Chapter 25
The Digestive System

Lecture Presentation by
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Introduction

• The digestive system consists of:
  • The digestive tract
  • Accessory organs of digestion

• Digestive tract
  • Mouth
  • Pharynx
  • Esophagus
  • Stomach
  • Small intestine
  • Large intestine
Introduction

• Accessory Organs of the Digestive Tract
  • Teeth
  • Tongue
  • Salivary glands
  • Pancreas
  • Liver
  • Gallbladder
Figure 25.1 Components of the Digestive System

**Major Subdivisions of the Digestive Tract**

**Oral Cavity**
Mechanical processing, moistening, mixing with salivary secretions

**Pharynx**
Muscular propulsion of materials into the esophagus

**Esophagus**
Transport of materials to the stomach

**Stomach**
Chemical breakdown of materials via acid and enzymes; mechanical processing through muscular contractions

**Small Intestine**
Enzymatic digestion and absorption of water, organic substrates, vitamins, and ions

**Large Intestine**
Enzymatic digestion and absorption of water, organic substrates, vitamins, and ions

**Accessory Organs of the Digestive System**

**Salivary Glands**
Secretion of lubricating fluid containing enzymes that break down carbohydrates

**Liver**
Secretion of bile (important for lipid digestion), storage of nutrients, many other vital functions

**Gallbladder**
Storage and concentration of bile

**Pancreas**
Exocrine cells secrete buffers and digestive enzymes; endocrine cells secrete hormones
Introduction

• Functions of the Digestive System
  • Ingestion
  • Mechanical processing
  • Digestion
  • Secretion
  • Absorption
  • Excretion
  • Compaction
Introduction

• Functions of the Digestive System (details)
  • **Ingestion**
    • Bringing food and liquids into the mouth
  • **Mechanical processing**
    • Chewing and swallowing food
  • **Digestion**
    • Chemical breakdown of food into nutrient form
  • **Secretion**
    • Secretion of products by the lining of the digestive tract
    • Secretion of products by the accessory organs of digestion
Functions of the Digestive System (continued)

- **Absorption**
  - The movement of nutrients from the small intestine to the bloodstream

- **Excretion**
  - The removal of waste products from the digestive tract

- **Compaction**
  - Progressive dehydration of organic wastes
An Overview of the Digestive System

• Histological Organization of the Digestive Tract
  • There are four major layers of the digestive tract
    • The mucosa
    • The submucosa
    • The muscularis externa
    • The serosa
Figure 25.2a Histological Structure of the Digestive Tract

Three-dimensional view of the histological organization of the general digestive tube

- Mesenteric artery and vein
- Mesentery
- Plica
- Mucosa
- Submucosa
- Muscularis externa
- Serosa (visceral peritoneum)

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An Overview of the Digestive System

• The **Mucosa**
  • The inner lining of the digestive tract
    • This is a mucous membrane
    • Cells of the mucosa are either stratified or simple
      • Oral cavity and esophagus are lined with nonkeratinized stratified squamous cells (resist stress and abrasion)
      • Stomach, small intestine, and large intestine are lined with simple columnar cells (for secretion and absorption)
An Overview of the Digestive System

• The Mucosa
  • The mucosa of the small intestine makes up folds called **plicae**
    • Plicae increase the surface area for increased absorption
  • **Lamina propria**
    • Contains blood vessels / nerves / smooth muscle / lymphatic vessels
Three-dimensional view of the histological organization of the general digestive tube

An enlarged section of the digestive tube showing the structure of a plica
An Overview of the Digestive System

• The Submucosa
  • Surrounds the muscularis mucosae
  • Large blood vessels and lymphatics are in this layer
  • **Submucosal plexus** innervates the mucosa
    • Consists of sensory neurons
    • Consists of parasympathetic ganglia
    • Consists of sympathetic postganglionic fibers
Figure 25.2ab Histological Structure of the Digestive Tract

Three-dimensional view of the histological organization of the general digestive tube

- Mesenteric artery and vein
- Mesentery
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- Mucosa
- Submucosa
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An enlarged section of the digestive tube showing the structure of a plica

- Mucosal epithelium
- Lamina propria
- Villi
- Mucosal glands
- Muscularis mucosae
- Lymphatic vessel
- Artery and vein
- Submucosal glands
- Muscularis mucosae
- Submucosal plexus
- Circular muscle layer
- Myenteric plexus
- Longitudinal muscle layer

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An Overview of the Digestive System

• The Muscularis Externa
  • Surrounds the submucosa
  • Dominated by smooth muscle fibers
  • Forms sphincters or valves
  • Innervated by myenteric plexus
    • This is a network of parasympathetic ganglia and sympathetic postganglionic fibers
Three-dimensional view of the histological organization of the general digestive tube

An enlarged section of the digestive tube showing the structure of a plica
An Overview of the Digestive System

• The Serosa
  • Covers the muscularis externa
  • Outermost layer of the digestive system
Figure 25.2ab Histological Structure of the Digestive Tract

Three-dimensional view of the histological organization of the general digestive tube

b An enlarged section of the digestive tube showing the structure of a plica
An Overview of the Digestive System

- Muscularis Layers and the Movement of Digestive Materials
  - The digestive tract consists of smooth muscle
  - Muscularis mucosa and muscularis externa have pacemaker cells
    - Produce two types of muscle contractions
      - Peristalsis
      - Segmentation
An Overview of the Digestive System

• Muscularis Layers and the Movement of Digestive Materials
  • Peristalsis
    • The muscularis externa propels material through the digestive tract
  • Segmentation
    • Material is churned and fragmented and at the same time is propelled through the digestive tract by peristaltic contractions
Peristalsis propels materials along the length of the digestive tract by coordinated contractions of the circular and longitudinal layers.
Segmentation movements primarily involve the circular muscle layers. These activities churn and mix the contents of the digestive tract, but do not produce net movement in a particular direction.
An Overview of the Digestive System

