Digestive System

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Digestive System

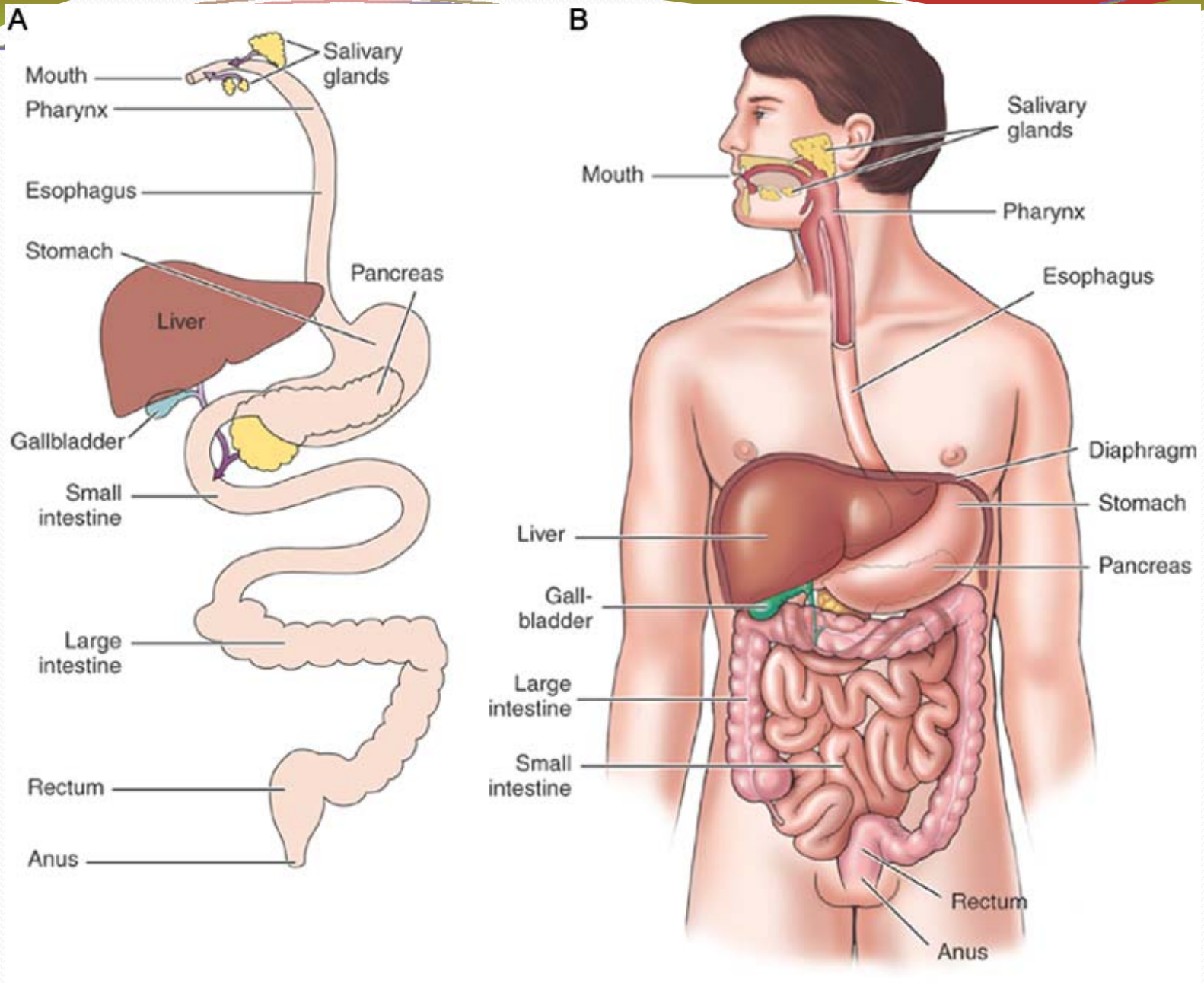
- Function of Digestive System:
  - Ingestion of food
  - Digestion
  - Absorption of end-products
  - Elimination of waste

Digestive System

- The digestive system consist of the following:
  - Mouth
  - Pharynx
  - Esophagus
  - Stomach
  - Small intestine
  - Large intestine
  - Rectum
  - Anus

Digestive System

- Accessory organs include:
  - Salivary glands
  - Teeth
  - Liver
  - Gallbladder
  - Pancreas
- Digestion is process by which food is broken down into smaller particles suitable for digestion
- Absorption is the process by which the end products of digestion move across the walls of the digestive tract into blood for distribution throughout the body


A
Mouth
Salivary glands
Pharynx
Esophagus
Stomach
Pancreas
Liver
Gallbladder
Small intestine
Large intestine
Rectum
Anus
B
Salivary glands
Mouth
Pharynx
Esophagus
Diaphragm
Stomach
Liver
Pancreas
Gall-bladder
Large intestine
Small intestine
Rectum
Anus

Digestion

- Two types of digestion:
  - Mechanical: is the breakdown of large food particles into smaller pieces by physical means
  - Chemical digestion: is the chemical alteration of food by chemical substances such as digestive enzymes, acid & bile
- The end products of digestion are absorbed across the lining of the digestive tract into the blood
- Digested nutrients are utilized by the cells of the body
- Any food not digested is eliminated from the body as feces
- Elimination is the last phase of digestion

