

Exercise 9: Digestive System

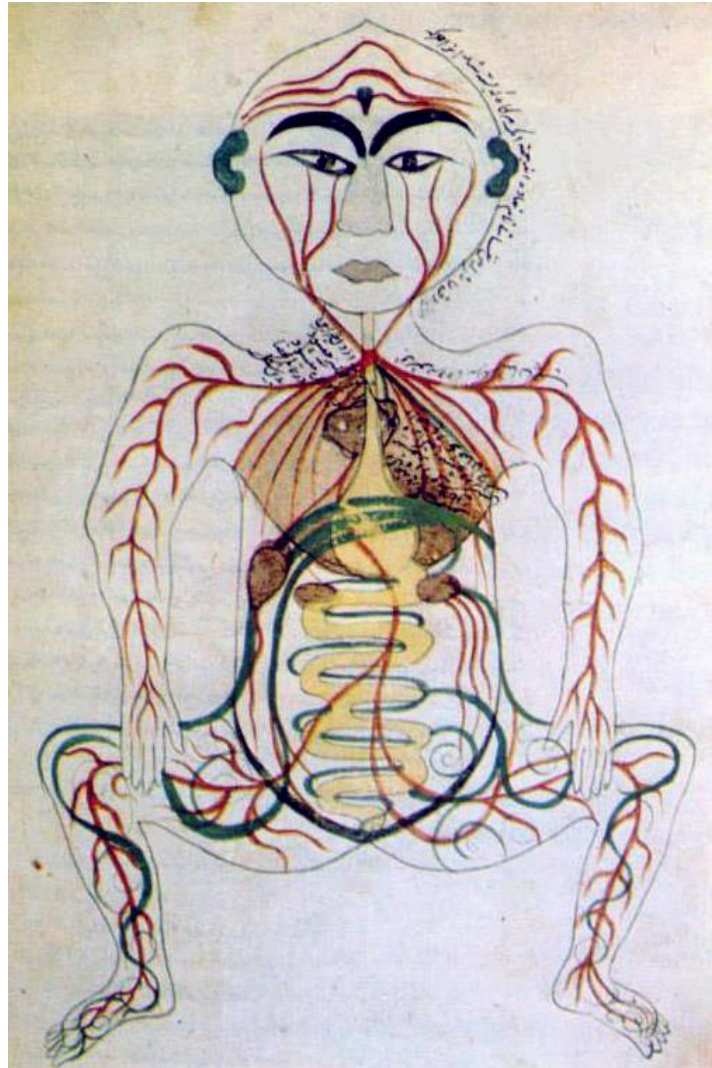


Figure 9.1. The above image is from a 17th century AD Persian manuscript by Mansur ibn Muhammad Ahmad illustrating the digestive system as it was known at that time.

(https://commons.wikimedia.org/wiki/Category:Human_digestive_system#/media/File:17th_century_Persian_digestive_system.jpg)

Exercise 9 Learning Goals

After completing this lab, you should be able to:

- Ascertain and define the organs of the digestive system
- Identify and describe the structure of the walls of the gastrointestinal tract
- Understand and dissect organs of the digestive system of the fetal pig
- Comprehend the chemistry of digestion and what is absorbed within different parts of the digestive system.

Pre-Lab Activity 9.1: Describe Structures of the Digestive System

Use an Anatomy and Physiology textbook to complete the table below.

| Structure | Function | Location | GI Tract or Accessory Organ |
|-----------------|----------|----------|-----------------------------|
| Mouth | | | |
| Pharynx | | | |
| Esophagus | | | |
| Stomach | | | |
| Small Intestine | | | |
| Large Intestine | | | |
| Teeth | | | |
| Tongue | | | |
| Salivary glands | | | |
| Liver | | | |
| Gallbladder | | | |
| Pancreas | | | |

Pre-Lab Activity 9.2: Digestive Structures

Use an Anatomy and Physiology textbook to label the structures numbered 1-30 below.

