CHAPTER 4

ABDOMEN

The abdomen is the portion of the trunk that lies between the thorax and the pelvis. The abdominal cavity is divided from the thoracic cavity by the diaphragm but it is continuous with the pelvic cavity. Viscera contained within the abdominal cavity are not bilaterally symmetrical. Therefore, it is worth noting that use of the words "right" and "left" in names and instructions refers to the right and left sides of the cadaver in the anatomical position.

SURFACE ANATOMY

Firm fixation of tissues in the cadaver may make it difficult to distinguish between bony landmarks and well-fixed soft tissue structures. Place the cadaver in the supine position and palpate the following structures (Fig. 4.01): **[N 239]**

- **Xiphoid process**
- **Costal margin**
- **Pubic symphysis**
- **Pubic crest**
- **Pubic tubercle**

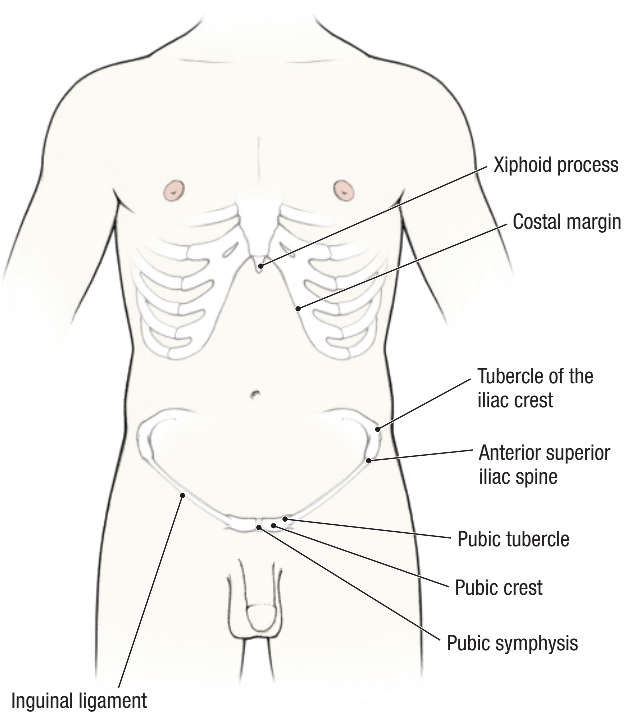

Figure 4.01. Surface anatomy of the abdomen.

KEY TO REFERENCES
G = Grant's Atlas, 11th ed., page number
N = Netter's Atlas, 3rd ed., plate number
R = Rohen's Color Atlas of Anatomy, 5th ed., page number
C = Clemente's Atlas, 4th ed., page number

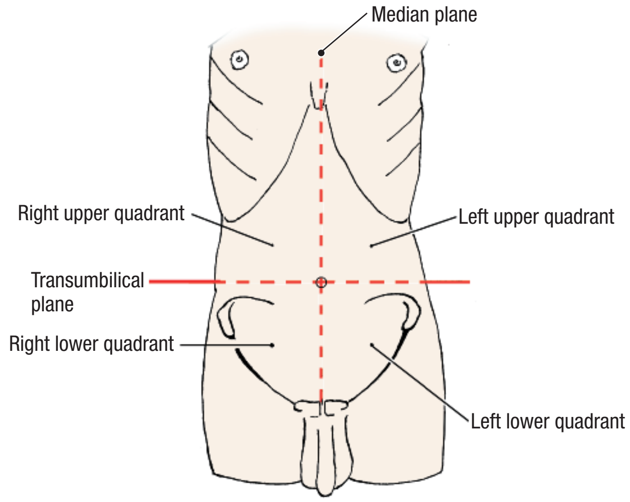

Figure 4.02. The four abdominal quadrants.

- **Inguinal ligament**
- **Anterior superior iliac spine**
- **Tubercle of the iliac crest**

To prepare patient notes, you will need to understand the terminology used to describe the abdomen. The quadrant and regional systems are in common use. The **quadrant system** divides the abdomen by means of the transumbilical plane and the median plane (Fig. 4.02). The quadrant system is suitable for general descriptions and will be used to describe the position of organs in this dissection guide. The **regional system** divides the abdomen based on the right and left midclavicular lines, the subcostal plane and the transtubercular plane (Fig. 4.03). Clinical symptoms may be more specifically described using the regional system.

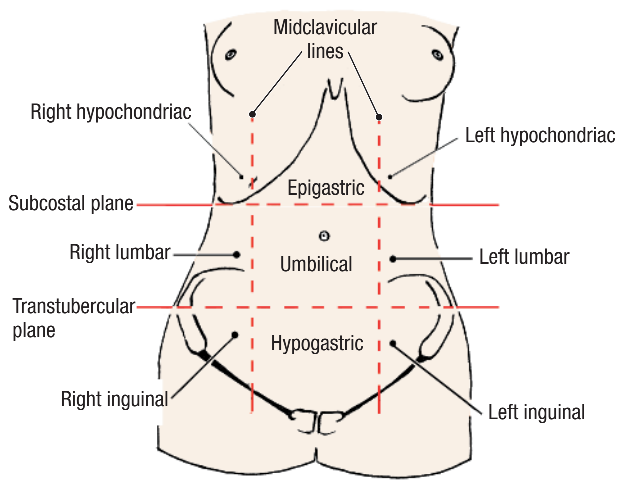

Figure 4.03. The nine abdominal regions.

SUPERFICIAL FASCIA OF THE ANTEROLATERAL ABDOMINAL WALL

Before you dissect . . .

The contents of the abdominal cavity are protected by the anterolateral abdominal wall. The organization of the layers forming the anterolateral abdominal wall is illustrated in Figure 4.04. The superficial fascia is unique in this region in that it has a **fatty (superficial) layer** called **Camper's fascia** and a **membranous (deep) layer** called **Scarpa's fascia**. The membranous layer is noteworthy, because it is continuous with named fascias in the perineum. [G 99; N 244; R 203; C 168]

Dissection Instructions

SKIN INCISIONS

1. Refer to Figure 4.05.
2. Make a midline skin incision from the xiphisternal junction (C) to the pubic symphysis (E), encircling the umbilicus.
3. Make an incision from the xiphoid process (C) along the costal margin to a point on the midaxillary line (V). If the thorax has been dissected previously, this incision has been made.
4. Make a transverse skin incision from the umbilicus to the midaxillary line.
5. Make a skin incision beginning 2 cm below the pubic crest (E). Extend this incision laterally, 2 cm inferior to the inguinal ligament to a point 2 cm below the anterior superior iliac spine. Continue the incision posteriorly, 2 cm below the iliac crest to a point on the midaxillary line (F).
6. Make a vertical skin incision along the midaxillary line from point "V" to point "F."
7. Reflect the skin from medial to lateral, detach it along the midaxillary line, and place it in the tissue container.

SUPERFICIAL FASCIA

1. Use a probe to tear through the superficial fascia approximately 7.5 cm lateral to the midline (Fig. 4.06). The **superficial epigastric artery and vein** are in the superficial fascia in this area, but do not make a special effort to find them.
2. Dissect through the superficial fascia down to the aponeurosis of the external oblique muscle. On the medial side of the incision, use your fingers to separate the superficial fascia from the aponeurosis of the external oblique muscle (Fig. 4.06, arrow 1).

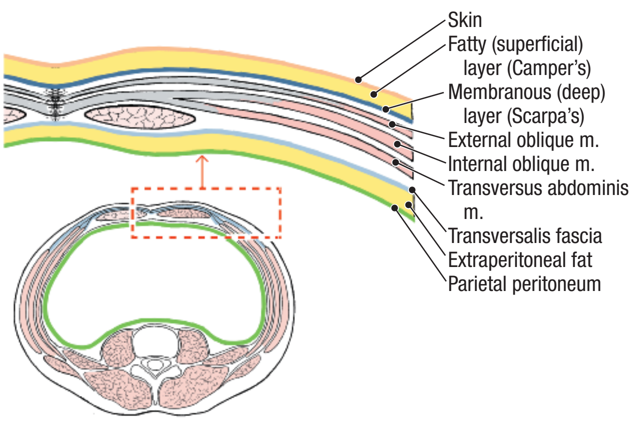

Figure 4.04. Layers of the anterior abdominal wall.

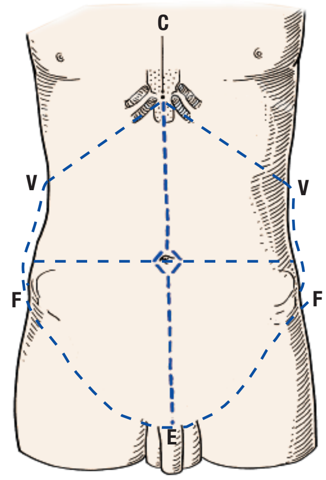

Figure 4.05. Skin incisions.

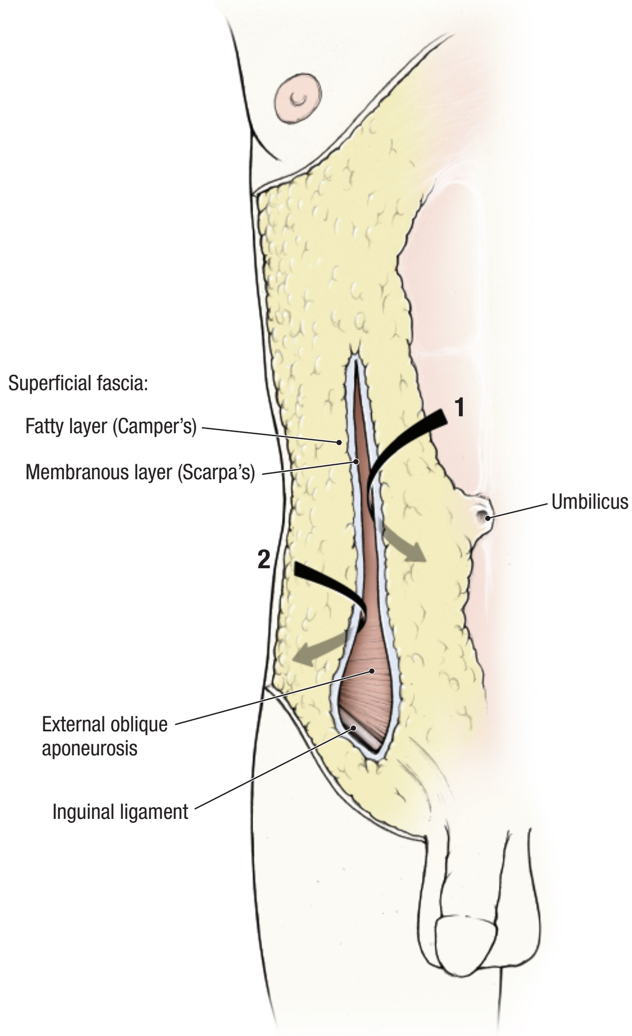

Figure 4.06. Removal of the abdominal superficial fascia.

3. As you approach the midline, palpate the **anterior cutaneous nerves** that enter the superficial fascia approximately 2 to 3 cm lateral to the midline. Clean one anterior cutaneous nerve. Anterior cutaneous nerves are branches of the **thoracoabdominal nerves (T7–T11), the subcostal nerve (T12), and the iliohypogastric and ilioinguinal nerves (L1)**. Consult a dermatome chart and note that: **[G 331; N 157; C 159]**
   - T7 innervates the skin overlying the xiphoid process.
   - T10 innervates the skin of the umbilicus.
   - T12 innervates the skin superior to the pubic symphysis.
   - L1 innervates the skin overlying the pubic symphysis. **[G 97; N 249; R 204; C 161]**
4. Lateral to the incision, use your fingers to separate the superficial fascia from the external oblique muscle (Fig. 4.06, arrow 2). As you near the midaxillary line, palpate the **lateral cutaneous nerves** entering the superficial fascia. The lateral cutaneous nerves are branches of thoracoabdominal nerves. Clean the branches of one lateral cutaneous nerve.
5. Remove the superficial fascia in an inferior direction until the lower border of the external oblique muscle is exposed (approximately 2.5 cm into the proximal thigh).
6. Detach the superficial fascia from the midline, midaxillary line, and proximal thigh and place it in the tissue container.

After you dissect . . .

Use an illustration to review the distribution of the superficial epigastric vessels. Review the abdominal distribution of the ventral primary rami of spinal nerves T7 to L1.

Superficial Veins of the Abdominal Wall

The superficial epigastric vein anastomoses with the lateral thoracic vein in the superficial fascia. This is an important collateral venous channel from the femoral vein to the axillary vein. In patients who have an obstruction of the inferior vena cava or hepatic portal vein, the superficial veins of the abdominal wall are engorged and become visible around the umbilicus (**caput medusae**).

MUSCLES OF THE ANTEROLATERAL ABDOMINAL WALL

Before you dissect . . .

Three flat muscles (external oblique, internal oblique, and transversus abdominis) form most of the anterolateral abdominal wall. The rectus abdominis muscle completes the anterior abdominal wall near the midline. The three flat muscles have fleshy proximal attachments (to the ribs, vertebrae, and the pelvis) and broad, aponeurotic distal attachments (to the ribs, linea alba, and pubis). Each of the three flat muscles contributes to the formation of the rectus sheath and the inguinal canal.

In the male, the testes are housed in the scrotum, which is an outpouching of the anterior abdominal wall. Each testis passes through the abdominal wall during development, dragging its ductus deferens behind it. This passage occurs through the **inguinal canal**. The inguinal canal is located superior to the medial half of the inguinal ligament and extends from the **superficial (external) inguinal ring** to the **deep (internal) inguinal ring**. In the female, the inguinal canal is smaller in diameter.

It must be noted that the structures forming the inguinal canal are identical in the two sexes, but the *contents* of the inguinal canal differ. In the male, the inguinal canal contains the **spermatic cord**, whereas in the female the inguinal canal contains the **round ligament of the uterus**. Dissection instructions are provided for male cadavers, but these instructions are applicable to female cadavers

The order of dissection will be as follows. The three flat muscles of the abdominal wall will be studied, particularly in the inguinal region. The composition and contents of the rectus sheath will be explored. The anterior abdominal wall will be reflected.

SKELETON OF THE ABDOMINAL WALL

Use a skeleton to identify the following structures (Fig. 4.07): **[G 10, 185; N 240; R 185; C 95, 253]**

- **Xiphisternal junction**
- **Xiphoid process**
- **Costal margin**
- **Pubic symphysis**
- **Pubic crest**
- **Pubic tubercle**
- **Anterior superior iliac spine**
- **Iliac crest**
- **Tubercle of the iliac crest**

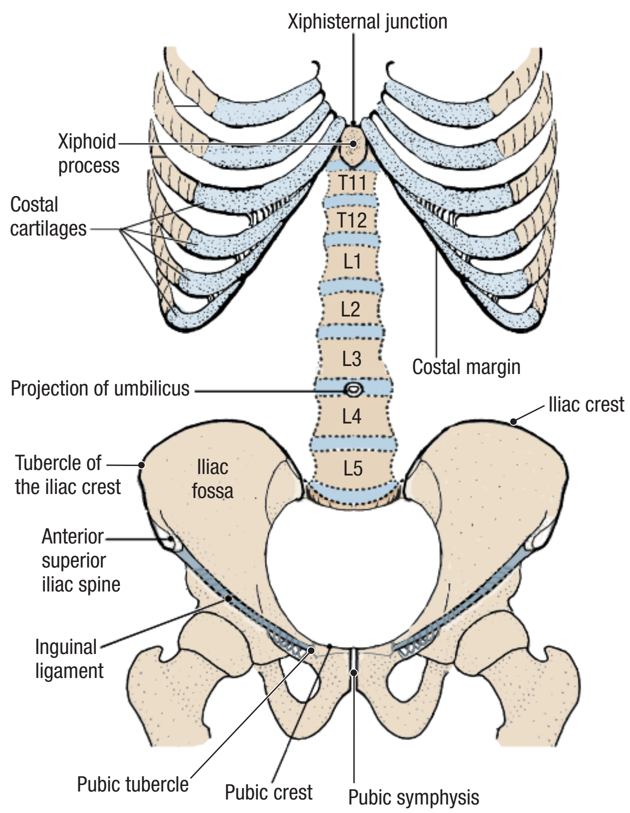

Figure 4.07. Skeleton of the anterior abdominal wall.

Dissection Instructions

EXTERNAL OBLIQUE MUSCLE [G 97; N 241; R 200; C 162]

The external oblique muscle forms the most superficial layer (first arch) of the inguinal canal (Fig. 4.08A, B).

1. Observe the **external oblique muscle**. The proximal attachments of the external oblique muscle are the external surfaces of ribs 5 to 12. The distal attachments of the external oblique muscle are the linea alba, pubic tubercle, and anterior half of the iliac crest. Observe that the fibers of the external oblique muscle course from superolateral to inferomedial.
2. In the inguinal region, use blunt dissection to clean the aponeurosis of the external oblique muscle. Gentle scraping motions with a dull scalpel blade yield good results. Be careful not to damage the **spermatic cord** (or **round ligament of the uterus**) where it emerges from the superficial inguinal ring. [G 100, 104; N 241; R 207, 210; C 163]
3. Identify the **superficial inguinal ring** (Fig. 4.08B), which is an opening in the external oblique aponeurosis.
4. Identify the **lateral (inferior) crus**. The lateral crus is the portion of the external oblique aponeurosis that forms the lateral margin of the superficial inguinal ring.
5. Identify the **medial (superior) crus**. The medial crus is the portion of the external oblique aponeurosis that forms the medial margin of the superficial inguinal ring.
6. Identify the **intercrural fibers**. Intercrural fibers span across the crura superolateral to the superficial inguinal ring. They prevent the crura from spreading apart.
7. Note that the **ilioinguinal nerve** emerges from the inguinal canal at the superficial inguinal ring, anterior to the spermatic cord (or round ligament of the uterus). The ilioinguinal nerve supplies sensory fibers to the skin of the external genitalia and the medial aspect of the thigh.
8. Identify the **inguinal ligament**. It is the inferior border of the aponeurosis of the external oblique muscle. Palpate the attachments of the inguinal ligament to the anterior superior iliac spine and to the pubic tubercle. Vessels and nerves exit the abdominal cavity and enter the lower limb by passing deep to the inguinal ligament.

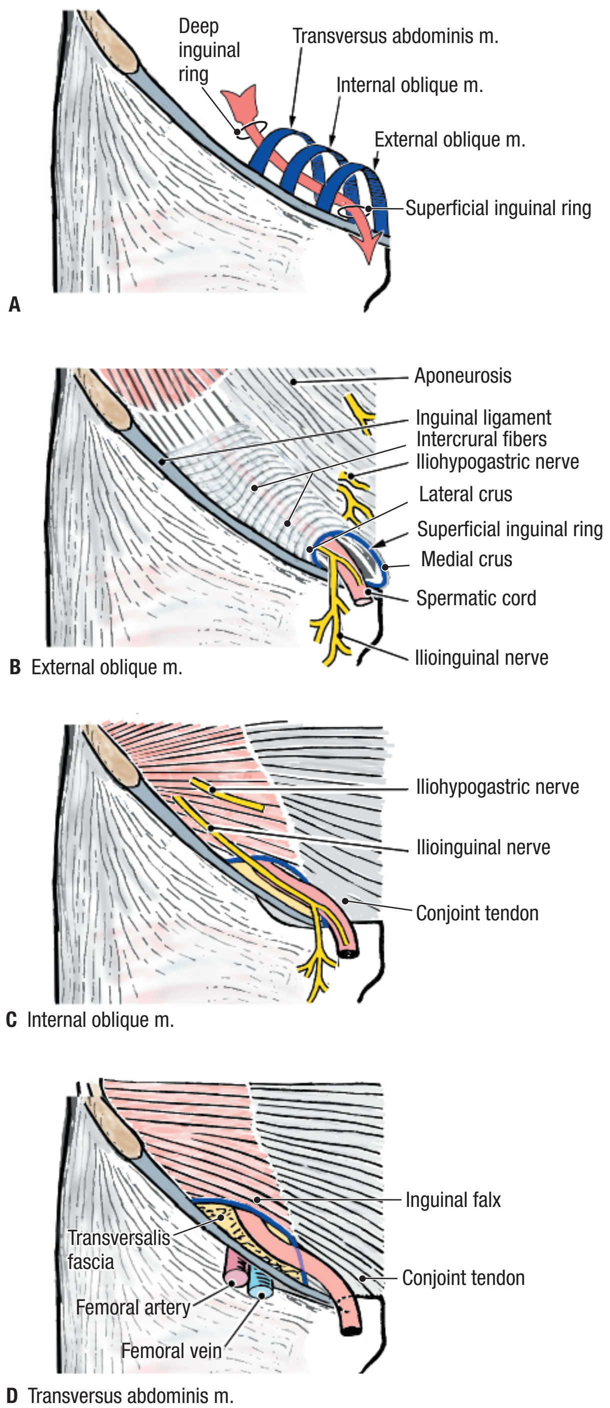

Figure 4.08. Contributions of the flat abdominal muscles to the inguinal canal.

INTERNAL OBLIQUE MUSCLE [G 98; N 242; R 202; C 164]

The internal oblique muscle lies deep to the external oblique muscle. The internal oblique muscle forms the intermediate layer (second arch) of the inguinal canal (Fig. 4.08A, C). To expose the internal oblique muscle, the external oblique muscle must be transected and reflected (Fig. 4.09). Perform this transection bilaterally.

1. In the midaxillary line at the level of the umbilicus, insert closed scissors between the fibers of the external oblique muscle. Open the scissors parallel to the fiber direction to split the external oblique muscle (Fig. 4.09A, cut 1). Make an opening that extends inferiorly as far as the anterior superior iliac spine.
2. Insert your fingers into cut 1 and use blunt dissection to separate the fibers of the external oblique muscle from the underlying internal oblique muscle.
3. Direct your fingers medially in the transumbilical plane and create a tunnel between the external oblique and internal oblique muscles. Note that your fingers cannot pass medial to the semilunar line because the external oblique aponeurosis is fused to the internal oblique aponeurosis.

