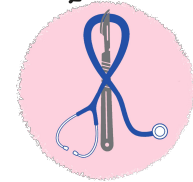


**MED441**  
KING SAUD UNIVERSITY

Revised & Reviewed  
by  
Abdulaziz & Bahammam  
Fayez Wael Sindi



6  
V1

Foundation  
Block - KSU

### Color Index:

- Main text
- Important
- Notes
- Boys slides'
- Girls slides'
- Extra

[Editing File](#)



# Objectives

- 1. Define and classify lipids.**
- 2. Understand the physiological importance of lipids.**
- 3. List the examples of simple and complex lipids.**
- 4. Correlate implications of lipids in clinical conditions.**

# 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.**

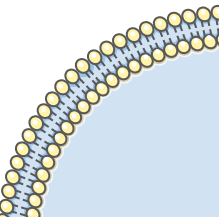
## Functions of lipids:

1. Lipids are **essential components** of biological membranes. (**cell membranes**)
2. Lipids with hydrocarbon chains serve as **major energy stores.**
3. **Cell signaling** involves lipid molecules e.g. Inositol triphosphate.
4. Fat-soluble vitamins (**Vit: A,D,E,K**), steroid hormones (**sex hormones**) and prostaglandins (**inflammation process**) are formed of lipids.

## lipids and diseases:

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

1. Atherosclerosis (**fat accume in artery**)
2. Coronary artery disease (**fat accumulation in coronary artery**)
3. Obesity
4. Metabolic syndrome
5. Hypertension





# classifications of lipids

## Lipids

### Simple lipids

### Complex lipids

#### Fatty acids

#### Triacylglycerols

#### Steroids (cholesterol)

#### Phospholipids

#### Glycolipids

#### Glycerophospholipids

#### Sphingophospholipid

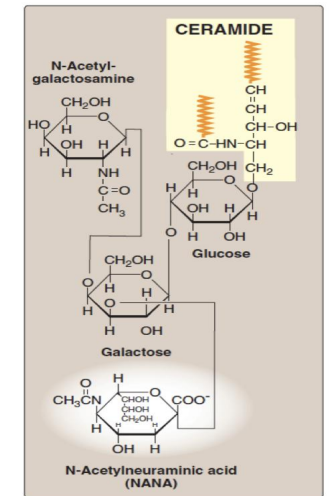
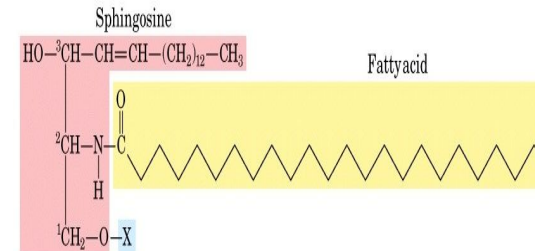
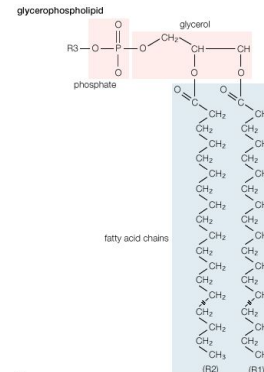
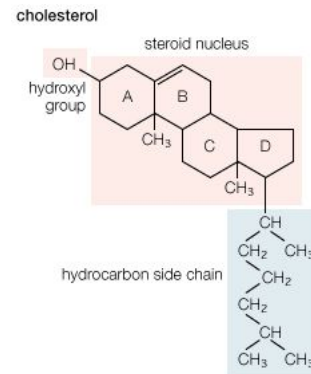
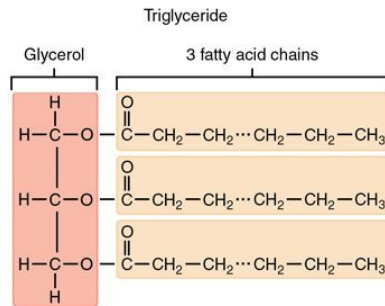
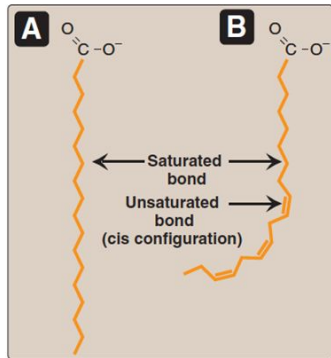
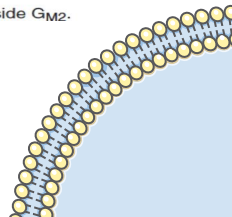


