Digestive System

General Overview

- Goal of the Digestive System is to:
  - provide the cells of body with the nutrients required to do their job…
  - be largely self reliant (autonomic)
  - provide defense against ingested pathogens
  - remove waste products

General Overview

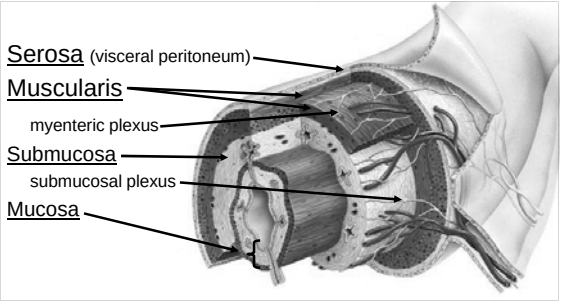
- The processes of digestion that allow this to happen (not necessarily in order) are:
  - Ingestion
  - Motility (mixing & propulsion)
  - Digestion
    - Mechanical
    - Chemical
  - Secretion
  - Absorption
  - Defecation

General Overview

- Structural Organization of the Digestive System – *Gross Anatomical*
  - Organs of the alimentary canal (GI-Tract)
    - Mouth to Anus & everything in between that materials pass through.
  - Accessory organs/structures
    - Salivary glands, pancreas, liver, gallbladder
    - Aid in the processing of nutrients

General Overview

Structural Organization of the Digestive System – *Histology of the GI-Tract*



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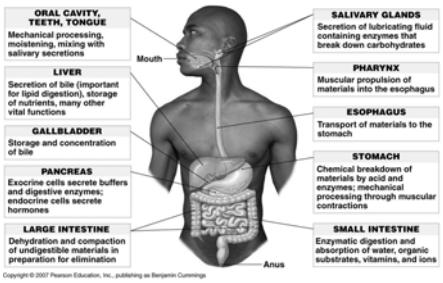
Starting from <u>the oral cavity:</u> an examination of the structures and function of each portion of the GI tract with accessory structures included.



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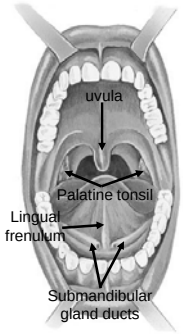
- Mouth (oral cavity)
  - Site of ingestion
  - Movement of food by tongue
    - Forms bolus & moves to posterior of oral cavity to trigger deglutition reflex!
  - Digestion
    - Mechanical
      - Mastication via teeth
      - types and functions?
    - Chemical
      - Salivary amylase
  - Secretion
    - Saliva (7ml/min max!)
      - Water, enzymes (salivary amylase), buffers, wastes, ions, mucin
  - Mucosa histology
    - Stratified squamous epithelium



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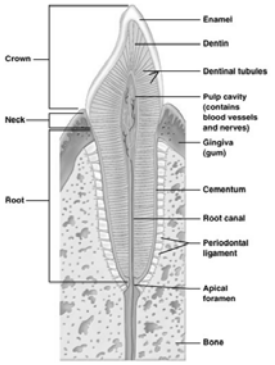
<u>Tooth structure</u>

- crown
  visible (enamel on outside, dentin & pulp cavity inside)
- Neck
  at the gum line (where the cementum ends and the enamel begins)
- root
  embedded in maxillae or mandible and contains the root

<u>Types of Teeth</u>

incisors - 2
canines (cuspid) - 1
bicuspids (premolars) - 2
molars - 3



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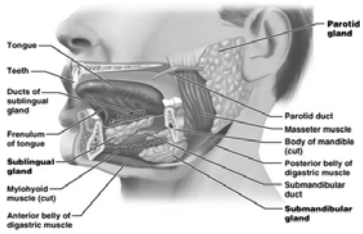
<u>Salivary Glands</u>

- All produce saliva, however…
  - More buffers and mucous from sublingual and submandibular
  - More enzymes from parotid!