Layers of the Digestive Tract

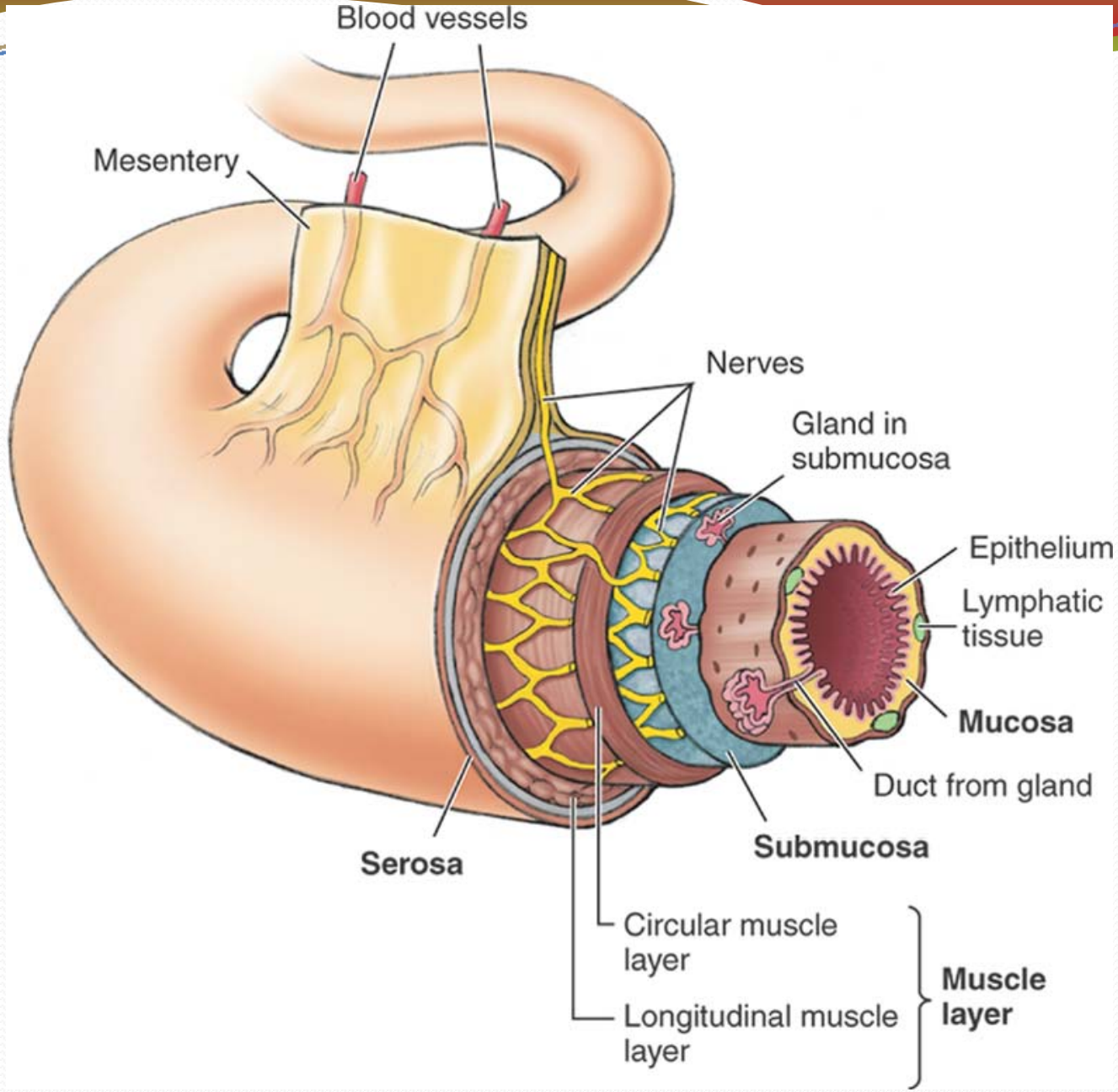
- The walls of the digestive tract has 4 layers:
  - Mucosa:
    - innermost layer of the tract composed of mucous membrane
    - Contains cells that secrete mucus, digestive enzymes & hormones
    - Ducts of exocrine glands empty into the lumen of the digestive tract
  - Submucosa:
    - Thick layer of connective tissue that lies next to the mucosa
    - Contains blood vessels, nerves, glands & lymphatic vessels

Layers of the Digestive Tract

- Muscle layer
  - Third layer of the GI tract
  - Two layers of smooth muscle consisting of: inner circular layer & outer longitudinal layer
  - Autonomic nerve fibers innervate the muscle layer
  - Responsible for mixing movements, contraction & relaxation of the stomach muscles to aid in the mechanical digestion of food
  - Peristalsis also occurs in the muscle layer which is the rhythmic alternating contraction & relaxation of the muscles that push the food in forward direction through the digestive tract; stimulated by the presence of food
  - Muscles are also responsible for swallowing & defecation

Layers of the Digestive Tract

- Serosa:
  - Outermost lining of the digestive tract
  - Extends as the peritoneal membrane
- Peritoneal Membranes:
  - Extension of the serosa
  - Mesentery & mesocolon are located behind the digestive organs
  - Greater & lesser omentum are located in front of organs
  - Form flat & folded structures that:
    - Help anchor digestive organs
    - Carry blood & lymph vessels & nerves to abdominal organs
    - Restrict the spread of infection in abdominal cavity


Blood vessels
Mesentery
Nerves
Gland in submucosa
Epithelium
Lymphatic tissue
Mucosa
Duct from gland
Submucosa
Serosa
Circular muscle layer
Longitudinal muscle layer
Muscle layer

Mouth

- Mouth
  - Beginning of digestive tract
  - AKA oral cavity, buccal cavity
  - Contains accessory structures:
    - Teeth—tongue—salivary glands
- Teeth
  - Used to chew food & begin mechanical digestion
  - Process of chewing food breaking larger particles into smaller is called mastication
  - Two set of teeth in lifetime:
    - Deciduous teeth: 20 teeth that appear around 6 months; baby teeth
    - Permanent teeth: 32 teeth that replace deciduous at 6-12 years

Teeth

- Names teeth:
  - Incisors
  - Cuspids (canines)
  - Premolars (bicuspids)
  - Molars (include wisdom teeth)
- Anatomy of the tooth
  - Crown: above level of the gum covered with hard enamel
  - Neck: connects crown with root
  - Root : embedded in jaw bone
- Outer surface of root is anchored to periodontal membrane by cementum which hold tooth in place
- Most of tooth contains bone-like material dentin
- Pulp is connective tissue of tooth that contains nerves, blood vessel within the pulp cavity; extends to root called root canal

Tongue

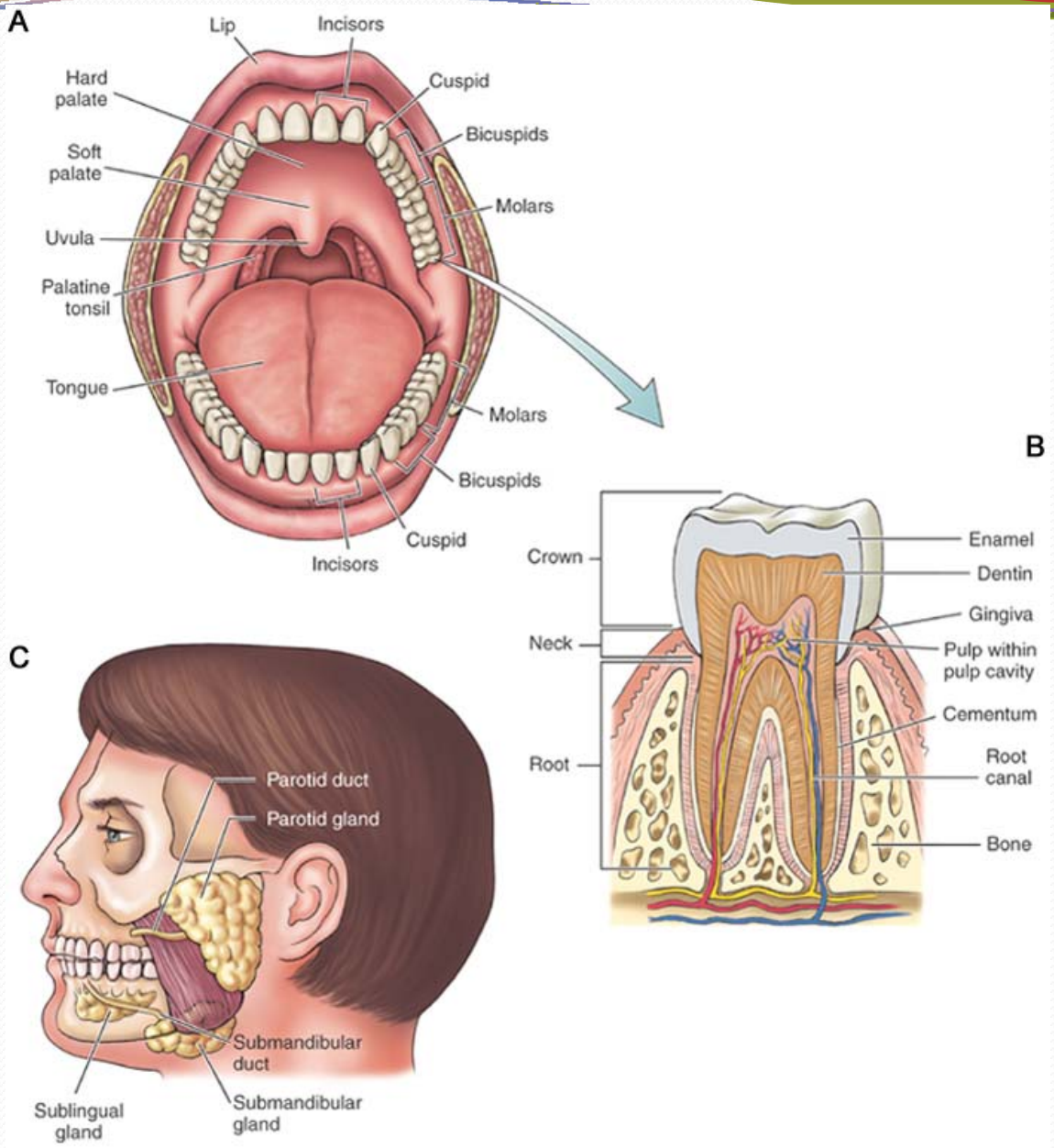
- Is muscular organ that occupies the floor of the mouth
- Two roles:
  - Facilitates chewing & swallowing by continuously repositioning food in the mouth & assist with swallowing
  - To taste food
- Two structures:
  - Mucous membrane called frenulum which anchors the tongue to the floor of the mouth & reason we swallow
  - Capillary network that provides sublingual area with rich blood supply

