EXERCISE 21

STRUCTURE OF THE HEART

OBJECTIVES

After completing this exercise, you should be able to:

- Describe the location and coverings of the heart and the three layers of the heart wall
- Identify major features of cardiac muscle tissue on a prepared microscope slide
- Identify the major heart structures on models or charts
- Describe the flow of a drop of blood through the pulmonary and systemic circulations, listing the vessels, chambers, and valves
- Describe the changes that take place in the heart after birth
- Identify the selected heart structures on a dissected sheep heart

MATERIALS

- human heart model
- human torso or chart showing the pulmonary and systemic circulations
- colored pencils
- preserved sheep heart (or other mammal heart)
- dissecting instruments, trays, disposable gloves, 5-inch blade knife
- compound microscope with cardiac muscle slide (for demonstration)

Your heart beats without external stimulation and rests only between heart beats. The heart is a small double pump that simultaneously pumps blood to and from body cells through the systemic circulation and to and from the lungs through the pulmonary circulation.

A. COVERINGS AND LAYERS OF THE HEART

The **heart** is about the size of a fist and lies in the thoracic cavity. 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 end pointing to the left. 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.

The heart is located between the lungs in the thoracic cavity and 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 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 **myocardium** or cardiac muscle tissue. The **endocardium** is a thin layer of endothelium deep to the myocardium that lines the chambers of the heart and the valves.

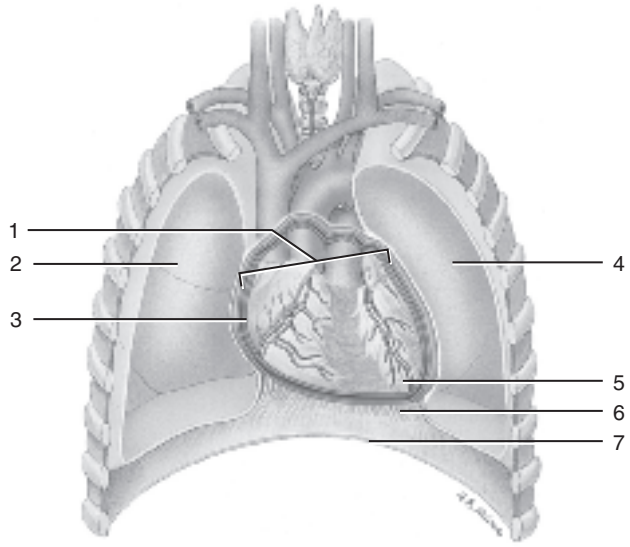
ACTIVITY 1 COVERINGS AND LAYERS OF THE HEART

1 Label the structures on Figure 21.1(a) and (b).

2 Pronounce each term as you write in the answer.

3 Using contrasting colors, color the layers of the heart and the pericardium.

4 Examine a slide of cardiac muscle tissue. Observe the striations, branching cardiac cells, nuclei, and intercalated discs. Refer to the photomicrograph of cardiac muscle tissue in Exercise 6 Tissues.



(a) Heart, anterior view

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

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

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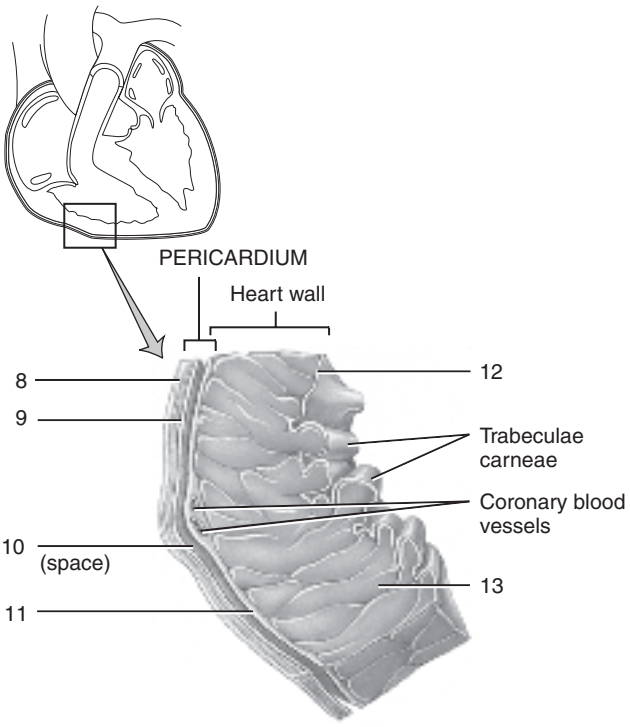

(b) Pericardium and layers of heart wall

FIGURE 21.1 Layers of the heart and pericardium.

