Bioquímica Geral
RFM0004

Lipídeos

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Departamento de Bioquímica e Imunologia
FMRP-USP

Collaborate!

O que são lipídeos?

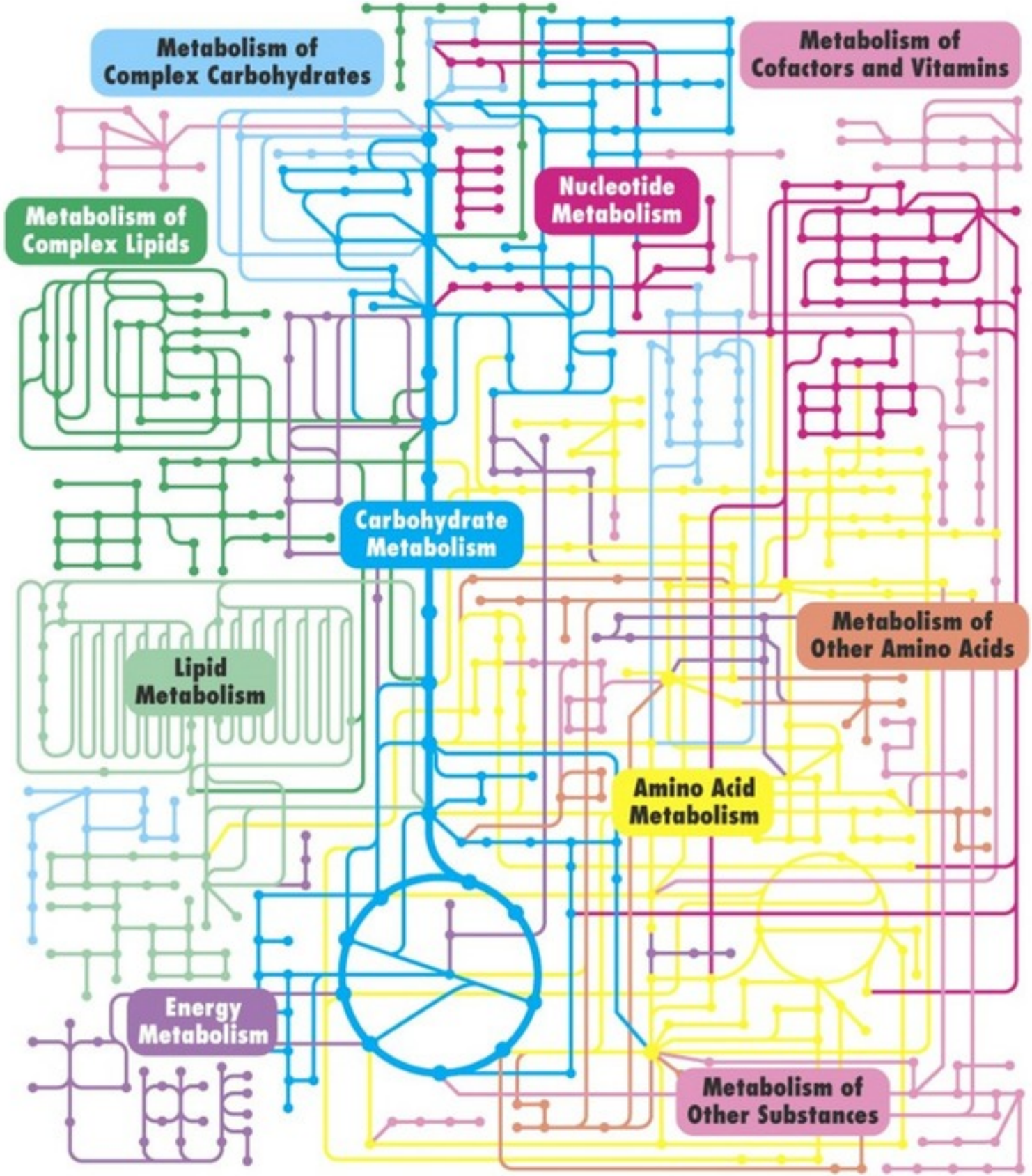


Figure 15-2
Biochemistry, Sixth Edition

Chapter 22 Opener part 1
Biochemistry, Sixth Edition

Lipídeos

Importância

ancoras hidrofóbicas

Membranas biológicas

armazenamento

pigmentos

hormônios

mensageiros intracelulares

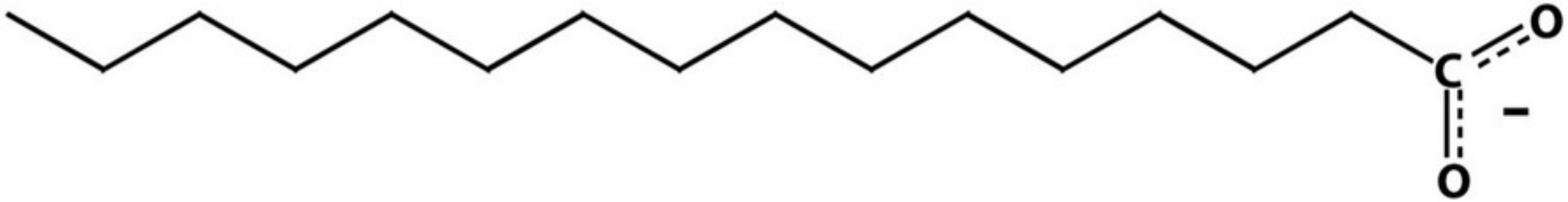
co-fatores enzimáticos

característica comum?

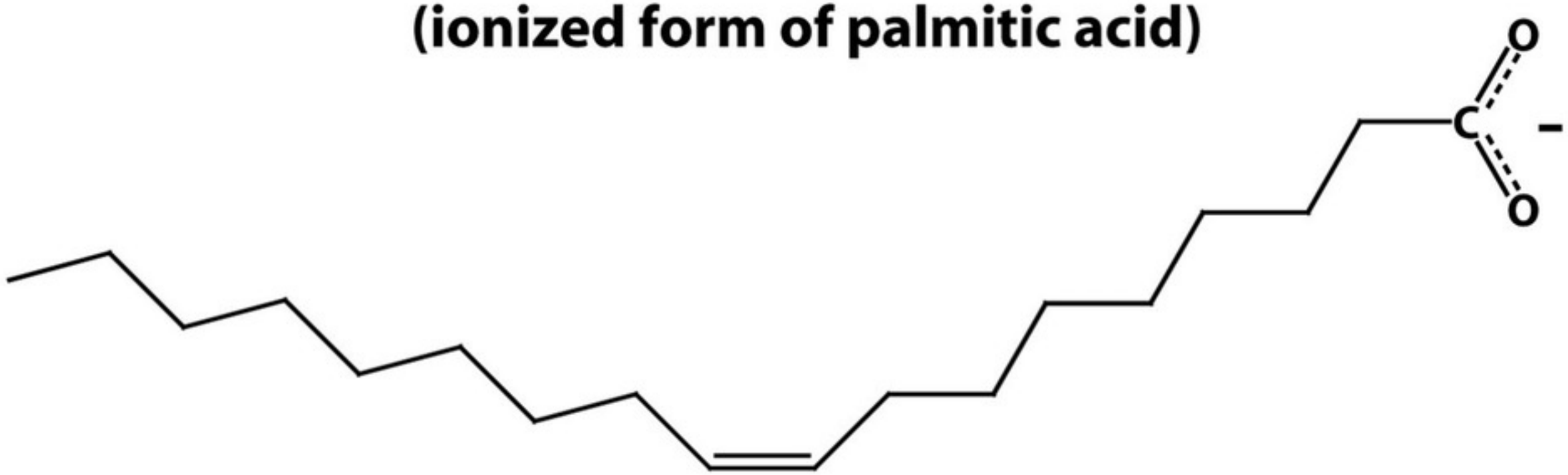
Ácidos Graxos

Ácidos carboxílicos
com cadeias hidrocarbônicas
comprimento variando de 4 a 36 carbonos.

Propriedades:
- dependentes do comprimento da cadeia
- dependentes do grau de insaturação



Palmitate
(ionized form of palmitic acid)



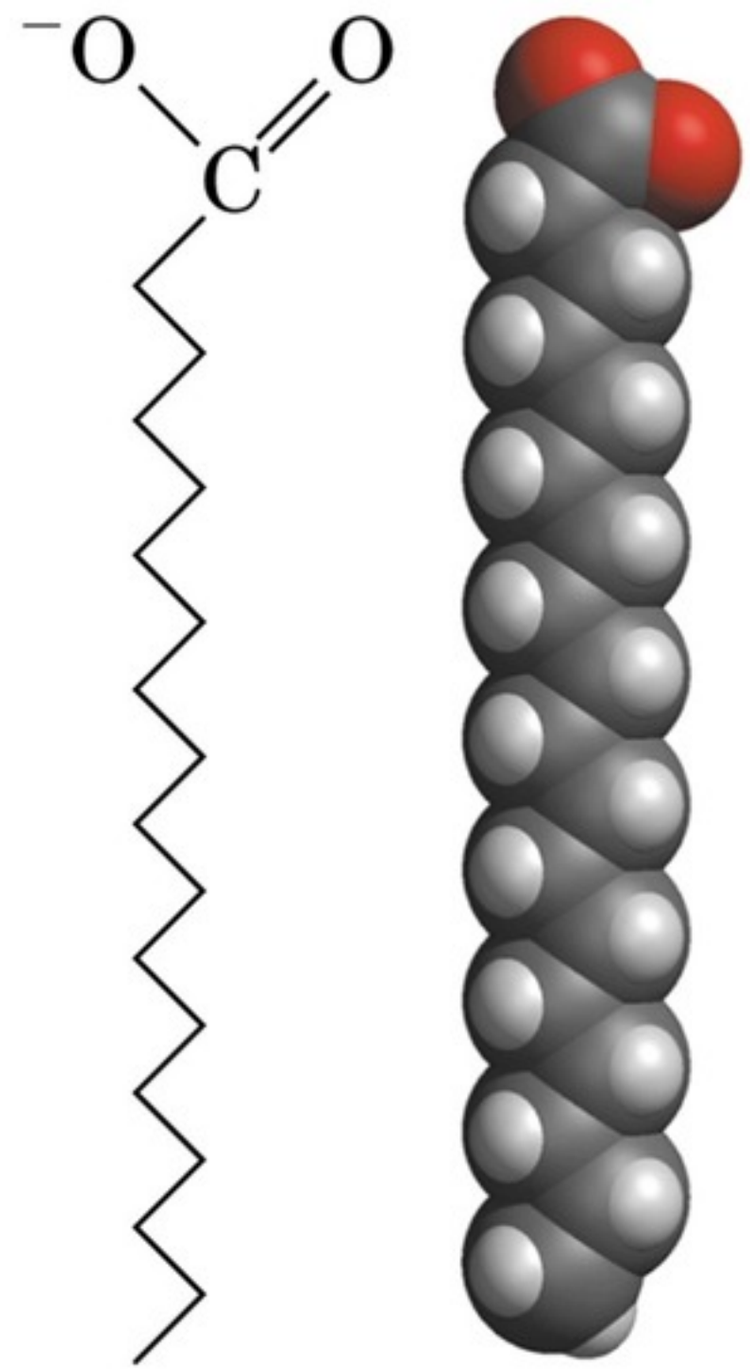
Oleate
(ionized form of oleic acid)

