Sheet no. 12

Biochemistry

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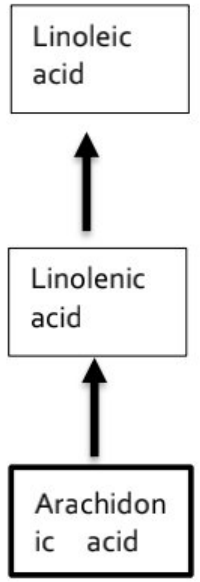
Polyunsaturated fatty acids
"Essential fatty acids"

essential fatty acids are the polyunsaturated fatty acids (such as linoleic acid) that the body cannot synthesize; they must be obtained from dietary sources

1-Linoleic (18;2): $C18:2\Delta^{9,12}$

It is the most important since other fatty acids can be synthesized from it in the body. ω6



This acid is considered to be essential and from it we can derive the two other ones

2-Linolenic acid (18;3): $C18:3\Delta^{9,12,15}$

In corn, peanut, olive, cottonseed & soybean oils. ω3

3-Arachidonic acid (20;4): $C20:4\Delta^{5,8,11,14}$

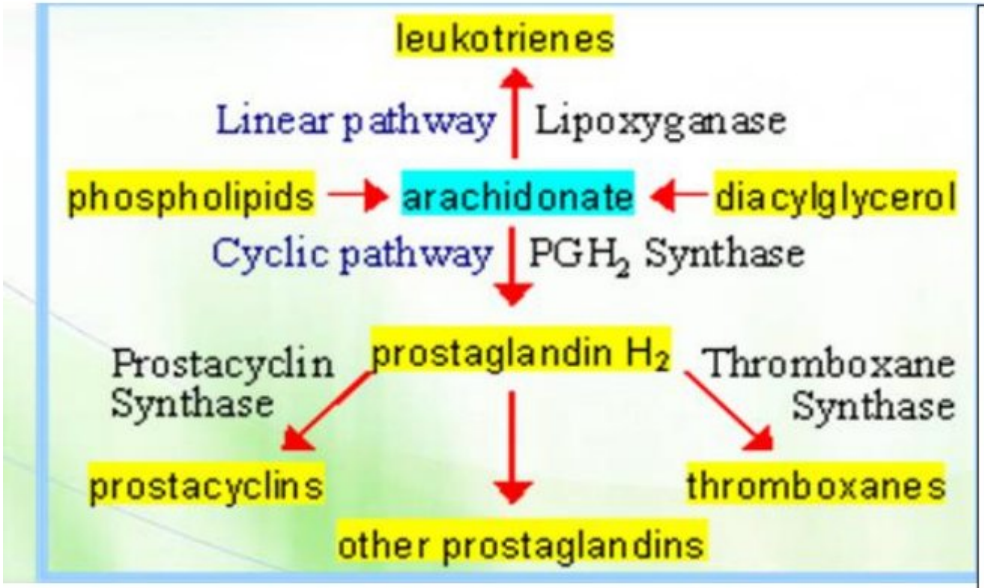
It is an important component of phospholipids in animal & inpeanut oil from which prostaglandins are synthesized

both linolenic and arachidonic are conditionally essential .How ?!
this means that both of them are essential if we don't have the linoleic acid in our bodies but if we have linoleic then they can be easily derived from it so in the second case they are not essential . Arachidonic acid is

derived from linolenic and linolenic is derived from linoleic .

DERIVED FATTY ACIDS
EICOSANOIDS

All types of eicosanoids are composed from 20 carbon atoms and they are derived from arachidonic acid (20:4) ---→ arachidonic acid is composed of 20 carbon atoms and four double bonds
Also as we said before arachidonic acid is derived directly from linolenic acid (18:3)
ponder this sketch please :



There are two main sources of arachidonic acid

1- Phospholipids in the cell membrane :
Arachidonic acid is esterified into cell membrane phospholipids at carbon number two of the glycerol and it can be released from these phospholipids using phospholipases (enzymes that break down the ester linkage at carbon number two)

في توضيح بسيط لهذه الفقرة بالصفحة التالية

2- Diacylglycerols

Simple clarification of the first source of arachidonic acid (phospholipids)
Firstly inside cell membranes there are phospholipids and they are composed of glycerol (3 carbon compound) , fatty acid , phosphate group bound to the third carbon of the glycerol molecule and the arachidonic acid bound to the second carbon by an ester bond the arachidonic acid can be released from the phospholipid by special enzymes called (phospholipases.)

Eicosanoids and their functions

Eicosanoids in general encourage inflammatory reactions

1-Prostaglandins

Inhibition of platelet aggregation
Blood clotting
they are called prostaglandins because they were first detected
in seminal fluid, which is produced by the prostate gland
each have a five-membered ring; they differ from one another in the numbers
and positions of double bonds and oxygen-containing functional groups
Prostaglandins are known to inhibit the aggregation of platelets. They may
thus be of therapeutic value by preventing the formation of blood clots

2-Prostacyclins

An inhibitor of platelet aggregation
A vasodilator
There are two fused rings in their structure

3- Leukotrienes

constriction of smooth muscles & asthma

they were first discovered in the Leukocytes(white blood cells)

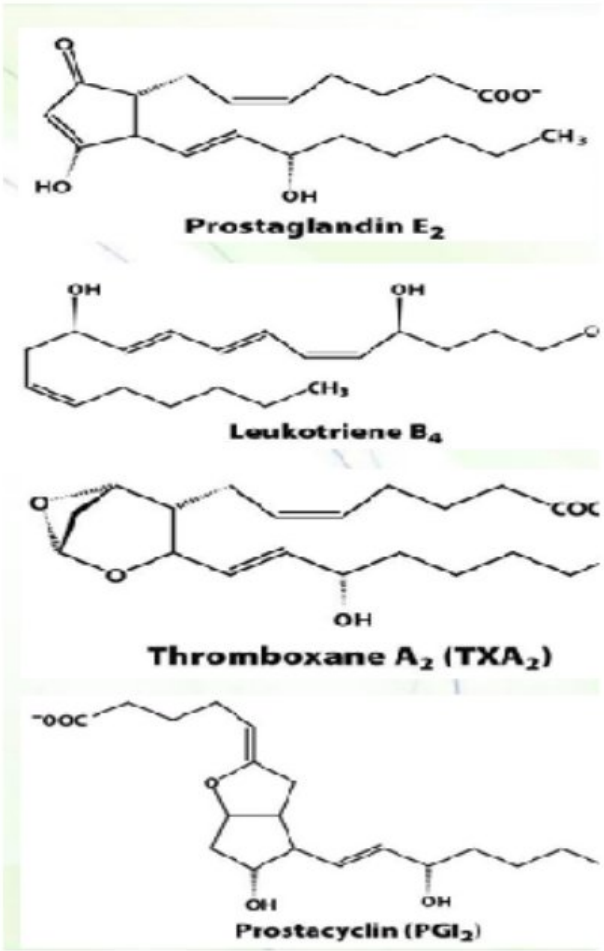
"trienes" means that they are composed of three conjugated double bonds and conjugated double bonds are bonds separated from each others by only one single bond .

