Exercise 3: Heart

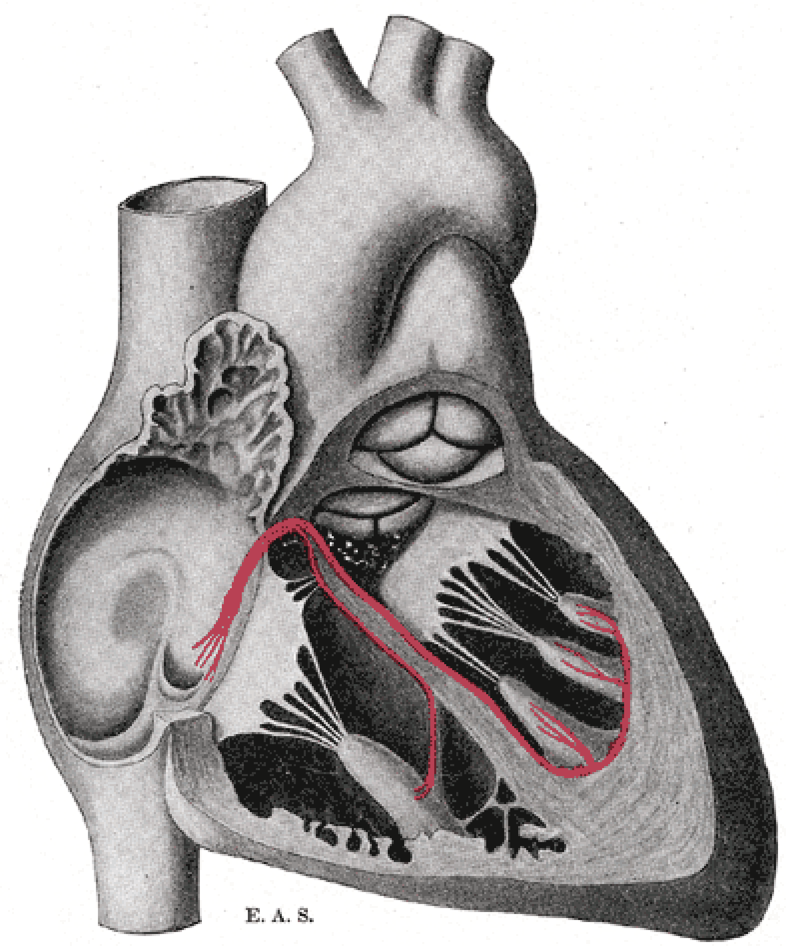


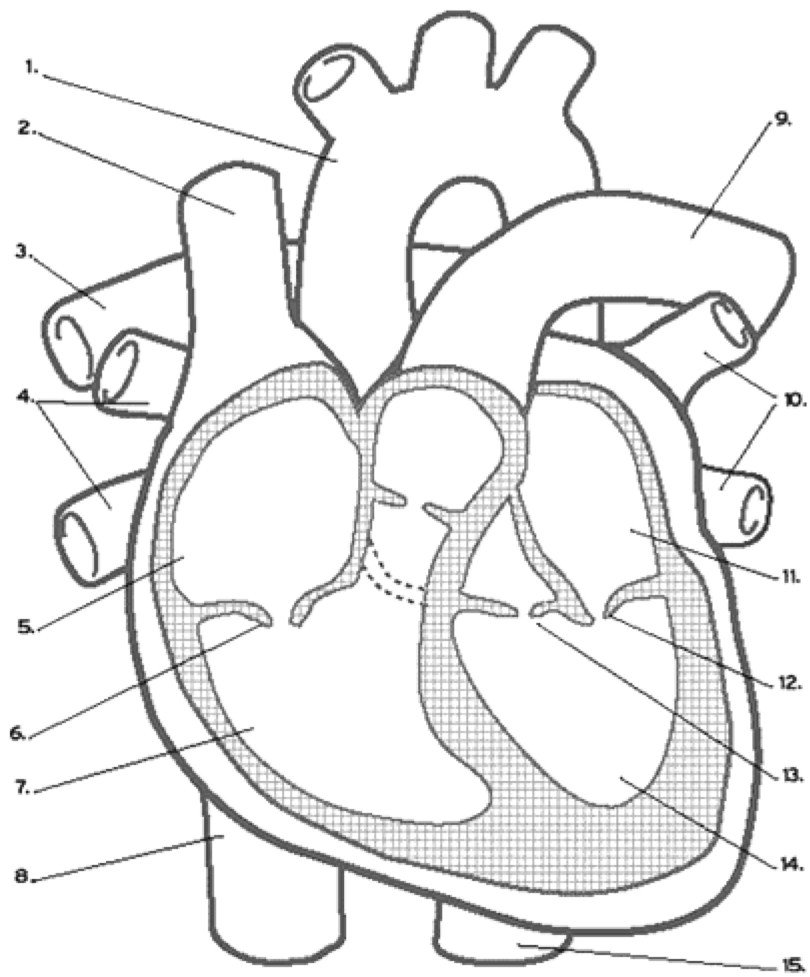
Figure 3.1. Illustration of a human heart in anterior view representing the internal anatomy of the heart. (https://commons.wikimedia.org/wiki/Heart#/media/File:Gray501.png)

