

Digestive System
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Digestive System

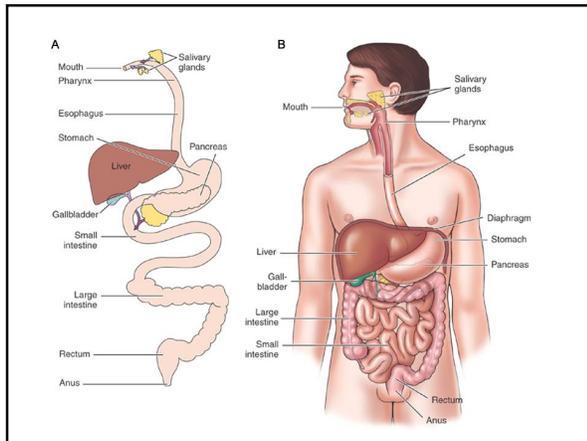
- Function of Digestive System:
 - Ingestion of food
 - Digestion
 - Absorption of end-products
 - Elimination of waste

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



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

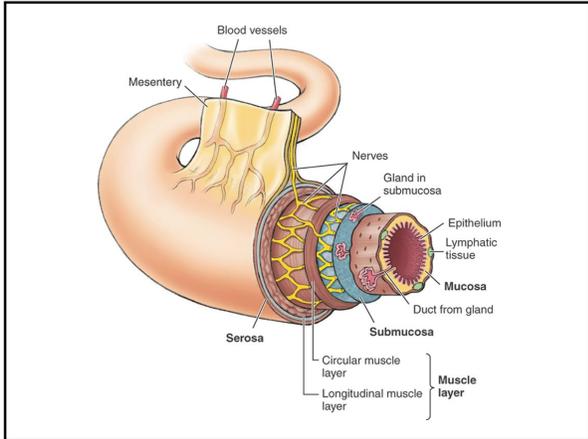
- The walls of the digestive tract has 4 layers:
 - Mucosa:
 - innermost layer of the tract composed of mucous membrane
 - Contains cells that secrete mucus, digestive enzymes & hormones
 - Ducts of exocrine glands empty into the lumen of the digestive tract
 - Submucosa:
 - Thick layer of connective 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



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 (bicuspid)
 - 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

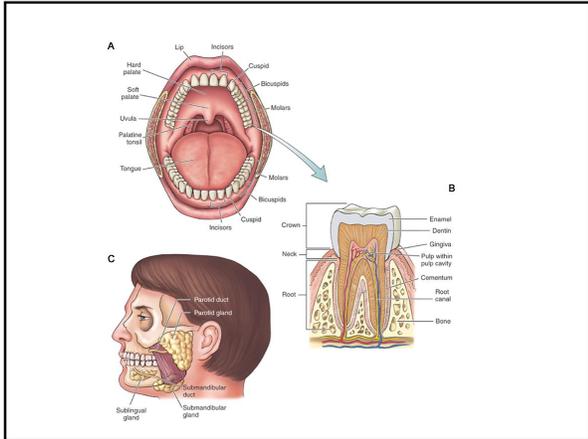
- Is muscular organ that occupies the floor of the mouth
- Two roles:
 - Facilitates chewing & swallowing by continuously repositioning food in the mouth & assist with swallowing
 - To taste food
- Two structures:
 - Mucous membrane called frenulum which anchors the tongue to the floor of the mouth & 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

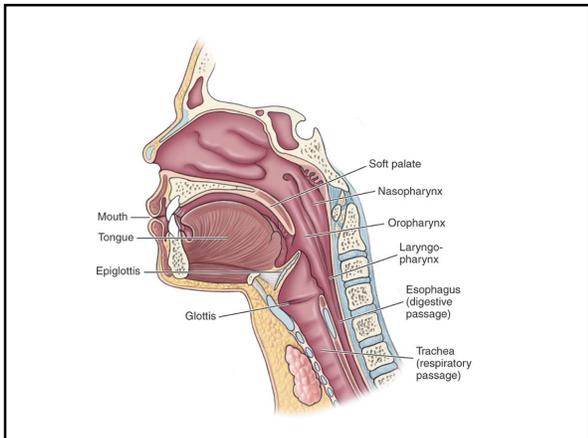
Hard & Soft Palate

- 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



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



Esophagus

- Esophagus:
 - Tube-like structure that carries the food from the pharynx to the stomach
 - Approx. 10 inches in length & descends through chest cavity penetrating the diaphragm
 - Swallowing pushes a bolus of food into the esophagus which stimulates peristaltic 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 & delivery of partially digested food to small intestine
 - Absorption of small quantities of water & dissolved substances

Stomach

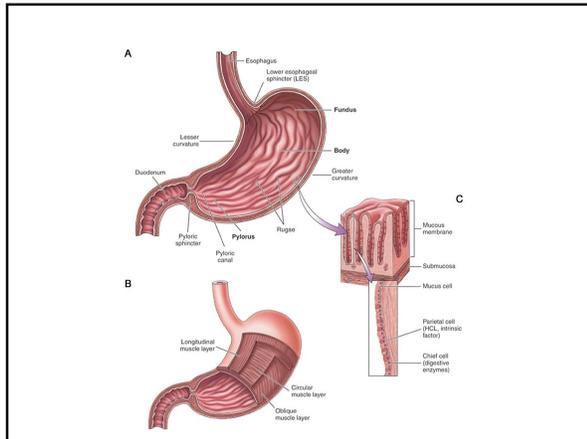
- Regions of the stomach:
 - Fundus : upper portion; closest to the esophagus & lower esophageal sphincter
 - Body: middle portion of stomach
 - Pylorus: lower portion of stomach; closest to duodenum
 - Pyloric canal: continuation of the pylorus
 - Pyloric sphincter: located at the end of the pyloric 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 churning & mixing of food with gastric juice to create thick paste-like mixture called chyme
- Peristalsis 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 are composed of three types of secreting 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



