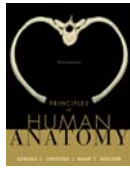


Chapter 25

The Digestive System



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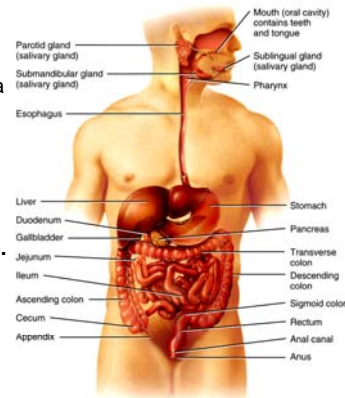
Introduction

- Food contains a variety of nutrients—molecules needed for building new body tissues, repairing damaged tissues, and sustaining needed chemical reactions.
- Most food cannot be used as a source of cellular energy. It must first be broken down into molecules small enough to cross the plasma membranes of cells.
- This breakdown process is known as **digestion**.
- The passage smaller molecules through cells into the blood and lymph is termed **absorption**.

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Overview

- The **gastrointestinal (GI) tract, or alimentary canal** is a continuous tube that extends from the mouth to the anus through the thoracic and abdominopelvic cavities.
- Consists of **mouth, pharynx, esophagus, stomach, small intestine, and large intestine**.
- The length of the GI tract is variable, ranging from about 5-15 meters (15 ft to 30 ft).
- The **accessory digestive organs** include the teeth, tongue, salivary glands, liver, gallbladder, and pancreas.



(a) Right lateral view of head and neck and anterior view of trunk.
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Layers of the GI Tract (Fig. 25.2)

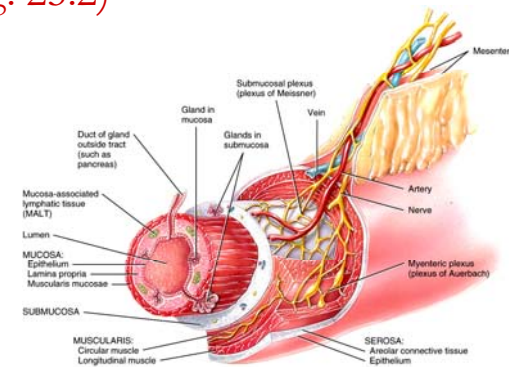


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Mucosa of GI Tract

The **mucosa** is a mucous membrane composed of:

1. The epithelium in the mouth, pharynx, esophagus, and anal canal is mainly nonkeratinized stratified squamous epithelium that serves a protective function. Located among the epithelial cells are exocrine cells that secrete mucus and fluid into the lumen of the tract, **enteroendocrine cells**, secrete hormones.

2. The lamina propria is an **areolar connective tissue layer** containing many blood and lymphatic vessels that carry the nutrients absorbed by the GI tract to the other tissues of the body. The lamina propria contains **mucosa-associated lymphoid tissue (MALT)**. MALT is present all along the GI tract, especially in the tonsils, small intestine, appendix, and large intestine, and it contains about as many immune cells

3. Muscularis mucosae is a thin layer of smooth muscle fibers that causes the mucous membrane of the stomach and small intestine to form many small folds, increasing the surface area for digestion and absorption

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Submucosa

- The **submucosa** is a thin meshwork of collagenous fibers, nerves, and blood vessels.
- **Areolar connective tissue** binds the mucosa to the middle layer, the muscularis.
- **Secretory cells** of mucosal glands, and the submucosal plexus is important in controlling secretions of the GI tract.

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Muscularis

- The **muscularis** of the mouth, pharynx, and superior and middle parts of the esophagus contains skeletal muscle.
- Skeletal muscle also forms the external anal sphincter, which permits voluntary control of defecation.
- The muscularis consists of smooth muscle an inner sheet of circular fibers and an outer sheet of longitudinal fibers.
- Involuntary contractions of the smooth muscles assist in the mechanical breakdown of food, mix it with digestive secretions, and propel it along the tract.
- This plexus mostly controls GI tract motility (movement)

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Serosa

- Superficial layer of those portions of the GI tract that are suspended in the abdominopelvic cavity.
- A **serous membrane** composed of areolar connective tissue and simple squamous epithelium (mesothelium).
- The epithelial portion is also called the **visceral peritoneum**, as it forms the portion of the peritoneum that surrounds the organs that are suspended in the peritoneal cavity, which we will examine in detail shortly.

