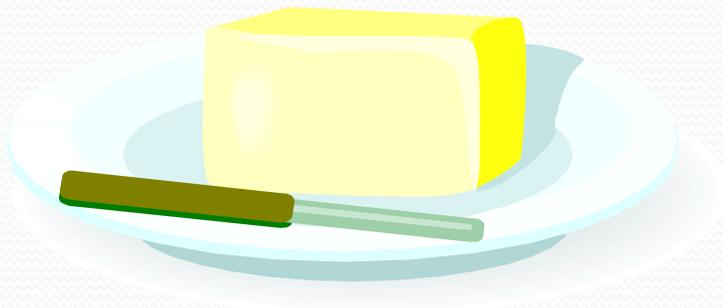


Lipid Metabolism

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Lipids

- Heterogenous group of biomolecules
- Water insoluble (hydrophobic)
- Soluble in organic and non-polar solvents
acetone, ether, chloroform and benzene



Classes of lipids

Simple lipids

e.g.
- Triglycerides
- Waxes

Esters of FA with
alcohols

Esters of FA with alcohols and
additional group

Conjugated (complex) lipids

- Phospholipids,
- Glycolipids
- Sphingo- phospholipids
- Lipoproteins.

Derived lipids

- Fatty acids
- Cholesterol
- Ketone bodies

Obtained on hydrolysis of
simplex or complex lipids

Functions

- Major **source of energy** for the body: Fat stored in the adipose tissue is a direct and potential source of energy.

1 gm lipids → 9.3 Kcal

1 gm CHO → 4.1 Kcal

- Storage form of energy-**triglyceride**
- Serves as **structural components** of cell membrane (Phospholipids, glycolipids)
- Some are **hormones** e.g. steroid hormone (cortisol, aldosterone, sex hormones)
- **Essential in the diet** to provide the body with some essential FA and of fat-soluble vitamins (A, D, E,K) which have regulatory or coenzyme function

Digestion and Absorption of Lipids

- In adult man ingests about **60-150 g of lipids/day** of which > 90% is normally TG, the remainder of dietary lipids is made of cholesterol, cholesteryl esters, PLs and FFAs
- In diabetes mellitus, The body 1st utilizes fats for energy production when glucose oxidation is impaired
- **1- No digestion of Fat in the mouth.**
- **2- Little fat digestion takes place in the stomach by Gastric Lipase** that degrade TG with short chain FAs at optimum PH 5.
- **Gastric Lipase** is **valuable in infants** due to high PH in their stomach and their milk diet with short chain FAs.
- While it is **insignificant in adults** due to its inhibition by gastric acidity.

- 
- **3- Digestion of dietary lipids start in the small intestine** where they are first emulsified by the bile salts, mechanical mixing due to peristalsis, phospholipid and colipase.
 - Emulsification increases the surface area of the lipid droplets, so that digestive enzymes can act effectively
 - After emulsification, lipids are hydrolysed by the **lipolytic enzymes** such as pancreatic lipase, phospholipase and cholesterol esterase, present in the pancreatic juice

A-Pancreatic lipase:

- secreted into the intestine
- It is the major enzyme of TG hydrolysis, with optimum PH 7.
- This enzyme is specific for esters α -positions of TG (linkage in position 1,3)
- It catalyzes hydrolysis of triacylglycerols at positions 1 & 3, forming 1,2-diacylglycerols, & then 2-monoacylglycerols .
- It prefers long chain FAs.

➤ **B- A protein colipase** secreted by the pancreas, is required to stabilize the lipase to its TG substrate.

