

# Biochemical Aspects of Digestion of Lipids



## The Objectives

By the end of this lecture, the student should be able to:

- Understand the process of digestion of dietary lipids including, the organs involved, the enzymes required, and the end products.
- Implement the basic science knowledge of the process of lipid digestion to understand the clinical manifestations of diseases that involve defective lipid digestion &/or absorption (Maldigestion and malabsorption syndrome)

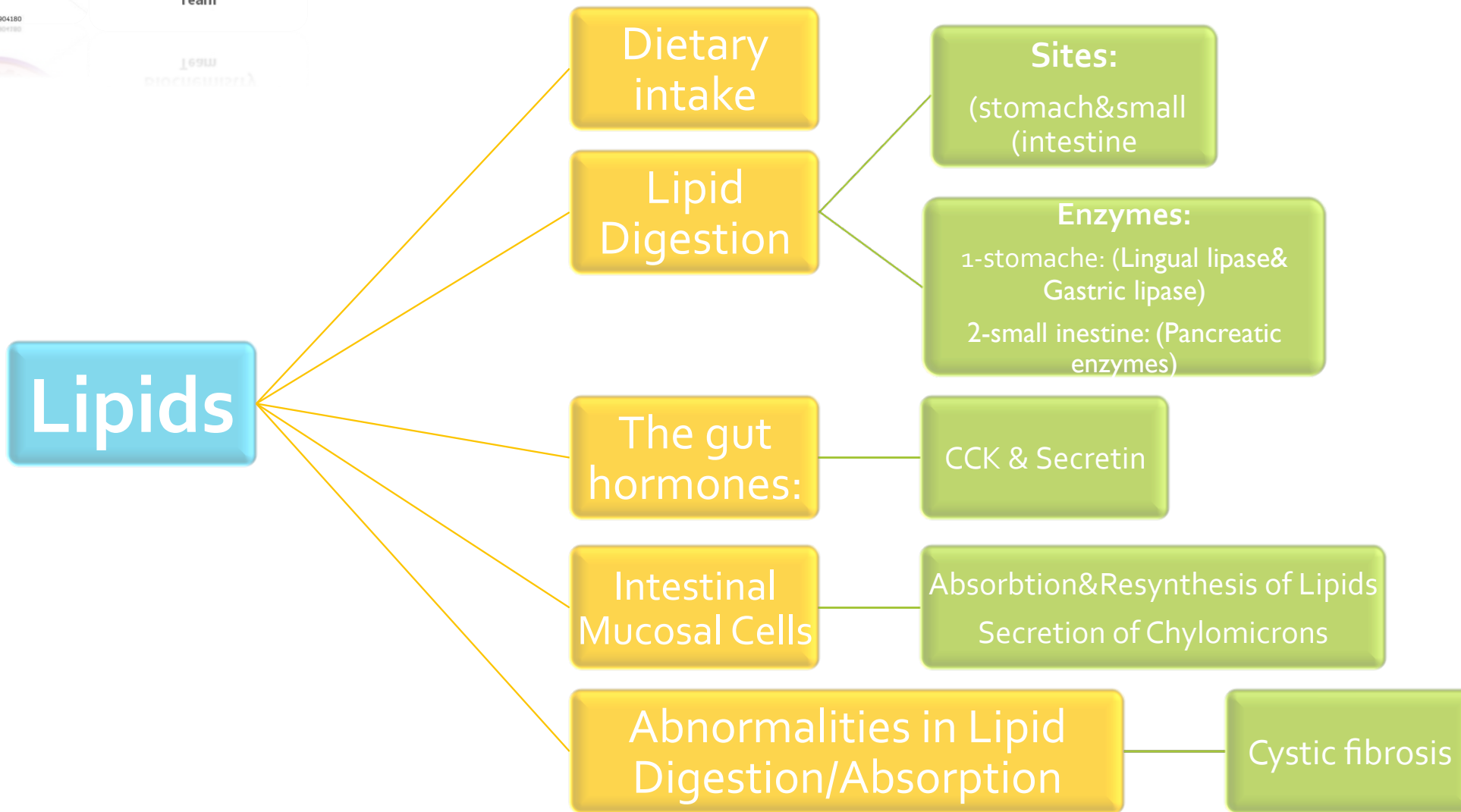
Red =  
Important

Blue =  
explain

Green =  
addition  
notes



# Mind Map





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# Lipids

## Dietary Lipids :

Dietary lipids intake is ~81 g/day

- Triacylglycerol is ~ 90%
- The remainder includes (10%):
  - Cholesterol
  - Cholesteryl ester (cholesterol with fatty acids)

