



Molecular Biology

Lec : 5

Done by : leen Al-Ashram

Lipids of biological importance- 1

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Majority of slides: Dr. Walaa Bayoumie El Gazzar

Why study lipids (importance)

الأغذية (الأغذية) طاقة
ولكن في
الأغذية

- High energy value (9 kcal /gm)

* main energy source: Carb.
* Highest energy source: lipids

- The fat-soluble vitamins and the essential fatty acids in foods

لا يستطيع الجسم
تأمينها، ولا زرع
فإنها من المواد الخارجية

- Lipids are found primarily in three **compartments** in the body:

* حيثما هو الجزيء للبروتين
* داخل البروتينs

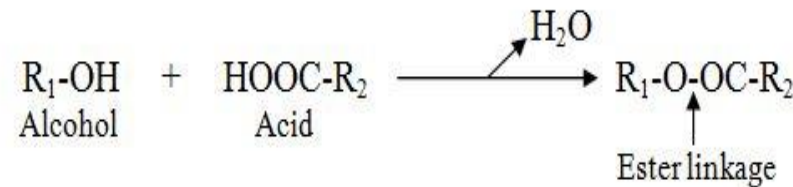
- Plasma
- Adipose tissue
- Biological membranes

- **Definition:** Lipids are organic substances
 - Which are related to **fatty acids**

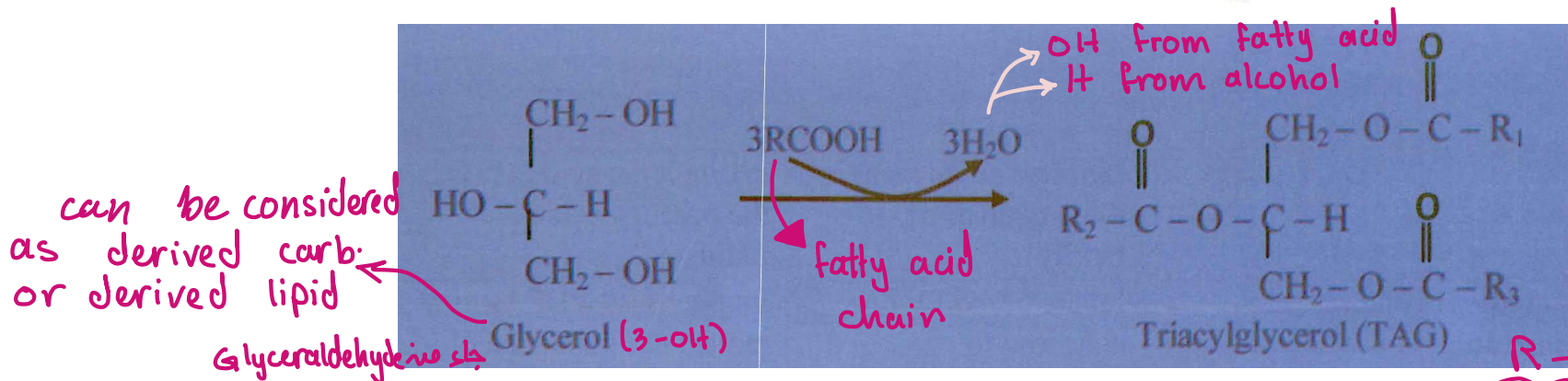
carb. were
organic
substances

- They are water insoluble (non-polar, hydrophobic) but soluble in fat solvents as alcohols, chloroform, benzene, acetone, ethers...etc

- Lipids are formed mainly of **alcohol** and **fatty acids** combined together by **ester linkage**



Glycerol can
be attached to
three fatty
acids



Classification of lipids

→ simple, But consist of two components

1- Simple lipids:

– TAG and wax

بیشتر TAG
لكن الكحول مختلف نوعي

→ one glycerol & three fatty acids

triacylglycerol

2-Compound, complex or structural lipids → lipid + $\frac{\text{تأثير}}$

- Phospholipids (lipid + phosphate)
- Glycolipids
- Lipoproteins

3-Derived Lipids

وليس
simple

- For example: fatty acids , glycerol

4-Substances associated with lipids

- Steroid hormones, lipid soluble vitamins

Classification of lipids

1- Simple lipids:

- These are **esters** of alcohols with fatty acids

- According to alcohol they are sub classified into:

يعمل 3 روابط، وكل رابطة
تسمى رابطة استرية
→ Ester Bond

ما نخفي انه روع
تم تكسير/نبلي
lipids في الجسم
فهو نه المهم صبور
TAG₁

→ 3OH alcohol / 3C
– **Triacylglycerols:** these are esters of glycerol with 3 fatty acids

- When **fatty acid** are esterified to glycerol **they lose their negative charge**, and hence the name neutral fats → another name for TAG₁

alcohol (glycerol) + 3 Fatty acids

- **Waxes:** these are esters of monohydric alcohols higher than glycerol with one fatty acid

alcohol + one Fatty acid

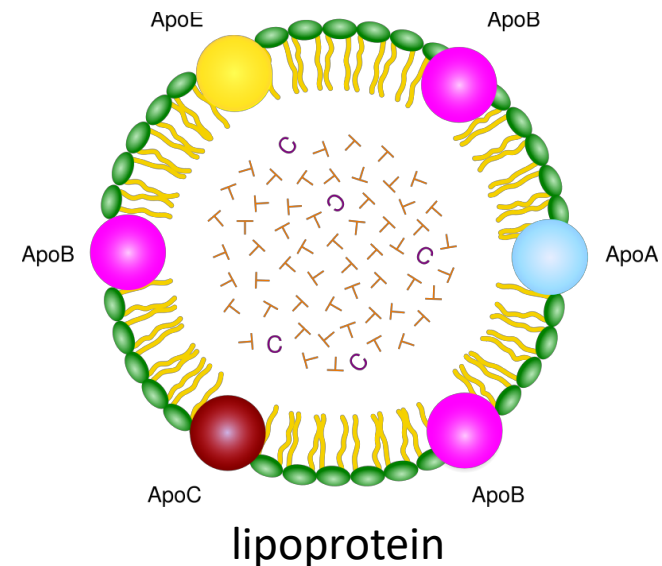
too many C / only one OH ←

Vegetable oil: triacylglycerols (92–98%), polar lipids (phospholipids and galactolipids), monoacylglycerols, diacylglycerols

↳ glycerol + one fatty acid ↳ glycerol + two fatty acids

2-Compound, complex or structural lipids:

- They are formed of simple lipids in addition to other substances or groups:
 - Phosphate → phospholipids
 - Carbohydrates → Glycolipids
 - Proteins → lipoprotein



