LIPIDS

Nomenclature and Classification

Outline

1 Fatty Acids
2 Triacylglycerols
3 Glycerophospholipids
4 Sphingolipids
5 Waxes
6 Terpenes, Steroids
7 Prostaglandins, Leukotrienes

Introduction

- Definition: water insoluble compounds
  - Most lipids are fatty acids or ester of fatty acid
  - They are soluble in non-polar solvents such as petroleum ether, benzene, chloroform
- Functions
  - Energy storage
  - Structure of cell membranes
  - Thermal blanket and cushion
  - Precursors of hormones (steroids and prostaglandins)
- Types:
  - Fatty acids
  - Neutral lipids
  - Phospholipids and other complex lipids

Classes of Lipids

All biological lipids are amphipathic

Fatty acids

Triacylglycerols

Glycerophospholipids

Sphingolipids

Waxes

Isoprene-based lipids (including steroids)

1. Fatty acids

- Carboxylic acid derivatives of long chain hydrocarbons
- Majority of the biological lipids are 'amphipathic' in nature [*this helps them to act as effective barriers to more polar molecules, in membranes*]
  - Nomenclature (somewhat confusing)
    - Stearate – stearic acid – $C_{18:0}$ – n-octadecanoic acid

n = 0 : CH_3COOH n = 1 : propionic acid

n is almost always even

Fatty acids

Fatty acids can be classified either as:

- saturated or unsaturated
- according to chain length:
  - short chain FA: 2-4 carbon atoms
  - medium chain FA: 6 –10 carbon atoms
  - long chain FA: 12 – 26 carbon atoms
  - essential fatty acids vs those that can be biosynthesized in the body:
    - linoleic and linolenic are two examples of essential fatty acid

Some lower microorganisms also have branched or cyclic fatty acids

Saturated Fatty acids

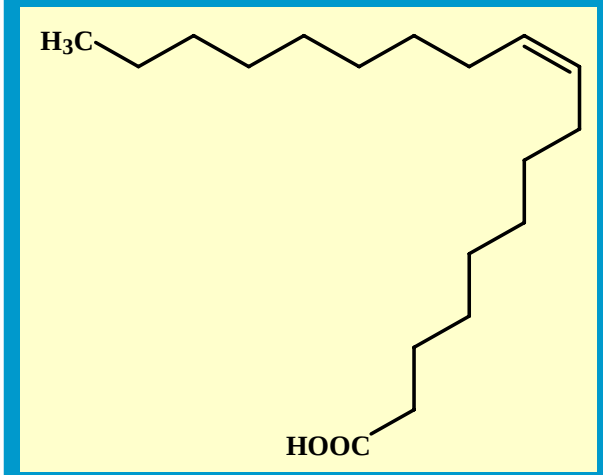
Saturated

- Lauric acid (12 C)
- Myristic acid (14 C)
- Palmitic acid (16 C)
- Stearic acid (18 C)
- Arachidic acid (20 C)

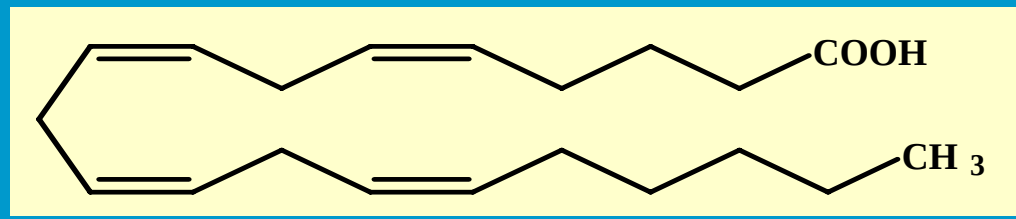
Unsaturated fatty acids

Slightly more abundant in nature than saturated FA, especially in higher plants. The number of double bonds varies from 1 to 4, but in most bacteria this number rarely exceeds one.

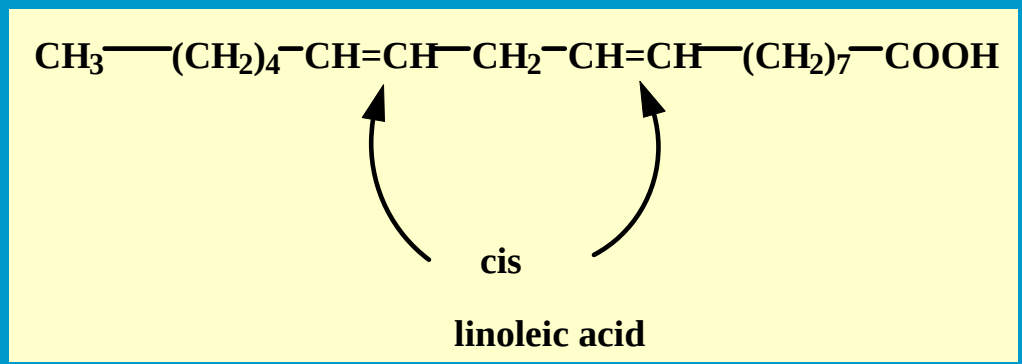
Monoenoic acid (monounsaturated):
Oleic, 18:1



Polyenoic acid (polyunsaturated):
Arachidonic, 20:4



Dienoic acid: linoleic acid, 18:2



Unsaturated fatty acids

Trienoic acids (3 double bonds)

- 18:3;6,9,12 ω6 : γ-linolenic acid (all ***cis***-6,9,12-octadecatrienoic acid)
- 18:3; 9,12,15 ω3 : α-linolenic acid (all-***cis***-9,12,15-octadecatrienoic acid)

Tetraenoic acids (4 double bonds)

- 20:4; 5,8,11,14 ω6: arachidonic acid (all-***cis***-5,8,11,14-eicosatetraenoic acid)

Pentaenoic acid (5 double bonds)

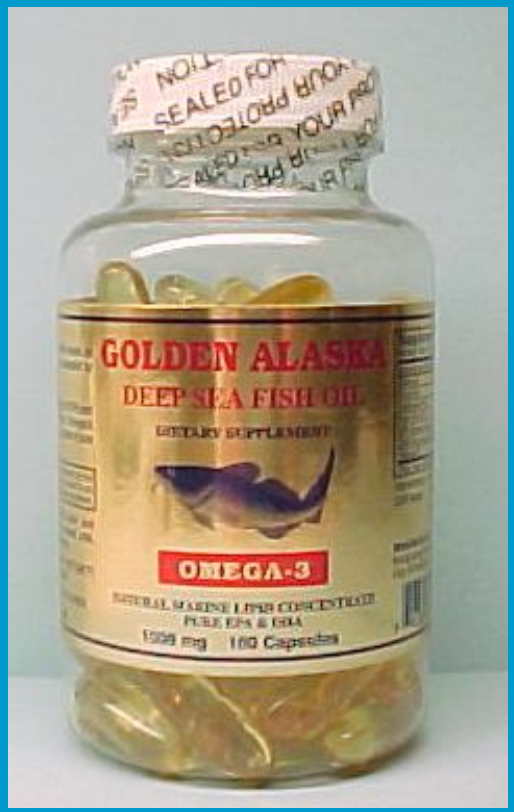
- 20:5; 5,8,11,14,17 w3: timnodonic acid or EPA (all-***cis***-5,8,11,14,17-eicosapentaenoic acid)*

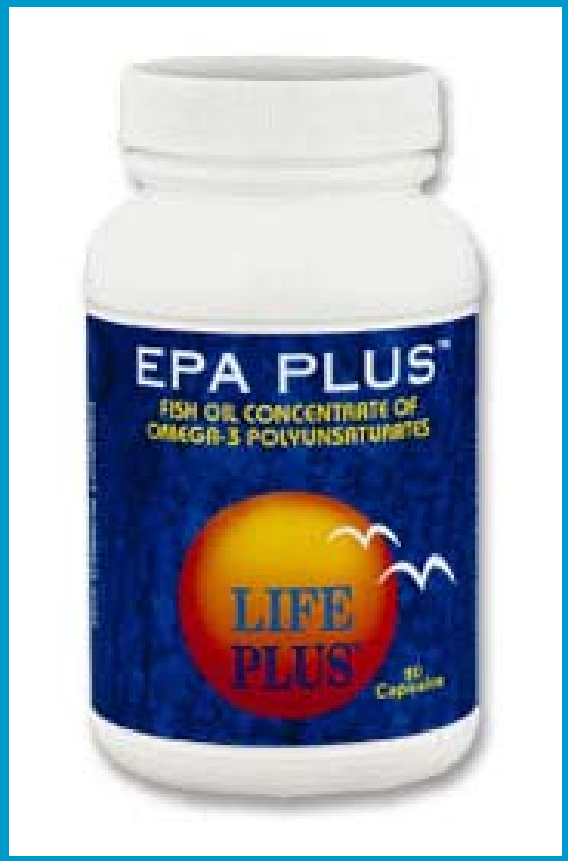
Hexaenoic acid (6 double bonds)

- 22:6; 4,7,10,13,16,19 w3: cervonic acid or DHA (all-cis-4,7,10,13,16,19-docosahexaenoic acid)*

***Both FAs are found in cold water fish oils**

Typical fish oil supplements





Unsaturated Fatty acids

Structural consequences of unsaturation

- **Double bond is always *cis* in natural fatty acids. This lowers the melting point due to “kink” in the chain**
- **Saturated chains pack tightly and form more rigid, organized aggregates (i.e., membranes)**
- **Unsaturated chains bend and pack in a less ordered way, with greater potential for motion**

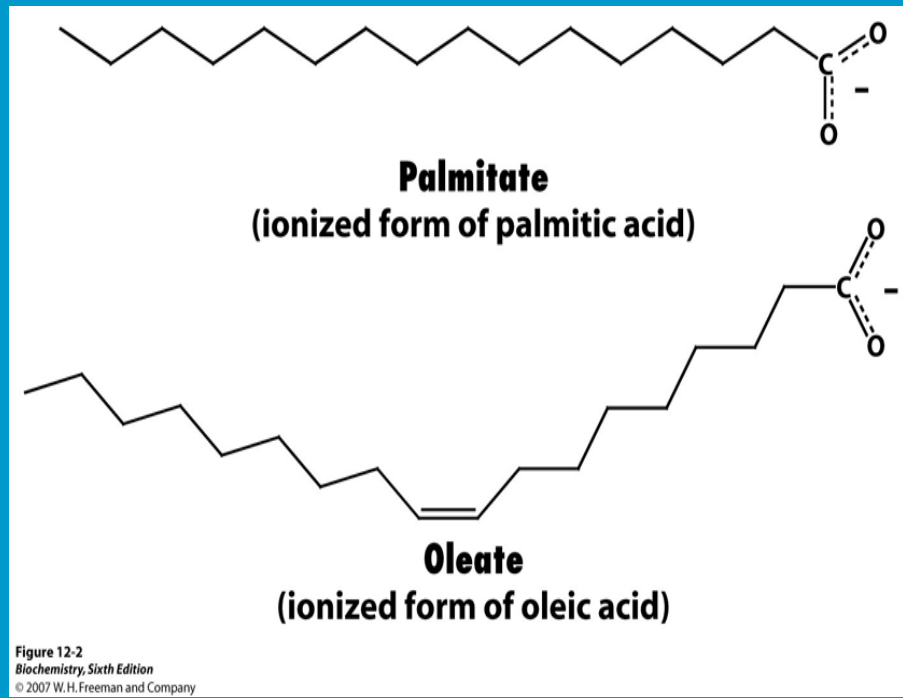
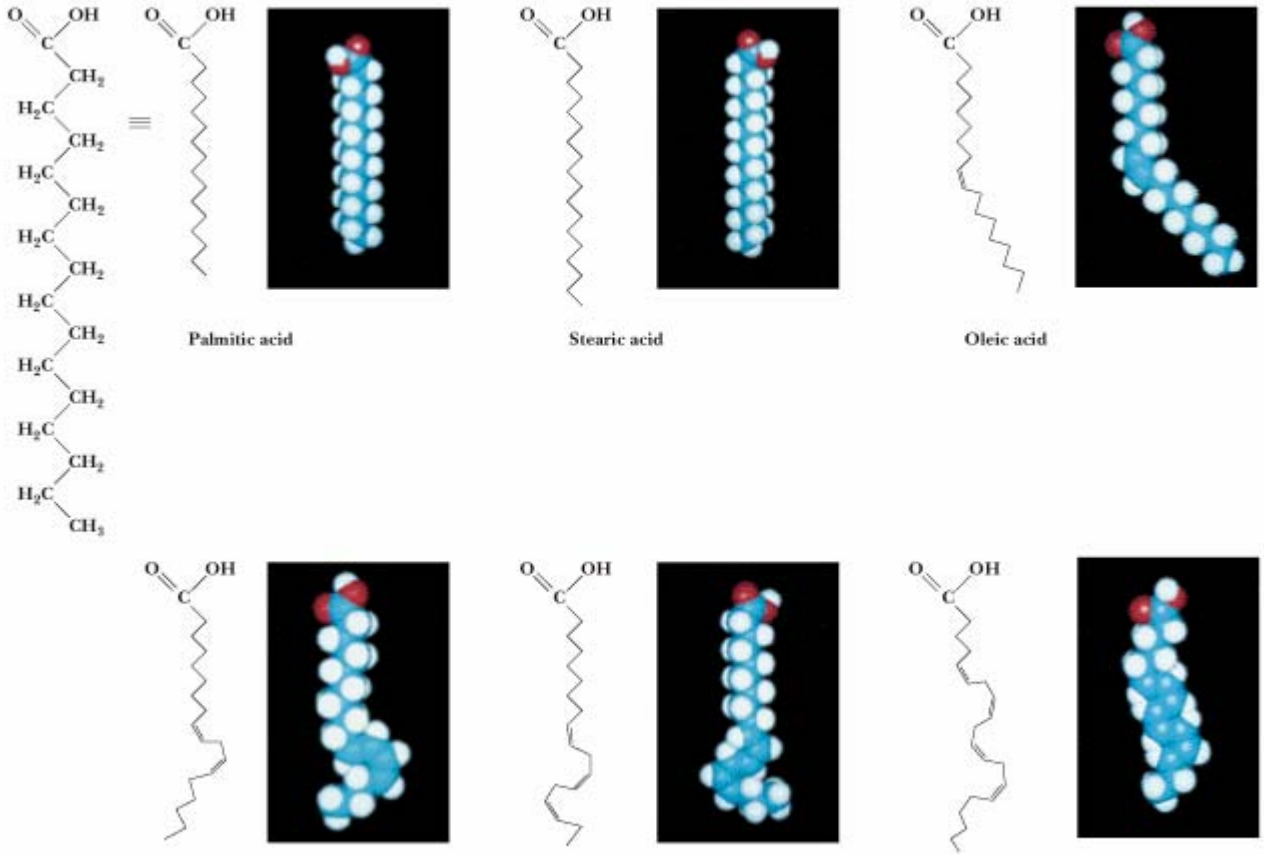


Figure 12-2
Biochemistry, Sixth Edition

Garrett & Grisham: Biochemistry, 2/e
Figure 8.1



Saunders College Publishing

Garrett & Grisham: Biochemistry, 2/e
Table 8.1

Table 8.1

Common Biological Fatty Acids

Number of Carbons	Common Name	Systematic Name	Symbol	Structure
Saturated fatty acids				
12	Lauric acid	Dodecanoic acid	12:0	$CH_3(CH_2)_{10}COOH$
14	Myristic acid	Tetradecanoic acid	14:0	$CH_3(CH_2)_{12}COOH$
16	Palmitic acid	Hexadecanoic acid	16:0	$CH_3(CH_2)_{14}COOH$
18	Stearic acid	Octadecanoic acid	18:0	$CH_3(CH_2)_{16}COOH$
20	Arachidic acid	Eicosanoic acid	20:0	$CH_3(CH_2)_{18}COOH$
22	Behenic acid	Docosanoic acid	22:0	$CH_3(CH_2)_{20}COOH$
24	Lignoceric acid	Tetracosanoic acid	24:0	$CH_3(CH_2)_{22}COOH$
Unsaturated fatty acids (all double bonds are *cis*)				
16	Palmitoleic acid	9-Hexadecenoic acid	16:1	$CH_3(CH_2)_5CH{=}CH(CH_2)_7COOH$
18	Oleic acid	9-Octadecenoic acid	18:1	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$
18	Linoleic acid	9,12-Octadecadienoic acid	18:2	$CH_3(CH_2)_4(CH{=}CHCH_2)_2(CH_2)_6COOH$
18	α-Linolenic acid	9,12,15-Octadecatrienoic acid	18:3	$CH_3CH_2(CH{=}CHCH_2)_3(CH_2)_6COOH$
18	γ-Linolenic acid	6,9,12-Octadecatrienoic acid	18:3	$CH_3(CH_2)_4(CH{=}CHCH_2)_3(CH_2)_3COOH$
20	Arachidonic acid	5,8,11,14-Eicosatetraenoic acid	20:4	$CH_3(CH_2)_4(CH{=}CHCH_2)_4(CH_2)_2COOH$
24	Nervonic acid	15-Tetracosenoic acid	24:1	$CH_3(CH_2)_7CH{=}CH(CH_2)_{13}COOH$

