

Tishk International University
Faculty of Applied Science
Nutrition and Dietetics Department
2nd Grade
Nutritional Biochemistry



Lipid and Metabolism

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Classification

Simple
Lipid

Complex
Lipid

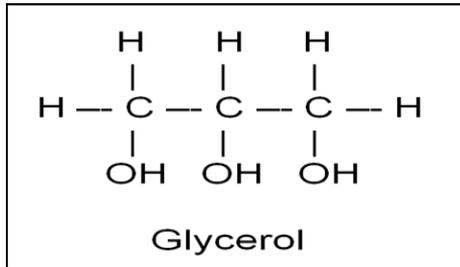
Derived
Lipids

Simple Lipids

They are esters of FA with various alcohols.

Neutral fats or oils

Esters of FA with alcohol GLYCEROL.



Waxes

Esters of FA with higher molecular weight (monohydric alcohols)

Example: Beeswax



Complex Lipids

These are esters of FA with alcohol containing additional (Prosthetic) groups.

Sub-classified according to the type of prosthetic group:

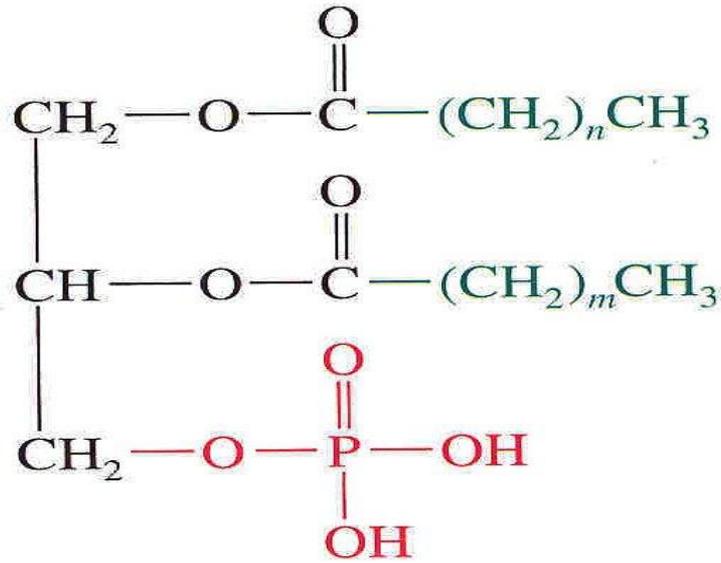
Phospholipids

Glycolipids

Lipoproteins

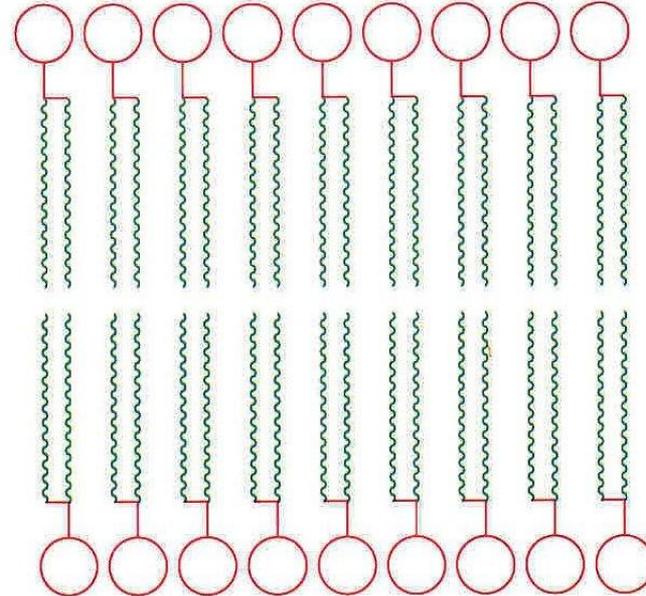
