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# Lipids

Color index :

Main text

IMPORTANT

Extra Info

Drs Notes

Foundation Block - Biochemistry Team

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MED439

# Objectives:

- Define and classify lipids
- Understand the physiological importance of lipids
- List the examples of simple and complex lipids
- Correlate implications of lipids in clinical conditions

# Lipids

A helpful video

## What are lipids ?

- A heterogeneous group of hydrophobic (water- insoluble) organic molecules that are soluble only in organic solvents.
- Body lipids are compartmentalized (packed) in cell membranes, tissue and plasma.

## Functions of lipids :

1. Lipids are essential components of biological membranes.
2. Lipids with hydrocarbon chains serve as major energy store.
3. Cell signaling involves lipid molecules e.g. Inositol triphosphate.
4. Fat-soluble vitamins, steroid hormones and prostaglandins are formed of lipids.
   - Prostaglandins are one of the significant contributors to the inflammatory processes they are one of the potent mediators that cause increased blood flow, chemotaxis (chemical signals that summon white blood cells), and subsequent dysfunction of tissues and organs

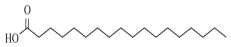
Diseases that are strongly associated with abnormality in **lipid metabolism**:

- **Atherosclerosis** — clogging of the artery by fat and lipids due to high cholesterol.
- **Coronary artery disease**
- **Obesity** — extra fat in your body can affect metabolism and other things
- **Metabolic syndrome**
- **Hypertension**

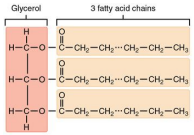
# Classification of Lipids

## Simple Lipids
Simple lipids don't have non lipid part

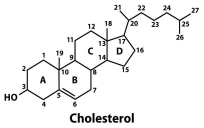
### Fatty acids
Fatty acids consist of methyl + carbonyl group



### Triacylglycerols

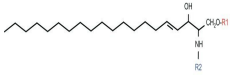



### Steroids (cholesterol)

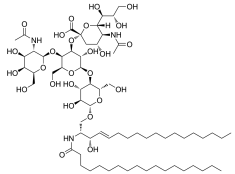



## Complex Lipids
Complex lipids consist of: lipid part + something else attached to it " non lipid "

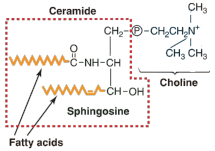
### Sphingolipids



### Glycolipids



### Phospholipids



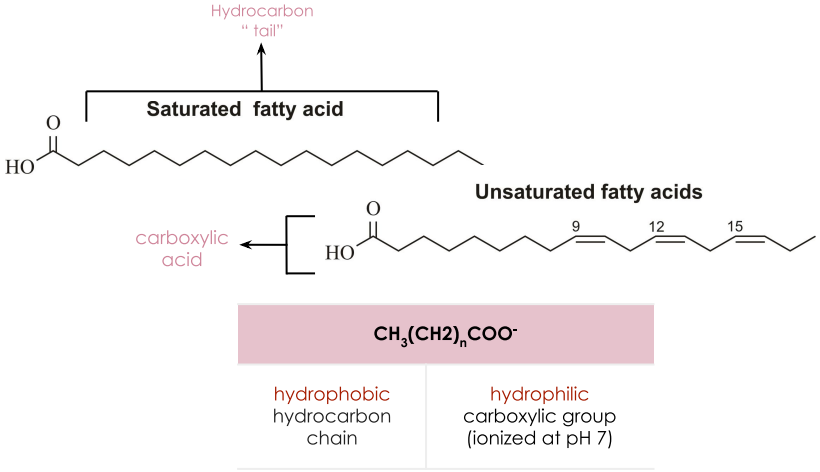
# 1- Fatty acids "FAs"
## one of the simple lipids

FAsare carboxylic acids with long-chain of hydrocarbon side group.

They are amphipathic in nature
( both hydrophilic and hydrophobic )

| The carboxylic group (COOH) is hydrophilic . | The hydrocarbon chain is hydrophobic . |
|---|---|

Fatty acids have hydrophobic terminal
( because of the hydrocarbon tail )




- FAs are highly insoluble in water.
- Must be transported in plasma with proteins like Albumin .
- Majority of plasma FA are esters of: Triacylglycerol, Phospholipids, and Cholesterol.
- there is a small amount of free FAs in our body, most of them are attached with cholesterol and phospholipids.
- ester linkage between the carboxyl group of a fatty acid and the hydroxyl group of an alcohol monomer COOH-COH .

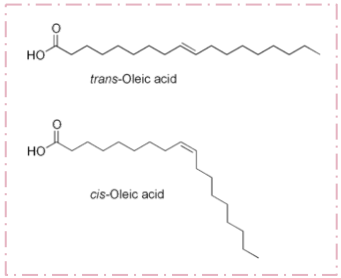
## Chain Length

- In mammals it varies from $C_{16}$-$C_{18}$ C means =carbon atoms
- Ex: palmitic, oleic, linoleic, and stearic acid.

