Digestive System

AKA
Alimentary Tract
or
Gastrointestinal Tract

Definitely NOT the way to a man’s heart
Functions of the Digestive System

1. Ingestion
2. Mastication
3. Propulsion
   - Deglutition – swallowing a bolus
   - Peristalsis – peristaltic waves – movement of material through the digestive tract
   - Mass movements – contractions over much of large intestines
4. Mixing – segmental contractions
5. Secretion – lubricate, liquefy, buffer and digest mucus – lubricates digestive tract
6. Digestion
   - Mechanical – mastication and mixing
   - Chemical – breakdown of organic molecules into components
7. Absorption – molecules move from the lumen to the blood or lymph
8. Elimination
Digestive Tract Regions

1. Oral Cavity
2. Pharynx
3. Esophagus
4. Stomach
5. Small Intestines
6. Large Intestines
7. Anus
Digestive Tract Tunics

1. Mucosa
   – Innermost tunic
   – 3 layers
     • Mucous epithelium
     • Lamina proprium
     • Muscularis mucosal
   – Contains mechanoreceptors for peristaltic reflexes

2. Submucosa
   – Thick connective tissue
   – Contains the submucosal plexus* – network of nerves that stimulates gland secretion
3. Muscularis
   – Inner layer of circular smooth muscle
   – Outer layer of longitudinal smooth muscle
   – Myenteric plexus* – found between the 2 muscle layers; controls the motility of the intestinal tract
   *Form the enteric plexus or intramural plexus

4. Serosa or Adventitia
   – Connective tissue layer and simple squamous epithelium
   – Serous membrane or visceral peritoneum
Nervous Regulation of the Digestive System

• Local Control
  – Occurs in the enteric nervous system (ENS) consisting of the enteric plexus
  – Controls peristaltic and mixing movements, and blood flow through the local reflexes
  – Normally works with the CNS
  – 3 types of enteric neurons
    1. enteric sensory neurons
    2. enteric motor neurons
    3. enteric interneurons

• General Control
  – AP from digestive tract travel to CNS
  – Sight, smell or taste can begin CNS reflexes stimulating hunger influencing parasympathetic control of the ENS
Chemical Regulation of the Digestive System

- Over 30 neurotransmitters associated with the ENS
  - Acetylcholine – stimulates
  - Norepinephrine – inhibits GI mobility and secretion
  - Serotonin – stimulates GI mobility

- Hormones Produced
  - Gastrin and Secretin – regulate GI functions and secretions of accessory glands

- Paracrine chemicals
  - Locally released chemicals that influence nearby cells
Peritoneum
- Body walls and organs lined with serous membranes
  - Visceral peritoneum, parietal peritoneum & serous fluid

Mesenteries
- Connective tissue sheets, hold organs in place
- 2 layers or serous membranes with connective tissue between them
- Contain blood and nerve supply to the organs
- Lesser omentum & greater omentum
- Small intestines mesentery – mesentery proper
- Colon mesenteries – transverse mesocolon and sigmoid mesocolon
- Appendix mesentery - mesoappendix

Retroperitoneal Organs
- No mesentery
- Duodenum, pancreas, colon, rectum, kidneys, adrenal glands, and the bladder
Membrane Coverings

- Parietal peritoneum
- Visceral peritoneum
- Peritoneal cavity containing peritoneal fluid
- Retroperitoneal organs
- Mesenteries
- Organs surrounded by visceral peritoneum
- Mesentery
- Retroperitoneal organs
Oral Cavity

1. Vestibule – space between lips or cheeks and alveolar processes
   – Lips and cheeks

2. Oral Cavity Proper – medial to alveolar processes
   – Palate and palatine tonsils, tongue
Teeth

• 32 Adult teeth in 2 dental arches, maxillary and mandibular

• 4 quadrants
  – 1 central and 1 lateral incisor (cut & tear)
  – 1 canine (cut & tear)
  – 1\textsuperscript{st} and 2\textsuperscript{nd} premolars (crush & grind)
  – 1\textsuperscript{st}, 2\textsuperscript{nd}, and 3\textsuperscript{rd} molars (crush & grind)

