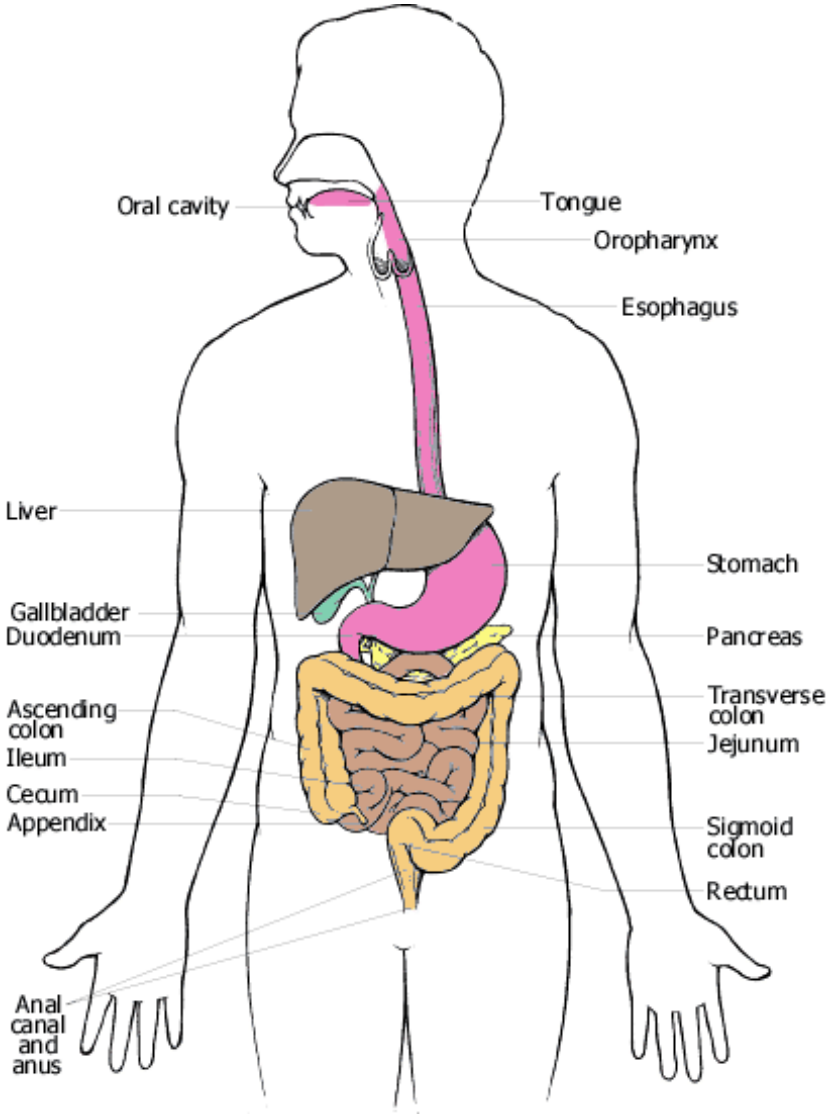
Physiology of Digestion and Absorption



Overview of the Digestive System

The Digestive System Consists of ;

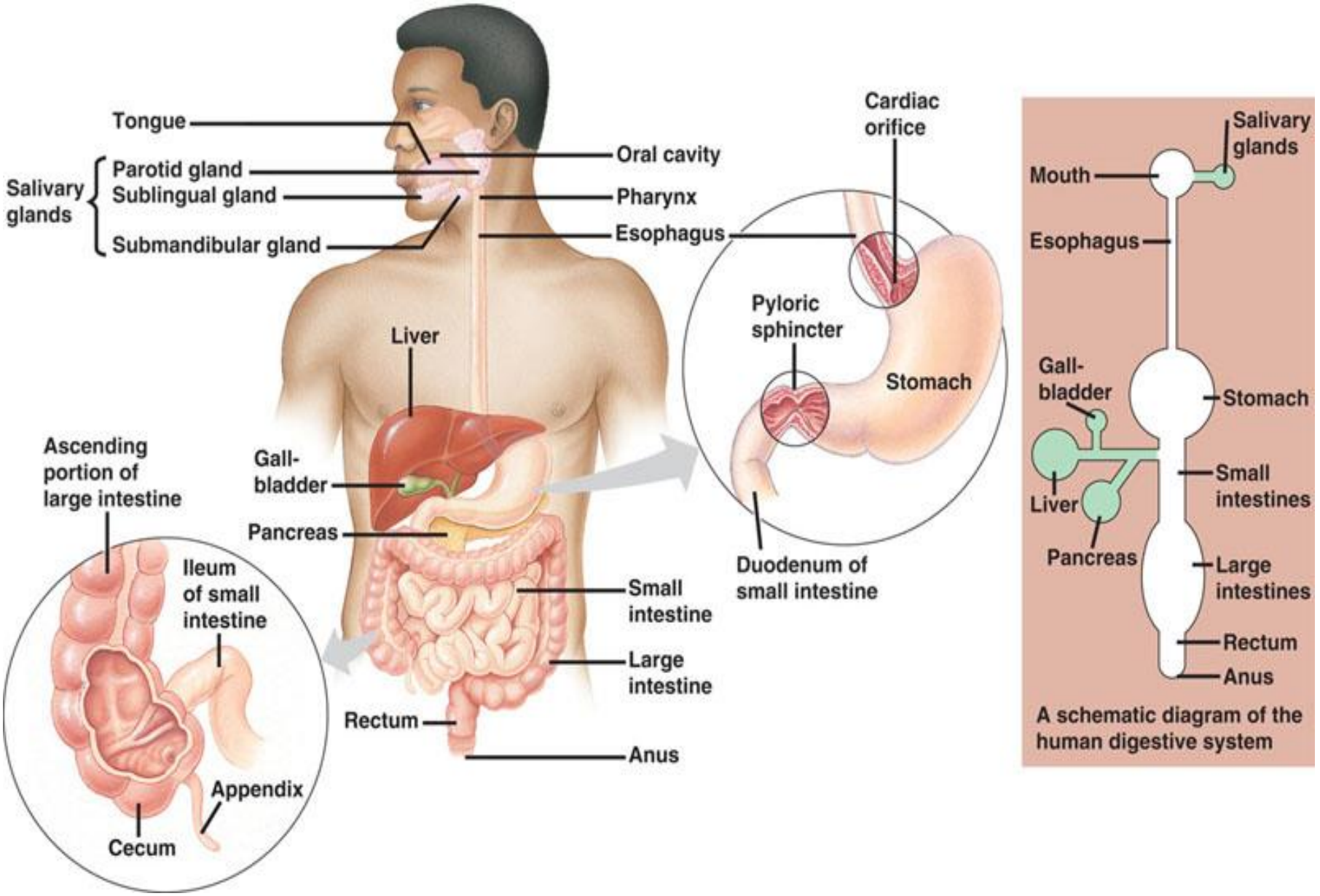
a) **Long hollow muscular tube** or canal or tract called gastrointestinal tract or **(GIT)**:

- it is about 5 meters long

b) Accessory glands: include:

- Salivary glands
- Liver and gall bladder
- Pancreas

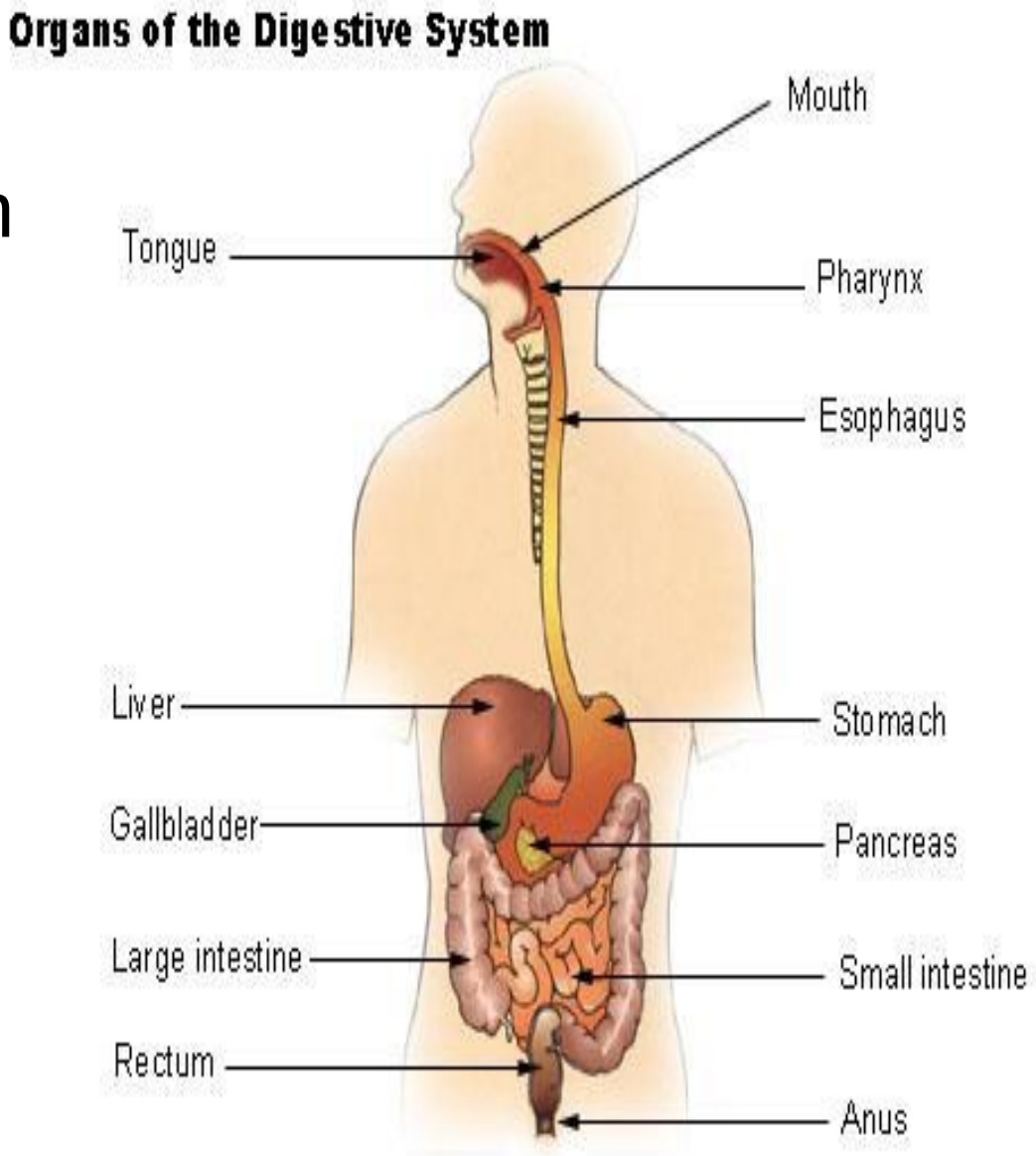
Overview of the Digestive System



Overview of the Digestive Tract

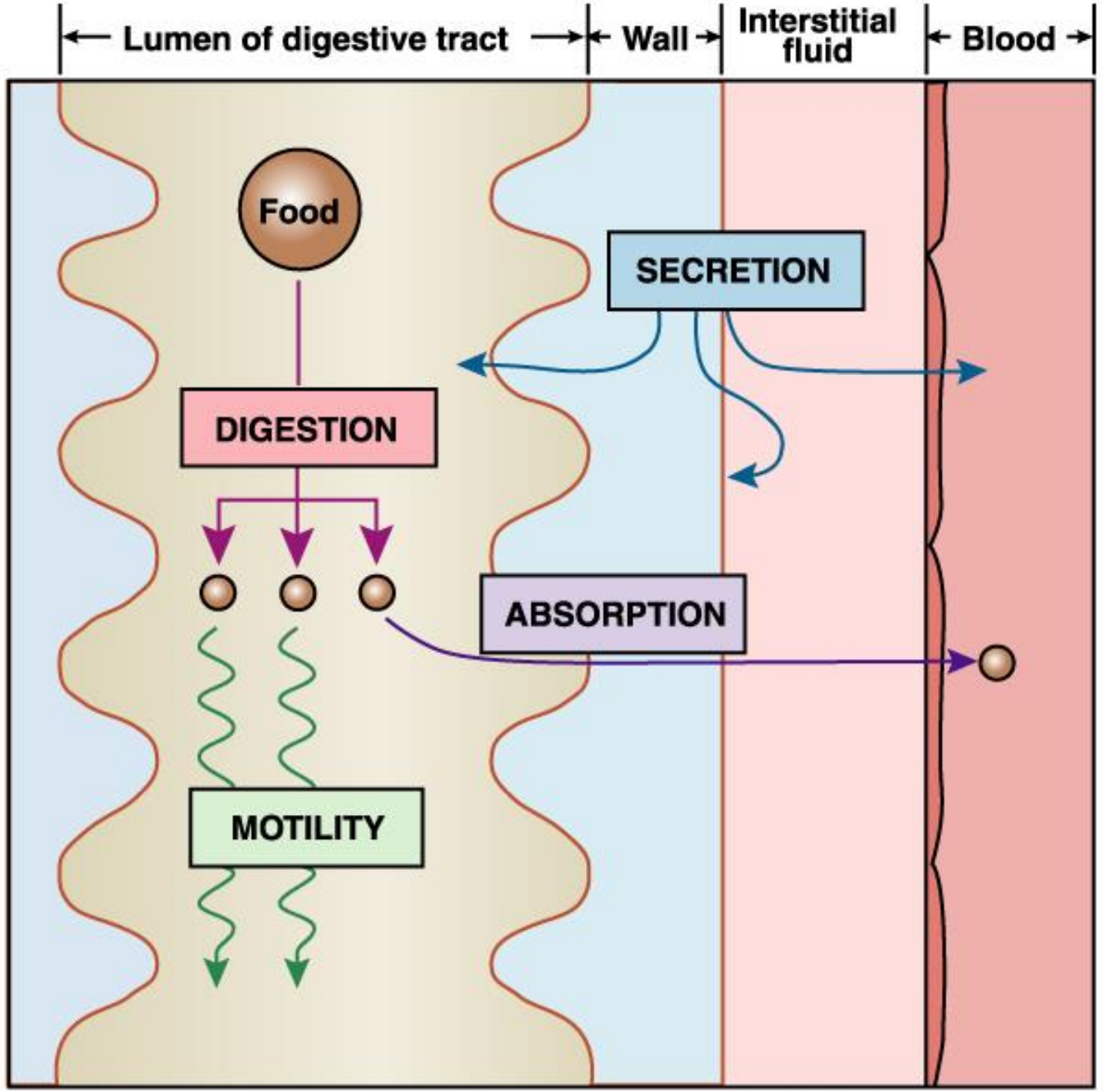
GIT consists of;

- Oral cavity or mouth
- Pharynx
- Esophagus
- Stomach
- Small intestine
- Large intestine
- Rectum
- Anus



Main Functions of Digestive Tract

- 4 major activities of GI tract
  1. **Motility**
     - Propel ingested food from mouth toward rectum
  2. **Secretion of juices e.g. saliva**
     - Aid in digestion and absorption
  3. **Digestion**
     - Food broken down into absorbable molecules
  4. **Absorption**
     - Nutrients, electrolytes, and water are absorbed or transported from lumen of GIT to blood stream


Lumen of digestive tract
Wall
Interstitial fluid
Blood
Food
SECRETION
DIGESTION
ABSORPTION
MOTILITY

Motor Functions (Motility) of GIT

Motility of the GIT

1. Motility in the mouth

2 types;

a) **Chewing or Mastication:**

- It is reflex in nature

Significance:

1. Breaks the food into small pieces to be easily swallowed
2. Expose food to salivary amylase enzyme, which begins digestion of starch
3. Help digestion of all types of food especially cellulose containing food e.g. vegetables

Motility of the GIT

b) Swallowing:

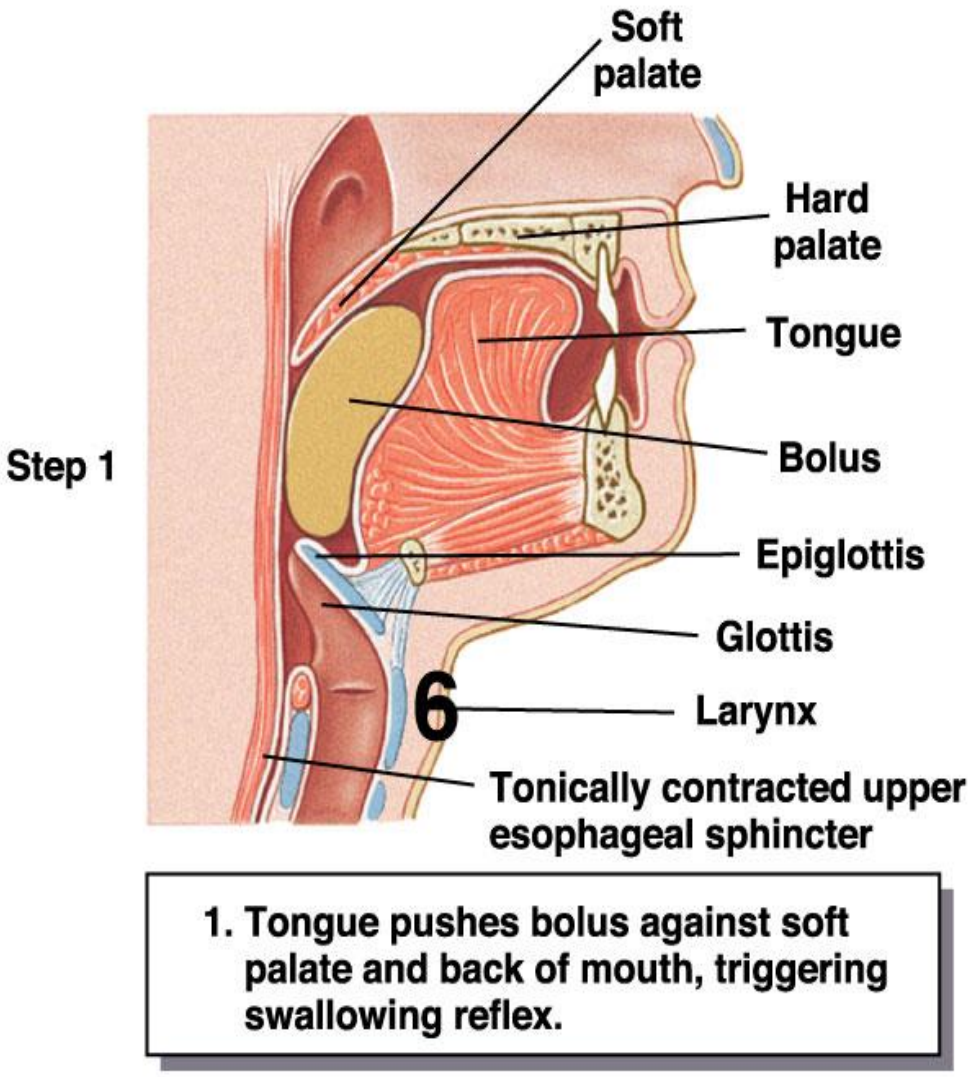
Def.

