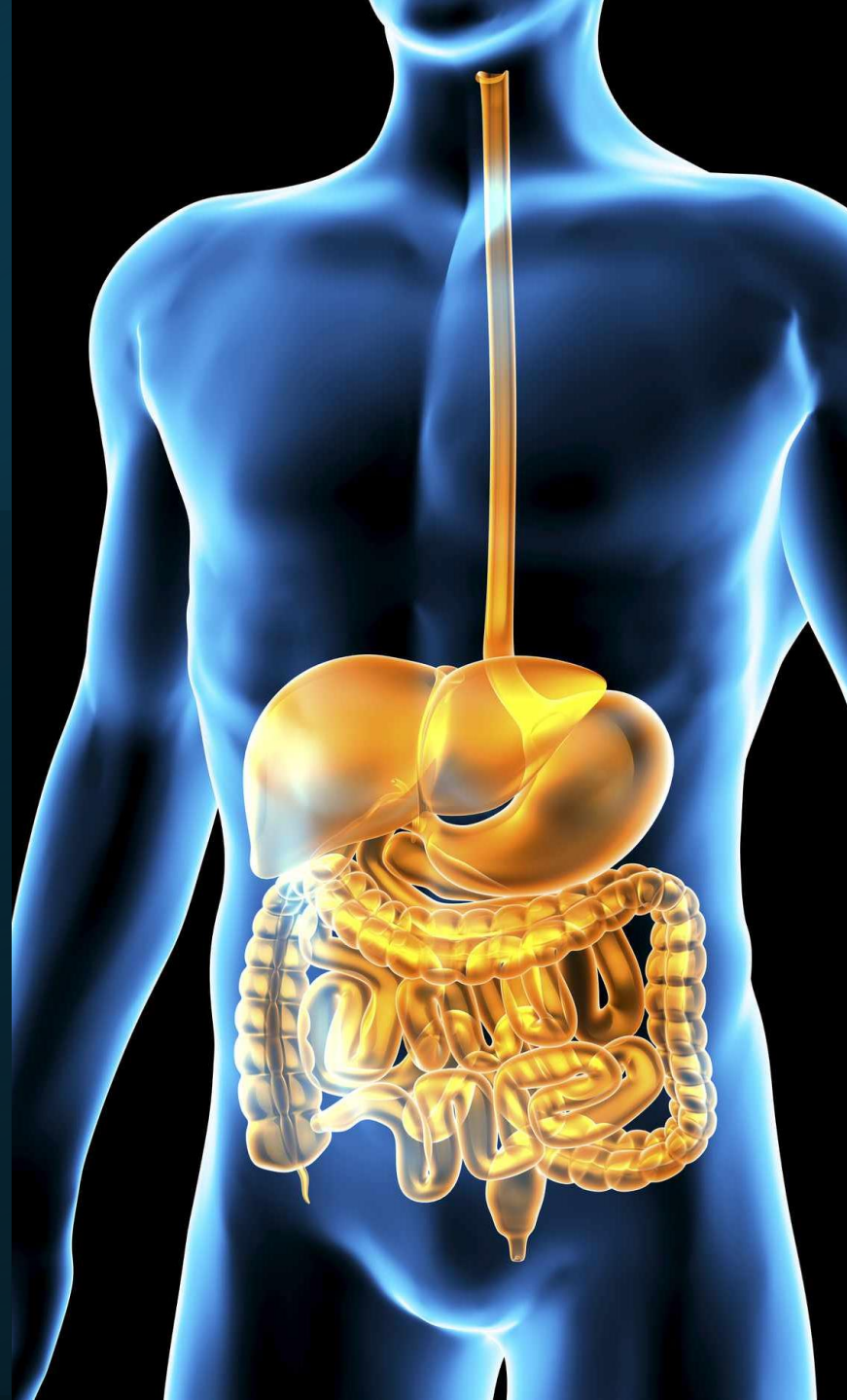
# CHAPTER 1
# DIGESTIVE SYSTEM

## ANATOMY & PHYSIOLOGY II

GHC 2013 / NMS 2012 / OHC 3013 / PTAP 1123



# Topic Outlines

- 1.1 Main Organs of Digestive System
- 1.2 Main Functions of Digestive System
- 1.3 Microscopic of Digestive System
- 1.4 Mouth
- 1.5 Pharynx
- 1.6 Esophagus
- 1.7 Stomach
- 1.8 Small Intestine
- 1.9 Large Intestine
- 1.10 Pancreas
- 1.11 Liver
- 1.12 Gallbladder
- 1.13 Phases of Digestion

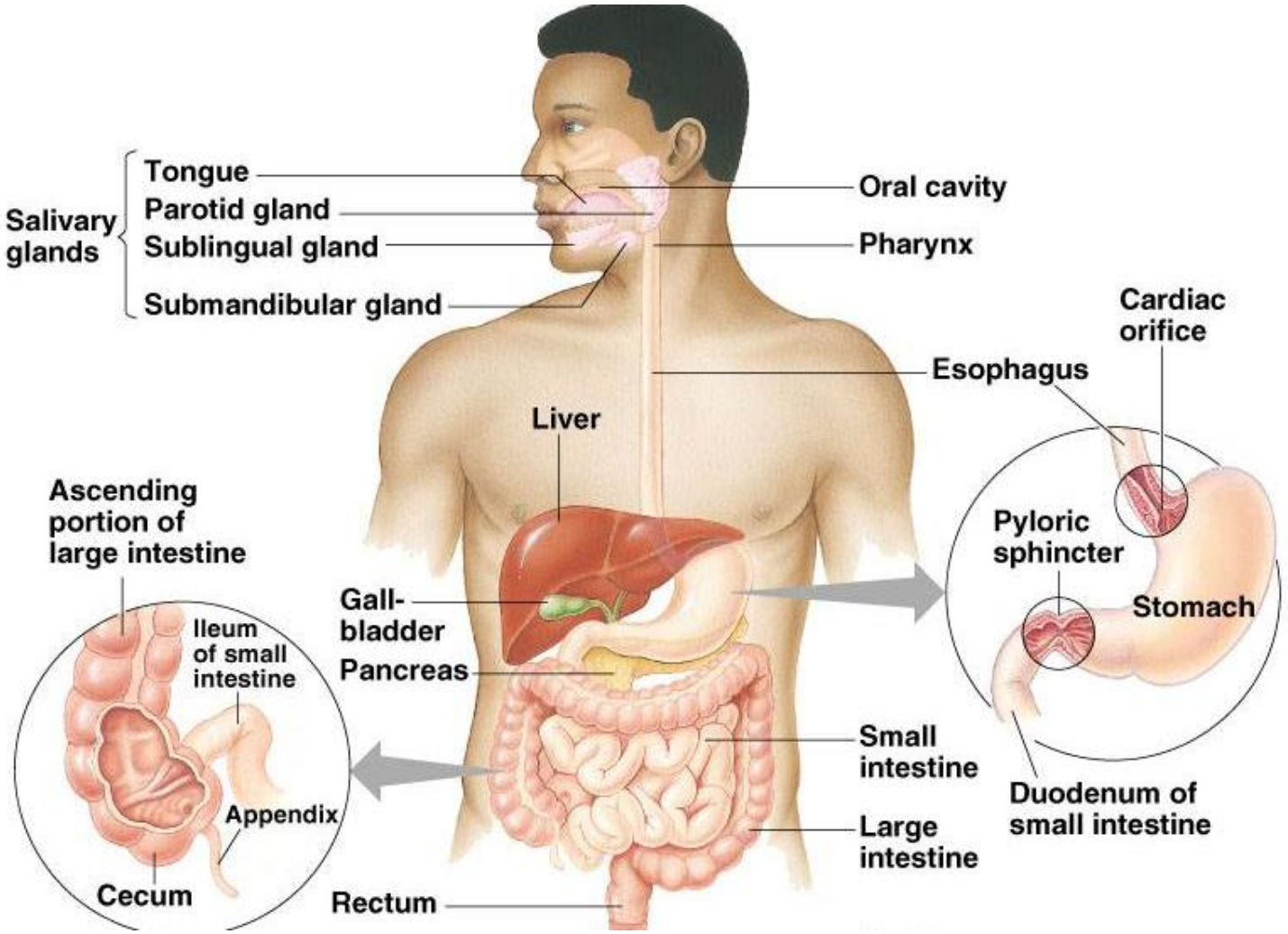
# Learning Outcomes

At the end of this chapter, students should be able to:

- ❑ Describe the main organs and functions of digestive system
- ❑ Explain the basic physiological process of digestive system
- ❑ Identify the enzymes and chemical activities involved in the system

# 1.1 Main Organs of Digestive System

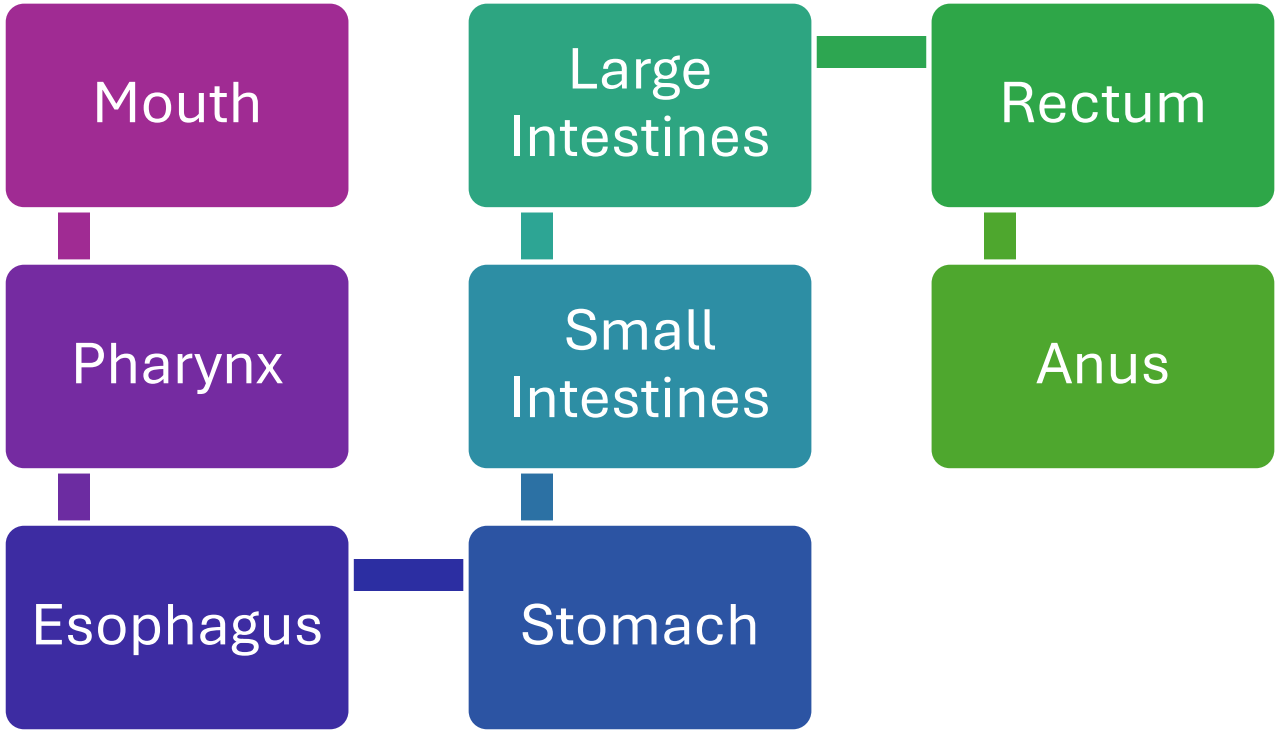
- Mouth
- Pharynx
- Esophagus
- Stomach
- Small intestine
- Large intestine
- Rectum & anal canal

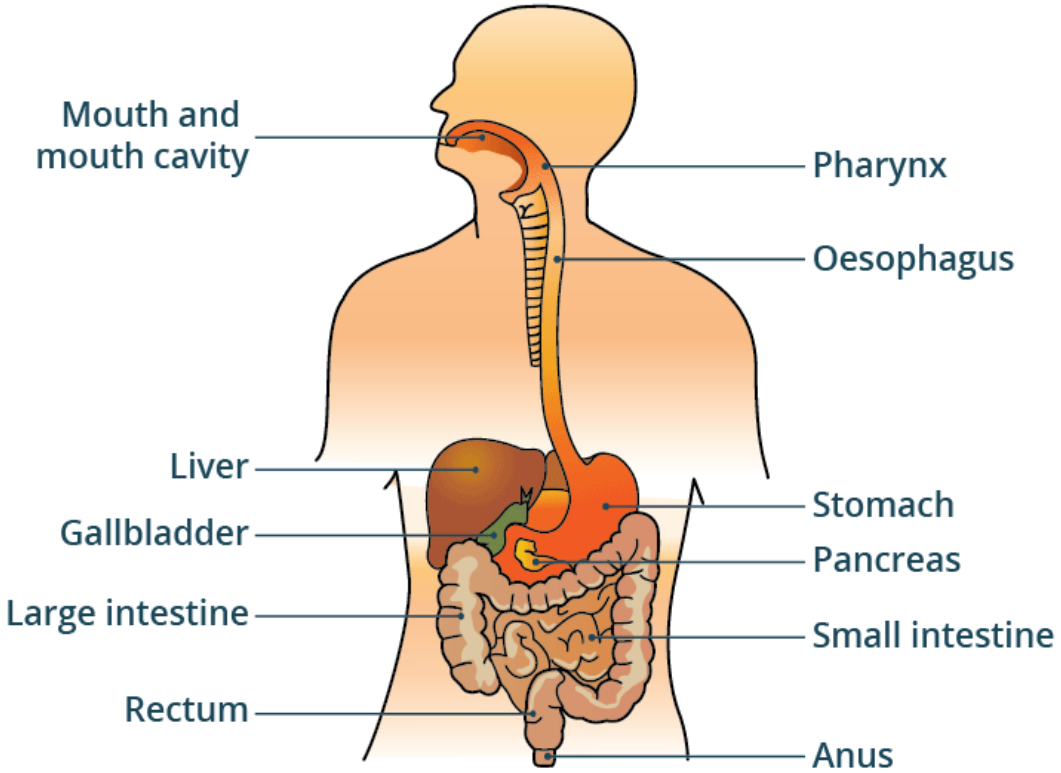


# 1.1.1 Pathway of Digestive System

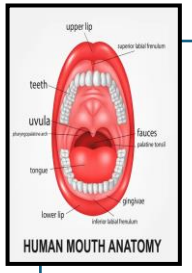
Gastrointestinal Tract (GIT)

- Continuous tube that begin at mouth & finish at anus

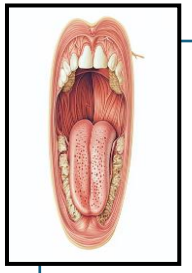


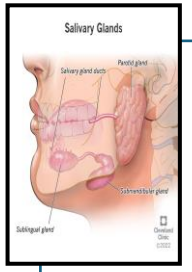
# 1.1.2 Accessory Organs of Digestive System