• The Peritoneum
  • The serosa (visceral peritoneum) is continuous with the parietal peritoneum
  • The abdominal organs lie within the peritoneal cavity or the abdominal cavity
    • Intraperitoneal organs
    • Retroperitoneal organs
    • Secondarily retroperitoneal organs
An Overview of the Digestive System

• **Intraperitoneal Organs**
  • Organs that lie within the peritoneal cavity
  • Organs are surrounded completely by the visceral peritoneum
  • Examples:
    • Stomach
    • Liver
    • Ileum
An Overview of the Digestive System

- **Retroperitoneal Organs**
  - Organs are covered by the visceral peritoneum on their anterior surface
  - These organs lie outside the visceral peritoneum
  - Examples:
    - Kidneys
    - Ureters
    - Abdominal aorta
An Overview of the Digestive System

• **Secondarily Retroperitoneal Organs**
  • These organs form as intraperitoneal but soon become retroperitoneal
    • The change occurs during embryonic development as the associated visceral peritoneum fuses with the opposing parietal peritoneum
  • Examples are:
    • Pancreas
    • Duodenum
An Overview of the Digestive System

• **Mesenteries**
  • These are fused double sheets of peritoneal membrane
  • Function:
    • Stabilize the position of organs
    • Stabilize the position of blood vessels
    • Provide the attachment of blood vessels going to and from the small intestine
An Overview of the Digestive System

• Mesenteries (continued)
  • All but the duodenum is suspended in a sheet of mesentery called the **mesentery proper**

• **Mesocolon**
  • Mesentery attached to the large intestine

• **Transverse mesocolon**
  • Mesentery attached to the transverse colon

• **Sigmoid mesocolon**
  • Mesentery attached to the sigmoid colon

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An Overview of the Digestive System

• Mesenteries (continued)
  • **Fusion Fascia**
    • The ascending colon, descending colon, and rectum are attached to the posterior abdominal wall via this fused mesentery
  • **Lesser Omentum**
    • This mesentery lies between the stomach and the liver
  • **Greater Omentum**
    • This mesentery extends from the stomach and covers the rest of the abdominal organs on the anterior surface

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The organization of mesenteries in the adult. This is a simplified view; the length of the small intestine has been greatly reduced.
Figure 25.4b Mesenteries

Mesenteries of the abdominopelvic cavity, as seen in a diagrammatic sagittal section.
The Oral Cavity

- Structures within the **Oral Cavity**
  - Tongue
  - Uvula
  - Palatoglossal arches
  - Salivary glands
  - Teeth
The Oral Cavity

• Anatomy of the Oral Cavity
  • Lined by oral mucosa
    • Consists of nonkeratinized stratified squamous cells
  • The oral mucosa is continuous with:
    • Lining of the cheeks
    • Lining of the lips
    • Lining of the gums
The Oral Cavity

• Anatomy of the Oral Cavity
  • The roof of the oral cavity consists of:
    • **Hard palate**
      • This is the palatine process of the maxilla and the palatine bone
      • Separates the oral cavity from the nasal cavity
    • **Soft palate**
      • Separates the oral cavity from the nasopharynx
      • The soft palate makes up the **palatoglossal arch** / **palatopharyngeal arch** / **uvula**
  • The floor of the oral cavity consists of:
    • The tongue
The Oral Cavity

- Anatomy of the Oral Cavity
  - The oral cavity also houses the palatine tonsils
    - These lie between the palatoglossal and palatopharyngeal arches
    - They are lateral to the uvula
An anterior view of the oral cavity as seen through the open mouth

- Frenulum of upper lip
- Frenulum of lower lip
- Hard palate
- Soft palate
- Fauces
- Pharyngeal Arches
  - Palatoglossal arch
  - Palatopharyngeal arch
- Palatine tonsil
- Lingual frenulum
- Tongue
- Openings of submandibular ducts
- Vestibule
- Gingiva
Figure 25.5a The Oral Cavity

The oral cavity as seen in sagittal section

- Hard palate
- Soft palate
- Nasal cavity
- Palatoglossal arch
- Opening of parotid duct
- Upper lip
- Cheek
- Dorsum of tongue
- Lower lip
- Gingiva
- Vestibule
- Body of tongue
- Root of tongue
- Pharyngeal tonsil
- Entrance to auditory tube
- Nasopharynx
- Uvula
- Palatine tonsil
- Fauces
- Palatopharyngeal arch
- Oropharynx
- Lingual tonsil
- Epiglottis
- Laryngopharynx
- Hyoid bone

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The Oral Cavity

• The **Tongue**
  • Has numerous functions
    • Manipulation of food
    • Sensory analysis
    • Secretion of enzymes to aid in fat digestion
    • Movement for the formulation of words
The Oral Cavity

• Tongue (continued)
  • Can be divided into different areas
    • **Body**
      • Anterior portion of the tongue
    • **Root**
      • Posterior portion of the tongue
    • **Dorsum**
      • Superior portion of the tongue
      • Contains the **papillae**
      • Papillae contain the **taste buds**
Figure 25.5a The Oral Cavity

The oral cavity as seen in sagittal section

- Hard palate
- Soft palate
- Nasal cavity
- Palatoglossal arch
- Opening of parotid duct
- Upper lip
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- Lingual tonsil
- Epiglottis
- Laryngopharynx
- Hyoid bone

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The Oral Cavity

• Tongue (continued)
  • Embedded glands
    • Release lingual lipase
      • Begins digestion of fat

• Lingual frenulum
  • Thin fold of mucous membrane that attaches the tongue to the floor of the mouth

• Ankyloglossia
  • Term referring to a short lingual frenulum
An anterior view of the oral cavity as seen through the open mouth.
The Oral Cavity

- Tongue (continued)
  - Consists of two muscle groups
    - **Intrinsic tongue muscles**
      - Alter the shape of the tongue
    - **Extrinsic tongue muscles**
      - Gross movements of the tongue
      - Examples:
        - Hyoglossus / Styloglossus / Genioglossus / Palatoglossus
  - Both sets of muscles are controlled by N XII
Figure 10.7 Muscles of the Tongue

