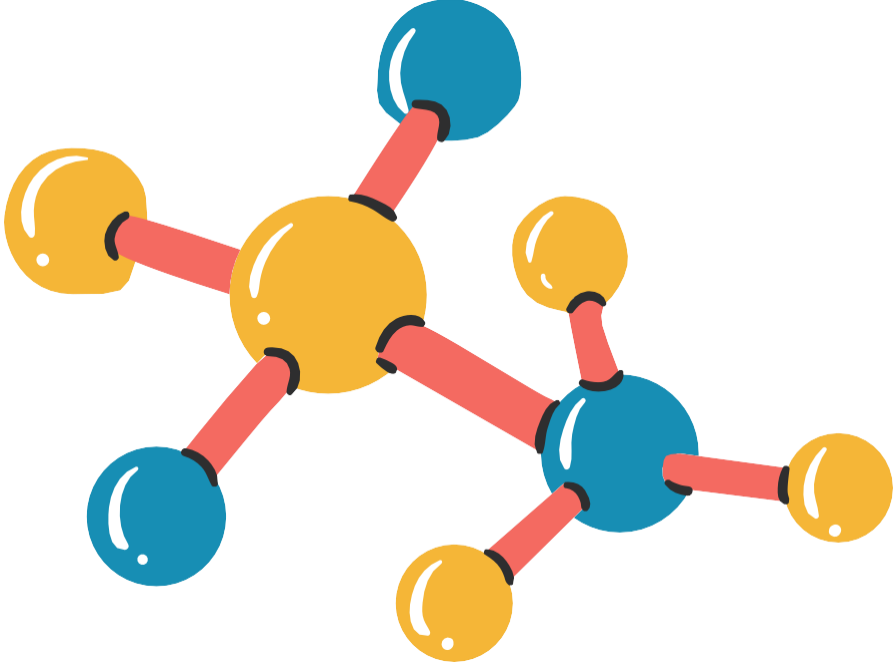

Sheet no.11

# Biochemistry

Summer 2022

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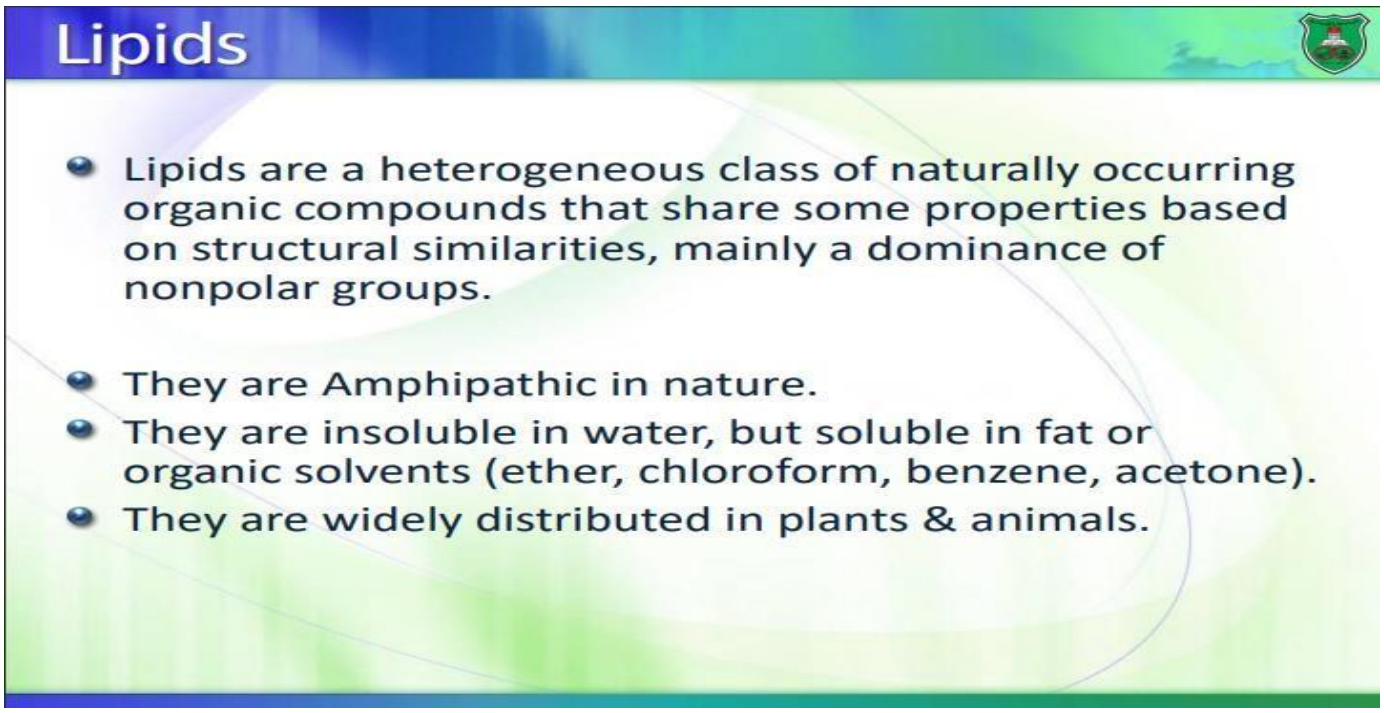
# Lipids




**What are lipids?? (introduction)**

**In the last lecture , we said that carbohydrates are polyhydroxy aldehydes or ketones and their classification in terms of organic chemistry.**