Salivary Glands

- Salivary Glands: there are 3 pairs that secrete their contents into the mouth
  - parotid glands: largest & lies below & anterior to the ears
  - Submandibular glands: located in floor of mouth
  - Sublingual glands: located under the tongue & are the smallest
- Secretion of the salivary glands reach mouth by way of tiny ducts
- Secrete saliva which is a watery fluid that contains mucus & salivary amylase(ptyalin) a digestive enzyme
- 1 liter is secreted daily
- Function is to moisten food for swallowing

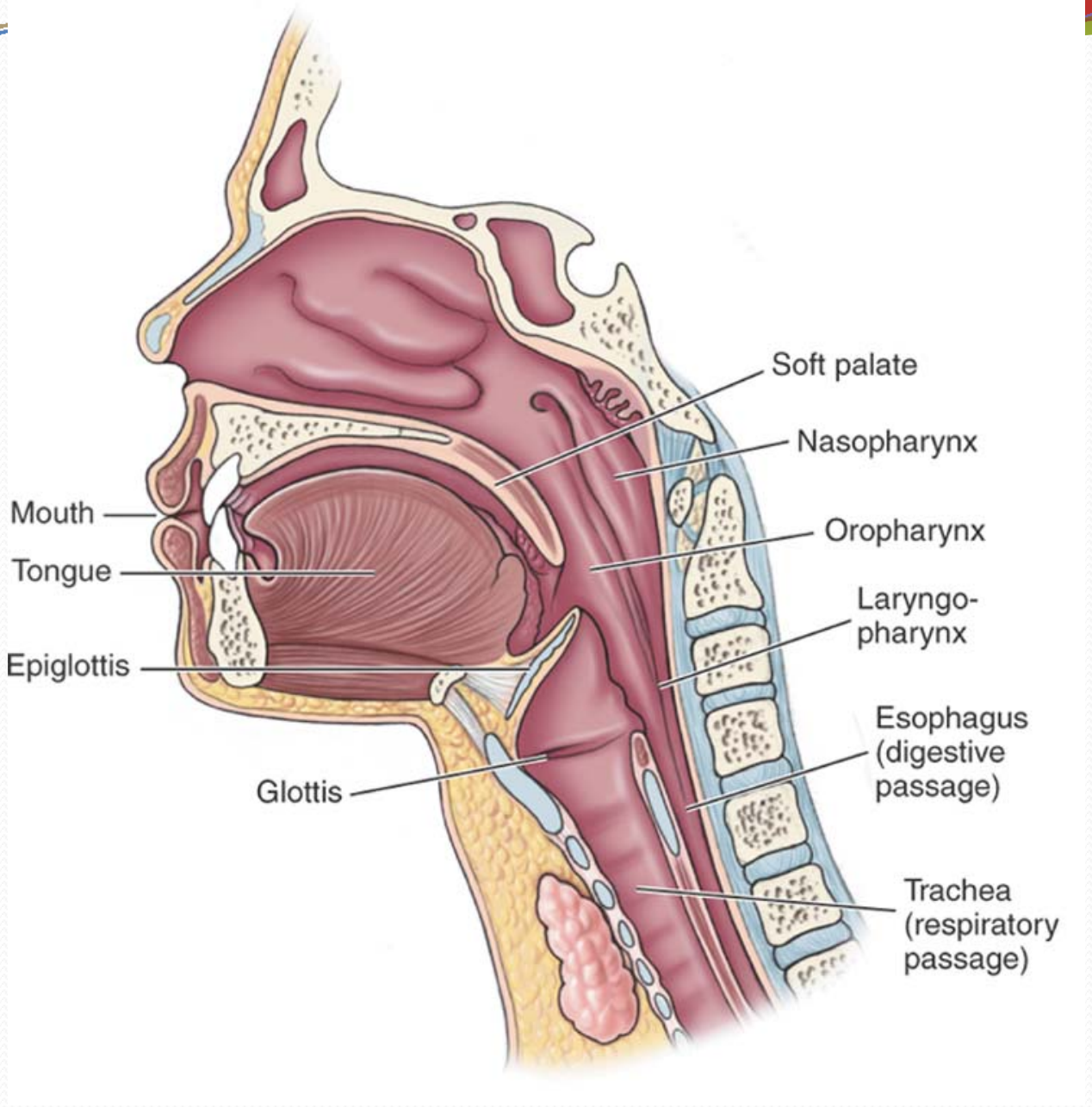
Hard & Soft Palate

- Hard & soft palate form the roof of the mouth
- The anterior hard palate separates the oral cavity from the nasal passages
- Posterior soft palate separates the oral cavity from the nasopharynx
- Soft palate extends toward the back of the oral cavity as the uvula
- Uvula is a V-shaped piece of soft tissue that hangs down from the upper back region of the mouth & aids in swallowing
- The palatine tonsils are masses of lymphoid tissue located on the sides of the posterior oral cavity & has the role of protection against infection


A
Lip
Incisors
Hard palate
Cuspid
Bicuspids
Soft palate
Molars
Uvula
Palatine tonsil
Tongue
Molars
Bicuspids
Cuspid
Incisors
B
Crown
Enamel
Dentin
Gingiva
Neck
Pulp within pulp cavity
Cementum
Root
Root canal
Bone
C
Parotid duct
Parotid gland
Submandibular duct
Sublingual gland
Submandibular gland

Pharynx

- Pharynx:
  - AKA throat
  - Involved in swallowing by reflex action called deglutition
  - Three parts:
    - Nasopharynx—oropharynx—laryngopharynx
  - Only the oropharynx & laryngopharynx are parts of digestive system
  - The act of swallowing directs food from the pharynx to the esophagus
  - The epiglottis cover the trachea to prevent aspiration & the opening of the nasophaynx is closed during swallowing


Soft palate
Nasopharynx
Mouth
Oropharynx
Tongue
Laryngo-
pharynx
Epiglottis
Esophagus
(digestive
passage)
Glottis
Trachea
(respiratory
passage)

