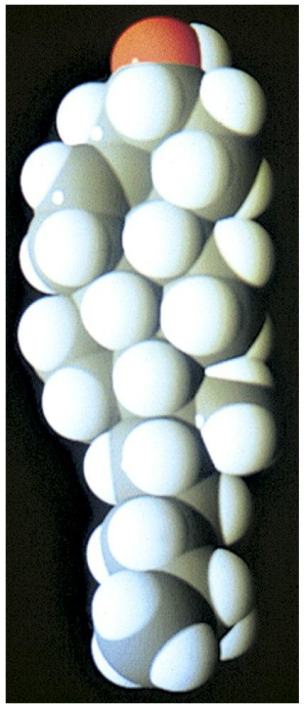
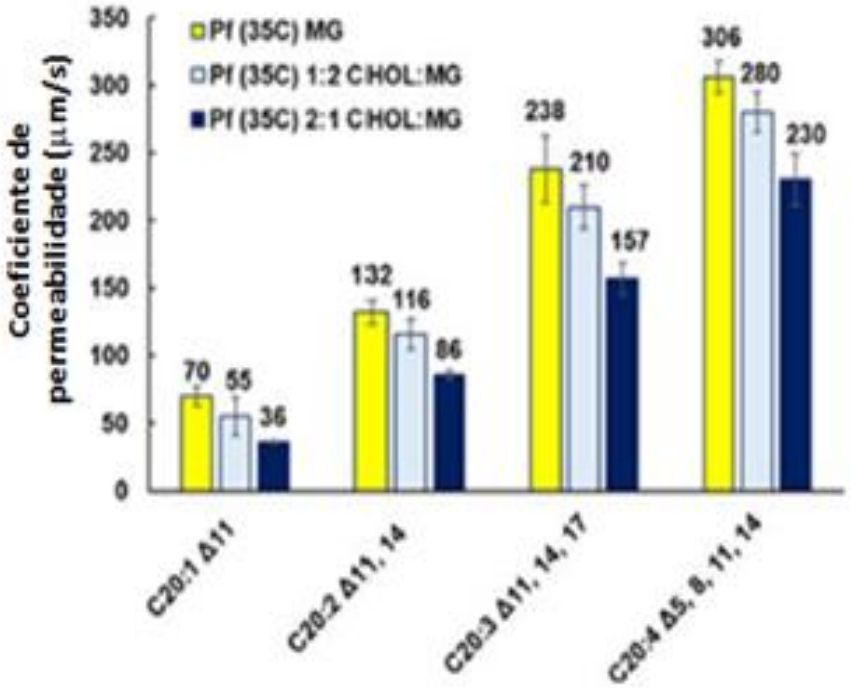
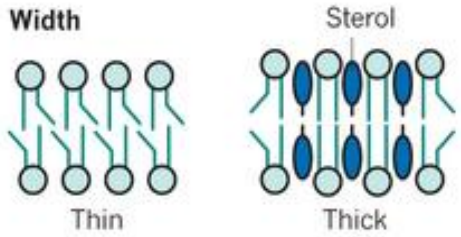


Figure 9-10b Fundamentals of Biochemistry, 2/e



Coeficiente de permeabilidade (μm/s) de bicamadas formadas por diferentes proporções entre monoglicerídeos e colesterol. Medidas feitas usando o modelo de BIG. Extraído de Langmuir Langmuir 34, 2147-2157 (2018).