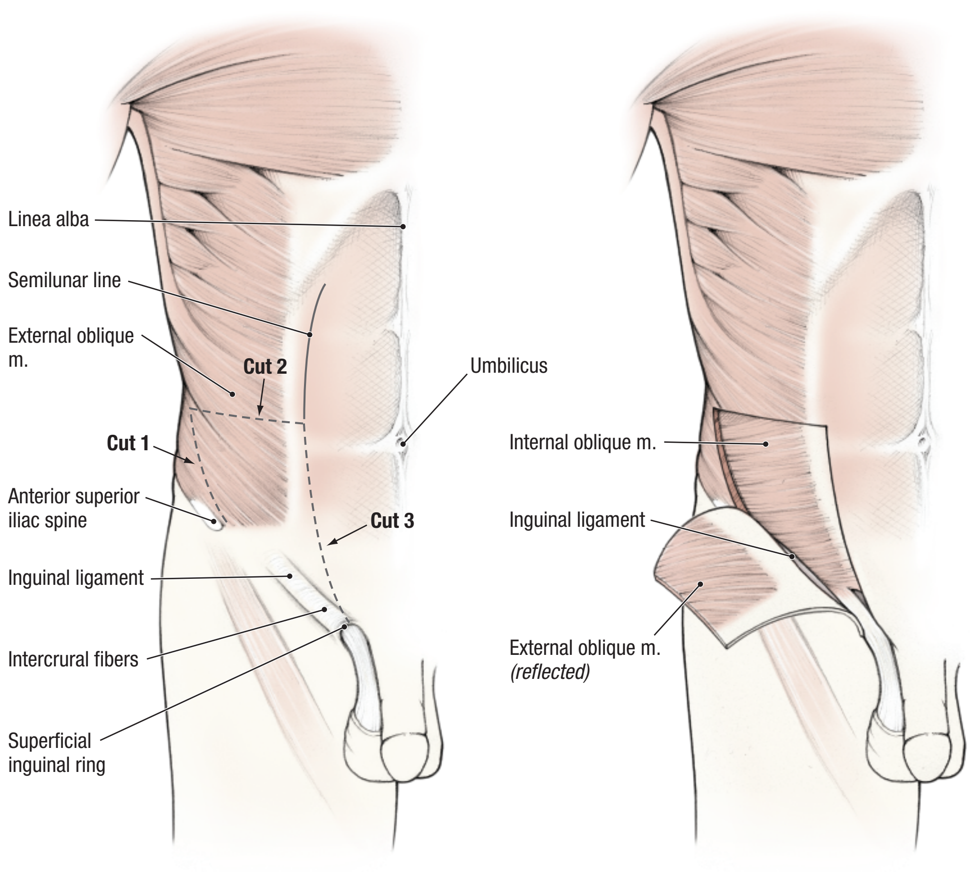

Figure 4.09. Cuts used to reflect the external oblique muscle.

4. Use scissors to cut the external oblique muscle in the transumbilical plane. Extend the cut as far medially as the semilunar line (Fig. 4.09A, cut 2).
5. Inferior to cut 2, use your fingers to separate the external oblique muscle from the internal oblique muscle. Be gentle as you approach the superficial inguinal ring.
6. Using scissors, make an incision from the medial end of cut 2 to the superior margin of the superficial inguinal ring (Fig. 4.09A, cut 3). Cut 3 should follow the lateral side of the semilunar line and cut only the external oblique aponeurosis.
7. Reflect the external oblique muscle in an inferior and lateral direction to reveal the lower half of the internal oblique muscle (Fig. 4.09B).
8. Identify the **internal oblique muscle**. The proximal attachments of the internal oblique muscle are the thoracolumbar fascia, the iliac crest, and the lateral half of the inguinal ligament. The distal attachments of the internal oblique muscle are the inferior border of ribs 10 to 12, the linea alba, the pubic crest, and the pecten pubis.
9. Observe the portion of the internal oblique muscle that arises from the lateral part of the inguinal ligament (Fig. 4.10). Note that this portion of the muscle arches medially to its distal attachment on the pecten pubis and contributes to the roof of the inguinal canal. **[G 101, 105; N 242; R 207, 210; C 165]**
10. Lateral to the spermatic cord (or round ligament of the uterus), observe muscle fibers connecting the internal oblique muscle with the spermatic cord (Fig. 4.10). This is the layer of **cremaster muscle and fas-**

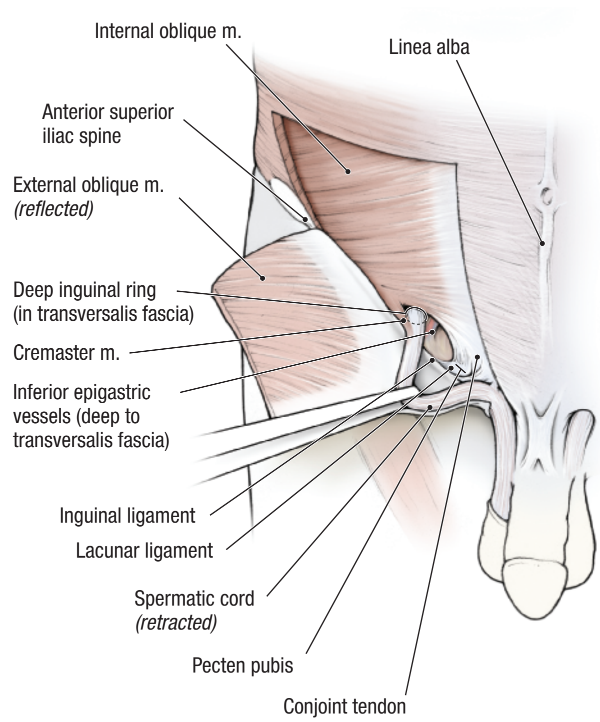

Figure 4.10. The internal oblique muscle in the inguinal region.

cia, which is the contribution of the internal oblique muscle to the coverings of the spermatic cord. In the female, the cremaster muscle and fascia surround the round ligament of the uterus.

11. Once again, find the **ilioinguinal nerve**, which courses through the inguinal canal to emerge at the superficial inguinal ring (Fig. 4.08C). Also, identify the **iliohypogastric nerve**, which runs parallel and superior to the ilioinguinal nerve.
12. Just medial to the superficial inguinal ring the aponeurosis of the internal oblique becomes fused with the aponeurosis of the transversus abdominis muscle to form the **conjoint tendon** (Fig. 4.08C).

TRANSVERSUS ABDOMINIS MUSCLE [G 98; N 243; R 205; C 167]

The **transversus abdominis muscle** lies deep to the internal oblique muscle. The transversus abdominis muscle forms the deepest layer (third arch) of the inguinal canal (Fig. 4.08A, D). In the inguinal region, the transversus abdominis muscle has attachments and fiber directions that are similar to the internal oblique muscle.

1. Use an illustration to study the proximal attachments, distal attachments, and fiber direction of the transversus abdominis muscle. The proximal attachments of the transversus abdominis muscle are the internal surfaces of the costal cartilages of ribs 7 to 12, the thoracolumbar fascia, the iliac crest, and the lateral third of the inguinal ligament. The distal attachments of the transversus abdominis muscle are the linea alba, the pubic crest, and the pecten pubis. [G 102; N 243; R 208; C 181]

Dissection note: The transversus abdominis muscle is often difficult to separate from the internal oblique muscle because their tendons are fused near their distal attachments (conjoint tendon), and the muscle bellies adhere to each other laterally. If you are not required to separate the internal oblique muscle from the transversus abdominis muscle, go to the section entitled “Deep Inguinal Ring.” If you are required to separate the internal oblique muscle from the transversus abdominis muscle, proceed with the next dissection step.

2. Use a probe to follow the ilioinguinal nerve superolaterally until it enters the internal oblique muscle (Fig. 4.08C).
3. Insert a pair of closed scissors into the internal oblique muscle superficial to the course of the ilioinguinal nerve and open the scissors parallel to the fiber direction to split the muscle. Follow the ilioinguinal nerve proximally and use it as a guide to find the plane between the internal oblique and transversus abdominis muscles.
4. Insert your finger through the split and into the plane between the internal oblique and transversus abdominis muscles. Push your finger inferiorly and medially to separate the muscles. Proceed until you reach the inferior borders of the two muscles. Observe that the aponeuroses of the two muscles are inseparable near their attachment to the pecten pubis (conjoint tendon).
5. Note that the inferior free edge of the transversus abdominis muscle is slightly superior to the inferior free edge of the internal oblique muscle. Below the arch formed by these two muscles, the abdominal wall is unsupported by muscle. This weak point occurs directly posterior to the superficial inguinal ring.

DEEP INGUINAL RING [G 103; N 251; R 208; C 181]

Transversalis fascia lines the inner surface of the abdominal muscles (Fig. 4.04). The **deep inguinal ring** is the point at which the testis passed through the transversalis fascia during development. The deep inguinal ring is located superior to the midpoint of the inguinal ligament and it marks the deep extent of the inguinal canal. In the male, the ductus deferens passes through the deep inguinal ring. In the female, the round ligament of the uterus passes through the deep inguinal ring.

1. Use a probe to lift the inferior margin of the fused internal oblique and transversus abdominis muscles.
2. Use blunt dissection to separate the transversus abdominis muscle from the transversalis fascia.
3. Retract the spermatic cord (or round ligament of the uterus) laterally and observe the **inferior epigastric vessels** through the transversalis fascia (Fig. 4.10). The inferior epigastric vessels are located within the layer of extraperitoneal (endoabdominal) fat.
4. The location of the deep inguinal ring is lateral to the inferior epigastric vessels and is identified by the presence of the ductus deferens (or round ligament of the uterus).
5. To review, the **boundaries of the inguinal canal** are (Fig. 4.08):
   - **Deep –** deep inguinal ring
   - **Superficial –** superficial inguinal ring
   - **Anterior –** aponeurosis of the external oblique muscle
   - **Inferior** (floor) **–** inguinal ligament
   - **Superior** (roof) **–** the arching fibers of the internal oblique and the transversus abdominis muscles
   - **Posterior –** transversalis fascia, reinforced medially by the conjoint tendon

Inguinal Hernias

The inguinal canal is a weak area of the abdominal wall through which abdominal viscera may protrude (inguinal hernia). The identifying characteristic of an inguinal hernia is its position relative to the inferior epigastric vessels. An **indirect inguinal hernia** exits the abdominal cavity through the deep inguinal ring *lateral* to the inferior epigastric vessels, and it follows the inguinal canal (an indirect course through the abdominal wall) (Fig. 4.11B). In contrast, a **direct inguinal hernia** exits the abdominal cavity *medial* to the inferior epigastric vessels and takes a direct course through the abdominal wall (Fig. 4.11C).

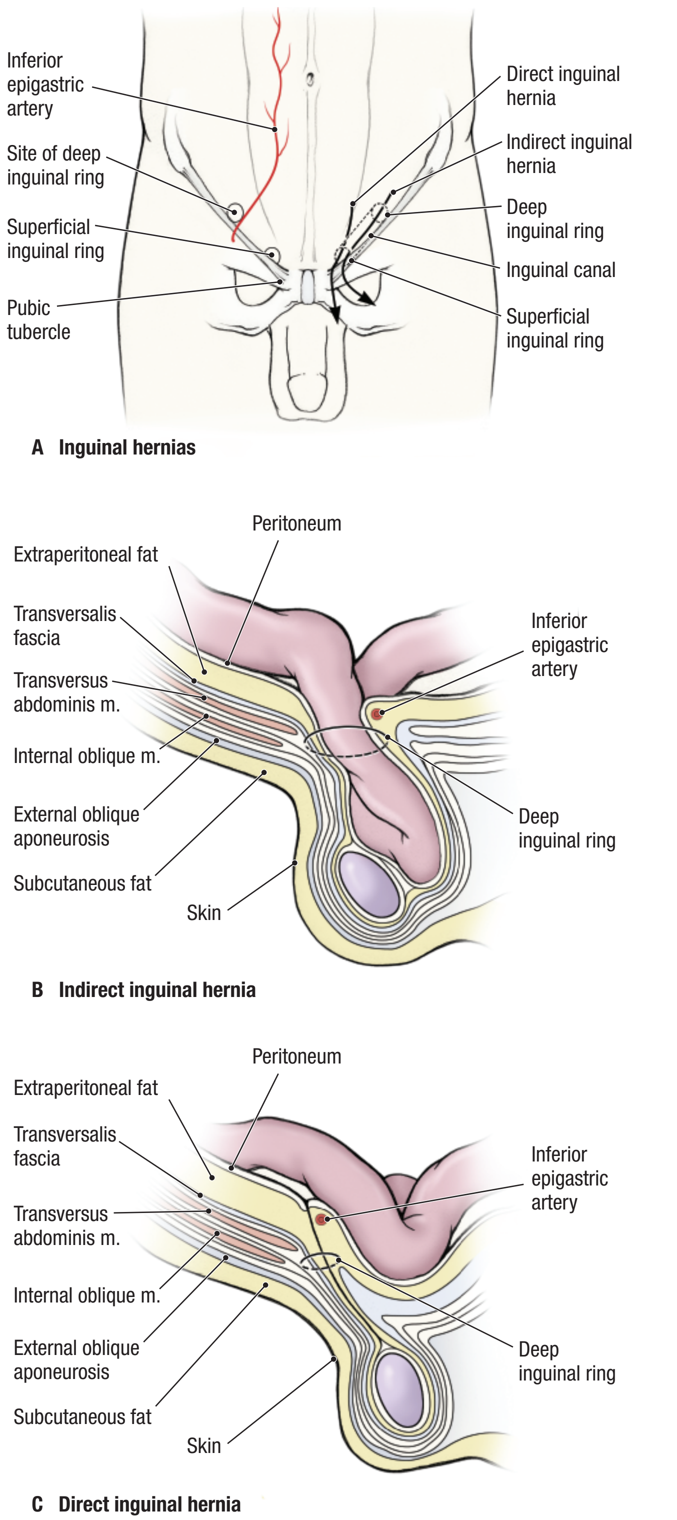

Figure 4.11. Inguinal hernias. **A.** Anatomical relationships and course through the abdominal wall. **B.** An indirect inguinal hernia leaves the abdominal cavity lateral to the inferior epigastric vessels and passes down the inguinal canal. **C.** A direct inguinal hernia leaves the abdominal cavity medial to the inferior epigastric vessels.

RECTUS ABDOMINIS MUSCLE [G 97; N 242; R 201; C 167]

The **rectus sheath** is formed by the aponeuroses of the three flat abdominal muscles. The rectus sheath contains the **rectus abdominis muscle**, the **superior** and **inferior epigastric vessels**, the terminal ends of the ventral primary rami of spinal nerves T7 to T12, and the **pyramidalis muscle**.

1. Reposition the internal oblique and external oblique muscles. The following cuts should be made bilaterally.
2. Use scissors to make a transverse incision across the anterior surface of the rectus sheath at the level of the umbilicus (Fig. 4.12, cut 1). Begin the cut approximately 2.5 cm lateral to the umbilicus and continue laterally as far as the semilunar line.
3. Use scissors to cut the rectus sheath along the medial border of the **rectus abdominis muscle** (Fig. 4.12, cut 2). This incision should extend in a superior direction, approximately 2.5 cm from the midline. Stop at the costal margin.
4. Extend the vertical incision inferiorly along the medial border of the rectus abdominis muscle (Fig. 4.12, cut 3). Cut 3 should be approximately 1.2 cm from the midline and stop at the pubic crest.
5. Insert your fingers into the vertical incision and bluntly dissect the anterior wall of the rectus sheath from the anterior surface of the rectus abdominis muscle. Observe that the anterior wall of the rectus sheath is firmly attached to the anterior surface of the rectus muscle by several **tendinous intersections** (Fig. 4.13). Use scissors to cut the tendinous intersections and free the rectus sheath from the rectus abdominis muscle.
6. Observe the **rectus abdominis muscle** (Fig. 4.13). The inferior attachment of the rectus abdominis muscle is the symphysis and body of the pubis. The superior attachment of the rectus abdominis muscle is onto the costal cartilages of ribs 5 to 7. The rectus abdominis muscle flexes the trunk.

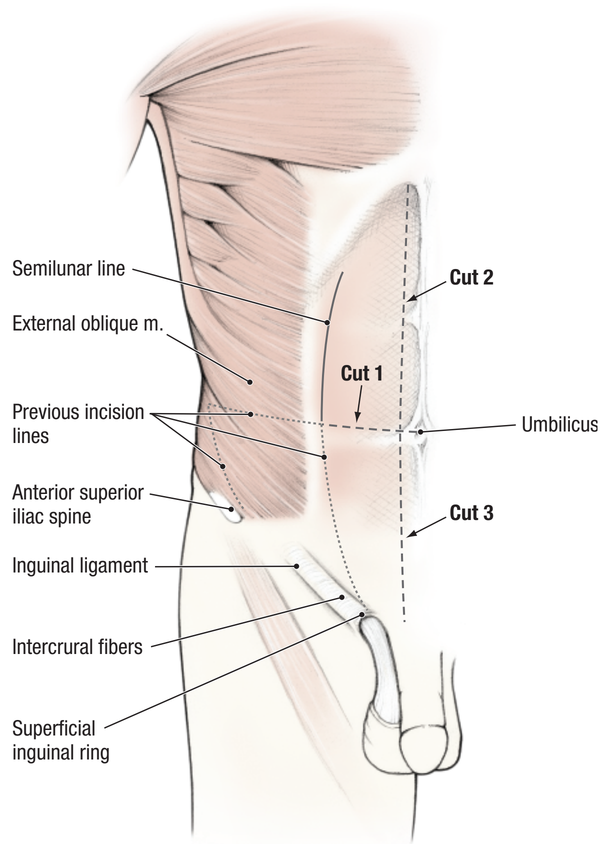

Figure 4.12. Cuts used to open the rectus sheath.

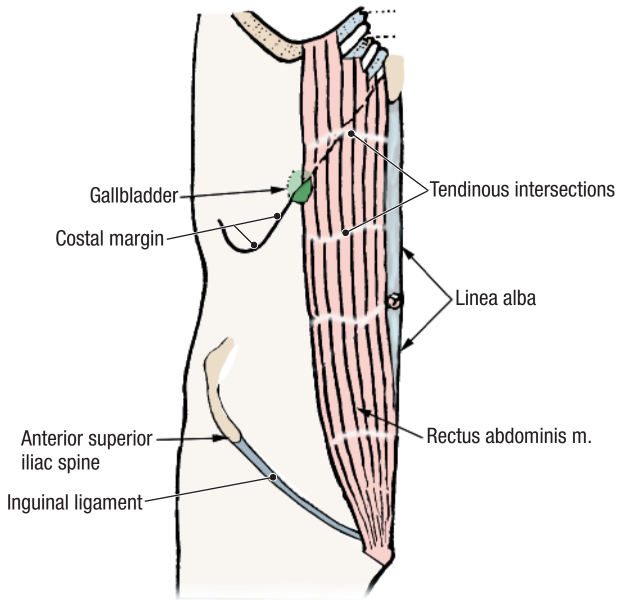

Figure 4.13. Rectus abdominis muscle.

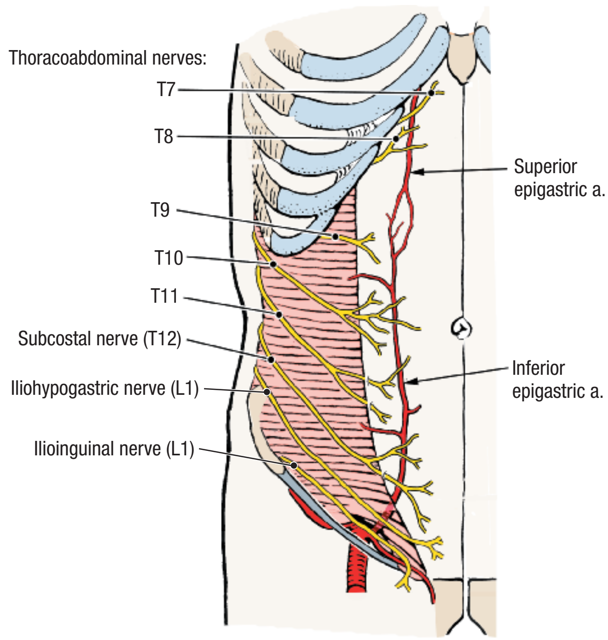

Figure 4.14. Nerves and arteries within the rectus sheath. The rectus abdominis muscle has been removed.

7. Observe that the branches of six thoracoabdominal nerves (T7–T12) enter the lateral side of the rectus sheath (Fig. 4.14). These nerves innervate the rectus abdominis muscle then continue toward the midline as **anterior cutaneous nerves**. **[G 98; N 249; R 206; C 170]**
8. Use your fingers to mobilize the medial border of the rectus abdominis muscle. At the level of the umbilicus, transect the rectus abdominis muscle with scissors. Reflect the two halves superiorly and inferiorly, respectively. If the thoracoabdominal nerves prevent full reflection of the rectus abdominis muscle, cut them along the lateral border of the muscle.
9. Observe the **superior epigastric artery and vein** on the posterior (deep) surface of the superior half of the rectus abdominis muscle. **[G 98; N 247; R 206; C 170]**
10. Observe the **inferior epigastric artery and vein** on the posterior surface of the inferior half of the rectus abdominis muscle.

Epigastric Anastomoses

The superior epigastric vessels anastomose with the inferior epigastric vessels within the rectus sheath (Fig. 4.14). If the inferior vena cava becomes obstructed, the anastomosis between the inferior epigastric and superior epigastric veins provides a collateral venous channel that drains into the superior vena cava. If the aorta is occluded, collateral arterial circulation to the lower part of the body occurs through the superior and inferior epigastric arteries.

