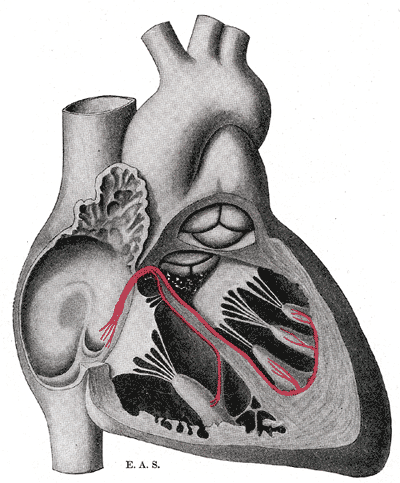
**Exercise 3: Heart Anatomy**

**Dissection Lab: You will need dissection goggles in the laboratory.**



**Figure 3.1** Illustration of a human heart in anterior view representing the internal anatomy.

**Exercise 3 Learning Goals**

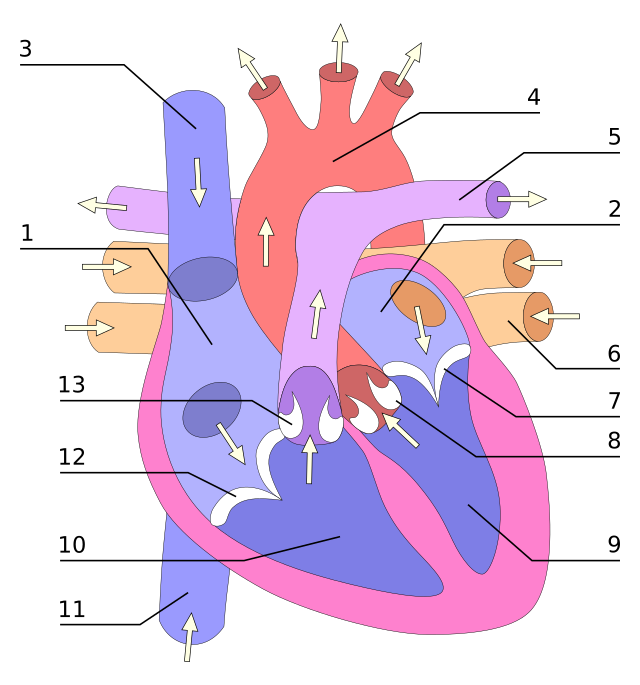
**After completing this lab, you should be able to:**

* Describe the size, shape, and location of the heart in the human body
* Define and locate the pericardial layers
* Identify and describe the interior and exterior features of the heart on models, images, or dissection specimen
* Describe the path of blood through the heart
* Differentiate the unique features of cardiac muscles cells compared to skeletal and smooth muscle

# **Pre-Lab Activities for Exercise 3**

# **Pre-Lab Activity 3.1:** **Identifying the Main Structures of the Heart**

Write the number from the diagram next to the corresponding structure name.



**Figure 3.2** Label the heart. The figure depicts the human heart with numbers pointing to specific structures.

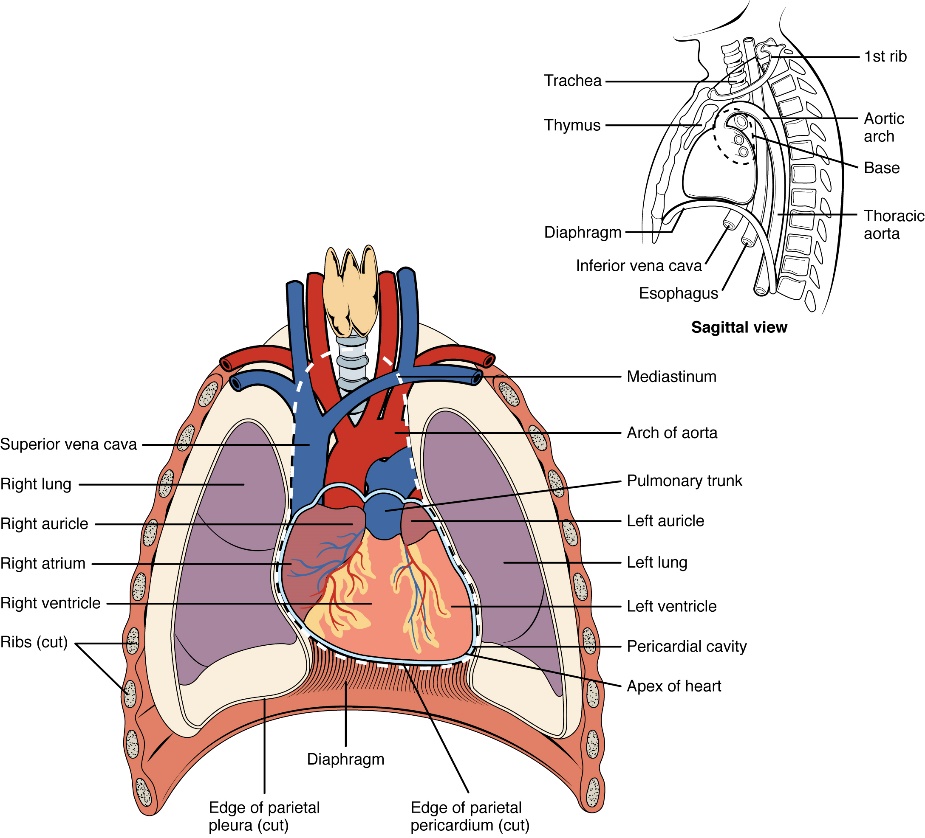
* Left Ventricle
* Right Ventricle
* Left Atrium
* Right Atrium
* Aorta
* Pulmonary artery
* Superior vena cava
* Inferior vena cava
* Pulmonary vein
* Bicuspid valve
* Tricuspid valve
* Aortic semilunar valve
* Pulmonary semilunar valve

