CHAPTER 3

THE THORAX

The main function of the thorax is to house and protect the heart and lungs. The protective function of the thoracic wall is combined with mobility to accommodate volume changes during respiration. These two dissimilar functions, protection and flexibility, are accomplished by the alternating arrangement of the ribs and intercostal muscles.

The superficial fascia of the thorax contains the usual elements that are common to superficial fascia in all body regions: blood vessels, lymph vessels, cutaneous nerves, and sweat glands. In addition, the superficial fascia of the anterior thoracic wall in the female contains the mammary glands, which are highly specialized organs unique to the superficial fascia of the thorax.

SURFACE ANATOMY [G 2; N 174; C 2]

The surface anatomy of the thorax can be studied on a living subject or on the cadaver. Turn the cadaver to the supine position and palpate the following structures (Fig. 3.01):

- **Clavicle**
- **Acromion of the scapula**
- **Jugular notch (suprasternal notch)**
- **Manubrium**

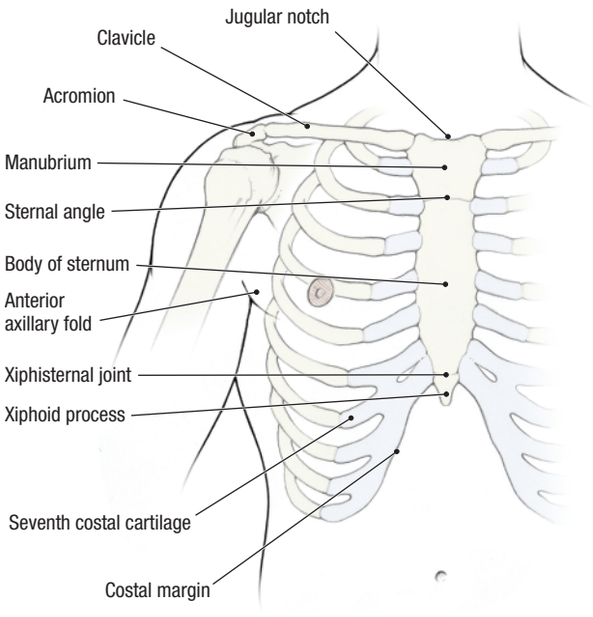

Figure 3.01. Surface anatomy of the anterior thoracic wall.

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

- **Sternal angle**
- **Body of the sternum**
- **Xiphisternal junction**
- **Xiphoid process**
- **Seventh costal cartilage**
- **Costal margin**
- **Anterior axillary fold (lateral border of the pectoralis major muscle)**

SKELETON OF THE THORAX

If you have previously dissected the back, review the parts of a **thoracic vertebra**. If you have not dissected the back, you must study the vertebrae now. Turn to pages 4–6, complete that exercise, and return to this page.

Refer to a skeleton. Examine a **rib** from the mid-thorax level and identify (Fig. 3.02): [G 13; N 179; R 191; C 96]

- **Head**
- **Neck**
- **Tubercle**
- **Angle**
- **Shaft (body)**
- **Costal groove**

On an articulated skeleton, note the following features:

- The **first rib** is the highest, shortest, broadest, and most curved of the ribs.
- The **head** of a rib usually articulates with two vertebral bodies and their intervertebral disc (the 1st, 10th, 11th, and 12th ribs are exceptions to this rule). For example, the head of rib 5 articulates with vertebral bodies T4 and T5 (Fig. 3.03).
- The **tubercle** of a rib articulates with the costal facet on the transverse process of the thoracic vertebra of the same number (Fig. 3.03).
- A **costal cartilage** is attached to the anterior end of each rib. Ribs are classified by the distal articulation of their costal cartilage:

True ribs (ribs 1–7) – costal cartilage is attached directly to the sternum.

False ribs (ribs 8–10) – costal cartilage is attached to the costal cartilage of the rib above.

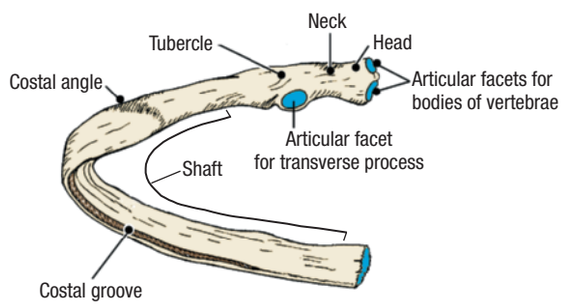

Figure 3.02. Typical left rib, posterior view.

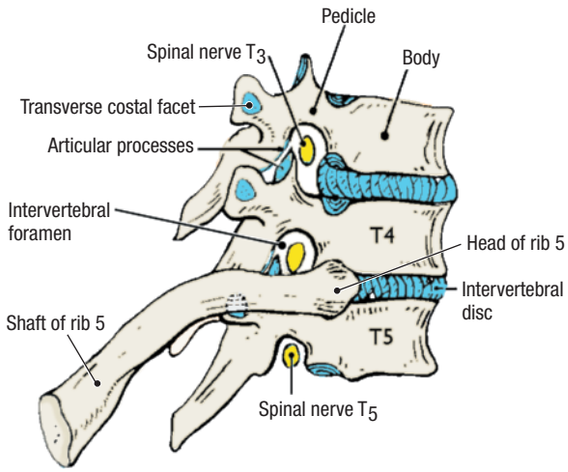

Figure 3.03. Part of the thoracic vertebral column.

Floating ribs (ribs 11 and 12) – costal cartilage is not attached to a skeletal element but ends in the abdominal musculature.

Examine the **sternum** and identify (Fig. 3.04): **[G 12; N 179; R 188; C 95]**

- **Jugular notch** (suprasternal notch)
- **Manubrium** (L. *manubrium*, handle)
- **Sternal angle** (at the level of the T4/T5 intervertebral disc; attachment of the second costal cartilage)
- **Body**
- **Xiphoid process** (Gr. *xiphos*, sword)

Examine a **scapula** and identify (Fig. 3.04): **[G 458; N 178; R 185; C 70]**

- **Acromion**
- **Coracoid process**

Observe that the medial end of the **clavicle** articulates with the manubrium of the sternum (**sternoclavicular joint**) and the lateral end of the clavicle articulates with the acromion of the scapula (**acromioclavicular joint**) (Fig. 3.04).

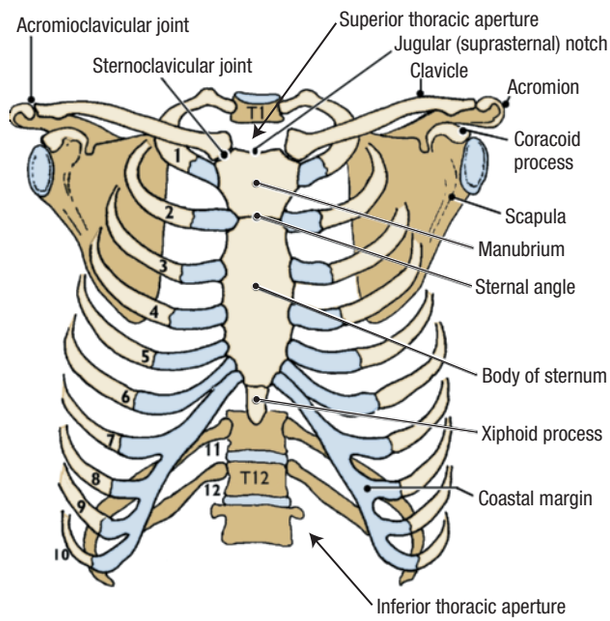

Figure 3.04. Skeleton of the thoracic region.

PECTORAL REGION

Before you dissect . . .

The **pectoral region** (L., *pectus*, chest) covers the anterior thoracic wall and part of the lateral thoracic wall. The order of dissection will be as follows: the skin will be removed from the thoracic wall, and the breast will be dissected in female cadavers. The superficial fascia will be removed.

Dissection Instructions

SKIN INCISIONS

1. Place the cadaver in the supine position.
2. Refer to Figure 3.05. If the back has been dissected previously, some of these incisions have already been made. Before cutting, realize that the skin is thin on the anterior thoracic wall.
3. Make a midline skin incision from the jugular notch (A) to the xiphisternal junction (C).
4. Make a skin incision from the jugular notch (A) along the clavicle to the acromion (B), continuing to a point that is approximately halfway down the arm (F).
5. At point F, make an incision around the anterior and posterior surfaces of the arm, meeting on the medial side (G).
6. Make an incision from the xiphoid process (C) along the costal margin to the midaxillary line (V).
7. Make an incision that begins at G on the medial surface of the arm and extends superiorly to the axilla. Extend this incision inferiorly along the lateral surface of the trunk to V.
8. Make a transverse skin incision from the middle of the manubrium to the midaxillary line, passing around the nipple.
9. Make a transverse skin incision from the xiphisternal junction (C) to the midaxillary line.
10. Remove the skin from medial to lateral. Detach the skin along the midaxillary line and place it in the tissue container.

BREAST [G 4, 5; N 175; R 280; C 5]

The breast is dissected in female cadavers only. Students with male cadavers must observe at another dissection table. Because of the advanced age of some cadavers, it

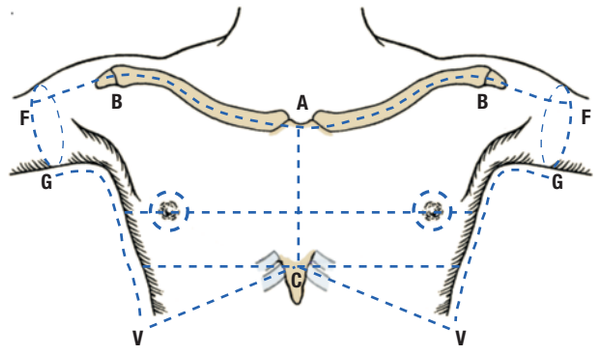

Figure 3.05. Skin incisions.

may be difficult to dissect and identify all of the structures listed. Expect the lobes of the gland to be replaced by fat with advanced age.

The **breast** extends from the lateral border of the sternum to the midaxillary line, and from rib 2 to rib 6. The mammary gland is a modified sweat gland that is contained within the superficial fascia of the breast (Fig. 3.06). The breast is positioned anterior to the **pectoral fascia** (the deep fascia of the pectoralis major muscle). The pectoral fascia is attached to the overlying skin by the **suspensory ligaments of the breast** that pass between the lobes of the mammary gland.

1. Identify the **areola** and the **nipple** (Fig. 3.06).
2. Use the handle of a forceps to scoop the fat out of several compartments between **suspensory ligaments**. These areas between suspensory ligaments once contained lobes of functional glandular tissue.
3. Make a parasagittal (superior to inferior) cut through the nipple that divides the breast into a medial half and a lateral half (Fig. 3.06).
4. On the cut edge of the breast, use a probe to dissect through the fat deep to the nipple. Confine your search area to within 3 cm deep to the areola. Find and clean one of the 15 to 20 **lactiferous ducts** that converge on the nipple. Identify the **lactiferous sinus**, which is an expanded part of the lactiferous duct located deep to the nipple.
5. Trace one lactiferous duct to the nipple and attempt to identify its opening.
6. Use an illustration to study the **lymphatic drainage of the mammary gland**. **[G 9; N 177; R 280; C 6]**
7. Insert your fingers behind the breast and open the **retromammary space**. Note that the normal breast can be easily separated from the underlying deep fascia of the pectoralis major muscle.
8. Remove the breast from the anterior surface of the pectoralis major muscle with the aid of a scalpel.
9. Store the breast in a plastic bag.

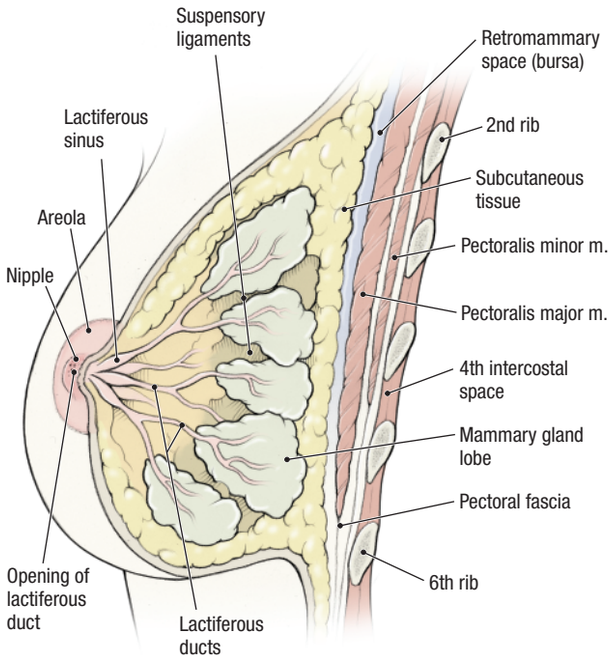

Figure 3.06. Breast in sagittal section.

CLINICAL CORRELATION

Breast

For descriptive purposes, clinicians divide the breast into four quadrants. The superolateral (upper outer) quadrant contains a large amount of glandular tissue and is a common site for breast cancers to develop. From this quadrant, an "axillary tail" often extends into the axilla.

In advanced stages of breast cancer, the tumor may invade the underlying pectoralis major muscle and its fascia. When this happens, the tumor and breast become fused to the chest wall, a condition that can be detected by palpation during a physical examination. As the breast tumor enlarges, it places traction on the suspensory ligaments, resulting in dimpling of the skin overlying the tumor.