Muscles of the Tongue:
- Palatoglossus (cut)
- Styloglossus
- Genioglossus
- Hyoglossus
- Styloid process
- Hyoid bone
- Mandible (cut)
The Oral Cavity

• Salivary Glands
  • There are three pairs of salivary glands
    • Parotid
    • Sublingual
    • Submandibular
  • All three glands produce salivary amylase
    • Partially digests carbohydrates
The Oral Cavity

• Salivary Glands
  • Parotid salivary glands
    • The largest of the three salivary glands
    • Located on the lateral side of the face in the area of the ramus of the mandible
    • Enzyme drains to the mouth cavity via the parotid duct
    • Parotid duct lies on the masseter muscle
Lateral view showing the relative positions of the salivary glands and ducts on the left side of the head. Much of the left half of the body and the left ramus of the mandible have been removed. For the positions of the ducts inside the oral cavity, see Figure 25.5.
The Oral Cavity

• Salivary Glands
  
  • **Sublingual salivary glands**
    
    • Covered by the mucous membrane of the floor of the mouth
    
    • Consists of numerous *sublingual ducts* that open along either side of the lingual frenulum
  
  • **Submandibular salivary glands**
    
    • Located on the floor of the mouth, deep into the mandible, inferior to the mylohyoid line
    
    • **Submandibular ducts** open posterior to the mandibular teeth
Lateral view showing the relative positions of the salivary glands and ducts on the left side of the head. Much of the left half of the body and the left ramus of the mandible have been removed. For the positions of the ducts inside the oral cavity, see Figure 25.5.
The Oral Cavity

• Regulation of the Salivary Glands
  • Secretions are controlled by the autonomic nervous system
    • **Parasympathetic**
      • Accelerates salivary secretions
    • **Sympathetic**
      • Reduces salivary secretions
The Oral Cavity

• The Teeth
  • Designed for **mastication**
  • Anatomy of teeth
    • Crown
    • Neck
    • Root
    • Dentine
    • Pulp cavity
    • Root canal
    • Apical foramen
    • Periodontal ligament
The Oral Cavity

- Teeth Anatomy
  - **Crown**
    - Covered by enamel
    - Consists of dentine
    - Consists of pulp (highly vascularized)
  - **Neck**
    - Area of gingiva
  - **Root**
    - Consists of root canal
    - Consists of artery, vein, and nerve

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The Oral Cavity

• Teeth Anatomy
  • Dentine
    • Mineralized matrix
    • Different than bone; it does not contain cells
  • Pulp cavity
    • Spongy area and highly vascularized
  • Root canal
    • Arteries and veins and nerves pass through the root canal to the pulp cavity area
The Oral Cavity

• Teeth Anatomy
  • **Apical foramen**
    • An opening at the distal end of the root canal
  • **Periodontal ligament**
    • Anchors the root of the tooth to the alveolar sockets
    • The articulation at this point is called **gomphosis**
Diagrammatic section through a typical adult tooth.
The Oral Cavity

• Types of Teeth
  • Designed for **mastication**
    • Four **incisors** per jaw
    • Two **cuspsids** per jaw
    • Four **bicuspids** per jaw
    • Four to six **molars** per jaw
The normal orientation of adult teeth. The normal range of ages at eruption for each tooth is shown in parentheses.
The adult teeth.

<table>
<thead>
<tr>
<th>Incisors</th>
<th>Cuspids (canines)</th>
<th>Bicuspids (premolars)</th>
<th>Molars</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Incisors" /></td>
<td><img src="image2" alt="Cuspids" /></td>
<td><img src="image3" alt="Bicuspids" /></td>
<td><img src="image4" alt="Molars" /></td>
</tr>
</tbody>
</table>

**Upper jaw**

**Lower jaw**
The Oral Cavity

• Dental Succession
  • During development, two sets of teeth form
    • Deciduous teeth
      • Usually 20 deciduous teeth
    • Permanent teeth
      • Usually 32 permanent teeth
The deciduous teeth with the age at eruption given in months.

Central incisors (7.5 mo)
Lateral incisor (9 mo)
Cuspid (18 mo)
Deciduous 1st molar (14 mo)
Deciduous 2nd molar (24 mo)
Deciduous 2nd molar (20 mo)
Deciduous 1st molar (12 mo)
Cuspid (16 mo)
Lateral incisor (7 mo)
Central incisors (6 mo)
The normal orientation of adult teeth. The normal range of ages at eruption for each tooth is shown in parentheses.
The Oral Cavity

• A Dental Frame of Reference
  • **Labial surface**
    • Outer surface of teeth nearest the lining of the cheeks or lips
  • **Palatal surface**
    • Inner surface of the teeth
  • **Mesial surface**
    • Opposing surface between the teeth
  • **Occlusal surface**
    • The surface of the teeth of the mandible that face the surface of the teeth of the maxilla (the “grinding” surface)
The Pharynx

• The Pharynx
  • Serves as a common passageway for food, liquid, and air
  • Pharyngeal muscles involved in swallowing:
    • Pharyngeal constrictors
    • Palatopharyngeus
    • Stylopharyngeus
    • Palatal
The Pharynx

• The Pharynx
  • Pharyngeal constrictors
    • Push the bolus toward the esophagus
  • Palatopharyngeus
    • Elevates the larynx
  • Stylopharyngeus
    • Elevates the larynx
  • Palatal muscles
    • Raise the soft palate
Figure 10.8a Muscles of the Pharynx

**Palatal Muscles**
- Tensor veli palatini
- Levator veli palatini

**Laryngeal Elevators**
- Stylopharyngeus
- Palatopharyngeus

**Pharyngeal Constrictors**
- Superior pharyngeal constrictor
- Middle pharyngeal constrictor
- Inferior pharyngeal constrictor

**Esophagus**

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The Pharynx

• The Swallowing Process
  • Process of swallowing is called **deglutition**
  • There are three phases
    • **Buccal phase**
      • The tongue pushes the food to the oropharynx area
    • **Pharyngeal phase**
      • The epiglottis closes over the glottis and swallowing begins
    • **Esophageal phase**
      • **Upper esophageal sphincter** opens and the bolus begins moving down the esophagus
Figure 25.8 The Swallowing Process