Figure 12-2
Biochemistry, Sixth Edition

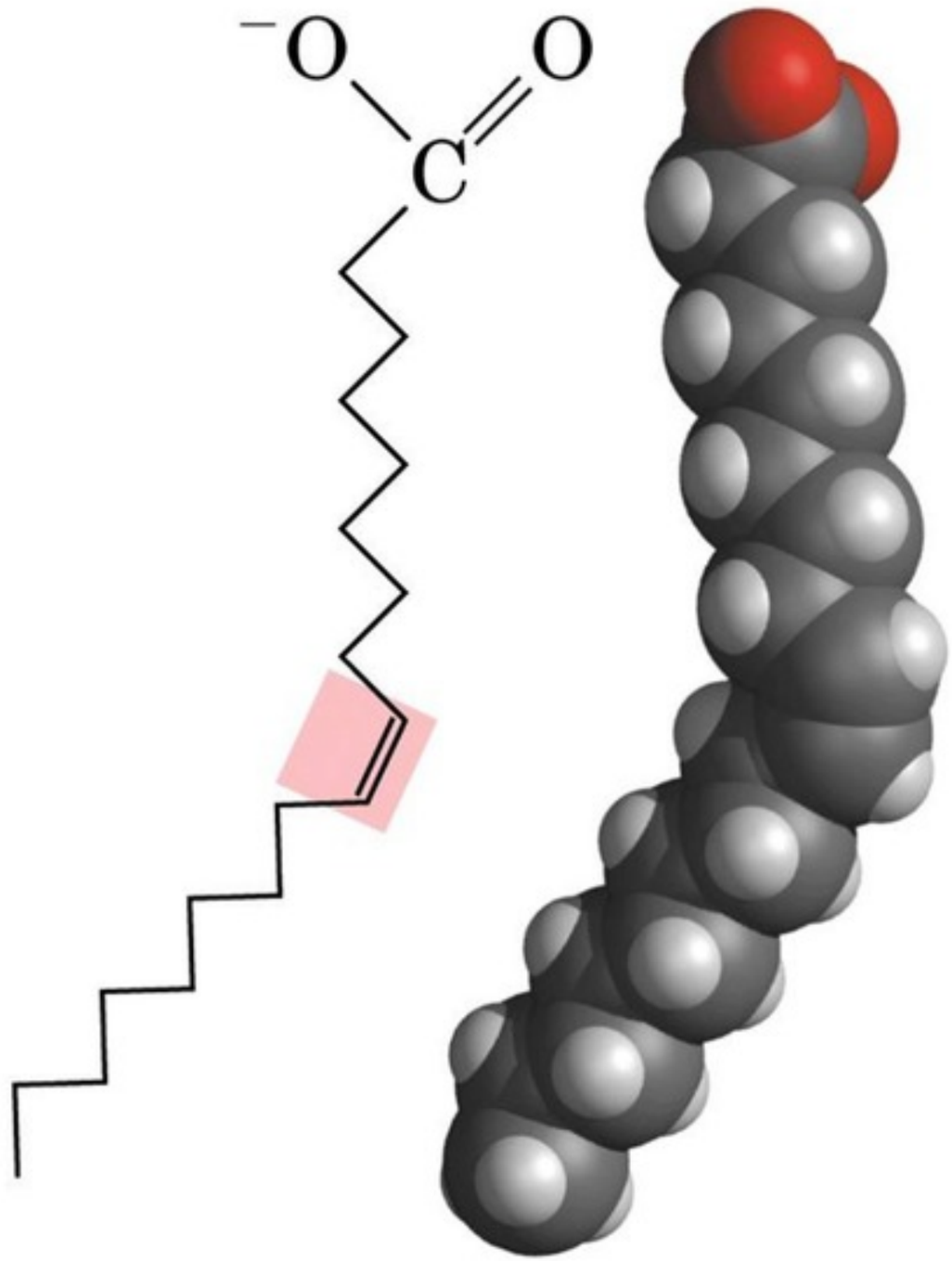
Um ácido graxo saturado

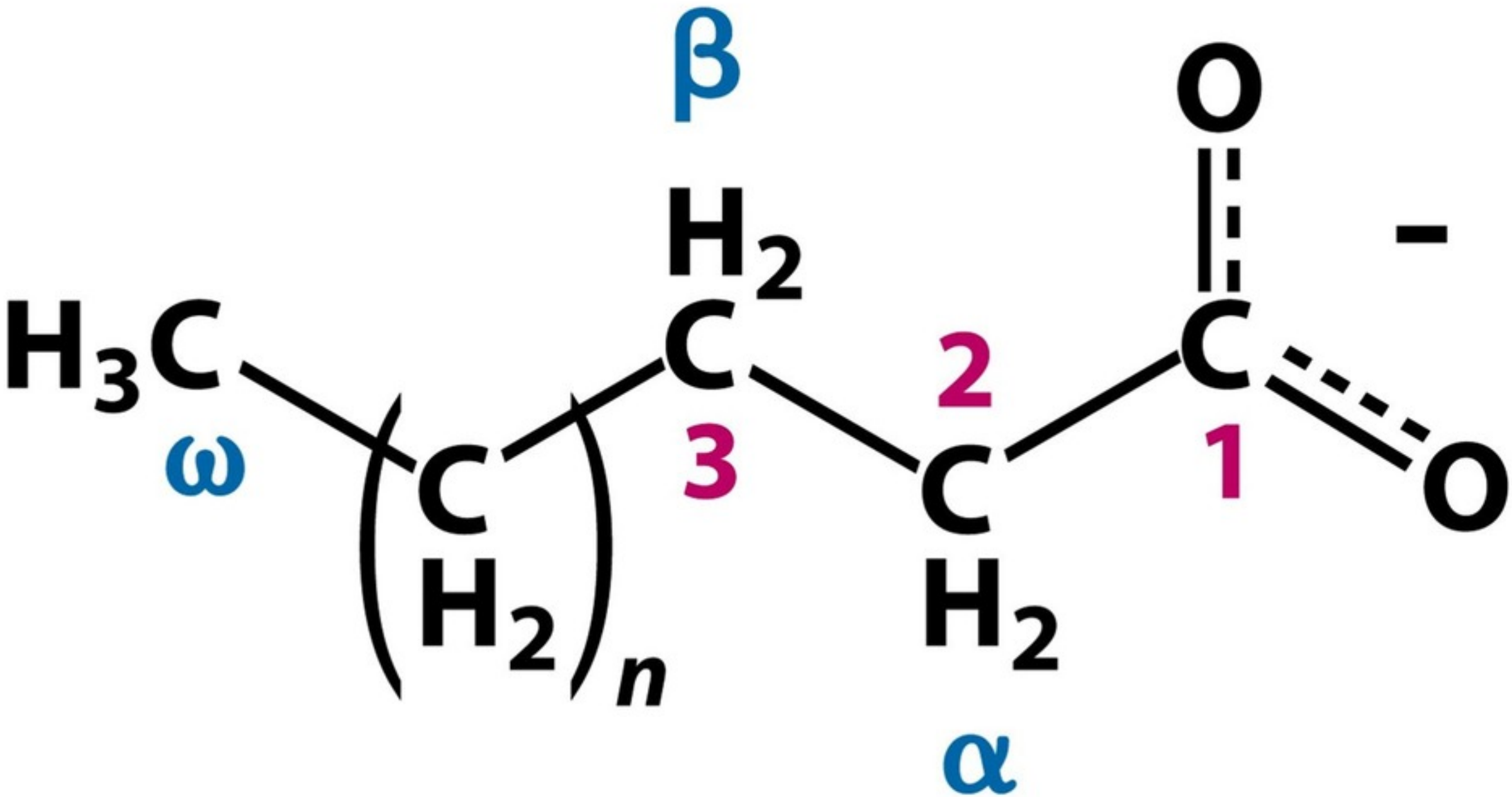
Carboxyl group

Hydrocarbon chain



Configuração *cis* de insaturação

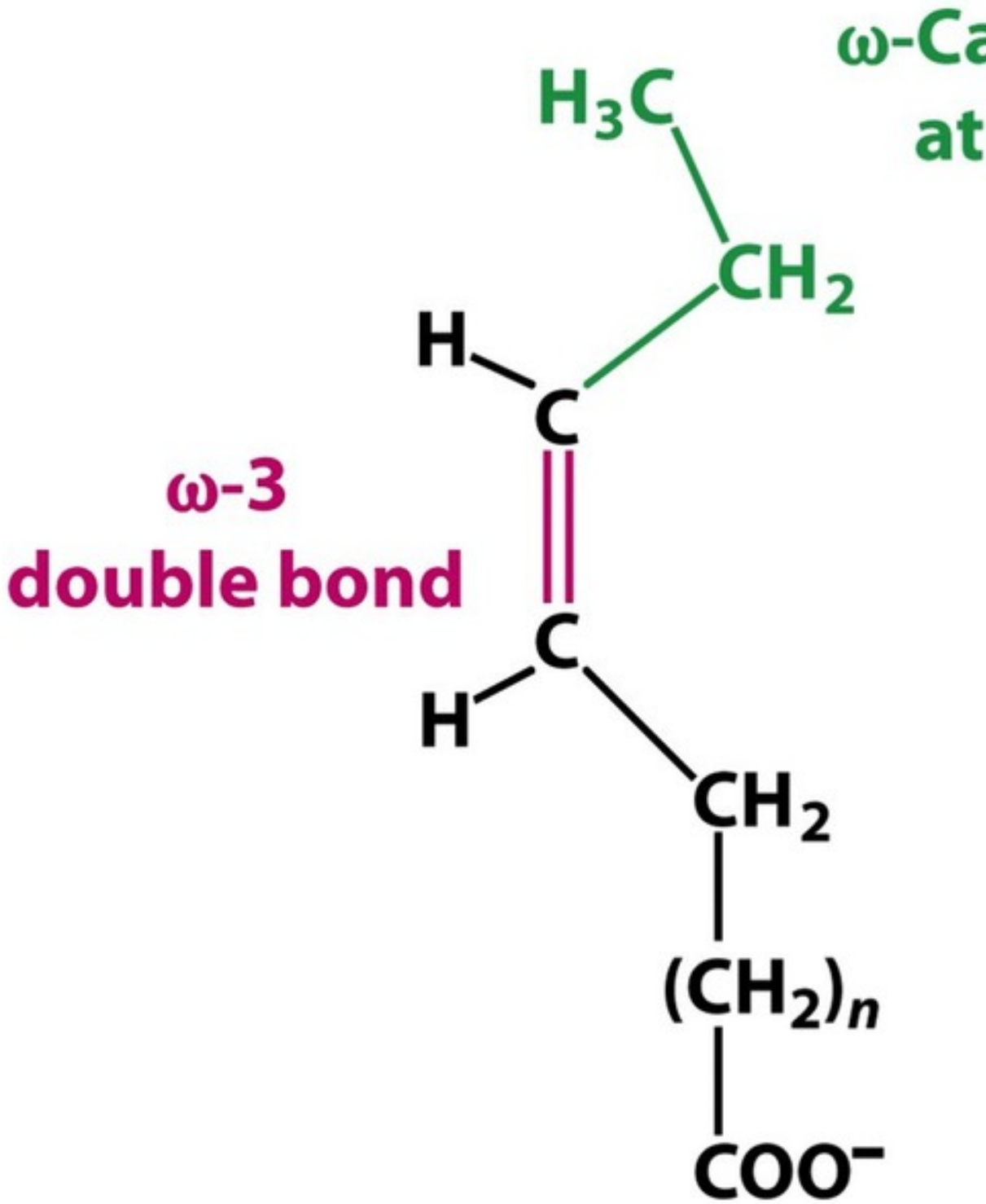




Unnumbered figure pg 328a
Biochemistry, Sixth Edition

Some Naturally Occurring Fatty Acids

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")		0.063	2,600
14:0	$CH_3(CH_2)_{12}COOH$	*n*-Tetradecanoic acid	Myristic acid (Latin *Myristica*, nutmeg genus)		0.024	874
16:0	$CH_3(CH_2)_{14}COOH$	*n*-Hexadecanoic acid	Palmitic acid (Latin *palma*, "palm tree")		0.0083	348
18:0	$CH_3(CH_2)_{16}COOH$	*n*-Octadecanoic acid	Stearic acid (Greek *stear*, "hard fat")		0.0034	124
20:0	$CH_3(CH_2)_{18}COOH$	*n*-Eicosanoic acid	Arachidic acid (Latin *Arachis*, legume genus)			
24:0	$CH_3(CH_2)_{22}COOH$	*n*-Tetracosanoic acid	Lignoceric acid (Latin *lignum*, "wood" + *cera*, "wax")			
16:1(Δ^9)	$CH_3(CH_2)_5CH{=}CH(CH_2)_7COOH$	*cis*-9-Hexadecenoic acid	Palmitoleic acid			
18:1(Δ^9)	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	*cis*-9-Octadecenoic acid	Oleic acid (Latin *oleum*, "oil")			
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")			
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			
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			



An ω-3 fatty acid

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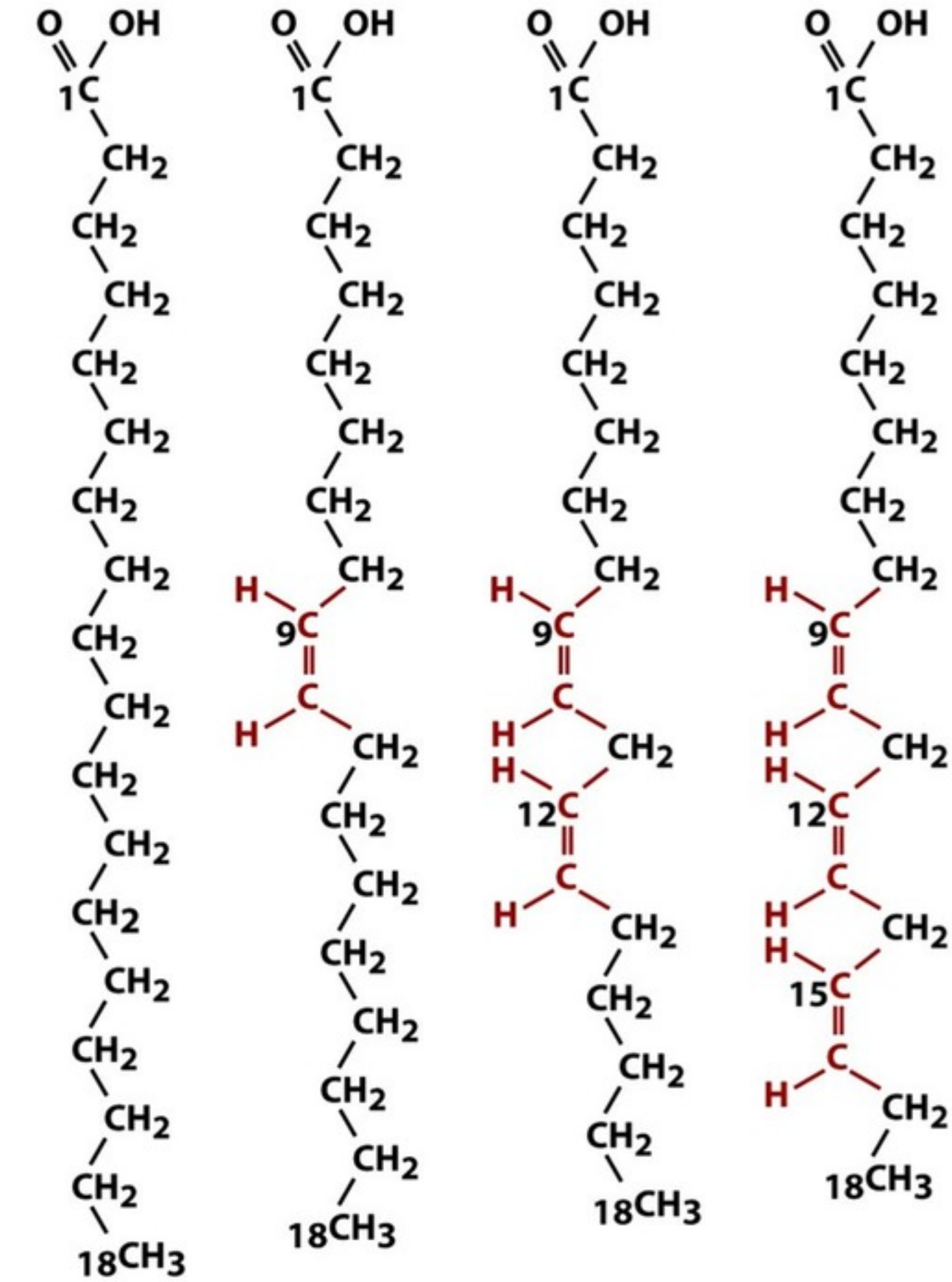
Biochemistry, Sixth Edition

Collaborate!

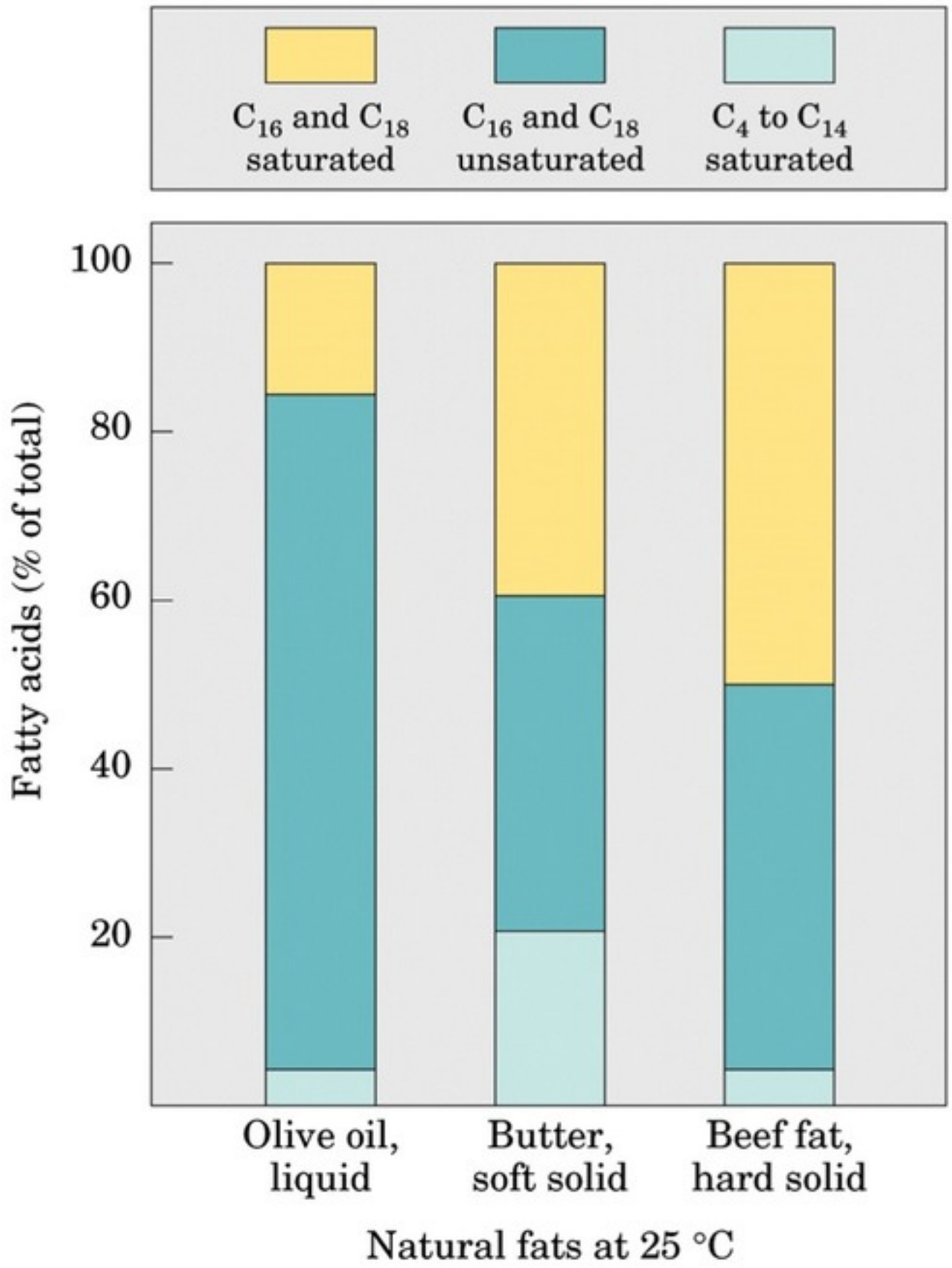
ômega 3 e 6


Stearic acid
Oleic acid
Linoleic acid
α-Linolenic acid

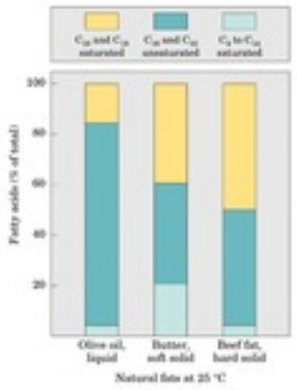
Nomenclatura

18:1(Δ^9)	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	*cis*-9-Octadecenoic acid	Oleic acid (Latin *oleum*, "oil")
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")
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

