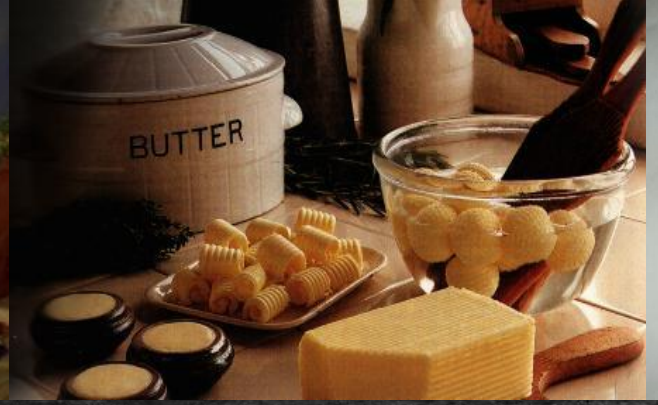
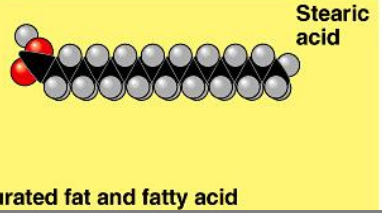
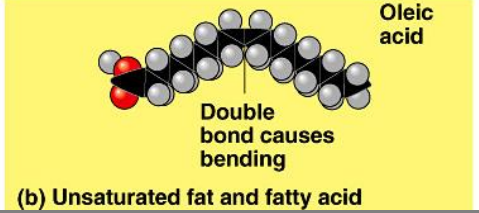

BUTTER


BRING OUT THE BEST
HELLMANN'S
REAL
MAYONNAISE

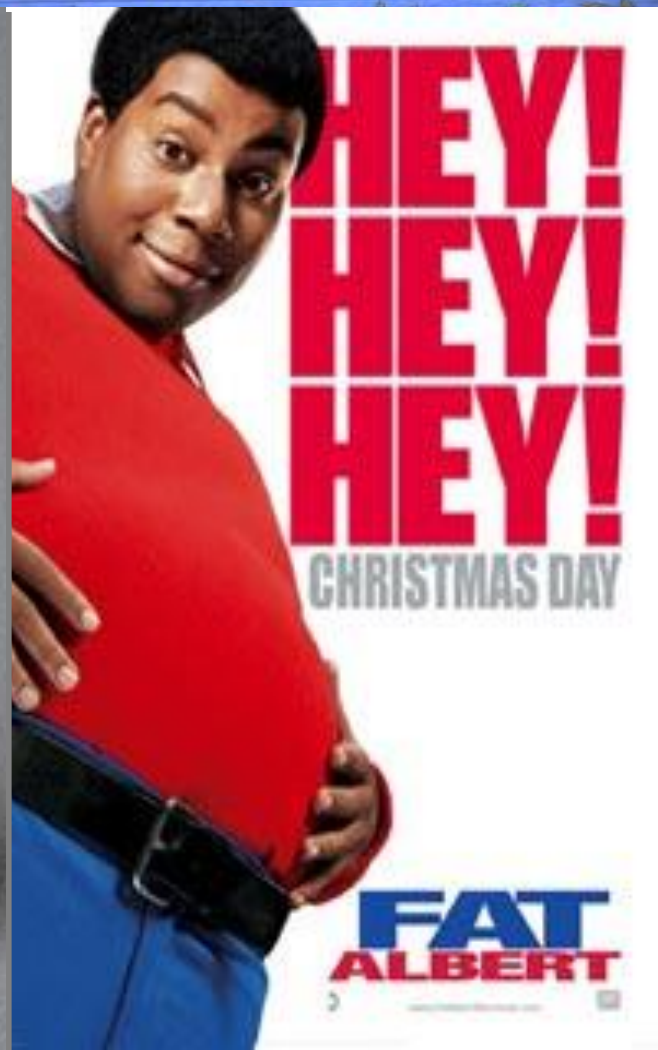

WHOLE KIDS
ORGANIC
SMOOTH
Peanut Butter
WHOLE KIDS
ORGANIC
CRUNCHY
Peanut Butter

Lipids


Stearic acid
(a) Saturated fat and fatty acid

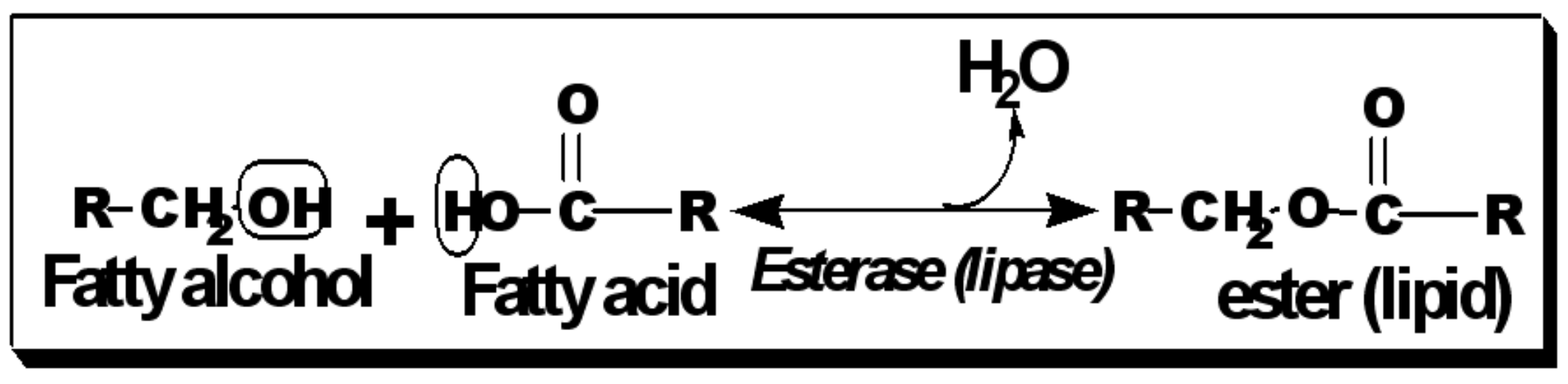

Oleic acid
Double bond causes bending
(b) Unsaturated fat and fatty acid


BUTTER
NET WT. 4 OZ. (113g)
1 FIRST QUALITY 1
LOWEST IN SATURATED FAT
Spectrum
NATURALS
PURE PRESSED
CANOLA OIL


HEY!
HEY!
HEY!
CHRISTMAS DAY
FAT
ALBERT

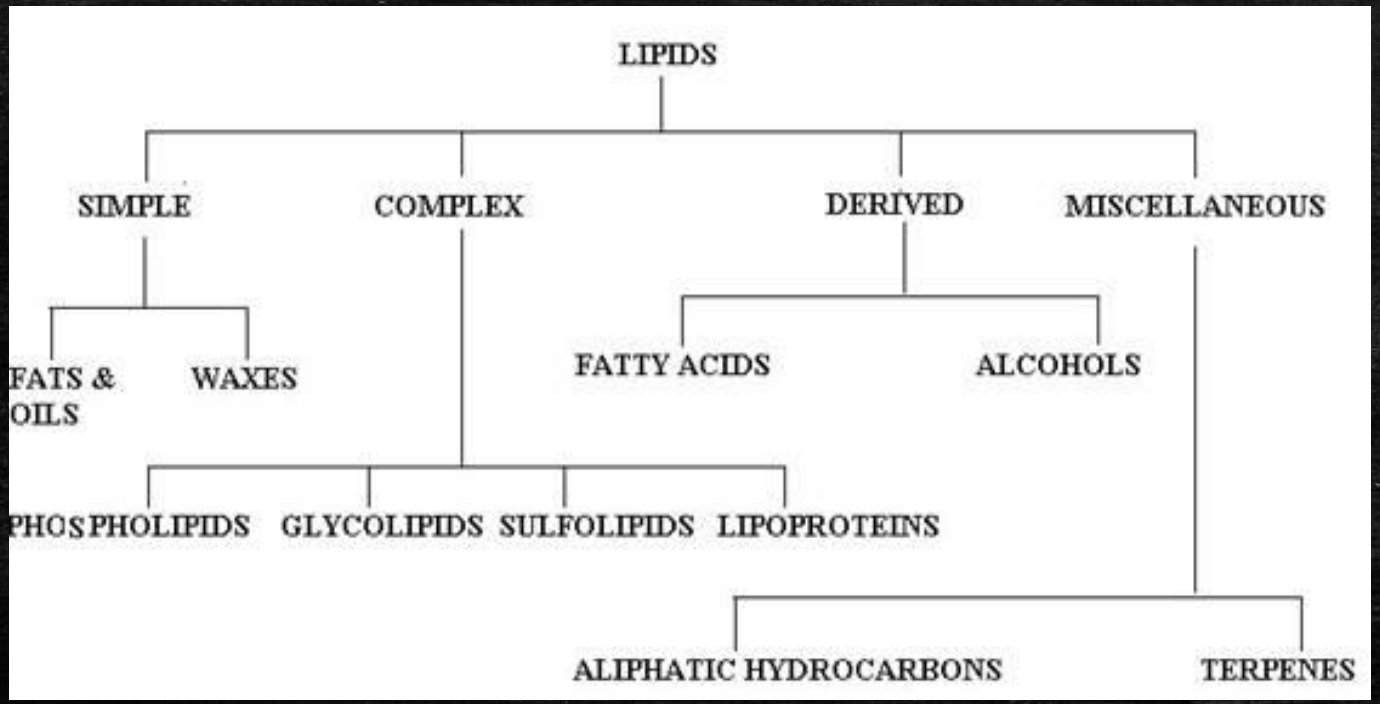
Definition & General Properties

- A heterogeneous class of naturally occurring organic compounds
- Amphipathic
- Insoluble



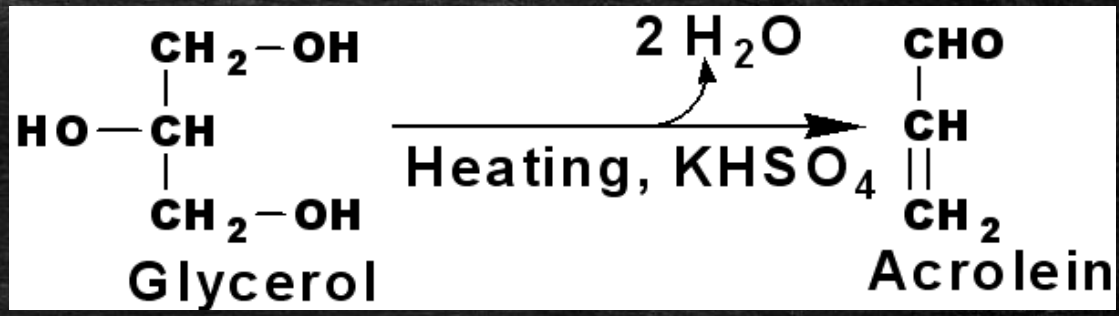
Classification

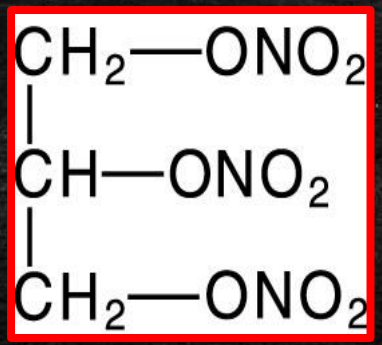
- Open chain vs. cyclic structures
- Simple vs. compound, conjugated, and complex lipids
- Function: storage, support, signaling



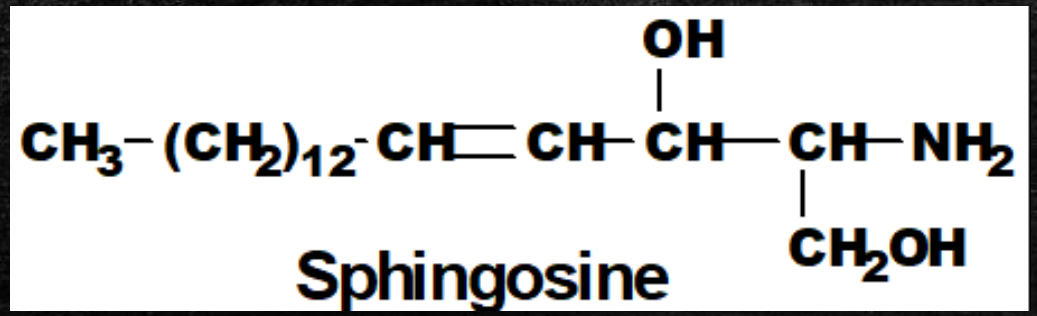
Alcohols

- Glycerol: glycerin, glucose derived
  - Colorless viscous oily liquid with sweet taste
  - Heating
  - Trinitroglycerin
  - Esterification (mono, di, and triglycerides)
- Sphingosine
  - Monohydric
  - Serine & palmitic acid

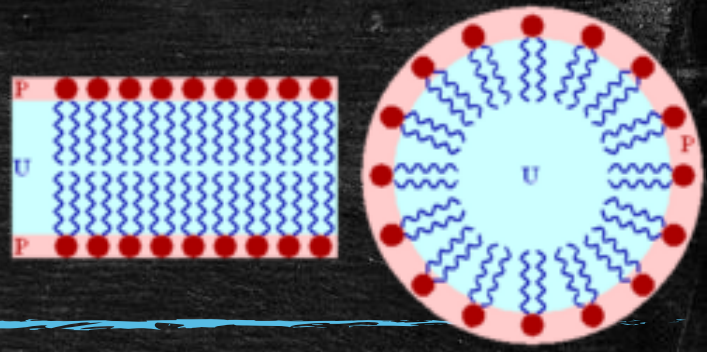




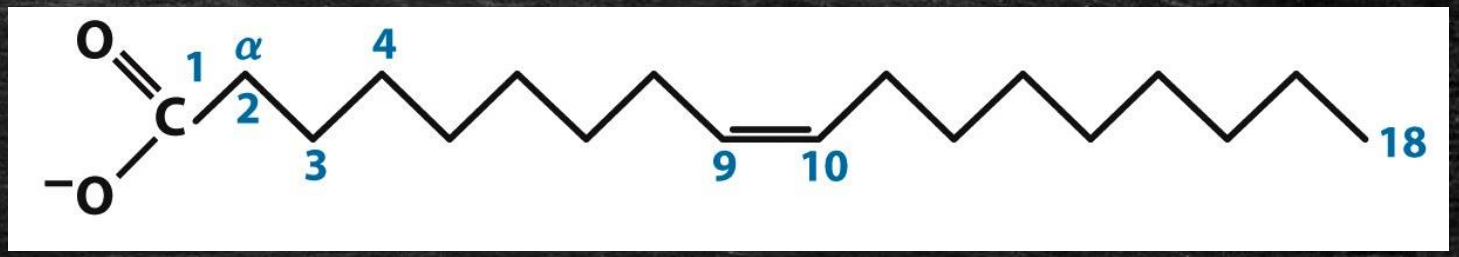
Trinitroglycerin

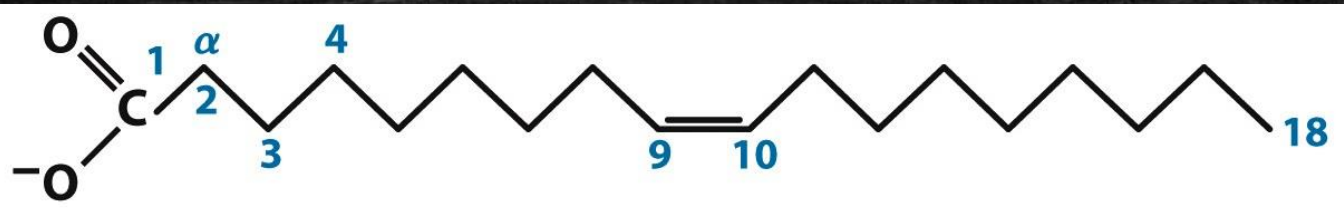


Fatty Acids

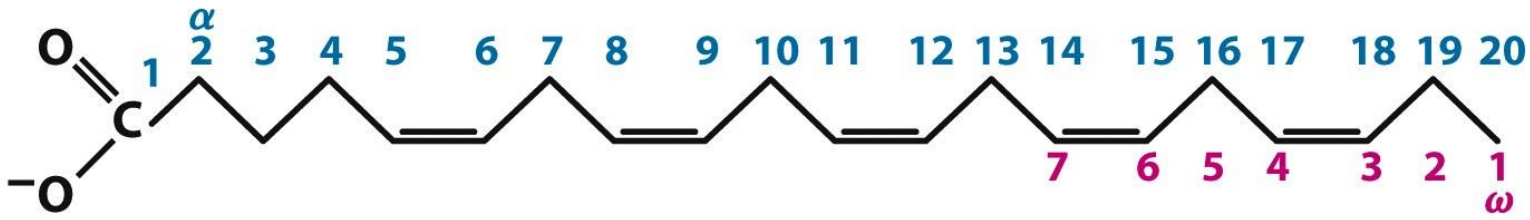


- Open chain mono-carboxylic acids
- R-(CH2)n-COOH (n mostly even)
- Mostly straight chain
- Saturated vs. unsaturated (cis)
- Naming





(a) 18:1(Δ^9) *cis*-9-Octadecenoic acid



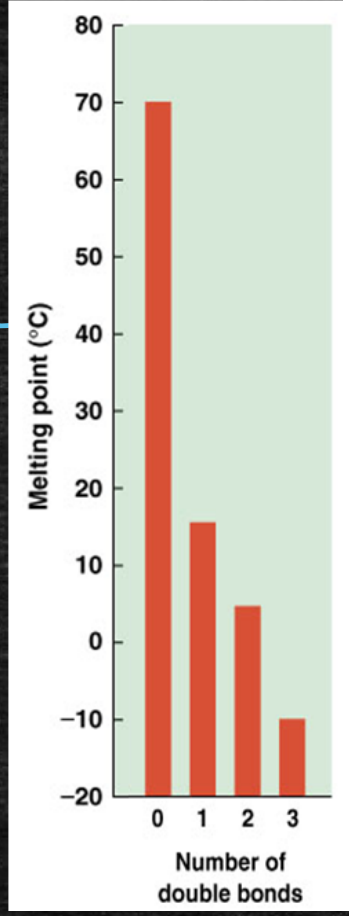
(b) 20:5($\Delta^{5,8,11,14,17}$) Eicosapentaenoic acid (EPA), an omega-3 fatty acid

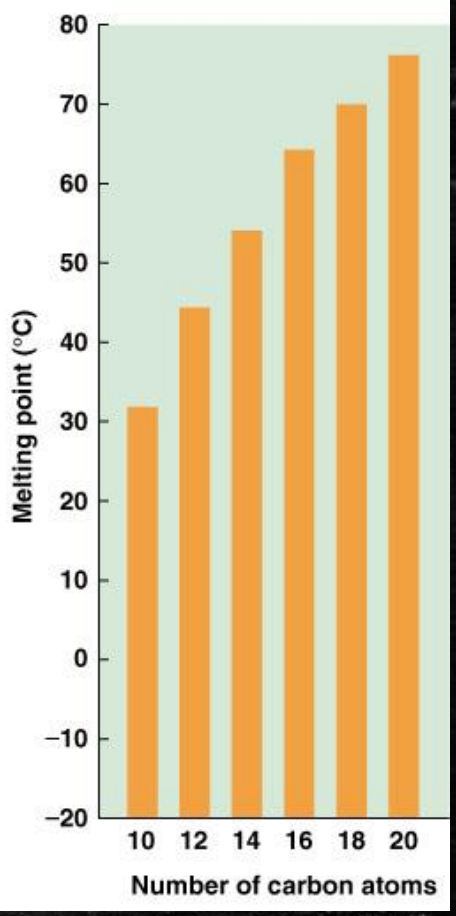
Physical Properties

- Solubility and melting point

Typical Naturally Occurring Saturated Fatty Acids

Acid	Number of Carbon Atoms	Formula	Melting Point (°C)
Lauric	12	$CH_3(CH_2)_{10}CO_2H$	44
Myristic	14	$CH_3(CH_2)_{12}CO_2H$	58
Palmitic	16	$CH_3(CH_2)_{14}CO_2H$	63
Stearic	18	$CH_3(CH_2)_{16}CO_2H$	71
Arachidic	20	$CH_3(CH_2)_{18}CO_2H$	77





Typical Naturally Occurring Unsaturated Fatty Acids

Acid	Number of Carbon Atoms	Degree of Unsaturation*	Formula	Melting Point (°C)
Palmitoleic	16	16:1—Δ^9	$CH_3(CH_2)_5CH{=}CH(CH_2)_7CO_2H$	−0.5
Oleic	18	18:1—Δ^9	$CH_3(CH_2)_7CH{=}CH(CH_2)_7CO_2H$	16
Linoleic	18	18:2—$\Delta^{9,12}$	$CH_3(CH_2)_4CH{=}CH(CH_2)CH{=}CH(CH_2)_7CO_2H$	−5
Linolenic	18	18:3—$\Delta^{9,12,15}$	$CH_3(CH_2CH{=}CH)_3(CH_2)_7CO_2H$	−11
Arachidonic	20	20:4—$\Delta^{5,8,11,14}$	$CH_3(CH_2)_4CH{=}CH(CH_2)_4(CH_2)_2CO_2H$	−50

Classification (saturated)

SHORT CHAIN

- They are liquid in nature
- Water-soluble
- Volatile at room temperature
- Examples: acetic, butyric, & caproic acids

Acetic F.A. (2C) CH_3-$COOH$
Butyric F.A. (4C) CH_3-$(CH_2)_2$-$COOH$
Caproic F.A. (6C) CH_3-$(CH_2)_4$-$COOH$

MEDIUM CHAIN

- Solids at room temperature
- Water-soluble
- Non-volatile at room temperature
- Examples: caprylic & capric F.A.