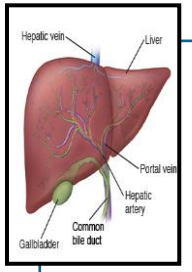

Teeth



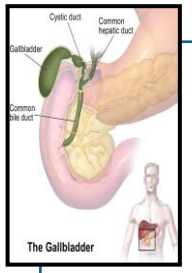
Tongue



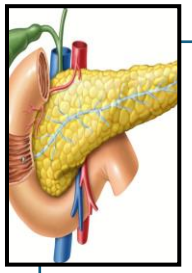

Salivary Glands




Liver




Gallbladder

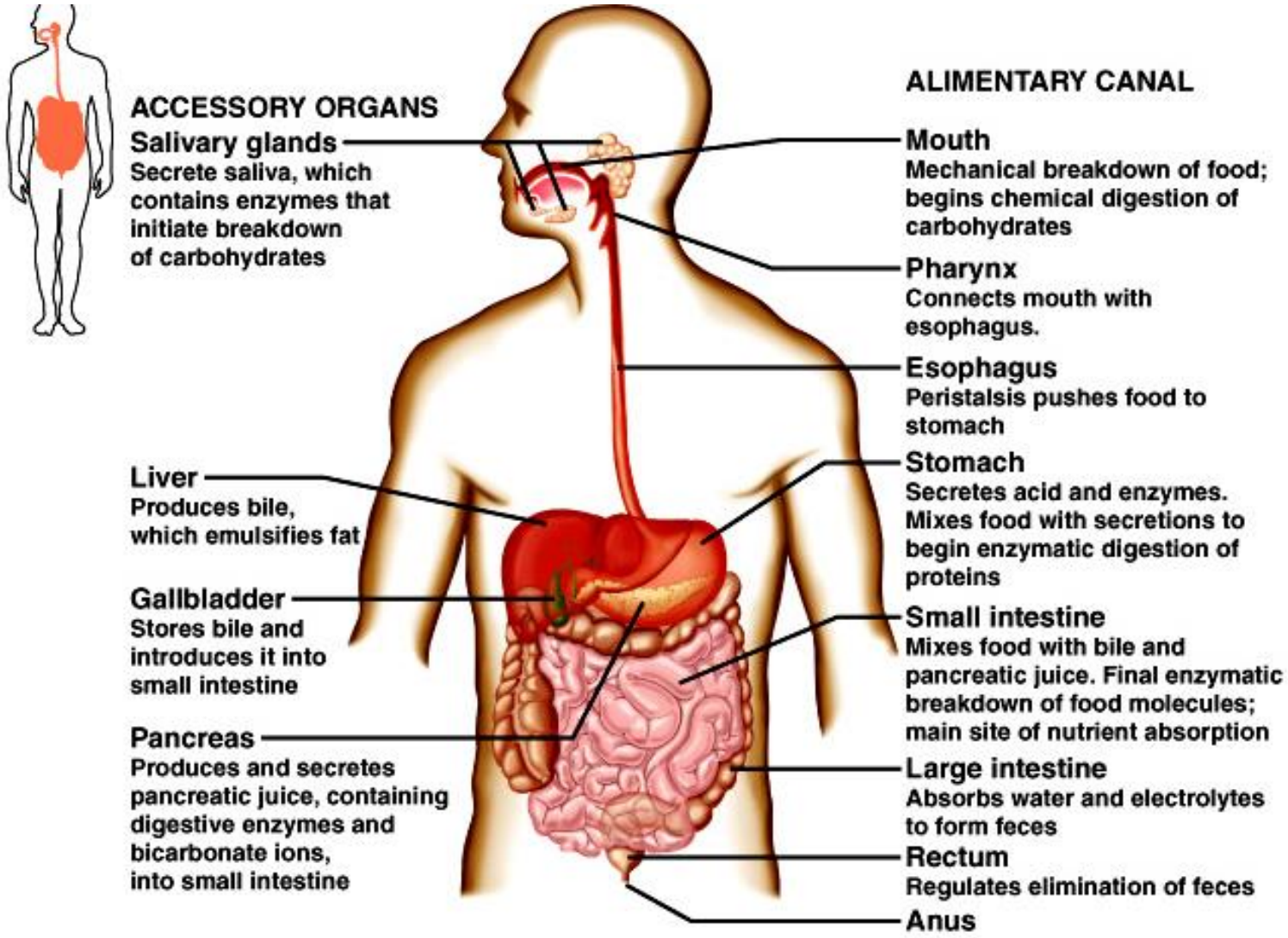


Pancreas

# 1.2 Main Functions of Digestive System

| INGESTION | SECRETION | PROPULSION | DIGESTION | ABSORPTION | DEFECATION |
|---|---|---|---|---|---|
| • taking foods or liquids into mouth *(eating)* | • release of water, enzymes, acids into the lumen of GIT<br>• example : *amilase enzyme secrete by mouth, hydrocloric acid secrete by gaster* | • contraction of GIT propel bolus toward anus<br>• motility by process of **peristalsis** | • process to break down foods into smaller molecules<br>• mechanical digestion = break down of food by mastication (chewing)<br>• chemical digestion = break down of food by enzymes actions<br>• example : *protein → acid amino, carbohydrate → glucose* | • digested smaller molecules *(nutrients)* pass through blood circulation or lymphatic system & carry to all body cells | • elimination of feces from GIT<br>• feces contains wasted, indigestible substances, bacteria |

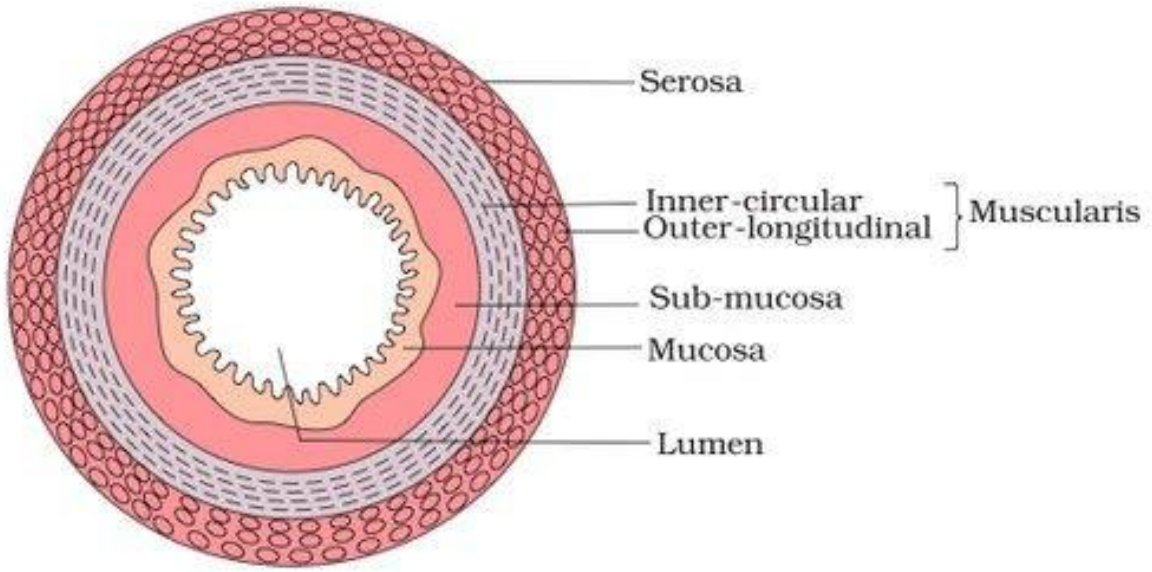
# 1.2 Main Functions of Digestive System



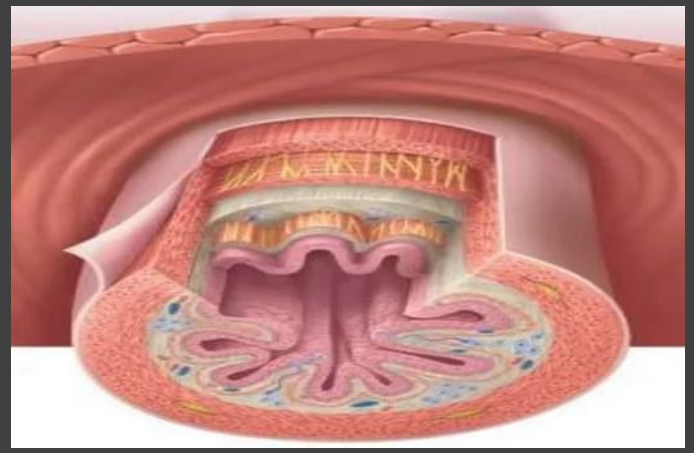

- Motility
- Secretion
- Digestion
- Absorption
- Elimination of waste

# 1.3 Microscopic of Digestive System

- The wall of digestive tract from esophagus to anus are consist of **FOUR (4)** layers:
  - Mucosa (*inner*)
  - Submucosa
  - Muscularis *(Smooth muscle*)
  - Serosa (*outer*)



# 1.3 Microscopic of Digestive System



**1) MUCOSA**

- Contact with lumen of GIT
- Have another 3 layers :

a) **epithelium** (deepest)

- *protection, secretion, absorption*

b) **lamina propria**

- *loose connective tissue*
- *provides structural support for lymphatics (protection) and vasculature*

c) **muscularis muscle**

- *mucus lubricates the wall and protects them from digestive enzymes*

**2) SUBMUCOSA**

- Contains of loose connective tissue & elastic fibres
- Highly vascular *(contain blood vessels, nerves, lymph vessels & lymphoid tissue)*
- Provides connective tissue support and delivers blood vessels, nerves & lymphatics
- Small intestine's part has many **glands** that produce mucus to protect organ from highly acidic material it receives from the stomach

# 1.3 Microscopic of Digestive System

**3) MUSCULARIS**

- Mouth, pharynx & superior part of esophagus contains skeletal muscle to control voluntary swallowing
- Lower esophagus → large intestine contain smooth muscles *(involuntary swallowing)*

➢ *muscular contraction =* ***Peristalsis***

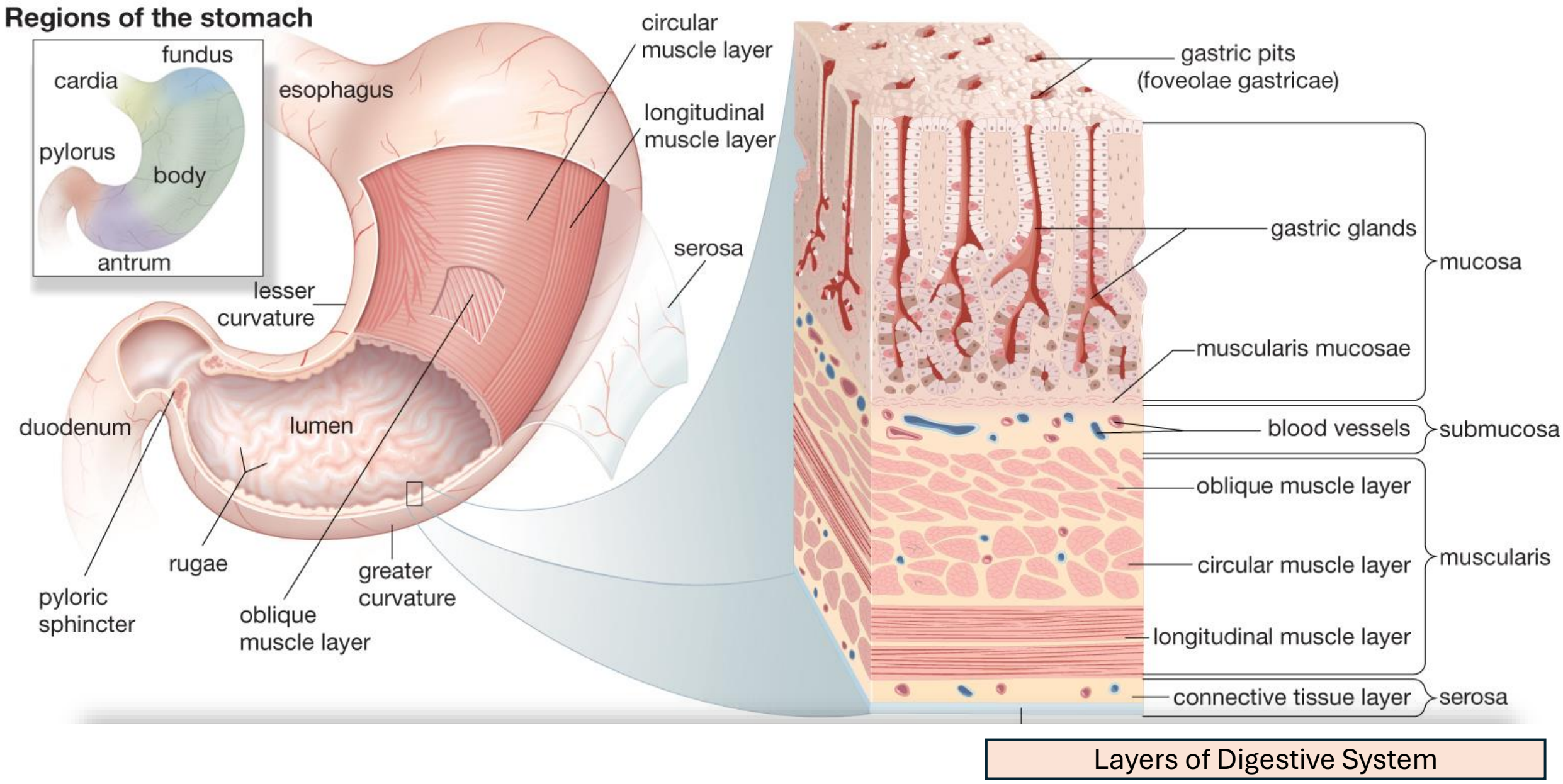
**4) SEROSA**

- The superficial layer
- Contains connective tissue & epithelium
- Part of peritoneum:

➢ *closed sac within the abdominal cavity, with a small amount of serous fluid*

➢ *provides a physical barrier to local spread of infection*

➢ *2 layers: Parietal layer & Visceral layer*




Layers of Digestive System

# 1.3 Microscopic of Digestive System

# 1.4 Mouth

- Also known as **oral cavity** or **buccal cavity**
- Formed by lips, cheeks, hard palates, soft palates & tongue
- Other structures: → uvula

  → labial frenulum
- Main function: **Mastication (chewing)**

→ *Receives food and breaks them into small portion with the help of teeth and digestive enzyme called salivary amylase*

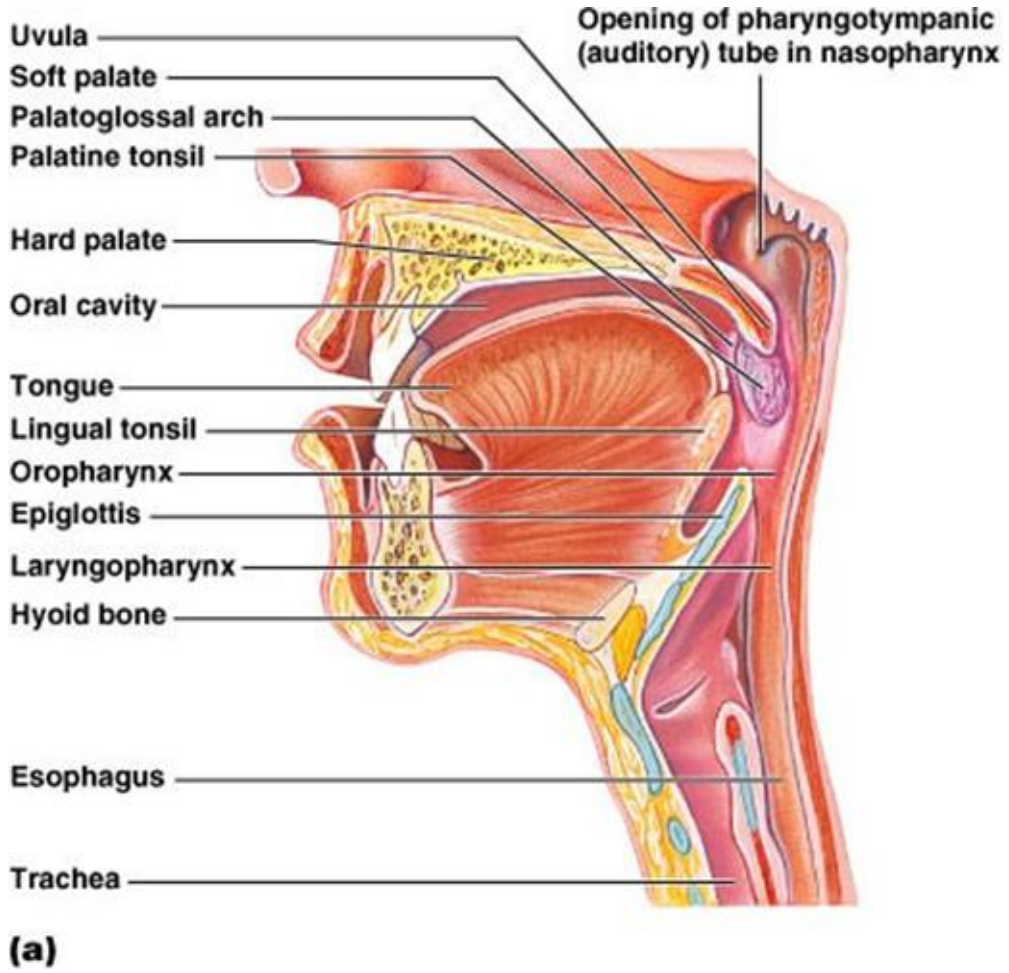
- Muscles involve in mastication:

