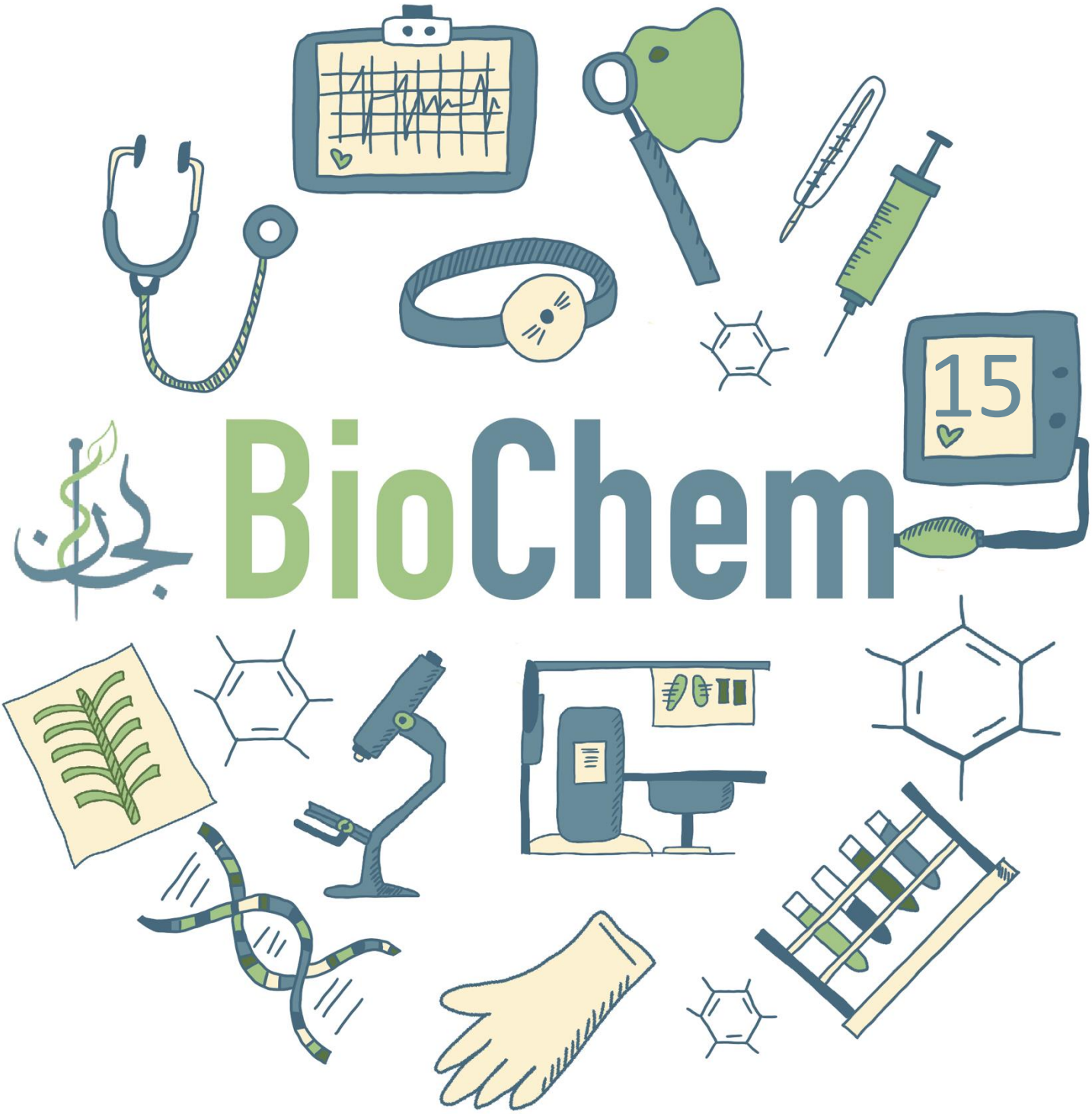

Writer: Abdelhadi Okasha

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Grammar: Waheed Al-sharif

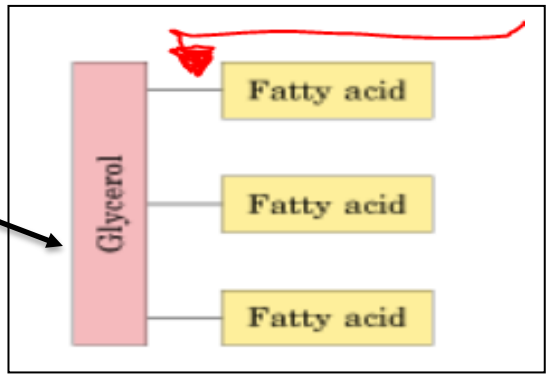
Doctor: Mamoun Ahram

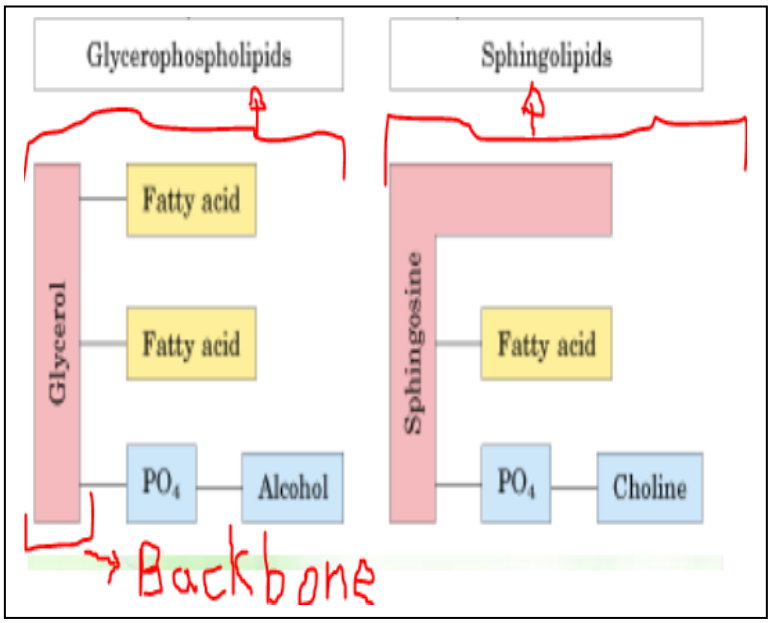
Complex lipids

Types of complex lipids:

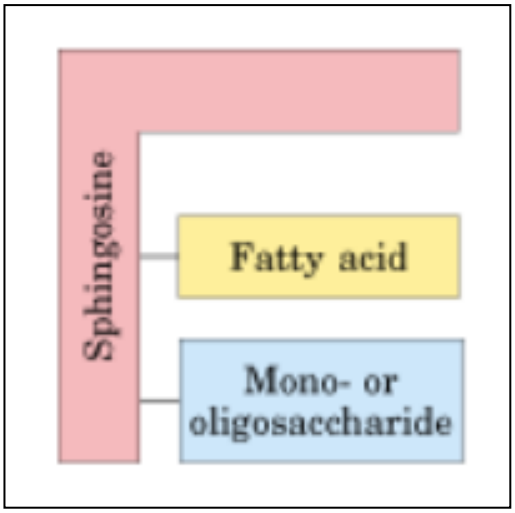
1. **Storage lipids** (neutral): used for **energy purposes**
types of storage lipids: **triacylglycerols**
→ wherever we have excess fat in our body, they're stored primarly in **adipose tissue** in the form of **triacylglycerols**

structure



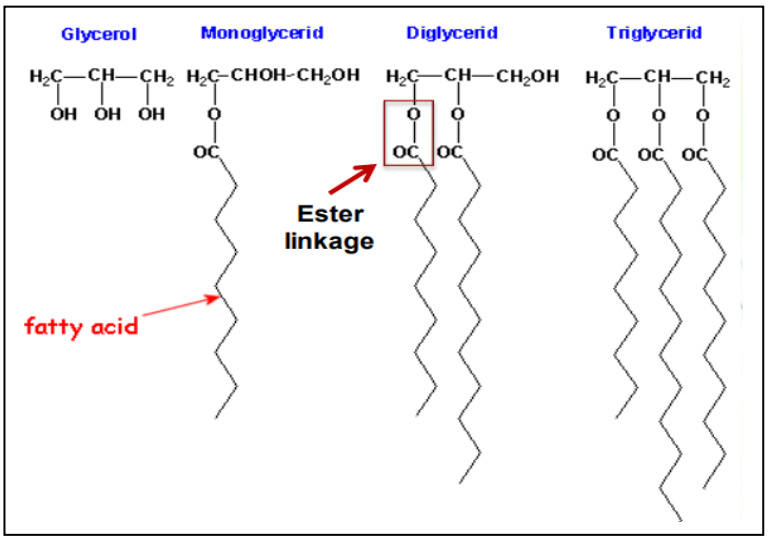


2. **Membrane lipids** (polar) : they primarly make up membranes, they're classified into **two** types:
A) **Phospholipids**: phospholipids are two types; **sphingolipids** and **glycerophospholipids**
→ **sphingolipids**: contains one type called **sphingomyelin**
→ **glycerophospholipids**: there are different types depending on **the group attached with the phosphate group (PO_4)**

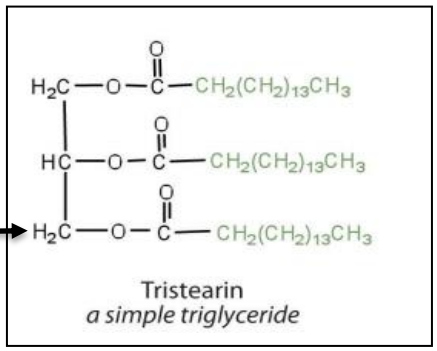


B) **Glycolipids**: there's one type: **sphingolipids**
<u>Question</u>: What is the difference between the sphigolipid of glycolipids and the sphingolipids of phospholipids?
<u>Answer</u>: In sphingolipid of glycolipids, there's a sugar attached to it rather than phosphate group

<u>(sphingolipid that is a type of glycolipid)</u>



Triglycerides (triacid glycerol) : it consists of a **glycerol backbone** attached with **three hydroxyl groups**, to each one of them we can have an attachment to a **fatty acid** by an **ester linkage.**

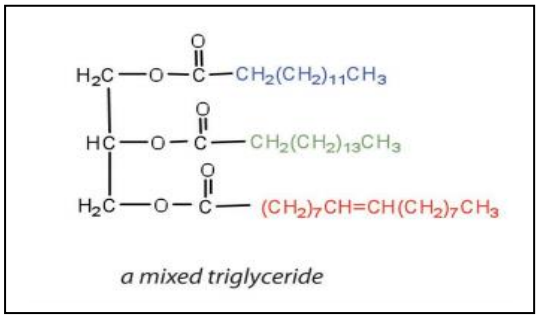

Tristearin
a simple triglyceride

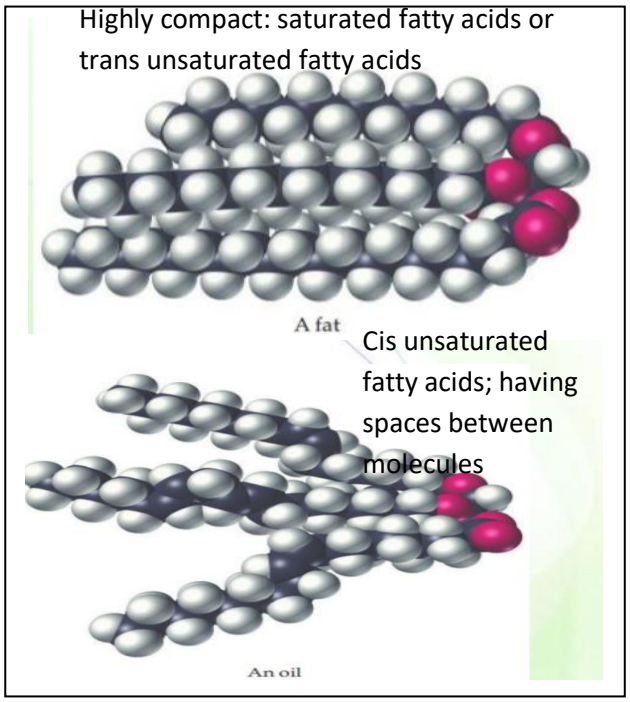
There are **two** types of triglycerides:

1. **simple triglyceride**: the hydrocarbon chains (fatty acids) are **similar in** in number of carbon atoms and double bonds**,** ex: tristearin (3 stearin; each chain has 18 carbons)
2. **Mixed triglyceride**: fatty acids are **different**, they may differ in **number of carbons** or in **the bonds between carbons (degrees of saturation)**

(the red chain in the picture contains double bond between two carbons)

(saturation decreases if number of double bond increases)


a mixed triglyceride



→ There are two types of double bond: **Cis** and **Trans**

→ Cis bond create a **kink** (طعجة), and kinks makes **spaces** between fatty acids