Caprylic (8 C) CH_3-$(CH_2)_6$-$COOH$
Capric (10 C) CH_3-$(CH_2)_8$-$COOH$

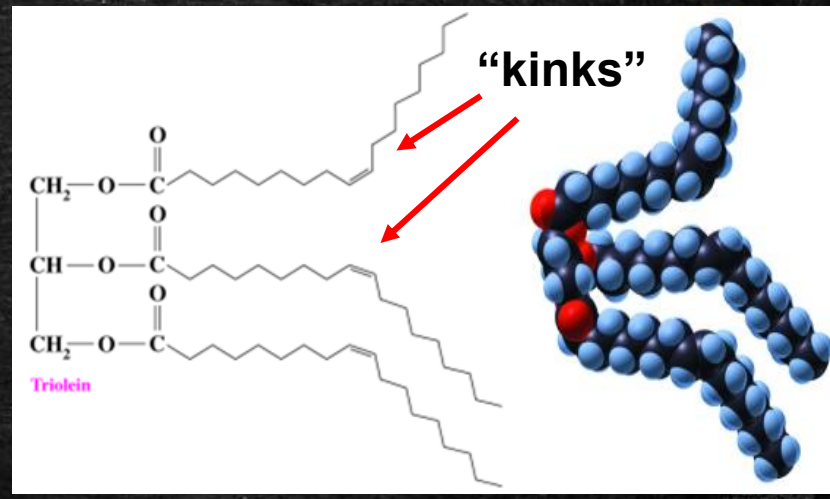
LONG CHAIN

- Occur in hydrogenated oils, animal fats, butter & coconut & palm oils
- Non-volatile & water-insoluble
- Examples: palmitic, stearic, & lignoceric F.A.

Palmitic (16C) CH_3-$(CH_2)_{14}$-$COOH$
Stearic (18 C) CH_3-$(CH_2)_{16}$-$COOH$
Lignoceric (24C) CH_3-$(CH_2)_{22}$-$COOH$

Classification (unsaturated)

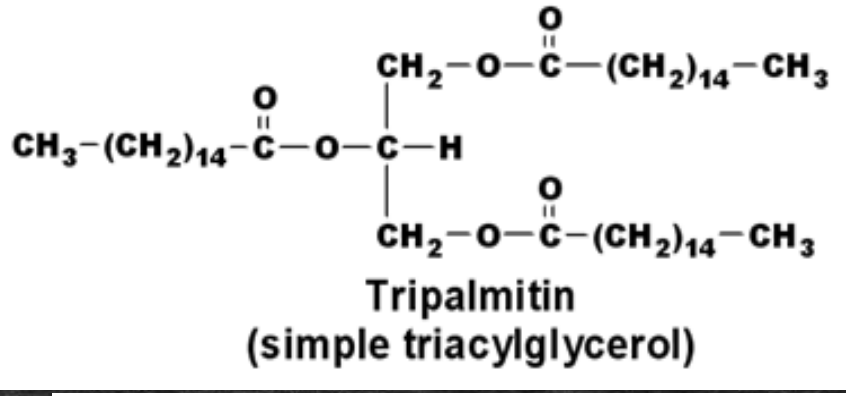
- Monounsaturated: Palmitoleic acid, Oleic acid
- Polyunsaturated:
  - More than one double bond
  - Essential fatty acids
  - Linoleic, Linolenic, and Arachidonic
  - $C18{:}2\Delta^{9,12}$
  - $C18{:}3\Delta^{9,12,15}$
  - $C20{:}4\Delta^{5,8,11,14}$
- Do not pack closely (Cis)

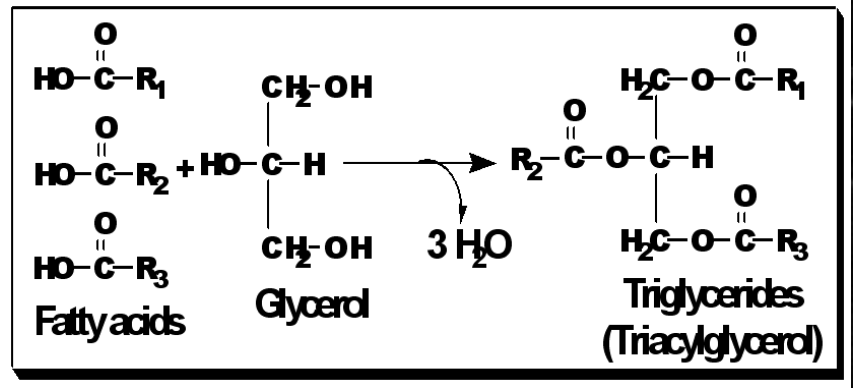


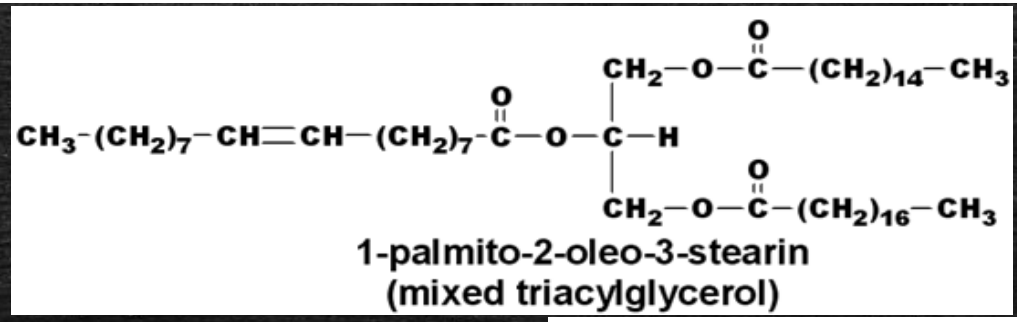
$CH_3\text{-}(CH_2)_5CH=CH\text{-}(CH_2)_7\text{–}COOH$

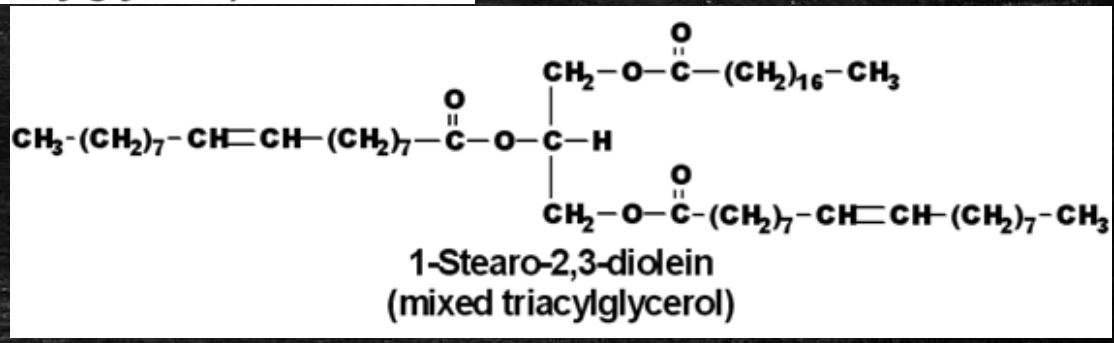
$CH_3\text{-}(CH_2)_7\text{-}CH=CH\text{–}(CH_2)_7\text{-}COOH$

Simple lipids
Neutral - TAGs

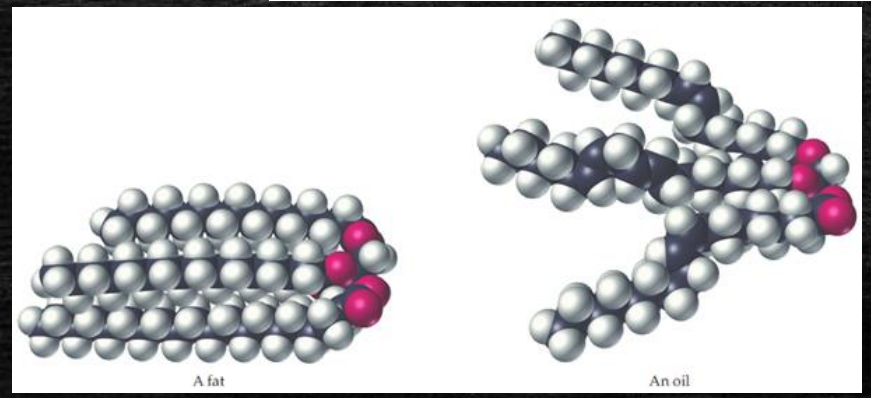






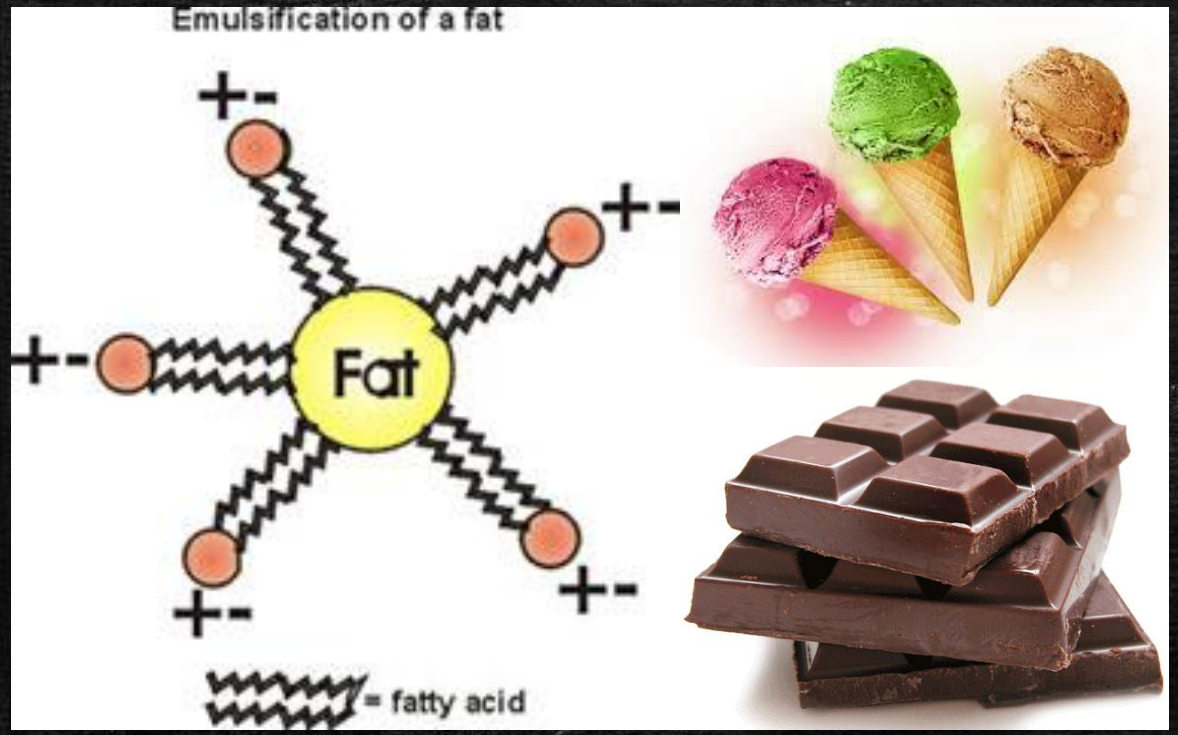


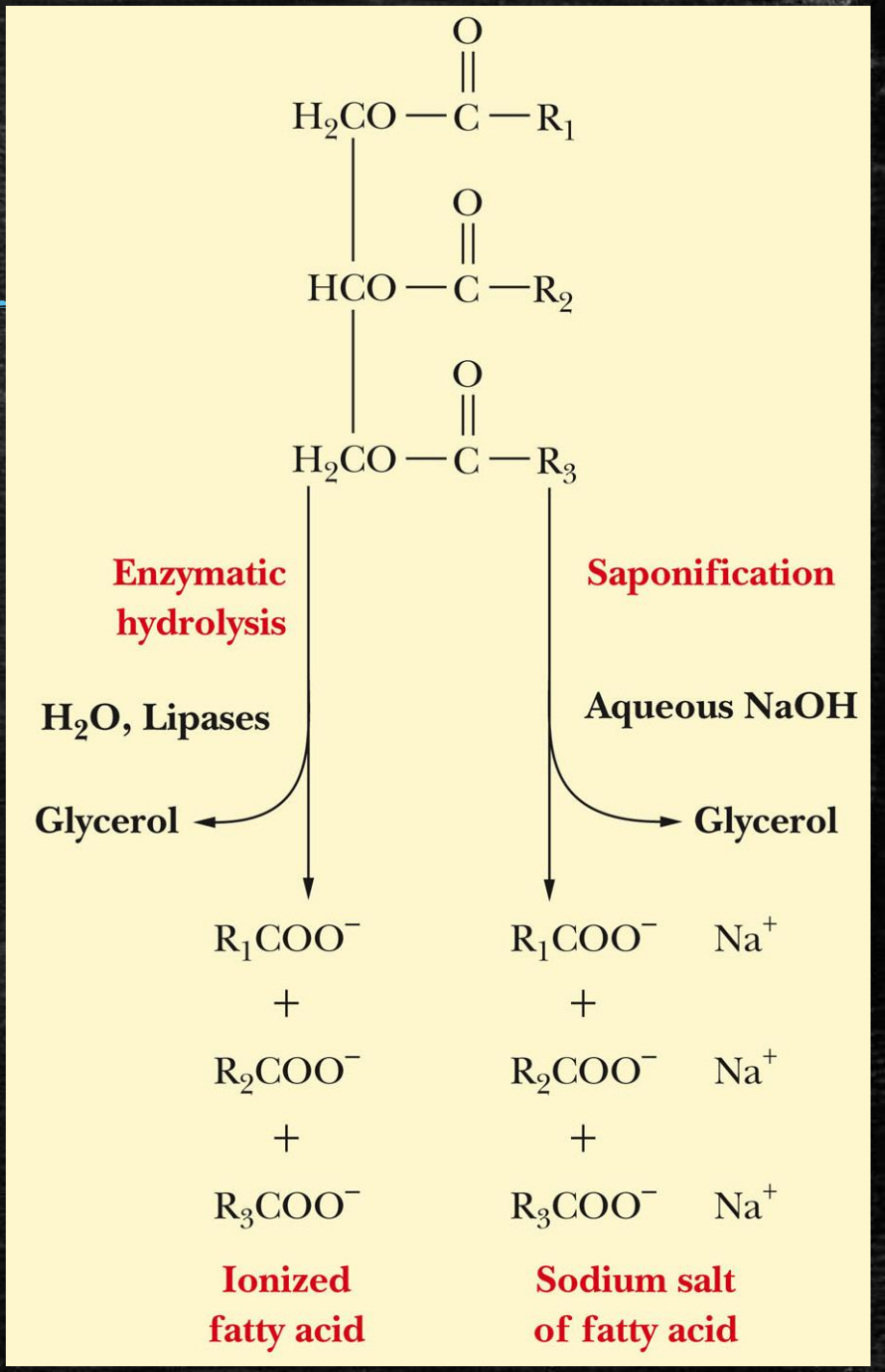
- Uncharged due to absence of ionizable groups in it
- Most abundant lipids in nature
- Either **simple or mixed**
- Physical:
  - Colorless, odorless & tasteless
  - Specific gravity less than 1
  - Insoluble
  - At room temp. (oils or fat)



Chemical reactions

- Hydrolysis and saponification (emulsification)