Figure 17.15 Structure of the ganglioside GM<sub>2</sub>.





# 1- Fatty acids (FAs): simple lipids

- FAs are **carboxylic acids** with long-chain hydrocarbon side groups.
- They are **amphipathic** in nature (have both hydrophilic and hydrophobic).
- The carboxylic group (**COOH**) is **hydrophilic** & the **hydrocarbon chain is hydrophobic**.

<b>CH<sub>3</sub>(CH<sub>2</sub>)<sub>n</sub></b>	<b>COO<sup>-</sup></b>
<b>Hydrophobic hydrocarbon chain</b>	<b>Hydrophilic carboxyl group (ionized at pH 7)</b>

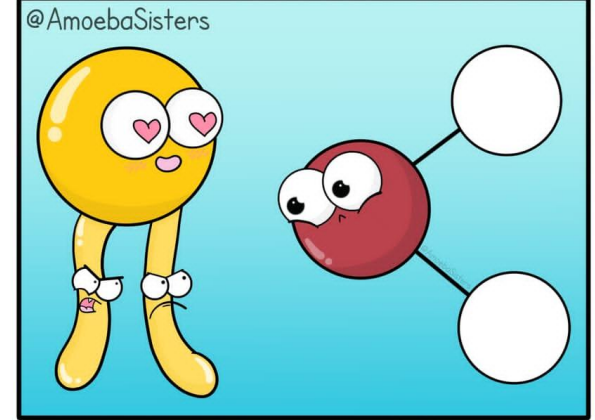
- FAs are highly **insoluble** in water. (b/c they're lipids and they're non-polar)
- Must be transported in plasma with proteins.
- Majority of plasma FAs are esters** of: Triacylglycerol, Cholesterol, Phospholipids.

## Chain length:

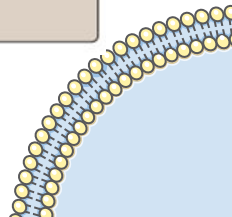
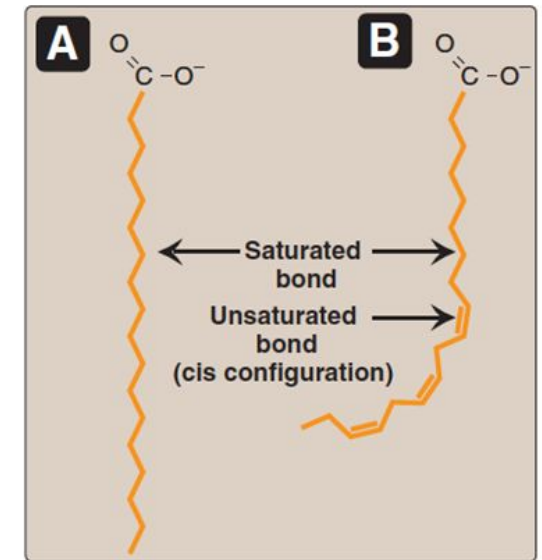
- In mammals it varies from **C<sub>16</sub>-C<sub>18</sub>**.
- Examples: palmitic, oleic, linoleic, stearic acids.

- The saturated (single) bond is heavier than the unsaturated (double) bond because the carbon in saturated bond attached to 4 atoms.