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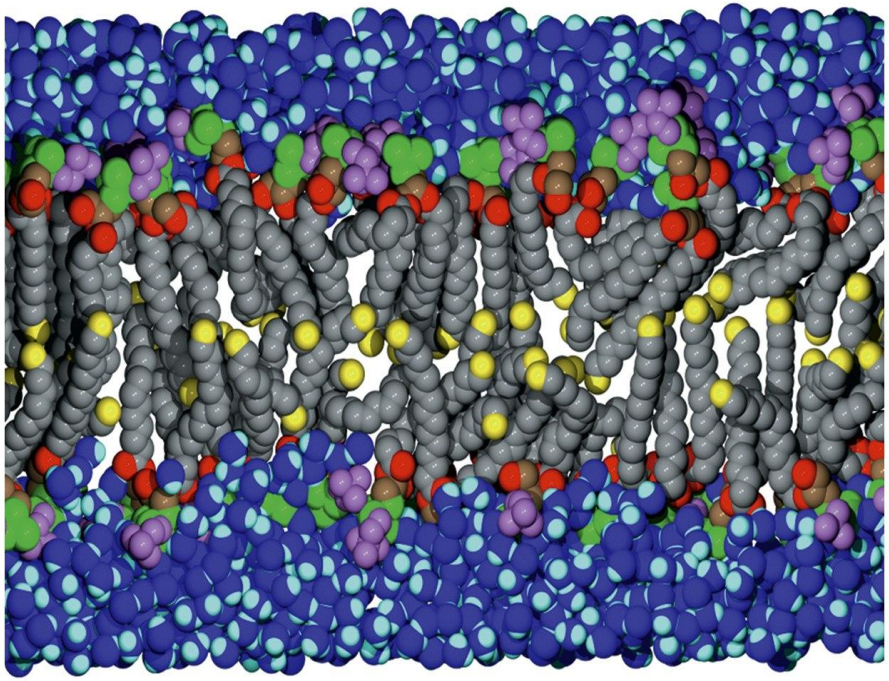
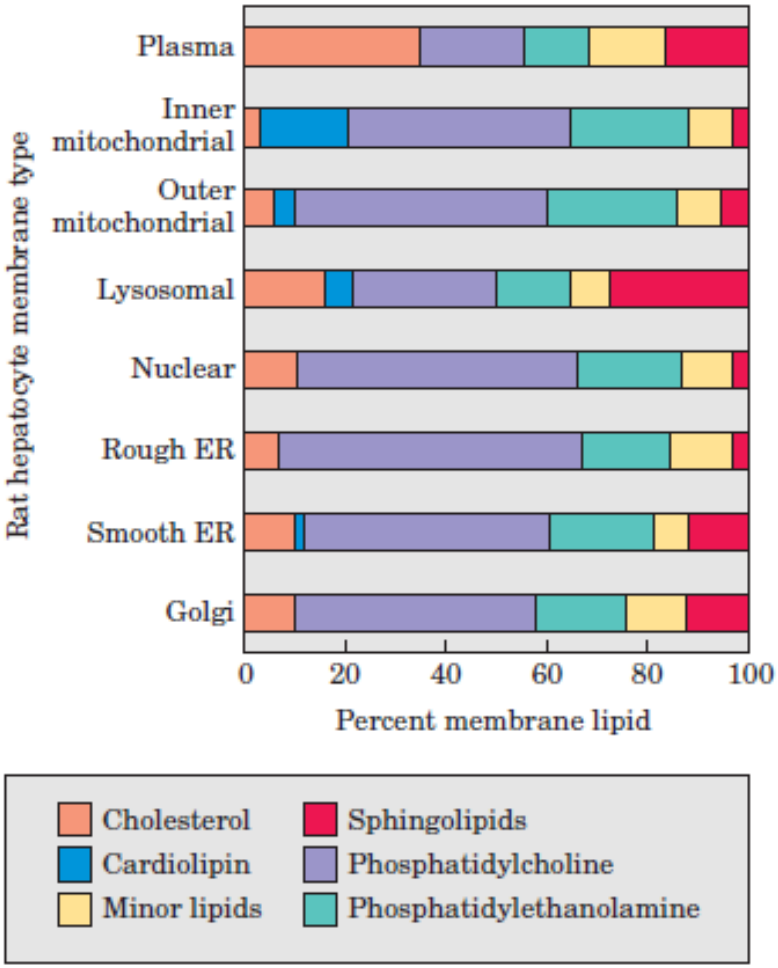


Figure 9-17 Fundamentals of Biochemistry, 2/e



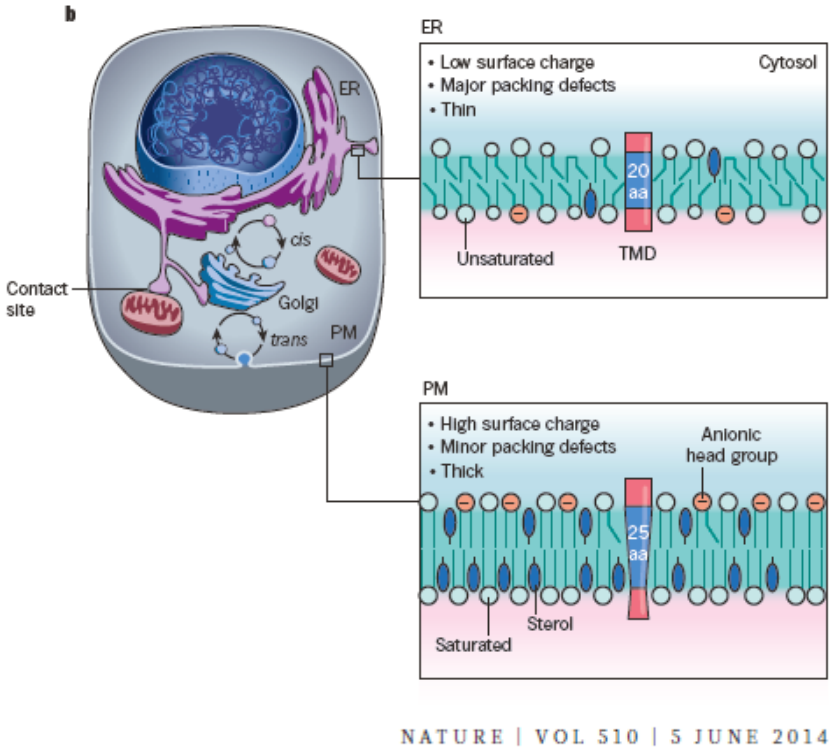


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FIGURE 11–2 Lipid composition of the plasma membrane and organelle membranes of a rat hepatocyte. The functional specialization of each membrane type is reflected in its unique lipid composition.