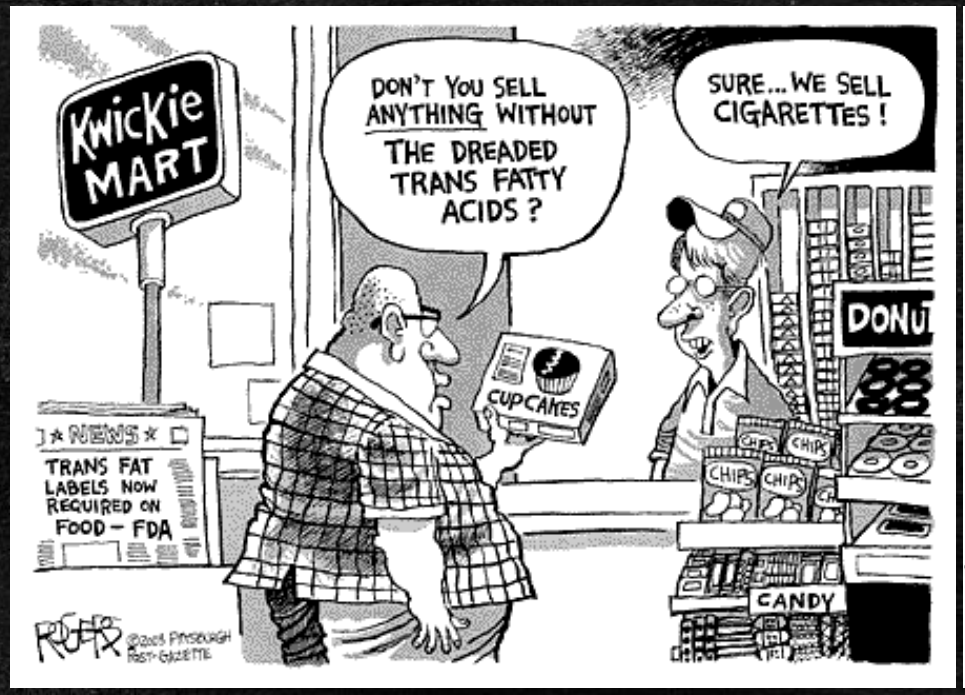


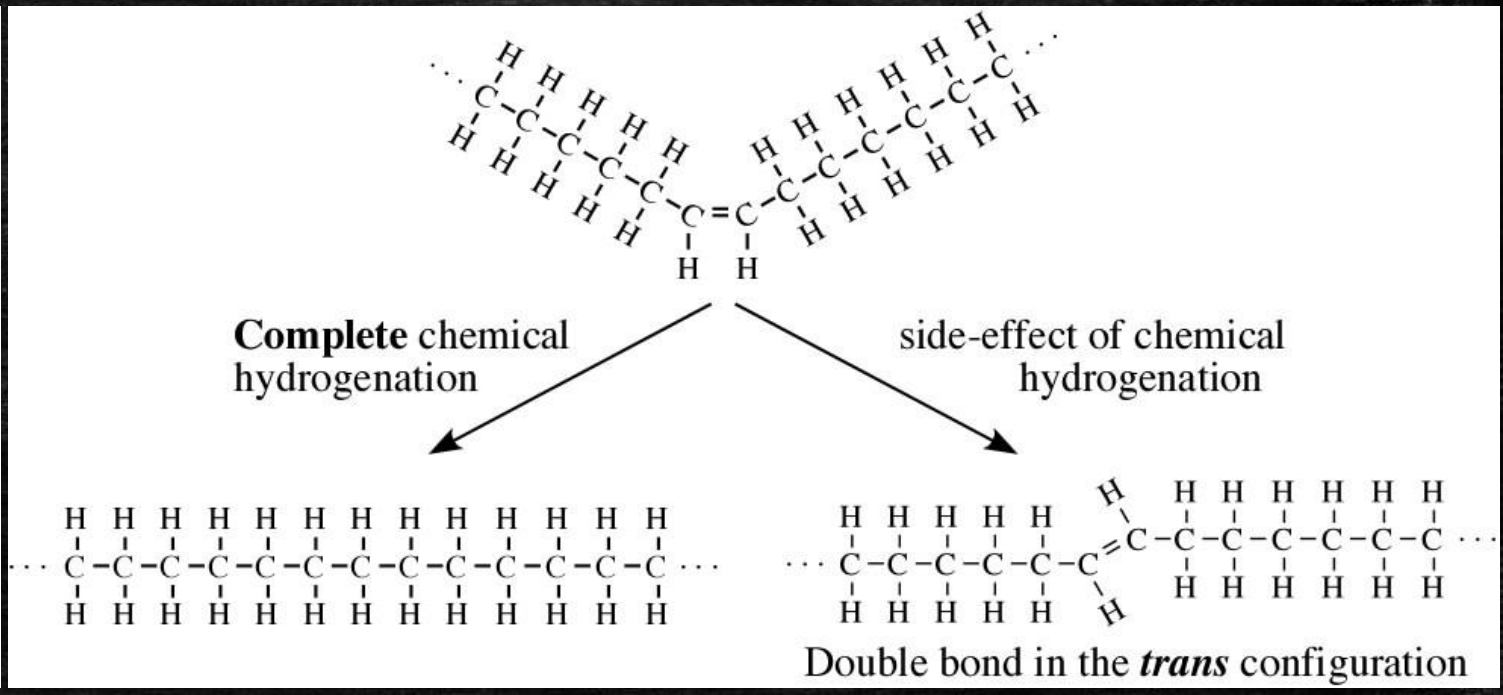


Chemical reactions

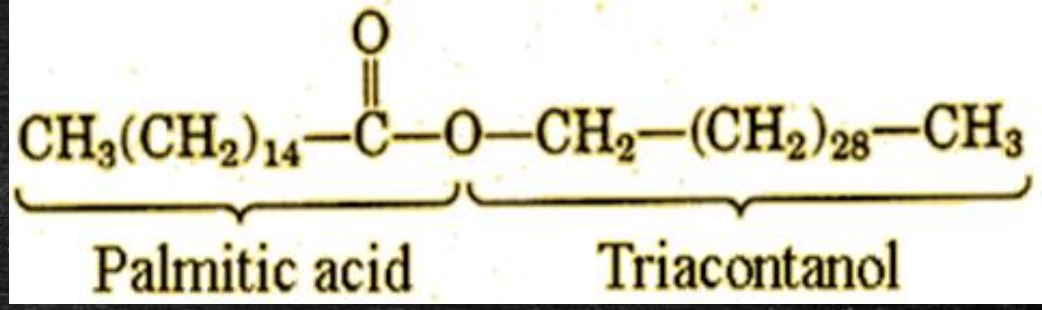
Oils (liquid) (with unsaturated fatty acids, e.g., oleic) —*Hydrogen, high pressure, nickel*→ Hard fat (margarine, solid) (with saturated fatty acids, e.g., stearic)

- Hydrogenation: margarine manufacturing





Simple lipids
Neutral - waxes



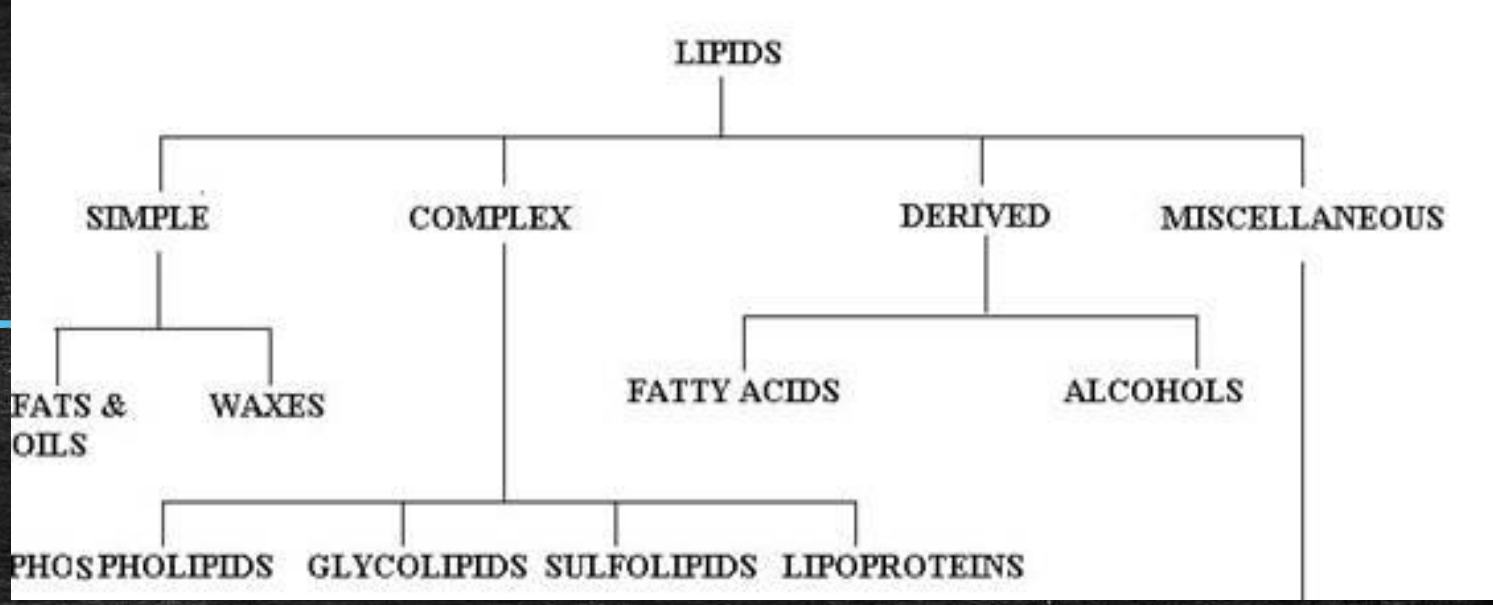
- A monohydric alcohol (C16 ~ C30, higher molecular weight than glycerol) esterified to long-chain fatty acids (C14 ~ C36)
- Insoluble, indigestible, coatings

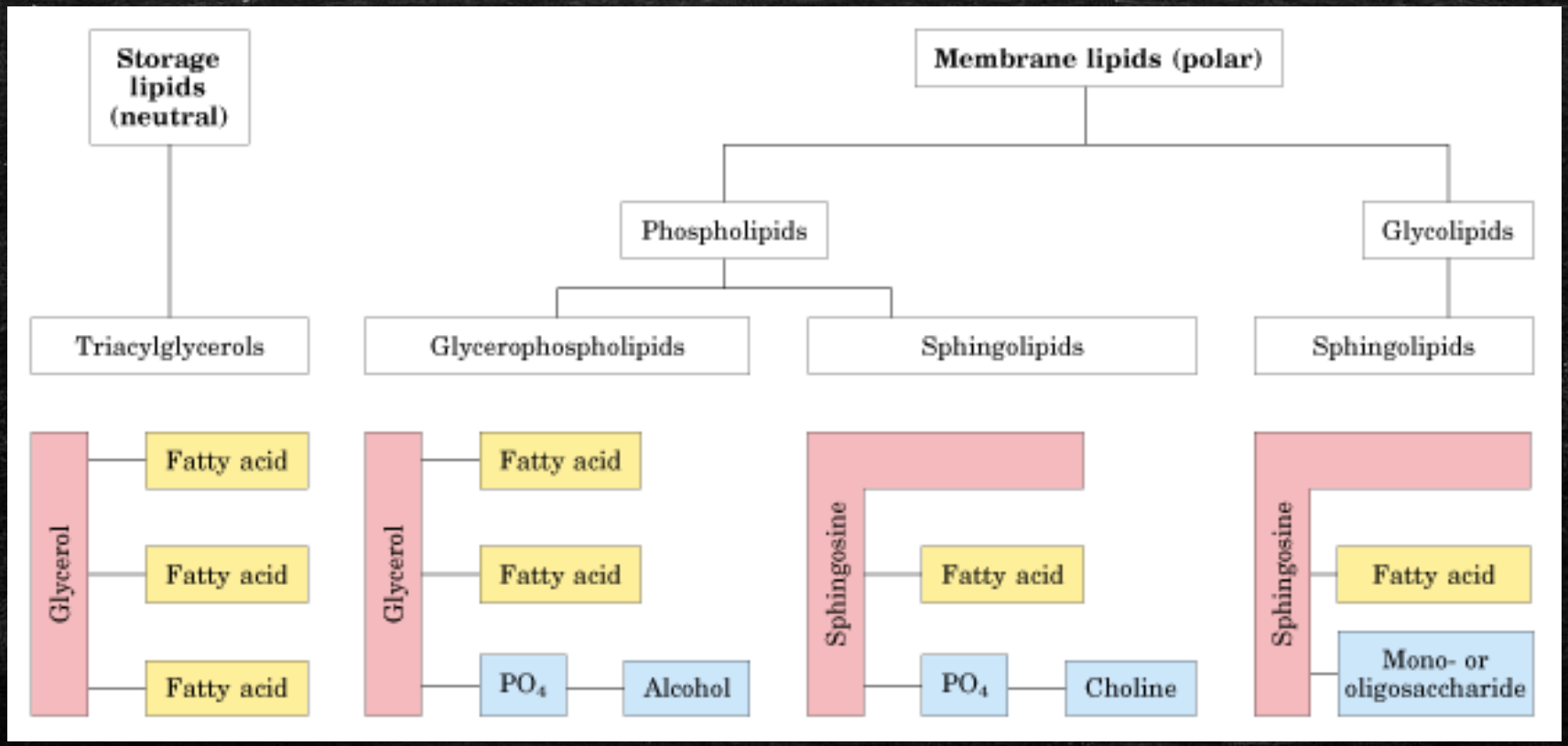
Type	Structural Formula	Source	Uses
Beeswax	$CH_3(CH_2)_{14}—C(=O)—O—(CH_2)_{29}CH_3$	Honeycomb	Candles, shoe polish, wax paper
Carnauba wax	$CH_3(CH_2)_{24}—C(=O)—O—(CH_2)_{29}CH_3$	Brazilian palm tree	Waxes for furniture, cars, floors, shoes
Jojoba wax	$CH_3(CH_2)_{18}—C(=O)—O—(CH_2)_{19}CH_3$	Jojoba	Candles, soaps, cosmetics

Differences between neutral lipids & waxes

Property	Waxes	Neutral lipids
1.Digestibility	Indigestible (not hydrolyzed by lipase)	Digestible (hydrolyzed by lipase)
2-Type of alcohol	Long-chain monohydric alcohol + one fatty acid	Glycerol (trihydric) + 3 F.A
3-Type of F.A	Mainly palmitic or stearic acid	Long & short chain F.A
4-Acrolein test	Negative	Positive
5-Nature at room temperature	Hard solid	Soft solid or liquid
6-Saponification	Nonsaponifiable	Saponifiable
7-Nutritive value	No nutritive value	Nutritive
8-Example:	Bees wax	Butter & vegetable oils