**This doesn't work on lipids molecules because they are a group of molecules [very heterogeneous].**

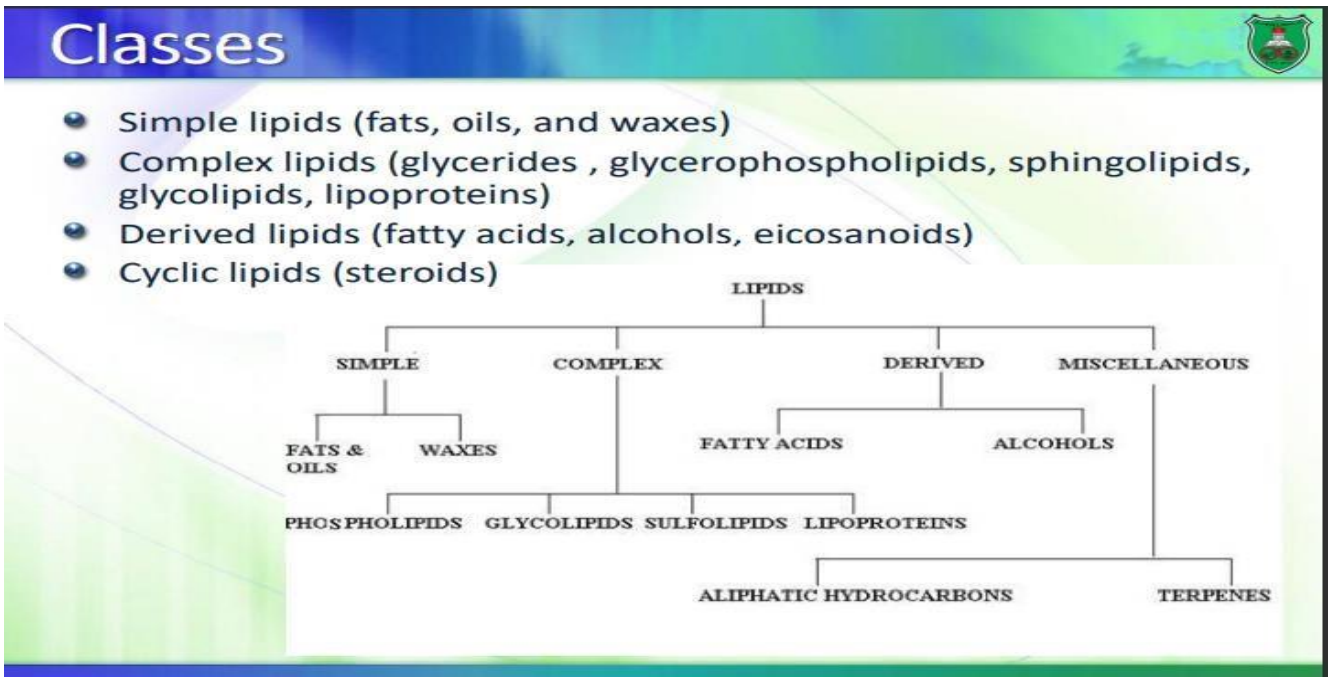
**-The only thing in common is that they are hydrophobic [water insoluble] . This indicates that they are different from each other .**

***in other words the general definition of lipids is that they're insoluble**

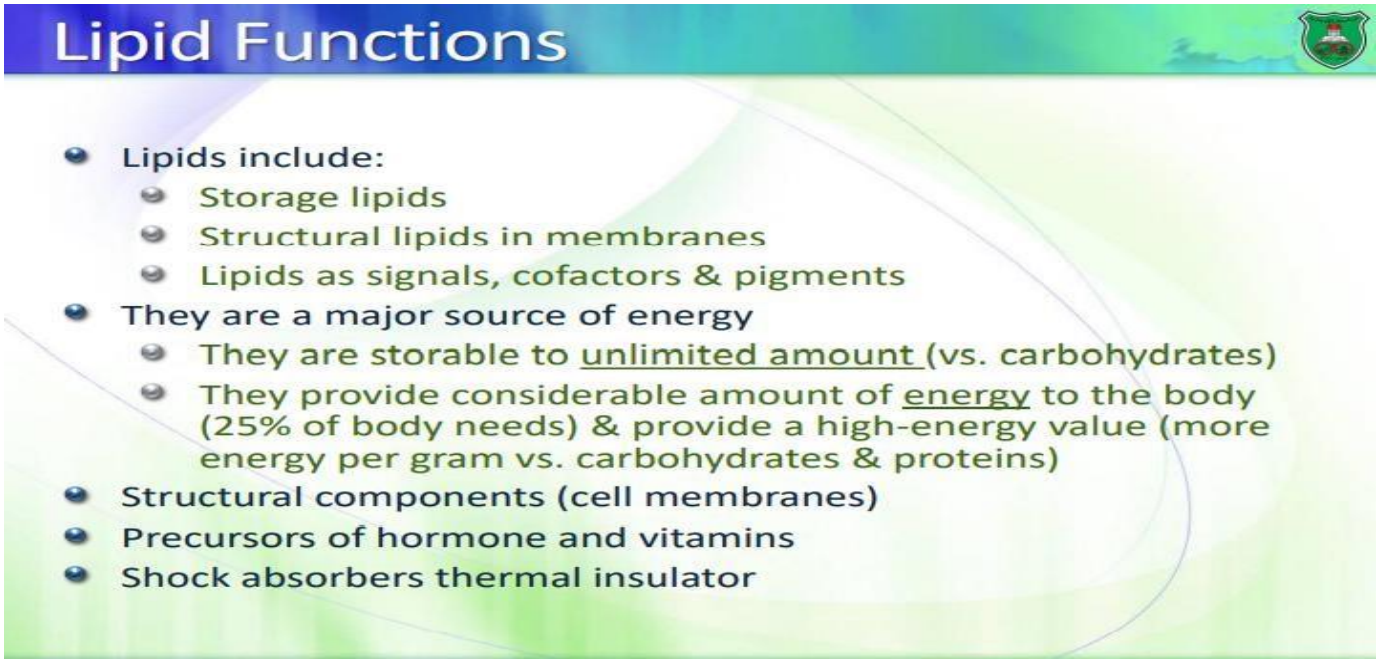
**-They are naturally occurring —> It means that they are present in nature (not manufactured)**

**They have a wide range of functions, so they have differences in the structure . We will divide it into different families to make it easier to study.**

**They can be considered amphipathic ,because not all structures are hydrophobic or non-polargroups , We can find some polar groups, but they are small compared to the whole compound. ( one side is polar and the otherside is non-polar )**




**We will memorize the families and will study their characteristics .**




**Before we go into the details of each subgroup, we are going to discuss the importance of lipids**

**1-energy storage: When we want to store energy, it is stored in the form of lipids because :**

**a) lipid molecules are big , so they can store a high amount of energy.**

**b) they are compacted easier than hydrophilic molecules.**

***Explanation: when we store sugars , it is stored with water molecules , so it occupies a large space and with low energy .**

**In hydrophobic molecules (lipids) , it isn't stored with water molecules , so the presence of $H_2O$ molecules is avoided reducing , but the amount of energy in them is larger than sugars as discussed in the slide above .**

**If the storage was in the form of carbohydrates instead of fats, the body size would increase.**

**2-Structural lipids :molecules that are part of the cell membrane (Barrier) (separating one place from another)**
**For example ,Inside the cell, we find a lysosome whose pH is 4 or 5 much lower than the one around it in the cytosol. It is the membrane that makes its pH low and does not affect others.**

**Each structure in the cell is surrounded by a membrane, separating it from the surrounding environment, that's why the environment is different in each structure .**