3-Derived Lipids:

- These types of lipids are derived from simple & compound lipids
 - Obtained by the hydrolysis of the above groups → fatty acids. ΔB / or glycerol ΔB *In fact, glycerol is both lipid + carbo. derived

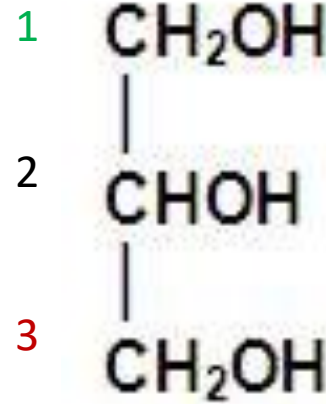
4-Substances associated with lipids:

- These are substances present associated with lipids in nature and related to them in properties and metabolism, as:
 - fat soluble vitamins (A, D, E & K)
 - sterols as cholesterol and provitamins as carotenes

Simple lipids

(TAG); its backbone is Glycerol

Primary carbons
(1+3)



Secondary carbon (2)

I. Glycerol:

→ 3OH

• It is the simplest form of trihydric alcohol

it has a hygroscopic nature [يسحب الماء]

• Glycerin suppository ← وذلك تحبلة الجلسرين

• It is commercially known as glycerin: $\text{CH}_2\text{OH}.\text{CHOH}.\text{CH}_2\text{OH}$

• Glycerol is the main component of neutral fats

• Since the glycerol contains three hydroxyl groups, it has the ability to combine with three FA through an **ester bond**.

↳ fatty acids might be the same, or different

• These FA may be the same to give simple triacylglycerols (TAG) or different to give mixed triacylglycerols.

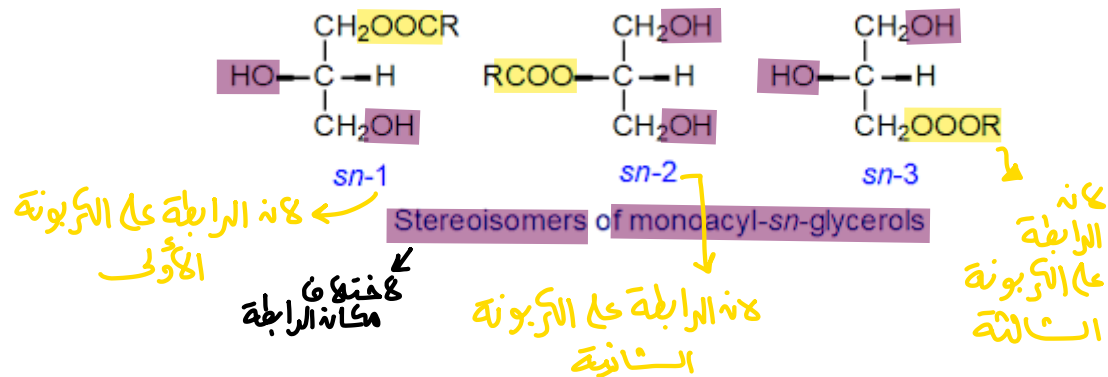
• The most common FAs which may enter in the structure of neutral fats are palmitic, stearic and/or oleic acids.

85 لماذا في
primary,
secondary?
أنه في إنزيمات
تستغل على
كربونات (3+1)
فقط وما تستغل
على 1 والوكس
مستجيب

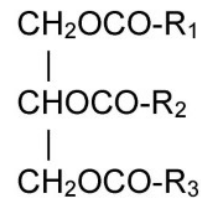
treats occasional
constipation → معالجة الإمساك

*acyl \Rightarrow fatty acid

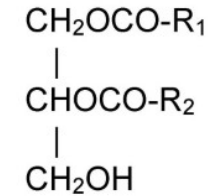
- Glycerol can be esterified with:
 - One FAs \rightarrow monoacylglycerol
 - Two FAs \rightarrow diacylglycerol
 - Three FAs \rightarrow triacylglycerol



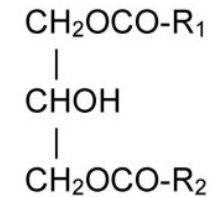
A. Triacylglycerol (TAG) B. Diacylglycerol (DAG)



a) 1,2-DAG
fatty acid is attached to C₁ + C₂



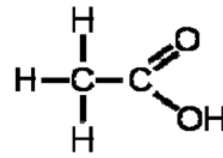
b) 1,3-DAG



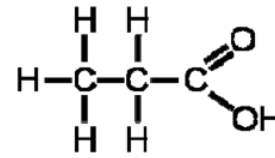
1,2-DAG:1,3-DAG = 3:7

كل من زيت ال glycerol الحيواني و 3OH / و لكن لا تظهر على الكربون بعد عمل الرابطة الاستيرية
 لأنها تزعجت منه أجله الرابطة

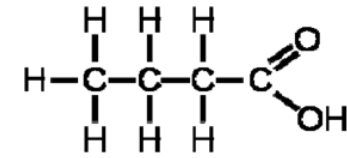
II. Fatty acids



Acetic acid



Propionic acid



Butyric acid

Compare with carbohydrates

- * Hydrocarbon chain - CH₂CH₂CH₃
- * carboxyl group - COOH

الأكثر انتشاراً **Most** fatty acids are monocarboxylic acids → contains only one carboxyl group

exception • 4 carbons, dicarboxylic → succinic acid
2-COOH

- They have the general structural formula; R-COOH

ذرات الهكسجين موجودة فقط في مجموعة الكربوكسيل، بينما في الكربوهيدرات على ذرة كربون واحدة هناك جزئ (C_nH_{2n}O_n)

- **General properties of FA:**

- The chain length may vary from 2 to 24 carbon atoms

called acetic acid

there is hydrocarbon chain and less than carbon

- Natural occurring FA had an even number that results in more energy with few exceptions
2-4-6-8

- energy is because of fatty acids (CH₃CH₂CH₂CH₂...)

ألفا تحوي طاقة أعلى

↑ الكاربوهيدرات، بينما الأخرى... وهذا الاختلاف يأتي بسبب طاقة C-H أكثر من طاقة O-H... وهذا الاختلاف يأتي بسبب... **They may be saturated or unsaturated in H**

Classification of Fatty acids:

There are different methods for classification of FA depending on:

1- The total number of carbon atoms

- **Even chain:** Most of the naturally occurring lipids contain even chain FA. They have carbon atoms 2, 4, 6 and similar series
- **Odd chain:** They are present in milk and microbial cell wall. They have carbon atoms 3, 5, 7. etc.