Exercise 3 Learning Goals

After completing this lab you should be able to:

- Identify and describe the interior and exterior parts of the human heart
- Describe the path of blood through the cardiac circuits
- Describe the size, shape, and location of the heart
- Compare cardiac muscle to skeletal and smooth muscle
- Describe the structures involved with the cardiac conduction system

Pre-Lab Activity 3.1 Identifying the main chambers and vessels of the heart



• Left Ventricle	• Inferior vena cava
• Right Ventricle	• Left pulmonary vein
• Left Atrium	• Right pulmonary vein
• Right Atrium	• Bicuspid valve
• Ascending aorta	• Tricuspid valve
• Descending aorta	• Aortic semilunar valve
• Left branch of pulmonary artery	
• Right branch of Pulmonary Artery	
• Superior vena cava	

Pre-Lab Activity 3.2 The circulatory pathway of oxygenated and deoxygenated blood through the heart

Using your own words, describe the flow of oxygenated blood and deoxygenated blood **through the heart**. Begin with the left ventricle. For example:

1. Oxygenated blood flows from the left ventricle into the aorta where it flows all around the body.
2. Deoxygenated blood from the body is returned to the heart by the superior and inferior vena cava

Lab Exercise 3: Heart Anatomy

Location of the Heart and its surrounding tissue

The heart is situated in the **mediastinum** (middle part of the thoracic cavity), between the left and right lungs, within a serous membrane known as the **pericardium** (figure 3.2). The pericardium is a double layered fluid filled 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 have 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** (figure 3.3). The heart wall is made up predominantly of **myocardium**, which contains the cardiac muscle tissue that you were introduced to in A&P 1. The **endocardium** is a simple squamous epithelium that is found adhered to the myocardium and makes up the inner lining of the chambers of the heart (figure 3.3).