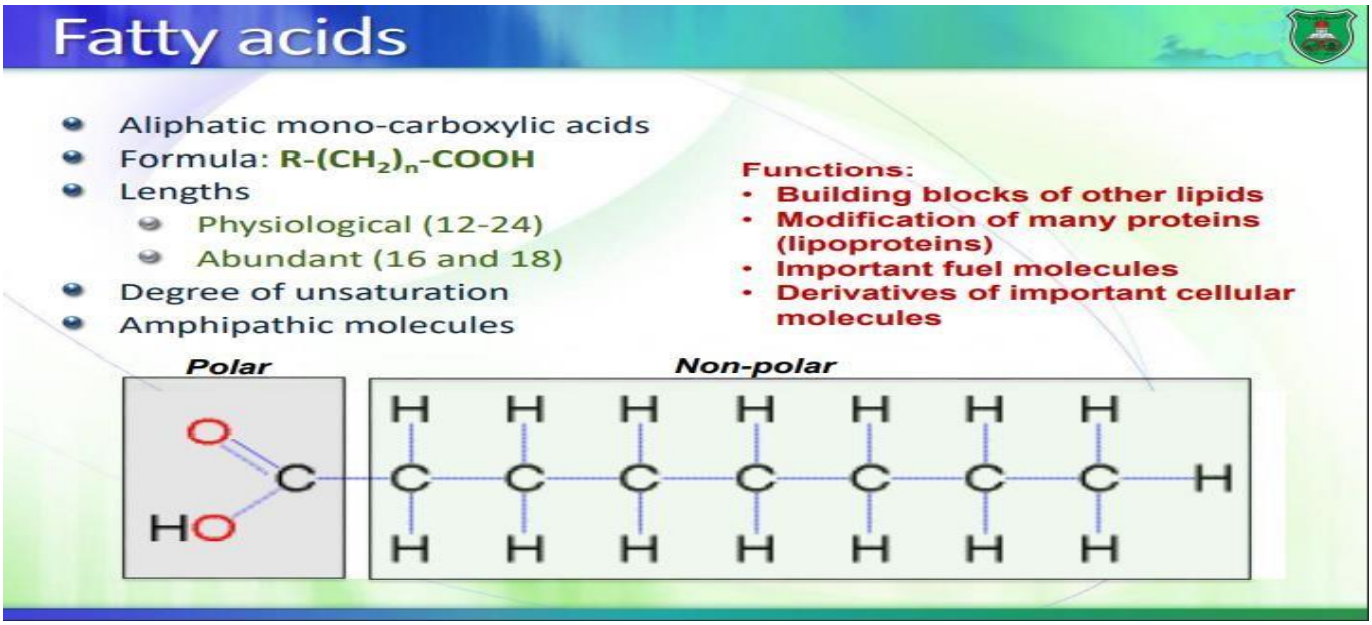
***but it is not completely separated (regulations and interactions occur).**

**3- Lipid molecules are precursors to synthesis other molecules: They can be used in the manufacture of vitamins such as vitamin D or in the manufacture of hormones (steroids) such as cortisol, aldosterone, sex hormone, and they can be used in the reactions of coenzymes (helping the enzyme with its function) and enter into the manufacture of pigments inside cells .**

**4- Shock absorption :for example the kidney is superficial if it wasn't covered by lipids it would be damaged easily.( acts as a cushion**

**5- Thermal insulators: heat insulating compounds.**

***These different functions makes them important molecules.**



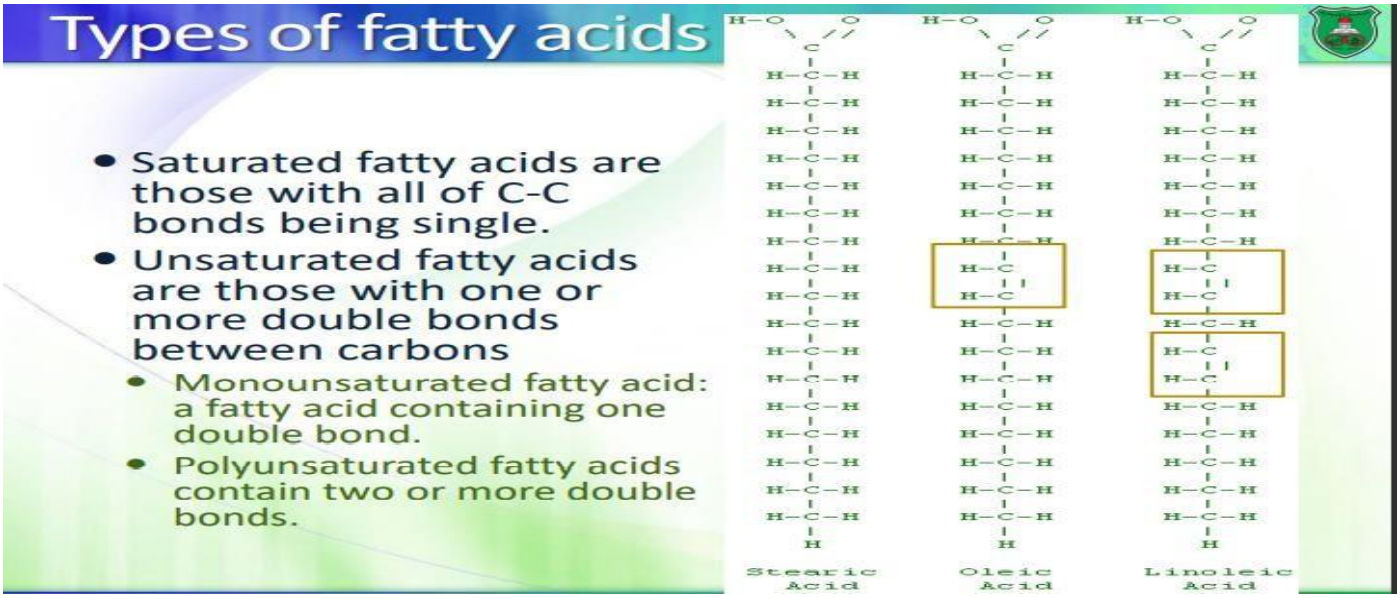

**Fatty acids:**

**In terms of organic chemistry, they are carboxylic acid with long hydrocarbon chains. Hydrocarbon chain can be either single bonds or double bonds( They are all hydrocarbons, containing no other functional group. (If there is another functional group , they are not fatty acid)**