11. Examine the posterior wall of the rectus sheath (Fig. 4.15). Identify the **arcuate line,** which is located midway between the pubic symphysis and the umbilicus.

The arcuate line is the inferior limit of the posterior wall of the rectus sheath, and it may be indistinct. At the level of the arcuate line, the inferior epigastric vessels enter the rectus sheath.

12. Inferior to the arcuate line, observe the **transversalis fascia** and, deep to it, the **parietal peritoneum** (Fig. 4.15).
13. In the midline, observe the **linea alba**. The linea alba is formed by the fusion of the aponeuroses of the right and left flat abdominal muscles (external oblique, internal oblique, and transversus abdominis).
14. Anterior to the inferior end of the rectus abdominis muscle, look for the **pyramidalis muscle**. It is frequently absent. When present, the pyramidalis muscle attaches to the anterior surface of the pubis and the linea alba and it draws down on the linea alba.

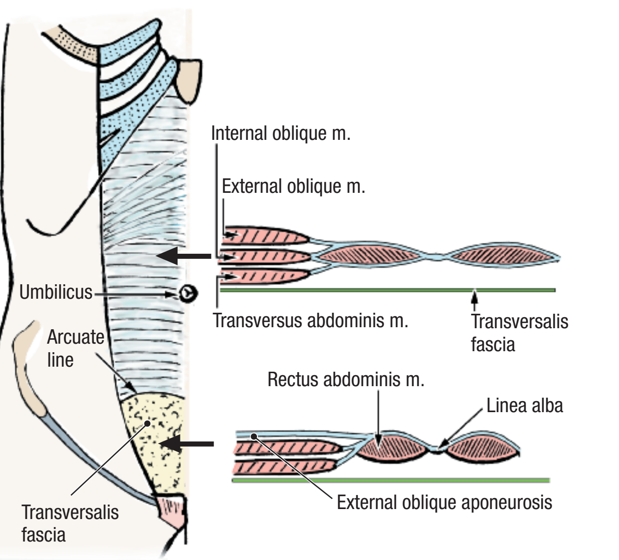

Figure 4.15. Posterior wall of the rectus sheath (left) and transverse sections of the rectus sheath at the two levels indicated by the arrows.

After you dissect . . .

Replace the muscles of the anterior abdominal wall in their correct anatomical positions. Review the proximal attachment, distal attachment, and action of each muscle. Review the structures that form the nine layers of the abdominal wall (Fig. 4.04). Use the dissected specimen to review the rectus sheath at the level of the umbilicus and just superior to the pubic symphysis (Fig. 4.15). Review the nerve supply to the anterior abdominal wall. Review the blood supply to the anterior abdominal wall.

LABIUM MAJUS IN THE FEMALE; SCROTUM, SPERMATIC CORD, AND TESTIS IN THE MALE

Before you dissect . . .

The **scrotum** is an outpouching of the anterior abdominal wall, and most layers of the abdominal wall are represented in its structure (Fig. 4.16). The superficial fascia of the scrotum contains no fat. Instead, the superficial fascia is represented by **dartos fascia**, which contains smooth muscle fibers (**dartos muscle**).

The order of dissection will be as follows. The scrotum (labium majus) will be opened by an anterior incision. The spermatic cord (round ligament of the uterus in the female) will be followed into the scrotum (labium majus in the female). The testis will be removed from the scrotum. The spermatic cord will be dissected. The testis will be studied.

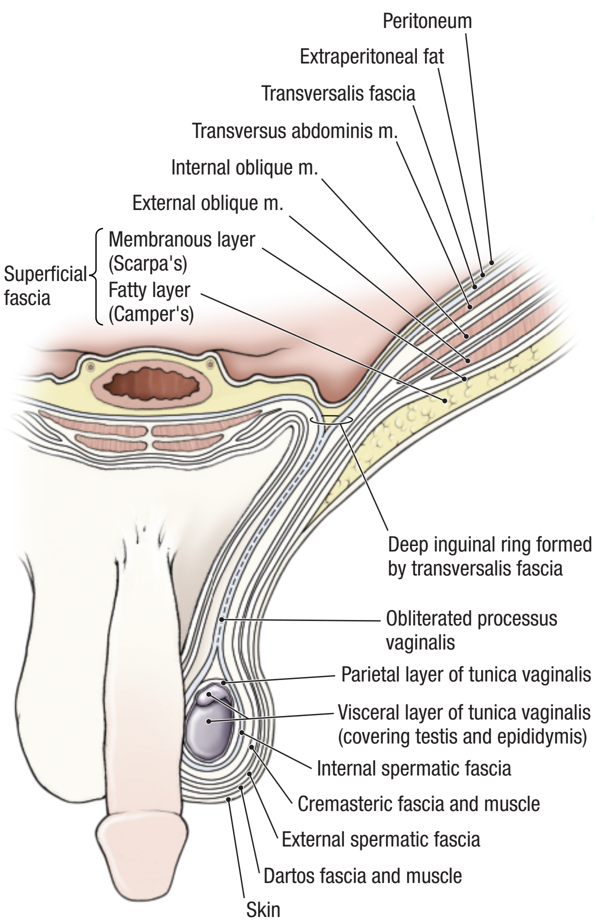

Figure 4.16. Contributions of the anterior abdominal wall to the coverings of the spermatic cord and testis.

Dissection Instructions

MALE AND FEMALE CADAVERS [G 104; R 210; C 176]

1. Partner with a dissection team that has a cadaver of the opposite sex for the following dissection.
2. Inferior to the superficial inguinal ring, insert your finger deep to the subcutaneous tissue of the lower anterior abdominal wall and push your finger into the scrotum. If you are dissecting a female cadaver, your finger will pass into the labium majus.
3. Use scissors to make an incision down the anterior surface of the scrotum (labium) through the skin, dartos, and superficial fascia.
4. Use your fingers to free the testis and spermatic cord from the scrotum. In the female cadaver, demonstrate that the round ligament of the uterus ends in the fatty tissue of the labium majus. This step completes the dissection of the female anatomy.

MALE CADAVER [G 107; N 370; R 329; C 182]

1. Observe a band of tissue that anchors the inferior pole of the testis to the scrotum. This is the **scrotal ligament** (the remnant of the gubernaculum testis).
2. Use scissors to cut the scrotal ligament. Use your fingers to remove the testis from the scrotum, but leave the testis attached to the spermatic cord.
3. Observe that the **scrotal septum** divides the scrotum into two compartments.

Spermatic Cord [G 108; N 370; R 329; C 182]

The spermatic cord contains the ductus deferens, testicular vessels, lymphatics, and nerves. The contents of the spermatic cord are surrounded by three fascial layers, the **coverings of the spermatic cord**, that are derived from layers of the anterior abdominal wall (Fig. 4.16). These coverings are added to the spermatic cord as it passes through the inguinal canal.

1. Study an illustration of a transverse section through the spermatic cord (Fig. 4.17).
2. Palpate the **ductus deferens (vas deferens)** within the spermatic cord. It is hard and cord-like.
3. Use a probe to longitudinally incise the **coverings of the spermatic cord**. The three coverings are fixed to each other at the time of embalming and cannot be

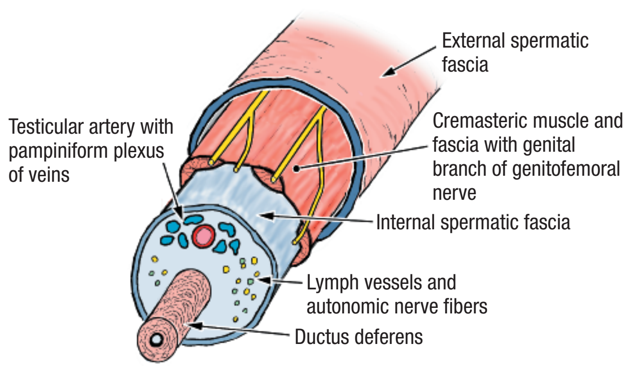

Figure 4.17. Transverse section through the spermatic cord.

separated. The coverings of the spermatic cord are (Fig. 4.16):

- **External spermatic fascia** – derived from the external oblique muscle
- **Cremasteric muscle and fascia** – derived from the internal oblique muscle
- **Internal spermatic fascia** – derived from the transversalis fascia

4. Use a probe to separate the ductus deferens from the **pampiniform plexus of veins**.
5. Follow the ductus deferens superiorly into the inguinal canal and toward the deep inguinal ring. Note that the ductus deferens passes through the deep inguinal ring lateral to the inferior epigastric vessels.
6. Use a probe to separate the **testicular artery** from the pampiniform plexus of veins. The testicular artery can be distinguished from the veins by its slightly thicker wall.
7. Note that sensory nerve fibers, autonomic nerve fibers, and lymphatic vessels accompany the blood vessels in the spermatic cord (Fig. 4.17), but they are too small to dissect.

CLINICAL CORRELATION

Vasectomy

The ductus deferens can be surgically interrupted in the superior part of the scrotum (vasectomy). As a precaution against reconnection, a small segment is removed. Sperm production in the testes continues but the spermatozoa cannot reach the urethra.

Testis [G 110; N 371; R 329; C 183, 184]

1. The testis is covered by the **tunica vaginalis**, a serous sac that is derived from the parietal peritoneum (Fig. 4.16). The tunica vaginalis has a visceral layer and a parietal layer (Fig. 4.18).
2. Use scissors to incise the parietal layer of the tunica vaginalis along its anterior surface and open it widely. Observe that the visceral layer of the tunica vaginalis covers the anterior, medial, and lateral surfaces of the testis, but not its posterior surface.
3. Use a probe to trace the ductus deferens inferiorly until it joins the epididymis. Identify the **tail**, **body**, and **head of the epididymis** (Fig. 4.18).
4. Use a scalpel to section the testis longitudinally from its superior pole to its inferior pole. Make the cut along its anterior surface. Use the epididymis as a hinge, and open the halves of the testis like a book.
5. Note the thickness of the **tunica albuginea**, which is the fibrous capsule of the testis. Observe the **septa** that divide the interior of the testis into **lobules** (Fig. 4.18).
6. Use a needle forceps to tease some of the **seminiferous tubules** out of one lobule.

CLINICAL CORRELATION

Lymphatic Drainage of the Testis

Lymphatics from the scrotum drain to the superficial inguinal lymph nodes. Inflammation of the scrotum may cause tender, enlarged superficial inguinal lymph nodes. In contrast, lymphatics from the testis follow the testicular vessels through the inguinal canal and into the abdominal cavity where they drain into lumbar (lateral aortic) nodes and preaortic lymph nodes. Testicular tumors may metastasize to lumbar and preaortic lymph nodes, not to superficial inguinal lymph nodes.

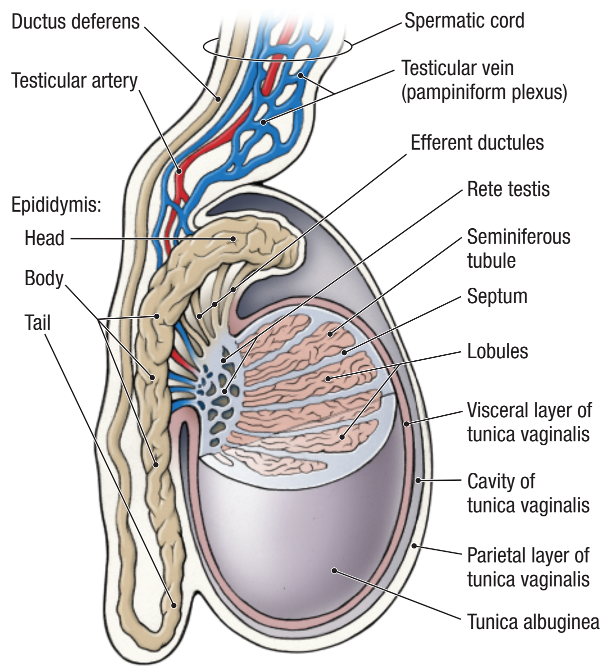

Figure 4.18. Parts of the testis and epididymis.

After you dissect . . .

Review the course of the ductus deferens from the abdominal wall to the testis. Review the coverings of the spermatic cord and recall the layers of the abdominal wall from which they are derived. Use an illustration to trace the route of spermatozoa from their origin in the seminiferous tubule to the ejaculatory duct.

REFLECTION OF THE ABDOMINAL WALL

Before you dissect . . .

The anterior abdominal wall will be reflected in such a way that the contents of the abdominopelvic cavity can be accessed, but the abdominal wall can be repositioned for review. The incision lines will be similar to the quadrant lines illustrated in Figure 4.02. The incisions are designed to give direct reference to the position of the abdominal organs within the abdominal quadrants.

The order of dissection is as follows. The anterior abdominal wall will be incised and opened. The inner surface of the anterior abdominal wall will be studied.

Dissection Instructions

1. Reflect the halves of the rectus abdominis muscles superiorly and inferiorly.
2. Refer to Figure 4.19. On the left side of the umbilicus, use scissors to create a small hole (2 cm) through the posterior wall of the rectus sheath, extraperitoneal fat, and parietal peritoneum.
3. Insert your finger through the hole into the abdominal cavity. Pull the posterior wall of the rectus sheath anteriorly to create a space between the abdominal wall and the abdominal viscera.
4. Use scissors to make a vertical incision through the linea alba to the xiphoid process (Fig. 4.19, cut 1). Stay 1 cm to the left of the midline to preserve the falciform ligament.
5. Extend the incision inferiorly as far as the pubic symphysis (Fig. 4.19, cut 2). Stay 1 cm to the left of the midline to preserve the median umbilical fold.
6. Return the rectus abdominis muscle and the external oblique muscle to their correct anatomical positions.
7. At the level of the umbilicus, place one hand through the vertical incision and raise the abdominal wall from the abdominal contents.
8. On the right side, use scissors to incise the posterior wall of the rectus sheath, extraperitoneal fat, and peritoneum in the transumbilical plane (Fig. 4.19, cut 3). The scissors should pass through the previous transverse cut that was made in the rectus abdominis muscle and the external oblique muscle. Extend the cut through all three flat abdominal muscles as far laterally as the midaxillary line. Duplicate the transverse cut on the left side.
9. Open the flaps of the abdominal wall.
10. Identify the **falciform ligament**, which is superior to the umbilicus. It is attached to the right upper quadrant flap. The falciform ligament connects the anterior abdominal wall to the surface of the liver. **[G 112; N 245; R 283; C 173]**
11. Identify the **median umbilical fold**, which is inferior to the umbilicus. It is attached to the right lower quadrant flap, but may have been cut longitudinally. The median umbilical fold contains the urachus (obliterated allantoic duct).
12. Identify the **medial umbilical fold**. There are two medial umbilical folds, one on each side of the median umbilical fold. The medial umbilical fold contains the obliterated umbilical artery.
13. Find a **lateral umbilical fold** just lateral to each medial umbilical fold. The lateral umbilical fold overlies the inferior epigastric artery and vein.
14. Lateral to the lateral umbilical fold, observe a small depression that marks the location of the **deep inguinal ring**.

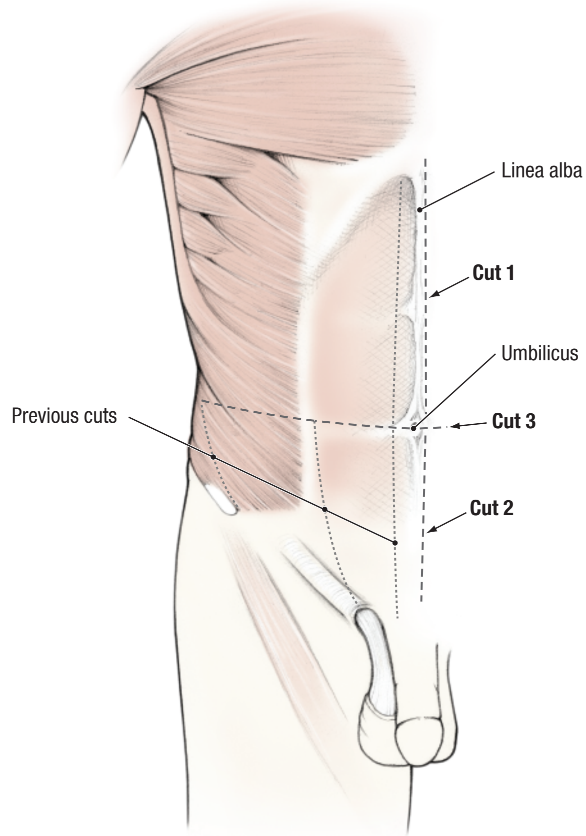

Figure 4.19. Cuts used to open the abdominal cavity.

PERITONEUM AND PERITONEAL CAVITY

Before you dissect . . .

All body cavities (thoracic cavity, pericardium, and abdominopelvic cavity) are lined by a serous membrane, which secretes a small amount of fluid to lubricate the movements of organs. In the abdominal cavity and pelvic cavity this membrane is called the **peritoneum**. There are two types (Fig. 4.20). **Parietal peritoneum** lines the inner surfaces of the abdominal and pelvic walls, and **visceral peritoneum** covers the surfaces of the abdominal and pelvic organs. Between these two types of peritoneum is a potential space called the **peritoneal cavity**.

During development, some organs grow into the peritoneal cavity and become **intraperitoneal** (invested in peritoneum). Examples of intraperitoneal organs include the stomach, small intestine, liver, and spleen. Some organs develop behind the peritoneum and are called **retroperitoneal organs.** The ureters and kidneys are examples. Some parts of the gastrointestinal tract begin as intraperitoneal organs then become attached to the abdominal wall during development. These organs are **secondarily retroperitoneal**. Examples of secondarily retroperitoneal organs include the duodenum, pancreas, ascending colon, and descending colon.

The order of dissection will be as follows. The abdominal viscera will be identified and localized by abdominal quadrant. The named specializations of the peritoneum will be studied. For a more complete understanding, review the development of the gastrointestinal tract before examining the peritoneal specializations.

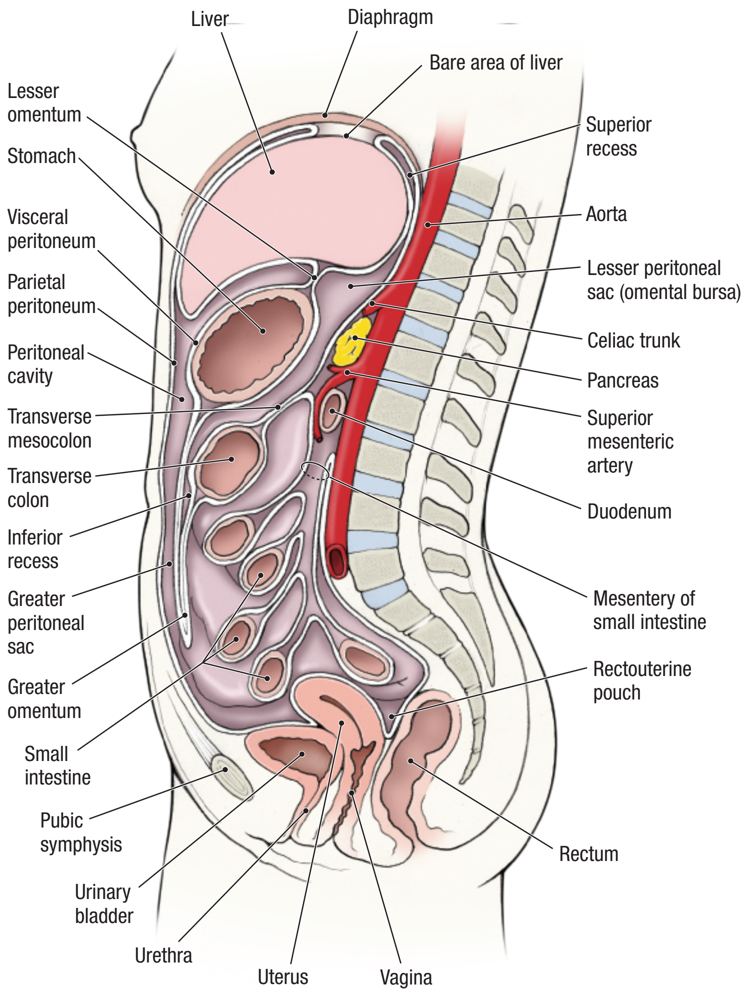

Figure 4.20. Peritoneum and peritoneal cavity, median section.

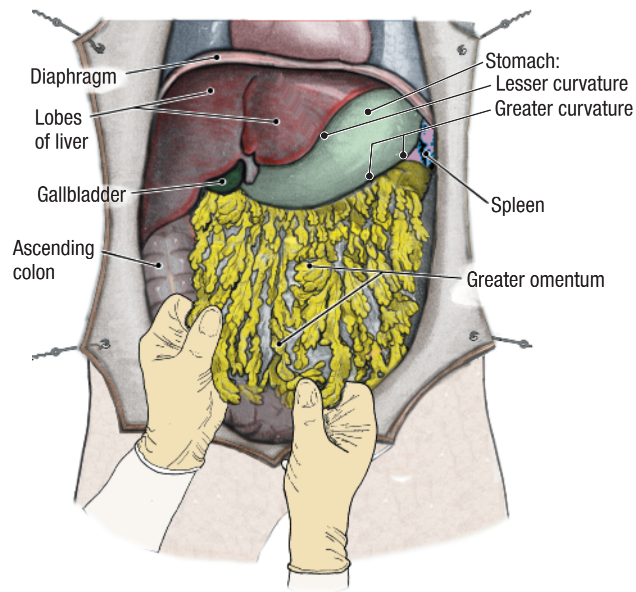

Figure 4.21. The relationship of the greater omentum to the abdominal viscera.

