

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 month

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 CTor
- **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 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 – tricuspid (molars)
  - 2 – bicuspid (premolars)
  - 1 - cuspid (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

## PHARYNX

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

**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

- **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:**

#### **HCl**

- \_\_\_\_\_
- nec. to convert pepsinogen to pepsin

#### **Mucus**

from goblet cells &  
mucus glands

### 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 → \_\_\_\_\_

**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 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 → 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. H<sub>2</sub>O \_\_\_\_\_
  - ~2 L. of water are *ingested*
  - ~ 7 L. *secreted* into alimentary canalOf 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

<u>Source</u>	<u>Function</u>	<u>Target Tissue</u>
Gastrin –		
CCK –		
Secretin –		
GIP -		