

**Principles of Anatomy and Physiology**  
14<sup>th</sup> Edition  
Gerard J. Tortora / Bryan Derrickson  
WILEY

**CHAPTER 24**  
**The Digestive System**

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**Introduction**

The purpose of this chapter is to

- Identify the anatomical components of the digestive system as well as their functions
- Discuss neural control of the digestive system
- Compare and contrast mechanical and chemical digestion
- Discuss the effects of aging and disease on the digestive system

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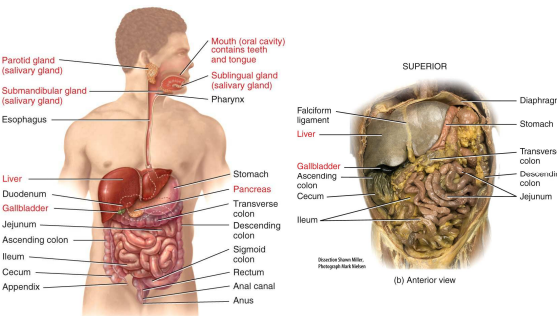
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**Organs of the Digestive System**



(a) Right lateral view of head and neck and anterior view of trunk

(b) Anterior view

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## Digestive System Overview

### Anatomy Overview:

- [Digestive System: Overview](#)

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## Digestive System Histology

### Anatomy Overview:

- [Digestive System Histology](#)

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## Gastrointestinal (GI) Tract

The GI tract is long tube that is open at both ends for the transit of food during processing

- Named portions of the tube include the esophagus, stomach, small intestine, large intestine, and rectum

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### Accessory Structures

Accessory structures are not part of the GI tract, but they do contribute to food processing

- Accessory structures include the teeth, tongue, salivary glands, liver, gall bladder, and pancreas

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### Digestive Processes

There are 6 basic processes involved in digestion

#### FUNCTIONS OF THE DIGESTIVE SYSTEM

- Ingestion:** taking food into mouth.
- Secretion:** release of water, acid, buffers, and enzymes into lumen of GI tract.
- Mixing and propulsion:** churning and movement of food through GI tract.
- Digestion:** mechanical and chemical breakdown of food.
- Absorption:** passage of digested products from GI tract into blood and lymph.
- Defecation:** elimination of feces from GI tract.

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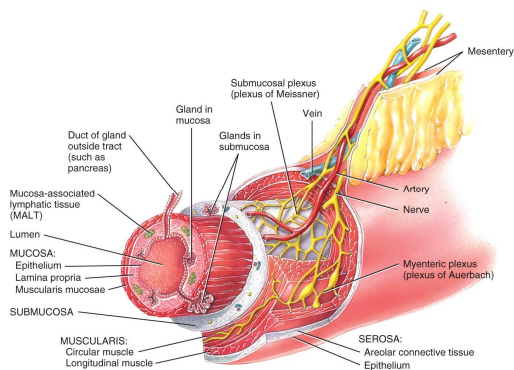
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### Layers of the GI Tract



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## Neural Innervation of the Gut

### Enteric Nervous System

- Submucosal plexus
- Myenteric plexus

### Autonomic Nervous System

- Parasympathetic
- Sympathetic

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## Neural Regulation of Digestion

### Interactions Animation:

- [Mechanical Digestion in the Gastrointestinal Tract](#)  
Neural Regulation: Animation sections 1.1-2.4

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## GI Reflex Pathways

GI reflex pathways regulate GI secretion and motility in response to stimuli within the GI tract

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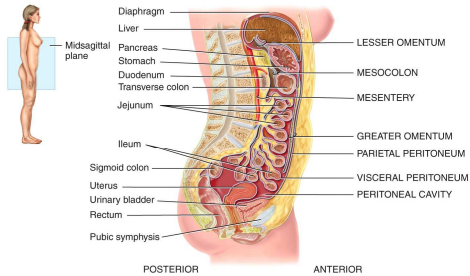
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## Peritoneum

The peritoneum is the largest serous membrane in the body



(a) Midsagittal section showing the peritoneal folds  
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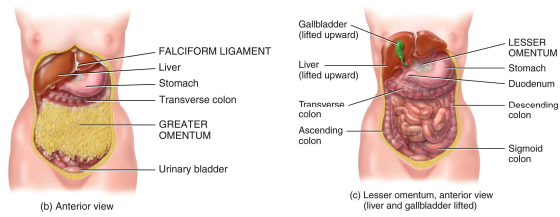
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## Peritoneum



(b) Anterior view (c) Lesser omentum, anterior view (liver and gallbladder lifted)  
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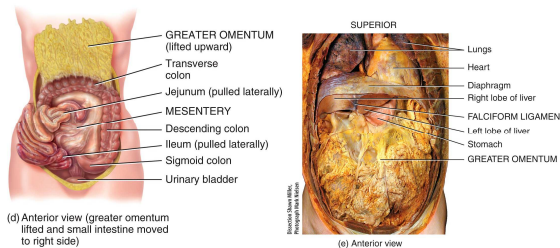
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## Peritoneum



(d) Anterior view (greater omentum lifted and small intestine moved to right side) (e) Anterior view  
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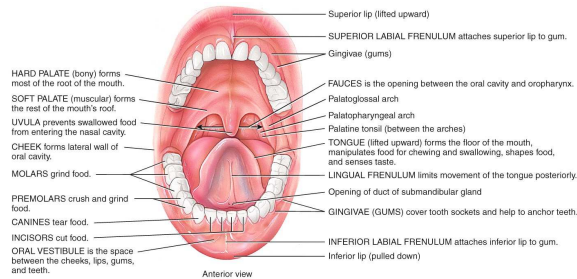
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## Mouth

The mouth is formed by the cheeks, hard and soft palates, and tongue



Anterior view  
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## Salivary Glands

Salivary glands lie outside the mouth and empty their contents into ducts which deliver saliva into the oral cavity

3 pairs:

1. Parotid
2. Submandibular
3. Sublingual

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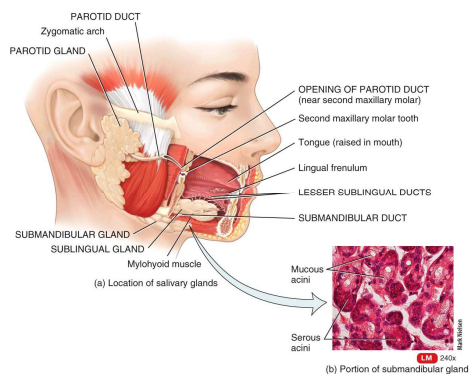
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## Salivary Glands