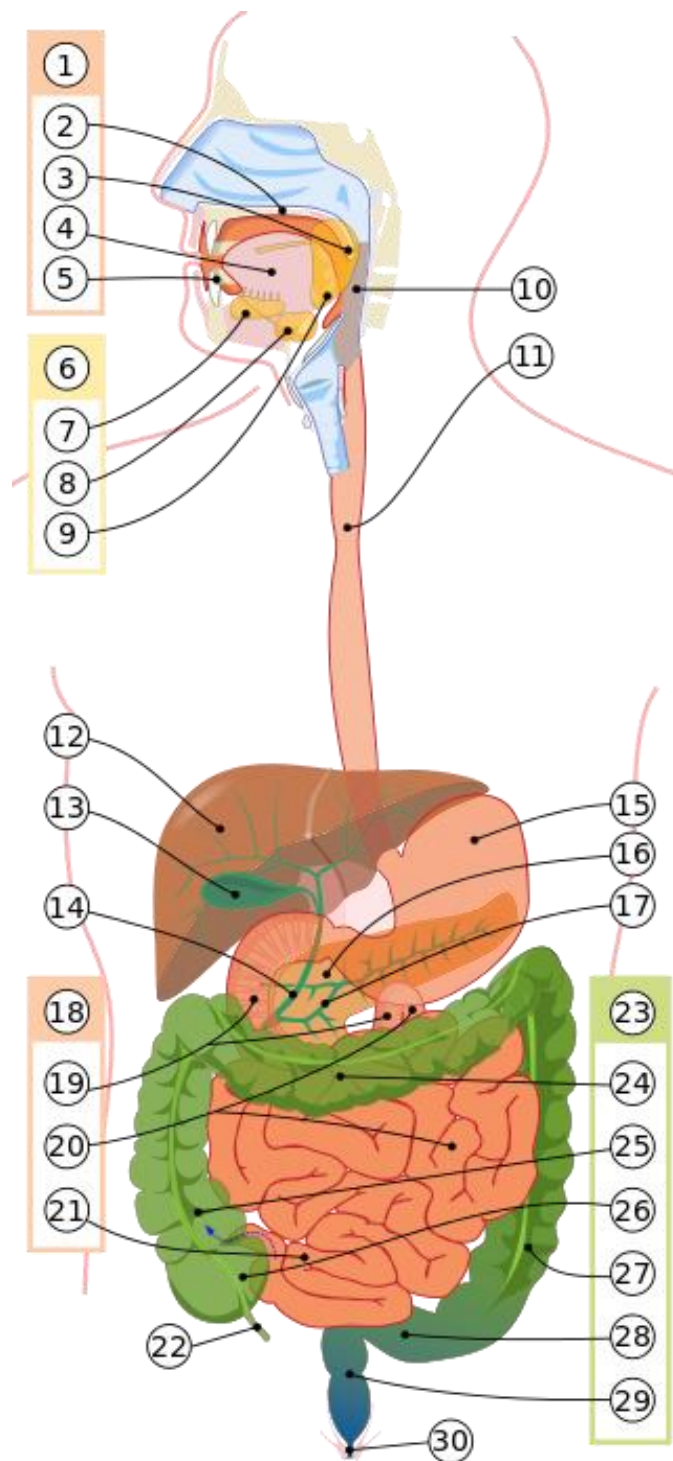


Figure 9.2 The Gastrointestinal tract.

https://commons.wikimedia.org/wiki/File:Digestive_system_diagram_en.svg#/media/File:Digestive_system_diagram_numbered.svg

Pre-Lab Activity 9.3: Layers of the GI Tract

Use an Anatomy and Physiology textbook to label the structures numbered in the figure below.

