DIGESTION AND ABSORPTION OF DIETARY LIPIDS

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Advance Clinical Biochemistry I (MA 407)

Summer Semester

Lecture Eight

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Outlines

- Objectives
- Introduction
- Dietary Lipid Digestion
- Digestion in Mouth
- Digestion in Stomach
- Digestion in Small intestine
- Absorption into blood
- Blood cholesterol
- Summary

Objectives

- **At the end of the lesson, the students should be able to understand:**

- The importance of dietary lipid

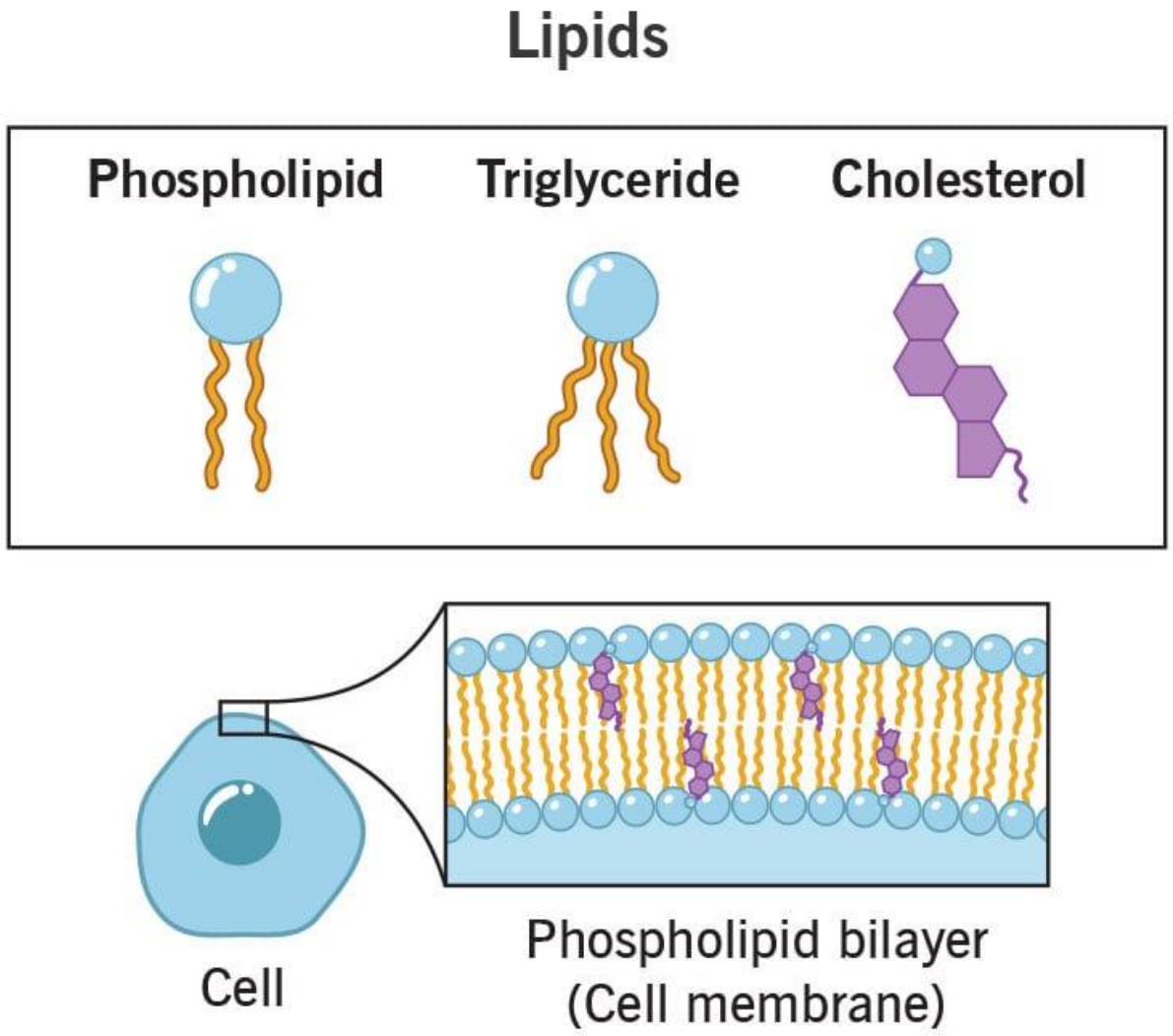
- Digestion of dietary lipids in the mouth, stomach & SI

- The concept of lipid absorption from the GIT

- The fate of dietary lipid and blood cholesterol

Introduction

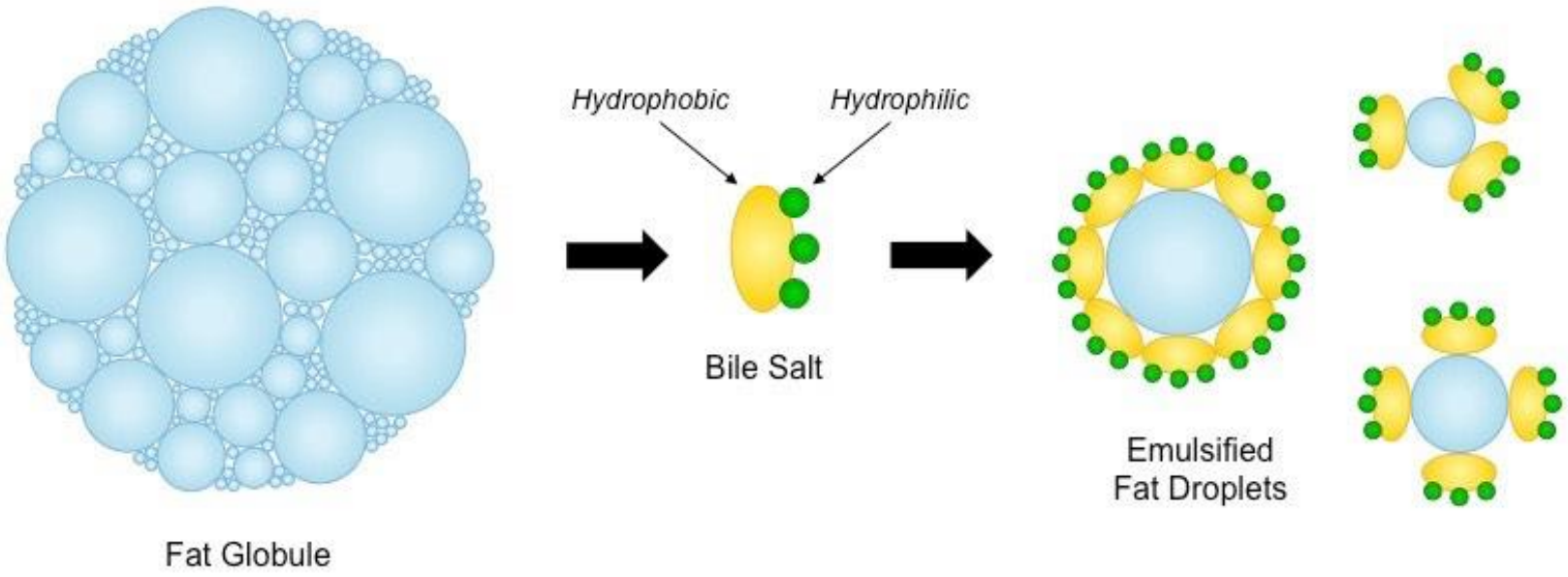
- Lipids are large molecules that are insoluble in water and broken into small components for absorption.
- Lipids are fatty compounds that perform a variety of functions in the body.
- They're part of the cell membranes and help control what goes in and out of the cells.
- Lipids help with moving and storing energy, absorbing vitamins, and making hormones.