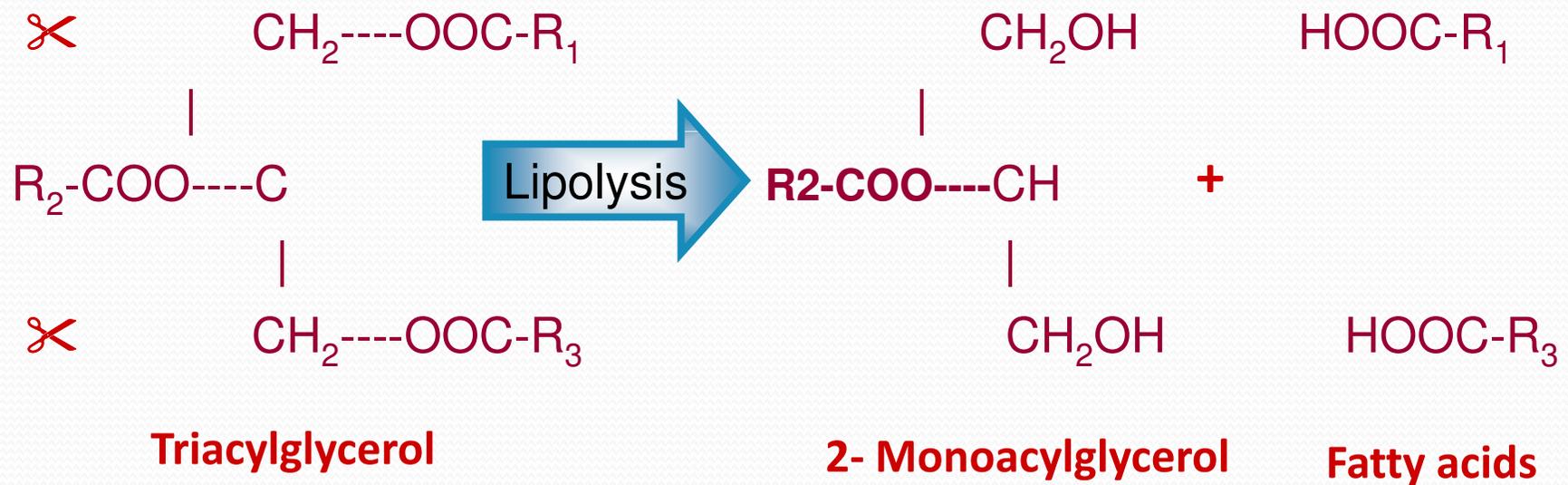


Figure: General structures of fatty acids and triacylglycerol Lipolysis of TG by pancreatic lipase produces fatty acids plus 2- Monoacylglycerol

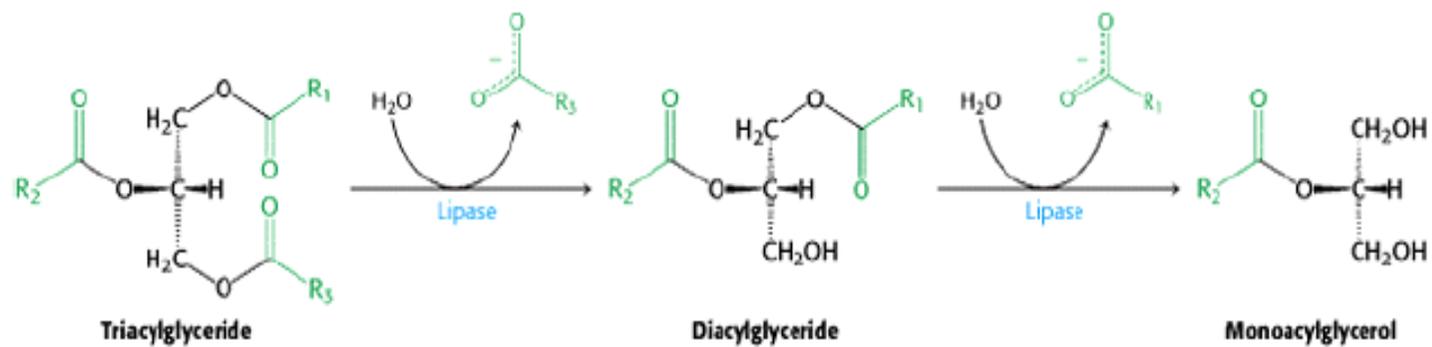


Figure 22.4. Action of Pancreatic Lipases. Lipases secreted by the pancreas convert triacylglycerols into fatty acids and monoacylglycerol for absorption into the intestine.



C-cholesterol ester hydrolase(estrerase)

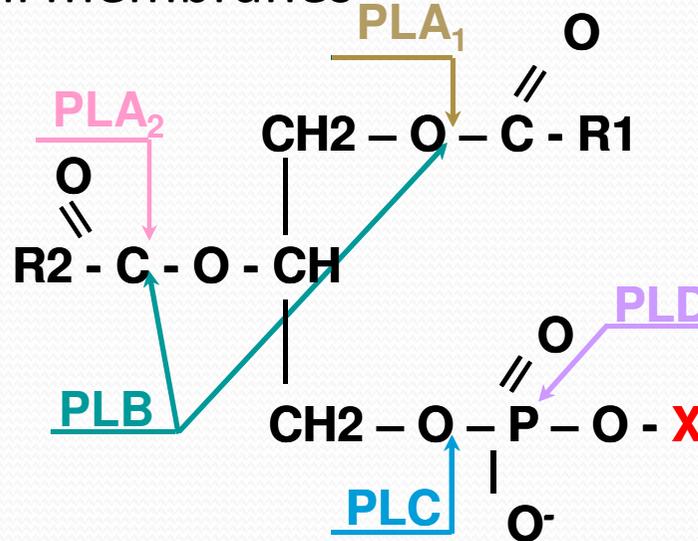
Present in the pancreatic secretion.