**Pre-Lab Activity 3.2: Pathway of Blood Flow through the Heart**

Read the corresponding section in your required textbook or review notes and using your own words, describe the flow of oxygenated blood and deoxygenated blood **through the heart**. Begin with the left ventricle.

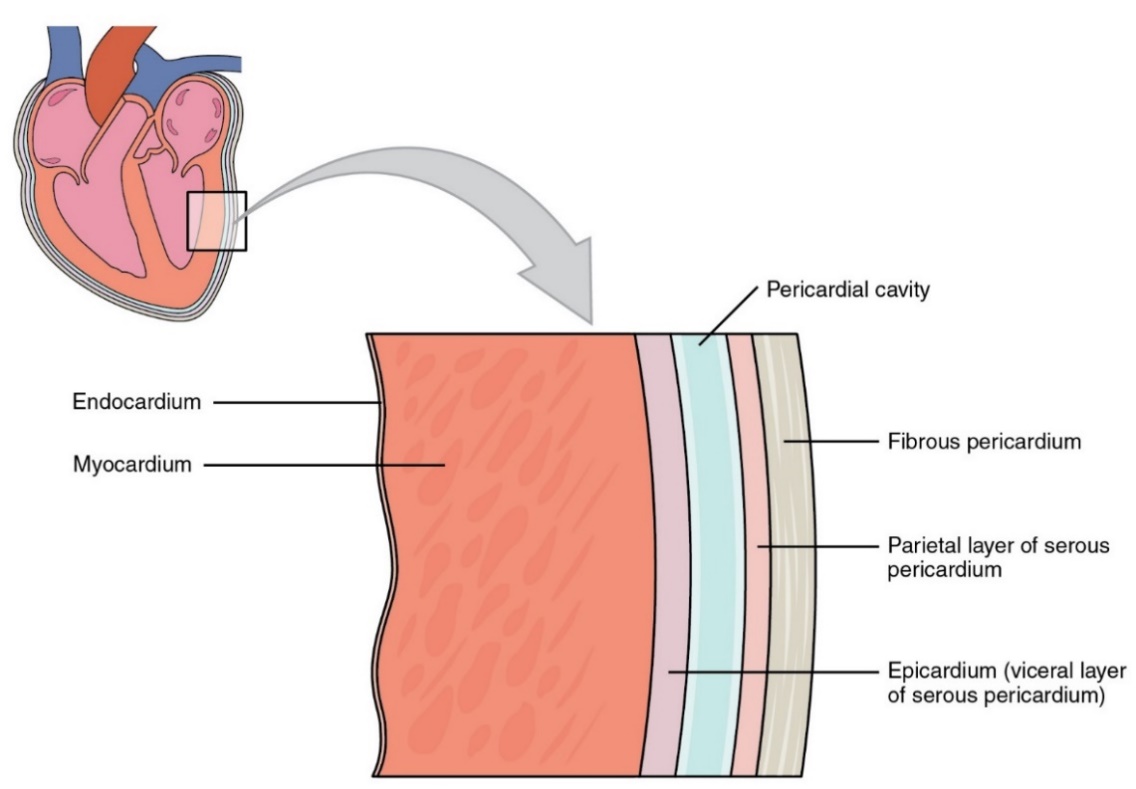
**Exercise 3 Activities: Heart**

The heart is in the mediastinum (middle part of the thoracic cavity), between the left and right lungs, within a serous membrane known as the **pericardium**. The pericardium is a double layered membrane with a fibrous covering. Its’ primary function is to protect and lubricate the heart, which is contracting around 100 times a minute.



All serous membranes are epithelial membranes with an inner layer and outer layer known as visceral and parietal layers, respectively. The parietal pericardium is fused with the fibrous covering while the visceral pericardium is attached to the heart wall and forms the **epicardium**. The heart wall is made up predominantly of **myocardium**, which contains the cardiac muscle tissue that you were introduced to in Anatomy and Physiology I. The **endocardium** is a simple squamous epithelium that is found adherent to the myocardium and makes up the inner lining of the chambers of the heart.