Saunders College Publishing

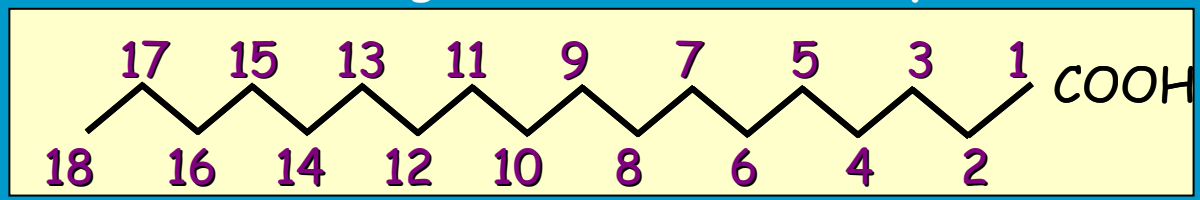
Fatty acid nomenclature

Nomenclature of Fatty Acids

Names		Abbreviations	
trivial	IUPAC	carboxyl-reference	ω - reference
palmitic acid	hexadecanoic acid	16:0	16:0
stearic acid	octadecanoic acid	18:0	18:0
oleic acid	9-octadecenoic acid	18:1 Δ^{9}	18:1 (ω-9)
linoleic acid	9,12-octadecenoic acid	18:2 $\Delta^{9,12}$	18:2 (ω-6)
linolenic acid	9, 12, 15-octadecenoic acid	18:3 $\Delta^{9,12,15}$	18:3 (ω-3)

Δ-Designation

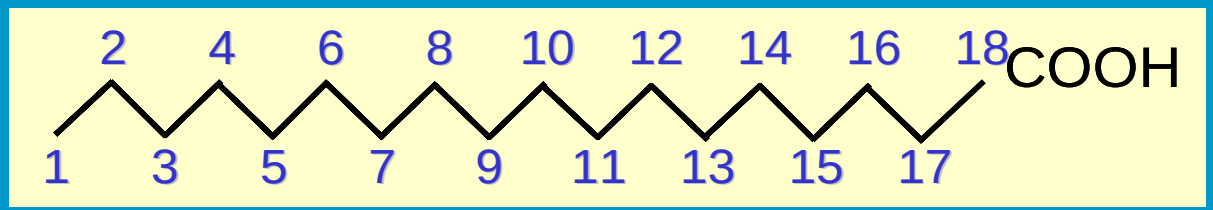
Carbon numbering starts from carboxylic acid end:



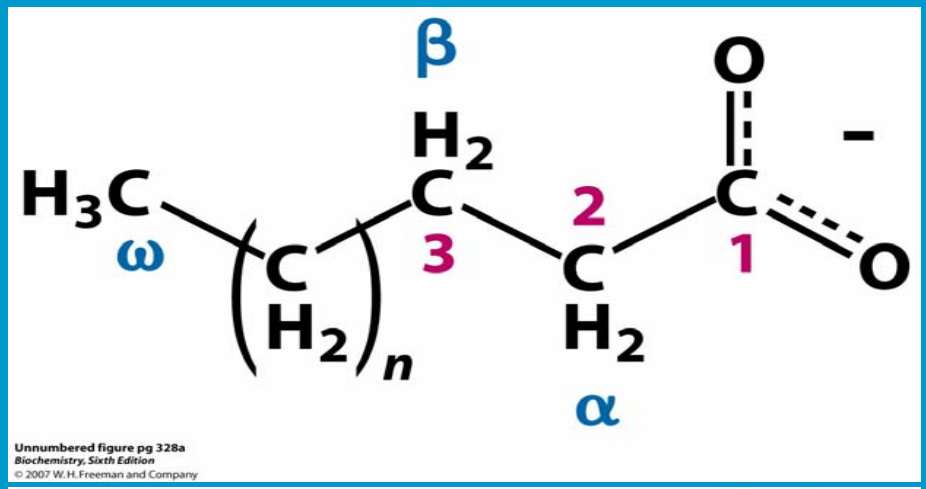
Changes as you add carbons to the carboxyl end

n-Designation

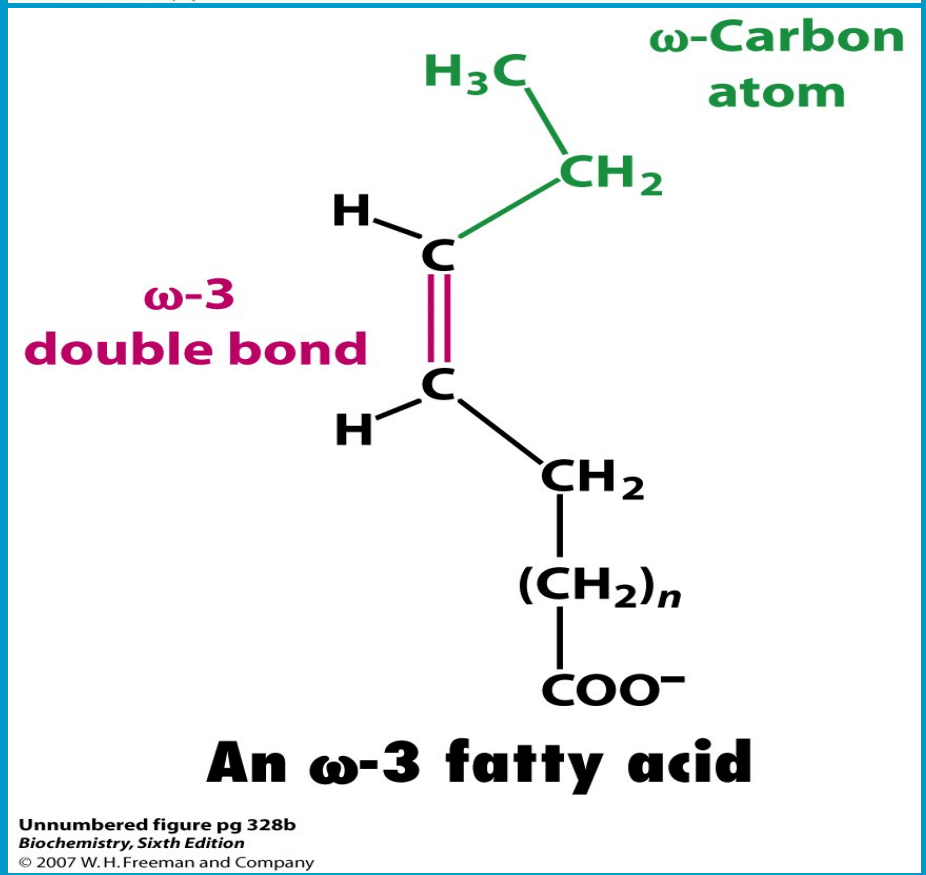
Carbon numbering starts from methyl end:



Doesn't change as you add carbons to the carboxyl end



Unnumbered figure pg 328a
Biochemistry, Sixth Edition

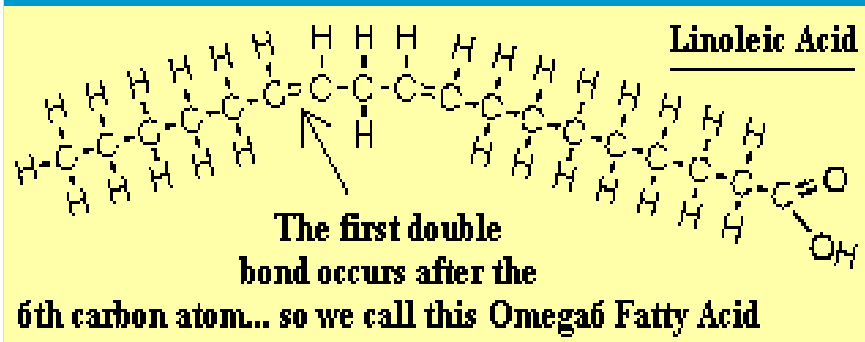


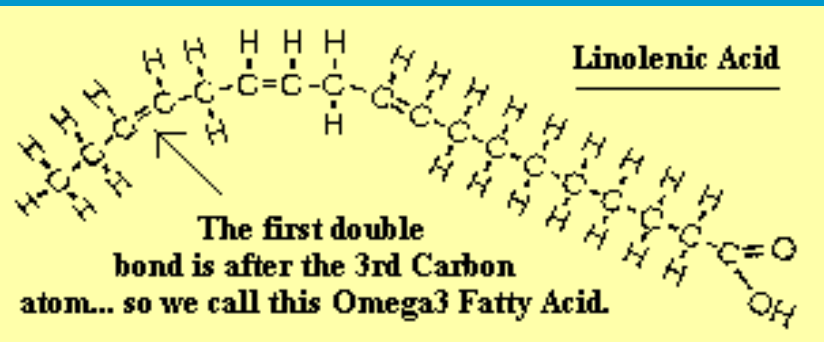
Unnumbered figure pg 328b
Biochemistry, Sixth Edition

Essential fatty acids:

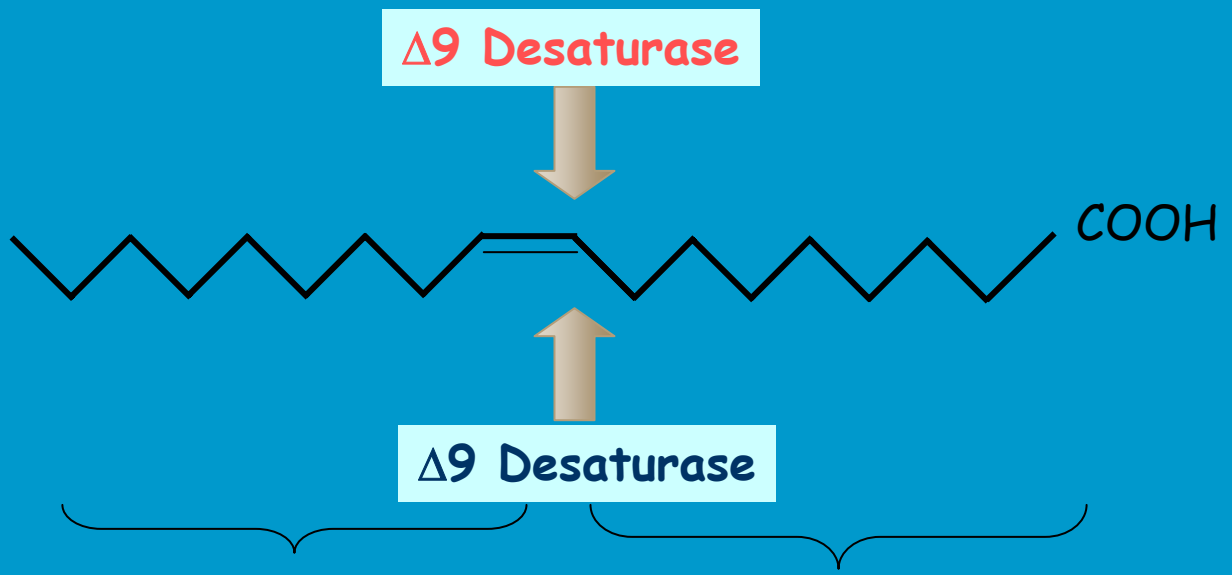
Linoleic acid (2 double bonds, Omega 6) 18:2n6

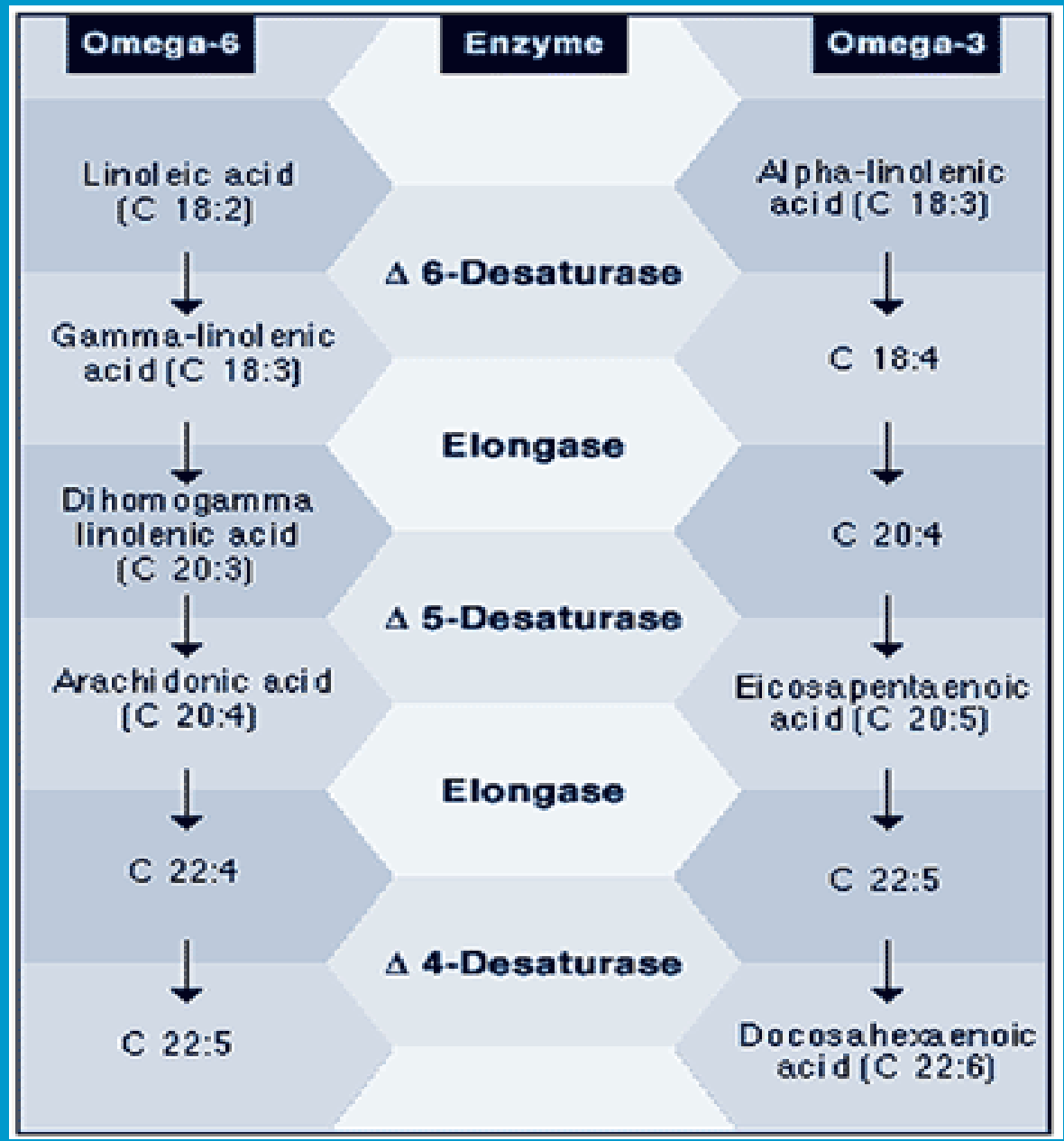
Linolenic acid (3 double bonds, Omega 3) 18:3n3





