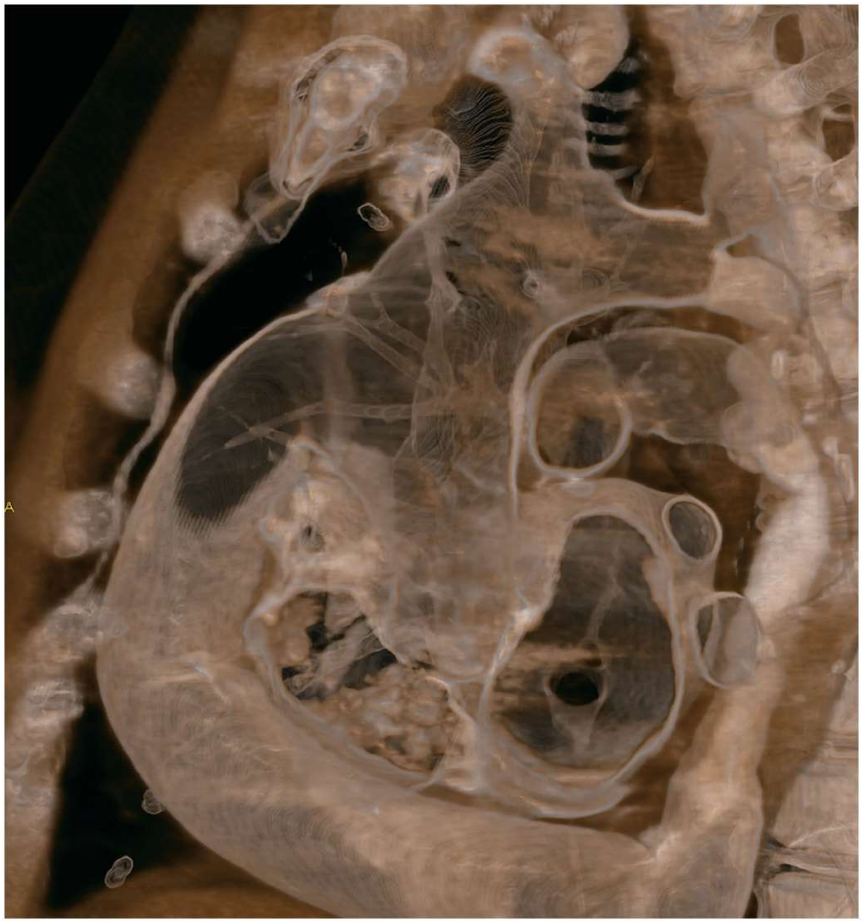
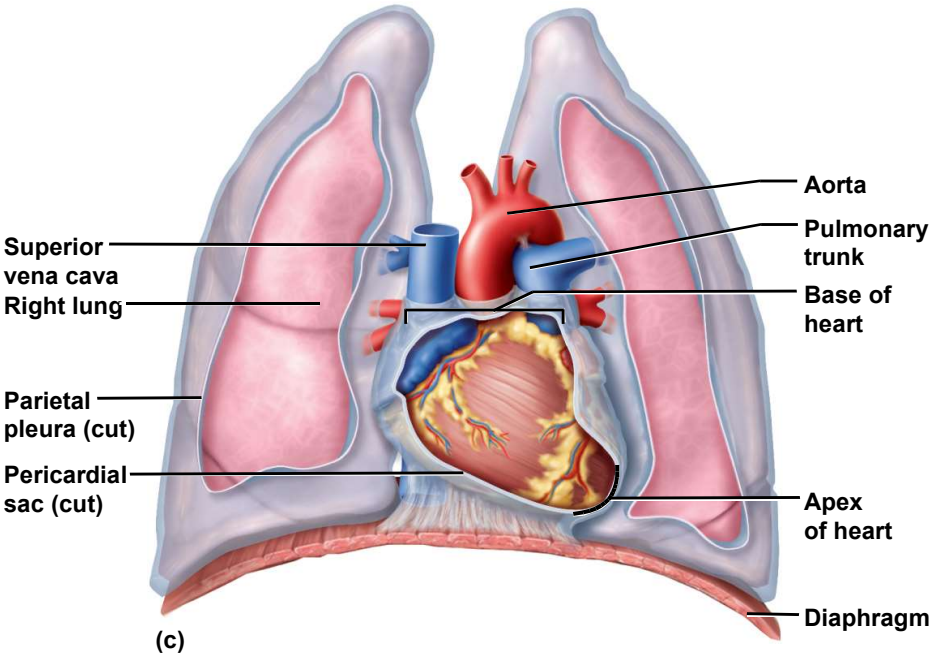
Chapter 19.1

Heart Structure

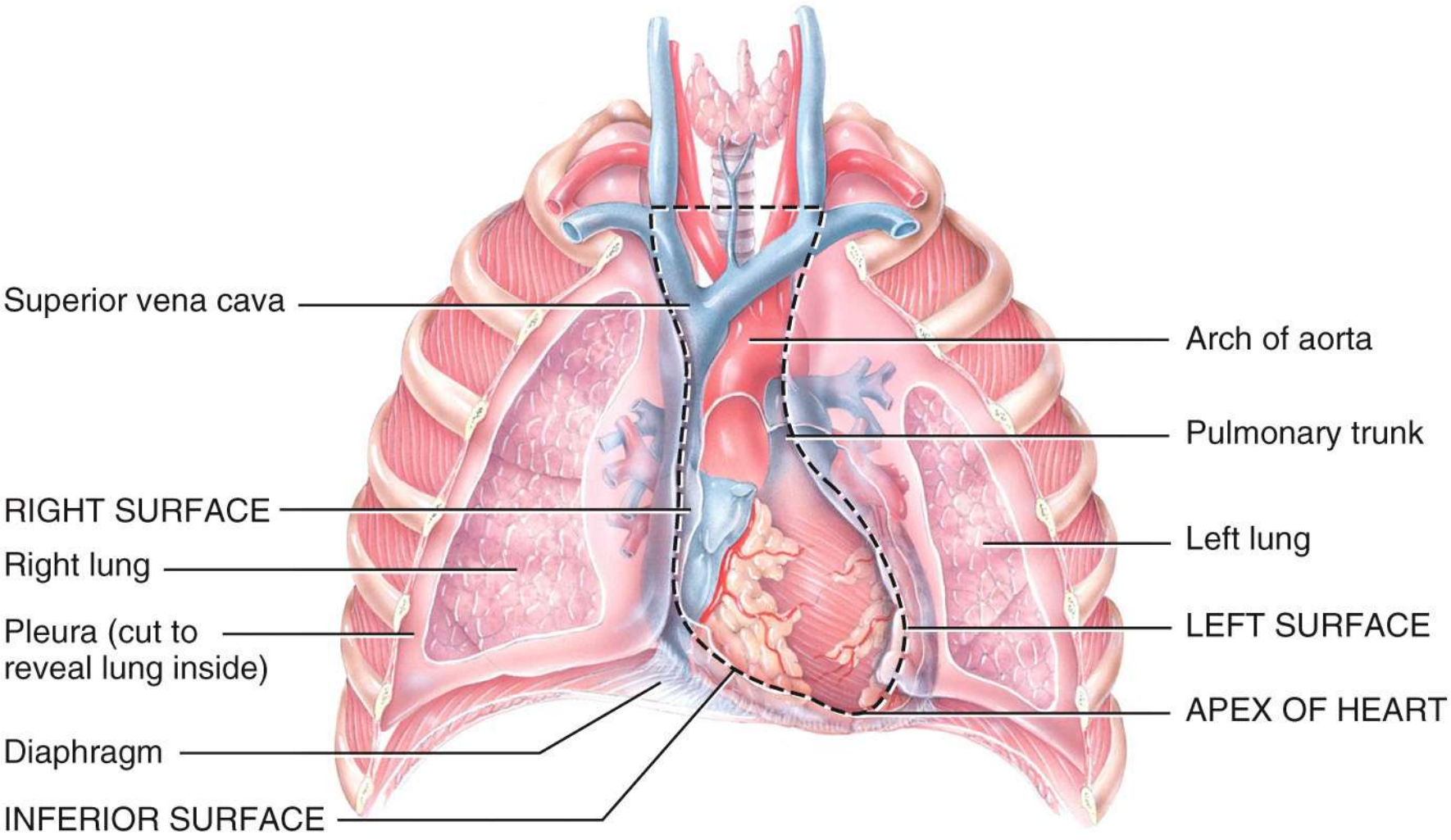


Position, Size, and Shape

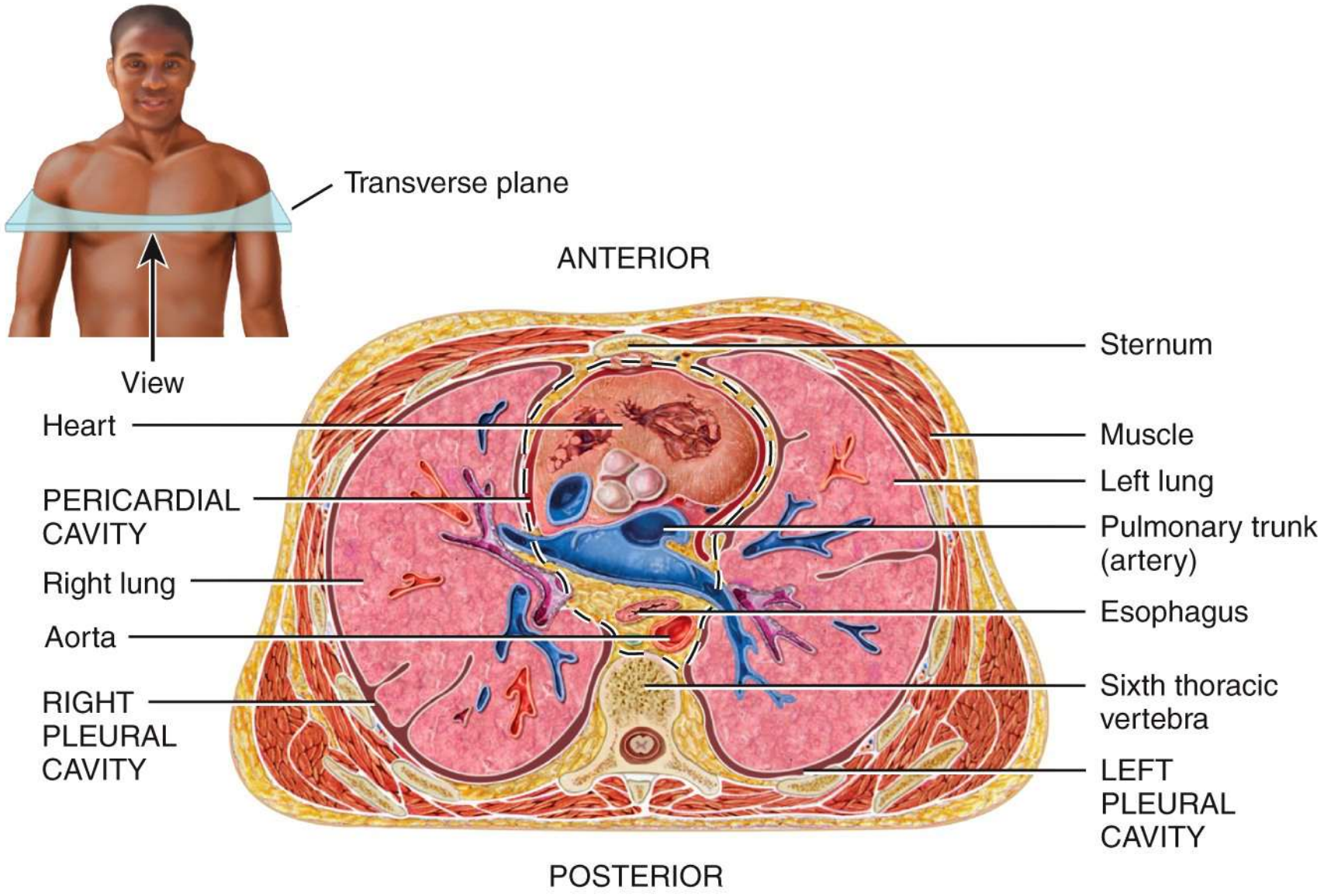
- heart located in mediastinum, between lungs
- **base** – wide, superior portion of heart, blood vessels attach here
- **apex** - inferior end, tilts to the left, tapers to point
- 3.5 in. wide at base
- 5 in. from base to apex
- 2.5 in. anterior to posterior
- weighs 10 oz.



Located in Mediastinum

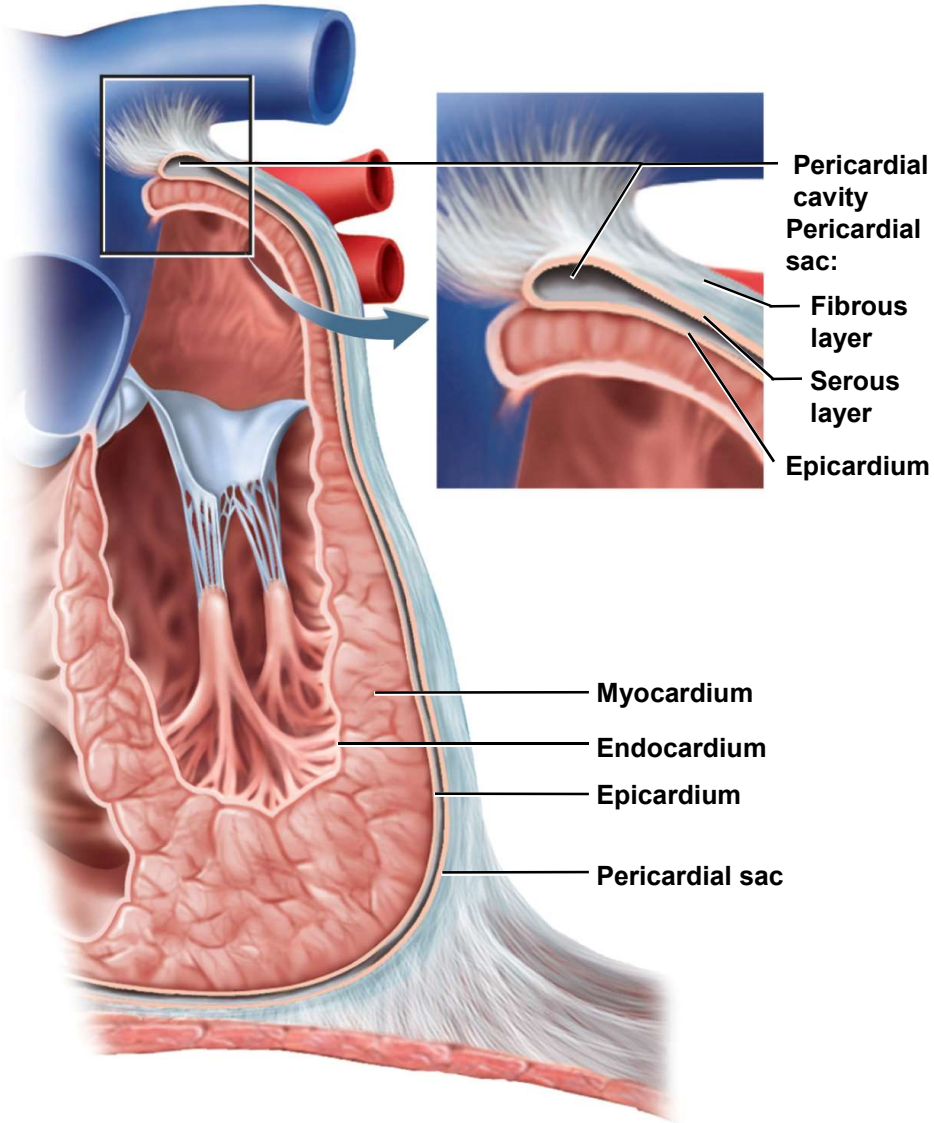


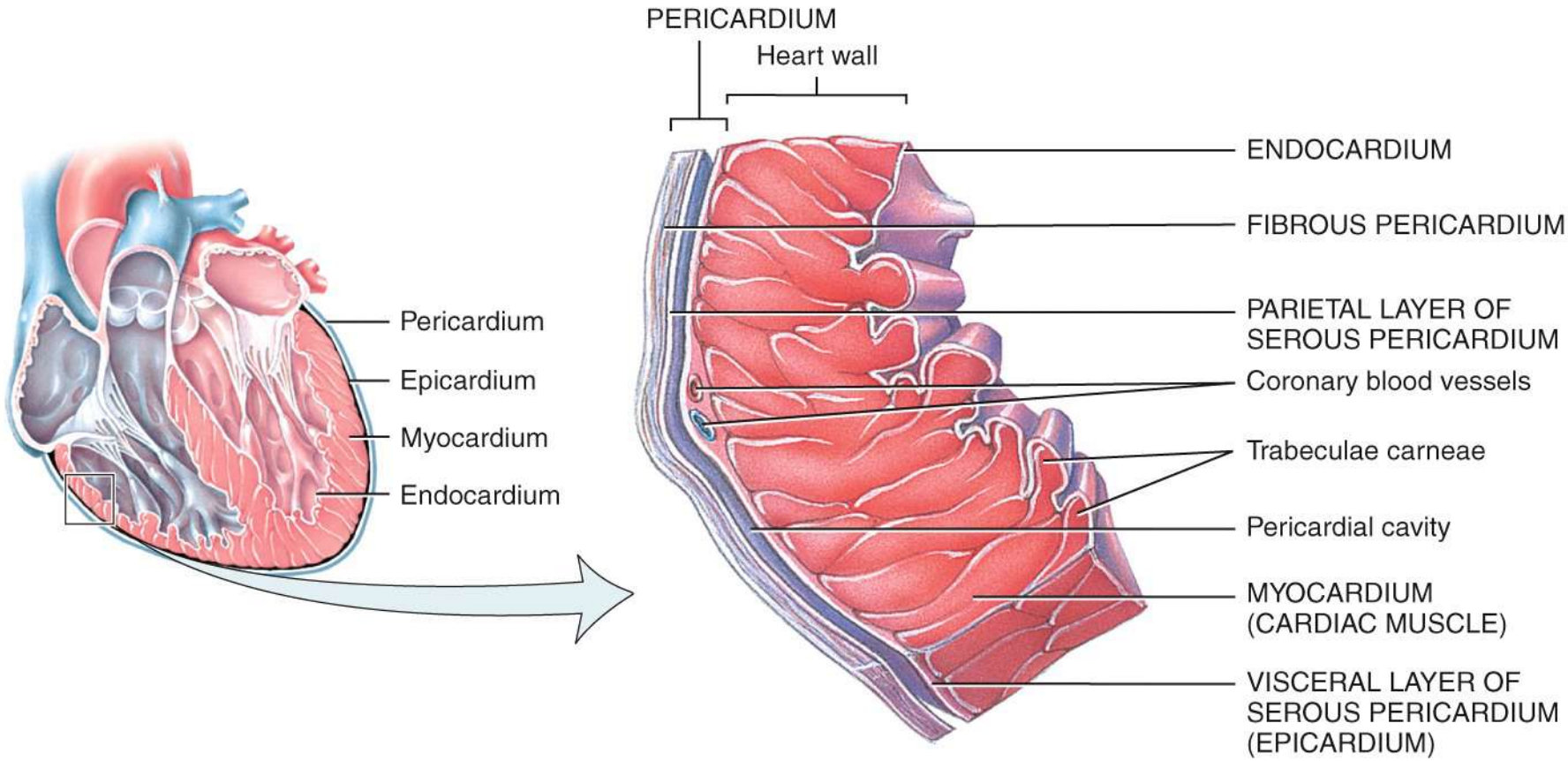
(b) Anterior view of the heart in the thoracic cavity



