Digestive System
Chapter 22

= Gastrointestinal (GI) tract or ______________________ plus accessory organs

Module 22.1: Overview of the Digestive System

INTRODUCTION

Digestive system
– breaks down food into nutrients that can be absorbed by bloodstream and delivered to body cells in useable form
= GI tract or alimentary canal and ______________

• Alimentary canal
– continuous tube consisting of __________(mouth), pharynx, esophagus, stomach, small intestine, and __________
• Accessory organs
– located around alimentary canal and assist in digestion in someway
- include teeth, tongue, salivary glands, liver, ______________

BASIC DIGESTIVE FUNCTIONS AND PROCESSES

Functions:
1. __________, break it down into its component nutrients to be used by body cells
2. ________________, and acid-base homeostasis
3. Ingest vitamins and minerals, produce hormones, excrete wastes

• Main processes include:
  1. **Ingestion** – bring food and water into mouth
  2. **Secretion** – mucus, enzymes, acid, and hormones
  3. __________ – via peristalsis
  4. **Digestion** – mechanical and chemical
  5. __________ – through wall of alimentary canal into blood or lymph
6. **Defecation** – eliminate waste products

REGULATION OF MOTILITY BY NERVOUS AND ENDOCRINE SYSTEMS

**Motility** - key process in *every* region of alimentary canal
- Oral cavity, pharynx, superior esophagus, and last portion of L.I. - ____________
- Remainder of alimentary canal - ____________

Types: *mixing* & *churning*, *propulsion*

**Regulation:**

1. **Nervous** ANS: SNS inhibits
   PSN stimulates

2. **Endocrine** hormones – stimulate or inhibit

HISTOLOGY OF THE ALIMENTARY CANAL

- ____________ = concentric layers of tissue surround a space
- 4 main layers:
  1. ____________ - epithelium
  2. **Submucosa** – CT
  3. **Muscularis externa** - smooth muscle
  4. **Serosa** (or______________) - CT & epithelium

- **Mucosa:**
  a. epithelium – ________________ or stratified squamous
     goblet cells → mucus
  b. lamina propria - CT
  c. muscularis mucosae – SMC

- ____________
  – *dense irregular CT*, with blood vessels and submucosal glands
  – **submucosal plexus** *(Meissner’s plexus)*
  regulate secretions

- **Muscularis externa**
  - inner circular SMC
- outer longitudinal SMC
  - __________________(Auerbach’s plexus)
    regulate motility

• **Serosa** = ________________
  - within peritoneal cavity
  - simple squam. epithelium & loose CT
  or

• **Adventitia**
  - outside peritoneal cavity
  - dense irregular CT

**ORGANIZATION OF ABDOMINOPELVIC ORGANS**

• **Peritoneal membranes:**
  – Outer **parietal peritoneum**
    - < peritoneal cavity- serous fluid>
  – Inner **visceral peritoneum (serosa)**

• **Mesenteries**
  - Folds of visceral peritoneum between loops of intestines
  - __________________ “fatty apron” : hangs from base of stomach
  - **Lesser Omentum** : lesser curvature of stomach to liver

**Peritonitis**

**Peritonitis** = *inflammation* of peritoneum

• Results when blood or contents of an abdominal organ leak into peritoneal cavity; usually due to *trauma*; often involves a bacterial infection

• Treatment for peritonitis may involve
Module 22.2: THE ORAL CAVITY, PHARYNX, AND ESOPHAGUS

**INTRODUCTION**

Oral cavity (*mouth*)
- posterior to teeth and bounded by cheeks
- lined with *stratified squamous nonkeratinized epithelial*.

