Chapter 7 – GI Tract and Digestion

Objectives

Given the synopsis in this chapter, competence in each objective will be demonstrated by responding to multiple choices or matching questions, completing fill-in questions, or writing short answers, at the level of 75% or greater proficiency for each student.

A. To describe the general organization and function of the digestive system.
B. To explain the movement of food in the mouth, esophagus, stomach, and intestines.
C. To explain the digestion of food in the mouth, stomach, and intestines.

The digestive system includes the gastrointestinal tract, the mouth, teeth, pharynx, esophagus, stomach, small intestines, and large intestines; and the accessory organs, the salivary glands, liver, gallbladder, and pancreas. An overview of the digestive system is shown in Figure 7.1.

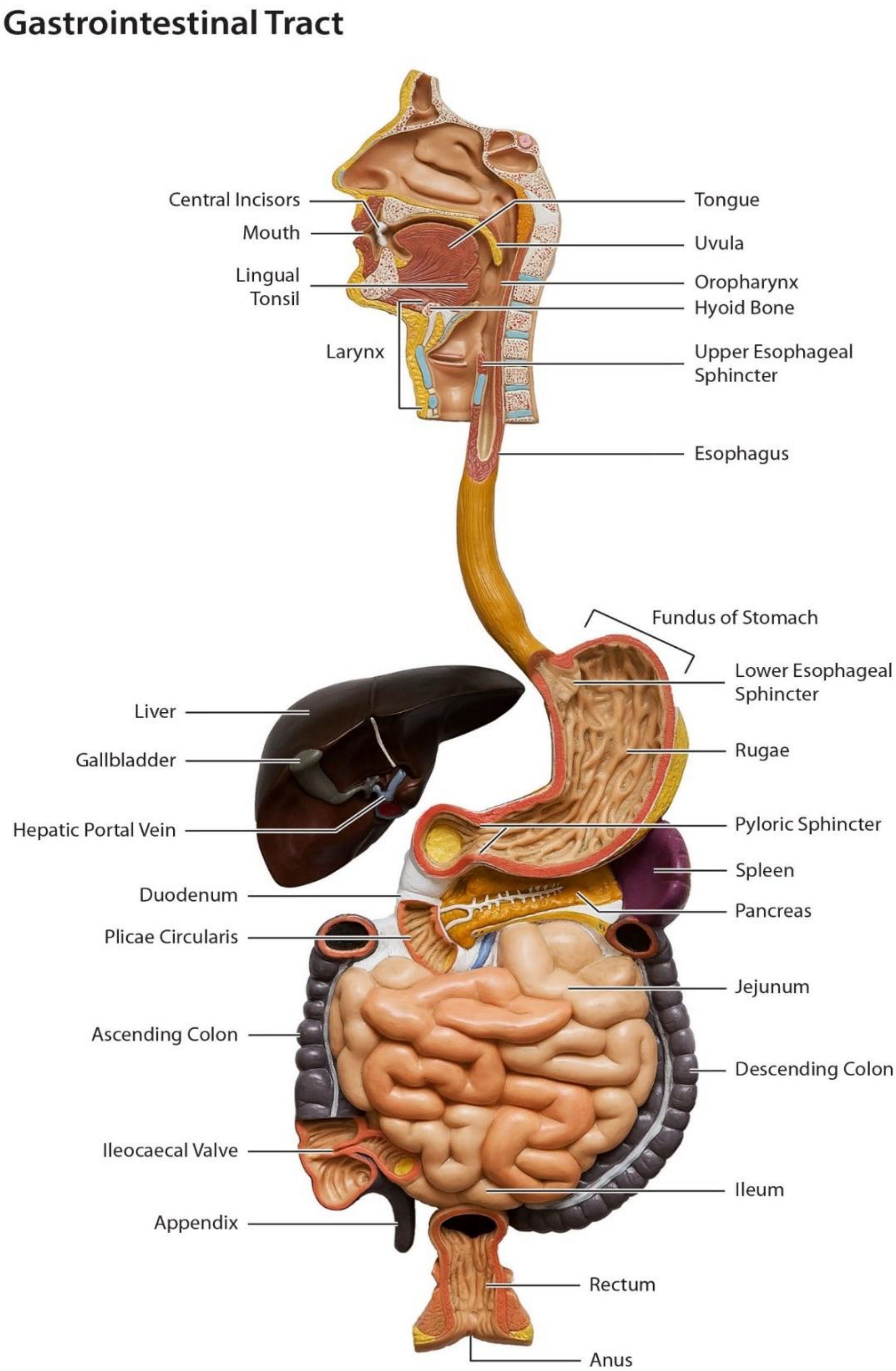

Figure 7.1 © 2014 David G. Ward, Ph.D., Atlas of Anatomy for Allied Health

The primary purpose of the digestive system is to convert food into molecules that can be transferred along with water and minerals into the blood and used by cells of the body. Accordingly, the digestive system is concerned with digestion, the process of breaking down food; absorption, the process of moving molecules across the epithelial cells of the gastrointestinal tract; and motility, the process of moving food through the gastrointestinal tract by smooth muscle contraction. The gastrointestinal system is under the control of an enteric nervous and endocrine system and by the central nervous system.

Movement of Food, Digestion, and Absorption

Food moves through the gastrointestinal tract by way of coordinated contraction and relaxation of smooth muscle. Contractions are controlled by the enteric nervous system and by the parasympathetic and sympathetic nervous systems. The enteric nervous system is a separate and relatively independent system of neurons in the walls of the gastrointestinal tract that coordinate the contraction and relaxation of smooth muscle and the release of many gastrointestinal secretions. These neurons are modulated by the parasympathetic and sympathetic nervous systems.