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The Pharynx & Esophagus

- Oropharynx & laryngopharynx
  - food (liquid & solid) & air pathway
  - still lined with stratified squamous
  - contains tonsils (pharyngeal, palatal, lingual)
  - muscles move food into esophagus
- Esophagus
  - Muscular tube (upper 1/3 is skeletal muscle, rest is smooth & involuntary)
  - Stratified squamous lining
  - Mucous secretion
  - Upper and lower esophageal sphincters define start and end of esophagus
  - **Function**: deglutition (swallowing)

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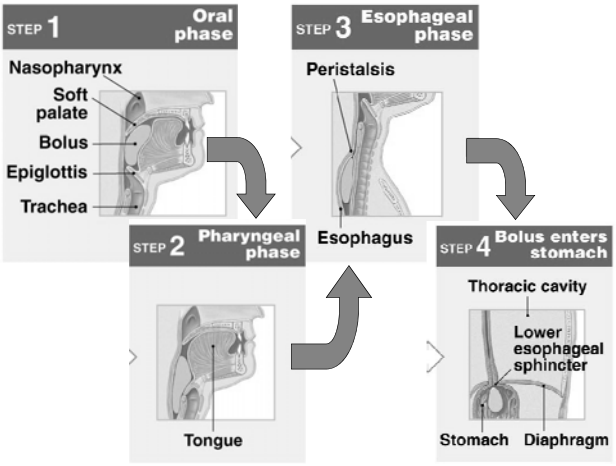
Deglutition

- Initially voluntarily, continues automatically
  - Voluntary process
    - The oral phase
      - formation and movement of bolus into pharynx
      - Soft palate elevates (prevents intrusion into nasopharynx)
    - The pharyngeal phase
      - Initiates the swallowing reflex:
        - Larynx elevates, epiglottis moves down to prevent bolus movement into glottis!
        - Pharyngeal muscles move bolus through the Upper Esophageal Sphincter (UES) and into the esophagus
  - Involuntary process
    - The esophageal phase
      - Peristalsis propels food to the stomach
      - Bolus must pass through the Lower Esophageal Sphincter (LES)



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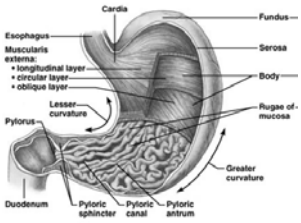
Stomach

- General functions:
  - Storage (temporary)
  - Mechanical digestion (churning)
  - Chemical digestion
    - Pepsin – a proteolytic enzyme
    - Continuation of salivary amylase… until?
  - Intrinsic factor production
    - Needed for Vit B_{12} absorption
- Gross Anatomy
  - Cardia
  - Fundus
  - Body
  - Pylorus & Pyloric sphincter



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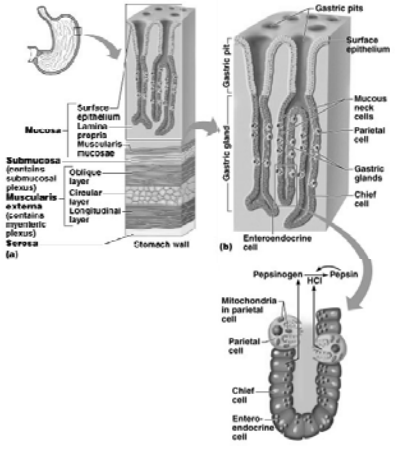
Stomach

- Histology
  - Mucosa – folded into rugae
    - Contains gastric glands which secrete
      - Mucous – from mucous cells in neck of gland (pit)
      - Parietal cells - secrete HCl & intrinsic factor
      - Chief cells – secrete pepsinogen
  - Muscularis – three layers
    - Internal oblique, middle circular, outer longitudinal



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Regulation of Stomach Activity - Controlled by CNS, reflexes & hormones!

Phases of regulation

1. Cephalic Phase
   - Seein', thinkin', smellin' . . . FOOD!!
     - Vagus nerve (X)
       - parasympathetic fibers innervate submucosa (via submucosal plexus) and start glandular secretion
         - Can produce up to ½ Liter/Hour
       - Also starts increased activity in muscularis (via innervation of myenteric plexus)

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2. Gastric Phase
   - Food enters stomach through LES
   - Stretch receptors are activated, causing an increase as activity of the submucosal & myenteric plexus (more secretion – ph drops, and movement – churning increases)
   - Gastrin is released by endocrine cells in the pylorus causing increased motility and relaxation of pyloric sphincter – movement of chyme into the duodenum results!!

