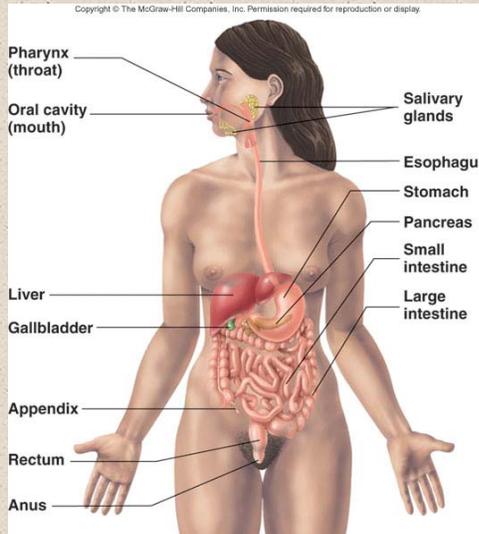


# Chapter 24

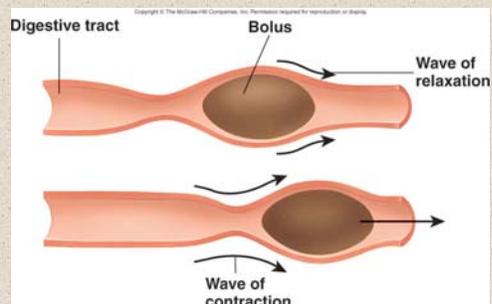
## Digestive System



24-1

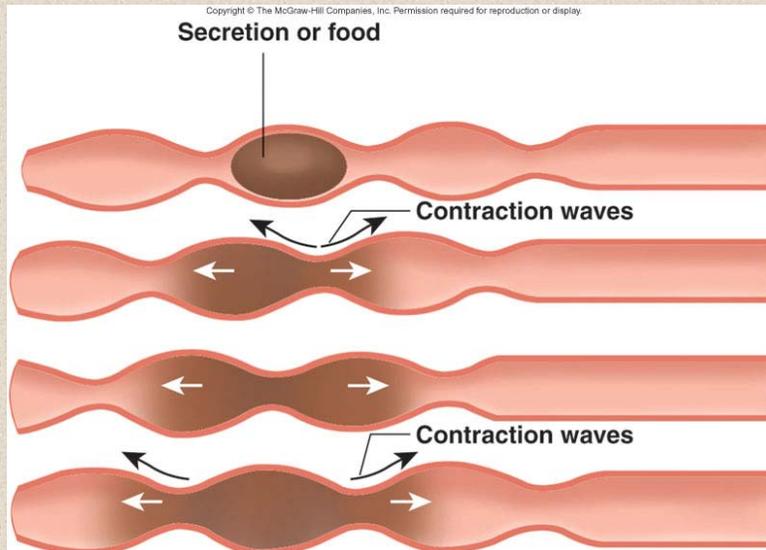
1. **Ingestion:** introduction of food into stomach
2. **Mastication:** chewing. Chemical digestion requires large surface area so breaking down large particles mechanically facilitates chemical digestion.
3. **Propulsion**
  - **Deglutition:** swallowing
  - **Peristalsis:** moves material through digestive tract . A wave of circular smooth muscle relaxation moves ahead of the bolus of food or chyme allowing the digestive tract to expand. Then a wave of contraction of the circular smooth muscles behind the bolus of food or chyme propels it through the digestive tract.
    - **Mass movements** in large intestine

## Functions



24-2

## 4. Mixing: Segmental contraction



## Functions, cont.

### 5. **Secretion:** lubricate, liquefy, digest

Mucus: secreted along entire digestive tract, lubricates food and lining, coats lining and protects from mechanical digestion, from acid and from digestive enzymes.

Water: liquefaction makes food easier to digest and absorb

**Bile:** emulsifies fats

**Enzymes:** chemical digestion

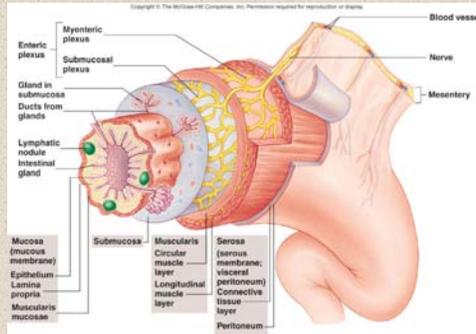
### 6. **Digestion:** Mechanical and chemical

### 7. **Absorption:** Movement from tract into circulation or lymph

### 8. **Elimination:** Waste products removed from body; feces. Defecation

24-4

## Digestive Tract Histology: The Tunics



- **Mucosa.** Innermost layer, consisting of mucous epithelium (stratified squamous in mouth, oropharynx, esophagus and anal canal), simple columnar epithelium in the rest of the tract.

