Lecture :..... 12 (Lipids part 1)

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Medical Committee
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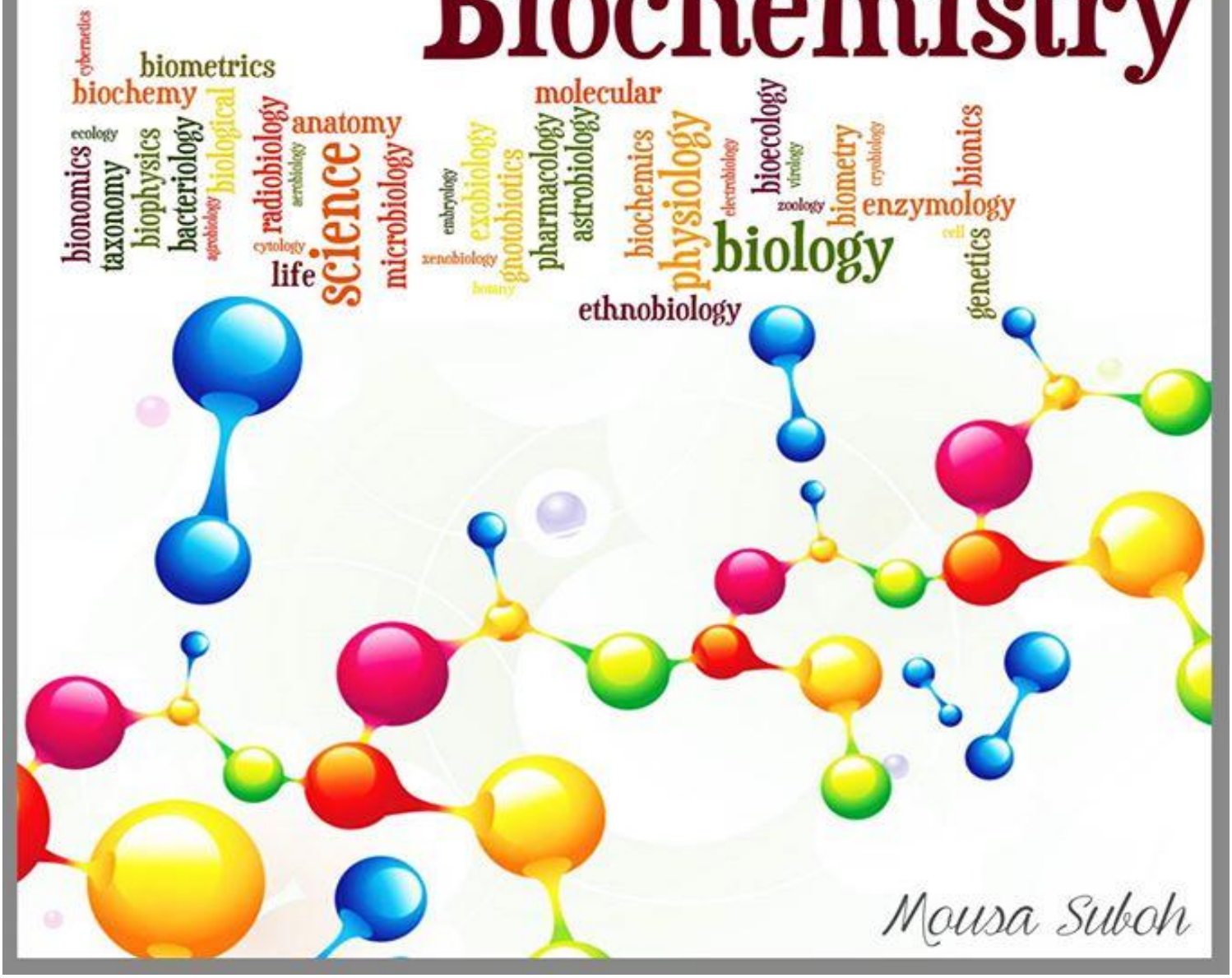
Biochemistry



Lipids

The easiest lipid lecture that you'll ever study in your life. 1 hour max :D

What is a lipid?