• Permanent teeth replace primary teeth starting at age 5 and finishing by age 11
Salivary Glands

- Paired, large, multi-cellular glands
  - Parotid – anterior to the ear; largest serous glands; duct opens near 2\textsuperscript{nd} molar
  - Submandibular – mixed glands (more serous than mucus); duct opens near frenulum under the tongue
  - Sublingual – mixed glands (more mucus than serous); floor of oral cavity with numerous openings here

- Small, tubular glands
  - Lingual – deep to epithelium of the tongue
  - Palatine – palate
  - Buccal – cheeks
  - Labial - lips

Saliva

- 1.0-1.5L/day is produced
- Contains salivary amylase – breaks down carbohydrates
- Contains lysozyme – weak antibacterial action and IgA to prevent bacterial infection
- Contains mucin - lubricates
Pharynx

- Nasopharynx
- Oropharynx
- Laryngopharynx
Esophagus
– Consists of skeletal muscle in the upper esophagus
– Contains an upper and lower esophageal sphincter
– Mucous glands produce thick lubricating mucus

• Deglutition or Swallowing
1. Voluntary Phase – bolus is pushed against the hard palate and posterior to the oropharynx
2. Pharyngeal Phase – soft palate elevates – pharynx elevates – bolus moves to the esophagus
3. Esophageal Phase
  • Moves food from the esophagus to the stomach
  • Lower esophageal sphincter relaxes to allow food to pass
  • Food stimulates enteric plexus to stimulate peristaltic waves
Stomach Anatomy

- Gastroesophageal opening
- Cardiac Part
- Lower esophageal sphincter or cardiac sphincter
- Fundus
- Body
- Greater curvature
- Lesser curvature
- Pyloric part – antrum and canal
- Pyloris orifice
- Pyloric sphincter or pylorus
Stomach Histology

• Serosa – outer layer of stomach
• Muscularis – 3 layers: outer longitudinal, middle circular and inner oblique
• Submucosa and mucosa form rugae
• Numerous gastric pits provide openings for gastric glands
  – Surface mucous cells – produce alkaline mucus
  – Mucous neck cells – produce mucus
  – Parietal cells – produce HCl and intrinsic factor
  – Chief cells – produce pepsinogen
  – Endocrine cells – produce regulatory hormones
Stomach Histology

- Simple columnar epithelium
- Lamina propria
- Gastric pit
- Gastric glands
- Mucous neck and mucous surface cells
- Surface epithelium
- Lamina propria
- Muscularis mucosa
- Submucosa (contains submucosal plexus)
- Muscularis externa (contains myenteric plexus)
- Oblique layer
- Circular layer
- Longitudinal layer
- Serosa

Stomach wall
Regulation of Stomach Secretions

1. Cephalic Phase
   - Taste, smell, tactile sensation stimulate the medulla to influence gastric secretions

2. Gastric Phase
   - Presence of food in the stomach stimulates the greatest volume of secretions

3. Gastrointestinal Phase
   - Chyme enters duodenum
   - Secretin release is stimulated by low pH – inhibits parietal and chief cells
   - Cholecystokinin release is stimulated by lipids or protein digestion products – inhibits gastric secretions

- Enterogastric reflex – nervous control to reduce gastric secretion
Movement of Food Through the Stomach

• Mixing waves – occur every 20 seconds
• Peristaltic waves – powerful and force chyme to pyloric sphincter
• Typical meal exits stomach within 3-4 hours
Small Intestines

• Duodenum

• Contains circular folds (plicae circulares) and villi
  – Each villus contains a lacteal with blood and lymph capillaries
  – Each cell of the villus have cytoplasmic extensions called microvilli called the brush border

• The mucosa has 4 types of cells
  – Absorptive cells – cells with microvilli, produce digestive enzymes and absorb food
  – Goblet cells – produce mucus
  – Granular or Paneth cells – protect from bacteria
  – Endocrine cells – produce regulatory hormoness
Small Intestines