18:1$n-9$	Oleic acid	9-Octadecenoic acid	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$
18:2$n-6$	Linoleic acid	9,12-Octadecadienoic acid	$CH_3(CH_2)_4(CH{=}CHCH_2)_2(CH_2)_6COOH$
18:3$n-3$	α-Linolenic acid	9,12,15-Octadecatrienoic acid	$CH_3CH_2(CH{=}CHCH_2)_3(CH_2)_6COOH$


C_{16} and C_{18} saturated
C_{16} and C_{18} unsaturated
C_4 to C_{14} saturated
Fatty acids (% of total)
100
80
60
40
20
Olive oil, liquid
Butter, soft solid
Beef fat, hard solid
Natural fats at 25 °C

Open Ended Question



A composição de três alimentos compostos de ácidos graxos está mostrado no gráfico. Qual a relação entre a proporção de ácidos graxos sturados ou insaturados e a temperatura de fusão desses alimentos?

Please enter your answer here.

Some Naturally Occurring Fatty Acids

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	−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")	−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		

Ácidos Graxos

Ponto de fusão dos ácidos graxos:

- dependentes do comprimento da cadeia hidrocarbônica

- dependentes do grau de insaturação
    - monoinsaturados
    - poliinsaturados

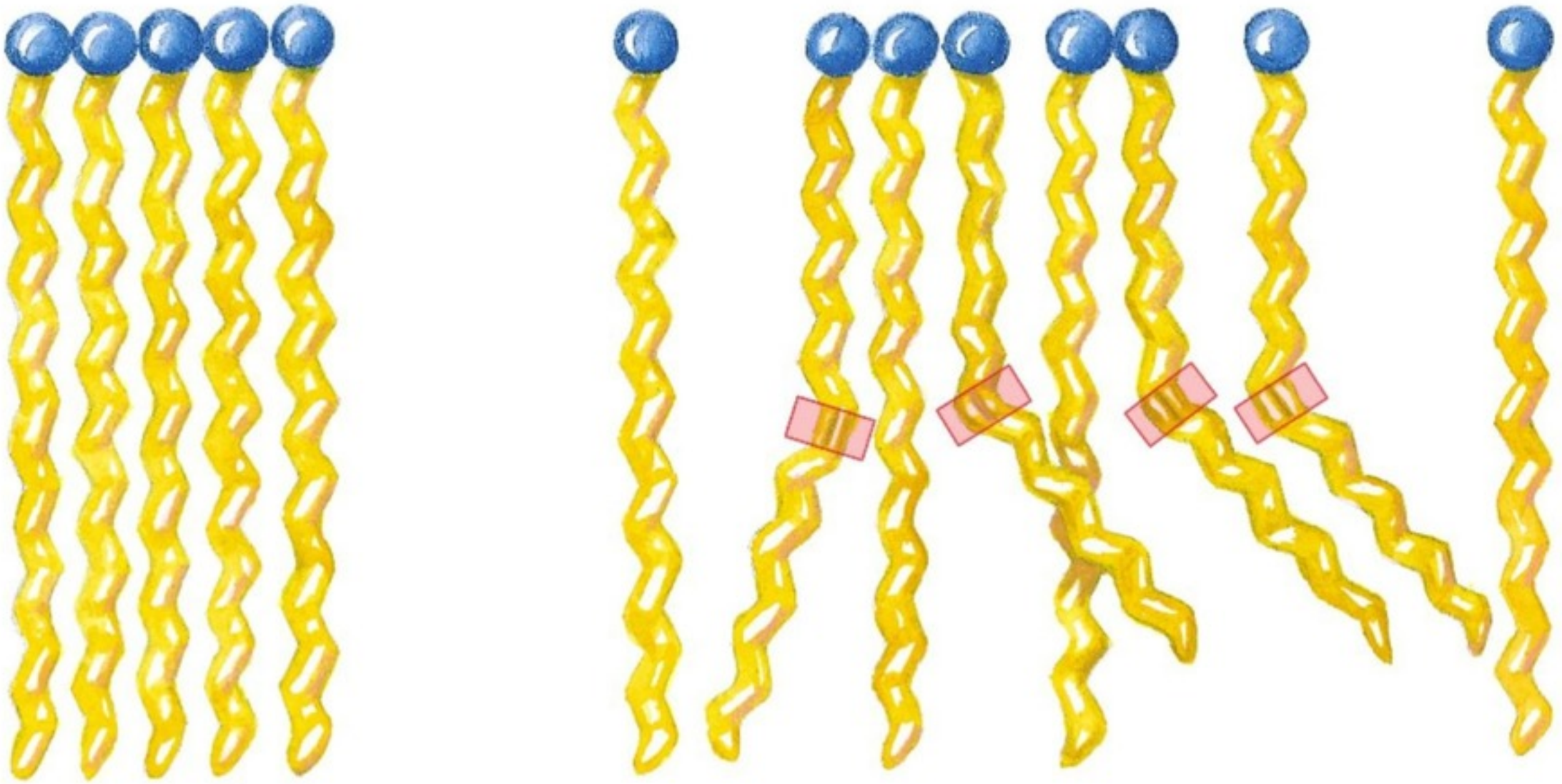
Por quê um ácido graxo de mesmo número de carbonos, em uma dada temperatura, assume um aspecto de cera se for saturado, ou de óleo se for insaturado ?

Open Ended Question

Por que um ácido graxo de mesmo número de carbonos, em uma dada temperatura, assume um aspecto de cera se for saturado, ou de óleo se for insaturado ?

Please enter your answer here.

Relação entre insaturação e grau de empacotamento

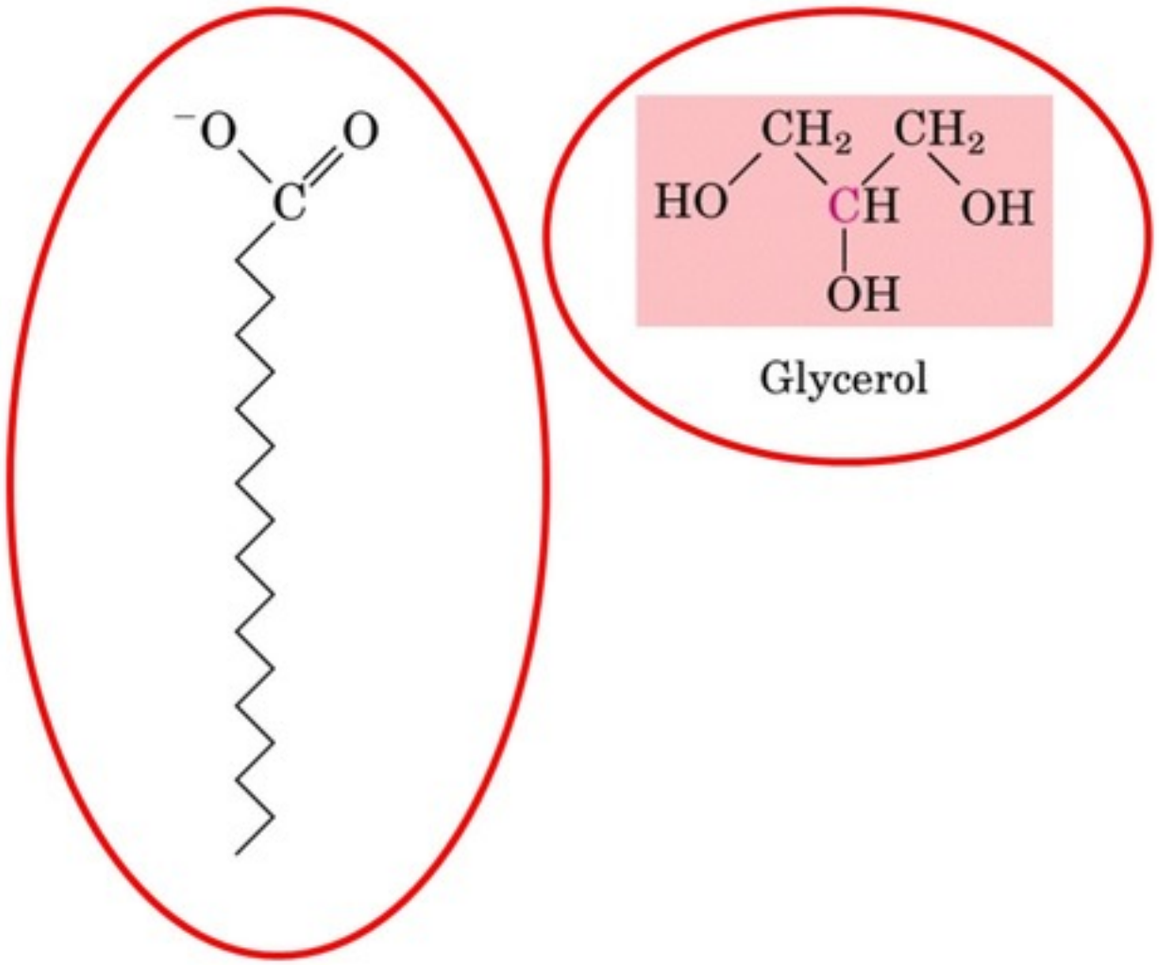


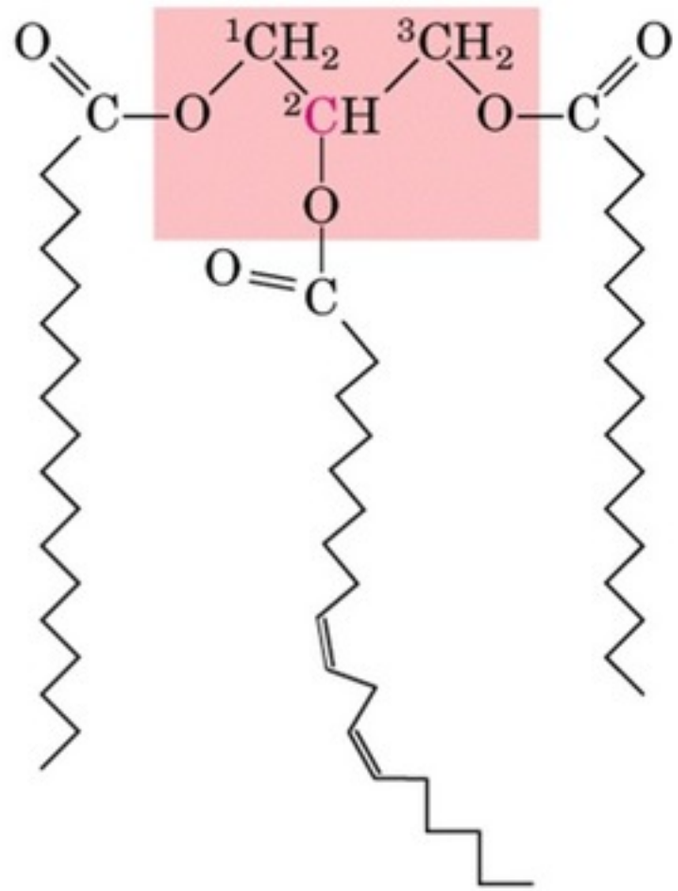
Saturated fatty acids

Mixture of saturated and unsaturated fatty acids

Triacilgliceróis

Também chamados de triglicerídios ou gorduras neutras, os triacilgliceróis podem ser simples ou mistos.





Os triacilgliceróis são reservas altamente concentradas de energia metabólica porque são reduzidos e anidros.