- ✧ Phospholipids
- ✧ Glycolipids
- ✧ Free fatty acids

## Lipid Digestion: Sites and Enzymes

### ✧ Sites:

- 1-The stomach
- 2-The small intestine

### ✧ Enzymes:

#### 1. Act in stomach:

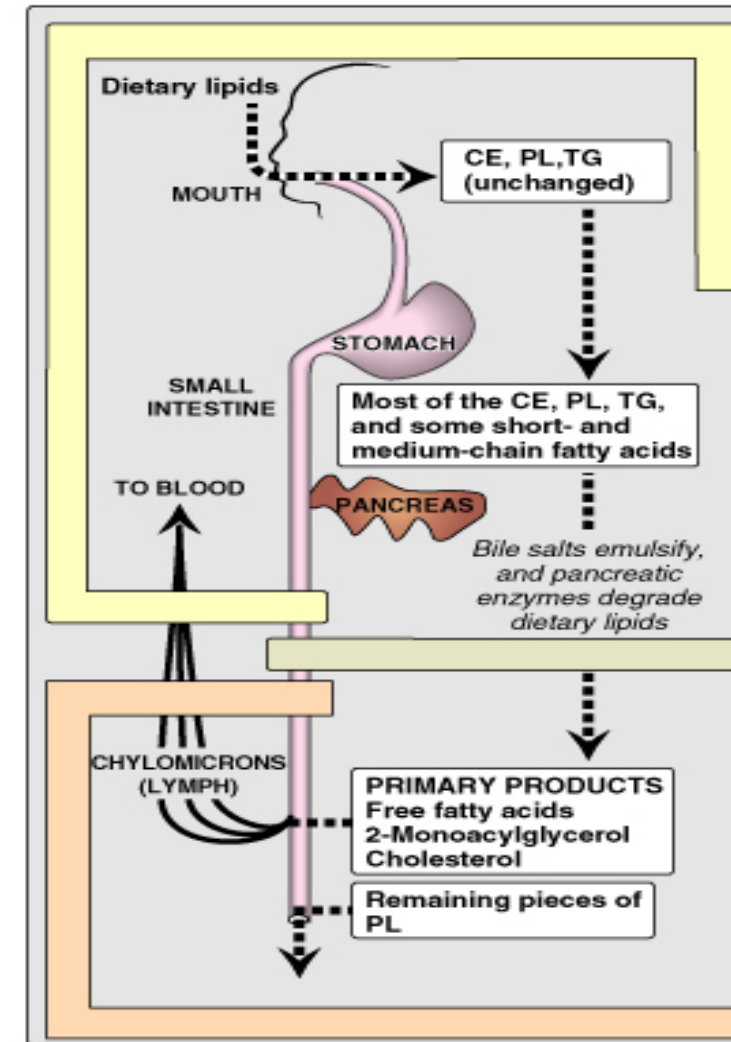
Mouth: Lingual lipase (first enzyme act on the food it is coming from base of salivary gland )

Stomach: Gastric lipase (gastric mucosa):  
+They act only on short and medium length fatty acids (<12 carbon fatty acid chains, e.g. milk).

So,It is essential for neonates and not that important for adults unless they have pancreatic insufficiency(e.g.cystic fibrosis)

#### 2. Act in small intestine:

- Pancreatic enzymes
- Lipase and co-lipase
  - Cholesterol esterase
  - Phospholipase A2
  - Lysophospholipase