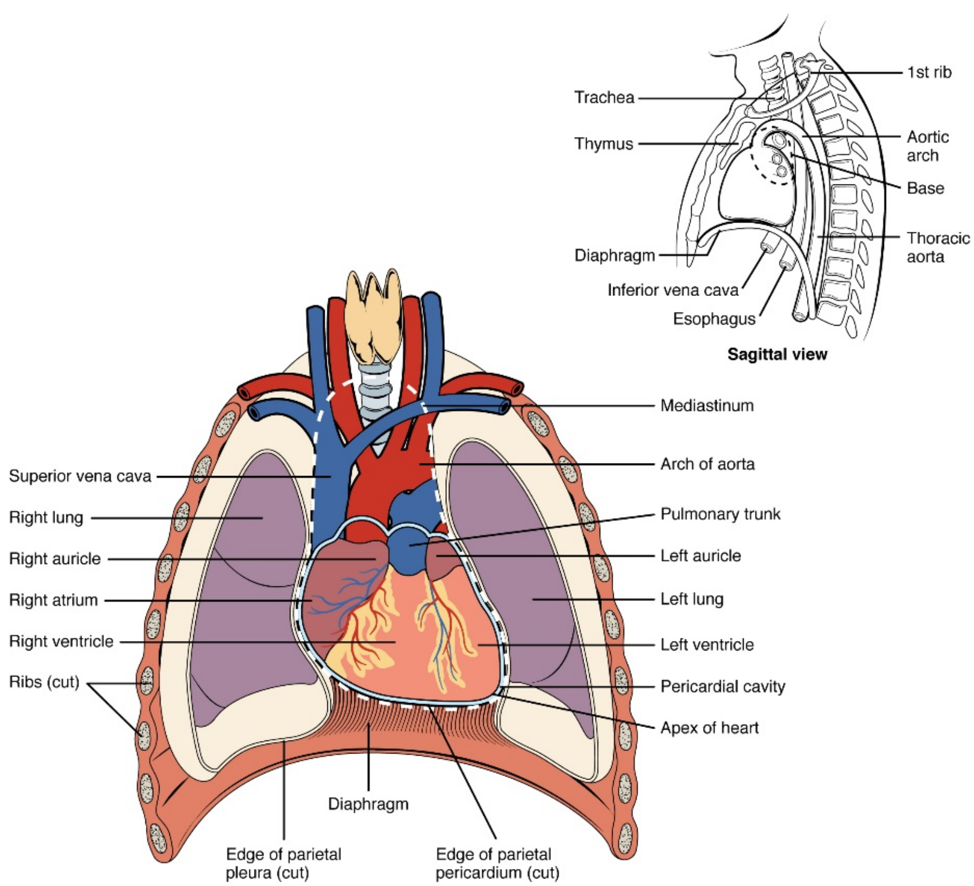


Figure 3.2 Location of the heart within the mediastinum. (http://cnx.org/contents/14fb4ad7-39a1-4eee-ab6e-3ef2482e3e22@15.5.)

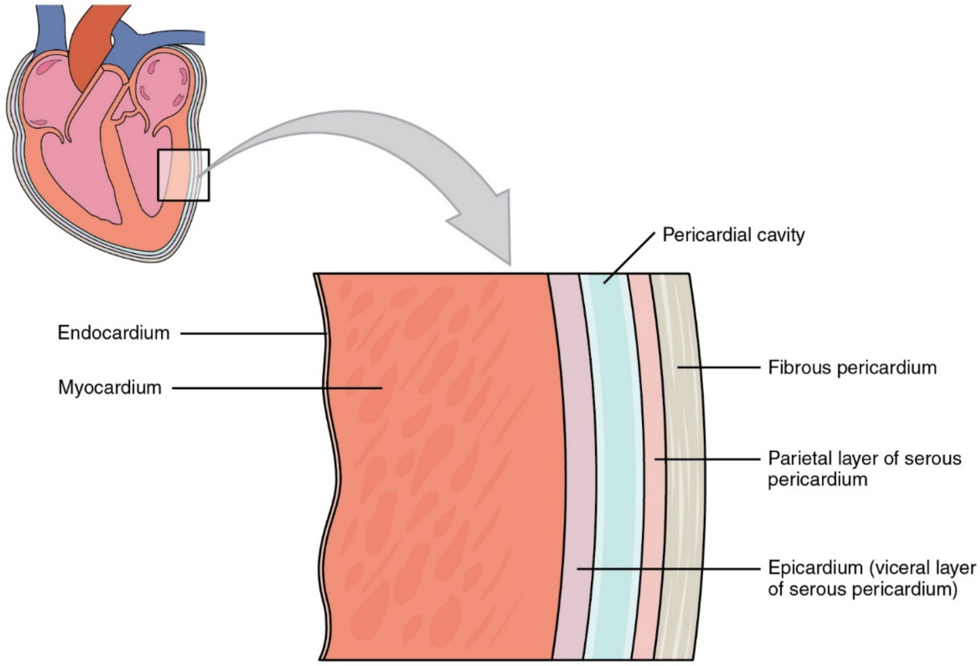


Figure 3.3 Pericardial layers surrounding the heart. (http://cnx.org/contents/14fb4ad7-39a1-4eee-ab6e-3ef2482e3e22@15.5.)

Chambers of the heart and the circulation of blood

The heart is approximately the size of a fist. Its external shape resembles that of a pinecone, with a broad superior surface that converges inferiorly before tapering off forming the **apex** (figure 3.2). 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 makes sure blood flows in one direction (figure 3.4). 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 (figure 3.4). 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 next to the heart (figure 3.4).

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.

