

CDL CHIMICA



Corso di Biochimica
(6 CFU) 48 ore

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Ricevimento studenti: **si riceve per appuntamento**

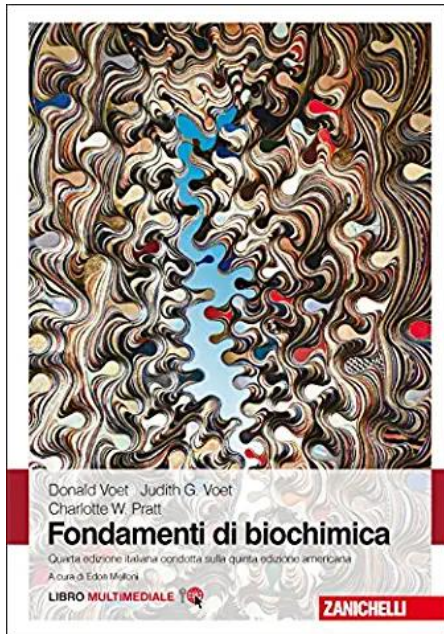
olianas@unica.it



Nelson, Cox.
**I Principi di Biochimica di
Lehninger.** Zanichelli



Berg, Tymoczko,
Stryer.



Voet, Voet, Pratt.
**Fondamenti di
Biochimica.**
Zanichelli



Campbell, Farrell,
Biochimica.
Edizione

LIPIDI

FUNZIONI BIOLOGICHE:

- 1) **Riserve energetiche** (trigliceridi), dalla loro ossidazione viene liberata un'elevata quantità di energia.
- 2) **Strutturale**: Costituzione delle membrane biologiche (glicerofosfolipidi, sfingolipidi).
- 3) Rivestimento e protezione delle superfici, isolamento termico (cere).
- 4) **Funzioni altamente specializzate**, di tipo ormonale, riconoscimento cellulare.

Sono molecole insolubili in soluzione acquosa.

Possono essere totalmente idrofobici oppure anfifilici.

Costituenti basilari dei lipidi sono gli ACIDI GRASSI

Carbon skeleton	Structure*	Systematic name†	Common name (derivation)
12:0	$\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$	ACIDO LAURICO	Lauric acid (Latin <i>laurus</i> , "laurel plant")
14:0	$\text{CH}_3(\text{CH}_2)_{12}\text{COOH}$	ACIDO MIRISTICO	Myristic acid (Latin <i>Myristica</i> , nutmeg genus)
16:0	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$	ACIDO PALMITICO	Palmitic acid (Latin <i>palma</i> , "palm tree")
18:0	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$	ACIDO STEARICO	Stearic acid (Greek <i>stear</i> , "hard fat")
20:0	$\text{CH}_3(\text{CH}_2)_{18}\text{COOH}$	<i>n</i> -Eicosanoic acid	Arachidic acid (Latin <i>Arachis</i> ,

Costituenti basilari dei lipidi sono gli ACIDI GRASSI

16:1(Δ^9)	$\text{CH}_3(\text{CH}_2)_5\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	ACIDO PALMITOLEICO
18:1(Δ^9)	$\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	ACIDO OLEICO
18:2($\Delta^{9,12}$)	$\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	ACIDO LINOLEICO
18:3($\Delta^{9,12,15}$)	$\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	ACIDO LINOLENICO
20:4($\Delta^{5,8,11,14}$)	$\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	ACIDO ARACHIDONICO

Acidi grassi: Composti da una coda idrocarburica e un gruppo CARBOSSILICO (-COOH in posizione 1)

I più comuni possiedono da 12 a 20 atomi di carbonio

Possono essere:

Saturi,

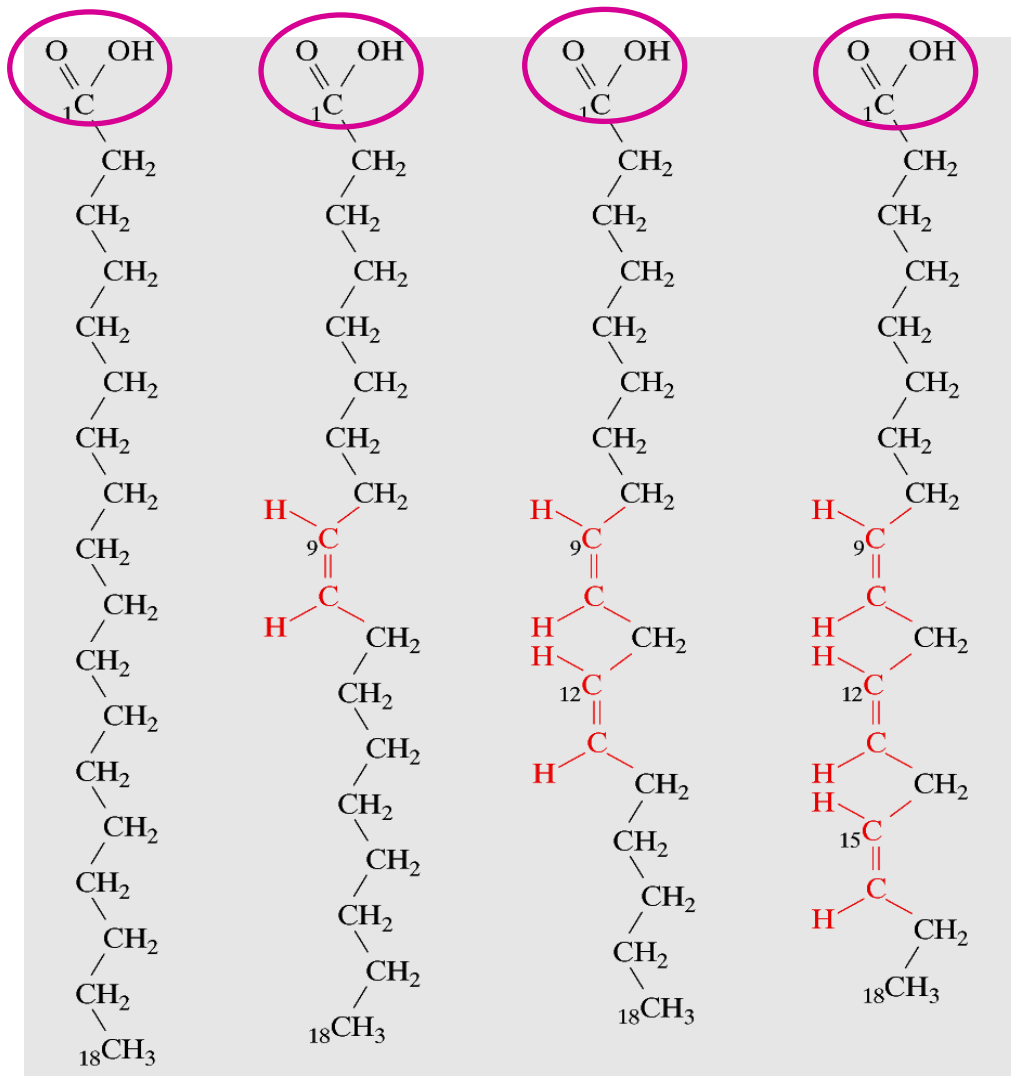
Monoinsaturi

Poliinsaturi

Se è presente 1 doppio legame è solitamente in posizione 9-10, i successivi in posizione 12-13, e 15-16, **non sono coniugati**).

In genere il doppio legame è in conformazione **CIS** e viene indicato nella nomenclatura con il simbolo Δ^n

n = posizione del doppio legame



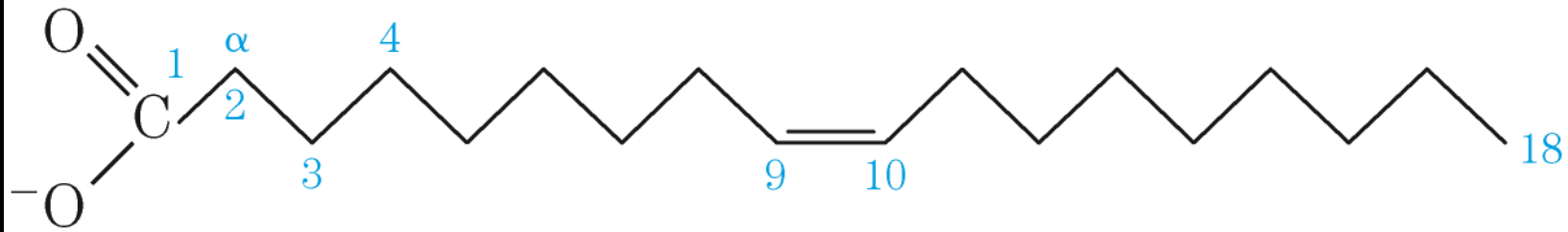
Ac. Stearico
Ac. ottadecanoico
Ac. *cis*- Δ^9 -ottadecanoico

Ac. Oleico
Ac. *cis*- $\Delta^{9,12}$ -ottadecanoico

Ac. Linoleico
Ac. *cis*- $\Delta^{9,12,15}$ -ottadecanoico

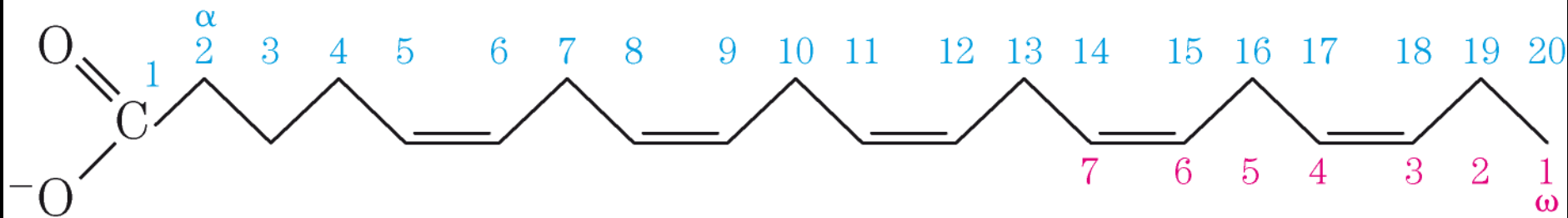
Ac. linolenico

Due convenzioni per la nomenclatura degli Acidi grassi naturali

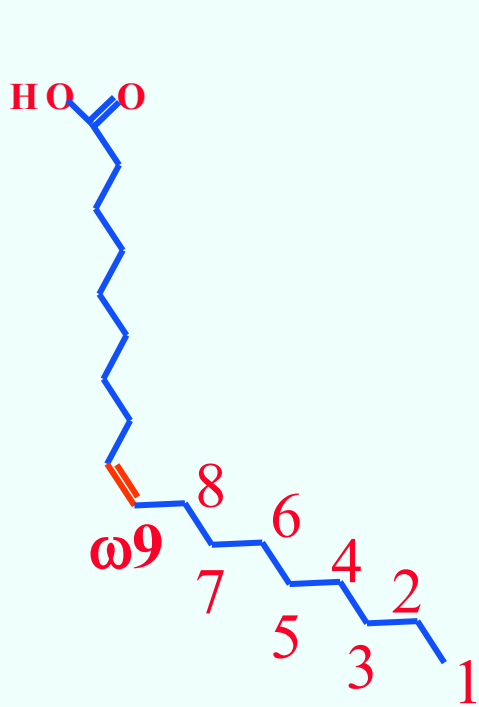


(a) 18:1(Δ^9) Acido *cis*-9-ottadecanoico

Acido oleico

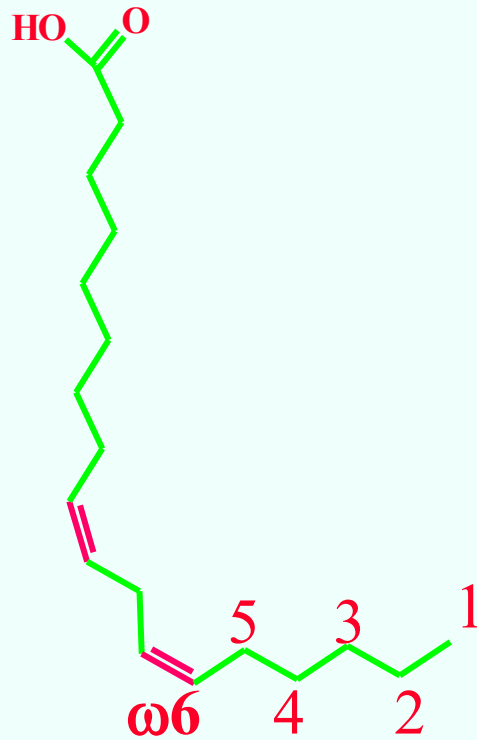


(b) 20:5($\Delta^{5,8,11,14,17}$) Acido eicosapentaenoico (EPA),
un acido grasso omega-3



Acido Oleico
(18:1 Δ^9)

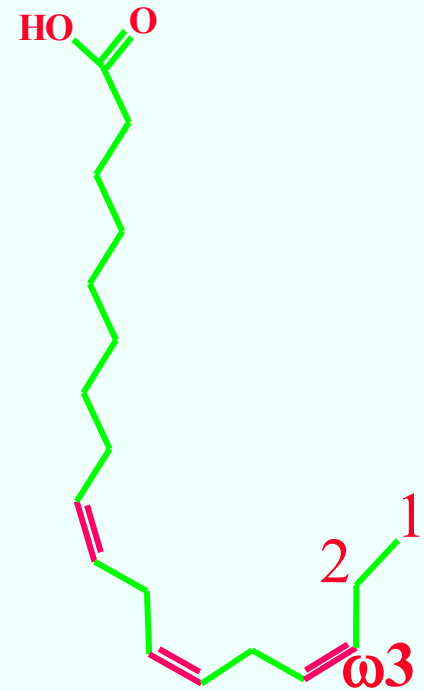
w-9



Acido Linoleico
(18:2 $\Delta^{9,12}$)

w-6

negli oli vegetali



Acido α -Linolenico
(18:3 $\Delta^{9,12,15}$)

w-3

grassi del pesce



Acidi Grassi Essenziali

Cibi ricchi di omega 3 (Acidi Grassi Essenziali)

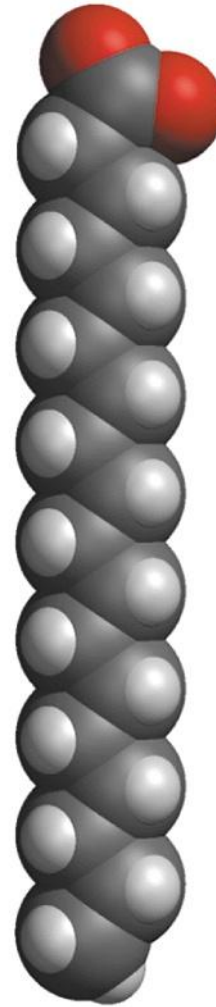
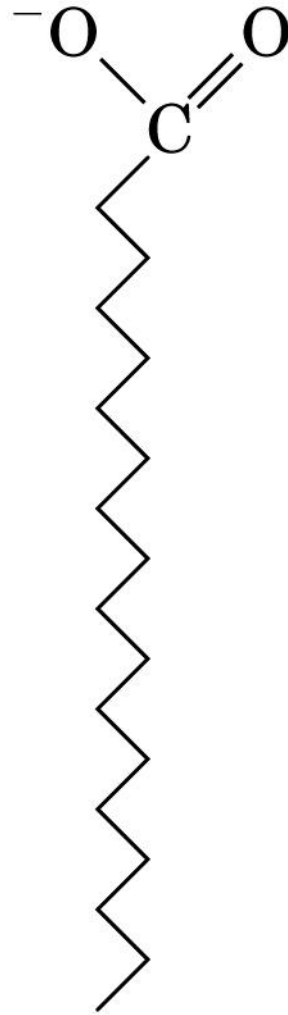
- noci.
- semi di lino e di chia.
- pesce (come salmone, sgombro, aringhe, trota)
- molluschi.
- verdure a foglia verde (come spinaci e lattuga)
- broccoli, cavolo verde.
- soia.
- ceci.

Cibi ricchi di omega 6 (Acidi Grassi Essenziali)

Oli di semi vegetali, (olio di germe di grano, olio di girasole, olio di mais, olio di sesamo, di arachidi e **olio di palma**).

