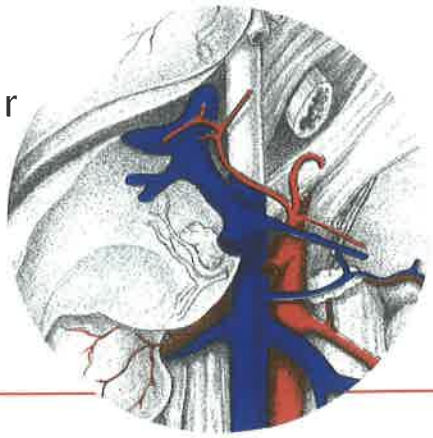
chapter four

THE DIGESTIVE SYSTEM



The digestive system is structurally divided into two main parts: a long, winding tube that carries food through its length, and a series of supportive organs outside of the tube. The long tube is called the **gastrointestinal (GI) tract**. The GI tract extends from the mouth to the anus, and consists of the mouth, or oral cavity, the pharynx, the esophagus, the stomach, the small intestine, and the large intestine. It is here that the functions of mechanical digestion, chemical digestion, absorption of nutrients and water, and release of solid waste material take place. The supportive organs that lie outside the GI tract are known as **accessory organs**, and include the teeth, salivary glands, liver, gallbladder, and pancreas.

Because most organs of the digestive system lie within body cavities, you will perform a dissection procedure that exposes the cavities before you begin identifying individual organs. You will also observe the cavities and their associated membranes before proceeding with your study of the digestive system.

EXPOSING THE BODY CAVITIES

With your skinned cat on its dorsal side, examine the cutting lines shown in Figure 4.1 and plan out your dissection. Note that the numbers indicate the sequence of the cutting procedure. Palpate the long, bony sternum and the softer, cartilaginous xiphoid process to find the ventral midline. Then, follow these instructions:

1. Begin your #1 incision by inserting the point of your scissors through the muscle layers about ¼-inch caudal to the tip of the xiphoid process. Make the cut large enough for your finger to poke through, then insert your finger into the body cavity to feel the space beneath the muscle layers. Your incision was very likely made just caudal to the **diaphragm**, an internal muscular partition dividing the thoracic and abdominopelvic cavities. Press your finger gently against the diaphragm; it should feel like the wall of a stretched balloon.

2. Extend the cut laterally in both directions, roughly 4 inches, still working with your scissors. Cut in a curved pattern as shown in Figure 4.1, which follows the contour of the diaphragm. Make your cut through all muscle layers and connective tissue, but be careful to avoid cutting too deeply and damaging the underlying organs. Find the diaphragm again, and with a scalpel, carefully cut it from its attachments to the ventral body wall. Allow the diaphragm to remain on top of the liver.

3. From your first incision, use your scissors to cut in a longitudinal direction roughly ¼-inch to one side of the ventral midline. While cutting, pull upward (toward you) with the scissors to create a space