Most of the food we consume is composed of large molecules such as proteins, polysaccharides, and fats which are unable to cross the intestinal epithelium. Food must therefore be dissolved and broken down into small molecules that can transfer out of the intestine and into the blood. This process is digestion and is accomplished by salivary enzymes in the mouth; hydrochloric acid and gastric enzymes in the stomach; and by bile from the liver, and a variety of intestinal and pancreatic enzymes in the small intestines.

Mouth, Teeth, and Esophagus

Teeth are essential for the chewing of food. The basic organization of a tooth is shown in Figure 7.2. The crown extends above the gum (gingiva) and the root extends below the gum into the jaw bone. The crown is encased in a very hard bone called enamel. Each tooth is made mainly of a softer bone called dentin. The interior of a tooth contains pulp (bone marrow) with blood vessels and nerves.

Each quarter of the mouth contains eight teeth. Most anterior are two incisors, followed by a canine (cuspid). Posterior to the cuspid are two premolars (bicuspids). Most posterior are three molars. Sometimes the third molar does not emerge.

A sagittal view of the mouth, oropharynx, and esophagus is shown in Figure 7.3. The mouth is mainly involved in chewing the food, which is a mechanical process rather than a chemical process. As a matter of fact, chewing and mixing the food with saliva is not necessary for digestion, it mainly makes swallowing easier. Nonetheless saliva starts some chemical digestion in the mouth, especially the breakdown of polysaccharides.