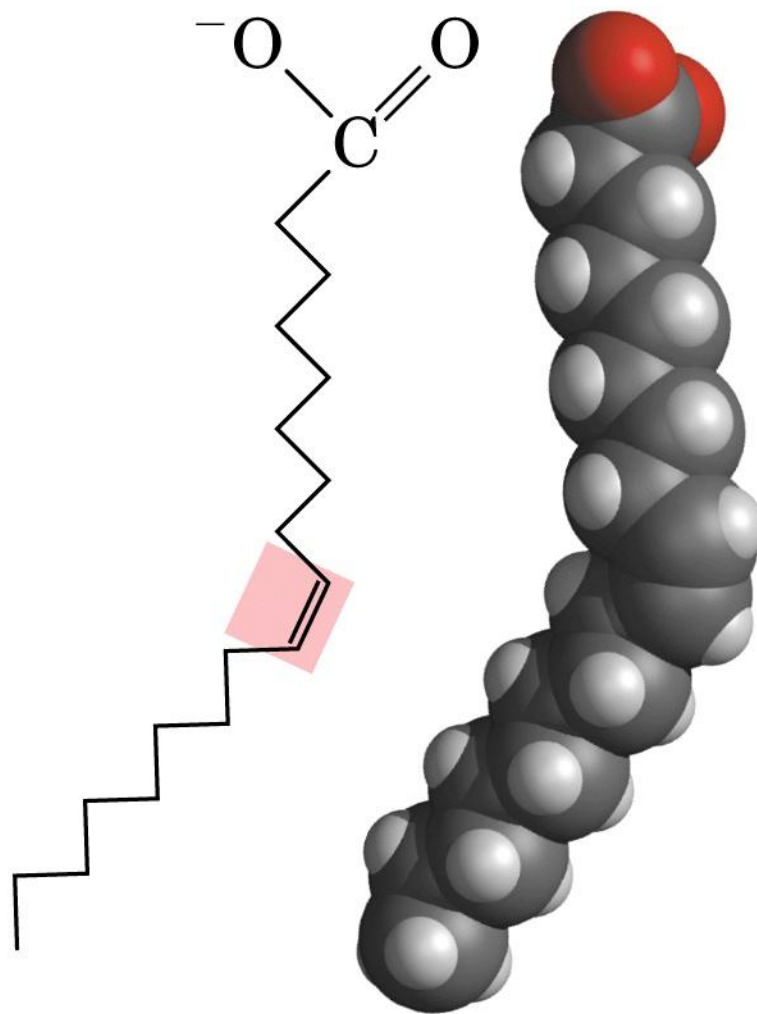
Omega 6/Omega 3 nella dieta occidentale è molto superiore a 10:1 mentre, per essere ideale, **dovrebbe essere compreso tra 4:1 o 8:1.**

Carboxyl
group



Hydrocarbon
chain

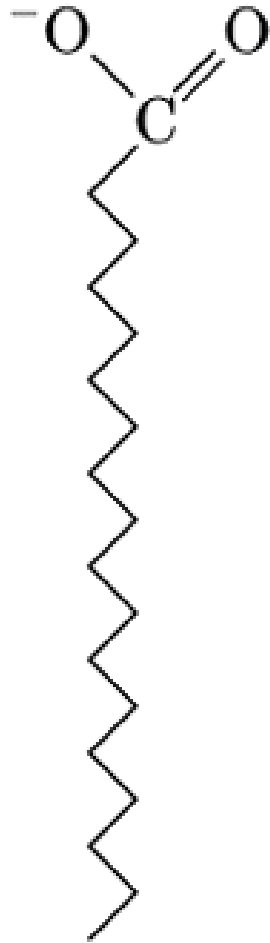
(a)



(b)

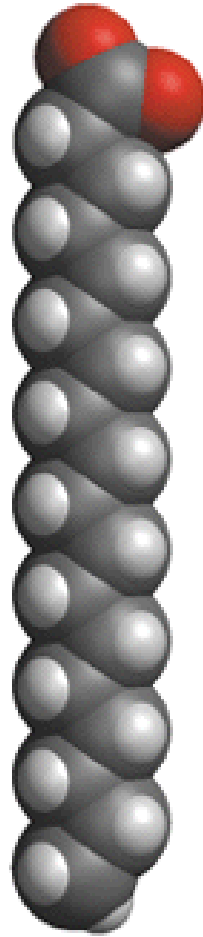
Conformazione

Carboxyl
group

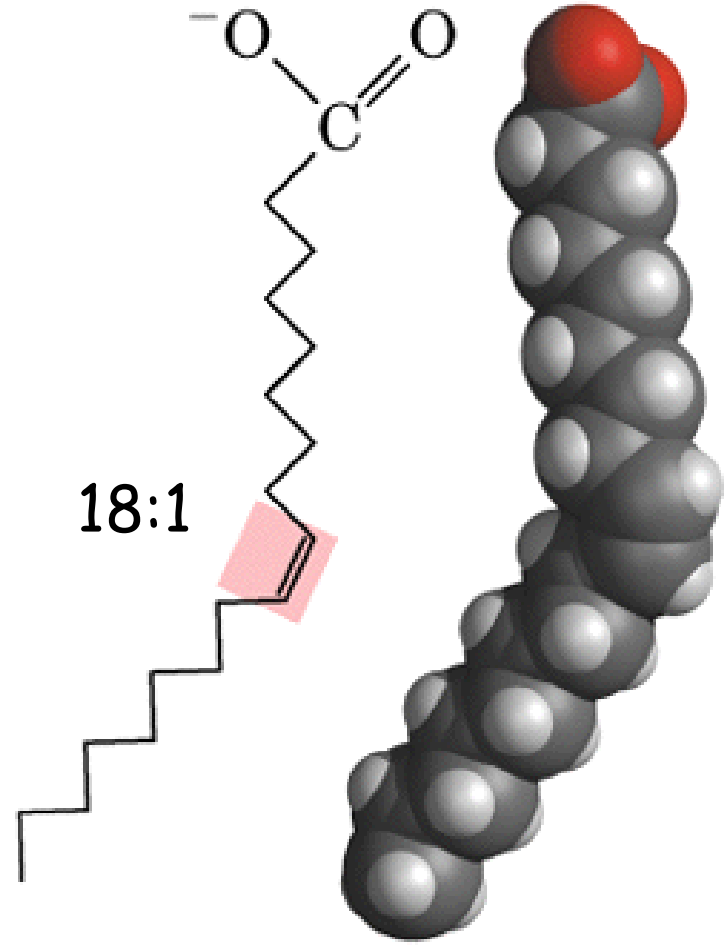


18:0

Hydrocarbon
chain



Ac. stearico
(stearato a pH 7)

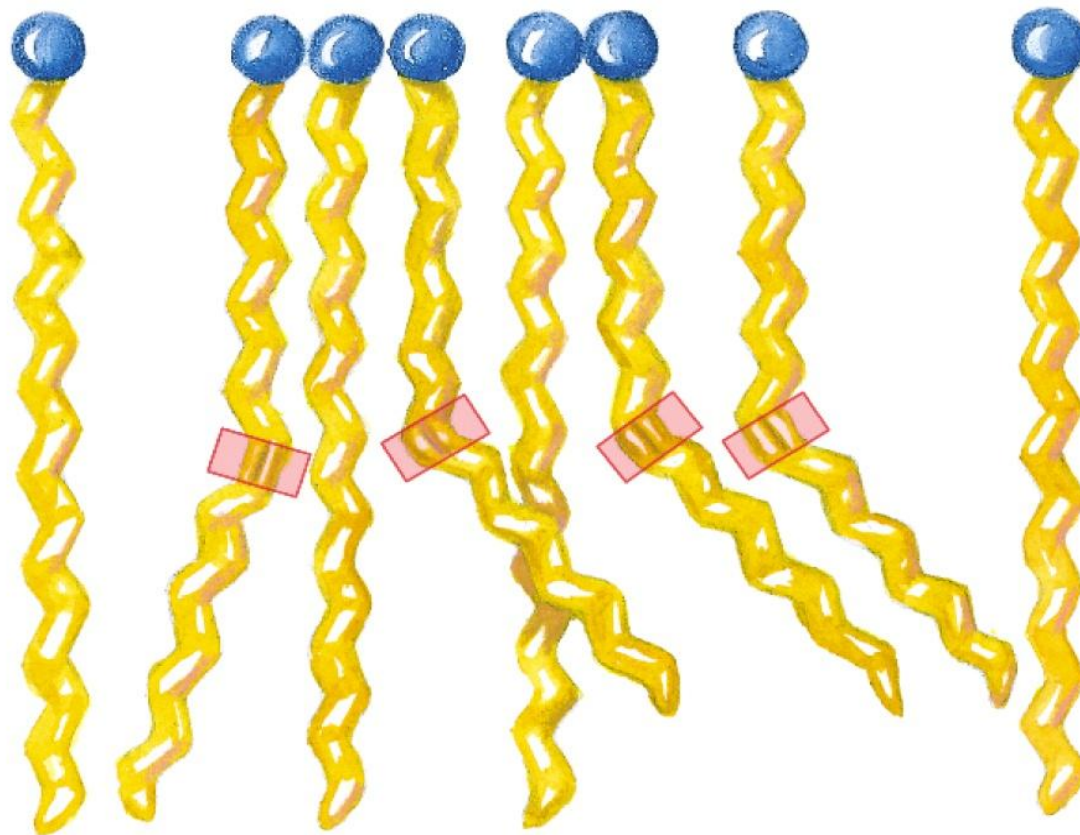


Ac. oleico
(oleato a pH 7)



Saturated
fatty acids

(c)



Mixture of saturated and
unsaturated fatty acids

(d)



Insaturi



Liquidi a temperatura ambiente



Saturi



Solidi a temperatura ambiente

Alcuni Acidi grassi naturali

SATURI



Carbon skeleton	Structure*	Systematic name [†]	Common name (derivation)	Melting point (°C)	Solubility at 30 °C (mg/g solvent)	
					Water	Benzene
12:0	$\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$	<i>n</i> -Dodecanoic acid	Lauric acid (Latin <i>laurus</i> , "laurel plant")	44.2	0.063	2,600
14:0	$\text{CH}_3(\text{CH}_2)_{12}\text{COOH}$	<i>n</i> -Tetradecanoic acid	Myristic acid (Latin <i>Myristica</i> , nutmeg genus)	53.9	0.024	874
16:0	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$	<i>n</i> -Hexadecanoic acid	Palmitic acid (Latin <i>palma</i> , "palm tree")	63.1	0.0083	348
18:0	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$	<i>n</i> -Octadecanoic acid	Stearic acid (Greek <i>stear</i> , "hard fat")	69.6	0.0034	124
20:0	$\text{CH}_3(\text{CH}_2)_{18}\text{COOH}$	<i>n</i> -Eicosanoic acid	Arachidic acid (Latin <i>Arachis</i> , legume genus)	76.5		
24:0	$\text{CH}_3(\text{CH}_2)_{22}\text{COOH}$	<i>n</i> -Tetracosanoic acid	Lignoceric acid (Latin <i>lignum</i> , "wood" + <i>ceras</i> , "wax")	86.0		

16:1(Δ^9)	$\text{CH}_3(\text{CH}_2)_5\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	<i>cis</i> -9-Hexadecenoic acid	Palmitoleic acid	-0.5		
18:1(Δ^9)	$\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	<i>cis</i> -9-Octadecenoic acid	Oleic acid (Latin <i>oleum</i> , "oil")	13.4		
18:2($\Delta^{9,12}$)	$\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	<i>cis</i> -, <i>cis</i> -9,12-Octadecadienoic acid	Linoleic acid (Greek <i>linon</i> , "flax")	-5		
18:3($\Delta^{9,12,15}$)	$\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	<i>cis</i> -, <i>cis</i> -, <i>cis</i> -9,12,15-Octadecatrienoic acid	α -Linolenic acid	-11		
20:4($\Delta^{5,8,11,14}$)	$\text{CH}_3(\text{CH}_2)_3\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_3\text{COOH}$	<i>cis</i> -, <i>cis</i> -, <i>cis</i> -, <i>cis</i> -5,8,11,14-Icosatetraenoic acid	Arachidonic acid	-49.5		

INSATURI

1) LIPIDI DI RISERVA e DI RIVESTIMENTO

2) LIPIDI DI MEMBRANA

3) STEROLI

1) LIPIDI DI RISERVA e DI RIVESTIMENTO

LIPIDI NEUTRI

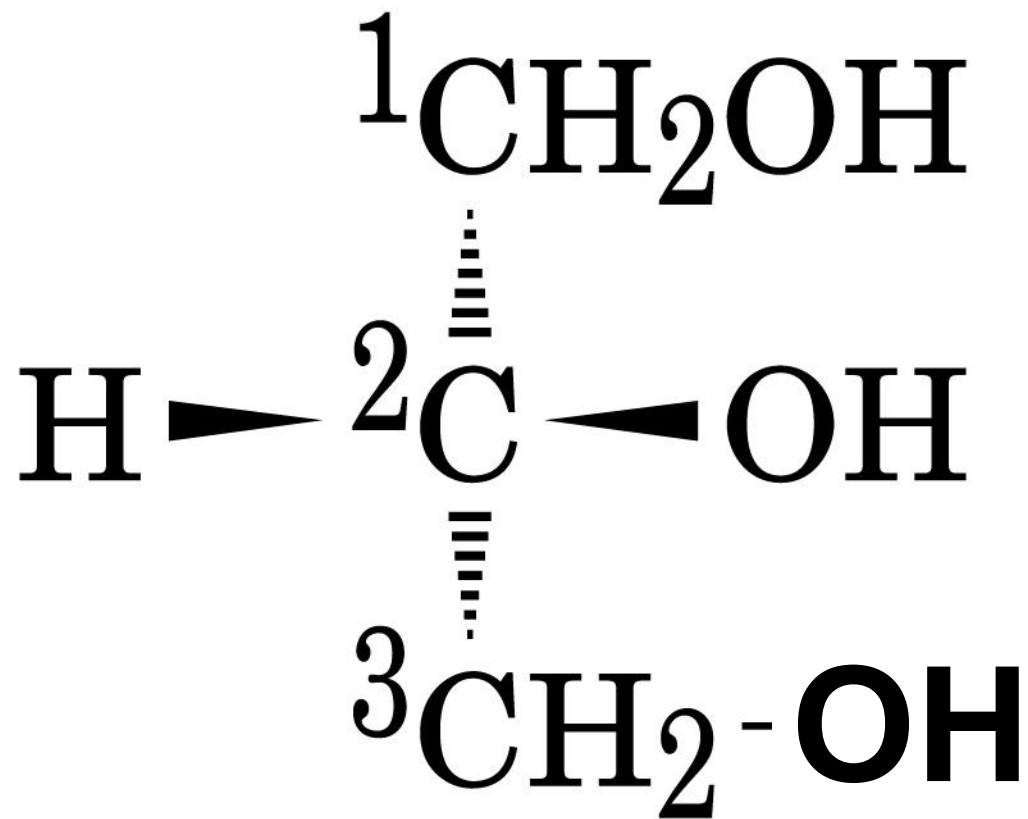
- **Trigliceridi** (*triacilgliceroli o glicerolipidi*)

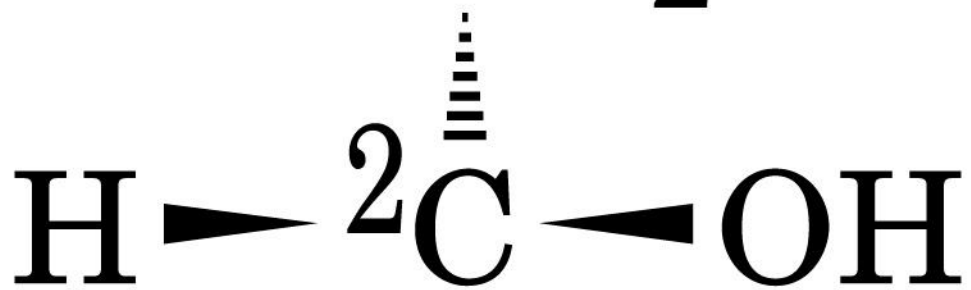
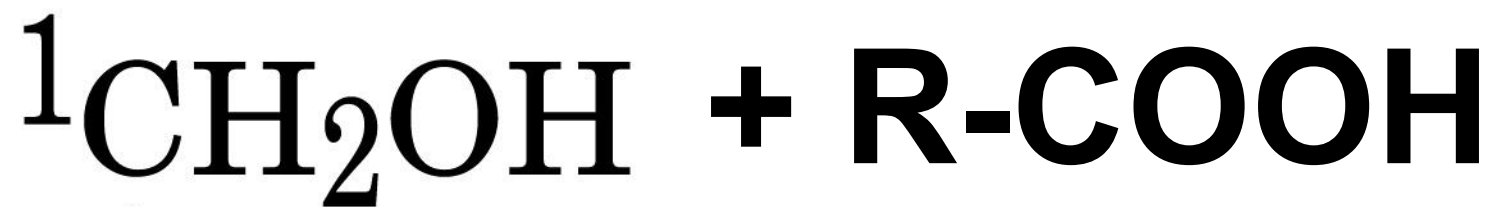
- **Cere** (esteri degli ac. Grassi con alcoli)

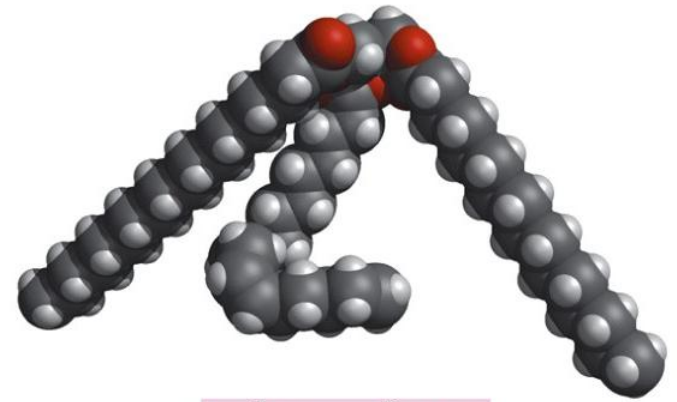
-Funzione di riserva

Grassi e oli (solidi o liquidi a 20° C)