B. MAJOR HEART STRUCTURES

1. Surface Structures of the Heart

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 with wrinkled edges. Shallow grooves called **sulci** (sulcus, singular) externally mark the boundaries between the four heart chambers. Although a considerable amount of external adipose tissue is present on the heart surface for cushioning, most heart models do not show this.

Cardiac muscle tissue that composes the heart walls has its own blood supply and circulation, the **coronary** (*corona* = crown) **circulation.** Coronary blood vessels encompass the heart similar to a crown and are found in sulci. 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, and travel in the sulcus separating the atria and ventricles. 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. A clinically important branch of the left coronary artery is the **anterior interventricular branch,** also known as the **left anterior descending (LAD) branch** that lies between the right and left ventricles and supplies both ventricles with oxygen-rich blood. This coronary artery is commonly occluded which can result in a myocardial infarct and, at times, death.

2. Great Vessels of the Heart

The great veins of the heart return blood to the atria and the great arteries 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. 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, oxygen-poor 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.**

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 fetal heart contains a short, temporary vessel, the **ductus arteriosus** (*ductus* = duct; *arteria* = artery), that connects the pulmonary trunk and the aorta. The ductus arteriosus is a right heart to left heart shunt that reroutes some of the blood destined for the lungs to the systemic circulation through the aorta. The ductus arteriosus changes into a ligament after birth and remains as the **ligamentum arteriosum.**

ACTIVITY 2 EXTERNAL STRUCTURES OF THE HEART

1. Label the structures on Figure 21.2(a) and (b).
2. Using contrasting colors, color the heart structures in Figure 21.2(a) and (b).
3. Identify each term on models or charts.
4. Pronounce each term as you point to it.

- aortic arch
- ascending aorta
- auricle of left atrium
- auricle of right atrium
- branch of left coronary artery or LAD
- descending aorta
- inferior vena cava
- left pulmonary artery
- left pulmonary veins
- left ventricle
- ligamentum arteriosum
- pulmonary trunk
- right coronary artery
- right pulmonary artery
- right pulmonary veins
- right ventricle
- superior vena cava

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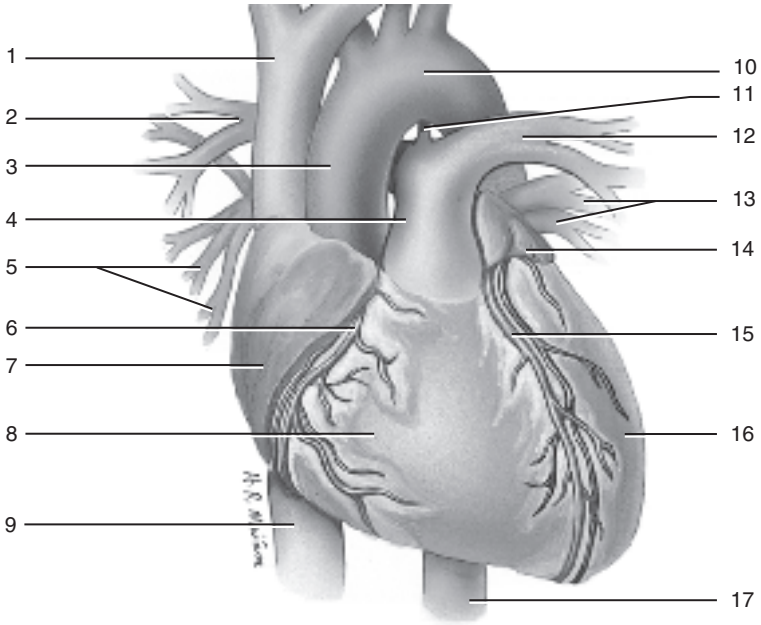