Introduction

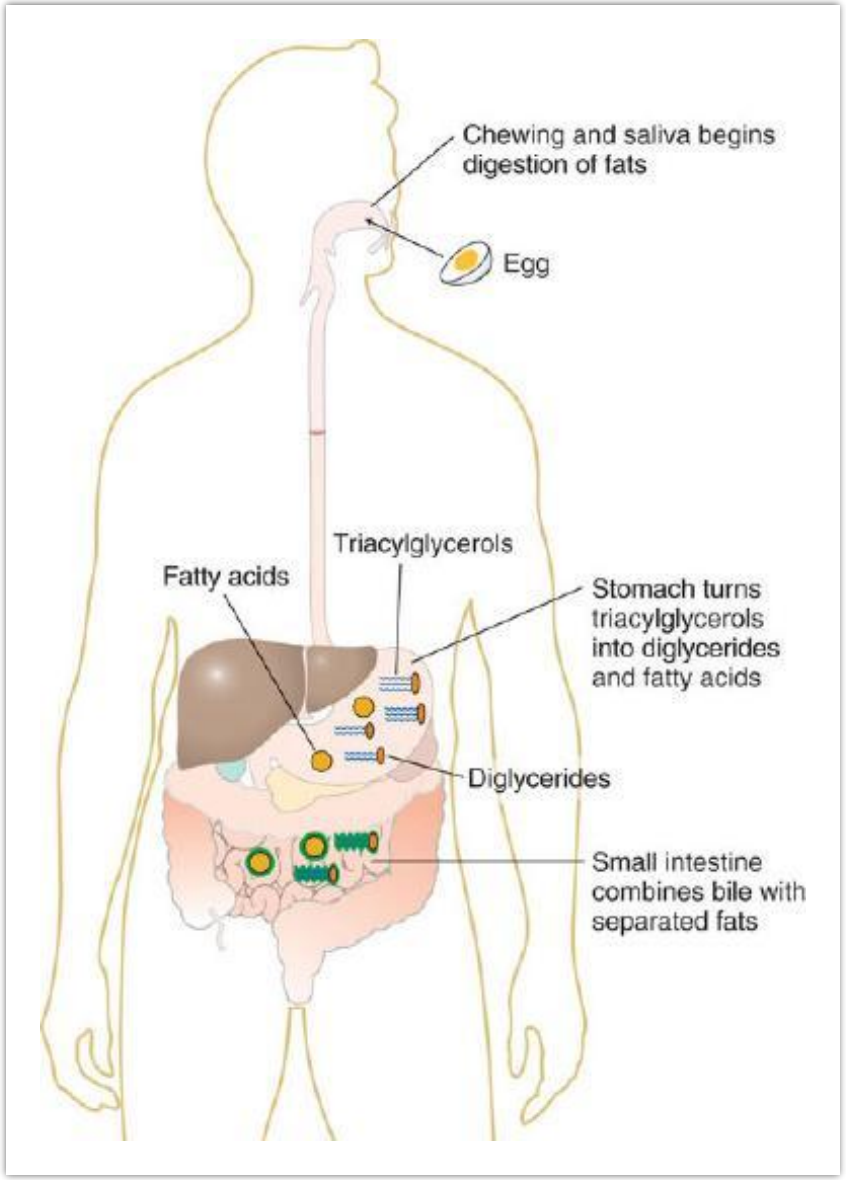
- Dietary lipids?
- The major dietary lipids:
  - Triacylglycerol.
  - Cholesterol.
  - Phospholipids.
- How many grams of lipids are in the daily diet of Kurdish men/women?

Through the emulsification processes



Introduction

- Most of the digestive enzymes in the body are water-based.
- How does the body break down fat and make it available for the various functions it performs in the human body?

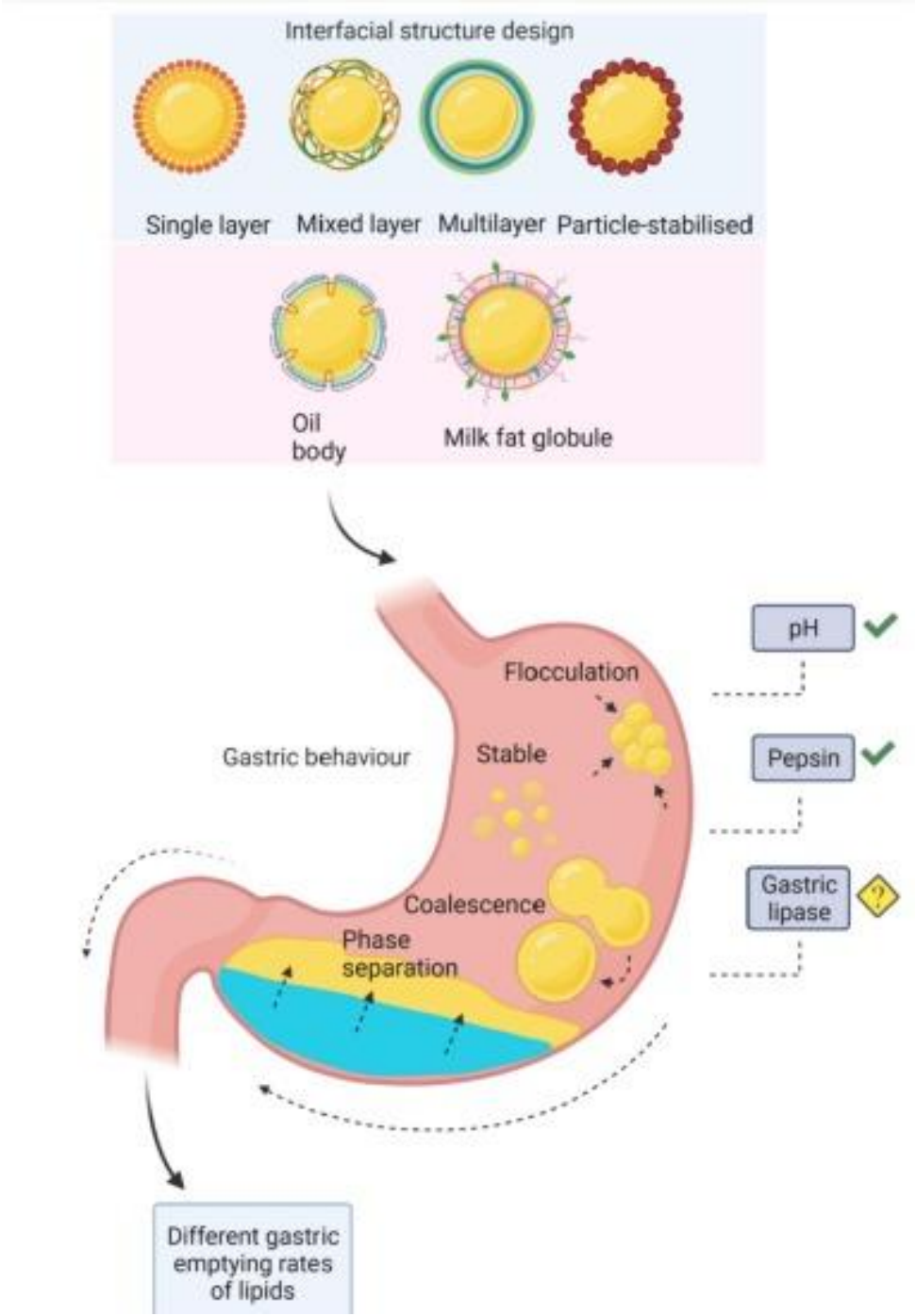


Digestion of lipids in the mouth

- The first step in the digestion of triglycerides and phospholipids begins in the mouth as lipids encounter saliva.
- Next, the physical action of chewing coupled with the action of emulsifiers enables the digestive enzymes to do their tasks.
- The enzyme lingual lipase, along with a small amount of phospholipid as an emulsifier, initiates the process of digestion.