- Loose connective tissue: *lamina propria*

Note: Muscularis mucosae: smooth muscle

- **Submucosa.** Thick C.T. layer with nerves, blood vessels, small glands. Parasympathetic submucosal plexus.

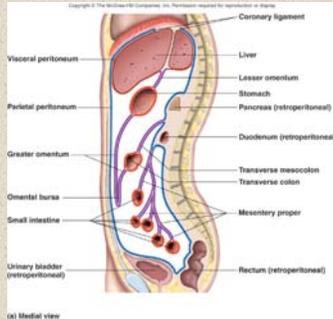
24-5

## Digestive System Regulation

- **Nervous regulation**
  - **Local: enteric nervous system**
    - Coordinates peristalsis and regulates local reflexes
  - **General:** coordination with the CNS. May initiate reflexes because of sight, smell, or taste of food. **Parasympathetic primarily.** Sympathetic input inhibits muscle contraction, secretion, and decrease of blood flow to the digestive tract.
- **Chemical regulation**
  - Production of hormones to be discussed later
    - Gastrin, secretin
  - Production of paracrine chemicals like histamine
    - Help local reflexes in ENS control the conditions of the internal environment of the digestive tract such as pH levels

24-6

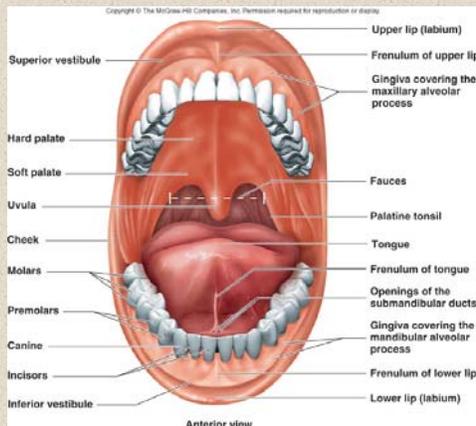
# Peritoneum and Mesenteries



- **Peritoneum**
  - **Visceral:** Covers organs
  - **Parietal:** Covers interior surface of body wall
  - **Retroperitoneal:** Certain organs covered by peritoneum on only one surface and are considered behind the peritoneum; e.g., kidneys, pancreas, duodenum
- **Mesenteries:** two layers of peritoneum with thin layer of loose C.T. between
  - Routes by which vessels and nerves pass from body wall to organs
  - **Greater omentum:** connects greater curvature of the stomach to the transverse colon.
  - **Lesser omentum:** connects lesser curvature of the stomach and the proximal part of the duodenum to the liver and diaphragm.
  - **Transverse mesocolon, sigmoid mesocolon, mesoappendix.**
- **Ligaments**

24-7

# Oral Cavity



- Bounded by lips anteriorly, **fauces** (opening into pharynx) posteriorly
  - **Vestibule:** space between lip/cheeks and alveolar processes with teeth
  - **Oral cavity proper:** medial to alveolar processes
  - Lined with moist stratified squamous epithelium

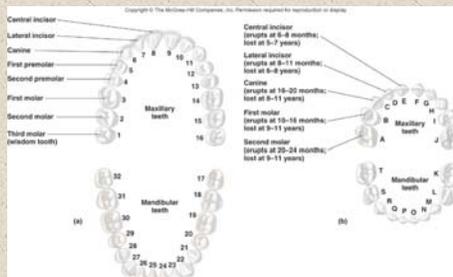
24-8

# Tongue

- Muscular with free anterior surface and attached posterior surface. Covered with moist stratified squamous epithelium.
  - **Intrinsic muscles:** change shape
  - **Extrinsic muscles:** protrude or retract tongue, move side to side
- **Lingual frenulum** attaches tongue inferiorly to floor of oral cavity
- Anterior part: **papillae**, some of which have taste buds
- Posterior part: no papillae and a few scattered taste buds. Lymphoid tissue embedded in posterior surface: **lingual tonsil**
- Moves food in mouth, participates in speech and swallowing