**Figure 3.3** Location of the heart within the mediastinum.

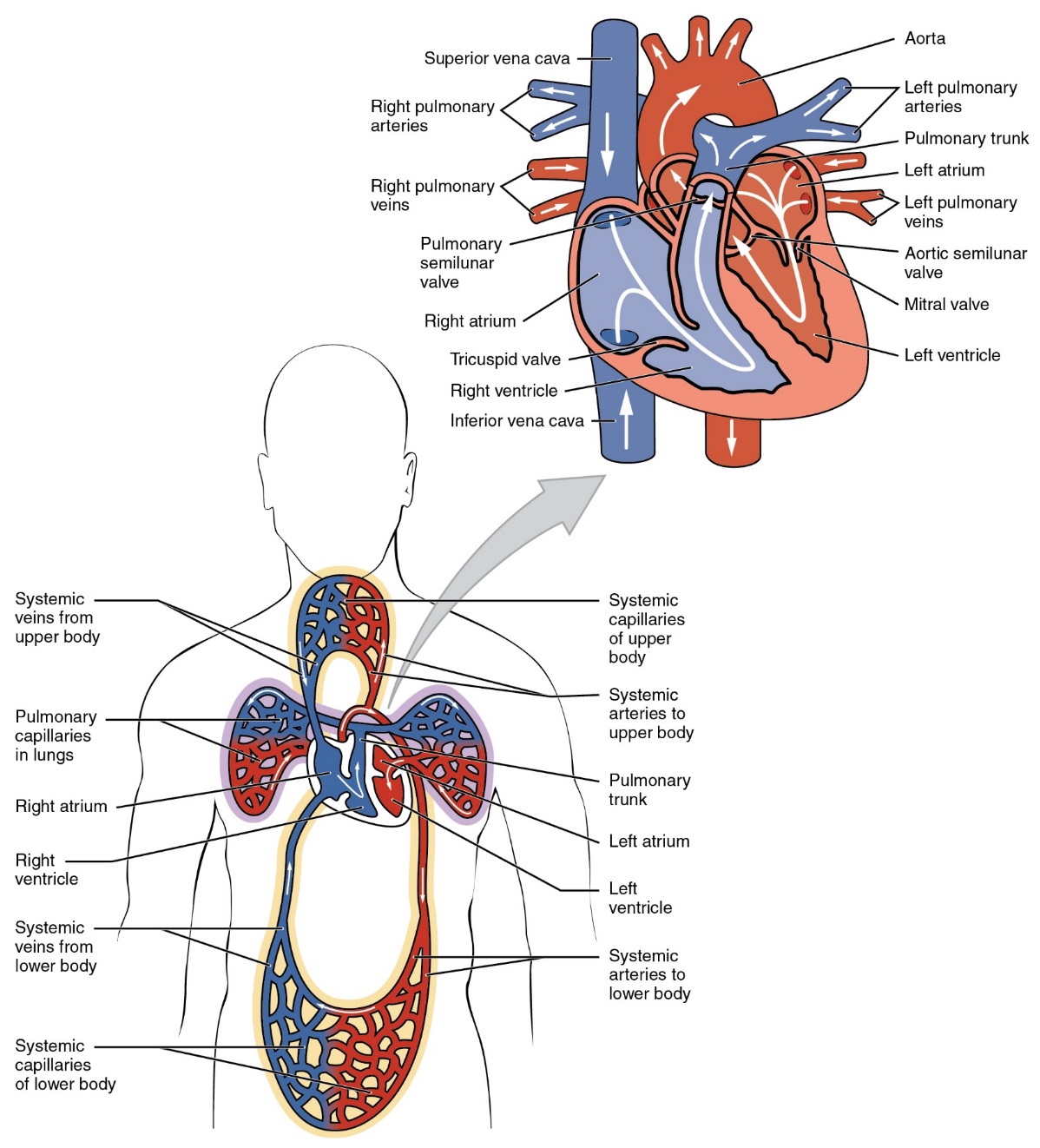
**Figure 3.4:** Pericardial layers surrounding the heart. The figure depicts the pericardial cavity, visceral, parietal and fibrous pericardial layers.

# **Chambers of the Heart and Circulation of Blood**

The heart is approximately the size of your fist. Its external shape resembles that of a pinecone, with a broad superior surface that converges inferiorly before tapering off forming the **apex**. The heart is split into four main chambers. There are two superior chambers called **atria** (singular atrium) and two inferior chambers called **ventricles.** The atria are separated from the ventricles by valves which ensure blood flows in one direction. The left atrium is separated from the left ventricle by a **bicuspid (or mitral) valve**. The right atrium is separated from the right ventricle by the **tricuspid valve**. The left and right sides of the heart are separated by **interatrial and interventricular septa** (singular septum). The aorta and pulmonary arteries also contain valves to stop the back flow of blood. These are called **aortic or pulmonary semilunar valves.**

When describing the main chambers of the heart, it is best to think of the direction of oxygenated and deoxygenated blood flow. The ventricles are the dominant structures of the heart as they have enlarged muscular walls to pump blood away from the heart. Oxygenated blood from the left ventricle gets pumped all around the body and so the **left ventricle has a much larger muscle wall than the right ventricle**, which only pumps deoxygenated blood to the lungs, which are situated lateral to the heart.

**Blood is returned to the atria** of the heart by two main veins, the **vena cava,** and the **pulmonary vein.** Deoxygenated blood from around the body is returned to the right atrium via the superior (blood from structures above the diaphragm) and inferior (blood from structures below the diaphragm) branches of the vena cava. The deoxygenated blood then flows to the right ventricle through the tricuspid valve before being sent to the lungs. Oxygenated blood from the lungs comes back to the left atrium of the heart by the right and left branch of the pulmonary vein. The blood then flows from the left atrium to the left ventricle via the bicuspid valve before being pumped around the body through the aorta.