An important property of leukotrienes is their constriction of smooth muscle, especially in the lungs. Asthma attacks may result from this constricting action

4-Thromboxane

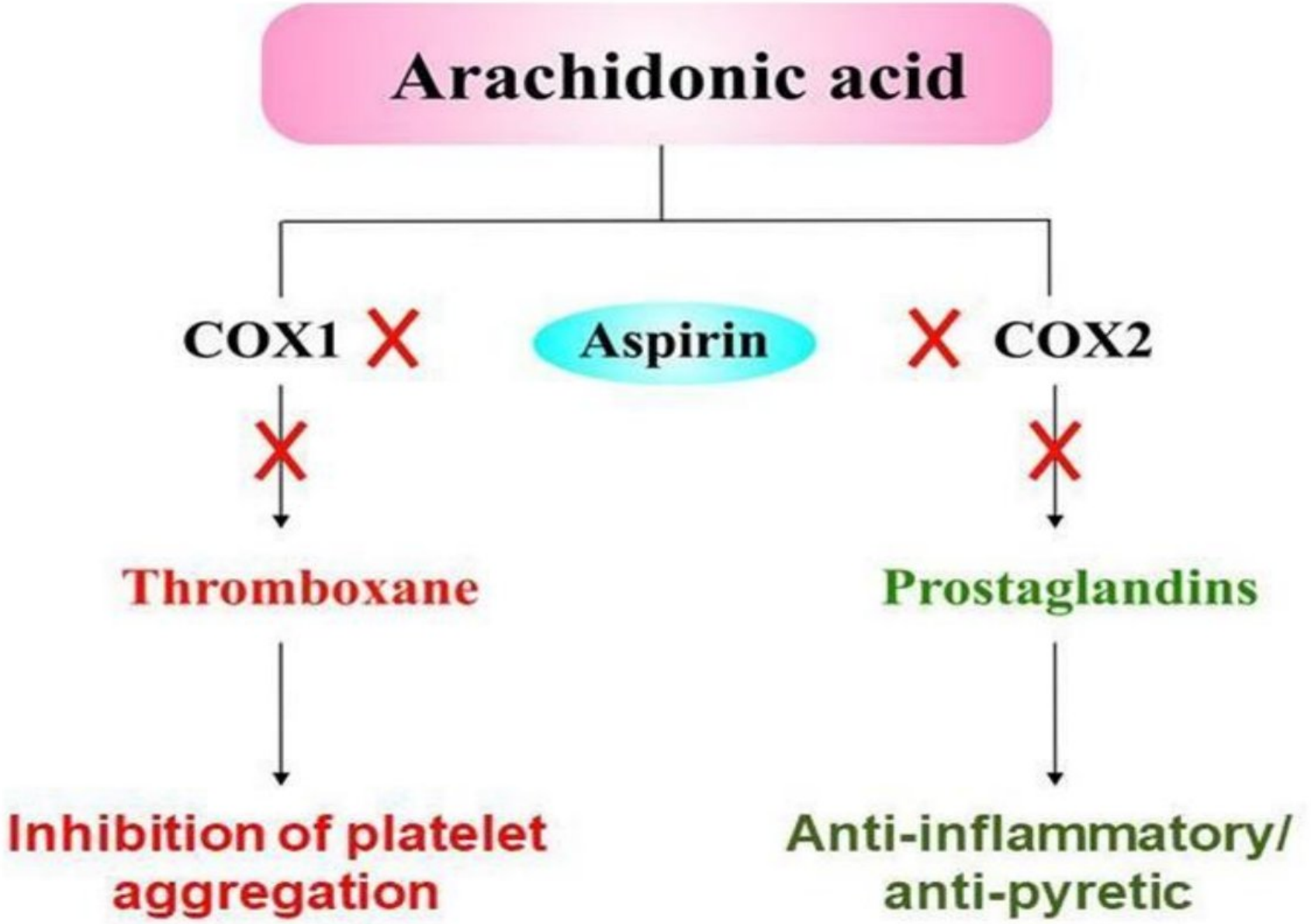
Constriction of smooth muscles Platelet aggregation

They have two ether groups and one 6-membered ring



You have only to differentiate different types of them depending on what is written before