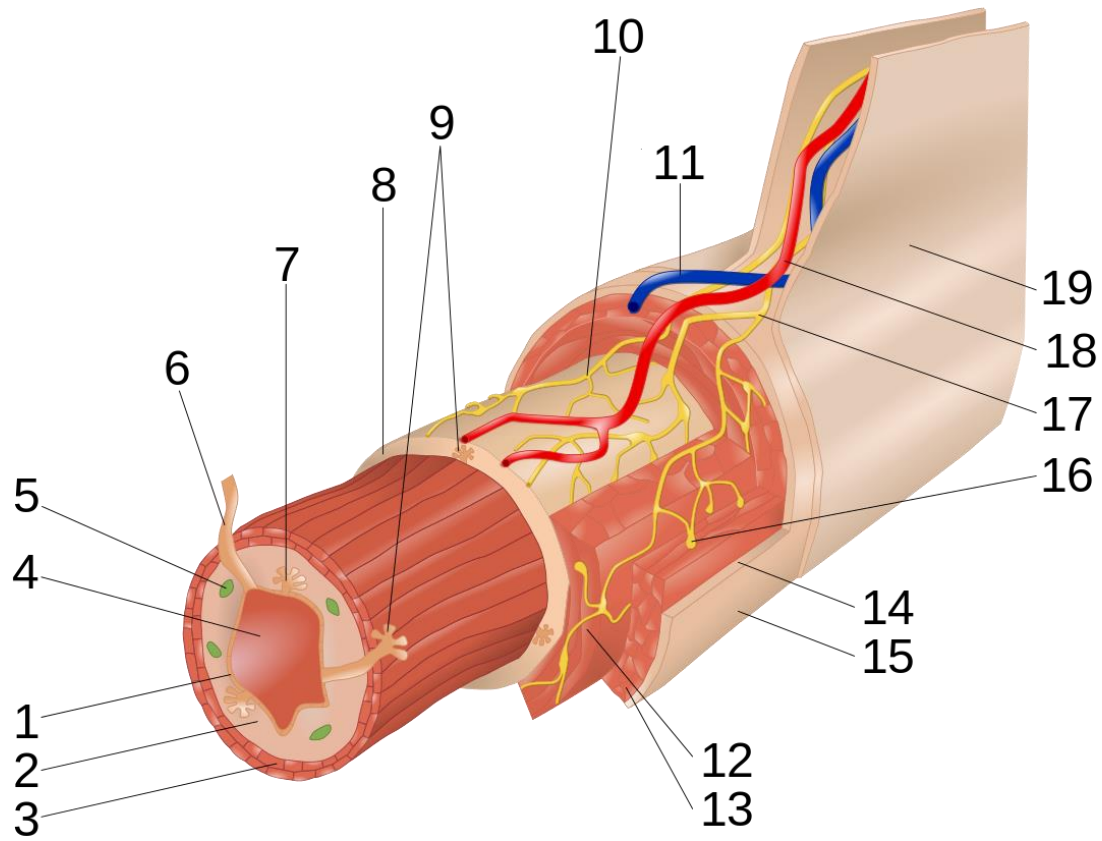


Figure 9.3 The wall of the GI Tract has four basic tissue layers: the mucosa, submucosa, muscularis, and serosa. (https://commons.wikimedia.org/wiki/File:Layers_of_the_GI_Tract_numbers.svg)

- | | |
|-----|-----|
| 1. | 11. |
| 2. | 12. |
| 3. | 13. |
| 4. | 14. |
| 5. | 15. |
| 6. | 16. |
| 7. | 17. |
| 8. | 18. |
| 9. | 19. |
| 10. | |

Pre-Lab Activity 9.4: Chemical and Mechanical Digestion

| Structure | Function or Definition | Location |
|--------------------|------------------------|----------|
| Masticate | | |
| Salivary amylase | | |
| Lysozyme | | |
| Deglutition | | |
| Rugae | | |
| Chyme | | |
| Pepsinogen | | |
| Gastrin | | |
| Cephalic Phase | | |
| Gastric Phase | | |
| Haustra | | |
| Defecation | | |
| Bile | | |
| Pancreatic amylase | | |
| Pancreatic lipase | | |
| Emulsification | | |

Lab Exercise 9: Digestive Anatomy

Location of Digestive Organs

The digestive system is critical for converting energy in food to potential chemical energy, a necessary process for muscle movement, nerve impulse conduction and other cellular events. Digestion involves both **chemical** and **mechanical** manipulation of macromolecules. Chemical digestion involves reactions that break down complex macromolecules into smaller molecules, which may then be used by cells for energy conversion. Mechanical digestion involves movements that facilitate chemical digestion. The digestive organs are divided into the gastrointestinal tract (GI) and accessory digestive organs. The GI tract is a long, hollow tube that extends from the oral cavity to the anus and includes the **mouth, pharynx, esophagus, stomach, small intestine, and large intestine**. The accessory organs assist with mechanical and chemical digestion and include the **teeth, tongue, salivary glands, liver, gallbladder and pancreas**.

