Bio104 Lecture Outline

Digestive System
Chapter 22

Digestive System = 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 some way
- 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

**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 epith.
- 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 - cuspsids (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 epith.
- **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, enz., 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 enz. kills bacteria
- IgA antibody that destroys pathogens
- Bicarbonate to neutralize acid
  - Parotid glands → water and enzymes
  - Submandibular glands → secrete enzymes, mucus
  - Sublingual glands → secrete mainly mucus, some enz.

• 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

Common passageway for 2 systems:
- extends from internal nares
  → ________________

• 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 DEGLUTITION

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:**

<table>
<thead>
<tr>
<th>HCl</th>
<th>Mucus</th>
</tr>
</thead>
<tbody>
<tr>
<td>________________</td>
<td>from goblet cells &amp; mucus glands</td>
</tr>
<tr>
<td>nec. to convert</td>
<td></td>
</tr>
<tr>
<td>pepsinogen to pepsin</td>
<td></td>
</tr>
</tbody>
</table>
**Pepsinogen**
- ________________
- inactive form of pepsin

**Intrinsic factor**
- from parietal cells
- req. for Vit. B12 absorption

**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
  → 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.

• ______________ → delays gastric emptying

• Duodenum needs to process incoming chyme
  (___________________________)

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 ______________
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 \( \rightarrow \) ________________

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

INTRODUCTION

THE PANCREAS, LIVER, AND GALL BLADDER

• 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**

- 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**

<table>
<thead>
<tr>
<th>DIGESTION AND ABSORPTION OF CARBOHYDRATES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Salivary amylase (salivary glands)</strong></td>
</tr>
<tr>
<td>- __________________________</td>
</tr>
<tr>
<td>- inactivated in stomach due to low pH</td>
</tr>
<tr>
<td><strong>Pancreatic amylase (exocrine pancreas)</strong></td>
</tr>
<tr>
<td>- picks up CHO digestion in duodenum</td>
</tr>
<tr>
<td><strong>Lactase, maltase, sucrase (brush border enz. S.I.)</strong></td>
</tr>
<tr>
<td>- __________________________</td>
</tr>
<tr>
<td>Lactose → G + galactose</td>
</tr>
<tr>
<td>Maltose → G + G</td>
</tr>
<tr>
<td>Sucrose → G + fructose</td>
</tr>
</tbody>
</table>

**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 → amino acids**

**Pepsin** (stomach)
- Chief cells of gastric glands
- Pepsinogen → pepsin (req. pH 2)

__________ (activated by brush border enz.)
- from trypsinogen (pancreas)

__________ (pancreas)

**Carboxypeptidase** (pancreas)

---

### DIGESTION AND ABSORPTION OF LIPIDS

**Triglycerides → ________________**

*Bile salts cause emulsification* of lipids

**Gastric lipase** (stomach)

**Pancreatic lipase** (pancreas)

__________ (protein-coated lipid pkg.) absorbed into lacteal →

lymphatic circulation → thoracic duct → Lt. Subclavian vein (blood circulation)

---

### DIGESTION AND ABSORPTION OF NUCLEIC ACIDS

**Nucleic acids (DNA, RNA) → nucleotides**

__________ (pancreas)
ABSORPTION OF WATER, ELECTROLYTES, AND VITAMINS

• > 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>
</tr>
</thead>
<tbody>
<tr>
<td>Gastrin –</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCK –</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secretin –</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GIP -</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>