

VEIN BATCH 2027



Sub: Molecular المادة:

Lecture: 7 المحاضرة:

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Edited: تعديل:



Lipids of biological importance- 3

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Steroids

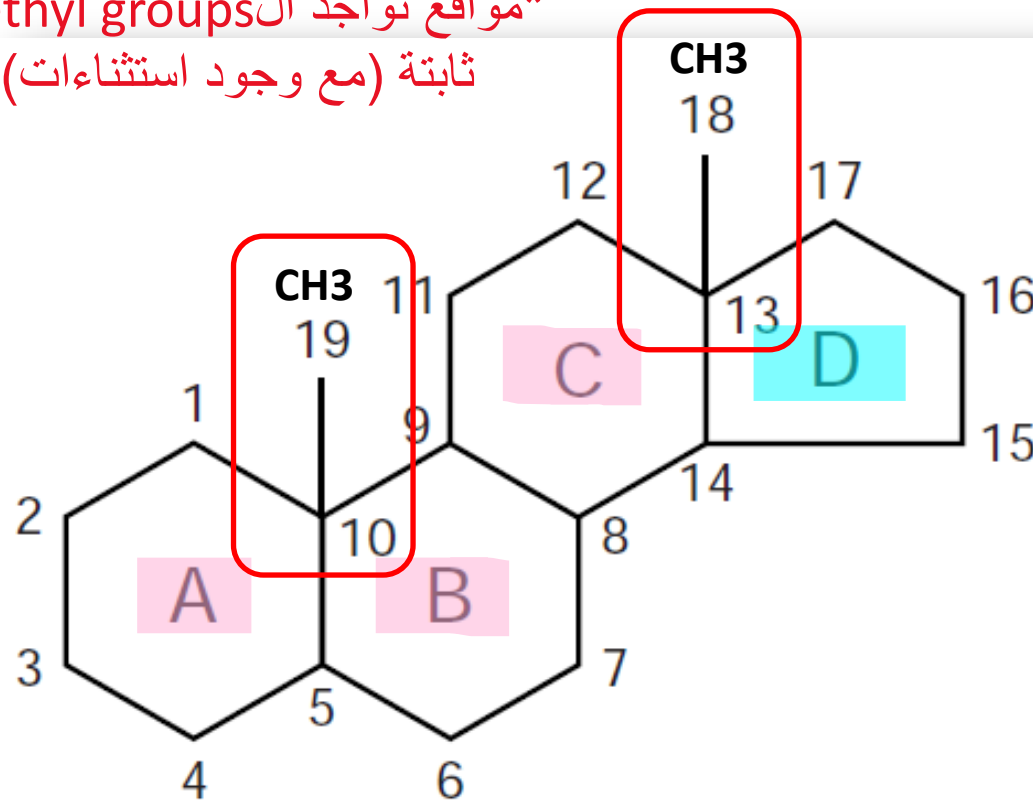
- **Definition:** Substances which are derived from C_{17} cyclopentanoperhydrophenanthrene ring (steroid nucleus)
Cyclic 5C ring Saturated 3 hexagonal rings
structure with H (3 حلقات سداسية)
- Steroids include sterols, bile acids and steroid hormones

Comments on the terminology used for steroids:

Cyclopentanoperhydrophenanthrene ring is due to:

- Cyclo → cyclic
- Pentano → 5 carbon ring (ring D)
- Phenanthrene ring → 3 hexagonal rings (A, B & C)
- Perhydro: saturated with hydrogen (unless noted otherwise)
double bonds (saturated) perhydro وبما إنه (باستثناء بعض الحالات)

*مواقع تواجد ال methyl groups
ثابتة (مع وجود استثناءات)



The steroid nucleus.

ال - A/B/C يتمثل
phenanthrene ال
rings

ال - D يتمثل ال
cyclopentano

- وعدد ال C داخل
ال rings هو 17 (ما
الي دخل بالتفرعات
لأنها برا ال steroid
(nucleus)

Cyclopentanoperhydrophenanthrene ring (Steroid nucleus)

General criteria of the steroids:

- All steroids are derived from C₁₇ cyclopentanoperhydrophenanthrene nucleus

2 Natural steroids contain:

- Methyl group attached to C₁₀ **except estrogens**
- Methyl group attached to C₁₃ **except aldosterone**
- Side chain at C₁₇ or oxygen or hydroxyl group
ال side chain ممكن تكون O أو OH أو (C-H) hydrocarbon chain
- Ring C & D are always saturated but ring A & B may contain double bond

Sterols

- These are steroid alcohols containing OH at C₃
- There are 3 types of sterols which are phytosterol, mycosterols and zoosterols

1. Phytosterols:

- Are of plant origin

- Sitosterol is an example phytosterol that can inhibit the absorption of cholesterol

- It is present in plant oil

- أهميته تكمن بتقليل الكوليسترول

2. Mycosterols: *موجود بالyeast أو الfungi*

- These types of sterols are of mycotic origin
- **Ergosterol** is an example of mycosterol
 - it is the precursor of vitamin D₂
 - It is present in yeast

3. Zoosterols: *موجودين بكثرة في الإنسان (خاصة الcholesterol)*

- These types of sterols are of animal origin
- **Cholesterol** is an example of zoosterol

*زي ما كنا نحكي إنه الTAG هو الأساسي والأهم بالsimple lipids ف هون الcholesterol بنفس المرتبة بالsterols (لأنه له كثير functions)

Types of steroids and sterols

- Cholesterol (animal origin)
- Ergosterol (plant origin) → بيحي من ergosterol
- Vitamin D group (D2 and D3) → بيحي من cholesterol
- Bile acids and salts
- Steroid hormones *يعني بنقدر نقول إنه ال cholesterol وال ergosterol عبارة عن precursors (الأسلاف/الأساس) لل vitamin D
 - Male sex hormones
 - Female sex hormones
 - Adrenocortical hormones
- Digitalis (?)

- Digitalis, a cardiac stimulant, is composed of galactose and a steroid alcohol
- Digitalis is used in treatment of heart failure (stimulate cardiac muscle contraction)

Cholesterol

- It is the main steroid in humans (present in **all** cells especially nervous system & plasma) & adrenal cortex

السلف / الأساس

- It is a precursor form **all** other steroids

صفار البيض

- Egg yolk, red meat, liver, kidney, butter and brain are rich in cholesterol

وهون بشوف ال side chain على C17

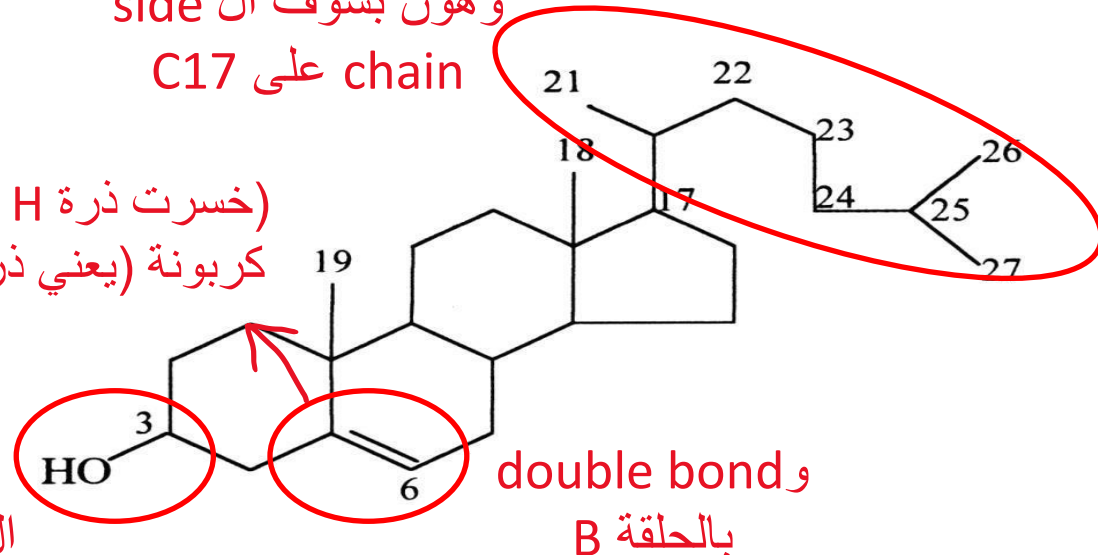
Properties:

Is it soluble in water?

مع سلسلة ال hydrocarbon الطويلة هاي أكيد not soluble

(خسرت ذرة H من كل كربونة (يعني ذرتين))

أول اشي عندي ال OH على ال C3



For your information only

*السلامة مش مطلوب

DON'T EGG-NORE THE YOLK

EGG YOLK



Per 100g serve (raw weight)

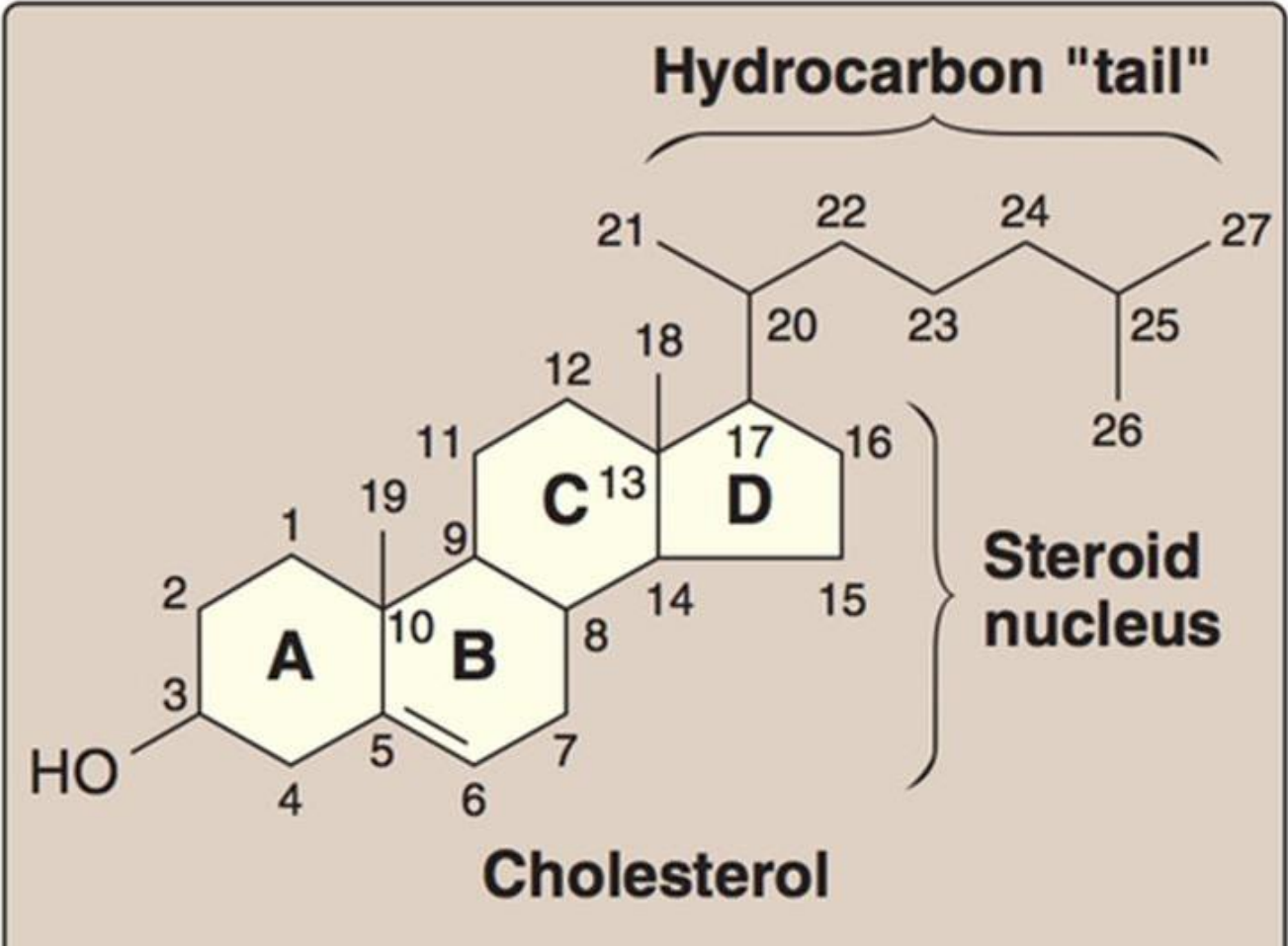
Calories: 313kcal
Protein: 15.6g
Total Fat: 28.2g
Saturated Fat: 8.6g
Cholesterol: 1050mg
Selenium: 56ug
Folate: 120ug
Vitamin B12: 4ug

EGG WHITE



Per 100g serve (raw weight)

Calories: 47kcal
Protein: 11.2g
Total Fat: 0g
Saturated Fat: 0g
Cholesterol: 0mg
Selenium: 11ug
Folate: 7ug
Vitamin B12: 0ug



- Cholesterol contains unsaturated double bond between C5 and C6
 - → It can accept two hydrogen atoms
- Esterification: Cholesterol has – OH at C3, so it can form esters with any fatty acid ولإنه عنده oh على أحد الأطراف ف هاض معناه إنه
 - Blood cholesterol is either present in: ممكن يصيرله esterification عادي
 - Free form (33%) → contains 27 carbons → 2 methyl و ring ال (17 داخل ال)
 - Esterified form (67%) والباقي على ال (side chain)
- Normal level of cholesterol in blood is **less** than 220 mg/dL → if increased it is called hypercholesterolemia *سؤال محتمل
 - *ولو نزل مستواه عن 120 mg/dL بسميه hypocholesterolemia وخطورة الموضوع تكمن بإنه موجود بكثر بجسمنا وإله أهمية كبيرة
 - (ومن هاي النقطة بستنتج إنه ال range لل cholesterol بالدم من 120 ل 220mg/dL)
 - *ايش مصدر ال cholesterol بالدم ؟ 1- liver -2 من الأكل ويتم هضمه بال intestine
- It is oxidized in liver, intestine & skin to give 7-dehydrocholesterol which is the precursor of vitamin D3 by exposure to UVR under the skin
 - لما يصيرله oxidation بخسر كمان ذرتين H وبصير عندي double bond بين C7-C8

Function of cholesterol

- Enters in structure of every body cell especially nervous system + cell membranes
- **Synthesis of:**
 - steroid hormones
 - Bile acids, salts
 - vit D3

*زي ما كان الفرق بين starch والglycogen إنه واحد بالplants والثاني بالanimals فهون نفس الفكرة.. فالergosterol مشابه جدا للcholesterol بس واحد بالنباتات والثاني بالحيوانات, بالإضافة لكم فرق بسيط يعني (مذكورات بالاسلايد التالي اللي هي نفسها صفات ال(ergosterol)..

سؤال متوقع أي واحد من أنواع الvit D أقوى (more potent) ؟
→ D3 is more potent

Ergosterol:

plant source

Extra double bond btwn C7-8

Unsaturated side chain

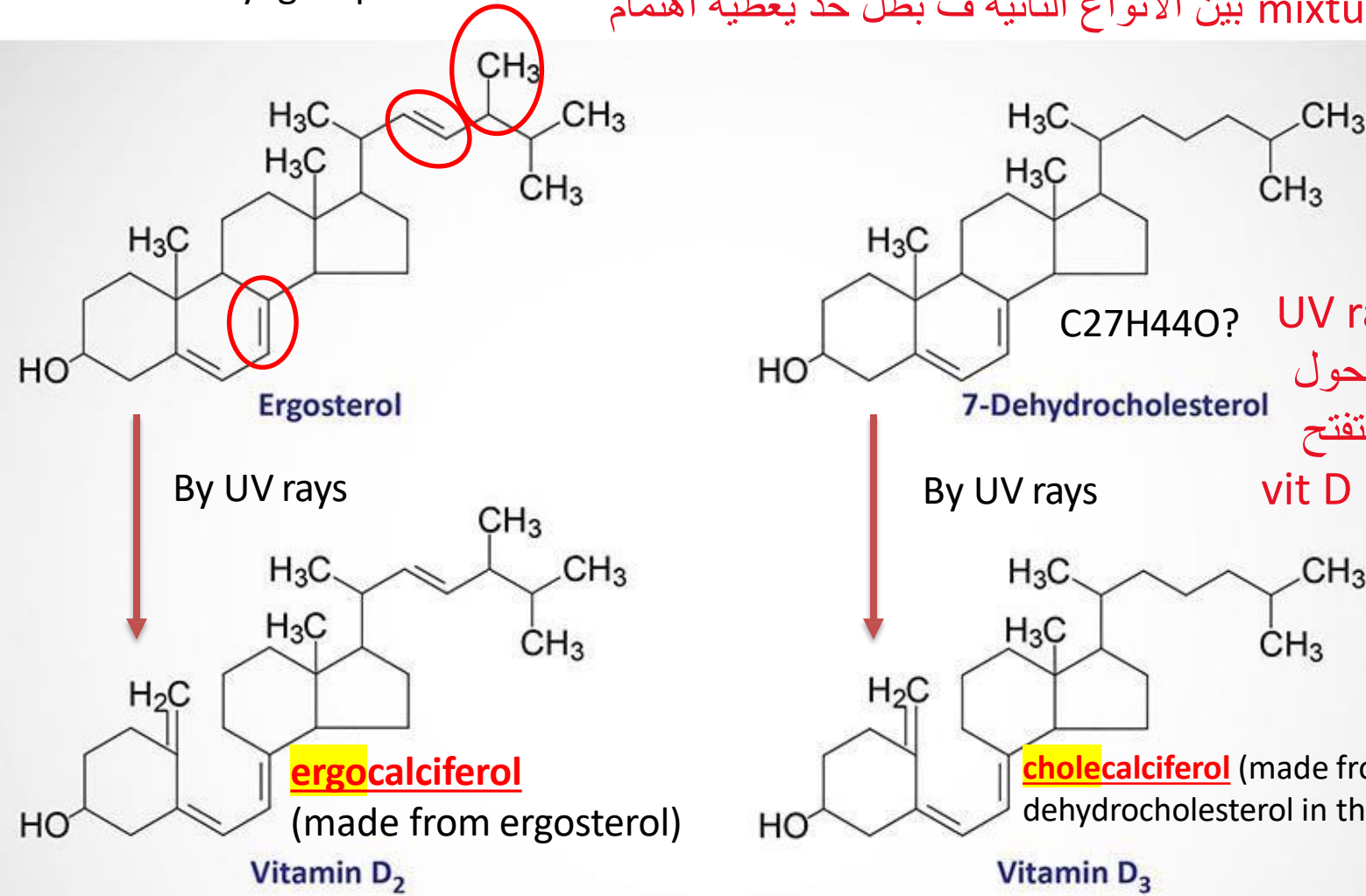
Extra methyl group

hydroxyl إضافة طريق عن الجسم يتم لل activation لل D2/D3

1,25-dihydroxy vitamin D2/D3 وبصفي اسمه C25 و C1 group

What about D1?