## The Ultimate Love/Hate Relationship



Phospholipids are **amphiphilic** - they have polar heads and nonpolar tails.





# Fatty acids (FAs) simple lipids, contd..

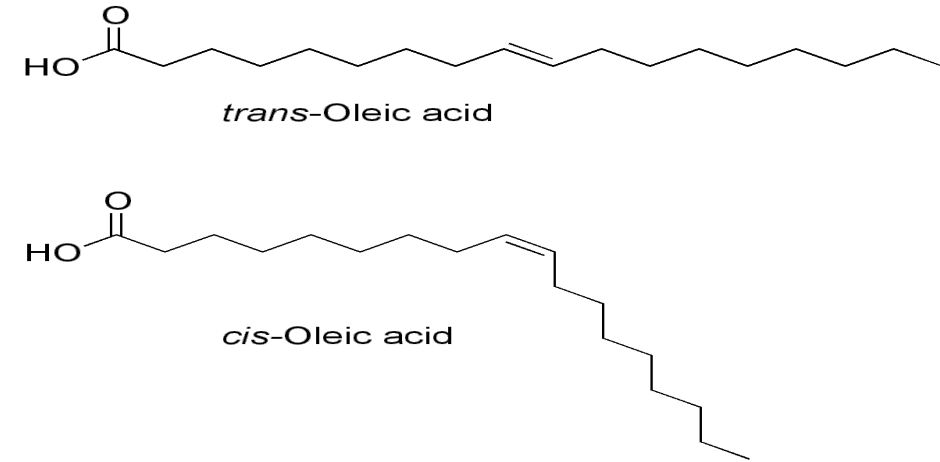
## Degree of saturation:

FAs may contain:

- No double bonds (Saturated / trans form)
- One or more double bonds (Mono or Polyunsaturated / cis form)

439 notes:

- Trans fatty acid " 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 means bends, they're **sites where cholesterol is found**. Important for membrane fluidity.



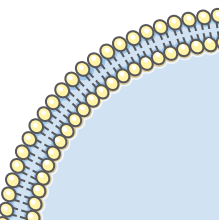
16:0  
16= No. of carbon atoms  
0= No. of double bonds

20:4  
20= No. of carbon atoms  
4= No. of double bonds

Saturated FAs	Unsaturated FAs
12:0 Lauric acid	18:1 Oleic acid
16:0 Palmitic acid	18:2 Linoleic acid
18:0 Stearic acid	20:4 Arachidonic acid

## Mnemonics:

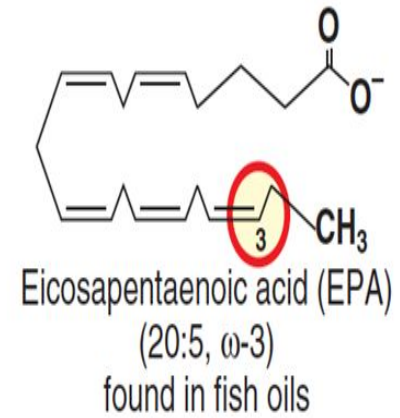
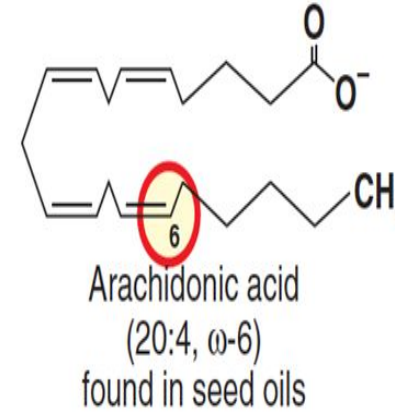
- **LaPS** اذا كنت شبعان (مشبع) واعطاك احد اكل بتقول له لا بس
- **ALO** اذا كنت جوعان (غير مشبع) بتتصل على المطعم الو