Lehninger Principles of Biochemistry, 6th Ed.

“Curvatura” da bicamada lipídica

glicerofosfolipídeo

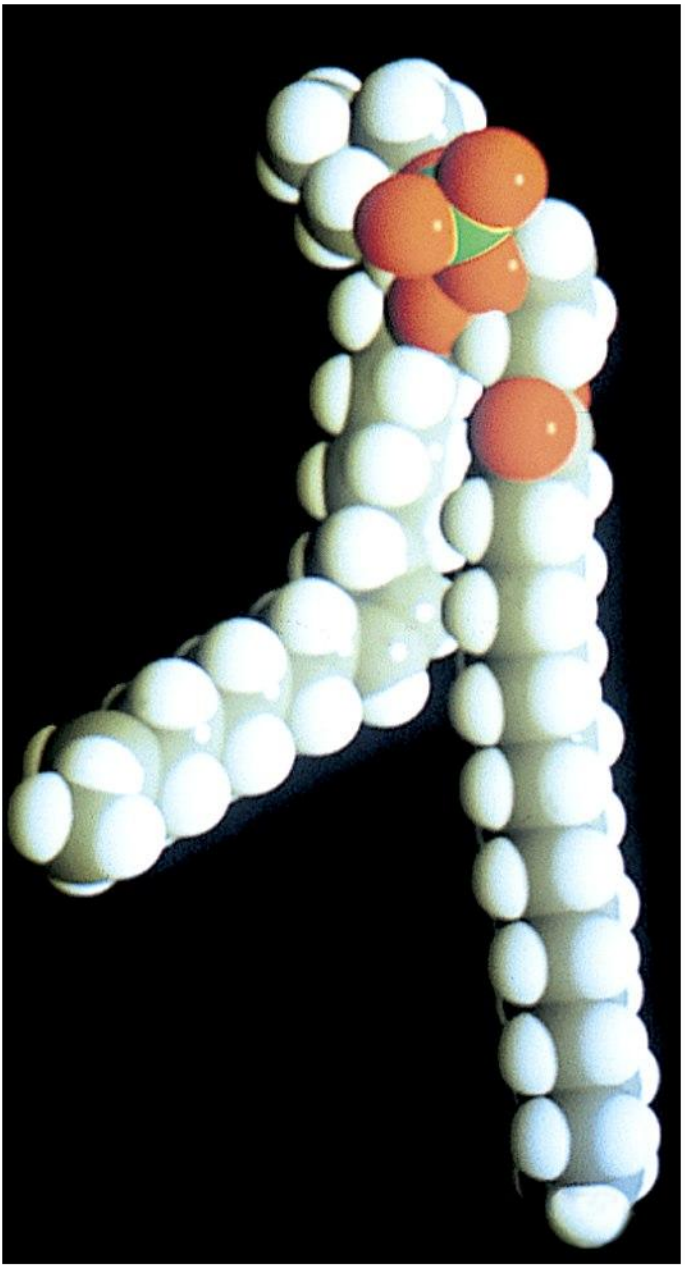


Figure 9-4b Fundamentals of Biochemistry, 2/e

esfingofosfolipídeo