أما بالنسبة لل D1 ف بعد ما اكتشفوا العلماء باقي انواع ال vit D لاحظوا انه D1 عبارة عن mixture بين الأنواع الثانية ف بطل حد يعطيه اهتمام



ولما يتعرض ل UV rays من الشمس مثلا يتحول زي ما بالشكل, فبتفتح ال B ring و بنتج عنا vit D

*مقطع calciferol في الاسم له علاقة بالCa (بشتغل عالكالسيوم لإنه)

Eicosanoids

20 C



EicoTetraEnoic *ممکن نسیمه



4 double bonds

- Derived from eicosa (20 carbons) polyenoic FAs (arachidonic acid 20:4)
- The dietary precursor is the essential FA linoleic acid (18:2)
- Produced by most mammalian cells
- Have physiological and pharmacological actions
- * ما بدخلوا بالدم (local effect)
- Hormone-like molecules: و hormone-like نسبة إلى طريقة إفراز الهرمونات (by endocrine glands) .. بحيث إنها تفرز مباشرة, ونفس الإشي ال molecules هون حيث يتم إفرازها من خلايا ف يا إما بشتغلوا على نفس الخلايا أو على خلايا مجاورة
 - Autocrine نفس الخلية
 - Paracrine خلية مجاورة
- Subscript number in an eicosanoid denotes n of double bond (e.g. PGE₂) و عدد ال double bonds ممكن استعمل نظام معين عشان أوصفه بالتسمية..
فمثلا اللي بين قوسين بحتوي على رابطتين

Classification of eicosanoids

*التقسيم تاعهم حسب ال pathway لتصنيعهم والإنزيمات اللي بتتدخل

- Cyclic compounds (prostanoids) مش شرط يكون المركب كامل حلقي.. لو فيه cycle وحدة بس صار cyclic
 - Prostaglandins (PG) → via cyclooxygenase pathway
 - Prostacyclins (PGI) → via cyclooxygenase pathway
 - Thromboxane (TX) → via thromboxane synthase
**بيجي من prostaglandin H
(VI note)
- Acyclic compounds (via lipoxygenase pathway)
 - Leukotrines (LT)
 - Lipoxins (LX)

التسمية نسبة لل prostate

Prostaglandins (PG)

- First discovered in prostate (hence name)
- Present in most human tissues (males & females)

بعض النظر عن التسمية.. بس بلاقيه بكل خلايا الجسم

- All have a cyclopentane ring in the middle (C8-12)
(خماسي)

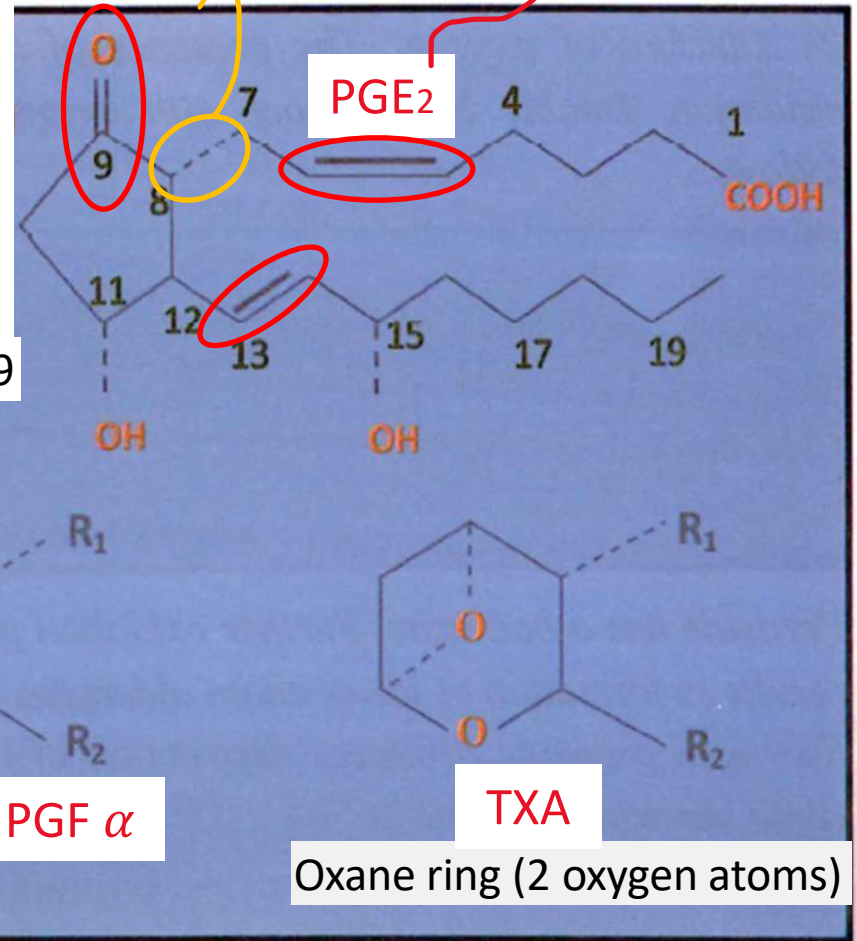
أهميته بتكون بصناعة ال thromboxane

- Many types: PGA, PGB, PGE, PGF, PGG, PGH ↑

في أنواع كثير بس هاي هي الأهم

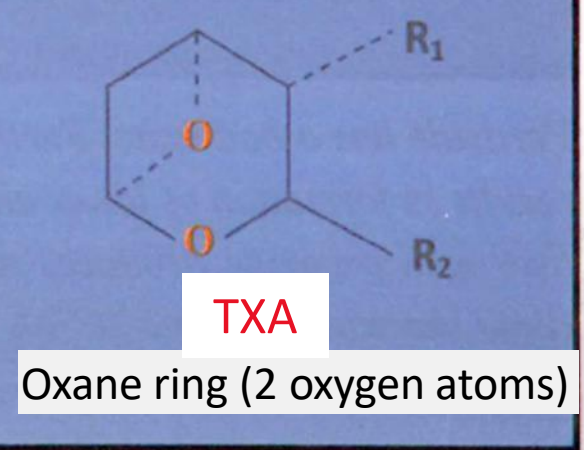
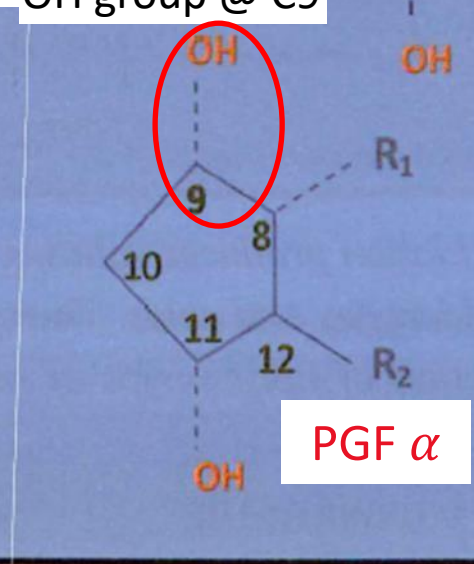
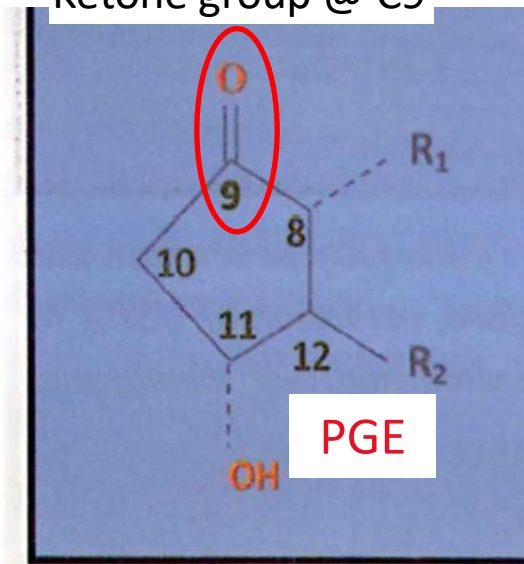
This dashed lines means that the link goes backward

2 double bonds + ketone group



Ketone group @ C9

OH group @ C9



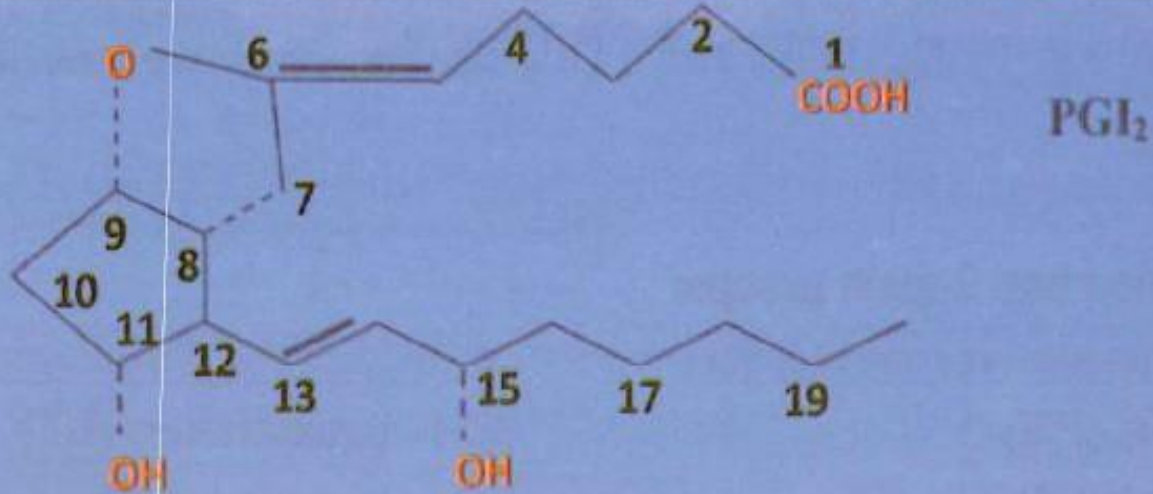
يحتوي على ذرتين O داخل الـ ring

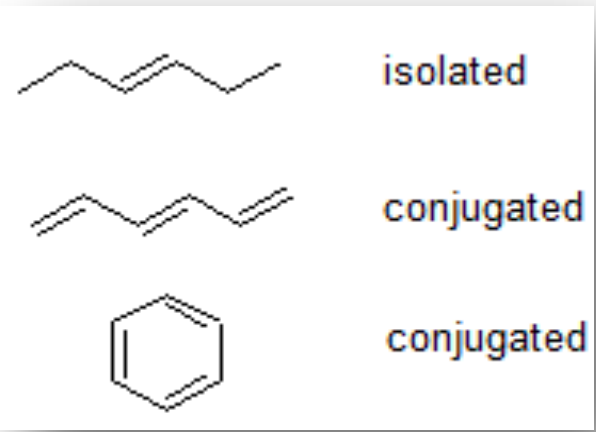
نسبة لوجود ring إضافي



3. Prostacyclins (PGI):

They contain an additional ring in their structure

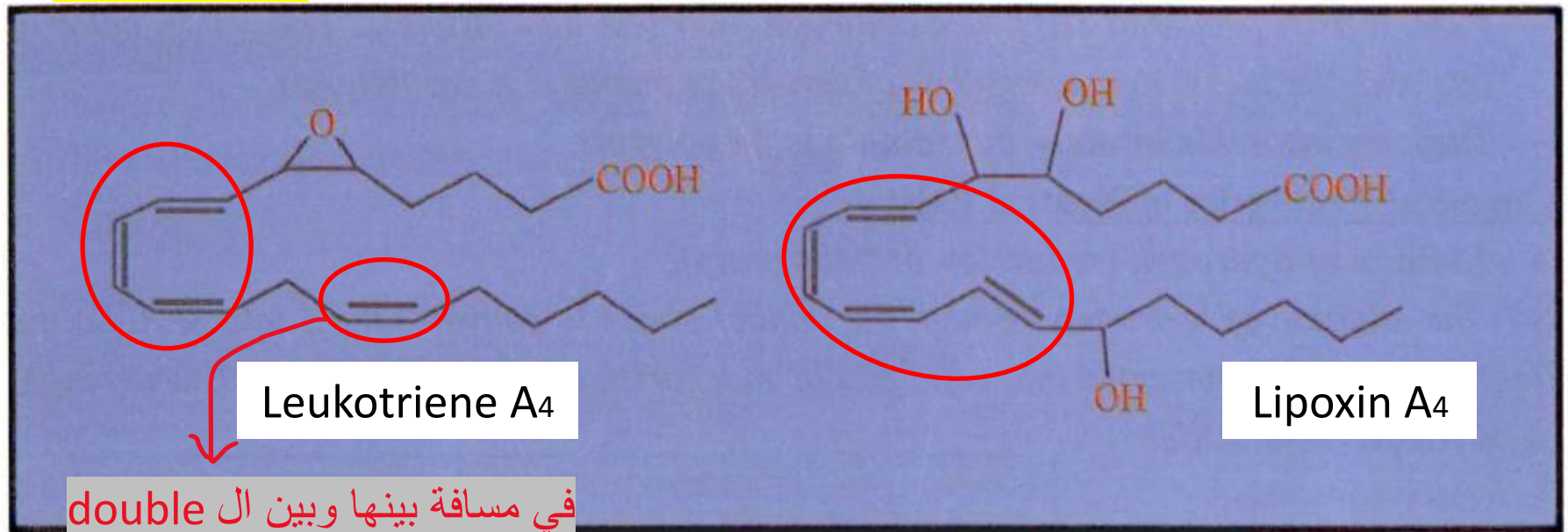




LT and LX are both acyclic compounds

LT : 3 conjugated double bonds (C=C-C=C-C=C) روابط متتالية 3

LX : 4 conjugated double bonds, contains more oxygen (C=C-C=C-C=C-C=C) روابط متتالية 4



في مسافة بينها وبين ال double bond
 isolated فتعتبر قبلها,

Effects of eicosanoids

- PGE2 → vasodilation, relaxation of uterus & intestines
the dilatation of blood vessels, which decreases blood pressure.
the constriction of blood vessels, which increases blood pressure.
 - PGF2 → vasoconstriction, contraction of uterus & intestines
(شغلة ممكن تساعد بحفظهم) بما إنه وظيفتهم عكس بعض فاعتبر ال F يعني force .. يعني بتعطي قوة لتعمل انقباض
 - PGI2 → vasodilation + inhibits platelet aggregation
 - TXA2 → vasoconstriction + stimulates platelet aggregation
لما الواحد ينجرح بتصير الخلايا تفرز TXA2 اللي رح يعمل على تقليل النزيف وبحفز تراكم الصفائح الدموية.. بس تخيل لو إنه ال effect تاعه مش hormone-like ودخل الدم رح يرفعلي ضغط الدم بالجسم كامل ويزيد من سوء الجرح مش يحسنه.. وبعد ما يخلص شغله ببلاش شغل ال PGI2 عشان ترجع الأمور لطبيعتها (لإنهم عكس بعض)
 - Leukotrienes → allergic mediators
 - Lipoxins → inflammatory functions
- يتم إفرازهم بشكل أساسي من ال arterioles

Which of the following statements about disaccharides is INCORRECT?

- 1) Deficiency of sucrase leads to diarrhea and flatulence
- 2) Deficiency of lactase leads to diarrhea and flatulence
- 3) Lactulose mainly comes from natural dietary sources**
- 4) Yeasts and fungi are the source of trehalose
- 5) Isomaltose comes from enzymatic hydrolysis of starch

Which of the following is a difference between Heparan sulfate and Heparin?

- 1) Heparan sulfate contains less glucuronic acid but more sulphated glucosamine
- 2) Heparan sulfate is intracellular while Heparin is present in the extracellular matrix
- 3) Heparan sulfate activates lipoprotein lipase while Heparin does not
- 4) Heparan sulfate is related to cell-cell interactions while Heparin is an anti-coagulant**
- 5) Heparan sulfate contains sulfate while Heparin does not contain sulfate

Inulin Q

Glycogen Q

Lipids of biological importance-

4

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Complex (compound) lipids

- Complex lipids are formed of:
 - simple lipids
 - **PLUS other substances such as:**
 - Phosphate radical/ group → phospholipids
 - carbohydrates → glycolipids
 - Proteins → lipoprotein

I. Phospholipids

Structure:

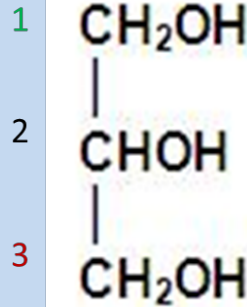
- **Phosphate group + alcohol (joined via ester bond) + FA**
- There are two classes of phospholipids (according to alcohol):
 - those that have glycerol as a backbone → **glycerophospholipids**
 - those that contain sphingosine → **sphingophospholipids**

A-Glycerophospholipids: There are 9 types & include:

- Phosphatidic acid and its esters with one alcohol
- Plasmalogens
- Cardiolipin

Simple lipids

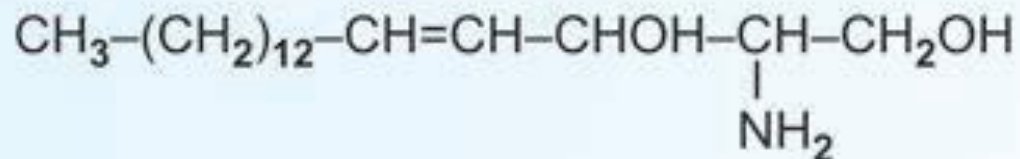
Primary carbons



Secondary carbon

I. Glycerol :

- It is the simplest form of trihydric alcohol
- It is commercially known as glycerin: CH₂OH.CHOH.CH₂OH
- Glycerol is the main component of neutral fats
- Since the glycerol contains three hydroxyl groups, it has the ability to combine with three FA through an **ester bond**.
- These FA may be the same to give simple triacylglycerols (TAG) or different to give mixed triacylglycerols.
- The most common FAs which may enter in the structure of neutral fats are palmitic, stearic and/or oleic acids.