Esophagus

- Esophagus:
  - Tube-like structure that carries the food from the pharynx to the stomach
  - Approxx 10 inches in length & descends through chest cavity penetrating the diaphragm
  - Swallowing pushes a bolus of food into the esophagus which stimulates peristalic activity causing the food to move into the stomach
  - Glands in the mucosa of the esophagus secrete mucus which lubricates food to facilitate passage

Esophagus

- Two sphincters:
  - Pharyngoesophageal sphincter: located at the top of the esophagus
  - Gastroesophageal or lower esophageal sphincter (LES): located at the base of the esophagus
- Swallowing pushes food past the pharyngoesophageal sphincter
- Relaxation of the LES keeps the base of the esophagus open allowing passage of food into the stomach
- When contracted LES closes the base of the esophagus preventing reflux or regurgitation

Stomach

- Stomach:
  - Pouch-like organ that lies in the upper left quadrant of the abdominal cavity under the diaphragm
  - Performs 5 digestive functions:
    - Digestion of food
    - Secretion of gastric juices, digestive enzymes & hydrochloric acid
    - Secretion of gastric hormones & intrinsic factor
    - Regulation of the rate of delivery of partially digested food to small intestine
    - Absorption of small quantities of water & dissolved substances

Stomach

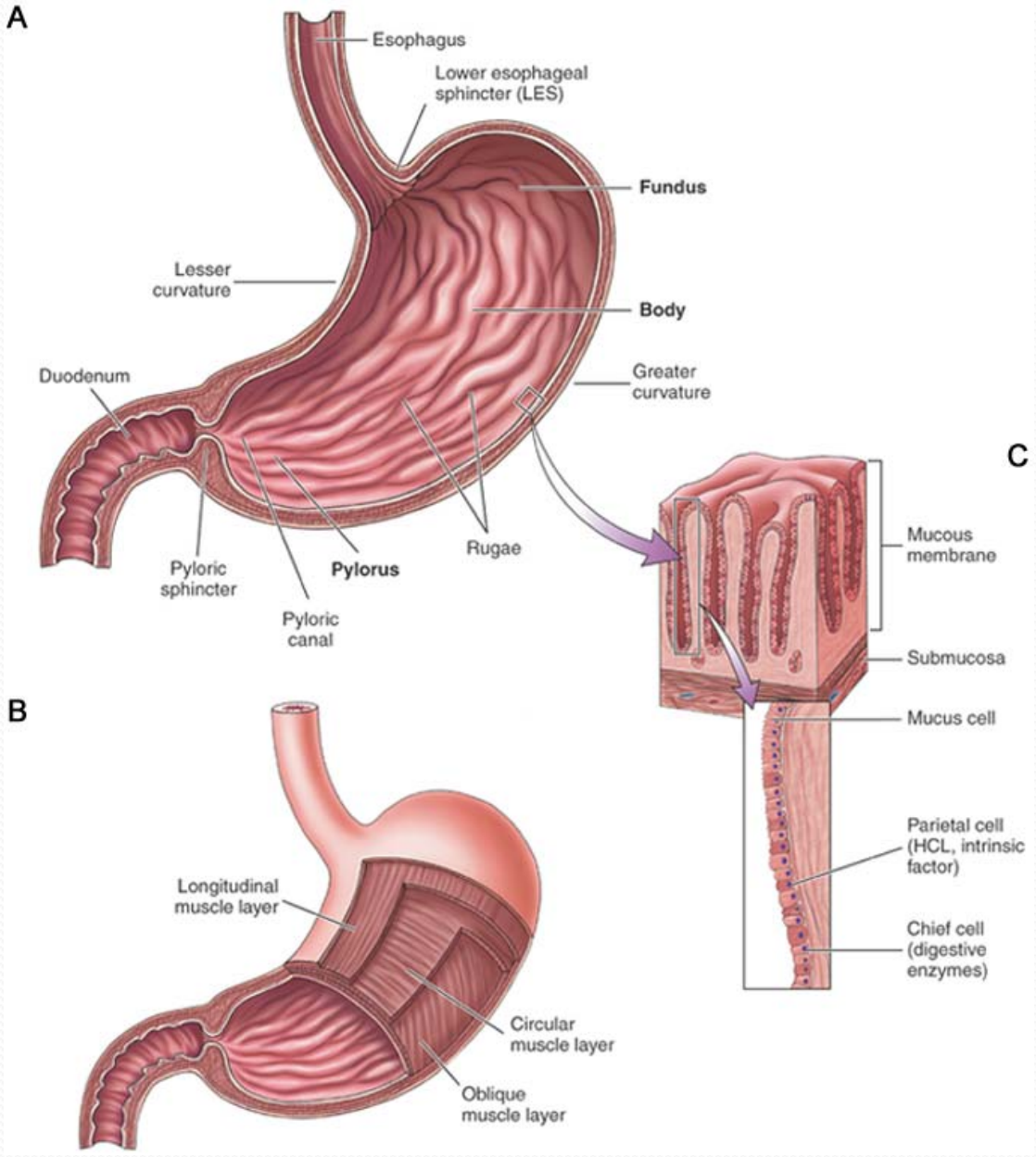
- Regions of the stomach:
  - Fundus : upper portion ; closest to the esophagus & lower esophgeal sphincter
  - Body: middle portion of stomach
  - Pylorus: lower portion of stomach; closest to duodenum
  - Pyloric canal: continuation of the pylorus
  - Pyloric sphincter: located at the end of the pyloric canal; regulates the rate of delivery of stomach contents to small intestine
- Landmarks of Stomach:
  - Greater curvature
  - Lesser curvature

Stomach

- Stomach contains rugae which allows for expansion when the stomach is full
  - When empty the stomach is the size & shape of a sausage
  - Has the capacity to expand 1 liter
- Three layers of stomach muscle:
  - Longitudinal muscle layer
  - Circular muscle layer
  - Oblique muscle layer
- The arrangement of the muscle layer allow for the churn & mix of food with gastric juice to create thick paste-like mixture called chyme
- Peristalisis moves the propels the food toward the pylorus

Stomach

- Nerves of the stomach:
  - The stomach is innervated by the vagus nerve
  - Stimulation increases motility & secretion of gastric juices
- Glands of the stomach:
  - The mucus membranes contain gastric glands
  - The glands secrete three types of secretory cells:
    - Mucus cells secrete mucus
    - Chief cells secrete digestive enzymes
    - Parietal cells secrete hydrochloric acid & intrinsic factor
  - Secretion of the gastric glands are called gastric juice
  - The secretion of thick mucus coats the stomach lining forming a protective barrier preventing the gastric juices from digesting the stomach itself


A
Esophagus
Lower esophageal sphincter (LES)
Fundus
Lesser curvature
Body
Duodenum
Greater curvature
Pyloric sphincter
Pylorus
Rugae
Pyloric canal
B
Longitudinal muscle layer
Circular muscle layer
Oblique muscle layer
C
Mucous membrane
Submucosa
Mucus cell
Parietal cell (HCL, intrinsic factor)
Chief cell (digestive enzymes)

Patho of Stomach

- Ulcer: erosion of stomach lining; cause can be Helicobacter pylori; treat with anti-ulcer medication
- Hiatal hernia: protrusion of stomach through diaphragm into the thoracic cavity
- Nasogastic tube: various reasons for use; one common reason is vomiting related to obstruction in bowel
- Gatric resection: may be due to cancer
- Pyloric stenosis: pylorus is too narrow & impedes movement of food out of the stomach
- Gastric hyperactivity: stimulation of vagus nerve increases gastric secretions & motility