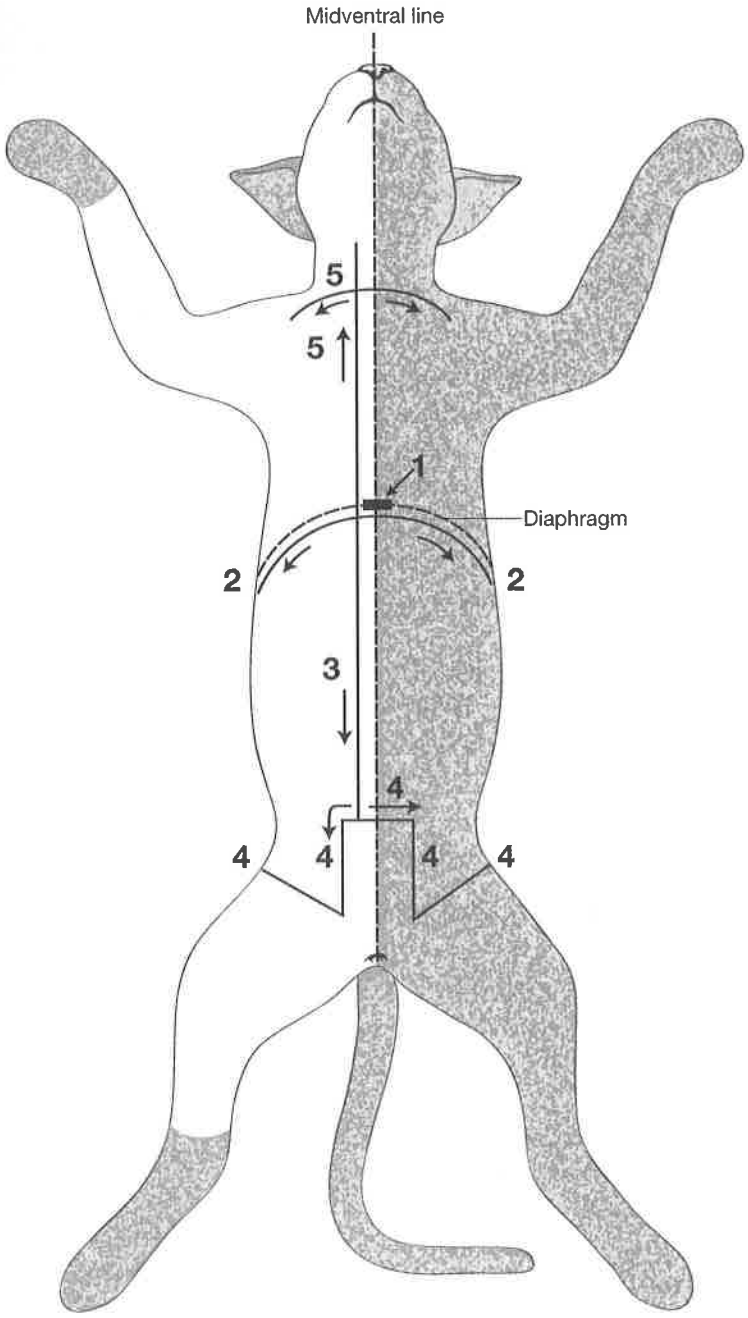


Figure 4.1 – Cutting guide for exposing body cavities (the numbers correspond to the sequences in the text).

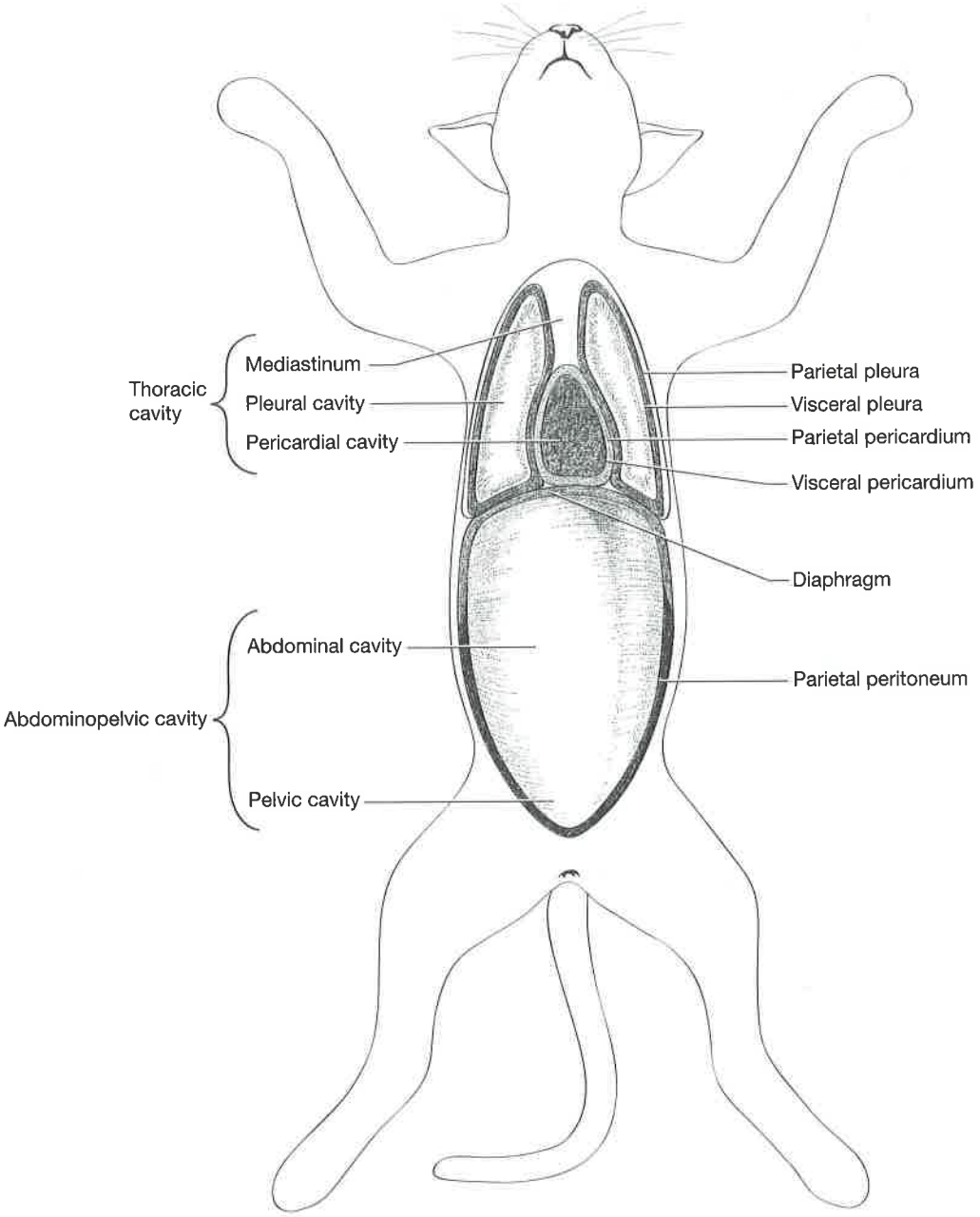


Figure 4.2 – Ventral body cavities.

between the body wall and the visceral organs. If performed carefully, this technique will help prevent the scissors from cutting into the organs.