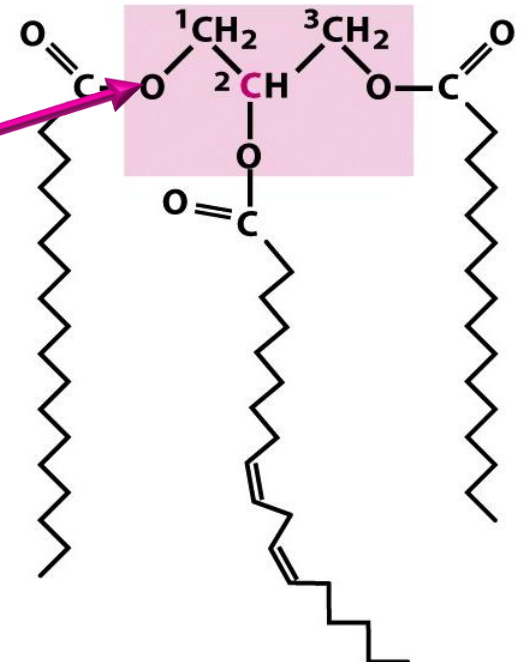
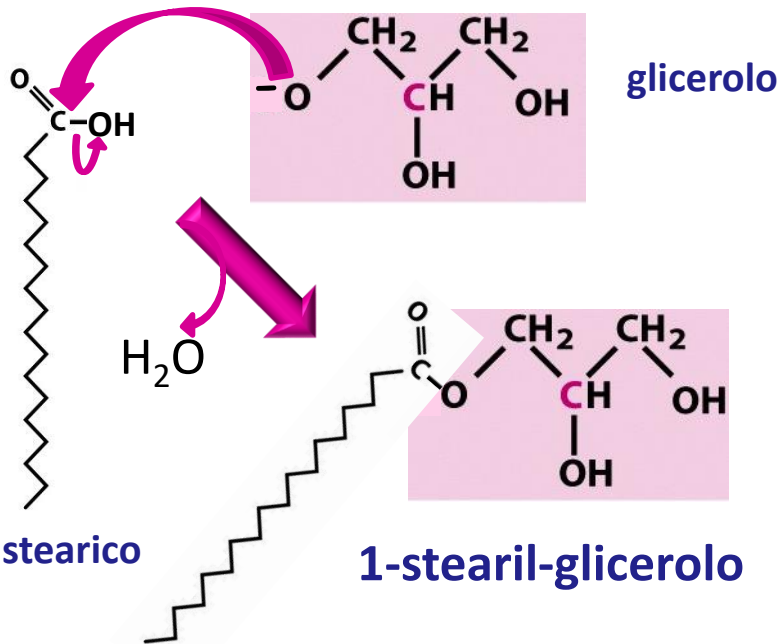
LIPIDI NEUTRI







Glicerolo + acidi grassi
(legati attraverso legame ESTERE)



1-stearil,2-linoleil,3-palmitoil glicerolo

Figure 10-3
Lehninger Principles of Biochemistry, Fifth Edition
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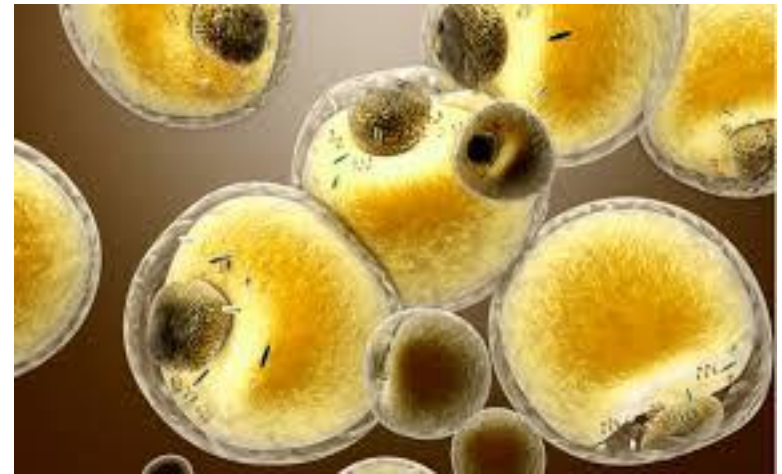
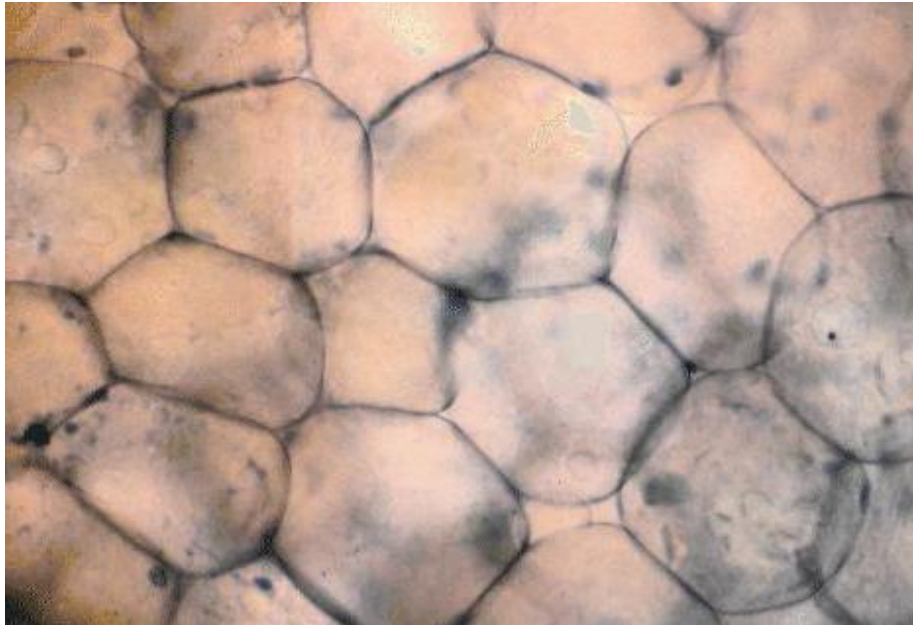
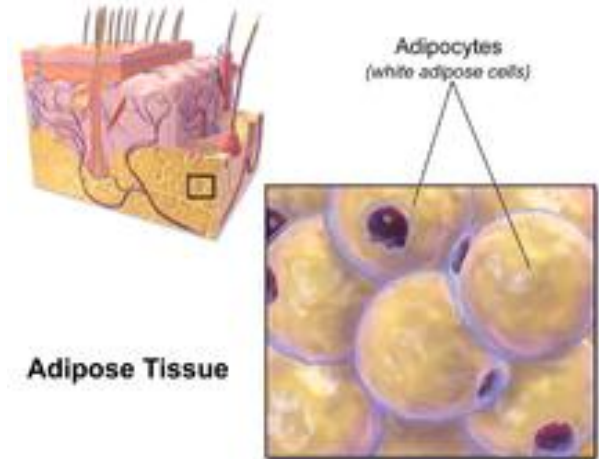
Esistono Triacilgliceroli, Diacilgliceroli, e Monoacilgliceroli.

1) LIPIDI DI RISERVA: TRIGLICERIDI

Lipidi di riserva energetica. Dalla loro ossidazione si ricava energia. Mantengono la temperatura corporea.

→ Sono lipidi **NEUTRI**, **totalmente APOLARI**

Sono immagazzinati in forma anidra nelle cellule adipose sotto forma di vacuoli limitati da membrane, da cui sono mobilizzati per produrre energia in condizioni di digiuno (es. durante il sonno).



-Cere (esteri degli ac. Grassi con alcoli)

Acido grasso a catena lunga (acido oleico C18:1)

Esterificato con un alcol (alcol oleico)

Debolmente idrofila

Insolubili in acqua

Piante

Piume

2) LIPIDI DI MEMBRANA

Funzione strutturale

LIPIDI POLARI

- 1. Glicerofosfolipidi***
- 2. Sfingolipidi***
- 3. Glicolipidi***

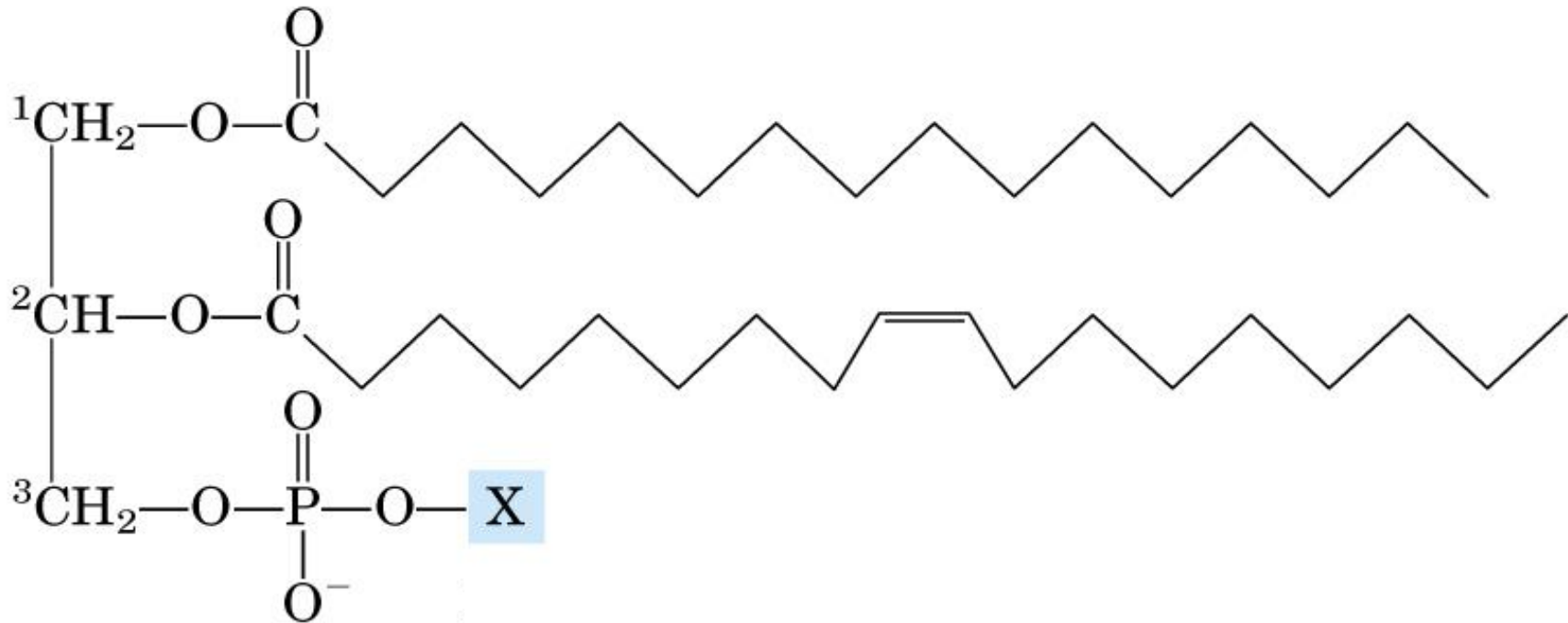
Sono lipidi ANFIFILICI perché costituiti da una

- Testa POLARE
- Coda APOLARE

»» principali costituenti delle membrane biologiche

LIPIDI POLARI

1. Glicerofosfolipidi

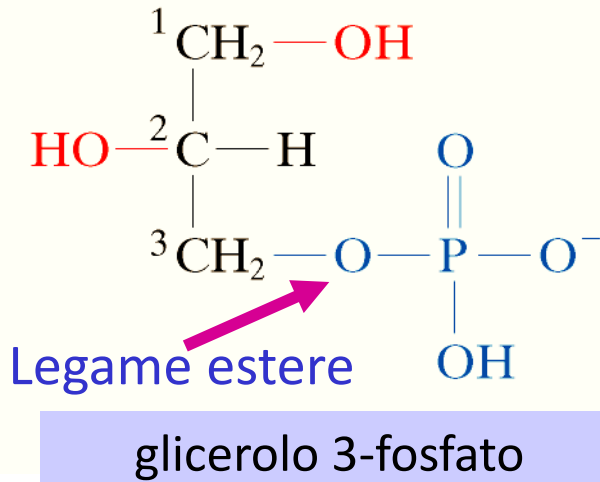


X = H acido fosfatidico

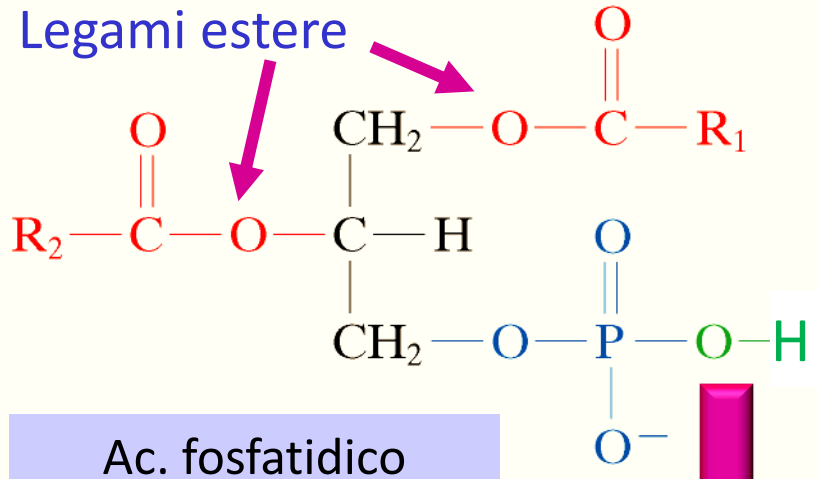
GLICEROFOSFOLIPIDI (costituenti delle membrane biologiche)

Sono costituiti da un acido fosfatidico o fosfatide a cui si lega una molecola alcolica

Composto da: Glicerolo 3-fosfato esterificato con 2 acidi grassi (C-1 e C-2)



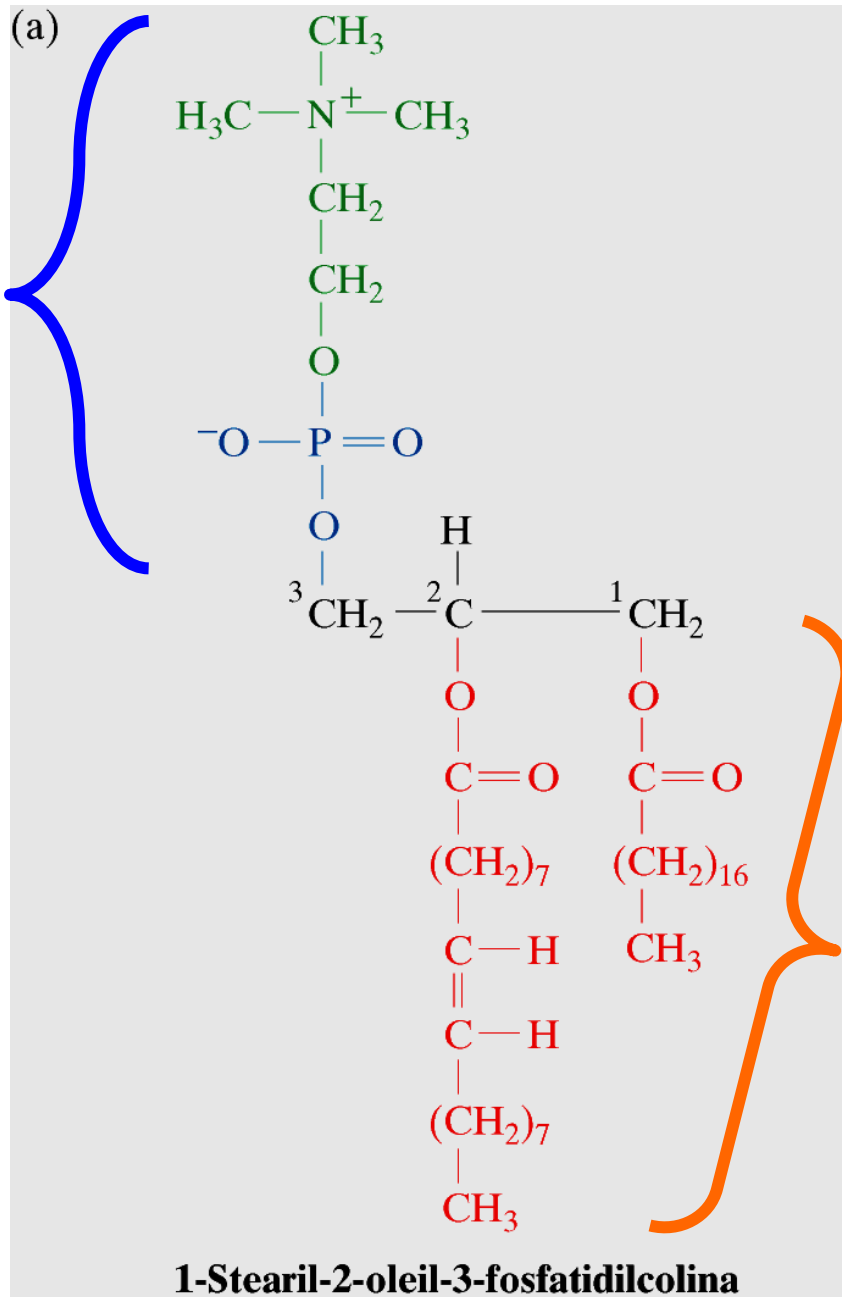
+ 2 R-COO⁻



Il gruppo fosfato solitamente forma un secondo legame estere con il gruppo alcolico di un'altra molecola con cui costituisce così la "testa polare" del glicerofosfolipide

I GLICEROFOSFOLIPIDI SONO MOLECOLE ANFIPATICHE

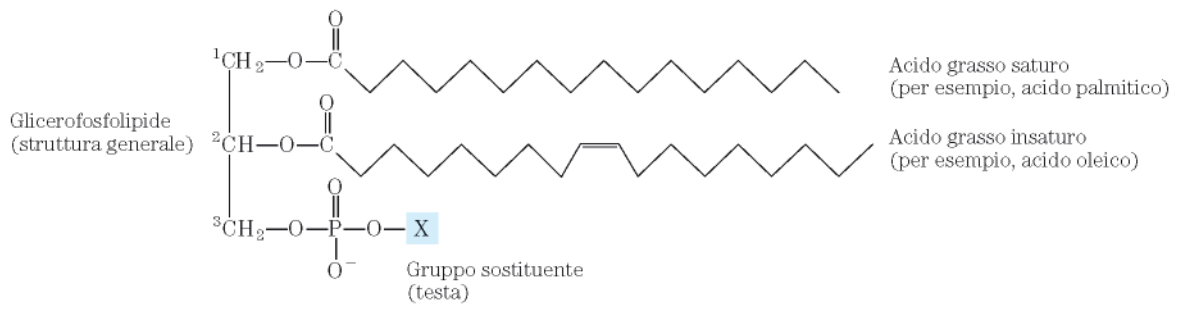
Testa polare
idrofilica:
Fosfato +
Colina

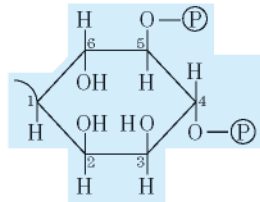
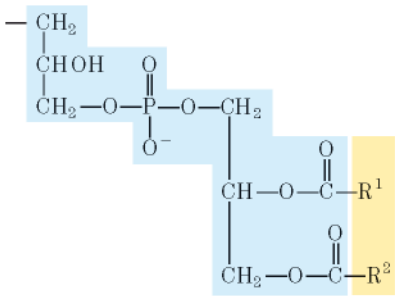


I glicerofosfolipidi si differenziano per la testa polare e il tipo di acidi grassi che portano, i quali differiscono tra loro per il n° di atomi di carbonio e le insaturazioni.