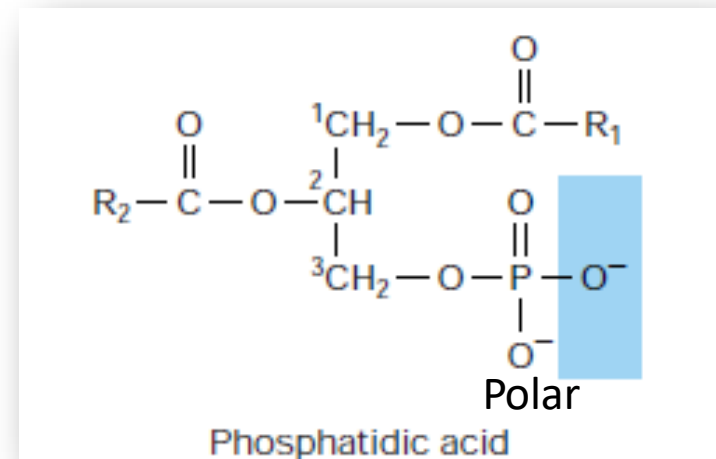


Sphingosine: an amino alcohol with 18C

1- Phosphatidic acid:

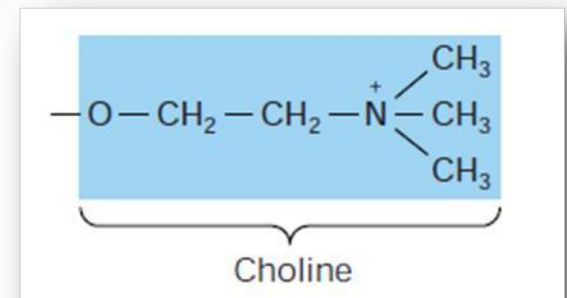
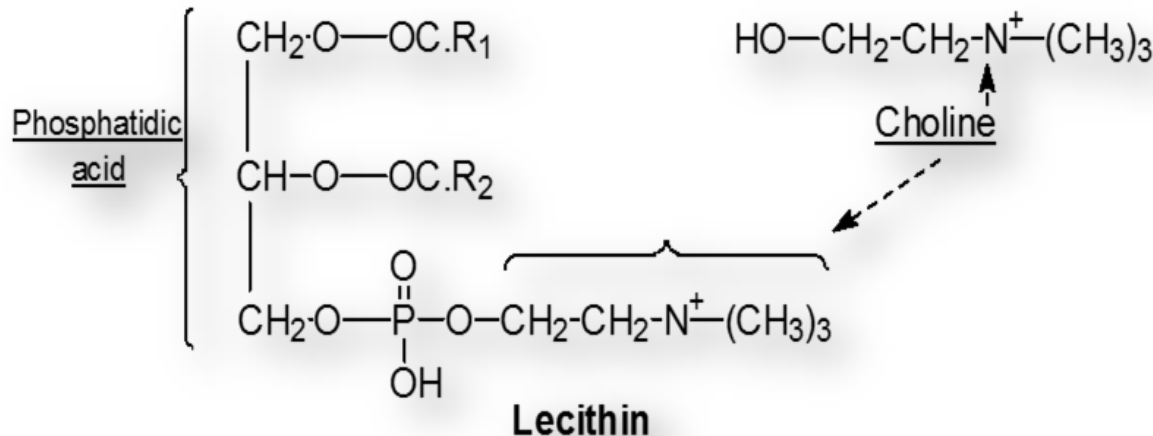
- Simplest phosphoglyceride & is the precursor of the other members of this group
- It is diacylglycerol phosphate:
 - It consists of glycerol to which are esterified :
 - (1) a fatty acid, usually saturated at the 1- position
 - (2) a fatty acid , usually unsaturated at the 2- position, and
 - (3) phosphate at the 3-position

Phosphatidic acid is an intermediate in metabolism ; little may be found in cell membranes.



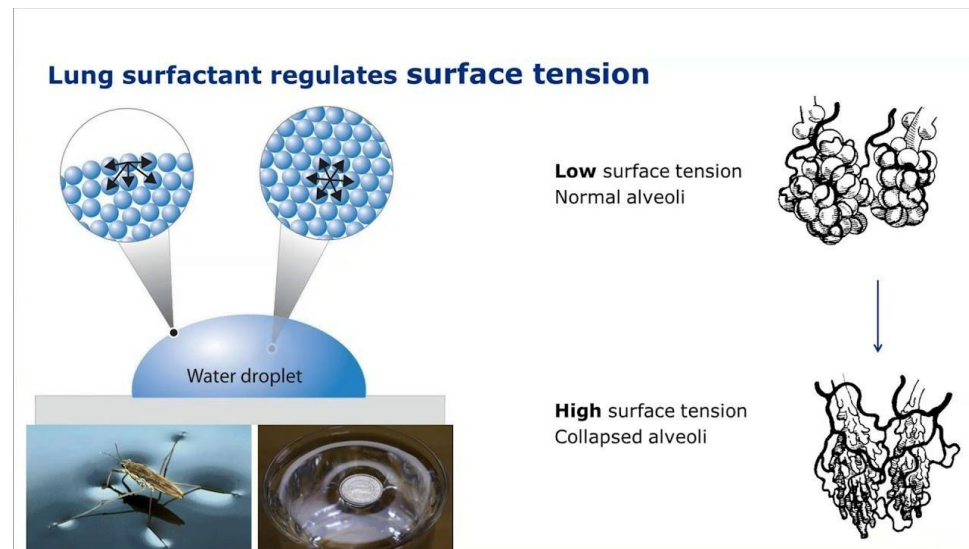
2- Phosphatidylcholine (lecithin):

- The phosphate group of phosphatidic acid is esterified to the alcoholic group of the nitrogenous base choline
- **It is the most abundant phospholipid in the cell membrane**
 - Represents a large proportion of body's stores of choline
- **Dipalmitoyl lecithin (two C₁₆ palmitic FA)** is the chief lung surfactant. Its deficiency leads to respiratory distress syndrome in premature infants



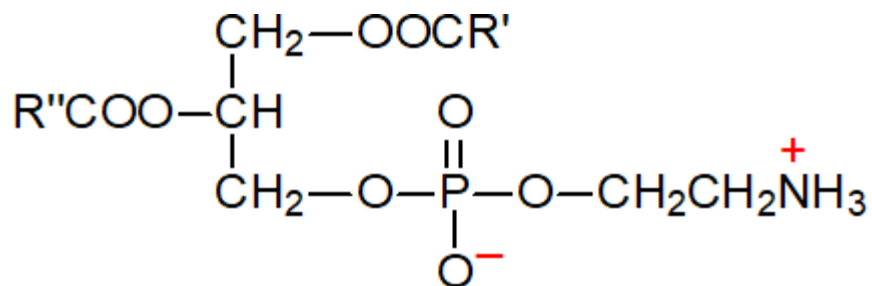
Lung surfactant

- ↓ surface tension in alveoli → Prevents collapse of lung alveoli
- Constituents: **dipalmitoyl lecithin**, phosphatidyl glycerol, Sphingomyelin, cholesterol and surfactant proteins A, B and C
- As foetus matures, more lecithin is synthesized
- Low levels of surfactant leads to respiratory distress syndrome (RDS)

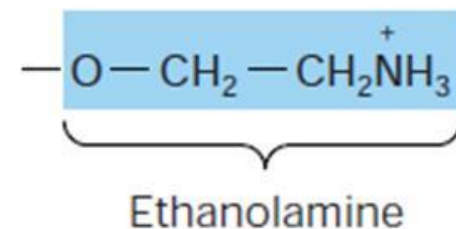


3-Phosphatidylethanolamine (Cephalin):

- The phosphate group of phosphatidic acid (PA) is esterified with the alcoholic group of the nitrogenous base **ethanolamine**
- It is the next common to lecithin in cell membranes and in blood plasma



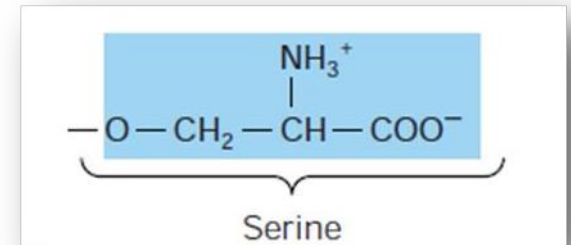
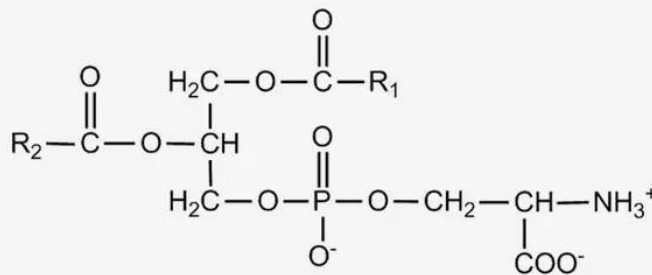
phosphatidylethanolamine



4- Phosphatidylserine:

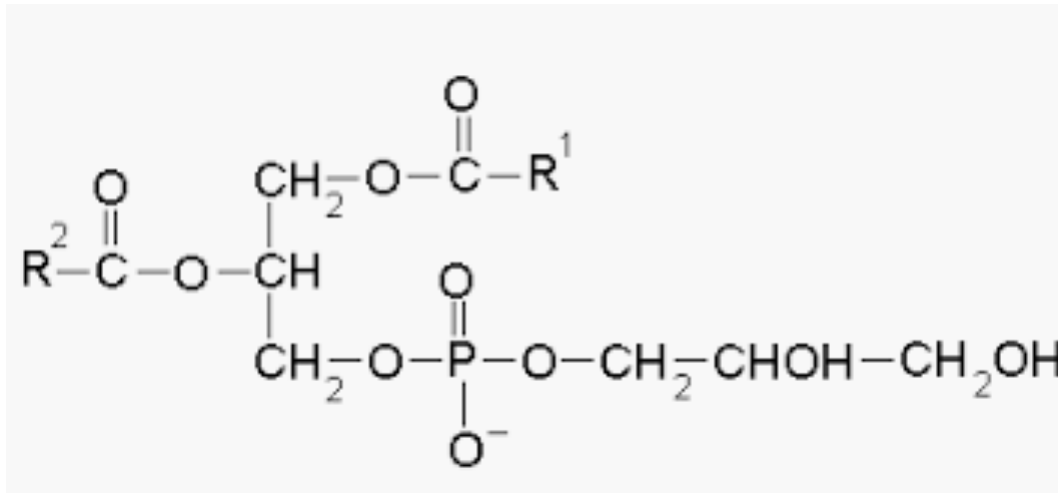
- The phosphate group of phosphatidic acid (PA) is esterified with the alcoholic group of the amino acid **serine**
- It is found in cell membranes.

PHOSPHATIDYLSERINE



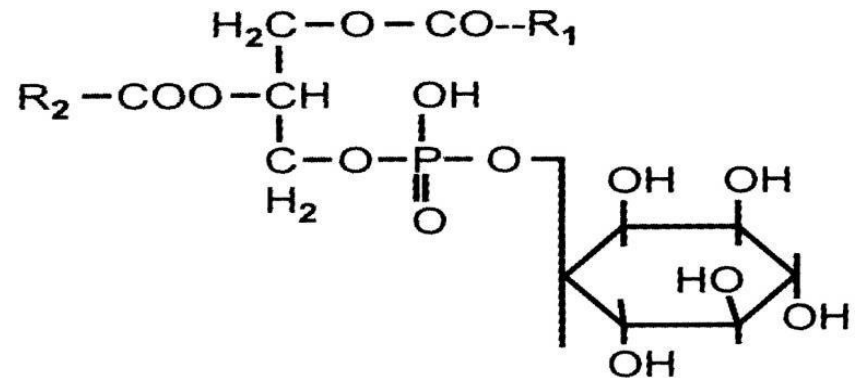
5- Phosphatidylglycerol:

- The phosphate group of phosphatidic acid was esterified with the alcoholic group of glycerol
- It forms part of the lung surfactant.



6-Phosphatidylinositol (lipositol):

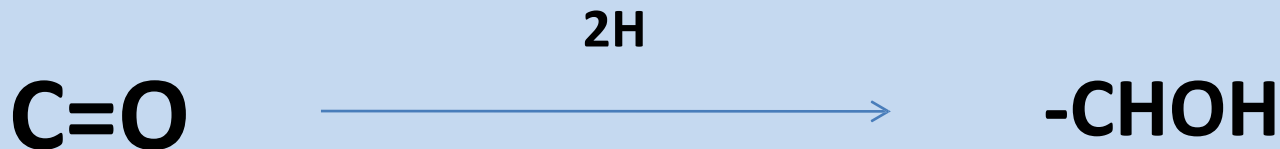
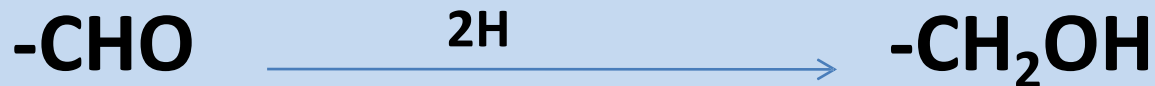
- The phosphate group of phosphatidic acid is esterified with the alcoholic group of inositol
- It is found in cell membranes, especially nuclear membrane
- **Phosphatidylinositol 4,5 biphosphate** found in the plasma membrane is important in the mediation of the action of some hormones



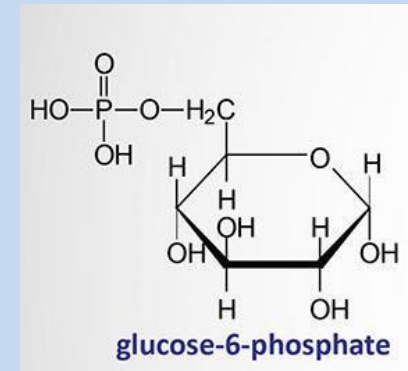
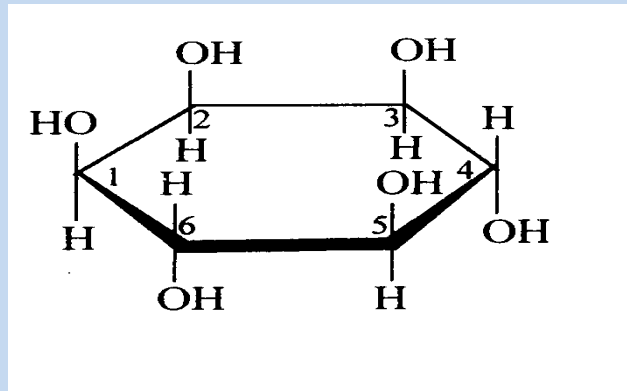
Which carbon?

5-Sugar alcohols

- Reduction of monosaccharides produce the corresponding alcohols
- They are produced by hydrogenation of aldoses and ketoses

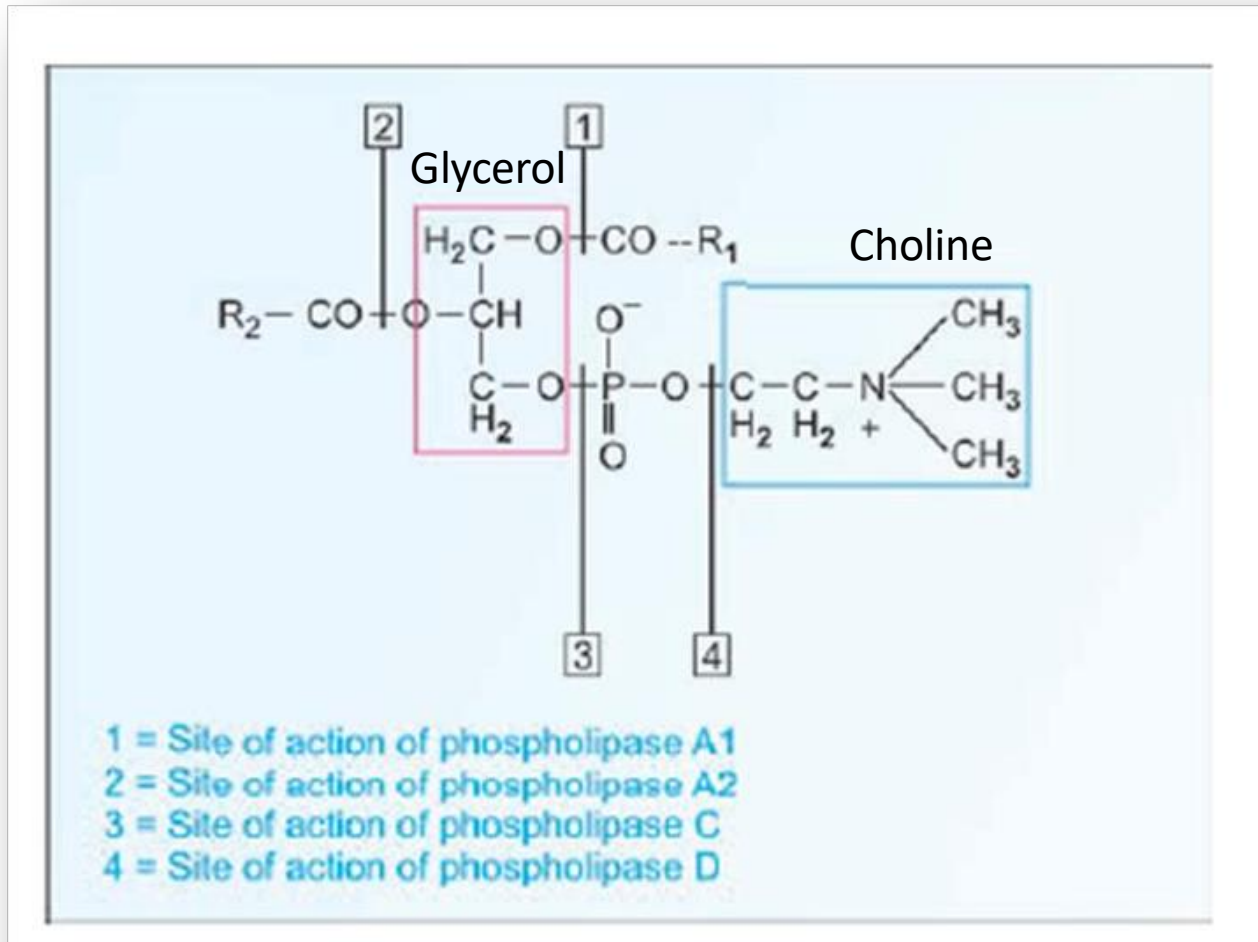


- **Myo-inositol:**



- Sugar alcohol synthesized from glucose-6-phosphate (G-6-P). It is abundant in brain and other mammalian tissues (in humans most inositol is synthesized in the kidneys)
- it is found in animal tissues in the free state as well as in the form of the phospholipid
- It is a constituent of certain phospholipids and hence its role in the mobilization of fats from the liver (lipotropic action i.e. encourages the export of fat from the liver)
- It forms phosphatidyl inositol that enters in structure of plasma membranes and can serve as a second messenger in action of some hormones (i.e. mediates cell signal transduction in response to a variety of hormones)
- ❖ *Second messengers are intracellular signaling molecules released by the cell in response to exposure to extracellular signaling molecules—the first messengers.*

