Human Anatomy & Physiology

17

Digestive System

Unit Five

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Be sure to watch the Video: "The Digestive System".

Digestive System URLs

http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookDIGEST.html

http://yahooligans.yahoo.com/reference/gray/244.html

http://digestive.niddk.nih.gov/ddiseases/pubs/yrdd/index.htm

http://arbl.cvmbs.colostate.edu/hbooks/pathphys/digestion/

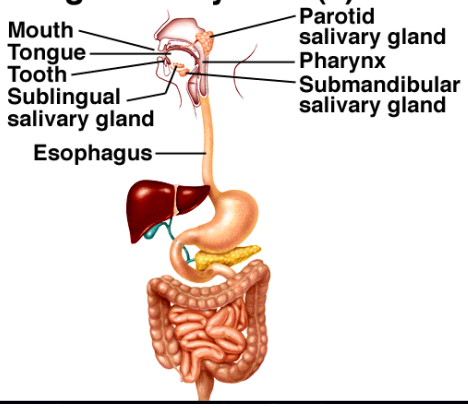
I. Introduction

A. Digestion refers to the mechanical and chemical breakdown of foods so that nutrients can be absorbed by cells.

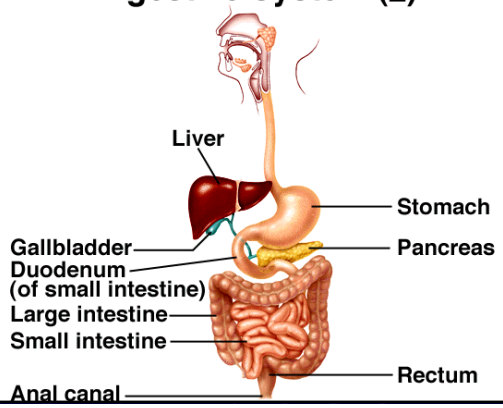
B. The digestive system carries out the process of digestion.

C. The digestive system consists of the alimentary canal, leading from mouth to anus, and several accessory organs whose secretions aid the processes of digestion.

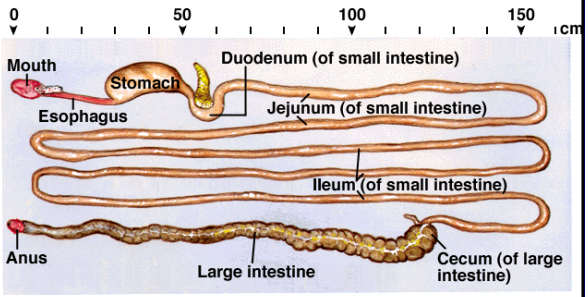
Digestive System (1)



Digestive System (2)



Alimentary Canal



II. General Characteristics of the Alimentary Canal

A. The alimentary canal is a muscular tube about 8 meters long that passes through the body's ventral cavity.

B. Structure of the Wall

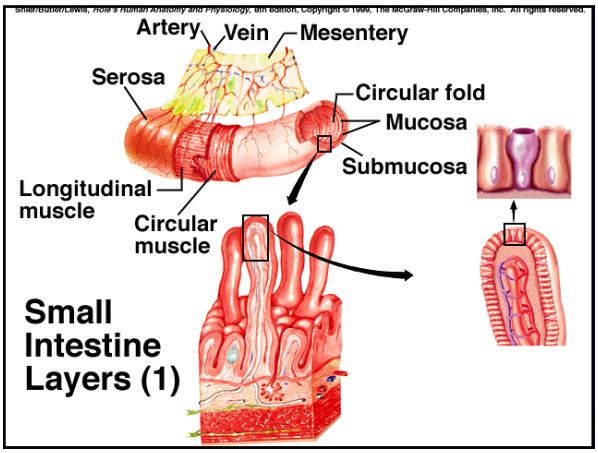
*4 layers in the wall of the alimentary canal:

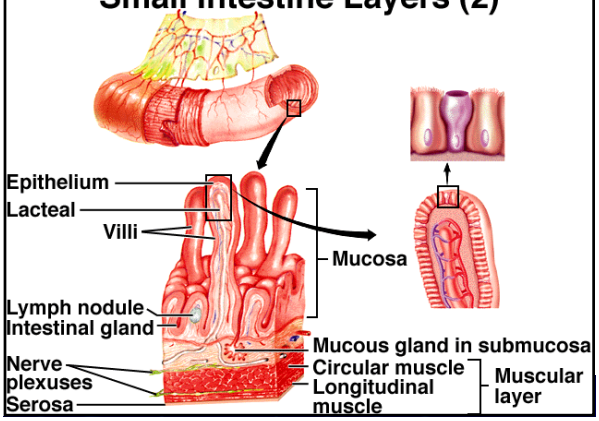
1) mucosa (inner layer) – epithelium, connective tissue, smooth muscle, has folds to increase surface area, glands for secretion of mucus & digestive enzymes, mucosa carries on secretion & absorption

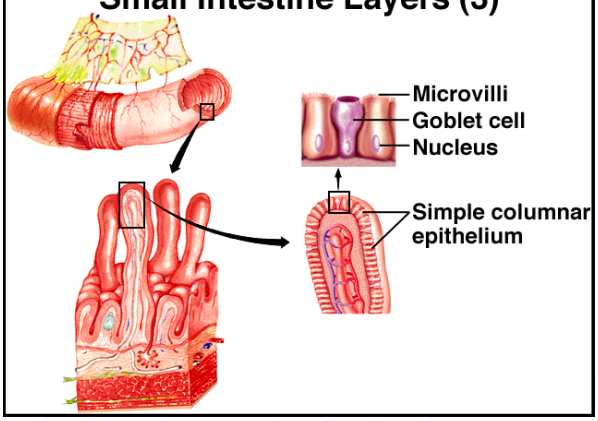
2) submucosa – loose connective tissue, glands, blood & lymphatic vessels, nerves, submucosa nourishes tissues & carries absorbed materials away

3) muscular layer – 2 coats of smooth muscle = circular & longitudinal fibers that provide movements for the tube

4) serosa layer (outer) – visceral peritoneum, serous cells protect underlying tissues & secrete serous fluid to reduce friction within the abdominal cavity







C. Movements of the Tube

*mixing & propelling movements of circular and longitudinal muscles

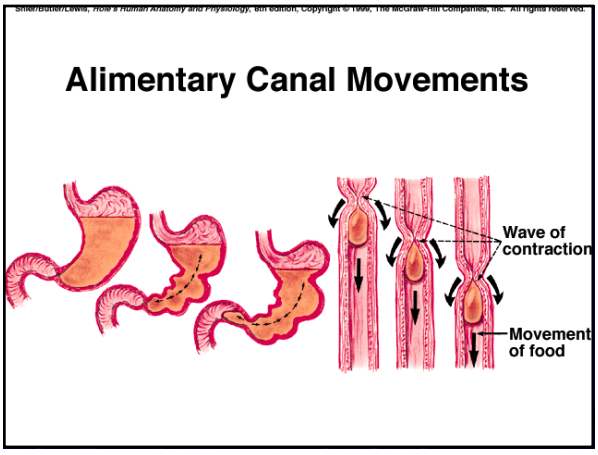
*peristalsis – propelling movements of contraction in the tube that move the food through the alimentary canal

D. Innervation of the Tube

*branches of the sympathetic & parasympathetic divisions of the autonomic nervous system innervate the tube