- beginning of alimentary canal
- accessory organs: ____________________________
- forms _______ = saliva and chewed food

**STRUCTURE OF ORAL CAVITY**

- Cheeks: ____________________________

- Lips:
  - *orbicularis oris* muscle and covered with ____________________________
  - *labial frenulum*
- Vestibule – space between lips, cheeks and gums
- Gums – __________
- Palate:
  - hard palate (ant. 2/3) = ____________________________
  - soft palate (post. 1/3) = skeletal muscle
  - __________ – prevents food from entering nasal cavity

**TEETH AND MASTICATION**

Teeth
- organs of mechanical digestion
- Mastication – ________ to increase surface area of food
- Teeth located in bony *sockets* called *alveoli* maxilla and mandible

- Dentition Formula: 3 2 1 4 1 2 3
  - 3 – tricuspids (molars)
  - 2 – bicuspids (premolars)
  - 1 - cuspids (canines)
  - 4 – incisors
• Secondary dentition (32 permanent teeth)
• Tooth structure
  • ___________ – above gum line
    - Enamel – hard mineralized substances
    - Dentin
  • ___________ – below gum line
    - Pulp – blood vessels, nerves

**TONGUE**

Tongue
– skeletal muscle covered w/ stratified squamous epithelial
- lingual frenulum ________________
- Papillae:
  1. ___________
  2. fungiform
  3. circumvallate
  4. foliate papillae
• All papillae except filiform contain sensory receptors called taste buds

**SALIVARY GLANDS**

Salivary glands → saliva contains water, enzymes, mucus, and other solutes
1. ________________ (25-30% of saliva)
   → parotid duct
   - located over masseter muscle
2. ________________ (65-70%)
   → submandibular ducts
   - located along mandible
3. ________________ (5%)
   → sublingual ducts
   – situated inferior to tongue
Saliva
- ________________
- ________________, initiates CHO digestion
  - Lysozyme an enzyme that kills bacteria
  - IgA antibody that destroys pathogens
  - Bicarbonate to neutralize acid
    - Parotid glands \(\rightarrow\) water and enzymes
    - Submandibular glands \(\rightarrow\) secrete enzymes, mucus
    - Sublingual glands \(\rightarrow\) secretes mainly mucus, some enzymes.

• **Functions of Saliva:**
  *Moistening, lubricating, and cleansing* oral mucosa
    - Lysozyme and IgA *deter* growth of bacteria
    - ________________ digestion by moistening and mixing ingested food into a bolus so it can be swallowed
    - ________________ digestion by salivary amylase
    - ________________ in water of saliva to stimulate taste receptors on tongue

**PHARYNX**

Common passageway for 2 systems:
- extends from internal nares \(\rightarrow\) ________________

**Pharynx** (throat)
- nasopharynx
- oropharynx
- laryngopharynx

Function of pharynx
• ________________ - bolus passes into esophagus
  - Pharynx is surrounded by three pairs of skeletal muscles: upper, middle, and lower *pharyngeal constrictor muscles*
Tonsils – defend body from pathogens that have entered nasal or oral cavities
1. ___________ tonsils
   - posterior oral cavity on either side of tongue
2. ___________ tonsils
   - located under base of tongue
3. ___________ tonsils
   - located on posterior wall of nasopharynx

Esophagus
- muscular tube about 25 cm (10 in.) long
- posterior to trachea
- transports bolus from pharynx to stomach
- mucosa: lined with ________________
  - muscularis: superior 1/3 skeletal
    - middle 1/3 skeletal & SMC
    - inferior 1/3 ______

Upper esophageal sphincter
- junction of pharynx and esophagus
- modified sphincter

Gastroesophageal sphincter (aka _______________LES
  or cardiac sphincter)
- regulates passage of bolus into stomach; also prevents reflux
  _________________ - opening in diaphragm

• Primary functions of esophagus are _____________________________

• During swallowing, skeletal muscle and smooth muscle of muscularis undergo

• Thick esophageal epithelium protects esophagus from abrasion by food, also prevents absorption
Swallowing or ________________
- specialized type of propulsion that pushes bolus of food from oral cavity through pharynx and esophagus to stomach