**The majority have an even number of carbons , but there are some examples with an odd number of carbons**

***physiological fatty acids , they range between 12 carbons to 24.**

**Common in human → 16 and 18**




**It can all be saturated (single bonds) and there can be a double bond (one or more)**

**If there is only one double bond, it is called <u>monounsaturated</u>**

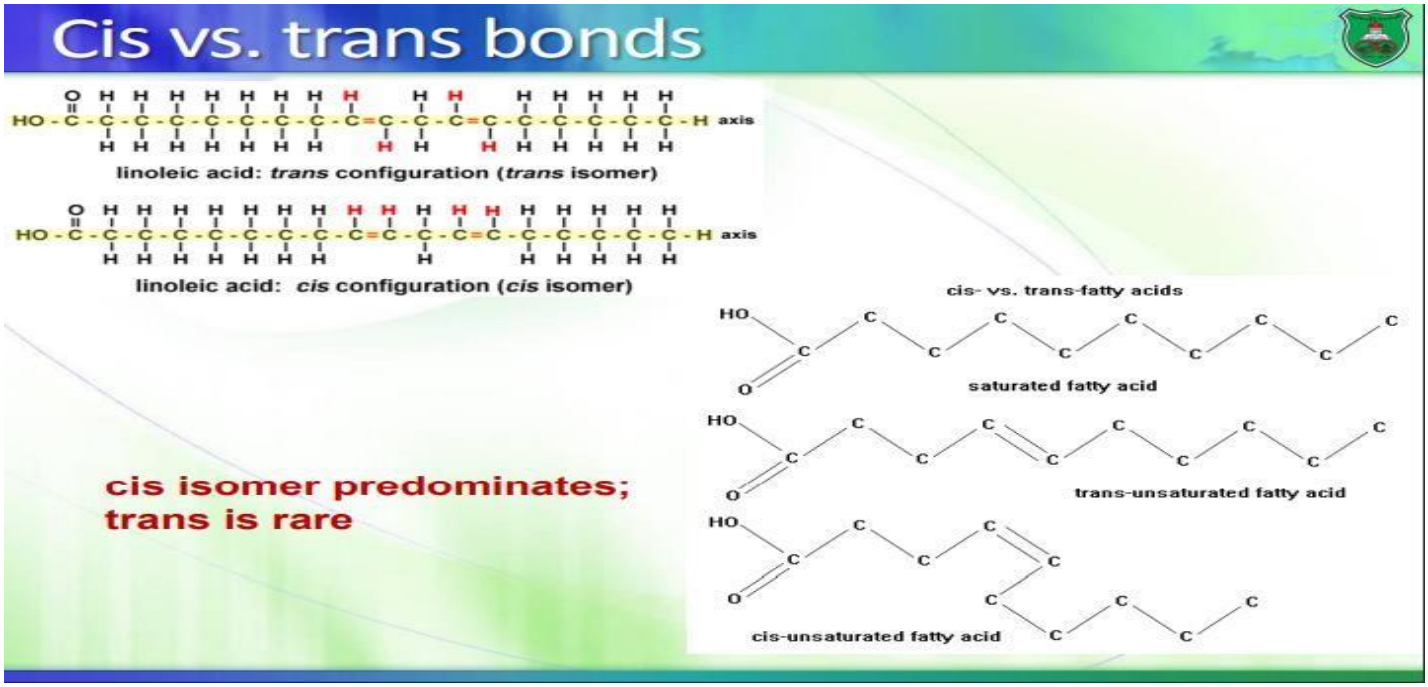
**If there is more double bonds , it is called <u>polyunsaturated</u>**

**When I use fat as a source of energy, it is broken down to carbon units (acetal CoA) for example: abundant ones that have 16 carbon break down into 2 chain and each chain contains 8 carbon and so on.**

**Also , when we use lipids as a source of energy and we can use them as building blocks to synthesis other molecules like triacylglycerol , phospholipids in the membrane , inflammatory mediators ( When you bump into something and that leads to inflammation and this infection is free of bacteria and viruses, the body will alert you that a certain damage has occurred as a result of this bruise and it will happen inflammatory reaction (inflammation) .**

**This interaction will lead to swelling of the area, its temperature will rise accompanied by pain and redness, and these changes require chemical molecules that cause certain changes in the area to appear in this way. This inflammatory mediators are made of fatty acids)**

**When talking about the double bonds in general we will have interest in their specific sites because there are certain types of enzymes that determine the site of the bond.**




**How does the structure get affected by the presence of double bonds ?**

**If the chain's bonds are single (saturated), then its shape will be zig zag If the chain contain one double bond (monounsaturated) , the double bond has two options (cis or trans)**

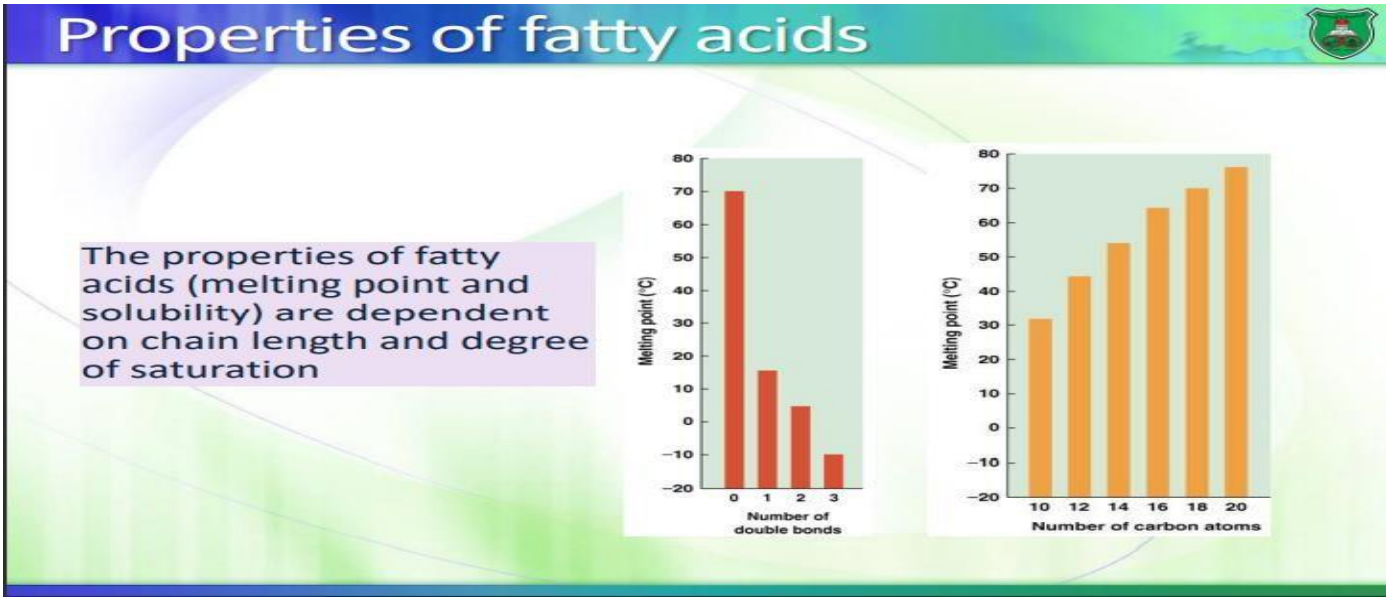
**Cis : the hydrogen atoms on the carbons of double bond in the same direction**
**Trans : the hydrogen atoms on the carbons of double bond in the opposite direction.**

**if the hydrogen atoms in the same direction (cis) , to reduce steric hindrance , I bend the molecule , but trans molecule ( opposite direction of hydrogen atoms) they don't have steric hindrance , they are going to be just like the saturated ( zig zag shape )**

**Most fatty acids are actually present as cis configuration. Fatty acids trans are produced by manufacturing processes*.**

***Unsaturated lipids are converted to saturated by hydrogenation . During hydrogenation, it does not occur completely some of the bonds remain the same and become trans .**