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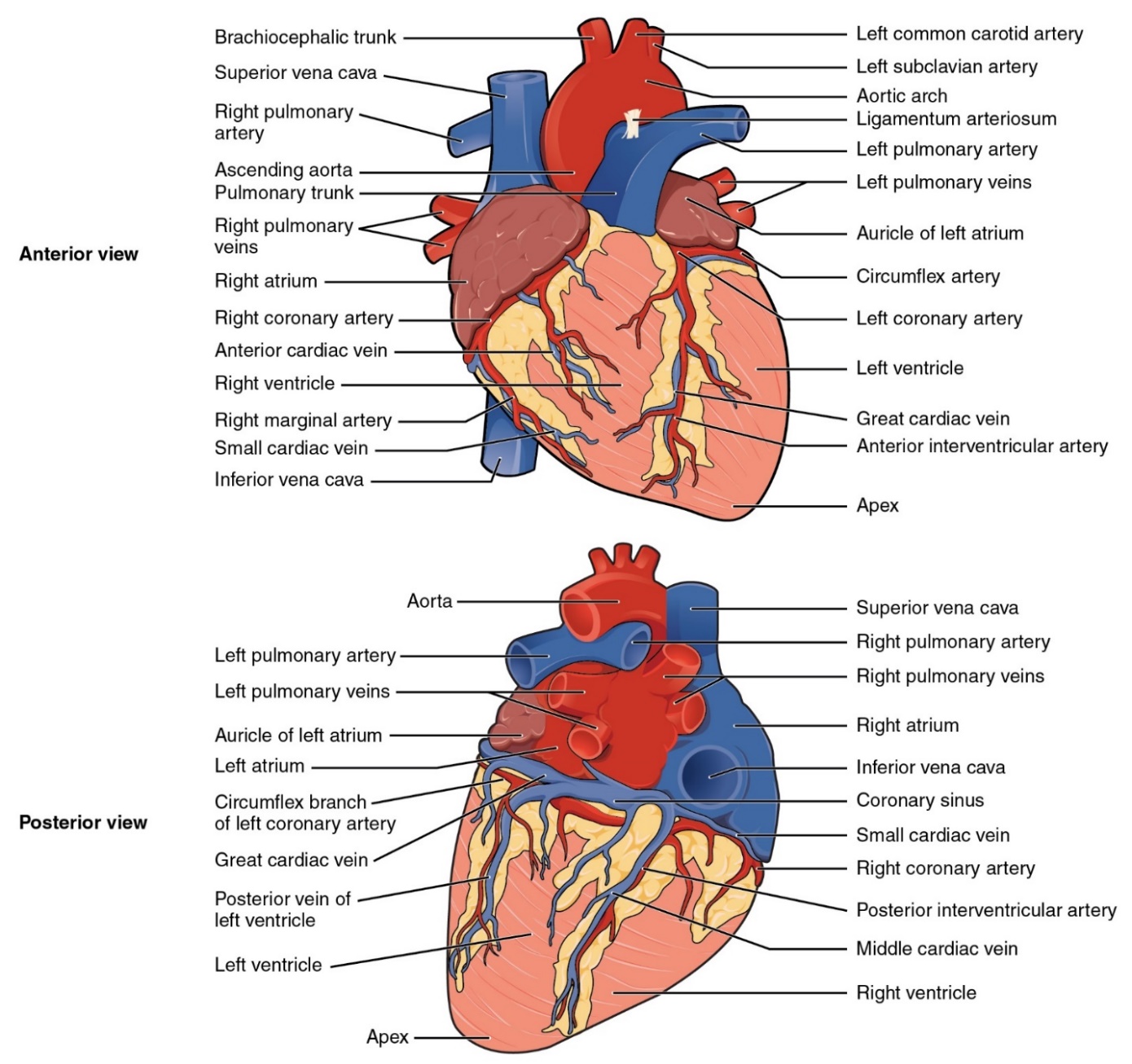
**Figure 3.5** Direction of blood flow through the heart. Note that blood circulates once through the body and returns to the heart before circulating through the lungs. This is known as a dual system of blood circulation.

**Structures to Know:**

|  |  |
| --- | --- |
| **External Heart Anatomy** | **Internal Heart Anatomy** |
| * Anterior interventricular sulcus | * Atria- R&L |
| * Aorta | * Aortic semilunar valve |
| * Apex of heart | * Bicuspid valve |
| * Atria- R&L | * Chordae tendineae |
| * Auricles – R&L | * Coronary sinus |
| * Brachiocephalic artery | * Endocardium |
| * Epicardium | * Interatrial septum |
| * Inferior vena cava | * Interventricular septum |
| * Ligamentum arteriosum | * Moderator band- R only |
| * Pericardium | * Myocardium |
| * Posterior interventricular sulcus | * Papillary muscle |
| * Pulmonary trunk | * Pectinate muscle |
| * Pulmonary vein(s) | * Pulmonary semilunar valve |
| * Superior vena cava | * Trabeculae carneae |
| * Ventricles- R&L | * Tricuspid valve |
|  | * Ventricles- R&L |

# **External Anatomy of the Heart**

The atria of the heart have easily identifiable external structures known as **auricles** (as they look like human ears). Auricles are appendages of the atria that give the atria extra volume when they fill with blood. Other surface structures of importance are the anterior and posterior **interventricular sulci** (singular sulcus), where the main **coronary vessels** run along the surface of the heart to provide cardiac muscle with oxygen. The coronary artery branches off the aorta and the coronary vein returns blood to the right atrium via the **coronary sinus**.