Coda idrofobica:
glicerolo + catene
idrocarburiche (stearato in
C1 e oleato in C2)
-in C1 solitamente una
catena acilica satura
-in C2 solitamente una
catena acilica insatura

TESTE POLARI DEI GLICEROFOSFOLIPIDI



Nome del glicerofosfolipide	Nome di X—O	Formula di X	Carica netta (a pH 7,0)
Acido fosfatidico	—	— H	-1
Fosfatidiletanolammina	Etanolammina	— CH ₂ —CH ₂ —NH ₃ ⁺	0
Fosfatidilcolina	Colina	— CH ₂ —CH ₂ —N ⁺ (CH ₃) ₃	0
Fosfatidilserina	Serina	— CH ₂ —CH(NH ₃ ⁺)—COO ⁻	-1
Fosfatidilglicerolo	Glicerolo	— CH ₂ —CH(OH)—CH ₂ —OH	-1
Fosfatidilinositolo 4,5-bisfosfato	<i>myo</i> -Inositolo 4,5-bisfosfato		-4
Cardiolipina	Fosfatidilglicerolo		-2

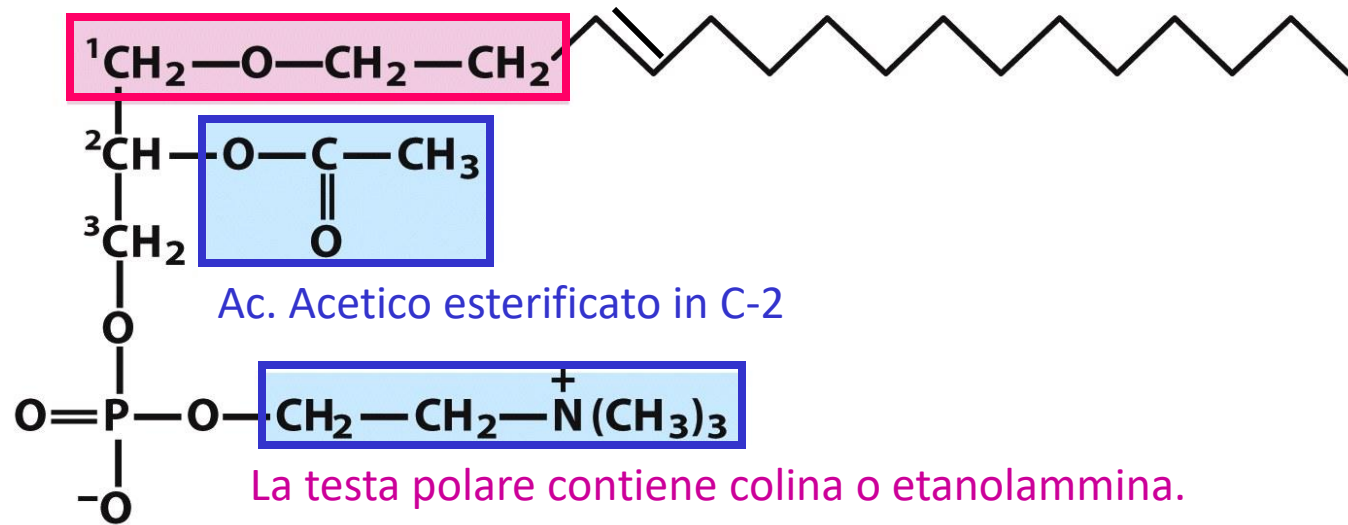
Name of glycerophospholipid	Name of X	Formula of X	Net charge (at pH 7)
Phosphatidic acid	—	— H	-1
Phosphatidylethanolamine	Ethanolamine	— CH ₂ —CH ₂ —NH ₃ ⁺	0
Phosphatidylcholine	Choline	— CH ₂ —CH ₂ —N ⁺ (CH ₃) ₃	0
Phosphatidylserine	Serine	— CH ₂ —CH—NH ₃ ⁺ COO ⁻	-1
Phosphatidylglycerol	Glycerol	— CH ₂ —CH—CH ₂ —OH OH	-1
Phosphatidylinositol 4,5-bisphosphate	<i>myo</i> -Inositol 4,5-bisphosphate		-4
Cardiolipin	Phosphatidyl-glycerol		-2

PLASMALOGENI

Glicerofosfolipidi che hanno in posizione 1 una coda idrocarburica legata attraverso un **LEGAME ETERE**, mentre in C-2 l'ac. grasso è legato mediante legame estere

Abbondanti nelle membrane dei neuroni (cervello e nervi periferici), nel tessuto muscolare e cardiaco. Sono molecole segnale.

Legame etere con una catena idrocarburica alchilica insatura



Agisce nel processo di coagulazione del sangue e riparazione delle ferite.

Secreto dai leucociti nel sangue, stimola le piastrine ad aggregarsi e a secernere serotonina (vasocostrittore).

FATTORE ATTIVANTE LE PIASTRINE

Figure 10-10b
Lehninger Principles of Biochemistry, Fifth Edition
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SFINGOLIPIDI (costituenti delle membrane biologiche)

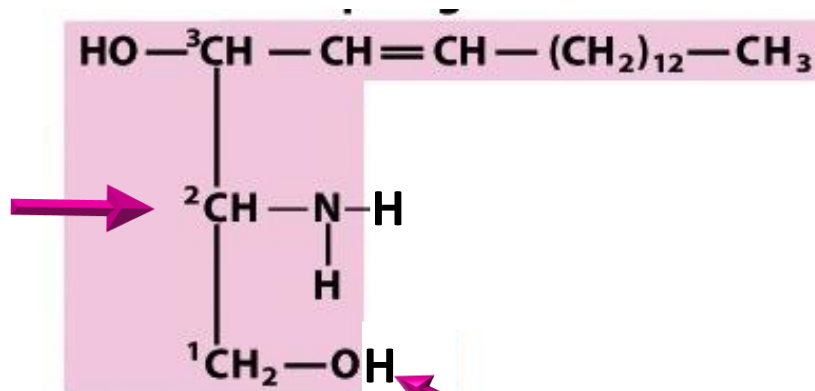
Lo scheletro degli sfingolipidi è la **SFINGOSINA** (amminoalcol) con una lunga catena idrocarburica monoinsatura che parte dal C-3,

- Due gruppi -OH legati in C-3 e in C-1
- Un gruppo amminico in C-2.

Quando la sfingosina è legata ad 1 ac. grasso si forma il CERAMIDE.

La CERAMIDE è la struttura base degli sfingolipidi:

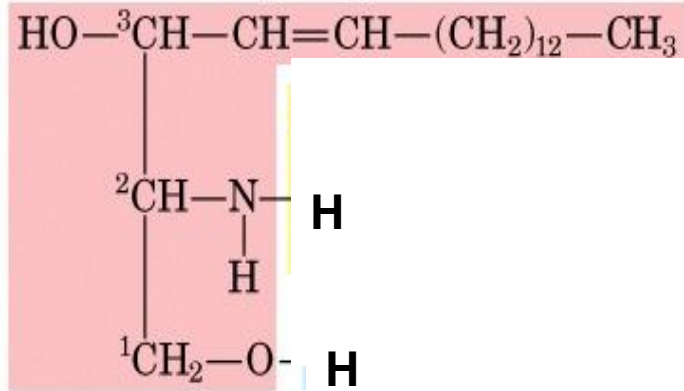
l'acido grasso è legato al gruppo amminico della sfingosina tramite legame CARBOAMMIDICO



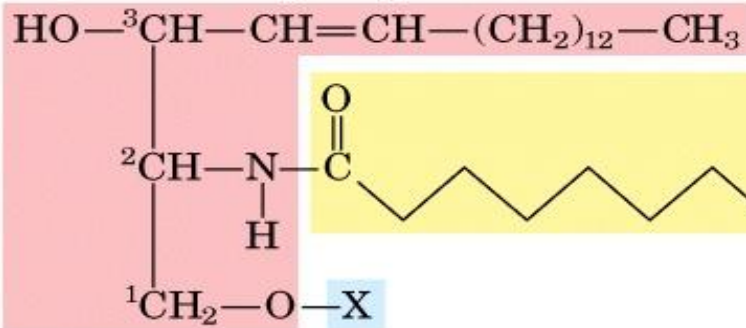
Catena
idrocarburica
dell'ac. grasso

La ceramide leggerà la testa polare sul carbonio 1

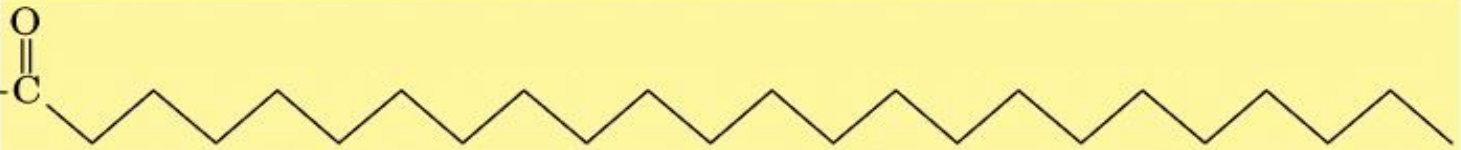
sfingosina



Sphingosine



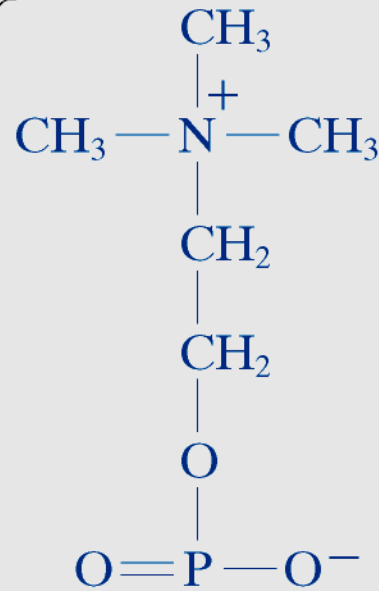
Fatty acid



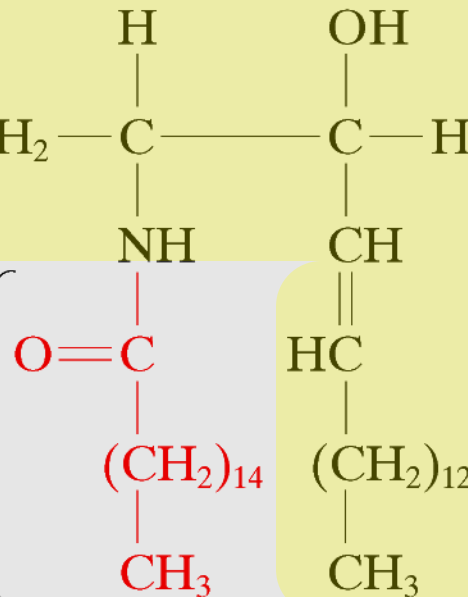
X = H ceramide

(a)

Testa polare
fosfocolina



Residuo di
palmitato



Una sfingomieline

SFINGOMIELINE:
Sono ANFIPATICHE
Sono Fosfolipidi

Coda idrofobica:
catena idrocarburica
della sfingosina e
catena acilica dell'ac.
grasso

sfingolipidi

Sfingolipide (formula generale)		
<p style="text-align: center;">Sfingosina</p> $\text{HO}-\overset{3}{\text{C}}\text{H}-\text{CH}=\text{CH}-(\text{CH}_2)_{12}-\text{CH}_3$ <p style="text-align: right;">Acido grasso</p>		
Nome dello sfingolipide	Nome di X—O	Formula di X
Ceramide	—	— H
1) Sfingomieline	Fosfocolina	
2) Glicolipidi neutri Glicosilcerebrosidi	Glucosio	
Lattosilceramide (un globoside)	Di-, tri- oppure tetrasaccaride	
3) Ganglioside GM2	Oligosaccaride complesso	

GLYCOSPHINGOLIPIDS

Not contain phosphorus

Contain carbohydrates in glycosidic linkage to the primary alcohol of a ceramide

1) Cerebrosides

2) Globosides

3) Gangliosides



NEUTRAL GLYGOLIPIDS

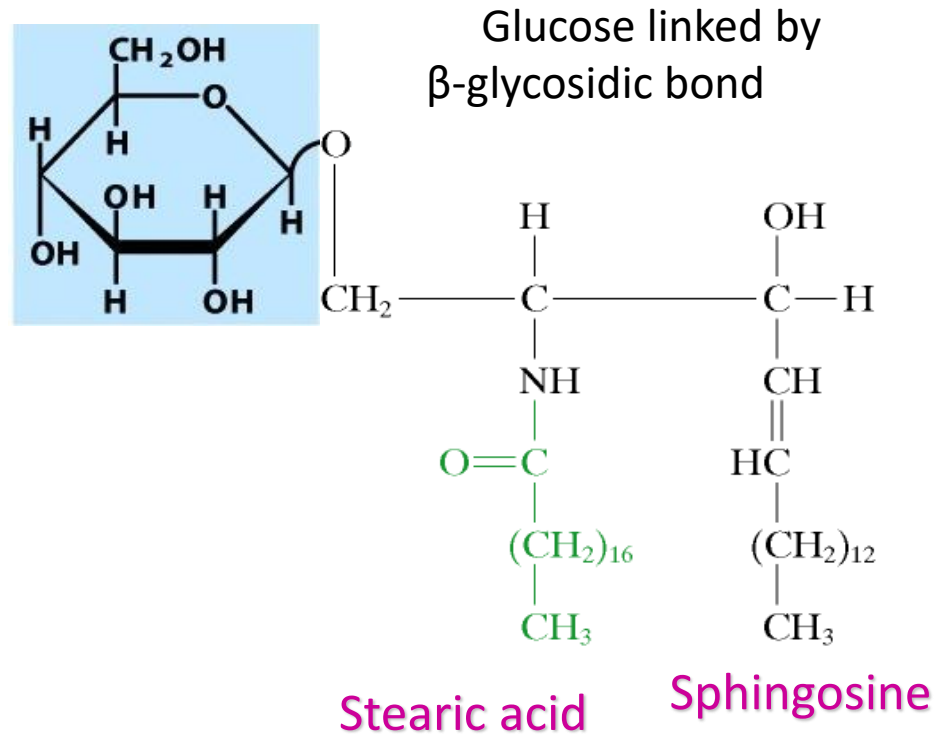
POLAR GLYGOLIPIDS

GLYCOSPHINGOLIPIDS

1) Cerebrosides

a single Glucose or galactose linked to a ceramide by glycosidic bond

GLUCOSYLCERAMIDE



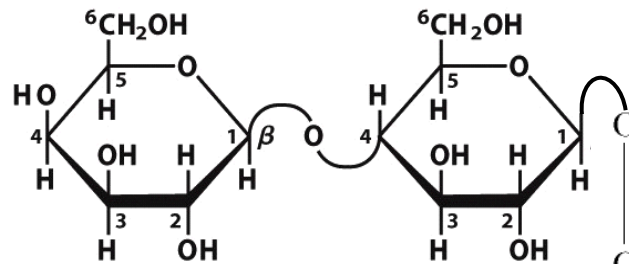
GLYCOSPHINGOLIPIDS

2) Globosides: are ceramide oligosaccharides

two or more neutral monosaccharides (usually galactose or glucose, or N-acetylgalactosamine) linked to a ceramide by glycosidic bond