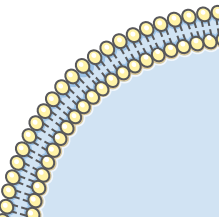


# Essential Fatty Acids:

- Body cannot synthesize (like essential amino acids)
- Must be supplied in the diet.
- Deficiency can cause dermatitis (التهاب الجلد), membrane function loss.
- Examples of essential fatty acids:
  - Linoleic acid (precursor of arachidonic acid) (Arachidonic is derived from Linoleic)
  - $\alpha$ -Linolenic acid.
  - Arachidonic acid is essential when linoleic acid is **deficient** in the diet (conditional).

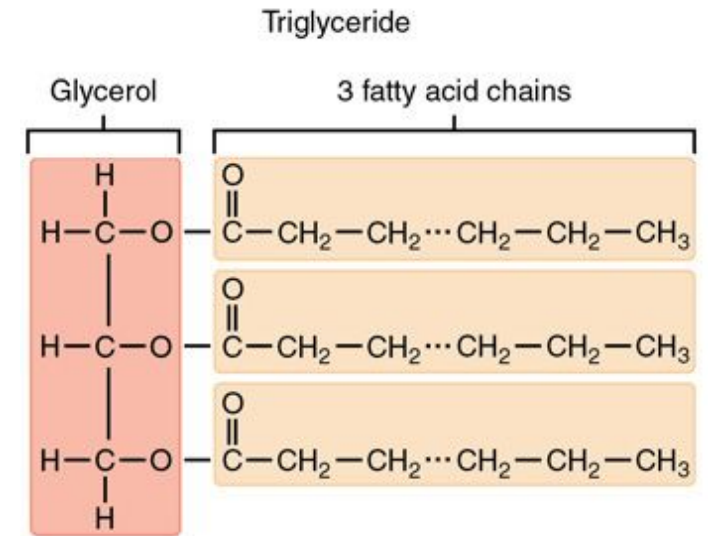


$\omega$ -3 fatty acids		$\omega$ -6 fatty acids
Long-chain polyunsaturated FAs with first double bond at the <b>3rd</b> carbon from the methyl end	<b>Definition</b>	Long-chain polyunsaturated FAs with first double bond at the <b>6th</b> carbon from the methyl end
Reducing serum <b>triglycerides</b> , blood pressure and risk for heart disease	<b>Function</b>	Reducing serum <b>cholesterol</b>
Major source: <b>fish</b>	<b>Sources</b>	major source: <b>vegetable oils, nuts</b>
$\alpha$ -Linolenic acid. EPA (Eicosapentaenoic acid). DHA (Docosahexaenoic acid).	<b>Examples</b>	Linoleic acid 18:2 Arachidonic acid 20:4



## 2-Triacylglycerols (TGs): simple lipids

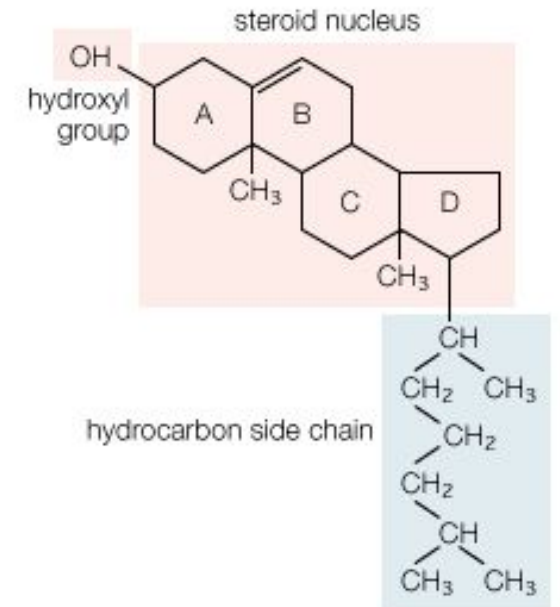
- TGs are tri-esters (3 ester linkages) of fatty acids also called fats. (ester linkage forms between OH of glycerol & Carboxyl of FA)
- Three FAs are bonded to a glycerol molecule (by ester linkage)
- Constitutes majority of dietary lipids
- Stored in adipocytes (fat cells) as energy reservoir
- NOT a component of cell membrane
- Subcutaneous layer (the fat layer under the skin) of fats provides thermal insulation