Small Intestine

- Small intestine:
  - Called small because the diameter is small
  - Considerable legnth at 20 feet long
  - Located in the center lower abdominal cavity
  - Held in place by the mesentery (extension of peritoneum)
  - Primary role is chemical digestion & absorption of food
  - Three parts:
    - Duodenum
    - Jejunum
    - ileum

Small Intestine

- Duodenum:
  - First segment
  - 10 inches in legnth
  - Receives chyme from stomach & secretions from accessory organs (liver, gallbladder & pancreas)
  - Secretions from mouth, stomach & accessory organs are responsible for digestion of all food
  - ***Most digestion & absorption occur in the duodenum***

Small Intestine

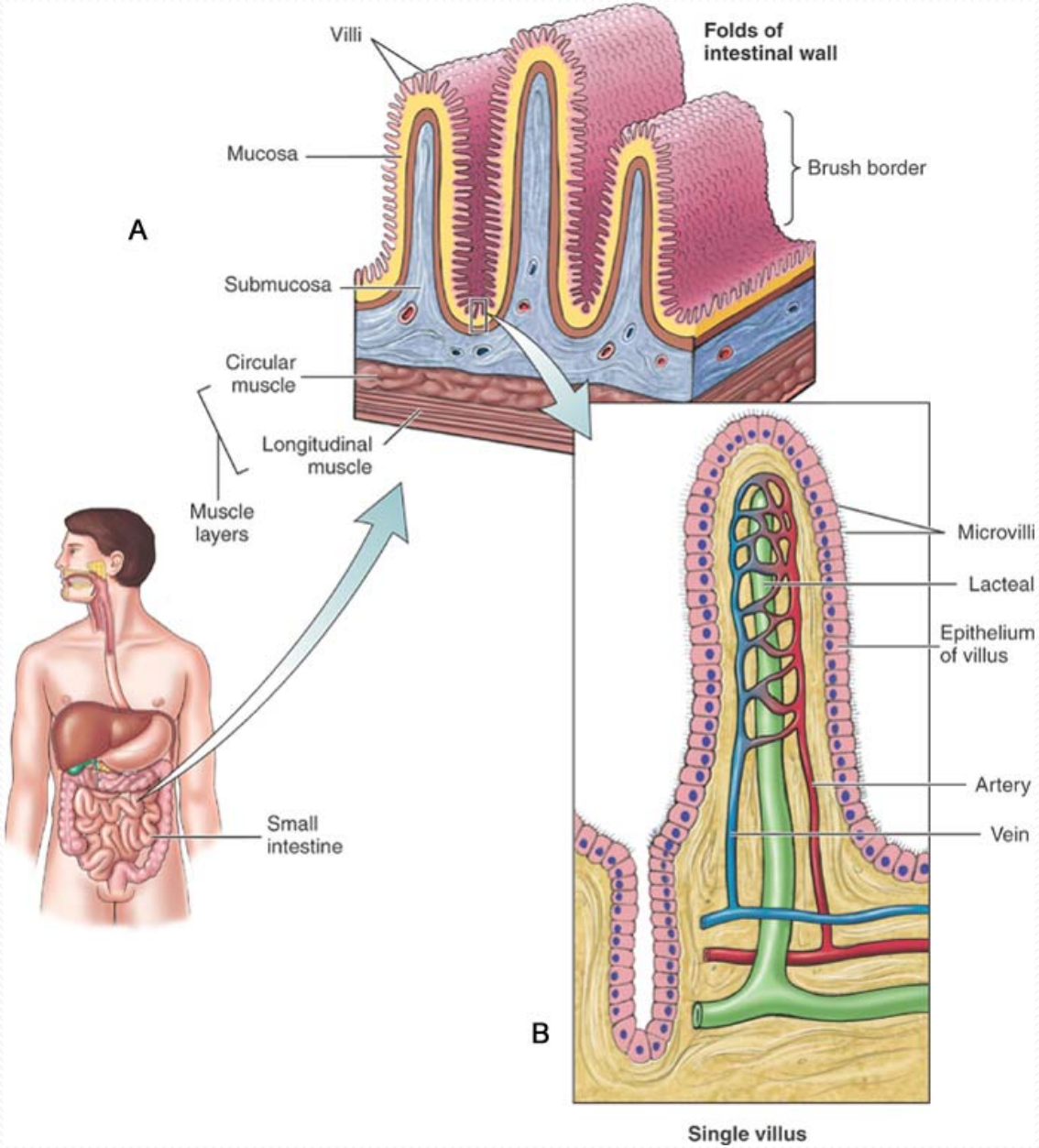
- Jejunum:
  - Second segment
  - 8 feet in length
  - Some digestion & absorption occurs is first portion of jejunum
- Ileum:
  - Third segment
  - 12 feet in legnth
  - Extends from jejunum to ileocecal valve
  - Ileocecal valve prevents reflux of contents from the cecum back into the ileum
  - Ileum is lined with lymphoid tissue called Peyer's patches which diminishes the bacterial content in the digestive system

Function of the Small Intestine

- The walls of the intestine contain circular folds with fingerlike projections called ***villi***
- The epithelial cells of each villus form extensions called microvilli
- The large number of villi & microvilli increase the amount of digested food that can be absorbed
- Each villus consists of a layer of epithelial tissue that surrounds a network of blood capillaries & a lymphatic capillary called a ***lacteal***
- The villus absorb the end products of digestion into either the blood capillaries or the lacteal

Function of the Small Intestine

- The capillary blood within the villus drains into the hepatic portal vein & into the liver
- The end products of carbohydrates & protein digestion first go to the liver for processing before being distributed throughout body
- End products of fat digestion enter the lacteal, forming a milky white lymph called ***chyle*** which empties directly into the lymph system
- The walls of the small intestine also secrete several digestive enzymes & two hormones: secretin & cholecystokinin


Villi
Folds of intestinal wall
Mucosa
Brush border
A
Submucosa
Circular muscle
Longitudinal muscle
Muscle layers
Small intestine
Microvilli
Lacteal
Epithelium of villus
Artery
Vein
B
Single villus