First double bonds always inserted at 9th C




Omega-6
Enzyme
Omega-3
Linoleic acid (C 18:2)
Δ 6-Desaturase
Alpha-linolenic acid (C 18:3)
Gamma-linolenic acid (C 18:3)
C 18:4
Elongase
Dihomogamma linolenic acid (C 20:3)
C 20:4
Δ 5-Desaturase
Arachidonic acid (C 20:4)
Eicosapentaenoic acid (C 20:5)
Elongase
C 22:4
C 22:5
Δ 4-Desaturase
C 22:5
Docosahexaenoic acid (C 22:6)

Cis vs. Trans Bonds of Unsaturated Fatty Acids

Trans: from food processing

- **Partial hydrogenation of polyunsaturated fats**

  [the purpose of hydrogenation is to make the oil/fat more stable to oxygen and temperature variation (increase shelf life) example of hydrogenated fats: Crisco, margarine]

- **Lowers fluidity - becomes more solid at room temp.**

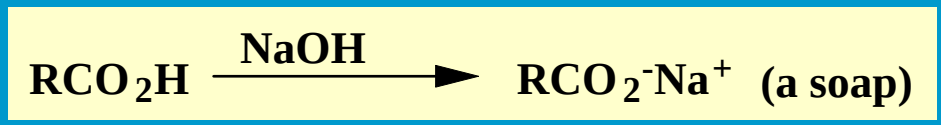
Fat composition in known diets

Myristic acid	Coconut and palm oils, most animal and plant fats
Palmitic acid	Animal and plant fats
Stearic acid	Animal fats, some plant fats
Arachidic acid	Peanut oil
Lignoceric acid	Most natural fats, peanut oil in small amounts
Palmitoleic acid	Marine animal oils, small amounts in animal and plant fats
Oleic acid	Animal and plant fats
Linoleic acid	Corn, safflower, soybean, cottonseed, sunflower seed, and peanut oils
Linolenic acid	Linseed, soybean, and other seed oils
Arachidonic acid	Animal fats in small amounts

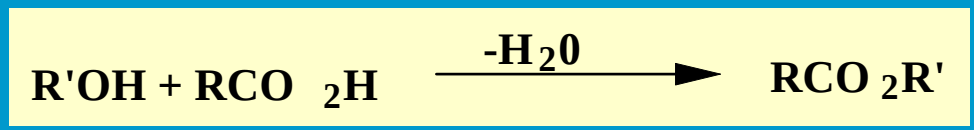
Food	Total lipid	Cholesterol	Saturated	Oleic	Linoleic	Linolenic
Milk	3.5	12	59	25	3	1.0
Egg	11.0	548	29	37	11	0.2
Beef -lean ground	22.0	70	50	41	3	0.7
Pork -lean	14.0	85	37	42	9-14	1.0
Chicken leg -flesh	3.5	74	27	47	22	2.0
Salmon	14.0	35	18	16	2	20.0
Whole wheat	2.0	0	21	14	55	4.0
Corn -whole	3.8	0	15	44	43	2.0
Soybeans -whole	18.0	0	13	22	54	5.0
Peanuts -butter	48.0	0	14	48	28	0.5
Coconut -fresh	38.0	0	83	5	2	0
Avocado -fresh	24.0	0	14	66	9	trace

Fatty acid reactions

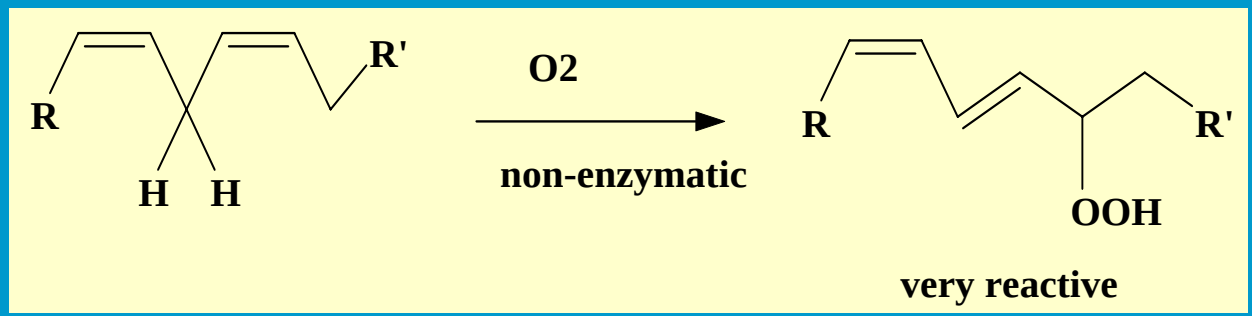
- salt formation



- ester formation

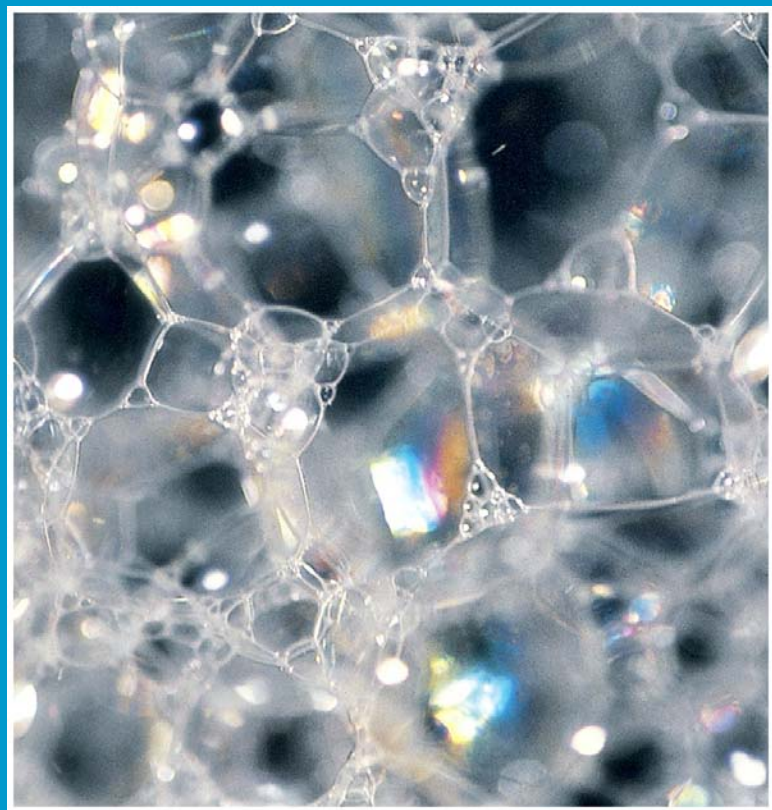


- lipid peroxidation



Soaps

- Process of formation is known as saponification
  - **Types of soaps:**
    - **Sodium soap – ordinary hard soap**
    - **Potassium soap – soft soap (shaving soaps are potassium soaps of coconut and palm oils)**
    - **Castile soap – sodium soap of olive oil**
    - **Green soap – mixture of sodium and potassium linseed oil**
    - **Transparent soap – contains sucrose**
    - **Floating soap – contains air**
    - **Calcium and magnesium soaps are very poorly water soluble (hard water contains calcium and magnesium salts –these insolubilize soaps)**



Chapter 12 Opener part 1
Biochemistry, Sixth Edition

2. Triacylglycerols

Also called triglycerides

Esters of Glycerol

1. A major energy source for many organisms

Why?

- **Most reduced form of carbon in nature [complete oxidation of 1g of TG yields 36kJ of energy compared to similar amounts of protein or carbohydrate, which yield only 17 kJ]**
- **No solvation needed [because of their hydrophopic nature they form aggregates of anhydrous form]**
- **Efficient packing**
- **Insulation**

2. MAG and DAG emulsify food during digestion

3. TAG core of lipoproteins, transports fat-soluble agents in bloodstream

- vitamins

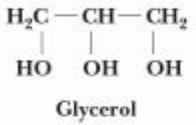
- drugs

- cholesterol

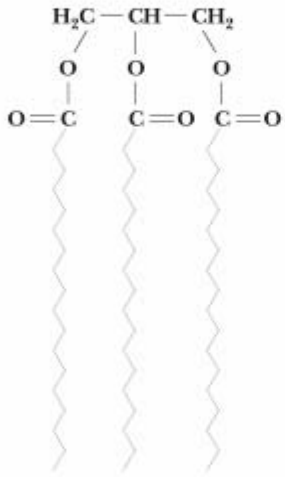
- toxins

4. TGs in animals are primarily found in the adipose tissue

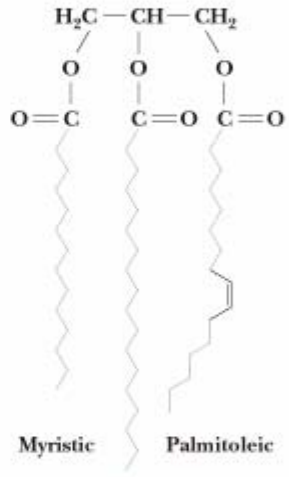
Garrett & Grisham: Biochemistry, 2/e
Figure 8.3



Glycerol



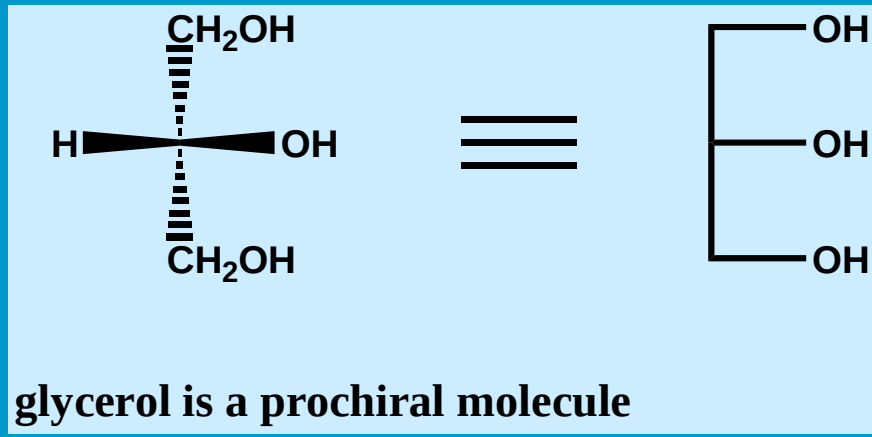
Tristearin
(a simple triacylglycerol)



A mixed triacylglycerol

Stereospecific numbering

- Carbon 2 of triglycerides is frequently asymmetric since C-1 and C-3 may be substituted with different acyl groups
- By convention we normally draw the hydroxyl group at C-2 to the left and use the designation of sn2 for that particular substituent
- C-1 and C-3 of the glycerol molecule become sn1 and sn3 respectively



glycerol is a prochiral molecule

3. Glycerophospholipids

A 1,2 diacylglycerol that has a phosphate group esterified at carbon atom 3 of the glycerol backbone

- **All glycerophospholipids are members of the broader class of lipids known as phospholipids**
- **Structural [essential component of cell membranes]**
- **Adds a hydrophilic region to lipid surfaces**
  - **lipoproteins**
  - **cell membranes**
- **Key source of intracellular signaling agents and hormones**
  - **eicosanoids**
  - **inositol**
  - **choline**

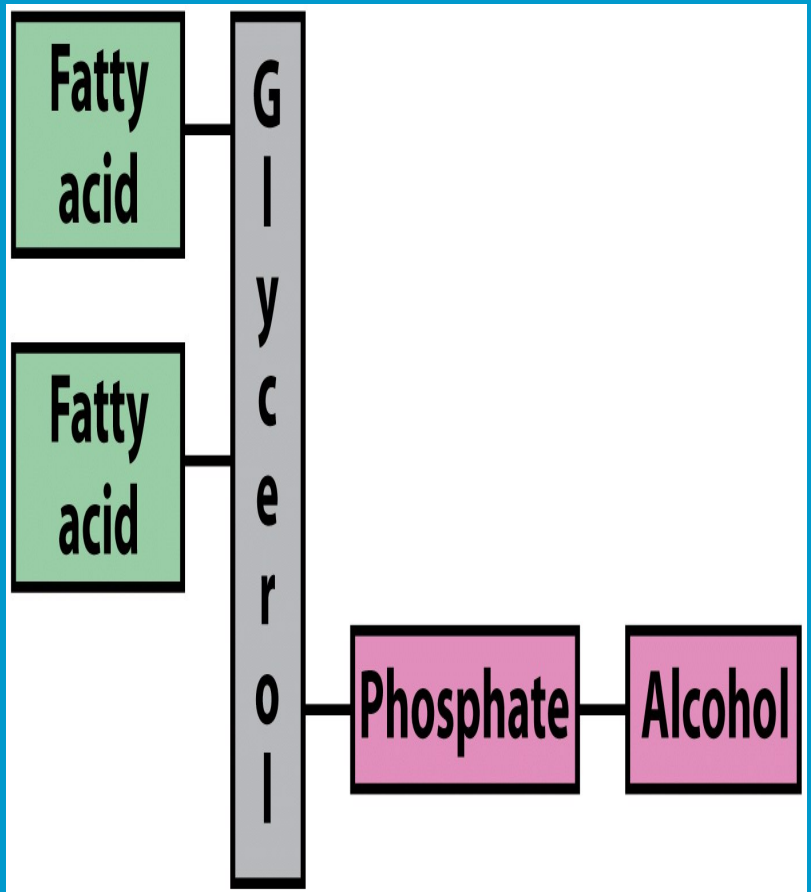


Figure 12-3
Biochemistry, Sixth Edition

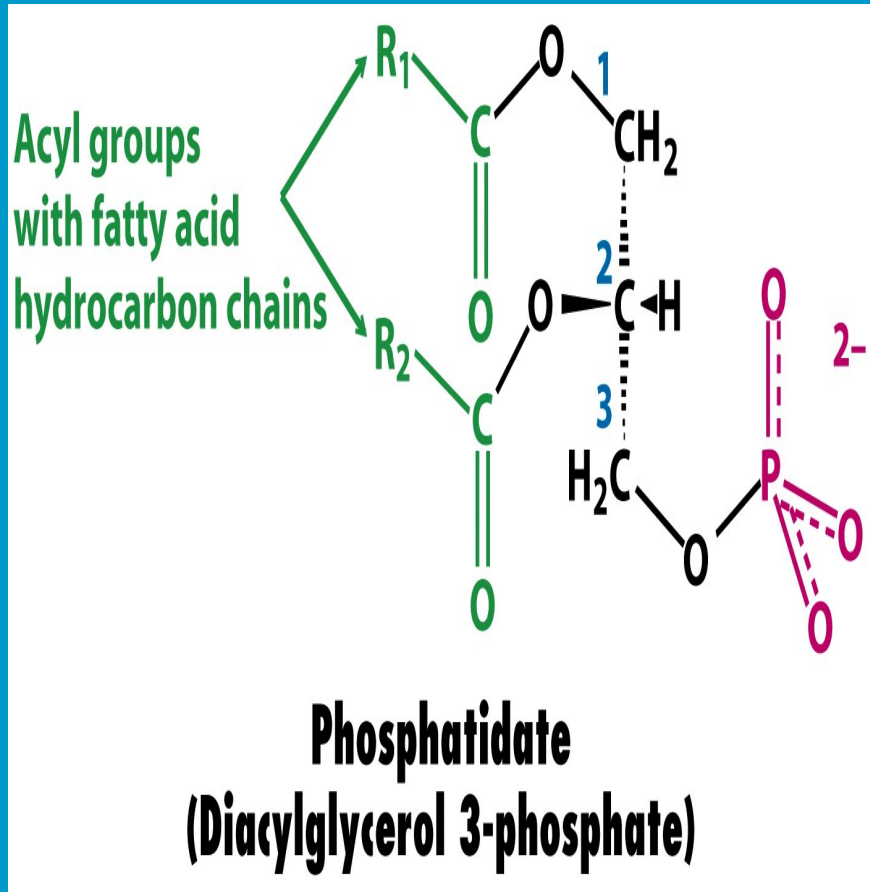
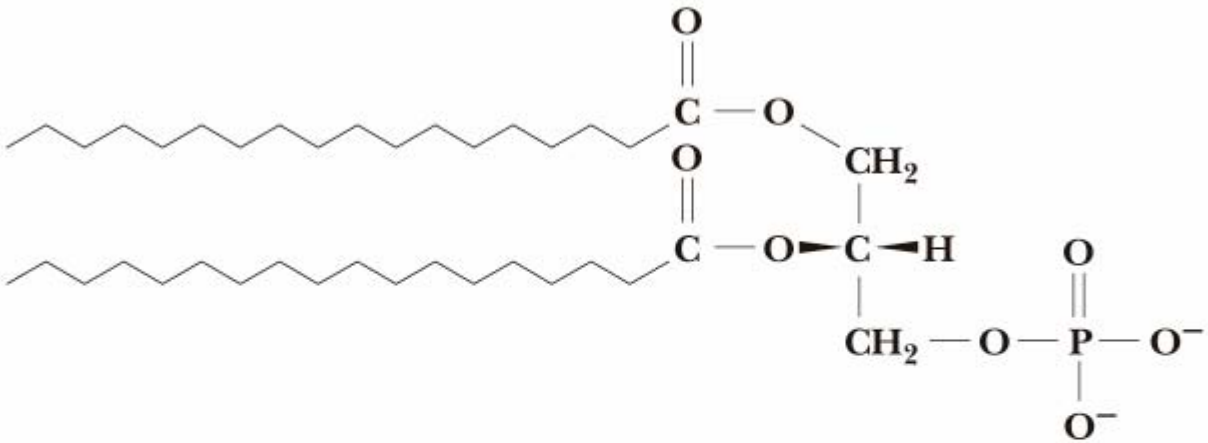
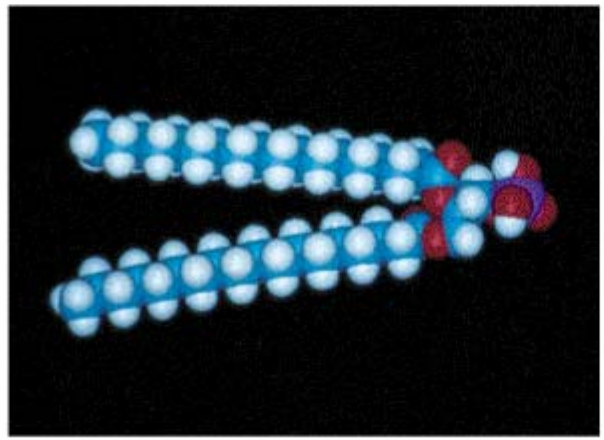