4. Extend your cut down one side of the ventral midline caudally at first, but stop when you feel the resistance of a membrane near the urinary bladder. Then cut laterally about ½ inch, then caudally another ½ inch, then continue the horizontal cut to the iliac crest (see Figure 4.1). These cuts will enable you to cut around the genital region without damaging it.

5. Now you are ready to expose the thoracic cavity. Extend your midventral incision toward the neck region from the #1 incision near the xiphoid process, and cut in a cranial direction. As you reach the neck region, you will have to proceed very slowly to avoid damaging the arteries (colored red with latex), veins (colored blue with latex), and nerves (white). Cut only muscle tissue to expose the organs lying deep in the neck, including the trachea, thyroid gland, and larynx.

6. With your cutting complete, reflect the thoracic and abdominal walls to reveal the internal cavities. You will have to fracture ribs to reflect the thoracic wall, so press the walls laterally until you hear the snapping sound. Since the fractured ends of the ribs can be sharp, take care to avoid cutting yourself.

VENTRAL BODY CAVITIES AND MEMBRANES

Now that you've exposed the ventral body cavities and their associated membranes, identify them from the descriptions that follow (Figure 4.2). The ventral body cavity is also known as the **coelom**, or **coelomic cavity**.

Thoracic Cavity

The thoracic cavity is the potential space located cranial to the diaphragm. It is lined by a moist membrane called the **parietal pleura**. The parietal pleura continues inward to cover both lungs, forming the **visceral pleura**. Between the two pleural membranes is a moist space called the **pleural cavity**. The thoracic cavity also includes the **pericardial cavity** along its midline, which contains the heart. The pericardial cavity is sandwiched between two layers of the **pericardium**, which includes an outer **parietal pericardium** (or pericardial sac) and an inner **visceral pericardium**. In addition, the potential space located cranial to the heart is known as the **mediastinum**, which contains the major vessels of the heart and the thymus gland.

Abdominopelvic Cavity

The abdominopelvic cavity is the large cavity located caudal to the diaphragm. It is lined by a membrane attached to the inner body wall called the **parietal peritoneum**. The parietal peritoneum extends inward to wrap around many of the organs of the abdominoplevic cavity. The part of the peritoneum covering most of the visceral organs is known as the **visceral peritoneum**. The cavity between the two peritoneal membranes is called the **peritoneal cavity**, and contains a small amount of fluid that helps reduce friction between adjacent visceral organs. The peritoneum also includes numerous extensions, or folds, which will be described later in this chapter. The abdominopelvic cavity contains many visceral organs, including the stomach, small intestine, large intestine, liver, pancreas, gallbladder, internal reproductive organs, and more. Its larger cranial portion is the **abdominal cavity**, which extends from the diaphragm to the level of the iliac crest. The smaller caudal area is the bowl-shaped **pelvic cavity**.

CRANIAL DIGESTIVE STRUCTURES

The organs and associated structures of the digestive system will be described sequentially from the

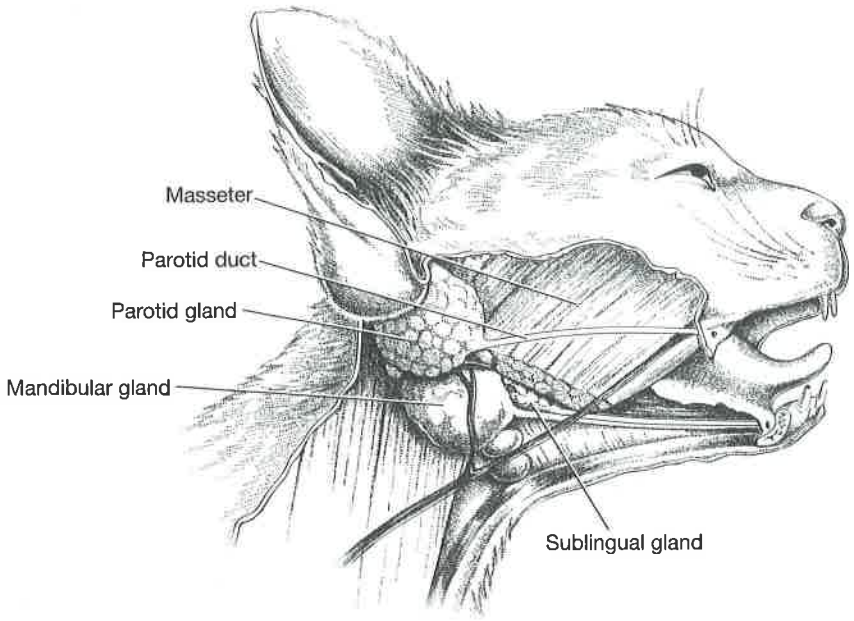


Figure 4.3 – Salivary glands (lateral view of the head and neck).

