Heart

Cardiac Muscle Cells
Hearth Anatomy
Excitation of the Hearth
ECG,Cardiac Cycle
Cardiac Arrythmias

Cardiac Muscle Cells
Chapter 9

Heart function as syncytium

- “ Cardiac muscle cells are mechanically, chemically, and electrically connected to one another, thus, the entire tissue resembles a single, enormous muscle cell. For this reason, cardiac muscle has been called a functional syncytium. “

- when one cardiac cell undergoes an action potential, the electrical impulse spreads to all other cells that are joined by gap junctions so they become excited and contract as a single functional syncytium.

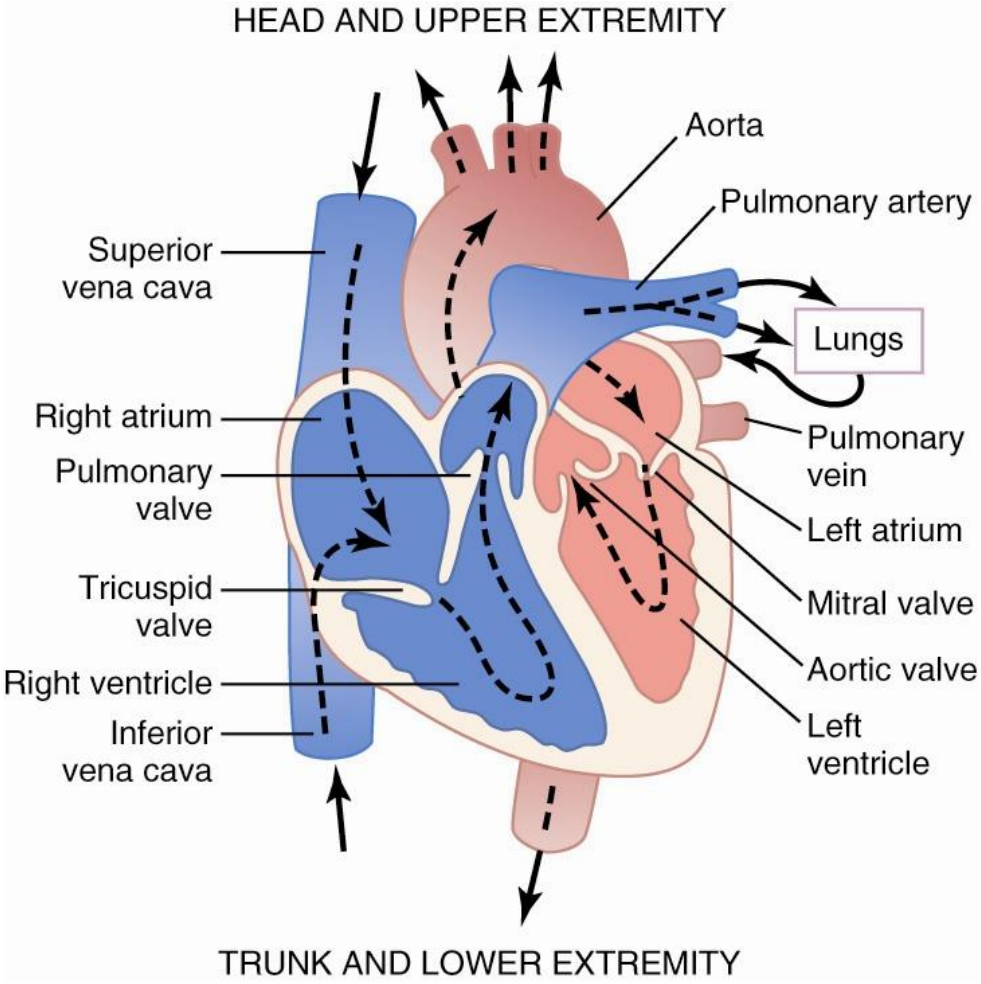


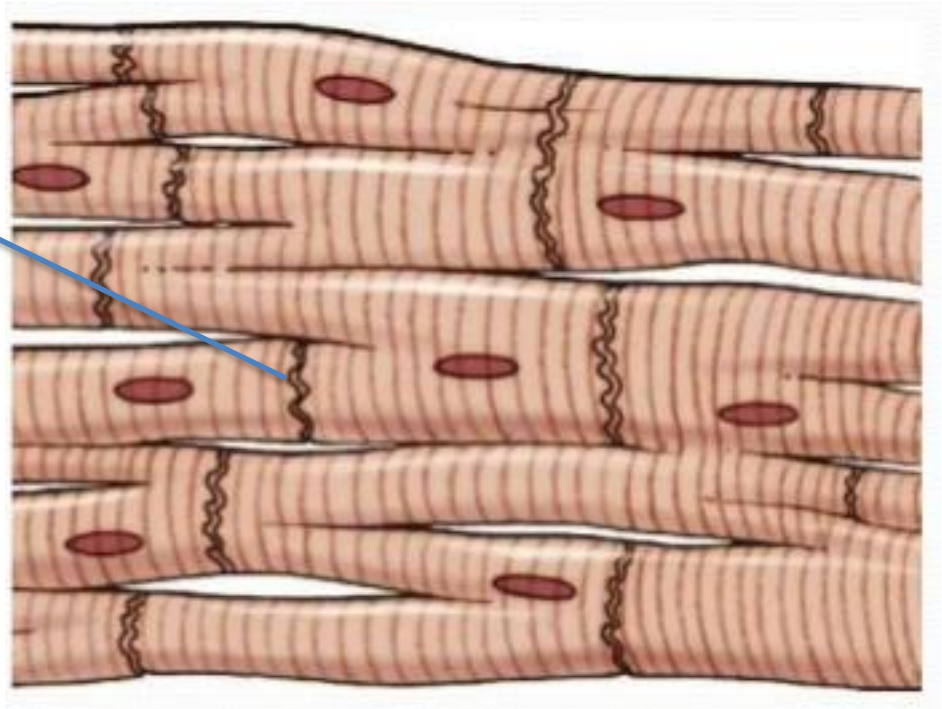
Figure 9-1; Structure of the heart, and course of blood flow through the heart chambers and heart valves.

The heart actually is composed of two syncytiums:

- Atrial syncytium
  - constitutes the walls of the two atria
- Ventricular syncytium
  - constitutes the walls of the two ventricles
- Fibrous insulator exists between atrium and ventricle
  - potentials are not conducted from the atrial syncytium into the ventricular syncytium directly through this fibrous tissue. Instead, they are conducted only by way of a specialized conductive system

Cardiac Muscle

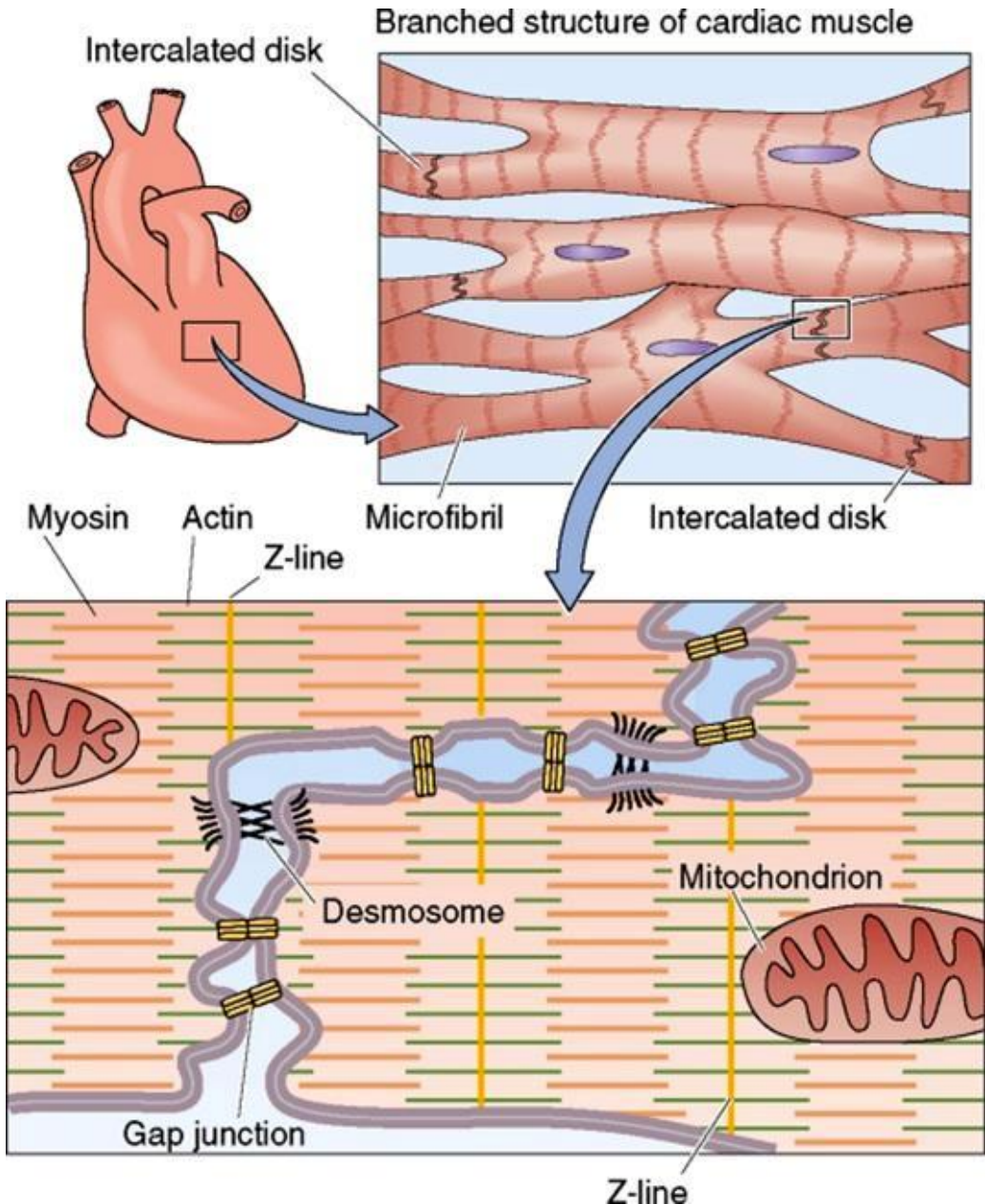
The dark areas crossing the cardiac muscle fibers in Figure 9–2 are called *intercalated discs*; they are actually cell membranes that separate individual cardiac muscle cells from one another.



"Syncytial," interconnecting nature of cardiac muscle fibers.

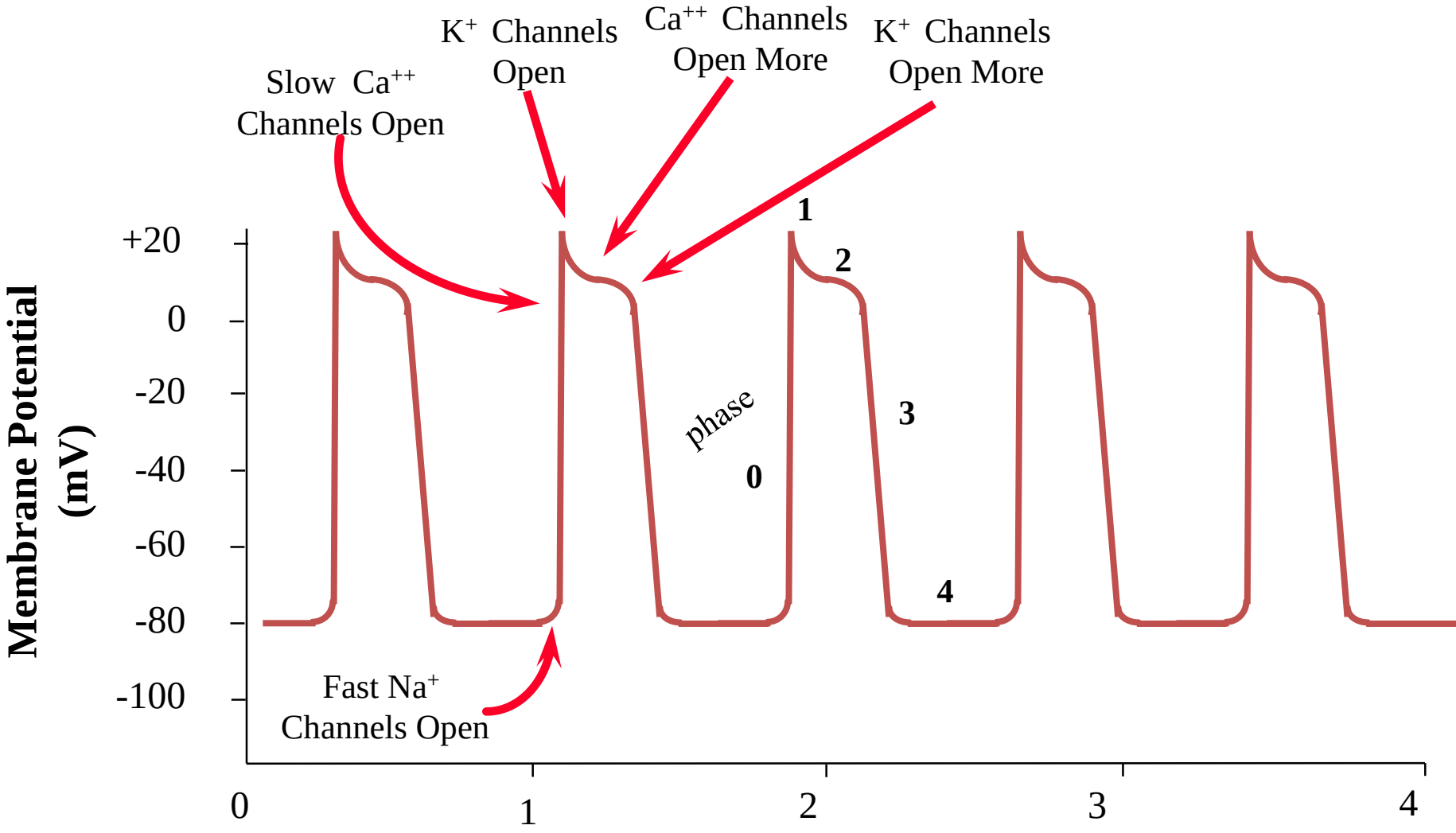
- cardiac muscle fibers arranged in a latticework, with the fibers dividing, recombining, and then spreading again

- cardiac muscle has typical myofibrils that contain actin and myosin filaments almost identical to those found in skeletal muscle
- cardiac muscle fibers are made up of many individual cells connected in series and in parallel with one another. Thus, cardiac muscle is a syncytium of many heart muscle cells in which the cardiac cells are so interconnected that when one of these cells becomes excited, the action potential spreads to all of them, spreading from cell to cell throughout the latticework interconnections.