سلسلة زوجية
even chain
differs from
odd chain

2- Length of hydrocarbon chain: in fatty acid

- **Short chain FA:** with 2 to 6 carbon atoms
- **Medium chain FA:** with 8 to 14 carbon atoms.
- **Long chain FA:** with 16 to 22 carbon atoms.
- **Very long chain FA:** with more than 24 carbon atoms.

السلسلة القصيرة
Short chain

وكل ما تحول ال
chains ثقيل
ال Solubility

فقط 2C acetic acid مثل الخليك insoluble ولكن في استثناءات، يزيد إلى 4 ما في بلا كاتو يكون من

3- Nature of hydrocarbon chain:

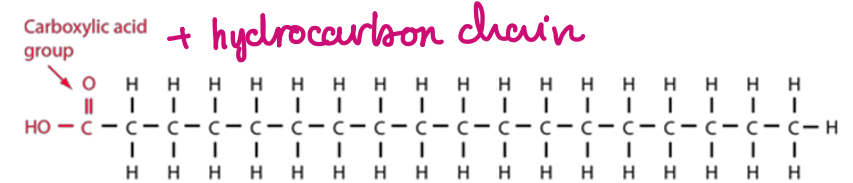
– **Saturated FA (SFA):** without any double bond (suffix: **anoic**)

fatty acid
أحماض دهنية
anoic الدهني
سبعة
saturated

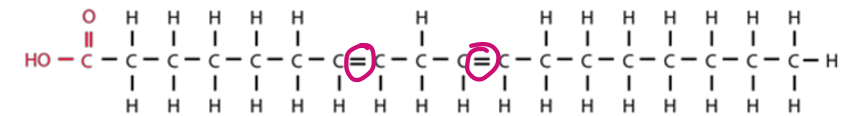
– **Unsaturated FA (USFA):** which may be subclassified into:

- mono-unsaturated (mono**enoic** or monoethenoid) containing one double bond or
- poly-unsaturated (poly**enoic** or polyethenoid) containing 2 or more double bonds.

← استة الدهني
enoic
بني
unsaturated
بني



Stearic acid, an example of a saturated fatty acid

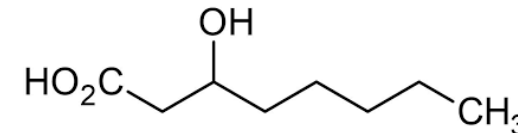


Linoleic acid, an example of an unsaturated fatty acid

exception

- **Branched FA:** e.g. isovaleric acid
- **Hydroxy FA:** e.g. cerebronic acid (brain lipid)

↳ extra OH



• **The most common fatty acids in nature are long chain and straight chain (aliphatic) with an even number of carbon atoms.**

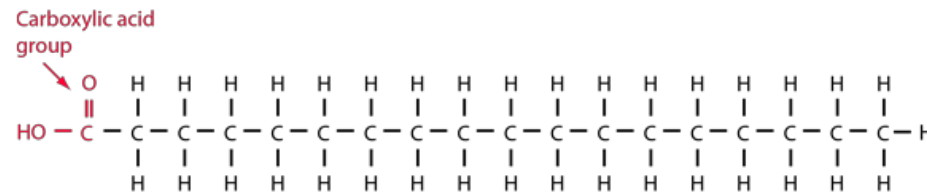
Chemistry of fatty acids

- Generally are hydrophobic → water insoluble
- Carboxyl group (COOH) at one end and methyl (CH₃) group at another
- Carboxyl group acquires negative charge:
 - Negative charge → polar so affinity for water
 - Hydrocarbon chain → water insoluble

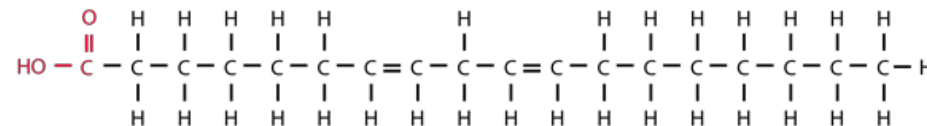
Amphipathic

- The longer the chain, the more hydrophobic it is , the shorter it is, more probable to be

hydrophilic



Stearic acid, an example of a saturated fatty acid



Linoleic acid, an example of an unsaturated fatty acid

Saturated fatty acids

- They have the general formula $\text{CH}_3 \cdot (\text{CH}_2)_n \cdot \text{COOH}$.
↑ ثابت
- These contain no double bonds
- All fatty acids containing an even number of carbon atoms from **C4 to C24** occur in natural fats and oils, **the most common being palmitic and stearic acids**
- Short and medium chain fatty acids are uncommon except in milk fat and butter.

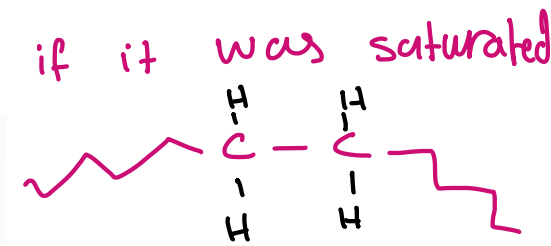
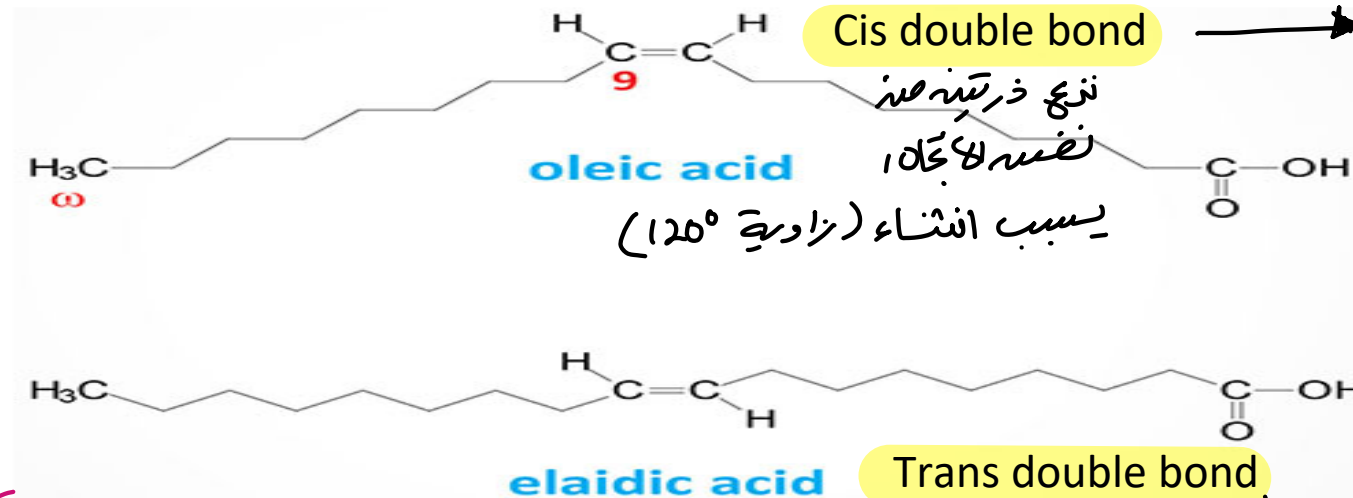
$\text{CH}_3 \cdot (\text{CH}_2)_n \cdot \text{COOH}$ ($n = \text{Total number of carbons} - 2$), for example:

Chain length	Name	C_{No}	Chemical formula
Short	- Acetic acid Vinegar	C_2	$\text{CH}_3\text{-COOH}$
	- Butyric acid Butter	C_4	$\text{CH}_3\text{-(CH}_2)_2\text{-COOH}$
	- Caproic acid	C_6	$\text{CH}_3\text{-(CH}_2)_4\text{-COOH}$
Medium	- Capric acid Coconut	C_{10}	$\text{CH}_3\text{-(CH}_2)_8\text{-COOH}$
Long	- Palmitic acid Body fat	C_{16}	$\text{CH}_3\text{-(CH}_2)_{14}\text{-COOH}$
	- Stearic acid	C_{18}	$\text{CH}_3\text{-(CH}_2)_{16}\text{-COOH}$
	- Arachidic acid Peanuts	C_{20}	$\text{CH}_3\text{-(CH}_2)_{18}\text{-COOH}$
	- Lignoceric acid	C_{24}	$\text{CH}_3\text{-(CH}_2)_{22}\text{-COOH}$

ما كا عرق
ما كا فقه ←

Unsaturated fatty acids

- Naturally occurring unsaturated FA contain **Cis** double bonds
- This makes them bend **120°** at the double bond and lowers their melting temperature.



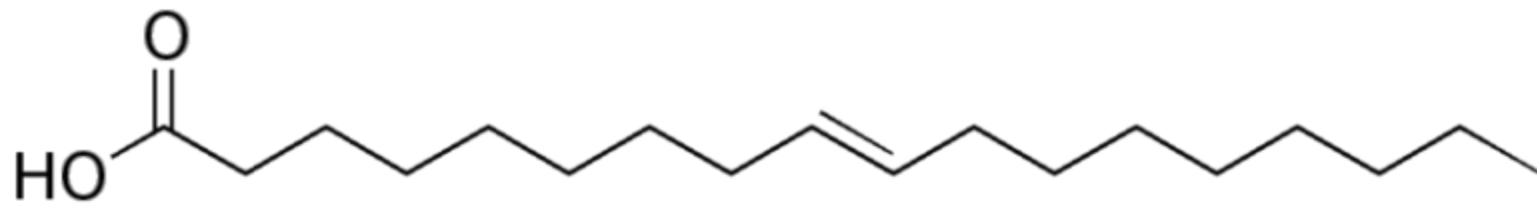
تدريج ذر، تقيمه
تضيقه لا يتكاد
يسبب انثناء (زاوية 120°)

تدريج منه
اتجاهيه
مختلفيه
(لا يسبب انثناء)

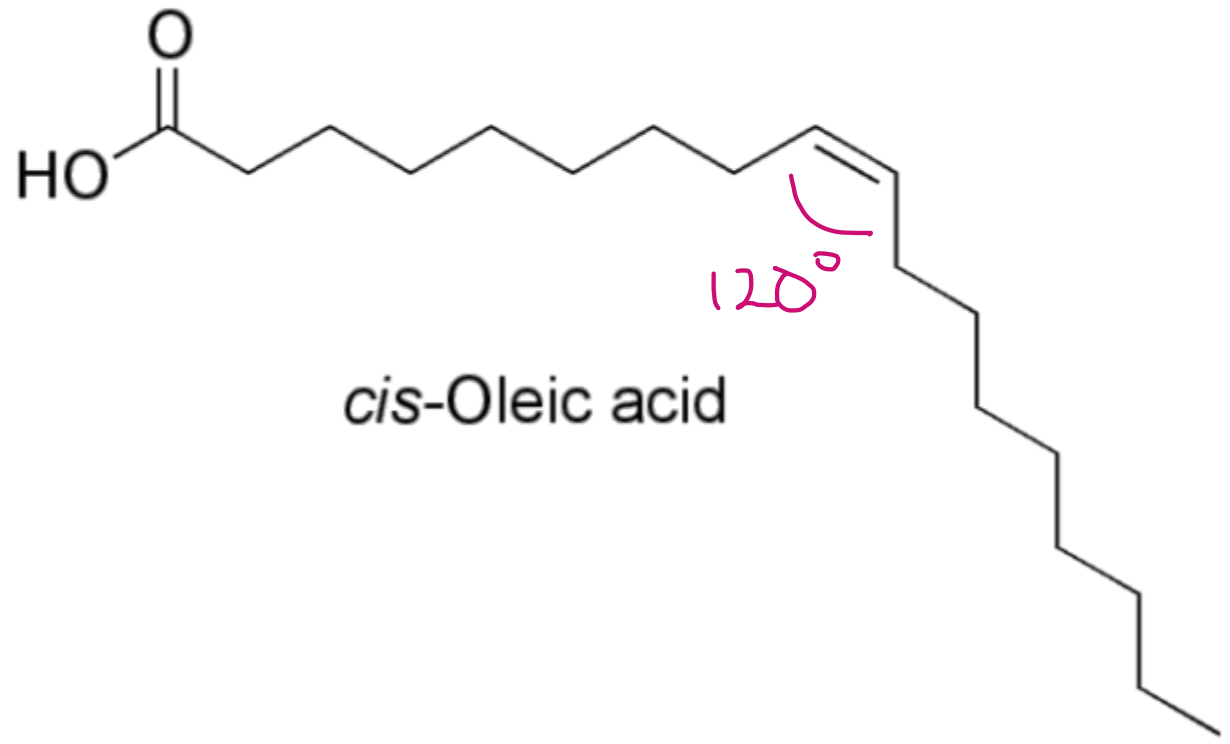
hydrogenation of liquid vegetable oils (during the manufacture of margarine)