(a) Anterior view showing surface features

- aortic arch
- ascending aorta
- coronary sinus
- inferior vena cava
- left pulmonary artery
- left pulmonary veins
- ligamentum arteriosum
- right pulmonary artery
- right pulmonary veins
- superior vena cava

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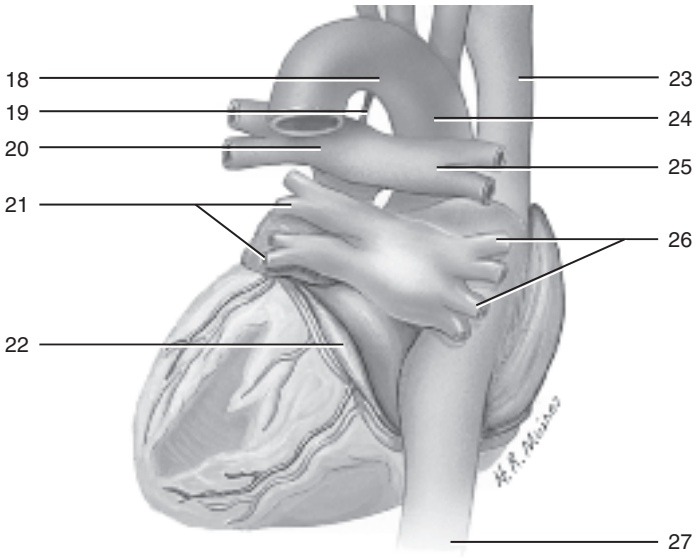


(b) Posterior view

FIGURE 21.2 External structure of the heart.

3. Internal Structures of the Heart

The heart has four valves that control the one-way flow of blood: two **atrioventricular (AV) valves** and two **semilunar valves** (*semi-* = half; *lunar* = 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. String-like cords called **chordae tendineae** (tendinous strands) attach and secure the cusps of the AV valves to enlarged **papillary muscles** that project from the ventricular walls. Chordae tendinae allow the AV valves to close during ventricular contraction, but prevent their cusps from getting pushed up into the atria.

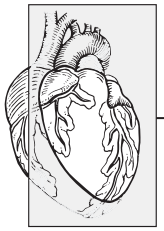
The two semilunar valves allow blood to flow from the ventricles to great arteries and exit the heart. Blood in the right ventricle goes through the **pulmonary (semilunar) valve** to enter the pulmonary trunk, a large artery. The **aortic (semilunar) valve** is located between the left ventricle and 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 two ventricles have a thick wall between them called the **interventricular septum.** Between the two atria is a thinner **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 remnant, forms over and closes the fetal foramen ovale after birth.

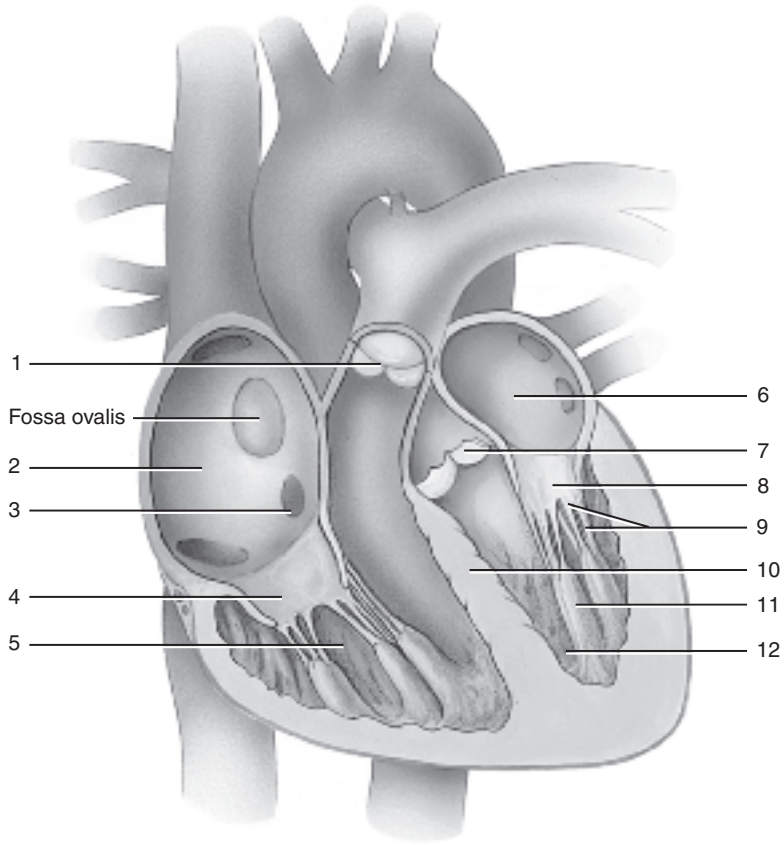
Note the difference in thickness between the right ventricle and the left ventricle. Which one has to pump blood a greater distance and therefore has to pump blood with more force?