## Emulsification of Dietary Lipids in duodenum

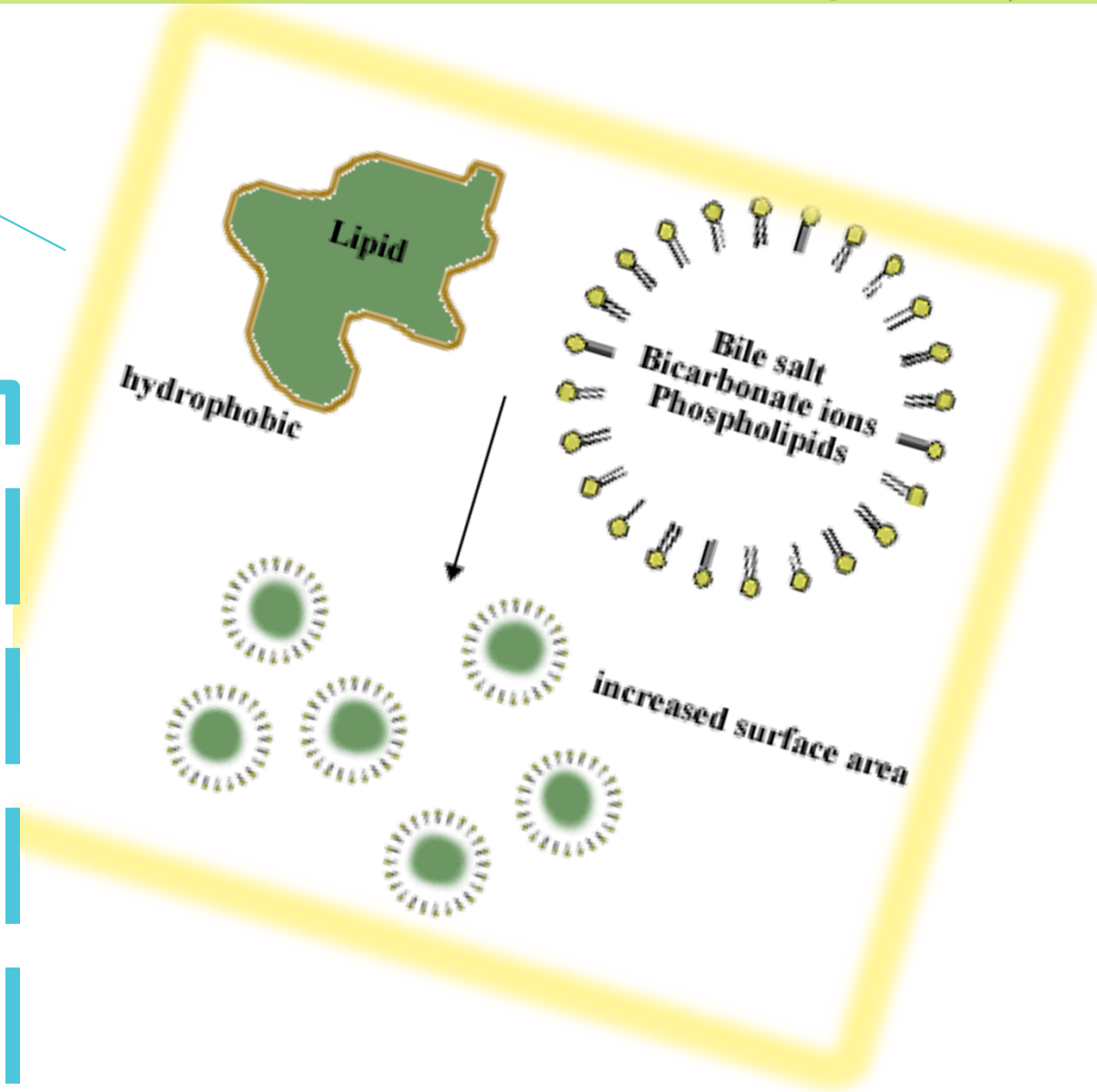
Emulsification increases the surface area of lipid droplets (enzyme can act only on the surface so when we break it to small droplet, the enzyme can act on much more molecules so the surface area increases), therefore the digestive enzymes can effectively act.

Mechanisms:

1-Mechanical mixing by peristalsis the rhythmic contractions and relaxations to mix the lipids with the bile salts.

2. Detergent effect of bile salts: (by hydrophobic end they interact with water & hydrophobic end they interact with lipids)

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





## 1-Digestion of lipids begins in the Stomach

The effects of lingual and gastric lipases on TAG:

- Important for digestion of milk fat in neonates and infants
- Little significance in adults

(because They act only on short and medium length fatty acids )

