

INDUCTION OF TOPIC

**Chief Constituents Of Food
OR
Enumerate Macro Nutrients**

Essential Food Nutrients



Carbohydrates



Proteins



Lipids

Body Constituents And Functional Biomolecules

Identify A Food Nutrient

Richly Associated

To Following Food Items



Ghee



Butter



Oil



Curds



Cheese



Milk



Chicken



Fish



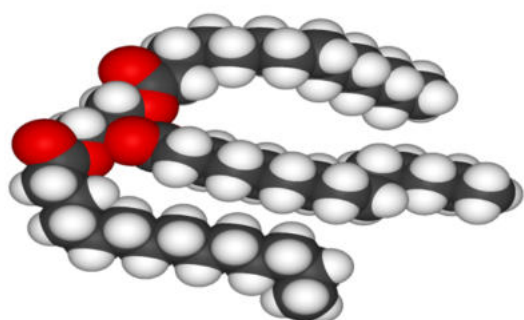
Eggs

Any Guesses Of Todays Topic???



LIPIDS

CHEMISTRY AND FUNCTIONS



SYNOPSIS/CONTENTS

- **WHAT ARE LIPIDS?**
- **DEFINITION OF LIPIDS**
- **CLASSIFICATION OF LIPIDS**
- **STUDY OF BIOMEDICALLY IMPORTANT LIPIDS wrt:**
 - **STRUCTURE**
 - **DISTRIBUTION**
 - **FUNCTIONS**
 - **PROPERTIES**
 - **RELATED DISORDERS**

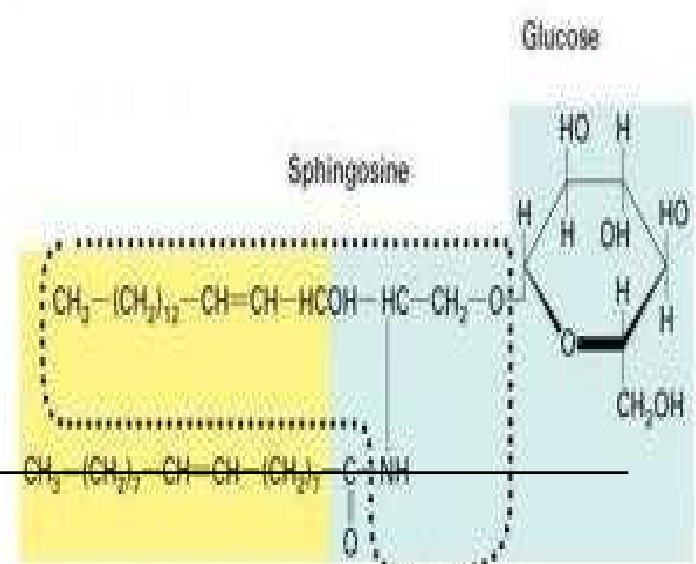
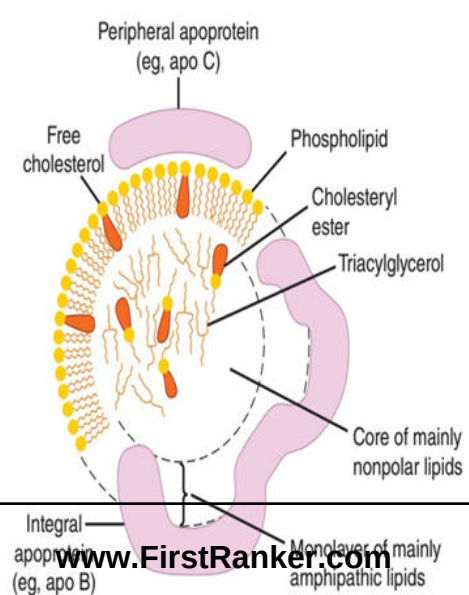
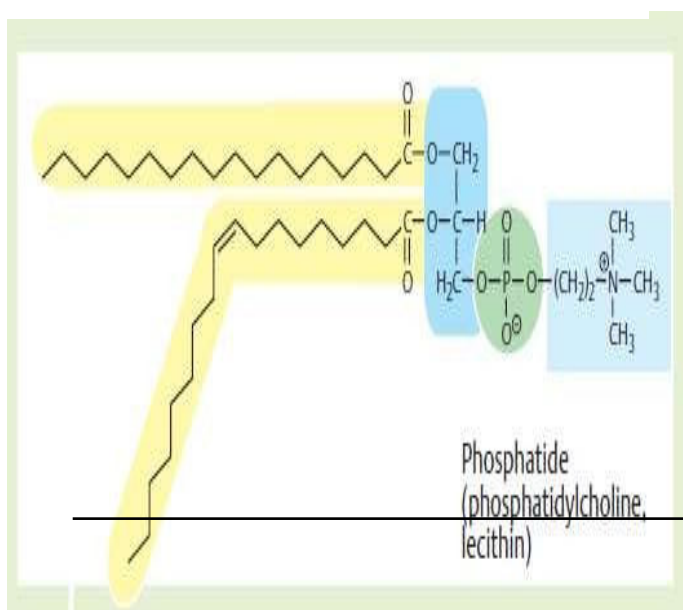
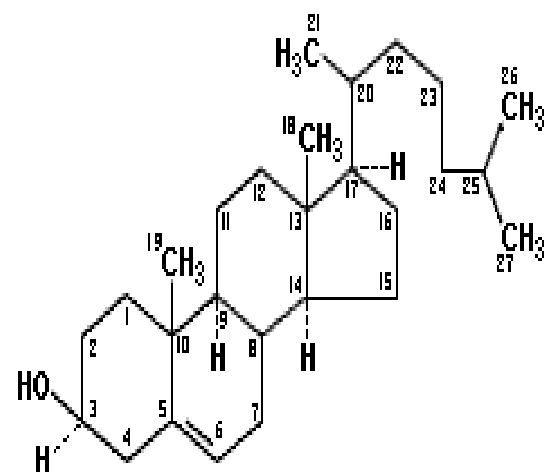
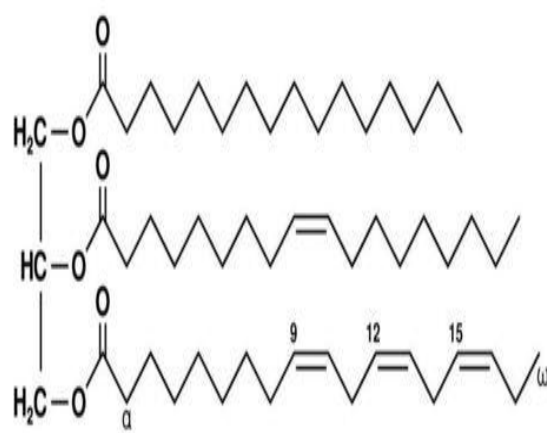
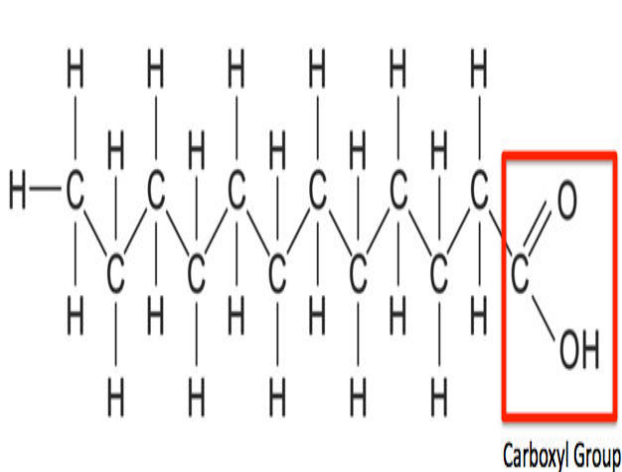
INTRODUCTION

WHAT ARE LIPIDS?

Pattern To Study Biomolecules

- Name of Biomolecule
- Class and Subclass
- Structural Features
- Sources
- Distribution in Body
- Functional aspects
- Interrelationships
- Derangements and Associated Disorders

Look At Structural Forms Of Lipids Depicts Its Features



- **Lipids are :**
- **Organic Biomolecules**
- **Occurs in Plants and Animals**
- **Food Constituents/Nutrients**
- **Chemically Esters - has Ester Bonds(-COO)**
- **Heterogeneous**
- **Hydrophobic**
- **Secondary Source of Energy**
- **Structural Components of Biomembranes**
- **Signaling and Nerve Impulse Transduction**

Names Of Various Lipids Associated To Human Body

Biomedically Important Lipids

1. Fatty Acids (**FAs**)
2. Triacylglycerol (**TAG**)
3. Phospholipids (**PL**)
4. Lipoproteins (**LP**)
5. Glycolipids
6. Cholesterol (**Free**)
7. Cholesterol-Ester (**Esterified**)

Important Features Of Lipids

Solubility Of Lipids

Solubility Of Lipids

Lipids are relatively Insoluble in Water/Polar Solvent

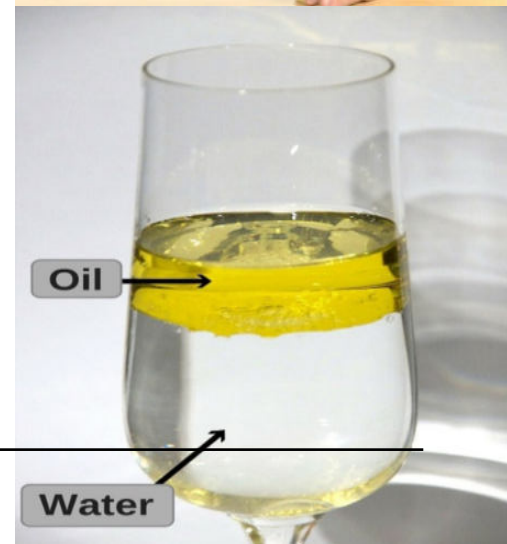
Since they have Uncharged/ Non polar and Hydrophobic groups in their structures

Lipids are soluble in Fat Solvents

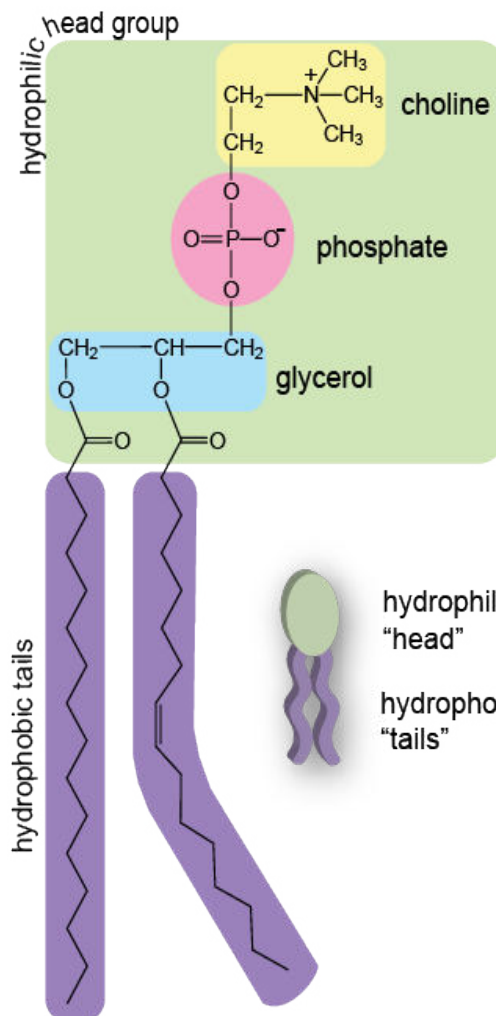
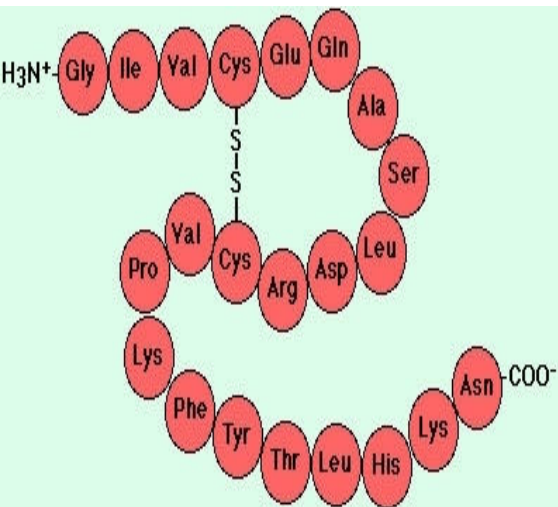
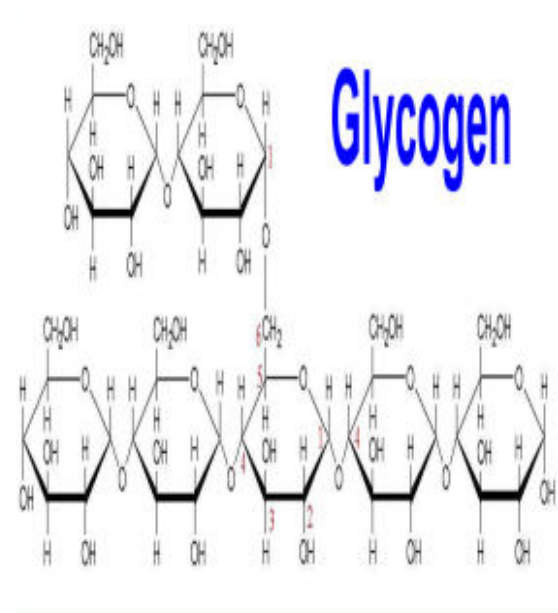
- Lipids are **readily soluble in**
- Non polar Organic solvents / Fat Solvents**
 - Acetone
 - Alcohol (Hot)
 - Benzene
 - Chloroform
 - Ether

Size And Density Of Lipids

- Lipids are biomolecules relatively :
 - Smaller in size**
 - Less dense**
 - (Buoyancy- Float in Water)**



Complex Lipid structures are not Bio-Polymers



- Unlike Complex Carbohydrates and Proteins

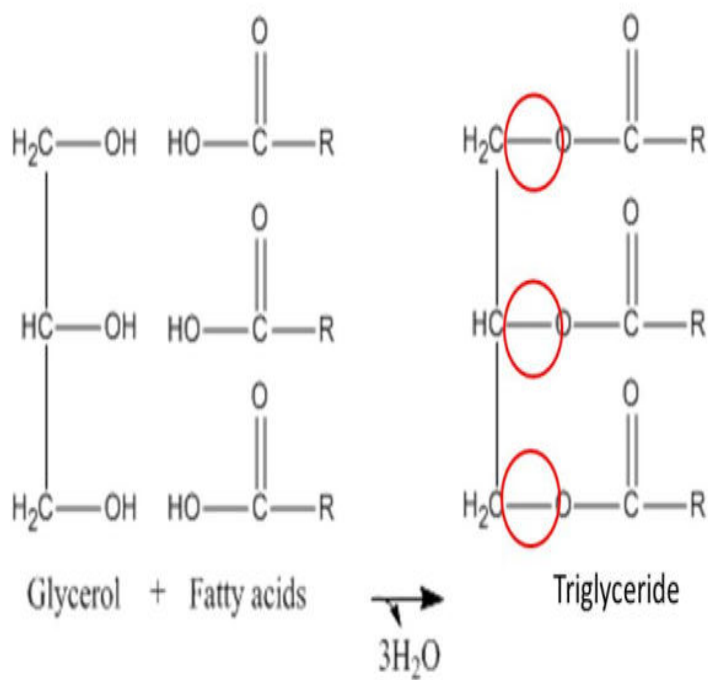
- Lipid structure contains **no repeatedly linked Monomeric units**

Chemical Nature Of Lipids

Chemically Lipids are Esters

- Most Lipids are Esters of **Fatty acids(-COOH)** with **Alcohol (-OH)**

Ester Bonds



- Lipids are relatively or potentially **associated with Fatty acids.**

DEFINITION OF LIPIDS

Bloor's Definition Of Lipids

- Lipids are **Organic, Heterogeneous Hydrophobic Biomolecules**
- Relatively insoluble in water** and **soluble in organic solvents.**
- Chemically **Esters of Fatty acids with Alcohol.**
- Utilized by body to produce energy (ATP)**

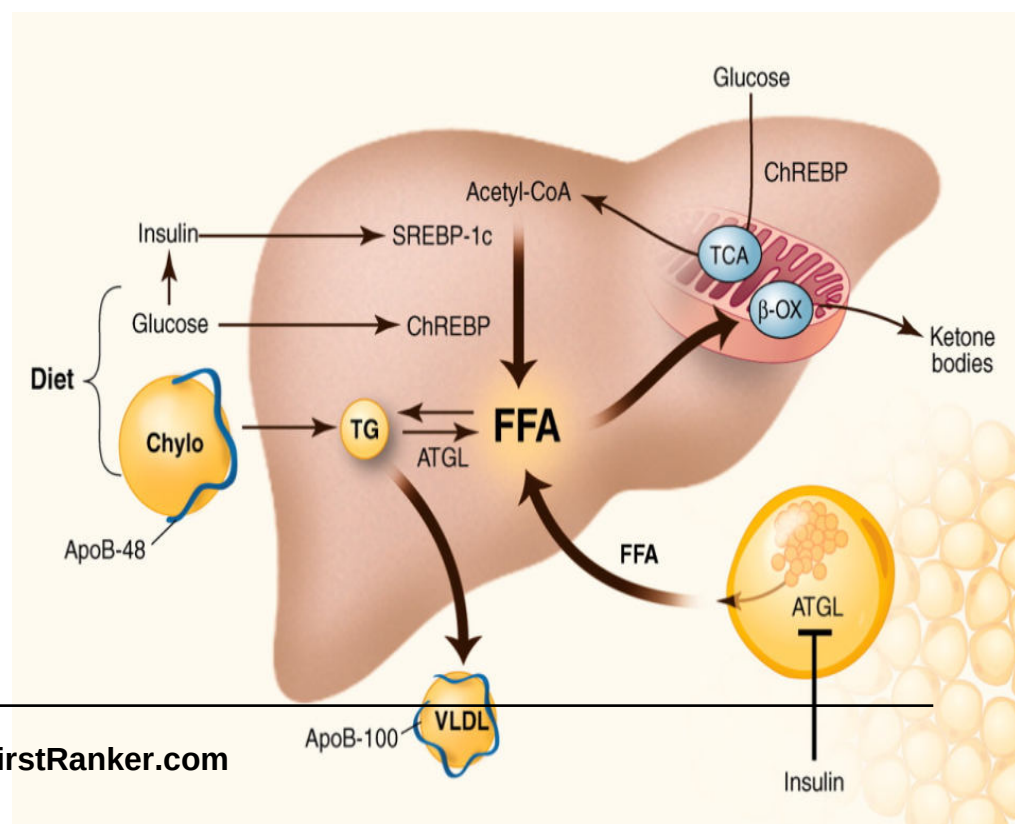
Sources Of Lipids To Human Body

- Exogenous Sources**
 - Ingestion Dietary

Healthy High-Fat Foods

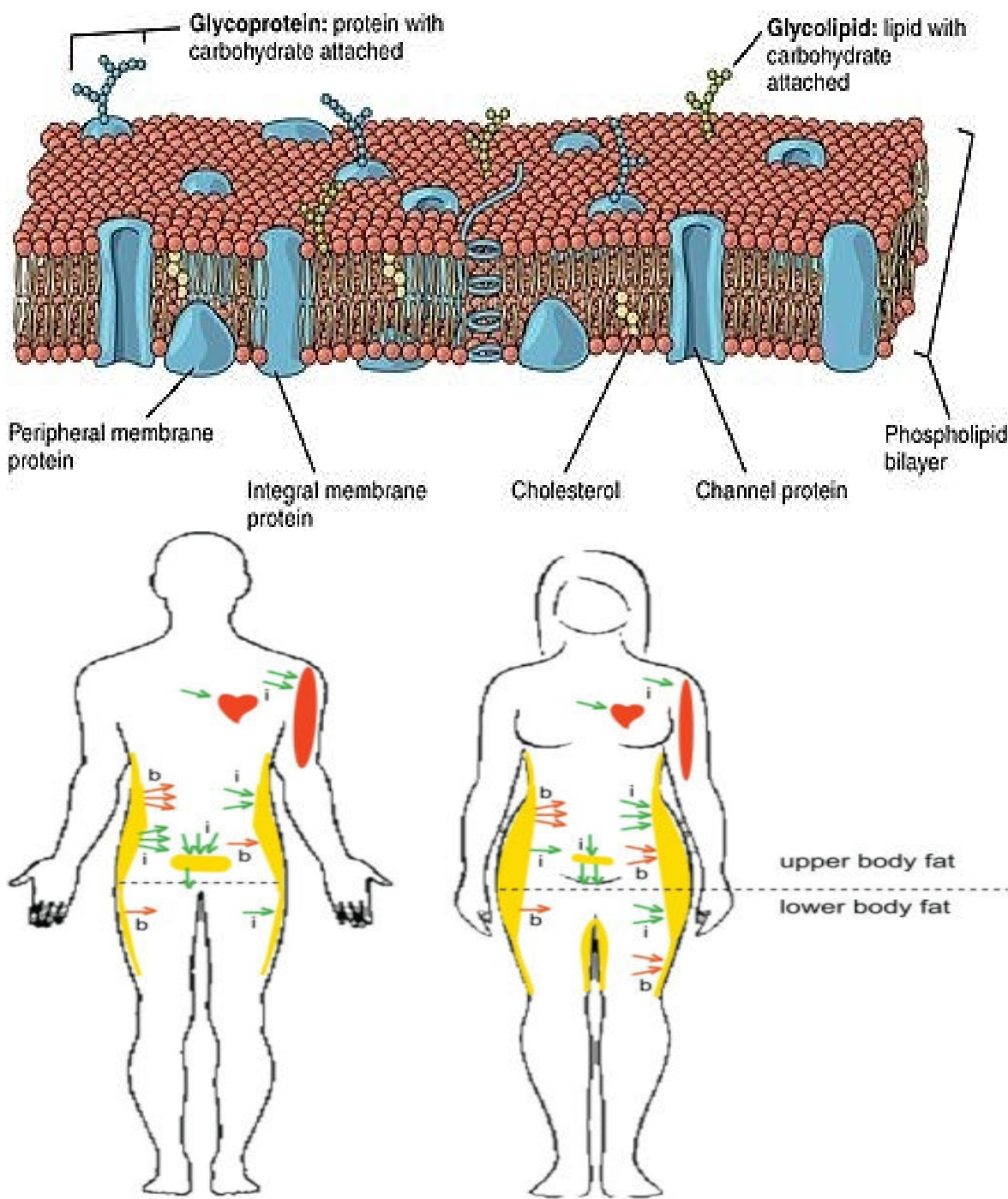


- Endogenous Sources**
 - Biosynthesis In Liver
 - Intestine



Occurrence /Distribution Of Lipids In Human Body

- Bio Membranes
- Depot Fat
- Nervous System – Brain
- Subcutaneous Layer of Skin
- Padding of Internal Soft Organs



Biological Functions Of Lipids

Calorific, Membrane Structural, Signaling

S.No	Lipid Form	Biochemical Role
1	Triacylglycerol	Predominant Lipid form of Diet Calorific Value Reservoir of Energy for long term Insulator and Mechanical Shock absorber

2	Fatty acids	FAs Stored as TAG Oxidize to generate ATP Components of Phospholipids & Glycolipids
---	-------------	--

3	Phospholipids	Components of Biomembranes Lung Surfactant Clotting Mechanism
---	---------------	--

S.No	Lipid Form	Biochemical Role
------	------------	------------------

4	Glycolipids	Components of Biomembranes Neurons, Myelin Sheaths
---	-------------	---

5	Cholesterol	Components of Biomembranes Nerve Impulse conduction Precursors of Steroids
---	-------------	--

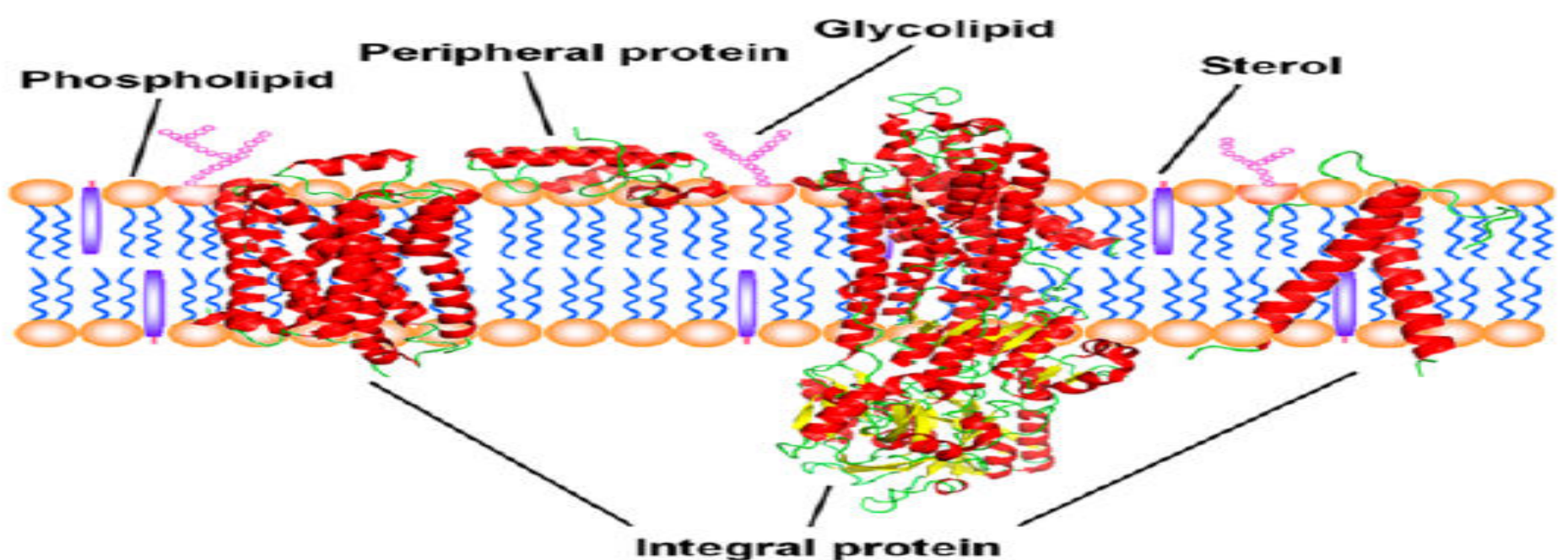
6	Cholesterol Ester	Transport ,Storage and excretory form of Cholesterol
---	-------------------	--

7	Lipoproteins	Vehicles for transportation of various forms of Lipids through aqueous phase of blood and lymph
---	--------------	---

- Lipids of **dietary and Calorific value**
 - Triacylglycerol
 - Fatty acids

Structural Role Of Lipids

Lipids Associated To Biomembranes



1. Phospholipid bilayer
2. Glycosphingolipids
3. Cholesterol

Lipids

Superior Than

Carbohydrates

Lipids are Superior Than Carbohydrates

- **Lipids have Higher Calorific value (9Kcal/gm)**
 - **High storage content** , can be stored in unlimited amount.
 - **They provide energy source for longer duration.**
- (During Marathon Races)**

- Thus Lipids serve as **major reservoir of energy** for long term use in human beings.

Classification Of Lipids

With Examples of Biomedically Important Lipids

Lipids are Classified Into Three Main Classes

- **Three Main Classes of Lipids are:**

- i. Simple Lipids**

- ii. Compound /Complex Lipids**

- iii. Derived Lipids**

1. Simple Lipids/Neutral Lipids

- Chemically Simple Lipids are:
- **Esters of Fatty acids with an Alcohol**

Sub Classes Of Simple Lipids **Based On Alcohol**

Neutral fats or Oils

Alcohol is
GLYCEROL

Waxes

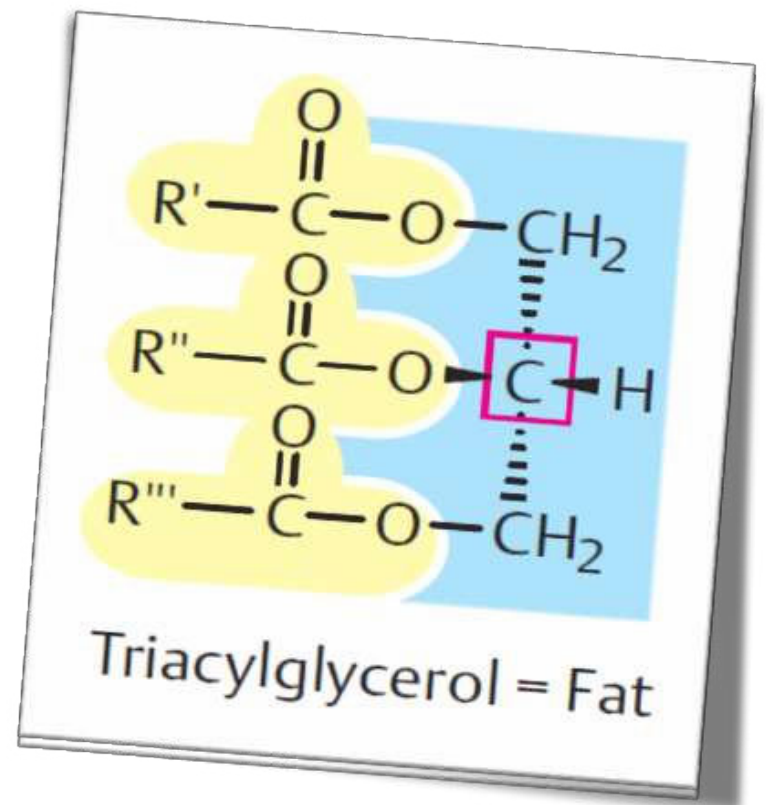
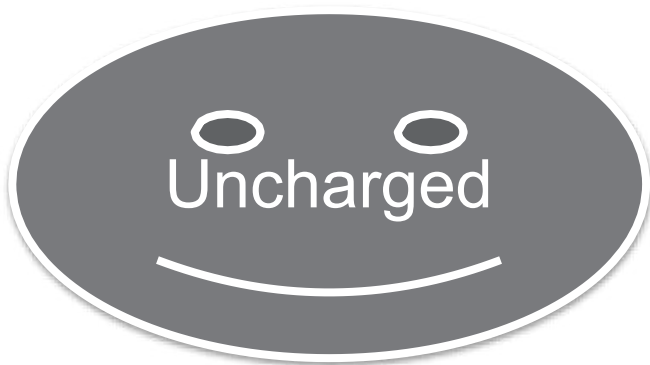
Alcohol other
than glycerol

- Depending upon the type of Alcohol :
- Simple Lipids are of two sub types:
 - Fats/Oils - Triacylglycerol
(Alcohol is Glycerol)
 - Waxes
(Alcohol- Cholesterol/ Retinol)

Chemical name of Fat /Oil
IS
Triacylglycerol (TAG)

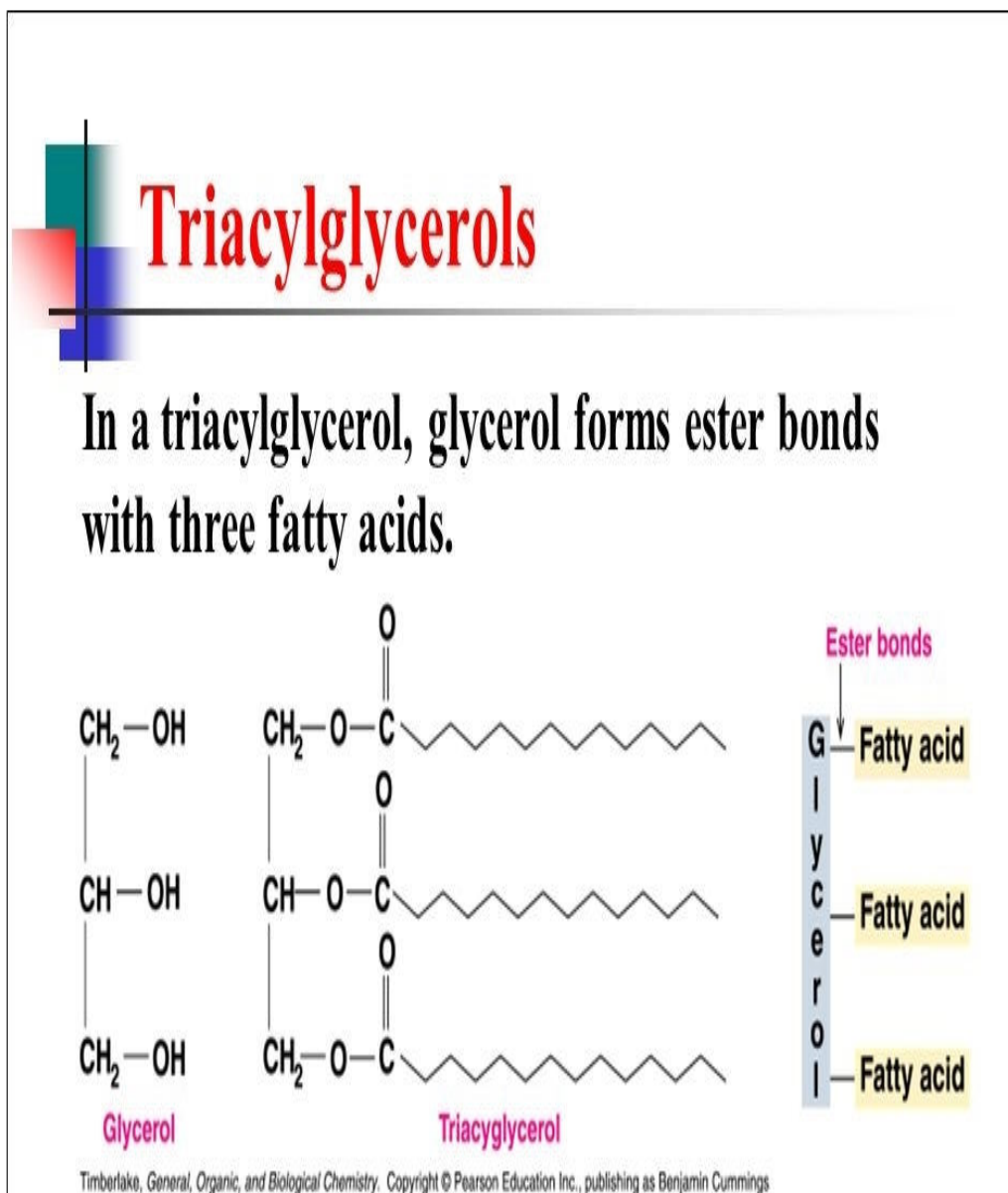
TAG- Simple Lipid /Neutral Lipid/ FATS or OILS

Esters of FA with the alcohol GLYCEROL



• Fats/Oils/TAG

- Esters of Fatty acids with **Glycerol** (Trihydric Alcohol)
- Three Fatty acids linked to a Glycerol by ester bonds.

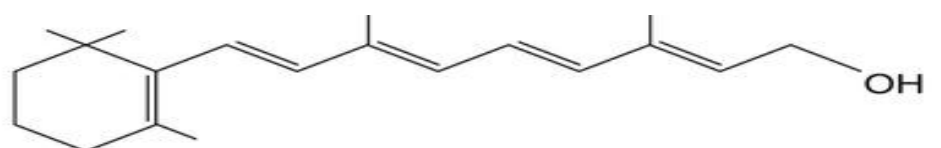
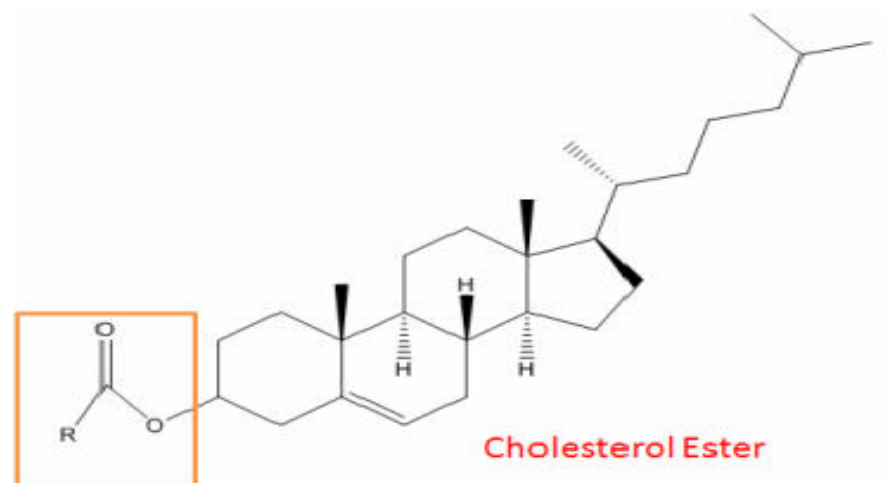


• Waxes :

- Waxes are Simple Lipids
- Waxes are **chemically Esters of Fatty acids** with **higher complex, monohydric ,Alcohols**, other than Glycerol.

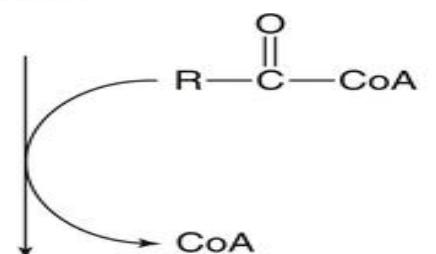
Examples Of Human Body Waxes :

- Cholesterol Ester
(**Cholesteryl Palmitate**)



Retinol

- Retinol Ester
(**Retinyl Palmitate**)



Compound/Complex Lipids

- Compound Lipids is a class of Lipids
- Chemically composed of **Fatty acids Alcohol** and an **Additional group**.

**Depending upon the
Type of Additional group**

Types of Compound Lipids are:

Three Main Compound Lipids

- 1. Phospholipids
- 2. Glycolipids
- 3. Lipoproteins

S. No	Type of Compound Lipids	Additional group Present
1	Phospholipids	Phosphoric acid and Nitrogen Base
2	Glycolipids	Carbohydrate moieties
3	Lipoproteins	Apoproteins

Types Of Phospholipids **Based On Alcohol**

» **Glycerophospholipids**
(Contains –Glycerol)

» **Sphingophospholipids**
(Contains –Sphingol)

Types Of Glycolipids/Glycosphingolipids

» **Cerebrosides**

» **Gangliosides**

» **Globosides**

» **Sulfatides**

• **All Has Alcohol Sphingol/Sphingosine**

Lipoproteins

Aggregation of Lipids and Apoproteins

- Chylomicrons
- Very Low Density Lipoprotein (VLDL)
- Low Density Lipoprotein (LDL)
- High Density Lipoprotein (HDL)

Derived Lipids

- Derived Lipids are **Hydrolytic products of Simple or Compound Lipids OR their derivatives.**

OR

- Hydrolytic products released from **Simple and Compound Lipids**, who has **potency to form them.**

Examples of Derived Lipids:

Hydrolytic Products of Simple and Compound Lipids

❖ Fatty Acids

❖ Alcohols:

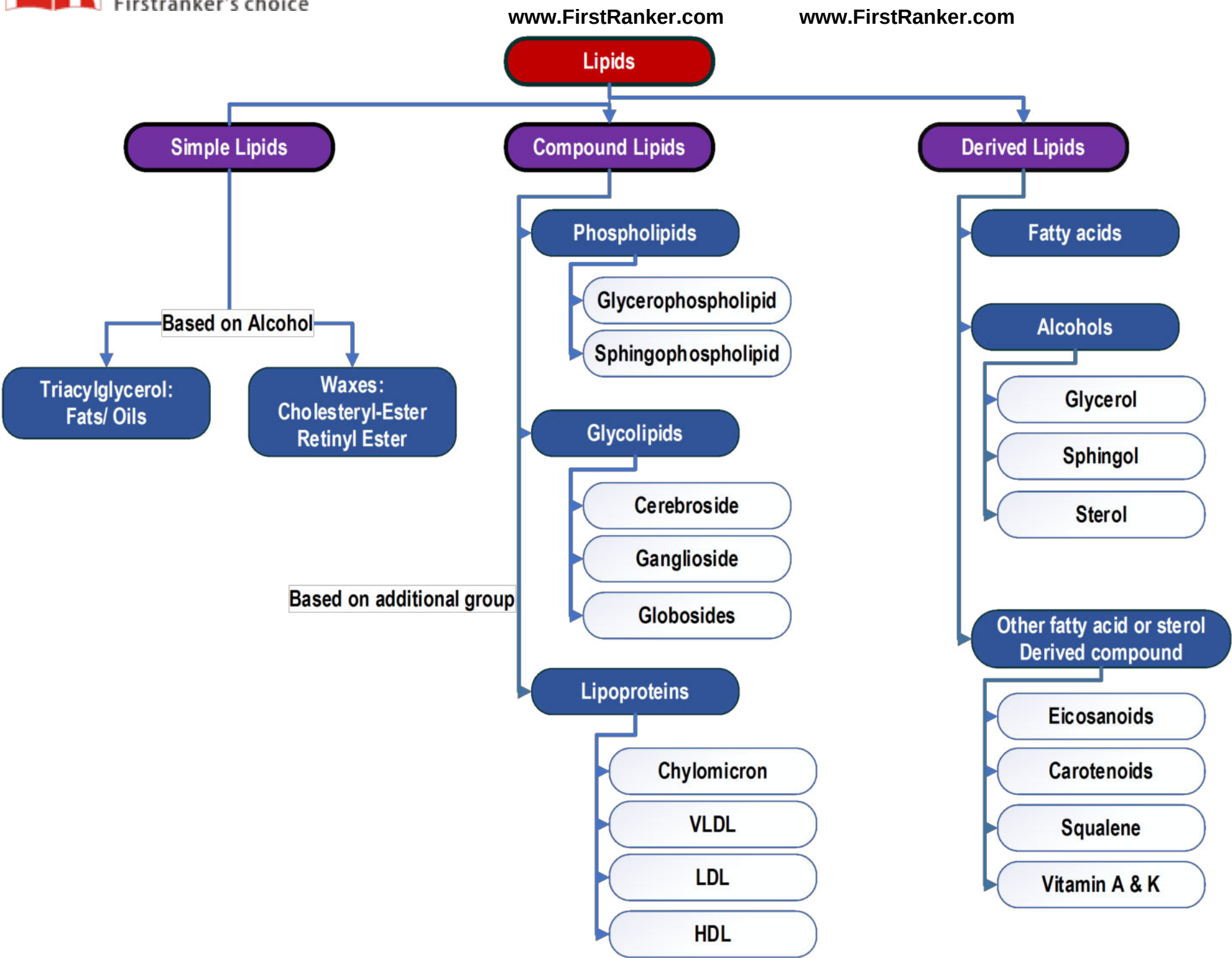
—Glycerol

—Sphingol

—Cholesterol

Other Examples Of Derived Lipids

- Lipid like compounds
- Derived from Fatty acids and Sterol/Cholesterol:
 - Eicosanoids (Prostaglandins , Leukotrienes ,Thromboxanes)
 - Steroidal Hormones: Derived from Cholesterol
 - Fat Soluble Vitamins (A,D,E and K)
 - Ketone Bodies (Partial Oxidized Products of Fatty acids)



Bloor's Classification Of Lipids

- **Four Classes of Lipids By Bloor**

A. Simple Lipids

B. Complex/Compound Lipids

C. Derived Lipids

D. Miscellaneous Lipids

D. Miscellaneous Lipids

Substances with Lipid characters

— Carotenoids: **β -Carotenoid**

- Squalene :
- Vitamin E and K
- Eicosanoids

Types of Lipids Depending Upon Polarity

- **Neutral Lipids: (Non Polar Lipids)**

(Contain No polar Groups/Charged groups)

» Triacylglycerol

» Cholesterol Ester (Cholesterol Palmitate)

- **Amphipathic/Amphiphilic Lipids:**

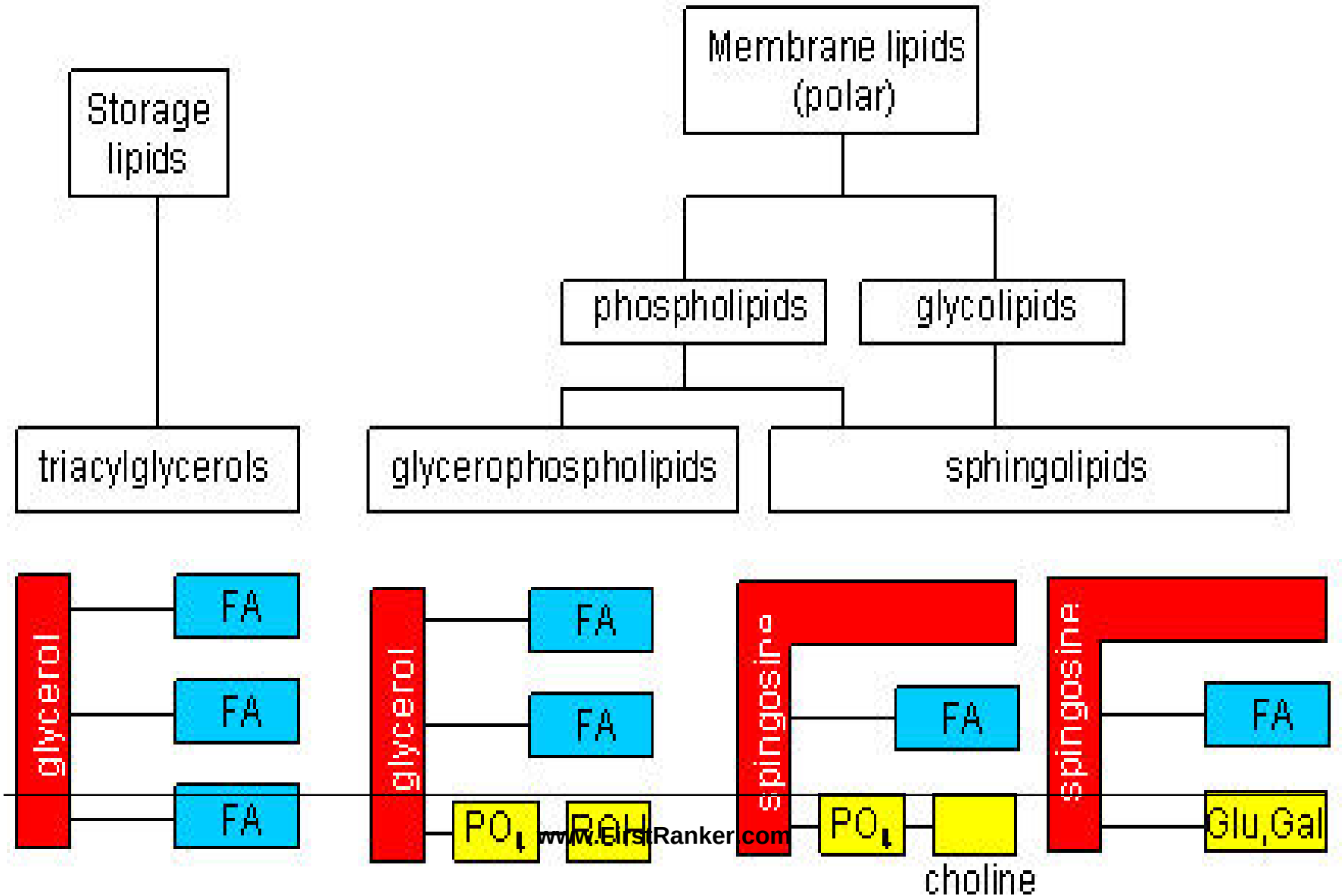
(Contain both Polar and Non polar Groups)

- Phospholipids

- Cholesterol

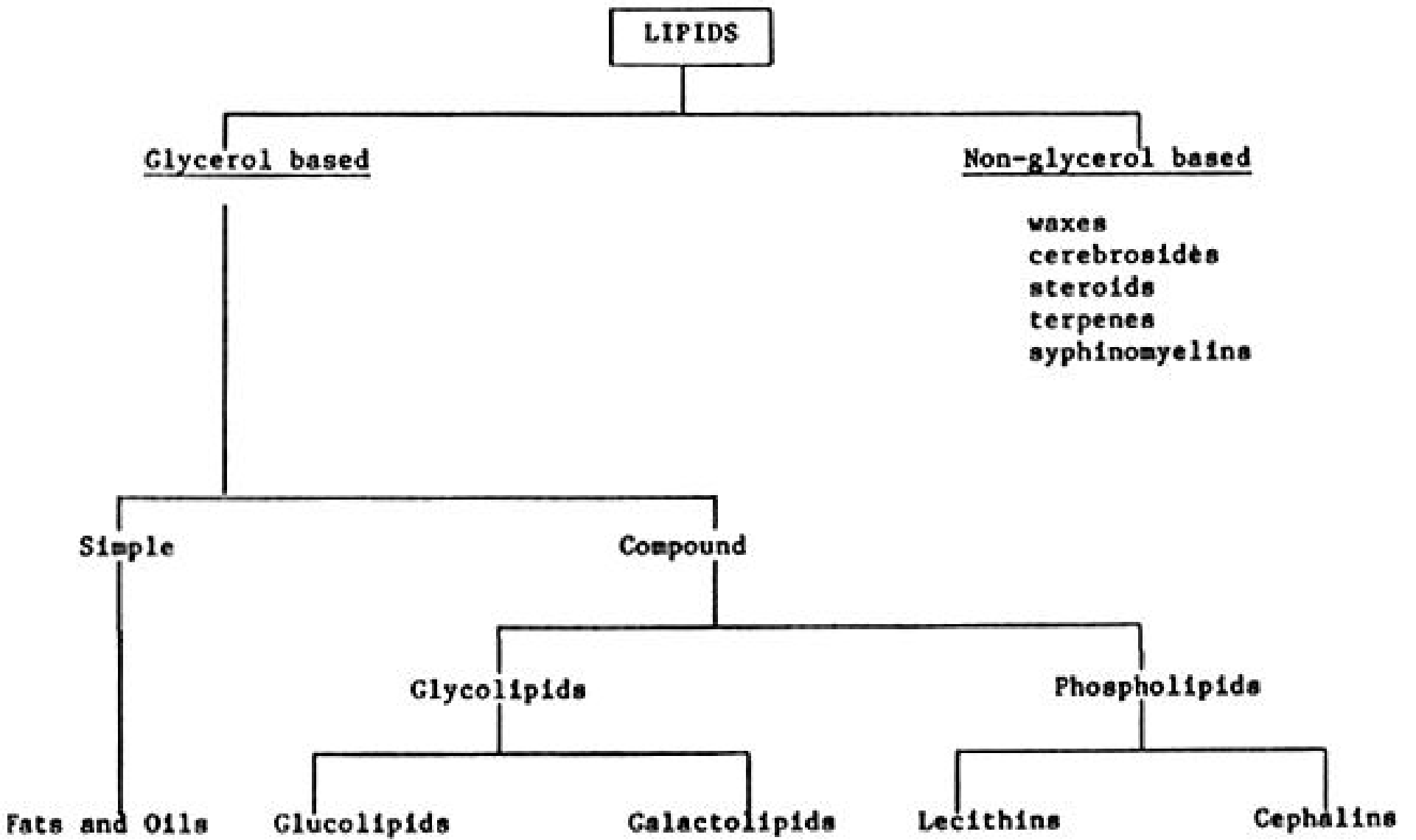
Types of Lipids

Depending Upon Functions

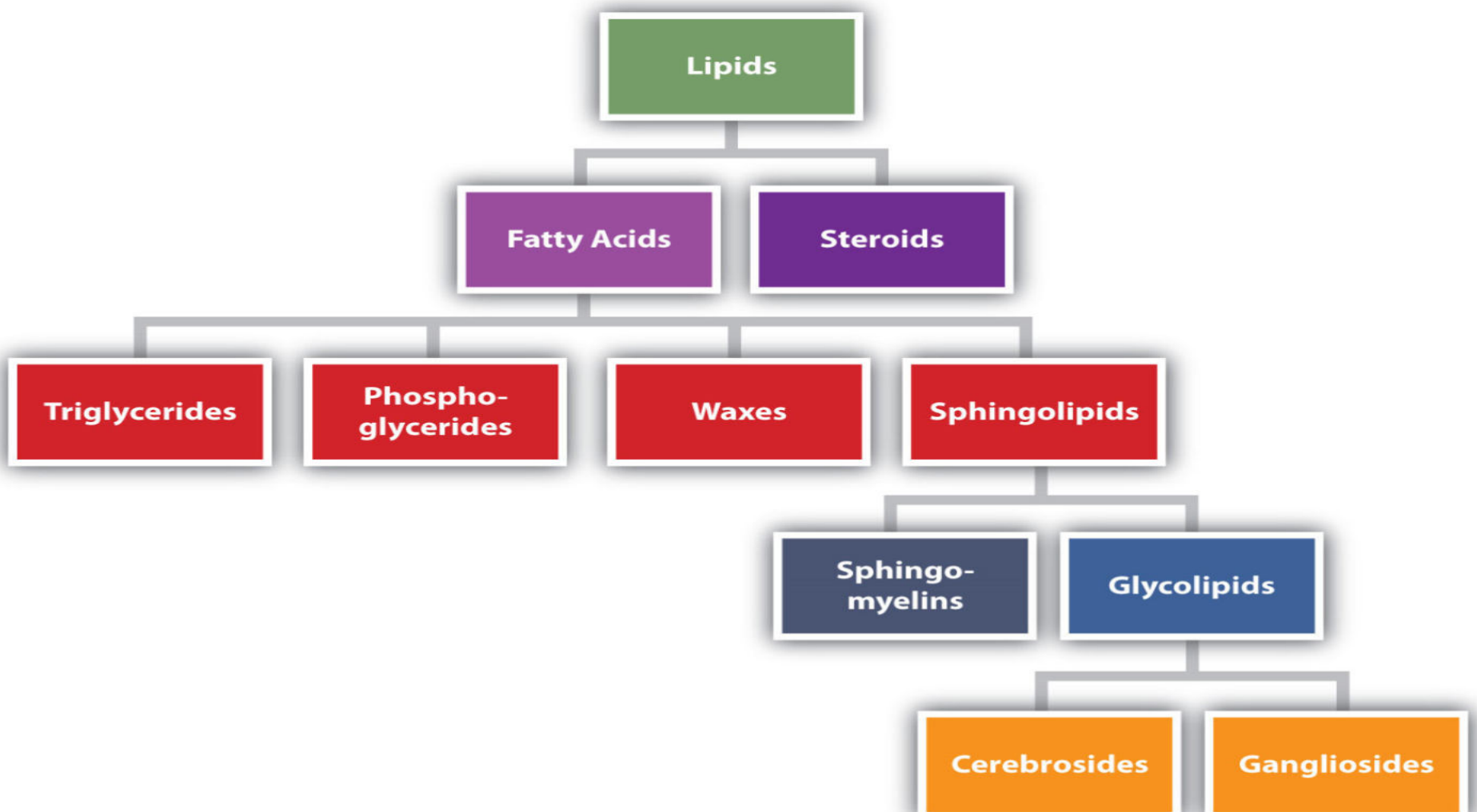


Types Of Lipids

Based On Alcohol



Types Of Lipids Based Upon the Main Components

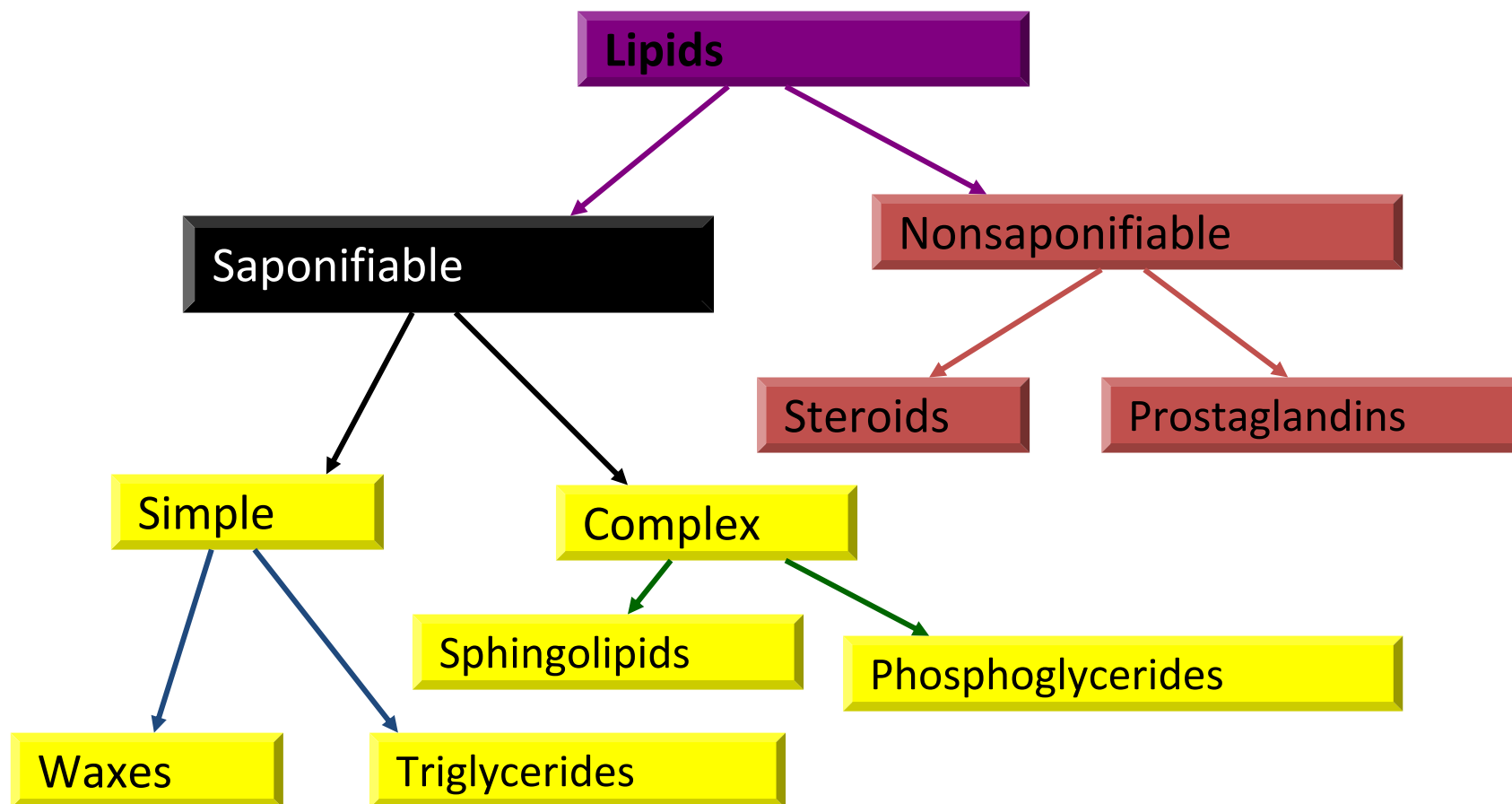


Types of Lipids Depending On Saponification Property

Saponifiable Lipids Undergo Alkaline Hydrolysis

- A **saponifiable lipid** is one who undergo Saponification reaction.
- **Saponification** is especially an **Alkaline hydrolysis of Ester bond of Fat or an Oil to form Soap.**
- In saponification an **Ester functional group** get **hydrolyzed** in presence of **Alkaline conditions (NaOH)** producing a **free alcohol and fatty acid salt (Soap)**

Lipid Based On Saponification



Study Of Various Classes Of Lipids

Study Of Derived Lipids

Study Of Fatty Acids

FATTY ACIDS(FAs)

Class- Derived Lipids

BASIC COMPONENT OF LIPID FORMS

What are Fatty Acids?

Fatty Acids Are Derived Lipids

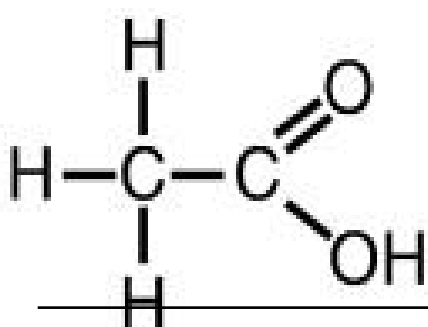
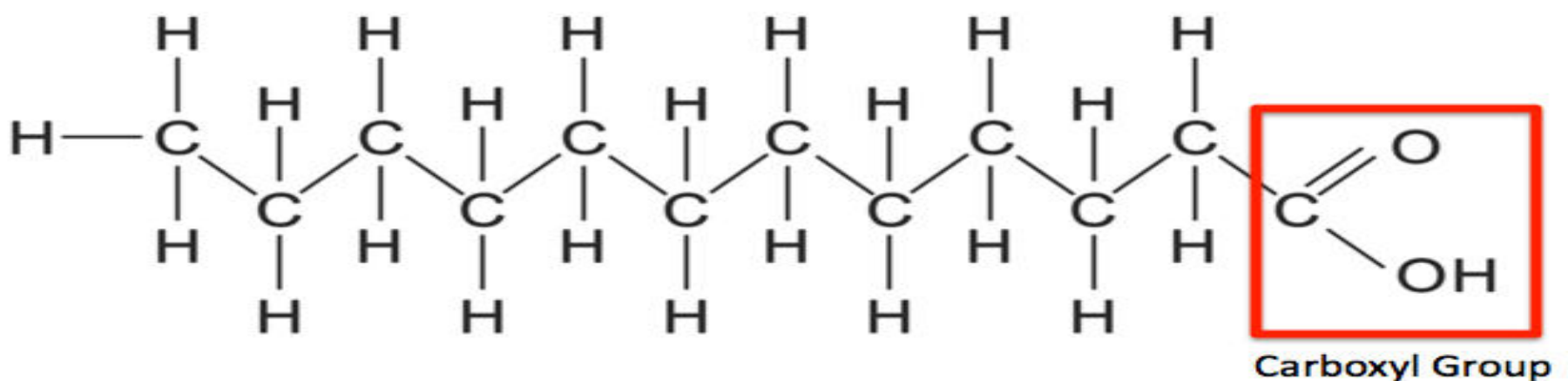
- Fatty acids are of Class **Derived Lipids**:
 - Since Fatty acids are **Hydrolytic products of Simple and Compound Lipids**.

Fatty Acids (FA)

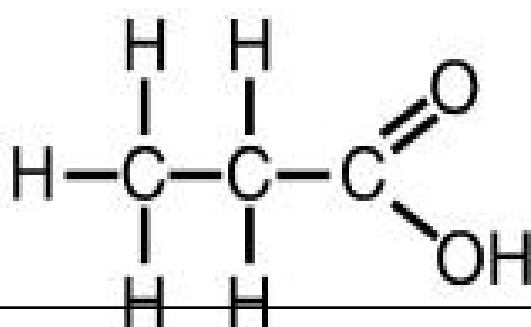
- Fatty Acids (FA) are relatively or potentially **related to various Lipid structures**.
 - Simple Lipids
 - Compound Lipids
 - Derivatives of Lipids

Structure And Chemical Nature Of Fatty Acids

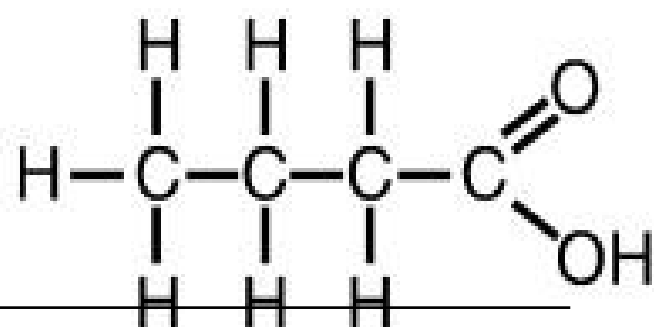
Chemical Structure Of Fatty Acids



Acetic acid



Propionic acid



Butyric acid

Fatty acid Structures Has Varied Hydrocarbon Chains

- The Hydrocarbon chain of each Fatty acid is of varying chain length (C2 - C26).

Human Body Fatty Acid From C2-C26

S.No	Fatty Acid Name	Fatty Acid Structure has Carbon atoms
1	Acetic Acid	C2
2	Propionic Acid	C3
3	Butyric Acid	C4
4	Valeric Acid	C5
5	Palmitic	C16
6	Stearic	C18
7	Oleic	C18

S.No	Fatty Acid Name	Fatty Acid Structure
8	Linoleic Acid	C18
9	Arachidic Acid	C20
10	Arachidonic Acid	C20
11	Behenic acid	C22
12	Lignoceric acid	C24
13	Cerotic acid	C26

- **Fatty acid** structure have **two ends**:
 - Carboxylic group(-COOH) at one end (**Delta end denoted as Δ /Alpha end α**)
 - Methyl group (-CH3) at another end (**Omega end denoted as ω**)

CCCCCCCCCCCCCCCC(=O)O

Methyl **PALMITIC ACID** Carboxyl
 Oil-Soluble 16 carbons Water-Soluble
 OMEGA (Ω) END DELTA (Δ) END

CCCCCCCCCCCCCCCCCCCC(=O)O

Methyl **STEARIC ACID** Carboxyl
 Oil-Soluble 18 carbons Water-Soluble
 OMEGA (Ω) END DELTA (Δ) END

Definition of Fatty acids

Fatty Acids are Defined as:

- Fatty acids are chemically **Organic acids**
- With **Aliphatic Hydrocarbon chain (of varying length C2 to C26)** with **Mono terminal Carboxylic acid group** as functional group.

Different Forms Of Fatty acids In Body

Free Fatty acid /Unesterified Fatty acid

- Fatty acid who **has free Carboxylic group**
- Fatty acid not reacted and linked to an Alcohol by an Ester bond.

Esterified Fatty acid/Bound form of Fatty Acid

- Fatty acid **has no free Carboxylic group**
- Fatty acid is linked to an Alcohol with an **Ester bond.**

Classification of Fatty acids

Biomedically Important Fatty Acids

Based On Six Different Modes:

- **Classification of FAs Based on Six Modes:**

- 1. Total number of Carbon atoms in a Fatty acid structure**
- 2. Hydrocarbon chain length of Fatty acid**
- 3. Bonds present in Fatty acid**
- 4. Nutritional requirement of Fatty acid**
- 5. Chemical Nature and Structure of Fatty acids**
- 6. Geometric Isomerism of UFA's**

Fatty acids Based on Total Number of Carbon atoms

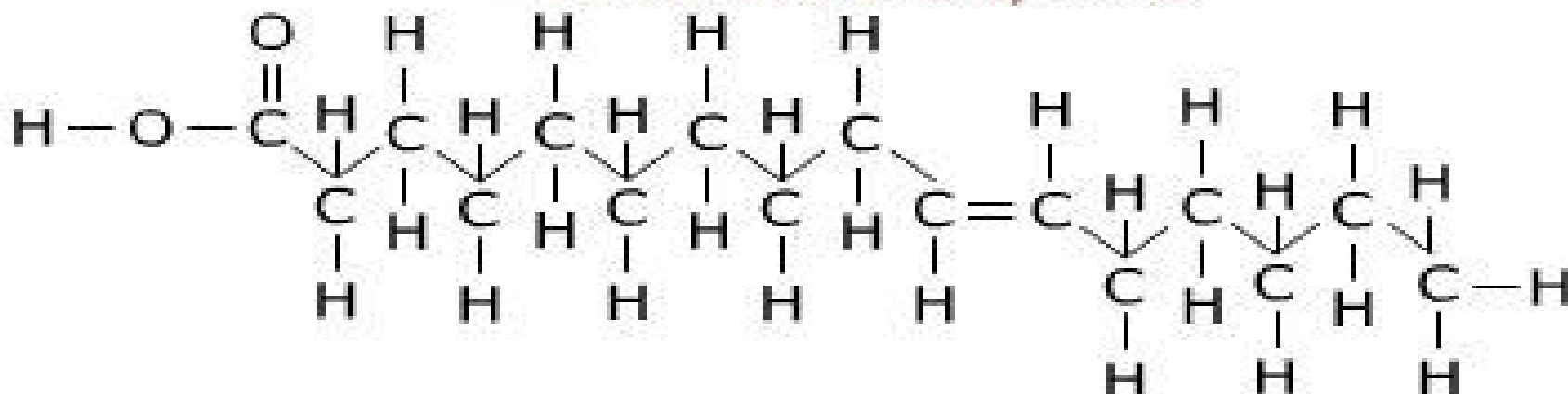
- **Even numbered Carbon** Atom Fatty acids (2,4,6,8,16,18,20 etc)
- **Odd numbered Carbon** Atom Fatty acids (3,5,7,---)

- Most **naturally occurring /human body** Fatty acids are **even carbon numbered FAs**.
- Since **biosynthesis of Fatty acids uses 2 Carbon units Acetyl-CoA (C2)**.
- **Examples of Even Carbon Numbered Fatty acids:**
 - Butyric Acid (C4)
 - Palmitic Acid (C16)
 - Stearic Acid (C18)
 - Oleic Acid (C18) **(Most Common)**
 - Linoleic acid (C18)
 - Linolenic Acid (C18)
 - Arachidic acid (C20)
 - Arachidonic acid (C20)

- Odd Carbon numbered Fatty acids are **less related to human body**
- Example of Odd carbon Fatty acid associated to human body
 - Propionic Acid (3C)

**Fatty acids Based on
Nature and Number of Bonds present**

Saturated Fatty Acids



Saturated

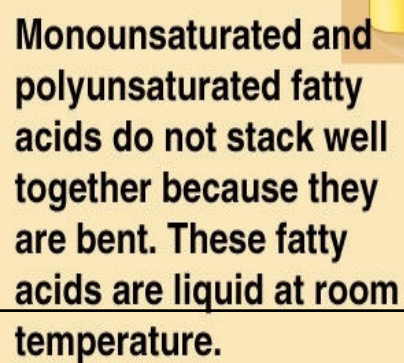


Double bonds

Long-chain saturated fatty acids stack well together to make solid forms at room temperature.



(b)



(c)

- **Saturated Fatty acids(SFAs)**

- Fatty acids having **single bonds** in hydrocarbon chain structure.
- **Examples:**
 - Acetic acid (C2)
 - Butyric acid (C4)
 - Palmitic acid (C16)
 - Stearic acid (C18)
 - Arachidic acid(C20)

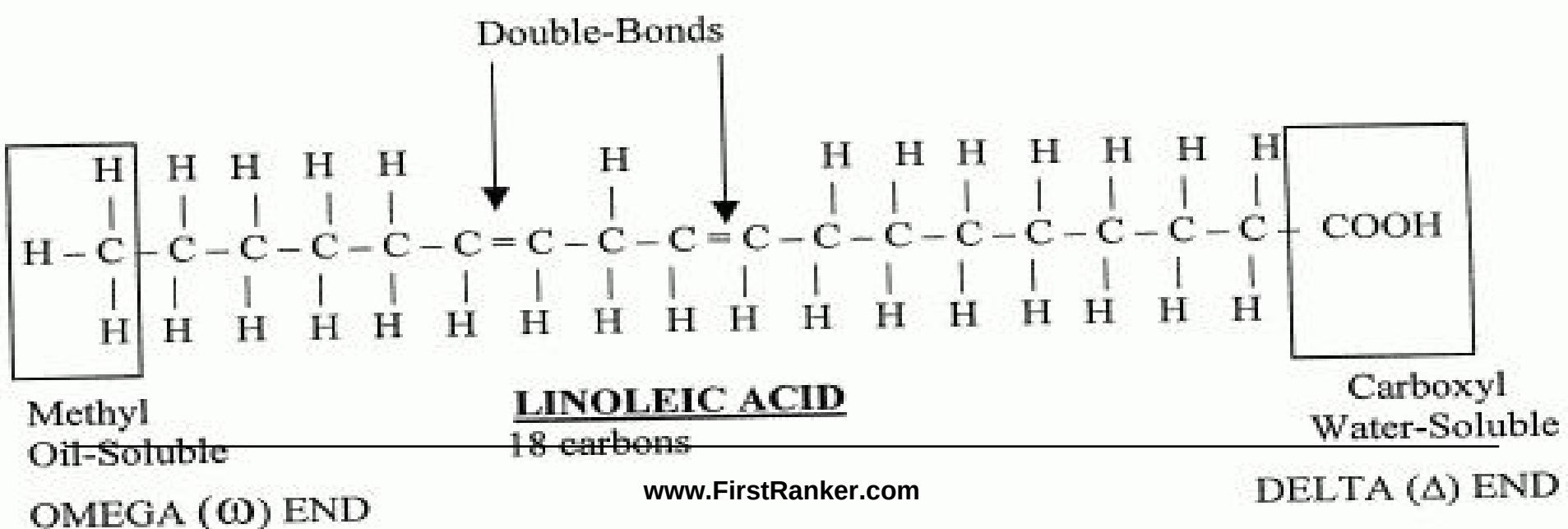
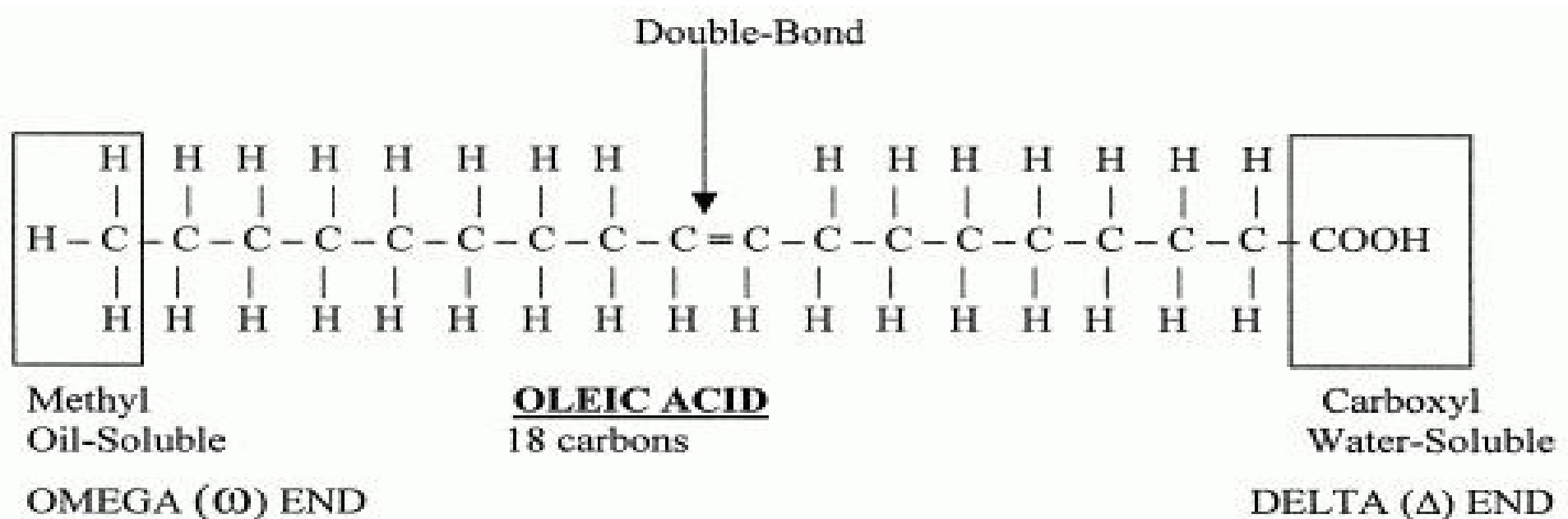
- **Unsaturated Fatty acids (UFAs)**

- Fatty acids having **double bonds** in its structure.

- **Types of UFAs:**

- **Monounsaturated Fatty acids (MUFAs)**
- **Polyunsaturated Fatty acids (PUFAs)**

- Human body have **no Enzyme system to introduce double bond beyond Carbon atom 10** in the hydrocarbon chain.
- Hence **PUFAs are not biosynthesized** in human beings.



- **Monounsaturated Fatty Acids(MUFAs):**

- MUFAs have **one double bond** in a fatty acid structure
- Examples of MUFAs :
 - **Palmitoleic acid (C16:1;9) (ω 7)**
 - **Oleic acid (C18:1;9)(ω 9)**
 - **Erucic acid (C22:1;9)(ω 9)**

- **Poly Unsaturated Fatty Acids (PUFAs):**

- UFAs with **two or more double bonds in** the structure are termed as **PUFAs**.
 - Examples Of PUFAS:
- **Linoleic(18:2;9,12) (ω 6)**
- **Linolenic(18:3;9,12,15) (ω 3)**
- **Arachidonic(20:4;5,8,11,14) (ω 6)**
- **Timnodonic (20:5;5,8,11,14,17) (ω 3)**
- **Cervonic/Docosa Hexaenoic acid(DHA)(22:6;4,7,10,13,16,19) (ω 3)**

- **Remember Unsaturated Fatty acids**

- **Double bonds are:**

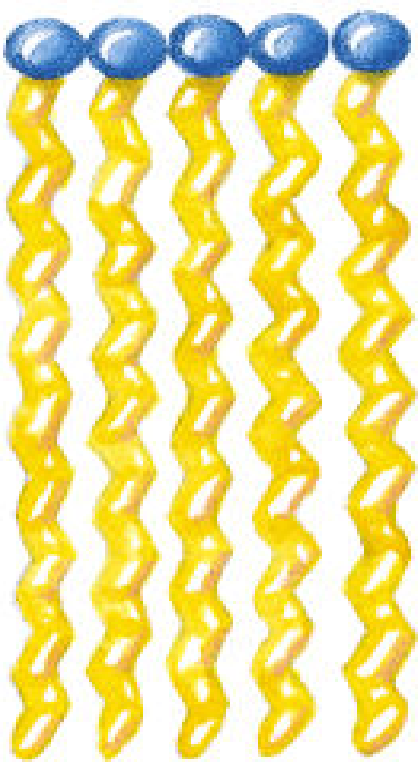
- **Weaker /unstable bonds.**

- **Get easily cleavable/metabolized**

- **More the degree of Unsaturation in Fatty acids.**

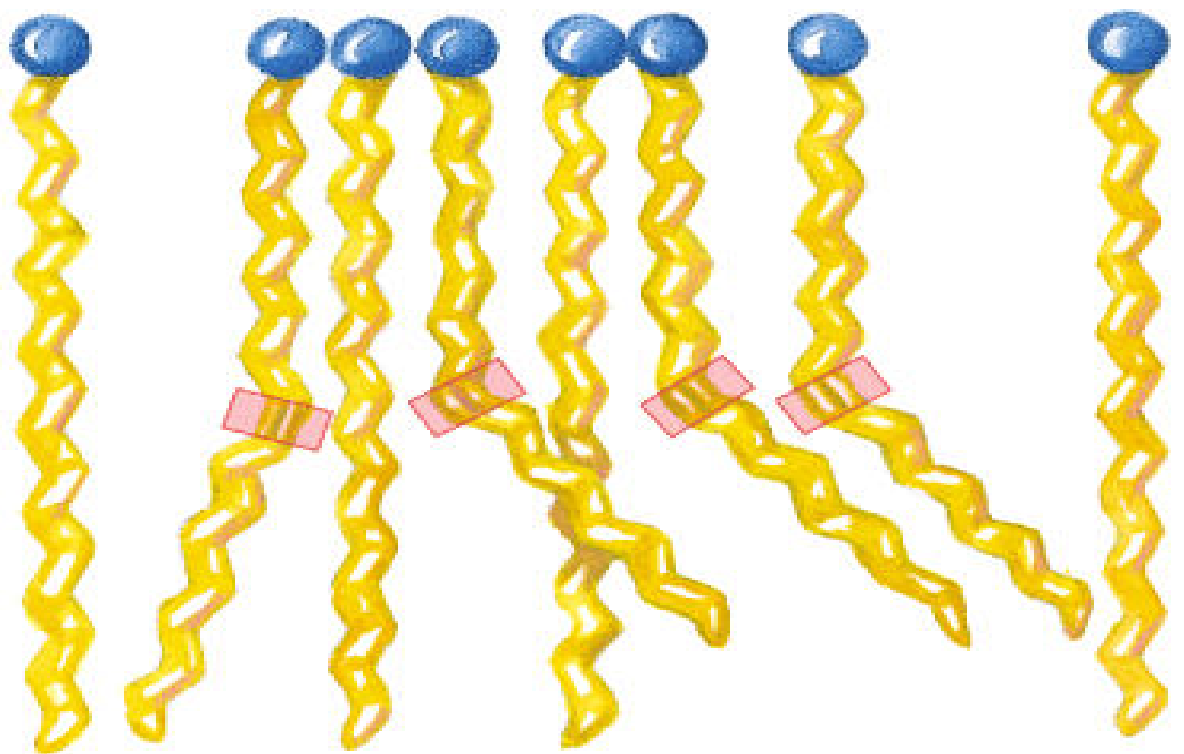
- **More is the instability** of Fatty acids.

- Saturated Fatty acids structures are **Straight**.
- Unsaturated Fatty acids structures are **bent** (Kink).



Saturated fatty acids

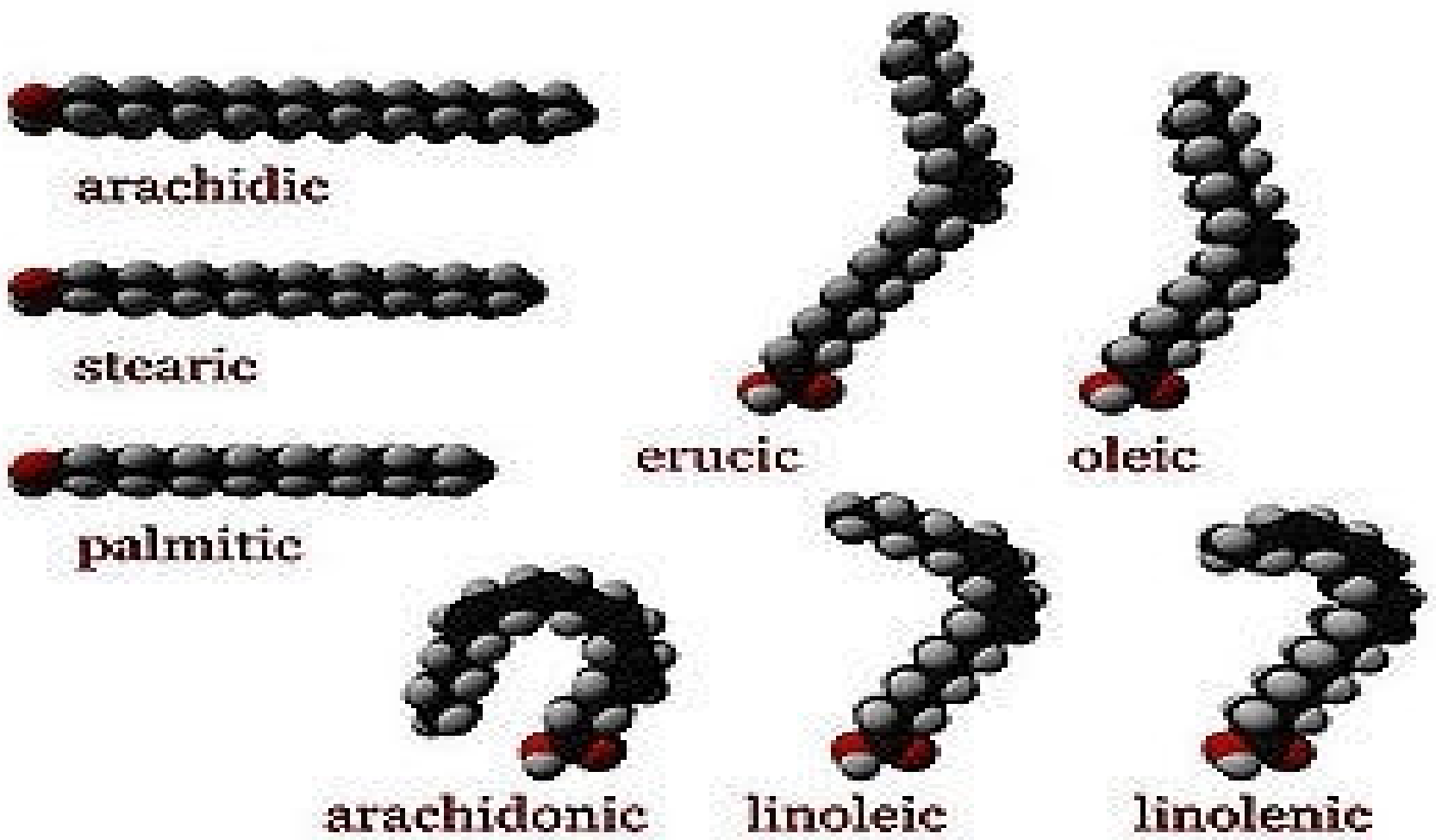
(c)



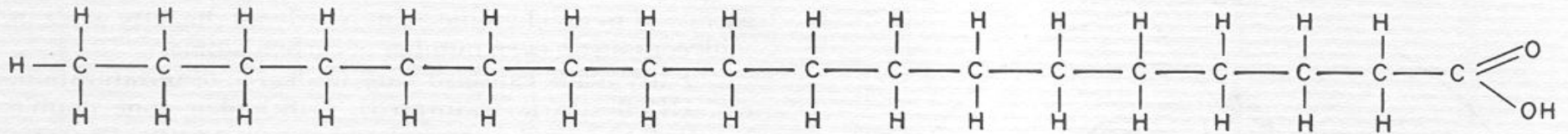
Mixture of saturated and unsaturated fatty acids

(d)

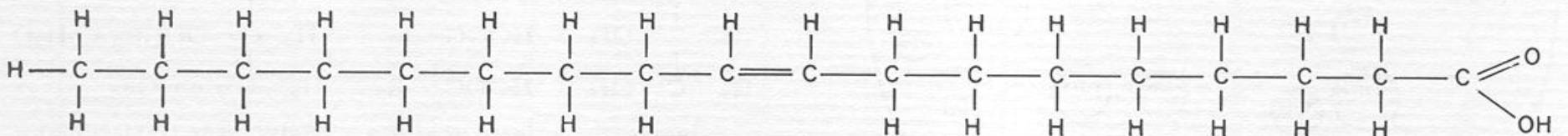
- www.FirstRanker.com**



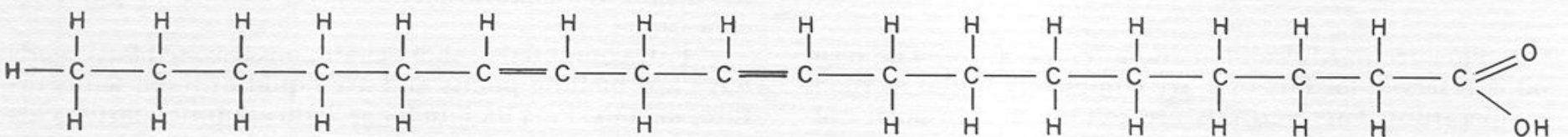
Stearic acid C18:0



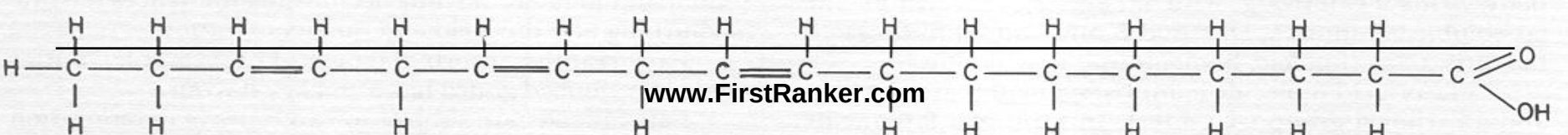
Oleic acid C18:1



Linoleic acid C18:2

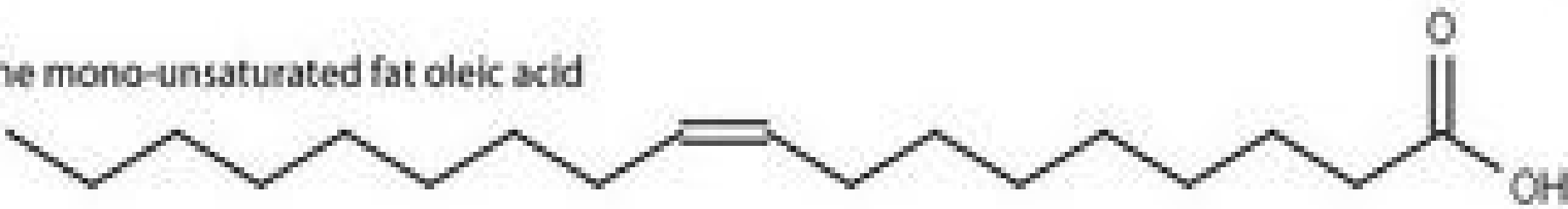


Linolenic acid C18:3



A

The mono-unsaturated fat oleic acid

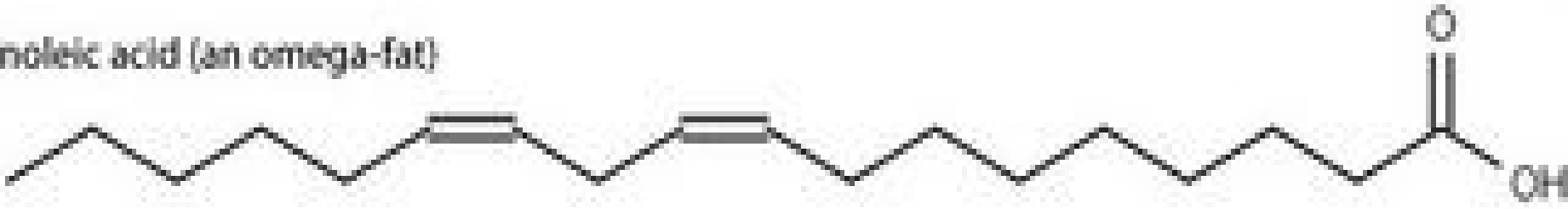


An 18 carbon saturated fatty acid-stearic acid

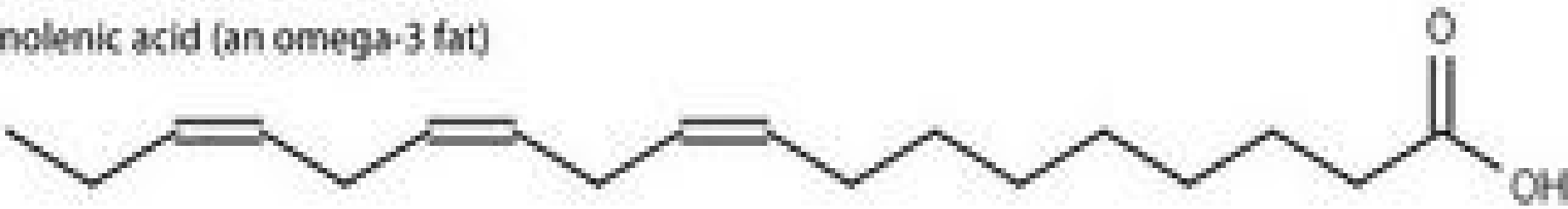


B

Linoleic acid (an omega-fat)



Linolenic acid (an omega-3 fat)



Fatty acids Based on the Nutritional Requirement

Nutritionally Essential Fatty acids

- Nutritionally Essential Fatty acids:
- Fatty acids **not biosynthesized in human body and indispensable through** nutrition/diet are termed as Essential Fatty acids.
- PUFAS are nutritionally essential Fatty acids.**

Examples of Essential Fatty Acids/PUFAs:

- Linoleic**
- Linolenic**
- Arachidonic acids**
- Timnodonic and**
- Cervonic**

Nutritionally Non Essential Fatty acids

- **Nutritionally Non essential Fatty acids:**
- Fatty acids which are **biosynthesized in the body** and are nutritionally non essential Fatty acids.
 - Saturated Fatty acids and MUFAs are non essential Fatty acids.