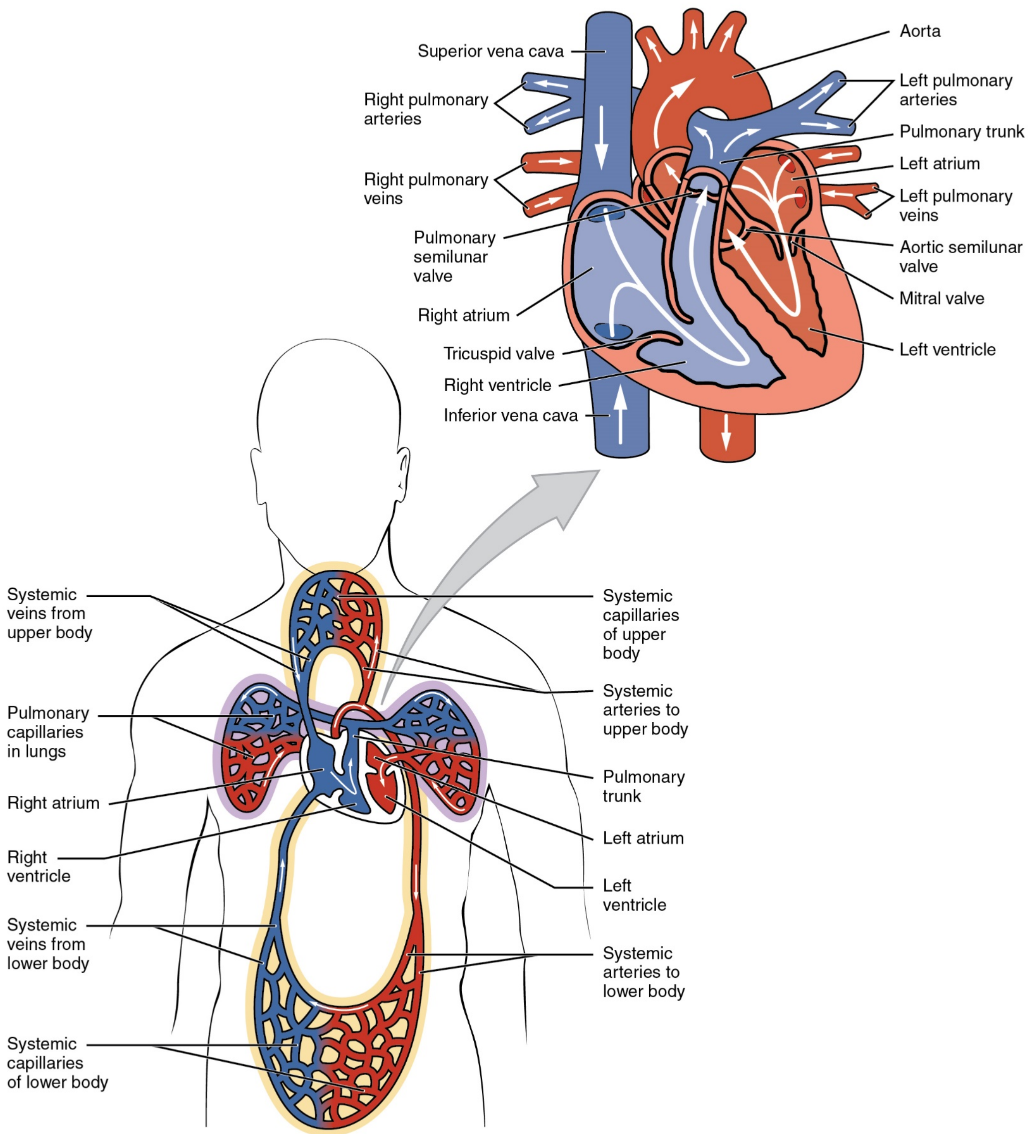


Figure 3.4 Direction of blood flow through the heart. Note that blood circulates once through the body and returns to the heart before circulating through the lungs. This is known as a dual system of blood circulation. (http://cnx.org/contents/14fb4ad7-39a1-4eee-ab6e-3ef2482e3e22@15.5.)

Structures to Identify:

External Heart Anatomy	Internal Heart Anatomy
• Anterior interventricular sulcus • Aorta • Apex of heart • Atria- R&L • Auricles – R&L • Brachiocephalic artery • Epicardium • Inferior vena cava • Ligamentum arteriosum • Pericardium • Posterior interventricular sulcus • Pulmonary trunk • Pulmonary vein(s) • Superior vena cava • Ventricles- R&L	• Atria- R&L • Aortic semilunar valve • Bicuspid valve • Chordae tendineae • Coronary sinus • Endocardium • Interatrial septum • Interventricular septum • Moderator band- R only • Myocardium • Papillary muscle • Pectinate muscle • Pulmonary semilunar valve • Trabeculae carneae • 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 heart muscles with oxygen (figure 3.5). The coronary artery branches off the aorta and the coronary vein returns blood to the right atrium via the **coronary sinus** (figure 3.5).

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.