Micrografia eletrônica de uma adipócito

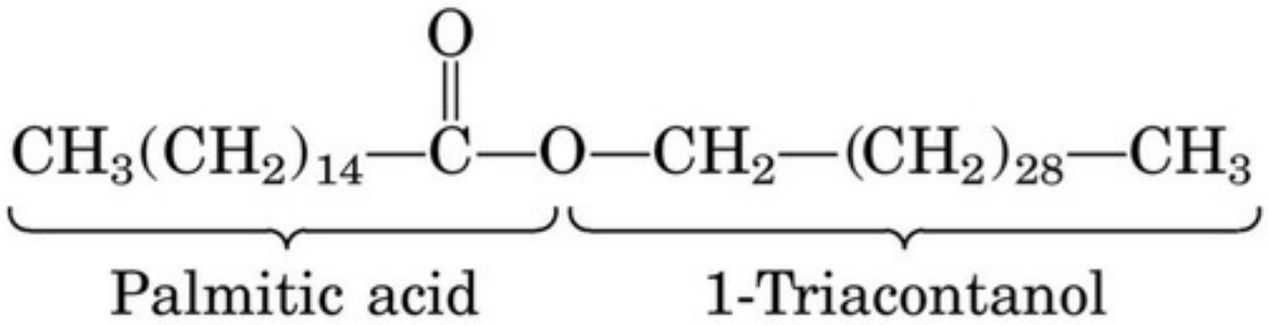
- **As células adiposas são especializadas para síntese e armazenamento de triacilgliceróis.**

- **Os triacilgliceróis são apolares e por isto são armazenados em forma quase anidra (sem água).**

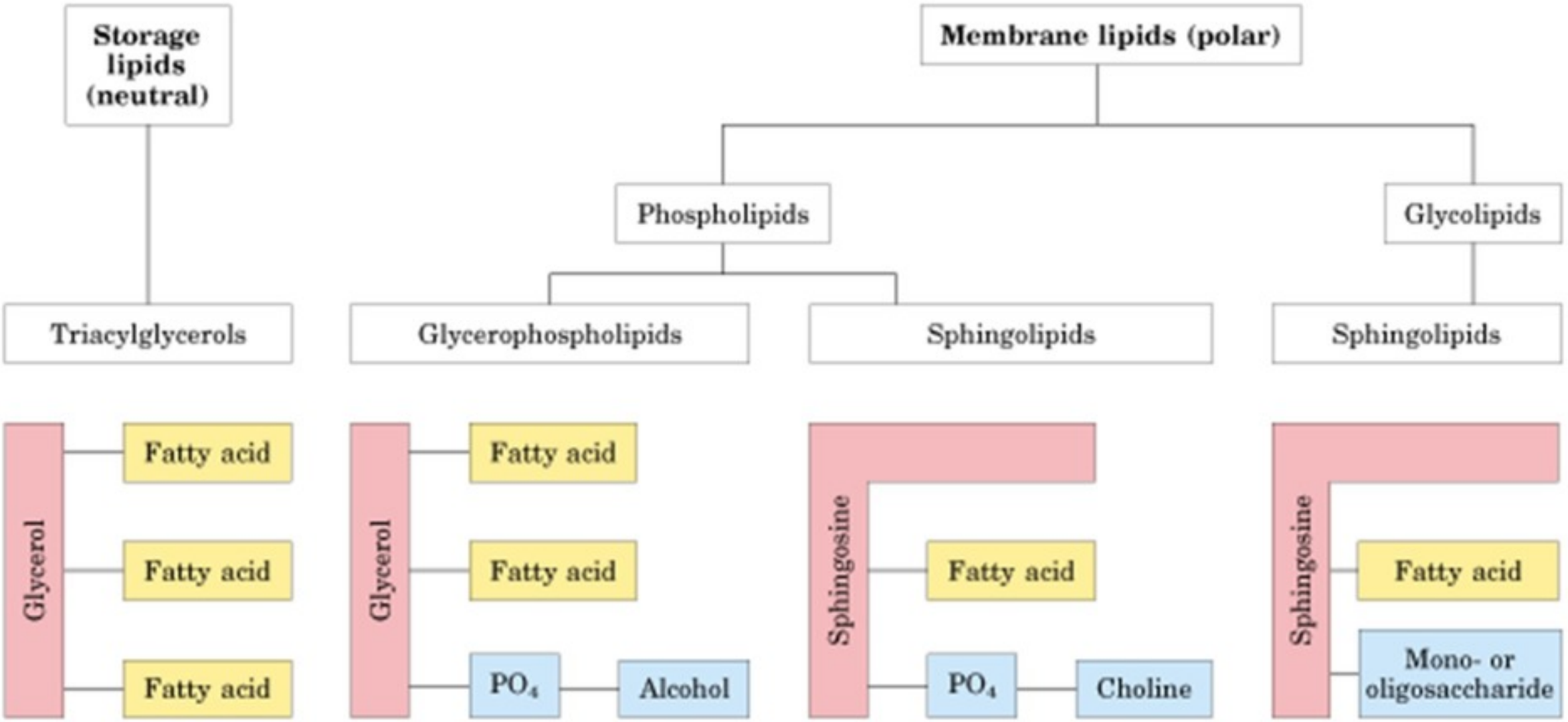
- **As reservas de triacilgliceróis podem sustentar energeticamente as funções biológicas por várias semanas.**

Ceras

São ésteres de ácidos graxos saturados e insaturados de cadeia longa, com álcoois de cadeia longa. Além de armazenar energia, também servem como repelentes de água.



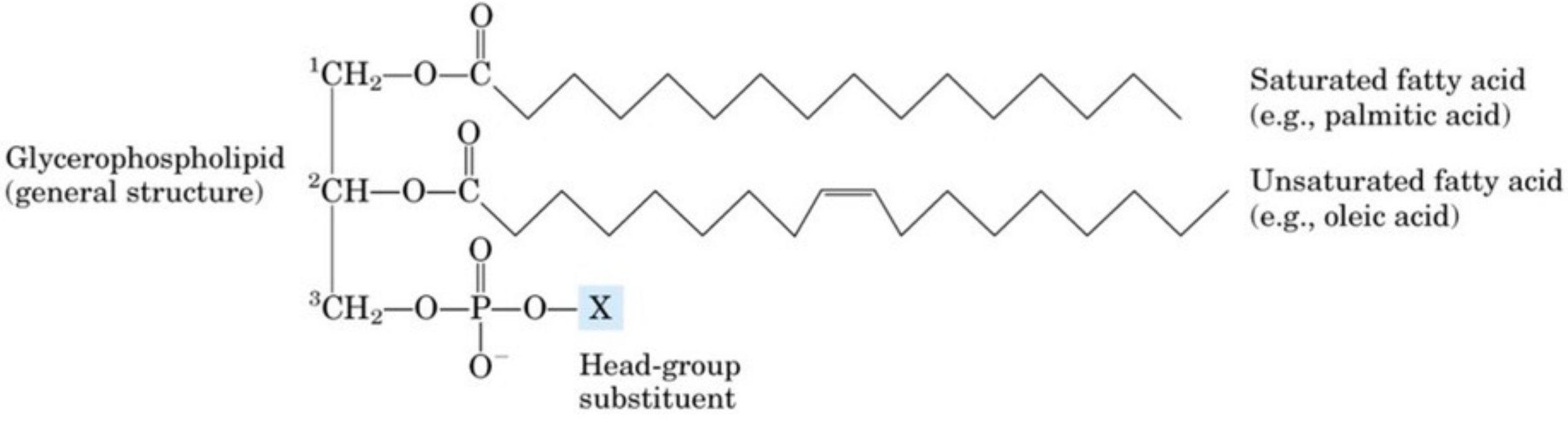
Lipídeos


Storage lipids (neutral)
Membrane lipids (polar)
Phospholipids
Glycolipids
Triacylglycerols
Glycerophospholipids
Sphingolipids
Sphingolipids
Glycerol
Fatty acid
Fatty acid
Fatty acid
Glycerol
Fatty acid
Fatty acid
PO4
Alcohol
Sphingosine
Fatty acid
PO4
Choline
Sphingosine
Fatty acid
Mono- or oligosaccharide

Collaborate!

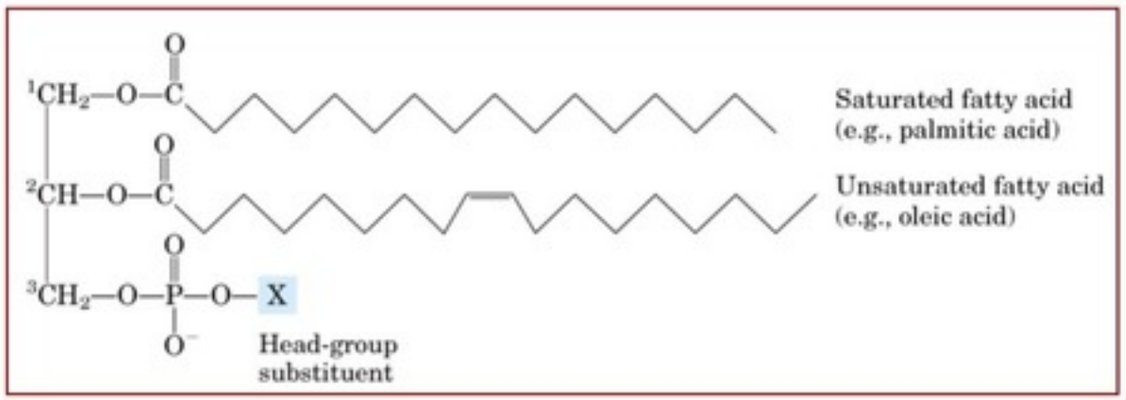
Lipídeos de armazenamento e estruturais

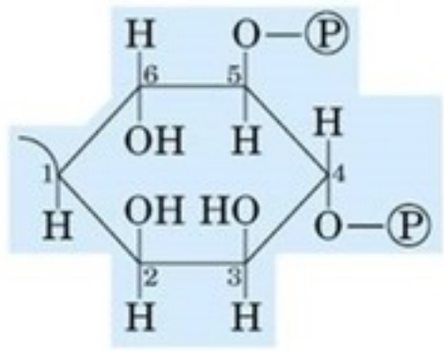
Glicerofosfolipídios



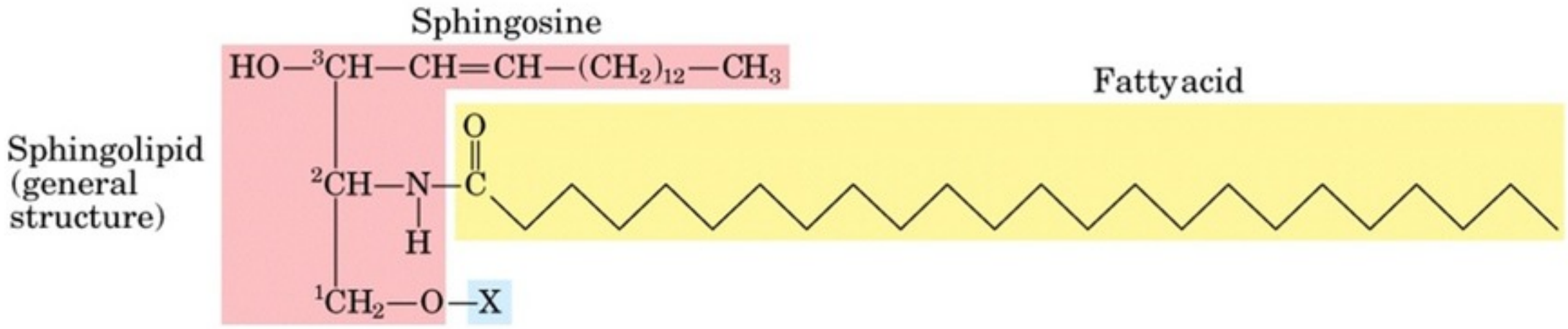
Existe uma enorme variedade de ácidos graxos que podem compor cada um dos glicerofosfolipídios

Glicerofosfolipídios



Name of glycerophospholipid	Name of X	Formula of X
Phosphatidic acid	—	— H
Phosphatidylethanolamine	Ethanolamine	— $CH_2—CH_2—\overset{+}{N}H_3$
Phosphatidylcholine	Choline	— $CH_2—CH_2—\overset{+}{N}(CH_3)_3$
Phosphatidylserine	Serine	— $CH_2—CH(\overset{+}{N}H_3)—COO^-$
Phosphatidylglycerol	Glycerol	— $CH_2—CH(OH)—CH_2—OH$
Phosphatidylinositol 4,5-bisphosphate	*myo*-Inositol 4,5-bisphosphate	

Esfingolipídios



É a segunda maior classe de lipídios de membrana.

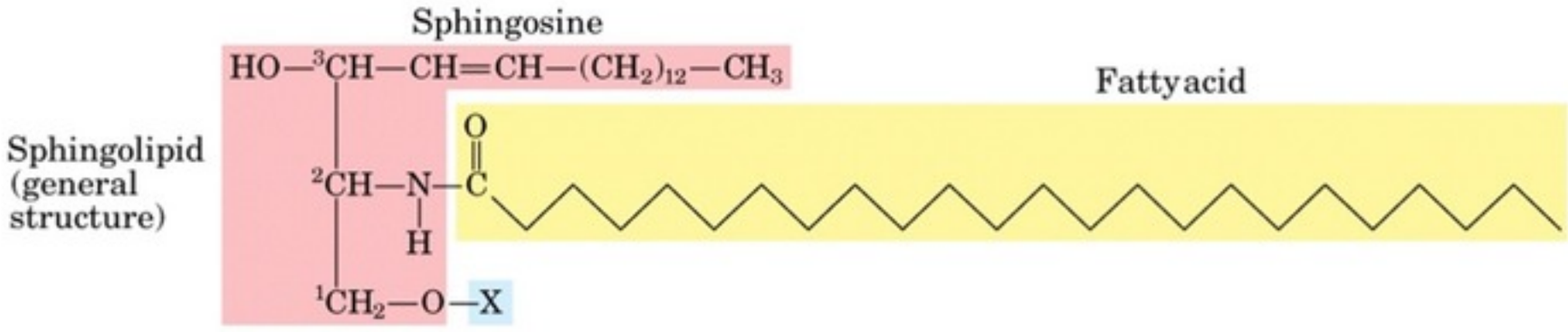
Também possuem um grupo cabeça polar e duas caudas apolares.

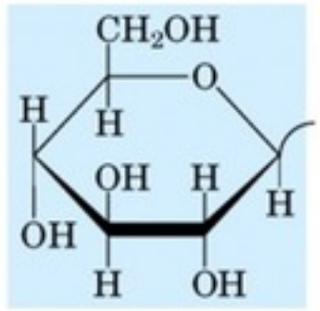
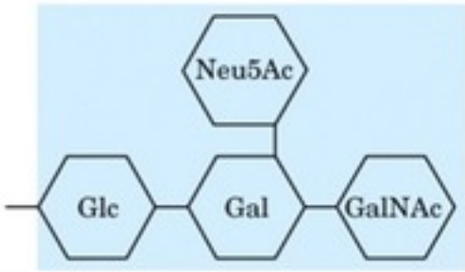
Ao invés do glicerol → um aminoálcool chamado esfingosina.