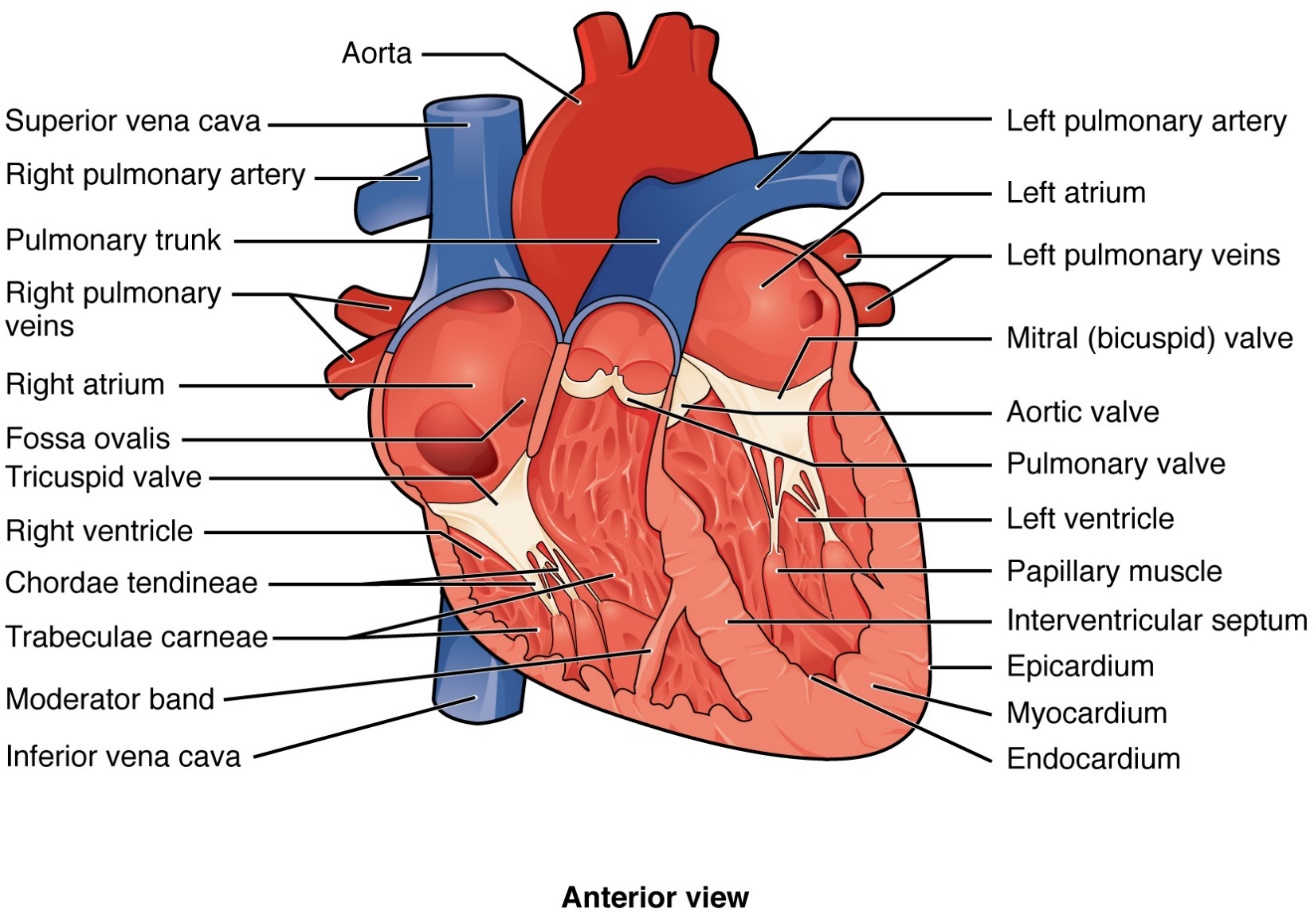
**Figure 3.6** External anatomy of the heart. Note the differences between the anterior and posterior view.

**Quick tip:** orientating the heart from anterior to posterior can be tricky. To figure out the anterior surface from the posterior surface, find the inferior and superior branches of the vena cava. You should be able to stick a probe through the superior branch which will be continuous with the inferior branch. This will help you find the right atrium as this is where the vena cava drains into.

# **Internal Anatomy of the Heart**

The anterior surface of the right atrium is internally lined by **pectinate muscles**. These muscles are prominent ridges that are only found in the right atrium and the left auricle.

The walls of the left and right ventricles are lined with cardiac muscle called **trabeculae carneae.** These are muscular ridges equivalent to pectinate muscles in the atria lined by endocardium. The ventricles also contain structures called **chordae tendineae**, which attach to the bicuspid and tricuspid valves and hence control the opening and closing of the valves. Chordae tendineae are attached to the ventricle walls by **papillary muscles**. These muscles contract along with the ventricles to close the valves and prevent blood from flowing back into the atria.

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**Figure 3.7:** Internal anatomy of the heart. Note the differences between the left and right ventricles.