Phospholipids

FA + Alcohol + Phosphoric acid



a phosphatidic acid

hydrophilic surface



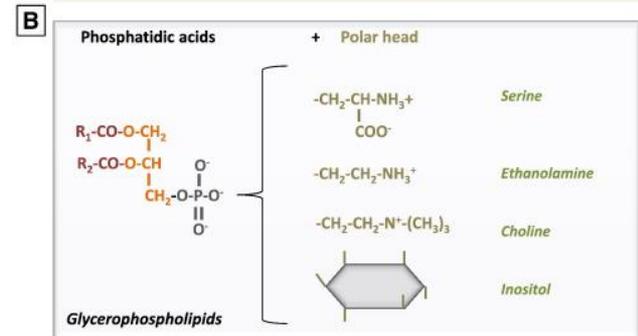
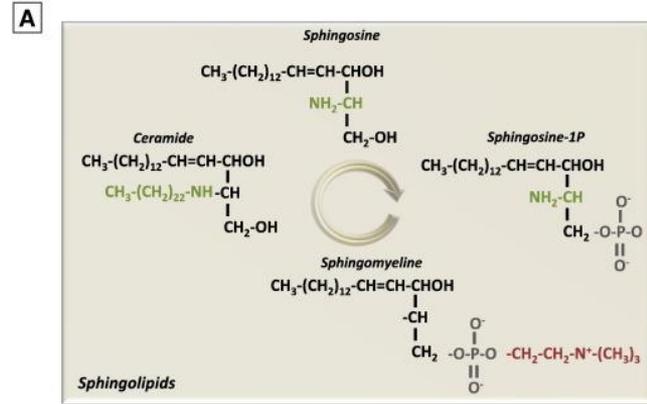
hydrophobic
interior of
cell wall

Cont.

✓ Phospholipids may be classified on the basis of the type of alcohol present:

- Glycerophospholipids

- Sphingolipids



Glycolipids

FA + Alcohol (Sphingosine) + carbohydrate
with Nitrogen base

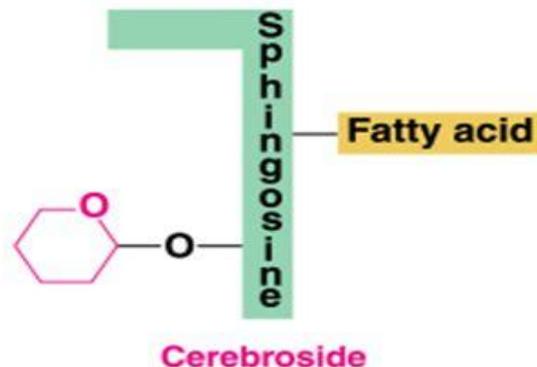
(They do not contain phosphate group).

Example:

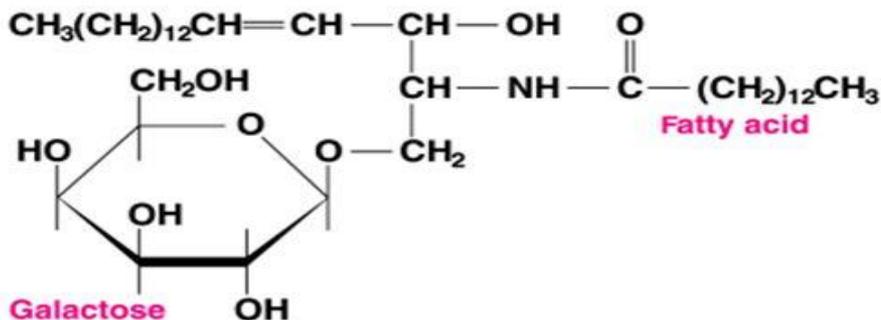
- ✓ Cerebrosides
- ✓ Gangliosides

Glycosphingolipids

- **Glycosphingolipids (cerebrosides and gangliosides)** contain monosaccharides bonded to the $-OH$ of sphingosine by a glycosidic bond.
- **Cerebrosides** contain only one monosaccharide.