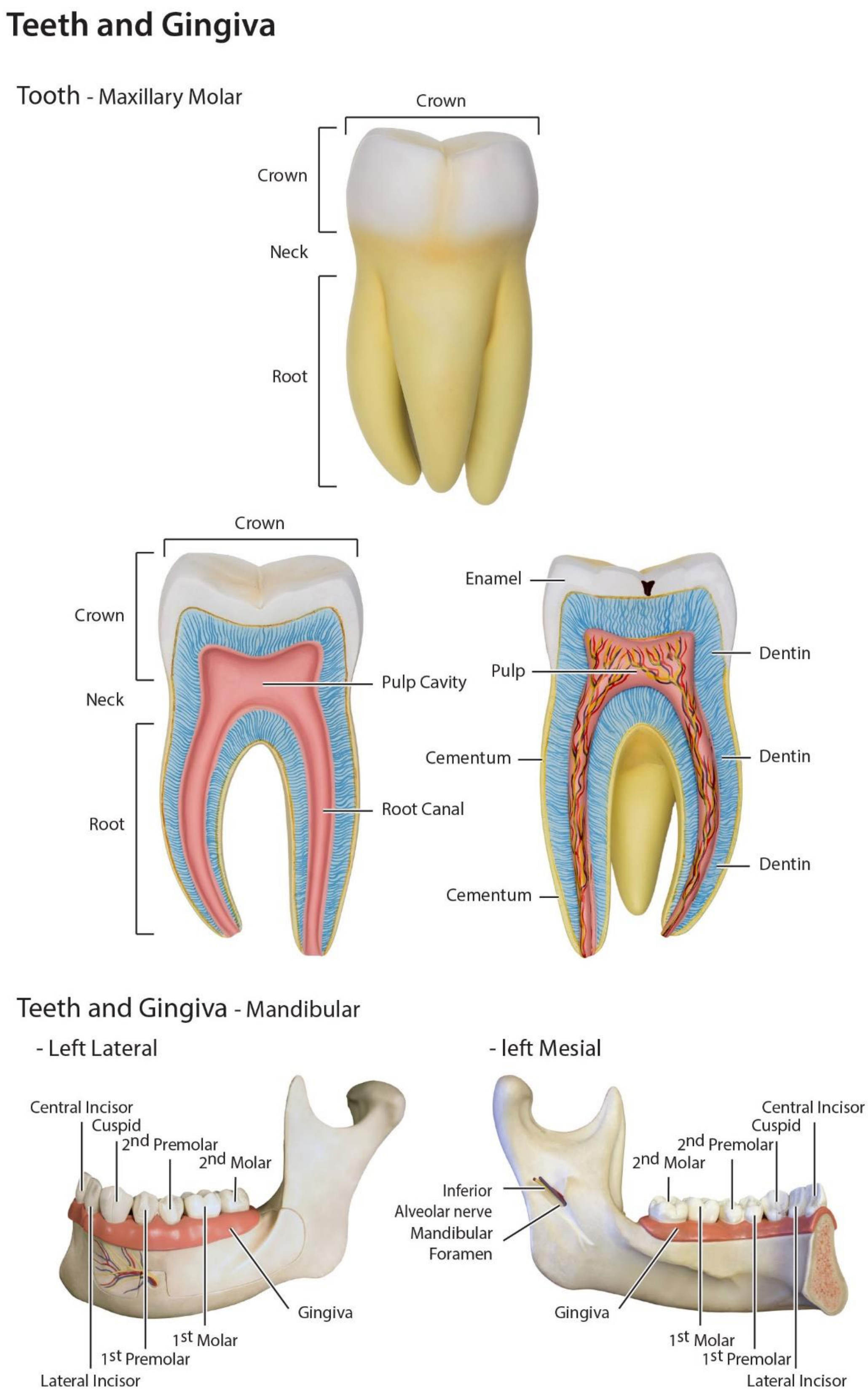

Figure 7.2 © 2014 David G. Ward, Ph.D., Atlas of Anatomy for Allied Health

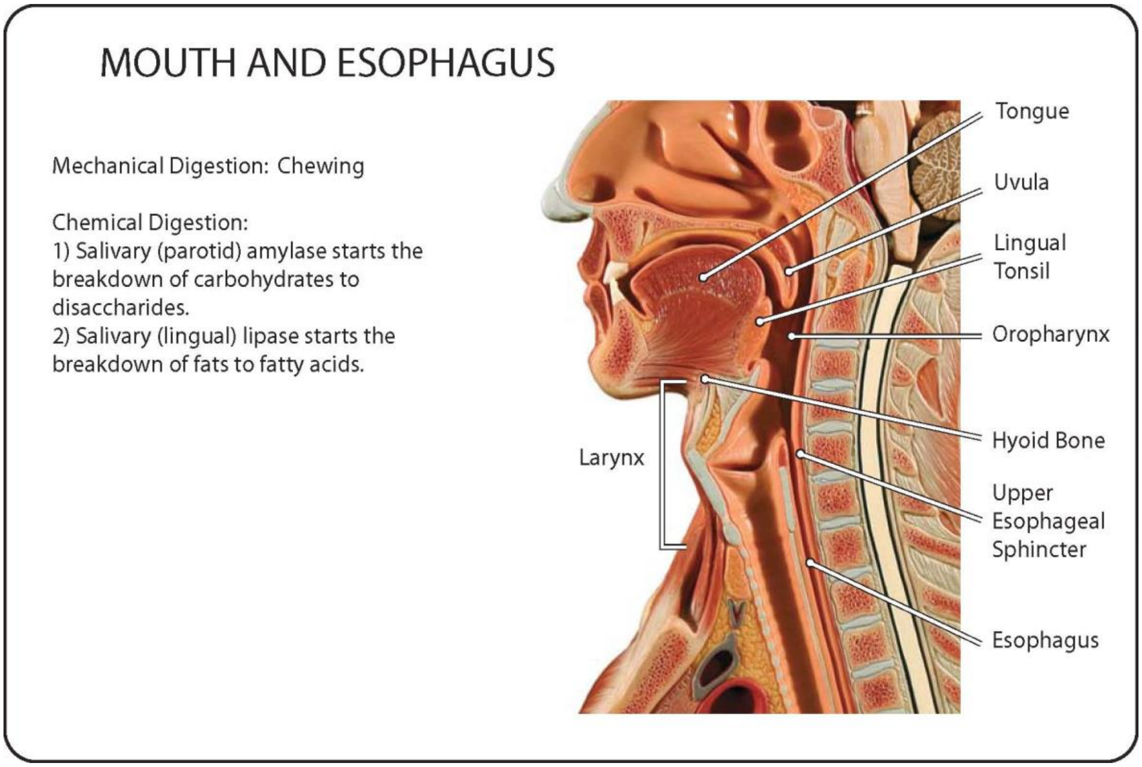

Figure 7.3 © 2007 David G. Ward, Ph.D.

The secretion of saliva is controlled mainly by the parasympathetic nervous system. The sight or smell of food induces salivary secretion. In addition, food in the mouth stimulates chemoreceptors and stimulation of pressure receptors in the walls of the mouth and on the tongue cause reflex increases in salivary secretion.

- The salivary glands secrete saliva.
- Salivary amylase starts the breakdown of carbohydrates (polysaccharides) to simpler sugars (disaccharides).

When the food is pushed by the tongue into the back of the mouth and touches the oropharynx, a series of reflexes occur.

- As the tongue pushes food to the back of the mouth the uvula is pushed up to prevent food from entering the nasal cavity
- Elevator muscles for the larynx pull the larynx up and into the bottom of the tongue, obstructing the opening to the larynx (glottis).
- The upper esophageal sphincter relaxes, food is pushed into the esophagus, and the sphincter closes.
- A wave of muscle contraction (peristalsis) moves the food through the esophagus
- The lower esophageal sphincter relaxes, food moves into the stomach, and the sphincter closes (see below)

Stomach

A sagittal view of the stomach is shown in Figure 7.4. The stomach is involved in the churning and mixing of the food, a mechanical process, and in chemical digestion. Churning and mixing is mediated by coordinated contraction and relaxation of smooth muscle. Digestion is mediated by gastric secretions. About 20% of the protein in food is broken down in the stomach. Only a very small amount of fat digestion occurs.