  → masseter

  → temporalis

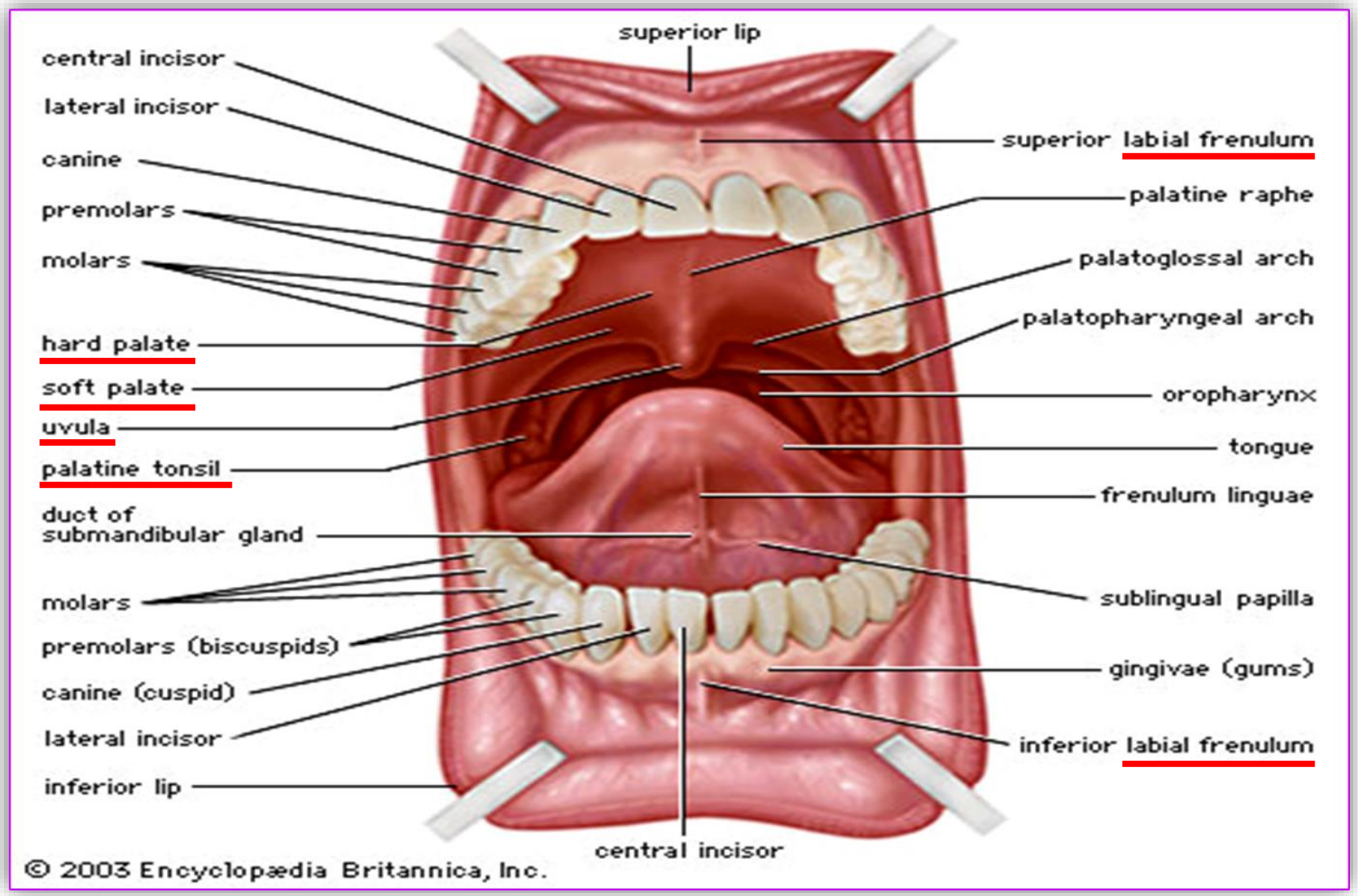
  → medial pterygoid

  → lateral pterygoid




Anatomy of Oral Cavity

# 1.4 Mouth

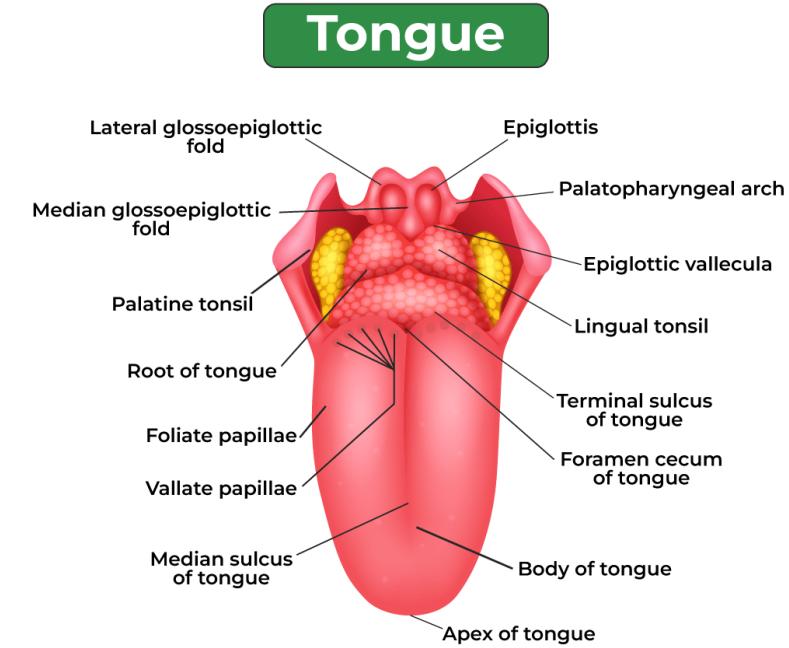


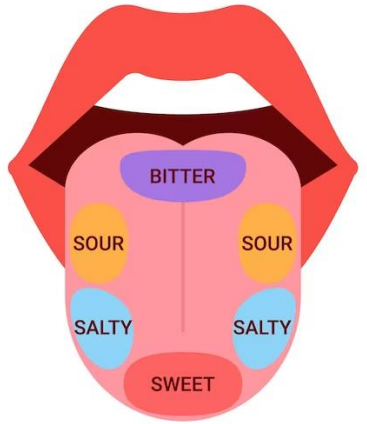

Anatomy of Oral Cavity

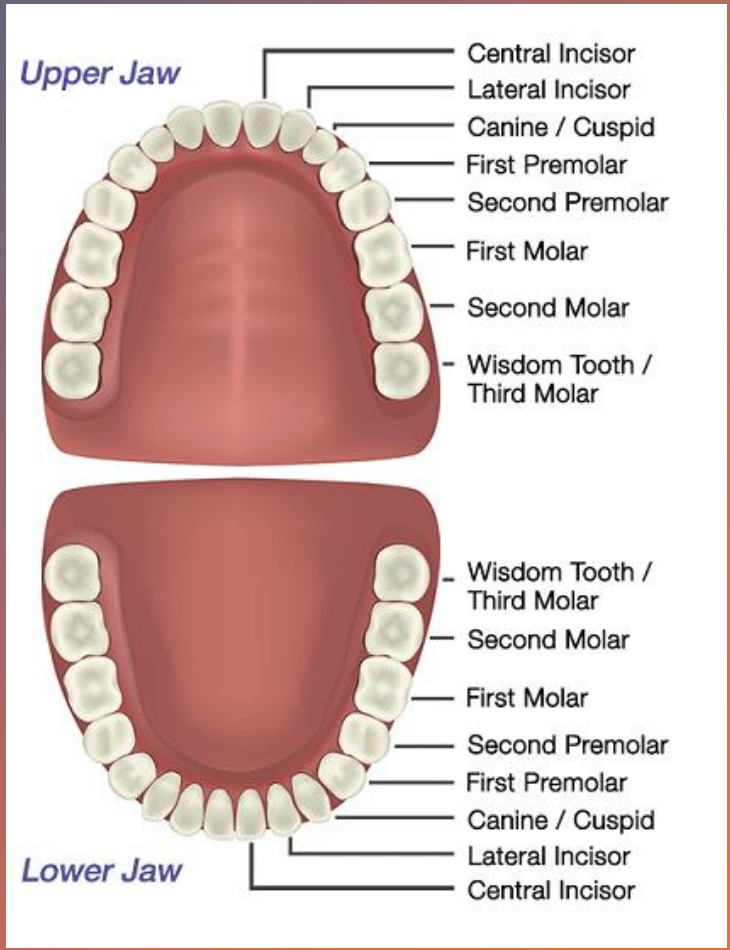
# 1.4.1 Tongue

- A muscular organ.
- Aid in **chewing and swallowing**.
- Principal organs of speech.
- Sensory receptors on its surface:-

➢ ***Taste buds (bitter, sweet, sour & salty)***




# 1.4.2 Teeth

- Adult = 32 tooth *(permanent dentition)*
- Child *(2 – 6 years old)* = 20 tooth *(deciduous dentition)*
- Main function: **Mechanical digestion (chewing)**
- Types of teeth :

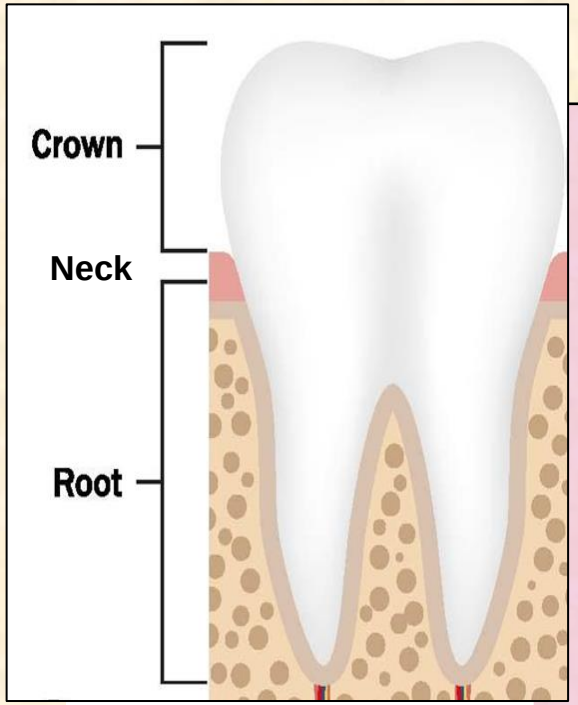
a) Molar = *grinding & chewing*

b) Pre-molar = *grinding & chewing*

c) Canine = *cutting & biting*

d) Incisor = *cutting & biting*

# 1.4.2.1 Structure of a Tooth




## Main structures:

- **Crown** = protrudes from gum
- **Root** = embedded in bone
- **Neck** = narrow region where crown merges with root

# 1.4.2.2 Cross Section of a Tooth

**Pulp cavity**

- Centre of tooth
- Contain blood vessels, lymph vessels and nerves

**Dentine**

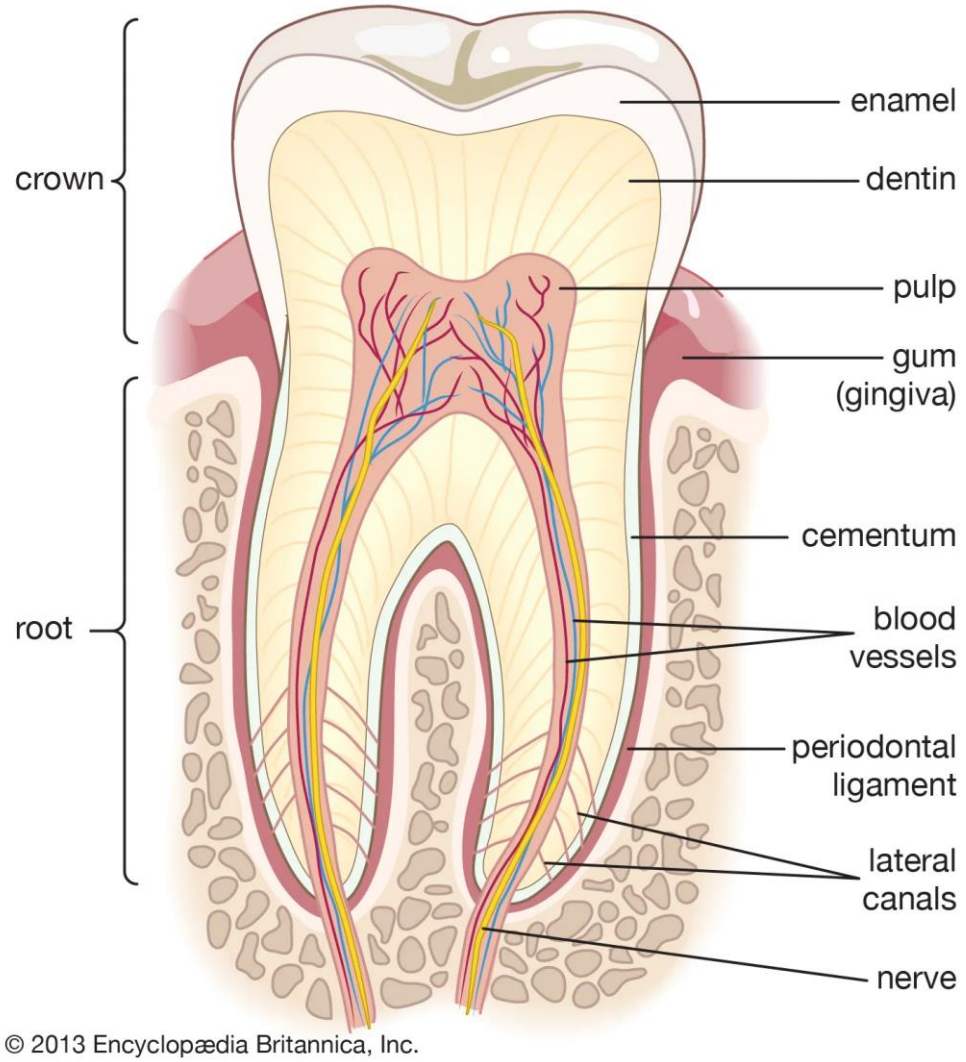
- Surrounding the pulp

**Enamel**

- Outside dentine
- Hardest substance in the body

**Cement**

- Substance-like bone that cover root of teeth



# 1.4.3 Salivary Glands

- Salivary glands secrete the **saliva** to oral cavity *(1.5L produced daily)*
- Composition of saliva:

→ *Water, mineral salts, salivary amylase (enzyme), mucus, lysozyme, immunoglobulins, blood-clotting factors*

- Function of saliva:

→ softens, moistens & dissolve food

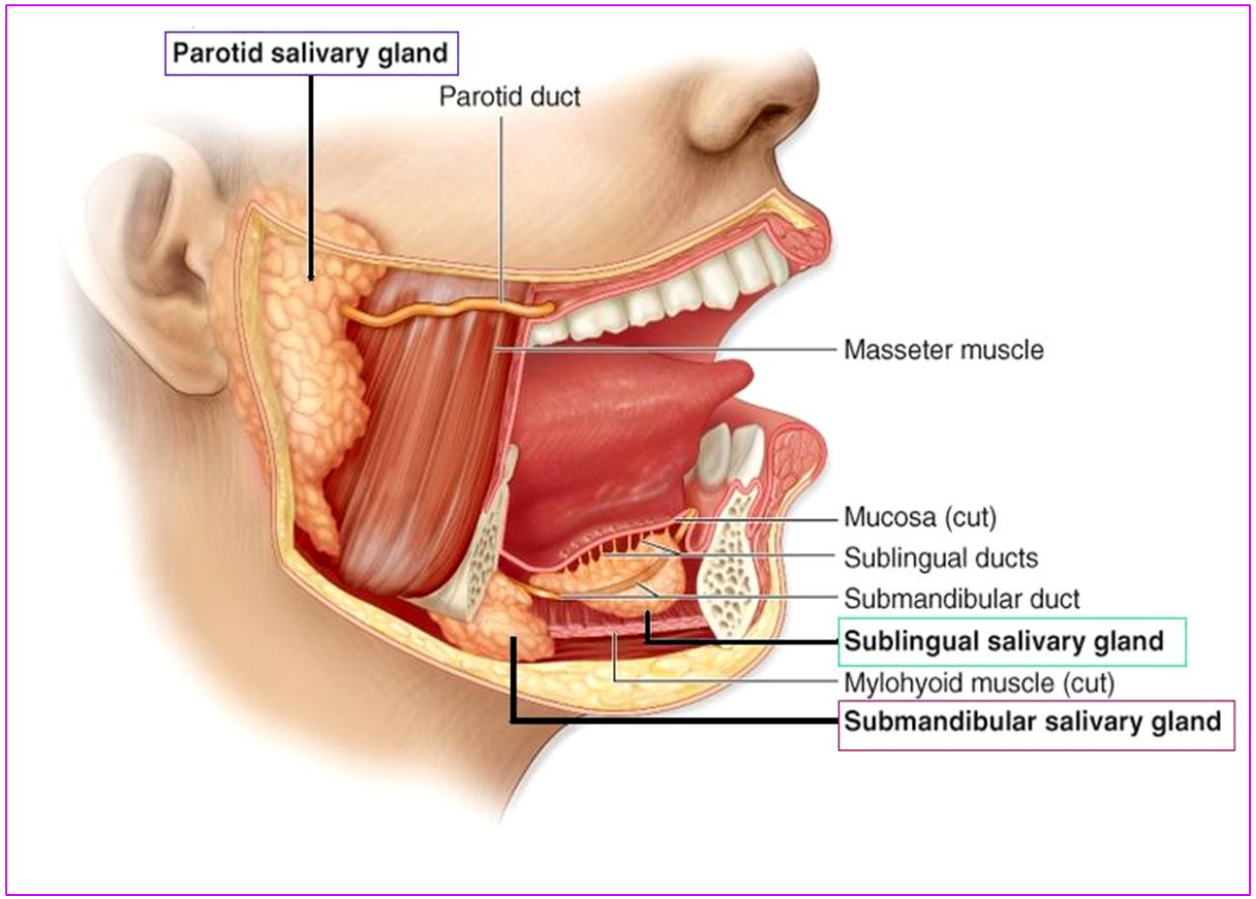
→ contain **salivary amylase enzymes** that **digest starch (carbohydrate) into smaller molecules (maltose)**