Figure 12-4
Biochemistry, Sixth Edition

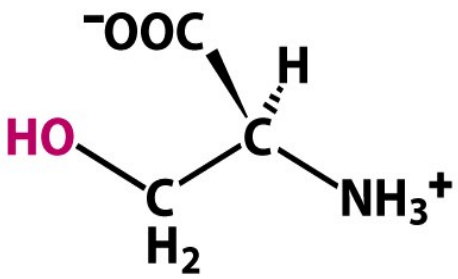
Remember that, in most cases glycerophospholipids have a saturated fatty acid at position 1 and an unsaturated fatty acid at position 2 of the glycerol

Garrett & Grisham: Biochemistry, 2/e
Figure 8.4

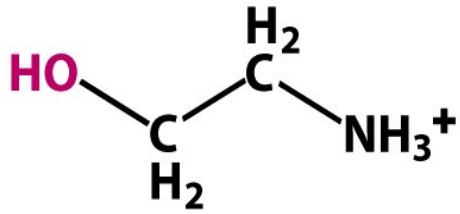




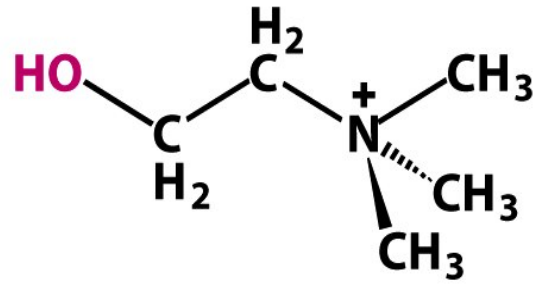
Saunders College Publishing



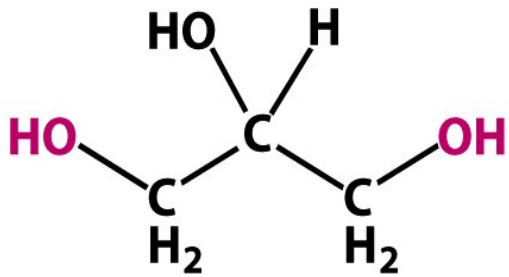
Serine



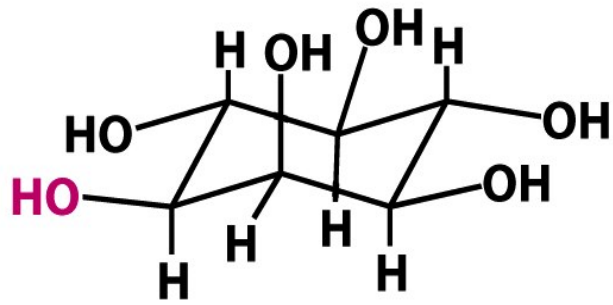
Ethanolamine



Choline

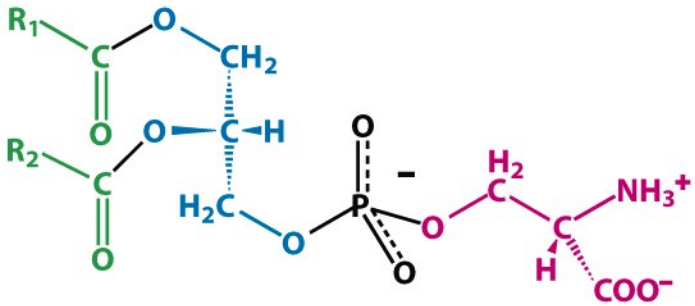


Glycerol

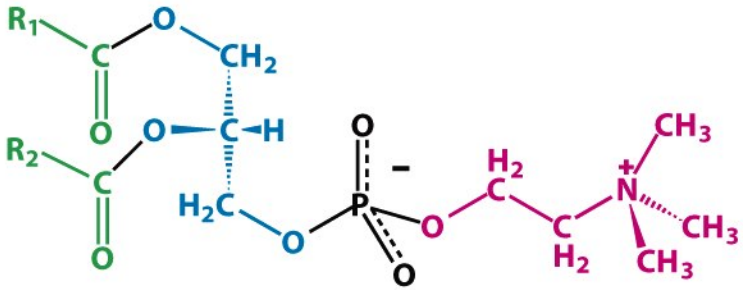


Inositol

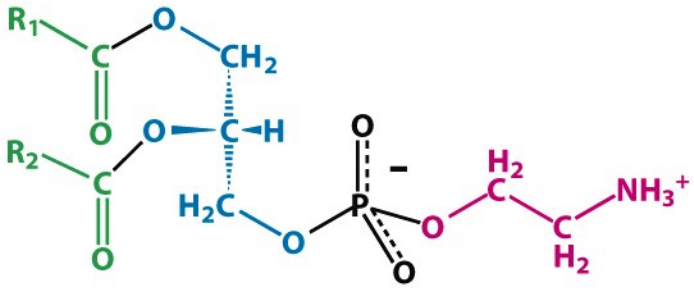
Unnumbered figure pg 330
Biochemistry, Sixth Edition



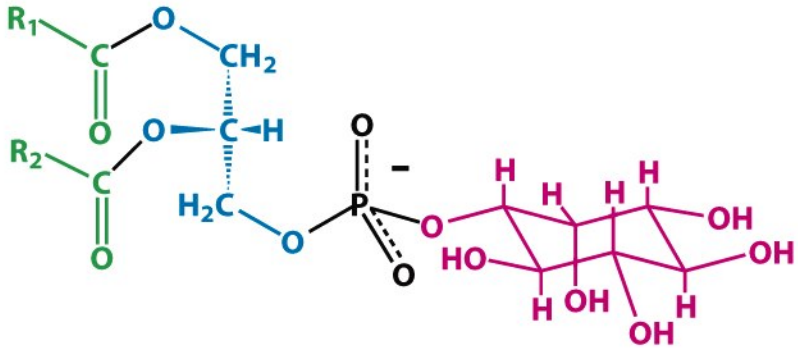
Phosphatidylserine



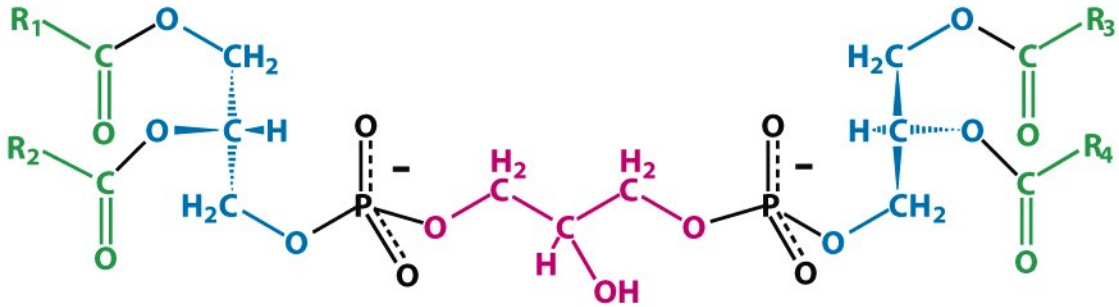
Phosphatidylcholine



Phosphatidylethanolamine

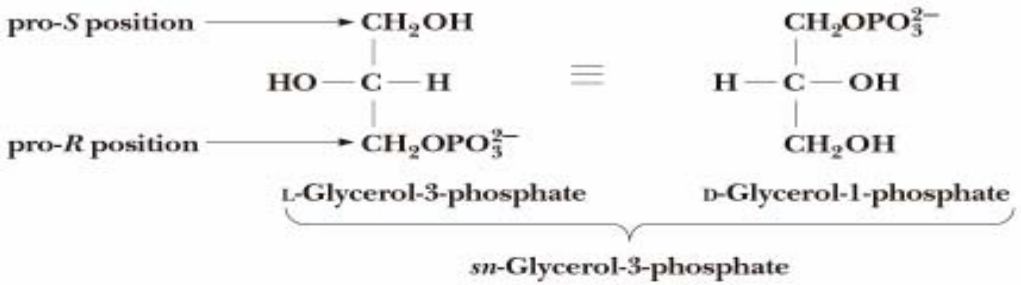


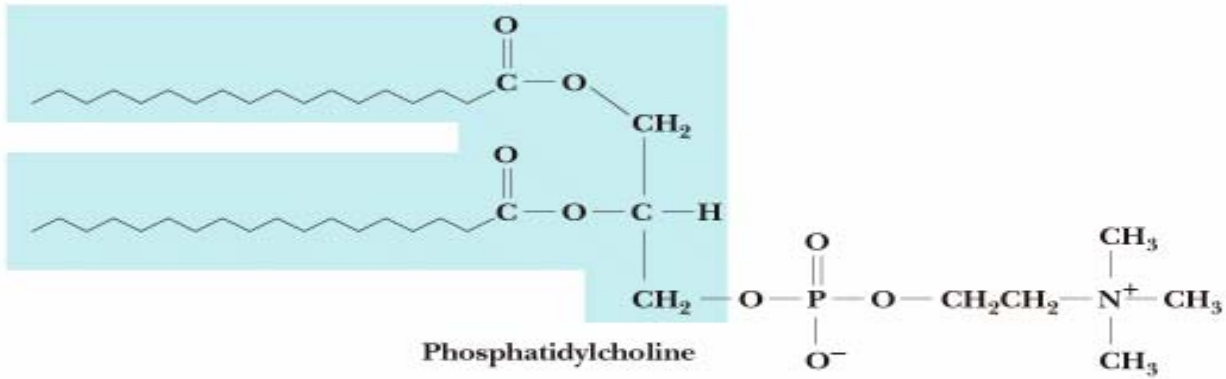
Phosphatidylinositol

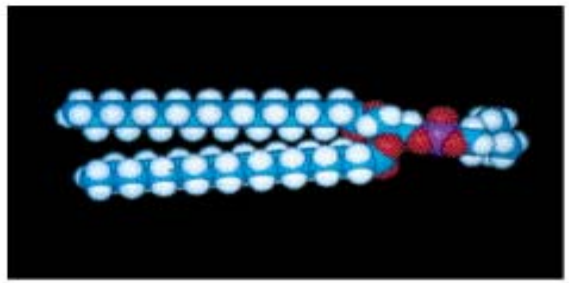


Diphosphatidylglycerol (cardiolipin)

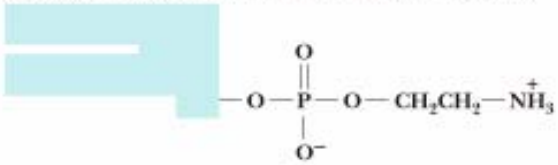
Figure 12-5
Biochemistry, Sixth Edition


pro-S position
pro-R position
L-Glycerol-3-phosphate
D-Glycerol-1-phosphate
sn-Glycerol-3-phosphate

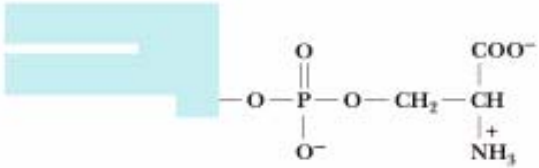

Phosphatidylcholine



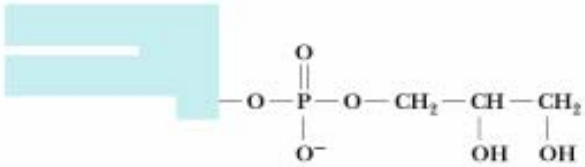
GLYCEROLIPIDS WITH OTHER HEAD GROUPS:



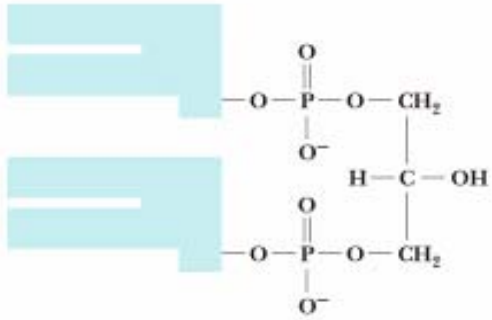
Phosphatidylethanolamine



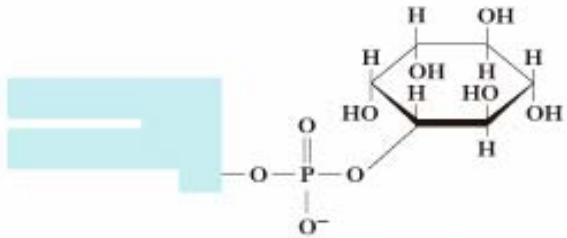
Phosphatidylserine



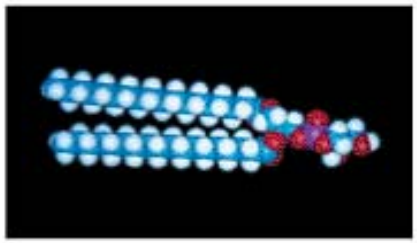
Phosphatidylglycerol

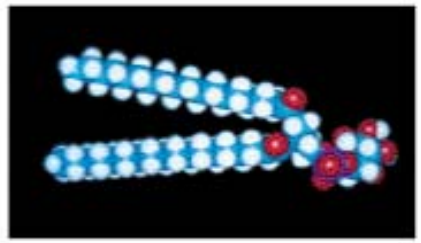


Diphosphatidylglycerol (Cardiolipin)