3. Intestinal Phase
   - Starts when chyme enters duodenum
     - enterogastric reflex
       - effects are inhibitory on stomach – why?
       - Increases secretion of intestinal hormones
         - CCK (cholecystokinin), GIP (gastric inhibitory peptide) & Secretin

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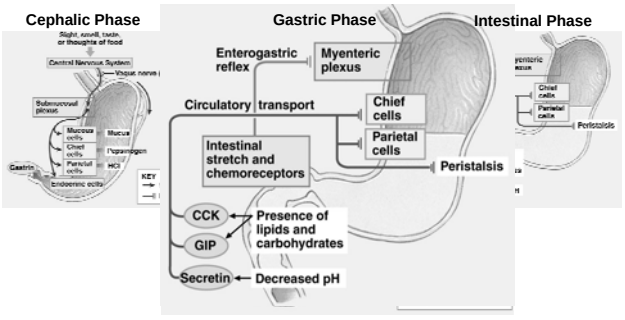
Regulation of Gastric Activity - Graphics



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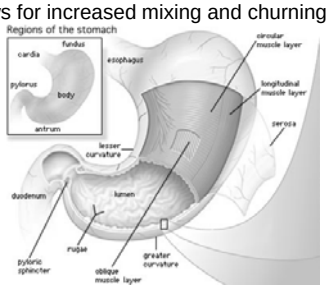
- Motility in the Stomach
  - Additional layer of muscle (oblique layer)
    - Allows for increased mixing and churning motion!



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- Digestion in the Stomach
  - Carbohydrate
    - Continuation of salivary amylase (until pH drops below 4.5)
  - Protein
    - Continues (from mastication) with churning and mixing with gastric juices until pH has dropped to 2 and below…
      - Pepsinogen is activated by HCl into pepsin
      - Pepsin breaks proteins into smaller peptide chains
  - Lipids – gastric lipase (milk fat digestion begins)
- Absorption in the Stomach
  - Very little
    - small amounts of certain lipid-soluble compounds can be taken up, including aspirin, other non-steroidal anti-inflammatory drugs, and ethanol (alcohol)

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The Small Intestine - Regions

- Duodenum
  - Starts at the pyloric sphincter
  - First foot of the small intestine
- Jejunum
  - Second portion of the small intestine
- Ileum
  - Third portion of the small intestine
  - Ends at the ileocecal sphincter

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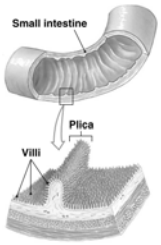
The Small Intestine – The Wall

- Visible circular folds are present (plicae circulares)
  - Forces chyme to mix and spiral as it moves
- Villi present throughout the mucosa
  - Though more at the duodenum, less at the ileum
  - Each villus contains a lacteal (lymphatic capillary) – why?
  - At base of villus is an intestinal gland
    - Some mucous (duodenal region mainly) secreted
    - Buffers secreted
- Lined with simple columnar epithelial cells with microvilli
  - Microvilli dramatically increase surface area for digestion and absorption of nutrients
  - Water also enters lumen through the mucosa
- Almost 2 Liters/day of intestinal juice is produced in the small intestine!



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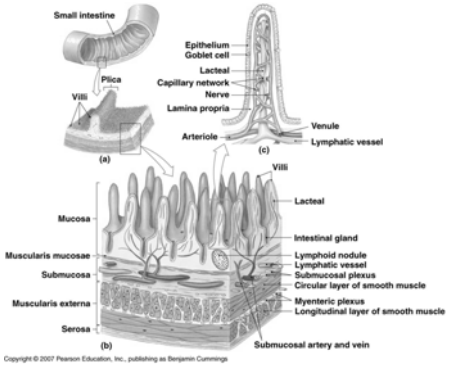

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The Small Intestine

- Motility
  - Segmentation
    - Alternate constriction of circular muscles only
  - Peristalsis
    - Causes a forward spiral movement of chyme
      - Due to plicae circulares
  - Hormonal issues
    - Enterogastric reflex – speeds up movement in all areas of small intestine
    - Gastroileal reflex – relaxation of ileocecal sphincter due to gastrin (from stomach), increases movement into large intestine