→ lubricate food to make it easy to swallow

→ lysozyme helps to destroy microorganisms

→ adequate flow is necessary to clean mouth

→ taste: taste buds are stimulated by chemical substances in solution



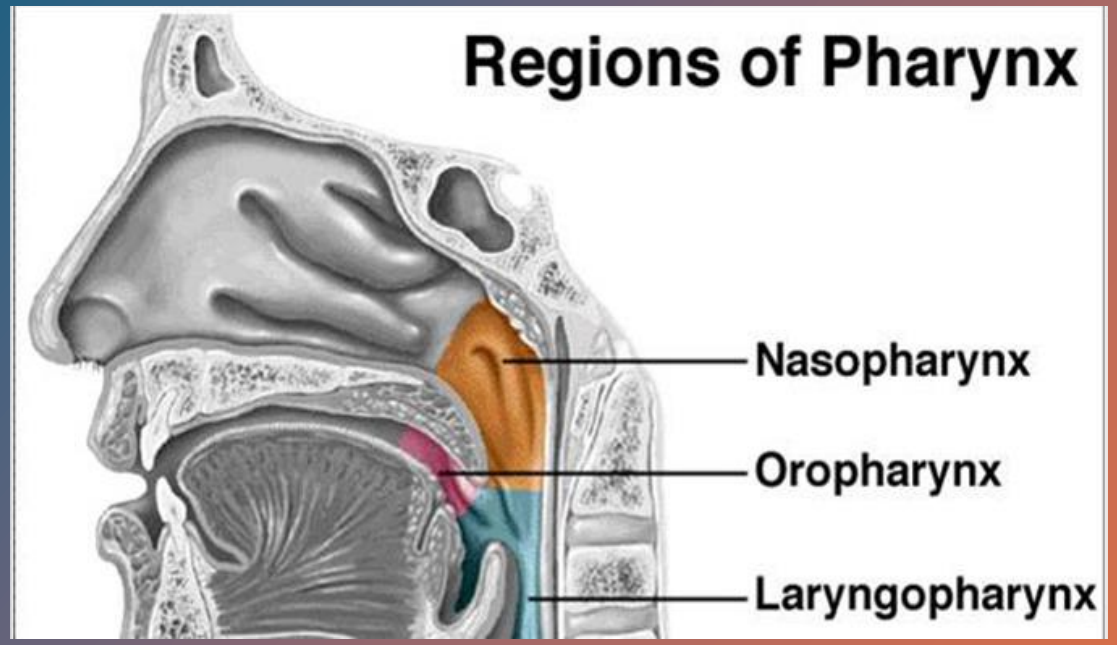

# 1.4.3 Salivary Glands

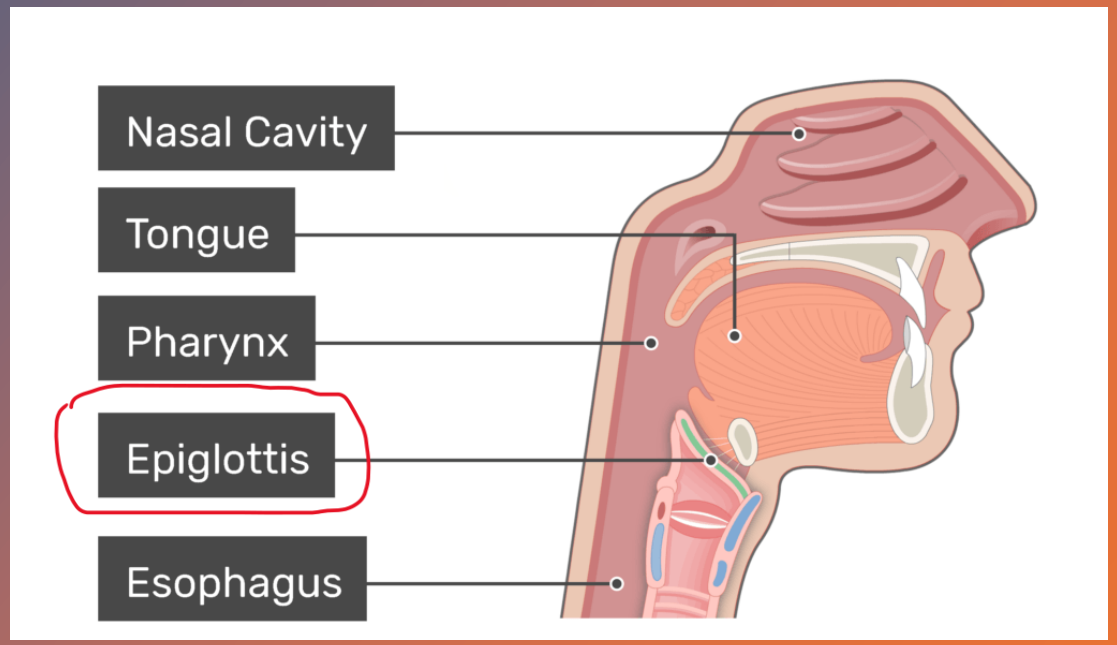
3 major salivary glands (paired):

a) Parotid glands *(locate at inferoanterior ear)*

b) Submandibular glands

c) Sublingual glands




# 1.5 Pharynx

- Divided into 3 parts: **nasopharynx, oropharynx** & **laryngopharynx**
- Oropharynx and laryngopharynx: *common passages for respiratory & digestive system*
- *Swallowing occurs rapidly by involuntary reflex action*
- Entrance of trachea is guarded during swallowing by a cartilage called **epiglottis,** which covers the opening of larynx
- Main function = Deglutition *(swallowing)*
- 3 stages of deglutition:

  [1] voluntary stage

  [2] pharyngeal stage

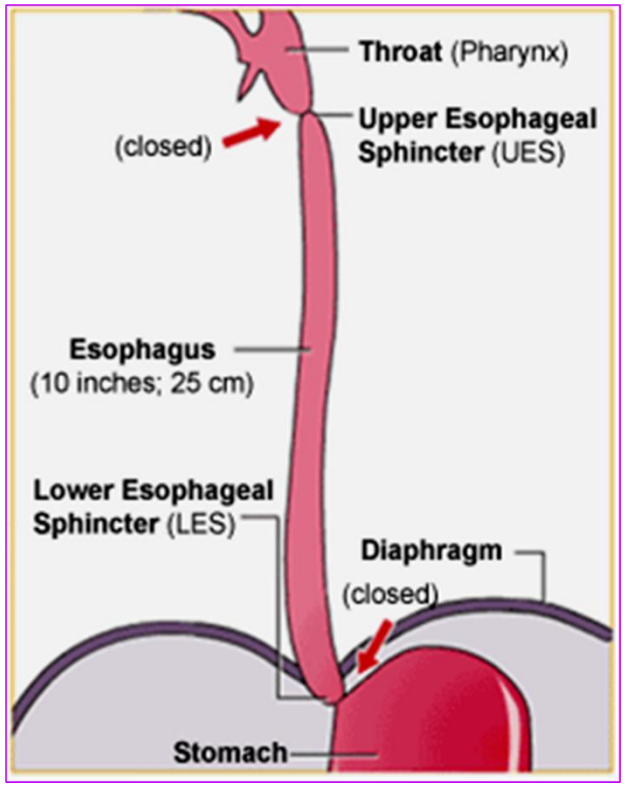
  [3] esophageal stage

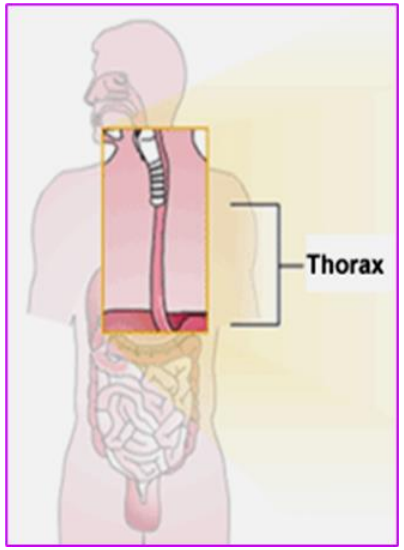
# 1.6 Esophagus

- A collapsible tubular structure (25cm long) that lie _____ to trachea
- Upper part = continue from laryngopharynx
- Lower part = continue to gaster
- Pierces the diaphragm through an opening called **esophageal hiatus**
- Circular band of muscle:

  → upper = upper esophageal sphincter *(function?)*

  → lower = cardiac sphincter *(function?)*
- It curves upwards before opening into stomach = *to prevent backflow of gastric contents*
- Functions: **secrete mucus & transport foods via peristalsis to stomach**
- **NO DIGESTION** occurs in the esophagus



# 1.7 Stomach

Also known as **GASTER**

Locate more to the left side of body (LUQ), under diaphragm

J – shape structure & dilated

Inferior part connect with duodenum, superior part?

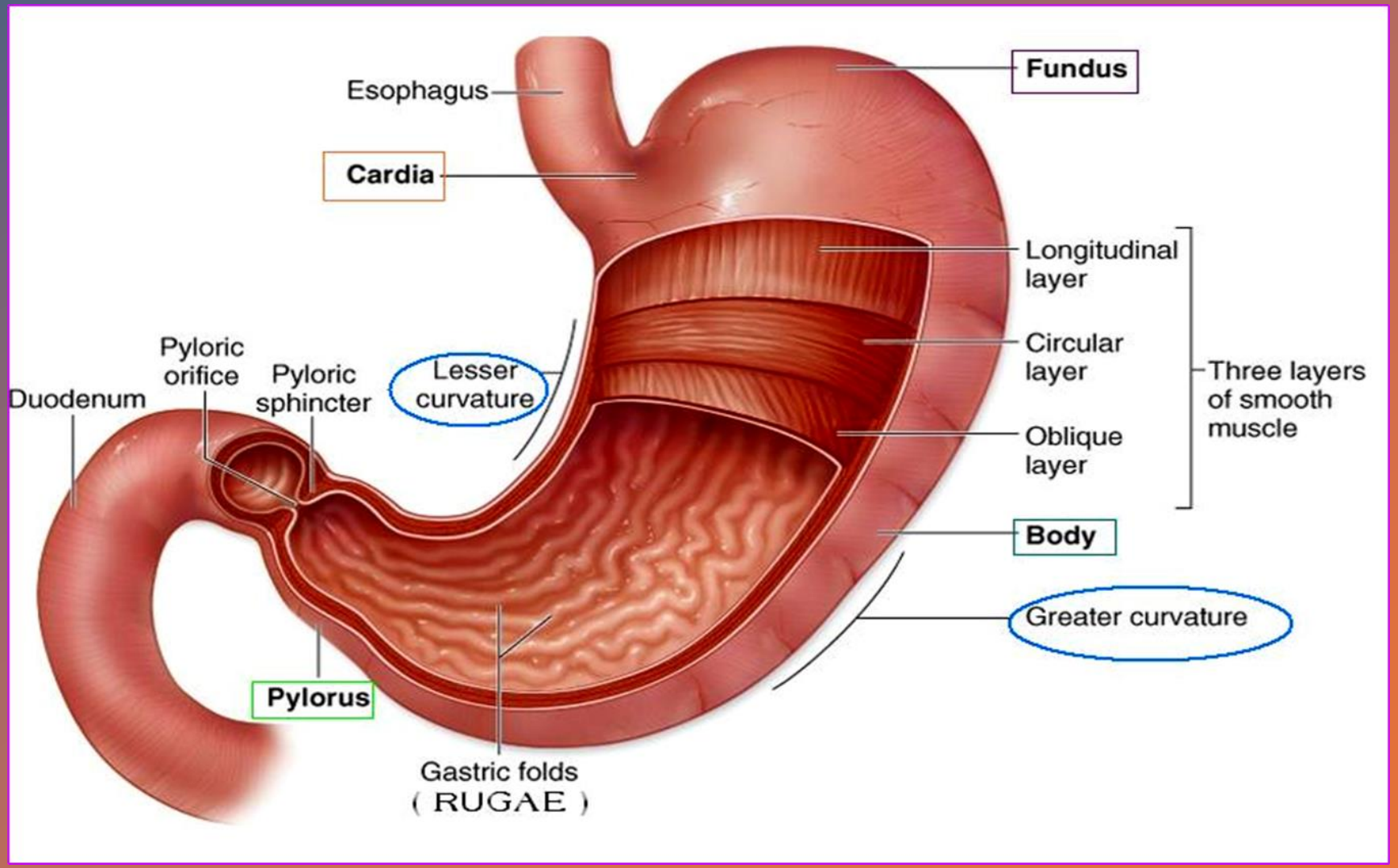
Divided into **3 regions**:

- → **Fundus** (contain air)
- → **Body**
- → **Pylorus**

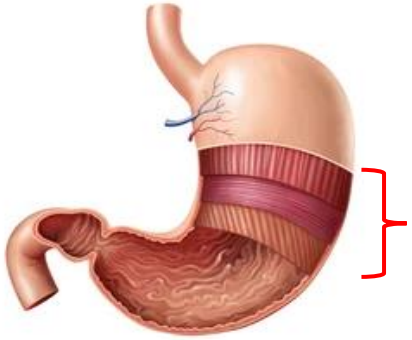
Inside the gaster mucosa = fold structure (**Rugae**)

Greater curvature?, Lesser curvature?

# 1.7 Stomach


Esophagus
Fundus
Cardia
Longitudinal layer
Circular layer
Oblique layer
Three layers of smooth muscle
Pyloric orifice
Pyloric sphincter
Duodenum
Lesser curvature
Body
Greater curvature
Pylorus
Gastric folds
( RUGAE )

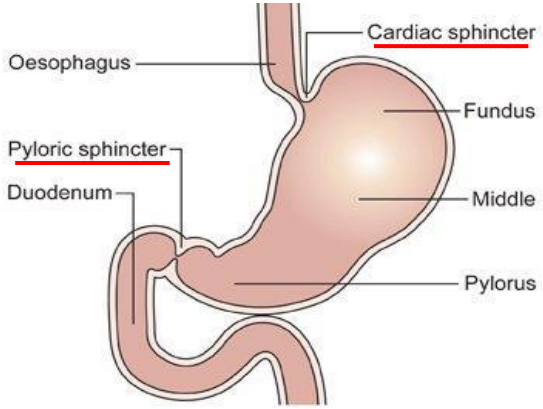
# 1.7 Stomach



## Layers

3 layers of smooth muscle: **longitudinal, circular** & **oblique**

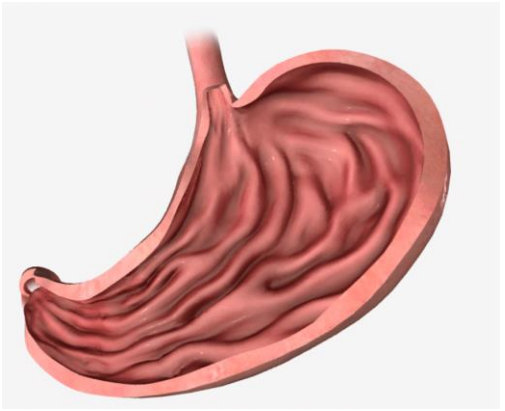
Arrangement allows for the **churning motion** and **peristalsis** movement