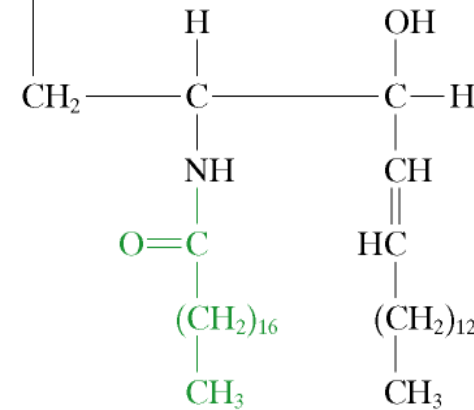
The oligosaccharides are uncharged

Lactosylceramide is present in the erythrocyte membrane



Globosidi:
LACTOSYLCERAMIDE

Another globoside of the nervous system is ceramide-tri-hexoside

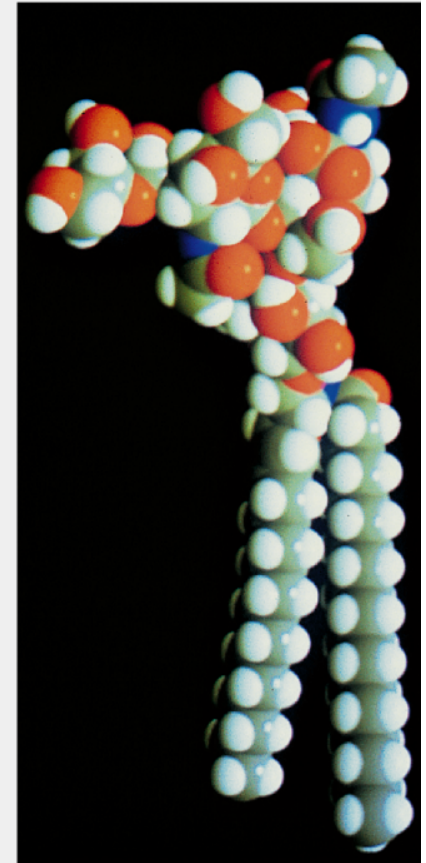
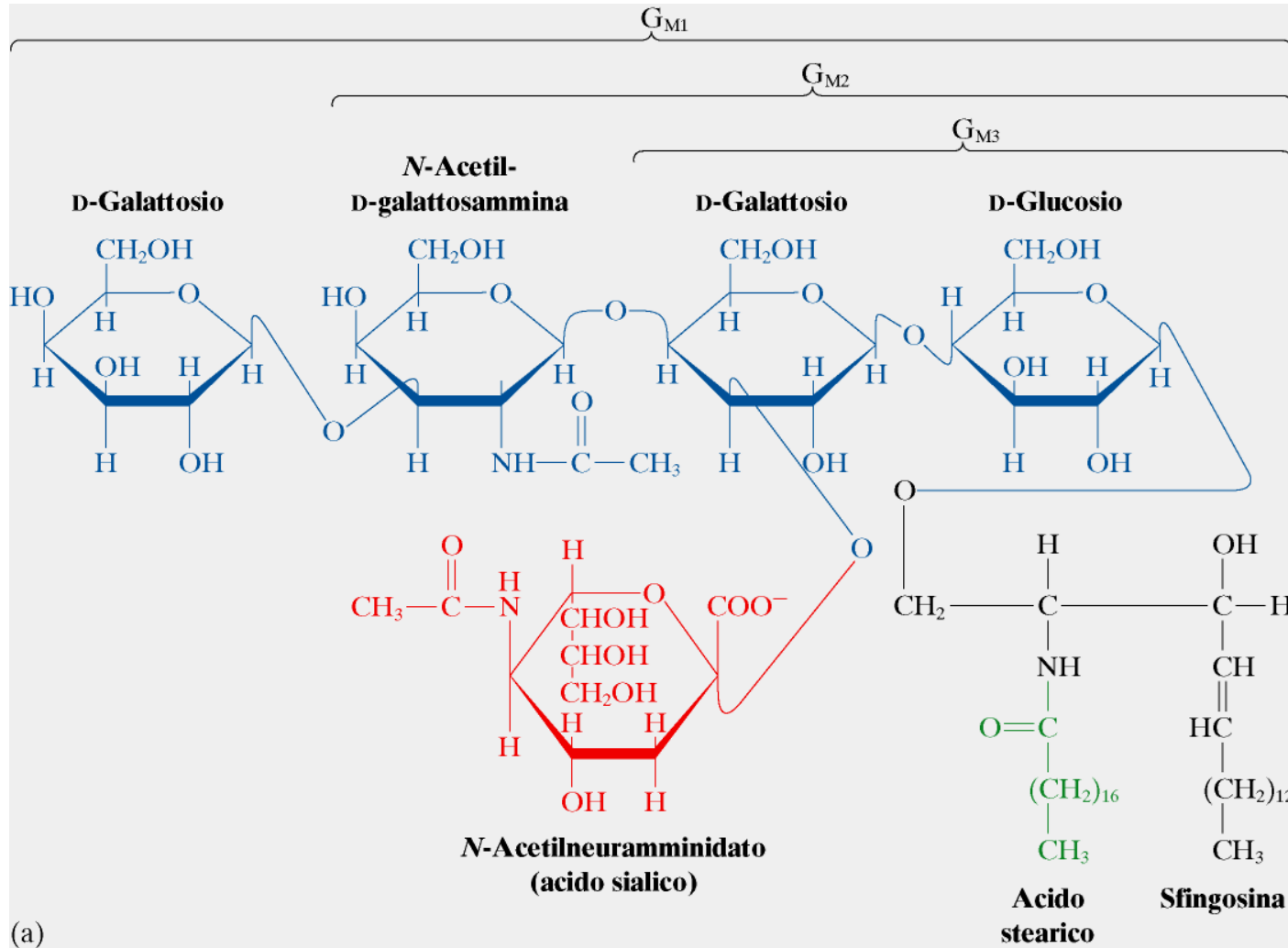


Stearic acid

Sphingosine

Ceramide-hexoside accumulates in kidney of patients with Fabry's disease,
A deficiency of lysosomal alpha-galactosidase .

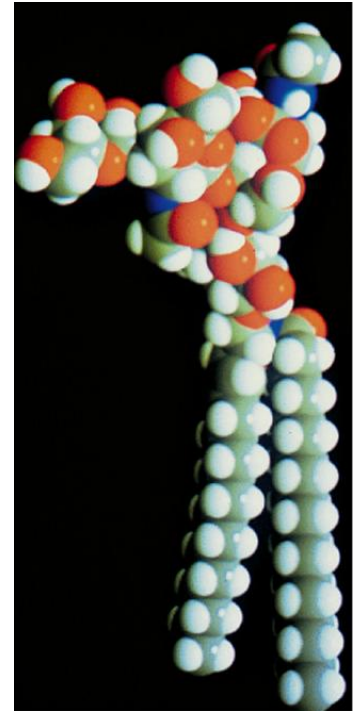
GANGLIOSIDE



GLYCOSPHINGOLIPIDS

3)Gangliosides: First identification in high concentrations in the central nervous system ganglia cells

Sialic acid is highly contained in ganglia cells of the central nervous system



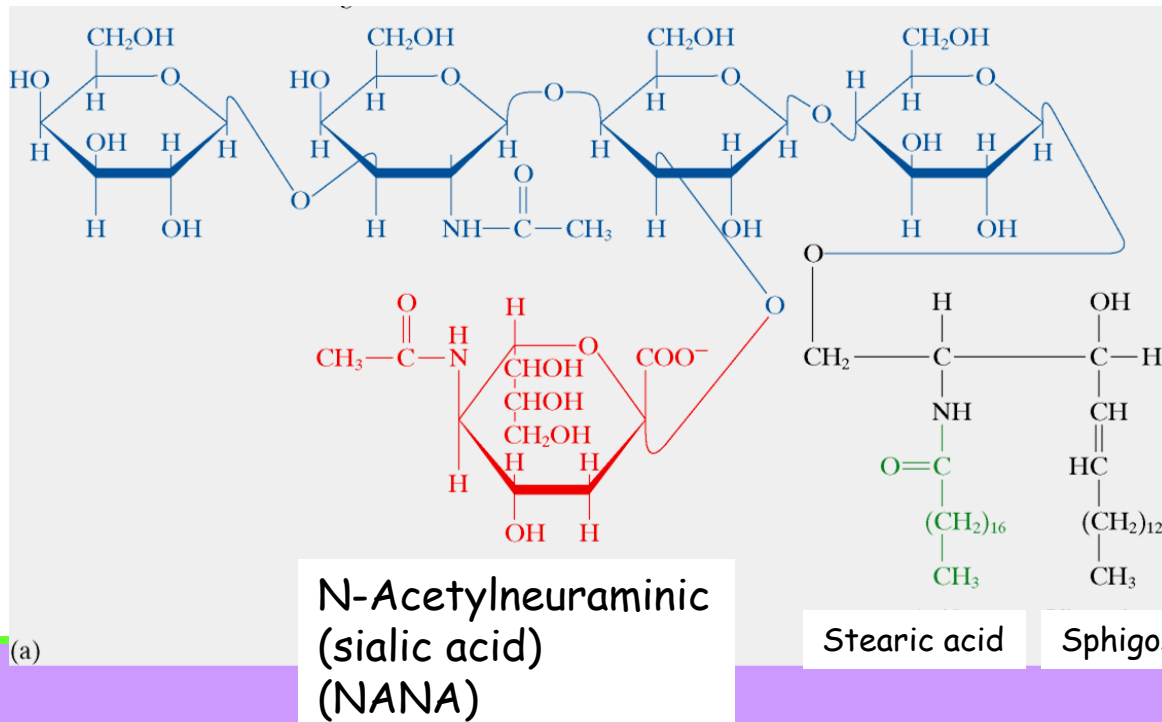
- CNS (50% of total sialic acid is represented)
- Non-nerveous cells (10% of the total sialic acid) (plasma membrane of cells or other tissue)
- Major components of cell-surface membranes
- Constitute 6% of brain lipids.

- Gangliosides have considerable physiological and medical significance.
- Receptors for bacterial protein toxins.

GLYCOSPHINGOLIPIDS

3) Gangliosides

- a oligosaccharide containing one or more **sialic acid**
- Have a polar head with negative charge at pH 7



GANGLIOSIDES

Nomenclature

Depends on the number of sialic acids

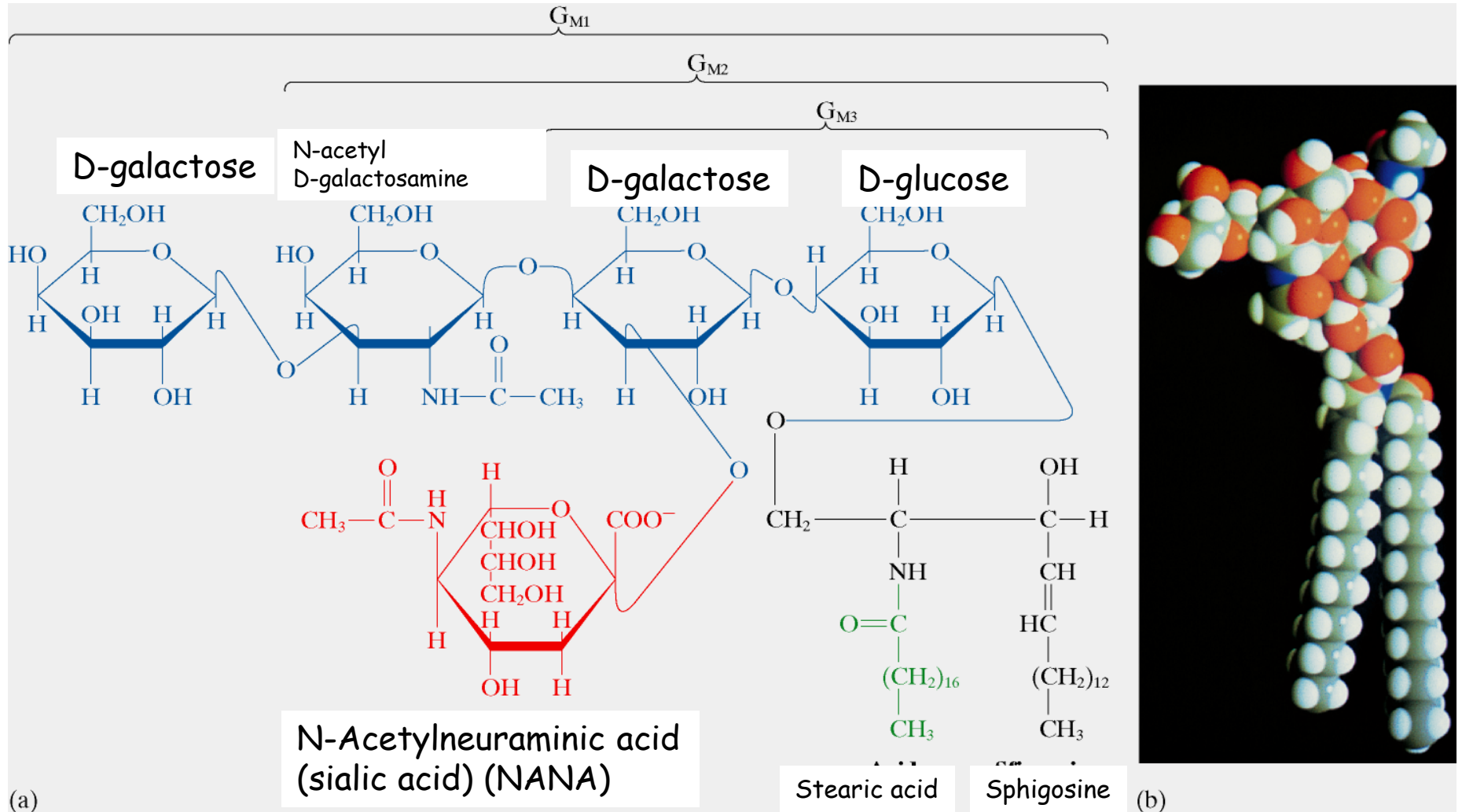
GM: one sialic acid residue

GD: two sialic acid residues

GT: three sialic acid residues

GQ: four sialic acid residues

GANGLIOSIDES

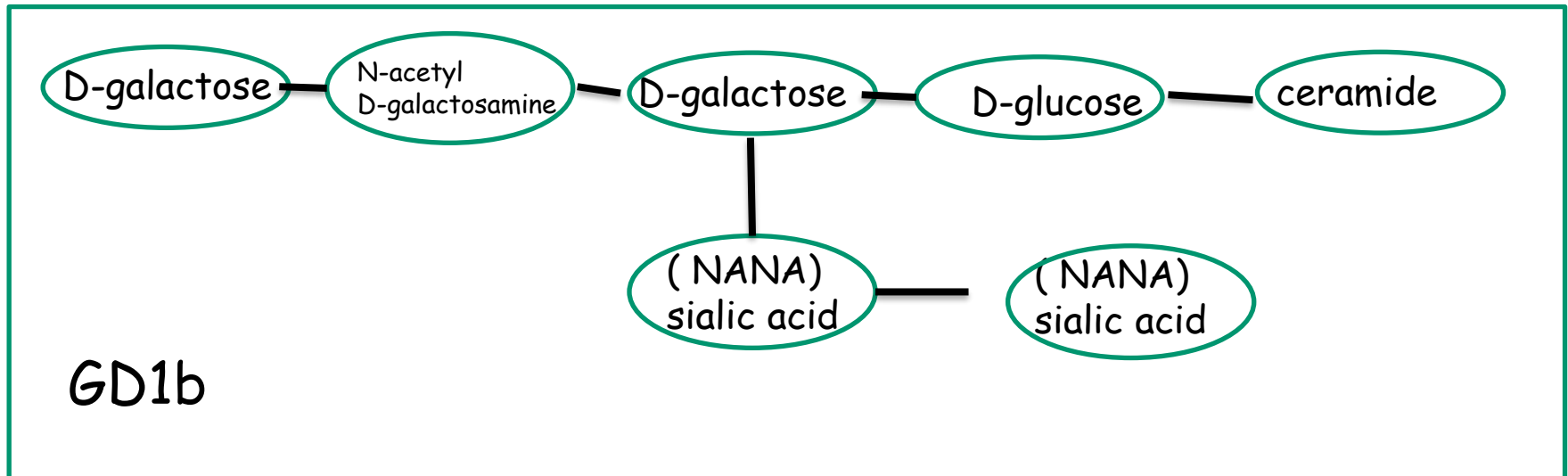
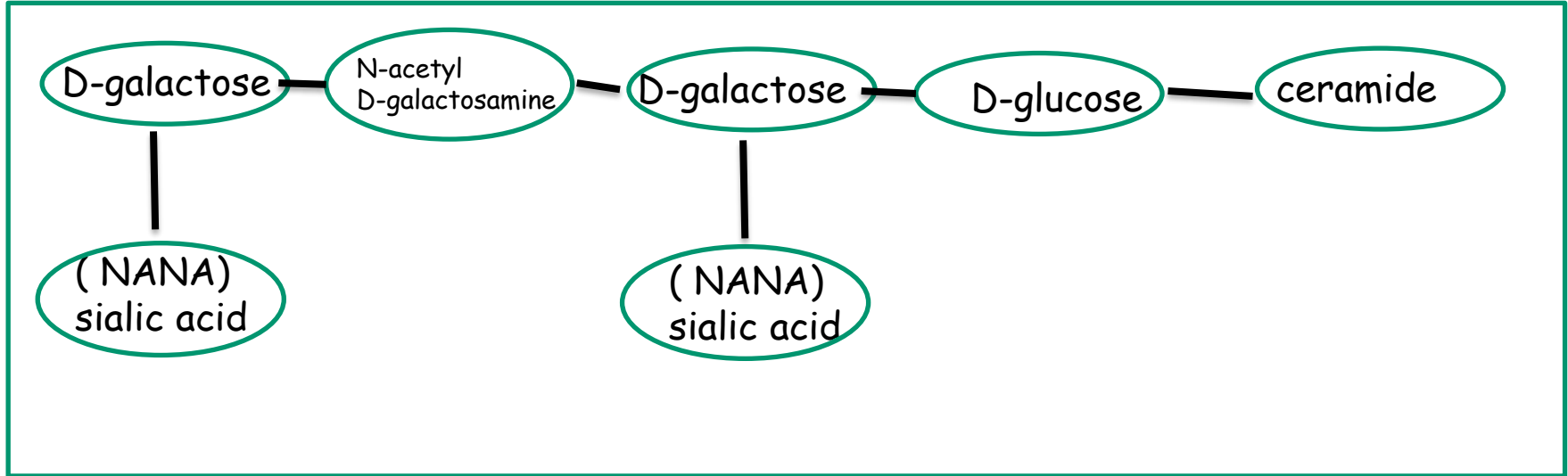


Gangliosides *GM2* e *GM3* differ from *GM1* only by the sequential absences of the terminal D-galactose and N-acetyl D-galactosamine residues.