• Jejunum and Ileum
  – Similar to duodenum
  – Peyer’s Patches – numerous in mucosa and submucosa of the ileum
  – Ileocecal junction – junction between ileum and the large intestines
    • Ileocecal sphincter and ileocecal valve
Liver

- Largest internal organ
- 2 major lobes, right and left
- 2 minor lobes, caudate and quadrate
- Inferior surface contains the porta
  - Hepatic portal vein
  - A nerve plexus and lymphatic vessels
  - 2 hepatic ducts exit the liver which unite to form the common hepatic duct
    - Cystic duct from the gall bladder joins the common hepatic duct to form the common bile duct
    - Common bile duct joins the pancreatic duct at the hepatopancreatic ampulla
Liver

- Divided into hexagonal shaped lobules with a portal triad at each corner
- Hepatic cords composed of hepatocytes
- Central vein
Liver

Functions of Hepatocytes

1. bile production
2. storage
3. interconversion of nutrients
4. detoxification
5. phagocytosis
6. synthesis of blood components
Functions of the Liver

Bile Production
- Neutralizes and dilutes stomach acid
- Emulsifies fats with bile salts
- Contains bile pigments, cholesterol, fats, fat soluble hormones, and lecithin

Storage
- Store glycogen, fat, vitamins A, B12, D, E, and K, copper and iron
- Stores glucose after a meal and slowly releases it as the body needs it

Nutrient Interconversion
- Ability to convert protein to ATP, lipids, and glucose
- Produces phospholipids from fats, chlorine and phosphorus

Detoxification
- Alters the structure of toxic materials to make them less toxic

Phagocytosis
- Kupffer cells take worn out RBC, WBC, bacteria and debris out of circulation

Synthesis
- Production of albumins, fibrinogen, globulins, heparin, and clotting factors
Gall Bladder

• Pouch on the underside of the liver
• Stores and concentrates bile that is produced by the liver
Pancreas

• Endocrine Tissue
  – Pancreatic islets
    • Produce insulin and glucagon
    • Produce somatostatin

• Exocrine Tissue
  – Produces pancreatic juice with 2 components
    • Aqueous portion
      – Contains sodium, potassium, and $\text{HCO}_3^-$ ions
    • Enzymatic portion
      – Acini – produce digestive enzymes for all classes of food
        – Trypsin, chymotrypsin, and carboxypeptidase
        – Deoxyribonucleases and ribonucleases
        – Pancreatic amylase and pancreatic lipases
Large Intestines

- Contains cecum, colon, rectum, and anal canal
- Material takes 18-24 hours to pass
- Absorption of water, salts, mucus secretion and microorganism activity
- Cecum
  - Ileocecal junction
  - Vermiform appendix attached
- Colon
  - Ascending colon
  - Transverse colon
  - Descending colon
  - Sigmoid colon
  - Puckered appearance is formed by haustra
  - Crypts are present – numerous tubular glands with 3 cell types
    - Absorptive, goblet, and granular
- Rectum
  - Straight, muscular tube
- Anal Canal
  - Internal anal sphincter
  - External anal sphincter
Digestive, Absorption, and Transport

• Carbohydrates
  – Salivary amylase – oral cavity
  – Pancreatic amylase – intestines
  – Dissaccharidases - intestines

• Lipids
  – Emulsification – large lipid drops are broken into small lipid drops by bile salts
  – Lipase – digests lipid molecules; produced by the pancreas
  – Lingual lipase and gastric lipase
  – Esterase – digests cholesterol
  – Phospholipase – digests phospholipids
  – Micelles – digested lipids surrounded by bile salts
Digestive, Absorption, and Transport

• Proteins
  – Pepsin – stomach
  – Proteolytic enzymes – produced by pancreas; small intestines
  – Peptidases – small intestines

• Ions
  – $\text{Na}^+$, $\text{K}^+$, $\text{Ca}^{2+}$, $\text{Mg}^{2+}$, $\text{PO}_4^{3-}$ actively transported
  – $\text{Cl}^-$ passive transport