24-9

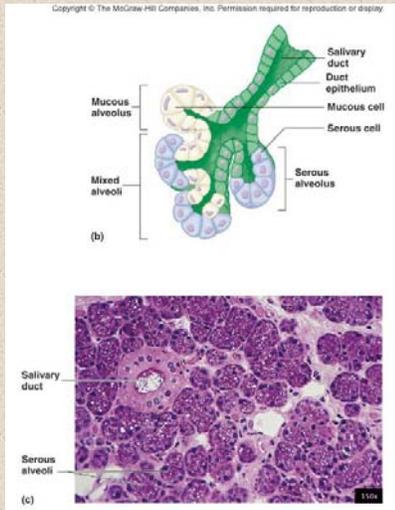
# Teeth



- Two sets
  - **Primary, deciduous, milk:** Childhood
  - **Permanent or secondary:** Adult (32)
- Types
  - **Incisors, canines, premolars and molars**

24-10

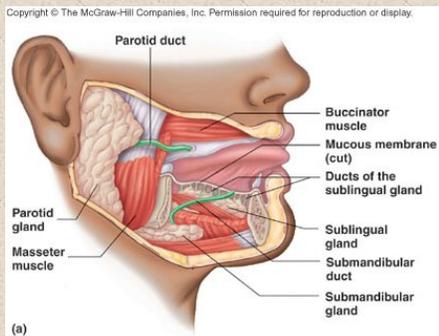
# Saliva



- EXOCRINE Compound alveolar salivary glands. Produce **saliva**
  - Prevents bacterial infection
  - Lubrication
  - Contains salivary amylase that breaks down starch into disaccharides maltose and isomaltose.
  - Helps to form bolus for swallowing
  - Parasympathetic input causes salivary production

24-11

# Salivary Glands



- Three pairs of multicellular glands
  - **Parotid**: largest. Serous. Just anterior to the ear. **Parotid duct** crosses over masseter, penetrates buccinator, and enters the oral cavity adjacent to the 2<sup>nd</sup> upper molar
  - **Submandibular**: mixed, but more serous than mucous. Posterior half of inferior border of mandible. Duct enters oral cavity on either side of lingual frenulum
  - **Sublingual**: smallest. Mixed, but primarily mucous. Each has 10-12 ducts that enter the floor of the oral cavity.
- **Lingual glands**. Small, coiled tubular glands on surface of

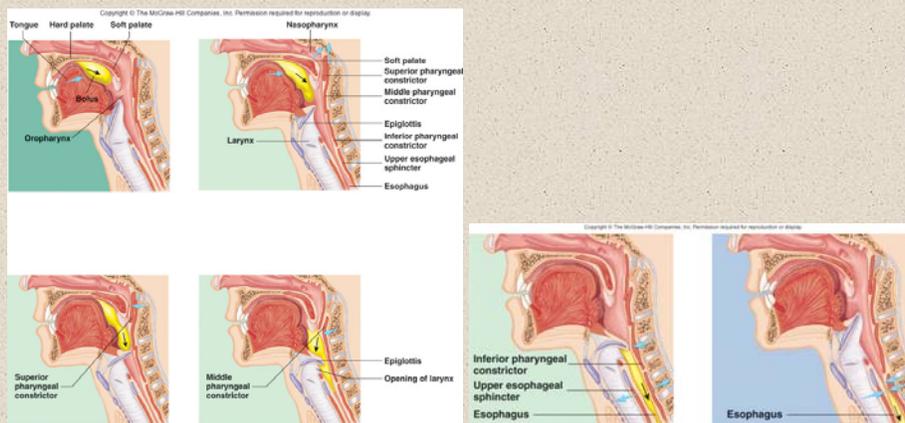
24-12

# Pharynx and Esophagus

- Pharynx
  - Posterior walls of oropharynx and laryngopharynx contains group of muscles called pharyngeal constrictors that contribute to swallowing
- Esophagus
  - Transports food from pharynx to stomach
  - Passes through **esophageal hiatus** (opening) **Hiatal hernia**: widening of hiatus
  - **Sphincters**
    - Upper. Striated
    - Lower. Smooth
  - Mucosa is moist stratified squamous epithelium. Produces thick layer of mucus.