**Lab Activity 3.1: Mammalian Heart Dissection**

**Important Safety Information:**

**Most of our dissection specimens were preserved in formalin, an aqueous colorless solution that is a suspected carcinogen. In most cases the formalin has been replaced with a nontoxic preservative that may cause mild skin irritation. There is no need for concern provided you follow the guidelines outlined here and wear proper protective equipment.**

1) WEAR GLOVES when handling your preserved specimen, tray, tools, or soiled paper towels.

2) WEAR SAFETY GLASSES when actively dissecting.

3) REMOVE GLOVES when you are not working at the lab bench or handling your specimen.

4) ALWAYS CONTAIN YOUR SPECIMEN inside the dissection tray.

5) ALL ORGANIC MATERIAL (identifiable animal parts) should be placed in the orange biohazard bins.

6) IN THE EVENT OF CONTACT: DO NOT PANIC. Wash skin with soap and water; flush eyes with water. There is an eye-wash station at every sink in the lab.Also, please inform your instructor immediately.

**Heart Dissection procedures:**

**1) Put on safety goggles and gloves**

**2) Obtain your dissecting tray and instruments**

**3) Obtain a mammalian heart**

1. Begin by identifying all the *external structures and markings* of the heart. To do this, the protective sac enclosing the heart called the **pericardium** must first be removed. Use your scissors to cut open the sac and then cut it away at the attachment points on the top of the heart. If the surface of the heart has large chunks of loose adipose tissue (fat) remove these by hand or with forceps to visualize the external surface anatomy more clearly. Do not try to remove embedded fat.
2. Once the surface of the heart is cleaned, identify the superior and inferior (apical) ends. The **apex** of the heart is the tip found at the very bottom of the heart. Also determine the left, right, anterior (ventral), and posterior (dorsal) aspects of the heart.
3. Structures visible on the surface of the heart include:
   1. The **epicardium** is the thin, membranous covering the entire heart.
   2. The **auricles (R & L)** are the ear-shaped structures attached to each of the **atria** (upper chambers).
   3. The **ventricles** **(R & L)** are the lower chambers of the heart.
   4. There are several grooves in the epicardium; these are the **sulci (singular: sulcus)**. The anterior interventricular sulcus is on the heart's anterior (ventral) side and separates the right and left ventricles. The **posterior interventricular sulcus** runs straight down the posterior (dorsal) aspect of the heart. Note that the main branches of the **coronary arteries and veins** are in the sulci.
   5. The **pulmonary trunk** connects with the right ventricle on the anterior (ventral) side of the heart.
   6. The **aorta** is directly posterior to the pulmonary trunk. The **brachiocephalic artery** is the first branch that comes off the aorta as it arches over the heart. The **ligamentum arteriosum** is a small strip of tissue that connects the pulmonary artery with the aorta (called the ductus arteriosus in fetal specimens). Your heart may not have a brachiocephalic artery and/or ligamentum arteriosum depending on where the aorta was cut.
   7. Immediately posterior to the aorta and next to the right auricle is the **superior vena cava**, which returns blood to the **right atrium** from areas superior to the heart. The major veins are typically missing or only partially intact on a preserved heart. You may only find the opening where it is connected to the heart.
   8. The **inferior vena cava** connects with the superior vena cava, just as both enter the right atrium. The inferior vena cava returns blood to the heart from all areas inferior to the heart.
   9. On the posterior left side of the heart, the **pulmonary vein(s)** empty into the **left atrium**. Depending on how your specimen has been cut, you may find 1-4 pulmonary veins or only the opening.
4. Once you have identified all the external structures of the heart, you will need to make 2 incisions to examine the internal anatomy of the **right side** of the heart.
   1. Make an incision beginning at the pulmonary trunk and cutting through the heart wall parallel to, but to the right (*REMEMBER: the specimen’s right, not yours*) of the anterior I.V. sulcus. Continue this cut around to the back right side of the heart, following parallel to the anterior interventricular sulcus all the way. (Note: Be sure not to cut too deeply or you will end up cutting into the wrong chamber.)
   2. The second incision should begin in the superior vena cava and continue straight down through the heart wall to connect with your first cut.
5. Now examine the structures inside the right side of the heart.
   1. Examine the layers of the heart wall you have just cut through. The **epicardium** is the thin outer layer, the **myocardium** is the thick, muscular middle layer, and the **endocardium** is the thin, shiny inner layer.
   2. The pectinate muscles are tissue ridges on the inside of the auricles.
   3. Find the 3 flaps of the **tricuspid valve**, which separates the right atrium from the right ventricle.
   4. The flaps of the tricuspid valve are attached to thin, thread-like structures called the **chordae tendineae**. The chordae tendineae are in turn attached to the large bulges of **papillary muscle**, that contract to close the valve. The rest of the lining of the ventricle is made up of irregular folds called the **trabeculae carneae**.
   5. The **moderator band** is a thin strip of tissue that connects the outer wall of the right ventricle to the inner wall. This serves as an electrical “short-cut” for the conduction pathway of the heart.
   6. **The pulmonary semilunar valve** is composed of three half-moon-shaped membranous flaps at the junction of the pulmonary trunk with the right ventricle.
   7. The opening of the **coronary sinus** can be found by looking to the left of your incision through the right atrium. You should see two openings: the larger top opening is the inferior vena cava; the smaller lower one is the coronary sinus. Put your blunt probe in this opening to follow where the coronary sinus goes.
6. To examine the inside of the left chambers of the heart, make an incision beginning at the leftmost side of the pulmonary vein and continuing down the left edge of the heart to the apex. *(Note: the myocardium is much thicker on the left side, so you will need to cut deeper to get all the way through.)*
7. The internal anatomy of the left side of the heart is essentially the same as the right side with a few exceptions. Example: *the left side has no moderator band.*