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Layers of the GI Tract (Fig. 25.2)

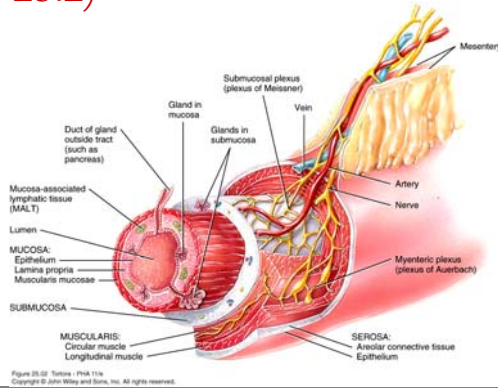


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Peritoneum

- The largest serous membrane of the body; it consists of a layer of simple squamous epithelium (mesothelium) with an underlying supporting layer of connective tissue.

1. **Parietal peritoneum** lines the wall of the abdominopelvic cavity

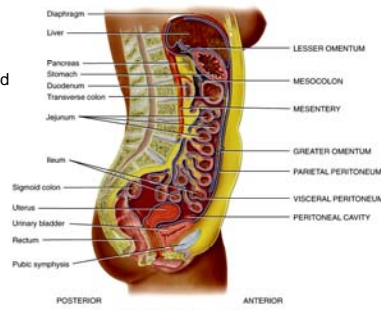
2. **Visceral peritoneum or serosa**, covers some of the organs in the cavity

- Organs that lie against the posterior abdominal wall and do not project into the peritoneal cavity, are called **retroperitoneal organs**, are covered by peritoneum only on their anterior surfaces (ascending and descending colon, duodenum, and pancreas) or are separated from the peritoneum by fat (kidney and adrenal glands).

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5 Major Peritoneal Folds

- The **greater omentum**, the largest peritoneal fold, drapes over the transverse colon and coils of them small intestine like a "fatty apron".
- The **falciform ligament** attaches the liver to the anterior abdominal wall and diaphragm.
- The **lesser omentum** arises as an anterior fold of the serosa of the stomach and duodenum. It suspends the stomach and duodenum from the liver.
- The **mesentery**, is fan-shaped and binds the jejunum and ileum of the small intestine to the posterior abdominal wall
- The **mesocolon** bind the transverse colon (transverse mesocolon) and sigmoid colons (sigmoid mesocolon) of the large intestine to the posterior abdominal



(a) Medial section showing the peritoneal folds
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Mouth (Fig. 25. 4)

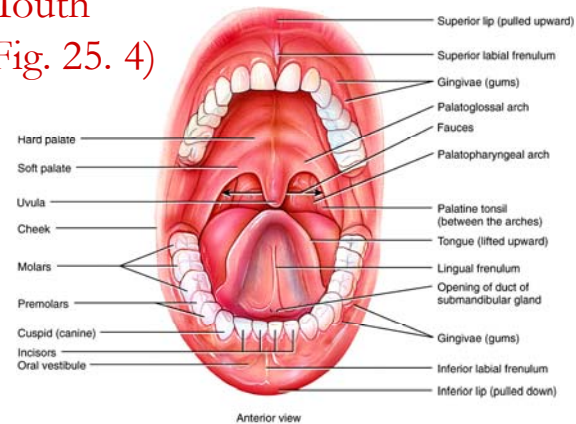


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3 Pairs of Major Salivary Glands

- The **parotid glands** are located inferior and anterior to the ears, between the skin and the masseter muscle. **Parotid (Stensen's) duct** pierces the buccinator muscle to open into the vestibule opposite the second maxillary (upper) molar tooth.
- The **submandibular glands** at the base of the tongue; are medial and partly inferior to the mandible. Their ducts, the **submandibular (Wharton's) ducts**, run under the mucosa on either side of the midline of the floor of the mouth and enter the oral cavity proper lateral to the lingual frenulum.
- The **sublingual glands** are superior to the submandibular glands. The **lesser sublingual (Rivinus') ducts**, open into the floor of the mouth in the oral cavity proper.