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## Tongue

- The tongue, together with associated muscle, forms the floor of the oral cavity
- Composed of skeletal muscle covered with mucous membrane
- Participates in chewing, swallowing, and speech
- The upper and lateral surfaces of the tongue are covered with papillae, some of which contain taste buds

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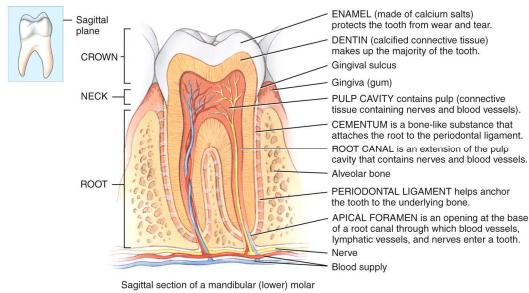
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## Teeth

The teeth project into the mouth and are adapted for mechanical digestion



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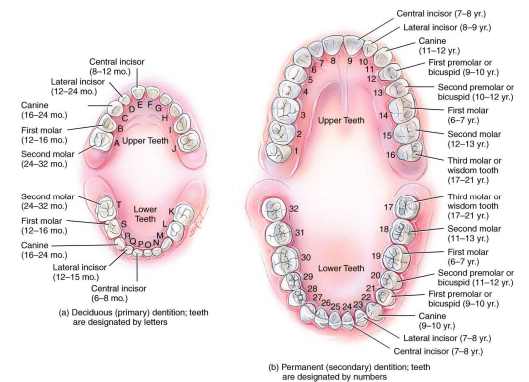
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## Teeth



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## Mechanical and Chemical Digestion in the Mouth

### Mechanical digestion

- Chewing mixes food with saliva and forms a bolus which can be easily swallowed

### Chemical digestion

- Salivary amylase converts polysaccharides to disaccharides

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## Mechanical Digestion: Mastication (chewing)

### Interactions Animation:

- [Mechanical Digestion in the Gastrointestinal Tract](#)  
Mastication: Animation section 3.1

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TABLE 24.1

Summary of Digestive Activities in the Mouth

STRUCTURE	ACTIVITY	RESULT
<b>Checks and lips</b>	Keep food between teeth.	Food is uniformly chewed during mastication.
<b>Salivary glands</b>	Secrete saliva.	Lining of mouth and pharynx moistened and lubricated. Saliva softens, moistens, and dissolves food and cleanses mouth and teeth. Salivary amylase splits starch into smaller fragments (maltose, maltotriose, and $\alpha$ -dextrins).
<b>Tongue</b>		
<b>Extrinsic tongue muscles</b>	Move tongue from side to side and in and out.	Food maneuvered for mastication, shaped into bolus, and maneuvered for swallowing.
<b>Intrinsic tongue muscles</b>	Alter shape of tongue.	Swallowing and speech.
<b>Taste buds</b>	Serve as receptors for gustation (taste) and presence of food in mouth.	Secretion of saliva stimulated by nerve impulses from taste buds to salivatory nuclei in brain stem to salivary glands.
<b>Lingual glands</b>	Secrete lingual lipase.	Triglycerides broken down into fatty acids and diglycerides.
<b>Teeth</b>	Cut, tear, and pulverize food.	Solid foods reduced to smaller particles for swallowing.

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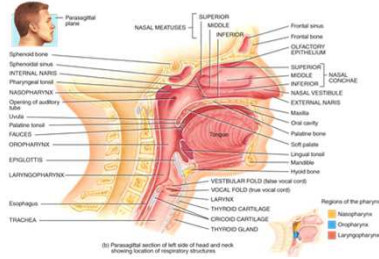
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## Pharynx

The pharynx is a funnel shaped tube that extends from the internal nares to the esophagus posteriorly and the larynx anteriorly



(B) Parasagittal section of left side of head and neck showing location of respiratory structures.  
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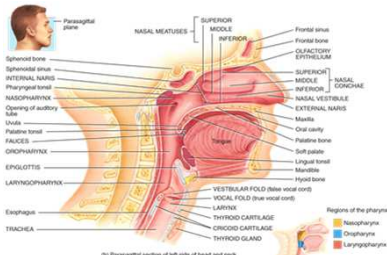
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## Pharynx

The pharynx is a funnel shaped tube that is composed of skeletal muscle and lined with mucous membrane



(B) Parasagittal section of left side of head and neck showing location of respiratory structures.  
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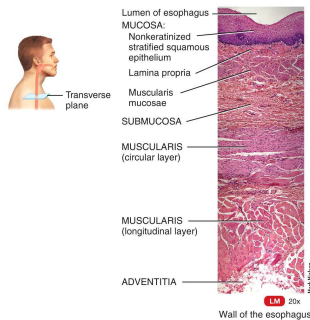
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## Esophagus

The esophagus is a collapsible, muscular tube that lies posterior to the trachea and connects the pharynx to the stomach



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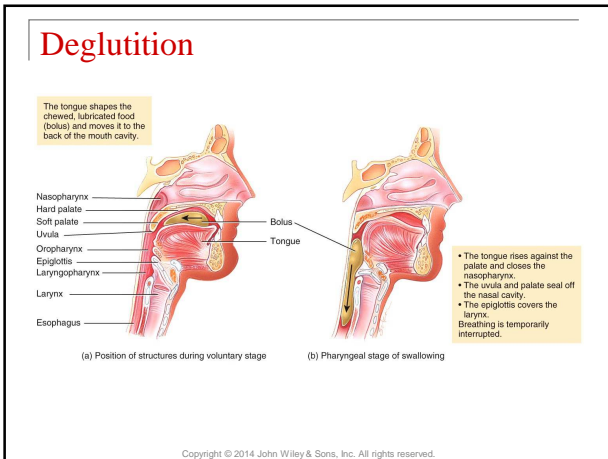
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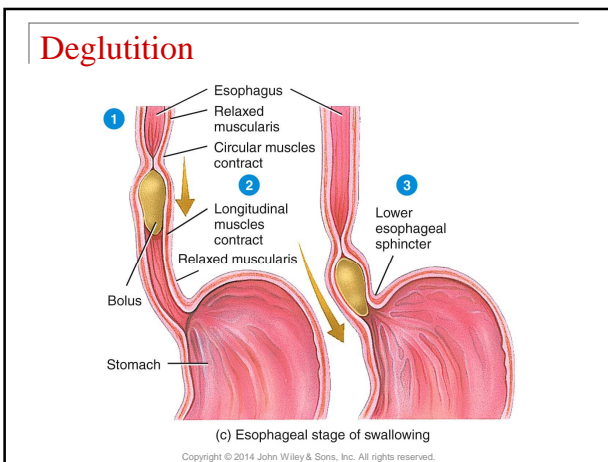
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## Mechanical Digestion: Deglutition (swallowing)