Examples Of Non Essential Fatty Acids

- **Palmitic**
- **Stearic**
- **Oleic acid**

Based on Geometric Isomerism of Unsaturated Fatty acids

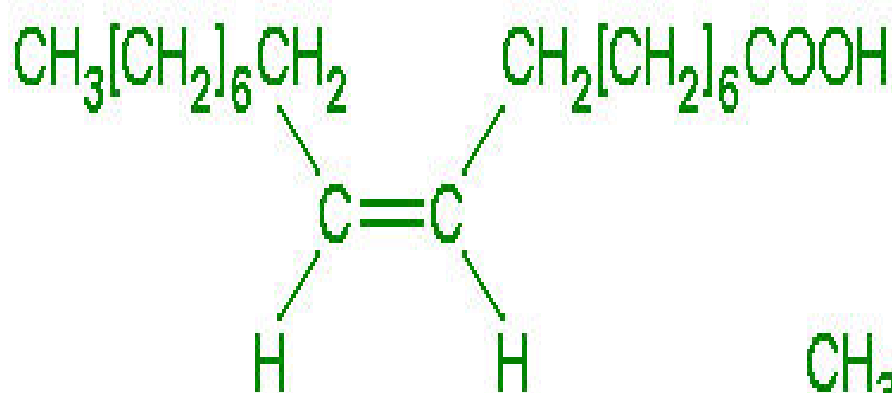
- **Cis Fatty Acids:**

The **Groups around double bond** of Unsaturated FAs are on **same side**.

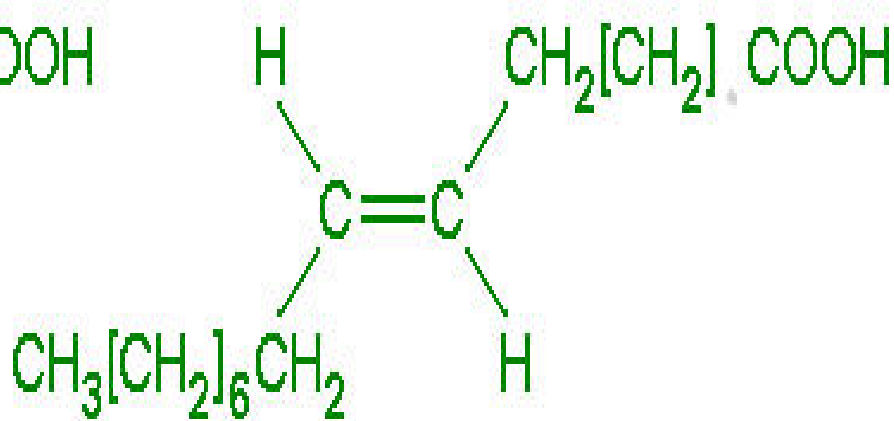
- **Examples:**
 - **Cis Oleic acid (rich in Olive oil)**
 - **Palmitoleic acid**

• Trans Fatty Acids :

- The groups around double bond of UFAs are on **opposite side**
- Example :
 - Elaidic acid /Trans Oleic acid (Hydrogenated Fats)



Oleic acid



Elaidic acid

Types Of Fatty acids Based on Hydrocarbon chain length

- **Short Chain Fatty acids (2-6 Hydrocarbon Chain length)**
- **Examples:**
 - Acetic acid (C2)
 - Propionic acid (C3)
 - Butyric acid (C4)
 - Valeric acid (C5)
 - Caproic acid (C6)

- **Medium Chain Fatty acids (8-14 Carbon length)**

- **Examples:**

- Caprylic acid (C8)
- Capric acid (C10)
- Lauric acid (C12)
- Myristic acid (C14)

- **Long Chain Fatty acids (16-20 Carbon length)**

- **Examples:**

- Palmitic acid (C16)
- Palmitoleic acid (C16)
- Stearic acid (C18)
- Oleic acid (C18)
- Linoleic acid (C18)
- Linolenic acid (C18)
- Arichidic acid (C20)
- Arachidonic acid /ETA(C20)
- Timnodonic acid/EPA (C20)

- **Very Long Chain Fatty Acids (C22 onwards)**
 - **Examples:**
 - Behenic acid/**Docosanoic** (C22)
 - Erucic acid/**Docosa 13 Enoic** (C22)
 - Clupanodonic/Docosapentaenoic acid (DPA) (C22)
 - **Cervonic acid/DocosaHexaenoic (DHA) (C22)**
 - Lignoceric acid /Tetracosanoic (C24)
 - **Nervonic /Tetracosanoic (C24)**
 - Cerotic acid/**Hexacosanoic** (C26)

Fatty acids Based on Chemical Nature and Structure

– Aliphatic Fatty acids:

Straight Hydrocarbon chain

- Examples:

- Palmitic acid (C16)

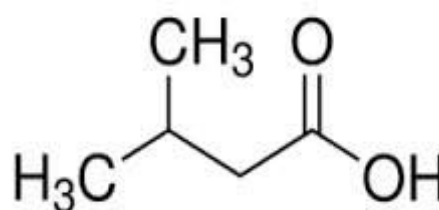
- Stearic acid (C18)

- **Branched Chain Fatty acids:**

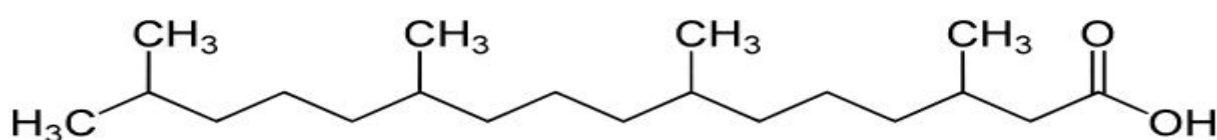
- Possess Branched chains

- Examples:

- Isovaleric (C5)



- Phytanic acid (Butter , dairy products)

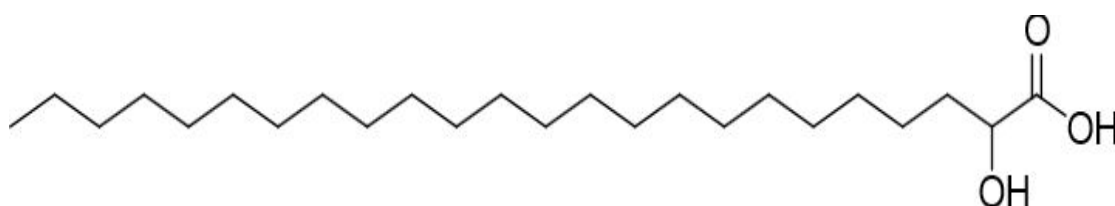


- **Cyclic Fatty acids :**
- Contains Ring structure
- **Examples:**
 - **Chaulmoogric acid**
(Used for Leprosy treatment in olden days)
 - **Hydnocarpic acid**

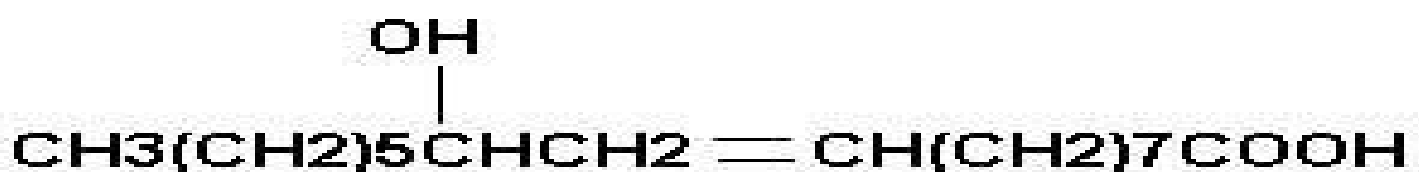


- **Hydroxy Fatty acids:**
- **Contain Hydroxyl Groups**

- **Examples:**
 - **Cerebronic acid (C24)/**
2-HydroxyTetracosanoic acid



- **Ricinoleic acid(C18) (Castor oil)**



RICINOLEIC ACID

Naming And Numbering Of Fatty Acids

- Every Fatty acids has a:
 - **Common Name**
 - **Systematic Name**

- Most of the Fatty acids are known by their **common names**. (Since easy to use)
- **Systematic names** of Fatty acids are **limited in use**. (Since not easy to use)

Remember

- **Long chain Fatty acids** are also termed as **Acyl chains**.

- ❖ The systematic names of **Saturated Fatty acids** are named by adding suffix 'anoic'.
- ❖ Example : Palmitic acid- C16/ **Hexadecanoic acid**

- The systematic names of **Unsaturated Fatty acids** are named by **suffix 'enoic'**.
- **Example:** Oleic acid- C18/ Octadeca**enoic** acid

S.N	Common Name	Systematic Name
1	Palmitic Acid	Hexadecanoic Acid
2	Stearic Acid	Octadecanoic Acid
3	Oleic acid	Octadecaenoic acid
4	Linoleic Acid	Octadecadienoic acid
5	Linolenic Acid	Octadecatrienoic acid
6	Arachidonic acid	Eicosatetraenoic acid

Numbering Of Fatty Acids

- **Numbering of Carbon atoms of Fatty acids is done from :**

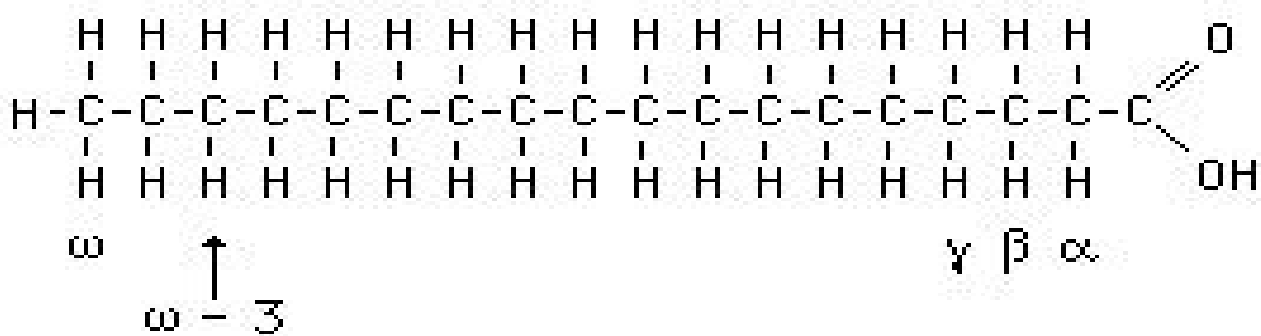
—Both ends of Fatty acids—

- Δ end/ α end
- ω end

Numbering Of Fatty acid From Carboxyl/ Δ end (α end)

- From **Carboxyl Group end(Δ end) :**
- Carboxylic acid group of Fatty acid is numbered as C1
- C2 is next adjacent Carbon atom ,
- C3 and so onn.....

- **α Carbon atom** is next to the functional group COOH of a Fatty acid.
- **Next to α Carbon is $\beta, \gamma, \delta, \epsilon$ and so on.**



Use of Greek letters to designate carbons

- Carbon atoms from Methyl(CH_3) group /non polar end(ω) of a fatty acid are numbered as **$\omega 1, \omega 2, \omega 3$** and so on.

Structure and nomenclature of fatty acids.

ω -terminus

carboxy terminus



10 9 8 7 6 5 4 3 2 1

ω $\omega 1$ $\omega 2$ $\omega 3$ δ γ β α



An ω -3 fatty acid

Nomenclature Of Fatty acids

- **FA Nomenclature is Based On**
- **Chain length/Total Number of Carbon atoms in a FA.**
 - Count Number of Carbon atoms in FA
- **Number and Position of Double bonds**
 - Position of double bond **from Carboxyl/Delta end**
 - Position of double bond **from Methyl/Omega**

Short Hand Representations of Fatty acids

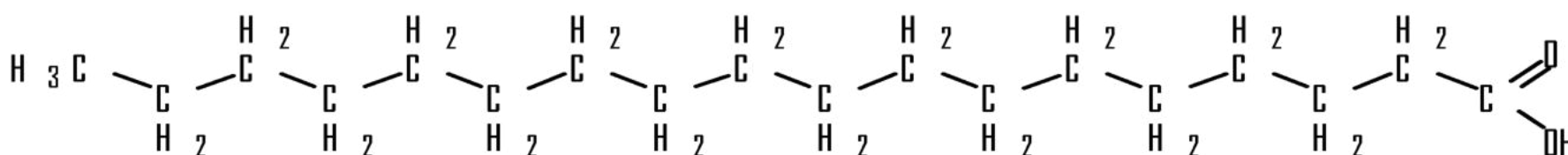
- **Short Hand Representations
of Fatty acids:**

- Palmitic Acid (16:0)
- Palmitoleic acid (16:1;9)
- \

- **First digit stands** for total number of carbon atoms in the fatty acid.
- **Second digit designates** number of double bonds.
- **Third digit onwards** indicates the position of double bonds.

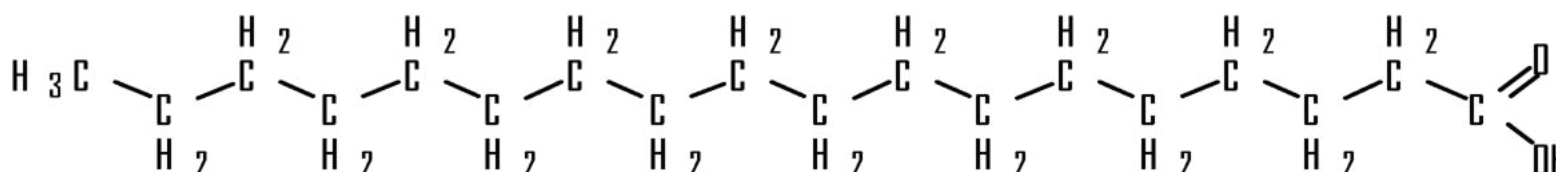
Fatty-acid Nomenclature

- Named according to chain length
– C18



Fatty-acid Nomenclature

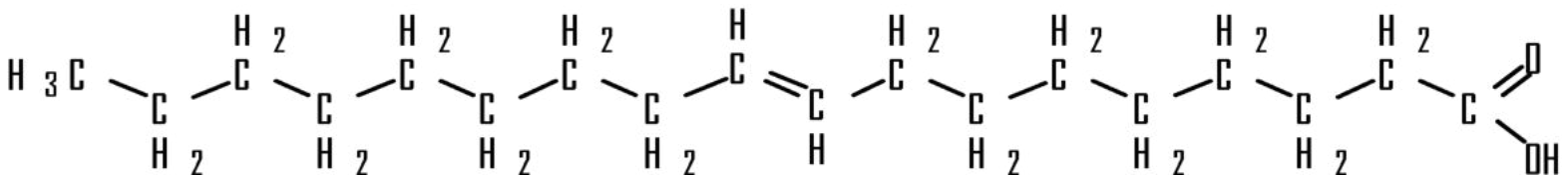
- Named according to the number of double bonds
– C18:0



Common name:
Stearic acid

Fatty-acid Nomenclature

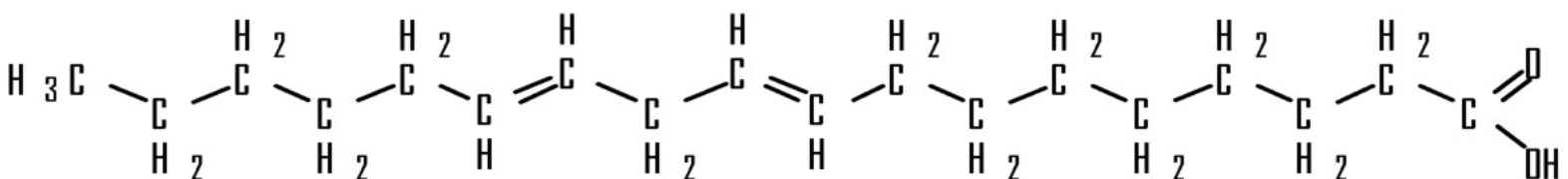
- Named according to the number of double bonds
 - C18:1



Common name:
Oleic acid

Fatty-acid Nomenclature

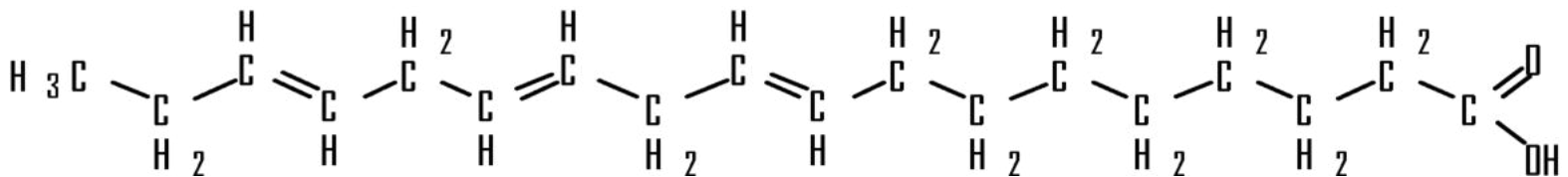
- Named according to the number of double bonds
 - C18:2



Common name:
Linoleic acid

Fatty-acid Nomenclature

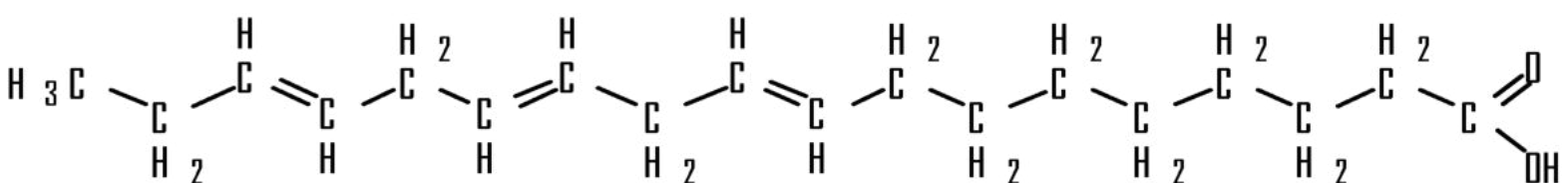
- Named according to the number of double bonds
 - **C18:3**



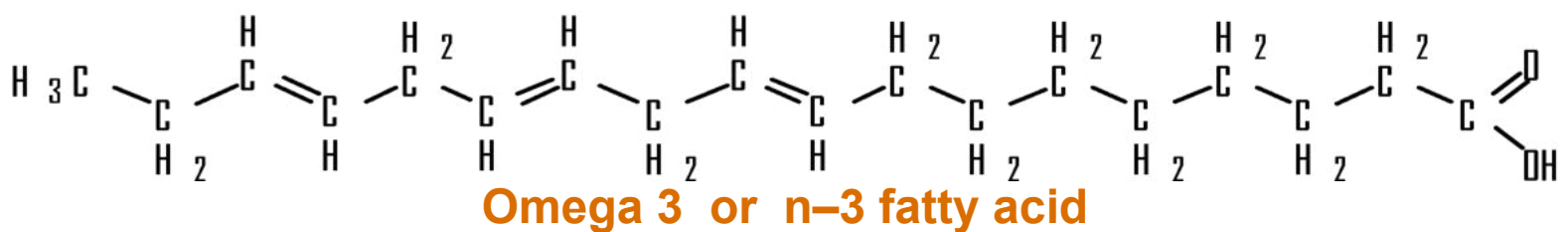
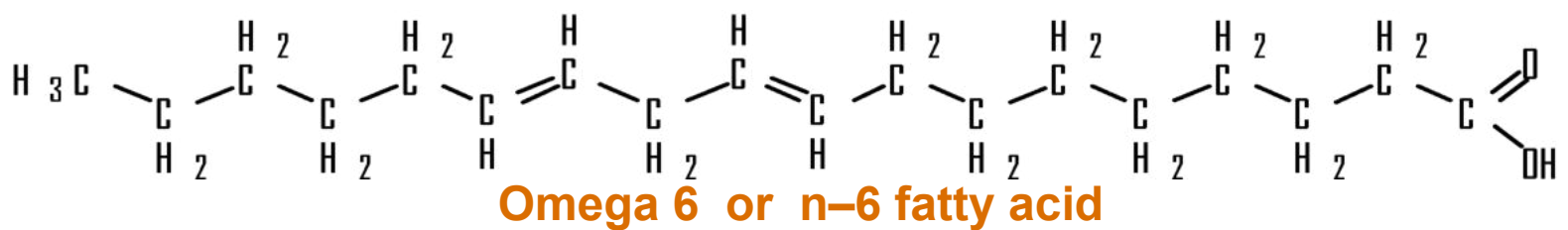
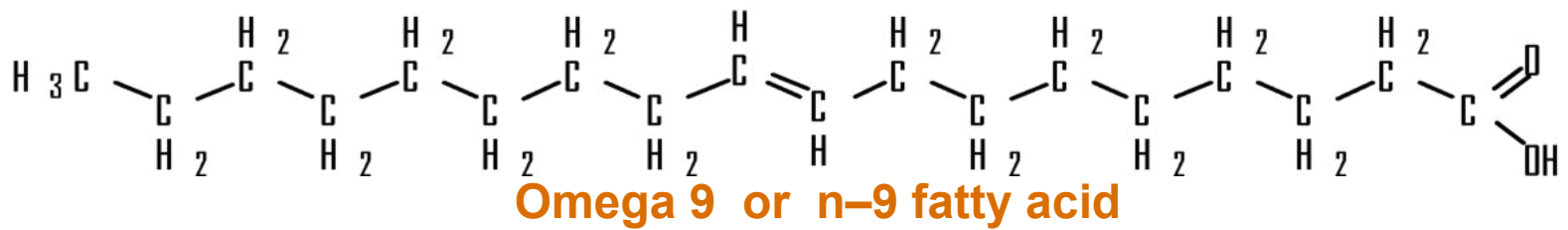
Common name:
Linolenic acid

Omega System Nomenclature

- Named according to the location of the **first double** bond from the non-carboxyl **Methyl end** (count from the Methyl end / **Omega end** ω)



Omega Fatty-acid Nomenclature



- Stearic acid (18:0)
- Oleic acid (18:1;9)
- Linoleic acid (18:2;9,12)
- Linolenic acid (18:3;9,12,15)
- Arachidonic acid (20:4;5,8,11,14)

- **A Fatty acid may also be designated as :**
- Linoleic acid ($18\text{C};\Delta^{9,12}$)
- Linolenic acid ($18\text{C};\Delta^{9,12,15}$)
- Δ indicates from COOH end.
- 9,12,15 are double bond positions from delta end.

Short Hand Presentation of FA

14:0 **Myristic acid**

16:0 **Palmitic acid**

18:0 **Stearic acid**

18:1 cis Δ^9 **Oleic acid** ($\omega 9$)

18:2 cis $\Delta^{9,12}$ **Linoleic acid** ($\omega 6$)

18:3 cis $\Delta^{9,12,15}$ **α -Linolenic acid** ($\omega 3$)

20:4 cis $\Delta^{5,8,11,14}$ **Arachidonic acid** ($\omega 6$)

20:5 cis $\Delta^{5,8,11,14,17}$ **Eicosapentaenoic acid** ($\omega 3$)

22:5 Cis $\Delta^{7,10,13,16,19}$ **Docosapentaenoic acid** ($\omega 3$)

Important Properties Of Fatty Acids

Properties Of Fatty Acids

- **Physical Properties**
- **Chemical Reactions**

Factors Responsible For Solubility Of Fatty Acids

1. Hydrocarbon chain length

2. Degree of Unsaturation- Number of Double Bonds

3. Hydrophobicity/Polarity of Fatty acids

4. Polarity of Solvents

- Small hydrocarbon chain length are **less hydrophobic and more soluble**
- Long Chain FA and VLCFA more hydrophobic are very less soluble
- Solubility of Fatty acids decreases with increase in Fatty acid hydrocarbon chain length.
- Double bonds increases solubility

Melting Point of Fatty Acids

Factors Responsible For Melting Points Of Fatty Acids

- 1. Hydrocarbon chain length**
- 2. Nature of Bonds**
- 3. Degree of Unsaturation/Number of double bonds**

Fatty Acids With Decreased Melting Points

- Short and Unsaturated Fatty acids has **low melting point**
- More degree of unsaturation **low is melting point of FAS**

Melting Points

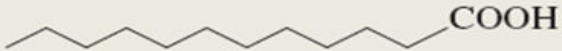
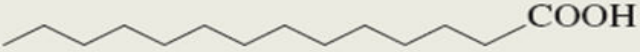
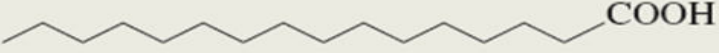
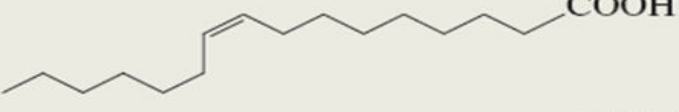
- Affected by chain length
—Longer chain = higher melting temp

Fatty acid:	C12:0	C14:0	C16:0	C18:0	C20:0
Melting point:	44°C	58°C	63°C	72°C	77°C

Melting Points

- Affected by **number of double bonds**
 - More saturated = higher melting temp

Fatty acid:	C18:0	C18:1	C18:2	C18:3
Melting point:	72°C	16°C	−5°C	−11°C

Number of carbons	Common name	Systematic name	Structure	Melting point °C
Saturated				
12	lauric acid	dodecanoic acid		44
14	myristic acid	tetradecanoic acid		58
16	palmitic acid	hexadecanoic acid		63
18	stearic acid	octadecanoic acid		69
20	arachidic acid	eicosanoic acid		77
Unsaturated				
16	palmitoleic acid	(9Z)-hexadecenoic acid		0
18	oleic acid	(9Z)-octadecenoic acid		13
18	linoleic acid	(9Z,12Z)-octadecadienoic acid		−5
18	linolenic acid	(9Z,12Z,15Z)-octadecatrienoic acid		−11
20	arachidonic acid	(5Z,8Z,11Z,14Z)-eicosatetraenoic acid		−50
20	EPA	(5Z,8Z,11Z,14Z,17Z)-eicosapentaenoic acid		−50

Fatty Acids With Increased Melting Points

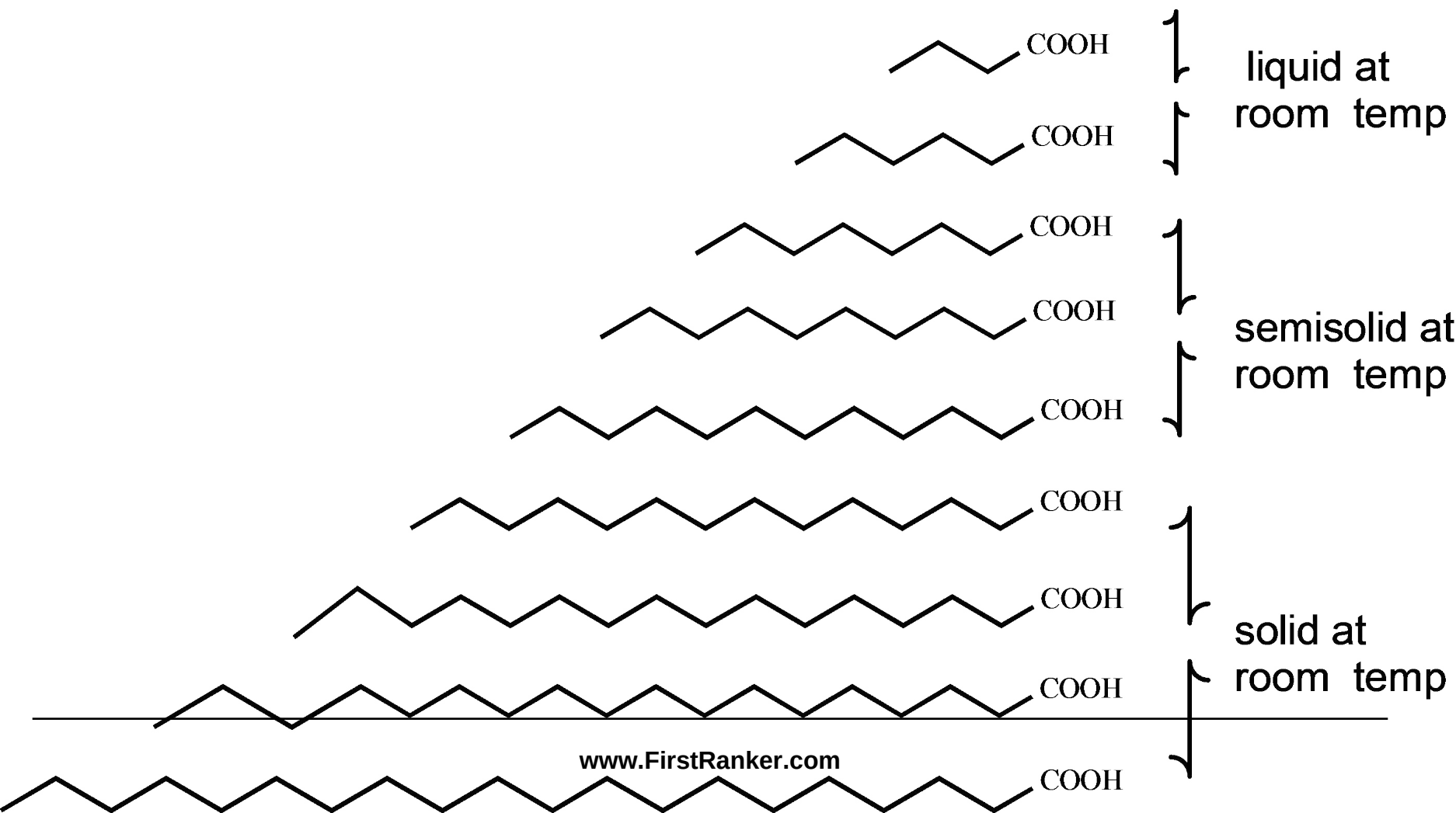
- Long and Saturated Fatty acids are has **high melting point.**
- Less degree of Unsaturation **more is melting point of Fatty acids**
- **Thus melting point of Fatty acids(FAs):**
 - Increases with increase in chain length of FAs.
 - Decreases with decrease in chain length of FAs.
 - Increases with low unsaturation of FAs
 - Decreases with more unsaturation of Fatty acids

Structures and Melting Points of Saturated Fatty Acids

Table 18.1 Structures and Melting Points of Common Fatty Acids				
Name	Carbon Atoms	Structure	Melting Point (°C)	Source
Saturated Fatty Acids				
Capric acid	10		32	Saw palmetto
Lauric acid	12		43	Coconut
Myristic acid	14		54	Nutmeg
Palmitic acid	16		62	Palm
Stearic acid	18		69	Animal fat
Arachidic acid	20		76	Peanut oil, vegetable and fish oils

Timberlake, General, Organic, and Biological Chemistry. Copyright © Pearson Education Inc., publishing as Benjamin Cummings

Fatty Acids



Chemical Reactions Of Fatty Acids

Types Of Chemical Reactions Of Fatty acids

Reactions due to Carboxyl group of Fatty acids:

- Esterification/Esterified forms of Lipids
- Saponification/Soap Formation

Reactions Associated to Double bonds of Fatty acids:

- Halogenation/Addition of Halogens around double bond
- Hydrogenation/Transform to UFAs to SFAs

Significance Of Halogenation

- Halogenation of fatty acids is an **index of assessing the degree of unsaturation**

- **Iodine Number** is a process of **Halogenation** which checks the **content of SFA and PUFAs** of Fats and Oils.
- **SFA** has **zero iodine number**.
- **PUFAs** has **high iodine number**.

Hydrogenation Of Fatty acids

Alters Geometric Isomerism Of Unsaturated Fatty acids

Transforms Natural Cis Form to Trans Form

Increases Shelf life of PUFAs

All-Cis Fatty acids

Good for Health

- Human body **contain Enzyme system** to **metabolize Cis form** of Fatty acids.
 - Cis forms when ingested through food are easily metabolized and **does not retain in the body.**
 - Hence All –Cis forms are good for health and **no risk of Atherosclerosis and CVD.**
 - **All Cis form of fatty acids are unstable and easily metabolizable.**
-
- More content of **Trans Fatty acids** are found in **processed/Refined foods** viz:
 - Hydrogenated Oils (Vanaspati Dalda)**
 - Ghee**
 - Margarine**
 - Bakery products /Fast foods**
 - Deeply Fried recipes in Oils which are prepared in repeatedly heated oils.**

- **Trans fatty acids increases risk of**
 -
 - Atherosclerosis
 - Cardio Vascular disorders:
 - Ischemia
 - Myocardial Infarction
 - Stroke(Brain attack)

Message

Learnt, Understood And To Be Implemented

For Good Fatty acid metabolism and Significant Health

- Eat natural Cis forms of Fatty acids
- Avoid Hydrogenated Trans Fatty acids
- Eat home made food
- Avoid Processed/Junk Foods

PUFAs And Omega Fatty Acids

Types Of Omega Fatty acids

- **In Nutrition and Clinical practice**

- » **ω 3 Fatty acids**

- » **ω 6 Fatty acids**

- » **ω 7 Fatty acids**

- » **ω 9 Fatty acids**

Omega Fatty Acids

Omega 3 Fas PUFAs	Omega 6 Fas PUFAs	Omega 7 Fas MUFAs	Omega 9 Fas MUFAs
Linolenic C18-(ODTA) Timnodonic C20-(EPA) Cervonic C22-(DHA) Clupanodonic C22-(DPA)	Linoleic C18- (ODDA) Arachidonic C20-(ETA)	Palmitoleic C16-(HDA)	Oleic – C18(ODA) Erucic – C22(DA) Nervonic C24-(TA)

Examples of ω3 Fatty acids

- **Linolenic** (18:3;9,12,15) (ω3)
- **Timnodonic**/Ecosapentaenoic Acid /EPA (20:5;5,8,11,14,17)(ω3)
- **Clupanodonic acid**/(Docosa Pentaenoic Acid): (DPA) (C22:5;7,10,13,16,19)(ω3)
- **Cervonic**/Docosa Hexaenoic Acid (DHA)(22:6;4,7,10,13,16,19)(ω3)

Rich sources of dietary Omega and nutritional essential PUFAS are:

- Vegetable Oils**
- Green Leaves, Algae**
- Fish and Fish oils**
- Flax Seeds**

**Sources, Distribution, Composition Of
Fatty Acids In Human Body**

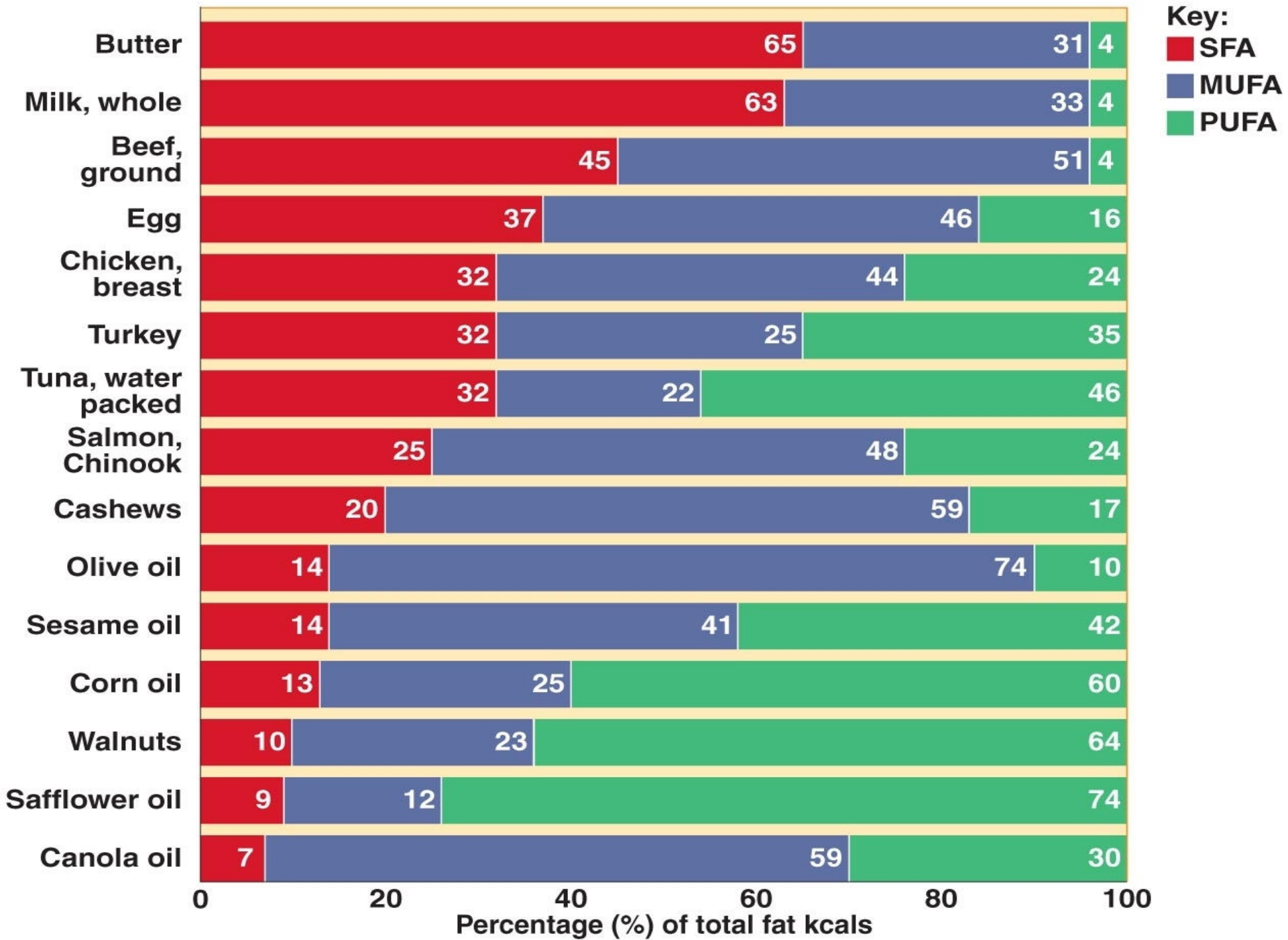
Sources Of Fatty Acids To Human Body

- **Exogenous Sources-** Dietary Food Items
- **Endogenous Biosynthesis-** From Free Excess Glucose in Liver

Forms of Dietary Fatty Acids To Be Ingested **Natural Forms Of Fatty Acids**

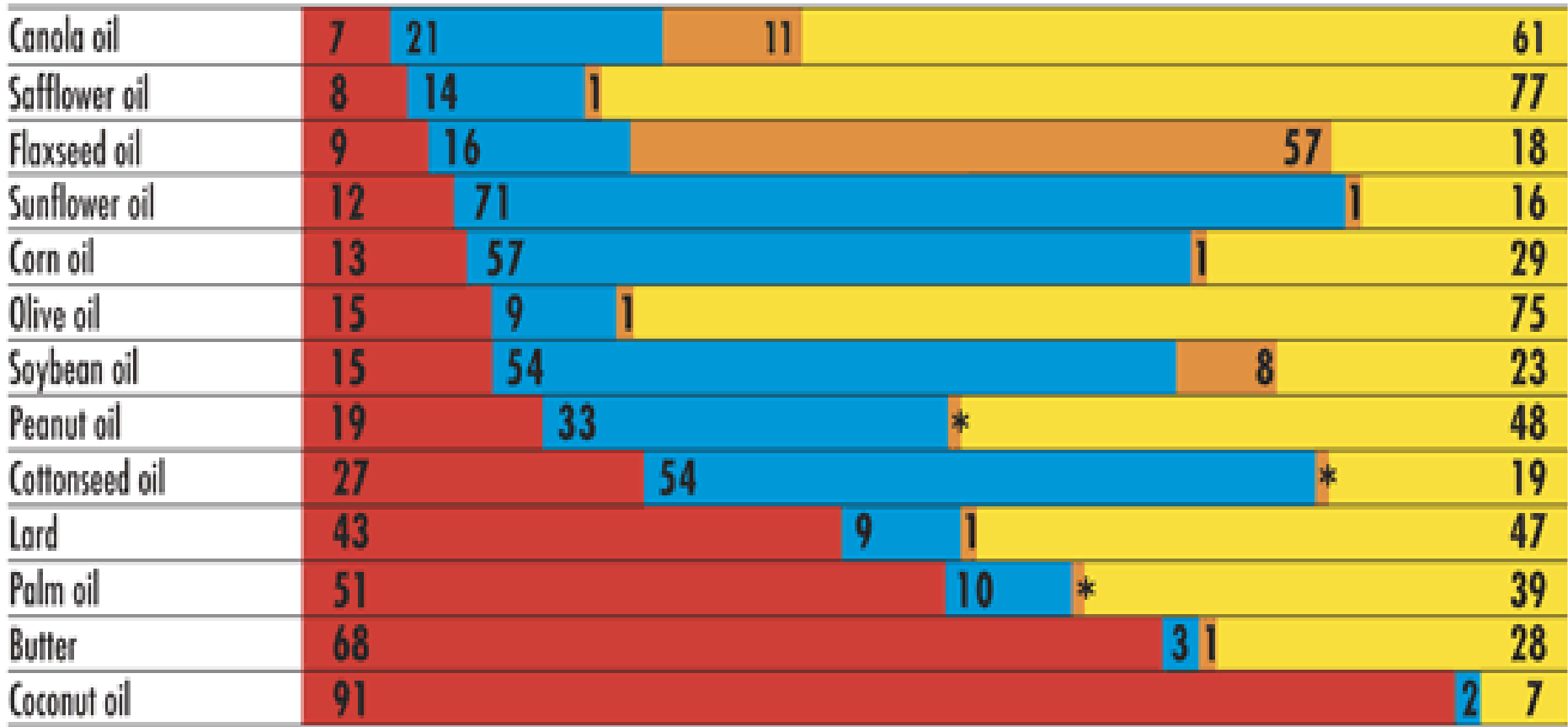
- Fatty acids in nature mostly presently in
 - **Esterified form of FAs– (TAG,PL,CE)**
 - **Even Numbered Carbon**
 - **Unsaturated- PUFAs/Omega 3 and 6**
 - **Cis forms**

Contents Of Fatty acids		Sources Of Oils	
Highest Content of MUFA		Olive Oil , Mustard Oil	
Highest content of PUFA		Safflower, Sunflower, Flax seed Oil	
Highest content of SFA		Coconut Oil	
Oils Rich In SFAs	Oils rich in MUFAs	Oils rich in PUFAs	
Coconut Oil	Olive Oil (75%)	Flax seeds/ Linseed Oil	
Palm Oil	Sunflower Oil (85%)	Soya /Safflower Oil	
Butter	Ground nut / Pea nut Oil	Almond Oil	
Animal Fat	Almond Oil	Rice Bran	
	Sesame Oil	Walnuts Oil	
	Beef Fat (Tallow Fat) 50%	Corn Oil	
	Lard (Pork Fat) 40%	Marine Fish	
	www.FirstRanker.com		



Comparison of Dietary Fats

DIETARY FAT



SATURATED FAT

POLYUNSATURATED FAT

MONOUNSATURATED FAT



linoleic acid
(an omega-6 fatty acid)

alpha-linolenic acid
(an omega-3 fatty acid)

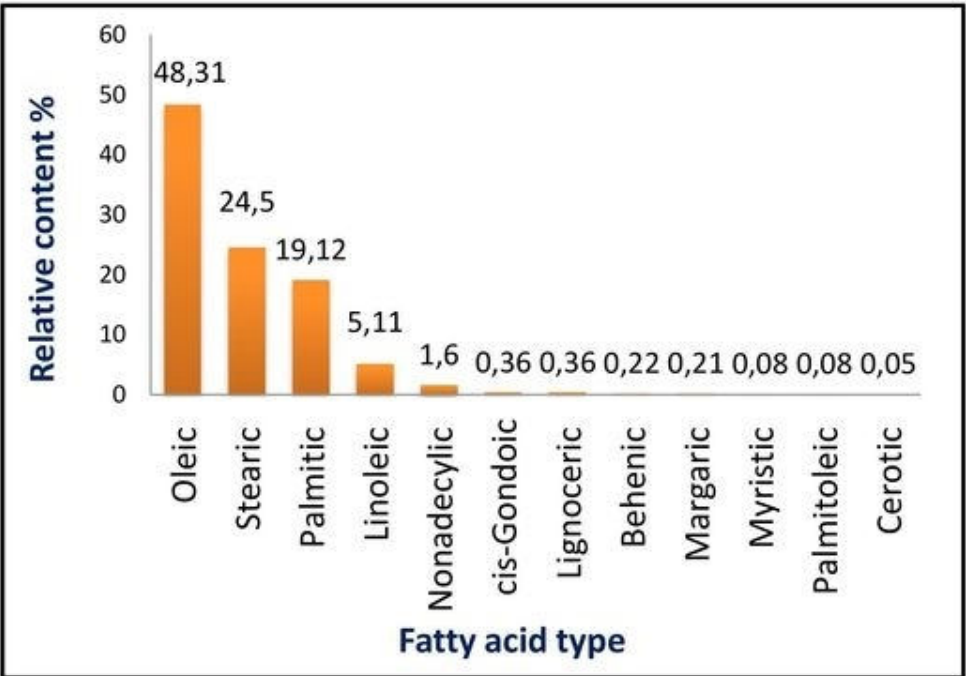
oleic acid
(an omega-9 fatty acid)

Fatty Acids	Carbons	Double bonds	Abbreviation	Source
Acetic	2	0	2:0	bacterial metabolism
Propionic	3	0	3:0	bacterial metabolism
Butyric	4	0	4:0	butterfat
Caproic	6	0	6:0	butterfat
Caprylic	8	0	8:0	coconut oil
Capric	10	0	10:0	coconut oil
Lauric	12	0	12:0	coconut oil
Myristic	14	0	14:0	palm kernel oil
Palmitic	16	0	16:0	palm oil
Palmitoleic	16	1	16:1	animal fats
Stearic	18	0	18:0	animal fats
Oleic	18	1	18:1	olive oil
Linoleic	18	2	18:2	grape seed oil
Linolenic	18	3	18:3	flaxseed (linseed) oil
Arachidonic	20	4	20:4	peanut oil, fish oil

Determination of fatty acid profile

Fatty acid		Relative content (%)
Myristic	C14:0	0.08
Palmitic	C16:0	19.12
Palmitoleic	C16:1	0.08
Margaric	C17:0	0.21
Stearic	C18:0	24.50
Oleic	C18:1	48.31
Linoleic	C18:2	5.11
Nonadecylic	C19:0	1.60
cis-Gondoic	C20:1	0.36
Behenic	C22:0	0.22
Lignoceric	C24:0	0.36
Cerotic	C26:0	0.05

Fatty acids (from highest to least as a %)



Total saturated fatty acids = 46.14%

Total MUFA = 48.75%

Total PUFA = 5.11%

S/U = 0.86

53.86%
total unsaturated
fatty acids

Fatty acid Composition of Human Body

Fatty acid	Percentage
Oleic acid	50% (MUFA)
Palmitic acid	35% (SFA)
Lionleic acid	10% (PUFA)
Stearic acid	5% (SFA)

- Thus most abundant Fatty acids present in human Lipids are:
 - Oleic acid (50%)
 - Palmitic acid(35%)

Ideal Requirement Of Fatty Acids To Human Body

- It is ideal to **consume ratio** of:
- **1 : 1 : 1**
- **SFA MUFA PUFAs**
- respectively **from the diet to maintain good health.**

- Naturally there is **no single oil** which has all **3 types of fatty acids** in ideal proportion.
- Hence it is always **advisable to mix a combination of oils** and consume.

Transportation Of Fatty Acids In Human Body

- **Bound form /Esterified Forms Of Fatty acids are Transported through various Lipoproteins.**

Fatty acids Transportation In body

- **More than 90%** of the fatty acids found in plasma are in the form of **Fatty acid esters**.
 - **Fatty acids Esters/Esterified form of Fatty acids exist as:**
 - **Triacylglycerol**
 - **Cholesteryl esters**
 - **Phospholipids**

- **Unesterified/Free Fatty acids (FFA)** are very less amount in body.
- **Long Chain FFA are transported in the blood circulation in association with Albumin.**

Functions Of Fatty Acids

1. Secondary Source Of Energy
 2. Components Of Biomembranes
 3. PUFA (Arachidonic Acid) Precursor for Eicosanoid Biosynthesis
 4. Esterification of Cholesterol and its Excretion
 5. PUFAs build and protect Brain and Heart
 6. PUFAs prevents early ageing, prolongs Clotting time.
-

- PUFAs of membrane play role in:(Less compact)
 - Membrane fluidity
 - Selective permeability

Functions Of PUFAS /Omega 3, and 6 FAs

- Components of **cell biomembranes**
- More **associated to Human brain and Heart**
- Involve in **Growth ,development and functioning of Brain**

- **Omega Fatty acids Reduces risk of Heart disease:**
 - **Reduces Platelet aggregation** by stimulating Prostaglandins and Prostacyclin's .
 - **Reduces blood clotting and Thrombus formation by Lowering the production of Thromboxane .**

- **Omega 3 Fatty acids have pleiotropic effects (more than one effect):**
 - **Cardio protective effect**
 - **Lowers Blood pressure**
 - **Anti-Inflammatory**
 - **Anti-Atherogenic**
 - **Anti-Thrombotic**

- **PUFAs Lowers Risk Of Atherosclerosis**

- Since **double bonds of PUFAs** are unstable and easily cleavable.
- PUFAs get easily metabolized and do **not get accumulated** in the blood arteries and capillaries.
- Thus PUFAs have **low risk of Atherosclerosis** and Cardio vascular disorders.

- **Fish (rich in Omega 3 Fatty acids) Eaters has Healthy Brain and Heart**

- **Brain development with an efficient nervous function.**
- **Protected from Heart attacks.**

- **Deficiency of Essential Fatty acids :**
 - **Affects every cell ,organ and system**
 - Growth retardation
 - Problems with reproduction
 - Skin lesions
 - Kidney and Liver disorders
 - Brain disorders/Behavioral disorders.

Deficiency Of PUFAs/ Omega 3,6 Fatty acids

- Deficit of omega fatty acids **affect the normal growth ,development and functioning of brain.**
- Persons may suffer from **mental illness** like:
 - Depression
 - Attention deficit
 - Dementia=**Alzheimer's Disease**

- Deficiency of **Omega 3 Fatty acids** :
 - **Alters the cell membrane structure.**
 - Increases the **risk of**
 - **Heart attack**
 - **Cancer**
 - **Rheumatoid Arthritis**

Phrynoderma /Toad Skin is due to PUFA deficiency.

- **Phrynoderma /Toad Skin Symptoms**

- The skin becomes dry with lesions
(Scaly Dermatitis).
- Presence of **horny eruptions** on the posterior and lateral parts of limbs, back and Buttock.
- **Loss of hair**
- **Poor wound healing**
- **Acanthosis and Hyperkeratosis**

- **Deficiency of PUFAs lower:**

- Oxidative Phosphorylation-ATP generation

- Fibrinolytic Activities

Fatty Acids At Glance

Name of Biomolecule	Fatty acids
Class	Derived Lipids
Structural Features	Organic acids ,Hydrocarbon Chain (C2-26) Terminal Mono Carboxylic Acid
Sources of FAs to body	From Exogenous and Endogenous
Distribution in Body	FAs mostly in esterified form, Associated with Simple and Compound Lipids. Distributed in all tissues.
Functional aspects	Energy, Biomembrane components
Interrelationships	Fatty acids associated to other form of Simple and Compound Lipids

Study Of Derived Lipids

Alcohols

Alcohols Involved In

Lipid Structures

3 Alcohols Involved In Various Forms Of Lipids

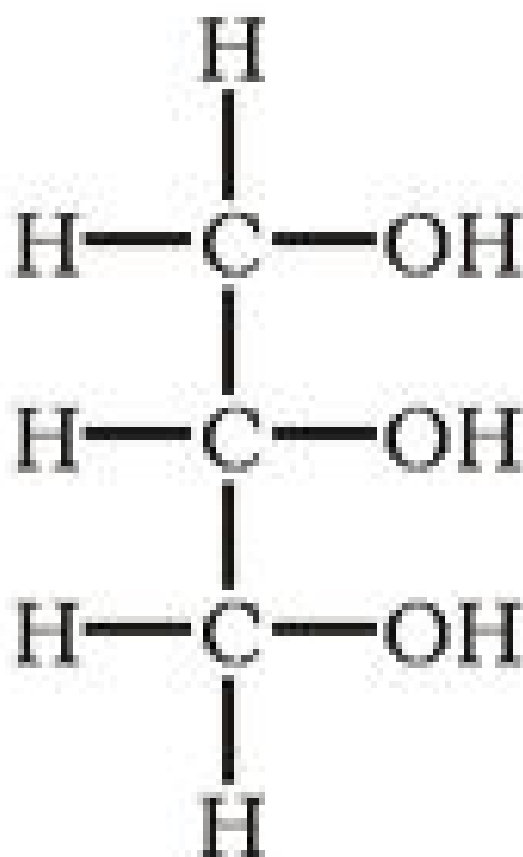
1. **Glycerol**
(C3-Trihydric Alcohol)
2. **Sphingol/Sphingosine**
(C18-Dihydric Alcohol)
3. **Cholesterol**
(C27-Monohydric Alcohol)

**Alcohols Of Lipids
Are
Classified
As
Derived Lipids**

Glycerol is a Derived Lipid

Obtained from Hydrolysis of
Simple and Compound Lipids

Figure 1. Structure of Glycerol



Glycerol/ Glycerin

- Glycerol [C₃] is a **POLYOL**
- Glycerol is chemically **Trihydric Alcohol** (3 –OH groups)
- Glycerol has **potency to interact with 3 same or different Fatty acids**.

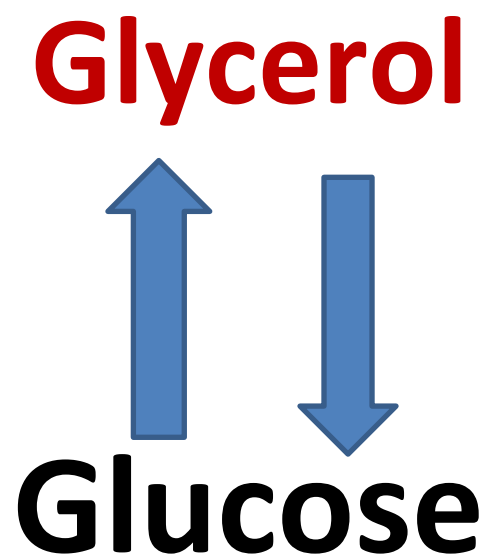
❖ Glycerol is a **backbone of Glycerol based Lipids** viz:

❖ **Triacylglycerol**

❖ **Glycerophospholipids**

Glycerol Sources To Human Body

Endogenous and Exogenous Sources



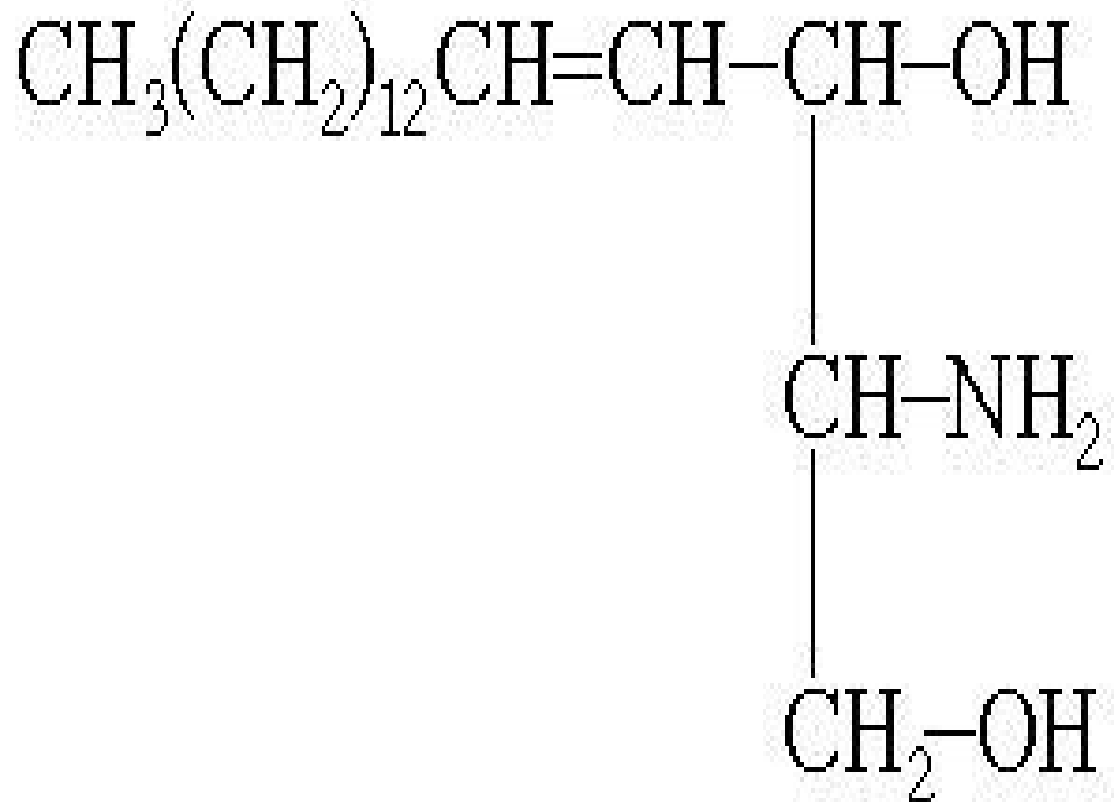
Source Of Glycerol To Human body

- Glucose is responsible for **biosynthesis of Glycerol** in human body
- Glucose transforms to **Glyceraldehyde**,
- **Glyceraldehyde** on **reduction** forms **Glycerol**.

- **Glycerol formed** is then used **for Biosynthesis of Glycerol based Lipids**.
- **Glycerol released from hydrolysis** of Glycerol based Lipids is **transformed to Glucose**.

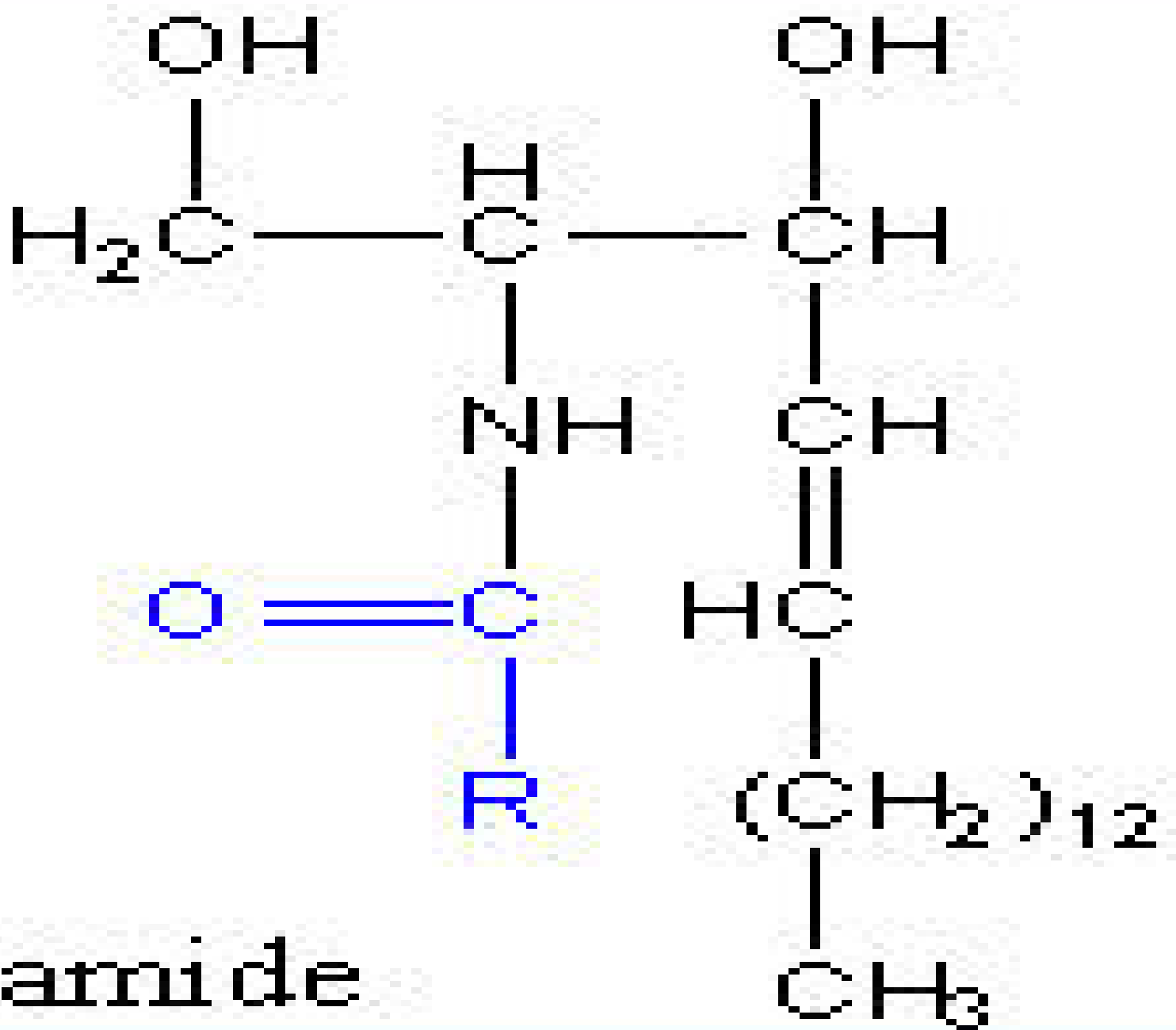
SPHINGOSINE/SPHINGOL

Sphingosine



- **Sphingosine is a derived Lipid.**
- **Obtained from Hydrolysis of Sphingolipids**

- Sphingosine is a **C18**, complex **Dihydric, Amino alcohol**.
- Sphingosine is **biosynthesized** in human body using **amino acid Serine**.
- **Serine** provides **NH₂** group of Sphingosine.
- **Sphingosine forms Sphingolipids /Compound Lipids with Alcohol Sphingol**
- **Examples of Sphingolipids:**
 - **Sphingophospholipids**
 - **Sphingoglycolipids**

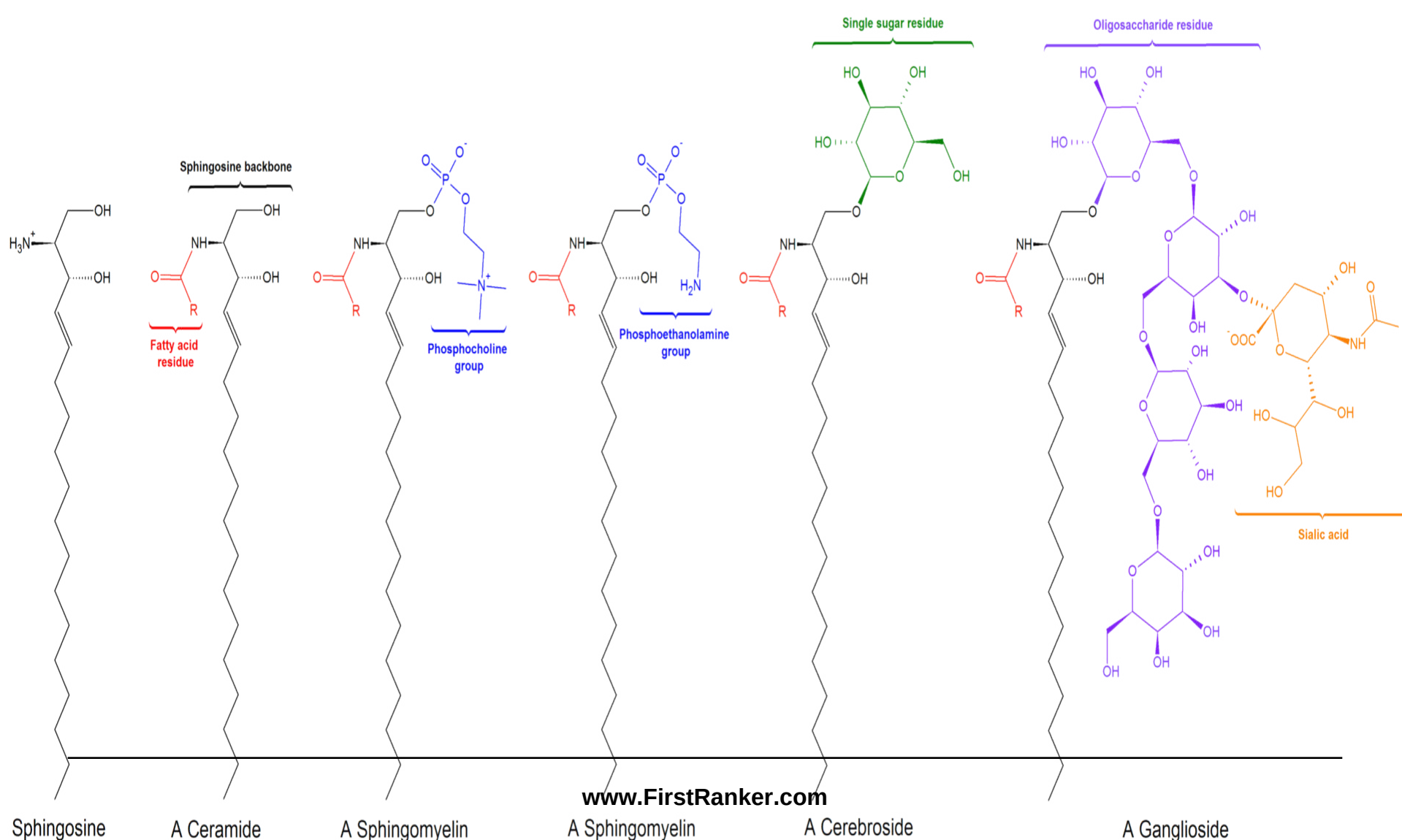


What Is a Ceramide?

- A Fatty acid linked to an amino group of **Sphingosine**
- With an amide linkage form a **Ceramide.**

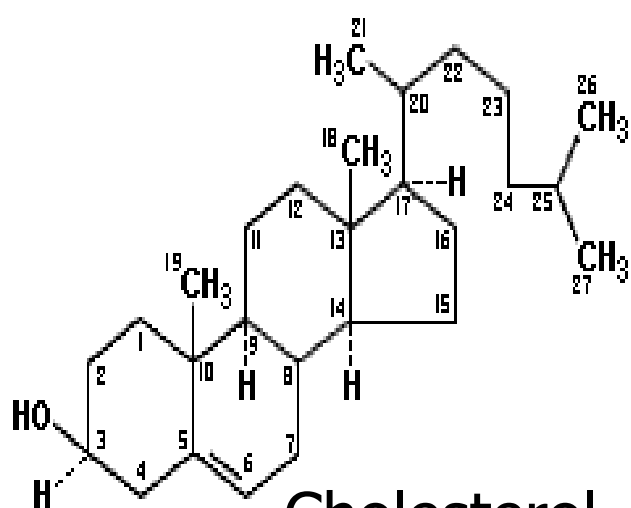
- Ceramide if linked to **Phosphate and Nitrogenous** groups forms **Sphingophospholipids**.
- Ceramide linked to **Carbohydrate moieties** form **Sphingoglycolipids**.

Sphingosine Based Lipids

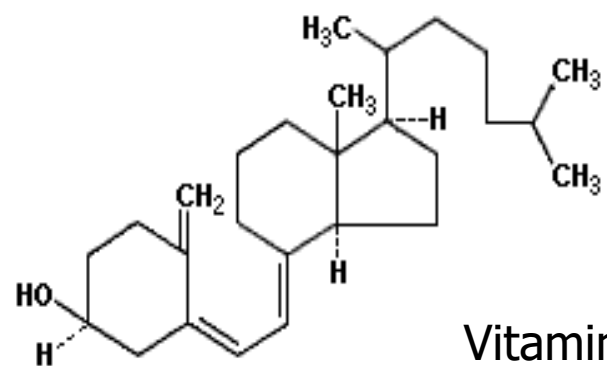


Sterols

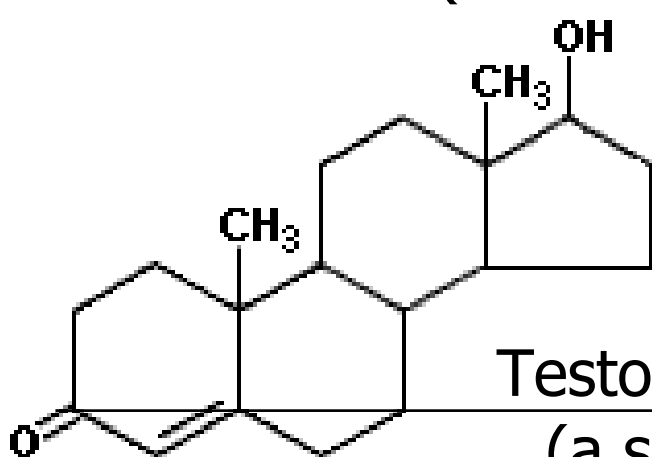
Common Sterol And Steroids



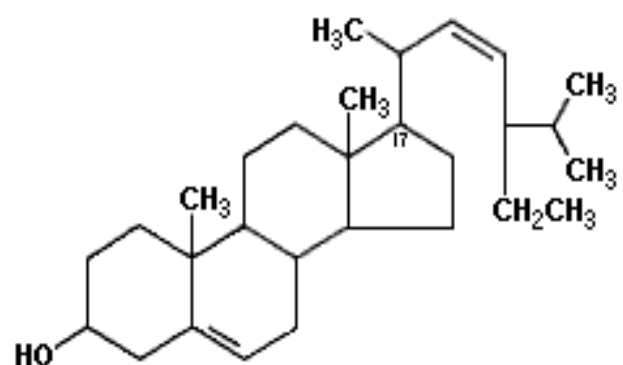
Cholesterol
(a sterol)



Vitamin D3
(cholecalciferol)



Testosterone
(a steroid hormone)



Stigmasterol
(a phytosterol)

- Sterols are chemically **complex, organic monohydric Alcohols.**
- Sterols has **cyclic ring structures**
- Sterols have a **parent ring**
- **Cyclo Pentano Perhydro Phenanthrene (CPPP)** nucleus.

Examples Of Sterols

- **Cholesterol** (Animal Sterol)
- **7 Dehydrocholesterol** (Provitamin D)
- **Coprosterol** (Excretory form Cholesterol)
- **Ergosterol** (Plant Sterol)
- **Sitosterol** (Plant Sterol)

Cholesterol

Most abundant Sterol of Human body

Cholesterol

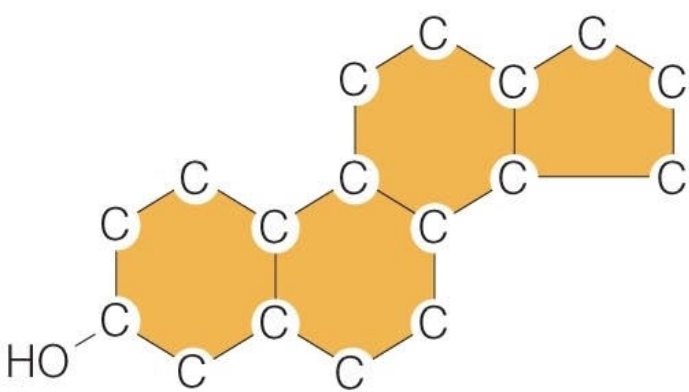
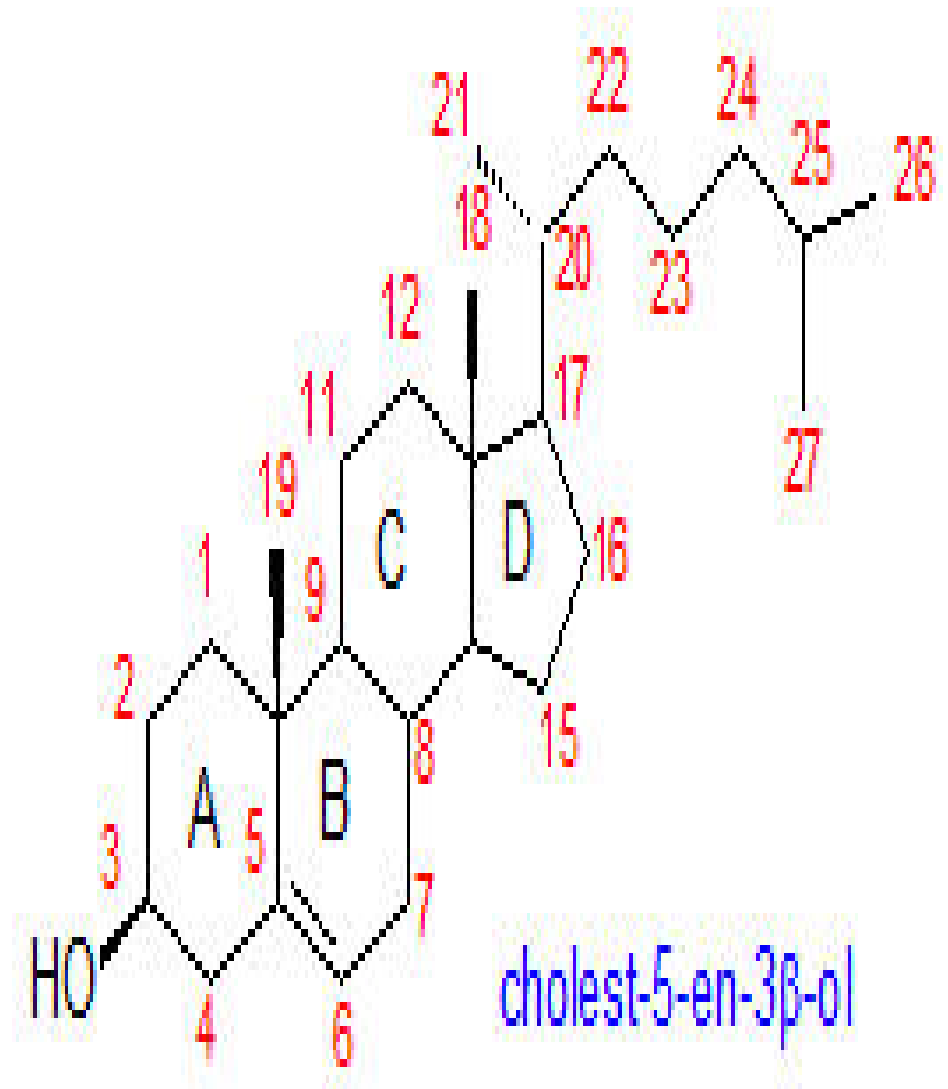
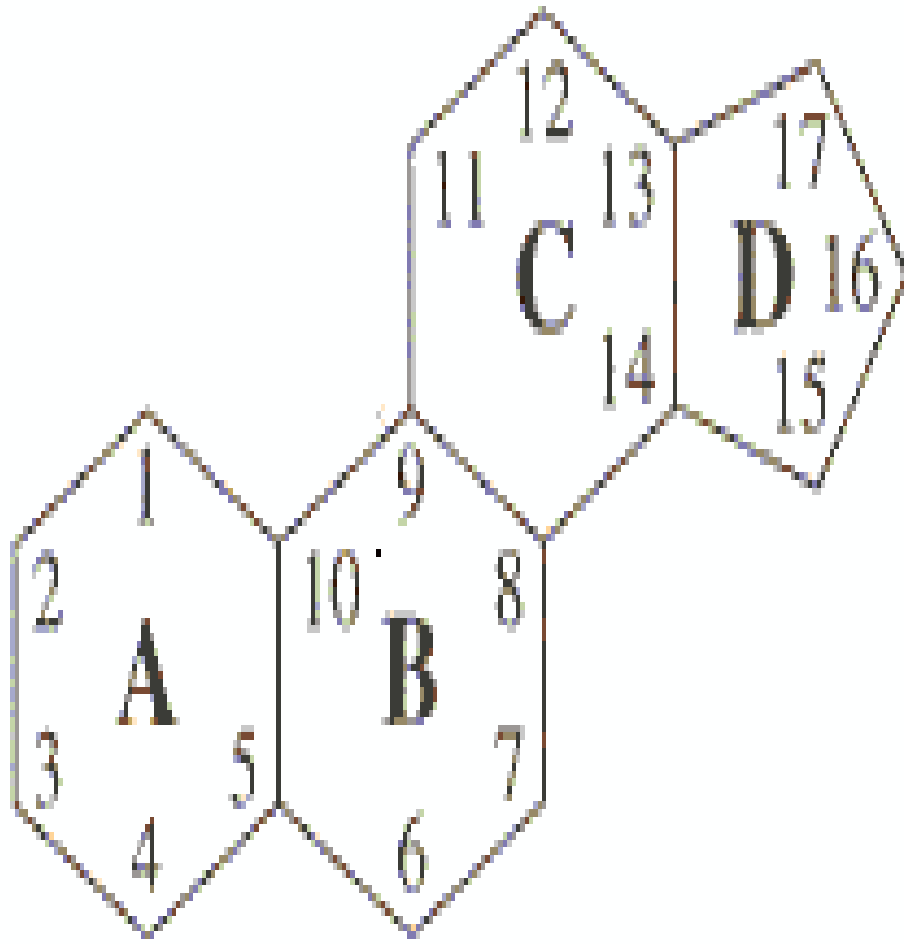
- Cholesterol is an **Animal Sterol** .
- Cholesterol means **Solid Alcohol** as it was **first obtained from gall stones** of bile.
- Cholesterol is excreted via bile hence **richly composed in bile ,Gall stones.**

Cholesterol Is A Derived Lipid

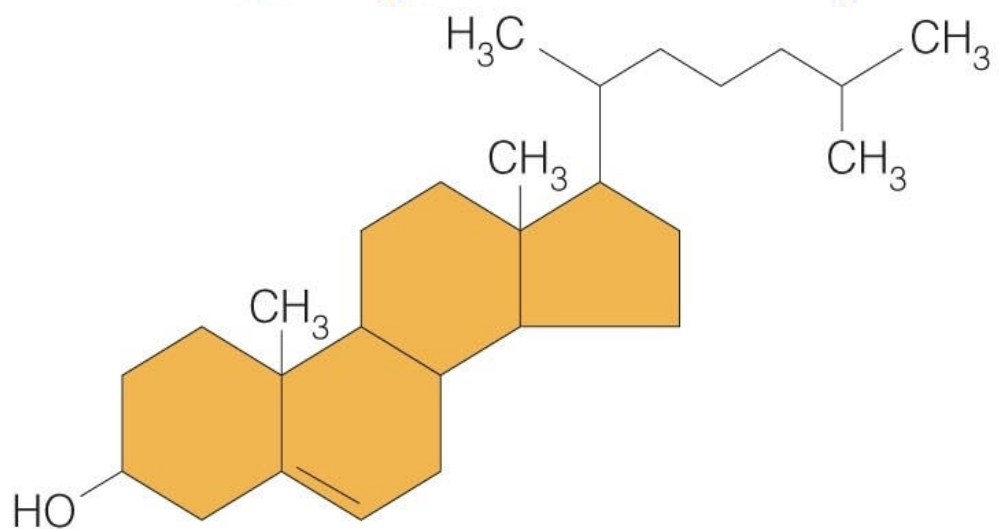
- Cholesterol is classified as **Derived Lipid**.
- It is **derived** from **hydrolysis of Cholesterol Ester** (Human Body Wax).

Chemical Structures Of Cholesterol and Cholesterol Ester

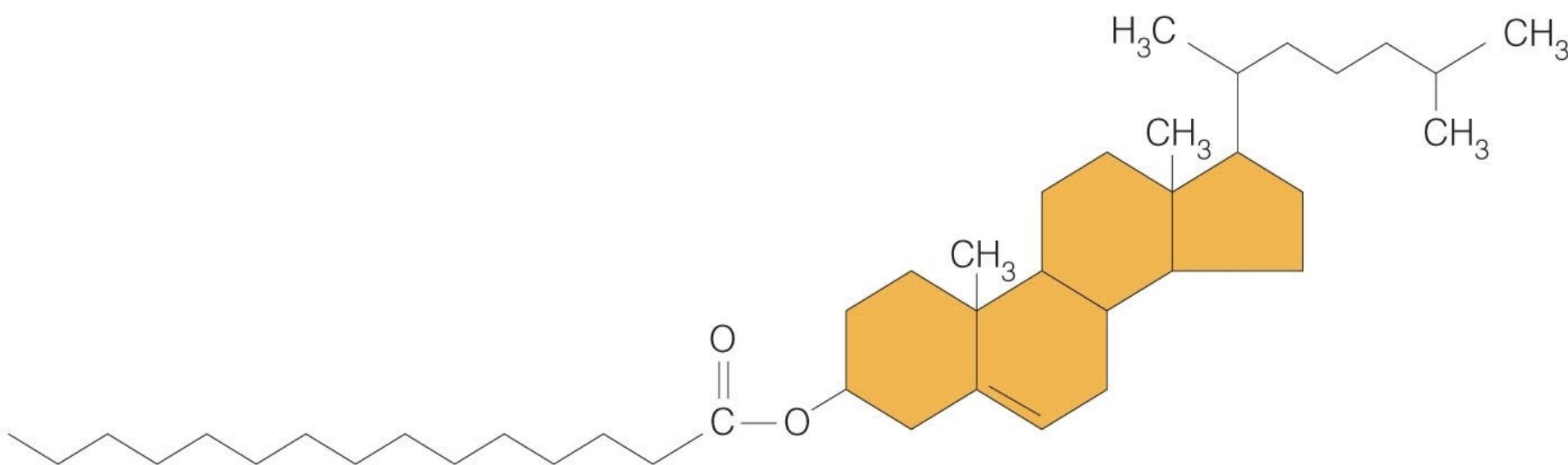
Pentahydrophenantrene (Sterane)



(a) Sterol ring structure



(b) Cholesterol



(c) Cholesterol ester

Structure Of Cholesterol

- Cholesterol is **complex, cyclic, unsaturated, monohydric** Alcohol.
- Molecular formula is **C₂₇H₄₅OH**
- Cholesterol has parent nucleus as **Cyclo Pentano Per hydro Phenanthrene ring** system(CPPP).
- The structure of CPPP has **four fused cyclic rings** (A,B,C and D)

- Hexane ring A,B,C is a **Phenatrene** nucleus.
- D ring is **Cyclopentane** ring.

- **The Structure of Cholesterol Possess:**

1. **Hydroxyl group (-OH) at C3.**
2. **Double bond between C5 and C6.**
3. **5 Methyl (-CH₃) groups.**
4. **8 Carbon side chain linked to C17 of the structure.**

Forms Of Cholesterol In Human Body

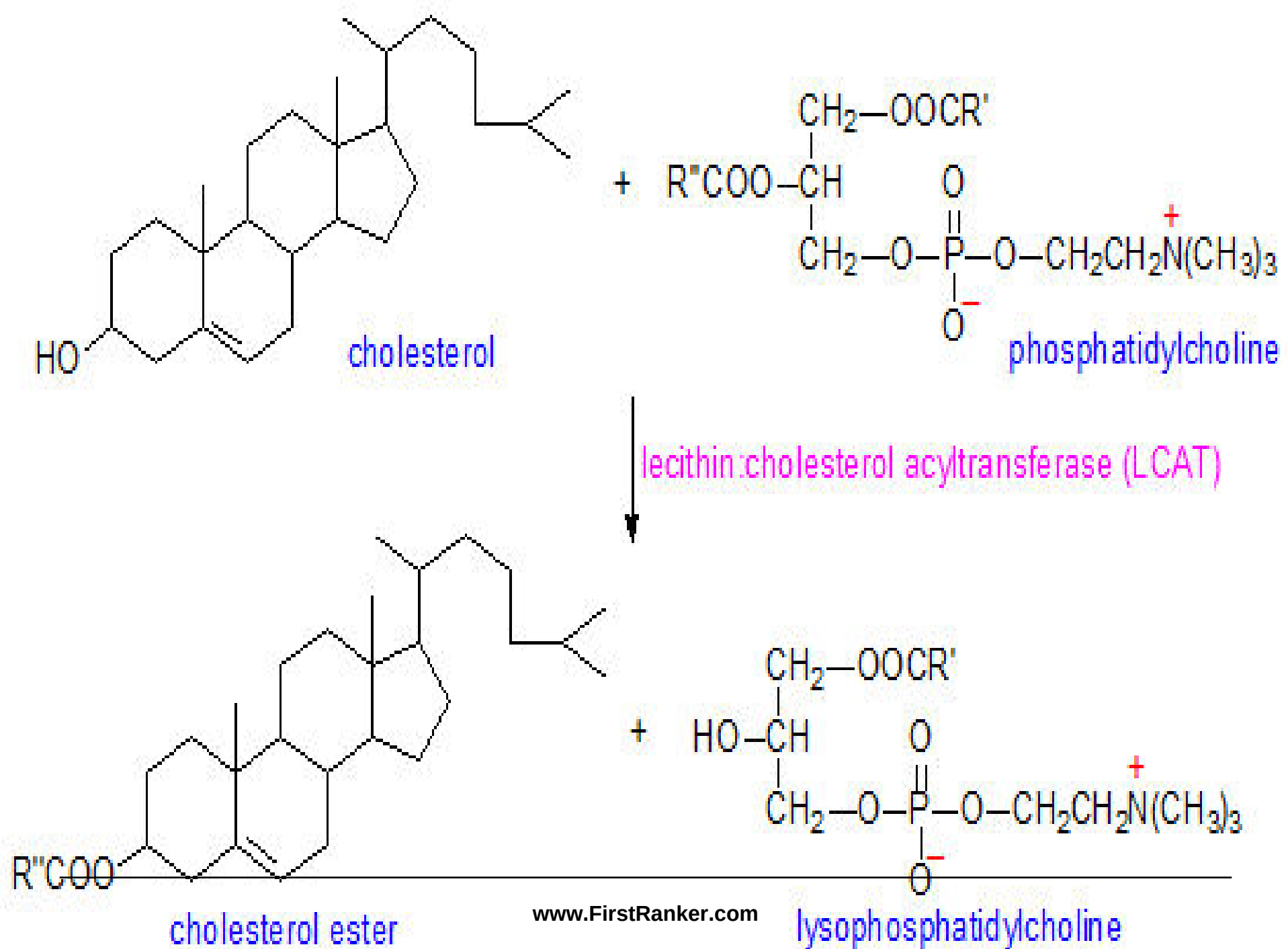
- **Cholesterol exists in two forms:**

–**Free Cholesterol - 30%**

(Amphipathic form)

–**Cholesterol Ester - 70%**

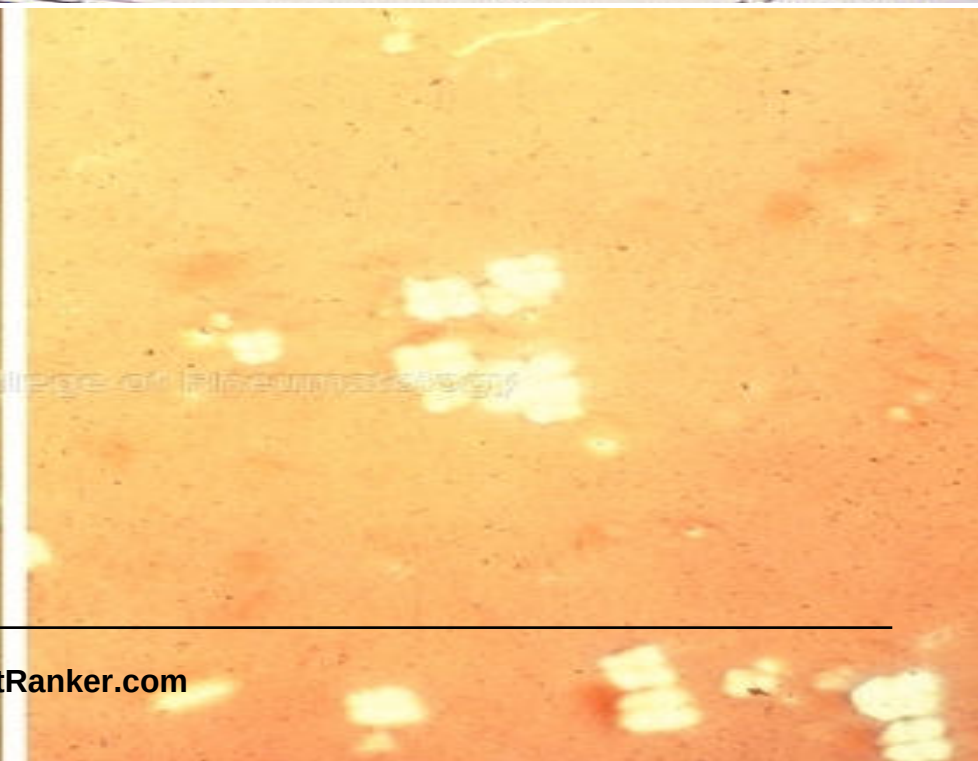
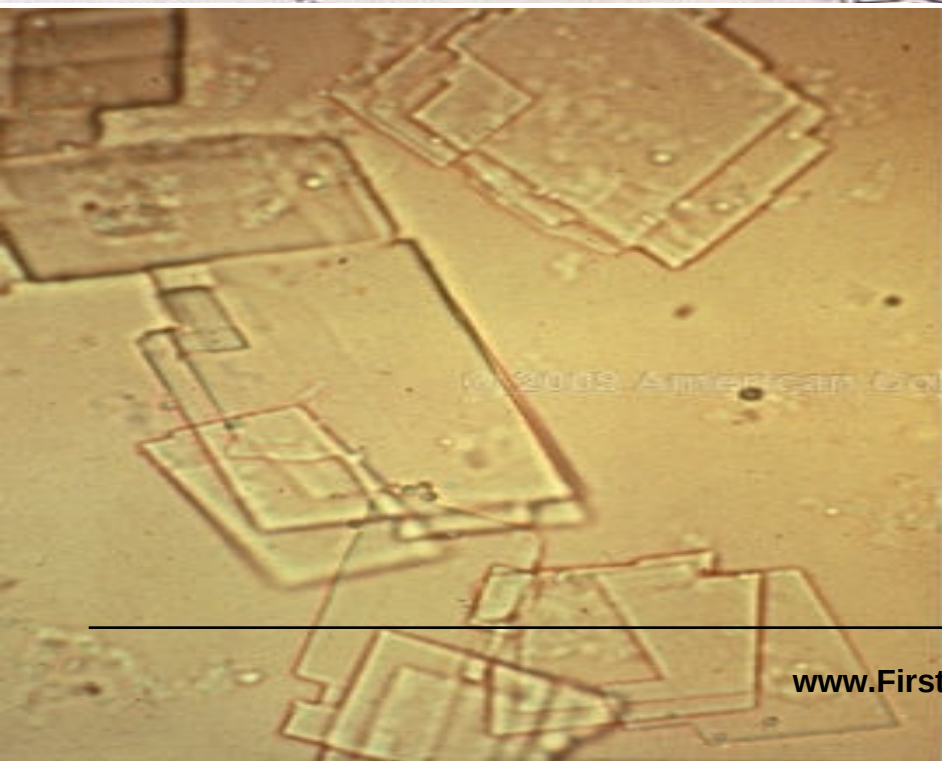
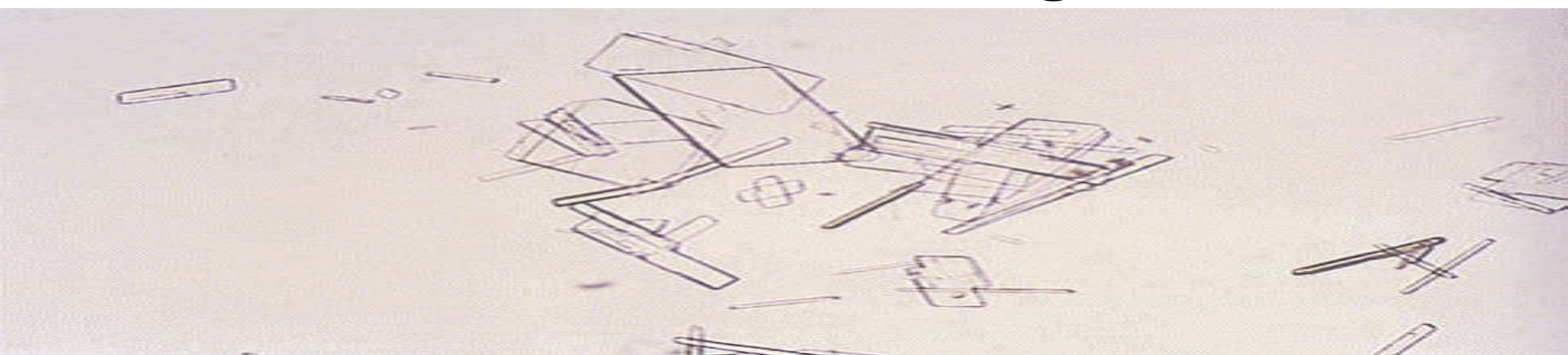
(Non polar form)



Properties Of Cholesterol

- Cholesterol is **white or pale yellowish, crystalline, odorless compound.**
- **Insoluble in water and soluble in organic solvents** like Ether and Chloroform.