- **gap junctions** couple the cardiac muscle cells electrically.
- **desmosomes** hold the cardiac muscle cells together during contraction

Ventricular Muscle Action Potential



phase 0- Fast Na^+ channels open then slow Ca^{++} channels
phase 1- K^+ channels open
phase 2- Ca^{++} channels open more
phase 3- K^+ channels open more
phase 4- Resting membrane potential

Why is the action potential of cardiac muscle so long, and why does it have a plateau, whereas that of skeletal muscle does not?

Skeletal Muscle

i. the action potential is caused almost entirely by sudden opening of large numbers of
   1. fast sodium channels that allow tremendous numbers of sodium ions to enter the skeletal muscle fiber from the extra- cellular fluid.

Cardiac Muscle

i. the action potential is caused by opening of two types of channels:
   1. fast sodium channels as those in skeletal muscle
   2. slow calcium channels, which are also called calcium-sodium channels.

- slow calcium channels differs from the fast sodium channels in that they are slower to open and, even more important, remain open for several tenths of a second. During this time, a large quantity of both calcium and sodium ions flows through these channels to the interior of the cardiac muscle fiber, and this maintains a prolonged period of depolarization, causing the plateau in the action potential.

! the calcium ions that enter during plateau phase activate the muscle contractile process, while the calcium ions that cause skeletal muscle contraction are derived from the intracellular sarcoplasmic reticulum

ii. Immediately after the onset of the action potential, the permeability of the cardiac muscle membrane for potassium ions decreases about fivefold, an effect that does not occur in skeletal muscle

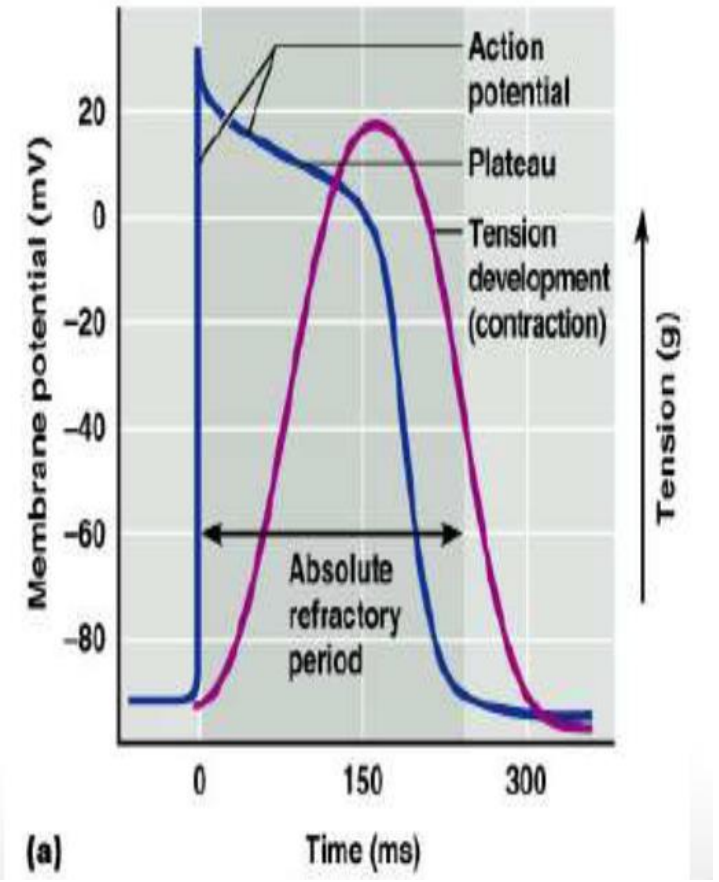
Refractory Period

- It is that period during which a second stimulus fails to evoke a response.

- Absolute Refractory Period : It is that period during which a second stimulus however high it is fails to evoke a response.

- Relative Refractory Period : It is that period during which a second stimulus evokes a response if it is sufficiently high.

  - Long refractory period (250 msec) compared to skeletal muscle (3msec)
  - During this period membrane is refractory to further stimulation until contraction is over.
  - It lasts longer than muscle contraction, prevents tetanus
  - Gives time to heart to relax after each contract ion, prevent fatigue
  - It allows time for the heart chambers to fill during diastole before next contraction



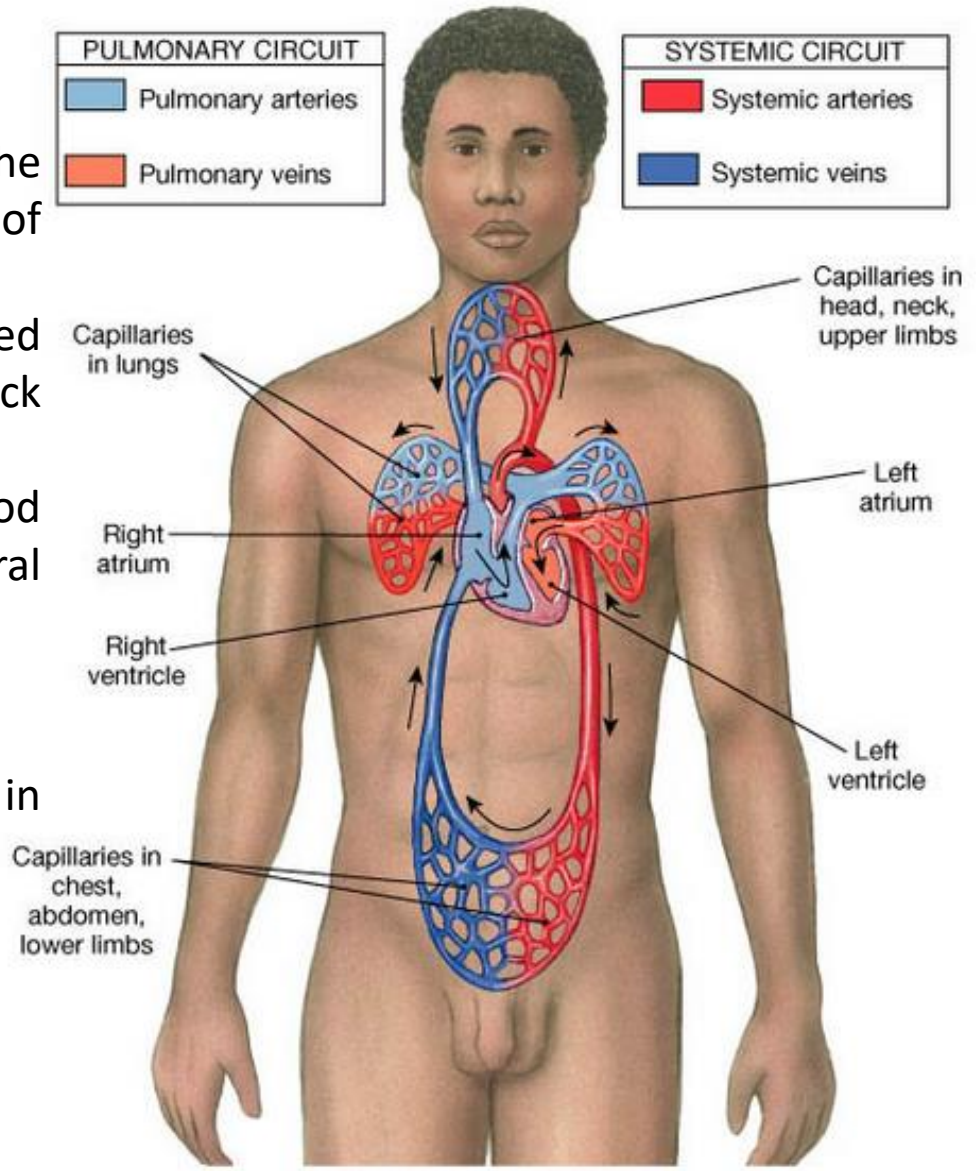
Hearth Anatomy

- The heart is the pump that maintains the circulation of blood. This circulation of blood can be divided into two circuits:

① Pulmonary circuit carries deoxygenated blood from the heart to the lungs and back to the heart.

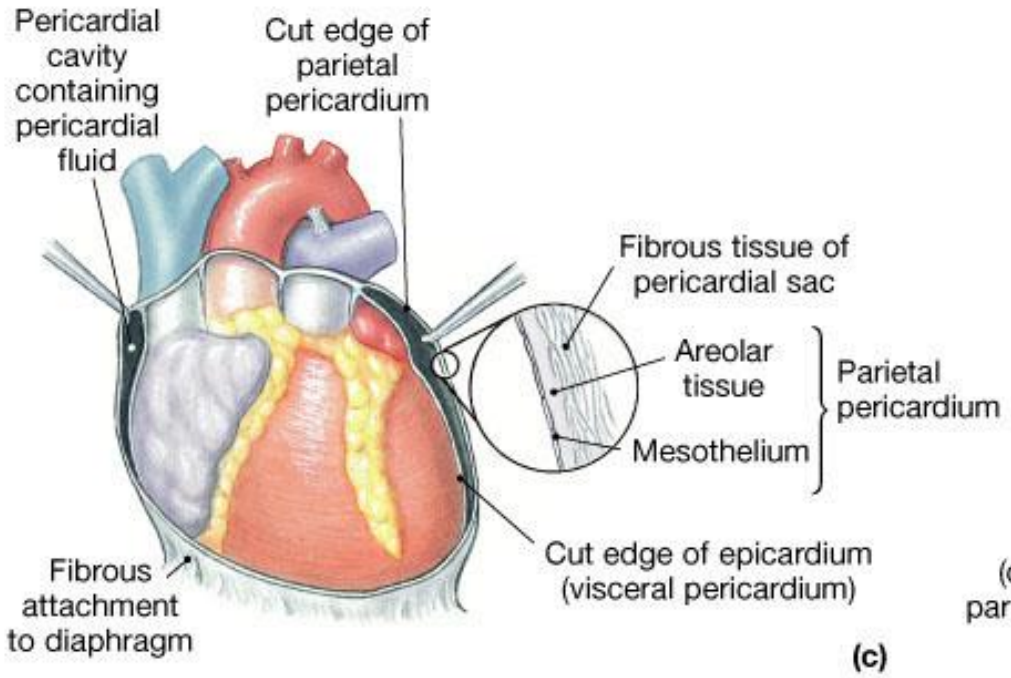
② Systemic circuit carries oxygenated blood from the heart to all the other peripheral tissues and back to the heart.

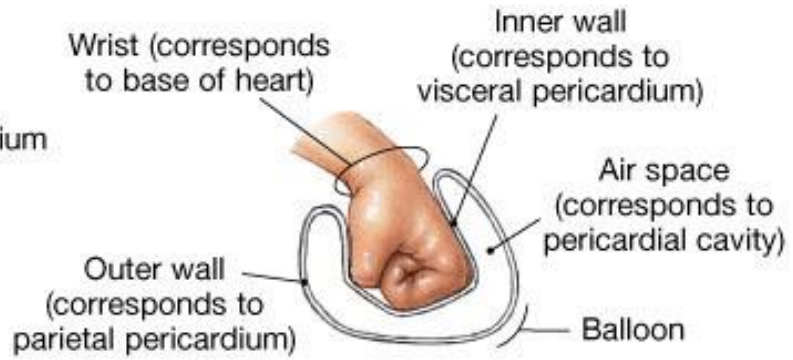
Blood flows through each of these circuits in sequence.

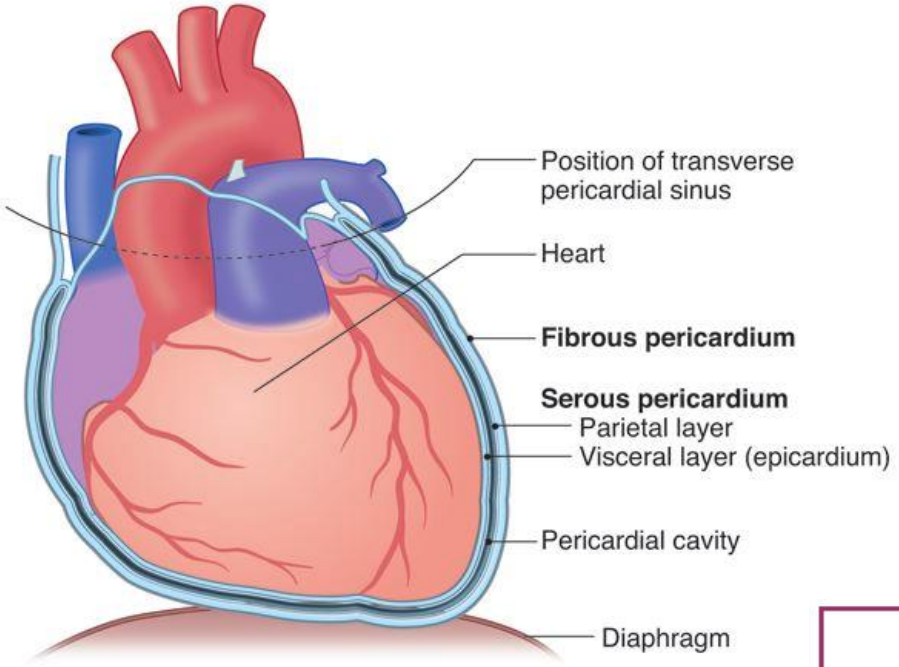


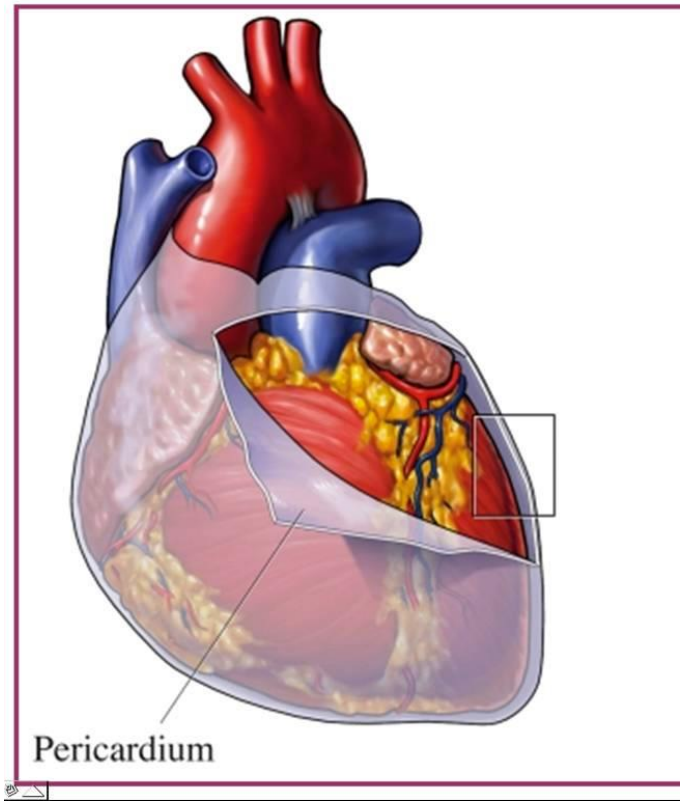
Pericardium

- The heart is located in the **mediastinum** in a cavity called the **pericardial cavity.**
- The **pericardium** is the serous membrane lining the cavity. The pericardium is a continuous membrane but the part that attaches to the surface of the heart is the **visceral pericardium** (**epicardium**) and the part that lines the outer wall of the cavity is the **parietal pericardium.**
- The outer surface of the parietal pericardium is reinforced by a layer of dense, irregular connective tissue called the **fibrous pericardium.**
- A small amount of **pericardial fluid** (10 to 20 ml) within the pericardial cavity reduces friction