SUPERFICIAL FASCIA

1. Dissection of the superficial fascia must be performed on both male and female cadavers.
2. The **platysma muscle** is a muscle of facial expression that may extend into the superficial fascia of the superior thorax. It is very thin, but broad. If the platysma muscle is present in the thorax, dissect it from the superficial fascia that lies deep to it and reflect it superiorly. Do not extend the dissection field superior to the clavicles.
3. Make a vertical cut through the superficial fascia in the midline of the sternum. Make additional cuts through the superficial fascia corresponding to skin incisions A to F, C to V, and G to V (Fig. 3.05).
4. Use blunt dissection to remove the superficial fascia, proceeding from medial to lateral.
5. Study an illustration of the **cutaneous branches of a typical spinal nerve**. The **anterior cutaneous branches** are small and emerge from the intercostal space lateral to the border of the sternum. Do not attempt to find them. **[G 20; N 187; R 204; C 7]**
6. As you peel back the superficial fascia, identify an intercostal space by palpation. Palpate the **lateral cutaneous branches** of the intercostal nerves where they leave the intercostal space and enter the superficial fascia. Identify one lateral cutaneous branch (from intercostal space 4, 5, or 6) while the superficial fascia is being removed. Trace its **anterior and posterior branches** for a short distance and preserve them.
7. Detach the superficial fascia along the midaxillary line and place it in the tissue container.

After you dissect . . .

Review the location and parts of the breast. Use an illustration to review the vascular supply to the breast. Discuss its pattern of lymphatic drainage and identify by name the lymph node groups that are involved. Use an illustration of the branching pattern of a typical spinal nerve to review the innervation of the anterior thoracic wall and breast.

MUSCLES OF THE PECTORAL REGION

Before you dissect . . .

The muscles of the pectoral region attach the upper limb to the thoracic skeleton. Therefore, they are also known as the **anterior thoracoappendicular group of muscles**. The pectoral muscles are positioned immediately deep to the superficial fascia (deep to the breast).

The dissection will proceed as follows: the pectoralis major muscle will be studied and reflected. The pectoralis minor muscle and clavipectoral fascia will be studied. The pectoralis minor muscle will be reflected, and the branches of the thoraco-acromial artery will be dissected.

Dissection Instructions

1. Clean the superficial surface of the **pectoralis major muscle**, using your fingers to define its borders (Fig. 3.07). Study an illustration and note that the deep fascia on the surface of the pectoralis major muscle is called **pectoral fascia** and that it is continuous with the **axillary fascia** that forms the floor of the axilla. **[G 478; N 407; R 394; C 11]**
2. Identify the two heads of the pectoralis major muscle: **clavicular head** and **sternocostal head** (Fig. 3.07). Observe that the juncture of these two heads is at the sternoclavicular joint.
3. Use your fingers to trace the tendon of the pectoralis major muscle to its distal attachment on the humerus. The pectoralis major muscle flexes, adducts, and medially rotates the humerus.
4. Between the clavicular head of the pectoralis major muscle and the adjacent deltoid muscle, use blunt dissection to define the borders of the **deltopectoral triangle** and find the **cephalic vein**. Preserve the cephalic vein in subsequent steps of this dissection.
5. Relax the sternal head of the pectoralis major muscle by flexing and adducting the arm. Gently insert your fingers posterior to the inferior border of the pectoralis major muscle. Create a space between the posterior surface of the pectoralis major and the **clavipectoral fascia**. Push your fingers superiorly to open this space.
6. Use scissors to detach the sternal head of the pectoralis major muscle from its attachment to the sternum (dashed line, Fig. 3.07).
7. Palpate the deep surface of the pectoralis major muscle to locate the **medial and lateral pectoral nerves and vessels**. Preserve these nerves and vessels.
8. Use scissors to cut the clavicular head of the pectoralis major muscle close to the clavicle (Fig. 3.07). Preserve the cephalic vein. Note that the **lateral pectoral nerve** and the **pectoral branch of the thoraco-acromial artery** enter the deep surface of the clavicular head.
9. Reflect the pectoralis major muscle laterally. If the nerves and vessels of the pectoralis major muscle prevent reflection, cut a small piece (1 cm^2) out of the muscle and leave it attached to the nerves and blood vessels.
10. Deep to the pectoralis major muscle are the **clavipectoral fascia** and **pectoralis minor muscle**. **[G 480; N 411; R 395]**
11. Note that the **medial pectoral nerve** pierces the **pectoralis minor muscle**, then enters the sternal head of the pectoralis major muscle.
12. Read a description of the **clavipectoral fascia** and understand that it is attached to the clavicle. It passes both superficial and deep to the subclavius muscle and

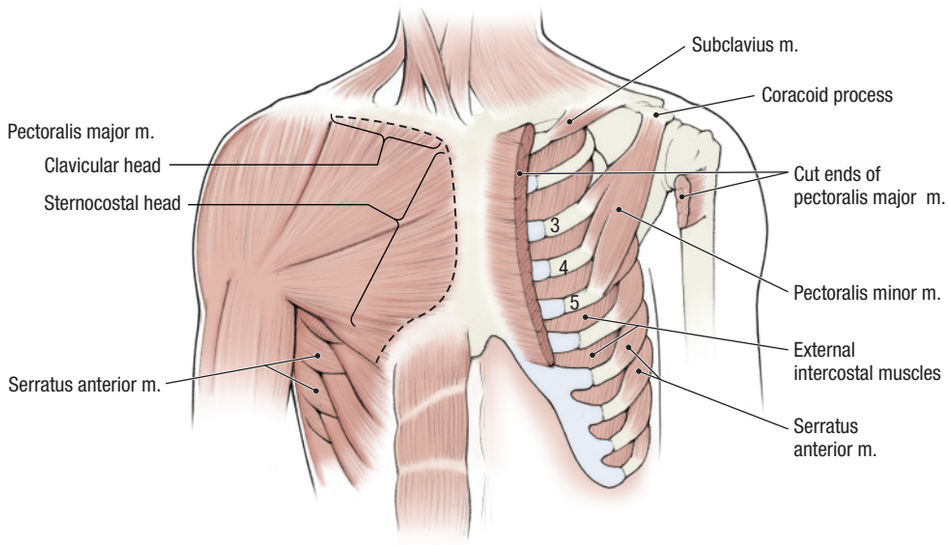

Figure 3.07. Cuts for reflection of the pectoralis major and pectoralis minor muscles.

the pectoralis minor muscle. The clavipectoral fascia is attached to the axillary fascia inferiorly.

13. Identify the **subclavius muscle**, which is located inferior to the clavicle (Fig. 3.07). The subclavius muscle, which is attached to the clavicle and the first rib, depresses the clavicle.
14. Clean the **cephalic vein** as it crosses the anterior surface of the pectoralis minor tendon. The cephalic vein passes through the **costocoracoid membrane** (part of the clavipectoral fascia) medial to the pectoralis minor tendon. The **thoraco-acromial artery** and the **lateral pectoral nerve** also pass through the costocoracoid membrane.
15. Use scissors to detach the pectoralis minor muscle from its proximal attachments on ribs 3-5 (Fig. 3.07).
16. Reflect the pectoralis minor muscle superiorly. Leave the muscle attached to the coracoid process of the scapula. **[G 480; N 410; R 398; C 13]**
17. Clean and define the branches of the thoraco-acromial artery (Fig. 3.08):
    - **Acromial branch –** passes laterally across the coracoid process to the acromion.
    - **Deltoid branch –** courses laterally in the **deltopectoral groove** between the deltoid muscle and pectoralis major muscle. The deltoid branch accompanies the cephalic vein.
    - **Pectoral branch –** passes between and supplies the pectoralis major muscle and the pectoralis minor muscle.
    - **Clavicular branch –** courses superiorly and medially to supply the subclavius muscle.
18. Along the lateral border of the pectoralis minor muscle, identify the origin of the **lateral thoracic artery** (Fig. 3.08). Do not follow the lateral thoracic artery at this time.
19. Identify the **serratus anterior muscle** (Fig. 3.07). Note its extensive proximal attachment on the upper eight ribs. The distal attachment of the serratus anterior muscle is the deep surface of the scapula along the entire length of its medial border. You cannot see the distal attachment at this time.
20. Do not disturb the contents of the axilla.

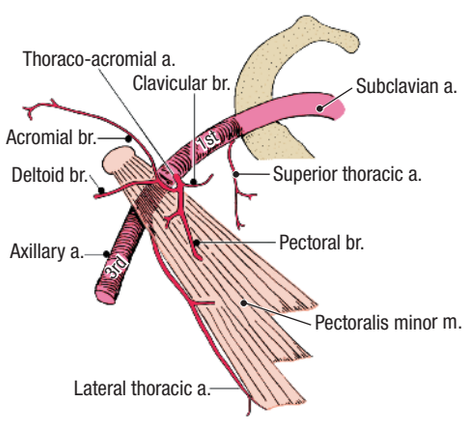

Figure 3.08. Blood supply to the pectoral region.

After you dissect . . .

Replace the pectoral muscles into their correct anatomical positions. Review the attachments of the pectoralis major and pectoralis minor muscles. Review their actions, innervations, and blood supply. Review the relationship of the clavipectoral fascia to the muscles, vessels, and nerves of this region. Name all branches of the thoraco-acromial artery and the structures supplied by each branch. Be sure that you understand the role played by the clavipectoral fascia in supporting the floor of the axilla.

INTERCOSTAL SPACE AND INTERCOSTAL MUSCLES

Before you dissect . . .

The interval between adjacent ribs is called the **intercostal space**. The intercostal space is only a space in a skeleton, because three muscles fill the intercostal space in the living body and the cadaver. From superficial to deep, the three muscles are the **external intercostal muscle**, the **internal intercostal muscle**, and the **innermost intercostal muscle**. There are 11 intercostal spaces on each side of the thorax. They are numbered corresponding to the rib above.

The order of dissection will be as follows: the external intercostal muscle will be studied in one intercostal space and reflected. The internal intercostal muscle will be studied and reflected. Branches of intercostal nerves and blood vessels will be identified. The innermost intercostal muscle will be identified.

Dissection Instructions

1. Detach the **serratus anterior muscle** from its proximal attachments on ribs 1 to 8 and reflect it laterally.
2. Palpate the ribs and the intercostal spaces. Begin at the level of the sternal angle (attachment of the second costal cartilage) and identify each intercostal space by number.
3. Dissect intercostal space 4 (the space between ribs 4 and 5).
4. Identify the **external intercostal muscle** (Fig. 3.09). The external intercostal muscle attaches to the inferior border of the rib above and the superior border of the rib below. The external intercostal muscle elevates the rib below. Note that the fibers of the external intercostal muscles pass diagonally toward the anterior midline as they descend. **[G 19; N 185; R 195; C 93]**
5. Identify the **external intercostal membrane**, which is located at the anterior end of the intercostal space between the **costal cartilages**. Note that the fibers of the external intercostal muscle end at the lateral edge of the external intercostal membrane.
6. Insert a probe deep to the external intercostal membrane just lateral to the border of the sternum in the fourth intercostal space. Push the probe laterally and note that it passes posterior to the external intercostal muscle.

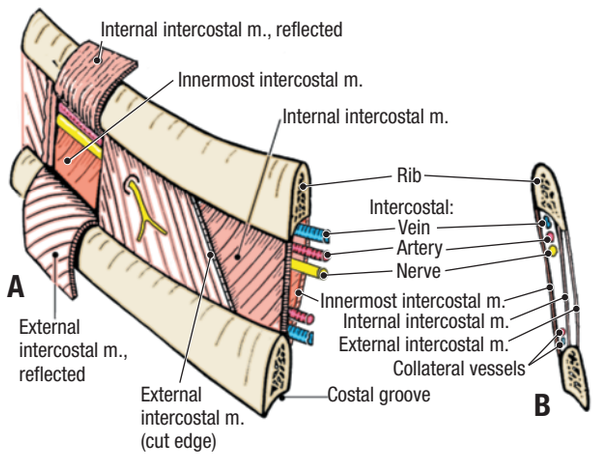

Figure 3.09. Structures in the intercostal space. **A.** Anterior view. **B.** Coronal section at the midaxillary line.

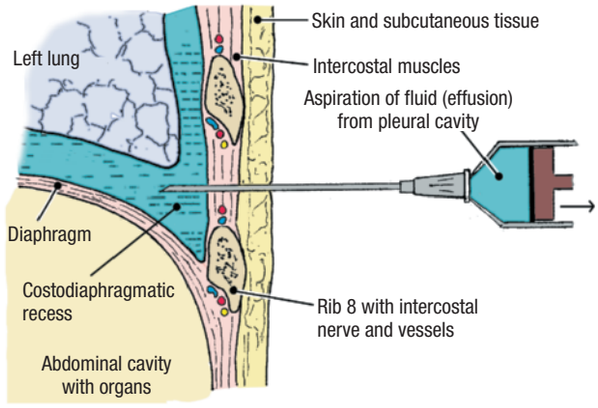

Figure 3.10. Anatomical relationships associated with a pleural tap.