\*The other important features are:

1. The **bicuspid valve** (only 2 flaps) separates the left atrium from the left ventricle.
2. The **aortic semilunar valve** connects the left ventricle with the aorta. It has the same appearance as the pulmonary semilunar valve.
3. The **interatrial septum** is the wall of tissue that separates the left and right atria; the **interventricular septum** does the same for the left and right ventricles.

**Clean up procedure:**

Dispose of all organic debris in the appropriate biohazard containers and clean the dissecting instruments and tray with soap and water before leaving the laboratory. Do not forget to wash your hands with water and soap, and to disinfect the lab bench.

**After the dissection, answer the following questions:**

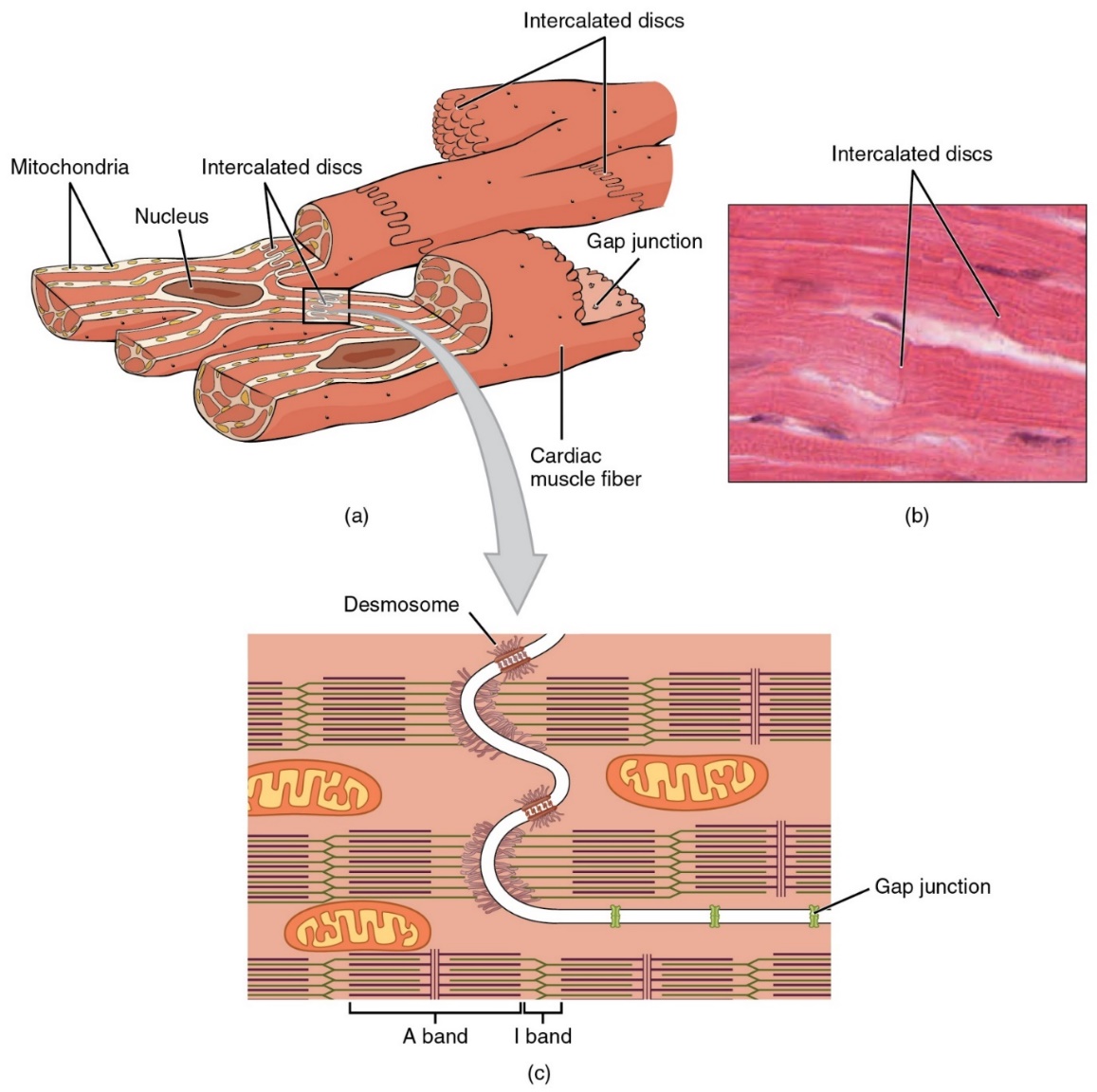
1. Describe the function of each of the following vessels:
   1. Aorta
   2. Pulmonary arteries/trunk
   3. Superior vena cava
   4. Inferior vena cava
   5. Pulmonary veins
   6. Auricles
2. What are the main differences between the left and right ventricles? What is the reason for these differences?
3. Describe the function of each structure listed below:
   1. Epicardium
   2. Endocardium
   3. Interventricular septum
   4. Tricuspid valve
   5. Bicuspid valve
   6. Pulmonary semilunar valve
   7. Aortic semilunar valve
   8. Chordae tendineae
   9. Papillary muscles