1 **Buccal Phase**

- Hard palate
- Tongue
- Epiglottis
- Larynx
- Bolus
- Esophagus

2 **Pharyngeal Phase**

- Esophagus
- Diaphragm
- Thoracic cavity

3 **Esophageal Phase**

- Peristalsis
- Stomach
- Thoracic cavity
The Esophagus

- This is a hollow muscular tube that extends from the pharynx region to the stomach
  - It is 25 cm long and 2 cm in diameter
  - Located posterior to the trachea
  - Enters the peritoneal cavity by passing through the esophageal hiatus of the diaphragm
  - Innervated by the vagus nerve from the esophageal plexus
  - Contains upper and lower esophageal sphincters
Major Subdivisions of the Digestive Tract

**Oral Cavity**
Mechanical processing, moistening, mixing with salivary secretions

**Pharynx**
Muscular propulsion of materials into the esophagus

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Transport of materials to the stomach

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Chemical breakdown of materials via acid and enzymes; mechanical processing through muscular contractions

**Small Intestine**
Enzymatic digestion and absorption of water, organic substrates, vitamins, and ions

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Accessory Organs of the Digestive System

**Salivary Glands**
Secretion of lubricating fluid containing enzymes that break down carbohydrates

**Liver**
Secretion of bile (important for lipid digestion), storage of nutrients, many other vital functions

**Gallbladder**
Storage and concentration of bile

**Pancreas**
Exocrine cells secrete buffers and digestive enzymes; endocrine cells secrete hormones
The Esophagus

• Histology of the Esophageal Wall
  • The esophageal wall is made of:
    • Mucosa lining
    • Submucosa
    • Smooth muscle layer (muscularis mucosae)
    • Muscularis externa
    • The esophagus does not have a serosa layer
Figure 25.9 Histology of the Esophagus

(a) Low-power view of a section through the esophagus

Muscularis mucosae
Mucosa
Submucosa
Muscularis externa
Adventitia

The esophagus

LM x 5

(b) The esophageal mucosa

Stratified squamous epithelium
Lamina propria
Muscularis mucosae

The esophageal mucosa

LM x 300
The Stomach

• The stomach performs three major functions:
  • Bulk storage of ingested food
  • Mechanical breakdown of ingested food
  • Chemical digestion of ingested food
    • The end result is the production of chyme
The Stomach

• Anatomy of the Stomach
  • The stomach is intraperitoneal and is located:
    • In the left hypochondriac, epigastric, and a portion of the umbilical and left lumbar regions
  • The stomach consists of:
    • Lesser curvature
    • Greater curvature
    • Cardia
    • Fundus
    • Body
    • Pylorus
Figure 25.1 Components of the Digestive System

**Major Subdivisions of the Digestive Tract**

**Oral Cavity**
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**Accessory Organs of the Digestive System**

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- Secretion of lubricating fluid containing enzymes that break down carbohydrates

**Liver**
- Secretion of bile (important for lipid digestion), storage of nutrients, many other vital functions

**Gallbladder**
- Storage and concentration of bile

**Pancreas**
- Exocrine cells secrete buffers and digestive enzymes; endocrine cells secrete hormones
Mesenteries of the Stomach

Lesser Omentum
The lesser omentum lies between the stomach and proximal duodenum and the liver.

- **Hepatogastric Ligament**
The hepatogastric ligament connects the liver to the lesser curvature of the stomach.

- **Hepatoduodenal Ligament**
The hepatoduodenal ligament connects the liver to the proximal segment of the duodenum.

Greater Omentum
The greater omentum forms a large pouch that hangs like an apron from the greater curvature of the stomach.
The Stomach

• Anatomy of the Stomach (continued)
  • **Gastric rugae**
    • Relaxed stomach: mucosa forms numerous muscular ridges
    • Rugae permits expansion of the stomach
    • A stretched stomach exhibits less prominent rugae
  • Smooth muscle layers
    • **Circular muscles**
    • **Longitudinal muscles**
    • **Oblique muscles**
<table>
<thead>
<tr>
<th>Mesenteries of the Stomach</th>
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The **fundus** is the region of the stomach superior to the junction between the stomach and the esophagus (the gastroesophageal junction).

The **cardia** is the superior, medial portion of the stomach within 3 cm of the gastroesophageal junction.

The **body**, the largest region of the stomach, is the area between the fundus and the pylorus.

The **pylorus** extends to the entrance to the duodenum. It is divided into the **pyloric antrum** and the **pyloric canal**. A muscular **pyloric sphincter** regulates the passage of materials into the duodenum.
The Stomach

• Mesenteries of the Stomach
  • The mesenteries associated with the stomach are called the greater and lesser omentum

• Greater omentum
  • Extends from the greater curvature of the stomach and drapes across the surface of the small intestine

• Lesser omentum
  • Extending from the lesser curvature of the stomach to the liver is the hepatogastric ligament
  • Extending from the pylorus/duodenum region to the liver is the hepatoduodenal ligament
Mesenteries of the Stomach

**Lesser Omentum**
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**Hepatogastric Ligament**
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The hepatoduodenal ligament connects the liver to the proximal segment of the duodenum.

**Greater Omentum**
The greater omentum forms a large pouch that hangs like an apron from the greater curvature of the stomach.

