The Digestive System

Part A 23

Digestive System: Overview

- The alimentary canal or gastrointestinal (GI) tract digests and absorbs food
- Alimentary canal – mouth, pharynx, esophagus, stomach, small intestine, and large intestine
- Accessory digestive organs – teeth, tongue, gallbladder, salivary glands, liver, and pancreas

Digestive Process

- The GI tract is a “disassembly” line
  - Nutrients become more available to the body in each step
  - There are six essential activities:
    - Ingestion, propulsion, and mechanical digestion
    - Chemical digestion, absorption, and defecation

Gastrointestinal Tract Activities

- Ingestion – taking food into the digestive tract
- Propulsion – swallowing and peristalsis
  - Peristalsis – waves of contraction and relaxation of muscles in the organ walls
- Mechanical digestion – chewing, mixing, and churning food
Peristalsis and Segmentation

Gastrointestinal Tract Activities

- Chemical digestion – catabolic breakdown of food
- Absorption – movement of nutrients from the GI tract to the blood or lymph
- Defecation – elimination of indigestible solid wastes

GI Tract

- External environment for the digestive process
- Regulation of digestion involves:
  - Mechanical and chemical stimuli – stretch receptors, osmolarity, and presence of substrate in the lumen
  - Extrinsic control by CNS centers
  - Intrinsic control by local centers

Receptors of the GI Tract

- Mechano- and chemoreceptors respond to:
  - Stretch, osmolarity, and pH
  - Presence of substrate, and end products of digestion
- They initiate reflexes that:
  - Activate or inhibit digestive glands
  - Mix lumen contents and move them along

Nervous Control of the GI Tract

- Intrinsic controls
  - Nerve plexuses near the GI tract initiate short reflexes
  - Short reflexes are mediated by local enteric plexuses (gut brain)
- Extrinsic controls
  - Long reflexes arising within or outside the GI tract
  - Involve CNS centers and extrinsic autonomic nerves
Peritoneum and Peritoneal Cavity

- Peritoneum – serous membrane of the abdominal cavity
  - Visceral – covers external surface of most digestive organs
  - Parietal – lines the body wall
  - Peritoneal cavity
    - Lubricates digestive organs
    - Allows them to slide across one another

Mesentery – double layer of peritoneum that provides:
- Vascular and nerve supplies to the viscera
- A means to hold digestive organs in place and store fat
- Retroperitoneal organs – organs outside the peritoneum
- Peritoneal organs (intraperitoneal) – organs surrounded by peritoneum

Blood Supply: Splanchnic Circulation

- Arteries and the organs they serve include
  - The hepatic, splenic, and left gastric: spleen, liver, and stomach
  - Inferior and superior mesenteric: small and large intestines
- Hepatic portal circulation:
  - Collects nutrient-rich venous blood from the digestive viscera
  - Delivers this blood to the liver for metabolic processing and storage

Histology of the Alimentary Canal

- From esophagus to the anal canal the walls of the GI tract have the same four tunic
  - From the lumen outward they are the mucosa, submucosa, muscularis externa, and serosa
- Each tunic has a predominant tissue type and a specific digestive function
Histology of the Alimentary Canal

Mucosa

- Moist epithelial layer that lines the lumen of the alimentary canal
- Its three major functions are:
  - Secretion of mucus
  - Absorption of the end products of digestion
  - Protection against infectious disease
- Consists of three layers: a lining epithelium, lamina propria, and muscularis mucosae

Mucosa: Epithelial Lining

- Consists of simple columnar epithelium and mucus-secreting goblet cells
- The mucus secretions:
  - Protect digestive organs from digesting themselves
  - Ease food along the tract
- Stomach and small intestine mucosa contain:
  - Enzyme-secreting cells
  - Hormone-secreting cells (making them endocrine and digestive organs)