الزيتون ابله، رجه منه مني اسه
ماذا؟ لانها تحتوي على
trans double bond





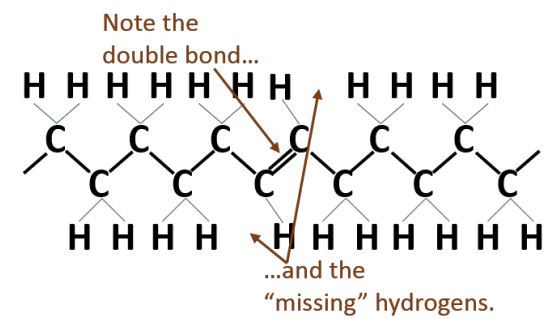
trans-Oleic acid



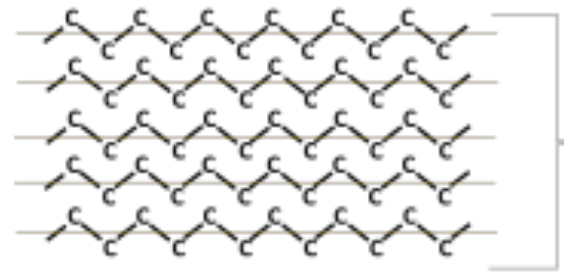
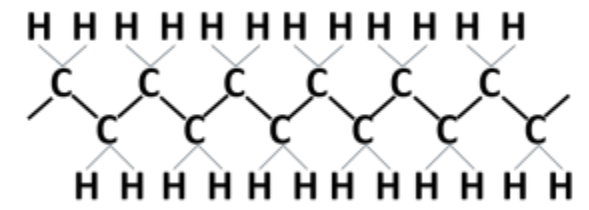
cis-Oleic acid

اي اشني صلب في درجة حرارة الغرفة يكون سيء
 ١)الدهنيات الحيوانية (صلبة) ف سيء
 ٢) السمنة سيء
 ٣) الزيت العادي (مش زيتون) سيء

Trans looks like saturated



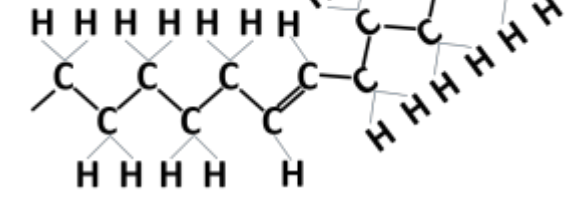
Saturated



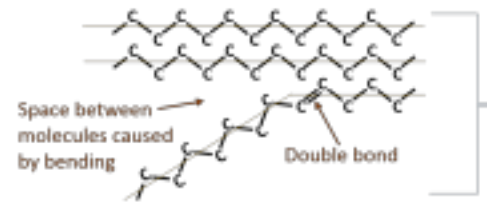
Linear structure allows for tightly packed fatty acids.

Unsaturated

-cis




Cis .. it bends
 The structure has spaces within it
 This results in a fluid structure in room T
 Oils are mostly liquid
 This means that they have double bond/s
 Cis double bond



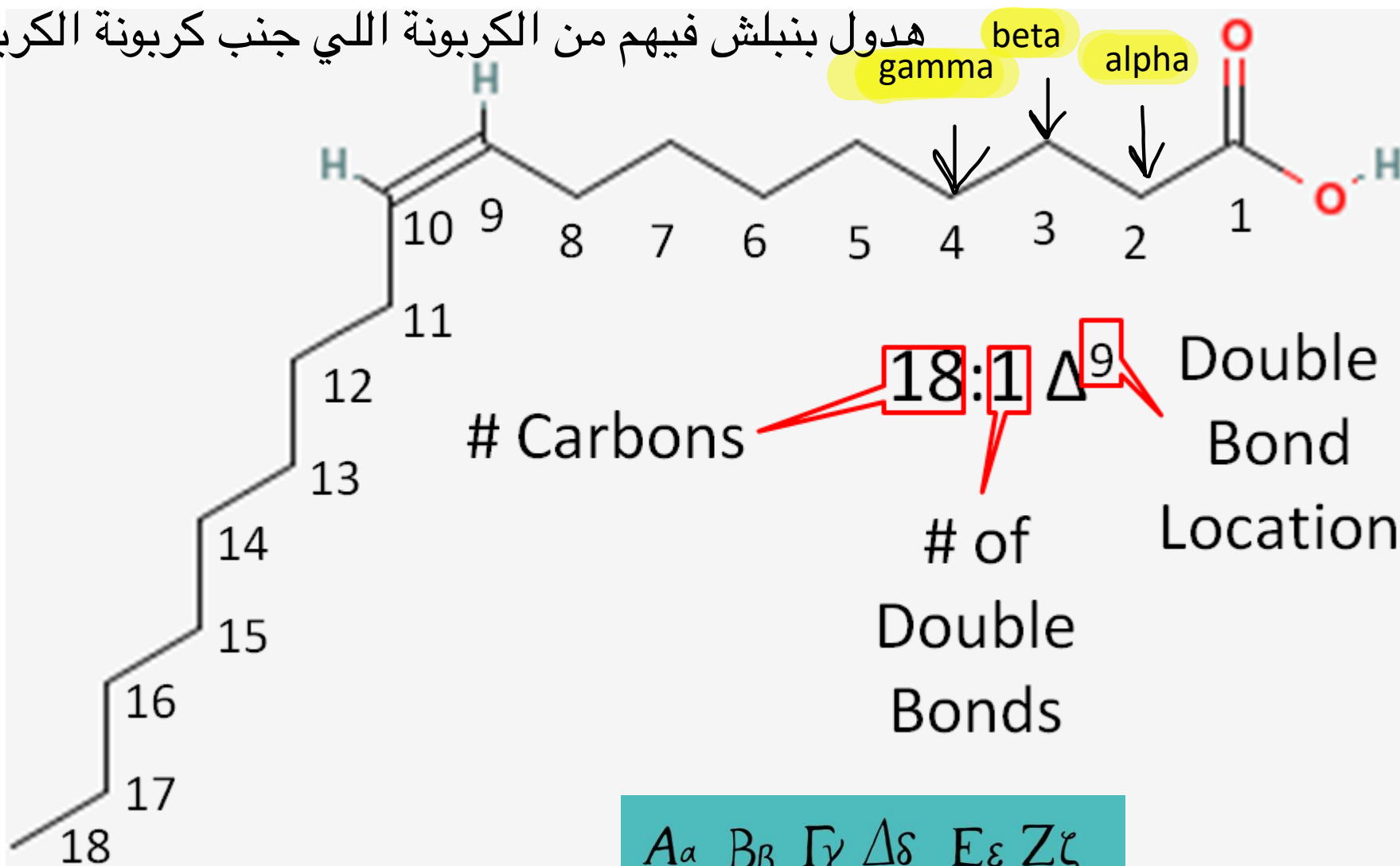
The "bent" structure prevents tight grouping; the resulting spaces keep these molecules fluid.