None specific enzyme.

Hydrolyses cholesterol ester(CE) into cholesterol and FFA

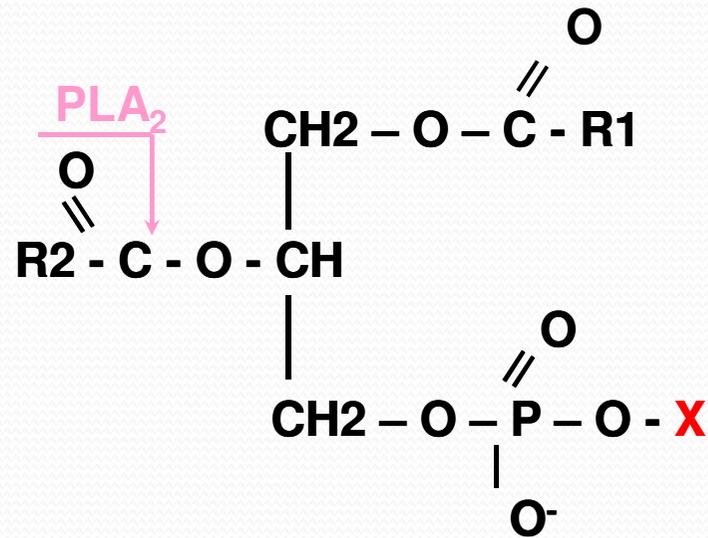
D - Phospholipases

- Glycerol + two fatty acids + phosphorus+ nitrogenous base.
- Phosphorus part makes it soluble in water
- Fatty acids make it soluble in fat
- Therefore can serve as an **emulsifier**
- Key role is in cell membranes



Phospholipase A₂

- Is secreted by the **pancreas** into the intestine where it is activated by **trypsin**
- It hydrolyzes the ester linkage between the fatty acid & the hydroxyl on **C₂** of phospholipids



Plase A₂

- Lecithin(phosphatidyl choline) \longrightarrow Lysolecithin+
FFA

Plase A₁

- Lysophospholipids \longrightarrow glycerolphosphorylbase
(Lysolecithin) + FFA

Plase A₁ remove FA at C₁

Glycerolphosphorylbase may be excreted in stool,

Or further degraded by **phospholipase C** to give
phosphoryl base and glycerol

Or degraded be **phospholipase D** to give glycerol
phosphate and nitrogeous base.

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- The end products of dietary phospholipids digestion are lysophospholipids (mainly), free fatty acids, glycerol phosphate and the nitrogenous bases

Figure: Five steps of lipid digestion and absorption

Lipids:

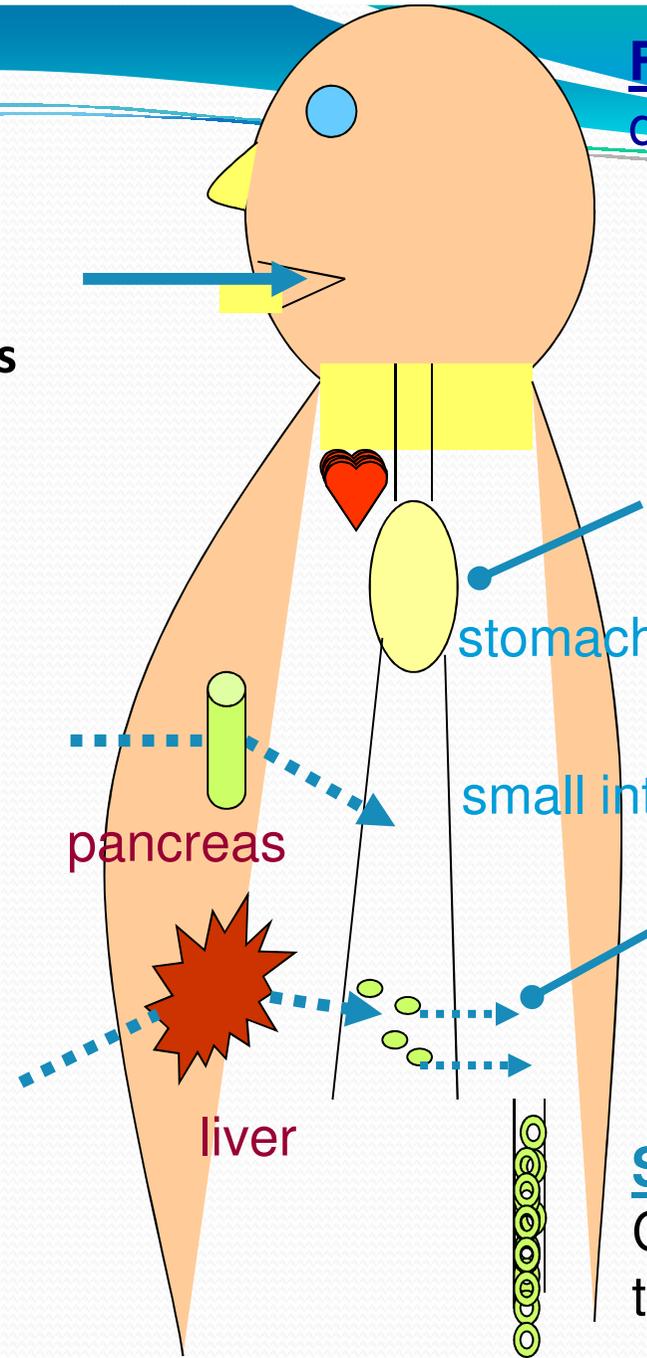
Triacylglycerol
Cholesterol esters
Phospholipids