•Swallowing is the transport of food from mouth to stomach

Steps:

• It consists of 3 **phases or steps**;

1) Buccal Phase: food is pushed back into pharynx from mouth

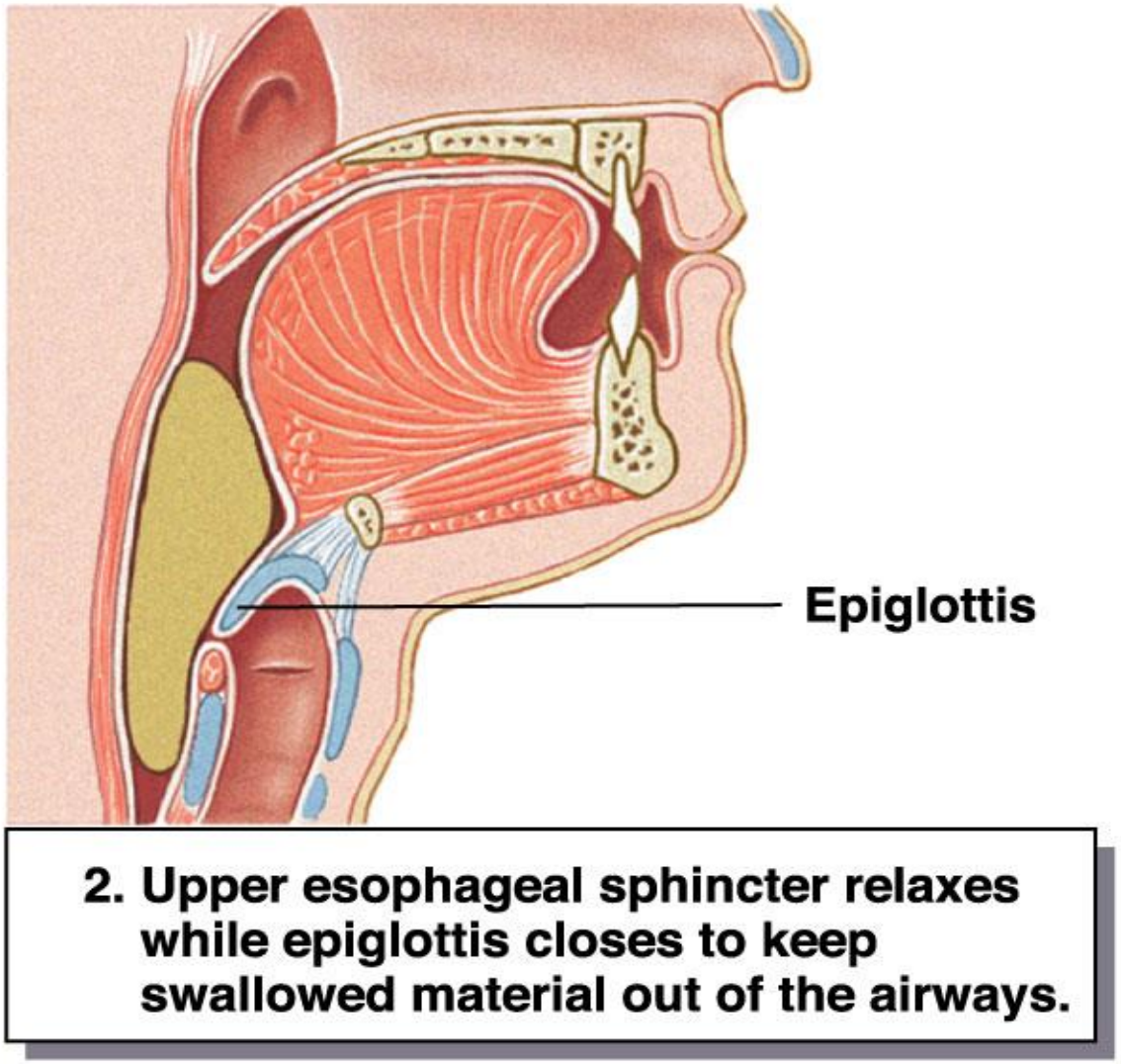


Motility of the GIT

b) Swallowing:

2) Pharyngeal Phase:

food pass through pharynx to esophagus

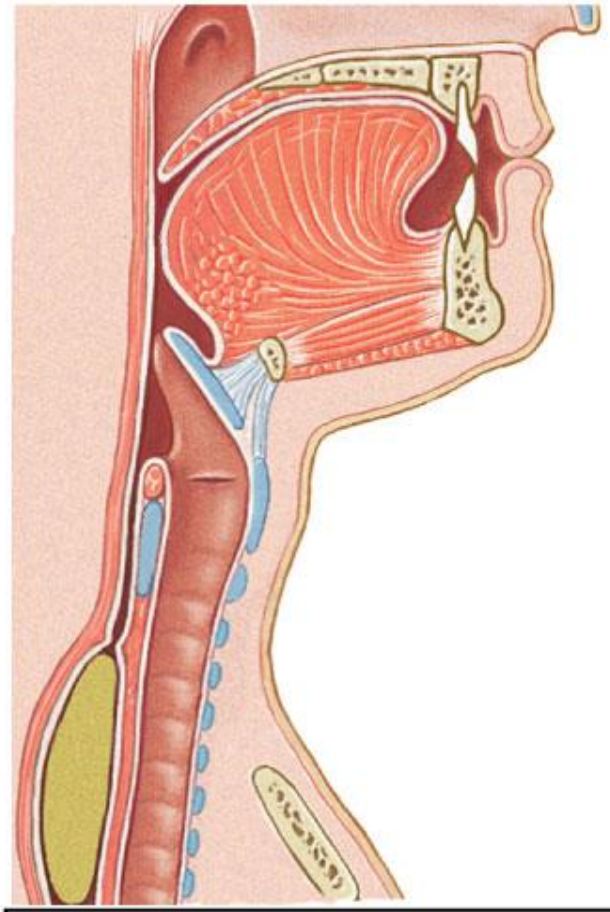


Motility of the GIT

b) Swallowing:

3) Oesophageal Phase:

food pass through esophagus to stomach by peristaltic movements



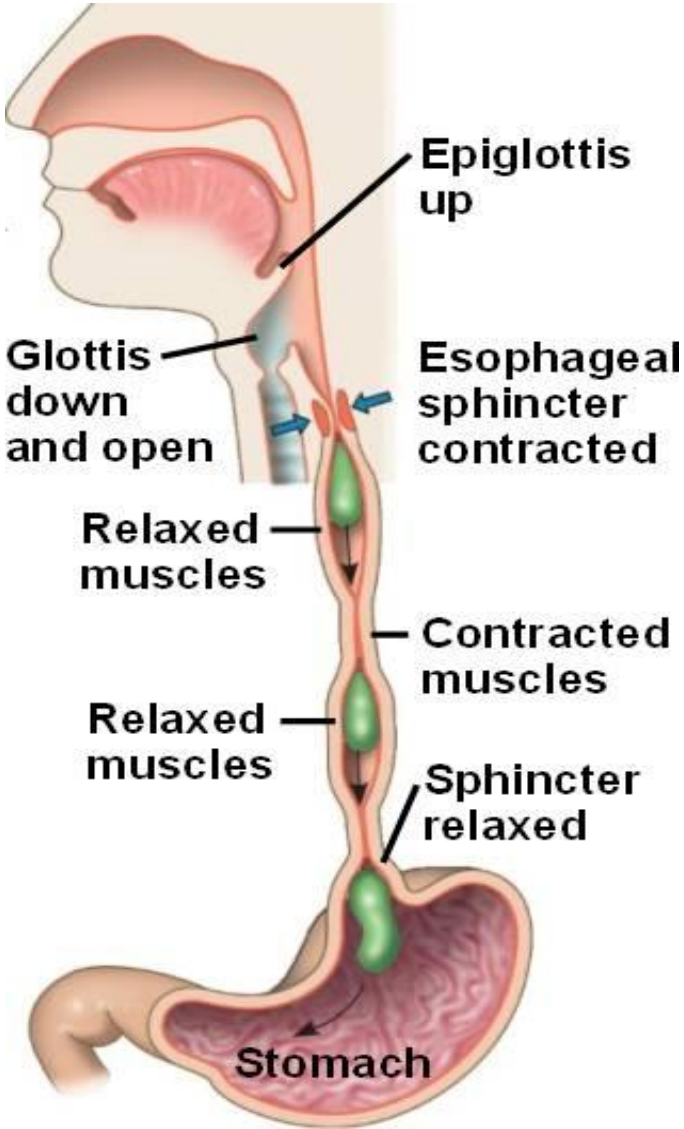
Motility of GIT

2. Motility of Esophagus

- The esophagus is 25 cm **ms tube**
- It is guarded by 2 sphincters;

1. **Upper esophageal sphincter** prevents **air** from entering the GIT
2. **Lower esophageal sphincter** prevents **gastric contents** from re-entering the esophagus from the stomach

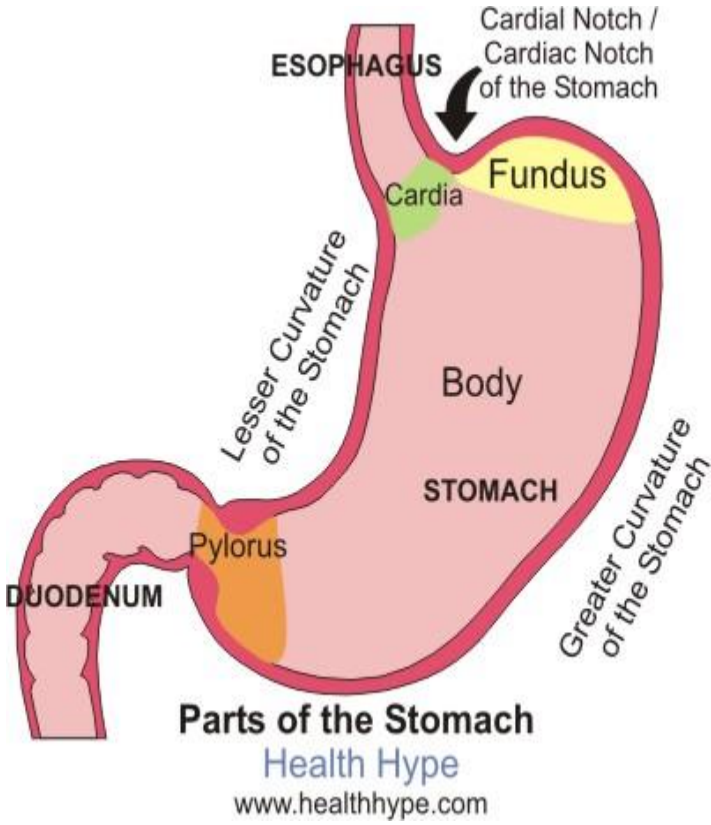
- **Esophageal peristalsis sweeps down** the esophagus



Motility of GIT

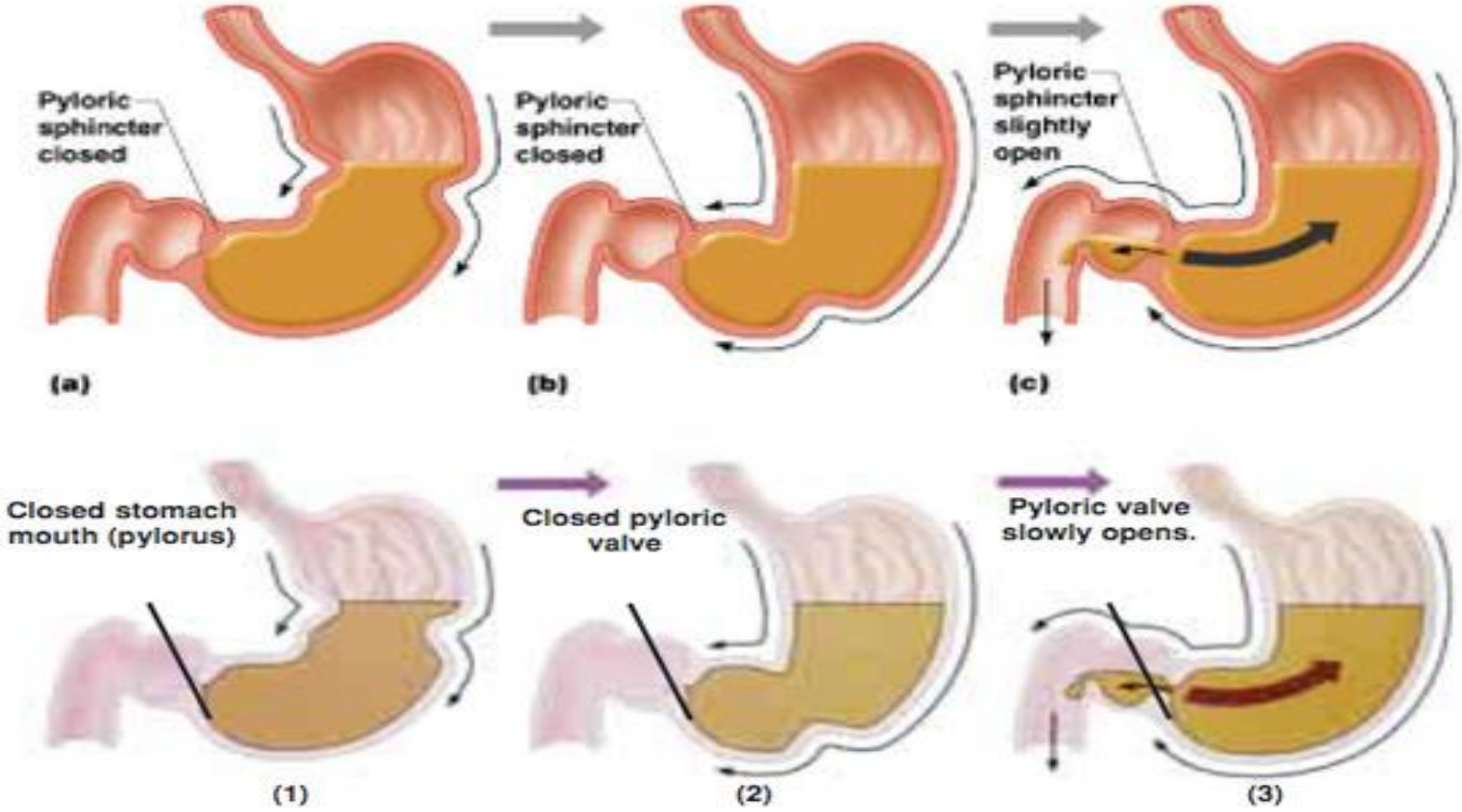
3. Motility of Stomach

- The stomach consists of fundus, body and pylorus
- **Proximal area (fundus and body) has** a **thin** wall and contracts weakly and infrequently → holds large volumes of food (**to store food**) because of **receptive relaxation**
- **Distal area (pylorus)** has **thick** wall with strong and **frequent peristaltic contractions** that **mix** and **propel** food into the duodenum.
- Also, **distal area** is responsible for **gastric emptying** into duodenum



Motility of GIT

3. Motility of stomach



Gastric peristalsis

Motility of GIT

4. Motility of Small intestine

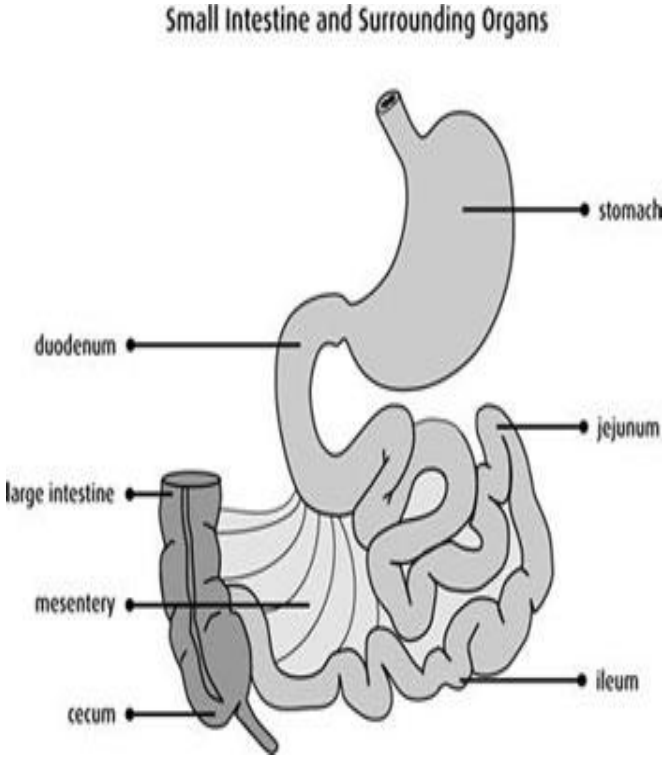
Types:

- **Two basic** motility patterns exist **segmentation** and **peristalsis**.