Aspirin and eicosanoids

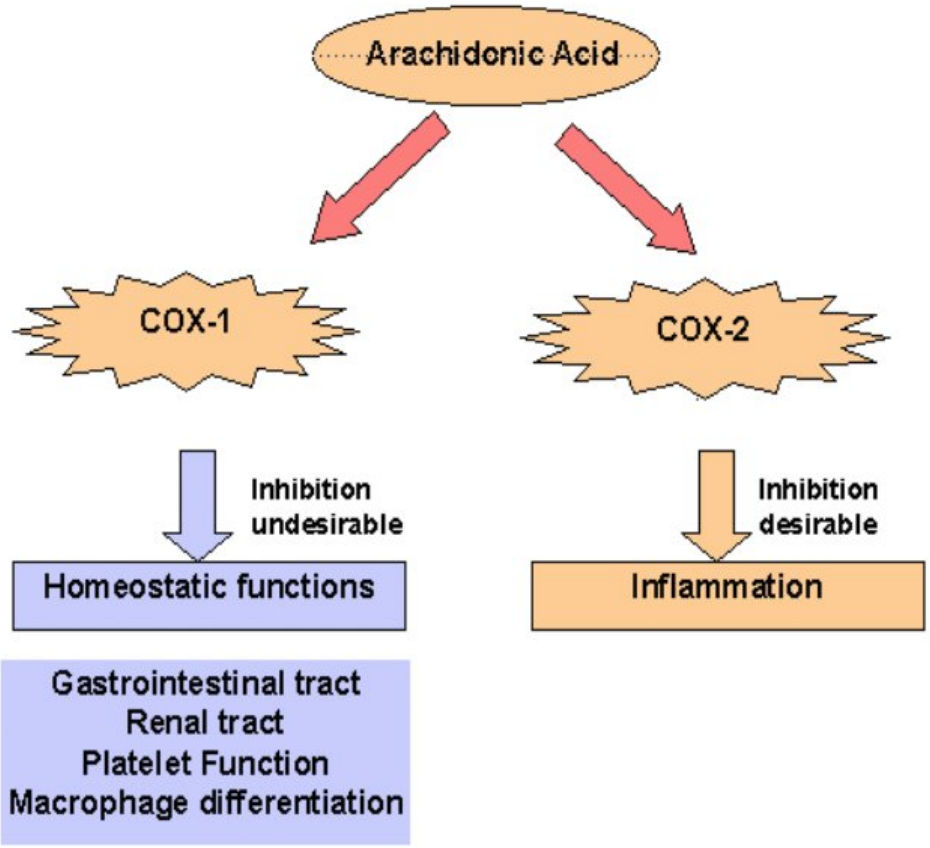


Aspirin and eicosanoids

COX: Cyclooxygenase

1- Cyclooxygenase is present in three forms in cells, COX-1, COX-2,and COX-3

2- Aspirin targets both, but COX-2 should onlybe the target.



Aspirin inhibits the synthesis of prostaglandins , a property that accounts for its anti-inflammatory and fever-reducing (anti-pyretic) properties ,but unfortunately aspirin inhibits all forms of cyclooxygenase (cox1, cox2 and even cox3)

and it is undesirable effect to aspirin to inhibit cox 1 (undesirable inhibition) because it would badly affect the homeostatic functions :

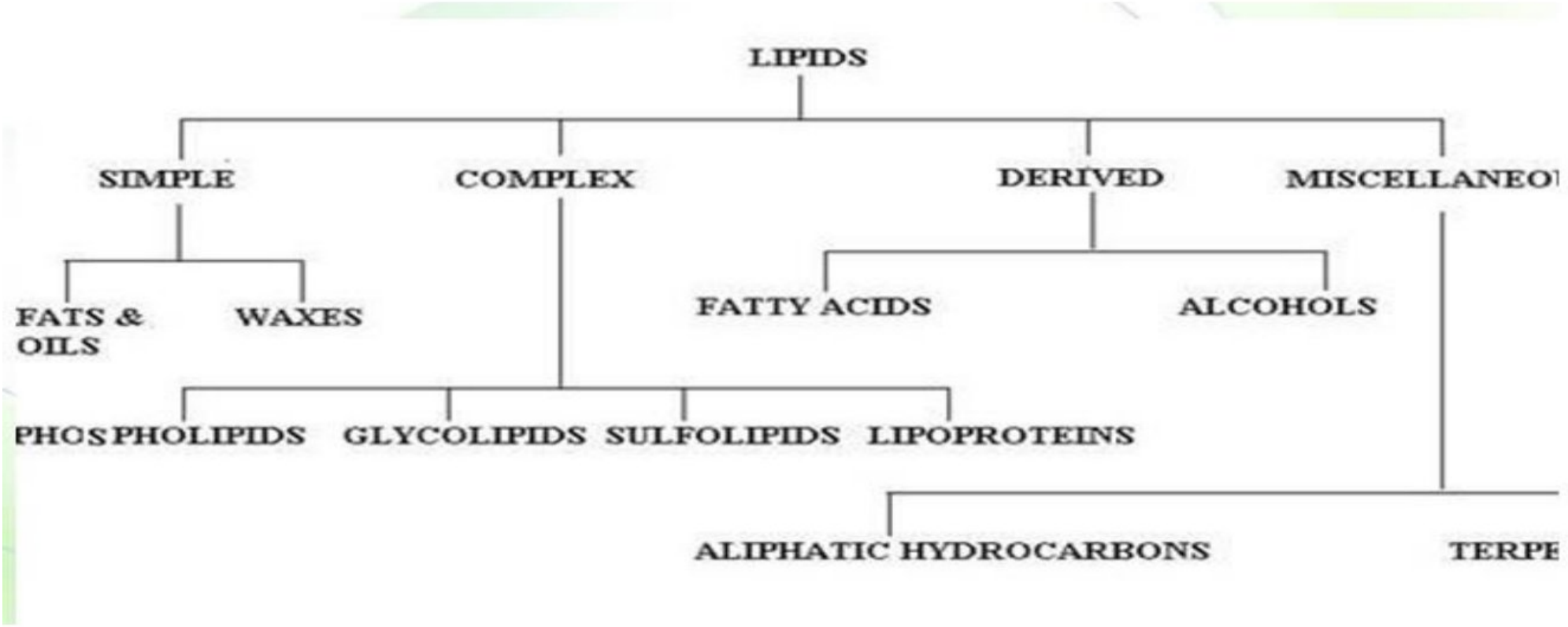
- Inhibition of cox1 would affect the GI tract leading to side effects such as ulcers and bleeding
- Affect platelet function

to get rid of these bad effects we use selective cox 2 inhibitors (Celebrex)

Celebrex

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

Remember



Simple lipids

Types of the simple lipids
A-neutral fats &oils (triacylglycerol)
B-waxes

Simple lipids in general are composed only of fatty acid esters with alcohols only without any other additional substances
The main simple lipids are triglycerides (also known as triacylglycerols)

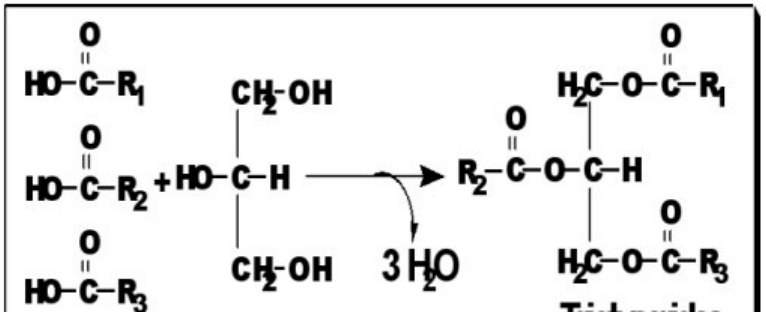
A-neutral fats &oils (triacylglycerol)

Glycerol is a simple compound that contains three hydroxyl groups
When all three of the alcohol groups form ester linkages with fatty acids, the resulting compound is a triacylglycerol; an older name for this type of compound is triglyceride.
So they are composed of glycerol backbone with three fatty acids
triacylglycerols are also called neutral fats due to the loss of negative charge associated with the fatty acids during esterification. Because they are neutral they do not attract water molecules so it help to consume the least space and enable us to depend on simple lipids for storage purposes .

