22

The Digestive System

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 _____

Introduction

- **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**, **_____**

Introduction

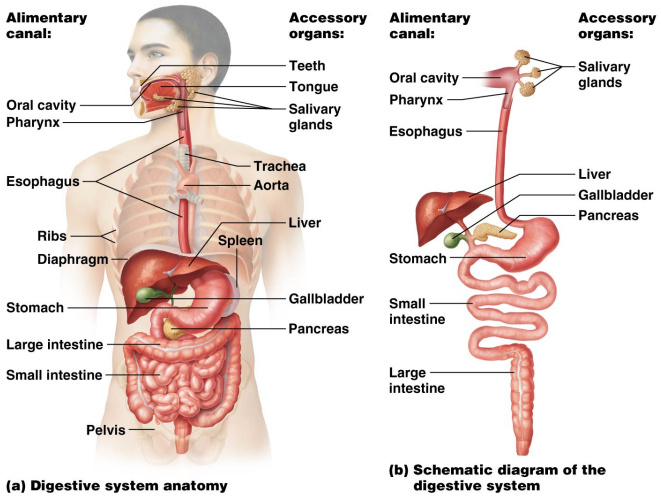


Figure 22.1 Overview of the digestive system.

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*

Basic Digestive Functions and Processes

- 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 <u>every</u> 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 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

Histology of the Alimentary Canal

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

Histology of Alimentary Canal

- _____
  - *dense irregular CT ,* with blood vessels and submucosal glands
  - **submucosal plexus** (**Meissner's plexus)** regulate secretions

Histology of Alimentary Canal

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

Histology of Alimentary Canal

- **Serosa** = _____
  - within peritoneal cavity
  - simple squam. epithelium & loose CT

or

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

Histology of Alimentary Canal

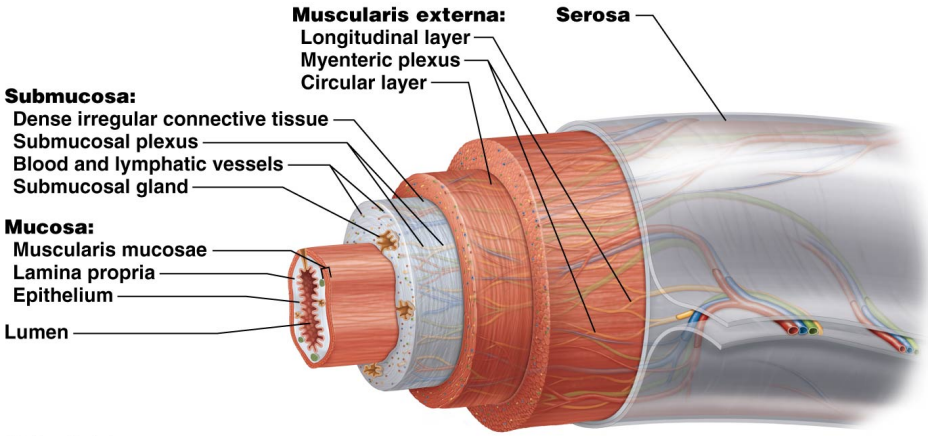


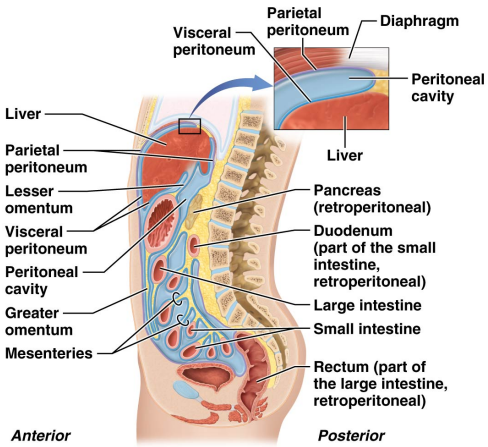
Figure 22.2 The basic tissue organization of most of the alimentary canal.

Organization of Abdominopelvic Organs

- **Peritoneal membranes** (**Figure 22.3**):
  - 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

Organization of Abdominopelvic Organs



(a) Sagittal section of the abdominopelvic cavity showing the peritoneal cavity

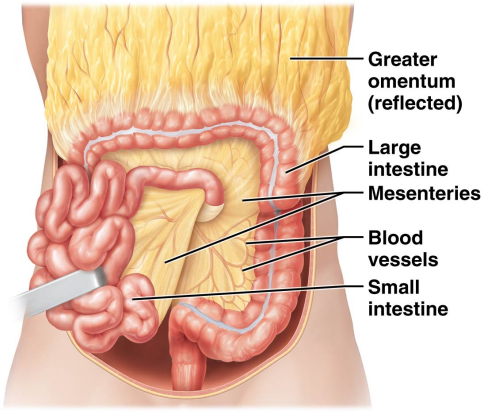
Figure 22.3a The peritoneum, the largest serous membrane in the body.

Peritonitis (p. 850)

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

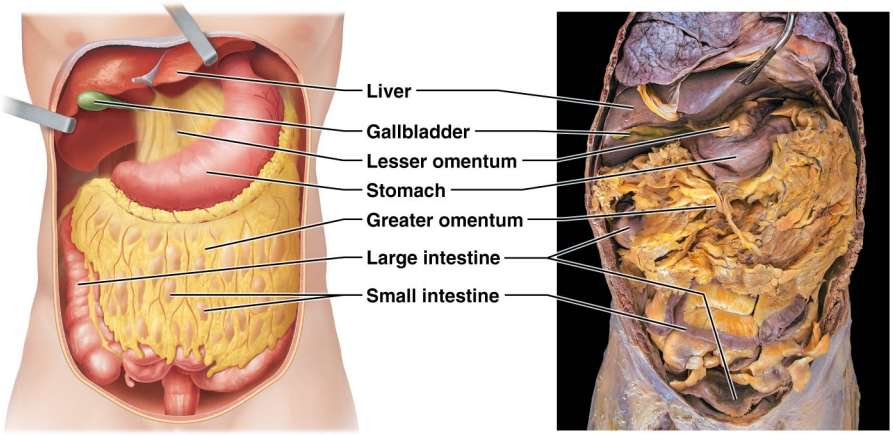
Organization of Abdominopelvic Organs



(b) Mesenteries with greater omentum reflected and small intestine pulled aside, anterior view

Figure 22.3b The peritoneum, the largest serous membrane in the body.

Organization of Abdominopelvic Organs



(c) Anterior view of the abdominal organs and omenta, illustration (left), and cadaver photo (right)

Figure 22.3c The peritoneum, the largest serous membrane in the body.

