DIGESTIVE SYSTEM

PREPARED MRIDHULMOHAN

ASSOCIATE PROFESSOR

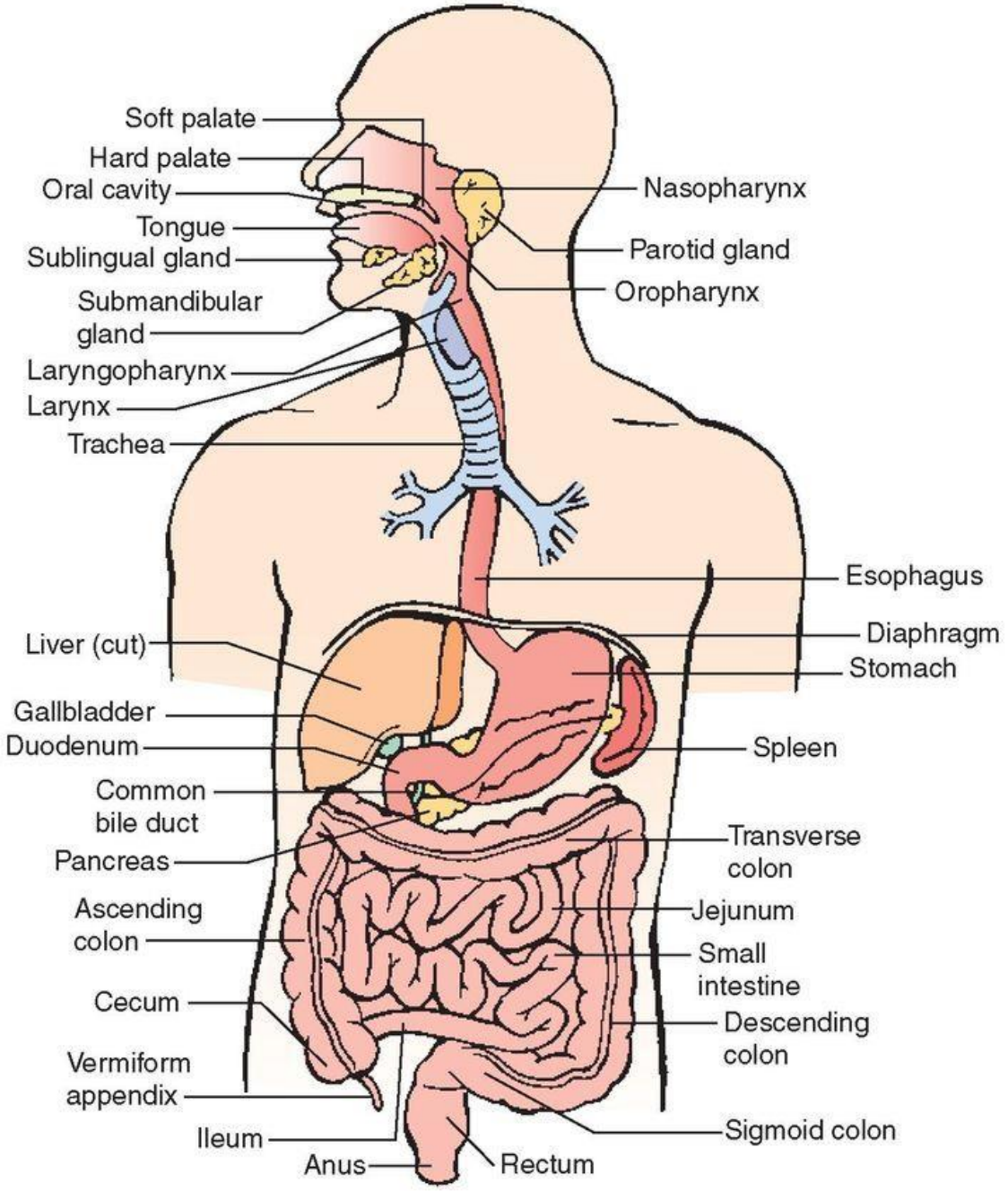
Detp of pharmacology

DIGESTION

- It is the sequence by which food is breakdown and chemically converted so that it can be absorbed by the cells of organism and used to maintain vital functions.

DIGESTIVE SYSTEM

- Group of organs involved in breakdown of food.



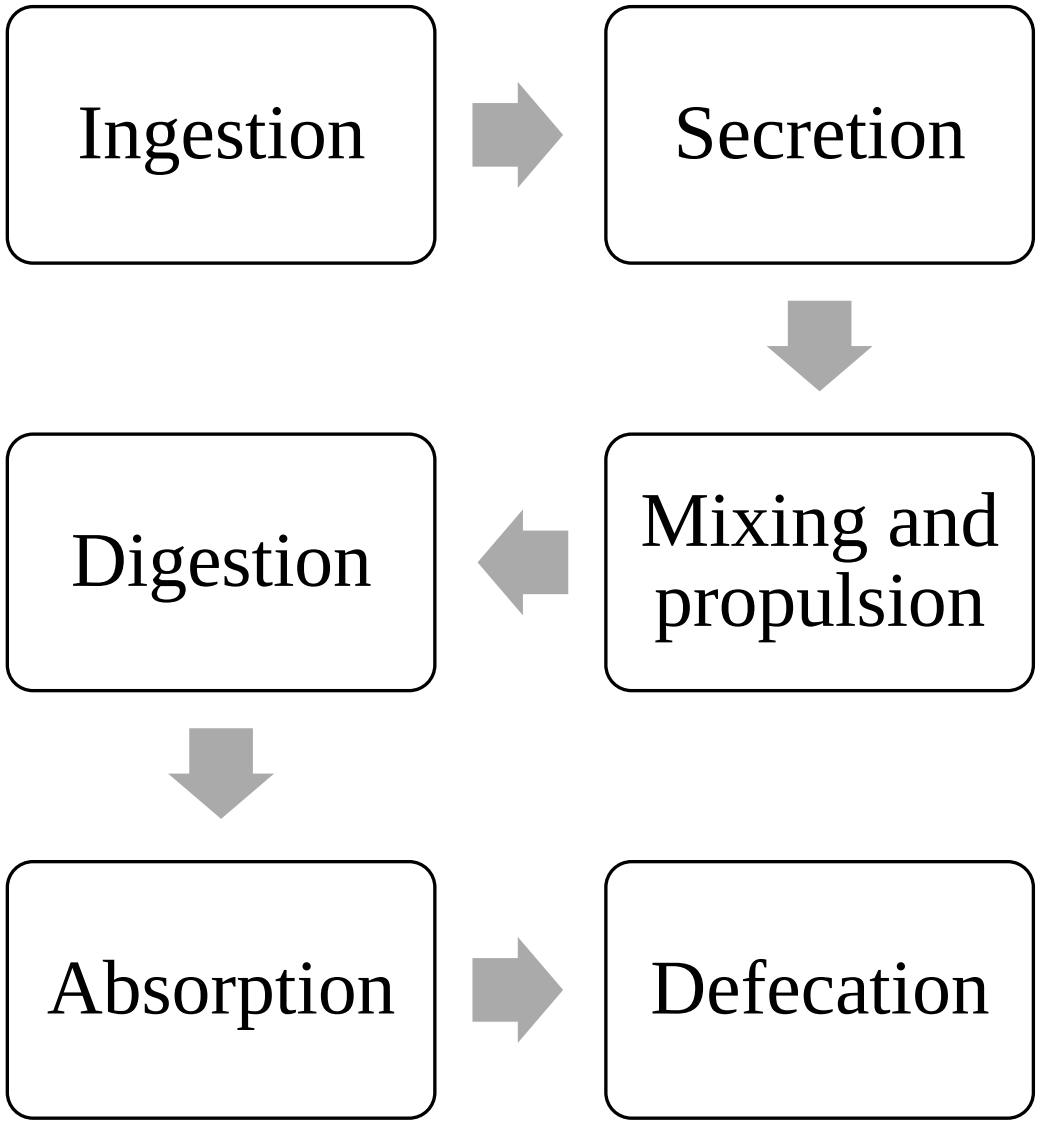
PROCESS OF DIGESTION

- **Ingestion**: process of taking in of food and liquids into mouth.
- **Secretion**: each day cells within walls of GI tract and accessory organs secrete 7L of water, acid, buffers and enzymes into the lumen of tract.
- **Mixing and propulsion**: alternating contractions and relaxations of smooth muscle in the walls of GI tract mix food and secretions and propel towards the anus.