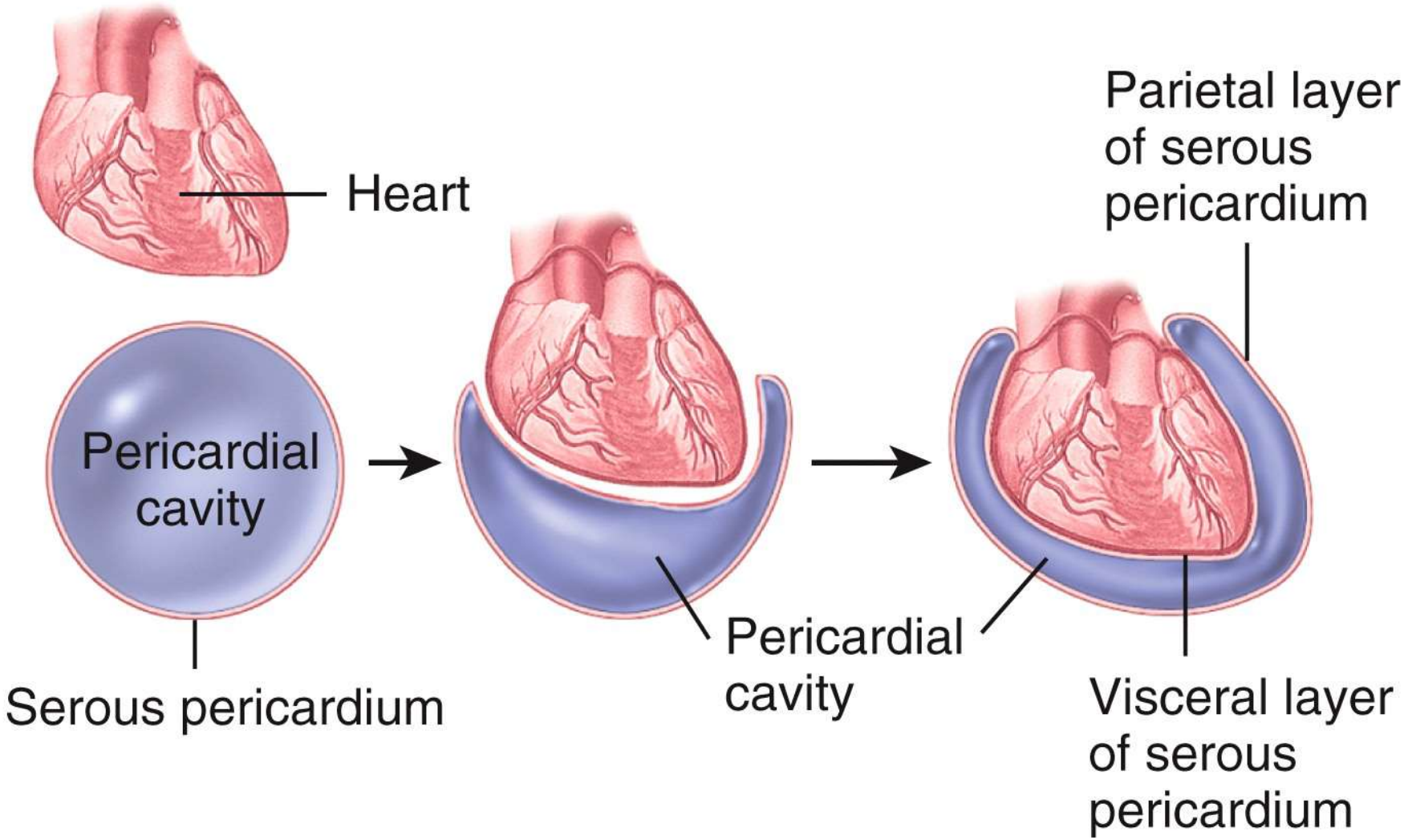
(a) Inferior view of transverse section of thoracic cavity showing the heart in the mediastinum

Pericardium and Heart Wall





(a) Portion of pericardium and right ventricular heart wall showing divisions of pericardium and layers of heart wall



(b) Simplified relationship of serous pericardium to heart

Pericardium

- **Pericardium**
  - double-walled sac (pericardial sac) that encloses the heart // fibrous pericardium with inner and outer surface
  - allows heart to beat without friction, provides room to expand // resists excessive expansion
  - anchored to diaphragm inferiorly and sternum on anterior surface

- **Parietal pericardium**
  - outer wall of sac
  - superficial **fibrous layer** of connective tissue
  - a deep, thin **serous layer**

Pericardium

- **Visceral pericardium (also called epicardium)**
  - simple squamous epithelium / heart covering
  - serous lining of pericardial sac // turns inward at base of heart to cover the heart surface
- **Pericardial cavity //** space inside the pericardial sac contains 5 to 30 mL of pericardial fluid
- **Pericarditis //** inflammation of the membranes // painful friction rub with each heartbeat // excess fluid accumulates in pericardial cavity

Heart Wall

- Epicardium (visceral pericardium)
  - serous membrane covering heart
  - adipose in thick layer in some places
  - coronary blood vessels travel through this layer
- Myocardium
  - layer of cardiac muscle proportional to work load
  - muscle spirals around heart which produces wringing motion

Heart Wall

- Endocardium
  - smooth inner lining of heart and blood vessels
  - covers the valve surfaces and continuous with endothelium of blood vessels

- Fibrous skeleton of the heart
  - framework of collagen and elastic fibers
  - provides structural support and attachment for cardiac muscle and firm support for valve tissue
  - electrical insulation between atria and ventricles important in timing and coordination of contractile activity

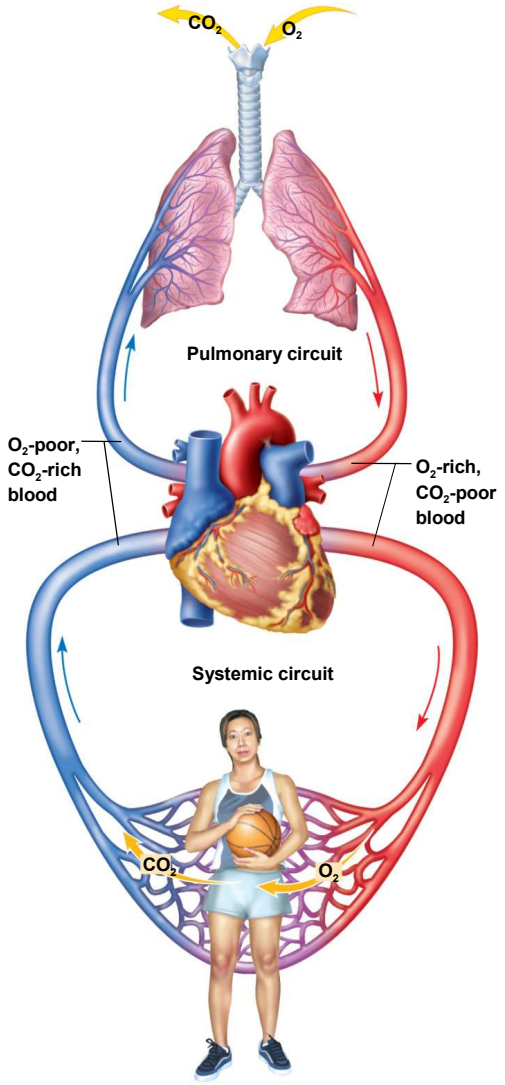
Three Circulatory Circuits of the Heart

– Pulmonary circuit

- right side of heart to lungs
- carries blood to lungs for gas exchange and back to heart // low pressure

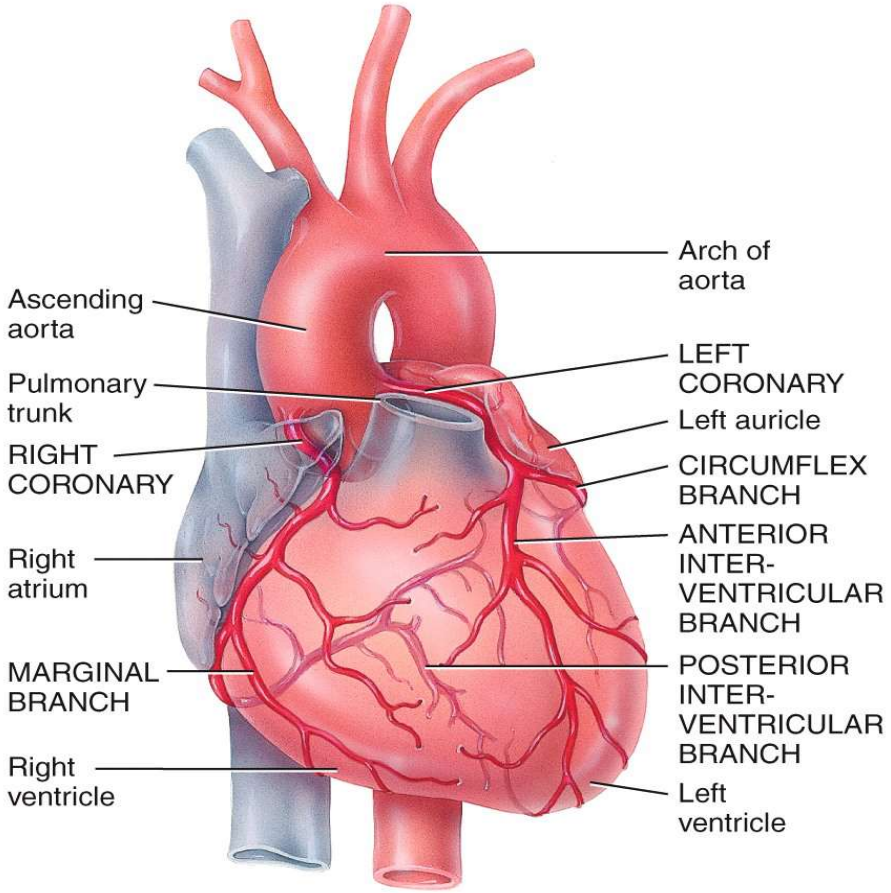
– Systemic circuit

- left side of heart to all tissue of body except lungs
- supplies oxygenated blood to all tissues of the body and returns it to the heart // high pressure



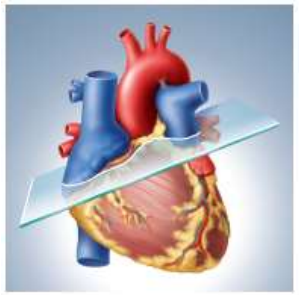
Three Circulatory Circuits of the Heart

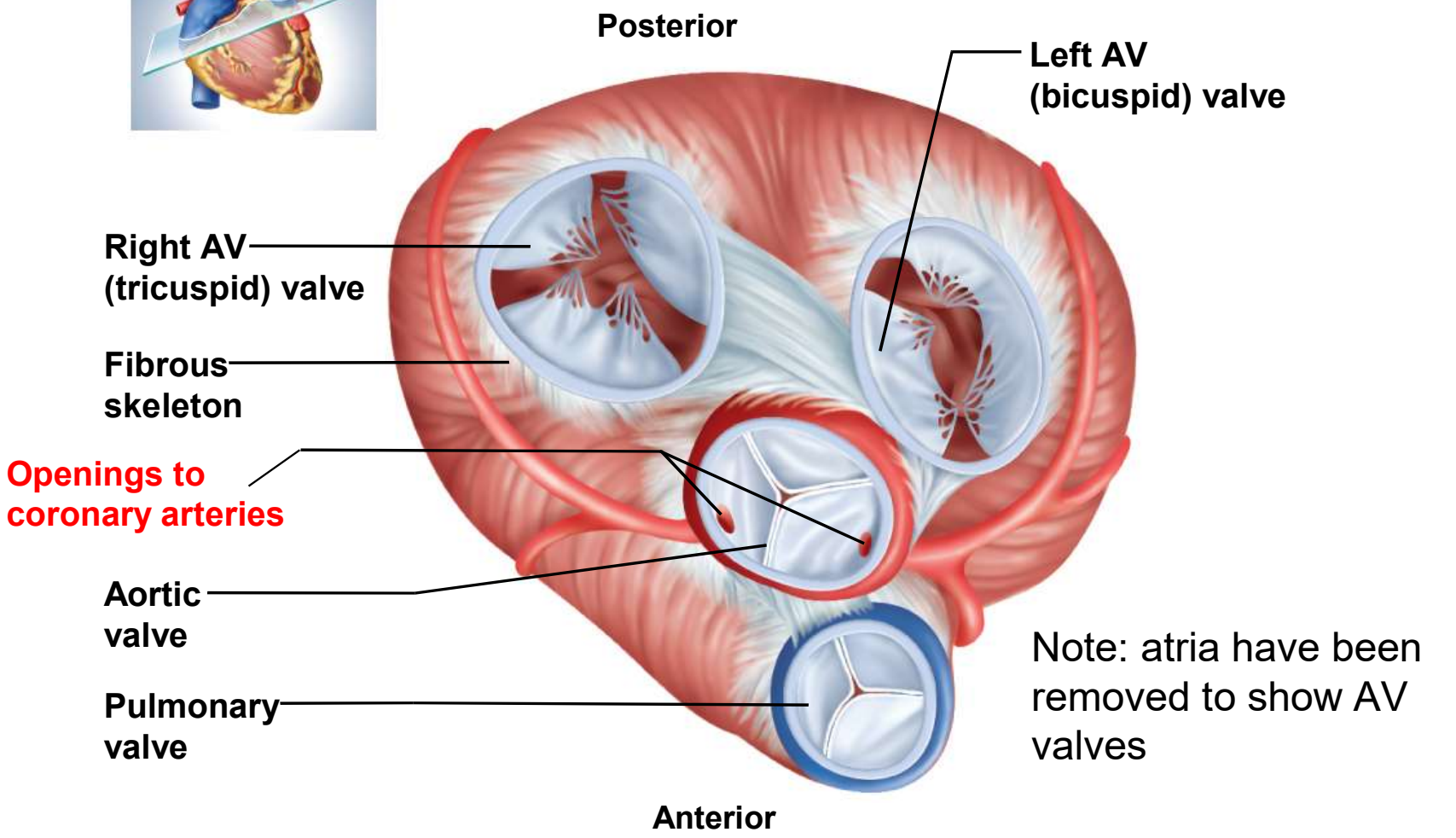
- Coronary Circuit
  - part of the systemic circuit
  - aortic recoil moves blood into the coronary arteries
  - supply the myocardiocytes (the cells making the walls of the heart) with blood circulation
  - RCA – divides into the marginal artery branch and the posterior interventricular branch
  - LCA – divides into circumflex brach and the anterior interventrcicular brach



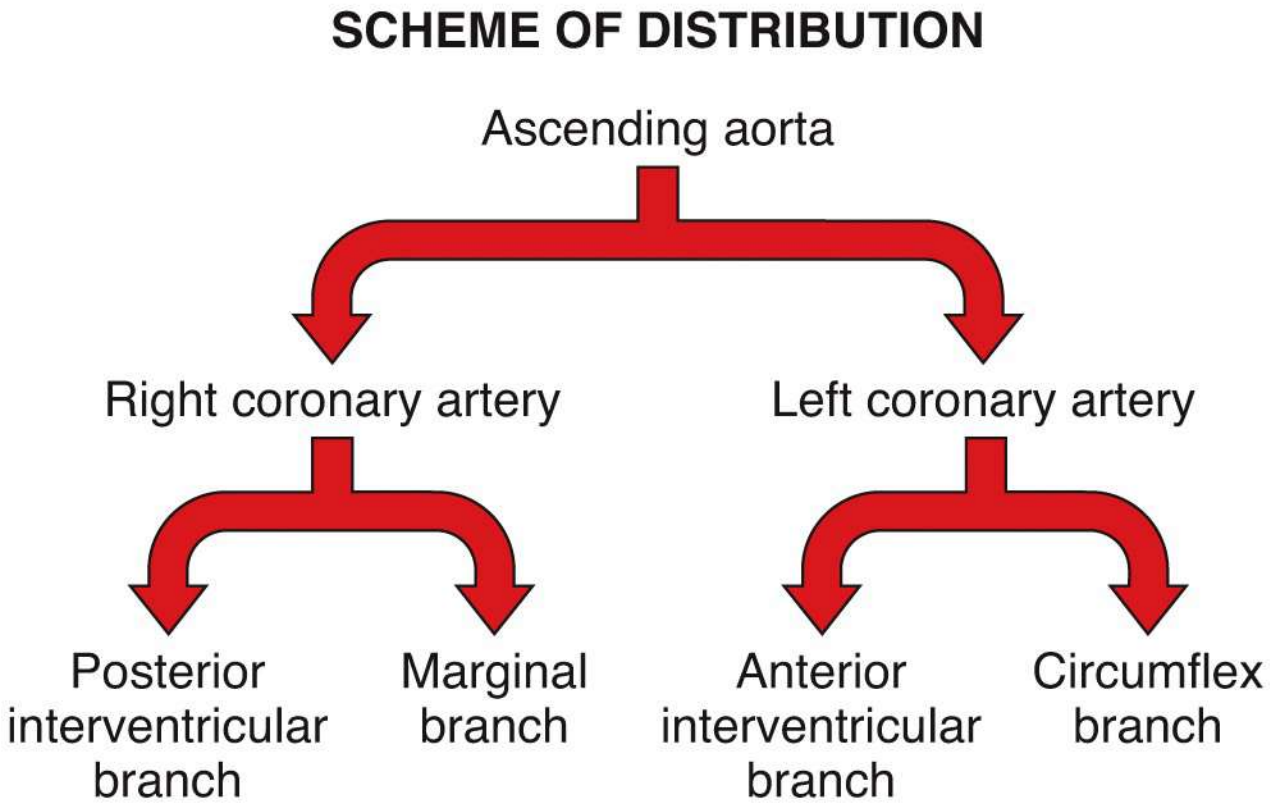
(a) Anterior view of coronary arteries

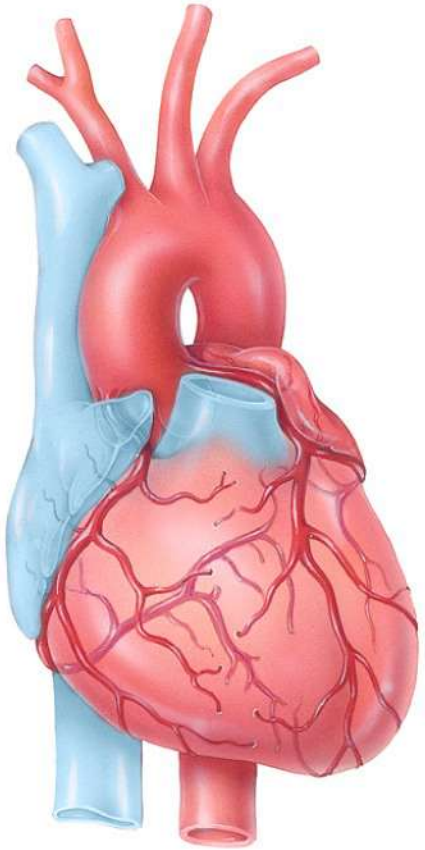
Entrance to Coronary Circuit





Note: atria have been removed to show AV valves





Important Lab Learning Objective!