*parasympathetic impulses increase the activities of the digestive system

*sympathetic impulses do the opposite & inhibit certain digestive actions; can contract sphincter muscles that can block movement of materials through the tube



III. Mouth

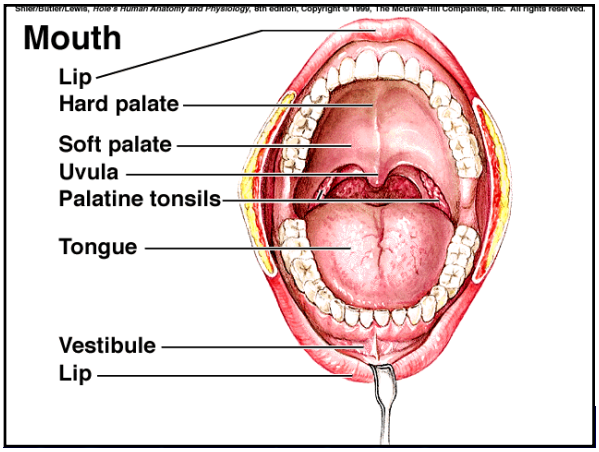
A. The mouth is the first portion of the alimentary canal; it functions to receive food and begins mechanical digestion by mastication. It also functions as an organ of speech & sensory reception. (includes oral cavity & vestibule)

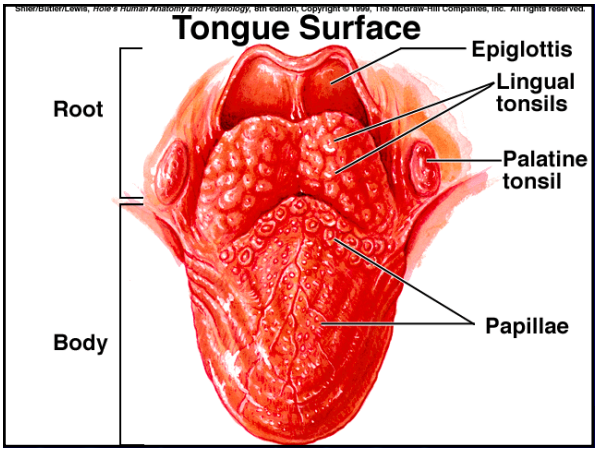
B. Cheeks and Lips
*cheeks – form lateral walls of mouth, help in chewing & expression
*lips – skeletal muscles & sensory receptors, red color due to presence of many blood vessels

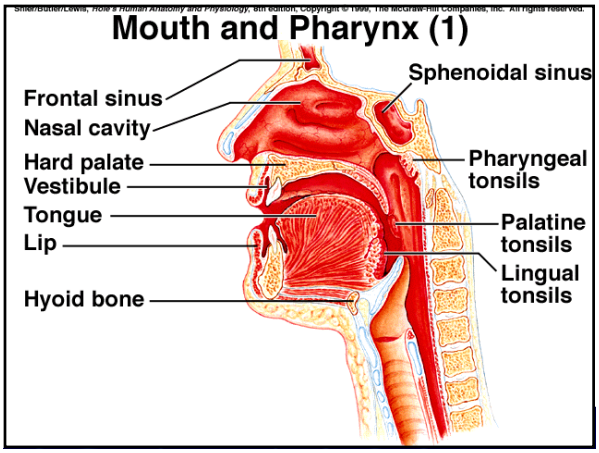
C. Tongue
*thick muscular organ, covered by mucous membrane
*frenulum – membranous fold that connects tongue to floor of mouth (found under the tongue)
*papillae – rough projections that provide friction for handling food
*lingual tonsils – lymphatic tissue over root of the tongue that anchors the tongue to the hyoid bone

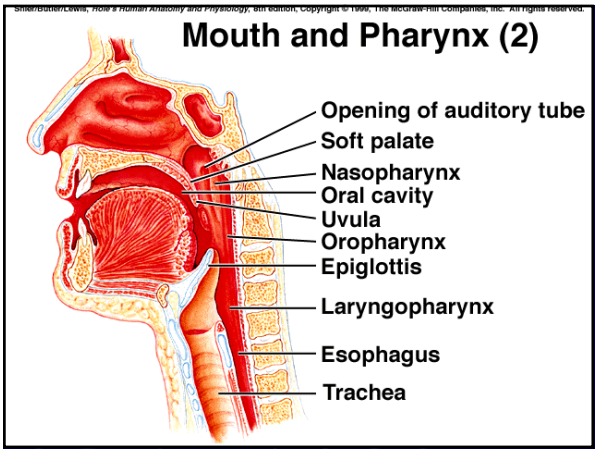
D. Palate – forms the roof of the oral cavity

*hard palate – (anterior) formed by the palatine processes of the maxillary bones
*soft palate – (posterior) forms a muscular arch which extends downward to form the uvula
*uvula – during swallowing, muscles draw the soft palate & the uvula upward; this action closes the opening between the nasal cavity & the pharynx preventing food from entering the nasal cavity
*palatine tonsils – masses of lymphatic tissues on either side of the tongue & help protect the body against infection; they sometimes get infected & have to be surgically removed
*pharyngeal tonsils (adenoids) – lymphatic tissue on the posterior wall of the pharynx; if they enlarge they can block the passage between the pharynx & the nasal cavity; can be surgically removed



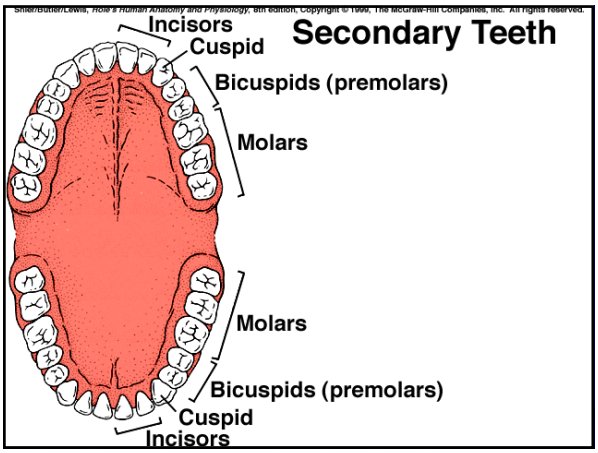


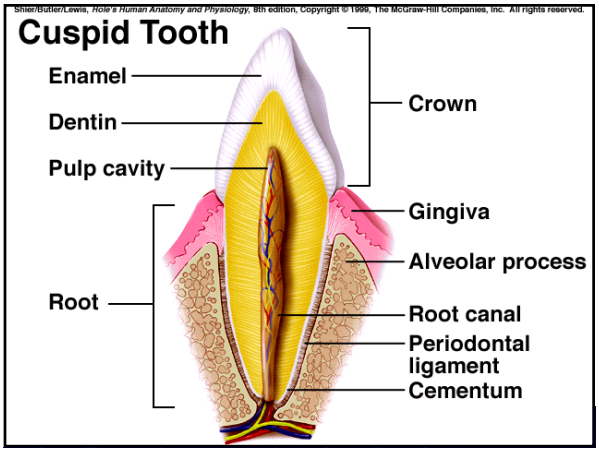




E. Teeth – hardest structures in the body

*not part of the skeletal system
*develop in sockets within the alveolar processes of the mandibular & maxillary bones
*20 primary & 32 secondary teeth
*teeth mechanically break food into smaller pieces to expose food surfaces to digestive enzymes
*teeth are adapted for biting, grasping, or grinding
*each tooth has a crown & root, & is composed of enamel, dentin, pulp, nerves, & blood vessels
*each tooth is attached to the alveolar process by collagenous fibers of the periodontal ligament