Dissection Instructions

ABDOMINAL VISCERA [G 113, 120; N 261; R 281, 282; C 188]

1. Use your hands to inspect the abdominal cavity. As you perform the inspection, you may encounter adhesions. If adhesions are present, tear them with your fingers.
2. Open the flaps of the abdominal wall. The incision lines correlate to the abdominal quadrant lines. As you examine the organs, you should close and open the flaps to help you relate the organs to the abdominal quadrants. Most of the organs to be identified are parts of the **gastrointestinal tract**.
3. Identify the **liver** (Fig. 4.21). It is an intraperitoneal organ. The liver occupies the right upper quadrant and extends across the midline into the left upper quadrant. The liver lies against the inferior surface of the diaphragm. The attachment of the falciform ligament divides the liver into **right** and **left lobes**.
4. The **gallbladder**, an intraperitoneal organ, is also in the right upper quadrant. The gallbladder extends below the inferior border of the liver. It is usually found at the tip of the right ninth costal cartilage in the midclavicular line. Confirm this relationship.
5. Identify the **stomach**. It is an intraperitoneal organ and lies in the left upper quadrant. It is continuous with the esophagus proximally and the duodenum distally. The liver partially covers the anterior surface of the stomach.
6. Find the **spleen**. It is an intraperitoneal organ, which lies in the left upper quadrant. It is found posterior to the stomach and may be difficult to find unless it is enlarged. Reach around the left side of the stomach with your right hand and palpate the spleen.
7. Identify the **greater omentum** (Fig. 4.21). The greater omentum is attached to the greater curvature of the stomach. Reflect the greater omentum superiorly over the costal margin (Fig. 4.22).
8. Identify the **small intestine** (Figs. 4.22, 4.23). The small intestine begins at the pyloric end of the stomach. It has three parts:
   - **Duodenum**
   - **Jejunum**
   - **Ileum**
9. Most of the duodenum is secondarily retroperitoneal. It will be studied with the pancreas.
10. The **jejunum** and **ileum** are intraperitoneal organs that extend from the left upper quadrant to the right lower quadrant, but because of their length and mobility, they occupy all four quadrants. Beginning in the left upper quadrant, pass the jejunum and ilium between your hands and appreciate its length, position, and termination.
11. Identify the **large intestine**. The large intestine begins in the right lower quadrant at the ileocecal junction (Fig. 4.23). It has six parts:
    - **Cecum** is in the right lower quadrant. The **appendix** is attached to the inferior end of the cecum.
    - **Ascending colon** extends from the right lower quadrant to the right upper quadrant. It ends at the **right colic (hepatic) flexure**. The ascending colon is secondarily retroperitoneal.

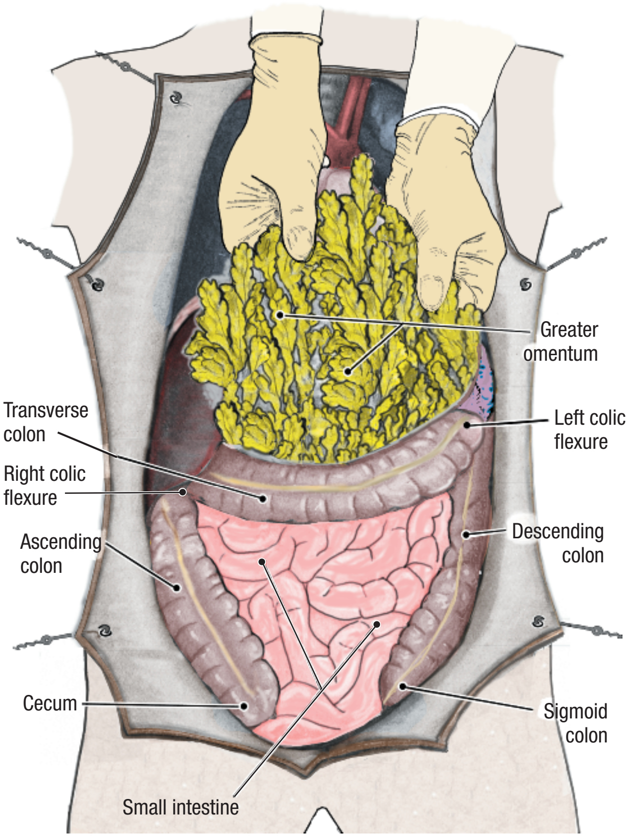

Figure 4.22. Reflect the greater omentum superiorly to expose the small intestine and large intestine.

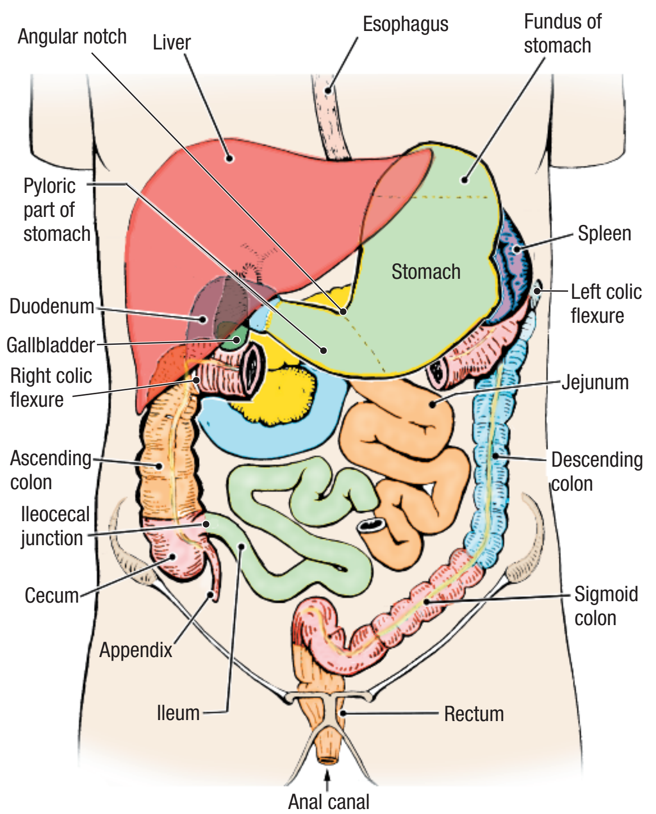

Figure 4.23. Schematic drawing of the abdominal organs. Part of the transverse colon has been removed.

- **Transverse colon** extends from the right upper quadrant to the left upper quadrant. The transverse colon ends at the **left colic (splenic) flexure**. The transverse colon is intraperitoneal.
- **Descending colon** extends from the left upper quadrant to the left lower quadrant. The descending colon is secondarily retroperitoneal.
- **Sigmoid colon** is in the left lower quadrant. The sigmoid colon ends in the pelvic cavity at the level of the third sacral vertebral level. The sigmoid colon is an intraperitoneal organ.
- **Rectum** is the pelvic portion of the gastrointestinal tract. It will be studied with the pelvic viscera.

12. Use your hands to trace the large intestine from the right lower quadrant to the left lower quadrant. Note the position and mobility of each of its parts.

PERITONEUM [G 113; N 261; R 294; C 192]

1. Observe the **visceral peritoneum** on the surface of the stomach or small intestine (Fig. 4.20). Note that visceral peritoneum is smooth and slippery.
2. Observe the **parietal peritoneum** on the inner surface of the abdominal wall (Fig. 4.20). Note that parietal peritoneum is also smooth and slippery.
3. Observe the **greater omentum** (Fig. 4.21). Spread this apron-like structure to appreciate its size. The greater omentum normally lies between the intestines and the anterior abdominal wall (Fig. 4.20). **[G 114; N 267; R 299; C 202]**
4. Elevate the inferior border of the liver and identify the **lesser omentum** (Fig. 4.20). The lesser omentum passes from the lesser curvature of the stomach and first part of the duodenum to the inferior surface of the liver. The lesser omentum has two parts:
   - **Hepatogastric ligament**
   - **Hepatoduodenal ligament**
5. Return the right upper quadrant flap to its anatomical position and review the **falciform ligament**. The falciform ligament passes from the parietal peritoneum on the anterior abdominal wall to the visceral peritoneum on the surface of the liver. The **round ligament of the liver (ligamentum teres hepatis)** is the obliterated umbilical vein, and it is found in the inferior free margin of the falciform ligament.
6. Follow the falciform ligament superiorly to find the **coronary ligament** that attaches the liver to the diaphragm. Two peritoneal ligaments are parts of the coronary ligament:
   - **Left triangular ligament** is between the left lobe of the liver and the diaphragm.
   - **Right triangular ligament** is between the right lobe of the liver and the diaphragm.
7. The **gastrophrenic ligament** connects the superior part of the greater curvature of the stomach to the diaphragm. Slide your hand superiorly to the left of the stomach to feel this ligament.
8. The **gastrosplenic (gastrolienal) ligament** passes from the greater curvature of the stomach to the spleen, and the **splenorenal (lienorenal) ligament**

connects the spleen to the posterior abdominal wall over the left kidney (Fig. 4.24).

9. Reflect the greater omentum superiorly over the costal margin and identify the **transverse mesocolon** (Fig. 4.20). The transverse mesocolon attaches the transverse colon to the posterior abdominal wall. At the left end of the transverse mesocolon is the **phrenicocolic ligament**, which attaches the left colic flexure to the diaphragm. **[N 263; R 294; C 212]**
10. Identify the **mesentery** (Fig. 4.20). The mesentery suspends the jejunum and ileum from the posterior abdominal wall. The root of the mesentery attaches to the posterior abdominal wall from the left upper quadrant to the right lower quadrant.
11. Observe the **mesoappendix**. The mesoappendix attaches the appendix to the posterior abdominal wall and it contains the appendicular artery.
12. Identify the **sigmoid mesocolon** in the lower left quadrant. The sigmoid mesocolon suspends the sigmoid colon from the posterior abdominal wall.
13. Note that these peritoneal structures all are found within a subdivision of the peritoneal cavity called the **greater peritoneal sac** (Fig. 4.20). Posterior to the stomach and lesser omentum is a smaller subdivision of the peritoneal cavity called the **lesser peritoneal sac (omental bursa)** (Fig. 4.24).
14. The **omental foramen (epiploic foramen, foramen of Winslow)** connects the greater and lesser peritoneal sacs. The omental foramen lies posterior to the hepatoduodenal ligament (Fig. 4.24). **[G 114; N 267; R 299; C 220]**
15. Insert your finger into the omental foramen and review its **four boundaries**:
    - **Anterior**—hepatic portal vein, hepatic artery proper, and bile duct contained within the hepatoduodenal ligament (Fig. 4.24)
    - **Posterior**—inferior vena cava and right crus of the diaphragm covered with parietal peritoneum
    - **Superior**—caudate lobe of the liver covered with visceral peritoneum
    - **Inferior**—first part of the duodenum covered with visceral peritoneum
16. Study a diagram of the **lesser peritoneal sac** (Fig. 4.20). The lowest part of the lesser peritoneal sac is called the **inferior recess** and it extends inferiorly as far as the greater omentum. During development, the inferior recess extended between the layers of the greater omentum (review an embryology text). The highest part of the lesser peritoneal sac is the **superior recess**. The diaphragm lies posterior to the superior recess and the caudate lobe of the liver is anterior to the superior recess. **[G 116; N 165; R 301; C 195]**
17. Posterior to the main part of the lesser peritoneal sac is the pancreas (Fig. 4.20). The peritoneum that covers the pancreas forms part of the posterior wall of the lesser peritoneal sac.

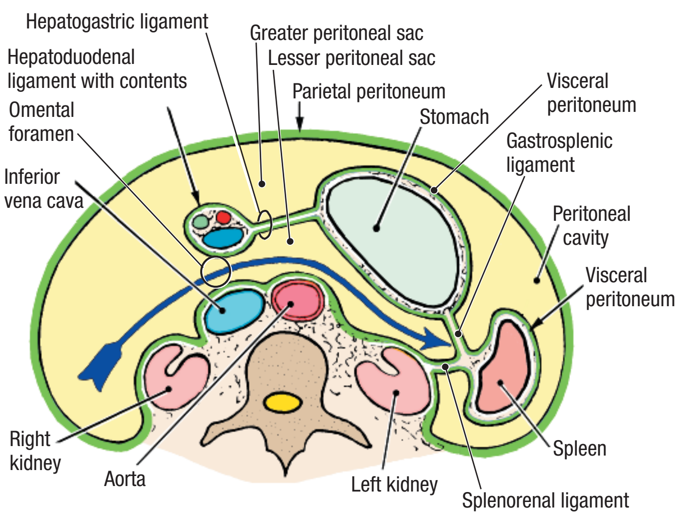

Figure 4.24. Schematic drawing of the peritoneal cavity in transverse section—inferior view. The arrow passes through the omental foramen.

After you dissect . . .

Use the cadaver specimen to review all parts of the gastrointestinal tract in proximal to distal order. State the quadrant(s) in which each abdominal organ normally is found. Review all parts and specializations of the peritoneum listed on the preceding pages. Review the development of the gut tube and mesenteries.

CELIAC TRUNK, STOMACH, SPLEEN, LIVER, AND GALLBLADDER

Before you dissect . . .

The order of dissection will be as follows. The surface features of the stomach will be studied. The vessels and ducts in the hepatoduodenal ligament will be demonstrated. The branches of the celiac trunk that supply the stomach, spleen, liver, and gallbladder will be dissected. The remainder of the field of supply of the celiac trunk (to the duodenum and pancreas) will be dissected later. The hepatic portal vein will be studied. The spleen, liver, and gallbladder will be studied.

Dissection Instructions

1. Place the greater omentum in its correct anatomical position.
2. Identify the parts of the stomach (Fig. 4.25): **[G 121; N 267; R 284; C 198]**
    - **Anterior surface**
    - **Greater curvature**
    - **Lesser curvature**
    - **Cardia**
    - **Cardial notch**
    - **Fundus**
    - **Body**
    - **Angular incisure (notch)**
    - **Pyloric part**
    - **Pylorus**

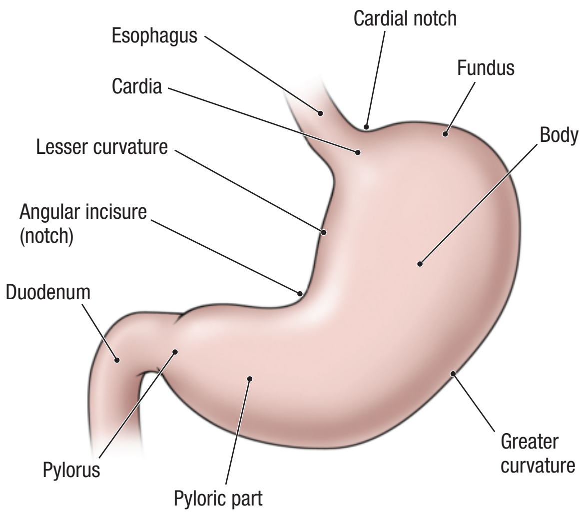

Figure 4.25. Parts of the stomach.

3. Identify the following features of the liver (Fig. 4.26A,B): **[G 142; N 279 ; R 288; C 207]**
   Right lobe
   Left lobe
   Diaphragmatic surface
   Inferior border
4. Use your hand to raise the inferior border of the liver. Identify the **visceral surface of the liver** (Fig. 4.26B). The visceral surface is in contact with the gallbladder and the peritoneum covering the stomach, duodenum, colon, right kidney, and right suprarenal gland.
5. Identify the **porta hepatis** on the visceral surface of the liver. It is the fissure through which vessels, ducts, lymphatics, and nerves enter the liver (Fig. 4.26B). **[G 143; N 279; R 289; C 207]**
6. Identify the **gallbladder** (Fig.4.26B). The gallbladder may have been surgically removed.

CELIAC TRUNK [G 128; N 292; R 303; C 196]

As you dissect the branches of the celiac trunk, realize that *arteries are named by their region of distribution, not by their origin or branching pattern.*

1. Insert your finger into the omental foramen. Anterior to your finger is the **hepatoduodenal ligament** and its contents: **bile ducts**, **hepatic artery proper**, **hepatic portal vein**, **autonomic nerves**, and **lymphatics**.
2. To aid dissection, place a strip of white paper into the omental foramen (Fig. 4.27).
3. Use blunt dissection to remove the peritoneum from the anterior surface of the hepatoduodenal ligament (anterior to the vessels and ducts).
4. Identify the three large structures that are contained within the hepatoduodenal ligament: **(common) bile duct**, **hepatic artery proper**, and **hepatic portal vein** (Fig. 4.27). The bile duct is the most lateral of the three.
5. Use a probe to trace the bile duct superiorly. Identify the **cystic duct** and the **common hepatic duct** (Fig. 4.28).

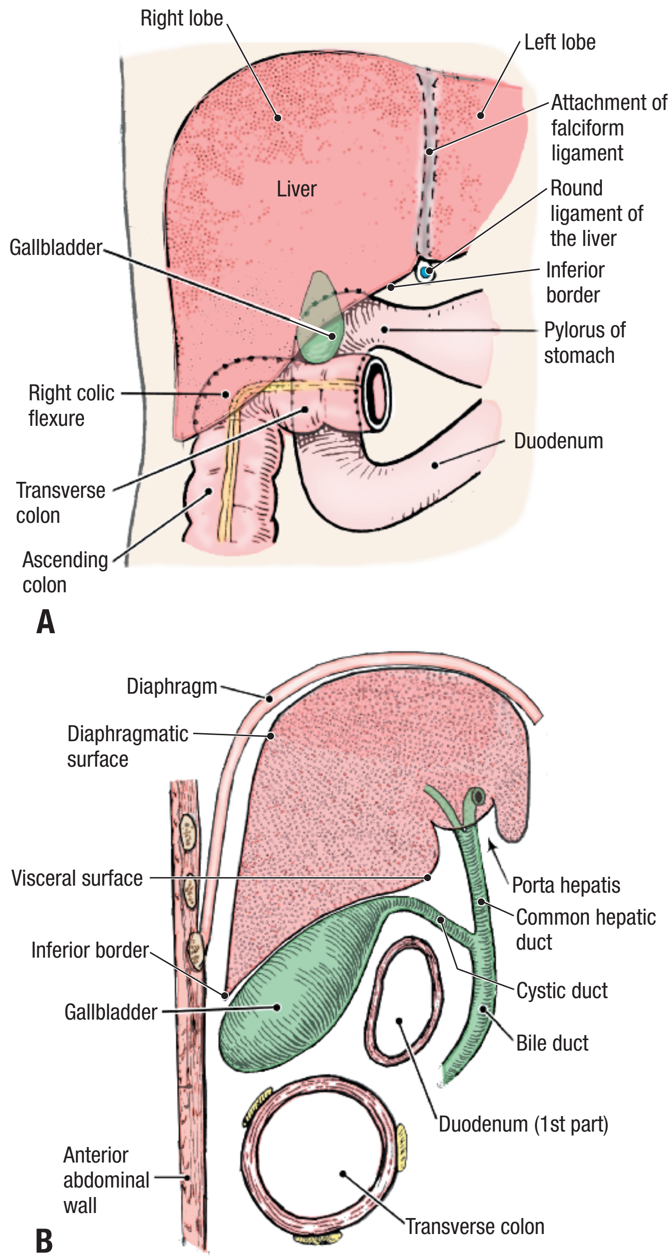

Figure 4.26. Relationships of the gallbladder. **A.** Anterior view. **B.** Sagittal view.

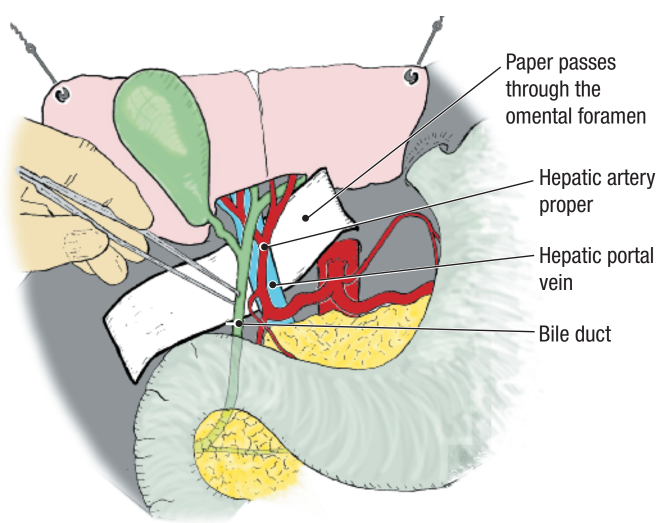

Figure 4.27. Structures contained within the hepatoduodenal ligament.

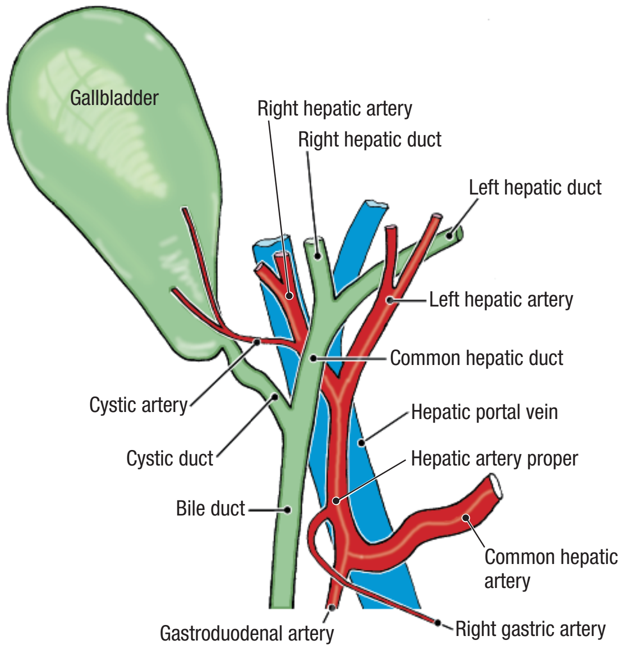

Figure 4.28. Structures contained within the hepatoduodenal ligament. Tributaries of the (common) bile duct and branches of the common hepatic artery.