1-Esters of glycerol with F.A

The most fatty acids are Commonest: palmitic, stearic & oleic

2-Uncharged due to absence of ionizable groups in it



3-Most abundant lipids in nature

note : the first three columns should be memorized

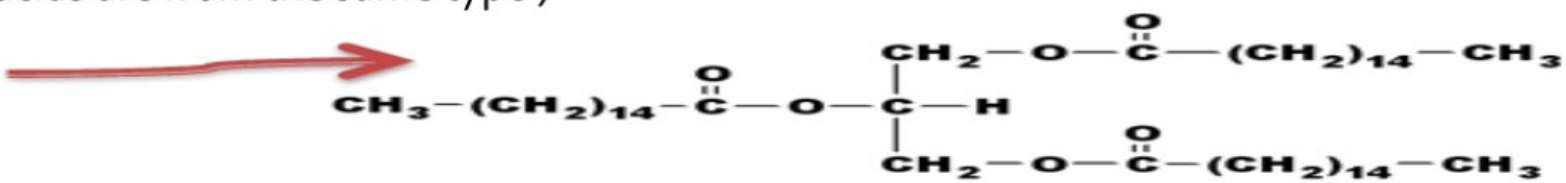
No. of carbons	No. of double bonds	Common name	Systematic name	Formula
16	0	Palmitate	n-Hexadecanoate	$CH_3(CH_2)_{14}COO^-$
18	0	Stearate	n-Octadecanoate	$CH_3(CH_2)_{16}COO^-$
18	1	Oleate	cis-Δ^9-Octadecenoate	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COO^-$

Triacylglycerides can be

Either

a)Simple: same type, e.g., tripalmitin

simple triglycerides are composed of a glycerol molecule and only one type of fatty acids (the three fatty acids are from the same type)



Tripalmitin
(simple triacylglycerol)

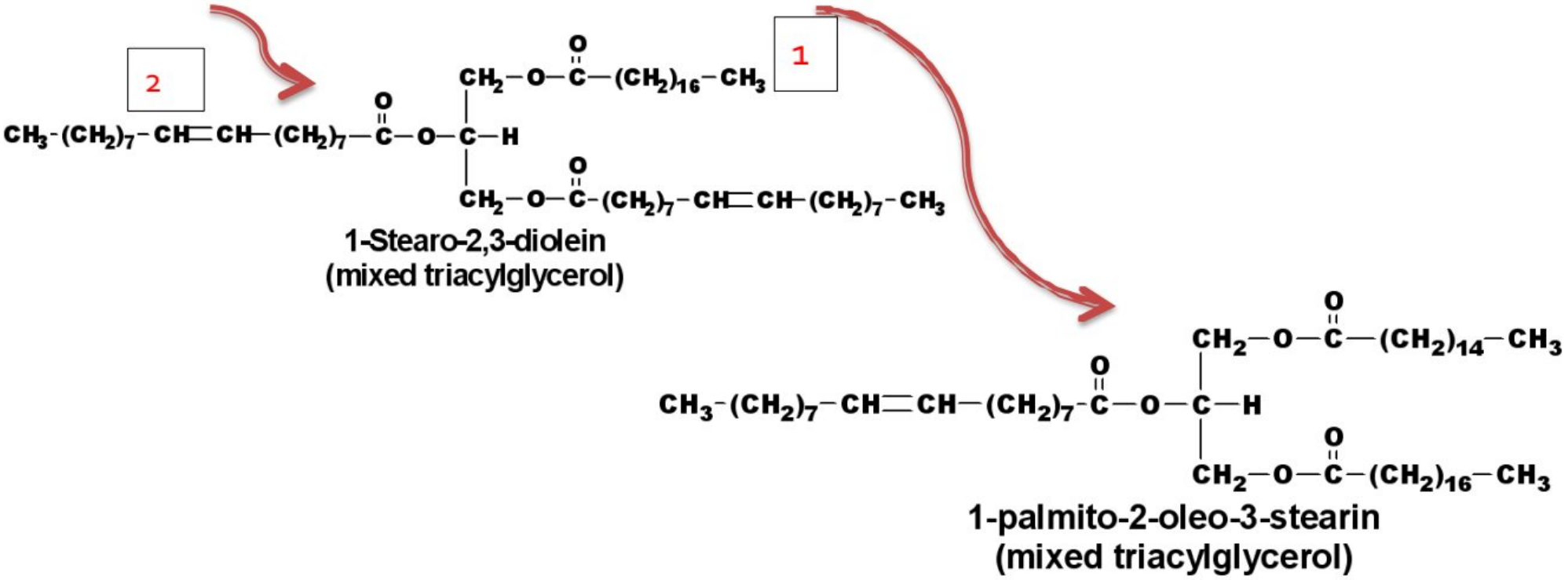
Note that the glycerol is connected to three palmitic acids so the name is tripalmitin

b)mixed: of different types, e.g., stearo- diolein & palmito-oleo-stearin

two or three different types of fatty acids

1 (note the first fatty acid) (18:0) so it is stearic acid

2(the one on the second carbon)(18:1) oleic acid



Physical properties of fat & oils

1. **Freshly prepared are colorless, odorless & tasteless (the yellowcolor is due to carotene pigments)**

Like water (لا لون ولا طعم ولا رائحة**)**

Note (additional) carotenoids are plant pigments responsible for bright red, yellow and orange hues in many fruits and vegetables

2. Fats have specific gravity less than 1

It means that fats float on water

Definition of specific gravity: the ratio of the density of a substance to the density of some substance (such as pure water) taken as a standard when both densities are obtained by weighing in air

3. Fats are insoluble in water (organic solvents as ether & benzene)

4. Room temperature: Oils (liquid) vs. fats (solids)

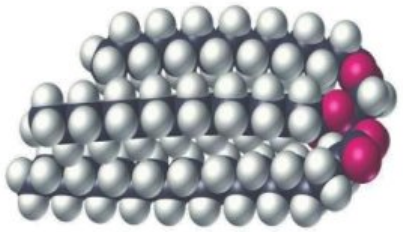
Why ??