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*
    - *uvula – prevents food from entering nasal cavity*

Structure of Oral Cavity

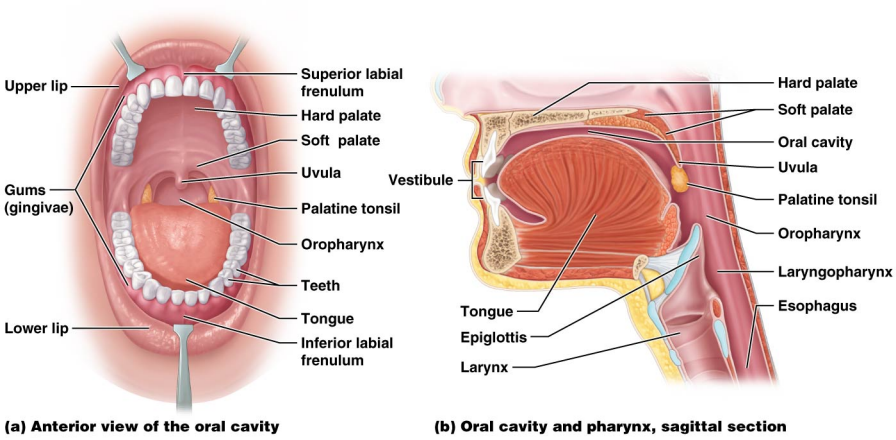


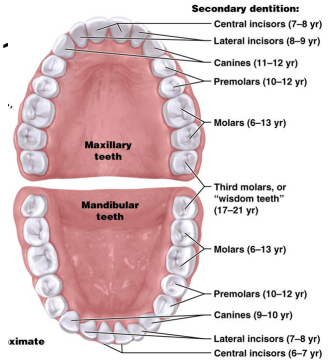
Figure 22.4 Oral cavity and pharynx.

Teeth and Mastication

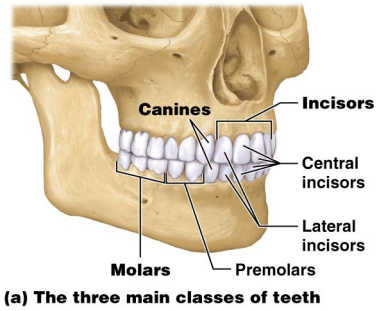
Teeth

- organs of mechanical digestion (Figures 22.5, 22.6)

- Mastication – _____ to <u>increase</u> surface area of food
- Teeth located in bony *sockets* called **alveoli** maxilla and mandible
- Dentition Formula: 3 2 1 4 1 1
  - 3 – tricuspids (molars)
  - 2 – bicuspids (premolars)
  - 1 - cuspids (canines)
  - 4 - incisors



The Teeth and Mastication



(a) The three main classes of teeth

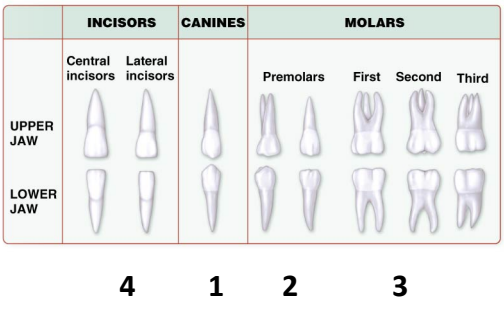
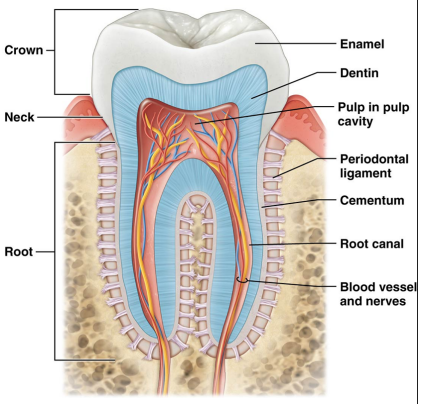


Figure 22.5a Types of teeth and the primary and secondary dentition.

Teeth and Mastication

- **Secondary dentition (_____ 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 <u>except</u> filiform contain sensory receptors called **taste buds**

Salivary Glands

Salivary glands → **saliva** contains water, enz., mucus, and other solutes (Fig. 22.7)

1. _____ (25-30% of saliva)
→ **parotid duct**
- located over masseter muscle

2. _____ **glands** (65-70%)
→ **submandibular ducts**
- located along mandible

3. _____ (5%)
→ **sublingual ducts**
– situated inferior to tongue

Salivary Glands

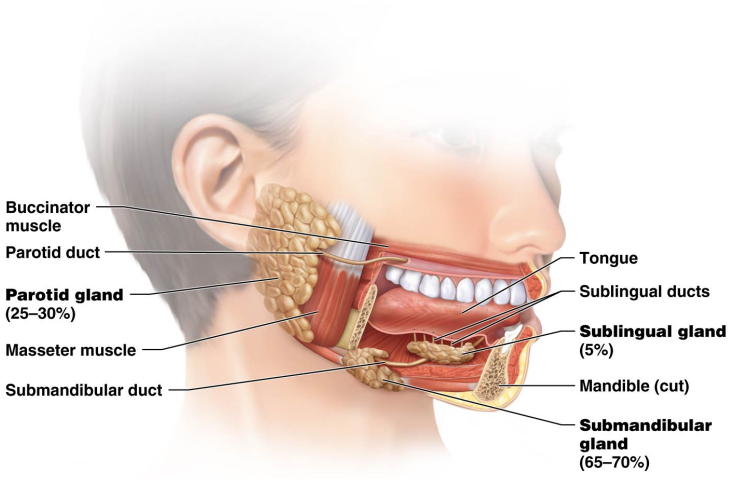


Figure 22.7 Anatomy of the salivary glands. The percentages indicate the portion of total salivary production for each type of gland.

Salivary Glands

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.

Salivary Glands

- **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**

Pharynx

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** (**Figure 22.8**)
  - 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 SMC

Esophagus

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

Esophagus

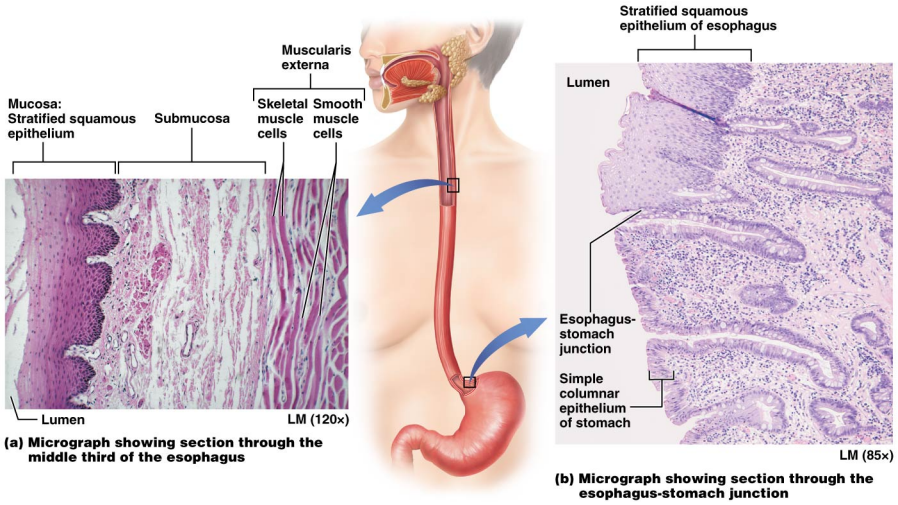


Figure 22.8 Histology of the esophagus.