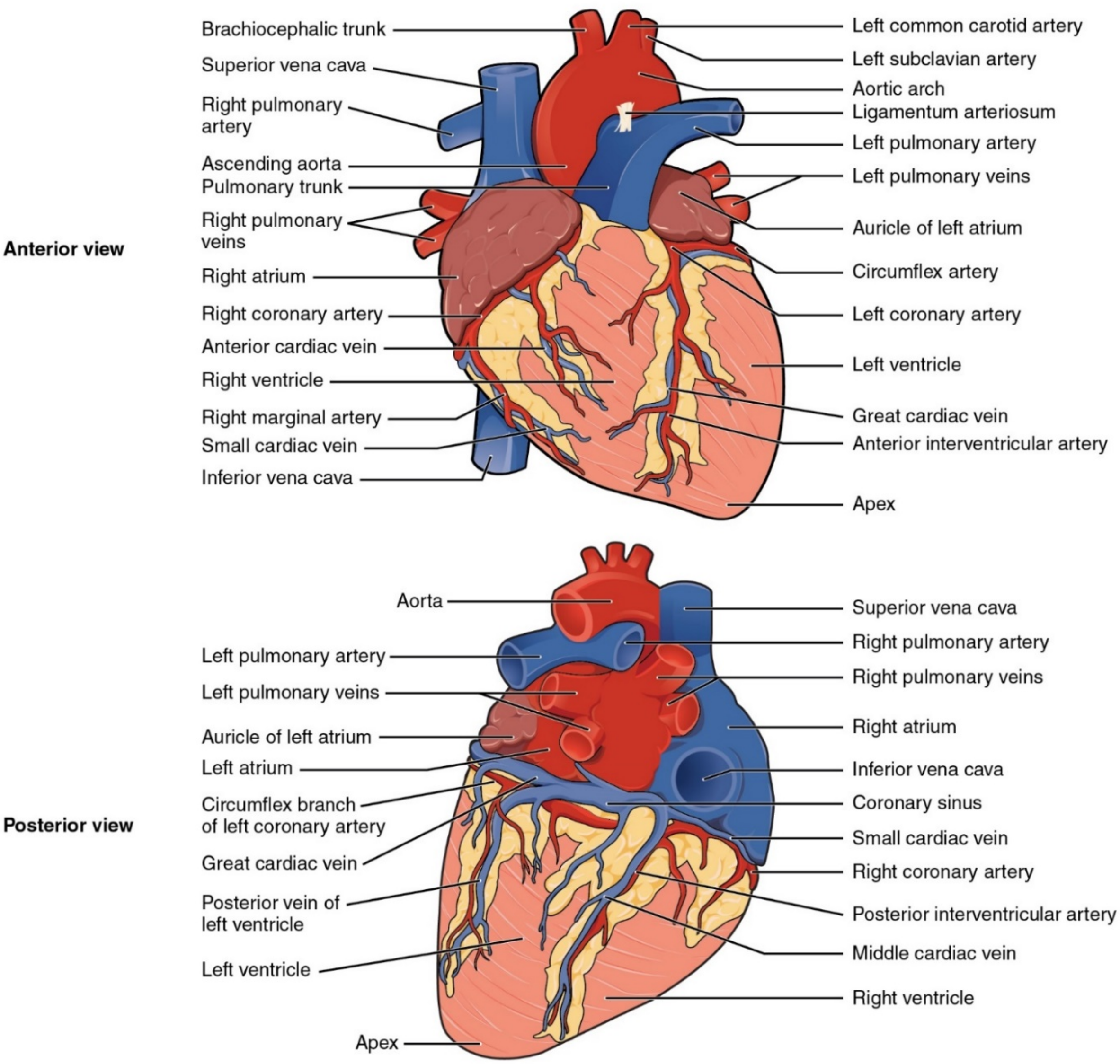


Figure 3.5 External anatomy of the heart. Note the differences between the anterior and posterior view. (

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 which are 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.