## 2- Digestion of Lipids in Small Intestine

-Digestion of lipids is preceded by emulsification

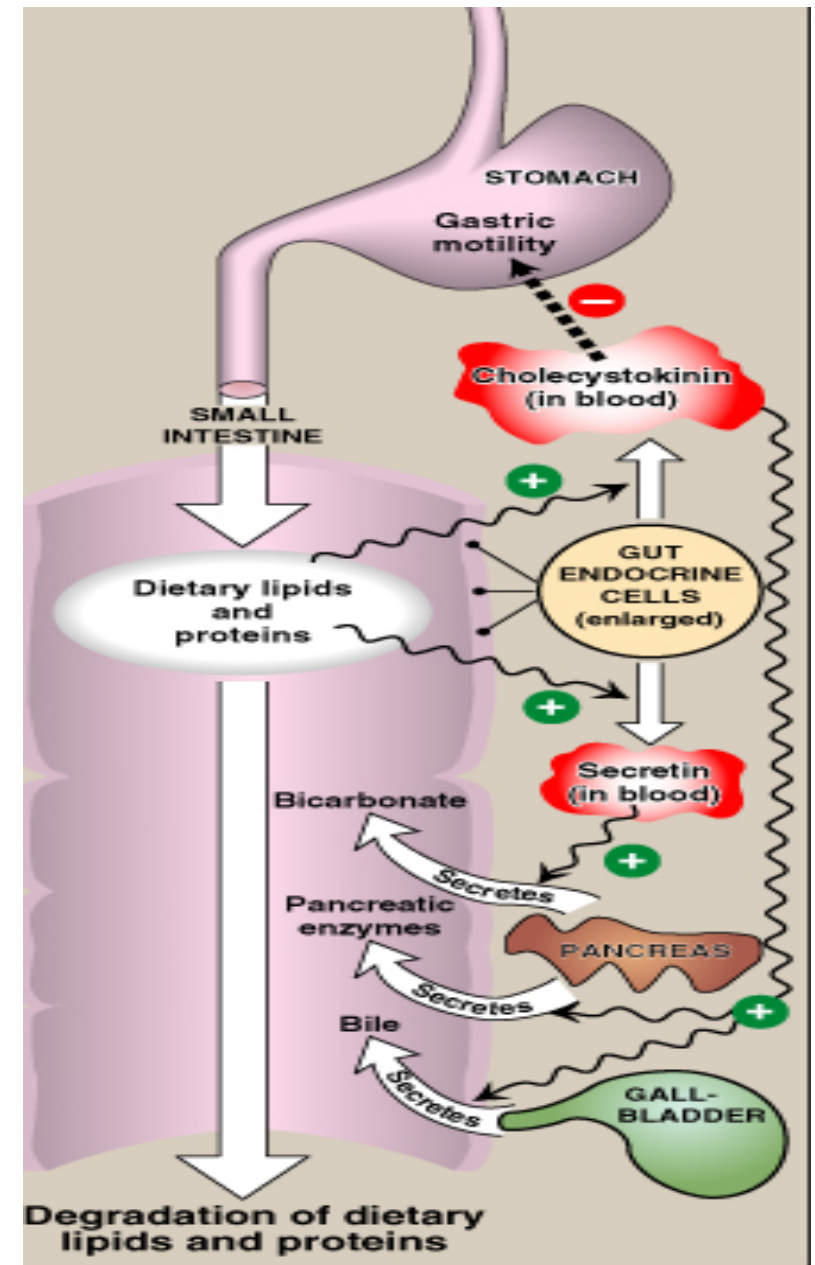
-Digestion in small intestine is **hormonally controlled**:

Two small peptide hormones are released from cells of the upper part of small intestine:

### 1-Cholecystikin (CCK)

- o Secretion of pancreatic enzymes (excitatory).
- o Bile secretion (excitatory).
- o Slow release of gastric contents (inhibitory).

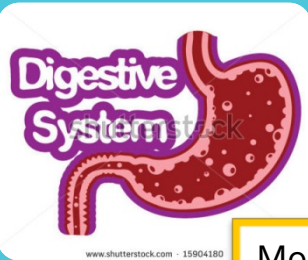
### 2-Secretin "Secretin regulates PH"





# The Gut hormones.

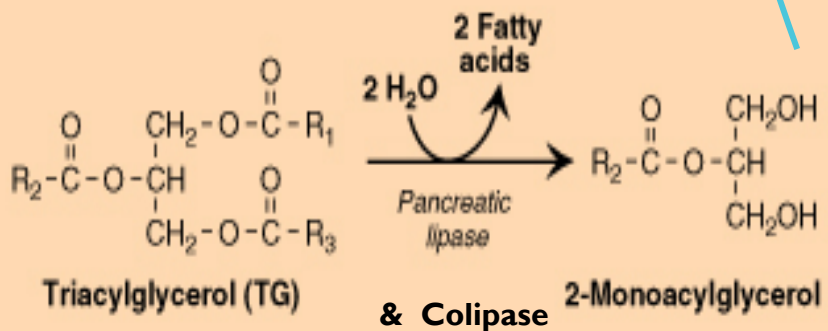
The gut hormone	Stimulus for Secretion	Effects
<b>1- Cholecystinin</b> (CCK)	The presence of partially digested proteins (& lipids) in the upper small intestine	<ul style="list-style-type: none"> <li>-Stimulates the release of pancreatic digestive enzymes</li> <li>- Stimulates the contraction of the gall bladder &amp; release of bile</li> <li>-Decreases gastric motility → slower release of gastric contents into the small intestine</li> </ul>
<b>2- Secretin</b>	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)



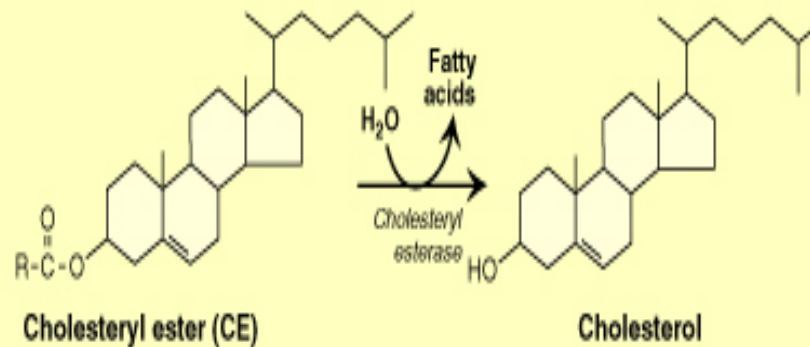
# Pancreatic enzymes for Digestion of Lipids