Significance:

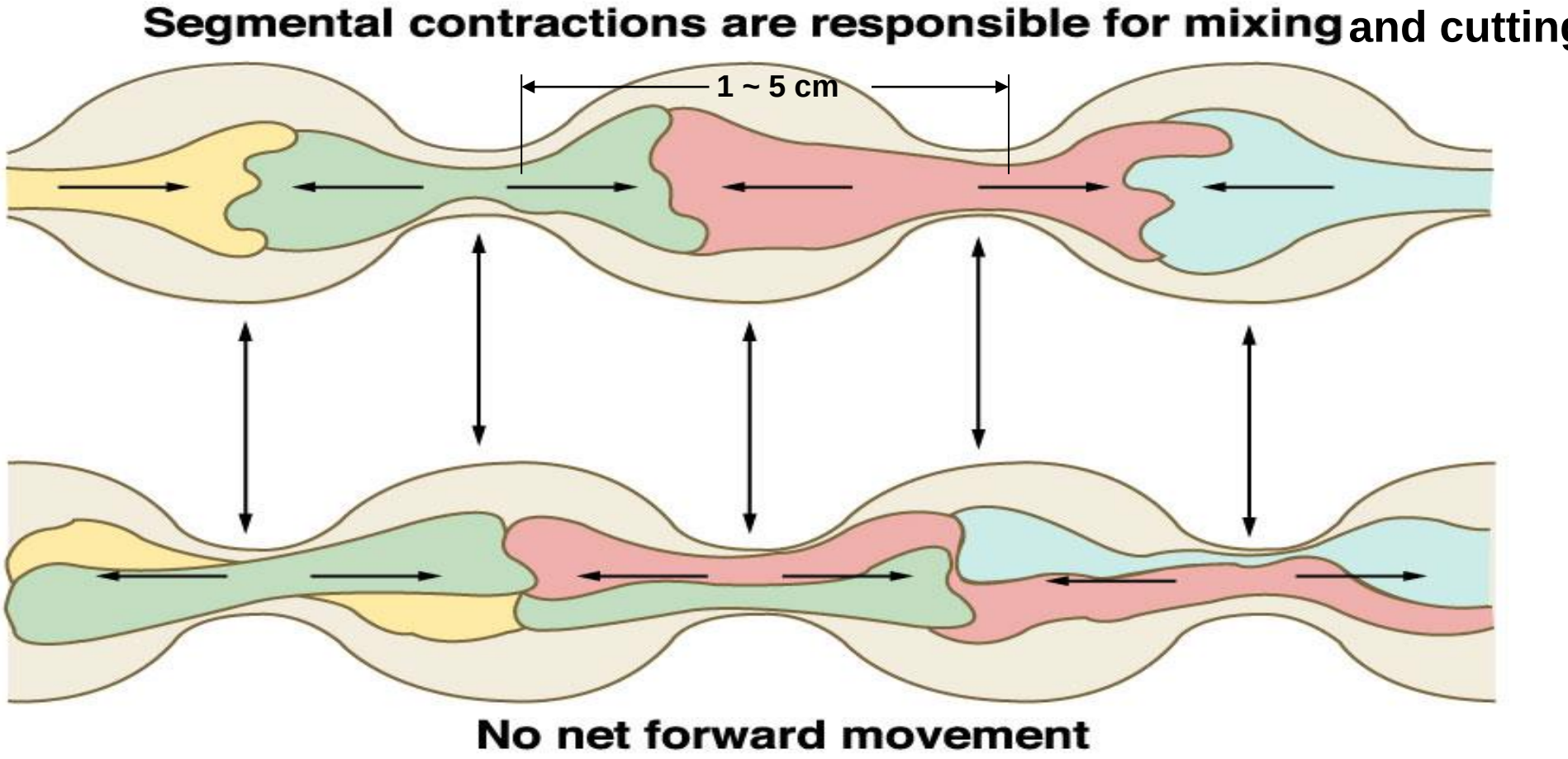
- Motility of the small intestine serves 3 functions:

1. **Mixing** contents with enzymes and other secretions → help digestion
2. Maximizing **exposure of the contents** to membranes of intestinal cells → help absorption and digestion.
3. **Propulsion** of contents into the large intestine.



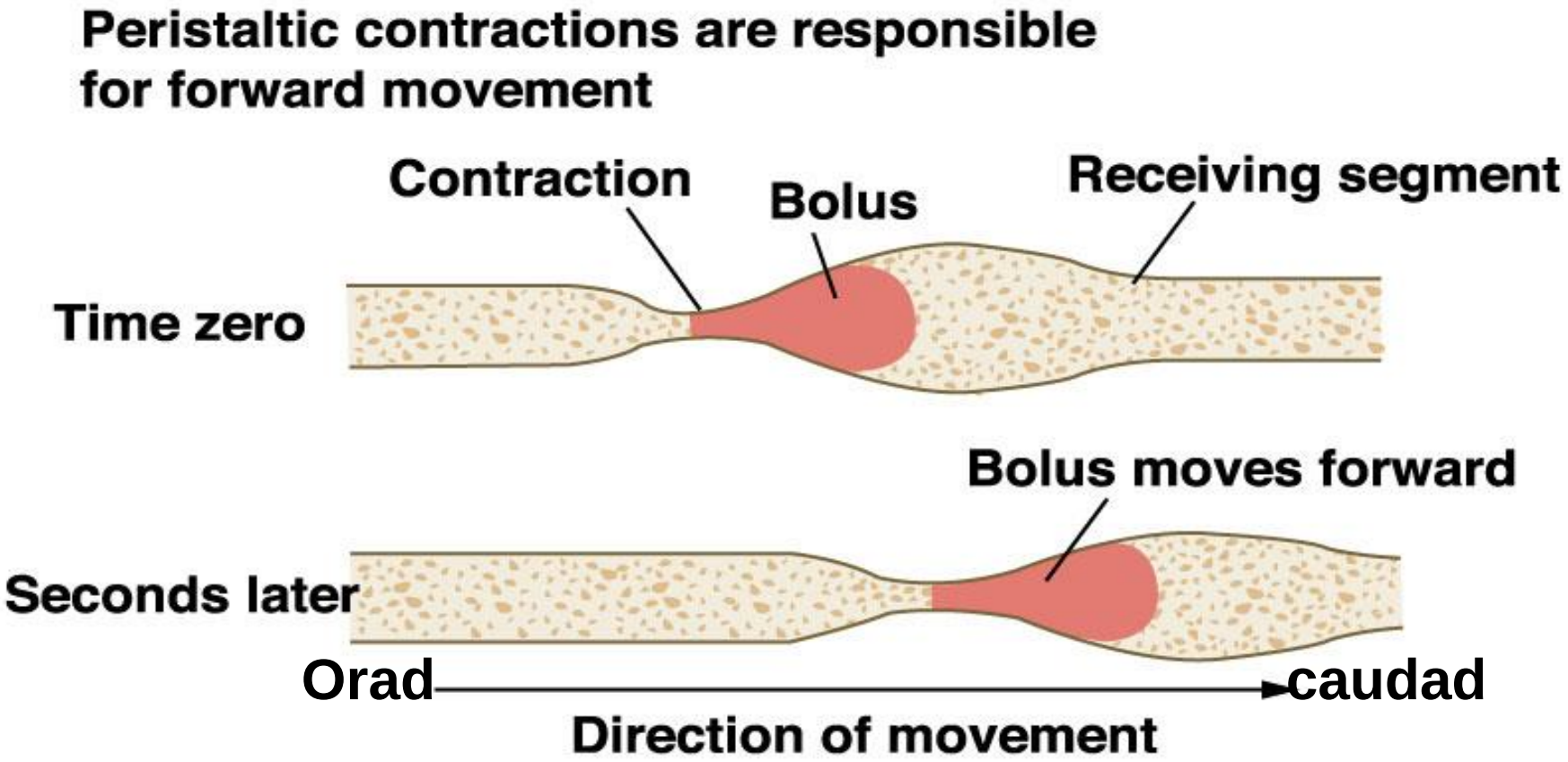
Motility of GIT

Segmentation movements



Motility of GIT

Peristalsis



Motility of GIT

5. Motility of Large intestine or colon

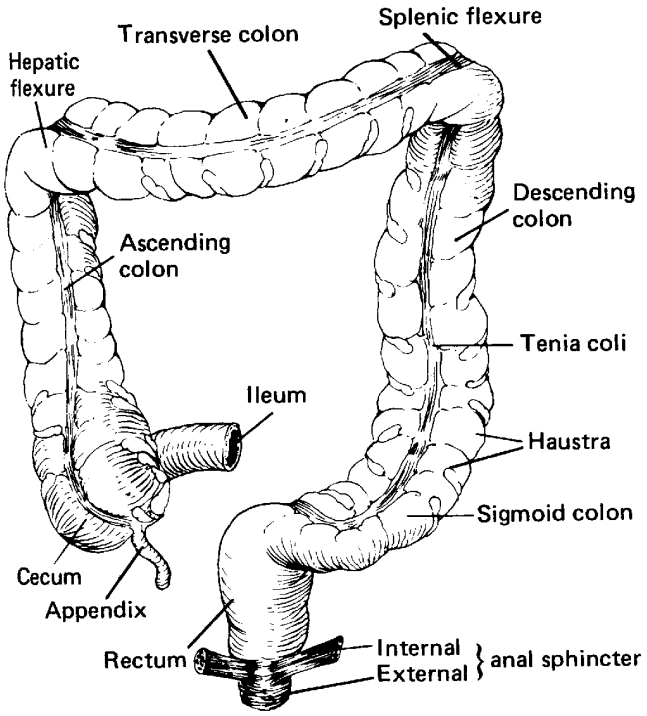
Types:

- Include :

a) Segmentation in the large intestine causes the contents to be continuously mixed

b) Mass movement propels the contents of one segment of the large intestine into the next downstream segment.

c) Defecation involves involuntary reflexes and voluntary reflexes → evacuation of colonic content through anal canal



The human colon.

Secretory Functions (Secretions) of GIT

Secretions of GIT

- The **total volume** of GIT secretions is about **6-8 L/day**
- Secretions arise from **specialized cells** lining the **GI tract**, the **pancreas**, **liver** and **gallbladder**.
- GI secretions function to **lubricate** (water and mucus), **protect** (mucus), **sterilize** (HCl), **neutralize** (HCO_3^-), and **digest** (enzymes).

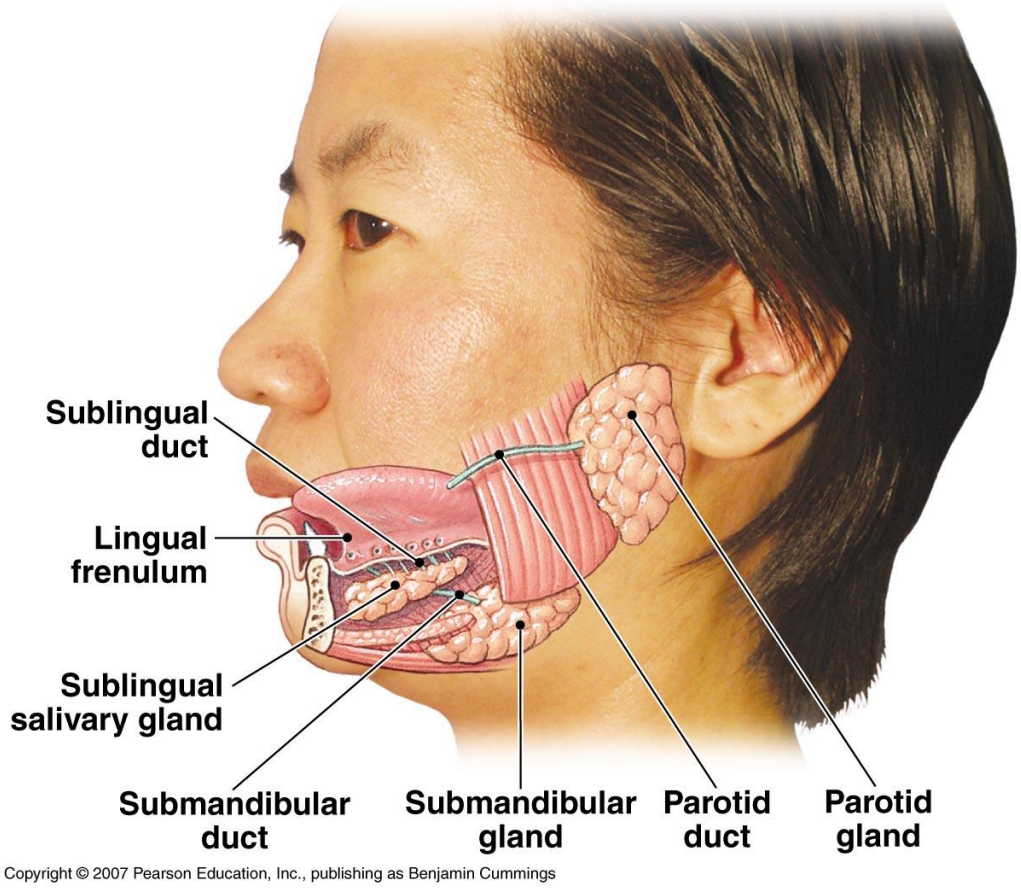
Secretions of GIT in Mouth

Salivary Glands

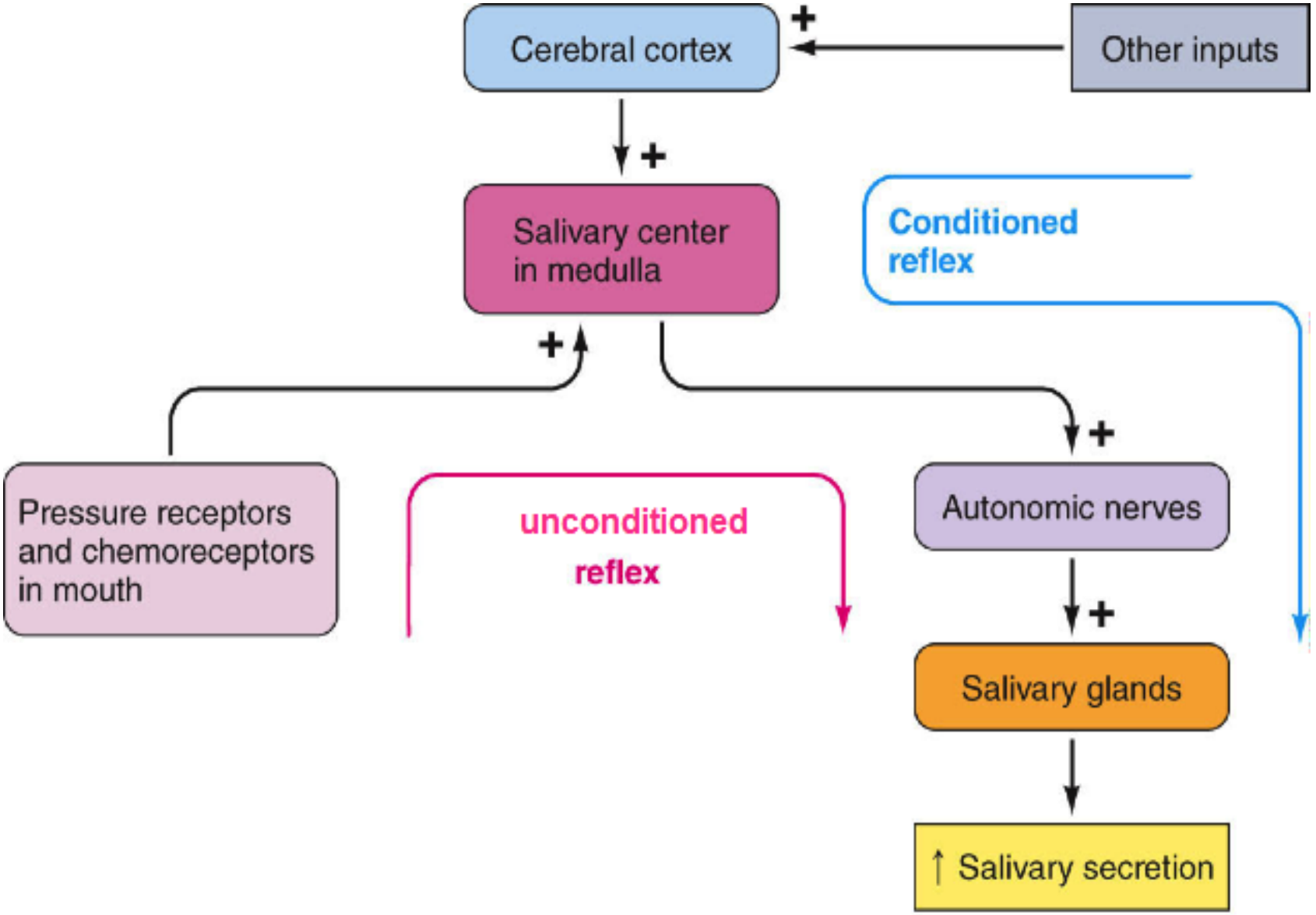
- **Three pairs** of glands
  - Parotid
  - Sublingual
  - Submandibular