Blood Flow

1 in	3 in
2 out	4 out

1. Blood enters right atria from superior vena cava, inferior vena cava, and coronary sinus

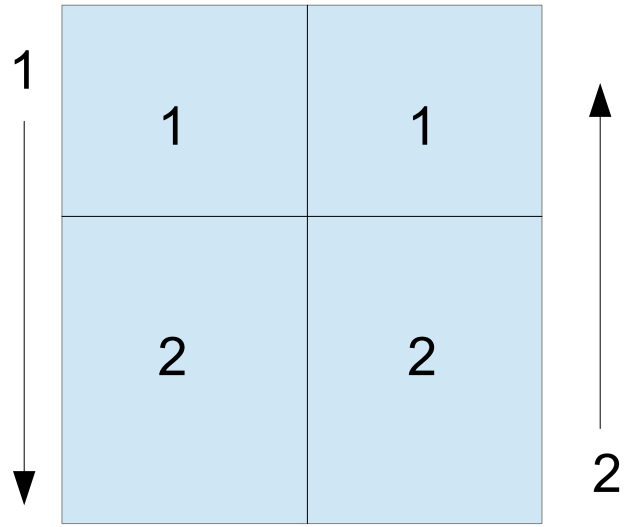
2. Blood moves into right ventricle and is ejected from heart into pulmonary trunk then to lungs

3. Blood returns from lungs to fill left atria.

4. Blood moves into left ventricle and then ejected from heart and moves into the aorta.

Note: the blood flow is a closed system. So the amount of blood moving through the right and left side of the heart must be the same volume.

Heart's Pumping Action



The cardiac cycle at rest is 0.8 sec. During the cycle the atria and ventricle muscles complete a single contraction and relaxation

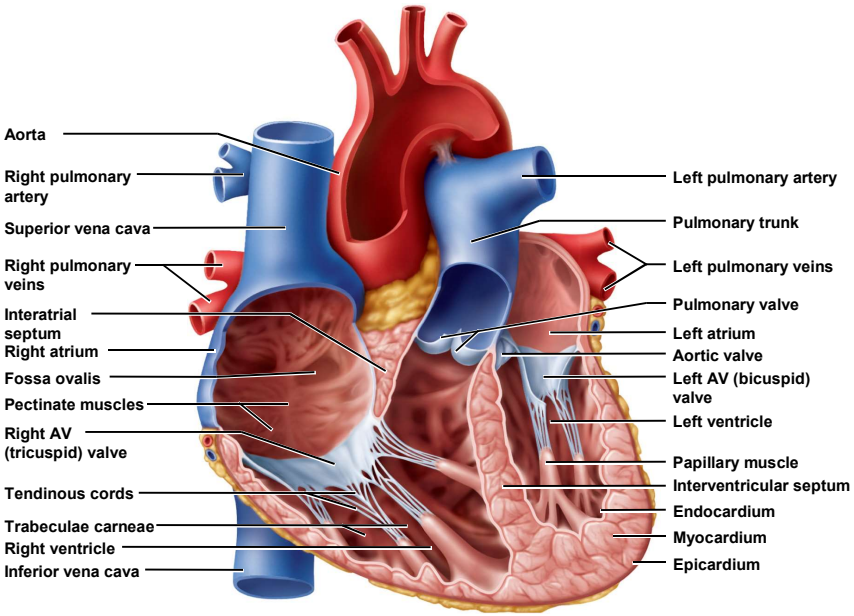
The cardia cycle occurs in two phases. The first phase forces blood down (1). The second phase pushes blood up (2).

1. The first phase occurs when the right and left atria contract, forcing blood into the ventricles. While the atria contract the ventricles are relaxed.

4. The second phase occurs after the atria completes its contraction. Then the ventricles contract to close the AV valves, open the semilunar vales, and efect blood from the heart. As the ventricles contract the atria relax.

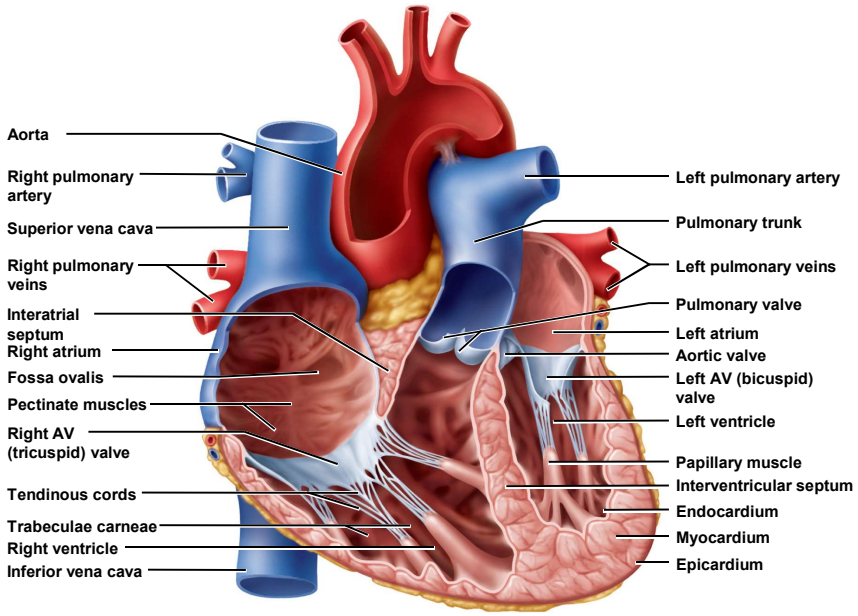
Four Chambers of he Heart

- Superior chambers
  - right and left atria_
  - two superior chambers
  - receive blood returning to heart from pulmonary veins and vena cava
  - auricles (seen on surface) allow chambers to expand volume
  - both upper chambers contract together to move blood downward into the right and left ventricles

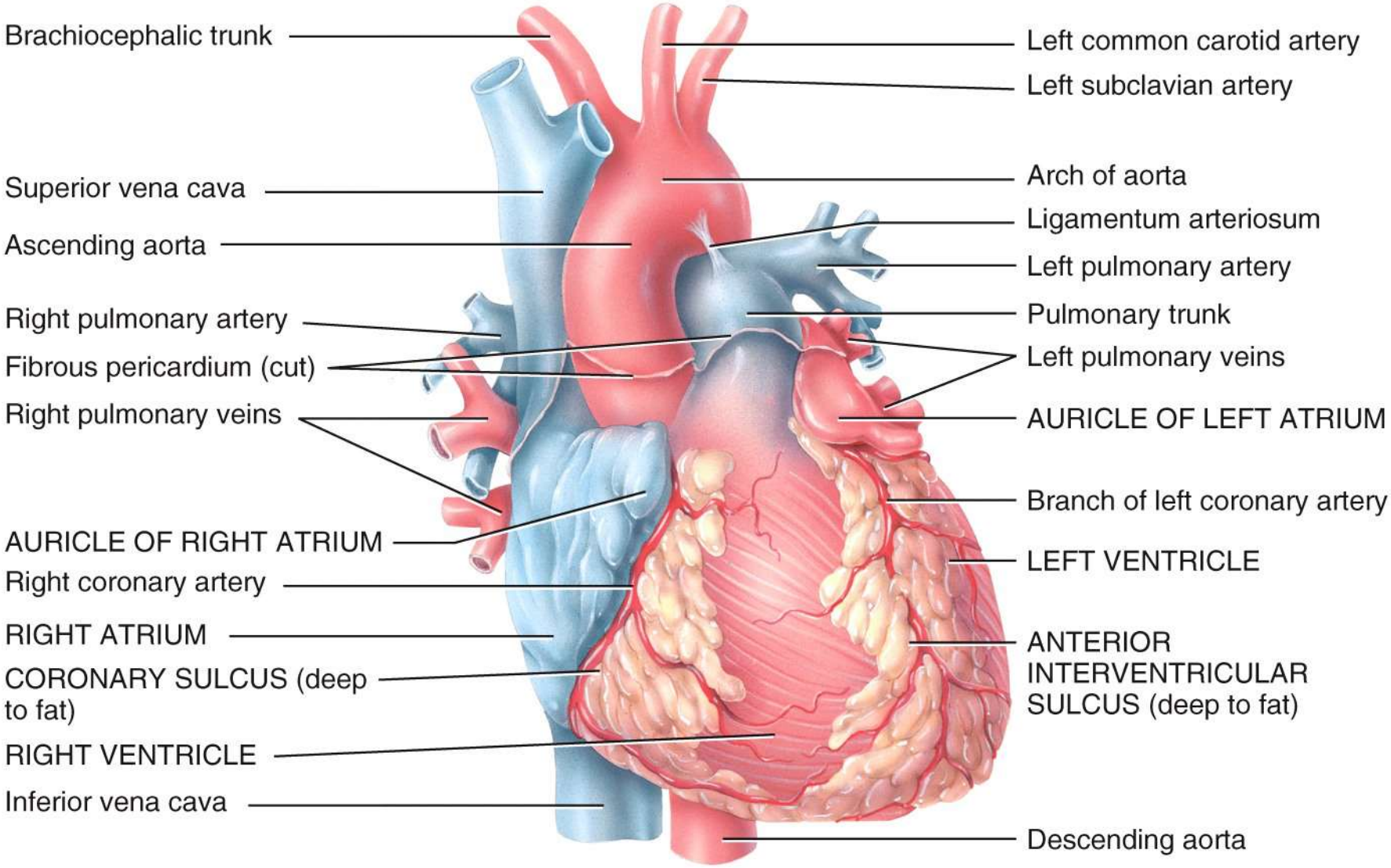


Four Chambers of he Heart

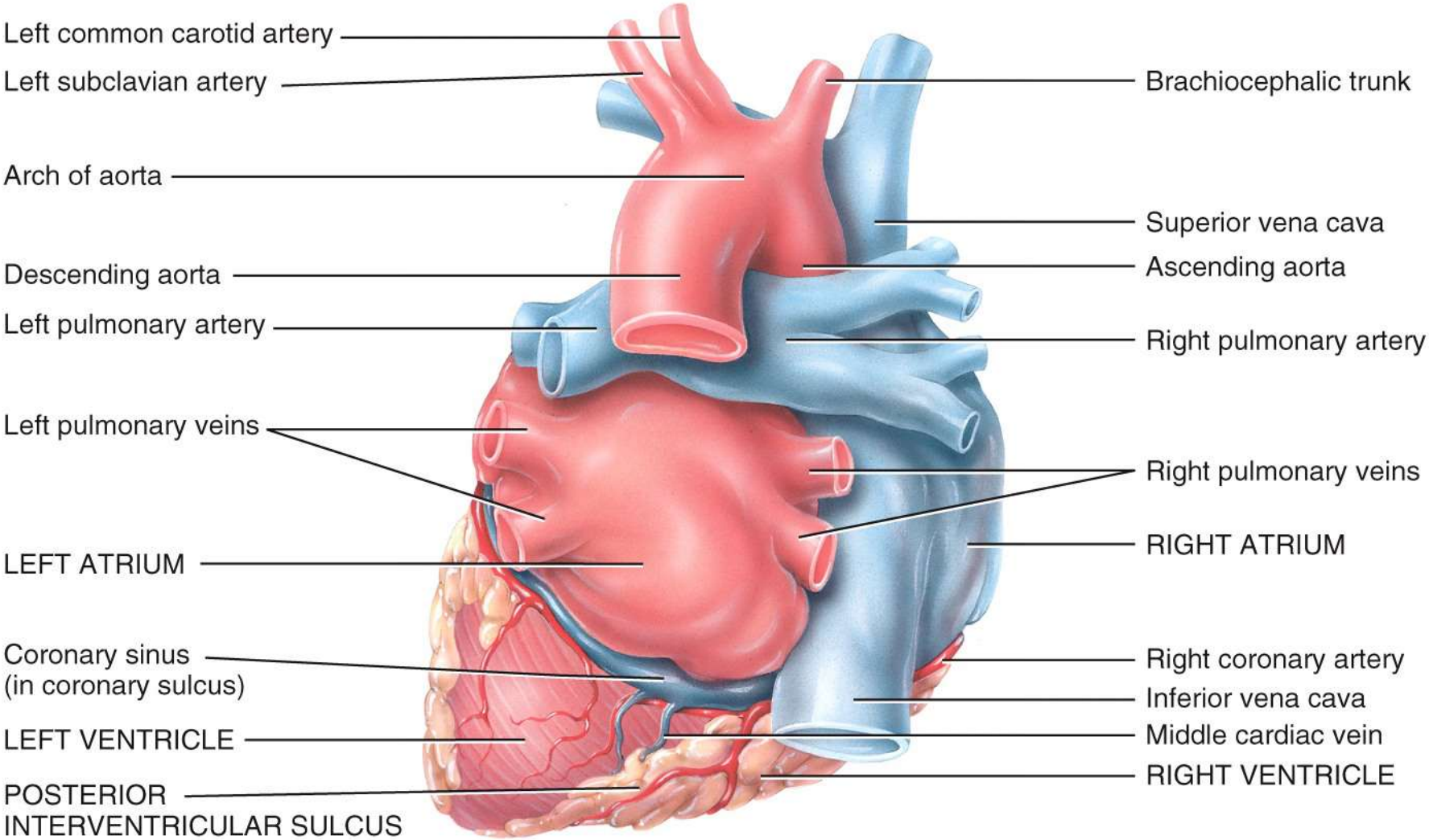
- Inferior chambers
  - right and left ventricles
  - both ventricles contract together
  - right ventricle pump blood into pulmonary truck
  - left ventricle pump blood into aorta



Note: heart is a four chamber pump // low pressure and high pressure sides // blood circulates through heart however blood flow moves as an “atrial downward” phase followed by a “ventricular upward” phase

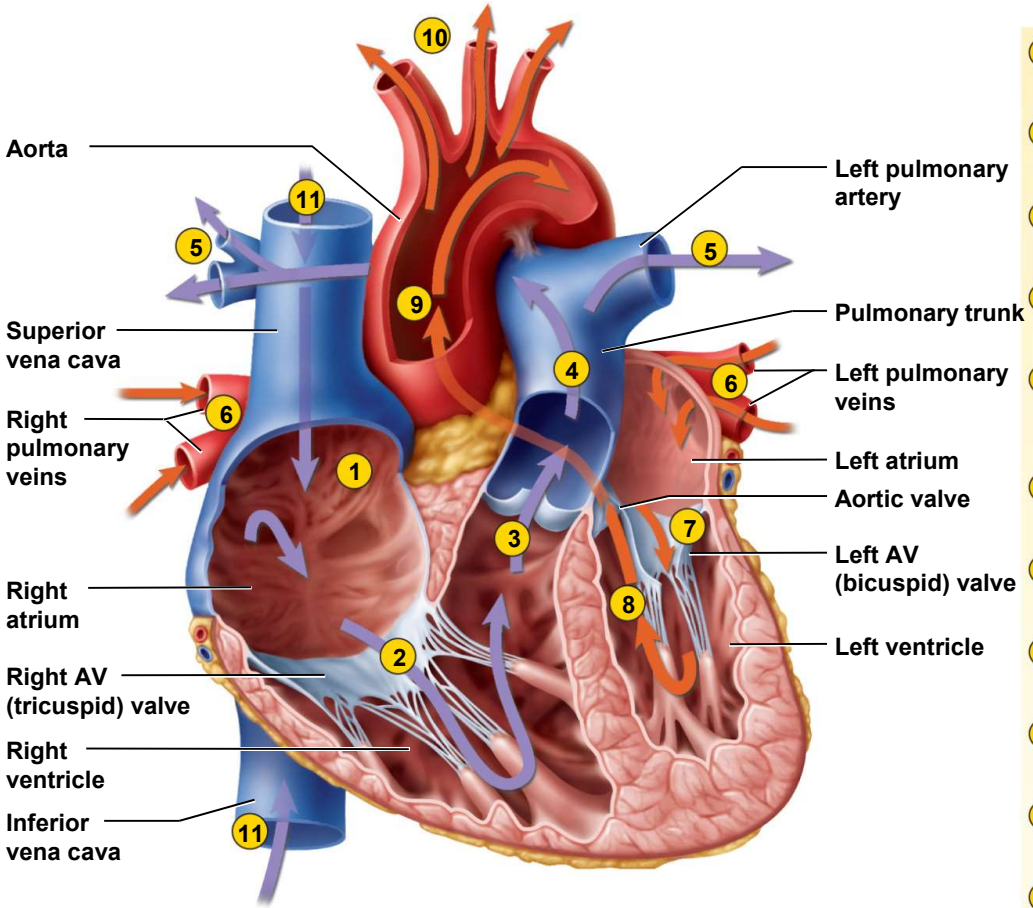


(a) Anterior external view showing surface features



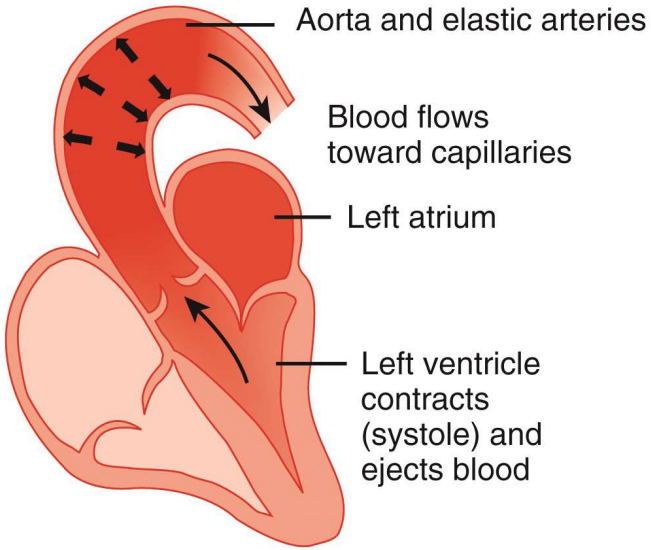
(c) Posterior external view showing surface features

Blood Flow Through Heart

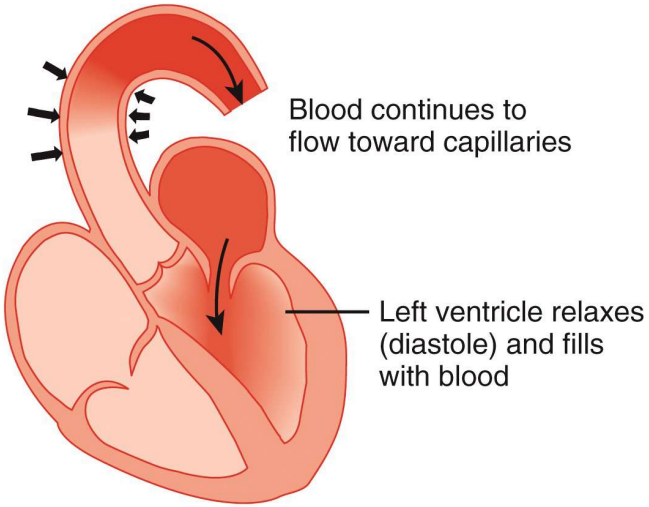


1. Blood enters right atrium from superior and inferior venae cavae.
2. Blood in right atrium flows through right AV valve into right ventricle.
3. Contraction of right ventricle forces pulmonary valve open.
4. Blood flows through pulmonary valve into pulmonary trunk.
5. Blood is distributed by right and left pulmonary arteries to the lungs, where it unloads CO_2 and loads O_2.
6. Blood returns from lungs via pulmonary veins to left atrium.
7. Blood in left atrium flows through left AV valve into left ventricle.
8. Contraction of left ventricle (simultaneous with step 3) forces aortic valve open.
9. Blood flows through aortic valve into ascending aorta.
10. Blood in aorta is distributed to every organ in the body, where it unloads O_2 and loads CO_2.
11. Blood returns to heart via venae cavae.

