After completing this exercise, you should be able to:

- Describe the location of the heart using anatomical landmarks
- Name and describe the two layers of the pericardium and the three layers of the heart wall
- Identify the major heart structures on models or charts
- Explain the flow of a drop of blood through the pulmonary and systemic circulations, listing the vessels, chambers, and valves
- Explain how the heart functions as a double pump
- Explain the differences in structure and function of the two types of heart valves
- Describe the changes that take place in the heart after birth
- Identify the major vessels involved in coronary circulation on models or charts
- Identify the selected heart structures on a dissected sheep heart
- Describe the microscopic structure of cardiac muscle

Your heart beats without external stimulation and never takes a very long rest. The heart is a small double pump that simultaneously pumps blood to the lungs and to the systemic circulation. The systemic circulation supplies all cells with oxygen and nutrients and removes carbon dioxide and waste materials. Oxygen-poor blood from the body returns to the right side of the heart to be pumped through arteries to the lungs to obtain oxygen. Oxygen-rich blood returns to the left side of the heart through veins to be pumped back into the systemic circulation.
A. LOCATION OF THE HEART

The heart is about the size of a fist and lies in the thoracic cavity within the mediastinum (mediastinus = midway), an area bounded by the lungs laterally, the sternum anteriorly, and the thoracic vertebrae posteriorly. The base of the heart is the wide superior portion of the heart from which the great vessels emerge, and the apex of the heart is the inferior pointed end.

The location of the heart in the thorax can be further defined by finding the superior and inferior right and left points of the heart. The **superior right point** of the heart is located at the superior border of the 3rd right costal cartilage at its attachment to the rib. The **superior left point** is located at the inferior border of the 2nd left costal cartilage at its attachment to the rib. The **inferior left point** is located in the 5th intercostal space, inferior to the fifth costal cartilage at its attachment to the rib. The **inferior right point** is at the inferior border of the 5th right costal cartilage, a little to the right of the border of the sternum. The heart is tilted at an angle so that its inferior surface lies against the diaphragm, with two-thirds of the heart to the left side of the sternum.

**ACTIVITY 1 Location of the Heart**

1. In Figure 23.1, identify the superior and inferior right and left points of the heart. Mark dots at these points and connect these four dots to outline the heart location.
2. Identify the superior and inferior right and left points for the heart location on an articulated skeleton and/or a torso model.
3. Palpate the superior and inferior right and left points on yourself.

**FIGURE 23.1** Location of the heart.
B. MAJOR
HEART STRUCTURES

1. The Pericardium and the Layers of the Heart Wall

In the mediastinum, the heart is surrounded and protected by the pericardium (peri- = around). The pericardium consists of an outer, tough fibrous pericardium and an inner, delicate serous pericardium. The fibrous pericardium attaches to the diaphragm and also to the great vessels of the heart. Like all serous membranes, the serous pericardium is a double membrane composed of an outer parietal layer and an inner visceral layer. Between these two layers is the pericardial cavity filled with serous fluid. The outer parietal (paries = wall) pericardium is attached to the fibrous pericardium, and the inner visceral (viscera = internal organs) pericardium covers the cardiac muscle.

ACTIVITY 2 The Pericardium and Layers of the Heart Wall

1. Label the structures in Figure 23.2.
2. Pronounce each term as you write the answer in the blank.

The wall of the heart has three layers: the outer epicardium (epi- = on, upon; cardia = heart), the middle myocardium (myo- = muscle), and the inner endocardium (endo- = within, inward). The epicardium is the visceral layer of the pericardium. The majority of the heart is the myocardium or cardiac muscle tissue. The endocardium is a thin layer of endothelium deep to the myocardium that lines the inside chambers of the heart and the valves.
EXERCISE 23  STRUCTURE OF THE HEART

- apex of heart
- base of heart
- diaphragm
- fibrous pericardium (peri-CAR-dee-um)
- left lung
- right lung

(a) Heart in the mediastinum, anterior view

- endocardium
- fibrous pericardium
- myocardium
- parietal layer of serous pericardium
- pericardial cavity
- visceral layer of serous pericardium (epicardium)

(b) Pericardium and layers of heart wall

Figure 23.2  External heart and pericardium.
2. Surface Features of the Heart

Like all mammalian hearts, the human heart has four chambers and is divided into right and left sides. Each side has an upper chamber called an atrium and a lower chamber called a ventricle. The two atria form the base of the heart, and the tip of the left ventricle forms the apex. Auricles (auricle = little ear) are pouch-like extensions of the atria. From the exterior, the auricles look like flaps with wrinkled edges.