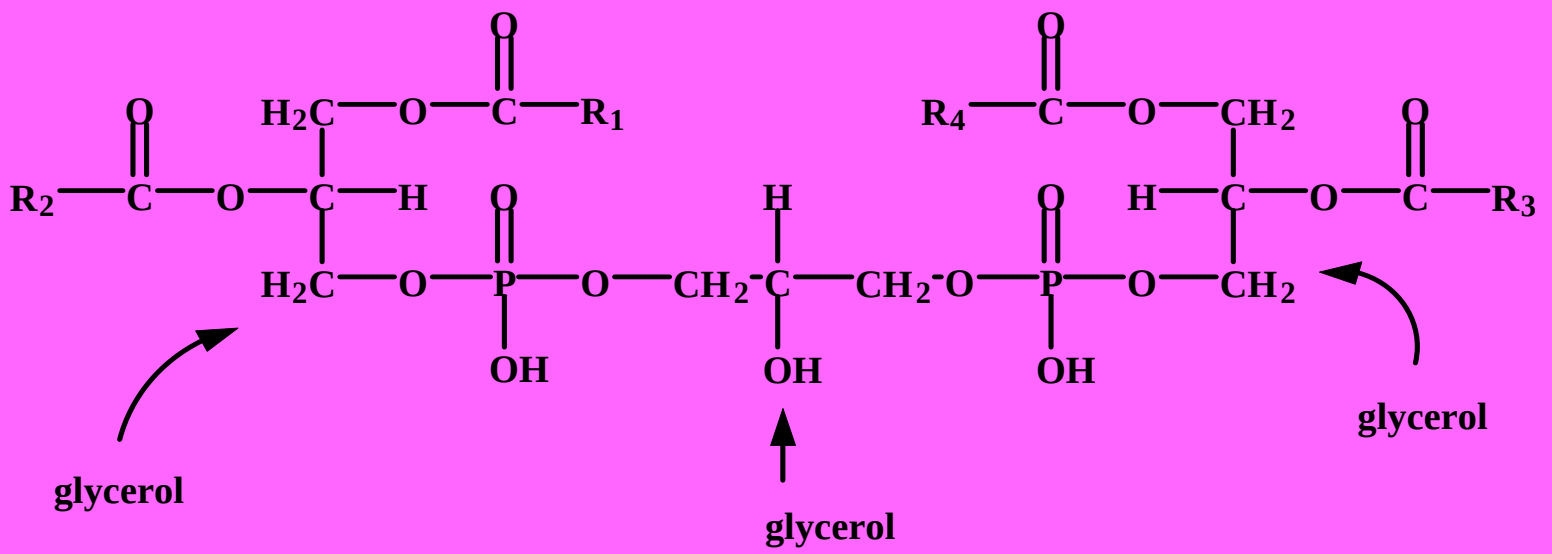


Phosphatidylinositol





Cardiolipids



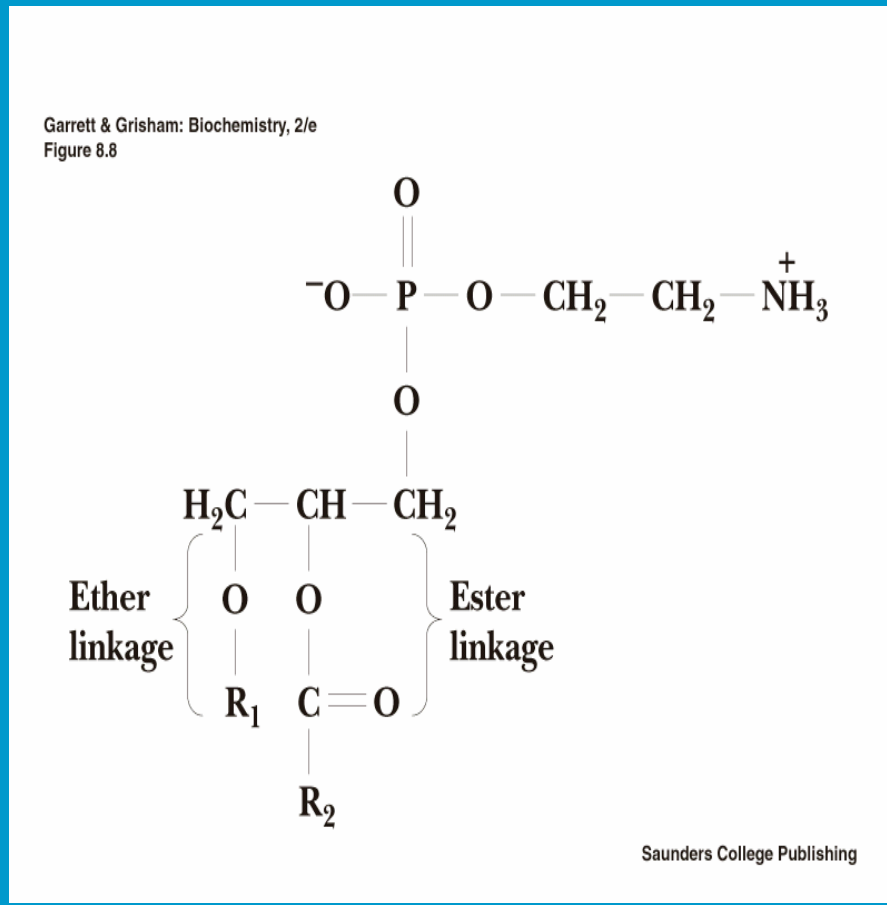
A polyglycerol phospholipid; makes up 15% of total lipid-phosphorus content of the myocardium – associated with the cell membrane

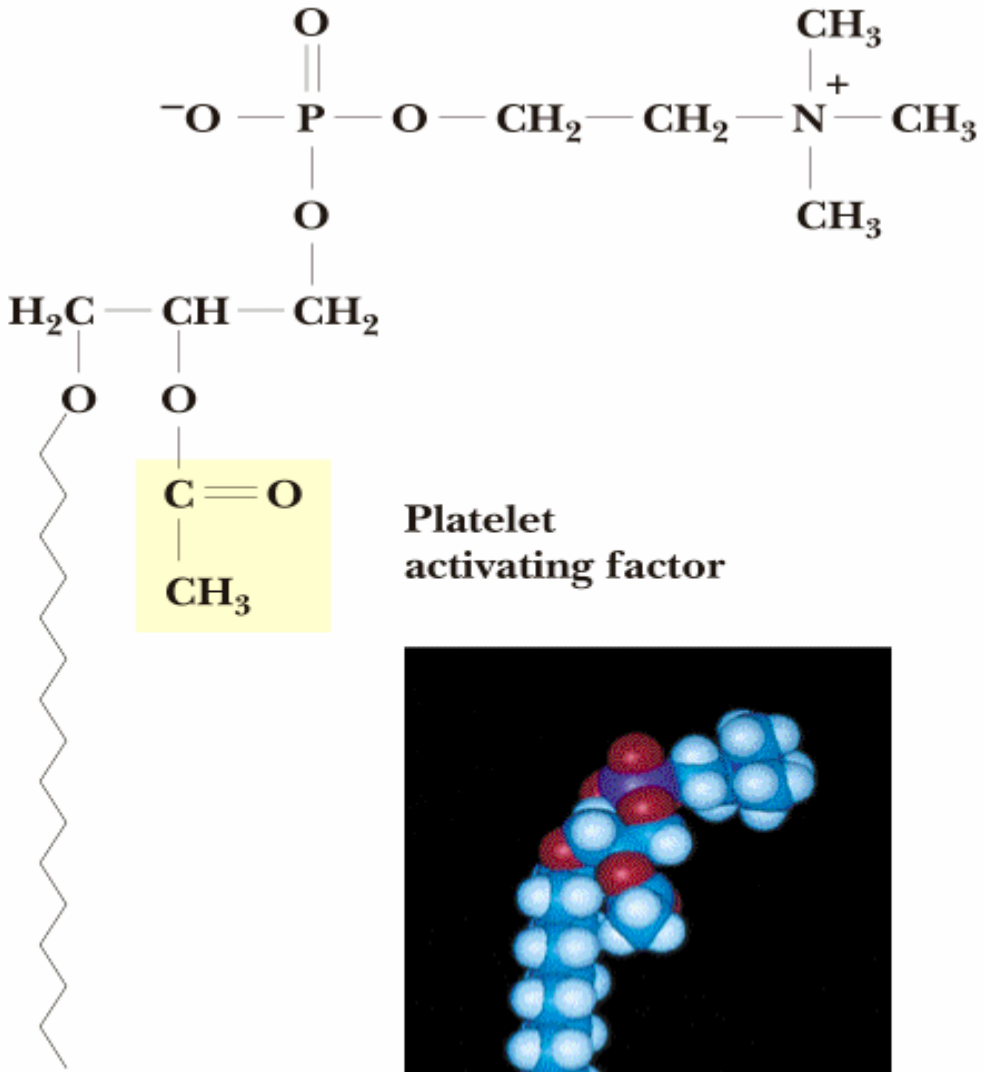
Cardiolipids are antigenic and as such are used in serologic test for syphilis (Wasserman test)

Ether Glycerophospholipids

An ether instead of an acyl group at C-1

- **Plasmalogens** are ether glycerophospholipids in which the alkyl chain is unsaturated
- Cis α,ß unsaturated ether
- Common plasmalogen head groups include choline, ethanolamine and serine [phosphatidal choline]

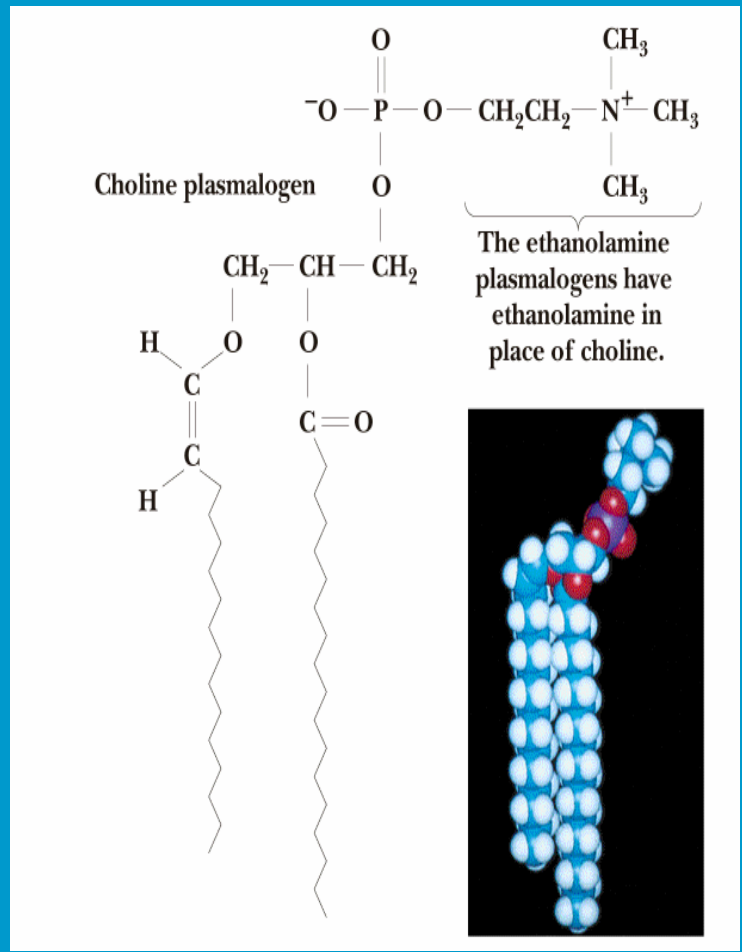




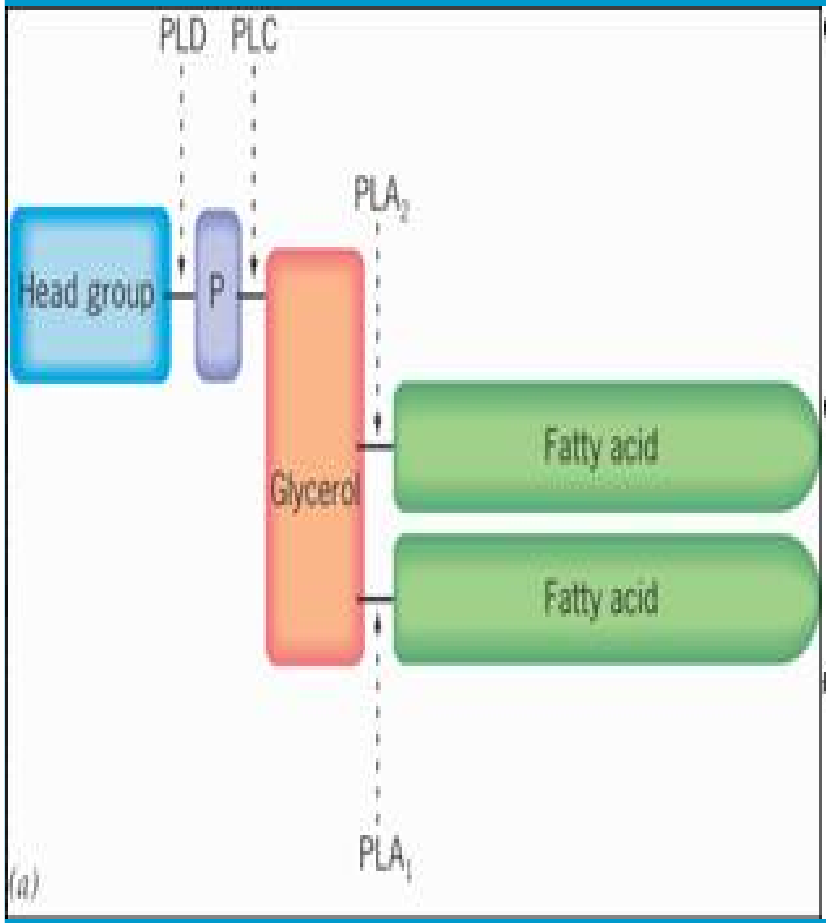
Platelet activating factor

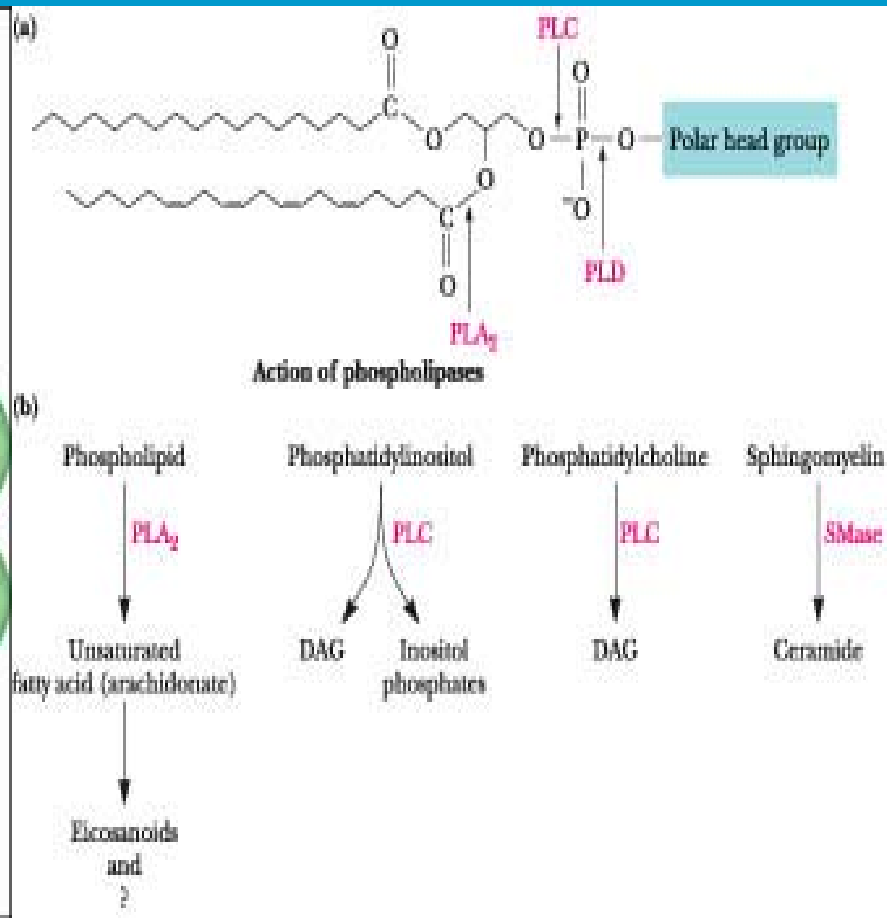
A potent ether glycerophospholipid: - PAF

- Platelet activating factor (PAF) is an ether glycerophospholipid
- PAF is a potent biochemical signal molecule [***platelet aggregation, dilation of blood vessels, potent mediator of inflammation, allergic responses and shock***]
- Note the short (acetate) fatty acyl chain at the C-2 position in PAF