**When the unsaturated fatty acids (cis or trans ) accumulate in large quantities in the blood vessels , It does a lot of reactions and turns into a solid state. This leads to a reduction in the diameter of the blood vessel and the thickness of its wall will increase and these fats will lose the blood vessel's elasticity and lead to hardening.(arteriosclerosis)**




**What are the important factors that determine the properties of fatty acids ?**

**1-number of carbons (The higher number of carbon atoms, the melting and boiling points will increase) because when the number of carbon atoms increase , the hydrophobic interactions will increase.**

***the higher number of carbon atoms , the solubility will decrease**

**2- the number of double bonds ( The higher number of double links , the melting and boiling points will decrease ) Because there will be kinks , they will move away from each other more and the interactions will decrease and therefore decrease melting and boiling points . (notice the huge drop in bp in the graph when adding the first double bond )**

## Properties of saturated fatty acids

| Short chain F.A. | Medium-chain F.A. | Long chain F.A. |
|---|---|---|
| They are liquid in nature | Solids at room temperature | Solids at room temperature |
| Water-soluble | Water-soluble | Water-insoluble |
| Volatile at RT | Non-volatile at RT | Non-volatile |
| Acetic, butyric, caproic FA | Caprylic & capric F.A. | Palmitic and stearic F.A |



**Calcification of fatty acids according the number of carbons:**

**1-Short chains (outside the physiological range )→(5-6 carbon atoms)**

**2-Medium chains → up to 11 and 12 carbon atoms**

**3-Long chains → 12-20 carbon atoms**

**4-Very long chains →21-24carbon atoms**

***Medium chains are less soluble than short chains .**

***Medium chains are abundant in breast milk .**

## Naming of fatty acids: Greek number prefix

| Number | prefix | Number | prefix | Number | prefix |
|---|---|---|---|---|---|
| 1 | Mono- | 5 | Penta- | 9 | Nona- |
| 2 | Di- | 6 | Hexa- | 10 | Deca- |
| 3 | Tri- | 7 | Hepta- | 20 | Eico- |
| 4 | Tetra- | 8 | Octa- | | |

## Naming of a fatty acid

- Alkane to oic
  - Octadecane (octa and deca) is octadecanoic acid
    - One double bond = octadecenoic acid
    - Two double bonds = octadecadienoic acid
    - Three double bonds = octadecatrienoic acid
- Designation of carbons and bonds
  - 18:0 = a C18 fatty acid with no double bonds
    - stearic acid (18:0); palmitic acid (16:0)
  - 18:2 = two double bonds (linoleic acid)
- Designation of location of bonds
  - $\Delta^n$: The position of a double bond
    - cis-$\Delta^9$ :a cis double bond between C 9 and 10
    - trans-$\Delta^2$:a trans double bond between C 2 and 3

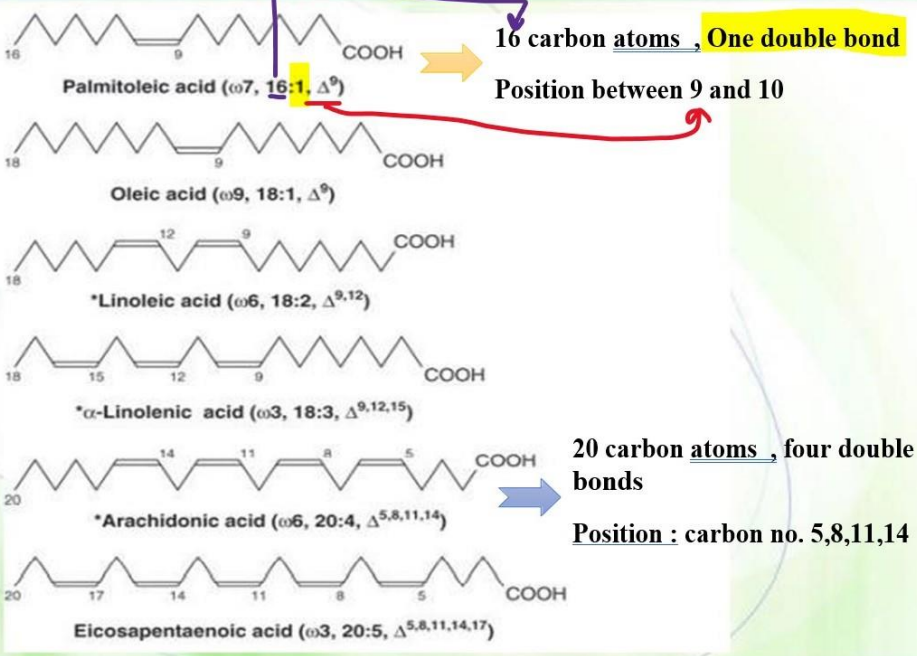
**18→ octa +deca**

**Octadecane : alkane → octadecanoic acid : carboxylic acid (18 carbon atoms and Saturated)**

**Octadecenoic acid one double bond**

**Octadecadienoic acid two double bonds ….. and so on .**

## Naming of a fatty acid




**16 carbon atoms , One double bond**

**Position between 9 and 10**

**20 carbon atoms , four double bonds**

**Position : carbon no. 5,8,11,14**

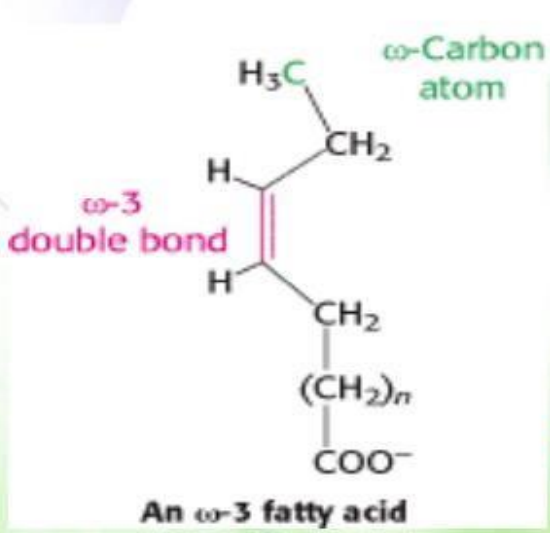
# Naming of a fatty acid

| Number of carbons | Number of double bonds | Common name | Systematic name | Formula |
|---|---|---|---|---|
| 14 | 0 | Myristate | n-Tetradecanoate | $CH_3(CH_2)_{12}COO^-$ |
| 16 | 0 | Palmitate | n-Hexadecanoate | $CH_3(CH_2)_{14}COO^-$ |
| 18 | 0 | Stearate | n-Octadecanoate | $CH_3(CH2)_{16}COO^-$ |
| 18 | 1 | Oleate | cis-$\Delta^9$-Octadecenoate | $CH_3(CH_2)_7CH=CH(CH_2)_7COO^-$ |
| 18 | 2 | Linoleate | cis,cis-$\Delta^9,\Delta^{12}$-Octadecadienoate | $CH_3(CH_2)_2(CH=CHCH_2)_2(CH_2)_6COO^-$ |
| 18 | 3 | Linolenate | all-cis-$\Delta^9,\Delta^{12},\Delta^{15}$-Octadecatrienoate | $CH_3CH_2(CH=CHCH_2)_3(CH_2)_6COO^-$ |
| 20 | 4 | Arachidonate | all-cis-$\Delta^5,\Delta^8,\Delta^{11},\Delta^{14}$-Eicosatetraenoate | $CH_3(CH_2)_4(CH=CHCH_2)_4(CH_2)_2COO^-$ |