Mono = 1 Fatty Acid  
 2 = The single Fatty Acid is attached to the second carbon atom

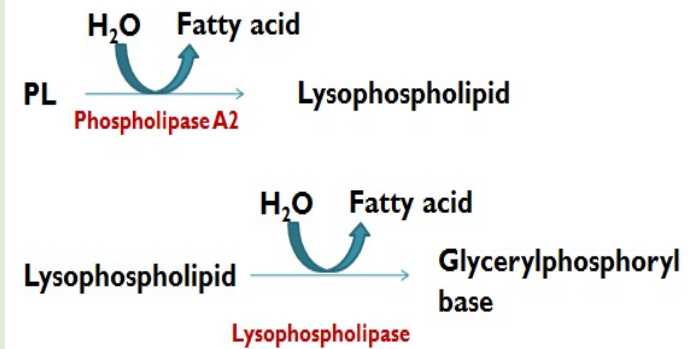
## Pancreatic Lipase and co-lipase (Digestion of TAG)



## Cholesterol esterase (Digestion of Cholesteryl ester)



## Phospholipase A2 & Lysophospholipase (Digestion of Phospholipids (PL))



### Pancreatic lipase :

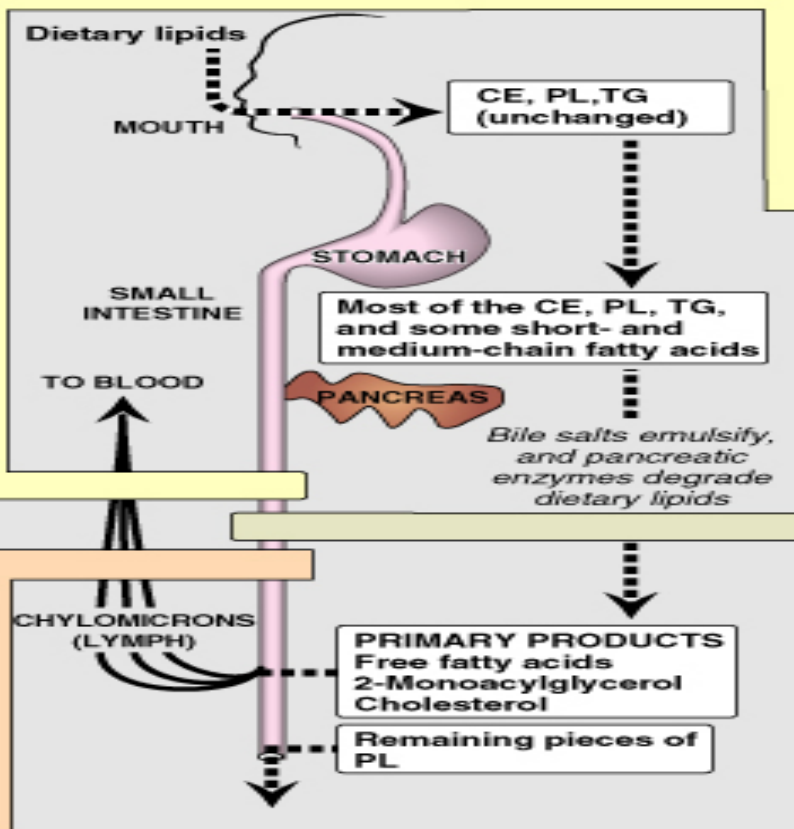
- Found in high conc. in pancreatic secretion (2-3% of total proteins)
- Inhibited by Orlistat, an antiobesity drug (It's side effect is steatorrhea because TAG is not broken down therefore not absorbed, so it gets excreted)
- Pancreatic Lipase acts mainly on long chain fatty acid and requires co lipase to work

Cholesterol esterase removes the fatty acid from the Cholesteryl ester and we are left with free cholesterol