**Activity 3.2: Cardiac muscle cells**

Cardiac muscle cells are slightly different compared to skeletal muscle cells. Cardiac muscle cells, like skeletal muscle cells, are **striated** but unlike skeletal muscle cells, are **branched** and are connected to form tissue by **intercalated discs**. Intercalated discs contain **desmosomes** and **gap junctions** which make cardiac muscle tissue contract in a synchronized fashion by allowing the transfer of ions between cells (gap junctions) whilst making sure they do not pull apart during each contraction (desmosomes).

**Using a microscope, view a cardiac muscle slide and identify all the primary structures associated with cardiac muscles using the 40x objective. After viewing the cardiac muscle tissue, answer the following questions:**

1. Where is cardiac muscle tissue found?
2. What is the function of the striations found within cardiac muscle tissue?
3. What are the two types of junctions found within intercalated discs and what are their functions?
4. Compare and contrast skeletal and cardiac muscles.
5. Why are mitochondria important in cardiac muscle tissue?



**Figure 3. 8:** (a) Structure of cardiac muscle tissue (b) longitudinal section of cardiac muscle tissue (c) Structures within an intercalated disc.

**Post-Lab 3 Review**

**Post-Lab Activity 3.1: Questions**

**A. Match the following:**

1. Lining of the heart a. Parietal layer
2. Heart muscle b. Epicardium
3. Serous Layer covering the heart muscle c. Myocardium
4. The outermost layer of the serous pericardium d. Endocardium

**B. True or False:**

1. Trabeculae carneae are found in the ventricles and never the atria. \_\_\_\_\_
2. The left side of the heart pumps the same volume as the right side of the heart. \_\_\_\_\_
3. **Cardiac muscle** has fewer mitochondria than skeletal muscle. \_\_\_\_\_
4. **Cardiac muscle** relies mostly on glycolysis for energy. \_\_\_\_\_
5. **Cardiac muscle** has two types of cell junctions that assist with contraction. \_\_\_\_\_
6. **Cardiac muscle** produces more lactic acid than skeletal muscle if oxygen is not present. \_\_\_\_\_

**Post-Lab Activity 3.2: Terminology**

**Match the term with the letter of the correct description.**

|  |  |  |
| --- | --- | --- |
| Letter | Term | Description |
|  | Tricuspid Valve | **a.** valve that separates the left atria from the left ventricle |
|  | Brachiocephalic | **b.** thin outer layer of the heart wall, also known as the visceral pericardium |
|  | Epicardium | **c.** the name of the ductus arteriosus after birth and connects the arch of the aorta to the pulmonary trunk |
|  | Mediastinum | **d.** myocardial ridges and folds found in the ventricles |
|  | Mitral valve | **e.** thick band of cardiac tissue that separates the right and left ventricles |
|  | Ligamentum arteriosum | **f.** valve that separates the right atria from the right ventricle |
|  | Auricles | **g.** located in the right ventricle; this structure connects the interventricular septum to the papillary muscles |
|  | Trabeculae carneae | **h.** first arterial branch of the aortic arch |
|  | Moderator band | **i.** wrinkled pouch that increases the volume of blood each atrium can hold |
|  | Interventricular septum | **j.** the median partition between pleura of the lungs located within the thoracic cavity |

**Post-Lab Activity 3.3: Identify Structures of the Heart**

A coronal dissection of a heart with lettered arrows pointing to the different structures.


**Figure 3. 9:** Mammalian heart dissection. A: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

B: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

C: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

D (Chamber): \_\_\_\_\_\_\_\_\_\_\_

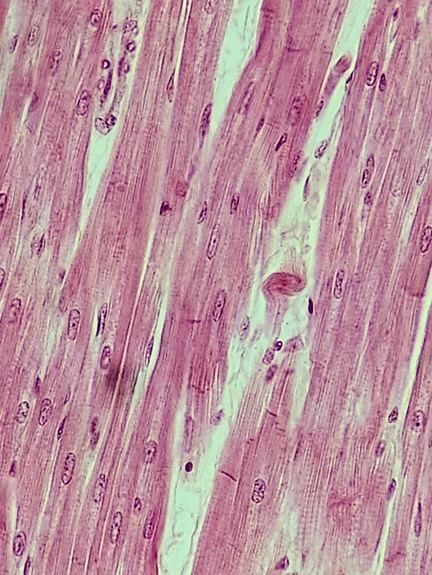
E: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

F (Chamber): \_\_\_\_\_\_\_\_\_\_\_\_

G: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

H: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Post-Lab Activity 3.4: Cardiac Muscle Tissue**

1. How would you distinguish the structure of cardiac muscle from the structure of skeletal muscle?
2. Add the following terms to the photo of cardiac muscle.

* Intercalated discs
* Nucleus of the muscle fiber
* Striations
* Cardiac muscle fiber

**Figure 3. 10:** Histology of cardiac muscle. Photograph by Gina Profetto