## 3-Steroids: simple lipids

- Derivatives of **cyclopentanoperhydrophenanthrene** "you don't have to memorize it"
- Consists of **four** fused rings called **steroid nucleus** with an **8-carbon chain**
- Steroids + hydroxyl group = sterols
- Cholesterol is a **major sterol** in humans and animals
- Cholesterol in plasma membrane is bound to fatty acids (the hydrophilic heads in phospholipid bilayer) called **cholesteryl esters**

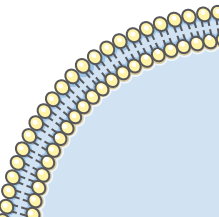
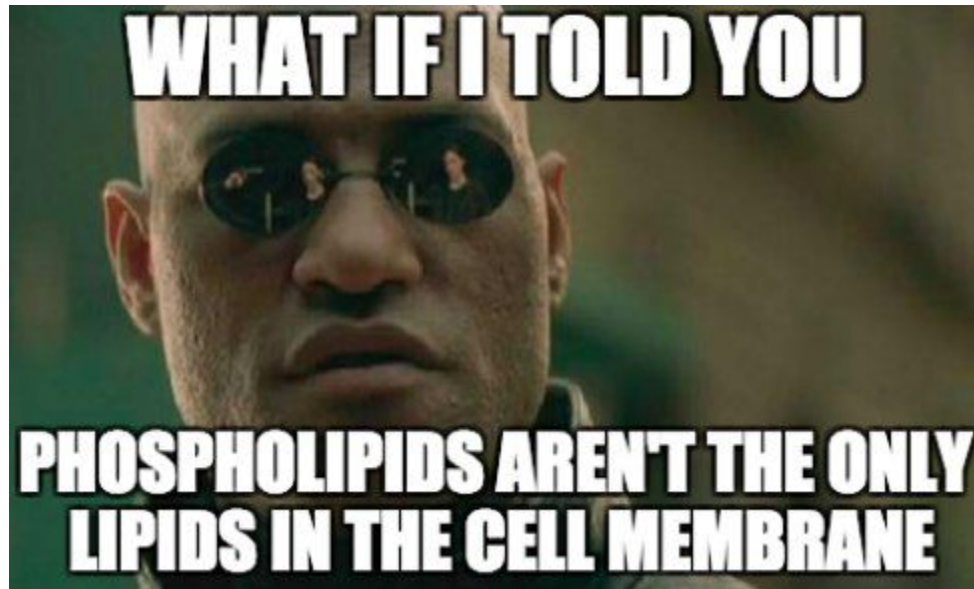
cholesterol





## Functions of cholesterol

- Component of cell membranes **increases membrane fluidity**
- Precursor for: أساسي لتصنيع
  - Bile acids / Bile salts They are responsible for digestion and absorption of fat
  - Vitamin D fat soluble molecule
  - Steroid hormones (Aldosterone, cortisol, testosterone, estrogen, progesterone)
- High levels of plasma cholesterol is strongly associated with coronary artery disease and atherosclerosis