Interactions Animation:

- [Mechanical Digestion in the Gastrointestinal Tract](#)  
Deglutition: Animation section 4.1

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**TABLE 24.2**  
**Summary of Digestive Activities in the Pharynx and Esophagus**

STRUCTURE	ACTIVITY	RESULT
<b>Pharynx</b>	Pharyngeal stage of deglutition.	Moves bolus from oropharynx to laryngopharynx and into esophagus; closes air passageways.
<b>Esophagus</b>	Relaxation of upper esophageal sphincter.	Permits entry of bolus from laryngopharynx into esophagus.
	Esophageal stage of deglutition (peristalsis).	Pushes bolus down esophagus.
	Relaxation of lower esophageal sphincter.	Permits entry of bolus into stomach.
	Secretion of mucus.	Lubricates esophagus for smooth passage of bolus.

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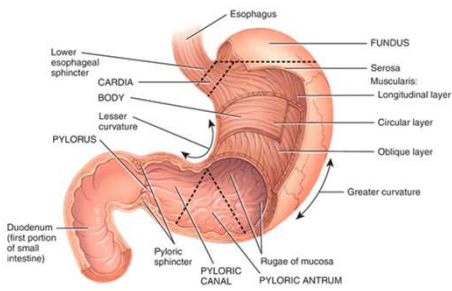
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## Stomach

The stomach is a J-shaped enlargement of the GI tract



(a) Anterior view of regions of stomach

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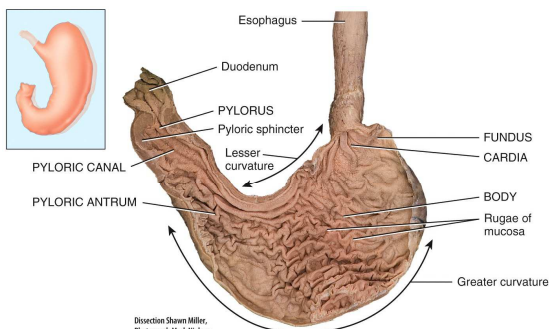
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## Internal Anatomy of the Stomach



(b) Anterior view of internal anatomy

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## Functions of the Stomach

### FUNCTIONS OF THE STOMACH

1. Mixes saliva, food, and gastric juice to form chyme.
2. Serves as reservoir for food before release into small intestine.
3. Secretes gastric juice, which contains HCl (kills bacteria and denatures proteins), pepsin (begins the digestion of proteins), intrinsic factor (aids absorption of vitamin B<sub>12</sub>), and gastric lipase (aids digestion of triglycerides).
4. Secretes gastrin into blood.

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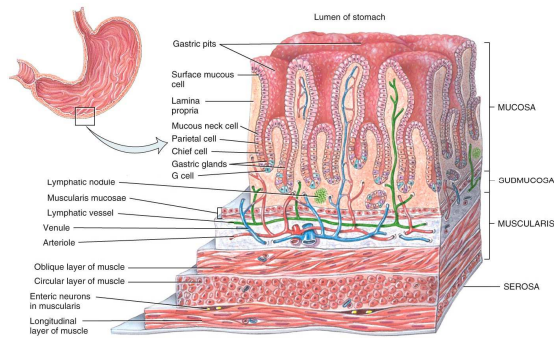
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## Histology of the Stomach



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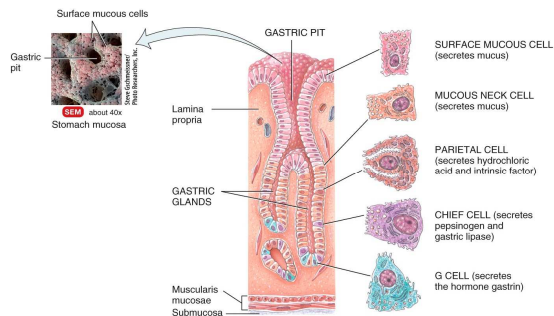
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## Gastric Glands and Cell Types in the Stomach



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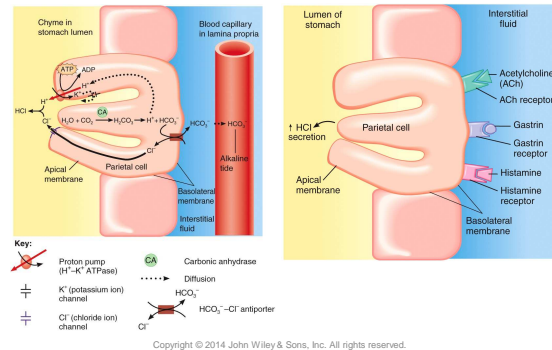
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## Secretion and Regulation of HCl in the Stomach




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## Mechanical Digestion: Stomach Peristalsis

### Interactions Animation:

- [Mechanical Digestion in the Gastrointestinal Tract](#)  
 Stomach Peristalsis and Enterogastric Reflex: Animation sections 5.1 and 6.1

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STRUCTURE	ACTIVITY	RESULT
<b>Mucosa</b>		
Surface mucous cells and mucous neck cells	Secrete mucus.	Form protective barrier that prevents digestion of stomach wall.
	Absorption.	Small quantity of water, ions, short-chain fatty acids, and some drugs enter bloodstream.
Parietal cells	Secrete intrinsic factor.	Needed for absorption of vitamin B <sub>12</sub> (found in red blood cell formation, or erythropoiesis).
	Secrete hydrochloric acid.	Kills microbes in food; denatures proteins; converts pepsinogen into pepsin.
Chief cells	Secrete pepsinogen.	Pepsin (activated form) breaks down proteins into peptides.
	Secrete gastric lipase.	Splits triglycerides into fatty acids and monoglycerides.
G cells	Secrete gastrin.	Stimulates parietal cells to secrete HCl and chief cells to secrete pepsinogen; contracts lower esophageal sphincter, increases motility of stomach, and relaxes pyloric sphincter.
<b>Muscularis</b>	Mixing waves (gentle peristaltic movements).	Churns and physically breaks down food and mixes it with gastric juice, forming chyme. Forces chyme through pyloric sphincter.
<b>Pyloric sphincter</b>	Opens to permit passage of chyme into duodenum.	Regulates passage of chyme from stomach to duodenum; prevents backflow of chyme from duodenum to stomach.