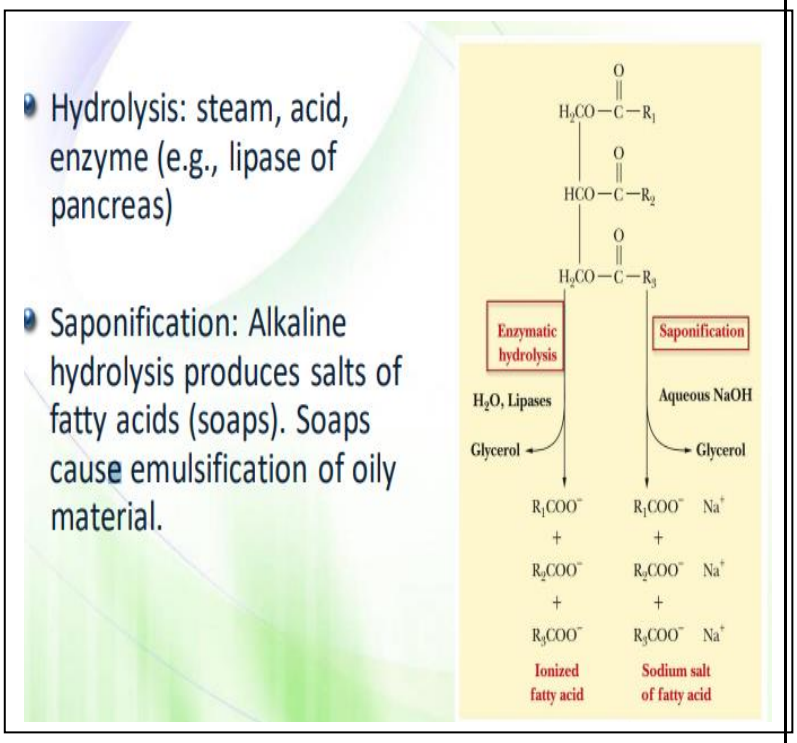
→ **Liquid fats** (like oil) contains a lot of **Cis double bonds** in fatty acids so there are **spaces** between molecule, making it a liquid

→ **Solid Fats,** fatty acids are fully **saturated**, so the fat molecule is **packed** and quietly **hydrophobic,** making it a **solid.**

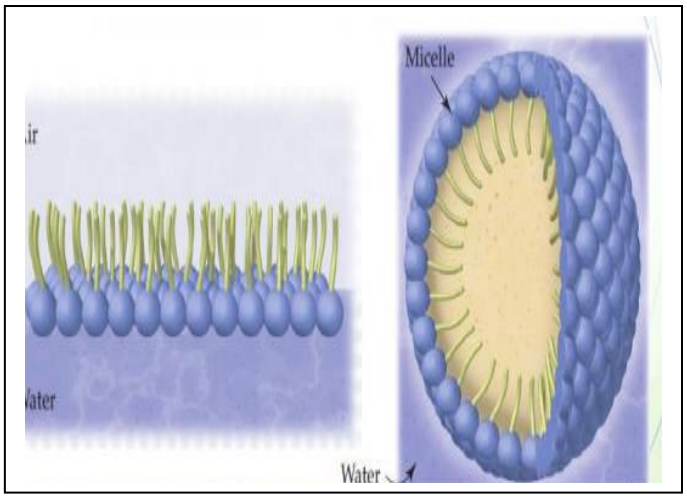
→ We can use triglycerides **(we use solid fats)** in production of **soap** by a process called **saponification**

→ **what happen in saponification?**

Fatty acids are separated from **triglycerides** by adding the triglycerides into an **alkaline** environment, so fatty acids will separate (carrying **negative charge** on oxygen) and attach after that with **positively charged ion**, fatty acids attached with positively charged ion from the alkaline solution is **the soap**



→ There is a similar process that occurs in our body: there's an enzyme called **lipases** that separates the fatty acids from glycerol in the presence of **water.**

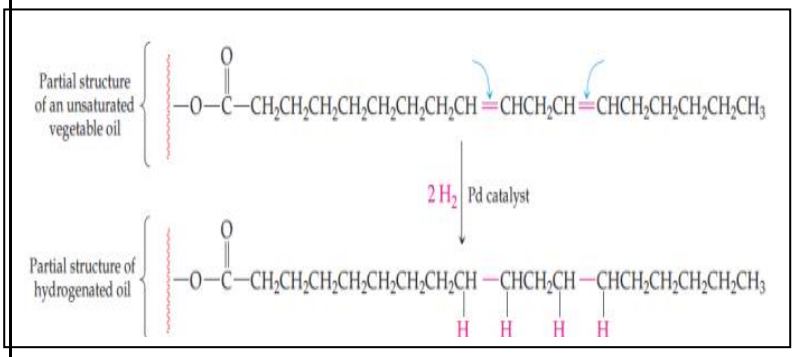


→ soap consists two regions: **hydrophilic heads** and **hydrophobic tails**

→When soap is mixed with water, the hydrophobic hydrocarbon tails **cluster** together to create a **nonpolar microenvironment** and the hydrophilic ionic heads **interact** with water.

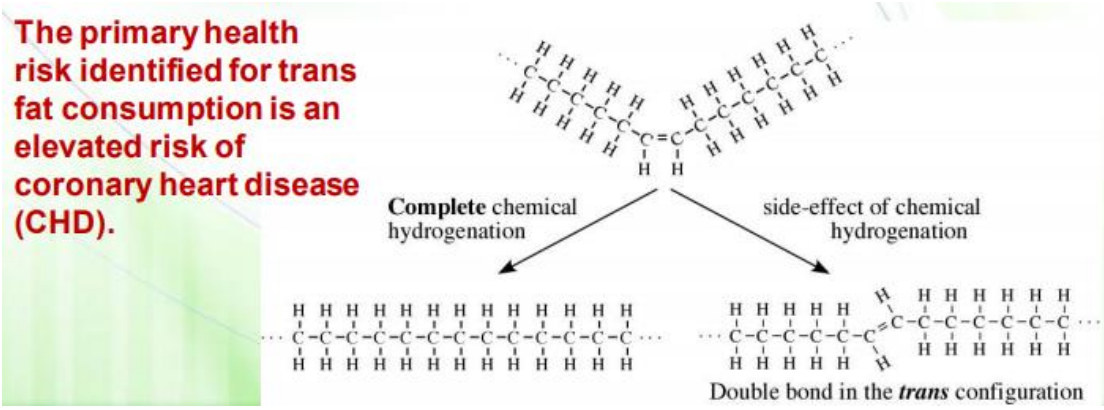
→The resulting spherical clusters are called **micelles**.

→Grease(الدهنيات) and dirt are **trapped** inside micelles and the complex can be **rinsed away**.



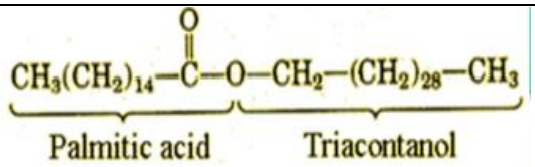
→ **Hydrogenation:** adding **H_2** to **double bonds** in fatty acid chains in order to increase the saturation of the fatty acid, we can do this with **vegetable oils** in order to convert them to **saturated fats**, the way that any alkene can react with hydrogen to yield an alkane.