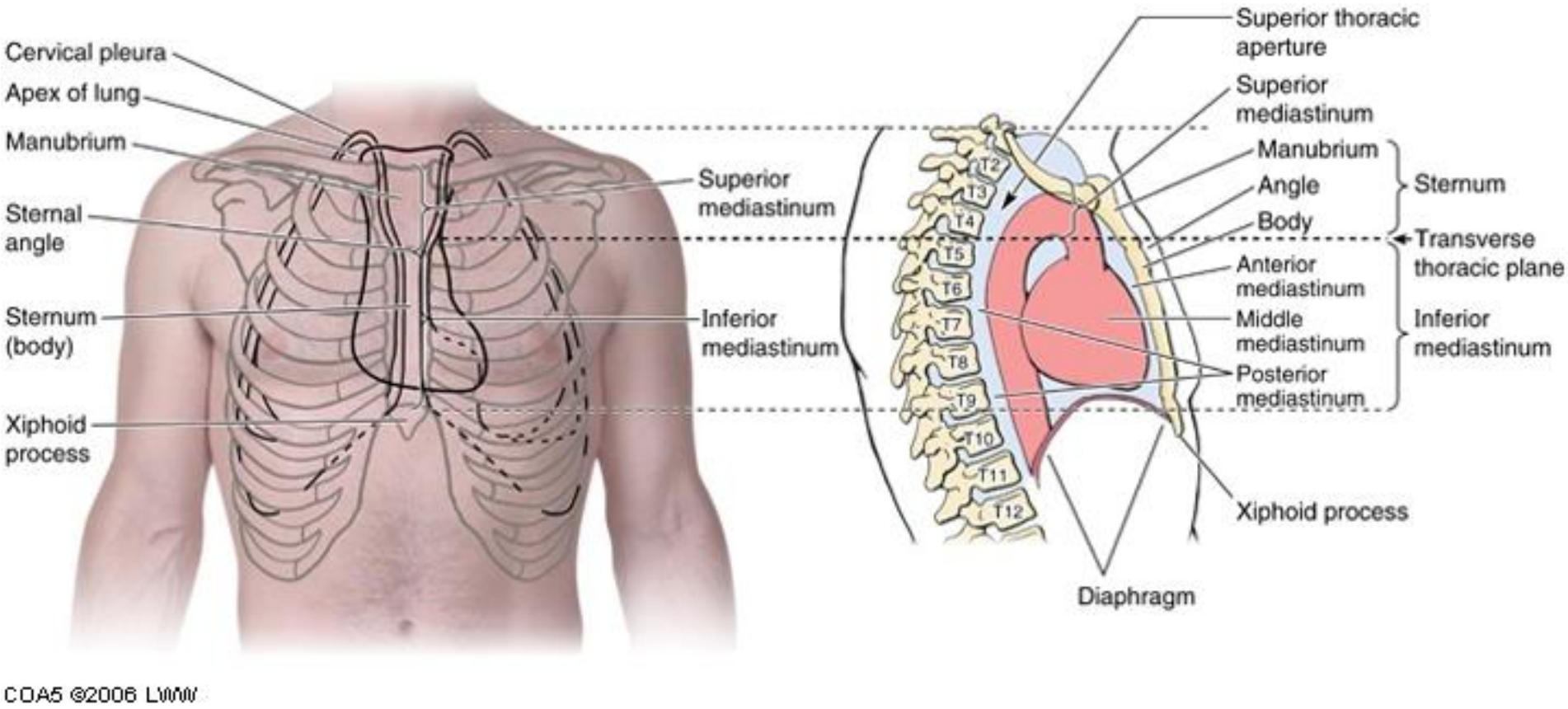




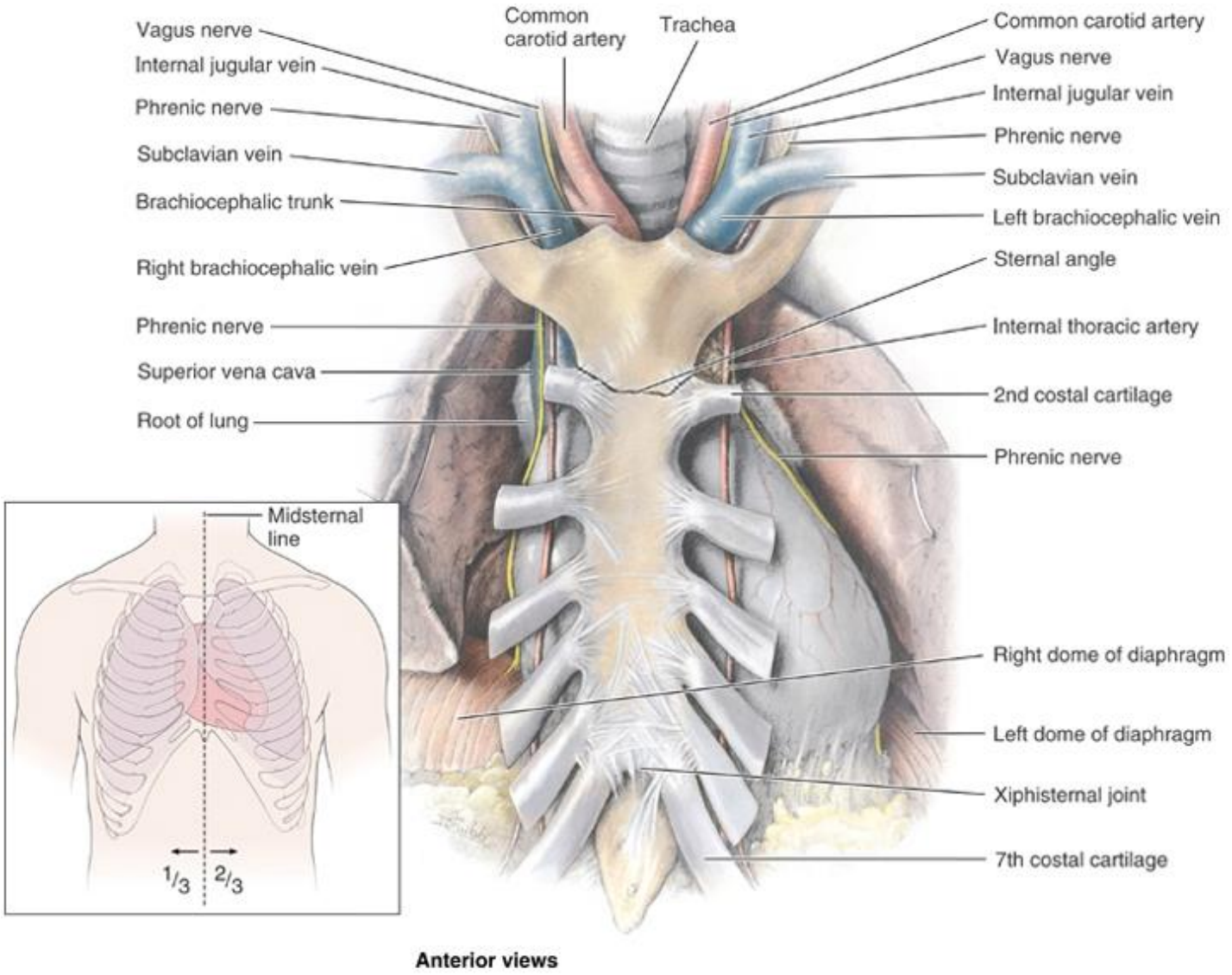

Position of transverse pericardial sinus
Heart
Fibrous pericardium
Serous pericardium
Parietal layer
Visceral layer (epicardium)
Pericardial cavity
Diaphragm


Pericardium

The Mediastinum

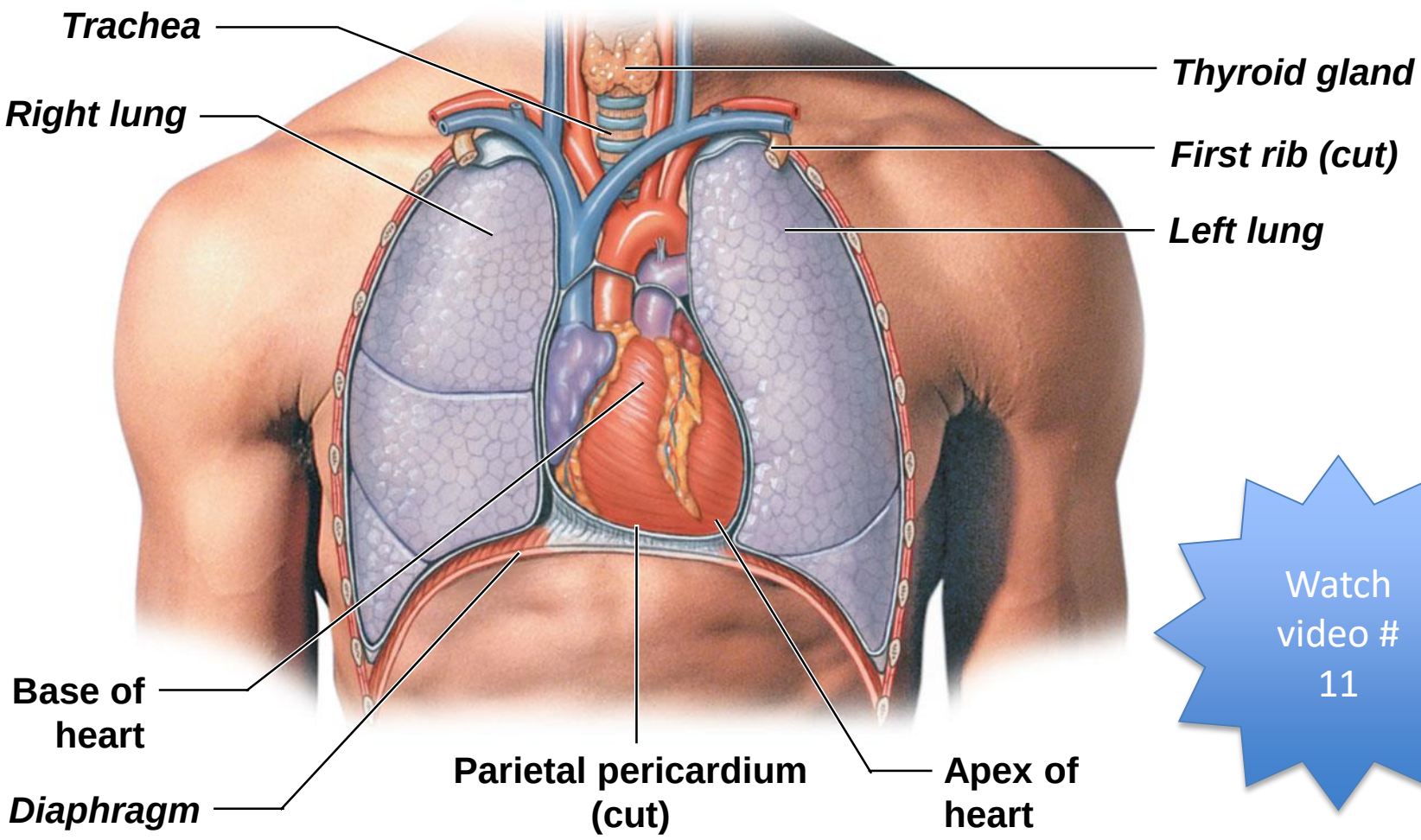


Heart Position in Thoracic Cavity



Anterior views

Figure 21.2a Location of the Heart in the Thoracic Cavity

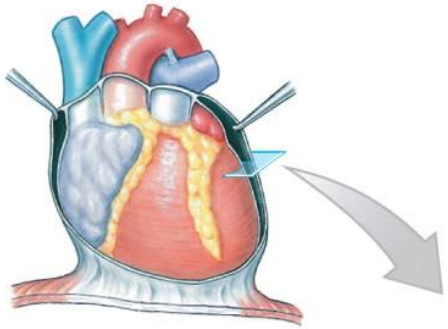


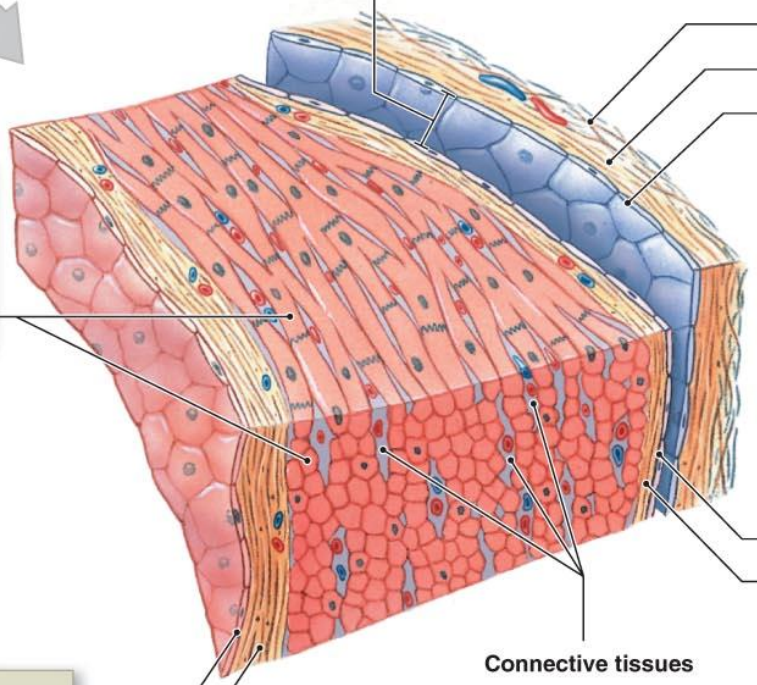
Watch video # 11

Anterior view of the open chest cavity showing the position of the heart and major vessels relative to the lungs.