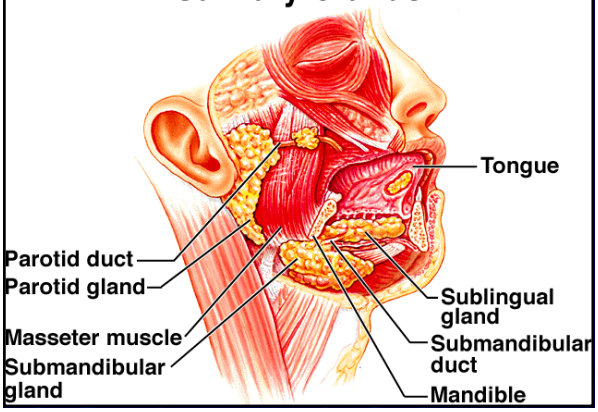
IV. Salivary Glands

A. The salivary glands secrete saliva, which moistens food particles, binds them together, allows tasting, helps to cleanse the mouth and teeth, begins carbohydrate digestion, & regulates pH in the mouth.
*3 pairs of major salivary glands:
parotid, submandibular, & sublingual glands

B. Salivary Secretions
*salivary glands include 2 types of secretory cells = serous cells that secrete digestive enzymes & mucous cells that secrete mucus
*amylase – digestive enzyme produced by serous cells (1st step in chemical digestion of carbohydrates)
*mucus – thick liquid produced by mucous cells that provides moisture for swallowing food

C. Major Salivary Glands

*3 pairs of major salivary glands:
parotid, submandibular, & sublingual glands
1) parotid glands – largest, secrete saliva rich in amylase; located near the ears
2) submandibular glands – produce viscous (thick & hard to flow) saliva; located on floor of the mouth
3) sublingual glands – smallest, secrete mucus (thick), located in floor of the mouth



V. Pharynx and Esophagus

A. The pharynx is a muscular vestibule lying behind the mouth, and the esophagus is a muscular tube leading to the stomach.

B. Both structures serve as passageways for food on its way to the stomach. Their muscular walls function in swallowing.

C. Structure of the Pharynx

*connects the nasal & oral cavities with the larynx & esophagus

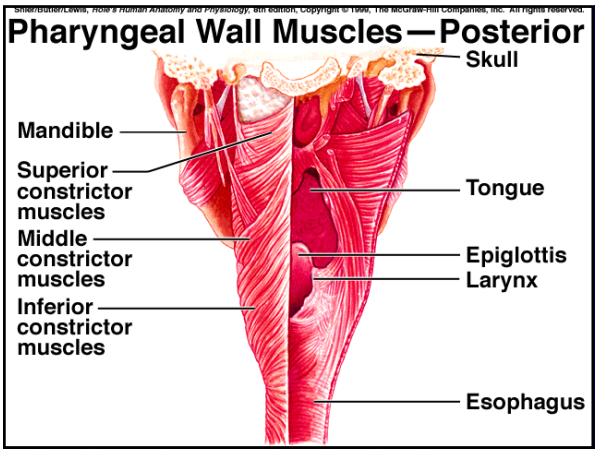
*3 parts:

1) nasopharynx – superior to soft palate; communicates with nasal cavity & provides a passageway for air during breathing; provides connections for auditory tubes

2) oropharynx – posterior to mouth; is a passageway for food moving downward from the mouth & for air moving to & from the nasal cavity

3) laryngopharynx – below the oropharynx; extends from the epiglottis to the lower border of the cricoid cartilage of the larynx; is a passageway for food to the esophagus

*the muscular walls of the pharynx contain fibers arranged in circular & longitudinal groups



D. Swallowing Mechanism

*3 stages:

1) food is mixed with saliva & forced into the pharynx

2) involuntary reflex actions move food into the esophagus

3) peristalsis transports food to the stomach

E. Esophagus

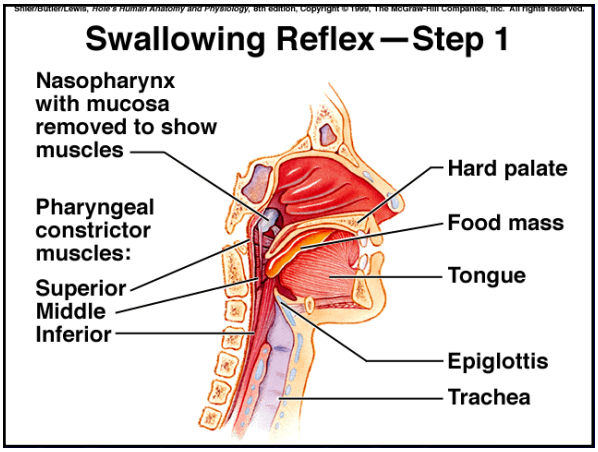
*straight, collapsible tube about 25cm long

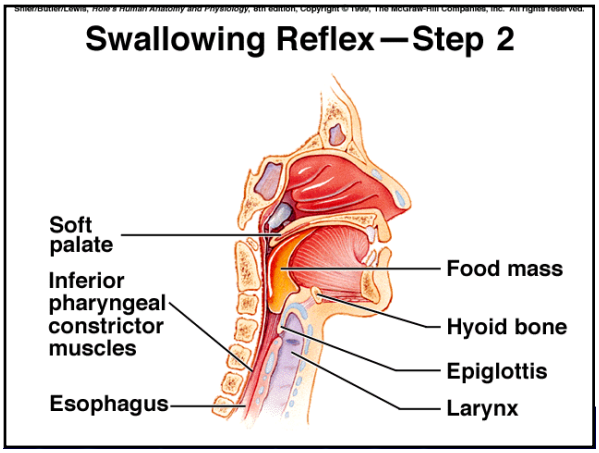
*provides a passageway for food from the pharynx to the stomach

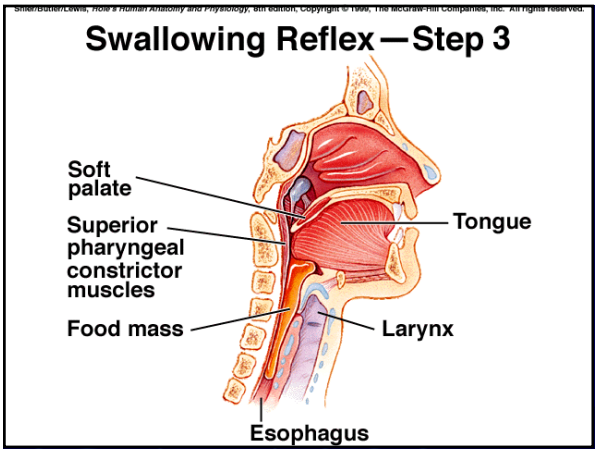
*passes through the mediastinum & penetrates the diaphragm through an opening called the esophageal hiatus