1. **Voluntary phase** – tongue pushes bolus posteriorly toward oropharynx
2. ________________ – bolus enters oropharynx
   - soft palate and epiglottis seal off nasopharynx and larynx
   - **swallowing reflex** initiated by medulla
   - all structures (uvula, larynx) move up and epiglottis depresses
3. ________________ – peristaltic waves move bolus down esophagus to stomach

**Module 22.3: THE STOMACH**

**GROSS ANATOMY OF STOMACH**

Anatomy

- **greater curvature** – convex left side
- **lesser curvature** - *concave* right side

5 regions:

- Cardia – receives bolus when LES relaxes
- Fundus – upper left domed-shaped
- _______ – largest section
- Pyloric antrum – inferior portion
- ____________ – connects with duodenum via pyloric sphincter

*Rugae* = ____________________________
HISTOLOGY OF STOMACH

- Stomach
  - same four tissue layers as rest of alimentary canal with modifications:
    - Muscularis externa: additional inner layer of oblique smooth muscle

Chyme –

- Mucosa - indentations to form __________
  Goblet cells ______________

Gastric glands, found at base of gastric pits
  - contain both endocrine cells that secrete hormones and acidic, enzyme-containing fluid called gastric juice

- 4 main cells types:
  1. ___________ cells → hormones
     G cells secrete hormone gastrin stimulates secretions
  2. _________ pepsinogen
     - precursor to enzyme pepsin which begins protein dig.
  3. ___________ hydrochloric acid (HCl)
     → intrinsic factor (req. for absorption of vitamin____)
  4. Mucous neck cells secrete acidic mucus

FUNCTIONS OF STOMACH

Gastric secretions:

HCl

- ___________
- Necessary to convert pepsinogen to pepsin

Mucus

from goblet cells & mucus glands
Pepsinogen

- from parietal cells
- inactive form of pepsin req. for Vit. B12 absorption

Intrinsic factor

Pepsin

- protein splitting enz.

Regulation of Gastric Secretions:

1. ______________________ (30 - 40%)
   - triggered by sight, smell, taste, or thought of food
   - PSN (Vagus n.) triggers gastric juice secretion

2. ______________________ (50 - 60%)
   - triggered by food in stomach
   - gastrin released
   - gastric juice secreted

3. ______________________ (~5%)
   - triggered by food moving into S.I.
   - intestinal gastrin released → secretion of gastric juice

Gastroesophageal Reflux Disease (GERD)

- Gastroesophageal sphincter normally closed except during swallowing;
  When this mechanism *fails*, acid from stomach *regurgitates* into esophagus

- If chronic, it is called *gastroesophageal reflux disease*, or GERD, and may lead to pain, difficulty swallowing, vocal cord damage, respiratory problems, and even *esophageal cancer*

- Multiple factors contribute

- Helicobacter pylori

- Treatment
• **Enterogastric reflex**
  - as chyme enters duodenum, declining pH (more acidic) and presence of lipids trigger enterogastric reflex
  \[ \Rightarrow \text{decreases vagal activity and reduces acid secretion} \]

• **Emptying function**
  
  • Liquids move rapidly
  
  • Solids must be converted to a *nearly liquid* state before entering S.I.
  
  • \[\text{__________} \Rightarrow \text{delays gastric emptying}\]
  
  • Duodenum needs to process incoming chyme
    \( \text{\__________} \)

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**Vomiting**

• Occasionally stomach contents move *backward*, an unpleasant process known as *vomiting* (*emesis*)

• Involves a complex motor response during which SMC of stomach and SI *relaxes* while abdominal skeletal muscles and diaphragm *contract* to increase intra-abdominal pressure

• In addition, upper and lower esophageal sphincters *relax*, soft palate *closes off* nasopharynx, and larynx *elevates* so that epiglottis covers glottis

• Can be a response of variety of stimuli:
  
  • Stimuli activate sensory components of Vagus nerve
  
  • Drugs that treat vomiting are known as \[\text{__________}\]
Module 22.4: THE SMALL INTESTINES