STEP 2

Pancreas releases:
Lipase (+colipase)
cholesterol esterase
phospholipase A₂

STEP 3

Liver releases bile
acids to solubilize
lipid products in
mixed micelles



STEP 1

Gastric Lipase

pH_{opt} ~5, Initiates
hydrolysis and acts on
TG with short chain FAs

stomach

small intestine

pancreas

liver

STEP 4

Lipids absorbed
from micelles into
epithelial cells

STEP 5

Chylomicrons form and
travel through lymphatics

➤ At the intestinal lining, **shorter-chain fatty acids** and **glycerol** are absorbed and pass directly to liver by portal circulation.

➤ The cells of the intestinal lining convert large lipid fragments back into **triglycerides** and combine them with protein forming **chylomicrons*** that travel in the lymph.

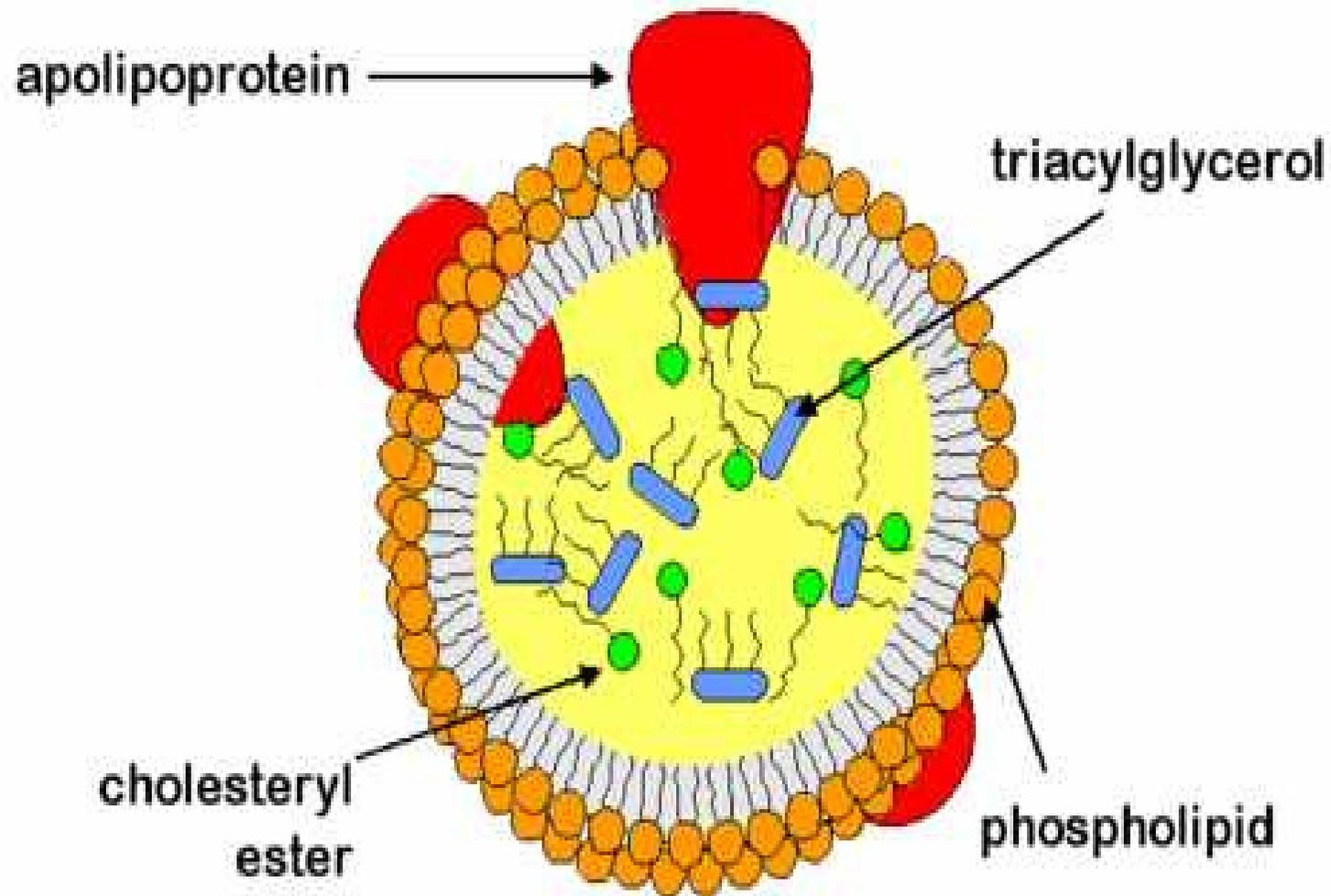
** lipoprotein – how fat is transported in the body; a mixture of fat and protein*