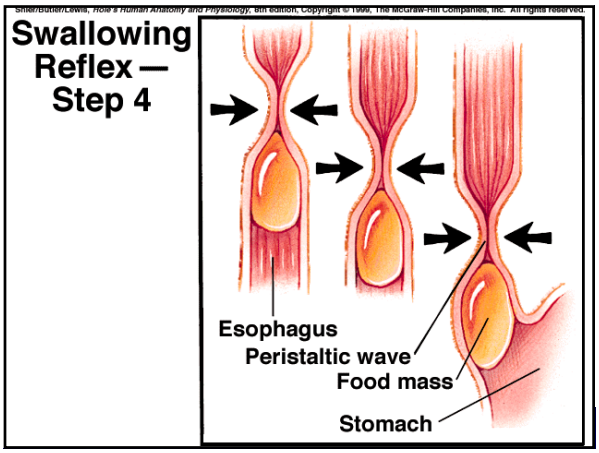
*mucous glands are scattered throughout; help moisten & lubricate

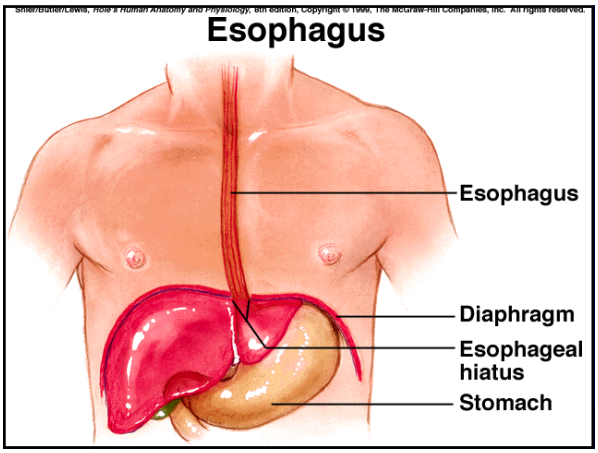
*lower esophageal sphincter – circular muscle fibers that help prevent the regurgitation of stomach contents back into the esophagus, serves as a valve between the esophagus & the stomach











VI. Stomach

A. The stomach is J-shaped muscular organ that receives and mixes food with gastric (digestive) juices, and propels food to the small intestine.

*hangs inferior to diaphragm, holds about 1 liter+, has rugae (thick folds), & receives food from the esophagus

*stomach initiates the digestion of proteins

*carries on some absorption

*moves food into the small intestine

B. Parts of the Stomach = 4 regions

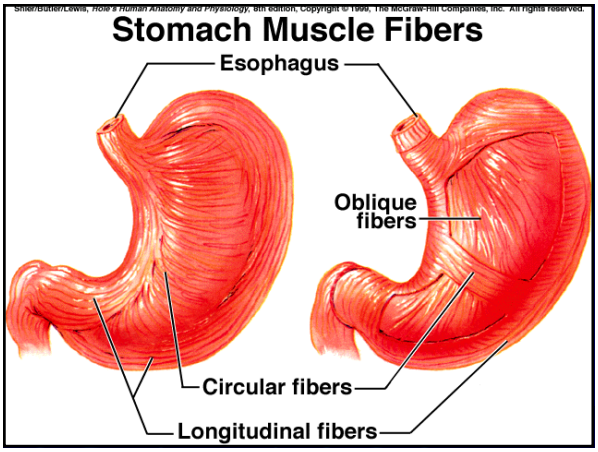
1) cardiac – small area near the esophageal opening

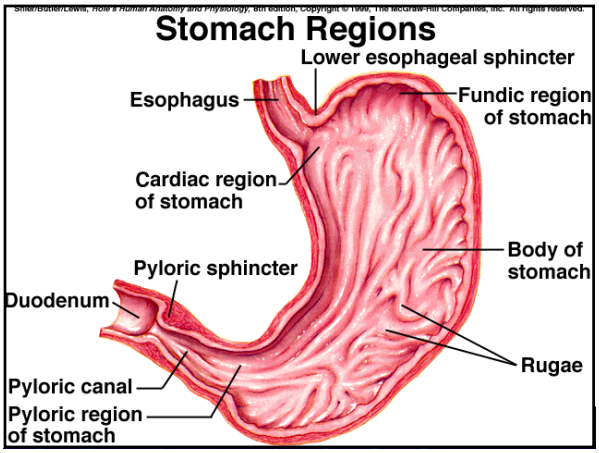
2) fundic – superior & balloons out; sometimes contains swallowed air

3) body - main part of the stomach

4) pyloric – funnel-shaped portion which becomes the pyloric canal

*pyloric sphincter – serves as a valve between the stomach & the small intestine





C. Gastric Secretions

*gastric glands in the stomach lining secrete gastric juice

*gastric glands contain 3 types of secretory cells:

1) mucous cells (goblet cells) – near openings of gastric pits & secrete mucus

2) parietal cells (oxyntic cells) – found in deeper parts of glands & secrete a solution of HCl

3) chief cells (peptic cells) – found in deeper parts of glands & secrete digestive enzymes (pepsinogen → pepsin)

*The products of these 3 types of cells together form gastric juice.

*gastric juice contains pepsin, HCl, lipase, & intrinsic factor

*pepsinogen is secreted by chief cells & when it combines with HCl from the parietal cells it changes to pepsin &

pepsin begins the digestion of proteins

*gastric lipase – a fat-splitting enzyme; action is weak (butterfat)

*mucus is alkaline & prevents the stomach from digesting itself

* intrinsic factor – secreted by parietal cells; is needed for B_{12} absorption from the small intestine

intrinsic factor – produced by parietal cells

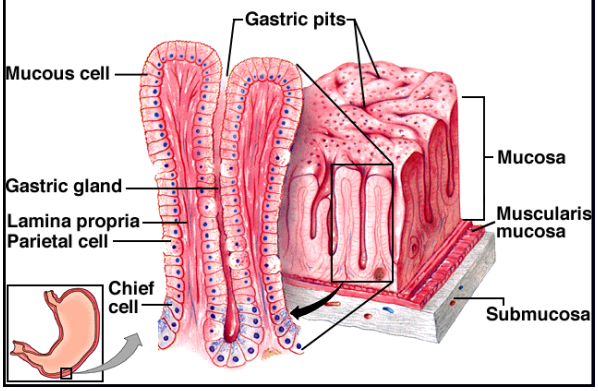
- promotes production of vitamin B_{12} from the small intestine

- vitamin B_{12} significantly influences red blood cell production (along with folic acid)

- vitamin B12 is also required for DNA synthesis (also folic acid)

- Lack of vitamin B12 is usually due to a disorder in the stomach lining rather than a dietary deficiency

Gastric Gland and Mucosa



D. Regulation of Gastric Secretions

*gastric juice is secreted continuously but the rate is controlled neurally and hormonally

*parasympathetic impulses & the hormone gastrin enhance gastric secretion

*somatostatin - hormone that inhibits gastric secretion in the stomach

*ACh will suppress the release of somatostatin & stimulates the release of gastric juice

*histamine – can stimulate more gastric juice secretion

*3 stages of gastric secretion:

1) cephalic phase – gastric secretion is stimulated by senses that involve food

2) gastric phase – starts when food enters the stomach; presence of food & distension of the stomach wall triggers the release of gastrin

3) intestinal phase – begins when food leaves the stomach & enters small intestine

*cholecystokinin – hormone that the small intestine secretes that stimulates the release of pancreatic juice from the pancreas & gall from the gall bladder; also inhibits release of gastric juices

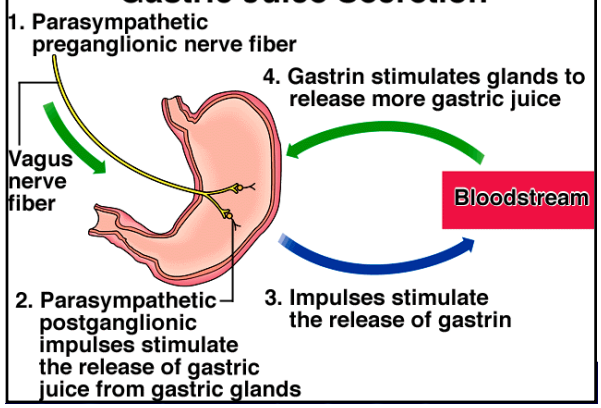
As food moves into the small intestine the secretion of gastric juice is inhibited.