Sphingosine



Galactocerebroside, a glycosphingolipid

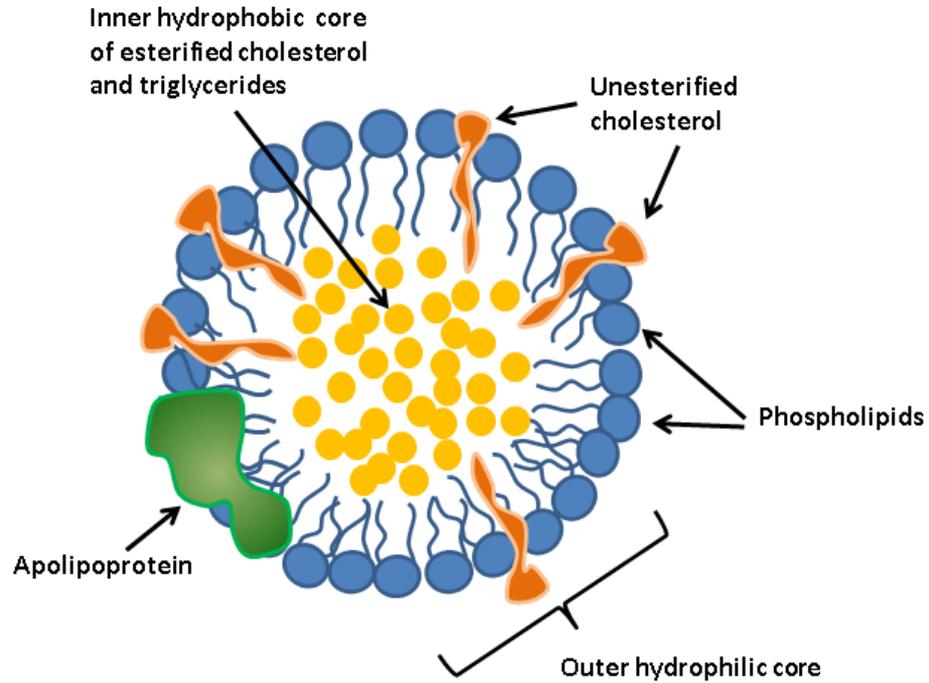
Lipoproteins



Lipid with prosthetic group PROTEIN.

- ✓ Chylomicrons
- ✓ Very Low Density Lipoprotein (VLDL)
- ✓ Low Density Lipoprotein (LDL)
- ✓ High Density Lipoprotein (HDL)

Structure



Derived Lipids

Derived from lipids (simple or complex) or precursors of lipids.

Example:

- Fatty acids
- Steroids
- Cholesterol
- Vitamin A and D

Fatty acids

- Simplest form of lipids.
- Carboxylic acids with HC side chain.
- Usually contain an even number of carbon atom.
- Chain may be saturated or unsaturated.
- It occurs mainly in an esterified form.
- Fats of animal origin are more simple than that of plant origin.
- Palmitic acid and stearic acid are most common.

Essential Fatty acids

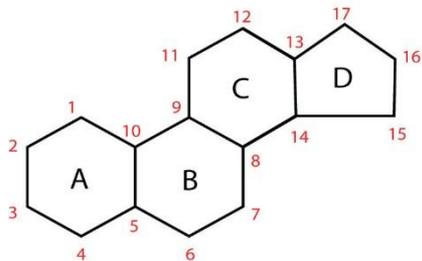
- The fatty acid can not be synthesized by the body and therefore has to be supplied in the diet.
- Ex: Linoleic acid, Linolenic acid
- *Functions of essential fatty acids:*
 - Membrane structures and functions
 - Transport of cholesterol
 - Formation of lipoprotein
 - Prevention of fatty liver
- Deficiency of EFA: Phrynoderma- toad skin

Steroids

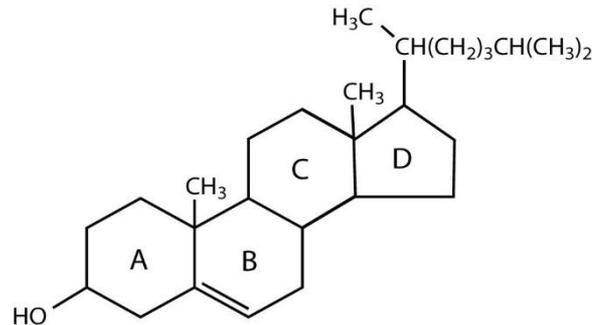
- Steroids are lipids because they are hydrophobic and insoluble in water, but they do not resemble lipids since they have a structure composed of four fused rings.
- Steroids are found in the brain and alter electrical activity in the brain.
- Because they can tone down receptors that communicate messages from neurotransmitters, steroids are often used in anesthetic medicines.