Hydrolysis of glycerolphospholipids



PLD is not present in humans, only in plants

Snake venom contains enzyme with PLA2 activity: converts PL in RBCs to lysophospholipids

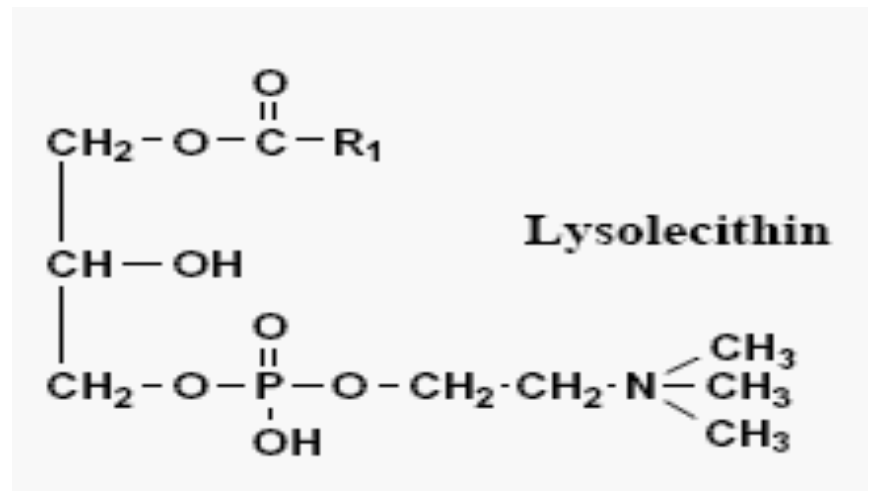
7-lysophospholipids:

- **Phospholipase A2** is an enzyme that removes the fatty acid in the 2- position of phospholipids → forming a lysophospholipid (contain one acyl radical):
 - e.g., from lecithin we get lysolecithin.

Lysophospholipids are intermediates in metabolism

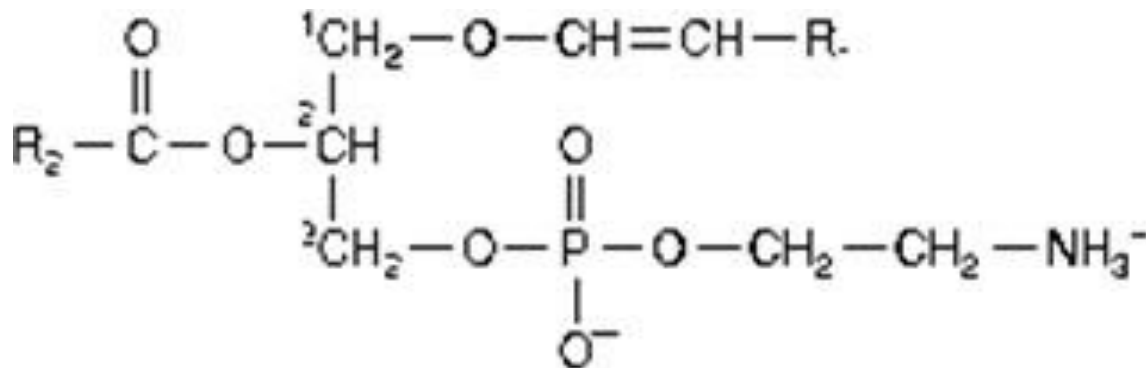
They are produced in the blood by the action of snake venom, where they produce hemolysis

Lysolecithin has been implicated in some of their effects in promoting atherosclerosis

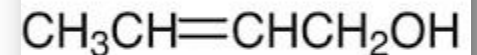


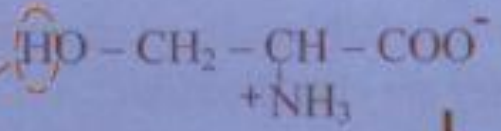
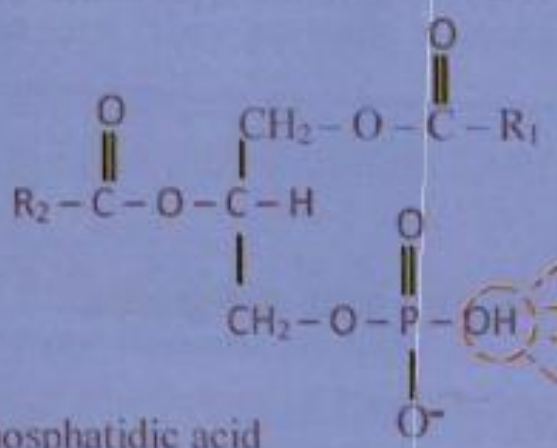
8- Plasmalogens:

- These are similar to cephalins, **but the fatty acid in the 1- position is replaced by a fatty alcohol**, usually unsaturated-
- The phosphate is usually esterified to ethanolamine; however it may also be esterified to choline or inositol
- **Plasmalogens** are found in cell membranes, especially in muscles and brain (10% of the phospholipids of brain and muscle are plasmalogens)



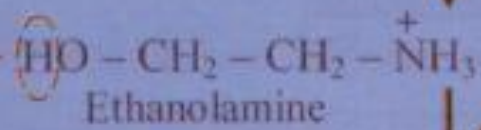
Example of fatty alcohol





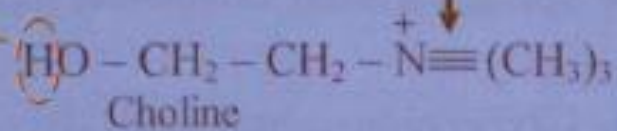
Serine

CO₂

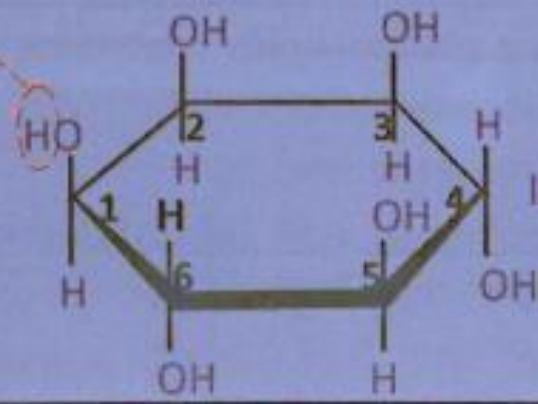
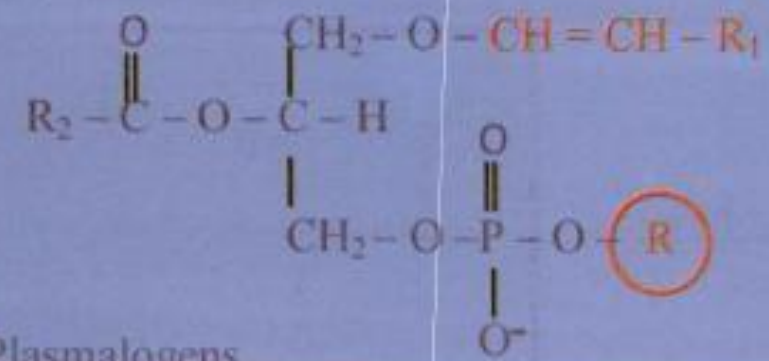


Ethanolamine

3 CH₃

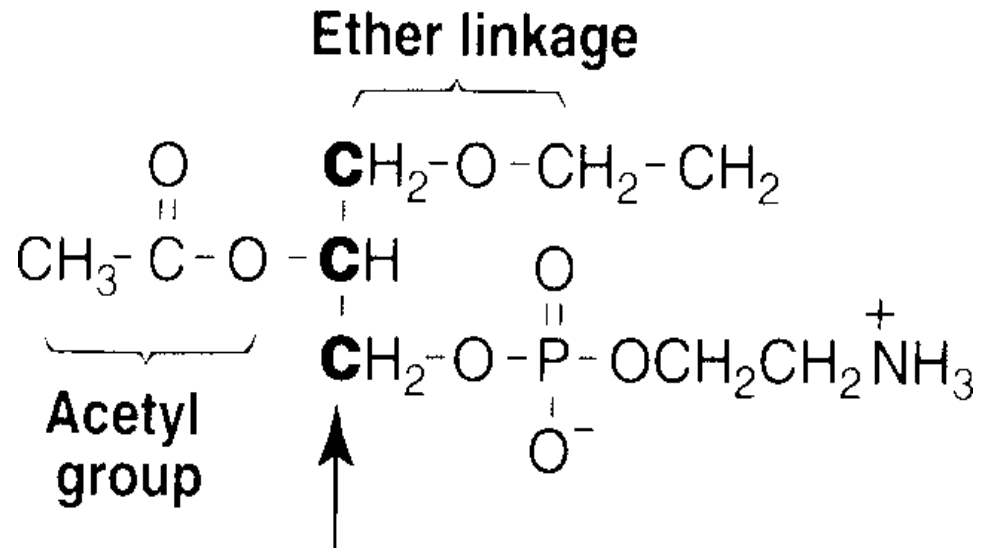


Choline



Inositol

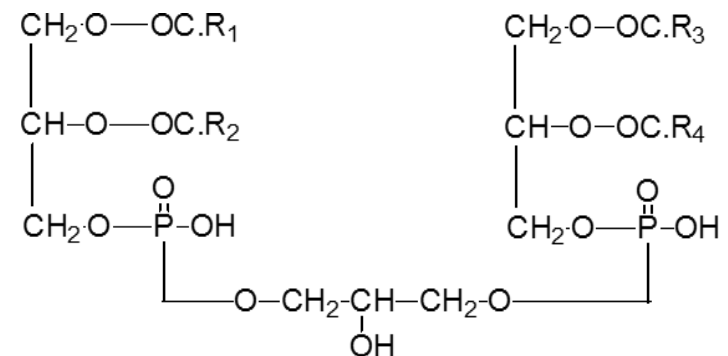
- **Platelet-activating factor (PAF)** is a choline plasmalogen in which position 1 contains saturated palmityl alcohol and position 2 contains acetic acid



Function: mediator of many leukocyte functions, platelet aggregation, inflammation and anaphylaxis.

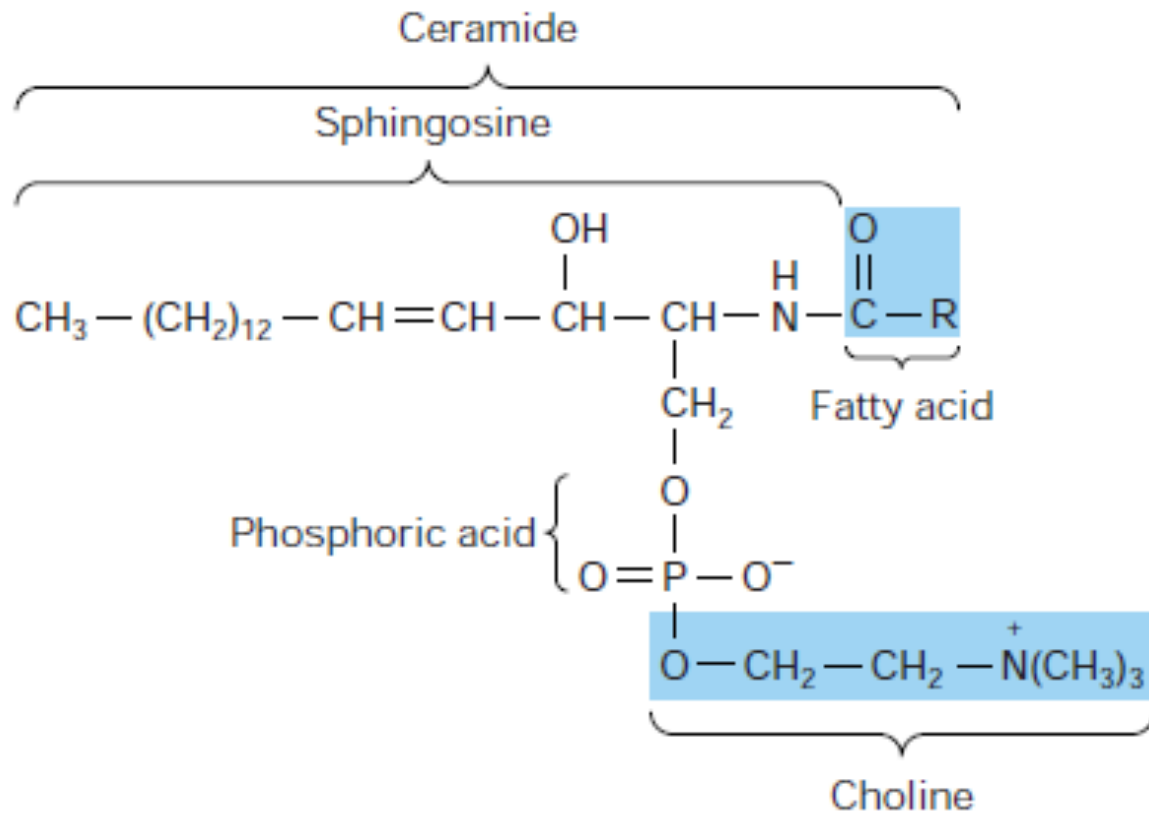
9-Diphosphatidylglycerol (Cardiolipin):

- Two molecules of phosphatidic acid esterified through their phosphate groups to an additional molecule of glycerol
- This is the only phospholipid that is antigenic
- It is an important component of the inner mitochondrial membrane (accounts for 20% of mitochondrial lipids) & bacteria
- Decreased cardiolipin levels or alterations in its structure or metabolism cause mitochondrial dysfunction in pathological conditions including heart failure & Barth syndrome
- **Barth syndrome** (cardioskeletal myopathy): genetic defect in coding for tafazzin, an enzyme involved in the biosynthesis of cardiolipin



B- Sphingophospholipids (Sphingomyelin):

- The backbone of sphingomyelin is the amino alcohol sphingosine rather than glycerol
-
- A long chain FA is attached to the amino group of sphingosine through an amide linkage, producing a ceramide, which can also serve as a precursor of glycolipids
- A phosphate is esterified to the 1- position of sphingosine and choline is esterified to the phosphate
- Sphingomyelin is found in cell membranes, especially in lungs (form part of lung surfactant) and brain (myelin sheath)
- * → which is present more in surfactant?



sphingomyelin

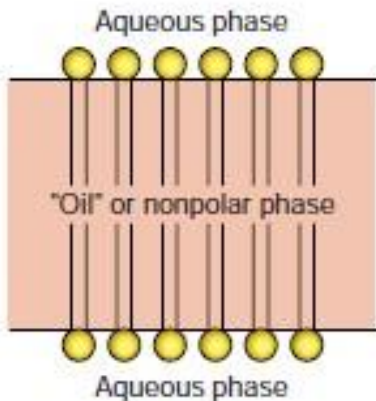
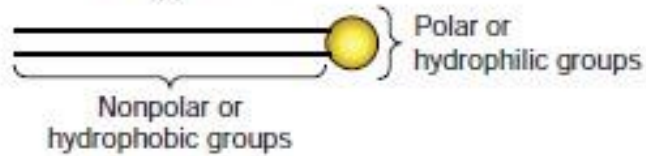
Solubility of phospholipids

- The presence of nonpolar groups → make them soluble in fat solvents
- The presence of polar groups (phosphate, choline, serine, ethanolamine, and inositol) → makes them water soluble, forming micelles (very fine emulsion) in water

- The presence of both nonpolar and polar groups enables PLs to facilitate emulsification of other insoluble fats
- The PL molecules are arranged around the emulsion particles so that the nonpolar groups are towards the lipid phase, and the polar groups are towards the surrounding aqueous phase
- This is important in the formation of the plasma lipoproteins and in the digestion and absorption of triacylglycerols