## Sphincter

**Cardiac sphincter** = prevents backflow of food in stomach from reentering the esophagus

**Pyloric sphincter** = governs the passage of food out of the stomach into the small intestine

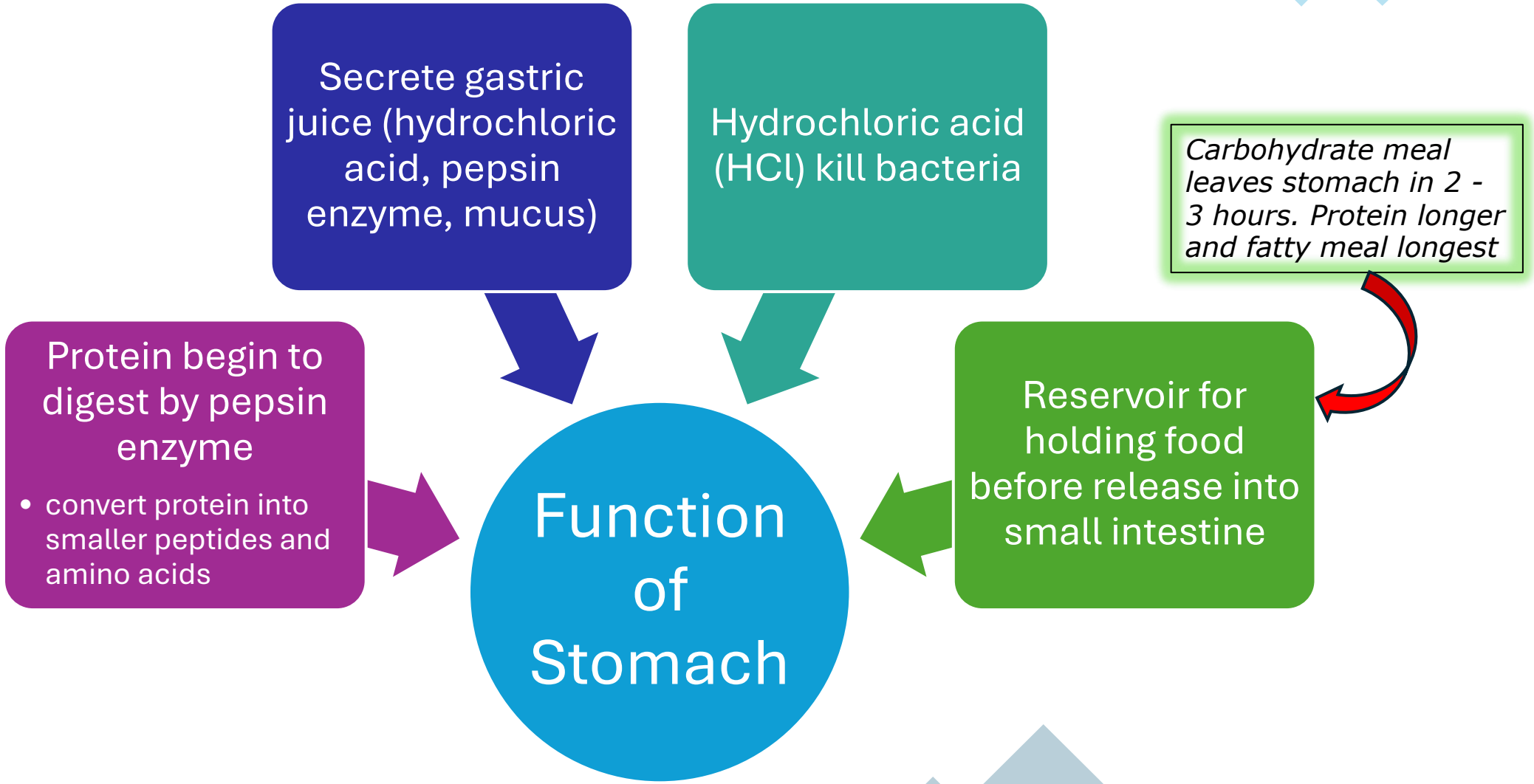


## Rugae

When stomach is empty, mucous membrane lining is thrown into longitudinal folds called **rugae.**

When stomach is full, rugae are “ironed out” and surface become smooth and velvety

# 1.7 Stomach


Secrete gastric juice (hydrochloric acid, pepsin enzyme, mucus)
Hydrochloric acid (HCl) kill bacteria
Carbohydrate meal leaves stomach in 2 - 3 hours. Protein longer and fatty meal longest
Protein begin to digest by pepsin enzyme
• convert protein into smaller peptides and amino acids
Function of Stomach
Reservoir for holding food before release into small intestine

# 1.7.1 Gastric Juice

## Composition

- Water (gastric glands)
- Mineral salts (gastric glands)
- Mucus (goblet cells)
- Hydrochloric acid (parietal cells)
- Pepsinogens (gastric chief cells) – inactive then converted to pepsin (active)
- Has a PH of 1 to 2
- Secreted daily = 2 Litres

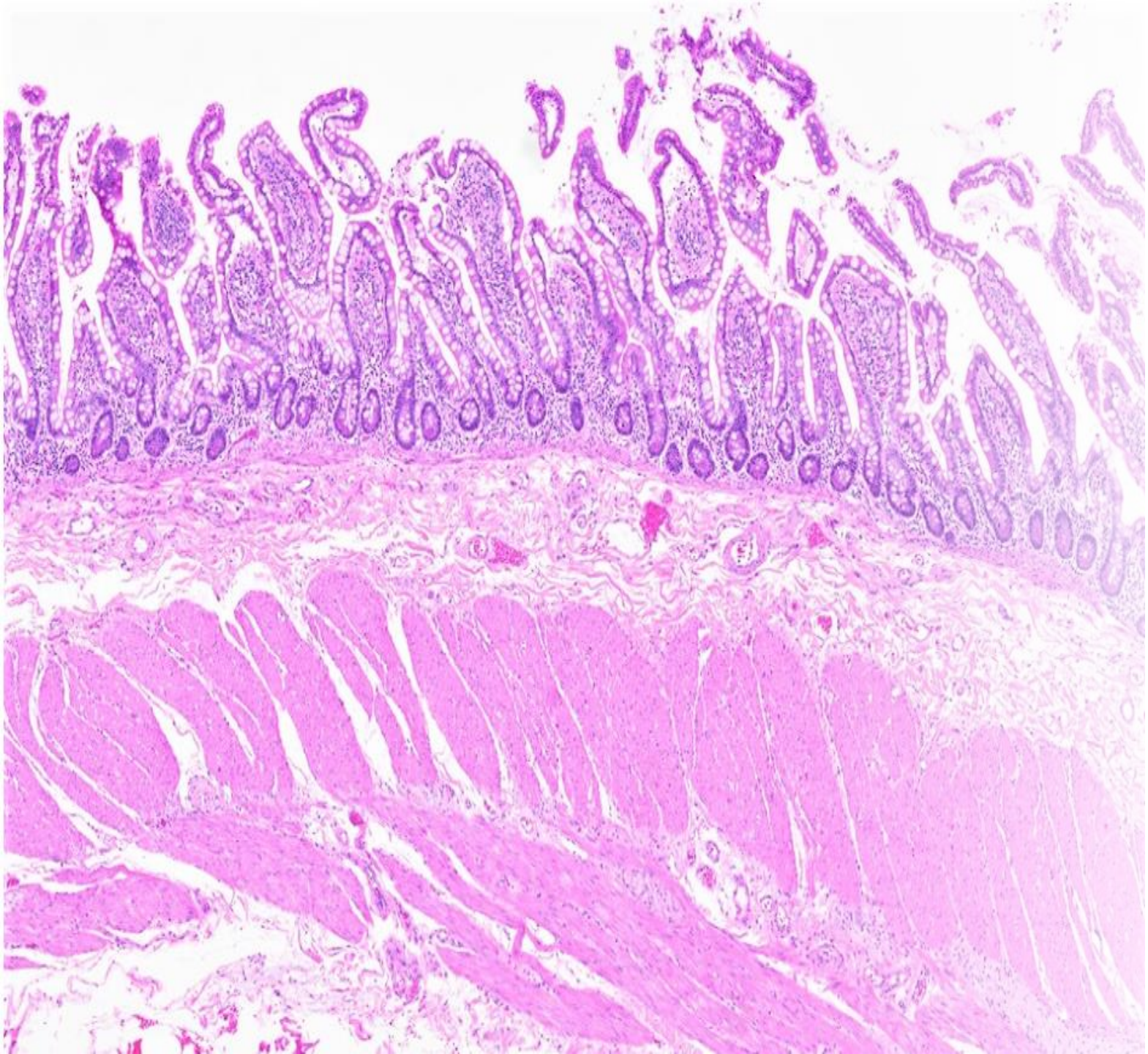
## Functions

- **Hydrochloric acid:**
  - Acidifies food and stop action of salivary amylase
  - Kills ingested microbes
  - Provides an acidic environment for effective digestion by **pepsins (convert protein into smaller peptides and amino acids)**
- Water liquefies the food swallowed
- Mucus prevent mechanical and chemical injury to stomach wall

# 1.8 Small Intestine

- 5 meter (length) and 2.5 cm (width)
- Lies in the abdominal cavity
- **Most of the digestion & absorption of foods occur in the small intestine**
- Divide into **3 regions**:
  - **Duodenum** = C-shape (*25 cm*)
  - **Jejunum** *(2 meters)*
  - **Ileum** = longest *(3 meters)*
- **Ileocecal valve** is the connection / junction between small intestine to large intestine:
  - *prevents food from travelling backward*


*# The surface area of the human small intestinal mucosa, due to enlargement caused by folds, villi and microvilli, averages 30 square meters (320 sq ft) which equal to* **the size of a tennis court**



# 1.8 Small Intestine

**Histology of small intestine**

- The mucosa layer have many villi (*singular called villus*)

- Components of a villus:

  - arteriole (*absorb nutrients*)

  - venules

  - capillary

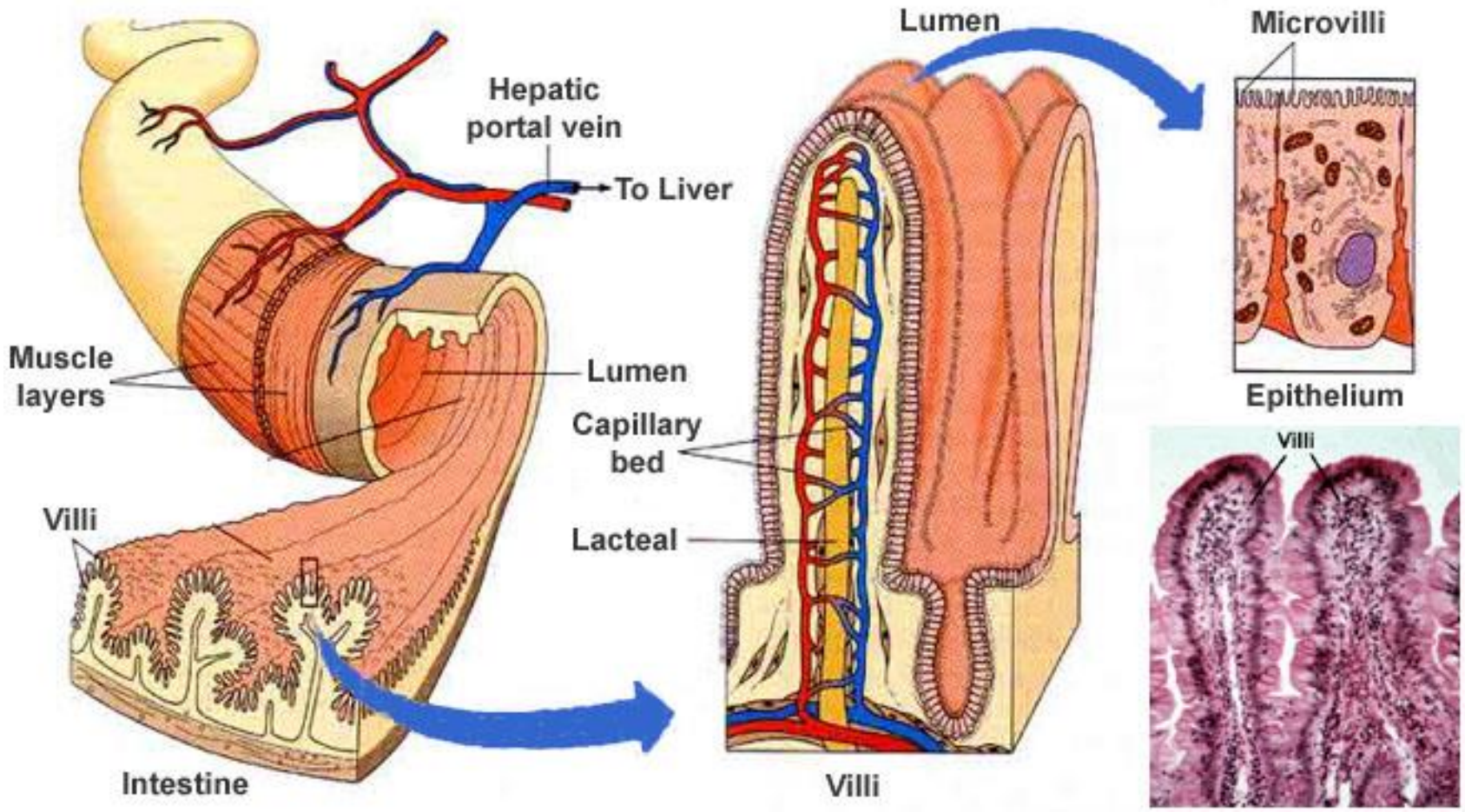
  - lacteal (*absorb fat*)

  - simple columnar epithelium (*microvilli*)

- Functions of villus:

  → **increase the surface area of digestion & absorption**

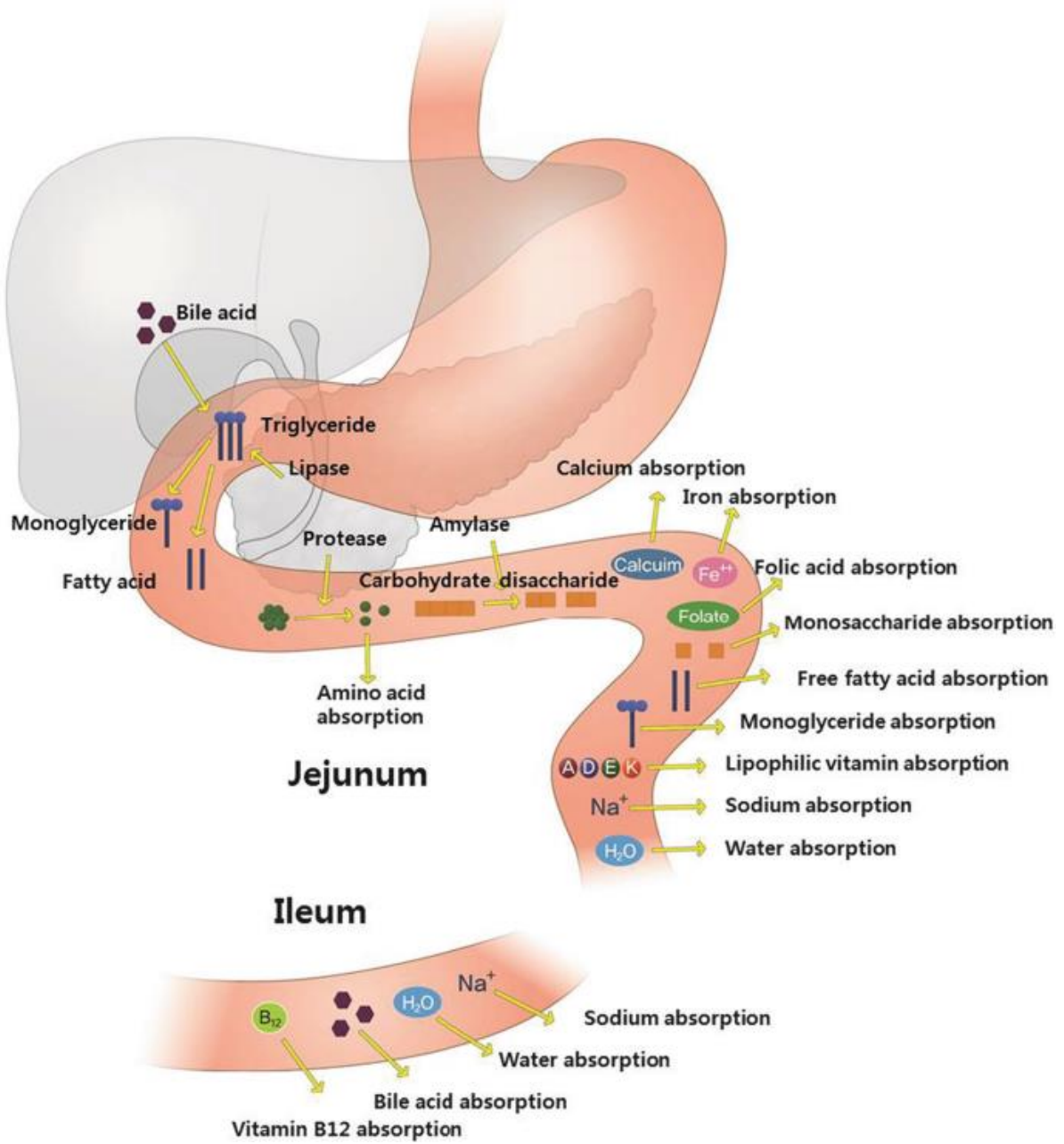
# 1.8 Small Intestine



# 1.8 Small Intestine

Main function of small intestine:

- Continue the peristalsis
- Secretion of intestinal juices
- Absorption of about 90% of all nutrient
- Completes the chemical digestion of:
  - **carbohydrate → glucose, fructose, galactose**
  - **proteins → amino acids**
  - **lipids → fatty acids & glycerol**



