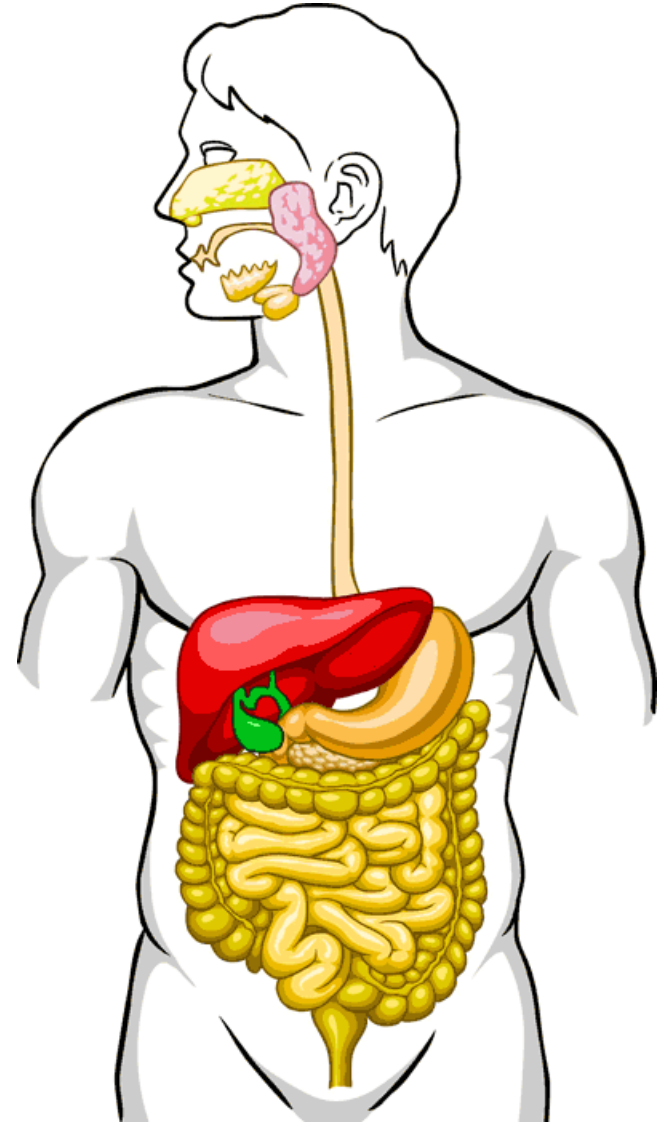


PHYSIOLOGY

D.Ghusoon

LEC. 2

Digestive system



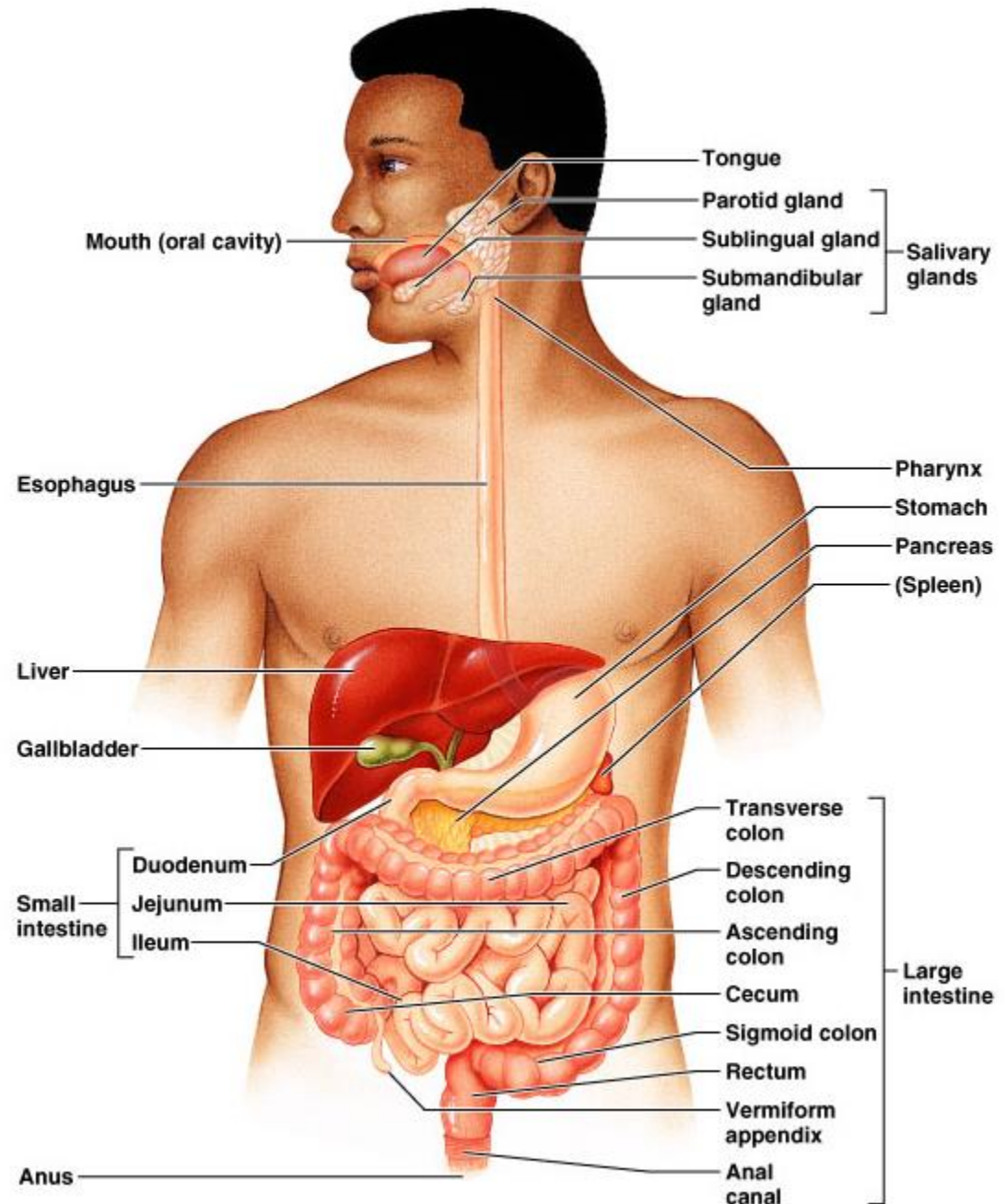
- **The GI tract** (gastrointestinal tract)

- Mouth
- Pharynx
- Esophagus
- Stomach
- Small intestine
- Large intestine
- Anus

- **The accessory digestive organs**

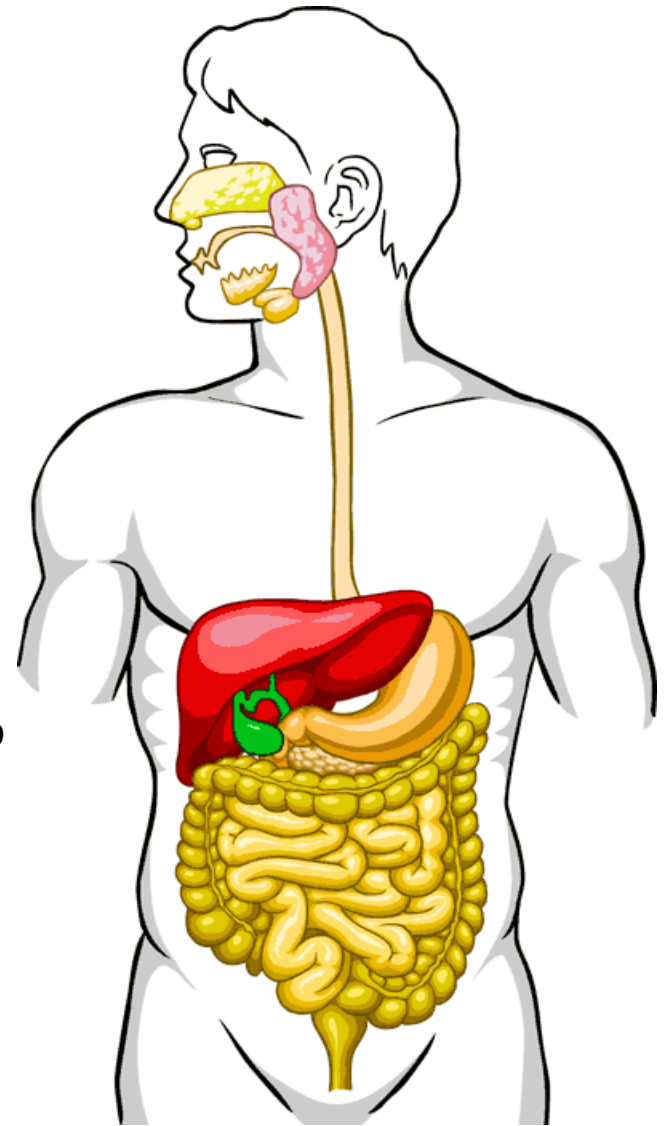
Supply secretions contributing to the breakdown of food