The Heart Wall

A section of the heart showing its three layers: epicardium, myocardium, and endocardium





Parietal Pericardium

The serous membrane that forms the outer wall of the pericardial cavity; it and a dense fibrous layer form the pericardial sac surrounding the heart

- Dense fibrous layer
- Areolar tissue
- Mesothelium

Myocardium

Muscular wall of the heart consisting primarily of cardiac muscle cells

Epicardium

Covers the outer surface of the heart; also called the visceral pericardium

- Mesothelium
- Areolar tissue

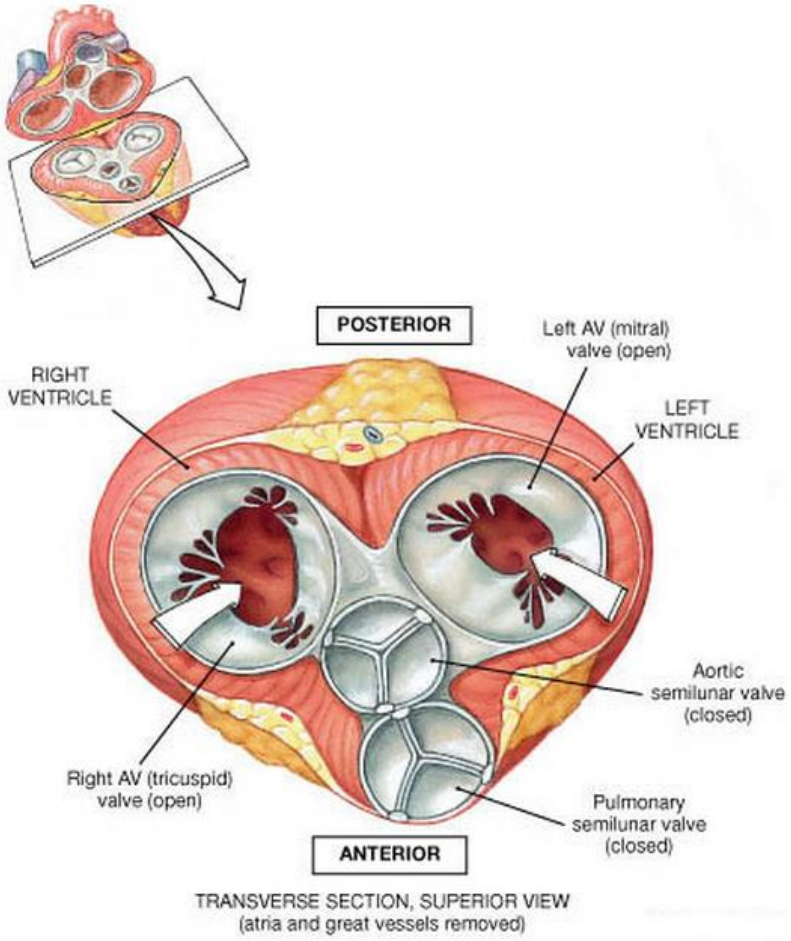
Endocardium

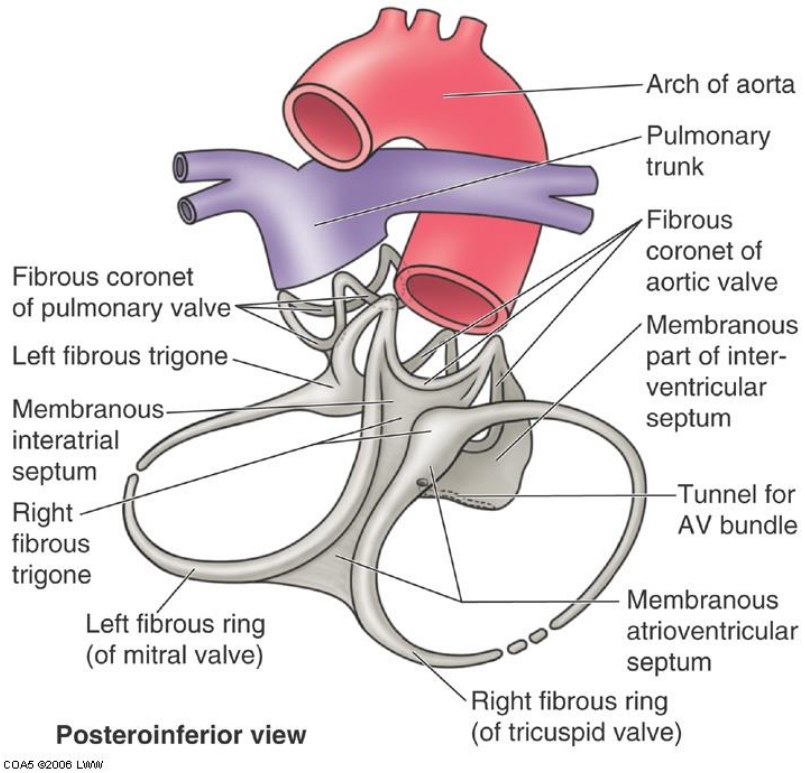
Covers the inner surfaces of the heart

- Endothelium
- Areolar tissue

Fibrous Skeleton of Heart

- The fibrous skeleton of the heart consists of four fibrous rings that surround the valve orifices and two triangular fibrous connections between these rings, the right and left fibrous **trigones**. The valves include the aortic and pulmonary semilunar valves and the right and left atrioventricular valves.
- The fibrous skeleton physically supports the valves, provides independent attachment for the atrial and ventricular myocardium, and acts an electrical insulator between the atria and ventricles.

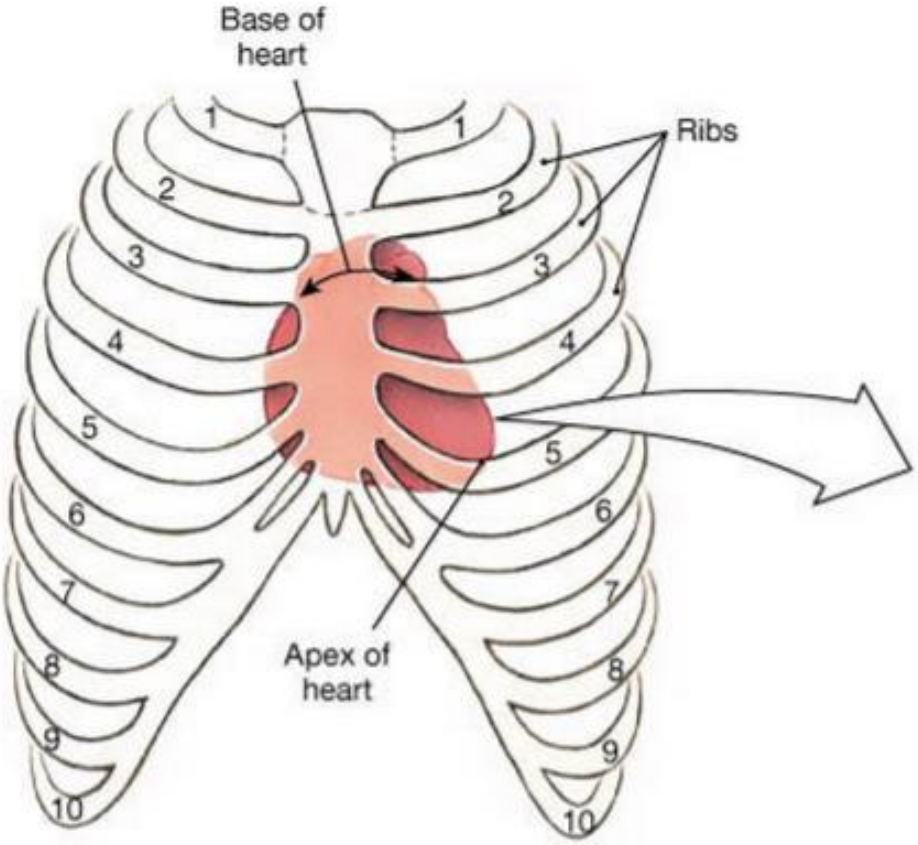


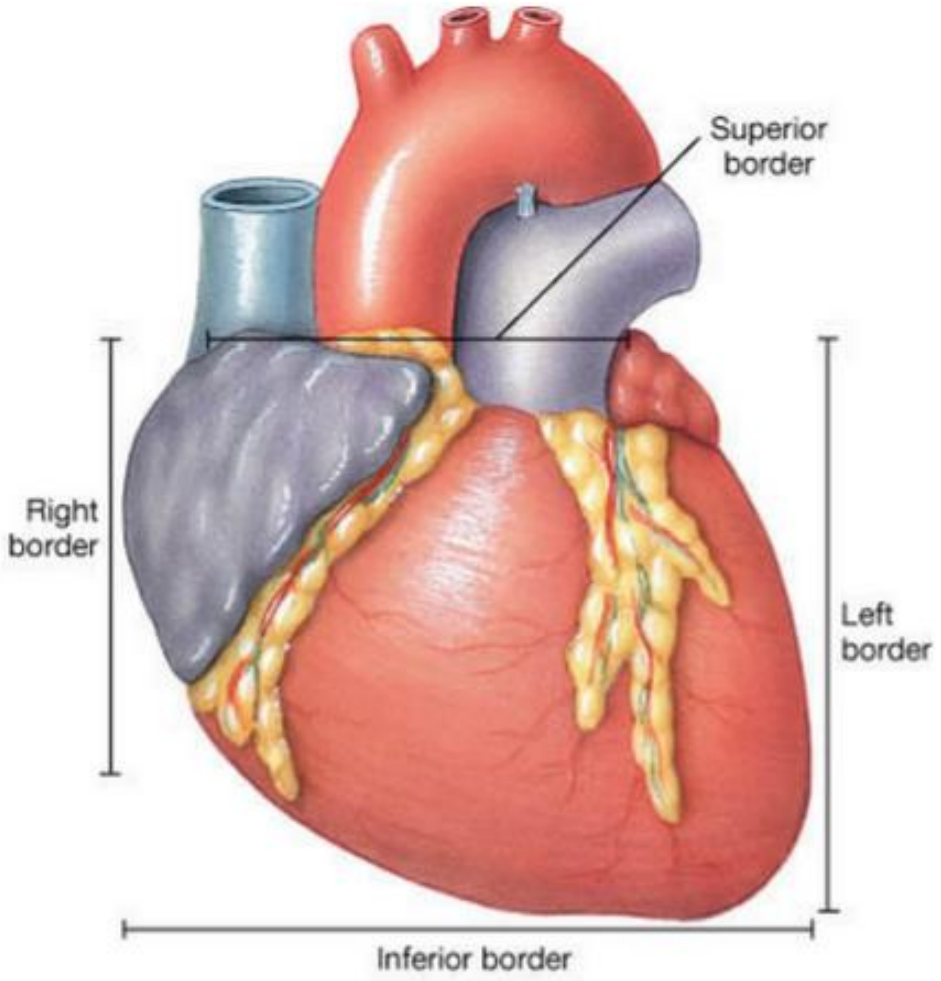


Orientation and Superficial Anatomy of Heart

1. *The heart lies slightly to left of midline.*

The **base** of the heart is formed mainly by the left atrium, and, to a small extent, by the back part of the right atrium. The **apex** is the inferior rounded tip.

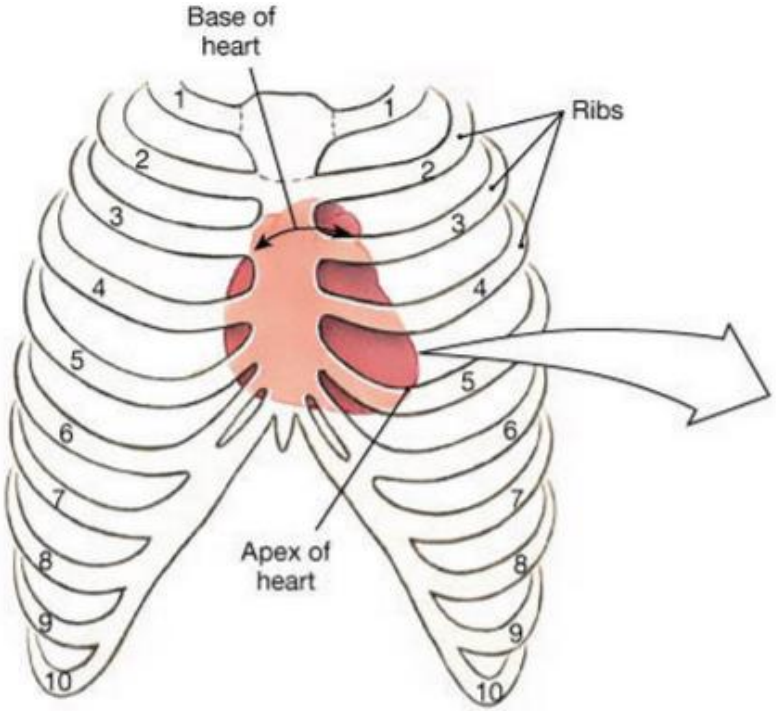


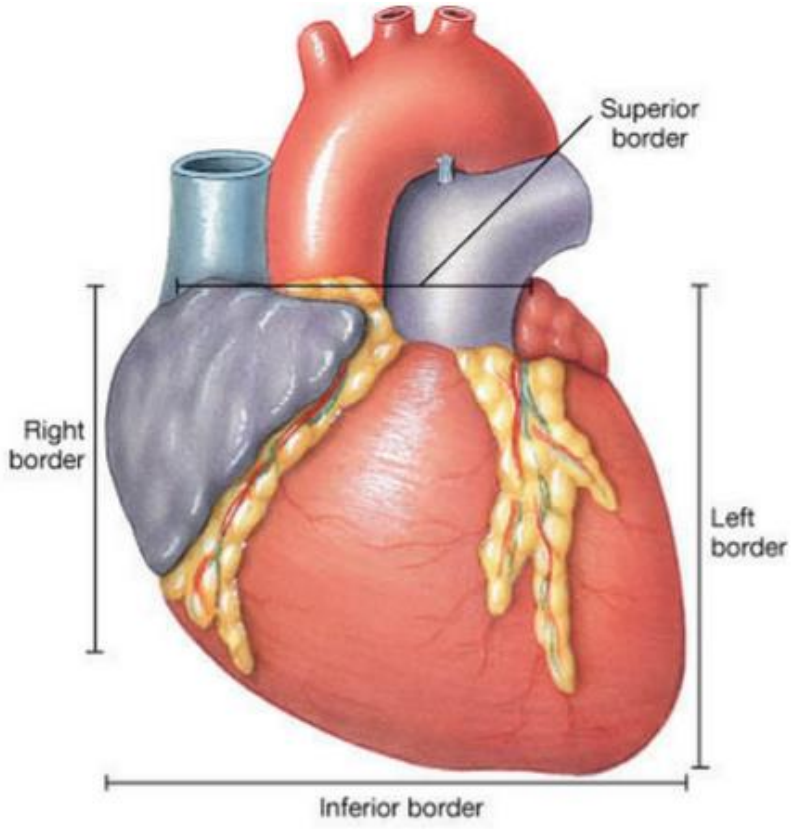


2. The heart at oblique angle to longitudinal axis.

Because of this tilt, the apex points obliquely toward the left.
This tilt in the orientation of the heart also causes the horizontal and vertical borders of the heart to be as follows:

1. The superior border is formed by the base.
2. The right border is formed by the right atrium.
3. The inferior border is formed by the inferior wall of the right ventricle.
4. The left border is formed by the left ventricle and a small portion of the left atrium.