Coronary blood vessels and adipose tissue are found in the sulci or grooves that externally mark the boundaries between the four heart chambers. Although a considerable amount of external adipose tissue is present on the heart surface for protection and padding, most heart models do not show this. The coronary sulcus is a deep sulcus that externally shows the separation of the atria and the ventricles. The anterior interventricular sulcus and the posterior interventricular sulcus are shallow grooves that depict the surface boundaries between the two ventricles.

ACTIVITY 3 Surface Features of the Heart

1. Label the structures in Figure 23.3.
2. Identify each term on a model or chart.
3. Pronounce each term as you point to it.
EXERCISE 23  STRUCTURE OF THE HEART

• anterior interventricular sulcus
• auricle of left atrium
• auricle of right atrium
• coronary sulcus
• left ventricle
• right ventricle

1 ______________________________
2 ______________________________
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6 ______________________________

(b) Posterior view

7 ______________________________
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FI G URE 23.3  Surface features of the heart.
3. Great Vessels of the Heart

The great vessels of the heart either return blood to the atria or carry blood away from the ventricles. The superior vena cava, inferior vena cava, and coronary sinus return oxygen-poor blood to the right atrium. The superior vena cava returns blood from the head, neck, and arms; the inferior vena cava returns blood from the body inferior to the heart; and the coronary sinus is a smaller vein that returns blood from the coronary circulation. Blood leaves the right atrium to enter the right ventricle. From here, blood passes out the pulmonary trunk, the only vessel that removes blood from the right ventricle. This large artery divides into the right and left pulmonary arteries that carry blood to the lungs where it is oxygenated. Oxygen-rich blood returns to the left atrium through two right and two left pulmonary veins. The blood then passes into the left ventricle that pumps blood into the large aorta. The aorta distributes blood to the systemic circulation. The aorta begins as a short ascending aorta, curves to the left to form the aortic arch, descends posteriorly, and continues as the descending aorta.

The fetal heart contains a short, temporary vascular channel, the ductus arteriosus (ductus = duct; arteriosus = artery), which connects the pulmonary trunk and the aorta. This right heart to left heart shunt re-routes some of the blood destined for the lungs to the systemic circulation via the aorta. In fetal life, oxygen is obtained through the placenta from the mother and not from the lungs. Therefore, it is not detrimental to the baby’s health for blood to bypass the lungs. The ductus arteriosus changes into a ligament after birth and remains as the ligamentum arteriosum.

ACTIVITY 4 Great Vessels of the Heart

1. Label the great vessels of the heart in Figure 23.4. Blood vessels carrying oxygen-rich blood are red, and those carrying oxygen-poor blood are blue.
2. Identify each great vessel on a model or chart.
3. Pronounce each term as you point to it.
EXERCISE 23  STRUCTURE OF THE HEART

• aortic arch
• ascending aorta
• descending aorta
• inferior vena cava
• left pulmonary artery
• left pulmonary veins
• ligamentum arteriosum
• pulmonary trunk
• right pulmonary artery
• right pulmonary veins
• superior vena cava

(a) Anterior view

(b) Posterior view

FIGURE 23.4  Great vessels of the heart.
4. Internal Features of the Heart

The myocardium of the anterior wall of the right atrium has a honeycombed appearance, and these myocardial ridges called pectinate muscles (pecten = comb-like) continue into the auricles. The walls of the right and left atria are separated by the thin interatrial septum. In the fetus, there is a hole in the interatrial septum called the foramen ovale. The foramen ovale allows blood to bypass the lungs and go from the right atrium to the left atrium, forming another right heart to left heart shunt. The fossa ovalis, a connective tissue membrane, forms over and closes the fetal foramen ovale.

The ventricles have ridges of muscles called trabeculae carneae (trabecula = little beam; carneae = flesh). The larger of these muscles, the papillary muscles, have string-like cords attached to them called the chordae tendineae (tendinous strands). The opposite ends of these cords are attached to the AV valves. The interventricular septum is a thin wall that separates the right and left ventricles.

The heart has four valves that control the one-way flow of blood: two AV valves and two semilunar valves (semi- = half; lunare = moon). Blood passing between the right atrium and the right ventricle goes through the right AV valve, the tricuspid valve (tri- = three; cusp = flap). The left AV valve, the bicuspid valve, is between the left atrium and the left ventricle. This valve clinically is called the mitral valve (miter = tall, liturgical headdress) because the open valve resembles a bishop’s headdress. The two AV valves are structurally similar, except the tricuspid valve has three cusps or flaps and the bicuspid valve has two cusps or flaps that prevent blood from flowing back into the atria.