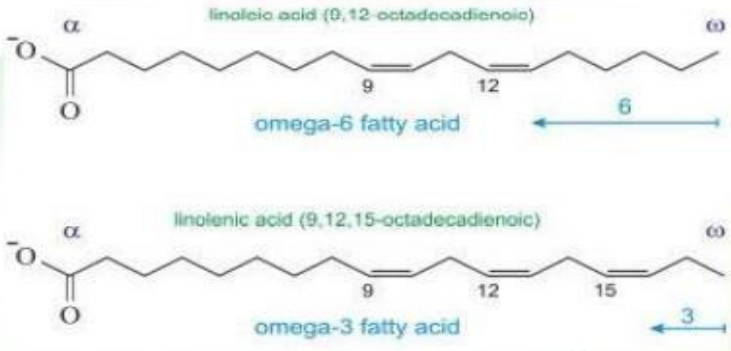
****The common name is very important .**

# Another way of naming (Omega)

- (ω)-C: distal methyl C as #1



An ω-3 fatty acid

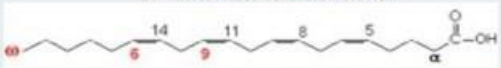
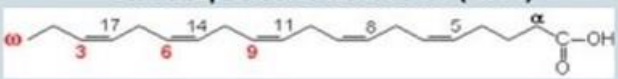



- **Linoleic acid: precursor of arachidonates**
- **Linolenic acid: precursor of EPA and DHA**

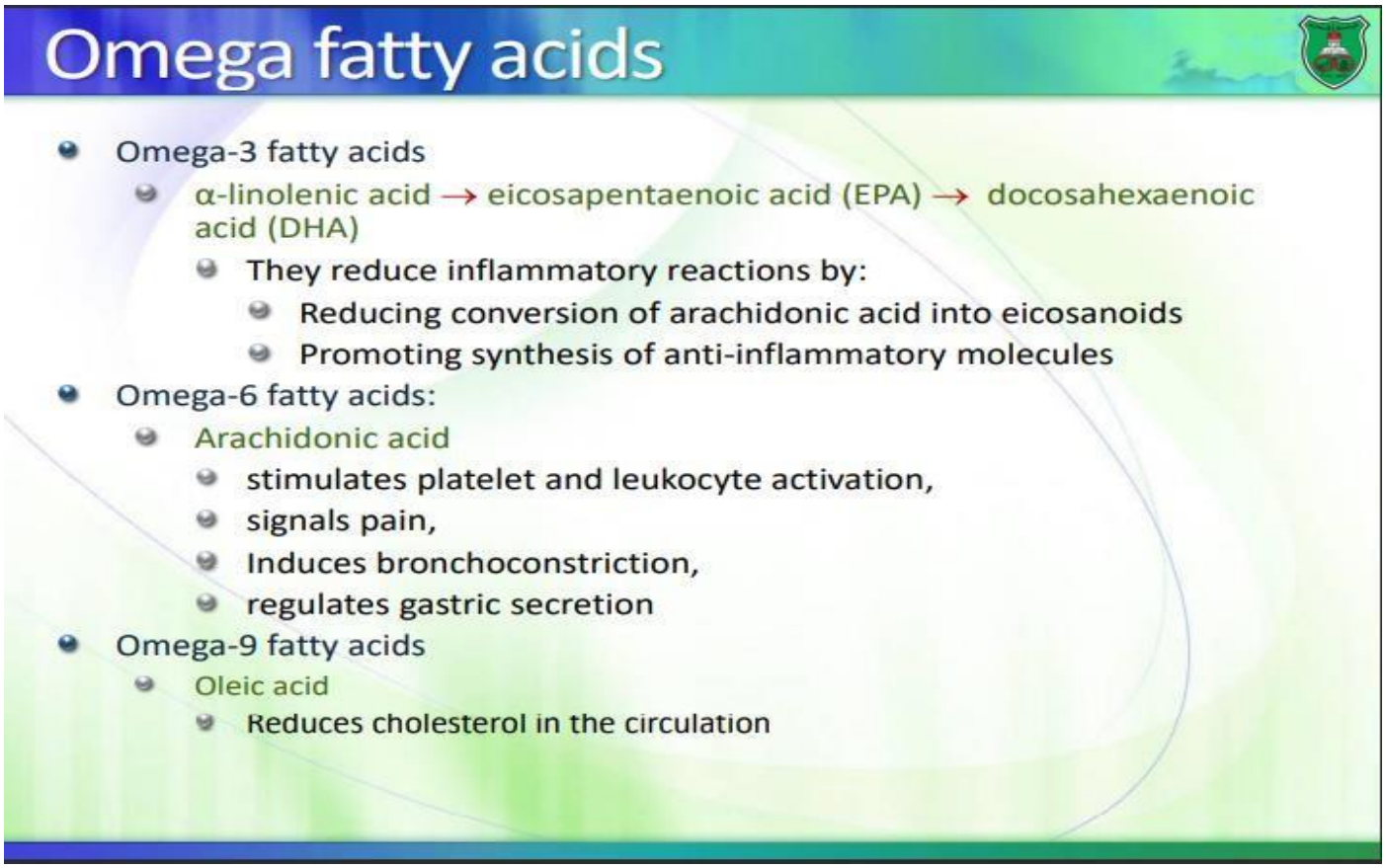
**Omega is the classification that depends one where did the first double bond is located .**

(بالعادة نبدأ نعدّ من جهة مجموعة الكربوكسيل، لكن لما ابدأ العد من الجهة الثانية ( من النهاية ) ،أول رابطة ثنائية بين كربونة 3 و كربونة 4 (بناءً على السلايد الي فوق ) و جبت fatty acid اخر ، كمان أول رابطة ثنائية بين كربونة 3 و كربونة 4) these fatty acids are similar in function

بس ما بقدر من خلالها أعرف كم رابطة ثنائية بالسلسلة .