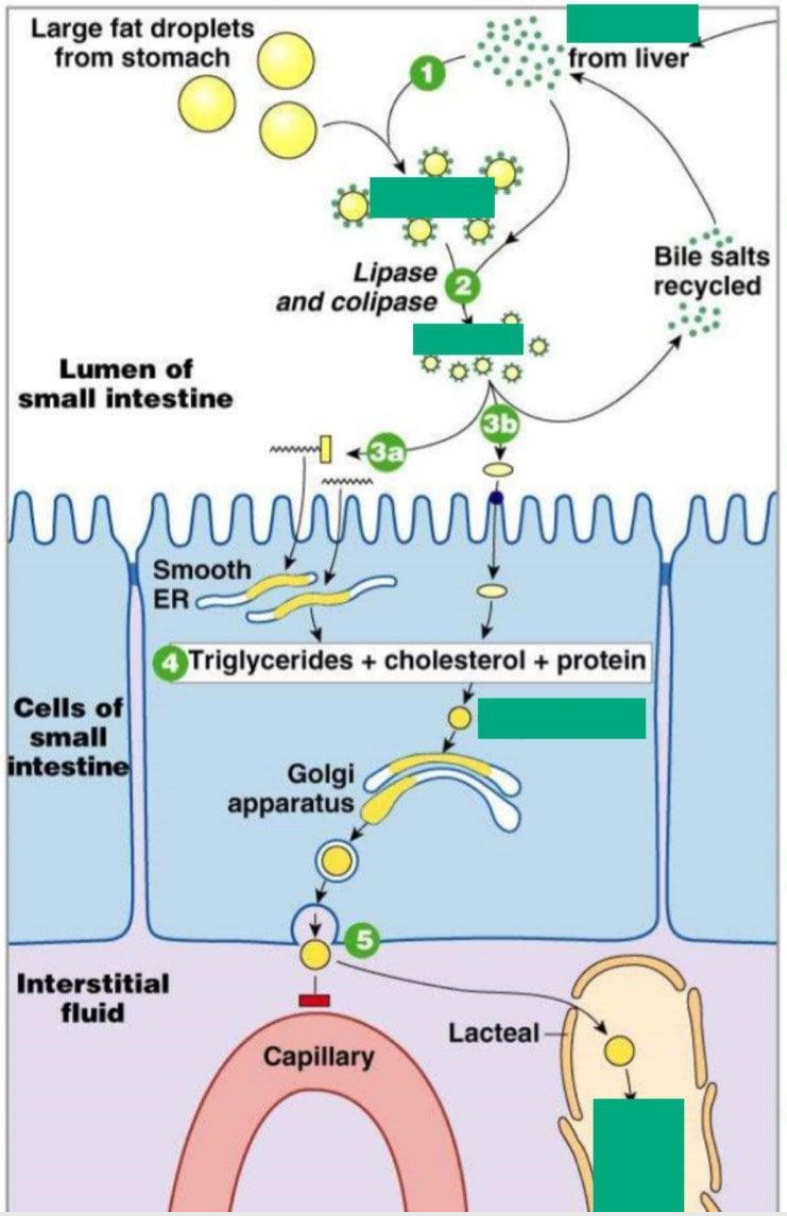
Digestion of Dietary lipids in the mouth

- Emulsification is considered the process of dispersing two or more immiscible liquids together to form a semi-stable mixture.
- These actions cause the fats to become more accessible to the digestive enzymes.
- As a result, the fats become tiny droplets and separate from the watery components.



Digestion of lipids in the stomach

- In the stomach, mixing and churning help to disperse food particles and fat molecules.
- Cells in the stomach produce another lipase, called gastric lipase that also breaks down triglycerides into diglycerides and fatty acids.
- Within two to four hours after eating a meal, roughly 30% of the triglycerides are converted to diglycerides & fatty acids (little digestion occurs).
- The stomach's churning and contractions help to disperse the fat molecules, while the diglycerides act as further emulsifiers.



Digestion of lipids in the small intestine

- As stomach contents enter the small intestine, the digestive system sets out to combine the separated fats with its own watery fluids using bile contents (salts, lecithin & cholesterol).
- It attracts and holds onto fat while it is simultaneously attracted to and held on to by water.
- Emulsification increases the surface area of lipids over a thousand-fold, making them more accessible to digestive enzymes.