It is a heterogeneous group of macromolecules made of 2 components:
1- Fatty alcohols (long carbon skeleton with a hydroxyl group)
2- Fatty Acids (made of a carboxylic group attached to a long carbon skeleton)
These two components are combined together by an ester link.
The hydroxyl group of the alcohol reacts with the carboxylic group of the acid by esterification.
This process is also a form of dehydration, as water molecules are lost. (Oxidation)
-Lipids are amphipathic (they consist of both hydrophilic and hydrophobic parts)
They are mainly insoluble in water, and soluble in organic solvents.
Lipids are found in every single animal and plant cell in the cell membrane.

The Importance and Uses of Lipids:

1-They provide considerable amount of energy to the body (25% of body needs) & provide a high-energy value (more energy per gram vs. carbohydrates & proteins).
Why don't we use lipids as the main energy provider?
Because energy liberation (freeing energy) from lipids takes too much time.
2-They are storable to unlimited amounts and deposit without limitations, unlike carbohydrates. This is due to the fact that lipids are water insoluble (carbs are soluble). Being insoluble in water, we don't need large quantities of water to dissolve it. This way, we can save space by cutting down on the water needed to store it.
3- Lipids supply essential fatty acids, like the PolyUnsaturated Fatty Acids (PUFAs).
What is an "essential" fatty acid? An essential fatty acid is a fatty acid that CAN ONLY BE OBTAINED outside of the body. The human body CANNOT synthesize it, and therefore requires it from other sources.

4-Lipids are also the means by which we obtain certain fat soluble vitamins, like vitamins A, D, E, and K.
5- Lipids are also very important in the nervous system.
6- They also have a structural role in every membrane (as cholesterol, fatty acids, and phospholipids)
7- They are found in ALL human cells. Lipids can also be used as:
Insulation: a layer of subcutaneous fat (under skin) to protect against body heat loss.
Protection of organs: they form a pad around organs that work as a shock absorber.
And of course, a store of energy.
8- They can form lipoproteins (by combining with proteins)
9- Lipids are the precursors of many hormones like:
Adrenal cortical hormones, Sex hormones (testosterone and estrogen), Vitamin D3, and Bile acids.
Good to know:
Bile acid: an acid made by the liver, stored in the gall bladder, and secreted into the bile duct where it finally reaches the intestines. It is released to break down lipidic, fatty foods by the process of emulsification. Just like soap ;)

Good to know:
Soap: Either solid or liquid material, used to clean stuff
How it works:
A droplet of fat is hydrophobic and hydrophilic. Soap breaks down these droplets into smaller ones by emulsification, which is easier to wash.

Classification of Lipids: Lipids can be classified according to many properties, a few are given below:
Classified by:
1- Structure: into open chained (aliphatic) or cyclic lipids.
2- Constituents: what they're derived from, and what they degrade into
3- As simple, compound, cycle, or vitamin lipids
4- By their function and storage properties.

Lipids are made up of two major parts: Fatty alcohols and Fatty acids.

Fatty alcohols: We have two major types; Glycerol and Sphingosine.

Glycerol: (also called glycerin)

Made up of 3 Carbon units, it is a trihydroxylic (3 OH groups attached to each carbon) alcohol. It is made from glucose, and glucose in turn can be made from it. This is why carbohydrates eaten can be converted into lipids in the body, AND lipids in the body can be converted to simple monosacharides.

Properties of glycerol:

1- It is a colorless, viscous, sweet liquid.

2- Upon heating with $KHSO_4$ or sulphuric acid H_2SO_4, glycerol undergoes a dehydration reaction (a type of oxidation) converting the –OH group into an aldehyde. Also, a double bond arises between the 2 carbons. In this process, 2 molecules of H_2O leave, and it becomes an UNSATURATED aldehyde called "Acrolein". Acrolein has a VERY bad smell. We can use this fact (Acrolein test) to detect the presence of glycerol. Take your sample, heat it with H_2SO_4, and if there's a bad smell (acrolein) then glycerol was present.