Fats vs oils

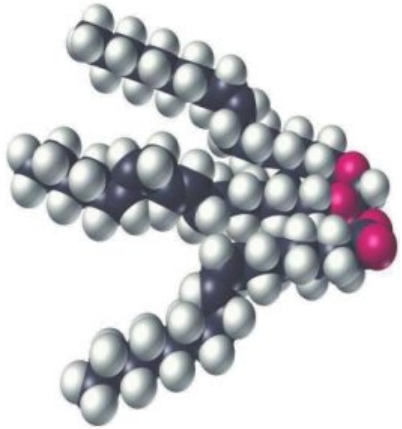
They differ adout eachother in the number of carbon atoms and degree of unsaturation (number of double bonds)

Fats: have longer fatty acids (more carbon atoms) and lower degree of unsaturation

Oils: shorter chains of fatty acids (less carbon atoms) and higher degree of unsaturation (more double bonds)



A fat



An oil

Chemical Properties of fats & oils (Reactions)

1-hydrolysis :

Steam, acid, enzyme (e.g lipase of pancreas)

the first way of breaking down lipids

hydrolysis reactions are the reverse of condensation reactions. In a hydrolysis reaction, a larger molecule forms two (or more) smaller molecules and water is consumed as a reactant. Hydrolysis ("hydro" = water and

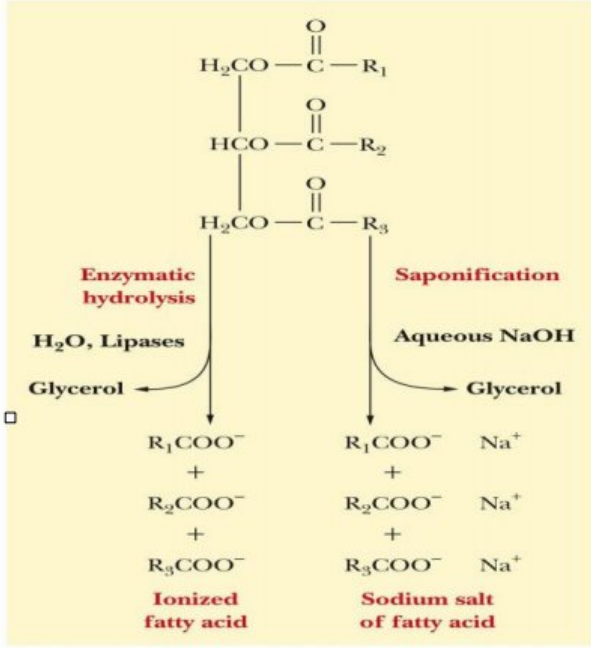
"lysis" = break) involves adding water to one large molecule to break it into multiple smaller molecules.
The product of hydrolysis is ionized fatty acid (carry a negative charge)
All macromolecules are formed by condensation reactions (remember what is meant by condensation reaction) enzymatic hydrolysis is the breakdown of a compound in presence of enzymes enzymes used for hydrolysis of:
carbohydrates --→ glucosidase
lipids --→lipases
nucleic acids -→ phosphodiesterase

2-sponification reactions :

- Alkaline hydrolysis: produces salts of fatty acids (soaps)
- Soaps cause emulsification of oily material(interesting !!)

The second way of breaking down lipids
Alkaline hydrolysis or spanoification (another way to release fatty acid in alkaline medium).. So the fatty acid will be in salt form (negative charge of fatty acid will bind to Na or K)

Additional note : according to the enzyme that hydrolyses carbs the doctor said that it is glycosidase enzyme but after searching we found that glucosidase is (enzyme) any enzyme that hydrolyses glucosides while glycosidase is (enzyme) any enzyme that catalyses the hydrolysis of a glycoside.



Emulsification

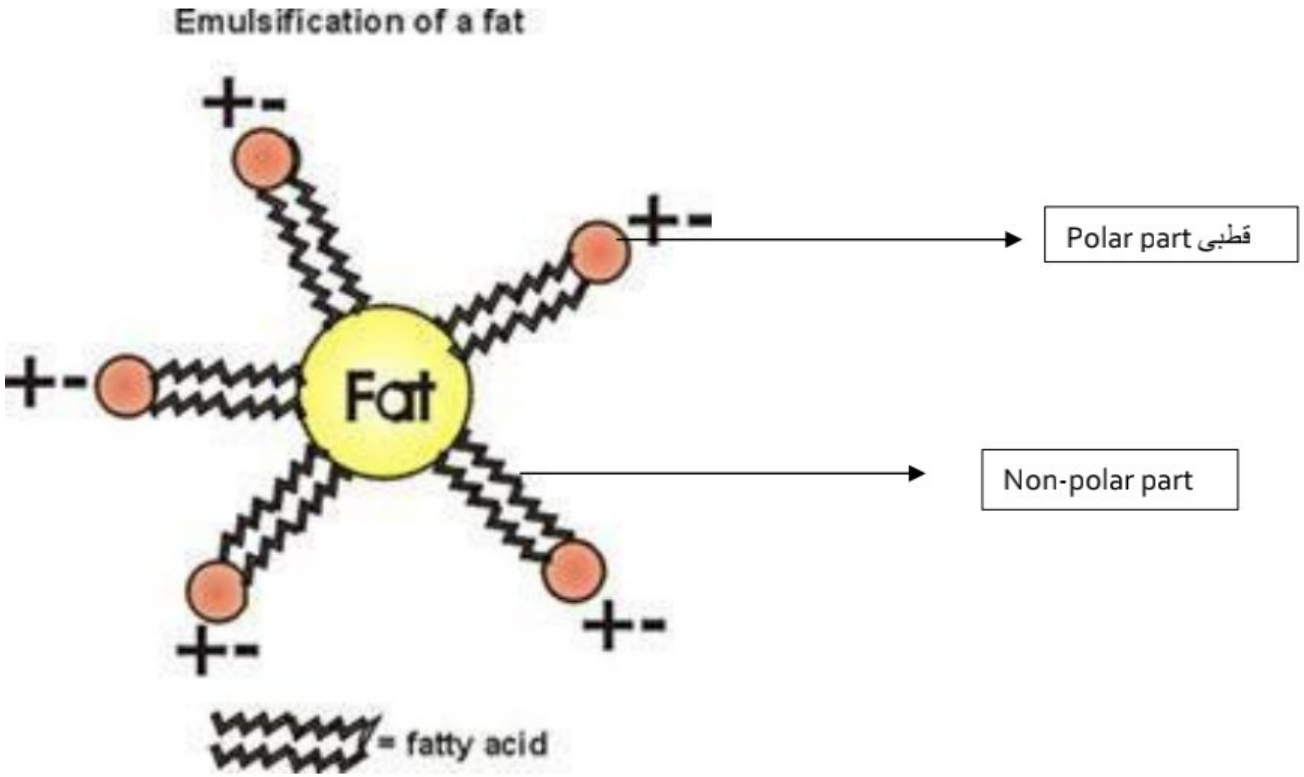
We said before that salts of fatty acids (soaps) cause emulsification of oily material so how does that occur ??
بداية طرح الدكتور السؤال التالي : كيف بنحصل على قوام متجانس للحليب رغم انه ناتج عن مزج مادة قطبية و هي الماء و أخرى غير قطبية (الحليب) ؟؟
It can happen by emulsification Which is the process by which a system comprising of two immiscible liquids (usually oil and water), one of which is dispersed as small droplets within the other .
يعني ببساطة الصابون عبارة عن املاح احماض دهنية و لما نذوبهم بالماء الايونات المرتبطة معهم سواء صوديوم
بوتاشيوم رح يتحرروا و بصير الحمض الكربوكسيلي بحالة تأين في جزء منه قطبي يذوب بالماء و الجزء الاخر غير قطبي كاره للماء
الجزء القطبي يرتبط مع جزيئات الماء و الغير قطبي يربط مع بقية المجموعات الهيدروكربونية في الحموض الكربوكسيلية المختلفة و بناء على هذا رح يتكون معنا micelles

