بسم الله الرحمن الرحيم

BioChemistry | Lecture 9

Lipids Pt.1

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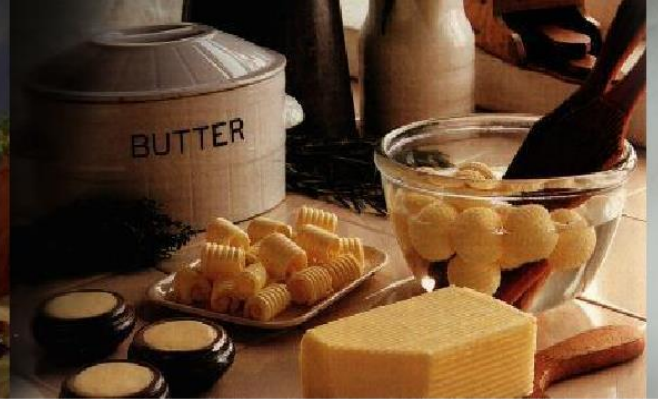
Notes about carbohydrates:

1. All **monosaccharides** are reducing sugars (if you dissolve 1000 glucose molecules in a solution, the anomeric carbon of each one of the 1000 glucose molecules can react with the oxidizing agent because glucose, as a monosaccharide, has a free anomeric carbon).

2. All **disaccharides** are reducing sugars except sucrose (non-reducing).

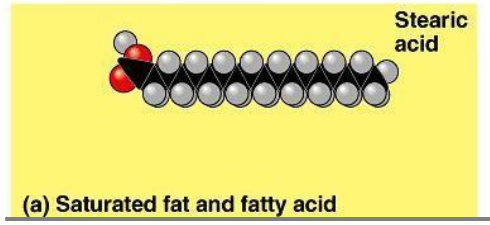
3. In **polysaccharides**, if you have a chain of 1000 glucose molecules attached to each other, only one anomeric carbon, located at the end of the chain, is free and able to be oxidized by the oxidizing agent, but with no significant effect on the solution, because the number of free reducing ends is very small, even though the number of glucose units in the solution is large.