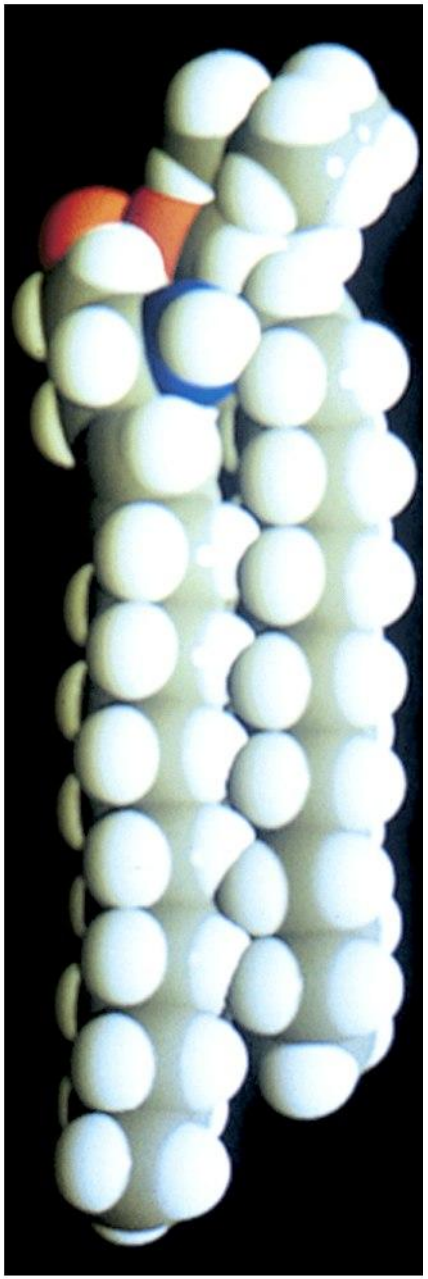


Figure 9-7b Fundamentals of Bioch

esfingoglicolipídeo

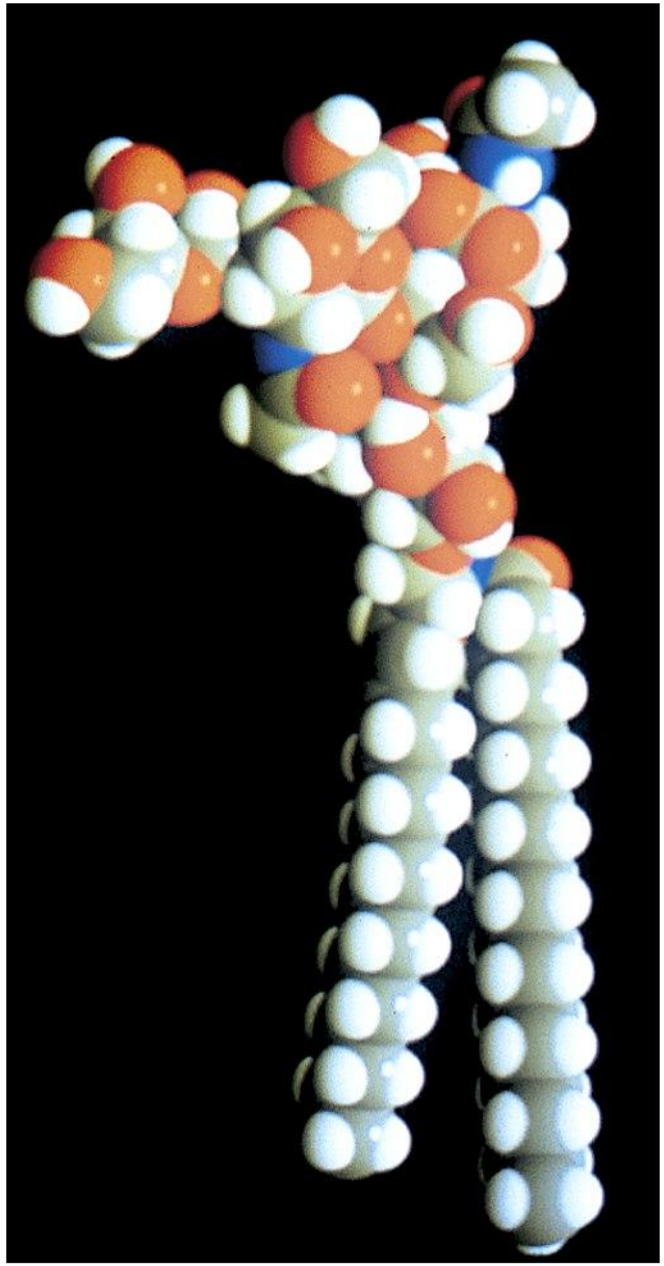


Figure 9-9b Fundamentals of Biochemistry, 2/e

glicerofosfolipídeo

esfingofosfolipídeo

esfingoglicolipídeo