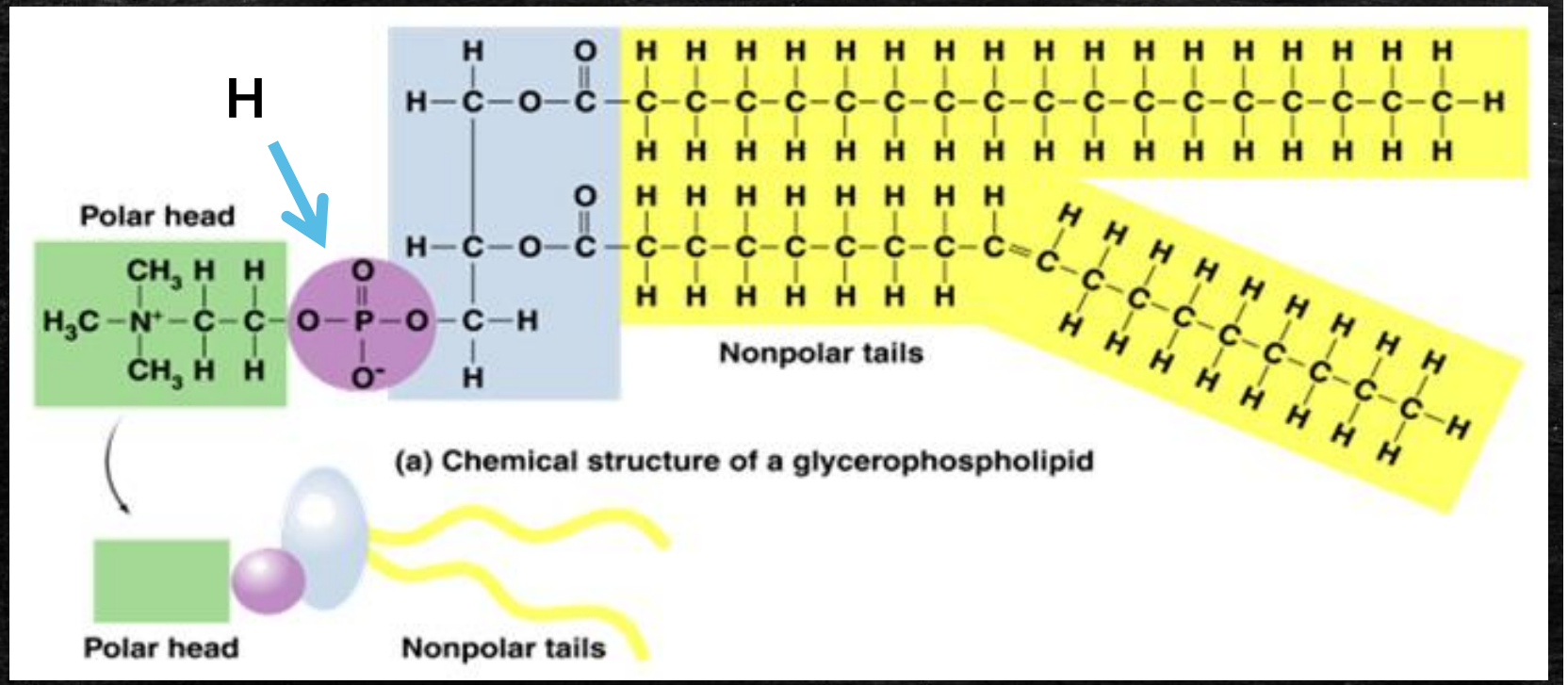
Complex lipids

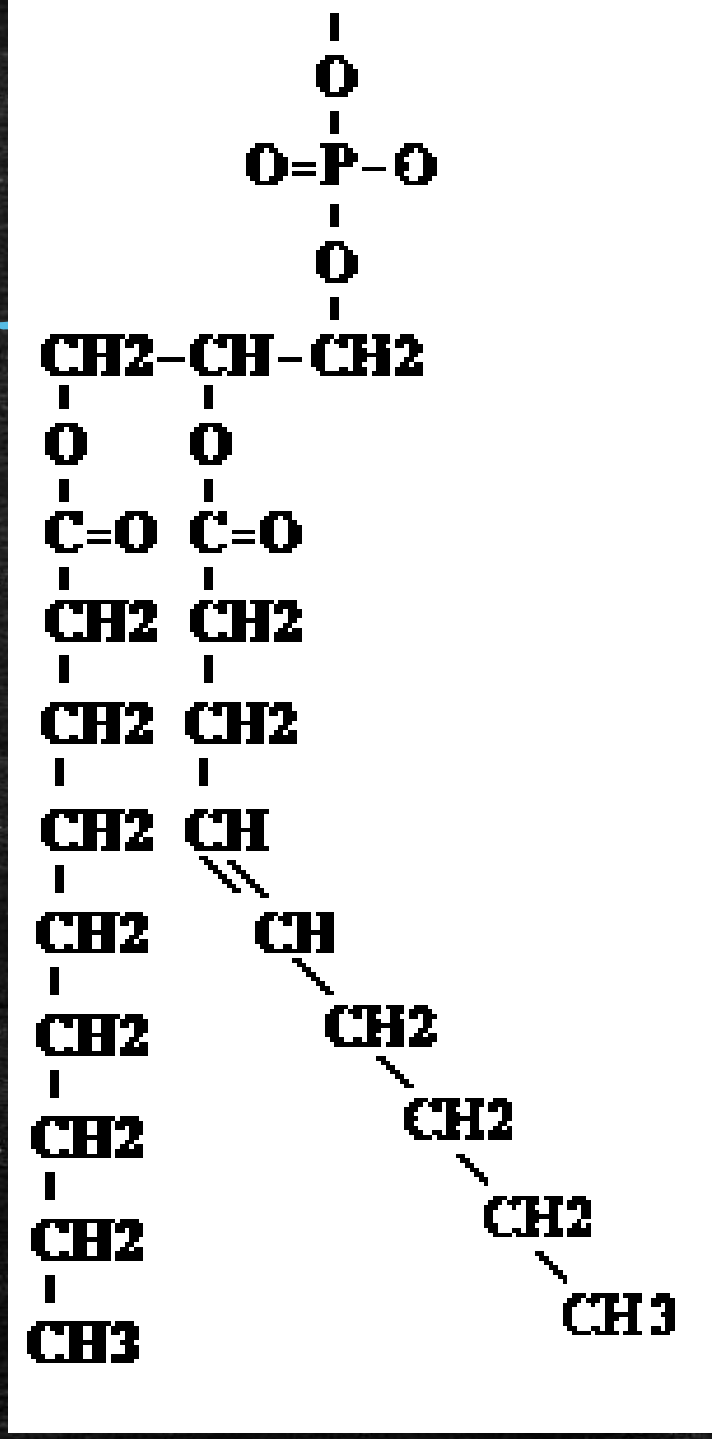




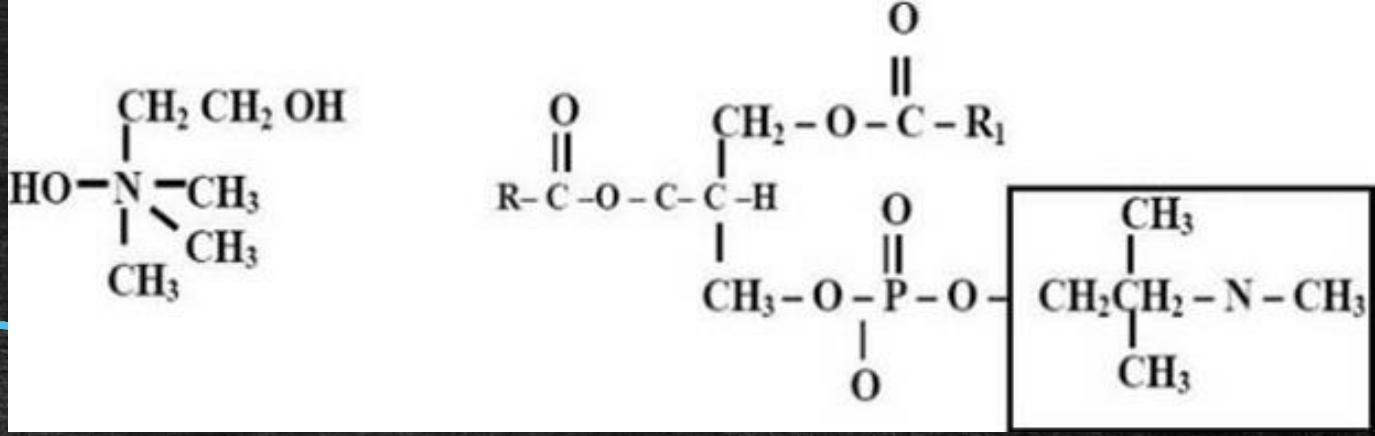
Glycero-phospholipids

- Simplest is phosphatidic acid

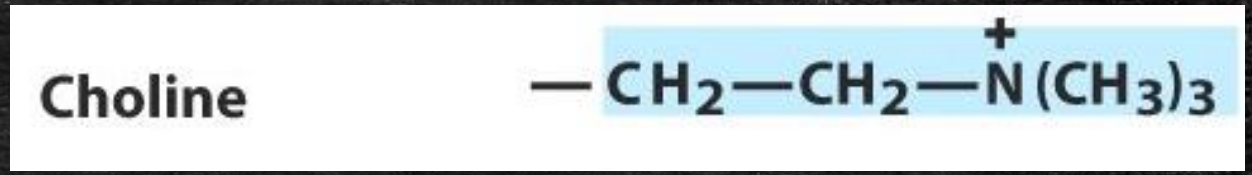


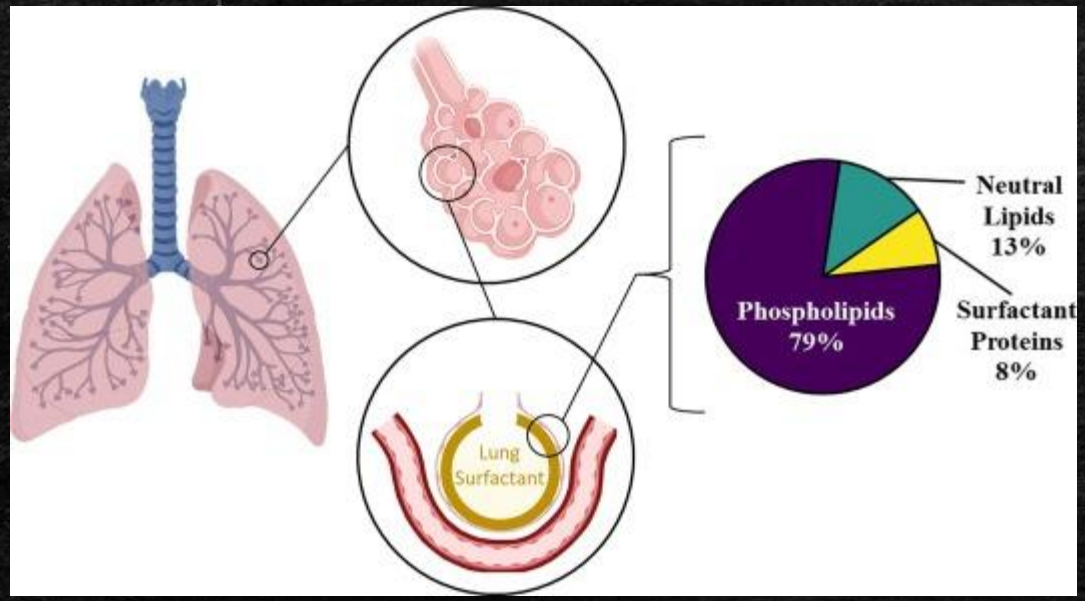


Lecithins



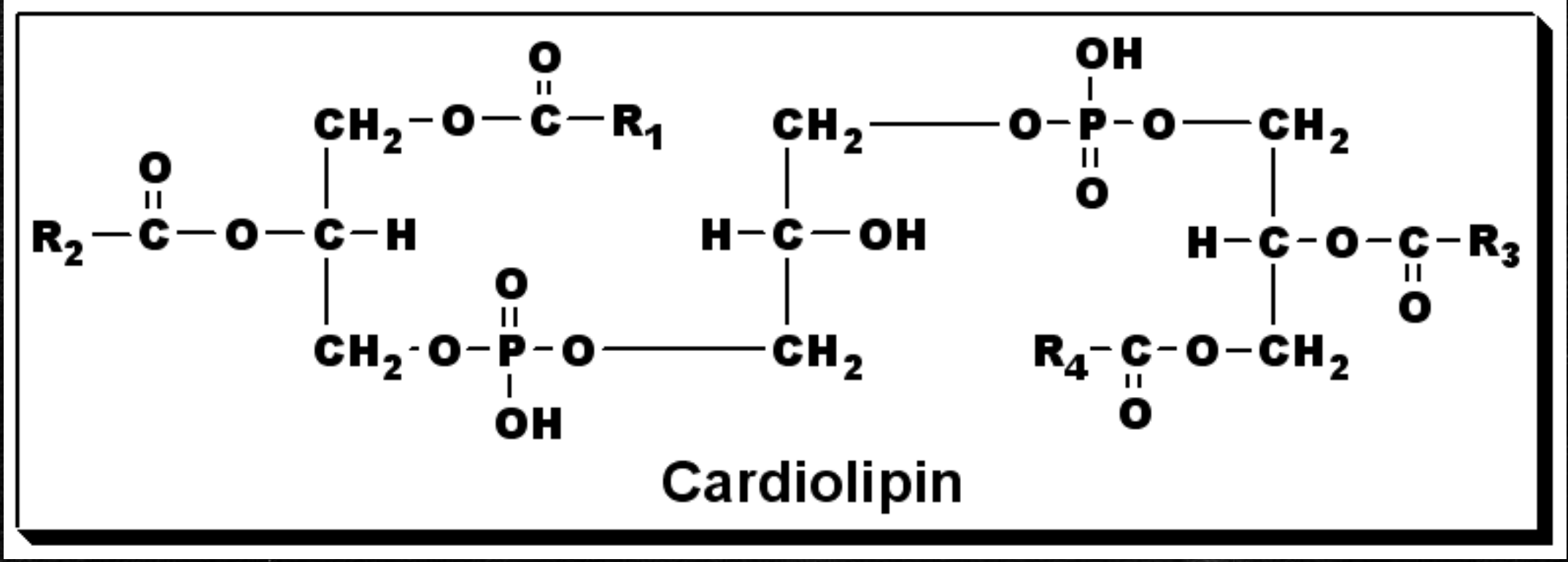
- Choline as a nitrogenous base
- Most abundant membrane lipid
- Snake venom
- Lung surfactant



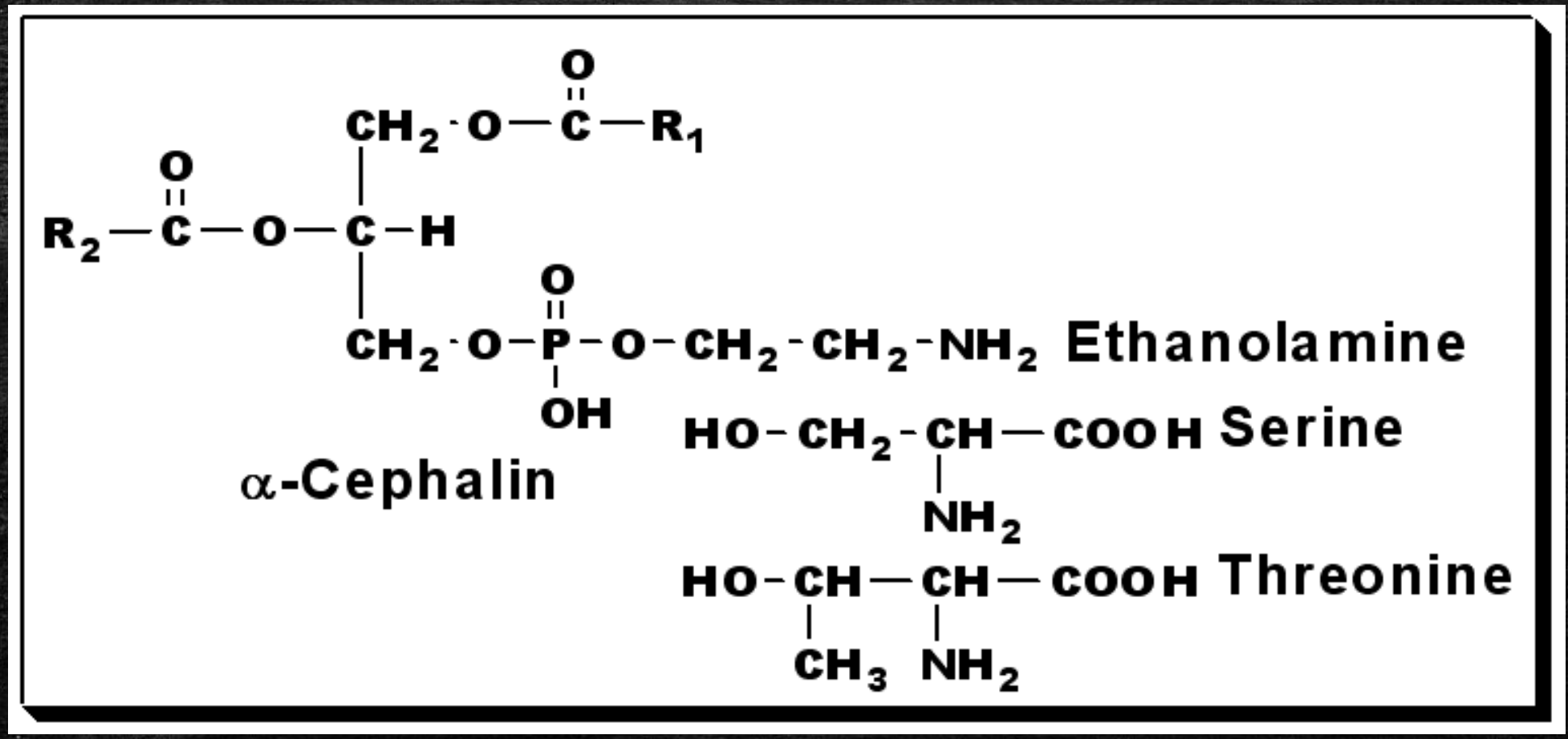


Cardiolipins

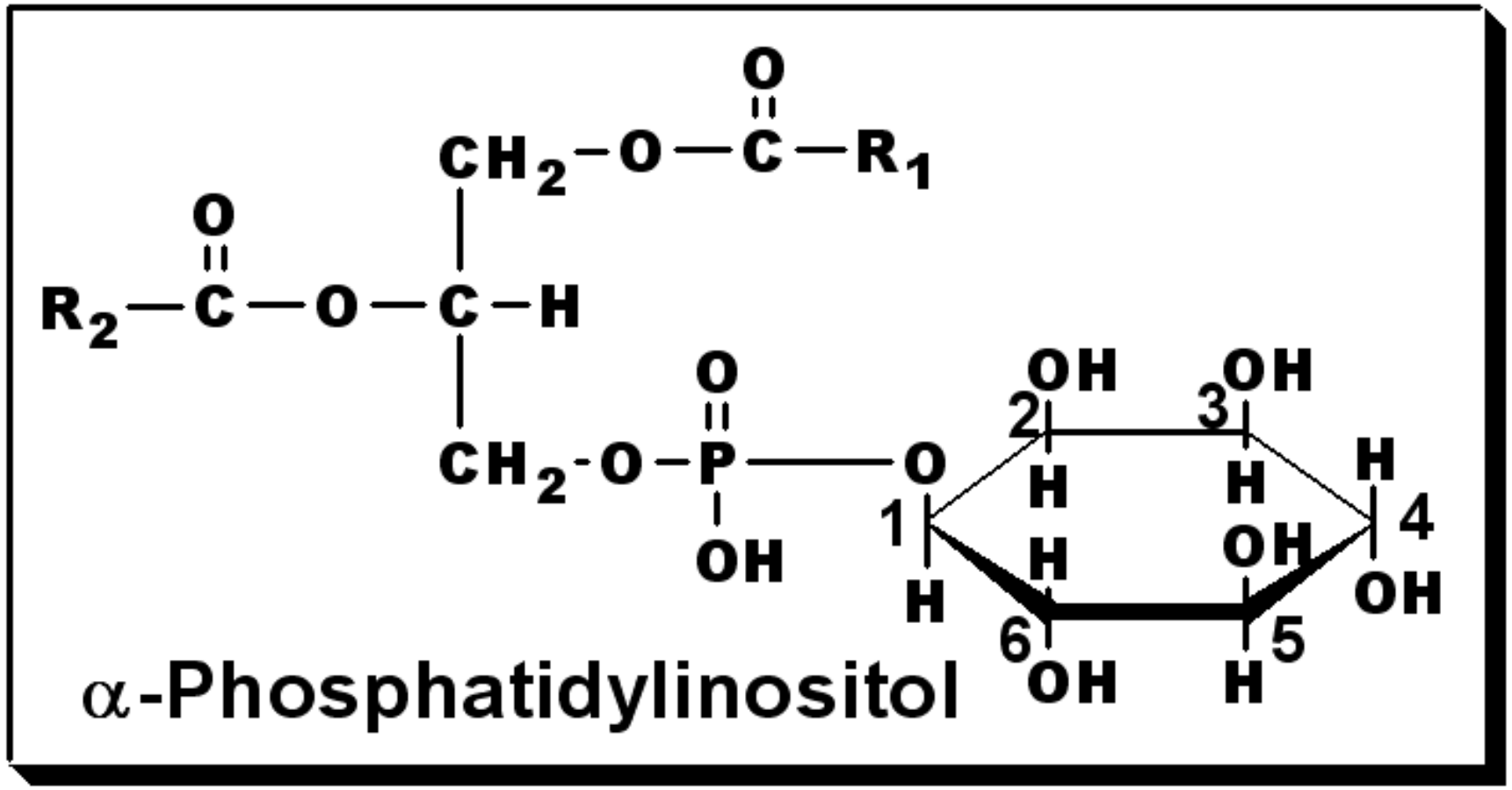
- Diphosphatidyl-glycerol
- Inner membrane of mitochondria