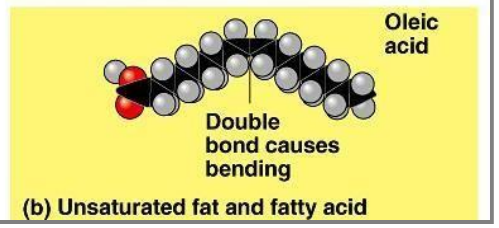

BUTTER


BRING OUT THE BEST
HELLMANN'S
REAL
MAYONNAISE

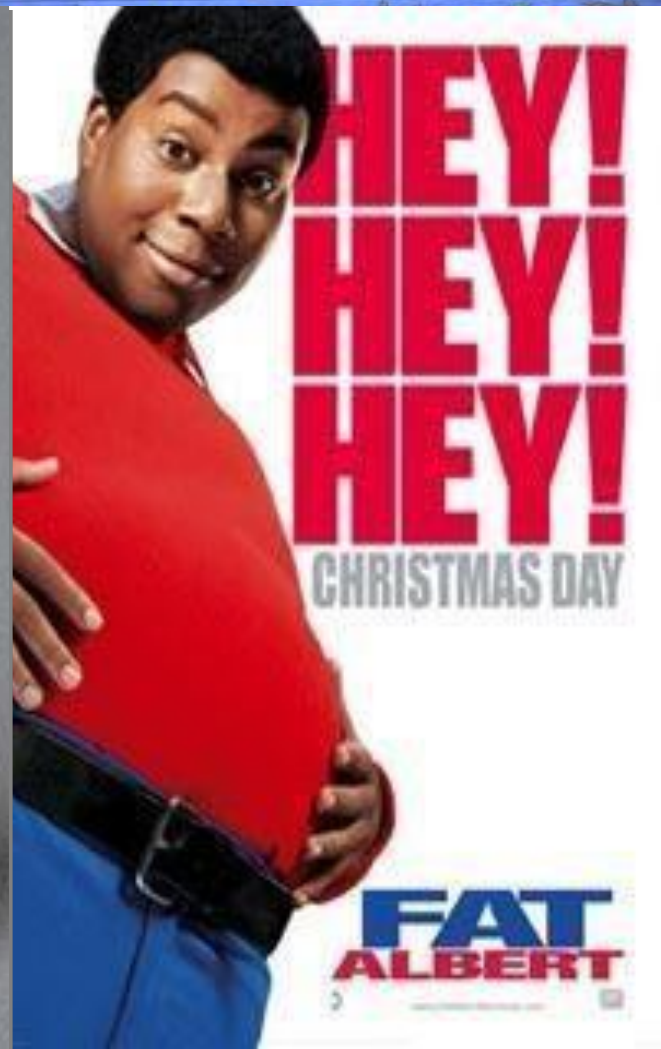

WHOLE KIDS
ORGANIC
SMOOTH
Peanut Butter
WHOLE KIDS
ORGANIC
CRUNCHY
Peanut Butter

Lipids


Stearic acid
(a) Saturated fat and fatty acid


Oleic acid
Double bond causes bending
(b) Unsaturated fat and fatty acid


LOWEST IN SATURATED FAT
Spectrum
NATURALS
PURE PRESSED
CANOLA OIL
BUTTER


HEY!
HEY!
HEY!
CHRISTMAS DAY
FAT
ALBERT

Functions of Lipids:

·Serve as a long-term energy reservoir
·Act as precursors for steroid hormone synthesis
·Contribute to the selective permeability of cell membranes
·Provide insulation against heat loss and electrical impulses(in our nervous system to protect it and transmit electrical signals efficiently)
·Protect vital organs by acting as a cushioning layer and shock absorbers

• Lipids play a crucial role in **compartmentalizing** cells in the body.Each compartment within a cell requires its own distinct environment to function properly. Without lipids, water—being abundant in the body—would freely move between compartments, disrupting their individuality. Lipids form selective barriers due to their hydrophobic nature, helping separate aqueous environments and maintain proper cellular organization.

- **Lipids** are hydrophobic and lipophilic compound formed by the combination (condensing) of fatty acids and alcohols through an **ester bond** (RCOOR'). Like other macromolecules, lipids are synthesized via a dehydration specifically (condensation) reaction releasing water (H2O) as a byproduct.

- In **carbohydrates**, a glycosidic covalent bond is formed during their synthesis, which involves a condensation reaction that produces water (H_2O) as a byproduct. This bond is also classified as an **ether bond** (R–O–R).

- Unlike carbohydrates, lipids are **heterogeneous** compounds. They do not share a single, uniform structure, which makes it difficult to identify a lipid based solely on its structure. This is because lipids are chemically and structurally diverse.

- **Yellow marrow** (النخاع) is a soft, jelly-like tissue found inside bones. It is primarily composed of lipids and is sometimes consumed as food.