Crystals of Cholesterol Rhombic plates with Notched edges.



- **Qualitative Tests For Cholesterol detection are:**

–Liebermann Burchard Reaction

–Salkowski Reaction

–Zak's Reaction

Sources Of Cholesterol To Human Body

- **Exogenous Sources of Cholesterol:**
 - **Animal Origin Food Items**
- **Endogenous Source Of Cholesterol:**
 - Obtained In **well fed condition from Excess Glucose**

Dietary Sources Of Cholesterol

- Cholesterol is exclusively present in **animal foods.**

- The dietary rich sources of Cholesterol **animal origin foods** like:

–Egg Yolk

–Meat

–Milk

–Butter

–Ghee

–Cream

Foods High in Cholesterol



Beef brain



Chicken liver



Egg yolk



Shrimps



Cheeseburger



Chicken legs

- Remember Cholesterol is **absent in plant origin food items.**

Endogenous Source Of Cholesterol

- Cholesterol Biosynthesized in human body from **Free Excess Glucose** in Liver.

Transportation Of Cholesterol

— **Cholesterol in blood is transported by Lipoproteins:**

- Chylomicrons (**Dietary origin**)
- **LDL** (From Hepatocytes to Extra hepatocytes)
- **HDL** (From Extra hepatocytes to Hepatocytes)

Occurrence and Distribution Of Cholesterol in the Body

—**70 %** of Cholesterol associated
with **cellular components**

—**30 %** of Cholesterol is in the
Blood.

- Cholesterol is richly present in **Nervous tissue Brain**.
- Other organs containing Cholesterol are:
 - **Liver**
 - **Adrenal Cortex**
 - **Gonads**
 - **Intestinal Mucosal cells**
 - **Skin**

Functions Of Cholesterol

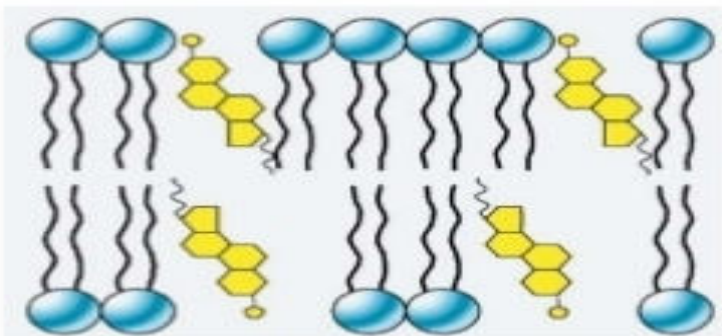
Depends Upon

Quality and Quantity

- Cholesterol is **constituent of biomembranes of cell**
- It give **structure, shape and fluidity to them.**

Cholesterol

- Embedded in membrane
- Helps stabilize and strengthen the cell membrane
- Important in cell metabolism
- Hydroxyl (OH) group is oriented to the outside



Effects on Membrane without Cholesterol

In Cold Environment	In Hot Environment
Rigid/ Not Flexible	Too Flexible
Not Fluid	Very Fluid
May Get damage	Not hold Shape

- Cholesterol richly present in **nervous tissue** and **covers Myelin sheaths**.
- Cholesterol **help in nerve impulse conduction**.
- Cholesterol helps in nerve impulse transmission since:
 - It has **high dielectric constant**.
 - It is a **poor conductor of heat and electricity**.

Cholesterol Serves Precursor for Biosynthesis Of Many Steroids

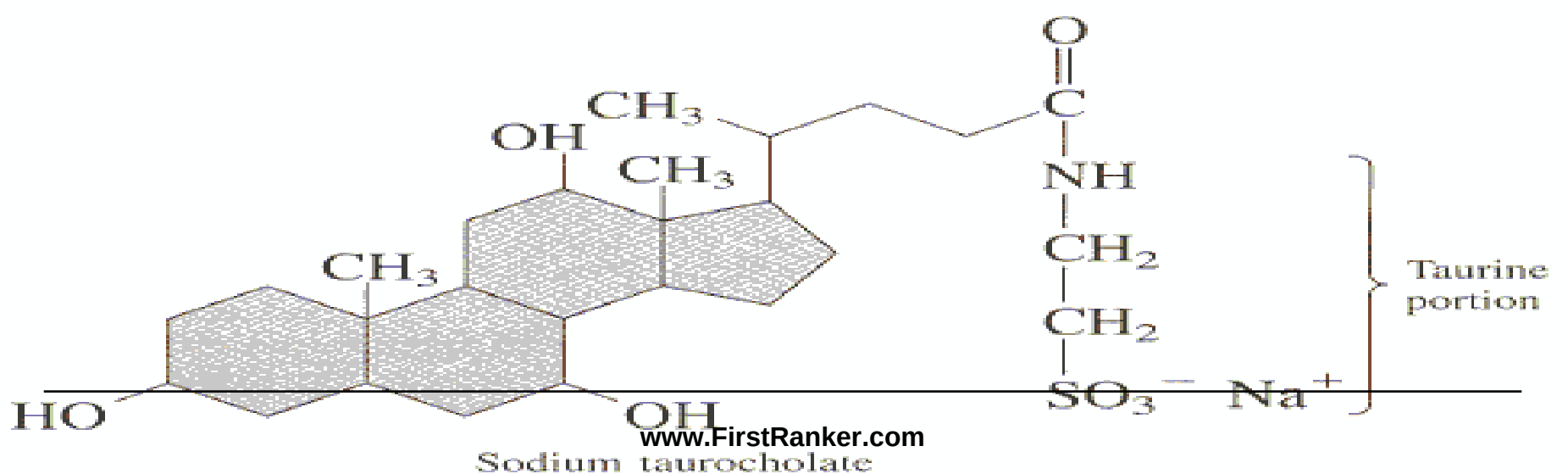
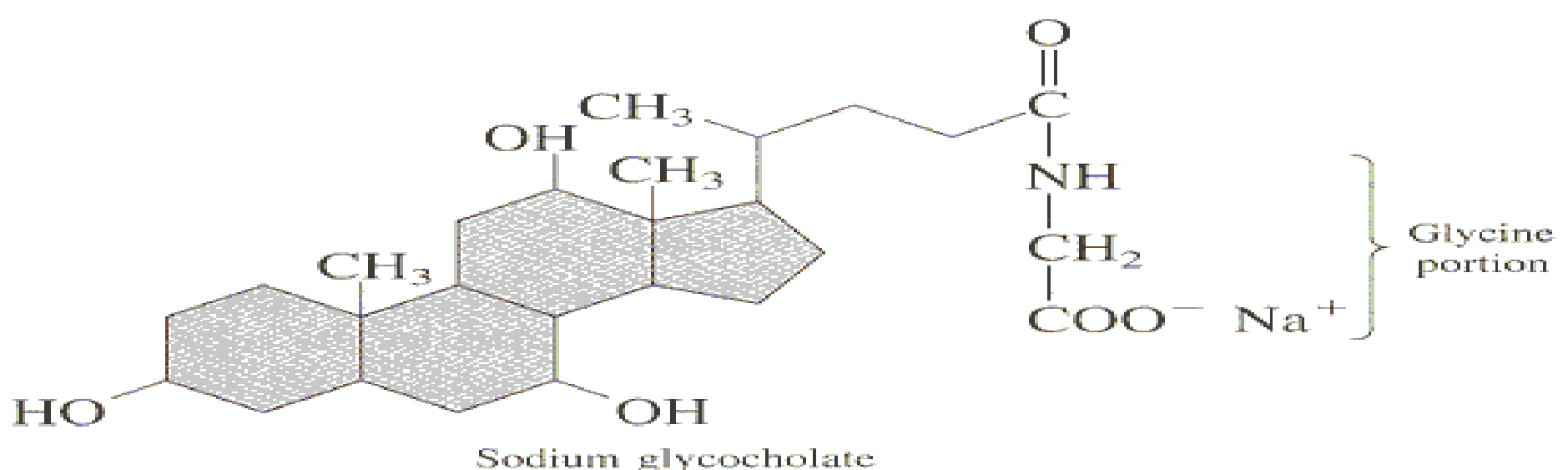
Derivatives of Cholesterol

- Steroids are **derivatives of Sterols.**
- Chemical Compounds obtained from Cholesterol are termed as **Steroidal compounds.**

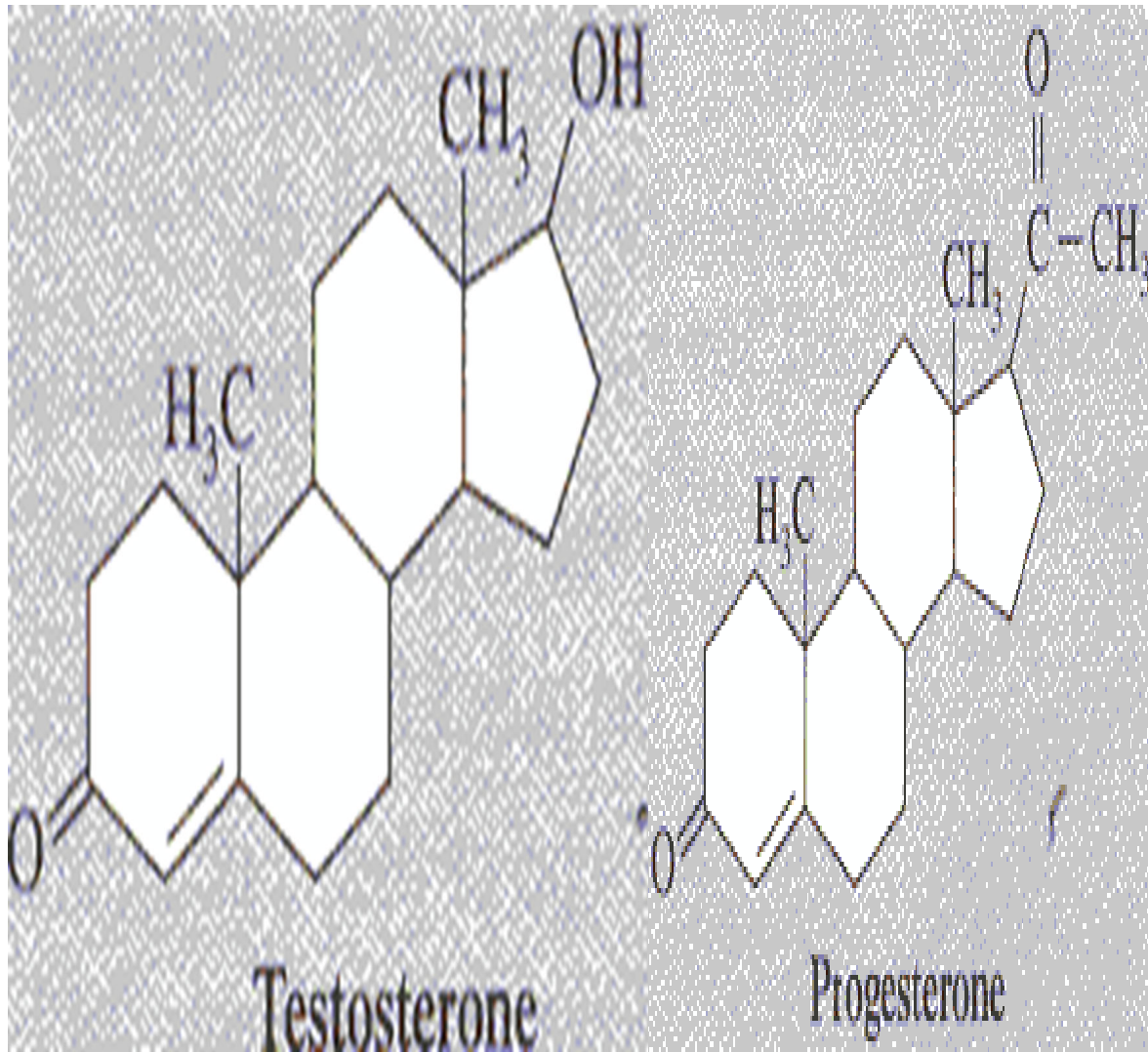
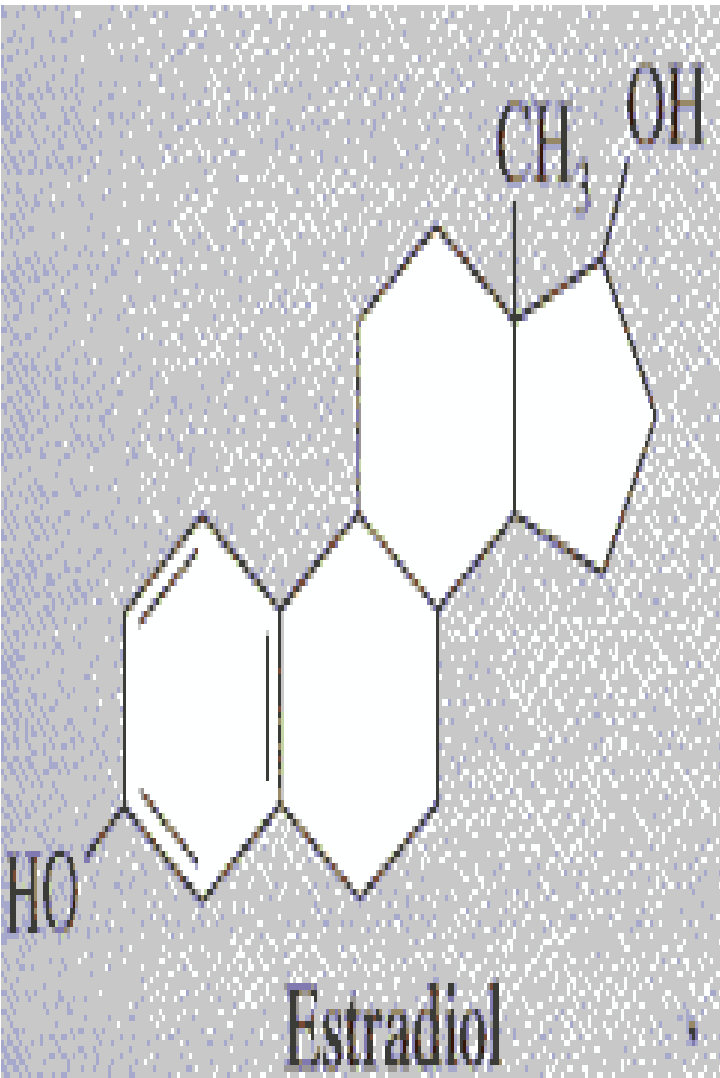
• Derivatives of Cholesterol

- Vitamin D (Cholecalciferol)
- Bile acids (Cholic and Chenodeoxycholic acid)
- Bile Salts are obtained from Bile acids.
- Steroidal Hormones
 - ACTH
 - Mineralocorticoids
 - Glucocorticoids
 - Sex Hormones: Androgens, Progesterone, Estrogen and Testosterone

Bile Acids and Bile Salts



Steroids Hormones



Disorders Related To Cholesterol

- **Serum Total Cholesterol level** of a Healthy human body is **150-200 mg%**

Hypercholesterolemia

- **Causes for Hypercholesterolemia**

- **High intake** of dietary Cholesterol (animal origin) is an exogenous source of Cholesterol.
- **Elevated endogenous Cholesterol biosynthesis** when a very **rich Carbohydrates** are ingested.
- **Defect in Cholesterol transport by Lipoproteins** in blood retains Cholesterol in blood.

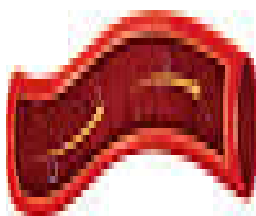
Conditions Of Hypercholesterolemia

- Diabetes mellitus
- Obstructive Jaundice
- Nephrotic Syndrome
- Hypothyroidism

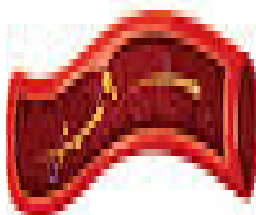
- **Hypercholesterolemia** leads to :
 - Deposits of **excess of Cholesterol** in **blood vessels**.
 - **Atherosclerosis** and atheroma /**plaque formation**.
 - Increased risk of **ischemia** and **Myocardial infarction** and **Stroke**.

ATHEROSCLEROSIS

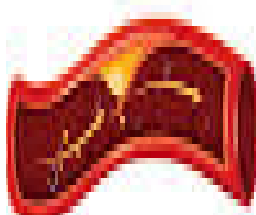
ILLUSTRATION OF
ATHEROSCLEROSIS STAGES



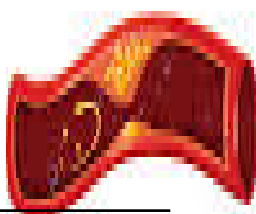
NORMAL FUNCTION



ENDOTHELIAL DYSFUNCTION



PLAQUE FORMATION



PLAQUE RUPTURE THROMBOSIS



—Cholesterol Summary

- Cholesterol is **exclusively found only in animals.**
- Exogeneous Cholesterol comes **from diet**
- Endogeneous** Cholesterol is **biosynthesized** by the **Liver from Glucose product Acetyl-CoA.**
- Cholesterol is an important **component of biomembranes, steroidal hormones, bile acids and Vitamin D**

Study Of Simple Lipids/Neutral Lipids

Triacylglycerols/Triglycerides

- Chemical name of Fat/Oil is **Triacylglycerol (TAG)**.
- **TAG is a Simple, Glycerol based ,Neutral Lipid.**

Chemical Structures Of Triacylglycerol (TAG)

Triacylglycerol/Fats/Oils

- TAG/Fats/Oils are
- Chemically Esters of
- **Three Fatty acids** (**Same or Different**)
- **with one Glycerol** (**Trihydric Alcohol**).

Fatty acids

The diagram illustrates a long-chain fatty acid molecule. On the left, the Carboxyl group (α) is highlighted in a white box, showing a carbon atom double-bonded to an oxygen atom and single-bonded to a hydroxyl group (OH). This carbon is connected to a chain of 15 methylene groups (CH₂). The chain ends on the right with a Methyl group (ω), which is also highlighted in a white box, showing a carbon atom bonded to three hydrogen atoms. Labels with arrows point to these groups: "Carboxyl group (α)" and "Methyl group (ω)".

(c)

Most Common Fatty Acids in Triacylglycerol

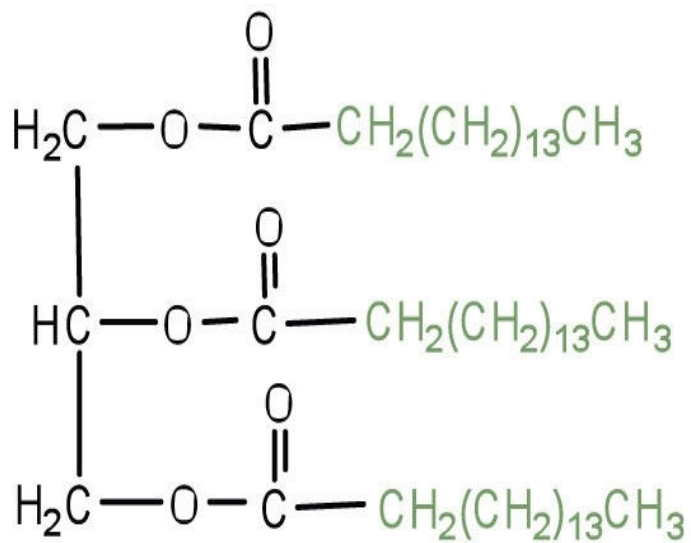
Fatty acid	Carbon:Double bonds	Double bonds
Myristic	14:0	
Palmitic	16:0	
Palmitoleic	16:1	<i>Cis</i> -9
Stearic	18:0	
Oleic	18:1	<i>Cis</i> -9
Linoleic	18:2	<i>Cis</i> -9,12
Linolenic	18:3	<i>Cis</i> -9,12,15
Arachidonic	20:4	<i>Cis</i> -5,8,11,14
Eicosapentaenoic	20:5	<i>Cis</i> -5,8,11,14,17
Docosahexaenoic	22:6	<i>Cis</i> -4,7,10,13,16,19

- **TAG is Neutral or Non polar lipid.**
- Since TAG structure has **no charged/polar groups** in its structure.

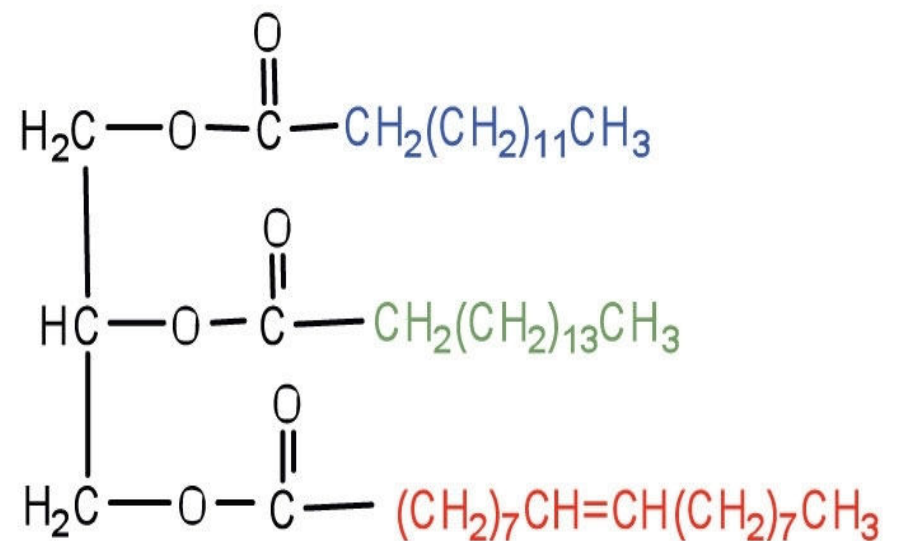
Types Of Triacylglycerol

Based On Nature Of Fatty Acid

- Simple TAG
- Mixed TAG



Tristearin

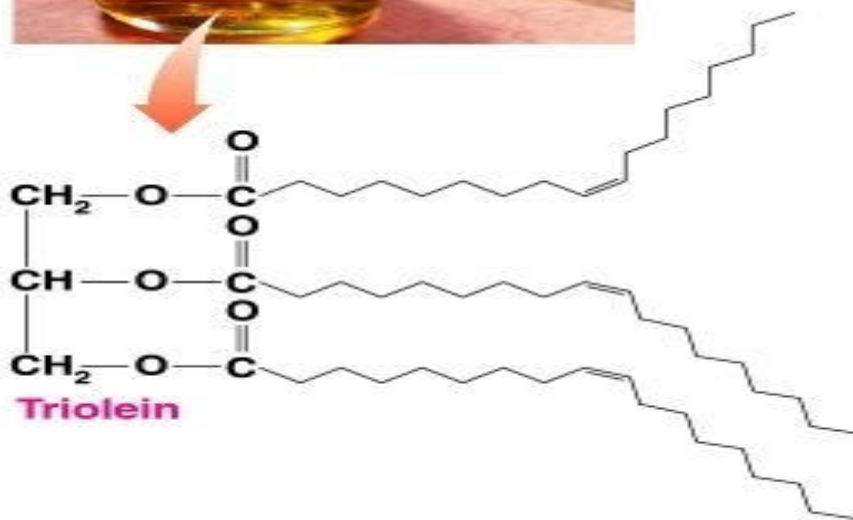
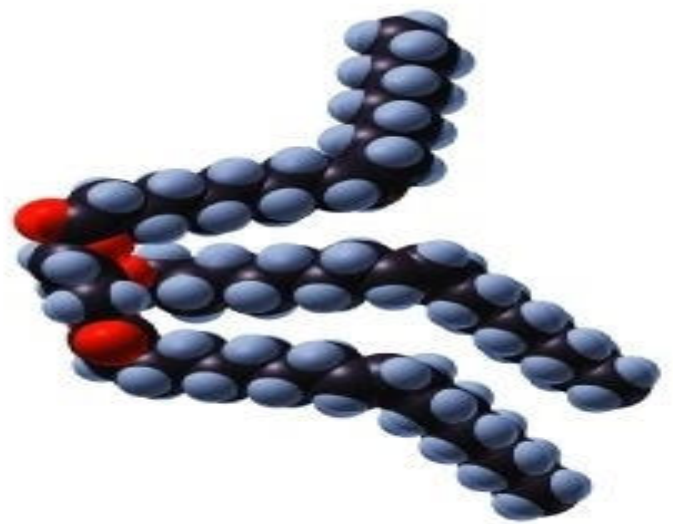


- Simple TAG: **Three same Fatty acids** are esterified to Glycerol to form simple TAG.
- Examples of Simple TAG:
 - TriPalmitin
 - TriStearin
 - TriOlein

- **Mixed TAG:**
- The **3 different Fatty acids** esterified to Glycerol to form a mixed TAG.
- Mixed TAG's are **more predominant in nature.**
- In a Mixed TAG
- **First Carbon C1** -has **Saturated Fatty acid**
- **Second position C2**-has **Unsaturated Fatty acid-PUFA**
- The **3rd position C3 Fatty acid** in TAG has - **either Saturated/Unsaturated fatty acid**

Olive Oil Rich In Simple TAG

- Olive oil contains mostly TAG as **Triolein**, which has **three Oleic acids**.



Timberlake, *General, Organic, and Biological Chemistry*. Copyright © Pearson Education Inc., publishing as Benjamin Cummings

Sources OF Triacylglycerol To Human Body

—Exogenesis source of TAG :

- **Dietary Fats/Oils**

—Endogenous source of TAG :

- **Liver Lipogenesis in well fed condition**
- **Using Glucose product Acetyl-CoA.**

Dietary Sources Of TAG

- **Animal Fat (Solid)**
- **Plant Oils (Liquid)**

Fats (solid Triacylglycerol) Oil (a liquid Triacylglycerol)



Occurrence/Distribution Of TAG

□ TAG is a most widely distributed abundant natural lipid.

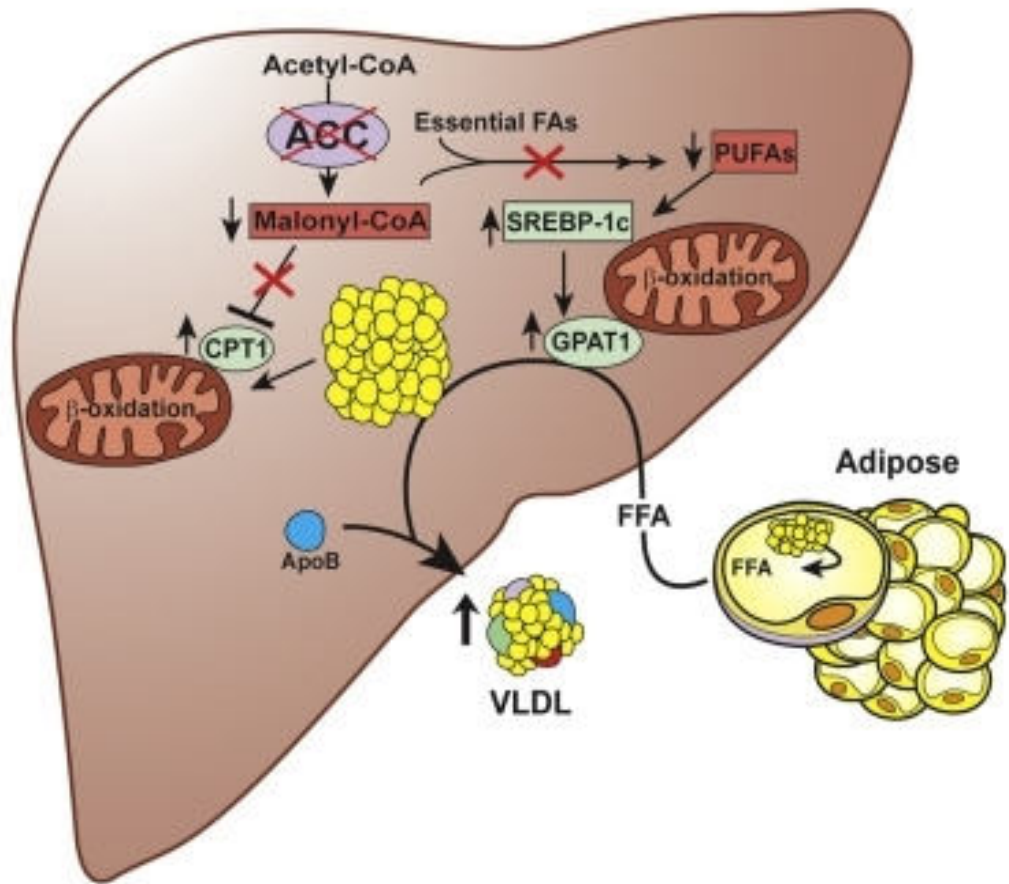
TAG Major Lipid Form Of Human Body

—Predominant Lipid ingested in Human diet is TAG 98%.

—Abundant Lipid of human body Lipid is TAG 95 %.

Transportation Of TAG in blood is By Lipoproteins

- » **Chylomicrons :**
- » Transports exogenous dietary TAG
- » **VLDL:**
- » Transports endogenous TAG



Biomedical Importance Of TAG

Triglycerides

Act as a source of energy

Protect internal organs from jarring trauma

S.No	Distribution/Location Of TAG in Human Body	Role of TAG
1	Predominant Dietary Form of Lipid Ingested in GIT	Dietary and Calorific Value- Secondary Source of Energy
2	Adiposecytes/Depot Fat- Exclusively TAG	Reservoir of Energy
3	Subcutaneous layer /Below Skin	Insulating Effect, Regulates Body Temperature
4	Fat Pad around Internal Soft Visceral Organs	Mechanical Shock absorbers

1.TAG Serves As Source Of Energy

- TAG has **high calorific value (9Kcal/gram)** more than Carbohydrates (4 Kcal/gram).

2.TAG Reservoir Of Energy

Storage form of **Lipid** in
human body is **TAG**.

Triacylglycerols In Its Structure

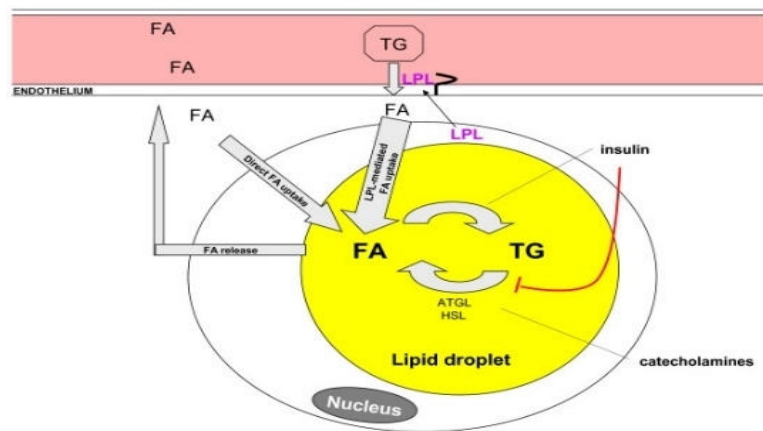
Links and Stores Fatty acids

- Fatty acids are **not stored in free form** in living beings.
- Fatty acids are stored in bound form as TAG.
- Thus **TAG** is a storage form of Fatty acids .

Criteria's For TAG To Be Chosen As Reservoir of Energy

- TAG is **highly reduced and anhydrous** form.
- Hence **chosen as energy reserve** of the body.

- **Because of insolubility of TAG in aqueous phase:**
- Body TAG are mostly found in **isolated compartments as droplets.**
- **TAG in anhydrous form** is packed in **Adipocytes (Depot Fat)**



**3.Store House Of TAG
is High
In Comparison To
Glycogen Stores**

- Hydrated molecules requires more space.
 - **TAG stored in anhydrous** form requires **less space**.
 - In contrast **Glycogen being hydrated** requires more space.
(1 gm of Glycogen binds with 2gm of water)
-
- **TAG When excess serves as an **energy reservoir** stored in Adipocytes as :**
 - Anhydrous form**
 - Concentrated**
 - Unlimited amount**

- Stores of TAG are utilized in **between meals** and **starvation phase**.
- A good storage of depot Fat can suffice for 2-3 months in **starvation condition**.
- The stored TAG is used as long term energy source for body activities.
- In **long marathon race** energy for muscle activity is provided by the hydrolysis of depot TAG.

4. TAG Regulates Body Temperature

- The **subcutaneous Fat** layer is a TAG
- TAG is a **bad conductor of heat and electricity** and serves as a **thermal and electrical insulator.**
- Which prevents loss of heat from the body and plays important role in **regulating body temperature.**

5.TAG Protects Internal Visceral Organ and Systems

- A presence of **Fatty (TAG) pad** around the **soft delicate internal visceral organs**
- **Protects from mechanical trauma or injury** by acting as a shock absorber.

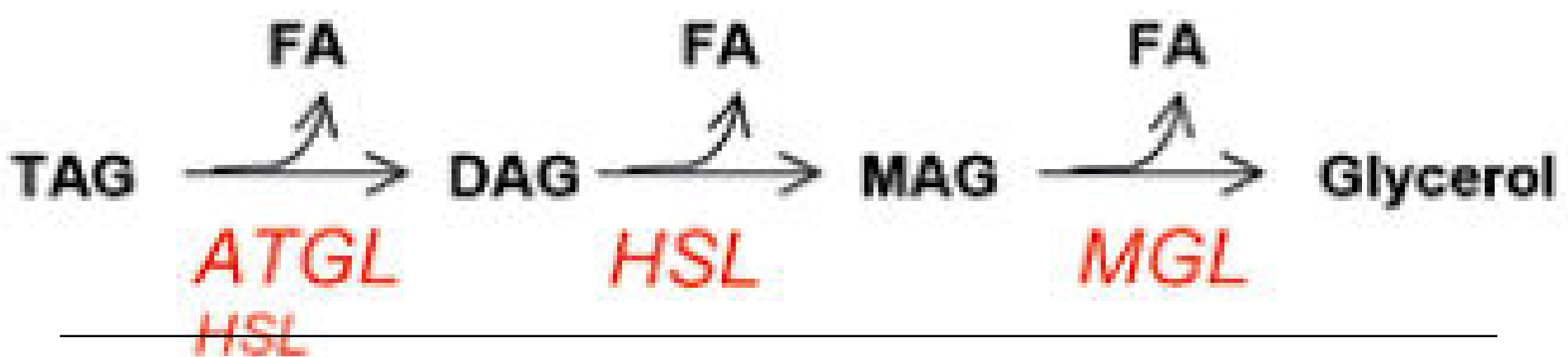
- TAG provides shape to body and
- Keep skin smooth and supple.



Remember TAG is
not associated to
biomembranes.

- **MAG and DAG are derived Lipids.**
- **Monoacylglycerol and Diacylglycerol are hydrolytic products of Triacylglycerol.**
- These are produced during **TAG metabolism** in the body.

- **Monoacylglycerol (MAG) / (Monoglycerides):** A Glycerol esterified with one fatty acid.
- **Diacylglycerol (DAG) (Diglycerides):**
 - A Glycerol esterified with two fatty acids.



Healthy TAG In Human Body

- Ingesting Natural Mixed Form – PUFAs and Short chain FAs
- Avoiding Trans Fats
- Balanced/Moderate ingestion
- No excess or deficient TAG stores
- Normal serum TAG levels < 150 mg%

Disorders Associated To TAG

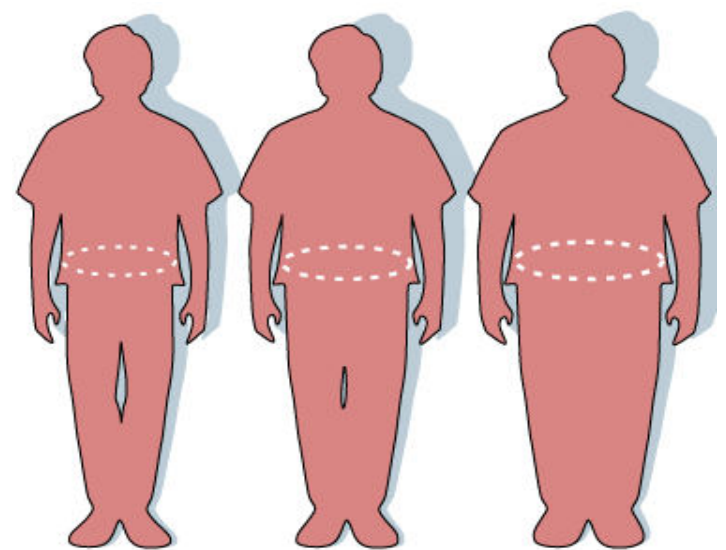
Triglyceride Levels

Normal, Borderline, High, Very High

Interpretation	Level mg/dL	Level mmol/L
Normal range, low risk	<150	<1.69
Borderline high	150-199	1.70-2.25
High	200-499	2.26-5.65
Very high: high risk	>500	>5.65

Bad About : TAG/ Fats and Oils

- Excess Fat leads to **Obesity**
- Increases risk for **Diabetes Mellitus**
- Leads to Coronary Artery disease
- MI, Stroke
- **Susceptible to Cancer**



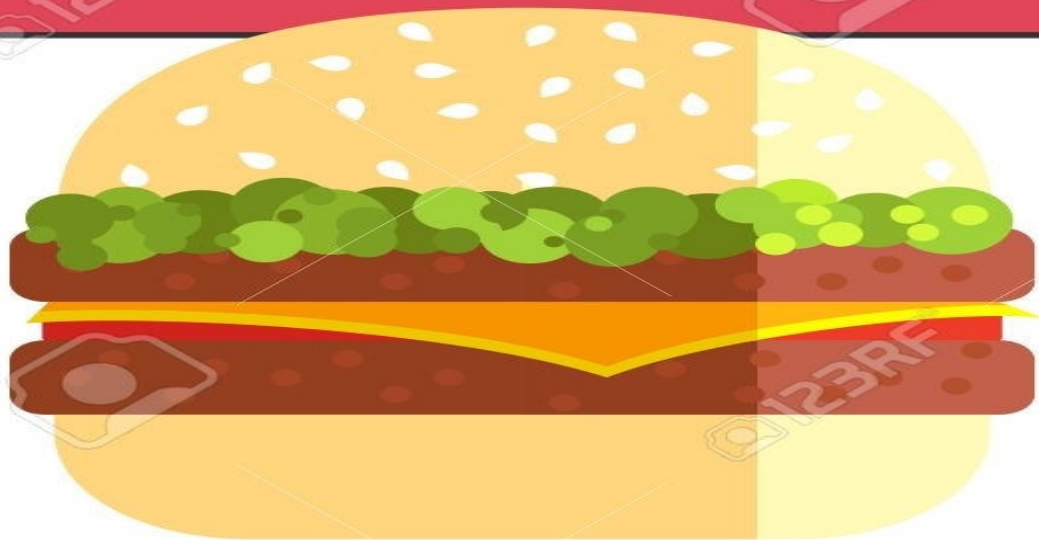
Disorders Related To TAG

-
- A word cloud shaped like a map of the United States, featuring terms related to obesity and health. The most prominent words are 'obesity', 'overweight', 'dieting', 'unhealthy', 'fat', 'nutrition', 'exercise', 'mass', 'large', 'control', 'fitness', 'junk', 'balance', 'danger', 'overeating', 'care', 'lifestyle', 'diet', 'weight', 'happier', 'weight', 'unhappy', 'weight', 'unhappy', 'weight', 'unhappy'. The words are arranged in a way that they fit the geographical shape of the country, with 'obesity' and 'overweight' being the largest and most central. Other words like 'dieting' and 'unhealthy' are also quite large and prominent. The colors of the words vary, with some in blue, some in orange, and some in green, adding visual interest to the cloud. The background is white, making the words stand out clearly.

OBESITY IS NOW A GLOBAL EPIDEMIC!



JUNK FOOD & OBESITY INFOGRAPHIC



80% PEOPLE
EAT JUNK FOOD ON A DAILY BASIS



360 000 AMERICANS
DIE EACH YEAR FROM DISEASES
DIRECTLY RELATED TO OBESITY
AND AN UNHEALTHY LIFESTYLE

CHILDREN WALKING TO SCHOOL BY FOOT



ONLY 19% OF PEOPLE
GET THE RECOMMENDED AMOUNT OF PHYSICAL ACTIVITY

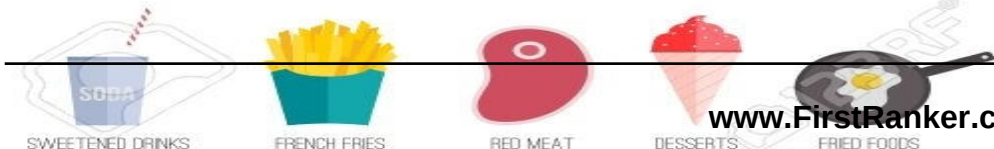
OVERWEIGHT BY ETHNICITY/RACE



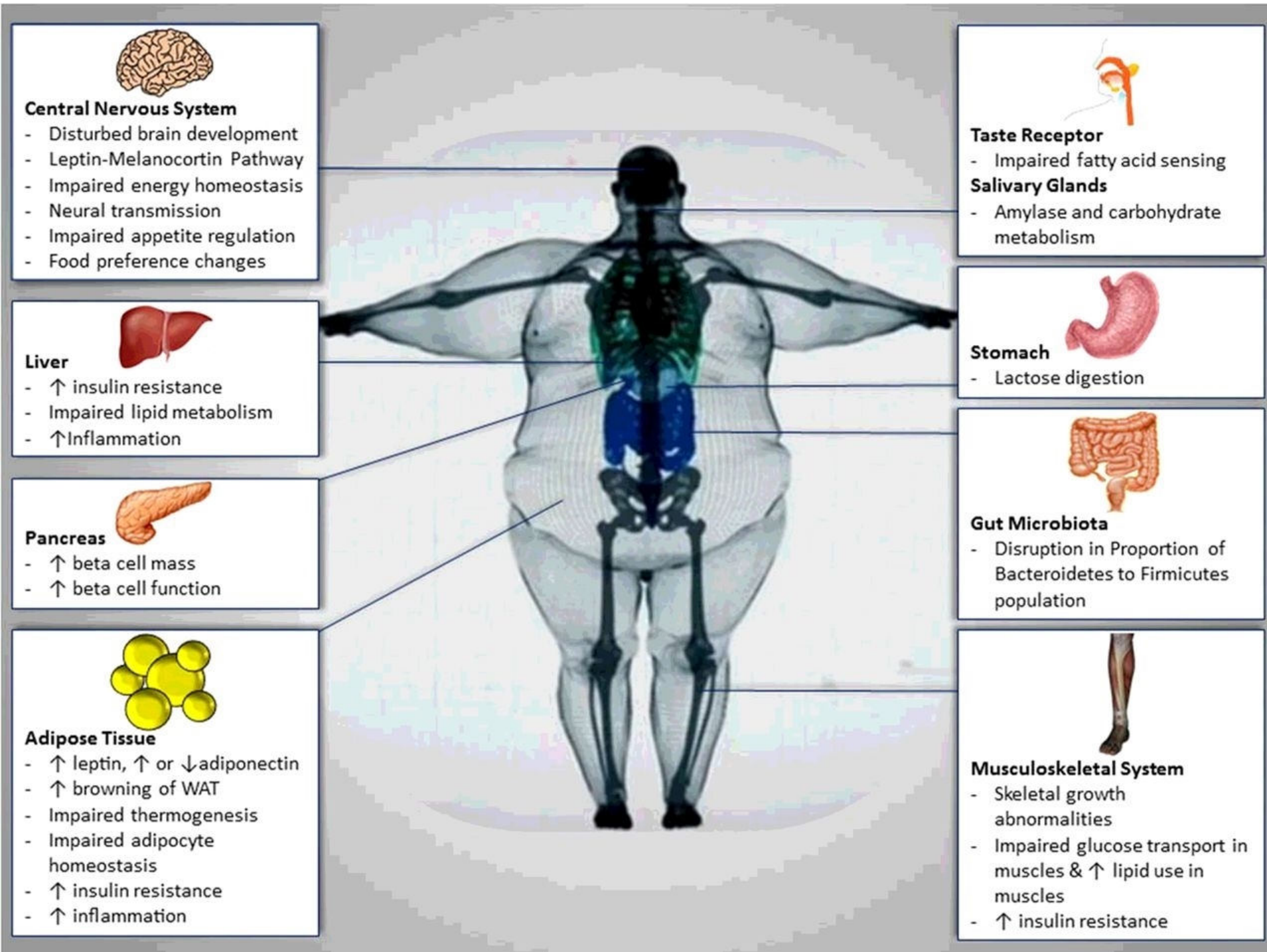
CALORIES CONSUMED PER DAY BY ADULTS



MAIN SOURCES OF EMPTY CALORIES



EVERY 5TH CHILD IN THE WORLD
IS OVERWEIGHT OR OBESE



• Obesity has **excess fat depots.**

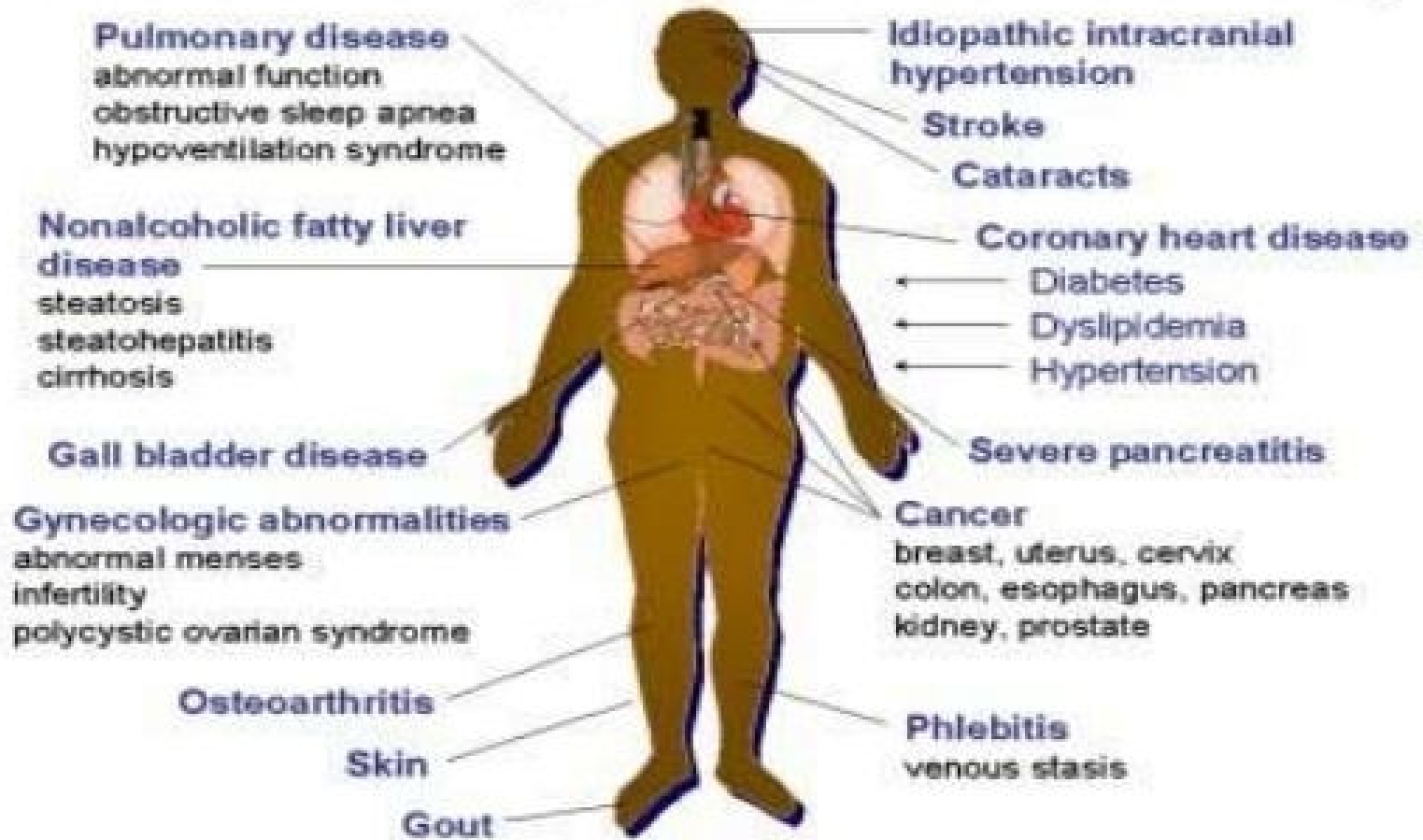
• **Truncal/central obesity** is a risk factor for heart attack.



- **Obesity** has abnormal Lipid metabolism.
 - Increased Blood Cholesterol and Lipoproteins.
-
- ❖ Obese persons has **high risk of**
 - ❖ **Diabetes mellitus**
 - ❖ **Atherosclerosis and CVD**
 - **Consequently lead to**
Metabolic Syndrome

Problems related to obesity :

Medical Complications of Obesity



Prevent Obesity



PREVENT OBESITY



AVOID STRESS

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.



EAT MORE FRUITS AND VEGETABLES

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.



GET ENOUGH SLEEP

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.



GET RID OF BAD HABITS

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.



STOP EATING FAST FOOD

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.



DRINK ENOUGH WATER

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.



DO PHYSICAL EXERCISES

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.



LESS TV

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.

Properties Of Triacylglycerol

Lipid Peroxidation (autoxidation)

Lipid Peroxidation

Is a source of Higher Free Radicals

- During Oxygen metabolism in body.
- Oxygen derived free radicals ($RO\cdot$, $OH\cdot$, $ROO\cdot$) with unpaired electrons are released.
- These Reactive Oxygen Species (ROS) , Free radicals interact and oxidize double bonds of PUFAs leads to chain reactions of lipid peroxidation.

- **Steps of Lipid peroxidation reaction:**
 - Initiation
 - Propagation
 - Termination
- **PUFAs are more prone for peroxidation.**
- **Lipid peroxidation Provide continuous Free radicals.**
- **Thus has potentially devastating effects in the body.**

- **In vitro peroxidation of Lipids**
deteriorates the quality of
Fats and Oils

- Makes the Fat/Oil **rancid and inedible.**
- Fat/oil has **bad taste and odor**
- **Decreases the shelf life of Fats and Oils.**

- **In vivo peroxidation of**
membrane Lipids damages cells & tissues

- Lipid peroxidation has devastating effects on body Lipids.
- Increases risk of Inflammatory diseases
- Ageing
- Cancer

- **Antioxidants control and reduces**
In vivo and In vitro Lipid peroxidation.
- **Naturally occurring antioxidants** are :
 - Vitamin E
 - Vitamin C
 - Beta Carotene
- **Body Enzymes as Antioxidants:**
 - Catalase
 - Glutathione Peroxidase
 - Superoxide Dismutase
- **Other Substances as Antioxidants:**
 - Urate
 - Bilirubin

- **Food Additives as Antioxidants:**

- Alpha Naphtol
- Gallic Acid
- Butylated Hydroxy Anisole (BHA)
- Butylated Hydroxy Toluene (BHT)

- **Preventive Antioxidants:**

- Reduces rate of Chain initiation of Lipid peroxidation
 - Catalase
 - Peroxidase
 - EDTA
 - DTPA

- **Chain Breaking Antioxidants:**
- Interferes the chain propagation of Lipid peroxidation.
 - Vitamin E
 - Urate

Rancidity Of Fats/Oils

Factors Causing Rancidity

- **Double bond** containing /Unsaturated Fatty acids are **unstable** and **ready** for **peroxidation and rancidity**.
- **Single bond** containing/Saturated Fatty acids are **stable and less peroxidized and made rancid**.

PUFAs are more prone to Rancidity

**Since Double bonds are
more susceptible to Lipid
peroxidation**

Causes Of Rancidity

- Fats and Oils get **Rancid on Ageing.**
- Various **Factors aggravates rancidity** of Oils and Fats:
- **Improper handling by an exposure to:**
 - Light
 - Air (Oxygen)
 - Moisture
 - Microbes

Types and Mechanism Of Rancidity

Types Of Rancidity

- **Oxidative Rancidity**
- **Hydrolytic Rancidity**
- **Ketonic Rancidity**

- **Oxidative Rancidity:**

- PUFAs having **double bonds** are easily oxidized to form its peroxides.
- By the action of **Oxygen Derived Free radicals (ODFR)**.

- The **cellular Lipids** are also likely to **get peroxidized** by **Free radical action** causing damage to biomembranes.

- **Hydrolytic Rancidity:**

- Long Chain Saturated fatty acids are **hydrolyzed** by **Bacterial Enzymes** .
- To produce **Dicarboxylic acids, Aldehydes, Ketones** etc which make a Fat rancid.

Ketonic Rancidity

- It is due to the **contamination** with certain **Fungi** such as **Asperigillus Niger on Oils** such as Coconut oil.
- **Ketones, Fatty aldehydes, short chain fatty acids and fatty alcohols** are formed.
- **Moisture accelerates Ketonic rancidity.**

- Rancidity gives bad odor and taste to rancid Fats/oils.
- **Due to Dicarboxylic acids ,Ketones , Aldehydes Produced during the process of**

Prevention of Rancidity of Fat/Oil By :

- ☐ **Good storage conditions**
- ☐ **Less Exposure to light**
- ☐ **Low Oxygen, moisture**
- ☐ **No very High temperatures**
- ☐ **No Bacteria or fungal contamination**
- ☐ **Addition of Antioxidants**

Prevention Of Rancidity

- Rancidity can be prevented by **proper handling of oils**
- By keeping fats or oils in **well closed containers in cold, dark and dry place.**

Prevention Of Rancidity

- Avoid** exposure to **direct sunlight, moisture and air.**
- Avoid over** and **repeated heating** of oils and fats.

- **Removal** of catalysts such as **Lead** and **Copper** from Fat/Oils that **catalyzes rancidity** prevents rancidity.

Antioxidants Prevent Rancidity

- Antioxidants are **chemical agents which prevent peroxidation and Hydrolysis of Fats/Oils.**

- **Examples Of Antioxidants:**

- Tocopherol(Vitamin E)
- Vitamin C
- Propyl Gallate
- Alpha Naphthol
- Phenols
- Tannins
- Hydroquinone's.
- Butylated Hydroxy Anisole(BHA)
- Butylated Hydroxy Toluene (BHT)

- **The most common natural antioxidant is vitamin E that is important in vitro and in vivo.**

- www.FirstRanker.com**

Hazards of Rancid Fats:

1. Rancidity **destroys the content of polyunsaturated essential fatty acids.**
2. Rancidity causes **economical loss** because **rancid fat is inedible.**
3. The products of rancidity are **toxic, i.e., causes food poisoning and cancer.**
4. Rancidity **destroys the fat-soluble vitamins** (vitamins A, D, K and E associated with it).

Others Properties Of TAG
Depends On Nature Of Fatty Acids

Chain Length Of Fatty acids Of TAG affects Melting Point

- “Hardness” of the Fat/TAG depends on chain length.
 - < 10 carbons in Fatty Acid = liquid
 - >20 carbons in Fatty Acid = solid

Acetic Acid (2 C)	Vinegar	Liquid
Stearic Acid (18 C)	Beef Tallow	Solid
Arachidic Acid (20 C)	Butter	Solid
	www.FirstRanker.com	

Differences In Fat and Oil

- Fat and Oils are **different in Physical Characteristics**
- **Fat is solid at room temperature.**
- **Oil is liquid at room temperature.**
- **TAG of Fat is solid** since chemically composed of **long and saturated fatty acids.**
- **Source of Fat is Animal foods.**
- **TAG of Oil is liquid** as composed of **short and unsaturated fatty acids.**
- **Source of Oil is plant.**

Fat

Carboxyl group



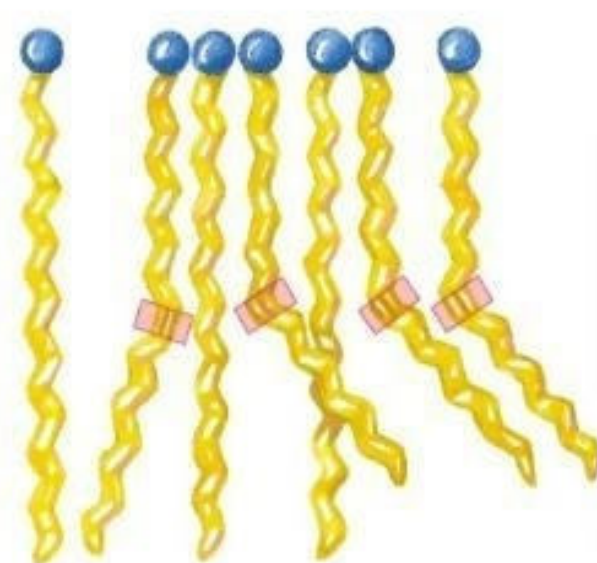
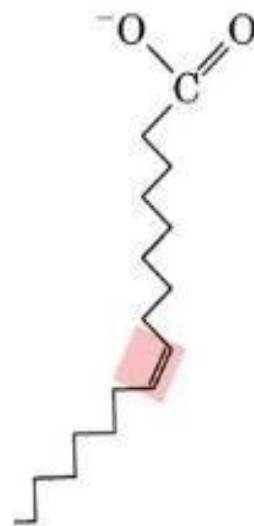
Hydrocarbon chain



Saturated fatty acids



Oil



Mixture of saturated and unsaturated fatty acids



Hydrogenation Of Fat/Oil

- Treatment of Oils(TAG) rich in PUFAs with Hydrogen gas, (H_2).
- Catalyst required (Nickel).
- Adding Hydrogen at double bonds of PUFAs.
- It is also called “Hardening of Oils”
- Hydrogenation converts PUFAs with cis form to trans form.
- Margarine
 - Vanaspati Dalda Crisco, Spry, etc.



Advantages and Disadvantages Of Hydrogenation Of Fat /Fatty acids

Advantages Of Fat Hydrogenation

- Hydrogenation transforms **unstable ,unsaturated , liquid TAGs:**
 - To stable, saturated, solid TAGs
 - Reduces risk of Rancidity
 - Increases shelf life and business.
 - Example : Vanaspati Dalda ,Margarine.

Disadvantages Of Hydrogenation Of Fat/Fatty acids

Trans Fats increases the risk of Atherosclerosis and CVD.

- Hydrogenated **trans Fats** are more stable.
- Body has no enzyme system to oxidize and metabolize trans fatty acids.

• Remember Hydrogenated Fats are Bad for Health.

- **Summary Of Fat Hydrogenation:**
- **Hydrogen atoms are added to unsaturated Fatty acids**
 - **Make liquid oils more solid and more saturated.**
 - Create *trans* fatty acids.
 - Reduces peroxidation of Fatty acids.
 - Resists rancidity
 - Reduces metabolism
 - Increases retention
 - Increase risk of cardiovascular disease.

- **Note**
- Try eat more natural TAGs.
- Avoid Processed Fats.

Tests To Check Purity Of Fat and Oil

- Several laboratory tests are employed to:
 - Check the purity
 - Degree of adulteration
 - **Biological value of Fat and Oils.**

Tests to Check Purity of Oils and Fats

Tests To Check Purity of Oils	Importance/Significance
Iodine Number	Index of unsaturation and content of unsaturated fatty acids
Saponification Number	To know Chain Lengths of Fatty acids
Acid Number	Checks purity of Refined oils
Reichert Meissl (RM) Number	Useful in testing the purity of butter

Iodine Number

- Iodine number is Grams/Number of Iodine absorbed by 100 gram of Fat /Oil .
- Iodine Number is calculated by method of Iodometry.

Use Of Iodine Number

- Iodine number is useful to know
- The **index of unsaturation and content of unsaturated fatty acids** present in the Fat/Oil.
- Iodine number is **directly proportional to unsaturated bonds of PUFAs** in a Fat/Oil.
- High value of Iodine number of oil **indicates more content of Unsaturated Fatty acids** in it.

Name Of Oils	Iodine Number
Coconut Oil Butter	7-10 (Least) 25-28
Ground Nut Oil	85-100
Sunflower Oil Soya bean Oil	125-145 135-150
Linseed Oil /Flax seed Oil	175-200 (Highest)

- Determination of Iodine number **helps in knowing the degree of adulteration** of tested oil sample.
- If **Linseed oil is adulterated** with an oil whose content is high in **saturated fatty acids** will **give lower Iodine number than the reference values.**

Saponification Number

- Saponification number is **milligram/number of KOH molecules required to hydrolyze and saponify one gram of Fat/Oil.**
- Saponification number gives the **idea of molecular size/chain length of Fatty acids** present in 1 gram of Fat.
- 1 gram of Fat/oil with **long chain fatty acids** has **lower saponification number.**
- 1 gram of oil containing **short chain fatty acids** has **high Saponification number.**

- www.FirstRanker.com**

Oils	Saponification Number
Coconut Oil	250-260
Butter	230-250
Jojoba Oil	69- 80
Olive Oil	135-142

Acid Number

- Acid number is milligram of KOH required **for complete neutralization** of **free fatty acids** present in one gram of Fat/Oil.
- Acid number checks the **purity of Refined oils.**

- Refined oils are free from free fatty acids and has zero Acid number.
- Increased Acid number of refined oil suggests bacterial/chemical contamination and unsafe for human consumption.

Reichert Meissl (RM)Number

- RM number is **0.1 N KOH** required for complete neutralization of **soluble volatile fatty acids** **distilled from 5 gram of Fat** .

- **R.M Number of Butter is 25-30.**
- **The R.M number of other edible oils is less than 1.**
- **R.M number is useful in testing the purity of butter**
- **Since it contains good concentration of free volatile fatty acids viz: Butyric, Caproic and Caprylic acid.**

- **Adulteration of butter reduces its R.M number.**

Differentiation Between Fats And Oils

Fats	Oils
Fats are TAGs composed of Long and Saturated Fatty acid .	Oils are TAGs composed of short and Unsaturated Fatty acids .
Fats solid at room temperature Fat has high melting point	Oils liquid at room temperature Oils have low melting point
Fats -animal In Origin Example: Lard (pork Fat)	Oils -Plant in Origin Example: Safflower Oil
Fats has low antioxidant content and get easily Rancid	Oils have high antioxidant content and do not get easily Rancid
Fats are more stable Fats are less metabolizable in body.	Oils are less stable Oils are readily metabolizable in the body.
High content of dietary Fats has high risk for Atherosclerosis .	Oils have low risk for Atherosclerosis .

Study Of Compound Lipids

Compound Lipids

- Compound lipids are class of Lipids
- Chemically Esters of Fatty acids with Alcohols attached with Additional groups.
- Additional Groups in Compound Lipids may be either of these:
 - Phosphoric acid
 - Nitrogenous Base
 - Carbohydrate moieties
 - Proteins
 - Sulfate groups

3 Main Compound Lipids

- **Phospholipids**
- **Glycolipids**
- **Lipoproteins**

Phospholipids

Phospholipids

- **Compound Lipids**

- **Components:**

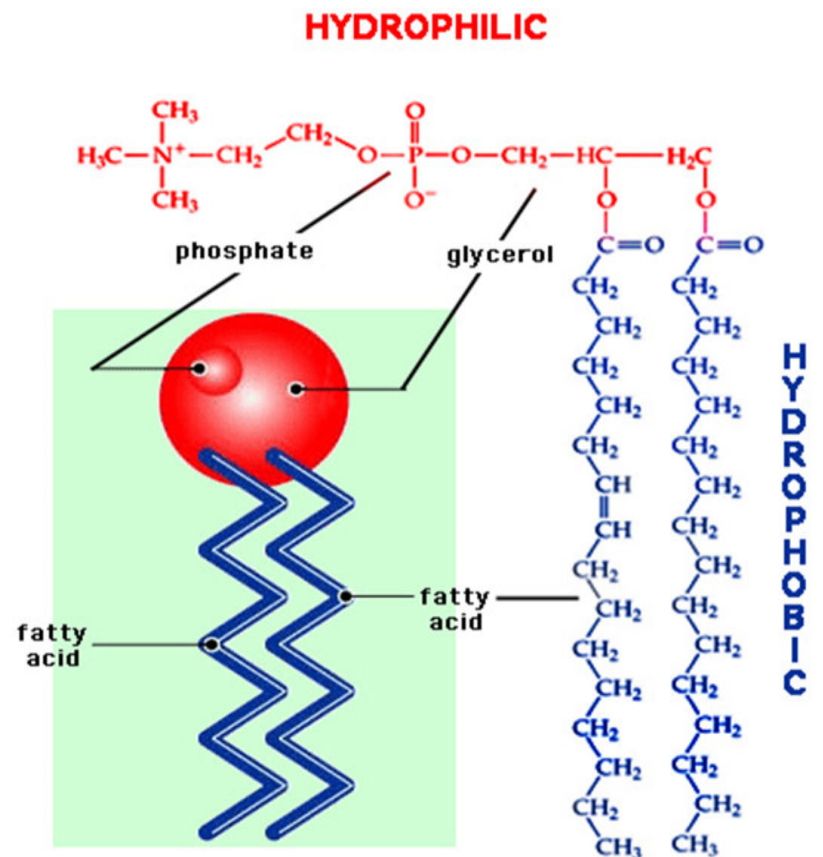
- **Alcohol**- Glycerol/Sphingol
- **Fatty Acids**- PUFAs and SFAs
- **Additional Group**- Phosphoric acid and Nitrogenous /Non Nitrogenous moiety

- **Nature**- Amphipathic

- **Phospholipids (PL) Chemically Possess:**

– **Fatty acids** esterified to **Alcohol** and

– **Phosphoric acid** attached with **Nitrogenous /non nitrogenous base.**



Types Of Phospholipds

Based upon Alcohol

Present in Phospholipid structure

- **Two Types of Phospholipids are :**

- Glycerophospholipids:**

- Glycerol containing Phospholipids**

- Sphingophospholipids:**

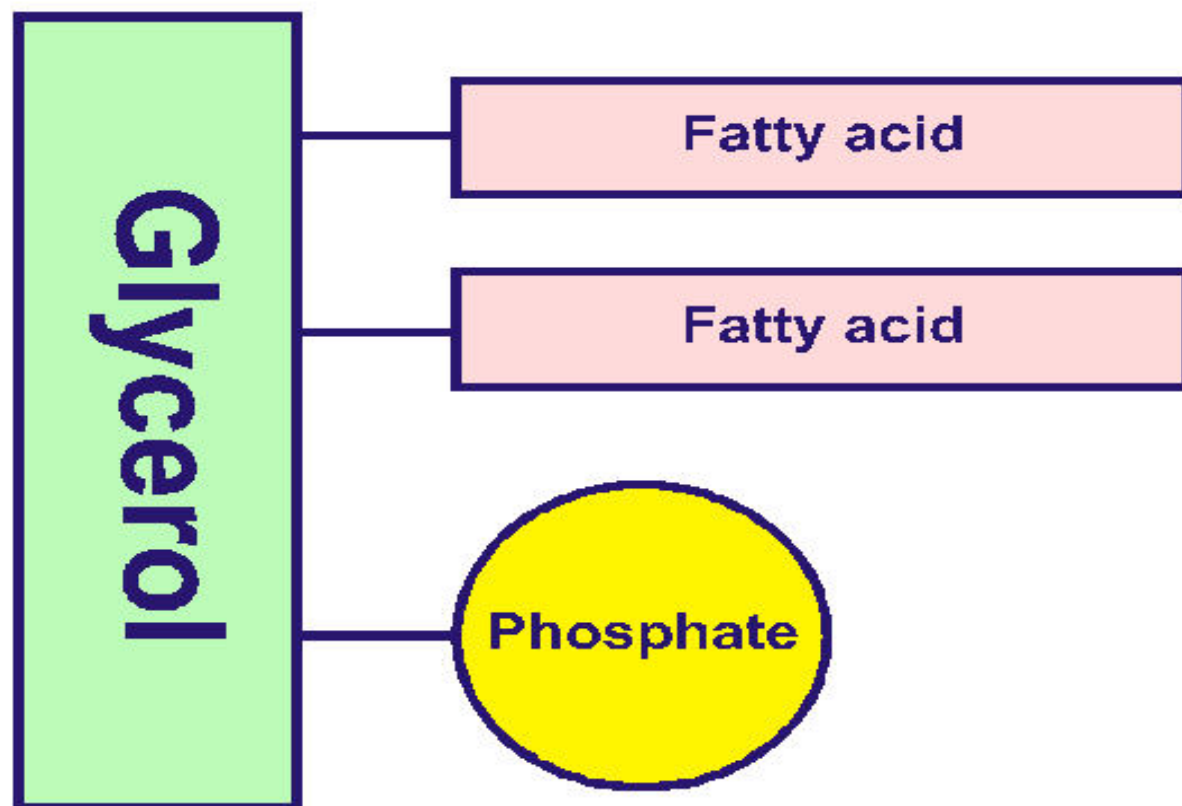
- Sphingosine/ Sphingol containing Phospholipids.**

Glycerophospholipids/ Glycerophosphatides

Names & Structures OF 7 Glycerophospholipids

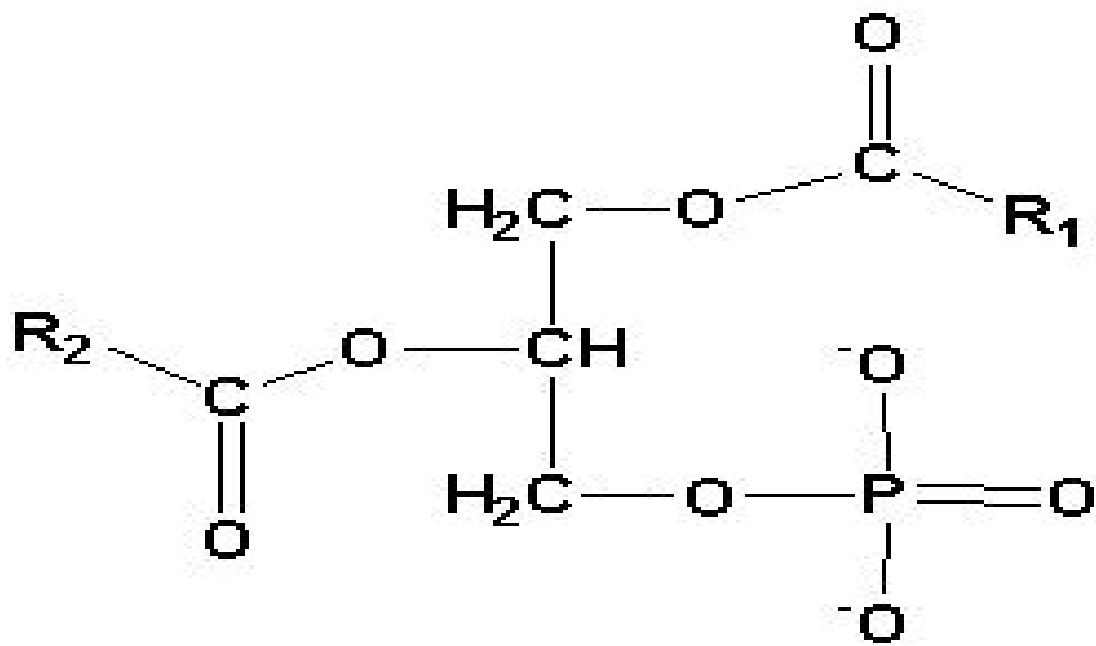
Simplest Glycerophospholipid

PHOSPHATIDIC ACID

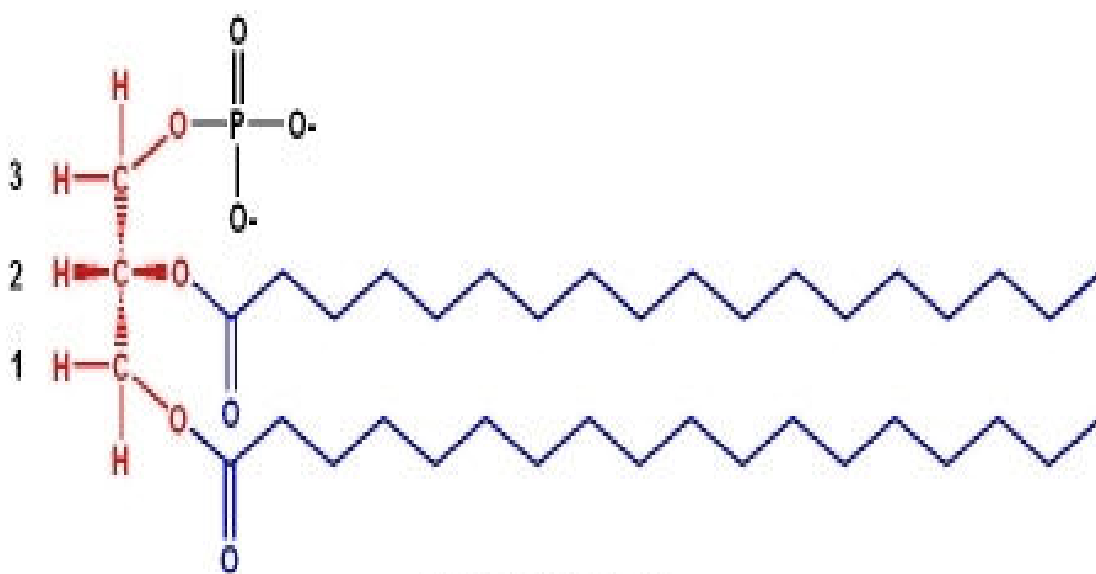


- Depending upon Nitrogenous and Non Nitrogenous moiety attached.

- Examples of 7 Glycerophospholipids are:
 1. Phosphatidic Acid (Simplest PL)
 2. Phosphatidyl Choline (Lecithin)
 3. Phosphatidyl Ethanolamine (Cephalin)
 4. Phosphatidyl Serine (Cephalin)
 5. Phosphatidyl Inositol/ Lipositol
 6. Phosphatidyl Ethanolamine/ Plasmalogen
 7. DiPhosphatidyl Glycerol/ Cardiolipin



Phosphatidic Acid



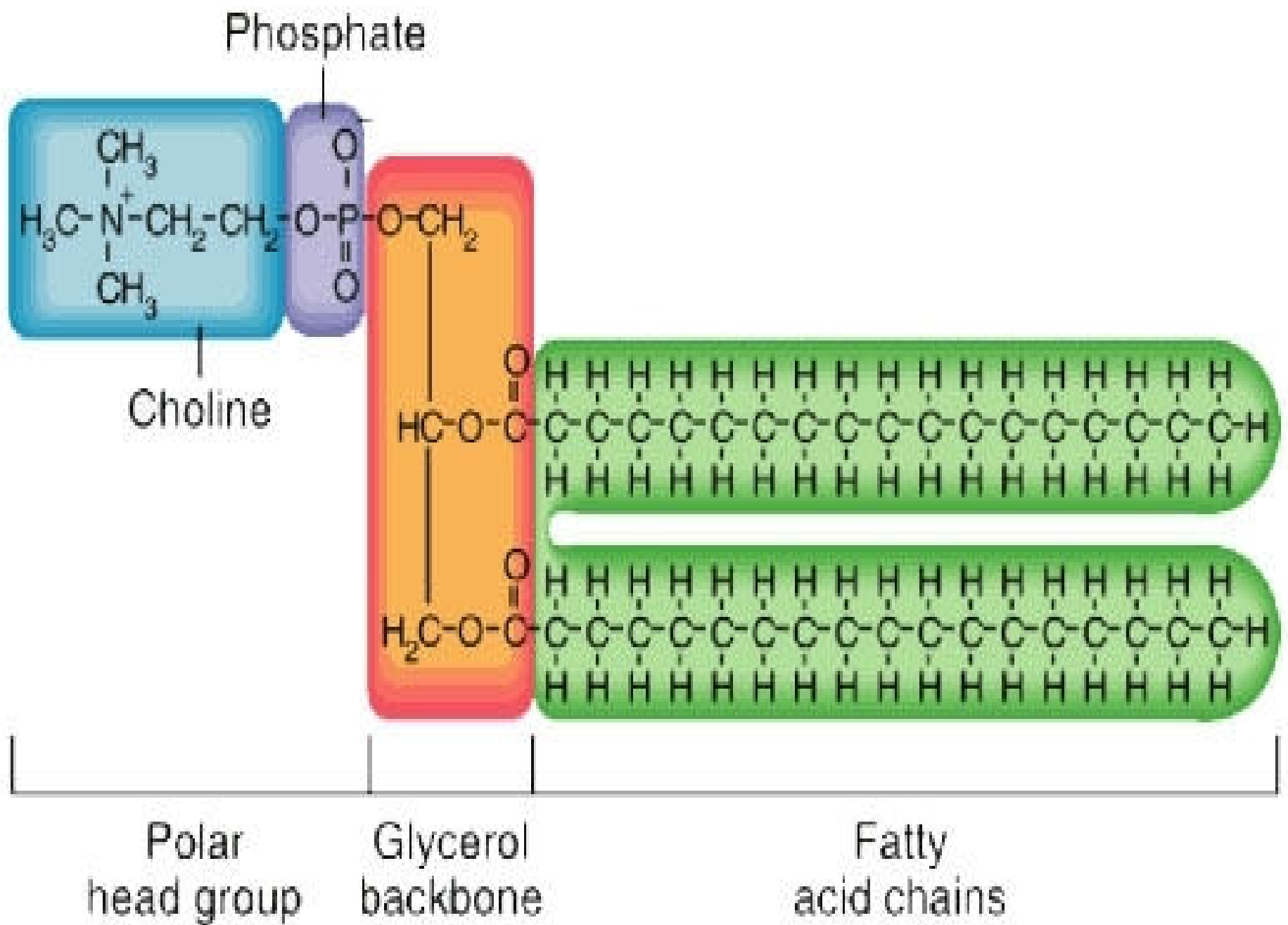
Phosphatidic Acid

Phosphatidic Acid

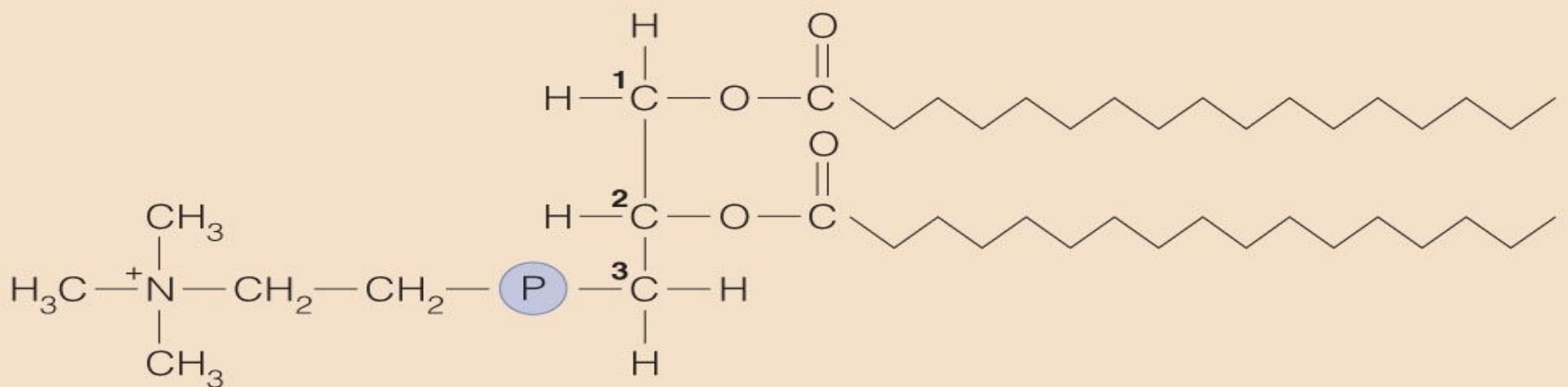
- Phosphatidic acid is a simplest Glycerophospholipid.
- Phosphatidic acid has Glycerol esterified with **two Fatty acids at C1 and C2**.
- C3 is esterified with **Phosphoric acid**.

- Phosphatidic acid **serve as a precursor** for biosynthesis of other **Glycerophospholipids**
- Either by linking of
 - Nitrogenous or
 - Non nitrogenous base**

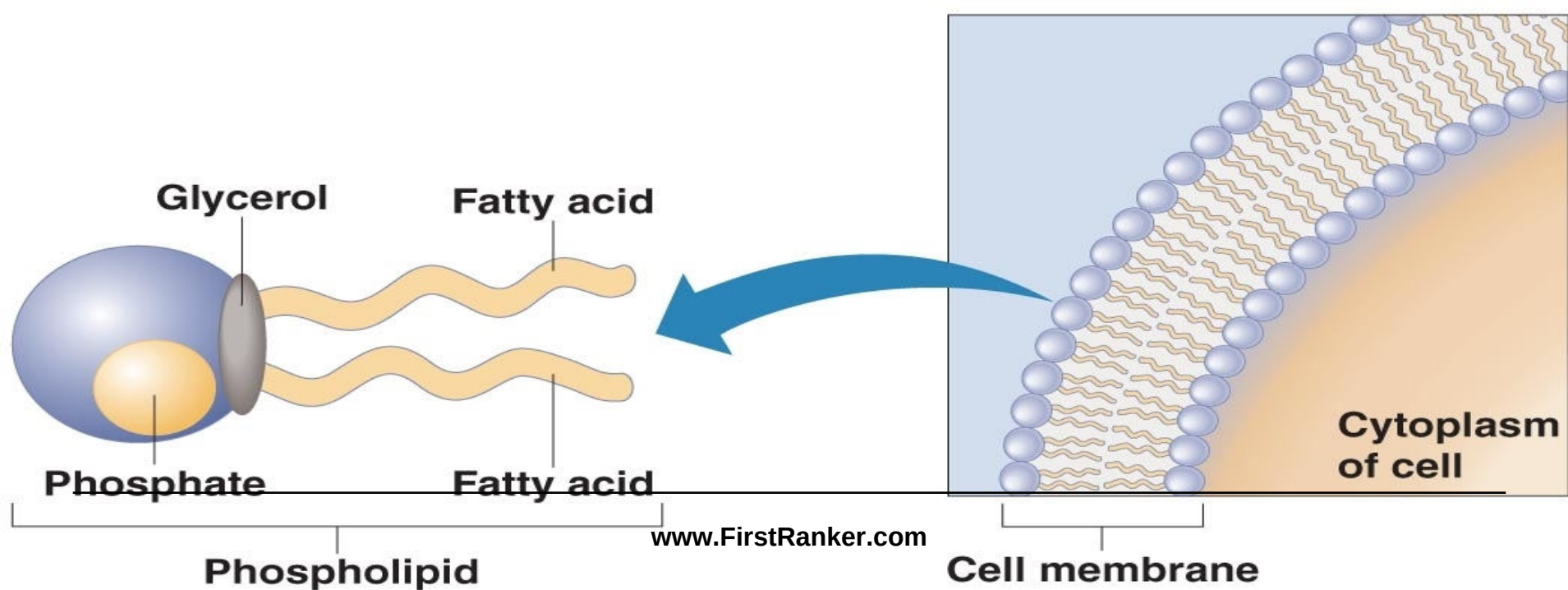
Phosphatidyl Choline/Lecithin



Phospholipid



(a)

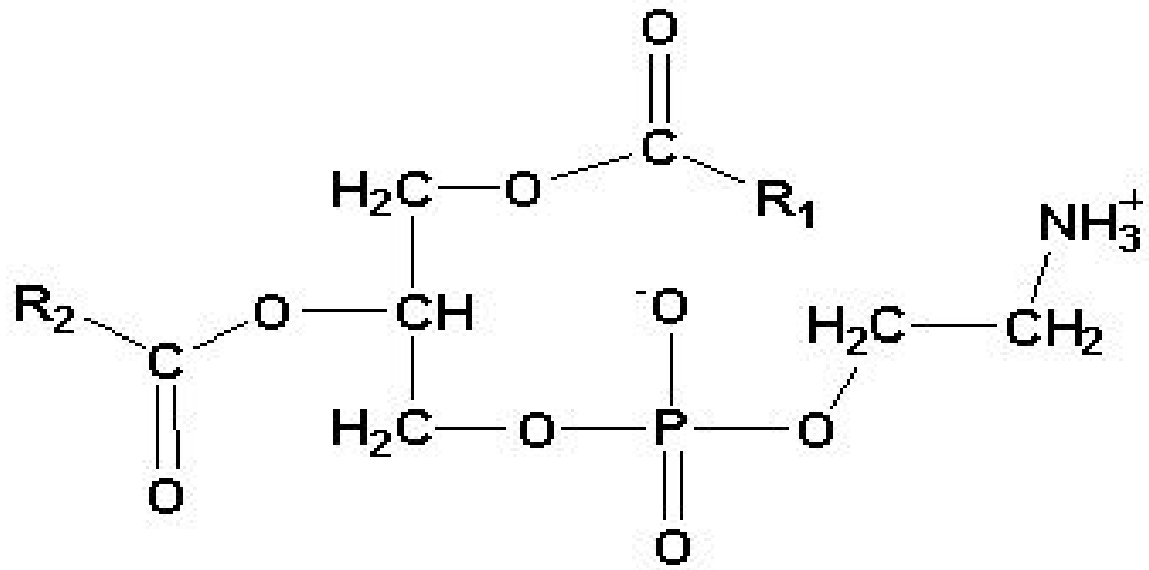


- **Phosphatidyl Choline (**Lecithin**)** is most **commonest** and **abundant** **Glycerophospholipid** in body.
- Phosphatidyl Choline is commonly called as **Lecithin**.
- Derived from word '**Lecithos**' meaning **Egg Yolk**.
- **Phosphatidic acid** is linked to a Nitrogenous base Choline to form **Phosphatidyl Choline**.