Esophagus

- Primary functions of esophagus
- During swallowing, skeletal muscle and smooth muscle of muscularis undergo *peristalsis*
  - 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 (Figure 22.9):

Swallowing or Deglutition

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

Swallowing or Deglutition

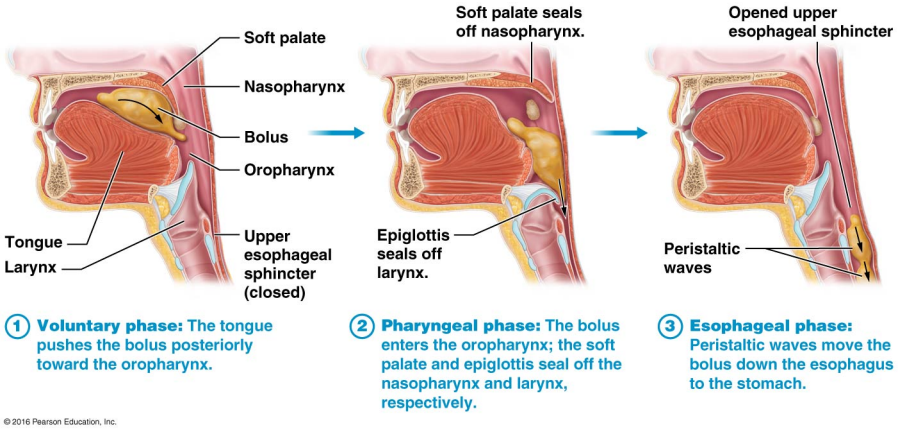


Figure 22.9 The process of swallowing (deglutition).

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

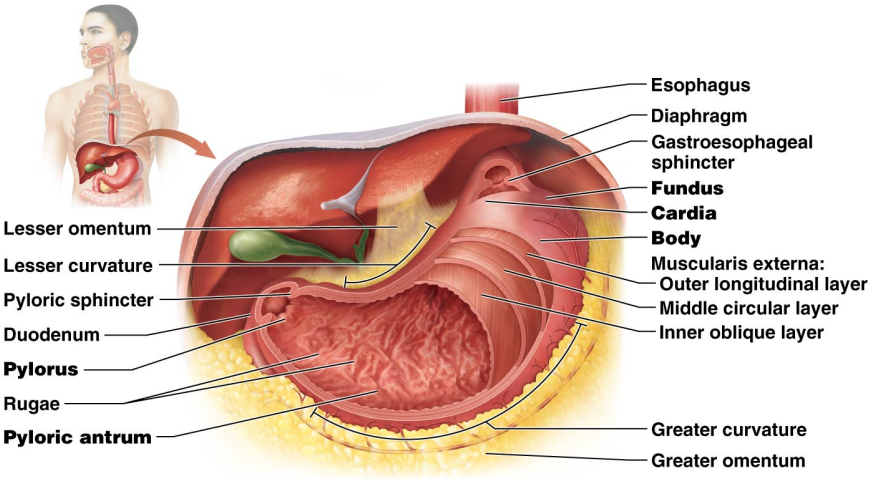
_____ – largest section

Pyloric antrum – inferior portion

_____ – connects with duodenum via pyloric sphincter

Rugae = _____

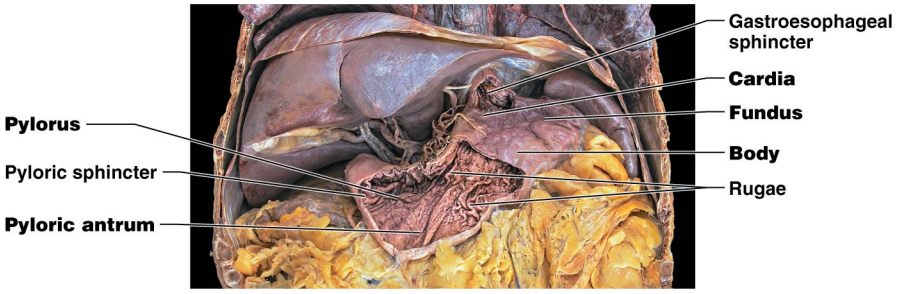
Gross Anatomy of Stomach



(a) Regions and tissue layers of the stomach

Figure 22.10a Gross anatomy of the stomach.

Gross Anatomy of Stomach



(b) Stomach and surrounding organs, cadaver photo

Figure 22.10b Gross anatomy of the stomach.

Histology of Stomach

- Stomach
  - same four tissue layers as rest of alimentary canal with modifications (**Figure 22.11**):
  - Muscularis externa : additional inner layer of _____

Chyme – _____

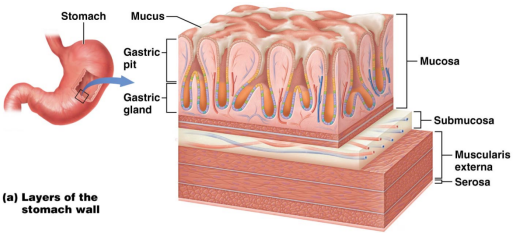
Histology of Stomach

- Mucosa - *indentations* to form _____(Fig. 22.11):

  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**



Histology of Stomach

- 4 main cells types (**Figure 22.11b**):
  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 B12)**
  4. **Mucous neck cells** → secrete acidic mucus

Histology of Stomach

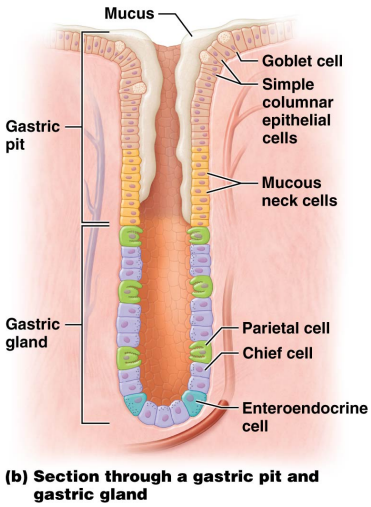


Figure 22.11b Structure and functions of the stomach mucosa and gastric glands.

Functions of Stomach

***Gastric secretions*:**

HCl

- _____
- nec. to convert pepsinogen to pepsin

Pepsinogen

- _____
- inactive form of pepsin

Pepsin

-

Mucus

- from goblet cells & mucus glands

Intrinsic factor

- from parietal cells
- req. for Vit. B_{12} absorption

Histology of the Stomach

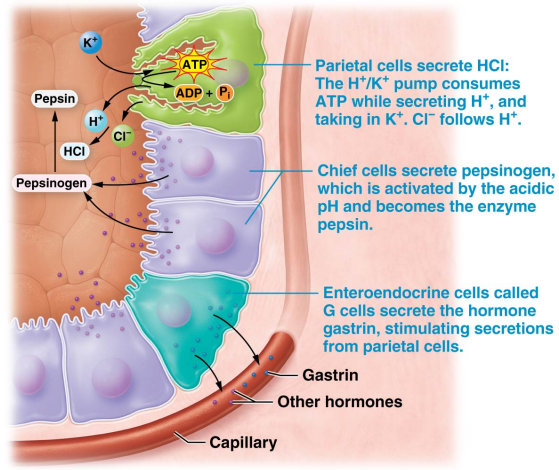


Figure 22.11c Structure and functions of the stomach mucosa and gastric glands.