7. With the probe as a guide, use scissors to cut the external intercostal muscle from the rib above and reflect it inferiorly. Continue the cut laterally to the midaxillary line.
8. Identify the **internal intercostal muscle**. The internal intercostal muscle attaches to the superior border of the rib below and the inferior border of the rib above. The internal intercostal muscle depresses the rib above. Note that the fiber direction of the internal intercostal muscle is perpendicular to the fiber direction of the external intercostal muscle (Fig. 3.09).
9. Begin at the midaxillary line and detach the internal intercostal muscle from its inferior attachment on rib 5. Reflect it superiorly. Continue to detach the internal intercostal muscle as far as the lateral border of the sternum.
10. Identify the fourth **intercostal nerve** and the fourth **posterior intercostal artery and vein** inferior to rib 4. The intercostal nerve and vessels run in the plane between the **internal intercostal muscle** and **innermost intercostal muscle** (Fig. 3.09). The **innermost intercostal muscle** has the same fiber direction, attachments, and action as the internal intercostal muscle, but it does not extend as far anteriorly in the intercostal space. **[G 20; N 187; R 204; C 7]**
11. The intercostal nerve and vessels supply the intercostal muscles, the skin of the thoracic wall, and the parietal pleura. Use an illustration to study their course and distribution.
12. The anterior end of the intercostal space is supplied by **anterior intercostal branches** of the **internal thoracic artery**. The internal thoracic artery runs a vertical course just lateral to the border of the sternum and crosses the deep surfaces of the costal cartilages. **[G 22; N 183; R 199; C 92]**

CLINICAL CORRELATION

Pleural Tap (Thoracocentesis)

The aspiration of pathological material from the pleural cavity (serous fluid, fluid mixed with tumor cells, blood, pus, etc.) may be performed through the intercostal space. The pleural tap is performed in the midaxillary line or slightly posterior to it. Usually, intercostal space 6, 7, or 8 is selected for the puncture to avoid penetrating abdominal viscera. A large-bore needle is inserted low in the intercostal space to avoid injury to the intercostal nerve and vessels (Fig. 3.10).

After you dissect . . .

Replace the internal and external intercostal muscles in their correct anatomical positions. Review the muscles that lie in the intercostal space. Review their actions. Understand how they assist respiration by elevating and depressing the ribs. Use an illustration and your dissected specimen to review the origin, course, and branches of the posterior intercostal artery and intercostal nerve. Consult a dermatome chart and compare the dermatome pattern to the distribution of the intercostal nerves. **[G 331; N 157; C 7]**

REMOVAL OF THE ANTERIOR THORACIC WALL

Before you dissect . . .

To open the thoracic cavity, the anterior thoracic wall must be reflected. The goal of this dissection is to reflect the thoracic wall with the underlying **costal parietal pleura**. The area to be reflected includes the anterior and lateral portions of ribs 1 through 5, the contents of the intercostal spaces, and the sternum.

The order of dissection will be as follows: the ribs and contents of the intercostal spaces will be cut at the midaxillary line. The clavicles will be cut. The costal cartilages and sternum will be cut. The anterior thoracic wall will be reflected superiorly, using the muscles of the lower neck as a hinge. The neck muscles will remain intact and will not be detached from their sternal and clavicular attachments. The inner surface of the thoracic wall will be studied.

Dissection Instructions

1. Reflect the serratus anterior muscle laterally.
2. Cut both clavicles at their mid-length using a saw (Fig 3.11, cuts 1 and 2).
3. Make a transverse cut across the sternum and costal cartilages at the level of intercostal space 5 (Fig. 3.11, cut 3). Allow the saw to pass through the bone and cartilage, but not the deeper tissues.
4. Use a saw or bone forceps to cut ribs 1 to 5 in the midaxillary line on both sides of the thorax.
5. With a scalpel, cut intercostal spaces 1 to 5 in the midaxillary line. Make the cut deep enough to cut the parietal pleura.
6. Use scissors to cut the intercostal muscles and underlying parietal pleura from the upper border of rib 6 on both sides of the thorax.
7. Gently, elevate the inferior end of the sternum with the attached portions of the severed ribs, and identify the **right and left internal thoracic vessels** (Fig. 3.11). Cut the internal thoracic vessels at the level of the fifth sternocostal joint and reflect them with the thoracic wall.
8. Reflect the anterior thoracic wall superiorly. Cut the parietal pleura with scissors where it reflects from the inner surface of the thoracic wall to the mediastinum. Leave the anterior thoracic wall attached to the muscles of the neck. **[G 23; N 184; R 196; C 100]**
9. On the internal surface of the anterior thoracic wall, identify the **costal parietal pleura**. Use blunt dissection to remove the parietal pleura from the inner surface of the anterior thoracic wall.
10. Identify the **transversus thoracis muscle**. Observe that the inferior attachment of the transversus thoracis muscle is on the sternum and its superior attachment is on costal cartilages 2 to 6. The transversus thoracis muscle depresses the ribs.
11. The **internal thoracic vessels** are located between the costal cartilages and the transversus thoracis muscle. Observe that the internal thoracic artery divides into the **superior epigastric artery** and the **musculophrenic artery**. Identify at least one of the **anterior intercostal branches** of the internal thoracic artery.

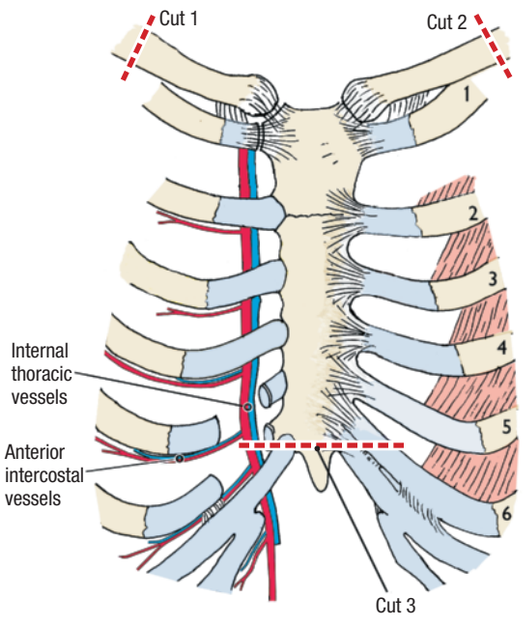

Figure 3.11. How to reflect the anterior thoracic wall.

After you dissect . . .

Replace the anterior thoracic wall in its correct anatomical position. Also replace the pectoralis minor muscle, making sure that its proximal attachments touch ribs 3, 4, and 5. Finally, replace the pectoralis major muscle in its original anatomical position. Review the attachments and the action of the pectoral muscles, the serratus anterior muscle, and the transversus thoracis muscle. Study the course of the internal thoracic artery from its origin to its bifurcation and name its branches.

CLINICAL CORRELATION

Anterior Thoracic Wall

The anterior and lateral approaches are the two most common surgical approaches to the contents of the thorax. In the anterior approach, the sternum is split vertically in the midline. This approach does not cross major vessels and allows good access to the heart. The incision through the sternum is closed with stainless steel wires. In the lateral approach, an intercostal space is incised to provide access to the lungs or to structures posterior to the heart.

PLEURAL CAVITIES

Before you dissect . . .

The thorax has two apertures (Fig. 3.04). The **superior thoracic aperture (thoracic inlet)** is relatively small and bounded by the manubrium of the sternum, the right and left first ribs, and the body of the first thoracic vertebra. Structures pass between the thorax, the neck, and the upper limb through the superior thoracic aperture (e.g., **trachea, esophagus, vagus nerves, thoracic duct, major blood vessels**).

The **inferior thoracic aperture** (**thoracic outlet**) is larger and bounded by the xiphisternal joint, the costal margin, ribs 11 and 12, and the body of vertebra T12. The **diaphragm** attaches to the structures that form the boundaries of the inferior thoracic aperture and separates the thoracic cavity from the abdominal cavity. Several large structures (e.g., **aorta**, **inferior vena cava**, **esophagus**) pass between the thorax and abdomen through openings in the diaphragm.

The thorax contains two **pleural cavities** (right and left) and the **mediastinum**. The two pleural cavities occupy the lateral parts of the thoracic cavity and each contains one **lung**. The mediastinum (L. *quod per medium stat*, that which stands in the middle) is the region between the two pleural cavities. It contains the **heart**, **aorta**, **trachea**, and **esophagus**. **[G 28; N 192; R 233; C 99]**

Each pleural cavity is lined by a serous membrane called the **parietal pleura** (Fig. 3.12). The parietal pleura has subdivisions that are regionally named:

- **Costal pleura—**lines the inner surface of the thoracic wall
- **Mediastinal pleura—**lines the mediastinum
- **Diaphragmatic pleura—**lines the superior surface of the diaphragm
- **Cervical pleura (cupula)—**extends superior to the first rib

The parietal pleura is sharply folded where the costal pleura meets the diaphragmatic pleura, and where the costal pleura meets the mediastinal pleura. The folds are called **lines of pleural reflection**. The lines of pleural reflection are acute, and the inner surfaces of the parietal pleurae are in contact with one another. The areas where parietal pleura contacts parietal pleura are called **pleural recesses**. The two **costomediastinal recesses** (left and right) occur posterior to the sternum where costal pleura meets mediastinal pleura. The two **costodiaphragmatic recesses** (left and right) are located at the most inferior limits of the parietal pleura (Fig. 3.12). During quiet inspiration, the inferior border of the lung does not extend into the costodiaphragmatic recess. **[G 28; N 192; R 255; C 101]**

The **endothoracic fascia** is a small amount of connective tissue between the thoracic wall and the costal parietal pleura. Endothoracic fascia provides a cleavage plane for surgical separation of the pleura from the thoracic wall.

Each lung is completely covered with **visceral pleura (pulmonary pleura)**. At the root of the lung, the visceral pleura becomes continuous with the mediastinal parietal pleura.

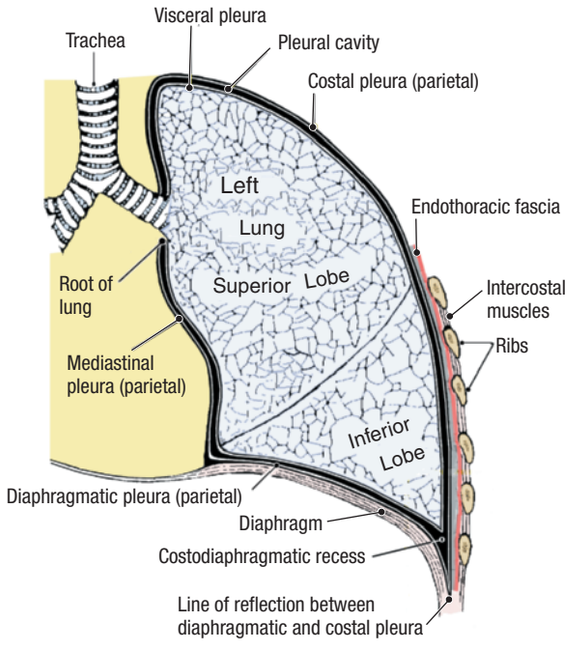

Figure 3.12. The pleurae and pleural cavity

Dissection Instructions

1. The **pleural cavity** is the space between the visceral pleura and the parietal pleura (Fig. 3.12). In the living body, the pleural cavity is a potential space and visceral pleura contacts parietal pleura.
2. Explore the right and left pleural cavities. *Caution: The ends of the ribs are sharp and can cut you.* To reduce the risk of injury, use a mallet or the side of the bone forceps to hit and blunt the ends of ribs 1 to 5. As an additional precaution, place paper towels over the cut ends of the ribs before you begin to palpate the pleural cavities.

CLINICAL CORRELATION

Pleural Cavity

Under pathological conditions, the potential space of the pleural cavity may become a real space. For example, if air enters the pleural cavity (pneumothorax), the lung collapses because of the elasticity of its tissue.

Excess fluid may accumulate in the pleural cavity, compress the lung, and produce breathing difficulties. The fluid could be serous fluid (plural effusion) or blood resulting from trauma (hemothorax).

3. Use paper towels or a large syringe to remove fluid that may have collected in the pleural cavity.
4. Identify the parts of the **parietal pleura**: **costal**, **diaphragmatic**, **mediastinal**, and **cervical**. Part of the costal pleura was removed with the anterior thoracic wall.
5. Place your fingers in the **costodiaphragmatic recess**. Follow it posteriorly and notice the acute angle that the diaphragm makes with the inner surface of the thoracic wall.
6. Place your hand between the lung and the mediastinum and palpate the root of the lung. At the root of the lung the mediastinal parietal pleura is continuous with the visceral pleura. Palpate the **pulmonary ligament**, which extends inferior to the root of the lung.
7. The root of the lung is attached to the mediastinum. All other parts of the lung should slide freely against the parietal pleura. Pleural adhesions may occur between visceral and parietal pleurae. Pleural adhesions are the result of disease processes, and you should use your fingers to break them.

After you dissect . . .

Replace the anterior thoracic wall in is correct anatomical position. Use an illustration and the dissected specimen to project the lines of pleural reflection to the anterior thoracic wall. Review the course of the intercostal nerves and understand that they are the source of somatic innervation (including pain fibers) to the costal parietal pleura.

LUNGS

Before you dissect . . .

The order of dissection will be as follows: the surface features and relationships of the lungs that can be seen from an anterior view will be studied with the lungs in the thorax. Then, the lungs will be removed and the study of surface features and relationships of the lungs will be completed. The hilum of the lung will be studied.

Dissection Instructions

LUNGS IN THE THORAX

1. Observe the lungs *in situ* (Fig. 3.13). **[G 25; N 194; R 258; C 101]**
2. Each lung has three surfaces: **costal, mediastinal**, and **diaphragmatic**. You can see only the costal surface with the lung *in situ*.
3. Observe the **oblique fissure** on both lungs. Replace the anterior thoracic wall and observe that the oblique fissure lies deep to the fifth rib laterally and that it is deep to the sixth costal cartilage anteriorly. Clinicians may refer to the oblique fissure as the **major fissure**.
4. Lift the anterior thoracic wall and identify the **horizontal fissure** on the right lung. Replace the anterior thoracic wall and observe that the horizontal fissure lies deep to the fourth rib and fourth costal cartilage. Clinicians may refer to the horizontal fissure as the **minor fissure** or **transverse fissure**.
5. Note that the right lung has three lobes (**superior**, **middle**, and **inferior**). The left lung has two lobes (**superior** and **inferior**).
6. Observe that the **apex** of the lung rises as high as the neck of the first rib, superior to the body of the first rib. Therefore, the apex of the lung lies superior to the plane of the superior thoracic aperture and is actually in the neck.
7. Identify the **pericardium** that occupies the midline between the lungs. The pericardium contains the heart.