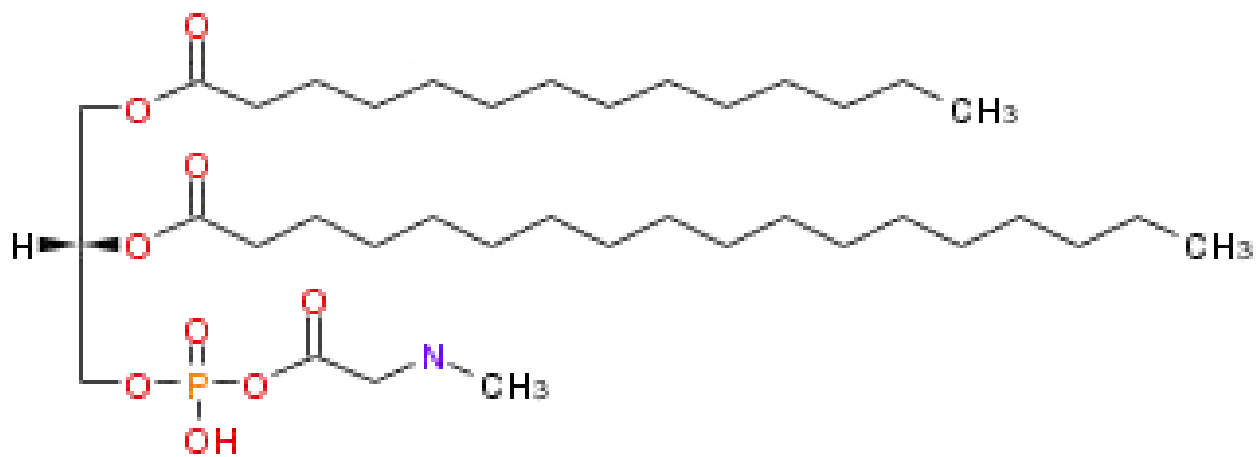
Cephalins

- Type of Glycerophospholipids
- Nitrogen base is **Ethanolamine or Serine.**
- Phosphatidylethanolamine and Phosphatidylserine are **Cephalins.**

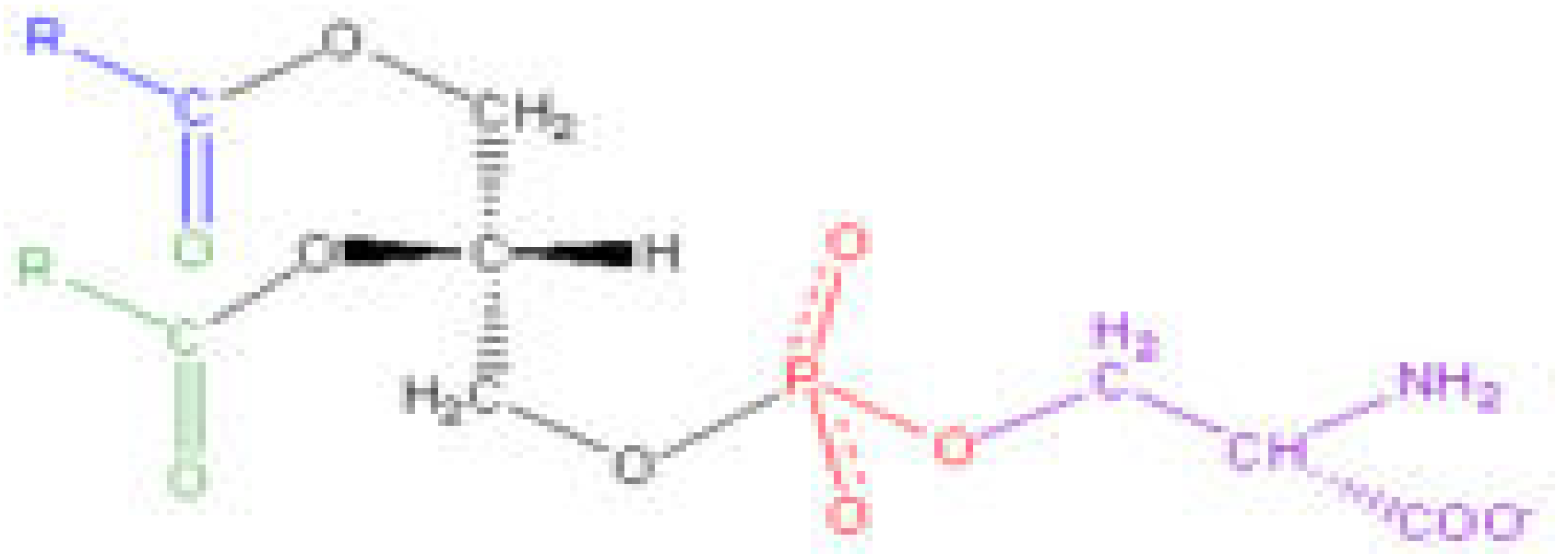
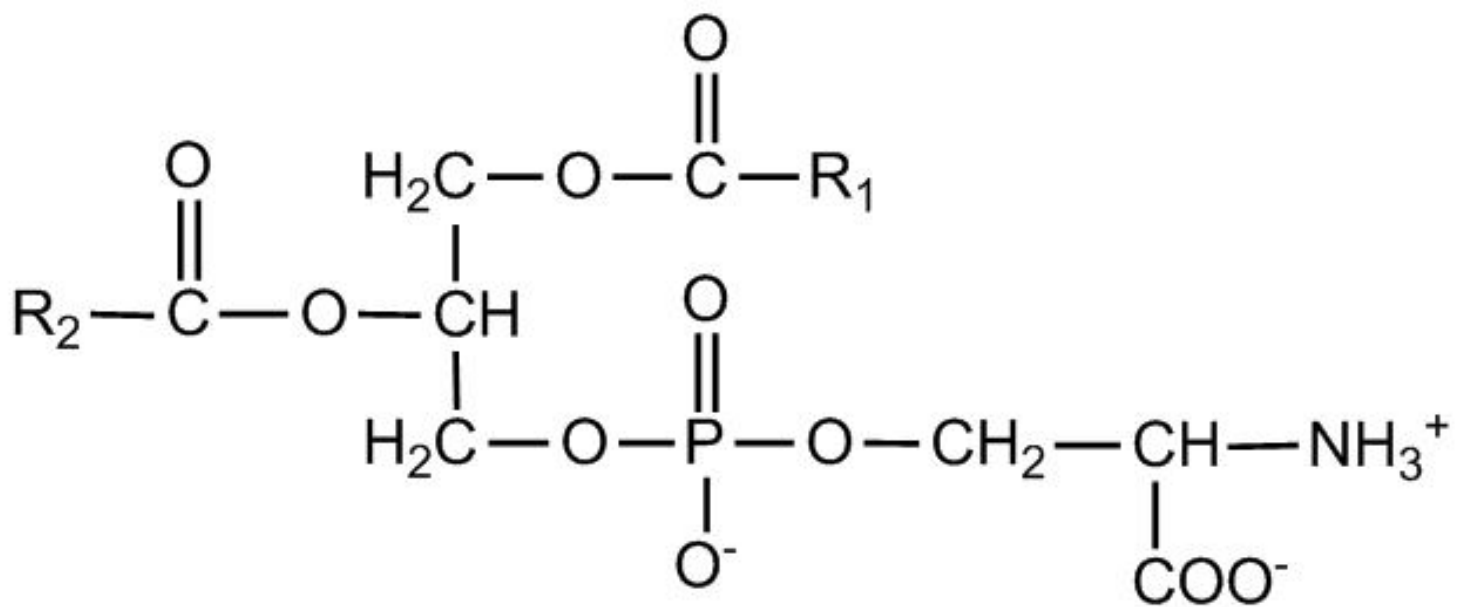
Phosphatidyl Ethanolamine



Phosphatidylethanolamine

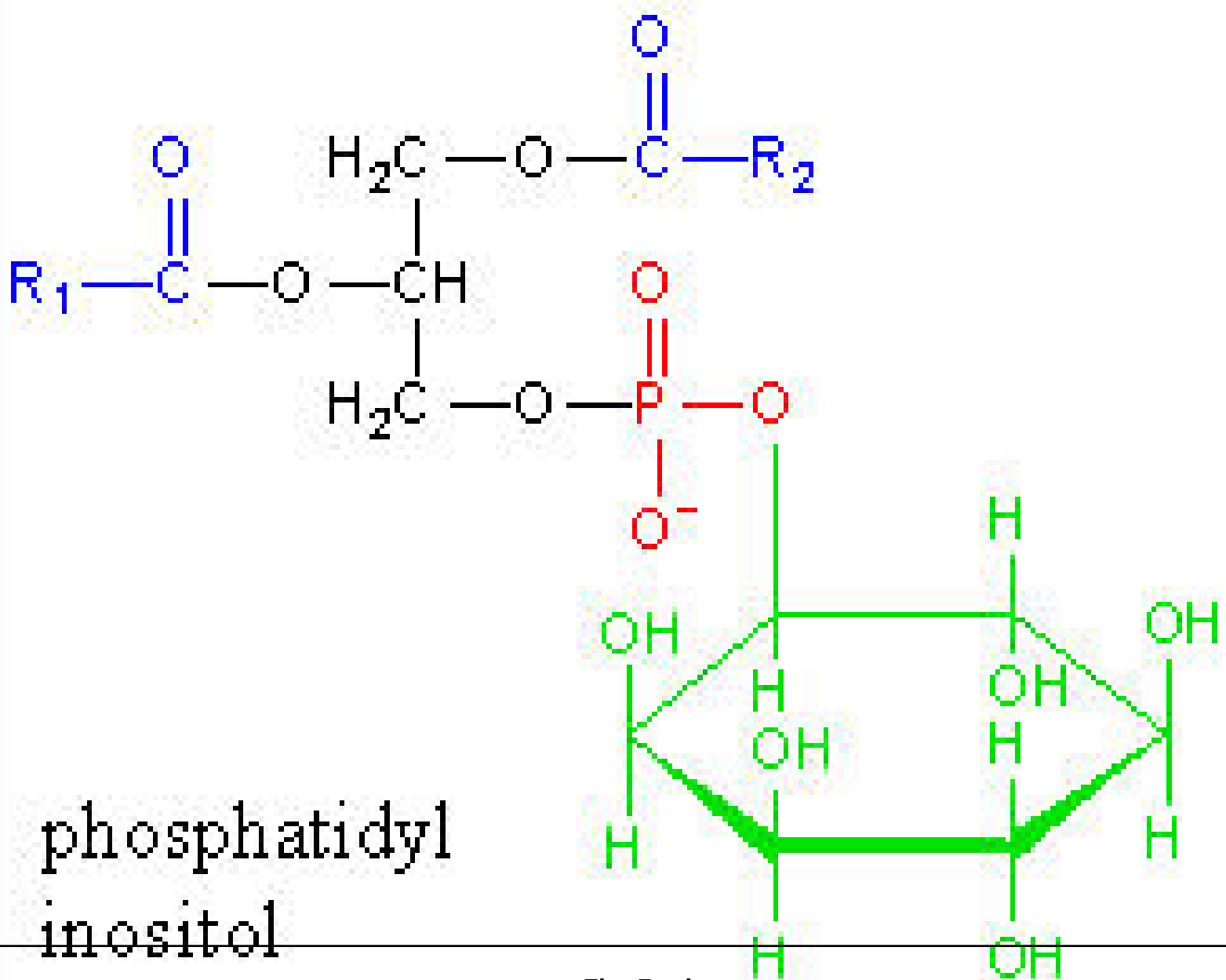


Phosphatidyl Serine

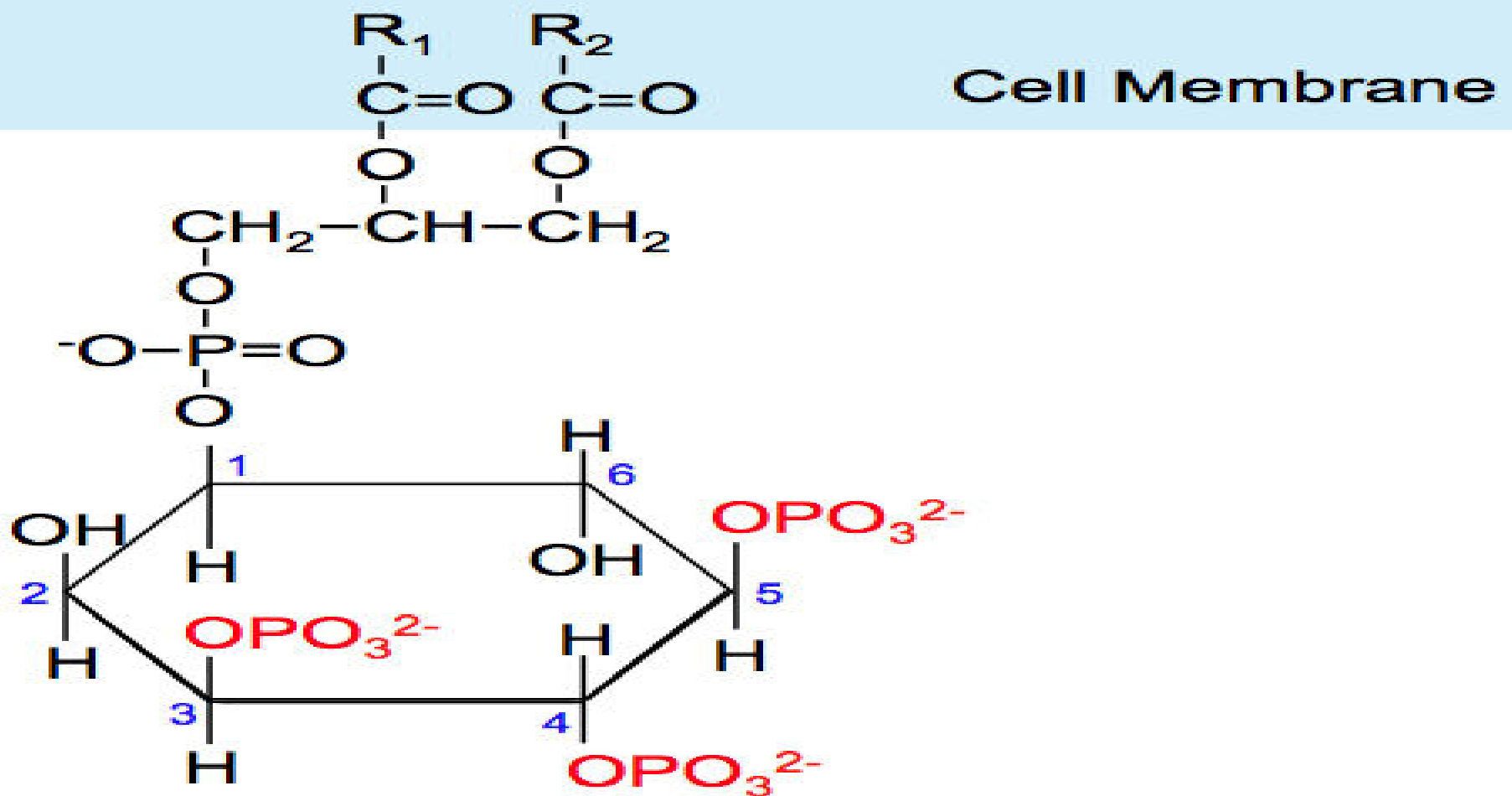


- An Amino acid **Serine** linked to **Phosphatidic acid** forms **Phosphatidyl Serine**.

Phosphatidyl Inositol/ Lipositol



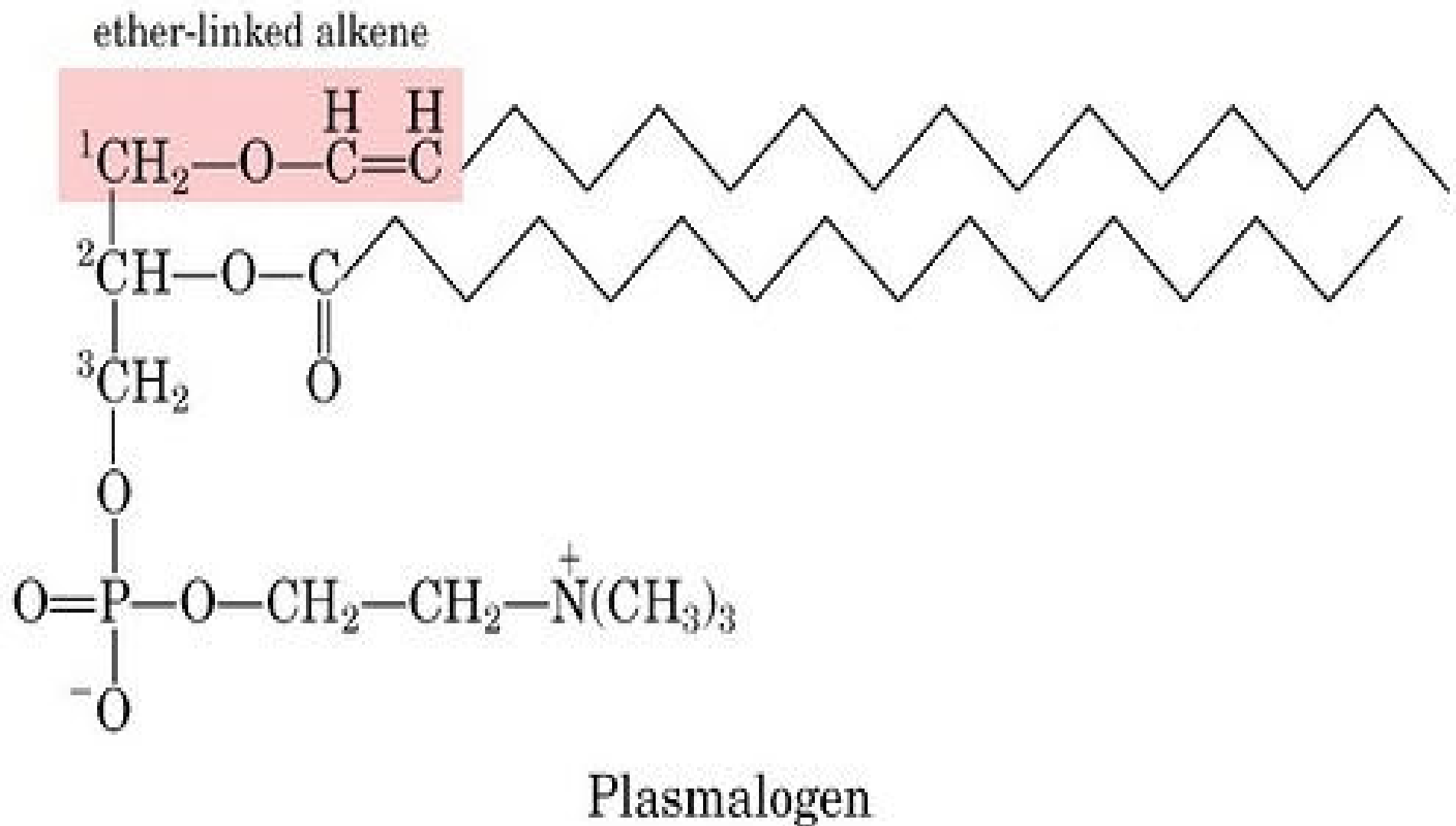
Phosphatidyl Inositol Tri Phosphate (PIP3)



- Inositol/Myo Inositol a **Polyol** derived from **Glucose**
- Non Nitrogenous ,
Carbohydrate Derivative.
- Inositol linked to Phosphatidic acid forms **Phosphatidylinositol**.

- **Phosphatidyl Inositol 3,4,5 Tri Phosphate (PIP3) in presence of enzyme **Phospholipase C****
- **Generates Diacyl Glycerol and Inositol Tri Phosphate.**

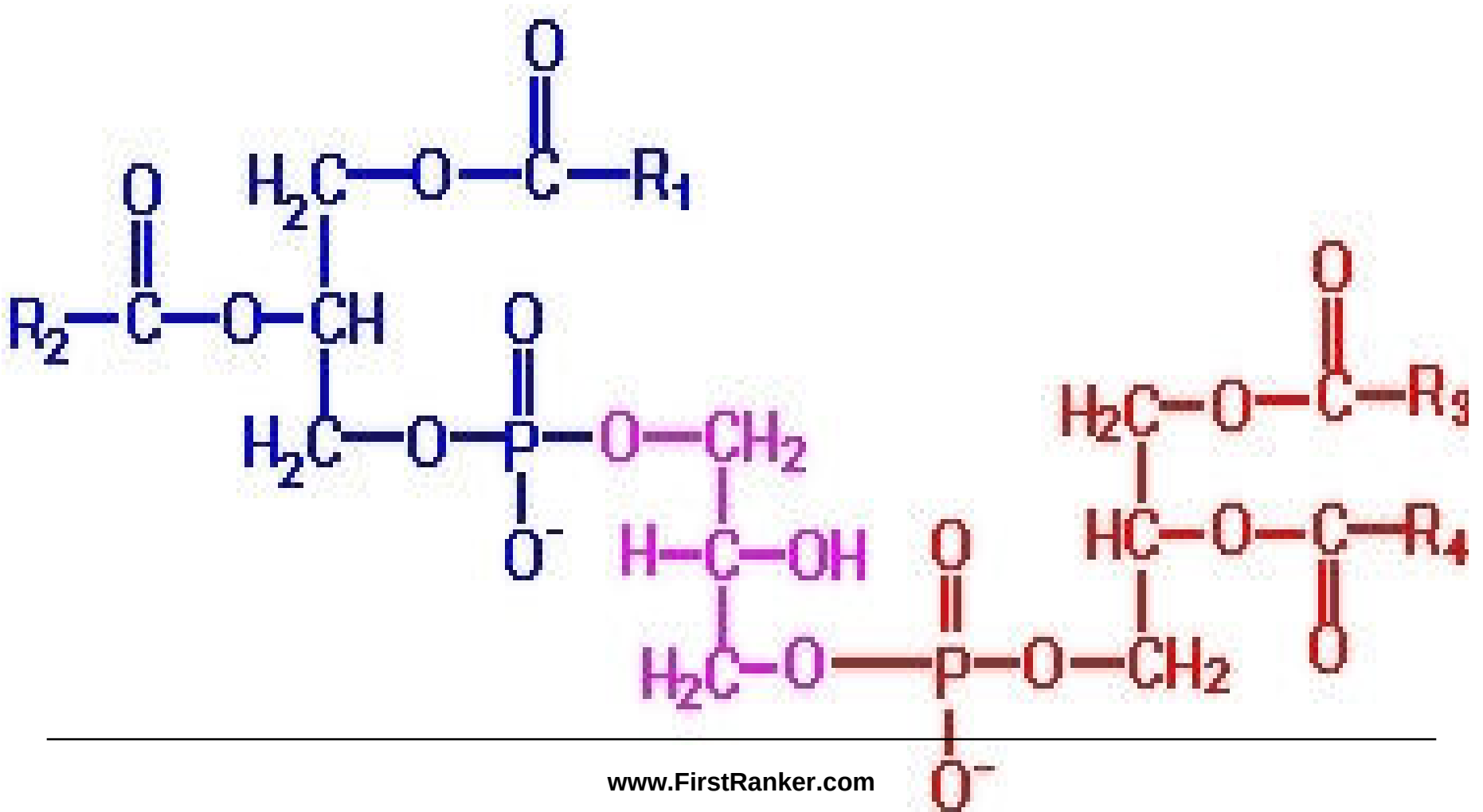
**Phosphatidalethanolamine/
Plasmalogen**

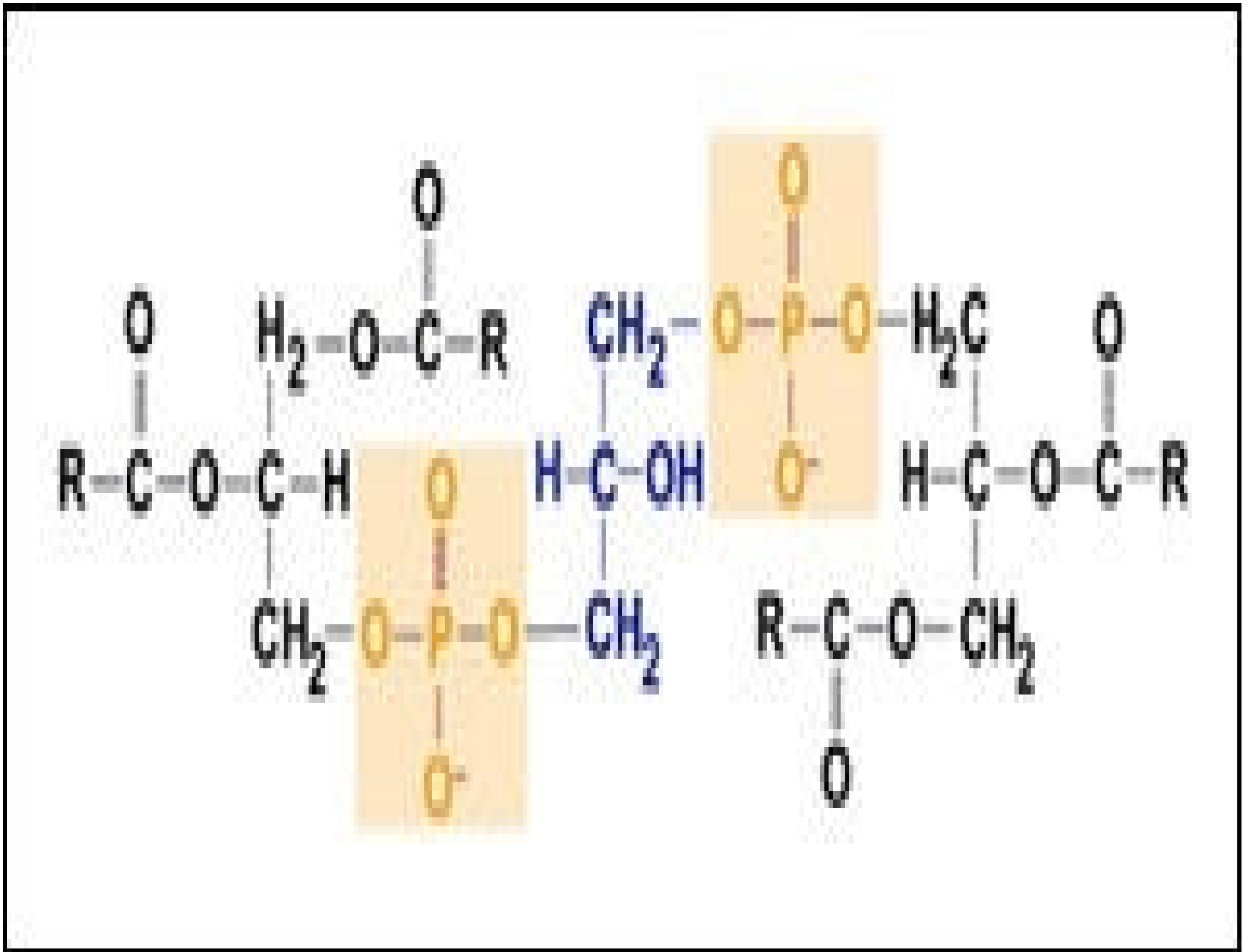


- **Plasmalogen** possess an **Ether linkage at C1**.
- **Fatty acid** is linked to **C1** of **Glycerol**, by an **Vinyl(CH=CH₂) Ether (C-O-C) linkage** instead of usual Ester bond.
- Nitrogen base linked are **Ethanolamine/Choline**.

Diphosphatidylglycerol/ Cardiolipin

Di Phosphatidyl Glycerol





- **Cardiolipin** was first isolated from **Cardiac Muscles of Calf** and hence the name derived.

- Diphosphatidylglycerol/Cardiolipin is chemically composed of
- **Two molecules of Phosphatidic acid linked to one Glycerol .**

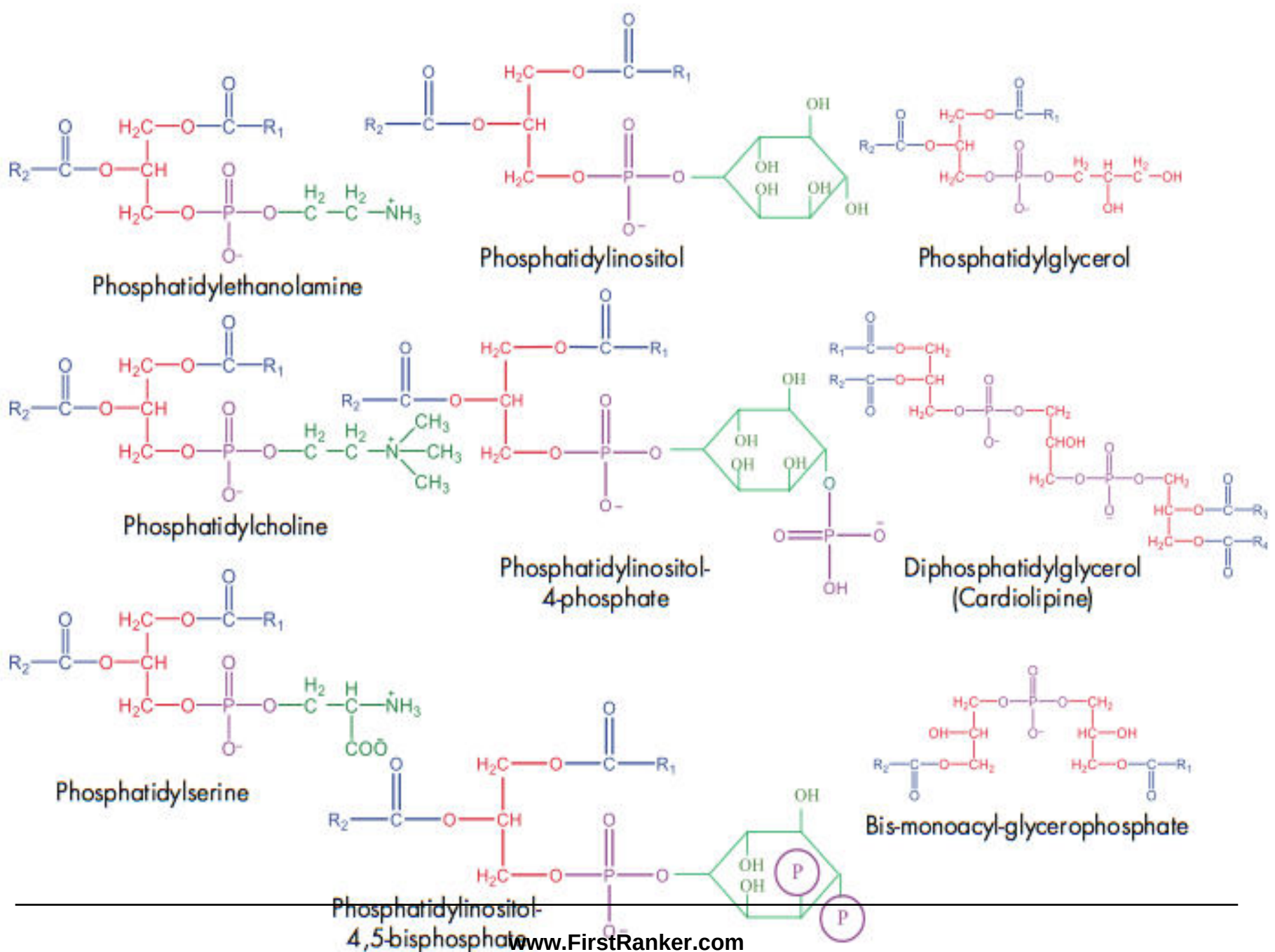
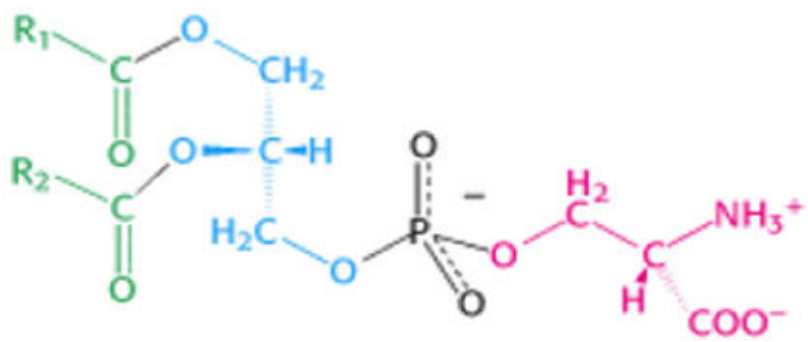
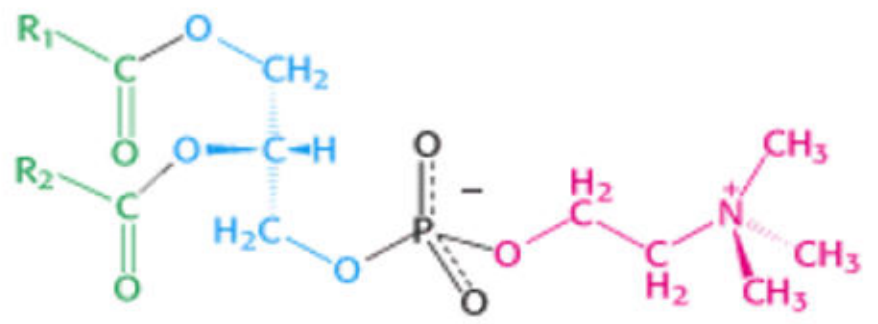


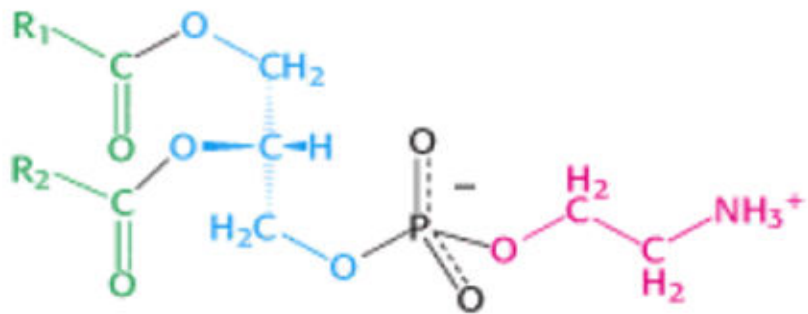
Figure 3 Different classes of glycerophospholipids according to their polar head group.



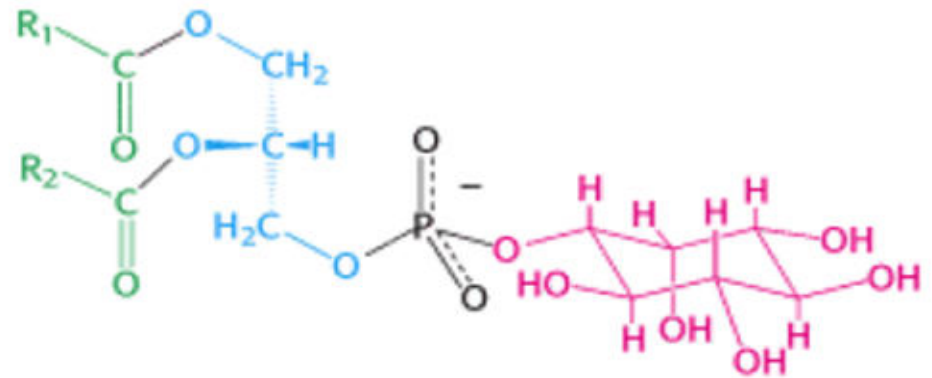
Phosphatidyl serine



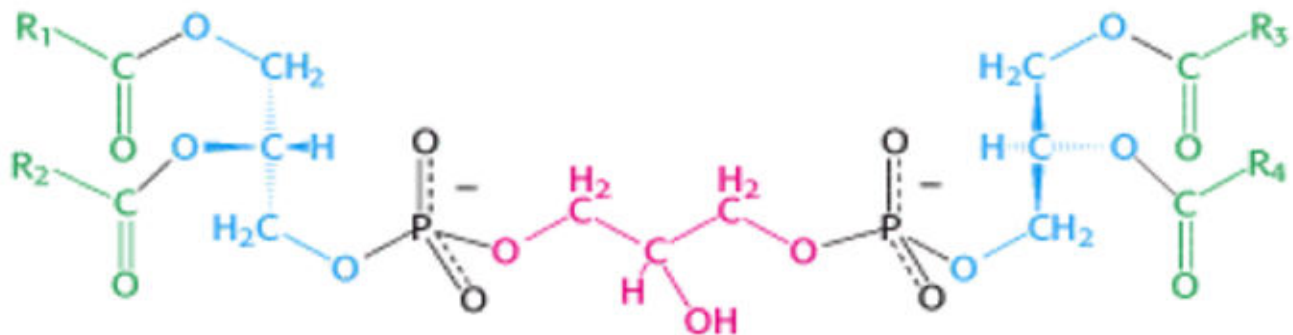
Phosphatidyl choline



Phosphatidyl ethanolamine

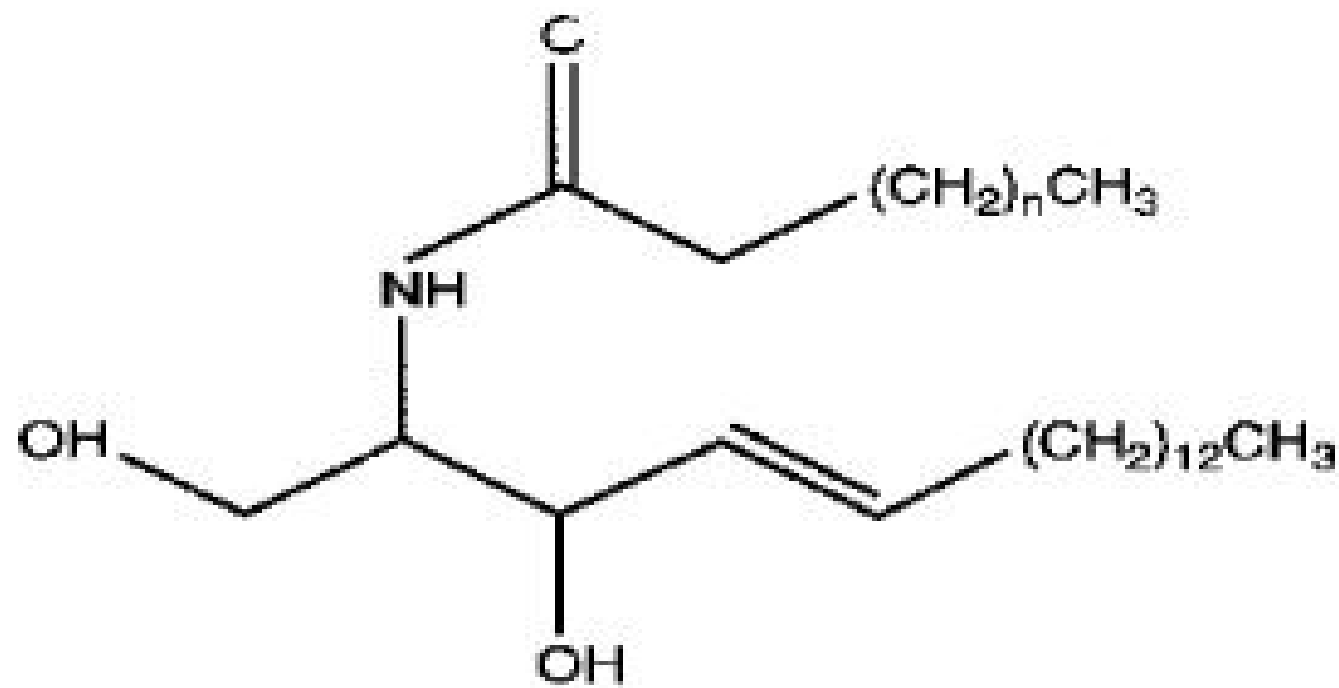


Phosphatidyl inositol

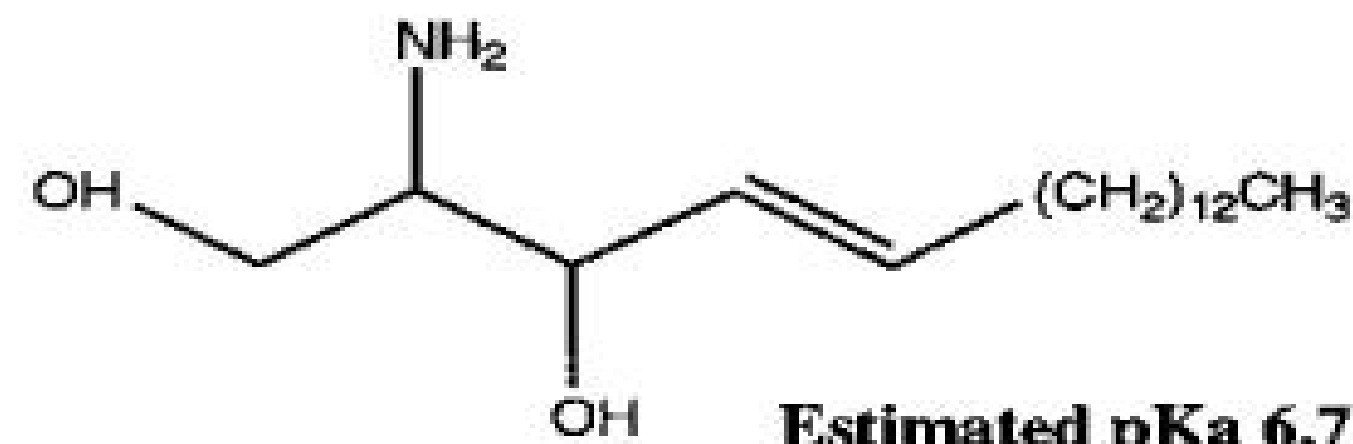


Diphosphatidyl glycerol (cardiolipin)

SphingoPhospholipids/ Sphingophosphatides



Ceramide

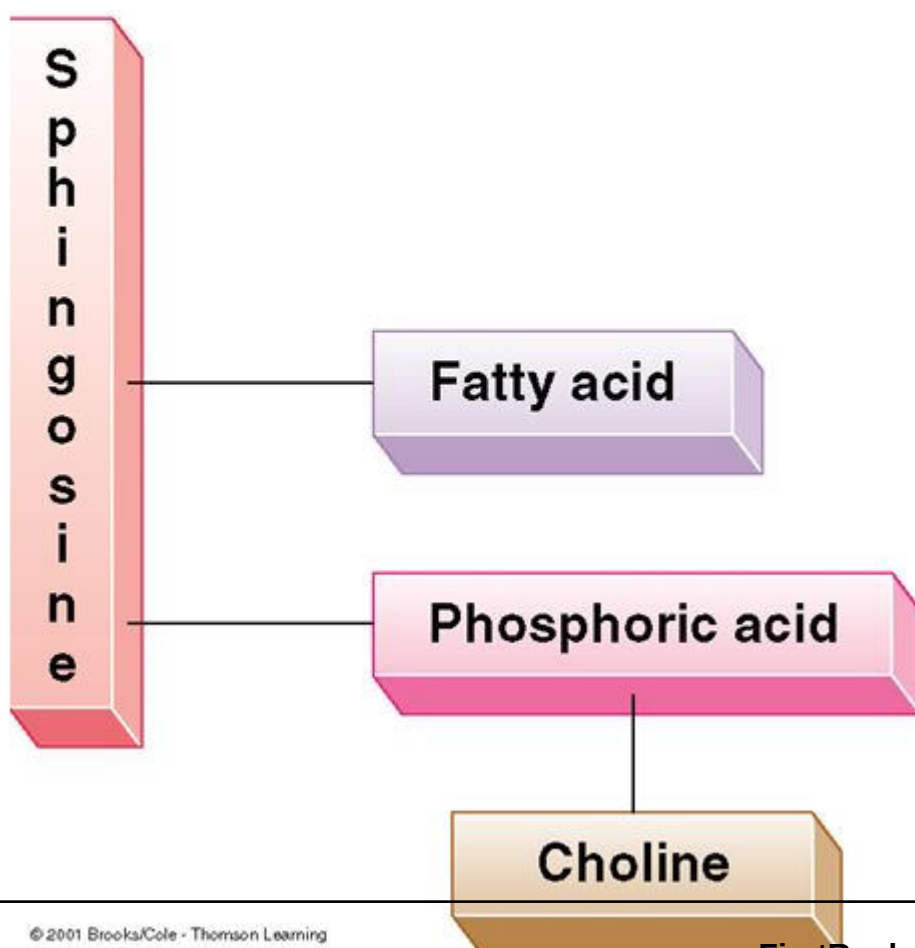


Sphingosine

Estimated pKa 6.7-8.4

Sphingomyelin: sphingosine, fatty acid, phosphate and choline

A sphingomyelin.



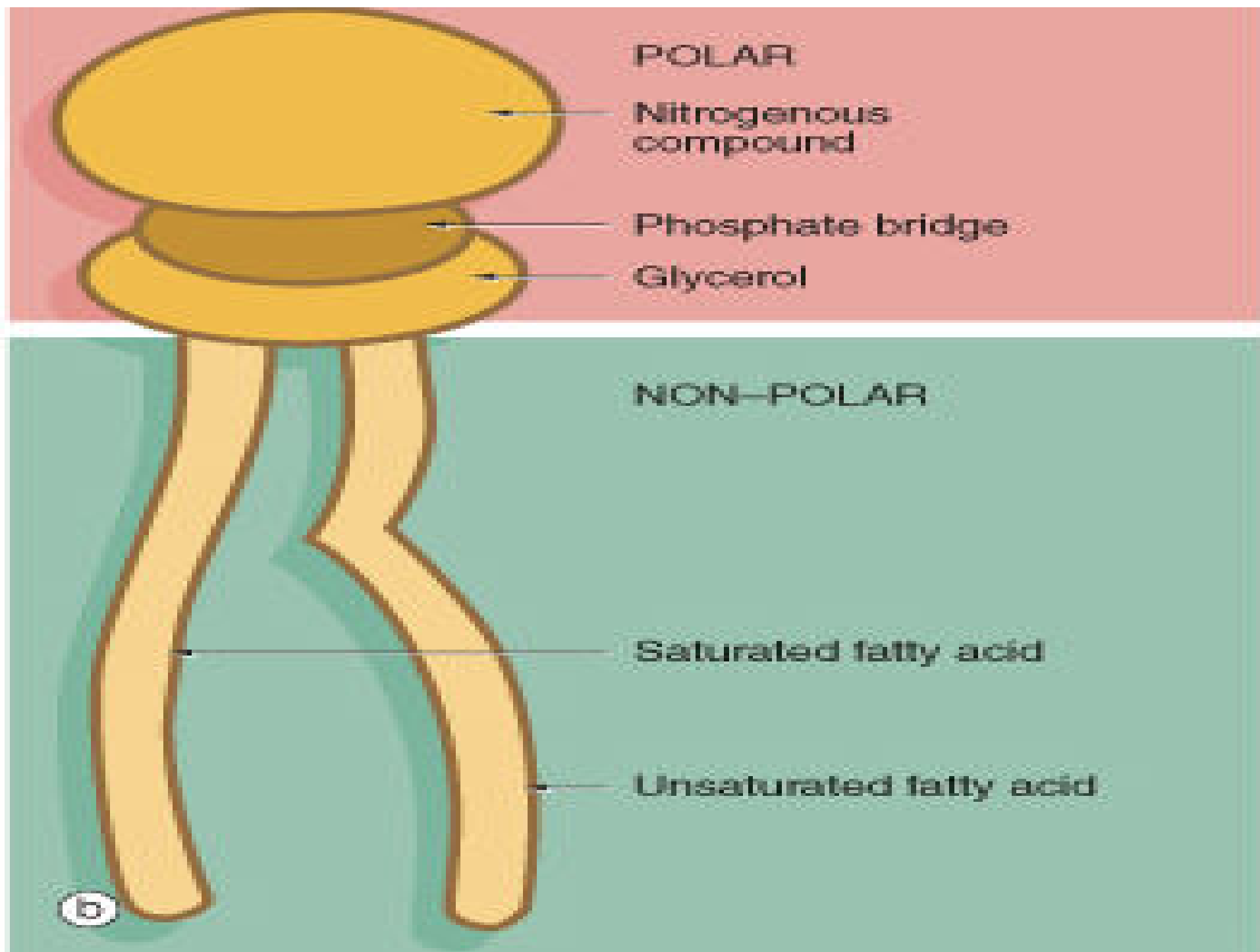
Sphingomyelins found in myelin sheath around neurons

- **Sphingophospholipid is Sphingosine based Lipid**
- Which has **Sphingosine linked with Fatty acid-Phosphate and Choline.**
- **Sphingosine** is linked with a Fatty acid by an **amide linkage** to form **Ceramide.**
- **Ceramide** is then linked to **Phosphoric acid and Choline** to form **Sphingomyelin.**

Properties Of Phospholipids

Amphipathic Nature Of PL

- **Phospholipids** are **Amphipathic/Amphiphilic** in nature.
- Since the structure of PL possess **both polar and nonpolar groups.**



- **Hydrophilic/Polar groups of Phospholipids:**
 - **Phosphoric acid**
 - **Nitrogenous groups**
- **Hydrophobic/non polar groups of Phospholipids :**
 - **Fatty acid/Acyl chains**

Exogenous And Endogenous Sources Of Phospholipids

Phospholipids in Foods

Lecithin (phosphatidylcholine)

- Major phospholipid



Found in:

- Liver
- Eggs
- Soybeans
- Peanuts
- Wheat germ

Liver produces lecithin as well.

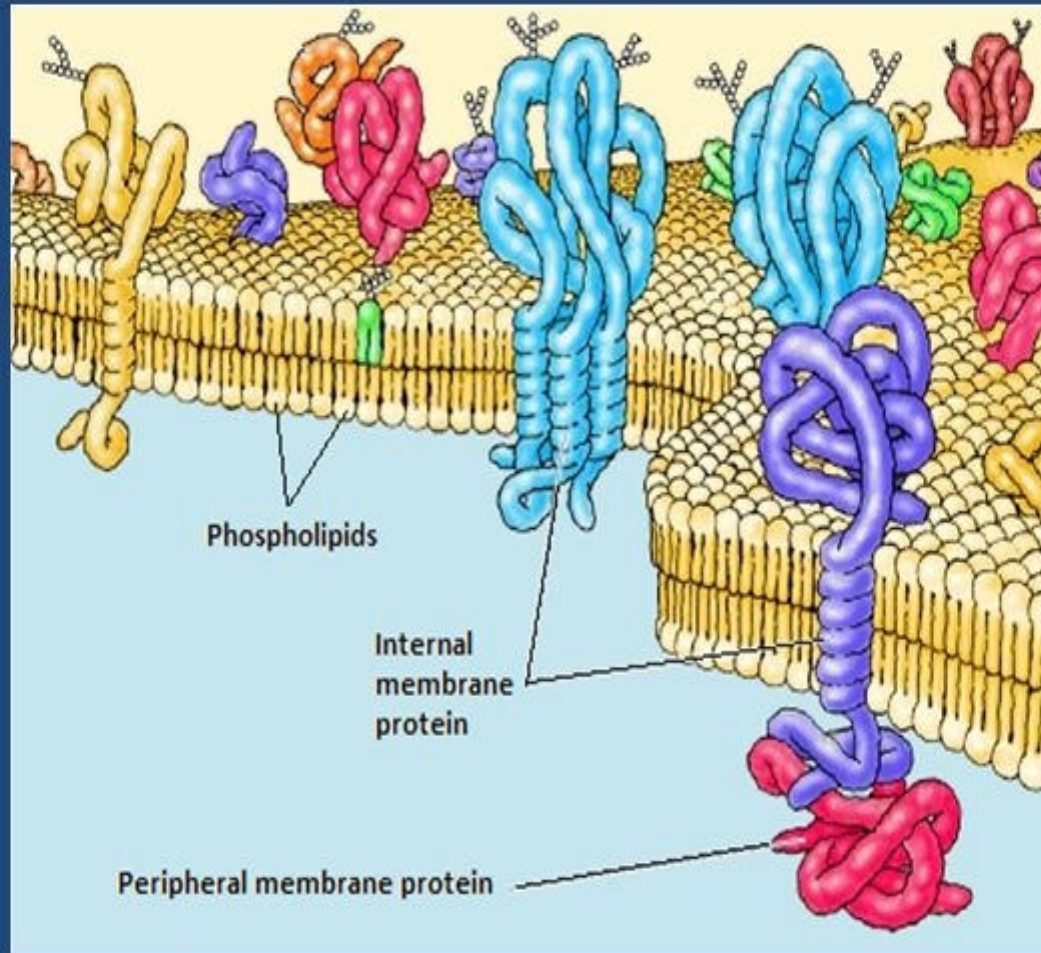


Occurrence And Distribution Of Phospholipids

- Various types of Phospholipids
Associated to all over body cells.
- Most predominantly associated to
Biomembranes
- **Myelin Sheath**
- **Alveoli in Lungs**

13. *Where are phospholipids found in the body?*

Phospholipids are found in cellular membranes, of which they are a major component.



Functions Of Phospholipids (PL)

- 1. Biomembrane Components**
- 2. Lung Surfactant**
- 3. Lipid Digestion and Absorption**
- 4. LCAT activity for Cholesterol Esterification and Excretion**
- 5. Lipotropic Factor**
- 6. Clotting Mechanism**
- 7. Cardiolipin role**
- 8. Coenzyme Role**
- 9. Choline from Lecithin Methyl Donor**
- 10. Detoxification role of Lecithin**
- 11. Eicosanoids biosynthesis**
- 12. Nerve Impulse Conduction**
- 13. Second Messenger of Hormone Regulation**

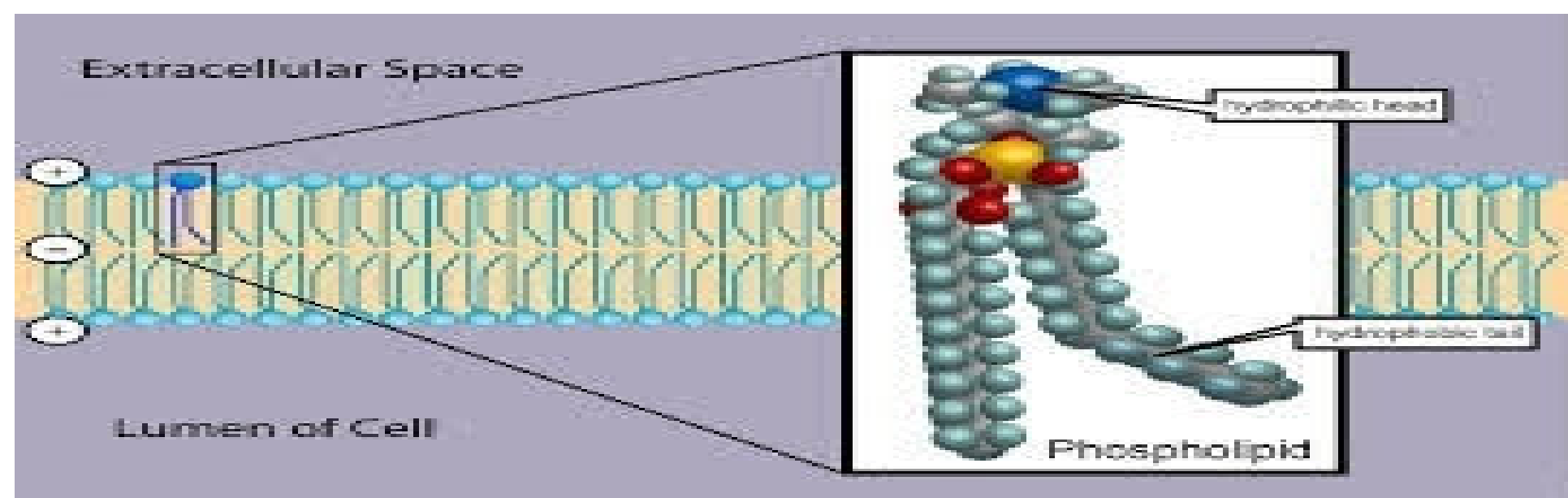
Functions of Phospholipids

- ☐ Components of cell membrane, mitochondrial membrane and lipoproteins
- ☐ Participate in lipid absorption and transportation from intestine
- ☐ Play important role in blood coagulation
- ☐ Required for enzyme action- especially in mitochondrial electron transport chain
- ☐ Choline acts as a lipotropic agent
- ☐ Membrane phospholipids acts as source of Arachidonic acid
- ☐ Act as reservoir of second messenger- Phosphatidyl Inositol
- ☐ Act as cofactor for the activity of Lipoprotein lipase
- ☐ Phospholipids of myelin sheath provide insulation around the nerve fibers
- ☐ Dipalmitoyl lecithin acts as a surfactant

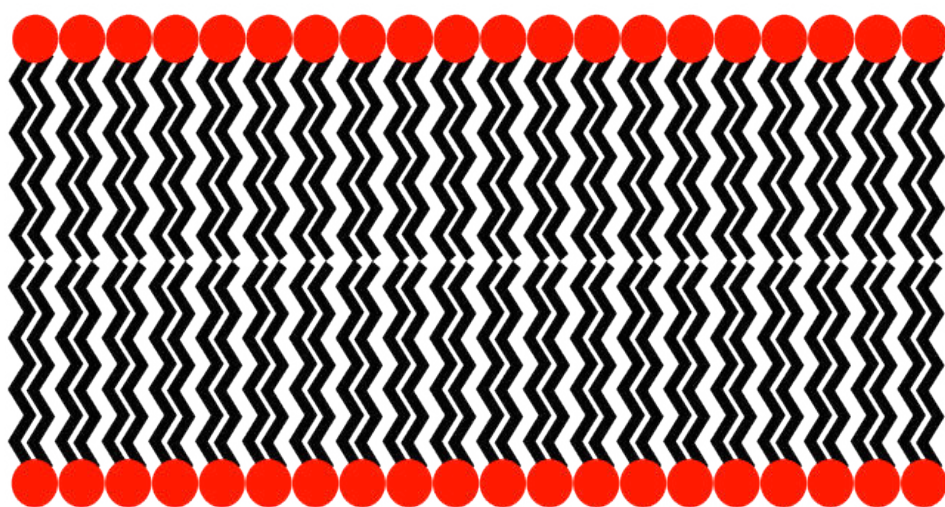
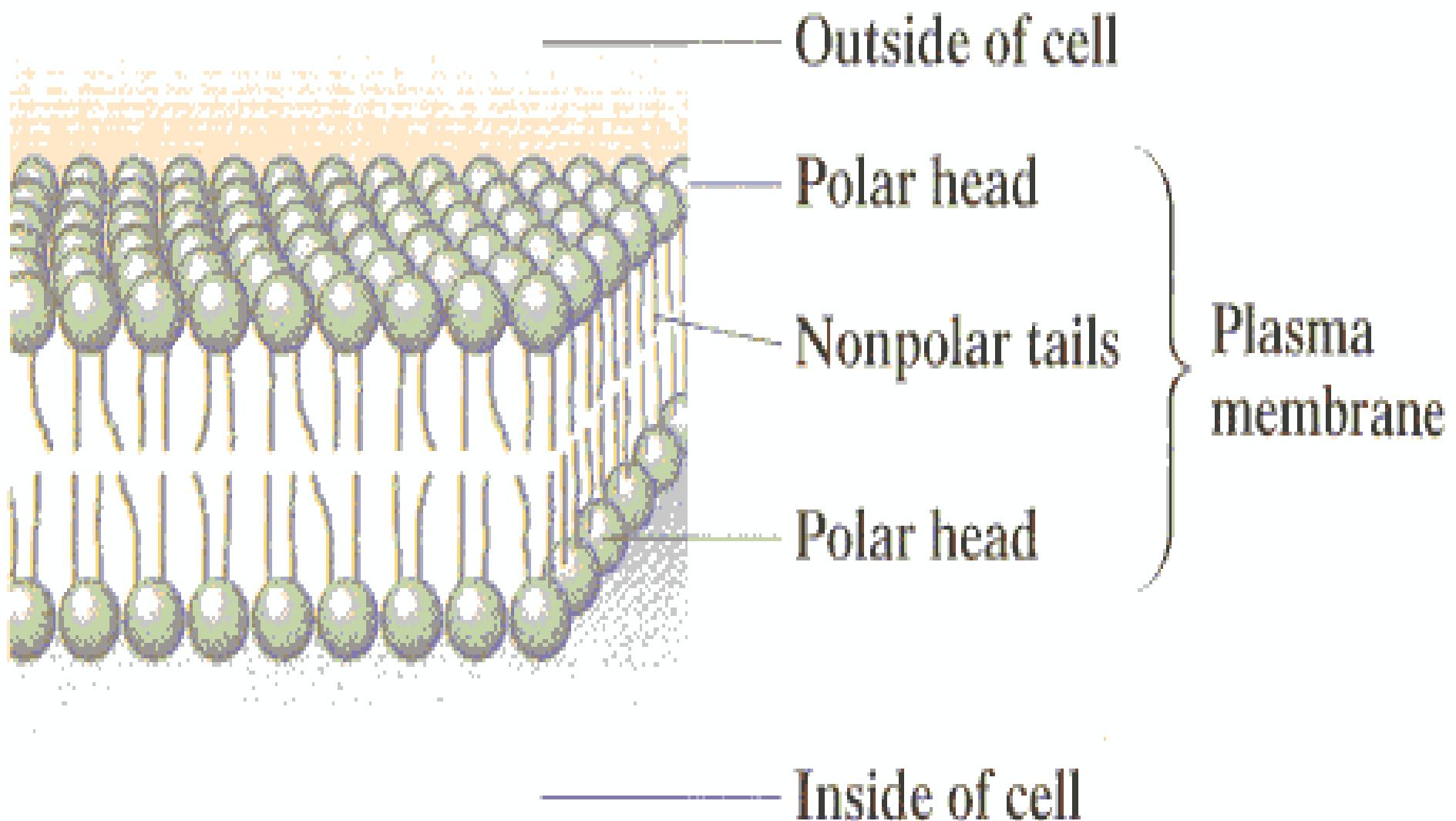
Glycerophospholipid Functions

Lecithin Is Most Functional Phospholipid

1. Phospholipids Components Of Biomembranes



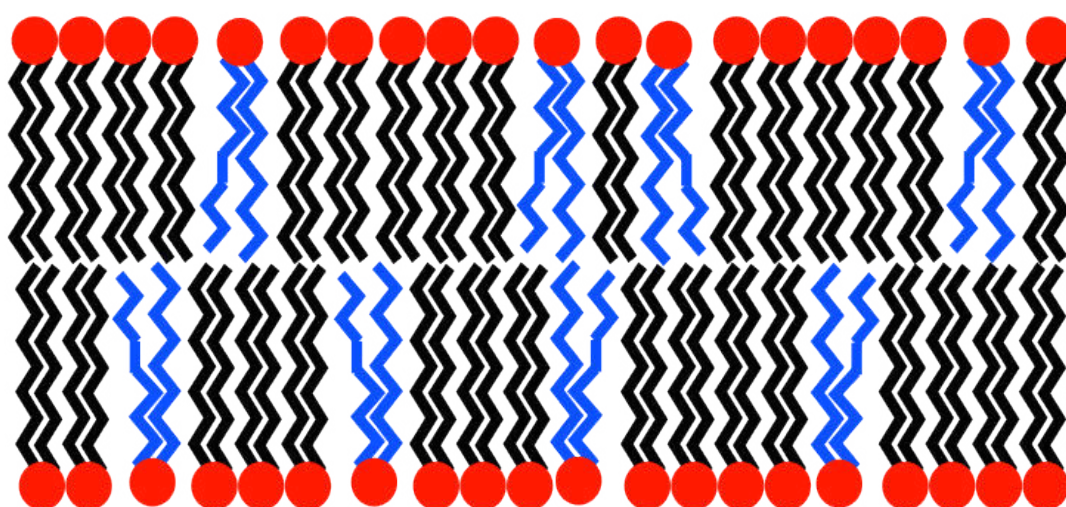
Phospholipid Bilayer of Plasma membrane



Saturated lipids only



Saturated



Mixed saturated and unsaturated

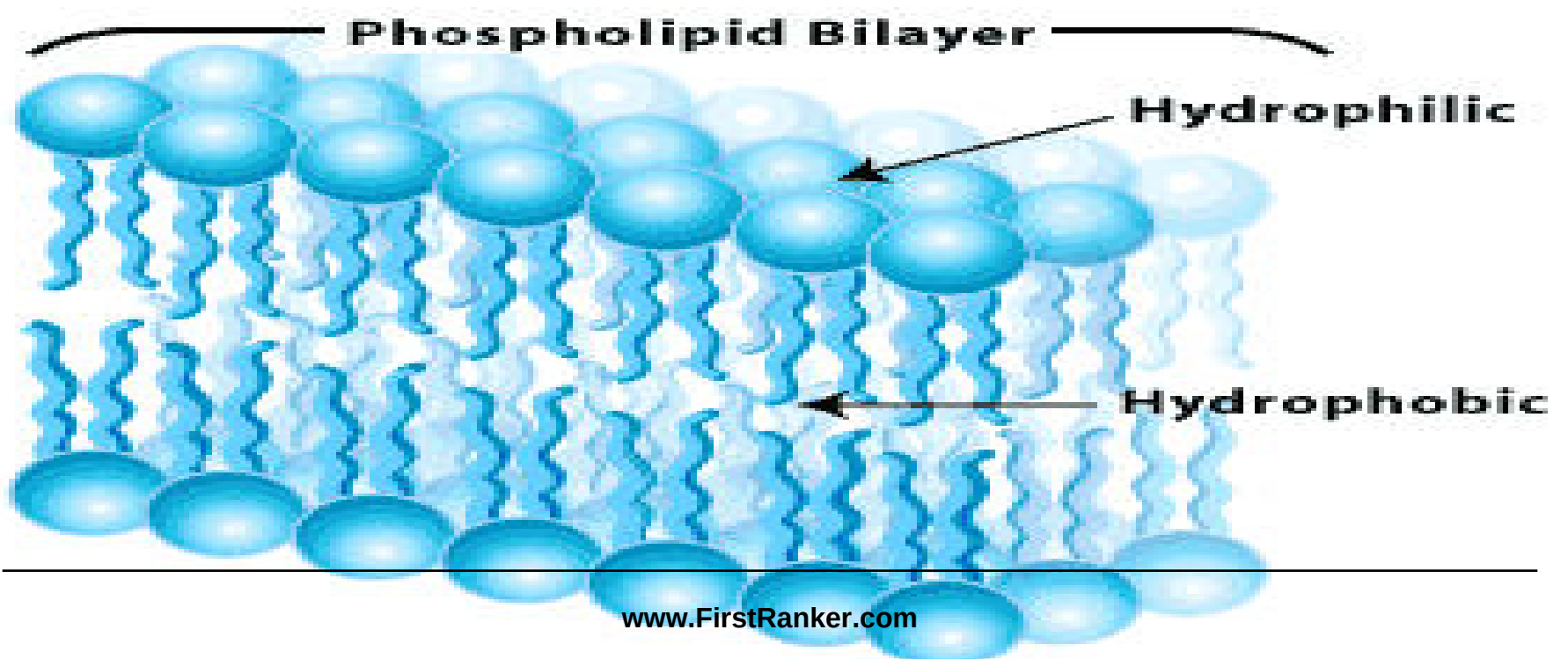
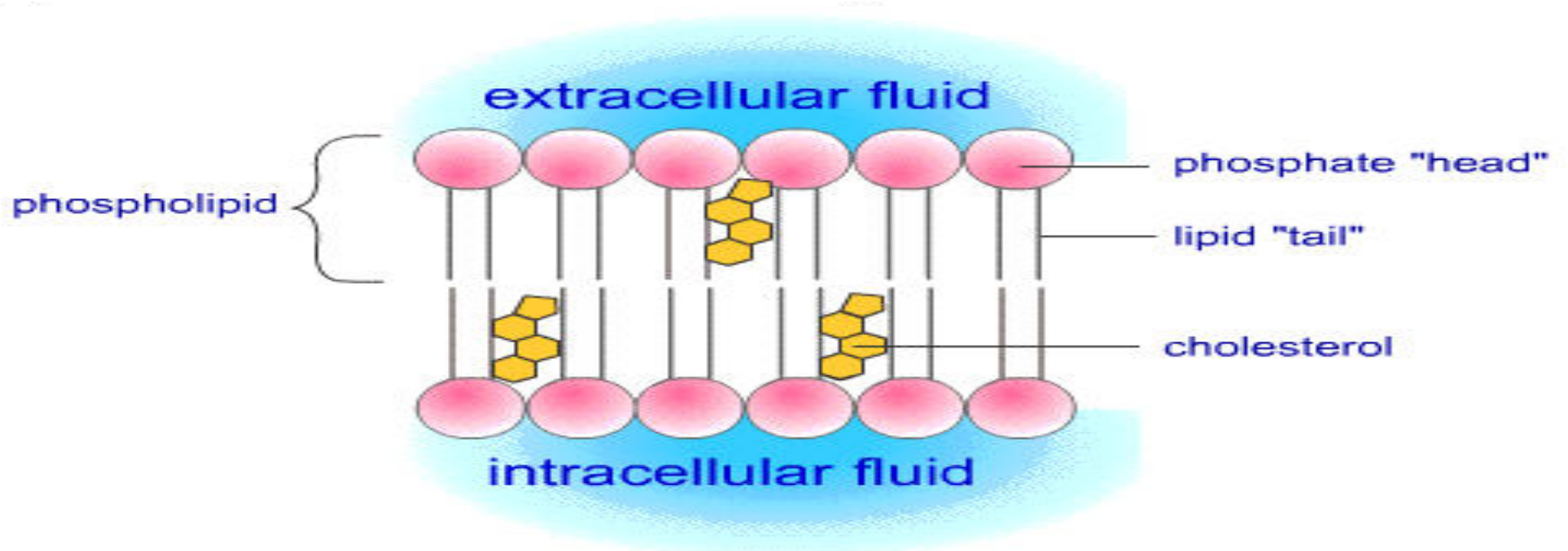
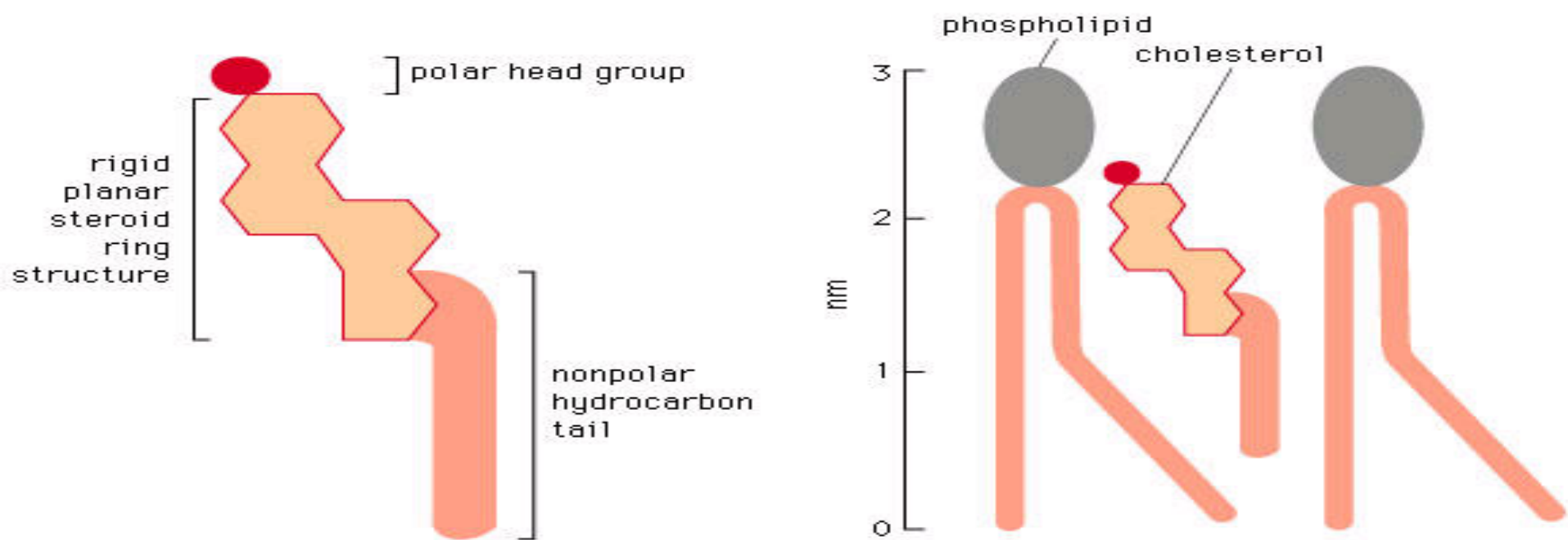


Monounsaturated

Cholesterol intercalates among Phospholipids.

Cholesterol fills in the spaces left by the kinks of PUFAs .

Cholesterol stiffens the bilayer and makes membrane less fluid and less permeable.



• **Role Of Lecithin**

- The **Glycerophospholipid Lecithin** is the major **structural components of biomembranes**.
- An **Amphipathic phospholipid bilayer** has polar head groups of PL directed outwards.
- **Membrane Phospholipid bilayer ,constituent of cell membranes imparts:**
 - Membrane Structural Integrity**
 - Membrane Fluidity**
 - Membrane Flexibility**
 - Selective Permeability**

- **Phospholipids** may have fatty acids which are **saturated or unsaturated**.
- This affects the properties of the resulting bilayer/cell membrane:
 - Most membranes have phospholipids derived from **unsaturated** fatty acids.
 - **Unsaturated fatty acids** add **fluidity** to a bilayer since **‘kinked’ tails do not pack tightly together**.

- Phospholipids (PL) derived from unsaturated phospholipids **allow faster transport of nonpolar substances across the bilayer.**
 - **Polar substances are restricted** to cross the membrane .
 - PL bilayer in membranes **protect the cell from an entry of polar reactive and interfering substances and serve as security guards of cells.**
 - **Membranes of Nerve cells, which are stiffer contain a much higher percentage of phospholipids derived from saturated fatty acids.**
 - They also contain **high levels of Cholesterol which stiffens membrane structure.**
-

2. Phospholipid As Lung Surfactant

Pulmonary surfactant composition

80% phospholipids

- Dipalmitoylphosphatidylcholine DPPC (60%)
- Phosphatidyl glycerol / ethanolamine / inositol (20%)

10% neutral lipids

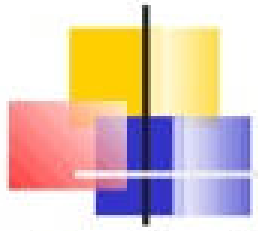
- Mostly cholesterol

10% Surfactant proteins

- SP-A, SP-D: hydrophilic
- SP-B, SP-C: hydrophobic

- **DiPalmitoyl Phosphatidyl Choline** serve as an **Lung surfactant**.
- It **Lowers surface tension** and keeps **Alveoli of lungs blown. (prevent adherence of alveoli)**
- Enables **effective exchange of gases** (Oxygen) in Lungs.
- After expiration of air the alveoli gets deflated.
- The **lung surfactant** reduces the surface tension and allow the **alveolar walls to reinflate**.

Pulmonary Surfactant



- **Surfactant** contains phospholipids, proteins and glycosaminoglycans, reduces the surface tension and prevents collapse of the alveolus during expiration.
- The reduced surface tension in the alveoli decreases the force that is needed to inflate alveoli during inspiration.
- Therefore surfactant stabilizes the alveolar diameters, facilitates their expansion and prevents their collapse by minimizing the collapsing forces.
- Surfactant also has bactericidal properties

Functions of Surfactant

1. Lowers surface tension of alveoli & lung

1. Increases compliance of lung
2. Reduces work of breathing

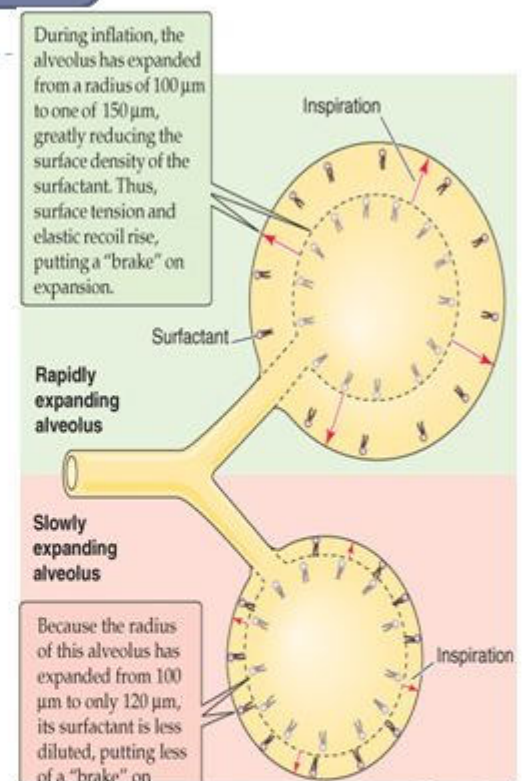
2. Promotes stability of alveoli

1. 300 million tiny alveoli have tendency to collapse
2. Surfactant reduces forces causing atelectasis
3. Assists lung parenchyma 'interdependant' support

3. Prevents transudation of fluid into alveoli

1. Reduces surface hydrostatic pressure effects
2. Prevents surface tension forces from drawing fluid into alveoli from capillary; LaPlace

4. Expansion of lungs at birth



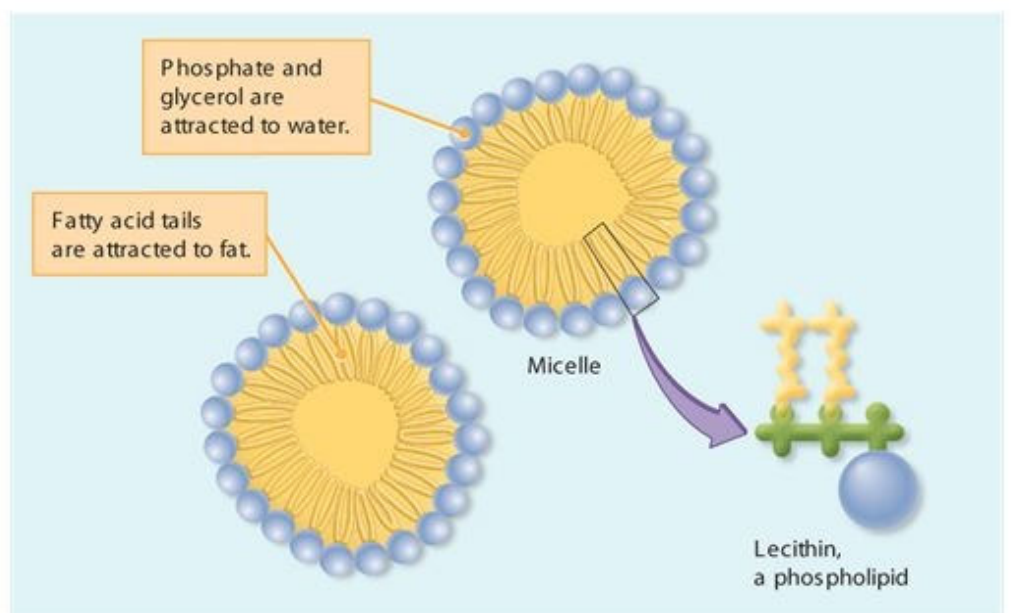
- **Phospholipid as Lung surfactant**
- Prevent body to suffer from **Respiratory Distress Syndrome (RDS)**.

3. Phospholipids
Help In Digestion And Absorption Of Dietary Lipids

- **Phospholipids** being amphipathic in nature act as good **emulsifying agents**.
- **Along with Bile Salts** they help in **digestion and absorption** of non polar dietary Lipids.

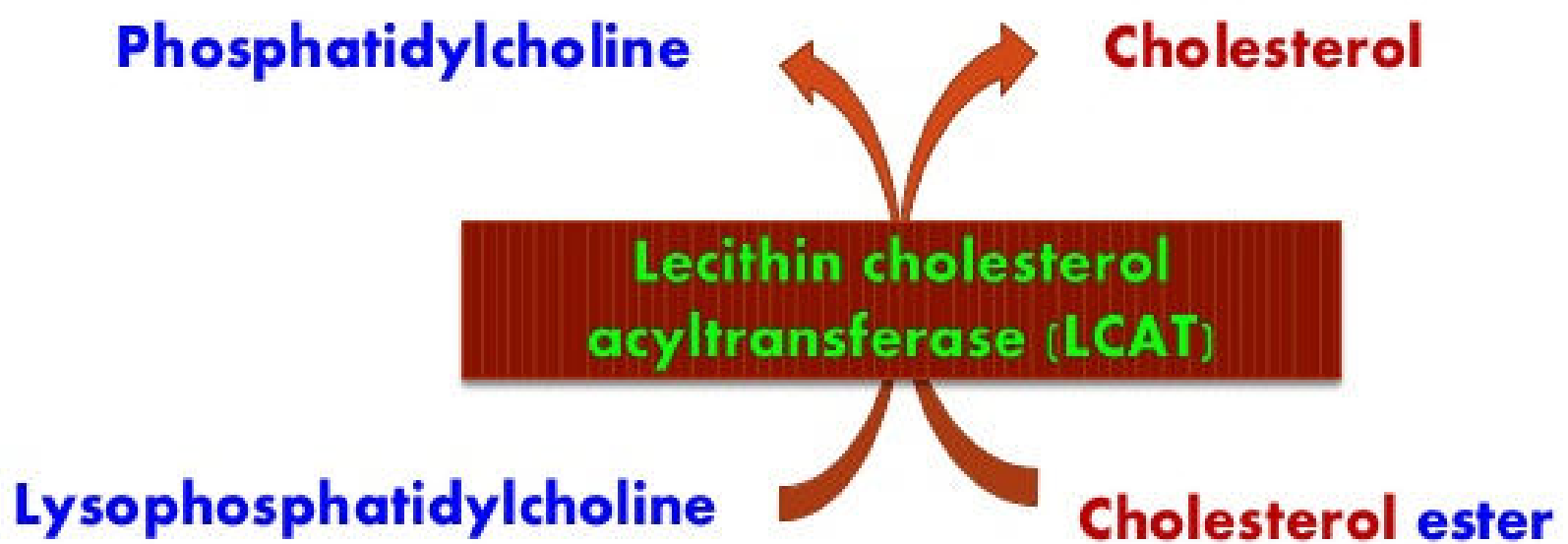
Phospholipids

- Emulsifiers (**Lecithin**)
 - In body
 - Phospholipid with **choline** → phosphatidylcholine
 - In food
 - Blend of phospholipids with different nitrogen-containing components
 - Used as emulsifiers (e.g. salad dressing, chili, sloppy-joe mixes, and chewing gum).

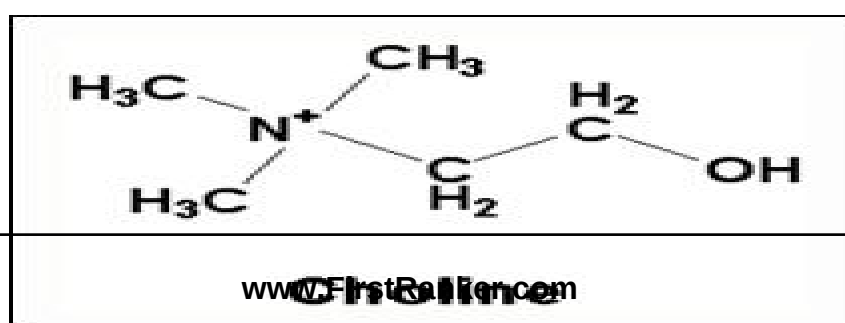


4. Phospholipid Lecithin Helps In Cholesterol Excretion

Reaction catalyzed by LCAT



- **Lecithin** helps in **Cholesterol Esterification** by **LCAT activity**.
- **Cholesterol Ester** is later dissolved in Bile and further excreted it out.
- **Lecithin** serve as a **storage depot of Choline**.
- **Choline** is a store of labile Methyl groups
- Hence **Choline** participate in **Transmethylation reactions** .



- **Choline** is used for generation of neurotransmitter '**Acetyl Choline**' which helps in nerve impulse transmission.
- **Choline** serve as **Lipotropic factor** hence helps in Lipoprotein formation in Liver to mobilize out Lipids and **prevent from Fatty Liver**.

6. Phospholipids Releases Arachidonic Acid For Eicosanoid Biosynthesis

- **Lecithin** at 2nd carbon has **Arachidonic acid (PUFA)**.
- **It donates Arachidonic acid** which is a precursor for **Eicosanoid biosynthesis**.
- Phosphatidyl Inositol **also provides Arachidonic acid** for Eicosanoids biosynthesis.

- Lecithin helps CYT450 system for **drug detoxification.**

8. Phospholipids Has Role In Blood Coagulation

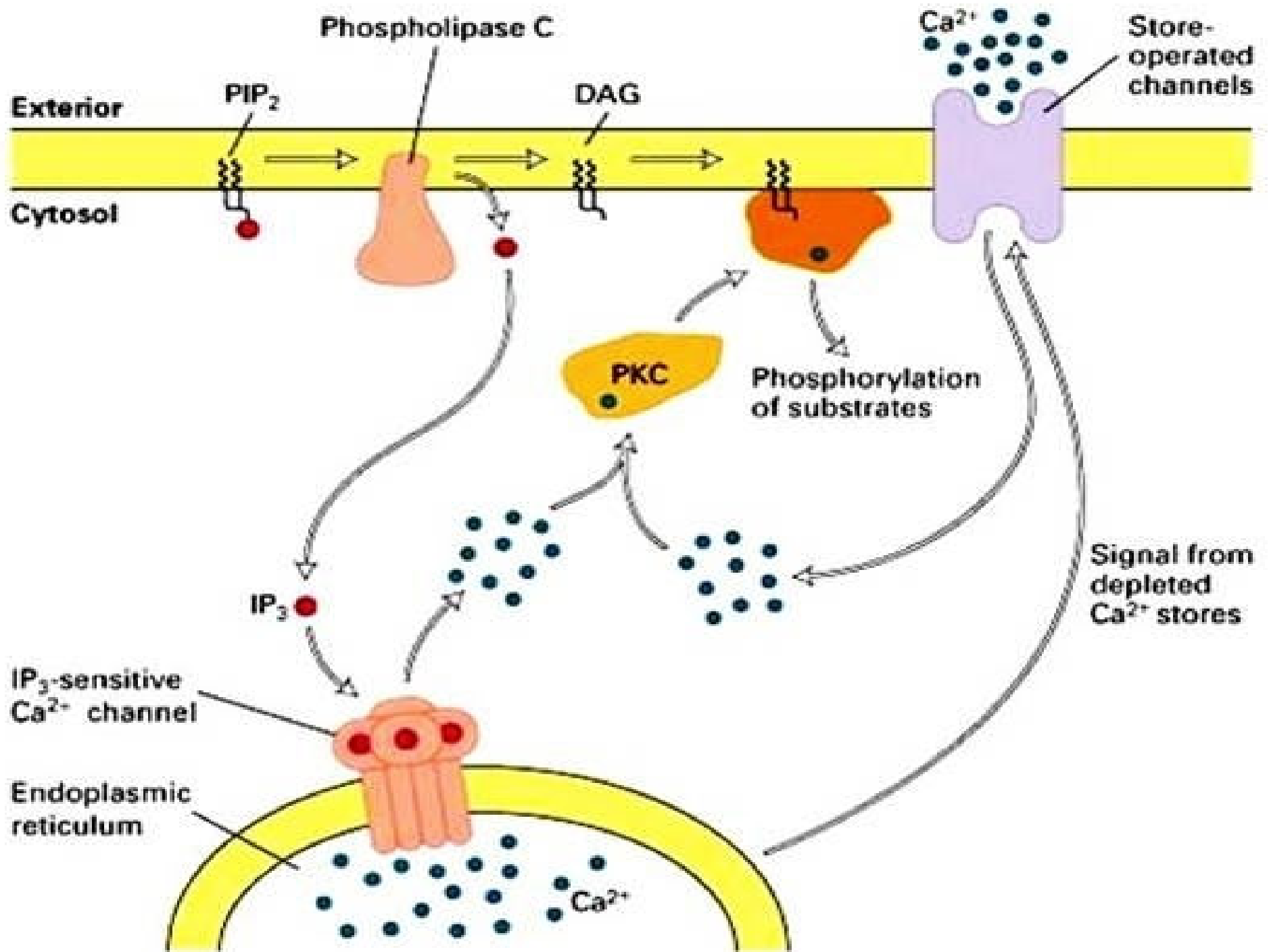
- **Role Of Cephalin**

- Phosphatidyl Ethanolamine has **role in blood coagulation.**
- It converts clotting factor **Prothrombin to Thrombin by factor X.**
- Phosphatidyl Serine has **role in Apoptosis** (Programmed Cell death).

10.Role Of Phospholipids In Hormonal Action

Mediates Cell Signal Transduction

- **Role Of Phosphatidylinositol**
- **Phosphatidyl Inositol Triphosphate (PIP3)** is a constituent of cell membrane
- It mediate hormone action /cell signal transduction and maintain intracellular Calcium.



- **Inositol tri phosphate** and **Diacylglycerol** are released from **PIP₃** by membrane bound **Phospholipase C**
- The Inositol triphosphate and DAG serve as **second messenger** to **hormones** **Oxytocin** and **Vasopressin**.

- **Plasmalogen**
associated to **brain and muscles** helps in Neural functions.

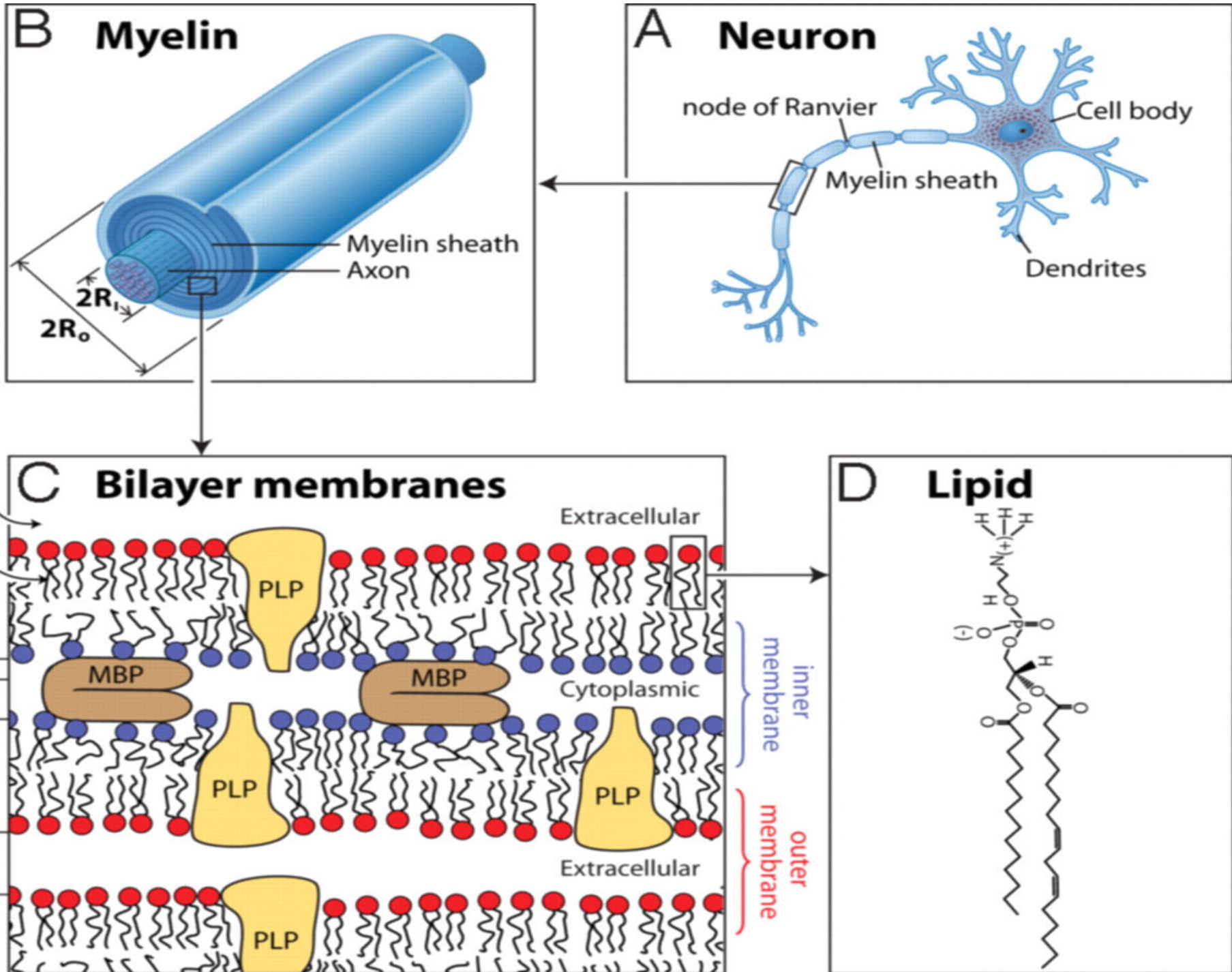
- **Role Of Cardiolipin**

- **Cardiolipin** is rich in **inner mitochondrial membrane** and supports **Electron Transport Chain** and cellular respiration.

