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Biochemical Aspects of Digestion of Lipids

** Dietary Lipids:

- **Dietary lipids intake is ~81 g/day**
  Triacylglycerol is ~ 90%
  The remainder includes (10%):
  Cholesterol , Cholesterol ester , Phospholipids , Glycolipids , Free fatty acids

** Lipid Digestion:

- **(start digestion of lipid in the stomach completed in small intestine)**
- food (TAG , PL , other lipids) → in the stomach (break down short & mediam chain FA up to 6-12 C
- Longer than 12 C → in the small intestine

Enzymes of lipid digestion	Site of secretion	Site of action	Effect on	product
Lingual lipase	Mouth	Stomach	- triacylglycerl - Little significance in adult (why ??) - Important for digestion of milk fat in neonates and infants	
Gastric lipase	Stomach			
Pancreatic Lipase and co-lipase	pancreas	Small intestine	On triacylglycerol	2-Monoacylglycerol + FA
Cholesteryl esterase			Cholesteryl ester	Cholesterol
Phospholipase A2			Phospholipids	Lysophospholipid Fatty acid
Lysophospholipase			Lysophospholipid	Glycerylphosphoryl base Fatty acid

Pancreatic lipase :
Found in high conc. in pancreatic secretion (2-3% of total proteins)

Inhibited by Orlistat, an antiobesity drug

Little significance in adults (Why?)
b\c our dite(adults) composed of long chain FA → pancreatic enzyme But infant (milk) composed of short chain FA → lipase enzyme "

** Digestion of Lipids in Small Intestine

- **Digestion of lipids is preceded by .**
- **Digestion in small intestine is hormonally controlled:**
  a. **Cholecystokinin (CCK)**
  b. **Secretin**

emulsification: try to mix 2 Liquid that can not mixed together by something else that fassilitate mixeing .
ex: oil & water

Emulsification of Dietary Lipids in duodenum:

Remember ! no more short&mediam chain FA (b\c of the action of lipase in the stomach.)

- **Emulsification increases the surface area of lipid droplets, therefore the digestive enzymes can effectively act.**
- **Mechanisms:**
  1. Mechanical mixing by peristalsis
  2. Detergent effect of bile salts(from gall bladder):

Bile salts interact with lipid particles and aqueous duodenal contents, stabilizing the particles as they become smaller, and preventing them from coalescing (joining together)

يمنع الـ small droplet إنها تتجمع مرة ثانية
Peristalsis make small droplet that should be stabilized by bile salt → ثابتة ما ترجع تتجمع مرة ثانية
↑ small droplet → ↑ total surface area →↑ enzyme contact → fast digestion

The gut hormone	Stimulus for secretion	Effects
1- Cholecystokinin (CCK)	The presence of partially digested proteins (& lipids) in the upper small intestine	1. Stimulates the release of pancreatic digestive enzymes and bile salts 2. Decreases gastric motility → slower release of gastric contents into the small intestine
2- Secretin	Low pH of the chyme entering the intestine	Stimulates the pancreas to release a watery solution rich in bicarbonate to neutralize the pH of the intestinal contents (to reach the optimum pH for digestive activity by pancreatic enzymes)

** Main End products of lipid digestion:

2-Monoacylglycerol
Free fatty acids } TAG
Cholesterol } Cholesteryl ester

** Absorption of Lipids by Intestinal Mucosal Cells:

Mixed micelles:

Disc-shaped clusters of amphipathic lipids.

Arranged with their hydrophobic groups on the inside and their hydrophilic groups on the outside.

Micelle includes end products of lipid digestion, bile salts and fat-soluble vitamins

Short- and medium-chain fatty acids do not require mixed micelle for absorption by intestinal cells (passive absorbed)

Absorption of Lipids by Intestinal Mucosal Cells:

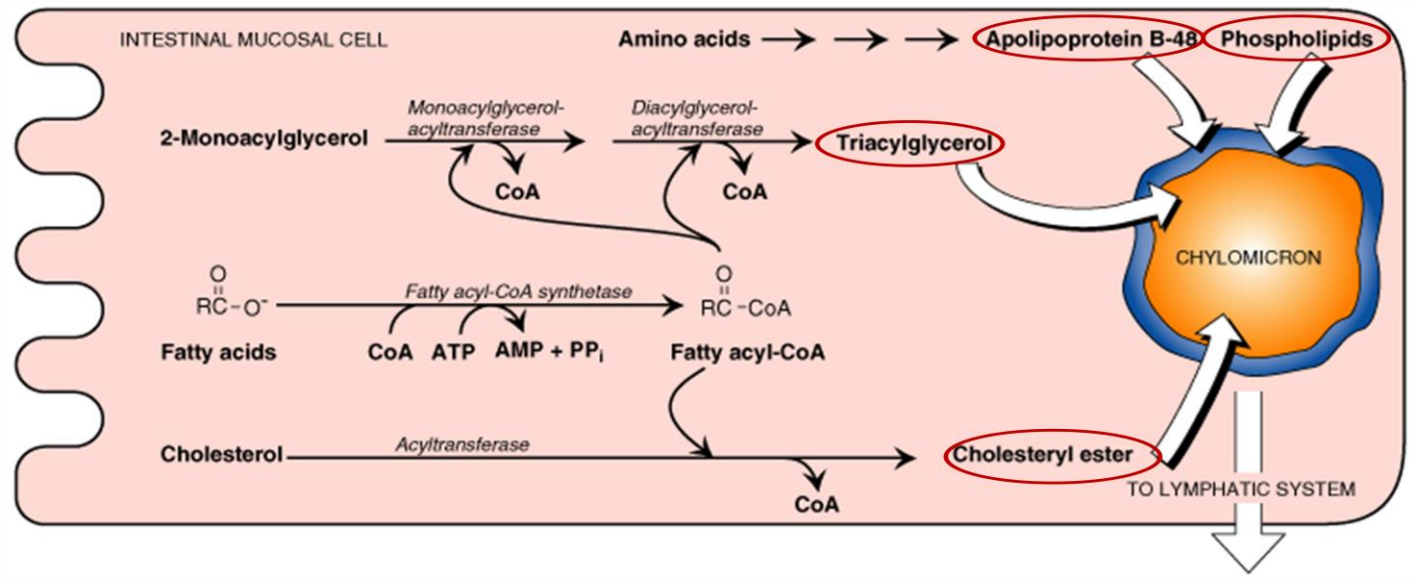
http://bcs.whfreeman.com/thelifewire/content/chp50/5002001.html