Large Intestine

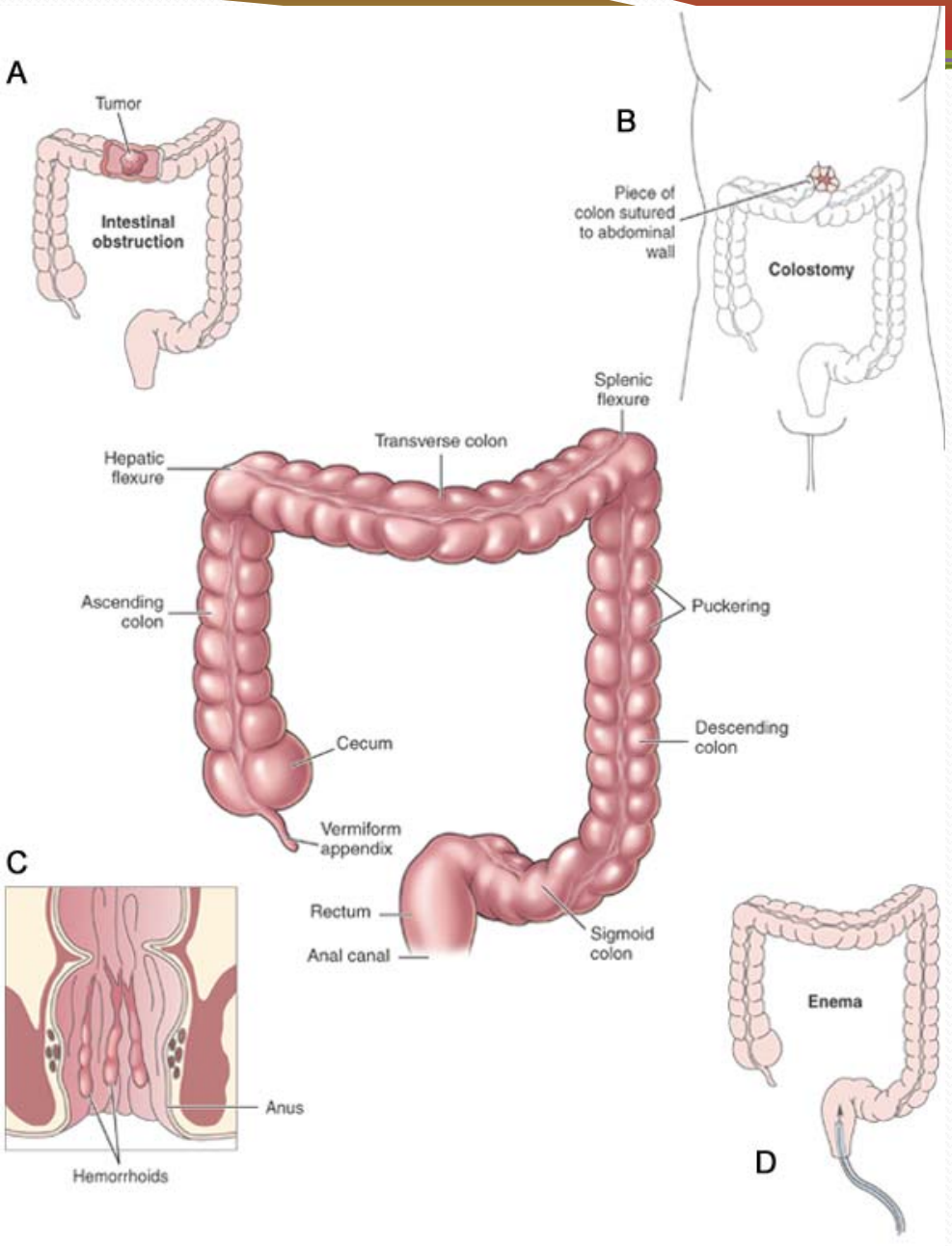
- Large intestine
  - Larger in diameter
  - 5 feet in legnth
  - Extends from the ileocecal valve to the anus
  - 4 parts:
    - Cecum
    - Colon
    - Rectum
    - Anal canal

Large Intestine

- Cecum:
  - First part of the large intestine
  - Located in the LRQ
  - Ascends on the right side as the ascending colon
  - Attached to the cecum is the appendix
  - Appendix has no physiologic role but can become inflammed & require surgical removal

Large Intestine

- Ascending Colon:
  - Ascend on the right side of & curves near liver
- Transverse Colon:
  - Crosses the upper abdomen
- Descending Colon:
  - Descends down the left side of the abdomen
- Sigmoid Colon:
  - S-shaped segment
- Distal end of large intestine includesL
  - Rectum—anal canal—anus
- Anus contains two sphincters : internal & external


A
Tumor
Intestinal obstruction
B
Piece of colon sutured to abdominal wall
Colostomy
Splenic flexure
Transverse colon
Hepatic flexure
Ascending colon
Puckering
Descending colon
Cecum
Vermiform appendix
Rectum
Anal canal
Sigmoid colon
C
Anus
Hemorrhoids
Enema
D

Function of Large Intestine

- 4 Functions:
  - Absorption of water & certain electrolytes
  - Synthesis of certain vitamins (Vit K & some B vitamins)
  - Temporary storage of feces
  - Elimination of waste from body
- Peristaltic waves move the fecal material from the cecum into the ascending , transverse & descending colon
- During the process water is being reabsorbed from the feces, across the intestinal wall into the capillaries which makes feces a semisolid mass

Fuction of the Large Intestine

- Bacterial Action:
  - Escherichia coli (E coli): synthesize Vitamin K & cetain B complex vitamins
  - E coli that is normal in intestinal tract causes serious health risks if in urine or blood
  - Bacteria produce the smell related to feces
  - Flatus is the passing of accumulated gas which is the results of digestion food residue

Patho of Large Intestine

- Bowel obstruction can occur for numerous reasons; tumor, twisted bowel, fecal impaction
- Colon cancer
- Colostomy
- Hemorroids

Accessory Digestive Organs

- Three important organs:
  - Liver
  - Gallbladder
  - Pancreas

Liver

- Liver:
  - Large reddish-brown organ located in the RUQ in abdomen below the diaphragm & protected by rib cage
  - Largest gland in the body
  - 2 lobes: right is larger & smaller left lobe which are separated by a ligament
  - The ligament secures the liver to the anterior abdominal wall & undersurface of the diaphragm
  - Liver is surrounded by a tough fibrous membrane called a capsule

Liver

- Function:
  - Synthesis of bile salts & secretion of bile: bile salts aid in fat digestion & in absorption of fat-soluble vitamins; bile secretion is the main digestive function of the liver
  - Synthesis of plasma proteins: play role in blood volume & blood coagulation
  - Storage of glycogen, fat-soluble vitamins (A,D,E & K) & Vit B_{12}
  - Detoxification of drugs & other harmful substances which allows for kidneys to excrete

Liver

- Function:
  - Excretion of bilirubin, cholestrol, drugs & other substances
  - Metabolism of carbohydrates which in turn regulates blood glucose levels; the liver either stores glucose as glycogen or makes glucose from glycogen dependent upon blood glucose levels;
    - if blood glucose is elevated it stores excess glucose as glycogen
    - if blood glucose is low the liver converts glycogen to glucose & releases it to blood
  - Metabolism of protein: liver can make different amino acids & also converts nitrogen (from ammonia) into urea for excretion by the kidneys
  - Metabolism of fats: liver breaks down fatty acids, synthesizes cholestrol & phospholipids & converts excess protein & carbohydrates into fat
  - Phagocytosis: the kupffer cells can phagocytose bacteria & other substances

Blood supply to the Liver

- Hepatic portal system:
  - Is the liver's unique arrangement of blood vessels
  - Receives 1.5 liters of blood/minute from the portal vein & hepatic artery
  - The portal vein drains the blood from all the organs of digestion containing digestive end products
  - The hepatic artery delivers oxygenated blood to the liver
  - The blood leaves the liver through the hepatic veins to the inferior vena cava

Liver lobules

- Liver lobules:
  - The liver contains thousand of liver lobules which are the functional unit of the liver
  - Liver lobules consist of a special arrangement of blood vessels & hepatic cells
  - There is a central vein with rows of hepatic cells surrounding it
  - The hepatic cells are bathed with blood that enter the lobule from the hepatic artery & portal vein
  - Blood from these two blood vessels mixes in the liver in spaces called sinusoids
  - The hepatic cells extract water & dissolved substances from the sinusoidal blood
  - The hepatic cells then secrete bile into the tiny canals called canaliculi
  - These tiny bile canals merge with the canals from other lobules to form larger hepatic bile ducts
  - Bile exits the liver through the hepatic bile ducts