blood enters right atria and starts its movement through heart / blood pressure and heart valves direct flow of blood / there are no valves at the inferior or superior vena cava



(a) Elastic aorta and arteries stretch during ventricular contraction



(b) Elastic aorta and arteries recoil during ventricular relaxation

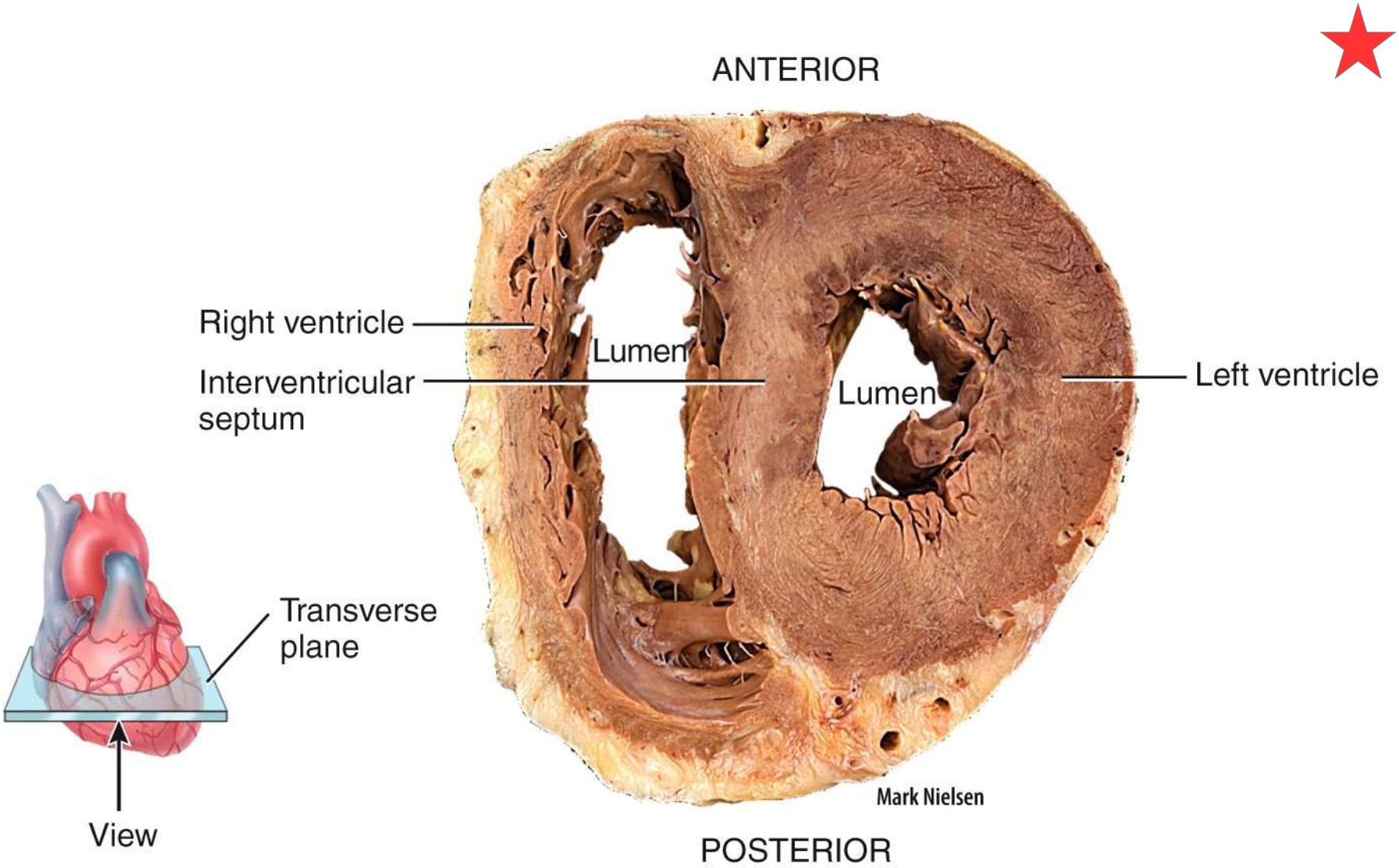
The start of ventricular diastole occurs at the same time as aortic recoil.

As blood moves into the systemic circuit, the walls of the aorta are stretched followed by aortic recoil. This moves blood further into the systemic circuit but also moves blood to flow back towards the left ventricle. This movement of blood towards the left ventricle closes the aortic semilunar valve.

As the semilunar valve closes, now the passage way into the right and left coronary arteries are open.

The force of the recoiling aorta moves blood into the coronary circuit at the same time as the myocardium enters into a relaxed state.

Why does this make sense?



(c) Inferior view of transverse section showing differences in thickness of ventricular walls

Blood Flow Through Heart

- Right atria
- Right ventricle
- Pulmonary truck into pulmonary circulation (lungs)
- Left atria
- Left ventricle
- Aorta to systemic circulation (all tissues of body except lungs)
- (see next slide)

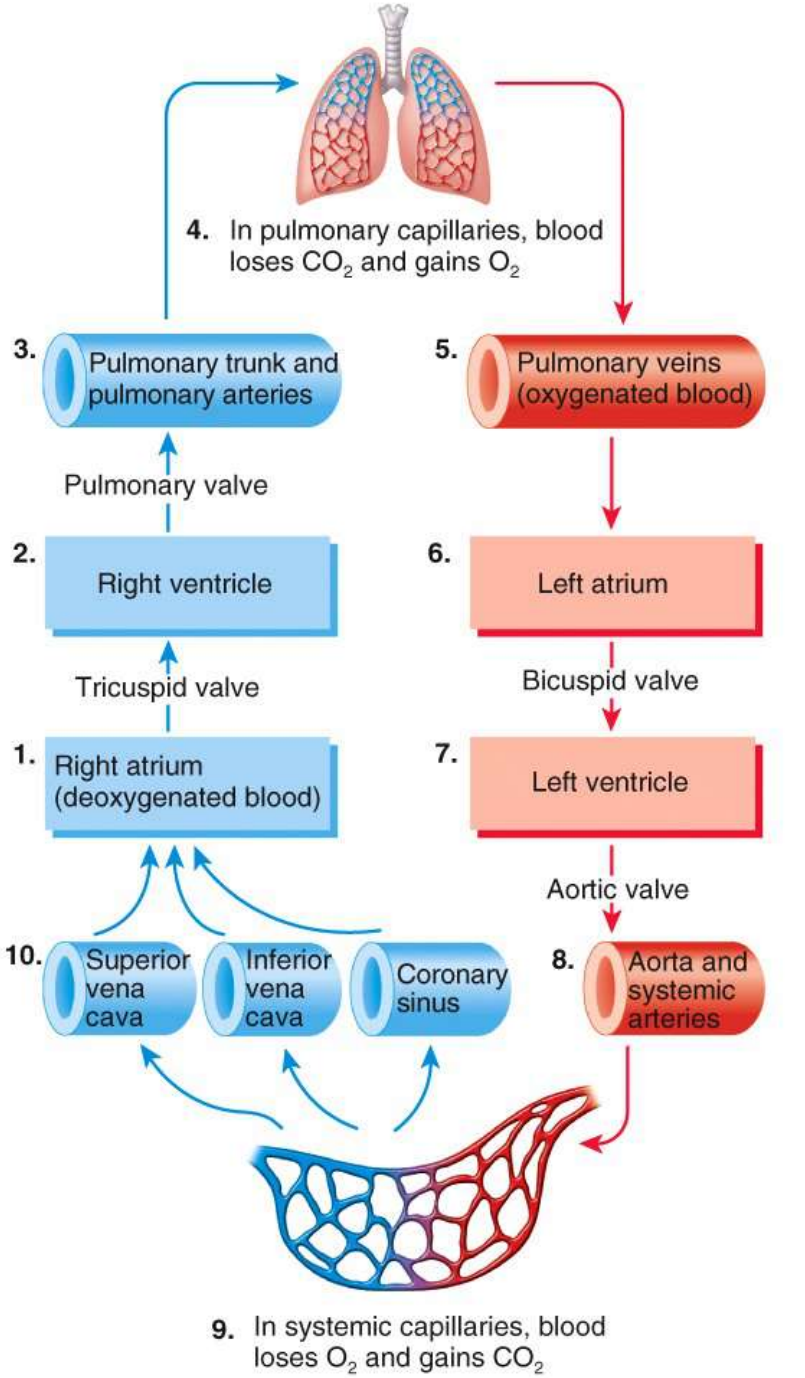
Note: blood enters the right atria via superior vena cava, inferior vena cava, coronary sinus, and thebesian veins (highest concentration in right atria and lowest concentration in left ventricle)

Note: <u>blood flow through the heart is different than the pumping action of the heart</u>

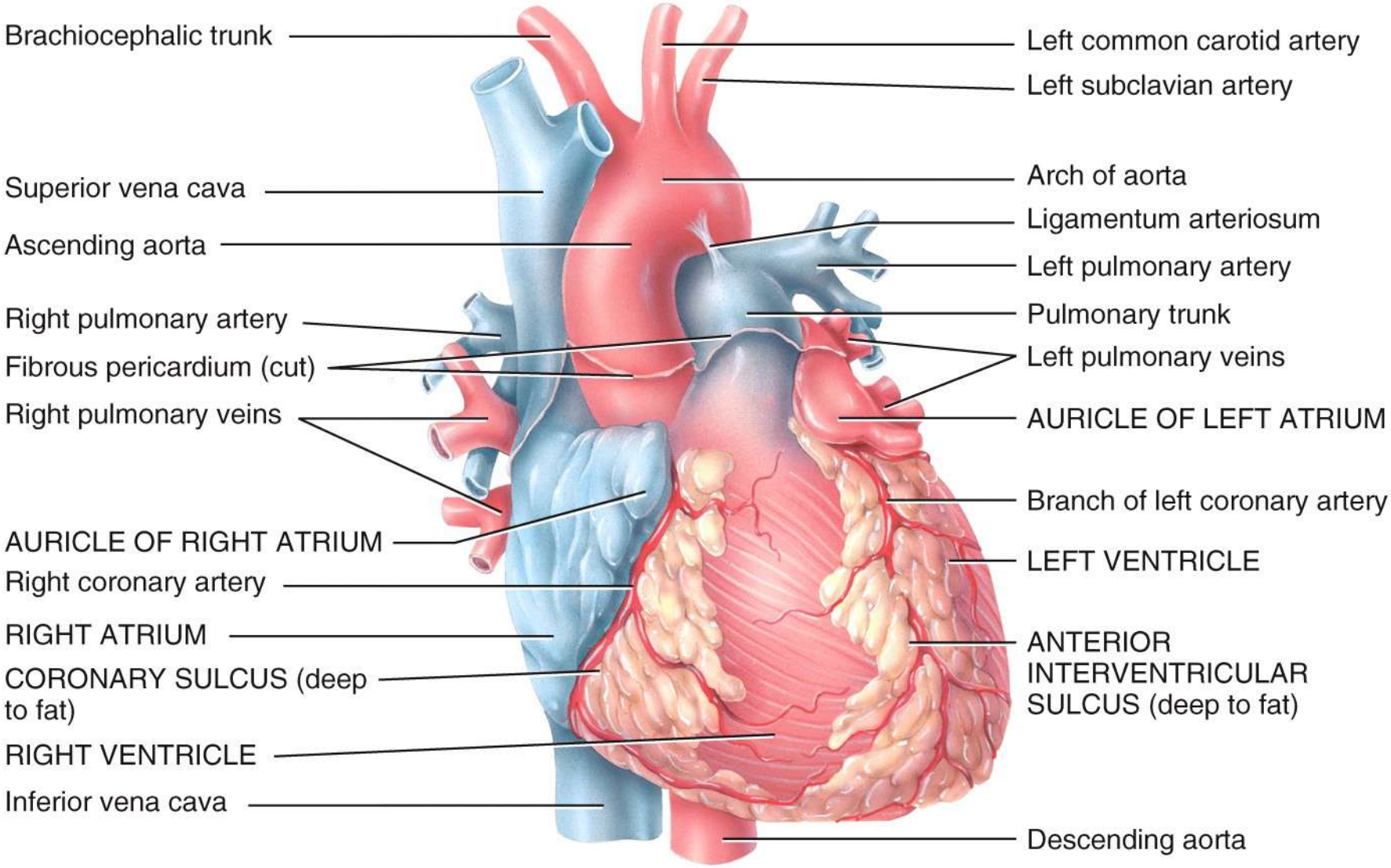
pumping action occurs as two separate pumps (right side & left side) working "in phase"

