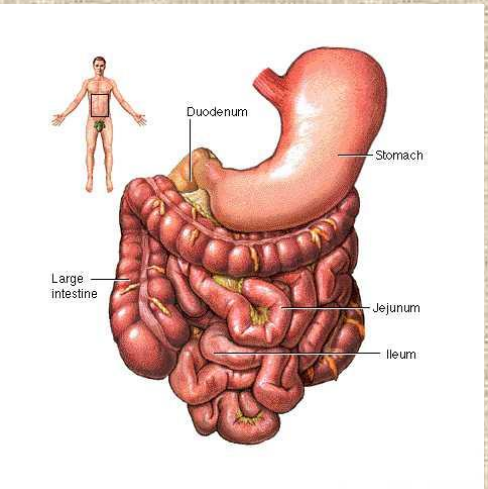
The Digestive System



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Digestion

- Processing of food
- Types
  - Mechanical (physical)
    - Chew
    - Tear
    - Grind
    - Mash
    - Mix
  - Chemical
    - Catabolic reactions
    - Enzymatic hydrolysis
      - Carbohydrate
      - Protein
      - Lipid

Digestion

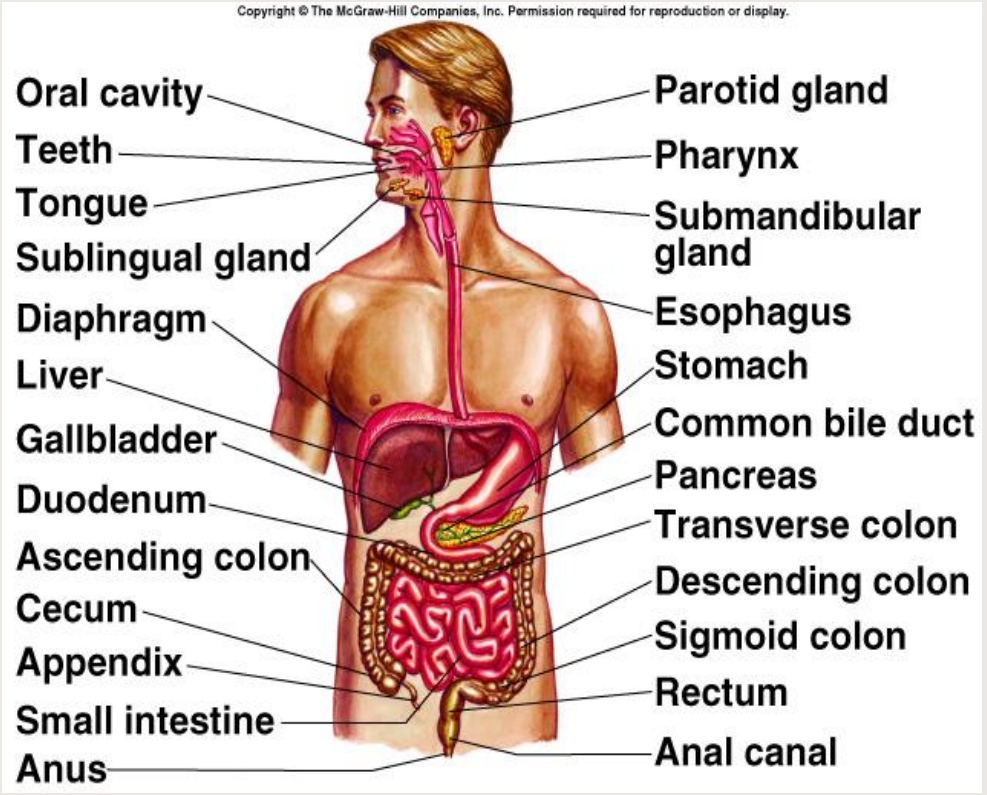
- Phases
  - Ingestion: taking food into mouth
  - Mastication: chewing food & mixing it with saliva
  - Deglutition: swallowing food
  - Peristalsis: rhythmic wave-like contractions that move food through GI tract
  - Absorption: entering the nutrients to the blood

Secretion

- Includes release of exocrine & endocrine products into GI tract
- Exocrine secretions include: HCl, H_20, $HC0_3^-$, bile, lipase, pepsin, amylase, trypsin, elastase, & histamine
- Endocrine includes hormones secreted into stomach & small intestine to help regulate GI system
  - E.g. gastrin, secretin, CCK, GIP, GLP-1, guanylin, VIP, & somatostatin

Digestive System Organization

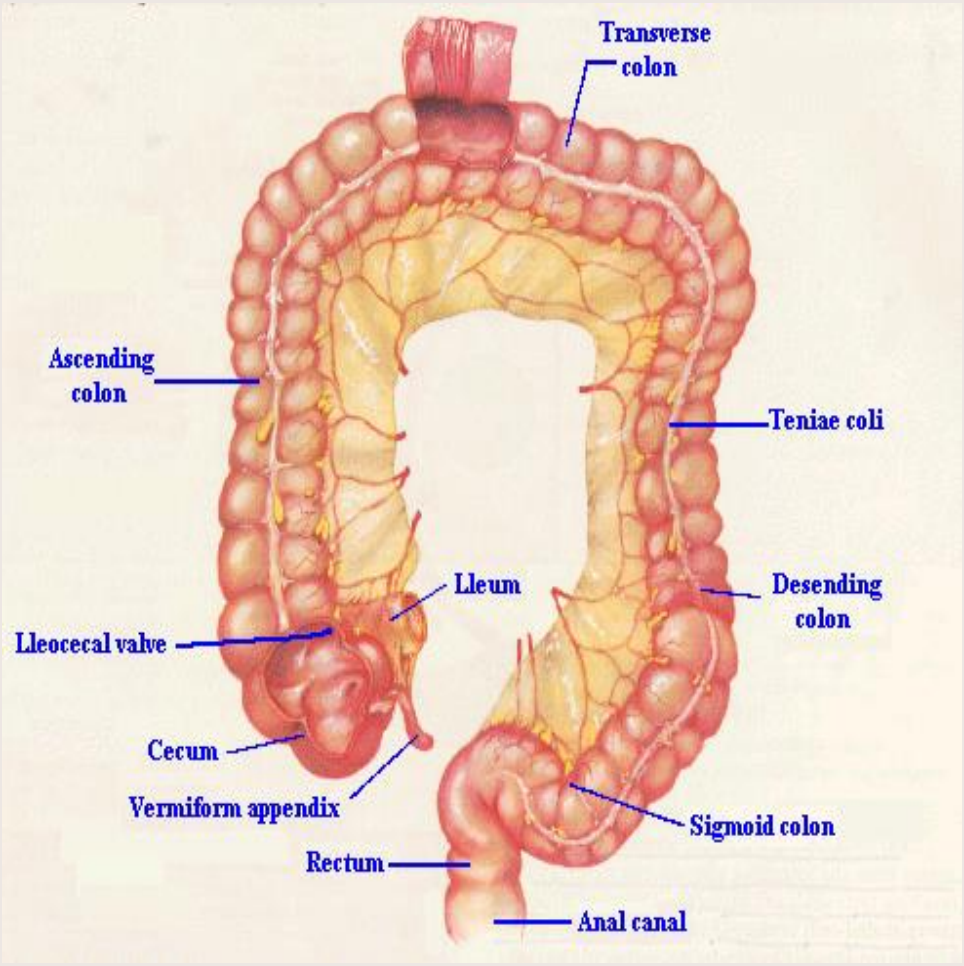
- Gastrointestinal (Gl) tract (Alimentary canal)
  - Structures
    - Mouth
    - Oral Cavity
    - Pharynx
    - Esophagus
    - Stomach
    - Duedenum
    - Jejenum
    - Ileum
    - Cecum
    - Ascending colon
    - Transverse colon



Digestive System Organization

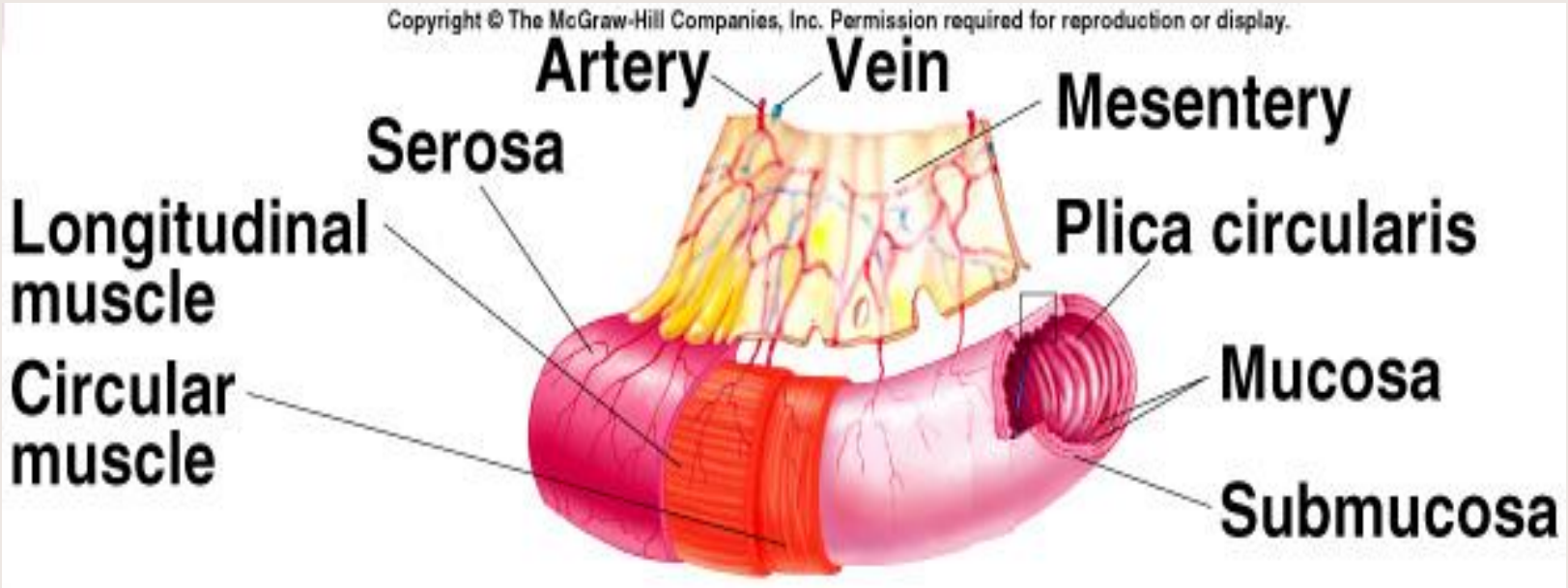
- Descending colon
- Sigmoid colon
- Rectum
- Anus

- Accessory structures
  - Not in tube path
  - Organs
    - Teeth
    - Tongue
    - Salivary glands
    - Liver
    - Gall bladder
    - Pancreas