# Fatty acids "FAs" , contd ...

## Degree of Saturation depends on the bond forming

- FAs may contain: no = bond (saturated / trans form)
- One or more = bonds (mono or polyunsaturated / cis form)
- Trans fatty acids " seen in unsaturated " , trans = straight , as you see in the pic .
- Cis kink fatty acids " seen in unsaturated ", kink = bending , as you see in the pic .
- Kinks are bends, and they're sites where cholesterol is found. It's important for membrane fluidity.




| Saturated FAs<br>دهون مشبّعة (مضرة اذا صارت كثيرة في الجسم) | Unsaturated FAs<br>دهون غير مشبّعة (مفيدة) |
|---|---|
| 12:0 Lauric acid | 18:1 Oleic acid |
| 16:0 Palmitic acid | 18:2 Linoleic acid |
| 18:0 Stearic acid | 20:4 Arachidonic acid |

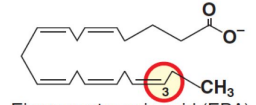
| X:X | |
|---|---|
| **1st x** : No. of carbon atoms | **2nd x** : No. of double bonds |

| More examples | | | |
|---|---|---|---|
| **16:0** | | **20:4** | |
| 16 carbon atoms | 0 double bonds | 20 carbon atoms | 4 double bonds |

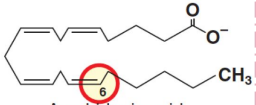
# Essential fatty acids

- Essential FAs ( the body can't synthesize ) , so we need them in our diet.
- Must be supplied in the diet .
- Deficiency can cause dermatitis " تشوهات ", membrane function loss " since the fatty acids contribute in structure of cell membrane .
- Examples of essential FAs :
  - Linoleic acid (precursor of arachidonic acid).
  - α-linolenic acid .
  - Arachidonic acid is essential when linoleic acid is deficient in the diet. means normally it will be conditional .

| | ω-3 fatty acids<br>ω= Omega | ω-6 fatty acids<br>ω= Omega |
|---|---|---|
| Definition | Long-chain polyunsaturated FAs with first double bond starting with 3rd carbon from the methyl end .<br>we call them omega 3 because the double bond start at carbon 3 | Long-chain polyunsaturated FAs with first double bond starting with 6th carbon from the methyl end.<br>we call them omega 6 because the double bond start at carbon 6 |
| Functions | They reduce serum triglycerides " TAG" , blood pressure and risk for heart disease. | They reduce serum cholesterol " C " |
| Sources | Its major source: Fish | Its major sources: Vegetable oils and nuts |
| Examples | - α-linolenic acid .<br>- EPA ( Eicosapentaenoic acid ) .<br>- DHA ( Docosahexaenoic acid ) . | - Linoleic acid 18:2 |



Eicosapentaenoic acid (EPA)
(20:5, ω-3)
found in fish oils

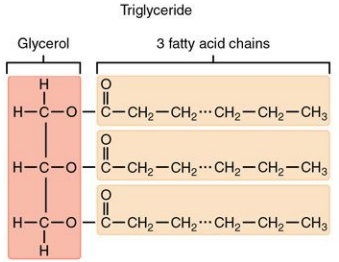


Arachidonic acid
(20:4, ω-6)
found in seed oils

# 2- Triacylglycerols (TGs) "Fat"
## one of the simple lipids

- **Definition** : They are tri-esters of fatty acids " three fatty acids " also called fats or triglycerides which bonded to a glycerol molecule.
- TGs consist of 3 fatty acids combined with 1 glycerol and they have 3 ester linkages .
- It's not a component of cell membranes .
- **Function :** Constitutes majority of dietary lipids .
- **Site : Stored in** adipocytes (fat cells) as energy reservoir " مخزن " .
- In case of starvation- or fasting- TG are converted into fatty acids and then sent to the blood .
- Subcutaneous layer of fats provides thermal insulation .