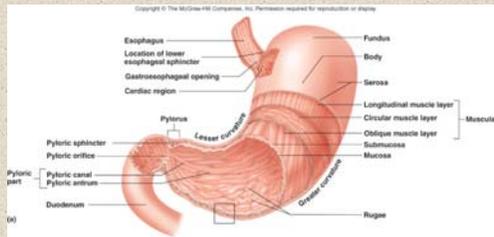
24-13

# Three Phases of Swallowing



24-14

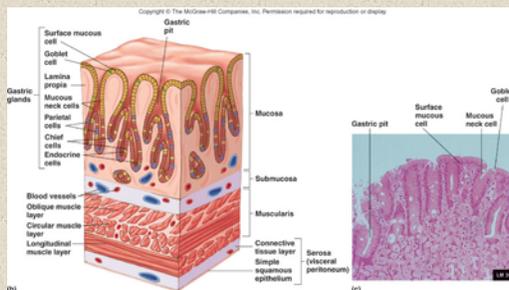
# Stomach Anatomy



- Openings
  - **Gastroesophageal (cardiac)**: to esophagus
  - **Pyloric**: to duodenum
- Regions
  - **Cardiac**
  - **Fundus**
  - **Body**
  - **Pyloric: antrum and canal**
- **Greater and lesser curvatures**: attachment sites for omenta
- **Sphincters**
  - **Cardiac** (lower esophageal)
  - **Pyloric**

24-15

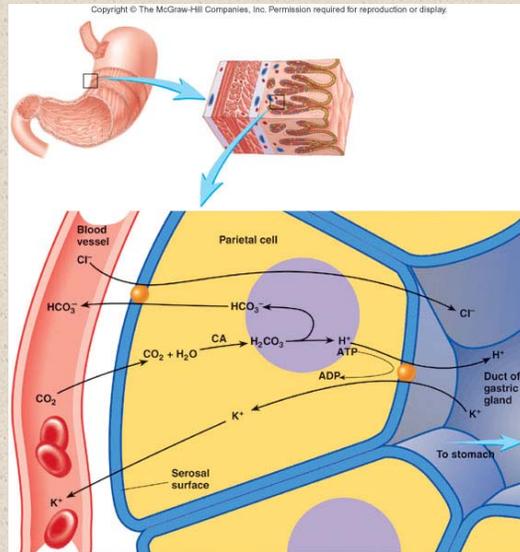
# Stomach Histology



- Layers
  - Serosa or visceral peritoneum: outermost
  - Muscularis: three layers
    - Outer longitudinal
    - Middle circular
    - (Inner oblique)
  - Submucosa
  - Mucosa
- **Rugae**: folds in stomach when empty.

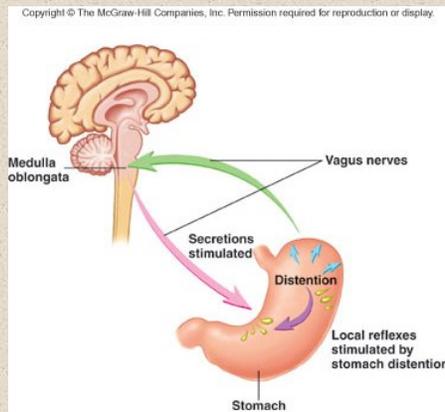
24-16

## Hydrochloric Acid Production



24-17

## Gastric Phase

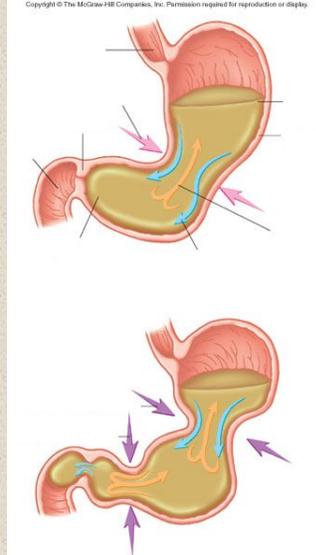


- Distention of the stomach activates a parasympathetic reflex. Action potentials are carried by the vagus nerves to the medulla oblongata.
- Medulla oblongata stimulates further secretions of the stomach.
- Distention also stimulates local reflexes that amplify stomach secretions.