Blood Supply to the Stomach

- Left gastric artery
- Left gastroepiploic artery
- Right gastric artery
- Right gastroepiploic artery
- Greater curvature (lateral surface)
- Duodenum
The Stomach

• Blood Supply to the Stomach
  • There are three branches from the celiac trunk that supply the stomach
    • Left gastric artery
      • Supplies blood to the lesser curvature and cardia
    • Splenic artery
      • Supplies blood to the fundus
      • Branches to form the left gastroepiploic artery, which supplies the greater curvature
    • Common hepatic artery
      • Branches to form the right gastric, right gastroepiploic, and gastroduodenal artery to supply the greater and lesser curvatures
Figure 22.15a Arteries of the Abdomen

Major arteries supplying the abdominal viscera
The Stomach

• Histology of the Stomach
  • Lined with simple columnar epithelium
  • Structures within the lining of the stomach
    • Gastric pits
    • Gastric secretory cells
      • Mucous neck cells
      • Parietal cells
      • Chief cells
      • Enteroendocrine cells
The Stomach

• Histology of the Stomach
  • **Gastric pits**
    • Produce cells to continuously replace lost stomach cells
  • **Mucous surface cells**
    • Produce copious amounts of mucus to protect the lining of the stomach
  • **Mucous neck cells**
    • Produce mucus to lubricate the food entering the stomach
The Stomach

- **Histology of the Stomach**
  - **Parietal cells**
    - Secrete intrinsic factor and hydrochloric acid
  - **Intrinsic factor**
    - Facilitates the absorption of vitamin $B_{12}$ from the small intestine into the bloodstream, which is used during erythropoiesis
  - **Hydrochloric acid**
    - Kills microorganisms and activates pepsinogen
The Stomach

• Histology of the Stomach
  • Chief cells
    • Secrete pepsinogen, which is converted to pepsin via the action of hydrochloric acid
  • Enteroendocrine cells
    • These are cells of the stomach that produce hormones. The G cells produce the hormone gastrin. Gastrin causes the parietal and chief cells to release their products
Figure 25.12ab Histology of the Stomach Wall

Diagrammatic view of the stomach and mucosa.

- Esophagus
- Diaphragm
- Fundus
- Cardia
- Greater curvature
- Greater omentum
- Pylorus
- Rugae
- Body
- Lesser curvature
- Lesser omentum

SEM x 35

Colorized SEM of the gastric mucosa.

- Mucous epithelial cells
- Entrances to gastric pits

Gastric mucosa
Figure 25.12cd Histology of the Stomach Wall

C Diagrammatic view of the organization of the stomach wall. This corresponds to a sectional view through the area indicated by the box in part (b).

D Diagrammatic view of a gastric gland and micrograph of the gastric mucosa.
The Stomach

• Regulation of the Stomach
  • The production of stomach acid and enzymes is controlled by the CNS
  • CNS regulation involves:
    • Vagus nerve (parasympathetic innervation)
      • Triggered by the sight and thought of food
    • Celiac plexus (sympathetic innervation)
The Stomach

• Regulation of the Stomach
  • Food enters the stomach and the stomach stretches
  • Stretching causes the G cells to release gastrin
  • Gastrin causes the parietal and chief cells to release their products
The Small Intestine

• Features of the Small Intestine
  • Approximately 20 feet in length / 1.5–2.5 inches in diameter
  • Consists of:
    • **Duodenum**
      • 10 inches long; receives digestive enzymes from the pancreas, bile from the liver and gallbladder
    • **Jejunum**
      • 8 feet long; most of the digestion and absorption occurs in the jejunum
    • **Ileum**
      • 12 feet long
### Major Subdivisions of the Digestive Tract

<table>
<thead>
<tr>
<th>Major Subdivision</th>
<th>Function</th>
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</thead>
<tbody>
<tr>
<td><strong>Oral Cavity</strong></td>
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### Accessory Organs of the Digestive System

<table>
<thead>
<tr>
<th>Accessory Organ</th>
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<tr>
<td><strong>Salivary Glands</strong></td>
<td>Secretion of lubricating fluid containing enzymes that break down carbohydrates</td>
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<tr>
<td><strong>Pancreas</strong></td>
<td>Exocrine cells secrete buffers and digestive enzymes; endocrine cells secrete hormones</td>
</tr>
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</table>
Figure 25.13 Regions of the Small Intestine

- Transverse colon
- Duodenum
- Jejunum
- Ileum
- Ascending colon
- Cecum
- Descending colon
- Sigmoid colon
- Rectum
The Small Intestine

• Support of the Small Intestine
  • Jejunum and ileum are supported by the mesentery proper
    • Duodenum is not associated with any mesentery
  • Blood supply
    • Branches of the superior mesenteric artery and intestinal arteries
  • Nerve supply
    • Parasympathetic innervation via the vagus nerve
    • Sympathetic innervation via the superior mesenteric ganglion
Figure 22.15a Arteries of the Abdomen

Major arteries supplying the abdominal viscera
The Small Intestine

• Histology of the Small Intestine
  • The lining contains:
    • Plicae
      • Each plica consists of numerous microvilli (villi)
      • Within each villus are capillaries
      • Villi will absorb the digested nutrients from the lumen of the small intestine into the capillaries
Characteristic features of the intestinal lining

- The organization of villi and the intestinal crypts

Layers of the Small Intestine:
- Mucosa
  - Muscularis mucosae
- Submucosa
- Muscularis externa
- Serosa

Diagrammatic view of a single villus showing the capillary and lymphatic supply

- Plica circularis
- Villi
- Intestinal crypt
- Lymphoid nodule
- Lacteal
- Goblet cell
- Columnar epithelial cell
- Lacteal
- Nerve
- Capillary network
- Lamina propria
- Arteriole
- Venule
- Lymphatic vessel
- Submucosal artery and vein
- Lymphatic vessel
- Submucosal plexus
- Circular layer of smooth muscle
- Myenteric plexus
- Longitudinal layer of smooth muscle
The Small Intestine

• Histology of the Small Intestine
  • **Intestinal crypts**
    • Appear at the base of the villi
    • New epithelial cells are formed in this area
    • Contain enteroendocrine cells
      • These cells produce intestinal hormones, including cholecystokinin and secretin
      • These cells produce enzymes with antibacterial activity
Figure 25.14b Histology of the Intestinal Wall