Hormones in the small intestine that affect gastric secretions:

*cholecystokinin – hormone the small intestine secretes that inhibits release of gastric juices; also stimulates the release of pancreatic juice from the pancreas & gall from the gall bladder

*intestinal somatostatin – inhibits release of gastric juice

Gastric Juice Secretion



E. Gastric Absorption

*the stomach is not well adapted for absorption

*a few substances such as water & other small molecules may be absorbed through the stomach wall

F. Mixing and Emptying Actions

*food entering the stomach stretches the muscles in its wall & internal pressure is unchanged

*chyme - a semifluid paste of food & gastric juice that is produced as a result of the mixing movements of the stomach wall; peristaltic waves move the chyme into the pyloric region

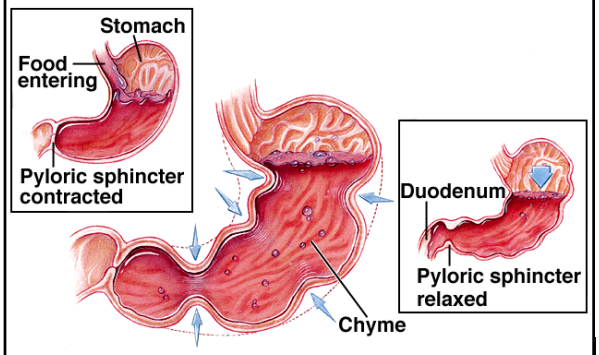
*the muscular wall of the pyloric region regulates chyme movement into the small intestine

*the rate of emptying depends of the fluidity of the chyme & the type of food present

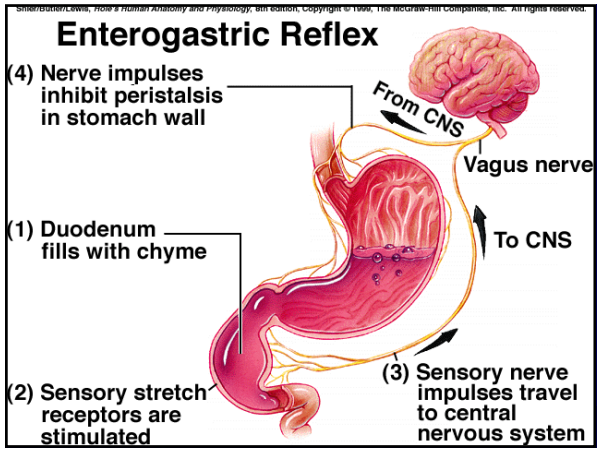
*the upper part of the small intestine fills & an enterogastric reflex inhibits peristalsis in the stomach

* vomiting results from a reflex that has many stimuli

Stomach Movements



Enterogastric Reflex



VII. Pancreas

A. The pancreas has an exocrine function of producing pancreatic juice that aids digestion.

*endocrine gland – secretes hormones directly into the blood or body fluids

*exocrine gland – secretes its products directly into a duct or on body surfaces

B. Structure of the Pancreas

*The pancreas is closely associated with the duodenum of the small intestine.

*The head of the pancreas is located in the C-shaped curve of the duodenum & its tail is against the spleen

*pancreatic juice – a digestive juice secreted by pancreatic acinar cells that make up most of the pancreas; these cells cluster around tiny tubes into which they release their secretions; these tubes lead to a pancreatic duct which extends the entire length of the pancreas & it connects with the duodenum at the same place where the common bile duct from the liver & gallbladder joins the duodenum

C. Pancreatic Juice

*pancreatic juice contains enzymes that digest carbohydrates, fats, proteins, & nucleic acids

*pancreatic amylase-splits starch/glycogen into disaccharides

*pancreatic lipase – breaks triglycerides into fatty acids & glycerol

*trypsinogen, chymotrypsin, & carboxypeptidase – proteolytic enzymes that digest proteins; they are inactive until they are activated by other enzymes; trypsinogen is activated to trypsin; chymotrypsin & carboxypeptidase are activated by pepsin. This mechanism prevents enzymatic digestion of proteins within the secreting cells and the pancreatic ducts.

*nucleases – enzymes in pancreatic juice that break down nuclei acids into nucleotides & bicarbonate ions

D. Regulation of Pancreatic Secretion

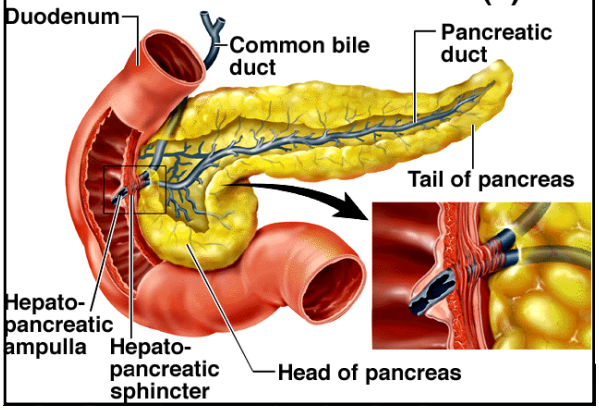
*nervous & endocrine systems regulate the release of pancreatic juice

*secretin (a peptide hormone) – from the duodenum stimulates the release of pancreatic juice in response to the acid in chyme

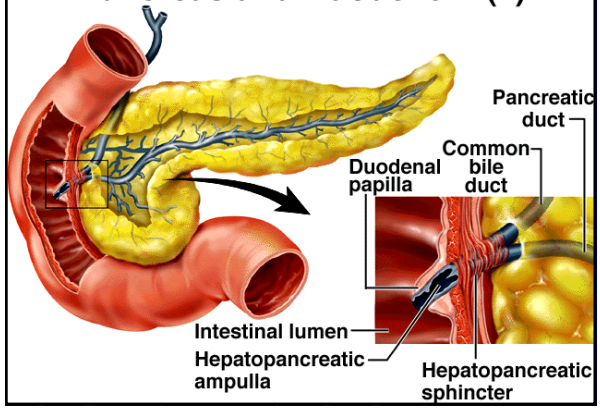
*the high bicarbonate concentration in pancreatic juice helps neutralize chyme & causes the intestinal contents to be alkaline

*cholescystokinin from the intestinal wall stimulates the release of pancreatic juice that has a high concentration of digestive enzymes & can break down fats & proteins

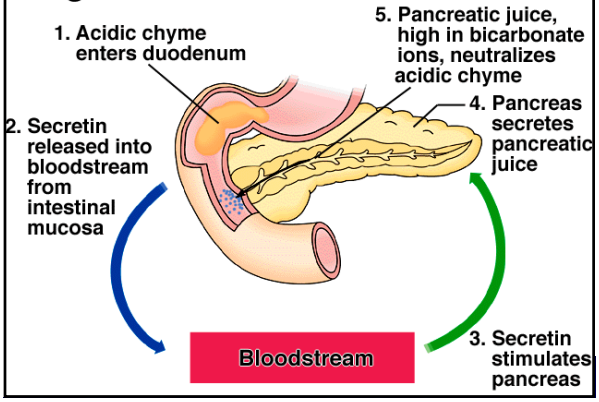
Pancreas and Duodenum (1)



Pancreas and Duodenum (2)



Regulation of Pancreatic Secretion



VIII. Liver

A. The reddish-brown liver, (well supplied with blood vessels), located in the upper right quadrant of the abdominal cavity, & partially surrounded by the ribs is the body's largest internal organ.