salivary glands around the mouth to the anus. The system has been divided into a cranial portion and a caudal portion, with the diaphragm serving as the line of division between the two. The cranial digestive structures include the salivary glands, oral cavity, pharynx, and esophagus. Locate each structure in your cat and identify its characteristic features.

Salivary Glands

To expose the **salivary glands**, carefully remove any connective tissue and fat that remains on the lateral side of the head and neck, especially on the surface of the masseter muscle. Be very careful to avoid damaging blood vessels, nerves, and small tubes that you see as you clean.

The salivary glands are located in the head region surrounding the oral cavity. They are soft, lobular structures that connect to the oral cavity by way of a duct. Salivary glands are exocrine glands that secrete a watery fluid, saliva, into ducts that carry it into the oral cavity when food is present. The cat has three major salivary glands and two minor glands.

PAROTID GLANDS: the largest of the salivary glands, they are paired structures located superficial to the masseter muscle on each side of the head just below the ear (Figure 4.3). Emerging from its rostral surface is the **parotid duct**, which crosses over the masseter muscle before entering the vestibule (space between the teeth and the lip). It opens opposite to the third upper premolar tooth.

MANDIBULAR GLANDS: paired glands, each located immediately ventral to the parotid gland and posterior to the angle of the mandible (Figure 4.3). The duct emerges from the anterior edge of each gland, then extends laterally beneath the digastric muscle to enter the floor of the oral cavity just anterior to the lingual frenulum (beneath the tongue).

SUBLINGUAL GLANDS: small, paired glands located at the anterior end of each mandibular gland. The sublingual duct extends parallel to the submandibular duct, although it is smaller and difficult to observe.

MOLAR GLANDS: a minor pair of salivary glands in the cat, each located at the angle of the jaw immediately deep to the skin (not shown). Several small, inconspicuous ducts open at the inner surface of the cheeks.

ZYGOMATIC GLANDS: a minor pair of salivary glands, each located in the floor of the eye orbit (not shown). A small duct from each gland opens at the posterolateral part of the roof of the mouth.

The salivary glands of humans include the large parotid glands, the submandibular glands, and the sublingual glands. The parotids are located similarly to those of the cat, and the parotid duct opens into the vestibule opposite the second maxillary molar tooth. The submandibulars are paralleled by the mandibulars in the cat. The sublinguals are located anterior to the submandibulars at the base of the tongue, and the sublingual duct opens into the floor of the oral cavity directly above the glands. Humans do not have molar and zygomatic glands.

Oral Cavity

To expose the mouth, or **oral cavity**, cut through the muscles and connective tissue suspending the jaw on one side of your cat. Using bone shears, cut the condyloid portion of the mandible on the same side. Pry the mouth open, and locate the following structures of the oral cavity (Figure 4.4).

VESTIBULE: the part of the oral cavity located between the teeth and cheeks. Notice the **labial frenulum**, which is a fold of tissue through the midline of the vestibule connecting the upper and lower lips.

TEETH: the dental formula for the cat is as follows: for the upper jaw, 6 incisors, 2 canines, 3 premolars, and 2 molars (6:2:3:2); for the lower jaw, 6 incisors, 2 canines, 4 premolars, and 2 molars (6:2:4:2). This dentition reflects adaptations for a carnivorous diet. *The comparative dental formula for adult humans is the same for both jaws: 4 incisors, 2 canines, 4 premolars, and 6 molars. Also, the human canines are shorter and more blunt, and the molars are more flat, which reflect the omnivore diet that includes less cutting and ripping, and more grinding.*