GANGLIOSIDES

Gangliosides GD1a differ from GD1b on the basis of the sialic acid position

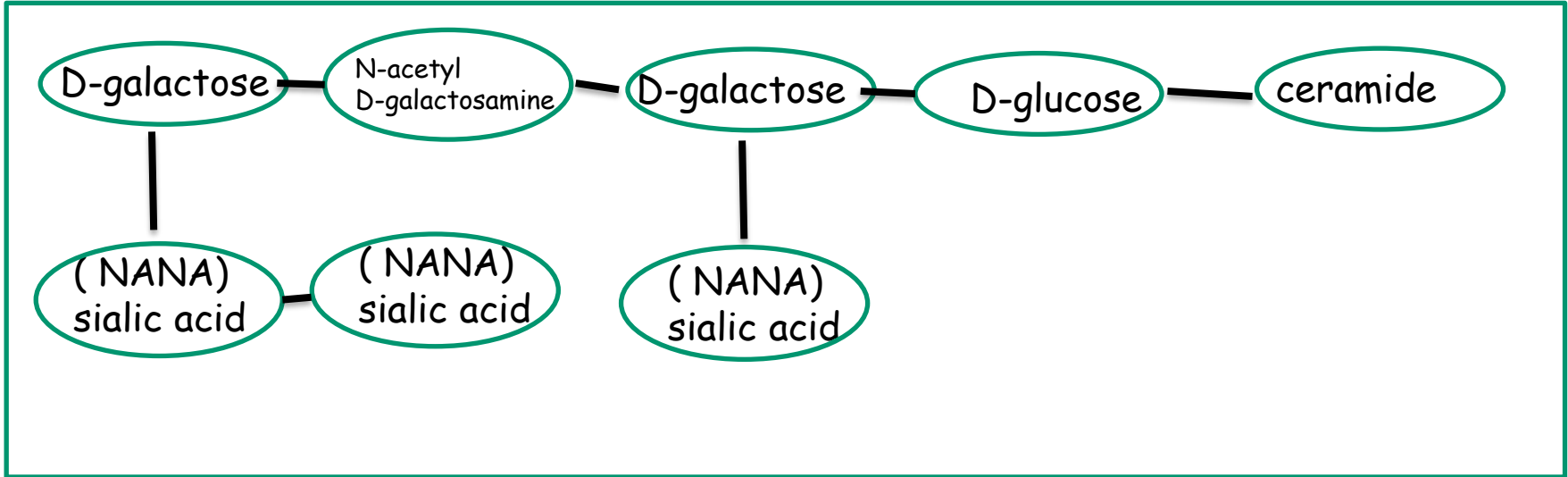
GD1a



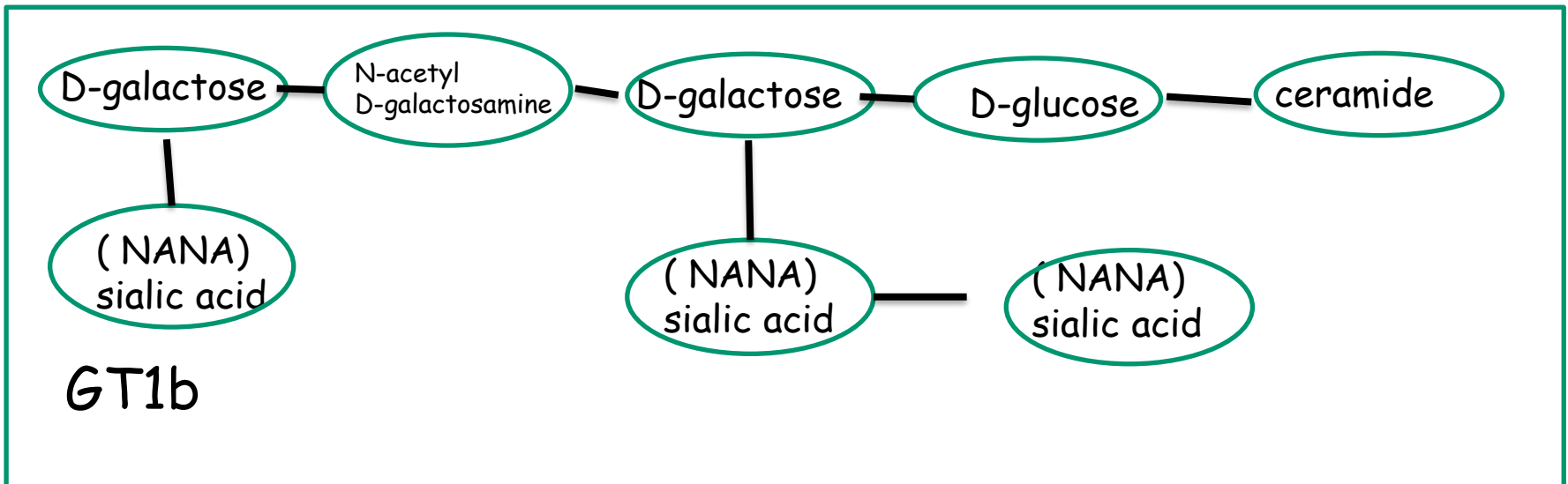
GANGLIOSIDES

Gangliosides GT1a differ from GT1b on the basis of the sialic acid position

GT1a

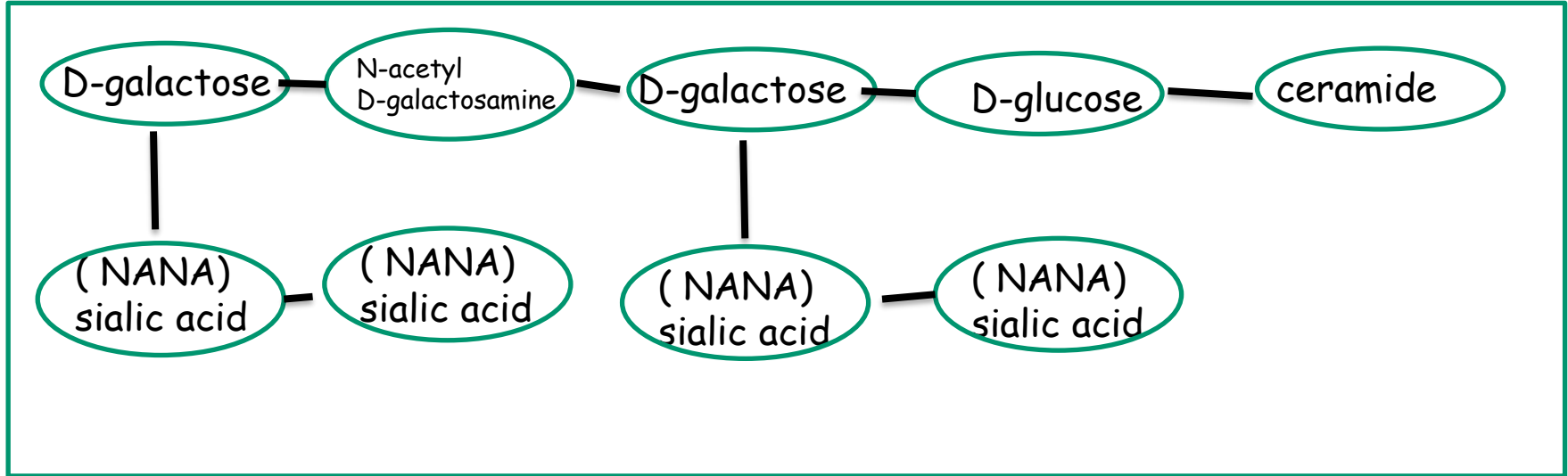


GT1b



GANGLIOSIDES

GQ1b



GQ: four sialic acid residues

GANGLIOSIDES

Gangliosides on intestinal mucosal cells bind cholera toxin, an 84-kDa protein secreted by pathogen *Vibrio cholerae*

The toxin stimulates secretion of chloride ions into the gut lumen, resulting in the copious diarrhea of cholera.

Gangliosides may also bind other toxins, such as tetanus toxin, and certain viruses, such as flu virus.

Disease:

- **GM1 Gangliosidosis** (autosomal recessive metabolic disease) characterized by:
 - Impaired psychomotor function
 - Mental retardation
 - Hepatosplenomegaly
 - Death within the first few years of life
- Accumulation of GM1 is due to a marked deficiency of B-galactosidase
-
- **Tay-Sachs disease** (accumulation of GM2 in brain)

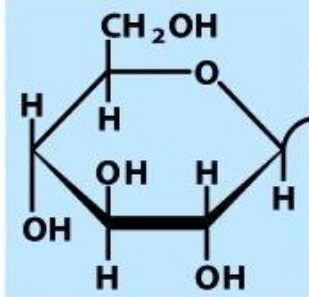
Cerebrosidi, globosidi e gangliosidi sono GLICOSFINGOLIPIDI

Non sono fosforilati

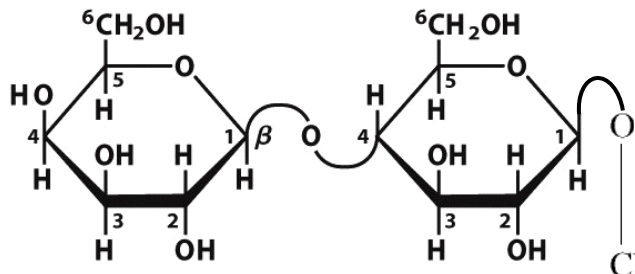
Cerebrosidi e globosidi sono **glicolipidi neutri**

Gangliosidi: possono avere uno o più residui di **zuccheri acidi** che hanno una testa polare carica negativamente a pH 7. La testa polare è molto voluminosa

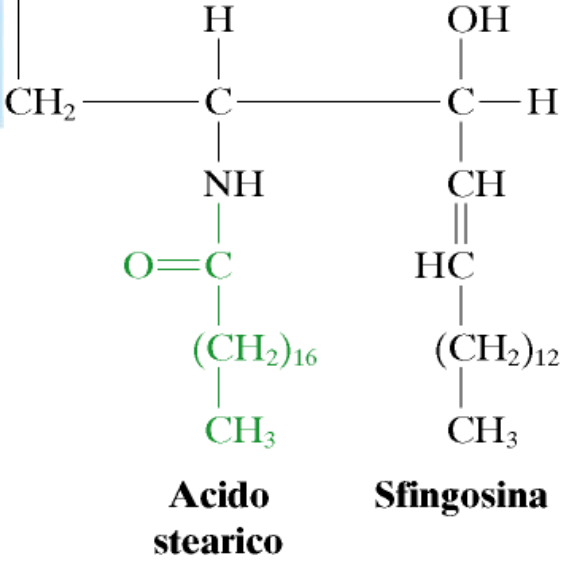
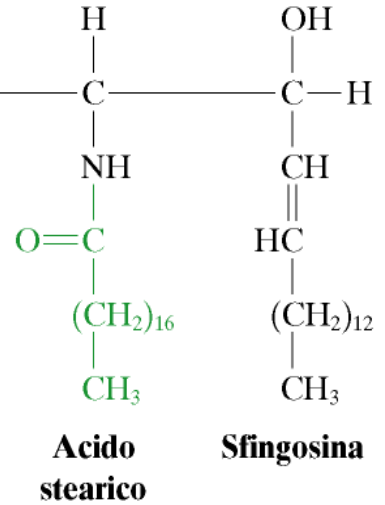
Cerebrosidi: GLUCOSILCERAMMIDE



Glucosio legato con legame β glicosidico



Globosidi: LATTOSILCERAMMIDE



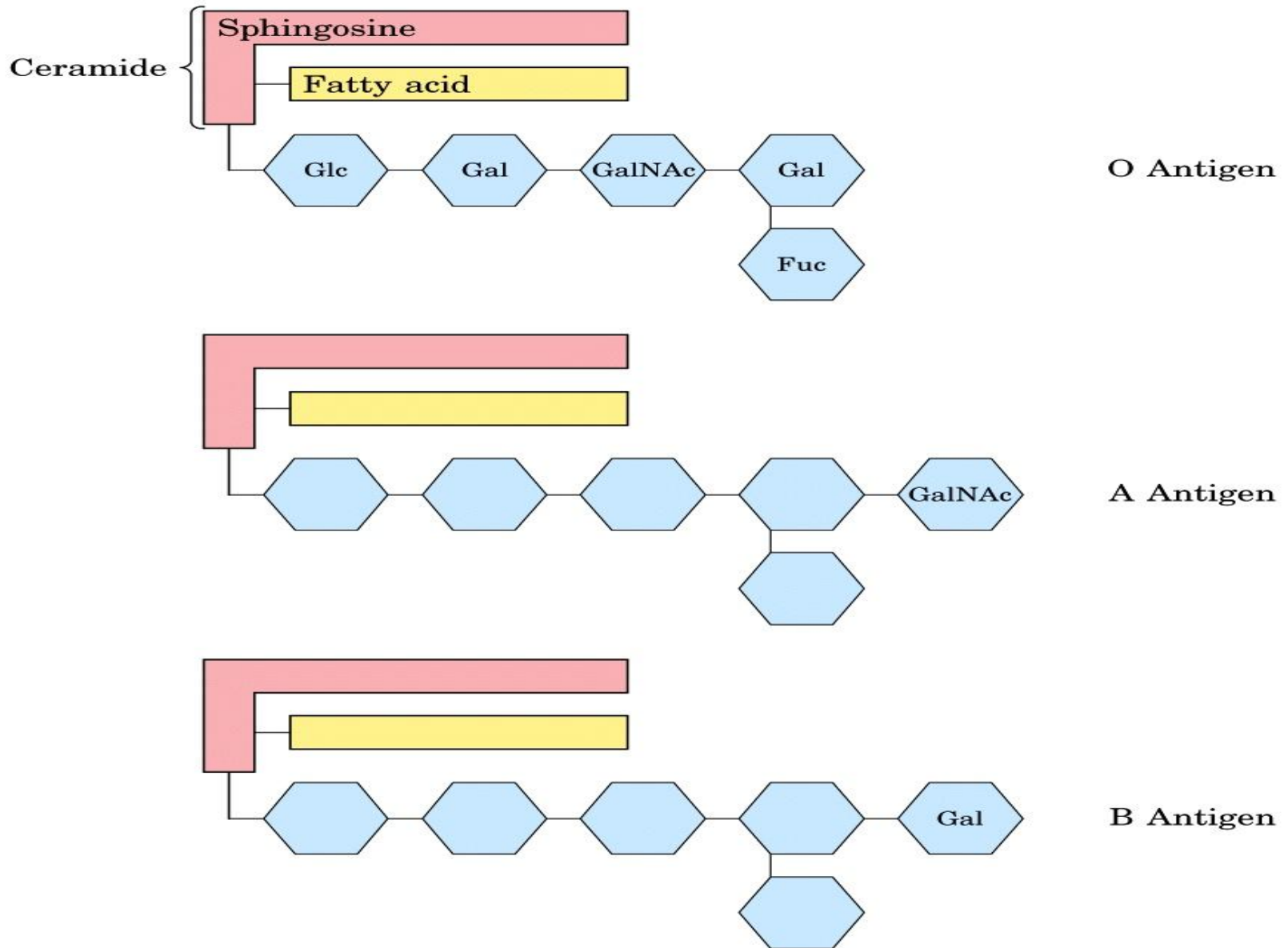
Acido stearico

Sfingosina

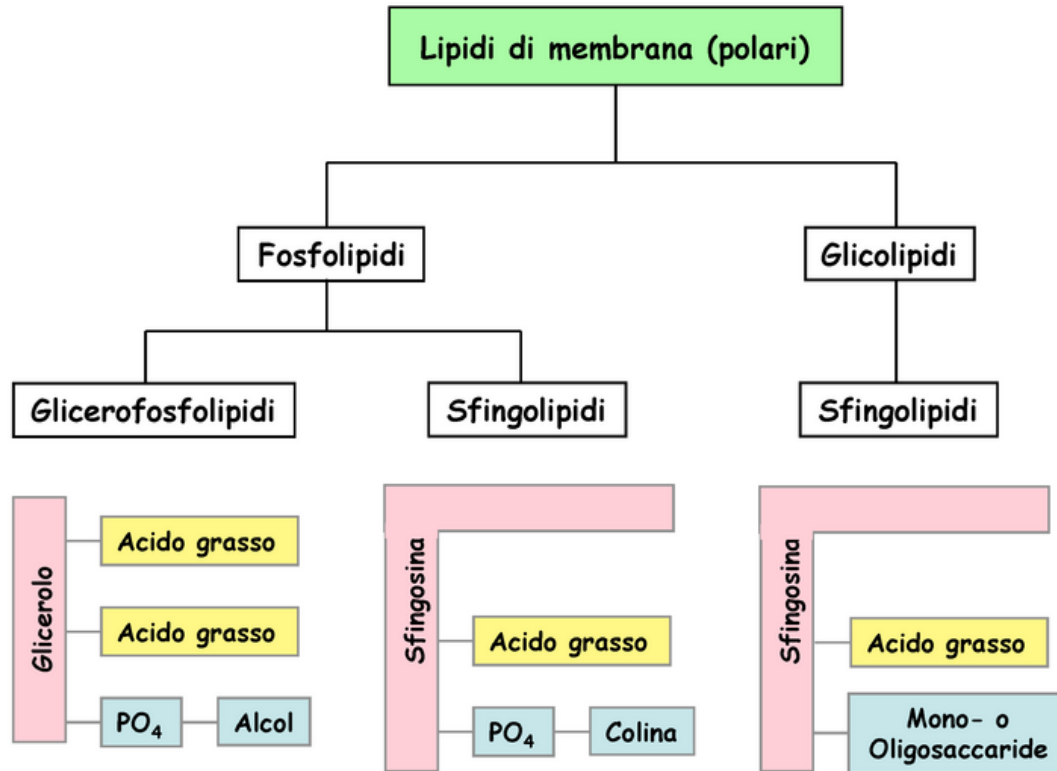
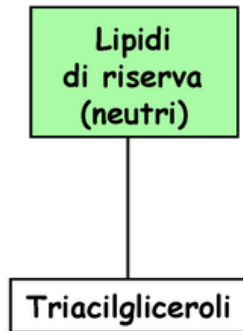
Acido stearico