The organization of villi and the intestinal crypts

Layers of the Small Intestine

Mucosa

Muscularis mucosae

Submucosa

Muscularis externa

Serosa

Villi

Intestinal crypt

Lymphoid nodule

Lacteal

Submucosal artery and vein

Lymphatic vessel

Submucosal plexus

Circular layer of smooth muscle

Myenteric plexus

Longitudinal layer of smooth muscle

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The Small Intestine

• Histology of the Small Intestine
  • Each villus also contains a lacteal
    • Lacteals absorb material that cannot be absorbed by the capillaries
    • Examples would be large lipid-protein complexes
Diagrammatic view of a single villus showing the capillary and lymphatic supply.
The Small Intestine

• Regional Specialization
  • The Duodenum
    • Contains *duodenal submucosal glands*
      • Produces large amounts of mucus
      • This mucus consists of buffers to provide some protection against the acidic chyme

  • Entering into the small intestine at the hepatopancreatic sphincter region
    • Bile from the liver and gallbladder
    • Buffers from the pancreas
    • Digestive enzymes from the pancreas
A view of the inferior surface of the liver showing the position of the gallbladder and ducts that support bile from the liver to the gallbladder and duodenum.

A portion of the lesser omentum has been cut away to make it easier to see the relationships among the common bile duct, the hepatic duct, and the cystic duct.
The Small Intestine

• Regional Specialization
  • The Jejunum and Ileum
    • Jejunum
      • Has prominent plicae and villi
      • Most nutrient absorption occurs here
    • Ileum
      • Contains prominent lymphoid centers called **aggregated lymphoid nodules** (Peyer’s patches)
The Small Intestine

- Regulation of the Small Intestine
  - Upon vagal stimulation, the enteroendocrine cells of the small intestine release:
    - **Secretin**
      - Causes the liver to begin making bile
      - Causes the pancreas to release buffers into the duodenum
    - **Cholecystokinin**
      - Causes the pancreas to release digestive enzymes into the duodenum
      - Causes the gallbladder to contract thus releasing stored bile into the duodenum
      - Causes the hepatopancreatic sphincter to open
The Large Intestine

- Features of the Large Intestine
  - Approximately 5 feet in length
  - Approximately 3 inches in diameter
  - Consists of the following regions
    - Cecum
    - Ascending colon
    - Transverse colon
    - Descending colon
    - Sigmoid colon
    - Rectum
Figure 25.1 Components of the Digestive System

**Major Subdivisions of the Digestive Tract**

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The Large Intestine

• Functions of the Large Intestine
  • Reabsorption of water
    • Results in compaction of waste (forms feces)
  • Absorption of vitamins produced by the housed bacteria
  • Storage of fecal material prior to defecation
The Large Intestine

- Blood Supply to the Large Intestine
  - Receives blood from branches of the superior mesenteric artery
  - Receives blood from branches of the inferior mesenteric artery
Figure 22.15a Arteries of the Abdomen

Major arteries supplying the abdominal viscera
The Large Intestine

• The Cecum
  • The cecum is intraperitoneal
  • The ileum connects to the medial surface of the cecum
  • An **ileocecal valve** regulates the movement of material from the ileum to the cecum
  • The **vermiform appendix** attaches to the cecum
    • Appendix is about 9 cm in length
  • The **mesoappendix** (mesentery) helps anchor the appendix to the ileum and the cecum
Figure 25.16a The Large Intestine

Gross anatomy and regions of the large intestine
The Large Intestine

• The Colon
  • The regions of the colon are:
    • Ascending colon
    • Transverse colon
    • Descending colon
    • Sigmoid colon
The Large Intestine

• The Colon
  • Waste material leaves the ileum and enters the cecum
    • Waste material goes “up” the ascending colon
    • Around the hepatic flexure
    • “Across” the transverse colon
    • Around the splenic flexure
    • “Down” the descending colon
    • Around the sigmoid flexure
    • To the sigmoid colon
    • Into the rectum
Gross anatomy and regions of the large intestine

- Rectum
- Ileum
- Rectal artery
- Intestinal arteries and veins
- Sigmoid flexure
- Taenia coli
- Sigmoid arteries and veins
- Left colic (splenic) flexure
- Greater omentum (cut)
- DESCENDING COLON
  - Left colic vein
  - Inferior mesenteric artery
  - Left colic artery
  - Haustra
  - Sigmoid arteries and veins
  - Taenia coli
  - Sigmoid flexure
  - SIGMOID COLON
- ASCENDING COLON
  - Omental appendices
  - Ileocecal valve
  - Cecum
  - Appendix
- Aorta
- Hepatic portal vein
- Superior mesenteric vein
- Inferior mesenteric vein
- Inferior vena cava
- Superior mesenteric artery
- Inferior mesenteric artery
- Left colic artery
- Left colic vein
- Hepatic portal vein
- Superior mesenteric vein
- Inferior vena cava
- Superior mesenteric artery
The Large Intestine

• The Colon
  • The wall of the colon has pouches that allow for expansion called haustra
  • Longitudinal muscles called taeniae coli aid in the process of peristalsis
  • The serosa of the large intestine has numerous “flaps” of sacs of fat attached to but yet extending from the intestine called omental appendices
Figure 25.16a The Large Intestine

Gross anatomy and regions of the large intestine

- Rectum
- Ileum
- Rectal artery
- Intestinal arteries and veins
- Sigmoid flexure
- Taenia coli
- Sigmoid arteries and veins
- Left colic (splenic) flexure
- Greater omentum (cut)
- Descending colon
- Left colic vein
- Inferior mesenteric artery
- Left colic artery
- Haustra
- Sigmoid arteries and veins
- Taenia coli
- Sigmoid flexure
- Ascending colon
- Omental appendices
- Ileocecal valve
- Cecum
- Appendix
- Ileum
- Rectum

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The Large Intestine

• The Rectum
  • Temporarily stores waste matter
  • The last portion of the rectum is the anal canal
    • The anal canal consists of anal columns
    • The anal canal ends at the anus
Figure 25.16a The Large Intestine