→Although the animal fat is unhealthy, it has better cooking properties and taste.
→Therefore, chemists invented a method of converting unsaturated oil into solid form (it's semi-solid in fact) by **partially hydrogenating** it.
→Partial hydrogenation converts **most** of unsaturated fatty acids into saturated one, one the other side, some of them are converted into unsaturated **Trans fats**
→ Consuming (استهلاك)a lot of food containing trans fats may cause **Coronary heart disease (CHD)**, because our body **can't handle** trans fats, so they tend to **accumulate in our blood vessels**.



→Example: margarine (something like butter but it's **semi-solid** so you can spread it on the bread better that butter)
→In margarine, only about two-thirds of the double bonds present in the starting vegetable oil are hydrogenated, so that the margarine remains soft in the refrigerator and melts on warm toast. (it's improved later on and some of margarine now contains no trans fats)

Triglyceride: 3 OH^- in alcohol; Wax: 1 OH^- in alcohol



→ **Wax** is made of **solid simple lipids** containing **a monohydric alcohol** (only one hydroxyl group; C16 ~ C30, higher molecular weight than glycerol) **esterified** to **long-chain fatty acids** (C14 ~ C36).

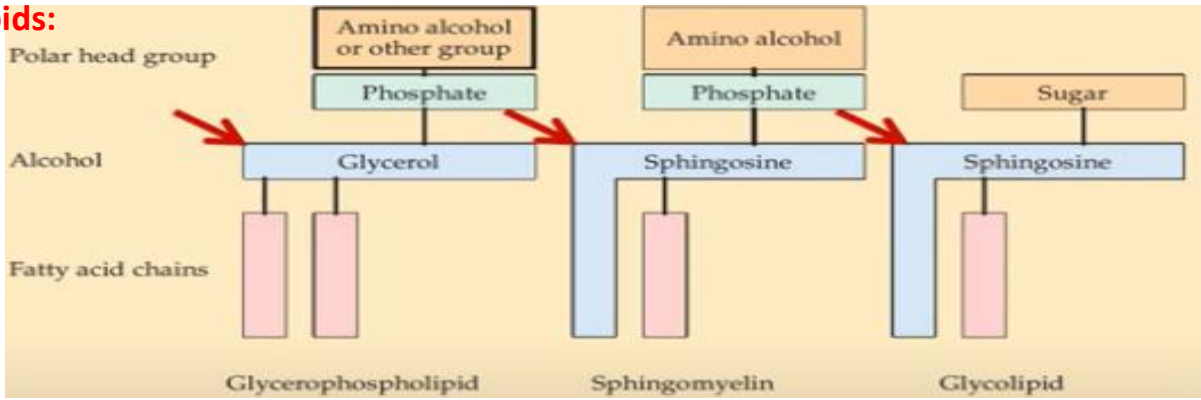
→ Ex: **palmitoyl alcohol**: from the reaction of **palmitic acid** with **hydrocarbon chain of an alcohol molecule** forming **ester** bond that link them to each other
→ Hydrocarbon chain of an alcohol molecule is formed as fatty acids can be converted into **alcohol groups (alcohol monetize)** that are long hydrocarbon chains alcohol.
→they aren't easily hydrolyzed(fats) , they also are indigestible by lipases ,they're very resistant to rancidity (do not rot), have no nutritional value , and it's Insoluble in water

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

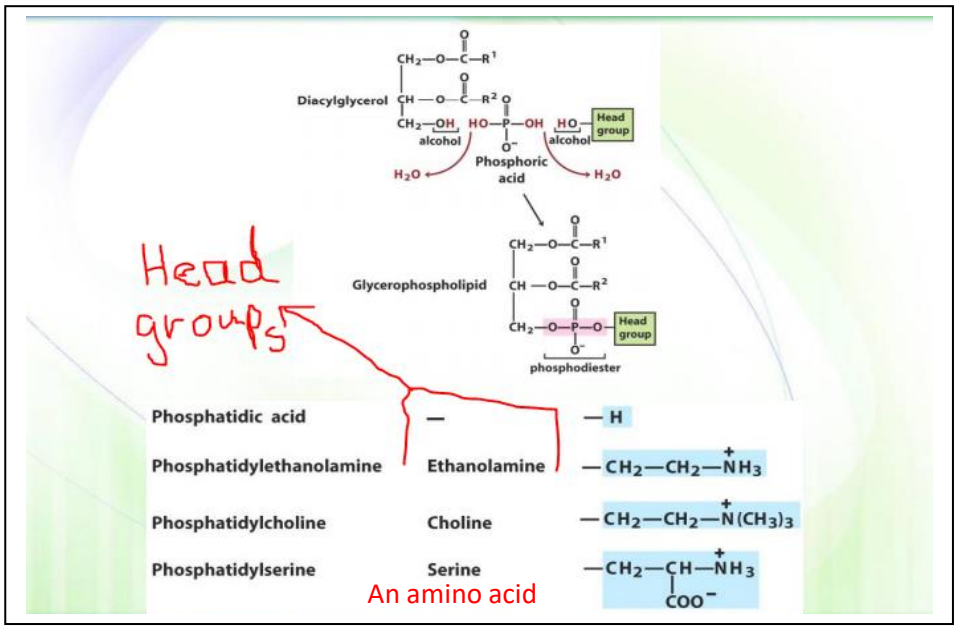
→Coats leaves that prevent loss of water in plants (so it's found in nature)

→ even we have the ester group which is **hydrophilic**, wax is **hydrophobic** because of the long hydrocarbon chains on the both sides

3 types of membrane lipids:



Phospholipids (phosphoacylglycerols)



The most prevalent class of lipids in membranes is the **glycerophospholipids**

→Classification of Glycerophospholipids

1. **Phosphatidic acids**: is the **simplest** Glycerophospholipids
2. **Phosphatidylcholine** (**lecithin**) :Most **abundant** membrane lipid, it's one of the components of **ice-cream**!

3. **Cephalins**: there are two types:
a)**Phosphatidylethanolamine**
b) **Phosphatidylserine**: abundant in **brain tissue**
4.**Phosphatidylinositol** (inositol is a **sugar molecule**):sends **messages** across **cell membranes** (signal transduction)
5. **Cardiolipin** (specialized type)
6. **Plasmalogens** (specialized type)

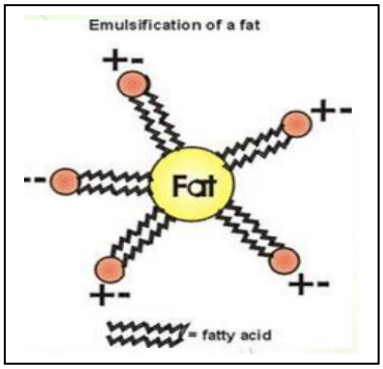
Lecithins

→ **lecithin** is the target of an enzyme called **lecithinase** (a component of **snake venom**) that **breaks** lecithin (**hydrolyzes** polyunsaturated fatty acids and converting lecithin into **lysolecithin**), this is **dangerous** as it can **breaks** the lecithin on the plasma membrane of red blood cells causing **hemolysis of RBCs.**

→ **lecithins** are used in **food industry** (ice-cream, chocolate, mayonnaise..) because it induces a process called **emulsification.**

→ **emulsification** : dissolving fats in hydrophilic environment, that tails of phospholipids will **surround** a fat droplet, and phosphate heads are **exposed** to hydrophilic environment, so fatty droplets are **dissolved** in the hydrophilic environment

→ Because of fatty acid's **amphipathic nature**, they act as **emulsifying** agents, that is substances which can surround nonpolar molecules and keep them in suspension in water.