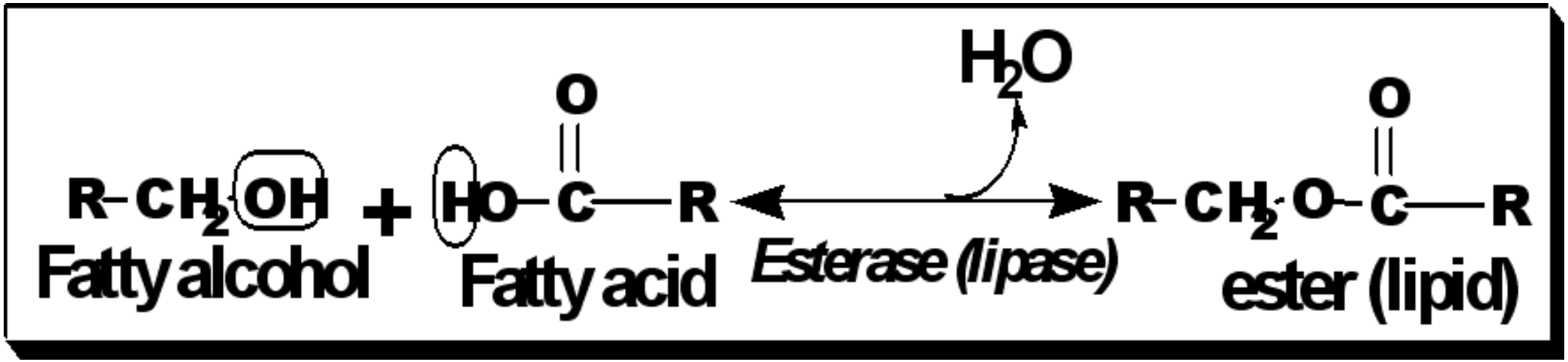
Definition & General Properties

A heterogeneous class of naturally occurring organic compounds

Amphipathic

Insoluble

Macromolecules cannot be broken down in water alone; enzymes are needed to catalyze their breakdown.



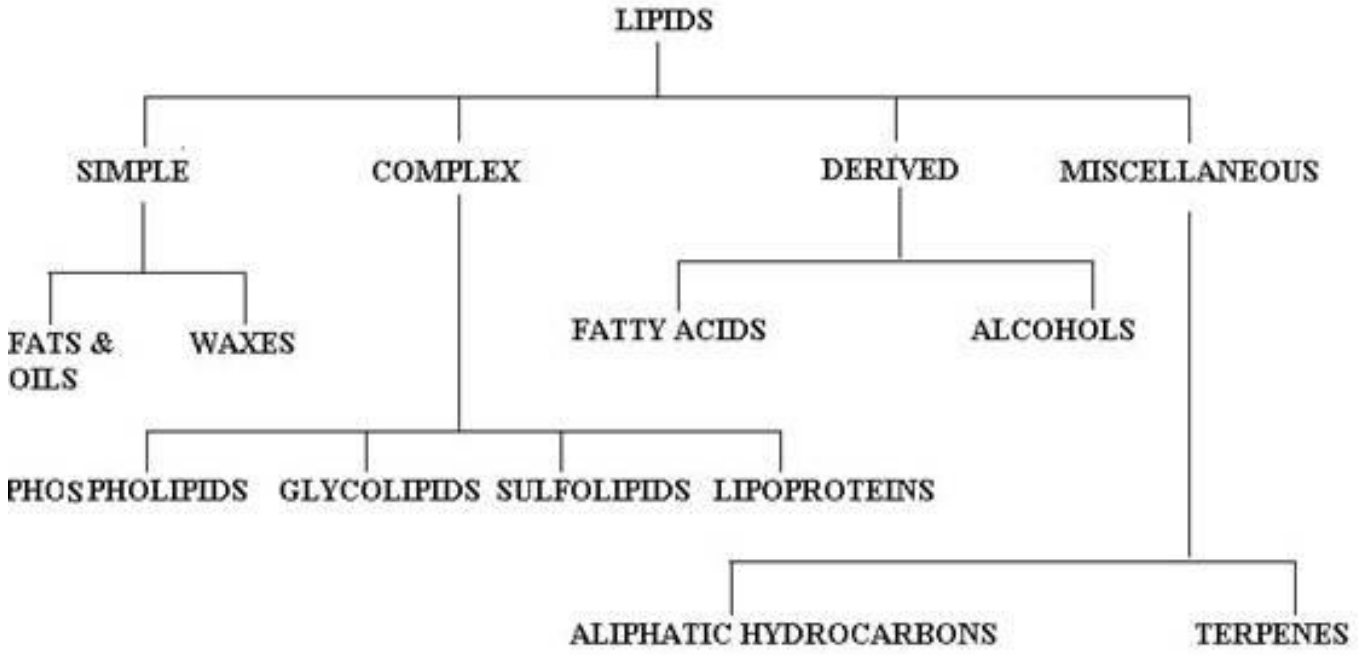
Classification

Open chain vs. cyclic structures

Simple vs. compound, conjugated, and complex lipids

Function: storage, support, signaling

Simple lipids are made only of lipid components, while **compound** and **conjugated lipids** consist of lipids attached to other molecules, as shown in the diagram below.