- Two systems are used for numbering of carbon atoms and denoting the position of double bonds in fatty acids:

➤ (1) Delta (Δ) numbering, or C-numbering, and Greek lettering system

- carbon atoms are numbered from the carboxyl group, which is given the number 1 
- The carbon atom adjacent to the carboxyl group is C-2, and is also known as the α -carbon
- The next carbon is C-3 and is also known as the β -carbon
- The position of the double bonds is shown by the Greek letter Δ (delta), e.g. Δ^9 indicates a double bond between carbons 9 and 10 such as in palmitoleic acid

هدول بنبلش فيهم من الكربونة اللي جنب كربونة الكربوكسيل

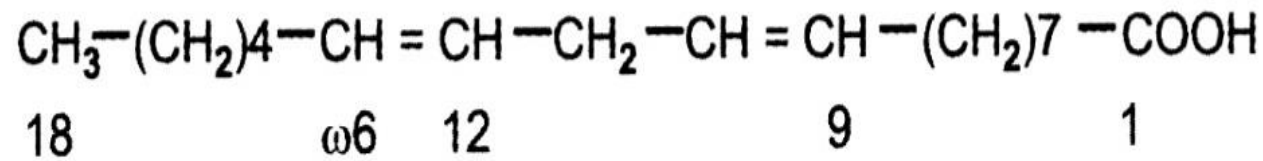


Carbons **18:1** Δ **9** Double Bond Location
 # of Double Bonds

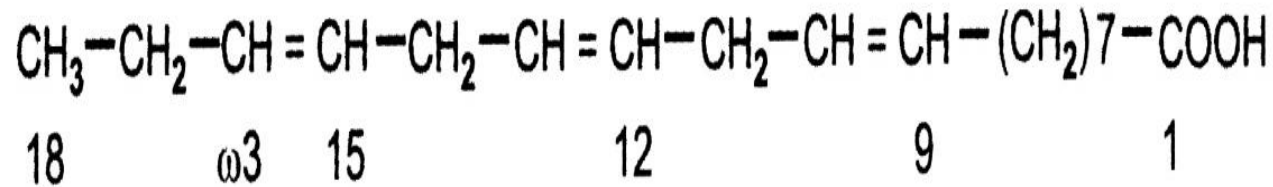
A _α	B _β	Γ _γ	Δ _δ	E _ε	Z _ζ
ALPHA	BETA	GAMMA	DELTA	EPSILON	ZETA
H _η	Θ _θ	I _ι	K _κ	Λ _λ	M _μ
ETA	THETA	IOTA	KAPPA	LAMBDA	MU
N _ν	Ξ _ξ	Ο _ο	Π _π	Ρ _ρ	Σ _ς Σ _σ
NU	XI	OMICRON	PI	RHO	SIGMA
Τ _τ	Υ _υ	Φ _φ	Χ _χ	Ψ _ψ	Ω _ω
TAU	UPSILON	PHI	CHI	PSI	OMEGA

بیت 9/10 ←
→ بیت 12/13

Linoleic (C₁₈) Δ9, 12 (two double bonds) (ω6 family)

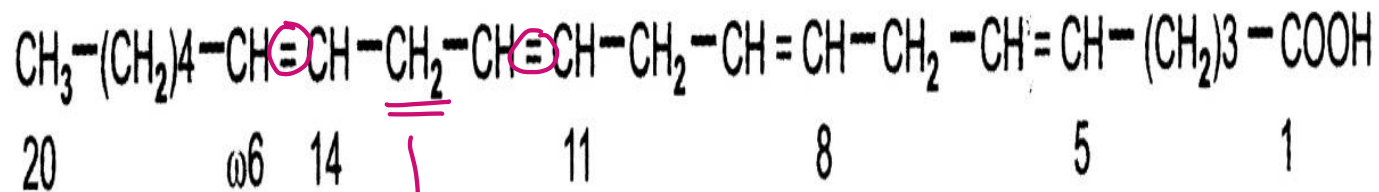


Linolenic (C₁₈) Δ9, 12, 15 (three double bonds) (ω3 family)



↘ 20:4Δ5,8,11,14

Arachidonic (C₂₀) Δ5, 8, 11, 14 (four double bonds) (ω6 family)



↓
btw 2 double Bonds, we must have normal C12

w system

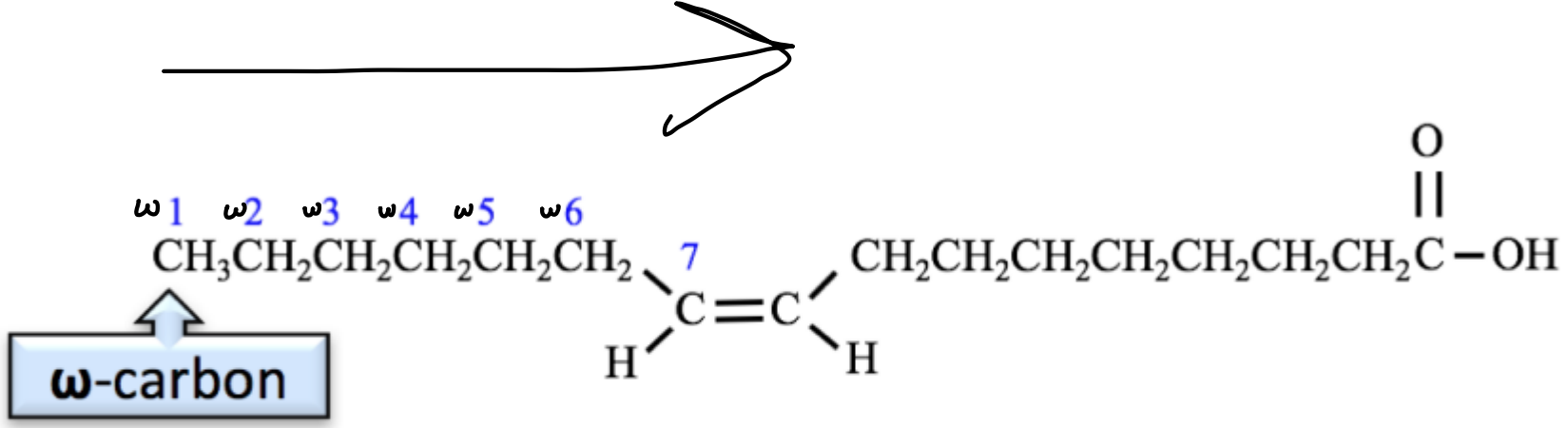
هون بنبلش نعد من جهة الميثيل جروب ، ونسميها اوميغا C