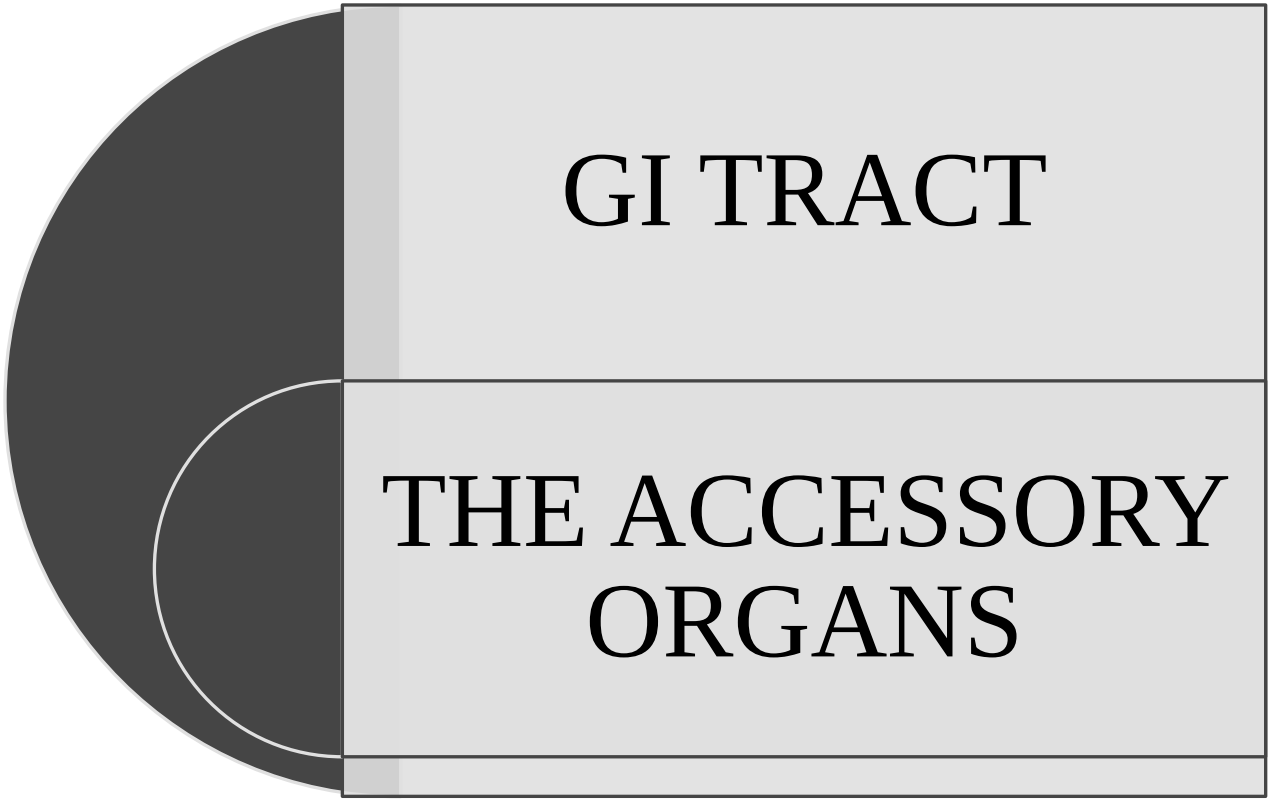
PROCESS OF DIGESTION

- **Digestion**: mechanical and chemical processes break down ingested ood into small molecules.
  - ✓ Mechanical digestion: the teeth cut and grind food before it is swallowed, and then smooth muscles of the stomach and small intestine churn the food. As a result, food molecules become dissolved and thoroughly mixed with digestive enzymes.
  - ✓ Chemical digestion : the large carbohydrate, lipid, protein and nucleic acid molecules in food are split into smaller molecules by hydrolysis.
- **Absorption:** the entrance of ingested and secreted fluids, ions and the products of digestion into the epithelial cells lining the lumen of GI tract.

FUNCTIONS OF DIGESTIVE SYSTEM

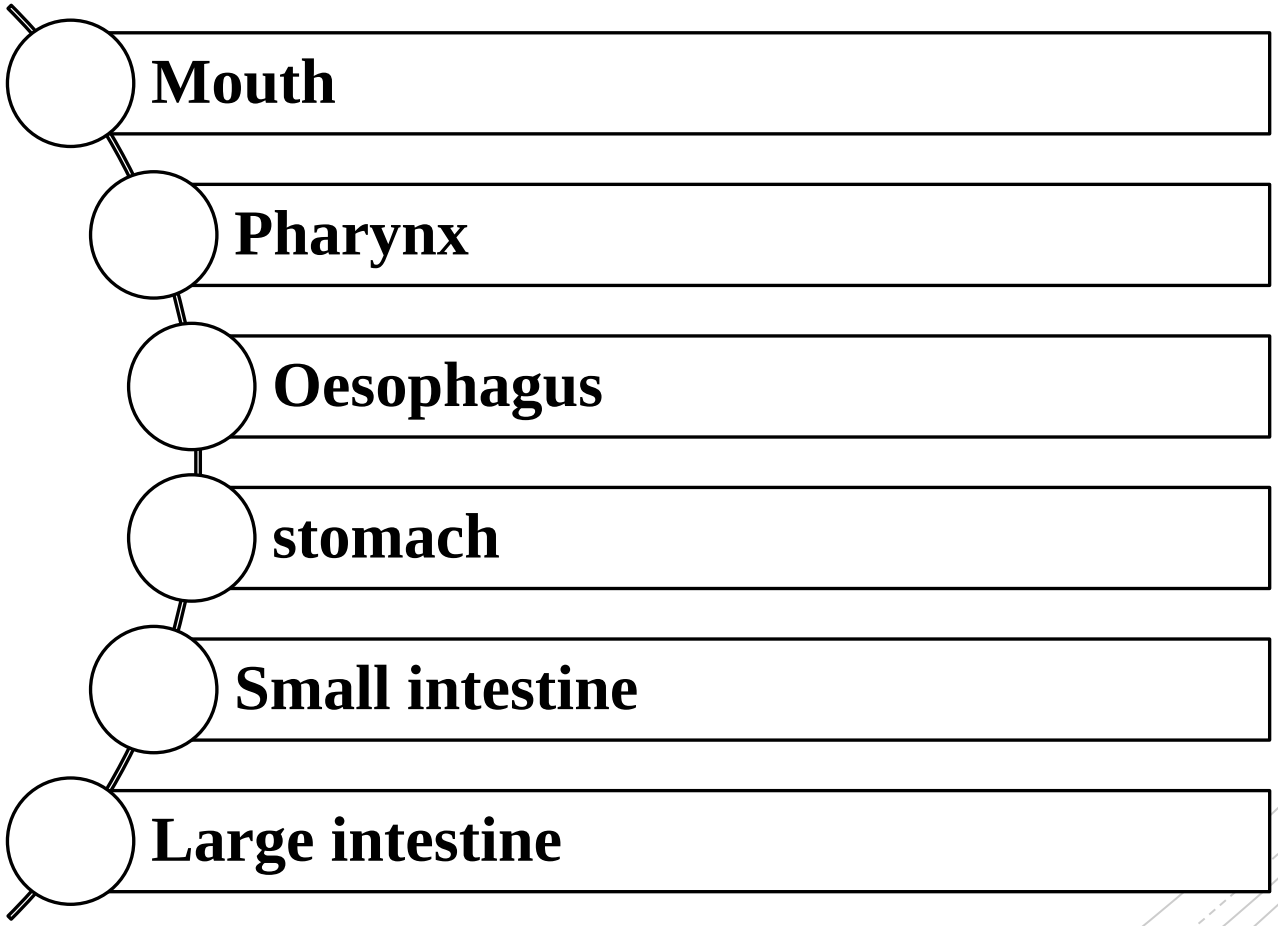


ORGANS OF DIGESTIVE SYSTEM



GASTROINTESTINAL TRACT

- Continues tube extends from mouth to anus through the thoracic and abdomino pelvic cavities.



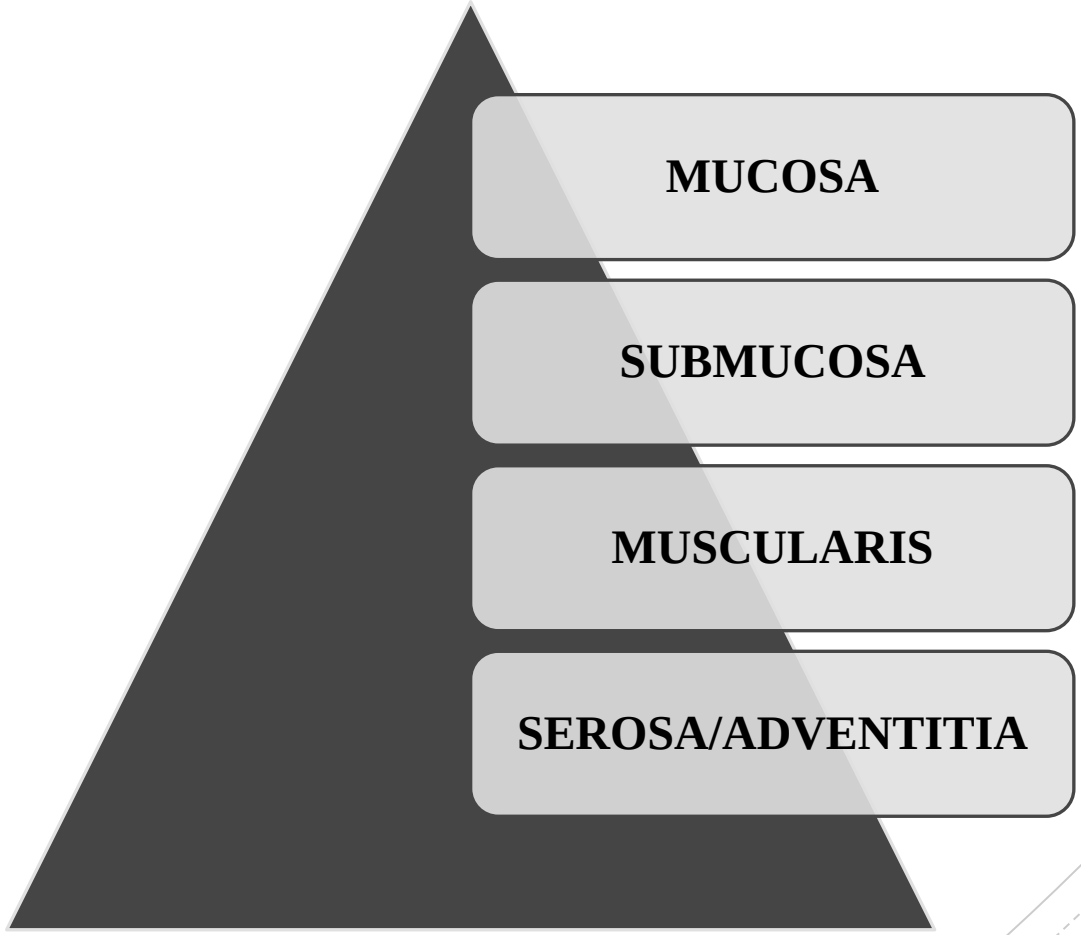
THE ACCESSORY ORGANS

- Most of them have no direct contact with food, produce or store secretions, that flow into the GIT aid in chemical breakdown of food.

- **Teeth**
- **Tongue**
- **Salivary gland**
- **Liver**
- **Gall bladder**
- **pancreas**

LAYERS OF GI TRACT

- The wall of GI tract from oesophagus to the anal canal has 4-layered arrangement of tissues.



MUCOSA

- It is composed of a layer of epithelium in direct contact with contents of GI tract.
- It is the inner lining.
- It consist of 3 layers:

1) **Epithelial layer**: Mouth, oesophagus, anal canal composed of stratified squamous epithelium, serves as protection. Stomach and intestine- simple columnar epithelium helps in absorption and secretion.
2) **Lamina propria**: layer of areolar connective tissue, consist of lymph and blood vessels.
3) **Muscularis mucosae**: thin layer of smooth muscle fibers makes stomach and intestine to small folds that increase surface area for absorption and digestion.

LAYERS OF GI TRACT

SUBMUCOSA:

- It consist of areolar connective tissue.
- It contains blood and lymphatic vessels that receive absorbed food molecules.
- It consist of extensive network of neurons known as submucosal plexus.