B. Liver Structure

*liver is highly vascularized, enclosed in a fibrous capsule, & divided into 4 lobes

*falciform ligament fastens the liver to the abdominal wall; coronary ligament attaches it to the diaphragm

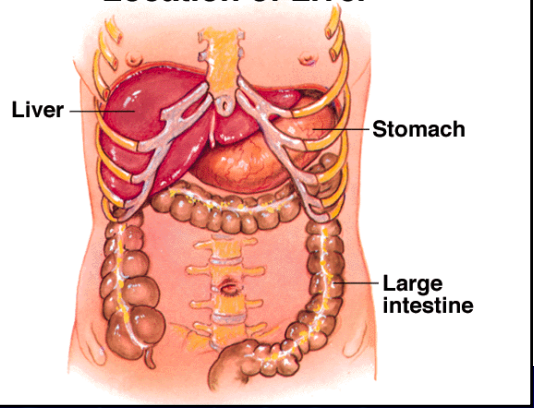
*hepatic lobules – functional units of the liver; each lobule consists of many hepatic cells that radiate from a central vein

*hepatic sinusoids – vascular channels that separate groups of the hepatic cells

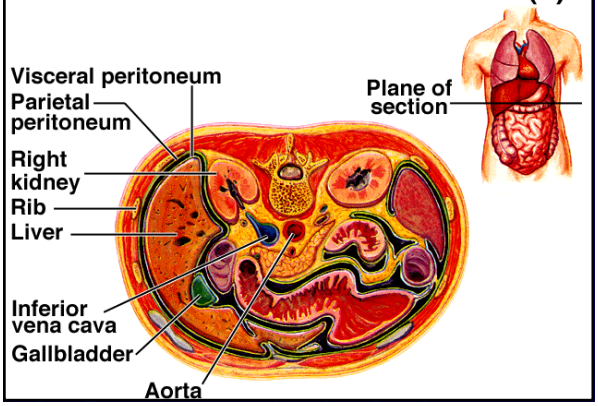
*Kupfer cells – remove bacteria from the blood that has entered through intestinal wall

*hepatic ducts – canals of neighboring lobules merge to form hepatic ducts that merge again & form common hepatic duct

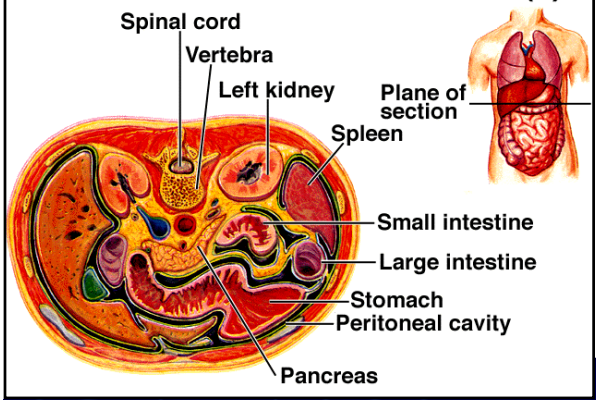
Location of Liver



Abdomen—Transverse Section (1)



Abdomen—Transverse Section (2)



C. Liver Function – many important metabolic activities

*carbohydrate metabolism – helps maintain the normal concentration of blood glucose

*lipid metabolism – oxidizes fatty acids, synthesizes lipoproteins, phospholipids, & cholesterol, & converts portions of carbohydrate & fat molecules into fat molecules, the blood transports fats synthesized in the liver to adipose tissue for storage (this is vital)

*protein metabolism – "the most vital liver function"; deaminize amino acids forming urea, synthesize plasma proteins that are blood clotting factors, convert amino acids to other amino acids

*storage role – glycogen, iron, & vitamins A, D, & B_{12}; plays a role in iron homeostasis; can store 200 - 400 ml of blood

*liver cells help destroy damaged red blood cells & phagocytize foreign antigens

*liver's role in digestion is to secrete bile

D. Composition of Bile

*bile – yellowish green liquid that hepatic cells continuously secrete; it contains H_2O, bile salts, bile pigments, cholesterol, & electrolytes; bile salts are the only bile substances that have a digestive function

*hepatic cells use cholesterol to produce bile salts, & in secreting these salts, some cholesterol is released into the bile

*bile pigments (bilirubin & biliverdin) are breakdown products of hemoglobin from red blood cells; jaundice results from excess deposition of bile pigments

E. Gallbladder

*pear-shaped sac located in a depression on the inferior surface of the liver; it is connected to the cystic duct which joins the hepatic duct; capacity of 30 – 50 ml

*stores bile between meals, concentrates bile by reabsorbing water, & releases bile into the duodenum when stimulated by cholecystokinin from the small intestine; *sphincter muscle controls release of bile from the common bile duct

*gallstones may sometimes form when cholesterol comes out of solution, if the bile is too concentrated, if too much cholesterol is secreted by the hepatic cells, or if the gallbadder is inflammed; can cause obstructive jaundice if gets into the bile duct

F. Regulation of Bile Release

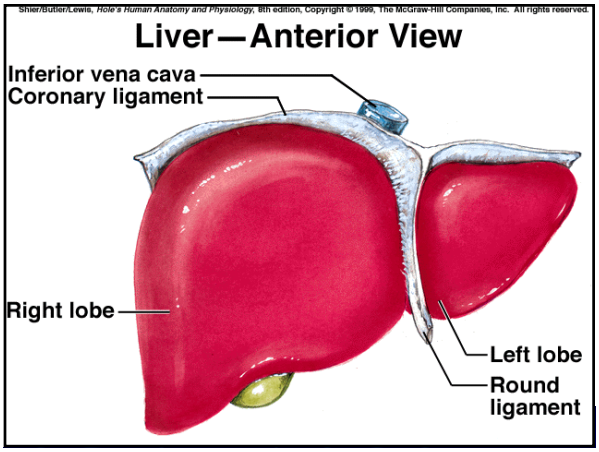
*normally bile does not enter the duodenum until cholecystokinin stimulates the gallbladder to contract

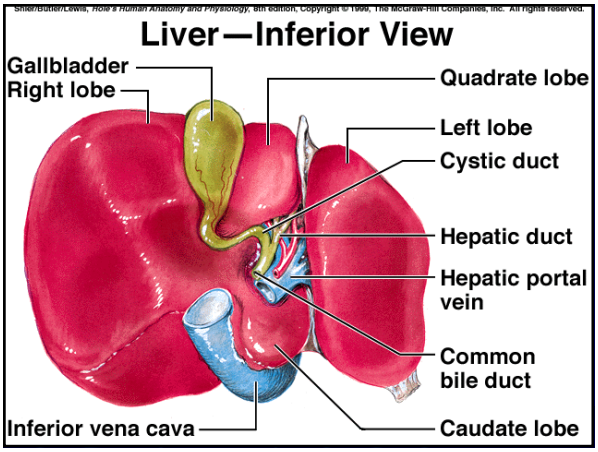
* The sphincter muscle at the base of the common bile duct relaxes as a peristaltic wave in the duodenal wall approaches.