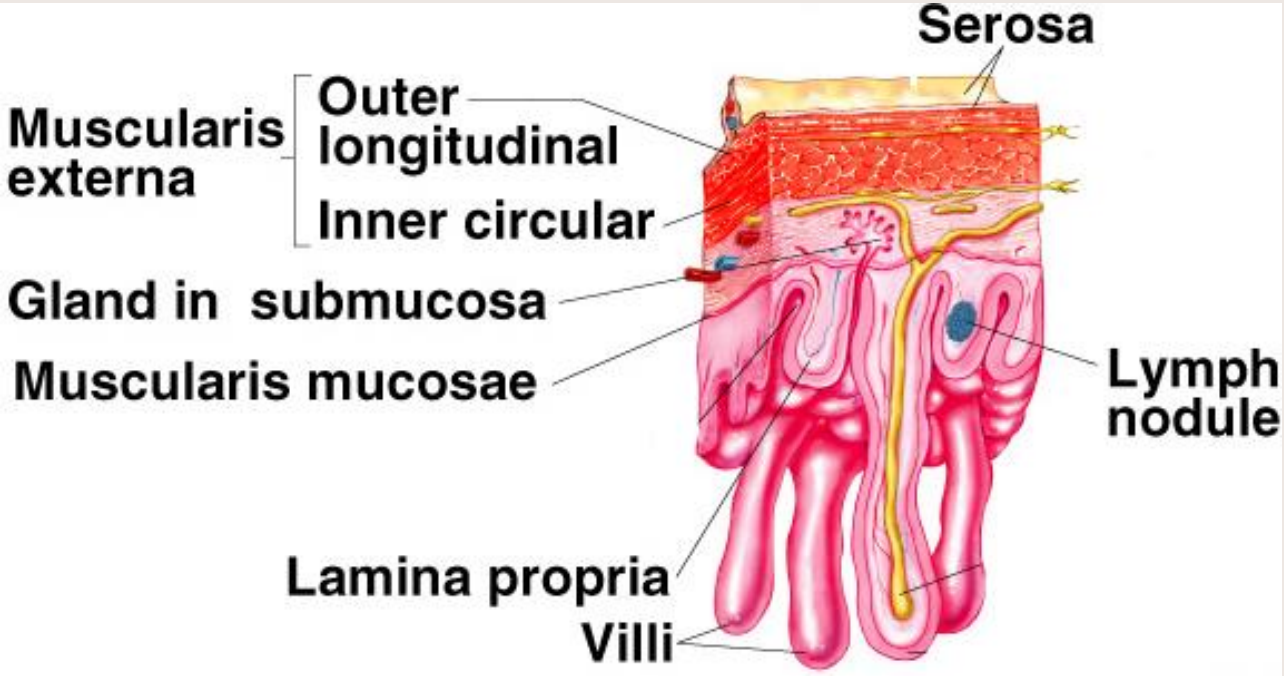
Layers of GI Tract

- Are called tunics
- The 4 tunics are mucosa, submucosa, muscularis, & serosa



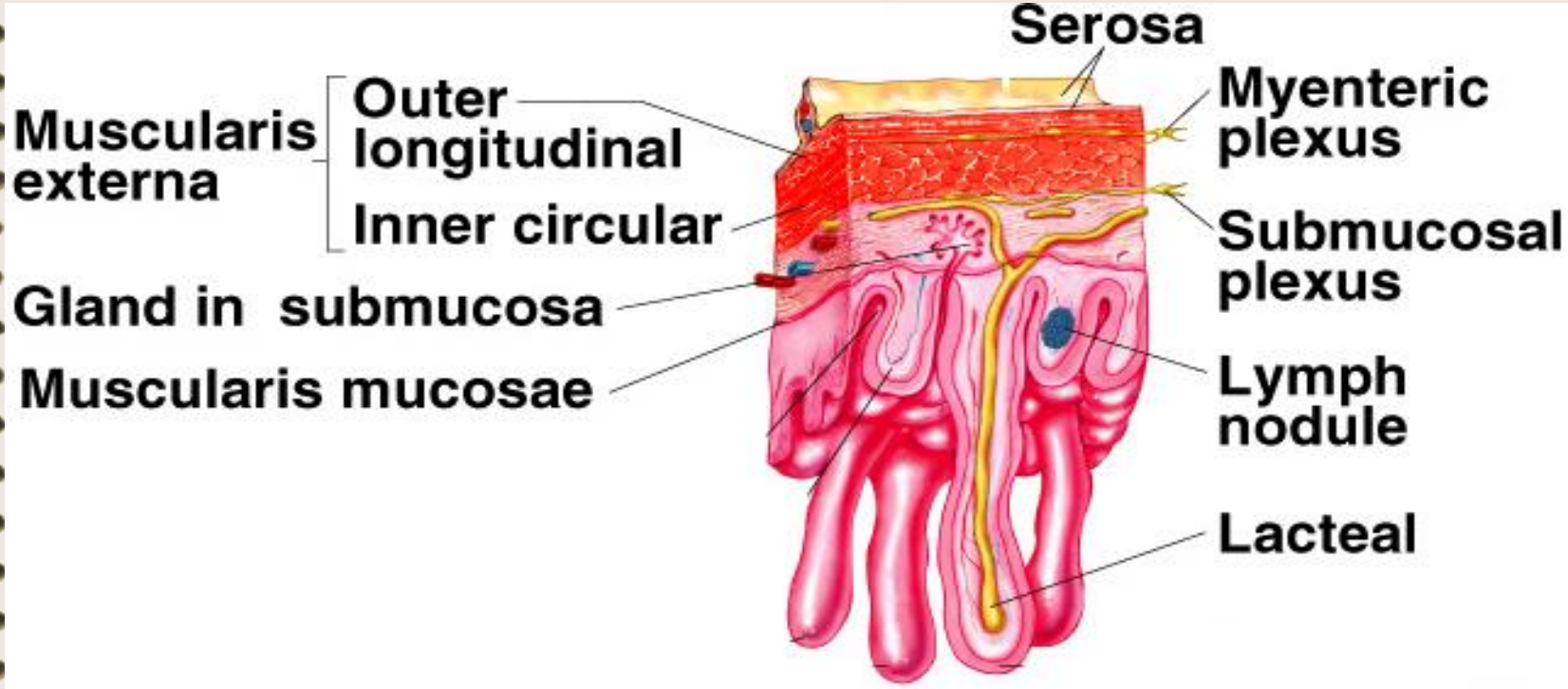
Mucosa

- Is the absorptive & secretory layer lining lumen of GI tract
- In places is highly folded with villi to increase absorptive area
- Contains lymph nodules, mucus-secreting goblet cells, & thin layer of muscle



Submucosa

- Is a thick, highly vascular layer of connective tissue where absorbed molecules enter blood & lymphatic vessels
- Contains glands & nerve plexuses (submucosal plexus) that carry ANS activity to muscularis

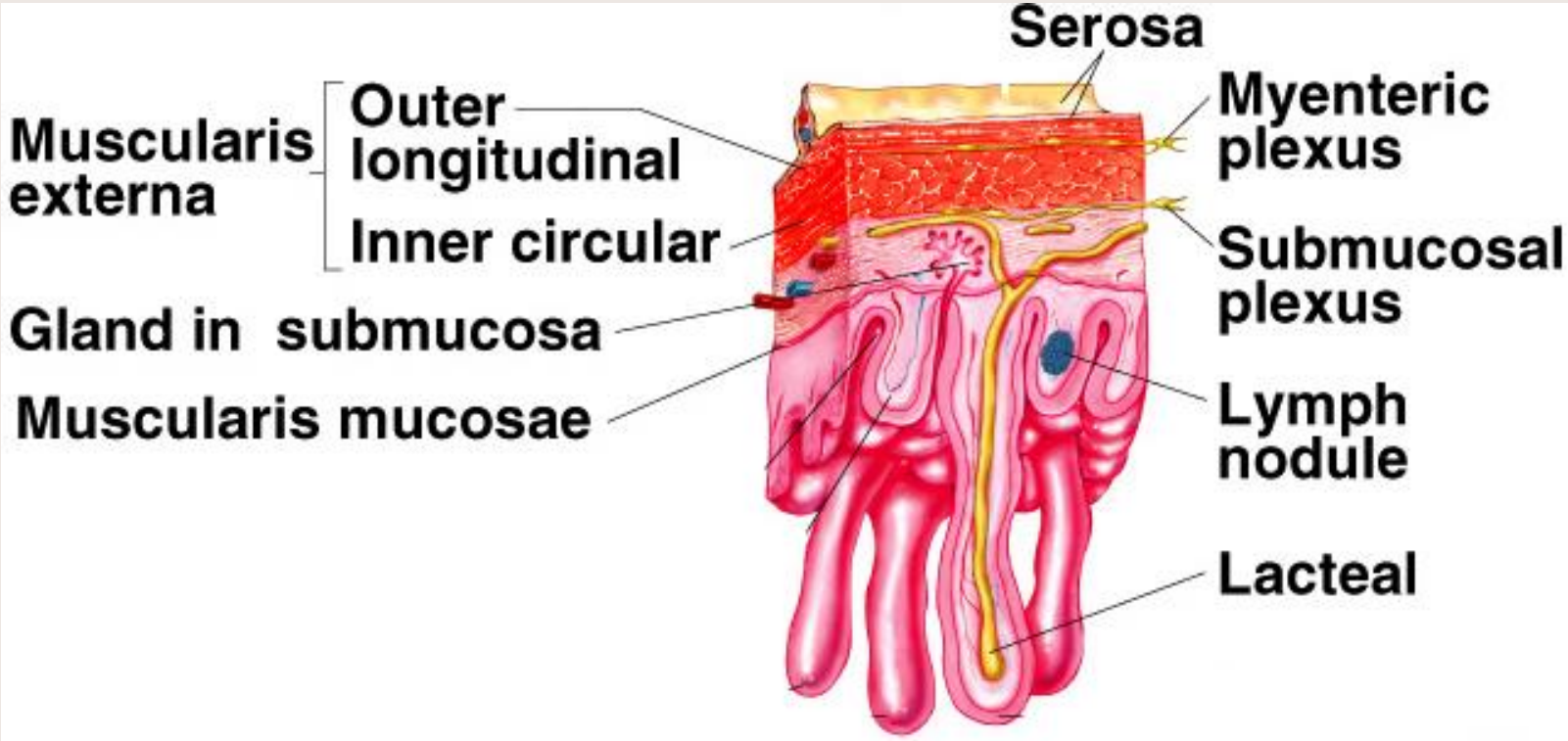


Muscularis

- Is responsible for segmental contractions & peristaltic movement through GI tract
- Has an inner circular & outer longitudinal layer of smooth muscle
  - Activity of these layers moves food through tract while pulverizing & mixing it
  - Myenteric plexus between these layers is major nerve supply to GI tract
    - Includes fibers & ganglia from both Symp & Parasymp systems

Serosa

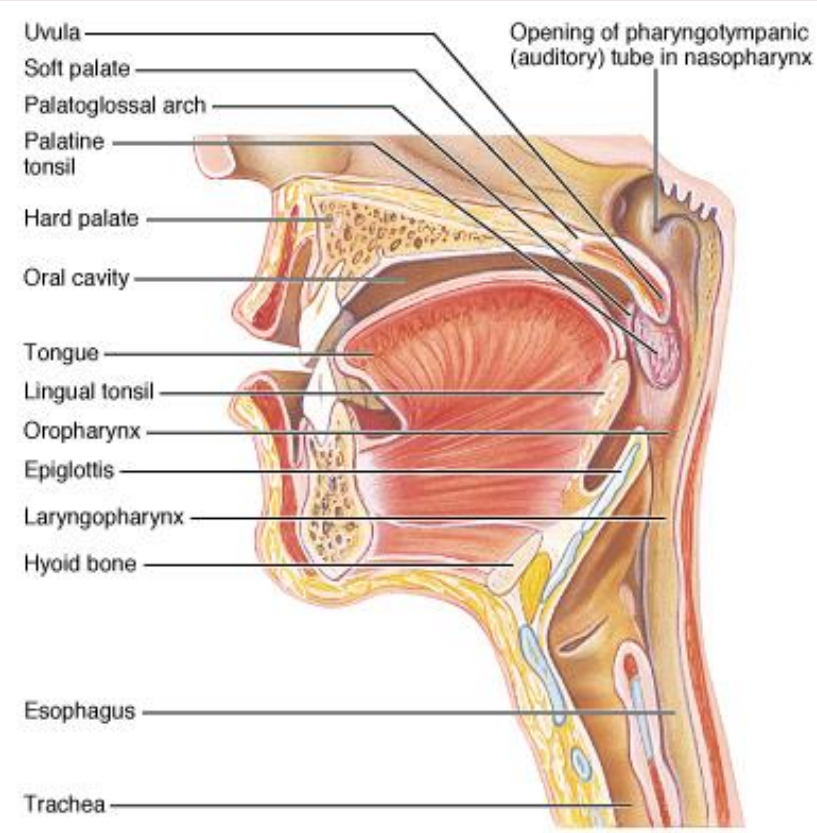
- Is outermost layer; serves to bind & protect
- Consists of areolar connective tissue covered with layer of simple squamous epithelium

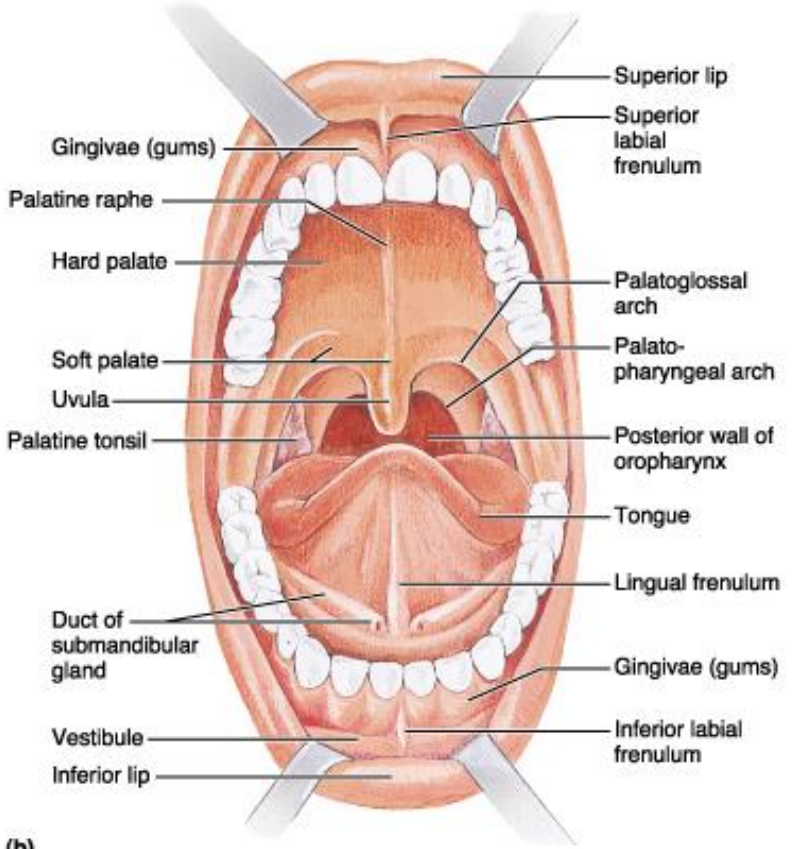


Regulation of GI Tract

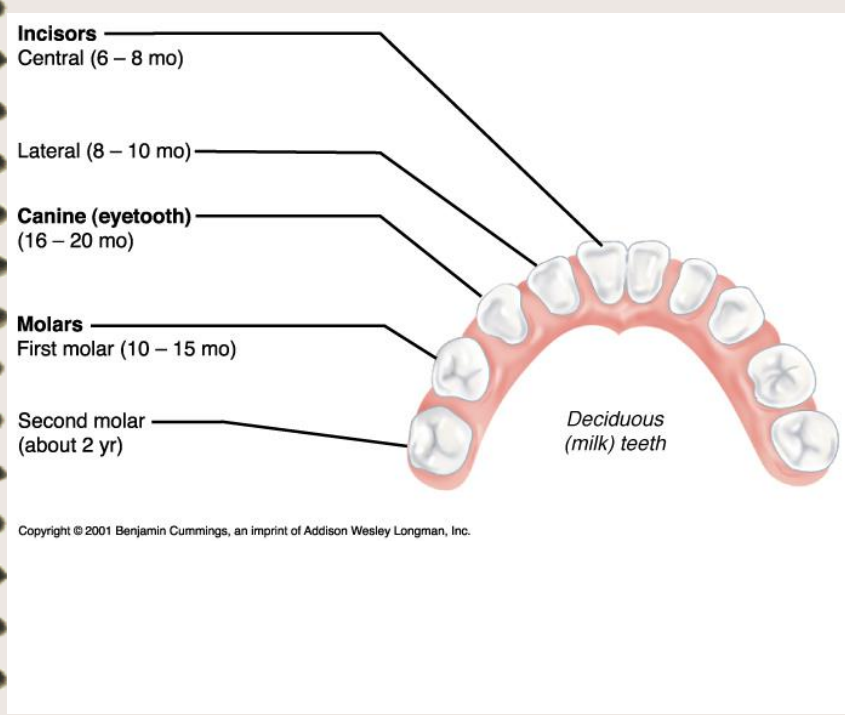
- Parasympathetic effects, arising from vagus & spinal nerves, stimulate motility & secretions of GI tract
- Sympathetic activity reduces peristalsis & secretory activity
- GI tract contains an intrinsic system that controls its movements--the enteric nervous system
- GI motility is influenced by paracrine & hormonal signals