- Teeth & tongue
- Salivary glands
- Gallbladder
- Liver
- Pancreas



Digestive system function

- Acquires nutrients from environment
- Anabolism
- Uses raw materials to synthesize essential compounds
- Catabolism
 - Lipids to fatty acids
 - Proteins to individual amino acids
 - Carbohydrates into simple sugars
- Decomposes substances to provide energy cells need to function



The Digestive System

Digestive system consists of:

- 1. Gastrointestinal Tract (GIT).**
- 2. Accessory organs.**

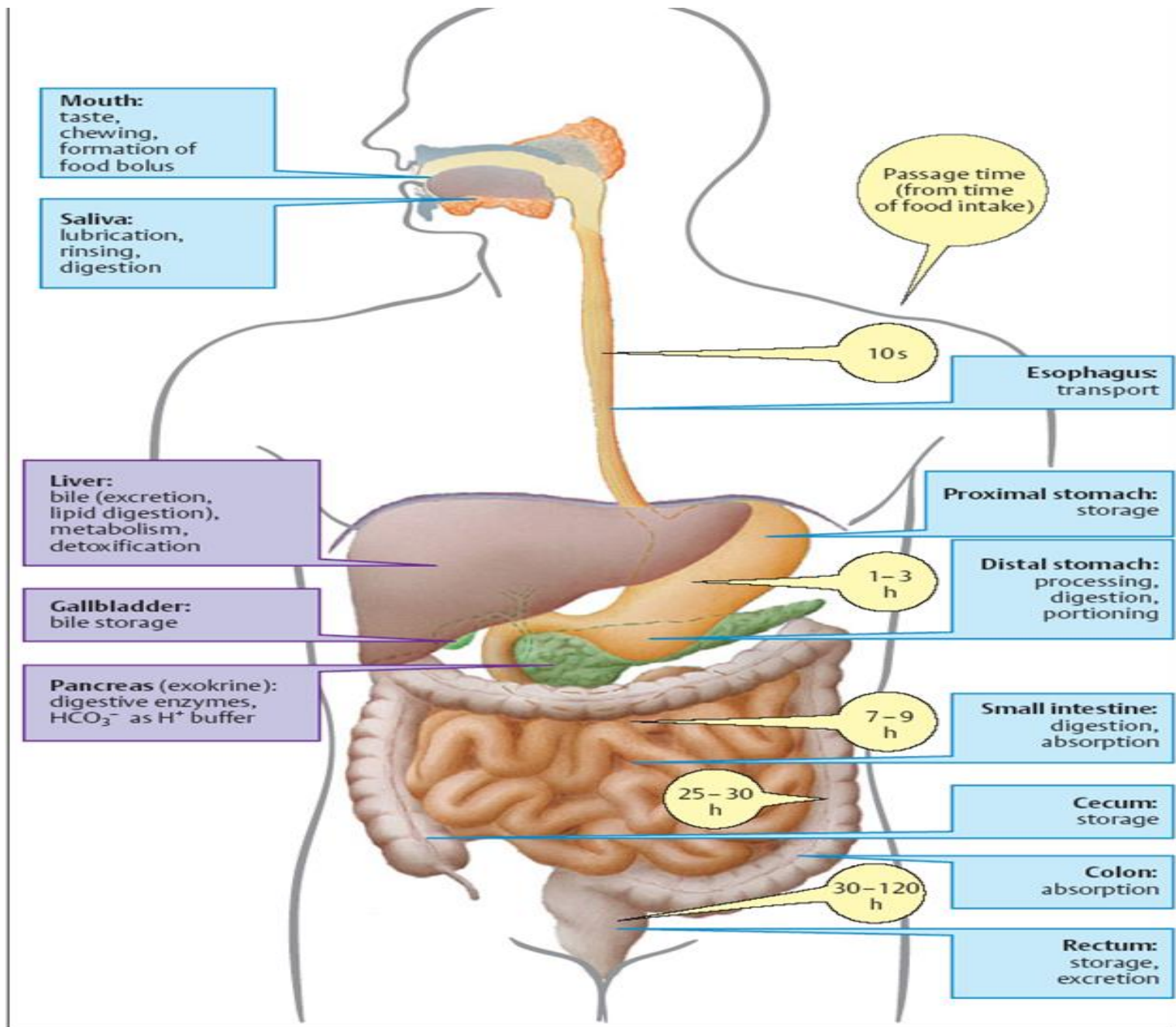
GIT is a digestive tract consists of oral cavity, pharynx, esophagus, stomach, small intestinal, large intestine, and anus.

The accessory organs of digestion are the teeth, tongue, salivary glands, liver, gallbladder, and pancreas. Digestion does not take place within these organs, but each contributes something to the digestive process.

The functions of the digestive system are to:

- 1. ingest the food;**
- 2. break food down into small molecules that can cross plasma membranes;**
- 3. absorb these nutrient molecules;**
- 4. eliminate no digestible wastes.**
- 5) control of all these functions by local, nervous, and hormonal systems.**

Tunic	Structure	Function
Mucosa	Simple columnar epithelium	Secretion and absorption
Submucosa	Highly vascular; autonomically innervated	Absorption
Muscularis	Smooth muscle	Peristalsis
Adventitia (visceral serosa)	Visceral peritoneum	Binding and protection



Actions of Digestive (GI) Tract

Ingestion

Occurs when material enters via the mouth

Mechanical Processing

Crushing – makes material easier to move through the tract

Digestion

Chemical breakdown of food into small organic compounds for absorption

Secretion

Release of water acids, buffers, enzymes & salts by epithelium of GI tract and glands

Absorption

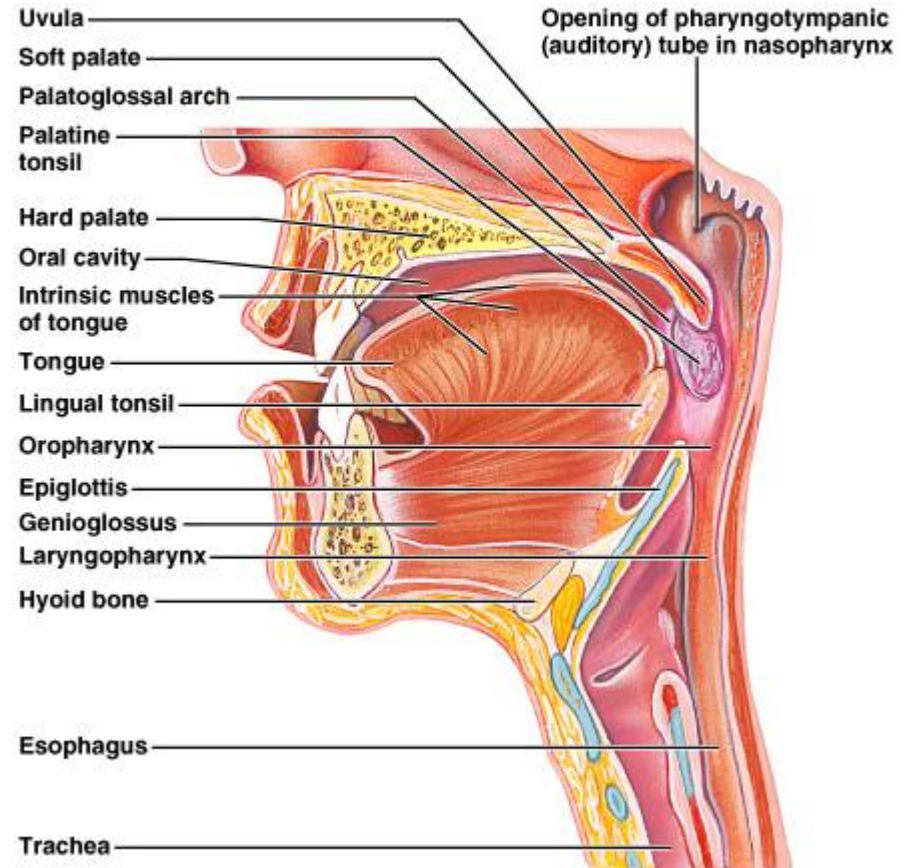
Movement of substrates, electrolytes, vitamins & water across digestive epithelium