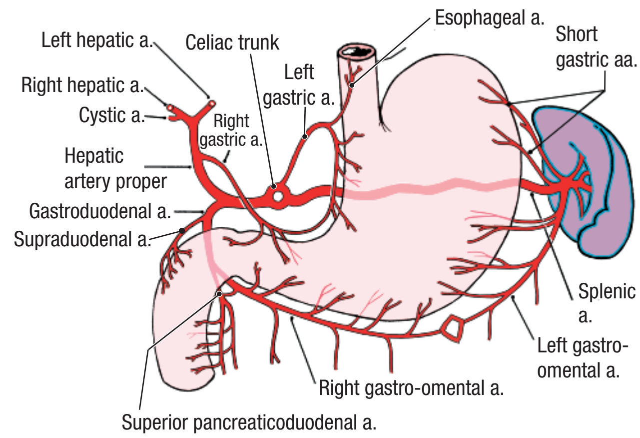

Figure 4.29. Schematic drawing of the branches of the celiac trunk.

6. Follow the common hepatic duct superiorly until it receives its tributaries, the **right hepatic duct** and the **left hepatic duct**. The right and left hepatic ducts exit the **porta hepatis**.
7. Clean the **hepatic artery proper**. The tough "connective tissue" around these vessels contains an **autonomic nerve plexus**. To clear the dissection field, remove the autonomic nerves. **[G 122; N 290; R 303; C 196]**
8. Follow the hepatic artery proper through the hepatoduodenal ligament to the porta hepatis where it branches into the **left hepatic artery** and the **right hepatic artery** (Fig. 4.28).
9. Two other arteries arise in the hepatoduodenal ligament (Fig. 4.28):
   - **Cystic artery**—arises from the right hepatic artery. Follow it to the gallbladder.
   - **Right gastric artery**—arises from the hepatic artery proper. Follow it to the lesser curvature of the stomach.
10. **Lymphatics** are also contained within the hepatoduodenal ligament. The lymphatic vessels are too small to dissect but **hepatic lymph nodes** can be seen. The lymph nodes may be removed to clear the dissection field.
11. Follow the hepatic artery proper inferiorly and confirm that it is the continuation of the **common hepatic artery** (Fig. 4.28).
12. Observe that the common hepatic artery gives rise to the **gastroduodenal artery**. The gastroduodenal artery passes posterior to the first part of the duodenum (Fig. 4.29). Follow the gastroduodenal artery until it divides to give rise to the **right gastro-omental (gastroepiploic) artery** and the **superior pancreaticoduodenal artery**.

CLINICAL CORRELATION

Anatomical Variation in Arteries

In approximately 12% of cases, the right hepatic artery arises from the superior mesenteric artery. An aberrant left hepatic artery may arise from the left gastric artery. During gastrectomy (surgical removal of the stomach), blood flow to an aberrant left hepatic artery could be interrupted, endangering the left lobe of the liver. The cystic artery usually arises from the right hepatic artery, but other origins are possible. The cystic artery may pass posterior (75%) or anterior (24%) to the common hepatic duct (Fig. 4.30).

13. Follow the common hepatic artery to the left toward the **celiac trunk** (Fig. 4.29). Note that the celiac trunk arises from the anterior surface of the abdominal aorta at the level of the twelfth thoracic vertebra. The celiac trunk is very short (less than 2 cm in most cases) and divides into three branches:
    - **Common hepatic artery** (already dissected)
    - **Left gastric artery**
    - **Splenic artery**
14. Use blunt dissection to follow the **left gastric artery** (Fig. 4.29). The left gastric artery reaches the stomach near the esophagus and then follows the lesser curva-

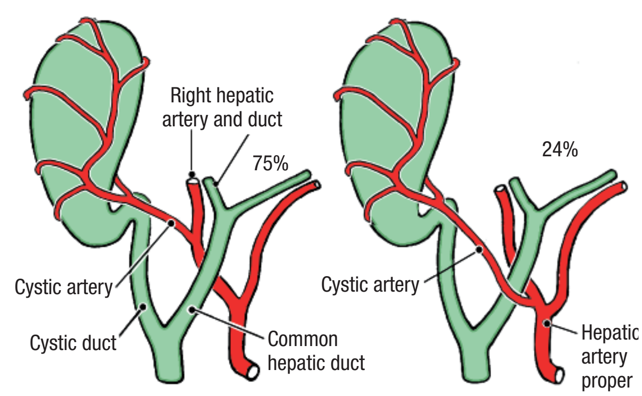

Figure 4.30. The two most common branching patterns of the cystic artery.

ture of the stomach within the lesser omentum. The left gastric artery forms an anastomosis with the right gastric artery along the lesser curvature of the stomach. Branches of the gastric arteries distribute to the anterior and posterior surfaces of the stomach.

15. Follow the **splenic artery** to the left for approximately 5 cm and verify that it lies against the posterior abdominal wall. The splenic artery courses along the superior border of the pancreas and may be partially imbedded in it. Do not dissect the splenic artery from the pancreas at this time. Note that **short gastric arteries** arise from the splenic artery to supply the fundus of the stomach (Fig. 4.29).
16. Find the **left gastro-omental (gastroepiploic) artery** in the greater omentum approximately 2 cm from the greater curvature of the stomach (Fig. 4.29). The left gastro-omental artery is a branch of the splenic artery.
17. Find the **right gastro-omental artery** in the greater omentum near the right end of the greater curvature of the stomach. The right gastro-omental artery anastomoses with the left gastro-omental artery. Follow the right gastro-omental artery to the right to find its origin from the gastroduodenal branch of the common hepatic artery. [G 128; N 292; R 302; C 196]
18. Return to the hepatoduodenal ligament and identify the **hepatic portal vein**. The hepatic portal vein lies posterior to both the hepatic artery proper and the bile duct (Fig. 4.27). Follow the hepatic portal vein superiorly and observe that it passes into the porta hepatis where it divides into **right and left portal veins**. The hepatic portal vein usually receives the **left and right gastric veins** as tributaries. Inferiorly, the hepatic portal vein passes posterior to the first part of the duodenum.

SPLEEN [G 123; N 289; R 305; C 202]

The spleen is the largest hematopoietic organ in the body. Its size and weight may vary considerably depending upon the blood volume that it contains. The spleen is covered by visceral peritoneum except at the hilum where the splenic vessels enter and leave.

1. Use your left hand to pull the fundus of the stomach to the right. Use your right hand to gently pull the spleen anteriorly.
2. Observe that the spleen has a smooth diaphragmatic surface. The spleen has sharp anterior, inferior, and superior borders. The superior border of the spleen is often notched.
3. The **visceral surface of the spleen** is related to four organs:
   - **Stomach**
   - **Left kidney**
   - **Transverse colon (left colic flexure)**
   - **Pancreas**
4. The **diaphragmatic surface of the spleen** is related (through the diaphragm) to ribs 9, 10, and 11 (Fig. 4.31).

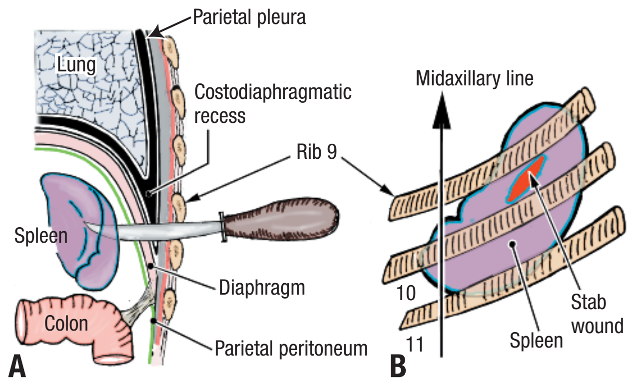

Figure 4.31. Relationships of the spleen to the thoracic wall. **A.** Frontal section. **B.** Lateral view. A penetrating wound through the ninth intercostal space, just posterior to the midaxillary line, will penetrate the pleural cavity, diaphragm, peritoneal cavity, and spleen.

CLINICAL CORRELATION

Spleen

The relationship of the spleen to ribs 9, 10, and 11 is of clinical importance in evaluating rib fractures and penetrating wounds. A lacerated spleen bleeds profusely into the abdominal cavity and may have to be removed surgically (splenectomy). It must be emphasized that there is a risk of puncturing the spleen during thoracocentesis (pleural tap).

An enlarged spleen (splenomegaly) may be encountered during physical examination. The spleen is considered enlarged when it can be palpated inferior to the costal margin.

LIVER [G 142; N 279; R 288; C 206]

The **liver** is the largest gland in the body, comprising approximately 2.5% of the body weight of an adult. To study the surface features of the liver, it must be detached from the diaphragm.

1. Review the falciform ligament and the coronary ligament of the liver.
2. Use scissors to cut the falciform ligament along its attachment to the anterior abdominal wall. Extend the cut superiorly and cut the right and left triangular ligaments along the inferior surface of the diaphragm.
3. Insert your fingers between the liver and the diaphragm and free the connective tissue attachment of the liver to the diaphragm. Cut the posterior layer of the coronary ligament.
4. Use scissors to cut the inferior vena cava between the liver and the diaphragm. Elevate the inferior border of the liver and cut the inferior vena cava again, as close to the inferior surface of the liver as possible. These two cuts will leave a short segment of the inferior vena cava within the liver (Fig. 4.32B).
5. The liver should now be freely mobile but attached to the other abdominal viscera by the bile duct, hepatic artery proper, and hepatic portal vein. Move the liver carefully to avoid tearing these structures.

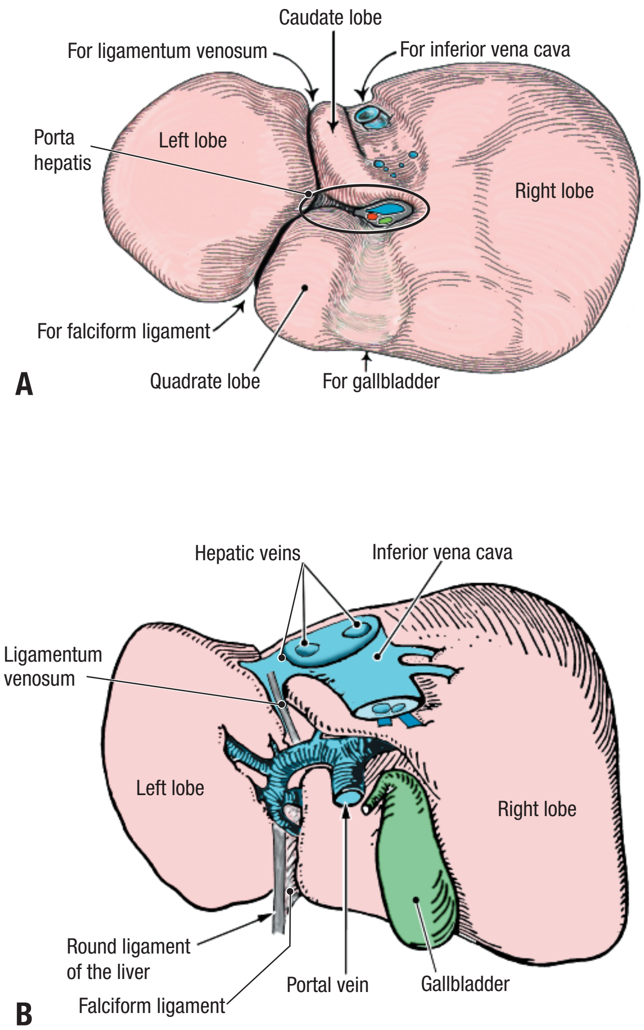

Figure 4.32. Posterior views of the liver. **A.** Fissures and sulci define the four lobes of the liver (right, left, quadrate, and caudate). **B.** Structures located in the H-shaped fissures.

6. Examine the **liver** and note that the **right lobe** is six times larger than the **left lobe**. The sharp **inferior border** of the liver separates the **visceral surface** from the **diaphragmatic surface**.
7. Identify the **bare area** on the posterior aspect of the diaphragmatic surface. Here, the liver was adjacent to the diaphragm and not covered by peritoneum. Around the bare area, note the cut edges of the **coronary ligament**.
8. Examine the **visceral surface** of the liver (Fig. 4.32A). An H-shaped set of fissures and fossae defines four lobes. Identify the **right lobe**, **left lobe**, **caudate lobe**, and **quadrate lobe**. **[G 143, 148; N 279; R 289; C 207]**
9. Observe that the **ligamentum venosum** and **falciform ligament** occupy the left fissure of the "H" (Fig. 4.32B). The **gallbladder** and **inferior vena cava** occupy the fossae that form the right side of the "H."
10. Identify the **porta hepatis**. It forms the horizontal bar of the "H." The structures passing through the hepatoduodenal ligament (bile ducts, hepatic arteries, hepatic portal vein, lymphatics, and autonomic nerves) enter or leave the liver at the porta hepatis.
11. Examine the small segment of the **inferior vena cava** that is attached to the liver. Note that several **hepatic veins** drain directly into the inferior vena cava (Fig. 4.32B).
12. Use a textbook to study the two conventions by which the liver may be divided into lobes. The falciform ligament divides the liver into **right and left anatomical lobes**. The pattern of its bile drainage and vascular supply are used to divide the liver into **right and left functional lobes**. **[G 146; N 281; R 289]**
13. The liver has a substantial lymphatic drainage. At the porta hepatis, small lymph vessels drain into **hepatic lymph nodes**. From the hepatic lymph nodes, lymphatic vessels follow the hepatic arteries to **celiac lymph nodes** located around the celiac trunk.

CLINICAL CORRELATION

Liver

The liver may undergo pathologic changes that could be encountered during dissection. The liver may be enlarged. This happens in liver congestion because of cardiac insufficiency (cardiac liver). In contrast, the liver may be small and have fibrous nodules. Such a finding may indicate cirrhosis of the liver. Because the liver is essentially a capillary bed downstream from the gastrointestinal tract, metastatic tumor cells are often trapped within it, resulting in secondary tumors.

GALLBLADDER [G 148; N 285; R 287; C 208]

The gallbladder is a reservoir for the storage and concentration of bile. The gallbladder occupies a shallow fossa on the visceral surface of the liver (Fig. 4.32B). The gallbladder is usually stained dark green by bile, which leaks through the wall of the gallbladder after death.

1. Replace the liver into its correct anatomical position.
2. Confirm that the gallbladder is located near the tip of the ninth costal cartilage in the midclavicular line.
3. Reposition the liver to expose the visceral surface. Use blunt dissection to remove the gallbladder from its fossa.
4. Identify the parts of the gallbladder (Fig. 4.33):
   - **Fundus**
   - **Body**
   - **Neck**
5. Review the course of the **cystic artery**. The cystic artery is stained green by bile and is often fragile and difficult to dissect.
6. Use scissors to make a longitudinal incision through the wall of the gallbladder, beginning at the fundus and continuing through the neck. If gallstones are present, remove them. Look for the **spiral fold**, which is present in the mucosal lining of the neck, continuing into the **cystic duct**.

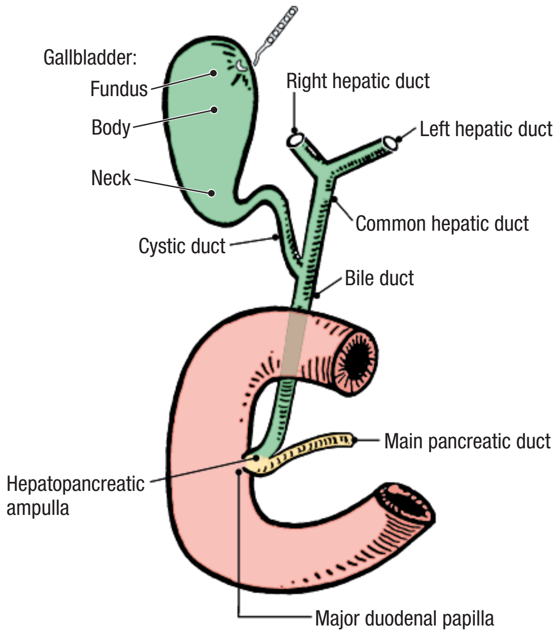

Figure 4.33. Extrahepatic bile ducts.

After you dissect . . .

Replace the organs in their correct anatomical positions. Close and open the flaps of the abdominal wall and review the location of each organ relative to the abdominal quadrant system. Use an illustration and the dissected specimen to trace the branches of the celiac trunk. Review the relationships of the structures in the hepatoduodenal ligament. Review the boundaries of the omental foramen. Review the parts of the organs dissected and their relationships to surrounding structures. Use an embryology textbook to review the development of the liver and the ventral mesogastrium. Review the derivatives of the embryonic foregut.

SUPERIOR MESENTERIC ARTERY AND SMALL INTESTINE

Before you dissect . . .

The order of dissection will be as follows. The mesentery will be examined. The branches of the superior mesenteric artery that supply the jejunum, ileum, cecum, ascending colon, and transverse colon will be dissected. The remainder of the field of supply of the superior mesenteric artery (to the duodenum and pancreas) will be dissected later, because these structures lie behind the attachment of the transverse mesocolon. The external features of the jejunum and ileum will be studied. The inferior mesenteric vessels will be dissected.

Dissection Instructions

SUPERIOR MESENTERIC ARTERY [G 136; N 295, 296; R 291; C 216]

The superior mesenteric artery arises from the anterior surface of the abdominal aorta approximately 1 cm inferior to the celiac trunk. At its origin, the superior mesenteric artery lies posterior to the neck of the pancreas. When the superior mesenteric artery emerges from posterior to the neck of the pancreas, it passes anterior to the uncinate process, third part of the duodenum, and left renal vein. The superior mesenteric artery then enters the mesentery. Within the mesentery the superior mesenteric artery courses toward the terminal end of the ileum.

1. Return the liver to its correct anatomical position.
2. Turn the transverse colon and greater omentum superiorly over the costal margin. The posterior surface of the transverse mesocolon should face anteriorly.
3. Move the coils of the **jejunum** and **ileum** to the left side of the abdomen so that the right side of the mesentery faces anteriorly (Fig. 4.34). Observe that the root of the mesentery is attached to the posterior abdominal wall along a line from the left upper quadrant to the right lower quadrant.
4. Remove the peritoneum on the right side of the mesentery to expose the branches of the superior mesenteric artery. To do this, use a probe to tear the peritoneum, then grasp it between your thumb and index finger (Fig. 4.35). Peel it slowly, using the handle of a forceps to scrape the peritoneum free from deeper structures.
5. Remove the parietal peritoneum from the posterior abdominal wall on the right side of the mesentery. Remove the peritoneum as far laterally as the ascending colon.
6. Identify the **superior mesenteric artery**. Use blunt dissection to trace the superior mesenteric artery proximally and observe that it crosses anterior to the third part of the duodenum. Note that the third part of the duodenum and the left renal vein can become compressed between the superior mesenteric vessels and the abdominal aorta.
7. Use blunt dissection to clean the branches of the superior mesenteric artery. As you dissect, note the dense autonomic nerve network surrounding the vessels. This is the **superior mesenteric plexus of nerves**. Remove the nerves as necessary to clear the dissection field.

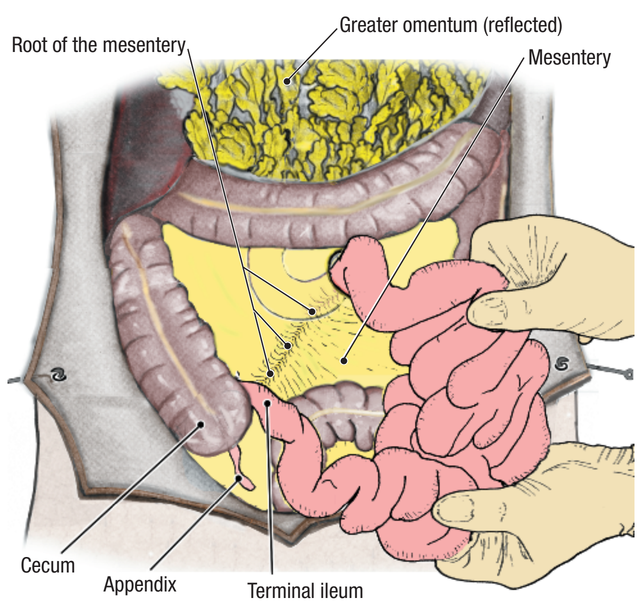

Figure 4.34. Move the small intestine to the left for dissection of the superior mesenteric artery.

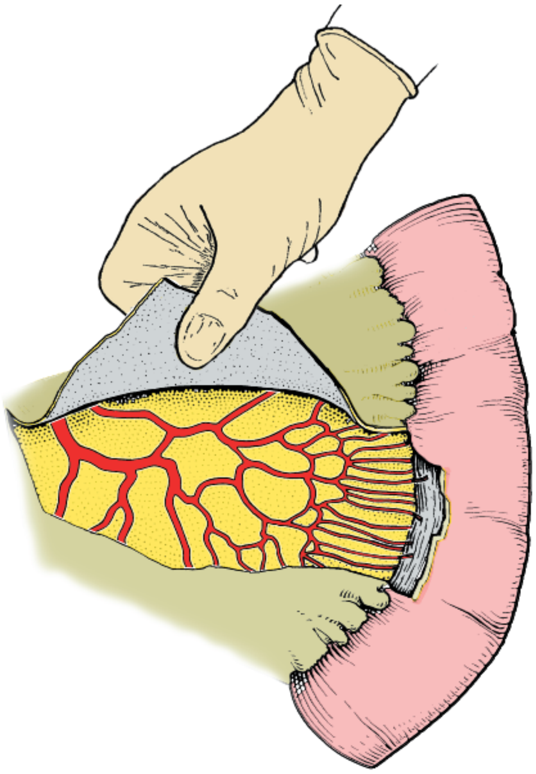

Figure 4.35. How to remove the peritoneum from the mesentery to expose the blood vessels.