24-18

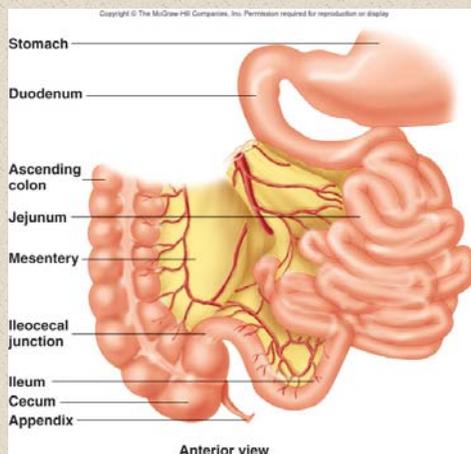
## Movements in Stomach

- Combination of mixing waves (80%) and peristaltic waves (20%)
- Both esophageal and pyloric sphincters are closed.



24-19

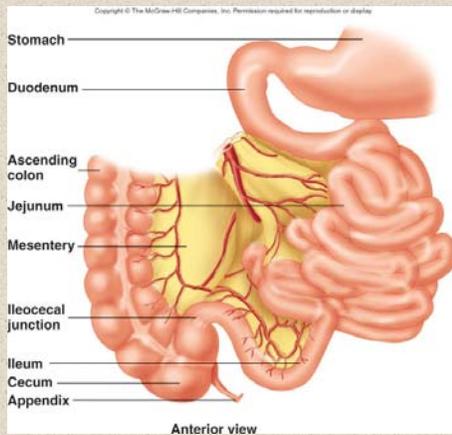
## Small Intestine



- Site of greatest amount of digestion and absorption of nutrients and water
- Divisions
  - **Duodenum**- first 25 cm beyond the pyloric sphincter.
  - **Jejunum**- 2.5 m
  - **Ileum**- 3.5 m. Peyer's patches or lymph nodules

24-20

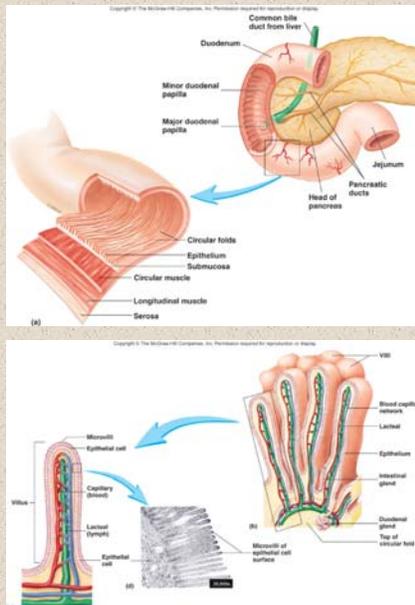
# Duodenum



- Curves to the left; head of pancreas in the curve
- Major and minor duodenal papillae: openings to ducts from liver and/or pancreas.

24-21

# Modifications to Increase Surface Area



- Increase surface area 600 fold
  - **Plicae circulares** (circular folds)
  - **Villi** that contain capillaries and lacteals. Folds of the mucosa
  - **Microvilli**: folds of cell membranes of absorptive cells

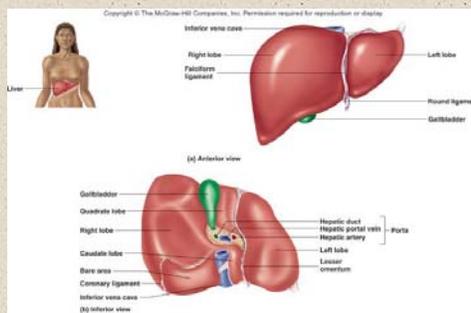
24-22

## Jejunum and Ileum

- Gradual decrease in diameter, thickness of intestinal wall, number of circular fold, and number of villi the farther away from the stomach
- Major site of nutrient absorption
- **Peyer's patches**: lymphatic nodules numerous in mucosa and submucosa
- **Ileocecal junction**: where ileum meets large intestine. **Ileocecal sphincter** and **ileocecal valve**