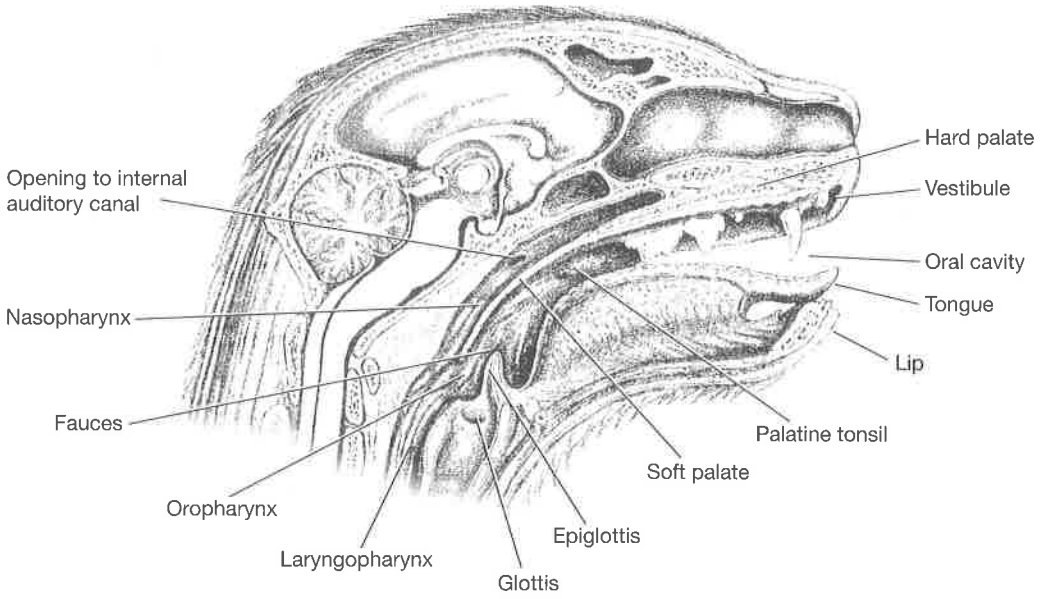


Figure 4.4 – Oral cavity and pharynx.

HARD PALATE: the rostral portion of the roof of the oral cavity. It is formed by the maxillary and palatine bones and is lined with mucous membrane.

SOFT PALATE: caudal to the hard palate, it is a muscular partition between the oral cavity and nasal cavity, and is lined with mucous membrane.

TONGUE: the large, muscular organ that makes up the floor of the oral cavity. It is attached to the floor of the mouth by a ventral fold of tissue called the **lingual frenulum**. The frenulum can be seen when the tongue is lifted from the floor. The tongue's surface contains four types of elevated structures called **papillae**, which house the taste buds for the reception of taste. In the cat, the most common papillae are the **filiform**, which include sharp projections to give the cat a friction surface for grooming. Other papillae include the mushroom-shaped **fungiform**, the large, rounded **vallate**, and the leaf-shaped **foliate**. *The human tongue is very similar, except filiform papillae are less abundant and not as sharply pointed, and foliate papillae are not present.*

PALATOGLOSSAL ARCHES: lateral folds on both sides of the oral cavity wall, extending from the caudal portion of the tongue to the soft palate. They represent the boundary between the oral cavity and the pharynx.

FAUCES: the opening at the extreme caudal portion of the oral cavity between the palatoglossal arches. The fauces leads into the oropharynx.

Pharynx

The **pharynx** is the chamber located caudal to the fauces, extending from the oral cavity to the larynx (Figure 4.4). It provides a passageway for air traveling to and from the lungs and for food traveling from the mouth to the esophagus. It is commonly divided into three sections, the nasopharynx, oropharynx, and laryngopharynx.

NASOPHARYNX: the cranial part of the pharynx. To view it, make a longitudinal incision along the midline of the soft palate, and carefully pry the two sections apart as far as possible. If one is available, shine a light into the cavity. In the lateral walls of the nasopharynx are the openings to the paired **internal auditory canals**, which communicate with the middle ear.

OROPHARYNX: located between the palatoglossal arches and the free caudal margin of the soft palate. The oropharynx communicates with the oral cavity through the fauces. Embedded within its laterodorsal walls are a pair of **palatine tonsils**, each of which lies partially recessed in a shallow depression called the tonsilar fossae.

LARYNGOPHARYNX: the caudal part of the pharynx. It extends from the oropharynx to the larynx. Its slit-like opening to the larynx is called the **glottis**, which is protected from passing food particles by a movable fold known as the **epiglottis**.

Esophagus

The **esophagus** is long, muscular tube that transports swallowed material from the pharynx to the stomach. It lies dorsal to the trachea and travels the length of the thoracic cavity. At its caudal end it penetrates the diaphragm to unite with the stomach in the abdominal cavity. Because it is located in the thoracic cavity dorsal to the heart and lungs, the esophagus will not be dissected at this time, but you will be able to observe it during your study of the respiratory system (Chapter 5).

CAUDAL DIGESTIVE STRUCTURES

The structures of the digestion system located caudal to the diaphragm include the liver, gallbladder, stomach, pancreas, small intestine, and large intestine. To observe these organs and their associated structures, pull back the flaps of the abdominal wall to expose the abdominopelvic cavity.

Peritoneum

The **peritoneum** is the extensive serous membrane of the abdominopelvic cavity, which you observed when you initially opened the cavity.