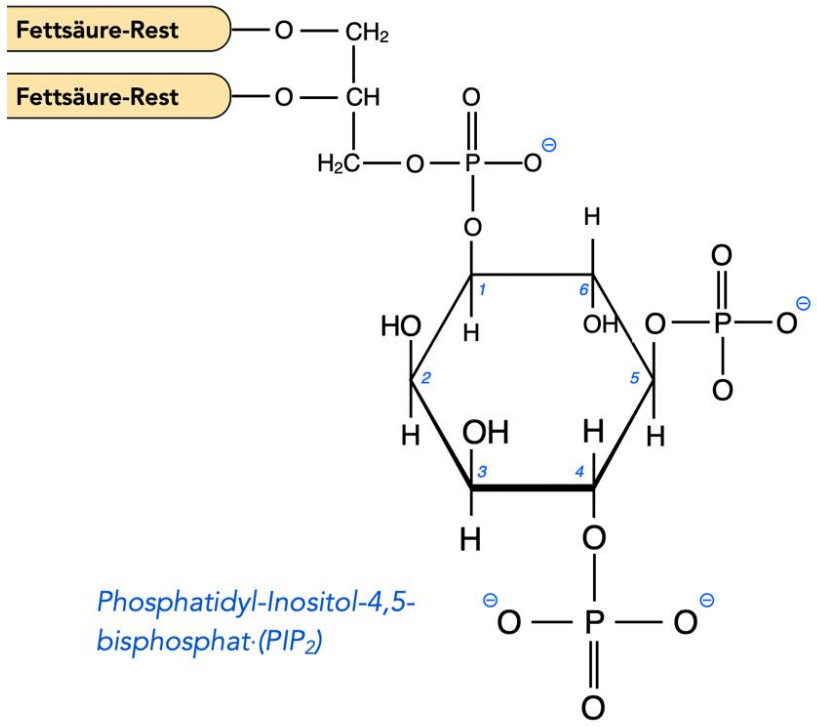


Cephalins or Kephalins



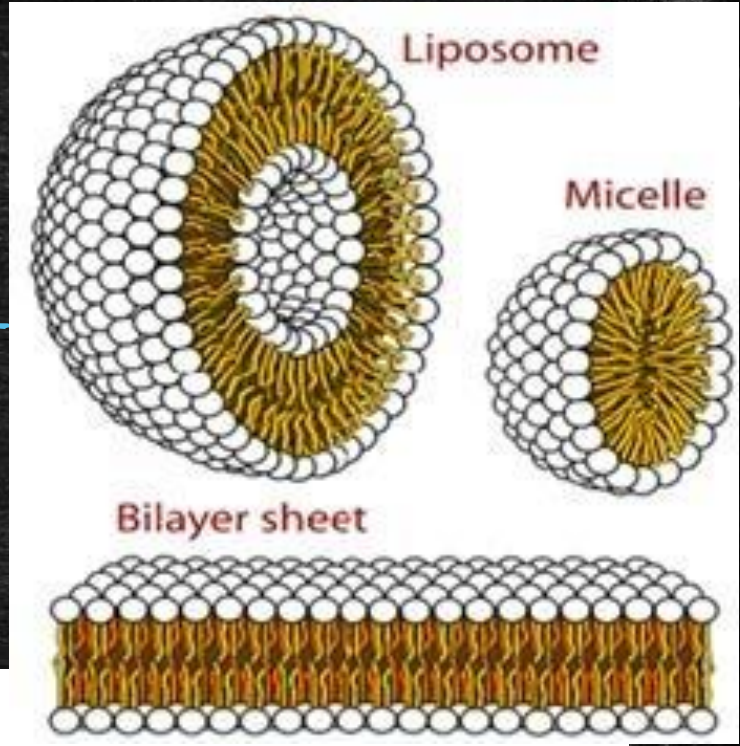
Inositides

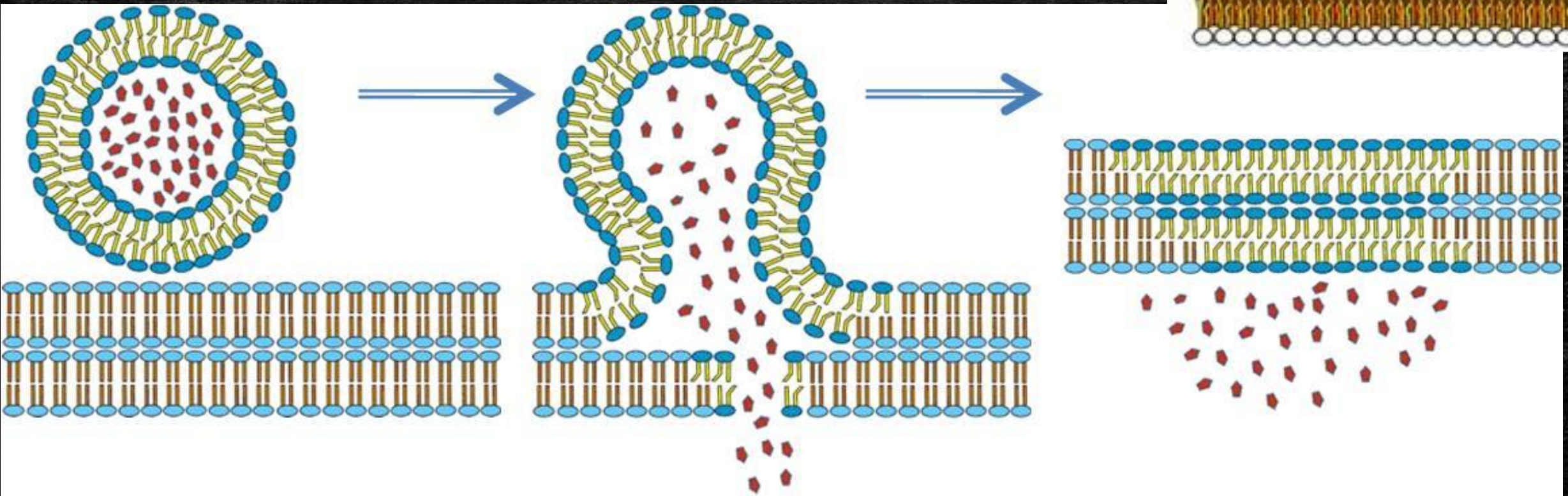

α-Phosphatidylinositol


Fettsäure-Rest
Fettsäure-Rest
Phosphatidyl-Inositol-4,5-bisphosphat·(PIP2)

Structures of phospholipids

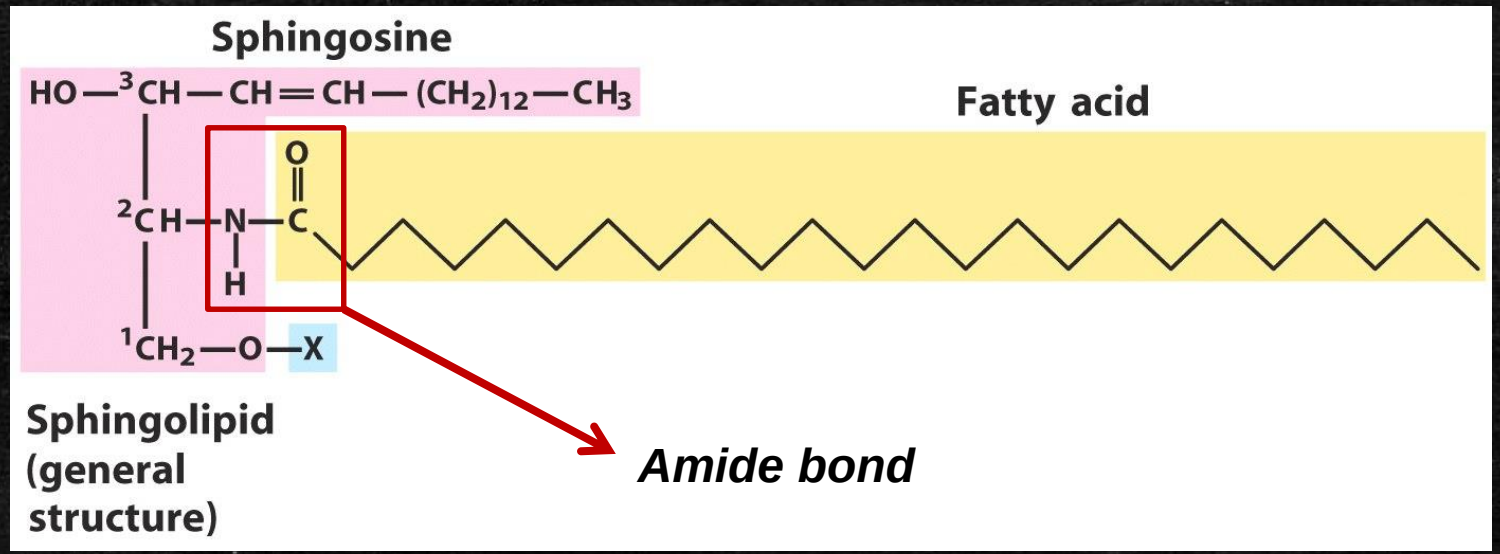
- Uses of liposomes: delivery

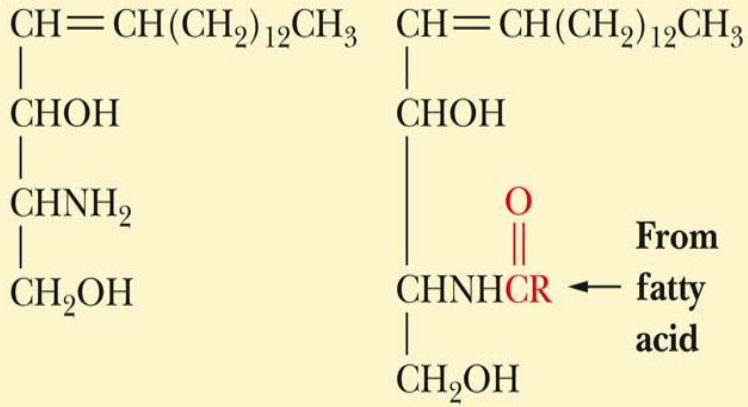


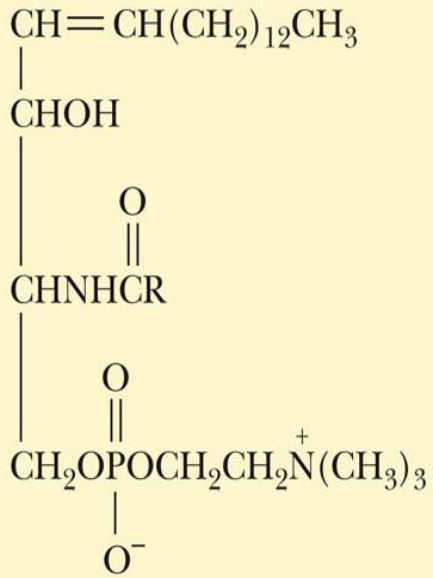


Sphingolipids

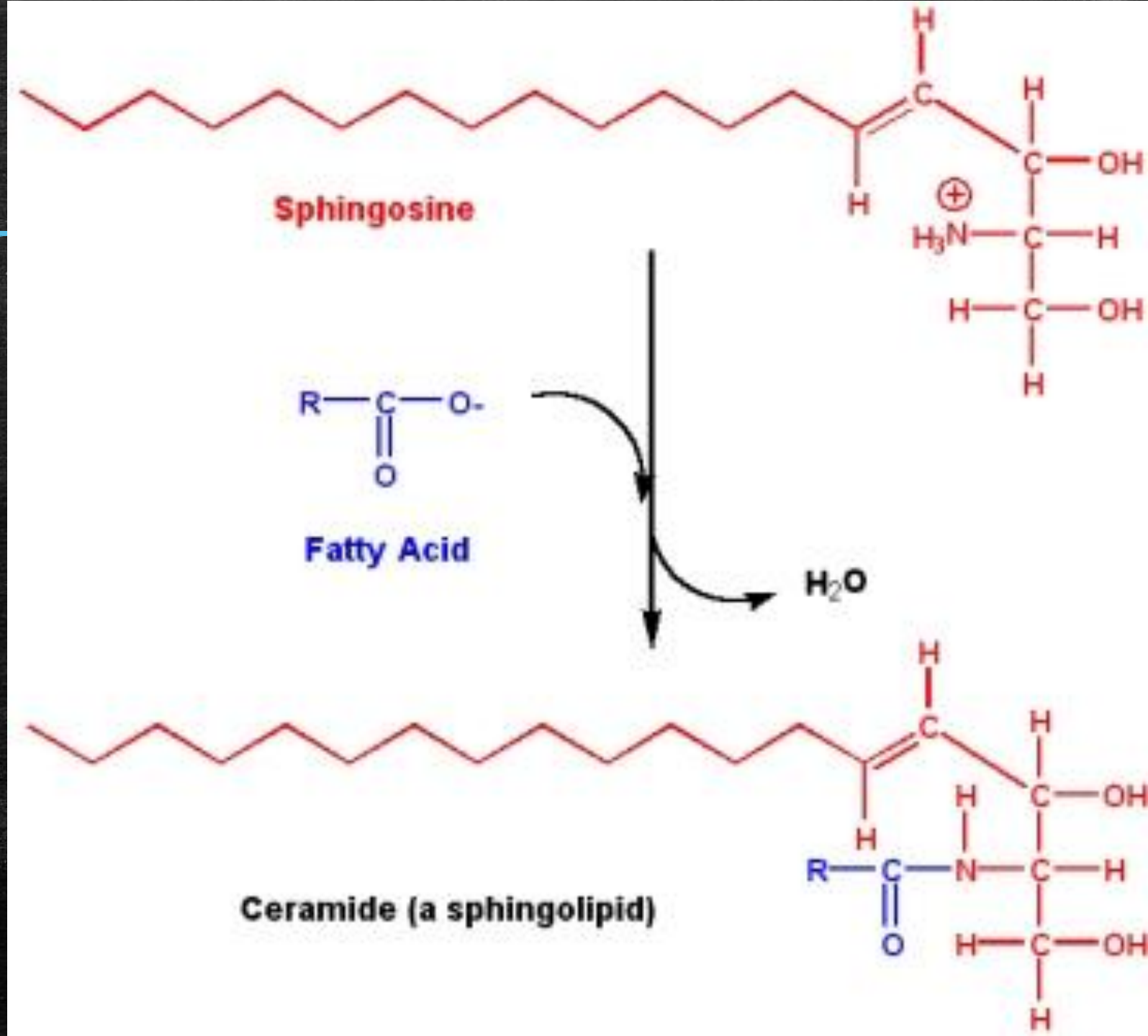
- The core: long-chain amino alcohol, sphingosine
- Highest in cells of CNS



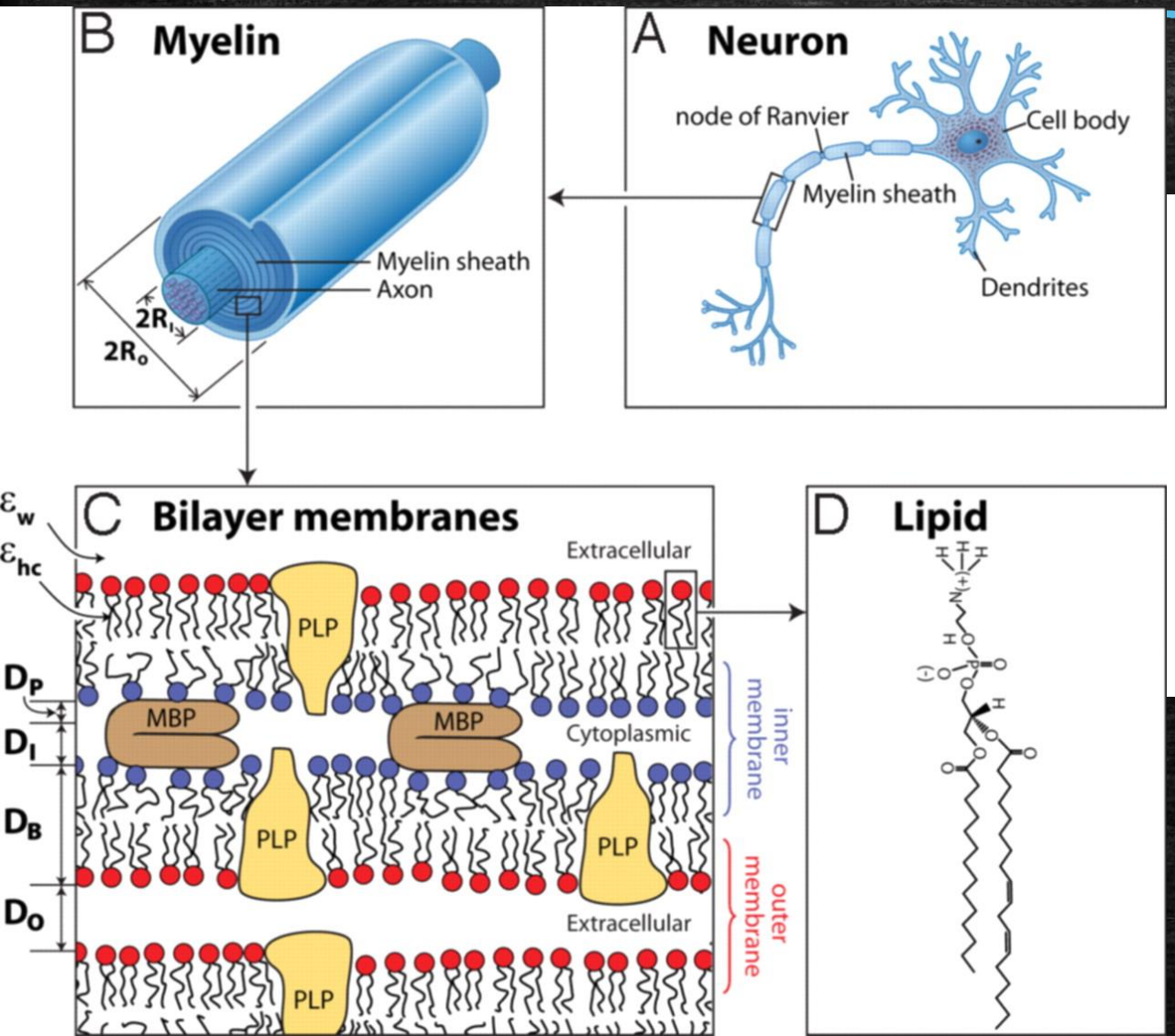


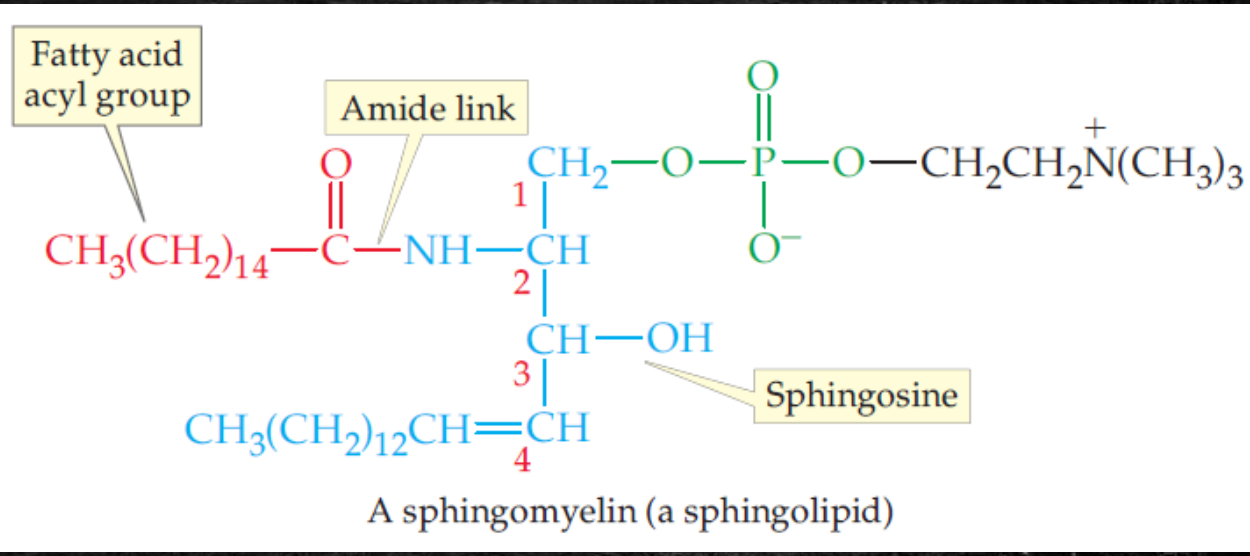


Ceramide



Classes - Sphingomyelins

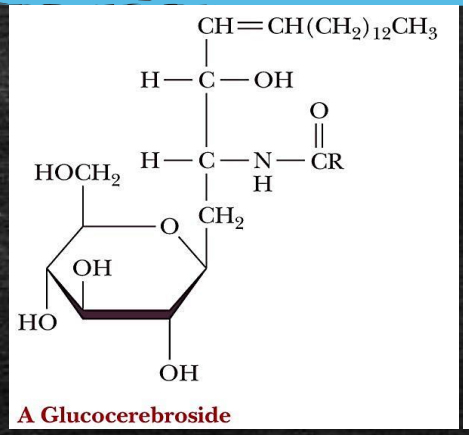




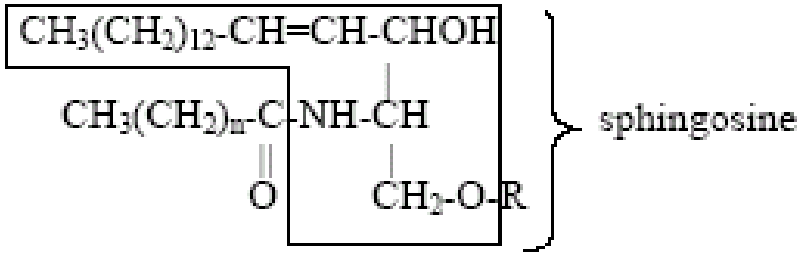
A sphingomyelin (a sphingolipid)