Small Intestine

- Small intestine:
 - Called small because the diameter is small
 - Considerable length 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 length
 - 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 occurs in the duodenum**

Small Intestine

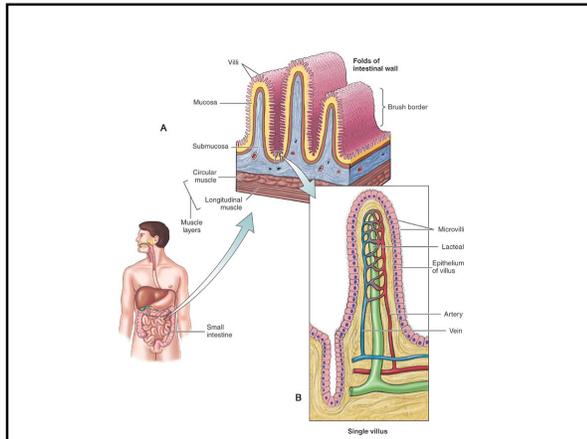
- Jejunum:
 - Second segment
 - 8 feet in length
 - Some digestion & absorption occurs in first portion of jejunum
- Ileum:
 - Third segment
 - 12 feet in length
 - Extends from jejunum to ileocecal valve
 - Ileocecal valve prevents reflux of contents from the cecum back into the ileum
 - Ileum is lined 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 capillaries 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



Large Intestine

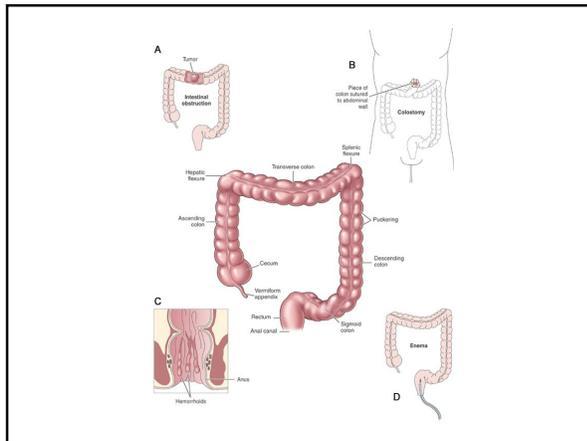
- Large intestine
 - Larger in diameter
 - 5 feet in length
 - Extends from the ileocecal valve to the anus
 - 4 parts:
 - Cecum
 - Colon
 - Rectum
 - Anal canal

Large Intestine

- Cecum:
 - First part of the large intestine
 - Located in the right lower quadrant
 - Ascends on the right side as the ascending colon
 - Attached to the cecum is the appendix
 - Appendix has no physiologic role but can become inflamed & 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 includes
 - Rectum—anal canal—anus
- Anus contains two sphincters : internal & external



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 & certain B complex vitamins
 - E coli that is normal in intestinal tract causes serious health risks if in urine or blood

Accessory Digestive Organs

- Three important organs:
 - Liver
 - Gallbladder
 - Pancreas

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 & left lobe smaller
- 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 & 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 B₁₂
- Detoxification of drugs & other harmful substances which allows for kidneys to excrete

Liver Function

- Excretion of bilirubin, cholesterol, 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

Liver

- Metabolism of protein: liver can make different amino acids
- Converts nitrogen (from ammonia) into urea for excretion by the kidneys
- Metabolism of fats: liver breaks down fatty acids, synthesizes cholesterol & phospholipids & converts excess protein & carbohydrates into fat
- Phagocytosis: the kupffer cells can phagocytose bacteria & other substances within the liver

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, pancreas & duodenum are called the biliary tree
 - Network of ducts which include the:
 - Hepatic bile ducts: receives bile from the canaliculi within 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 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 which 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

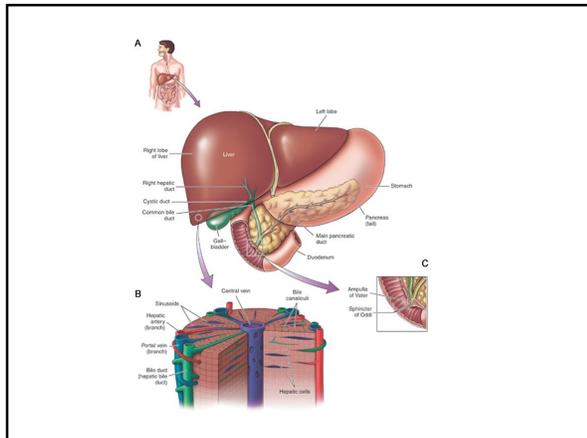
- Pancreas
 - Accessory organ of digestion located just under the stomach
 - The head of the pancreas rests in the curve of the duodenum & the tail is near the spleen in LUQ of abdomen
 - The main pancreatic duct travels the length of the pancreas & joins the common bile duct at the ampulla of Vater
 - 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, are secreted by the pancreatic acinar cells in an inactive form & travel through the main pancreatic duct to the duodenum
 - Alkaline substances, rich in bicarbonate, neutralize the highly acidic chyme coming out of stomach & entering the duodenum;
 - Digestive enzymes in the duodenum work best in an alkaline environment

Pancreas

- Endocrine substances:
- Secretion of digestive enzymes & bicarbonate are 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 cholecystikinin (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



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 disaccharides into monosaccharides
 - Sucrase—lactase—maltase
- Disaccharides are broken down in the duodenum on the surface of the intestinal villus where disaccharidase is secreted & 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 A, D, E, K