Blood in the right ventricle goes through the pulmonary (semilunar) valve to enter the pulmonary trunk (artery). The aortic (semilunar) valve is located between the left ventricle and the aorta. These two semilunar valves are identical, with each having three pockets that fill with blood, preventing blood from flowing back into the ventricles.

The thinner walled atria receive the blood returning to the heart from veins. The pressure of blood in the atria opens the atrioventricular (AV) valves, and most of the blood flows into the ventricles. Both atria then contract simultaneously to pump the remaining blood into the ventricles. The larger, thick ventricular walls are double pumps that contract simultaneously to send the blood from the right ventricle to the lungs and from the left ventricle to the systemic circulation. The wall of the left ventricle is thicker than the right because the left side requires more force to pump blood through the systemic circulation.

ACTIVITY 5 Internal Features of the Heart

1. Label the structures in Figure 23.5.
2. Identify each term on a model or chart.
3. Pronounce each term as you point to it.
• aortic (semilunar) valve
• bicuspid valve (mitral)
• chordae tendineae (CHOR-dee ten-DIN-ee)
• coronary sinus opening
• interventricular septum (inter-ven-TRIC-u-lar)
• left atrium
• left ventricle
• papillary muscle (PAP-ih-lary)
• pulmonary (semilunar) valve
• right atrium
• right ventricle
• trabeculae carneae (tra-BEC-u-lee CAR-nee)
• tricuspid valve

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**FIGURE 23.5** Internal features of the heart, frontal section.
C. SYSTEMIC AND PULMONARY CIRCULATIONS

As you trace a drop of blood through the heart to the lungs and then to the rest of the body, you will be examining the pulmonary and systemic circulations. The **pulmonary circulation** takes blood from the right ventricle to the lungs and back to the left atrium. The **systemic circulation** takes blood from the left ventricle to the body tissues and back to the right atrium. Note that each circulation begins and ends at the heart, and each circulation is composed of arteries, capillaries, and veins.

**ACTIVITY 6 Systemic and Pulmonary Circulations**

1. In Figure 23.6, color the vessels that are carrying oxygen-poor blood blue and the vessels carrying oxygen-rich blood red, being careful to note the color switch in the pulmonary vessels. Color the four capillary beds purple.

2. Trace the pathway of blood in Figure 23.6 through the pulmonary circulation with one color of arrows and the systemic circulation with different colored arrows, starting and ending with the right atrium.

3. Indicate whether the following blood vessels contain oxygen-poor or oxygen-rich blood.
   - aorta
   - pulmonary arteries
   - pulmonary trunk
   - pulmonary veins
   - venae cavae

   **Blood Vessels with Oxygen-Poor Blood**
   1. 
   2. 
   3. 

   **Blood Vessels with Oxygen-Rich Blood**
   4. 
   5. 

4. In the blanks below, trace a drop of blood through the heart and lung by listing *in order* all vessels, heart chambers, and valves through which the blood passes, starting with the right atrium.
   - aorta
   - aortic (semilunar) valve
   - bicuspid valve (mitral)
   - left atrium
   - left ventricle
   - pulmonary arteries
   - pulmonary capillaries
   - pulmonary (semilunar) valve
   - pulmonary trunk
   - pulmonary veins
   - right atrium
   - right ventricle
   - systemic arteries
   - systemic capillaries
   - systemic veins
   - tricuspid valve
   - venae cavae

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

   ____________________________________________________________________________
FIGURE 23.6 Systemic and pulmonary circulations.
D. Coronary Circulation

The walls of the heart have their own blood supply and circulation, the **coronary** (corona = crown) circulation. These vessels encompass the heart similar to a crown. The endothelium lining the heart chambers is too thick for blood in the chambers to supply nutrients to cardiac muscle tissue. Coronary blood vessels supply blood to cardiac muscle tissue.

On the anterior surface of the heart, the **right and left coronary arteries** branch off the base of the ascending aorta just superior to the aortic semilunar valve. These small arteries are supplied with blood when the ventricles are resting. When the ventricles contract, the cusps of the aortic valve open to cover the openings to the coronary arteries. If the coronary arteries were not covered, they would not be able to withstand the blood pressure and would burst like an overinflated balloon.