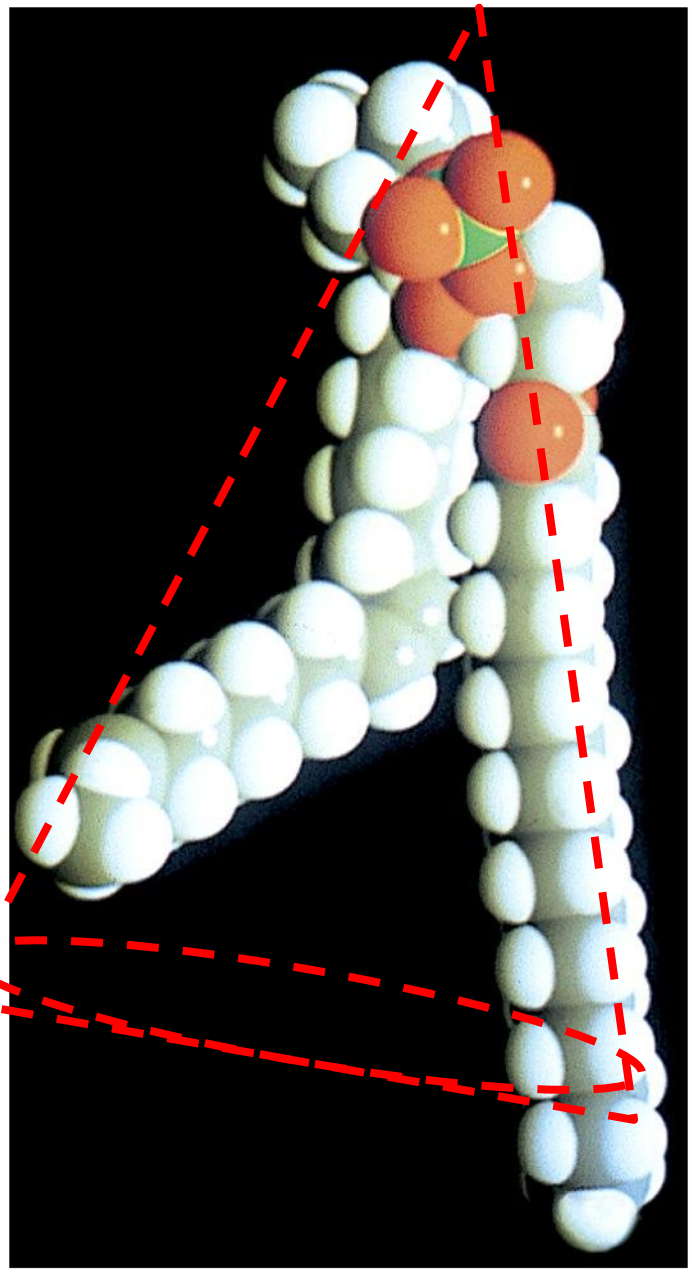


Figure 9-4b Fundamentals of Biochemistry, 2/e

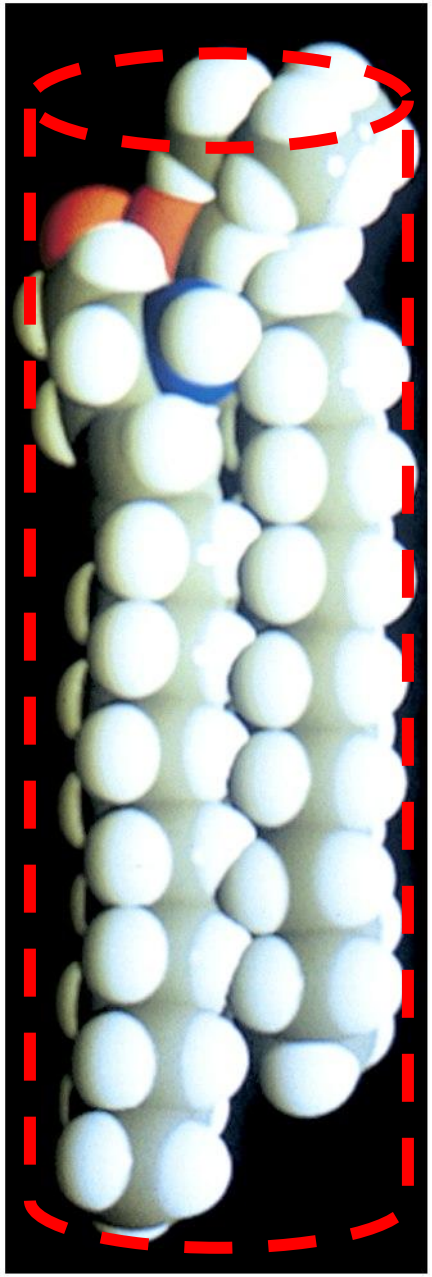


Figure 9-7b Fundamentals of Bioch

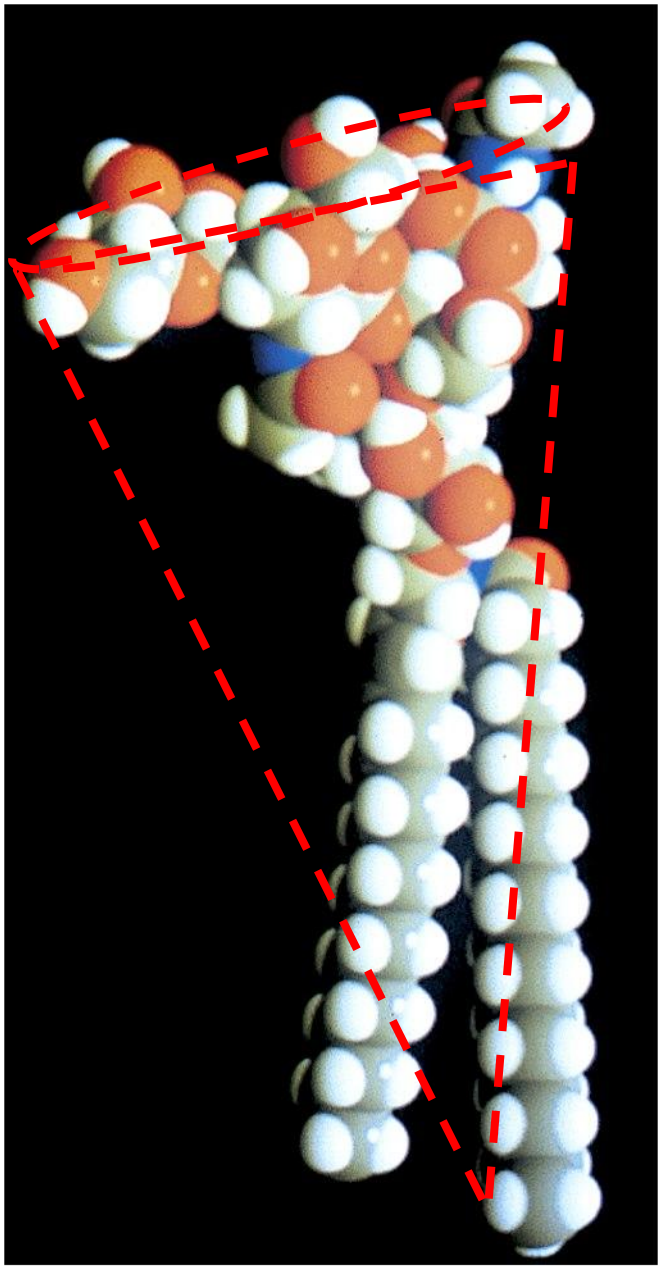