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The Small Intestine

- Control of secretion of enzymes into the duodenum
- Under parasympathetic control (starts in cephalic phase)
  - Under hormonal control
    - Gastrin
      - ↑ secretion of enzymes in stomach
    - Secretin
      - ↑ secretion of pancreas (buffers) & liver (bile)
      - ↓ gastric secretion
    - CCK (cholecystokinin)
      - ↓ feeling of hunger, slows stomach motility & gastrin secretion
      - Relaxes hepatopancreatic sphincter (allows bile in SI)
      - ↑ production of pancreatic enzymes
      - Contracts gallbladder
    - GIP (Gastric Inhibitory Peptide)
      - Release of insulin by beta cells of pancreatic islets (islets of Langerhans)

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The Small Intestine

- Digestion (chemical) in the Small Intestine
  - Proteins
    - via pancreatic enzymes (like the stomach, activated in the lumen of the small intestine)
      - Trypsin, Chymotrypsin & carboxypeptidase
        - Act like molecular scissors, cutting proteins in chains of aa's and also taking off individual aa's.
  - Carbohydrates
    - Reduced by enzymatic action (pancreatic amylase & enzymatic action in microvilli) to absorbable units
      - Glucose, Galactose & Fructose
  - Lipids
    - Emulsified by bile secretions & digested by pancreatic lipase

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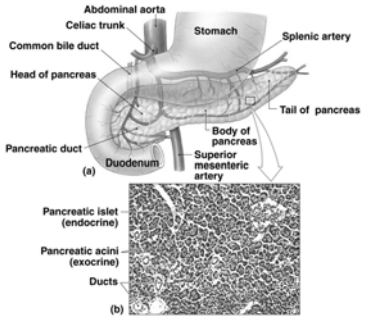
Pancreatic Anatomical Features



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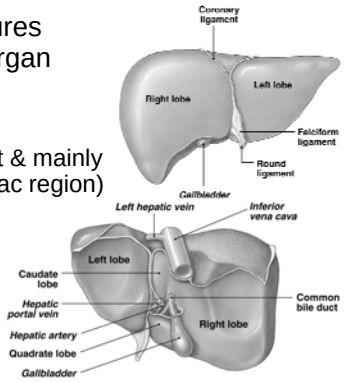
The Liver - Features

- Largest visceral organ (3 ½ lbs)
- Four lobes
  - Right lobe (largest & mainly in rt. Hypochondriac region)
  - Left lobe
  - Caudate lobe
  - Quadrate lobe



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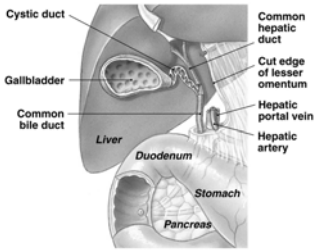
The Gallbladder & Ducts

- Bile produced in liver
- Transported via hepatic ducts (right & left) to common hepatic duct
- If not needed, stored in gallbladder via cystic duct
- Cystic duct joins hepatic duct to make common bile duct which empties into duodenum



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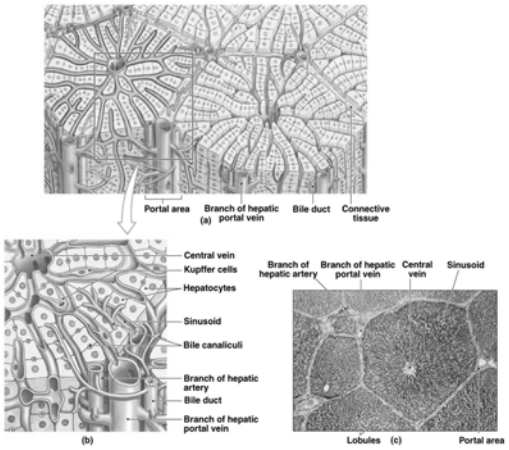
Liver Histology

- Lobes of liver consist of many lobules (small functional units)
  - Each lobule contains
    - Hepatocytes (main cells of liver)
    - Kupffer Cells – macrophages in the lobule
    - Blood vessels
      - Blood from hepatic portal vein
      - Blood from hepatic arteries
      - Sinusoids
        - enlarged capillaries lined with hepatocytes & Kupffer cells
      - Central Vein – in middle of lobule
    - Bile canaliculi
      - transport bile away from lobule via bile ducts