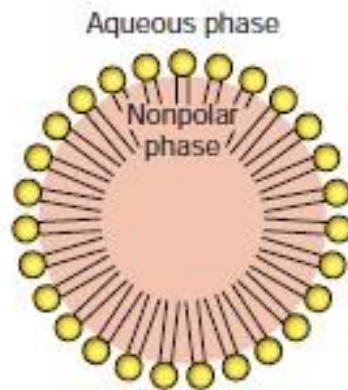
Amphipathic lipid

A



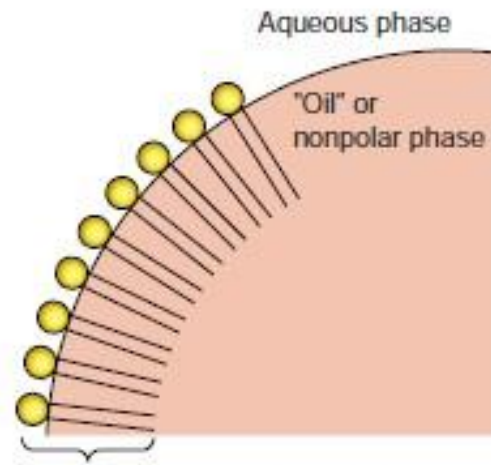
Lipid bilayer

B



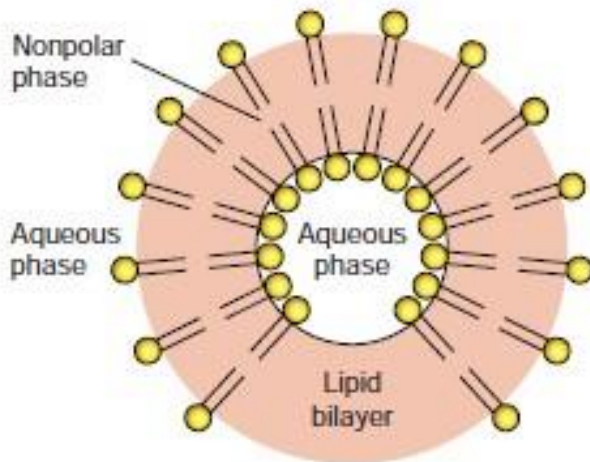
Micelle

C



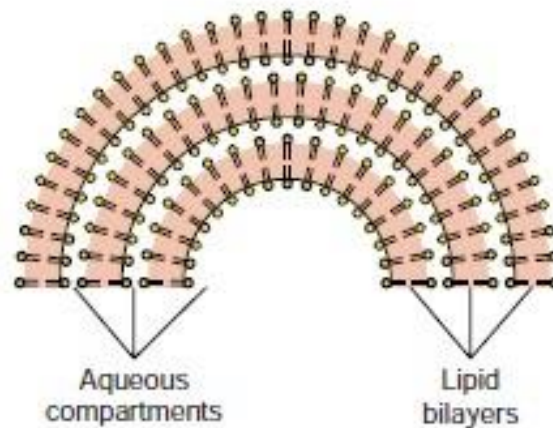
Oil in water emulsion

D



Liposome (Unilamellar)

E



Liposome (Multilamellar)

F

II Glycolipids

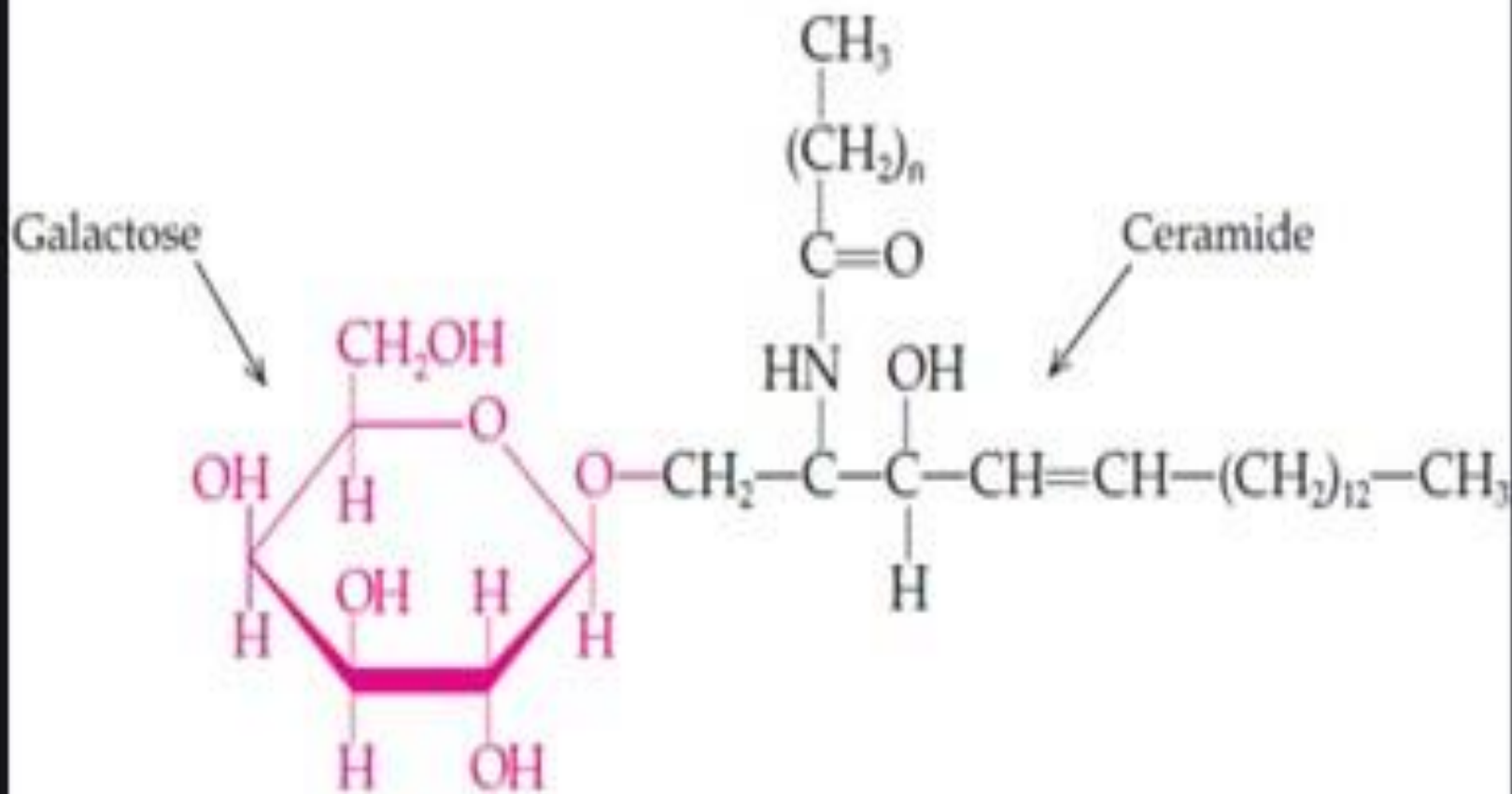
- Glycolipids are lipids containing a carbohydrate radical
- They also contain sphingosine and are, therefore, classified with sphingomyelin as **sphingolipids**
- They are widely distributed in every tissue of the body, particularly in nervous tissue such as brain + outer part of cell membrane

Types:

1. **Cerebrosides:**

- These consist of sphingosine, FA (usually 24 carbon lignoceric, cerebronic, or nervonic acid), and galactose or glucose.

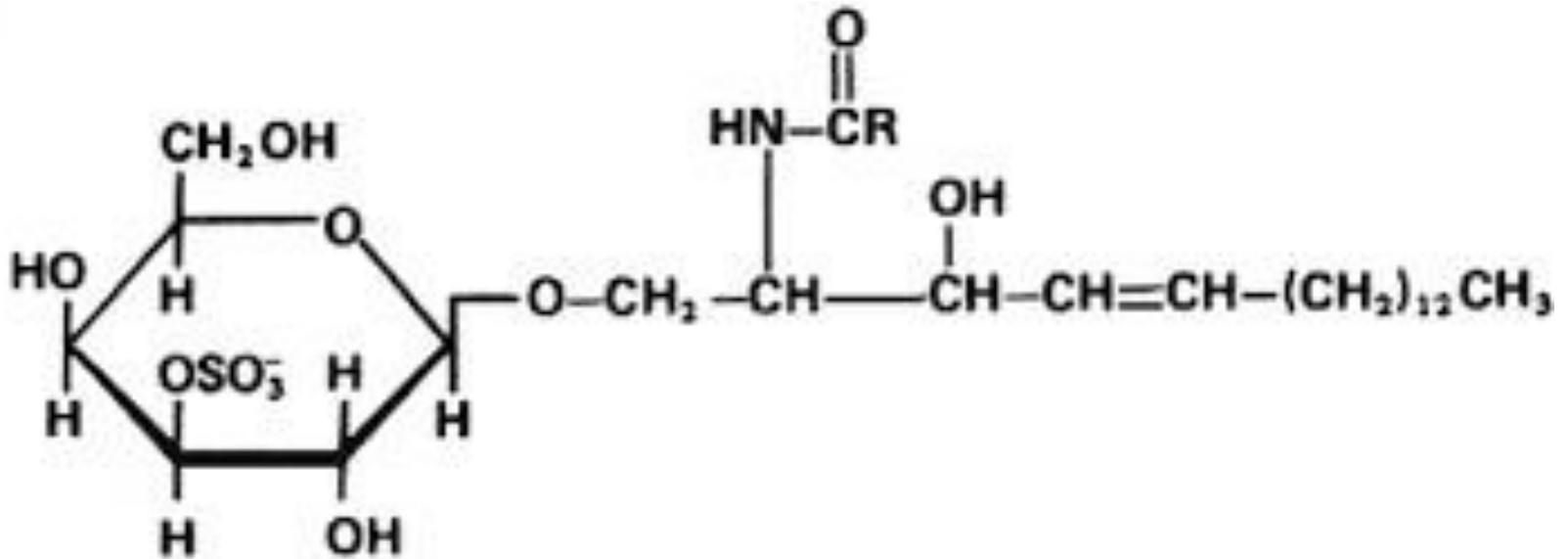
- The FA is connected to the amino group of sphingosine in amide linkage
- The sugar is connected to the primary alcohol group of sphingosine in **β -glycosidic linkage**
- **Galactocerebrosides** predominate in nervous tissue
- **Glucocebrosides** predominate in extra-neural tissues



Galactocerebroside

2. Sulpholipids:

- Sulpholipids, or sulphatides, are galactocerebrosides in with sulfuric acid @C3 in galactose



3. Globosides (ceramide oligosaccharides)

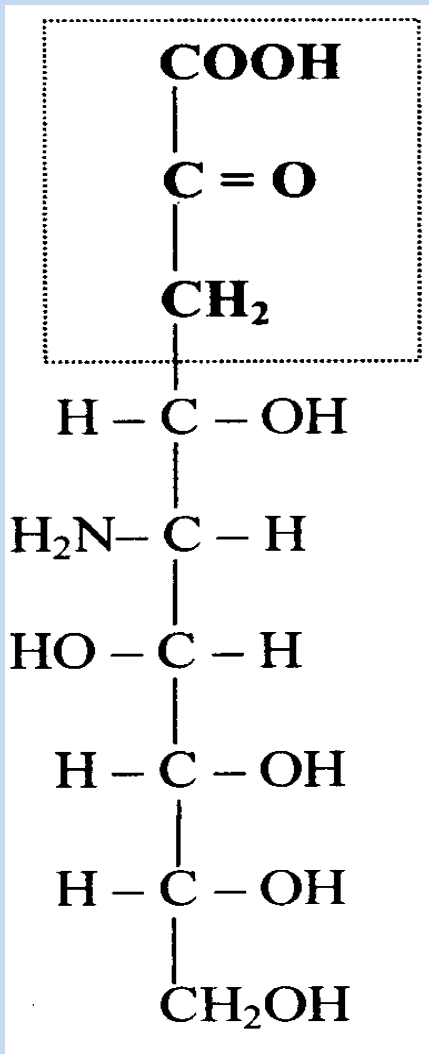
- These are cerebrosides in which the sugar is replaced by an oligosaccharide chain (hexose/ hexosamine) that **does not include a sialic acid as a component**
- Found in cell membrane

4. Gangliosides

- They are found in the ganglion cells of central nervous system (CNS)
- They are similar to Globosides but **contain a sialic acid (N-acetylneuraminic acid) as a component.**

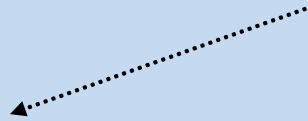
2-Amino sugar acids

- Formed by addition of acids to aminosugars
- They are occurring in glycoproteins, glycolipids
- Examples include neuraminic acid (pyruvic acid and mannosamine)
- Neuraminic acid is unstable and so, it is present in an acetylated form called sialic acid (NANA)

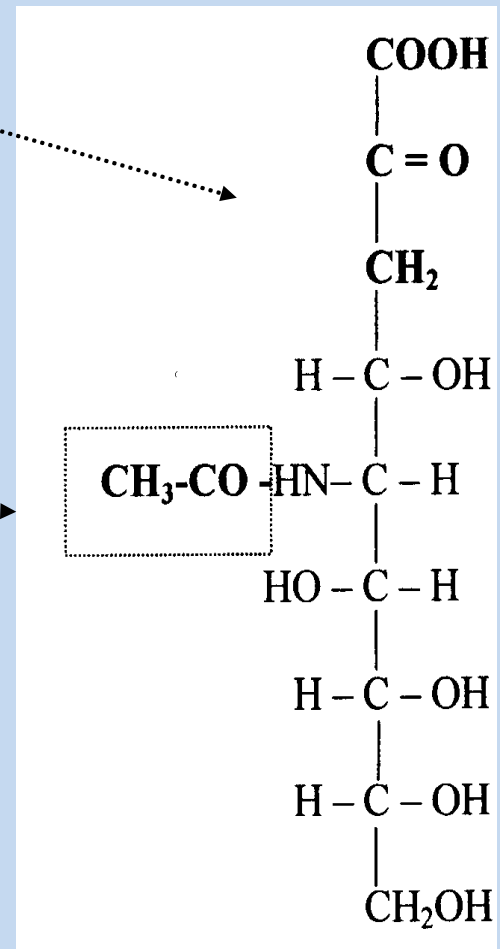
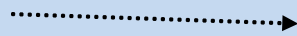


Neuraminic acid

Pyruvic acid

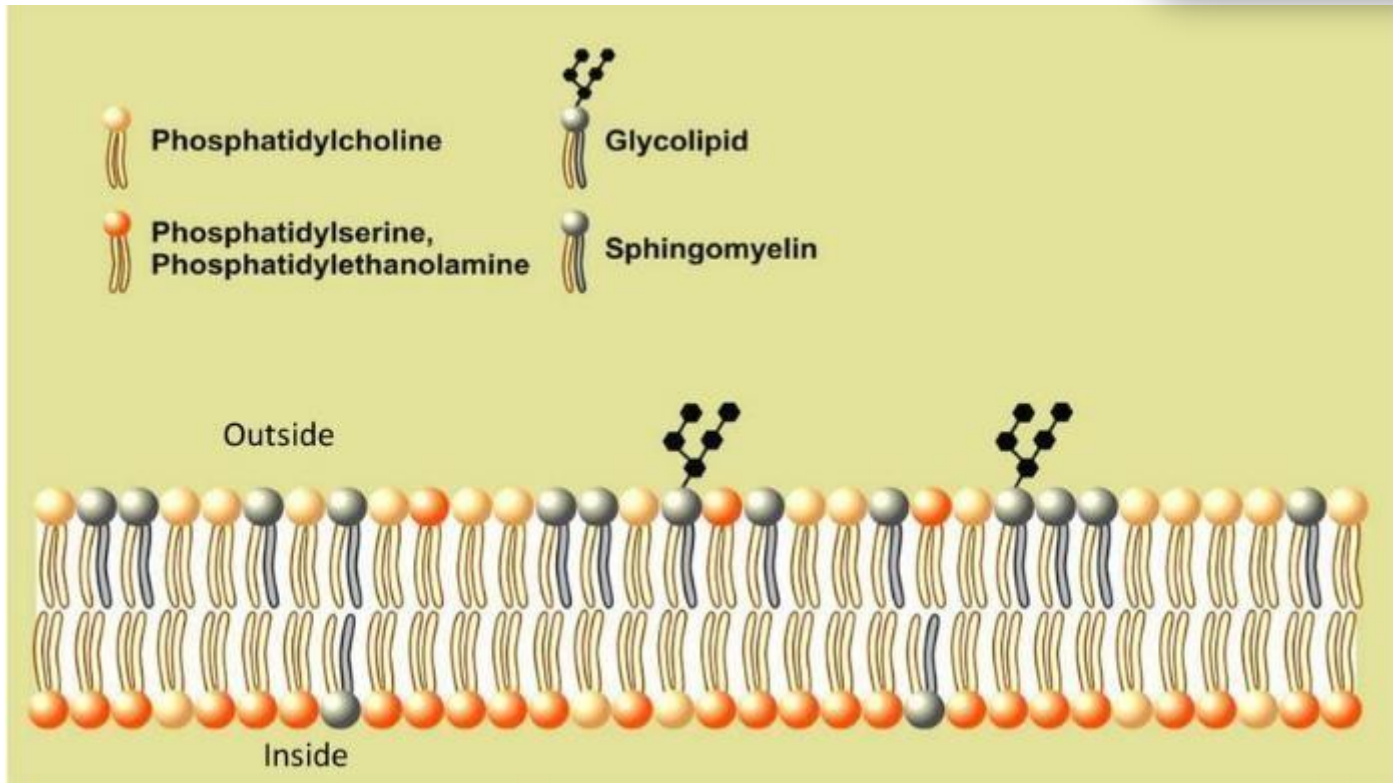
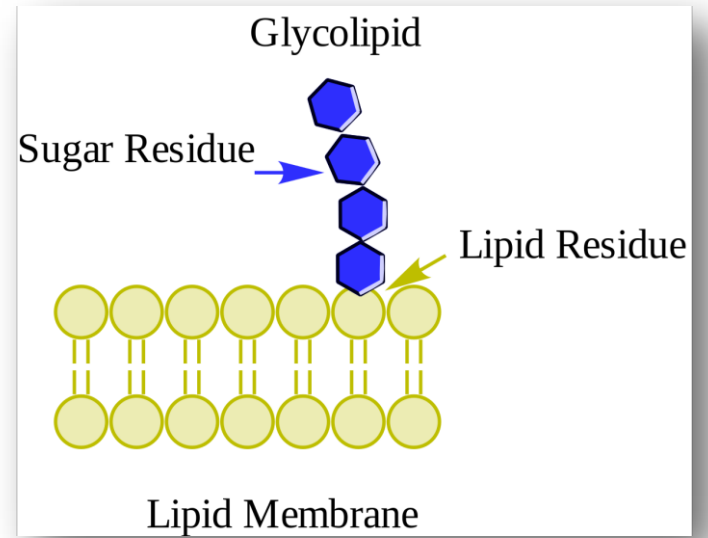