Functions of saliva

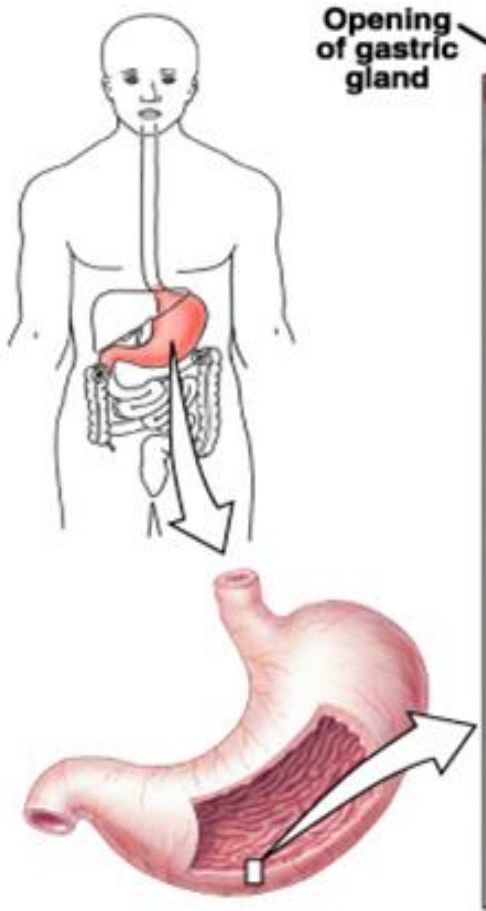
1. Lubricates, cleanes oral cavity
2. Dissolves chemicals
3. Suppresses bacterial growth
4. Digest starch by amylase

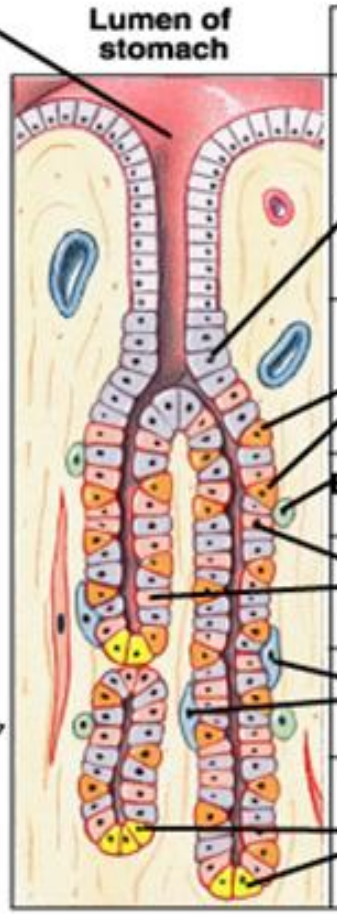


Regulation of salivary secretion



GIT secretions in Stomach





Source	Substance Secreted	Function
Mucous neck cell	Mucus	Physical barrier between lumen and epithelium
	Bicarbonate	Buffers gastric acid to prevent damage to epithelium
Parietal cells	Gastric acid (HCl)	Activates pepsin; kills bacteria
	Intrinsic factor	Complexes with vitamin B_{12} to permit absorption
Enterochromaffin-like cell	Histamine	Stimulates gastric acid secretion
Chief cells	Pepsin(ogen)	Digests proteins
	Gastric lipase	Digests fats
D cells	Somatostatin	Inhibits gastric acid secretion
G cells	Gastrin	Stimulates gastric acid secretion

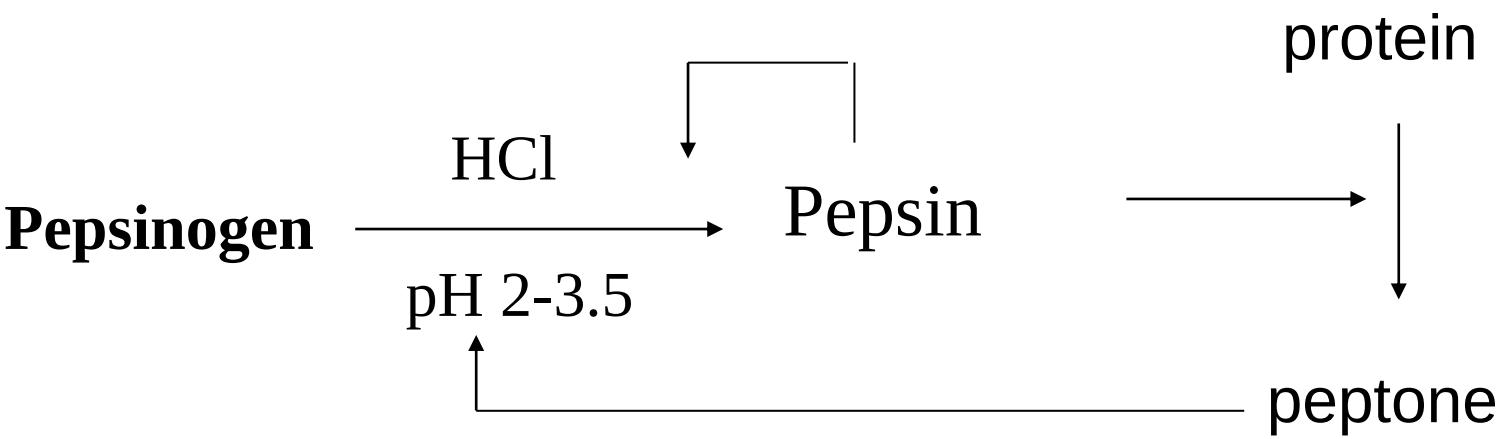
Function of Gastric HCL

1. Activates pepsinogen into pepsins
2. Provides optimum for pH for action of pepsins
3. Denatures protein denaturation → help its digestion
4. Kills bacteria in food
5. Help Fe^{2+}、Ca^{2+} absorption.
6. Promotes pancreatic, small intestinal and bile secretion


HCl Acid
Pepsin
Pepsin +
HCl Acid
SCIENCE PHOTO LIBRARY

Function of pepsins

Function of pepsinogen



Function of mucous and intrinsic factor

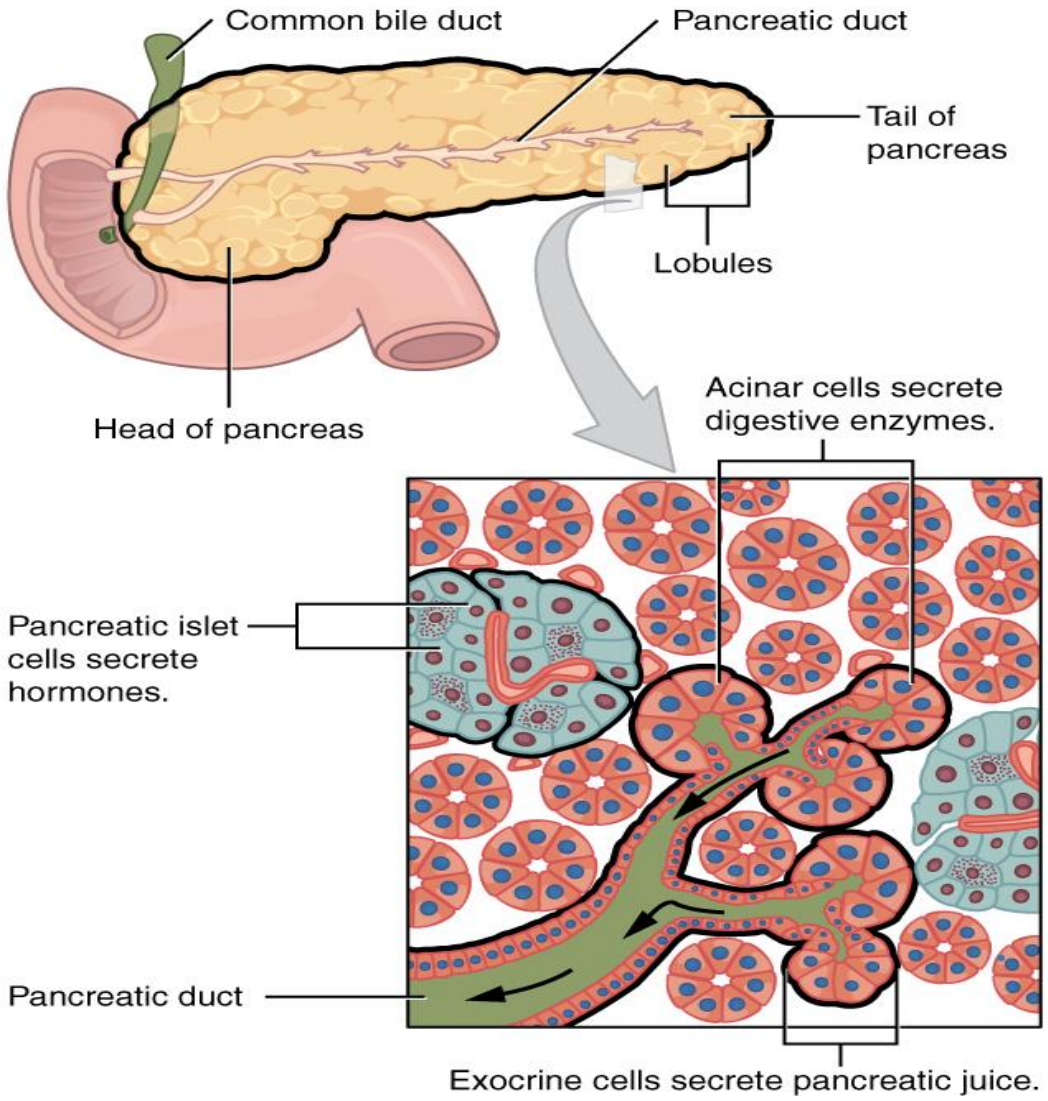
Mucus secretion

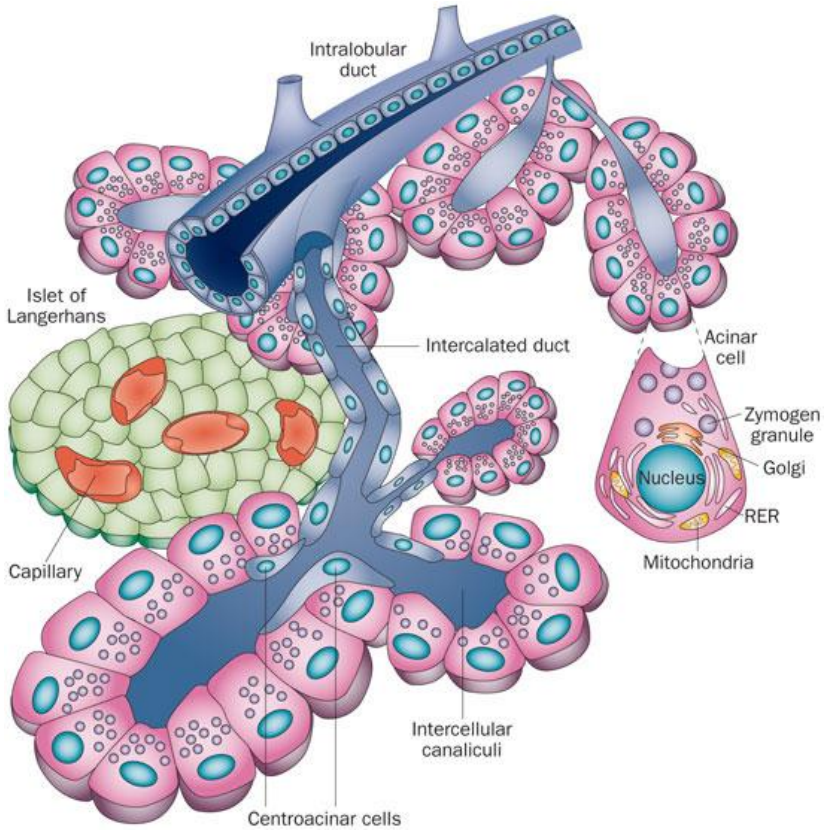
- Soluble and insoluble mucus are secreted by cells of the stomach.
- **Soluble mucus** mixes with the contents of the stomach and helps to lubricate chyme.
- **Insoluble mucus** forms a protective barrier against the high acidity of the stomach content.

Intrinsic Factor

- Help absorption of vitamin B12

Pancrease


Common bile duct
Pancreatic duct
Tail of pancreas
Lobules
Head of pancreas
Acinar cells secrete digestive enzymes.
Pancreatic islet cells secrete hormones.
Pancreatic duct
Exocrine cells secrete pancreatic juice.


Intralobular duct
Islet of Langerhans
Intercalated duct
Acinar cell
Zymogen granule
Golgi
Nucleus
RER
Mitochondria
Capillary
Intercellular canaliculi
Centroacinar cells

Pancreatic Secretion

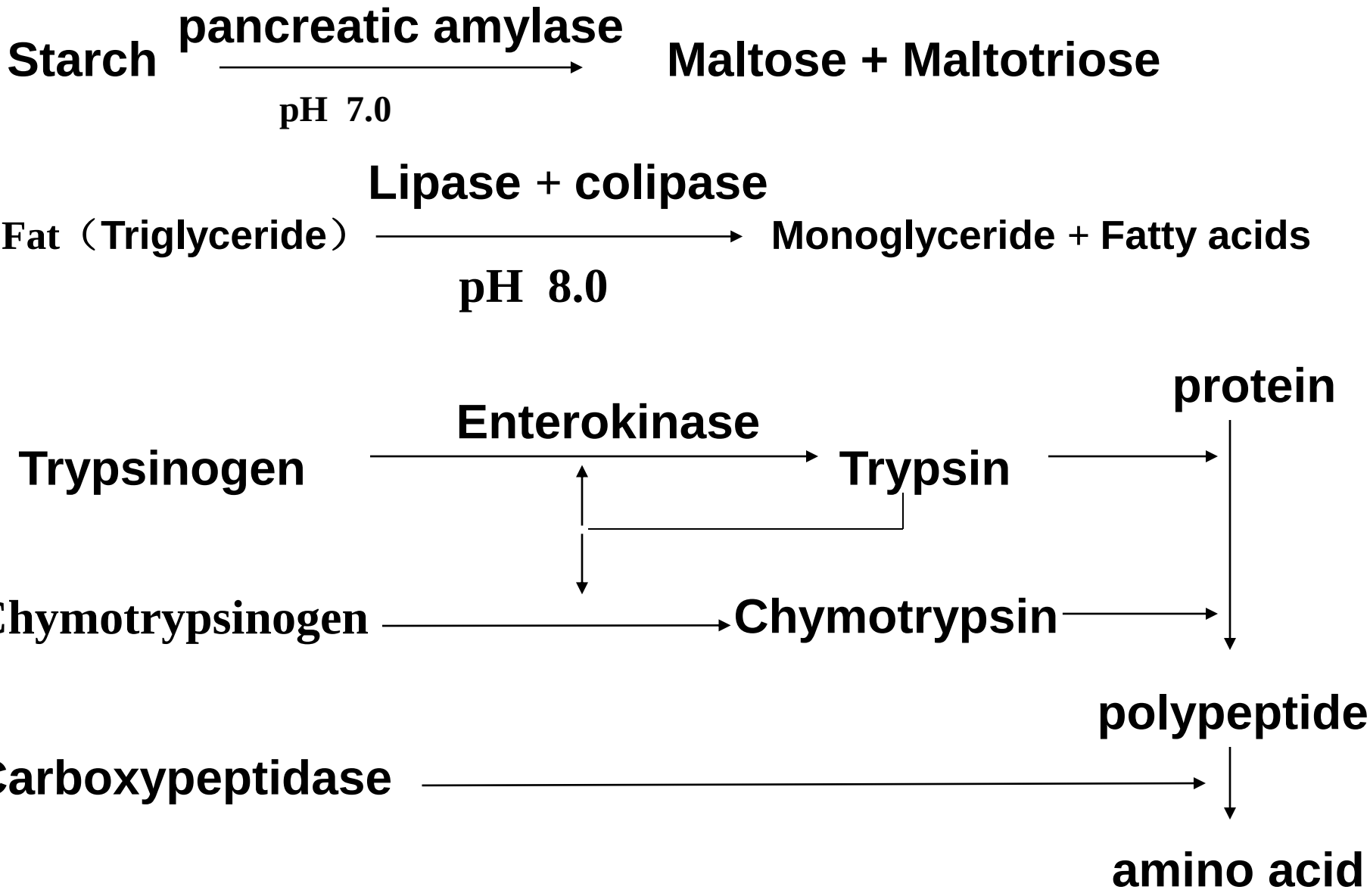
- Pancreas has **2 functions**:

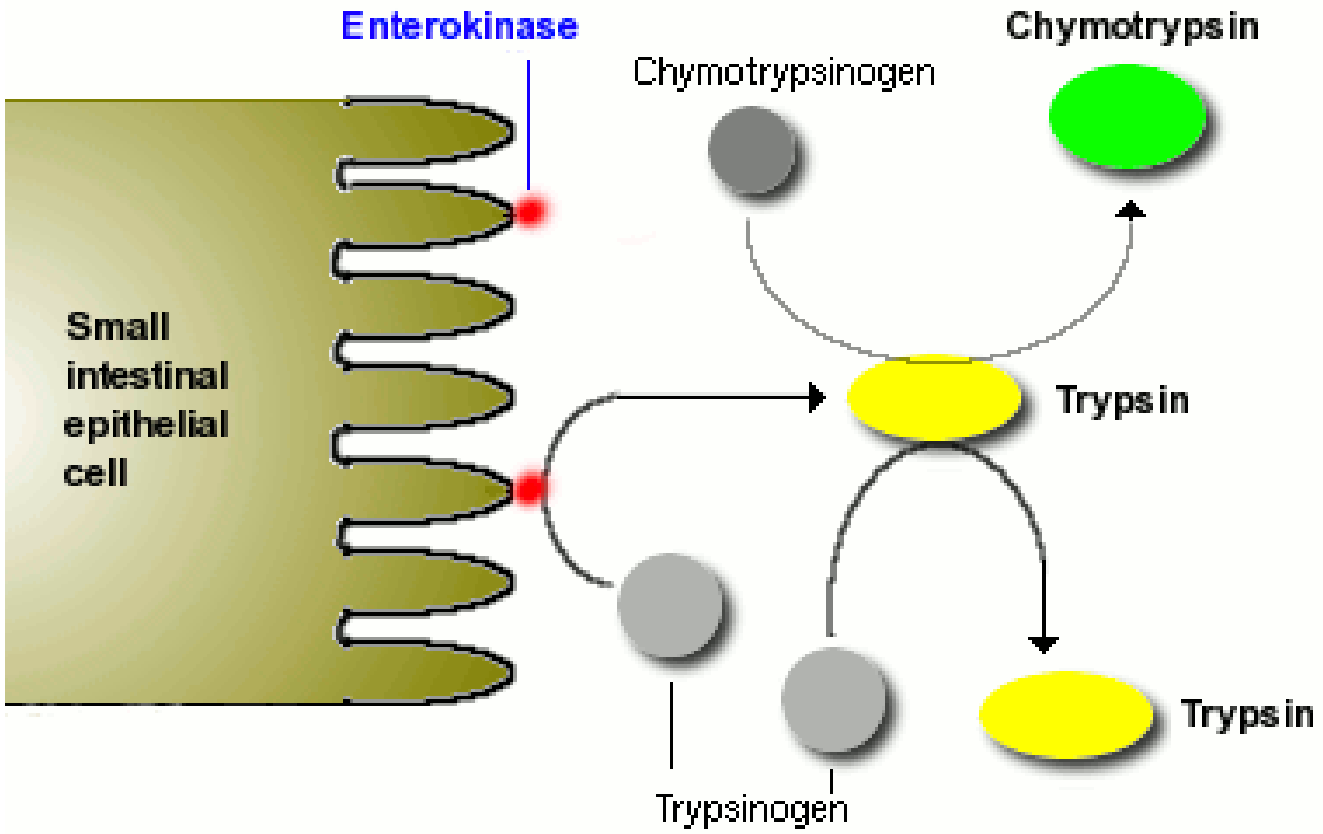
a) Endocrine functions: secretes insulin and glucagon from islets of Langerhans

b) Exocrine function: secretion of pancreatic juice

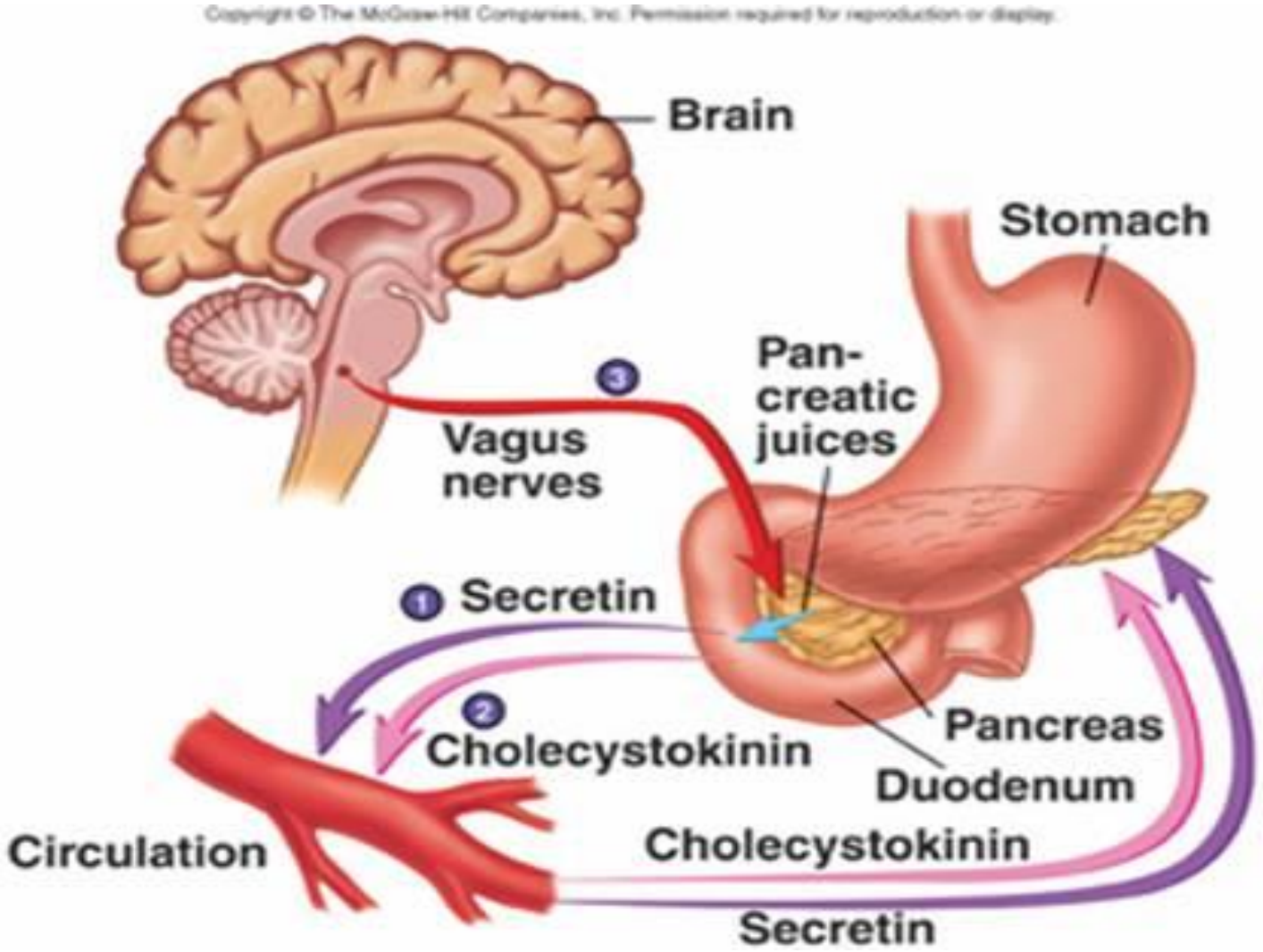
- It has **2 components**: aqueous and enzymatic components.
- **Aqueous component** (contains HCO3) is important for neutralizing stomach acid in the duodenum so pancreatic enzymes can function properly
- **Enzymatic component** is essential for the proper digestion and absorption of carbohydrates, fats, and proteins
- **Pancreatic enzymes** include trypsin, chemotrypsin, lipase, and amylase

Functions of pancreatic juice enzymes

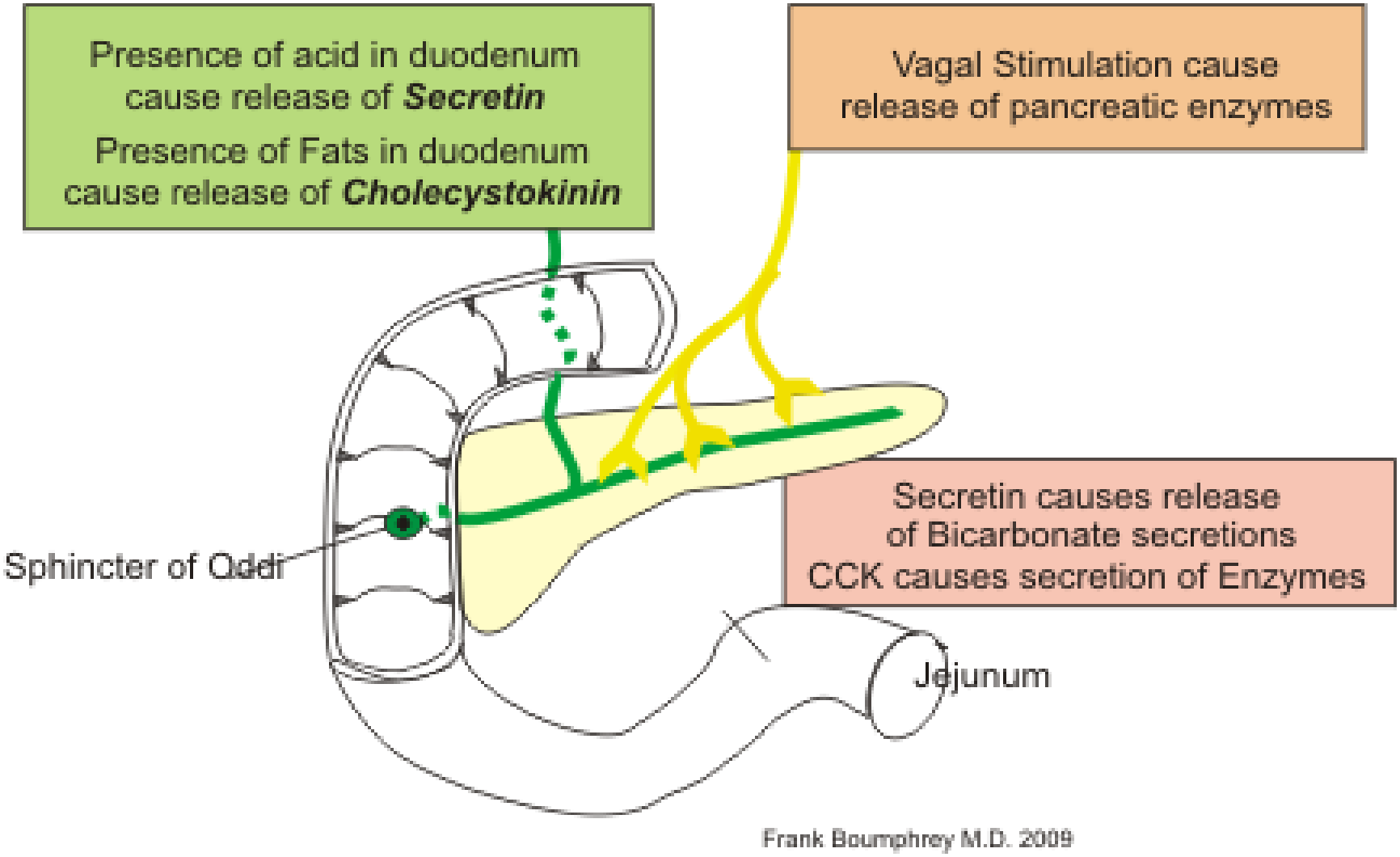



Enterokinase
Chymotrypsinogen
Chymotrypsin
Small intestinal epithelial cell
Trypsin
Trypsin
Trypsinogen