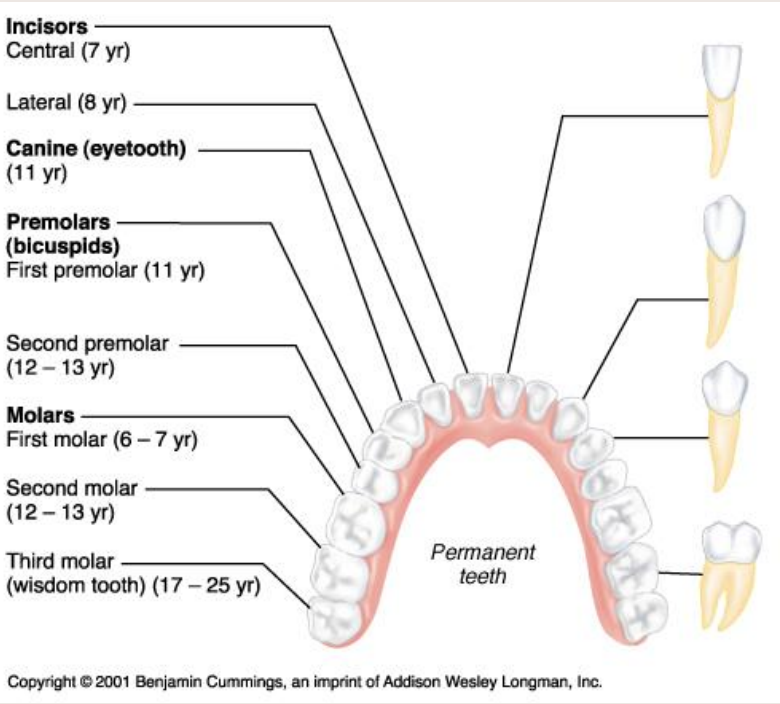
Anatomy of the Mouth and Throat



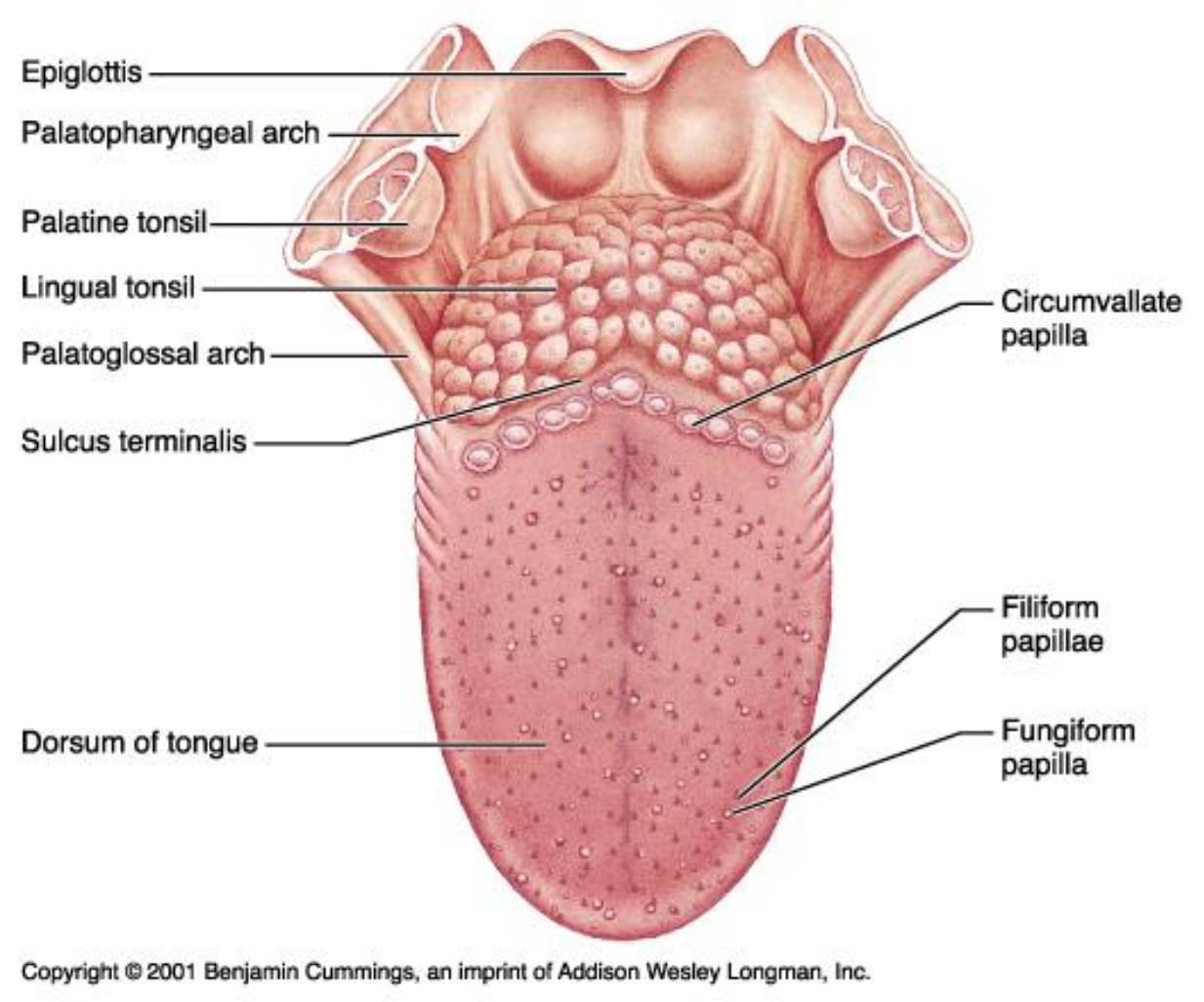


Human Deciduous and Permanent Teeth

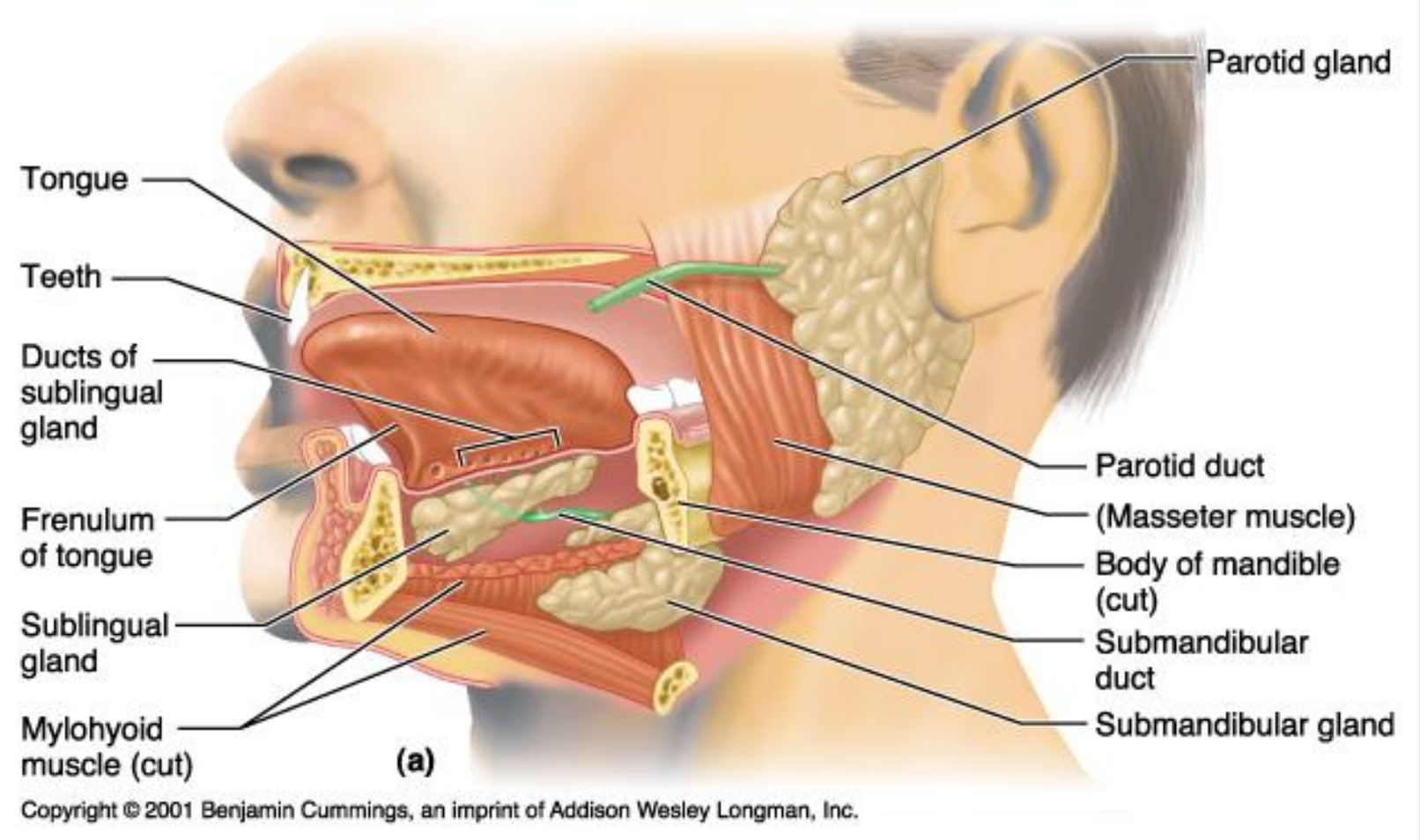




Dorsal Surface of the Tongue

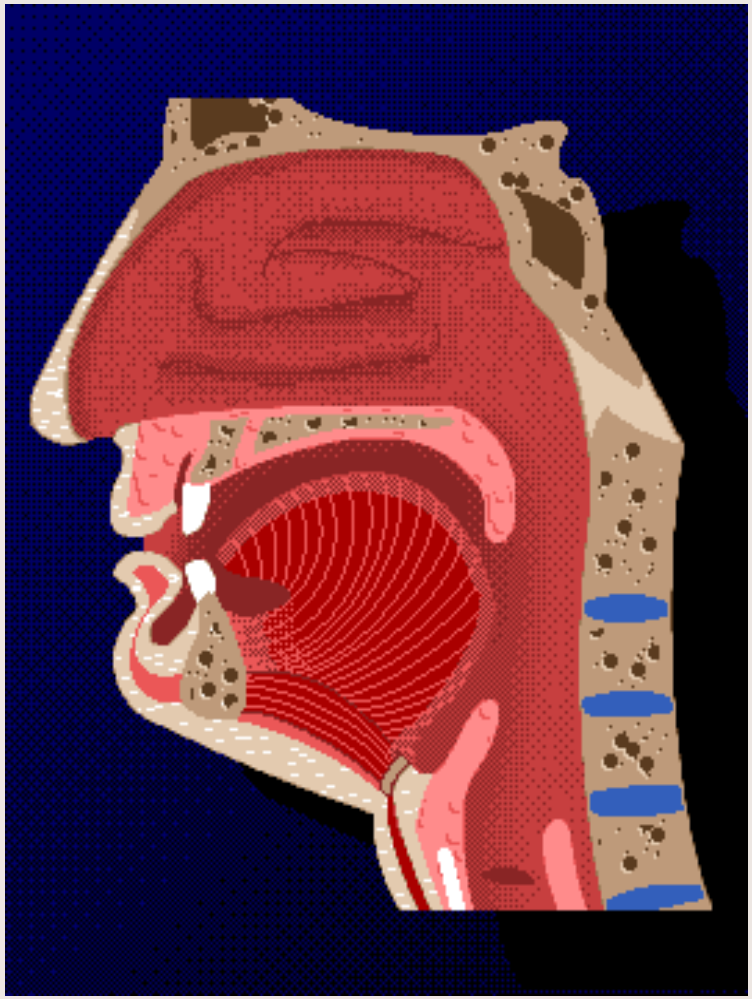


The Major Salivary Glands



Deglutition (swallowing)

- Sequence
  - Voluntary stage
    - Push food to back of mouth
  - Pharyngeal stage
    - Raise
      - Soft palate
      - Larynx + hyoid
      - Tongue to soft palate
  - Esophageal stage
    - Contract pharyngeal muscles
    - Open esophagus
    - Start peristalsis