اخذناهم في ثالث محاضرة لهذا الفصل تقريبا هاي التراكيب رح تحتجز الجزيئات الغير قطبية من زيوت و اوساخ

كوننا نتحدث عن الصابون في منتصفها بالداخل و بالخارج سطحها يلتصق مع الماء و نفس الفكرة بالنسبة لمزج الحليب بالماء الجزيئات غير
و
القطبية رح تدخل in the core of the micelles

بعد هيك هاي ال micellesرح تتوزع بكافة ارجاء وعاء الحليب على سبيل المثال و بذلك ينتج معنا محلول متجانس يا سادة يا كرام
If it is still not obvious you can watch this great video about emulsification : https://youtu.be/ZMhyD-wUPjo

Because of their amphipathic nature(the doctor means the salts of fatty acids), the act as emulsifying agents, that is substances that cansurround nonpolar molecules and keep them in suspension in water



Notice that the ionized fatty acids have aggregated and formed a micelle

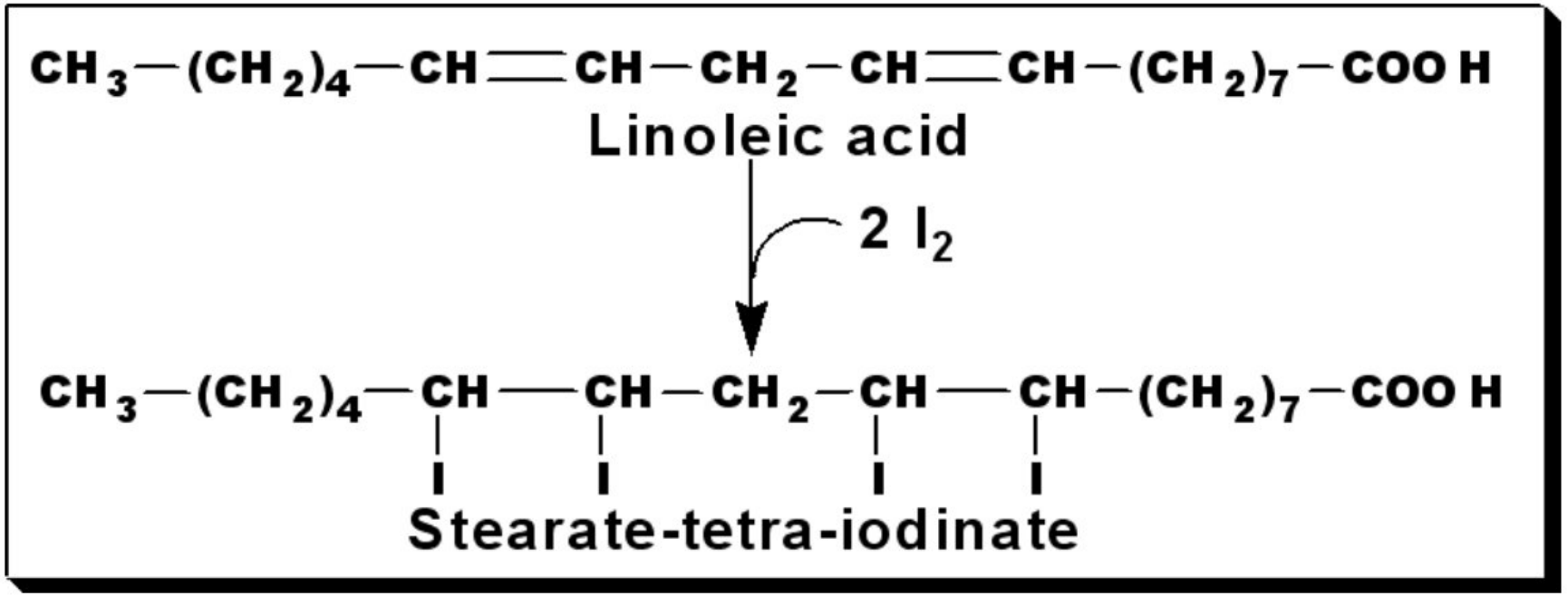
You can find emulsifiers in plenty of prepackaged and processed food (where emulsification takes place) such as : mayonnaise, chocolate and ice cream

الدكتور ذكر مثال الحليب و الصابون لكن ها الأمثلة من الصور الموجودة بالسلايدات

The doctor did not mention any thing about this reaction but it is written in the slides it is simple read it

-3Halogenation: added to unsaturated F.A (e.g., iodination)

Used to determine the degree of unsaturation of the fat or oil that determines its biological value