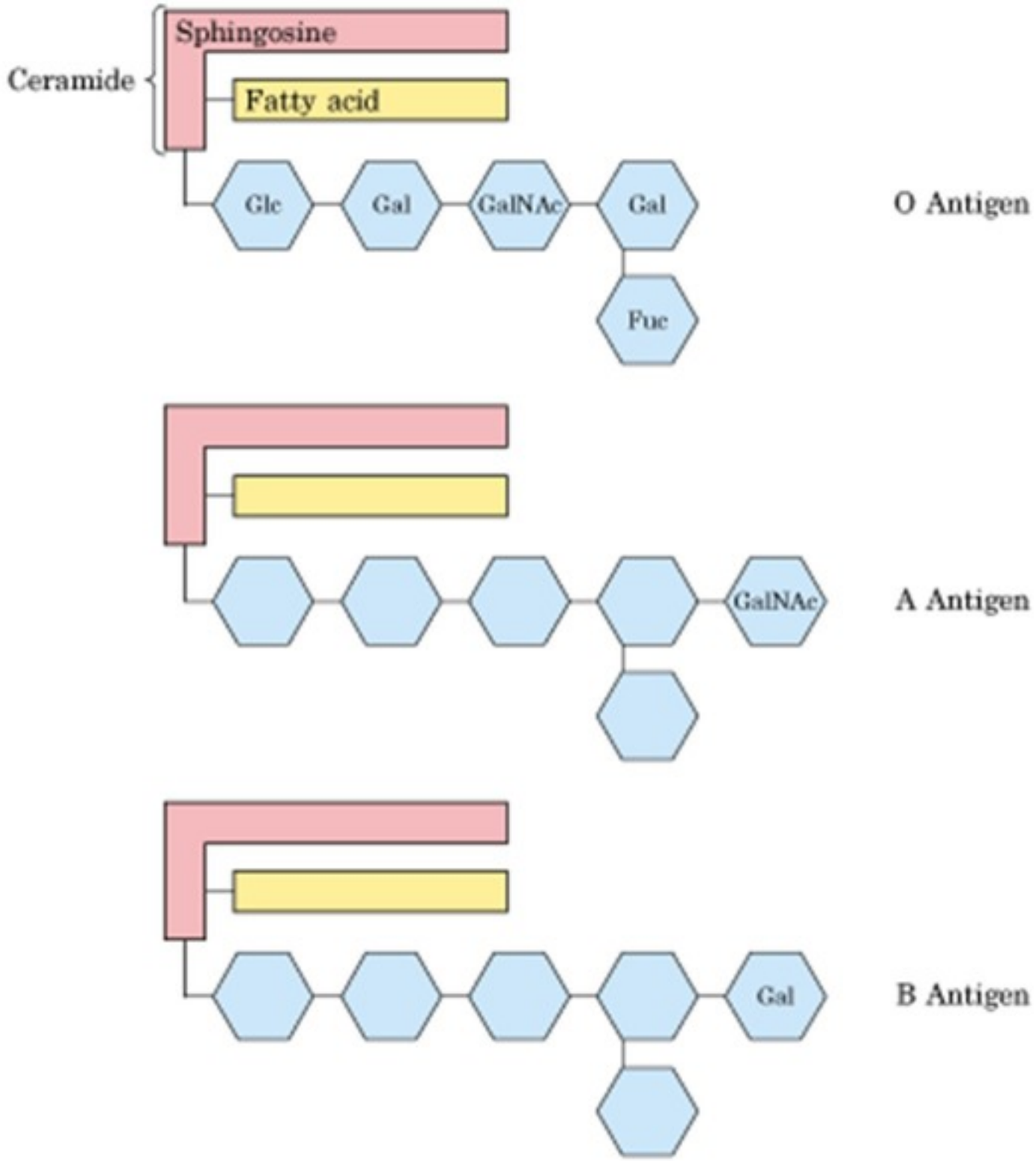
O grupo cabeça polar pode estar ligado através de uma ligação glicosídica ou de uma ligação fosfodiéster.

São importantes sítios de reconhecimento celular.

Esfingolipídios

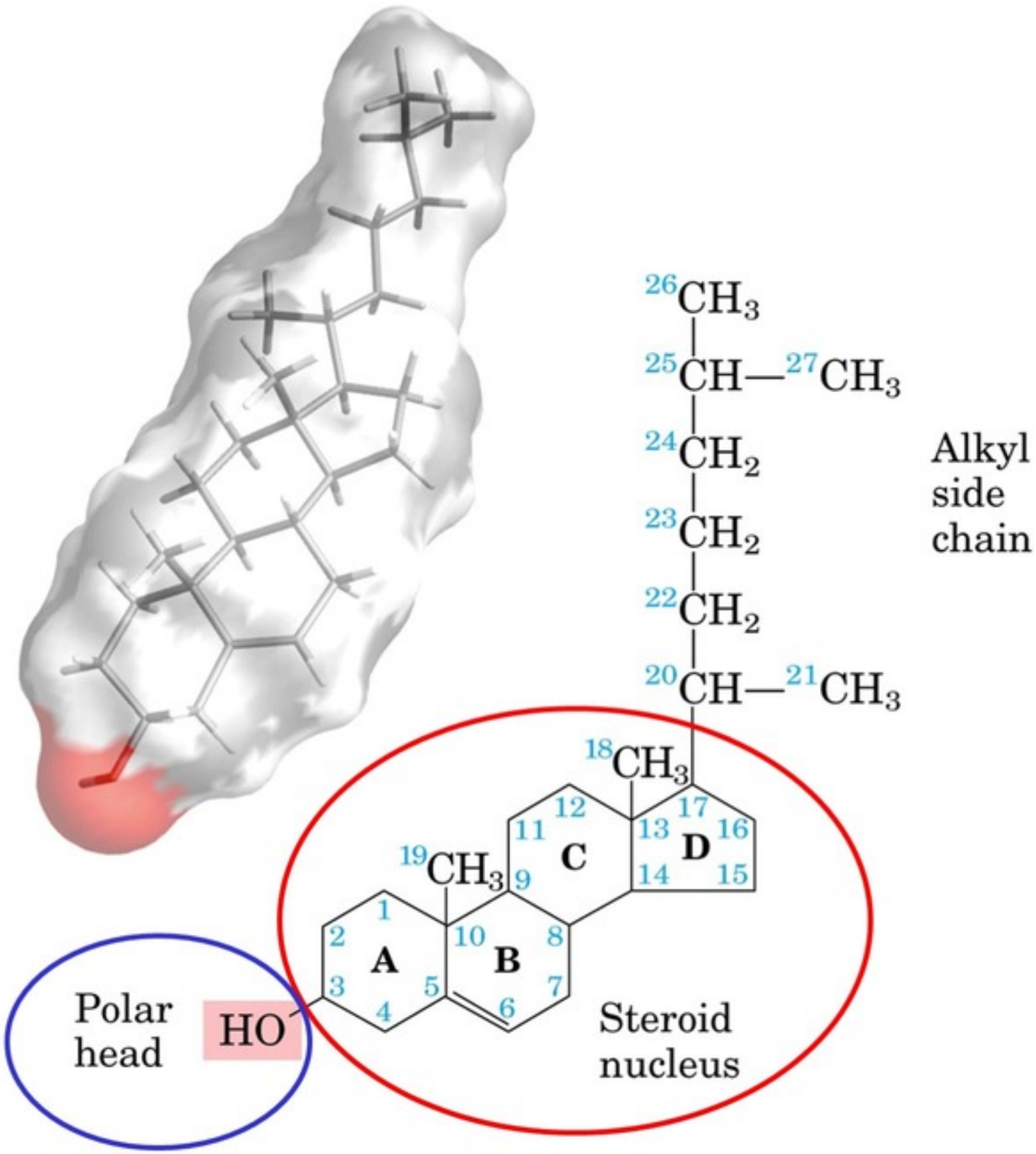


Name of sphingolipid	Name of X	Formula of X
Ceramide	—	—H
Sphingomyelin	Phosphocholine	—P(=O)(O⁻)—O—CH₂—CH₂—N⁺(CH₃)₃
Neutral glycolipids Glucosylcerebroside	Glucose	
Lactosylceramide (a globoside)	Di-, tri-, or tetrasaccharide	
Ganglioside GM2	Complex oligosaccharide	

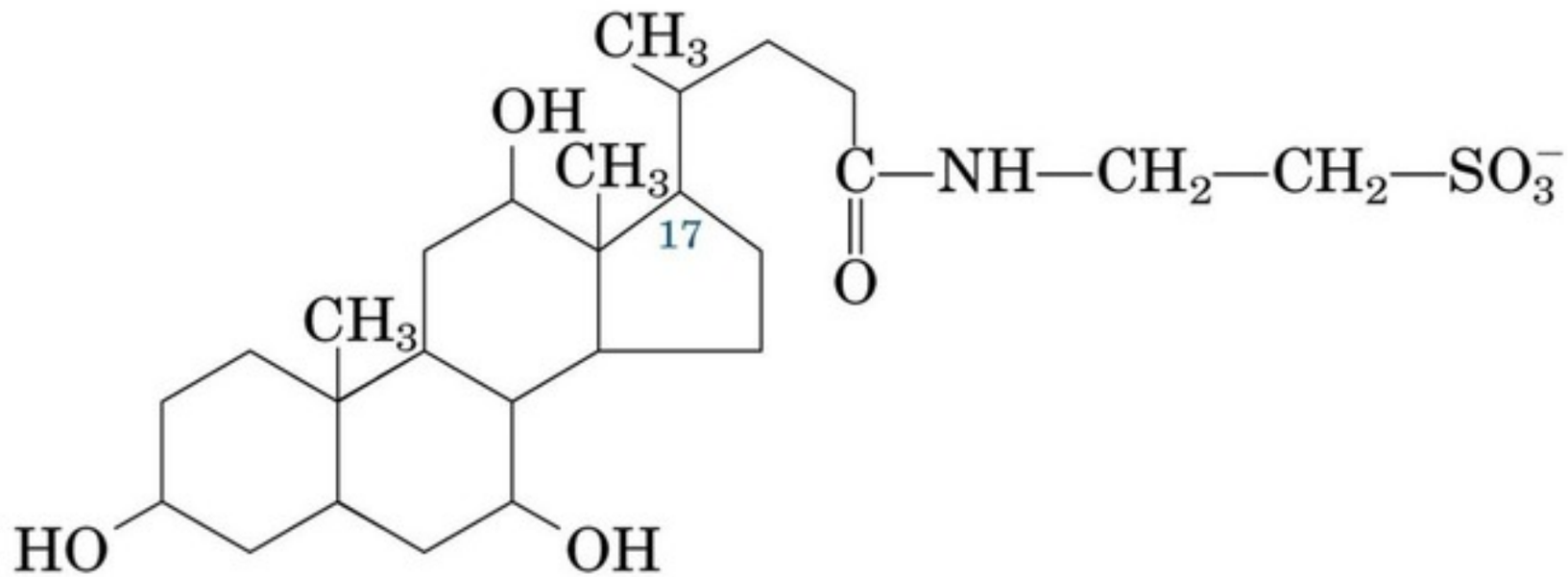


Glicoesfingolipideos : grupo sanguineo

Esteróis

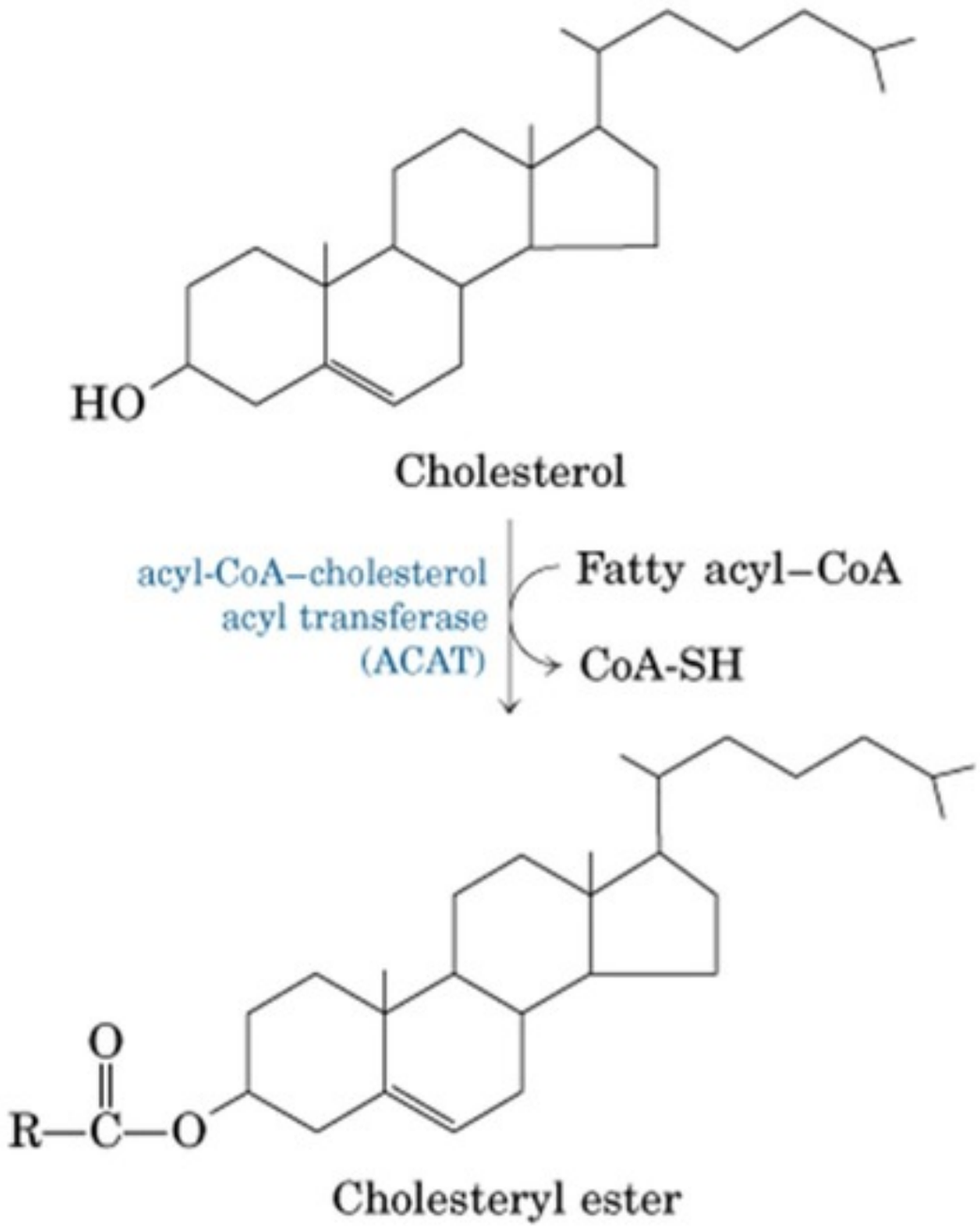

26CH3
25CH—27CH3
24CH2
23CH2
22CH2
20CH—21CH3
Alkyl side chain
18CH3
19CH3
A
B
C
D
Polar head
HO
Steroid nucleus

O colesterol também é precursor dos ácidos biliares, que emulsificam as gorduras para facilitar ação das lipases.