بمعنى تشكل طبقة تحت الجلد تعمل كعازل حراري يحمي الجسم من البرودة

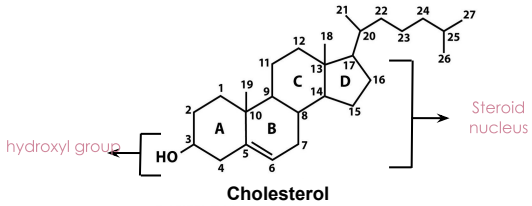


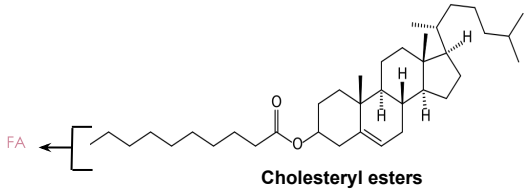

# 3- Steroids
## one of the simple lipids

- **Definition** : it's derivatives of cyclopentanoperhydrophenanthrene ring " no need to memorize the name " and it consists of four fused rings **called** steroid nucleus with an 8-carbon chain . as you see on the right
- Steroids with a hydroxyl group are **called** sterols that's why we call cholesterol sterol.
- Cholesterol " C" is a major sterol in humans and animals .
- Cholesterol in plasma is bound to fatty acids **called** cholesteryl esters " CE " .

بمعنى مكان OH ارتبط FA

More details about cholesterol and cholesteryl esters sand their structures in CVS block.

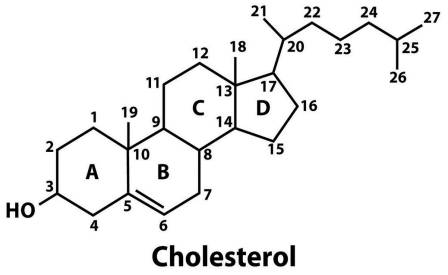


# Functions of cholesterol

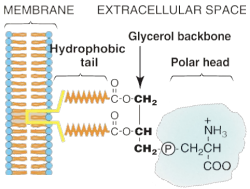
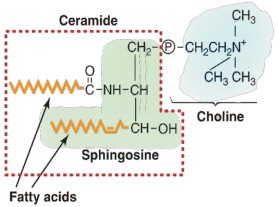
1. Component of cell membranes it maintain the liquidity of the membrane .
2. Precursor for: اساس لتصنيع
   a. Bile acids / Bile salts.
   b. Vitamin D.
   C. Steroid hormones (Aldosterone, cortisol, testosterone, estrogen, progesterone).
3. High levels of plasma cholesterol is strongly associated with coronary artery disease and atherosclerosis.

- coronary artery disease Is the narrowing or blockage of coronary arteries, the arteries that supply blood to the heart itself " more details about it in CVS block "
- Cholesterol is not harmful, but high level of cholesterol (specifically LDL) can be dangerous.



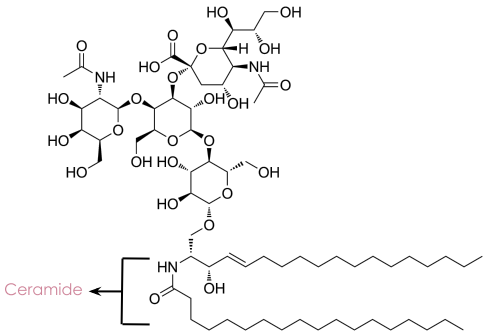
Cholesterol

# Phospholipids
## one of the complex lipids

| | Glycerophospholipids<br>( contain glycerol backbone ) | Sphingophospholipids<br>( contain sphingosine backbone ) |
|---|---|---|
| Structure | - Glycerol-3-$PO_4$ is bonded to two fatty acid chains .<br>- The $PO_4$ group is linked to a hydrophilic group .<br>- Amphiphilic in nature because they have :<br>1- hydrophobic tail .<br>2- hydrophilic phosphoryl head.<br>  <br><br>- The head is hydrophilic (always outside) and the tail is hydrophobic (always inside) | - Long-chain fatty acids attached to sphingosine.<br>  <br><br>- **ceramide** contains 2 fatty acids and no glycerol.<br>- **Phosphocholine** = a phosphate group + choline.<br>- So CERAMIDE + PHOSPHOCHOLINE = SPHINGOMYELIN. |
| Functions | Major components of biological membranes. | An important component of myelin that protects and insulates nerve fibers. |
| Examples | 1- phosphatidic acid. " the simplest Glycerophospholipids "<br>2- phosphatidylcholine<br>3- Phosphatidylserine. | Sphingomyelin<br>sphingosine + fatty acid + choline = Sphingomyelin |

# Glycolipids
## one of the complex lipids

- Contain both carbohydrate and lipid components.
- CERAMIDE + CARBOHYDRATES = GLYCOLIPIDS .
- Derivatives of ceramide.
- A long chain fatty acid is attached to sphingosine.
- It also called glycosphingolipids.
- **Examples :** Ganglioside, glucocerebroside.
- **Act as :** Blood group antigens, cell surface receptors for bacteria / viruses



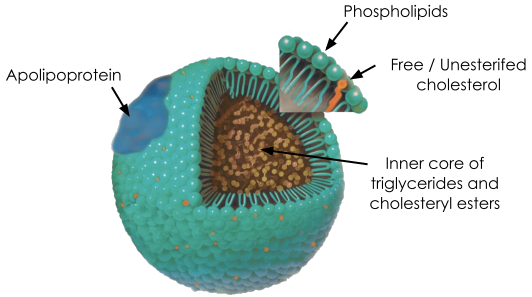

# Transport of Plasma Lipids

- Plasma lipids are transported as lipoprotein particles ( lipids + protein ).