MUSCULARIS:

- Mouth, pharynx and superior and middle part of oesophagus consist of skeletal muscles that produces voluntary swallowing.

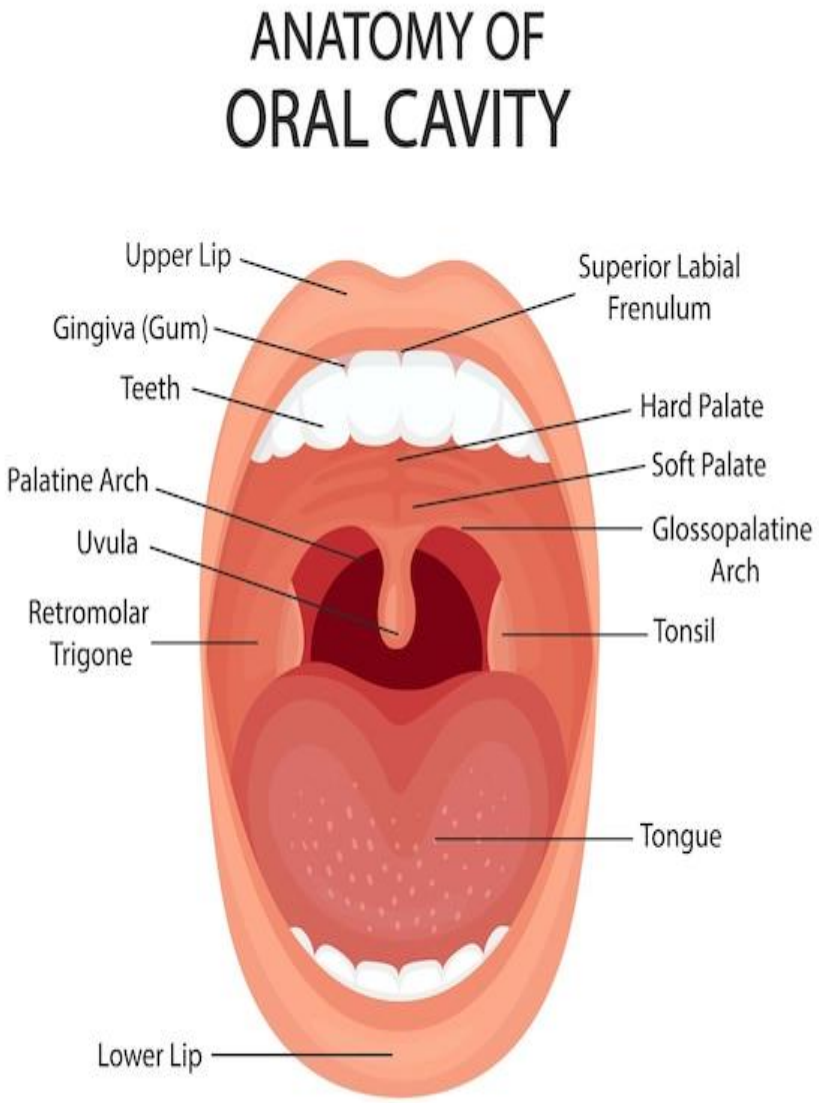
SEROSA:

- Superficial layer of GIT.
- It composed of areolar connective tissue and simple squamous epithelium.

1. MOUTH

MOUTH/ORAL CAVITY OR BUCCAL CAVITY:

- It is formed by the cheeks, hard and soft palates and tongue.
- Cheeks form lateral walls of oral cavity, covered externally by skin and internally by mucous membrane.
- Anterior portion of cheeks end at lips, posteriorly continues with oropharynx, laterally muscles of cheeks, superiorly bony hard palate and muscular soft palate, interiorly by muscular tongue of soft tissue of the floor of mouth.



ORAL VESTIBULE: Part of mouth between gum and cheek.

PALATE: it is the wall or septum that seperate oral cavity from nasal cavity.

- It forms roof of mouth.
- Hard palate: anterior portion of roof of mouth.
- Soft palate: posterior portion of roof of mouth.

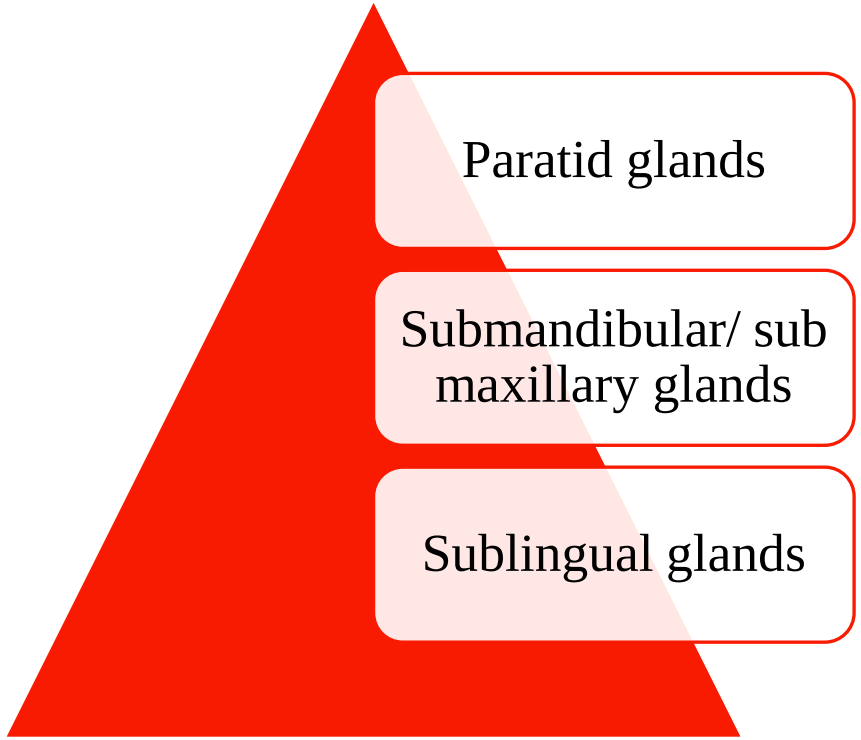
UVULA: Hanging from free border of soft palate is a conical muscular process.

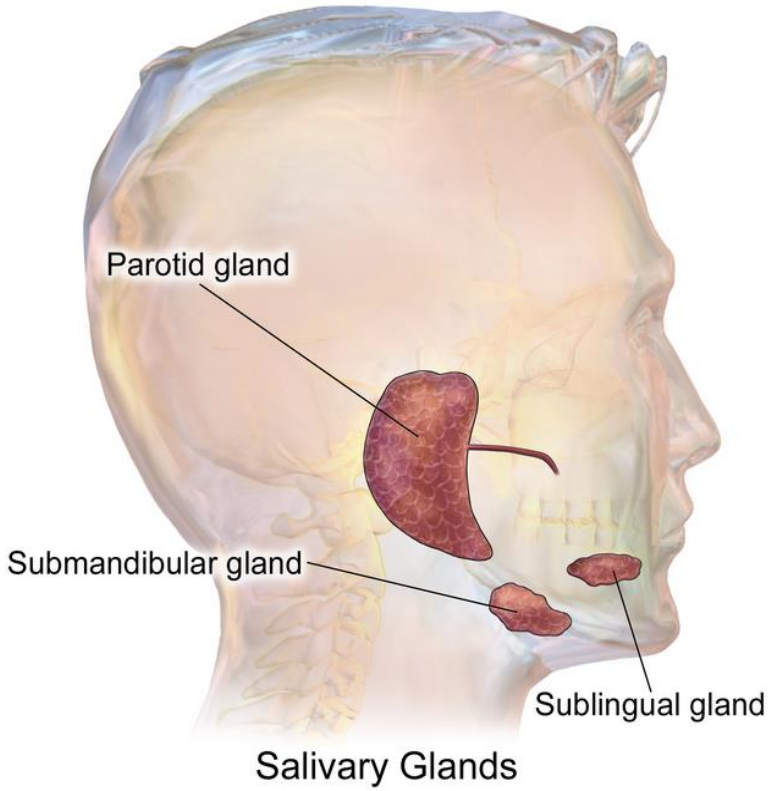
- It is closing off nasopharynx during swallowing to prevent the entry of food to nasal cavity.

- **<u>PALATOPHARYNGEAL ARCH</u>:** posteriorly extends to the side of pharynx.
- Palatine tonsils- situated between arches
- Lingual tonsils- situated at the base of tongue.

SALIVARY GLANDS

- It is a gland that releases a secretion called saliva into the oral cavity.
- 3 pairs of salivary glands:





Salivary Glands

PARATID GLANDS: located inferior and anterior to the ears, between skin and masseter muscles.

- Largest pair of glands.
- 25% of saliva produced by this gland.

SUBMANDIBULAR GLANDS:

- These are found in the floor of mouth beneath the base of tongue.
- 70% of saliva produced.

SUBLINGUAL GLANDS:

- They are located beneath the tongue and superior to submandibular glands.
- 5% of saliva produced.

SALIVA

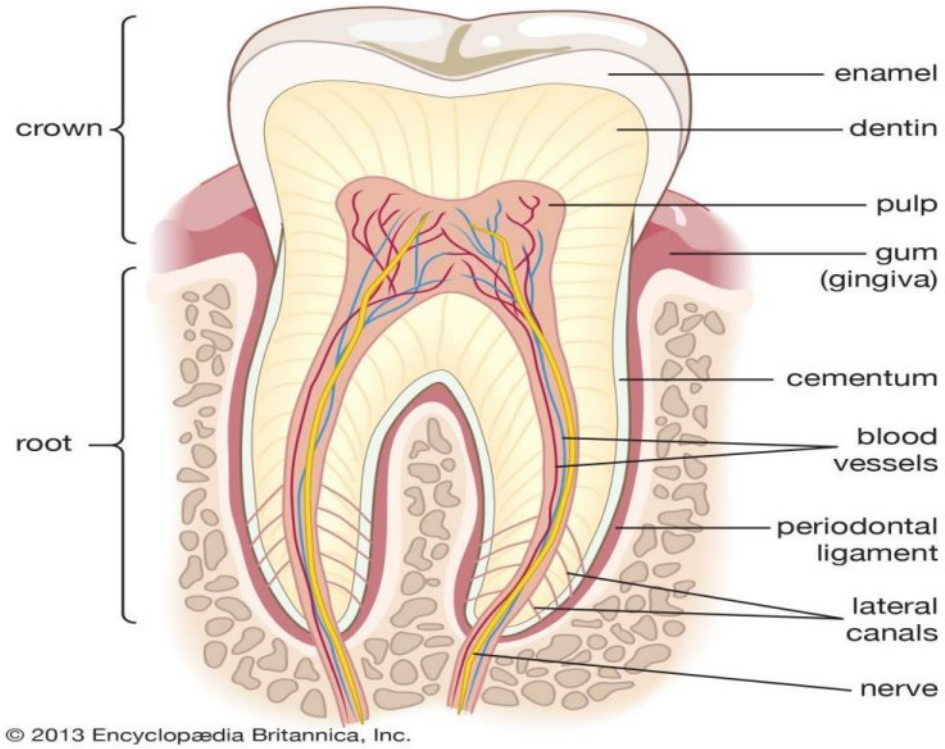
- Saliva consist of 99.5% of water and 0.5% solutes.
- Solids includes anions like chlorides, sulphates and cations like sodium, potassium, calcium and magnesium.
- Volume is 1-1.5L/day.
- PH is slightly acidic (6.35- 6.85)
- **FUNCTIONS**:

1) Chemical digestion of polysaccharides.
2) Liberation of food.
3) Keep mouth moistens and helps in speech.
4) Play role in water and electrolyte balance.
5) Non- specific defence.