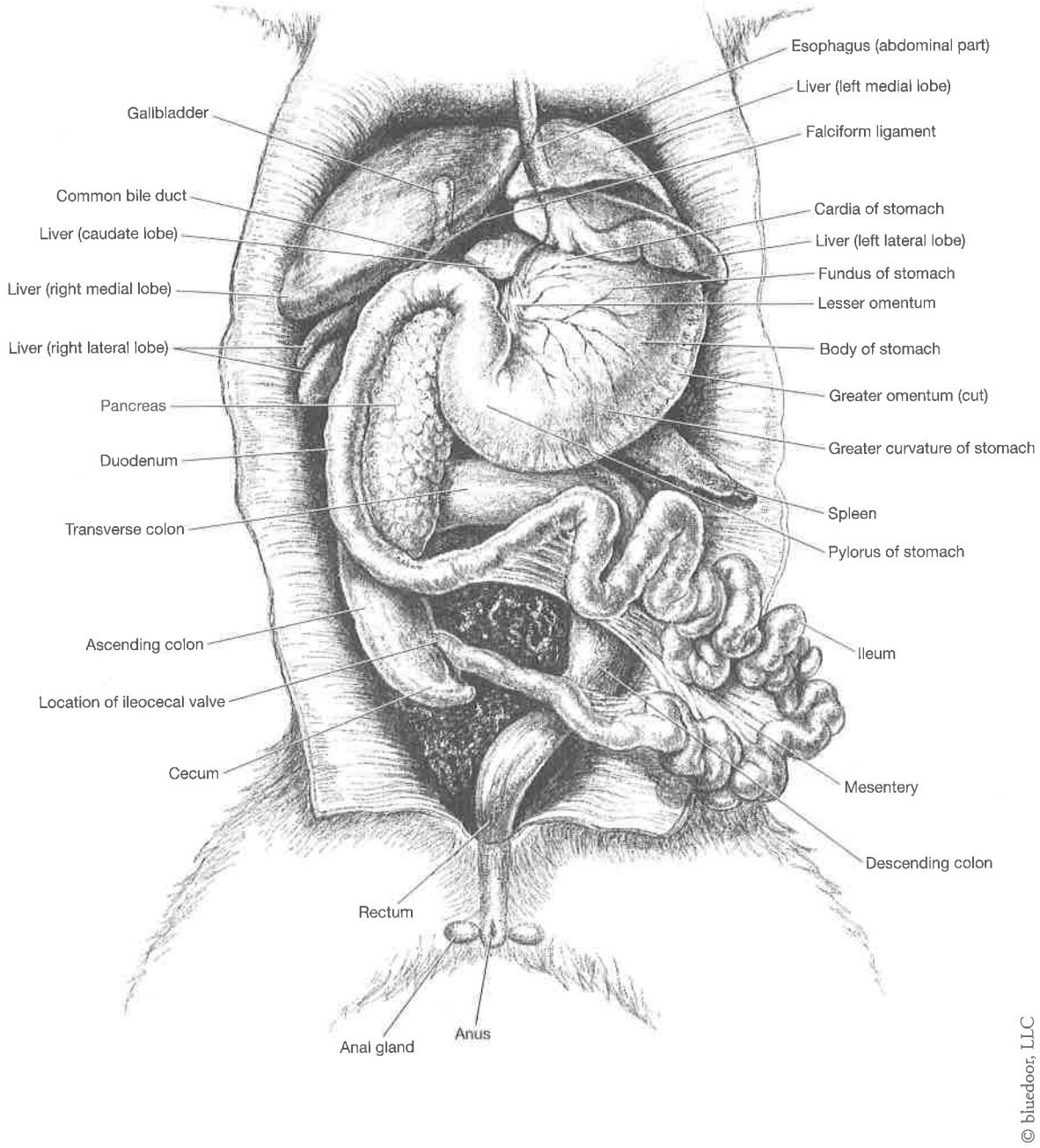


Figure 4.5 – Organs and peritoneum of the abdominopelvic cavity.

The **peritoneal folds** are extensions of the visceral and parietal peritonea, and include the following (Figure 4.5):

FALCIFORM LIGAMENT: a double-layered extension of the visceral peritoneum of the liver. It anchors the liver to the dorsal wall of the abdomen and the diaphragm, and separates the liver into right and left lobes.

MESENTERY: a double layer of peritoneum that extends from the visceral peritoneum of the small and large intestines to the dorsal abdominal wall. The portion that suspends the small intestine is called the **mesentery proper**, the part supporting the large intestine is the **mesocolon**, and the part attached to the rectum is the **mesorectum**. Note that the pancreas is located within the mesentery proper.

LESSER OMENTUM: a double layer of peritoneum extending from the lesser curvature of the stomach and the duodenum of the small intestine to the liver. Notice the common bile duct, which is located on the free edge of the lesser omentum. This duct transports bile from the liver and gallbladder to the duodenum.