Mucosa: Lamina Propria and Muscularis Mucosae

- Lamina Propria
  - Loose areolar and reticular connective tissue
  - Nourishes the epithelium and absorbs nutrients
  - Contains lymph nodes (part of MALT) important in defense against bacteria
  - Muscularis mucosae – smooth muscle cells that produce local movements of mucosa

Mucosa: Other Sublayers

- Submucosa – dense connective tissue containing elastic fibers, blood and lymphatic vessels, lymph nodes, and nerves
- Muscularis externa – responsible for segmentation and peristalsis
- Serosa – the protective visceral peritoneum
  - Replaced by the fibrous adventitia in the esophagus
  - Retroperitoneal organs have both an adventitia and serosa

Enteric Nervous System

- Composed of two major intrinsic nerve plexuses
  - Submucosal nerve plexus – regulates glands and smooth muscle in the mucosa
  - Myenteric nerve plexus – Major nerve supply that controls GI tract mobility
- Segmentation and peristalsis are largely automatic involving local reflex arcs
- Linked to the CNS via long autonomic reflex arc
Mouth

- Oral or buccal cavity:
  - Is bounded by lips, cheeks, palate, and tongue
  - Has the oral orifice as its anterior opening
  - Is continuous with the oropharynx posteriorly
- To withstand abrasions:
  - The mouth is lined with stratified squamous epithelium
  - The gums, hard palate, and dorsum of the tongue are slightly keratinized

Lips and Cheeks

- Have a core of skeletal muscles
  - Lips: orbicularis oris
  - Cheeks: buccinators
- Vestibule – bounded by the lips and cheeks externally, and teeth and gums internally
- Oral cavity proper – area that lies within the teeth and gums
- Labial frenulum – median fold that joins the internal aspect of each lip to the gum

Palate

- Hard palate – underlain by palatine bones and palatine processes of the maxillae
  - Assists the tongue in chewing
  - Slightly corrugated on either side of the raphe (midline ridge)

Anatomy of the Oral Cavity: Mouth

- Uvula
- Soft palate
- Palatoglossal arch
- Palatine tonsil
- Hard palate
- Oral cavity
- Tongue
- Lingual tonsil
- Oropharynx
- Epiglottis
- Epiglottic tonsil
- Laryngopharynx
- Hyoid bone
- Eustachian tube
- Opening of pharyngotympanic (auditory) tube in nasopharynx

Oral Cavity and Pharynx: Anterior View

- Soft palate – mobile fold formed mostly of skeletal muscle
  - Closes off the nasopharynx during swallowing
  - Uvula projects downward from its free edge
  - Palatoglossal and palatopharyngeal arches form the borders of the fauces
Tongue

- Occupies the floor of the mouth and fills the oral cavity when mouth is closed
- Functions include:
  - Gripping and repositioning food during chewing
  - Mixing food with saliva and forming the bolus
  - Initiation of swallowing, and speech

Intrinsic muscles change the shape of the tongue
- Extrinsic muscles alter the tongue’s position
- Lingual frenulum secures the tongue to the floor of the mouth

Superior surface bears three types of papillae
- Filiform – give the tongue roughness and provide friction
- Fungiform – scattered widely over the tongue and give it a reddish hue
- Circumvallate – V-shaped row in back of tongue
- Sulcus terminalis – groove that separates the tongue into two areas:
  - Anterior 2/3 residing in the oral cavity
  - Posterior third residing in the oropharynx

Salivary Glands

- Produce and secrete saliva that:
  - Cleanses the mouth
  - Moisens and dissolves food chemicals
  - Aids in bolus formation
  - Contains enzymes that break down starch
  - Three pairs of extrinsic glands – parotid, submandibular, and sublingual
  - Intrinsic salivary glands (buccal glands) – scattered throughout the oral mucosa