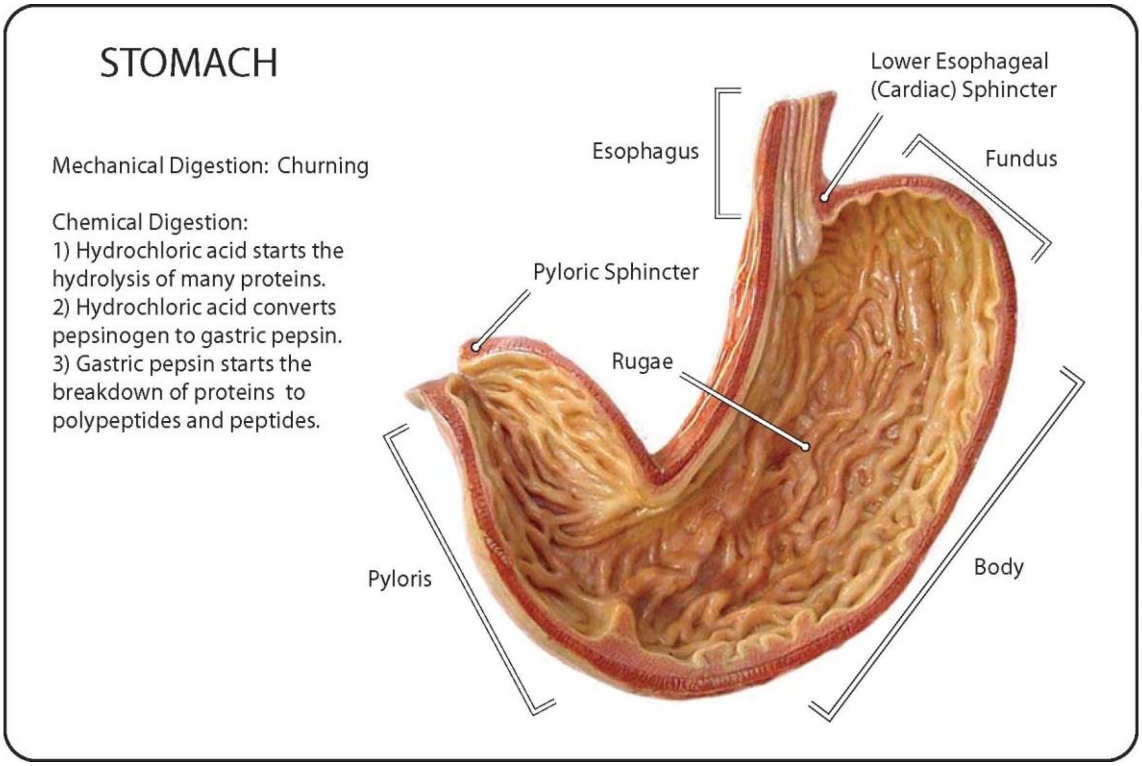

Figure 7.4 © 2007 David G. Ward, Ph.D.

As food is swallowed and arrives in the stomach, waves of muscle contraction (peristalsis) are produced. Contractions start out weak in the body and become stronger toward the antrum (pylorus). The smooth muscle of the pyloric sphincter closes upon arrival of the peristaltic wave. Most of the chyme is forced back toward the body of the stomach, and little is expelled into the duodenum. The lower esophageal sphincter prevents the contents of the stomach from entering the esophagus.

A photomicrograph of the mucosa of the stomach, including the gastric glands and surface epithelium is shown in Figure 7.5. The sight or smell of food induces gastric secretion largely by activating the parasympathetic nervous. Parietal cells secrete HCl and chief cells secrete pepsinogen.