Classes – Glycolipids

- There are three types of glycolipids
  - Cerebrosides
  - Globosides
  - Gangliosides
  - Sulfatides

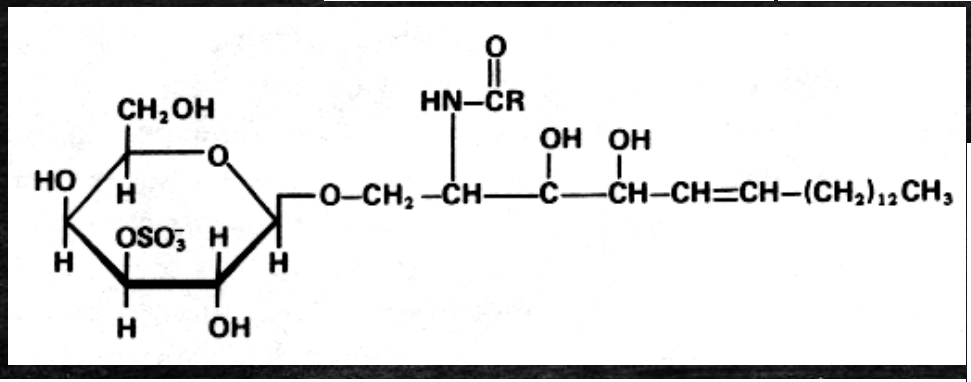


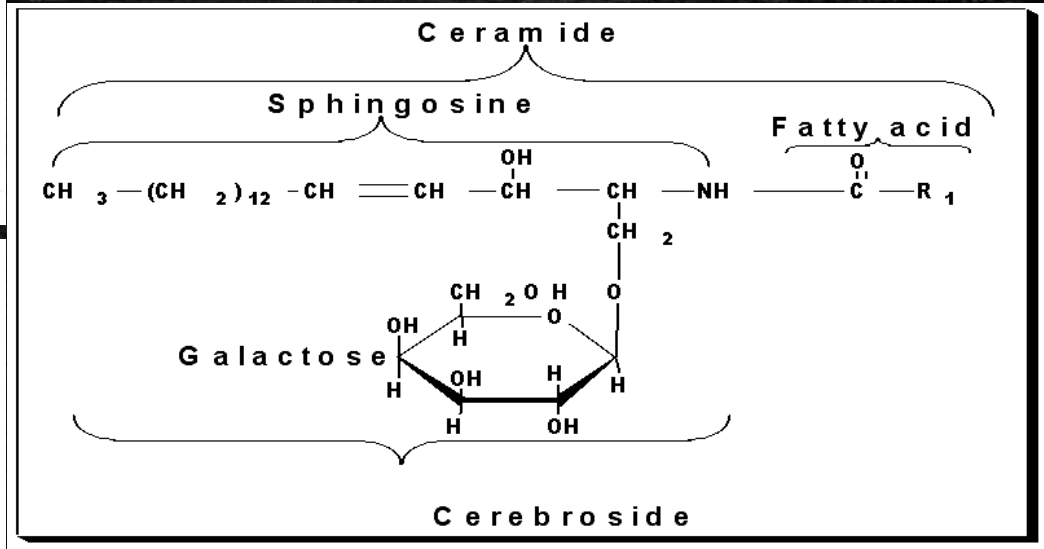
A Glucocerebroside



glycolipids

Sphingolipid type	R group
Ceramide	H
Sphingomyelin	phosphocholine
Cerebroside	monosaccharide (galactose or glucose)
Globoside	two or more sugars (galactose, glucose, N-acetylglucosamine
Ganglioside	three or more sugars including at least one sialic acid



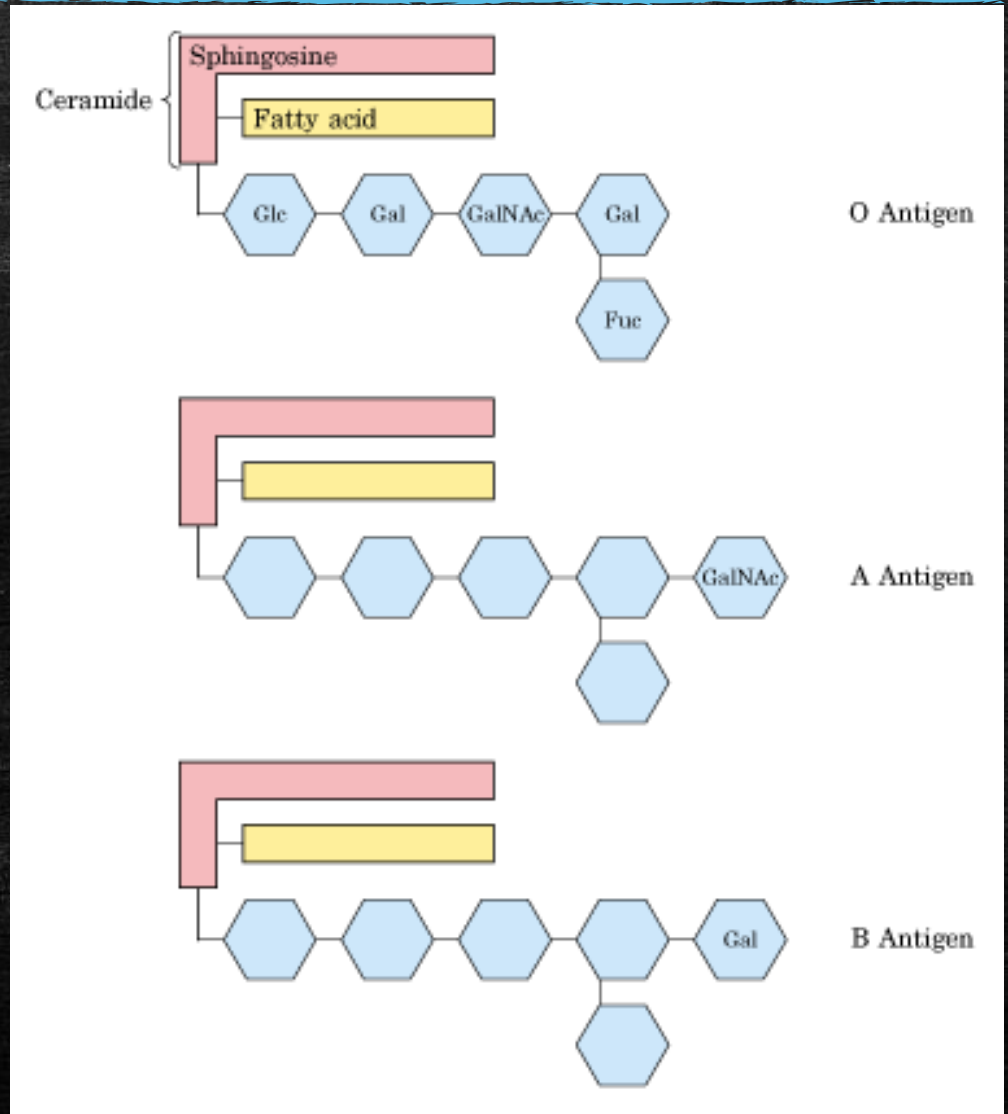


Ceramide-Glucose-Galactose-N-acetylgalactosamine-Galactose

Sialic acid

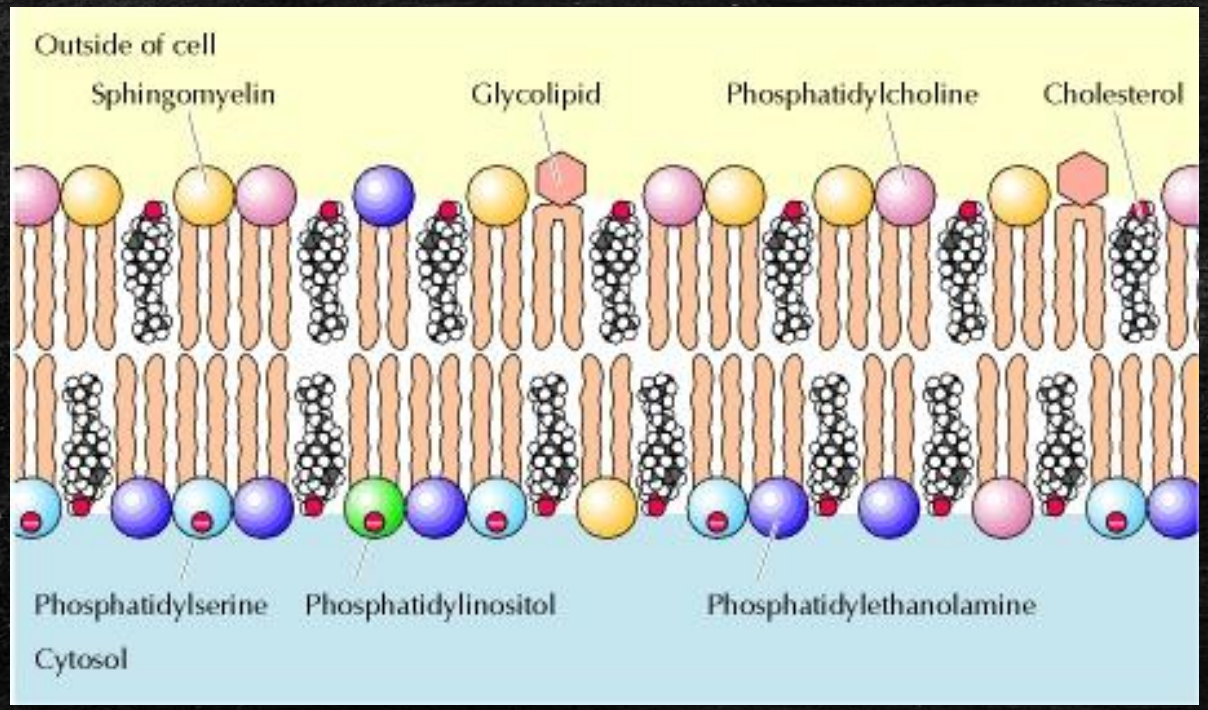
Monosialoganglioside

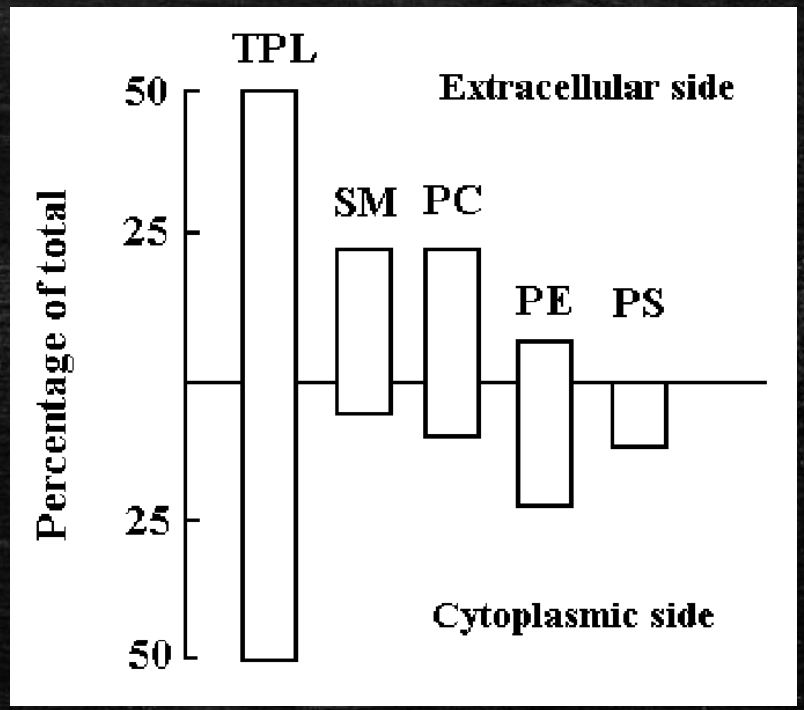
Sphingolipids & blood groups



Phospholipids and membranes distribution

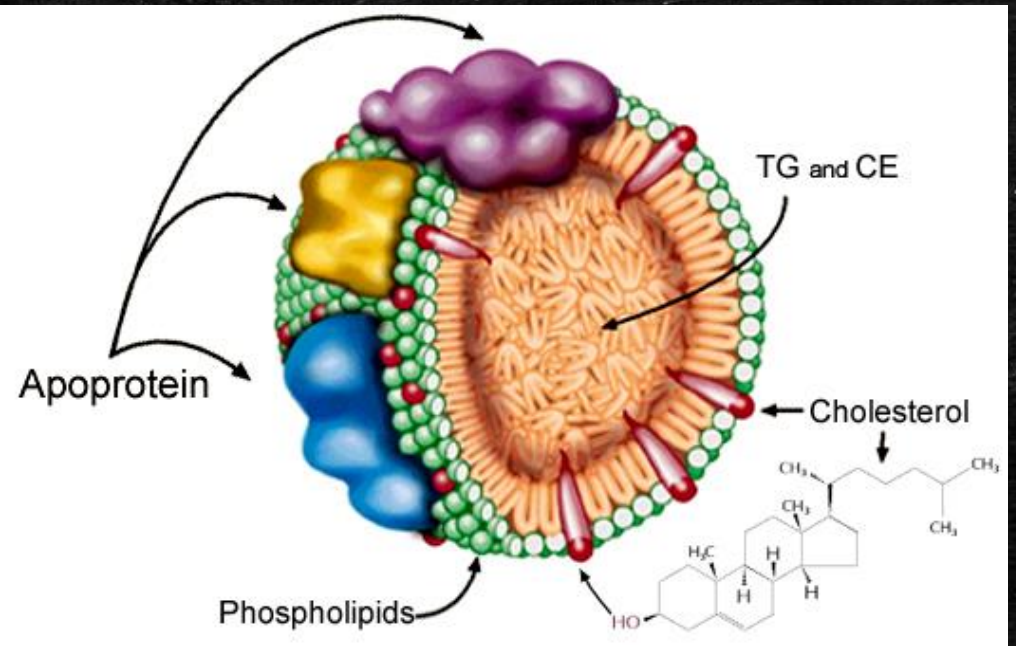
- The outer: phosphatidylcholine, sphingomyelin, and glycolipids(cell recognition)
- The inner: phosphatidylethanolamine, phosphatidylserine, and phosphatidylinositol (signaling)

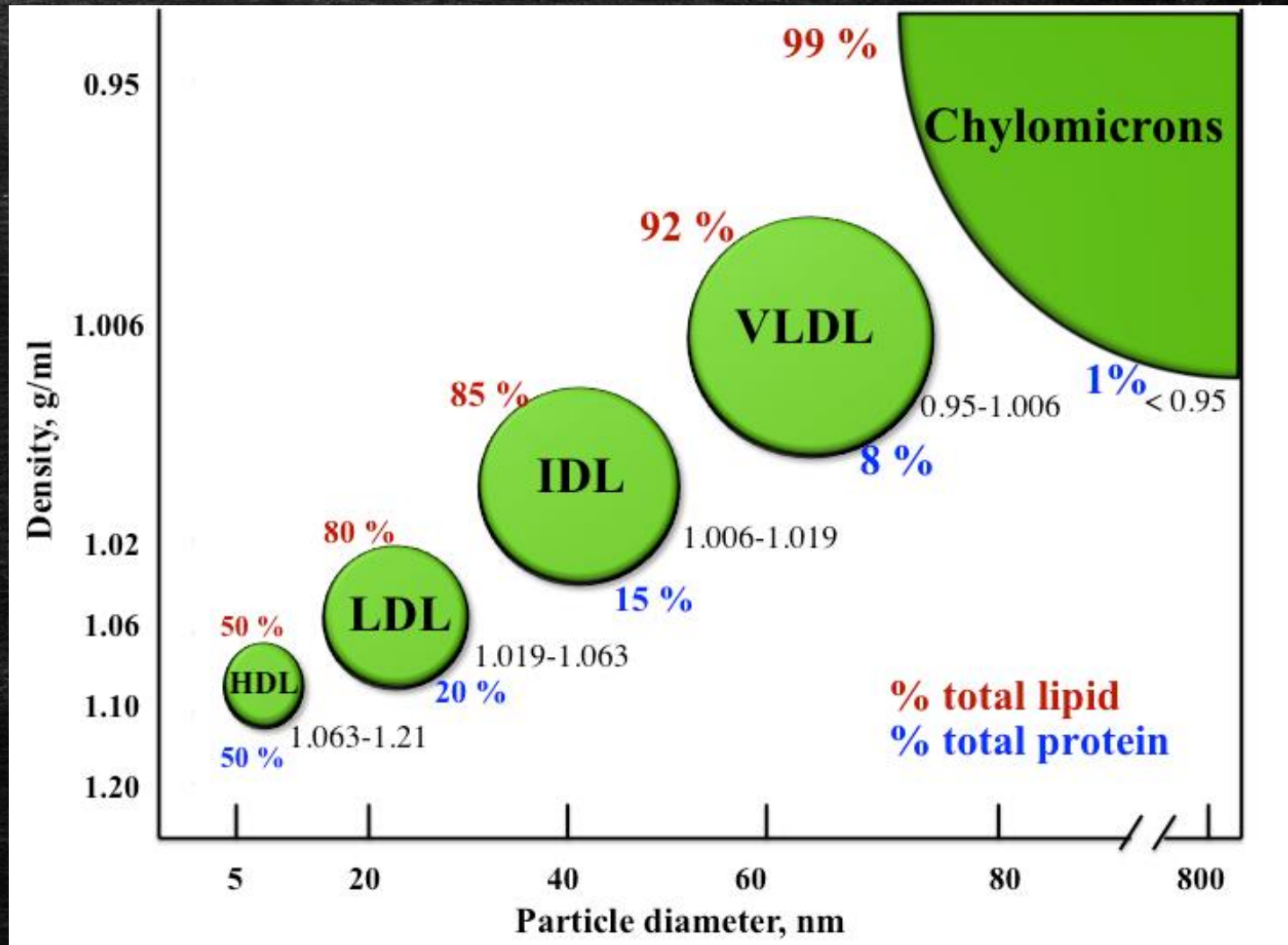




Lipoproteins

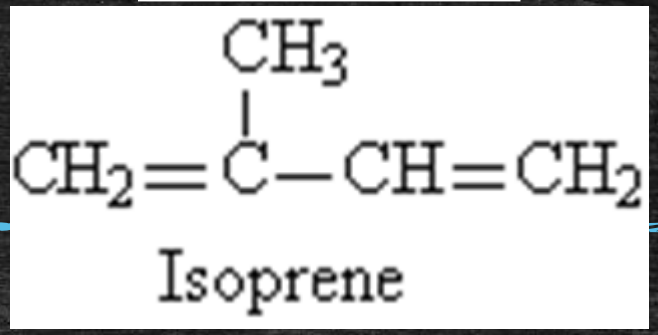
- Either structural
  - or transport f different types of lipids (cholesterol, cholesterol esters, phospholipids & triacylglycerols) in blood plasma