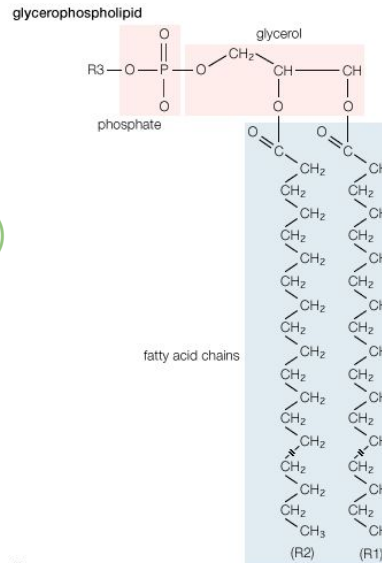


**Glycerophospholipids**  
(contain **glycerol** backbone)

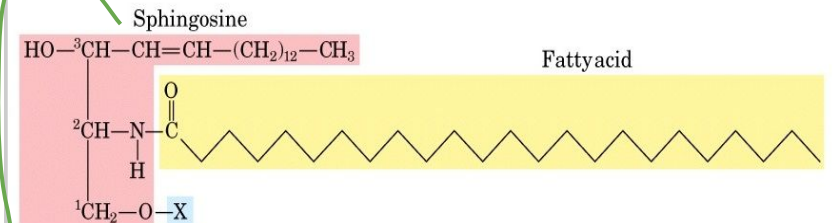
**Sphingophospholipids**  
(contain **sphingosine** backbone)

Structure

- Glycerol - phosphate is bonded to **two FAs chains**
- The PO<sub>4</sub> group is linked to a **hydrophilic** group (from glyc)
- Amphiphilic in nature
  - 1- Hydrophobic tail
  - 2- Hydrophilic phosphoryl heads



- Long-chain fatty acids attached to **sphingosine**



- Notice the FA chain in sphingosine itself
- FA+Sphingosine=Ceramide

Function

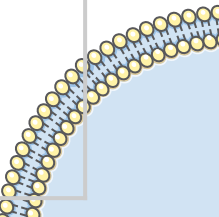
Major components of biological membranes

An important component of myelin that **protects and insulates nerve fibers**

Examples

Phosphatidic acid  
Phosphatidyl- choline and Serine

Sphingomyelin



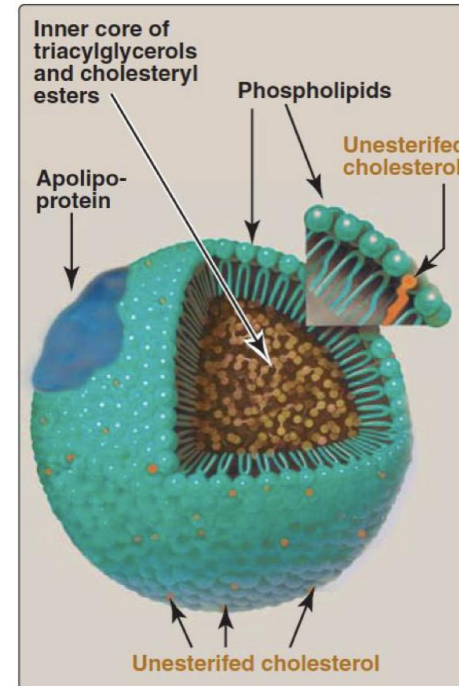
## Glycolipids: complex lipids

- ★ Contain both carbohydrate and lipid components
- ★ **Derivatives of ceramide**
- ★ **Ceramide + Carbohydrate = Glycolipid**
- ★ A long chain fatty acid is attached to sphingosine
- ★ Also called **glycosphingolipids**
- ★ e.g. Ganglioside & Glactocerebroside
- ★ Acts as: Blood group antigens (A,B,AB,O), cell surface receptors for bacteria/viruses