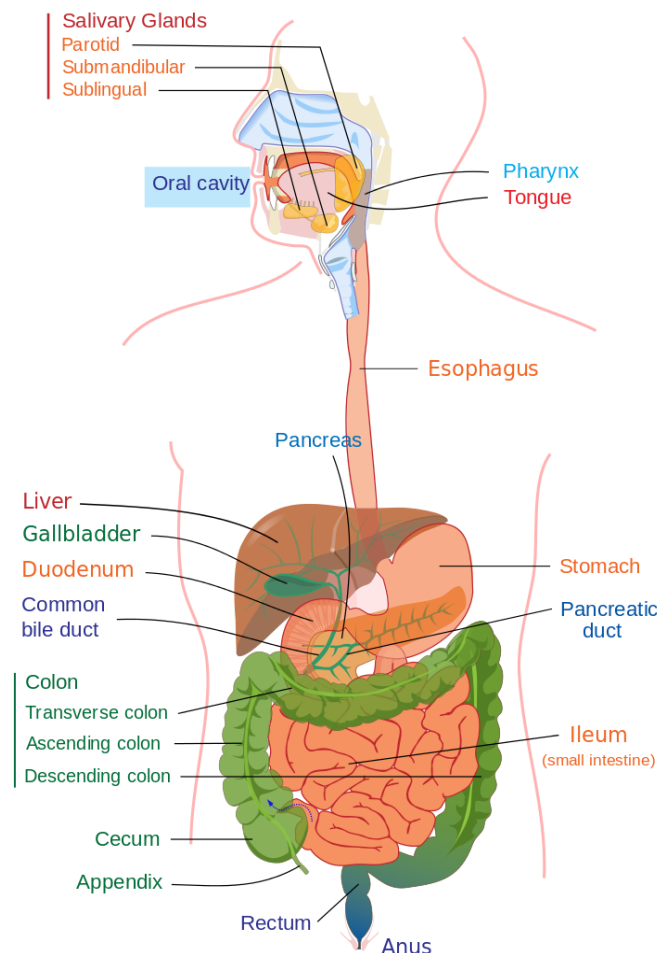


Figure 9.4 The Digestive System.

(https://commons.wikimedia.org/wiki/File:Digestive_system_diagram_en.svg#/media/File:Digestive_system_diagram_edit.svg)

Anatomically, the **mouth** (oral or buccal cavity) is formed by the cheeks, hard palate, soft palate and the **tongue**. Functionally, the mouth is the initial site of mechanical digestion through the **teeth** via chewing (mastication) food into smaller pieces and chemical digestion through saliva from the **salivary glands** which secrete the carbohydrate digesting enzymes and mixes with food. When swallowed, food passes into the **pharynx** a funnel-shaped tube also known as the throat. In the mouth food is reduced to a bolus or flexible mass that passes through the pharynx into the esophagus. The **esophagus** is a flexible and collapsible muscular tube that begins at the pharynx and connects to the stomach. The esophagus moves food from the pharynx to the stomach via peristalsis. Food passes from the esophagus to the **stomach**, a J-shaped sac, which is divided into four main regions, the **cardia** which surrounds the opening of the stomach, a rounded **fundus**, the central **body** and the **pylorus** which communicates with the duodenum of the small intestine. Further mechanical digestion of food occurs in the stomach via peristaltic waves, reducing the mass of food to a soupy liquid known as **chyme**. Chemical digestion in the stomach occurs by the addition of gastric juices to chyme and this begins digestion of lipids and proteins. There are two sphincters which regulate movement of the food bolus into and out of the stomach. The lower esophageal sphincter allows movement of the food from the esophagus into the cardia and the pyloric sphincter which regulates movement of food from the stomach to the small intestine. Located retroperitoneally, the **pancreas** delivers pancreatic juice to the duodenum of the small intestine. Pancreatic juice buffers the acidity of chyme coming from the stomach and is composed of enzymes that digest starches, proteins and lipids. The **liver** is located inferior to the diaphragm and is divided into a large right lobe and a smaller left lobe. The liver produces bile which is stored and concentrated in the gallbladder. The **gallbladder** is a pear-shaped sac that hangs inferiorly from the liver and stores **bile**. Bile plays an important role in the emulsification of fats. The majority of digestion and absorption of nutrients occurs in the **small intestine**. The small intestine is divided into three regions, the **duodenum** which is a short segment connected to the stomach and retroperitoneal; the **jejunum**, which connects the duodenum to the ileum; and the **ileum** which connects to the large intestine at the ileocecal sphincter. Mechanical digestion in the small intestine occurs via segmentation and peristalsis. Chyme entering the small intestine has partially digested carbohydrates, proteins, and lipids. In the small intestine this chemical digestion is continued and the majority of nutrients and water absorption occurs here. Any undigested material passes into the large intestine. The **large intestine** is the final portion of the GI tract. The large intestine functions to complete absorption, produce vitamins, form feces and expel feces from the body. The large intestine is structured into four regions the cecum, the **colon**, the rectum and the anal canal. The **anus** is the opening of the anal canal to the exterior and is guarded by an internal and external anal sphincter.