Excretion

Removal of waste products from body fluids

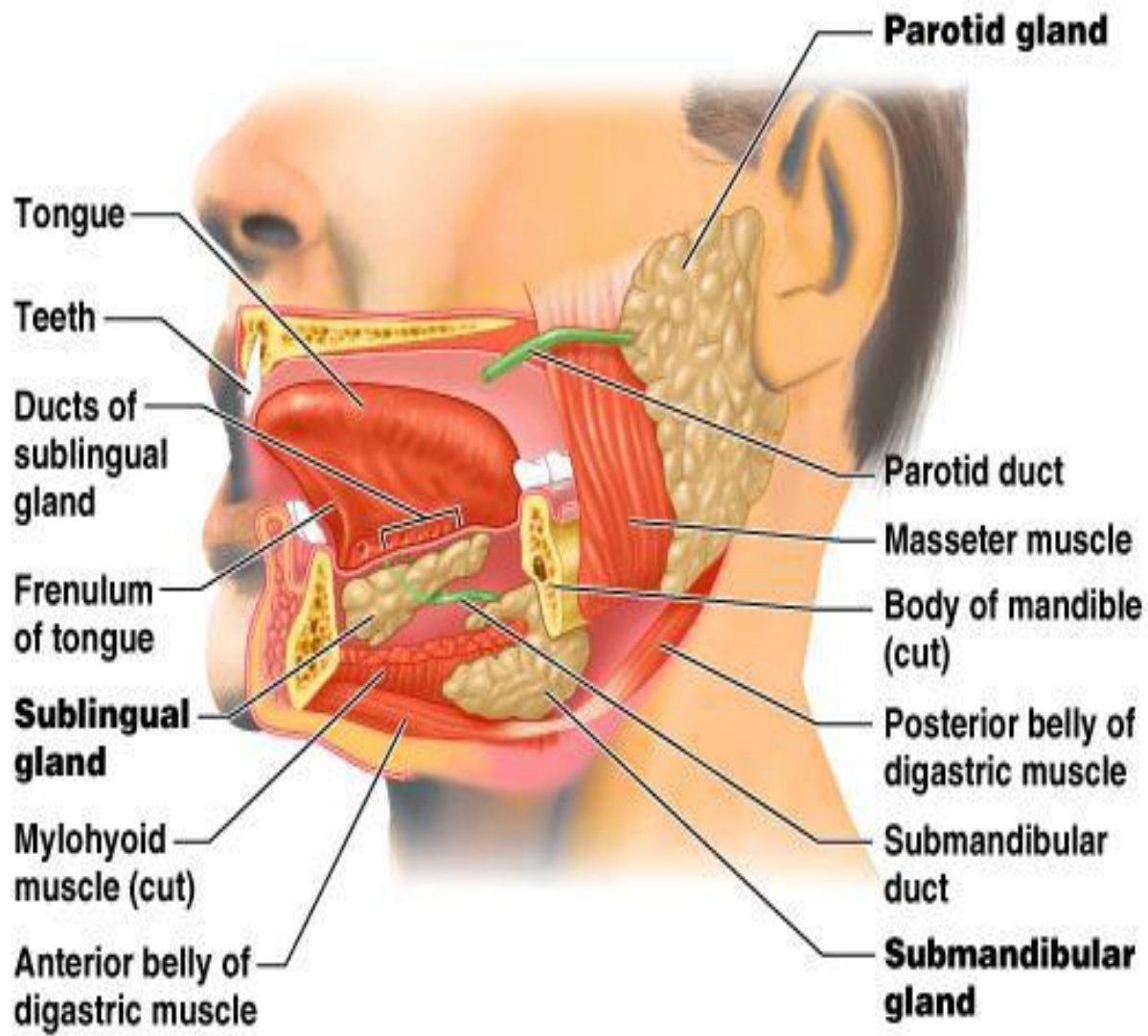
The Mouth

- Mouth = oral cavity
- Lips
- Cheeks



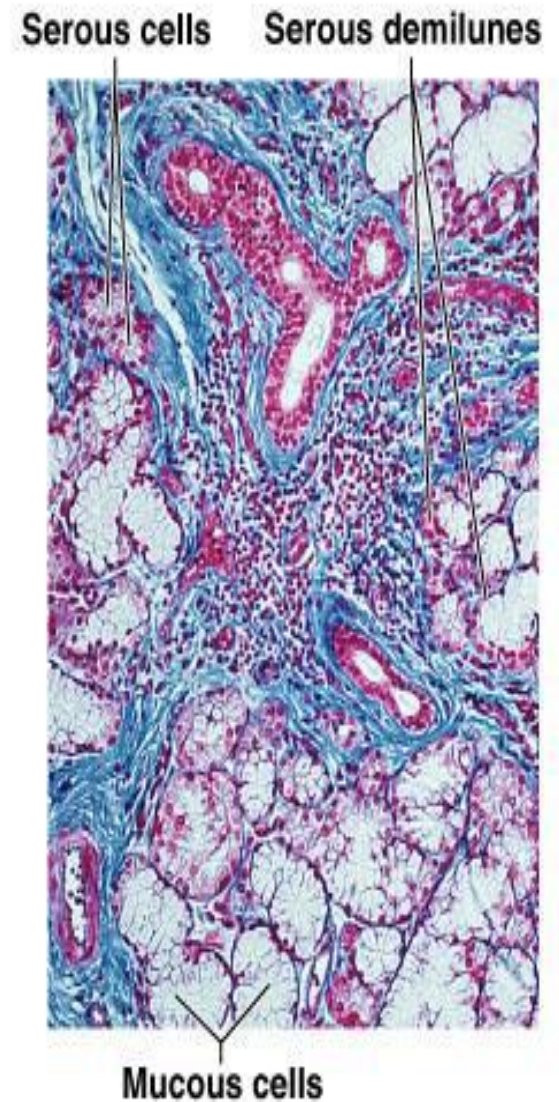
(a)

- SALIVARY GLANDS :-
- The digestive secretion in the oral cavity is saliva, produced by three pairs of salivary glands, which are :
 - 1- The parotid glands :- are just below and in front of the ears.
 - 2- The submandibular (also called submaxillary) glands :-are at the posterior corners of the mandible, and
 - 3- the sublingual glands :-
 - are below the floor of the mouth.
 - Each gland has at least one duct that takes saliva to the oral cavity.
- Saliva composition :
 - 1. Water 99.4%.
 - 2. Electrolytes (Na⁺, Cl⁻, Hco₃⁻) to regulate osmotic pressure.
 - 3. Buffers keep pH near (7.0).
 - 4. Glycoprotein.
 - 5. Antibody (IgA) and lysozyme. 0.6%
 - 6. Enzyme –amylase (ptyalin) to digest CHO.
 - 7. Waste product like urea.
 - 8. Mucins



(a)