Functions of Stomach

- Regulation of Gastric Secretions: (**Figure 22.12**):
  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

Functions of the Stomach

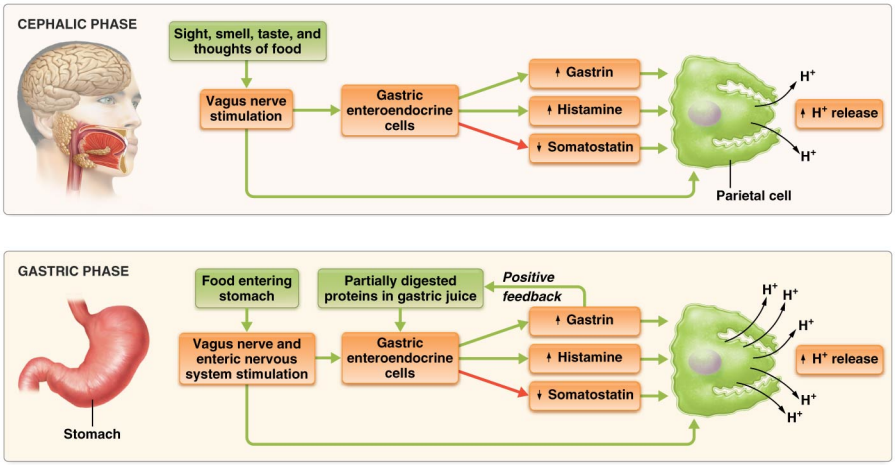


Figure 22.12 The three phases of acid secretion from the stomach.

Functions of the Stomach

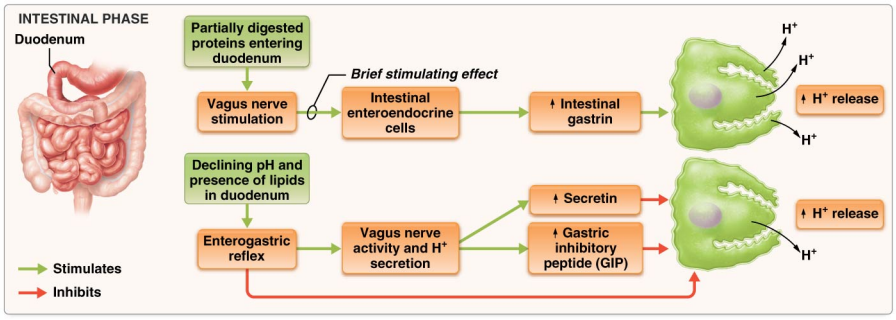


Figure 22.12 The three phases of acid secretion from the stomach.

Gastroesophageal Reflux Disease (GERD)

- Gastroesophageal sphincter normally remains closed except during swallowing; when this mechanism *fails*, acid from stomach *regurgitates* into esophagus
- If this occurs on a chronic basis, it is called **gastroesophageal reflux disease**, or **GERD**, and may lead to pain, difficulty swallowing, vocal cord damage, respiratory problems, and even **esophageal cancer**

Gastroesophageal Reflux Disease (GERD) (p. 865)

- Causes
  - Acid
  - H. pylori
  -
- Treatment

Functions of the Stomach

- **Enterogastric reflex**
  - as chyme enters duodenum, declining pH (more acidic) and presence of lipids trigger enterogastric reflex

  →<u>decreases</u> vagal activity and reduces acid secretion → _____

Functions of the Stomach

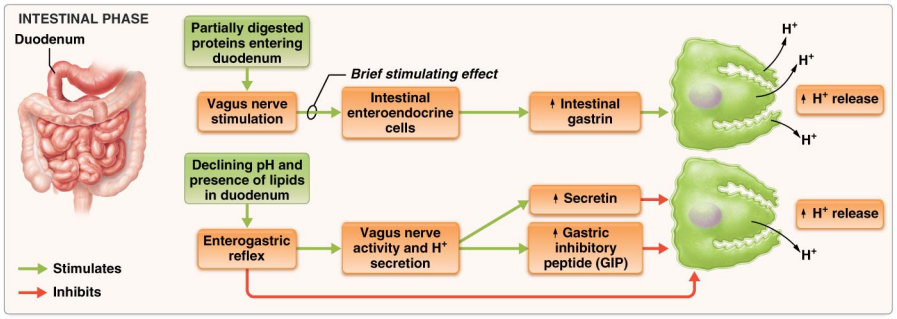


Figure 22.12 The three phases of acid secretion from the stomach.

Functions of the Stomach

- **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 (_____)

Functions of the Stomach

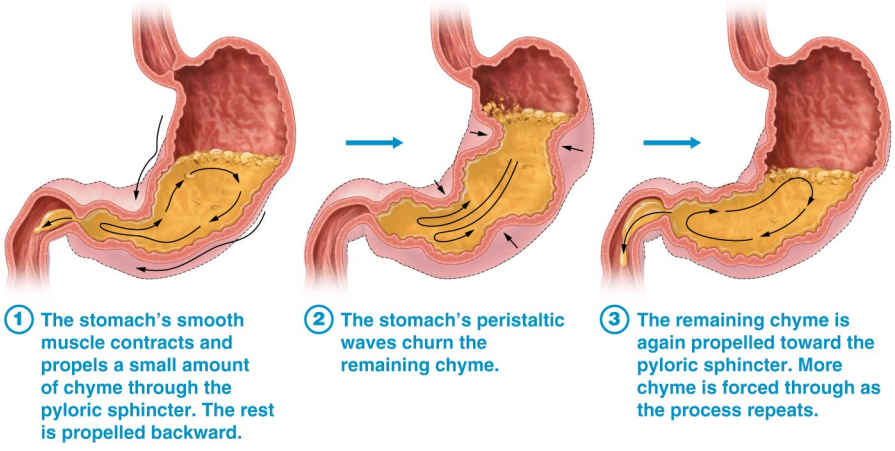


Figure 22.13 The process of churning in the stomach.

Vomiting (p. 865)

- **Vomiting** (**emesis**)
- Complex motor response

- Due to:

- Drugs (anti emetics

MODULE 22.4: THE SMALL INTESTINE

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 → _____

Divisions of Small Intestine

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

   -

Divisions of Small Intestine

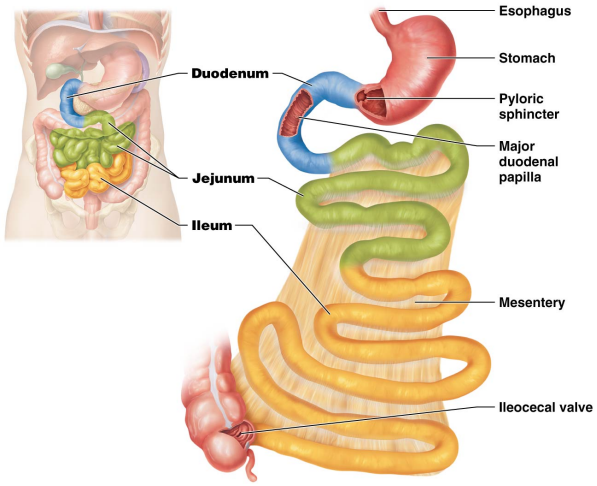
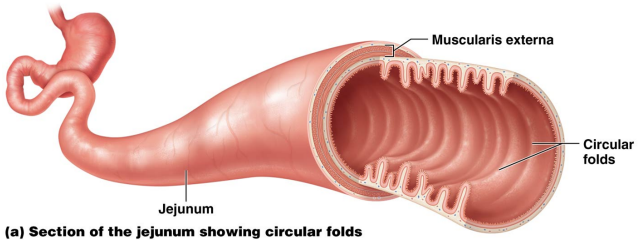


Figure 22.14 Gross anatomy of the small intestine.