Taurocholic acid
(a bile acid)

Destino do Colesterol



Destino do Colesterol

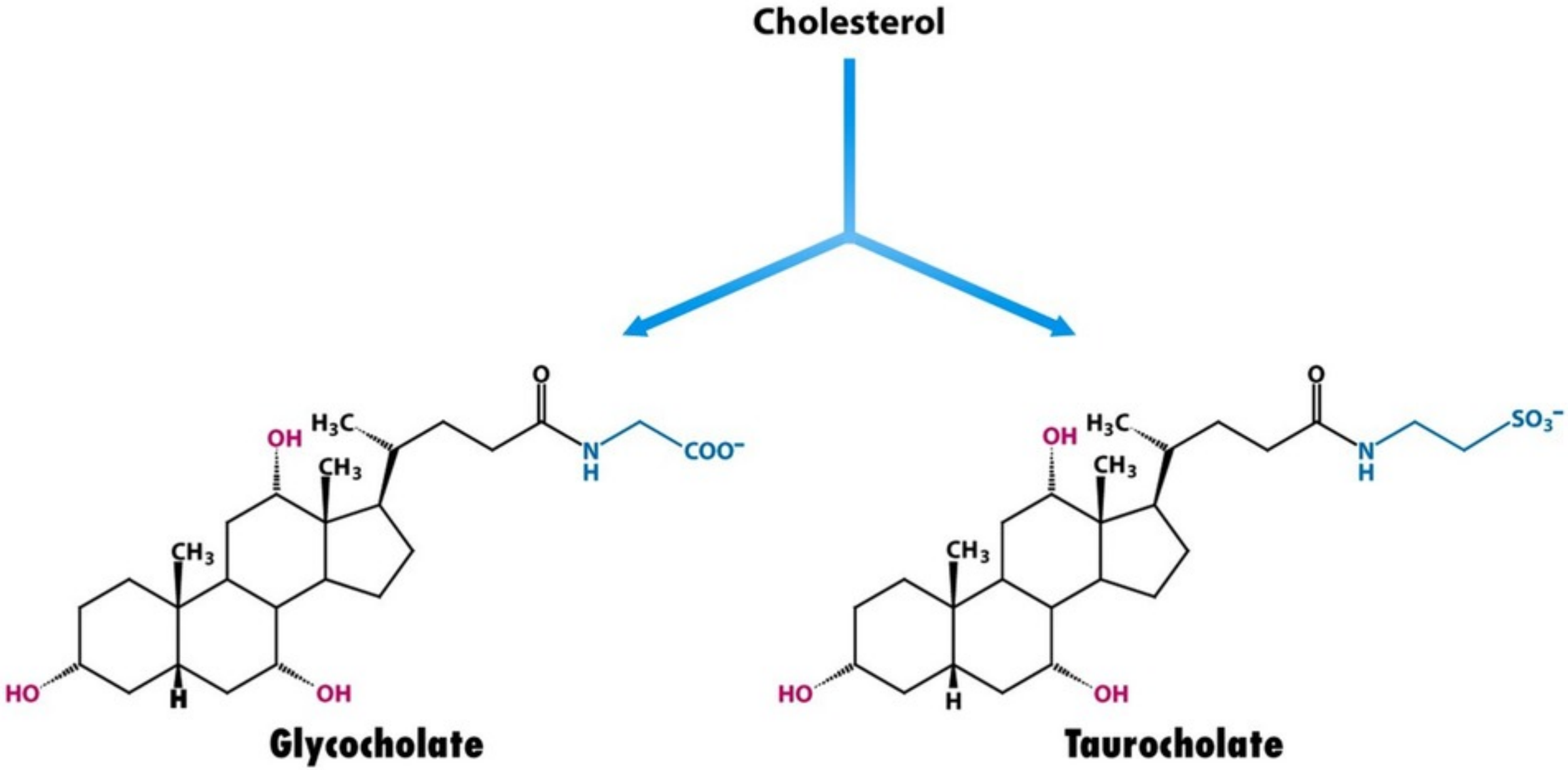
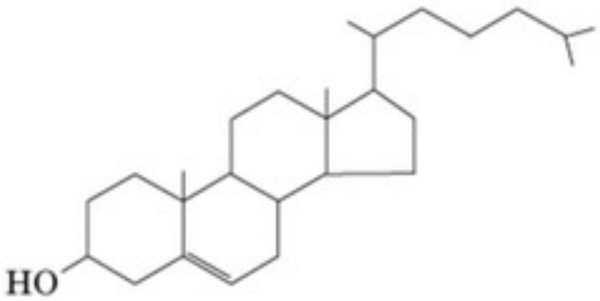


Figure 26-22
Biochemistry, Sixth Edition

Sais biliares
Aumento da excreção de colesterol para bile = cálculos biliares
Emulsificação e solubilização lipídeos

Destino do Colesterol

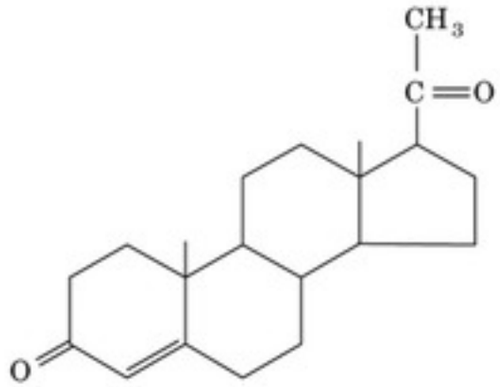


Cholesterol

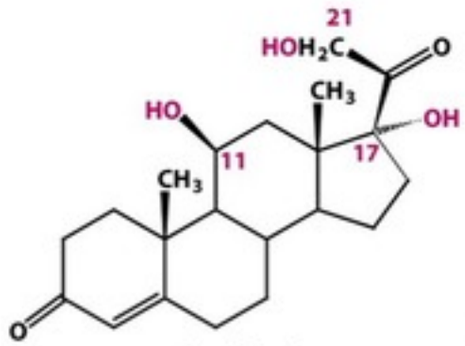
Cholesterol

Pregnenolone

Progesterone



Progestero



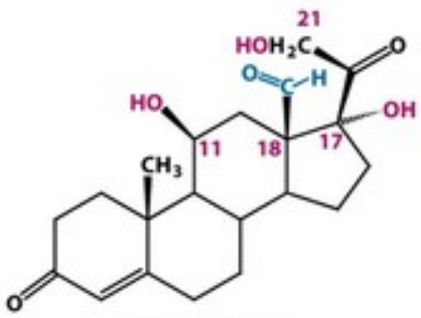
Cortisol

Cortisol (glucocorticoid)

Affects protein and carbohydrate metabolism; suppresses immune response, inflammation, and allergic responses.

Corticosterone (mineralocorticoid)

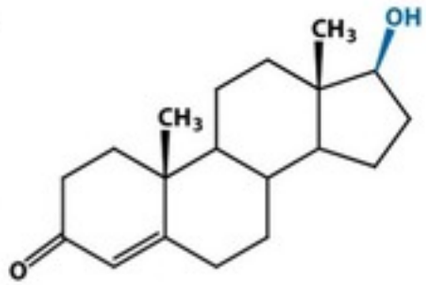
Aldosterone (mineralocorticoid)



Aldosterone

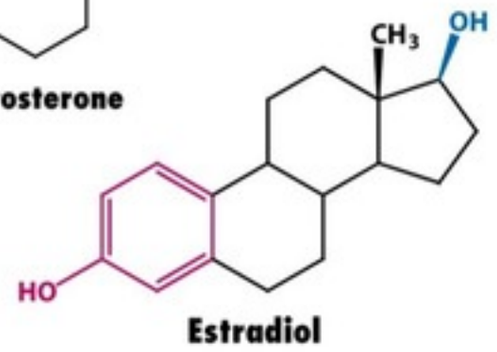
Regulate reabsorption of Na^+, Cl^-, HCO_3^- in the kidney.

Testosterone



Testosterone

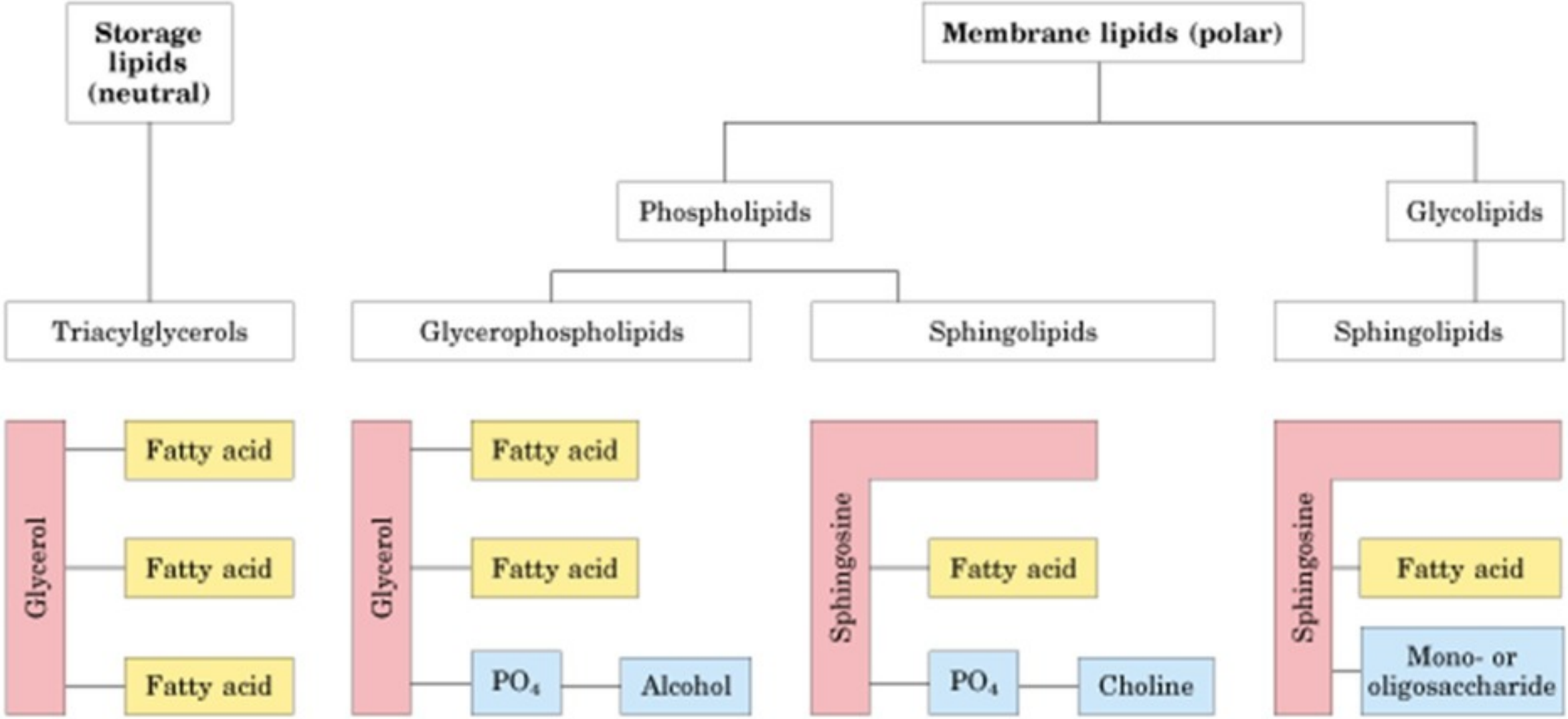
Estradiol



Estradiol

Male and female sex hormones. Influence secondary sexual characteristics; regulate female reproductive cycle.

Lipídeos:
Sinalizadores, cofatores e pigmentos



80% massa de um adipócito (sem contar água)

5-10% massa da célula (sem contar água)

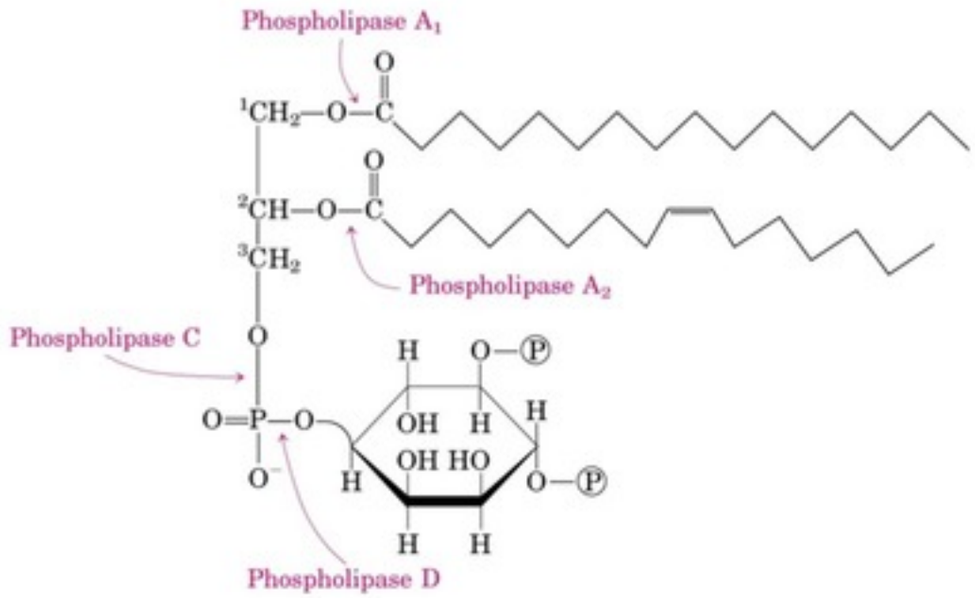
Fosfatitilinositóis

Phosphatidylinositol

phosphorylation in plasma membrane — 2ATP → 2ADP

Phosphatidylinositol 4,5-bisphosphate

hormone-sensitive phospholipase C in plasma membrane — H_2O



Inositol 1,4,5-trisphosphate → Release of intracellular Ca^{2+} → Regulation of other enzymes (by Ca^{2+})

Diacylglycerol → Activation of protein kinase C → ?

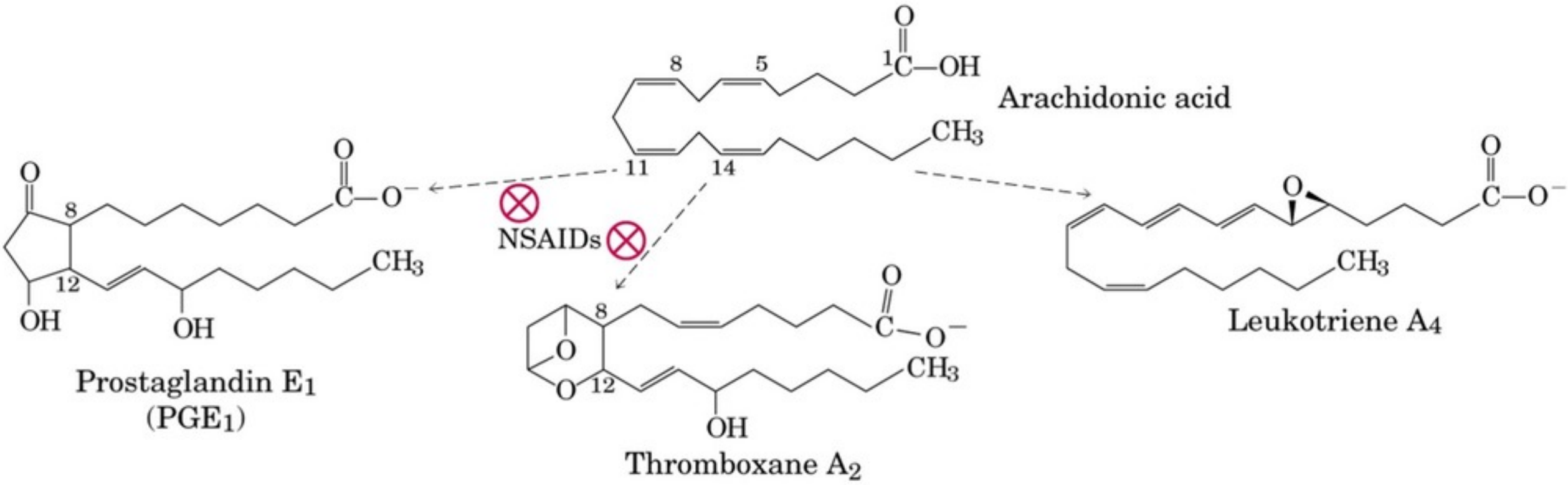
Activation of protein kinase C → Regulation of other enzymes (by protein phosphorylation)

Eicosanóides

São derivados de ácidos graxos que agem como hormônios parácrinos. Envolvidos em inflamação, dor, funções reprodutivas, etc.

Derivados do ácido graxo de 20 carbonos, ácido aracdônico.