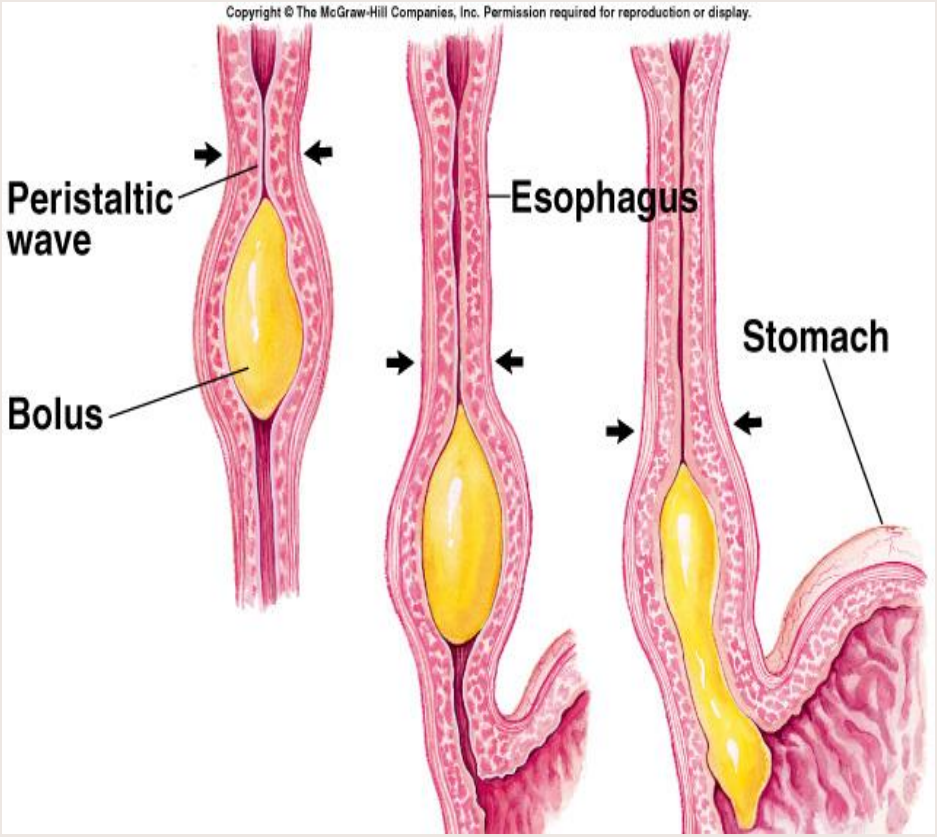


Deglutition (swallowing)

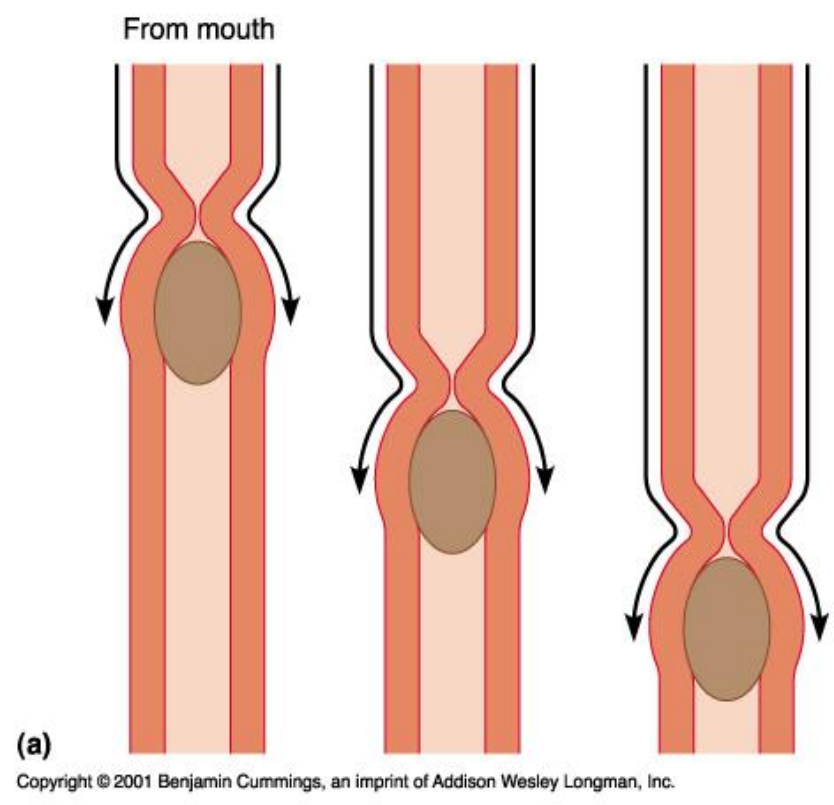
- Control
  - Nerves
    - Glossopharyngeal
    - Vagus
    - Accessory
  - Brain stem
    - Deglutition center
      - Medulla oblongata
      - Pons
  - Disorders
    - Dysphagia
    - Aphagia

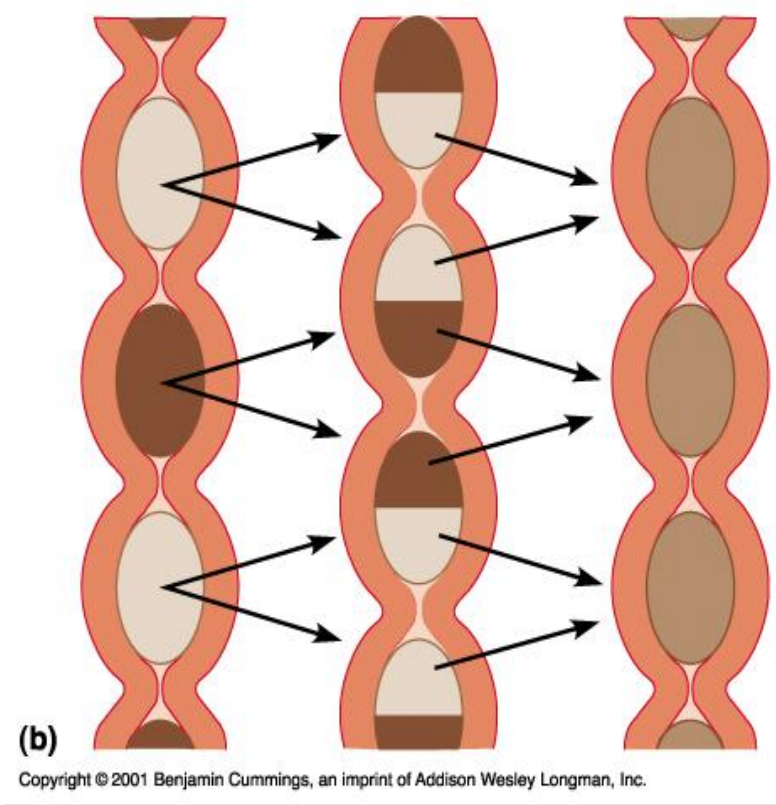
Esophagus

- Usually collapsed (closed)
- 3 constrictions
  - Aortic arch
  - Left primary bronchus
  - Diaphragm
- Surrounded by
  - SNS plexus
  - Blood vessels
- Functions
  - Secrete mucous
  - Transport food



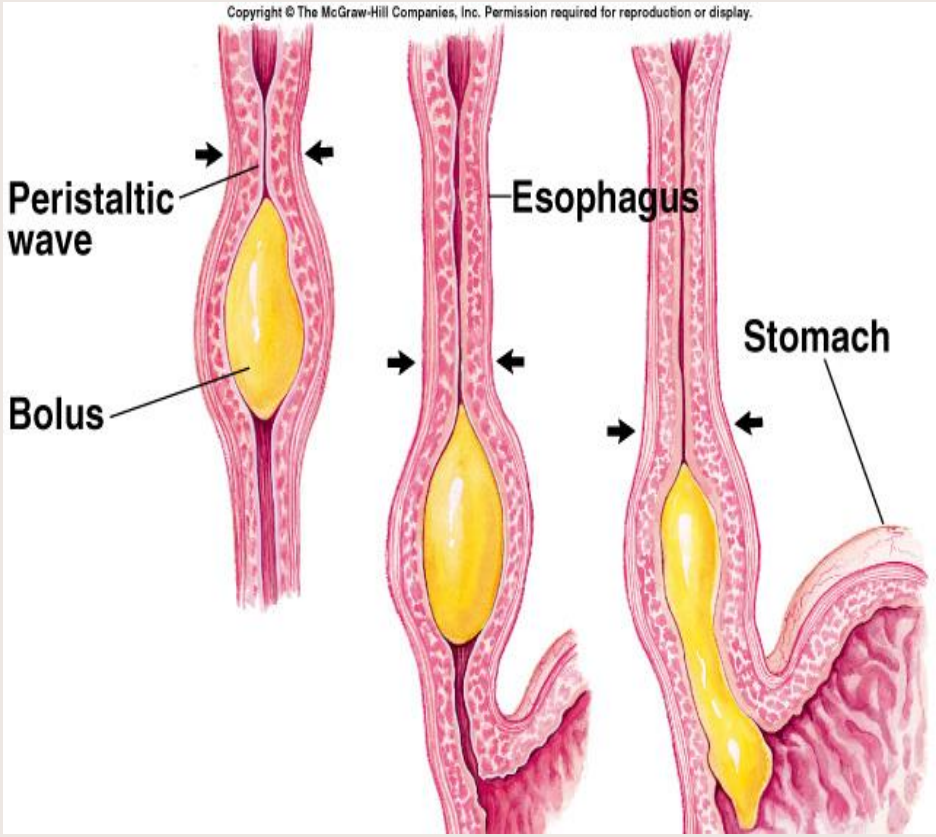
Peristalsis and Segmentation





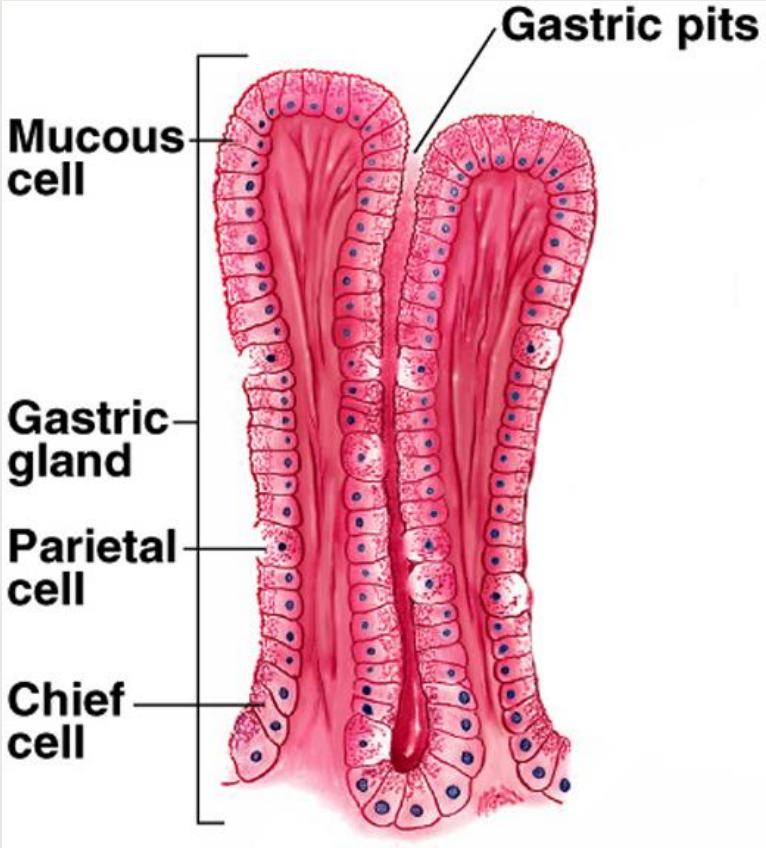
Esophagus

- Sphincters
  - Upper
  - Lower
- Abnormalities
  - Achalasia
  - Atresia
  - Hernia
  - Barret's esophagus
  - Esophageal varices



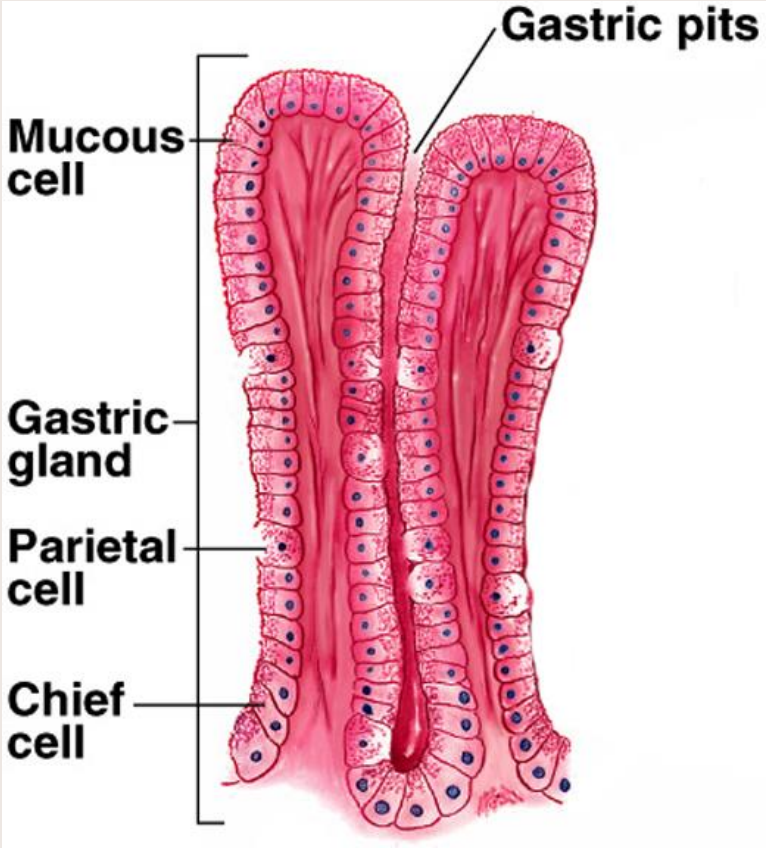
Stomach

- Gastric glands contain cells that secrete different products that form gastric juice
  - Goblet cells secrete mucus
  - Parietal cells secrete HCl & intrinsic factor (necessary for B_{12} absorption in intestine)
  - Chief cells secrete pepsinogen (precursor for pepsin)