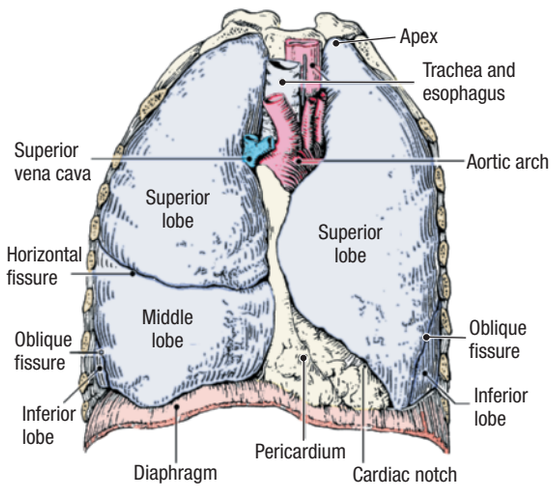

Figure 3.13. The lungs *in situ*.

8. Palpate the **root of the lung**. Feel the hard structures within the root of the lung. These are the pulmonary vessels, filled with clotted blood, and the main (primary) bronchus.
9. Observe that the **phrenic nerve** and **pericardiacophrenic vessels** pass anterior to the root of the lung and medial (deep) to the mediastinal pleura. Use an illustration to observe that the **vagus nerve** passes posterior to the root of the lung. **[G 78, 79; N 226, 227; R 270, 271; C 115, 117]**

REMOVAL OF THE LUNGS

1. Preserve the phrenic nerve, pericardiacophrenic vessels, and the vagus nerve during lung removal.
2. Place your hand into the pleural cavity between the lung and mediastinum. Retract the lung laterally, to stretch the root of the lung.
3. While retracting the lung, use scissors to transect the root of the lung halfway between the lung and the mediastinum. Take care not to cut into the mediastinum or the lung. Remove both lungs.
4. Compare the two lungs (Fig. 3.14). Note that the right lung is shorter but has greater volume than the left lung. **[G 32; R 239; C 106]**
5. Identify the **surfaces of the lung**: **costal**, **mediastinal**, and **diaphragmatic**.
6. Identify the **borders of the lung**: **anterior, posterior**, and **inferior**.
7. Recall that each lung has a **superior lobe** and an **inferior lobe** separated by the **oblique fissure**. Observe the lung from the lateral view, and note that most of the inferior lobe lies posteriorly and that most of the superior lobe lies anteriorly (Fig. 3.14).
8. Recall that the right lung has a **horizontal fissure**, which defines a small **middle lobe** (Fig. 3.14). Identify the middle lobe.
9. Identify the **cardiac notch** on the superior lobe of the left lung (Fig. 3.14). The cardiac notch is located on the anterior border of the left lung, anterior to the heart.
10. Identify the **lingula** of the left lung. The lingula is the inferior, medial portion of the superior lobe of the left lung.
11. Identify **contact impressions** on the mediastinal surface of each lung (Fig. 3.15). These impressions are artifacts of embalming and illustrate the close proximity of the mediastinal structures to the lung.
    - On the mediastinal surface of the **right lung**, identify the **cardiac impression**, the **groove for the esophagus**, the **groove for the arch of the azygos vein**, and the **groove for the superior vena cava**.
    - On the mediastinal surface of the **left lung**, identify the **cardiac impression**, the **groove for the aortic arch,** and the **groove for the thoracic aorta**. **[G 34, 35; N 195; R 239; C 108]**
12. Examine the **hilum of the lung**. Identify the **main bronchus, pulmonary artery,** and **pulmonary veins**. At the hilum, the main bronchus usually lies posterior to the pulmonary vessels, and the pulmonary artery is superior to the pulmonary veins (Fig. 3.15). To help

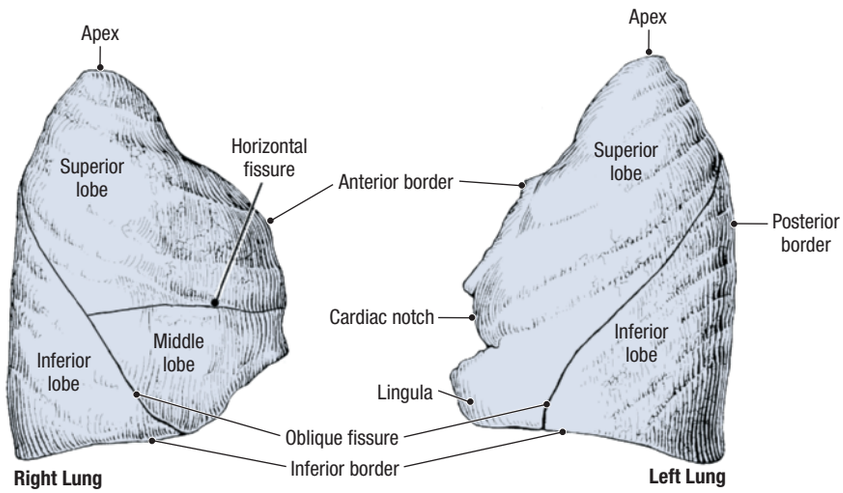

Figure 3.14. Lateral view of the lungs.

distinguish the artery from the veins, compare the relative thickness of the walls of the vessels (arteries have thicker walls).

13. At the hilum of each lung, use blunt dissection to follow the **main bronchus** into the lung.
14. In the left lung, identify the **superior** and **inferior lobar (secondary) bronchi**. **[G 41; N 199; R 237; C 110]**
15. In the right lung, identify the **superior**, **middle**, and **inferior lobar bronchi**. Note that the **right superior lobar bronchus** passes superior to the right pulmonary artery and it is named the "**eparterial bronchus**."
16. Use blunt dissection to follow one lobar bronchus deeper into the lung (approximately 3 cm) until it branches into several **segmental bronchi**. Each lung contains 10 segmental bronchi, and each segmental bronchus supplies one **bronchopulmonary segment** of the lung. In your textbook, find a description of the bronchopulmonary segments and the internal organization of the lung.
17. Identify one of the **bronchial arteries**. The bronchial arteries are branches of the thoracic aorta that course along the surface of the main bronchus. The lumen of the bronchial artery can be seen where the main bronchus was cut during lung removal.
18. The hilum of the lung contains lymph nodes, lymph vessels, and autonomic nerve fibers. Use an illustration to confirm this. **[G 42, 43; N 204, 205; R 265; C 151]**
19. Note that the lungs have a rich nerve supply via the anterior and posterior pulmonary plexuses. Sympathetic contributions are received from the right and left sympathetic trunks, while parasympathetic contributions are received from the right and left vagus nerves.

After you dissect . . .

Review the parts of the lungs. Replace the lungs in their correct anatomical positions within the pleural cavities. Review the relationships of the phrenic and vagus nerves to the root of the lung. Replace the anterior thoracic wall. Project the borders, surfaces, and fissures of the lungs to the surface of the thoracic wall. Review the relationship of the pleural reflections to the thoracic wall. Review the costomediastinal and costodiaphragmatic recesses.

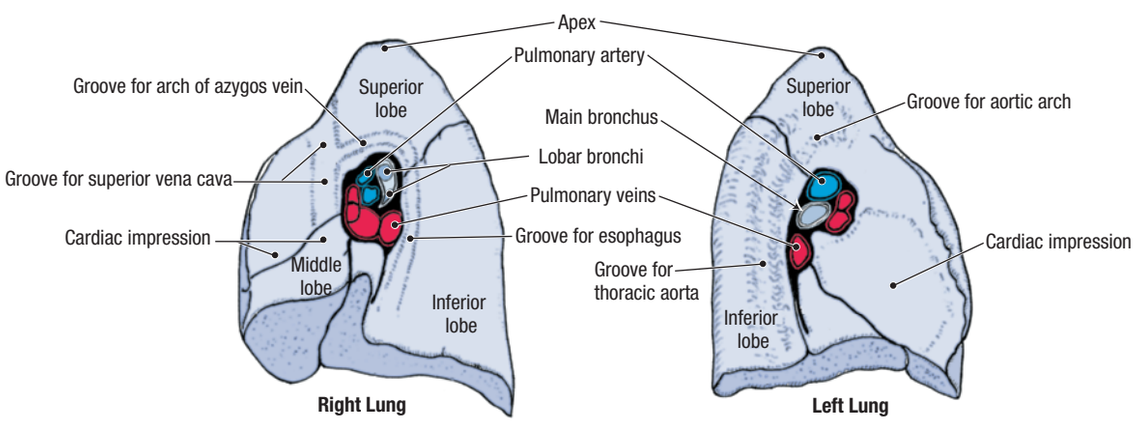

Figure 3.15. Mediastinal surface of the lungs.

MEDIASTINUM

Before you dissect . . .

The region between the two pleural cavities is the mediastinum. The **boundaries of the mediastinum** are:

- **Superior boundary –** superior thoracic aperture
- **Inferior boundary –** diaphragm
- **Anterior boundary –** sternum
- **Posterior boundary –** bodies of vertebrae T1 to T12
- **Lateral boundaries –** mediastinal parietal pleura (left and right)

For descriptive purposes, the mediastinum is divided into four parts (Fig. 3.16). An imaginary horizontal plane at the level of the sternal angle (**plane of the sternal angle**) intersects the intervertebral disk between vertebrae T4 and T5. The plane of the sternal angle separates the **superior mediastinum** from the **inferior mediastinum**. The pericardium divides the inferior mediastinum into three parts: **[G 29; R 233; C 118]**

- **Anterior mediastinum –** the part that lies between the sternum and the pericardium. In children and adolescents, part of the thymus may be found in the anterior mediastinum.
- **Middle mediastinum –** the part that contains the pericardium, the heart, and the roots of the great vessels.
- **Posterior mediastinum –** the part that lies posterior to the pericardium and anterior to the bodies of vertebrae T5 to T12. The posterior mediastinum contains structures that pass between the neck, thorax, and abdomen (esophagus, vagus nerves, azygos system of veins, thoracic duct, thoracic aorta).

Some structures that course through the mediastinum (esophagus, vagus nerve, phrenic nerve, thoracic duct) pass through more than one mediastinal subdivision. The **plane of the sternal angle** marks the level of the **superior border of the pericardium**, **bifurcation of the trachea**, and the **beginning and ending of the arch of the aorta**.

The order of dissection will be as follows: the mediastinal pleura will be examined and mediastinal structures will be palpated. The costal and mediastinal pleurae will then be removed.

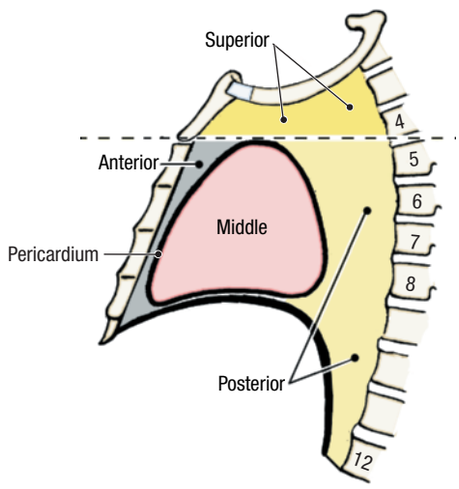

Figure 3.16. Subdivisions of the mediastinum.

Dissection Instructions

1. Observe the **mediastinal pleura**. You may be able to see structures through the mediastinal pleura. **[G 78, 79; N 226, 227; R 270, 271; C 115, 117]**
2. Palpate the **mediastinal pleura** from anterior to posterior. Observe that it is in contact with the **pericardium**, **root of the lung**, **esophagus (right side)**, and **thoracic aorta (left side)**.
3. Follow the mediastinal pleura further posteriorly until it sweeps laterally onto the sides of the vertebral bodies. At this location, the **mediastinal pleura** becomes the **costal pleura**.
4. To examine the mediastinum more closely, the parietal pleura must be removed bilaterally. Note that the **endothoracic fascia** provides a natural cleavage plane for separation of costal pleura from the thoracic wall.
5. Use your fingers to pick up the costal pleura at the cut ends of ribs 1 to 5. Peel the costal pleura off the inner surface of the posterior thoracic wall, moving from lateral to medial.
6. Continue to remove the parietal pleura where it covers the vertebral column, aorta, esophagus, and pericardium.
7. Identify the left and right **phrenic nerves** and the left and right **pericardiacophrenic vessels**. The phrenic nerve and pericardiacophrenic vessels are located between the mediastinal pleura and the pericardium approximately 1.5 cm anterior to the root of the lung. Follow the phrenic nerve and pericardiacophrenic vessels to the diaphragm. Each phrenic nerve is the only motor innervation to that half of the diaphragm.

MIDDLE MEDIASTINUM

Before you dissect . . .

The **middle mediastinum** contains the **pericardium**, the **heart**, and the **roots of the great vessels**. The **pericardium** is a sac that encloses the heart and it is pierced by the great vessels (aorta, pulmonary trunk, superior vena cava, inferior vena cava, and four pulmonary veins). The outer surface of the pericardium is fibrous, whereas the inner surface of the pericardium is serous and smooth. The pericardium is attached to the central tendon of the diaphragm. Thus, the heart moves with the diaphragm during inspiration and expiration.

The order of dissection will be as follows: the pericardium will be opened and its relationship to the heart and great vessels will be explored. The characteristics of the parietal serous pericardium will then be studied. The heart will be removed by cutting the great vessels.