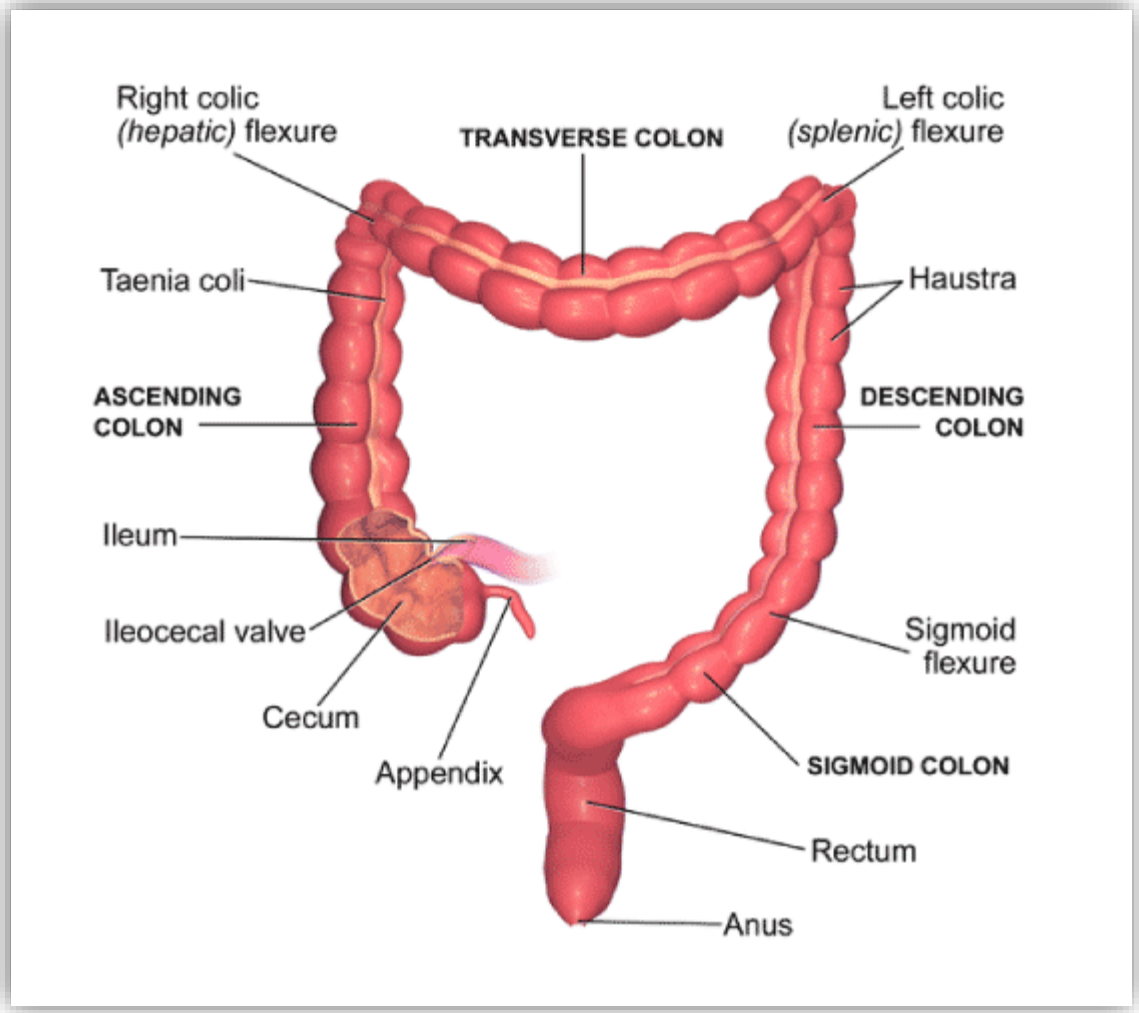
# 1.8.1 Intestinal Juices

- 1.5 liters secreted daily.
- Consists of water, mucus and mineral salts.

| Enzymes | Function |
|---|---|
| Peptidase | digest peptones and proteases into amino acids |
| Nucleases | break down nucleic acids |
| Sucrase | digest sucrose into glucose and fructose |
| Maltase | digest maltose into glucose |
| Lactase | digest lactose into glucose |

# 1.9 Large Intestine

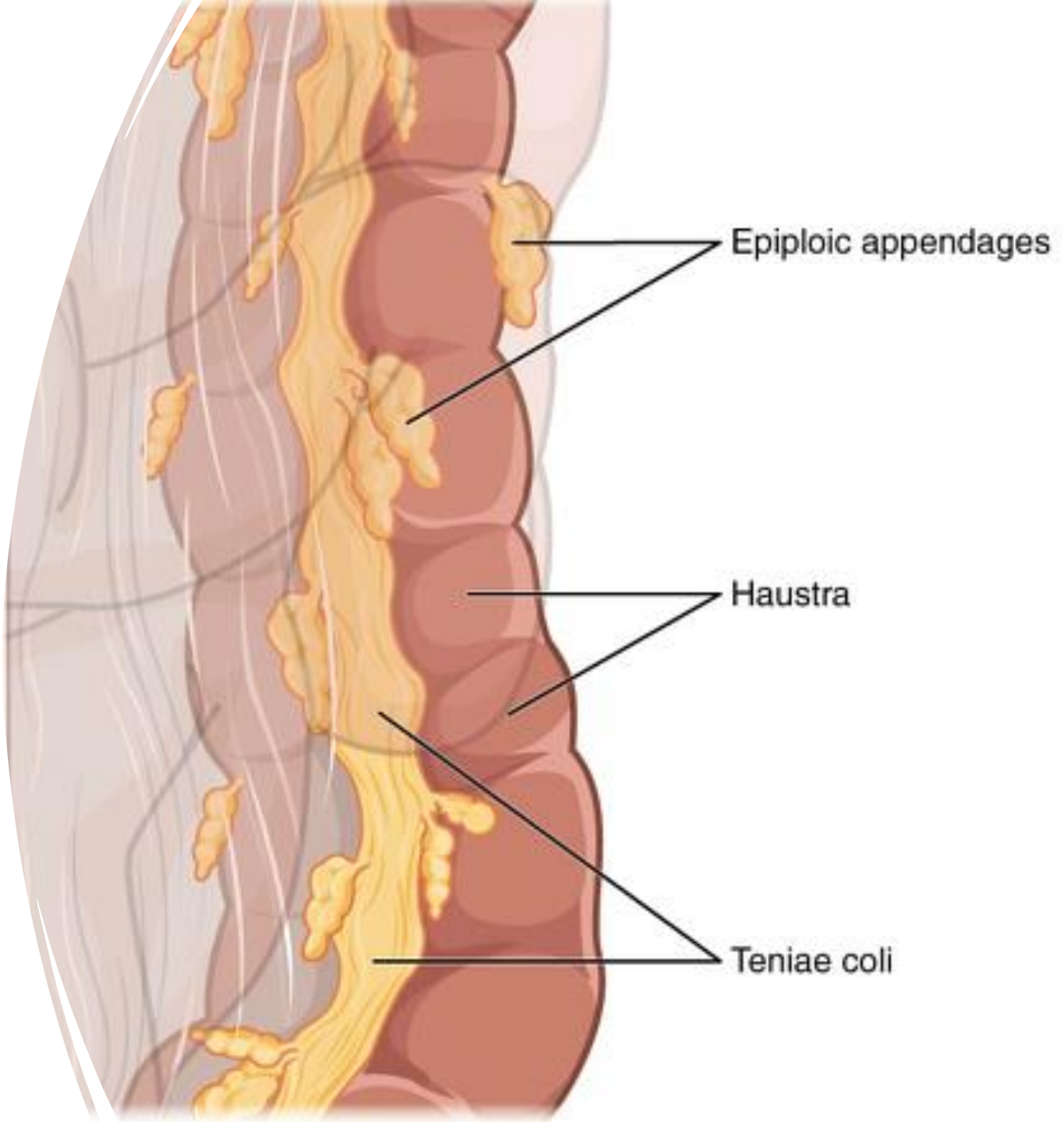
- Also known as large bowel
- 1.5 meter long and 6.5 cm in diameter
- Begins at the end of ileum and ends at the anus
- **Vermiform appendix** (*small, blind tube of lymphoid tissue)* attach at cecum
- Divided into 7 sections:
  - cecum
  - ascending colon
  - transverse colon
  - descending colon
  - sigmoid colon
  - rectum
  - anal canal



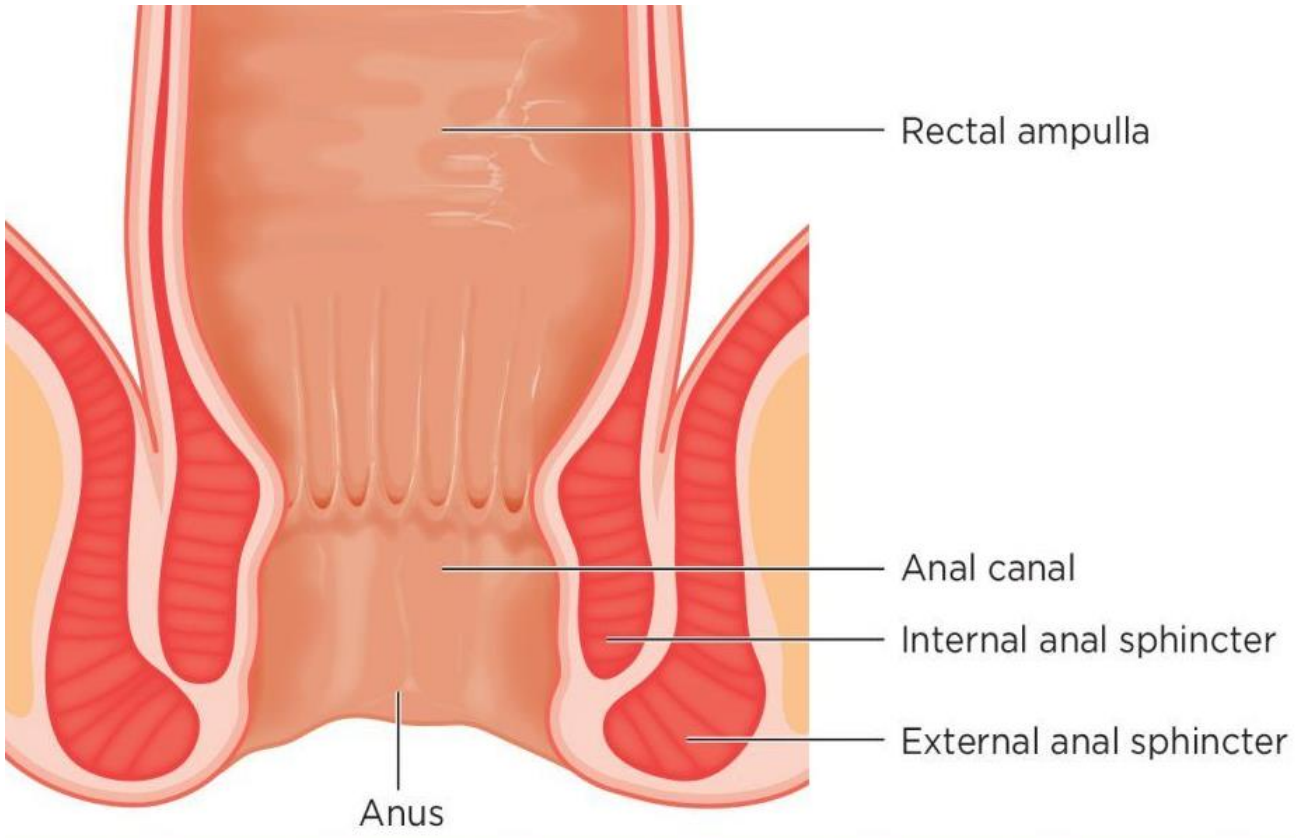
# 1.9 Large Intestine

Other components of large intestine:

- **Taenia coli** - longitudinal muscle
- **Epiploic appendages** - small pouch filled with fat
- **Haustra** - series of pouches
- **Hepatic flexure** - 1st colon junction
- **Splenic flexure** - 2nd colon junction



# 1.9 Large Intestine




The terminal 1 inch of the rectum is called the **anal canal**

The external opening is called the **anus**

Anus is guarded by an **internal sphincter (smooth, involuntary muscle)** and an **external sphincter (skeletal muscle and voluntary)**