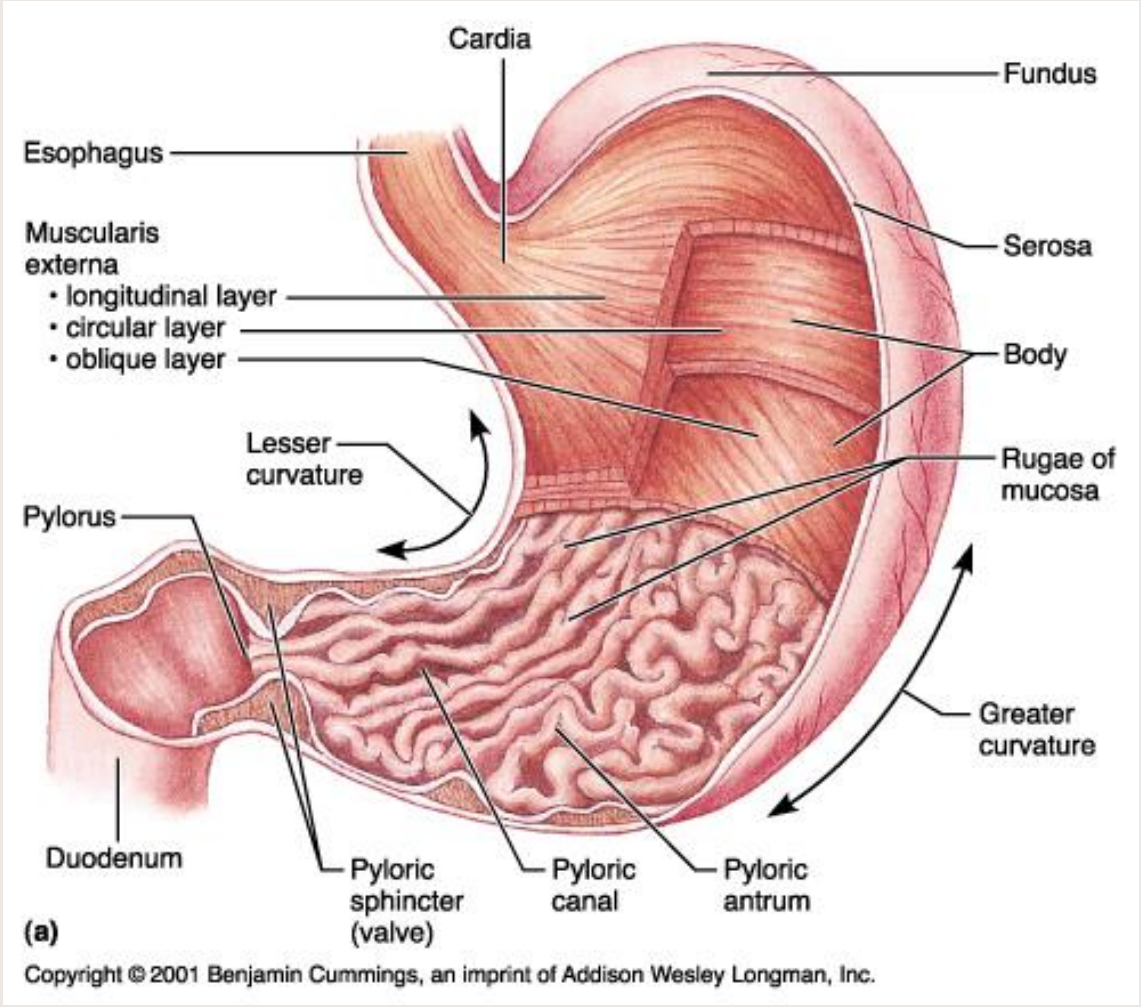


Stomach

- Enterochromaffin-like cells secrete histamine & serotonin
- G cells secrete gastrin
- D cells secrete somatostatin

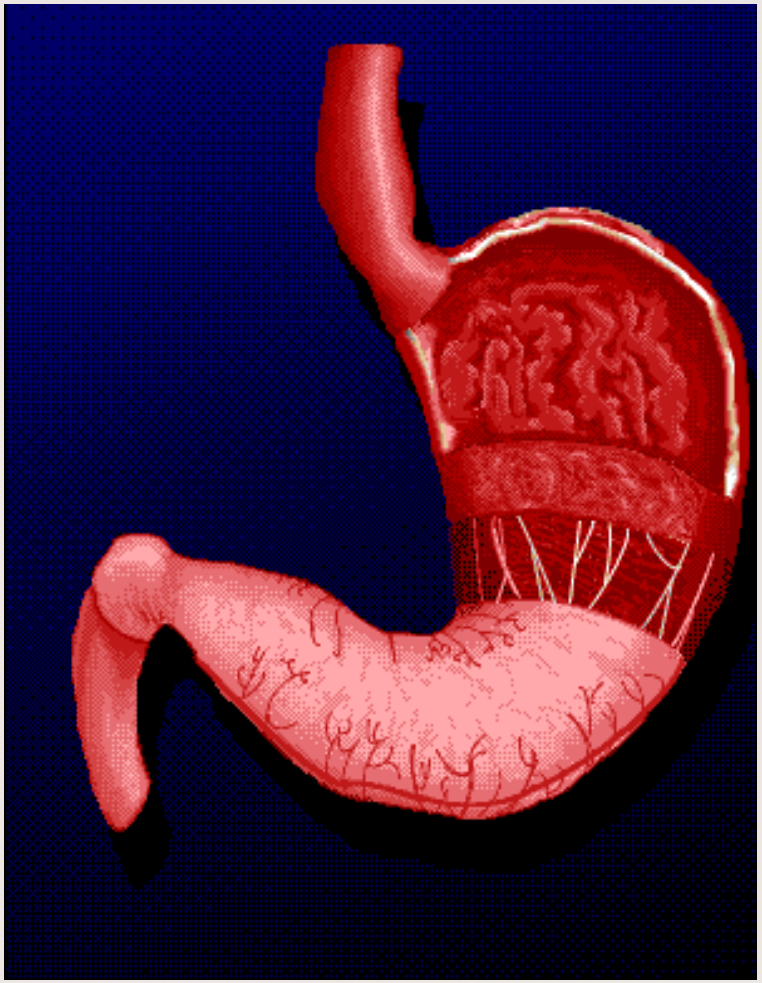


Anatomy of the Stomach



Stomach

- 3 muscle layers
  - Oblique
  - Circular
  - Longitudinal
- Regions
  - Cardiac sphincter
  - Fundus
  - Antrum (pylorus)
  - Pyloric sphincter
- Vascular
- Inner surface thrown into folds – Rugae
- Contains enzymes that work best at pH 1-2

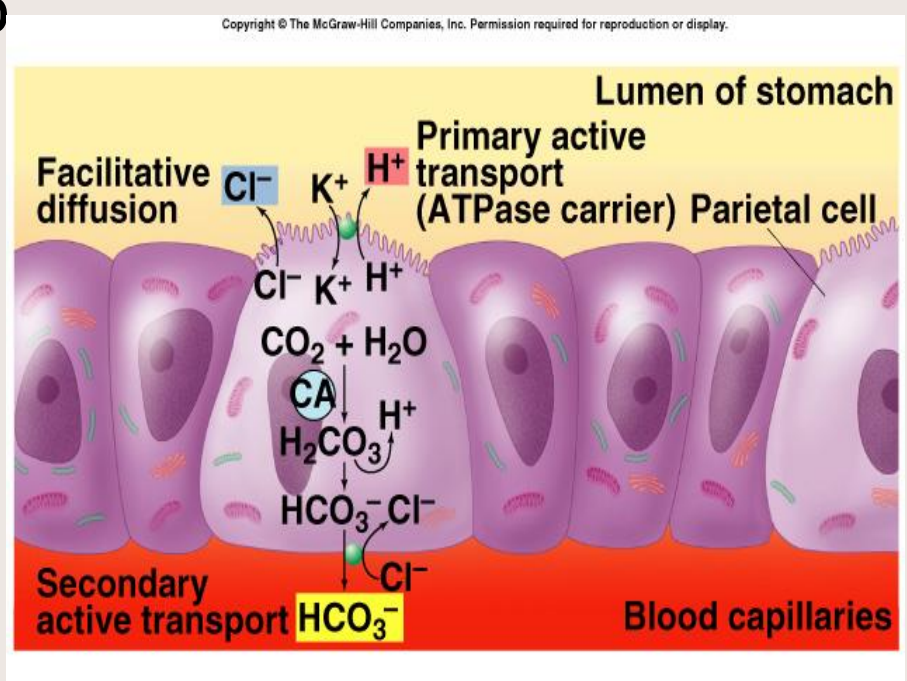


Stomach

- Functions
  - Mix food
  - Reservoir
  - Start digestion of
    - Protein
    - Nucleic acids
    - Fats
  - Activates some enzymes
  - Destroy some bacteria
  - Makes intrinsic factor – B 12 absorption
  - Destroys some bacteria
  - Absorbs
    - Alcohol
    - Water
    - Lipophilic acid
    - B 12

HCl in Stomach

- Is produced by parietal cells which AT H^+ into lumen via an H^+/ K^+ pump (pH ≈1)
- Cl^- is secreted by facilitated diffusion
- H+ comes from dissociation of H_2CO_3
- Cl- comes from blood side of cell in exchange for $HC0_3^-$

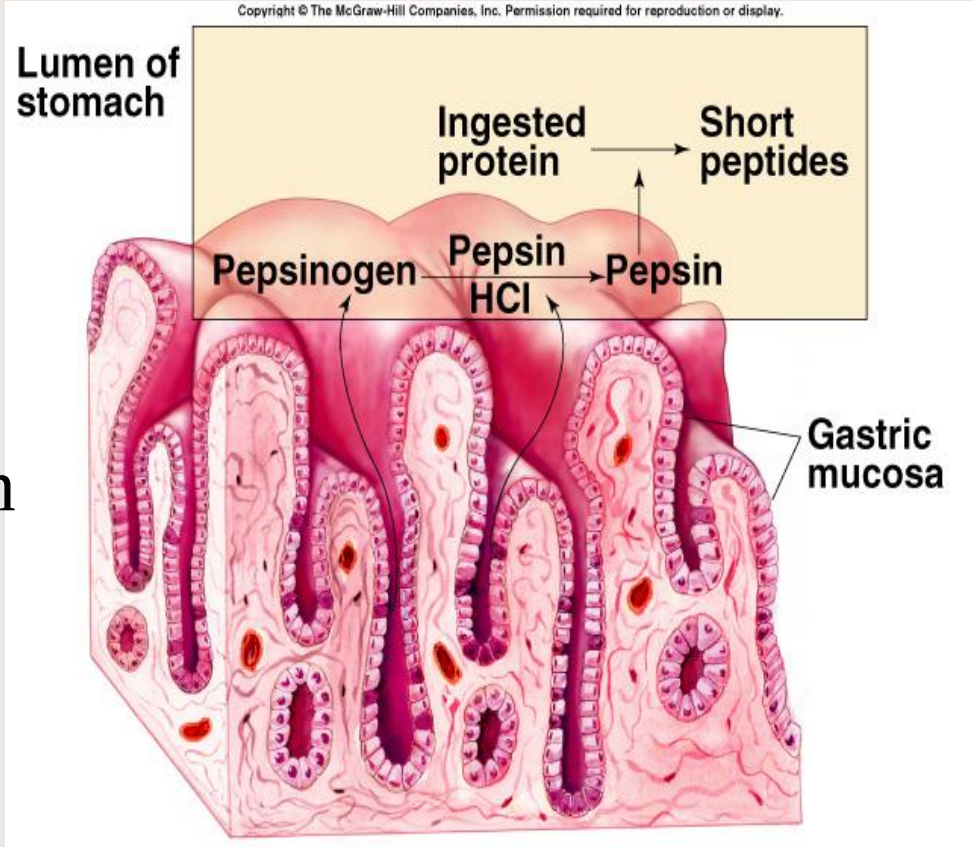


HCl in Stomach

- Is secreted in response to the hormone gastrin; & ACh from vagus
  - These are indirect effects since both stimulate release of histamine which causes parietal cells to secrete HCl

HCl in Stomach

- Makes gastric juice very acidic which denatures proteins to make them more digestible
- Converts pepsinogen into pepsin
  - Pepsin is more active at low pHs

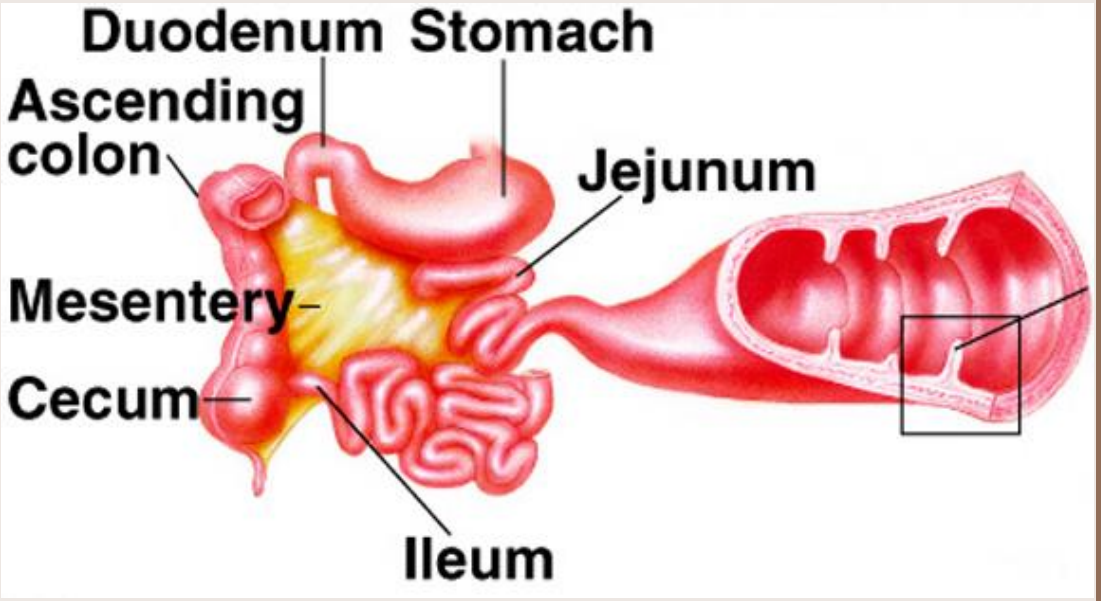


Digestion & Absorption in Stomach

- Proteins partially digested by pepsin
- Carbohydrate digestion by salivary amylase is soon inactivated by acidity
- Alcohol & aspirin are only commonly ingested substances absorbed