Regulation of pancreatic secretion

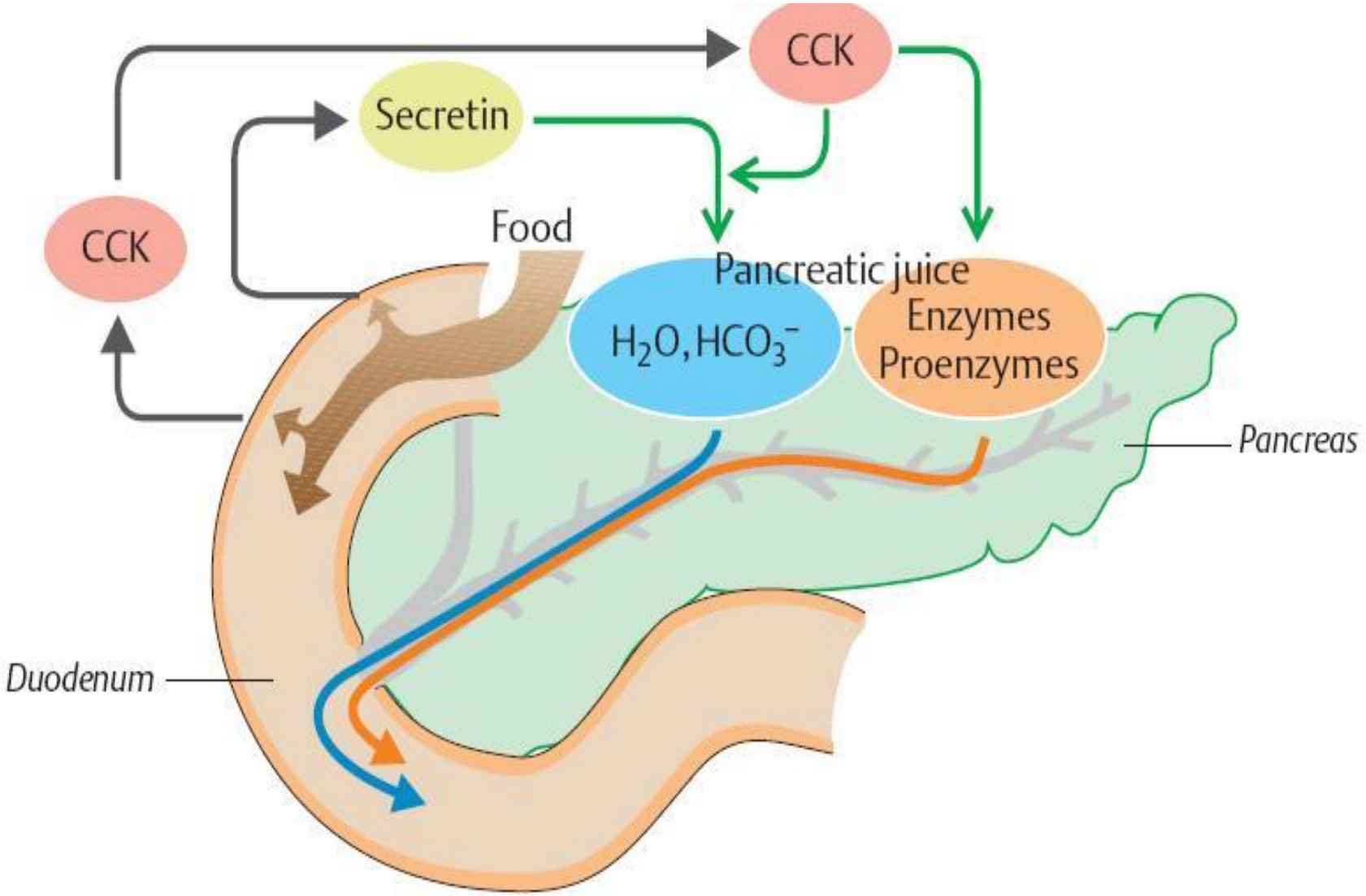


Regulation of pancreatic secretion

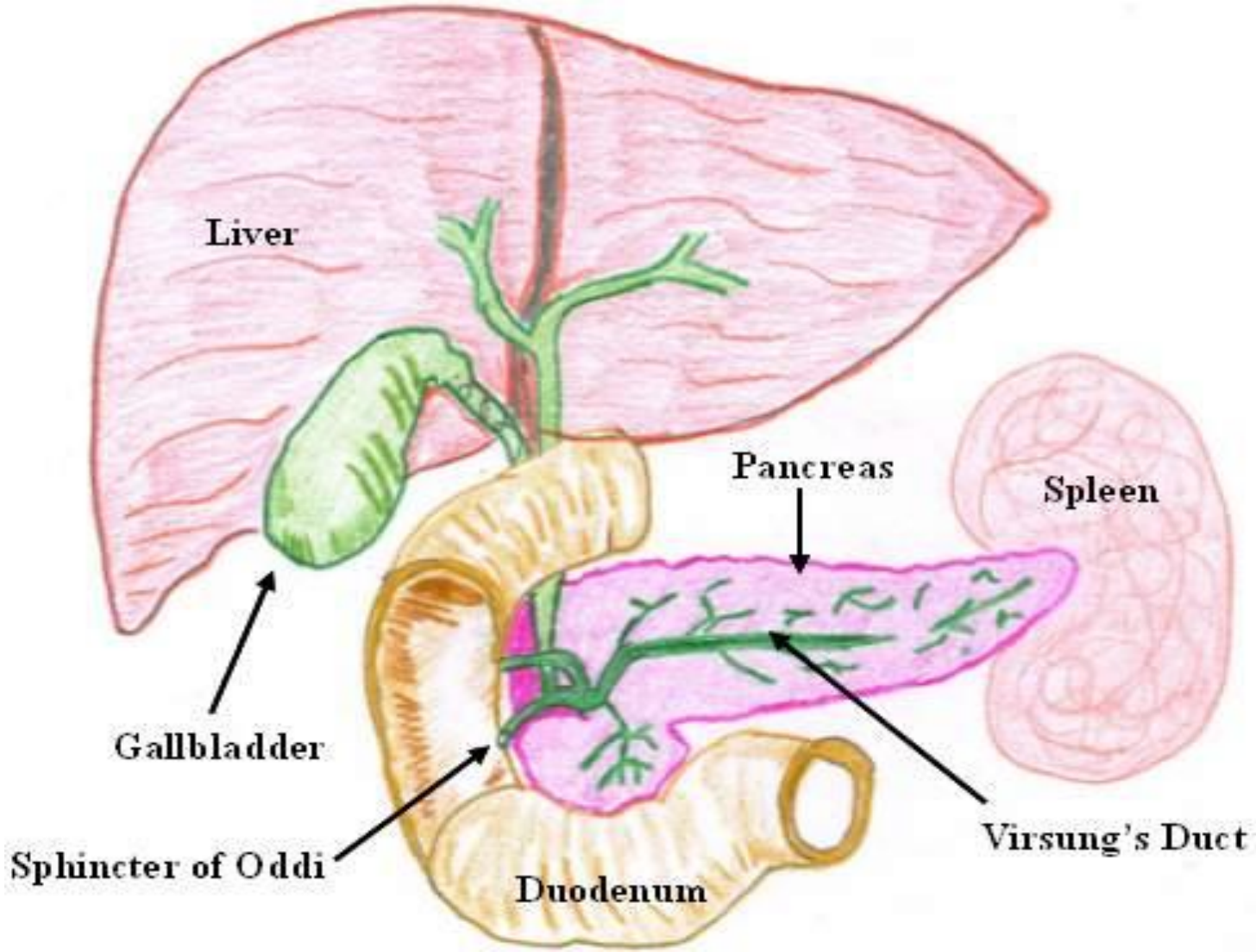


Control of Pancreatic Secretions

Regulation of pancreatic secretion



Liver and Gallbladder



Liver

Functions of the Liver:

1) Metabolic regulation

- Store absorbed nutrients, vitamins
- Release nutrients as needed

2) Hematological regulation

- Plasma protein production
- Remove old RBCs

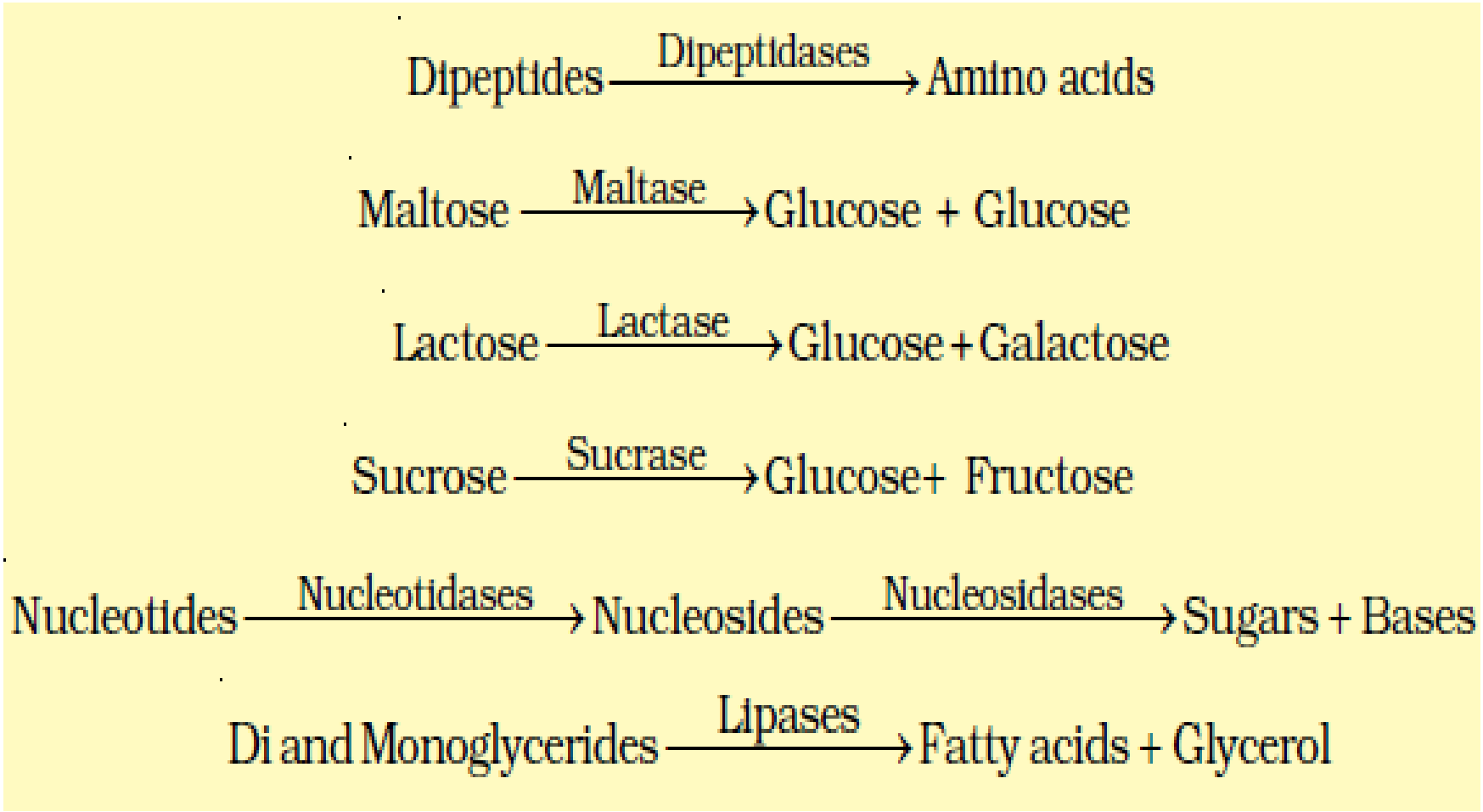
3) Production of bile

- Required for fat digestion and absorption

Small intestine Secretion

- Secretion from duodenal gland and intestinal gland
- Secretory volume is 1～3L/day
- It contains inorganic ion, mucoprotein, IgA, various enzyme, e.g. enterokinase ,etc
- **Function:**
  1. Protective effect by mucous
  2. Digestion by enzymes such as peptidase, sucrase, lipase
  3. Dilution

Small intestine Enzymes



Secretion of large intestine

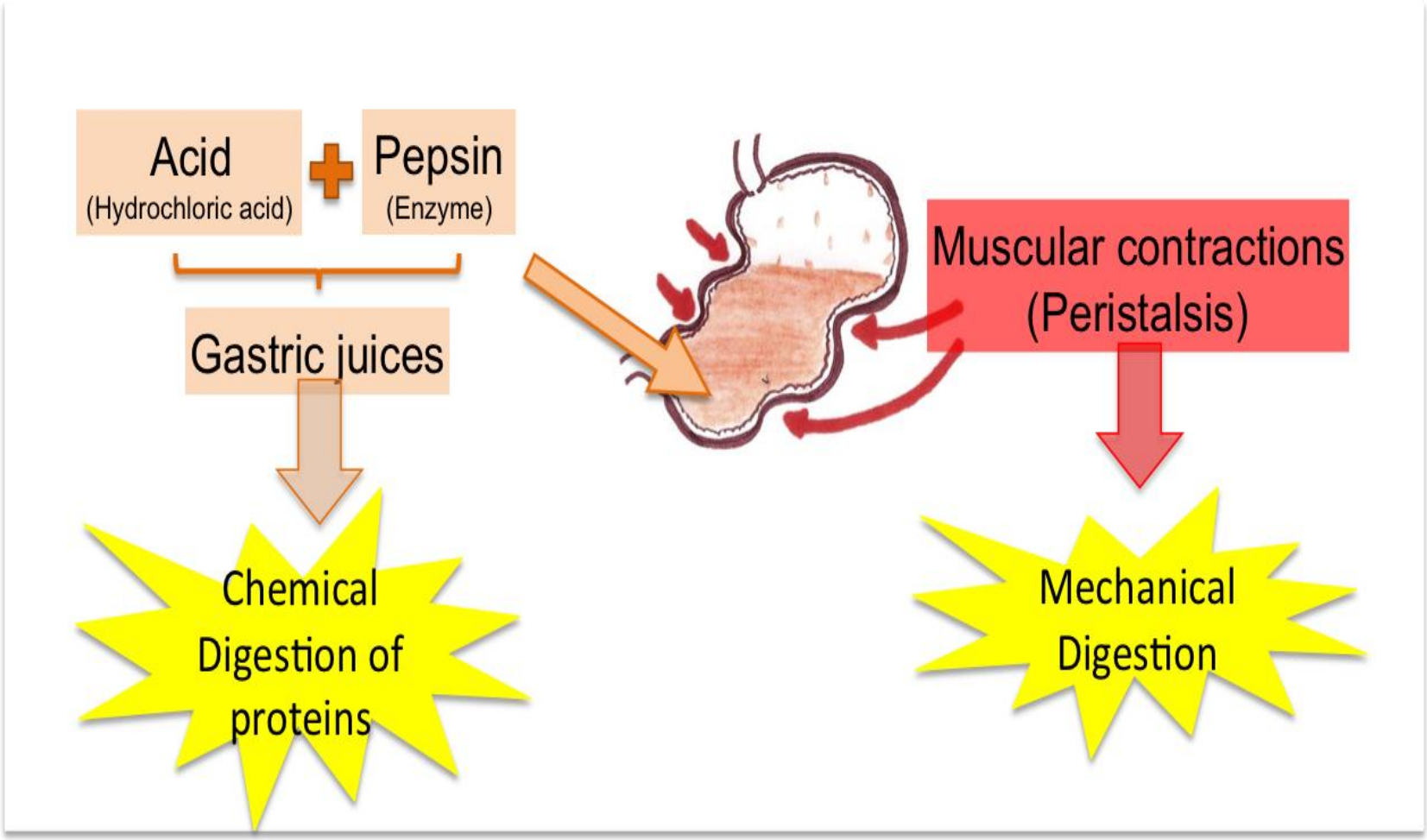
1. Colonic **alkaline secretion** to neutralize acids produced by intestinal bacteria
2. Secretion of **mucous** for protection, lubrication of fecal matter
3. **Vitamin B and K absorption** made from bacterial flora in colon

Digestion and Absorption

Digestion and Absorption

- **Digestion is a process essential for the conversion of food into a small and simple form.**
  - **Mechanical digestion** by mastication and swallowing
  - **Chemical digestion** by enzymes
- **Absorption is the process of transporting small molecules from the lumen of the gut into blood stream or** lymphatic vessel**.**

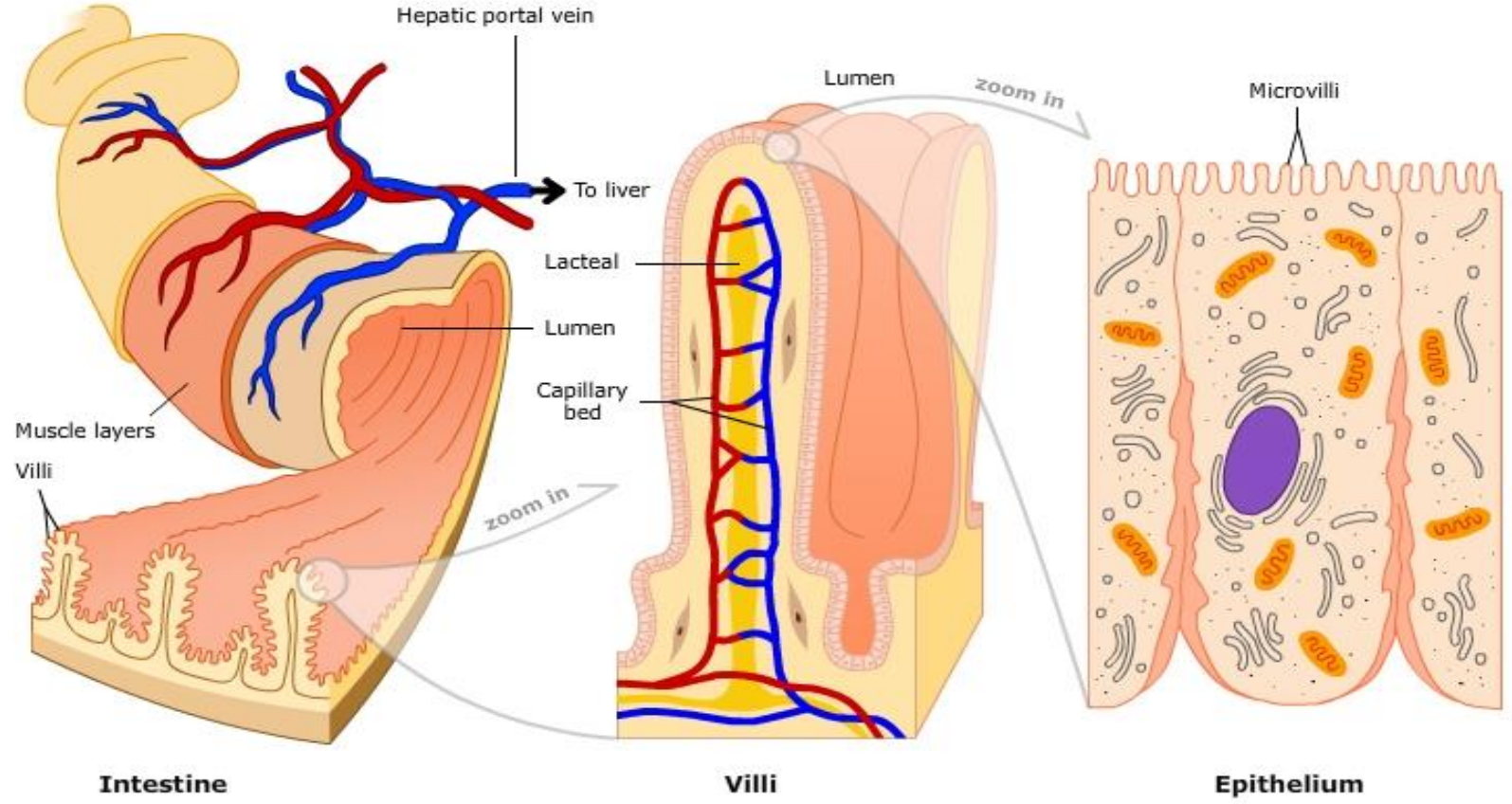
Chemical and Mechanical Digestion



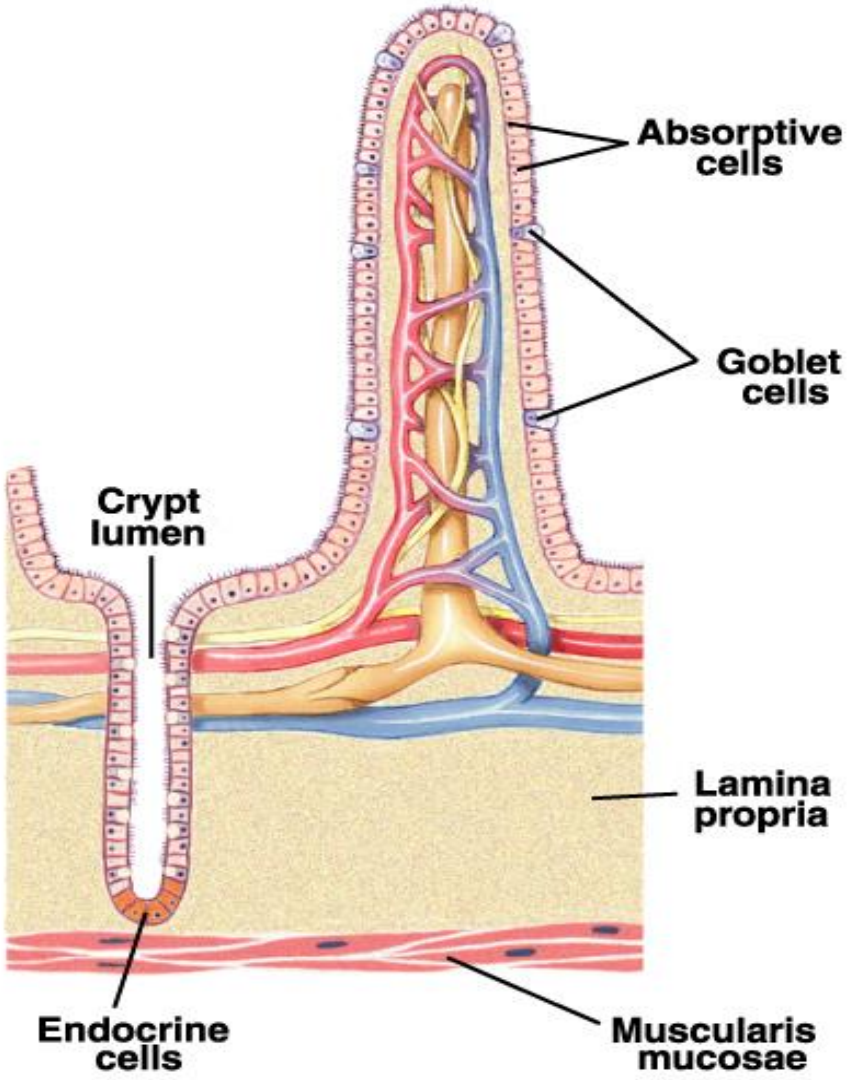
Digestion and Absorption

- **Small intestine** is primary site **for digestion** and **absorption** of food.
- **Digestion** occurs in the GI lumen by **secreted enzymes** and on surface of enterocytes by **membrane-bound enzymes**.
- Absorption occurs by **simple diffusion**, **facilitated diffusion**, **active transport**, **endocytosis**, and **paracellular transport**.
- **Surface area** of small intestine is greatly increased by extensive **folding** and the projection of **fingerlike villi** covered with **microvilli**.

