

**3.**

**LIPID DIGESTION AND  
ABSORPTION**

- Like carbohydrate and protein lipids are also broken into small component for absorption.
- They poses a special problem because of the insolubility of fats in water and because of lipolytic enzyme (these are a number of enzyme present in the pancreatic juice).

- These are solved in the gut by emulsification (a process of dispersion of lipid into small droplet by reducing surface tension.) , particularly by bile salt present in bile and pancreatic lipase.
- With the emulsification the rate of digestion is proportionally increase.

# Digestion in the mouth

- It was earlier believed that little or no fat digestion take place in the mouth, but recently a lipase has been detected called **lingual lipase** which is secreted by the dorsal surface of the tongue (Ebner's gland)

# Lingual Lipase

- Its pH is 2.0-7.5, and its activity is continued in stomach, and also where the pH value is low
- Due to retention of food bolus for 2-3 hours, about 30% dietary TG (Triacyl glycerol) are digested in the stomach
- More active on TG and more specific for ester linkage at position-3 rather than position-1.
- Milk fat contain short and medium fatty acid . So milk fat appears to be the best substrate for this enzyme.

- More soluble, this short fatty acid and can be absorbed directly from the stomach wall and enter the portal vein.
- After the action of lingual lipase it pass to the stomach and the action of gastric lipase start.

# Gastric Lipase

- There is evidence of presence of small amount of gastric lipase in gastric secretion.
- The overall digestion of fats , brought about by gastric lipase is negligible because;
  - No emulsification occur.
  - Small quantity of enzyme.
  - It need  $Ca^{++}$ .
  - pH (not conducive which is highly acidic)

# Digestion in Small intestines

- Small intestine is the major site of fat digestion. Its due to the presence of;
  - Lipase (Steapsin).
  - Bile salts.
- These two enter the intestine through pancreatic and bile ducts to duodenum.

# Cholecystokinin (CCK-PZ)

- Presence of acidic chyme in the small intestine stimulates the secretion of pancreatic enzyme, **CCK-PZ**, cause contraction of the gallbladder and discharge of bile.
- CCK stimulates the acinar cells to release the pancreatic juices which has lipase.
- CCK also relaxes the sphincter of ODDI to let pancreatic juice and bicarbonates enter the deodenum

# Pancreatic Juice

- There are a number of enzyme present in the pancreatic juice but those that digest lipids are:
  - Pancreatic lipase
  - Phospholipase A2
  - Cholesterol esterase.
- Pancreatic lipase is the most important enzyme which hydrolyze TG containing short and long chain fatty acid.

# Pancreatic lipase

- TG is hydrolyzed by lipase to remove one fatty acid at one terminal to form  $\alpha,\beta$ -diglyceride.
- Then the other fatty acid is removed and  $\alpha,\beta$ -diglyceride is converted to  $\beta$ -diglyceride.
- The middle fatty acid is not easily removable, so it is first converted into 1 or 3 position by isomerase, and then removed to form glycerol and fatty acid.

# Digestion of Phospholipids

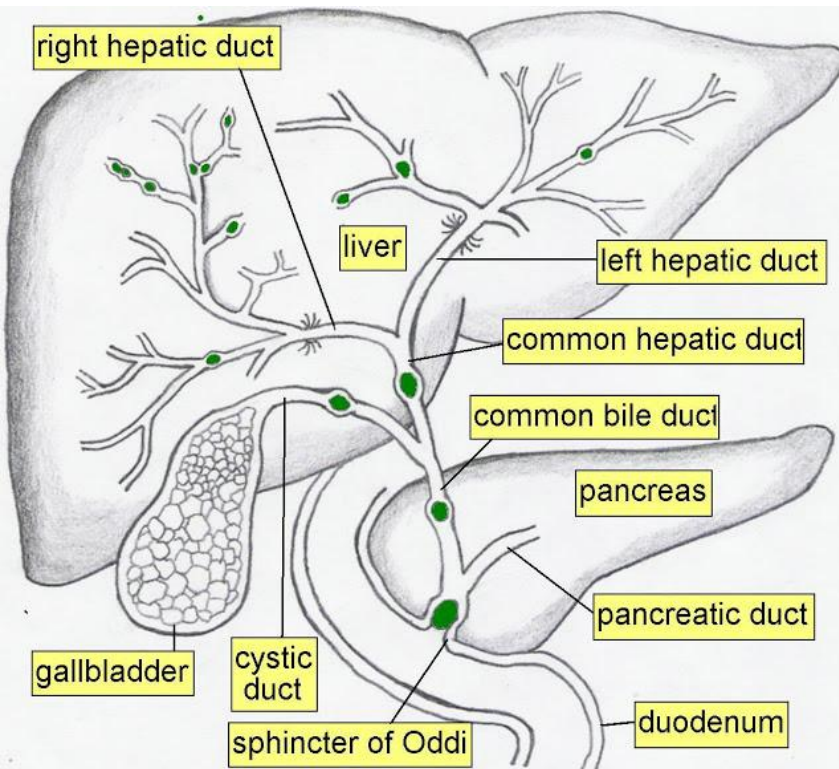
- Pancreatic juice also contain a type of enzyme called phospholipase A2 (also called Lecithinase).
- It is an esterase, and secreted as a zymogen which is changed to active form, by hydrolysis of peptide molecule with the help of trypsin
- In the presence of bile salt and  $\text{Ca}^{++}$ , the active phospholipase A2 hydrolyses the ester linkage between fatty acid and secondary alcohol group of position-2 of glycerol in phospholipids molecule so that free fatty acid and lysophospholipid are formed and absorbed