Phospholipase A2 & Lysophospholipase each removes 1 fatty acid

## Main End products of lipid digestion:

- 2-Monoacylglycerol
- Cholesterol
- Free fatty acids



## Absorption of Lipids by Intestinal Mucosal Cells

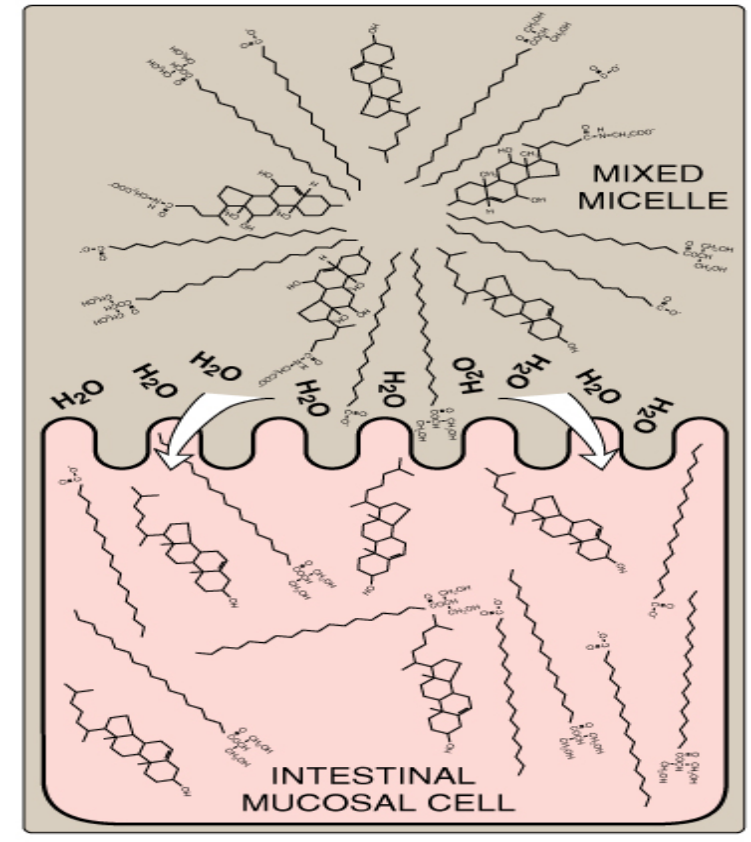
**Mixed micelles\*:**  
Disc-shaped clusters of amphipathic lipids. Arranged with their hydrophobic groups on the inside and their hydrophilic groups on the outside.

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 (They directly go to the portal circulation)**

\*Difference between Micelles and Chylomicrons.

Click please





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

## Resynthesis of Lipids by Intestinal Mucosal Cells

## Assembly of Chylomicrons by Intestinal Mucosal Cells

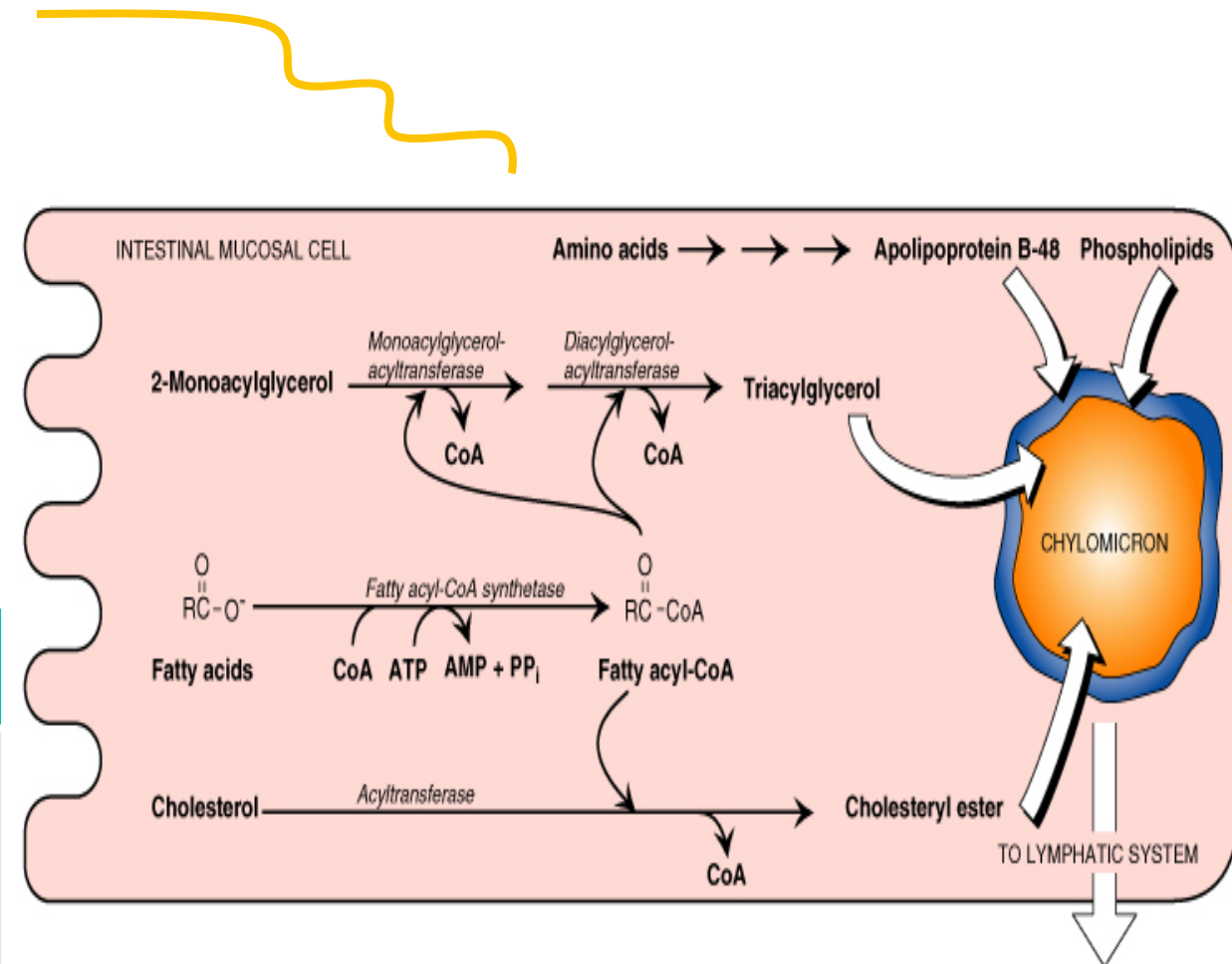
1. Activation of long chain fatty acids into acyl CoA
2. - Synthesis of TAG from monoacylglycerol  
- Cholesterol ester from cholesterol  
- Phospholipids from glycerylphosphoryl base
3. Short- and medium-chain fatty acids are not converted into their CoA derivatives. Instead, they are released into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