INTRODUCTION

Small intestine (small bowel)
- 6 meters long (~20 feet)
- secretion, digestion, absorption, and propulsion

3 regions:

1. Duodenum
   • ~25 cm, retroperitoneal, “C” shaped
   • Major duodenal papilla – __________
   • Duodenal (Brunner’s) glands → __________

2. Jejunum
   – middle segment
   ~ 2.5 meters (7.5 feet) in length
   - ________________

3. Ileum
   – final segment, is also intraperitoneal
   ~ 3.6 meters (10.8 feet) in length
   - ________________

STRUCTURE AND FUNCTIONS OF SMALL INTESTINE

Increased surface area for absorption ~400 to 600x:

1. Circular folds or ________________
   - mucosa and submucosa of S.I.
   - ________________ to give enterocytes (S.I. cells)
     more time to absorb nutrients

2. Villi
   layer of enterocytes surrounding blood capillaries and lymphatic vessel
   (______________)

3. Microvilli ________________
   - Modification of plasma membrane of enterocytes
MOTILITY OF SMALL INTESTINE

- Types of movement:
  - **Peristalsis**
    - ________________
  - **Segmentation**
    - ________________

Appendicitis

- Small size of appendix and fact that it is blind-ended cause it to occasionally become blocked, generally by fecal matter
- Bacteria within feces multiply in appendix and cause infection; results in inflammation, a condition known as appendicitis
- Signs and symptoms
- Requires immediate treatment
- Can lead to __________

Module 22.5: THE LARGE INTESTINE

INTRODUCTION

Large intestine (large bowel)

- ~1.5 meters (5 feet) long
- receives material from S. I. not digested or absorbed
- _______________ (mucus), propulsion, defecation
- _______________ and electrolytes
- bacteria mfr. Vitamins
GROSS ANATOMY OF LARGE INTESTINE

L. I. = Cecum, Colon (ascending, transverse, descending, sigmoid), rectum, anus
- Cecum
  - vermiform appendix contains lymphatic nodules
- _______________ – right side
- _______________
- _______________ – left side
- Sigmoid colon

Rectum
Rectal valves - horizontal folds to hold feces in

Anal canal
Internal anal sphincter – _______________
External anal sphincter – _______________

HISTOLOGY OF LARGE INTESTINE

Histological features:
- Mucosa_________ and its cells lack _______________
- Many goblet cells
  → protective and lubricating mucus
- Taeniae coli = _______________
- Haustra = pockets or saccules
- Epiploic appendages
  = _______________

BACTERIA IN LARGE INTESTINE

Normal flora (gut flora)
~ 500 different bacterial species that have symbiotic (_______________) relationship
- Produce Vit. K (_______________)
- Metabolize undigested materials
- Deter growth of pathogens
- Stimulate immune system
MOTILITY OF LARGE INTESTINE AND DEFECATION

- Two main types of motility:
  
  **Segmentation** (churning)

**Mass movement (mass peristalsis)** 3-4 times per day

  - Defecation reflex –
  - __________ of internal & __________ anal sphincters, contraction of SMC

- **Diarrhea**
  - __________, not have enough time to absorb water → produces **watery feces**

- **Constipation**
  - motility __________, too much water absorption and fecal material becomes **hard**

PANCREAS, LIVER, AND GALL BLADDER

INTRODUCTION

- Pancreas, liver, and gallbladder
  - accessory organs
  - __________ secrete a product into a duct to outside of body

PANCREAS

- Pancreas – both endocrine and exocrine functions

  - **Hormones** (pancreatic islets: beta & alpha cells)
    - insulin (__________)
    - glucagon (__________)

  - Pancreatic juice (exocrine) enzymes secreted by __________

- Pancreas
  - left upper quadrant of abdomen
  - 3 regions: ________________
    - Pancreatic duct & accessory duct

- Pancreatic juice
  - Bicarbonate ions
- Pancreatic amylase
- Pancreatic lipase
- Trypsin, chymotrypsin, carboxypeptidase
- Nucleases