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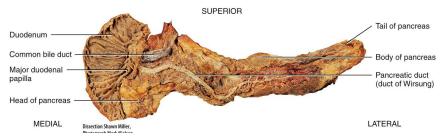
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## Pancreas

### The pancreas:

- Is a gland that lies posterior to the stomach
- Produces enzymes that digest carbohydrates, proteins, fats, and nucleic acids
- Produces sodium bicarbonate which buffers stomach acid
- Empties its contents into the duodenum



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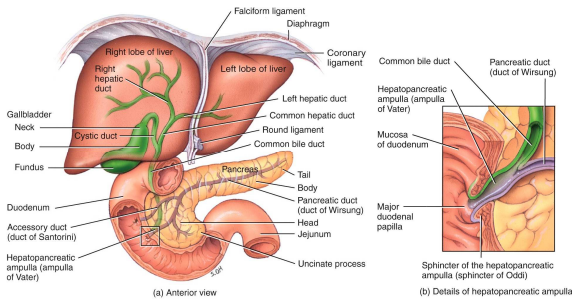
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## Pancreas, Liver, and Gallbladder



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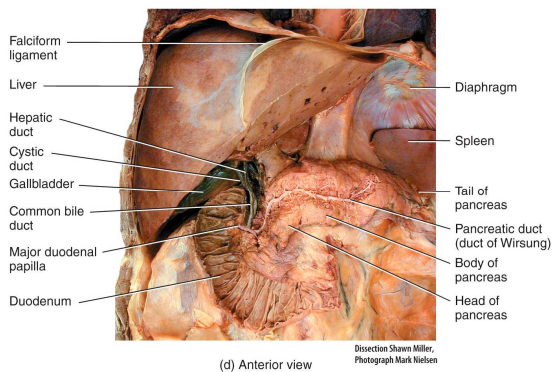
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## Pancreas, Liver, and Gallbladder



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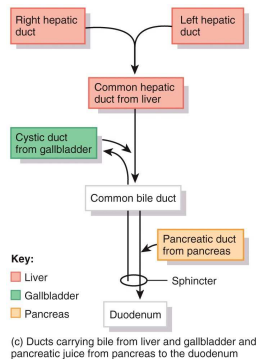
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## Liver and Gallbladder

- The liver makes bile, important in the emulsification of fats
- The gallbladder stores bile until it is needed



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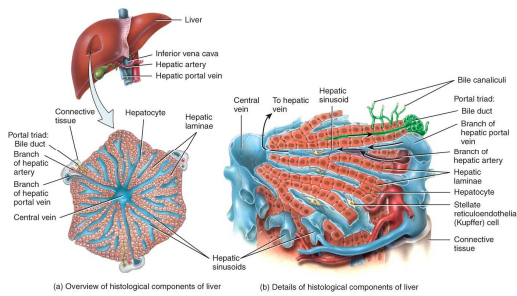
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## Histology of the Liver

The liver is composed of hepatocytes, bile canaliculi, and hepatic sinusoids



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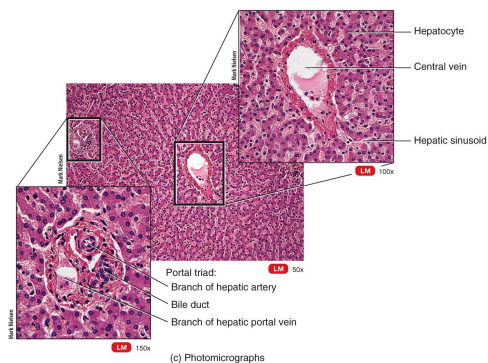
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## Histology of the Liver



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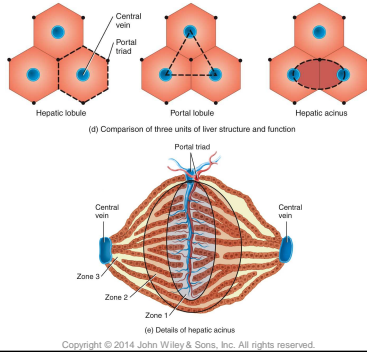
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## Hepatic Acinus Model of Liver Function




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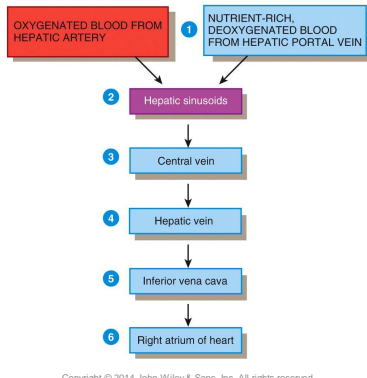
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## Blood Supply of the Liver




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## Functions of the Liver and Gallbladder

- Carbohydrate, lipid, and protein metabolism
- Processing of drugs and hormones
- Bilirubin excretion
- Bile salt synthesis
- Storage
- Phagocytosis
- Vitamin D activation

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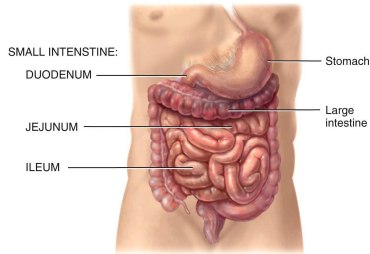
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## Small Intestine (SI)