Acetyl group

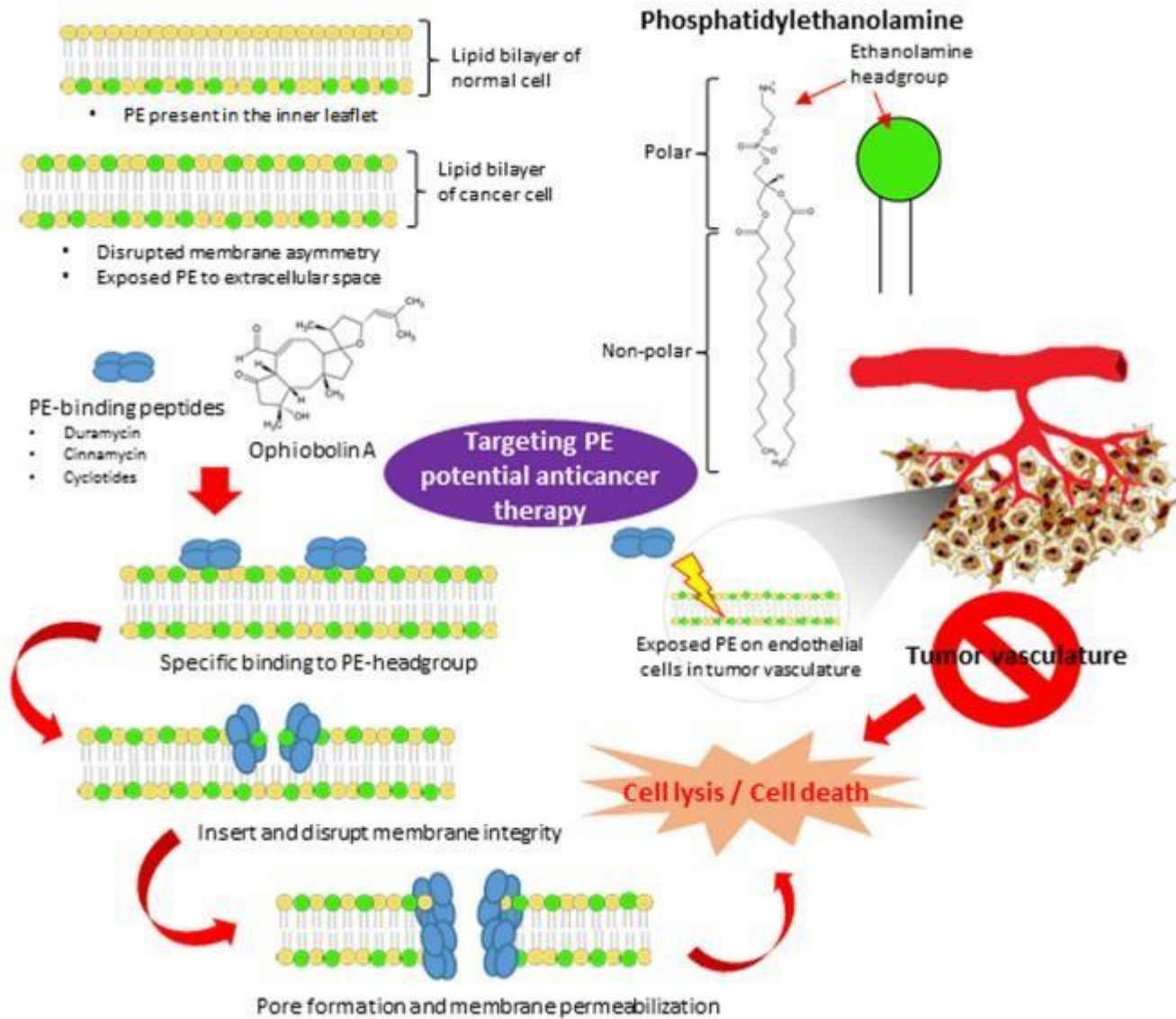


**N-Acetyl neuraminic acid
(NANA)
(Sialic acid)**

- Glycolipids are found in cell membranes, especially in myelin sheath
- In the plasma membrane (outer leaflet), the CHO radical of glycolipids projects outside the cell and may have a receptor function (for some toxins and viruses, cellular connections)
- CHO radicals of gangliosides and globosides are **antigenic**; they form the blood group antigens, certain tumor antigens
- Malignant cells show marked changes in the composition of glycolipids in cell membranes

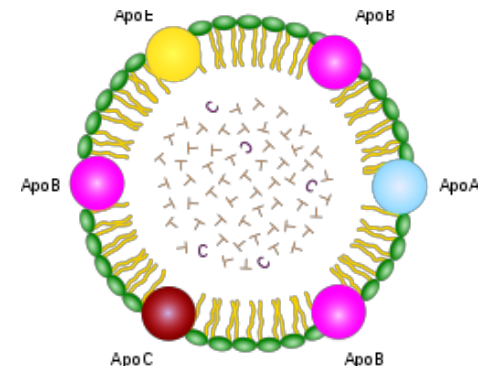


For info only

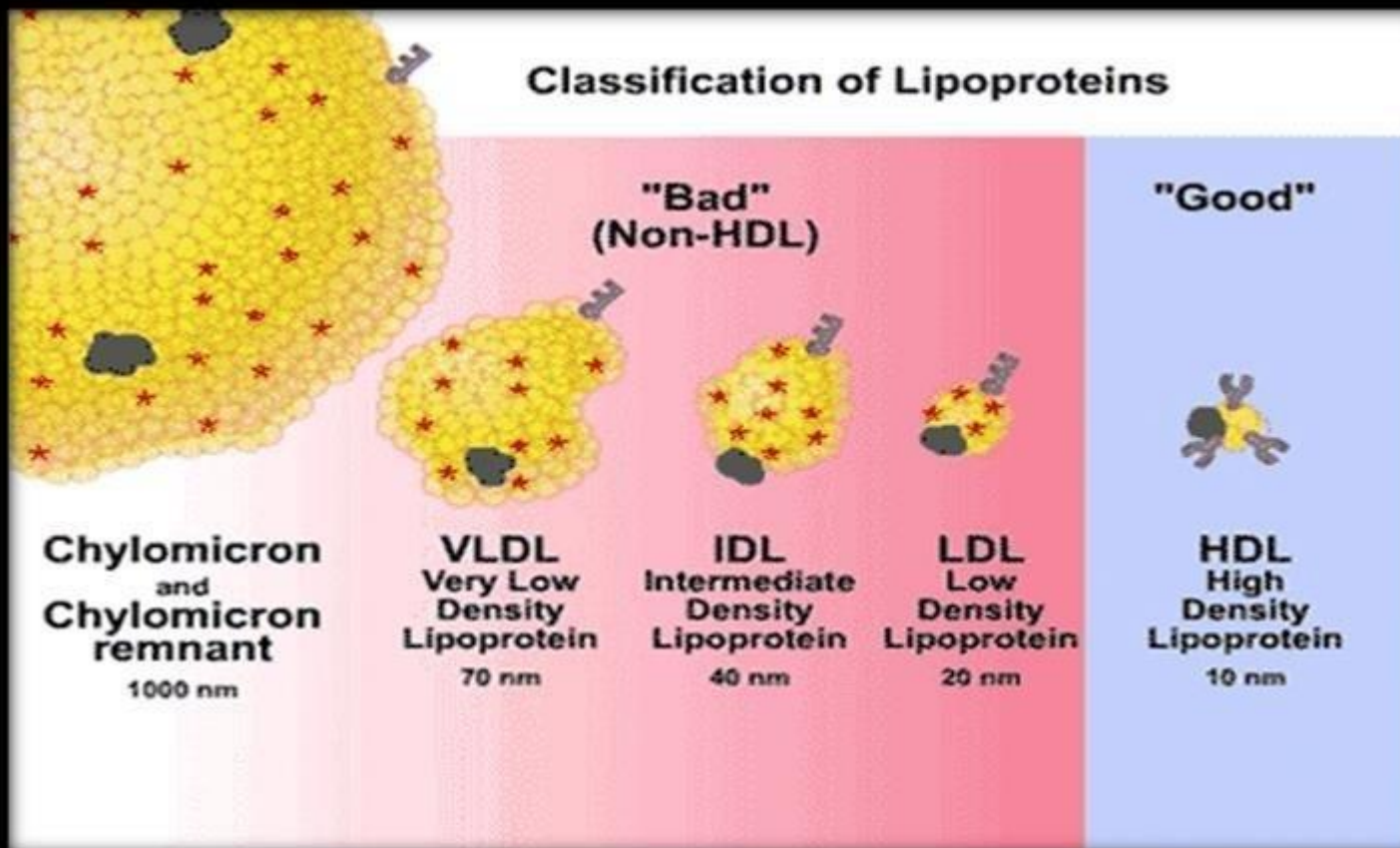


III Lipoproteins

- Lipoproteins are arranged as:
 - lipid part to the interior of the molecule
 - protein part to the exterior of the molecule
- This gives the structure a property of its solubility in water (**lipoproteins are water-soluble**)
- Used to transport lipids in plasma



Classification of Lipoproteins



**Chylomicron
and
Chylomicron
remnant**

1000 nm

**VLDL
Very Low
Density
Lipoprotein**

70 nm

**IDL
Intermediate
Density
Lipoprotein**

40 nm

**LDL
Low
Density
Lipoprotein**

20 nm

**HDL
High
Density
Lipoprotein**

10 nm

Derived lipids

- These lipids are derived from both simple & compound lipids.

1- Alcohols: These are.

- Glycerol. It is the backbone of glycerol phospholipids.
- Higher alcohols. E.g. myricyl alcohol
- Sterols: as cholesterol, ergosterol. Their esters with fatty acids are waxes
- Vitamins: as vit. A (retinol) & D
- Sphingosine: This alcohol as previously mentioned in sphingomyelin & Glycolipids

2- Fatty acids

3- Substances associated with lipids

These substances are present in association with lipids.

- **Vitamins:** vitamins E & K are fat soluble & are associated with food fat
- **Carotenoids:** important precursors of vitamin A

Amino acids/ peptides/ proteins of biological importance- 1

Ahmed Salem, MBBCH, MSc, PhD, FRCR
asalem@hu.edu.jo

Majority of sides: Dr. Walaa Bayoumie El Gazzar

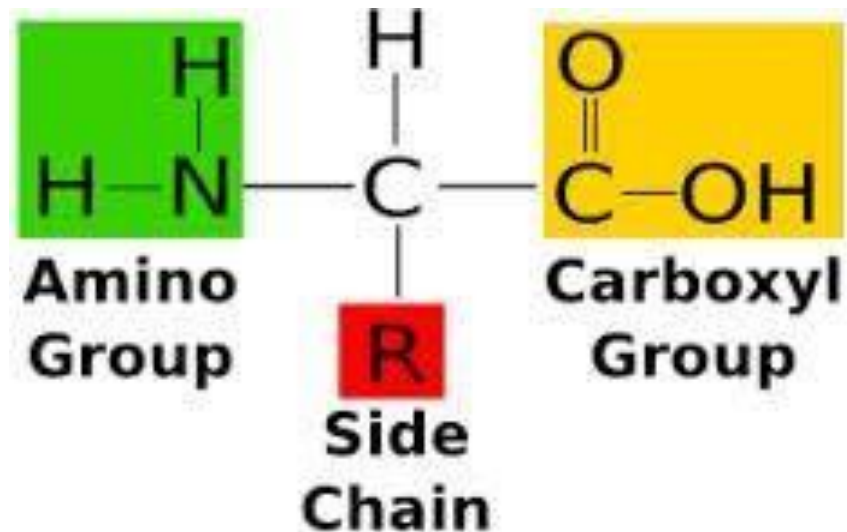
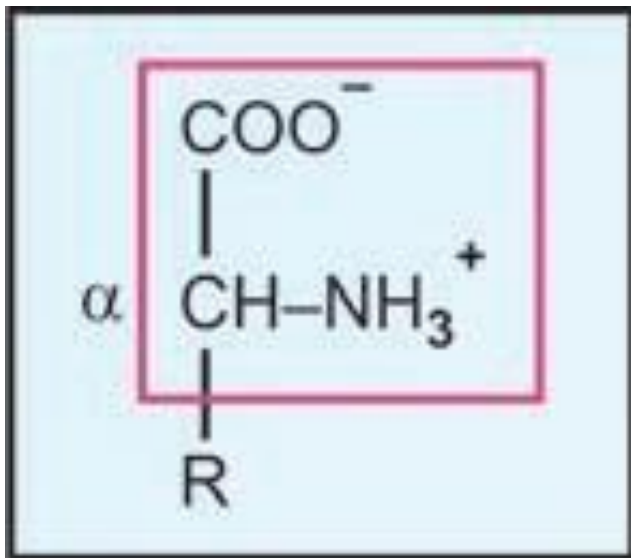
Protein

- **Definition:** Organic compounds with high molecular weight formed from amino acids
 - Composed of carbon, hydrogen, oxygen, nitrogen +/- sulphur
 - Nitrogen forms appx 16% of their weight (characteristic for proteins)
- **Amino acids:** organic acids with one or more amino groups (NH₂)

Importance of amino acids/ peptides/ proteins

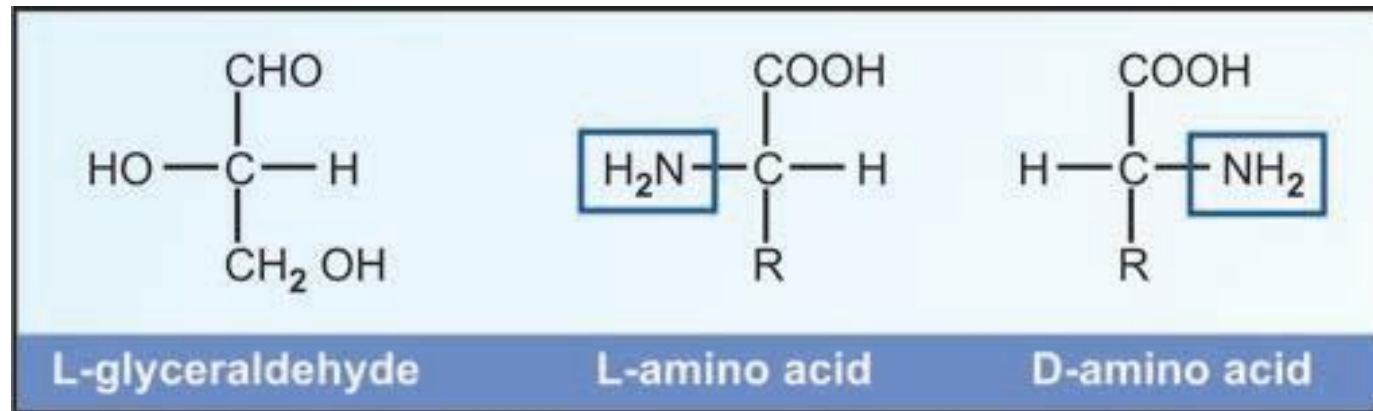
- Amino acids participate in the biosynthesis of:
 - Porphyrins
 - Purines
 - Pyrimidines
 - Urea
- AA form **peptides** (2-50 amino acids) which have a roles as:
 - Hormones
 - Neurotransmitters
- AA form **proteins** (>50 amino acids) which have a roles as:
 - Plasma membrane
 - Hormones
 - Enzymes

- Amino acids are carboxylic acids containing an amino group.
- With the exception of the proline **which is an imino acids (NH)**, the building blocks of proteins are L- α - amino acids, having the general formula:



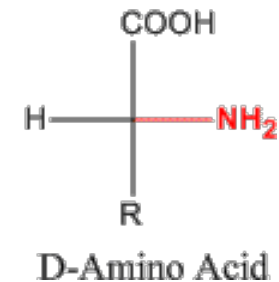
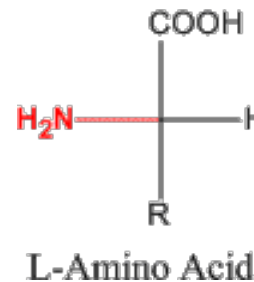
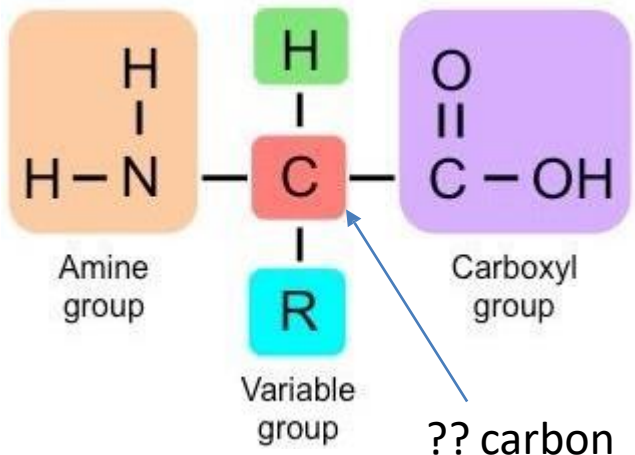
Optical Activity

- **Except in glycine**, in which R is a hydrogen atom, the α -carbon is chiral, being connected to 4 different groups
- Therefore, amino acids are optically active, and each may exist in the D- or L-form.