Phospholipases



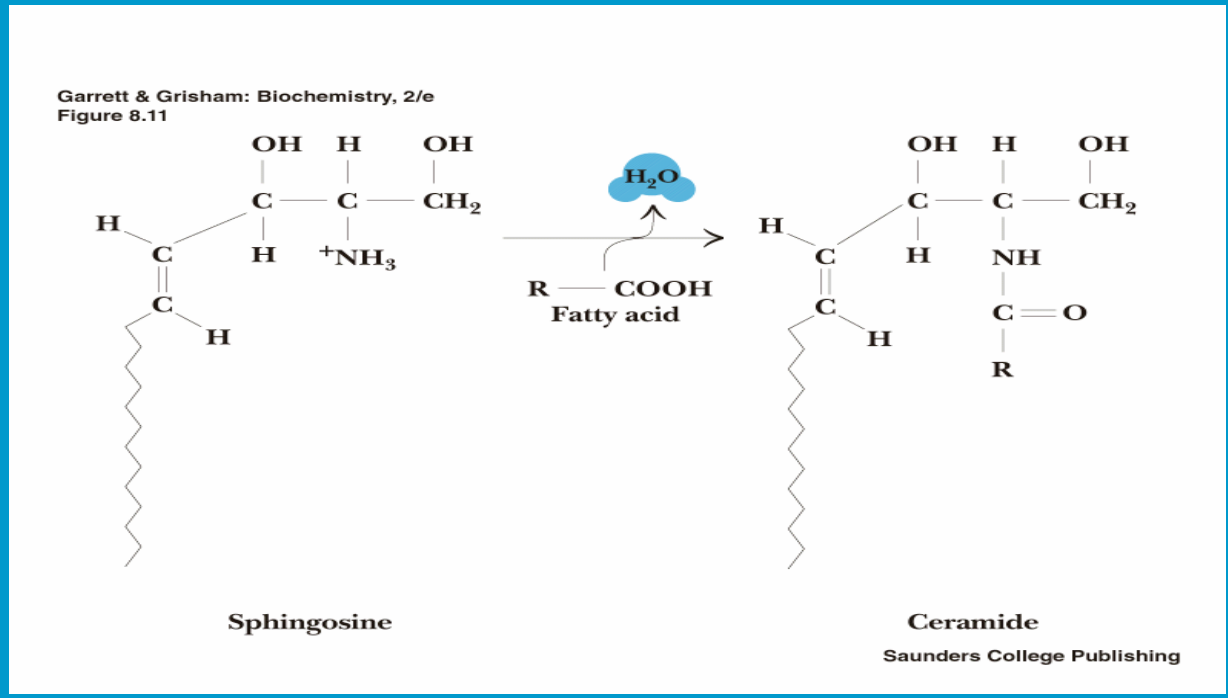


4. Sphingolipids

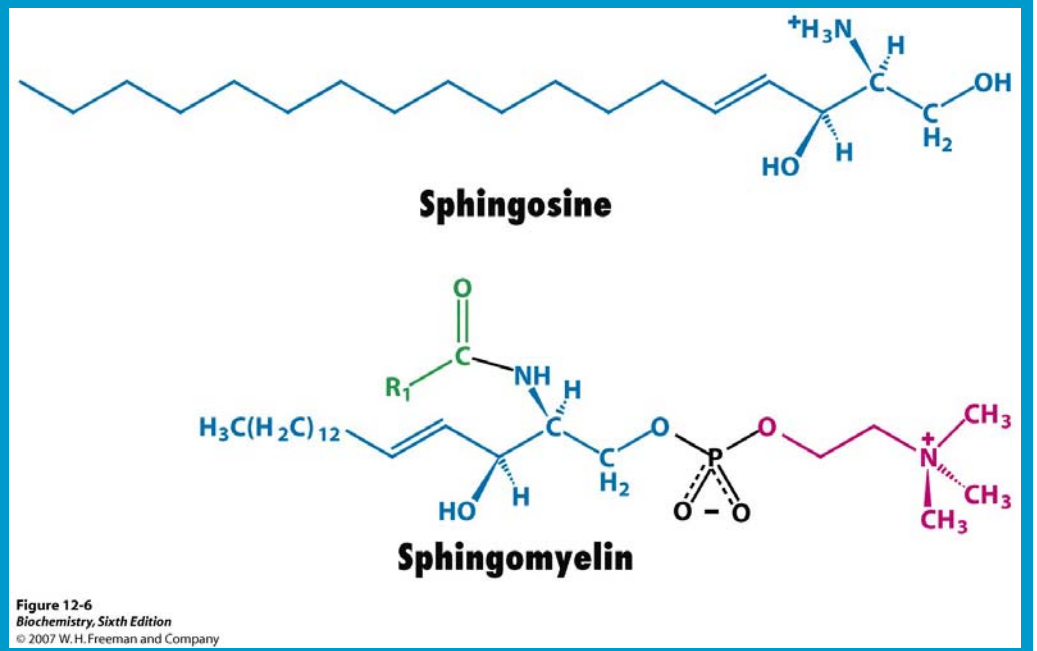
Frequently found in biological membranes

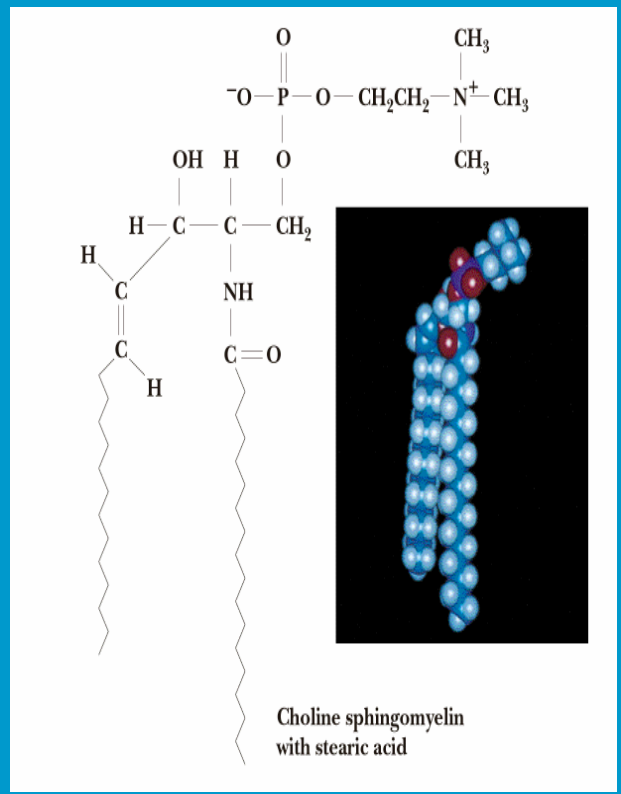
Base structure is sphingosine
Sphingosine is an 18-carbon amino alcohol

Ceramides are amide linkages of fatty acids to the nitrogen of sphingosine



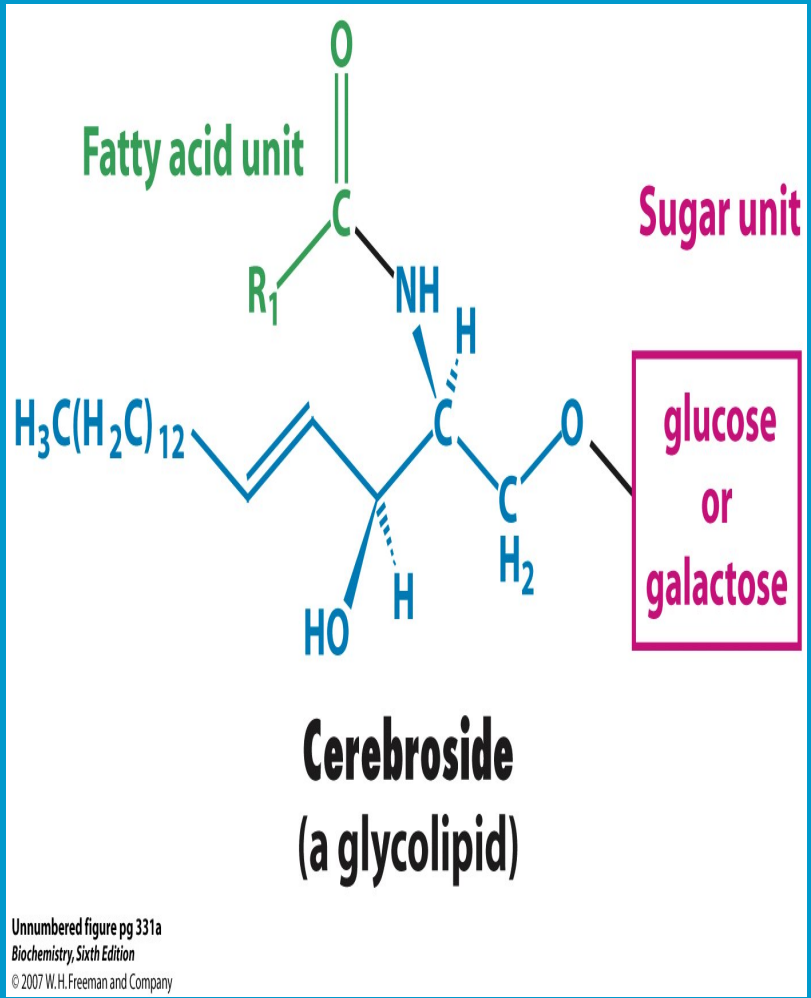
- Sphingomyelins represent a phosphorus-containing subclass of sphingolipids are especially important in the nervous tissue of higher animal.
- Formed by the esterification of a phosphorylcholine or phosphorylethanolamine to the 1-hydroxy group of a ceramide

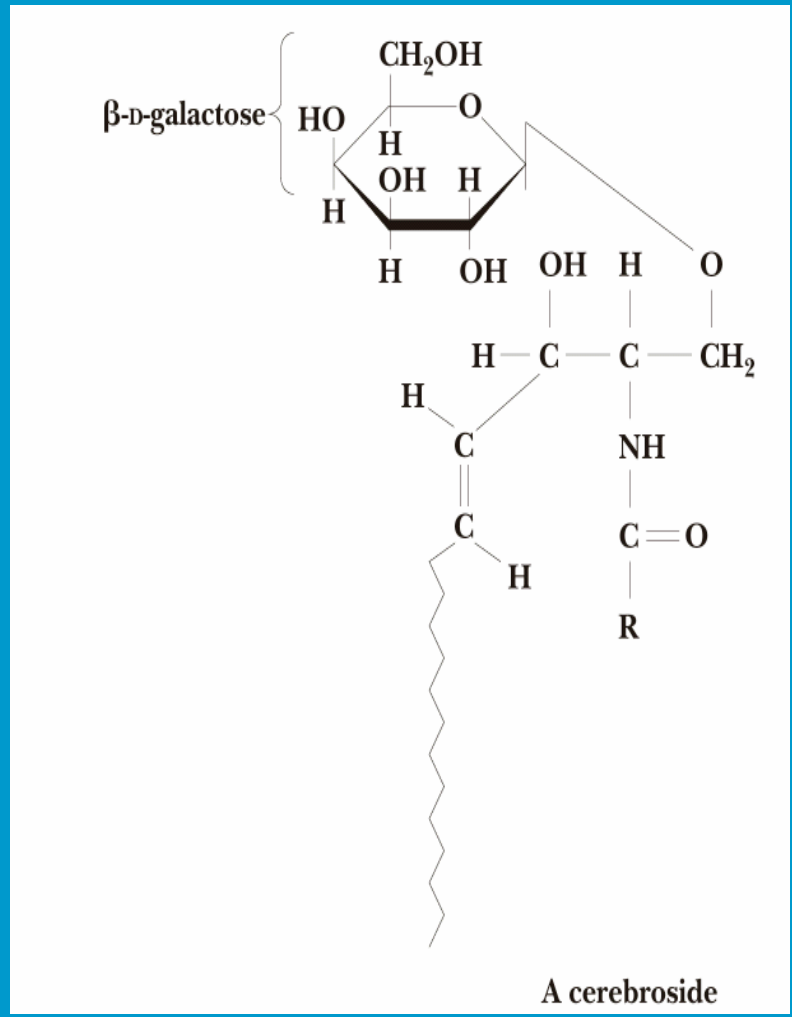




Glycosphingolipids

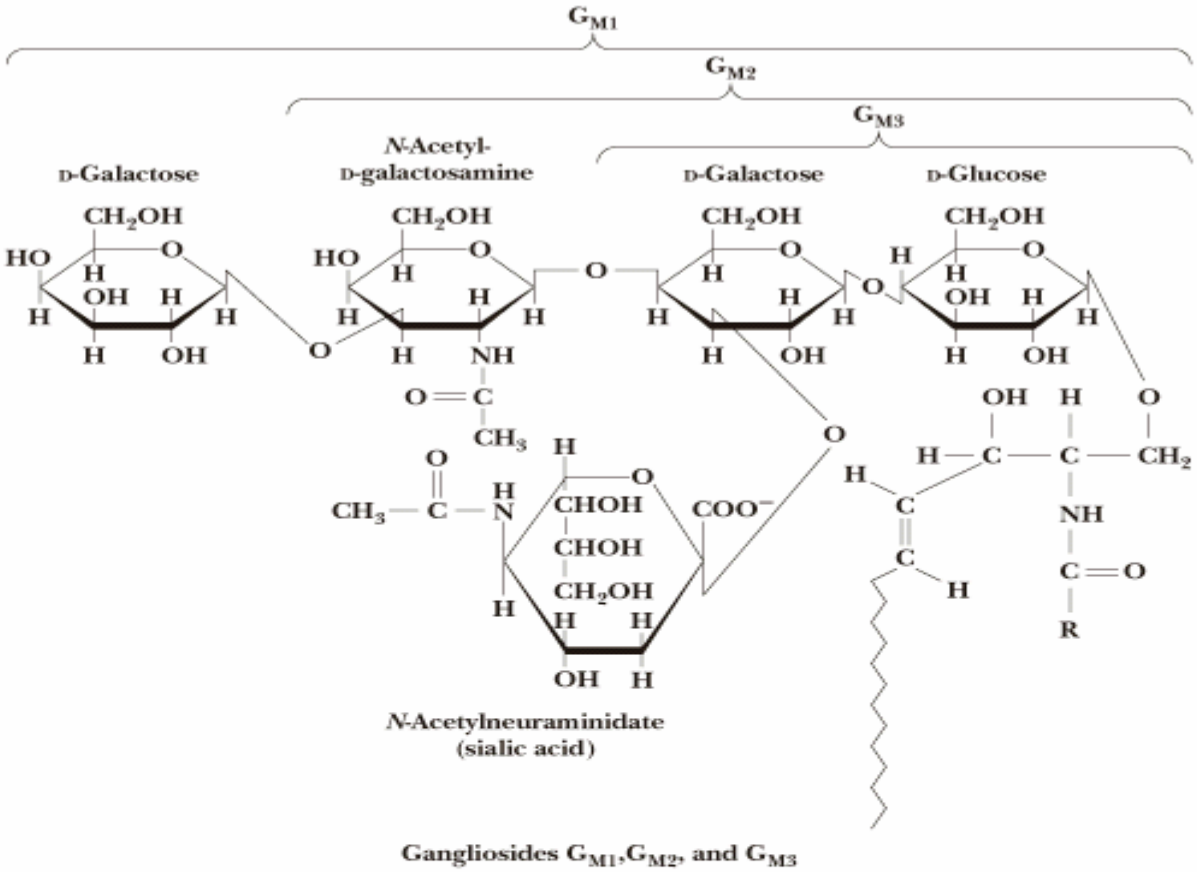
- **Another class of ceramide-based lipids, and like sphingomyelins are important components of muscle and nerve membranes in animals.**
- **Glycosphingolipids are ceramides with one or more sugars in beta-glycosidic linkage at the 1-hydroxyl group**
- **The *neutral* glycosphingolipids contain only neutral (uncharged) sugar residues)**
- **Glycosphingolipids with one sugar are cerebrosides**
- **Gangliosides - ceramides with 3 or more sugars, one of which is a sialic acid (n-acetyl neuraminic acid). These latter compounds are referred to as *acidic* glycosphingolipids, and they have a net negative charge at neutral pH.**


Fatty acid unit
Sugar unit
glucose
or
galactose
Cerebroside
(a glycolipid)
Unnumbered figure pg 331a
Biochemistry, Sixth Edition
© 2007 W.H.Freeman and Company