The majority of digestion and absorption occur in the small intestine



(a) Anterior view of external anatomy

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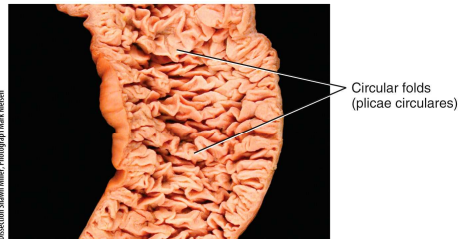
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## Circular Folds in the SI

Circular folds increase the surface area for digestion and absorption in the small intestine



(b) Internal anatomy of jejunum

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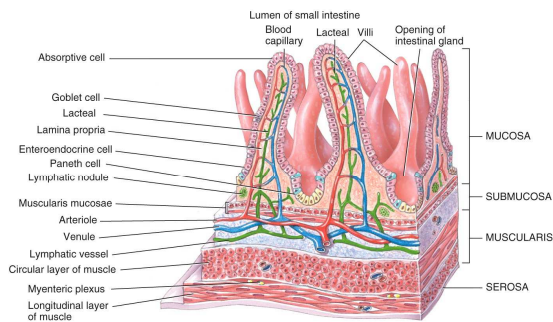
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## Histology of the SI



(b) Three-dimensional view of layers of the small intestine showing villi

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### Intestinal Juice and Brush Border Enzymes

- Intestinal juice provides a vehicle for absorption of substances from chyme as they come in contact with the villi
- Brush border enzymes, found on the surfaces of the microvilli of absorptive cells, break down food products

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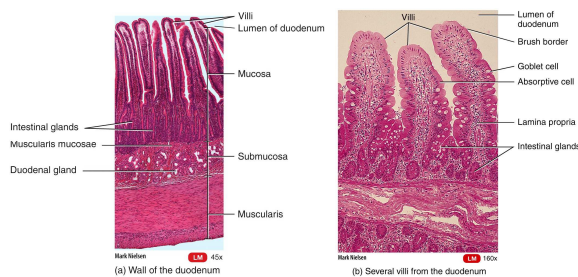
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### Wall of the Duodenum



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### Mechanical Digestion in the SI

#### Segmentation

- Localized contractions

#### Peristalsis

- Propulsive contractions

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## Mechanical Digestion: Segmentation and Migrating Motility Complexes

### Interactions Animation:

- [Mechanical Digestion in the Gastrointestinal Tract](#)  
 Segmentation and MMCs and Gastroileal Reflex: Animation section 7.1 and 8.1

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## Chemical Digestion in the SI

### Digestion of:

- Carbohydrates
- Proteins
- Lipids
- Nucleic Acids

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**TABLE 24.4**  
**Summary of Digestive Activities in the Pancreas, Liver, Gallbladder, and Small Intestine**

STRUCTURE	ACTIVITY
<b>Pancreas</b>	Delivers pancreatic juice into duodenum via pancreatic duct to assist absorption (see Table 24.5 for pancreatic enzymes and their functions).
<b>Liver</b>	Produces bile (bile salts) necessary for emulsification and absorption of lipids.
<b>Gallbladder</b>	Stores, concentrates, and delivers bile into duodenum via common bile duct.
<b>Small intestine</b>	Major site of digestion and absorption of nutrients and water in gastrointestinal tract.
<b>Mucosa/submucosa</b>	
<b>Intestinal glands</b>	Secrete intestinal juice to assist absorption.
<b>Absorptive cells</b>	Digest and absorb nutrients.
<b>Goblet cells</b>	Secrete mucus.
<b>Enteroendocrine cells (S, CCK, I)</b>	Secrete secretin, cholecystokinin, and glucose-dependent insulinotropic peptide.
<b>Paneth cells</b>	Secrete lysozyme (bactericidal enzyme) and phagocytosis.
<b>Brush border (Brunner's) glands</b>	Secrete alkaline fluid to buffer stomach acids, and mucus for protection and lubrication.
<b>Circular folds</b>	Folds of mucosa and submucosa that increase surface area for digestion and absorption.
<b>Villi</b>	Fingerlike projections of mucosa that are sites of absorption of digested food and increase surface area for digestion and absorption.
<b>Microvilli</b>	Microscopic, membrane-covered projections of absorptive epithelial cells that contain brush-border enzymes (listed in Table 24.5) and that increase surface area for digestion and absorption.
<b>Muscularis</b>	
<b>Segmentation</b>	Type of peristalsis: alternating contractions of circular smooth muscle fibers that produce segmentation and resegmentation of sections of small intestine; mixes chyme with digestive juices and brings food into contact with mucosa for absorption.
<b>Migrating motility complex (MMC)</b>	Type of peristalsis: waves of contraction and relaxation of circular and longitudinal smooth muscle fibers passing the length of the small intestine; moves chyme toward ileocecal sphincter.

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TABLE 24.5 Summary of Digestive Enzymes			
ENZYME	SOURCE	SUBSTRATES	PRODUCTS
<b>SALIVA</b>			
Salivary amylase	Salivary glands.	Starches (polysaccharides).	Maltose (disaccharide), maltotriose (trisaccharide), and $\alpha$ -dextrins.
Lingual lipase	Lingual glands in tongue.	Triglycerides (fats and oils) and other lipids.	Fatty acids and diglycerides.
<b>GASTRIC JUICE</b>			
Pepsin (activated from pepsinogen by pepsin and hydrochloric acid)	Stomach chief cells.	Proteins.	Peptides.
Gastric lipase	Stomach chief cells.	Triglycerides (fats and oils).	Fatty acids and monoglycerides.

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TABLE 24.5 Summary of Digestive Enzymes			
ENZYME	SOURCE	SUBSTRATES	PRODUCTS
<b>PANCREATIC JUICE</b>			
Pancreatic amylase	Pancreatic acinar cells.	Starches (polysaccharides).	Maltose (disaccharide), maltotriose (trisaccharide), and $\alpha$ -dextrins.
Trypsin (activated from trypsinogen by enterokinase)	Pancreatic acinar cells.	Proteins.	Peptides.
Chymotrypsin (activated from chymotrypsinogen by trypsin)	Pancreatic acinar cells.	Proteins.	Peptides.
Elastase (activated from proelastase by trypsin)	Pancreatic acinar cells.	Proteins.	Peptides.
Carboxypeptidase (activated from procarboxypeptidase by trypsin)	Pancreatic acinar cells.	Amino acid at carboxy end of peptides.	Amino acids and peptides.
Pancreatic lipase	Pancreatic acinar cells.	Triglycerides (fats and oils) that have been emulsified by bile salts.	Fatty acids and monoglycerides.
<b>Nucleases</b>			
Ribonuclease	Pancreatic acinar cells.	Ribonucleic acid.	Nucleotides.
Deoxyribonuclease	Pancreatic acinar cells.	Deoxyribonucleic acid.	Nucleotides.