ACTIVITY 3 INTERNAL FEATURES OF THE HEART

1. Label the structures on Figure 21.3.
2. Using contrasting colors, color the internal structures of the heart in Figure 21.3.
3. Identify each term on models or charts.
4. Pronounce each term as you point to it.



Frontal plane



Heart, frontal section

- 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
- tricuspid valve

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FIGURE 21.3 Internal structures of the heart.

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. Simultaneously, the **systemic circulation** takes blood from the left ventricle to the body tissues and back to the right atrium. Each circulation begins and ends at the heart, and each circulation is composed of arteries, capillaries, and veins. Arteries carry blood from the heart to the capillaries, microscopic vessels within tissues. Blood travels from capillaries into veins, which carry blood back to the heart.

The thinner walled atria receive blood returning to the heart from the great veins. Both atria contract simultaneously to pump the 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 pulmonary circulation 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 4 SYSTEMIC AND PULMONARY CIRCULATIONS

1. In Figure 21.4, 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 on Figure 21.4 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. Using a heart model, trace the pathway of blood through the great vessels and heart structures.
4. Indicate whether the following blood vessels contain oxygen-poor or oxygen-rich blood.
   - aorta
   - pulmonary arteries
   - pulmonary trunk
   - pulmonary veins
   - venae cavae