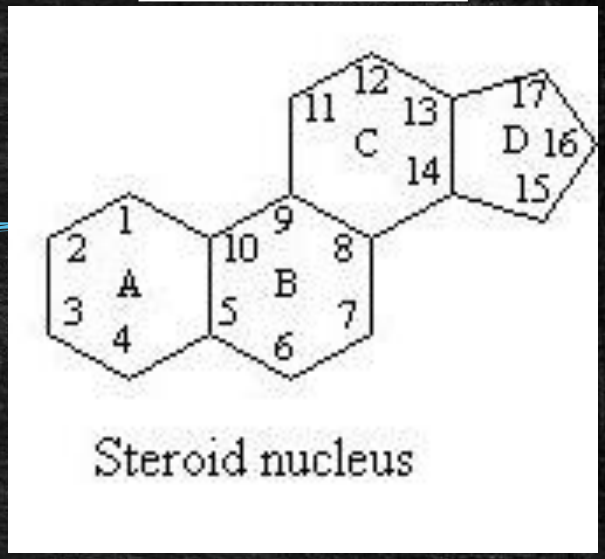
Steroids

The precursor

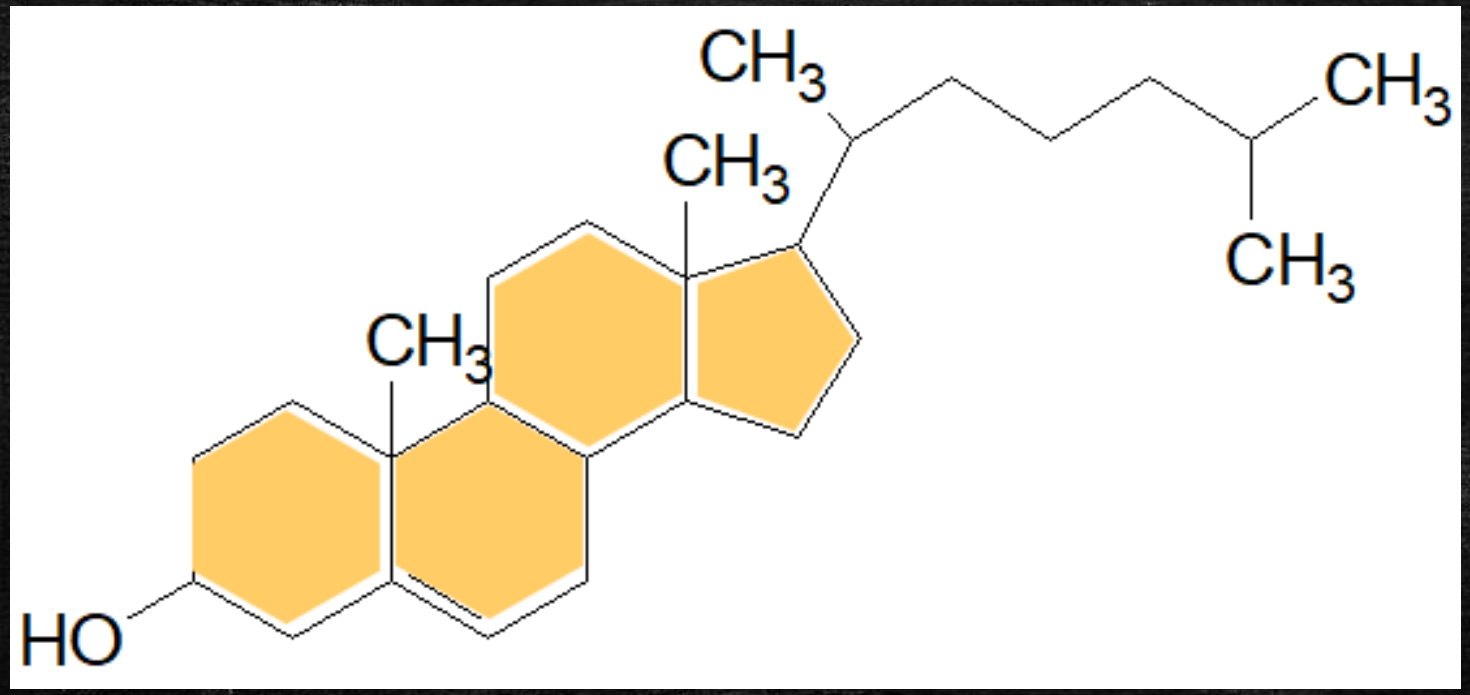


Isoprene

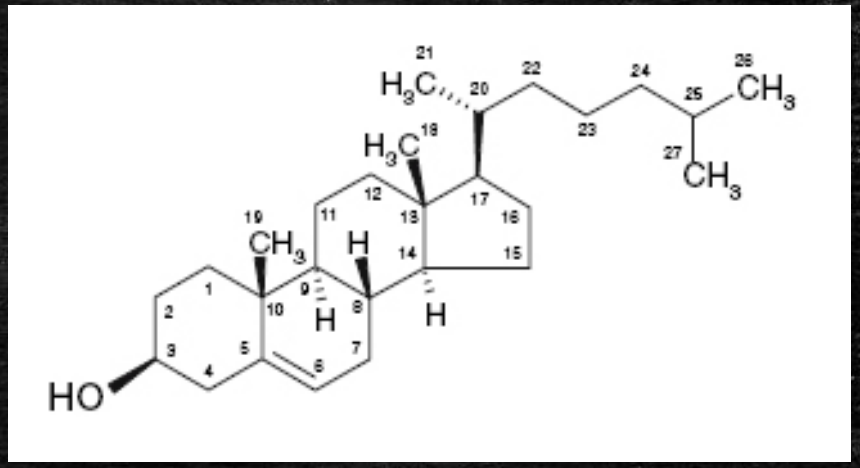
The nucleus



Steroid nucleus

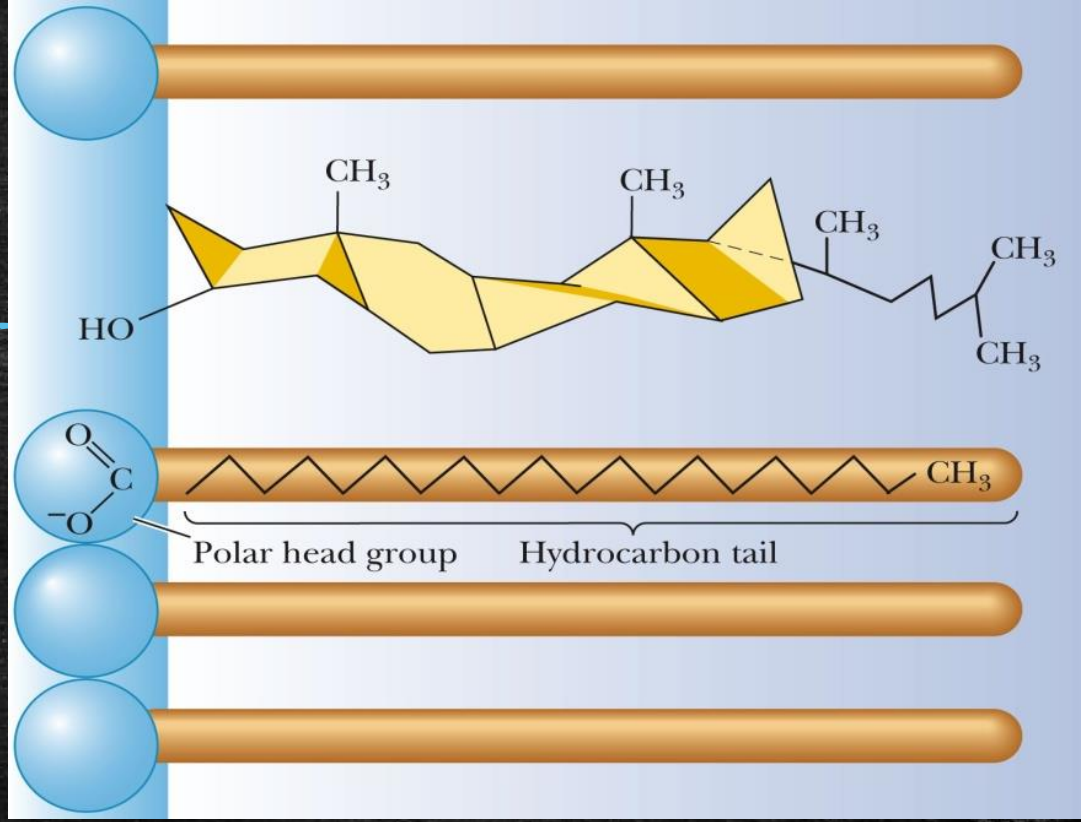


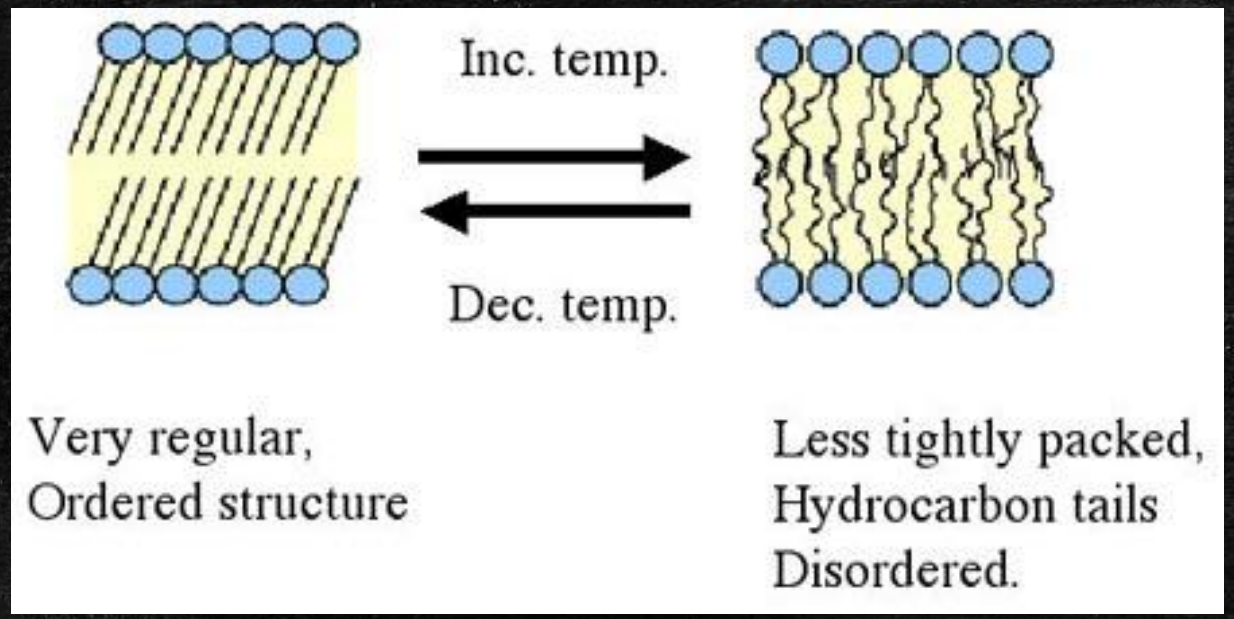
The most common steroid

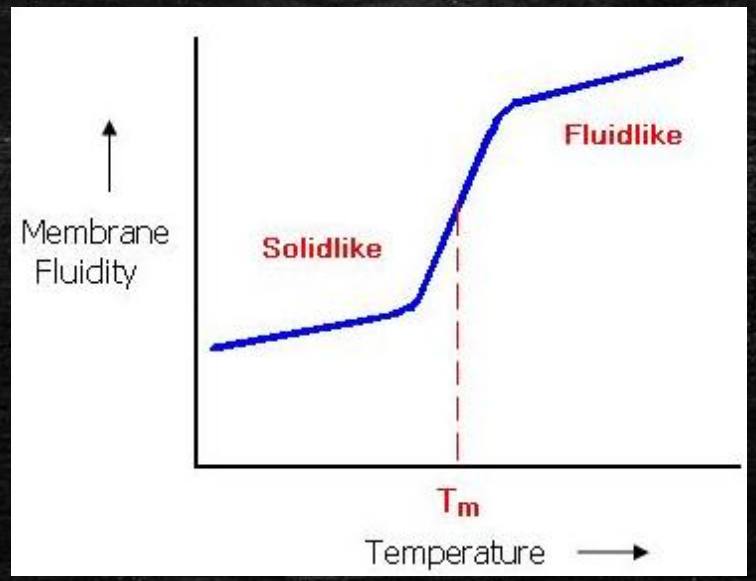


Cholesterol

- Vary among tissues
- Acts as a fluidity buffer in membranes: makes a membrane less solid at low temperatures and more solid at high temperatures

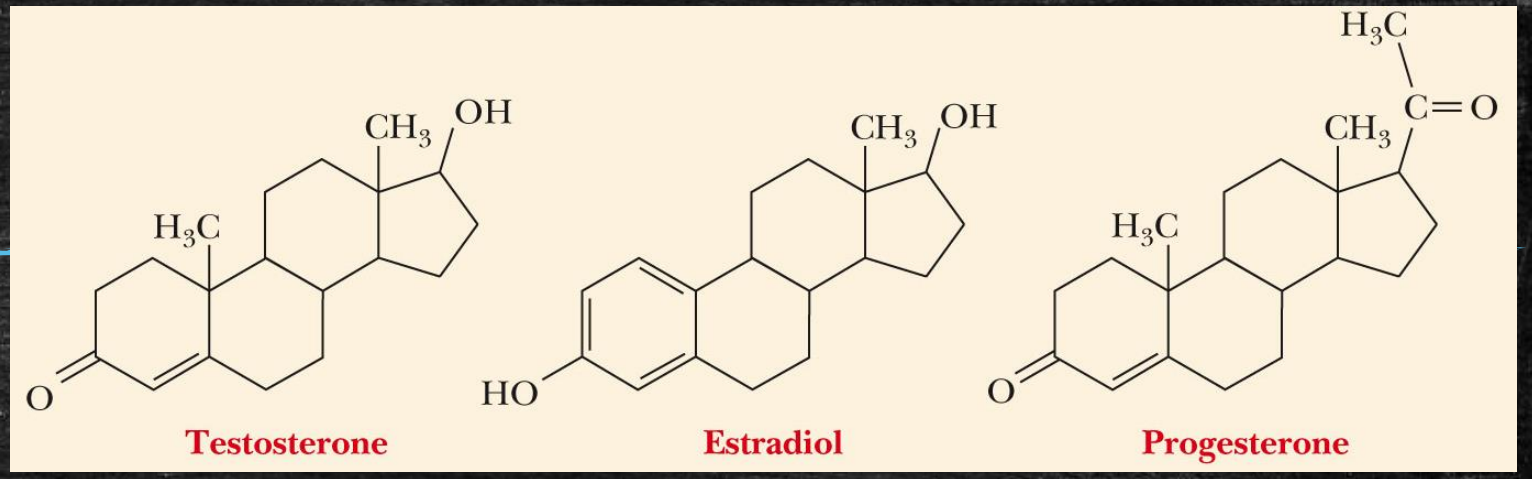


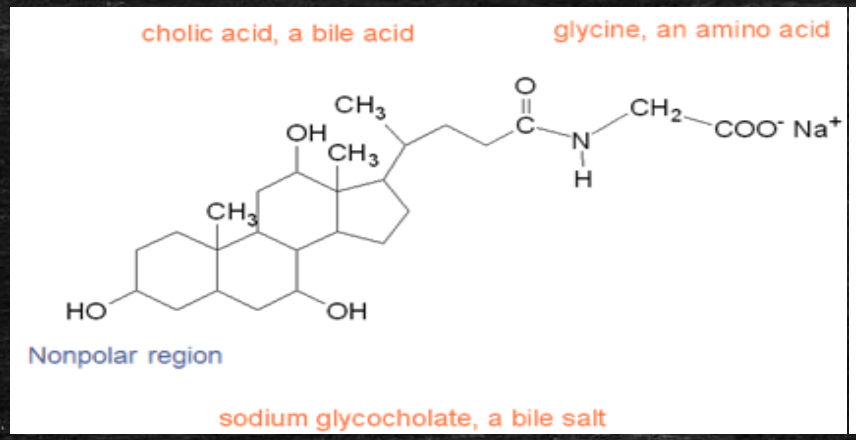


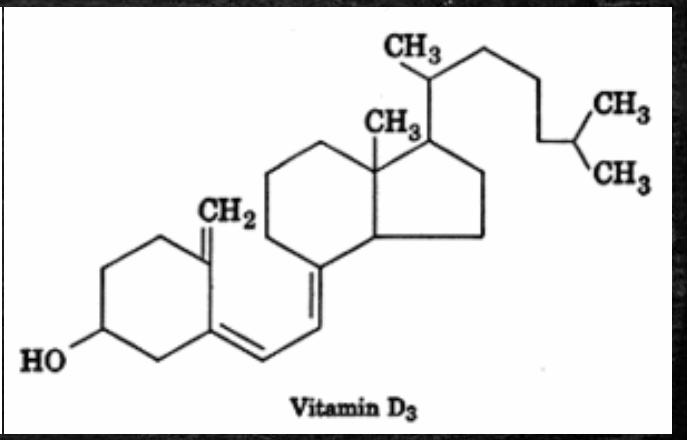


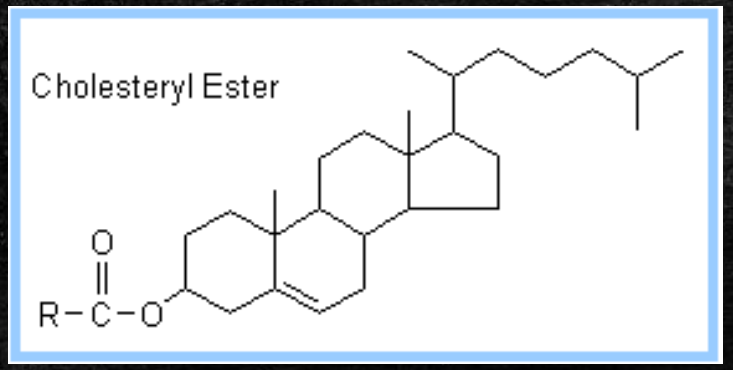
Products of cholesterol

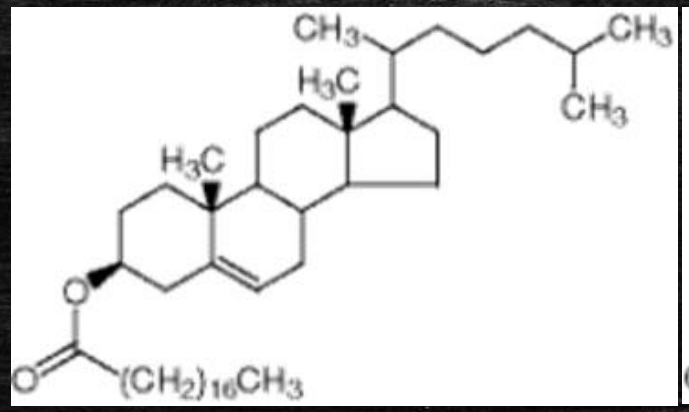
- Sterols
- Adrenal cortical hormones
- Male and female sex hormones
- Vitamin D group
- Bile acids
- Cholesterol esters