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TABLE 24.5 Summary of Digestive Enzymes			
ENZYME	SOURCE	SUBSTRATES	PRODUCTS
<b>BRUSH-BORDER ENZYMES IN MICROVILLI PLASMA MEMBRANE</b>			
$\alpha$ -Dextrinase	Small intestine.	$\alpha$ -Dextrins.	Glucose.
Maltase	Small intestine.	Maltose.	Glucose.
Sucrase	Small intestine.	Sucrose.	Glucose and fructose.
Lactase	Small intestine.	Lactose.	Glucose and galactose.
Enterokinase	Small intestine.	Trypsinogen.	Trypsin.
<b>Peptidases</b>			
Aminopeptidase	Small intestine.	Amino acid at amino end of peptides.	Amino acids and peptides.
Dipeptidase	Small intestine.	Dipeptides.	Amino acids.
Nucleosidases and phosphatases	Small intestine.	Nucleotides.	Nitrogenous bases, pentoses, and phosphates.

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## Chemical Digestion

### Interactions Animation:

- [Introduction to Chemical Digestion](#)

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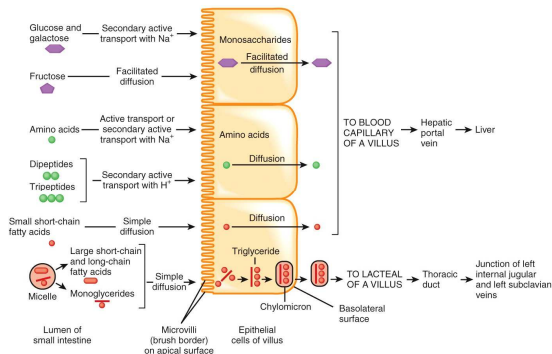
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## Absorption in the Small Intestine



(a) Mechanisms for movement of nutrients through absorptive epithelial cells of villi  
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## Digestion and Absorption of Carbohydrates

### Interactions Animation:

- [Carbohydrate Digestion and Absorption](#)

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## Digestion and Absorption of Proteins

### Interactions Animation:

- [Protein Digestion and Absorption](#)

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## Digestion and Absorption of Lipids

### Interactions Animation:

- [Lipid Digestion and Absorption](#)

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## Absorption of Nucleic Acids

### Interactions Animation:

- [Nucleic Acid Digestion and Absorption](#)

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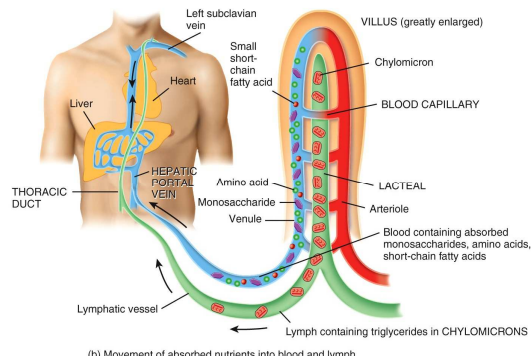
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### Movement of Nutrients



(b) Movement of absorbed nutrients into blood and lymph

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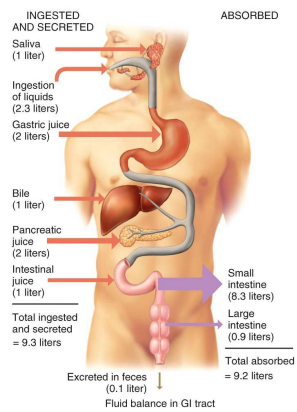
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### Fluid Balance



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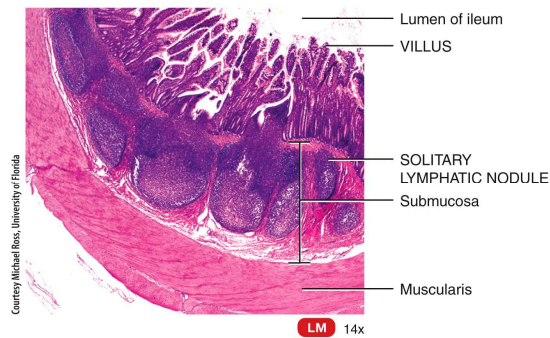
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### Lymphatic Nodules in the Ileum



(c) Lymphatic nodules in ileum

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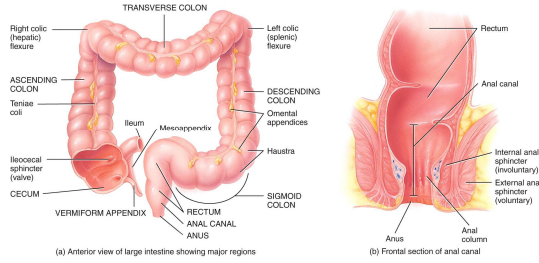
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## Anatomy of the Large Intestine (colon)



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## Functions of the Colon

### FUNCTIONS OF THE LARGE INTESTINE

1. Haustral churning, peristalsis, and mass peristalsis drive contents of colon into rectum.
2. Bacteria in large intestine convert proteins to amino acids, break down amino acids, and produce some B vitamins and vitamin K.
3. Absorption of some water, ions, and vitamins.
4. Formation of feces.
5. Defecation (emptying rectum).