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Salivary Glands (Fig. 25.5)

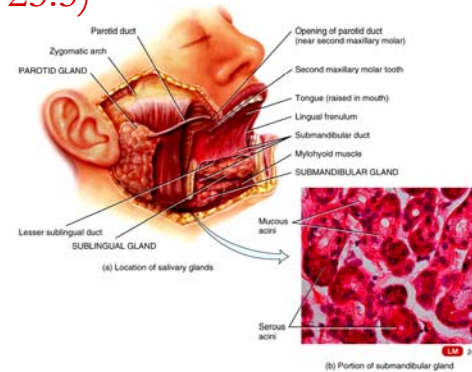


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A Typical Tooth (Fig. 25.6)

- **Gingivae** cover alveolar processes extend into each socket to form the **gingival sulcus**.
- The sockets are lined by the **periodontal ligament or membrane**, consists of dense fibrous connective tissue that anchors teeth in position and acts as a shock absorber.
- 1-3 **roots** are embedded in each socket.
- The **neck** is the constricted junction of the crown and root near the gum line.
- Internally, the **dentin** forms most of the tooth, consists of calcified connective tissue.
- The **crown** of a tooth is covered by **enamel**, primarily composed of calcium phosphate and calcium carbonate. Enamel is also harder than bone because of its even higher content of calcium salts

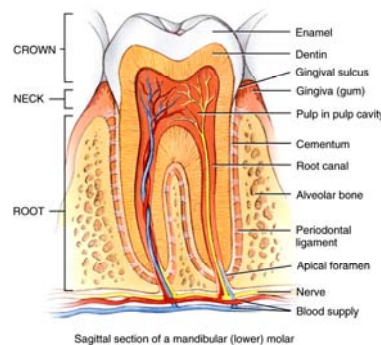


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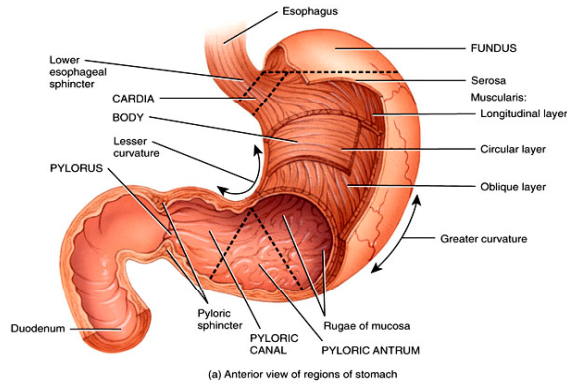
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Pharynx

- The **pharynx** extends from the internal nares to the esophagus posteriorly and the larynx anteriorly.
- The pharynx is composed of skeletal muscle and lined by mucous membrane.
- The nasopharynx functions only in respiration, but the oropharynx and laryngopharynx have both digestive and respiratory functions. Swallowing, or **deglutition**, is a mechanism that moves food from the mouth to the stomach.
- Swallowing is helped by saliva and mucus and involves the mouth, pharynx, and esophagus. Food that is swallowed passes from the mouth into the oropharynx and laryngopharynx before passing into the esophagus.
- Muscular contractions of the oropharynx and laryngopharynx help propel food into the esophagus and then into the stomach.