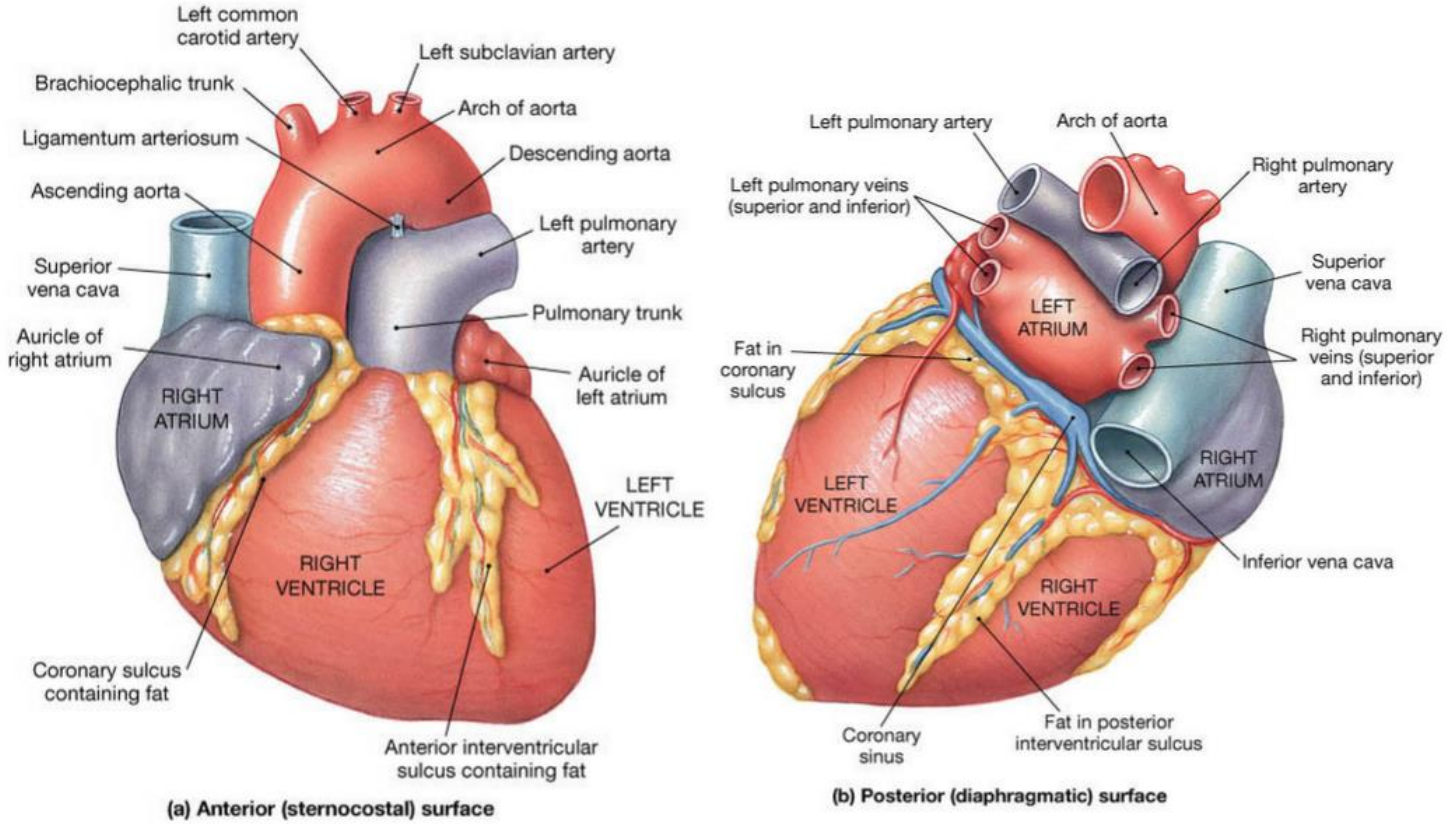




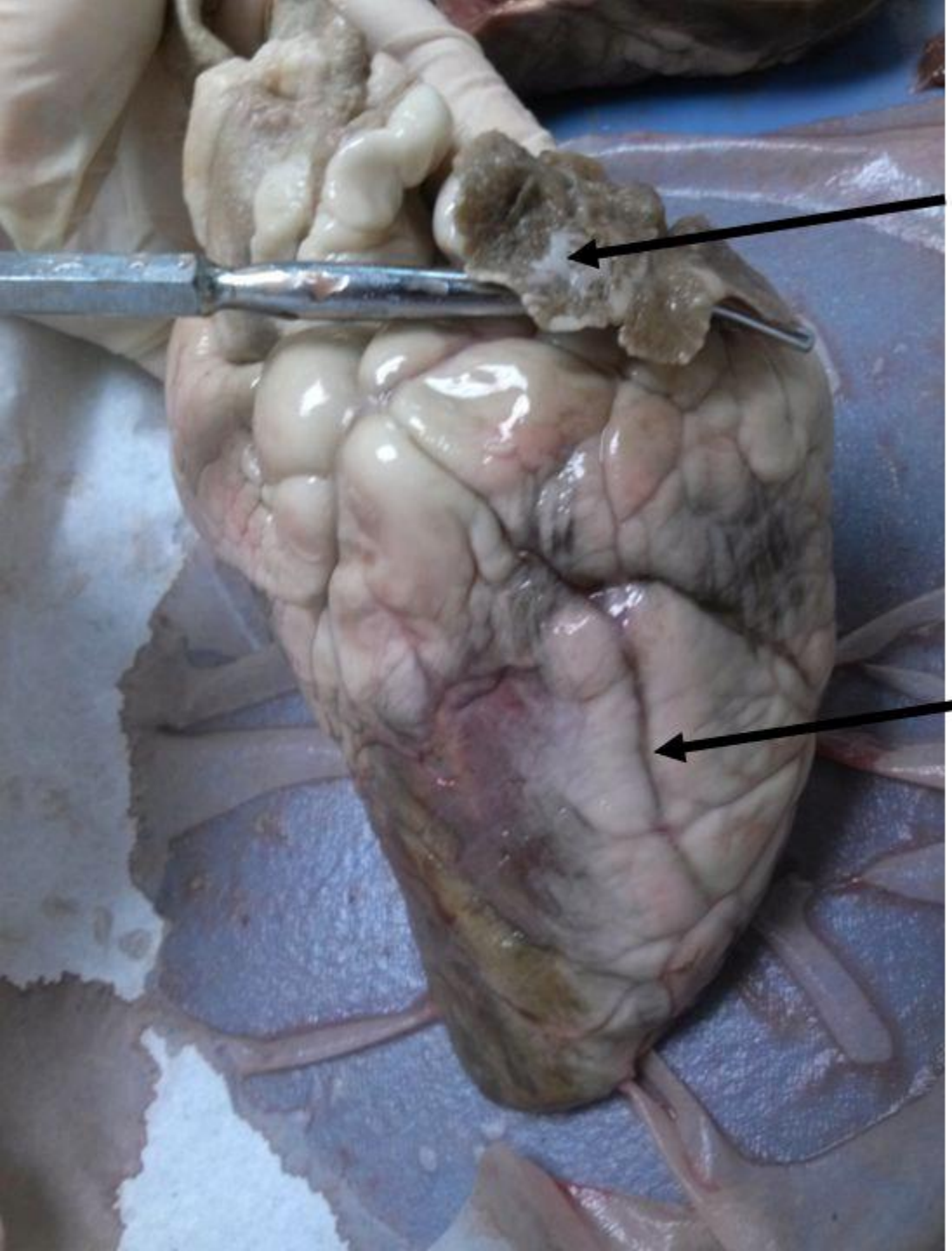
3. The heart rotated slightly toward left.

Because of this rotation:

- The surface of the heart underneath the sternum and the ribs on the left side, the **sternocostal** surface, is that of the right atrium and ventricle.
- The surface of the heart that rests on the diaphragm, which curves directly behind the heart, is called the **diaphragmatic surface**, and is formed by the posterior walls of the right and left ventricles



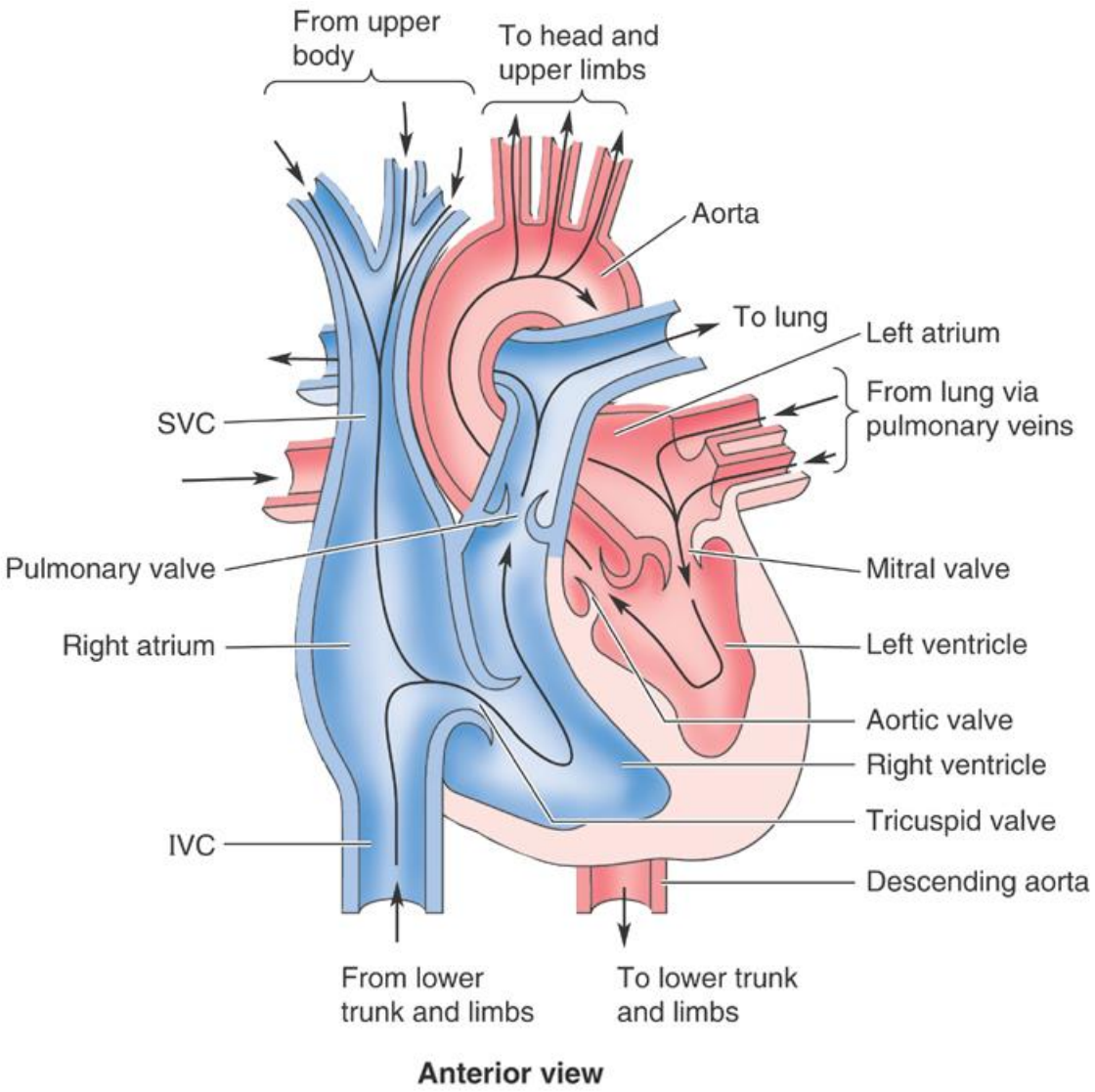
- The atria have thin muscular walls that are distended as they receive blood. When contracted, the anterior walls form flaps that are called **auricles**. A deep groove between the atria and ventricles is called the **coronary sulcus**. The boundary between the right and left ventricles is indicated externally by a shallow groove on the anterior surface, the **anterior interventricular sulcus**, and the posterior surface, the **posterior interventricular sulcus.**



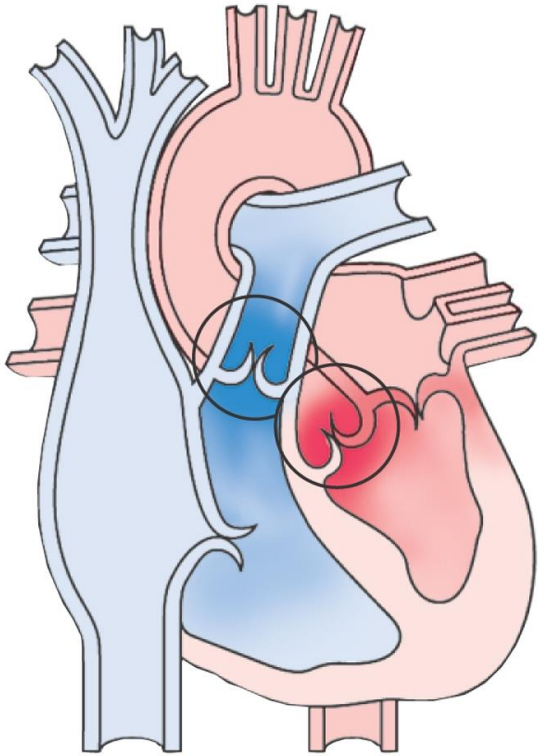
Auricle (atrial appendage) increases the blood holding capacity of the atrium

You can find the anterior side of the heart by finding the auricle that you can see completely; it is the left auricle. The anterior longitudinal sulcus is on that side and the coronary sinus is on the posterior side.