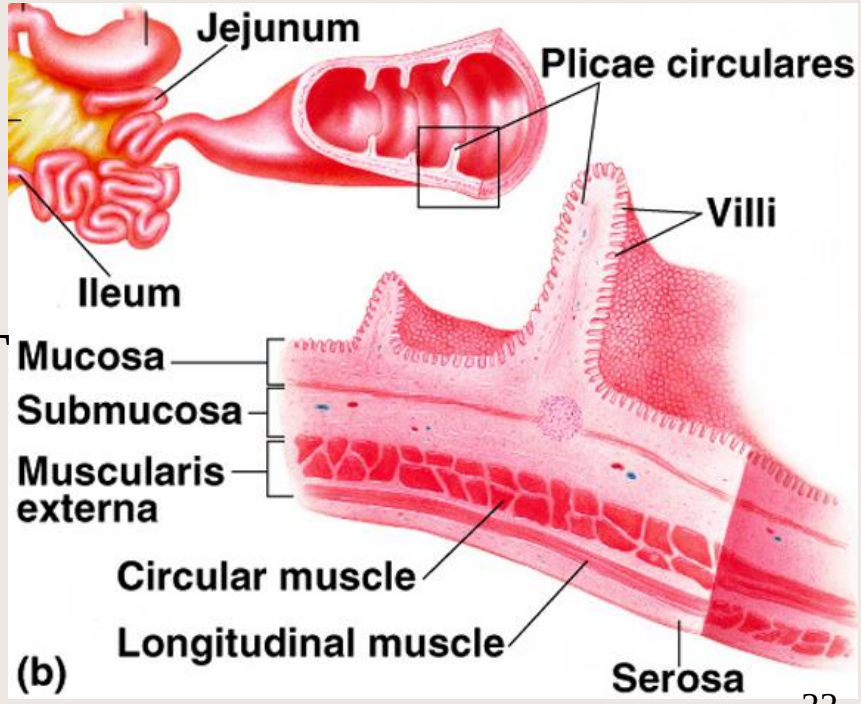
Small Intestine

- Extends from pyloric sphincter → ileocecal valve
- Regions
  - Duodenum
  - Jejenum
  - Ileum
- Movements
  - Segmentation
  - Peristalsis



Small Intestine

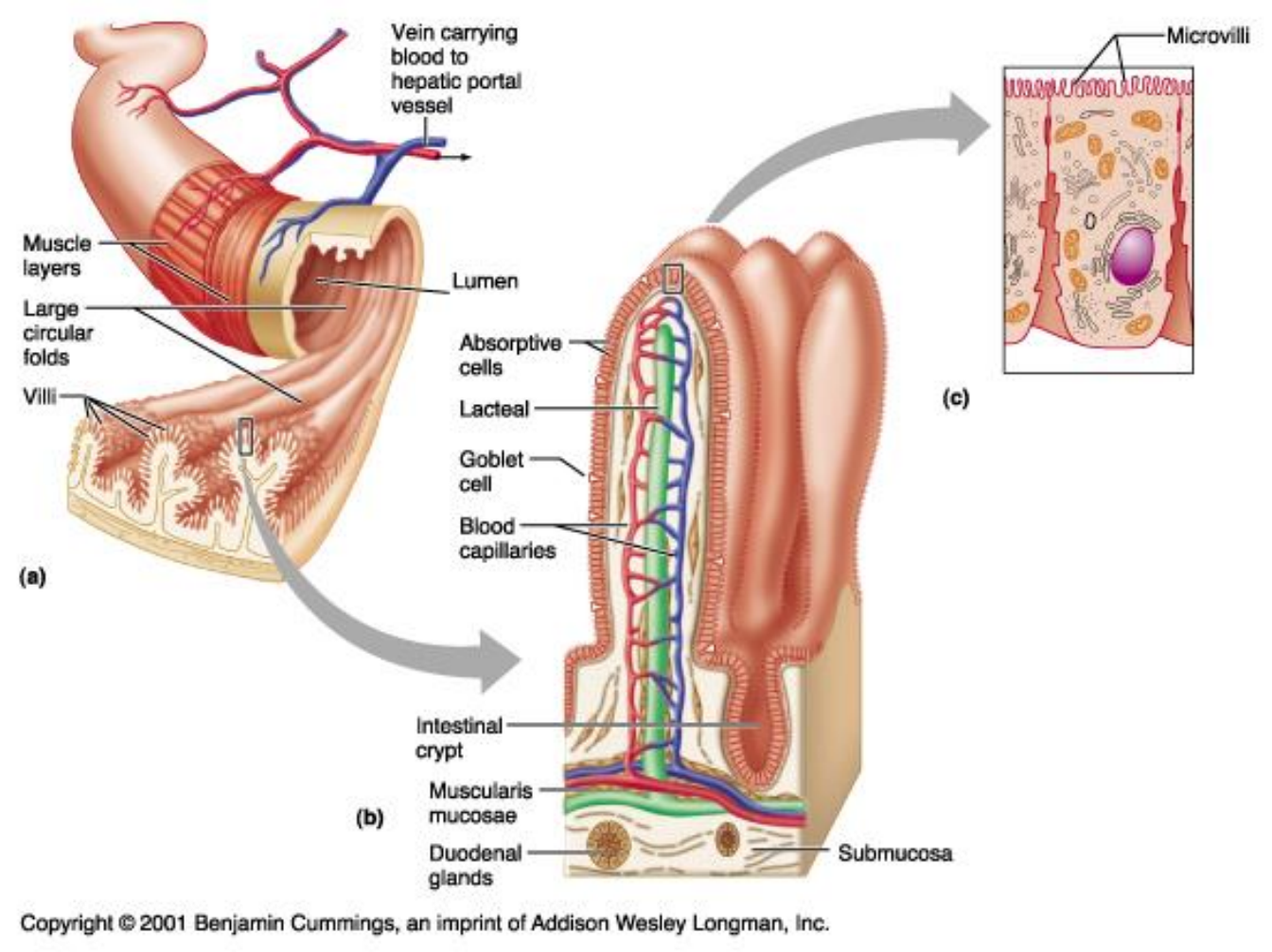
- Histology
  - Intestinal glands – Intestinal enzymes
  - Duodenal glands – Alkaline mucous
  - Paneth cells – Lysozyme
  - Microvilli
  - Lacteals
  - Plica circularis
  - Smooth muscle
  - Lymphatic tissue – GALT
  - Vascular



Small Intestine

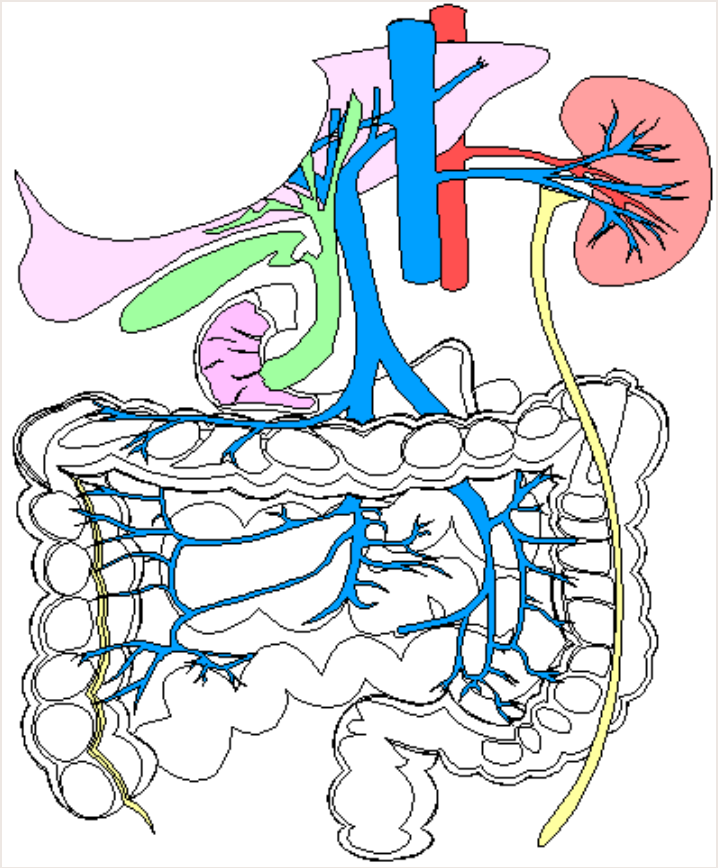
- Absorbs
  - 80% ingested water
  - Electrolytes
  - Vitamins
  - Minerals
  - Carbohydrates
    - Active/facilitated transport
    - Monosaccharides
  - Proteins
    - Di-/tripeptides
    - Amino acids
  - Lipids
    - Monoglycerides
    - Fatty acids
    - Micelles
    - Chylomicrons

Structure of the Villi in the Small Intestine



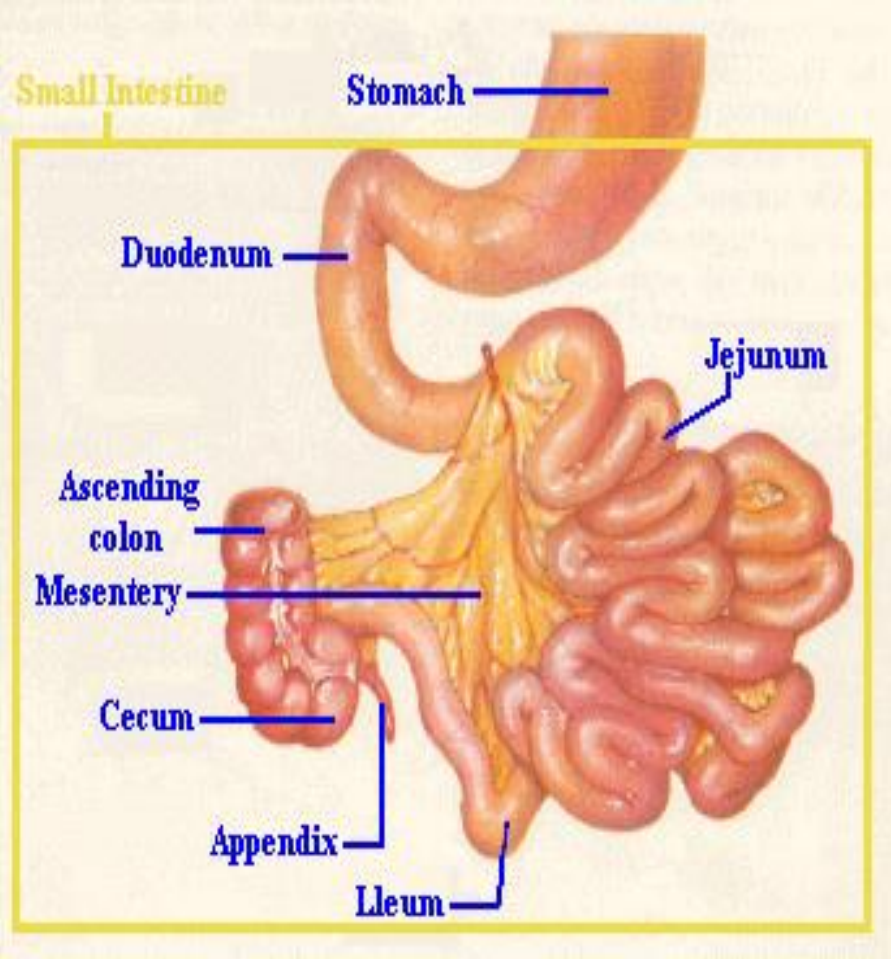
Small Intestine

- Secretes digestive enzymes
  - Peptidases
    - Amino-
    - Di-
    - Tri-
  - Sucrases
  - Maltase
  - Lactase
  - Saccharidases
    - Di-
    - Tri-
  - Lipase
  - Nucleases