$20:4(\Delta^{5,8,11,14})$



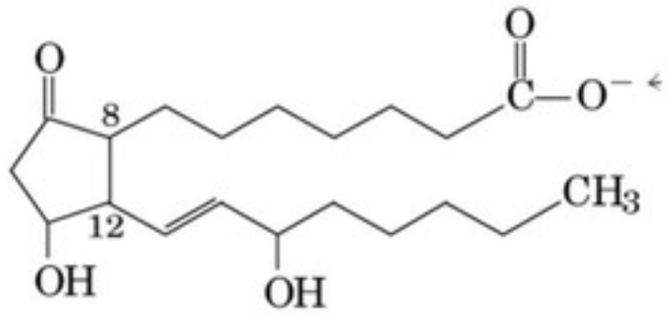
Eicosanoids

Eicosanóides

Podem ser divididos em:

- prostaglandinas

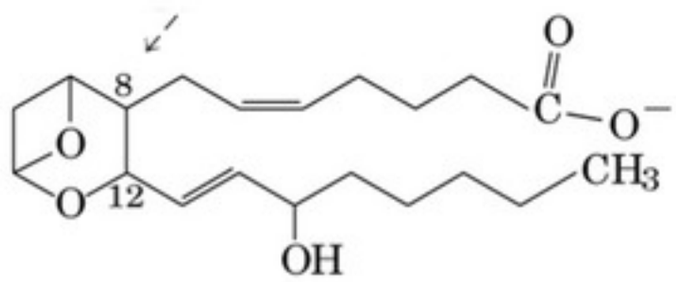
Ex. Ação em vários tecidos, regulando a síntese de cAMP. Contração uterina, dor, inflamação.



Prostaglandin E_1
(PGE_1)

- tromboxanos

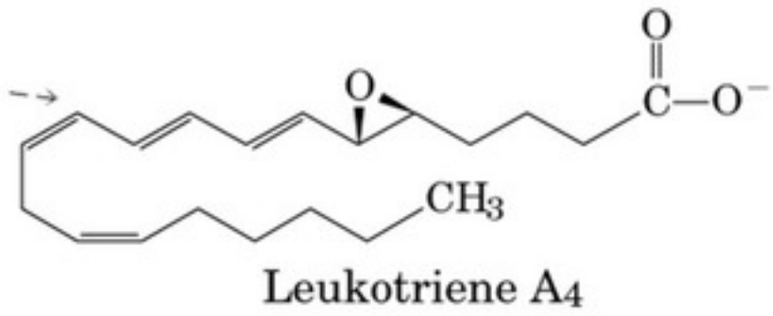
Ação na formação de coágulos, redução do fluxo sangüíneo.



Thromboxane A_2

- leucotrienos

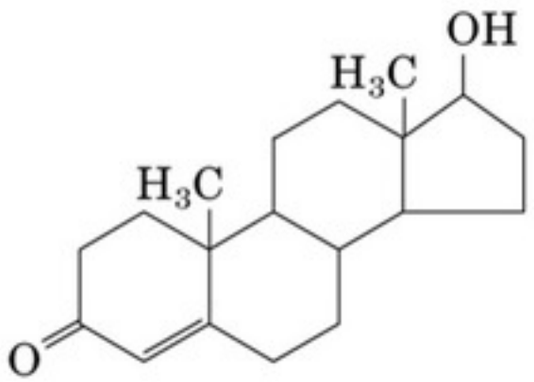
Ex. Contração de músculos relacionados a vias aéreas/pulmão



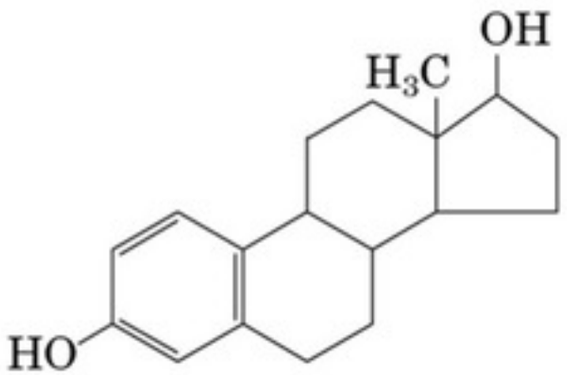
Leukotriene A_4

prednisona

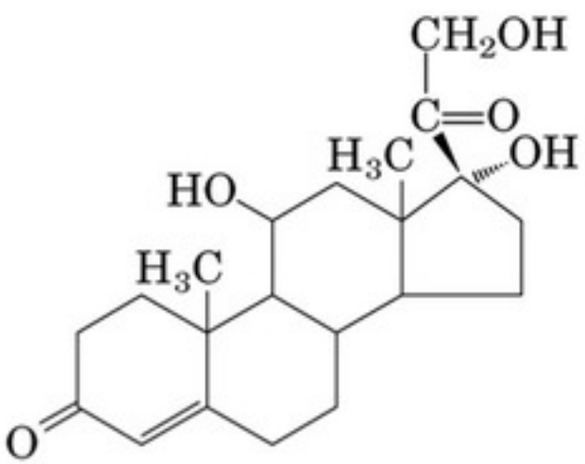
Hormônios esteróides



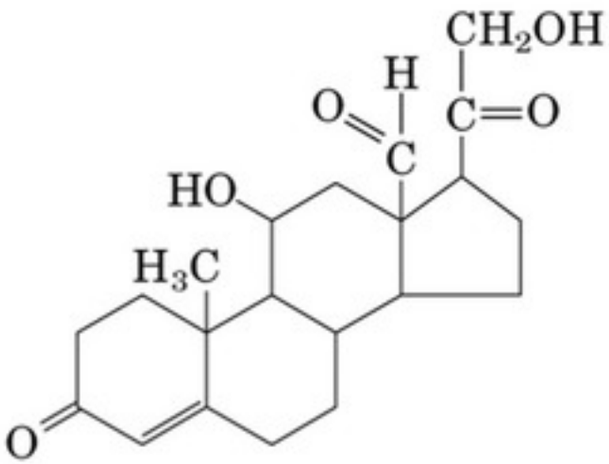
Testosterone



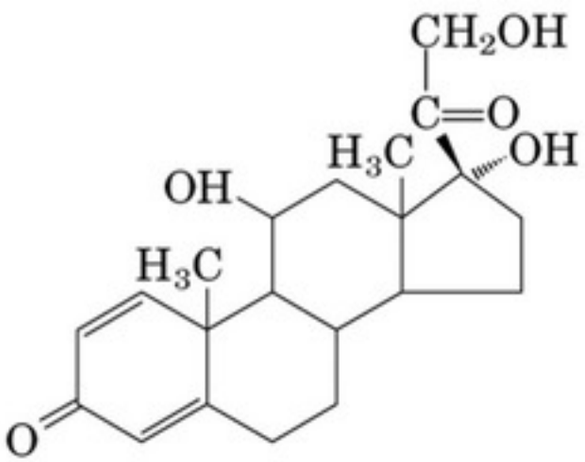
Estradiol



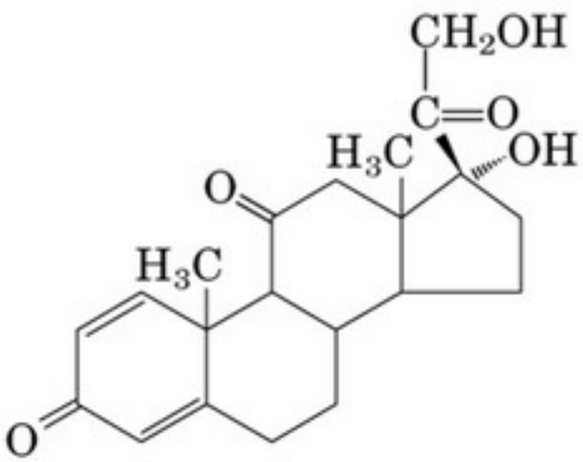
Cortisol



Aldosterone



Prednisolone



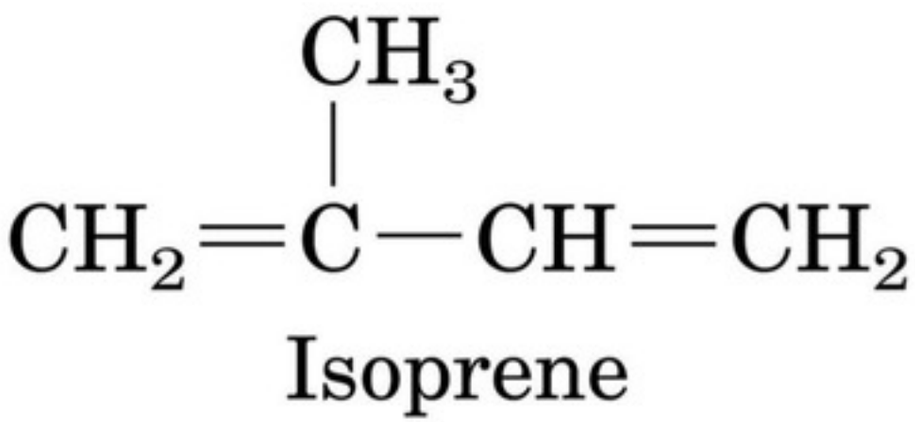
Prednisone

Vitaminas

As vitaminas foram divididas inicialmente entre solúveis e insolúveis.

Insolúveis: A, D, E e K.

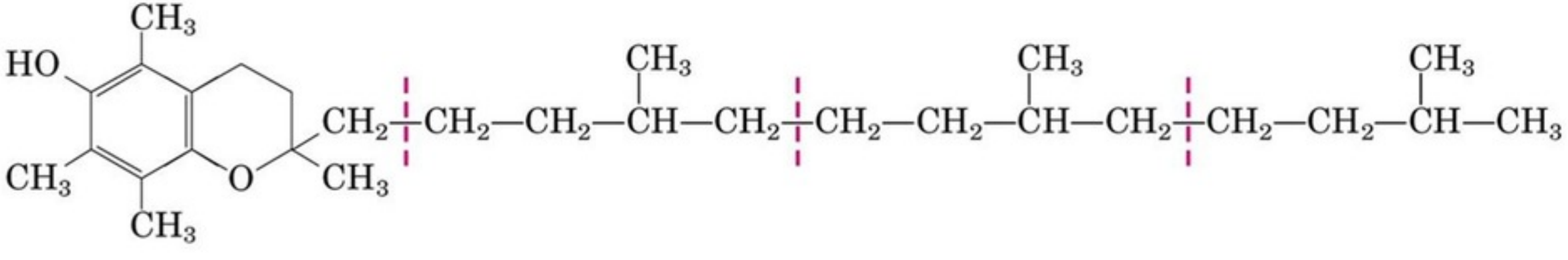
Todas são compostos isoprenóides, ou seja, derivadas do composto isopreno.



Isoprene

Exemplo: Vitamina E

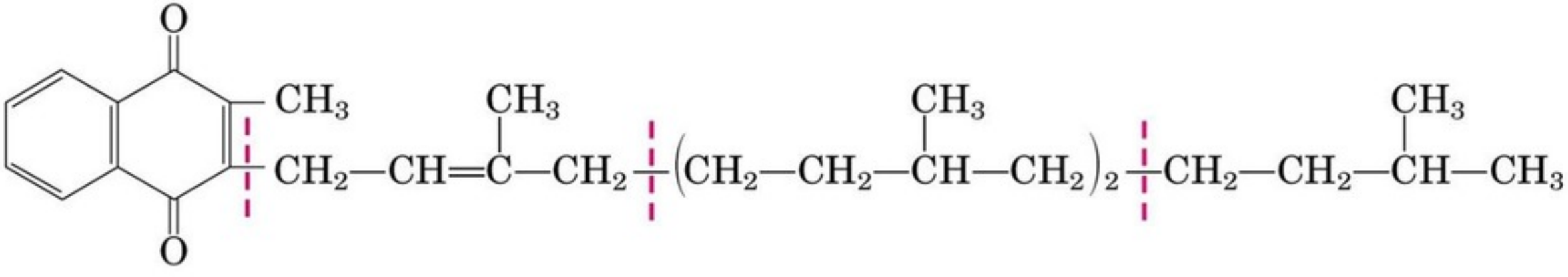
Grupo de lipídios chamados tocoferóis, possuem uma cadeia lateral isoprenóide e possuem ação antioxidante.



Hidrofóbicos: associam com a membrana celular, depósitos de lipideos e lipoproteínas no sangue

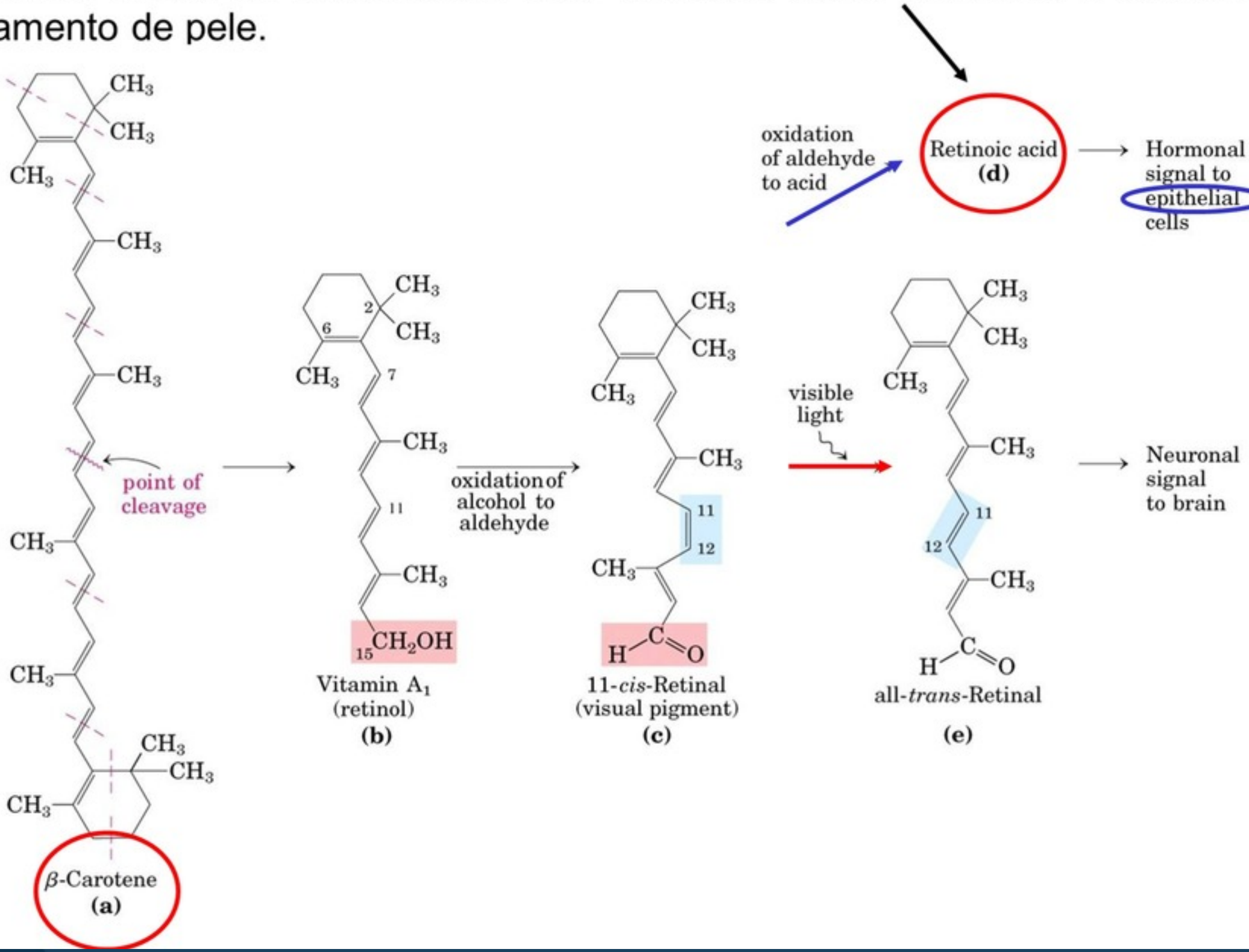
Exemplo: Vitamina K

Participa das reações de formação de pró-trombina, e logo participa do processo de coagulação.