8. Identify the **branches of the superior mesenteric artery**:
   - **Inferior pancreaticoduodenal artery –** the first branch of the superior mesenteric artery. The inferior pancreaticoduodenal artery will be dissected later.
   - **Intestinal arteries –** 15 to 18 arteries to the jejunum and the ileum. Intestinal arteries end in straight terminal branches called **vasa recta** (Fig. 4.36). **Arcades** connect the intestinal arteries. Observe the blood supply to the proximal jejunum and note that only one or two arcades are found between adjacent intestinal arteries, resulting in relatively long vasa recta (Fig. 4.36A). Examine the distal ileum and note that four or five arcades occur between adjacent intestinal arteries, resulting in relatively short vasa recta (Fig. 4.36B).
   - **Ileocolic artery –** supplies the cecum. The ileocolic artery gives rise to the **appendicular artery** (Fig. 4.37). The ileocolic artery anastomoses with intestinal branches and with the right colic artery.
   - **Right colic artery –** supplies the ascending colon. The right colic artery arises from the right side of the superior mesenteric artery and passes to the right in a retroperitoneal position. It divides into a superior branch and an inferior branch.
   - **Middle colic artery –** supplies the transverse colon. The middle colic artery arises from the anterior surface of the superior mesenteric artery and courses through the transverse mesocolon. It divides into a right branch and a left branch.
9. Identify the **superior mesenteric vein**. The superior mesenteric vein is formed by branches that correspond in name and position to the branches of the superior mesenteric artery. The superior mesenteric vein courses along the right side of the superior mesenteric artery. Posterior to the pancreas, the superior mesenteric vein joins the splenic vein to form the **hepatic portal vein**.
10. The mesentery may contain up to 200 **mesenteric lymph nodes**. Identify one or two of these lymph nodes along the branches of the superior mesenteric vessels. The **superior mesenteric lymph nodes** are located near the origin of the superior mesenteric artery from the abdominal aorta. Lymph nodes may be removed to clear the dissection field.

SMALL INTESTINE [G 132, 133; N 262; R 298; C 218]

The small intestine consists of the duodenum, jejunum, and ileum. The function of the small intestine is to absorb nutrients from food. It has elaborate folds of mucosa that increase surface area and a rich blood supply to transport the absorbed nutrients. The **jejunum** (proximal two-

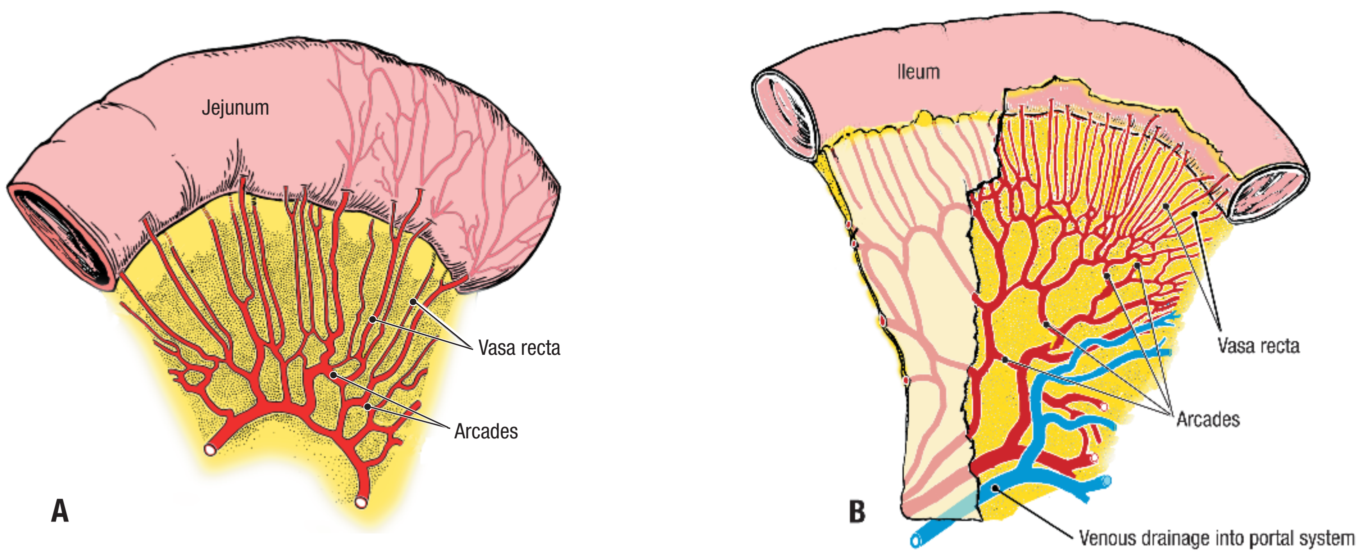

Figure 4.36. Comparison of intestinal arteries. **A.** Arteries of the jejunum. **B.** Arteries of the ileum.

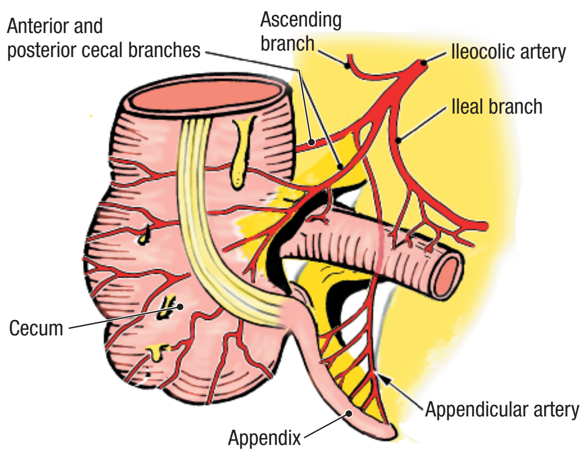

Figure 4.37. Branches of the ileocolic artery.

fifths) and **ileum** (distal three-fifths) are studied together because their transition is not obvious.

1. Move the small intestine to the left side of the abdominal cavity and follow the jejunum proximally (Fig. 4.38). Find the **duodenojejunal junction**.
2. Note that the **suspensory ligament of the duodenum** is a fibromuscular ligament that arises from the right crus of the diaphragm and anchors the intestine at the duodenojejunal junction (Fig. 4.38, inset).
3. Palpate the small intestine and note that the wall of the jejunum is thicker than the wall of the ileum.
4. Identify the termination of the ileum where it empties into the **cecum** at the **ileocecal junction** (Fig. 4.38).
5. Verify that the **root of the mesentery** crosses the posterior abdominal wall from the duodenojejunal junction to the ileocecal junction (Fig. 4.38). The root of the mesentery is approximately 15 cm long. The **intestinal attachment of the mesentery** is nearly 6 m long.

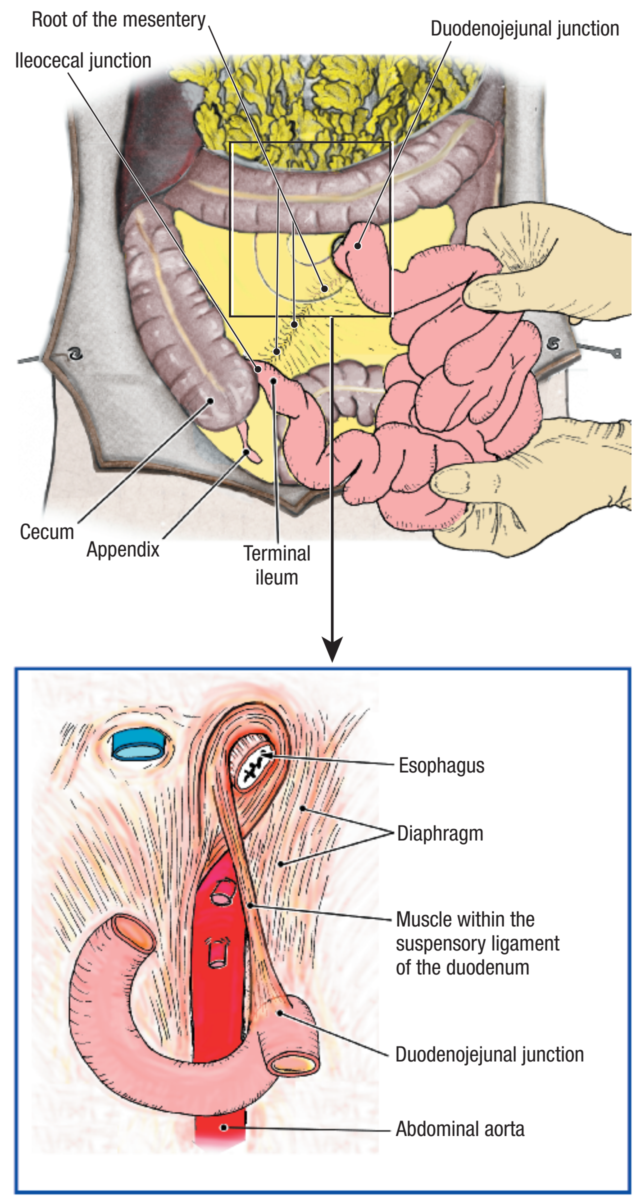

Figure 4.38. Move the small intestine to the left side to find the duodenojejunal junction. Inset: The duodenojejunal junction is suspended by the suspensory muscle (ligament) of the duodenum.

After you dissect . . .

Replace the small intestine in its correct anatomical position. Close and open the flaps of the abdominal wall and review the location of the jejunum and ileum relative to the abdominal quadrant system. Review the relationships of the jejunum and ileum to surrounding structures. Use an illustration and the dissected specimen to review the branches of the superior mesenteric artery. Use an embryology textbook to review the derivatives of the embryonic midgut.

INFERIOR MESENTERIC ARTERY AND LARGE INTESTINE

Before you dissect . . .

The **inferior mesenteric artery** arises from the anterior surface of the abdominal aorta at the level of the intervertebral disk between vertebrae L2 and L3. The objective is to demonstrate the field of supply of the inferior mesenteric artery (left half of the transverse colon, descending colon, sigmoid colon, and most of the rectum). Except for the branches that pass through the sigmoid mesocolon to supply the sigmoid colon, the inferior mesenteric artery and its branches lie retroperitoneally.

The order of dissection will be as follows. The inferior mesenteric artery and its branches will be dissected. The external features of the large intestine will be studied.

Dissection Instructions

INFERIOR MESENTERIC ARTERY [G 138; N 296; R 293; C 218]

1. Turn the transverse colon and greater omentum superiorly over the costal margin to expose the posterior surface of the transverse mesocolon.
2. Move the small intestine to the right so that the descending colon is visible from the left colic flexure to the sigmoid colon (Fig. 4.39).

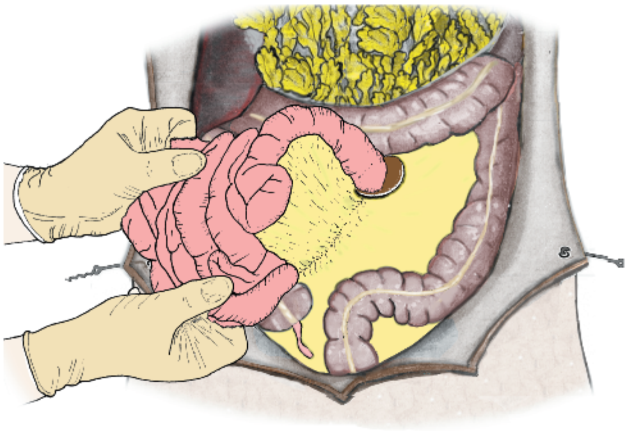

Figure 4.39. Move the small intestine to the right for dissection of the inferior mesenteric artery.

3. The origin of the inferior mesenteric artery lies posterior to the third part of the duodenum. If you have trouble finding it, find one of its branches in the sigmoid mesocolon and trace the branch back to the main vessel. Then proceed with the dissection of the peripheral branches.

Dissection note: The left ureter could be mistaken for the inferior mesenteric artery or one of its branches. The inferior mesenteric artery and vein and the ureter all lie in the retroperitoneal space, but the vessels pass anterior to the ureter.

4. Use a probe to clean the **branches of the inferior mesenteric artery** (Fig. 4.40):
   - **Left colic artery –** supplies the descending colon and the left half of the transverse colon. The left colic artery anastomoses with the middle colic branch of the superior mesenteric artery.
   - **Sigmoid arteries –** supply the sigmoid colon. Sigmoid arteries pass through the sigmoid mesocolon. Note that they form arcades similar to those of the intestinal arteries.
   - **Superior rectal artery –** supplies the proximal part of the rectum. The superior rectal artery divides into a **right branch** and a **left branch**. The right and left branches of the superior rectal artery descend into the pelvis on either side of the rectum. Do not follow them into the pelvis.
5. Observe the tributaries of the **inferior mesenteric vein**. The tributaries of the inferior mesenteric vein correspond to the branches of the inferior mesenteric artery. The inferior mesenteric vein ascends on the left side of the inferior mesenteric artery, passes posterior to the pancreas, and joins either the **splenic vein** or (less frequently) the **superior mesenteric vein**.
6. The inferior mesenteric artery and vein are accompanied by lymph vessels that drain into the **inferior mesenteric nodes** around the origin of the inferior mesenteric artery.

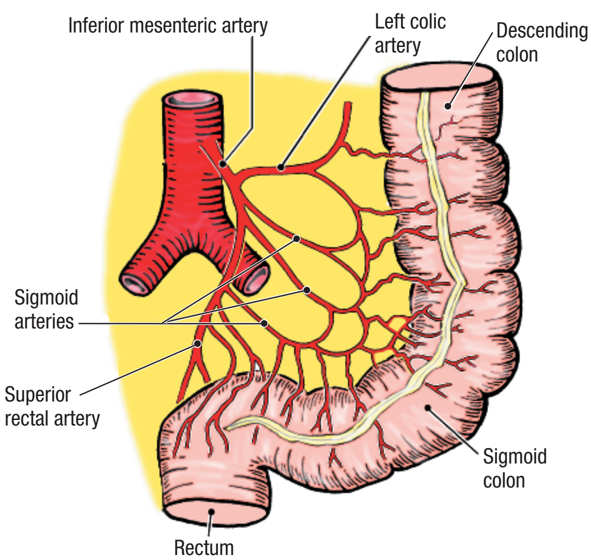

Figure 4.40. Branches of the inferior mesenteric artery.

LARGE INTESTINE [G 132, 133; N 276; R 295; C 212, 214]

The large intestine consists of the **cecum** (with attached **appendix)**, **colon** (ascending, transverse, descending and sigmoid), **rectum**, and **anal canal**. Absorption of water from fecal material is a major function of the large intestine. The relatively smooth mucosal surface of the large intestine is well-suited for this function, because a smooth surface is less likely to impede the movement of progressively more solid fecal matter.

1. Return the small intestine and transverse colon to their correct anatomical positions.
2. In the right lower quadrant, identify the **cecum** (L. *caecus*, blind). The length of its mesentery and the degree of its mobility vary considerably from individual to individual.
3. The **appendix (vermiform appendix)** (L. *appendere*, to hang on) is attached to the end of the cecum. The appendix may be found in one of several positions (Fig. 4.41). Recall that the appendix is suspended on a mesentery called the **mesoappendix**. The **appendicular artery** is found within the mesoappendix (Fig. 4.37).
4. Identify the **ascending colon**. It is a secondarily retroperitoneal organ. The ascending colon extends from the cecum to the **right colic flexure** (Fig. 4.23).

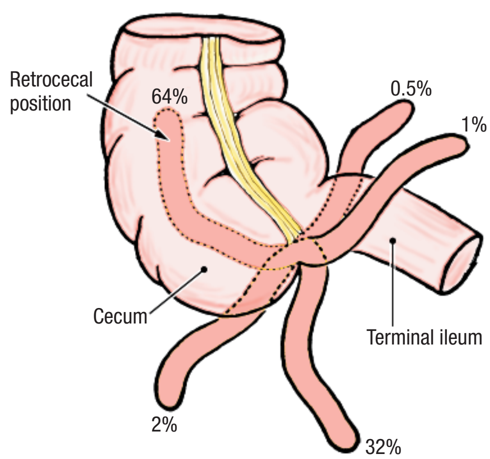

Figure 4.41. Variations in the position of the appendix.

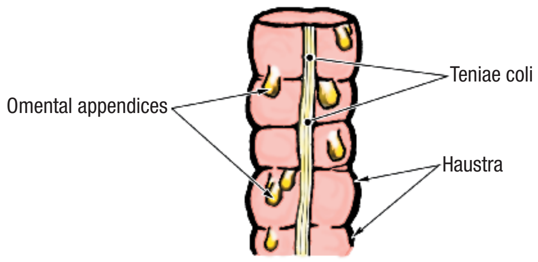

Figure 4.42. Surface features of the large intestine.

5. Identify the **transverse colon**. The transverse colon extends from the **right colic flexure** to the **left colic flexure**. Observe that the left colic flexure is at a more superior level than the right colic flexure. Between the two flexures, the transverse colon is freely movable.
6. Observe the **descending colon.** It is a secondarily retroperitoneal organ. The descending colon descends from the left colic flexure to the left lower quadrant (Fig. 4.23).
7. In the left lower quadrant, find the **sigmoid colon**. Observe that the sigmoid colon has a mesentery (**sigmoid mesocolon**) and is mobile. The sigmoid colon ends in the pelvis at the level of the 3rd sacral segment, where it becomes continuous with the rectum.
8. The **rectum** is contained entirely within the pelvic cavity and will be dissected at a later time.
9. Observe the external surface of the large intestine and note three features that distinguish it from the small intestine (Fig. 4.42):
   - **Teniae coli –** three narrow bands of longitudinal muscle
   - **Haustra –** outpouchings of the wall of the colon
   - **Omental appendices (epiploic appendages) –** small accumulations of fat covered by visceral peritoneum
10. Review the branches of the superior mesenteric artery and inferior mesenteric artery that supply the large intestine. **[G 141; N 296; R 296; C 216, 218]**

After you dissect . . .

Close and open the flaps of the abdominal wall to review the location of each part of the large intestine relative to the abdominal quadrant system. Review the relationship of each part of the large intestine to the surrounding structures. Use an illustration and the dissected specimen to trace the branches of the inferior mesenteric artery. Use an embryology textbook to review the derivatives of the embryonic hindgut.

DUODENUM, PANCREAS, AND HEPATIC PORTAL VEIN

Before you dissect . . .

The duodenum is the part of the small intestine between the stomach and the jejunum. The duodenum is the drainage point for the ducts of the liver and pancreas. The pancreas lies within the bend of the duodenum. The pancreas is both an endocrine and an exocrine organ and has a rich blood supply arising from the celiac trunk and the superior mesenteric artery.

The order of dissection will be as follows. The parts of the duodenum will be studied. The pancreas will be dissected. The formation of the hepatic portal vein will be demonstrated.

Dissection Instructions

DUODENUM [G 125, 126; N 270; R 304; C 210]

1. Turn the transverse colon and greater omentum superiorly over the costal margin.
2. Use blunt dissection to remove the remaining connective tissue and peritoneum from the anterior surface of the duodenum and pancreas.
3. Observe the **four parts of the duodenum** (Fig. 4.43):
   - **Superior (first) part –** at the level of vertebra L1. The superior part of the duodenum lies in the transverse plane and the hepatoduodenal ligament is attached to it. It is mostly intraperitoneal.
   - **Descending (second) part –** at the level of vertebra L2. The descending part of the duodenum is positioned to the right of the midline and anterior to the right kidney, right renal vessels, and inferior vena cava. It is retroperitoneal. The bile duct and the pancreatic duct drain into the descending part of the duodenum.
   - **Horizontal (third) part –** at the level of vertebra L3. The horizontal part of the duodenum lies anterior to the inferior vena cava and the abdominal aorta. It is retroperitoneal. The horizontal part of the duodenum is crossed anteriorly by the superior mesenteric vessels and posteriorly by the inferior mesenteric vessels.
   - **Ascending (fourth) part –** ascends to the level of vertebra L2. The ascending part of the duodenum is retroperitoneal throughout most of its length. The ascending part of the duodenum turns anteriorly to join the jejunum at the duodenojejunal junction.

PANCREAS [G 125, 130; N 288; R 305; C 211]

1. Identify the **pancreas** within the bend of the duodenum. Note that it is a secondarily retroperitoneal organ that lies across the midline and that it is positioned against the vertebral bodies.

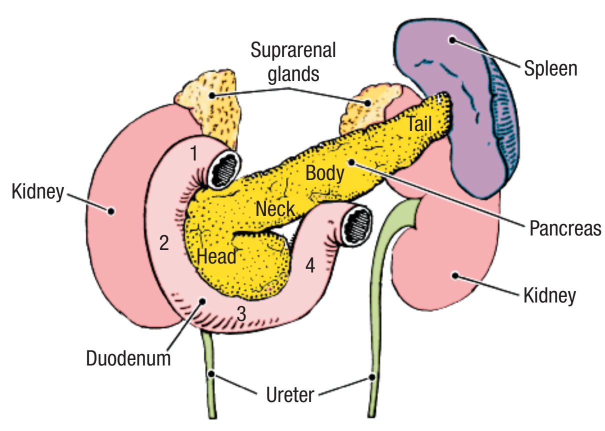

Figure 4.43. Relationships of the spleen, pancreas, duodenum, and kidneys.