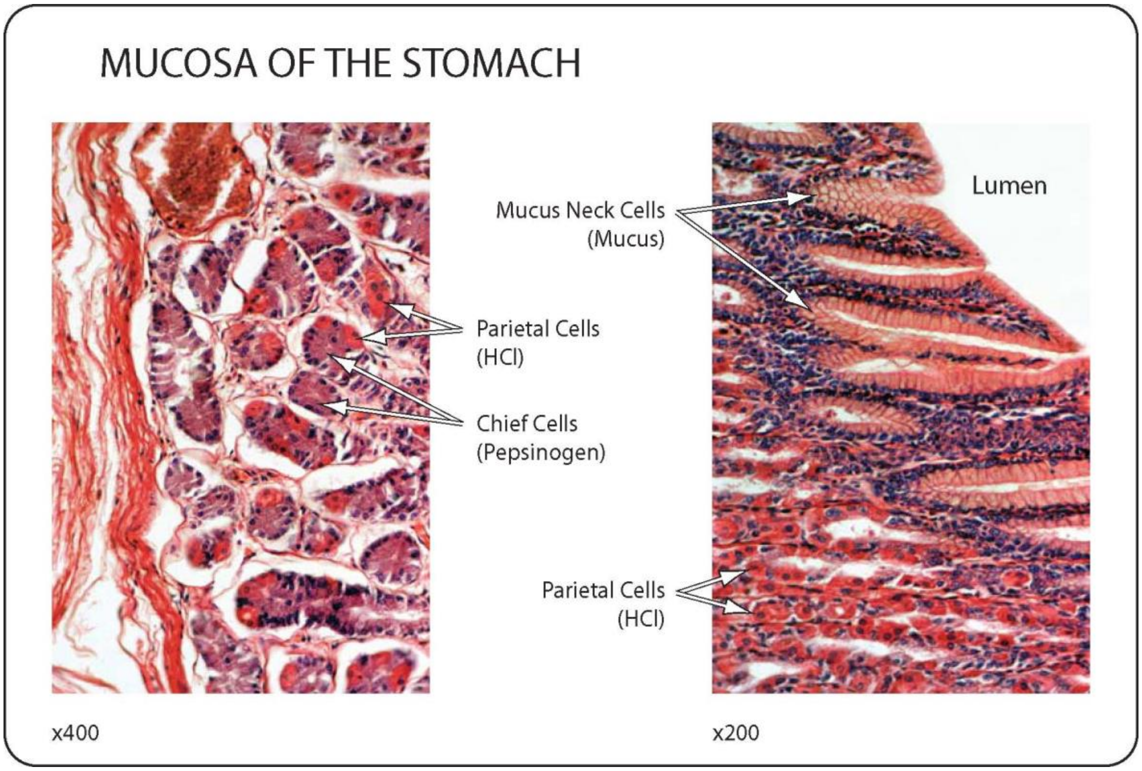

Figure 7.5 © 2007 David G. Ward, Ph.D.

When food enters the fundus of the stomach, distension of the stomach and the presence of peptides and amino acids stimulate secretion of HCl by parietal cells and pepsinogen by chief cells.

- The gastric mucus neck cells and surface epithelium secrete mucus and bicarbonate which protects the stomach from the digestive processes within the lumen of the stomach.
- Parietal cells secrete HCl.
- Chief cells secrete pepsinogens.
- HCl hydrolyzes many proteins and cleaves pepsinogens to form pepsins.
- Pepsins breaks down proteins to peptides.

Small intestine, pancreas and liver

An anterior view of the intestines and pancreas are shown in Figure 7.6. The small intestine is involved in mixing of the food with digestive enzymes, in chemical breakdown, and in absorption of nutrients and fluid. Most of the new enzymes mixed with the food come from the pancreas and liver. Most of the digestion of carbohydrates, proteins and fats in food occur in the small intestine.