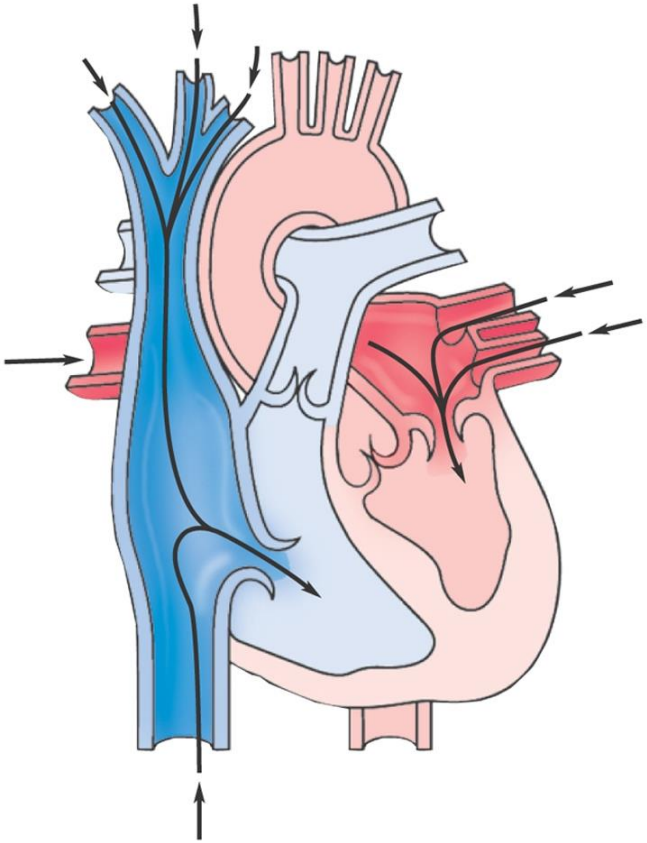
Bloodflow Through Heart



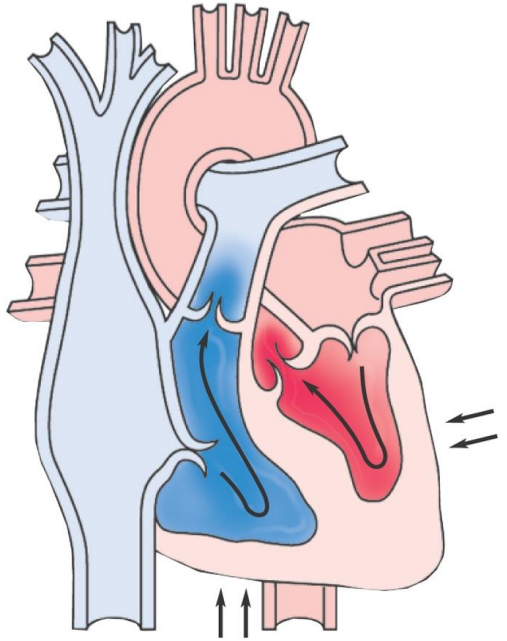
Valves of Heart



Beginning of diastole upon closure of aortic and pulmonary valves



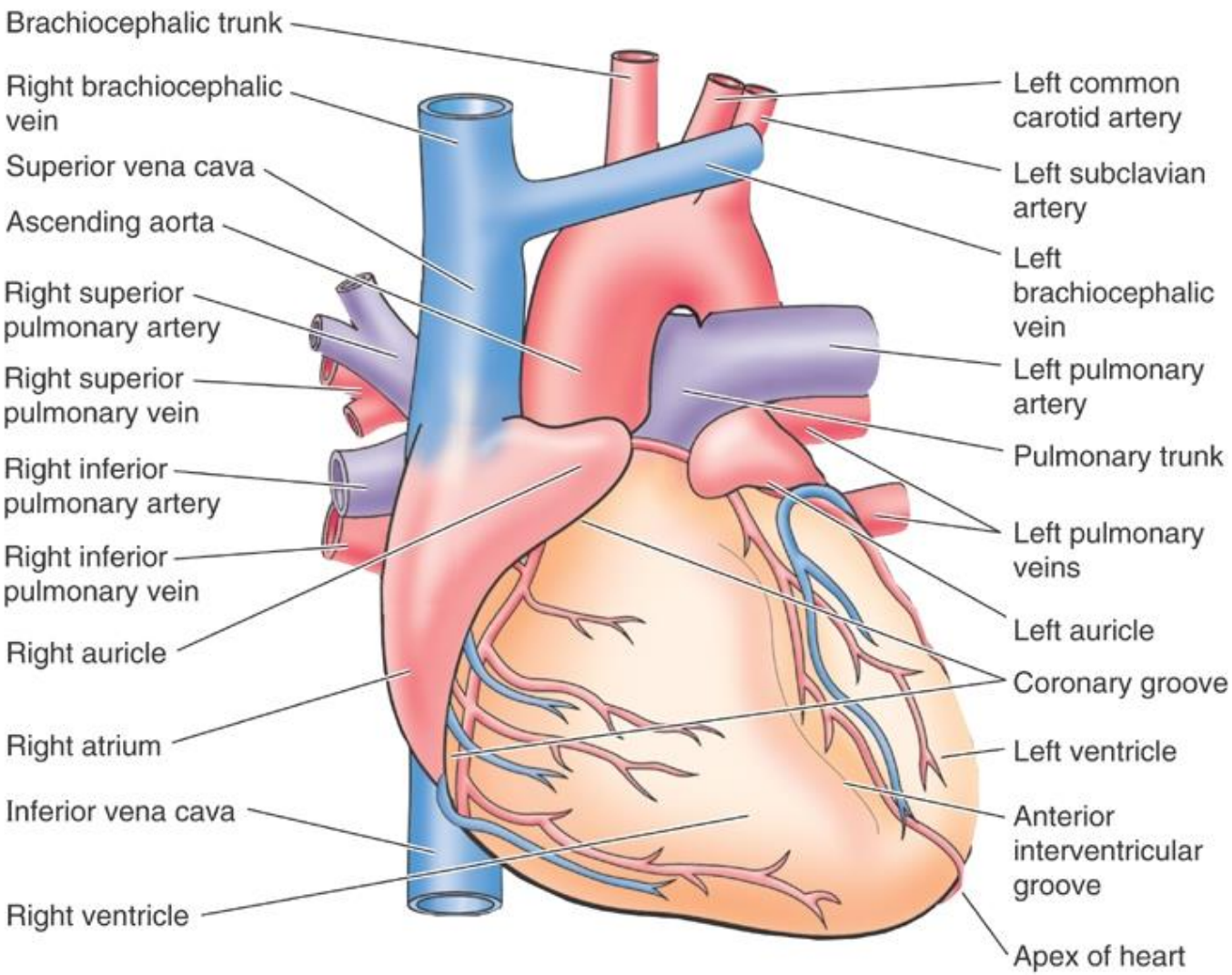
Opening of atrio-ventricular valves during early moments of diastole



Closure of atrioventricular valves (tricuspid and mitral) very soon after systole begins

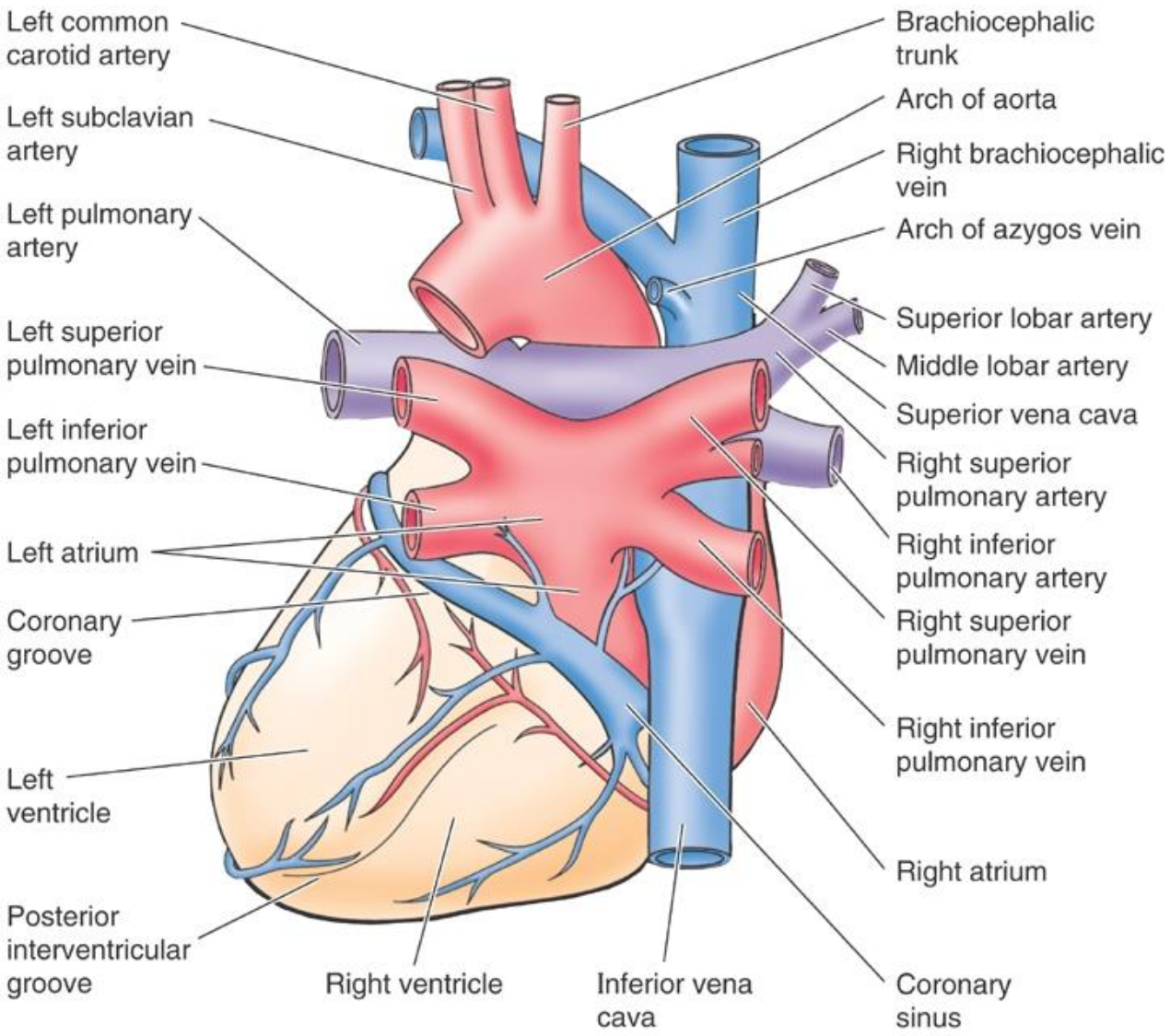
Anterior views

Anterior Heart



Anterior views

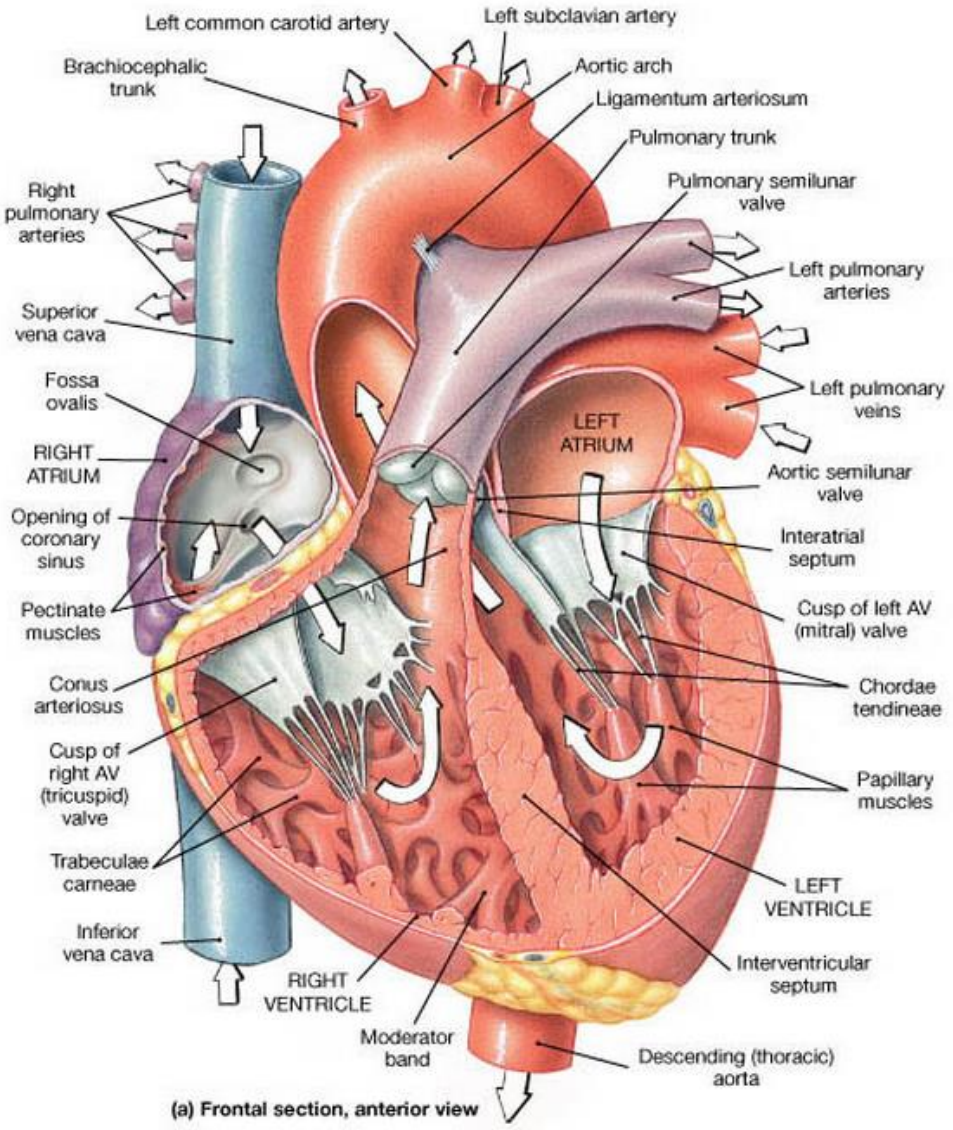
Posterior Heart



Right atrium

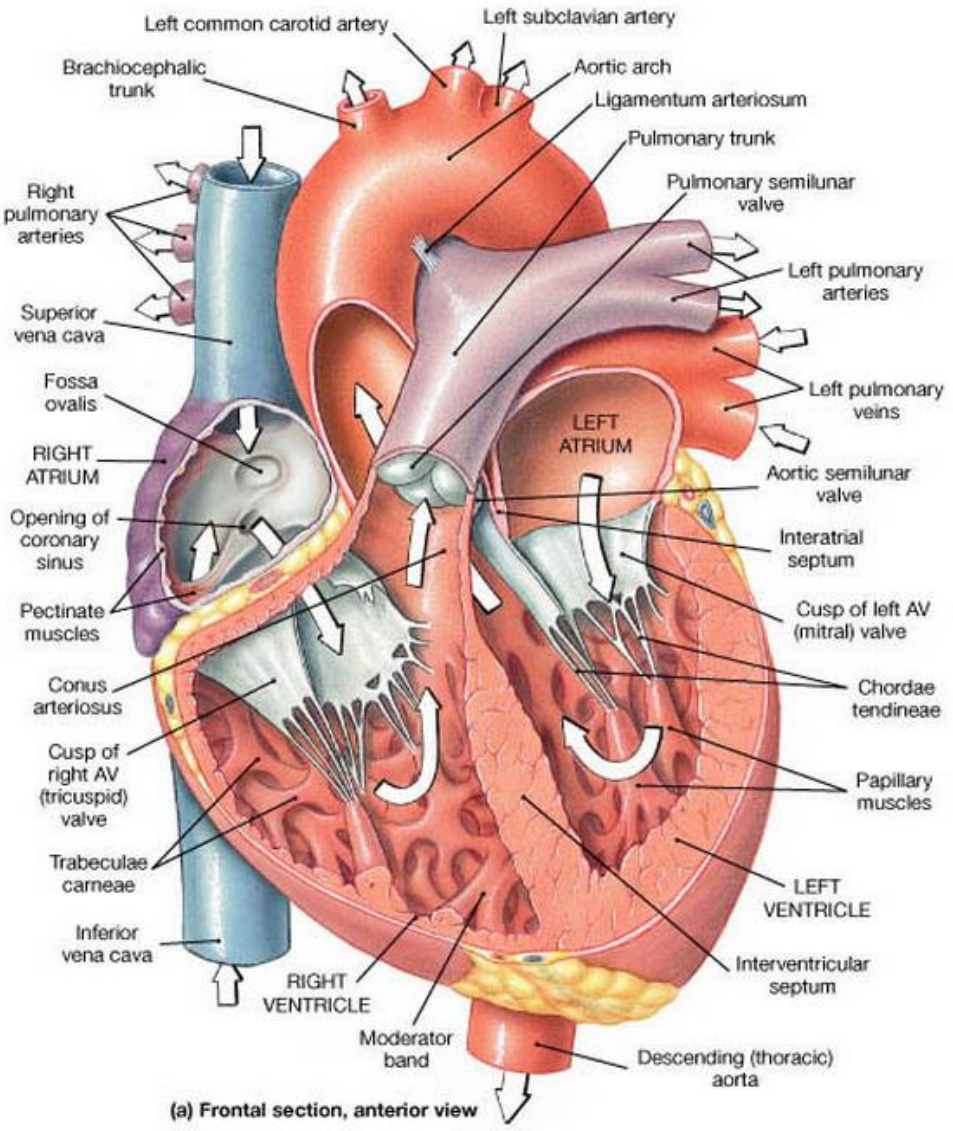
The right atrium receives deoxygenated blood from **superior vena cava**, **inferior vena cava** and **coronary sinus**.