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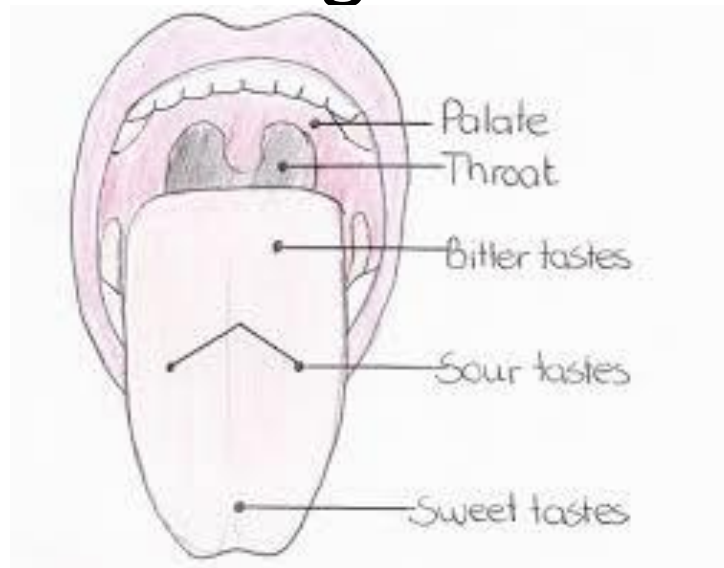


(b)

- The functions of saliva are reflected by its constituents. Saliva is mostly water, which is important to dissolve food for tasting and to moisten food for swallowing.
- Mucins :- serve to lubricate the food, making it easier to swallow, and to keep the mouth moist to facilitate masticatory and speech-related movement.
- Saliva has a low NaCl concentration and is hypotonic, making it suitable
- for rinsing of the taste receptors (NaCl) while eating. Infants need saliva to seal the lips when suckling.
- Saliva also contains α -amylase:- which starts the digestion of starches in the
- Mouth.
- while immunoglobulin A and lysozyme are part of the immune defense system
- The high HCO_3 concentration in saliva results in a pH of around 7, which is optimal for α -amylase-catalyzed digestion.
- Control of Salivary Secretion:
- Each salivary gland receives parasympathetic and sympathetic innervation .the parasympathetic increase the secretion of saliva by all salivary glands. Sympathetic innervation remains uncertain.

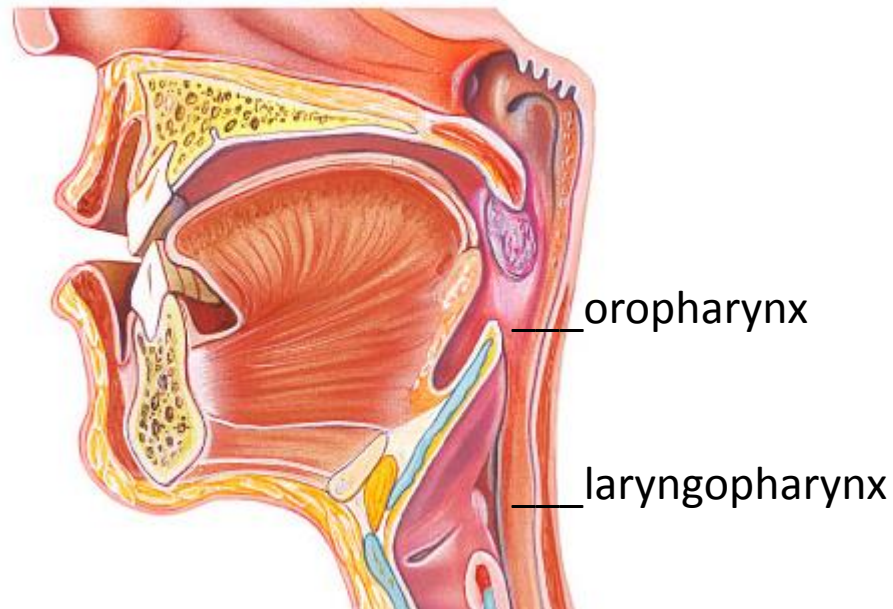
Tongue

- Mostly muscles
 - Grip food
 - Help in swallowing
- Taste buds
- Tonsil – back of tongue



Pharynx

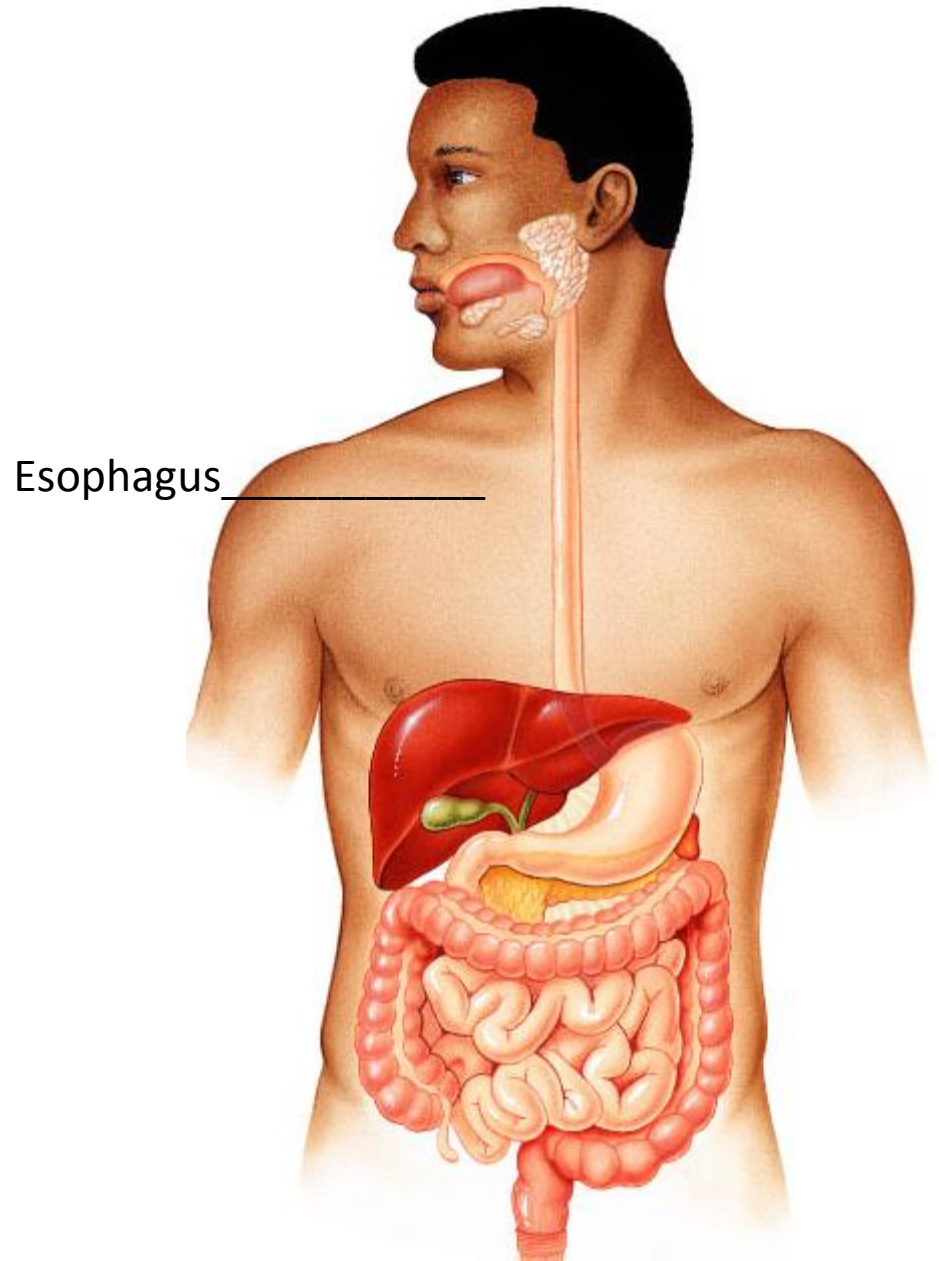
- Oropharynx and laryngopharynx
Sequentially squeeze food into esophagus



- The PHARYNX :-
- No digestion takes place in the pharynx. Its only related function is swallowing, the mechanical movement of food. The pharynx has three parts: (1) The nasopharynx, posterior to the nasal cavity, serves as a passageway for air;
- (2) the oropharynx, posterior to the soft palate, is a passageway
- for both air and food.
- (3) the laryngopharynx, just inferior to the esophagus, is a passageway for food entering the esophagus.