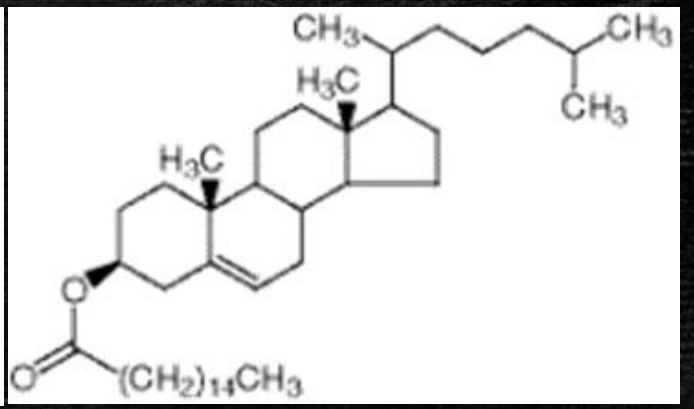




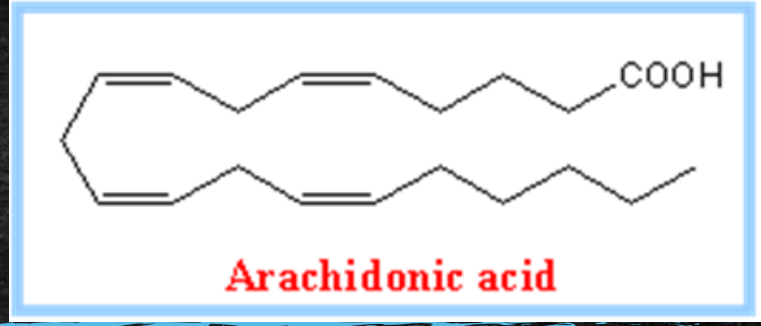




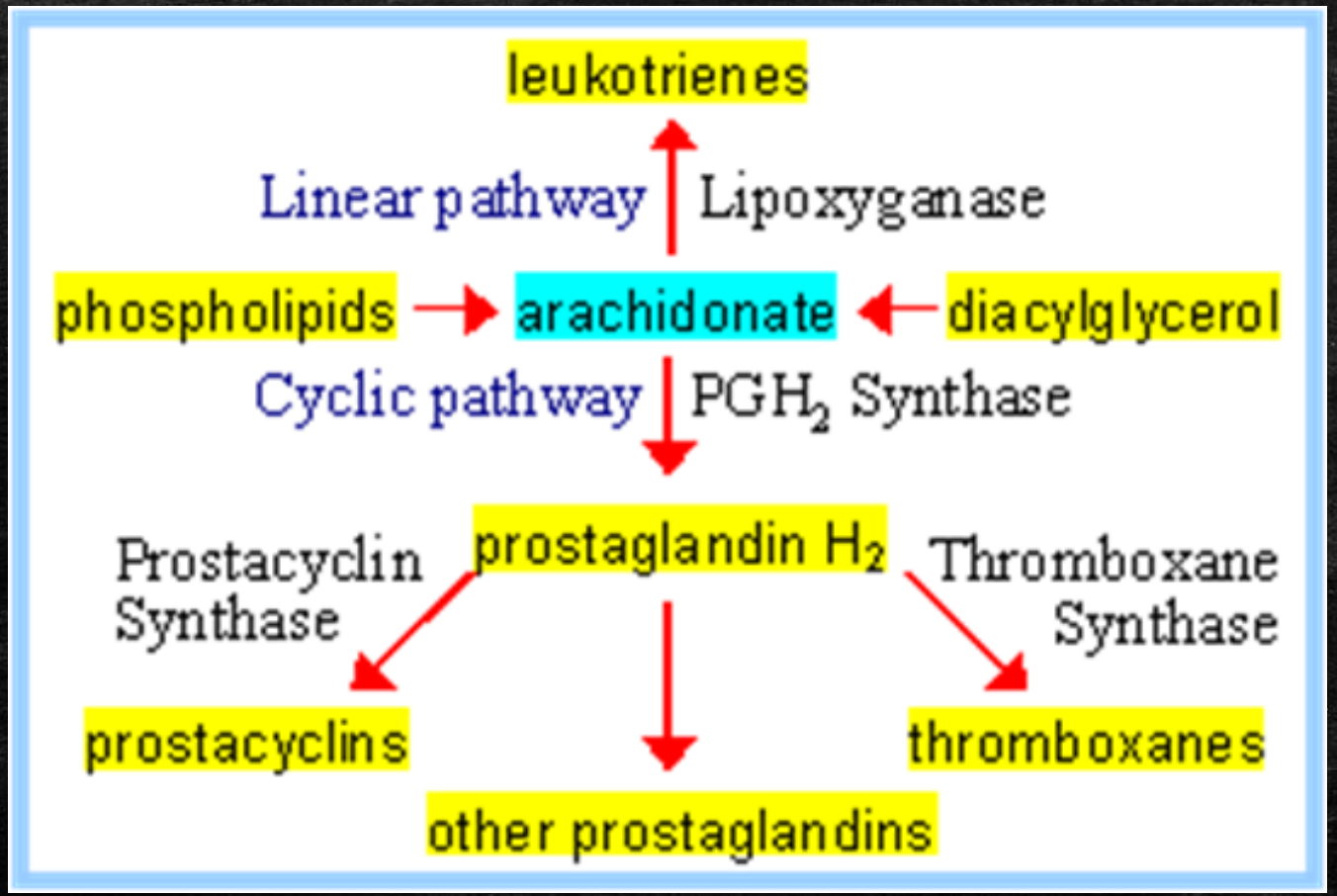




Derived fatty acids: Eicosanoids (icosanoids)

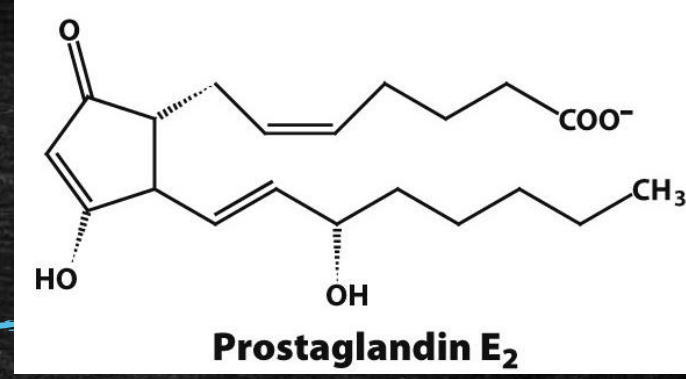


- all *cis*-$\Delta^5,\Delta^8,\Delta^{11},\Delta^{14}$-eicosatetraenoate, $CH_3(CH_2)_4(CH{=}CHCH_2)_4(CH_2)_2COO^-$

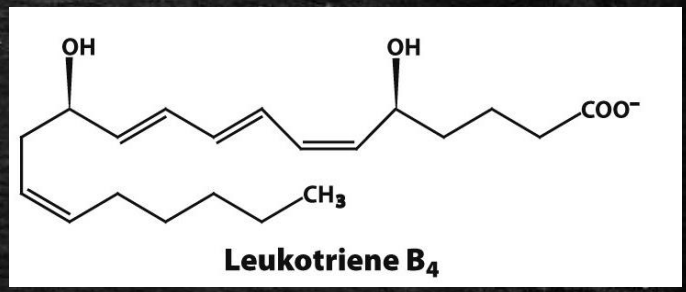


Functions

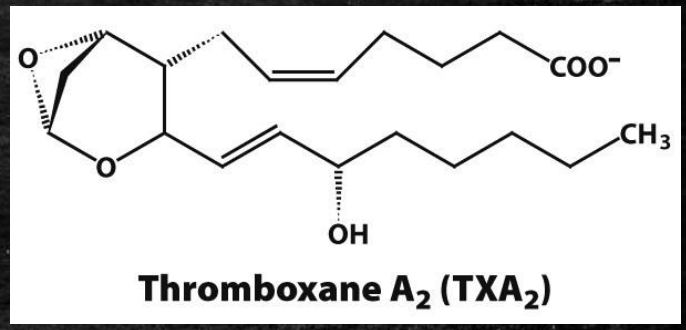
- Prostaglandins
  - Inhibition of platelet aggregation
  - Blood clotting
- Leukotrienes
  - Constriction of smooth muscles
  - Asthma
- Thromboxanes
  - Constriction of smooth muscles
  - Platelet aggregation
- Prostacyclins
  - An inhibitor of platelet aggregation
  - A vasodilator



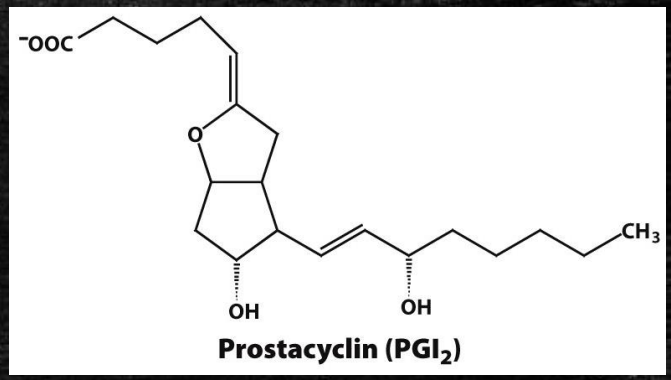
Prostaglandin E_2



Leukotriene B_4

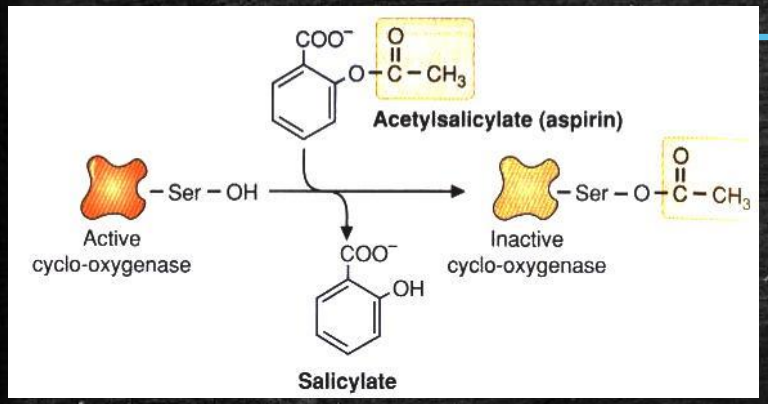


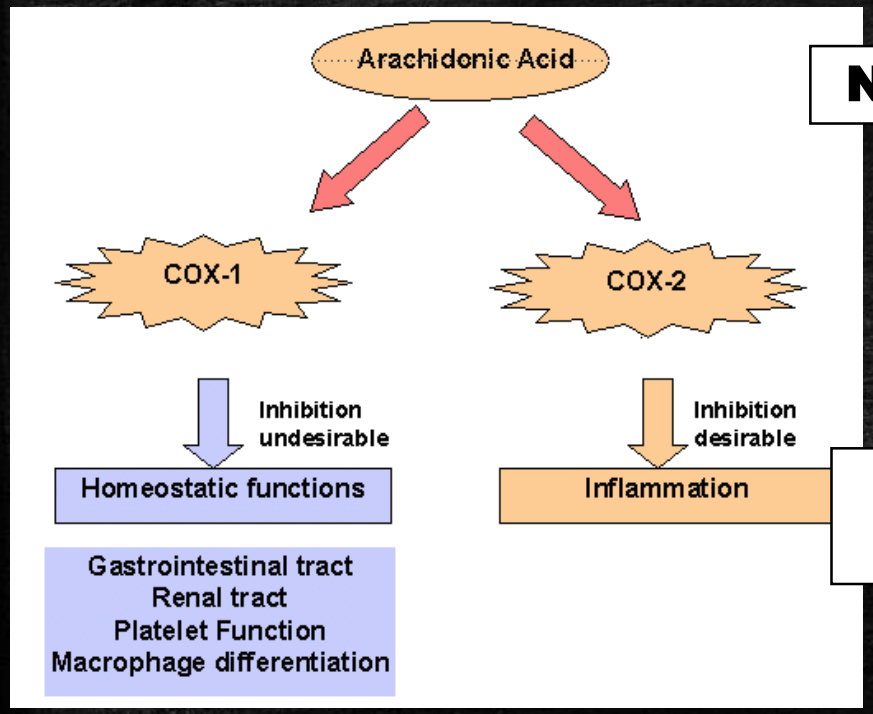
Thromboxane A_2 (TXA_2)

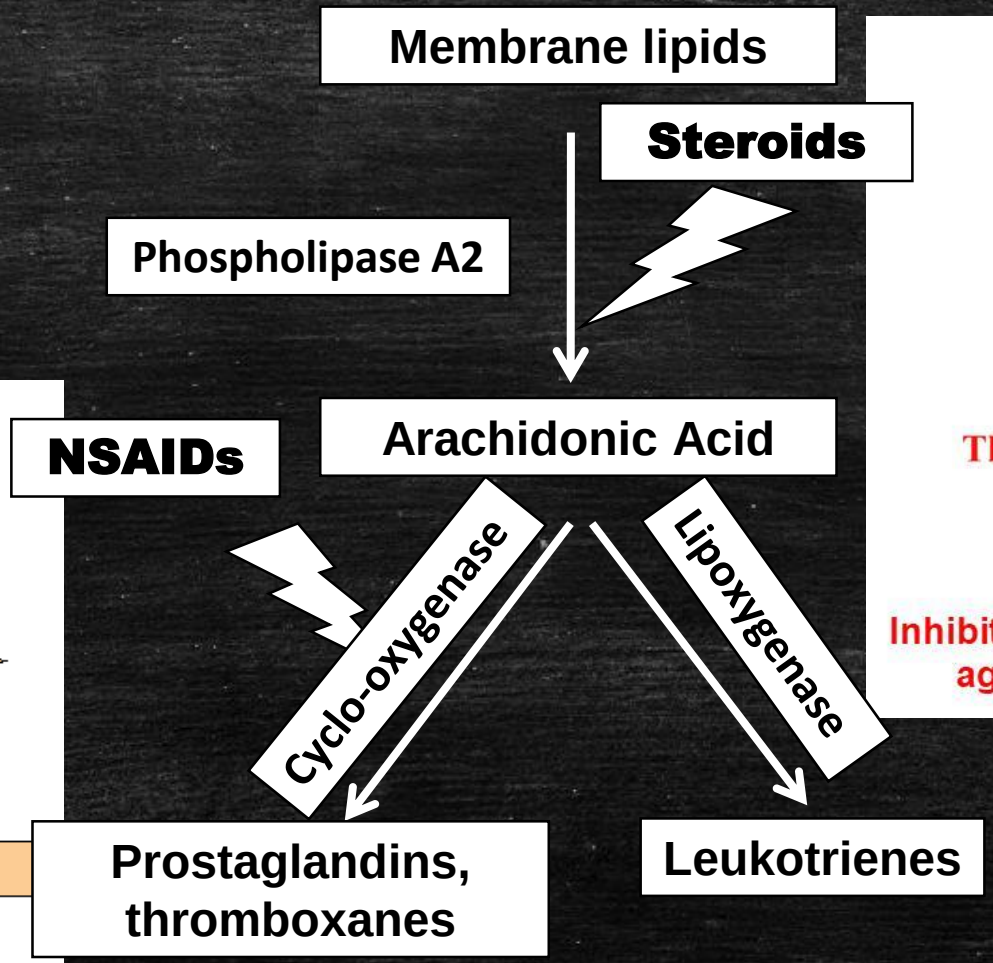


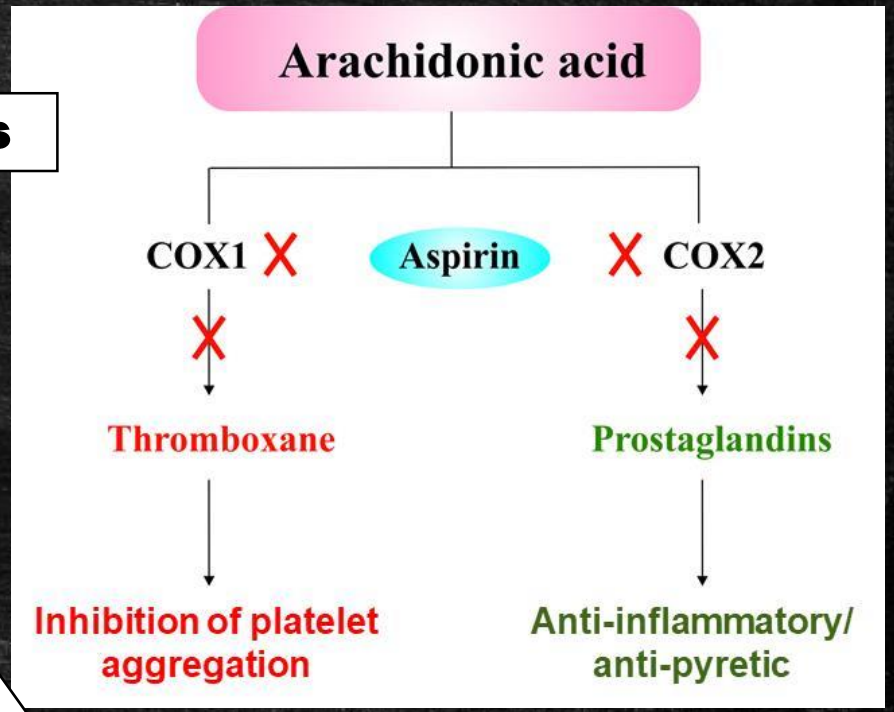
Prostacyclin (PGI_2)

Aspirin and NSAIDS









COX: Cyclooxygenase

Selectives: Celebrex

- A new generation drug, Celebrex, targets COX2, but is prescribed with a strong warning of side effects on the label