Parallel ridges of muscle called **pectinate muscles** are found in the interior of the right auricle.



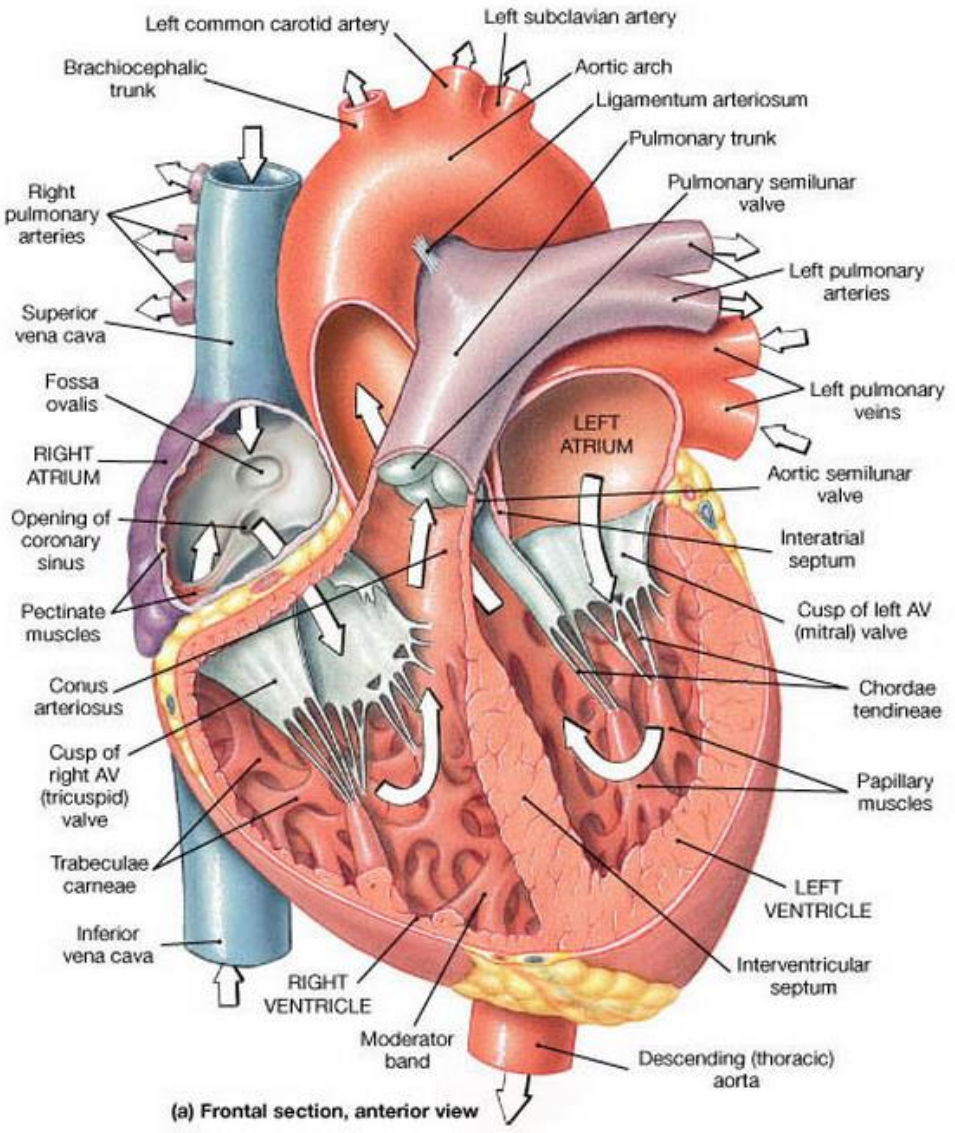
Right ventricle

- The deoxygenated blood from right atrium enters the right ventricle through an opening bounded by three flaps, or cusps, of the right **atrioventricular (tricuspid) valve**.
- The inner surface of the right ventricles has irregular, muscular folds called **trabeculae carneae**.
- The pulmonary trunk branches into the **right and left pulmonary arteries.**
- Backflow of blood is prevented by three half-moon flaps attached to the base of the pulmonary trunk that forms the **pulmonary semilunar valve**



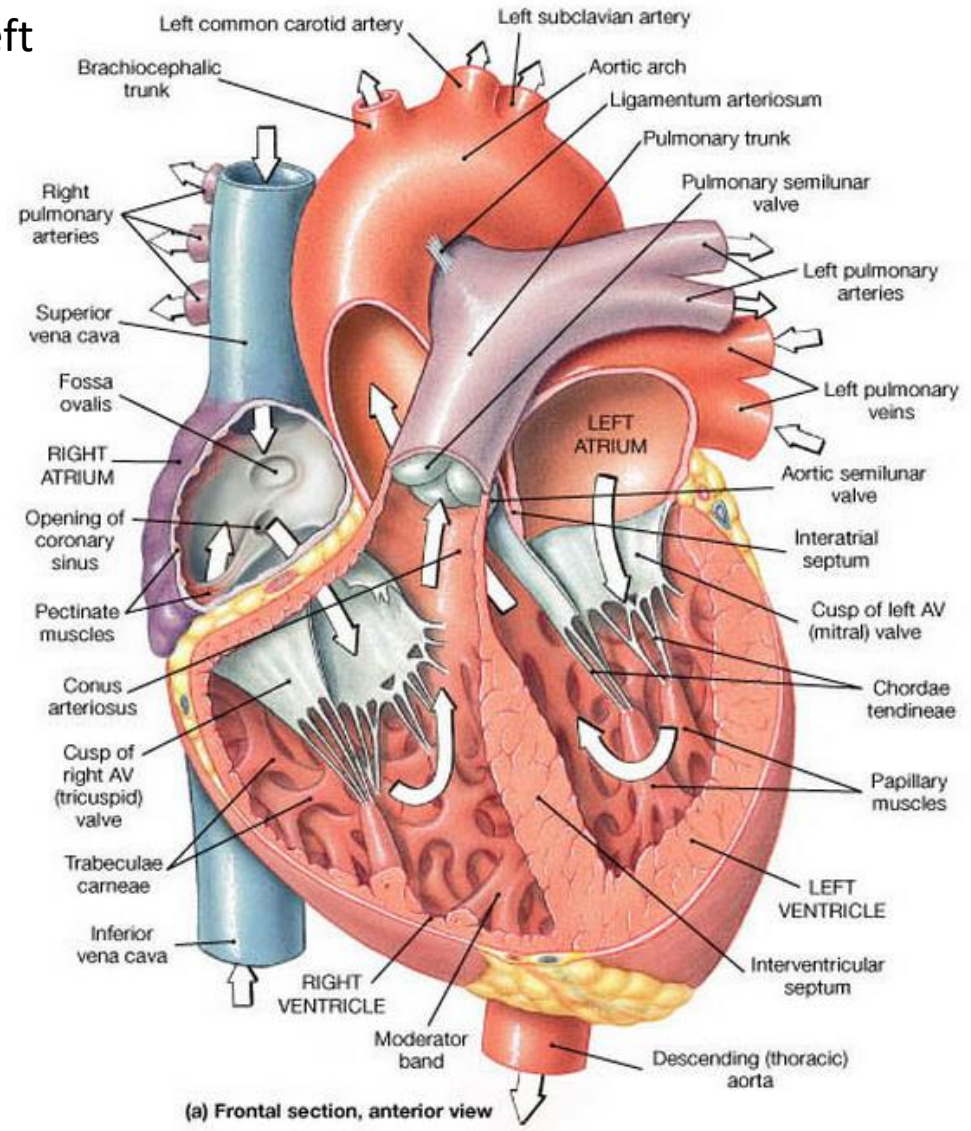
Left atrium

- The left (2) and right (2) pulmonary veins drain oxygenated blood from the lungs into the left atrium.
- The auricle of the left atrium lacks **pectinate** muscles.
- The oxygenated blood enters the left ventricle through a valve with two flaps, the **left atrioventricular (bicuspid, mitral) valve.**