Small Intestine

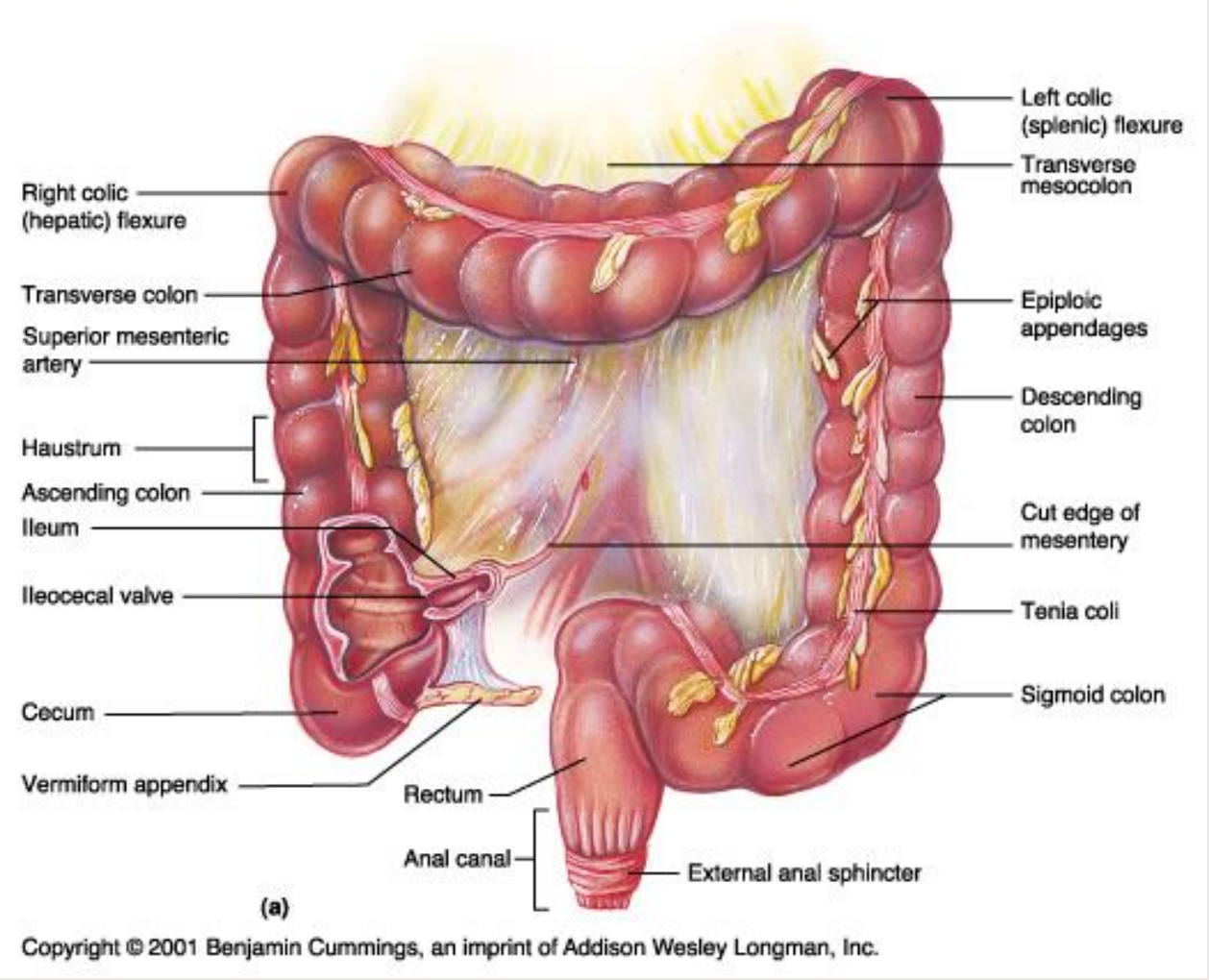
- Control
- Requires pancreatic enzymes & bile to complete digestion



Large Intestine

- Extends from ileocecal valve to anus
- Regions
  - Cecum – Appendix
  - Colon
    - Ascending
    - Transverse
    - Descending
  - Rectum
  - Anal canal

Anatomy of the Large Intestine



Large Intestine

- Histology
  - No villi
  - No permanent circular folds
  - Smooth muscle
    - Taeniae coli
    - Haustra
  - Epiploic appendages
  - Otherwise like rest of Gl tract

Large Intestine

- Functions
  - Mechanical digestion
    - Haustral churning
    - Peristalsis
    - Reflexes
      - Gastroileal
      - Gastrocolic
  - Chemical digestion – Bacterial digestion
    - Ferment carbohydrates
    - Protein/amino acid breakdown
  - Absorbs
    - More water
    - Vitamins
      - B
      - K
  - Concentrate/eliminate wastes

Feces Formation and Defecation

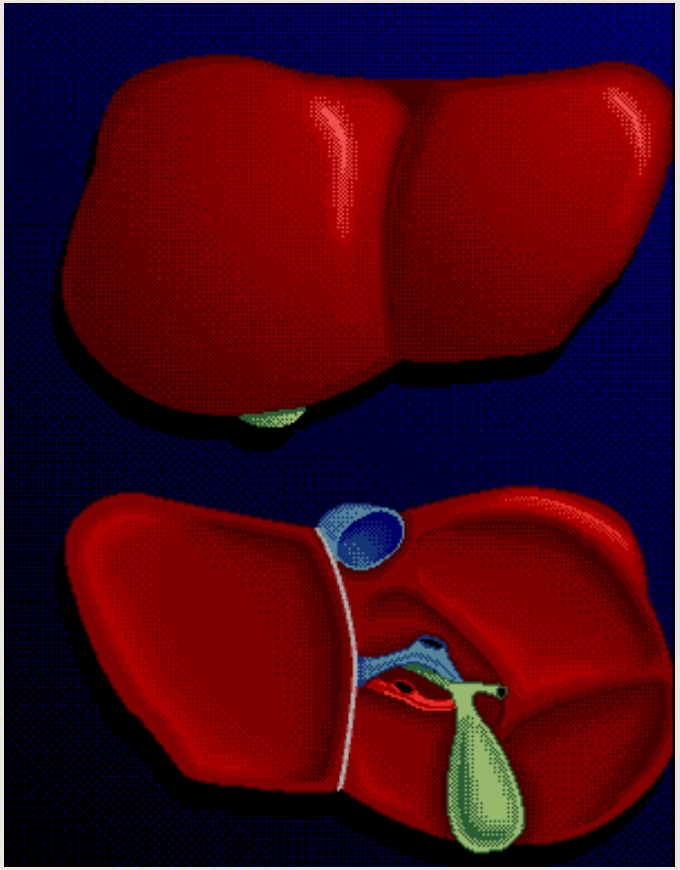
- Chyme dehydrated to form feces
- Feces composition
  - Water
  - Inorganic salts
  - Epithelial cells
  - Bacteria
  - Byproducts of digestion
- Defecation
  - Peristalsis pushes feces into rectum
  - Rectal walls stretch
- Control
  - Parasympathetic
  - Voluntary

Liver

- Location
  - R. Hypochondrium
  - Epigastric region
- 4 Lobes
  - Left
  - Quadrate
  - Caudate
  - Right
- Each lobe has lobules – Contains hepatocytes – Surround sinusoids – Feed into central vein

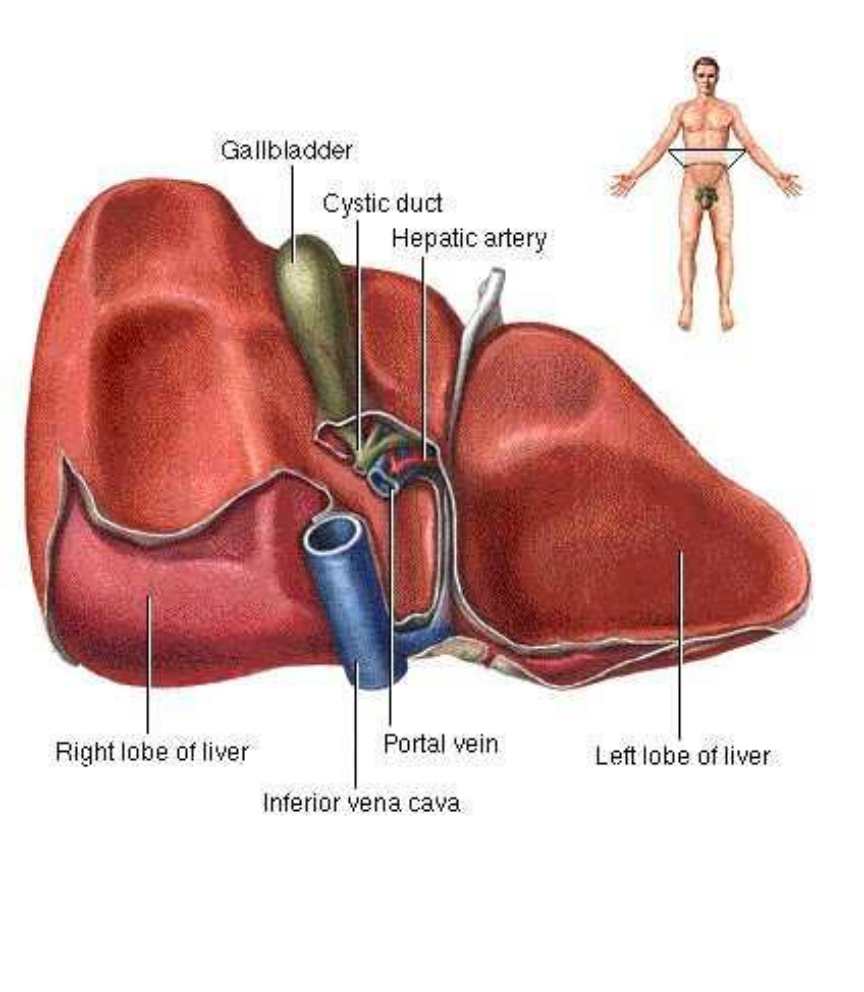
Liver

- Functions
  - Makes bile
    - Detergent – emulsifies fats
    - Release promoted by:
      - Vagus n.
      - CCK
      - Secretin
    - Contains
      - Water
      - Bile salts
      - Bile pigments
      - Electrolytes
      - Cholesterol
      - Lecithin



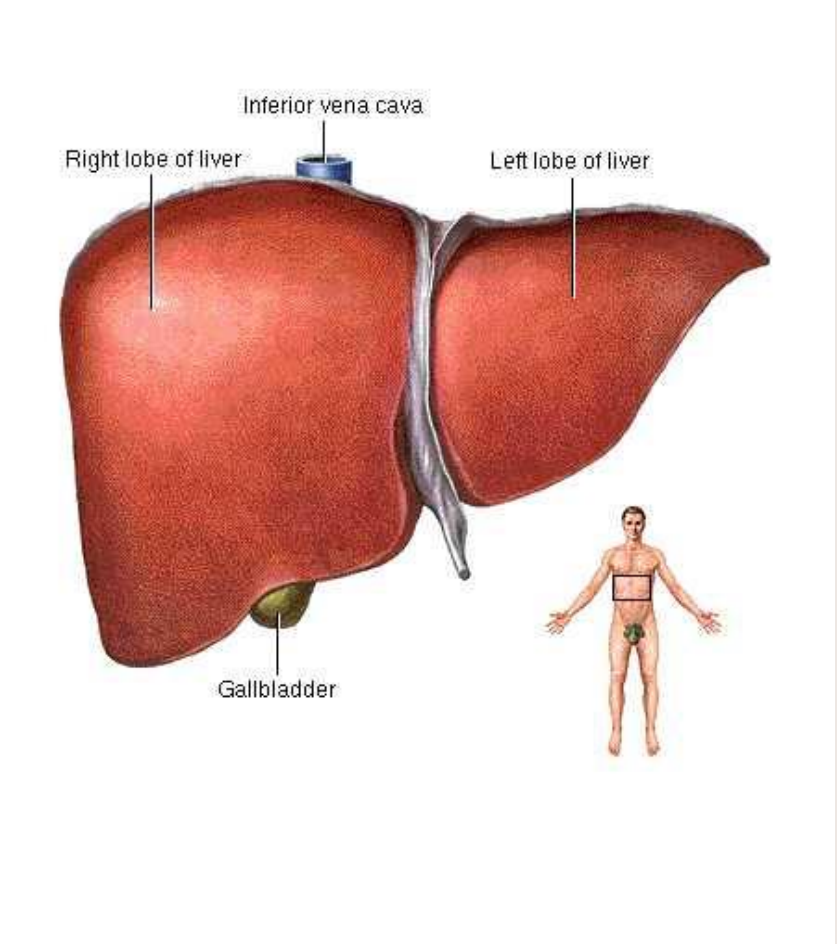
Liver

- Detoxifies/removes
  - Drugs
  - Alcohol
- Stores
  - Glycogen
  - Vitamins (A, D, E, K)
  - Fe and other minerals
  - Cholesterol
- Activates vitamin D
- Fetal RBC production
- Phagocytosis
- Metabolizes absorbed food molecules
  - Carbohydrates
  - Proteins
  - Lipids