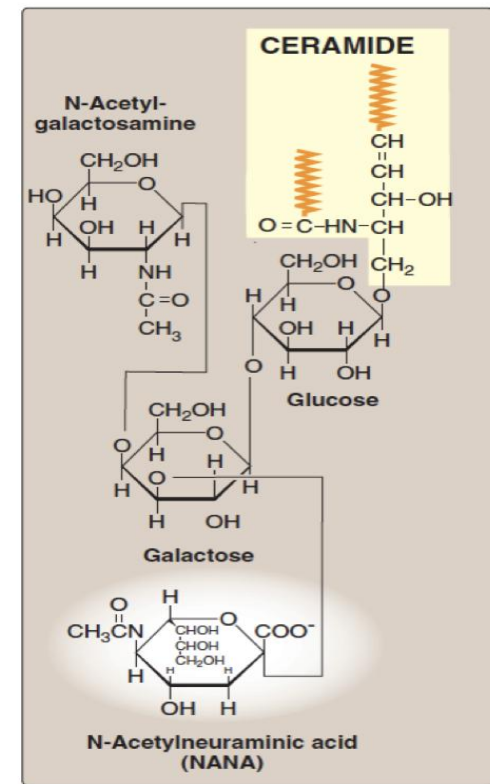
## Transport of plasma lipids:

- ★ Plasma lipids are transported as lipoprotein particles (**lipids + protein**) (it presents in blood plasma)
- ★ **Protein part:** **Apoproteins** or **Apolipoproteins** (outside)
  - e.g. **Apolipoproteins A, B, C**
- ★ **Lipid part:** contains lipids of **various types** (inside)
- ★ Functions: lipid transport, enzymatic functions, ligands for receptors (ligands are molecules which will bind to the receptors as a recognition molecule)

the protein part is hydrophilic  
the lipid part is hydrophobic



**Figure 18.14**  
Structure of a typical lipoprotein particle.



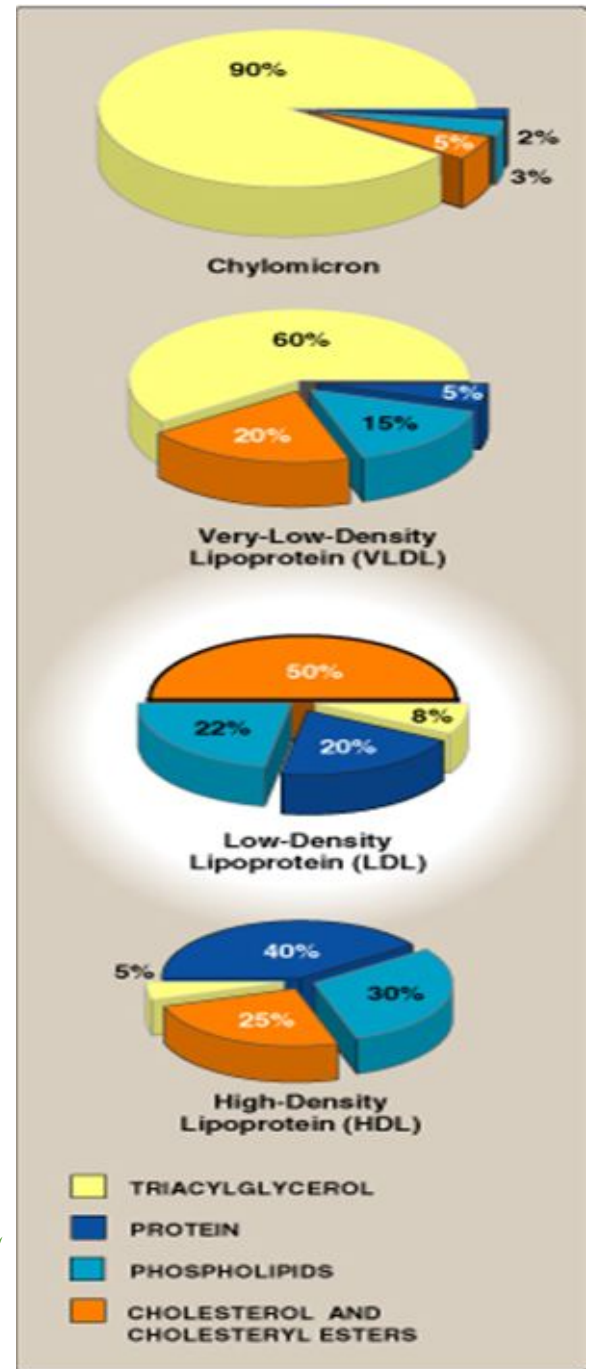
**Figure 17.15**  
Structure of the ganglioside  $G_{M2}$ .