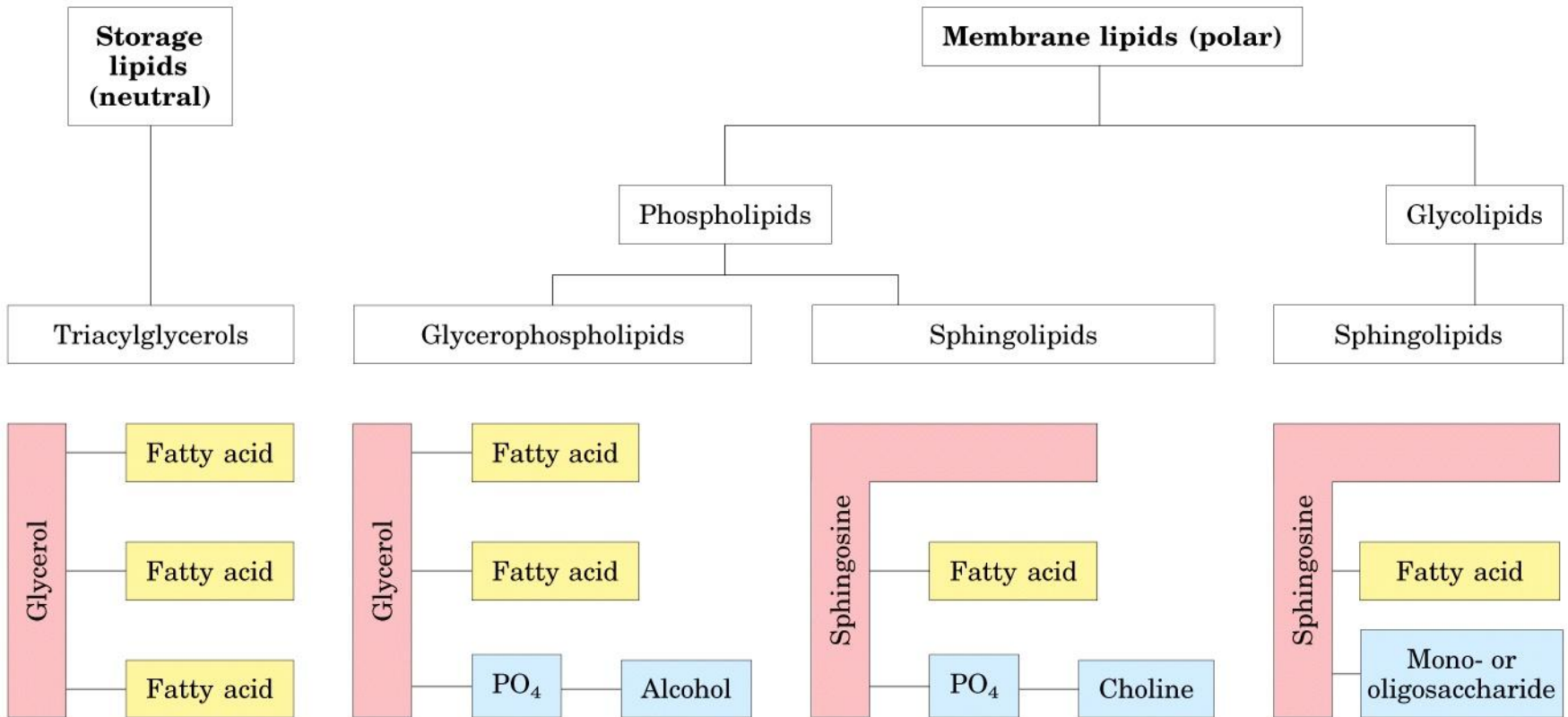
Sfingosina

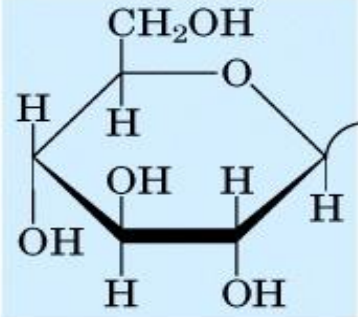

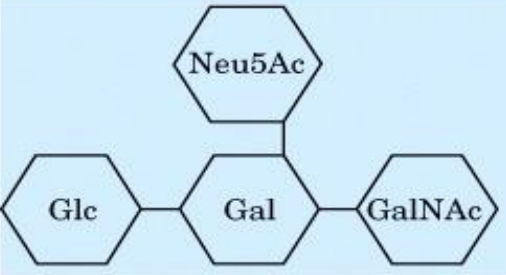
glicosfingolipidi determinanti dei gruppi sanguigni



LIPIDI





Name of sphingolipid	Name of X	Formula of X
Ceramide	—	— H
Sphingomyelin	Phosphocholine	$\begin{array}{c} \text{O} \\ \parallel \\ \text{— P — O — CH}_2\text{— CH}_2\text{— N}^+(\text{CH}_3)_3 \\ \\ \text{O}^- \end{array}$
Neutral glycolipids Glucosylcerebroside	Glucose	
Lactosylceramide (a globoside)	Di-, tri-, or tetrasaccharide	
Ganglioside GM2	Complex oligosaccharide	

3) STEROLI

colesterolo e suoi derivati:

Esteri del colesterolo

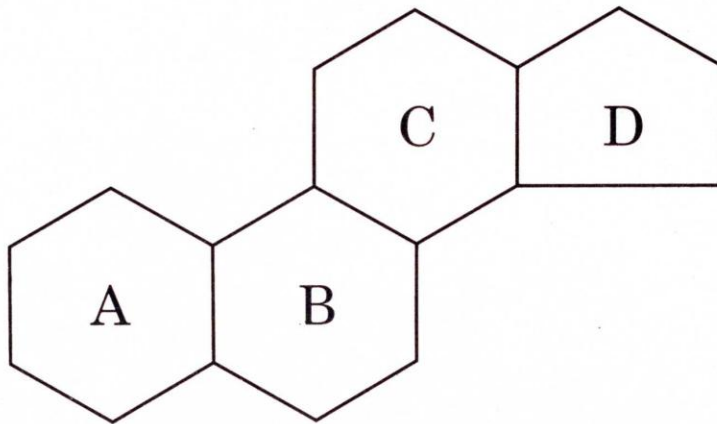
Vitamina D

Ormoni

Acidi biliari

➤ Steroli

- Lipidi strutturali di membrana
- Precursori di acidi biliari
- Precursori di ormoni e vitamine
- Cofattori in molte reazioni



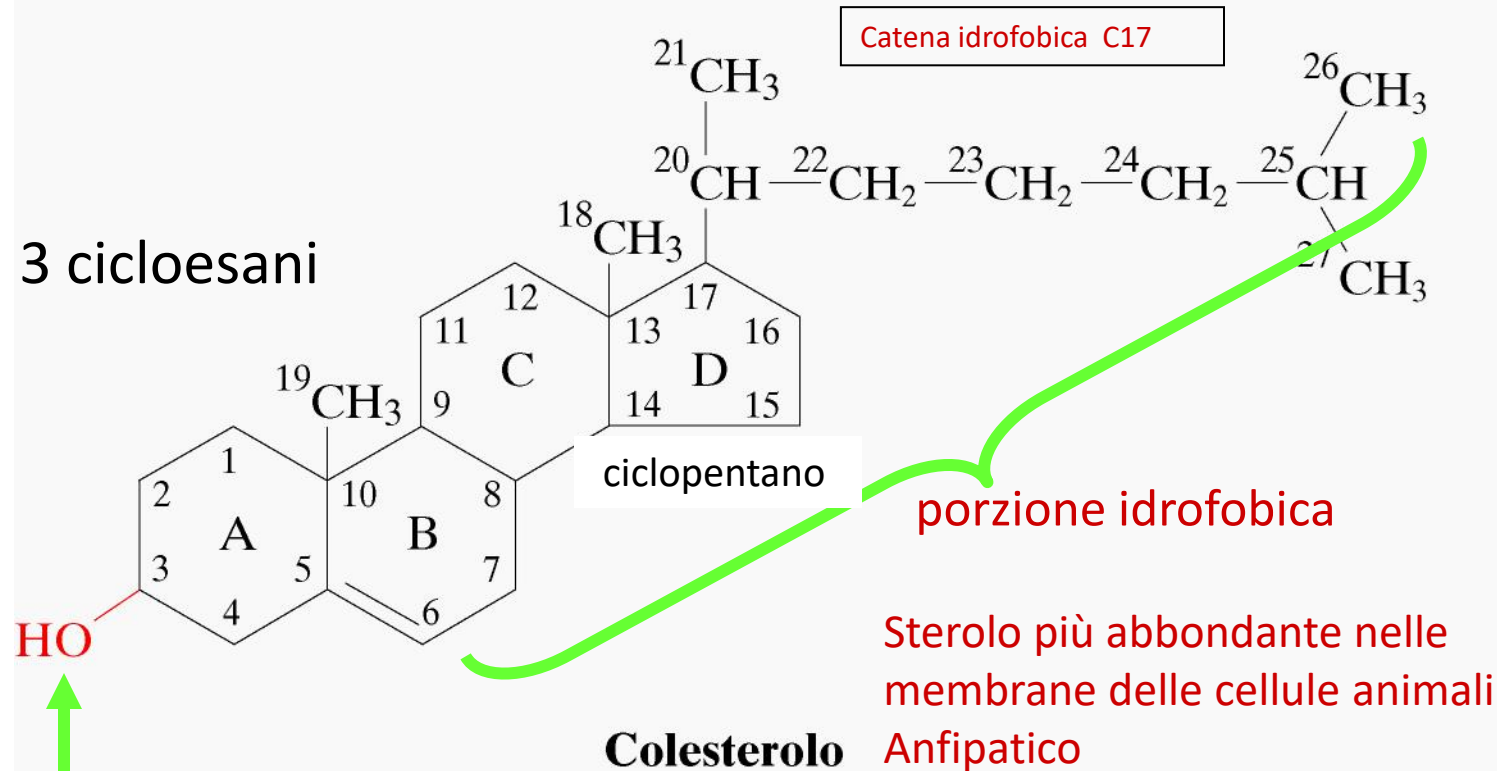
Cyclopentanoperhydrophenanthrene

Anello tetraciclico condensato:
3 cicloesani e
1 ciclopentano

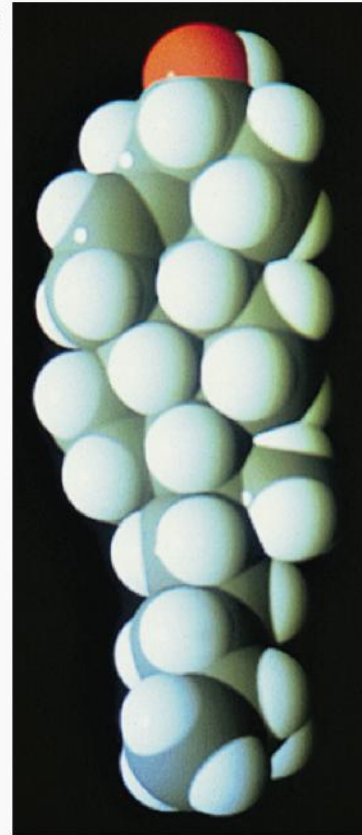
STEROLI

Lipidi strutturali delle membrane plasmatiche
Nucleo steroideo, rigido e planare

(a)



(b)



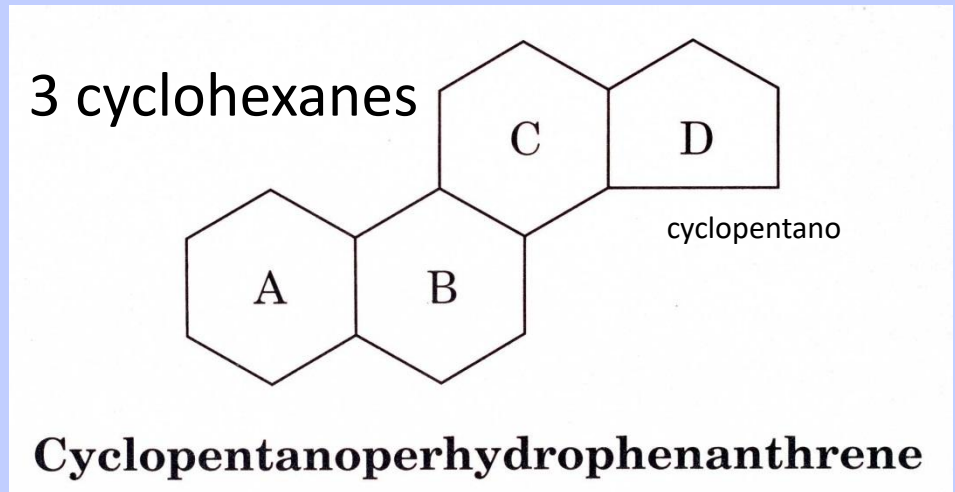
Testa polare.

Il colesterolo libero è esterificato in questa posizione con un ac. grasso

Nelle piante = stigmasterolo
Nei funghi = ergosterolo

Cholesterol

Componente delle membrane



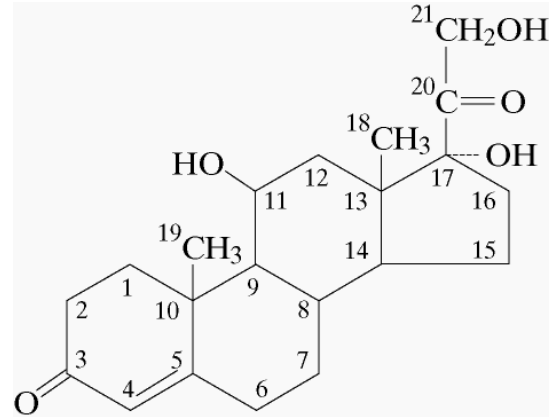
È chiaramente essenziale per la vita, ma la sua deposizione nelle arterie è stata associata a malattie cardiovascolari e ictus, due delle principali cause di morte negli esseri umani.

Steroli : precursori degli ormoni steroidei

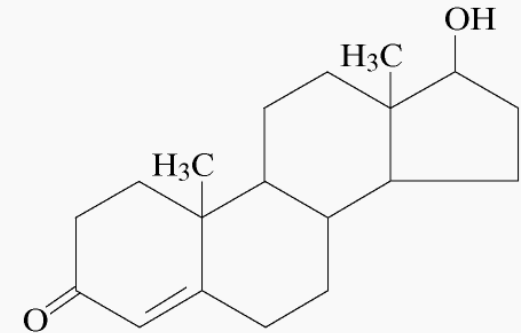
ORMONI STEROIDEI =
controllano la funzionalità di
diversi organi e regolano
l'espressione genica, il
metabolismo, la
riproduzione...