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Anatomy of the Stomach (Fig. 25.10)



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Gastric Glands

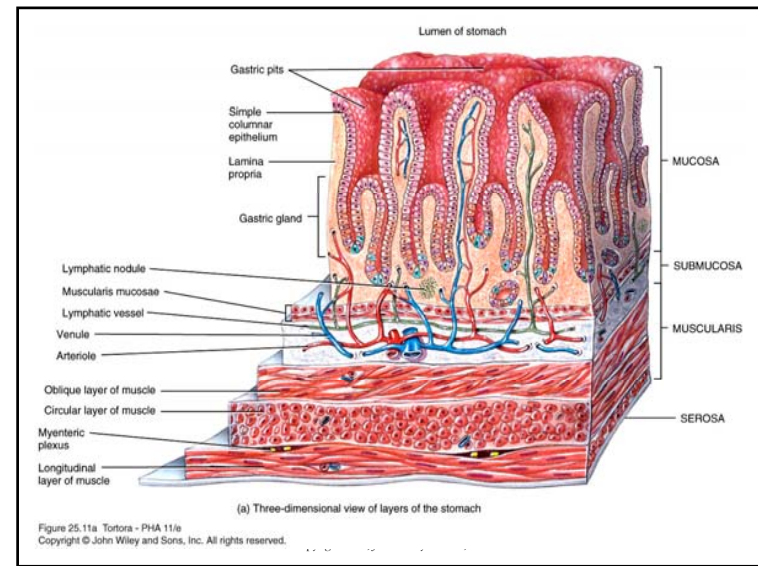
- The gastric glands contain three types of exocrine gland cells that secrete their products into the stomach lumen: **mucous neck cells, chief cells, and parietal cells.**
- Both mucous surface cells and mucous neck cells secrete mucus.
- Parietal cells produce intrinsic factor (needed for absorption of vitamin B12) and hydrochloric acid.
- The **chief (zymogenic) cells secrete** pepsinogen and gastric lipase.
- The secretions of the mucous, parietal, and chief cells form **gastric juice, which totals 2000–3000 mL (roughly 2–3 qt) per day.**
- In addition, a type of enteroendocrine cell, the **G cell**, located mainly in the pyloric antrum, secretes the hormone gastrin into the bloodstream.

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Histology of the Stomach

- The **submucosa** of the stomach is composed of areolar connective tissue.
- The **muscularis** has three layers of smooth muscle (rather than the two found in the lower esophagus and small and large intestines): **an outer longitudinal layer, a middle circular layer, and an inner oblique layer.**
- The oblique layer is limited primarily to the body of the stomach, allowing the stomach to more effectively churn and mix the food.
- The **serosa is composed** of simple squamous epithelium (mesothelium), the visceral peritoneum, and areolar connective tissue.

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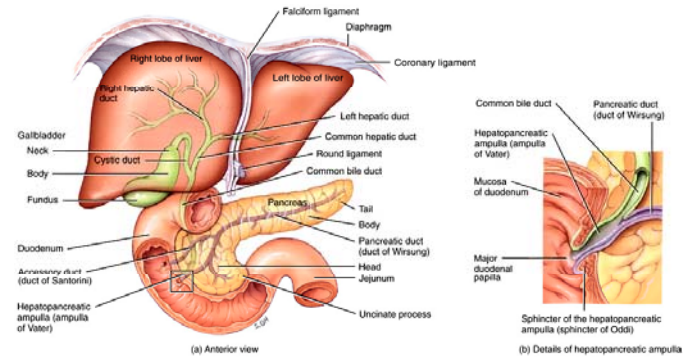


Pancreas

- The pancreas is made up of glandular epithelial cells, about 99% are arranged in clusters called **acini** (exocrine cells).
- The acini secrete a mixture of fluid and digestive enzymes called **pancreatic juice**.
- 1% of the cells are organized into clusters called **pancreatic islets (islets of Langerhans)**, the **endocrine** cells of the pancreas. These cells secrete the glucagon, insulin, somatostatin, and pancreatic polypeptide.
- Each day the pancreas produces 1200–1500 mL (about 1.2–1.5 qt) of **pancreatic juice**, consisting mostly of water, some salts, sodium bicarbonate, and several enzymes. The sodium bicarbonate gives pancreatic juice a slightly alkaline pH (7.1–8.2) that buffers acidic gastric juice in chyme.
- **Pancreatic amylase, trypsin, chymotrypsin, Carboxypeptidase, and elastase**; the principal triglyceride-digesting enzyme in adults, called **pancreatic lipase**; and **nucleic acid-digesting** enzymes called **ribonuclease and deoxyribonuclease** are produced by the pancreas.