GREATER OMENTUM: a double layer of peritoneum that extends from the greater curvature of the stomach to the dorsal abdomi-

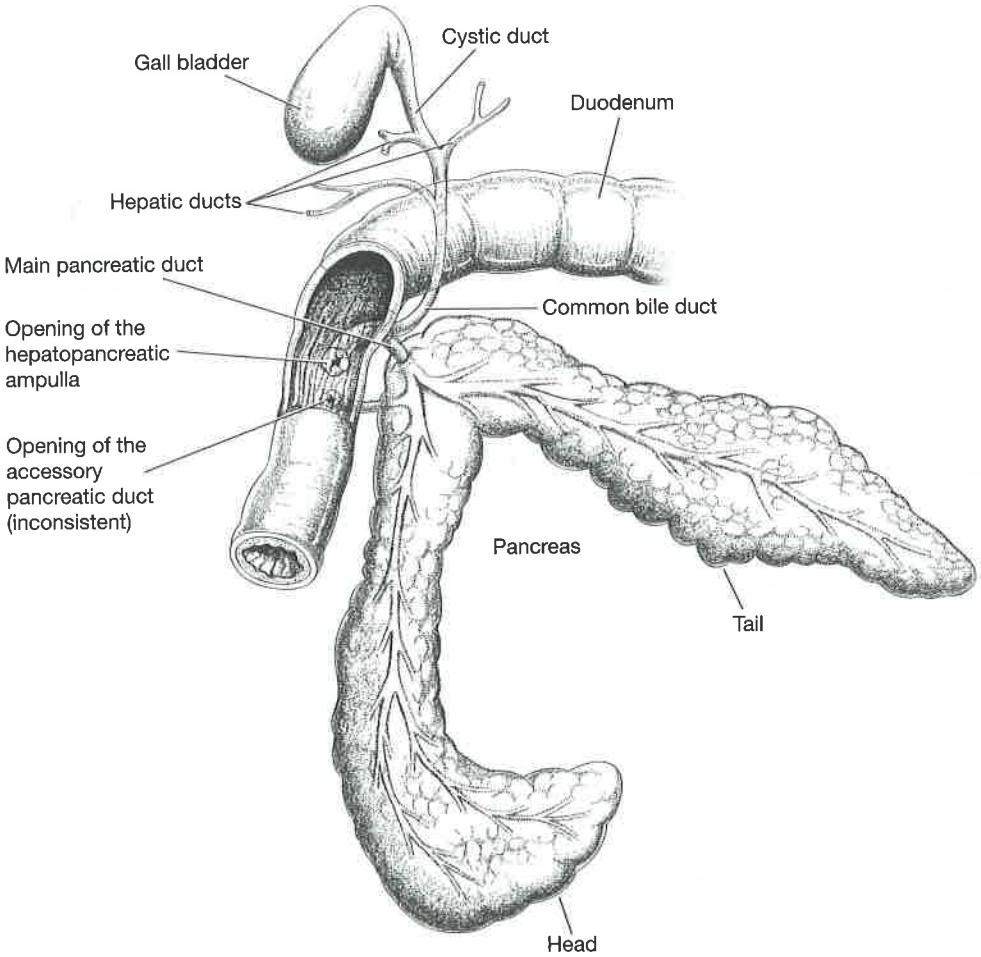


Figure 4.6 – Gallbladder, biliary ducts, and pancreas.

nal wall. The double-layered sac extending ventrocaudally to the small intestine is called the **omental bursa**, or lesser peritoneal sac, and contains fat deposits, lymph nodes, and lymphatic vessels.

Liver

The **liver** is the prominent, dark-brown organ lying immediately deep to the diaphragm, with most of its bulk on the right side (Figure 4.5). Its functions include management of sugar and fat levels in the blood, storage of toxins, and production of a yellow-green fluid that breaks down fats, called bile. In the cat, the liver is divided into six lobes. Identify the falciform ligament once again, which divides the liver into right and left portions. The left side of the liver includes a **left medial lobe** and a **left lateral lobe**. The right side of the liver includes a **quadrate lobe** adjacent to the falciform ligament, which is partially united with the **right medial lobe**. Between these two lobes is a depression that contains the greenish sac known as the gallbladder. Dorsolateral to the right medial lobe is the **right lateral lobe**, and dorsal to it is the smaller **caudate lobe**. *The human liver is also a prominent organ, but contains only four lobes: a large right lobe separated from the smaller left lobe by the falciform ligament, a quadrate lobe, and a caudate lobe.*

Gallbladder

Elevate the right medial lobe and quadrate lobe of the liver to observe the **gallbladder**, located in a depression between the two lobes, known as the cystic fossa (Figures 4.5 and 4.6). The gallbladder is a thin-walled sac that receives newly manufactured bile from the liver for temporary storage. When a meal is consumed, the gallbladder contracts to push bile into the **cystic duct**. The cystic duct combines with numerous **hepatic ducts** arising from the left lobes and right lateral lobe of the liver to form the **common bile duct**. The common bile duct extends caudally to unite with the duodenum of the small intestine at the hepatopancreatic ampulla. Once in the small intestine, bile assists in the digestion of fats.