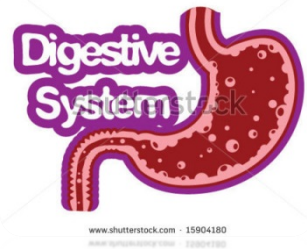
Newly synthesized TAG and cholesteryl ester are packaged as lipid droplets surrounded by thin layer of:

1. Apolipoprotein B-48 (apo B-48)
2. Phospholipids
3. Free cholesterol

## Secretion of Chylomicrons by Intestinal Mucosal Cells

-By exocytosis into lymphatic vessels around villi of small intestine (lacteals) then enter into systemic circulation  
-Milky-appearance of serum after lipid-rich meal





# Abnormalities in Lipid Digestion/ Absorption

Pancreatic  
insufficiency

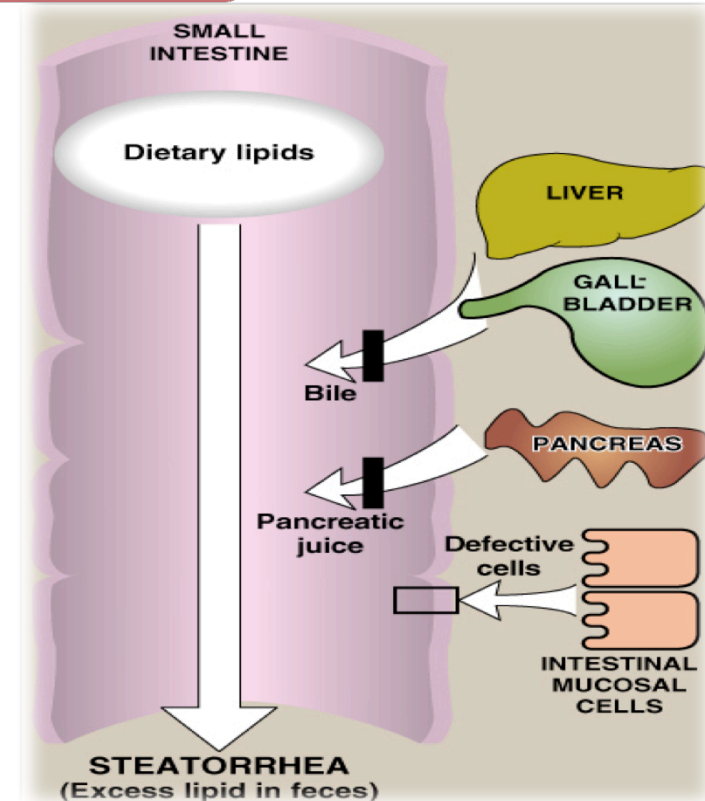
- 1-chronic pancreatitis
- 2-cystic fibrosis
- 3-surgical removal of the pancreas

Intestinal  
diseases:

e.g., Intestinal  
resection  
(shortened bowel)

Liver and gall  
bladder diseases

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





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# Cystic Fibrosis:

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- The name *cystic fibrosis* refers to the characteristic scarring (fibrosis) and cyst formation within the pancreas, first recognized in the 1930s
- It affects most critically the **lungs**, and also the **pancreas, liver, and intestine**. It is characterized by abnormal transport of chloride and sodium across an epithelium, leading to **thick, viscous secretions**.
- Autosomal recessive disorder due to mutation to the **CF Transmembrane Conductance Regulator** (CFTR ) gene
- CFTR protein is a **chloride channel on epithelium**
- Defect leads to decreased secretion of chloride and increased reabsorption of sodium and water
- In the pancreas, decreased hydration results in thickened secretions which cannot reach intestine, causing **pancreatic insufficiency** We give the patient **enzyme supplements and vitamins**