| Numerical Symbol | Common Name and Structure | Comments |
|---|---|---|
| $18:1^{\Delta 9}$ | Oleic acid  | Omega-9 monounsaturated |
| $18:2^{\Delta 9,12}$ | Linoleic acid  | Omega-6 polyunsaturated |
| $18:3^{\Delta 9,12,15}$ | α-Linolenic acid (ALA)  | Omega-3 polyunsaturated |
| $20:4^{\Delta 5,8,11,14}$ | Arachidonic acid  | Omega-6 polyunsaturated |
| $20:5^{\Delta 5,8,11,14,17}$ | Eicosapentaenoic acid (EPA)  | Omega-3 polyunsaturated (fish oils) |
| $22:6^{\Delta 4,7,10,13,16,19}$ | Docosahexaenoic acid (DHA)  | Omega-3 polyunsaturated (fish oils) |

**Common name is very important**



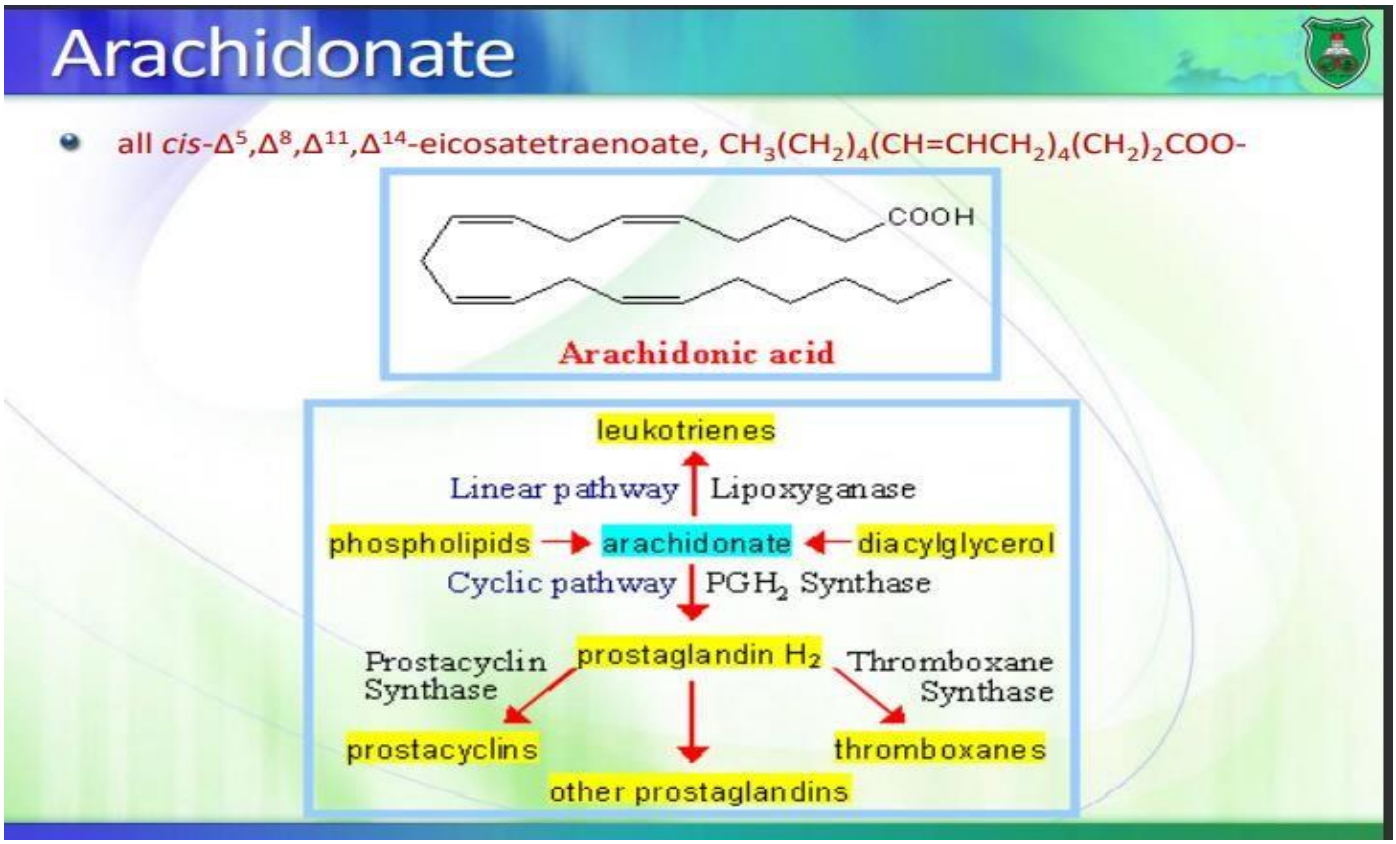

***Arachidonic acid will be used to synthesis other compounds like eicosanoids (inflammatory mediators) includes: prostaglandins, decortins... etc.**

**These are important because they reduce inflammatory reactions .**

***If inflammatory reaction occurs frequently in the same area , one of the types of cancer will form .**

***oleic acid -> found in olive oil**


**Eicosanoids are group of compounds derived from Arachidonaic acid**




**Arachidonate (a polyunsaturated fatty acid with 20 carbon atoms and 4 double bonds) are synthesized from omega 6 (linoleic acid)**