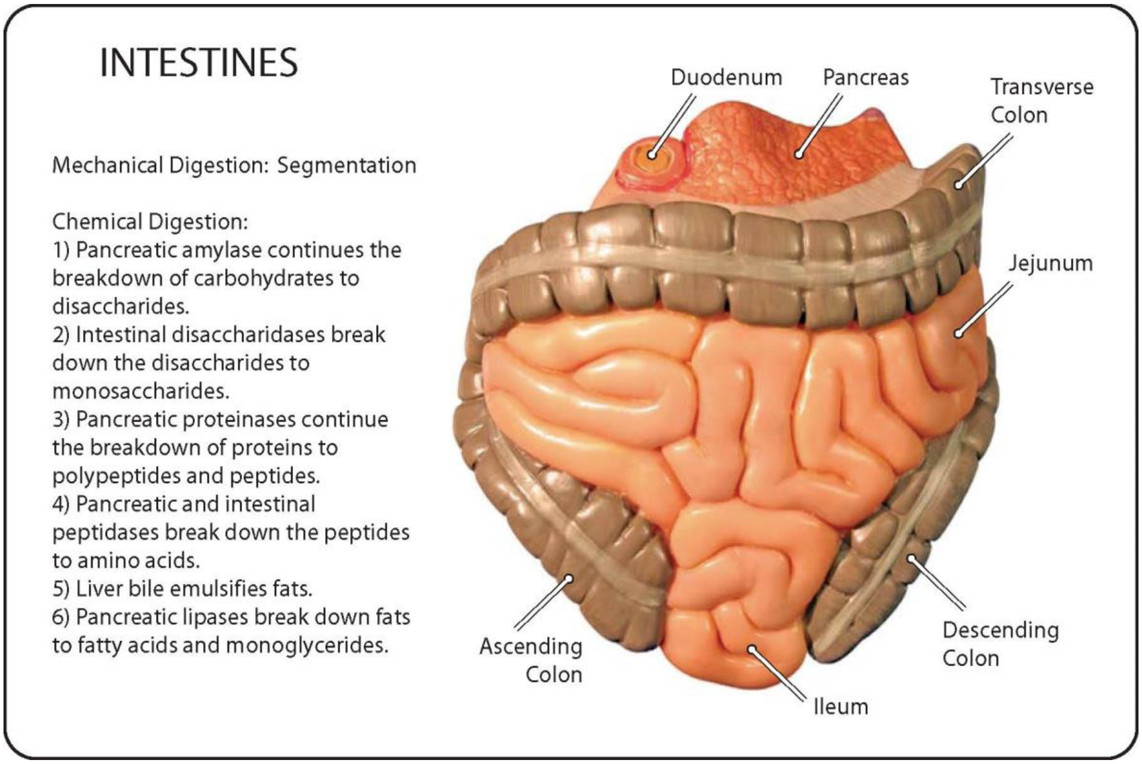

Figure 7.6 © 2007 David G. Ward, Ph.D.

In contrast to the peristaltic waves seen in the esophagus and stomach, the most common type of mechanical activity in the small intestines is stationary contraction and relaxation of intestinal segments. This sort of activity thoroughly mixes the contents of the intestines and brings them into contact with the intestinal wall.

Most of the new enzymes and related substances that are mixed with the food in the small intestines come from the pancreas and liver. As shown in Figure 7.7, the pancreatic duct (and sometimes an accessory pancreatic duct) and common bile duct travel to the duodenum where they merge to form the duodenal ampulla.

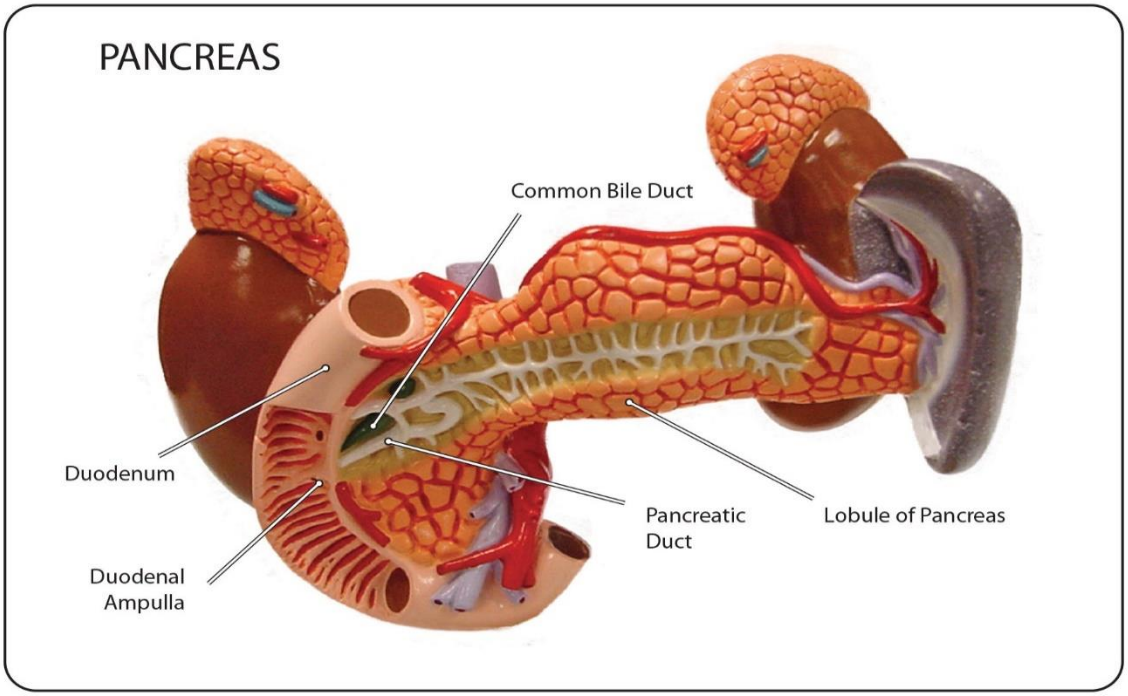

Figure 7.7 © 2007 David G. Ward, Ph.D.