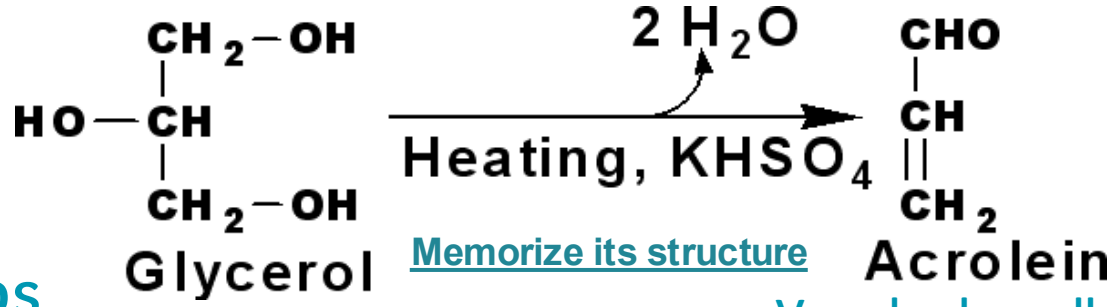
Alcohols

The acrolein test is a chemical test used to detect the presence of glycerol or fats/oils (which contain glycerol) in a sample.

Glycerin is used as a skin softener

Glycerol: glycerin, glucose derived

- Colorless viscous oily liquid with sweet taste
- Heating. transparent
- Trinitroglycerin **Glycerol + 3 Nitrate groups**
- Esterification (mono, di, and triglycerides) Happens at any –OH group



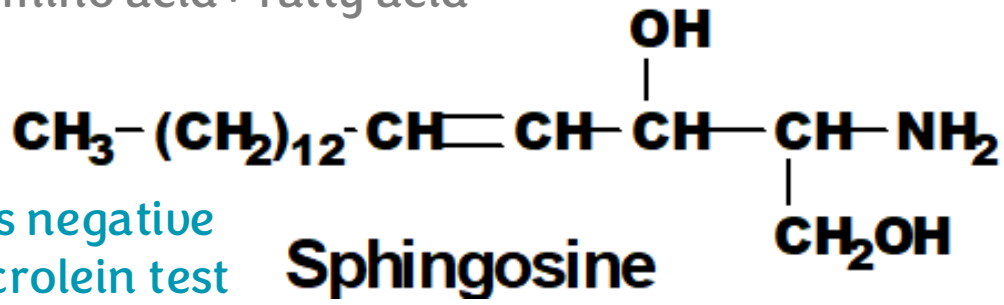
Memorize its structure

Very bad smell

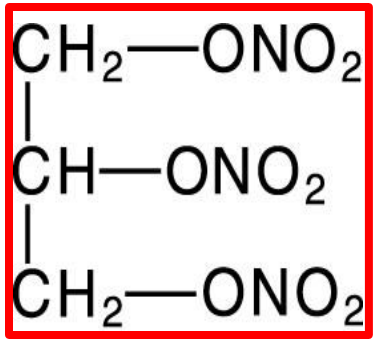
Sphingosine

- Monohydric
- Serine & palmitic acid

Amino acid+ fatty acid



Tests negative in acrolein test



Trinitroglycerin

Vasodilator; used in cases of myocardial infarctions جلطات قلبية and Atherosclerosis تصلب الشرايين

Trinitroglycerin is often given sublingually الحبة تحت اللسان

In biochemistry, the prefix “acet-” typically denotes a two-carbon unit.