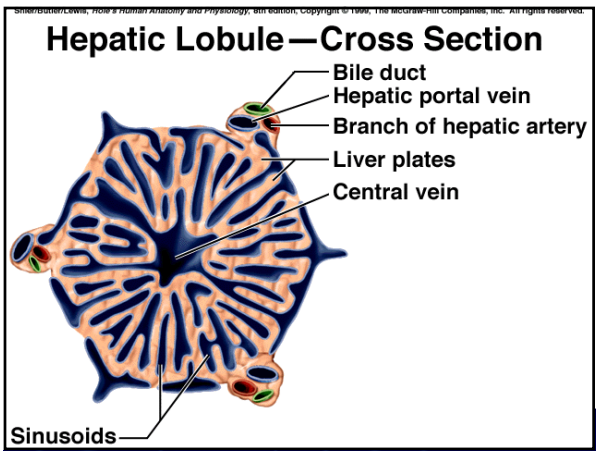
G. Functions of Bile Salts

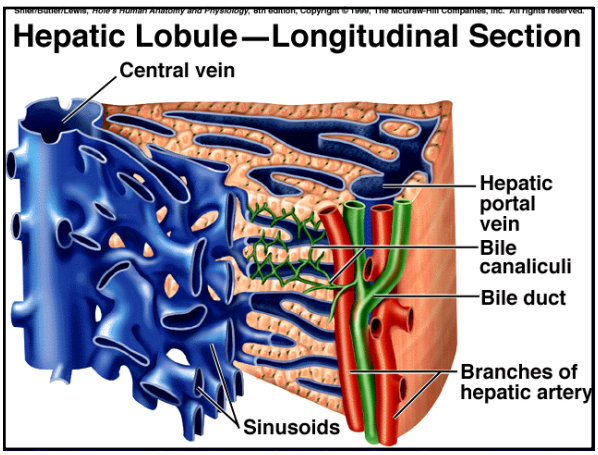
*bile salts emulsify fats (like soap acts on grease) & aid in the absorption of fatty acids, cholesterol, & certain vitamins

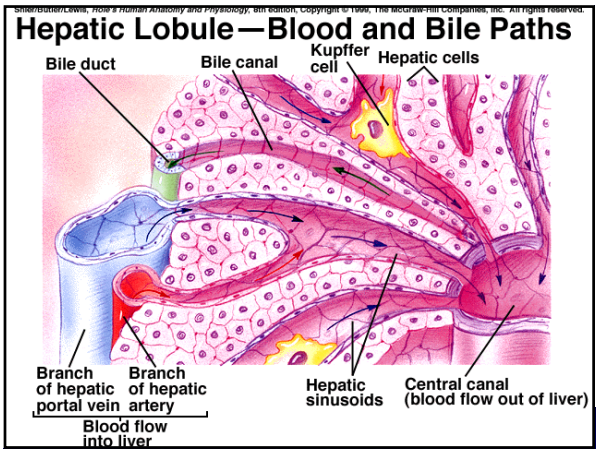
*bile salts are reasbsorbed in the small intestine

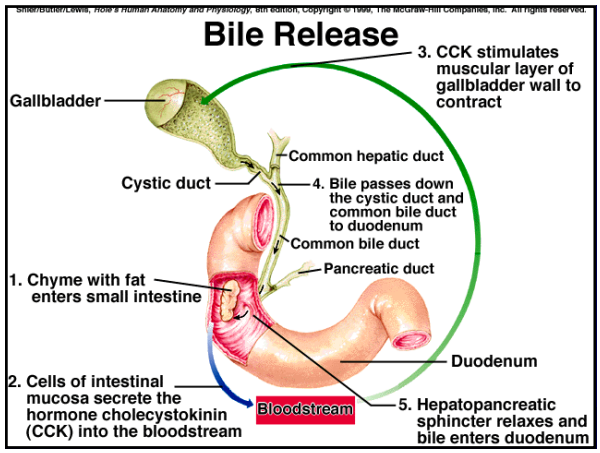












IX. Small Intestine

A. The lengthy small intestine extends from the pyloric sphincter to the large intestine. It receives secretions from the pancreas and liver, completes digestion of the nutrients in chyme, absorbs the products of digestion, and transports the remaining residues to the large intestine. (about 18-20 feet long)

B. Parts of the Small Intestine (3)

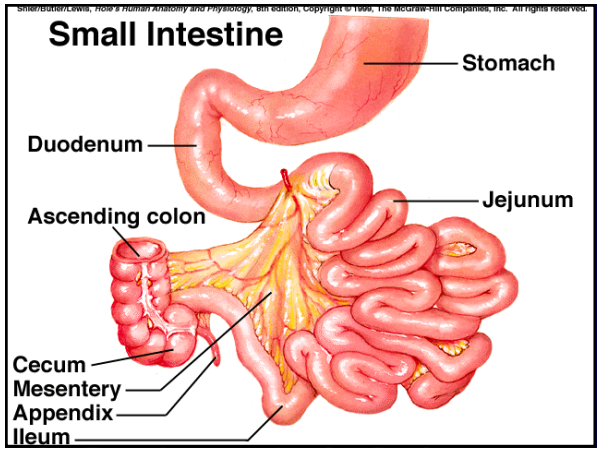
*duodenum – C-shaped path, shortest & most fixed part

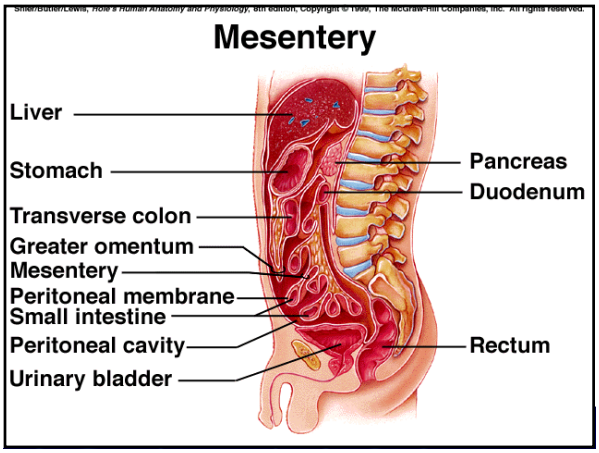
*jejunum – mobile & lies free in the peritoneal cavity

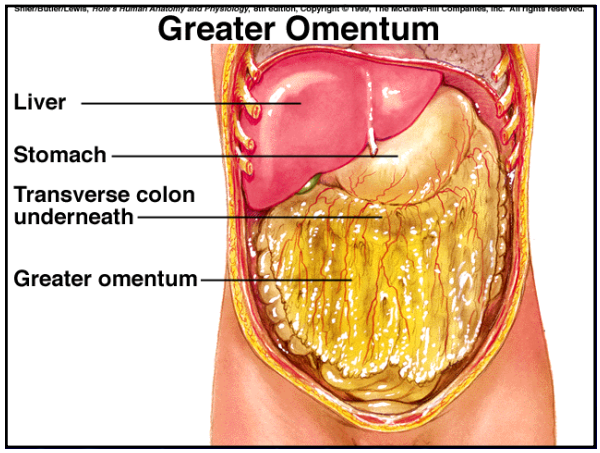
*ileum – most distal portion of the small intestine

*mesentery – peritoneal tissue that suspends the jejunum & ileum to the abdominal wall; has blood vessels, nerves, & lymphatic vessels that supply the intestinal wall