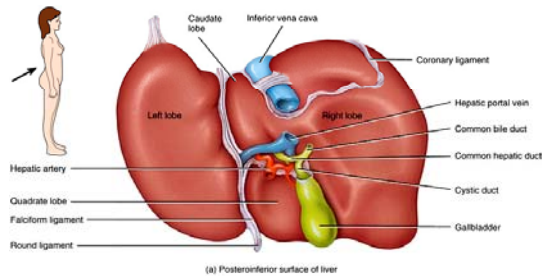
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Pancreas (Fig. 25.12)



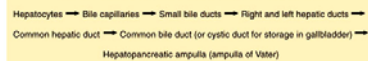
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Liver (Fig. 25.13)



(a) Posteroinferior surface of liver

PATH OF BILE FLOW FROM THE LIVER INTO THE DUODENUM



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3 Regions of the Small Intestine

- The **Duodenum**, the shortest region, is retroperitoneal and extends about 25 cm (10 in.).
- The **Jejunum** is about 1 m (3 ft) long and extends to the ileum.
- The **Ileum** is the longest region of the small intestine, measures about 2 m (6 ft) and joins the large intestine at a smooth muscle sphincter called the **ileocecal sphincter**.

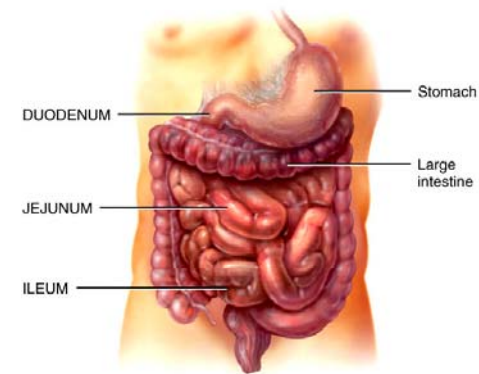
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Histology of the Small Intestine

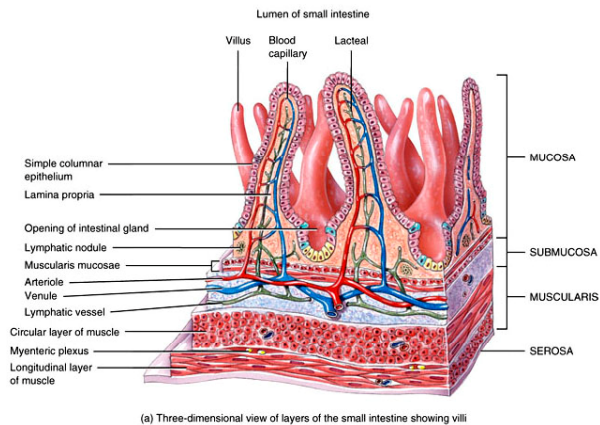
- The **mucosa** is composed of a layer of epithelium, lamina propria, and muscularis mucosae. The epithelial layer of the small intestinal mucosa consists of simple columnar epithelium that contains many types of cells.
- **Absorptive cells of the epithelium digest and absorb** nutrients in small intestinal chyme.
- **Goblet cells** secrete mucus.
- **The small intestinal mucosa** contains many deep crevices lined with glandular epithelium. Cells lining the crevices form the **intestinal glands (crypts of Lieberkuhn)** and **secrete intestinal juice**.
- **Paneth cells secrete lysozyme, a bactericidal enzyme, and are** capable of phagocytosis. May have a role in regulating the microbial population in the small intestine.