➤ The end products of PL hydrolysis are absorbed along with the digestive products of the triglycerides

➤ Phospholipids are resynthesised in the intestinal mucosa and form part of the chylomicrons

- **Cholesterol** is absorbed in the free form
- The cholesterol esters are hydrolyzed by **cholesterol esterase** secreted in the pancreatic juice
- Cholesterol and free fatty acids are then absorbed from the intestine
- Cholesterol is **re-esterified** in the intestinal mucosa and passes along with triglycerides in the form of **chylomicrons** to the lymph vessel then systemic circulation.(milky appearance of serum after fatty meals which is cleared specific enzyme lipoprotein lipase on the surface of blood capillaries).
- After absorption, lipids are either **oxidised** mainly in the liver or are **stored** in the depot (adipose tissue)

Structure of a chylomicron



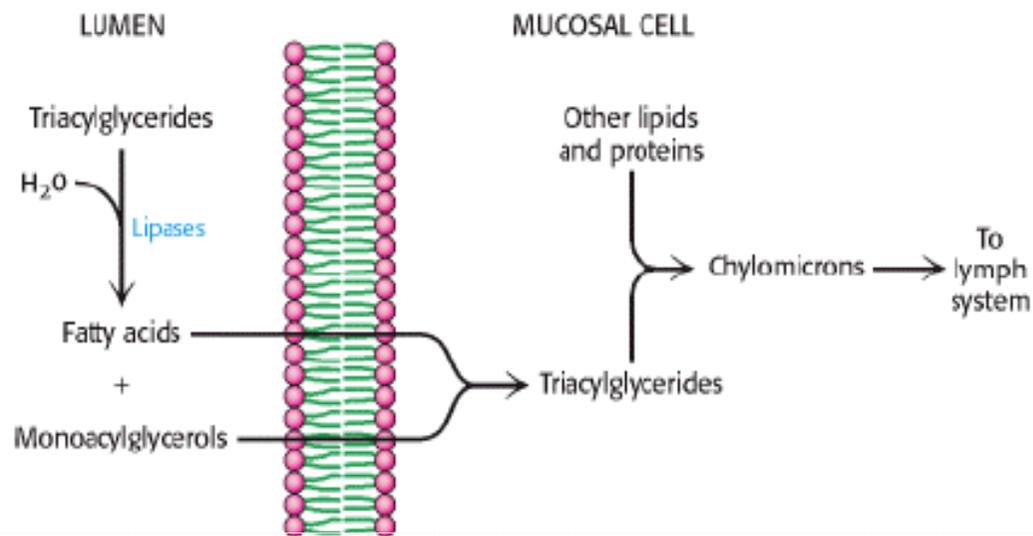


Figure 22.5. Chylomicron Formation. Free fatty acids and monoacylglycerols are absorbed by intestinal epithelial cells. Triacylglycerols are resynthesized and packaged with other lipids and apoprotein B-48 to form chylomicrons, which are then released into the lymph system.

Malabsorption of lipids(steatorrhea); causes loss of lipids include fat soluble vitamins and essential FAs in feces.