- Gross anatomy and regions of the large intestine

- Rectum
- Ileum
- Rectal artery
- Intestinal arteries and veins
- Sigmoid flexure
- Taenia coli
- Sigmoid arteries and veins
- Left colic (splenic) flexure
- Greater omentum (cut)
- Descending colon
- Left colic vein
- Inferior mesenteric artery
- Left colic artery
- Haustra
- Sigmoid flexure
- SIGMOID COLON
- Rectum

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Figure 25.16c The Large Intestine

- Rectum
- Anal canal
- Anal columns
- Internal anal sphincter
- External anal sphincter
- Anus

Detailed anatomy of the rectum and anus

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The Large Intestine

- Histology of the Large Intestine
  - Walls are thinner than the walls of the small intestine
  - The walls lack villi
  - Has numerous goblet cells
  - Has very distinctive intestinal crypts
    - Produces lots of mucus to lubricate undigested material
  - Contains large lymphoid nodules
Figure 25.18a The Wall of the Large Intestine

- Taenia coli
- Omental appendices
- Hastrum

Layers of the Large Intestine:
- **Mucosa**
  - Muscularis mucosae
- **Submucosa**
- **Muscularis externa**
  - Circular layer
  - Longitudinal layer (taenia coli)
- **Serosa**

Diagrammatic view of the colon wall:
- Simple columnar epithelium
- Goblet cells
- Intestinal crypt
- Lymphoid nodule

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The Large Intestine

• Regulation of the Large Intestine
  • Movement of waste material to the transverse colon is slow
    • This allows for appropriate reabsorption of water
  • Movement through the rest of the large intestine is rapid (mass movement)
    • This forces material into the rectum for later defecation
      • Distension of the rectal wall stimulates the urge to defecate / internal sphincter opens
      • Fecal material moves into the anal canal / external sphincter opens
Figure 25.17 Anterior/Posterior Radiograph of the Colon

- Left colic (splenic) flexure
- Right colic (hepatic) flexure
- Transverse colon
- Haustra
- Ascending colon
- Descending colon
- Cecum
- Sigmoid colon
- Rectum
Accessory Glandular Digestive Organs

- The accessory organs of digestion are:
  - Salivary glands
  - Liver
  - Gallbladder
  - Pancreas
Major Subdivisions of the Digestive Tract

**Oral Cavity**
Mechanical processing, moistening, mixing with salivary secretions

**Pharynx**
Muscular propulsion of materials into the esophagus

**Esophagus**
Transport of materials to the stomach

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Accessory Organs of the Digestive System

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**Liver**
Secretion of bile (important for lipid digestion), storage of nutrients, many other vital functions

**Gallbladder**
Storage and concentration of bile

**Pancreas**
Exocrine cells secrete buffers and digestive enzymes; endocrine cells secrete hormones
Accessory Glandular Digestive Organs

• The Liver
  • The largest visceral organ of the body
  • The liver is involved in:
    • Metabolic regulation
    • Hematological regulation
    • Bile production
• Metabolic Regulation
  • All blood leaving the digestive tract enters the liver through the hepatic portal system
  • Hepatocytes adjust the circulating metabolites before the blood enters into systemic circulation
Accessory Glandular Digestive Organs

- Hematological Regulation
  - The liver is the largest blood reservoir of the body
  - As blood passes through the liver:
    - Phagocytic cells remove old or damaged erythrocytes
    - Liver cells synthesize plasma proteins for blood clotting (for example)
Accessory Glandular Digestive Organs

• Bile Production
  • Bile is made by liver cells (hepatocytes)
  • Bile is stored in the gallbladder
  • Bile is secreted into the duodenum when it is needed
  • Bile *emulsifies* fat (from the diet) in the small intestine
    • This emulsification process makes it easier for lipase to do the actual digestion of fat
<table>
<thead>
<tr>
<th>Table 25.1</th>
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<tr>
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<tr>
<td>Synthesis and secretion of bile</td>
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<tr>
<td>Storage of glycogen and lipid reserves</td>
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</tr>
<tr>
<td>Maintenance of normal blood glucose, amino acid, and fatty acid concentrations</td>
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</tr>
<tr>
<td>Synthesis and interconversion of nutrient types (e.g., transamination of amino acids, or conversion of carbohydrates to lipids)</td>
<td></td>
</tr>
<tr>
<td>Synthesis and release of cholesterol bound to transport proteins</td>
<td></td>
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<tr>
<td>Inactivation of toxins</td>
<td></td>
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<tr>
<td>Storage of iron reserves</td>
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<tr>
<td>Storage of fat-soluble vitamins</td>
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<tr>
<td><strong>OTHER MAJOR FUNCTIONS</strong></td>
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<tr>
<td>Synthesis of plasma proteins</td>
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<tr>
<td>Synthesis of clotting factors</td>
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<tr>
<td>Synthesis of the inactive hormone angiotensinogen</td>
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<tr>
<td>Phagocytosis of damaged red blood cells (by Kupffer cells)</td>
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<tr>
<td>Blood storage (major contributor to venous reserve)</td>
<td></td>
</tr>
<tr>
<td>Absorption and breakdown of circulating hormones (including insulin and epinephrine) and immunoglobulins</td>
<td></td>
</tr>
<tr>
<td>Absorption and inactivation of lipid-soluble drugs</td>
<td></td>
</tr>
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</table>
Accessory Glandular Digestive Organs

• Anatomy of the Liver
  • Falciform ligament
    • Marks the boundary between the left and right lobes
    • The inferior portion of the falciform ligament becomes thick and round and is called the round ligament
      • The round ligament used to be the fetal umbilical vein
    • The falciform ligament spreads on the surface of the liver attaching to the inferior side of the diaphragm
      • This spreading ligament is called the coronary ligament
Anatomical landmarks on the anterior surface of the liver

- Right lobe
- Left lobe
- Coronary ligament
- Falciform ligament
- Round ligament
- Gallbladder
Accessory Glandular Digestive Organs

• Blood Supply to the Liver
  • Two blood vessels supply the liver
    • Hepatic artery proper
    • Hepatic portal vein
Figure 22.15a Arteries of the Abdomen

- Celiac trunk
- Right gastric
- Ileocolic
- Left common iliac
- Rectal
- Sigmoid colon
- Right external iliac
- Inferior pancreaticoduodenal
- Pancreatic
- Right gastroepiploic
- Superior mesenteric
- Superior pancreaticoduodenal
- Duodenal
- Inferior pancreaticoduodenal
- Middle colic (cut)
- Ascending colon
- Right colic
- Ileocolic
- Intestinal
- Right external iliac
- Right internal iliac
- Major arteries supplying the abdominal viscera

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• Histological Organization of the Liver
  • The liver is divided into approximately 100,000 liver lobules
    • Each lobule is separated by the interlobular septum
    • The center of each lobule consists of a vein from the hepatic portal system
    • The hepatocytes are arranged in such a manner forming cellular lines extending from the central vein outward
Figure 25.20a Liver Histology

Diagrammatic view of lobular organization.