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Location and Histology of the Small Intestine



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Large Intestine

- As chyme moves through the large intestine, bacteria act on it and water, ions, and vitamins are absorbed
- The **large intestine, is about 1.5 m (5 ft) long and 6.5 cm (2.5 in.)** in diameter, extends from the ileum to the anus.
- The ascending colon and descending colon are retroperitoneal, while the the colon and cecum are attached to the posterior abdominal wall by their **mesocolon, a double layer of peritoneum connecting** the parietal peritoneum to the visceral peritoneum.
- The four principal regions are the cecum, colon, rectum, and anal canal.
- The opening from the ileum into the large intestine is **ileocecal sphincter or valve, which allows materials from the small intestine to pass into** the large intestine.
- The **cecum**, a small pouch about 6 cm (2.4 in.) long.
- Attached to the cecum is the the **appendix or vermiform appendix**. *The mesentery* of the appendix, called the **mesoappendix, attaches the** appendix to the inferior part of the mesentery of the ileum.

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Anatomy of the Large Intestine (Fig. 25.19)

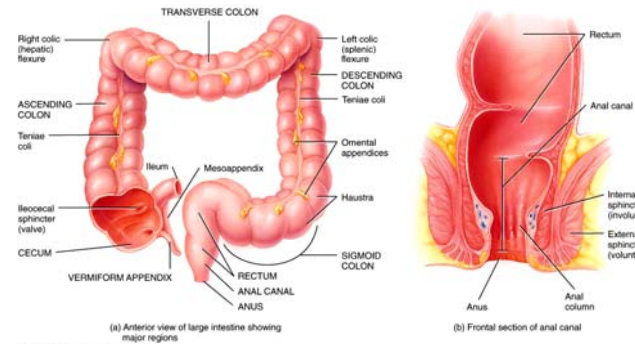


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Large Intestine

- The wall of the large intestine contains the typical four layers found in the rest of the GI tract: **mucosa, submucosa, muscularis, and serosa**. The **mucosa** consists of **simple columnar epithelium**, lamina propria (areolar connective tissue), and muscularis mucosae (smooth muscle).
- Both absorptive and goblet cells are located in long, straight, tubular **intestinal glands (crypts of Lieberkühn)** that extend the full thickness of the mucosa.
- The **submucosa consists of areolar** connective tissue.
- The **muscularis consists of an external layer** of longitudinal smooth muscle and an internal layer of circular smooth muscle. Unlike other parts of the GI tract, portions of the longitudinal muscles are thickened, forming three conspicuous bands called the **teniae coli** that run most of the length of the large intestine or no longitudinal muscle.
- Tonic contractions of the bands gather the colon into a series of pouches called **haustra**, which give the colon a puckered appearance. A single layer of circular smooth muscle lies deep to the teniae coli.

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Histology of the Large Intestine (Fig. 25.20)

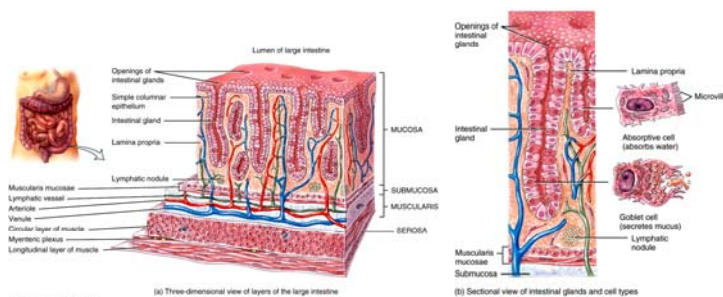


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Digestion in Large Intestine

- Mucus** is secreted by the glands of the large intestine, but no enzymes are secreted.
- Chyme** is prepared for elimination by the action of bacteria, which ferment any remaining carbohydrates and release hydrogen, carbon dioxide, and methane gases.
- These gases contribute to **flatus** (gas) in the colon, termed flatulence when it is excessive.
- Bacteria** also convert any remaining proteins to amino acids and break down the amino acids into simpler substances: indole, skatole, hydrogen sulfide, and fatty acids
- Bacteria also decompose **bilirubin** to simpler pigments, including **stercobilin**, which give feces their brown color.
- Several vitamins needed for normal metabolism, including some **B vitamins** and **vitamin K**, are bacterial products that are absorbed in the colon.
- By the time chyme has remained in the large intestine 3–10 hours, it has become solid or semisolid as a result of water absorption and is now called **feces**.

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