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Liver Functions

- Hundreds of functions, but 3 main categories
  - Metabolic Regulation
    - Blood flow from GI tract via hepatic portal vein renders this a good site for processing nutrients & removal of toxins
      - Glucose balance controlled (glucose ↔ glycogen)
      - Storage of lipid (fat) soluble vitamins (A,D,E,K)
  - Blood Regulation
    - Phagocytic activity of Kupffer cells removes rbc's
    - Kupffer cells are capable of starting an immune response by processing and presenting antigenic material
    - Hepatocytes produce plasma proteins for
      - Osmotic balance
      - Transports
      - Clotting proteins (hemostasis) & Complement proteins (immune function)
  - Bile Production
    - Contains biliverdin (bilirubin) rbc waste (by-product of rbc recycling)
    - Cholesterol
    - Lipids (bile salts) – emulsifying agents!
    - Water

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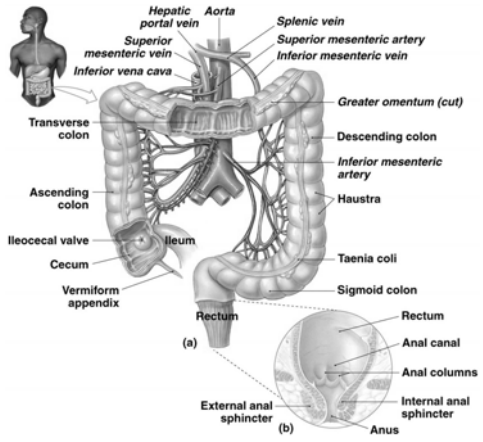
The Large Intestine

- Gross Anatomical Features
  - Starting point
    - at end of ileum – the ileocecal sphincter
  - Ending point
    - Anus
  - Portions:
    - Cecum & appendix
    - Colon (ascending, transverse & descending)
    - Rectum
      - The last 6 inches of the large intestine



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The Large Intestine

- Layers of the Wall
  - Mucosa
    - Large quantity of goblet cells
    - No villi
  - Muscularis
    - Circular muscle forms pouches = haustra
    - Longitudinal muslce forms a band = taenia coli
  - Serosa
    - Visceral peritoneum forms mesenteries to attach colon to abdominal wall.

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The Large Intestine

- Functions
  - Absorption
    - water!
      - 1500 mls of substance enters daily, only 200 mls leaves
      - 1.3 L/day reabsorbed!
    - Other:
      - Bile salts, bilirubin (unintentional, modified & excreted by kidney later), toxins – if present (from bacterial action)
      - Vitamins
        - Vitamin K – required for proper clotting
        - Biotin – required for glucose metabolism
        - Pantothenic Acid (B5) – required for some hormones and neurotransmitters synthesis

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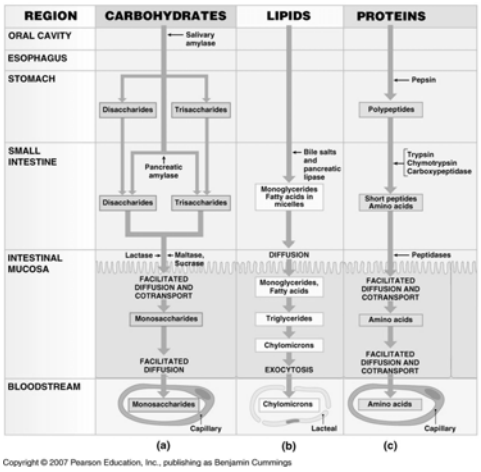
The Large Intestine

- Functions
  - Movement
    - Haustral churning
      - Sequential contraction of haustral pockets
    - Mass movement (peristalsis)
      - In response to gastrin (gastric phase & intestinal phase)
      - Creates urge to defecate as fecal matter is moved into rectum (initiates defecation reflex)
  - Defecation – 2 positive feedback loops!!
    - Stretch receptors in rectum (when stretched) – starts process
      - increase activity in sigmoid colon and rectum
        - This moves feces towards the anus, stretching the rectum and anal canal
      - Parasympathetic motor neurons are activated, initiating mass movement!
      - Voluntary Aspect – control over external anal sphincter – yeah!

Digestive Overview



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