*greater omentum – double fold (drape) of peritoneum that helps protect the peritoneal cavity







C. Structure of the Small Intestinal Wall

*wall is lined with villi that greatly increase the surface area & aid in mixing & absorption

*lumen – passageway of the alimentary canal

*villi – have a layer of simple columnar epithelium, core of connective tissue, containing blood capillaries & lacteals

*lacteal – a lymphatic capillary on each villi

*microvilli on the free ends of the epithelial cells increase the surface area & aid in mixing & absorption

*intestinal glands are located between the villi

*circular folds in the lining of the intestinal wall also increase its surface area

D. Secretions of the Small Intestine

*intestinal glands secrete a watery fluid that lacks digestive enzymes but provides a vehicle for moving chyme to the villi; digestive enzymes embedded in the surfaces of microvilli split sugar, protein, & fat molecules

E. Regulation of Small Intestinal Secretions

*secretion is stimulated by gastric juice, chyme, & reflexes stimulated by distension of the small intestinal wall

F. Absorption in the Small Intestine

*villi absorb monosaccharides, amino acids, fatty acids, & glycerol

*villi also absorb water & electrolytes

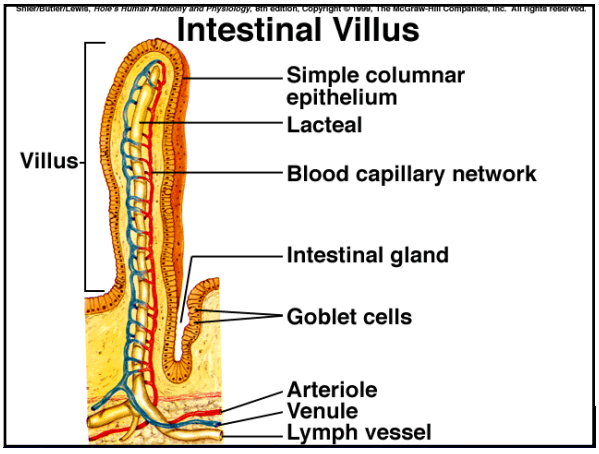
*fat molecules with longer chains of carbon atoms enter the lacteals of the villi; fatty acids with relatively short carbon chains enter the blood capillaries of the villi

G. Movements of the Small Intestine

*mixing by segmentation & peristalsis

*over distension or irritation may stimulate a peristaltic rush & bring on diarrhea

*the ileocecal sphincter controls movement of the intestinal contents from the small intestine into the large intestine



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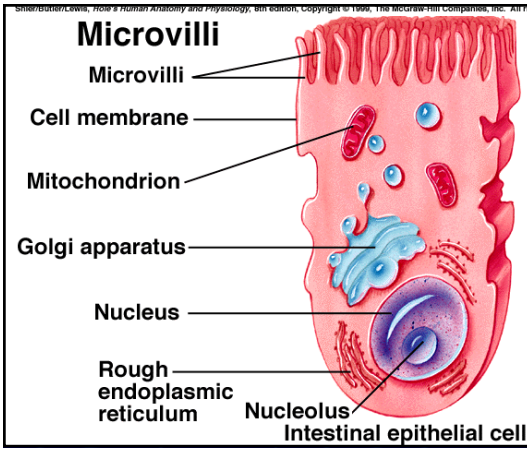

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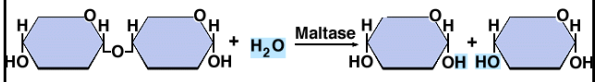
Carbohydrate Digestion



Maltose + Water $\xrightarrow{\text{Maltase}}$ Glucose + Glucose

Disaccharide — Monosaccharides

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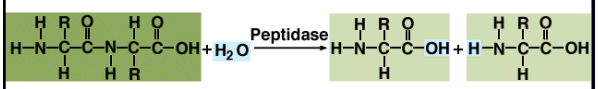
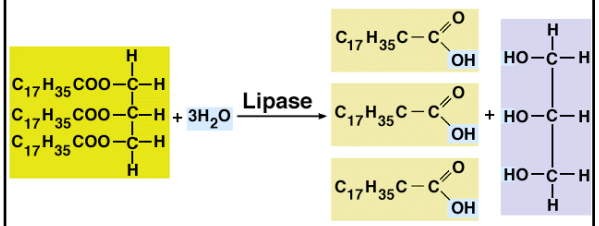
Dipeptide Digestion



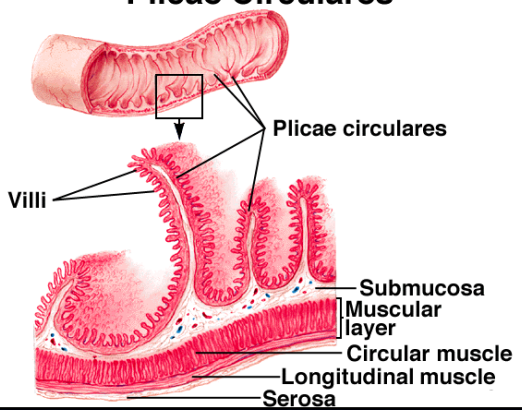
Peptide (portion of a protein molecule) + Water $\xrightarrow{\text{Peptidase}}$ Amino acid + Amino acid

Fat Digestion

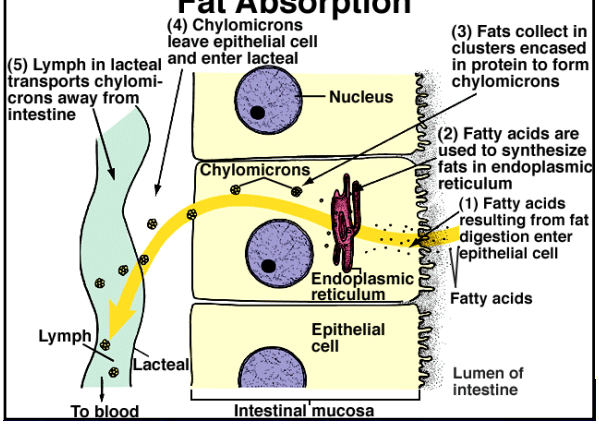


Fat + Water $\xrightarrow{\text{Lipase}}$ Fatty acids + Glycerol

Plicae Circulares



Fat Absorption



X. Large Intestine

A. The large intestine absorbs water and electrolytes from the chyme remaining in the alimentary canal, reabsorbs & recycles water & remnants of digestive secretions, and forms & stores feces.

B. Parts of the Large Intestine

*consists of cecum, colon, rectum, & anal canal

*is divided into ascending, transverse, descending, & sigmoid portions

C. Structure of the Large Intestinal Wall

*resembles the wall in other parts of the alimentary canal

*lacks villi

*has a unique layer of longitudinal muscle fibers arranged in distinct bands

D. Functions of the Large Intestine

*has little or no function in digestion; it does secrete mucus

*mechanical stimulation & parasympathetic impulses control the rate of mucus secretion

*absorbs water & electrolytes

*many bacteria inhabit the large intestine, where they break down certain undigestible substances & synthesize certain vitamins

E. Movements of the Large Intestine

*similar to the small intestine; mass movements occur 2 – 3 times a day; defecation is stimulated by a reflex

F. Feces

*formed & stored in the large intestine

*consists of water, undigested material, mucus, & bacteria

*feces color is due to bile pigments that have been altered by bacterial action

Large Intestine (1)