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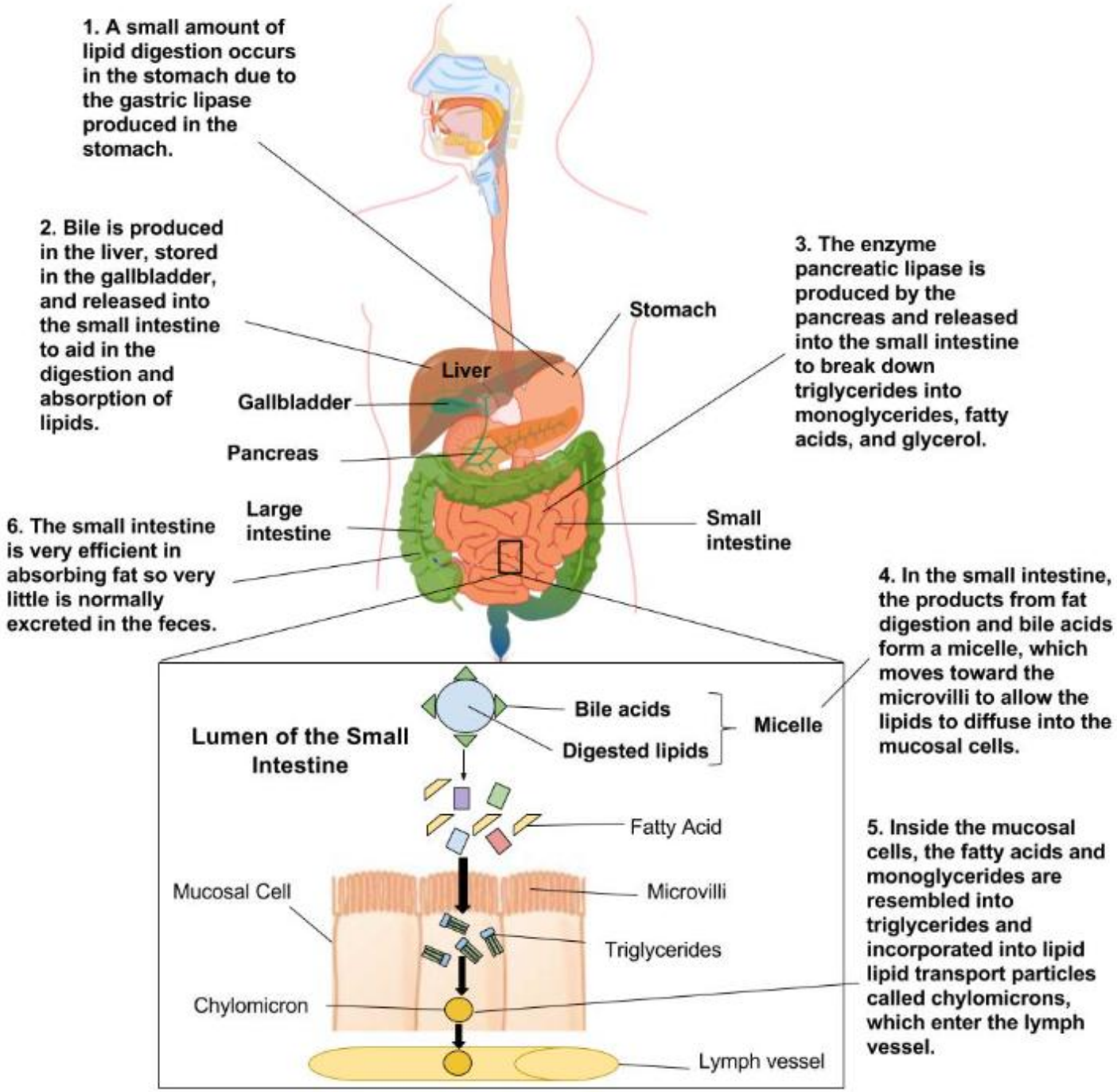