- **Cardiolipin** exhibits antigenic properties and used in **VDRL serological tests** for diagnosis **Syphilis**.
- Phospholipid serve as **Coenzyme** for certain **Enzymes** :
 - **Lipoprotein Lipase**
 - **Cytochrome Oxidase**

Functions OF Sphingophospholipids

- Sphingomyelins are rich in **Myelin sheaths** which surrounds and insulate the axons of neurons.
- Sphingomyelin helps in nerve impulse transmission.



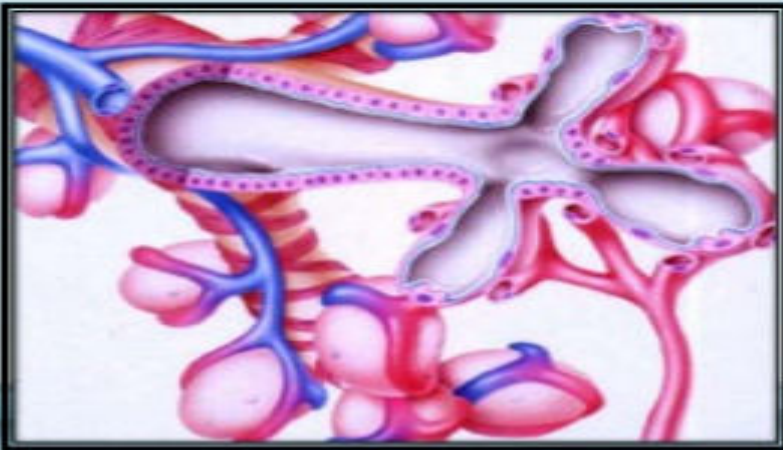
Disorders Related To Phospholipids

- **Respiratory Distress Syndrome (RDS)**

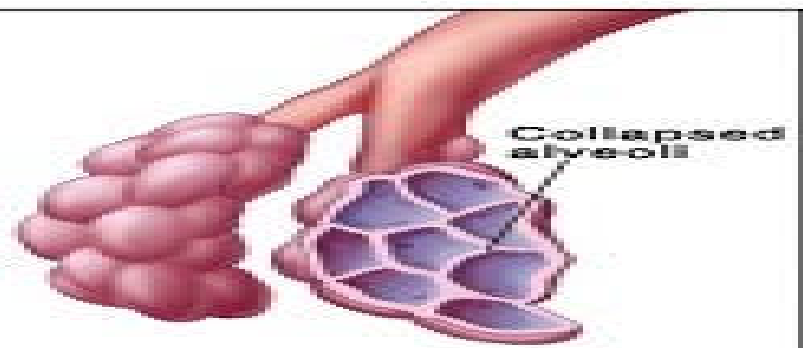
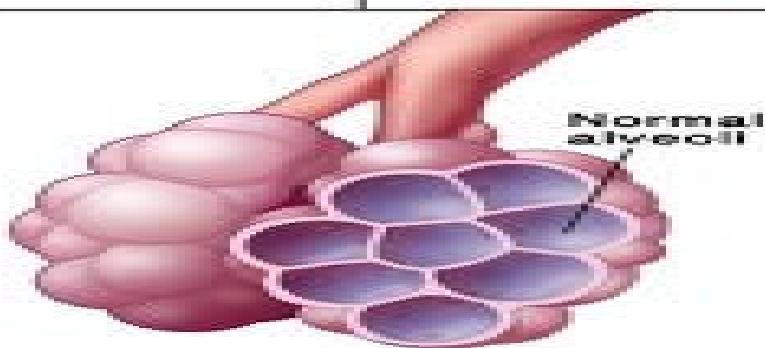
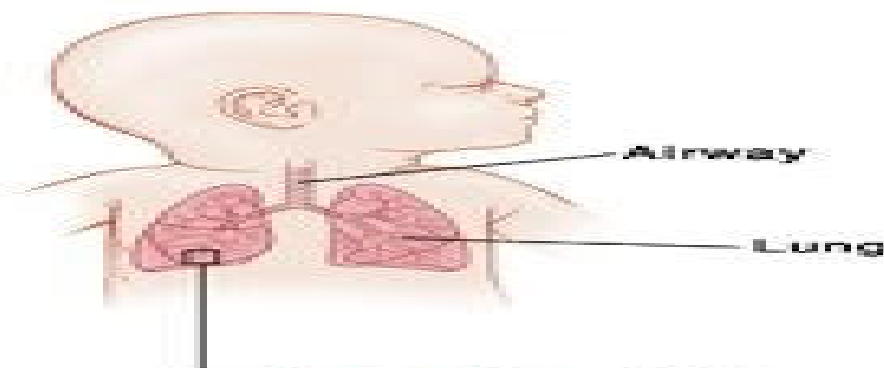
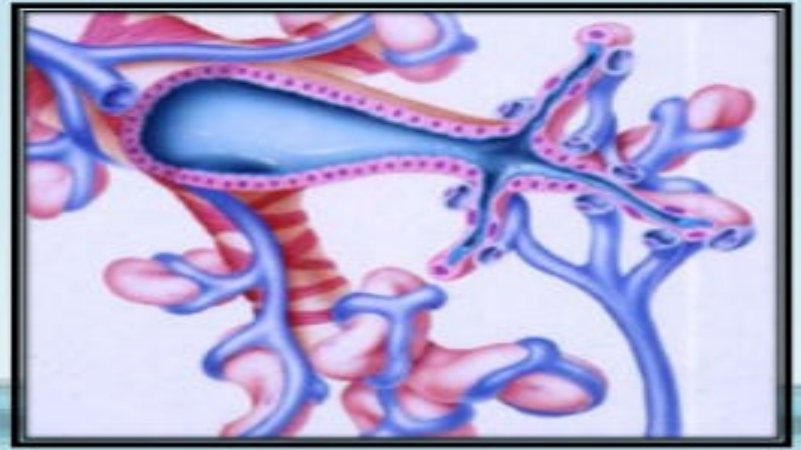
- Suffered by **premature born infants**.
- Caused due to **deficiency of Lung surfactant DiPalmitoyl Phosphatidyl Choline**.
- Since **Lung** is last organ to mature.
- **Premature babies** has insufficient lung surfactant lining in the alveoli walls.
- Which supports **no normal respiration**.
- Has respiration difficulties due to **alveolar collapse**.

What difference does it make....????

**Normal Expiration
With Surfactant**



**Abnormal Respiration
Without Surfactant**



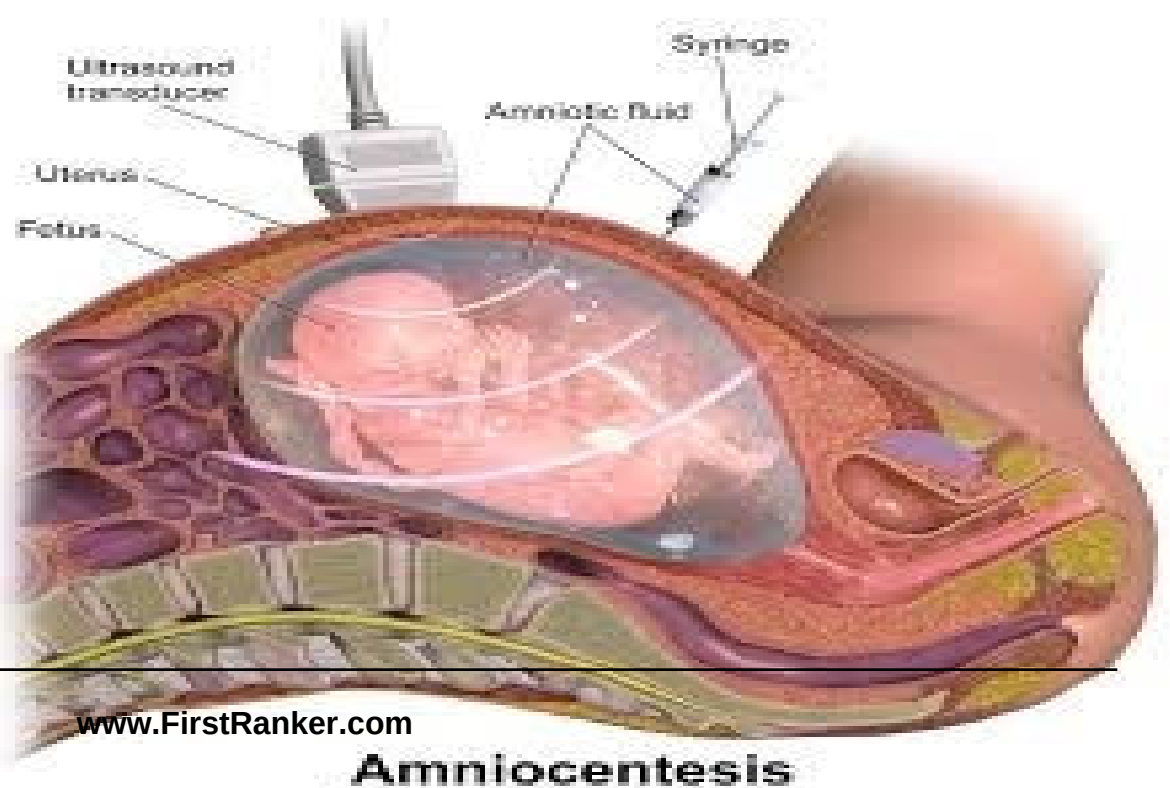
• Signs And Symptoms Of RDS

- Low ATP production
- Weakness ,Lethargy
- Low Cellular Functions
- Poor Coordination

Lecithin/Sphingomyelin (L/S) Ratio of Amniotic Fluid

Assessment Of Fetal Lung Maturity And Diagnostic Criteria For RDS

- Lecithin /Sphingomyelin (L/S) ratio of amniotic fluid, collected by Amniocentesis is a good indicator to evaluate fetal lung maturity.



Amniocentesis

- Prior to 34 weeks of gestation the concentration of **Lecithin and Sphingomyelin** in amniotic fluid is equal.
- In Later weeks of gestation the **Lecithin levels are markedly increased.**
- **At full term** L/S ratio is **> 2/>5**
- In pre term infants L/S ratio is **1.5 or < 1** results to suffer from RDS.

OTHER RDS Sufferers

Individual with Lung Damage and Dysfunctions

- Old aged Persons
 - Smokers
 - Severely Infected Lungs
 - Lungs toxicated and damaged by chemicals
-
- **Old age persons and Adults with Lung damage**
(Due to Smoking/ Infections)
-
- Who **unable to biosynthesize the lung surfactant** may also **exhibit RDS.**

Lecithin-Sphingomyelin (L/S) Ratio

- Considered the reference method
- Lecithin is the primary component of the lung surfactants; increased production occurs after the 35th week
- Sphingomyelin is produced at a constant rate after the 26th week and serves as a control for the rise in lecithin
- L/S ratio is 1.6 prior to week 35 and rises to 2.0 or greater for alveolar stability after week 35
- Therefore, preterm delivery is considered safe with an L/S ratio of 2.0 or higher
- Test is performed using thin-layer chromatography
- Many laboratories have replaced the L/S ratio with the quantitative phosphatidyl glycerol immunoassays and lamellar body density procedures

Management of RDS:

A) General:

*** Basic support including thermal regulation and parenteral nutrition and medications (antibiotics).**

*** Oxygen administration, preferably heated and humidified**

B) *Specific:*

Surfactant replacement therapy through ET tube.

Prevent And Manage RDS

- Pregnant Women **Diet** for biosynthesis of L and S
- Pregnant Women **Activities** and Positions
- Prevent Damaging **Environment** Exposures

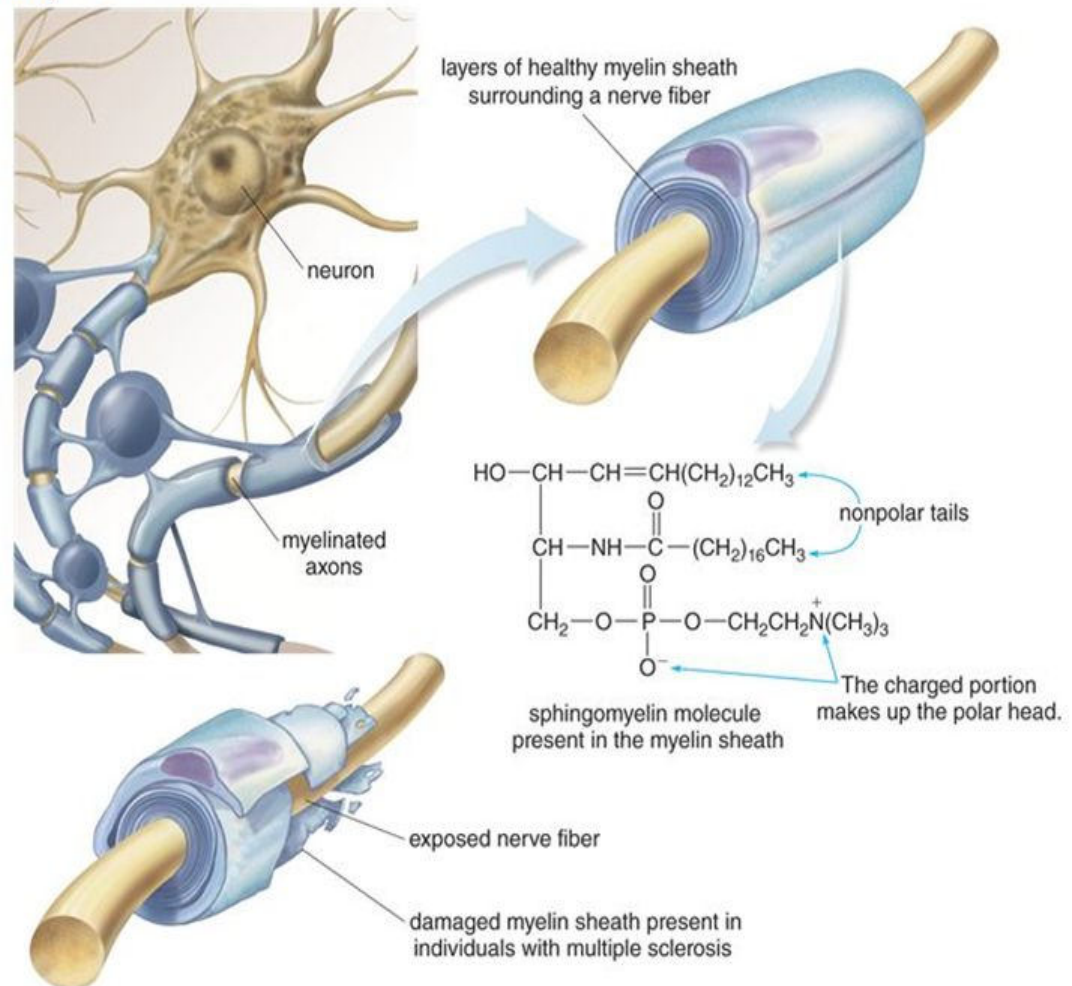
Membrane Related Disorders Due To Defective Phospholipids

Multiple Sclerosis Due to Defect In Sphingomyelins and Myelin Sheaths

Further modifications to the hydroxyl group, leads to a variety of other sphingolipids. One important example is **sphingomyelin**.

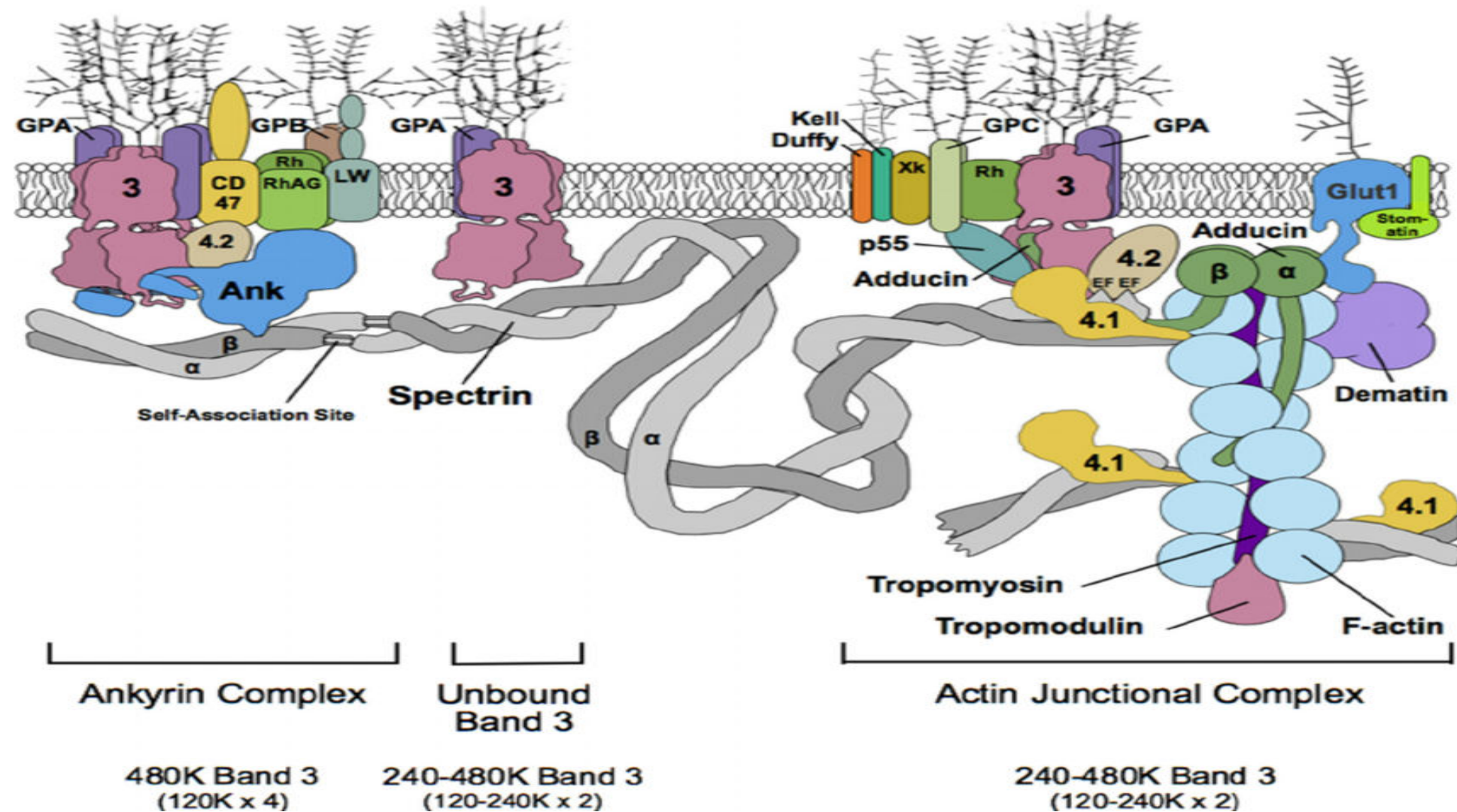
The coating that surrounds and insulates nerve cells, the **myelin sheath**, is particularly rich in sphingomyelins, and is vital for proper nerve function. Deterioration of the myelin sheath, as seen in multiple sclerosis, leads to disabling neurological disorders.

Multiple sclerosis (MS) is a degenerative disease characterized by scarring of the myelin sheath, the insulating layer that surrounds a nerve fiber. Without the protective myelin sheath, normal nerve transmission is disrupted and a variety of effects—numbness, blindness, speech disorders, and tremors—can result.

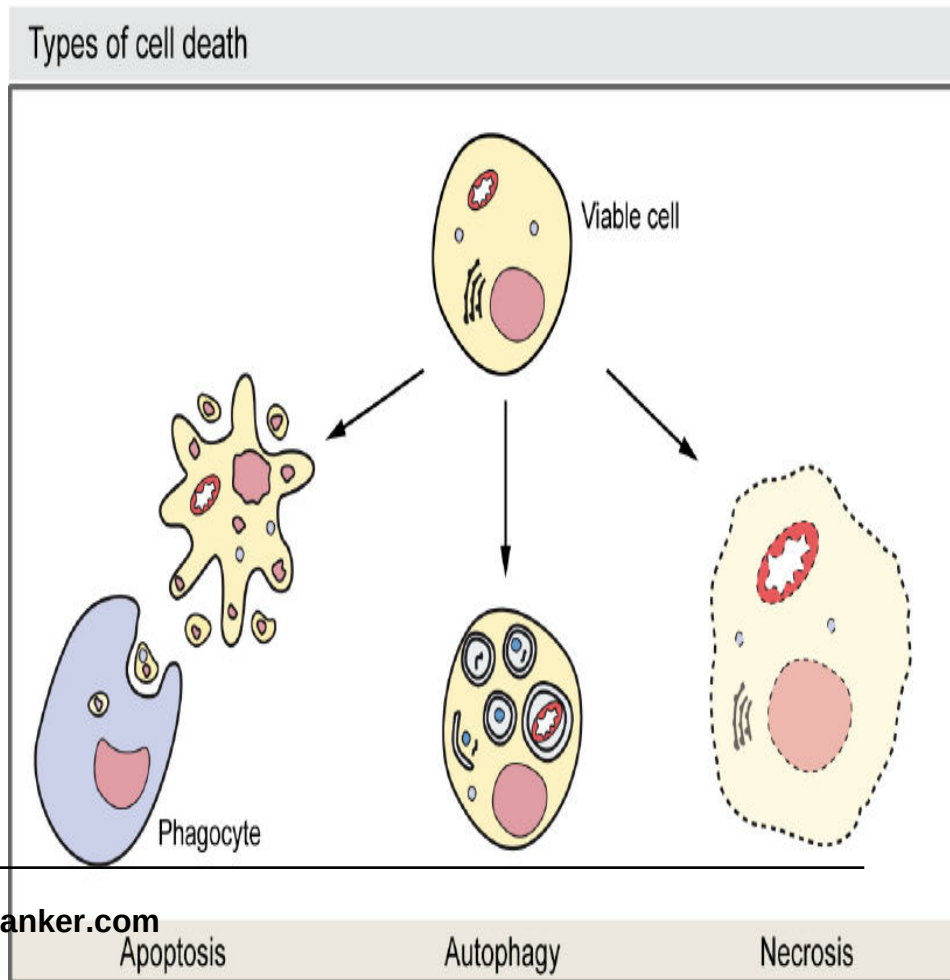
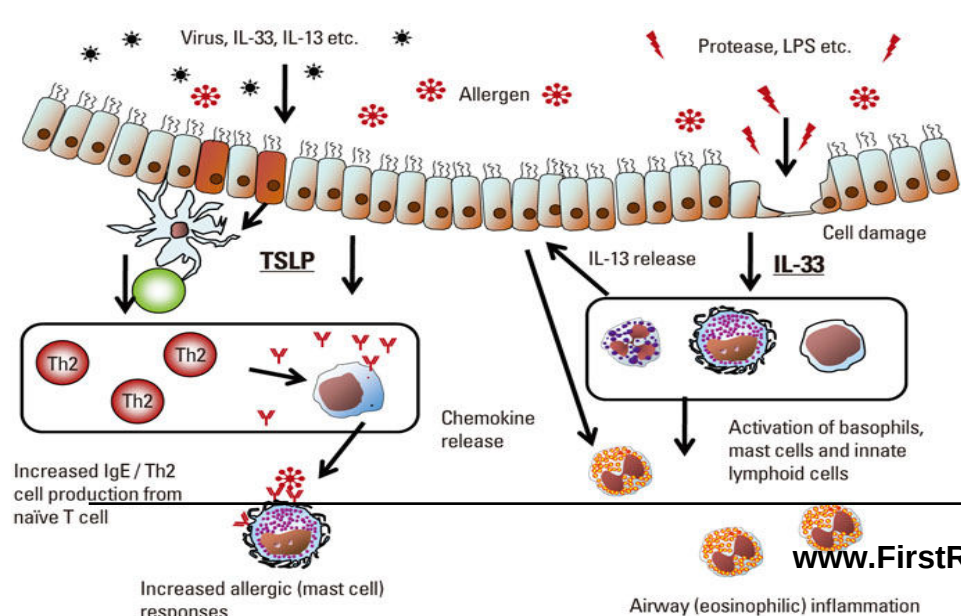


Defect In Sphingomyelins May Affect Nerve Impulse Conduction

Membrane Carbs,Lipids and Proteins Structurally Important For Functional Role

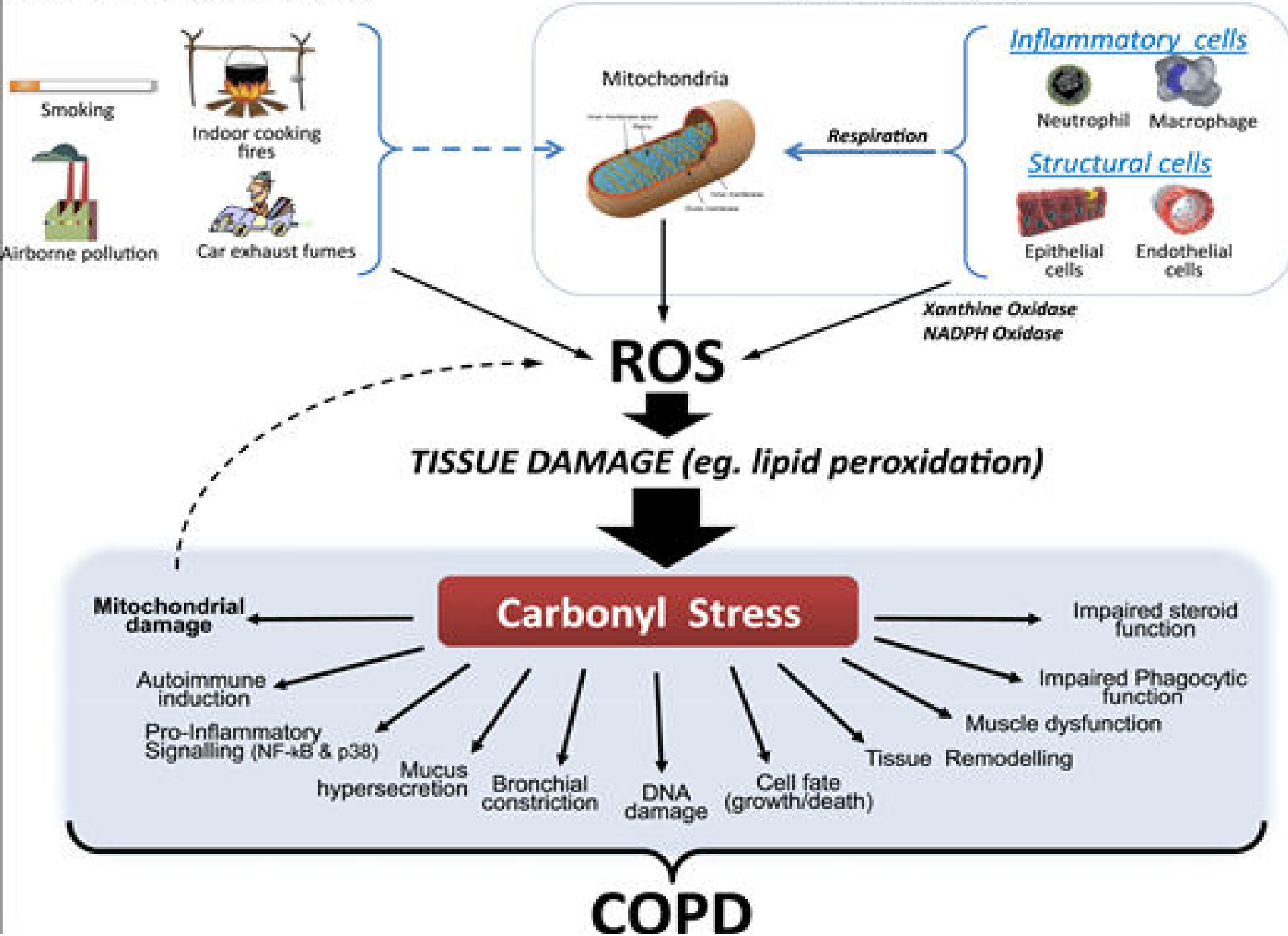


- Deranged Cellular Environment
- Cell membrane Damage
- Tissue Necrosis
- Cell Death

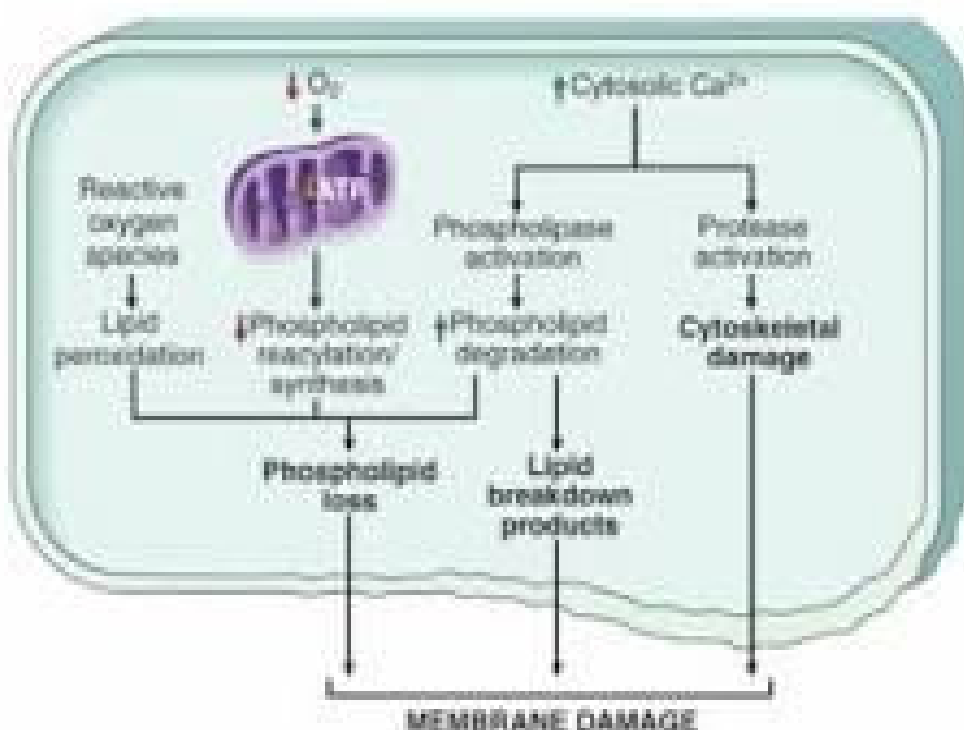


Environmental Sources

Cellular Sources



5. Defects in Membrane Permeability



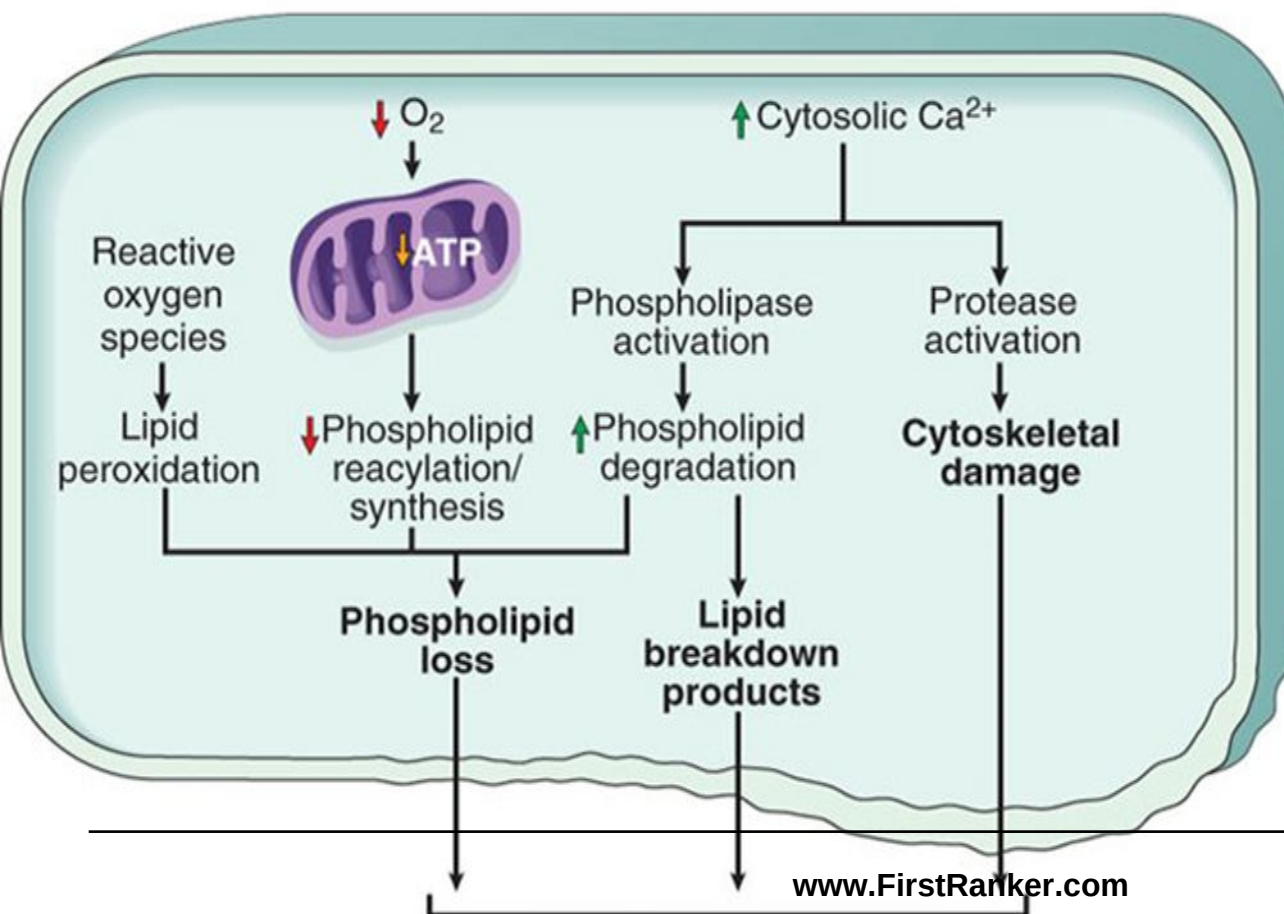
- The plasma membrane can be damaged by:
 - ischemia,
 - various microbial toxins,
 - lytic complement components,
 - physical and chemical agents.
- The most important sites of membrane damage during cell injury are:
 - Mitochondrial membrane damage
 - Plasma membrane damage
 - leads to loss of osmotic balance and influx of fluids and ions, as well as loss of cellular contents.
 - Injury to lysosomal membranes
 - leads to leakage of their enzymes into the cytoplasm and enzymatic digestion of cell components, necrosis.

Mitochondrial Electron Transport Chain Defects

Due to Phospholipid Deficits

Membrane Damage

- ROS → lipid peroxidation
- ↓ phospholipid synthesis
- ↑ phospholipid degradation (Ca influx activates phospholipases)
- Cytoskeletal damage (Ca influx also activates proteases)

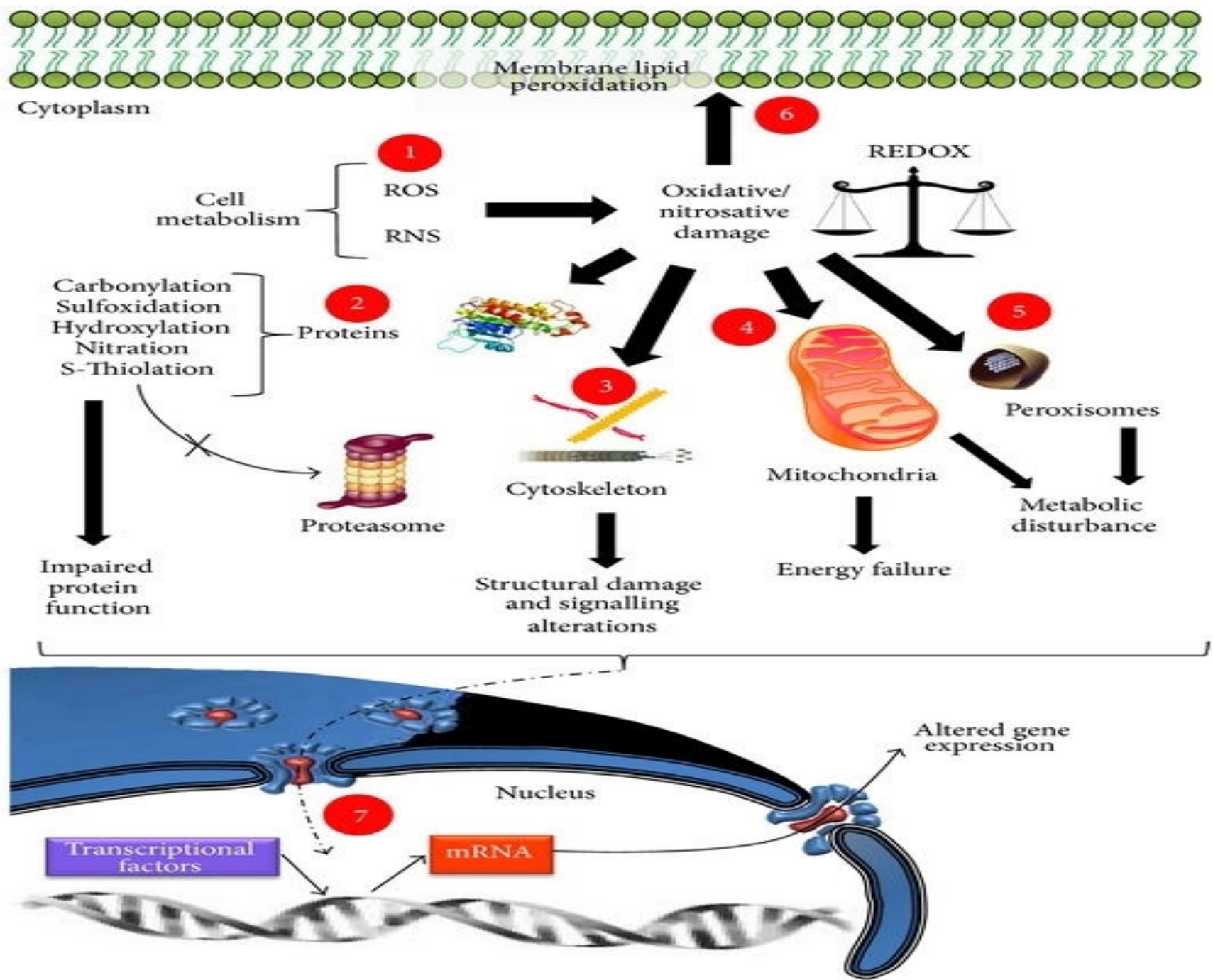


EFFECTS:

Mitochondrial membrane damage causes increased cytosolic Ca^{++} , oxidative stress, lipid peroxidation, phospholipase activity, loss of membrane potential, leakage of Cytochrome c

Plasma membrane damage causes loss of osmotic balance, loss of proteins, enzymes and nucleic acids.

Injury to lysosome membranes causes leakage of enzymes with destruction of cellular components.



Autophagy: ROS acts as a signal transducer and irreversibly oxidizes DNA and other critical cellular biomarkers

Apoptosis: Induced in inflammatory cells, i.e. neutrophils, macrophages, and eosinophils, leading to damaged DNA and protein

Necrosis: Initiated via TNF, causes swelling of cells and eventual leakage of contents

Entosis: Accumulated ROS in vacuoles can trigger cells to recruit autophagy proteins necessary for cell death

Anoikis: ROS serves as a cell adhesion mediator that allows cells to avoid programmed death

Mitotic catastrophe: Triggered by oxidative stress, ROS enhances p53 function and programmed cell death

Cornification: Small proline-rich proteins (SPRR) in cell envelope are responsible for ROS quenching, preventing damage to the skin

Paraptosis: As a result of mitochondrial Ca^{2+} influx, ROS production leads to mitochondrial membrane loss of function

Pyroptosis: ROS stimulates inflammasome production, which downstream disrupts the cell ion gradient leading to cell lysis

Cell death

Wallerian degeneration: Neuronal degradation as a result of an accumulation of ROS in absence of Sarm1

Excitotoxicity: leads to lethal influx of Ca^{2+} , resulting in excessive ROS production and cell death

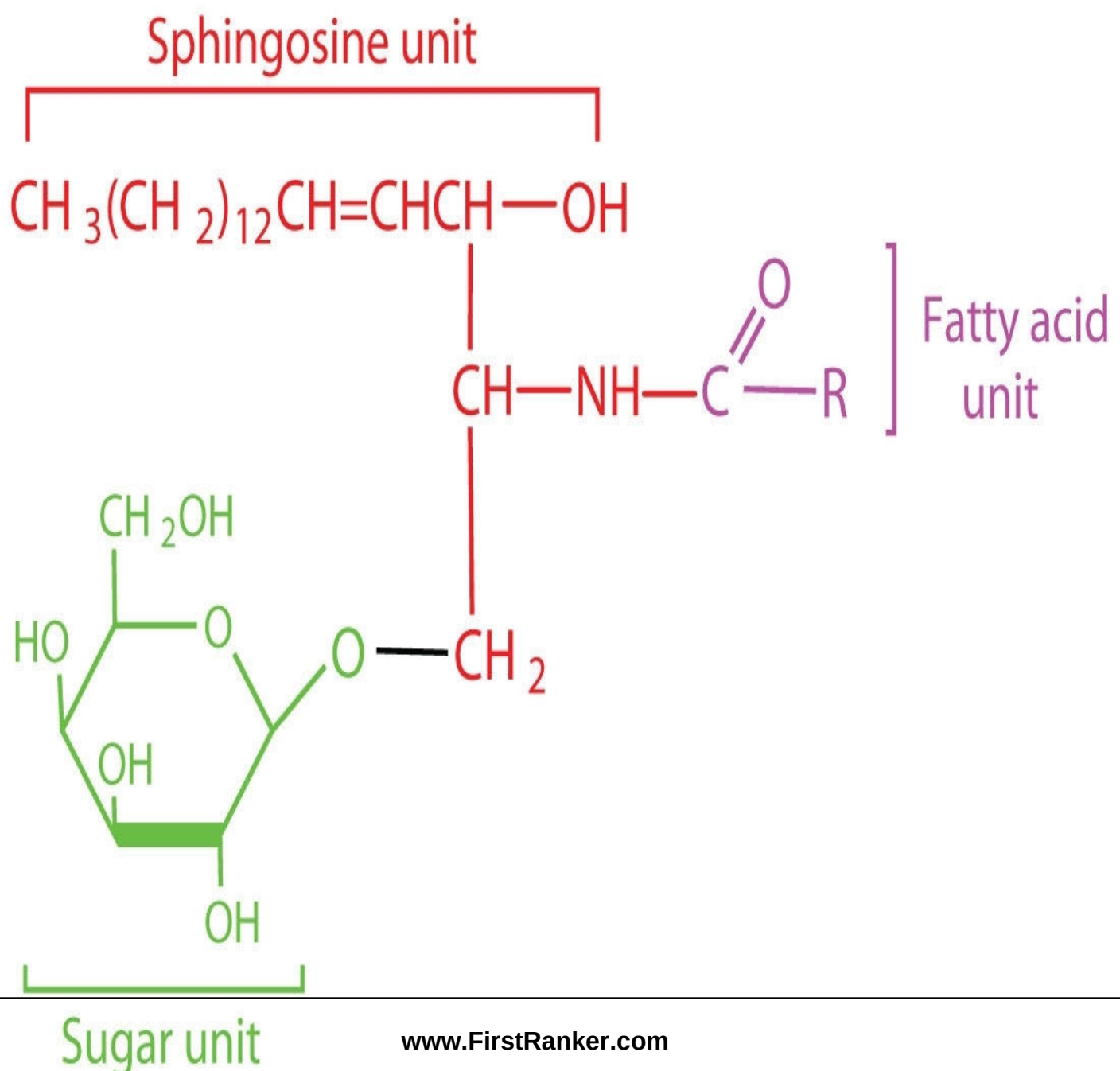
Pyroptosis: ROS leads to inflammasome complex production, which causes the production of inflammatory cytokines and further cell damage

Fatty Liver Due to Phospholipid Defects.

**Glycolipids
OR
Glycosphingolipids**

What are Glycolipids?

- Glycolipids are type of **compound Lipids**.
- **Chemically Esters of Fatty acids with Alcohol and contain additional group as Carbohydrate moieties**



Types Of Glycosphingolipids Based Upon

- **Alcohol**
- **Fatty acid**
- **Number and Type of Carbohydrate moieties and there derivatives linked to a Ceramide**

Types OF Glycolipids Based on Alcohol

1. **Glyco**glycerolipids****
(More In Plants)
Glycerol as Alcohol
2. **Glyco**sphingolipids****
(Predominant in Animals and Human)
Sphingosine as Alcohol

Classification of glycolipids:

- **(A). Glycerolipids:** *Glycerol backbone with carbohydrates*
 - a) *Galactolipids*
 - b) *Sulfolipids*
- **(B). Sphingolipids:** *Sphingosine backbone with carbohydrates*
 - a) *Cerebrosides*
 - b) *Gangliosides*
 - c) *Globosides*



www.easybiologyclass.com

Glycosphingolipids **Predominant Animal Glycolipids**

- **Ceramide linked with one or more sugar residues /there derivatives**

Human Glycosphingolipids

All has Ceramide in Their Str

- 1) Cerebrosides**
- 2) Gangliosides**
- 3) Globosides**

Cerebrosides

Simplest GlycoSphingolipids

Monoglycosylceramide

Cerebrosides

- **Cerebrosides** are type of Glycosphingolipids
- **Ceramide linked with one sugar residue**

Types of Cerebrosides

- Depending upon Carbohydrate moiety
Types of Cerebrosides are:

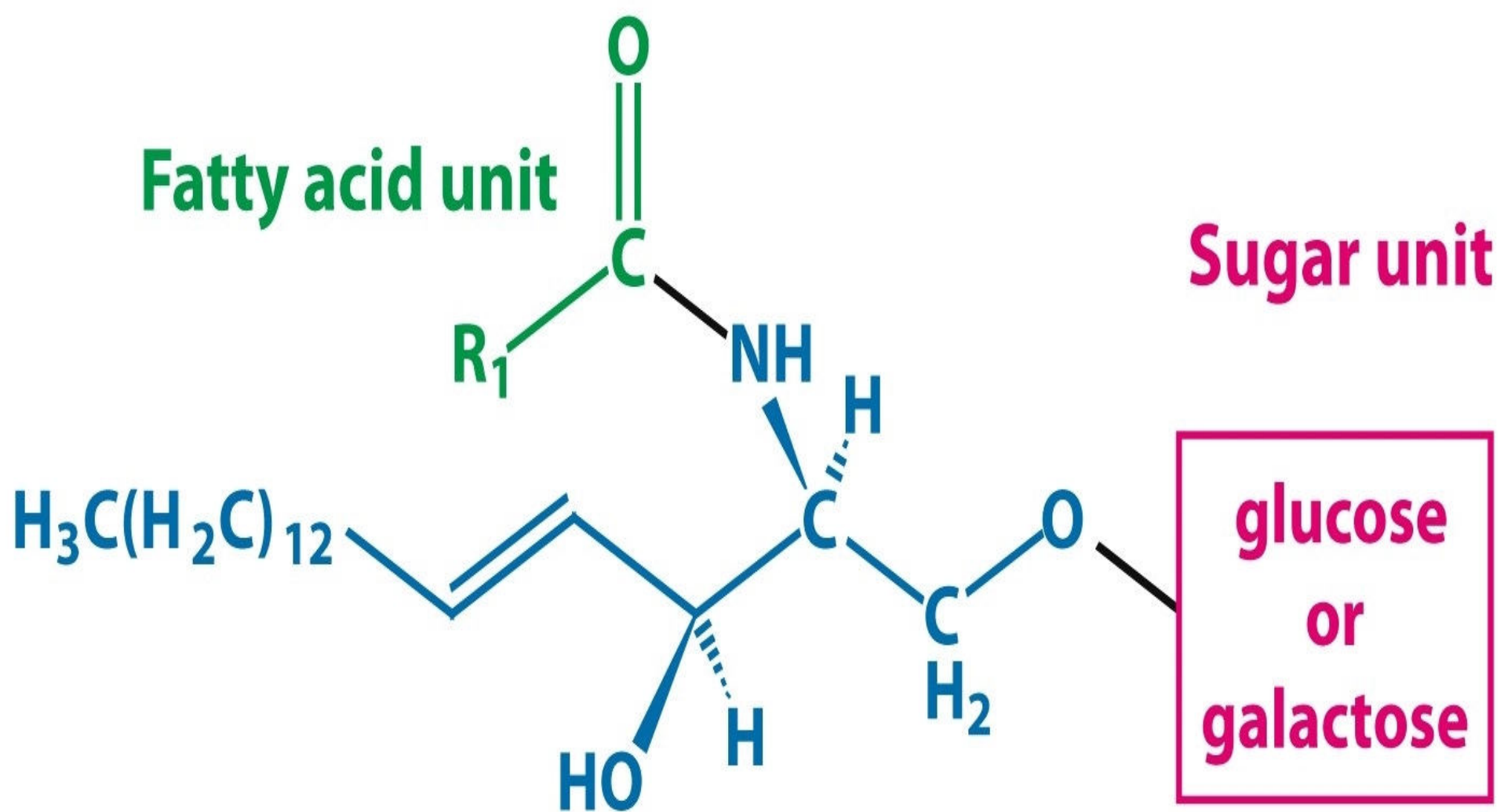
—**Glucocerebrosides**

(Occur In Extra neural/Other tissues)

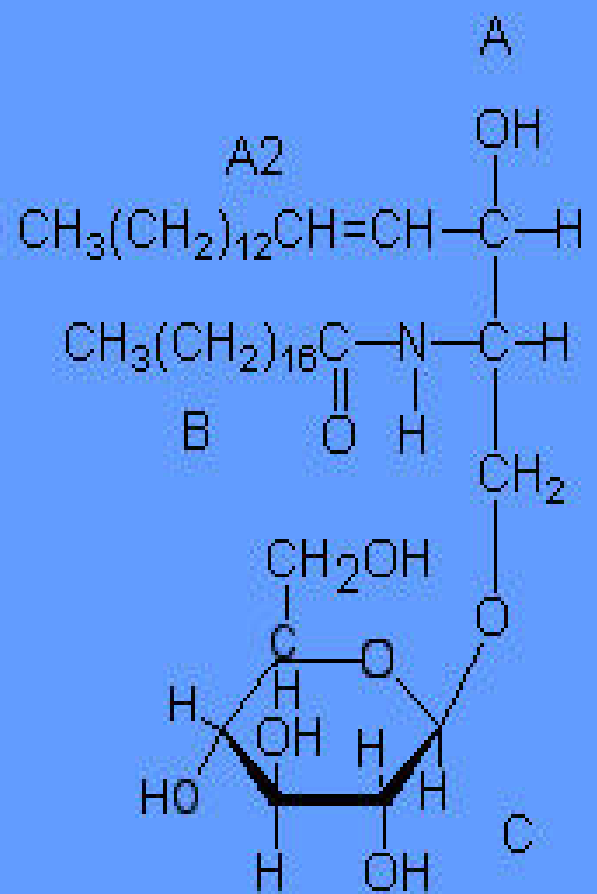
—**Galactocerebrosides**

(Present In Neural)

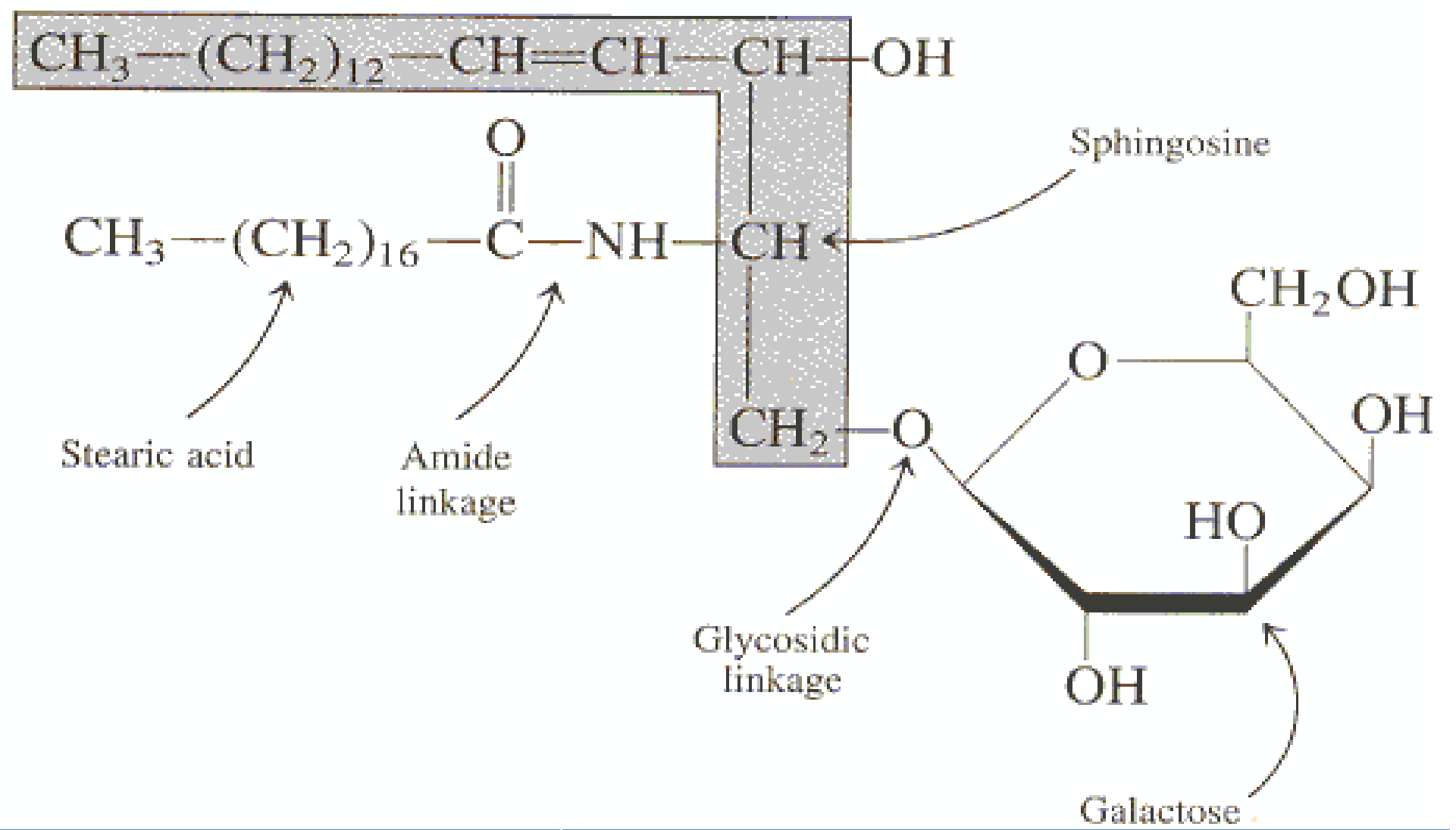
Structures Of Cerebrosides



A Glucocerebroside



Galactocerebroside



Cerebrosides	Fatty Acid Composed In
Kerasin	Lignoceric acid (C24) SFA
Cerebron	Cerebronic acid (C24) Hydroxy SFA
Nervon	Nervonic acid (C24) MUFA
Oxynervon	Oxynervonic acid (C24) MUFA

Gangliosides

Complex Glycosphingolipids

Gangliosides

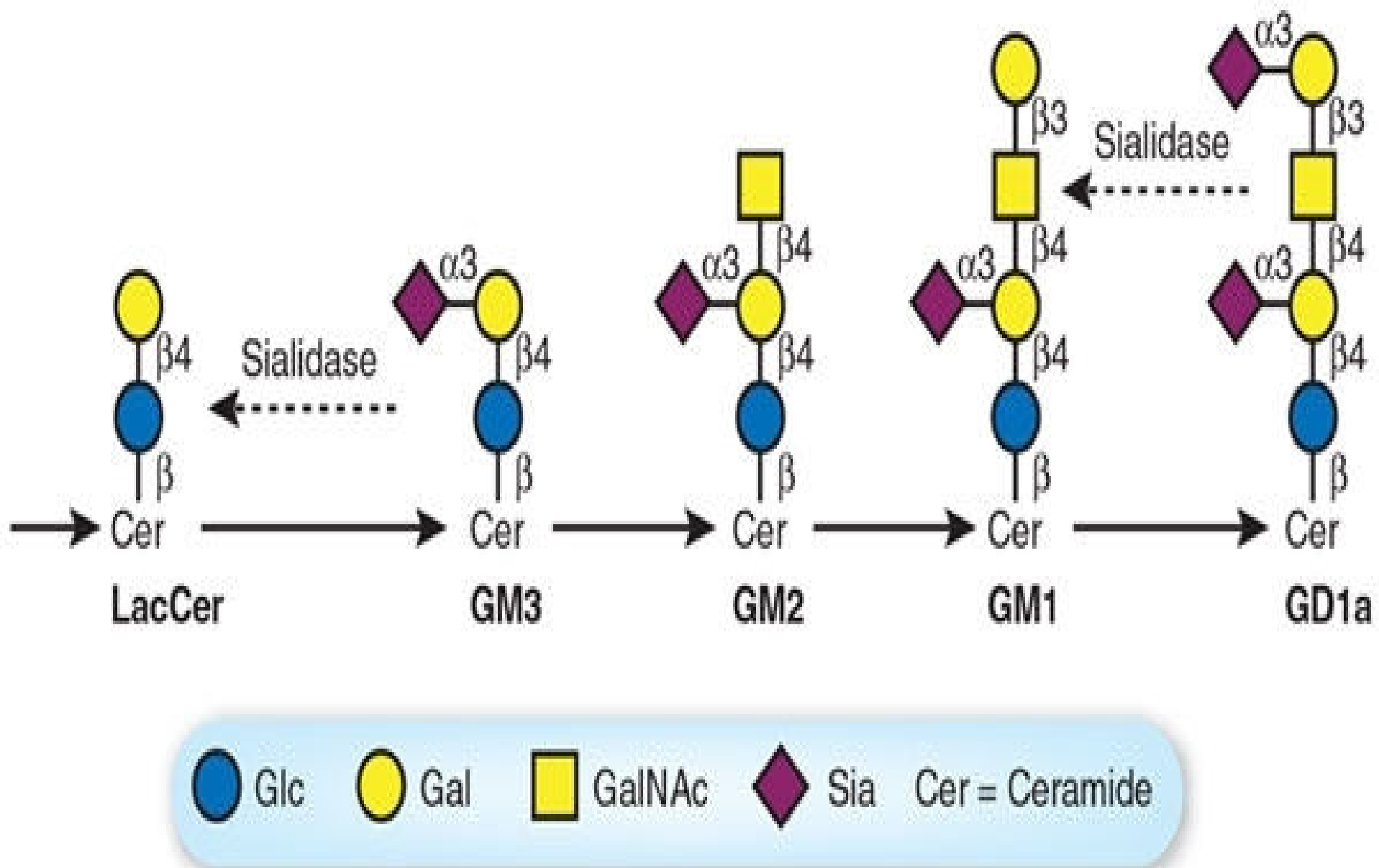
- Gangliosides are **Type of Glycosphingolipids**
- In comparison to **Cerebrosides**, Gangliosides are more **complex.**

NANA in Gangliosides

- Characteristic feature of Gangliosides is
- Structure contains **one or more N-Acetyl Neuraminic Acid (NANA)/Sialic acid residues**
- **NANA/Sialic acid is derived from N-Acetyl Mannose and Pyruvate.**

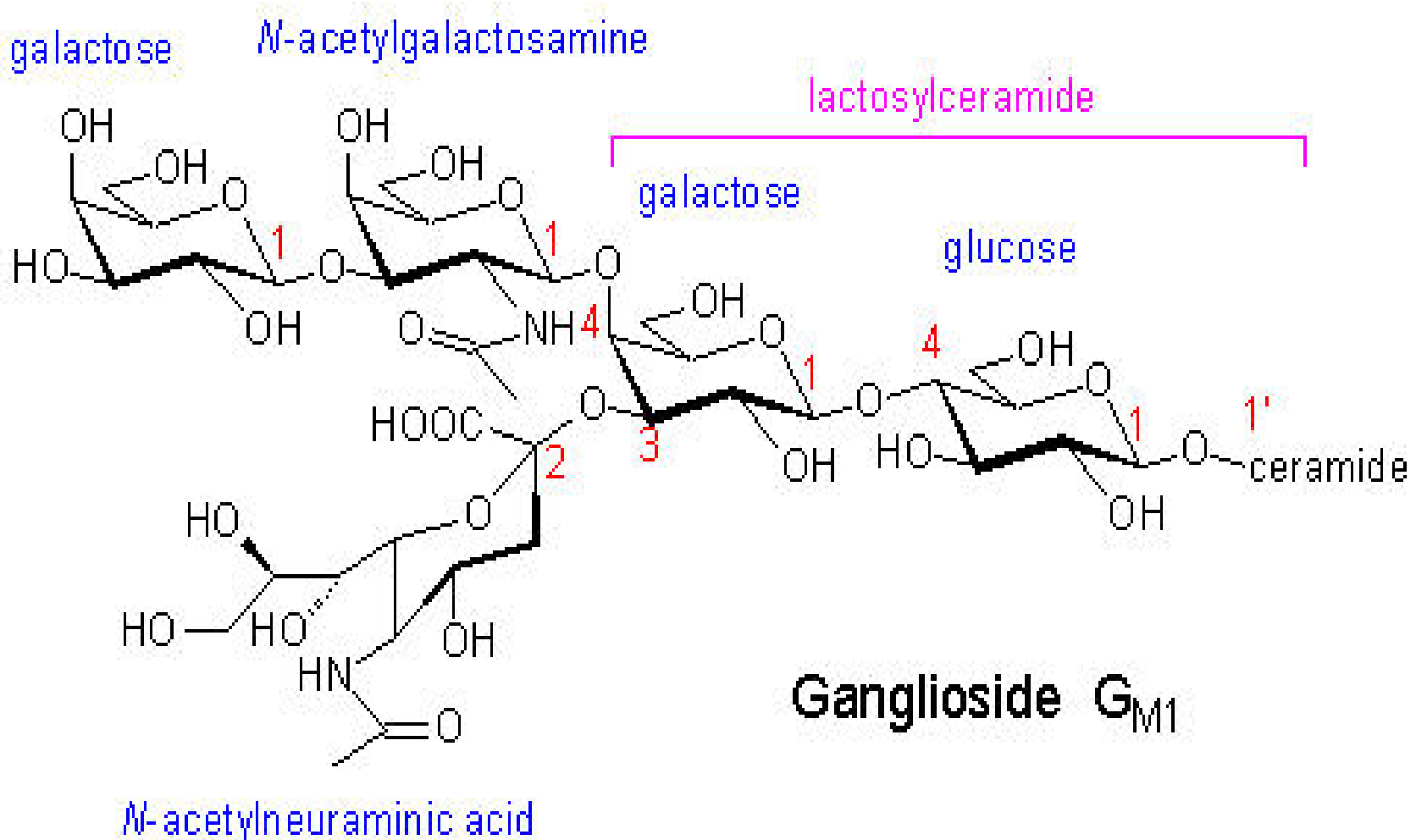
- **Gangliosides** structure has Carbohydrate moieties as
 - **Glucose**
 - **Galactose**
 - **N-Acetyl Galactosamine**
 - **N-Acetyl Neuraminic Acid (NANA)/Sialic acid.**

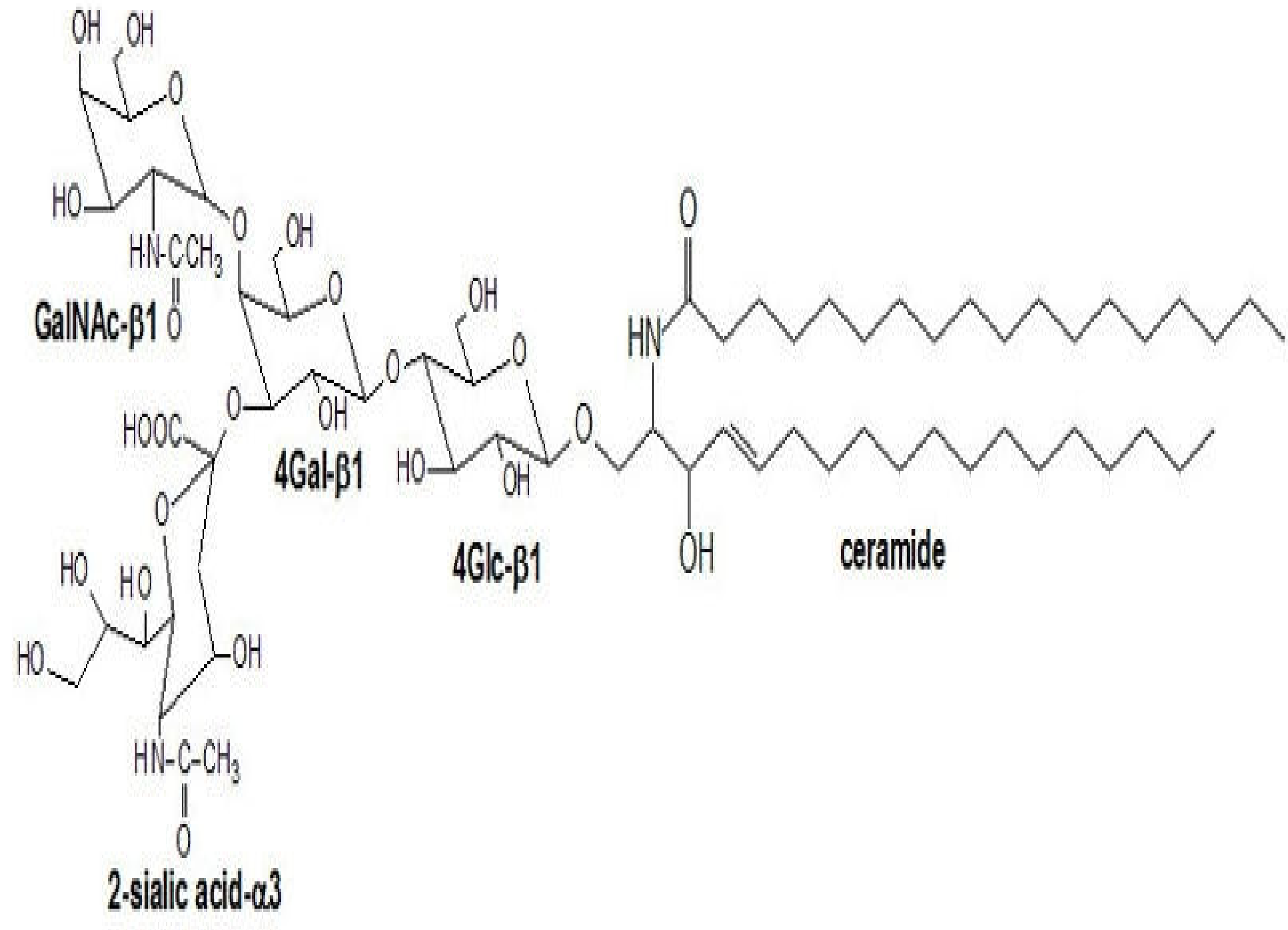
Structure Of Gangliosides



- **GM3 is more common and simplest Ganglioside.**
- GM3 has **single Sialic acid** and **less carbohydrate moieties.**

- **GM1 is a more complex Ganglioside.**
- **GM1 is obtained from GM3.**





Types Of Gangliosides

- Depending upon the Chemical structure and Chromatographic separations
- **More than 30 Types of Gangliosides** are isolated:

Types Of Gangliosides

- Based on **Number and Position of NANAs** in Ganglioside structure
- Various types and subtypes of Gangliosides are existing in human body

Types of Gangliosides

—Gangliosides with **one** NANA residue

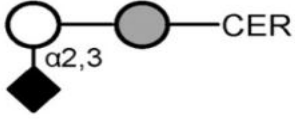
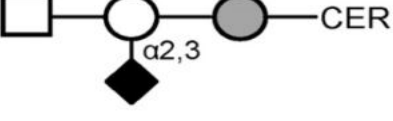
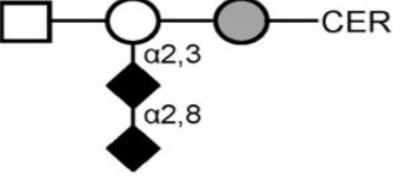
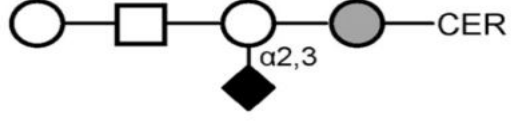
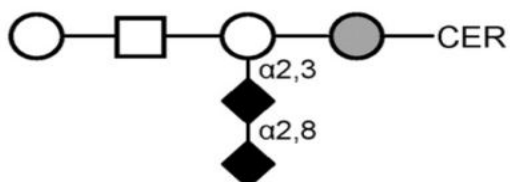
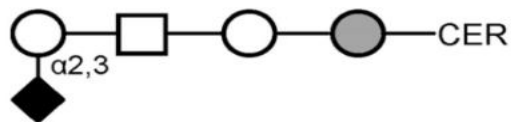
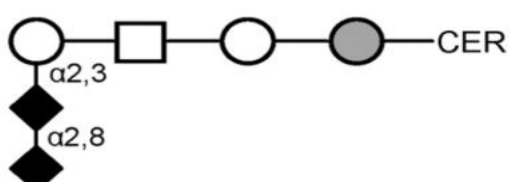
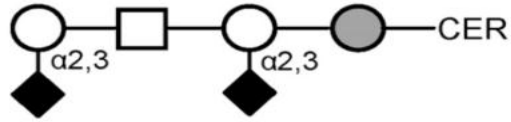
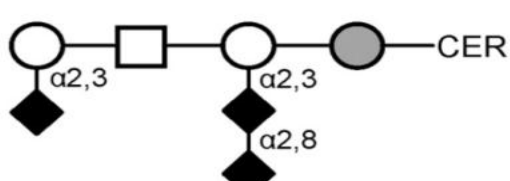
- **GM1**
- **GM2**
- **GM3**

—Gangliosides with **two** NANA residues

- **GD**

—Gangliosides with **three** NANA residues

- **GT**

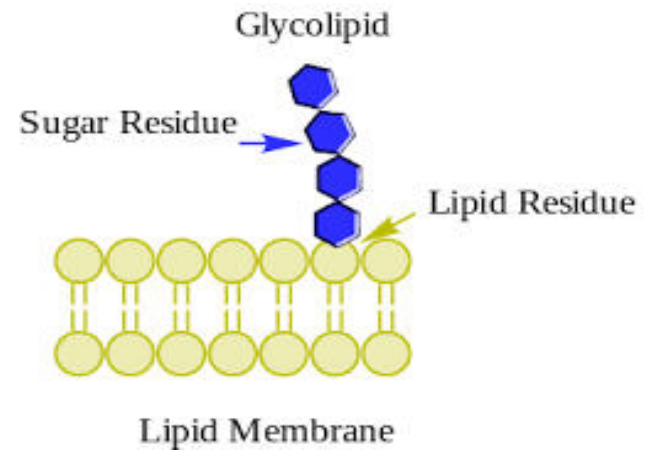
GM3		GD3	
GM2		GD2	
GM1a		GD1b	
GM1b		GD1c	
GD1a		GT1b	
GA1*			
GA2*			
GA3*			

○ galactose, □ N-acetyl-galactosamine, ● glucose, ◆ sialic acid, CER = ceramide

Sources Of GlycoSphingolipids

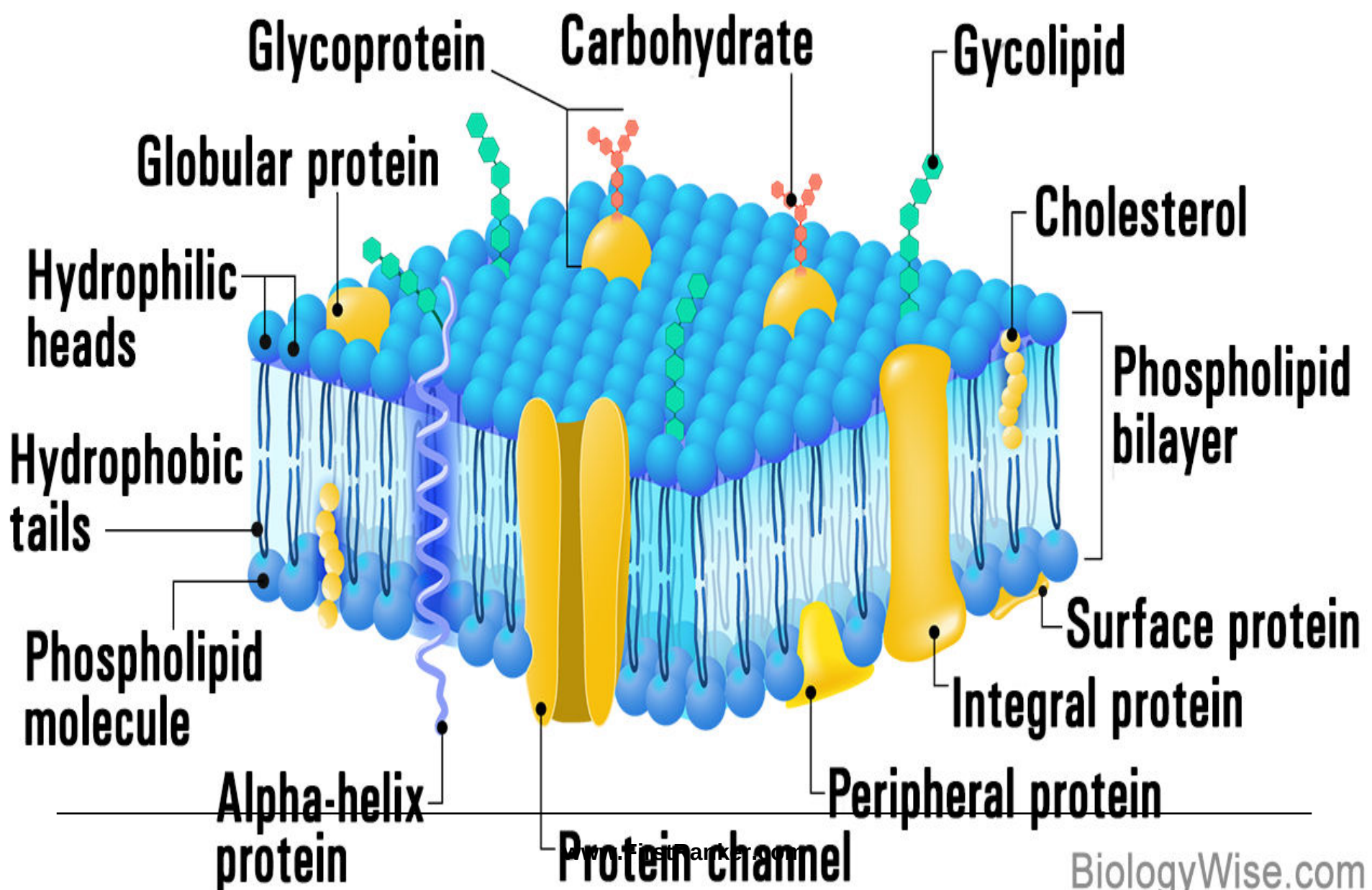
- Dietary has **no much role**
- All forms of Glycolipids **Endogenously Biosynthesized**
- Utilized for **Structure and Functional Role**

Occurrence/Distribution Of Glycolipids

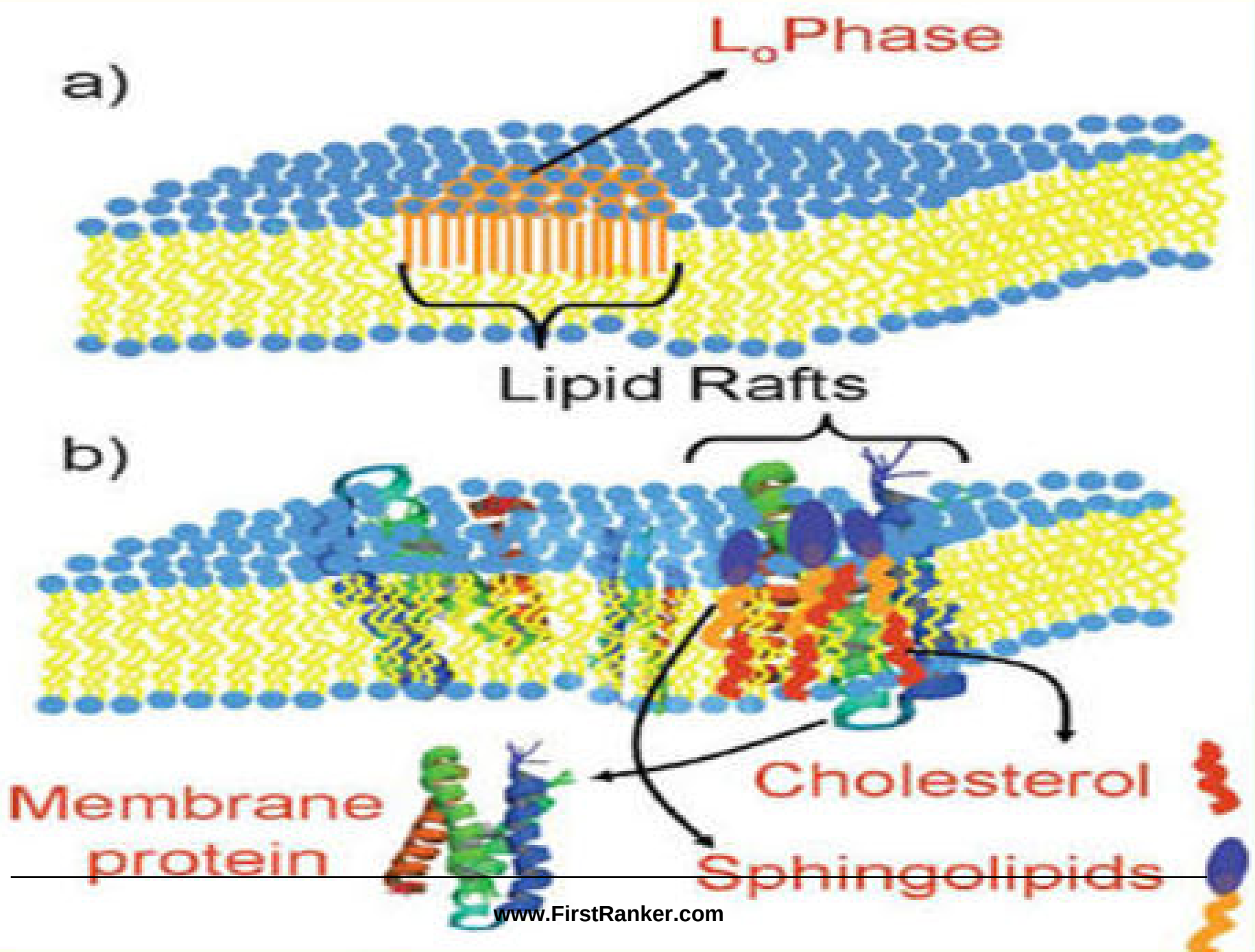


- **Glycosphingolipids** are widely distributed
- In **every cell and tissue of human body**
- Occur particularly in **outer leaflet of Cell membrane/Glycocalyx /Cell Rafts**
- They are **richly present in nervous cells.**

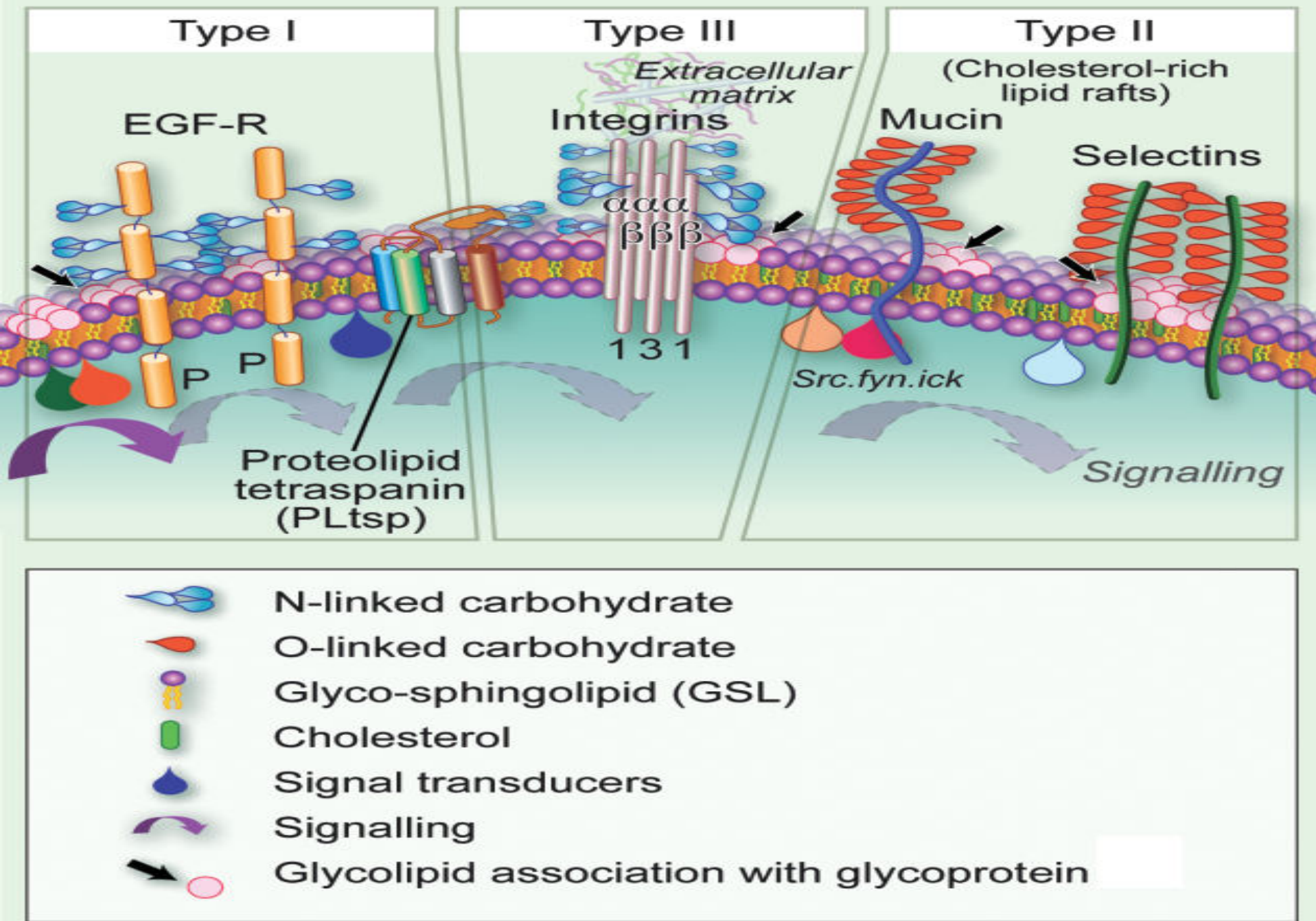
Fluid Mosaic Model



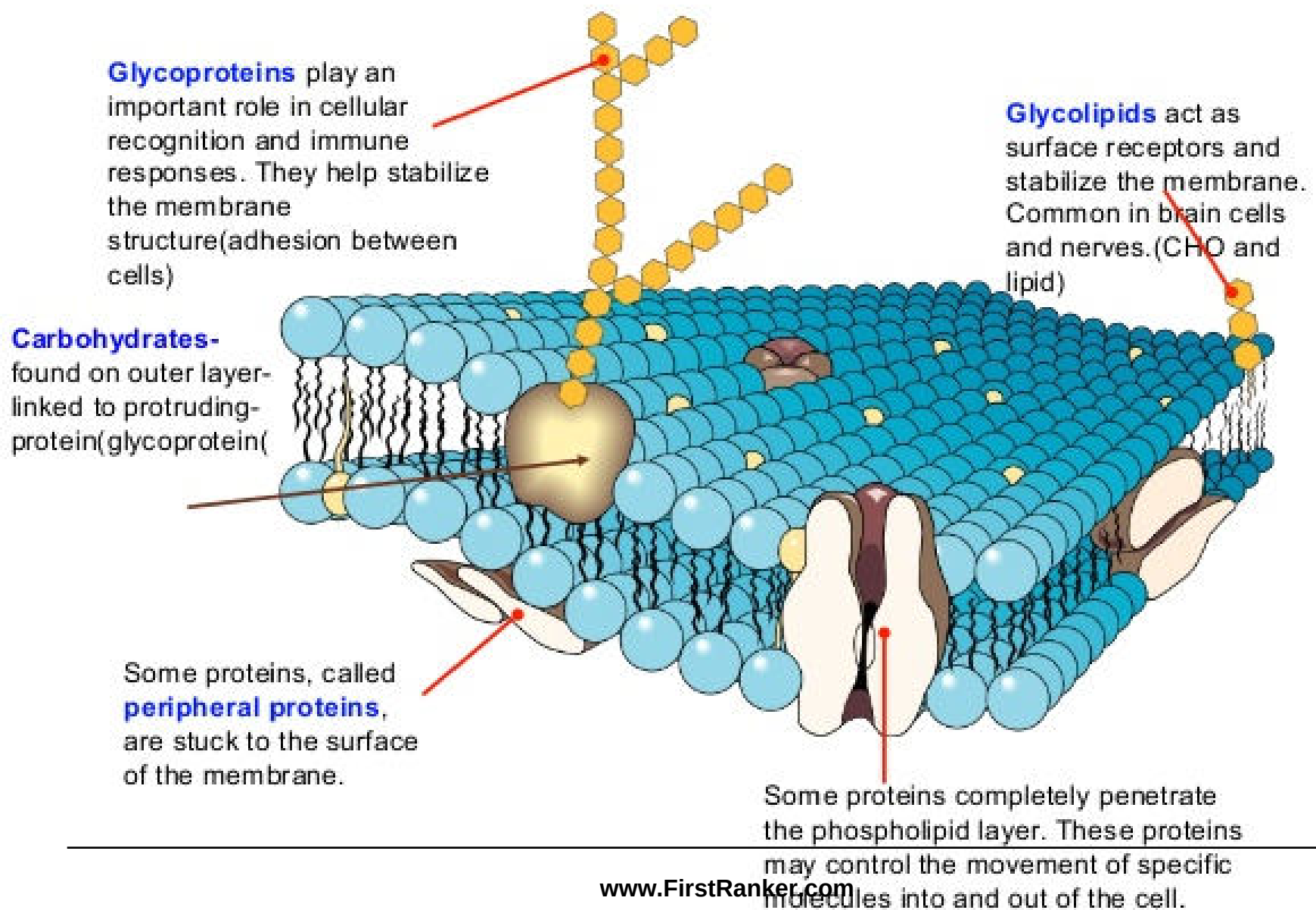
- **Glycolipids** occur on the outer surface of every **cell membrane** as component of **Glycocalyx / (Cell raft)**.