Structure and Functions of Small Intestine

Increased surface area for absorption ~400 to 600x:

1. **Circular folds** or _____ (**Figure 22.15a**)
   - mucosa and submucosa of S.I.
   - _____ to give **enterocytes** (S.I. cells) more time to absorb nutrients

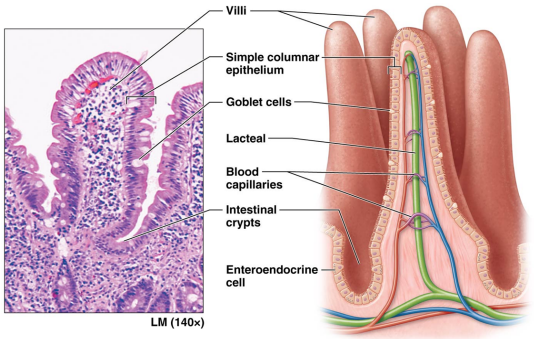


(a) Section of the jejunum showing circular folds

Structure and Functions of Small Intestine

2. Villi

- layer of enterocytes surrounding blood capillaries and lymphatic vessel _____

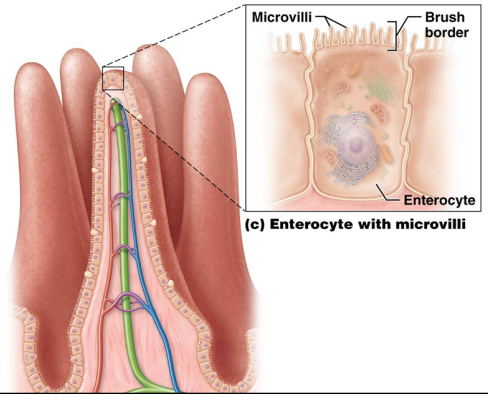


(b) Intestinal villi, photomicrograph (left) and illustration (right)

Structure and Functions of Small Intestine

3. Microvilli _____

- Modification of plasma membrane of enterocytes (**Figure 22.15c**)



(c) Enterocyte with microvilli

Motility of Small Intestine

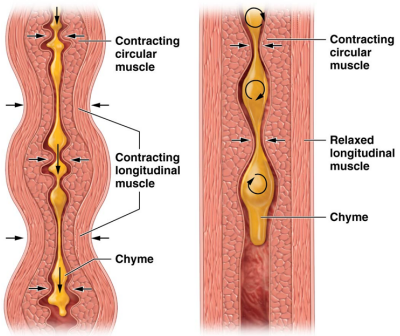
- Types of movement:

Peristalsis

- _____

Segmentation

– _____



(a) Peristalsis: propulsive, alternating contractions of longitudinal and circular smooth muscle

(b) Segmentation: mixing contractions of circular smooth muscle only

Motility of the Small Intestine

Table 22.1 Hormones and Paracrines Involved in Secretion and Motility of the Digestive Organs

Hormone	Stimulus for Production	Effects
Stomach Hormones		
Gastrin	Partially digested proteins; stimulation from the vagus nerve	Increases acid secretion by parietal cells
Histamine	Stimulation from the vagus nerve	Increases acid secretion by parietal cells
Serotonin	Distention of the stomach	Stimulates gastric motility
Somatostatin	Decreasing stomach pH	Decreases acid secretion by parietal cells
Intestinal Hormones		
Cholecystokinin (CCK)	Partially digested proteins and lipids in chyme entering the duodenum	Causes gallbladder to contract and release bile; stimulates secretion of pancreatic enzymes from acinar cells; relaxes hepatopancreatic sphincter
Gastric inhibitory peptide	Chyme entering the small intestine	Inhibits acid secretion from parietal cells
Intestinal gastrin	Chyme entering the small intestine	Stimulates acid secretion from parietal cells
Motilin	Released regularly during fasting	Stimulates the migrating motor complex of the small intestine
Secretin	Partially digested proteins in the duodenum	Inhibits gastric motility and acid secretion; stimulates bicarbonate release from pancreatic duct cells; increases bile production by the liver
Vasoactive intestinal peptide	Partially digested proteins in the duodenum	Inhibits acid secretion by parietal cells; stimulates pancreatic secretion; increases intestinal blood flow

Table 22.1 Hormones and Paracrines Involved in Secretion and Motility of the Digestive Organs.

Appendicitis (p. 870)

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

-

-

- bacteria mfr. vitamins

Gross Anatomy of Large Intestine

L. I. = Cecum, Colon (ascending, transverse, descending, sigmoid), rectum, anus

- **Cecum**
  - **vermiform appendix** contains *lymphatic nodules*
- _____ *colon – right side*
- _____ *colon*
- _____ *colon – left side*
- *Sigmoid colon*

Gross Anatomy of Large Intestine

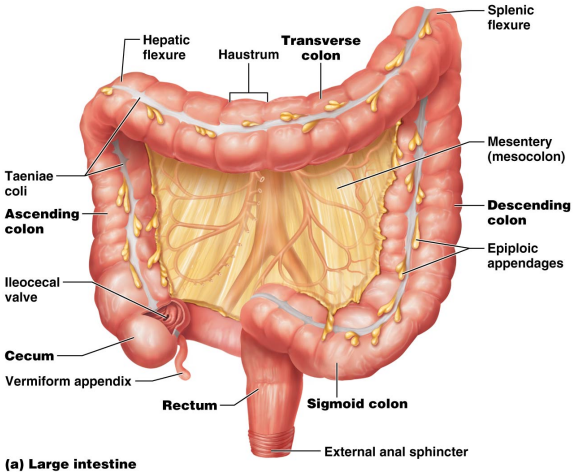


Figure 22.17a Gross anatomy of the large intestine

Gross Anatomy of Large Intestine

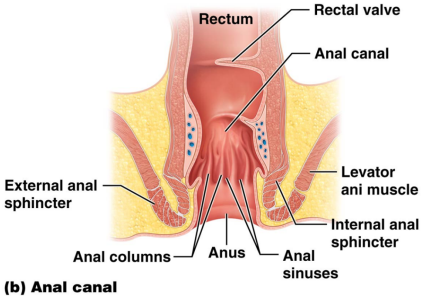
Rectum

Rectal valves - horizontal folds to hold feces in

Anal canal

Internal anal sphincter – _____

External anal sphincter – levator ani muscle



Histology of Large Intestine

Histological features:

- Mucosa _____ and its cells lack *microvilli*
- Many _____
  → *protective* and *lubricating* mucus
- **Taeniae coli** = _____ (**Fig. 22.17a**)
- **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

Histology of Large Intestine

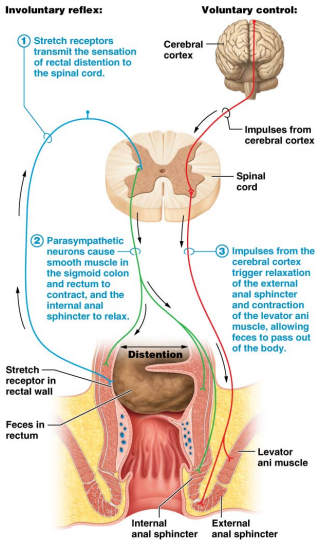
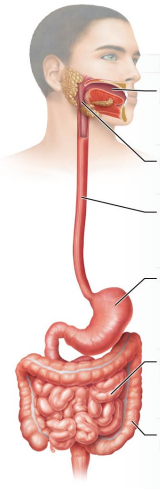


Figure 22.18 Defecation.