TONGUE

- It is an accessory digestive organ composed of skeletal muscles covered with mucous membrane.
- Forms floor of mouth.
- Each half of tongue consist of an identical complement of extrinsic and intrinsic muscles.
- Upper and lateral surface of tongue are covered with papillae.
- They are 4 types:

1) Vallate
2) Folate
3) Fungi form
4) Filliform

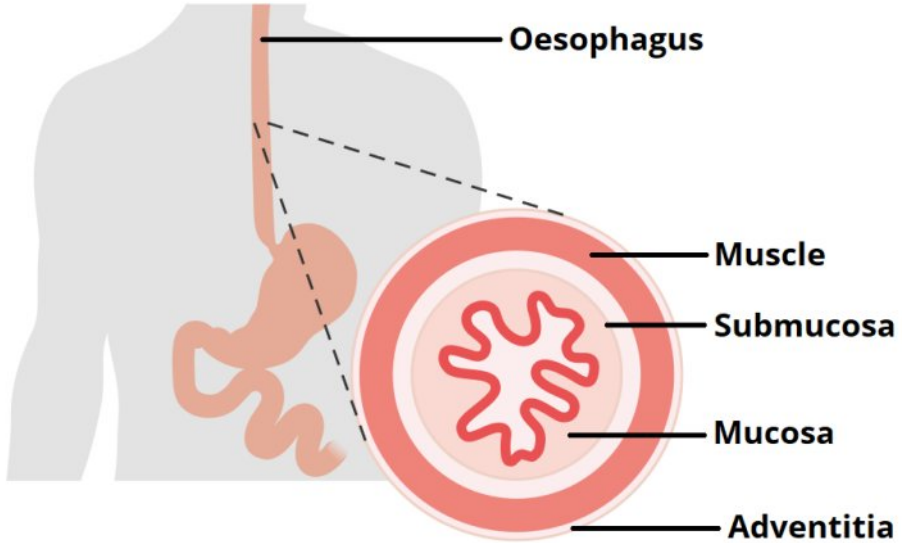


TEETH

- Located in the sockets of alveolar processes of mandible and maxillae.
- Alveolar processes covered by gums.
- Typical teeth has 3 major regions:

1) Crown
2) Neck
3) Root

- Dentine: forms majority of tooth- calcified connective tissue- gives teeth its shape and rigidity.
- Cementum: root of teeth.



OESOPHAGUS

- It is a collapsible muscular tube, 25cm long and lies posterior to trachea.
- Food passes from pharynx through oesophagus finally pushed to stomach.
- It secretes mucus.
- It has 3 layers:

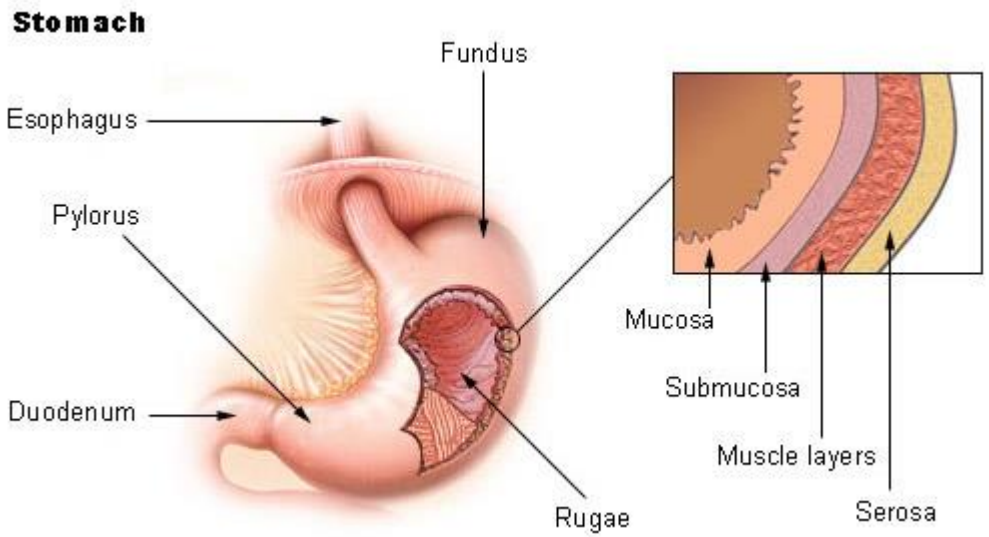
1. **Mucosa** – non- keratinized stratified squamous epithelium.
2. **Submucosa** – areolar connective tissue
3. **Muscularis** – superior layer- skeletal muscles

- At each end of oesophagus, muscularis becomes slightly more prominent and forms 2 sphincters.

1. **Upper oesophageal sphincters**- skeletal muscles, regulates movement of food from pharynx to oesophagus.
2. **Lower oesophageal sphincters**- smooth muscles, regulates movement of food from oesophagus to stomach.

STOMACH

- It is J- shaped enlargement of GI tract.
- It connects oesophagus and duodenum.
- Act as mixing chamber and holding reservoir.
- It forces small amount of food into first part of small intestine.
- Digestion of starch and triglycerides continues, digestion of proteins begins.



ANATOMY OF STOMACH

- It has 4 main regions: the cardia, fundus, body and pyloric part.
- **Cardia**: surrounds the superior opening of stomach.
- **Fundus**: rounded and superior and left of cardia.
- **Pylorus**: region of stomach connecting to duodenum.
- **Rugae:** mucosa has large folds.
- **Pyloric sphincter**: pylorus communicates with duodenum of small intestine via a smooth muscle sphincter.
- **Lesser curvature-** concave medial border of stomach.
- **Greater curvature-** convex lateral border.

FUNCTIONS OF STOMACH

1) It mixes saliva, food and gastric juice to form chyme.
2) Serves as reservoir for food.
3) Secretes gastric juice which contains Hcl, pepsin, intrinsic factor and gastric lipase.

- Hcl: kills bacteria and denatures protein.
- Pepsin: begins digestion of protein.
- Intrinsic factor: aids in absorption of vit B12.
- Gastric lipase: aids in digestion of triglycerides.

4) Secretes gastrin into blood.

GASTRIC GLAND

- The gastric glands contains 3 types of exocrine gland cells that secrete products into stomach lumen.

1. Surface mucous cells or mucous neck cells: secrete mucus.
2. Parietal cells: intrinsic factors and Hcl.
3. Chief cells: pepsinogen and gastric lipase.

- These 3 forms gastric juice- 2000-3000ml/day.
- Enteroendocrine cells (G-cells) located in pyloric antrum and secretes hormone gastrin into the blood stream.

GASTRIC JUICE

- It is a clear colourless fluid containing 0.4% Hcl .
- The gastric juice contains enzyme pepsin, gastric renin and gastric lipase.
- The PH of gastric juice is 0.9-1.5.
- The glands in the mucosa secretes the gastric juice.

COMPOSITION OF GASTRIC JUICE

- Water is the main constituent.
- Mineral salts
- Mucus secreted by the mucus gland in the stomach
- Hydrochloric acid- secreted by parietal cells
- Pepsin – secreted by peptic glands.

FUNCTIONS OF GASTRIC JUICE

1. Water further liquifies the swallowed food.
2. Hydrochloric acid : acidifies the food and stop the action of salivary amylase.
   - Kills ingested microbes
   - Provide acid environment needed for effective digestion by pepsin.
3. Pepsinogen is activated to pepsin in the presence of Hcl.
4. Intrinsic factor is necessary for absorption.
5. Mucus prevents the mechanical injury to the stomach wall by liberating contents.

SECRETION OF GASTRIC ACID

- Both neural and hormonal mechanism control the secretion of gastric juice and contraction of smooth muscle in the stomach wall.
- Gastric secretion occurs in 3 phases.

1) Cephalic phase
2) Gastric phase
3) Intestinal phase

1. CEPHALIC PHASE

- Produces 30% gastric secretion.
- Occurs even before food enters stomach, while eating.
- Smelling, tasting, chewing, swallowing and conditioned reflexes stimulate gastric juice secretion.
- Two mechanisms:

1) Direct stimulation or sensitization of parietal cell by vagus nerves.
2) Indirect stimulation of parietal cell by gastrin.

- Signal originate from cerebral cortex and enters the appetite centres of hypothalamus.
- They send nerve impulses to the medulla oblongata.
- Medulla oblongata transmits impulses to parasympathetic preganglionic neurons in the vagus nerves.
- It stimulates parasympathetic postganglionic neurons in the submucosal plexus.
- Stimulate gastric gland to secrete pepsinogen, Hcl, mucus into stomach, chyme and gastrin into blood.
- It increases stomach motility.
- Emotions such as anger, fear and anxiety may slow down digestion because they stimulate sympathetic nervous system which inhibit gastric activity.

2. GASTRIC PHASE

- It is a period in which swallowed food and semi-digested protein activates gastric activity.
- Ingested food stimulates gastric activity in 2 ways:

1. By stretching the stomach
2. By gastric contents stimulating receptors in stomach.

- The stretch receptors send a message to medulla and then back to stomach via vagus nerve.
- This stimulates parasympathetic neurons to release acetylcholine that provokes secretion of gastric juice.
- Partially digested proteins stimulate release of gastrin from G cells that induce parietal cells to increase production of Hcl.
- The release of gastrin activates vigorous smooth muscle contractions.
- Whenever PH drops too low, cells in stomach react by suspending Hcl secretion and increasing mucus secretion.