first action is to move blood downward in both pumps

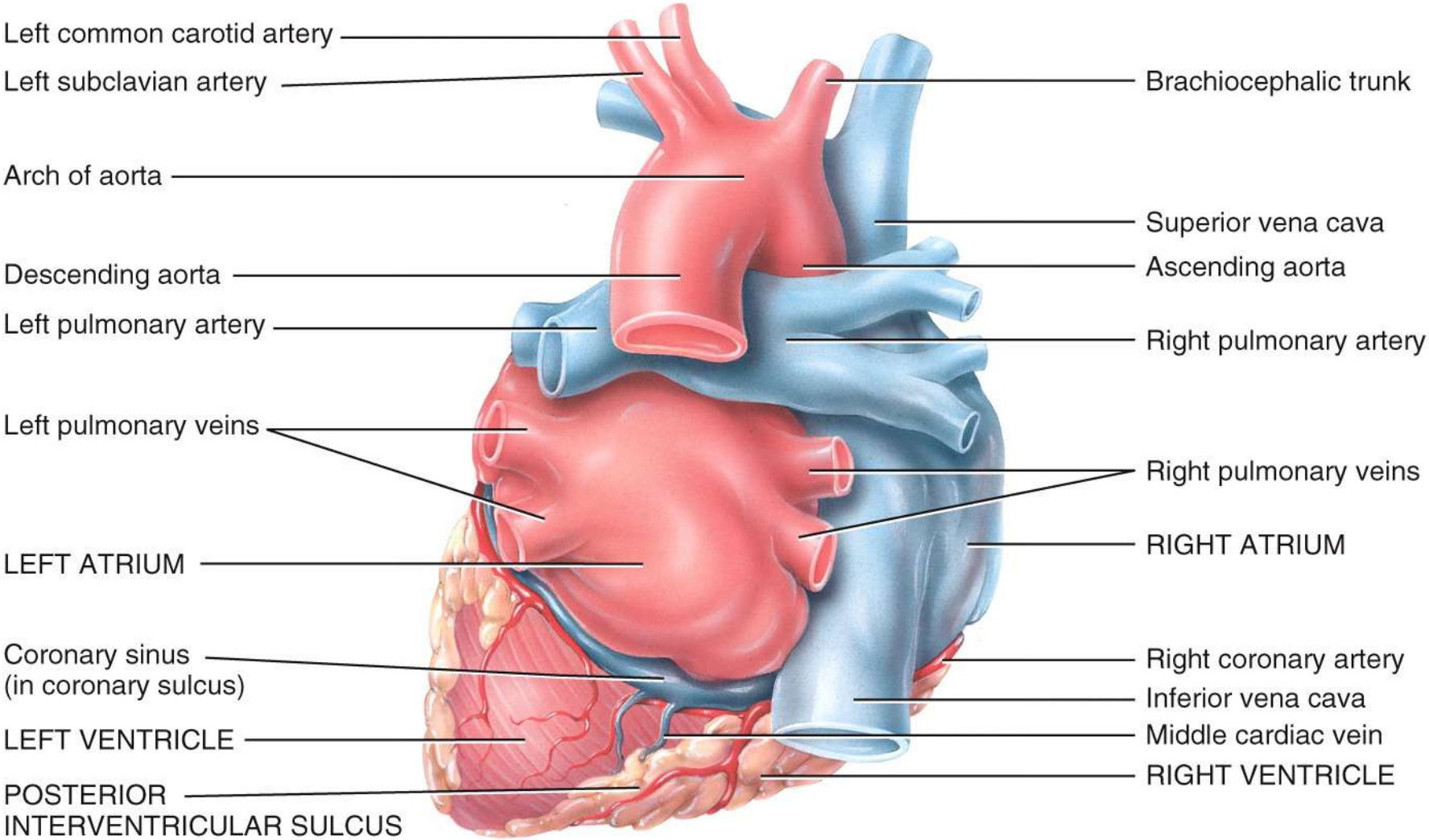
Second action is to pump blood upward



(b) Path of blood flow through systemic and pulmonary circulations

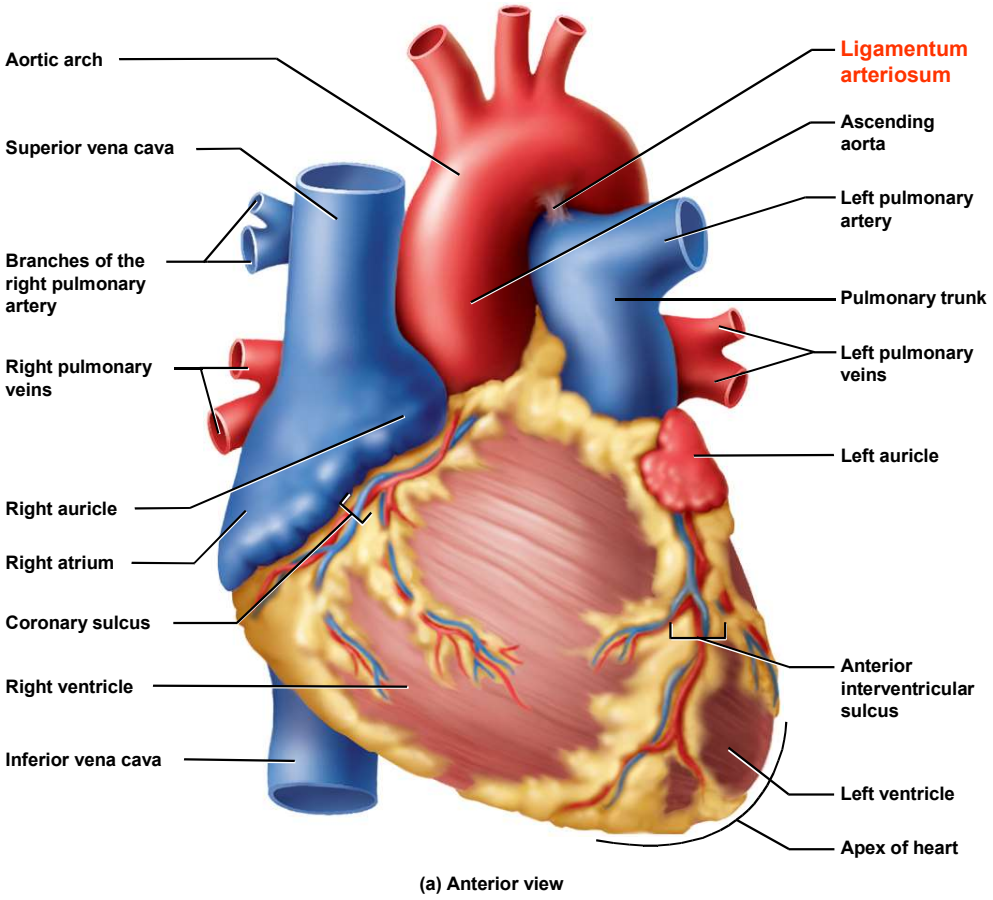


(a) Anterior external view showing surface features



(c) Posterior external view showing surface features

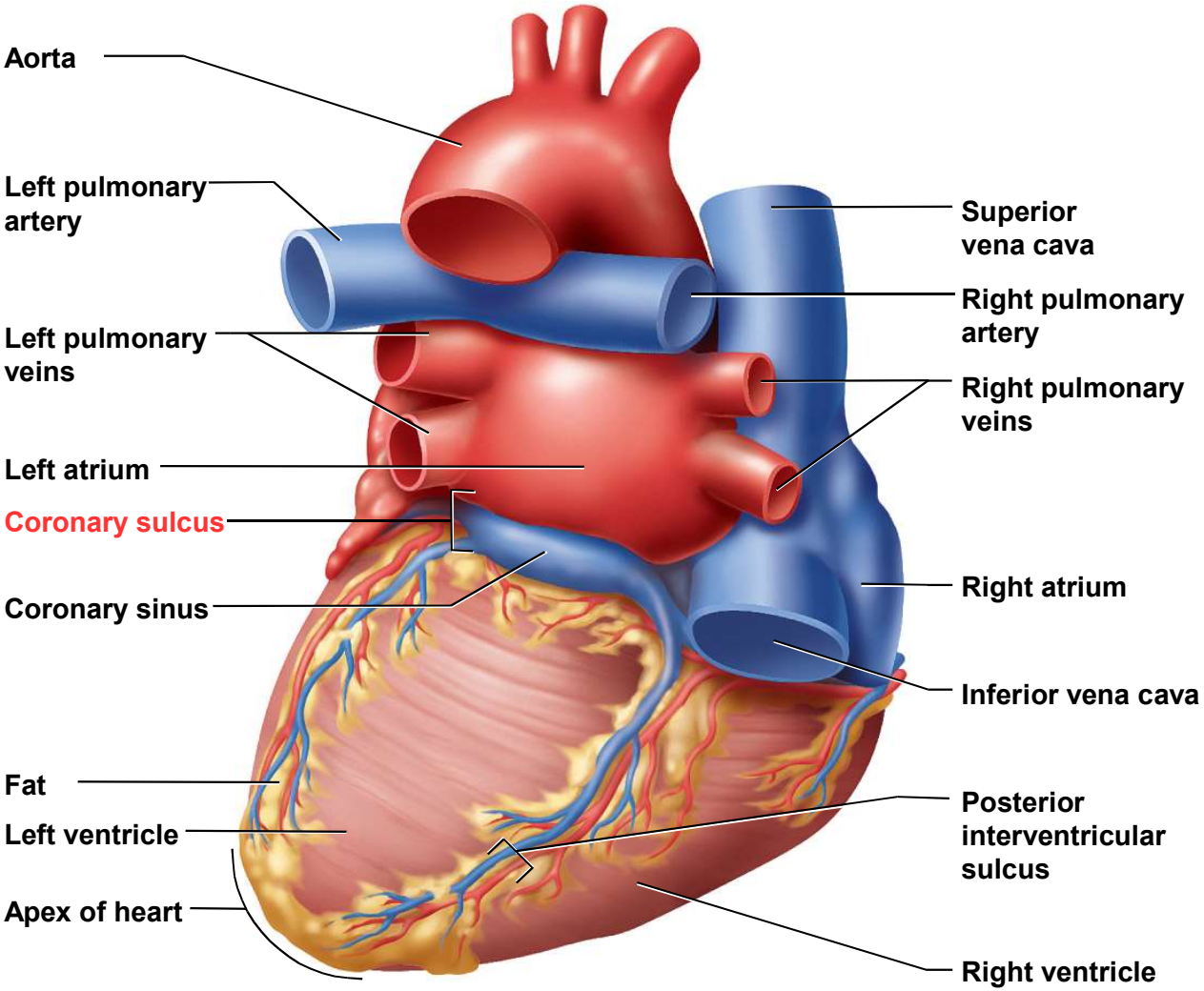
External Anatomy - Anterior



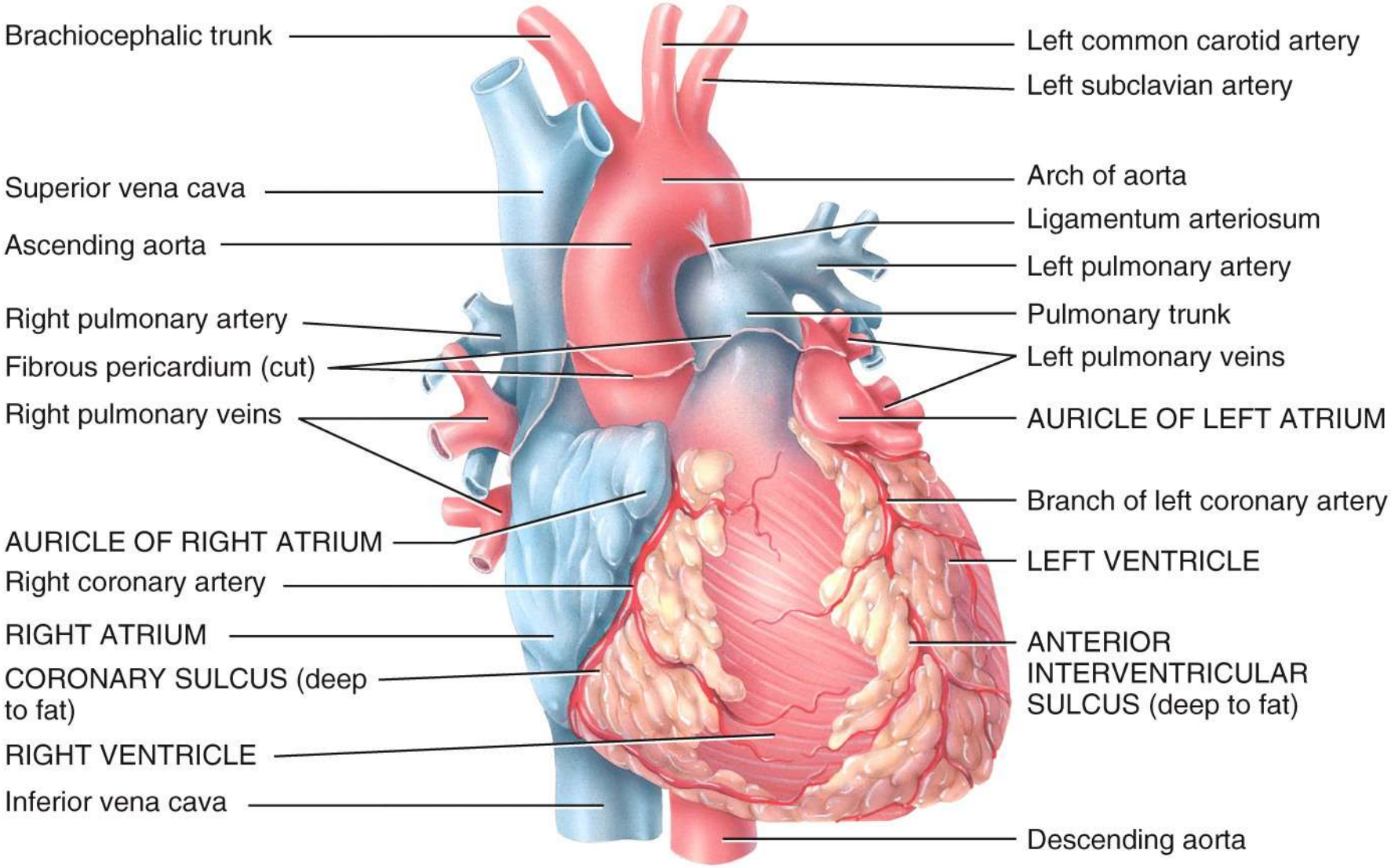
(a) Anterior view

- atrioventricular sulcus
  - separates atria and ventricles
- interventricular sulcus
  - lies over the interventricular septum that divides the right ventricle from the left
  - anterior and posterior
- Note: sulci are grooves on surface of heart that contain coronary arteries, as well as other heart arteries and veins

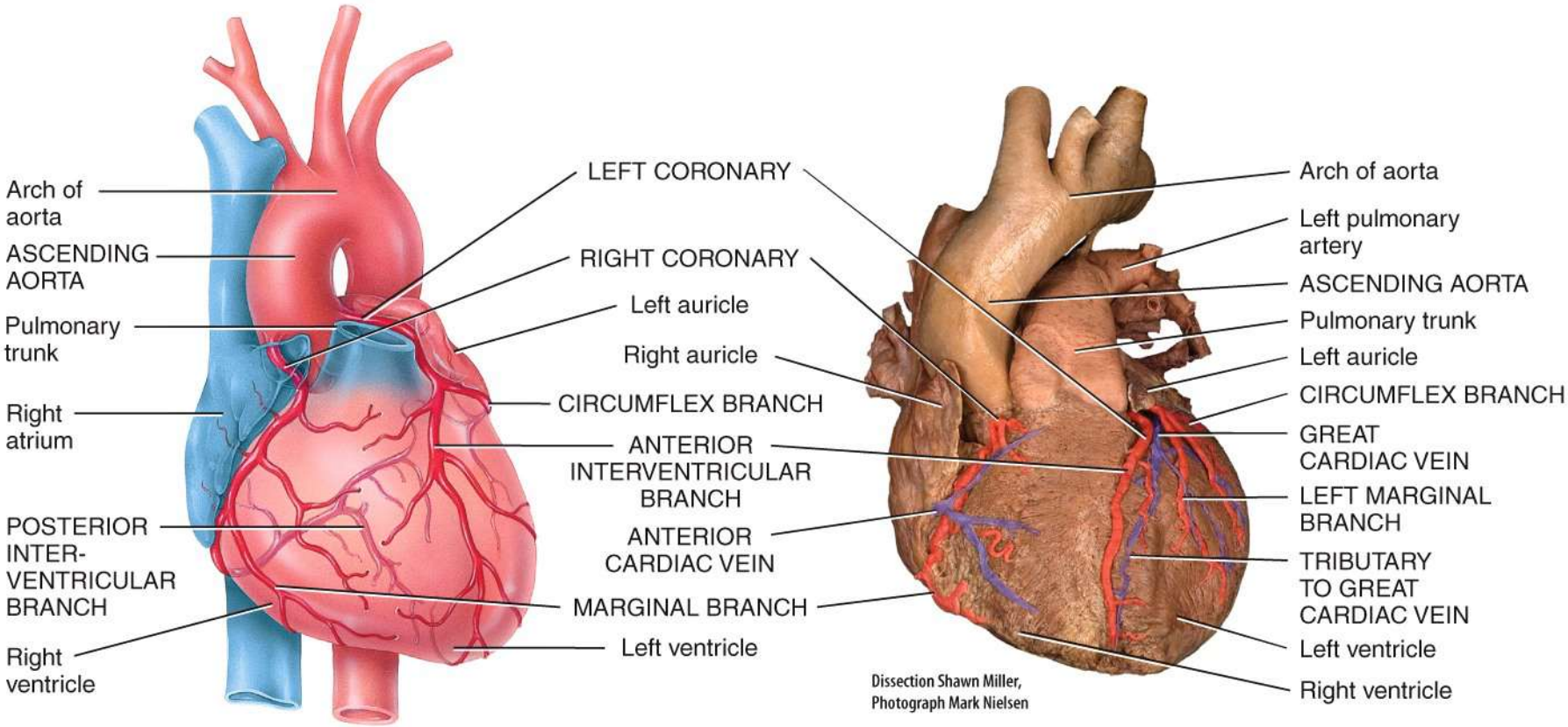
External Anatomy - Posterior



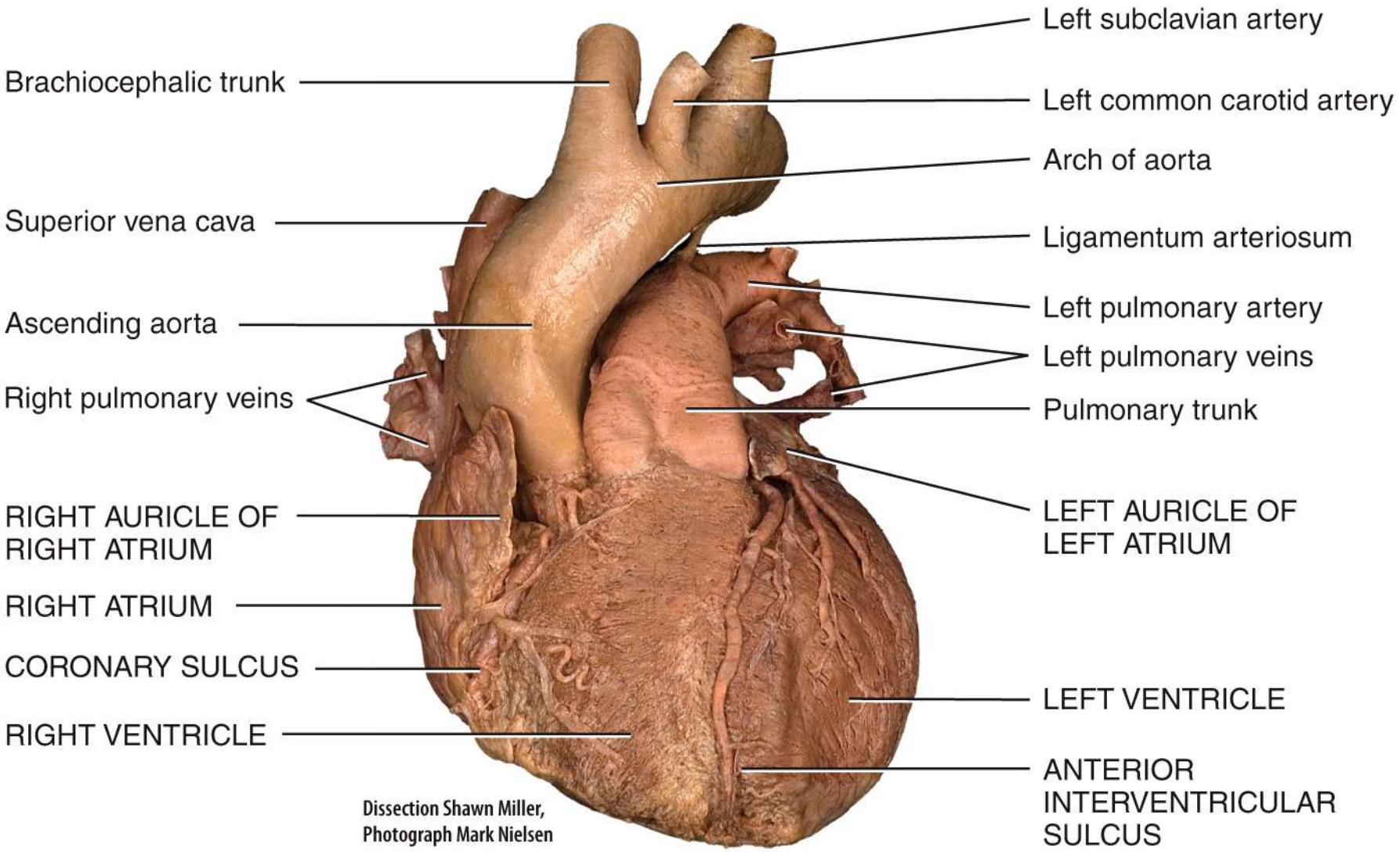
(b) Posterior view



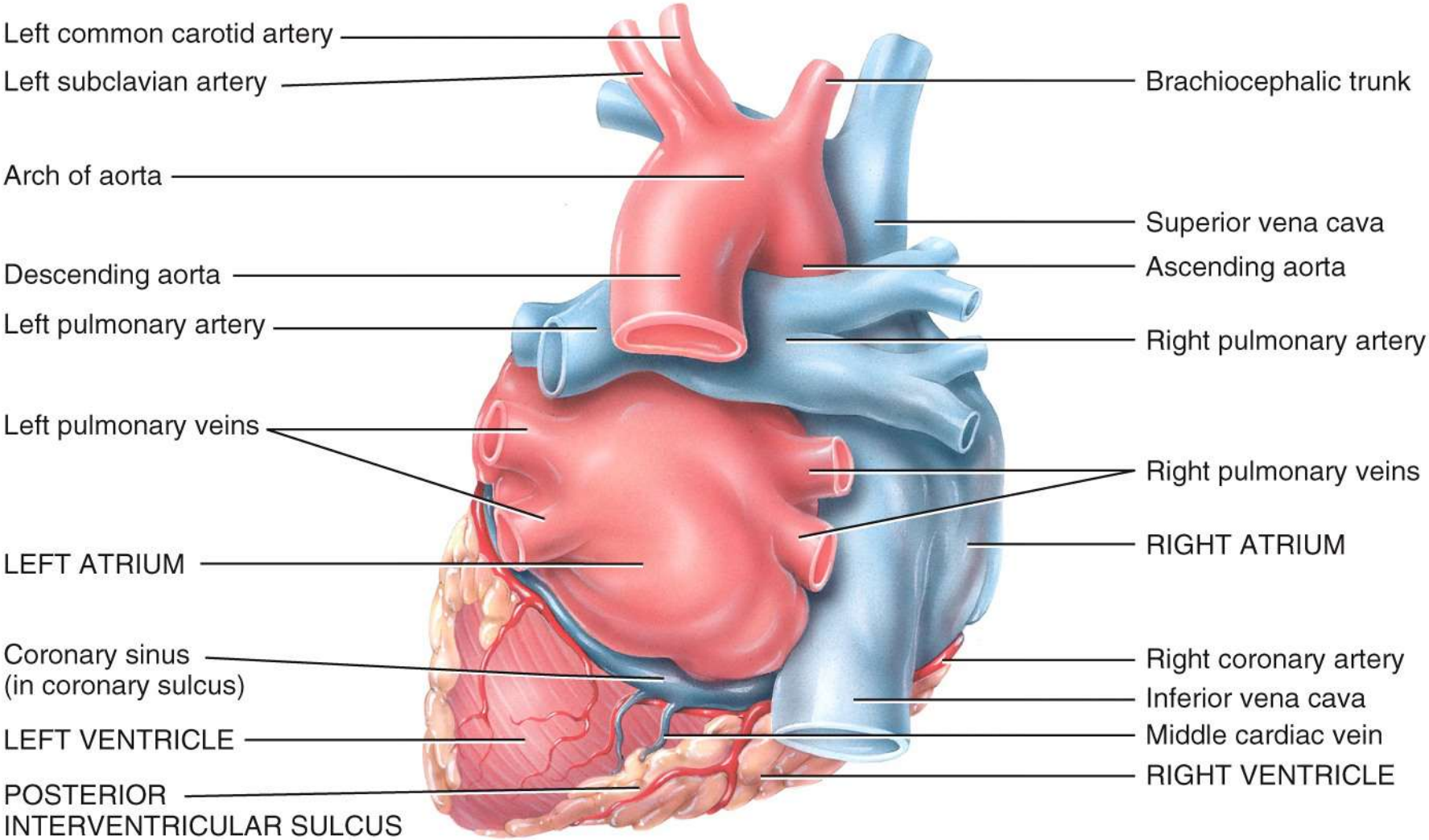
(a) Anterior external view showing surface features