Motility of Large Intestine and Defecation

- **Diarrhea**
  - _____, not have enough time to absorb water → produces *watery feces*
- **Constipation**
  - motility _____, too much water absorption and fecal material becomes *hard*

Motility of Large Intestine and Defecation



ORGAN	STRUCTURAL PROPERTIES	FUNCTIONAL ROLES
Oral cavity (mouth)	• Region posterior to the teeth and bounded by the hard and soft palate, and the tongue, lips, and teeth • Lined with stratified squamous epithelium • Associated with accessory organs: contains the tongue and teeth, and is surrounded by salivary glands	• Ingestion • Mechanical digestion (mastication) • Propulsion (swallowing) • Secretion
Pharynx	• Region posterior to the oral cavity and larynx • Includes oropharynx and laryngopharynx • Lined with stratified squamous epithelium	• Propulsion (swallowing)
Esophagus	• Muscular tube extending from the pharynx to the stomach • Lined with stratified squamous epithelium • Muscularis of superior third is skeletal, middle third is both skeletal and smooth, and inferior third is smooth muscle	• Propulsion (swallowing) • Limited secretion
Stomach	• J-shaped muscular organ extending from the esophagus to the duodenum • Lined with simple columnar epithelium • Mucosa folded into gastric pits that contain gastric glands • Muscularis contains a third layer of oblique smooth muscle	• Propulsion • Chemical digestion • Mechanical digestion • Secretion • Limited absorption
Small intestine	• Long tube extending from the stomach to the large intestine • Lined with simple columnar epithelium • Wall arranged into three progressively smaller folds: circular folds, villi, and microvilli	• Chemical digestion • Mechanical digestion • Absorption • Secretion • Propulsion
Large intestine	• Terminal portion of the alimentary canal extending from the small intestine to the anal canal • Lined with simple columnar epithelium • Muscularis arranged into ribbon-like taeniae coli • Contains large number of bacterial flora	• Absorption of water, electrolytes, and vitamins • Propulsion • Limited secretion • Defecation

Figure 22.19 Summary of the structure and function of the organs of the alimentary canal.

MODULE 22.6: THE PANCREAS, LIVER, AND GALLBLADDER

Introduction

- Pancreas, liver, and gallbladder

- accessory organs

- _____ secrete a product into a duct to outside of body

The Pancreas

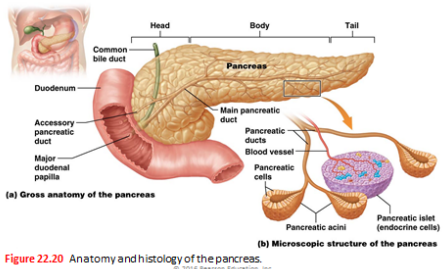


Figure 22.20 Anatomy and histology of the pancreas.

Pancreas

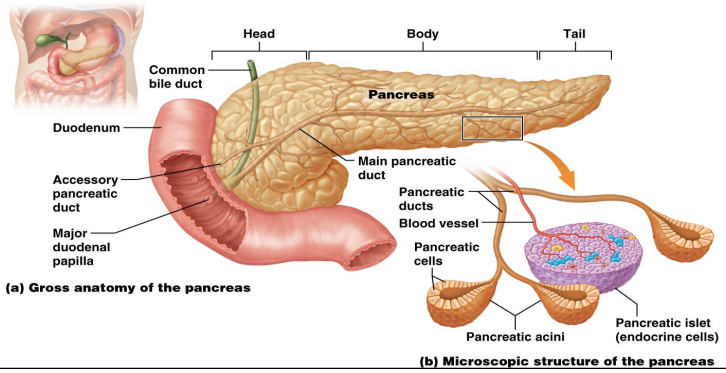
Pancreas – both endocrine and exocrine functions (**Figure 22.20**)

- H*ormones* (pancreatic islets: beta & alpha cells)
  - **insulin** (_____)
  - **glucagon** (_____)

- Pancreatic juice (exocrine) *enzymes* secreted by _____

Pancreas

- **Pancreas**
  - left upper quadrant of abdomen
  - **3 regions: _____**
  - **Pancreatic duct & accessary duct**



The Pancreas

- **_____**
  - **Bicarbonate ions**
  - ***Pancreatic amylase***
  - ***Pancreatic lipase***
  - ***Trypsin, chymotrypsin, carboxypeptidase***
  - ***Nucleases***

Pancreas

Hormonal stimulation of Pancreas

- **Cholecystokinin** (**CCK**) (duodenum)
  -
- **Secretin** (duodenum)
  -

The Pancreas

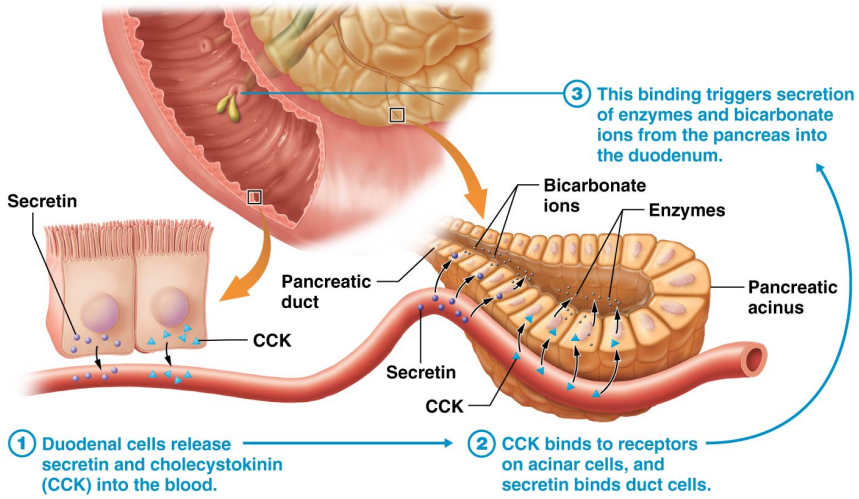


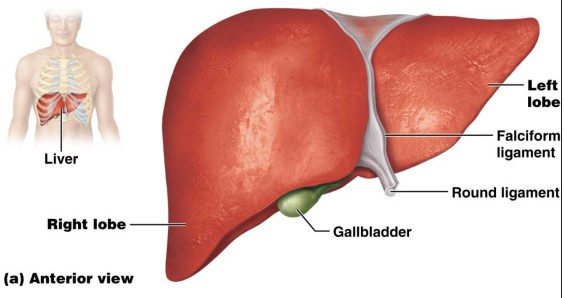
Figure 22.21 Secretion of pancreatic juice.