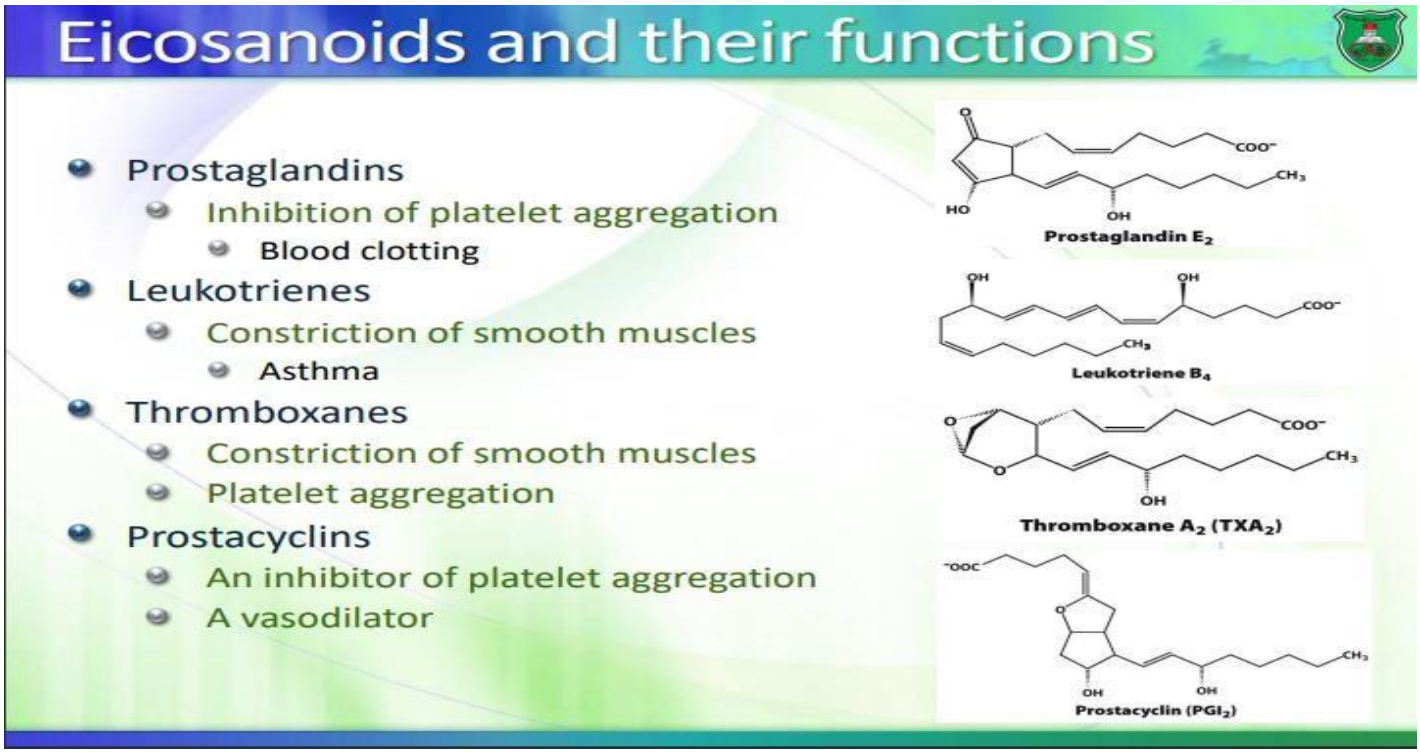
**Arachidonic acid are synthesized either directly from essential fatty acids or it is being made and exists as a fatty acid of a phospholipid and cutting it (phospholipid ) and taking it as a precursor molecule to synthesis Eicosanoids. Eicosanoids includes a group of molecules like (leukotrienes, prostaglandins, thromboxanes, prostacyclins ...etc)**

**Manufacturing process :**

**1*linear pathway → mediated or catalyzed by lipoxyganase to generate leukotrienes**

**2*cyclic pathway → started with $PGH_2$ synthase (prostaglandin $H_2$ )**

**and other types of prostaglandin are also made from it as well as prostacyclin and thromboxanes**




***prostaglandins (found in many cells)**
**-The structure of prostaglandins ($E_2$)**
**- All prostaglandins own the pentagonal ring**
**Other modifications (OH , $COO^-$,....) → different from prostaglandins to another**

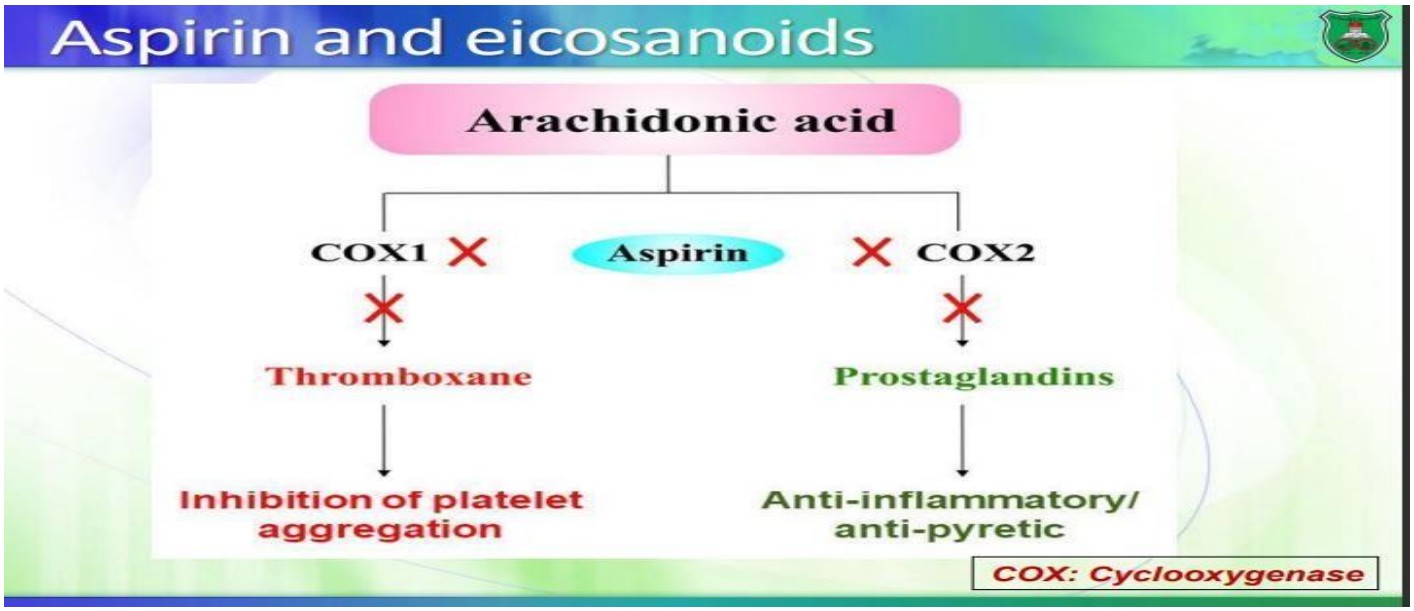
**Function: Inhibition of platelet aggregation**
**When a person is injured, he will bleed; to stop the bleeding, blood clotting occurs (it takes a relatively long time) and the rapid reaction platelet collects on the place of the wound in the form of a bandage from the inside and the bleeding stops as a first step.**

***Leukotrienes (linear pathway):**
**Found in many cells . They have 3 conjugated double bonds .**
**Function: They can induce constriction of smooth muscles (in the airways)**
**A patient who has a crisis ( has an inflammatory response ) is exposed to many irritants and inflammation occurs , and for that to happen , it needs to leukotriene . When the leukotrienes are secreted , the smooth muscles in the airways are constricted . they have difficulty releasing $CO_2$ and releasing air in exchange .**

*** Thromboxanes (cyclic pathway)**
**They have cyclic ether (R-O-R)**

**Function: They can induce constriction of smooth muscles and they affect platelet aggregation (increase)**

***Prostacyclins (cyclic compounds (more than one ring) )**
**Function: Inhibition of platelet aggregation**
**A vasodilator (relaxation)**




**Until the Arachidonic acid follows this pathways (specific cyclic pathway ( thromboxanes , prostacyclins , prostaglandins ) the enzyme it needs is called cyclooxygenase ($COX_1$ , $COX_2$ ) . These 2 enzymes have the same result , but the difference between them which condition we use these enzymes in and other functions of the resulting compounds (physiological functions) .**

***$COX_1$ works under normal conditions**

***$COX_2$ works under inflammation .**

**Aspirin (analgesic , antipyretic , anti-inflammatory ) , it inhabits two enzymes ($COX_1$, $COX_2$)**