Dissection Instructions

HEART IN THE THORAX [G 49; N 208; R 258; C 120]

1. Open the pericardium in the following manner (Fig. 3.17). Use forceps to elevate the anterior surface of the pericardium. Use scissors to make a longitudinal inci-

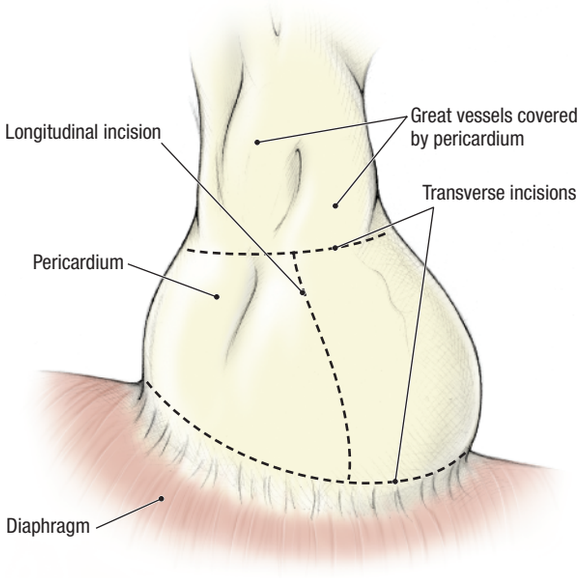

Figure 3.17. How to open the pericardium.

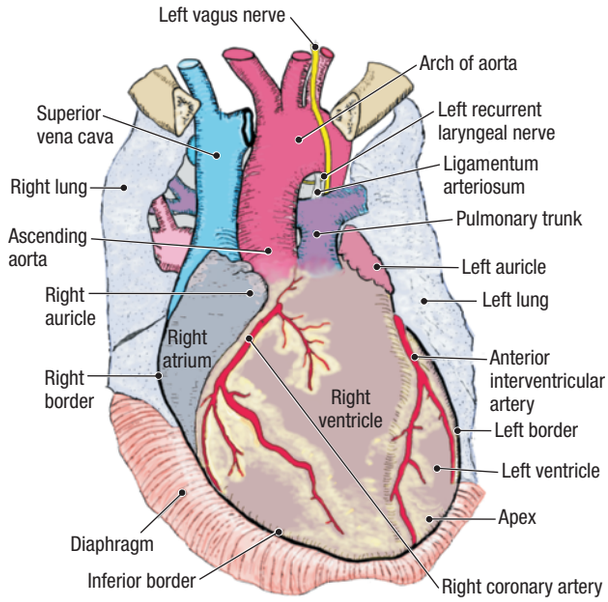

Figure 3.18. Anterior view of the heart *in situ*.

sion from the diaphragm to the aorta. Make the transverse incisions illustrated in Figure 3.17 and open the flaps widely.

2. Identify the following structures (Fig. 3.18): **superior vena cava**, **ascending aorta**, **arch of the aorta**, and **pulmonary trunk**.
3. Use your fingers to gently open the interval between the concavity of the aortic arch and pulmonary trunk, and identify the **ligamentum arteriosum** (Fig. 3.18). The ligamentum arteriosum connects the left pulmonary artery to the arch of the aorta.
4. Use a probe to dissect the **left vagus nerve** where it crosses the left side of the aortic arch (Fig. 3.18). Identify the initial portion of the **left recurrent laryngeal nerve**. The left recurrent laryngeal nerve is located inferior to the aortic arch and adjacent to the ligamentum arteriosum.
5. Examine the heart and identify the chambers that can be seen from the anterior view: **right atrium**, **right ventricle**, and **left ventricle** (Fig. 3.18). Note that the right ventricle forms the anterior part of the heart.
6. Identify the **borders of the heart**:
   - **Right border –** formed by the right atrium
   - **Inferior border –** formed by the right ventricle and a small part of the left ventricle
   - **Left border –** formed by the left ventricle
   - **Superior border –** formed by the right and left atria and auricles
7. Identify the **apex of the heart**. Note that the apex of the heart is part of the left ventricle. The apex of the heart is normally located deep to the left 5th intercostal space, approximately 9 cm from the midline.
8. Identify the **base of the heart**. The left atrium and part of the right atrium form the base of the heart, although clinicians refer to the emergence of the great vessels from the heart as its base.
9. Observe that the inner surface of the pericardium is lined by the smooth, shiny **parietal layer of serous pericardium**.
10. Use the cadaver and an illustration to observe that the parietal layer of serous pericardium is reflected onto the heart as the **visceral layer of serous pericardium (epicardium).** The line of reflection of parietal serous pericardium to visceral serous pericardium occurs at the roots of the great vessels. **[G 49; N 208; R 259; C 120]**
11. The **pericardial cavity** is a potential space between the parietal layer and visceral layers of serous pericardium. Normally it contains only a thin film of serous fluid that lubricates the serous surfaces and allows free movement of the heart within the pericardium.
12. Place your right hand in the pericardial cavity with your fingers posterior to the heart. Lift the heart gently and push your fingers superiorly until they are stopped by the reflection of serous pericardium. Your fingertips are located in the **oblique pericardial sinus** (Fig. 3.19). Remove your hand from the oblique pericardial sinus. **[G 51; N 211; R 262; C 121]**
13. In the transverse plane, push your right index finger posterior to the pulmonary trunk and ascending aorta. Proceed from left to right and make your finger tip emerge between the superior vena cava and the aortic arch. Your finger is in the **transverse pericardial sinus** (Fig. 3.19).
14. Gently insert the tip of a probe between the pericardium and the anterior surface of the ascending aorta. Slowly advance the probe until it stops. This is the superior limit of the pericardial cavity.
15. Use your fingers to explore the lines of reflection of the serous pericardium where the great vessels (aorta, pulmonary trunk, superior vena cava, inferior vena

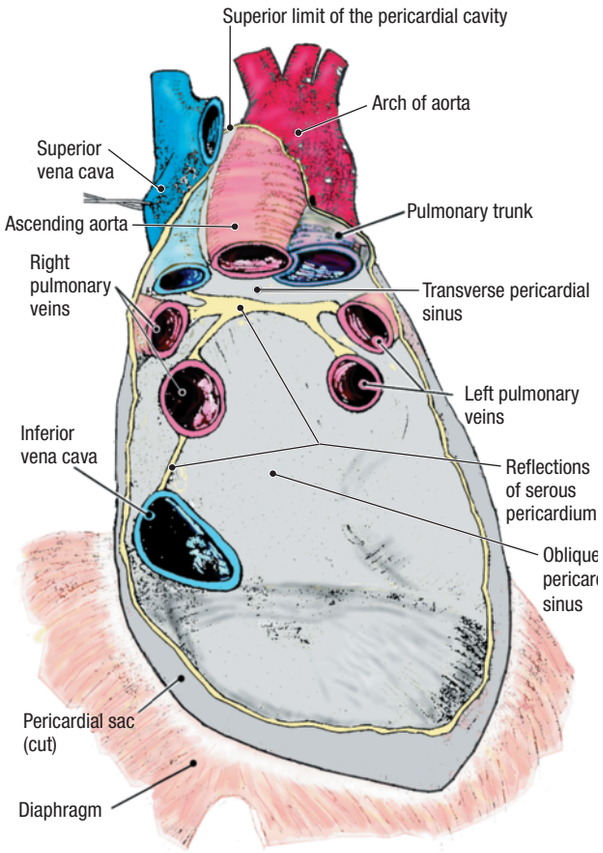

Figure 3.19. Inner surface of the posterior wall of the pericardium showing sinuses and serous reflections.

cava, and four pulmonary veins) enter and exit the heart (Fig. 3.19).

16. Replace the anterior thoracic wall into its correct anatomical position. Use the cadaver and an illustration to project the outline of the heart to the surface of the thoracic wall. **[G 26; N 192; R 242; C 99]**

CLINICAL CORRELATION

Pericardium

Inflammatory diseases can cause fluid to accumulate in the pericardial cavity (pericardial effusion). Bleeding into the pericardial cavity (hemopericardium) may result from penetrating heart wounds or perforation of a weakened heart muscle after myocardial infarction. Because the pericardium is composed of fibrous connective tissue, it cannot stretch, and fluids collected in the pericardial cavity compresses the heart (cardiac tamponade).

REMOVAL OF THE HEART

1. The heart will be detached from the great vessels along the lines of reflection of the serous pericardium (Fig. 3.19).
2. Place a probe through the transverse pericardial sinus.
3. Use scissors to cut the **ascending aorta** and the **pulmonary trunk** anterior to the probe, approximately 1.5 cm superior to the point where the aorta and pulmonary trunk exit the heart.
4. Lift the apex of the heart and cut the **inferior vena cava** close to the surface of the diaphragm.
5. Use scissors to cut the **superior vena cava** approximately 1 cm superior to its junction with the right atrium.
6. Lift the apex of the heart superiorly. Use scissors to cut the **four pulmonary veins** where they form the boundary of the oblique pericardial sinus (Fig. 3.19). Cut the pulmonary veins very close to the parietal pericardium.
7. The heart is now held in place only by reflections of serous pericardium from its posterior surface (Fig. 3.19). Cut these reflections and remove the heart.
8. Refer to Figure 3.19. Examine the posterior aspect of the pericardium and identify the openings of the eight vessels and the lines of the pericardial reflections.

After you dissect . . .

Review the parts of the mediastinum and state their boundaries. Review the attachments of the pericardium to the diaphragm and to the roots of the great vessels. Review the embryonic origin of the transverse and oblique pericardial sinuses. Compare the structural and functional properties of parietal serous pericardium to the properties of parietal pleura.

EXTERNAL FEATURES OF THE HEART

Before you dissect . . .

Dissection of the heart will proceed in two stages. The external features of the heart will be studied, including its vascular supply. The internal features of the chambers of the heart will then be studied.

Dissection Instructions

SURFACE FEATURES

1. Examine the external surface of the heart. Identify the following: **[G 46, 47; N 210; R 242; C 122, 123]**
   - **Coronary (atrioventricular) groove (sulcus)**—it runs obliquely around the heart, separating the atria from the ventricles.
   - **Anterior interventricular groove (sulcus)** and the **posterior interventricular groove (sulcus)**. The interventricular grooves indicate the location of the interventricular septum. The interventricular grooves join the coronary groove at a right angle.

2. Identify the **surfaces of the heart**:
   - **Sternocostal (anterior) surface –** formed mainly by the right ventricle.
   - **Diaphragmatic (inferior) surface –** formed mainly by the left ventricle and a small part of the right ventricle.
   - **Pulmonary (left) surface –** formed mainly by the left ventricle. The pulmonary surface of the heart is in contact with the cardiac impression of the left lung.
3. On the surface of the heart, identify the chambers:
   - **Right atrium** and **right auricle**
   - **Right ventricle**
   - **Left ventricle**
   - **Left atrium** and **left auricle**
4. Examine the heart in superior view. Identify:
   - **Aorta** and **aortic valve**
   - **Pulmonary trunk** and **pulmonary valve**
   - **Superior vena cava**
5. Examine the diaphragmatic surface of the heart and identify the **inferior vena cava**.
6. Observe that the coronary groove and the interventricular grooves mark the boundaries of the four chambers of the heart. The cardiac veins and coronary arteries are located in the grooves.

CARDIAC VEINS [G 53; N 212; R 252; C 122, 123]

1. The **cardiac veins** course superficial to the **coronary arteries**, so they will be dissected first. The coronary groove and the interventricular grooves are filled with fat that must be removed to observe the vessels. Use blunt dissection to remove the fat. Scraping motions with the handle of a forceps usually yield good results.
2. Identify the **coronary sinus** on the diaphragmatic surface of the heart (Fig. 3.20). The coronary sinus is a dilated portion of the venous system of the heart that is located in the coronary groove. The coronary sinus is approximately 2 to 2.5 cm in length and opens into the right atrium. Its opening will be seen when the internal features of the right atrium are dissected.
3. Use a probe to clean the surface of the coronary sinus. Note that most veins of the heart are tributaries to the coronary sinus (Fig. 3.20).
4. Follow the coronary sinus superiorly in the coronary groove to the point where it receives the **great cardiac vein**.
5. Use blunt dissection to follow the great cardiac vein onto the sternocostal surface of the heart. The great cardiac vein courses from the apex of the heart toward the coronary sinus in the anterior interventricular groove.
6. In the posterior interventricular groove, identify the **middle cardiac vein** and trace it to the coronary sinus.
7. Near the inferior end of the coronary sinus, identify the **small cardiac vein**. Use a probe to dissect the small cardiac vein and follow it to the anterior surface of the heart where it courses along the inferior border of the heart.

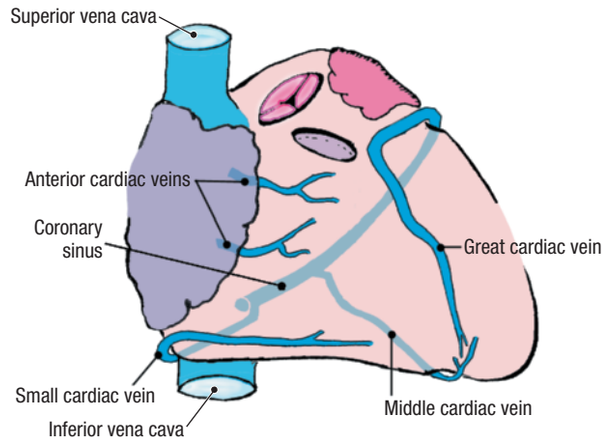

Figure 3.20. Cardiac veins.

8. **Anterior cardiac veins** bridge the atrioventricular groove between the right atrium and right ventricle. The anterior cardiac veins drain the anterior wall of the right ventricle directly into the right atrium. Anterior cardiac veins pass superficial to the right coronary artery.