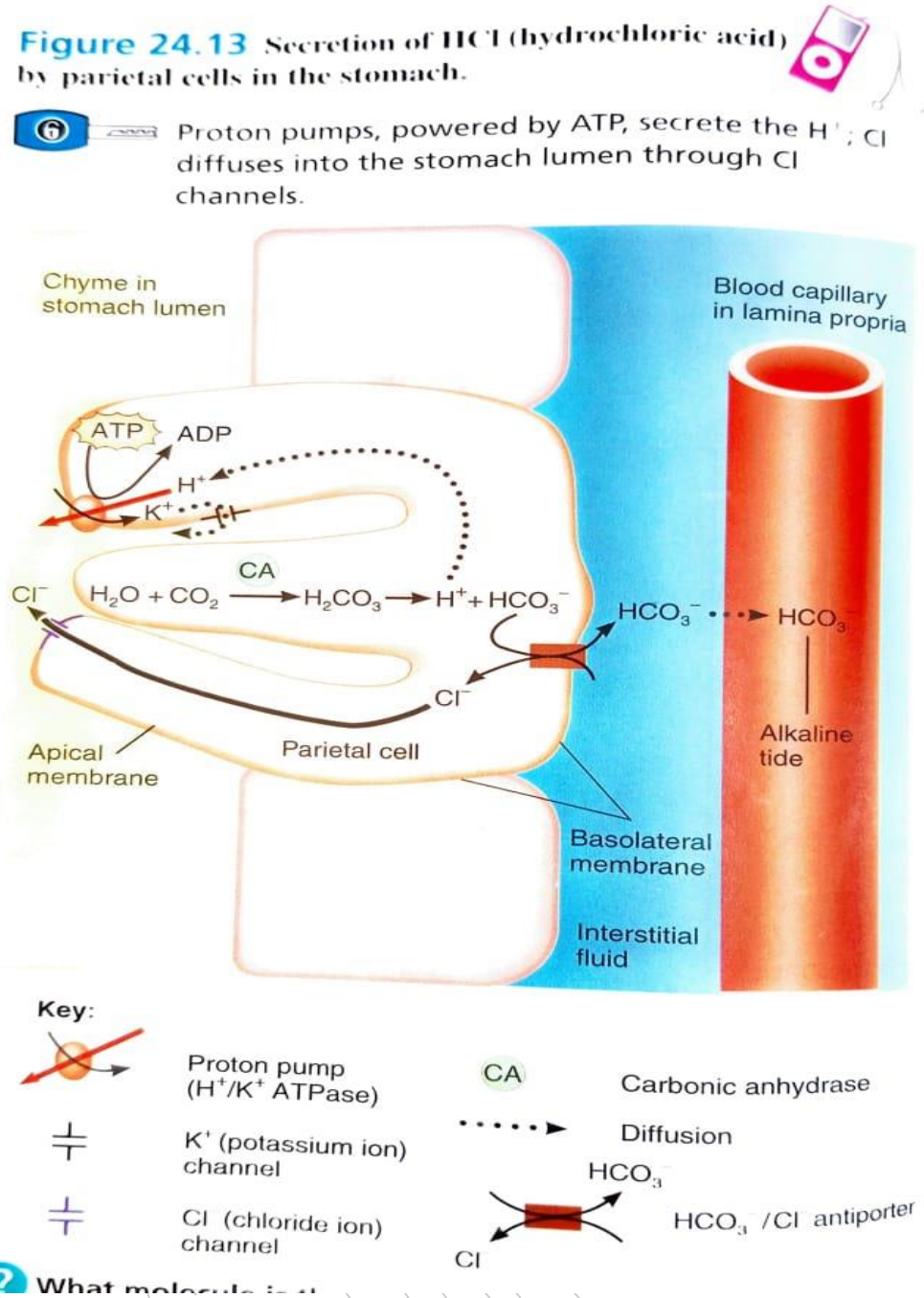
3. INTESTINAL PHASE

- Minor role in acid secretion.
- Duodenum play a major role in regulating the stomach and its emptying.
- When partially digested food fills the duodenum, it triggers enteroendocrine cells in mucosa to release hormones into blood-gastric inhibitory peptide, secretin and CCK.
- Presence of food in small intestine initiates a neural reflex called enterogastric reflex.
- It slow down gastric acid secretion and reduces gastric motility.

ACID PRODUCTION

- The strongly acidic fluid of the stomach destroy so many microbes in food.
- Enzymatic digestion of proteins also begin in the stomach.
- Secretion of Hcl by parietal cells in the stomach.
- Parietal cells secretes hydrogen ions and chloride ions separately in the stomach lumen, the net effect is secretion of Hcl.

H20+ Co2 – H2C03- H+ + HCO3-



- The H+ ion that is formed is transported into the stomach lumen via H+- K+ ATPase ion pump.
- This pump use ATP as an energy source to exchange K+ ions into parietal cells of stomach with H+ ions.
- The HCO3- ion is transported out the cell into blood via a transporter protein called anion exchanger which transports the HCO3- ion out the cell in exchange for a Cl-.
- It is then transported into stomach lumen via a chloride channel, results in presence of both H+ and Cl- ions.
- The opposing charges leads to associate each other to form HCl.

MECHANICAL DIGESTION OF STOMACH

- Several minutes after food enters the stomach, gentle, rippling, peristaltic movements called mixing waves pass over the stomach every 15-25 seconds.
- These waves macerate food, mix it with secretions of gastric glands, reduces it to a soupy liquid called chyme.
- As digestion proceeds in the stomach and intensify as they reach pylorus.
- The pyloric sphincter normally remains, almost but not not completely closed.

MECHANICAL DIGESTION OF STOMACH

- Most of the chyme is forced back into the body of stomach, where mixing continues.
- The next wave pushes the chyme forward again and forces a little more into the duodenum.
- These forward and backward movements of the gastric contents are responsible for most mixing in stomach.

CHEMICAL DIGESTION

- Food may remain in the fundus for about an hour with out becoming mixed with gastric juice.
- Digestion due to lingual lipase and salivary amylase continues.
- The chyme is formed by food mixes with gastric secretions, the enzymes are inactivated.
- Parietal cells secretes Hcl , kills the microbes in the food and denatures proteins in the food.
- The enzymatic digestion of proteins begins in the stomach.

CHEMICAL DIGESTION

- The pepsin (proteolytic enzyme) breaks the proteins in to smaller molecules.
- The another enzyme in stomach is gastric lipase , splits the triglycerides in to fat molecules.
- Renin milk protein convert caseinogen to casein, which is then digested by pepsin.
- The stomach wall is impermeable to the passage of most materials into blood.
- So most substances are not absorbed until they reach to small intestine.

PANCREAS

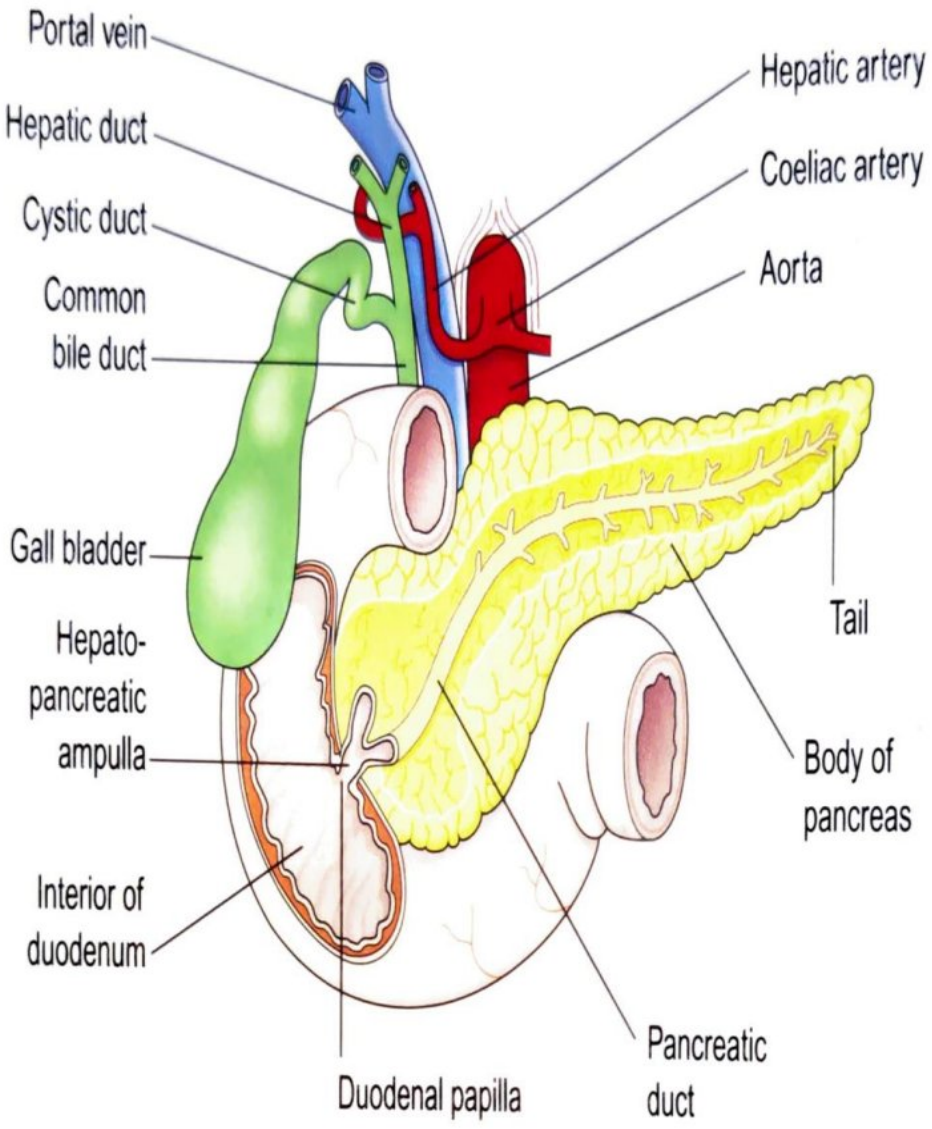
- From stomach chyme passes into small intestine.
- Chemical digestion in the small intestine depends on the activities of pancreas, liver and gall bladder.