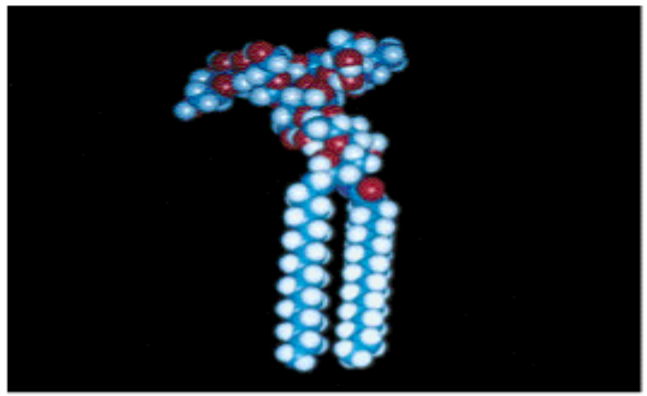

β-D-galactose
A cerebroside

Gangliosides

- Complex glycosphingolipids that consist of a ceramide backbone with 3 or more sugars esterified, one of these being a sialic acid such as N-acetylneuraminic acid
- Common gangliosides: G_{M1}, G_{M2}, G_{M3}, G_{D1a}, G_{D1b}, G_{T1a}, GT_{1b}, G_{q1b}
- Letter G refers to the name ganglioside
- The subscripts M, D, T and Q indicate mono-, di-, tri, and quatra (tetra)-sialic (n-acetyl neuraminic acid)-containing gangliosides
- The numerical subscripts 1, 2, and 3 designate the carbohydrate sequence attached to ceramide



Gangliosides G_{M1}, G_{M2}, and G_{M3}



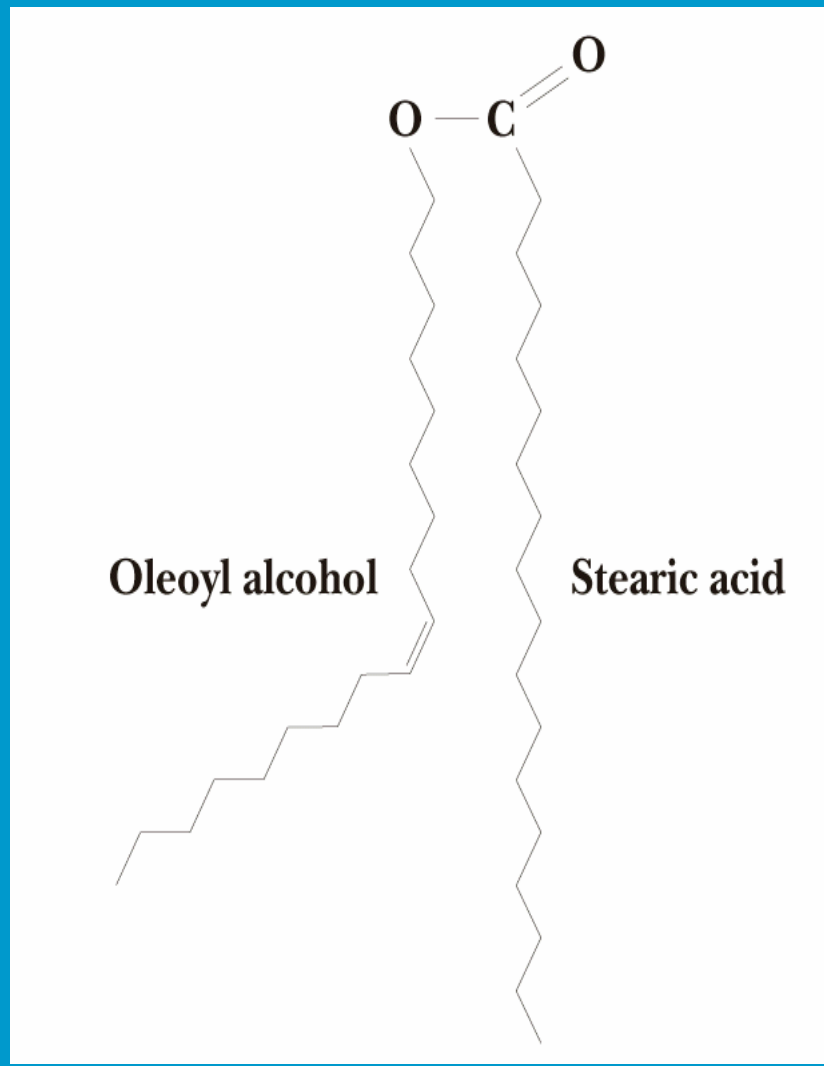
Functions of glycosphingolipids

- They are present only in small amounts in most membranes [sugars are always on the extracellular side]
- Glycosphingolipids at cell surface appear to determine, at least in part, certain elements of tissue and organ specificity
- Cell-cell recognition and tissue immunity appear to depend on specific Glycosphingolipids
- Gangliosides are present in nerve endings and appear to be important in nerve impulse transmission
- A number of genetically transmitted diseases involve the accumulation of specific glycosphingolipids due to an absence of the enzymes needed for their degradation.

5. Waxes

Esters of long-chain alcohols with long-chain fatty acids

- Weakly polar head and a long non-polar tail
- Fatty acids found are usually saturated and alcohols may be saturated, unsaturated and may include sterols such as cholesterol
- Highly water insoluble
- Water repellant characteristic to the animal skin and fur are wax-coated
- Leaves of many plants
- Bird's feathers

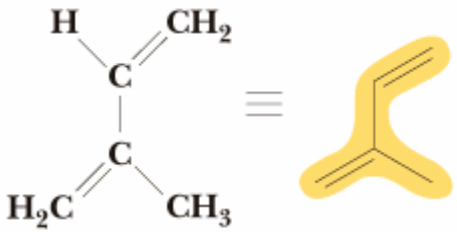


6. Terpenes

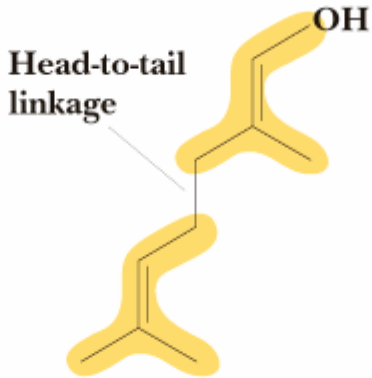
Based on the isoprene structure

- Simple lipids, but lack fatty acid component
- Formed by the combination of 2 or more molecules of 2-methyl-1,3-butadiene (isoprene-a five carbon unit abbreviated as C5)
  - Monoterpene (C-10) – made up of 2 isoprene units
  - Sesquiterpene (C-15) – made up of 3 isoprene units
  - Diterpene (C-20) – made up of 4 isoprene units
- All sterols (including cholesterol) are terpene-based molecules
- Steroid hormones are terpene-based

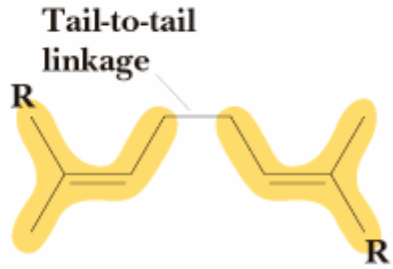
Garrett & Grisham: Biochemistry, 2/e
Figure 8.16



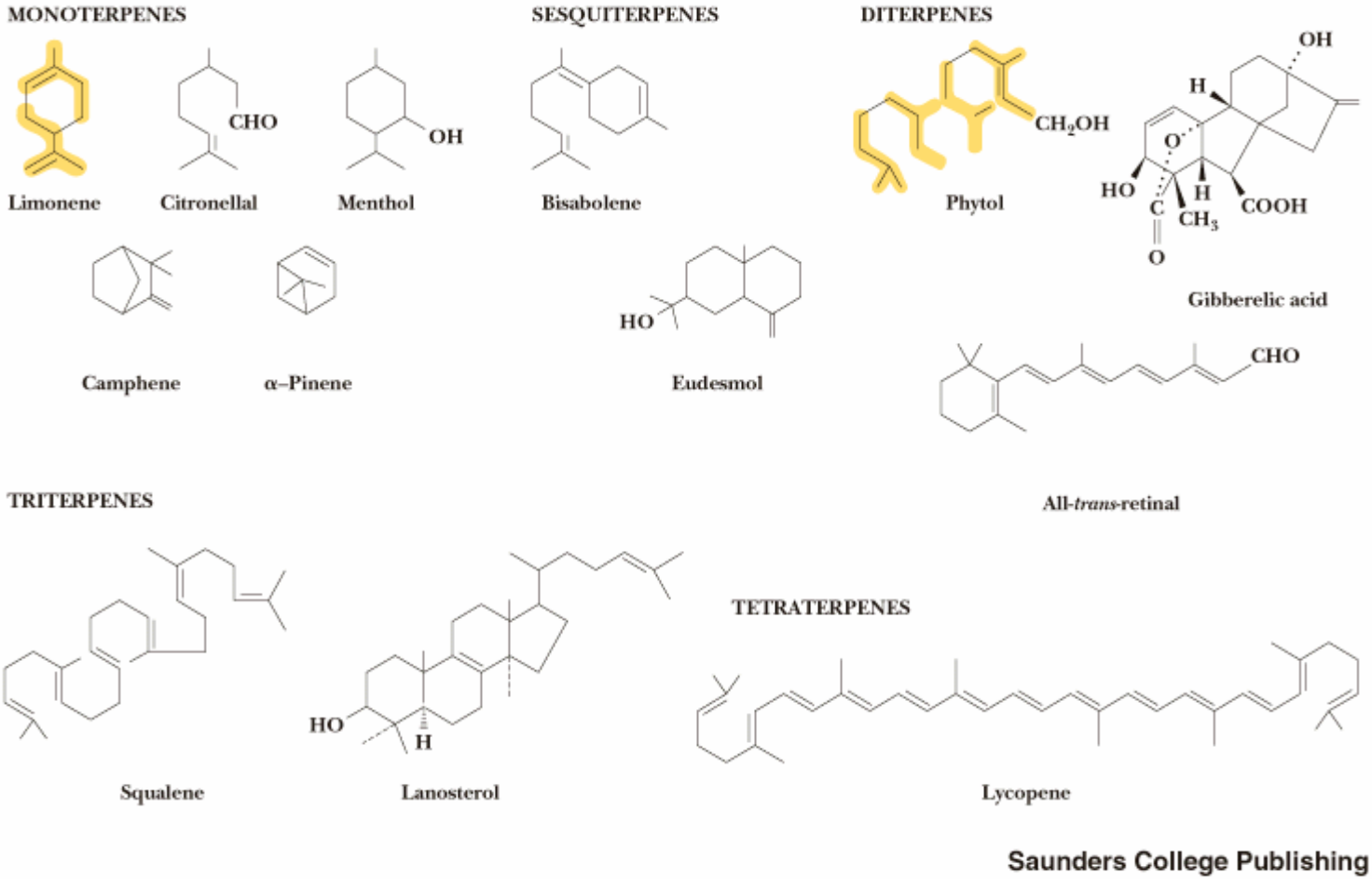
Isoprene



Geraniol

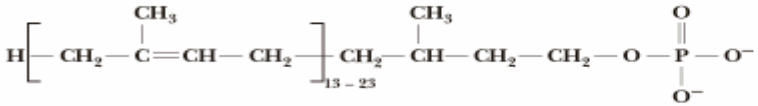


Garrett & Grisham: Biochemistry, 2/e
Figure 8.17

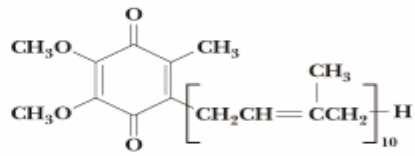


Long-chain polyisoprenoid molecules with a terminal alcohol moiety are called **polyprenols.** The **dolichols**, one class of polyprenols, consist of 16 to 22 isoprene units and in the form of dolicyl phosphates, function to carry carbohydrate units in the biosynthesis of glycoproteins. Undecaprenyl phosphate, delivers sugars from the cytoplasm for the synthesis of cell wall components such as peptidoglycans, LPS, and glycoproteins. Polyprenyls also serve as side chains of Vit K, ubiquinones, tocopherols

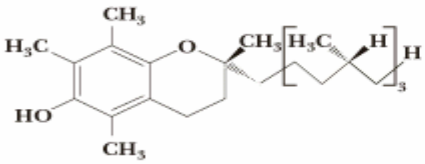
Garrett & Grisham: Biochemistry, 2/e
Figure 8.18



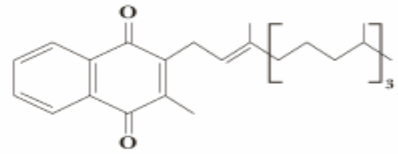
Dolichol phosphate



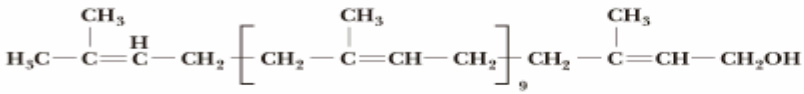
Coenzyme Q (Ubiquinone, UQ)



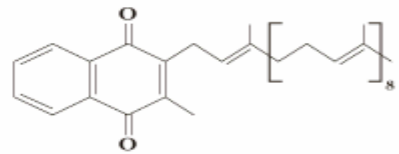
Vitamin E (α-tocopherol)



Vitamin K_1 (phylloquinone)



Undecaprenyl alcohol (bactoprenol)



Vitamin K_2 (menaquinone)

Saunders College Publishing

Steroids

Cholesterol is the most common steroid in animals and precursor for all other steroids in animals

Steroid hormones serve many functions in animals - including salt balance, metabolic function and sexual function

Sources:

- Cholesterol - animal tissue only
- Plant sterols: ~5% of dietary lipid - can block bile and cholesterol absorption

Functions:

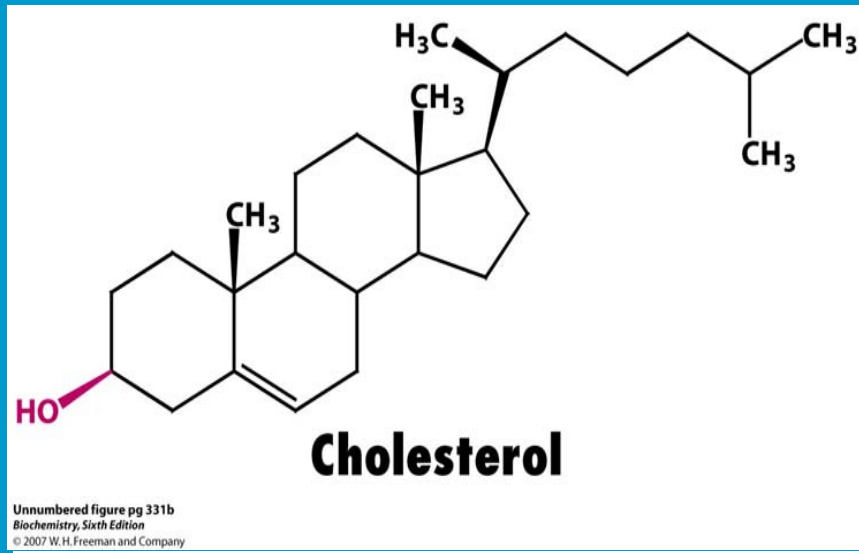
- Membrane and lipoprotein component - cholesterol
- Hormones
  - precursors for vitamin D, sex steroids and glucocorticoids
- Bile salts - solubilize lipids during digestion

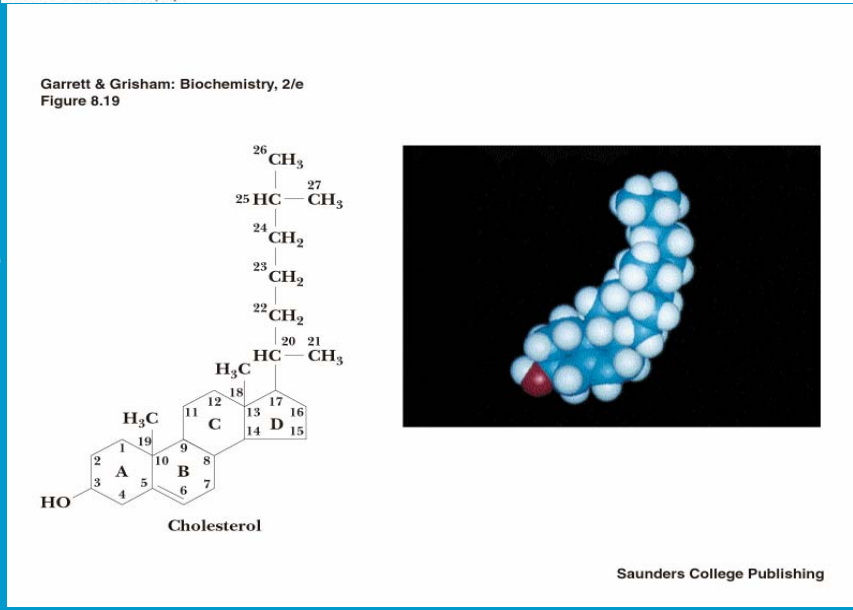
Consumption:

- 1960-1979 700 - 800 mg daily
- 1960-1980s 500 mg daily

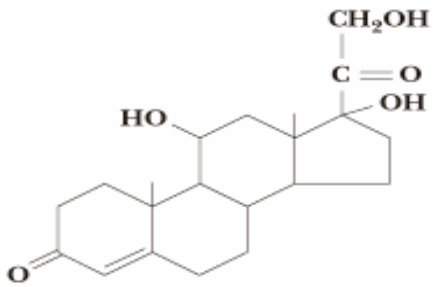
Steroid Structure

- Based on a core structure consisting of three 6-membered rings and one 5-membered ring, all fused together
- The numbering system for cholesterol applies to all such molecules.
- Many steroids contain methyl group at positions 10 and 13 and an 8- to 10- carbon alkyl side chain at position 17.
- Many steroids contain an oxygen at C-, either a hydroxyl group in steroids or a carbonyl group in other steroids
- The carbons at positions 10 and 13 and the alkyl group at position 17 are nearly always oriented on the same side of the steroid nucleus, the beta-orientation.
- Alkyl groups that extend from the other side of the steroid backbone are in an alpha-orientation.