Anterior view of coronary arteries and their major branches

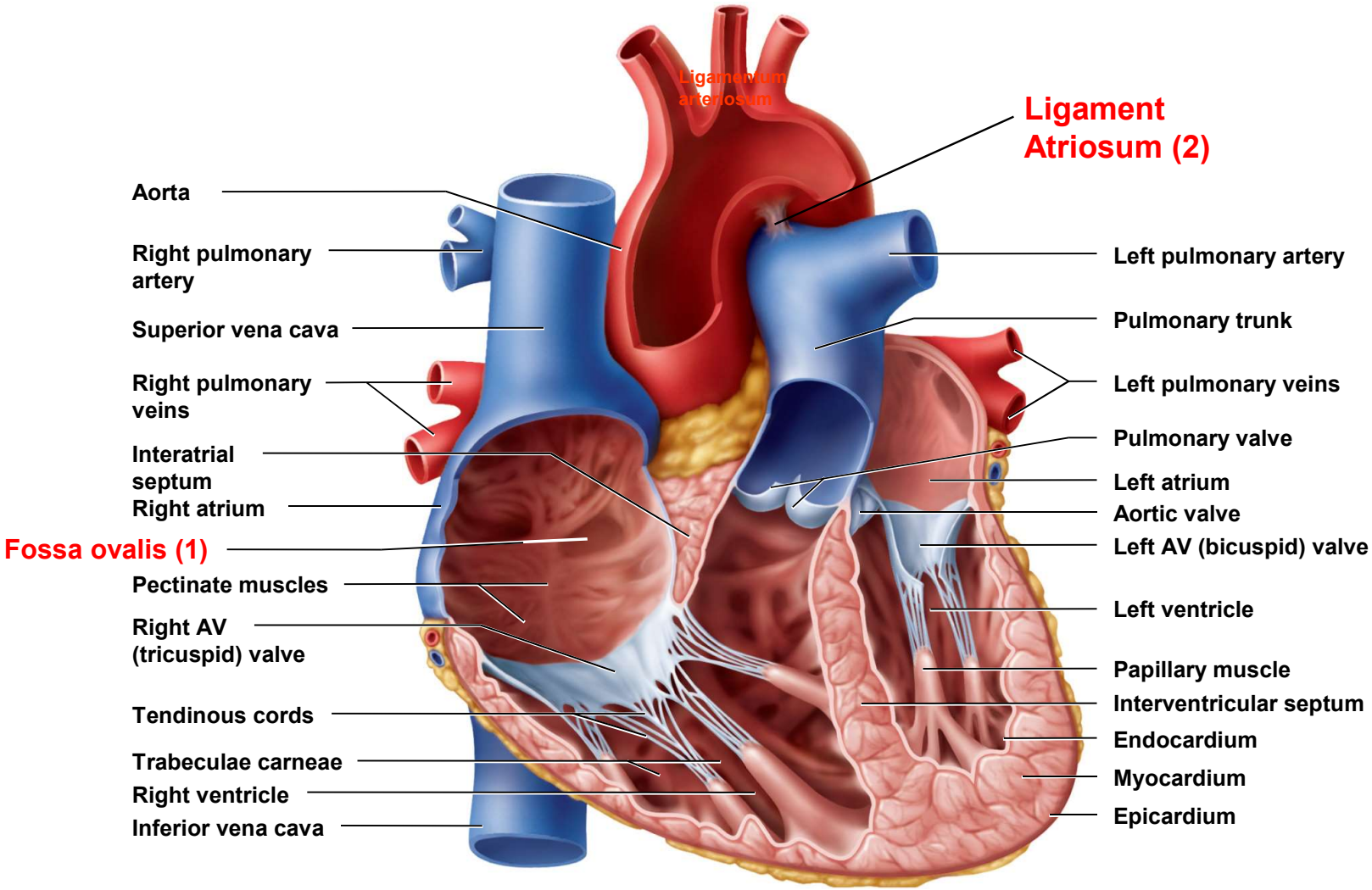


(b) Anterior external view



(c) Posterior external view showing surface features

Internal Anatomy - Anterior

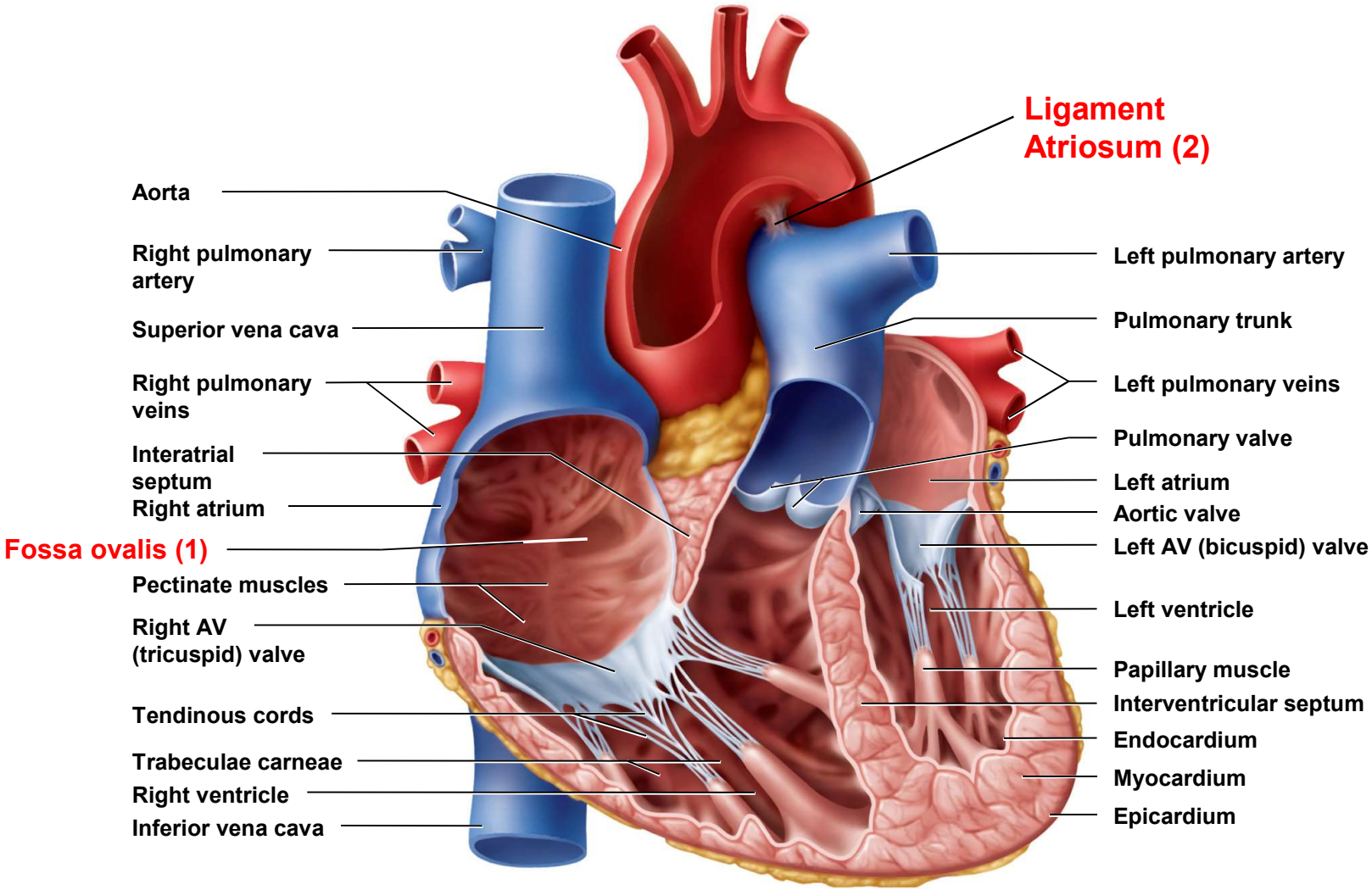


Notes: (1) foramine ovalis / (2) Dutus Atriosum / fetal structures to redirect blood into systemic circulation

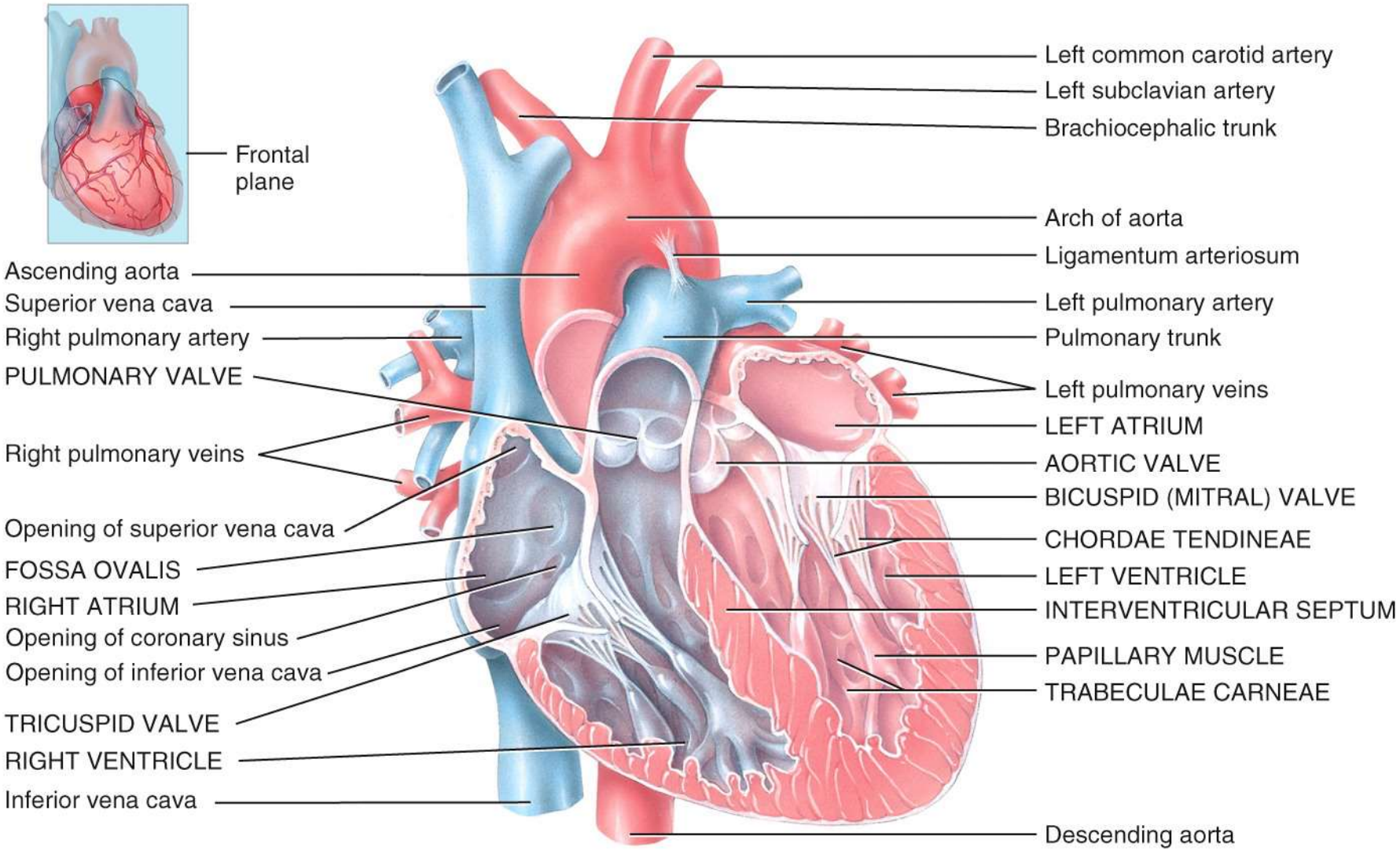
Heart Chambers – Internal Structures

- interatrial septum
  - wall that separates atria
- pectinate muscles
  - internal ridges of myocardium in right atrium and both auricles
- interventricular septum
  - muscular wall that separates ventricles
- trabeculae carneae
  - internal ridges in both ventricles

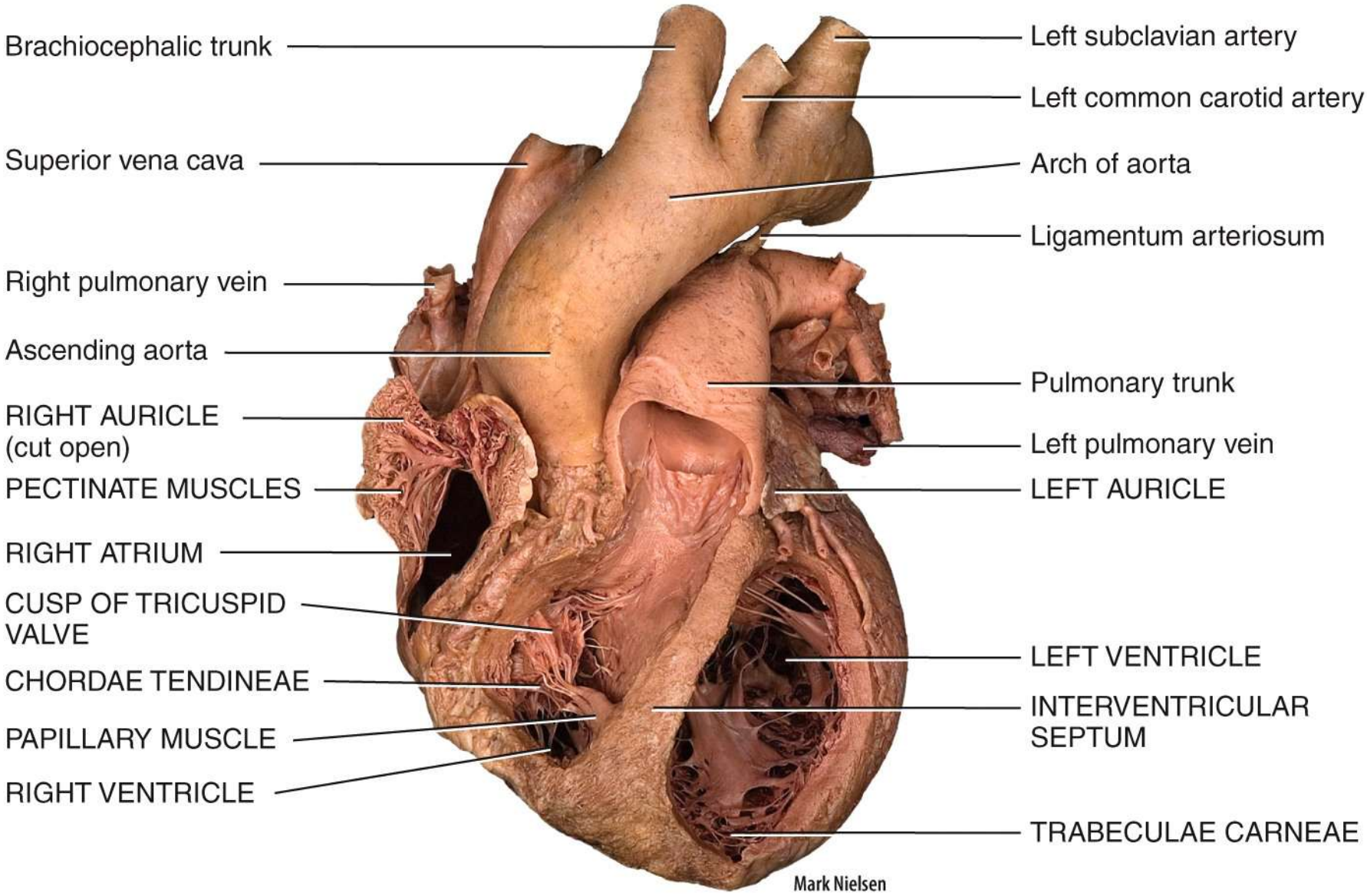
Internal Anatomy - Anterior



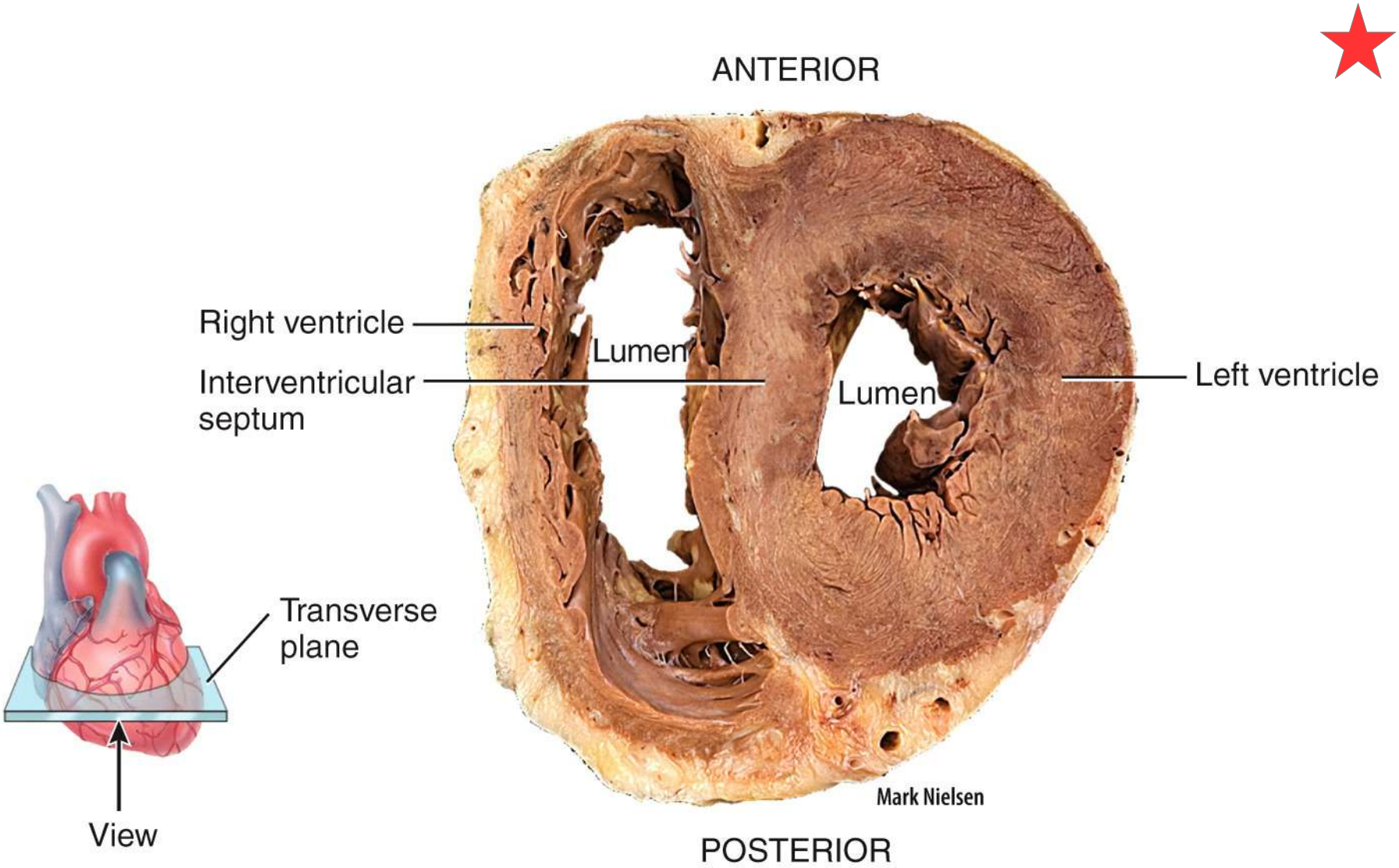
Notes: (1) foramine ovalis / (2) Dutus Atriosum / fetal structures to redirect blood into systemic circulation