3- Glycerol can also combine with 3 molecules of nitric acid HNO_2 to form trinitroglycerin. This compound is used for relieving pains of heart attacks by causing vasodilatation of blood vessels. It comes in the form of a pill that is placed under the tongue.

4- Because Glycerol is related to glucose, it has a nutritional value.

5- It is a big part of the structure of phospholipids.

6- Upon esterification with fatty acids, either 1 of the OH groups react, 2, or even all 3.

When ONE –OH group reacts with a fatty acid ------ > MONOacyl glycerol (or monoglyceride)

When TWO –OH groups react with fatty acids ---- > DIacyl glycerol (or diglyceride)

When THREE –OH groups react with fatty acids -- > TRIacyl glycerol (or triglyceride)

The second type of fatty alcohols is known as sphingosine:

Sphingosine has many groups, including –NH2, -OH, and double bonds. It has an amino group, next to it a carbon atom attached to hydrogen and a random R group, and next to that a carboxylic acid derivative. This structure reminds us of something, but what….?

If you guessed amino acid, YOURE RIGHT! Sphingosine contains the amino acid serine.

Sphingosine is composed of the amino acid Serine and a fatty acid called palmitic acid.

Sphingosine tests negative with the Acrolein test. (So no bad smell upon heat with H_2SO_4)

The second major component of lipids are Fatty Acids.

Fatty acids are monocarboxylic acids (only give one proton). They consist of a long Carbon skeleton attached to a carboxyl group at one end.

Hydrolyzing lipids will break them down into alcohols and fatty acids.

-Fatty acids are mostly straight with no branches.

-They are also amphipathic (both hydro philic and phobic ends). They can form bilayers and micelles.

-Fatty acids can have either: 1- ONLY single bonds between carbons --- > saturated

OR: 2- one or more double bonds between carbons -- > unsaturated

If one double bond --- > mono-unsaturated.

If more than one --- > poly-unsaturated

Saturated Fatty Acids have 0 double bonds.

-The properties of unsaturated fatty acids depend on the number and position of double bonds.

-Because unsaturated fatty acids have double bonds, they can either have *cis* or *trans* configuration.

In nature, the *cis* configuration predominates. (Just like how L-amino acids and D-

monosaccharides predominate)

How to name Fatty Acids:

Step 1: Count how many Carbon atoms are present

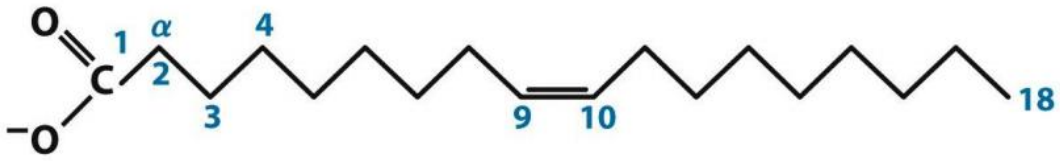
Step 2: Count the number of double bonds

Step 3: Place the "Delta" sign Δ after the number of double bonds, then at the top of the Δ sign, put the numbers of the carbons in the chain that have the double bonds.

Step 4: write the number of carbons using Greek numbers. Ex. 18 = octadeca

remember: Mono, Di, Tri, Tetra, Penta, Hexa, Hepta, Octa, Nona, Deca (1-10)

20 is " Eico"



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

-Note: the 7 common fatty acids in the table are to be MEMORIZED. Name, structure, everything.

3 of these fatty acids are saturated, and 4 are unsaturated.

Oleate, linoleate, linolenate, and arachidonate differ in the number of double bonds.

Arachiodonate is the precursor of Prostagalndins.