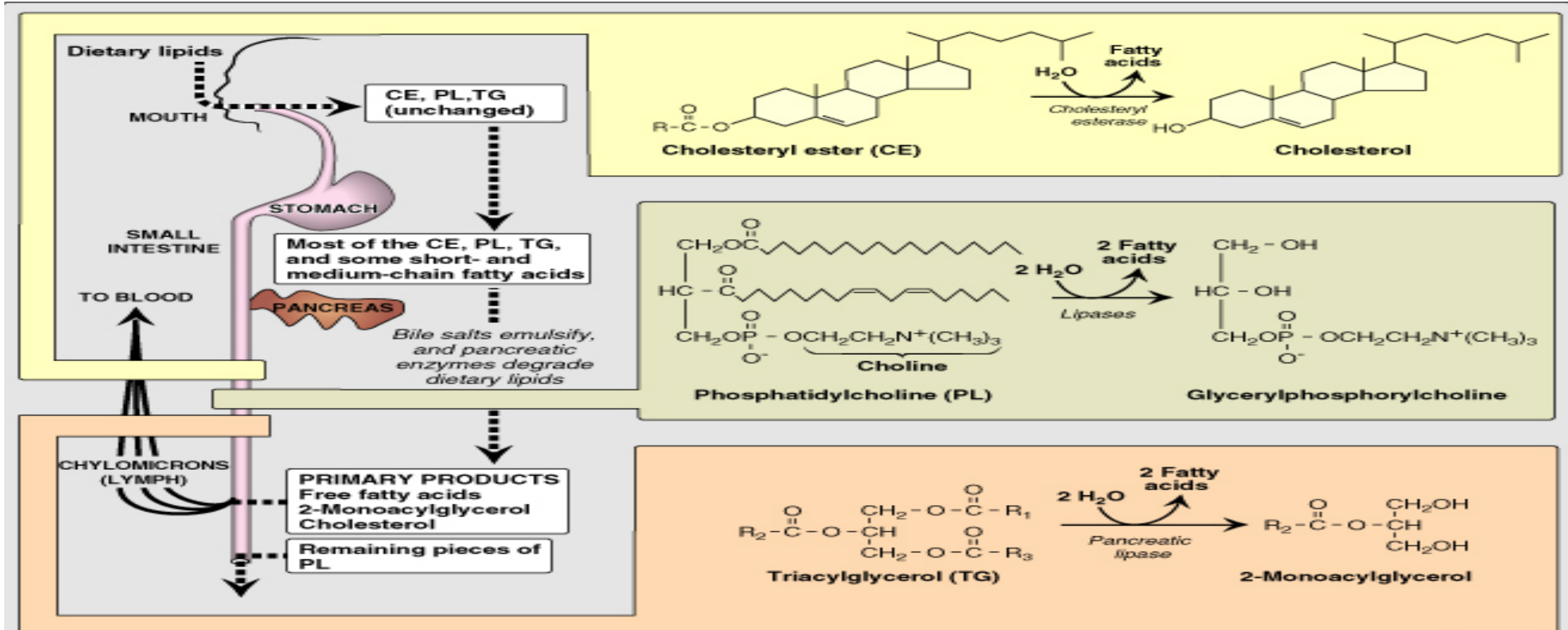
## Videos:

[Lipid Digestion](#)

[What is Cystic Fibrosis](#)

[Cystic Fibrosis](#)

# The Big Picture





# Take home message

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- 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, cholesteryl 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 (Malabsorption syndrome)



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# Questions!!

## 1- Lipid digestion occurs in :

- a. Stomach
- b. Colon
- c. Small intestine
- d. A&C

## 2- Which one of those does not require micelle for absorption:

- a. Long chain fatty acid
- b. Phospholipids
- c. Short- and medium-chain fatty acids
- d. Cholesterol

## 3- Which one of those enzymes is essential for neonates and not that important for adults :

- a. Cholesterol esterase
- b. Phospholipase A<sub>2</sub>
- c. Gastric lipase
- d. Lysophospholipase

## 4- The effect of Secretin is :

- a. Stimulates the release of pancreatic digestive enzymes
- b. Stimulates the contraction of the gall bladder & release of bile
- c. Decreases gastric motility
- d. Stimulates the pancreas to regulate the pH of the intestinal contents

1-D  
2-C  
3-C  
4-D

S  
R  
E  
W  
S  
N  
A



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If you find any mistake, please contact us:)

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Thank you