في حالات اللتام nutrition في \Rightarrow allows more double Bond

في السمك omega-3
w-3

وبنا اله كثير
cis =
لانه بصينه في الكيفيان
وفي بودة كثير
بدنا داخل جسمه
زيت سائل

زيت الزيتون vs زيت دوار الشمس
↓
داخل التاجه يبي سائل
↓
أكثر double Bonds
↓
داخل التاجه يتجمد

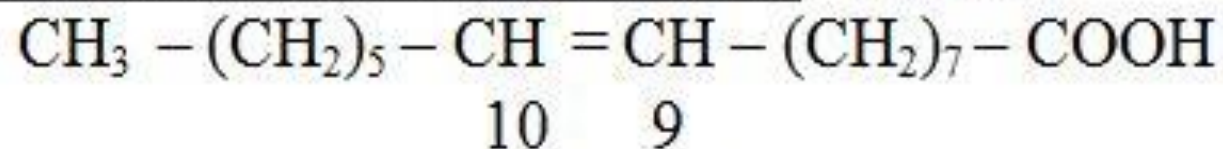


palmitoleic acid (an omega-7 fatty acid)

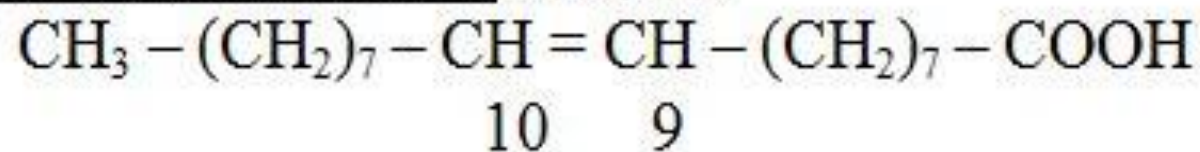
➤ (2) Omega (ω) numbering system

- the methyl carbon **at** the end of the hydrocarbon chain is known as the ω 1 carbon (omega 1 carbon)
- From the nutritional point of view, it is better to indicate the position of the double bond as related to the ω -carbon rather than the carboxyl carbon
- In this way palmitoleic acid is ω 7, oleic acid is ω 9, linoleic and arachidonic acids are ω 6, and α -linoenic and timnodonic acids are ω 3.

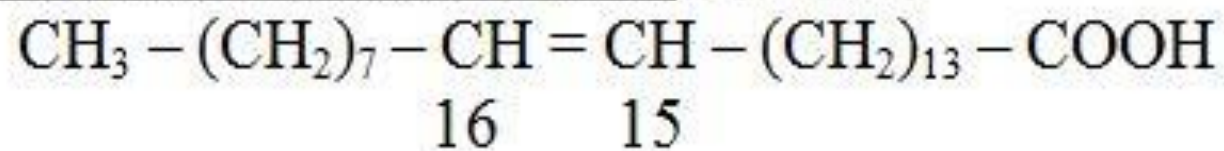
***Palmitoleic (unsaturated palmitic acid): 16:1:w7**

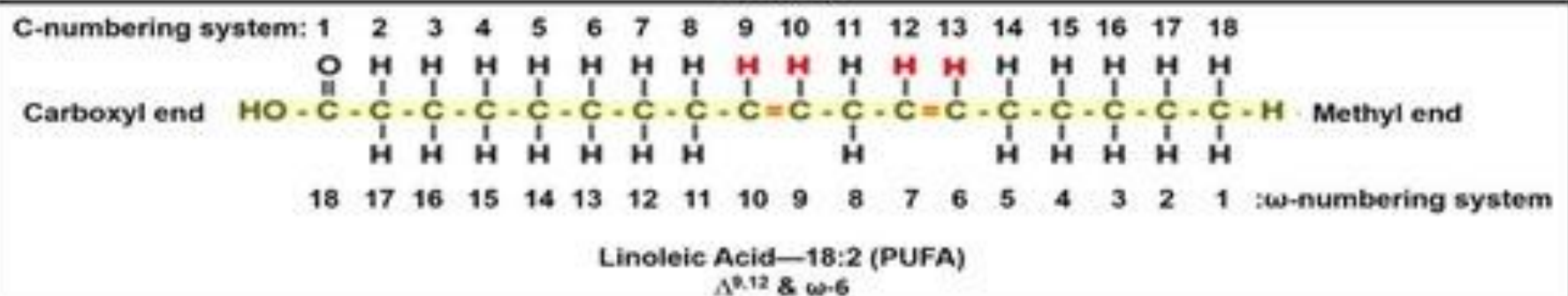
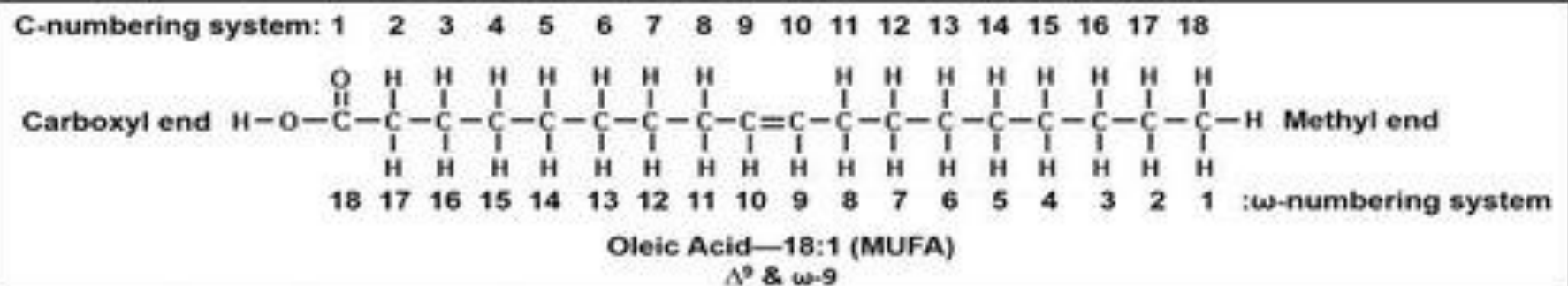
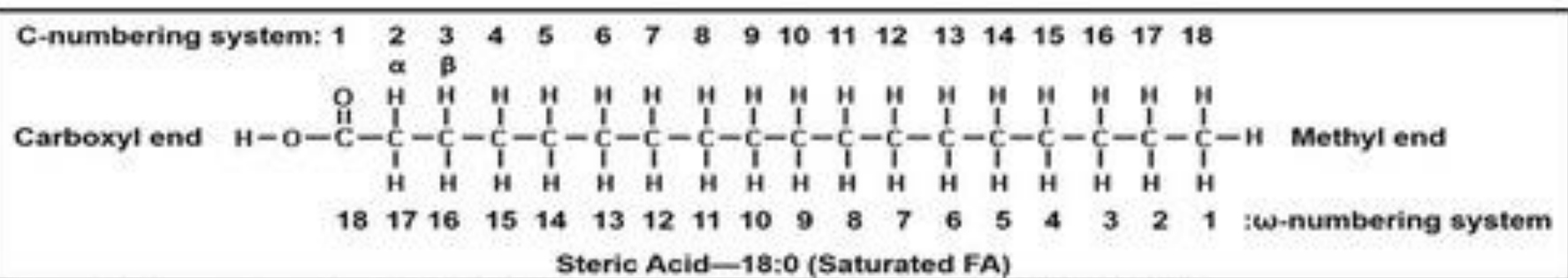