Esophagus

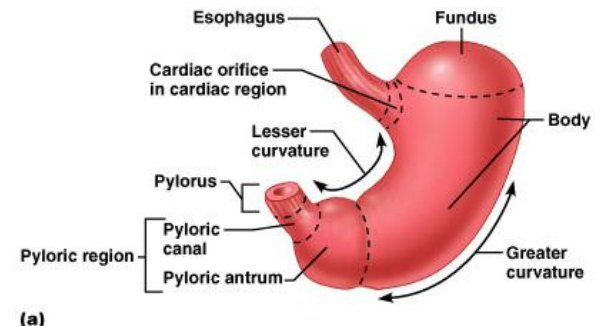
- Continuation of pharynx in mid neck
- Muscular tube collapsed when lumen empty
- Descends through thorax



- The esophagus is a muscular tube that takes food from the pharynx to the stomach; no digestion takes place here.
 - Peristalsis of the esophagus propels food in one direction and ensures that food gets to the stomach even if the body is horizontal or upside down.
 - At the junction with the stomach, the lumen (cavity) of the esophagus is surrounded by the lower esophageal sphincter (LES or cardiac sphincter), a circular smooth muscle. The LES relaxes to permit food to enter the stomach, then contracts to prevent the backup of stomach contents.
-
- Swallowing mechanism :-
 - During swallowing, food normally enters the esophagus because other possible avenues are blocked.
 - Swallowing is a reflex action performed automatically (without our willing it). When we swallow, the soft palate moves back to close off the nasopharynx,
 - and the trachea moves up under the epiglottis so that food is less likely to enter it. (We do not breathe when we swallow.) The tongue presses against the
 - soft palate, sealing off the oral cavity, and the esophagus opens to receive a food bolus .

Stomach

- J-shaped; widest part of alimentary canal
- Temporary storage and mixing – 4 hours
- Starts food breakdown
 - Pepsin
 - HCl (hydrochloric acid) helps kill bacteria
 - *Stomach tolerates high acid content but esophagus doesn't – why it hurts so much when stomach contents refluxes into esophagus (heartburn)*
- Most nutrients wait until get to small intestine to be absorbed; exceptions are:
 - Water, electrolytes, some drugs like aspirin and alcohol (absorbed through stomach)
 - Capacity: 1.5 L food; max capacity 4L



- The term gastric always refers to the stomach which is a thick-walled, J-shaped organ that lies on the left side of the abdominal cavity deep to the liver and diaphragm.
 - The stomach is continuous with the esophagus above and the duodenum of the small intestine below.
 - The length of the stomach remains at about 25 cm (10 in.) regardless of the amount of food it holds, but the diameter varies, depending on how full it is. As the stomach expands, deep folds in its wall, called rugae, gradually disappear.
 - When full, it can hold about 4 liters (1 gallon).
 - The stomach receives food from the esophagus, stores food, mixes food with its juices (thereby starting the digestion of proteins), and moves food into the small intestine.
-
- Regions of the Stomach :-
 - The stomach has four regions:-
 - 1- The cardiac region:- which is near the heart, surrounds the lower esophageal sphincter where food enters the stomach.
 - 2- The fundic region:- which holds food temporarily, is an expanded portion superior to the cardiac region.
 - 3- The body region:- which comes next, is the main part.
 - 4- The pyloric region :- narrows to become the pyloric canal leading to the pyloric sphincter through which food enters the duodenum, the first part of the small intestine.
-
- Digestive Functions of the Stomach :-
 - The stomach both physically and chemically acts on food.
 - The motor functions of the stomach are three fold:
 - (1) storage of large quantities of food until the food can be processed in the stomach, duodenum, and lower intestinal tract .
 - (2) mixing of this food with gastric secretions until it forms a semifluid mixture called chyme .
 - (3) slow emptying of the chyme from the stomach into the small intestine at a rate suitable for proper digestion and absorption by the small intestine .

- **Its wall contains three muscle layers: One layer is longitudinal, another is circular, and the third is obliquely arranged.**
- **This muscular wall not only moves the food along, but it also churns, mixing the food with gastric juice and breaking it down to small pieces.**

- **The columnar epithelial lining of the stomach has millions of gastric pits,**
- **which lead into gastric glands.**
- **The gastric glands produce gastric juice, which contains pepsinogen, HCl, and**
- **mucus.**
- **Chief cells secrete pepsinogen, which becomes the enzyme pepsin when exposed to hydrochloric acid (HCl) released by parietal cells.**
- **The HCl causes the stomach to have a high acidity with a pH of about 2, and this is beneficial because it kills most of the bacteria present in food. Although HCl does not digest food, it does break down the connective tissue of meat and activate pepsin.**

- **The wall of the stomach is protected by the thick layer of mucus secreted by the mucous cells.**
- **Normally, the stomach empties in about 2–6 hours. When food leaves the stomach, it is a thick, soupy liquid called chyme.**
- **Chyme enters the small intestine in squirts by way of the pyloric sphincter, which acts like a valve, repeatedly opening and closing.**

Gastric Secretion:

1. Mucus cells secrete mucous, trefoil peptide and bicarbonate.
2. Parietal cells secrete acid and intrinsic factors.
3. Enterochromaffin like cells secrete histamine.
4. Chief cells secrete Pepsinogen.
5. G-cells secrete gastrin.
6. D-cells secrete somatostatin.

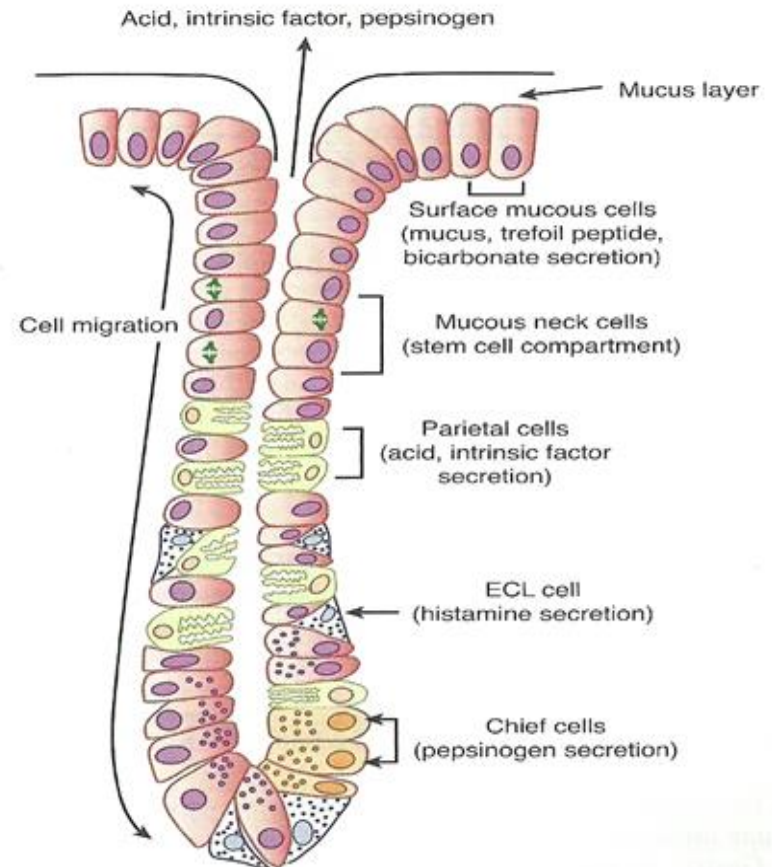
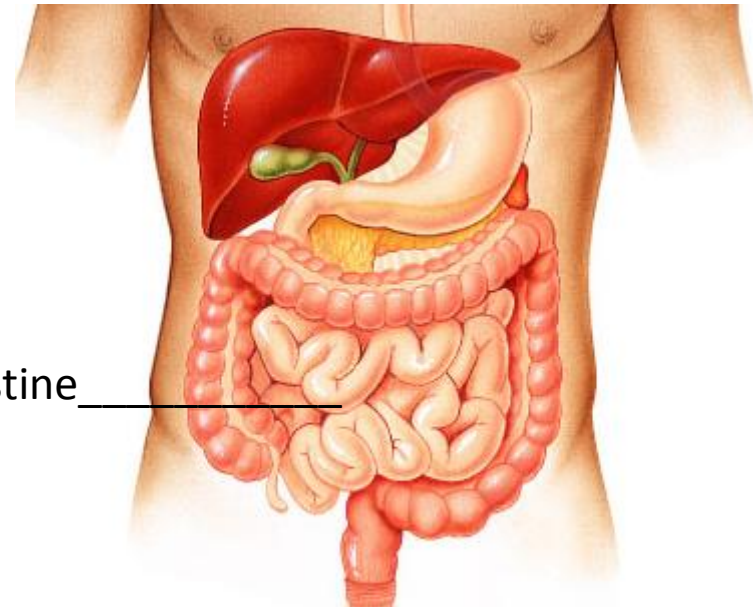


FIGURE 26–5 Structure of a gastric gland from the fundus and body of the stomach. These acid- and pepsinogen-producing glands are referred to as “oxyntic” glands in some sources. (Adapted from Barrett KE: *Gastrointestinal Physiology*. McGraw-Hill, 2006.)