CORONARY ARTERIES [G 52; N 212; R 252; C 126]

1. Begin the dissection of the coronary arteries by observing the superior surface of the **aortic valve**. Identify the **right**, **left**, and **posterior semilunar cusps** of the aortic valve. Behind each valve cusp is a small pocket called an **aortic sinus** (**right**, **left**, and **posterior**, respectively).
2. In the left aortic sinus, identify the **opening of the left coronary artery**. Place the tip of a probe into the opening. On the surface of the heart, palpate the tip of the probe between the left auricle and the pulmonary trunk. This is the initial portion of the left coronary artery.
3. Use blunt dissection to clean the left coronary artery. In the coronary groove, the left coronary artery divides into the **anterior interventricular branch** and the **circumflex branch** (Fig. 3.21).
4. Trace the **anterior interventricular branch** in the anterior interventricular groove to the apex of the heart. Clinicians call the anterior interventricular branch of

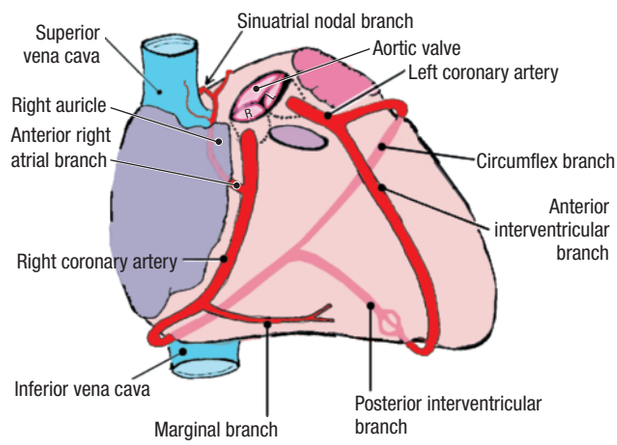

Figure 3.21. Coronary arteries and their branches.

the left coronary artery the **L**eft **A**nterior **D**escending artery (**LAD**). Note that the anterior interventricular artery accompanies the great cardiac vein.

5. Follow the **circumflex branch of the left coronary artery** in the coronary groove and around the left border of the heart. The circumflex branch of the left coronary artery has several unnamed branches that supply the posterior wall of the left ventricle. The circumflex branch of the left coronary artery accompanies the coronary sinus in the coronary groove.
6. To begin the dissection of the **right coronary artery**, identify the **right semilunar cusp of the aortic valve** (Fig. 3.21). Insert a probe into the opening of the right coronary artery in the **right aortic sinus**. On the surface of the heart, palpate the tip of the probe in the coronary groove between the right auricle and the ascending aorta. This is the beginning of the right coronary artery.
7. Use blunt dissection to clean the right coronary artery and identify the **anterior right atrial branch** (Fig. 3.21). The anterior right atrial branch arises close to the origin of the right coronary artery and ascends along the anterior wall of the right atrium toward the superior vena cava. The anterior right atrial branch gives rise to the **sinuatrial nodal branch**, which supplies the sinuatrial node.
8. Follow the right coronary artery in the coronary groove. Preserve the anterior cardiac veins. The **marginal branch** of the right coronary artery usually arises near the inferior border of the heart. The marginal branch accompanies the small cardiac vein along the inferior border of the heart.
9. Continue to follow the right coronary artery in the coronary groove to the diaphragmatic surface of the heart. When the right coronary artery reaches the posterior interventricular groove, it gives rise to the **posterior interventricular branch**. The posterior interventricular branch courses along the posterior interventricular groove to the apex of the heart where it anastomoses with the anterior interventricular branch of the left coronary artery. The posterior interventricular branch accompanies the middle cardiac vein.
10. Note that the **artery to the atrioventricular node** arises from the right coronary artery at the point where the posterior interventricular groove meets the coronary groove.

After you dissect . . .

Review the borders of the heart. On the surface of the heart, review the boundaries of the four chambers. Review the coronary groove and interventricular grooves of the heart and the vessels that course within these grooves. Trace a drop of blood from the right aortic sinus to the coronary sinus. Trace a drop of blood from the left aortic sinus to the apex of the heart and its venous return to the coronary sinus.

INTERNAL FEATURES OF THE HEART

Before you dissect . . .

The atria and ventricles of the heart will be opened and their internal features will be studied. The incisions that will be used are designed to preserve most of the vessels that you have previously dissected. The heart will contain clotted blood, which must be removed. The clots will be hard and may need to be broken before they can be extracted. The chambers will be dissected in the sequence that blood passes through the heart: **right atrium**, **right ventricle**, **left atrium**, and **left ventricle**. All descriptions are based on the heart in anatomical position.

Dissection Instructions

RIGHT ATRIUM [G 56; N 216; R 248; C 130]

1. The cuts used to open the right atrium are illustrated in Figure 3.22.
2. Use scissors to make a cut through the tip of the right auricle. Insert one blade of the scissors through the opening and make a short horizontal cut toward the right.
3. Turn the scissors and cut through the anterior wall of the right atrium in an inferior direction. Stop superior to the inferior vena cava.
4. Make a horizontal cut toward the left, stopping just short of the coronary groove.
5. Turn the flap of the atrial wall toward the left and open the right atrium widely (Fig. 3.23). Remove blood clots and take the heart to the sink to rinse it with water.
6. Observe the inner surface of the **anterior wall of the right atrium**. Identify (Fig. 3.23):
   - **Pectinate muscles –** horizontal ridges of muscle
   - **Crista terminalis –** a vertical ridge of muscle that connects the pectinate muscles

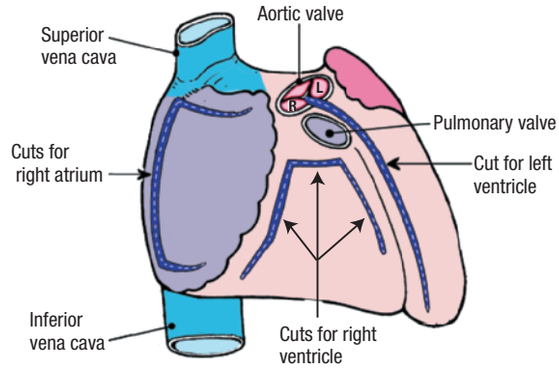

Figure 3.22. Cuts used to open the right atrium, right ventricle, and left ventricle of the heart.

CLINICAL CORRELATION

Coronary Arteries

In approximately 75% of hearts, the right coronary artery gives rise to the posterior interventricular branch and supplies the left ventricular wall and posterior portion of the interventricular septum. In approximately 15% of hearts, the left coronary artery gives rise to the posterior interventricular branch. Other variations account for 10%.

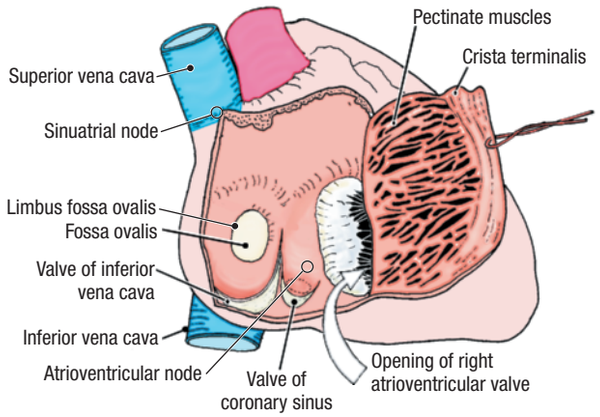

Figure 3.23. Interior of the right atrium. Approximate locations of the nodes of the conducting system are indicated.

7. Observe the **posterior wall of the right atrium**. Identify (Fig. 3.23):
   - **Opening of the superior vena cava**
   - **Opening and valve of the inferior vena cava**
   - **Opening and valve of the coronary sinus**
   - **Fossa ovalis** and the **limbus fossa ovalis** (L. *limbus*, a border)

CLINICAL CORRELATION

Fossa Ovalis

The **fossa ovalis** is the remnant of the **foramen ovale**. In fetal life, blood from the placenta is delivered to the heart by way of the inferior vena cava. This oxygen-rich and nutrient-rich blood is directed toward the foramen ovale, which allows passage into the left atrium and out to the body without entering the lungs.

8. Parts of the **conducting system of the heart** are located in the walls of the right atrium but cannot be seen in dissection. Familiarize yourself with their approximate locations in the dissected specimen (Fig. 3.23). The **sinuatrial node** (SA node) lies at the superior end of the crista terminalis at the junction between the right atrium and the superior vena cava. The **atrioventricular node** (AV node) is located in the lower part of the interatrial septum, near the opening of the coronary sinus.
9. Identify the opening of the **right atrioventricular valve**, which leads into the right ventricle.

RIGHT VENTRICLE [G 57; N 216; R 251; C 130]

1. The cuts used to open the right ventricle are illustrated in Figure 3.22.
2. Insert your finger into the pulmonary trunk and determine the level of the **pulmonary valve**. Inferior to the level of the pulmonary valve, use scissors to make a short horizontal cut through the **anterior wall of the right ventricle**.
3. Insert one blade of the scissors into the right end of the first cut and make a second cut parallel to the coronary groove. The second cut should be approximately 1 cm from the coronary groove and end at the inferior border of the heart. Cut only the ventricular wall, not the atrioventricular valve cusp.
4. Insert your finger through the opening and palpate the **interventricular septum**. From the left end of the first cut, make a third cut toward the inferior border of the heart. The third cut should be approximately 2 cm to the right of the anterior interventricular groove and should parallel the right side of the interventricular septum.
5. Turn the flap of the right ventricular wall inferiorly (Fig. 3.24).

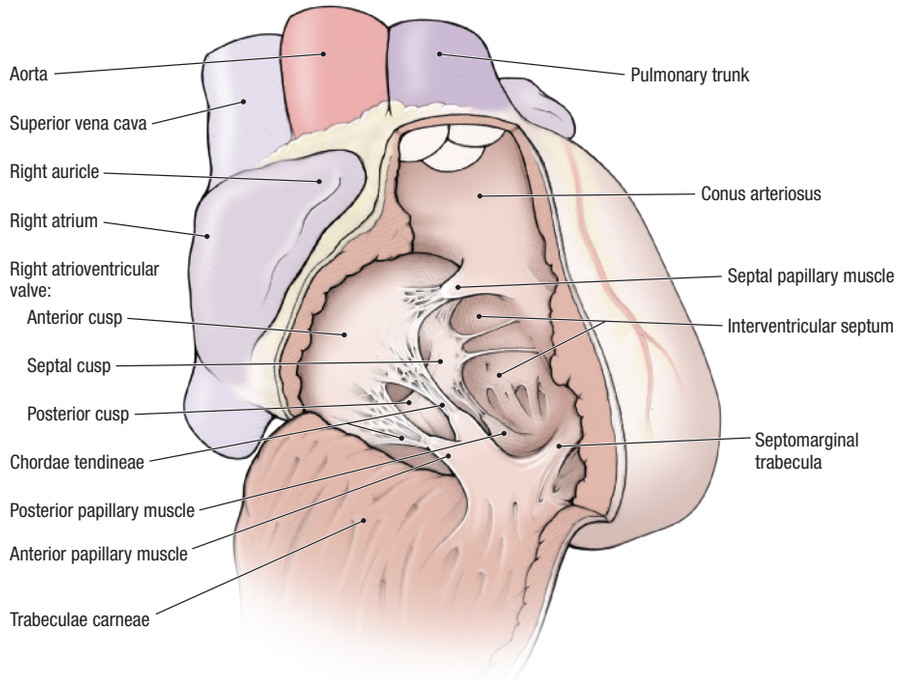

Figure 3.24. Interior of the right ventricle.

6. Remove blood clots. Use care to avoid damaging the **chordae tendineae**. Rinse the right ventricle with water.
7. Identify the **opening of the right atrioventricular valve**. Observe that the right atrioventricular valve has **three cusps**: **anterior**, **septal**, and **posterior** (Fig. 3.24)**.** The right atrioventricular valve is also called the **tricuspid valve**.
8. Identify the **chordae tendineae**. Observe that these delicate tendons pass from the valve cusps to the apices of **papillary muscles**. The papillary muscles arise from the walls of the right atrium.
9. Identify **three papillary muscles**: **anterior**, **septal**, and **posterior**. The anterior papillary muscle is the largest and most prominent. The septal papillary muscle is very small and may be multiple. Note that the chordae tendineae of each papillary muscle attach to the adjacent sides of two valve cusps.
10. Observe that the inner surface of the wall of the right ventricle is roughened by muscular ridges called **trabeculae carneae** (L. *trabs*, wooden beam; *carneus*, fleshy).
11. Identify the **septomarginal trabecula (moderator band**). The septomarginal trabecula extends from the interventricular septum to the base of the anterior papillary muscle. The septomarginal trabecula contains part of the right bundle of the conducting system, the part that stimulates the anterior papillary muscle.
12. Identify the **opening of the pulmonary trunk** (Fig. 3.24). The **conus arteriosus** (**infundibulum)** is the cone-shaped portion of the right ventricle inferior to the opening of the pulmonary trunk. The inner wall of the conus arteriosus is smooth.
13. Observe that the **pulmonary valve** consists of **three semilunar cusps**: **anterior**, **right**, and **left**. **[G 60, 61; N 218; R 149; C 122]**
14. Look into the pulmonary trunk from above and examine the superior surface of the semilunar valve. Observe that each semilunar valve cusp has one fibrous **nodule** and two **lunules**. The nodule and lunules help to seal the valve cusps and prevent backflow of blood during diastole.