# Digestion of Cholesterol

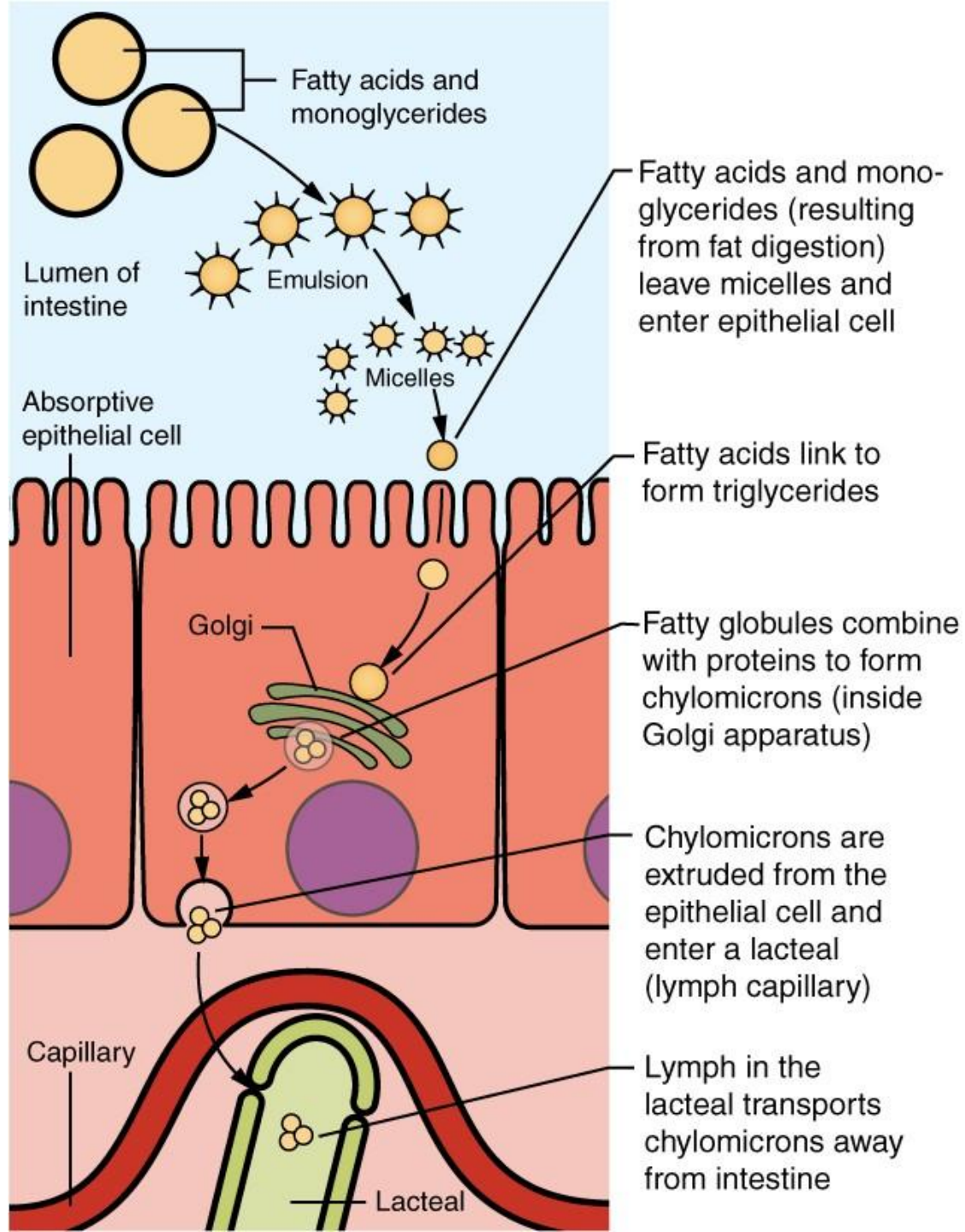
- Pancreatic juice also contain an enzyme cholesterol esterase, which may either catalyze the esterification of free cholesterol with fatty acid or it may catalyze opposite reaction.
- The cholesterol appears to be absorbed from the intestine almost entirely in free form.