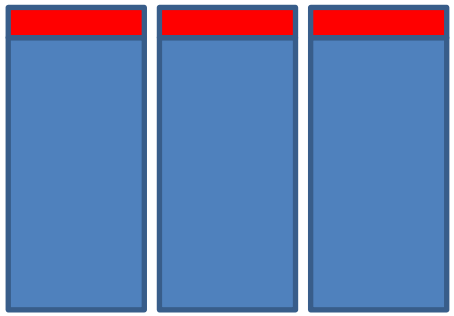
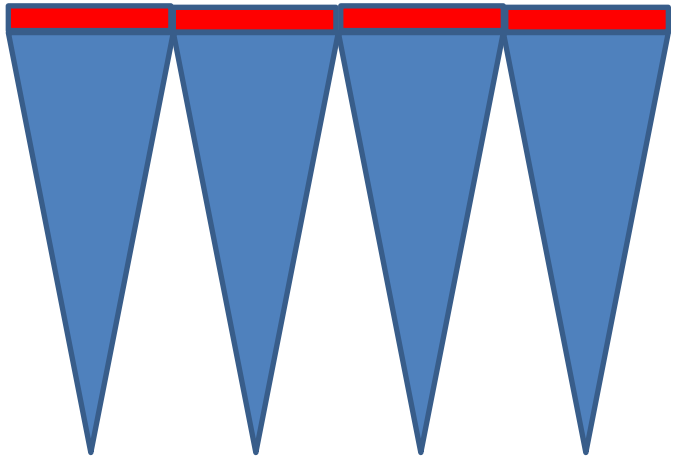


Figure 9-9b Fundamentals of Biochemistry, 2/e



“cabeça polar”



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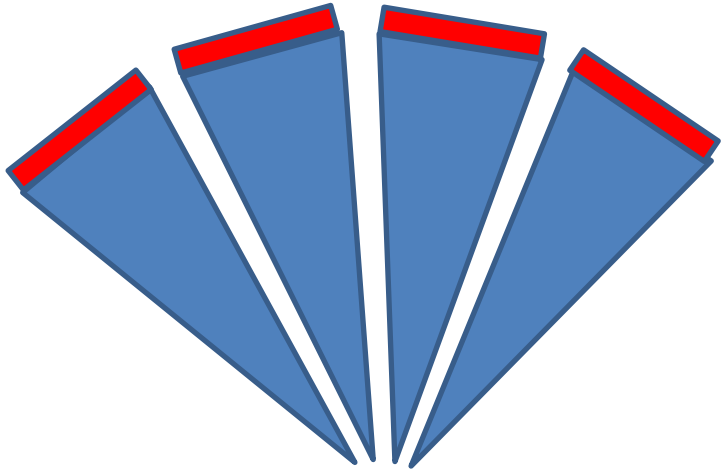