Lab Activity 9.1: Using a torso model identify the following structures of the digestive system.

- mouth
- salivary glands
- tongue
- pharynx
- Stomach body
- cardia
- fundus
- pylorus
- sigmoid colon
- transverse colon
- anus
- pancreas
- liver
- gallbladder
- duodenum
- jejunum
- ileum
- cecum
- ascending colon
- descending colon
- rectum

Lab Activity 9.2: Fetal pig digestion system dissection

| | |
|--|---|
| <input type="checkbox"/> Anus | <input type="checkbox"/> Liver |
| <input type="checkbox"/> Cardiac sphincter | <input type="checkbox"/> Lingual frenulum |
| <input type="checkbox"/> Cecum | <input type="checkbox"/> Lymph nodes |
| <input type="checkbox"/> Common bile duct | <input type="checkbox"/> Masseter muscle |
| <input type="checkbox"/> Cystic bile duct | <input type="checkbox"/> Mesentery |
| <input type="checkbox"/> Descending colon | <input type="checkbox"/> Oral cavity |
| <input type="checkbox"/> Diverticulum | <input type="checkbox"/> Papillae of tongue |
| <input type="checkbox"/> Duodenum | <input type="checkbox"/> Pancreas |
| <input type="checkbox"/> Duodenal papilla | <input type="checkbox"/> Parietal peritoneum |
| <input type="checkbox"/> Esophagus | <input type="checkbox"/> Parotid glands (R&L) |
| <input type="checkbox"/> Facial nerve | <input type="checkbox"/> Pyloric sphincter |
| <input type="checkbox"/> Fundus | <input type="checkbox"/> Rectum |
| <input type="checkbox"/> Gall bladder | <input type="checkbox"/> Small intestine |
| <input type="checkbox"/> Greater curvature | <input type="checkbox"/> Soft palate |
| <input type="checkbox"/> Greater omentum | <input type="checkbox"/> Spleen |
| <input type="checkbox"/> Hard palate | <input type="checkbox"/> Stensen's duct (R&L) |

| | |
|--|--|
| <input type="checkbox"/> Hepatic bile duct | <input type="checkbox"/> Stomach |
| <input type="checkbox"/> Ileocecal sphincter | <input type="checkbox"/> Sublingual gland (R&L) |
| <input type="checkbox"/> Ileum | <input type="checkbox"/> Submandibular gland (R&L) |
| <input type="checkbox"/> Jejunum | <input type="checkbox"/> Teeth |
| <input type="checkbox"/> Large intestine | <input type="checkbox"/> Tongue |
| <input type="checkbox"/> Lesser curvature | <input type="checkbox"/> Vestibule |
| <input type="checkbox"/> Lesser omentum | <input type="checkbox"/> Visceral peritoneum |

Supplies needed: Gloves, scalpel/scissors, blunt probe, tweezers

Use human terminology wherever terms for the pig may differ.

For the fetal pig digestive system:

1. To begin- gently peel the skin back from one side of the face, beginning at the ear and extending toward to the eye. The **parotid glands** lie on either side of the jaw, just beneath the skin. If you attempt to “rip” the skin back the gland will be destroyed or stay stuck to the skin.
2. Once the skin is removed you should be able to see the salivary glands. The **parotid gland** is the large pebble-textured tissue extending in a triangle from the base of the ear toward the mandible. The **submandibular gland** lies beneath the parotid at the angle of the mandible. It is approximately bean sized. The much smaller **sublingual gland** (approximately pea-sized) lies just anterior, sometimes slightly medial to the submandibular gland.
3. Gently separate the parotid gland to view the large muscle in the cheek- the **masseter muscle**. You should also see the facial nerve lying across the top of the masseter.
4. Locate the Stensen’s (parotid) duct, which carries saliva from the parotid glands, around the base of the masseter muscle, and then into the oral cavity.
5. To see the next set of structures, you must open up the oral cavity if you have not already done so. To do this, make an incision, beginning at the back of the mouth, extending through the masseter muscle, and ending at the back of the jaw. Be sure and make this incision on both sides of the face. When finished, you should be able to open the mouth nearly 180 degrees.

Observe the **tongue** and the papillae on its surface. The **lingual frenulum** is the tissue underneath the tongue that attaches it to the base of the oral cavity.