(a) Anterior view of frontal section showing internal anatomy

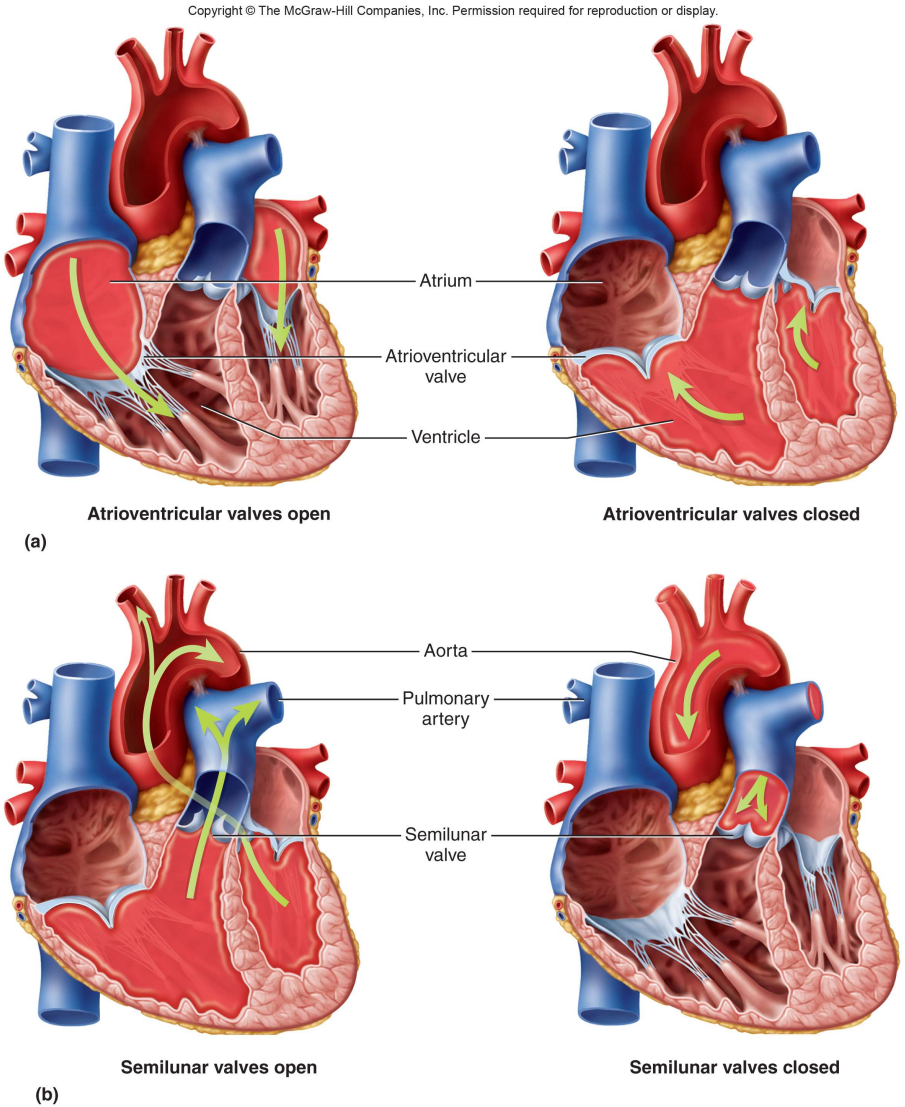


(b) Anterior view of partially sectioned heart



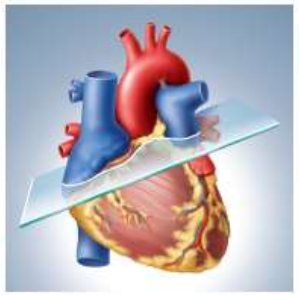
(c) Inferior view of transverse section showing differences in thickness of ventricular walls

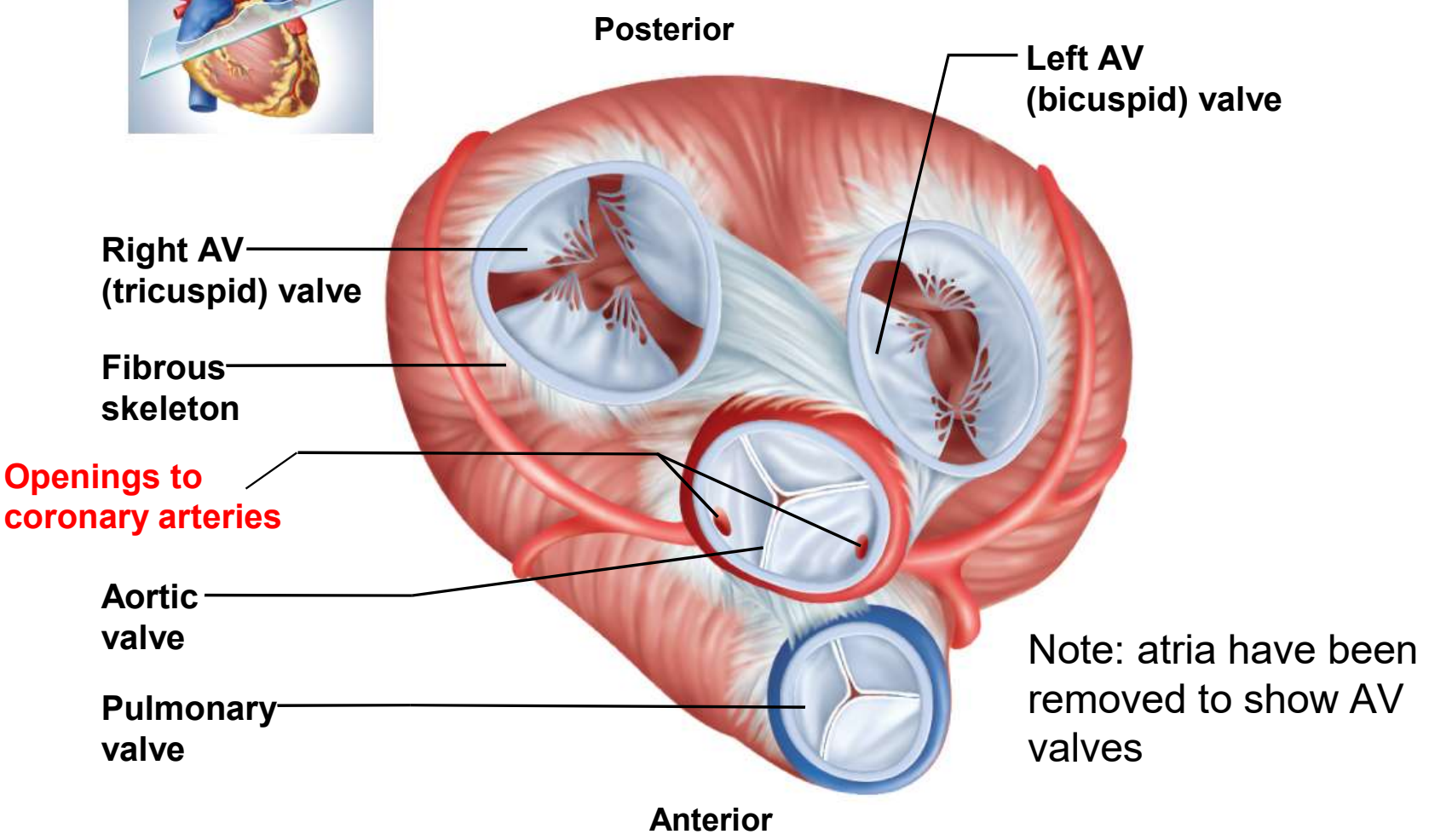
Function of Heart Valves



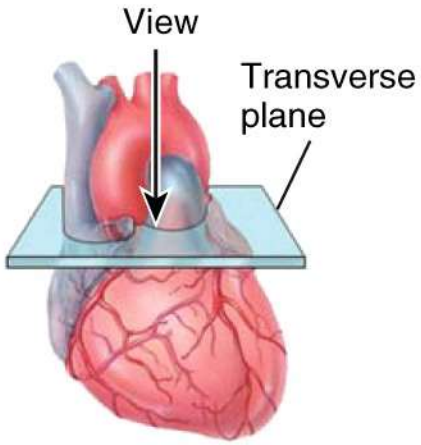
- Valves ensure a one-way flow of blood through the heart
- Blood flows from an area of high pressure to an area of low pressure
- The pressure difference across the valve open and close these valves

Heart Valves

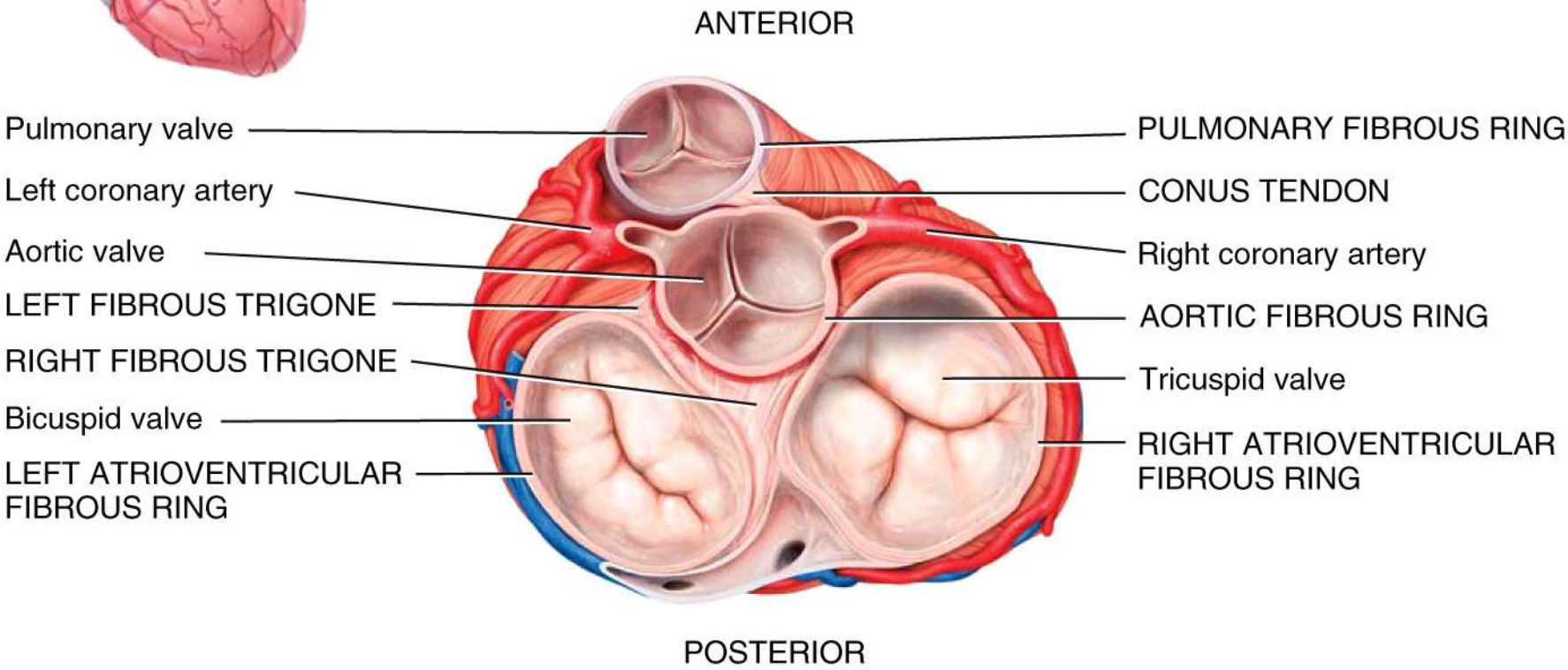




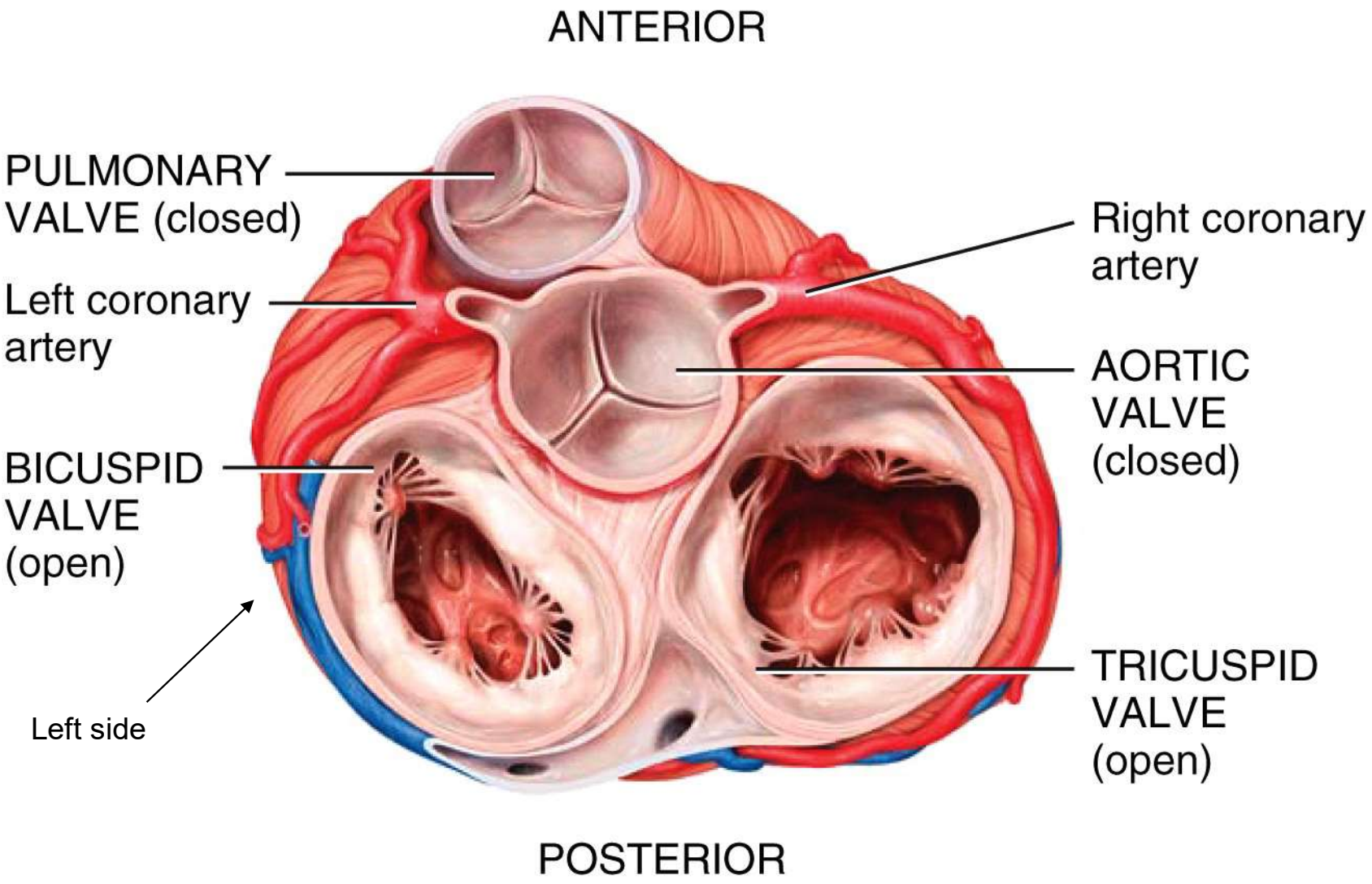
Note: atria have been removed to show AV valves



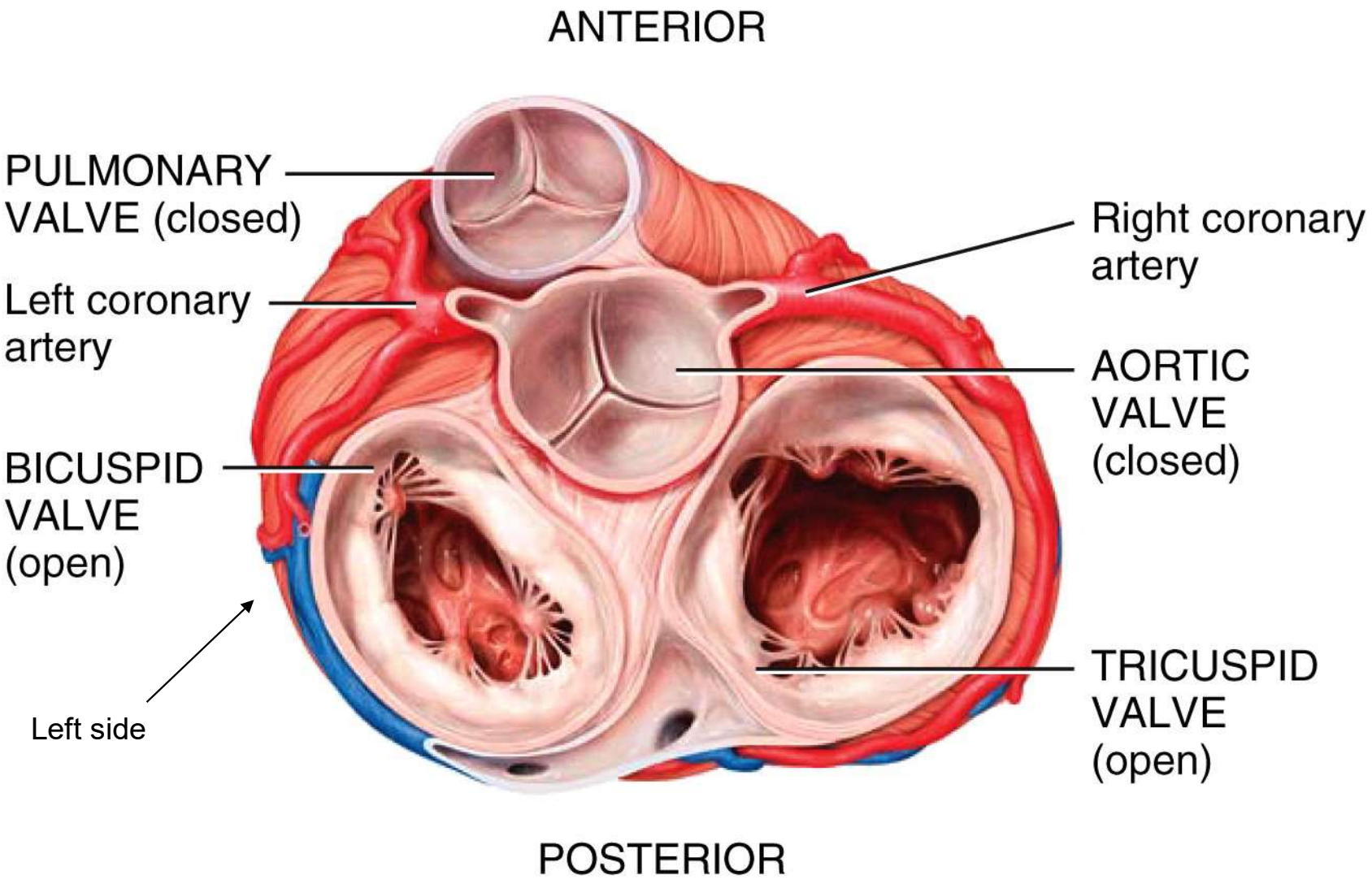
Note: all valves are “built” into the atrioventricular septum / it is a strong connective tissue transverse plane / this also prevents action potentials from moving into ventricles via gap junctions