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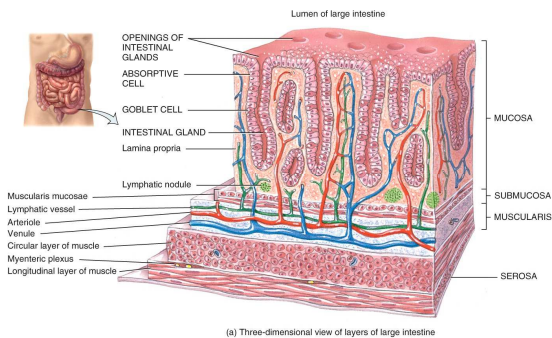
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## Histology of the Colon



(a) Three-dimensional view of layers of large intestine

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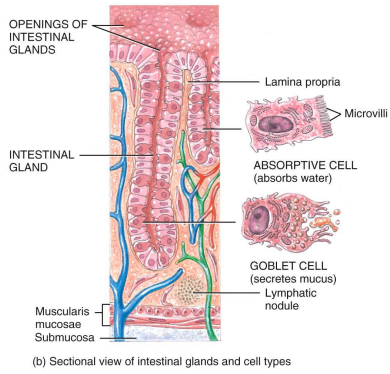
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## Glands and Cell Types of the Colon



(b) Sectional view of intestinal glands and cell types

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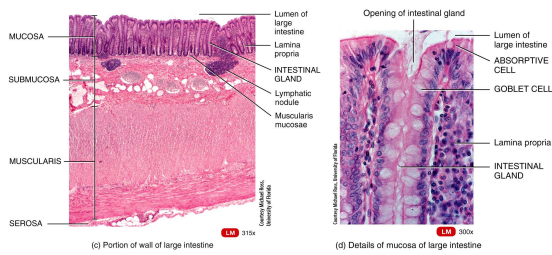
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## Wall and Mucosa of the Colon



(c) Portion of wall of large intestine

(d) Details of mucosa of large intestine

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## Mechanical Digestion in the Colon

### Haustral churning

- Distension reaches a certain point and the walls of the haustra contract to squeeze contents onward

### Peristalsis

- Propulsive contractions

### Mass peristalsis

- A strong peristaltic wave that begins in the transverse colon and quickly drives the contents of the colon into the rectum

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## Mechanical Digestion: Haustral Churning and Mass Peristalsis

### Interactions Animation:

- [Mechanical Digestion in the Gastrointestinal Tract](#)  
Haustral Churning and Mass Peristalsis:  
Animation sections 9.1 and 10.1

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## Chemical Digestion in the Colon

The last stages of digestion occur through bacterial action

- Substances are further broken down by bacteria
- Some vitamins are synthesized by bacterial action

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## Absorption and Feces Formation

### Absorption

- The colon absorbs water, electrolytes, and some vitamins

### Feces

- Consist of water, inorganic salts, sloughed-off epithelial cells, bacteria, products of bacterial decomposition, and undigested portions of food

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## Defecation Reflex

- Rectal wall distends
- Stretch receptors send sensory nerve impulses to the sacral spinal cord
- Motor impulses travel back to the descending colon, sigmoid colon, rectum, and anus
- Longitudinal rectal muscles contract and the internal anal sphincter opens
  - If the external anal sphincter is voluntarily relaxed, defecation occurs and the feces are expelled

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## Mechanical Digestion: Defecation Reflex

### Interactions Animation:

- [Mechanical Digestion in the Gastrointestinal Tract](#)
- Defecation: Animation section 11.1

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**TABLE 24.6**

**Summary of Digestive Activities in the Large Intestine**

STRUCTURE	ACTIVITY	FUNCTION(S)
Lumen	Bacterial activity.	Breaks down undigested carbohydrates, proteins, and amino acids into products that can be expelled in feces or absorbed and detoxified by liver; synthesizes certain B vitamins and vitamin K.
Mucosa	Secretes mucus. Absorption.	Lubricates colon; protects mucosa. Water absorption solidifies feces and contributes to body's water balance; solutes absorbed include ions and some vitamins.
Muscularis	Haustral churning. Peristalsis.  Mass peristalsis.  Defecation reflex.	Moves contents from haustrum to haustrum by muscular contractions. Moves contents along length of colon by contractions of circular and longitudinal muscles.  Forces contents into sigmoid colon and rectum.  Eliminates feces by contractions in sigmoid colon and rectum.

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TABLE 24.7

Summary of Organs of the Digestive System and Their Functions

ORGAN	FUNCTION(S)
<b>Tongue</b>	Maneuvers food for mastication, shapes food into a bolus, maneuvers food for deglutition, detects sensations for taste, and initiates digestion of triglycerides.
<b>Salivary glands</b>	Saliva produced by these glands softens, moistens, and dissolves foods; cleanses mouth and teeth; initiates the digestion of starch.
<b>Teeth</b>	Cut, tear, and pulverize food to reduce solids to smaller particles for swallowing.
<b>Pancreas</b>	Pancreatic juice buffers acidic gastric juice in chyme, stops the action of pepsin from the stomach, creates the proper pH for digestion in the small intestine, and participates in the digestion of carbohydrates, proteins, triglycerides, and nucleic acids.
<b>Liver</b>	Produces bile, which is required for the emulsification and absorption of lipids in the small intestine.
<b>Gallbladder</b>	Stores and concentrates bile and releases it into the small intestine.
<b>Mouth</b>	See the functions of the tongue, salivary glands, and teeth, all of which are in the mouth. Additionally, the lips and cheeks keep food between the teeth during mastication, and buccal glands lining the mouth produce saliva.
<b>Pharynx</b>	Receives a bolus from the oral cavity and passes it into the esophagus.
<b>Esophagus</b>	Receives a bolus from the pharynx and moves it into the stomach; this requires relaxation of the upper esophageal sphincter and secretion of mucus.
<b>Stomach</b>	Mixing waves combine saliva, food, and gastric juice, which activates pepsin; initiates protein digestion; kills microbes in food; helps absorb vitamin B <sub>12</sub> ; contracts the lower esophageal sphincter; increases stomach motility; relaxes the pyloric sphincter; and moves chyme into the small intestine.
<b>Small intestine</b>	Segmentation mixes chyme with digestive juices; peristalsis propels chyme toward the ileocecal sphincter; digestive secretions from the small intestine, pancreas, and liver complete the digestion of carbohydrates, proteins, lipids, and nucleic acids; circular folds, villi, and microvilli help absorb about 90% of digested nutrients.
<b>Large intestine</b>	Haustral churning, peristalsis, and mass peristalsis drive the colonic contents into the rectum; bacteria produce some B vitamins and vitamin K; absorption of some water, ions, and vitamins occurs; defecation.