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



The Liver and Gallbladder

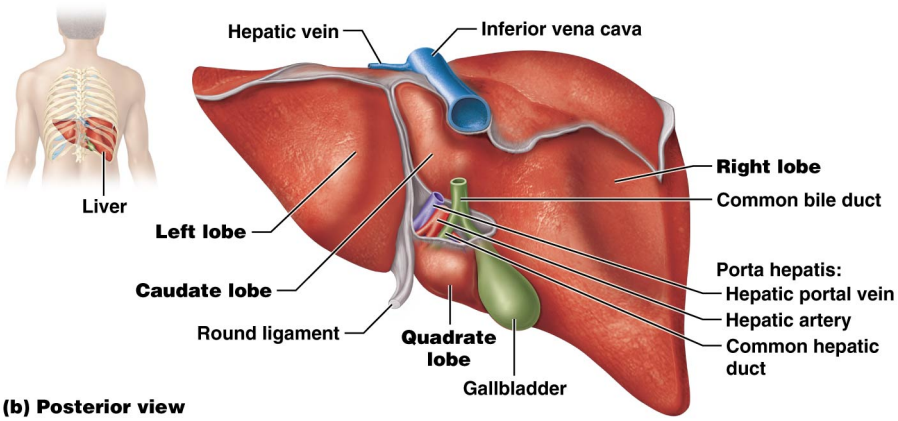


Figure 22.22b Gross anatomy of the liver.

The Liver and Gallbladder

- **Liver lobule**

– basic unit of liver

- composed cords of **hepatocytes** arranged around a central vein → hepatic v. → IVC

- hepatic sinusoids drain

The Liver and Gallbladder

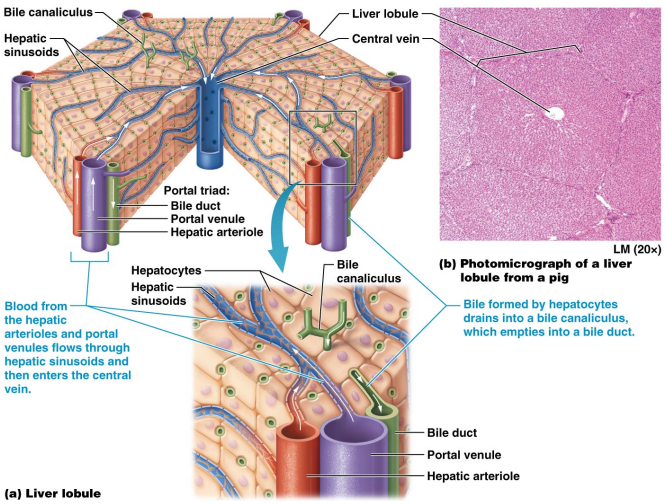


Figure 22.23 The structure of a liver lobule.

Liver and Gallbladder

- **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

Liver and Gallbladder

- **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**

Liver and Gallbladder

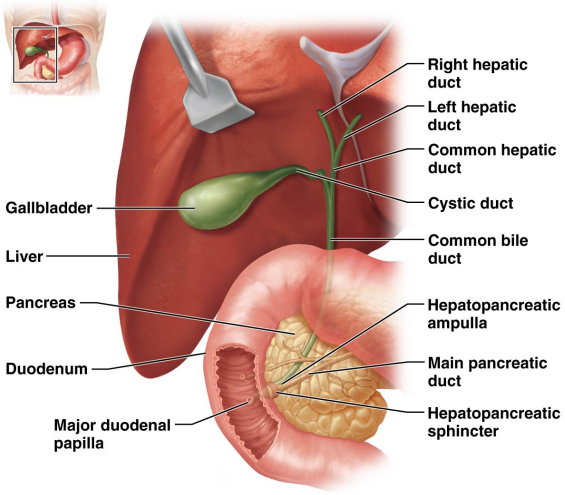


Figure 22.24 Structure of the gallbladder and its ducts.

Liver and Gallbladder

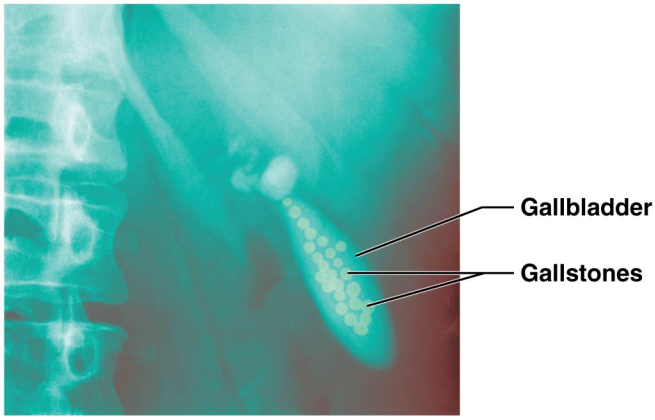


Figure 22.25 Radiograph of a gallbladder showing gallstones.

The Liver and Gallbladder

- **CCK** causes _____ of G.B.
  - Relaxation of h-p sphincter
- **Secretin** stimulates bile *production*

Liver and Gallbladder

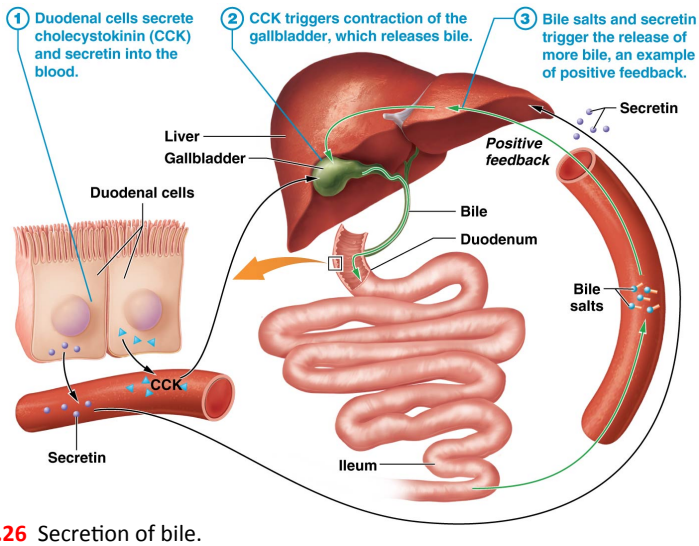
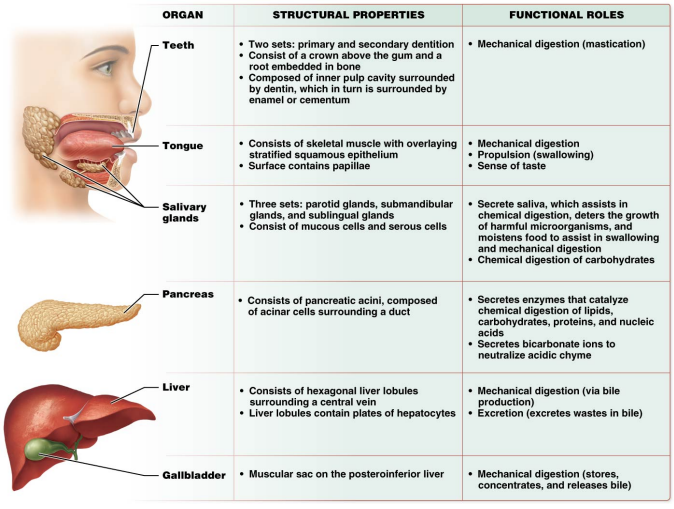


Figure 22.26 Secretion of bile.