Small intestine

- Longest part of alimentary canal (2.7-5 m)
- Most enzymatic digestion occurs here
 - Most enzymes secreted by *pancreas*, not small intestine
- Almost all absorption of nutrients
- 3-6 hour process

Small intestine



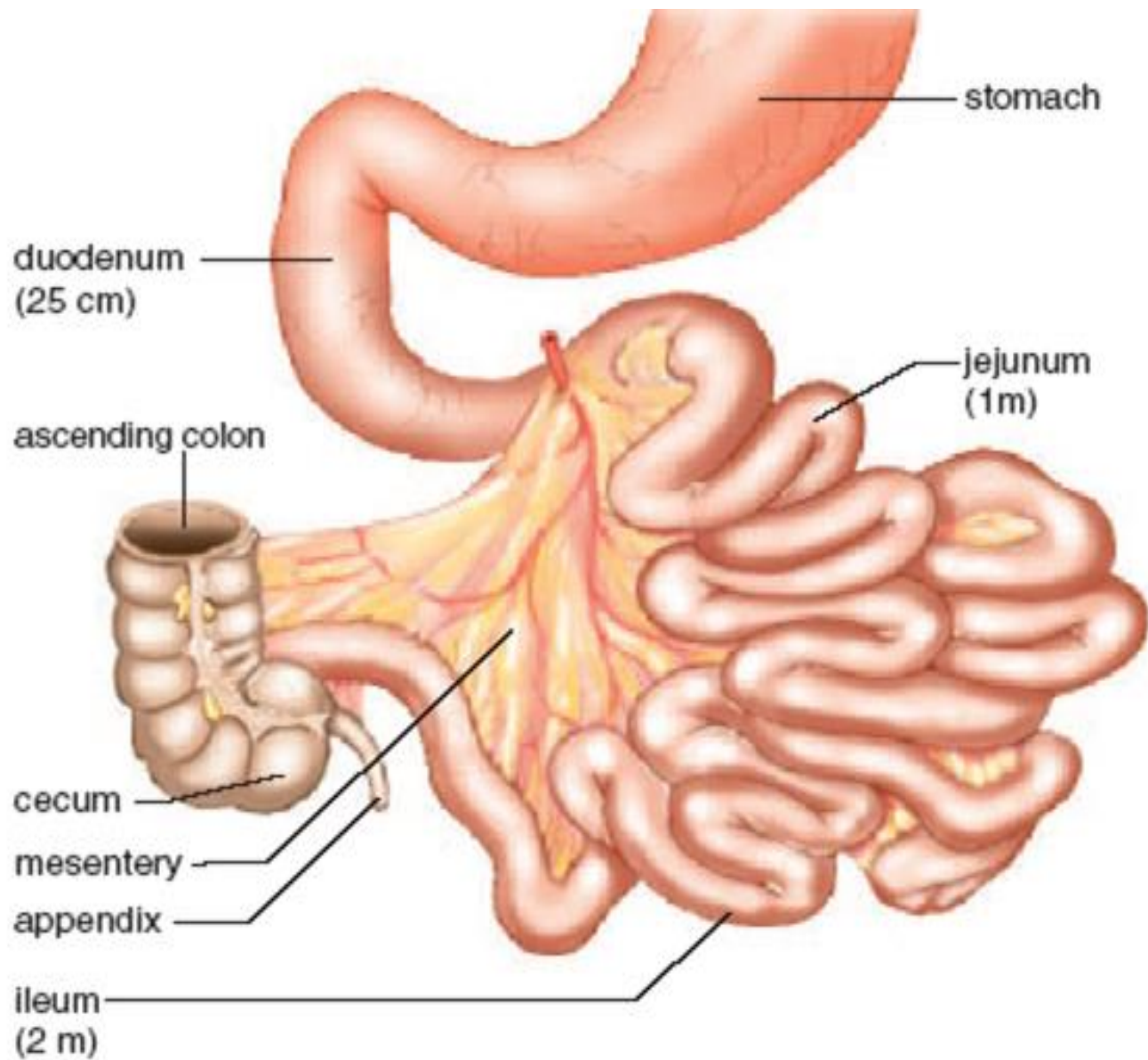
- The small intestine extends from the pyloric valve of the stomach to the ileocecal valve, where it joins the large intestine.
- It is named for its small diameter (compared to that of the large intestine), but perhaps it should be called the long intestine.
- The small intestine takes up a large portion of the abdominal cavity, averaging about 6 m (18 ft) in length. All the contents of food—fats, proteins, and carbohydrates—are digested in the small intestine to soluble molecules that can be absorbed.
- To this end, the small intestine receives secretions from the pancreas and liver and produces intestinal juices. Absorption of nutrients for the body's cells, such as amino acids and sugars, occurs in the small intestine. It also transports non digestible remains to the large intestine.

- **Regions of the Small Intestine**
- **The small intestine has the following regions:**
- **1- Duodenum :-** The first 25 cm ,contain distinctive glands that secrete mucus and also receive the pancreatic secretions and the bile from the liver through a common duct. Folds and villi are more numerous at the end than at the beginning.
- **2- Jejunum :-** The next 2.5 meters contains folds and villi, more at the beginning than at the end.
- **3- Ileum** The last 3.5 meters contain fewer folds and villi than the jejunum, The ileum wall contains Peyer patches, aggregates of lymph nodules mentioned in the small intestine .

- **The Characteristic, Histological Structures of Small Intestinal :-**
- **1. Plica:** the intestinal lining show transverse folds called plica and this is a permanent feature that dose not disappear when the small intestine fills, small intestine contains roughly 800 plica to increase the surface for absorption .
- **2. Villi:** mucosa of small intestine is project into a series of fingerlike structures called intestine villi.
- **Structures of Villi:**
- **a. Lacteal b. Goblet cells c. Nerves d. Capillaries**
- **e- Lamina propria .**

- **3. Intestinal glands:**
- **a. Goblet cells. b. Intestinal glands or crypts of lieberkuhn.**
- **c. Submucosal glands or Brunner's glands**

- **4. Payer's patches (aggregated lymphoid nodules):**
- **Lamia propria of ileum contains 20-30 masses of lymphoid tissue (lymphoid nodules) called payer's patches to protect small intestine from bacteria.**