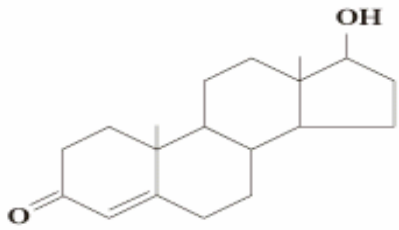




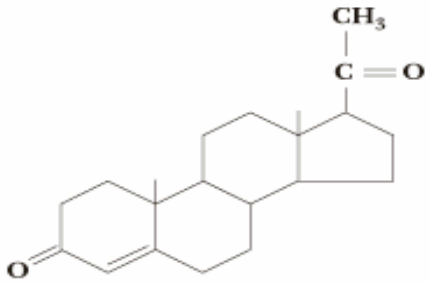
Steroids derived from cholesterol in animals include five families of hormones (the androgens, estrogens, progestins, glucocortocoids, and mineralocorticoids) and bile acids



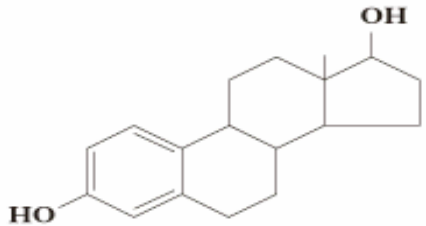
Cortisol



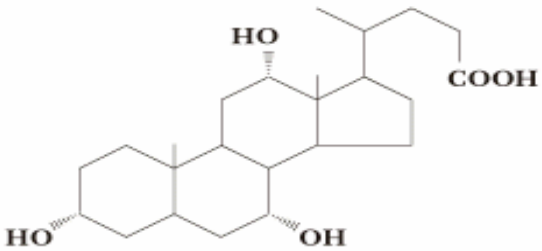
Testosterone



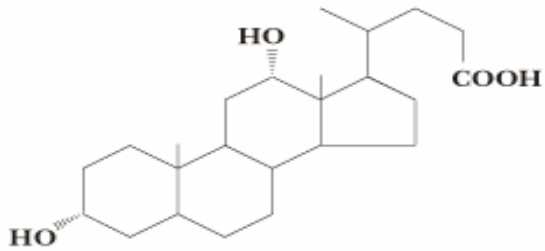
Progesterone



Estradiol

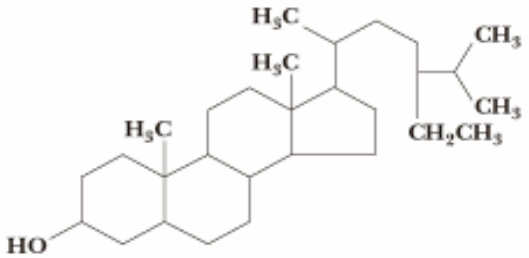


Cholic acid

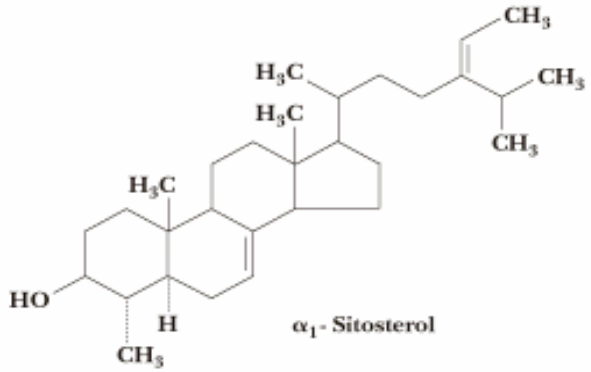


Deoxycholic acid

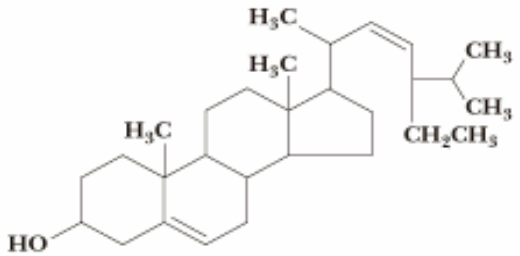
PLANT STEROLS



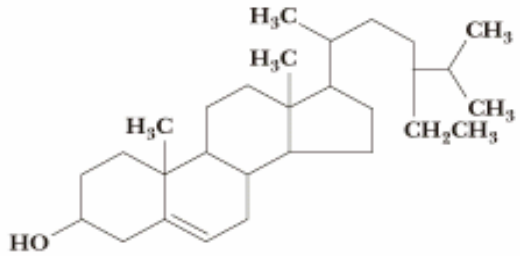
Stigmastanol



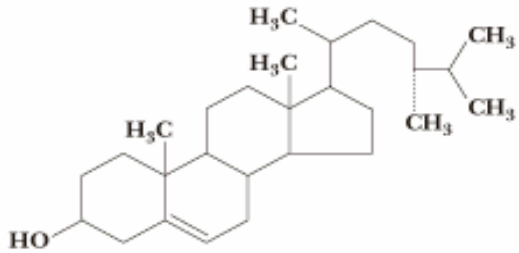
α_1- Sitosterol



Stigmasterol



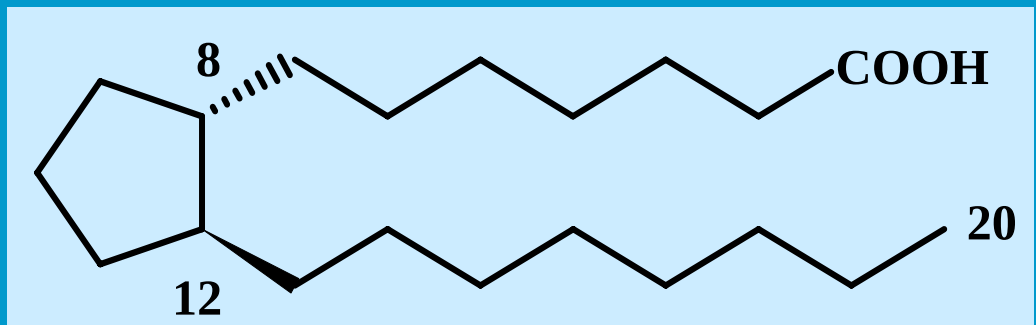
β-Sitosterol



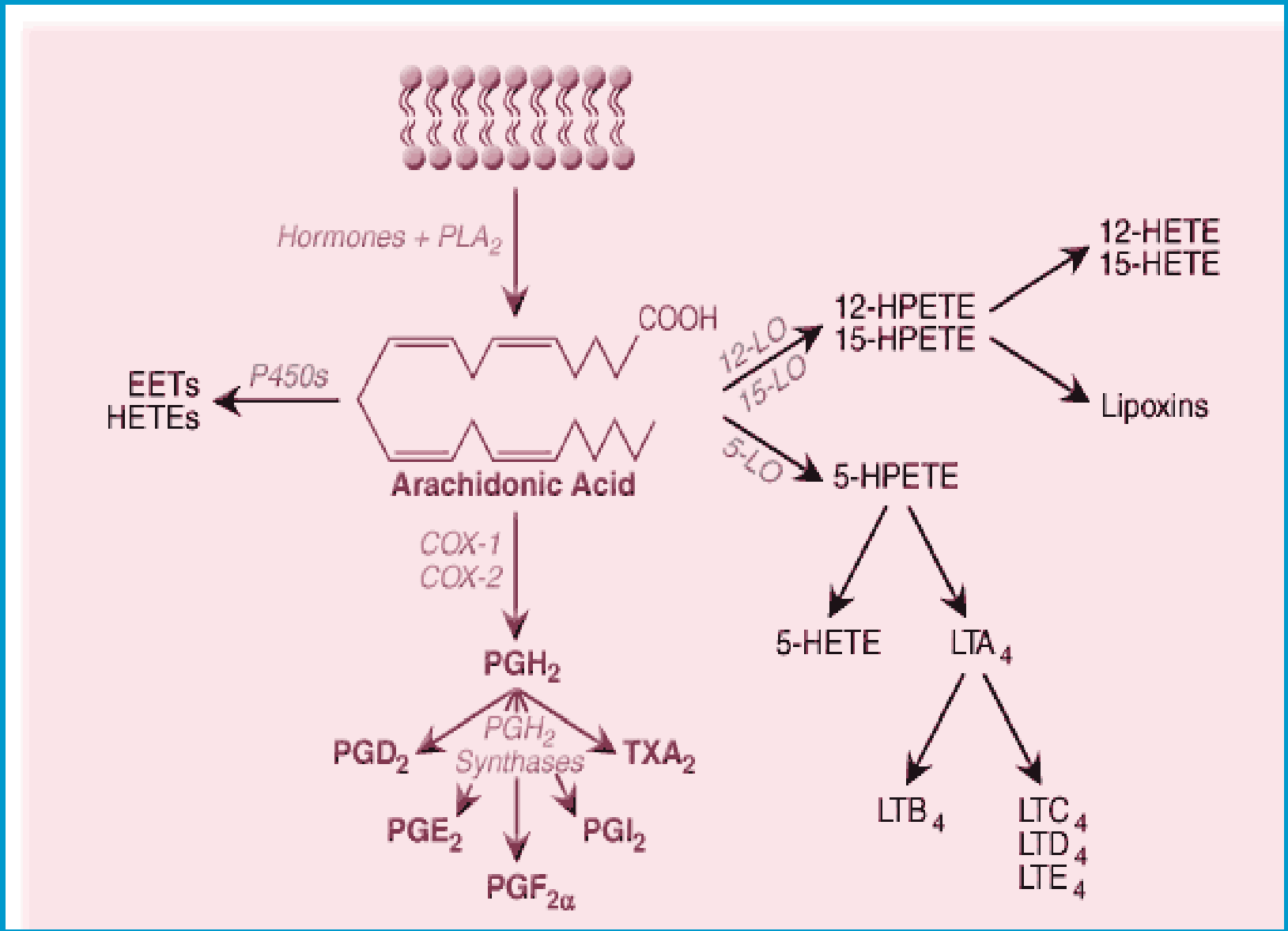
Campesterol

7. Prostaglandins, eicosanoids, Leukotrienes

- Local hormones, unstable, key mediators of inflammation
- Derivatives of prostanoic acid



prostanoic acid


Hormones + PLA2
COOH
Arachidonic Acid
EETs
HETEs
P450s
12-LO
15-LO
12-HPETE
15-HPETE
12-HETE
15-HETE
Lipoxins
5-LO
5-HPETE
5-HETE
LTA4
LTB4
LTC4
LTD4
LTE4
COX-1
COX-2
PGH2
PGD2
PGH2
Synthases
TXA2
PGE2
PGI2
PGF2α

Prostacyclins and thromboxanes

- PGH_2 in platelets is converted to thromboxane A_2 (TXA_2) a vasoconstrictor which also promotes platelet aggregation
- PGH_2 in vascular endothelial cells is converted to PGI_2, a vasodilator which inhibits platelet aggregation
- Aspirin's irreversible inhibition of platelet COX leads to its anticoagulant effect

Eicosanoids

- Prostaglandins – particularly PGE_1 – block gastric production and thus are gastric protection agents
- PGF_{2a} – causes constriction of the uterus
- PGE_2 is applied locally to help induce labor at term

Leukotrienes

- Leukotrienes are derived from 20:4 via the enzyme 5-lipoxygenase which converts 20:4 to 5-HPETE and subsequently by dehydration to LTA_4.
- Leukotrienes are synthesized in neutrophils, monocytes, macrophages, mast cells and keratinocytes. Also in lung, spleen, brain and heart.
- A mixture of LTC4, LTD4 and LTE4 was previously known as the *slow-reacting substance of anaphylaxis.* LTA4 is formed by dehydration of 5-HPETE, and LTB4 by hydrolysis of the epoxide of LTA4

Biological activities of leukotrienes

1. LTB_4 - potent chemoattractent
   - mediator of hyperalgesia
   - growth factor for keratinocytes
2. LTC_4 - constricts lung smooth muscle
   - promotes capillary leakage
   1000 X histamine
3. LTD_4 - constricts smooth muscle; lung
   - airway hyperactivity
   - vasoconstriction
4. LTE_4 - 1000 x less potent than LTD4

Lipoproteins

Particles found in plasma that transport lipids including cholesterol

Lipoprotein classes

- **chylomicrons: take lipids from small intestine through lymph cells**
- **very low density lipoproteins (VLDL)**
- **intermediate density lipoproteins (IDL)**
- **low density lipoproteins (LDL)**
- **high density lipoproteins (HDL)**

Spherical particles with a hydrophobic core (TG and esterified cholesterol)

Apolipoproteins on the surface

- **large: apoB (b-48 and B-100) atherogenic**
- **smaller: apoA-I, apoC-II, apoE**

Classified on the basis of density and electrophoretic mobility (VLDL; LDL; IDL;HDL; Lp(a)

Lipoprotein class	Density (g/mL)	Diameter (nm)	Protein % of dry wt	Phospholipid %	Triacylglycerol % of dry wt
HDL	1.063-1.21	5 – 15	33	29	8
LDL	1.019 – 1.063	18 – 28	25	21	4
IDL	1.006-1.019	25 - 50	18	22	31
VLDL	0.95 – 1.006	30 - 80	10	18	50
chylomicrons	< 0.95	100 - 500	1 - 2	7	84

Composition and properties of human lipoproteins

most proteins have densities of about 1.3 – 1.4 g/mL and lipid aggregates usually have densities of about 0.8 g/mL

The apolipoproteins

- Major components of lipoproteins
- Often referred to as apoproteins
- Classified by alphabetical designation (A thru E)
- The use of roman numeral suffix describes the order in which the apolipoprotein emerge from a chromatographic column
- Responsible for recognition of particle by receptors

- A-1 (28,300)- principal protein in HDL
  - 90 –120 mg% in plasma
- A-2 (8,700) – occurs as dimer mainly in HDL
  - 30 – 50 mg %
- B-48 (240,000) – found only in chylomicron <5 mg %
- B-100 (500,000) – principal protein in LDL
  - 80 –100 mg %
- C-1 (7,000) – found in chylomicron, VLDL, HDL
  - 4 – 7 mg %
- C-2 (8,800) - found in chylomicron, VLDL, HDL
  - 3 – 8 mg %
- C-3 (8,800) - found in chylomicron, VLDL, IDL, HDL
  - 8 15 mg %
- D (32,500) - found in HDL
  - 8 – 10 mg %
- E (34,100) - found in chylomicron, VLDL, IDL HDL
  - 3 – 6 mg %