- Acetyl-CoA is a two-carbon unit (acetyl group) attached to coenzyme A.
- Acetate (ionized form of acetic acid) both have two-carbon units.
- Acetoacetate has 4 carbons.
- Acetone is an exception; it’s a 3-carbon ketone (simplest).

Tip: if “O” comes after “acet-“ , its not two-carbon unit

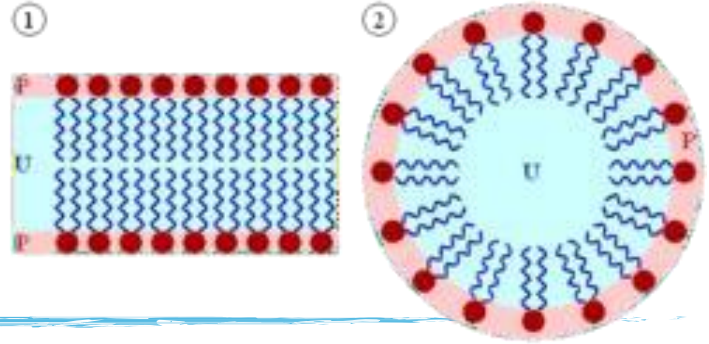
”acyl-“ is used when the molecule contains a carbonyl-attached carbon group without specifying the exact number of carbons.

- Monoacylglycerol = Glycerol + 1 fatty acid
- Diacylglycerol = Glycerol + 2 fatty acids
- Triacylglycerol (triglycerides)= Glycerol + 3 fatty acids

Mono = one
Acyl = fatty acid group (R-CO-)
Glycerol = 3-carbon alcohol

A lipid profile is a blood test that checks cholesterol-related and triglyceride levels.

Fatty acids



Open chain mono-carboxylic acids

R-(CH_2)n-COOH (n mostly even)

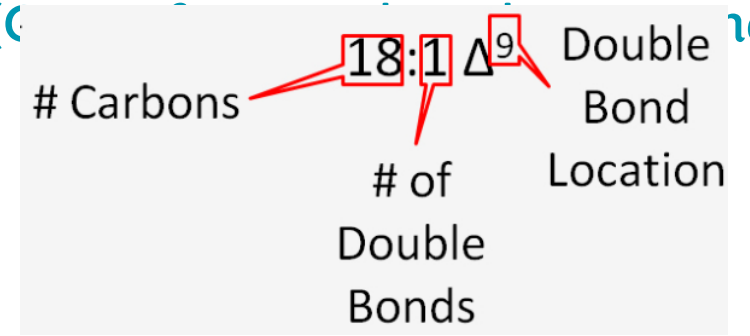
Mostly straight chain

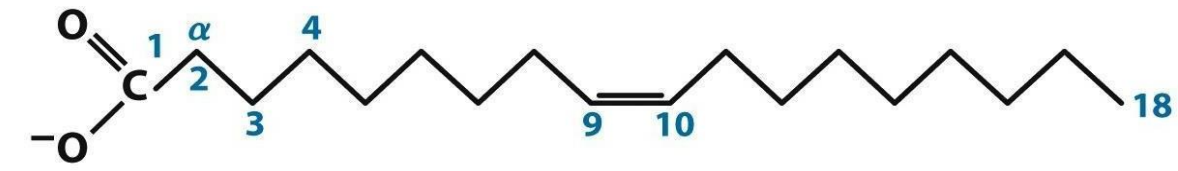
Saturated vs. unsaturated (cis)

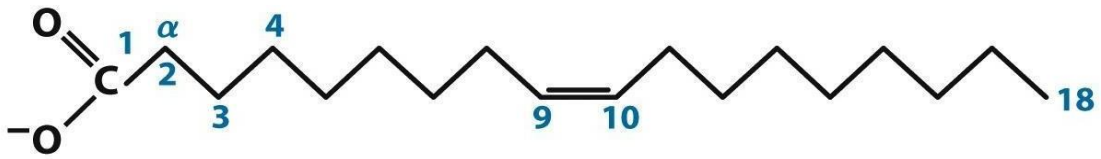
Naming

Systematic (IUPAC)naming system:

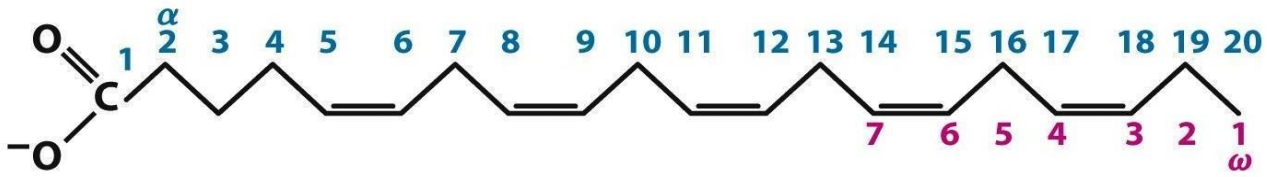
(C… …nd)







(a) 18:1(Δ^9) *cis*-9-Octadecenoic acid



(b) 20:5($\Delta^{5,8,11,14,17}$) Eicosapentaenoic acid (EPA), an omega-3 fatty acid

Omega (ω) Naming: Count from the methyl end (ω).
Eg. ω-3: First double bond at C3 (non-specific)

Physical Properties

Solubility and melting point

Solubility increases in 2 cases:
1- When Chain length decreases
2-Degree of unsaturation increases

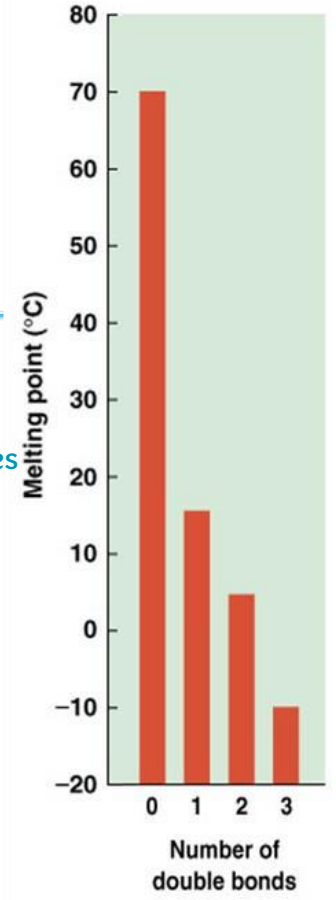
Melting point increases in 2 cases:
1-When Chain length increases
2-Degree of unsaturation decreases

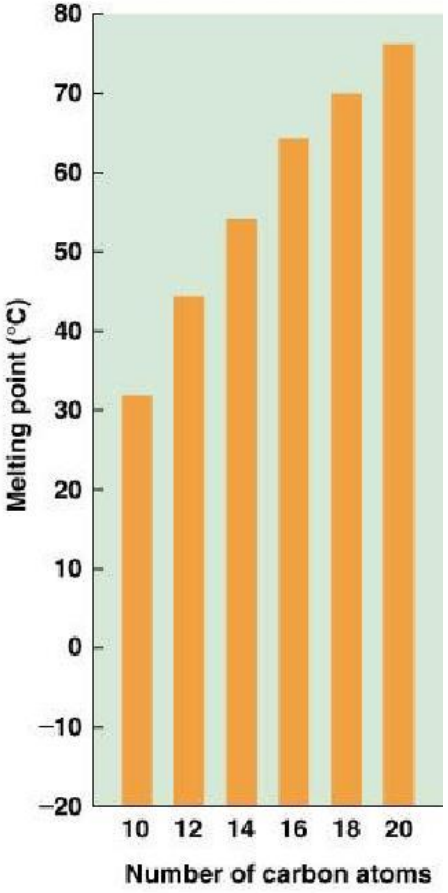
From palms, Solid at room temp.