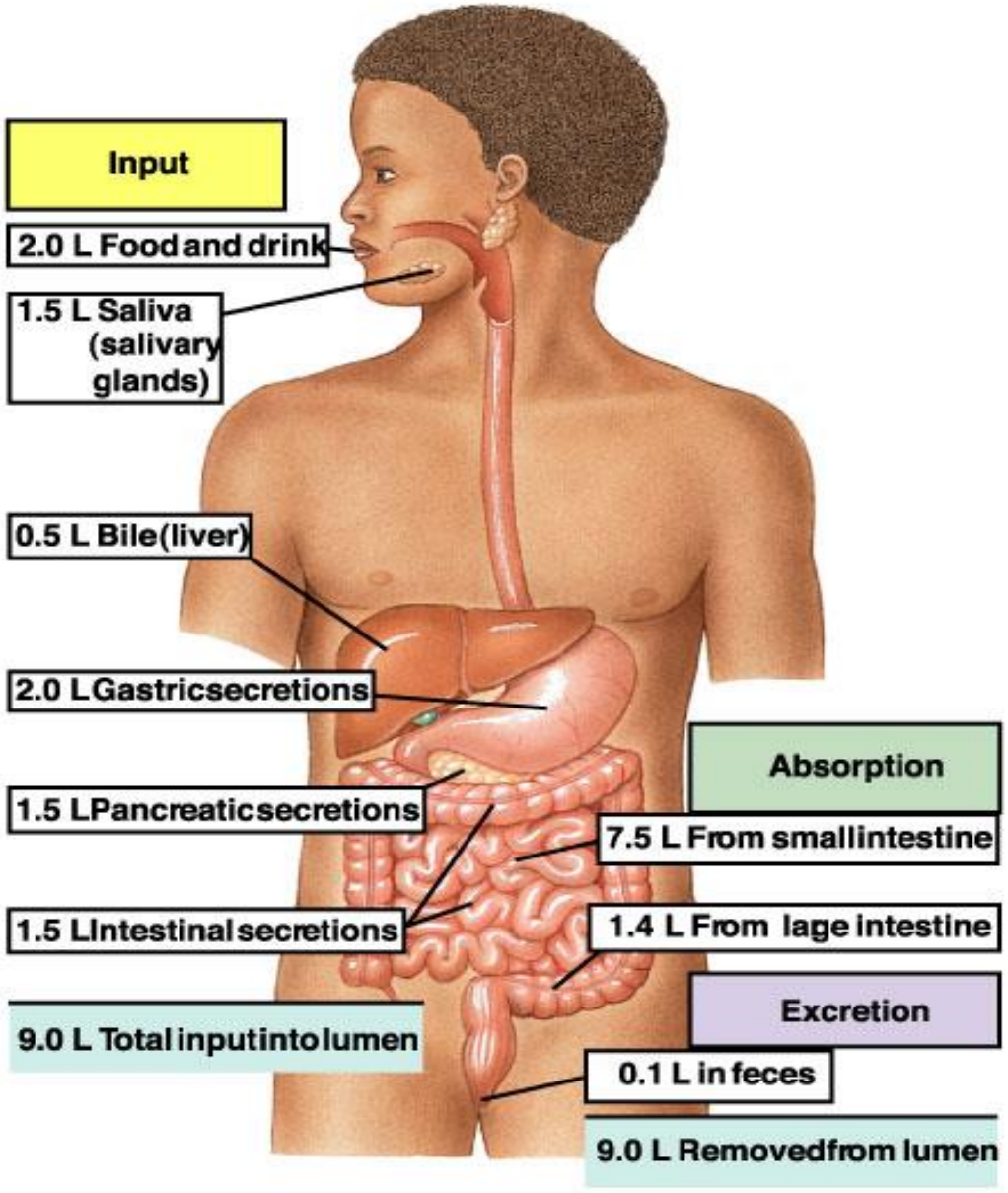
Intestinal Mucosa



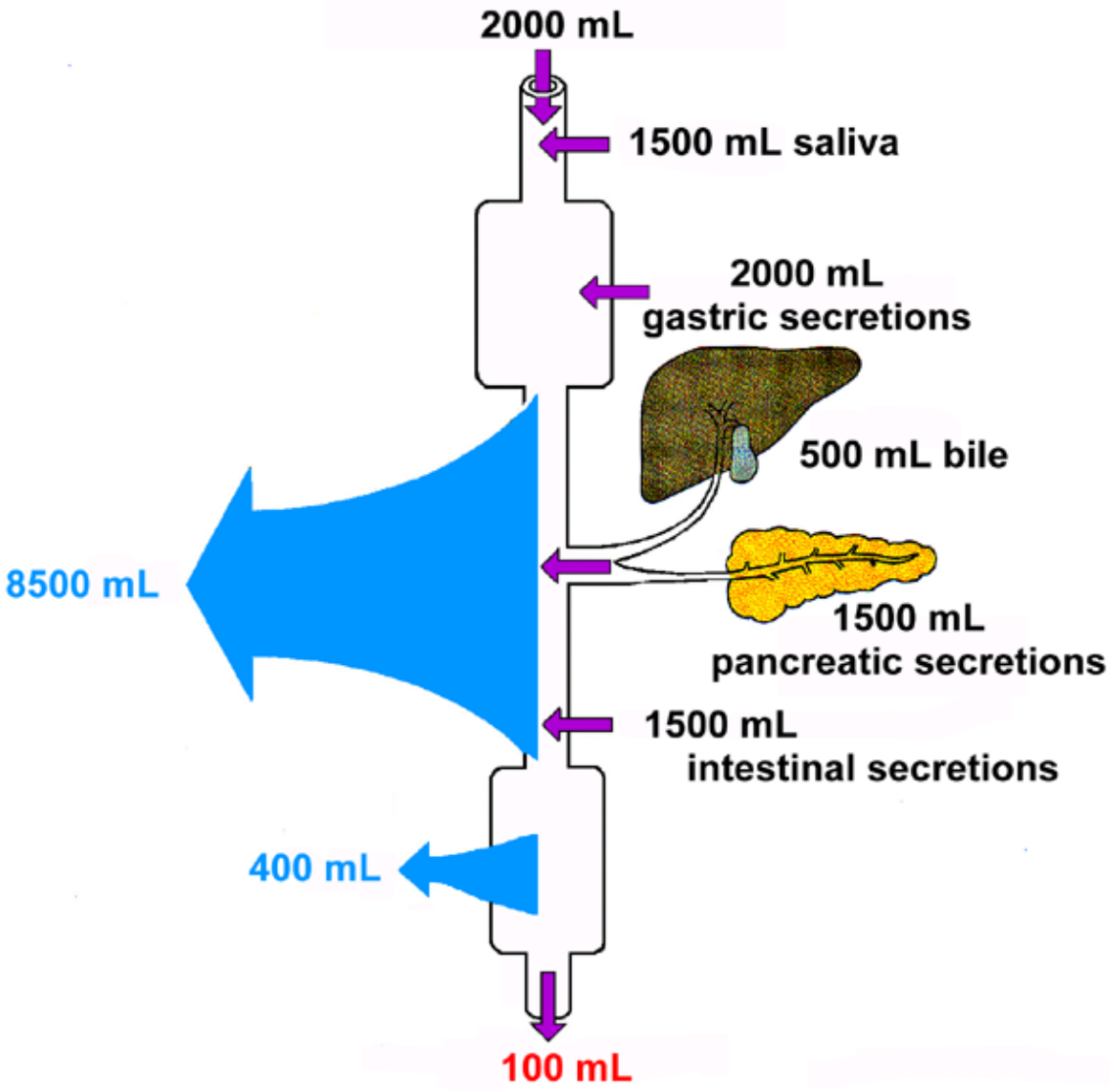
Intestinal Villi



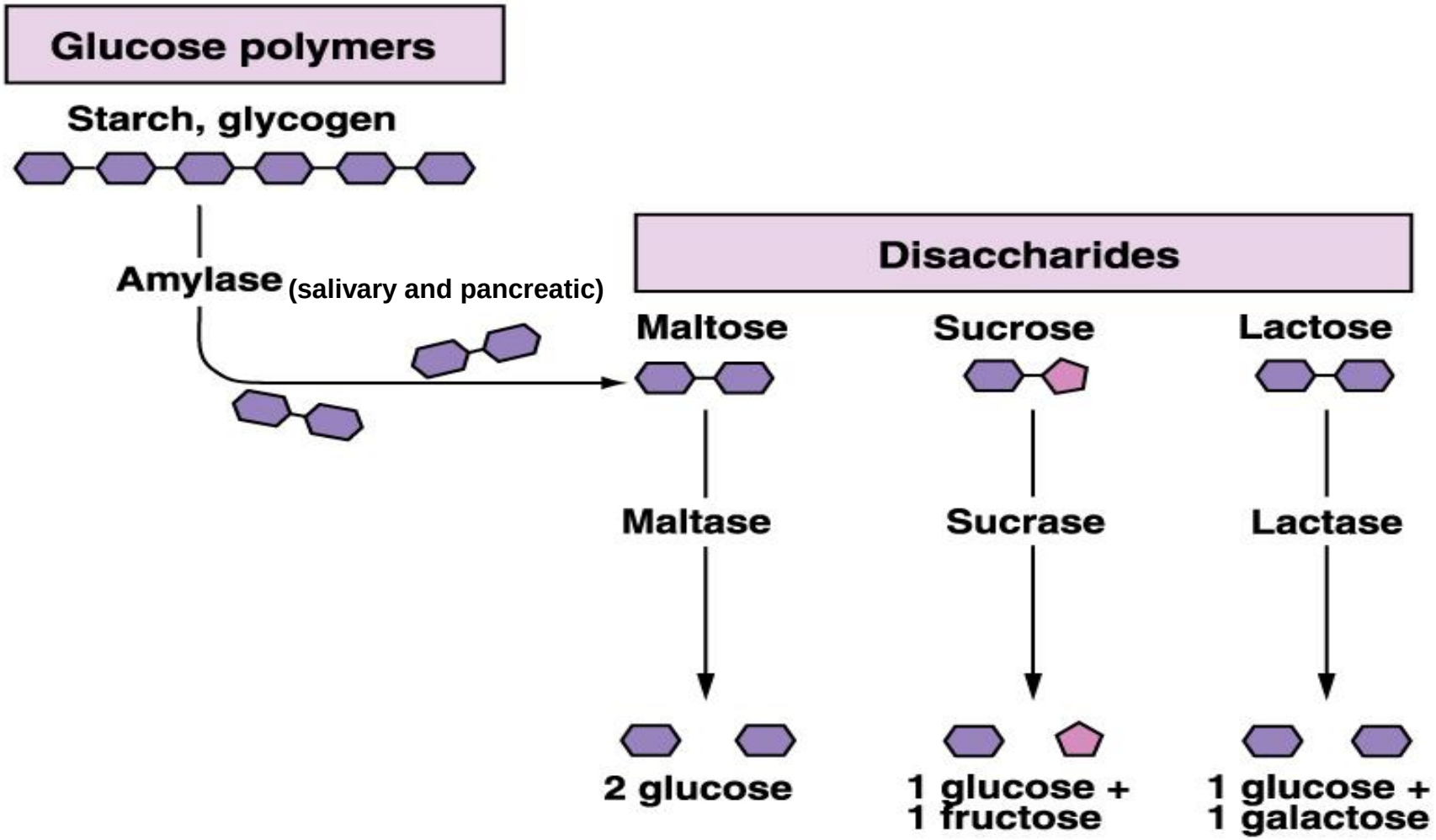
Absorption of Water



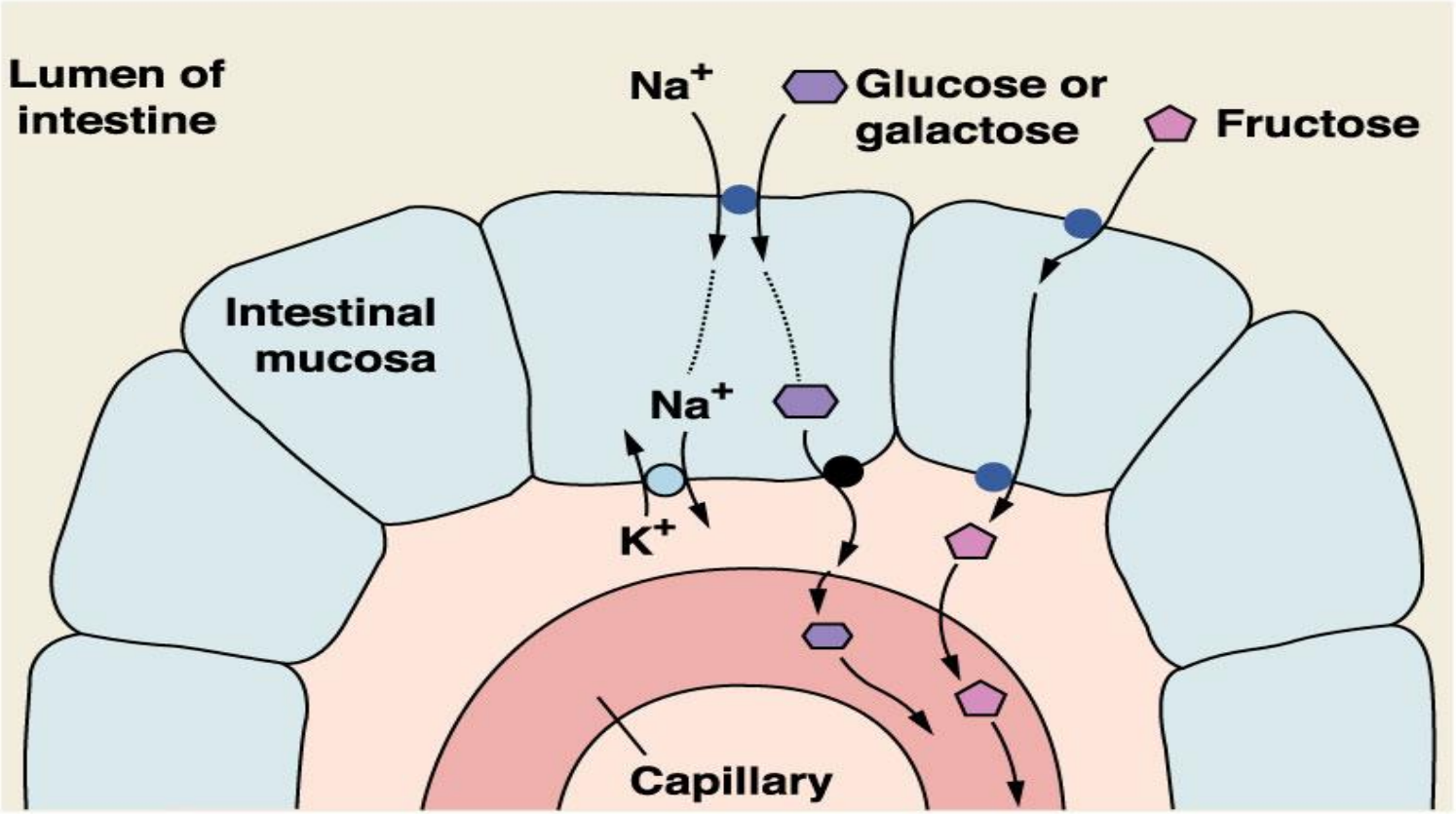
Absorption of Water



Digestion of CHO

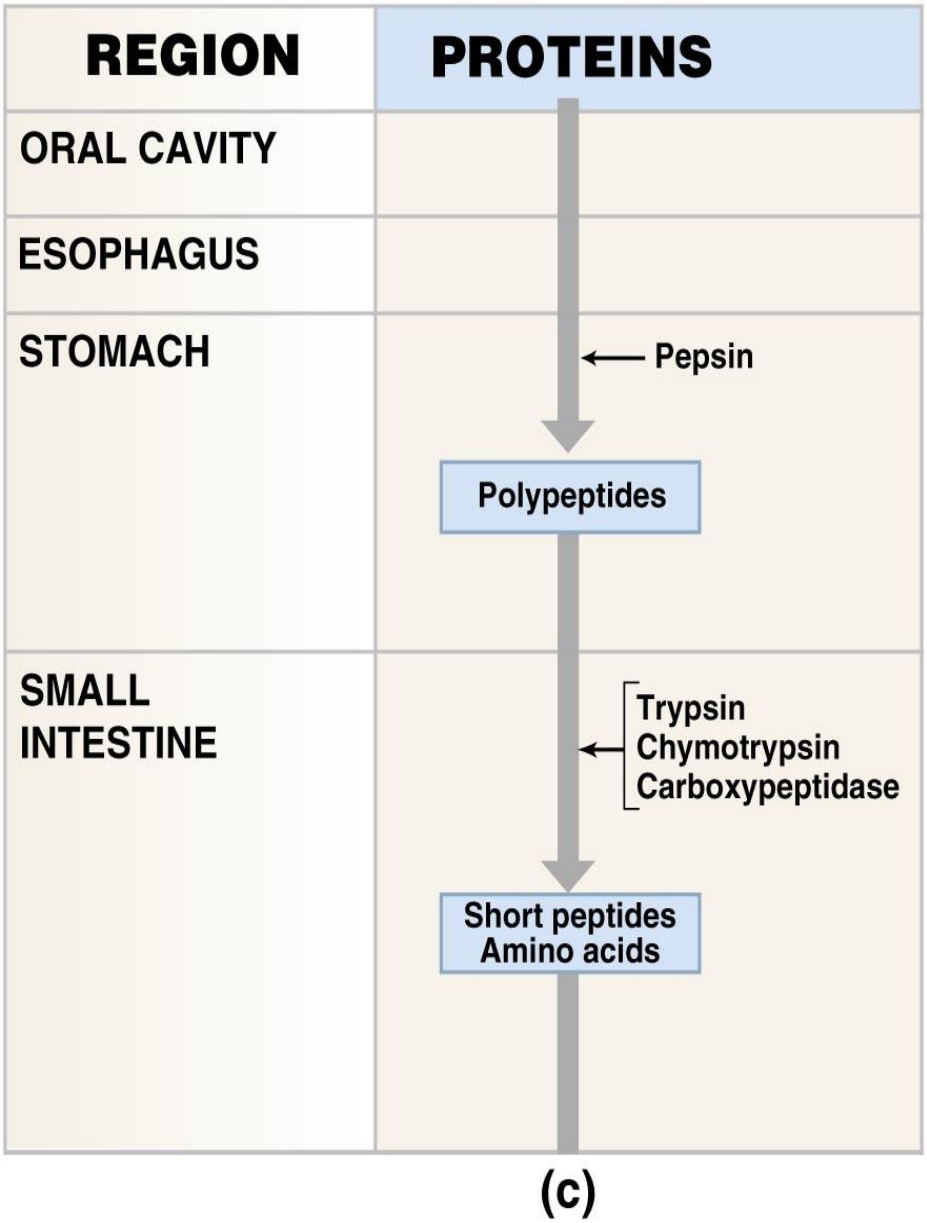


Absorption of CHO



Enterocytes absorb **glucose and galactose** through an **Na-dependent secondary active transport process**, while **fructose** is absorbed by **facilitated transport**.