** Re-synthesis of Lipids by Intestinal Mucosal Cells:

(breakdown → resynthesis → go to circulation to send to the organ)

1. **Activation of long chain fatty acids into acyl CoA**
2. **Synthesis of TAG from monoacylglycerol Cholesteryl ester from cholesterol Phospholipids from glycerylphosphoryl base**
3. **Short- and medium-chain fatty acids are not converted into their CoA derivatives. Instead, they are released into portal circulation, carried by serum albumin**

Resynthesis of Lipids and assembly of Chylomicrons by Intestinal Mucosal Cells:



** Assembly of Chylomicrons by Intestinal Mucosal Cells:

Assembly of chylomicrons:

Newly synthesized TAG and cholesteryl ester are packaged as lipid droplets surrounded by thin layer of:

Apolipoprotein-48 (apo-48)

Phospholipids

Free cholesterol

** Secretion of Chylomicrons by Intestinal Mucosal Cells:

Secretion of chylomicrons:

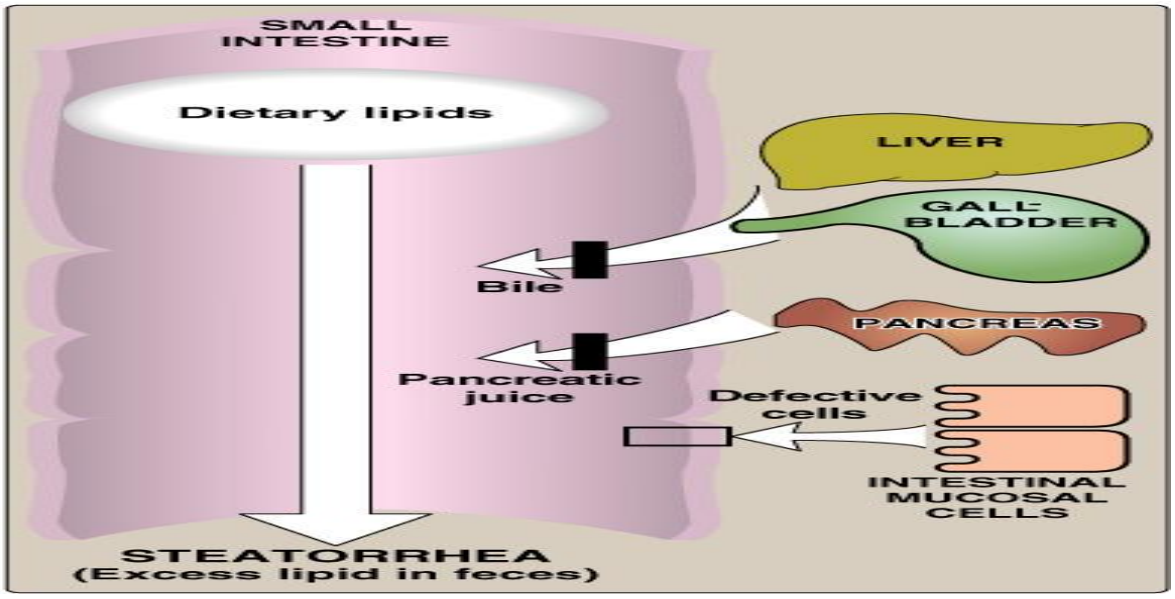
By exocytosis into lymphatic vessels around villi
of small intestine (lacteals) then enter into
systemic circulation
Milky-appearance of serum after lipid-rich meal (when we take bio sample from blood circulation after fat rich meal , in serology → see milky appearance " chyl")

** Abnormalities in Lipid Digestion/Absorption:

- **Liver and gall bladder diseases**
- **Pancreatic insufficiency**
  e.g., chronic pancreatitis, cystic fibrosis, surgical removal of the pancreas
- **Intestinal diseases:**
  e.g., Intestinal resection (shortened bowl)

→ incomplete digestion & absorption of fat & protein → abnormal appearance of lipids (steatorrhea) & undigested protein in the feces (Malabsorption syndrome)

Maldigestion/Malabsorption of Lipids:



**** Take home message:**

- Dietary lipids are relatively hydrophobic
- Lipid digestion begins in stomach
- Emulsification of lipids occurs in duodenum, helped by peristalsis and bile salts
- Intestinal digestion of lipids by pancreatic enzymes
- Lipid absorption by formation of mixed micelles
- Re-synthesis of TAGs, cholesterol ester and PLs inside the intestinal mucosal cells
- Assembly and secretion of chylomicrons into lymphatic lacteals and then into systemic circulation
- Short- and medium-chain fatty acids:
  Do not require micelle for absorption
  Do not participate in re-synthesis of TAGs & PLs
  Released directly from intestinal cells into portal circulation
- Liver diseases, pancreatic insufficiency, or intestinal diseases → incomplete digestion and absorption of fat & protein → steatorrhea & appearance of undigested proteins in the feces (Malabsorpton syndrome)