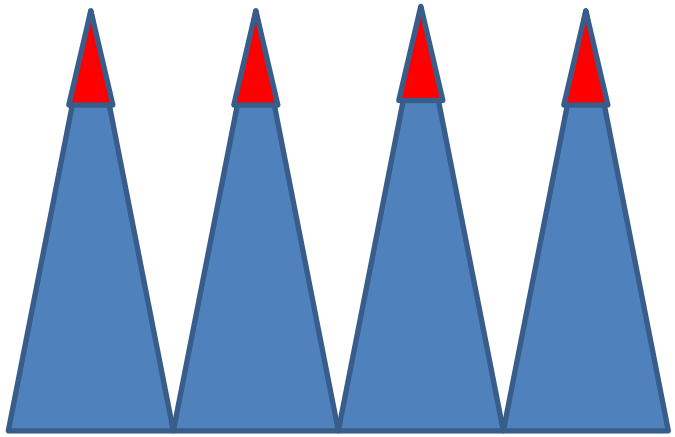

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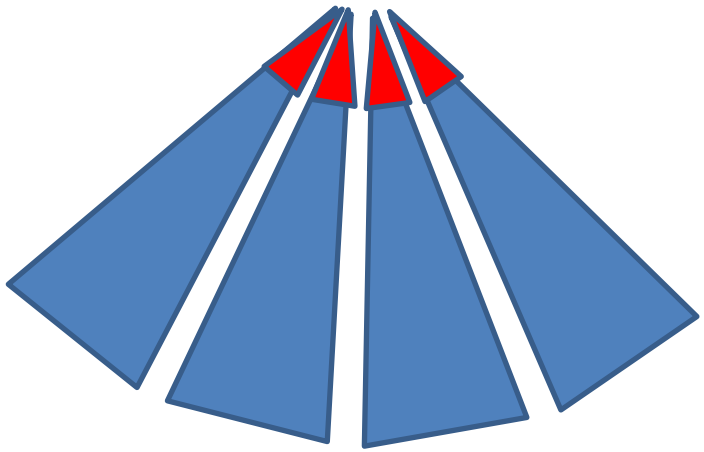

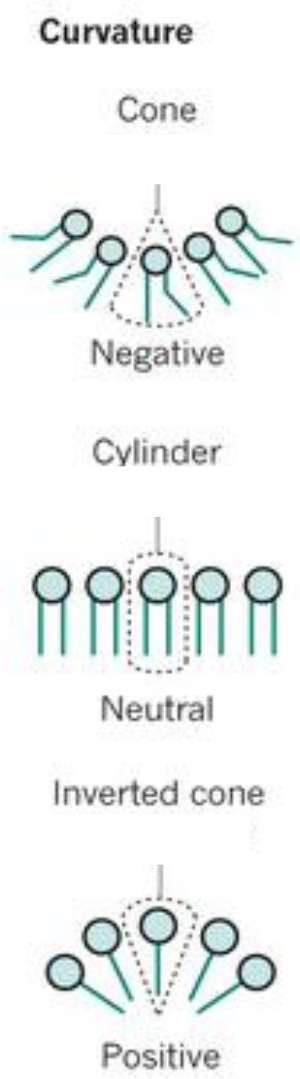

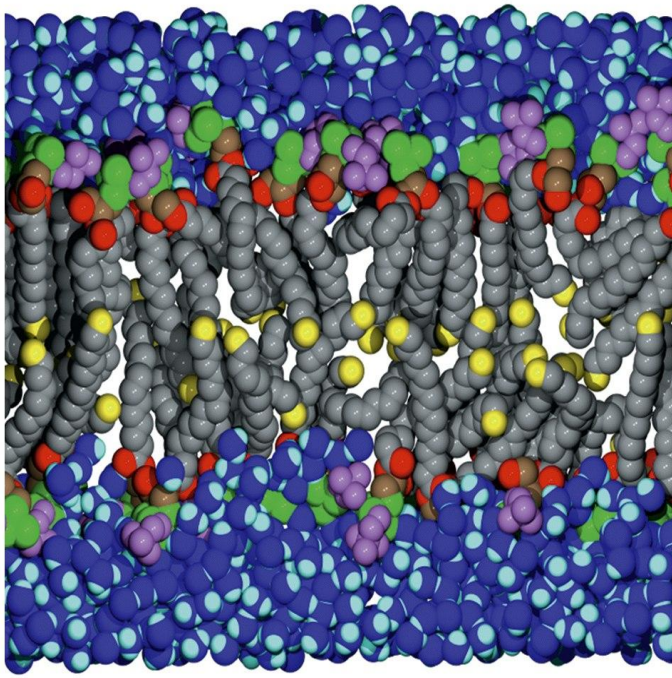

Figure 9-17 Fundamentals of Biochemistry, 2/e

Distribuição assimétrica de fosfolipídeos em membranas plasmáticas de eritrócitos