24-23

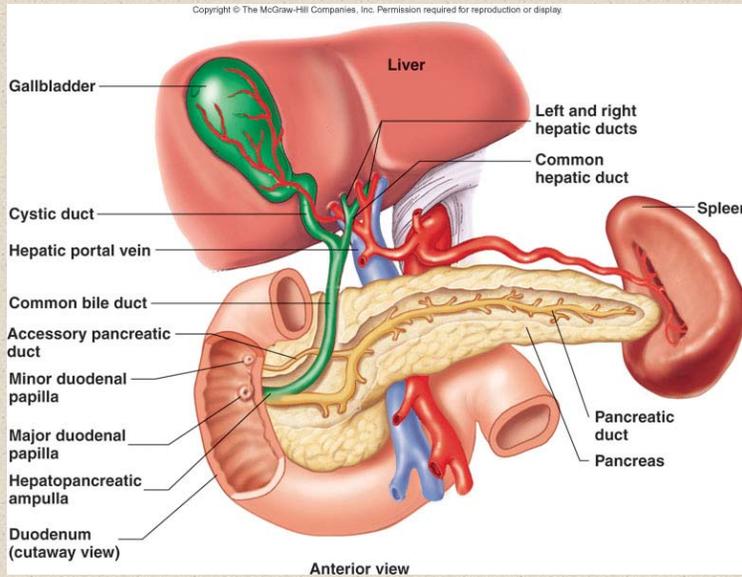
## Liver



- **Lobes**
  - **Major**: Left and right
  - **Minor**: Caudate and quadrate
- **Porta**: on inferior surface. Vessels, ducts, nerves, exit/enter liver
- **Ducts**
  - **Right and left hepatics** unite to form
  - **Common hepatic**
  - **Cystic**: from gallbladder
  - **Common bile**: union of cystic duct and common hepatic duct

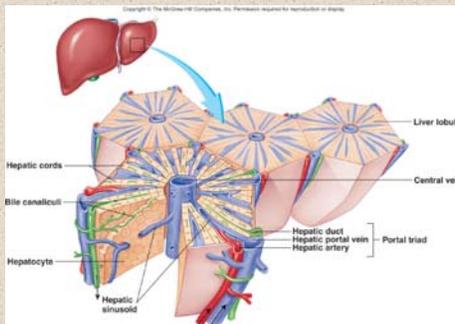
24-24

# Liver, Gallbladder, Pancreas and Ducts



24-25

## Histology of the Liver



- C.T. Divides liver into **lobules**
- Nerves, vessels and ducts follow the septa
- Lobules: **portal triad** at each corner
  - Three vessels: hepatic portal vein, hepatic artery, hepatic duct
  - **Central vein** in center of lobule
- Central veins unite to form hepatic veins that exit liver and empty into inferior vena cava

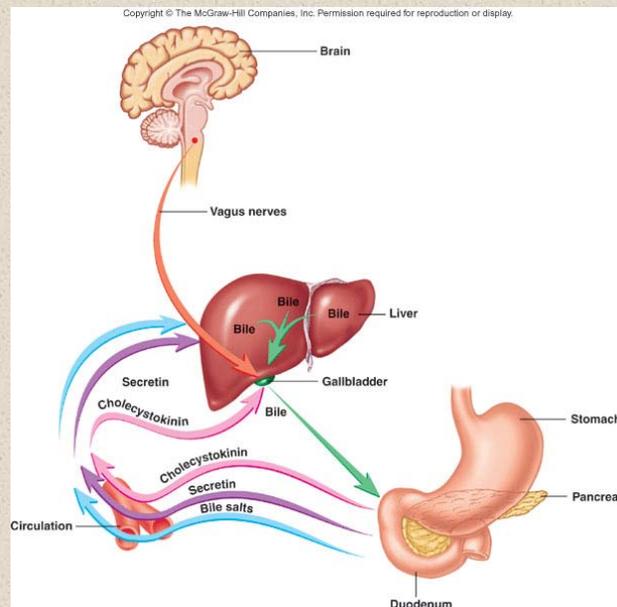
24-26

## Functions of the Liver

- **Bile production:** 600-1000 mL/day. Bile salts (bilirubin), cholesterol, fats, fat-soluble hormones, lecithin
  - Neutralizes and dilutes stomach acid
  - Bile salts emulsify fats. Most are reabsorbed in the ileum.
  - Secretin (from the duodenum) stimulates bile secretions, increasing water and bicarbonate ion content of the bile
- **Storage**
  - Glycogen, fat, vitamins, copper and iron. Hepatic portal blood comes to liver from small intestine.
- **Nutrient interconversion**
  - Amino acids to energy producing compounds
  - Hydroxylation of vitamin D. Vitamin D then travels to kidney where it is hydroxylated again into its active form
- **Detoxification**
  - Hepatocytes remove ammonia and convert to urea
- **Phagocytosis**
  - Kupffer cells phagocytize worn-out and dying red and white blood cells, some bacteria
- **Synthesis**
  - Albumins, fibrinogen, globulins, heparin, clotting factors