**Lipoprotein is made of :**

1. **lipid part :**
   - Contains lipids of various types more details about it in CVS block .
2. **Protein part** ( Apoproteins or apolipoproteins ) :
   - Examples: Apolipoproteins A, B, C
   - Functions: lipid transport, enzymatic functions, ligands for receptors.

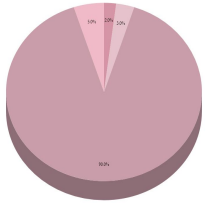
" lipids are inside and proteins are outside "



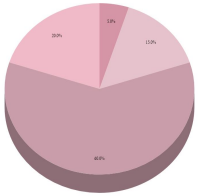
Structure of a typical lipoprotein particle.

# Types and Functions of Lipoproteins

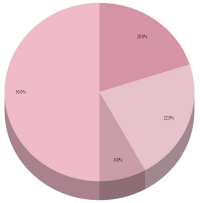
| Lipoproteins | Transport | Major components |
|---|---|---|
| Chylomicrons | Dietary TAGs<br>( from the intestine to the liver ) | Triacylglycerol<br>as you see in the chart . |
| Very low density lipoprotein ( VLDL ) | Endogenous TGs<br>( from the liver to other tissues ) | Triacylglycerol<br>as you see in the chart . |
| Low density lipoprotein ( LDL ) | Free cholesterol | 1- cholesterol<br>2- cholesterol esters<br>as you see in the chart . |
| High density lipoprotein ( HDL ) | Cholesteryl esters | Protein<br>as you see in the chart . |

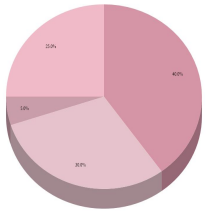
Chylomicrons



VLDL



LDL



HDL

# Take home messages

- Lipids are a group of hydrophobic molecules.
- Perform essential physiological functions in the body.
- Simple lipids include: fatty acids, TGs and steroids .
- Complex lipids include: phospholipids , sphingolipids and glycolipids .
- A number of diseases are associated with abnormal lipid metabolism.

# Quiz

| | | | |
|---|---|---|---|
| Q1 : Sphingolipids are considered as : | | | |
| A ) Complex lipids | B ) Simple lipids | C ) Triacylglycerol | D ) Phospholipids |
| Q2 : Which one of these diseases is not associated with abnormality in lipid metabolism: | | | |
| A ) Atherosclerosis | B ) Gout | C ) Coronary heart disease | D ) Obesity |
| Q3 : Major Omega 6 source is : | | | |
| A ) Fish | B ) Vegetable oils | C ) Non-meat proteins | D ) A and C |
| Q4 : how many fatty acid is bonded to glycerol in triacylglycerol ? | | | |
| A ) One | B ) Two | C ) Three | D ) Four |
| Q5 : which one of the following is a saturated fatty acid: | | | |
| A) Oleic acid | B) Linoleic acid | C) Lauric acid | D) Arachidonic acid |
| Q6 : chylomicrons transport : | | | |
| A) Endogenous TGs | B) Free cholesterols | C) Dietary TGs | D) Cholesteryl esters |

## SAQs :

Q1: Enumerate three functions of Lipids .

Q2: Enumerate the types of lipoproteins .

★ **MCQs Answer key:**

1) A 2) B 3) B 4) B 5) C 6) C

★ **SAQs Answer key:**

1) Chick **slide 3**

2) Chylomicrons - VLDL - LDL- HDL .

## Girls team:

Alia Zawawi
Nada Babilli
Rania Aqil
Reem alamri
Reema Alomar
Reem Alqahtani
Renad Alhumaidi
Shaden Alobaid
Noura Alsalem
Lama Alahmadi
Sadem Alhazmi
Somow Abdulrahman
Budoor Almubarak
Samar Almohammedi
Nuha Alkudsi
Norah Alsheikh
Muneerah Alssdhan
Mayasem Alhazmi
Noura alshathri
Duaa Alhumoudi

## Boys team:

Mansour albawardi
Hassan alshuraf
Abdulrahman almbki
Mohammed alsayari
Abdullaziz alomar
Abdulaziz alrabiah
Saud alrasheed
Abdullah almazro
Hamad almousa
Ahmad alkhayat

Persistence is very important. you should not give up UNLESS you are forced to give up.

Elon Musk.

Made by

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