***Oleic (unsaturated stearic): 18:1:w9**



***Nervonic (unsaturated lignoceric): 24:1:w9**





Nomenclature of Fatty Acids

International Union of Pure and Applied Chemistry

Names	Abbreviations	
	carboxyl-reference	ω - reference
trivial		
IUPAC		
palmitic acid	hexadecanoic acid	16:0
stearic acid	octadecanoic acid	18:0
oleic acid	9-octadecenoic acid	18:1 Δ^9
linoleic acid	9,12-octadecenoic acid	18:2 $\Delta^{9,12}$
linolenic acid	9,12,15-octadecenoic acid	18:3 $\Delta^{9,12,15}$

Trivial Names System:

- Trivial names contain no clues to the structures; The names typically derive from a common source of the compound or the source from which it was first isolated. For example, palmitic acid is found in palm oil, oleic acid is a major constituent of olive oil (oleum) and stearic (from the Greek word meaning solid) acid is solid at room temperature. Spiders (arachnids) contain arachidonic acid.

بترت
بعدها
CH
بغيره
CH₂
بعدها
CH
= بعدها
اللي بعدهها

Anoic: saturated
Enoic: unsaturated

Classification of fatty acids

- **Non-essential fatty acids:** can be synthesized in our bodies
- **Essential fatty acids:**
 - Not synthesised in our body (must be taken in diet)

– Linoleic, ($\omega 6$), linolenic ($\omega 3$) are essential fatty acids (EFA), they cannot be synthesized by the body and

These two fatty acids cannot be synthesized by humans because humans lack the desaturase enzymes required for their production

20:4

– Arachidonic acid is not one of the essential fatty acids

- However it does become essential if there is a deficiency in linoleic acid or if there is an inability to convert linoleic acid to arachidonic acid

لأن الجسم لا يستطيع
تصنيع ال double bond
إلا في ال position
الخاص

لو عينا
linoleic + linolenic
بنقدر نصنعها

Importance

صلب في درجة حرارة الغرفة

سواء ، ولكنه نأكله

غير مهدرج

مهدرج؟

أقل خطورة

خطورة

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• Saturated fatty acids:

- Palmitic acid is the commonest fatty acid in human tissues
- Source in diet: animal fats (e.g. milk), palm & coconut oil
- \uparrow intake \rightarrow \uparrow blood cholesterol + \uparrow coronary heart disease.

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• Trans un-saturated fatty acids:

- V small amounts found in butter but the main source in diet is from hydrogenated vegetable oils (eg, margarine).
- Trans fatty acids compete with essential fatty acids \rightarrow may exacerbate essential fatty acid deficiency
- Structurally similar to saturated fatty \rightarrow hypercholesterolemia & atherosclerosis

Importance

- **Cis unsaturated fatty acids :**
 - Either mono or polyunsaturated

	Monoenoic acids	Polyenoic acids	
		ω6 PUFAs	ω3 PUFAs
Sources	are present in all animal and vegetable oils. Olive oil is a particular rich source.	are present in nuts, olives, various oils as sunflower, cottonseed and corn oil.	are present in plant oils as flaxseed and canola and in fish oil.
		Linoleic acid (18:2) is the precursor of ω 6 family	α -Linolenic acid (18:3) is the precursor of ω 3 family
Biomedical importance	Intake has beneficial health effects as: -Decreased plasma cholesterol	Intake of ω 6 PUFAs may lead to: -decreased plasma cholesterol	Intake of ω 3 PUFAs may reduce the incidence of cardiovascular disease as they: -lower the blood pressure, -lower plasma triacylglycerol levels -decrease the tendency to thrombosis

Students to present (next week)

- Compare and contrast of MUFA, PUFA, SFA content of oils present in the market (5 min)
 - What is the most healthy and most unhealthy oil and why
- List foods that contain harmful fats (trans and saturated fats) – as a main ingredient or as one of the ingredients (5 min) – why are they unhealthy

Which of the following fatty acids is considered essential and must be obtained from the diet?

- a) Stearic acid
 - b) Oleic acid
 - c) Linoleic acid
 - d) Palmitic acid
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- Answer: c) Linoleic acid

Which of the following types of fatty acids has been associated with an increased risk of cardiovascular disease?

- a) Saturated fatty acids
- b) Monounsaturated fatty acids
- c) Polyunsaturated fatty acids
- d) Omega-3 fatty acids

Answer: a) Saturated fatty acids

- Which of the following lipids is a major component of adipose tissue and serves as a source of energy storage?
- a) Triglycerides
- b) Cholesterol
- c) Phospholipids
- d) Glycolipids

Answer: a) Triglycerides

- Which of the following lipids is a branched-chain fatty acid commonly found in dairy products and has been associated with a reduced risk of cardiovascular disease?
- a) Myristic acid
- b) Lauric acid
- c) Palmitic acid
- d) Pentadecanoic acid

Answer = d

A fatty acid has 3 double bonds and 18 carbon atoms. Which of the following is the correct representation of this fatty acid

A. 18: 1 delta 9

B. 18: 2 delta 9, 12

C. 18:3 delta 9, 12, 15

D. 18:3 delta 9, 10, 11

E. 18:3 delta 9-15

← = مستحيل
در آن موقع

Answer: C