Structure of Steroid Molecules

Unlike phospholipids and fats, steroids have a fused ring structure. Although they do not resemble the other lipids, they are grouped with them because they are also hydrophobic and insoluble in water. All steroids have four linked carbon rings, and many of them, like cholesterol, have a short tail. Many steroids also have the $-OH$ functional group, and these steroids are classified as alcohols called sterols.



(a) Steroid skeleton



(b) Cholesterol

Cholesterol



- Cholesterol is the most common steroid and is the precursor to vitamin D, testosterone, estrogen, progesterone, aldosterone, cortisol, and bile salts.
- Cholesterol is a component of the phospholipid bilayer and plays a role in the structure and function of membranes.

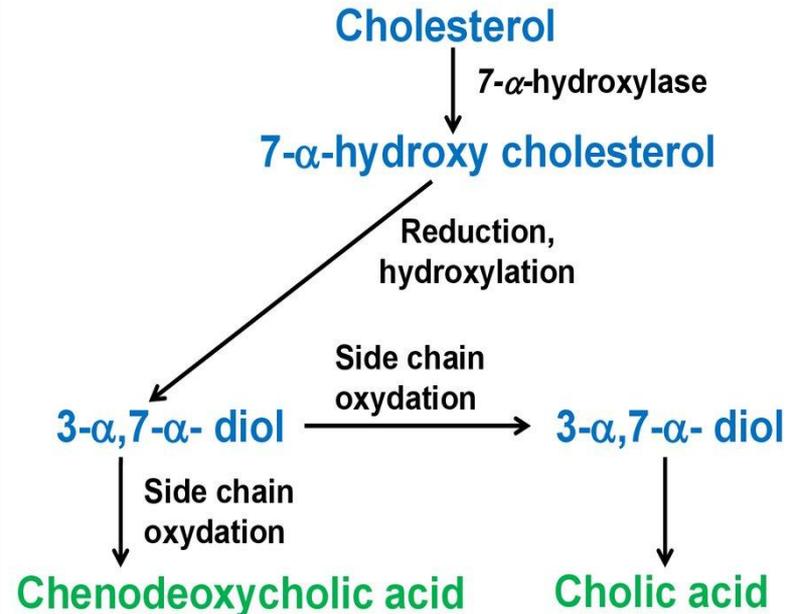
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- Cholesterol is mainly synthesized in the liver; it is the precursor to vitamin D.
- Cholesterol is also a precursor to many important steroid hormones like estrogen, testosterone, and progesterone, which are secreted by the gonads and endocrine glands. Therefore, steroids play very important roles in the body's reproductive system.
- Cholesterol also plays a role in synthesizing the steroid hormones aldosterone, which is used for osmoregulation, and cortisol, which plays a role in metabolism.

Bile acids

- Synthesized from cholesterol in the liver.
- It keeps bile cholesterol in a soluble state as micelles and promote the digestion of lipids in the intestine.