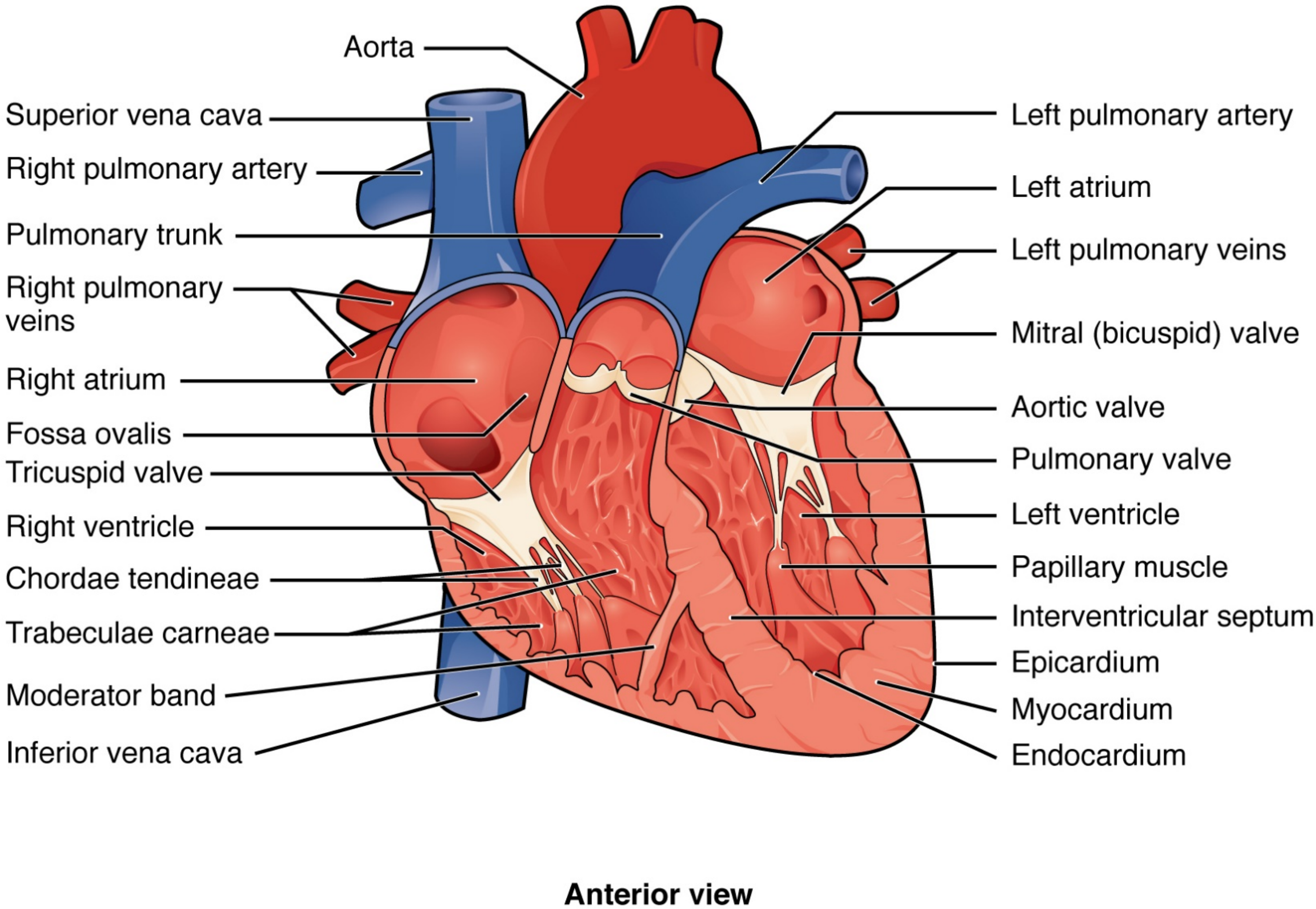


Figure 3.6 Internal anatomy of the heart. Note the differences between the left and right ventricles (http://cnx.org/contents/14fb4ad7-39a1-4eee-ab6e-3ef2482e3e22@15.5.)

Lab Activity 3.1: Mammalian heart dissection

1. Begin by identifying all of 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 tweezers to more clearly visualize the external surface anatomy. 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 across 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 located on the anterior (ventral) side of the heart 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 located 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 connected to the heart.
    8. The **inferior vena cava** connects with the superior vena cava, just as both enter into 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 the ridges of tissue located 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. Ex.: *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 exactly 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.

After the dissection, answer the following questions:

1. Identify the main vessels of the heart and describe the function of each vessel
    a. Aorta

    b. Pulmonary arteries/trunk

    c. Superior vena cava

    d. Inferior vena cava

    e. Pulmonary veins

    f. Auricles

2. Identify the four chambers of the heart.
   What are the main differences of the left and right ventricles? What is the reason for these differences?

3. Identify the following structures and describe the function of each structure
    a. Epicardium
    b. Endocardium
    c. Interventricular septum
    d. Tricuspid valve
    e. Bicuspid valve
    f. Pulmonary semilunar valve
    g. Aortic semilunar valve
    h. Chordae tendinae
    i. Papillary muscles

Activity 3.2: Cardiac muscle cells

As you should recall from A&P 1, cardiac muscle cells are slightly different 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** (figure 17.7) 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 of the primary structures associated with cardiac muscle.

After viewing the cardiac muscle tissue, answer the following questions:

1. Cardiac muscle tissue is found where?
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 muscle.
5. Why are mitochondria important in cardiac muscle tissue?