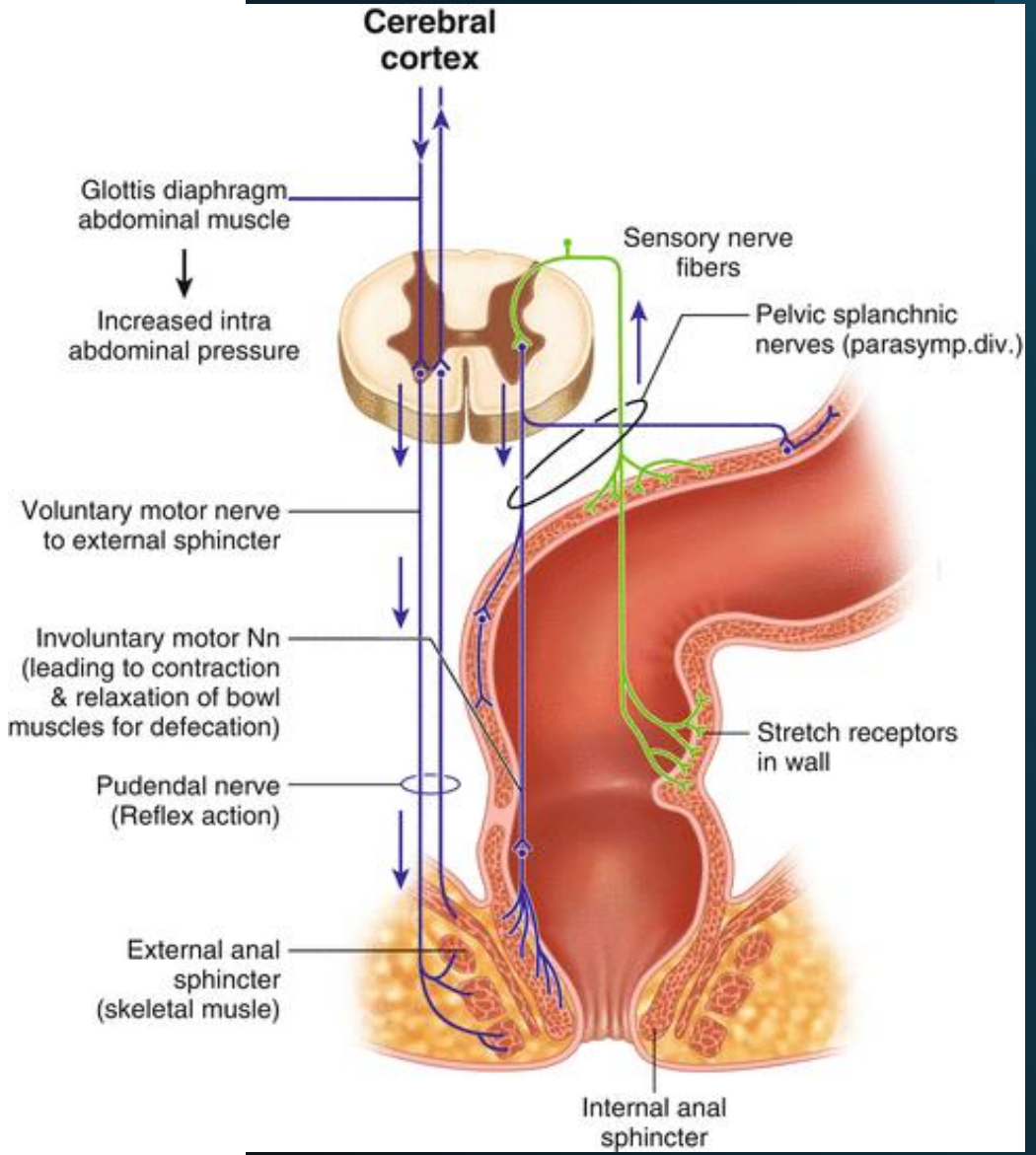
# 1.9 Large Intestine

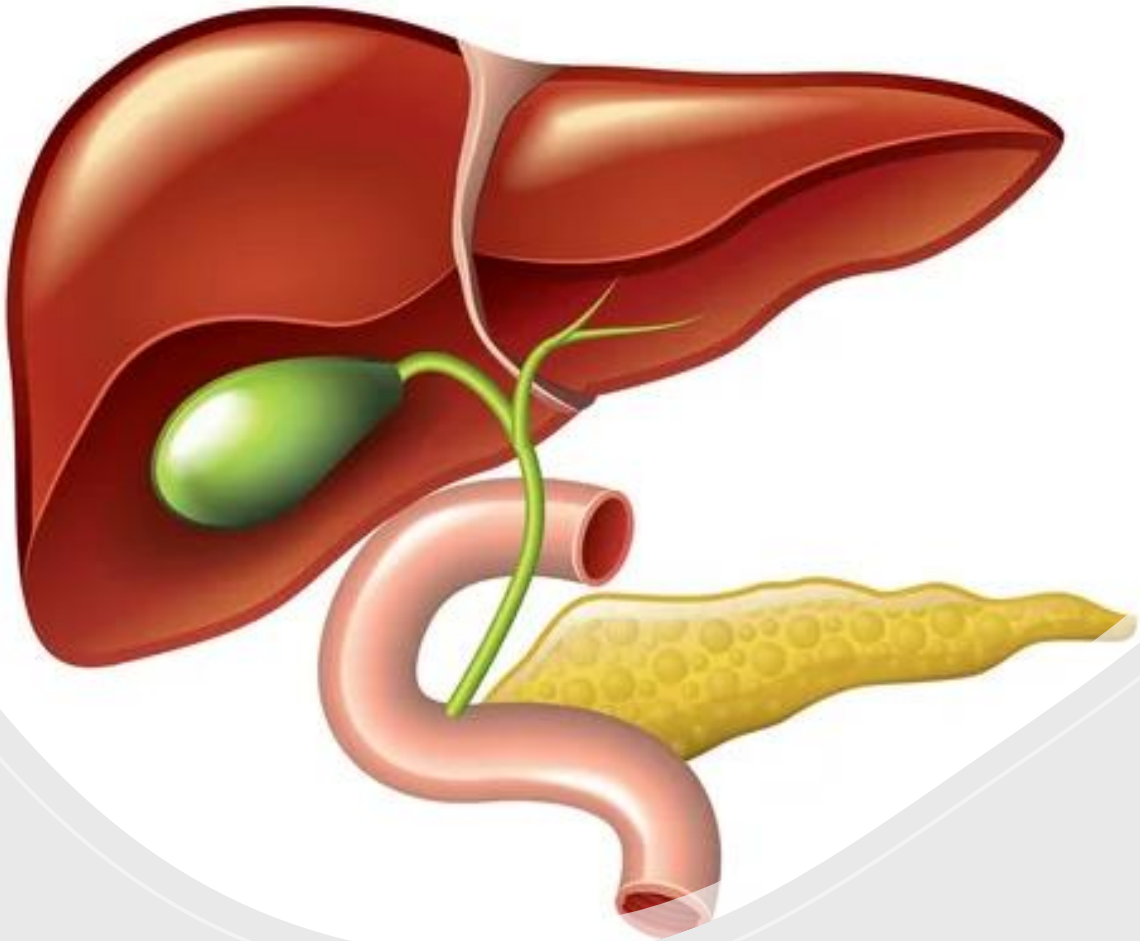
## Main functions of large intestine

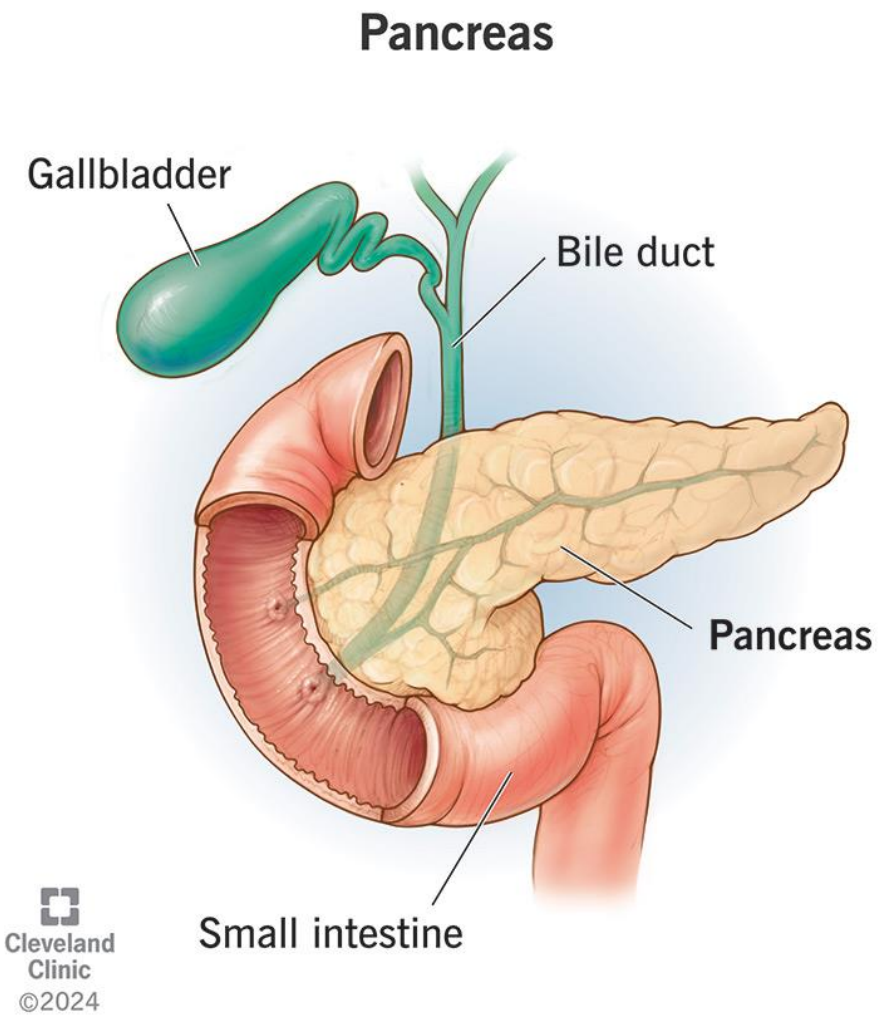
- Absorption of water, ions, mineral salts & vitamins
- Bacteria in large intestine produce some vitamin B & vitamin K
- Continue of peristalsis by haustra
- Temporary storage area for undigested non-absorbable food residue (*Sigmoid & rectum*)
- Defecation

# 1.9.1 Defecation

- The act of expelling feces from the digestive tract via the anus
- After meals, involuntary muscles within walls propel solid waste to rectum. Stretching of rectum stimulates contraction of smooth muscle. With the contractions of diaphragm and abdominal muscles, feces are eliminated
- Distension of rectal walls caused by feces:
- – *Stimulates contraction of the rectal walls*
- – *Relaxes the internal anal sphincter*
- Voluntary signals stimulate relaxation of the external anal sphincter and defecation occurs



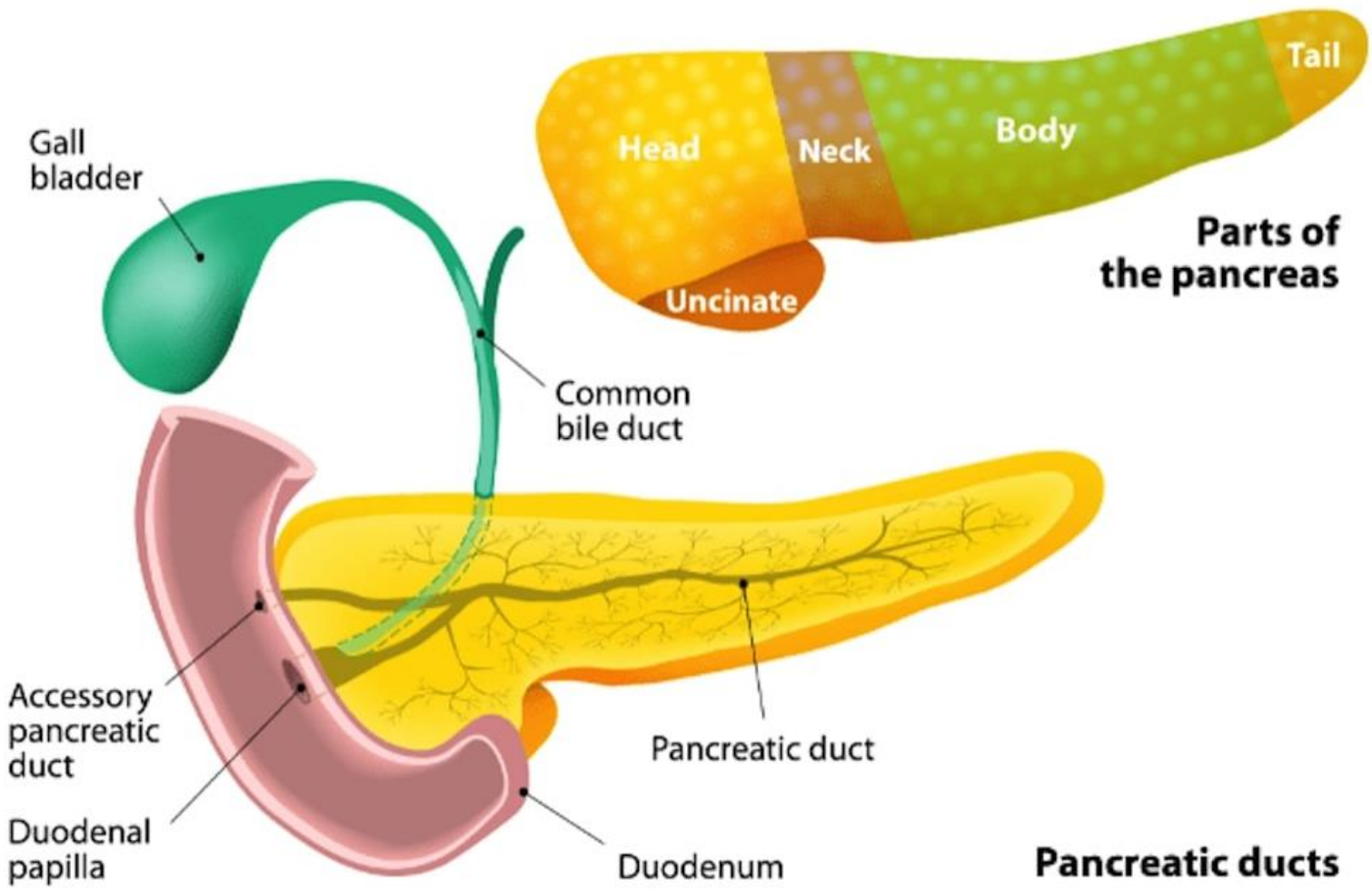




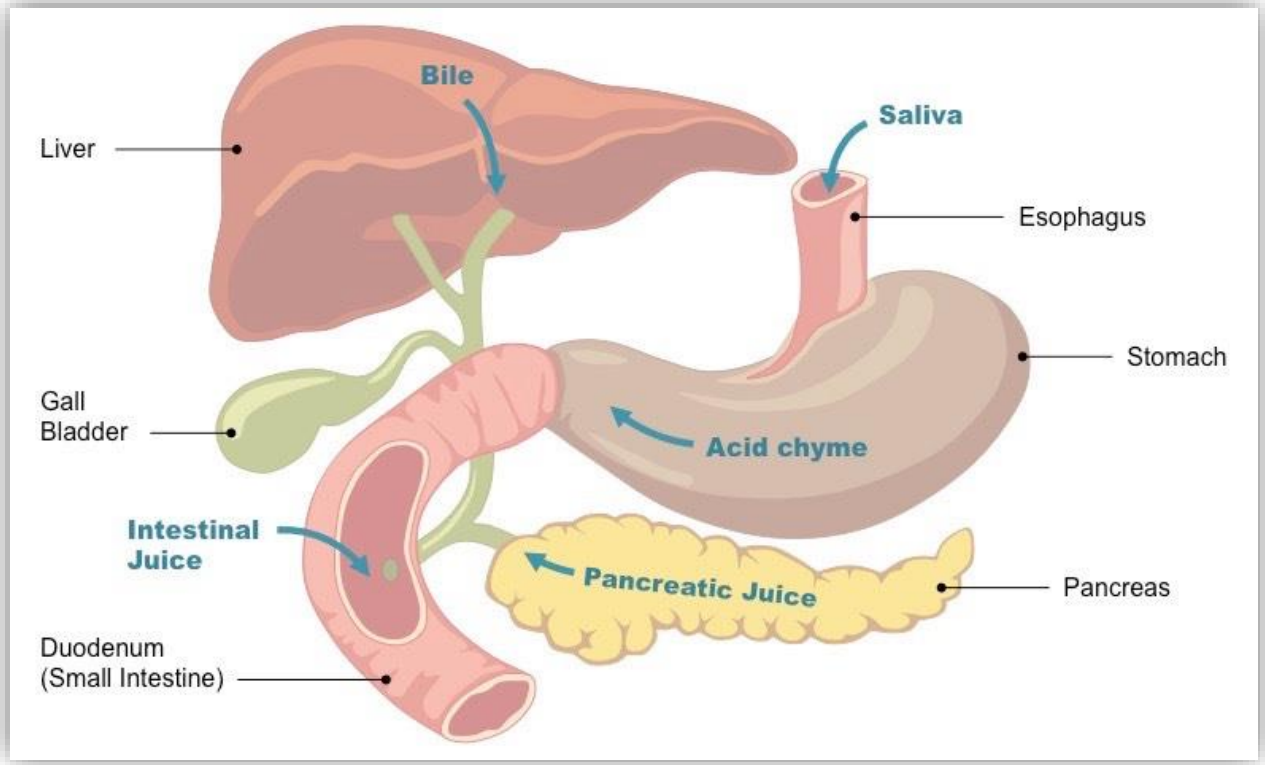

# 1.10 Pancreas

- A pale long gland situated in the epigastric and left hypochondriac regions
- Consist of head, body & tail
- Head of pancreas surround by duodenum
- Inside have pancreatic duct
- Pancreatic duct joint with common bile duct (CBD) from gallbladder & enter duodenum
- **Function: Digest carbohydrate, protein & lipid by pancreatic juice enzyme**

# ANATOMY OF THE PANCREAS



# 1.10.1 Pancreatic Juice




- Secreted by the pancreas

- It consists of:

a) The **sodium hydrogen carbonate =** neutralises chyme in the stomach

b) The **digestive enzymes**:

– **Amylase** = changes carbohydrate (starch) to maltose

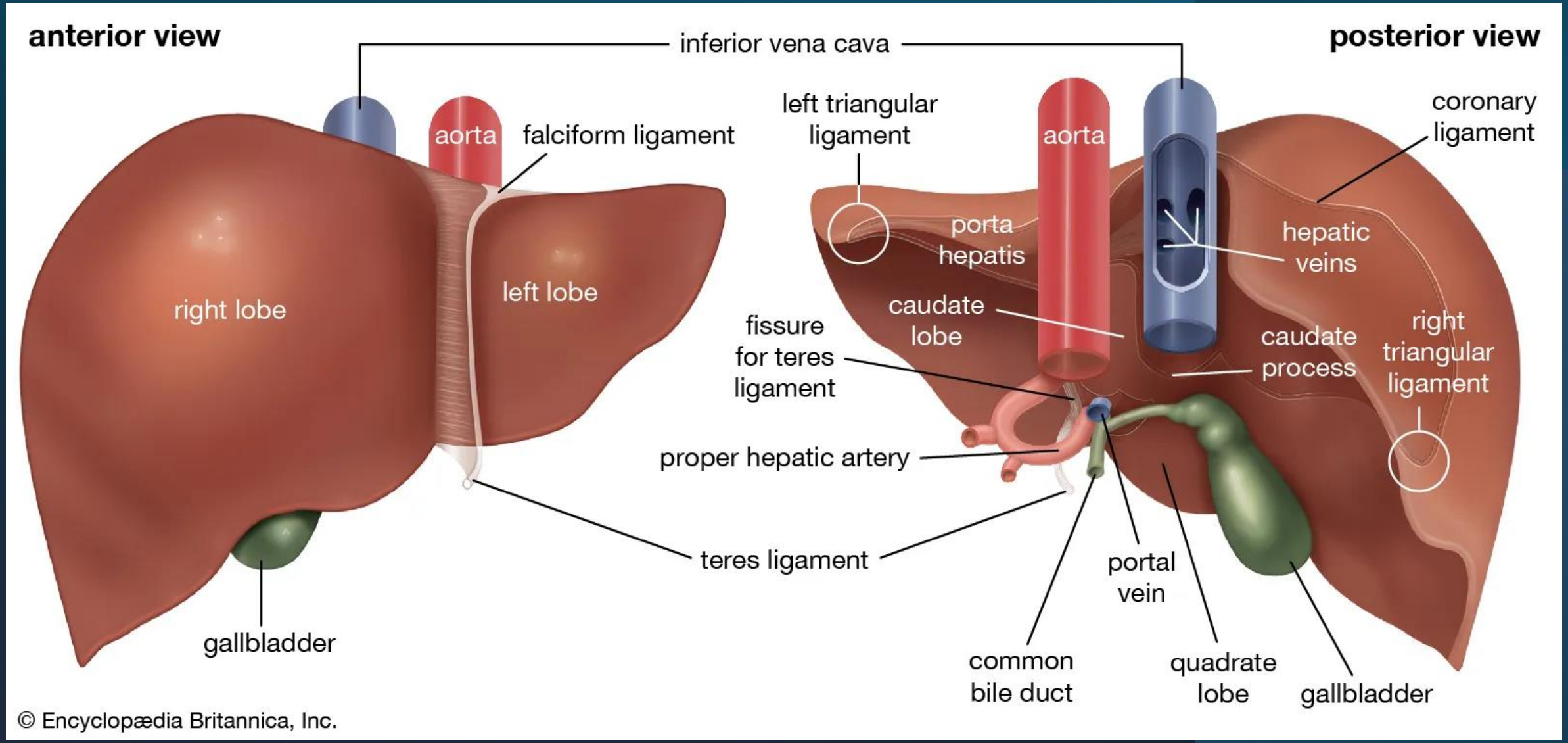
– **Lipase** = changes lipids to fatty acids and glycerol