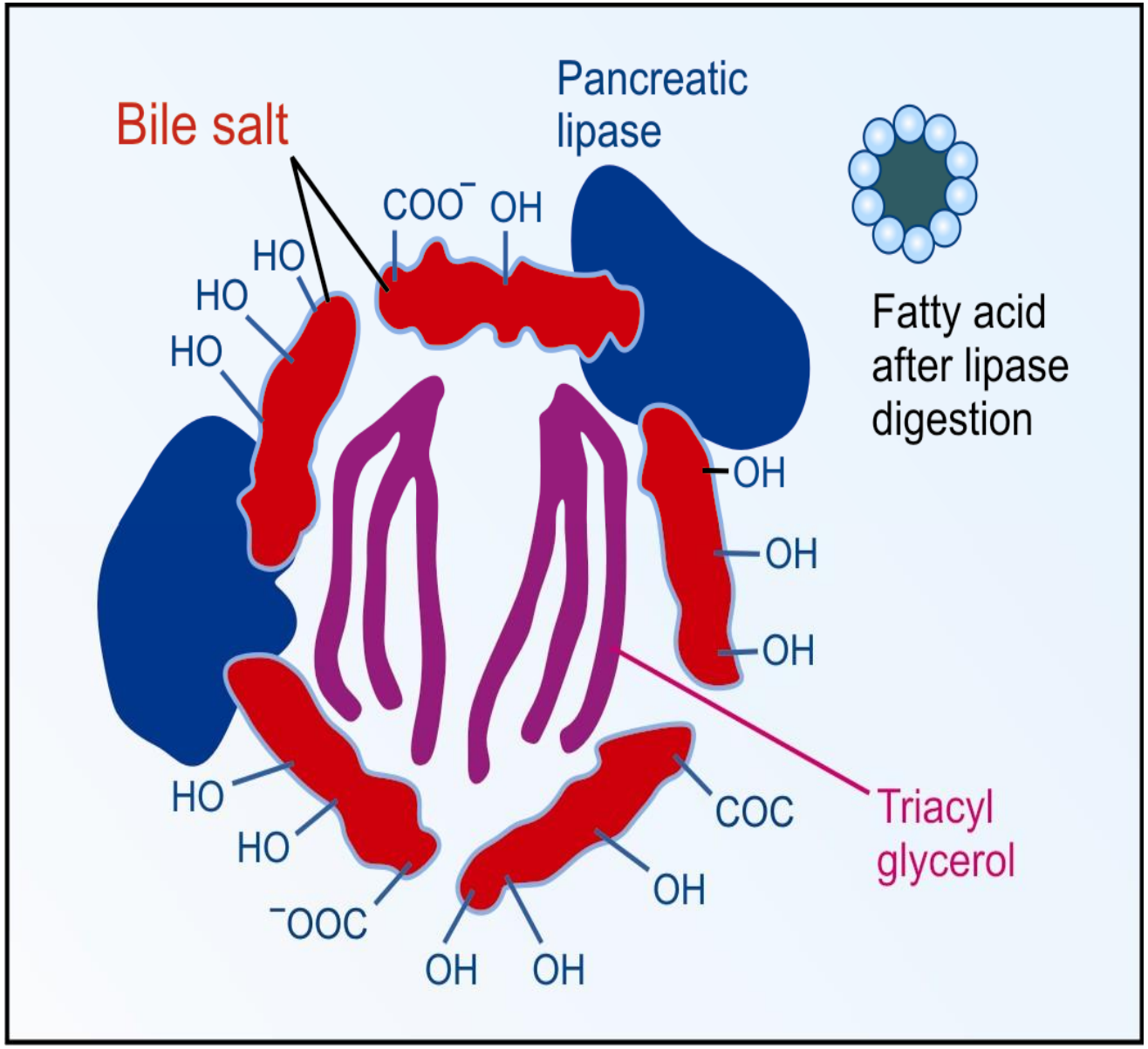
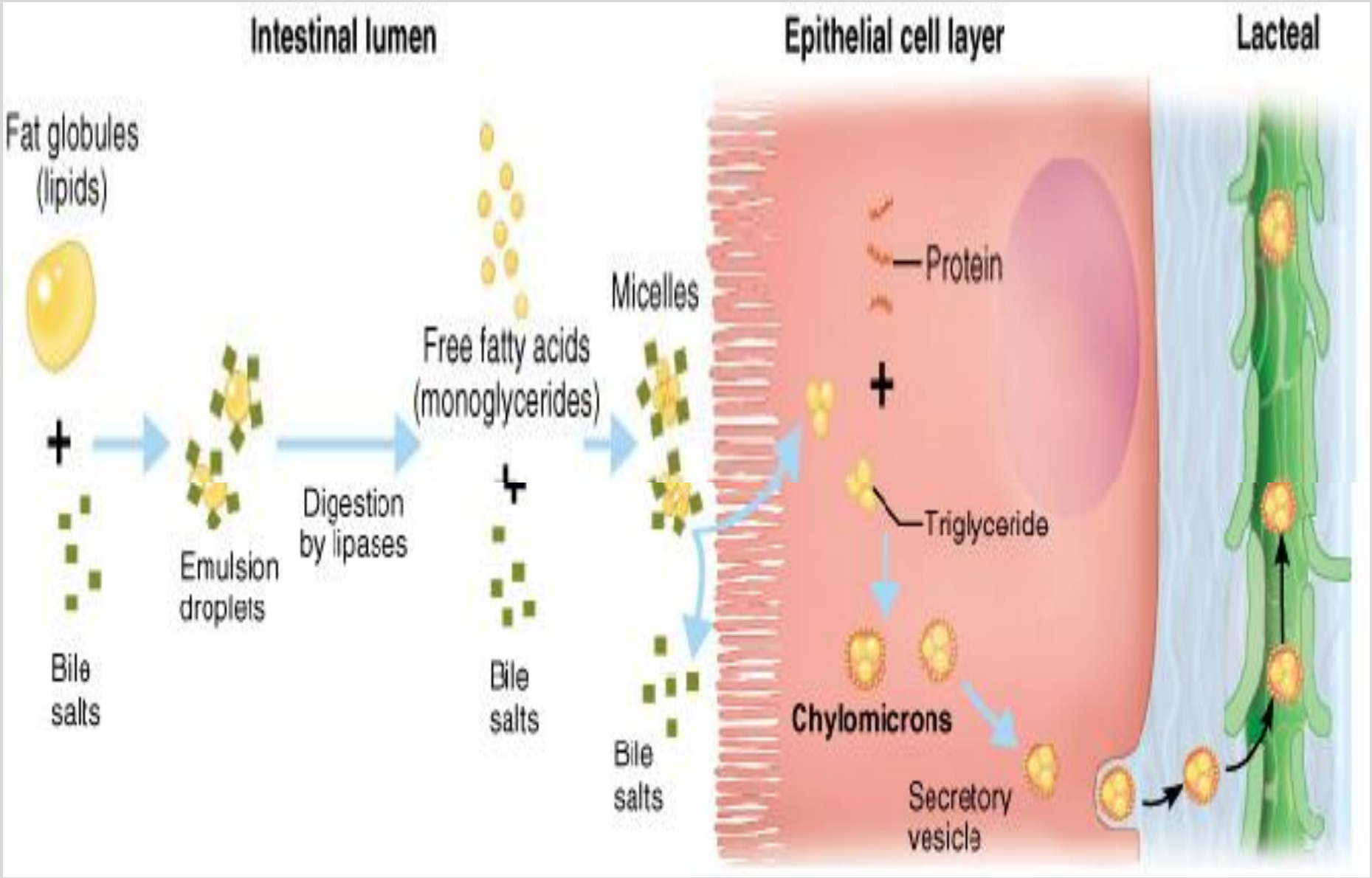
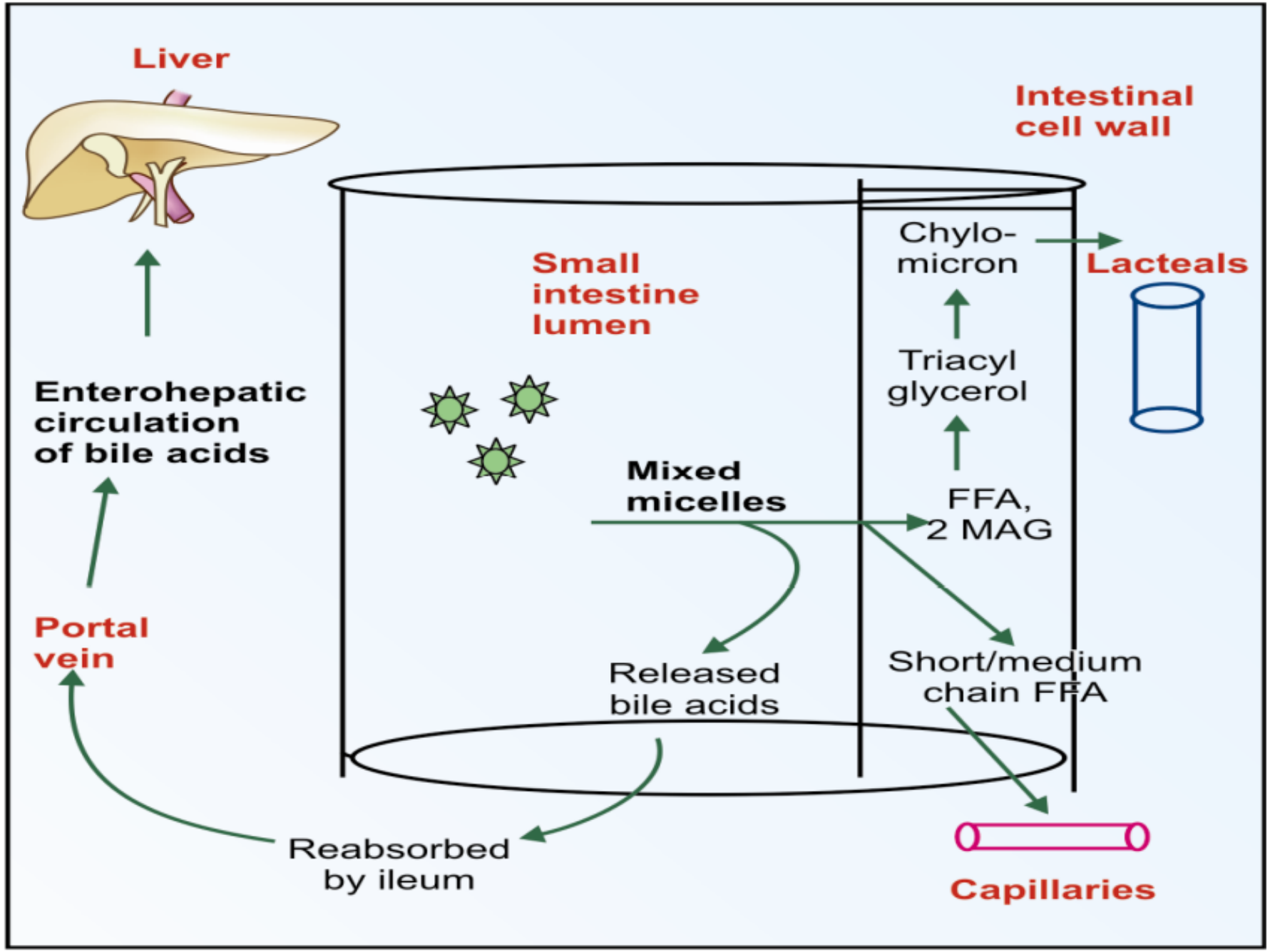