2. Identify the parts of the pancreas (Fig. 4.43):
   - **Head –** lies within the curve of the duodenum. The head of the pancreas lies anterior to the origin of the superior mesenteric artery. The **uncinate process** is a small projection from the inferior margin of the head that passes posterior to the superior mesenteric vessels. The inferior vena cava lies posterior to the head of the pancreas.
   - **Neck –** a short portion that lies anterior to the superior mesenteric vessels and connects the head of the pancreas to the body.
   - **Body –** extends from right to left and slightly superiorly as it crosses the posterior abdominal wall. The abdominal aorta lies posterior to the body of the pancreas.
   - **Tail –** the narrow left end of the gland. The tip of the tail lies in the splenorenal ligament and contacts the hilum of the spleen.
3. Use a probe to dissect into the anterior surface of the head of the pancreas and find the **main pancreatic duct**. Trace the main pancreatic duct through the neck and into the body. The **accessory pancreatic duct** joins the main pancreatic duct from the superior side.
4. Follow the main pancreatic duct toward the descending part of the duodenum. Observe that the main pancreatic duct is joined by the bile duct.
5. Identify the **superior pancreaticoduodenal artery** (Fig. 4.44), a branch of the gastroduodenal artery. **[G 127; N 291; R 304; C 213]**
6. The **inferior pancreaticoduodenal artery** is usually the most proximal branch of the superior mesenteric artery, although its origin is variable (Fig. 4.44). The inferior pancreaticoduodenal artery enters the inferior portion of the head of the pancreas.
7. Return to the celiac trunk and follow the splenic artery as it passes to the left along the superior margin of the pancreas (Fig. 4.44). The splenic artery will supply up to 10 small arteries to the body and tail of the pancreas. Identify only two:
   - **Dorsal pancreatic artery –** enters the neck of the pancreas.
   - **Greater pancreatic (pancreatica magna) artery –** enters the pancreas at the junction of the medial two-thirds and lateral one-third of the gland.
8. Follow the splenic artery to the hilum of the spleen and identify the **left gastro-omental artery**. Complete the dissection of the left gastro-omental artery by following it through the greater omentum to its anastomosis with the right gastro-omental artery.
9. The veins of the pancreas correspond to the arteries. They drain into the superior mesenteric and splenic veins and ultimately are tributary to the hepatic portal vein.

HEPATIC PORTAL VEIN [G 152; N 301; R 290; C 201]

Use an illustration to review the hepatic portal venous system. The **superior mesenteric vein** and the **splenic vein** join to form the hepatic portal vein posterior to the neck of the pancreas. The **hepatic portal vein** carries venous blood to the liver from the abdominal portion of the gastrointestinal tract, the spleen, and the pancreas.

1. The **splenic vein** courses posterior to the pancreas, inferior to the splenic artery. Use a probe to dissect posterior to the body of the pancreas and find the splenic vein.
2. Follow the splenic vein to the right, where it is joined by the superior mesenteric vein. This is the origin of the **hepatic portal vein**. Recall that the hepatic portal vein ascends in the hepatoduodenal ligament to the porta hepatis.
3. Return to the field of distribution of the inferior mesenteric vein. Find it and follow it superiorly. The inferior mesenteric vein usually joins the splenic vein, but it may join the superior mesenteric vein, or the junction of the superior mesenteric and splenic veins.
4. Use a textbook or atlas to review the portal–systemic (portal–caval) anastomoses:
   - **Gastroesophageal –** left gastric vein/esophageal veins/azygos vein
   - **Anorectal –** superior rectal vein/middle and inferior rectal veins
   - **Paraumbilical –** paraumbilical veins/superficial epigastric veins
   - **Retroperitoneal –** colic veins/retroperitoneal veins

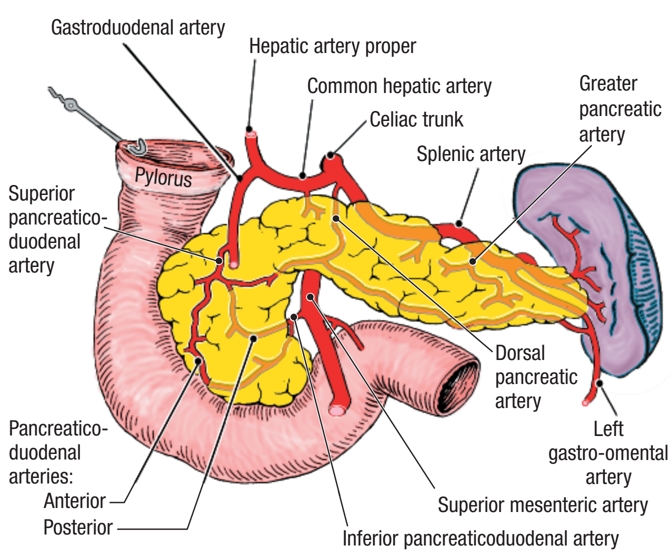

Figure 4.44. Blood supply of the duodenum and pancreas.

Portal Hypertension

The hepatic portal system of veins has no valves. When the hepatic portal vein becomes blocked, blood pressure increases in the hepatic portal system (portal hypertension) and its tributaries become engorged. Portal hypertension causes hemorrhoids, and varicose gastric and esophageal veins. Bleeding from ruptured **gastroesophageal varices** is a dangerous complication of portal hypertension.

After you dissect . . .

Review the relationship of each part of the duodenum to surrounding structures. Review the branches of the celiac trunk and superior mesenteric artery. Use an illustration and the dissected specimen to reconstruct the blood supply to the pancreas and duodenum. Review the formation and field of drainage of the hepatic portal vein. Trace a drop of blood from the small intestine to the inferior vena cava. Use an embryology textbook to review the development of the liver, pancreas, and duodenum.

REMOVAL OF THE GASTROINTESTINAL TRACT

Before you dissect . . .

The order of dissection will be as follows. The arteries to the gastrointestinal tract (celiac trunk, superior mesenteric artery, and inferior mesenteric artery) will be cut close to the aorta. The esophagus and rectum will be cut, using ligatures to prevent spillage of their contents. The gastrointestinal tract will then be removed and reviewed outside of the body. The gastrointestinal tract will be taken to a sink and selected areas will be opened and rinsed to study specializations of the mucosa.

Dissection Instructions

1. Tie two strings 4 cm apart around the superior end of the rectum. Use scissors to cut the rectum *between the strings*. Cut the superior rectal artery.
2. Inferior to the diaphragm, tie one string around the esophagus and cut the esophagus superior to the string. Cut the vagus nerve trunks at the same level.
3. Use scissors to cut the celiac trunk close to the aorta, leaving no stump.
4. Use scissors to cut the superior and inferior mesenteric arteries near the aorta, leaving a 1 cm stump of each.
5. Free the stomach from any peritoneal attachments it may still have to the posterior abdominal wall.
6. Grasp the spleen and gently pull medially. Insert your fingers posterior to the spleen and carefully free the splenic vessels, tail of the pancreas, and body of the pancreas from the posterior abdominal wall.
7. Use scissors to cut the suspensory ligament of the duodenum close to the duodenojejunal junction.
8. Insert your fingers posterior to the duodenum and free it from the posterior abdominal wall.
9. Use scissors to cut the parietal peritoneum lateral to the ascending colon and use your fingers to free the ascending colon from the posterior abdominal wall. Roll the ascending colon toward the midline and use your fingers to loosen its blood vessels from the posterior abdominal wall.
10. Cut the parietal peritoneum lateral to the descending colon and use your fingers to free the descending colon from the posterior abdominal wall. Roll the descending colon toward the midline and use your fingers to loosen its blood vessels from the posterior abdominal wall.
11. The gastrointestinal tract, liver, pancreas, and spleen should now be free of attachments. Remove them from the abdominal cavity. Be careful not to twist or tear the structures in the hepatoduodenal ligament.
12. Arrange the abdominal viscera on the dissecting table in anatomical position and study the parts from the anterior view. Trace the branches of the celiac trunk, superior mesenteric artery, and inferior mesenteric artery to their areas of distribution. Note the differences between the branching pattern of the arteries and the veins. Turn the viscera and repeat the exercise from a posterior view.
13. Carry the viscera to a sink to examine their internal features.
14. Use scissors to open the stomach along its anterior surface. Extend the cut into the first portion of the duodenum. Rinse the mucosa and observe the following features (Fig. 4.45): **[G 121; N 268; R 284; C 199]**
    - **Gastric canal**
    - **Gastric folds (rugae)**
    - **Pyloric antrum**
    - **Pyloric canal**
    - **Pyloric sphincter**
    - **Pyloric orifice**
15. Use scissors to make a longitudinal incision in the anterior wall of the duodenum. In the second part of the duodenum, identify the following (Fig. 4.46): **[G 125; N 271; R 287; C 211]**
    - **Circular folds** (**plicae circulares**)
    - **Major (greater) duodenal papilla** – an elevation of mucosa on the medial wall of the second part of the duodenum. The major duodenal papilla is the shared opening of the main pancreatic duct and bile duct.
    - **Minor (lesser) duodenal papilla** – the site of drainage of the accessory pancreatic duct. If present, it will be approximately 2 cm superior to the major duodenal papilla.

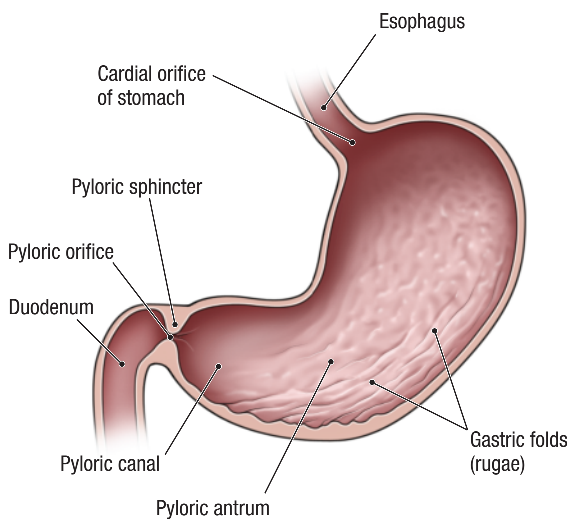

Figure 4.45. Internal features of the stomach.

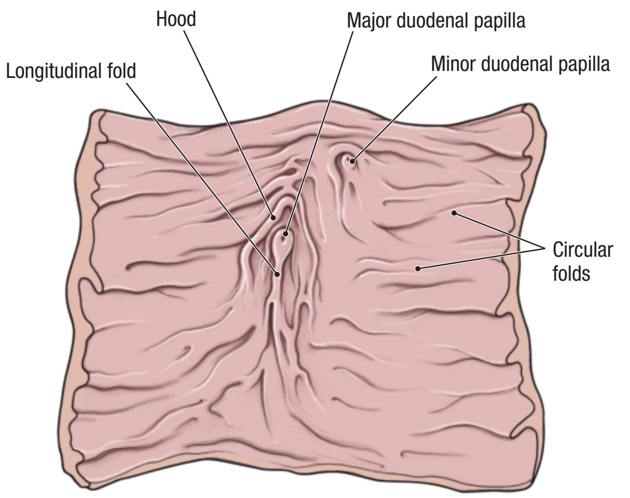

Figure 4.46. Mucosal features in the descending (second) part of the duodenum.

16. Use scissors to make one 5-cm longitudinal incision in the **proximal jejunum** and another in the **distal ileum**. Rinse the mucosa and compare features. Note that the circular folds are larger and closer together in the jejunum (Fig. 4.47). **[G 132; N 272]**
17. Use scissors to make an incision approximately 7.5 cm long in the anterior wall of the **cecum**. Rinse the mucosa and identify the following (Fig. 4.48): **[G 135; N 274; R 298; C 222]**
    - **Ileocecal orifice**
    - **Superior and inferior lips of the ileocecal valve**
    - **Opening of the appendix**

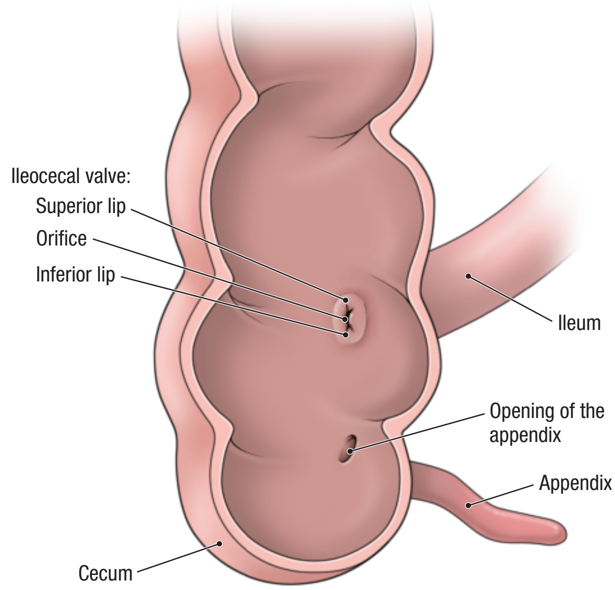

Figure 4.48. Interior of the cecum, from an anterior view.

18. Make an incision approximately 5 cm long in the anterior surface of the transverse colon. Note the **semilunar folds (plicae semilunares)** between adjacent **haustra**. Observe the relative smoothness of the mucosa. **[G 133; N 276; C 224]**
19. The viscera may be stored in a large plastic bag or in the abdominal cavity. Wet these specimens frequently with mold-inhibiting solution.

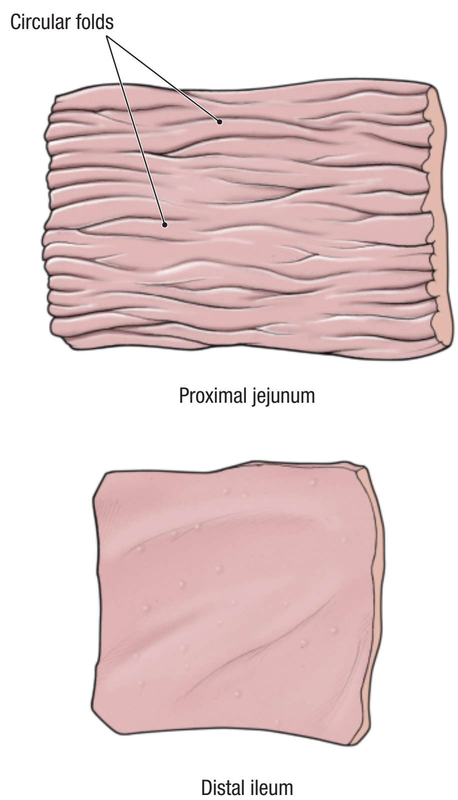

Figure 4.47. Comparison of mucosal features in the proximal jejunum and distal ileum.

After you dissect . . .

Review the features of the gastrointestinal mucosa. Compare the quantity and complexity of circular folds in the proximal and distal parts of the small intestine. Compare this arrangement to the mucosal features seen in the stomach and large intestine. Correlate your findings to the function of the organs dissected. Recall the locations of valves in the gastrointestinal tract.

POSTERIOR ABDOMINAL VISCERA

Before you dissect . . .

The posterior abdominal viscera are located in an area that is referred to as the **retroperitoneal space**. The retroperitoneal space is not a real space. It is that part of the body between the parietal peritoneum and the muscles and bones of the posterior abdominal wall (Fig. 4.49). The retroperitoneal space contains the kidneys, ureters, suprarenal glands, aorta, inferior vena cava, and the abdominal portions of the sympathetic trunks. **[G 163; N 332; R 312; C 247]**

The order of dissection will be as follows. The posterior abdominal viscera will be palpated. The kidneys and suprarenal glands will be removed from the renal fascia and studied. The abdominal aorta and the inferior vena cava will be studied. The muscles of the posterior abdominal wall will be studied. The lumbar plexus of nerves will be examined. Finally, the diaphragm will be studied.

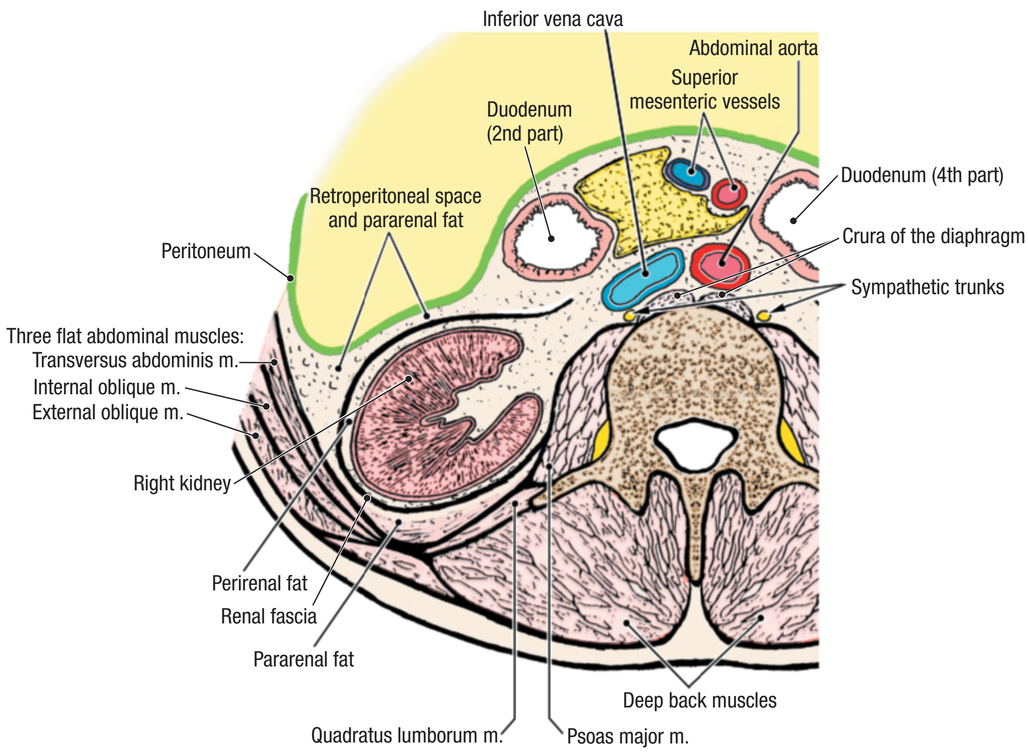

Figure 4.49. Transverse section through the posterior abdominal wall at the level of the kidneys.

Dissection Instructions

1. Use a sponge or paper towels to clean the posterior abdominal wall.
2. Palpate the **kidneys** and the **suprarenal (adrenal) glands**. They lie lateral to the vertebral column at vertebral levels T12 to L3. **[G 155; N 319; R 319; C 228]**
3. Palpate the abdominal aorta.
4. To the right of the abdominal aorta, palpate the inferior vena cava.
5. Remove any remaining parietal peritoneum from the posterior abdominal wall.
6. If you are dissecting a female cadaver, go to step 10.
7. Identify the **testicular artery and vein** at the deep inguinal ring. The testicular artery is quite small and delicate. Follow the testicular vessels superiorly and note that they cross anterior to the ureter. Do not damage the ureter.
8. Observe that the left testicular vein drains into the left renal vein. The right testicular vein drains directly into the inferior vena cava.
9. The **right** and **left testicular arteries** branch directly from the aorta at about vertebral level L2. This origin is inferior to the origin of the renal arteries.
10. In the **female cadaver**, identify the **ovarian vessels**. Their origin is comparable to that of the testicular vessels in the male. Note that the ovarian vessels cross anterior to the ureter.
11. Inferiorly, the ovarian vessels end in the pelvic cavity. Follow the ovarian vessels inferiorly until they cross the external iliac vessels. Do not follow them into the pelvis at this time.

KIDNEYS [G 155; N 319; R 319; C 228]

The position of the kidneys is well-illustrated on transverse section (Fig. 4.49). The kidneys are well-protected by their position within the body as well as by a cushioning layer of fat.

1. Note that the kidneys lie against the posterior abdominal wall. The anterior aspect of the kidney faces anterolaterally (Fig. 4.49).
2. Use your fingers to separate the **kidney** from the **perirenal fat** and **renal fascia** (Fig. 4.49).
3. Observe that the **superior pole** of the kidney is separated from the suprarenal gland by a thin layer of renal fascia. Carefully insert your fingers between the kidney and the suprarenal gland and separate the two organs. Be careful not to remove the suprarenal gland with the fat.
4. Note the size and shape of the kidney.
5. Identify the **left renal vein**. Use a probe to trace the left renal vein from the left kidney to the inferior vena cava. Observe that it crosses anterior to the renal arteries and aorta.
6. Identify and clean the tributaries of the left renal vein:
   - **Left testicular** (or **ovarian**) **vein**
   - **Left suprarenal vein**

Testicular Varicocele

Varicocele is a varicose condition of the pampiniform plexus of veins. Varicocele is more common on the left side because the left testicular vein drains into the left renal vein, and the left renal vein is subject to compression where it passes inferior to the superior mesenteric artery.