– **Trypsin** = changes protein to amino acids

- These enzymes enter the duodenum through the **pancreatic duct**

# 1.11 Liver

- The largest gland in the body
- 2nd largest organ of the body
- Between 1 – 2.3 kg *(weight)*
- Inferior to diaphragm
- More to the right side of body (RUQ + epigastric)
- 2 principle lobes → Right lobe & Left lobe *(separate by falciform ligament)*
- Liver cells = hepatocytes *(function: secrete bile)*
- 2 sources of blood supply → Hepatic artery
  → Portal vein


anterior view
inferior vena cava
posterior view
aorta
falciform ligament
left triangular ligament
aorta
coronary ligament
porta hepatis
hepatic veins
right lobe
left lobe
caudate lobe
fissure for teres ligament
caudate process
right triangular ligament
proper hepatic artery
teres ligament
portal vein
gallbladder
common bile duct
quadrate lobe
gallbladder
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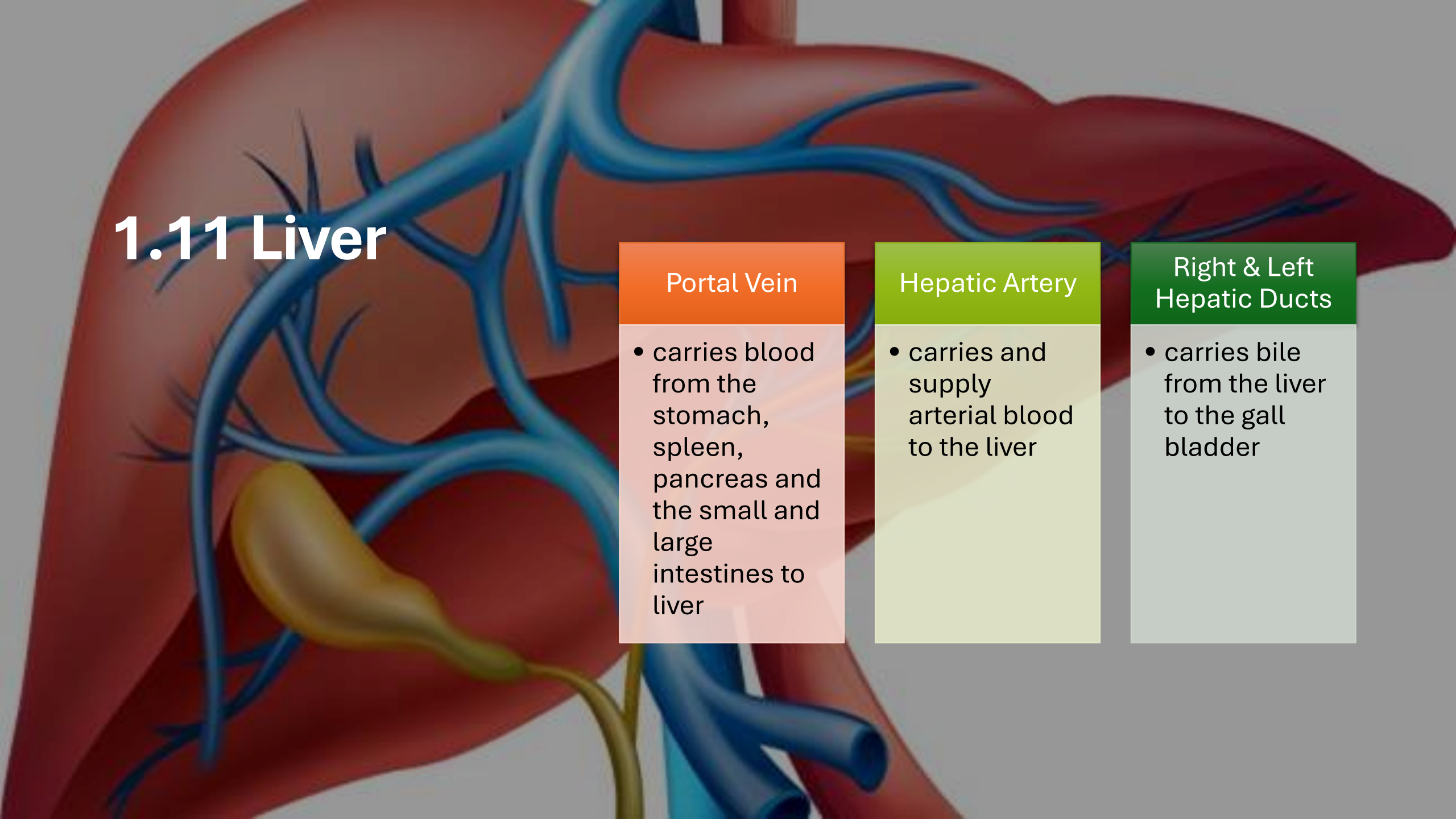
# 1.11 Liver



| Portal Vein | Hepatic Artery | Right & Left Hepatic Ducts |
| --- | --- | --- |
| • carries blood from the stomach, spleen, pancreas and the small and large intestines to liver | • carries and supply arterial blood to the liver | • carries bile from the liver to the gall bladder |

# Main Functions of Liver

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| a) **Manufacture bile**<br>• *needed for digestion of fat* | b) **Storage**<br>• *Glucose in the form of glycogen*<br>• *Fat soluble vitamins – A,D,E,K*<br>• *Iron, copper*<br>• *Water soluble vitamins – B12* | c) **Formation of blood plasma proteins**<br>• *Albumin, globulins and clotting factors* | d) **Excretion of bilirubin**<br>• *An orange-yellowish pigment that is formed by the breakdown of hemoglobin in red blood cells. Eliminated in bile and give stool its color.* | e) **Manufacture antibodies and antitoxins** | f) **Detoxification of alcohol and certain drugs** | g) **Has a high metabolic rate**<br>• *Carbohydrate, lipid & protein metabolism* | h) **Synthesis of urea**<br>• *A waste product of protein metabolism. Urea is released into blood and transported to kidneys for elimination.* |

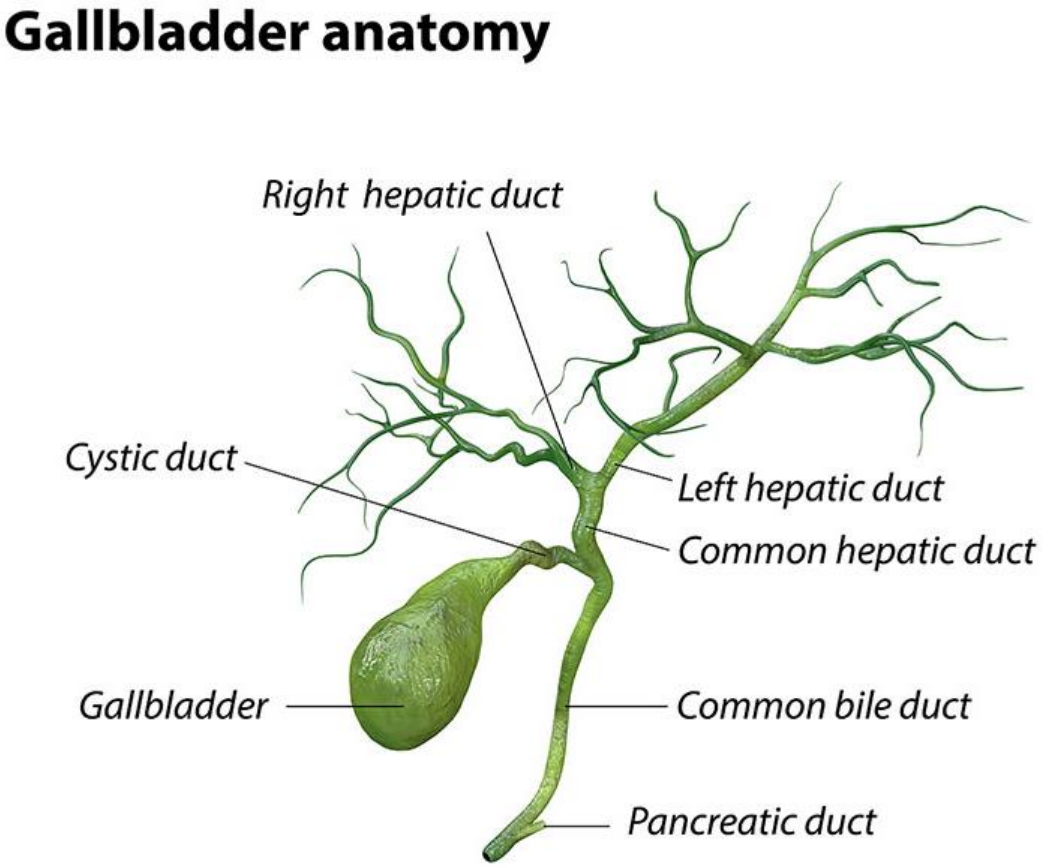
# 1.11.1 Bile

- A yellow-green alkaline fluid that is produced in the liver and stored in the gall bladder.
- Enters the duodenum through the **bile duct**.
- 500 ml – 1000 ml secreted daily.
- Has a pH of around 8.
- Consists of:
  - Water
  - Mineral salts
  - Bile pigment (bilirubin)
  - Bile salts
  - Cholesterol
  - Na, K, Ca and Cl
  - Bicarbonate ions
  - Sodium ion

# 1.11.1 Bile

## Function of bile:

- **Emulsifies lipids** - It breaks down large fat and oil molecules into tiny droplets. The surface area of the lipids is then increased, and enzyme action is more efficient.
- Helps **neutralise chyme** in the stomach with its sodium hydrogen carbonate.
- **Excretes** the pigments **bilirubin**, a waste product of the breakdown of red blood cells in the liver.




# 1.12 Gallbladder

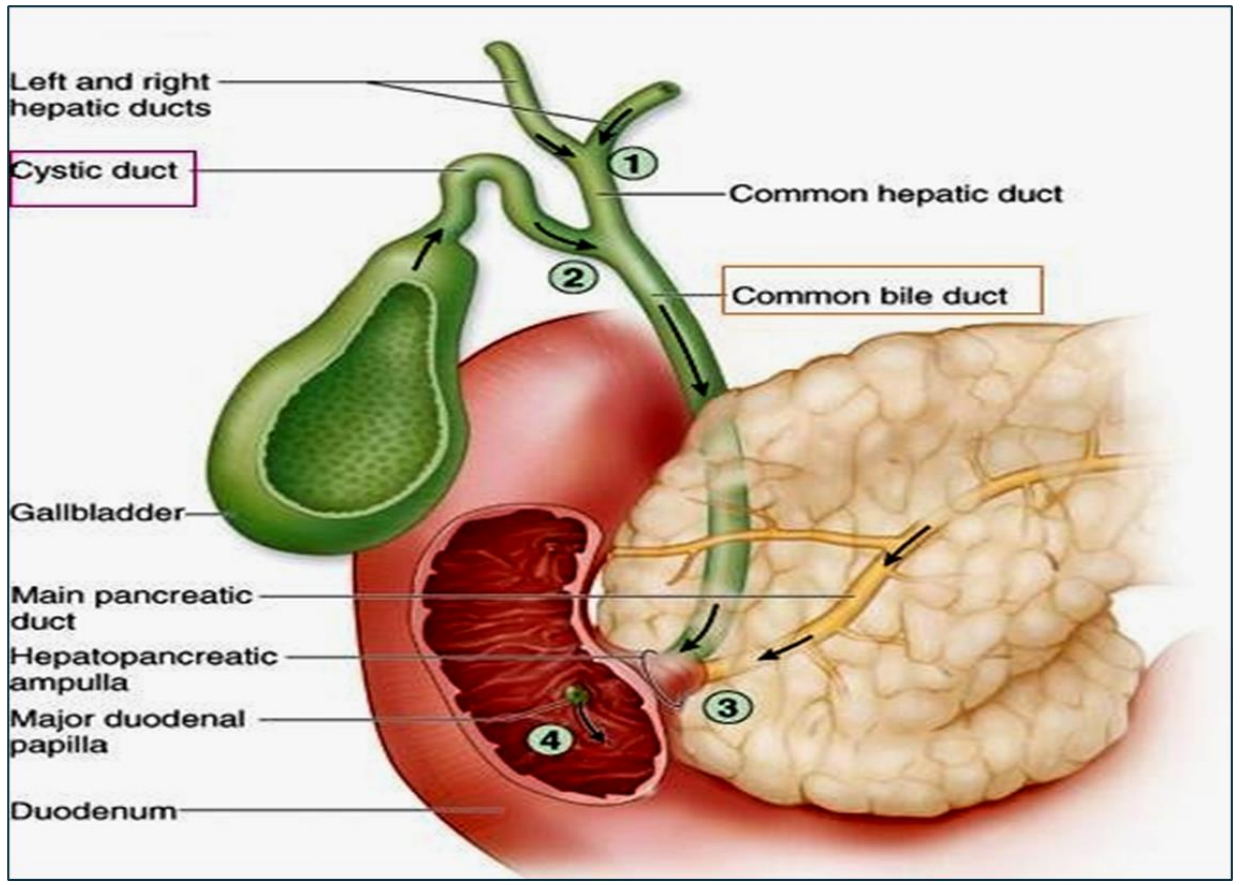
- Pear-shape sac structure
- Locate at posterior surface of liver (RUQ)
- Bile – yellow, brownish liquid
- Bile salt inside the bile play role in **emulsification = break down of large lipid**

# 1.12 Gallbladder

- **Bile Circulation**

i) Bile from liver flows into the hepatic ducts and then through the cystic duct, connected with gallbladder.

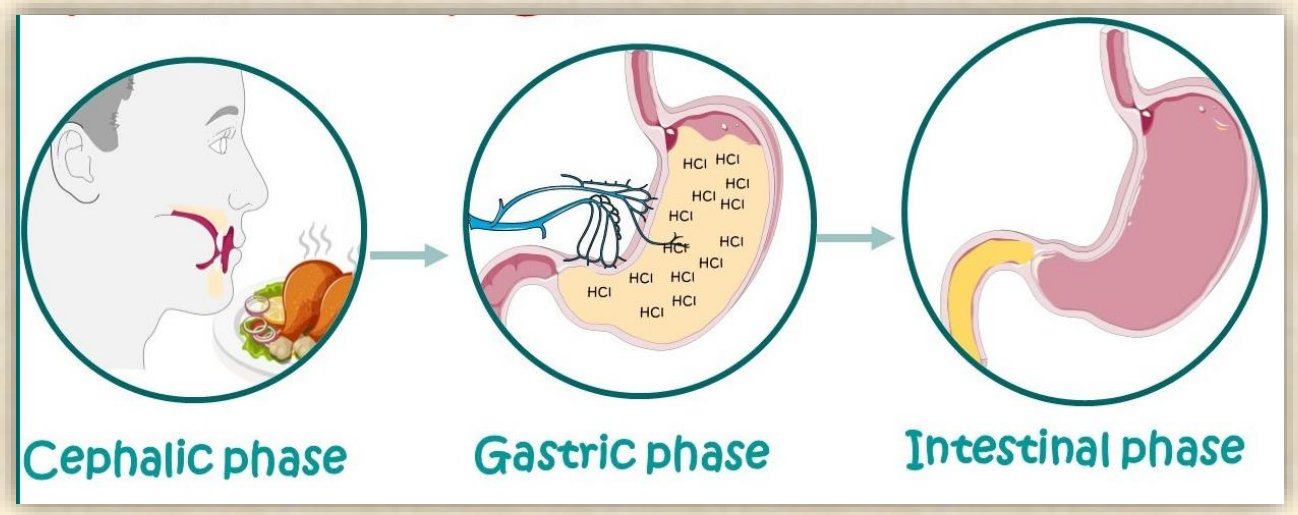
ii) When chyme enters the duodenum, gall bladder contracts and squeeze bile through cystic duct, into common bile duct, leading to duodenum.



# 1.13 Phases of Digestion

- Digestion is carried out by the pancreatic juice, bile and intestinal juice.
- Three (3) phases of digestion:

1. The **cephalic phase** – *when someone think of, see or smell food, the brain will stimulate the release of saliva and gastric juice → purpose is to prepare the mouth and stomach for food that is about to be eaten*
2. The **gastric phase** – *when food is in stomach purpose is to continue gastric → secretion and to promote gastric motility*
3. The **intestinal phase** – *when food enters the duodenum. Pancreatic and intestinal juices are mixed with food and further digest the food*



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THANK YOU!