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## Phases of Digestion

### Cephalic phase

- Stimulates gastric secretion and motility

### Gastric phase

- Neural and hormonal mechanisms

### Intestinal phase

- Neural and hormonal mechanisms

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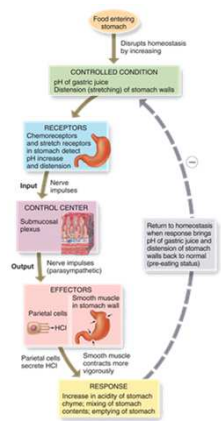
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## Gastric Phase of Digestion: Regulation of Gastric Juice pH and Gastric Motility



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TABLE 24.8 Major Hormones That Control Digestion		
HORMONE	STIMULUS AND SITE OF SECRETION	ACTIONS
<b>Gastrin</b>	Distension of stomach, partially digested proteins and caffeine in stomach, and high pH of stomach chyme stimulate gastrin secretion by enteroendocrine G cells, located mainly in mucosa of pyloric antrum of stomach.	<b>Major effects:</b> Promotes secretion of gastric juice, increases gastric motility, promotes growth of gastric mucosa. <b>Minor effects:</b> Constricts lower esophageal sphincter, relaxes pyloric sphincter.
<b>Secretin</b>	Acids (high H <sup>+</sup> level) chyme that enters small intestine stimulates secretion of secretin by enteroendocrine S cells in the mucosa of duodenum.	<b>Major effects:</b> Stimulates secretion of pancreatic juice and bile that are rich in HCO <sub>3</sub> <sup>-</sup> (bicarbonate ions). <b>Minor effects:</b> Inhibits secretion of gastric juice, promotes normal growth and maintenance of pancreas, enhances effects of CCK.
<b>Cholecystokinin (CCK)</b>	Partially digested proteins (amino acids), triglycerides, and fatty acids that enter small intestine stimulate secretion of CCK by enteroendocrine CCK cells in mucosa of small intestine; CCK is also released in brain.	<b>Major effects:</b> Stimulates secretion of pancreatic juice rich in digestive enzymes, causes ejection of bile from gallbladder and opening of sphincter of the hepatopancreatic ampulla (sphincter of Oddi), induces satiety (feeling full to satisfaction). <b>Minor effects:</b> Inhibits gastric emptying, promotes normal growth and maintenance of pancreas, enhances effects of secretin.

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## Hormonal Control of Digestion

### Interactions Animation:

- [Hormonal Control of Digestive Activities](#)

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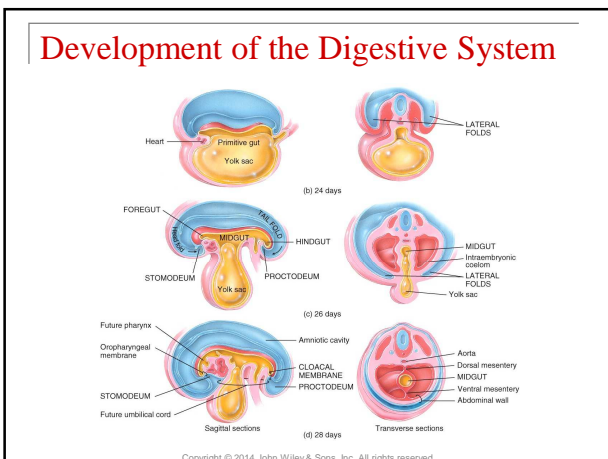
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## Aging and the Digestive System

Aging results in:

- Decreased secretory mechanisms and motility
- Loss of strength and tone of digestive muscular tissue
- Changes in neurosecretory feedback
- Diminished response to pain and internal sensations

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### FOCUS on HOMEOSTASIS

**CONTRIBUTIONS OF THE DIGESTIVE SYSTEM FOR ALL BODY SYSTEMS**

The digestive system breaks down dietary macromolecules into forms that can be absorbed and used by body cells for producing ATP and building body tissues. Absorbs water, minerals, and vitamins needed for growth and function of body tissues. Excretes wastes from body tissues in feces.

**INTEGUMENTARY SYSTEM**

- Small intestine absorbs vitamin D, which skin and kidneys modify to produce the hormone calcitriol.
- Excess dietary vitamins are stored as triglycerides in adipose cells in dermis and subcutaneous layer.

**SKELETAL SYSTEM**

- Small intestine absorbs dietary calcium and phosphorus ions needed to build bone extracellular matrix.

**MUSCULAR SYSTEM**

- Liver can convert lactate and triglycerides to muscles during exercise for glucose.

**NERVOUS SYSTEM**

- Gluconeogenesis: synthesis of new glucose molecules in liver plus digestion and absorption of dietary carbohydrates provide glucose, needed for ATP production by neurons.

**ENDOCRINE SYSTEM**

- Liver synthesizes some hormones, ending their activity.
- Pancreatic cells release insulin and glucagon.
- Cells in the mucosa of stomach and small intestine release hormones that regulate digestive activities.
- Liver produces angiotensinogen.

**CARDIOVASCULAR SYSTEM**

- Fat from alcoholic water must be broken into fatty acid chylomicrons and enter that is needed for synthesis of hemoglobin in red blood cells.
- Myofibrils from hemoglobin breakdown is partially excreted in feces.
- Liver synthesizes most plasma proteins.

**LYMPHATIC SYSTEM and IMMUNITY**

- Acidity of gastric juice destroys bacteria and most toxins in stomach.
- Lymphatic nodules in lamina propria of mucosa of gastrointestinal tract (PALS) destroy microbes.

**RESPIRATORY SYSTEM**

- Pressure of abdominal organs against diaphragm helps equal air quickly during forced exhalation.

**URINARY SYSTEM**

- Absorption of water by GI tract provides water needed to excrete waste products in urine.

**REPRODUCTIVE SYSTEMS**

- Digestion and absorption provide adequate nutrients, including fats, for normal development of reproductive structures, for production of gametes (sperm and ova), and for fetal growth and development during pregnancy.

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## Digestive System Disorders

- Tooth decay
- Periodontal diseases
- Ulcers
- Diverticula
- Tumors
- Hepatitis
- Anorexia nervosa

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**End of Chapter 24**

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