7. Use scissors to cut the left renal vein close to the inferior vena cava. Reflect the left renal vein toward the left. Do not detach the testicular (or ovarian) vein or the left suprarenal vein from the left renal vein.
8. Identify the **left renal artery**, which lies posterior to the left renal vein. Follow the left renal artery to the hilum of the kidney. The renal artery usually divides before it enters the kidney, and accessory renal arteries are common.
9. Observe small branches of the left renal artery to the ureter and left suprarenal gland.
10. Using the left renal artery as a hinge, turn the left kidney toward the right. At the most posterior part of the hilum, identify the **renal pelvis** and its inferior continuation, the **ureter**.
11. Use blunt dissection to follow the ureter inferiorly. Observe that the abdominal part of the ureter passes posterior to the testicular (or ovarian) vessels and crosses the anterior surface of the psoas major muscle. The pelvic part of the ureter will be seen later.
12. Return the left kidney to its correct anatomical position.
13. Clean the relatively short right renal vein. Note that it has no tributaries.
14. Reflect the inferior vena cava inferiorly and slightly toward the right. Identify the **right renal artery**, which lies posterior to the right renal vein and inferior vena cava. Note that the right renal artery is longer than the left renal artery. The right renal pelvis lies posterior to the right renal artery.
15. Follow the right ureter inferiorly and observe its relationship to the right testicular (ovarian) vessels.
16. Use an illustration to review the relationships of the kidneys: [G 154; N 319; R 306; C 229]
    - The suprarenal gland is superior to the kidney.
    - Through the peritoneum, the right kidney is in contact with the right colic flexure, the visceral surface of the liver and the second part of the duodenum.
    - Through the peritoneum, the left kidney is in contact with the tail of the pancreas, the left colic flexure, the stomach, and the spleen.
17. Divide the left kidney into anterior and posterior halves by splitting it longitudinally along its lateral border. Open the two halves of the kidney like a book.
18. Identify (Fig. 4.50): [G 158; N 321; R 314; C 233]
    - **Renal capsule –** a fibrous capsule which can be stripped off of the surface of the kidney
    - **Renal cortex –** the outer zone of the kidney (approximately one-third of its depth)
    - **Renal medulla –** the inner zone of the kidney consisting of **renal pyramids** and **renal columns** (approximately two-thirds of its depth)
    - **Renal sinus –** the space within the kidney that is occupied by the renal pelvis, calices, vessels, nerves, and fat.
    - **Renal papilla –** the apex of the renal pyramid that projects into a minor calyx
    - **Minor calyx –** a cup-like chamber that is the beginning of the extrarenal duct system. Several minor calyces combine to form a major calyx.
    - **Major calyx –** two or three per kidney that combine to form the renal pelvis
    - **Renal pelvis –** the funnel-like end of the ureter that lies within the renal sinus
    - **Ureter –** the muscular duct that carries urine from the kidney to the urinary bladder

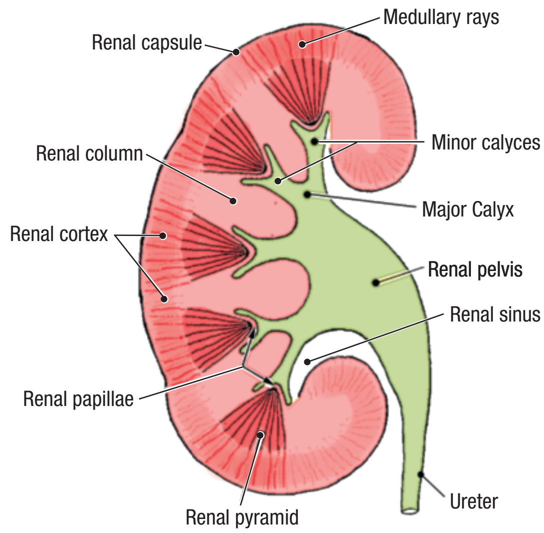

Figure 4.50. Internal features of the kidney in longitudinal section.

Kidney Stones

Kidney stones (renal calculi) may form in the calyces and renal pelvis. Small kidney stones may spontaneously pass through the ureter into the bladder. Larger kidney stones may lodge at one of three natural constrictions of the ureter: (1) where the renal pelvis joins the ureter; (2) where the ureter crosses the pelvic brim; and (3) at the entrance of the ureter into the urinary bladder.

SUPRARENAL GLANDS [G 155; N 322, 333; R 314; C 230]

The **suprarenal (adrenal) glands** are fragile and easily torn. They are closely related to the superior poles of the kidneys (Fig. 4.51). The suprarenal glands are highly vascularized endocrine glands.

1. Observe that the **right suprarenal gland** is triangular in shape. Part of the right suprarenal gland lies posterior to the inferior vena cava.
2. Observe that the **left suprarenal gland** is semilunar in shape.
3. The suprarenal glands receive multiple arteries (Fig. 4.51). Identify **superior suprarenal arteries** arising

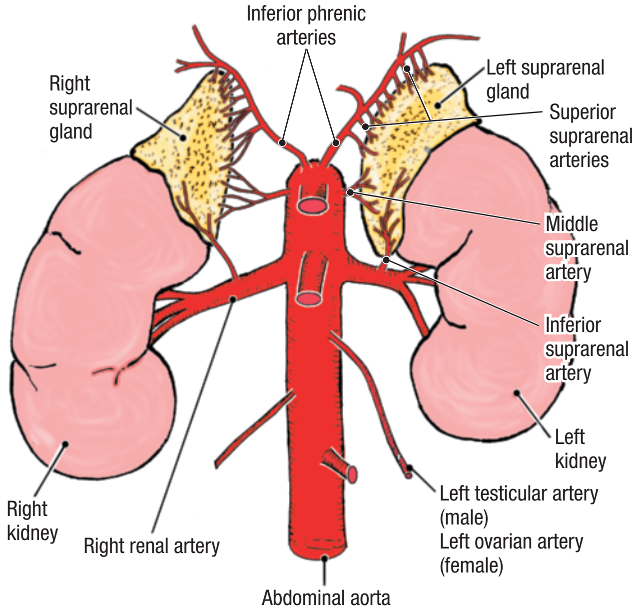

Figure 4.51. Blood supply of the suprarenal glands.

from the **inferior phrenic arteries**. **Middle suprarenal arteries** arise from the aorta near the celiac trunk. **Inferior suprarenal branches** arise from the renal arteries.

4. Note that the left suprarenal vein empties into the left renal vein. The right suprarenal vein drains directly into the inferior vena cava.
5. The suprarenal glands receive numerous sympathetic nerve fibers.

Suprarenal Glands

The kidneys and suprarenal glands have different embryonic origins. If the kidney fails to ascend to its normal position during development, the suprarenal gland develops in its normal position lateral to the celiac trunk.

ABDOMINAL AORTA AND INFERIOR VENA CAVA [G 167; N 319; R 319; C 238]

1. Use an illustration to study the abdominal aorta. Observe that the abdominal aorta has three types of branches:
   - **Unpaired arteries to the gastrointestinal tract** (celiac trunk, superior mesenteric and inferior mesenteric arteries)
   - **Paired arteries to the three paired abdominal organs** (suprarenal, renal, and testicular or ovarian arteries)
   - **Paired arteries to the abdominal wall** (inferior phrenic and lumbar arteries)
2. Identify at least one **lumbar artery** (Fig. 4.52). Four pairs of lumbar arteries supply the posterior abdominal wall. Trace one lumbar artery to its origin from the posterior aspect of the abdominal aorta. Note that the lumbar arteries pass deep to the psoas major muscles positioned on either side of the vertebral column.
3. Observe the **bifurcation of the abdominal aorta** at vertebral level L4 (Fig. 4.52). In a thin person, the umbilicus projects superior to the bifurcation of the aorta.
4. Identify the **common iliac arteries**, which arise at the bifurcation of the aorta. The common iliac artery supplies blood to the pelvis and lower limb.
5. Review the **inferior vena cava** and its tributaries. Recall that a segment of the inferior vena cava was removed with the liver. Note that the inferior vena cava has no unpaired visceral tributaries because the hepatic portal system collects blood from the gastrointestinal tract. Review the hepatic portal vein. Recall that the hepatic portal vein drains into the liver, and that the hepatic veins drain into the inferior vena cava.

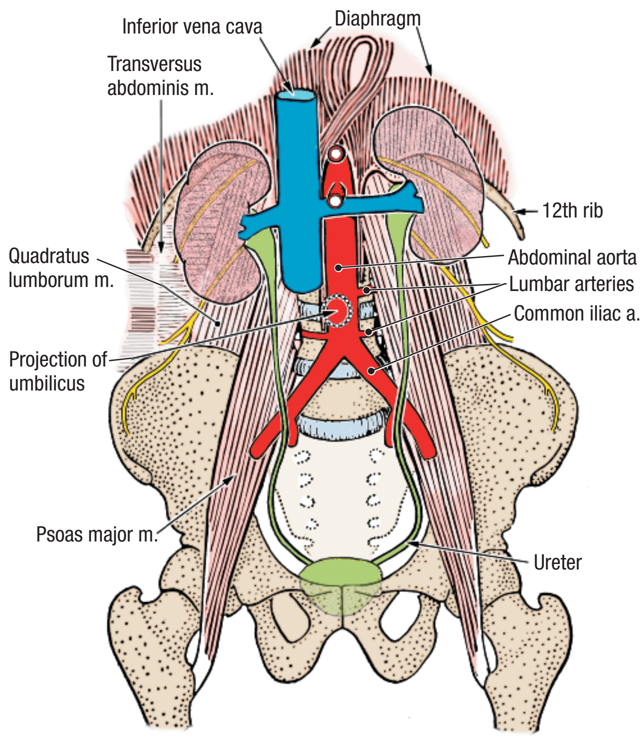

Figure 4.52. Posterior relationships of the kidneys.

After you dissect . . .

Replace the kidneys in their correct anatomical positions. Use an illustration and the dissected specimen to review the relationships of each kidney to surrounding structures. Trace the path taken by a drop of urine from the renal papilla to the ureter. Review the position, relationships, and blood supply of each suprarenal gland. Review the branches of the abdominal aorta.

POSTERIOR ABDOMINAL WALL

Before you dissect . . .

The posterior abdominal wall is composed of the vertebral column, muscles that move the vertebral column, muscles that move the lower limb, and the diaphragm. The nerves that supply the abdominal wall and the lumbar plexus of nerves that supply the lower limb will be dissected with the posterior abdominal wall.

The order of dissection will be as follows. The branches of the lumbar plexus will be studied. Muscles that form the posterior abdominal wall will be dissected. The sympathetic trunk will be studied.

Dissection Instructions

1. Move the kidneys and suprarenal glands toward the midline (do not cut their vessels) and use your hands to remove the remaining fat and the renal fascia from the posterior abdominal wall.
2. Identify the **psoas major muscle** (Fig. 4.53). The proximal attachments of the psoas major muscle are the lumbar vertebrae (bodies, intervertebral discs, and transverse processes). Its distal attachment is the lesser trochanter of the femur. The psoas major muscle is a strong flexor of the thigh and vertebral column. **[G 164; N 255; R 323; C 235]**
3. Look for the **psoas minor muscle**. The psoas minor muscle is absent in approximately 40% of cases and may be present on only one side of the cadaver. The psoas minor muscle has a long flat tendon that passes down the anterior surface of the psoas major muscle to its distal attachment on the pubis.
4. Identify the **iliacus muscle** (Fig. 4.53). The proximal attachment of the iliacus muscle is the iliac fossa. Its distal attachment is on the lesser trochanter of the femur. The iliacus muscle flexes the thigh. The iliacus and psoas major muscles form a functional unit, and together they are called the **iliopsoas muscle**.
5. Identify the **quadratus lumborum muscle** (Fig. 4.53). The proximal attachments of the quadratus lumborum muscle are the twelfth rib and lumbar transverse processes. Its distal attachments are the iliolumbar ligament and iliac crest. The quadratus lumborum muscle flexes the vertebral column laterally and anchors the inferior end of the rib cage during respiration.
6. Review the **transversus abdominis muscle**. The transversus abdominis muscle forms the lateral part of the posterior abdominal wall. The transversus abdominis muscle lies posterior to the quadratus lumborum muscle.
7. Use an illustration and the dissected specimen to study the relationships between the kidneys and the posterior abdominal wall (Fig. 4.52). Verify that the dorsal surface of each kidney is related, through the renal fat and fascia, to the diaphragm, psoas major muscle, quadratus lumborum muscle, and the transversus abdominis muscle. The superior pole of the right kidney is at the level of the twelfth rib. The superior pole of the left kidney is at the level of the eleventh rib.

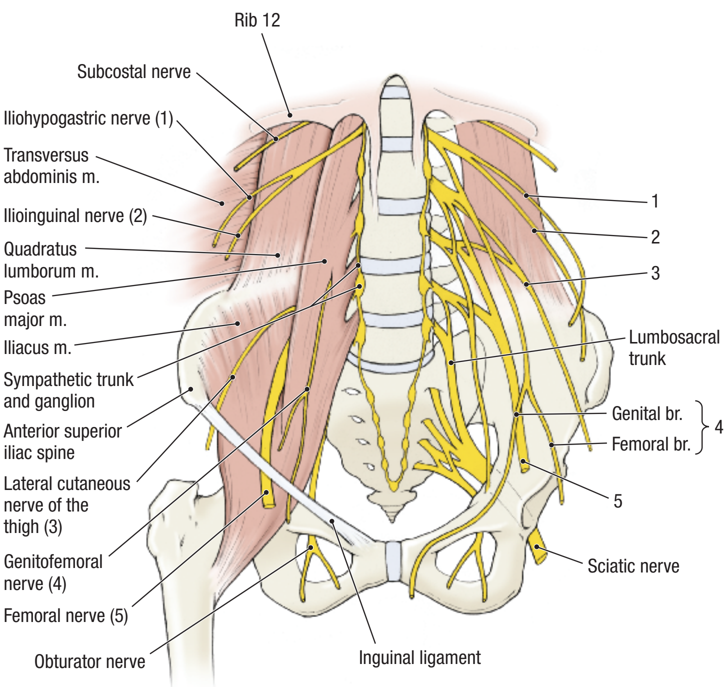

Figure 4.53. Lumbar plexus of nerves.

LUMBAR PLEXUS [G 164, 165; N 259; R 321; C 238]

The nerves of the posterior abdominal wall arise from the ventral primary rami of spinal nerves T12 to L4. The **lumbar plexus** (L1–L4) is formed within the psoas major muscle and its branches can be seen as they emerge from the lateral border of this muscle. The lumbar plexus can be seen only after removal of the psoas major muscle.

Dissect the lumbar plexus on the left side only. Because each branch of the lumbar plexus passes through the psoas major muscle at a different depth, it is necessary to follow each nerve proximally into the psoas major muscle, removing the muscle piece by piece. The nerves of the lumbar plexus are variable in their branching. Use the peripheral relationships of the nerves (their region of distribution or a point of exit from the abdominal cavity) for positive identification.

1. Identify the **genitofemoral nerve**. It is found on the anterior surface of the psoas major muscle (Fig. 4.53). It is the motor nerve to the cremaster muscle (genital part) and supplies a small area of skin inferior and medial to the inguinal ligament (femoral part). The two parts of the genitofemoral nerve divide on the anterior surface of the psoas major muscle superior to the inguinal ligament.
2. Use blunt dissection to remove the fascia from the posterior abdominal wall lateral to the psoas major muscle. The branches of the lumbar plexus are in the extraperitoneal fat and care must be taken to move the dissection instrument parallel to the course of the nerves (Fig. 4.53).
3. To find the **subcostal nerve**, palpate rib 12 and look for the subcostal nerve approximately 1 cm inferior to it.

4. Find the **iliohypogastric** and **ilioinguinal nerves**. They descend steeply across the anterior surface of the quadratus lumborum muscle. Frequently, these two nerves arise from a common trunk and do not separate until they reach the transversus abdominis muscle. To positively identify the ilioinguinal nerve, follow it to the superficial inguinal ring.
5. Identify the **lateral cutaneous nerve of the thigh**. The lateral cutaneous nerve of the thigh passes deep to the inguinal ligament near the anterior superior iliac spine. The lateral cutaneous nerve of the thigh supplies the skin on the lateral aspect of the thigh.
6. Identify the **femoral nerve**. The femoral nerve lies on the lateral side of the psoas major muscle in the groove between the psoas major and iliacus muscles. The femoral nerve innervates these two muscles. The femoral nerve passes deep to the inguinal ligament and provides motor and sensory branches to the anterior thigh.
7. To find the **obturator nerve**, insert your finger on the medial side of the psoas major muscle and move your finger parallel to the muscle, creating a gap between the psoas major muscle and the common iliac vessels. The obturator nerve supplies motor and sensory innervation to the medial thigh.
8. Identify the **lumbosacral trunk**. The lumbosacral trunk is a large nerve that is formed by a contribution from the ventral primary ramus of L4 and all of the ventral primary ramus of L5. The lumbosacral trunk passes into the pelvis to join the sacral plexus.

SYMPATHETIC TRUNK [G 168; N 308; R 322; C 329]

1. Study the location of the **sympathetic trunk** on a transverse section of the abdomen (Fig. 4.49). Note that each sympathetic trunk is found on the vertebral body between the crus of the diaphragm and the psoas major muscle.
2. Identify **lumbar splanchnic nerves** that pass anteriorly from the sympathetic trunk to the aortic autonomic nerve plexus.
3. Identify **rami communicantes** that pass posteriorly from the sympathetic ganglia to lumbar ventral primary rami. Note that each ramus communicans passes between the psoas major muscle and the vertebral body. The gray rami of the lower lumbar region are the longest in the body because the sympathetic trunk crosses the anterolateral surface of the lumbar vertebral bodies.
4. Use an illustration to review the autonomic nerve supply of the abdominal viscera.

After you dissect . . .

Use the dissected specimen to review the proximal and distal attachments, as well as the action of each of the muscles of the posterior abdominal wall. Review the three muscles that form the anterolateral abdominal wall (external oblique, internal oblique, and transversus abdominis). Follow each branch of the lumbar plexus peripherally. Review the region of innervation of each of these nerves. Use an atlas drawing to review the sympathetic trunk.

DIAPHRAGM

Before you dissect . . .

The **diaphragm** forms the roof of the abdominal cavity and the floor of the thoracic cavity (Fig. 4.54). It is the principal muscle of respiration. The diaphragm has a right half and a left half (the **hemidiaphragms**).

The order of dissection will be as follows. The parts of the diaphragm will be identified. The phrenic nerve will be reviewed. The greater splanchnic nerves that pass through the diaphragm will be studied.

Dissection Instructions

1. Use blunt dissection to strip the parietal peritoneum and connective tissue off of the abdominal surface of the diaphragm. [G 166; N 255; R 273; C 237]
2. Identify the parts of the diaphragm (Fig. 4.54):
   - **Central tendon –** the aponeurotic center of the diaphragm, which is the distal attachment of all of its muscular parts.
   - **Sternal part –** two small bundles of muscle fibers that attach to the posterior surface of the xiphoid process.
   - **Costal part –** the muscle fibers that attach to the inferior six ribs and their costal cartilages.
   - **Lumbar part –** formed by two crura (right and left).
3. Identify the **right crus**. The proximal attachments of the right crus of the diaphragm are the bodies of vertebrae L1 to L3. The **esophageal hiatus** is an opening in the right crus.
4. Observe the **left crus** (Fig. 4.54). The proximal attachments of the left crus of the diaphragm are the bodies of vertebrae L1 to L2.
5. Identify the **arcuate ligaments (lumbocostal arches)**. The arcuate ligaments are thickenings of fascia that serve as proximal attachments for some of the muscle fibers of the diaphragm. There are two arcuate ligaments on each side of the body:

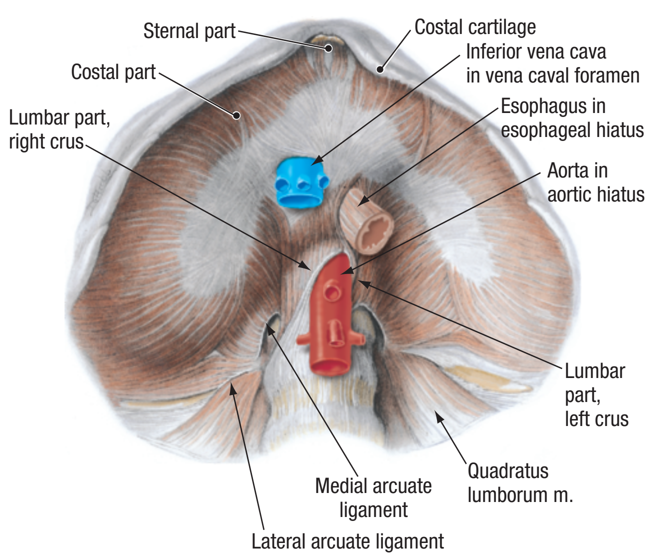

Figure 4.54. Diaphragm.

- **Medial arcuate ligament –** bridges the anterior surface of the psoas major muscle.
- **Lateral arcuate ligament –** bridges the anterior surface of the quadratus lumborum muscle.

6. There are three large openings in the diaphragm (Fig. 4.54). Identify the **vena caval foramen**, which passes through the central tendon (vertebral level T8) and the **esophageal hiatus**, which passes through the right crus (vertebral level T10). The aorta passes through the **aortic hiatus** (vertebral level T12).
7. The **right** and **left phrenic nerves** innervate the diaphragm. Each phrenic nerve provides motor innervation to one half of the diaphragm (one hemidiaphragm). The phrenic nerves supply most of the sensory innervation to the abdominal (parietal peritoneum) and thoracic (parietal pleura) surfaces of the diaphragm. The pleural and peritoneal coverings of the peripheral part of the diaphragm receive sensory fibers from the lower intercostal nerves (T5–T11) and the subcostal nerve.
8. Identify the **greater splanchnic nerve** in the thorax and follow it to the superior surface of the diaphragm. **[G 168; N 259; C 238]**
9. Push a probe through the diaphragm parallel to the greater splanchnic nerve. Note that the greater splanchnic nerve penetrates the crus to enter the abdominal cavity.
10. Observe that the main portion of the greater splanchnic nerve distributes to the celiac ganglion where its sympathetic axons will synapse. The greater splanchnic nerve also innervates the suprarenal gland.
11. Find the **celiac ganglia**. The celiac ganglia are found on the left and right sides of the celiac trunk near its origin from the aorta. The celiac ganglia are the largest of the sympathetic ganglia that are located on the surface of the aorta.
12. Use an illustration or textbook description to review the autonomic nerve supply of the abdomen.

CLINICAL CORRELATION

Diaphragm

The phrenic nerves arise from cervical spinal cord segments (C3–C5). Therefore, pain from the diaphragm is referred to the shoulder region (supraclavicular nerve territory). The diaphragm is paralyzed in cases of high cervical spinal cord injuries, but is spared in low cervical spinal cord injuries. A paralyzed hemidiaphragm cannot contract (descend), so it will appear high in the thorax on a chest X-ray.

After you dissect . . .

Review the attachments of the diaphragm to the skeleton of the thoracic wall. Trace the course of the thoracic aorta as it passes through the aortic hiatus to become the abdominal aorta. Review the course of the esophagus and the vagus nerve trunks through the esophageal hiatus. Recall the position of the heart on the superior surface of the diaphragm and review the course of the inferior vena cava. Study an illustration and observe that the thoracic duct passes through the aortic hiatus and that the splanchnic nerves (greater, lesser, and least) penetrate the crura.