- Interlobular septum
- Bile duct
- Branch of hepatic portal vein
- Portal area
- Bile ductules

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Accessory Glandular Digestive Organs

• Histological Organization of the Liver
  • Spaces are created between the lines of *hepatocytes*; these spaces are called sinusoids
  • Sinusoids consist of:
    • Capillaries: leading to the central vein
    • *Kupffer cells*: phagocytic cells of the liver
Accessory Glandular Digestive Organs

- Histological Organization of the Liver
  - Each lobule of the liver has a hexagonal shape
  - At each of the six corners is:
    - Branch of the **hepatic portal vein**
    - Branch of the **bile duct**
    - Branch of the **hepatic artery proper**
  - The above three branches form the hepatic triad
Magnified view showing the portal area and central vein.
Accessory Glandular Digestive Organs

• Bile Secretion and Transport
  • **Hepatocytes** produce bile
  • Bile enters:
    • Bile canaliculi
    • Bile travels to the **bile ducts**
    • Bile then collects in the **left** and **right hepatic ducts**
    • Bile travels through the **common hepatic duct**
    • Bile can travel through the **common bile duct** to the duodenum (through the **hepatopancreatic sphincter**) or travel through the **cystic duct** into the gallbladder for storage
A view of the inferior surface of the liver showing the position of the gallbladder and ducts that support bile from the liver to the gallbladder and duodenum.
Accessory Glandular Digestive Organs

• The Gallbladder
  • The gallbladder is divided into three regions
    • Fundus
    • Body
    • Neck
  • The cystic duct leads from the neck of the gallbladder to the common bile duct
**Major Subdivisions of the Digestive Tract**

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Accessory Glandular Digestive Organs

- Gallbladder Function
  - Storage of bile
  - Bile modification
Accessory Glandular Digestive Organs

• Bile Storage and Modification
  • When the hepatopancreatic sphincter is closed:
    • Bile enters the cystic duct and into the gallbladder
      • The gallbladder can store 40–70 ml of bile
      • Water is continuously removed from the stored bile thereby concentrating the bile more and more
    • If food entering the small intestine is high in fat content, the small intestine cells will release **cholecystokinin**
      • Cholecystokinin will cause the gallbladder to release bile
Accessory Glandular Digestive Organs

- Gallbladder (bile release)
  - CCK will cause the gallbladder to contract to release bile
  - CCK also causes the hepatopancreatic sphincter to open
    - Bile enters the cystic duct
    - Bile enters the common bile duct
    - The hepatopancreatic sphincter opens
    - Bile enters the duodenum of the small intestine
    - Bile will then emulsify fat
Figure 25.21a The Gallbladder and Associated Bile Ducts

A view of the inferior surface of the liver showing the position of the gallbladder and ducts that support bile from the liver to the gallbladder and duodenum.
Accessory Glandular Digestive Organs

• The Pancreas
  • The pancreas is posterior to the stomach
  • The pancreas consists of:
    • **Head**: nearest the curvature of the duodenum
    • **Body**: extends toward the spleen
    • **Tail**: rounded end of the pancreas nearest the spleen
    • **Pancreatic duct**: delivers secretions from the pancreas to the duodenum (through the hepatopancreatic sphincter)
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Accessory Glandular Digestive Organs

- Histological Organization of the Pancreas
  - Consists of lobules
    - Within each lobule are:
      - **Acinar cells**
        - Produce digestive enzymes
        - Enzymes travel through the pancreatic duct to the small intestine
      - **Pancreatic islets**
        - Produce hormones
        - Hormones enter into the bloodstream to travel to target organs
Gross anatomy of the pancreas. The head of the pancreas is tucked into a curve of the duodenum that begins at the pylorus of the stomach.
Diagrammatic view of the histological organization of the pancreas showing exocrine and endocrine regions.
Figure 25.22c The Pancreas

Histology of the pancreas showing exocrine and endocrine cells.

Pancreatic acini (exocrine)

Pancreatic islet (endocrine)

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Accessory Glandular Digestive Organs

- Pancreatic Enzymes (from Acinar Cells)
  - Lipases
    - Digest lipids
  - Carbohydrases
    - Digest carbohydrates
  - Nucleases
    - Digest nucleic acids
  - Proteininases
    - Digest protein
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- Pancreatic Hormones (from Pancreatic Islets)
  - Insulin
  - Glucagon
  - Somatostatin
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• The Regulation of Pancreatic Secretion
  • **Cholecystokinin**
    • From the small intestine will cause the pancreas to release its digestive enzymes
  • **Secretin**
    • From the small intestine will cause the pancreas to release **buffers**
      • When food leaves the stomach and enters the duodenum, the chyme is mixed with acid in the stomach. Therefore, **acidic chyme** is entering the duodenum. Buffers are used to maintain a normal small intestine pH of about 7 or 8
Aging and the Digestive System

• Stem cell reproduction declines
  • Tissue repair decreases – the tissues become more fragile
• Smooth muscle tone decreases
  • Motility decreases – constipation increases
• Cumulative damage becomes apparent
  • Gradual loss of teeth
  • Accumulation of toxins over time
• Cancer rate increases
  • Colon cancer
  • Pharyngeal cancer