Glycosynapse:



Membrane Structure



—**Cerebrosides:** Richly present in

- **White matter of brain**
- **Myelin sheath**

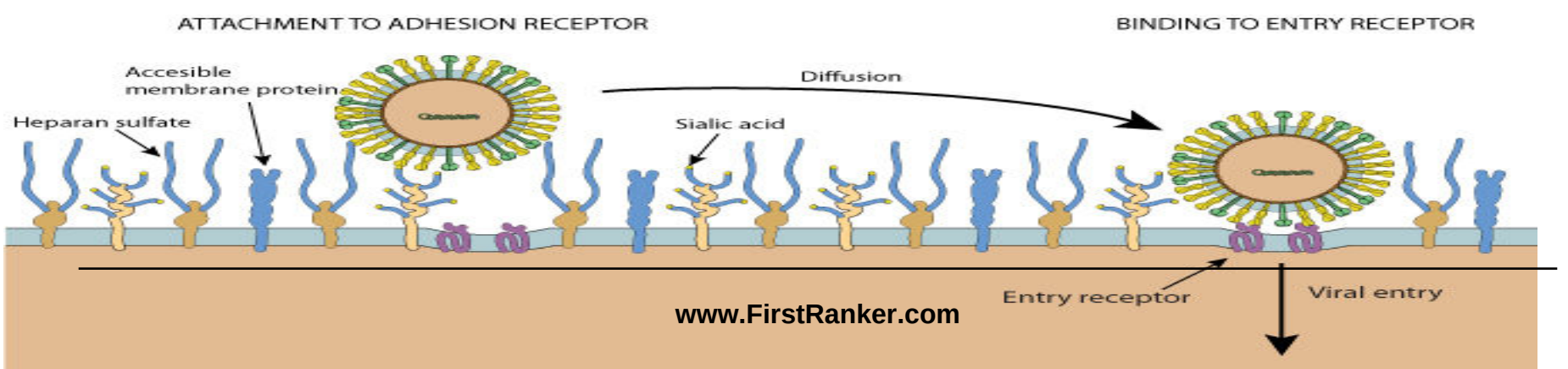
—**Gangliosides:** Predominantly present in

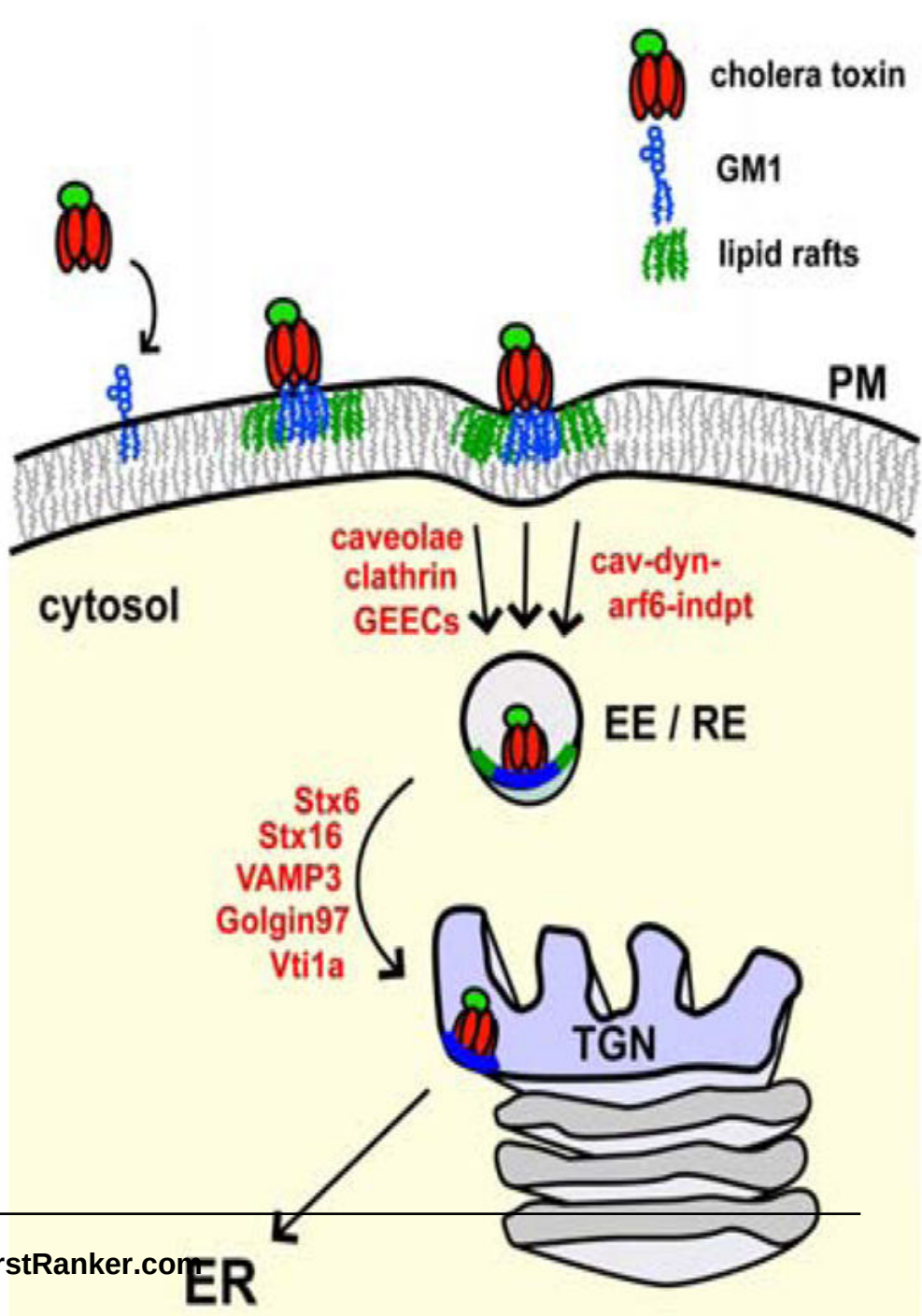
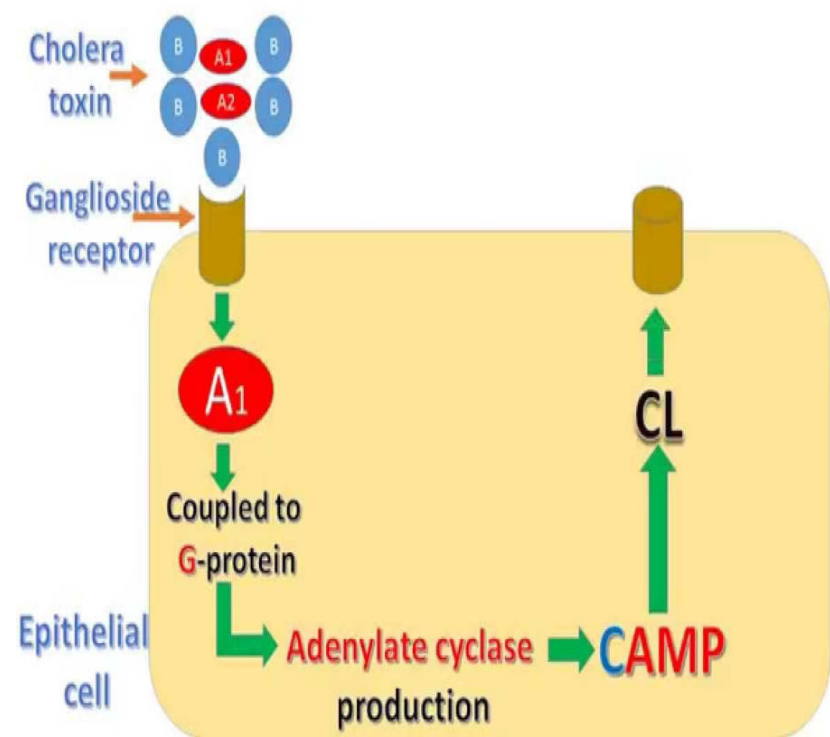
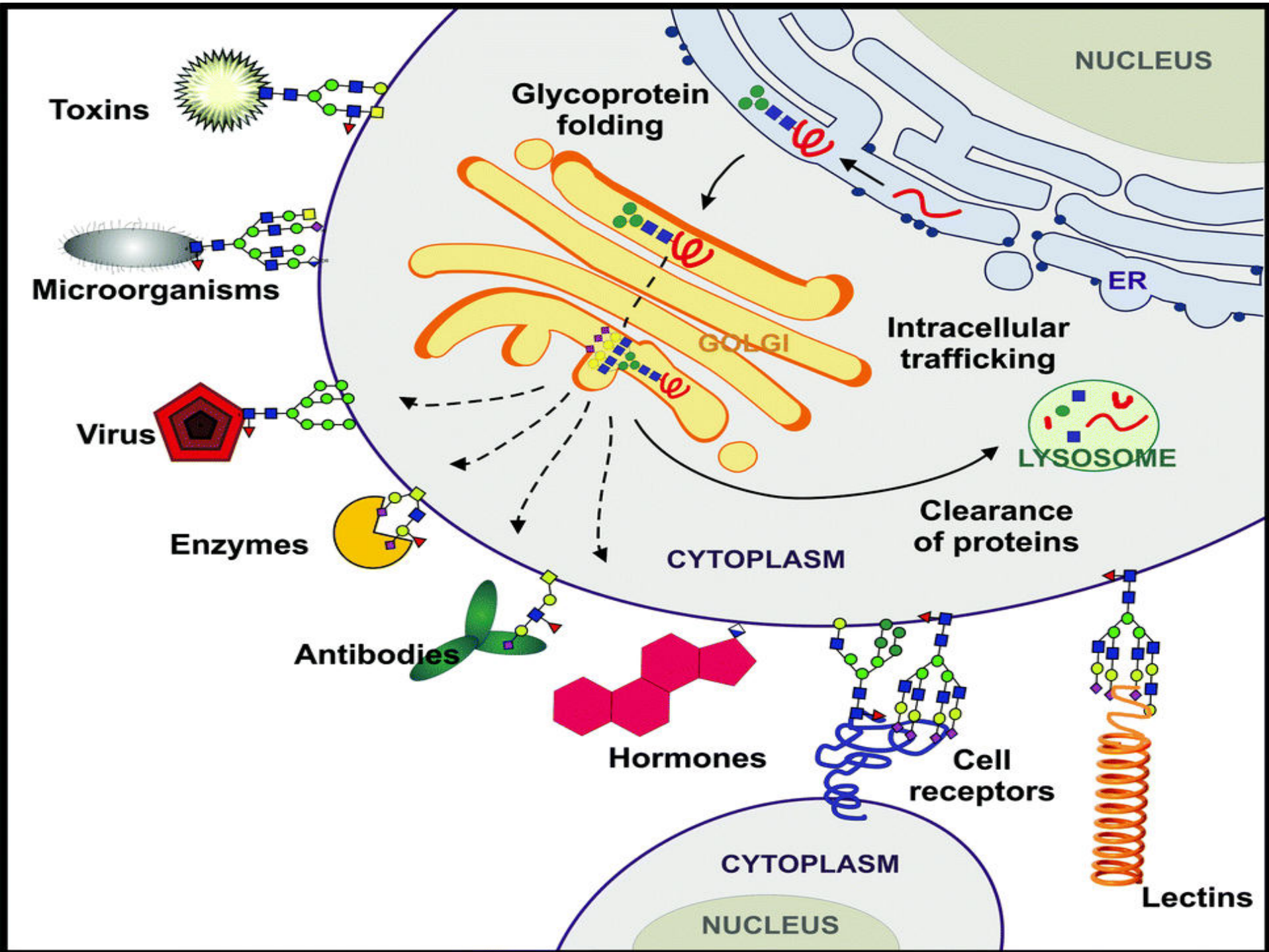
- **Grey matter of brain**
- **Ganglions and Dendrites**

Functions Of Glycolipids

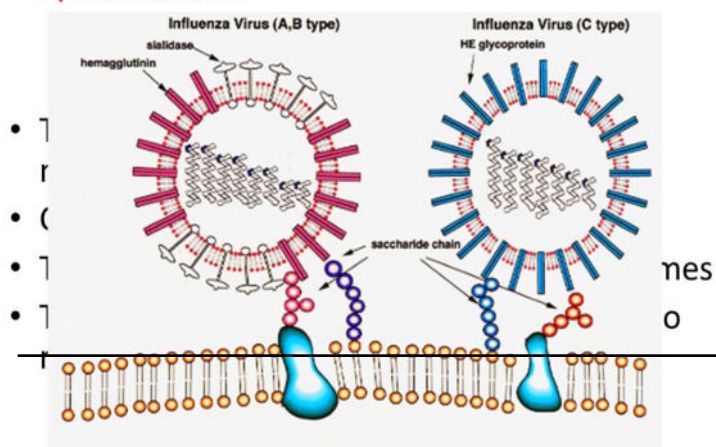
- Glycolipids are richly present in nervous tissue, they help in:
- **Development and function of brain.**
- **Nerve impulse conduction**
- Glycolipids present in cell membranes
Serve as :
 - Antigens**
 - Blood group Antigens
 - Embryonic Antigen
 - Receptor sites for Hormones.**

- **Glycolipids of cell membrane serve as:**
- **Markers for cellular recognition which helps in:**
 - Cell Functioning
 - Cell-Cell interaction
 - Cell Signaling/Signal Transduction
 - Anchoring sites for Antigens, Toxin and Pathogens
 - Cell Growth and Differentiation
- **GM1** serve as **receptor** /**anchoring** site to :
 - Cholera toxin
 - Tetanus toxin
 - Influenza viruses



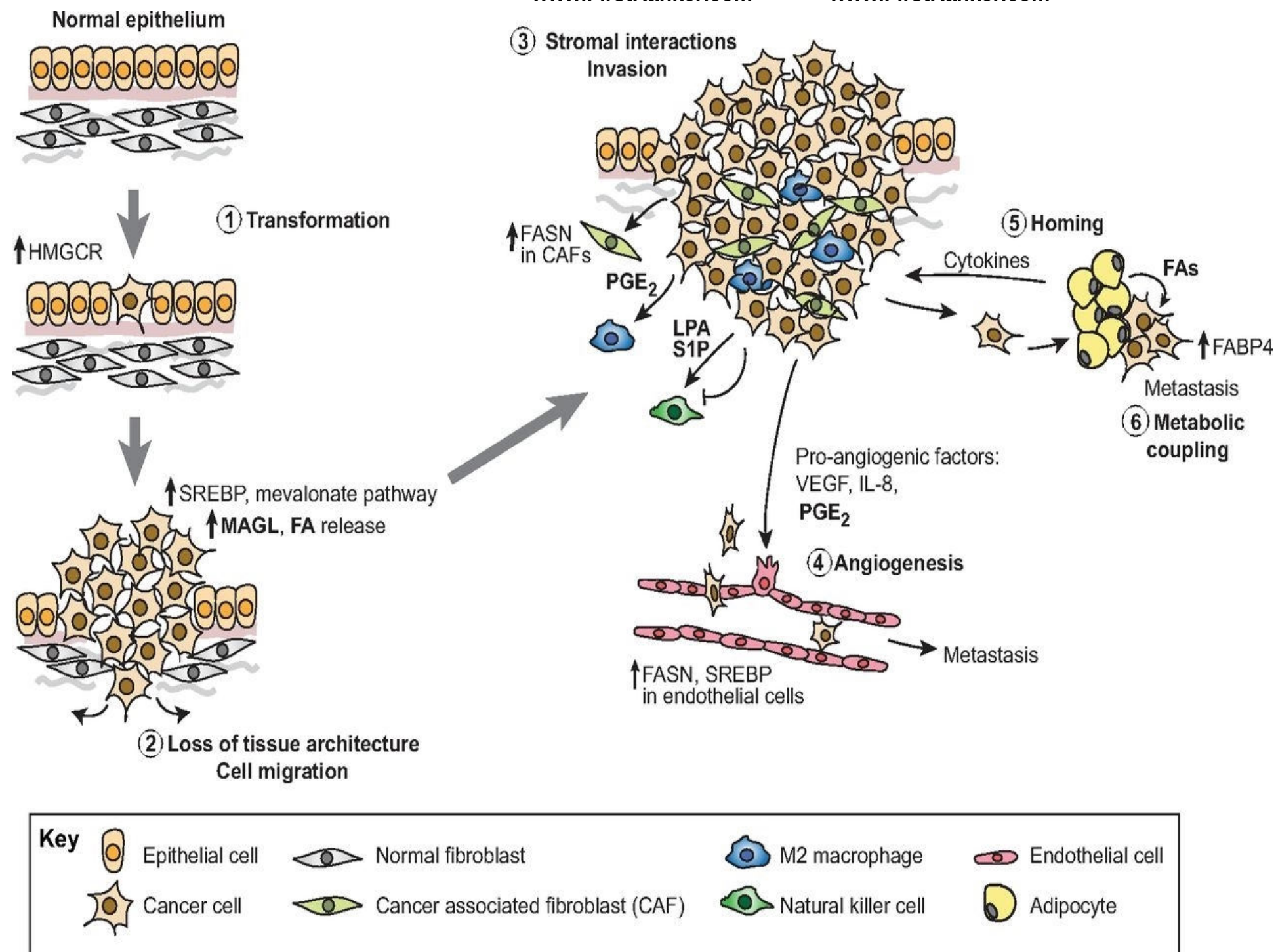


- Influenza viruses bind through **hemagglutinin** onto **sialic acid** sugars on the surfaces of **epithelial cells**



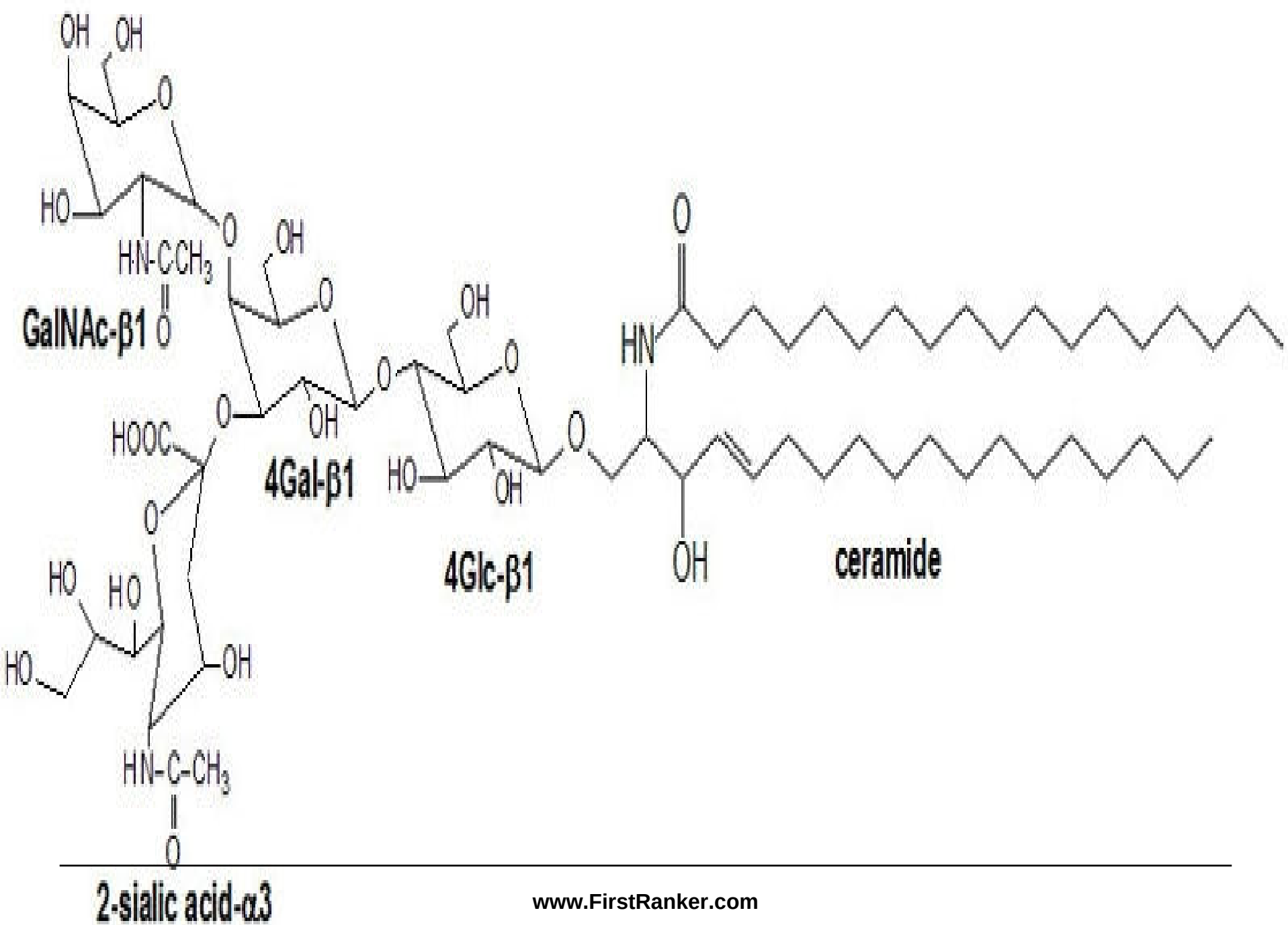
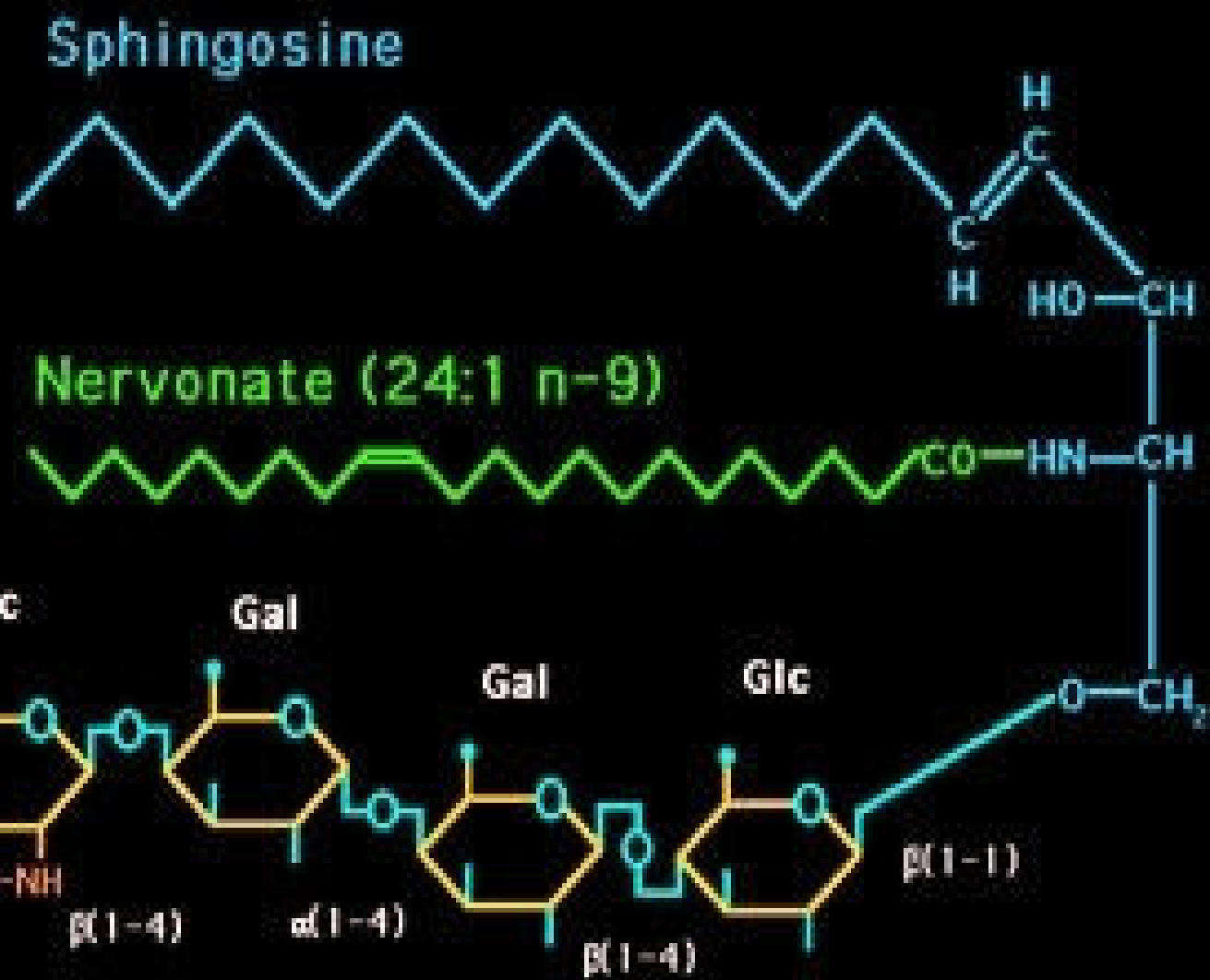
- The **Cholera toxin** on binding to intestinal cells
- Stimulates secretion of Chloride ions into gut lumen.
- **Resulting in copious diarrhea of Cholera.**

- In various malignancies dramatic changes in **membrane Glycolipid** composition are noted.



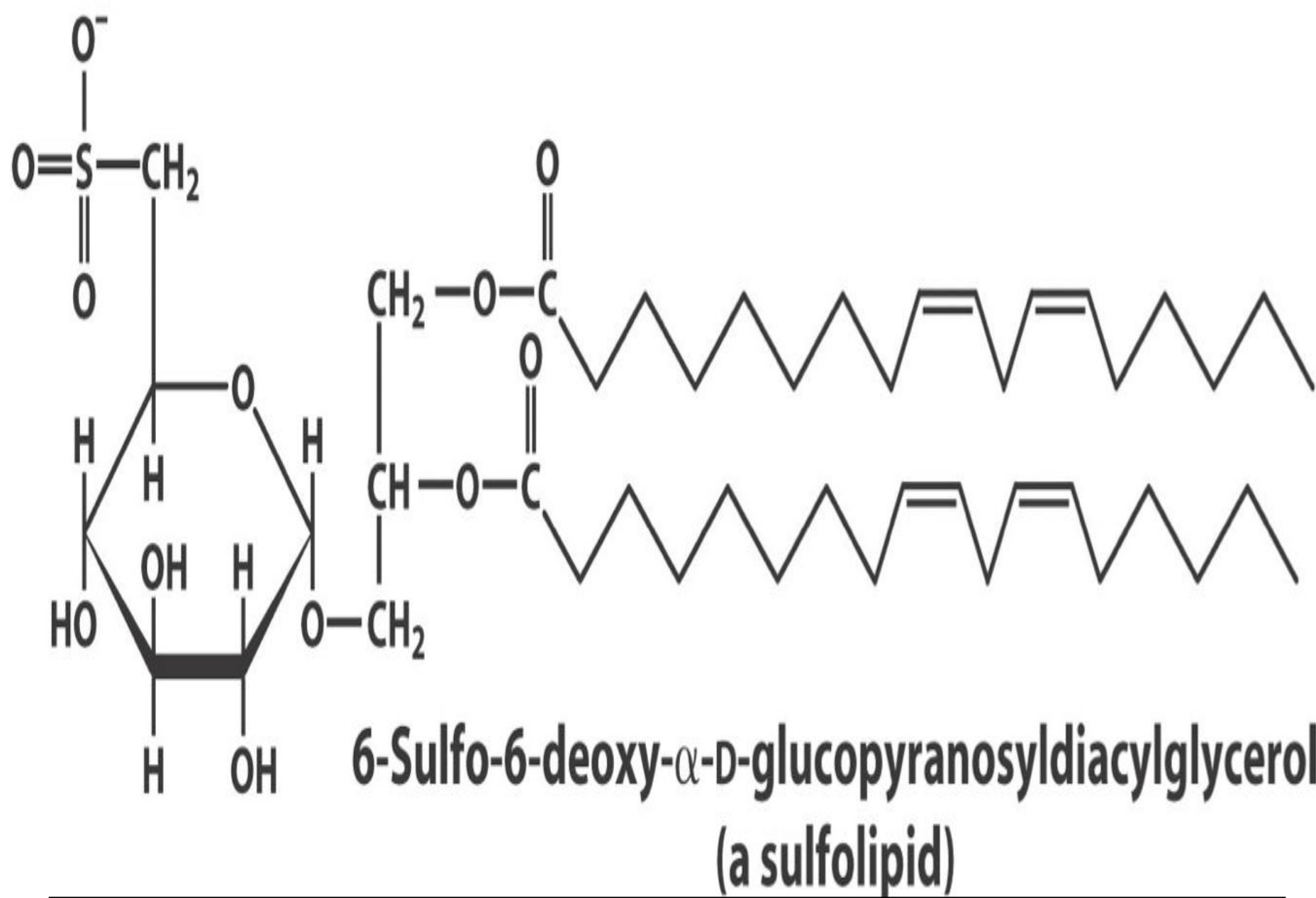
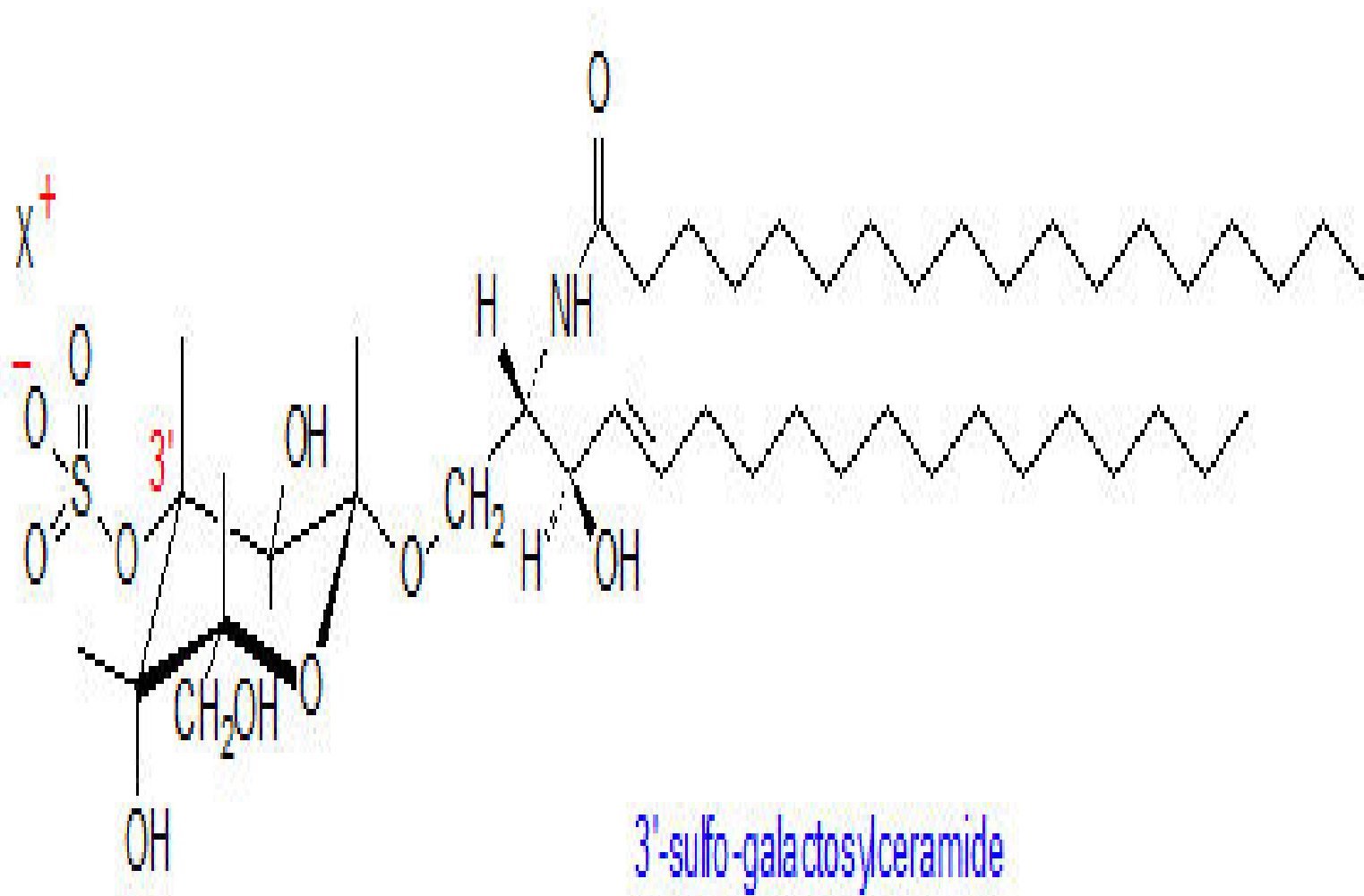
Globosides

- Globosides are **type of Glycolipids**.
- Structurally **Ceramide linked with Oligosaccharide** is Globosides.



Sulfatides/Sulfolipids

- **Sulfolipids** are compound Lipids.
- Sulfolipids are **Ceramide** linked to **Sulfated sugar units/Oligosaccharides**.
- Structurally Sulfolipids may also has Glycerolipids containing **Sulfate groups**.
- Sulfolipids are component of **nervous tissue**.



Lipidosis

Lipid Storage Disorders

Inborn Errors Of Lipid Metabolism

Lysosomal Storage Disorders

Rare Genetic Lipid Associated Disorders

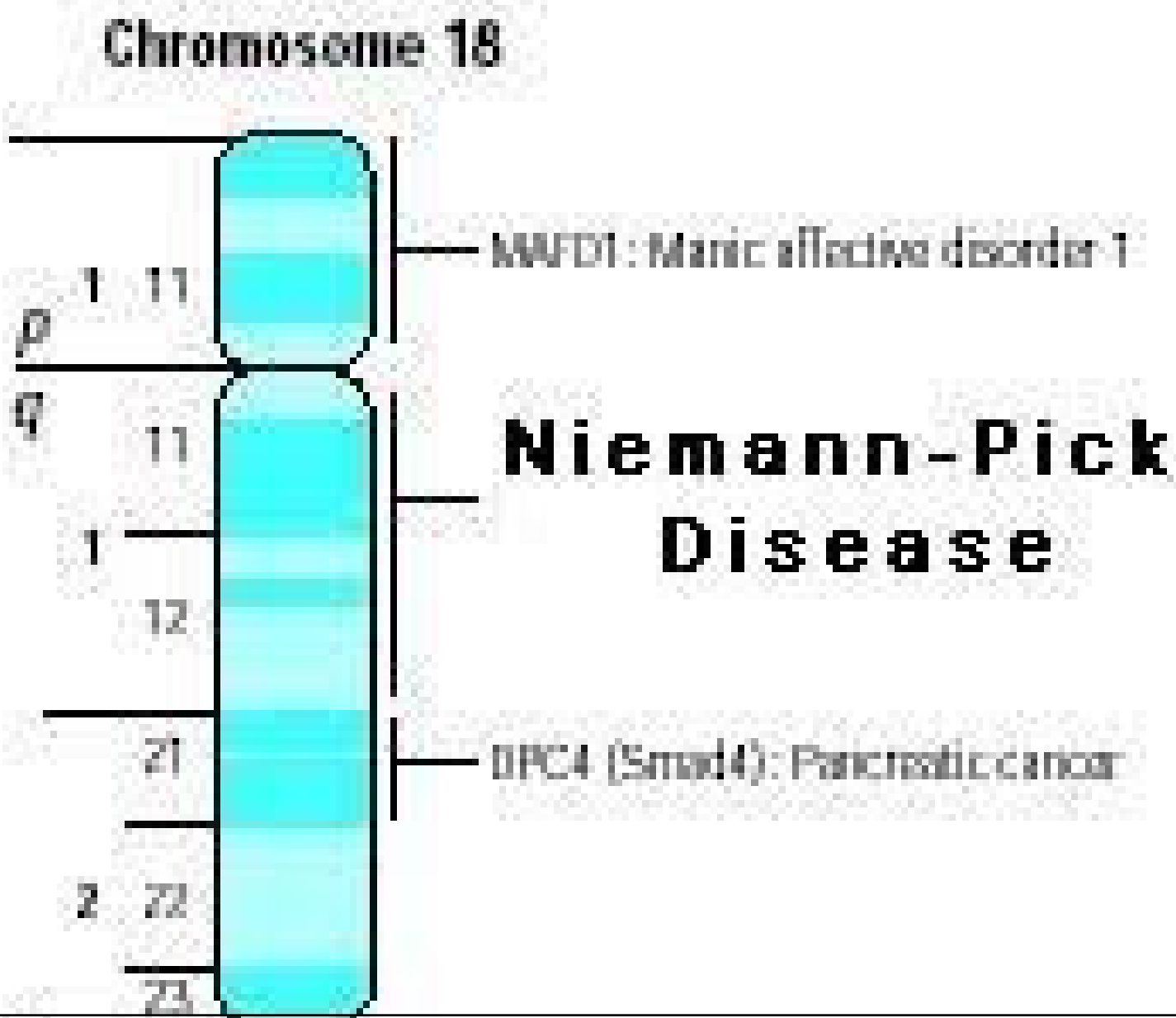
- Niemann Picks Disease
 - Tay Sach's Disease
 - Gauchers Disease
 - Farbers Disease
 - Krabbes Disease
 - Sandhoff's Disease
-

• Tay-Sachs disease — Developmental regression, Blindness, — Cherry-red spot, Deafness	AR	Hexosaminidase -A
• Gaucher's disease — Joint and limb pains, Splenomegaly — Spasticity, fits, death	AR	Glucosylceramide Type I β - Glucosidase Type II
• Niemann-Pick disease — Failure to thrive, Hepatomegaly — Cherry-red spot, Developmental	AR	Sphingomyelinase

www.FirstRanker.com

Niemann-Pick disease

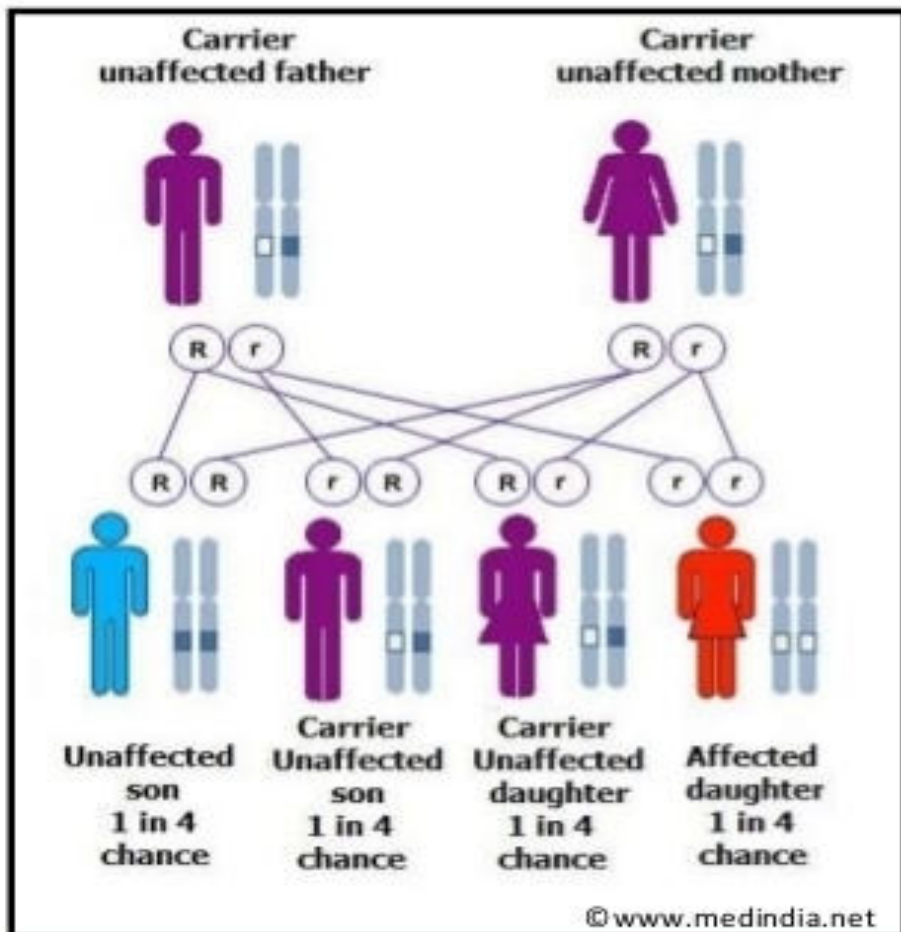
- Sphingomyelinase deficiency causes **sphingomyelin** accumulation within mononuclear phagocyte system (and neurons and glial cells)
 - Autosomal recessive
 - **cherry red spot** similar to Tay-Sachs disease.



Niemann Picks Disease

Autosomal Recessive Disorder

Is it Hereditary?



- The disease has an **autosomal recessive** pattern of inheritance.
- Both alleles of the gene must be mutated in such a way that function is impaired.
- If both parents are carriers, there is a 25% chance for an affected child with each pregnancy.

10

Niemann-Pick disease

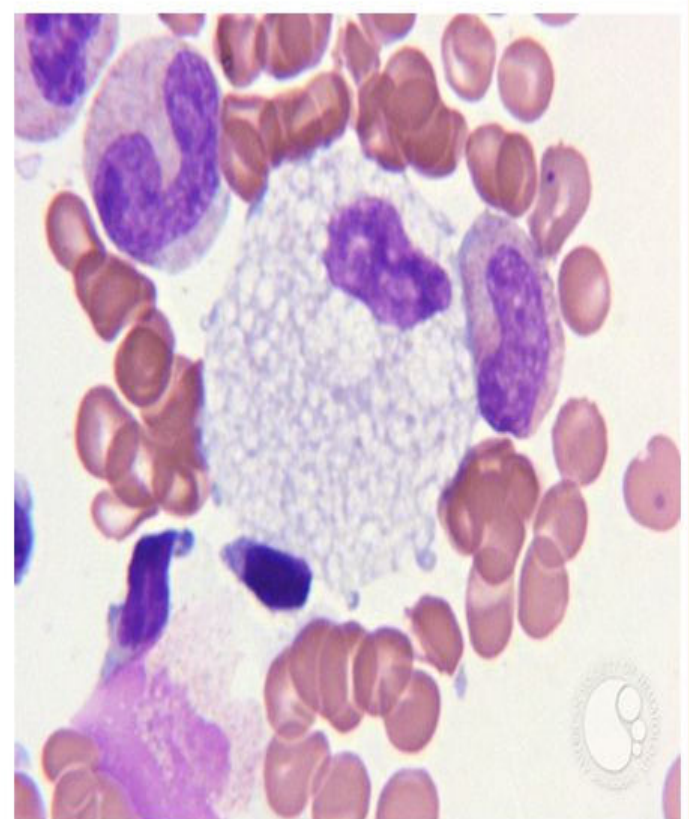
Heterogeneous group of disorders

Increased incidence in Jewish population

This disorder is divided into five main types based on the genetic cause and the signs and symptoms (A,B,C,D,E)

Clinical manifestation

- Retardation
- Hepatosplenomegaly
- Lymphadenopathy
- Pigmentation
- Impaired neurologic function
- Niemann-Pick cells – **lipid-laden giant foam cells found in affected tissues**



TYPES OF NIEMANN-PICK DISEASES

TYPE A

Most severe form, occurs in early infancy.

characterized by an enlarged liver and spleen, swollen lymph nodes, and profound brain damage by six months of age.

TYPE B

Involves an enlarged liver and spleen, occurs in the pre-teen years.

The brain is not affected

TYPE C

May appear early in life or develop in the teen or adult years. individuals have only moderate enlargement of the spleen and liver,

brain damage

Signs and Symptoms

(related to the **organs** in which they accumulate)

Type A

- ✓ Large abdomen within 3-6 months
- ✓ Cherry red spot in the eye
- ✓ Feeding difficulties (**dysphagia**)
- ✓ Loss of early motor skills (**ataxia**)
- ✓ Rapid decline in the child after 6 months

Type B

- ✓ Abdominal swelling may occur in early childhood
- ✓ No brain and nervous system involvement
- ✓ Some may develop repeated respiratory infections and breathing problems



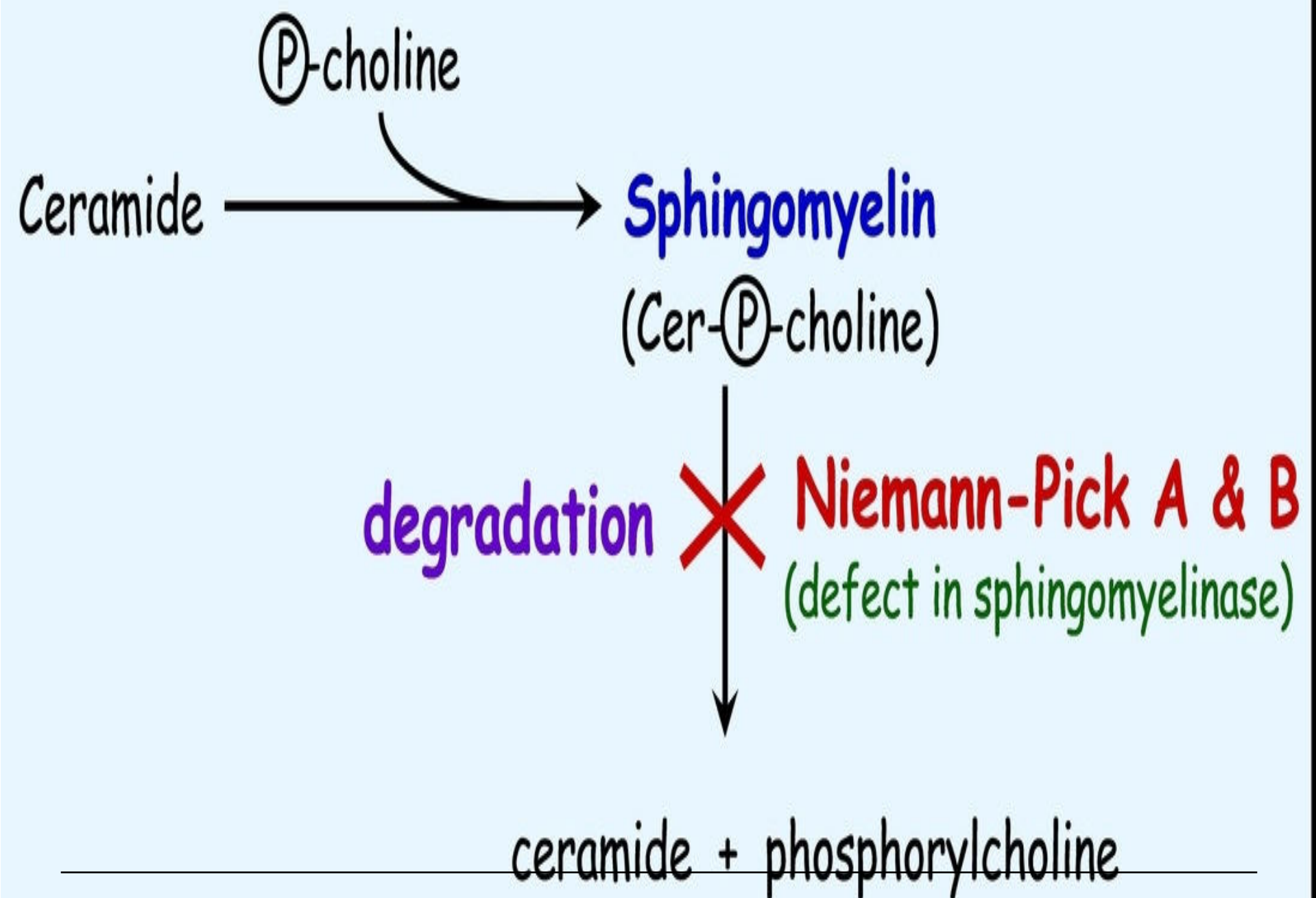
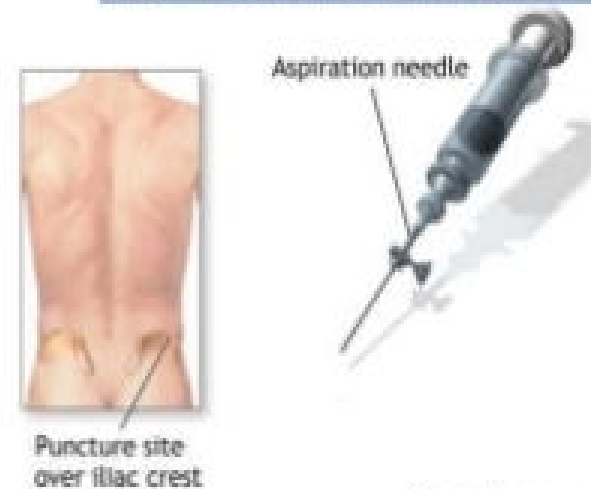
Diagnosis

Type A and B:

- * **Measurement of ASM amount in WBC**
 - by using a blood/bone marrow sample.
 - can detect patients, not carriers.
- * **DNA tests** (to determine if carriers have type A or type B)

Type C:

- * **Skin biopsy** : scientists closely examine how the skin cells grow, keep track of how they move & store cholesterol.
- * **DNA tests**
 - Few centers offer tests for **prenatal diagnosis**.
 - Other tests might include:
 - * Bone marrow aspiration
 - * Liver biopsy
 - * Slit-lamp eye exam



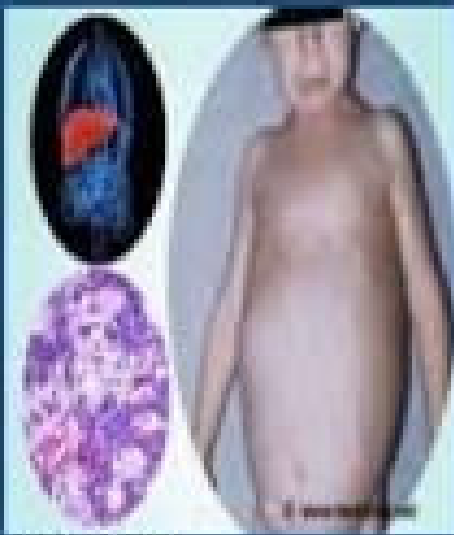
Niemann-Pick Disease^{1,6}

Clinical Manifestations

Neurological Deterioration

- Cherry-red spot on the retina the eye
- Enlarged liver and spleen
- Lipid-laden cells in bone marrow
- Pulmonary disease
- Liver dysfunction

Foam Cells



17/12/2014

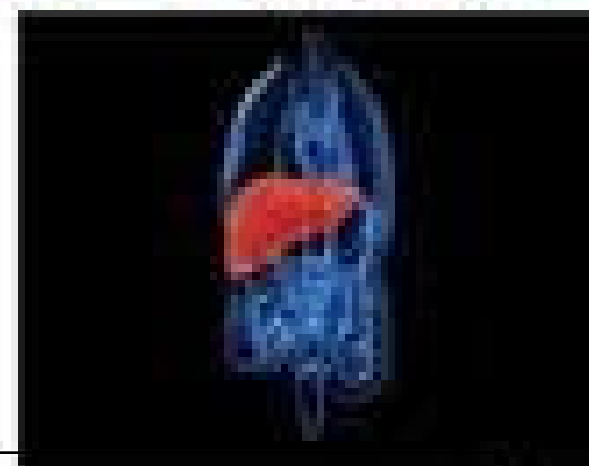


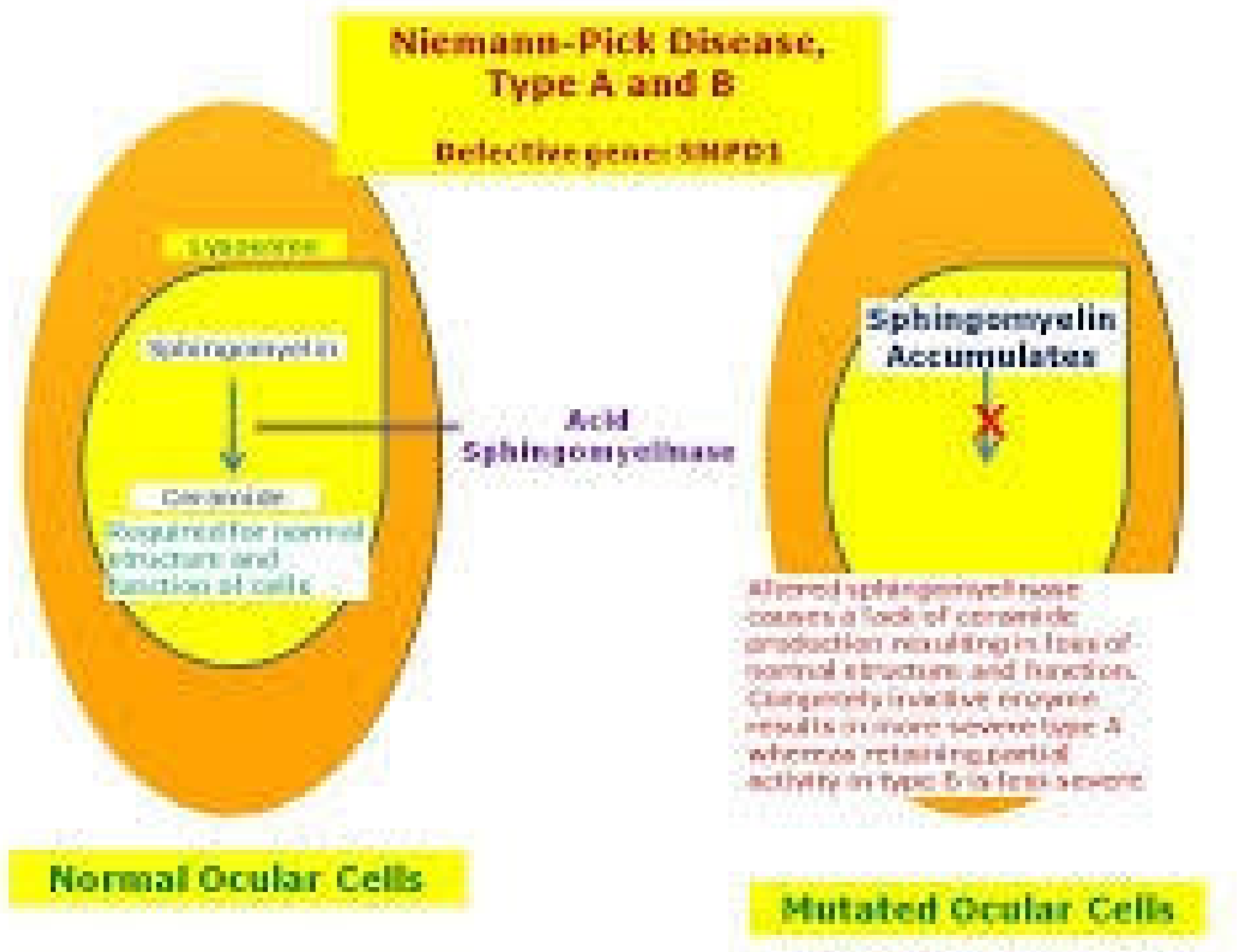
37

Introduction

Niemann-Pick disease refers to

- a fatal inherited metabolic disorder
- classified in a subgroup of lysosomal storage disorders called **sphingolipidoses**
- involves dysfunctional metabolism of sphingolipids
- accumulation of harmful quantities of lipids in the spleen, liver, lungs, bone marrow, and brain.





Lipid Storage Disorders Related To Glycosphingolipids

Disorders Of GlycoSphingolipids

- Gaucher's Disease
- Tay Sach's Disease
- Farbers Disease
- Krabbes Disease

- **Gaucher's Disease:**

- **Defect:** Deficiency of Cerebroside degrading enzyme **Glucocerebrosidase**.
 - **Biochemical Alteration:** Abnormal **accumulation of Cerebrosides** in tissues.
 - **Consequences:** **Affect normal function** of tissues where it is accumulated.
-

Gaucher Disease: A Lysosomal Storage Disorder

Gaucher Disease:

- Most common lysosomal storage disorder
- Autosomal recessive
- Genetic defect on chromosome 1
- Enzyme deficiency
- Reticuloendothelial system
- Progressive, multisystemic, multiorgan dysfunction



Philippe Gaucher
1854 – 1918

Incidence & inheritance of Gaucher disease

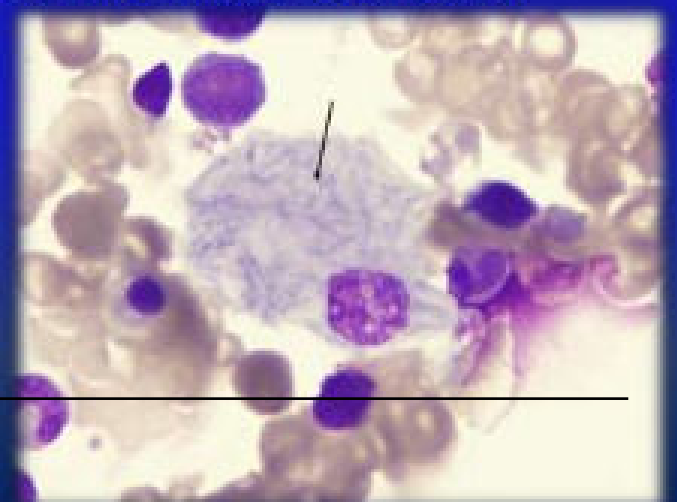
1 in 40,000
people worldwide
But type 1 is more common in
people of Ashkenazi Jewish
heritage: 1 in 855 people

Both parents must carry the faulty gene to have an affected child, and men and women are affected equally



Gaucher Disease: Overview

- ▣ The most common lysosomal storage disease
 - Incidence: approximately 1 in 40,000 for non-Jewish populations
- ▣ Caused by a deficiency of the enzyme glucocerebrosidase
- ▣ The glycolipid glucocerebroside accumulates in lysosomes of macrophages
- ▣ Lipid-filled Gaucher cells displace normal cells in
 - Bone marrow
 - Spleen
 - Liver
 - Lungs
 - CNS*

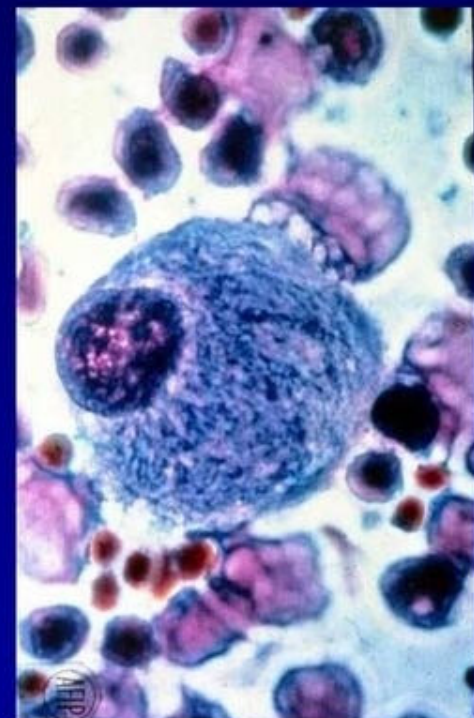


Gaucher disease

- defect of glucocerebrosidase - 3 types (type 1 - survival, type 2 - lethal, type 3 - intermediate)
- accumulation of glucocerebroside (Glc-ceramide) - kerosin
- Gaucher cells - spleen (red pulp), liver (sinuses), bone marrow

GAUCHER DISEASE (TYPE II)

- Can diagnosed by ***Gaucher cells*** in bone marrow
- Neuropathology:
 - Little lipid storage
 - Neuron loss, especially in *brainstem*



Gaucher Disease (this is a hereditary disease)

- Symptoms
 - Distended abdomen
 - Bone pain
 - Anemia
 - Cognitive impairment



When to Suspect Gaucher Disease and Establishing the Diagnosis

Observations

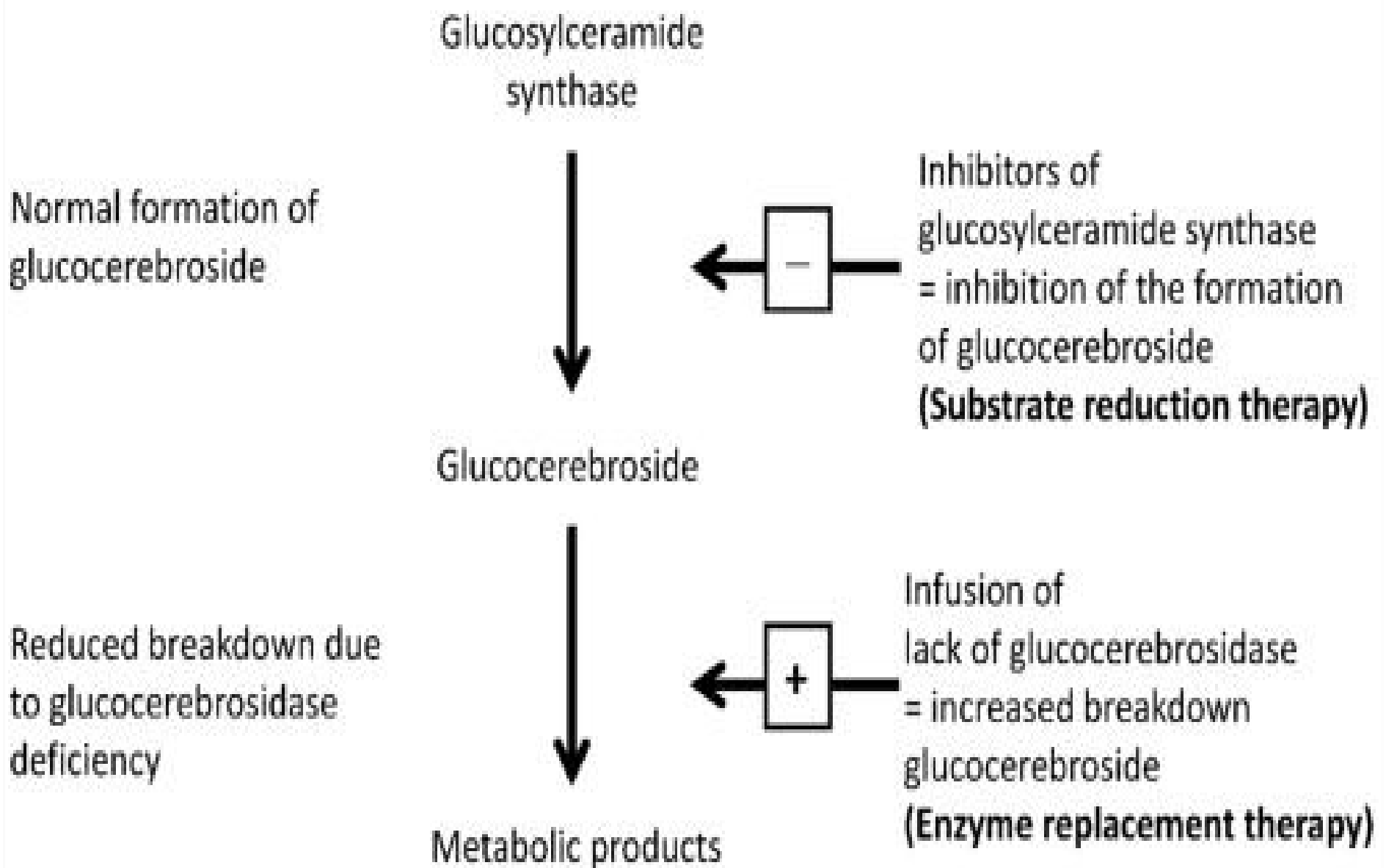
- Splenomegaly in any age group
- Nosebleeds and unexplained bruising
- Persistent anemia or thrombocytopenia
- Bone pain
- Failure to thrive
- Neurologic deterioration in a young infant
- Congenital ichthyosis
- Horizontal gaze disorder or visual apraxia

After clinical suspicion has been raised, diagnosis can be confirmed by

- Enzymatic analysis in white blood cell pellet in expert lab
- Mutation analysis
- Bone marrow biopsy is NOT required for the diagnosis

Gaucher disease

Treatment



• Tay Sach's Disease:

- **Defect:** Deficiency of Ganglioside degrading enzyme: **Hexoseaminidase-A**.
- **Biochemical Alteration:** Abnormal **accumulation of Gangliosides** in the tissues.
- **Consequences:** **Affect normal function of tissues.**

Tay Sach's features:

TAY SACHS

- **T**esting recommended
- **A**utosomal recessive
- **Y**oung death (<4 yrs.)
- **S**pot in macula (cherry red spots)
- **A**shkenazi Jews
- **C**NS degeneration
- **H**ex A deficiency
- **S**torage disease

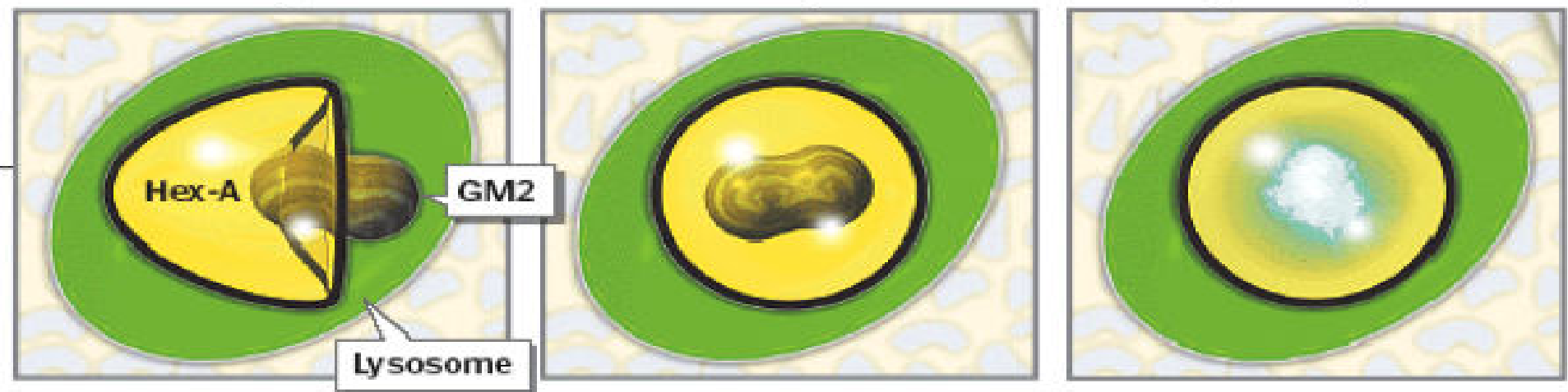
Cells in healthy children

In a healthy child, a lipid, or fat, called GM2 ganglioside enters the nerve cell as a source of food. Among the components of the cell are lysosomes, which might be thought of as the "stomachs" of the cell. They contain an enzyme called Hexosaminidase A, or Hex-A, that digests the GM2.

GM2 enters the lysosome ...

... where it is engulfed ...

... and digested by the Hex-A.



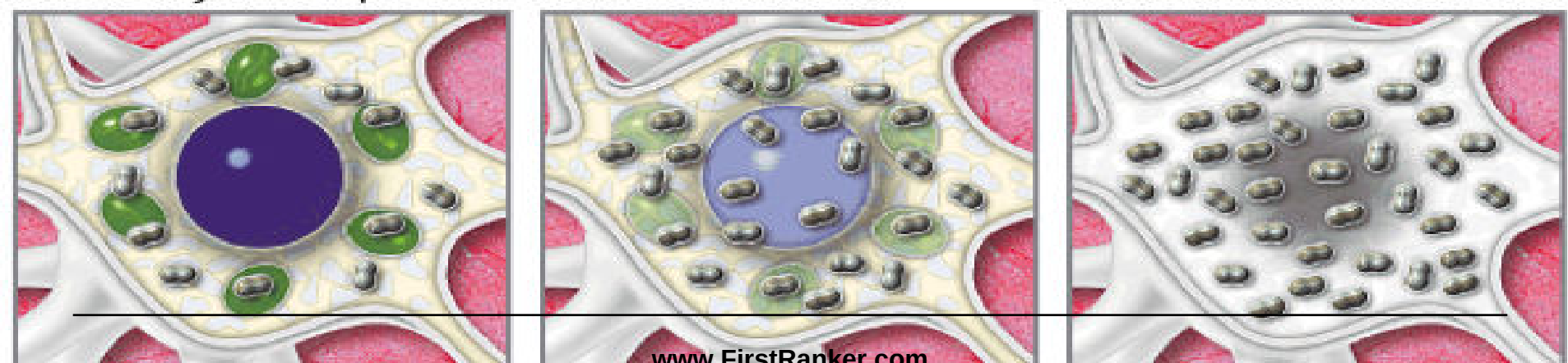
Cells in children with Tay-Sachs disease

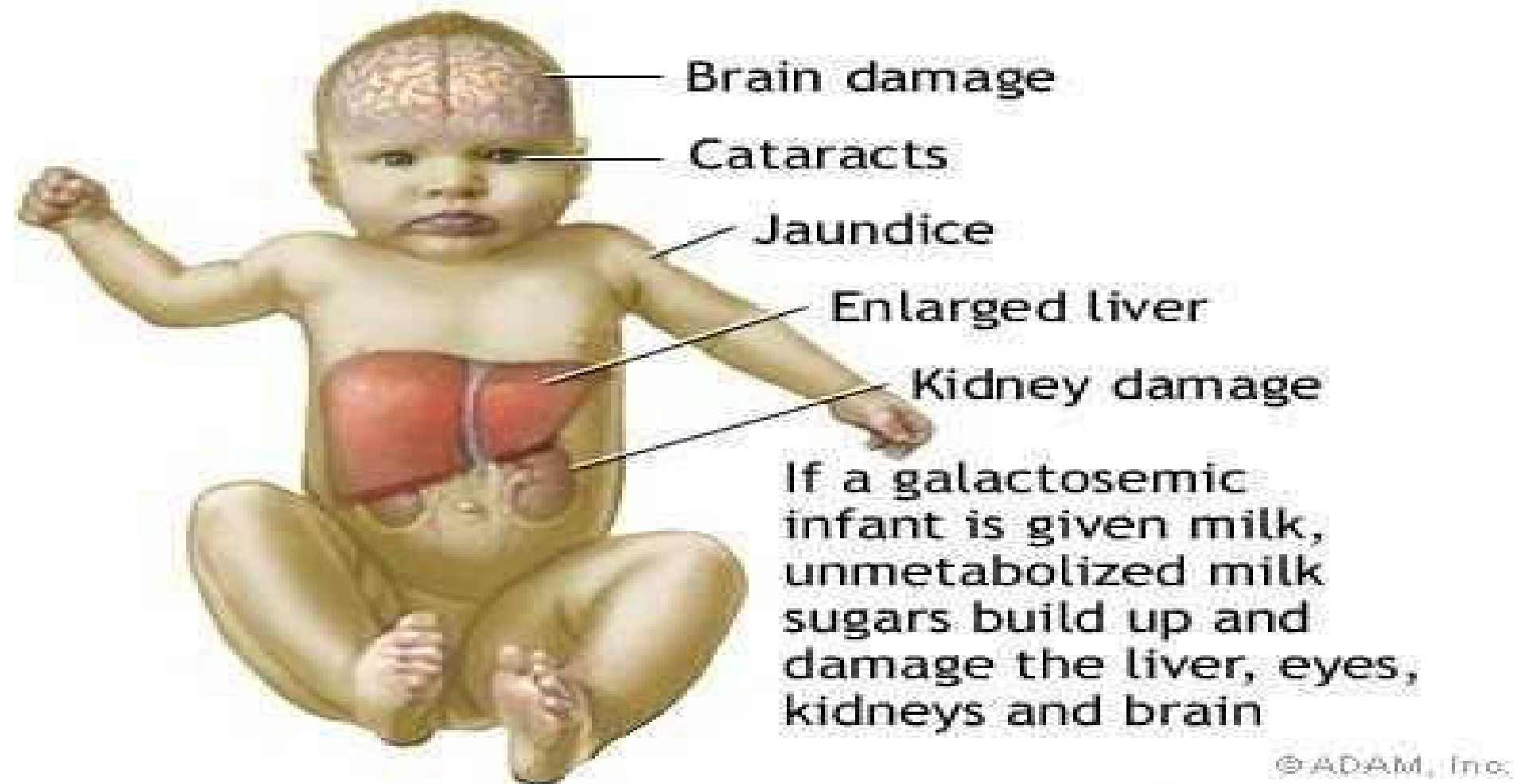
Children with Tay-Sachs lack Hex-A, so the GM2 proliferates to such a degree that it eventually kills the cell, gradually shutting down the central nervous system.

If Hex-A enzyme is not present ...

... GM2 accumulates ...

... and in time chokes off the cells.





WHAT IS KRABBE'S DISEASE?

- Krabbe's disease (globoid cell leukodystrophy) is a degenerative disorder that affects the nervous system.
- It's hereditary autosomal recessive disease.
- Occurrence of 1 in 100,000 newborns.
- It affects the myelin sheath of the nervous system.

• Knud Haraldsen Krabbe

HOW IS KRABBE DISEASE CAUSED?

- Mutations in the GALC gene, causing deficiency of enzyme galactosylceramidase.
- This effects the growth and maintenance of myelin, which causes severe degeneration of motor skills.
- Krabbe disease is a leukodystrophy.

Structure of a Typical Neuron

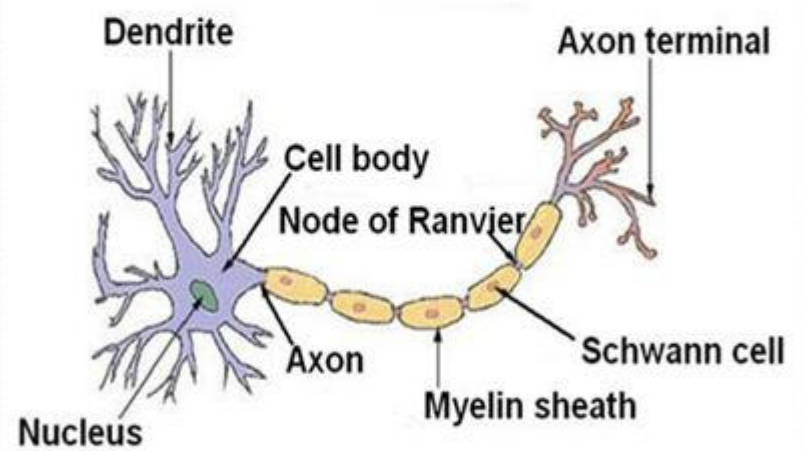


Fig.1 – www¹.

Demyelination or
Loss of Myelin
Sheath in the
Brain.

Symptoms of Krabbe Disease?

- Feeding difficulties
- Unexplained crying
- Extreme irritability
- Fever without any clear etiology
- Developmental delays
- Muscle spasms
- Poor head control
- Frequent episodes of vomiting
- Developmental regression

For Information,
Visit: www.epainassist.com

Farber Disease

- Autosomal recessive disorder
- Results from deficiency of lysosomal enzyme ceramidase & the accumulation of ceramide in various tissues especially joints.
- Symptoms begin as early as 1st year of life with painful jt. swelling & nodule formation.
- It's diagnosis should be suspected in patients who have nodule formation over jt's. but no other finding of RA.

Farber's Disease

Cause

- Deficiency of the enzyme called ceramidase
- Resulting in accumulation of ceramide in joints , tissues and central nervous system

Clinical features

- Dyspnea
- Dysphagia
- Vomiting
- Arthritis
- Horseness
- Xanthemas

Treatment

- no specific treatment for Farber's disease
- Most children with the disease die by age 2

-
- Joint contractures

Farber's Lipogranulomatosis

Symptoms of Farber's Lipogranulomatosis

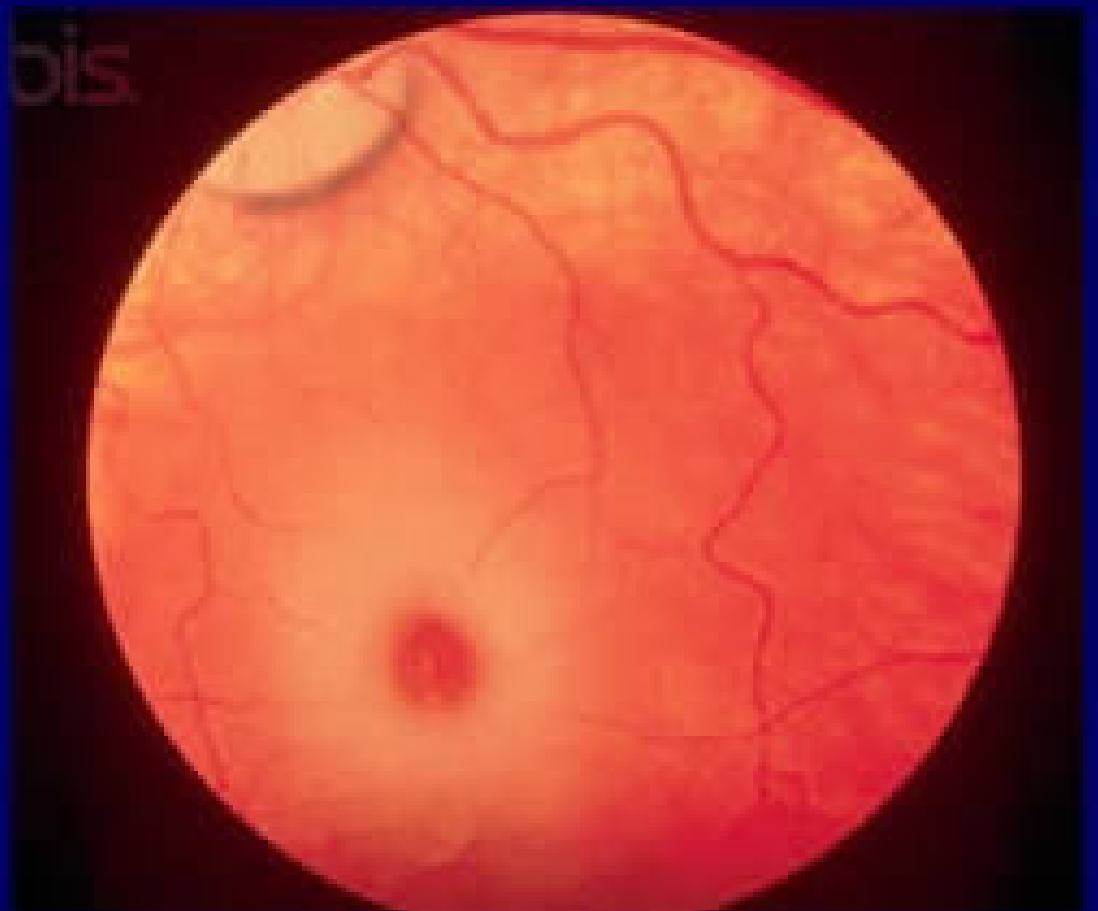
- Hoarseness in voice.
- Swollen joints and lymph nodes.
- Impaired motor and mental ability.
- Difficulty while swallowing.
- Vomiting.
- Arthritis.
- Enlargement of spleen and liver.



Lysosomal storage disease: ocular features

Lysosomal lipid storage disorders associated with cherry red macula:

- Niemann-Pick A
- GM1 gangliosidosis
- Tay-Sachs disease
- Sandhoff disease
- Farber lipogranulomatosis
- Sialidosis



Sandhoff Disease

- Deficiency of both Hexosaminidase A and B.
- Clinical course is very similar to Tay-Sachs



Sialidosis

- AR
- Accumulation of a **sialic acid oligosaccharide** complex secondary to a deficiency in the lysosomal enzyme **neuraminidase**
- Urinary excretion of sialic acid containing oligosaccharides is increased
- **Sialydotis type 1**
 - Cherry red spot-myoclonus syndrome
 - Visual deterioration
 - Myoclonus
- **Sialydotis type 2**
 - Infantile
 - Juvenile
 - Cherry red spots, myoclonus, somatic involvement, coarse facial features
 - Lymphocytes show vacuoles in the cytoplasm
 - Liver biopsy
 - Cytoplasmic vacuoles

CASE REPORT 1

A 19 months old child from Rajasthan came with a history of apparently normal growth and development upto 5 months of age. There after the child developed gradual distension of abdomen, unable to hold neck and unable to recognize her parents.

On examination :

- Liver and spleen were enlarged by 10 and 12 cm respectively.
- Blood examination showed reduced haemoglobin.
- All the deep reflexes were diminished and there was hypotonia in all four limbs.
- Bone marrow examination showed infiltration of foamy cells in macrophages.
- **Fundus examination** revealed cherry red spot in the macula of both eyes. Hence, this characteristic is seen in many types of storage diseases so this cannot simply confirm the presence of Niemann-Pick.

Expected Diseases according to above information- 1) Gaucher Disease

2) Tay Sachs Disease

3) Hurler's syndrome

4) Niemann-pick disease

- **Further Enzymatic and gene studies** revealed the presence of **Niemann-Pick Type A** disease. In gene study, gene expression was studied.

CASE REPORT 2

An Afghan girl was growing normally till 1 year of age. Later on, hepatomegaly with developmental delay was observed. Parents also noticed unexplained frequent falls without any sign of seizure.

She was the 5th sibling with one elder sister dying of respiratory failure and hepatosplenomegaly at the age of 5 years. Two elder brothers and one sister were normally growing till that date.

On examination: At the age of 4 yrs, she had

- neurological regression
- hypotonia
- facial dyskinesia
- Bone-marrow examination revealed presence of storage cells

Expected Diseases related to these symptoms- 1) Gaucher Disease

2) Niemann-Pick Disease

Similarities and Dissimilarities Of Cerebrosides and Gangliosides

Similarities Of Cerebrosides and Gangliosides

- **Both are Glycolipids** containing Carbohydrate moieties.
- Both contain **Sphingosine/Ceramide** in their structures.
- Both are richly present in **Nervous tissue**.

Dissimilarities Of
Cerebroside and Gangliosides.

S.No	Cerebrosides	Gangliosides
1	Structurally Simple Ceramide linked with Glucose or Galactose.	Structurally complex Ceramide linked to Glucose, Galactose , NAGalactosamine ,and NANA
2	Occur in White matter of brain and Myelin Sheaths .	Occur in Grey matter of brain and Ganglions .
3	Types : Glucocerebrosides Galactocerebrosides	Types : GM1,GM2, GM3,GM4
4	Function : Conducts nerve impulse	Transfer Biogenic Amines
5	Related Disorder: Gauchers Disease	Related Disorder: Tay Sachs Disease

Lipoproteins

Lipoproteins

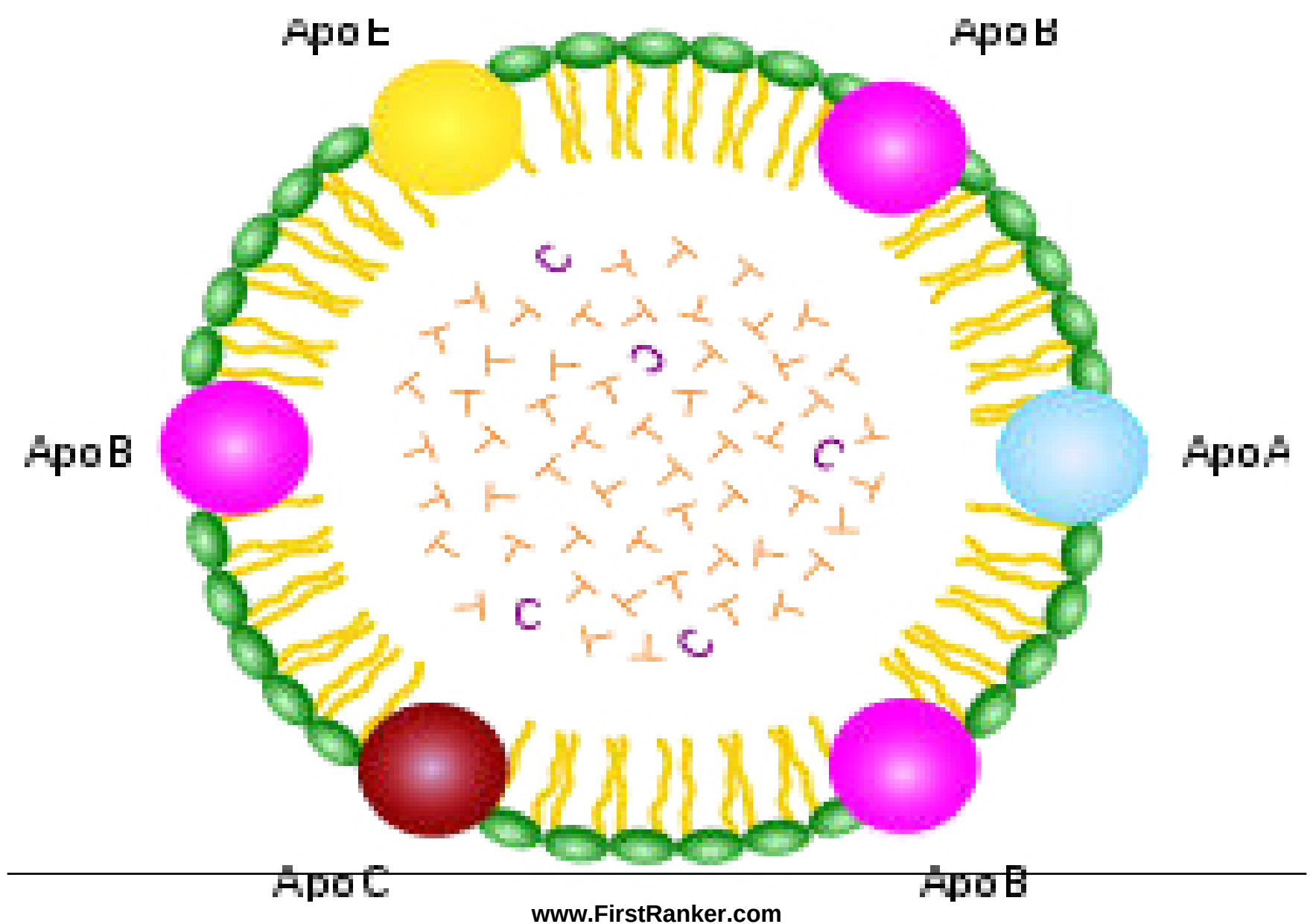
- **Lipoproteins** are types of **Compound Lipids / Conjugated Proteins.**

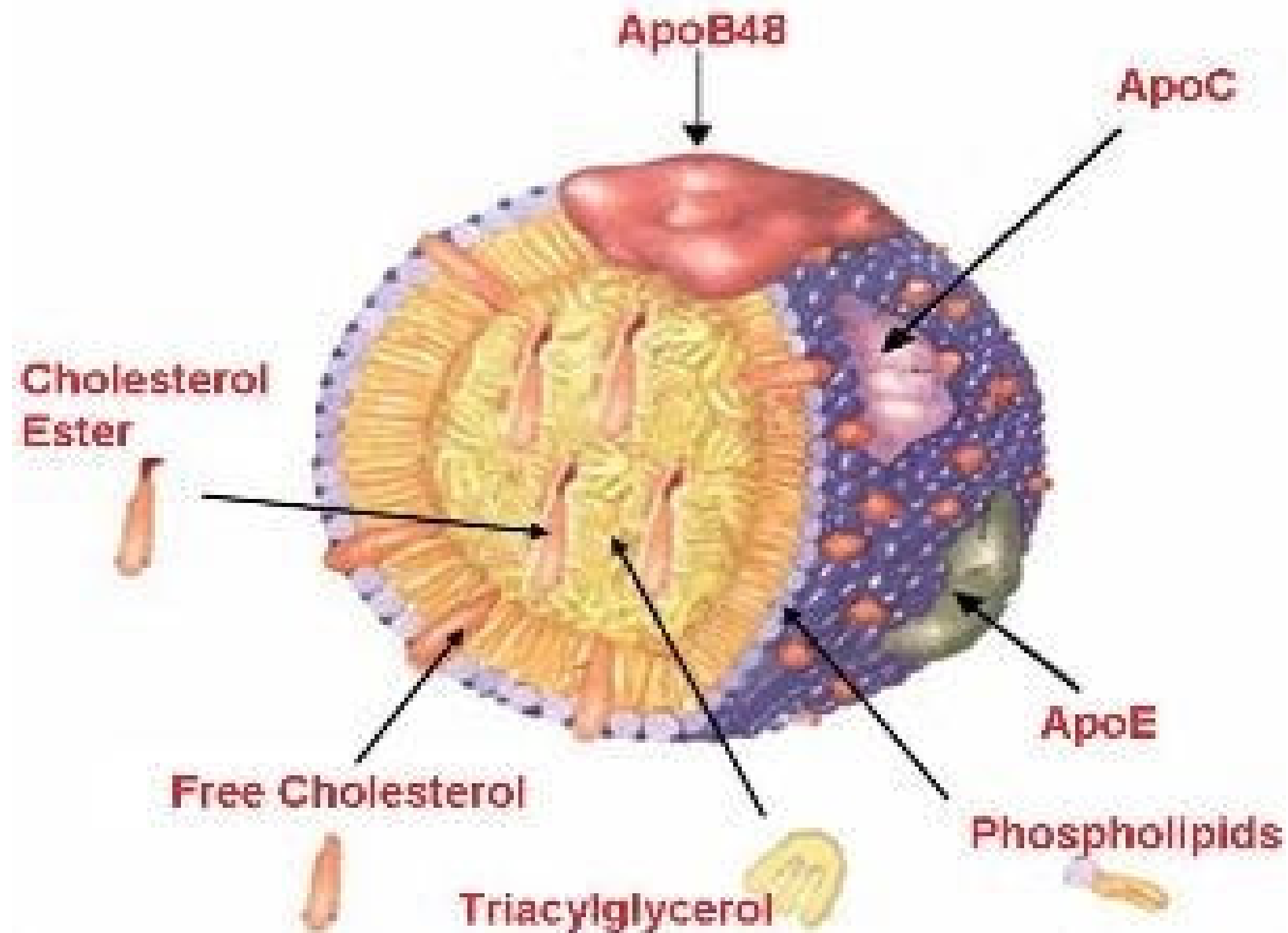
- **Lipoproteins** are **macromolecules** formed by aggregation of :
- **Lipids** (Neutral and Amphipathic)
- **Proteins**(Apoprotein) in the human body.

- **Lipoproteins acquire polarity**
(Hydrophilic Property)

- **Lipoprotein** serve as **vehicles** for transportation of **Neutral and Amphipathic Lipids** through aqueous media **blood and lymph**.
- Lipoproteins are **biosynthesized within the cells of tissues**.
- By aggregation of various forms of **Lipids and Apoproteins**.