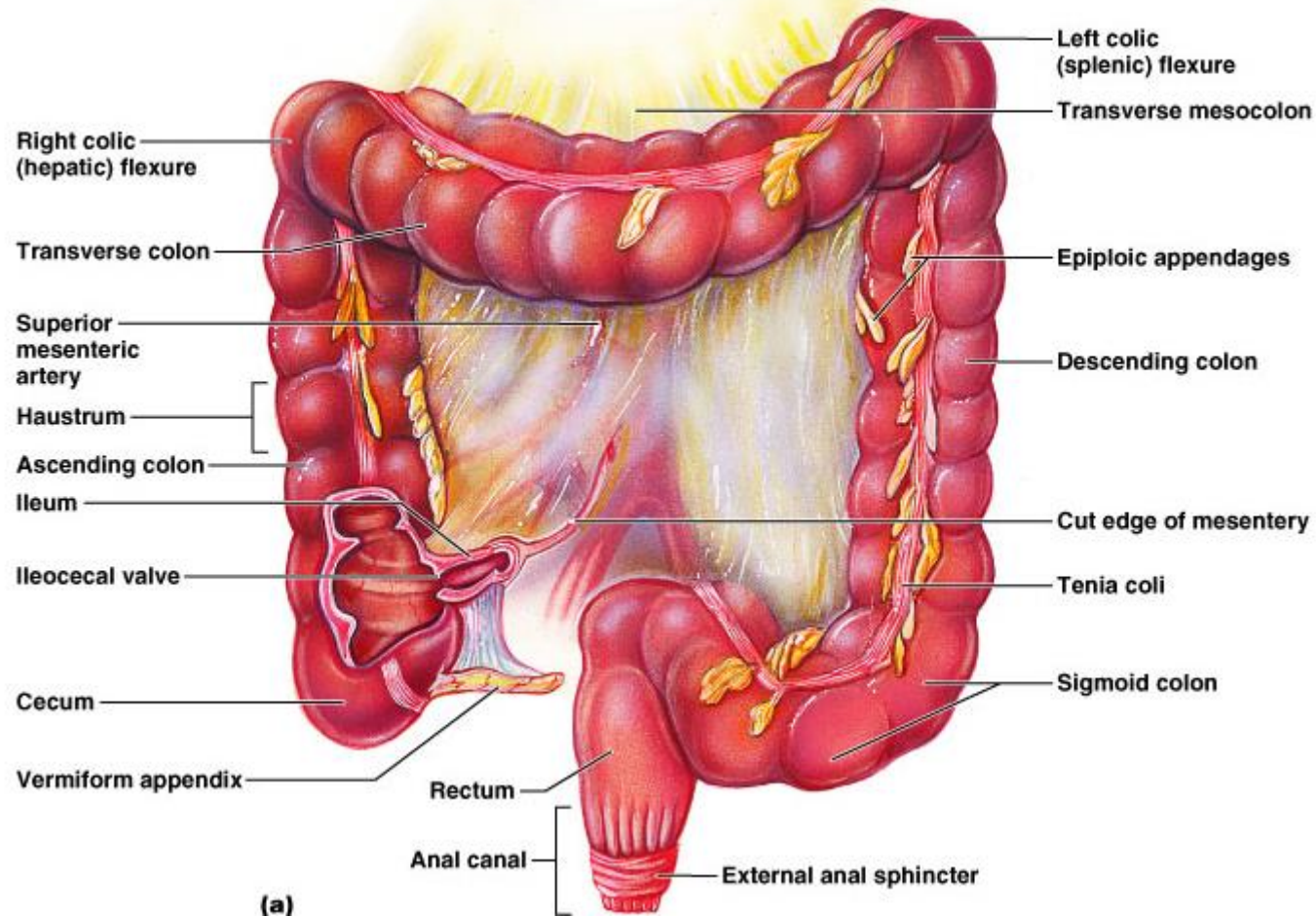
- **Large Intestine is Divided into Four Structures "parts" :**
- **1. Cecum and appendix.**
- **2. Colon: Ascending colon, Transverse colon, Descending colon, Sigmoid.**
- **3. Rectum.**
- **4. Anal canal.**
- **Functions of Large Intestine :-**
- **1. Absorptions of less than 10% of the nutrients in large intestine.**
- **2. Large intestine prepares fecal material for ejection from the body.**
- **3. Reabsorption of water and other substances such as, bile salts, vitamins, urobilinogen, toxins of bacteria.**
- **4. Bacteria in the colon produce 3 vitamins (Mutual Symbiotic Bacteria).**
- **a. Vitamin K. b. Biotin. c. Vitamin B5.**
- **5. Colonic Bacterial actions are:**
- **a. Breaks down peptides and produce ammonia, indole, skatole and H₂S.**
- **b. Toxins.**
- **c. Digestion of polysaccharide such as cellulose to provide nutrient source for colonic bacteria whose responsible for intestinal gases (flatus), large numbers of indigestible carbohydrate such as beans stimulate bacterial gas production, leading to distension of the colon, cramps, and frequent discharge of intestinal gases.**

Large intestine

- Main function: to absorb water and electrolytes

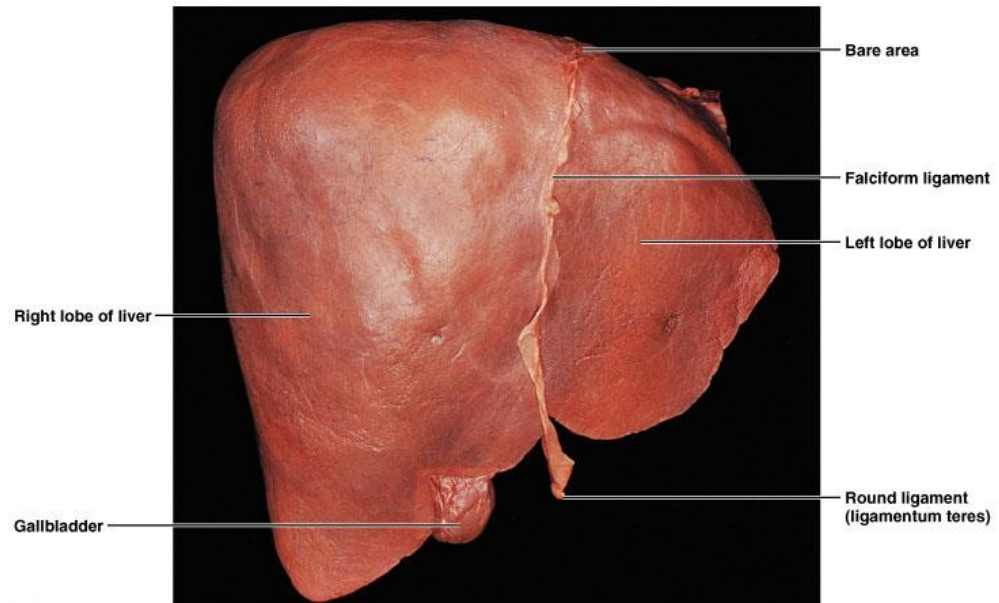
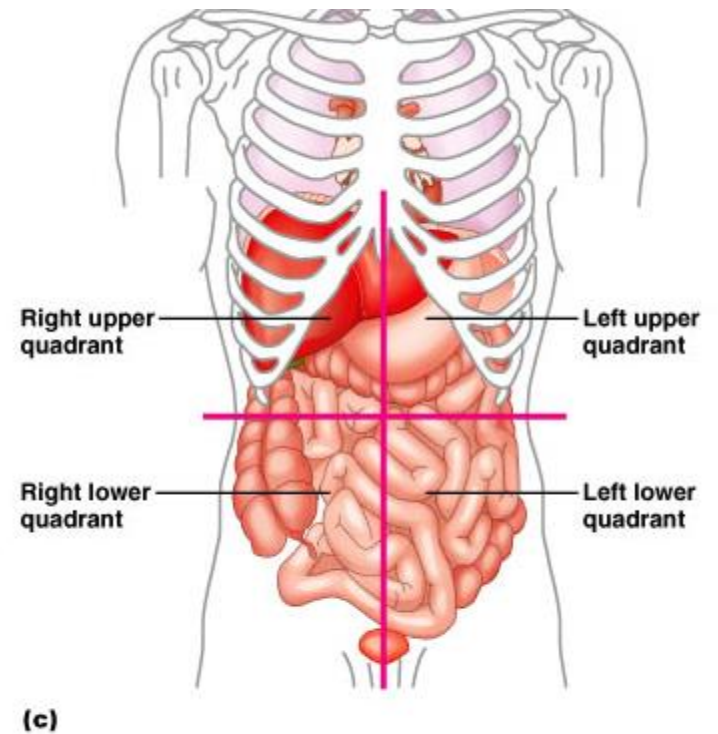
Subdivisions