.Classificati in:

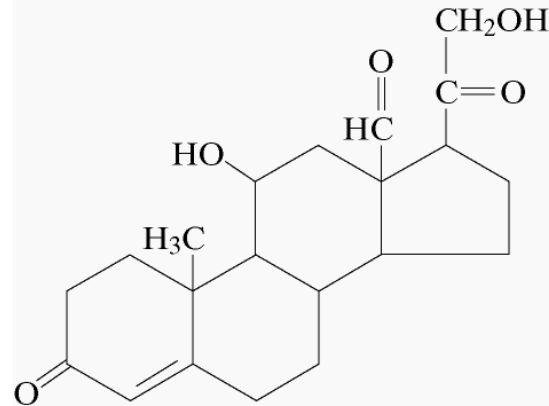
- Glucocorticoidi
- Mineralcorticoidi
- Androgeni and estrogeni



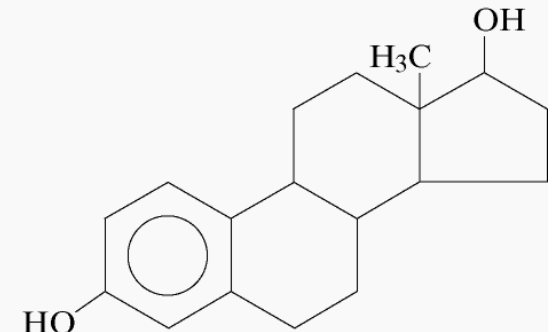
Cortisolo (idrocortisone)
(un glucocorticoide)



Testosterone
(un androgeno)



Aldosterone
(un mineralcorticoide)

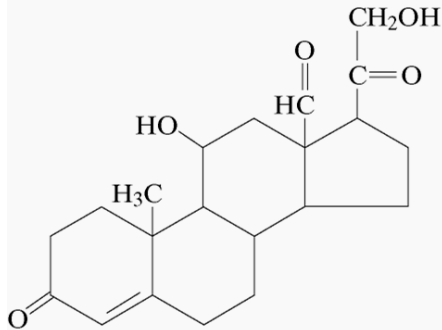


β-Estradiolo
(un estrogeno)

Ormoni Steroidei

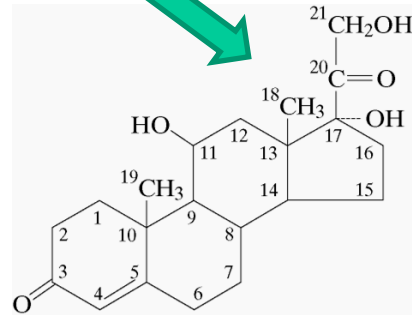
Adrenal cortex produce at least 50 different adrenocortical steroid

Corteccia surrenale



Aldosterone
(un mineralcorticoide)

- Regolano l'escrezione dell'acqua e dei Sali mediante i reni
- Contribuiscono nella regolazione della pressione sanguigna e dell'equilibrio elettrolitico.

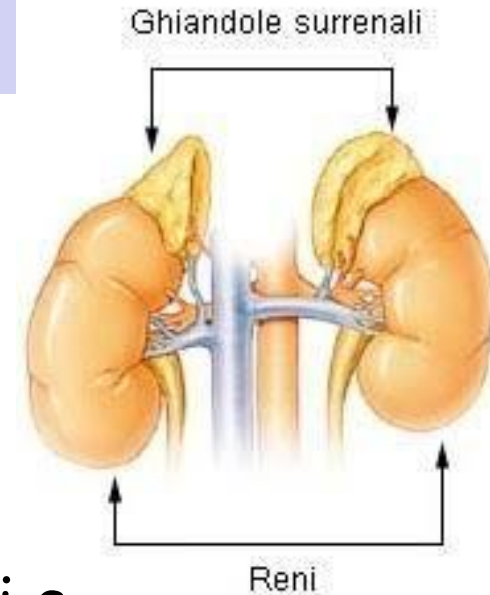


Cortisolo (idrocortisone)
(un glucocorticoide)

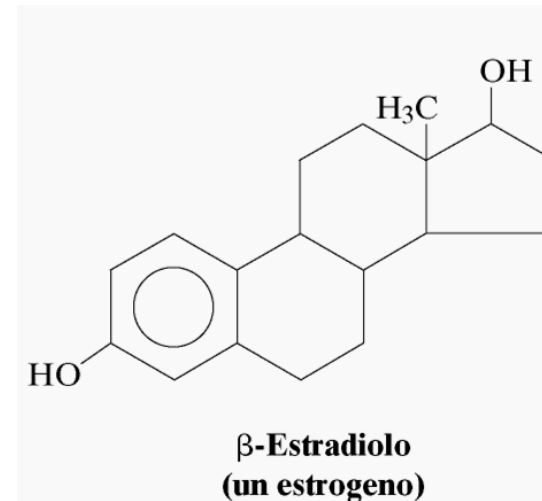
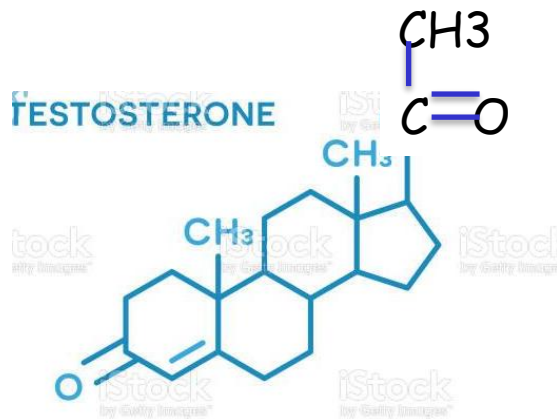
Regolazione del metabolismo e la soppressione del sistema immunitario.

- **La parte midollare** produce le catecolamine adrenalina e noradrenalina che servono per avere una risposta rapida di tutto l'organismo nelle situazioni di stress.

- **Androgeni e estrogeni**



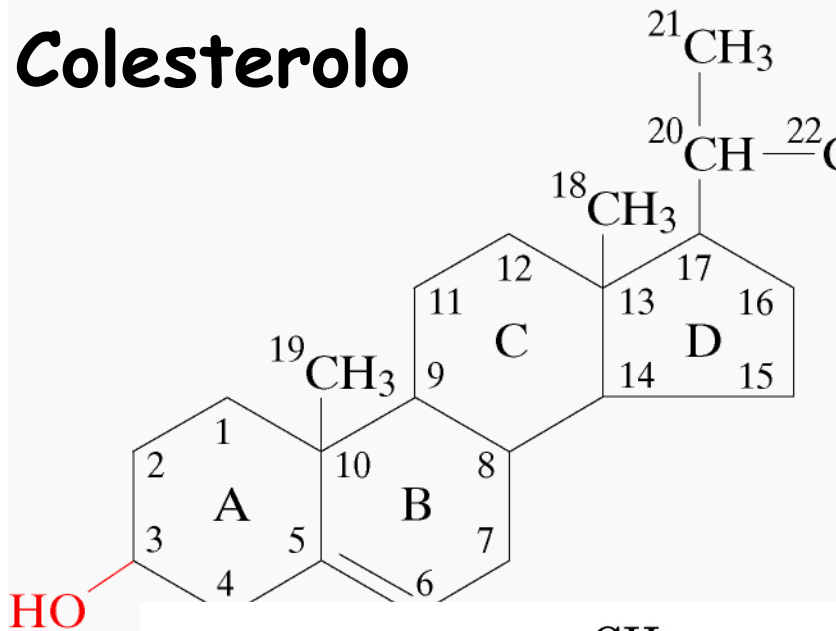
- **Androgeni e estrogeni**
- (produced by testes and ovaries)
- (affect sexual development and function.)



Sali biliari: derivati dal colesterolo

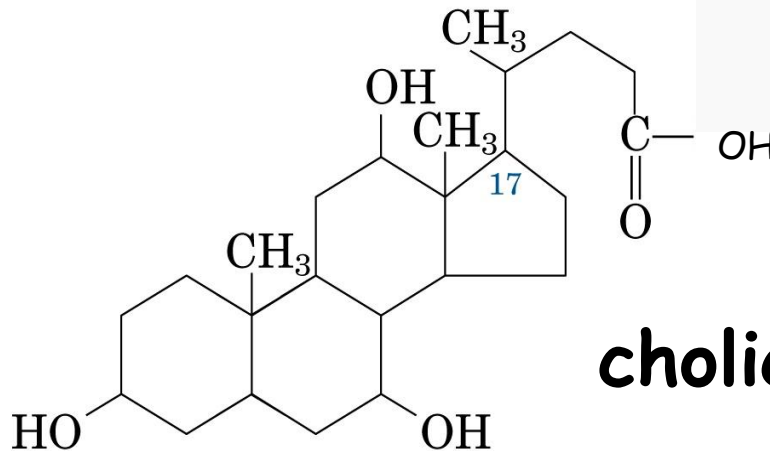
(a)

Colesterolo



- 500-600 grams of cholesterol per day is sent to the intestine by bile

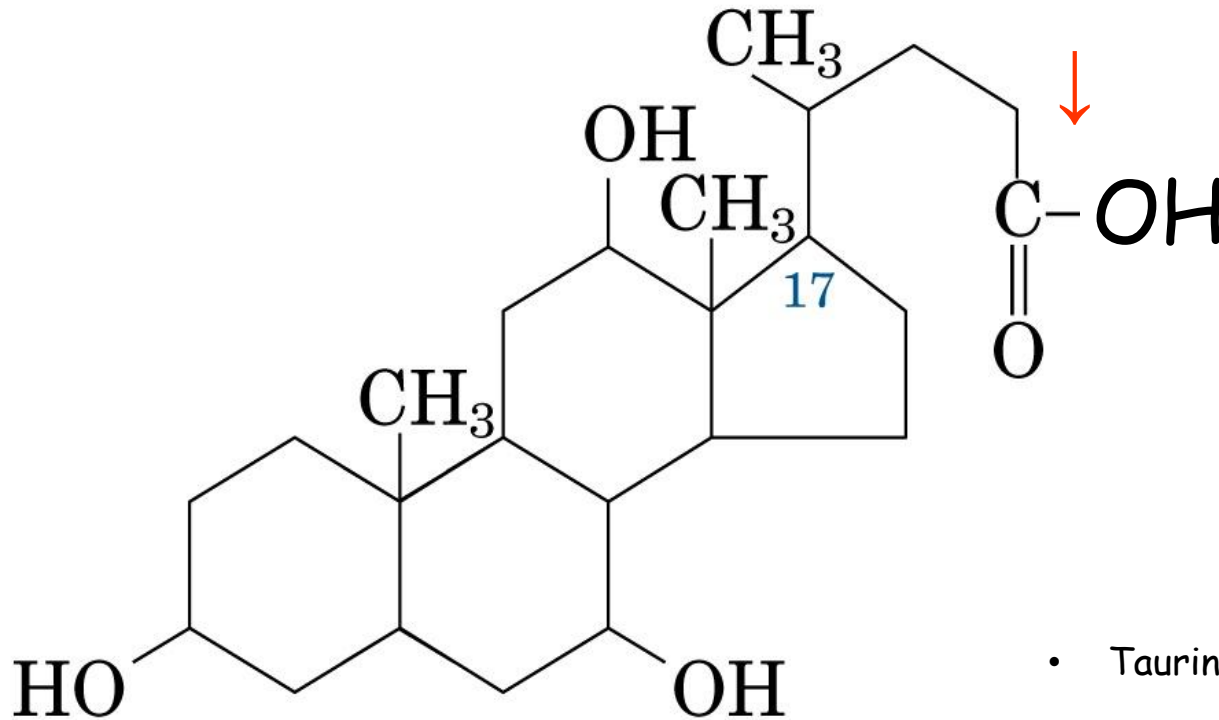
- A glycine or taurine molecule is bound to the COOH



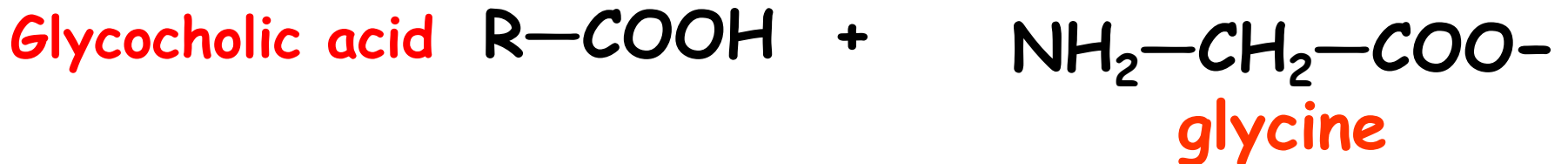
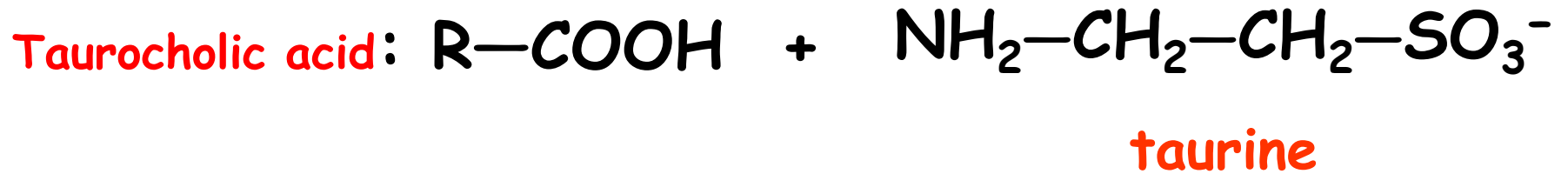
Steroid nucleus is hydroxylated at C7 and the chain is shortened and carboxylated

cholic acid

Bile salts: cholic acid + taurine o glycine

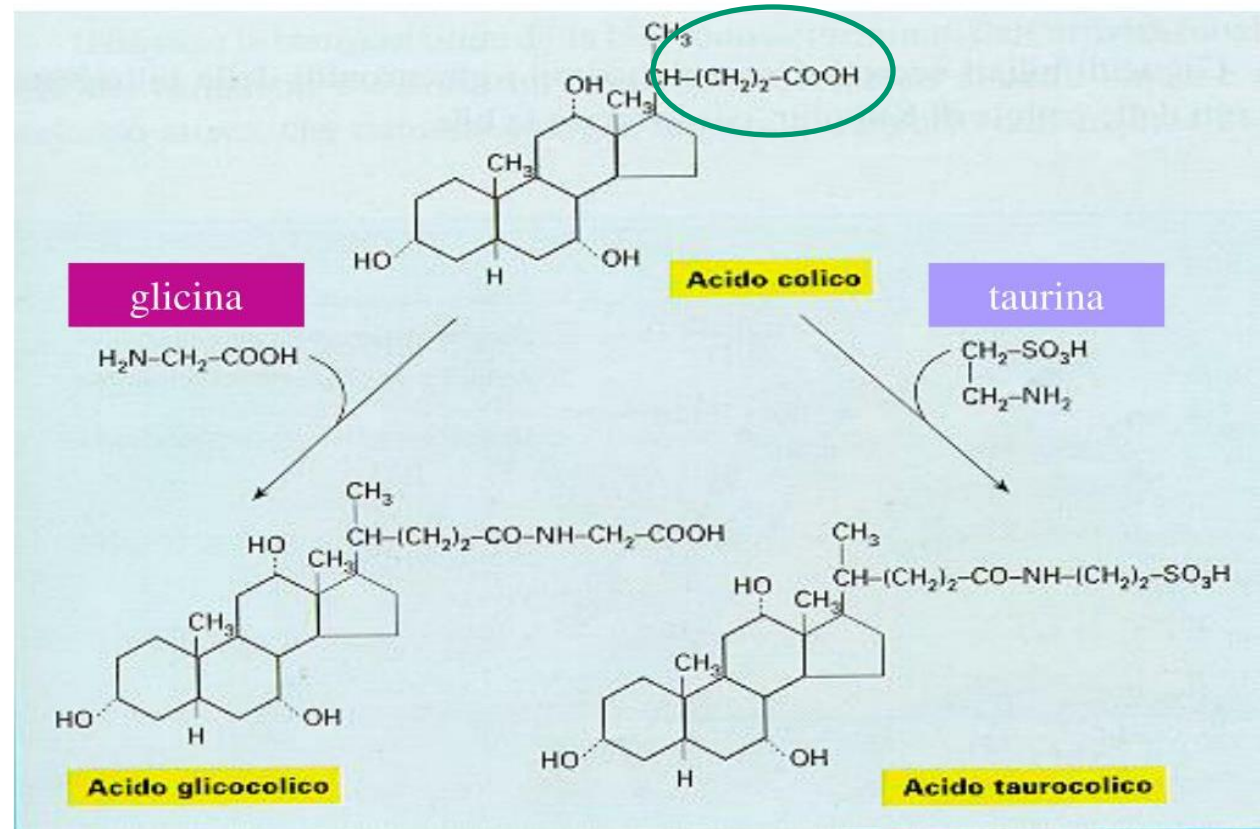


- Taurine is an amine with a sulfonic group



Sali biliari: acidi colici + taurina o glicina

SALI BILIARI = prodotti dal fegato, immagazzinati nella cistifellea e liberati nell'intestino durante la digestione agiscono come detergenti dei grassi favorendo a loro degradazione



Gli acidi glicocolico e taurocolico derivano dalla coniugazione dell'acido colico rispettivamente con glicina e taurina (analogamente per gli acidi glicochenodesossicolico e taurochenodesossicolico).