Digestion and absorption of proteins



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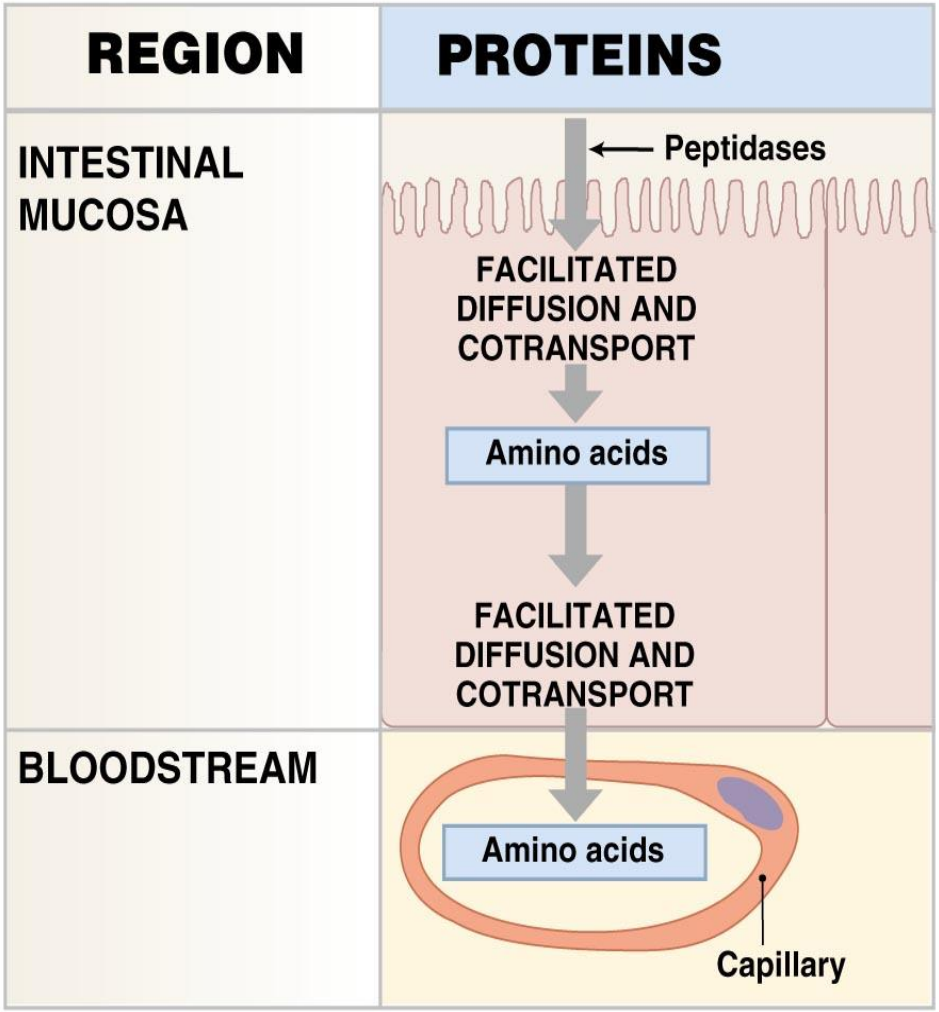
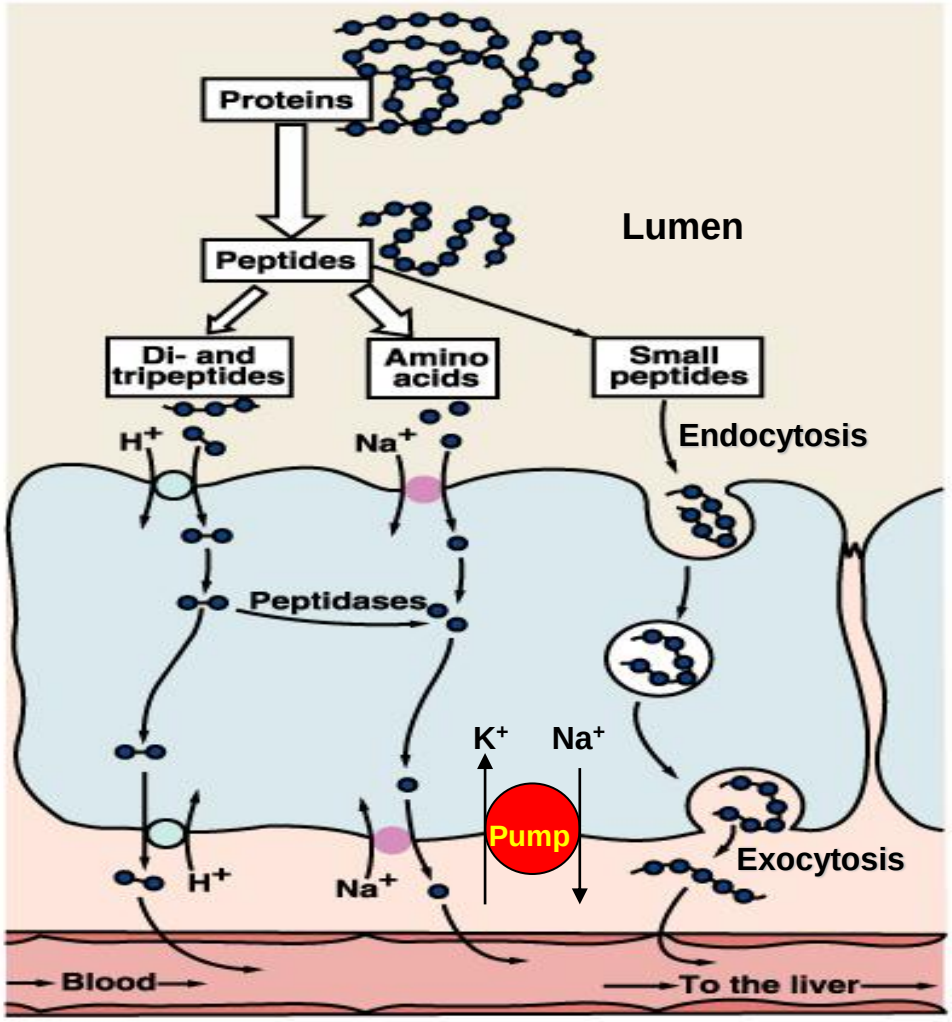


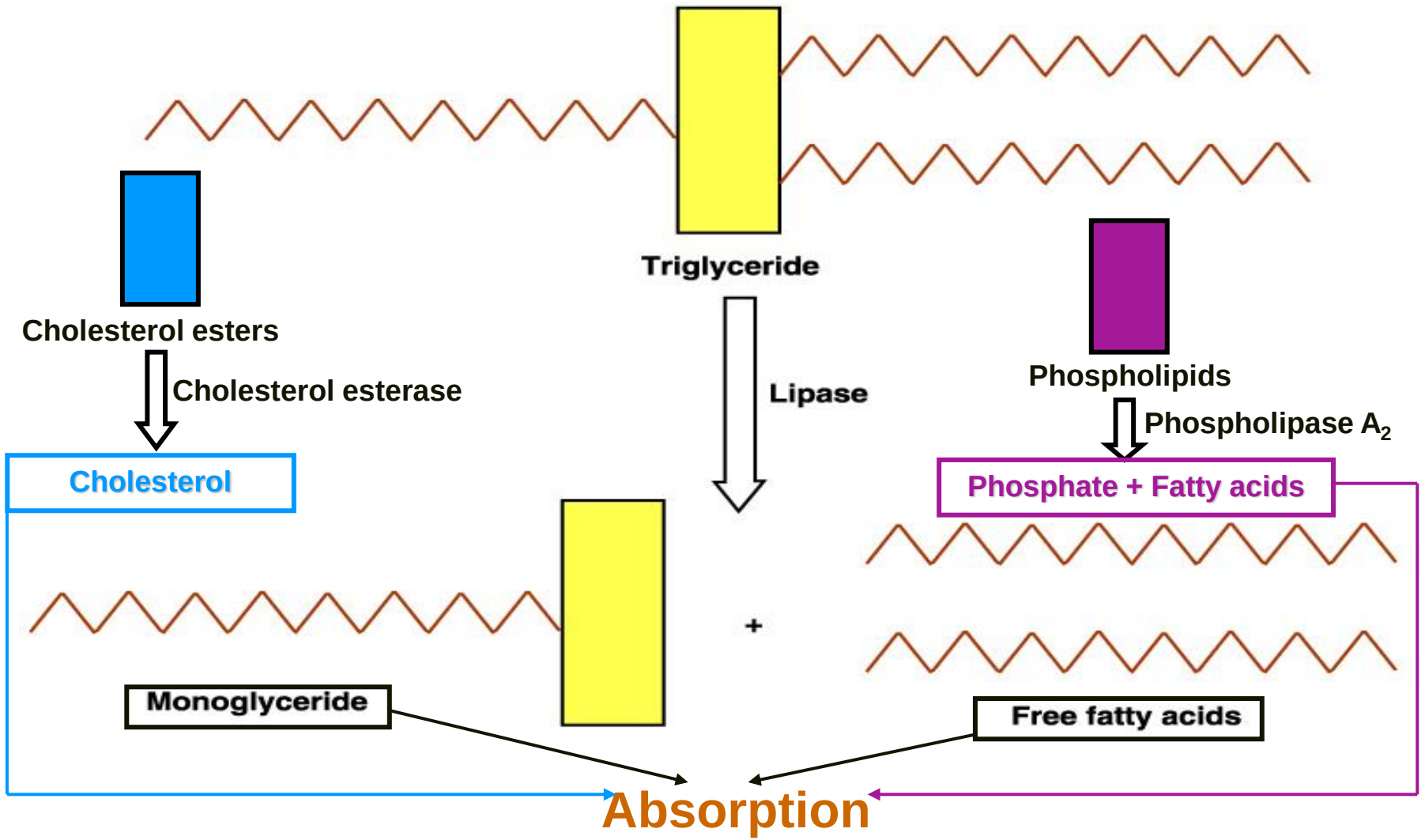
(c)

Absorption of proteins

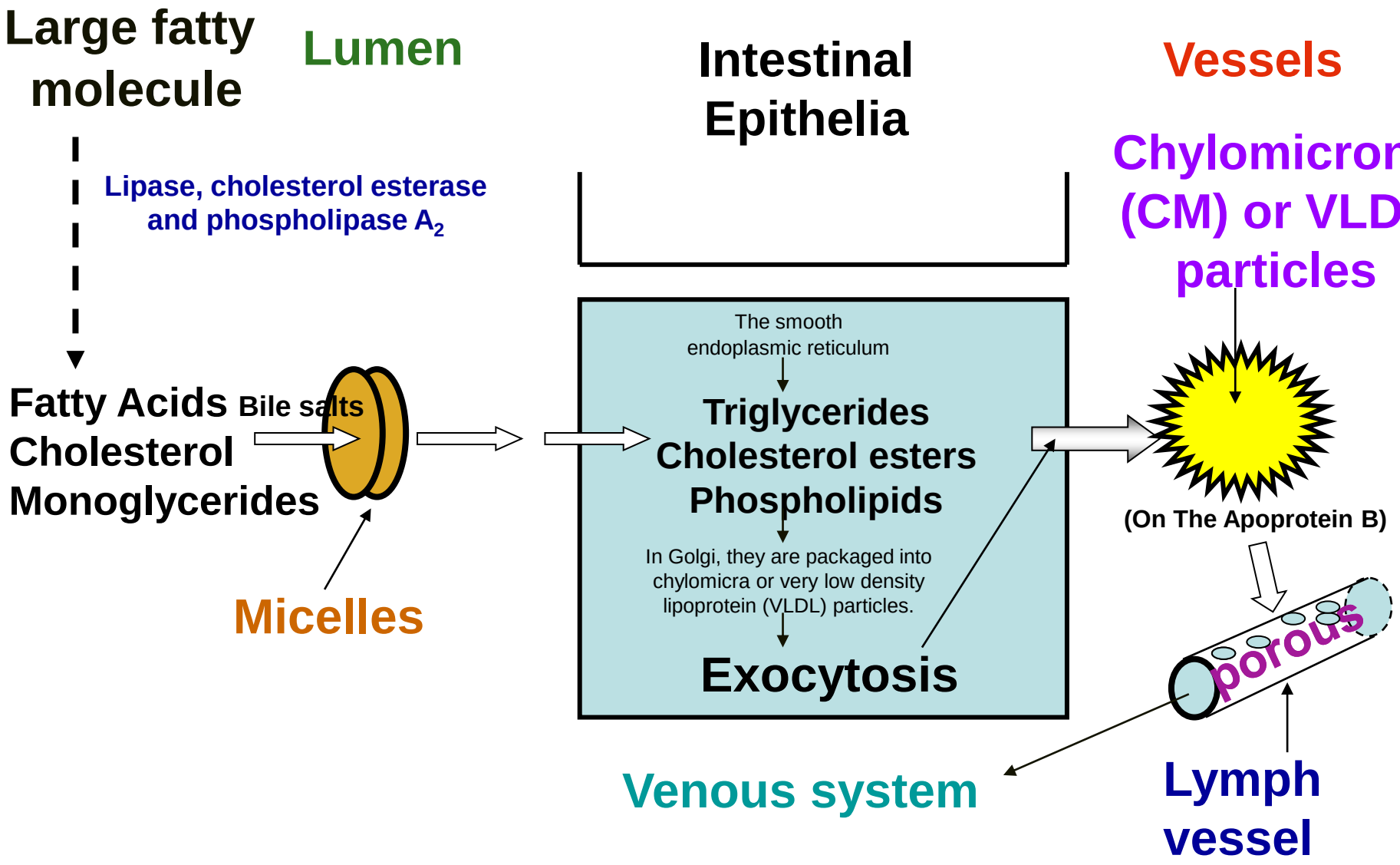
- The whole proteins by **endocytosis**
- Amino acids and di and tripetides by **Na-dependent 2ry** active transport



Digestion of fats



Absorption of Lipids



Absorption of Fats in the Small Intestine