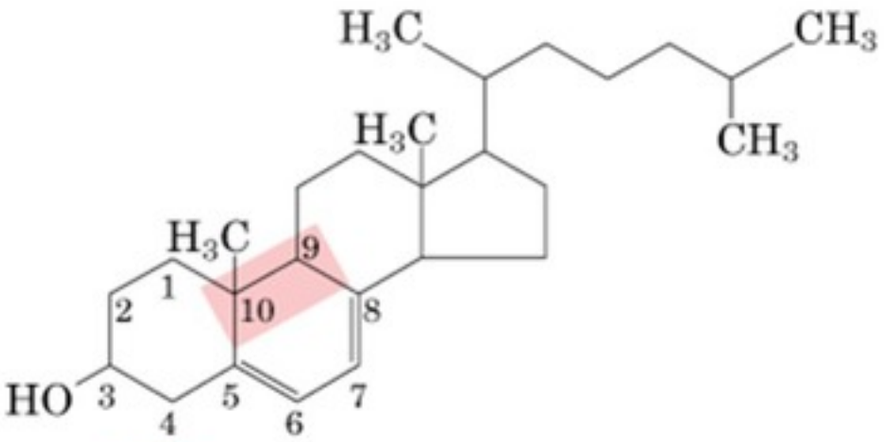
Exemplo: Vitamina A

Também chamado de retinol, possui atividade como hormônio e como o pigmento visual de vertebrados. Seu derivado, ácido retinóico, é utilizado no tratamento de pele.



Exemplo: Vitamina D_3

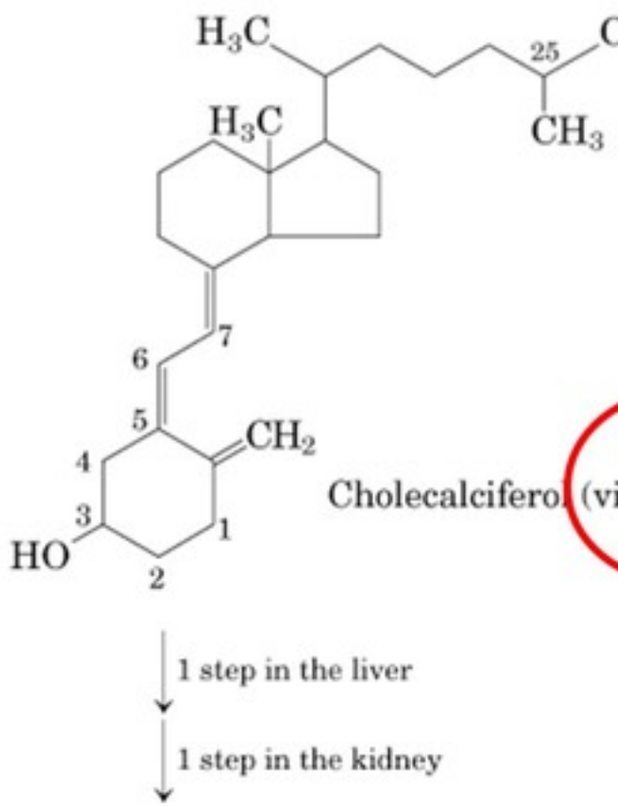
Também chamada de colecalciferol, ela participa da regulação de absorção de cálcio.



7-Dehydrocholesterol

UV light

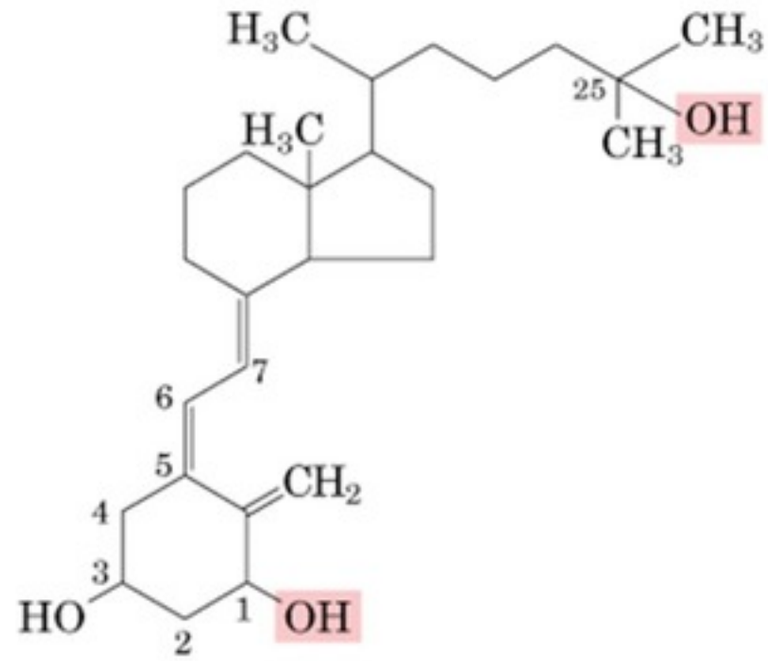
2 steps (in skin)



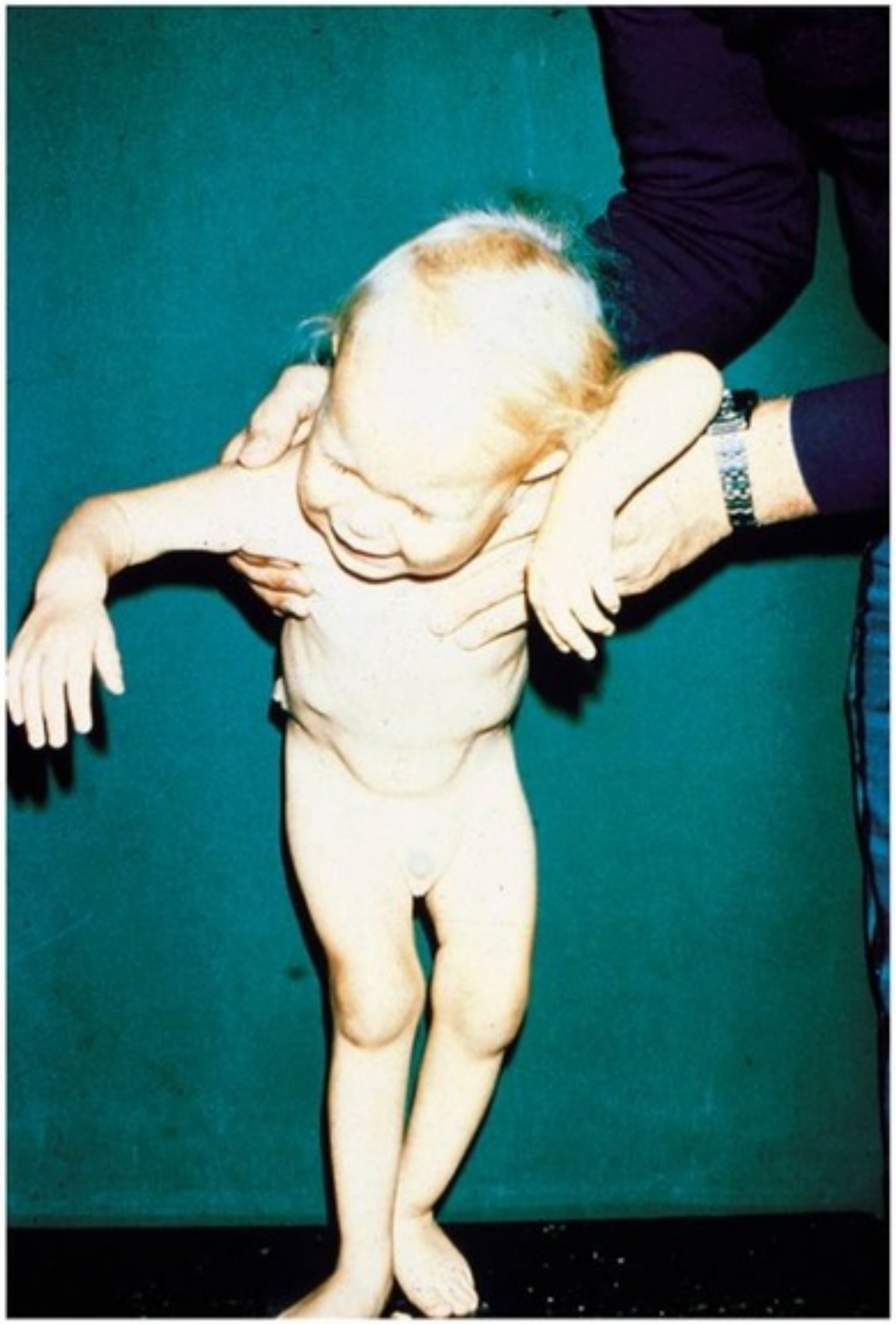
Cholecalciferol (vitamin D_3)

1 step in the liver

1 step in the kidney



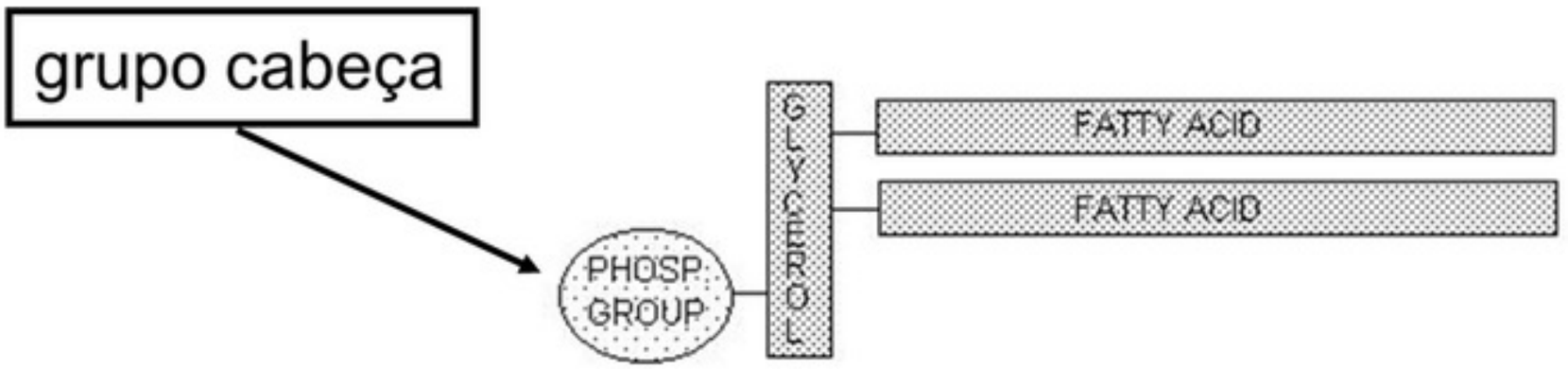
1,25-Dihydroxycholecalciferol
(1,25-dihydroxyvitamin D_3)

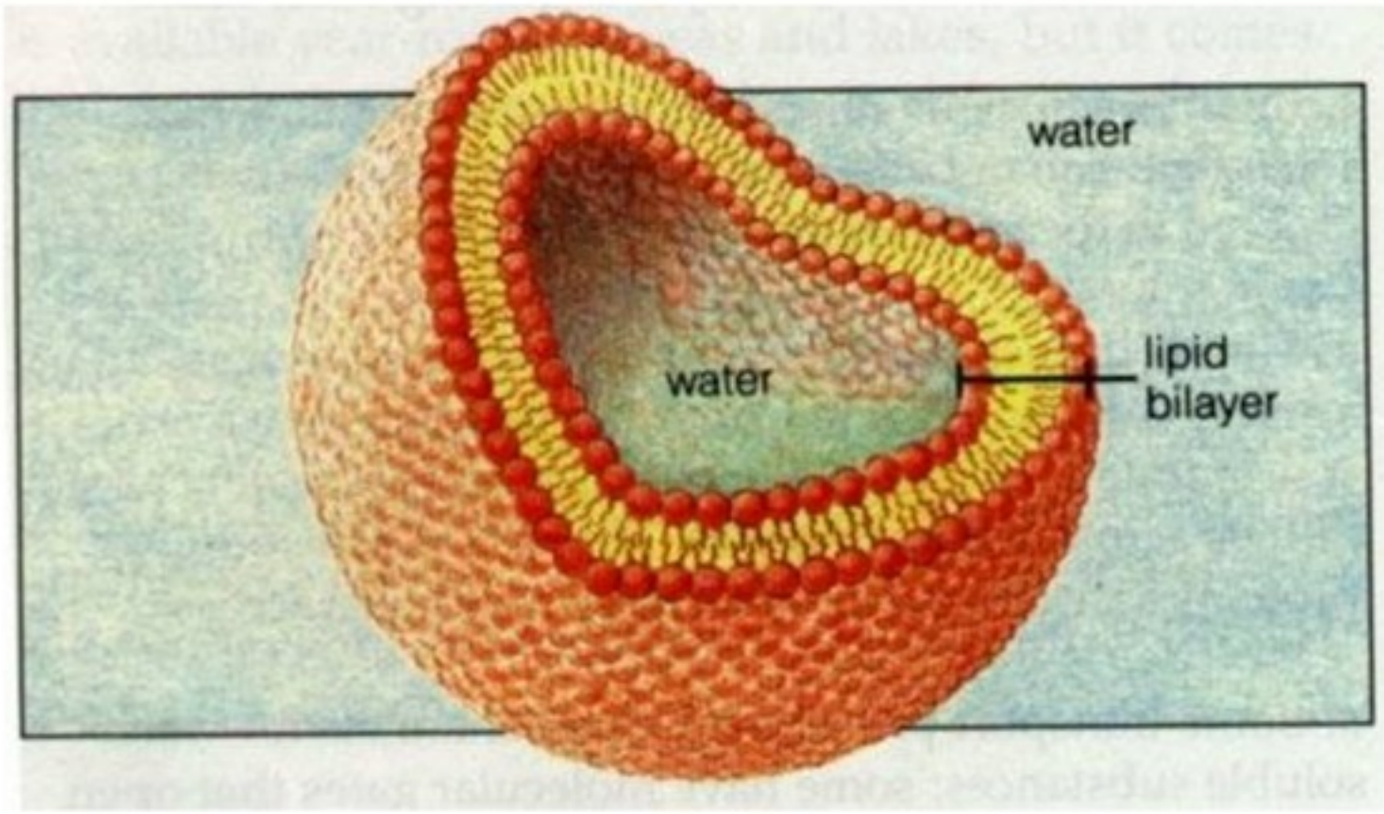


Before vitamin D treatment

After 14 months of vitamin D treatment

Organização membranar





A composição da membrana vai depender da função da célula ou da organela em questão.