Structure Of Lipoproteins

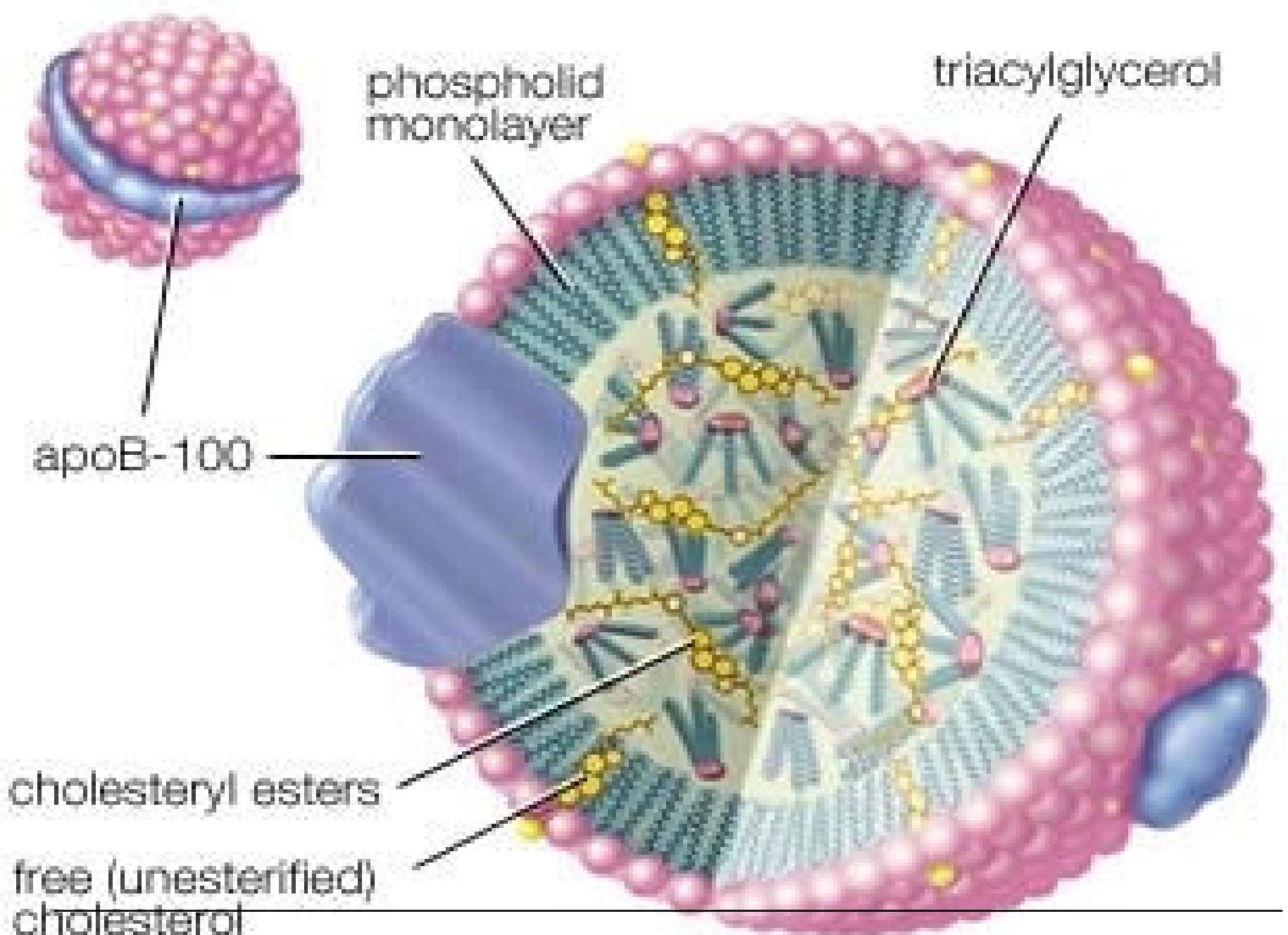


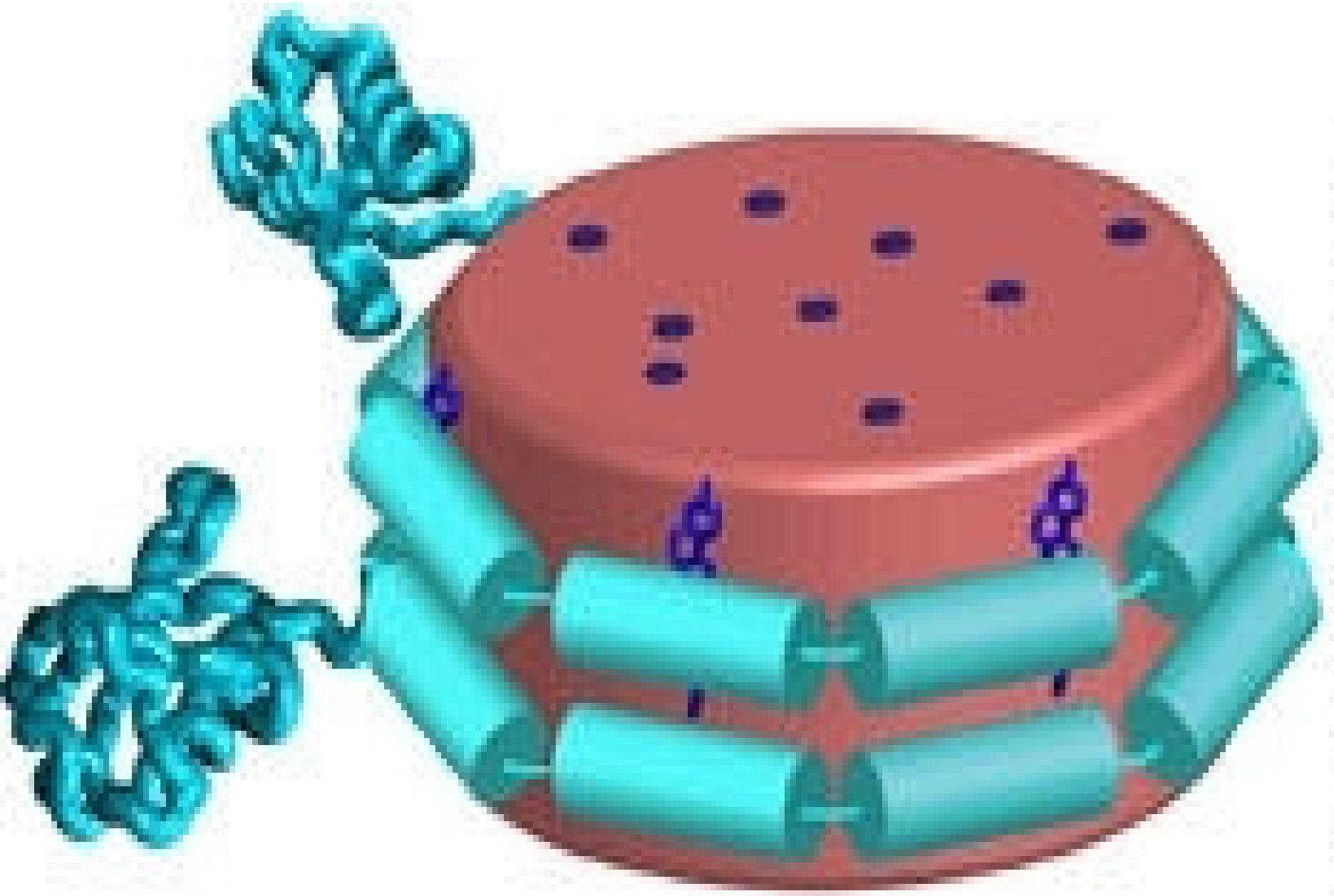


Structure of Lipoproteins

- The non polar /hydrophobic Lipids **TAG and Cholesterol Ester** are gathered centrally to form the core of LipoProtein particle.
- At the periphery of Lipoprotein are **Apoprotein and Amphipathic Lipids** viz **Phospholipids and Cholesterol**.

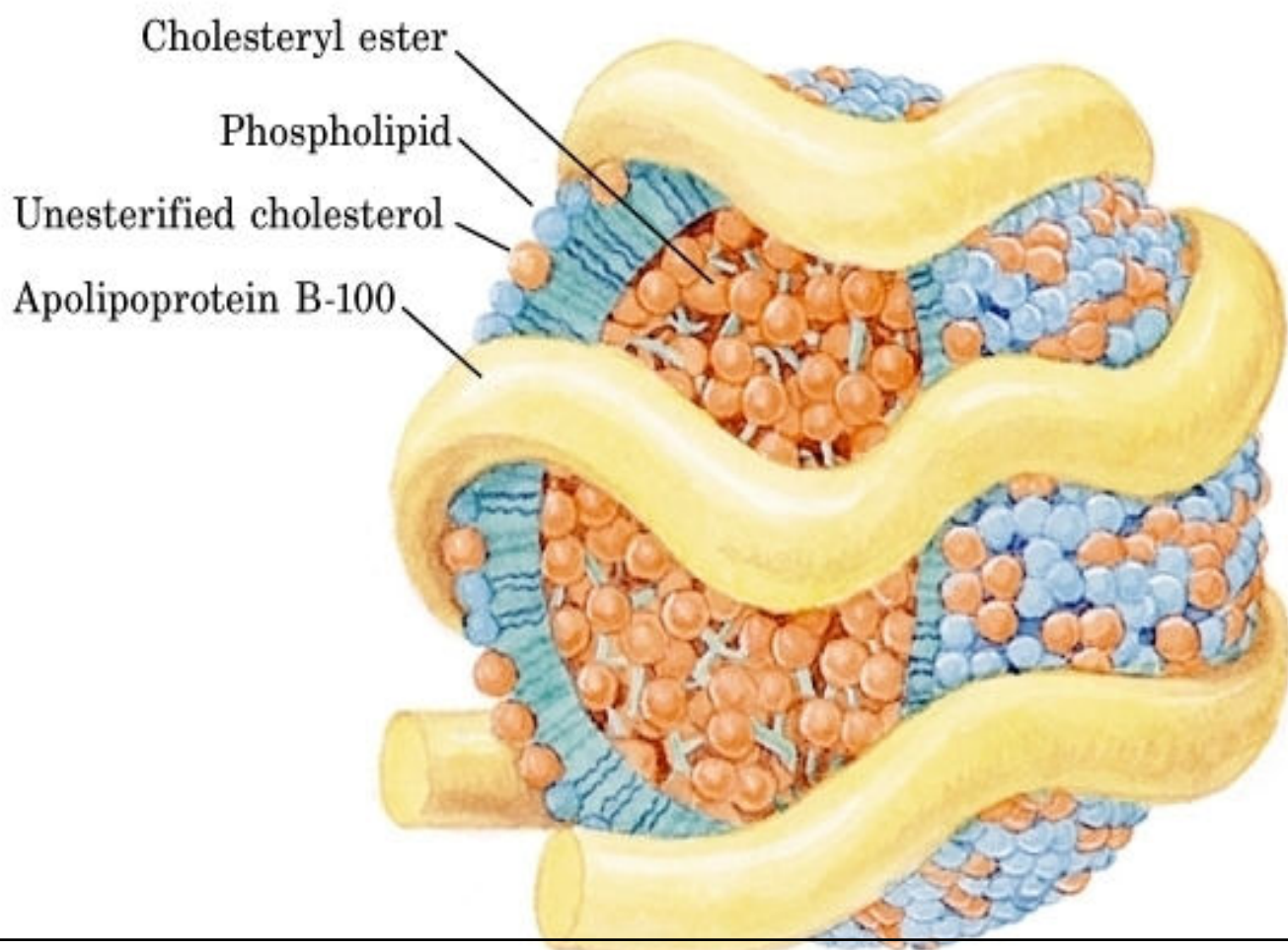
- The Apoprotein and polar groups of Amphipathic Lipids **impart hydrophilic property** to Lipoprotein molecules
- This **helps in transportation of Lipids**
- **From site of origin to site of utilization through blood.**





Discoidal HDL

Cholesterol Transported as Lipoprotein Complex (LDL)



Functions Of Lipoproteins

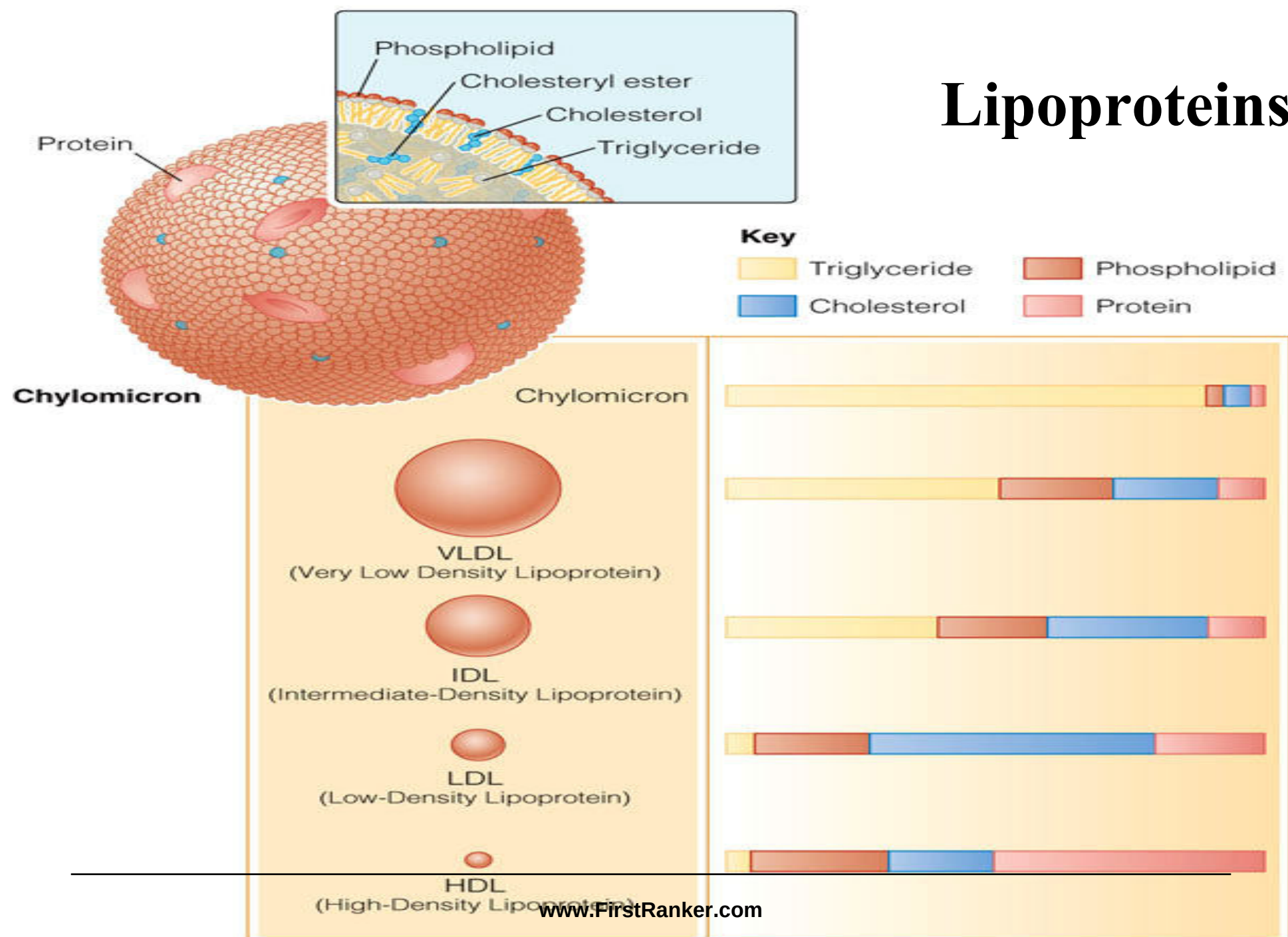
- Lipoproteins serve as a **vehicle in transportation** of non polar Lipids
- From the **site of its biosynthesis to the site of utilization** through **aqueous media of blood or lymph.**

Types Of Lipoproteins

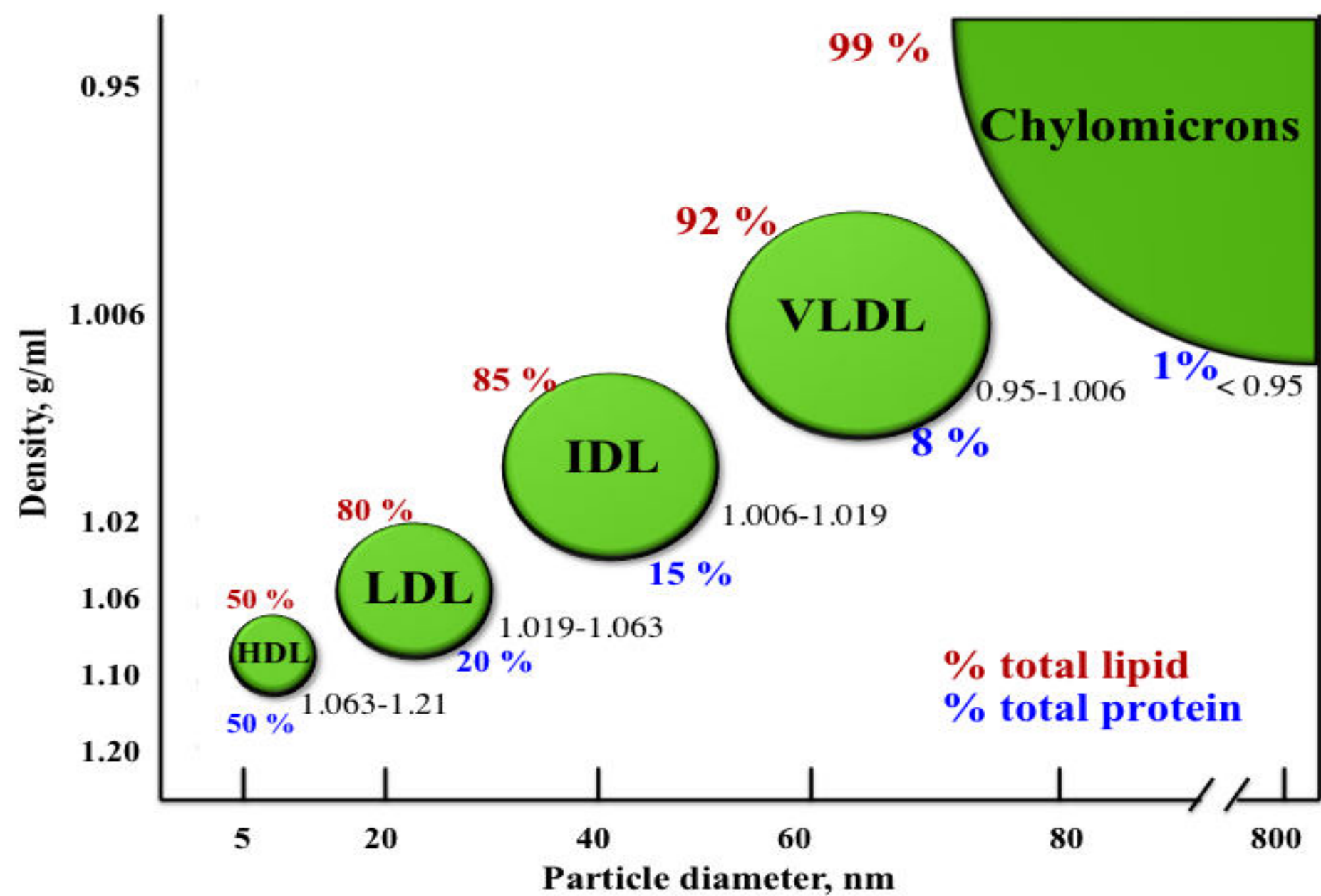
- Depending upon the **composition** and other **properties** following are **the types of Lipoproteins**:

- Chylomicrons (CM)
- Very Low Density Lipoprotein (VLDL)
- Low Density Lipoproteins (LDL)
- High Density Lipoproteins (HDL)
- Free Fatty acid -Albumin

Lipoproteins



Lipoproteins



Types of Lipoprotein

(all contain characteristic amounts TAG, cholesterol, cholesterol esters, phospholipids and Apoproteins - NMR Spectroscopy)

Increasing density ↓	Class	Diameter (nm)	Source and Function	Major Apolipoproteins
	Chylomicrons (CM)	500 Largest	Intestine. Transport of <u>dietary</u> TAG	A, B48, C(I,II,III) E
	Very low density lipoproteins (VLDL)	43	Liver. Transport of <u>endogenously</u> synthesised TAG	B100, C(I,II,III) , E
	Low density lipoproteins (LDL)	22	Formed in circulation by partial breakdown of IDL. Delivers cholesterol to peripheral tissues	B100
	High density lipoproteins (HDL)	8 Smallest	Liver. Removes "used" cholesterol from tissues and takes it to liver.	A, C(I,II,III), D, E
			Donates apolipoproteins to CM and VLDL	

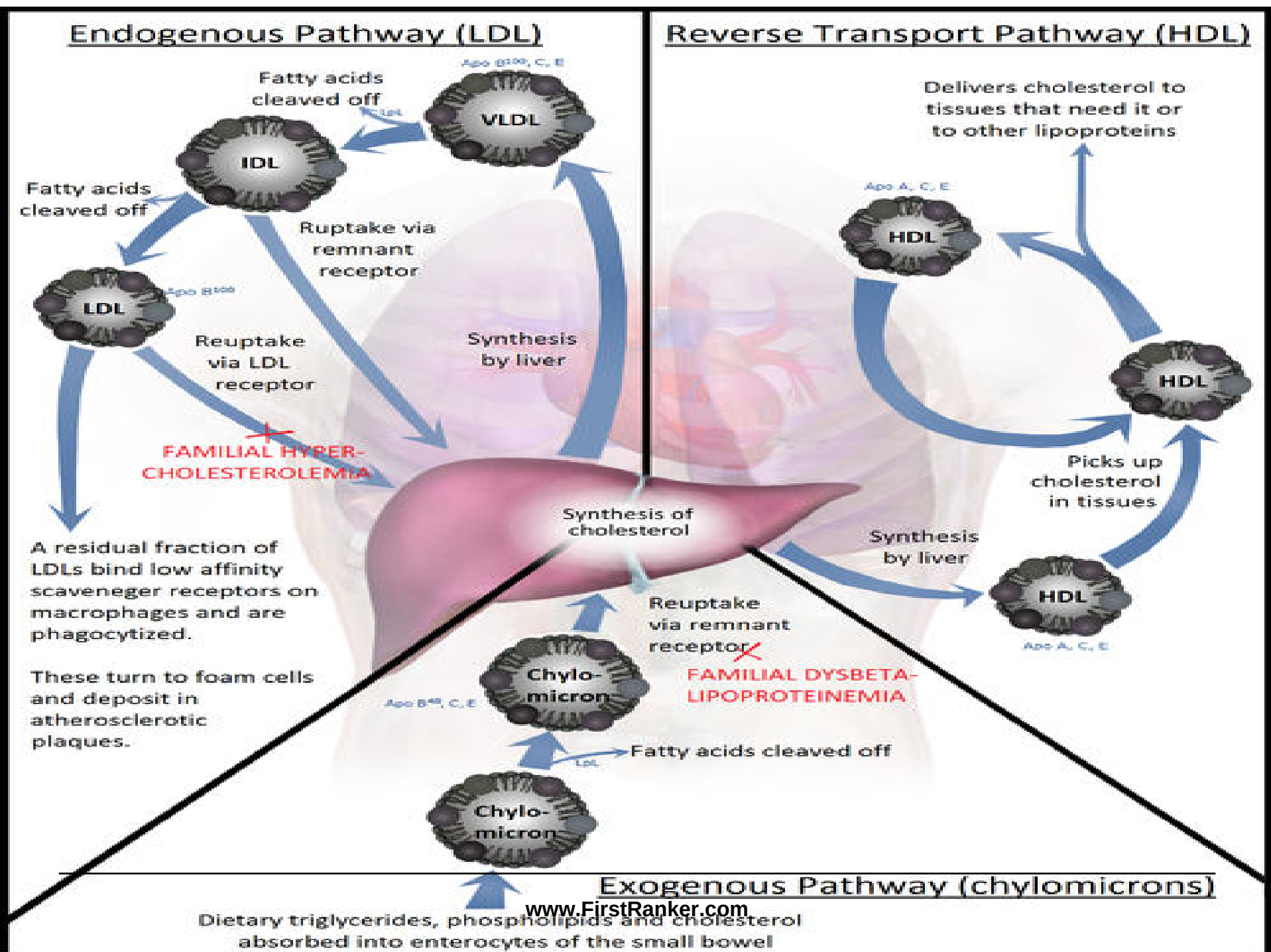
Features	Chylomicrons	VLDL	LDL	HDL
Site of Synthesis	Small Intestine	Hepatocytes Liver -80% Intestine -20%	Blood Circulation From VLDL	Nascent HDL Liver
Lipids %	99%	92%	80%	50%
Protein %	1%	8%	20%	50%
Rich Lipid Form	TAG Exogenous	TAG Endogenous	Cholesterol	Phospholipids
Associated Apoprotein	Apo B48, Apo CII ,Apo E	Apo B100,Apo CI,Apo CII,Apo E	Apo B100, Apo CI, Apo CII and Apo E	Apo A I,Apo A II Apo C I, Apo C II Apo D & Apo E
Transport From	Dietary Lipids Intestine	Liver	Liver	Extrahepatic Tissues
Transport To	Liver	Extrahepatic Tissues	Extrahepatic Tissues	Liver

HDL Has Scavenging Role

OR

Reverse Transport of Cholesterol

HDL Is Associated With Enzyme LCAT Responsible For Cholesterol Esterification And Its Excretion



- **HDL** has scavenging role with protective mechanism.
- HDL Transports Cholesterol from Extrahepatic tissues back to Liver for its excretion.
- HDL reduces risk of Atherosclerosis.
- HDL clears the body Lipids and do not allow accumulation of Lipids in blood.

- Thus when the levels of HDL are **within normal range**
- **Cholesterol** associated with HDL is termed as **Good Cholesterol**
- Based on Electrophoretic pattern the Lipoproteins are termed as:
 - **LDL:** Beta Lipoproteins
 - **VLDL:** Pre Beta Lipoproteins
 - **HDL:** Alpha Lipoproteins

Classification of plasma Lipoproteins according to their electrophoretic mobility

Electrophoretic Pattern of Serum Lipoproteins



α -lipoprotein (HDL)

Pre- β -Lipoprotein (VLDL)

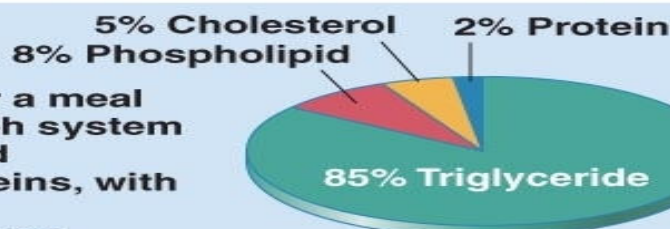
β -lipoprotein (LDL)

CM

Lipoprotein class	Density (g/mL)	Diameter (nm)	Protein % of dry wt	Phospholipids %	Triacylglycerols % of dry wt
HDL	1.063-1.21	5 - 15	50	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

Chylomicron

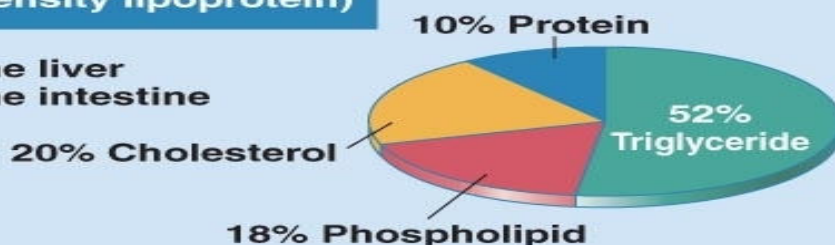
- Formed in the gut after a meal
- Released into the lymph system and then into the blood
- Largest of the lipoproteins, with the lowest density
- Taken up by the liver once triglycerides are removed



Transports dietary fat into the blood and to the tissues of the body

VLDL (Very-low-density lipoprotein)

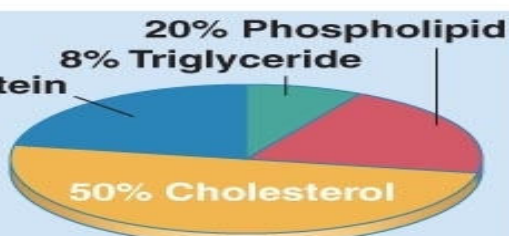
- 80% formed in the liver
- 20% formed in the intestine



Transports endogenous lipids, especially triglycerides, to the various tissues of the body

LDL (Low-density lipoprotein)

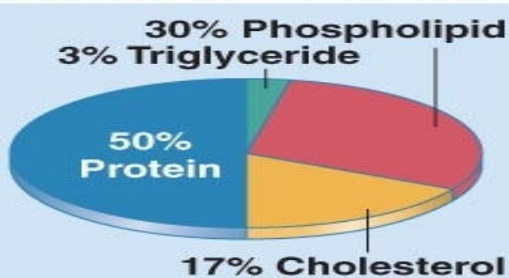
- Formed in blood from VLDL (transformation from VLDL to LDL occurs as the triglycerides are removed from the VLDL)



Transports cholesterol to the cells of the body

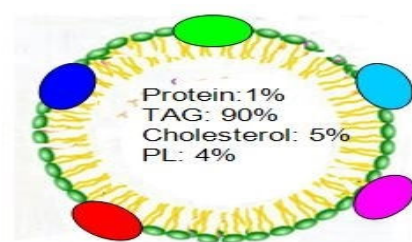
HDL (High-density lipoprotein)

- Synthesized in liver and released into the blood
- Transported by the blood throughout the body, picking up free cholesterol



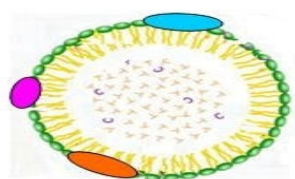
Transports cholesterol from tissues back to the liver

© 2011 Pearson Education, Inc.



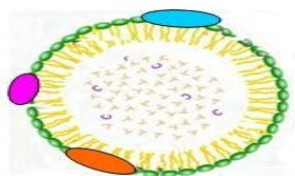
Lipoprotein type: Chylomicron
Density: <0.950 g/mL
Diameter: 80-1000 nm
Major lipids: dietary triacylglycerols
Apolipoproteins: B48, A1, A2, C, E

Protein: ~1%
Triglyceride: ~90%
Cholesterol: ~5%
Phospholipids: ~4%



Lipoprotein type: VLDL
Density: 0.950-1.006 g/mL
Diameter: 30-80 nm
Major lipids: endogenous triacylglycerols
Apolipoproteins: B100, C, E

Protein: ~10%
Triglyceride: ~65%
Cholesterol: ~13%
Phospholipids: ~13%



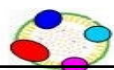
Lipoprotein type: IDL
Density: 1.006-1.019 g/mL
Diameter: 25-30 nm
Major lipids: endogenous triacylglycerols and cholesterol
Apolipoproteins: B100, C, E

Protein: ~18%
Triglyceride: ~34%
Cholesterol: ~22%
Phospholipids: ~22%



Lipoprotein type: LDL
Density: 1.019-1.063 g/mL
Diameter: 20-22 nm
Major lipids: cholesterol and cholesteryl ester
Apolipoproteins: B100

Protein: ~20%
Triglyceride: ~10%
Cholesterol: ~45%
Phospholipids: ~23%



Lipoprotein type: HDL
Density: 1.063-1.090 g/mL
Diameter: 9-15 nm
Major lipids: cholesteryl ester and phospholipids
Apolipoproteins: A1, A2, C, E

Protein: ~50%
Triglyceride: ~20%
Cholesterol: ~18%
Phospholipids: ~30%

	CM	VLDL	LDL	HDL
Density (g/ml)	< 0.94	0.94-1.006	1.006-1.063	1.063-1.210
Diameter (Å)	6000-2000	600	250	70-120
Total lipid (wt%) *	99	91	80	50
Triacylglycerol	85	55	10	6
Cholesterol esters	3	18	50	40
Cholesterol	2	7	11	7
Phospholipid	8	20	29	46
Apoprotein %	1	9	20	50

Fatty acid compositions (wt% of the total) in the main lipids of human Lipoprotein

	Triacylglycerols			Cholesterol Esters			Phospholipids		
Fatty acid	VLDL	LDL	HDL	VLDL	LDL	HDL	VLDL	LDL	HDL
16:0	27	23	23	12	11	11	34	36	32
18:0	3	3	4	1	1	1	15	14	14
18:1	45	47	44	26	22	22	12	12	12
18:2	16	16	16	52	60	55	20	19	21
20:4 (n-6)	2	5	8	6	7	6	14	13	16

The main properties of the Apoproteins.*

Apoprotein	Molecular weight	Lipoprotein	Function
Apo A1	28,100	HDL	Lecithin:cholesterol acyltransferase (LCAT) activation. Main structural protein.
Apo A2	17,400	HDL	Enhances hepatic lipase activity
Apo A4	46,000	CHYLOMICRON(CM)	
Apo AV(5)	39,000	HDL	Enhances triacylglycerol uptake
Apo B48	241,000	CHYLOMICRON	Derived from Apo B100 – lacks the LDL receptor
Apo B100	512,000	LDL, VLDL	Binds to LDL receptor
Apo C1	7,600	VLDL, CM	Activates LCAT
Apo C2	8,900	VLDL, CM	Activates lipoprotein lipase
Apo C3	8,700	VLDL, CM	Inhibits lipoprotein lipase
Apo D	33,000	HDL	Associated with LCAT, progesterone binding
Apo E	34,000	HDL	At least 3 forms. Binds to LDL receptor
Apo(a)	300,000-800,000	LDL, Lp(a)	Linked by disulfide bond to apo B100 and similar to plasminogen

Disorders Of Lipoproteins

3) Disorders associated with Lipoprotein Metabolism

A Hyper-Lipoproteinaemias :-

- Type-I: familial lipoprotein lipase deficiency.
- Type-II: familial hypercholesterolæmia.
- Type-III: familial dys-beta Lipoproteinaemia.
- Type-IV: familial hypertriglyceridaemia.
- Type-V: Combined hyperlipidaemias.

B Hypolipo-proteinaemias:-

- A-beta- Lipoproteinaemia.
- Familial alpha-Lipoprotein deficiency (Tangier's disease).



Table I Lipid levels (mg/DL) in human beings with known heart disease

Test	Desirable	Borderline	Undesirable
Total cholesterol	<200	200-240	>240
HDL cholesterol	>45	35-45	<35
Triglycerides	<200	200-400	>400
LDL cholesterol	<130	130-160	>160
Cholesterol/HDL	<4.5	4.5-7.5	>5.5
LDL/HDL	<3.0	3.5	>5.0

- Defect in Lipoprotein metabolism leads to Lipoprotein disorders:
 - Hyperlipoproteinemias
 - Hypolipoproteinemias

TOTAL CHOLESTEROL			
2004	2006	2008	2011
390	Very High		
380			
370			
360			
350			
340			
330			
320			
310			
300			
290			
280	High		
270			
260			
250			
240			
230			
220			
210			
196	198		195
190	188 Good		
180			
170			
160			
150	Very Good		
140			
130			
120			
110			

LDL (bad) CHOLESTEROL			
2004	2006	2008	2011
320	Very High		
310			
300			
290			
280			
270			
260			
250			
240			
230			
220	Very High		
210			
200			
190	High		
180			
170			
160			
150			
140			
130	131		
120	119 Good		123
110			
100*			
90	Very Good		
80			
70*			
60			
50			
40			

HDL (good) CHOLESTEROL			
2004	2006	2008	2011
130			
125			
120			
115			
110			
105			
100			
95			
90			
85			
80	Protective		
75			
70			
65			
60			
55			
49			
45	44	46	45
40	High Risk		
35			
30			
25			
20			
15			
10			
5			
0			

TOTAL/HDL Cholesterol Ratio		
7.0	Very High	
6.5		
6.0		
5.5	High	
5.0		
4.5		
4.0	4.5	4.3
3.5	Good	
3.0		
2.5		
2.0		
1.5		
1.0		
0.5		
0.0		

- www.FirstRanker.com**

- The Cholesterol associated to high LDL levels is said to be **bad Cholesterol**.
- This increases the risk of Atherosclerosis ,Ischemia, MI and Stroke.
- Recently evidenced high levels of blood HDL are also **bad to body**.
- This increases the risk of Atherosclerosis ,Ischemia, MI and Stroke.

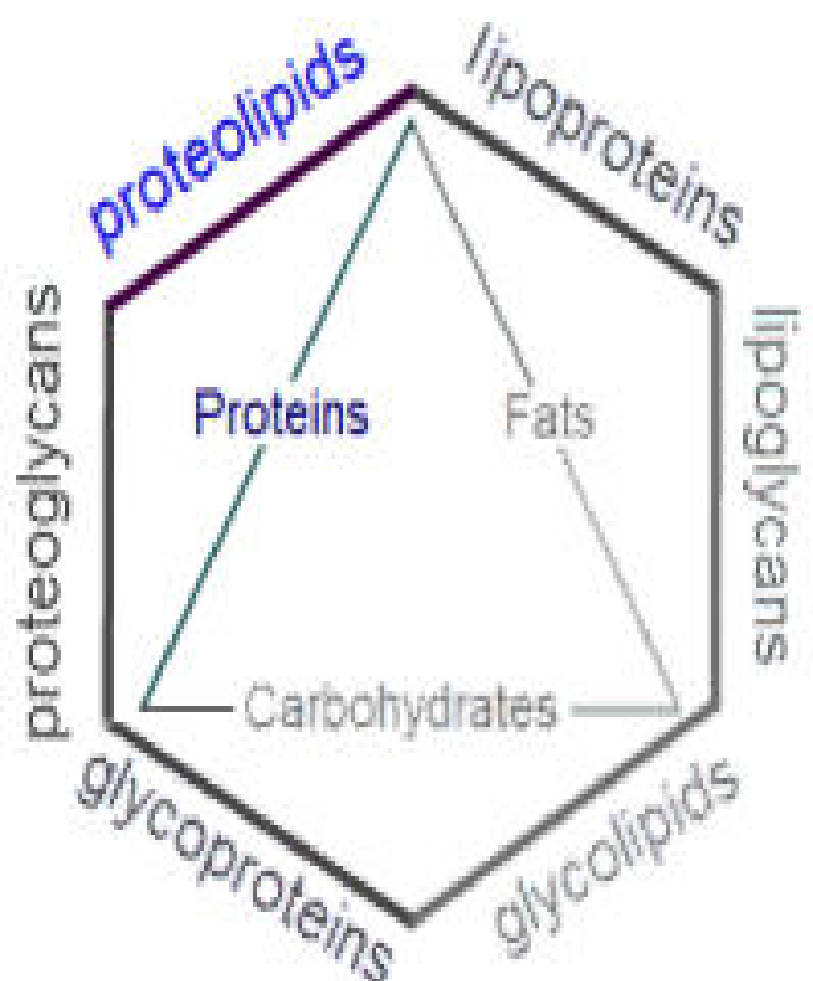
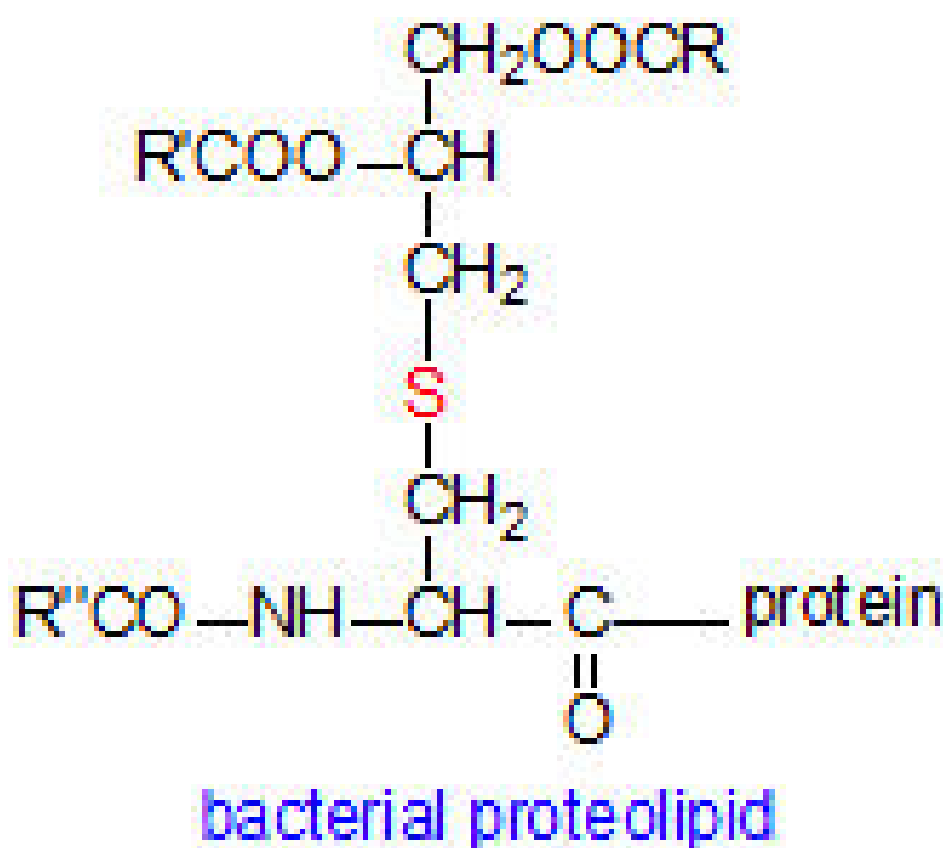
Proteolipids/ Lipophilin

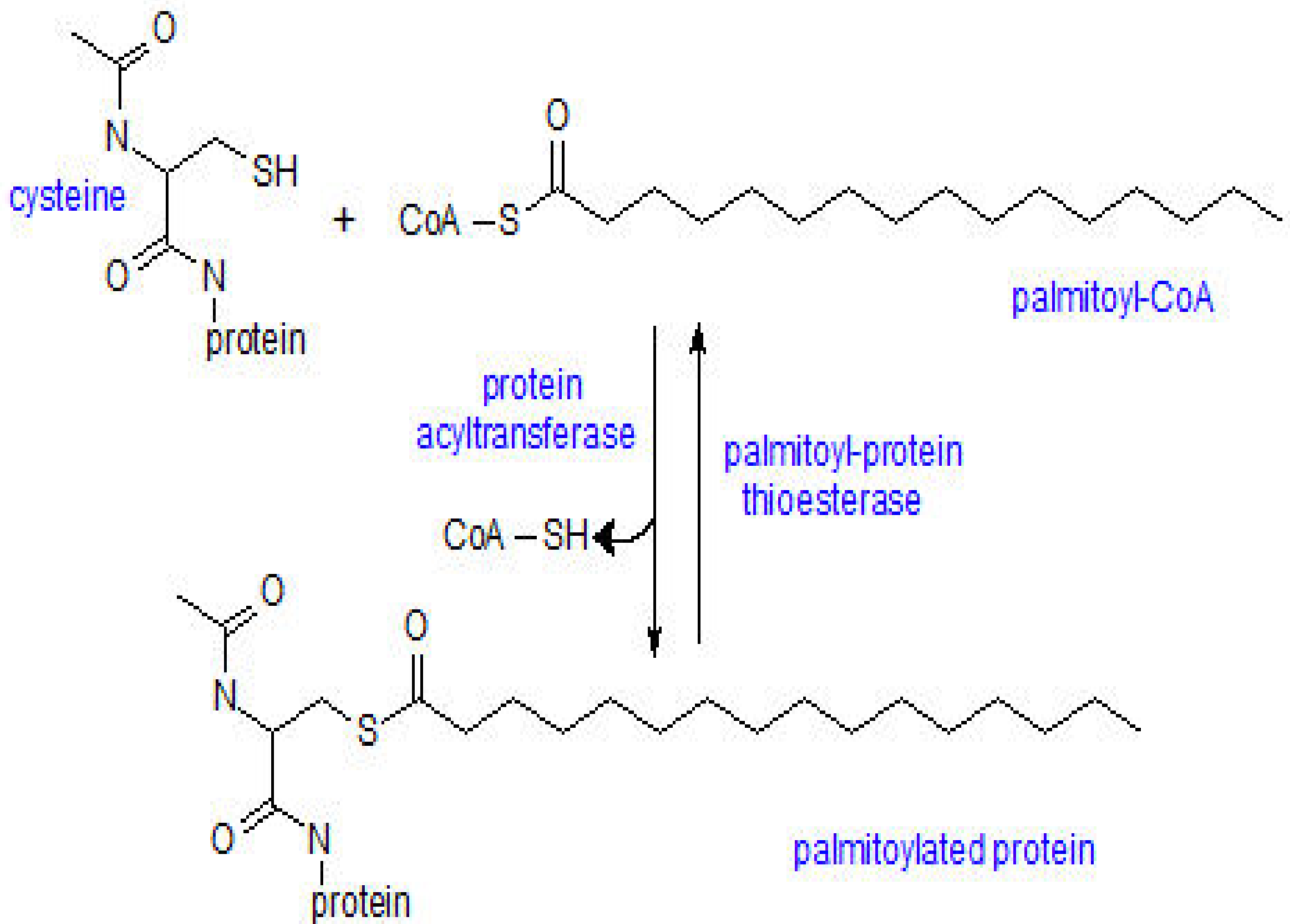
Proteolipids/ Lipophilin

- Proteolipids are compound lipids which have **more content of Proteins than Lipids.**
- Proteolipid is a **transmembrane domain protein** bound with **Lipids.**

Occurrence Of Proteolipids

- Proteolipids are structural Lipids
- Present on the **extracellular side of the membrane.**
- Proteolipids are also present in **Myelin Sheath.**





Miscellaneous Lipids

Miscellaneous Lipid

Eicosanoids

- **Eicosanoids are**
Classified under
Miscellaneous Lipids.

- **Eicosanoids** is a **generic term collectively** used for
- **Biologically active 20 carbon(Eicosa) Lipid like compounds**

Name Of Eicosanoids

- **Eicosanoids** is a Generic term for the 20 Carbon related compounds like:
 - I. **Prostaglandins (PGs)**
 - II. **Prostacyclins (PGI₂)**
 - III. **Thromboxanes (TX)**
 - IV. **Leukotrienes (LT)**
 - V. **Lipoxins (LX)**
 - VI. **Resolvins**
 - VII. **Eoxins**

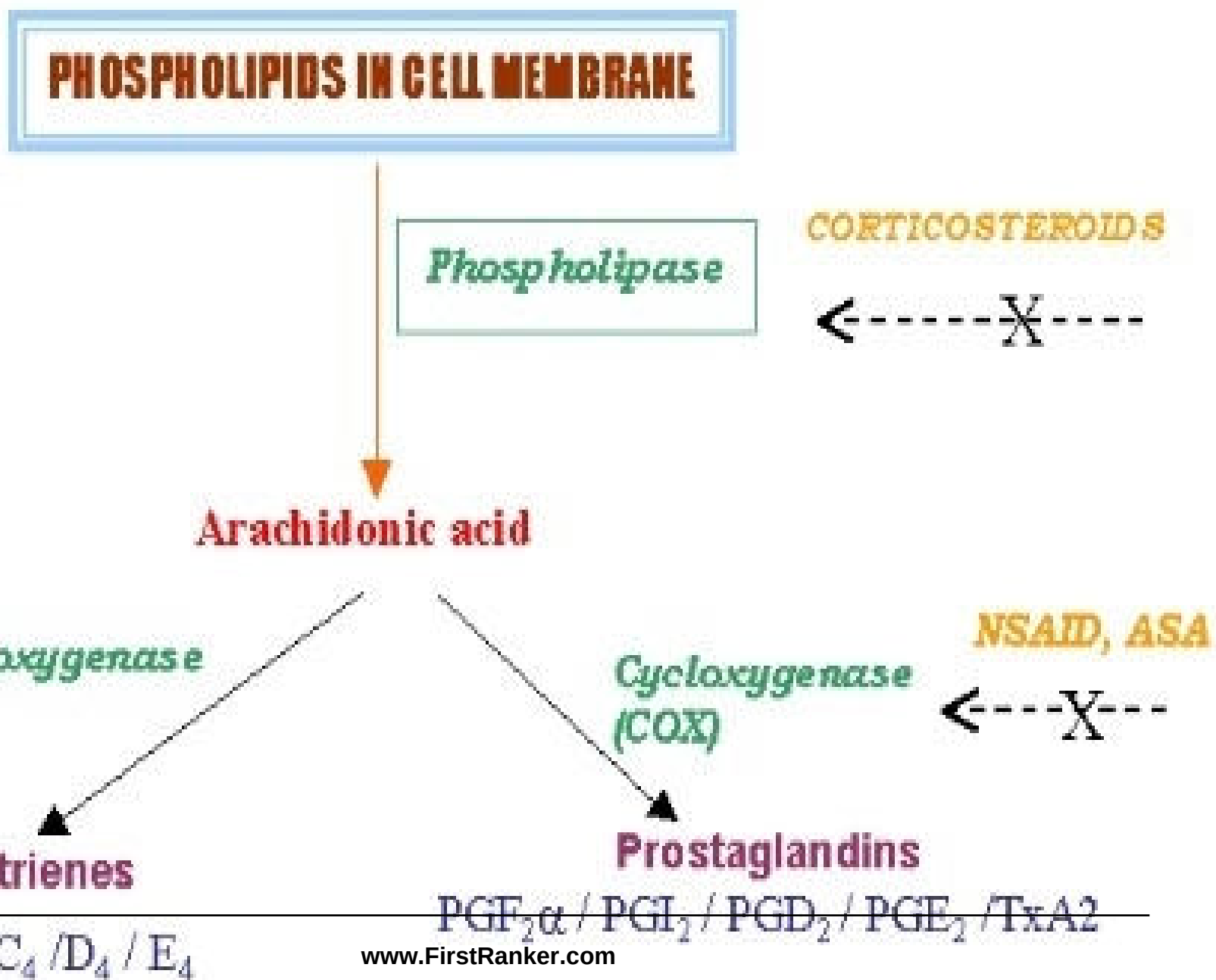
Biosynthesis Of Eicosanoids

- **Eicosanoids are derivatives of Nutritional Essential Fatty acid/PUFAs.**

- **Eicosanoids** are biosynthesized in the body from **PUFAs**:

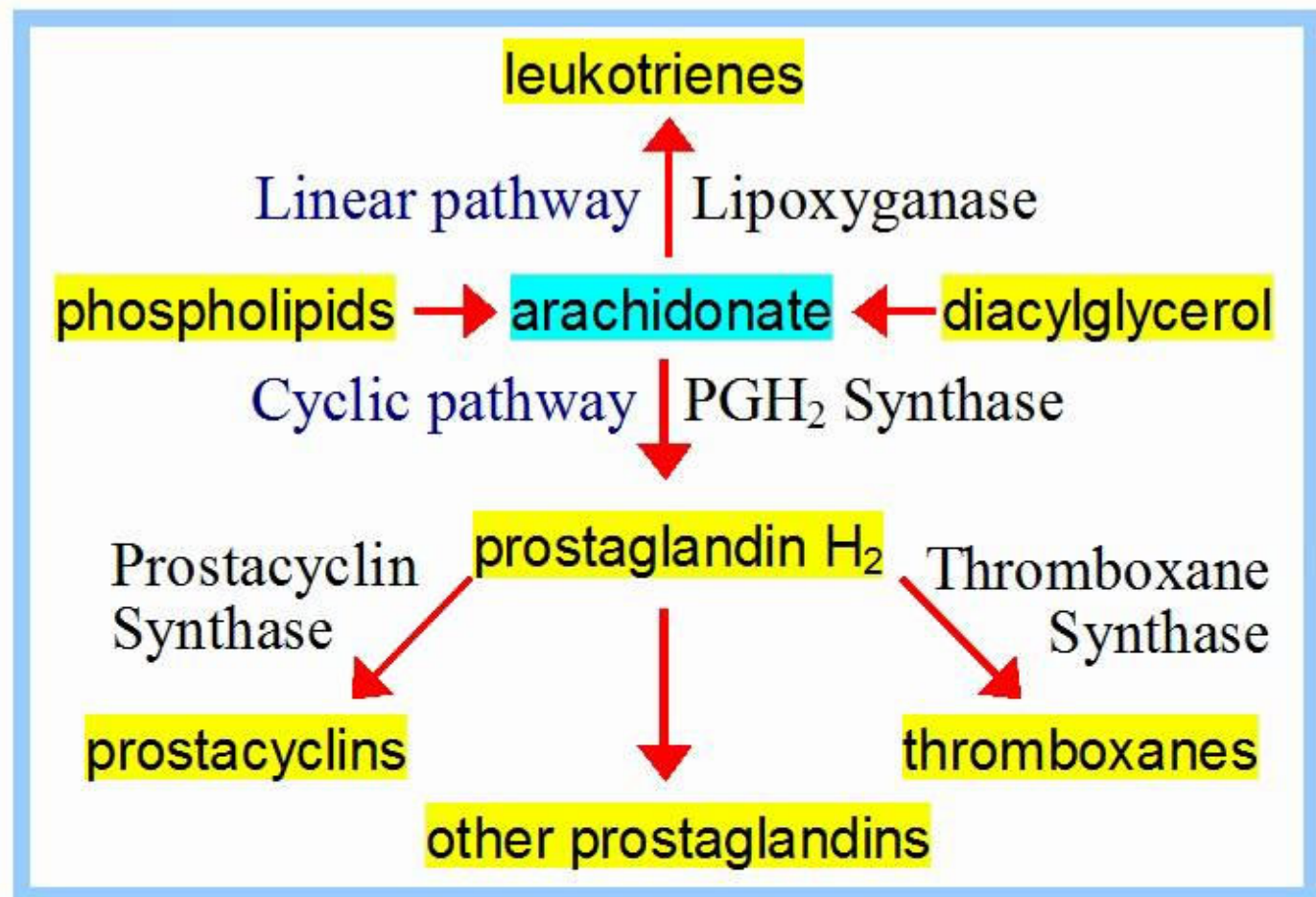
1. Mostly from **Arachidonic acid/Eicosatetraenoic acid (PUFA)/Omega 6 Fatty acid**
2. Minorly from **Timnodonic acid/Eicosapentaenoic /Omega 3 Fatty acid**

- During Eicosanoid Biosynthesis Mostly
- Arachidonic acid is released by **Phospholipids Viz: Lecithin/PIP3**
- By Phospholipase A2 activity



Two major pathways of eicosanoid metabolism.

Cyclic pathway:



Prostaglandin H₂ Synthase catalyzes the **committed step** in the “cyclic pathway” that leads to production of prostaglandins, prostacyclins, & thromboxanes.

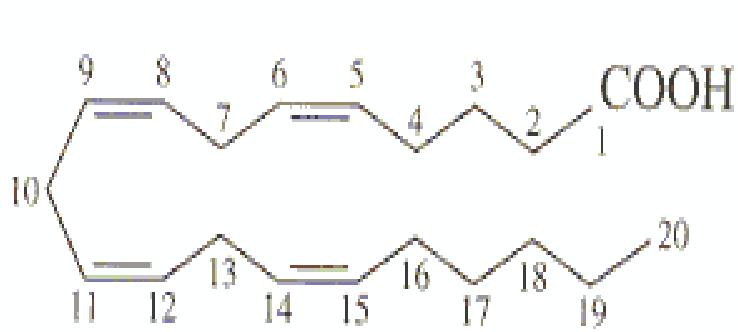
Different cell types convert PGH₂ to different compounds.

- Eicosanoids has **very short half life**
- From seconds to few minutes

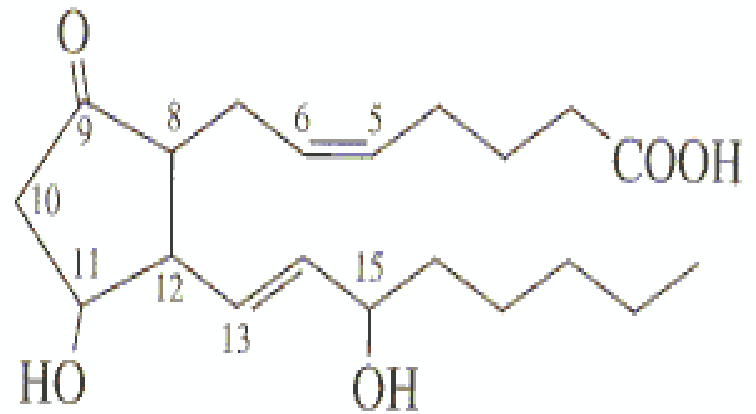
Classification Of Eicosanoids

- **Prostanoids** : Obtained by **Cyclooxygenase System** :
 - Prostaglandin
 - Prostacyclins
 - Thromboxanes
- **Leukotrienes and Lipoxins** are obtained by **Lipoxygenase System**

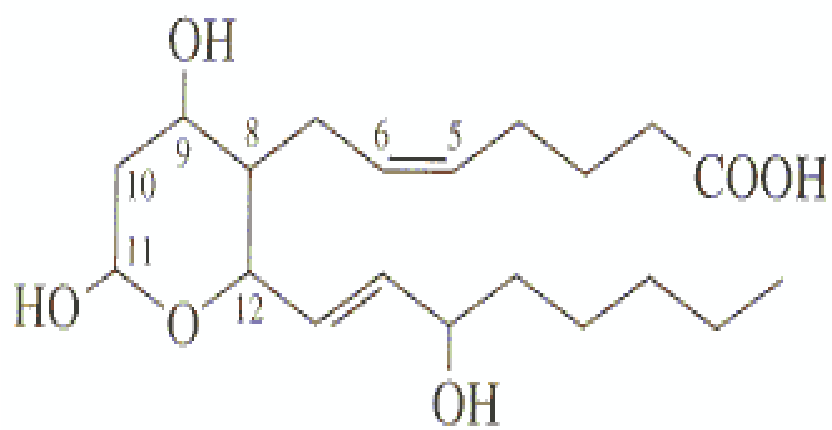
Prostaglandins are Derivative of Arachidonic acid



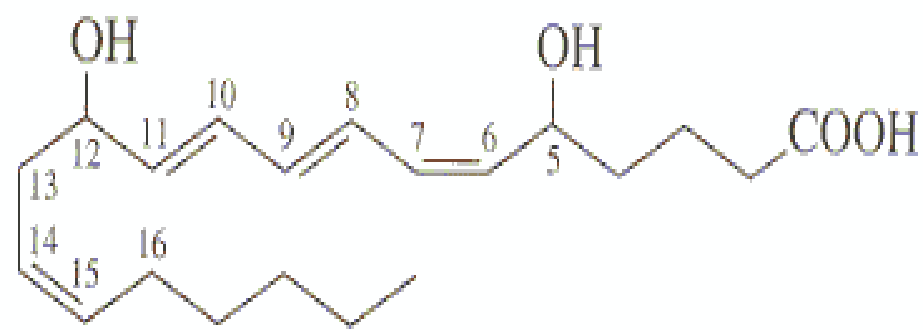
(a) Arachidonic acid



(b) Prostaglandin E₂



(c) Thromboxane B₂



(d) Leukotriene B₄

1. Prostaglandins (PGs)

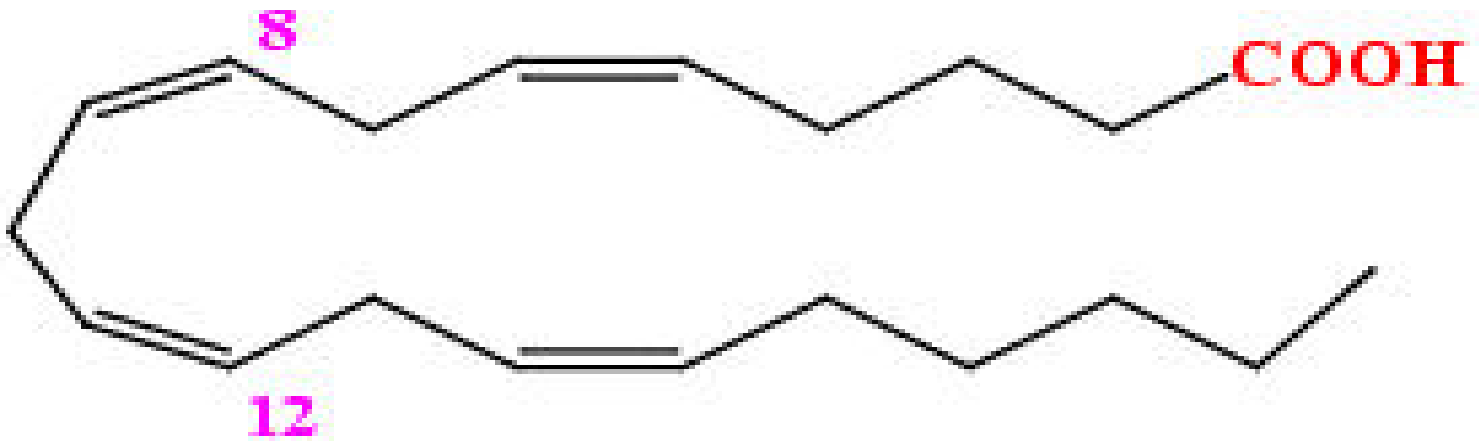
- **Prostaglandins** are type of **Eicosanoids**.
- **PGs** also termed as **Prostanoids**
- Since they are obtained from parent compound **Prostanoic acid**

Biosynthesis Of Prostaglandins

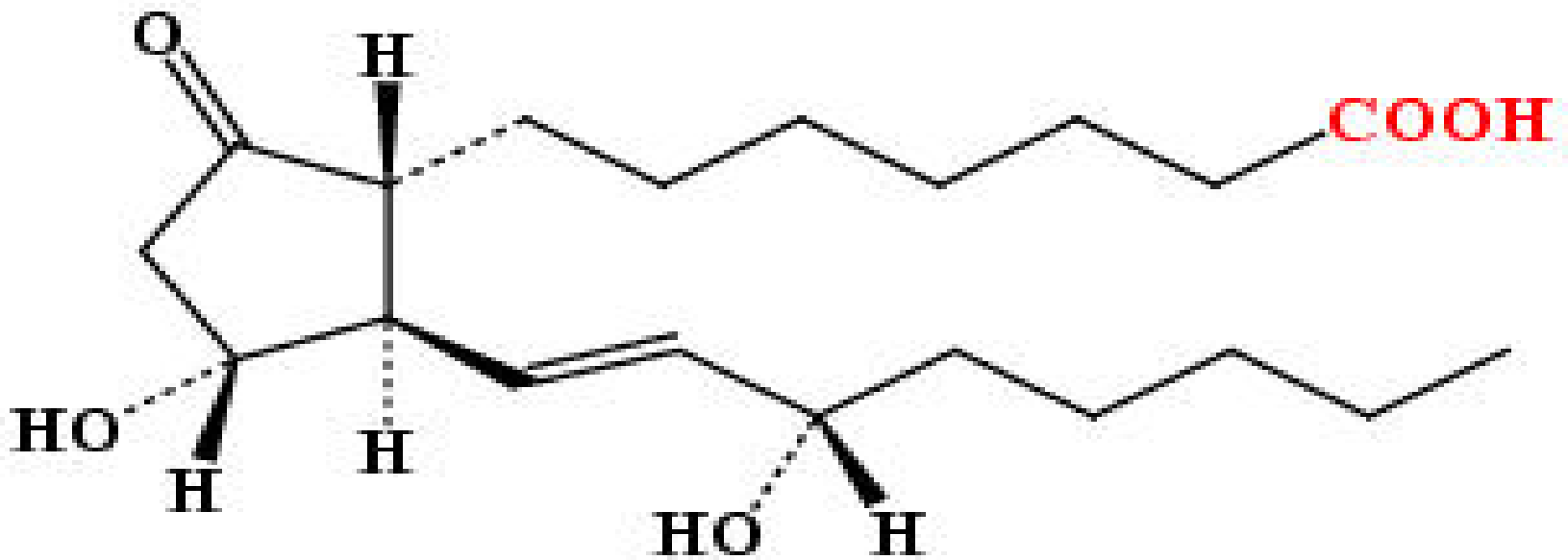
- **Per day 1 mg of Prostaglandins are biosynthesized in human body.**
- Prostaglandins are derived from **Arachidonic acid** by **Cyclooxygenase system.**

- **Phospholipid Lecithin** releases **Arachidonic acid**
- **Arachidonic acid** is used for **Prostanoic acid synthesis.**
- **Prostanoic acid** then **biosynthesizes Prostaglandin** in human body.

Structure and Types Of PGs



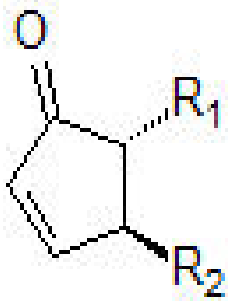
arachidonic acid



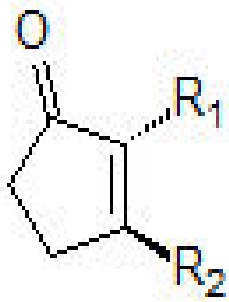
a prostaglandin

- Prostaglandin structure is complex and possess:
 - Cyclopentane ring
 - Double bond
 - Carboxylic and Hydroxyl groups

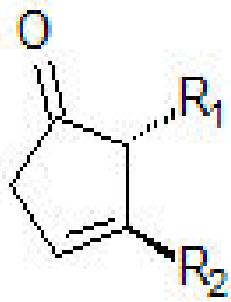
- **Prostaglandins** contains a
- **Cyclopentane ring with Hydroxyl groups at C11 and C15**
- **Prostaglandins (PG) are of following Types:**
 - PG A
 - PG B
 - PG C
 - PG D
 - PG E
 - PG F
 - PG G
 - PG H



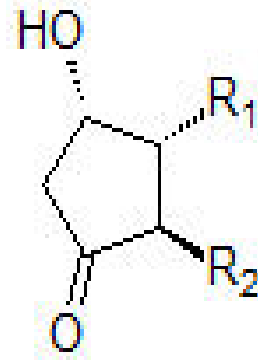
PGA



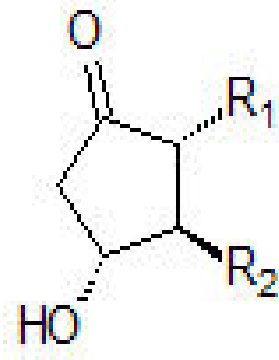
PGB



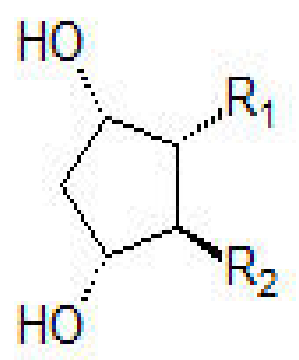
PGC



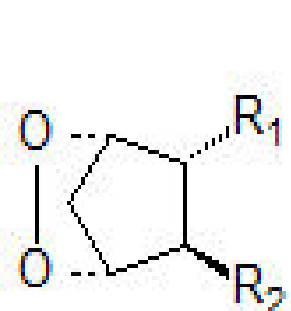
PGD



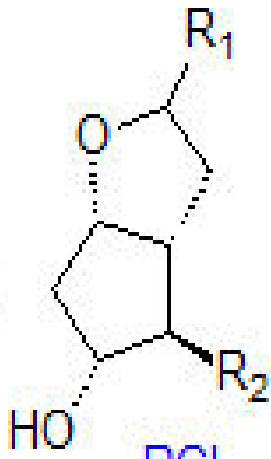
PGE



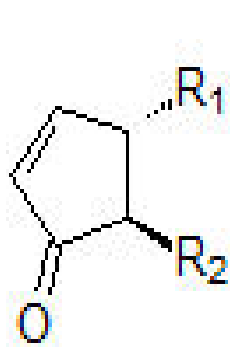
PGF_α



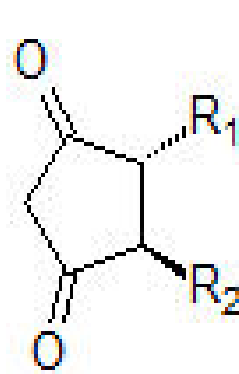
PGG
PGH



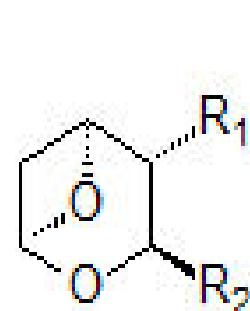
PGI



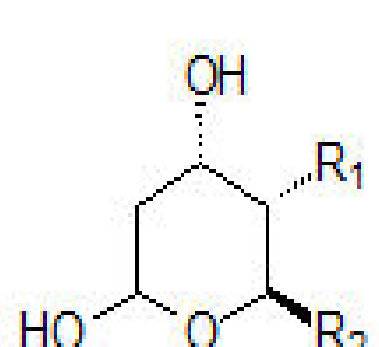
PGJ



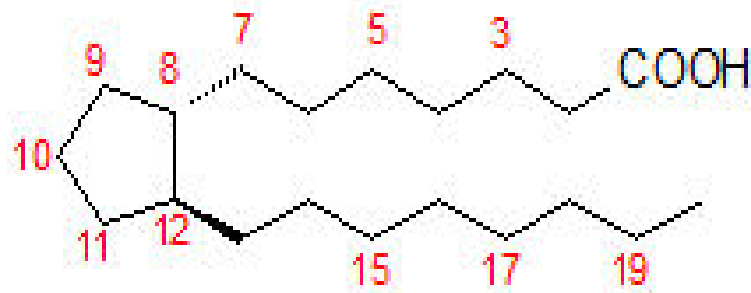
PGK



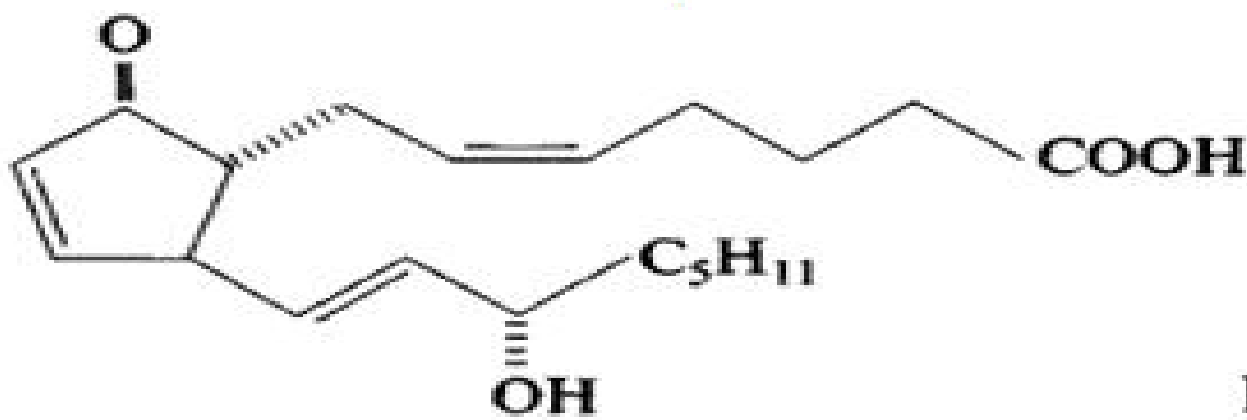
TXA



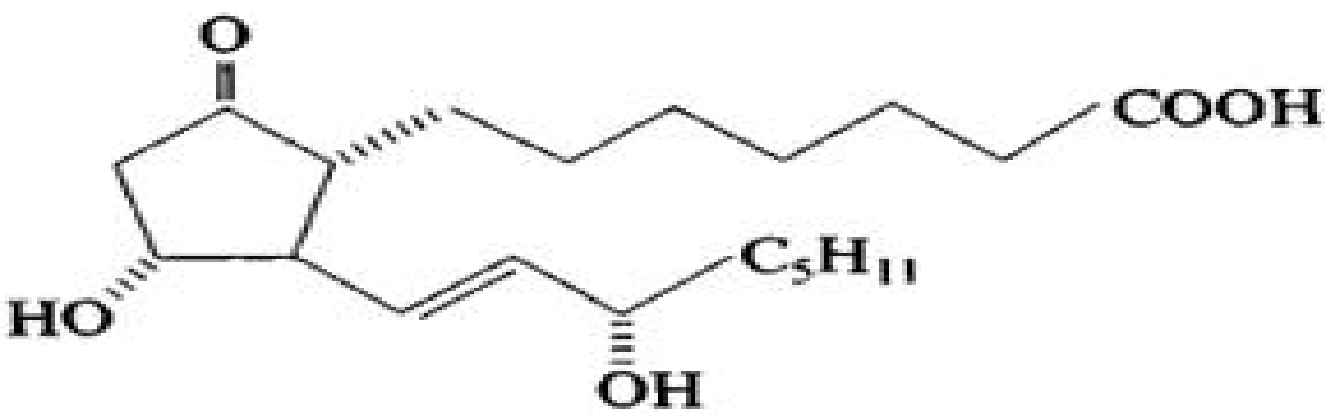
TXB



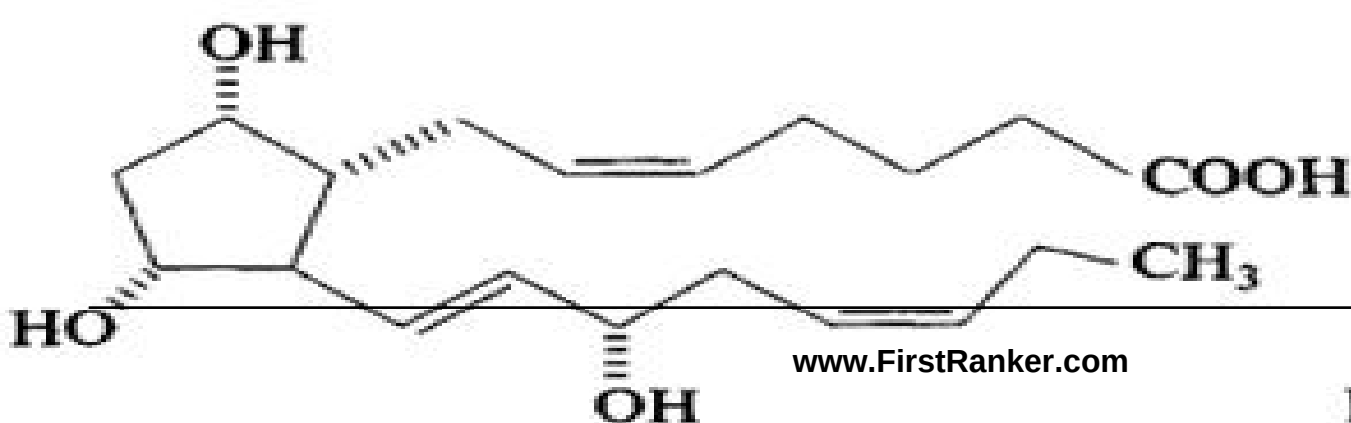
prostanoic acid



Prostaglandin A₂



Prostaglandin E₁



Prostaglandin F_{3α}

Occurrence/Distribution Of PGs

Occurrence Of PGs

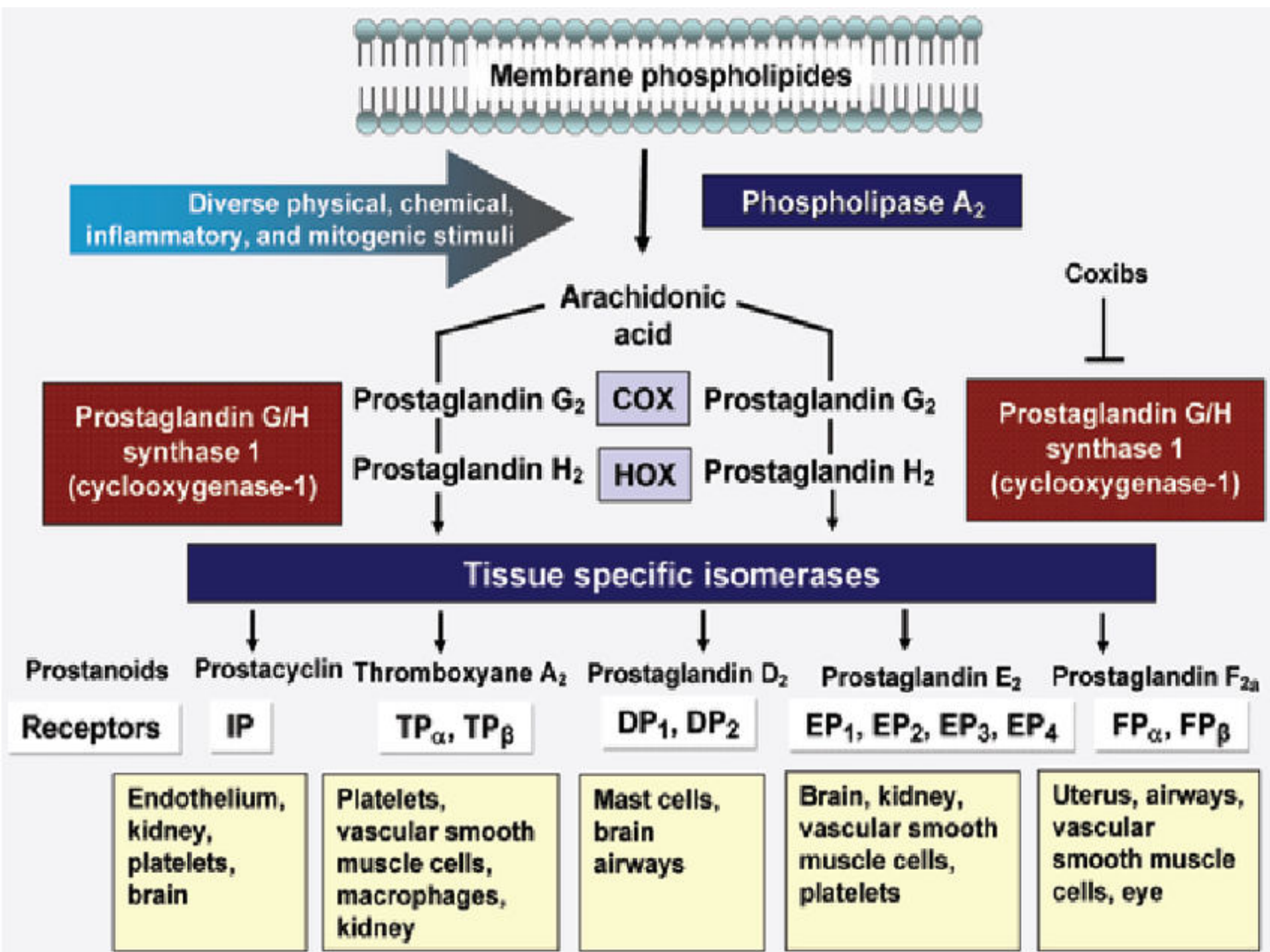
- Prostaglandin was **first** seen in **Prostatic secretion** and **Semen**.
- **Later** it was found that **Prostaglandins** are **ubiquitous**
- Present all over **in human body tissues**.

Functions OF Prostaglandins

- Prostaglandins serve as **Cell Signaling Agents/Local Hormones** with.
 - **Paracrine in action** (act on sites closely where they are produced/ neighboring cells).
 - **Autocrine in action** that the **sites where they are produced.**

- PGs exert their function through **G-Protein linked membrane receptors.**

Prostaglandins have diverse functions on many tissues



- **Action of one PG** is different in different tissues.
- Sometimes PGs bring out opposing action in same tissue.

1.

Regulate Blood Pressure

4.

Inhibits Gastic secretion

2.

Help in Parturition

5.

Promotes Kidney Function

FUNCTIONS OF Prostaglandins

3.

Bronchodilation

6.

Produces pain, inflammation and Fever

1.Role Of PGs In Blood Vessels

PGs Regulate Blood Pressure

- **PG A and PG E** are Vasodilators.
- **PGs lowers the blood pressure by:**
 - Increasing blood flow and
 - Decreasing vascular resistance** in blood vessels.
- PGs are used **Therapeutically** in treating Hypertension.

Prostaglandin occur at Platelets Inhibits Platelet Aggregation and Thrombus formation

**2. PGs Has Role in Uterus At The Time
Of Parturition**

- PG naturally **increases uterine** contraction of smooth muscles which **induces** the delivery of baby.
- PGs can be **therapeutically used** as **Abortifacients** during Medical Termination of Pregnancies (MTPs)
- PGs also arrests **postpartum hemorrhage**.

Prostanoids Therapeutic Uses

- Uterine Stimulation
- Carboprost (15-methyl $\text{PGF}_{2\alpha}$)
- Used by IM route for induction of abortion between 12th -20th gestational weeks
- Used at a dose of 250 μg every 1-3 hrs
- Dinoprost ($\text{PGF}_{2\alpha}$)
- Injection form for intra-amniotic administration
- Used to induce labour or abortion

3. Role Of Prostaglandins In Lungs

- PGs in Lungs serve as **Bronchodilators and Bronchoconstrictor** of Lungs.
 - PG E-**Bronchodilator**
 - PG F- **Bronchoconstrictor**
- **PG E is used in treatment of Bronchial Asthma.**

4. Role Of Prostaglandin In GIT

- Prostaglandin in stomach **increases its motility** and **inhibits gastric secretion of HCL.**
- PG is used in **treatment of gastric ulcers.**

5. Role Of Prostaglandins in Kidneys

- PGs in Kidneys **increases GFR** and **promotes urine formation** and **urine out put.**
- Thus helps in **removing waste out of the body.**

PGs Regulate Sleep and Wake Process

- **Use of PG D2 promotes Sleep**

6.Effect Of PGs on Metabolism

- PGs **Decreases Lipolysis** (breakdown of TAG).
- PGs **increases Glycogenesis**.
- PGs **promotes Steroidogenesis** (Biosynthesis of Steroid hormones)
- PGs **promotes mobilization of ionic Calcium** from bones.

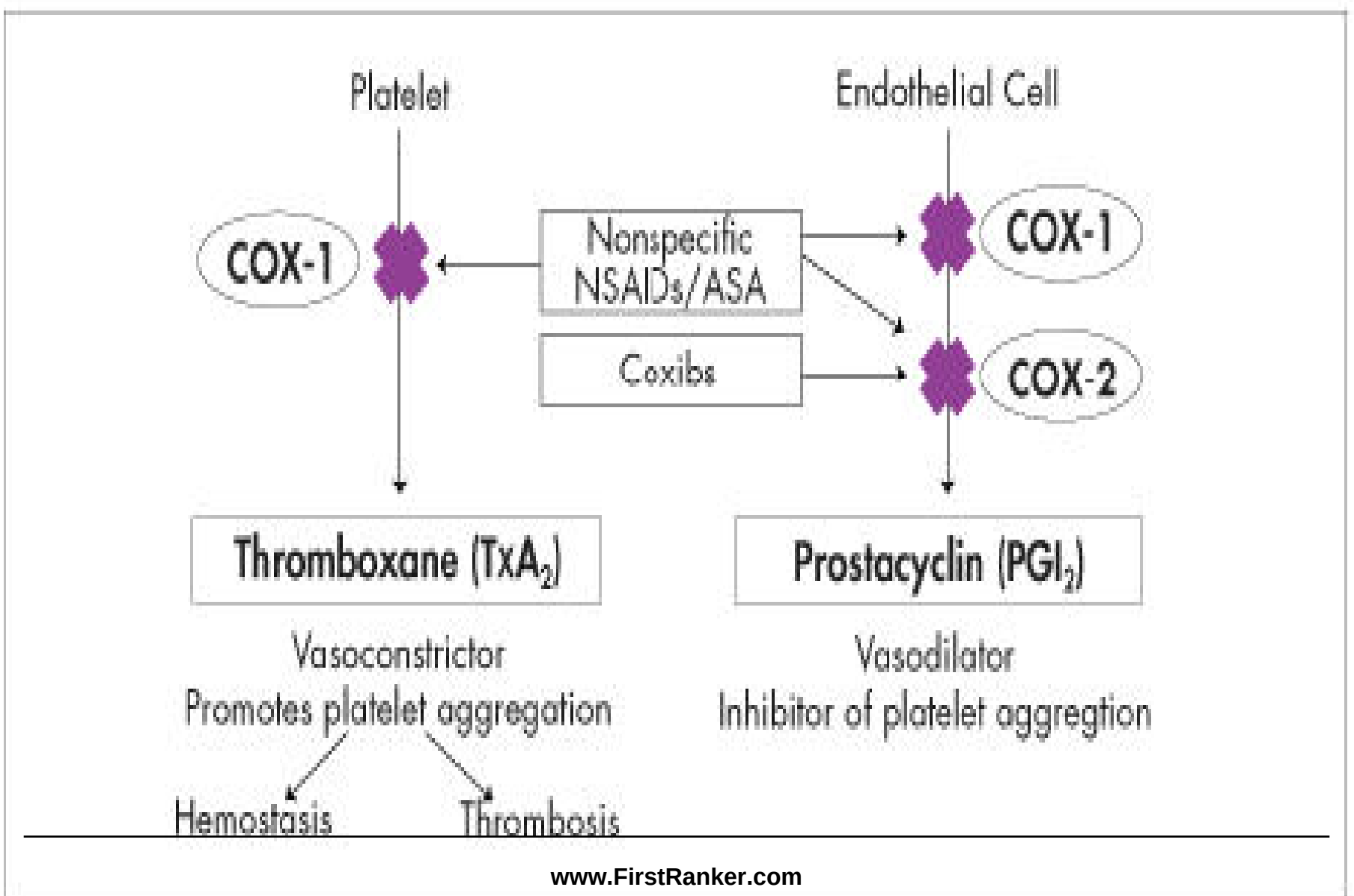
Production of PGs
Promote
Fever , Pain , Nausea
Vomiting and Inflammation

Role Of PGs In Immunity And Inflammation

- Prostaglandins are produced in more amounts at the time of :
 - Fever
 - Pain
 - Nausea and Vomiting
 - Inflammation
- Provide non specific immunity to body
- PGs are more produced in inflammatory disorders like **Rheumatoid Arthritis**

- Drugs like **NSAIDs Aspirin** used in treating inflammatory disorders.
- Inhibits the Enzyme of **Cyclooxygenase system**
- **Which in turn inhibits the biosynthesis of Prostaglandins.**

FIGURE 7. Effects of NSAIDs on platelets and endothelium.



Drug	Preparation	Use
Dinoprostone	Vaginal tab/gel	Induction labour Mid term abortion
Dinoprost	Intra amniotic inj	Mid term abortion
Carboprost	IM, Intra amniotic inj	Mid term abortion Control of PPH
Gemeprost	Vaginal pessary	Cervical priming in early pregnancy
Alprostadiol	IV infusion, IV inj Intra cavernosal inj	Maintenance of a patent ductus arteriosus in neonates Erectile dysfunction
Misoprostol Enoprostil	Oral	Abortion & Peptic ulcer Peptic ulcer
Epoprostenol	IV infusion	Pulmonary hypertension
Latanoprostol	Topical	Glaucoma
iloprost	IM	Dec. infact size, when given IM after MI

TABLE 7-1

Prostaglandins

Prostaglandin	Locations	Effects
D ₂ E ₂	Airways, brain, mast cells Brain, kidneys, vascular smooth muscle cells, platelets	• Bronchoconstriction • Bronchodilation • Gastroprotection • Increased activity of GI smooth muscle • Increased sensitivity to pain • Increased body temperature • Vasodilation
F ₂	Airways, eyes, uterus, vascular smooth muscle	• Bronchoconstriction • Increased activity of GI smooth muscle • Increased uterine contraction (eg, menstrual cramps)
I ₂ (Prostacyclin)	Brain, endothelium, kidneys, platelets	• Decreased platelet aggregation • Gastroprotection • Vasodilation
Thromboxane A ₂	Kidneys, macrophages, platelets, vascular smooth muscle	• Increased platelet aggregation • Vasoconstriction

PHYSIOLOGICAL EFFECT

Inflammation

- PGs are natural mediators of inflammation
- PGE2 & PGE1 induce signs of inflammation- redness, heat (vasodilation), swelling, edema, etc

Pain & Fever

- Pyrogen stimulates PG synthesis & release of PGE2 in the Hypothalamus region of brain where temp is regulated.
- PGE2 can enhance the intensity & duration of pain caused by bradykinin & histamine.

Reproduction

- PGE2 and PGF2 have been used to induce parturition as well as to terminate pregnancy.
- Cytotec
- PGE series of PG may play a role in male infertility

PHYSIOLOGICAL EFFECTS

Peptic Ulcer

- Synthetic PGs have been useful in inhibiting gastric secretions in patients with gastric ulcers.

Regulation of Blood Pressure

- PGE, PGA & PGI2 being vasodilators lower the systemic arterial pressure; increase local blood flow.
- Might help in treating Hypertension

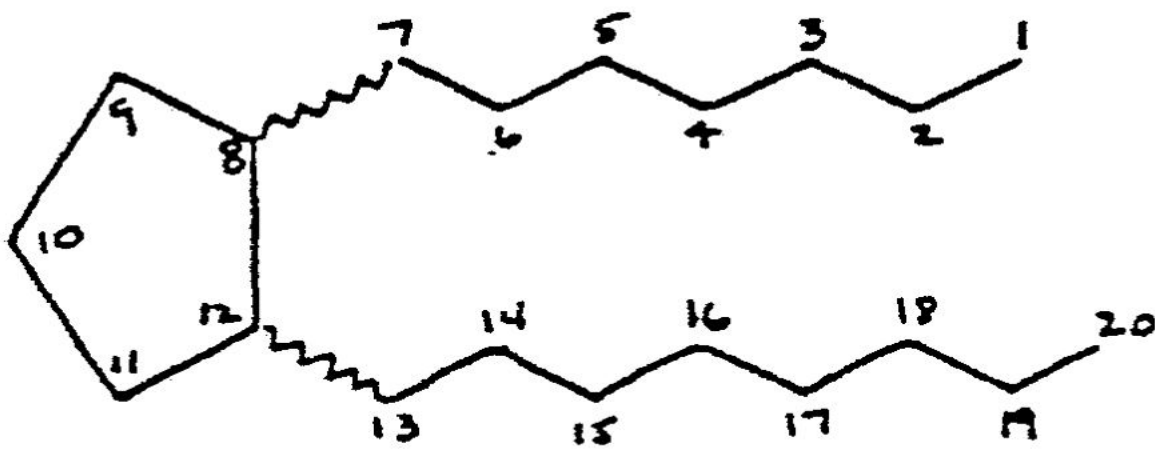
Ductus Arteriosus

- PGE2 maintains the patency of DA prior to birth.
- If DA remains open after birth COO inhibitor like indomethacin can be given
- Infants with congenital abnormalities are administered PG to maintain blood flow.