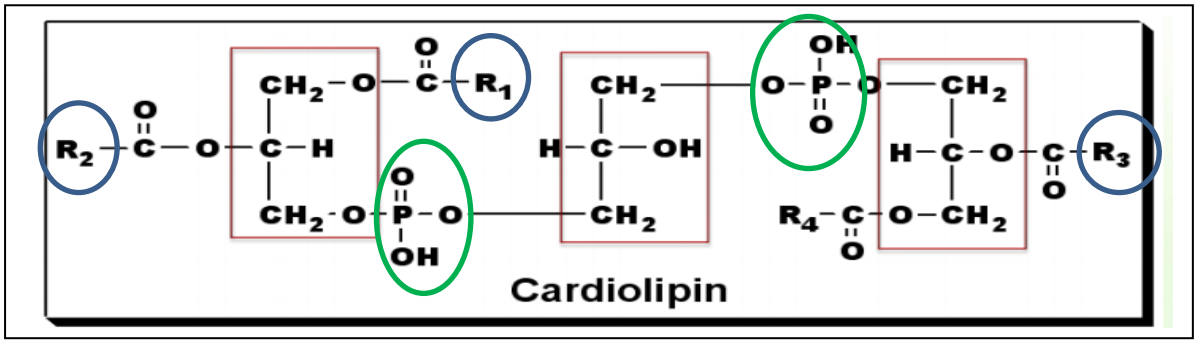


Cardiolipin

→ It's found a lot in **cardiac tissues**, primarily in the **inner membrane of mitochondria**

→ Initially isolated from **heart muscle (cardio)**

→ Structure: 3 molecules of glycerol, 4 fatty acids & 2 phosphate groups (Diphosphatidyl-glycerol)



plasmalogens

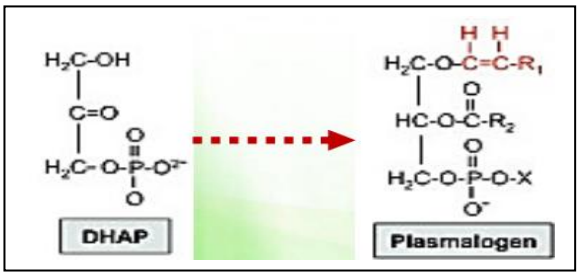
→ They are found in the **cell membrane phospholipids fraction** of brain & muscle, liver, and semen.

→ They have a **protective** role, for the cell and its component like proteins and lipids, against **reactive oxygen species** (reactive oxygen species: oxygen containing chemicals that are highly reactive meaning that they like to **participate in oxidation-reduction** reactions, so they like to be reduced (sacrificing themselves) oxidizing other reactants causing **damaging** to these reactants → (eg. Hydrogen peroxide -H_2O_2- // Oxygen radicals { oxygen molecules missing an electron}…))

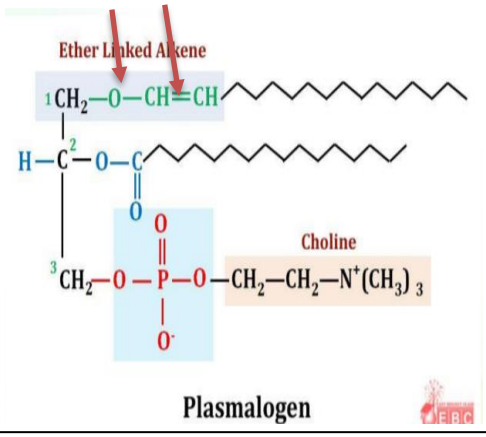
→ Structure:

Precursor (backbone) : **Dihydroxyacetone phosphate.**

Unsaturated fatty alcohol at C1 connected by **ether** bond.



Notice the alkene and ether group in sphingosine



In mammals: at C3; phosphate + **ethanolamine** or **choline.**

→Major classes of plasmalogens

1. **Ethanolamine plasmalogen** (myelin-nervous tissues)
2. **Choline plasmalogen** (cardiac tissue):

Platelet activating factor during platelet aggregation

3. **Serine plasmalogens.**

These are found in mammals

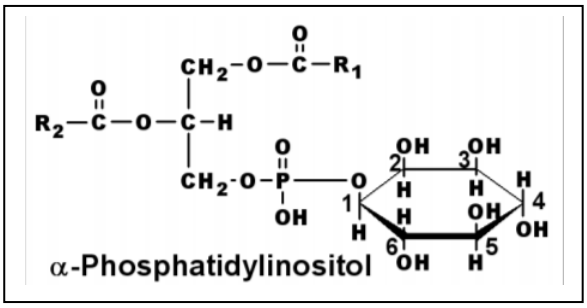
Inositides

→ There is a **sugar** attached to the phosphate group

→ It presents in the **cytosolic** side of cells

→**Phosphatidyl inositol**

→Nitrogenous base: **cyclic sugar alcohol** (inositol)



→Structure: glycerol, saturated FA, unsaturated FA, phosphoric acid, & inositol

→Source: **Brain** tissues

Functions:

- Major component of **cell membrane**

▪ **Second messenger** during signal transduction

▪ On hydrolysis by phospholipase C, phosphatidyl-inositol-4,5- diphosphate produces diacyl-glycerol (DAG) & inositoltriphosphate (IP3) (both of them activate signaling pathways); which liberates calcium