Bile acid synthesis



Functions of lipids

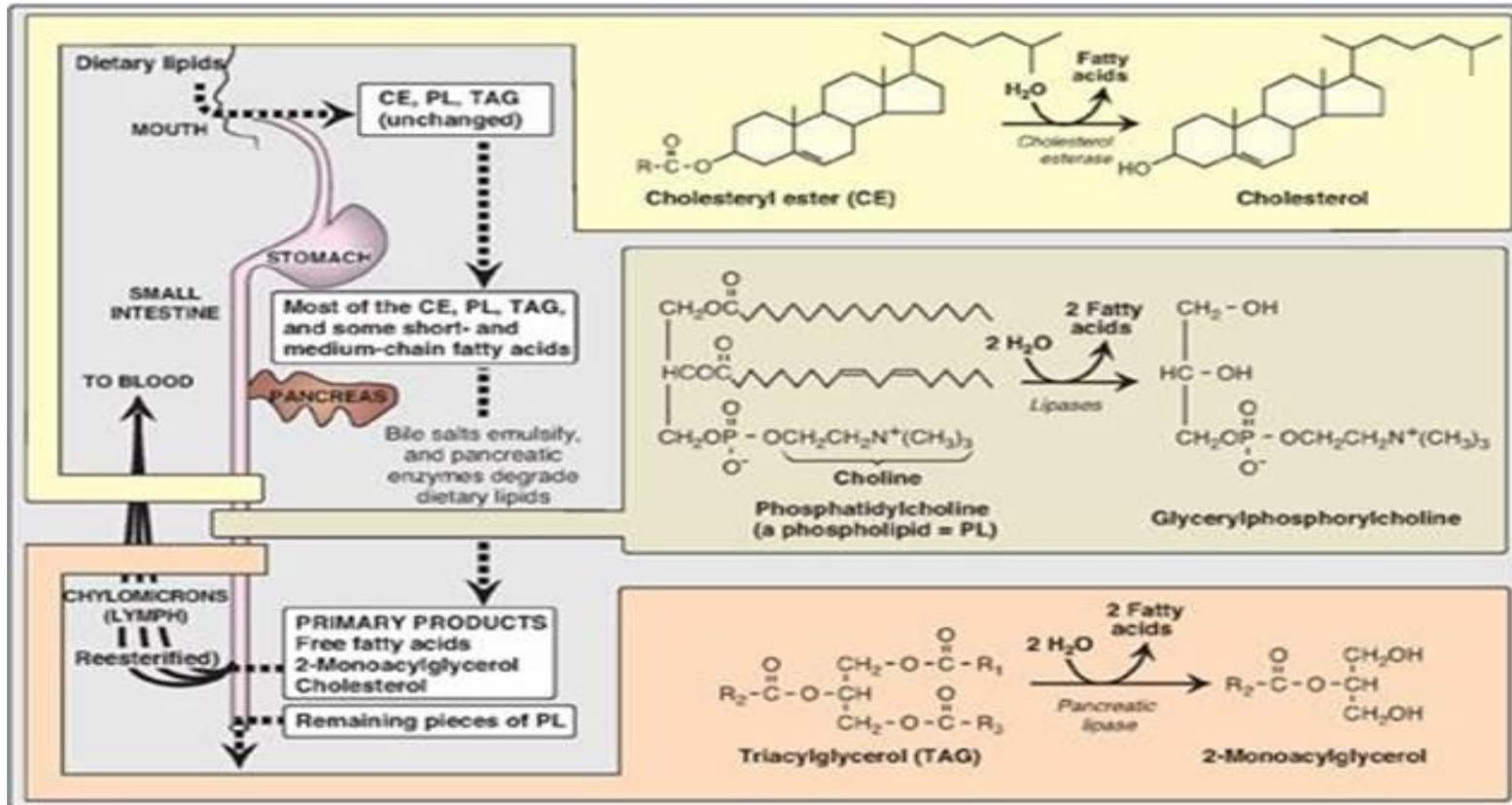


- Storage form of energy
- Structural component of cell membrane
- Precursor of many steroid hormones, vitamin D
- Act as thermal insulator
- Protection of internal organs
- Help in absorption of fat soluble vitamins
- Lipoproteins transporting lipids
- Fats serve as surfactants by reducing surface tension
- Improve taste and palatability
- Acts as electric insulators in neurons

Dietary Lipid Metabolism

- The average daily intake of lipids by U.S. adults is about 81g, of which more than 90% normally Triacylglycerol (TAG).
- The remainder of the dietary lipids consist of cholesterol, cholesteryl esters, phospholipids and free fatty acids.