Hormonal stimulation of Pancreas & other target tissues
- **Cholecystokinin (CCK)** (duodenum)
  - Inhibits gastric glands
  - Stim. G.B. to release bile
- **Secretin** (duodenum)
  - Increases bile production in Liver
- **GIP**

**LIVER AND GALLBLADDER**

**Liver**
- covered by thin CT capsule
  - 4 lobes: right, left, ______________________
  - falciform ligament separates right and left lobes
  - round ligament: remnant of umbilical vein

**Liver lobule**
- basic unit of liver
  - composed cords of hepatocytes arranged around a central vein → hepatic v. → IVC
  - hepatic sinusoids drain __________________________

**Functions of liver**
- Hepatocytes → __________________
  - **Nutrient metabolism**
  - **Detoxification** – *detoxifies* substances produced by body, and substances that we eat or drink
– directly excretes bilirubin in bile, antibiotics and other substances liver processes

• Gallbladder
  – small sac on posterior liver
    - CCK triggers contraction of SMC causing release bile into ____________
    - Cystic duct joins with common hepatic duct → ________________
    - hepatopancreatic ampulla through hepatopancreatic (h-p) sphincter
  • CCK causes ____________ of G.B.
    – Relaxation of h-p sphincter

• Secretin stimulates bile production

**Module 22.7: NUTRIENT DIGESTION AND ABSORPTION**

**DIGESTION AND ABSORPTION OF CARBOHYDRATES**

Salivary amylase (salivary glands)
  - __________________________
    - inactivated in stomach due to low pH

Pancreatic amylase (exocrine pancreas)
  - picks up CHO digestion in duodenum

Lactase, maltase, sucrase (brush border enz. S.I.)
  - __________________________
    - Lactose → G + galactose
    - Maltose → G + G
    - Sucrose → G + fructose

**Lactose Intolerance**

• Many adults lack enzyme lactase and as a result cannot digest milk sugar lactose
• Most people produce lactase as infants, but production of enzyme declines as we age
• **Without** lactase, disaccharides such as lactose cannot be absorbed into enterocytes of small intestine
• Lactose intolerance can be managed by *avoiding* lactose-containing foods or by taking **lactase supplements**

**DIGESTION AND ABSORPTION OF PROTEINS**

Proteins $\rightarrow$ amino acids

**Pepsin** (stomach)
- Chief cells of gastric glands
- Pepsinogen $\rightarrow$ pepsin (req. pH 2)
  
  **------------** (activated by brush border enz.)
  
  - from trypsinogen (pancreas)

**------------** (pancreas)

**Carboxypeptidase** (pancreas)

**DIGESTION AND ABSORPTION OF LIPIDS**

**Triglycerides** $\rightarrow$ **------------**

*Bile salts* cause *emulsification* of lipids

**Gastric lipase** (stomach)

**Pancreatic lipase** (pancreas)

**------------** (protein-coated lipid pkg.) absorbed into lacteal $\rightarrow$
  
  lymphatic circulation $\rightarrow$ thoracic duct $\rightarrow$ Lt. Subclavian vein (blood circulation)

**DIGESTION AND ABSORPTION OF NUCLEIC ACIDS**

**Nucleic acids** (DNA, RNA) $\rightarrow$ nucleotides

**------------** (pancreas)
• > 9 L. H₂O
  – ~2 L. of water are ingested
  – ~7 L. secreted into alimentary canal

Of the 9 liters, ______ are absorbed into enterocytes of S.I.

– Most of remaining water is absorbed into enterocytes of L.I., leaving only about 0.1 liter of water to be excreted in feces

**REVIEW OF HORMONES**

<table>
<thead>
<tr>
<th>Source</th>
<th>Function</th>
<th>Target Tissue</th>
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<tbody>
<tr>
<td>Gastrin</td>
<td>–</td>
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<tr>
<td>CCK</td>
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<td>Secretin</td>
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