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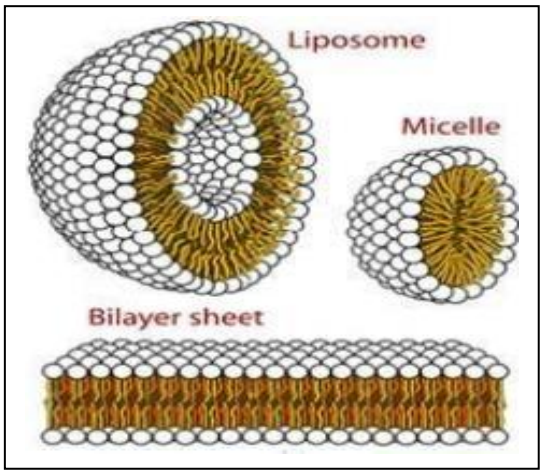
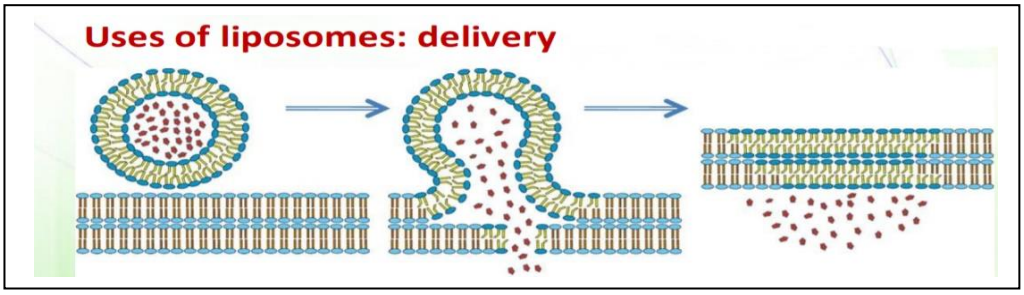
→ **There are different structures of phospholipids:**



1. **Micelle**: we have taken about it before
2. **Liposomes**: it's like a ball, there are hydrophilic head in the core and of the surface, there are two hydrophobic layers (two fatty acid chains), they can be used in delivery of molecules that are hydrophilic, as it transfer from one cell to another and fuses in the target cell's membrane releasing it's component inside it, we use liposomes to deliver DNA and RNA inside cells, and drugs as well.
3. **Bilayer sheet**: the basic structures of membranes.



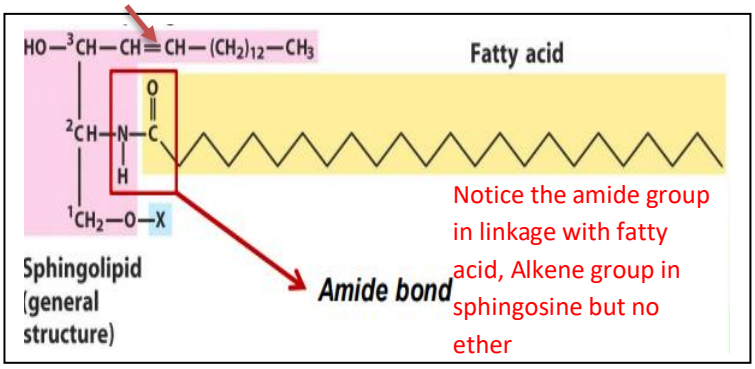
If phosphorlipids are in hydrophilic→ it makes bilayer

If it found hydrophobic → forms micelle

<u>Sphingolipids</u>

→ It's named like that because this molecule was mysterious when first discovered, like sphinx

→ Have **sphingosine** backbone that contains **double bond** , it doesn't contain ether group as well, and **fatty acid** chain that is attached by an **amide** bond to the **second carbon**, at the **first carbon**, it can be attached to any group.

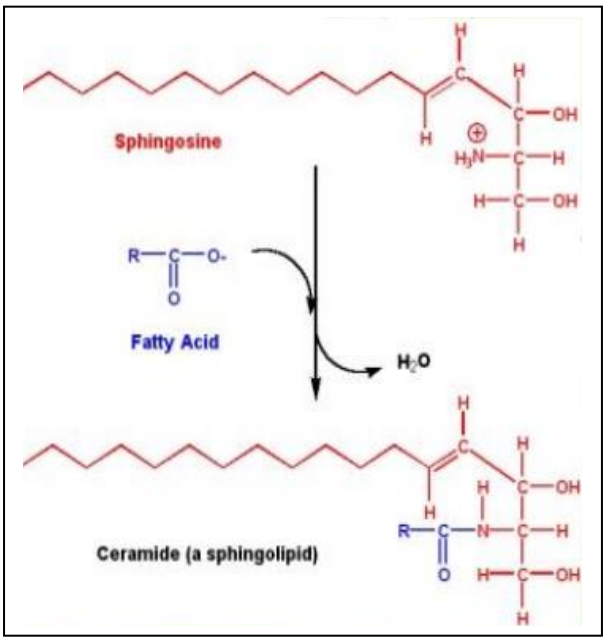


→ Sphingolipids are found in the plasma membranes of all eukaryotic cells and is highest in the cells of the central nervous system.

→ The core of sphingolipids is the long-chain amino alcohol, sphingosine

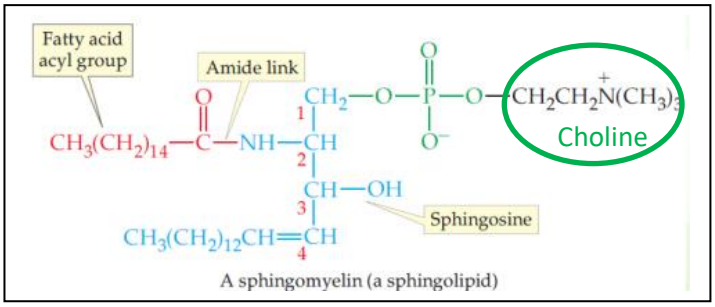
→ The basic and simplest sphingolipid is known as **ceramide.**

→ Here is the reaction that it comes from:

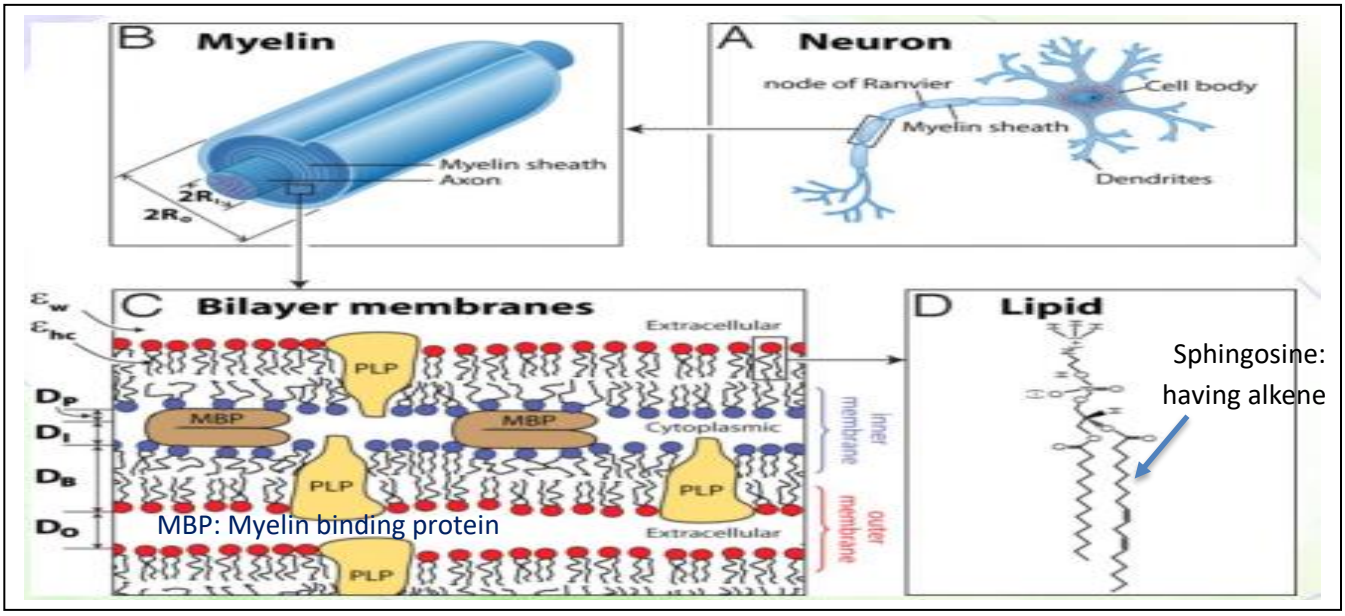


The sphingolipids are divided into the two subcategories according to the group attached to carbon1:

1. **Sphingomyelins:** is a **sphinglolipid** that is a **major** component of the myelin sheath coating around **nerve fibers,** the second carbon of sphingosine in its strucure is attached to a fatty acid chain by an amide linkage, and the first carbon is attached to a phosphocholine



It's better to return to the video at 29:55 as the doctor was pointing by the laser



2. **Glycosphingolipid (or glycolipids)**

→ Sphingolipids can also contain carbohydrates attached at C-1 and these are known as **glycolipids**

→ Glycolipids are present on **cell membranes** and act as **cell surface receptors** that can function in **cell recognition** (e.g., pathogens) and **chemical messengers**

→ **Types of glycolipids:**

notes on the slides:

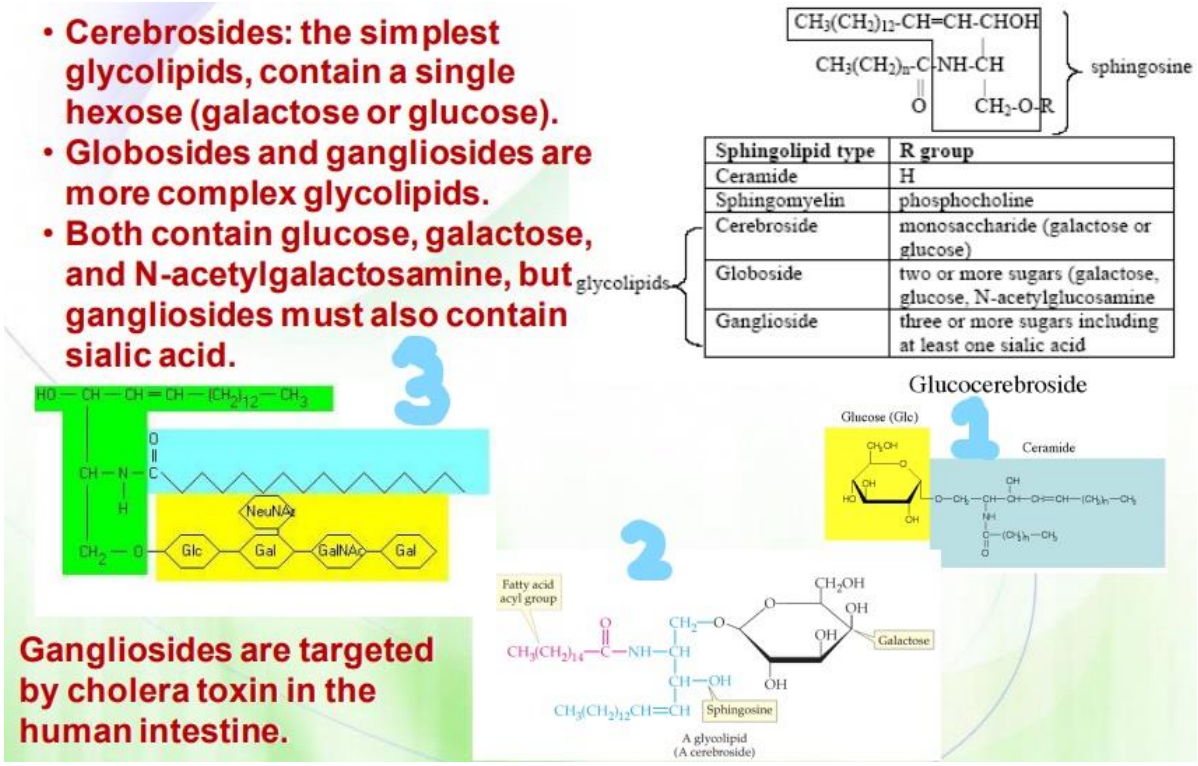
◦ **Gangliosides and Cerebrosides** are rich in **nervous system**

◦ **structure1:** cerebroside containing **glucose**

◦ **structure2:** cerebroside containing **galactose**

◦ **structure3:** globoside

◦ If we add sialic acid to the carbon attached to (OH) in the globoside, it will change to ganglioside, and this sialic acid would be attached to the chain



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

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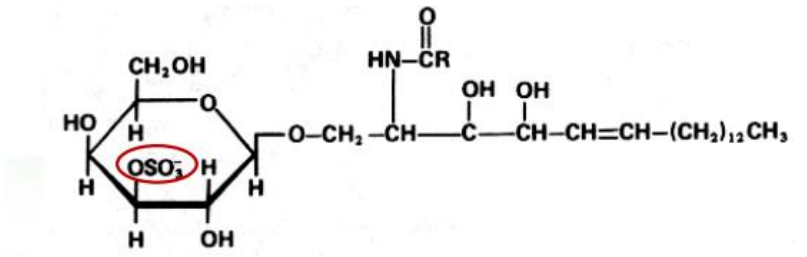
Sulfatide

→ Synthesized from **galactocerebroside** by adding sulfate group to the galactose, sulfur is negative so that's why it's negatively charged.