Amino acid (AA) structure

- Contain carboxyl group (COOH) → **acid**
- Contain amino group (NH₂) → **amino**
- 300 naturally occurring AA, but only 20 constitute monomer units of protein & coded by DNA
- Only L alpha amino acids occur in protein in humans (except D-serine and D-aspartate in brain tissue)
- Nineteen L-α- amino acids and 1 imino acid (proline) are required for the synthesis of all proteins
- **Selenocysteine** is 21st L-alpha amino acid



Classification of amino acids

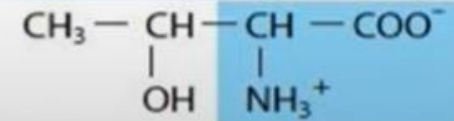
- **Chemical classification:** according to their chemical structure
- **Polar vs non-polar:** according to the polarity of the side chain; can be charged or neutral
- **Acidic vs basic**
- **Nutritional classification:** according to their nutritional importance (essential vs non-essential)
- **Metabolic classification:** according to their metabolic fate

3- butyric acid: 4c (CH₃-CH₂-CH₂-COOH)

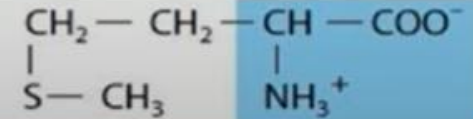
- **Threonine:** (alpha amino, beta hydroxy butyric acid)

- **Methionine:** (alpha amino, gamma methyl thiol butyric acid)

Threonine



Methionine

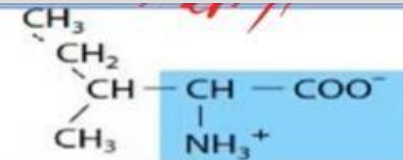


4- Valeric acid: 5c (CH₃-CH₂-CH₂-CH₂-COOH)

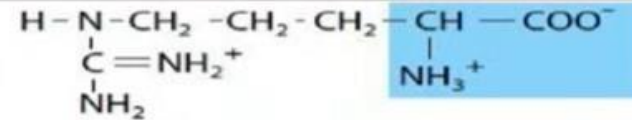
- **Isoleucine:** (alpha amino, beta methyl Valeric acid)

- **Arginine:** (alpha amino, delta guanido Valeric acid)

Isoleucine



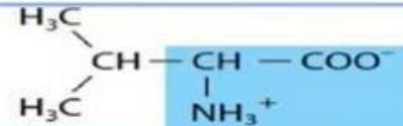
Arginine



5- Isovaleric acid: 5c

- **Valine:** (alpha amino, Isovaleric acid)

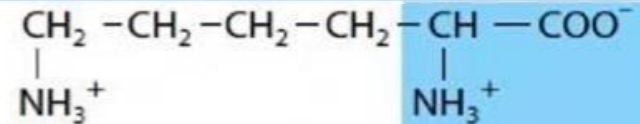
Valine



6- Caproic acid: 6c

- **Lysine:** (alpha amino, epsilon amino caproic acid)

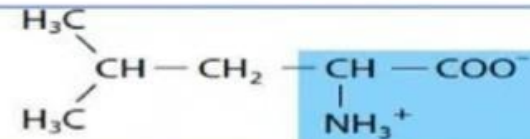
Lysine



7- Isocaproic acid: 6c

- **Leucine:** (alpha amino isocaproic acid)

Leucine

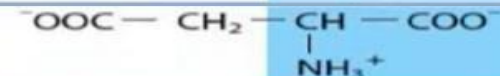


8- Succinic acid: 4c dicarboxylic acid

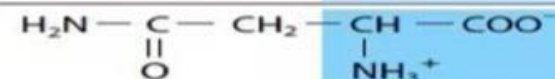
- **Aspartate:** (alpha amino succinic acid)

- **Asparagine:** (alpha amino succinic

Aspartic acid



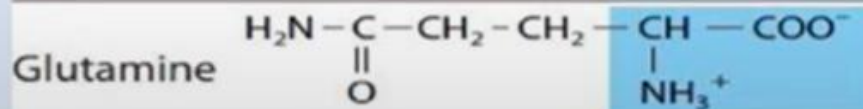
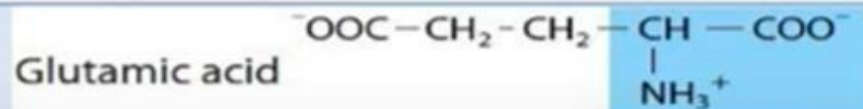
Asparagine



9- **Glutaric acid:** 5c dicarboxylic acid

- **Glutamate:** (alpha amino glutaric acid)

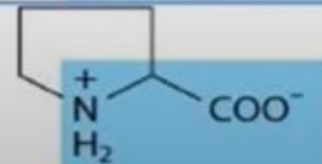
- **Glutamine:** (alpha amino glutaric acid amide)



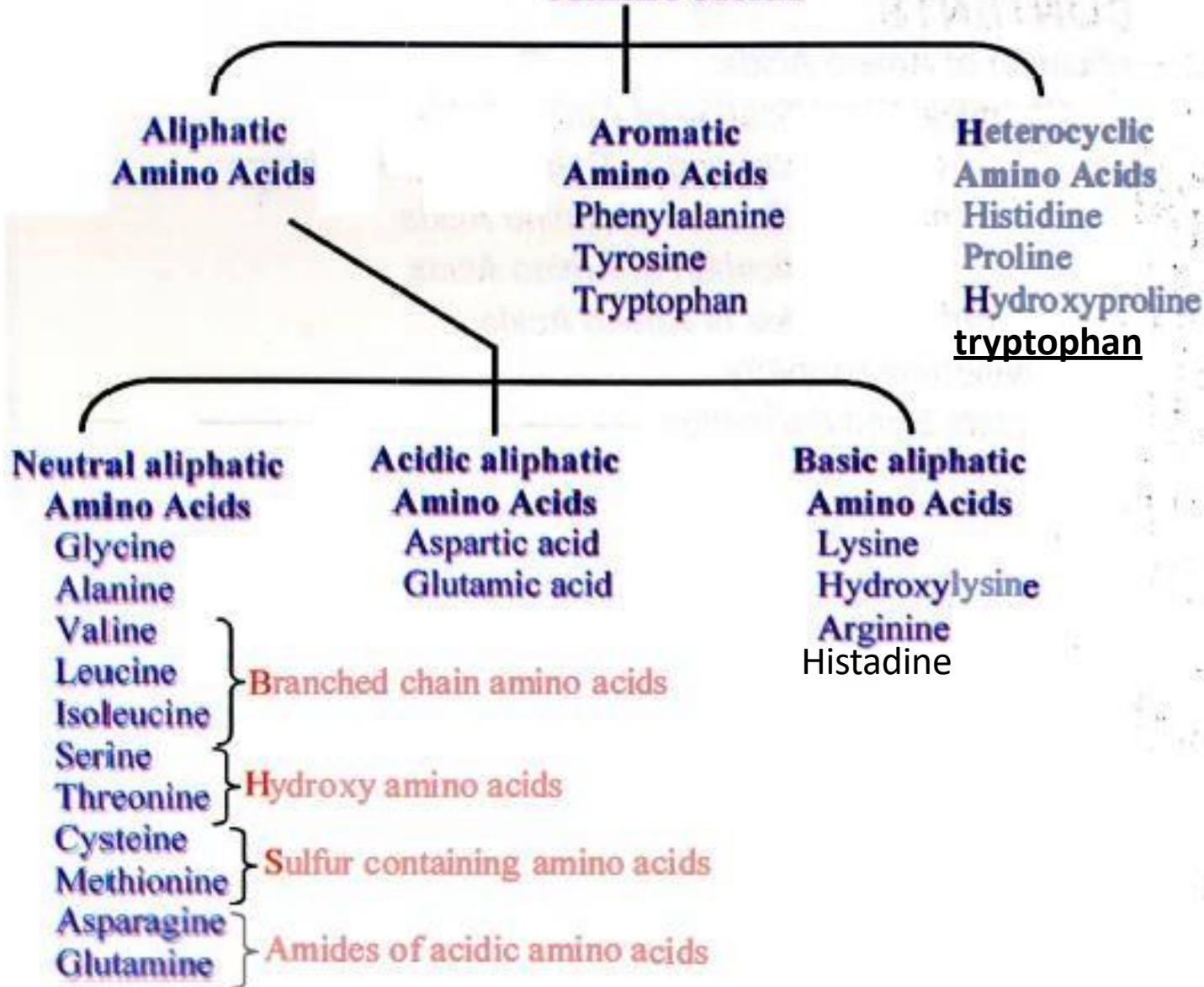
10- **pyrrolidine ring:** 4c

- **Proline:**

Proline



Chemical Classification of Amino Acids

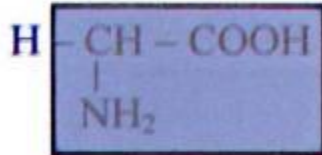


Neutral aliphatic amino acids

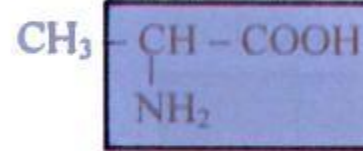
- These are amino acids that **contain no ring structure.**
- According to their side-chain, these are classified into 3 groups:
 - (1) Amino acids with a hydrocarbon side chain
 - (1) Branched amino acids
 - (2) Unbranched amino acids
 - (2) Hydroxyl-containing amino acids
 - (3) Sulfur-containing amino acids

Amino acids with aliphatic side chain

1- Glycine (Gly or G)
α-aminoacetic acid

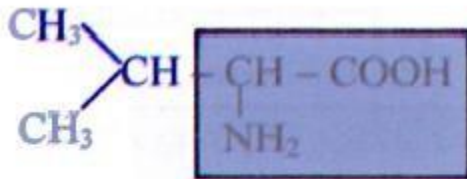


2- Alanine (Ala or A)
α-aminopropionic acid

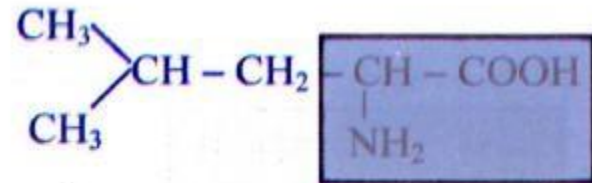


3- Branched Chain Amino Acids

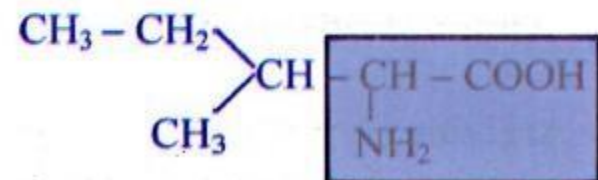
A- Valine (Val or V)
α-aminoisovaleric acid



B- Leucine (Leu or L)
α-aminoisocaproic acid



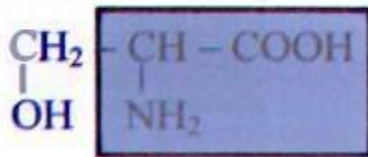
C- Isoleucine (Ile or I)
α-amino, β-methyl, β-ethylpropionic acid



Amino acids with aliphatic side chain containing a hydroxyl group

1- Serine (*Ser* or *S*)

α-amino, *β*-hydroxypropionic acid



2- Threonine (*Thr* or *T*)

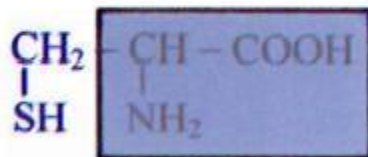
α-amino, *β*-hydroxybutyric acid



Amino acids with aliphatic side chain containing sulphur atoms

1- Cysteine (*Cys* or *C*)

α-amino, *β*-thiolpropionic acid



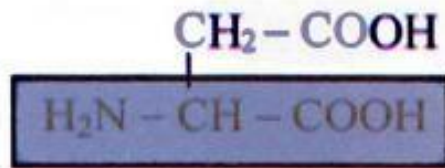
2- Methionine (*Met* or *M*)

α-amino, *γ*-methylthiolbutyric acid

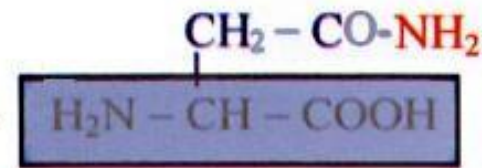


Amino acids containing **acidic** groups or their amides

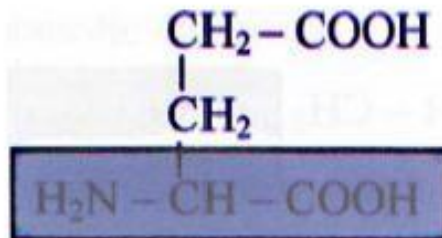
1- Aspartic acid (Asp or D)
 α -aminosuccinic acid



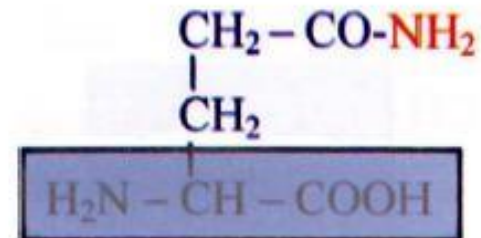
2-Asparagine (Asn or N)
Amide of aspartic acid



3-Glutamic acid (Glu or E)
 α -aminoglutaric acid



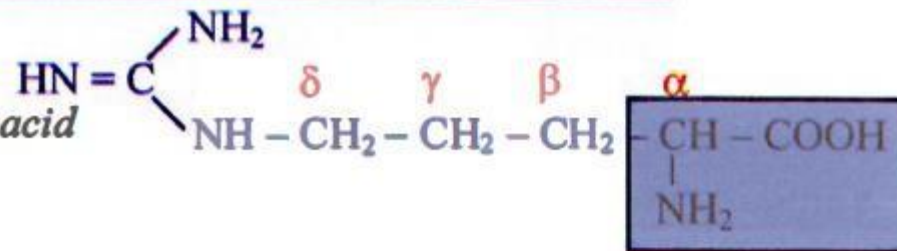
4- Glutamine (Gln or Q)
Amide of glutamic acid



Amino acids with basic groups

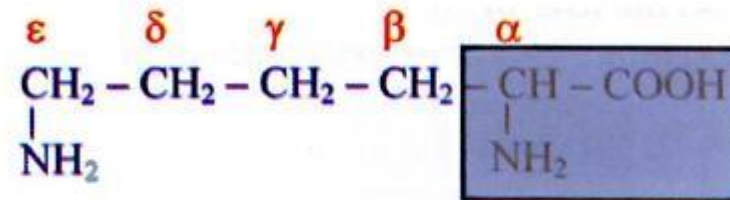
1- Arginine (*Arg or R*)

α amino, *δ*-guanidovaleric acid

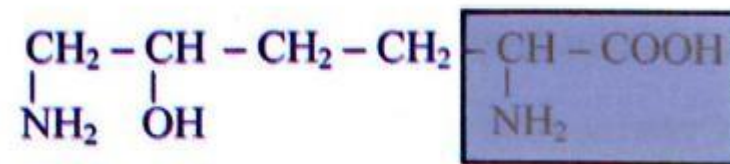


2- Lysine (*Lys or K*)

α, ε-diaminocaproic acid

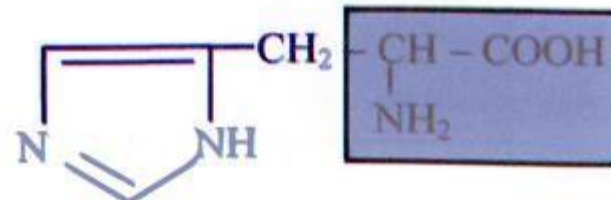


3- Hydroxylysine



4- Histidine (*His or H*)

α-amino, *β*-imidazole propionic acid

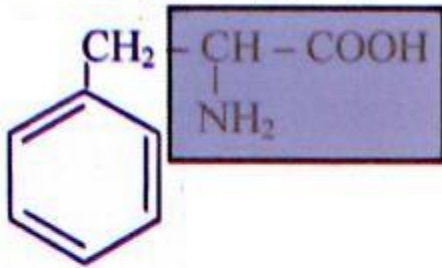


Amino acids containing aromatic rings

These are amino acids that contain an aromatic ring

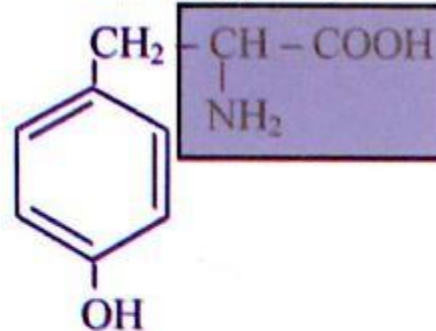
1- Phenylalanine (*Phe* or *F*)

α-amino, *β*-phenylpropionic acid



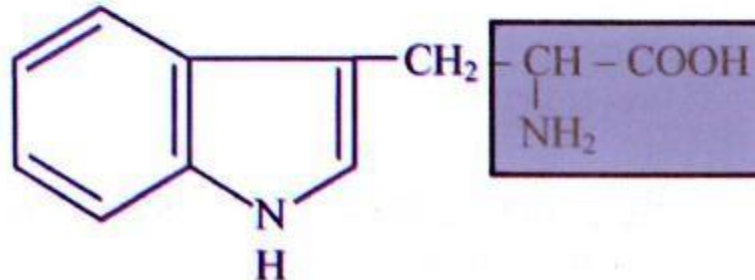
2- Tyrosine (*Tyr* or *Y*)

p-hydroxyphenylalanine



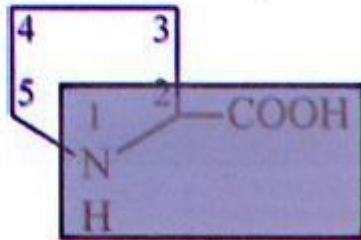
3- Tryptophan (*Trp* or *W*)

α-amino, *β*-indole propionic acid

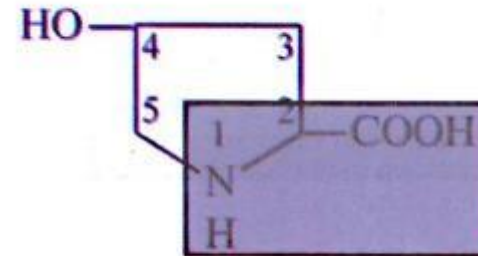


Imino acids: contain imino group

1- Proline (*Pro or P*)
(2-Pyrrolidine, carboxylic acid)