ANATOMY OF PANCREAS

- Pancreas is a pale grey gland weighing about 12-15cm in length, 2.5cm thickness.
- Situated in the epigastric and left hypochondriac regions of the abdominal cavity.
- Lies posterior to the greater curvature of stomach.
- Pancreas consist of head, body and a tail, usually connected to duodenum by 2 ducts.
- The head lies in the curve of duodenum, the body behind the stomach and the tail lies infront of the left kidney.

ANATOMY OF PANCREAS

- Pancreas is both an exocrine and endocrine gland.
- The exocrine pancreas: made up of small clusters of glandular epithelial cells.
- About 99% of the cells are arranged in clusters called acini and constitute the exocrine portion of pancreas.
- Remaining 1% of clusters to form pancreatic islets form the endocrine portion of pancreas.
- They secrete hormones, glycogen, insulin and pancreatic peptide.
- Pancreatic juices are secreted by exocrine cells into small ducts that ultimately unite to form 2 larger duct that convey secretions into small intestine.



PANCREATIC DUCT: in most people pancreatic duct joins the common bile duct from the liver and gall bladder and enters the duodenum as a dilated common duct known as Hepatopancreatic ampulla.

- The duodenal opening of the ampulla is controlled by hepatopancreatic sphincter.

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PANCREATIC JUICE

- Daily pancreas produces 1200-1500ml of pancreatic juice.
- It is clear, colourless liquid consist of water, sodium bicarbonate, some salts and several enzymes.
- The sodium bicarbonate gives pancreatic juice a slightly alkaline PH (7.1- 8.2) ,that buffers acidic gastric juice in chyme, creates proper PH for action of digestive enzymes in the small intestine.
- The enzymes in pancreatic juice includes:

1. Pancreatic amylase- carbohydrate digesting enzyme (starch).
2. Trypsin, chymotrypsin, carboxy peptidase and elastase- protein digesting enzymes.

PANCREATIC JUICE

3. Pancreatic lipase- triglyceride digesting enzymes in adults.

4. Ribonuclease- nucleic acid digesting enzymes.

5. Deoxyribonuclease – digest RNA and DNA into nucleotides.

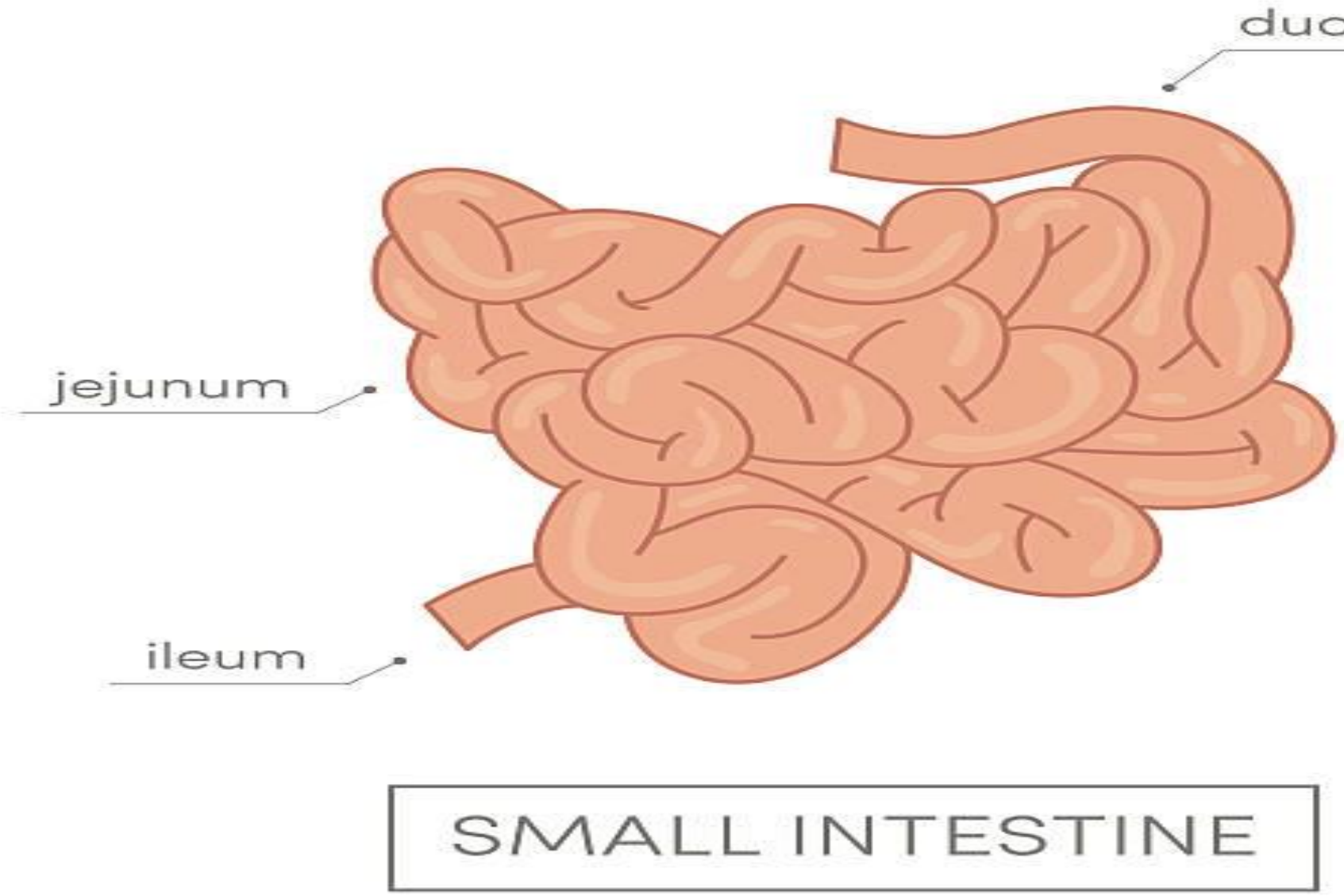
- Trypsin is secreted in an inactive form called trypsinogen.
- When trypsinogen reaches the lumen of small intestine, it comes in contact with an activating brush border enzyme called enterokinase.
- It split off trypsinogen molecule to trypsin.
- Trypsin act as an inactive precursors to produce chymotrypsin, carboxypeptidase and elastase.

FUNCTIONS OF PANCREATIC JUICE

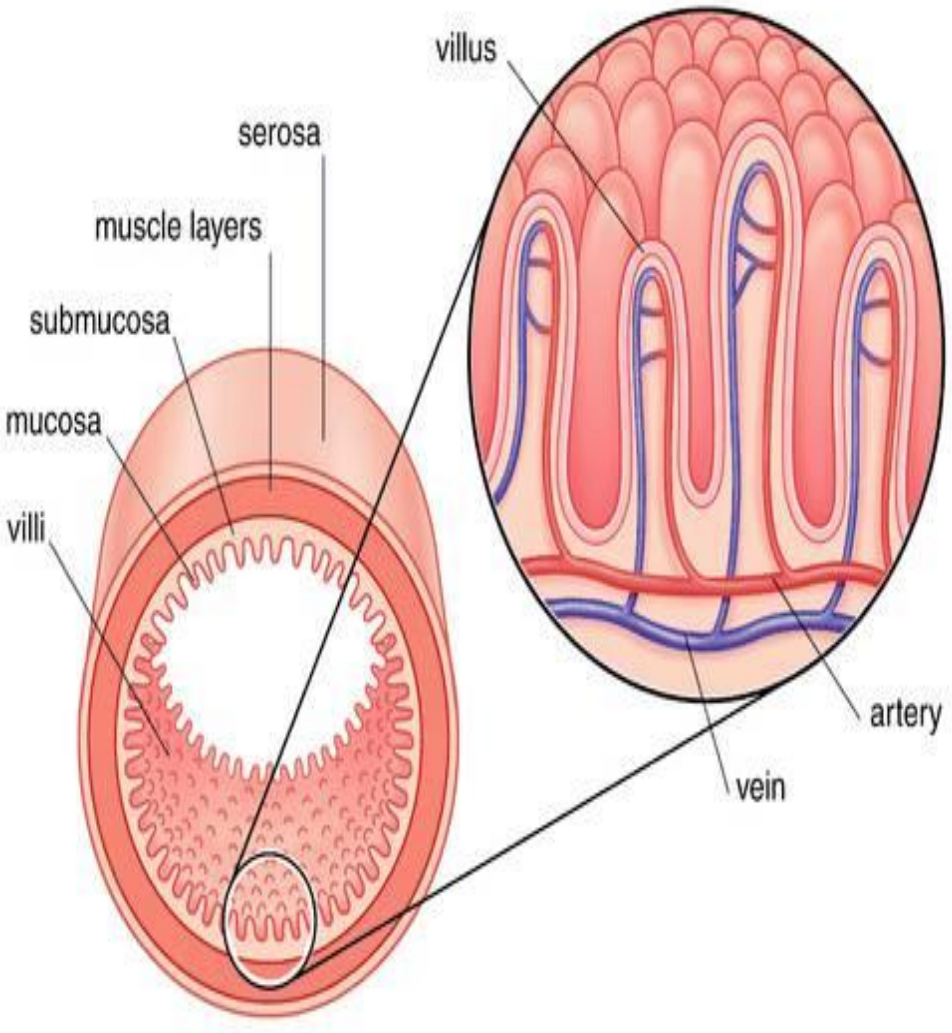
1. Digestive function: digest proteins, fats, carbohydrates and nucleic acids.
2. Neutralization: highly alkaline neutralizes Hcl in chyme that enters duodenum.

SMALL INTESTINE

- Small intestine is extended from pylorus of stomach to the colon .
- It is approximately 5-7 meters in length and 2.5 inch in diameter.
- It is lies in the abdominal cavity surrounded by the large intestine.
- Small intestine is divided in to 3 parts
  1. Duodenum
  2. Jejunum
  3. ileum


duodenum
jejunum
ileum
SMALL INTESTINE

HISTOLOGY OF SMALL INTESTINE



- The wall of small intestine consists of 4 layers of tissues.

1. Serosa: The outer layer consist of circular folds, villi and microvilli.
2. Muscular layer: The middle layer consists of smooth muscles ,circular muscles.
3. Sub mucosa: It consists of loose connective tissue.
4. Mucosa: This layer consists of some permanent folding, these help to mixing of chyme as it passes along.