Stomach

The stomach is a J-shaped enlargement of the GI tract, located directly beneath the diaphragm on the left side of the abdominal cavity (Figure 4.5). It functions as a temporary reservoir for swallowed food, and its inner lining contains **gastric glands** that secrete hydrochloric acid and the enzyme pepsinogen to begin the process of protein digestion. The lateral border of the stomach forms a rounded, convex surface called the **greater curvature**, and its medial border forms a concave angle known as the **lesser curvature**. Note the peritoneal fold called the greater omentum, which originates from the greater curvature to hang downward. Also note the flat, elongate, dark-reddish **spleen** near the left dorsolateral surface of the greater curvature. The spleen is part of the lymphatic system. Similar to the human stomach, the stomach of the cat is divided into the following parts:

CARDIA: the part of the stomach that receives the esophagus. It surrounds the **lower esophageal sphincter**, the ring of muscle that separates the stomach from the esophagus.

FUNDUS: a sac-like, rounded portion that extends laterally to the cardia and slightly craniad.

BODY: the large, central portion of the stomach, which is located caudal to the fundus.

PYLORUS: the narrow, caudal part that communicates with the duodenum of the small intestine via a sphincter muscle called the **pyloric valve**.

Once you've identified the parts of the stomach, make an incision along the greater curvature from the fundus to the pylorus, taking great care to avoid damaging the greater omentum. Notice the folds in the wall of the stomach, which are called **rugae**. They allow the organ to expand with incoming food.

Small Intestine

The small intestine is a long, winding tube that extends from the pyloric valve of the stomach to its junction with the large intestine (Figure 4.5). The small intestine finalizes chemical digestion

and is the only site for nutrient absorption. Its inner lining is characterized by the presence of tiny, fingerlike **villi**, which increase its absorptive surface area. Similar to the human small intestine, the small intestine of the cat is divided into three segments:

DUODENUM: the largest of the three segments in diameter, but the shortest in length, it extends from the pyloric valve to its union with the jejunum. In the cat, it ranges in length from 12-18 cm (5-7 inches). The duodenum receives the common bile duct from the liver and gallbladder and the pancreatic duct from the pancreas.

JEJUNUM: the middle segment of the small intestine, it is the longest, with an average length of about 50 cm (20 inches) in the cat.

ILEUM: the caudal segment, it extends from its union with the jejunum to the large intestine about 35 cm (14 inches) in the cat. A doughnut-shaped muscle called the **ileocecal valve** surrounds the junction of the ileum and large intestine. Similar to the pyloric valve, it regulates the movement of materials from one organ (the small intestine) to the next (the large intestine), and prevents the reflux of contents in the opposite direction.

Large Intestine

The caudal portion of the GI tract, the large intestine extends from the ileocecal valve to the anus (Figure 4.5). It gets its name from being larger in diameter along its entire length than the small intestine, although it is roughly one-third the length. The large intestine absorbs water from the contents that arrive from the small intestine, and prepares and forms the feces. Smooth muscles in the wall of the large intestine contract to move the feces and release it during defecation. The large intestine contains the following segments:

CECUM: the cranial segment, which communicates with the ileum via the ileocecal valve. It is a short, blind diverticulum in the right caudal aspect of the abdominal cavity. *The human cecum includes a fingerlike tube extending from it, known as the appendix, which is lacking in the cat.*

COLON: a long, wide segment extending from the cecum to the rectum. The colon is divided into an **ascending colon**, which ascends from its union with the cecum to the area occupied by the liver; a **transverse colon** that travels transversely from the right side near the liver to the left side of the cranial abdominal cavity; and a **descending colon**, which curves caudally to descend to the pelvic cavity.

RECTUM: the terminal segment of the large intestine. The short rectum opens to the exterior via the **anus**, which is surrounded by sphincter muscles. A pair of scent glands, known as **anal glands**, open into the rectum near the anus. Secretions from the anal glands are important for marking territorial boundaries. *The large intestine of the human is similar to that of the cat, except the human includes a sigmoid colon between the descending colon and rectum, which is an S-shaped curvature. Also, humans lack anal glands.*

Pancreas

The **pancreas** is a diffuse mass of soft glandular tissue located within the mesentery proper of the small intestine (Figures 4.5 and 4.6). It is located just below the greater curvature of the stomach, and slightly dorsal to it, and includes a caudal head portion and a cranial tail portion. The pancreas functions in the secretion of hormones that regulate blood sugar levels, and also in the secretion of digestive enzymes and sodium bicarbonate. The digestive enzymes and sodium bicarbonate form the pancreatic juice, which is channeled out of the pancreas by the main **pancreatic duct**. This duct unites with the common bile duct to be delivered into the duodenum. At the union of the common bile duct and duodenum is a small elevation known as the ampulla of Vater, or **hepatopancreatic ampulla**. An accessory duct may also be present.