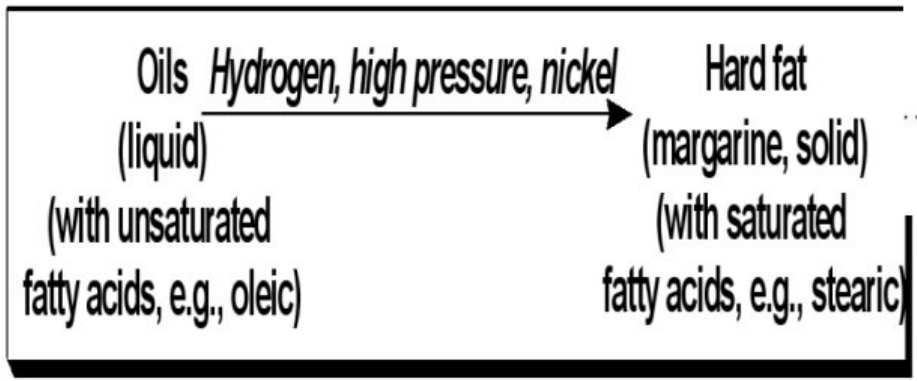


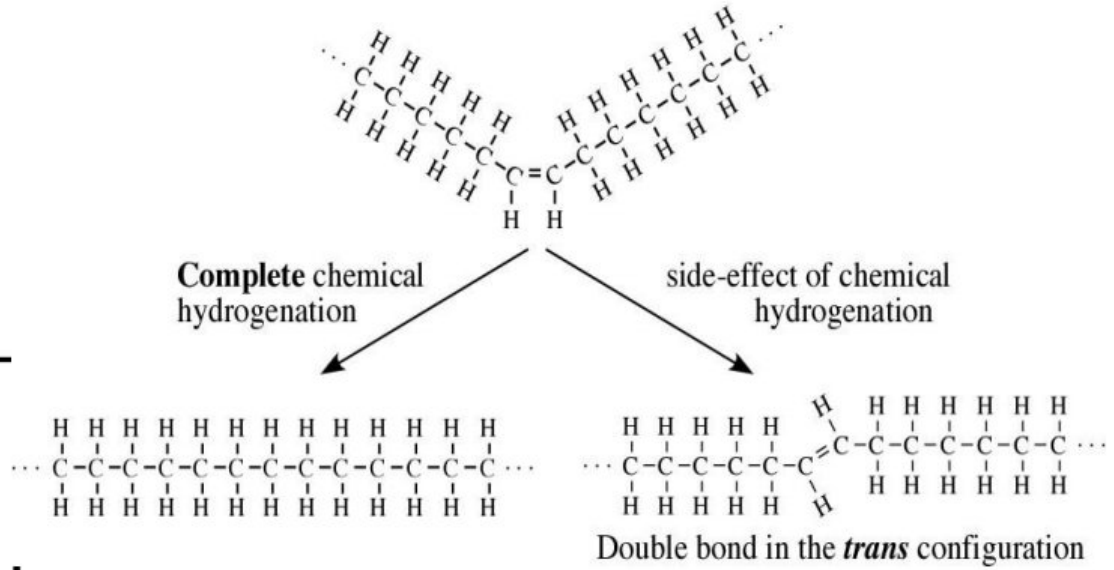
4-Hydrogenation or hardening of oils:

- ✓ Addition reaction (unsaturated F.A)
- ✓ Done under high pressure of hydrogen
- ✓ The basis of hardening oils (margarine manufacturing)
- ✓ Hydrogenation converts cis-double bonds to trans

Hydrogenation reaction is done to oils (unsaturated fatty acids double bonds) and it converts oils to the solid state

The hydrogenation reaction can be complete and converts the Unsaturated fatty acid to saturated one or it can convert the cis double Bond to trans





There are two types of hydrogenation reaction as said before

Hydrogenation or hardening of oils:

Chemists invented partial hydrogenation

Converts some, but not all, double bonds into single bonds

Called (trans fat): elevated risk of coronary heart disease (CHD)

Hydrogenation reaction in general :

- ✓ advantages: more pleasant, easily stored & transported, less liable to oxidation
- ✓ Disadvantages: lack of fat- soluble vitamins (ADEK) &essential fatty Acids

Oils (unsaturated like alkenes) so they have double bonds which makes them more reactive (can't be stored for long time but the synthetically saturated fatty acids are similar to alkanes (only single bonds and so they are less reactive)

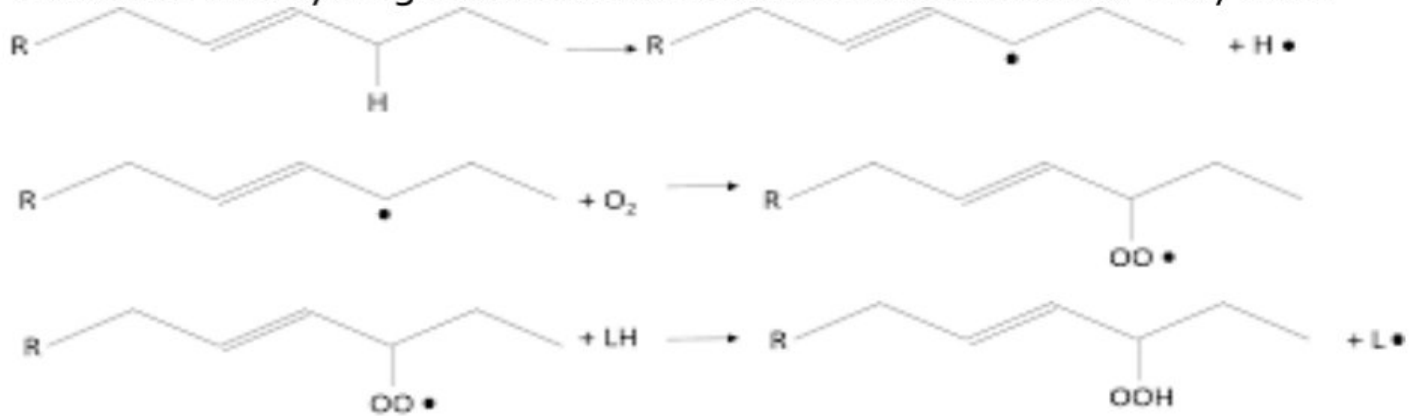
Alkanes are the least reactive compounds

5-oxidation (rancidity)

oxidative rancidity is a reaction of fatty acids with oxygen.More specifically it is the reaction of double bonds in unsaturated fatty acids with oxygen. Upon reacting with oxygen very reactive components (among others hydroperoxides) will be formed (radicals will be formed)

*It is caused by exposure towards air or light

*Oxidation and hydrogenation reactions occur to unsaturated fatty acids



Radicals are very unstable molecules and they can hit any other compound to steel an electron if they hit DNA molecule they will leave it as radical and they easily cause cancer

Note : we can reduce the risks of rancidity by using cyclic antioxidants which are really great because they can deal with free radical in which free radical revolves around them due to their cyclic structures

Simple lipids
Waxes

1-Solid simple lipids
2-Contains a monohydric alcohol (C16 ~ C30), (higher molecular weight than glycerol) esterified to long-chain fatty acids (C14 ~ C36). Examples: palmitoyl alcohol
3-Insoluble in water & Negative to acrolein test
4-Are not easily hydrolyzed (fats) & are indigestible by lipases (nutritional value)
5-Coatings: prevent loss of water by leaves of plants

wax is a simple lipid which is an ester of a long-chain alcohol and a fatty acid and both contain (large numbers of carbon)
Very long chain alcohol with long chain fatty acid
Focus one(alcohol):one(fatty acid)
We don't have the hydrolytic enzymes of waxes in our bdies (as it goes in , it goes out)
It is usually solid in room temperature
It is found on tree leaves and the outer surface of fruits to prevent loss of water

Differences between neutral lipids and waxes

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

Note : the most abundant lipids in nature are triacylglycerols…. Whereas the most abundant lipids in the membranes of cells are glycerophospholipids

Compound (conjugated) Lipids

They are lipids that contain additional substances, e.g.,sulfur, phosphorus, amino group, carbohydrate, or proteins beside fatty acid & alcohol

And they have structural and functional purposes in the membranes

- Classified into the following types according to thenature of the additional group

1. Phospholipids

phospholipids consist of two hydrophobic "tails," which are fatty acid chains, and one hydrophilic "head," which is phosphate group. they are made of glycerol molecule (that has 3 OH groups). The first two carbons are connected to fatty acids and the third carbon is attached to a phosphate group.