1. A small amount of lipid digestion occurs in the stomach due to the gastric lipase produced in the stomach.
2. Bile is produced in the liver, stored in the gallbladder, and released into the small intestine to aid in the digestion and absorption of lipids.
3. The enzyme pancreatic lipase is produced by the pancreas and released into the small intestine to break down triglycerides into monoglycerides, fatty acids, and glycerol.
4. In the small intestine, the products from fat digestion and bile acids form a micelle, which moves toward the microvilli to allow the lipids to diffuse into the mucosal cells.
5. Inside the mucosal cells, the fatty acids and monoglycerides are resembled into triglycerides and incorporated into lipid lipid transport particles called chylomicrons, which enter the lymph vessel.
6. The small intestine is very efficient in absorbing fat so very little is normally excreted in the feces.
Stomach
Liver
Gallbladder
Pancreas
Large intestine
Small intestine
Lumen of the Small Intestine
Bile acids
Digested lipids
Micelle
Fatty Acid
Mucosal Cell
Microvilli
Triglycerides
Chylomicron
Lymph vessel



Absorption of Lipids

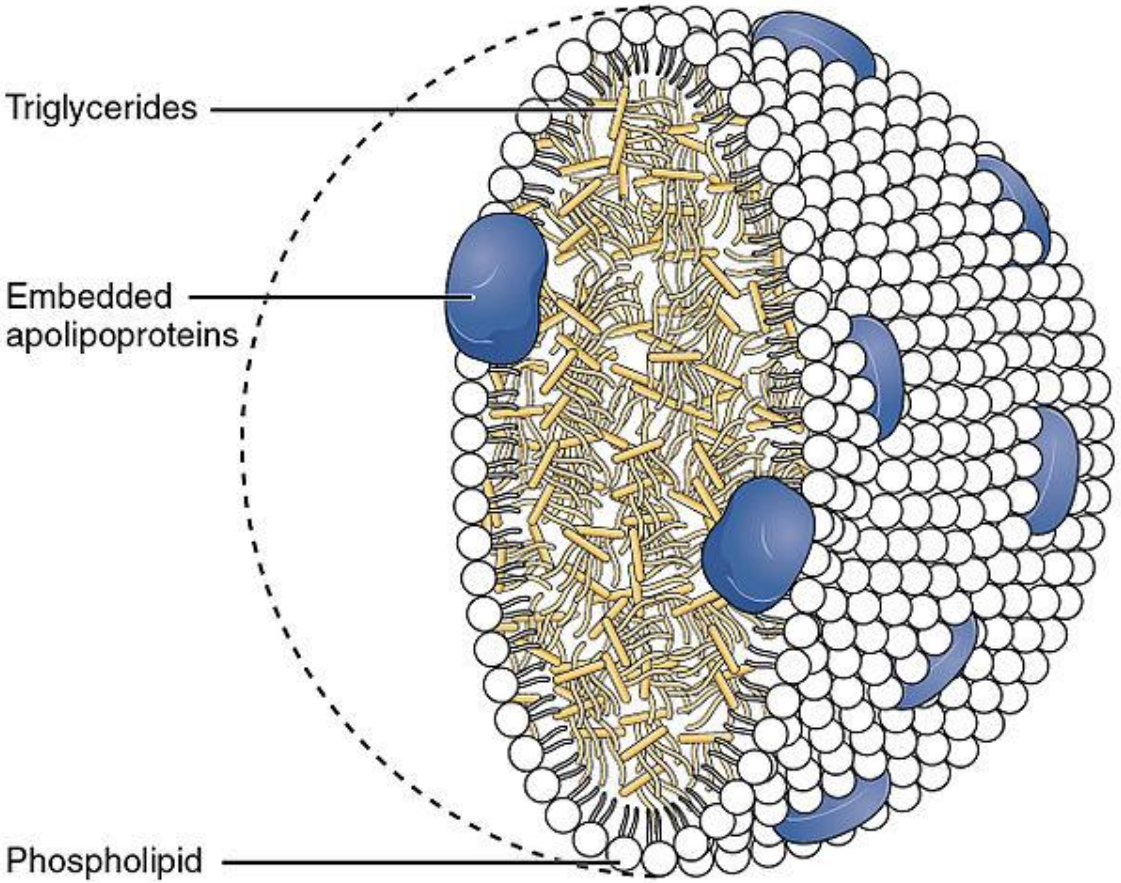
- Bile salts envelop the fatty acids & MGR to form micelles.
- Micelles have a fatty acid core with a water-soluble exterior.
- This allows efficient transportation to the intestinal microvillus.
- The fat is released into the cells of the digestive tract lining.


Intestinal lumen
Epithelial cell layer
Lacteal
Fat globules (lipids)
Bile salts
Emulsion droplets
Digestion by lipases
Free fatty acids (monoglycerides)
Bile salts
Micelles
Bile salts
Protein
Triglyceride
Chylomicrons
Secretory vesicle


Liver
Intestinal cell wall
Small intestine lumen
Chylo-micron
Lacteals
Triacyl glycerol
Enterohepatic circulation of bile acids
Mixed micelles
FFA, 2 MAG
Portal vein
Released bile acids
Short/medium chain FFA
Reabsorbed by ileum
Capillaries

Absorption of Lipids

- Similarly, lipids require proper handling to travel in the bloodstream.
- Inside the intestinal cells, the MGR and fatty acids reassemble themselves into TGR.
- TGR, cholesterol, and phospholipids form lipoproteins when joined with a protein carrier.
- Lipoproteins have an inner core that is primarily made up of TGR and cholesterol esters (cholesterol linked to a fatty acid).



Absorption of Lipids

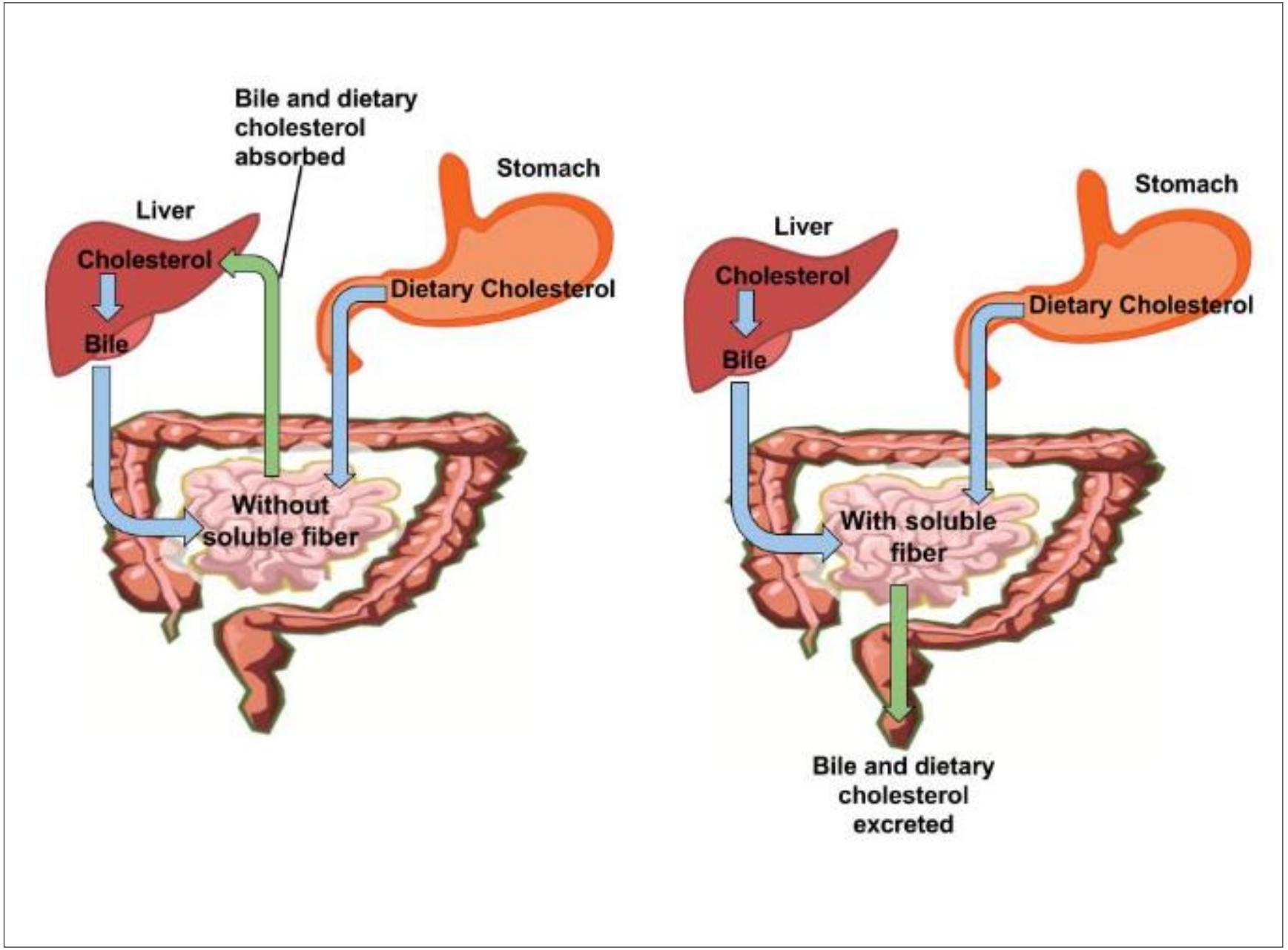
- The P-lipids, proteins & cholesterol form a chylomicron (lipoprotein), which enters the bloodstream via the lymphatic system.