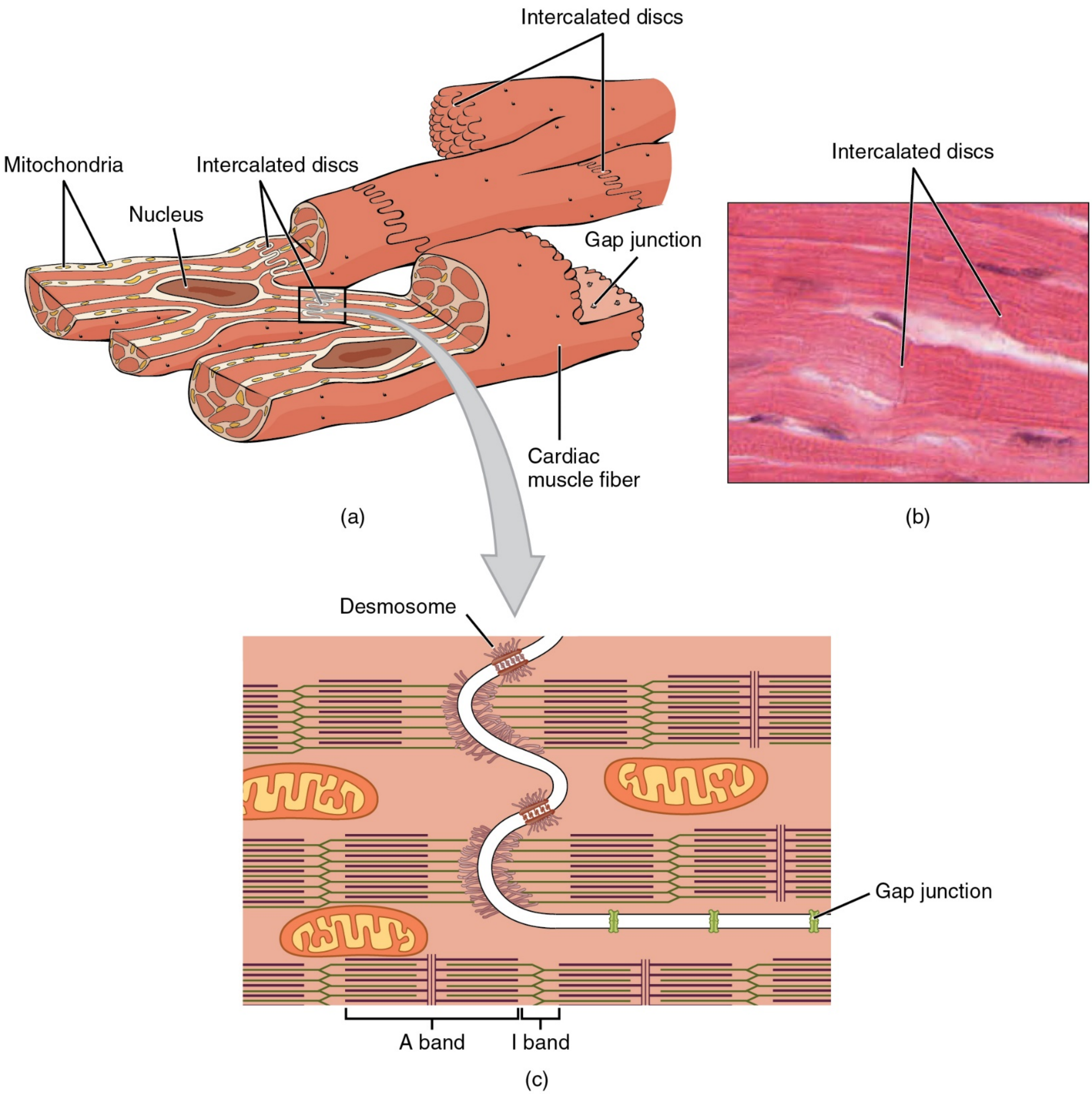


Figure 3. 7 (a) Structure of cardiac muscle tissue (b) longitudinal section of cardiac muscle tissue (c) Structures within an intercalated discs. (http://cnx.org/contents/14fb4ad7-39a1-4eee-ab6e-3ef2482e3e22@15.5.)

Conduction of Cardiac Muscle

Cardiac muscle tissue is found in the walls of the heart chambers and plays a big role in making sure blood flows around the body by contracting the atria and vesicles.