The table is very important

As we go down: Triacylglycerol dec & Protein inc.

## Types and functions of lipoproteins

Lipoprotein	Transports
Chylomicrons (Largest in size & lowest in density)	Dietary TGs
Very low density lipoprotein (VLDL)	Endogenous TGs (produced by body not from diet)
Low density lipoprotein (LDL) (Bad Cholesterol)	Free cholesterol
High density lipoprotein (HDL) (Good Cholesterol) (Smallest in size & Heaviest in density)	Cholesteryl esters

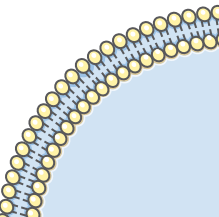


[- a helpful video](#)



## Take home message

- 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: Three fatty acids are bonded to a glycerol molecule**

- A Phospholipid      B Cholesterol      C Triacylglycerol      D Glycolipid

**Q2: The combination of ceramide + carbohydrate is ?**

- A Phospholipid      B Glycolipid      C Fatty acid      D Triacylglycerol

**Q3: Which of the following isn't a function of  $\omega$ -3 fatty acids?**

- A Reducing serum cholesterol      B Reducing serum triglycerides      C Reducing blood pressure      D Reducing risk for heart disease

**Q4: High density lipoprotein transports:**

- A Dietary TGs      B Endogenous TGs      C Free cholesterol      D Cholesteryl esters

**Q5: Which of the following lipids isn't a component of cell membrane ?**

- A Cholesterol      B Glycerophospholipids      C Both A & B      D Triacylglycerol

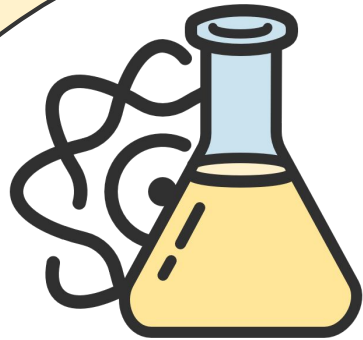
**Q6: When do Arachidonic acid becomes essential?**  
when linoleic acid is deficient in the diet

**Q7: What is a ceramide?**  
It is a fatty acid attached to sphingosine

**Q8: Enumerate the types of saturated fatty acids**  
12:0 Lauric acid  
16:0 Palmitic acid  
18:0 Stearic acid

**Q9: Enumerate the types of lipoproteins**  
Chylomicrons  
VLDL  
LDL  
HDL

Answer key: 1)C 2)B 3)A 4)D 5)D



**Biochemistry 441**

**Girls**



★ **Ghadah Alarify - Leader**

Yara Almufleh  
Reema Alrashedi  
Wareef Almousa  
Joud Alangari  
Fay Alluhaidan  
Sarah Alhamlan  
Arwa Almobeirek  
Jumana AL-qahtani

Latifa Alkhdiri  
Alanoud Alhaider  
Futoon Almotairi  
Manal Aldhirgham  
Raaoum Jabor  
Norah alawlah  
Shahad Helmi  
Rand Aldajani

**Boys**



★ **Khalid Alhamdi - Leader**

Ahmed Alayban  
Sultan Alosaimi  
Abdullah Alomran  
Bassam Alghizzi  
Ibrahim Aljurayyan  
Mohammed Almutairi  
Turki Alkhalifa  
Malik Alshaya

Faisal Alhmoud  
Abdulrahman Alnoshan  
Ahmed Alqahtani  
Hamad Alshaalan  
Anas Alharbi  
Mohammed Alwahibi  
Saad Alghadir  
Firas Alqahtani