As the **left coronary artery** passes the base of the left auricle, it branches into the:

- anterior interventricular branch (left anterior descending branch, or LAD)
- circumflex branch

The **anterior interventricular branch** (LAD) supplies both ventricles with oxygen-rich blood and lies within the anterior interventricular sulcus, a shallow depression between the two ventricles. The anterior interventricular branch is commonly occluded and can result in a myocardial infarct and at times death. The **circumflex branch** continues around the left side of the heart, lying within the coronary sulcus (atrioventricular sulcus), and supplies blood to the left ventricle and left atrium. The circumflex branch forms anastomoses (connections) with the posterior interventricular branch near the posterior interventricular sulcus.

The **right coronary artery** passes the right auricle, supplying it with blood, and continues inferiorly to the auricle in the coronary sulcus. The right coronary artery branches into the:

- marginal branch
- posterior interventricular branch

The **marginal branch** supplies the anterior right side of the right ventricle. The **posterior interventricular branch** lies in the posterior interventricular sulcus on the posterior surface of the heart, supplying oxygen-rich blood to both ventricles.

Arteries branch into smaller vessels, arterioles, which penetrate the heart muscle and divide into narrower vessels called capillaries which deliver oxygen to the cardiac muscle. Capillaries drain into venules which exit the heart muscle and connect to veins that receive oxygen-poor blood, returning it to the heart. The **great cardiac vein** is the principal vein of the coronary circulation, draining the left anterior portion of the heart. It lies near the anterior interventricular branch in the interventricular sulcus. The **small cardiac vein** drains the right anterior portion of the heart. The **middle cardiac vein** that lies next to the posterior interventricular branch in the posterior interventricular sulcus drains the posterior portion of the heart. Both of these veins empty into a large, thin-walled venous sinus called the **coronary sinus** located on the posterior surface of the heart. The coronary sinus empties its oxygen-poor blood into the right atrium.

**Activity 7: Coronary Circulation**

1. Label the structures in Figure 23.7.
2. Identify each vessel on a model or chart.
3. Pronounce each term as you point to it.
EXERCISE 23  STRUCTURE OF THE HEART

- anterior interventricular branch (LAD)
- circumflex branch
- coronary sinus
- great cardiac vein
- left coronary artery
- marginal branch
- middle cardiac vein
- posterior interventricular branch
- right coronary artery
- small cardiac vein

F I G U R E  23.7  Coronary circulation.
E. DISSECTION OF A SHEEP HEART

The sheep heart is similar to the human heart in both structure and size. It provides students the opportunity to observe the flexibility of the valves and tissues.

ACTIVITY 8 Dissection of a Sheep Heart

1. Obtain a dissecting tray, tools, disposable gloves, and a sheep heart.

2. Examine the anterior surface of the heart. Great vessels are often cut close to the base of the heart and may be difficult to find. Refer to Figure 23.8(a) and a heart model to identify the following structures:
   - pericardium (if present)
   - epicardium
   - base
   - apex
   - right auricle
   - left auricle
   - right ventricle
   - left ventricle
   - pulmonary trunk

3. Examine the posterior surface of the heart using Figure 23.8(b), and identify the following structures:
   - coronary sulcus
   - left auricle
   - left ventricle
   - right auricle
   - right ventricle
   - left ventricle

4. Insert a blunt probe into the collapsed superior vena cava and into the right atrium. Maneuver the probe to find the interior opening of the inferior vena cava in the right atrium and push the probe out into this vessel.

5. Examine the interior of the heart by making a coronal section of the heart. Using a knife with about a 5-inch blade, make a coronal cut of a sheep heart starting at the apex and cutting toward the base (see Figure 23.8(c)). Cut through both auricles (to ensure cutting through both atria) but not all the way through the base and the great vessels, so the two halves do not get separated. This cut allows you to observe both atria and both ventricles simultaneously (similar to a heart model), and easily compare the size of the walls of the right and left ventricles.

6. Using Figure 23.8(c), identify the following interior structures on the right side of the heart:
   - myocardium
   - endocardium
   - right atrium
   - right auricle
   - pectinate muscle
   - opening of superior and inferior vena cava
   - opening of the coronary sinus
   - tricuspid valve
   - right ventricle
   - chordae tendineae
   - papillary muscles
   - moderator band (cord between the two walls of the right ventricle)
   - interventricular septum
   - pulmonary trunk
   - pulmonary semilunar valve

7. In the right atrium, insert a blunt probe in the small opening of the coronary sinus that is inferior to the opening of the inferior vena cava. Observe the movement of the probe in the coronary sinus from the posterior view of the heart.