Electrical impulses are required for contraction of cardiac muscle cells. There are specialized cardiac muscle cells that transfer electrical impulses through the heart muscular walls (figure 3.8). These specialized cells allow for the coordination of muscle contractions within the heart. The coordination of muscle contraction within the heart ensures the blood is always flowing in the right direction. Be aware that these electrical conductions occur within the muscular walls of the heart. You will learn the importance of these structures in the next lab.

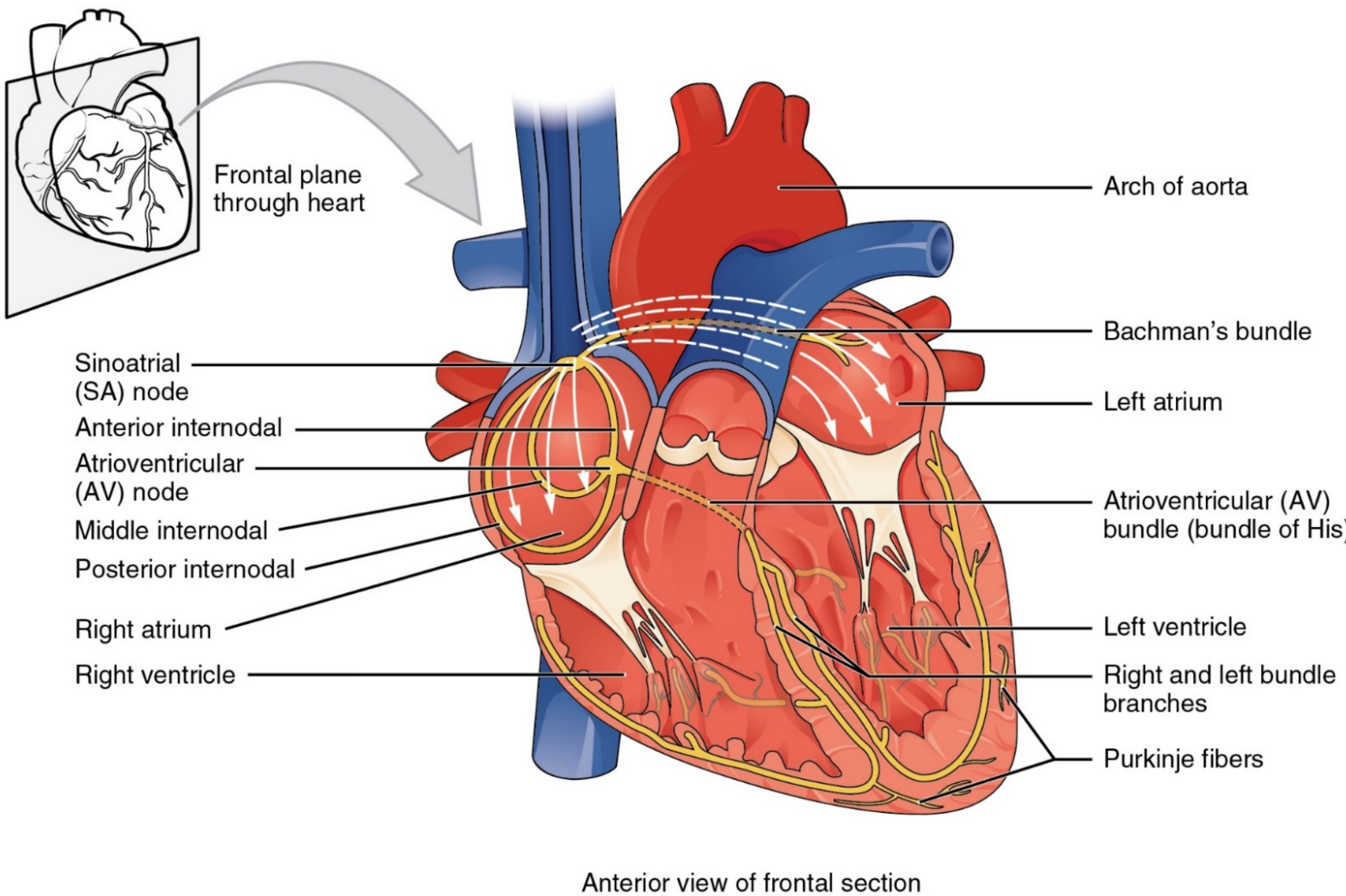


Figure 3.8 Specialized cardiac muscle tissue distribute electrical impulses through the heart. (http://cnx.org/contents/14fb4ad7-39a1-4eee-ab6e-3ef2482e3e22@15.5.)