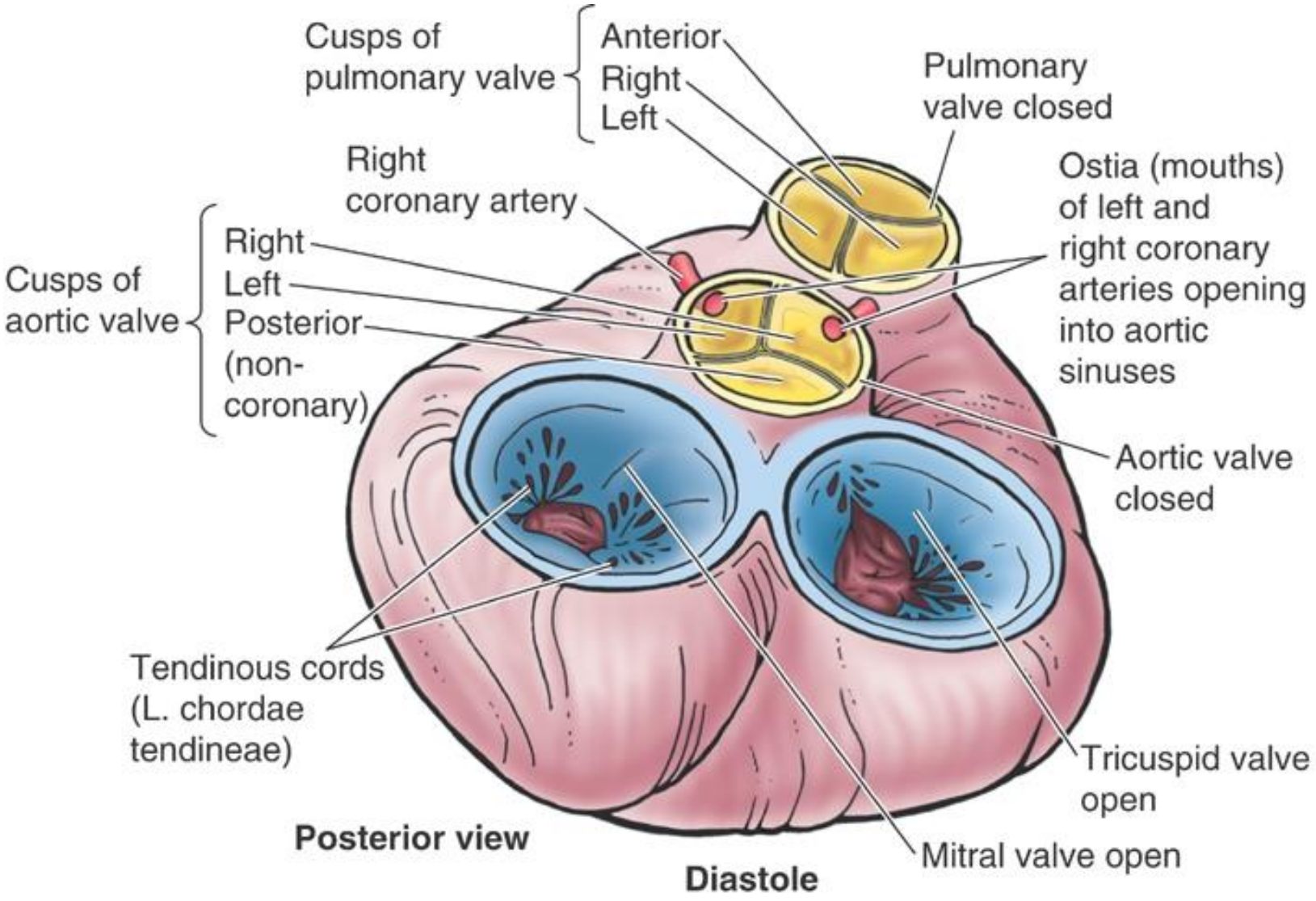


Left ventricle

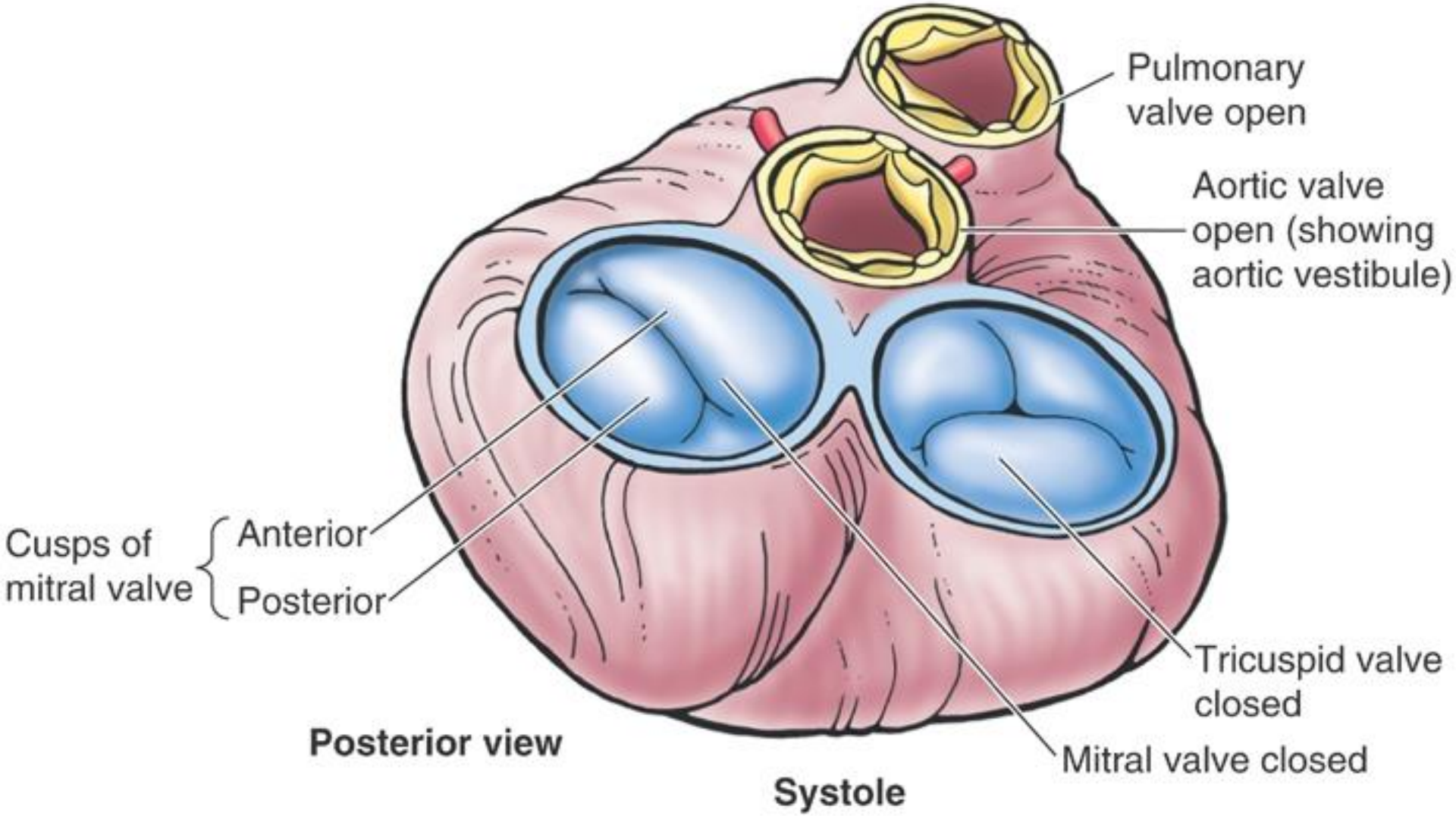
- As oxygenated blood is ejected from the left ventricle is passes through the **aortic semilunar valve** and enters the **ascending aorta.**
- The left ventricle, has a thicker wall than the right. It also has more prominent **trabeculae carneae.**



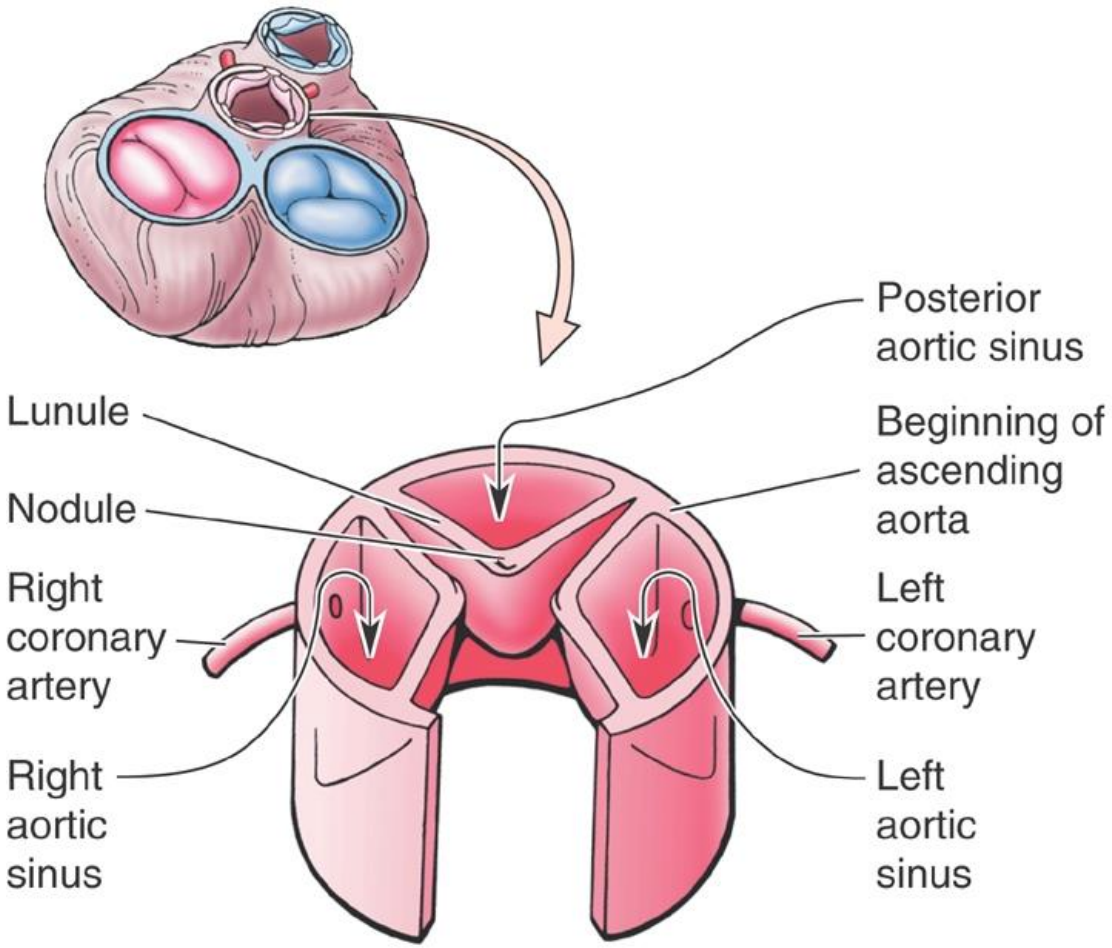
Valves during ventricular diastole



Valves during ventricular systole



Aortic Semilunar Valve



Anterior view of aortic valve

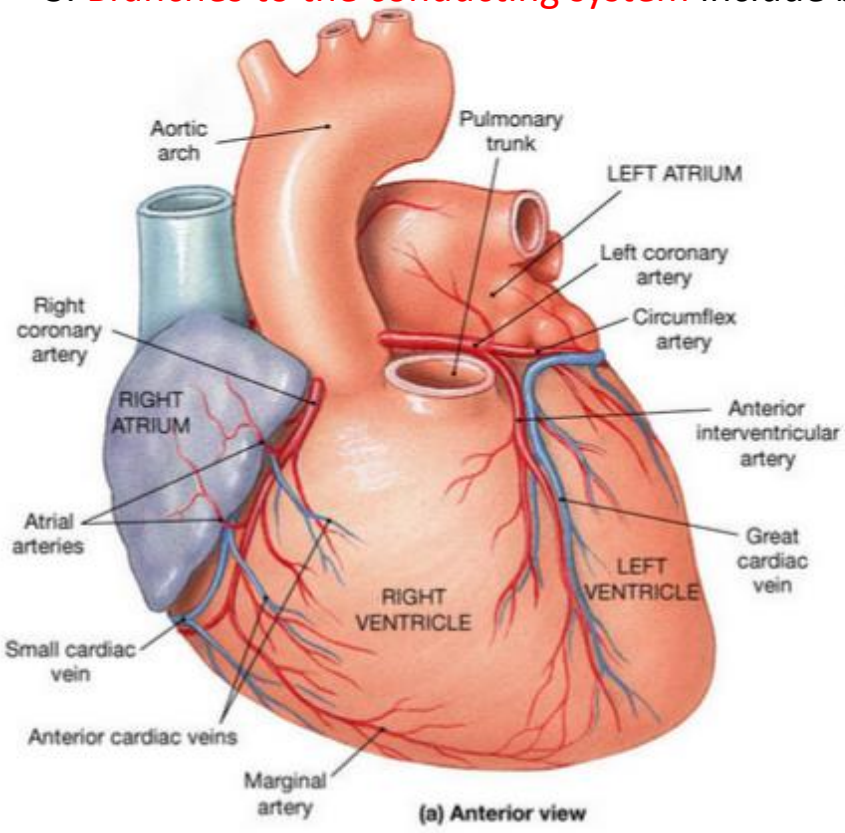
Coronary Blood Vessels

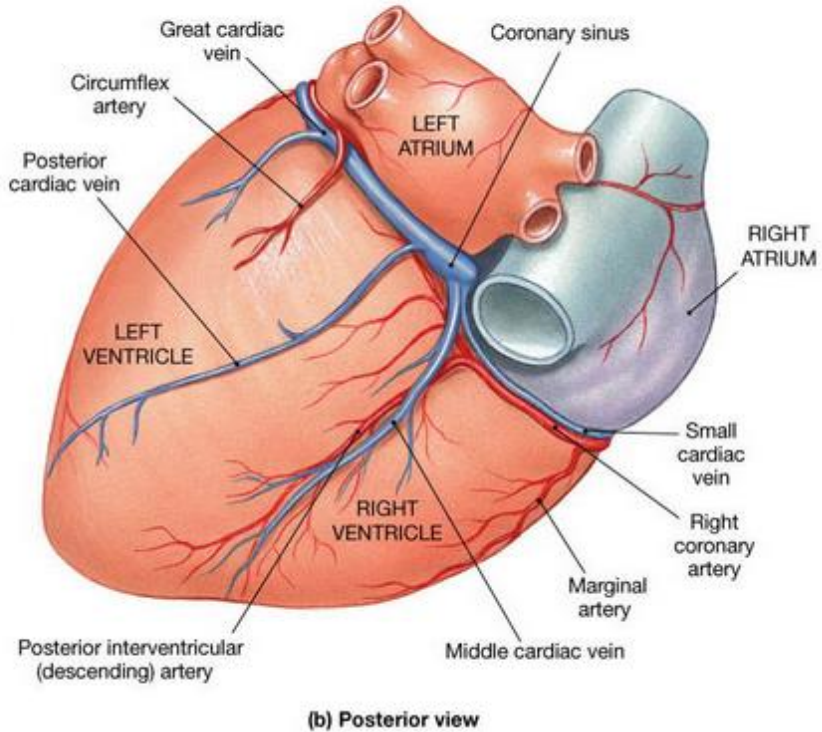
- The coronary circulation supplies blood to heart tissue.
- **The right** and **left coronary arteries** come off ascending aorta at the aortic sinuses

right coronary artery

The right coronary artery branches include:

1. Atrial branches that supply the myocardium of the right atrium.
2. Ventricular branches include the right marginal branch that extends toward the apex along the anterior surface of the right ventricle, and the posterior interventricular branch that descends toward the apex along the posterior interventricular sulcus.
3. Branches to the conducting system include branches to the sinoatrial and atrioventricular nodes.

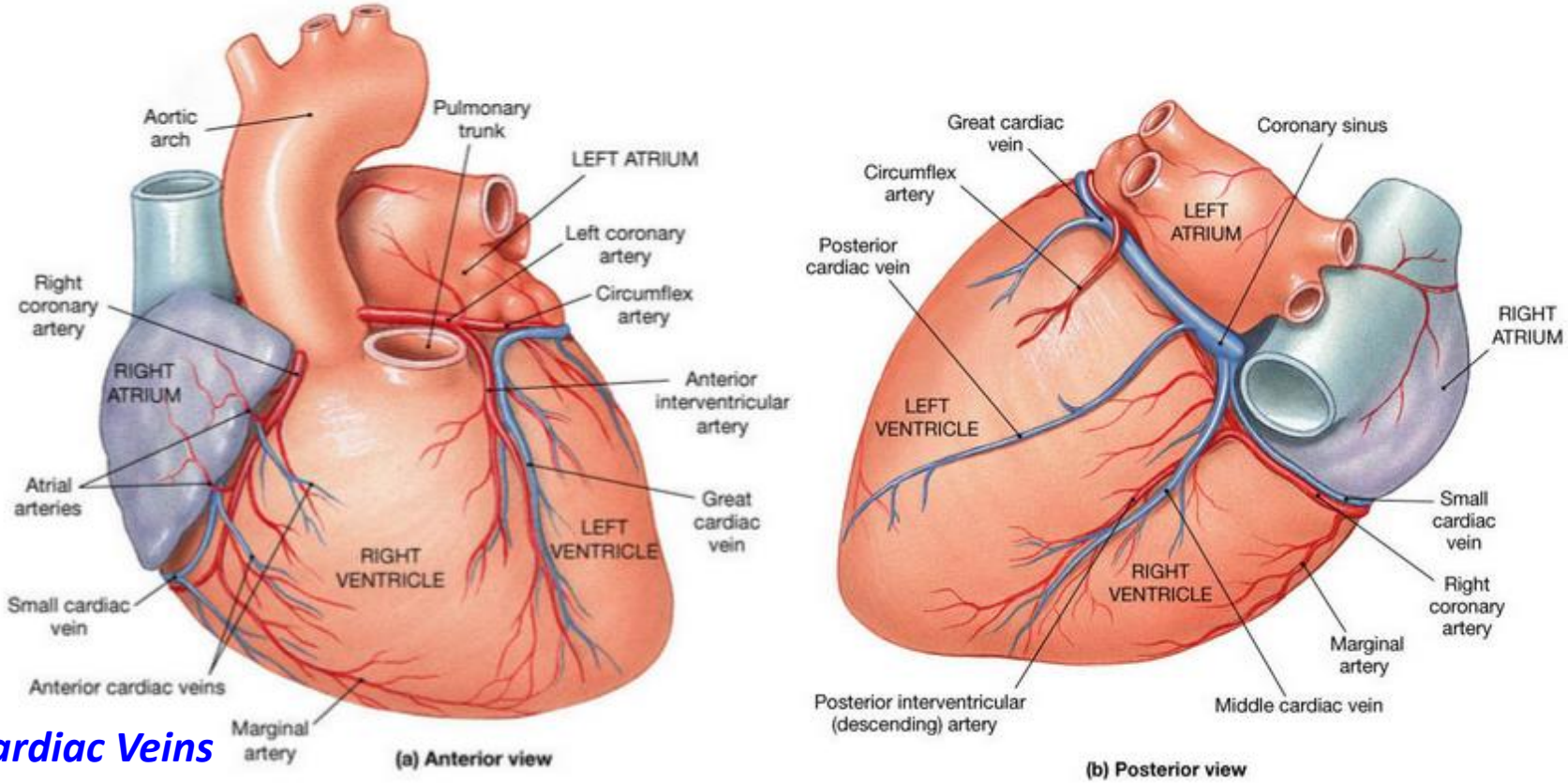




left coronary artery

The left coronary artery supplies the left atrium and ventricle and contributes to the supply to the interventricular septum. As it reaches the anterior surface it divides into two branches:

1. The circumflex branch curves to left in coronary sulcus.
2. The anterior interventricular branch descends along anterior interventricular sulcus.



Cardiac Veins

The great cardiac vein and middle cardiac vein are found in the anterior interventricular sulcus and posterior interventricular sulcus, respectively. Both veins drain blood into the coronary sinus that is a thin-walled vein that lies in the posterior coronary sulcus.


Watch video
12 and # 13