Overview of lipid digestion



Processing of dietary lipid in the stomach

- Digestion of lipids begins in the stomach, catalyzed by a *lipase* (lingual lipase) that originates from glands at the back of the tongue.
- TAG molecules, particularly those containing fatty acids of short- or medium chain length (fewer than 12 carbons such as are found in milk fat), are the primary target of this enzyme.

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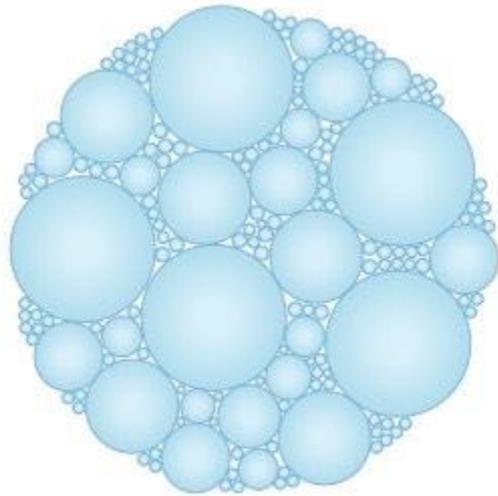
- *Gastric lipase*, secreted by the gastric mucosa also degrade TAGs.
- Both enzymes are relatively acid stable, with pH optimums of 4 to 6.
- These “acid lipases” contribute in lipid digestion in neonates (for whom milk fat is the primary source of calories).
- These acid lipases are vital enzymes in individuals with pancreatic insufficiency such as those with *cystic fibrosis* (CF).

Emulsification of dietary lipid in the small intestine

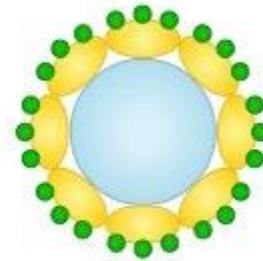
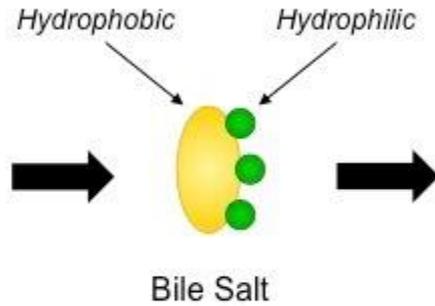


- The critical process of emulsification of dietary lipids occurs in the duodenum.
- Emulsification is a process in which large lipid globules are broken down into several small lipid globules. The bile salts' hydrophilic side can interface with water, while the hydrophobic side interfaces with lipids, thereby emulsifying large lipid globules into small lipid globules.
- Emulsification increases the surface area of the hydrophobic lipid droplets so that the digestive enzymes, which work at the interface of the droplet and the surrounding aqueous solution, can act effectively.