24-27

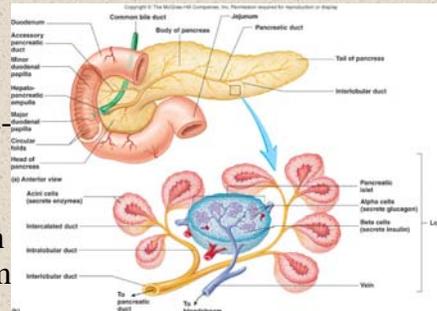
## Control of Bile Secretion and Release



24-28

- Pancreas both endocrine and exocrine
- **Head, body** and **tail**
- Endocrine: **pancreatic islets**. Produce insulin, glucose, and somatostatin
- Exocrine: groups **acini** (grape-like cluster) form **lobules** separated by septa.
- Pancreatic duct joins common bile duct and enters duodenum at the **hepatopancreatic ampulla** controlled by the **hepatopancreatic ampullar sphincter**

## Pancreas



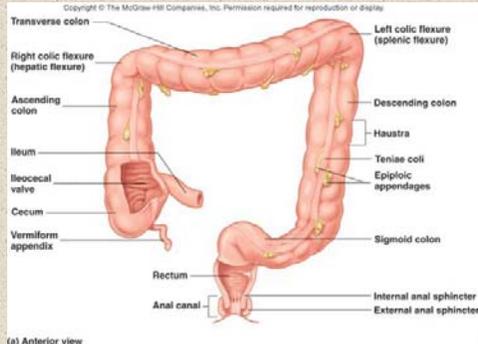
24-29

## Pancreatic Secretions: Pancreatic Juice

- Aqueous. Produced by columnar epithelium lining smaller ducts.  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{HCO}_3^-$ , water. Bicarbonate lowers pH inhibiting pepsin and providing proper pH for enzymes
- Enzymatic portion:
  - Interaction of duodenal and pancreatic enzymes.
    - **Enterokinase** from the duodenal mucosa and attached to the brush border activates trypsinogen to **trypsin**.
    - Trypsin activates chymotrypsinogen to **chymotrypsin**
    - Trypsin activates **procarboxypeptidase** to carboxypeptidase.
- Trypsin, chymotrypsin and carboxypeptidase digest proteins: proteolytic.
- Pancreatic amylase continues digestion of starch
- Pancreatic lipase digests lipids
- Deoxyribonucleases and ribonucleases digest DNA and ribonucleic acid, respectively

24-30

# Large Intestine



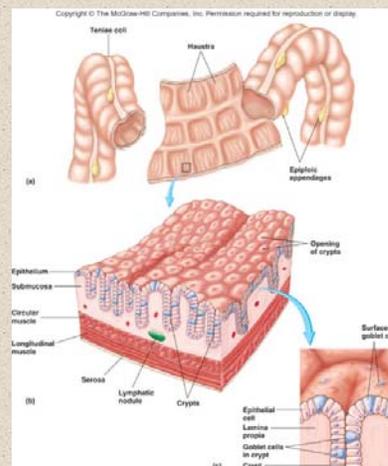
(a) Anterior view

- Extends from ileocecal junction to **anus**
- Consists of **cecum, colon, rectum, anal canal**
- Movements sluggish (18-24 hours); chyme converted to feces.
- Absorption of water and salts, secretion of mucus, extensive action of microorganisms.
- 1500 mL chyme enter the cecum, **90%** of volume reabsorbed yielding 80-150 mL of feces

24-31

- Cecum
  - Blind sac, **vermiform appendix** attached. Appendix' walls contain numerous lymph nodules
- Colon
  - **Ascending, transverse, descending, sigmoid**
  - Circular muscle layer complete; longitudinal incomplete (three **teniae coli**). Contractions of teniae form pouches called **haustra**. Small fat filled pouches called **epiploic appendages**
  - Mucosa has numerous straight tubular glands called **crypts**. Goblet cells predominate, but there are also absorptive and granular cells as in the small intestine