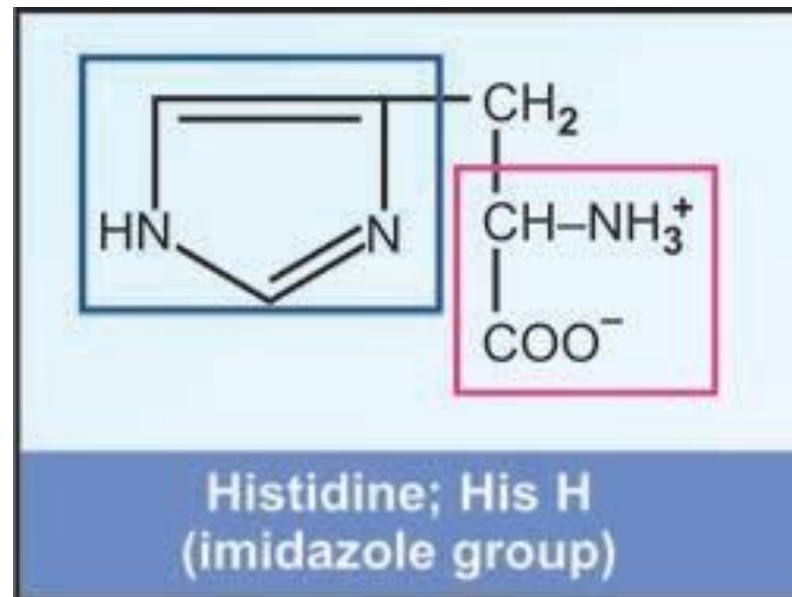
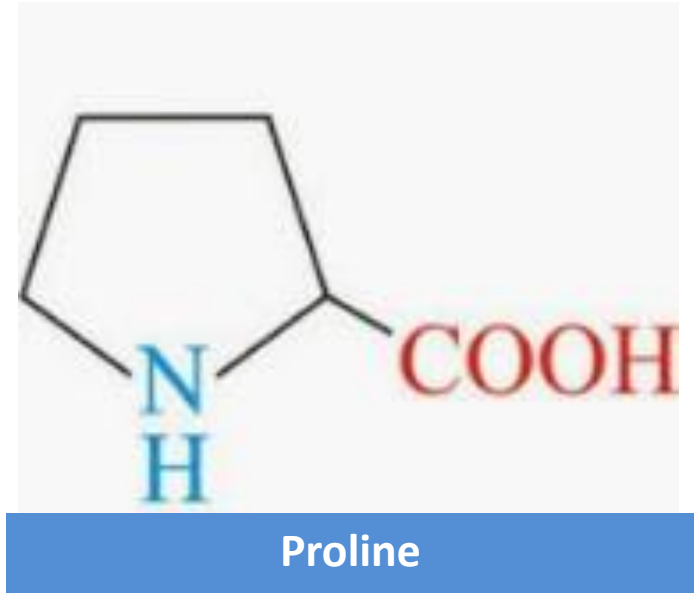
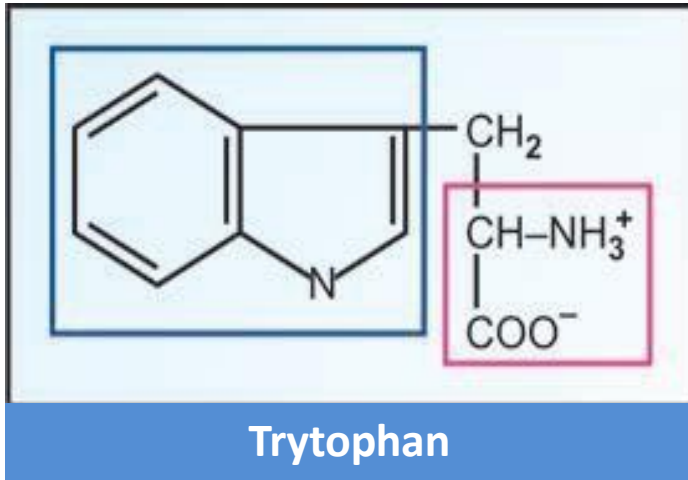
2- Hydroxyproline



N.B. Heterocyclic amino acids are those containing rings other than phenyl ring and they include tryptophan, histidine, proline and hydroxyproline.

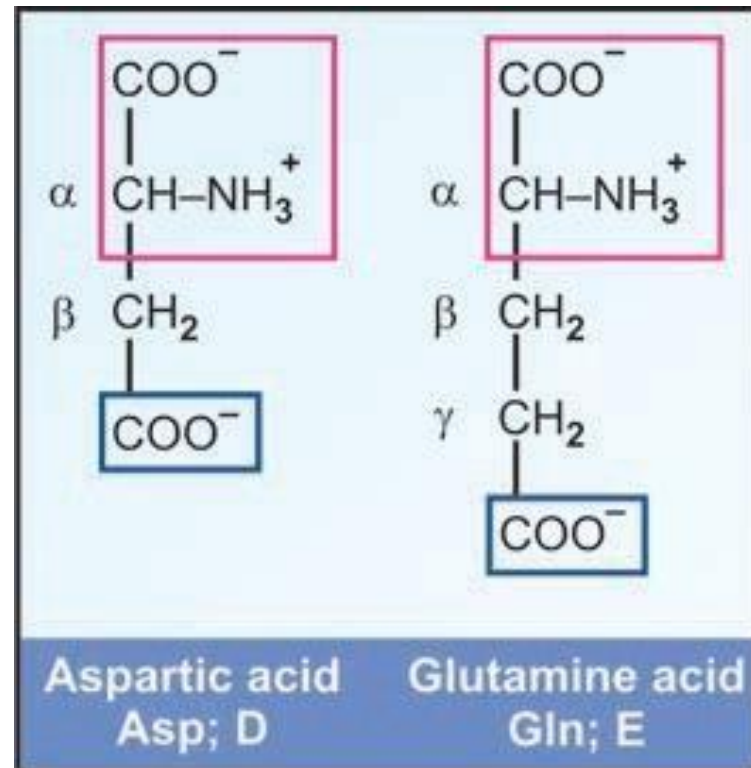
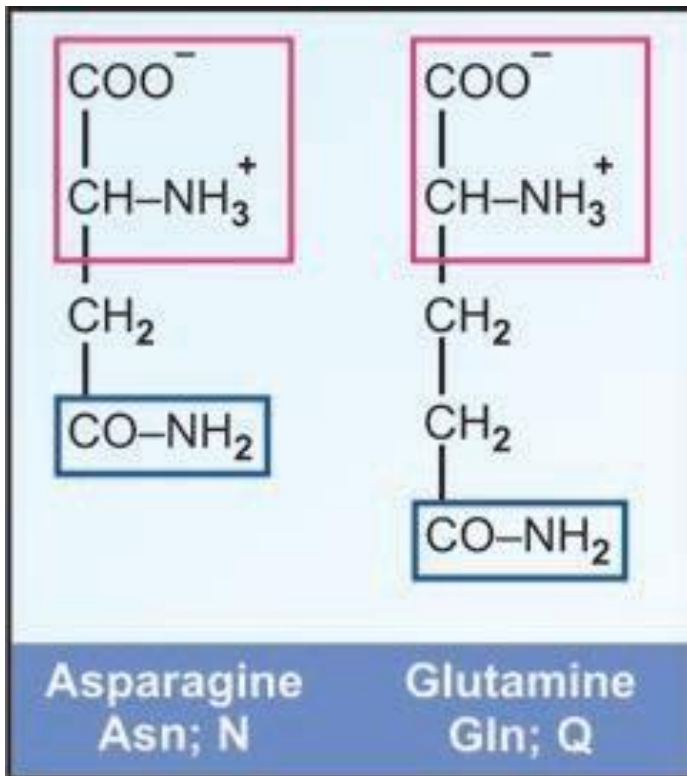
Neutral Heterocyclic amino acids

- These are amino acids that contain a heterocyclic ring
 - **Heterocyclic ring:** A ring containing at least one atom other than carbon
 - They include tryptophan , histidine, proline, hydroxyproline
 - Proline is an imino acid (contain imino group (NH) rather than amino group)
- ❖ Note: **Histidine** is also a basic amino acid



❖ Acidic amino acids and their amides:

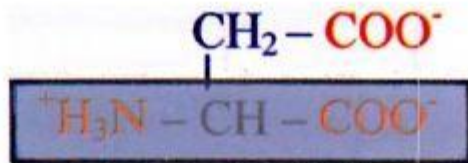
- The acidic amino acids are monoamino-dicarboxylic acids
- They include Aspartic acid, Glutamic acid
- Asparagine and glutamine, the amides of aspartic and glutamic acids, respectively, **are neutral**



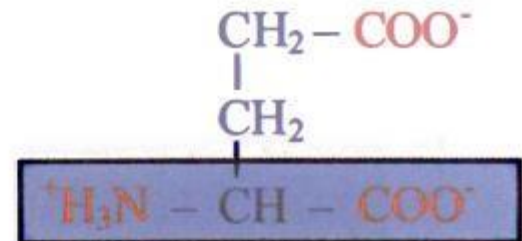
B- Acidic Amino Acids (monoamino-dicarboxylic acids)

They include the following:

1- Aspartic acid

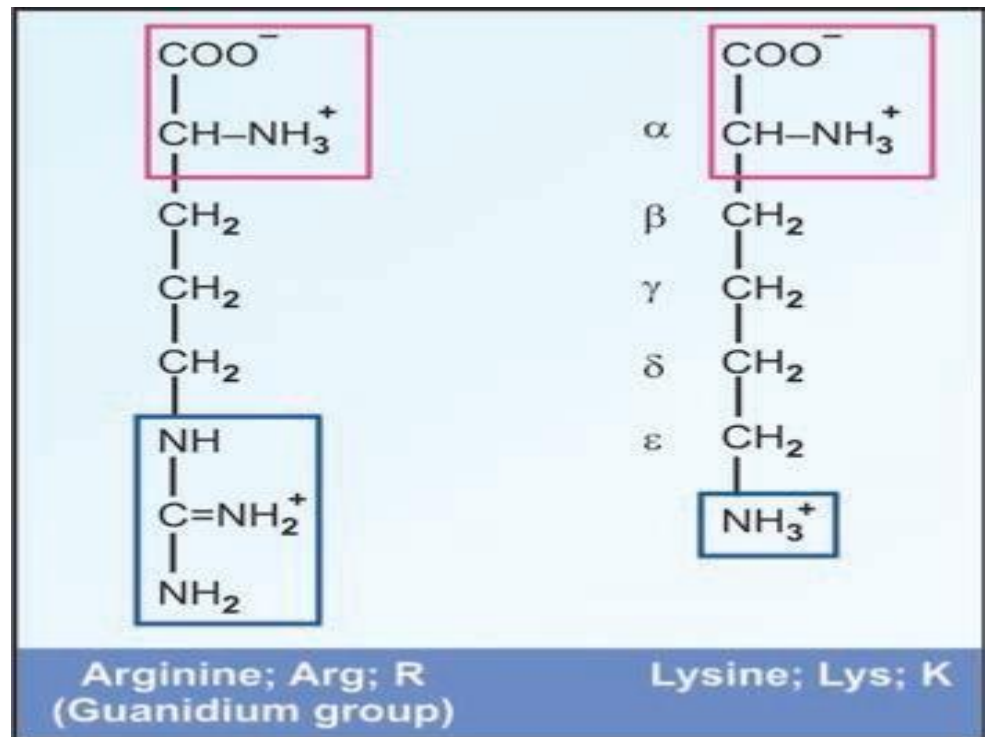
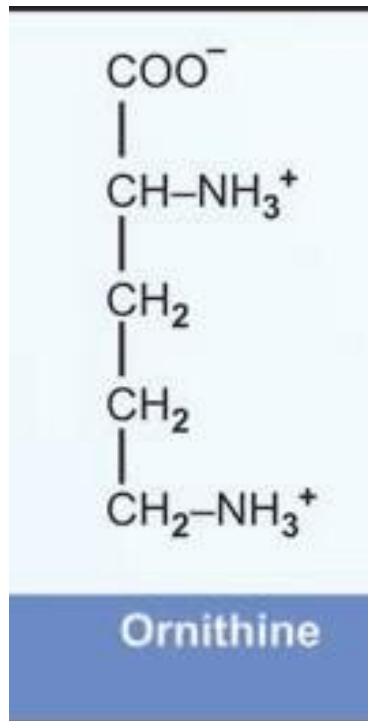


2- Glutamic acid



❖ Basic amino acids

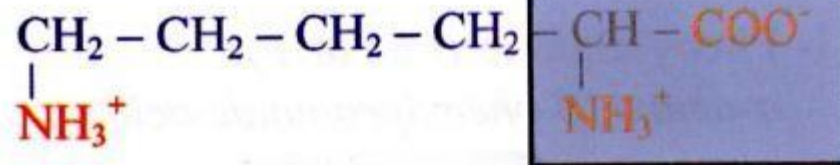
- Histidine, Arginine and Lysine are the only members of this group required for protein synthesis
- Ornithine is not found in proteins (non-proteinogenic) but is important in metabolism



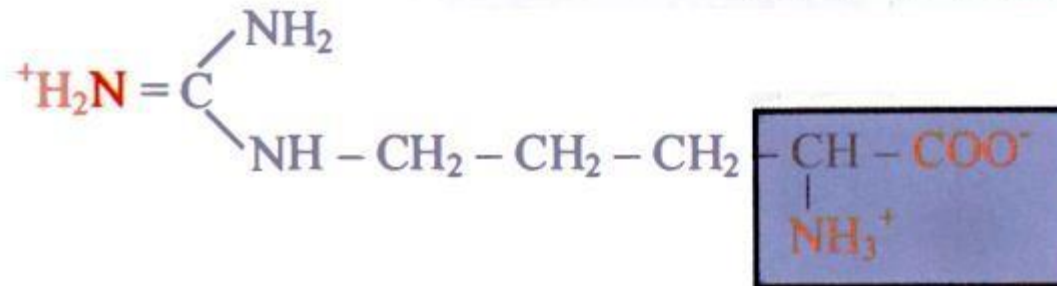
A- Basic Amino Acids (diamino-monocarboxylic acids)

They include the following:

1- Lysine and hydroxylysine



2- Arginine



3- Histidine



Nutritional Classification of Amino acids

- 20 amino acids are needed for protein synthesis
- 9 of these amino acids can not be synthesized in the body:
 - Phenylalanine
 - Valine
 - Threonine
 - Tryptophan
 - Methionine
 - leucine, isoleucine
 - Lysine
 - Histidine
- They should be supplied in the diet, and hence the name ESSENTIAL (Indispensable) AMINO ACIDS.
- Arginine is only essential for growing infants, but not for adults hence the name semiessential (10 essential amino acids for infants)
- Proteins that are rich in essential amino acids are known as proteins of high biological value

Essential Amino Acid Mnemonic

Private Tim Hall => PVT TIM HALL

P.V.T.

- P - Phenylalanine
- V - Valine
- T - Threonine

T.I.M.

- T - Tryptophan
- I - Isoleucine
- M - Methionine

H.A.L.L.

- H - Histidine
- A - Arginine*
- L - Leucine
- L - Lysine



* Only essential during (+)Nitrogen Balance

10 ESSENTIAL AMINO ACIDS

- 22
- ✓ Tryptophan
 - ✓ Threonine ✓ The
 - ✓ Histidine
 - ✓ Valine ✓ Val
 - ✓ Isoleucine ✓ Isole =
 - ✓ Phenylalanine ✓ Phe
 - ✓ Methionine ✓ Met
 - ✓ Arginine ✓ Arg
 - ✓ Lysine ✓ Lys
 - ✓ Leucine ✓ Leu

3

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- **NONESSENTIAL (Dispensable)AMINO ACIDS:**
- Nonessential means that our bodies produce an amino acid, even if we do not get it from the food we eat
- Nonessential amino acids include: alanine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, proline, serine, and tyrosine
- Proteins that are deficient in one or more of the essential amino acids are of low biological value, e.g. zein of maize (deficient in tryptophan).

Metabolic classification

- According to their metabolic fate, amino acids can be classified into 3 main groups:
 - **Pure glucogenic:** give glucose inside the body
 - include all amino acids except the members of the other two groups
 - **Pure ketogenic:** give ketone bodies inside the body
 - Include leucine and lysine
 - **Mixed glucogenic and ketogenic:** give both glucose and ketone bodies inside the body
 - include phenylalanine, tyrosine, tryptophan and isoleucine

Polarity and charge classification

- **AA with non-polar R groups:**
 - 1 -Glycine & 2-Alanine
 - 3-Valine
 - 4-Leucine and 5-Isoleucine
 - 6-Methionine and 7- Phenylalanine
 - 8-Tryptophan and 9-Proline
- **AA with uncharged polar groups:** These are more soluble in water than the first group
 - Their (R) groups contain neutral polar functional groups, which form hydrogen bonds with water, they include:
 - 1- Serine, threonine, tyrosine and hydroxyproline (contain hydroxyl group)
 - 2- Cysteine (contains SH group)
 - 3- Asparagine and glutamine (contain amide group)

➤ Amino acids having charged or ionic polar side chains:

- These are amino acids in which the R group carries a full charge due to:
 - **Ionization** of the acidic groups (aspartic and glutamic acids) → giving amino acids negative charges
 - **Protonation** of basic groups (arginine, lysine and histidine) giving amino acids positive charge

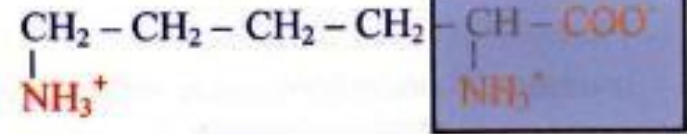
When amino acids are connected together to form peptides and proteins their carboxyl and amino groups lose their charges

III- Amino Acids with Charged (R) Groups:

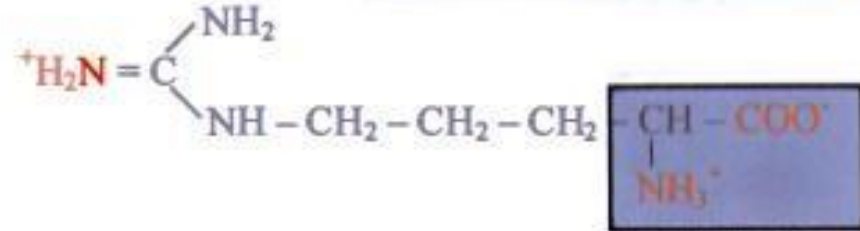
A- Basic Amino Acids (diamino-monocarboxylic acids)

They include the following:

1- Lysine and hydroxylysine



2- Arginine



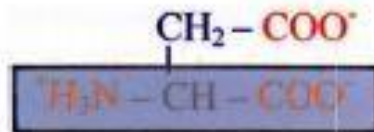
3- Histidine



B- Acidic Amino Acids (monoamino-dicarboxylic acids)

They include the following:

1- Aspartic acid



2- Glutamic acid