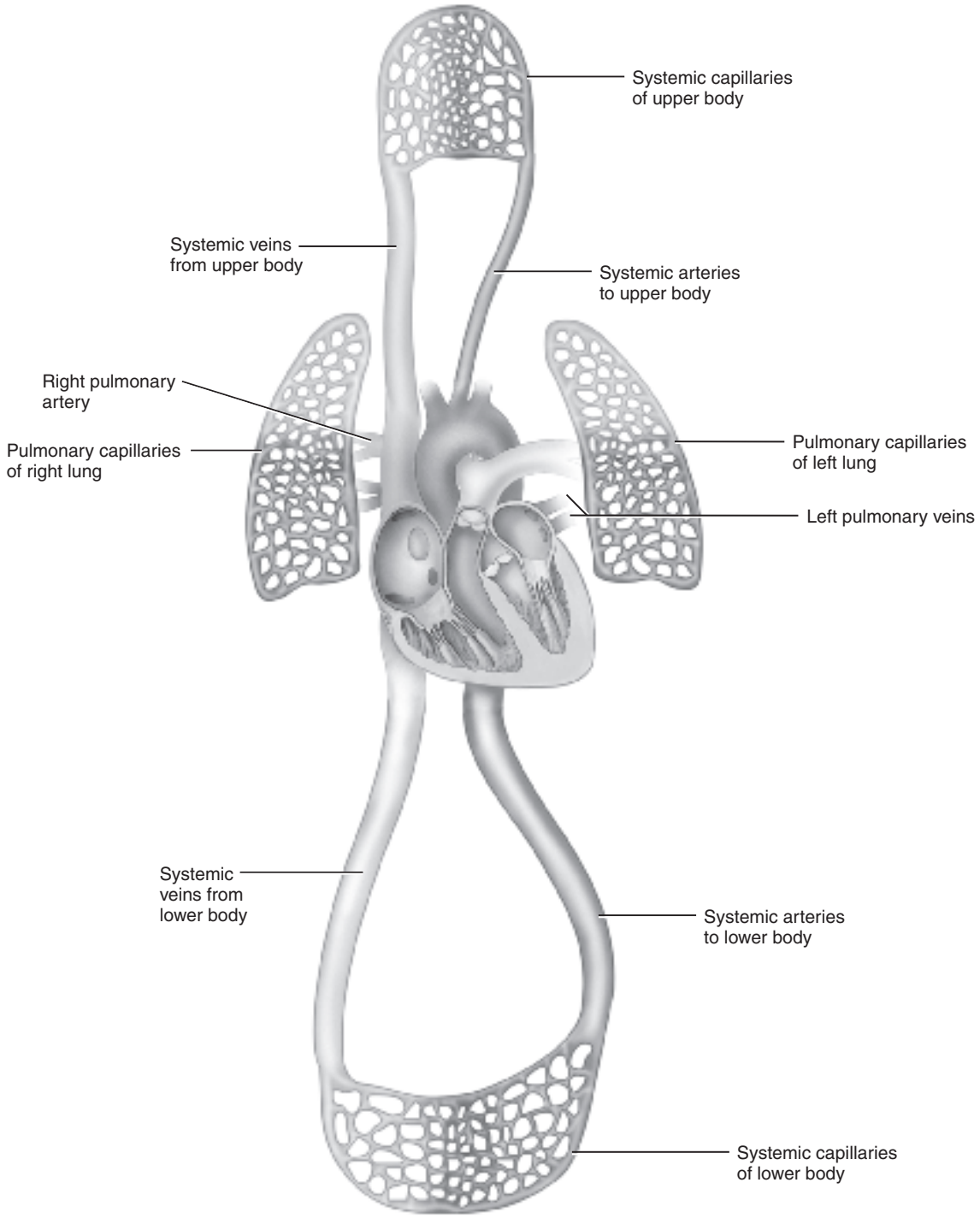


FIGURE 21.4 Systemic and pulmonary circulations.

E. DISSECTION OF A SHEEP HEART

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

ACTIVITY 5 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 21.5(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 and identify the coronary sulcus.

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 frontal (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 (Figure 21.5(b)). 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 21.5(b), identify the following interior structures on the right side of the heart:

- myocardium
- endocardium
- right atrium
- right auricle
- opening of superior and inferior vena cava
- opening of the coronary sinus
- tricuspid valve
- right ventricle
- chordae tendinae
- 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 medial 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 use 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 and its cusps 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

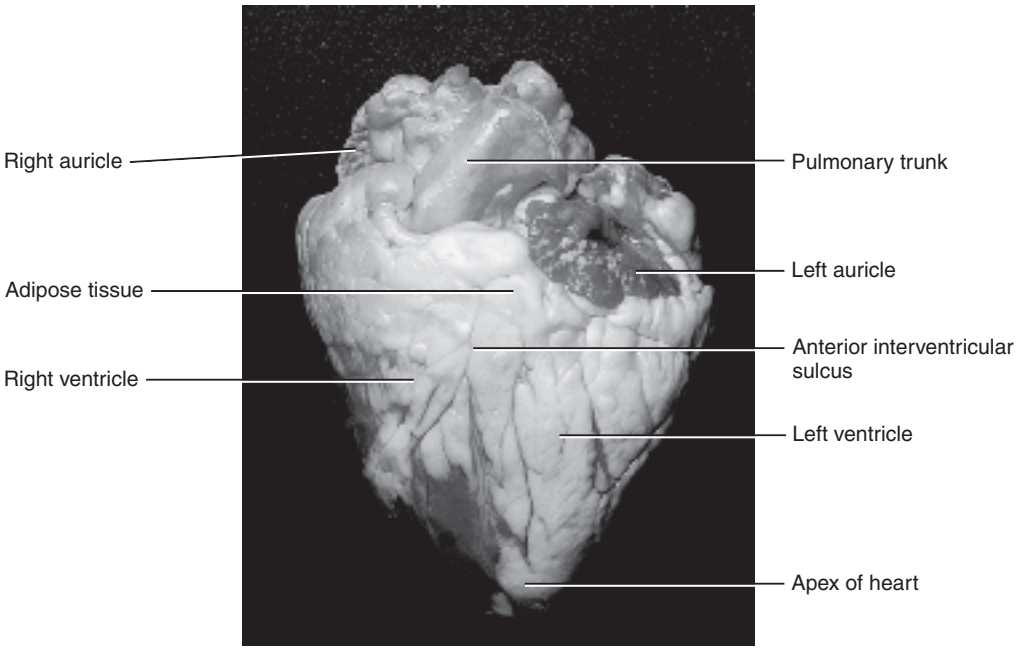
10 How many cusps does the bicuspid valve have? _____ Does this valve look similar otherwise to the other AV valve? _____ Are there **chordae tendineae** and **papillary muscles?** _____ Does the left ventricle have a greater or lesser number of papillary muscles compared with the right side? _____ Compare 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.