Saturated fats are unhealthy, because they can stack easily and pack tightly which might Causes arteries blockage

Typical Naturally Occurring Saturated Fatty Acids

Acid	Number of Carbon Atoms	Formula	Melting Point (°C)
Lauric	12	$CH_3(CH_2)_{10}CO_2H$	44
Myristic	14	$CH_3(CH_2)_{12}CO_2H$	58
Palmitic	16	$CH_3(CH_2)_{14}CO_2H$	63
Stearic	18	$CH_3(CH_2)_{16}CO_2H$	71
Arachidic	20	$CH_3(CH_2)_{18}CO_2H$	77





Typical Naturally Occurring Unsaturated Fatty Acids

Acid	Number of Carbon Atoms	Degree of Unsaturation*	Formula	Melting Point (°C)
Palmitoleic	16	16:1—Δ^9	$CH_3(CH_2)_5CH{=}CH(CH_2)_7CO_2H$	−0.5
Oleic	18	18:1—Δ^9	$CH_3(CH_2)_7CH{=}CH(CH_2)_7CO_2H$	16
Linoleic	18	18:2—$\Delta^{9,12}$	$CH_3(CH_2)_4CH{=}CH(CH_2)CH{=}CH(CH_2)_7CO_2H$	−5
Linolenic	18	18:3—$\Delta^{9,12,15}$	$CH_3(CH_2CH{=}CH)_3(CH_2)_7CO_2H$	−11
Arachidonic	20	20:4—$\Delta^{5,8,11,14}$	$CH_3(CH_2)_4CH{=}CH(CH_2)_4(CH_2)_2CO_2H$	−50

Olive, liquid at room tempera-ture

Classification (saturated)

The carboxylic acid group makes fatty acids somewhat water-soluble, but as the hydrocarbon chain gets longer, the fatty acid becomes increasingly insoluble in water.

SHORT CHAIN

- They are liquid in nature
- Water-soluble
- Volatile at room temperature
- Examples: acetic, butyric, & caproic acids

Vinegar

Acetic F.A. (2C) CH_3-$COOH$
Butyric F.A. (4C) CH_3-$(CH_2)_2$-$COOH$
Caproic F.A. (6C) CH_3-$(CH_2)_4$-$COOH$

MEDIUM CHAIN

- Solids at room temperature
- Water-soluble
- Non-volatile at room temperature
- Examples: caprylic & capric F.A.

Caprylic (8 C) CH_3-$(CH_2)_6$-$COOH$
Capric (10 C) CH_3-$(CH_2)_8$-$COOH$

LONG CHAIN

- Occur in hydrogenated oils, animal fats, butter & coconut & palm oils
- Non-volatile & water-insoluble
- Examples: palmitic, stearic, & lignoceric F.A.

Palmitic (16C) CH_3-$(CH_2)_{14}$-$COOH$
Stearic (18 C) CH_3-$(CH_2)_{16}$-$COOH$
Lignoceric (24C) CH_3-$(CH_2)_{22}$-$COOH$

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1	11		Many Changes
V1 → V2	9 2	Acetate group	Acetyl group 4th note removed

Additional Resources:

رسالة من الفريق العلمي:

عن شداد بن أوس رضي الله عنه قال:
قال رسول الله ﷺ:
"اللَّهُمَّ أنتَ رَبِّي، لا إلهَ إلَّا أنتَ، خَلَقْتَنِي، وأنا عبدُكَ، وأنا على عهدِكَ ووَعْدِكَ ما اسْتَطَعْتُ، أعُوذُ بكَ من شَرِّ ما صَنَعْتُ، أَبُوءُ لكَ بنِعْمَتِكَ عَلَيَّ، وأَبُوءُ بذَنْبِي، فاغْفِرْ لي، فإنَّه لا يَغْفِرُ الذُّنوبَ إلَّا أنتَ."

ثم قال ﷺ:
"من قاله من النهار موقنًا به، فمات من يومه قبل أن يمسي، فهو من أهل الجنة، ومن قاله من الليل وهو موقن به، فمات قبل أن يصبح، فهو من أهل الجنة."

رواه البخاري