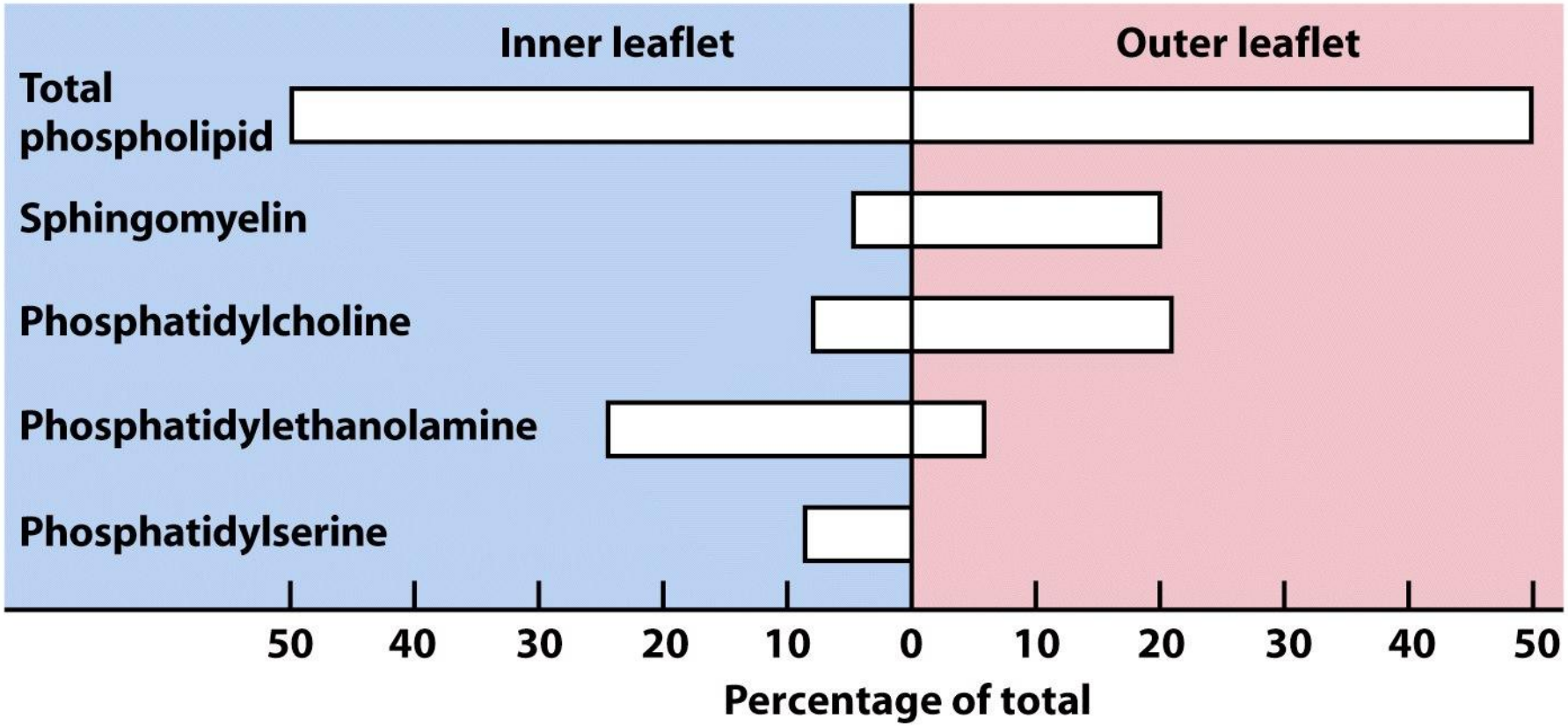

Figure 9-33 Fundamentals of Biochemistry, 2/e

Composição das membranas biológicas

TABLE 11–1 Major Components of Plasma Membranes in Various Organisms

	Components (% by weight)				
	Protein	*Phospholipid*	*Sterol*	*Sterol type*	*Other lipids*
Human myelin sheath	30	30	19	Cholesterol	Galactolipids, plasmalogens
Mouse liver	45	27	25	Cholesterol	–
Maize leaf	47	26	7	Sitosterol	Galactolipids
Yeast	52	7	4	Ergosterol	Triacylglycerols, steryl esters
Paramecium (ciliated protist)	56	40	4	Stigmasterol	–
E. coli	75	25	0	–	–

Note: Values do not add up to 100% in every case, because there are components other than protein, phospholipids, and sterol; plants, for example, have high levels of glycolipids.

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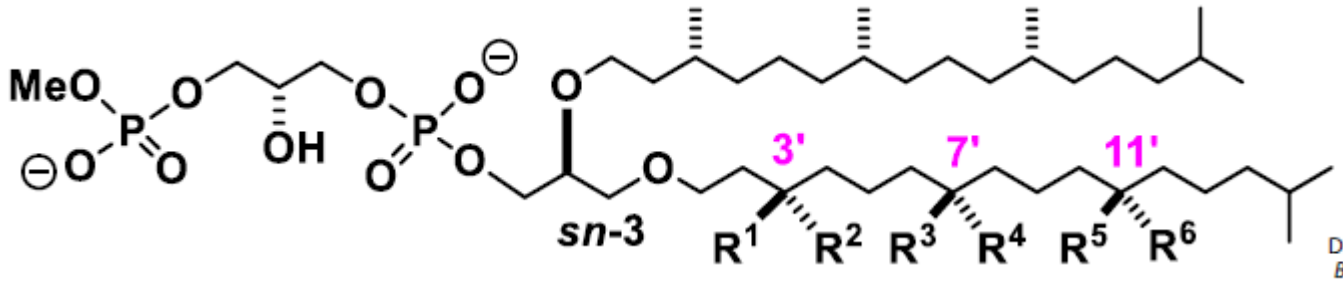

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