Bile

- Bile:
  - Green-yellow secretion produced by the liver & stored in the gallbladder
  - 800-1000 ml is secreted in 24 hours
  - Composed of water, electrolytes, cholesterol, bile pigments & bile salts
  - Bile pigments bilirubin & biliverdin are formed from the hemoglobin of old RBC's
  - Bile salts are more abundant & aid in digestion of fat & absorption of fat-soluble vitamins & give stool brownish color

Biliary Tree

- Biliary tree:
  - The ducts that connect the liver, gallbladder & duodenum are called the biliary tree
  - Network of ducts which include the:
    - Hepatic bile ducts: receives bile from the canaliculi with the liver lobules
    - Cystic duct merges with the hepatic duct to form the common bile duct
    - The common bile duct carries both the hepatic ducts & cystic ducts to the duodenum
  - The base of the common bile duct swells to form the ampulla of Vater (hepatopancreatic ampulla) which is the site the main pancreatic duct joins the common bile duct
  - The sphincter of Oddi (hepatopancreatic sphincter) encircles the base of the ampulla where it enters the duodenum
  - The sphincter of Oddi is controls the release of bile to the duodenum & is sensitive to nervous, hormonal & pharmacologic control

Gallbladder

- Gallbladder:
  - pear-shaped sac attached to the underside of the liver
  - The cystic duct connects the gallbladder with the common bile duct
  - Bile, produced in the liver, flows through the hepatic ducts & cystic ducts & gallbladder
  - Gallbladder concentrates & stores approx. 1.2 liters/day
  - The fat in the duodenum stimulates the release of cholecystokinin (hormone) into the blood & travels to the gallbladder causing the smooth muscle of the gallbladder to contract
  - The contraction of the smooth muscle cause the ejection of bile into the cystic duct then the common bile duct & duodenum

Pancreas

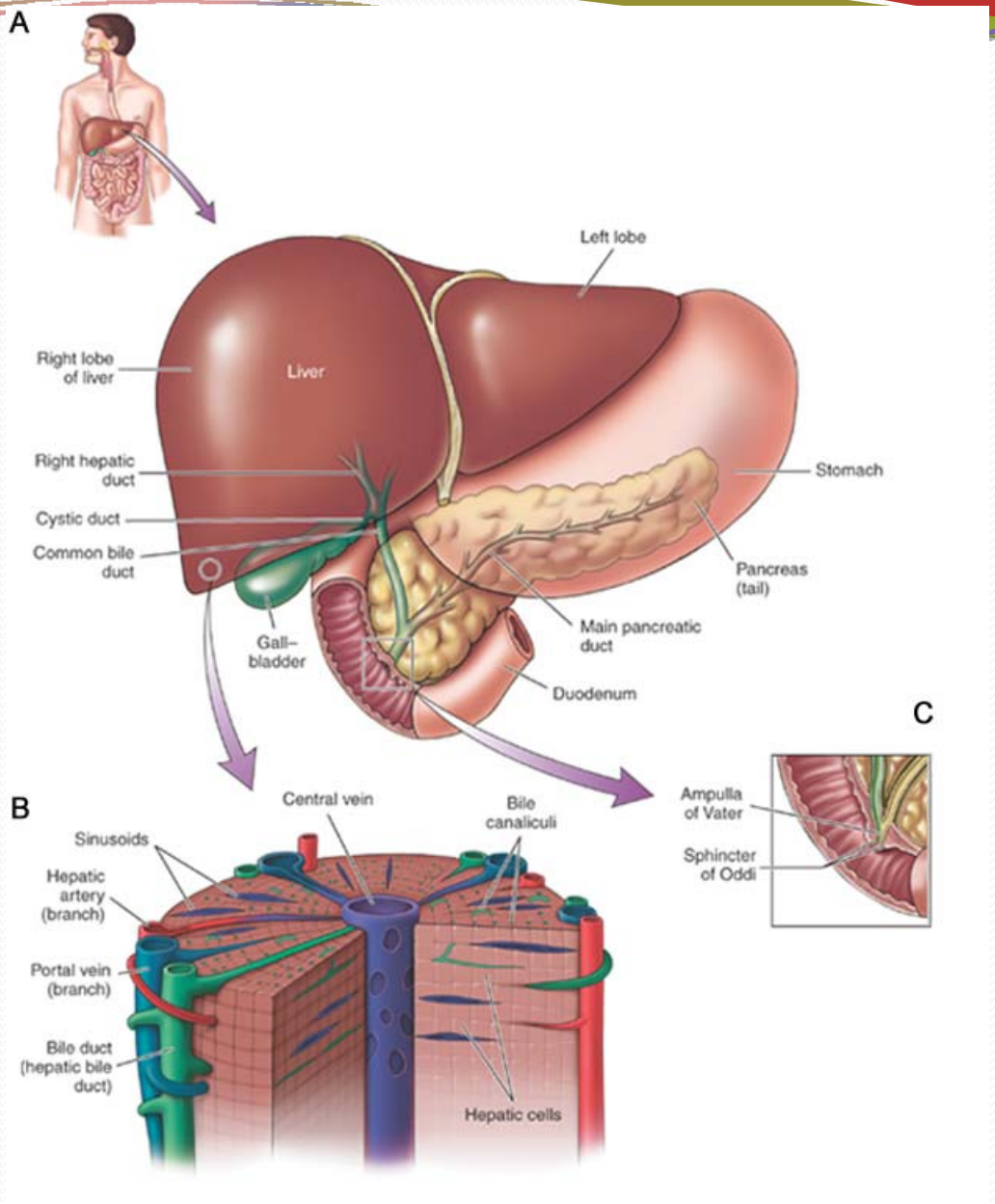
- Pancreas
  - Accessory organ of digestion located just under the stomach
  - The head of the pancreas rests in the curve of the duodenum & the tail is near the spleen in LUQ of abdomen
  - The main pancreatic duct travels the length of the pancreas & joins the common bile duct at the ampulla of Vater
  - The pancreatic duct carries digestive enzymes from the pancreas to the duodenum which is the meeting point for digestion

Pancreas

- The pancreas secretes endocrine & exocrine substances
- Exocrine substances include:
  - digestive enzymes, which are the most important digestive enzyme, secreted by the pancreatic acinar cells in an inactive form & travel through the main pancreatic duct to the duodenum
  - Alkaline substances which are rich in bicarbonate that neutralize highly acidic chyme coming out of stomach & entering the duodenum; digestive enzymes in the duodenum work best in alkaline environment

Pancreas

- Endocrine substances:
- Secretion of digestive enzymes & bicarbonate is controlled by nervous & hormonal control
  - The presence of food in the stomach & duodenum is the stimulus for nervous & hormonal response
  - The presence of chyme in the duodenum stimulates the release of cholecystokinin (CCK) from the duodenal walls
  - CCK travels in the blood to the pancreas stimulating the release of pancreatic digestive enzymes
  - The acid in the duodenum stimulates the release of a second hormone, secretin, from the duodenal walls
  - Secretin travels through the blood to the pancreas stimulating the release of alkaline (bicarbonate) secretions


A
Left lobe
Liver
Right lobe of liver
Right hepatic duct
Cystic duct
Common bile duct
Gall-bladder
Stomach
Pancreas (tail)
Main pancreatic duct
Duodenum
C
Ampulla of Vater
Sphincter of Oddi
B
Central vein
Bile canaliculi
Sinusoids
Hepatic artery (branch)
Portal vein (branch)
Bile duct (hepatic bile duct)
Hepatic cells