- Parotid – lies anterior to the ear between the masseter muscle and skin
  - Parotid duct – opens into the vestibule next to the second upper molar
- Submandibular – lies along the medial aspect of the mandibular body
  - Its ducts open at the base of the lingual frenulum
- Sublingual – lies anterior to the submandibular gland under the tongue
  - It opens via 10-12 ducts into the floor of the mouth
Salivary Glands

Saliva: Source and Composition
- Secreted from serous and mucous cells of salivary glands
- A 97-99.5% water, hypo-osmotic, slightly acidic solution containing
  - Electrolytes – Na⁺, K⁺, Cl⁻, PO₄²⁻, HCO₃⁻
  - Digestive enzyme – salivary amylase
  - Proteins – mucin, lysozyme, defensins, and IgA
  - Metabolic wastes – urea and uric acid
  
Control of Salivation
- Intrinsic glands keep the mouth moist
- Extrinsic salivary glands secrete serous, enzyme-rich saliva in response to:
  - Ingested food which stimulates chemoreceptors and pressoreceptors
  - The thought of food
  - Strong sympathetic stimulation inhibits salivation and results in dry mouth

Teeth
- Primary and permanent dentitions have formed by age 21
- Primary – 20 deciduous teeth that erupt at intervals between 6 and 24 months
- Permanent – enlarge and develop causing the root of deciduous teeth to be resorbed and fall out between the ages of 6 and 12 years
  - All but the third molars have erupted by the end of adolescence
  - There are usually 32 permanent teeth

Deciduous Teeth

Permanent Teeth
- Incisors: Central (7 yr), Lateral (8 yr), Canine (eyeteeth) (11 yr)
- Premolars: (bicuspid) (12–13 yr)
- Second premolar (12–13 yr)
- Molars: First molar (8–7 yr), Second molar (15–13 yr), Third molar (wisdom tooth) (17–25 yr)
Classification of Teeth

- Teeth are classified according to their shape and function
- Incisors – chisel-shaped teeth adapted for cutting or nipping
- Canines – conical or fanglike teeth that tear or pierce
- Premolars (bicuspid) and molars – have broad crowns with rounded tips and are best suited for grinding or crushing
- During chewing, upper and lower molars lock together generating crushing force

Dental Formula: Permanent Teeth

- A shorthand way of indicating the number and relative position of teeth
- Written as ratio of upper to lower teeth for the mouth
- Primary: 2I (incisors), 1C (canine), 2M (molars)
- Permanent: 2I, 1C, 2PM (premolars), 3M

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Tooth Structure

- Two main regions – crown and the root
- Crown – exposed part of the tooth above the gingiva (gum)
- Enamel – acellular, brittle material composed of calcium salts and hydroxyapatite crystals is the hardest substance in the body
- Encapsules the crown of the tooth
- Root – portion of the tooth embedded in the jawbone

- Dentin – bonelike material deep to the enamel cap that forms the bulk of the tooth
- Pulp cavity – cavity surrounded by dentin that contains pulp
- Pulp – connective tissue, blood vessels, and nerves
- Root canal – portion of the pulp cavity that extends into the root
- Apical foramen – proximal opening to the root canal
- Odontoblasts – secrete and maintain dentin throughout life
Tooth and Gum Disease

- Dental caries – gradual demineralization of enamel and dentin by bacterial action
  - Dental plaque, a film of sugar, bacteria, and mouth debris, adheres to teeth
  - Acid produced by the bacteria in the plaque dissolves calcium salts
  - Without these salts, organic matter is digested by proteolytic enzymes
  - Daily flossing and brushing help prevent caries by removing forming plaque

Tooth and Gum Disease: Periodontitis

- Gingivitis – as plaque accumulates, it calcifies and forms calculus, or tartar
- Accumulation of calculus:
  - Disrupts the seal between the gingivae and the teeth
  - Puts the gums at risk for infection
- Periodontitis – serious gum disease resulting from an immune response
- Immune system attacks intruders as well as body tissues, carving pockets around the teeth and dissolving bone