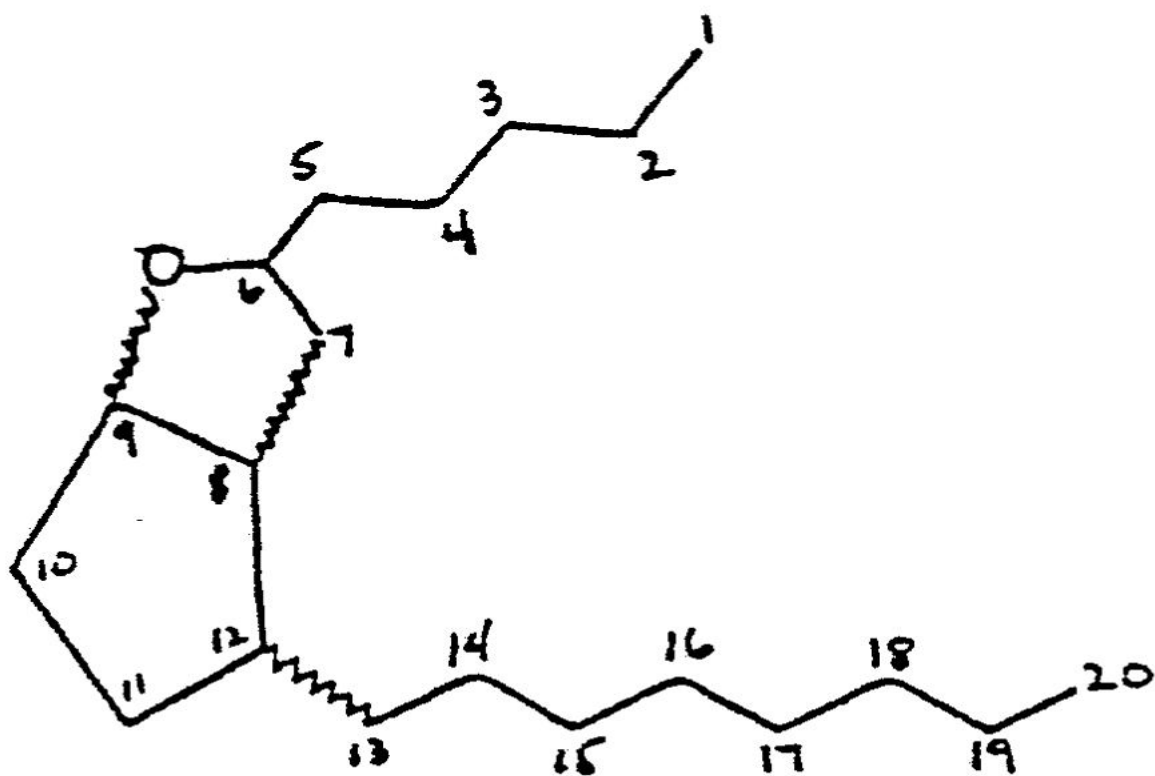
2. Prostacyclins (PGI₂)

Prostacyclins (PGI₂)

- Prostacyclins are type of **Eicosanoids/ Prostanoids**.
- Principally **formed in vascular endothelium**
- **They are Platelet Aggregation Inhibition Factors**
- Biosynthesized by enzyme **Prostacyclin Synthetase**.



Prostaglandin



Prostacyclin

Roles of Prostacyclins

- Prostacyclins are **Vasodilators**.
- Prostacyclins like Prostaglandins **inhibit platelet aggregation**.
- Prostacyclins **prevent Thrombus/clot formation**.

3. Thromboxanes (TX)

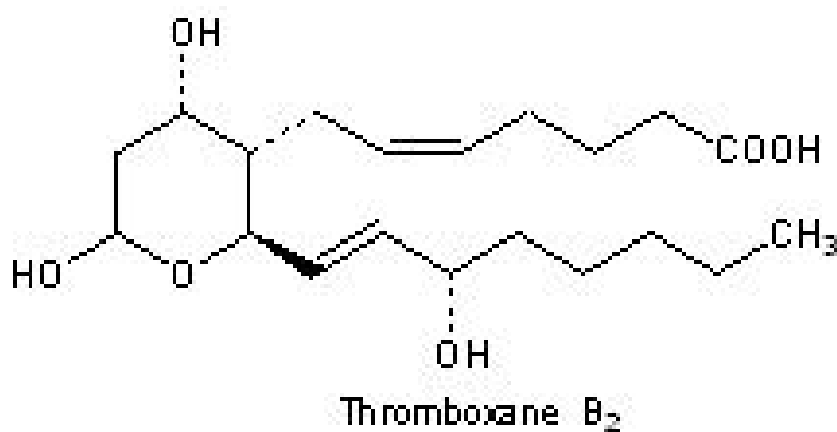
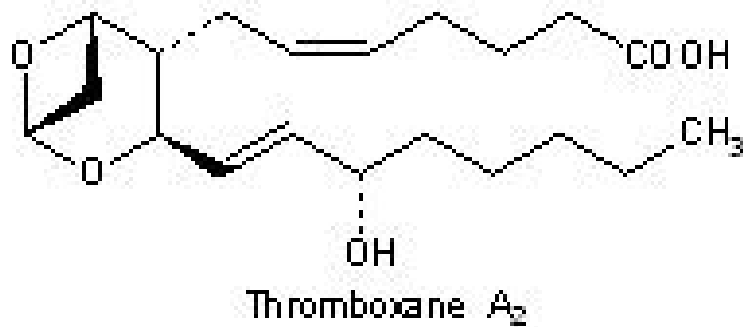
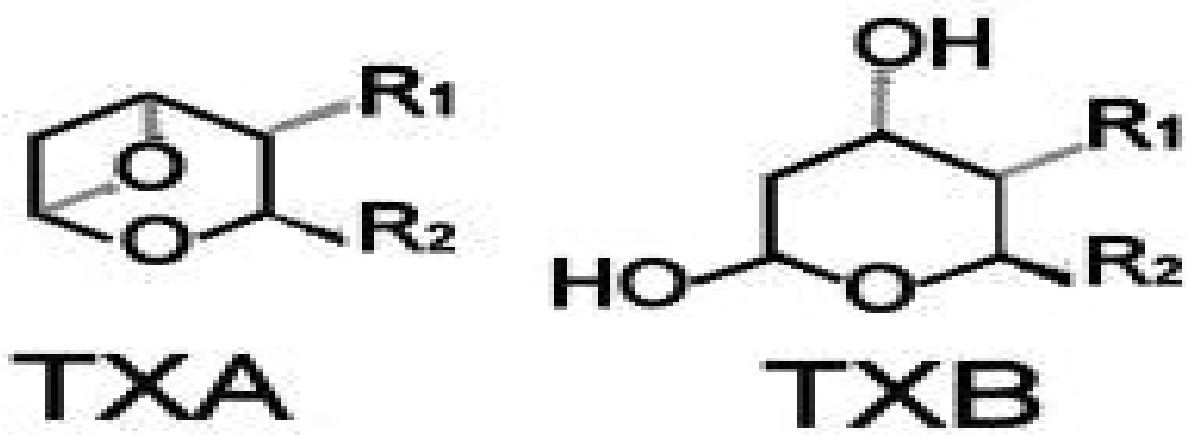
Thromboxanes (TX)

- **Thromboxanes** are also termed as **Platelet Aggregating Factor (PAF)**.

- **Thromboxanes are Prostanoids produced by Thrombocytes (platelets)**
- **By Enzyme Thromboxy Synthase.**

Structure Of Thromboxanes

- **Thromboxanes possess a cyclic Ether in their structures.**



Types Of Thromboxanes

- **TX A and TX B** are types of Thromboxanes.
- **TXA₂** is more prominent in human body.

Functions Of Thromboxanes

- Thromboxanes are **vasoconstrictors**.
- Thromboxanes **enhances platelet aggregation**.
- Thromboxanes **favors blood clot formation** during **blood coagulation**.
- Thromboxanes and Prostacyclins are **antagonistic to each other** balancing their activities.
- Increased Thromboxane activity results in **Thrombosis**.

4. Leukotrienes

Leukotrienes

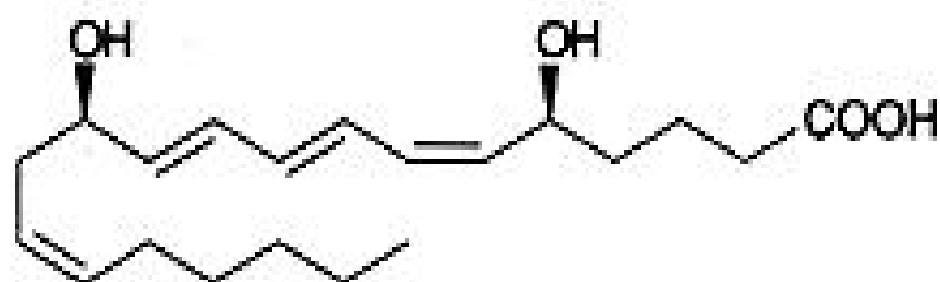
- Leukotrienes are **type of Eicosanoids**
- Biosynthesized through **Lipoxygenase system in Leukocytes.**

- **Leukotrienes** are a family of **Eicosanoid**
- They are **Inflammatory mediators produced in leukocytes.**

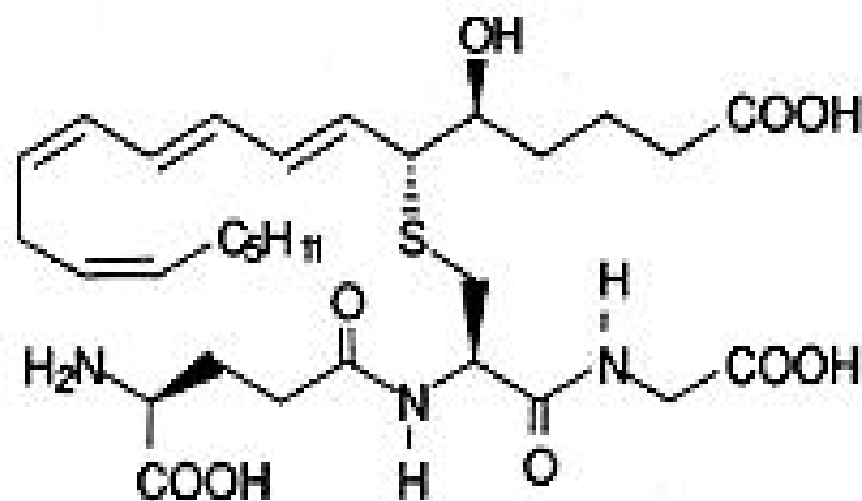
Occurrence Of Leukotrienes

- **Early discovery of Leukotrienes was in Leukocytes.**
- **Leukotrienes are also produced and present in.**
 - **Mast cells**
 - **Lung**
 - **Heart**
 - **Spleen**

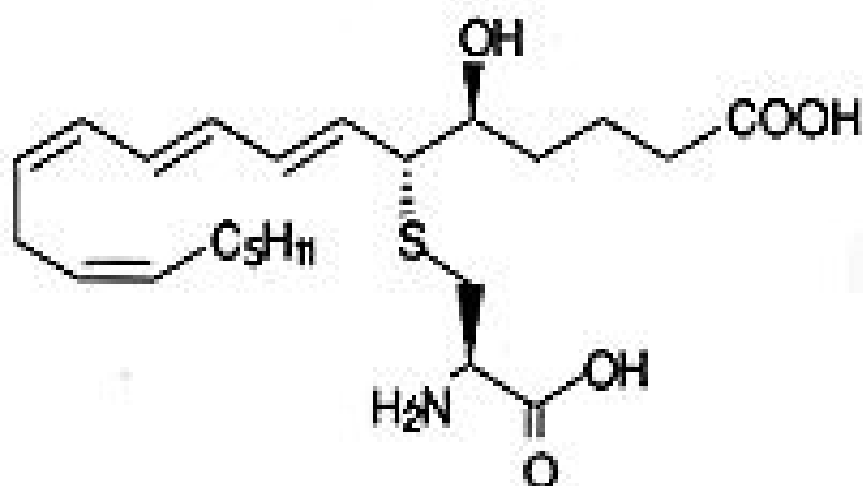
Structure And Types Of Leukotrienes



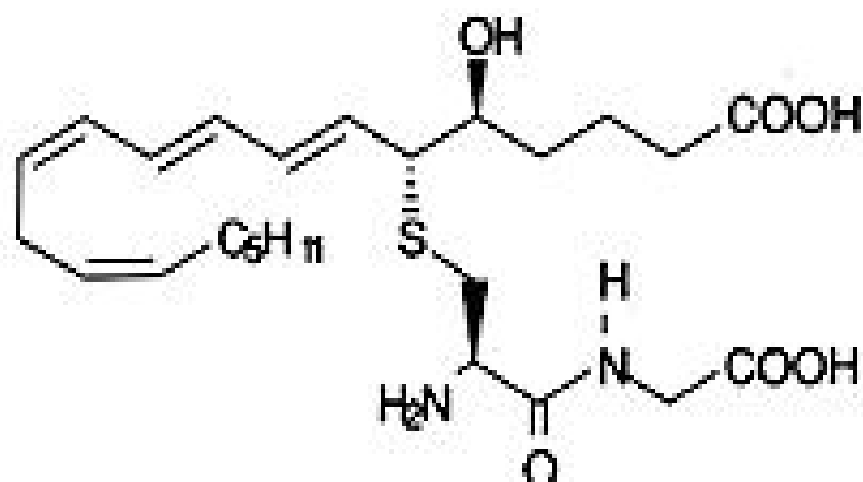
LEUKOTRIENE B₄



LEUKOTRIENE C₄



LEUKOTRIENE E₄



LEUKOTRIENE D₄

Leukotrienes Structure and Types

- **Leukotrienes** are Hydroxy derivatives possessing conjugated Trienes .
- **Types of Leukotrienes:**
- **LTB4, LTC4, LTD4 and LTE4**

Effect Of Leukotrienes

- Leukotrienes are **components of Slow Reacting Substances (SRS-A)**.
- **SRS-A** are released during **Allergic reactions/Anaphylaxis**.

- **Leukotrienes** are **100-1000 times more potent** than **Histamine** during allergic reactions.

- **LTB₄** is a potent chemotactic agent.

(chemical substance which mediates movement of cells).

- Leukotrienes by action are:
 - Bronchoconstrictors**
 - Vasoconstrictors**
- **LTC₄, LTD₄ and LTE₄** are **Slow - Releasing Substance of anaphylaxis (SRS - A)**,
- **SRS-A** causes fluid leakage from blood vessels to an inflamed area.

- Overproduction of Leukotrienes causes **Asthmatic attacks /Anaphylactic shocks.**
- An **Antiasthmatic drug** **Prednisone** inhibits **Leukotriene biosynthesis.**

5. Lipoxins

Lipoxins

- **Lipoxins** are Eicosanoids produced in Leukocytes of human body.
- **Lipoxins are:**
 - Vasoactive/Vasodilators
 - Anti-inflammatory
 - Immunoregulatory
 - Chemotactic substances

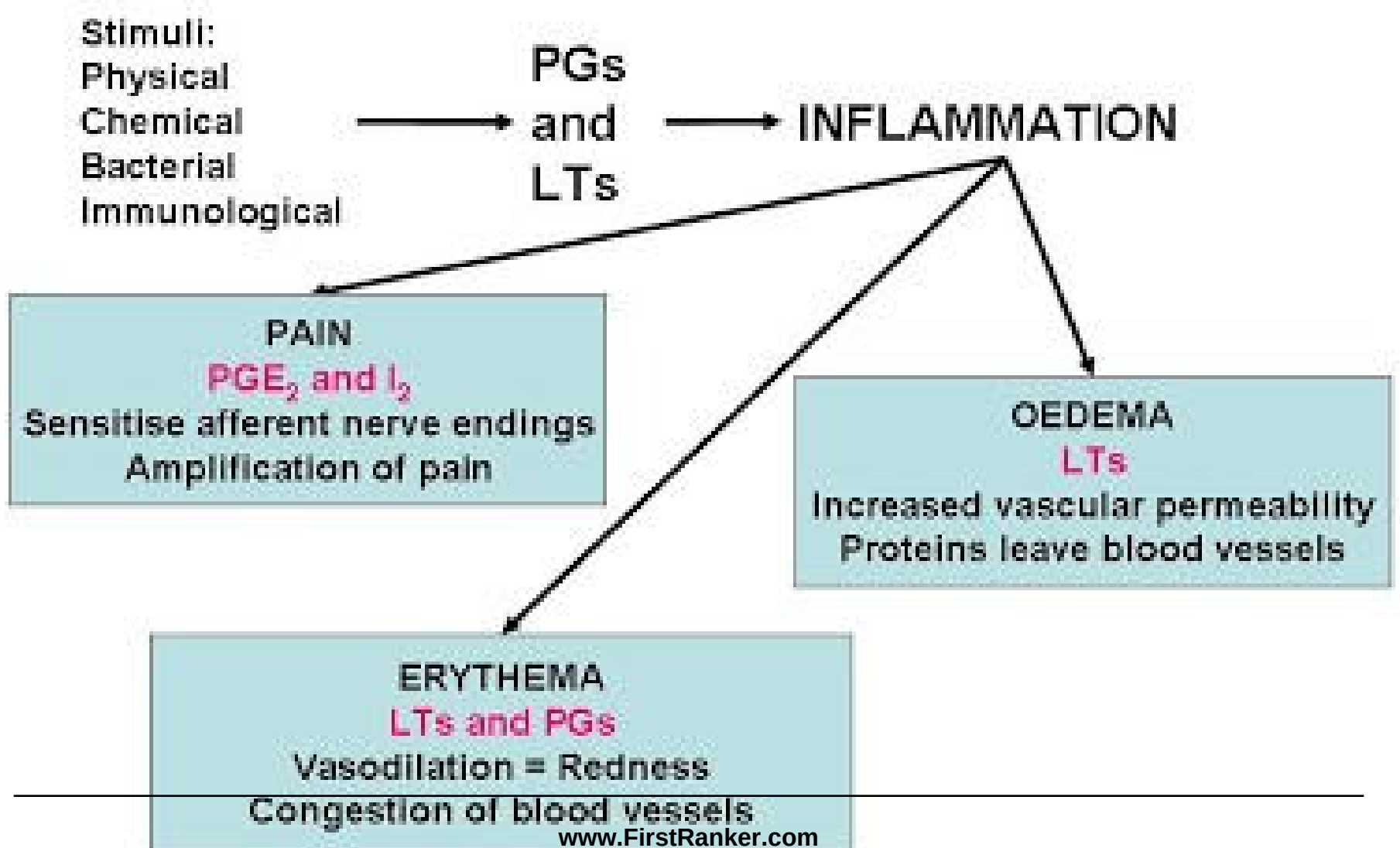
Omega 6 and Omega 3 Derived Eicosanoids Are Opposite in Action

- **Omega 6 Derived Eicosanoids**
- **Prostaglandins:**
 - Promotes Inflammation
- **Omega 3 Derived Eicosanoids**

Resolvins and Eoxins are:

- Anti Inflammatory
- Anti Allergy
- Anti Hypertensive
- Anti Cancer
- Anti Atherosclerotic

Effects of Eicosanoids



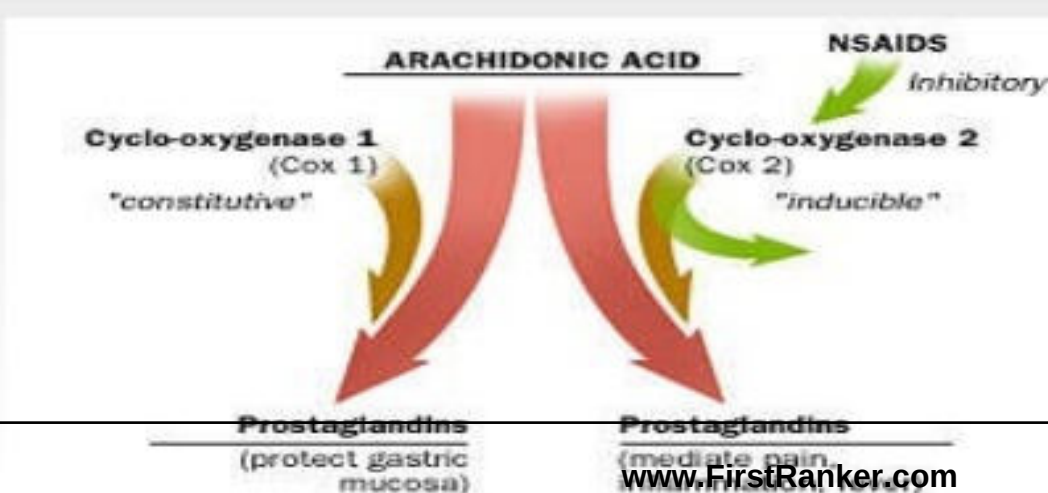
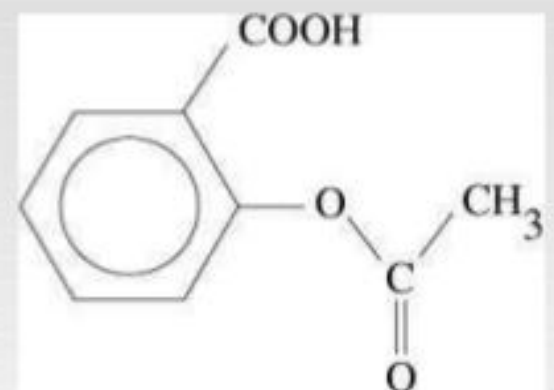
- Local pain and irritation
- Bronchospasm
- Gastrointestinal disturbances: nausea, vomiting, cramping, and diarrhea.

NSAID: ASPIRIN

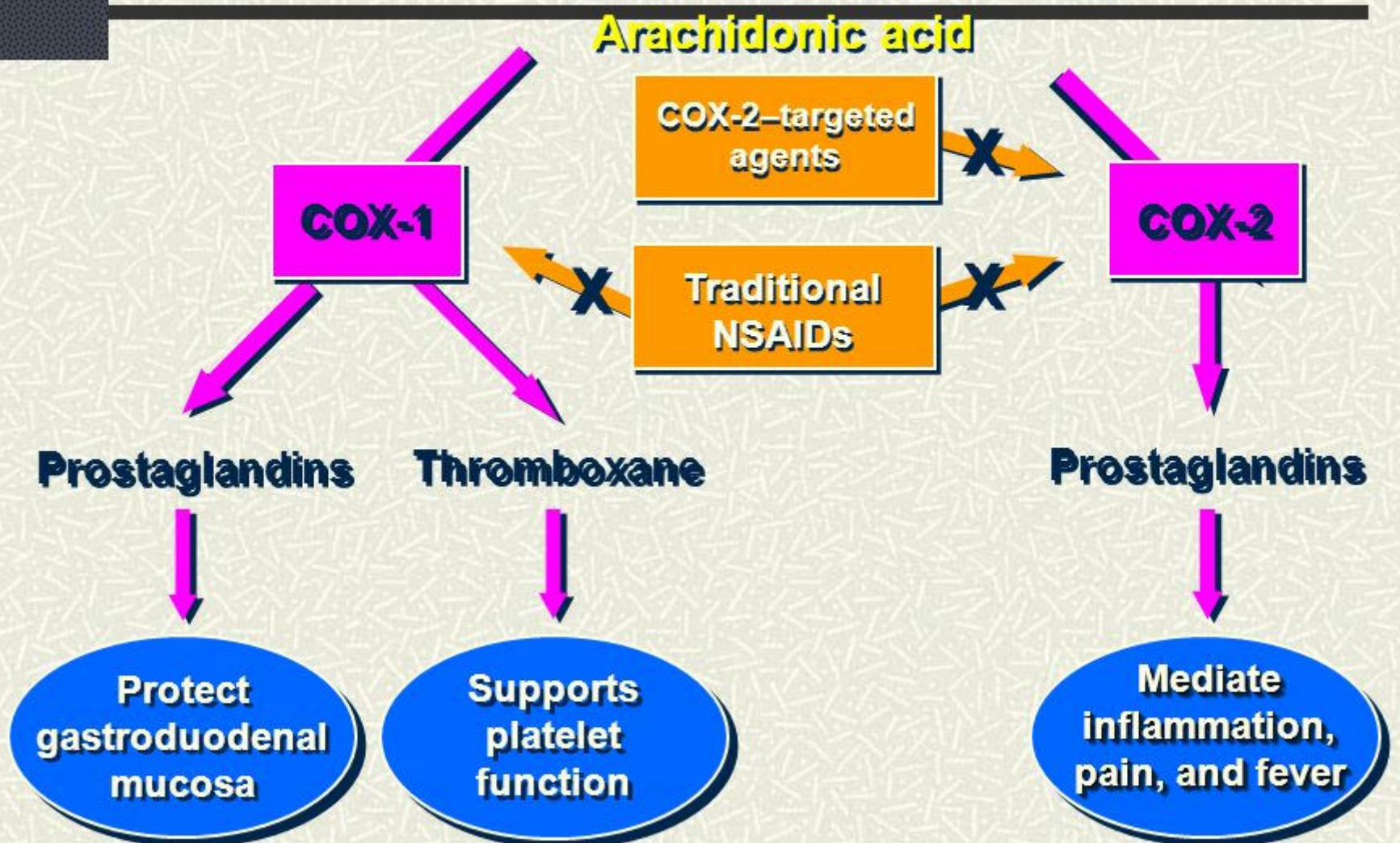
- Acetyl salicylic acid (Aspirin) is an effective anti-platelet aggregator.
- It irreversibly acetylates the platelets COO system and inhibits it thus hampering in formation of Thromboxane A₂
- At time same time it opposes the formation of PGI₂ in the endothelial cells, which is a vasodilator.

CLINICAL USES:

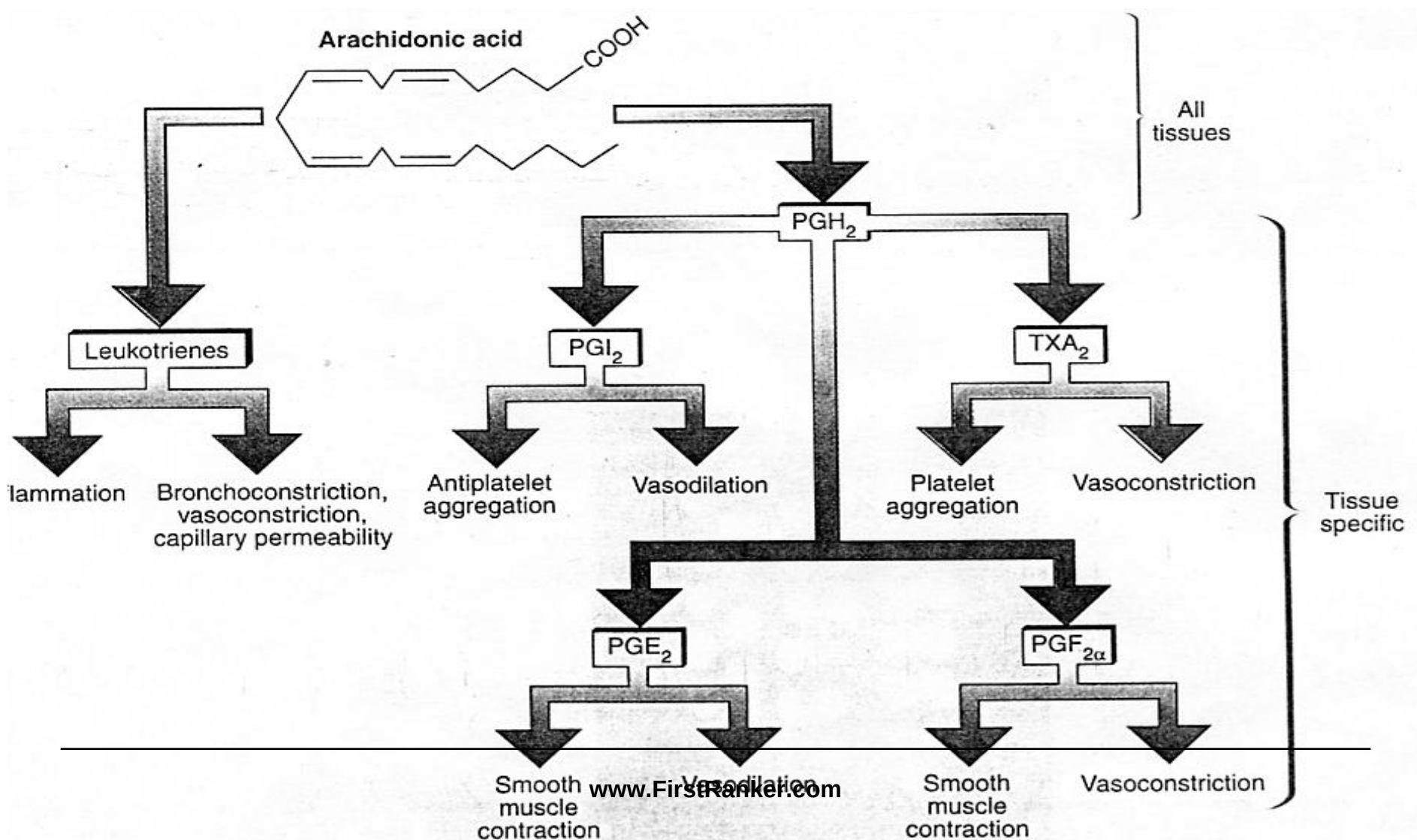
- Management of angina & MI
- Prevention of stroke & cerebral ischemic attacks

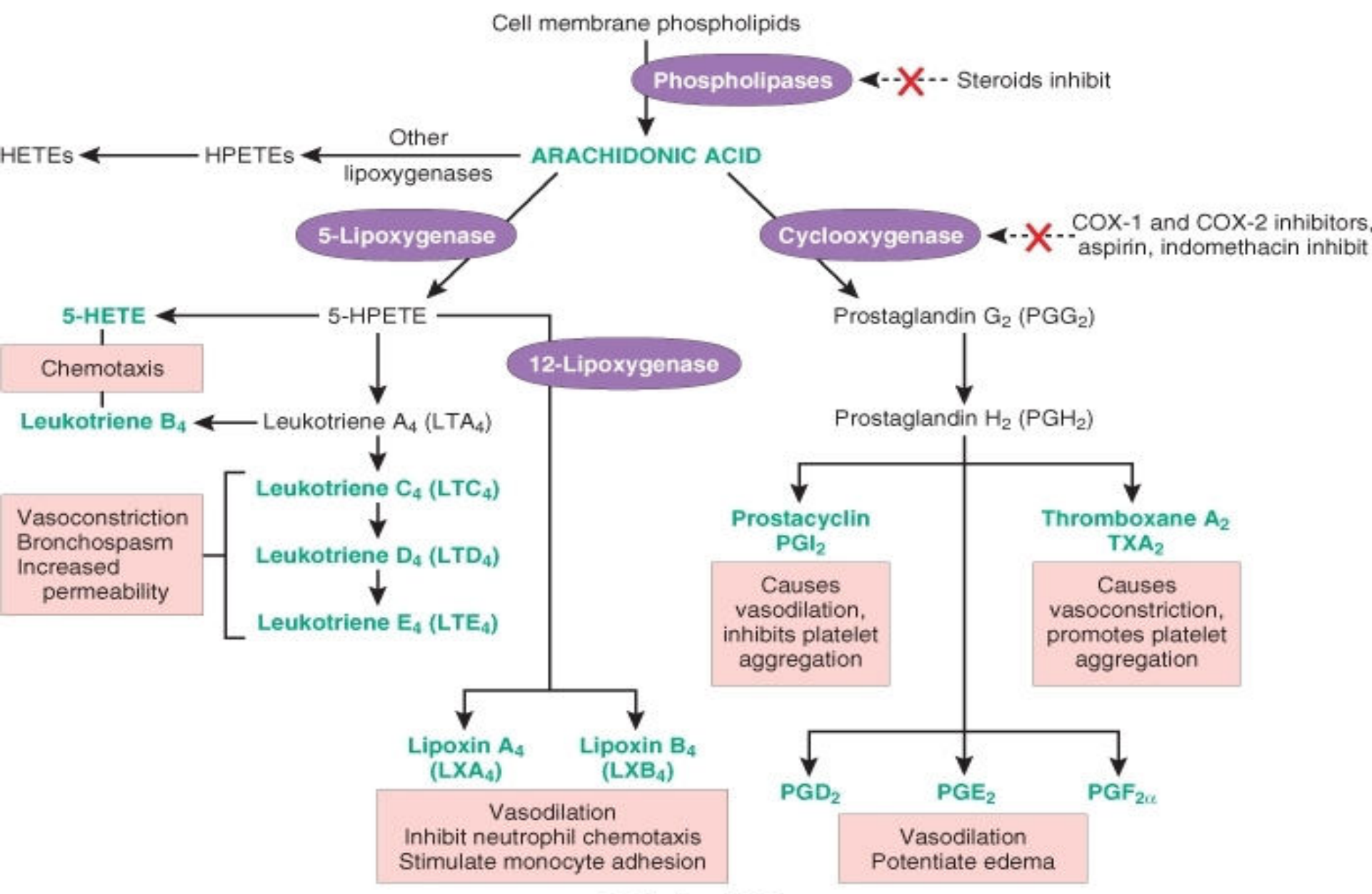


Mechanism of Action of Anti-inflammatory Agents



Biological Actions of Selected Eicosanoid Molecules





Amphipathic Lipids

Examples Of Amphipathic Body Lipids

- **Phospholipids**
- **Glycolipids**
- **Free Fatty acids**
- **Free Cholesterol**

Features Of Amphipathic Lipids

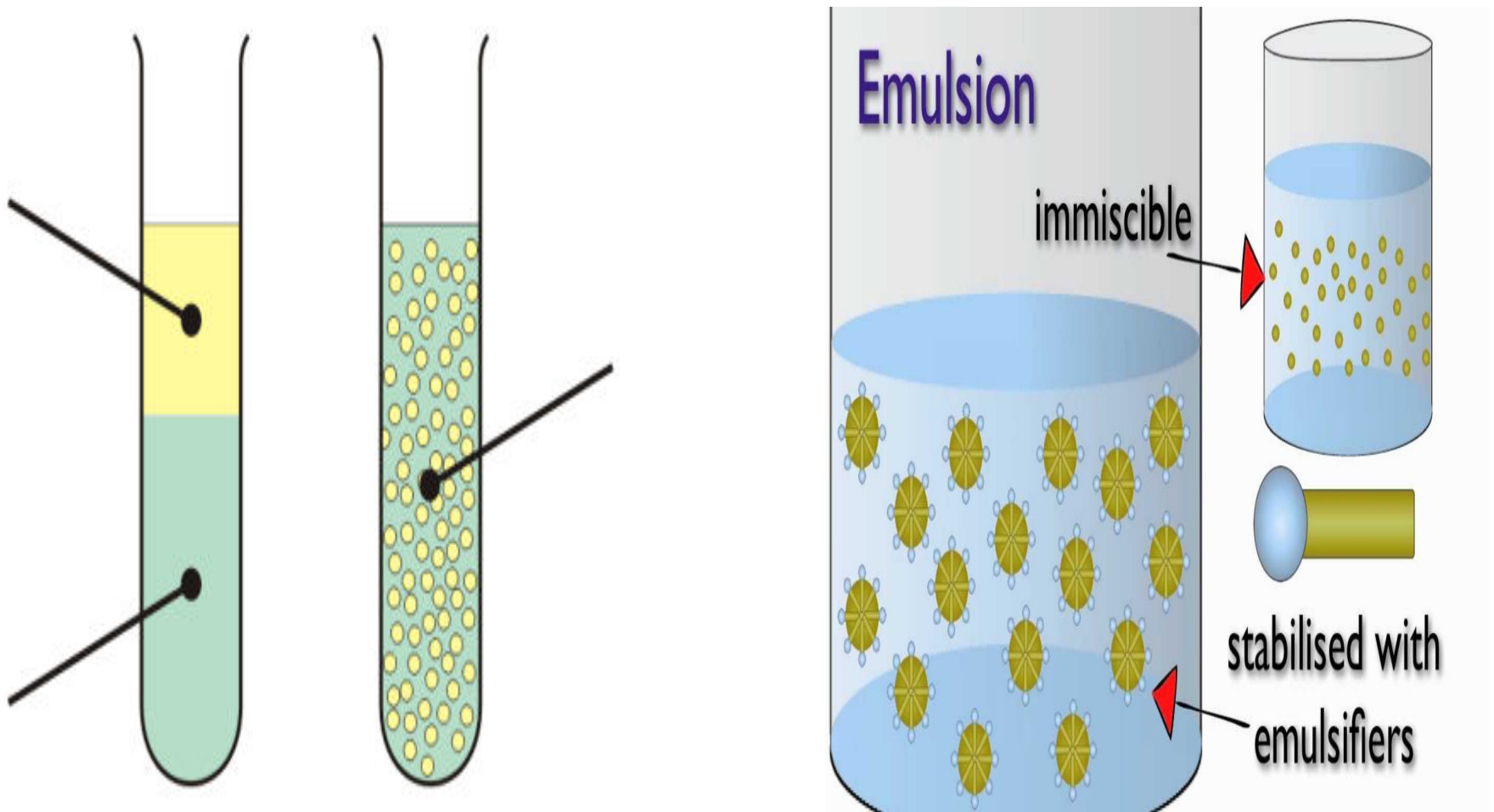
- **Structure has both polar and non polar groups**
- **Partially soluble**
- **Orientation of groups:**
 - **Polar group** directed towards **water phase**
 - **Non polar group** directed in **oil phase/away from water.**

Role Of Amphipathic Lipids

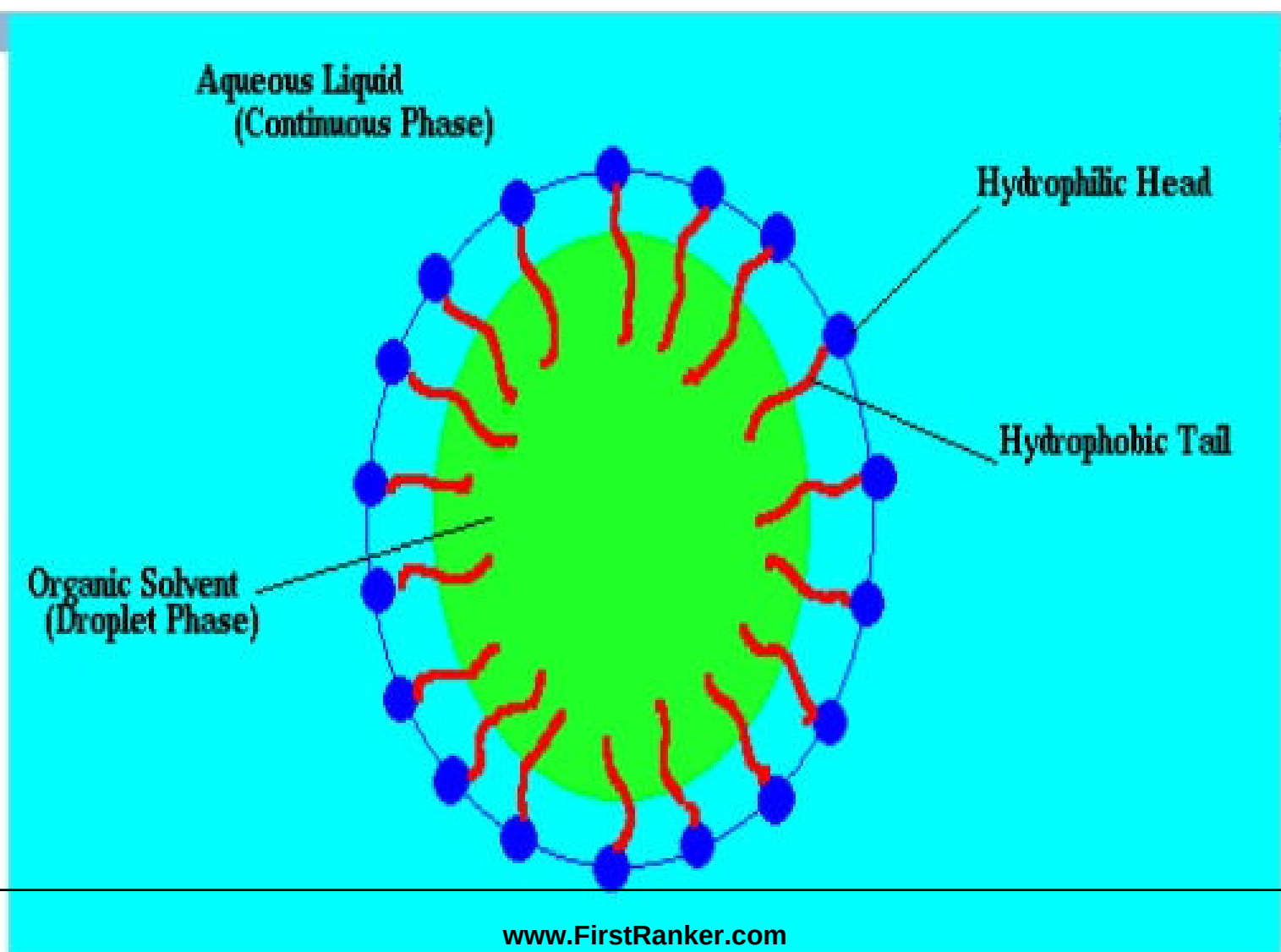
- **Amphipathic Lipids have following biological Significances in forming:**
 - **Biomembranes:**
(Phospholipid bilayer, Glycolipids and Cholesterol)
 - **Emulsions:**
 - In intestine PL help in Lipids Digestion
 - **Micelles:**
 - In intestine help in Lipids Absorption
 - **Lipoproteins:**
 - For transport of nonpolar/neutral Lipids
 - **Liposomes:**

 - Agents for Drug /Gene carrier

Emulsions



Theory of emulsification



Emulsions

- **Emulsions** are small droplets of oils miscible in aqueous phase.
- **Emulsions** are usually formed by Nonpolar and Amphipathic Lipids along with Bile Salts in aqueous phase.

In Human GIT

- Emulsions are formed as **small, miscible** dietary Lipid droplets in aqueous phase of intestinal juice in intestinal lumen.

- **Emulsions are formed during the process of Emulsification in GIT.**

Requirements For Emulsification

- **Emulsifying agents :**
 - **Bile salts (Major)**
 - **Amphipathic Lipids (Minor)**
- **Mechanical force aids emulsification.**

- www.FirstRanker.com**

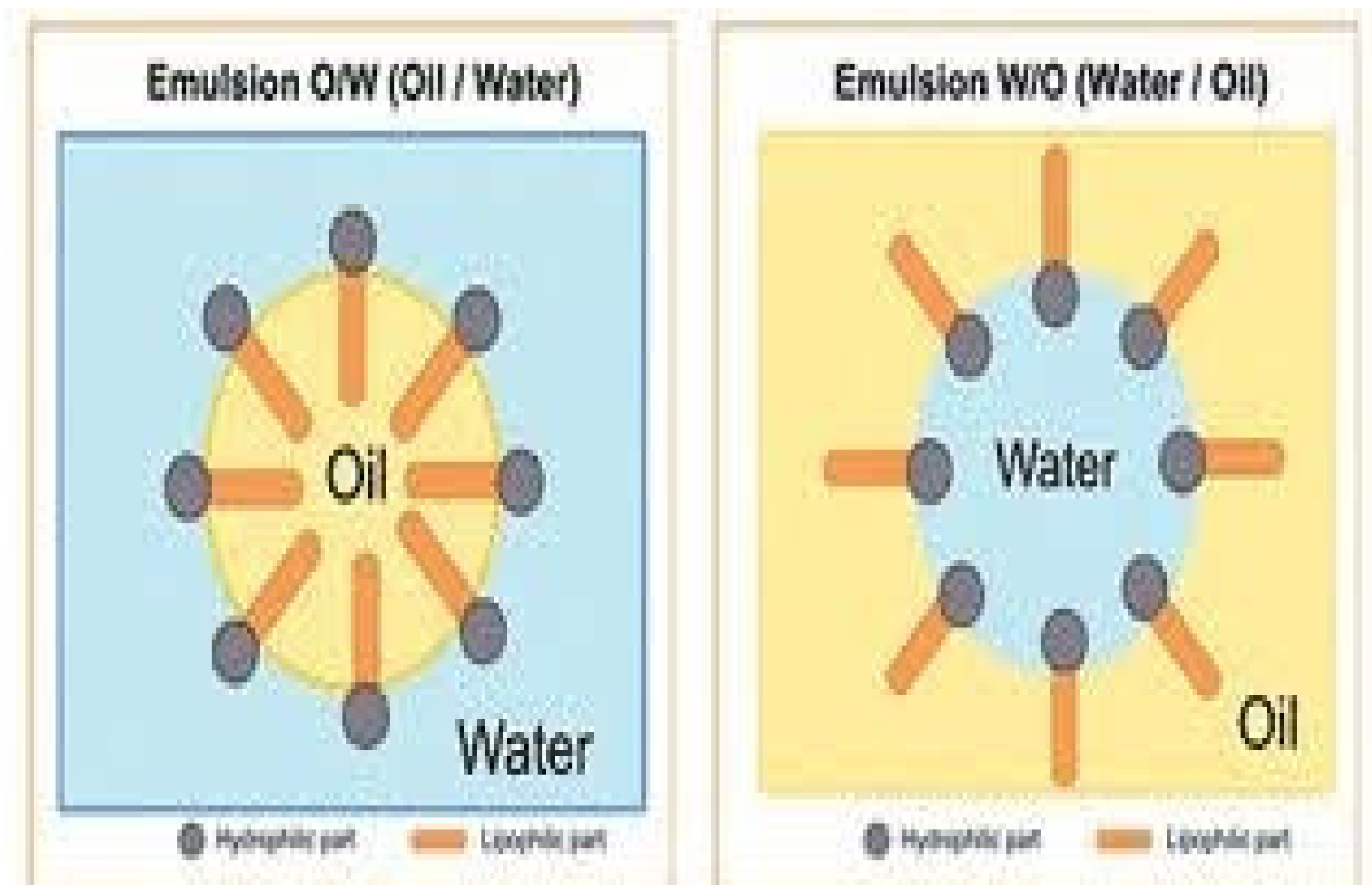
Emulsification Process

- **Emulsification** process takes place in an aqueous phase of **intestinal juice in intestinal lumen** and forms **Emulsions**.
- During Emulsification Hydrophobic or **nonpolar dietary Lipids (TAG)** are mixed with an **emulsifying agents**:
 - Bile salts
 - Lecithin(**Amphipathic Lipids**)
- **Mechanical force**(provided by **intestinal peristaltic movement**) facilitates the **process of Emulsification**.

Types Of Emulsions

I. Oil In Water

II. Water In Oil



Significance Of Emulsions

- Emulsions formed in the intestinal lumen **help in the digestion of dietary Lipids.**
- The dietary large droplets of Fat/Oil are transformed to **small ,miscible droplets** as Emulsions.
- **Emulsions** bring the dietary Lipids in **contact with Lipid digesting Enzymes** present in aqueous phase of **intestinal juice.**

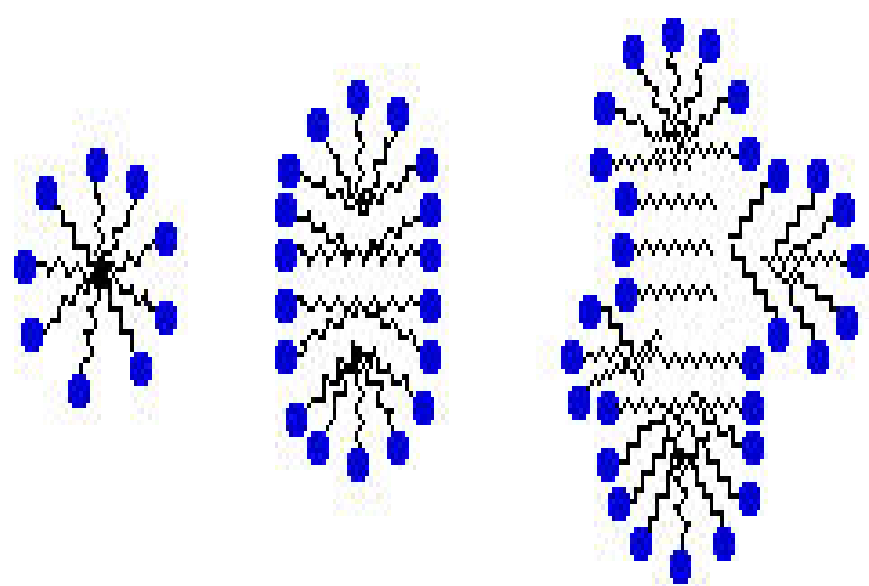
Micelles

- Micelles have a **disc like shape** .
- Critical concentration of **Amphipathic Lipids** in aqueous medium form **Micelles(~200 nm)**.
- **Bile salts** help in forming **Mixed Micelles**.
- **Mixed Micelles** are formed in Intestine **after digestion of Lipids**.
- By an aggregation of various forms of dietary digested Lipids with Bile salts.

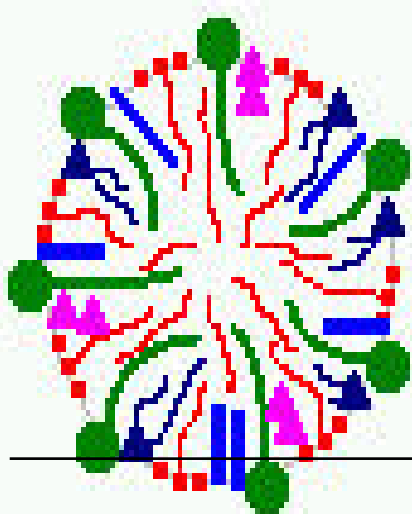
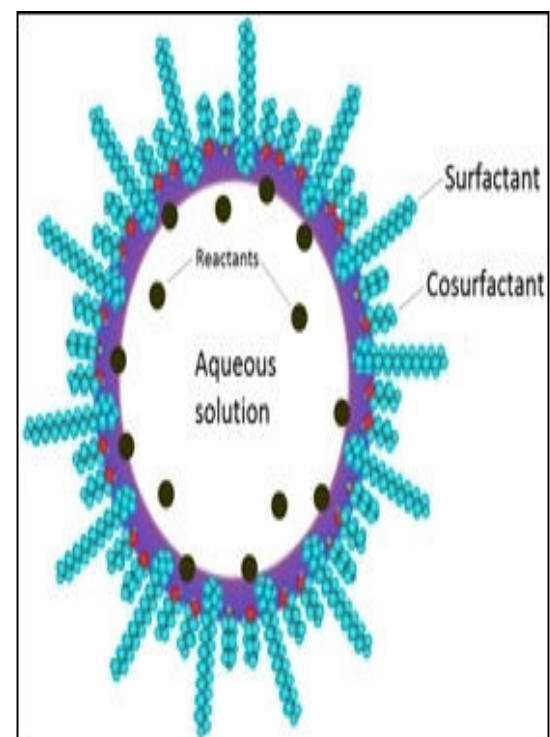
- Aggregation of various **digestive end products** of dietary Lipids covered with a peripheral layer of **Bile salts** form **Mixed Micelles** in intestinal lumen.
- Mixed Micelles contain the non polar Lipids in the interior portions and polar **Bile salts** on the exterior.

Significance Of Mixed Micelles

- **Mixed Micelles helps in absorption of dietary Lipids**
- **From intestinal lumen into intestinal mucosal cells.**



micelle assemblies of amphiphiles



Bile salts
Monoglyceride
Fatty acids
Phospholipids
Cholesterol

Liposomes

- **Amphipathic Lipids** when exposed to **high frequency sound waves (Ultra Sonication)** in aqueous medium to agitate particles and **form Liposomes**.
- Liposomes can be prepared by **disrupting biological membranes by ultra sonication(>20 KHz)**

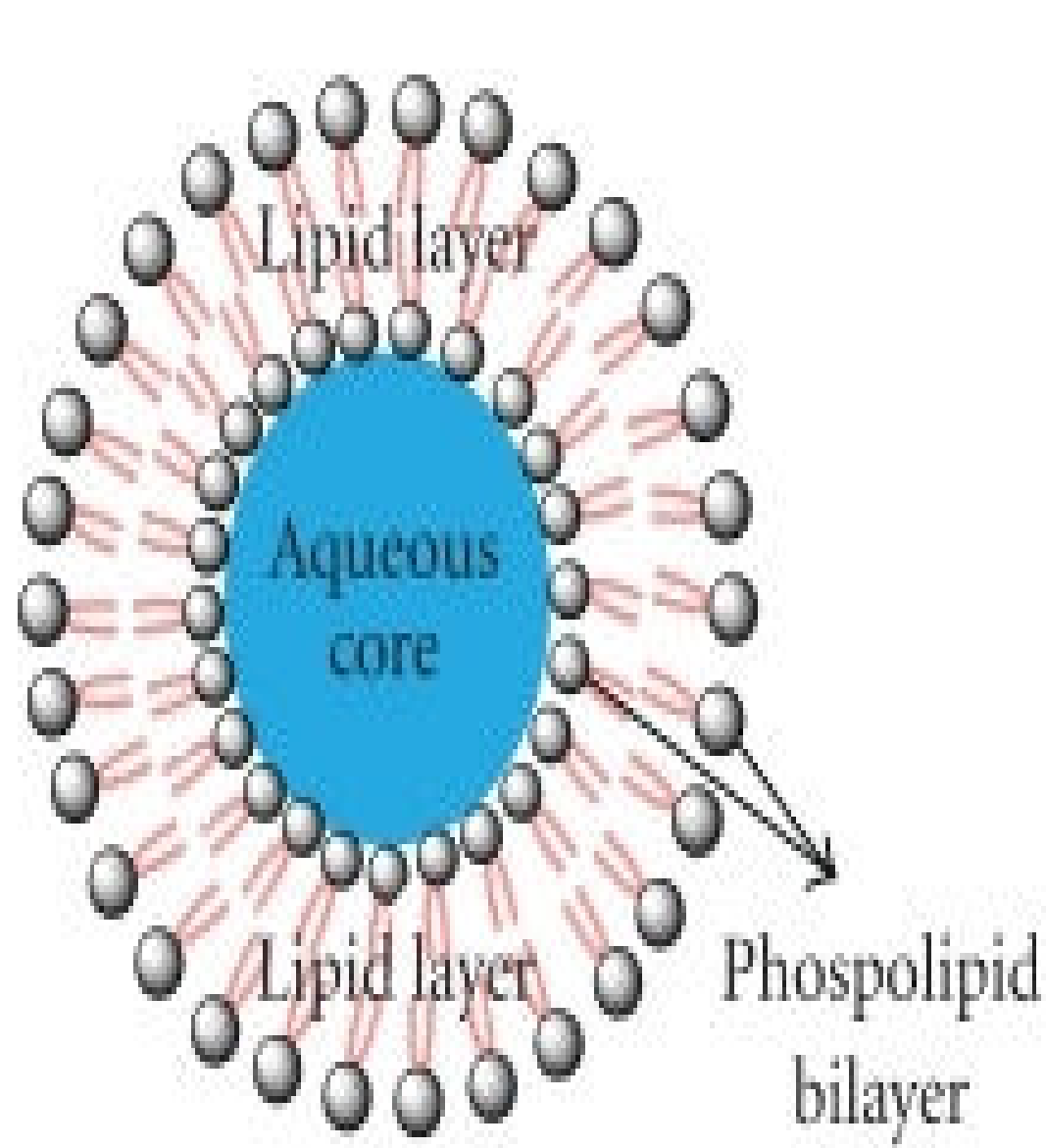
Structures Of Liposomes

- Liposomes are **composite structures made of largely phospholipids** and small amounts of other molecules
- Liposomes has **spheres of one/ many Lipid bilayers**.
- Liposomes contain **aqueous regions**(polar phase) and intermittently **lipid bilayer** (non polar phase).

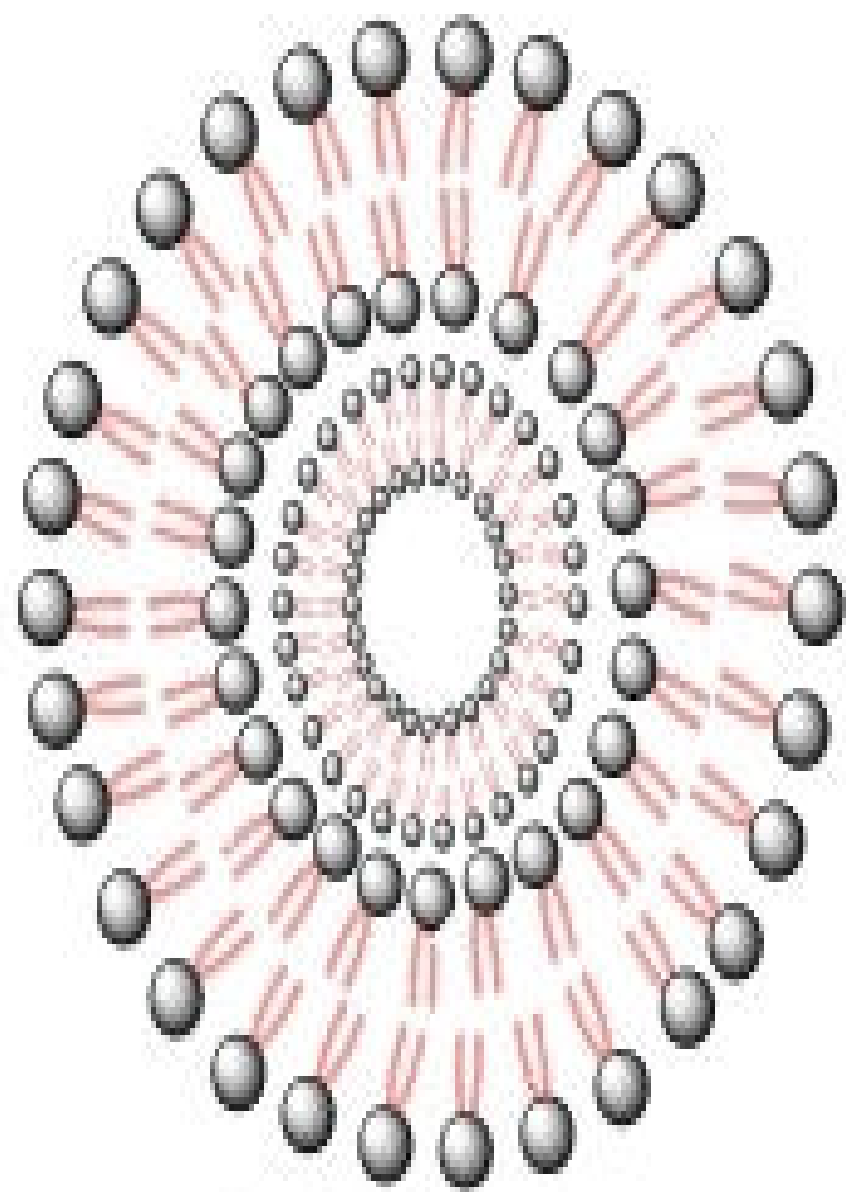
Types Of Liposomes

- **Unilamellar Liposome**
- **Multilamellar Liposome**

Structures Of Liposomes

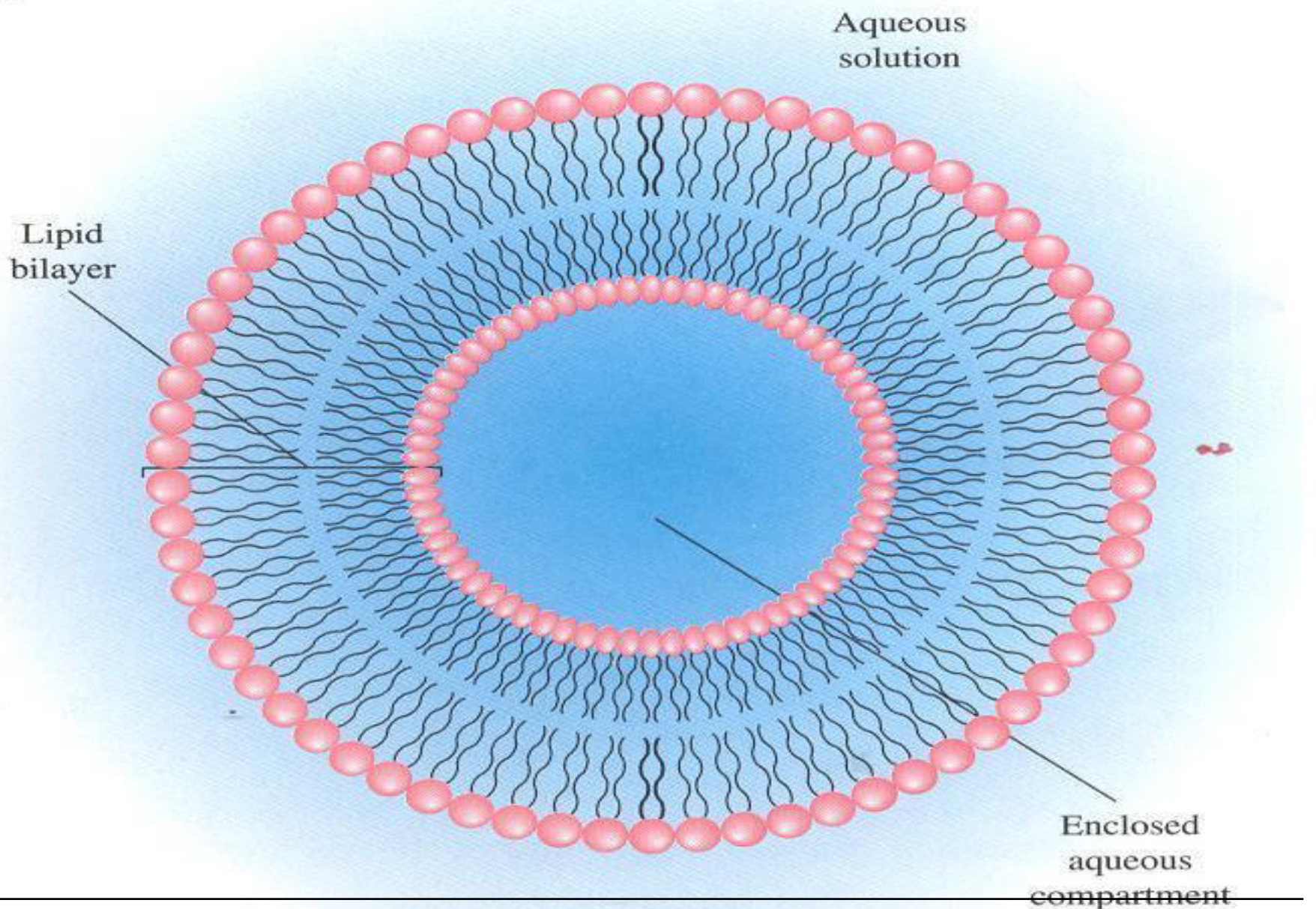


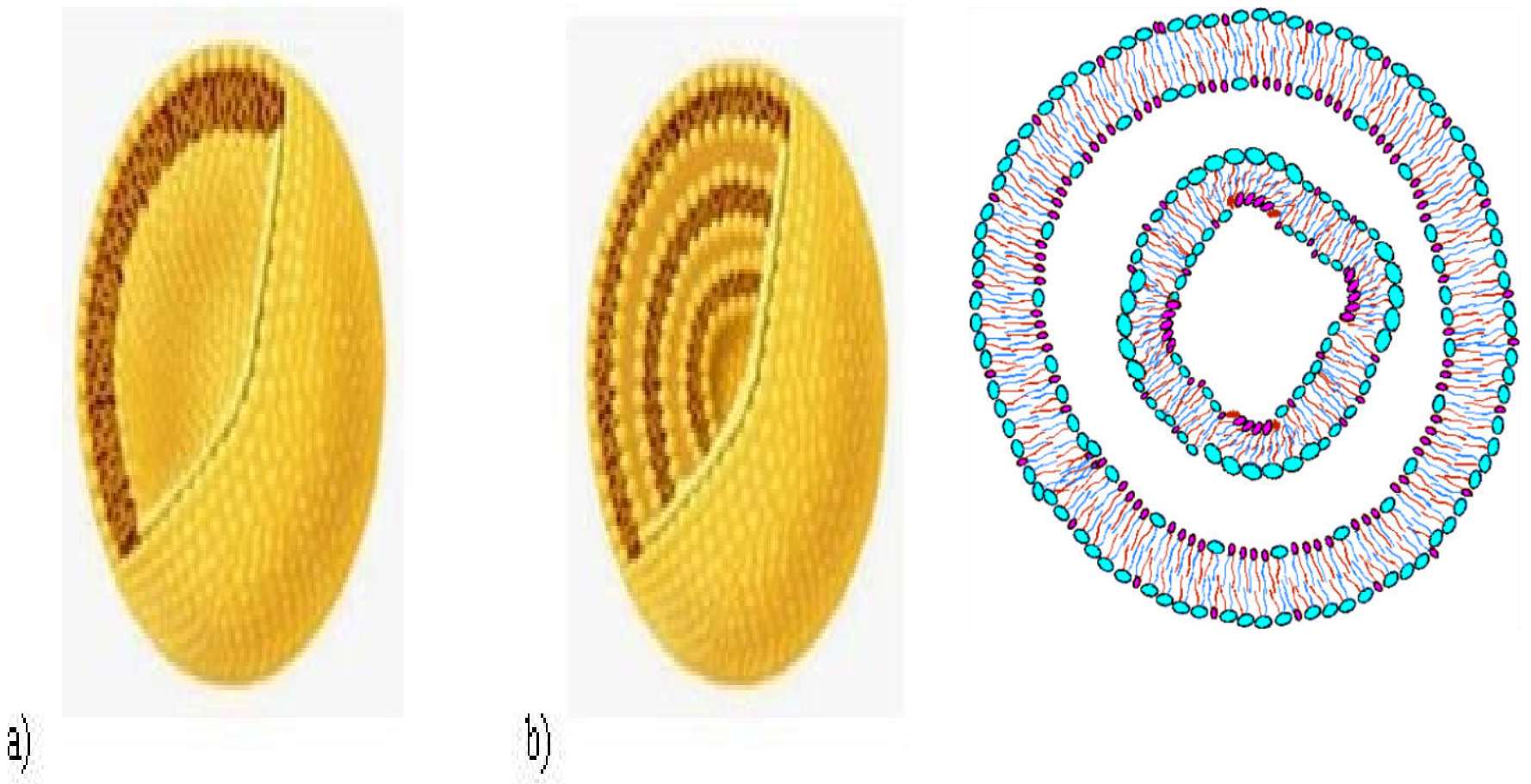
Unilamellar liposomes



Multilamellar liposomes

Liposome

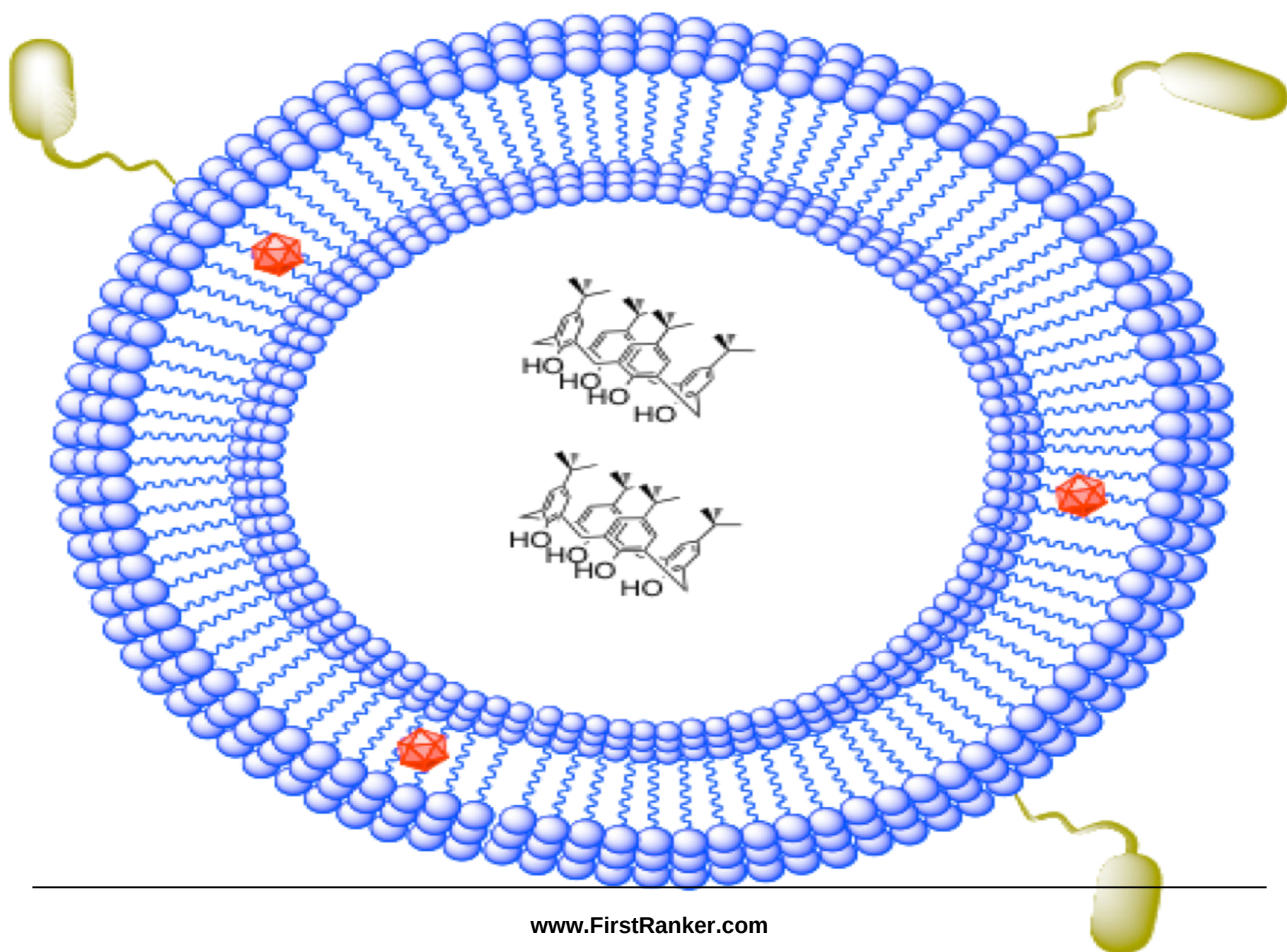




Uses Of Liposomes

- Liposomes are vehicles for **administration of drug through blood**, targeted to specific organs.
- Topical **transdermal delivery of drugs**.
- **Transfer of Gene** into vascular cells

- **Water insoluble drugs** are carried in **Hydrophobic region** of Liposome.
- **Water soluble drugs** are carried in **Hydrophilic region** of Liposomes.

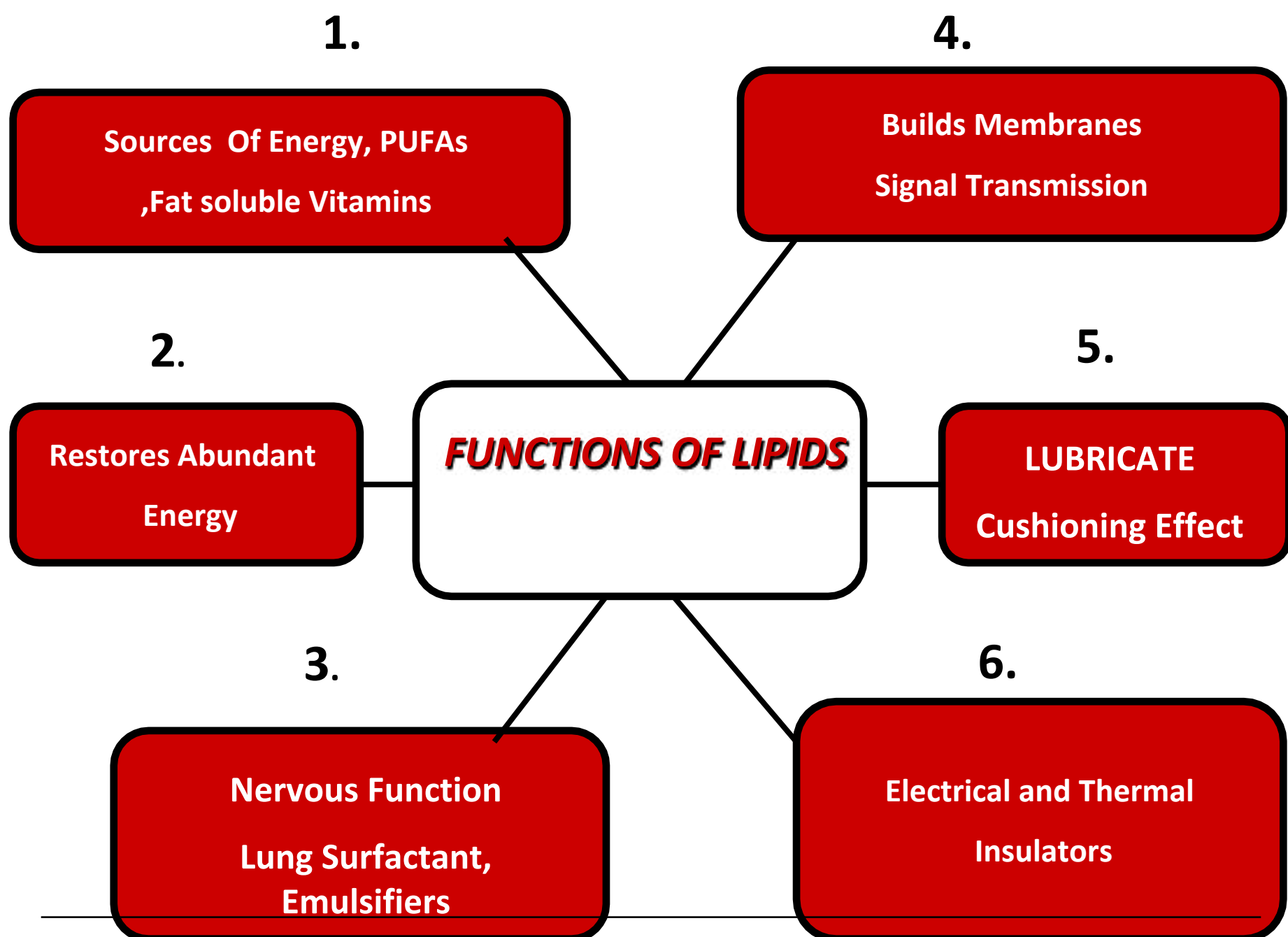


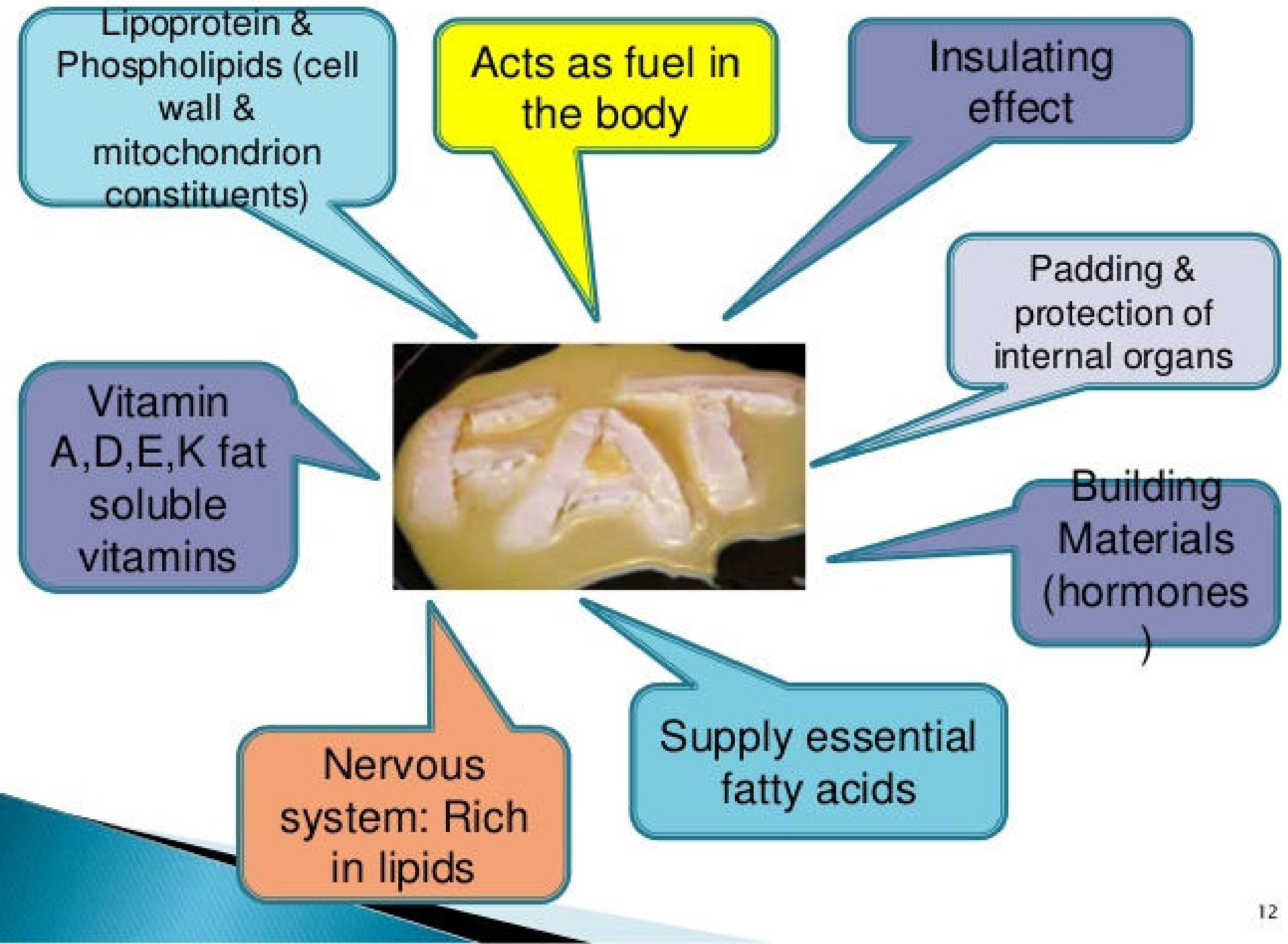
Biomedical Importances Of Body Lipids

- **The Role of various Body Lipids:**
 - Triacylglycerol
 - Free Fatty acids
 - Phospholipids
 - Glycolipids
 - Lipoproteins
 - Cholesterol and Cholesterol Ester
 - Eicosanoids
-

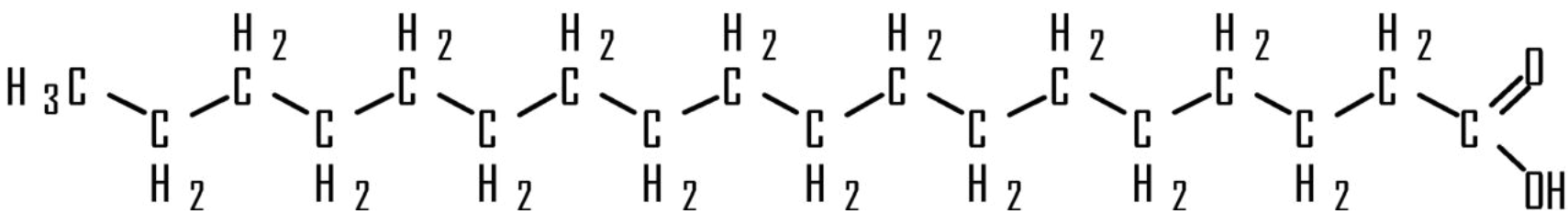
Body Lipids Functions

1. Secondary Source of Energy
2. Energy Storage Lipids- Long term use
3. Thermal and Electrical Insulators
4. Cushioning Effect and Shock absorber
5. Shape and Contour to body
6. Structural Lipids- Biomembrane components
7. Cell antigens, receptors, anchoring sites
8. Signal Transduction and Nerve Impulse conduction
9. Lung Surfactant helps in normal respiration
10. Emulsifiers helps in Lipid digestion and absorption
11. Transport Lipids
12. Metabolic regulatory Lipids

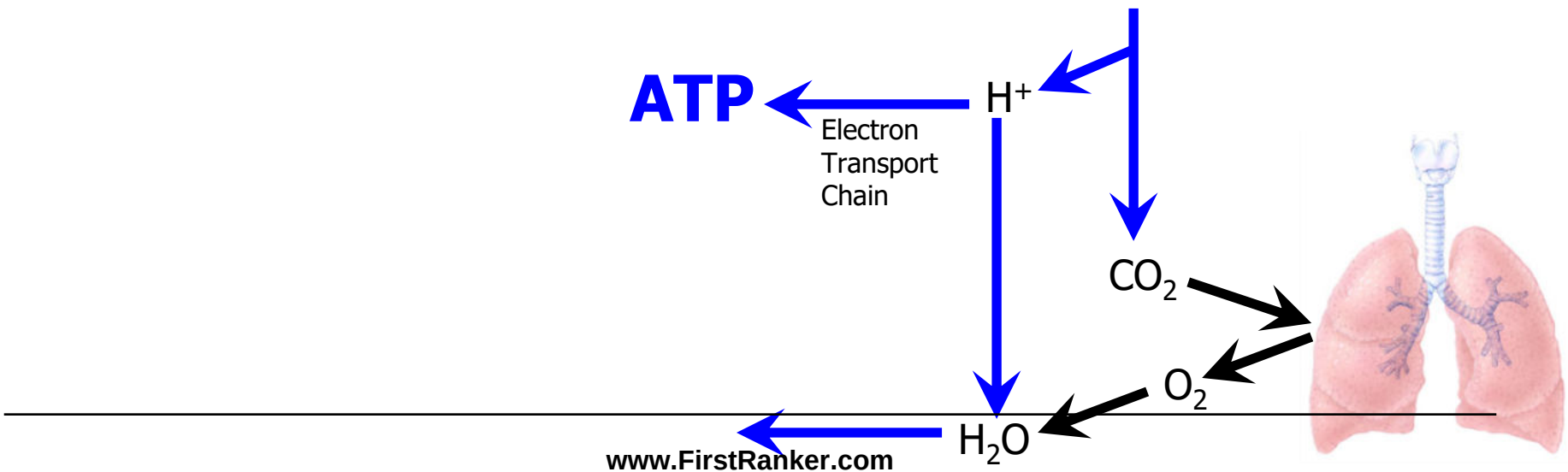




Fatty acids of TAG is a Source of Energy

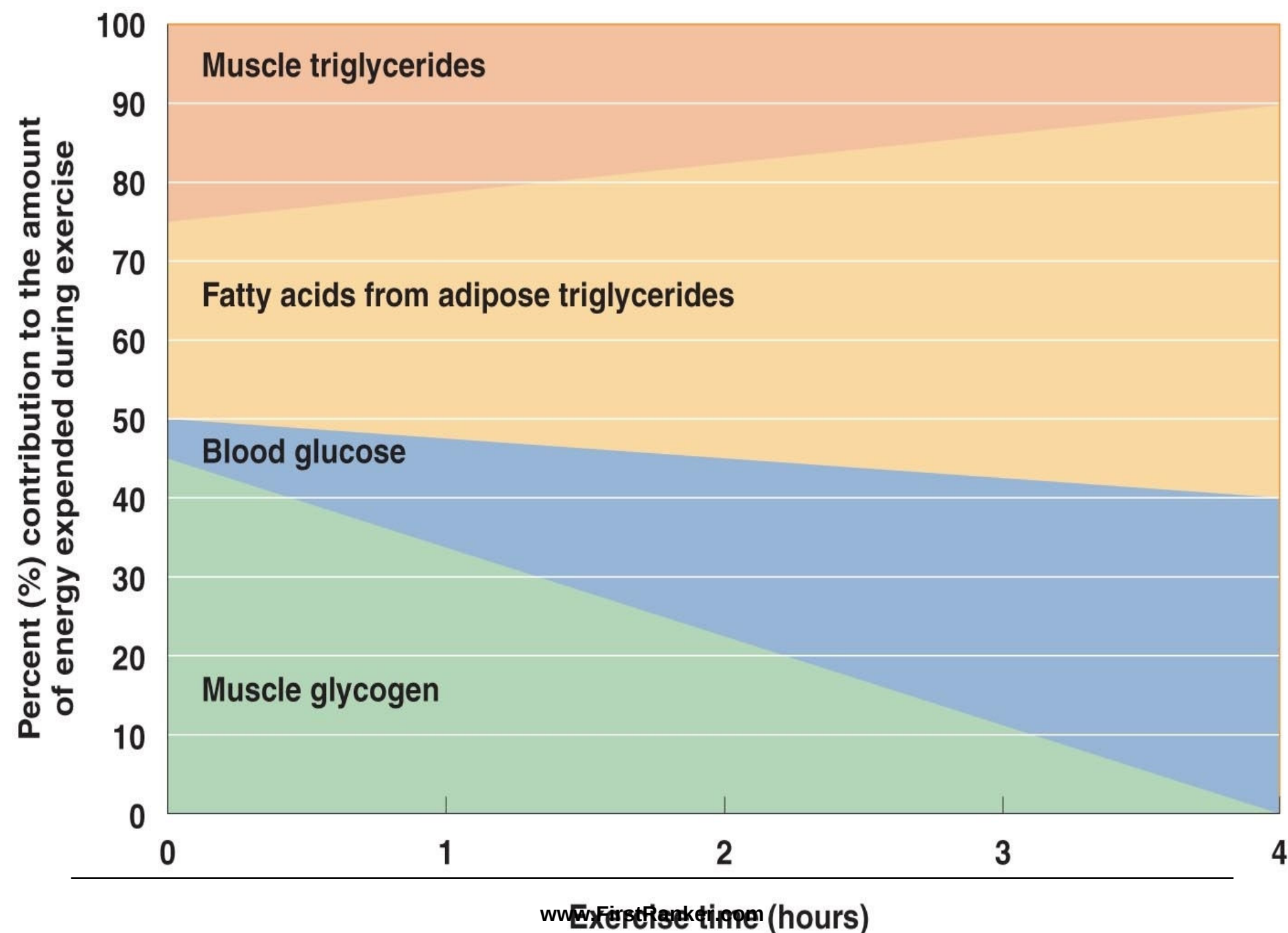


Energy-Containing Nutrients (C and H)



Good About Body Lipids

- Liberate 9 kcal per gram of TAG.
- Major fuel at rest
- **Endurance Exercise**
- Stores Energy
- Source of :
 - Essential fatty acids
 - Fat-soluble vitamins
- **Regulates cell function**
- **Maintains membrane structure**
- **Improve nerve function**
- **Provides flavors and textures of foods**
- **Helps us feel satiated**



Disorders Associated To Lipids

- Obesity
- Atherosclerosis
- Respiratory Distress Syndrome
- Fatty Liver
- Hyperlipoproteinemias
- Hypolipoproteinemias
- Necrosis ,Oxidative damage of biomembranes due to Lipid peroxidation
- Lipid Storage Disorders

Common Lipids Associated Disorders

- **Obesity**
- **Metabolic Syndrome**
 - Atherosclerosis
 - Coronary Heart Disease
 - Hypertension
 - Diabetes Mellitus

Lipid Storage Disorders

Inborn Errors Of Lipid Metabolism

- Congenital Defects where deficient of Enzymes
- Affects an **Abnormal accumulation of Lipid forms**
- In cells and tissues affecting there functionality.

Table I Lipid levels (mg/DL) in human beings with known heart disease

Test	Desirable	Borderline	Undesirabl
Total cholesterol	< 200	200-240	> 240
HDL cholesterol	> 45	35-45	< 35
Triglycerides	< 200	200-400	> 400
LDL cholesterol	< 130	130-160	> 160
Cholesterol/HDL	< 4.5	4.5-7.5	> 5.5
LDL/HDL	< 3.0	3.5	> 5.0

Source: Medical Essay (1993)

S.No	Lipid Storage Disorder	Enzyme Defect and Abnormal Accumulation of
1	Niemann Picks Disease	Sphingomyelinase Sphingomyelins
2	Gaucher's Disease	Beta Glucocerebrosidase Glucocerebrosides
3	Krabbe's Disease	Beta Galactosidase Galactocerebrosides
4	Tay Sach’s Disease	Hexoseaminidase-A Gangliosides
5	Farber's Disease	Ceramidase Ceramides

Questions

- **Long Answer Questions**
- **Define Lipids (Bloor's Definition).** Classify Lipids with suitable examples.
- **Define Fatty acids. Classify** them with different modes and suitable examples.
- **What are Compound lipids?** Describe Phospholipids wrt Chemistry, Types, Nature, Sources Distribution, Functions and associated disorders of.
- **What are Sterols?** Describe the structure, dietary sources, properties & functions of **Cholesterol.**

- **Write Short Notes.**

- Biomedical importance of various forms of body Lipids
 - Enlist various disorders associated to Lipid forms with biochemical defect and alterations.
 - Essential fatty acids (PUFAs) & their role in the body.
 - Triacylglycerol/Neutral Fats- Structure & Function.
-
- Rancidity- Causes & Prevention.
 - Glycolipids/Cerebrosides/Gangliosides
 - Lipoproteins- Chemistry, types & functions
 - Eicosanoids/Prostaglandins

- Therapeutic uses of Prostaglandins
 - Distinguish between Fats & Waxes
 - Nomenclature & Isomerism of fatty acids
 - Omega 3 fatty acids and their importance
 - Amphipathic nature of lipids and their roles
 - Distinguish between Fats & Oils
 - Enumerate biomedical important lipids with their classes
 - Properties of Fatty acids.
-
- Simple Lipids with their examples
 - Enumerate Compound Lipids & one function of each
 - Name Derived lipids & their functions
 - Trans Fats and their harmful effects
 - Tests to check the purity of fats & oils/Characteristic number of Fats

Revision Questions

- Define Lipids
 - Number and Names of Lipid Classes
 - Define Derived Lipids
 - Examples of Derived Lipids
 - Define Fatty acids
 - What is Delta and Omega end of FAs
 - What is Beta Carbon of a Fatty acid
 - 6 Modes of Classification of Fatty acids
-

- www.FirstRanker.com**

- Criteria for Sub classification of Simple Lipids
 - Define Simple lipids
 - Examples/Subtypes of Simple Lipids
 - What is a Class of Fat/Oil and its chemical name
 - Define Waxes
 - Name human body Wax
-
- Differences of Fats and Oils
 - Differentiate between Cerebrosides and Gangliosides
 - Occurrence and Role of TAG
 - Definition of Compound Lipids
 - Types of Compound lipids
 - Sphingophospholipid Example
-

- Number and Names Of Glycerophospholipids
 - Hormonal role of Phospholipids
 - Chemical composition of Lung Surfactant
 - Which Compound Lipid is classified under classes of Lipid and Protein?
-
- Enzyme defect in Niemann Picks Disease
 - Red Spot Macula is noted in which all conditions
 - In which disorder Ceramides get accumulated in joints
 - Emulsions and Liposomes results due to which Lipid forms.
 - On what criteria's TAG is selected as reservoir of energy for long term use
 - Enumerate various Lipid Storage disorders with biochemical defect and abnormal accumulated Lipid form
-

- What value of L/S ratio shows lung maturity and immaturity?
- What are components of Lung Surfactant?
- What are roles of Lung surfactant?
- What form of energy source helps in endurance of exercises of body?
- Which Lipids are associated to biomembranes?
- What are applications of Amphipathic Lipids?
- What clinical conditions shows Hypercholesterolemia?
- Enzymes associated for Eicosanoids biosynthesis.
- Therapeutic roles of Prostaglandins

Biochemistry Department