LEFT ATRIUM [G 58; N 217; R 248; C 132]

1. Examine the posterior surface of the heart. Observe the openings of the **four pulmonary veins** into the left atrium. The pulmonary veins are usually arranged in pairs, two from the right lung and two from the left lung.
2. The cut used to open the left atrium is illustrated in Figure 3.25A.
3. Use scissors to make an inverted, U-shaped incision through the posterior wall of the left atrium. Do not cut into the openings of the pulmonary veins; cut between them. Turn the flap inferiorly (Fig. 3.25B).
4. Remove blood clots and rinse with water.
5. Note that the inner surface of the wall of the left atrium is smooth except for its auricle, which has a rough inner surface.

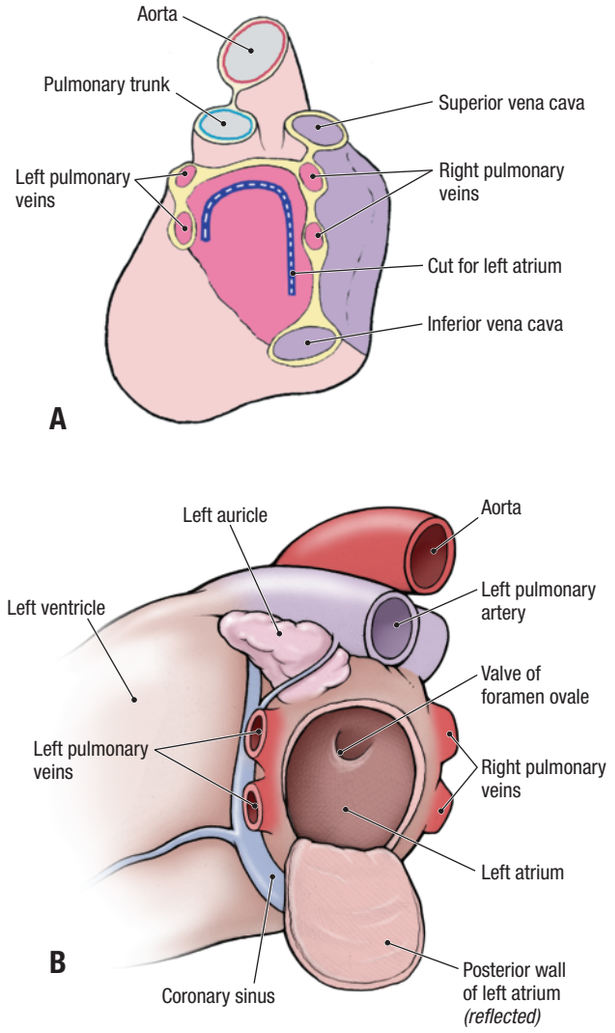

Figure 3.25. The left atrium of the heart. **A.** Cuts used to open the left atrium. **B.** Interior of the left atrium.

6. Observe the following features in the left atrium (Fig 3.25B):
   - **Valve of the foramen ovale** on the **interatrial septum**
   - **Opening into the left auricle**
   - **Opening of the left atrioventricular valve**

LEFT VENTRICLE [G 59; N 217; R 248; C 133]

1. The cut used to open the left ventricle is illustrated in Figure 3.22. Note that the following procedure will cut the anterior interventricular branch of the left coronary artery and the great cardiac vein.
2. Look into the aorta from above and identify the **aortic valve**. Identify **three semilunar valve cusps**: **right**, **left**, and **posterior**. **[G 60, 61; N 218, 219; R 249; C 122]**
3. Insert one blade of a scissors between the left and right semilunar cusps (Fig. 3.22).
4. Make a cut through the anterior wall of the ascending aorta between the left and right semilunar cusps. This cut should be anterior and parallel to the left coronary artery.

5. Continue the cut to the apex of the heart. The cut should be approximately 2 cm to the left of the anterior interventricular groove and should parallel the left side of the interventricular septum. The cut will cross the anterior interventricular branch of the left coronary artery and the great cardiac vein.
6. Open the left ventricle and the ascending aorta widely (Fig. 3.26). Remove blood clots and rinse with water.
7. In the left ventricle, identify the **left atrioventricular valve** (**bicuspid valve**, **mitral valve**). Identify the **anterior cusp** and the **posterior cusp** (Fig. 3.26).
8. Identify the **anterior papillary muscle** and the **posterior papillary muscle**. Observe that the **chordae tendineae** of each papillary muscle attach to both valve cusps.
9. Observe that the inner surface of the wall of the left ventricle is roughened by **trabeculae carneae**.
10. Examine the **aortic valve**. Again identify its **right, left**, and **posterior semilunar cusps**. Observe that each semilunar valve cusp has one nodule and two lunules.
11. Palpate the **muscular part of the interventricular septum**. Place the thumb of your right hand in the right ventricle and your index finger in the left ventricle and palpate the thickness of the muscular part of the interventricular septum.
12. Move your thumb and index finger superiorly along the interventricular septum and identify the thin **membranous part of the interventricular septum**. It is located inferior to the attachment of the right cusp of the aortic valve.
13. In the aorta, observe the openings of the **coronary arteries** and study their relationship to the semilunar valve cusps and the **aortic sinuses**. The posterior cusp is also called the **noncoronary cusp** because there is no coronary artery arising from its sinus.
14. Use an illustration to study the **conducting system of the heart**. Recall that the **sinuatrial (SA) node** is in the wall of the right atrium, at the superior end of the crista terminalis near the superior vena cava. Impulses from the SA node pass through the wall of the right atrium to the **atrioventricular (AV) node**. Impulses that originate in the AV node pass in the **atrioventricular (AV) bundle** through the membranous part of the interventricular septum. Subsequently, the AV bundle divides into **right and left bundles**, which lie on either side of the muscular part of the interventricular septum and stimulate the ventricles to contract. The right bundle is noteworthy because it carries impulses to the anterior papillary muscle through the **septomarginal trabecula**. **[G 62; N 221; R 251; C 136, 137]**

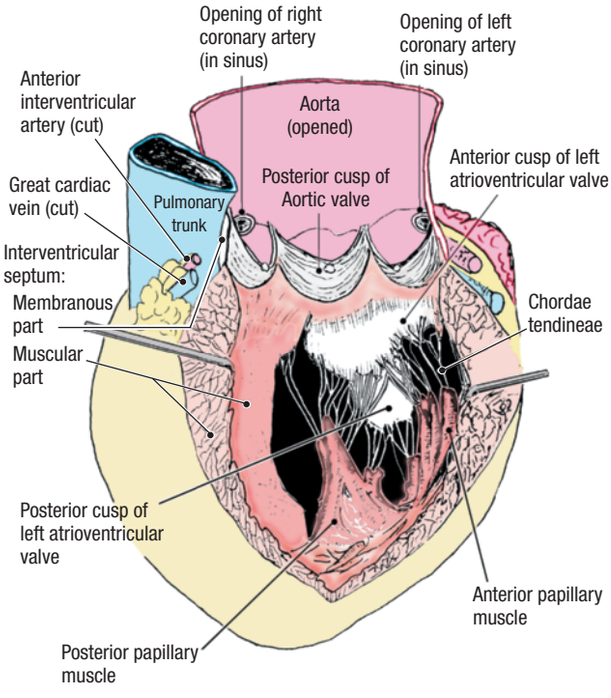

Figure 3.26. Interior of the left ventricle.

After you dissect . . .

Review the internal features of each of the chambers of the heart. Replace the heart into the thorax in its correct anatomical position. Return the thoracic wall to its anatomical position. Use an illustration, a textbook description, and the dissected specimen to project the heart valves to the surface of the anterior thoracic wall. Read a description of the auscultation point used to listen to each heart valve. Review the course of blood as it passes through the heart, beginning in the superior vena cava and ending in the ascending aorta. In the correct sequence, name all of the chambers and valves that the blood passes through. Review the blood supply to the heart. Trace a drop of blood from the left coronary artery and the right coronary artery to the coronary sinus, naming all vessels traversed. Review the connections of the great vessels to the heart. Use an illustration to review the conducting system of the heart and relate the illustration to the dissected specimen.

SUPERIOR MEDIASTINUM

Before you dissect . . .

The superior mediastinum contains structures that pass between the thorax and the neck, or the thorax and the upper limb. These structures include several of the great vessels and their primary branches, the trachea, the esophagus, and the thoracic duct.

The order of dissection will be as follows: the brachiocephalic veins will be studied and reflected. The aortic arch and its branches will be dissected. The trachea and its bifurcation will be studied. The upper part of the esophagus and the vagus nerves will be dissected. Note that only the proximal ends of some of the large vessels will be seen in this dissection. The distal parts of these vessels will be dissected with the neck or the upper limb.

Dissection Instructions

1. Study the **boundaries of the superior mediastinum** (Fig. 3.16).
   - **Superior –** superior thoracic aperture
   - **Posterior –** bodies of vertebrae T1 to T4:
   - **Anterior –** manubrium of the sternum
   - **Lateral –** mediastinal pleurae (left and right)
   - **Inferior –** plane of the sternal angle
2. Reflect the anterior thoracic wall superiorly.
3. Identify the **thymus**. In the adult, the thymus is a fatty remnant that lies immediately posterior to the manubrium of the sternum. **[G 64-67; N 208; R 259; C 119]**

CLINICAL CORRELATION

Thymus

In the newborn, the thymus is an active lymphatic organ that can be visualized on a chest radiograph. The thymus is replaced by connective tissue and fat after puberty. It may be difficult to recognize the thymus in the cadaver.

4. Remove the remnant of the thymus by blunt dissection.
5. Trace the superior vena cava superiorly until it bifurcates. Identify the **left brachiocephalic vein** (Fig. 3.27). Clean the anterior surface of the left brachiocephalic vein and free it from the structures that lie posterior to it.

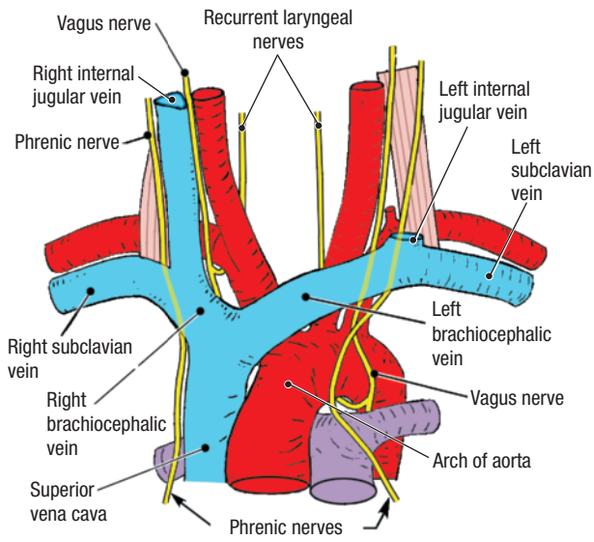

Figure 3.27. Relationships of the phrenic nerves and the vagus nerves to the great vessels.

6. Identify the **right brachiocephalic vein**. The two **brachiocephalic veins** meet to form the **superior vena cava** posterior to the inferior border of the right first costal cartilage.
7. Follow the superior vena cava inferiorly. Note that the superior vena cava passes anterior to the root of the right lung. **[G 78; N 226; R 270; C 115]**
8. Identify the **azygos vein** on the right side of the mediastinum. The **arch of the azygos vein** passes superior to the root of the right lung and drains into the posterior surface of the superior vena cava.
9. Cut the superior vena cava just superior to the entrance of the azygos vein. Reflect the superior vena cava and the brachiocephalic veins superiorly.
10. Identify the **right phrenic nerve** and the **left phrenic nerve** that pass posterior to the brachiocephalic veins. The phrenic nerves were previously dissected in the middle mediastinum. Note that the right and left phrenic nerves pass anterior to the roots of the right and left lungs, respectively. Demonstrate that the phrenic nerves accompany the pericardiacophrenic vessels and that they enter the superior surface of the diaphragm.
11. Identify the **arch of the aorta** (Fig. 3.28). The arch of the aorta begins and ends at the level of the sternal angle. **[G 79; N 227; R 271; C 117]**
12. Identify the three arteries that arise from the arch of the aorta (Fig. 3.28). From anterior to posterior, they are the **brachiocephalic trunk**, the **left common carotid artery**, and the **left subclavian artery**.
13. Identify the **ligamentum arteriosum**. The ligamentum arteriosum is a fibrous cord that connects the concavity of the arch of the aorta to the left pulmonary artery (Fig. 3.28).
14. Identify the **left vagus nerve** and the **left recurrent laryngeal nerve** on the left side of the arch of the aorta (Fig. 3.29). Follow the left vagus nerve inferiorly and note that it passes posterior to the root of the left lung toward the esophagus. Review the relationship of the left recurrent laryngeal nerve to the ligamentum arteriosum.

CLINICAL CORRELATION

Left Recurrent Laryngeal Nerve

The left recurrent laryngeal nerve has a close relationship to the aortic arch and passes through the superior mediastinum. In cases of mediastinal tumors or an aneurysm of the aortic arch, the left recurrent laryngeal nerve may be compromised, resulting in paralysis of the left vocal fold and hoarseness.

15. On the right side, note that the **right vagus nerve** passes posterior to the root of the right lung (Fig. 3.29). The **right recurrent laryngeal nerve** (a branch of the right vagus nerve) loops around the right subclavian artery.

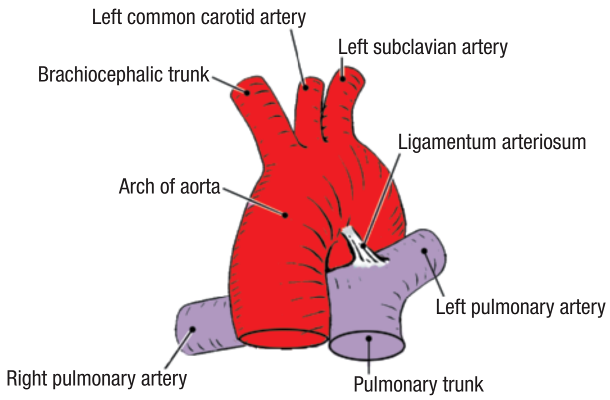

Figure 3.28. Branches of the arch of the aorta.