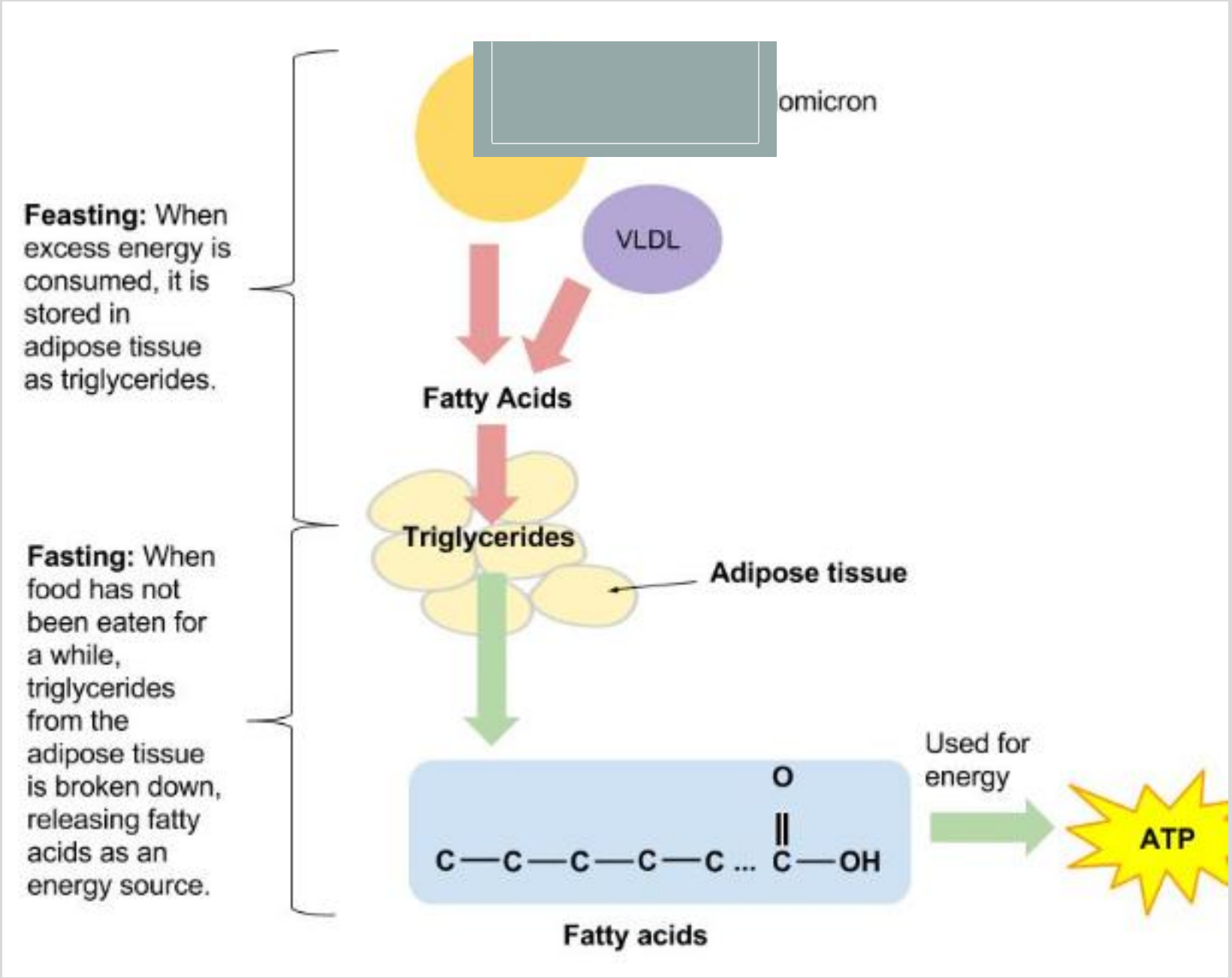
- Chylomicrons transport dietary fats to specific destinations (liver and body tissues).

Absorption of lipids

- Cholesterols are poorly absorbed when compared to phospholipids and TGR. Its absorption is hindered by high fiber content.
- Foods high in fiber bind bile salts and cholesterol, preventing their absorption.
- If fats are not absorbed properly, a person's stool will contain high amount of fats.
- Persistence of fat malabsorption may result in steatorrhea, a condition of Crohn's disease and cystic fibrosis.

- Fate of cholesterol with & without soluble Fiber

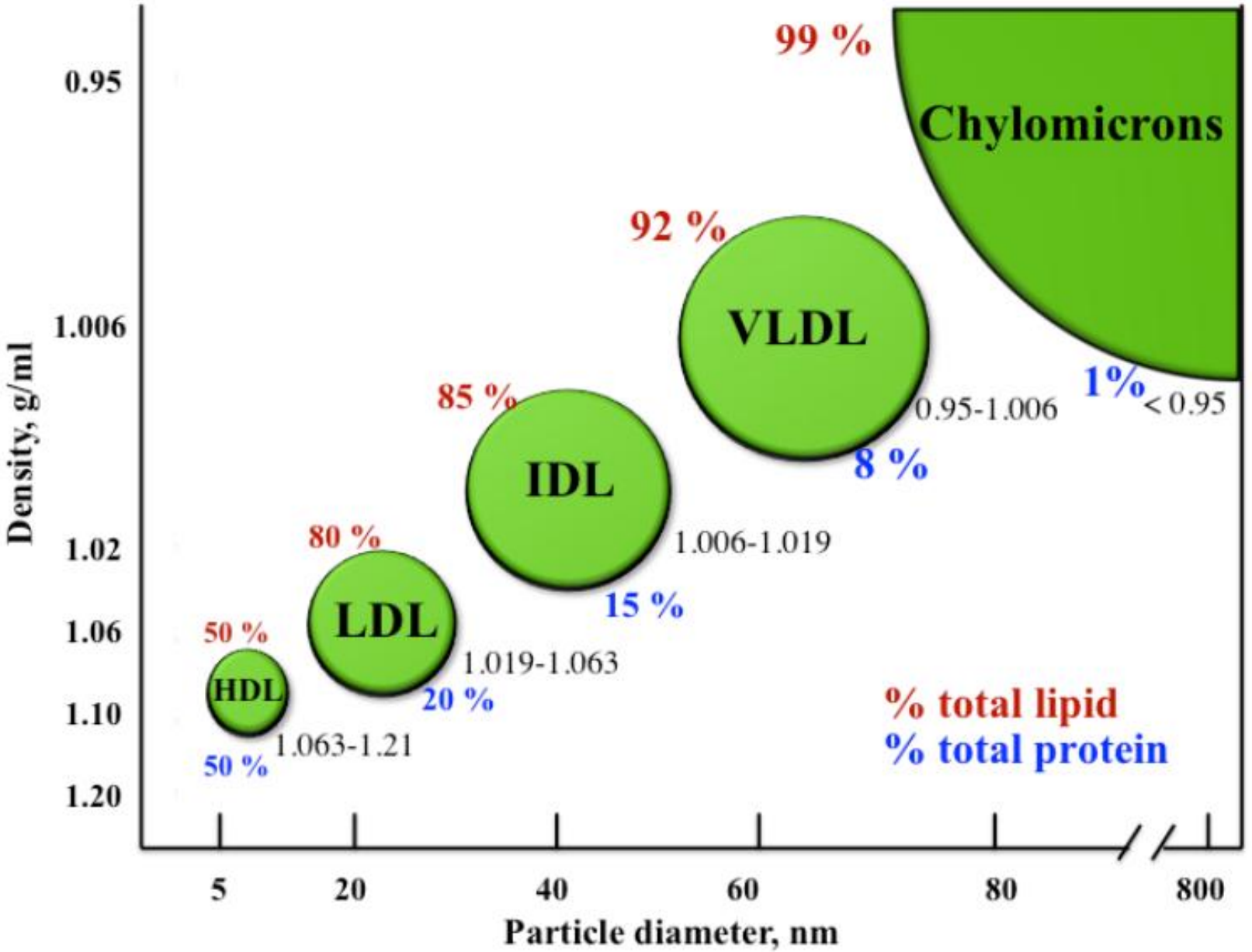



omicron
VLDL
Fatty Acids
Triglycerides
Adipose tissue
Used for energy
ATP
Fatty acids
Feasting: When excess energy is consumed, it is stored in adipose tissue as triglycerides.
Fasting: When food has not been eaten for a while, triglycerides from the adipose tissue is broken down, releasing fatty acids as an energy source.