Another way of naming:

Step 1: Look at the final carbon (omega carbon). The Omega carbon is the one on the OPPOSITE side of the carboxyl group (the carbon of the carboxyl group is called the alpha carbon)

Step 2: Start counting from the omega carbon until you reach a double bond. Write down the number of that carbon.

In this way, we have 3 classes of fatty acids (based on the first double bond from omega)

*omega-3 fatty acid: this is the healthiest kind
*omega- 6 Fatty acid: moderately healthy
*omega-9 Fatty acid: least healthy. اقل ملاحة
The second table is basically just to practice using this naming method.

Physical properties of Fatty Acids: 2 major properties, solubility and melting point

1-**Solubiltiy**

Solubility depends on the carbon-carbon double bonds. It also depends on the LENGTH of the carbon skeleton.
THE LONGER THE CHAIN, THE LESS SOLUBLE
Why?
Because carbon-carbon (single) bonds are nonpolar and hydrophobic. The more of them there is, the more hydrophobic the whole molecule is.
AS THE NO. OF C=C INCREASES, SOLUBILTY INCREASES

2-**Melting Point**

The greater the carbon content, the greater the melting point. In the chart, this is clearly demonstrated. Also, as the number of C=C increases, the melting point decreases because the molecule cannot pack well due to the numerous kinks of the *cis* double bonds.
Looking at the tables, let's take an example:
Palmitic acid is a 16 carbon acid, however since it has only single bonds it is saturated. Its melting point is 63 degrees, which means at room temperature and pressure it is a solid. دهن و لية
HOWEVER, its counterpart, Palmitoleic acid, also has 16 carbons, BUT its melting point is -0.5 degrees and a liquid at room temp. , because it is unsaturated. (note: any fatty acid with "oleic" as its ending is unsaturated)
-Oleic acid comes from olive oil. Its melting point is 16 degrees, so in the cold it hardens.

Classification of fatty acids: They can be either saturated or unsaturated.

Saturated: no C=C bonds. Solids at room temp. C's even or odd.
Depending on the Carbon Skeleton, they can be short-chained (up to 6 C), medium (7-10), or long (>10)

Short chained: ex. Acetic Acid
These fatty acids are small liquids, due to their small carbon number count.
They are water soluble, because of the carboxyl and because the hydrocarbon content is small, they are not hydrophobic.
They are also volatile at room temp.
Medium chained: ex. Capryilic and Capric
Solids at room temp.
Water soluble, but non-volatile at room temp.
Long chained: ex. Palimitic and Stearic
Occur in hydrogenated oils. They are non-volatile, and insoluble in water.
The second type of fatty acids are the Unsaturated. They can be either:
Mono: One double bond. Ex. Palmitoleic acid, Oleic acid, Nervonic acid (found in nervous tissue).
Poly: More than one C=C.
They are the essential fatty acids, obtained from outside the body.
Ex. Linoleic, Linolenic, and Arachidonic acid (the precursor of prostaglandins)

"لازم الواحد دائماً يتذكر لما ييجي على الجامعة انه مش بس محاضرات و علم، لو ما اله دخل بالشخصية لبطل حدا ييجي على الجامعة ياخد معلومات، لأنها متوفرة بالكتب و الانترنت والمكتب و كل اشي ثاني. انت بتيجي على الجامعة عشان تحتك بالناس و عشان تعرف تحكي و تعرف تتعامل مع الناس، عشان تقوى شخصيتك و تصير بني آدم! بتيجي لهون، لازم يكون الك شخصية، و تكون قوية، و تكون مؤدب في نفس الوقت. اطلع، ما تستحي اذا غلط، انت جاي تتعلم. اما اذا تطلب من ١٥٠ واحد يطلع و ما حدا بطلع، اذا الجامعة كلها على الفاضي"

-د. نافذ ابو طربوش

Ya3teekum alf 3afyeh inkum imwasleen la hay al mu7adarah, bil tawfeeq da2iman w Abadan ya duf3it 2013 ^.^