They can be formed from two types of alcohol either glycerol (glycerophospholipid) or from sphingosine (sphingophospholipids)

So again for more clarification glycerophospholipids (GPLs) are fatty acid diglycerides with a phosphatidyl ester attached to the terminal carbon

Different head groups are linked to the phosphate group to make different types of phosphoacylglycerols.

Notice that all groups are polar (except for H; however, phosphate is polar), thus molecules have a polar head. Notice that

regarding to the negative charged phosphate group and the positive charged head group, you may say that the net charge is zero and that's correct but even if the net charge is zero look at it as two different charged regions within the polar head.

Phosphatidic acid is the simplest and smallest type. It is the parent molecule

2. Glycolipids

glycolipids are lipids with a carbohydrate attached by a glycosidic (covalent) bond
Here there is only one possible type of the alcohol, which forms them, and it is glycerol

3. Lipoproteins

4. Sulfolipids & amino lipids

Phospholipids

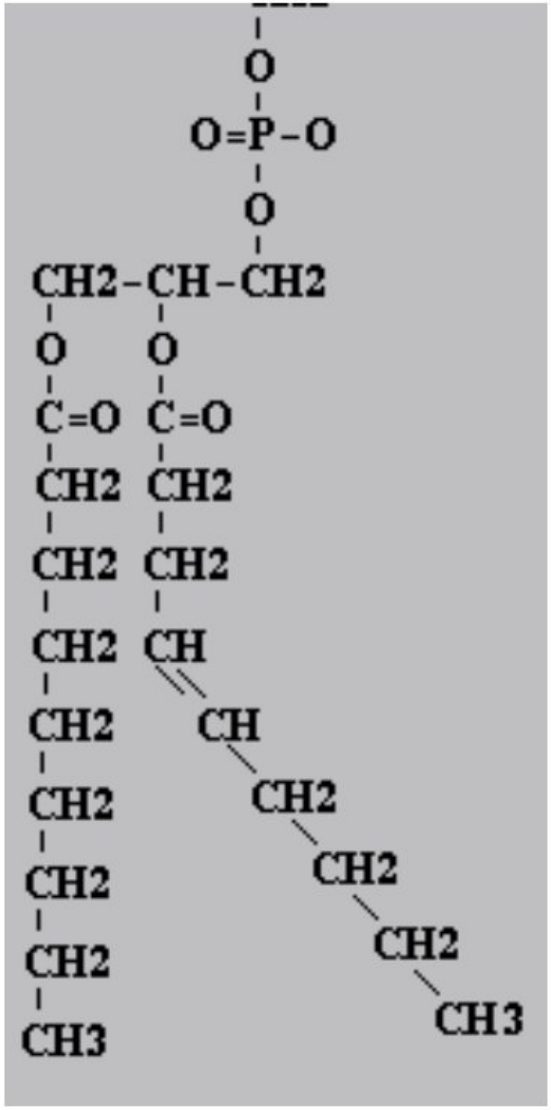
1. Contain phosphoric acid group

2. Every animal & plant cell:
   - ✓ Membranes of cells & subcellularorganelles

3. Important role in signal transduction across membranes

4. Snake venom hydrolyses membranephospholipids

1. A source of polyunsaturated F.



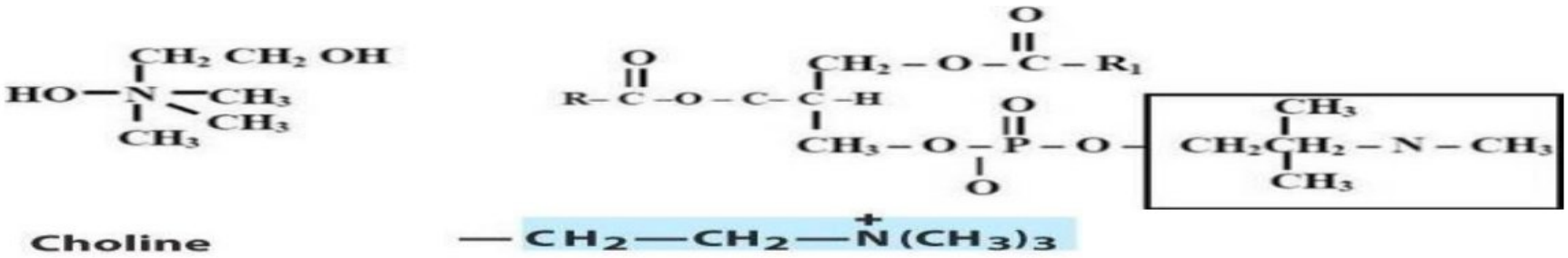
phospholipids

- Structure:

1. Fatty acids (saturated& unsaturated)
2. Fatty alcohols(glycerol & sphingosine)
3. Phosphoric acid
4. Nitrogenous base(choline, Ser, Thr,or ethanolamine)

- Classification: according to thetype of the alcohol
  - Glycerophospholipids
    - ✓ Phosphatidic acids
    - ✓ Lecithins
    - ✓ Cephalins
    - ✓ Plasmalogens
    - ✓ Inositides
    - ✓ Cardiolipin
  - Sphingophospholipids: sphingosine as an alcohol

Lecithins



- Has Choline as a nitrogenous base and most abundant in membrane lipids

Lecithin is an important molecule in our system and exists a lot in the plasma membrane of RBCs. Snake venom contain lecithinase, which hydrolyzes polyunsaturated fatty acids and converting lecithin into lysolecithin. So, these blood cells will be ruptured (hemolysis of RBCs)

"فصبرًا في محال العلم صبرًا
فما نيلُ المنى سهلُ المرادِ