8. In the right atrium, insert a blunt probe into the opening of the pulmonary trunk and push it through to the superior end of the vessel. Remove the probe and take a scalpel to cut the wall of the pulmonary trunk longitudinally to expose the pulmonary semilunar valve. Count the three cusps. How does this valve differ from the tricuspid valve?

9. Continue identifying structures on the left side of the heart.
   - left atrium
   - left auricle
   - bicuspid valve
   - left ventricle
   - aortic semilunar valve
   - aorta

10. How many cusps does the bicuspid valve have? ______ Does this valve look similar otherwise to the other AV valve? ______ Are there chordae tendineae and papillary muscles? ______ Does the left ventricle have a greater or smaller number of papillary muscles compared with the right side? ______ Compare the thickness of the right and left ventricles. Which one is thicker? ______ Why? __________
11 Look just above the cusps of the aortic valve for the openings to the right and left coronary arteries. Use the blunt probe to push into these small vessels.

12 Dispose of any removed dissection material in the proper container (NOT the sink!).

13 Wash the dissection pan, instruments, and hands with soap and water when finished.

14 Clean up your lab space and wash the countertops with disinfectant.

**Figure 23.8a** Sheep heart.
EXERCISE 23  STRUCTURE OF THE HEART

FIGURE 23.8b Sheep heart, continued.

FIGURE 23.8c Coronal section of the sheep heart.
The heart is the only structure in the body composed of cardiac muscle tissue, which is striated and involuntary. Cardiac fibers have one or two nuclei and demonstrate branching. Cardiac muscle has intercalated discs that contain gap junctions and desmosomes that hold cardiac fibers together. Gap junctions enable action potentials to spread quickly from cell to cell, allowing the atrial fibers to contract as a unit, as do the ventricular fibers.

**ACTIVITY 9** Histology of Cardiac Muscle

1. As a review, label the photomicrograph of cardiac tissue (Figure 23.9).
2. Pronounce the terms as you label the figure.

**Figure 23.9** Photomicrograph of cardiac muscle fibers.
A. Location of the Heart

1. Describe the location of the heart using the lungs, rib cartilages, and intercostal spaces as landmarks.

B. Major Heart Structures

Completion: Fill in the blank with the word that fits the description.

__________________________ 1. Arteries that supply blood to cardiac muscle.

__________________________ 2. Layer of heart wall containing cardiac muscle.

__________________________ 3. Extensions of the atria.

__________________________ 4. Heart is located here (area between the lungs).

__________________________ 5. Lines the heart chambers.

__________________________ 6. Pointed inferior part of the heart.

__________________________ 7. Two heart pumps; lower heart chambers.

__________________________ 8. Superior heart chambers.

__________________________ 9. Another name for visceral pericardium.

__________________________ 10. Wide superior part of the heart.

__________________________ 11. Blood pumped by right ventricle (oxygen-rich or oxygen-poor).

__________________________ 12. Blood pumped by left ventricle (oxygen-rich or oxygen-poor).

__________________________ 13. Enlarged muscles in ventricles attached to chordae tendinae.


__________________________ 15. Ridges in anterior wall right atrium.

__________________________ 16. Strings attached to AV cusps.
C. Coronary Circulation—Blood Vessels

Completion: After reviewing the coronary circulation in Figure 23.7, fill in the blank with the word that fits the description.

1. Anterior branch of the left coronary artery.
2. Posterior branch of the right coronary artery.
3. Coronary artery that lies in anterior coronary sulcus.
4. Curving branch of the left coronary artery.
5. Main artery supplying anterior part of ventricles.
6. Shorter coronary artery that divides at the base of an ile.
7. Vein that drains coronary circulation into right atrium.
8. Vein that drains most of anterior ventricles.
9. Vein that drains the posterior ventricles.
10. Vein that drains the right anterior side.

D. The Heart and Pulmonary Circulation

Place the following structures in order, tracing the blood flow from the superior vena cava to the heart, to the lungs, and out of the heart to the systemic circulation.

- aorta
- aortic valve
- bicuspid valve
- left atrium
- left ventricle
- pulmonary capillaries
- right atrium
- right ventricle
- pulmonary arteries
- pulmonary trunk
- pulmonary valve
- pulmonary veins
- superior vena cava
- tricuspid valve

1. ____________________________ 8. ____________________________
2. ____________________________ 9. ____________________________
3. ____________________________ 10. ____________________________
4. ____________________________ 11. ____________________________
5. ____________________________ 12. ____________________________
6. ____________________________ 13. ____________________________
7. ____________________________ 14. ____________________________