Patho of Digestive Organs

- Jaundice
- Bleeding
- Portal hypertension & ascites
- Portal hypertension & hemorrhage
- Pancreatitis

Digestion & Absorption

- Primary role of the digestive system is break down of food into particles suitable for absorption
- Food is digested mechanically & chemically
- Mechanical digestion occurs by chewing in the mouth & mixing & churning activities of muscles in the digestive organs
- Chemically it occurs by chemical changes in response to digestive enzymes
- Chemical digestion refers to a change in the chemical composition of the food molecule
- Food is made up of carbohydrates, proteins & fats
- Digestive enzymes & digestive aids play key role in digestion
- Specific enzymes digest each food type

Carbohydrates & Enzymes

- Carbohydrates are organic compounds composed of carbon, hydrogen & oxygen
- Classification includes:
  - Monosaccharides: single sugars
    - Glucose—fructose—galactose
  - Disaccharides: double sugars
    - Sucrose—lactose—maltose
  - Polysaccharides: many glucose molecules together
    - Starches are polysaccharides

Carbohydrates & Enzymes

- Polysaccharides are digested in two stages:
  1. Amylases: an enzyme breaks polysaccharide into disaccharide
     - Salivary amylase & Pancreatic amylase
  2. Disaccharidase breaks diasaccharides into monosaccharides
     - Sucrase—lactase—maltase
  - Disaccharides are broken down in the duodenum on the surface of the intestinal villus, which is the site of secretion of disaccharidase, & immediately absorbed into the blood capillaries
  - Cellulose, a carbohydrate, cannot be digested & provides fiber & bulk to the stool

Protein & Enzymes

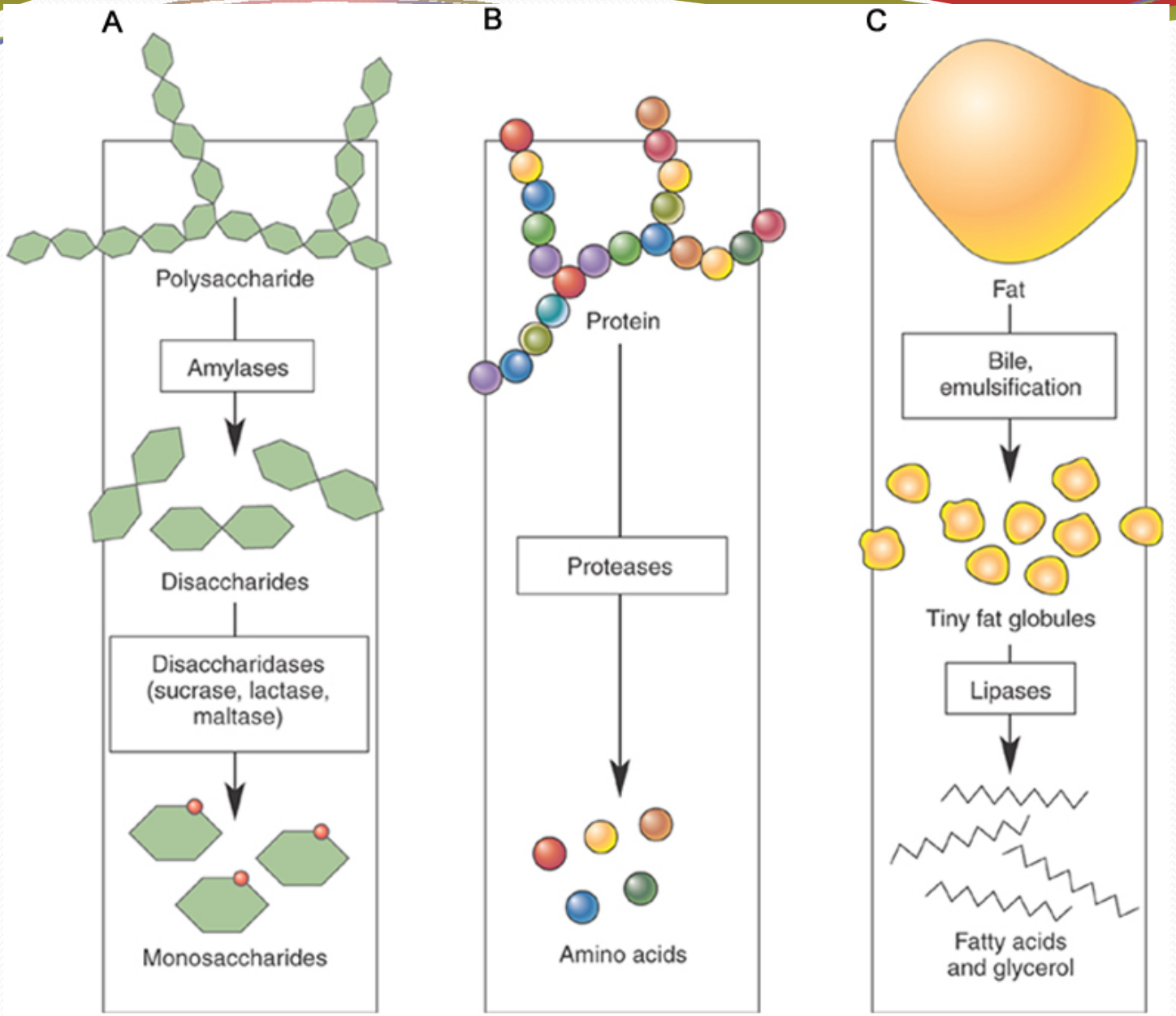
- Protein is comprised of amino acids
- Several amino acids linked together form a peptide
- Proteins are very long peptide chains
- In order to be digested these chains must be broken down into small peptides & amino acids
- Protease (or proteolytic enzymes) is the enzyme that digests proteins
- Protease is secreted by 3 organs:
  - Stomach secretes pepsin
  - Intestinal cells secrete enterokinase
  - Pancreas secretes trypsin & chymotrypsin—most potent protease

Protein & Enzymes

- Proteins are broken down into amino acids & absorbed across the intestinal villi into the blood capillaries
- Hydrochloric acid aid in digestion of protein by
  - Unraveling strands of protein making them more sensitive to protease
  - Activating gastric proteolytic enzyme, pepsinogen into pepsin; pepsin facilitates breaking protein into small peptides

Fat & Enzymes

- Fats are long chain molecules composed of carbon, hydrogen & oxygen
- Lipase is the enzyme that digests fats
- Pancreatic lipase is the most important
- End product of fat digestion is fatty acids & glycerol
- Fat is absorbed into the lacteals of the villus
- Bile aids in the digestion of fat because they are not soluble in water so they clump forming large fat globules
- Bile breaks down these large fat globules into tiny fat globules in a process called emulsification
- Lipase can work on the surface of the tiny globules; digesting fat
- Bile salts aid in 2 ways:
  - Prevent fatty acid from reforming into large fat globules
  - Helps in absorption of fat soluble vitamins Q, D, E, K


A
Polysaccharide
Amylases
Disaccharides
Disaccharidases (sucrase, lactase, maltase)
Monosaccharides
B
Protein
Proteases
Amino acids
C
Fat
Bile, emulsification
Tiny fat globules
Lipases
Fatty acids and glycerol