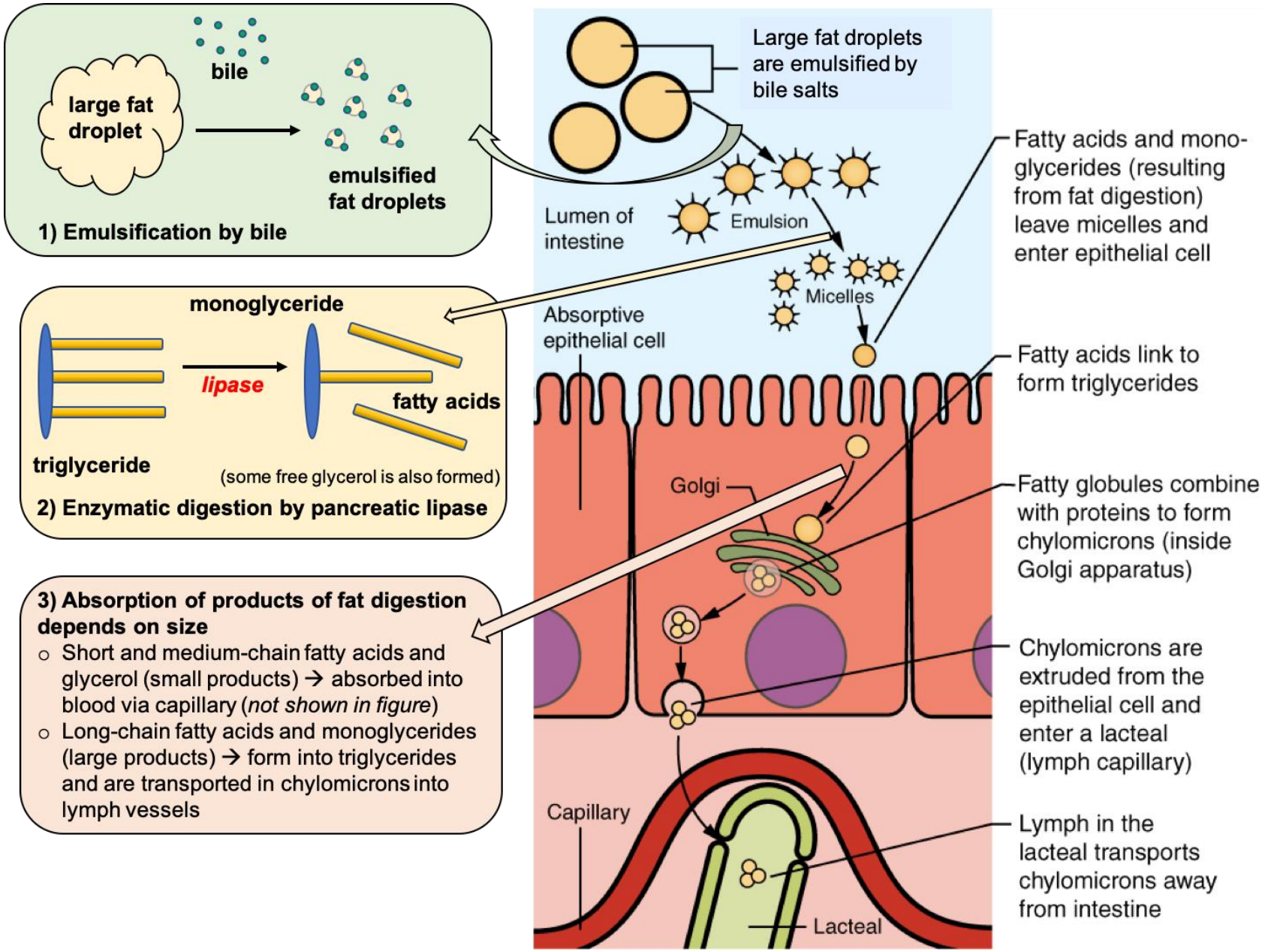
EXCESS FATS

Blood cholesterol

- Recall: LDL and HDL with respect to heart health.
- Lipoproteins are characterized by size, density, and composition.
- As the size of the lipoprotein increases, the density decreases.
- This means that HDL is smaller than LDL.
- Why are they referred to as “good” and “bad” cholesterol?
- What should you know about these lipoproteins?



Lipoproteins and the percentage of the individual macromolecules


bile
large fat droplet
emulsified fat droplets
1) Emulsification by bile
monoglyceride
lipase
fatty acids
triglyceride
(some free glycerol is also formed)
2) Enzymatic digestion by pancreatic lipase
3) Absorption of products of fat digestion depends on size
Short and medium-chain fatty acids and glycerol (small products) → absorbed into blood via capillary (not shown in figure)
Long-chain fatty acids and monoglycerides (large products) → form into triglycerides and are transported in chylomicrons into lymph vessels
Large fat droplets are emulsified by bile salts
Lumen of intestine
Emulsion
Micelles
Absorptive epithelial cell
Golgi
Capillary
Lacteal
Fatty acids and mono-glycerides (resulting from fat digestion) leave micelles and enter epithelial cell
Fatty acids link to form triglycerides
Fatty globules combine with proteins to form chylomicrons (inside Golgi apparatus)
Chylomicrons are extruded from the epithelial cell and enter a lacteal (lymph capillary)
Lymph in the lacteal transports chylomicrons away from intestine

SUMMARY

Summary

- Dietary lipids, mainly triglycerides, cholesterol, and phospholipids, are water-insoluble molecules that must undergo emulsification and enzymatic digestion before absorption.
- Digestion begins in the mouth with lingual lipase, continues in the stomach with gastric lipase, and is completed in the small intestine with the help of bile salts and pancreatic enzymes.
- Absorbed lipids are packaged into micelles and later reassembled into triglycerides, cholesterol esters, and phospholipids to form chylomicrons, which enter the bloodstream via the lymphatic system.
- Cholesterol absorption is less efficient than triglycerides, and excessive fat intake or malabsorption can lead to steatorrhea and altered blood cholesterol levels (LDL and HDL).

Activity

- Lipid digestion starts in the stomach with gastric lipase. **True/False**
- Emulsification increases the surface area of lipids, making them more accessible to enzymes. **True/False**
- Chylomicrons are lipoproteins that transport dietary fats through the lymphatic system into the bloodstream. **True/False**
- Cholesterol is absorbed more efficiently than triglycerides and phospholipids. **True/False**
- HDL is smaller and denser than LDL, which is why it is often called “good cholesterol.” **True/False**
- The major dietary lipids include _____, _____, and _____.
- The enzyme _____ lipase initiates lipid digestion in the mouth.
- Bile salts and lecithin form _____ that transport fatty acids and monoglycerides to the intestinal cells.


Questions
Comments
Feedback