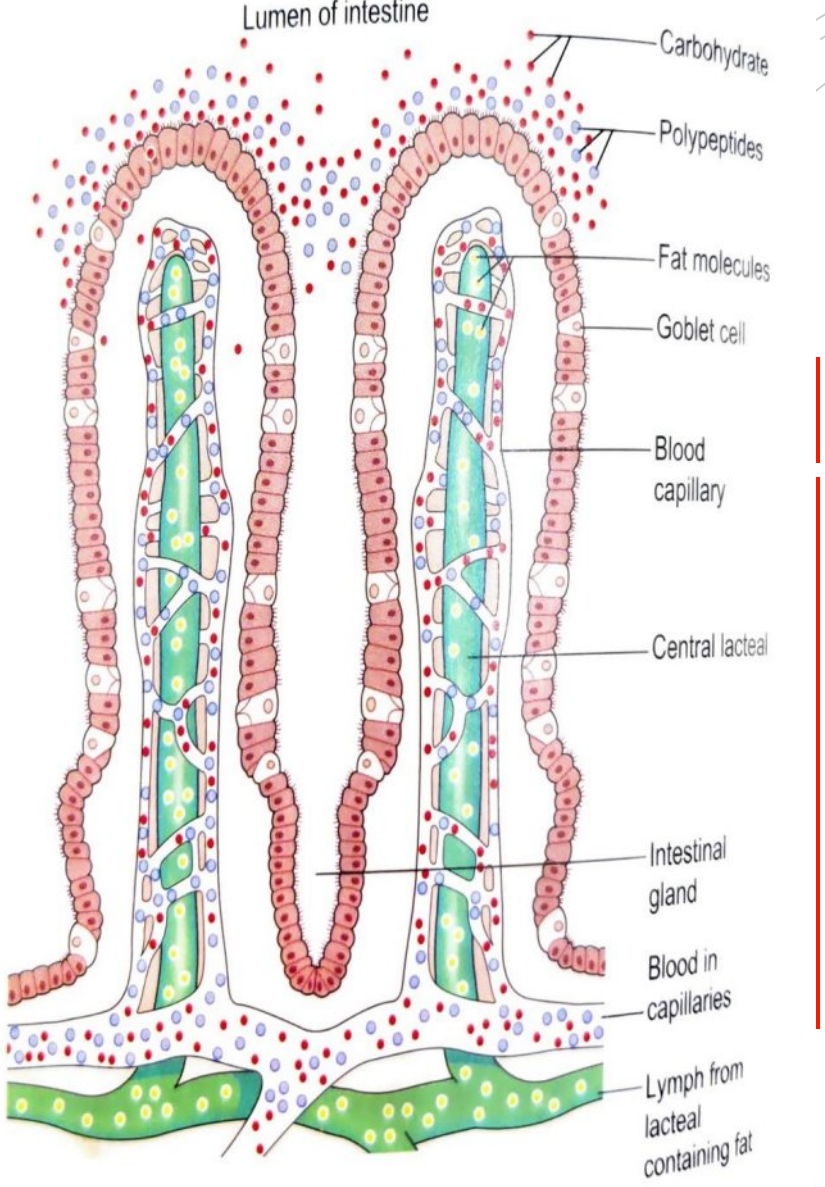


Figure 12.27 The absorption of nutrients into villi.

- The surface of mucous membrane of small intestine covered with minute finger like projections called villi
- Villi is about 0.5-1mm long. Their wall consists of columnar epithelium with tiny microvilli on their borders.
- These epithelial cells encloses a network of blood and lymph capillaries.
- These lymph capillaries known as lacteals.
- Absorption and some final stage of digestion of nutrients take place in the cells of villi before entering the blood and lymph capillaries.

INTESTINAL JUICE

- It is a clear yellow fluid secreted in 1-2L per day.
- Slightly alkaline PH of 7.6.
- Composition : water, mucous, enzymes like enterokinase, amlyase, peptidases, lipase, sucrase, maltase and lactase.
- Functions: Amylase converts polysaccharides to disaccharides, peptidases and polypeptidases converts peptides into amino acids ,Lipase converts fats in to fatty acids and glycerol, sucrase, maltase and lactase converts to disaccharides.

BRUSH BORDER ENZYMES

- The absorptive cells of small intestine produces several digestive enzymes known as brush border enzymes.
- 4 carbohydrate digesting enzymes- α – dextrinase, maltase, sucrase and lactase.
- Protein digesting enzymes- peptidases
- Nucleotide digesting enzymes- nucleotidases and phosphatases.

MOVEMENTS OF SMALL INTESTINE

- Movements of small intestine are important to mix the chyme with digestive juices, absorption of digested food and to propel the chyme further.
- 3 types of movements seen in small intestine.

1. Peristalsis
2. Segmentation
3. pendular

MOVEMENTS OF SMALL INTESTINE

1. **PERISTALSIS**: it is a wave of contraction proceeded by wave of relaxation. It helps in propelling the chyme further.
2. **SEGMENTATION**: In this movement circular muscle contract at regular intervals thus dividing the intestine into number of segments. It helps in the mixing of food with digestive juices and absorption of digested food.
3. **PENDULAR**: This movement similar to the segmentation but here segments move to and fro over the food in the pendular fashion at the rate of 5cm/sec. It helps in the mixing and absorption of the digested food.

FUNCTIONS OF SMALL INTESTINE

- SEGMENTATION: It mix chyme with digestive juices and bring food with mucosa for absorption.
- ABSORPTION: Absorbs about 90% of nutrients and water that pass through digestive system.
- Secretion of hormones, eg: secretin, choleocytokinin (CCK).
- DIGESTION: Complete digestion of proteins, carbohydrates and lipids.
- Secretion of intestinal juice.

MECHANICAL DIGESTION OF SMALL INTESTINE

- Movement segmentation are localized and mix chyme with digestive juices and bring the particles of food in contact with the mucosa for absorption.
- They donot push the intestinal contents along the tract.
- Segmentation occur rapidly in duodenum- 12 times/ min and slow down to 8 times/min in the ileum.
- After most absorption peristalsis begins- migrating motility complex.

CHEMICAL DIGESTION OF SMALL INTESTINE

- The chyme entering the small intestine contains partially digested carbohydrates, proteins and lipids.
- The completion of digestion of carbohydrates, proteins and lipids is a collective effort of pancreatic juice, bile and intestinal juice in the small intestine.

DIGESTION OF CARBOHYDRATES

- In stomach only a few starches are breakdown.
- Pancreatic amylase breaks starch to maltose, maltriose and alpha dextrins.
- 3 brush border enzymes breakdown disaccharides to monosaccharides.
- Sucrase breaks sucrose to glucose and fructose.
- Maltase converts maltose to glucose and glucose.
- Lactase converts lactose to glucose and galactose.
- Digestion of carbohydrates ends with the production of monosaccharides.

DIGESTION OF PROTEINS

- Protein digestion starts in the stomach where proteins are fragmented into peptides by the action of pepsin.
- Enzymes in pancreatic juice- trypsin, chymotrypsin, carboxypeptidase and elastase continue to breakdown proteins into peptides and also these enzymes convert whole proteins to peptides.
- Protein digestion is completed by 2 brush border enzymes- aminopeptidase and dipeptidase they split dipeptides to single amino acids.

DIGESTION OF LIPIDS

- The most abundant lipids in the diet are triglycerides, which consist of a molecule of glycerol bonded to 3 fatty acid molecules.
- Lipases are the enzymes that split triglycerides and phospholipids.
- 3 lipases- lingual lipase, gastric lipase, pancreatic lipase.
- Lipid digestion in stomach is by lingual and gastric lipase.
- Small intestine by action of pancreatic lipase it converts triglycerides to fatty acids and monoglycerides.

DIGESTION OF NUCLEIC ACIDS

- 2 types of pancreatic nuclease responsible for their digestion.
- Deoxyribonuclease, which digest DNA and Ribonuclease digest RNA.
- Nucleotides hydrolysed by brush border enzymes- nucleotidases and phosphatases into phosphates and nitrogen bases.
- This can be absorbed through the alimentary canal via active transport.

LIVER

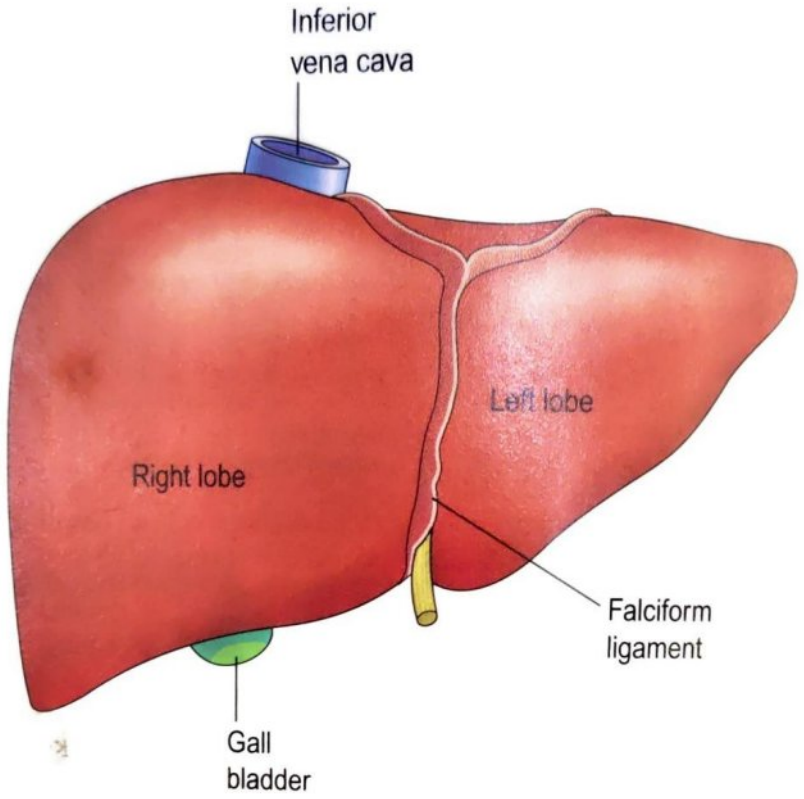


Figure 12.33 The liver: anterior view.

- Heaviest gland in the body, weighing 1-2.3kg.
- Situated in the upper part of abdominal cavity, inferior to diaphragm and occupies greater part of right hypochondriac region and part of epigastric region. Of abdominopelvic cavity.

ANATOMY

- Liver is almost completely covered by visceral peritoneum as well as completely covered by a dense irregular connective tissue layer that lies deep to the peritoneum.