- Cecum
- Appendix
- Colon
- Rectum
- Anal canal



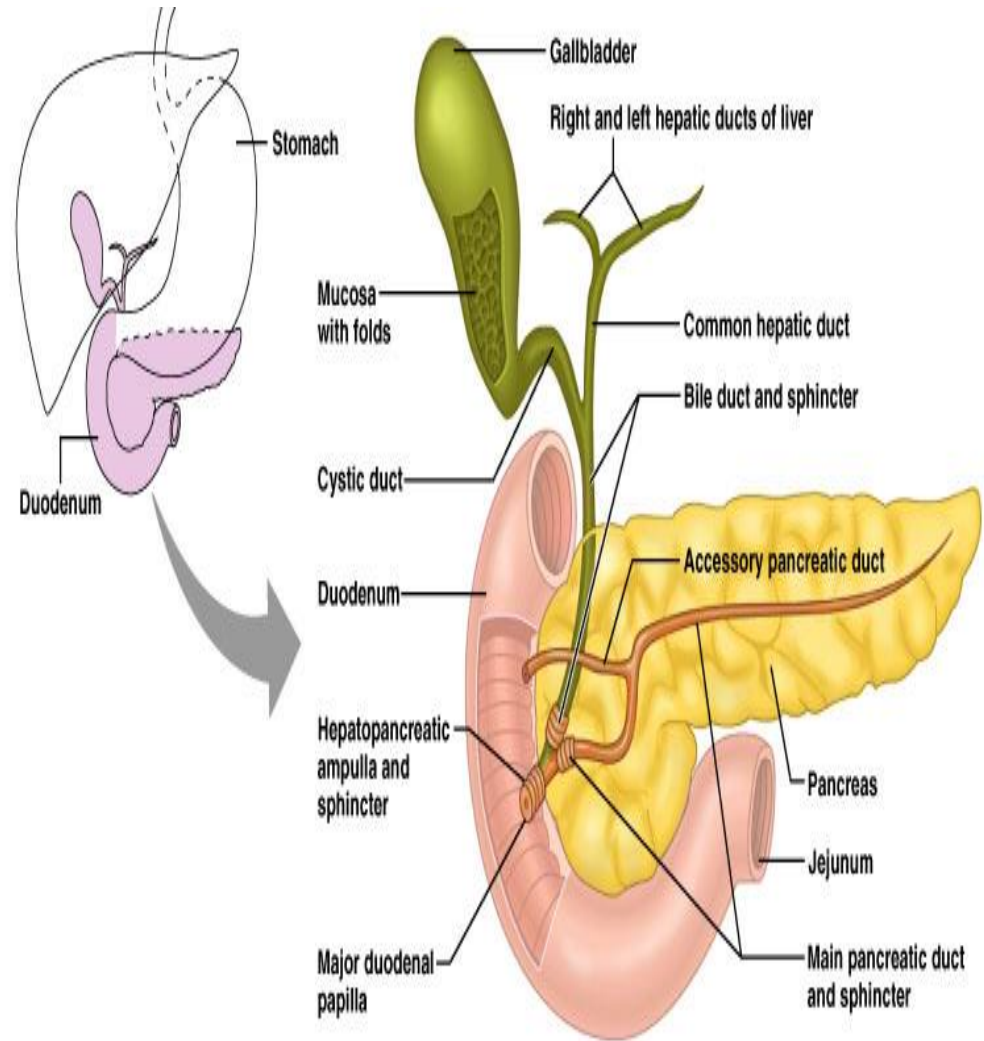
The Liver

- Largest gland in the body
- Over 500 functions
- R and L lobes



Gallbladder

- Bile is produced in the liver
- Bile is stored in the gallbladder
- Bile is excreted into the duodenum when needed (fatty meal)
- Bile helps dissolve fat and cholesterol
- If bile salts crystallize, gall stones are formed



- The gallbladder is a sac about 7.5 to 10 cm long located on the undersurface of the right lobe of the liver.
- About 1,000 ml of bile are produced by the hepatic duct of the liver each day, and flows through the cystic duct into the gallbladder.
- excess bile is stored in the gallbladder until it is needed in the small intestine.
- The gallbladder also concentrates bile by absorbing water .
- When fatty foods enter the duodenum, the enteroendocrine cells of the duodenal mucosa secrete the hormone cholecystinin (CCK)which stimulates contraction of the smooth muscle in the wall of the gallbladder, which forces bile into the cystic duct, then into the common bile duct, and on into the duodenum.

Pancreas

Pancreatic function

(hormones released into blood)

Islets of Langerhans are the hormone secreting cells

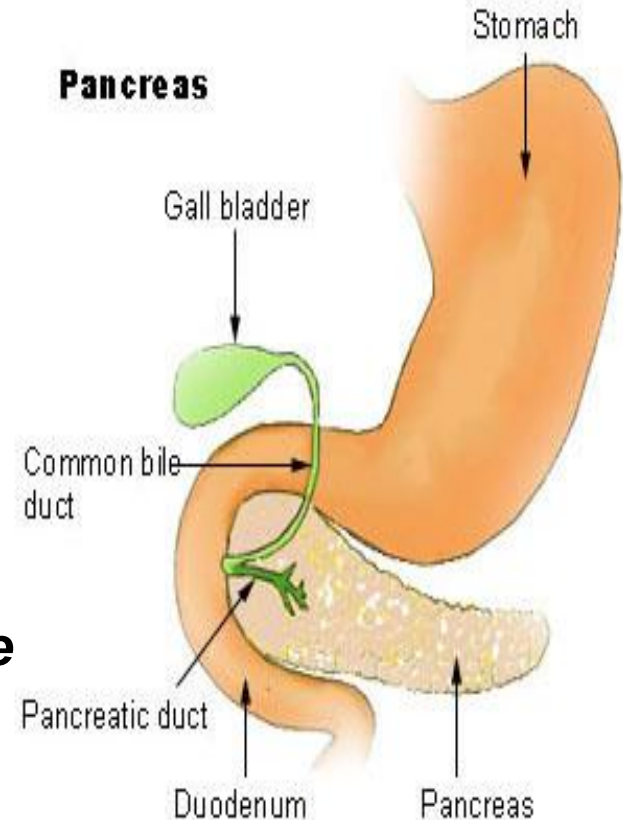
1. *Insulin*

Lowers blood glucose (sugar)

2. *Glucagon*

Raises blood glucose (sugar)

- ***The pancreas lies deep in the abdominal cavity, behind the peritoneum, resting on the posterior abdominal wall.***
- ***The pancreas has both an endocrine (endocrine tissue (pancreatic islets): 1%) and an exocrine function Exocrine tissue (pancreatic acini): 99% .***



- ***Pancreatic islets (islets of Langerhans) :***
- ***secrete insulin and glucagon, hormones that help keep the blood glucose level within normal limits.***
- ***Most pancreatic cells, called pancreatic acinar cells, produce pancreatic juice, which is secreted into tiny tubes that unite, forming ever-larger ones.***
- ***Finally, a single pancreatic duct extends the length of the pancreas to the duodenum.***
- ***Pancreatic Juice :-***
- ***Pancreatic juice contains sodium bicarbonate (NaHCO₃) and digestive enzymes for all types of food.***
- ***Sodium bicarbonate neutralizes chyme; whereas pepsin acts best in an acid pH of the stomach, pancreatic enzymes require a slightly basic pH.***
- ***Pancreatic amylase digests starch, trypsin digests protein, and lipase digests fat.***
- ***Pancreatic juice also contains two nucleases, which are enzymes that break down nucleic acid molecules into nucleotides.***

Diseases of the Digestive System

The most common problems experienced are: bloating, heartburn and acidity, colitis, constipation, diarrhea, nausea and vomiting, trouble digesting...

1. Tooth Decay (dental caries) Bacterial Diseases of the Upper Digestive Tract (Mouth)

- Most common infectious disease of humans
- Young are more susceptible than old

Diseases of the Digestive System

2. Gastritis

- Inflammation of the stomach associated with the production of gastric ulcers
- Caused by *Helicobacter pylori*
- Infection can persist for years or life
- Can develop either peptic or duodenal ulcers or both

Diseases of the Digestive System

3. Mumps

- Mumps is an acute viral infection of the parotid glands (Parotitis)
- Humans are the only source of the virus

Diseases of the Digestive System

4. Hepatitis – inflammation of the liver (A, B, C, D, E, & G)

- Hepatitis A (HAV) – formerly called infectious hepatitis
- Spreads via fecal-oral route
- Most infections are asymptomatic or show only mild symptoms