16. Identify the **trachea**. Observe that **tracheobronchial lymph nodes** are located on both sides of the trachea near its bifurcation.
17. Identify the **bifurcation of the trachea**. The trachea bifurcates at the plane of the sternal angle to form the **right main bronchus** and the **left main bronchus**. Note that the arch of the azygos vein passes superior to the right main bronchus and the arch of the aorta passes superior to the left main bronchus.
18. Palpate the anterior and posterior surfaces of the trachea near its bifurcation. Observe that the **tracheal rings** are "C-shaped" and that the open part of the "C" is located posteriorly.
19. Observe that the esophagus is located posterior to the trachea in close relationship to the open part of the tracheal cartilages.
20. Use scissors to make a longitudinal cut through the anterior surface of the right and left main bronchi. The cuts should meet anterior to the tracheal bifurcation. Make a third cut superiorly through the anterior surface of the trachea for a distance of 2.5 cm. Inside the tracheal bifurcation, identify the **carina** (L. *carina*, keel of a boat). The carina is a specialized piece of tracheal cartilage (Fig. 3.29).
21. Compare the right and left main bronchi. Observe that the right main bronchus is larger in diameter, shorter, and oriented more vertically than the left main bronchus.

Bifurcation of the Trachea

During bronchoscopy, the carina serves as an important landmark because it lies between the superior ends of the right and left main bronchi. The carina is usually positioned slightly to the left of the median plane of the trachea. When foreign bodies are aspirated, they usually enter the right main bronchus because it is wider and more vertically oriented than the left main bronchus.

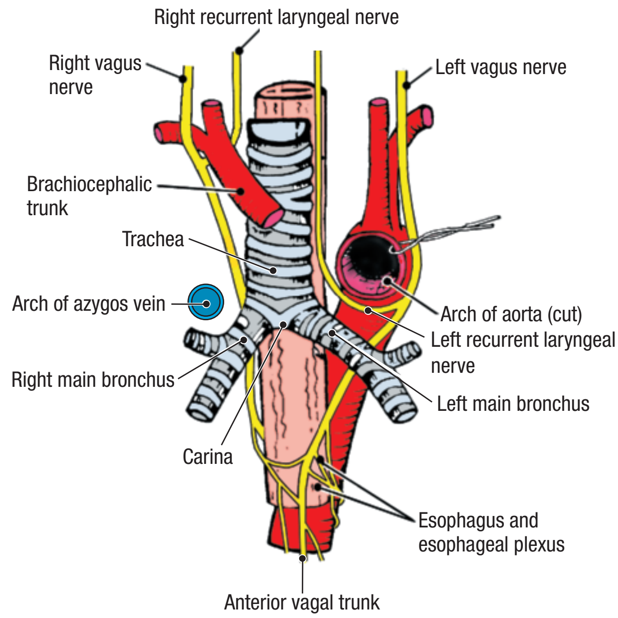

Figure 3.29. Course of the right and left vagus nerves.

After you dissect . . .

Replace the contents of the superior mediastinum into their correct anatomical positions. Return the anterior thoracic wall to its correct anatomical position. Project the structures of the superior mediastinum to the surface of the thoracic wall. Reflect the anterior thoracic wall. Review the formation of the superior vena cava and the position of the arch of the azygos vein. Review the position of the ascending aorta and the position of the arch of the aorta. Review the branches of the arch of the aorta. Compare the relationships of the phrenic and vagus nerves at the root of the lung. Contrast the thoracic course of the left recurrent laryngeal nerve to the thoracic course of the right recurrent laryngeal nerve.

POSTERIOR MEDIASTINUM

Before you dissect . . .

The posterior mediastinum contains structures that course between the thorax and the abdomen. The posterior mediastinum lies posterior to the pericardium. The structures in the posterior mediastinum will be approached through the **posterior wall of the pericardium**.

The order of dissection will be as follows: the pericardium will be reviewed and its posterior wall will be removed. The esophagus will be studied. The azygos vein and its tributaries will be studied. The thoracic duct will be identified. Then, the aorta and its branches will be dissected. Finally, the thoracic portion of the sympathetic trunk and its branches will be dissected.

Dissection Instructions

1. Study the **boundaries of the posterior mediastinum** (Fig. 3.16):
   - **Superior –** plane of the sternal angle
   - **Posterior –** bodies of vertebrae T5 to T12:

- **Anterior –** pericardium
- **Lateral –** mediastinal pleurae (left and right)
- **Inferior –** diaphragm

2. Review the interior of the pericardium (Fig. 3.19).
3. Place the heart back into the pericardium. From the right side of the thorax, examine the relationship of the heart to the esophagus. Note that the esophagus lies immediately posterior to the left atrium and part of the left ventricle. Remove the heart.
4. Remove the posterior wall of the pericardium in the **area of the oblique sinus** (Fig. 3.30). Identify the **esophagus**. The esophagus is a muscular tube that sits just to the right of the midline. To the left and slightly posterior to the esophagus is the **thoracic aorta**.
5. Use blunt dissection to remove the remainder of the posterior wall of the pericardium. Leave the portion adhering to the diaphragm undisturbed. Use scissors to cut the pericardium at its attachments to the great vessels and diaphragm and place the pericardium in the tissue container. **[G 80; N 228; R 264; C 148]**
6. Use blunt dissection to clean the **esophagus**. Note that the surface of the esophagus is covered by the **esophageal plexus of nerves** (Fig. 3.30). The esophageal plexus innervates the inferior portion of the esophagus.
7. Identify the **right vagus nerve** posterior to the root of the right lung (Fig. 3.31). Follow the right vagus nerve inferiorly and verify that its fibers spread out on the surface of the esophagus.
8. Identify the **left vagus nerve** as it crosses the left side of the arch of the aorta. Follow the left vagus nerve posterior to the root of the left lung and confirm that its fibers contribute to the esophageal plexus.

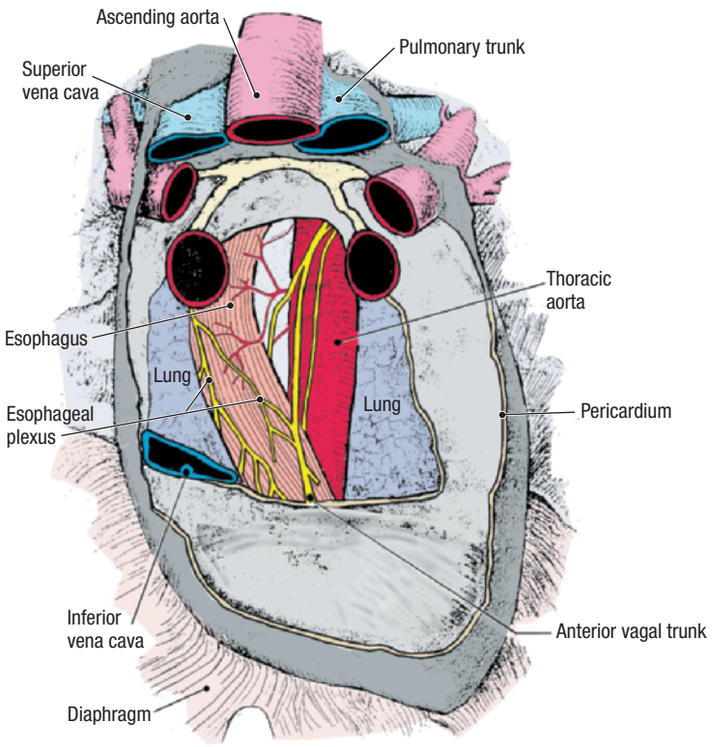

Figure 3.30. The relationship of the posterior mediastinum to the pericardium.

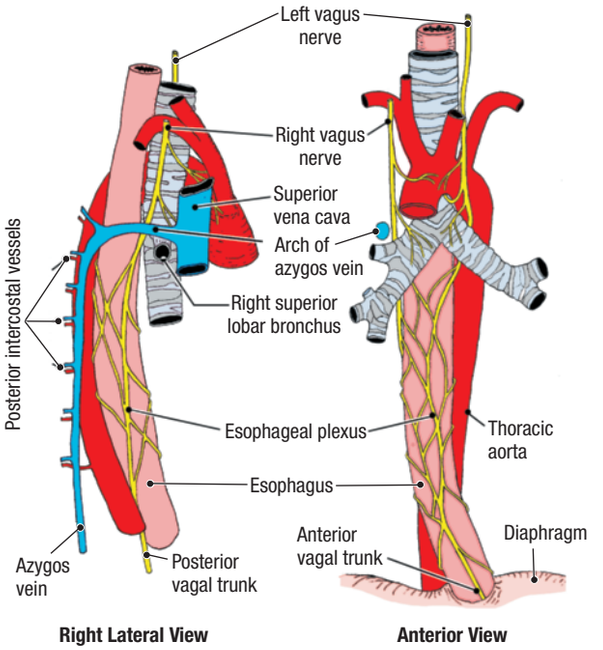

Figure 3.31. Contents of the posterior mediastinum.

9. Identify the **anterior vagal trunk** and the **posterior vagal trunk**. The vagal trunks are found on the inferior part of the esophagus, just before it passes through the diaphragm (Fig. 3.31). The vagal trunks pass through the diaphragm with the esophagus to supply a large part of the gastrointestinal tract.
10. Use an illustration to study the **azygos system of veins**. **[G 76; N 234; R 269; C 149]**
11. Identify the **azygos vein** where it arches superior to the root of the right lung (Fig. 3.31). Clean the azygos vein and follow it inferiorly to the level of the diaphragm. Note that the **posterior intercostal veins** on the right side are tributaries to the azygos vein. **[G 80; N 234; R 269; C 149]**
12. On the left side of the posterior mediastinum, observe that the left posterior intercostal veins drain into the **hemiazygos vein** and **accessory hemiazygos vein**. Note that variations of the azygos system are common.
13. Identify the **thoracic duct**. To find the thoracic duct, retract the esophagus to the left and explore the interval between the **azygos vein** and the **thoracic aorta**. The thoracic duct lies immediately to the left of the azygos vein and is posterior to the esophagus. The thoracic duct is thin-walled and easily torn. It has the appearance of a small vein without blood in it. **[G 74; N 305; R 267; C 149]**
14. Use a probe to free the thoracic duct from the surrounding connective tissue. The thoracic duct may be a network of several small ducts instead of a single duct. The thoracic duct passes through the diaphragm with the thoracic aorta. Superiorly, the thoracic duct drains into the junction of the left internal jugular vein and left subclavian vein. Do not demonstrate its termination at this time.

15. Note that the thoracic duct crosses the anterior surface of the **right posterior intercostal arteries**, the **hemiazygos vein,** and the **accessory hemiazygos vein**. Demonstrate the veins but preserve the thoracic duct.
16. Identify the **thoracic aorta.** Use a probe to clean it from the surrounding connective tissue.
17. Identify **esophageal arteries** and **bronchial arteries.** Both types of arteries are unpaired vessels that arise from the anterior surface of the aorta. They are distinguished by their area of distribution.
18. Dissect one pair of **posterior intercostal arteries** (right and left). Follow them to the intercostal space. Note that the right posterior intercostal arteries cross the midline on the anterior surface of the vertebral bodies. The right posterior intercostal arteries pass posterior to all other contents of the posterior mediastinum.
19. On both sides, identify and clean one **intercostal nerve**. Follow it laterally until it disappears posterior to the **innermost intercostal muscle**.
20. On both sides of the thorax, identify the **sympathetic trunk**. Starting high in the thorax, follow the sympathetic trunk inferiorly and observe that it crosses the heads of ribs 2 to 9. Inferior to rib 9, observe that the sympathetic trunk lies on the sides of the thoracic vertebral bodies. **[G 80; N 236; R 270; C 152]**
21. Observe that the sympathetic trunk has one **sympathetic ganglion** for each thoracic segment.
22. Demonstrate that two **rami communicantes** (**white ramus communicans, gray ramus communicans**) connect each intercostal nerve with its corresponding thoracic sympathetic ganglion. During dissection, it is impossible to distinguish white and gray rami from each other based on color.
23. Use a probe to dissect the **greater splanchnic nerve** on both the right and left sides. Note that the greater splanchnic nerve receives contributions from the fifth through the ninth thoracic sympathetic ganglia and that it is not completely formed until lower thoracic levels. As an aid to identification, observe that the greater splanchnic nerve is found on the sides of vertebral bodies T5 to T9, whereas the sympathetic trunk crosses the heads of ribs 5 to 9 (i.e., the sympathetic trunk is located more posteriorly).
24. The **lesser splanchnic nerve** arises from the tenth and eleventh thoracic sympathetic ganglia. The **least splanchnic nerve** arises from the twelfth thoracic sympathetic ganglion. Because of the curvature of the diaphragm, these two nerves cannot be seen at this time.

After you dissect . . .

Review the boundaries of the anterior, middle, and posterior mediastina. Study a transverse section through the mid-level of the thorax and identify the contents of the posterior mediastinum. Note the relationship of the contents of the posterior mediastinum to the heart and vertebral bodies. Review the course and function of an intercostal nerve, naming all structures that it innervates. Review the parts of the aorta (ascending, arch, thoracic), naming all branches and describing their distribution. Review the origin and course of the right and left posterior intercostal arteries. Name the structures in the posterior mediastinum that course anterior to the right posterior intercostal arteries.