ANATOMY OF LIVER

- It is divided into 2 principle lobes- a large right lobe and a smaller left lobe by falciform ligament.
- Right lobe is divided into inferior quadrate lobe and posterior caudate lobe.
- Portal fissure- this is the region on the posterior surface of liver where various structures enter and leave the gland.
- Ligamentum- a fibrous cord that is remenant of umbilical vein of fetus.

HISTOLOGY OF LIVER

- The lobes of liver are made up of many functional units called lobules.
- A lobule consist of specialized epithelial cells called hepatocytes.
- **Hepatocytes**- major functional cells of the liver perform metabolic, secretory and endocrine functions.
- They are specialized epithelial cells with 5-12 sides that make up about 80% volume of the liver.

- They form complex 3D arrangements called **hepatic laminae.**
- **Bile canaliculi**- small ducts between hepatocytes that collect bile produced by hepatocytes.
- **Hepatic sinusoids**- instead of capillaries liver has a large endothelial spaces called sinusoids through which blood passes.
- Sinusoids through which stellate reticular endothelial cells (**kupffers cells**).
- These phagocytes destroy worn out while RBC, bacteria and other foreign matter in the blood draining the GIT.

FUNCTIONS OF LIVER

- Carbohydrate metobolism
- Fat metabolism
- Protein metabolism
- Storage of fat soluble vitamins, iron, copper, water soluble vitamins- niacin, riboflavin.
- Detoxification of drugs
- Synthesis of bile salts, vit A from carotene.
- Produces large quantity of heat.

BILE

- Bile secreted by hepatocytes enters bile canaliculi which are narrow intercellular canals that empty into small bile duct.
- These form the larger right and left hepatic ducts, which unite and exit the liver as the common hepatic duct.
- Then the common hepatic diet joins the cystic diet from the gall bladder to form the common bile duct.
- Bile is temporarily stored in the gall bladder.

BILE

- Each day hepatocytes secrets 800-1000ml of bile.
- A yellowish brownish or olive green liquid.
- PH- 7.6- 8.6.
- Consists of water, mineral salts, mucus, bile pigments, bile salts, cholesterol and a phospholipid called lecithin.
- Principle bile pigment is bilirubin.

FUNCTIONS OF BILE

1. Fat digestion.
2. Absorption- bile salts.
3. Buffer action- mucin.
4. Excretion- heavy metals, toxins.
5. Secretagogue: stimulates secretin.

GALL BLADDER

- It is a pear-shaped sac that is located in a depression of posterior surface of liver.
- It is 7-10cm long, typically hangs from the anterior inferior margin of the liver.
- ANATOMY: part of gall bladder include broad fundus- projects inferiorly beyond the inferior border of liver.
- Body- central portion
- Neck- tapered portion- body and neck projected upward.

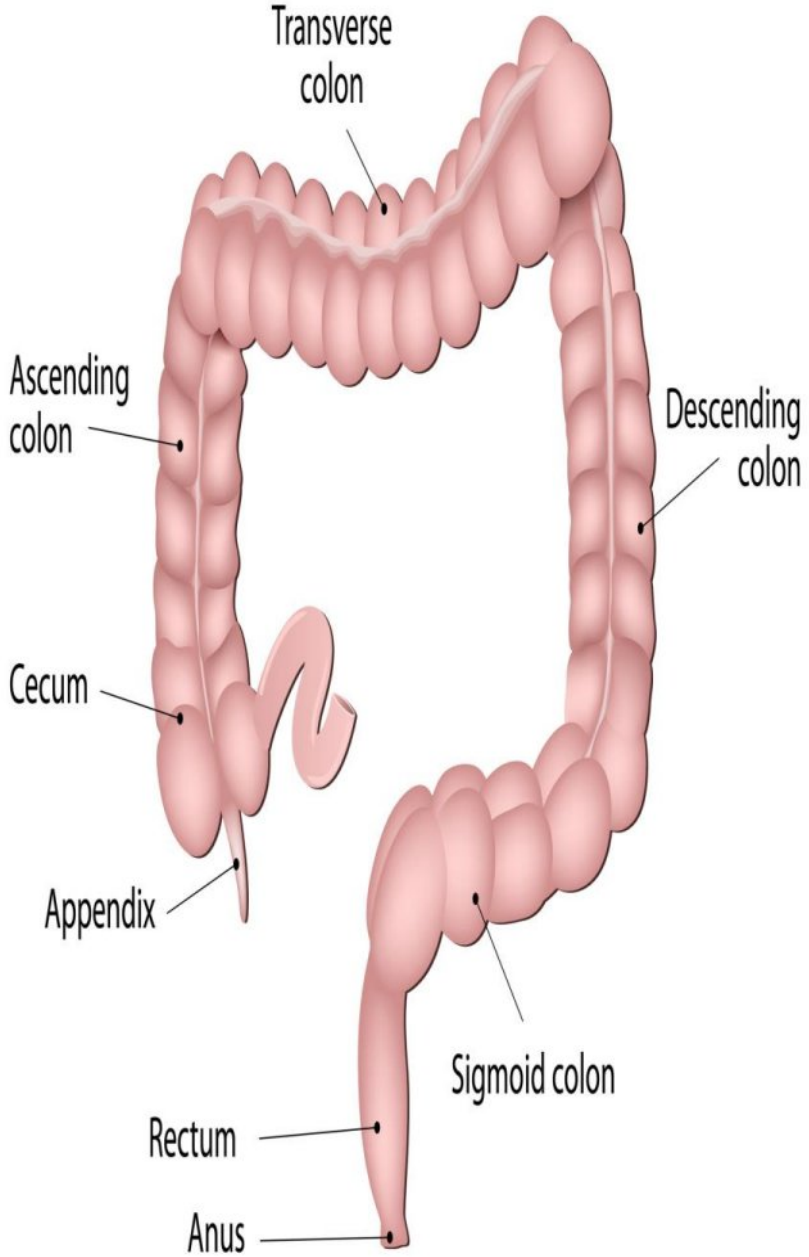
- Mucosa of the gall bladder arranged like rugae in stomach.
- Composed of simple columnar epithelium.
- Contraction of smooth muscles fibers ejects the contents of gall bladder into cystic duct.
- Outer coat- visceral peritoneum.

FUNCTIONS:

1. Storage of bile.
2. Concentration of bile by reabsorbing water and electrolytes except K and Ca.
3. Secretion of mucin.
4. Regulates pressure in biliary system by appropriate contraction and relaxation.

LARGE INTESTINE

- Large intestine is about 5 feet in length and wider than small intestine.
- Last part of digestive system.
- Four regions: cecum, colon, rectum and anus.
- Absorption of water and removal of waste material by defecation.
- Waste materials is stored in rectum as feces.



ANATOMY OF LARGE INTESTINE:

- **Ileocecal sphincter**: folds of mucous membrane which guard the opening from ileum to large intestine, passes food from small intestine to large intestine.
- **Cecum**: sac like , first part of large intestine.
- **Appendix**: hanging from the cecum , a potential trouble spot, since its an ideal location for accumulation of bacteria.

ANATOMY OF LARGE INTESTINE

- **Ascending colon**: it travels up the right side of the abdominal cavity and makes a turn, the right colic flexure, to travel across the abdominal cavity.
- **Transverse colon**: the ascending colon makes a turn and continuous to be the transverse colon as it travels across the abdominal cavity.
- **Descending colon**: it then turns again at the left colic flexure, and continue the left side as descending colon.

ANATOMY OF LARGE INTESTINE

- **Sigmoid colon**: the intestine then enters the pelvis, where it becomes the S-shaped sigmoid colon.
- **Anal canal**: it ends at the anus which opens to the exterior.
- **External anal sphincter**: the anal canal has an external voluntary sphincter, composed of skeletal muscle.
- **Internal involuntary sphincter**: it is formed by smooth muscles.

HISTOLOGY OF LARGE INTESTINE

- 4 layers: mucosa, submucosa, muscularis, serosa.
- Mucosa: simple columnar epithelium.
- Lamina propria: areolar connective tissue.
- Muscularis : longitudinal and circular smooth muscles.
- Epithelial layers of large intestine includes absorptive and goblet cells.
- Absorptive cells- water absorption
- Goblet cells- mucus secretion, lubricates the passage.
- No circular folds or villi.

FUNCTIONS OF LARGE INTESTINE

1. Absorption of water
2. Absorption of glucose, amino acid.
3. Mucous in the large intestine act as a lubricant.
4. Helps in maintaining the body temperature.
5. Forms and stores feces.
6. Carries out defecation.

MECHANICAL DIGESTION OF LARGE INTESTINE

- The passage of chyme from the ileum into the cecum is regulated by the action of ileocecal sphincter.
- Movements of the colon begin when substances pass the ileocecal sphincter.
- It fills the cecum and accumulates in the ascending colon.
- Haustral churning- haustra remain relaxed and become distended while they fill up.

MECHANICAL DIGESTION OF LARGE INTESTINE

- When the distension reaches a certain point, the walls contract and squeeze the contents into the next haustrum.
- Peristalsis occurs- final type of movement is mass peristalsis.
- A strong peristaltic wave begins at about middle of transverse colon and quickly drives the contents of the colon into the rectum.

CHEMICAL DIGESTION OF LARGE INTESTINE

- Final stage of digestion occurs in the colon.
- Mucus is secreted by the glands of large intestine, but no enzymes are secreted.
- Chyme prepared for dimination of bacterial action which ferment remaining carbohydrates and release hydrogen, CO2 and methane gas.
- This contribute to the flatus gas in the colon.
- Bacteria breakdowns remaining proteins to amino acids and it to simpler substances: indole, skalole are eliminated in feces and contributes to the odour.

CHEMICAL DIGESTION OF LARGE INTESTINE

- Bacteria also decomposes bilirubin to simpler pigments including stercobilin gives feces brown color.
- By the time chyme remained in the large intestine 3-10hrs, it become semi-solid due to water absorption and is now called feces.
- Chemically feces consist of water, inorganic bacteria, products of bacterial decomposition, indigestible parts of food.
- 90% of water absorption occurs in small intestine but some amount by osmosis.
- It also absorbs ions such as sodium, chlorides and some vitamins.

ABSORPTION OF NUTRIENTS

- Huge surface area due to villi and microvilli.
- Increase in surface area increases absorption.

ABSORPTION OF CARBOHYDRATES

- All the carbohydrates in the food are absorbed in the form of monosaccharides only a small fraction are absorbed as disaccharides.
- Glucose, galactose- active transport of sodium symporter.
- Fructose- facilitated diffusion in luminal membrane.
- Pentose- passive diffusion.