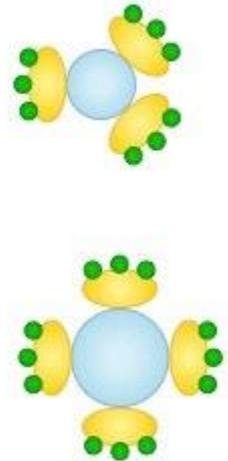
Emulsification



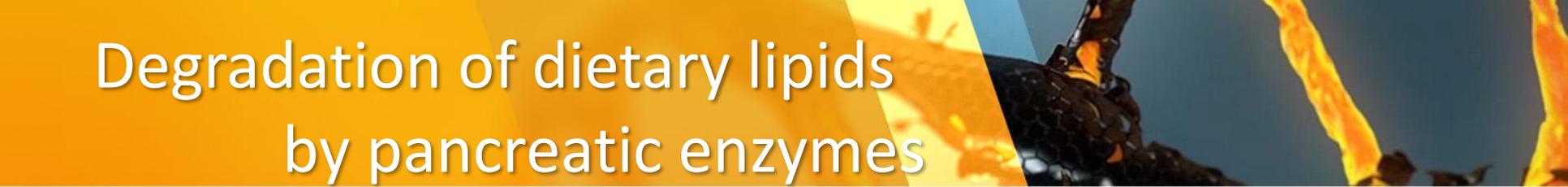
Fat Globule



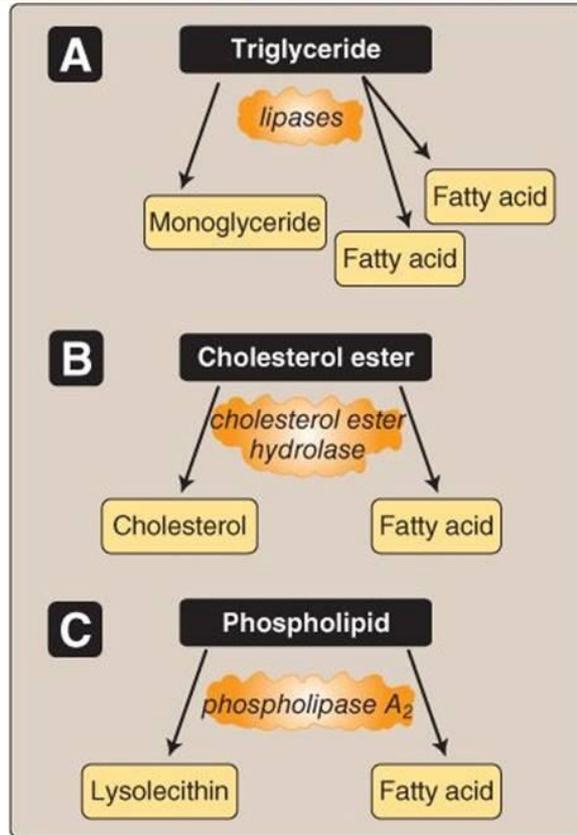
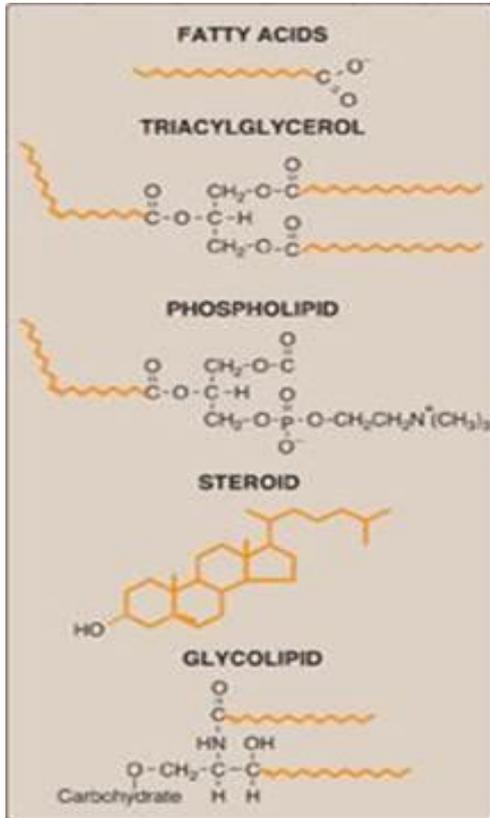
Emulsified Fat Droplets



Degradation of dietary lipids by pancreatic enzymes



- The dietary TAG, cholesteryl esters and phospholipids are enzymically degraded by pancreatic enzymes, whose secretion is hormonally controlled.



Biomedical importance of lipids:

1. Act as fuel in body yielding energy.
2. Lipids supply essential fatty acids in the diet.
3. Some vitamins like A, D, E, and K, are fat soluble.
4. Nervous system is rich in lipids, and are essential for proper functioning.
5. Break down products of fats like acetyl-CoA can be used by the body for synthesis of cholesterol, steroid hormones.

Cont.

6. Lipoproteins and phospholipids are important constituents of many natural membranes such as cell walls and mitochondria.
7. Some lipid deposited around internal organs have protective function.
8. Lipoproteins are carriers of triglycerides, phospholipids and cholesterol in the blood.