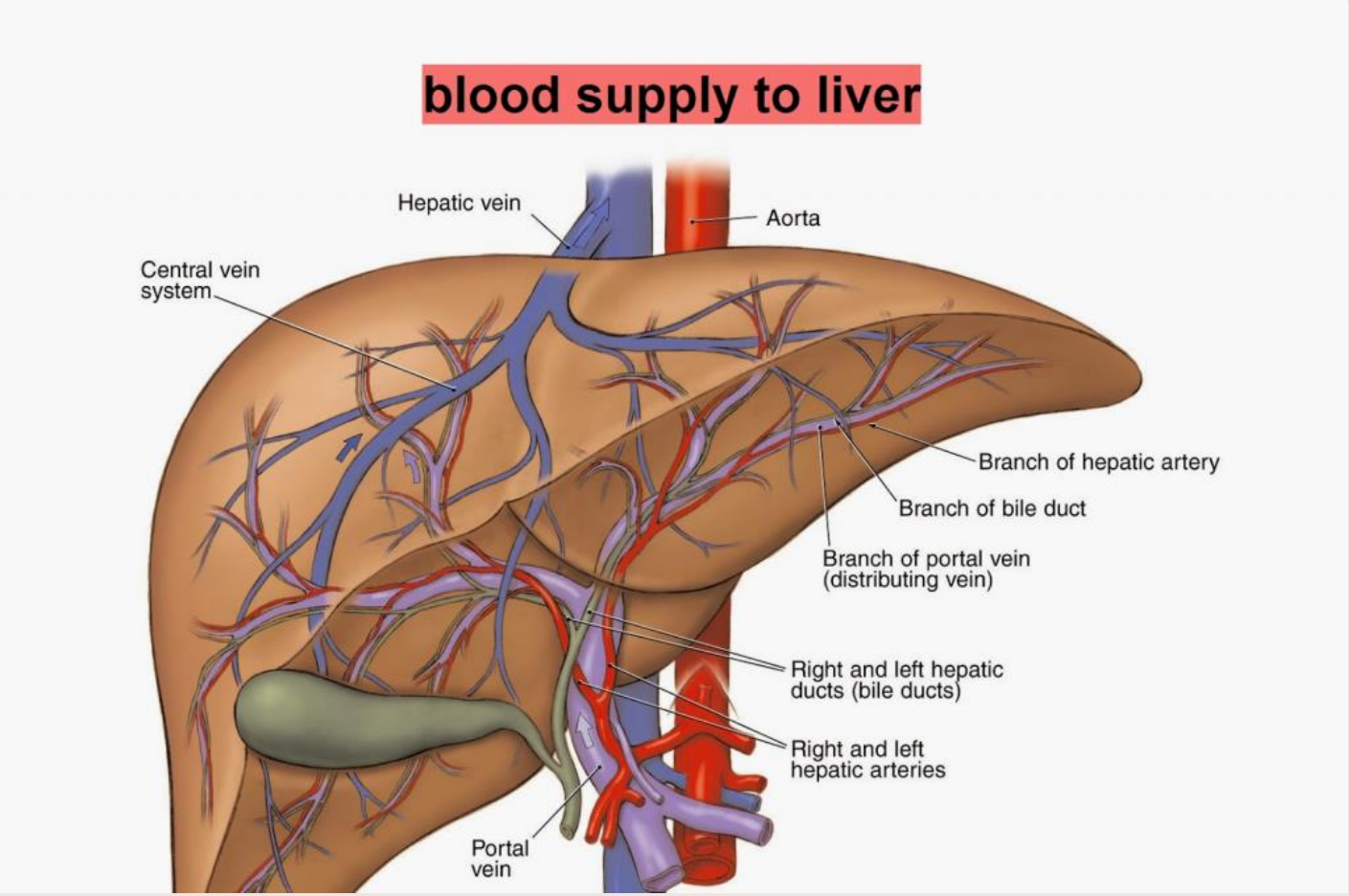


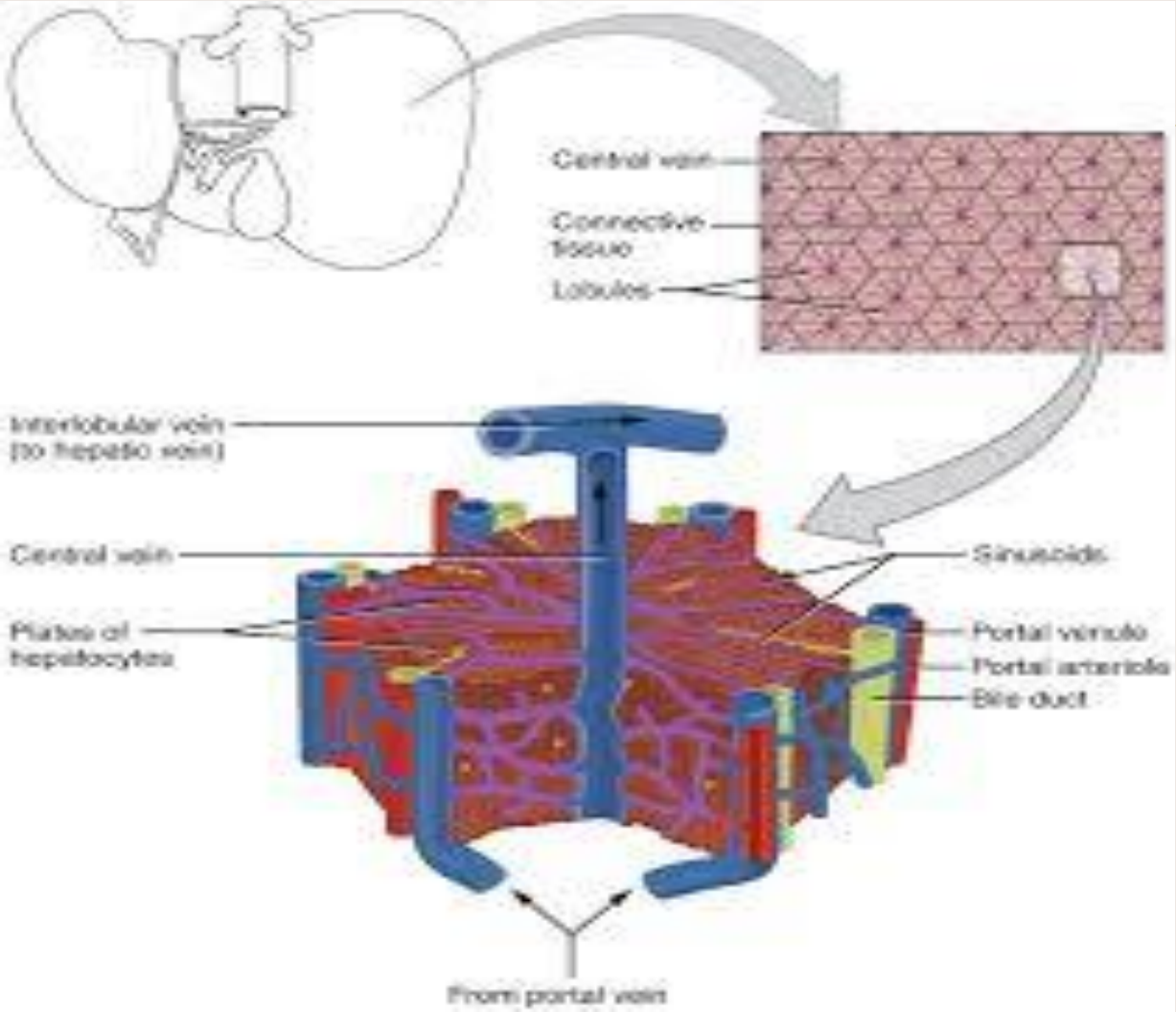
Liver

- Dual blood supply
  - Hepatic portal vein
    - Direct input from small intestine
  - Hepatic artery/vein
    - Direct links to heart

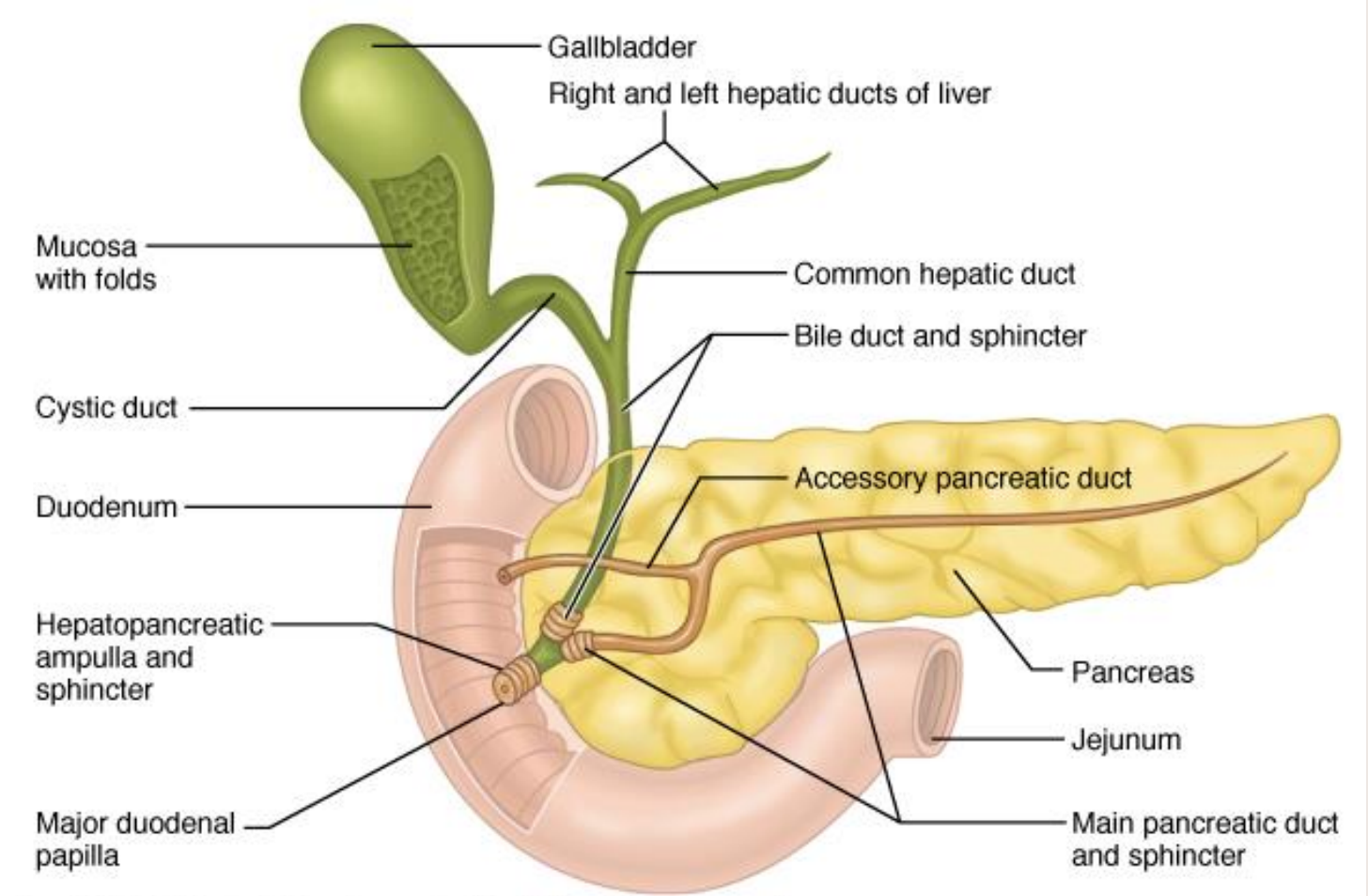


Liver

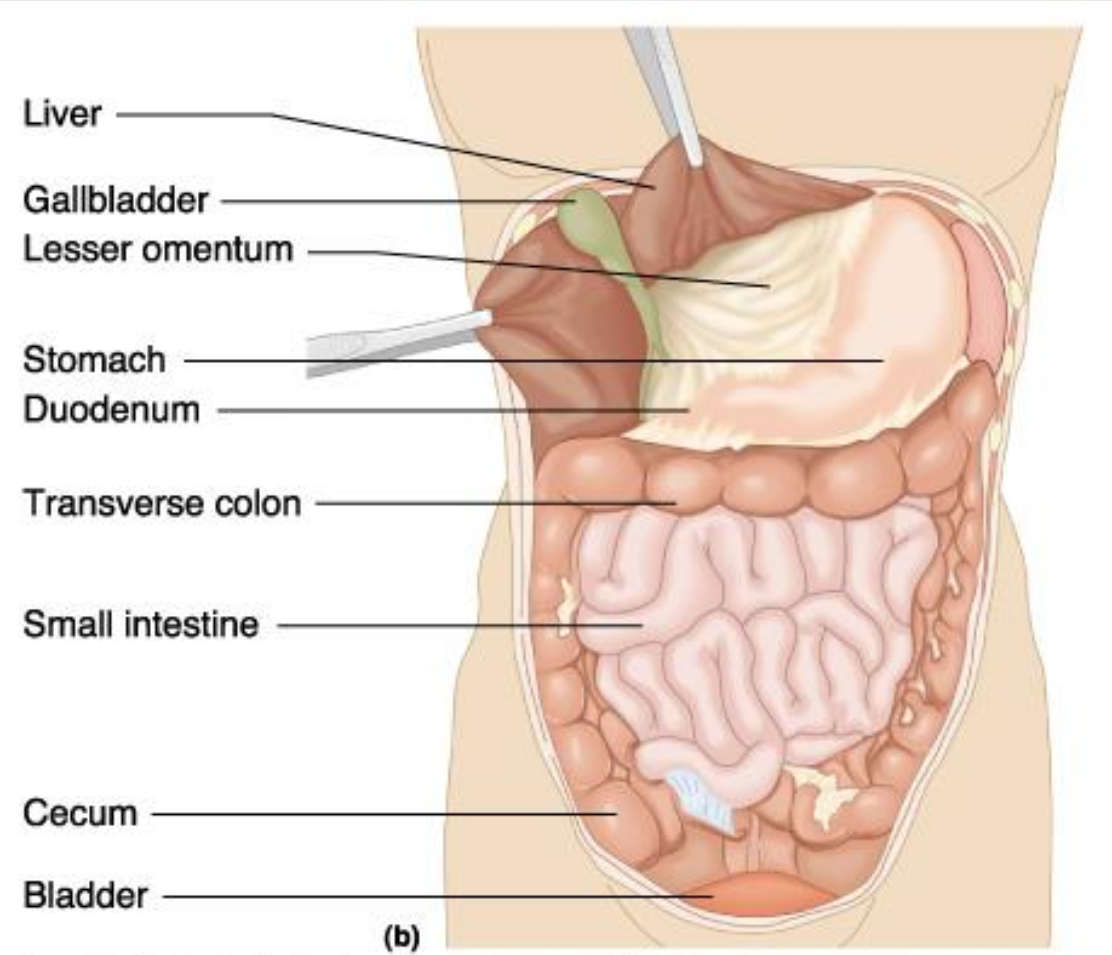

blood supply to liver
Hepatic vein
Aorta
Central vein system
Branch of hepatic artery
Branch of bile duct
Branch of portal vein (distributing vein)
Right and left hepatic ducts (bile ducts)
Right and left hepatic arteries
Portal vein


Central vein
Connective tissue
Lobules
Interlobular vein (to hepatic vein)
Central vein
Sinusoids
Plates of hepatocytes
Portal venule
Portal arteriole
Bile duct
From portal vein

The Duodenum and Related Organs



The Organs and Positions in the Abdominal Cavity



Structures of the Alimentary Canal