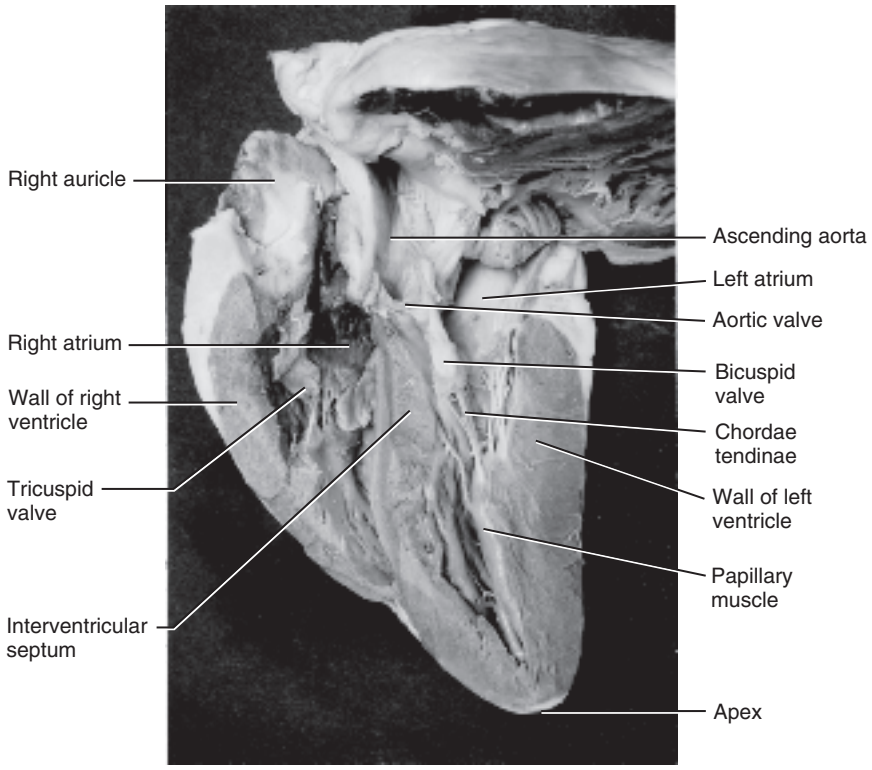
12 Dispose of any removed dissection material in the proper container (*not* the sink!).

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

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



(a) Anterior view



(b) Coronal section

FIGURE 21.5 Sheep heart.

Name _____ Section _____ Date _____

EXERCISE 21

REVIEWING YOUR KNOWLEDGE

A. Major Heart Structures

Write the name of the structure that each phrase describes.

apex
atria
auricles
base
chordae tendinae
coronary arteries
endocardium
epicardium
ligamentum arteriosum
myocardium
papillary muscles
ventricles

_____ **1.** Arteries that supply blood to cardiac muscle.

_____ **2.** Layer of heart wall containing cardiac muscle.

_____ **3.** Wrinkled extensions of the atria.

_____ **4.** Lines the heart chambers.

_____ **5.** Pointed inferior part of the heart.

_____ **6.** Two heart pumps; lower heart chambers.

_____ **7.** Superior heart chambers.

_____ **8.** Another name for visceral pericardium.

_____ **9.** Wide, superior part of the heart.

_____ **10.** Enlarged muscles in ventricles attached to chordae tendinae.

_____ **11.** Strings attached to AV cusps.

_____ **12.** Remnant of a fetal vessel that closed at birth.

B. The Heart and Pulmonary Circulation

Trace a drop of blood from the *neck area* to the heart, to the lungs, and out of the heart to the systemic circulation by placing the following structures in order, numbering them 1–14.

_____ 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

_____ superior vena cava

_____ tricuspid valve