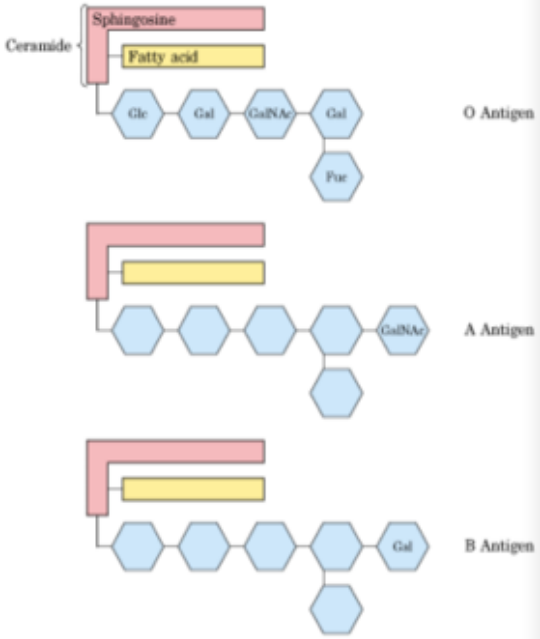
→ Abundant in brain myelin, in myelin sheath too.



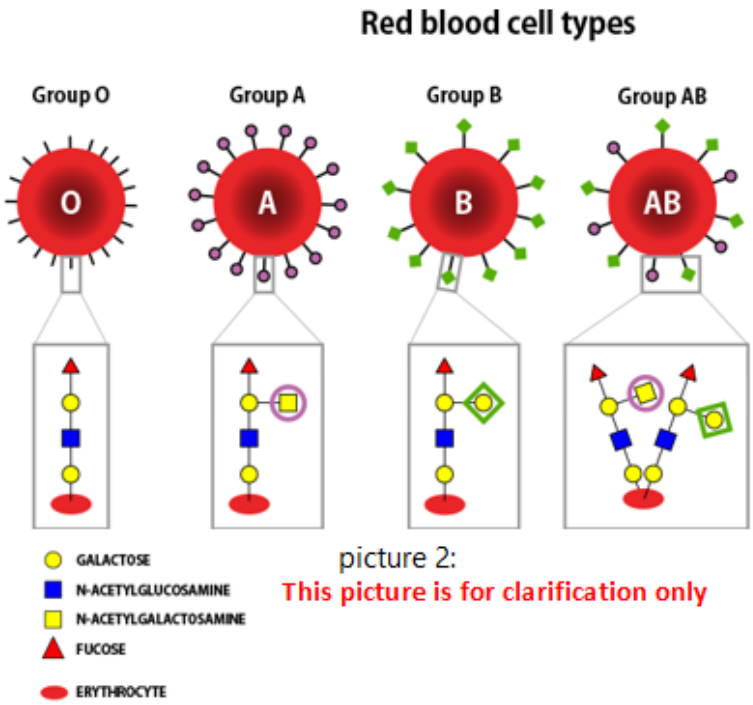
Blood groups:

ABO blood system depends on glycolipids and glycoproteins, how?

Now we'll focus on **glycolipids,** the sugars attached to the sphingosine in the RBCs membrane



picture 1



picture 2:
This picture is for clarification only

عبدالعزيز الطريفي
@abdulaziztarefe

صلّوا عليه
وسلّموا تسليما

تعظيم النبي سبب لغفران
الذنوب وعلامة للتقوى
(إن الذين يغضون أصواتهم عند
رسول الله أولئك الذين امتحن
الله قلوبهم للتقوى لهم مغفرة
وأجر عظيم)

SHORT QUIZ

TEST BANK

1) Biological waxes are all

A) trimesters of glycerol and palmitic acid.
B) esters of single fatty acids with long-chain alcohols.
C) trimesters of glycerol and three long chain saturated fatty acids.
D) sphingolipids.....

2) Fatty acids are a component of:

A) carotenes.
B) cerebrosides.
C) sterols.
D) vitamin D.
E) vitamin K.

3) Which of the following is true of sphingolipids?

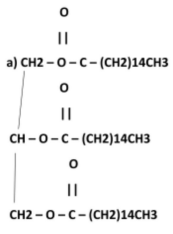
A) Cerebrosides and gangliosides are sphingolipids.
B) Phosphatidylcholine is a typical sphingolipid.
C) They always contain glycerol and fatty acids.
D) They contain two esterified fatty acids.
E) They may be charged, but are never amphipathic.

4)A compound containing N-acetylneuraminic acid (sialic acid) is:

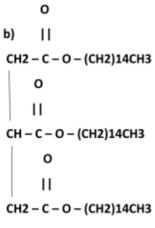
A) cardiolipin.
B) ganglioside GM2.
C) phosphatidylcholine.
D) platelet-activating factor.
E) sphingomyelin.

5)Which of the following structures is a triglyceride?

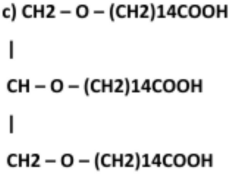
A)



B)



C)



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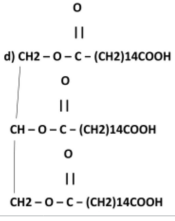


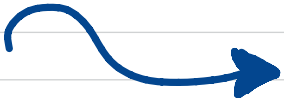
6)Which of the following is a characteristic of both triacylglycerols and glycerophospholipids?

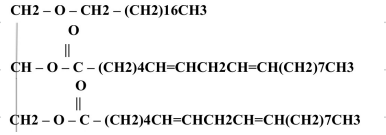
A) Both contain carboxyl groups and are amphipathic
b) Both contain fatty acids and are saponifiable.
c) Both contain glycerol and ether bonds.
d) Both can be negatively charged at cellular pH

7)Which is a characteristic of sphingolipids?

a) They all contain a fatty acid joined to glycerol.
b) They all contain a long-chain alcohol joined to isoprene.
c) They all contain ceramide joined to a polar group.
d) They all contain a carbohydrate joined to a phosphate group.

8) Which is a characteristic of all the fatty acid components in this lipid?





a) They all contain an unbranched carbon chain.
b) They all contain unconjugated cis double bonds.
c) They all are joined to glycerol through an ester bond.
d) They all are hydrophilic because they contain oxygen.

9) Which property does this lipid share with a typical triacylglycerol? (Same lipid above)

a) Both contain an ether bond.
b) Both contain a long-chain alcohol.
c) Both are amphipathic.
d) Both are saponifiable.

10) Which type of membrane lipid contains an acidic oligosaccharide?

a) phosphatidylinositol
b) cerebroside
c) ganglioside
d) globoside

11) Which component is found in all sphingolipids?

a) a carbohydrate
b) a negative charge
c) a phosphate group
d) an amino alcohol

12) Which characteristic is most likely shared by a cell membrane and a lipoprotein

a) Both are composed of a lipid bilayer.
b) Both contain a high amount of triacylglycerols.
c) Both contain hydroxyl groups on the surface.
d) Both contain proteins in the interior

13) Which type of membrane lipid could contain serine?

a) a globoside
b) a cerebroside
c) a glycerophospholipid
d) a ganglioside

ANSWERS

Q1	Q2	Q3	Q4	Q5	Q6	
B	B	A	B	A	B	
Q7	Q8	Q9	Q10	Q11	12	13
C	A	D	C	D	C	C

TEST BANK