# Anatomy of Large Intestine



24-32

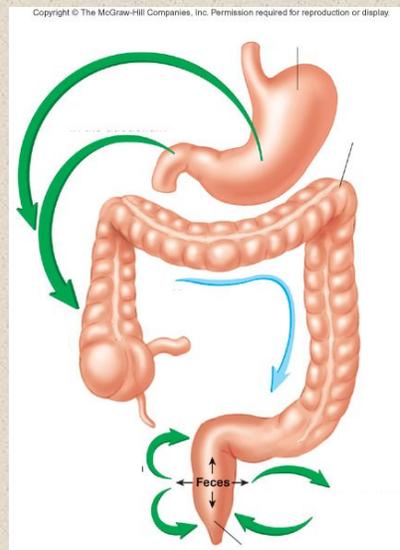
## Secretions of Large Intestine

- Mucus provides protection
  - Parasympathetic stimulation increases rate of goblet cell secretion
- **Pumps:** bacteria produce acid and the following remove acid from the epithelial cells that line the large intestine
  - Exchange of bicarbonate ions for chloride ions
  - Exchange of sodium ions for hydrogen ions
- Bacterial actions produce gases (flatus) from particular kinds of carbohydrates found in legumes and in artificial sugars like sorbitol
- Bacteria produce vitamin K which is then absorbed
- Feces consists of **water, undigested food (cellulose), microorganisms, sloughed-off epithelial cells**

24-33

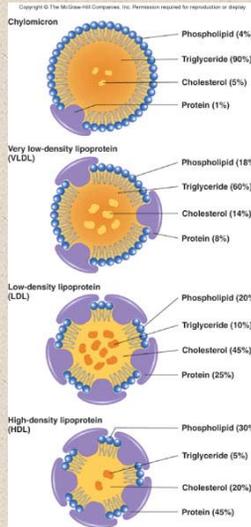
## Movement in Large Intestine

- **Mass movements**
  - Common after meals
  - Integrated by the enteric plexus
- **Local reflexes** instigated by the presence of food in the stomach and duodenum
  - **Gastrocolic:** initiated by stomach
  - **Duodenocolic:** initiated by duodenum
- **Defecation**
  - **Defecation reflex:** distension of the rectal wall by feces
  - Parasympathetic stimulation
  - Usually accompanied by voluntary movements to expel feces. Abdominal cavity pressure caused by inspiration and by contraction of muscles of abdominal wall.



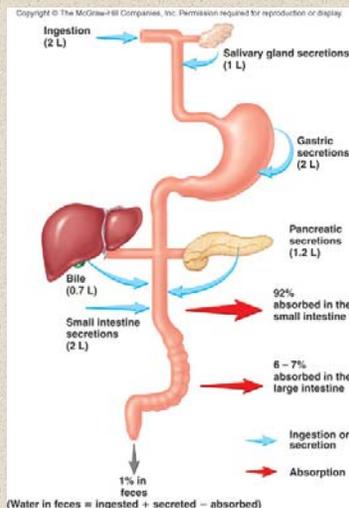
24-34

# Lipoproteins



- All lipids carried in the blood are done so in combination with protein to make them soluble in plasma.
- Cholesterol: 15% ingested; 85% manufactured in liver and intestinal mucosa
- Lipids are lower density than water; proteins are higher density than water
- Chylomicrons: 99% lipid and 1% protein (extremely low density); enter lymph
- VLDL: 92% lipid, 8% protein
  - Form in which lipids leave the liver
  - Triglycerides removed from VLDL and stored in adipose cells. VLDL has been converted to LDL.
- LDL: 75% lipid, 25% protein
  - Transports cholesterol to cells
  - Cells have LDL receptors
  - # of LDL receptors become less once cell's lipid/cholesterol needs are met.
- HDL: 55% lipid, 45% protein
  - Transports excess cholesterol from <sup>24-35</sup> cells to liver

# Water and Ions



- Water: can move in either direction across wall of small intestine depending on osmotic gradients
- Ions: sodium, potassium, calcium, magnesium, phosphate are actively transported

24-36

## Effects of Aging

- Decrease in mucus layer, connective tissue, muscles and secretions
- Increased susceptibility to infections and toxic agents, increase in incidences of ulcerations and cancers

24-37