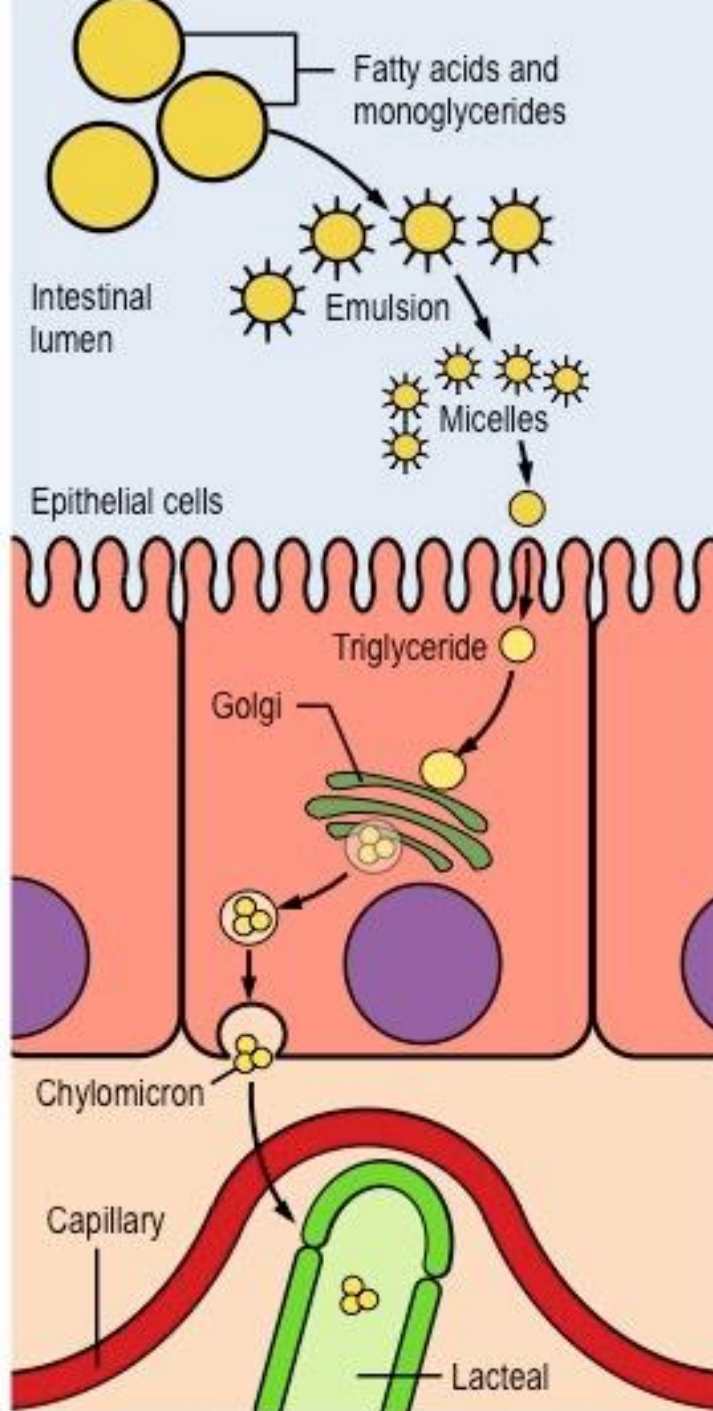
- Nevertheless , 85 to 90% of cholesterol in the lymph is found to be in esterified form, indicating that esterification of cholesterol must take place within the mucosal cell of intestine.
- Absorption of cholesterol has been reported to be facilitated by presence of unsaturated fatty acid and bile are necessary for absorption of cholesterol.
- Certain plant sterol like sitosterol and stigmasterol are not absorbed, rather their presence can inhibit cholesterol absorption.

# Bile and its function



- Liquid substance stored in the gall bladder, but synthesized by liver, released into main pancreatic duct to duodenum.
- It contains bile salts that break down the large lipid molecules into smaller ones through the emulsification process.





Fatty acids and monoglycerides are emulsified by bile salts to form micelles

Fatty acids enter the epithelial cells and link to form triglycerides

Triglycerides combine with proteins inside the Golgi body to form chylomicrons

Chylomicrons enter the lacteal and are transported away from the intestine

# Large Intestine

- Composed of three segments : Cecum, Colon and Rectum
- Function
  - Fermentative digestion
    - No enzyme secretion
    - Relies on microbes or secretions washed out of the SI
  - Absorption of remaining water, volatile fatty acids (VFAs) from microbial fermentation and minerals
  - Digesta storage

Degree of development is species dependent

# Monogastric Cecum

- Located at junction of small and large intestine
- Function similar to rumen in ruminants
  - Microbial activity and digestion of feeds
    - Contains a microbial population similar to the rumen
      - Cellulolytic & hemicellulolytic bacteria
- Since cecum is located **AFTER** major site of nutrient absorption (small intestine), then microbial cell proteins are not available to the animal
  - Fecal loss