Observe the **hard palate**, the ridged, bony roof of the mouth. The **oral cavity** is the space between the hard palate and the tongue. The **soft palate** is the portion of the roof of the mouth at the back of the mouth.

Note the **teeth**, which are just beginning to erupt in the jaw. The **vestibule** is the space between the lips and the front teeth.

6. You are now finished with the structures in the mouth and will now trace the remaining length of the digestive tract. First, locate the **esophagus**, the collapsible tube lying underneath the trachea.

Trace the esophagus through the thoracic cavity to where it connects with the **stomach**. The ring of smooth muscle at the connection of the stomach and the esophagus is the **cardiac sphincter**. The **pyloric sphincter** is another ring of smooth muscle located at the other end of the stomach at its connection with the small intestine. The stomach is divided into various regions: the cardiac region is the area around the cardiac sphincter, the pyloric region is the area around the pyloric sphincter, the **fundus** is the small, finger-like projection on the upper left side of the stomach, and the body is what remains. In addition, the long outside curve of the stomach is called the **greater curvature**. Note the **spleen**, which is attached by a membrane, the **greater omentum**, to the greater curvature of the stomach (this membrane, which is very fragile, also extends from the spleen to the intestines). The short, inside curve of the stomach (to the right of the cardiac sphincter) is the **lesser curvature**. The **lesser omentum** is the membrane that attaches the liver to the lesser curvature of the stomach.

7. Make an incision along the length of the greater curvature of the stomach, beginning at the pyloric sphincter and ending at the fundus. You should now be able to see the internal anatomy of the stomach.

The gastric mucosa is the entire internal lining of the stomach. Some of the gastric mucosa is organized into folds or ridges of tissue known as rugae. The **diverticulum** is the small pouch or pocket in the upper left region of the stomach (to the left of the cardiac sphincter). The diverticulum is the fundus, seen from the inside. Also, note the internal appearance of the cardiac and pyloric sphincters.

8. Now look on the right underside of the liver. You should see a membranous pouch. This is the **gall bladder**. The thin tube extending from the gall bladder is the **cystic bile duct**. It joins with the **hepatic bile duct** coming from the liver and together they form the **common bile duct** that connects with small intestine.

9. Observe the small intestine. The short, straight region of the small intestine that begins at the pyloric sphincter is the **duodenum**. The small intestine of the pig then begins to coil. The first half of this section is called the **jejunum** and the second half is the **ileum**.

10. Return to your incision through the greater curvature of the stomach. Extend your incision through the pyloric sphincter and the first part of the duodenum.

Observe the **duodenal papilla**, the small knob of tissue located within the pyloric sphincter. This is where secretions from the common bile duct and the pancreas enter the small intestine.

Note the villi which cover the entire inner lining of the small intestine, giving it the appearance of crushed velvet.

11. Locate the **pancreas**, the white, pebbled structure located beneath the stomach and the small intestines.

Trace the small intestine to where it connects with the large intestine (also called the colon).

Note the short, dead-end section of the colon at its connection with the small intestine. This is the **cecum**.

Make an incision through the cecum. You should now be able to see the **ileocecal sphincter**, which is the small ring of smooth muscle that connects the small intestine to the colon.

12. Trace the rest of the length of the large intestine. In the pig, the spiral colon is the tightly wound portion immediately beyond the cecum. Humans do not have this arrangement- rather it is an ascending and transverse colon.

13. The **descending colon** emerges from the spiral colon and extends directly down through the abdominal cavity. The descending colon becomes the **rectum** as it enters the pelvis (note: you will be able to observe the rectum more clearly when you dissect the fetal pig reproductive systems). The **anus** is the external opening of the rectum and can be observed by lifting up the tail.

14. Return to the small intestine and note the membranes filled with blood vessels that extend along its length. This is the **mesentery**. Note at the base of the mesentery the numerous **lymph nodes**, which appear as small brown beads.

15. Finally, observe the peritoneum. The **parietal peritoneum** is the outer layer of the peritoneum that covers the abdominal cavity. The **visceral peritoneum** is the inner layer that covers the organs of the abdominal cavity (the greater and lesser omenta that you observed earlier are portions of the visceral peritoneum)

Post-Exercise 9 Review Questions

1. List the main organs of the digestive system.
2. Starting with the mouth, list the organs through which a chicken nugget would pass during a trip through the GI tract.
3. Describe the enzymes involved in chemical digestion.
4. List the regions of the small and large intestine and list their functions.