Bile is produced by the liver and stored in the gallbladder. As shown in Figure 7.8, bile travels from the liver through hepatic ducts into the common hepatic duct. In turn, the common hepatic duct joins with the cystic duct from the gall bladder to form the common bile duct. As a result of this pattern of connections, bile can move to the duodenum directly from the liver or from storage in the gallbladder.

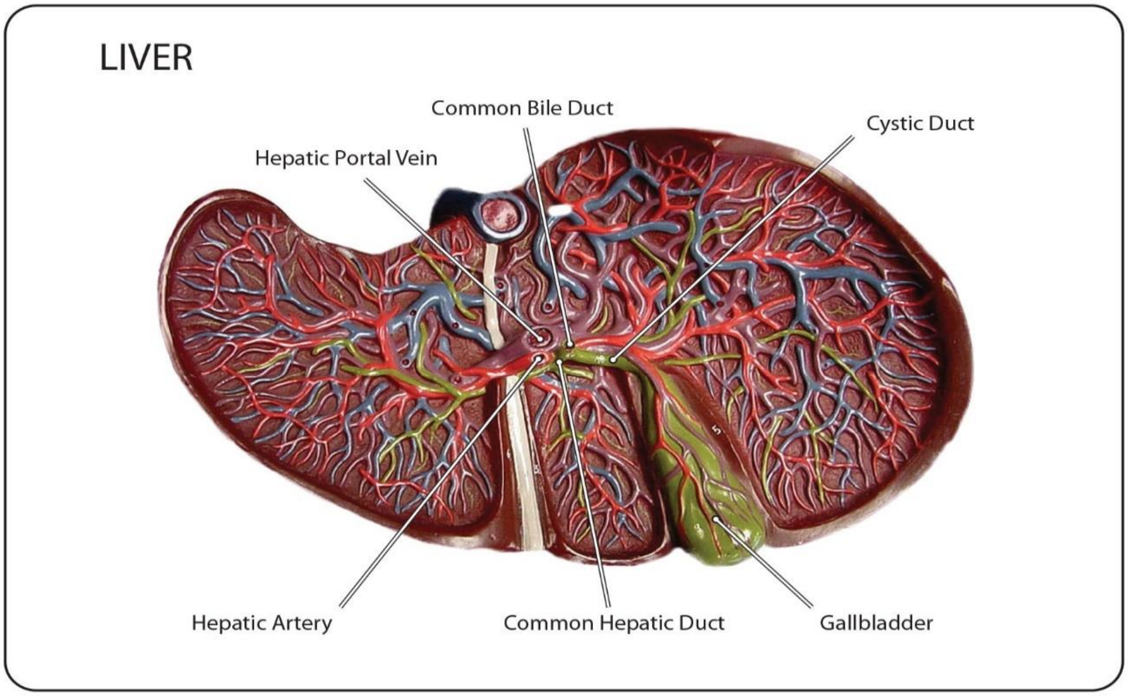

Figure 7.8 © 2007 David G. Ward, Ph.D.

Bile is a heterogeneous fluid that is composed of bicarbonate, bile salts, cholesterol, and bile pigments. Bile pigments (bilirubin) are derived from the breakdown of the heme group of hemoglobin. Bile salts are amphipathic steroid molecules produced from cholesterol that emulsify fat in the small intestine.

Large intestine (AKA Colon)

Contraction of the circular muscle of the large intestines produces a slow segmentation movement. Three or four times a day an intense contraction, called a mass movement, moves from the transverse colon toward the rectum. Control of these movements is mediated by the enteric nervous system and involves, at least, serotonin and acetylcholine. Unlike peristalsis the contraction persist for a prolonged time. The force of contraction of the slow segmentation movement is increased by the parasympathetic nervous system. The force of the mass movement is decreased by the sympathetic nervous system.