Liver and Gallbladder



ORGAN	STRUCTURAL PROPERTIES	FUNCTIONAL ROLES
Teeth	• Two sets: primary and secondary dentition • Consist of a crown above the gum and a root embedded in bone • Composed of inner pulp cavity surrounded by dentin, which in turn is surrounded by enamel or cementum	• Mechanical digestion (mastication)
Tongue	• Consists of skeletal muscle with overlaying stratified squamous epithelium • Surface contains papillae	• Mechanical digestion • Propulsion (swallowing) • Sense of taste
Salivary glands	• Three sets: parotid glands, submandibular glands, and sublingual glands • Consist of mucous cells and serous cells	• Secrete saliva, which assists in chemical digestion, deters the growth of harmful microorganisms, and moistens food to assist in swallowing and mechanical digestion • Chemical digestion of carbohydrates
Pancreas	• Consists of pancreatic acini, composed of acinar cells surrounding a duct	• Secretes enzymes that catalyze chemical digestion of lipids, carbohydrates, proteins, and nucleic acids • Secretes bicarbonate ions to neutralize acidic chyme
Liver	• Consists of hexagonal liver lobules surrounding a central vein • Liver lobules contain plates of hepatocytes	• Mechanical digestion (via bile production) • Excretion (excretes wastes in bile)
Gallbladder	• Muscular sac on the posteroinferior liver	• Mechanical digestion (stores, concentrates, and releases bile)

Figure 22.27 Structure and function of the accessory digestive organs.

MODULE 22.7 NUTRIENT DIGESTION AND ABSORPTION

Digestion and Absorption of Carbohydrates

S**alivary amylase** (salivary glands)

-

- inactivated in stomach due to low pH

Pancreatic amylase (exocrine pancreas)

- picks up CHO digestion in duodenum (**Fig. 22.29**)

Lactase, maltase, sucrase (brush border enz. S.I.)

-

Lactose → G + galactose

Maltose → G + G

Sucrose → G + fructose

Lactose Intolerance, (p. 884)

Lactose intolerance -lack of enzyme **lactase** and as a result cannot *digest* milk sugar lactose (in adults)

Digestion and Absorption of Proteins

Proteins → _____

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 _____ 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 Lipids

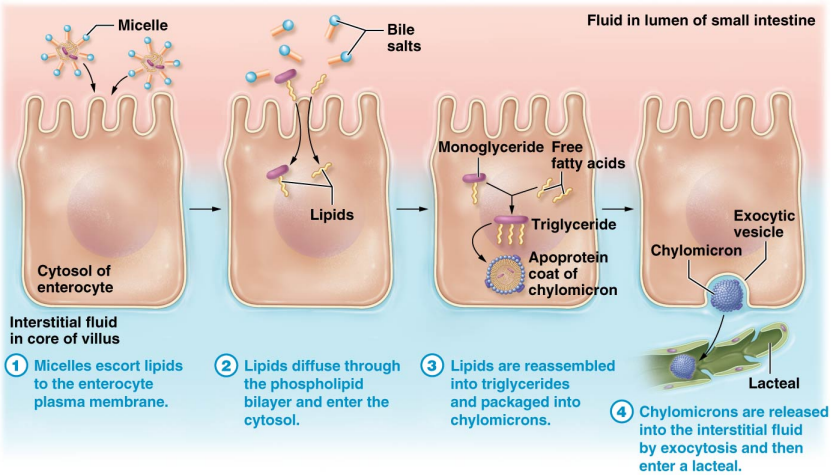


Figure 22.33 Lipid absorption in the small intestine.

Digestion and Absorption of Lipids

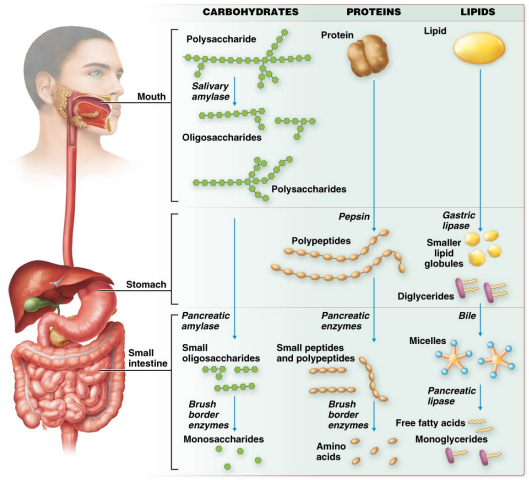


Figure 22.32 Summary of the digestion of carbohydrates, proteins, and lipids.

Digestion and Absorption of Nucleic Acids

Nucleic acids (DNA, RNA) → nucleotides

_____ (pancreas)

Digestion and Absorption of Nucleic Acids

Table 22.2 Digestive Enzymes

Enzyme(s)	Source	Reaction Catalyzed
Carbohydrates		
Salivary amylase	Salivary glands	Polysaccharides into smaller polysaccharides and oligosaccharides
Pancreatic amylase	Pancreatic juice	Polysaccharides into oligosaccharides
Maltase, sucrase, lactase	Intestinal brush border	Oligosaccharides into monosaccharides
Proteins		
Pepsin	Chief cells of gastric glands (secreted as precursor pepsinogen)	Proteins into polypeptides and oligopeptides
Trypsin	Pancreatic juice	Oligopeptides into small peptides; activates itself and other pancreatic enzymes
Chymotrypsin	Pancreatic juice	Oligopeptides into small peptides
Carboxypeptidase	Pancreatic juice	Oligopeptides into small peptides
Dipeptidase and tripeptidase	Intestinal brush border	Dipeptides and tripeptides into amino acids
Lipids		
Gastric lipase	Gastric glands	Triglycerides into free fatty acids and diglycerides
Pancreatic lipase	Pancreatic juice	Triglycerides into free fatty acids and monoglycerides
Nucleic Acids		
Nucleases	Pancreatic juice	Nucleic acids into nitrogenous bases and simple sugars

Table 22. 2 Digestive Enzymes.

Absorption of Water, Electrolytes, and Vitamins

- > 9 L. H_2O _____
  - ~2 L. of water are *ingested*
  - ~ 7 L. *secreted* into alimentary canal

  Of the 9 liters, about _____ 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

The Big Picture of Digestion

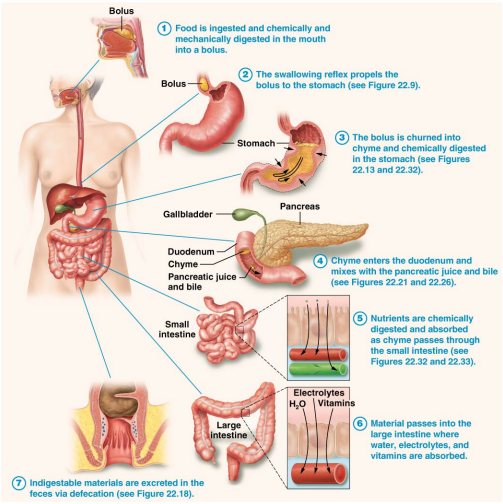


Figure 22.34 The Big Picture of Digestion.