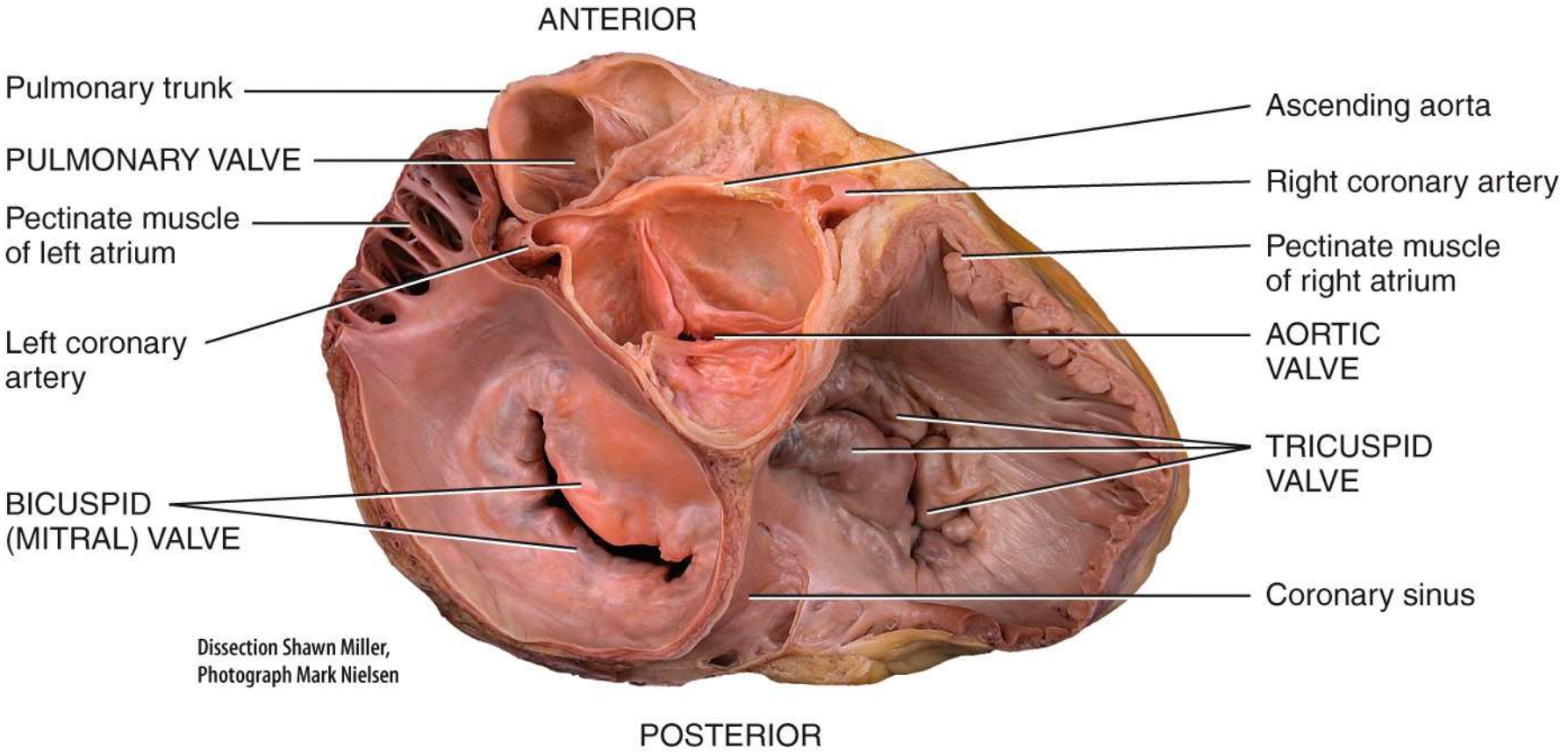
Superior view (the atria have been removed)



(d) Superior view with atria removed: pulmonary and aortic valves closed, bicuspid and tricuspid valves open

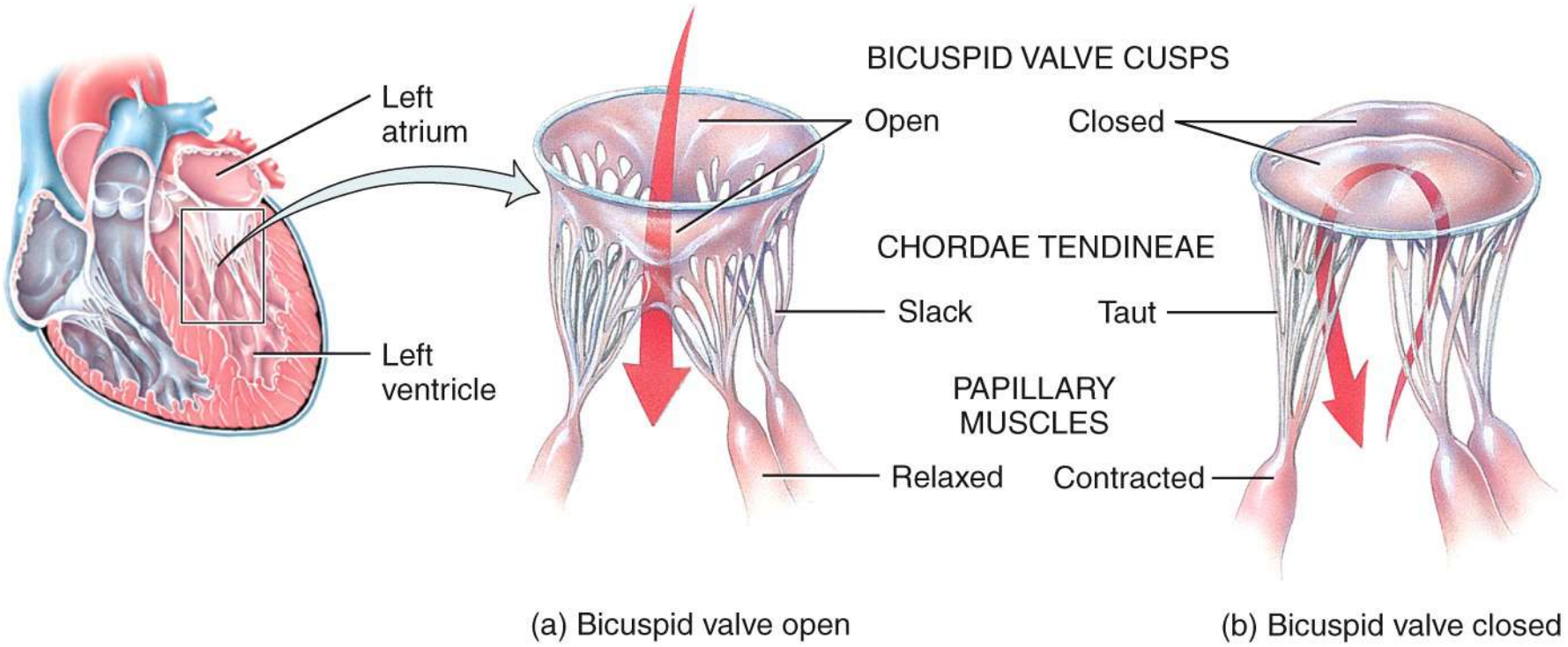


(d) Superior view with atria removed: pulmonary and aortic valves closed, bicuspid and tricuspid valves open



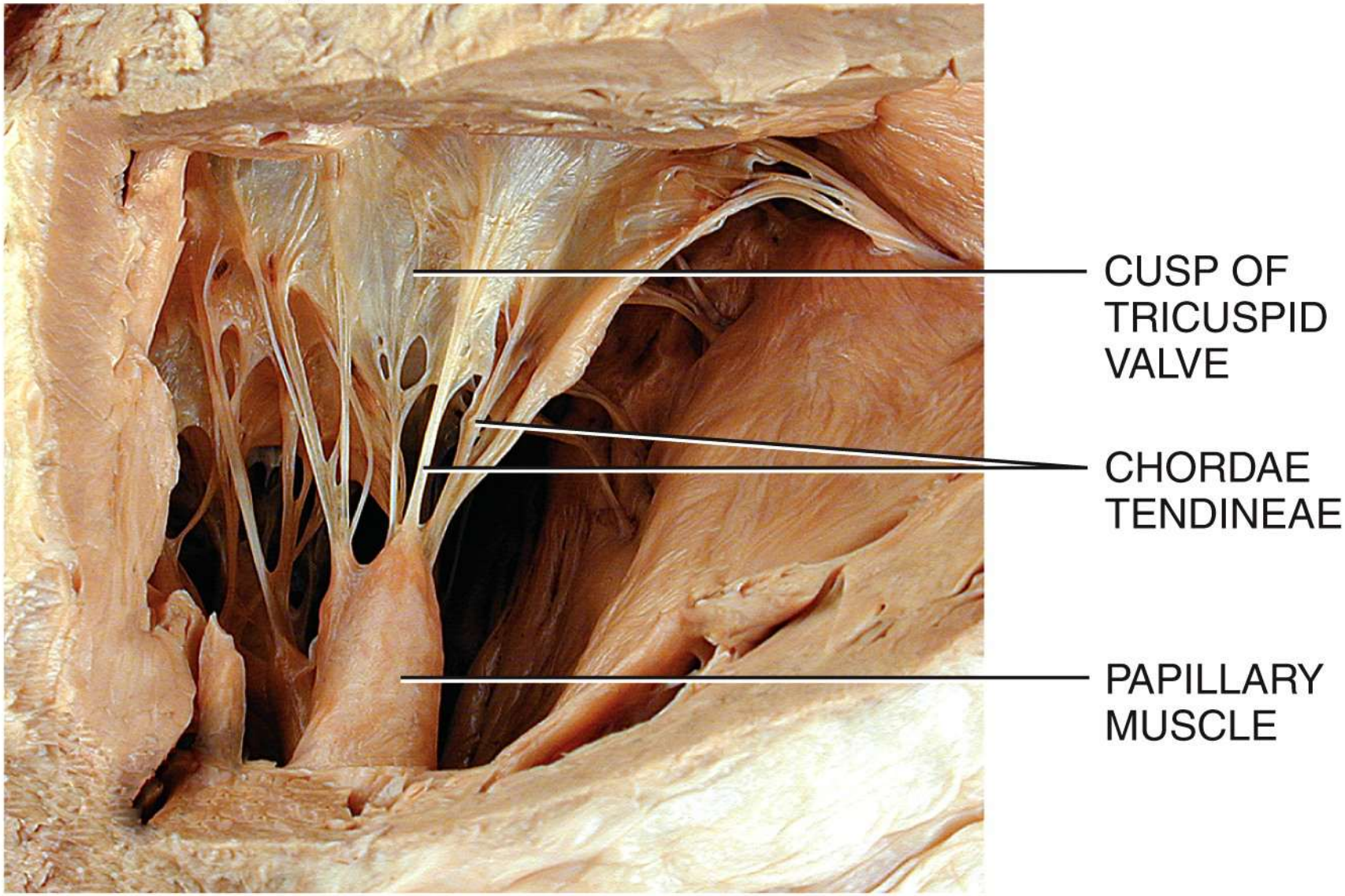
(f) Superior view of atrioventricular and semilunar valves

Note: All four valves are on same plane // the atrialventricular septum – connective tissue – no gap junctions unite atrial and ventricular myocariocytes!



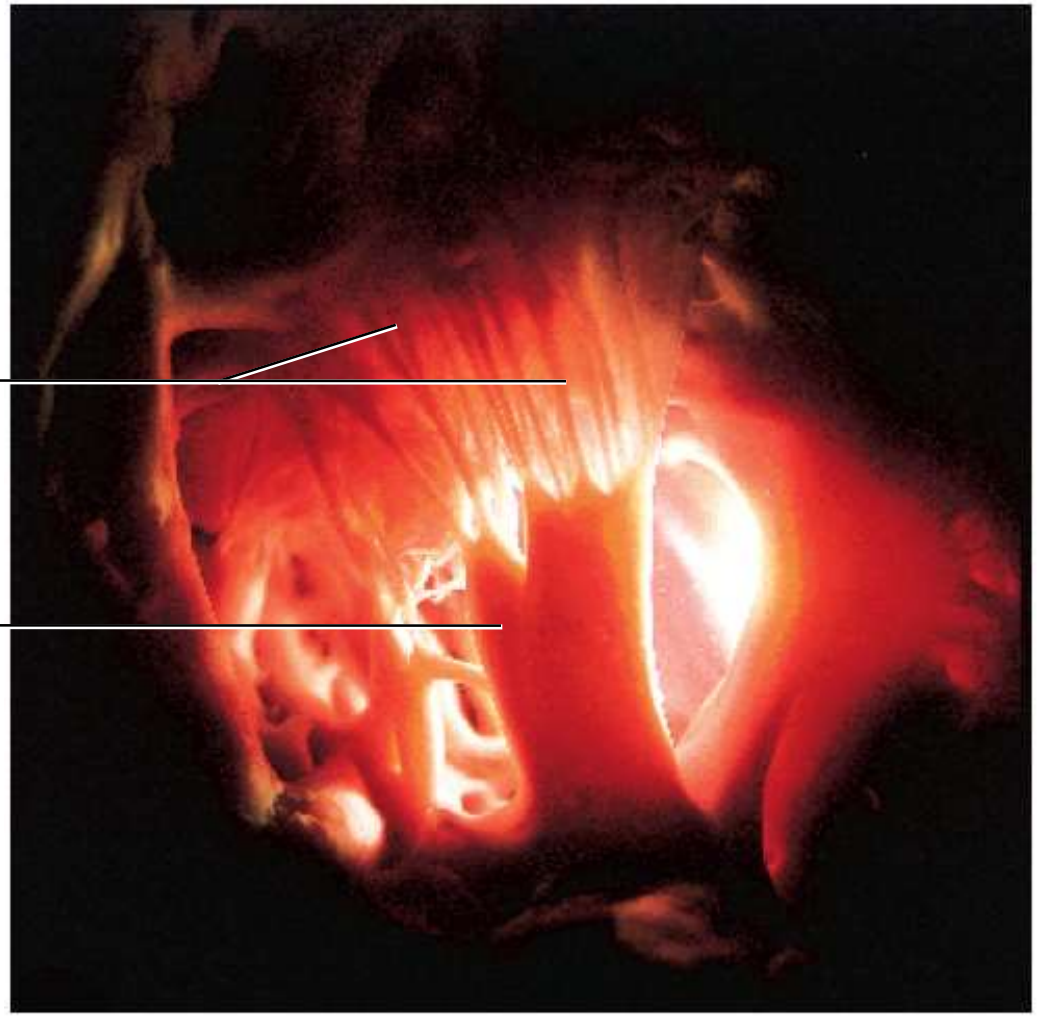
> What is the function of the papillary muscles?
> What do papillary muscles prevent ?

Dissection Shawn Miller, Photograph Mark Nielsen



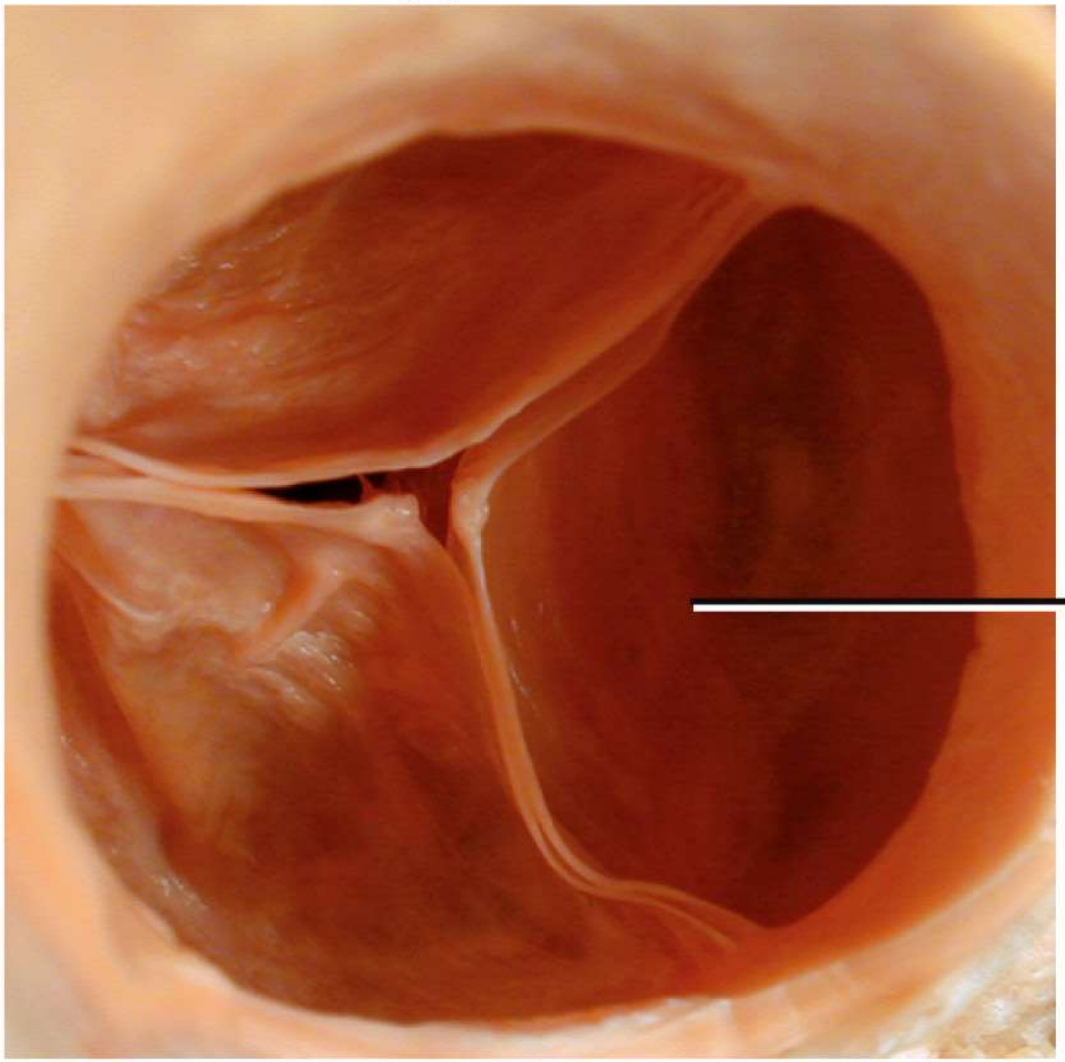
(c) Tricuspid valve open

AV Valves



Endoscopic View of Semi Lunar Heart Valve

Dissection Shawn Miller, Photograph Mark Nielsen



(g) Superior view of aortic valve

No papillary muscles or cordae tendinae

Heart Valve Functions / Atrioventricular

- controls blood flow between atria and ventricles
- Valves open and close due to blood pressure between chambers guarded by valves
- right AV valve has 3 cusps (tricuspid valve)
- left AV valve has 2 cusps (mitral or bicuspid valve)
- chordae tendineae – connective tissue fibers that connect AV valves to papillary muscles on floor of ventricles
- papillary muscles prevent AV valves from flipping inside out or bulging into the atria when the ventricles contract

AV Valve Mechanics

- When ventricles relax
  - pressure drops inside the ventricles
  - semilunar valves close as blood attempts to back up into the ventricles from the vessels
  - AV valves open
  - blood flows from atria to ventricles
- When ventricles contract
  - AV valves close as blood attempts to back up into the atria
  - pressure rises inside of the ventricles
  - semilunar valves open and blood flows into great vessels

Heart Valve Function / Semilunar

- control flow into pulmonary truck and aorta // the great arteries of the heart
- these valves open and close because of blood pressure (causes blood to floow)
- pulmonary semilunar valve // between right ventricle and pulmonary trunk
- aortic semilunar valve // between left ventricle and aorta
- semilunar valves do not have chordae tenineae
- cusps of valves close as ventricles relax and blood starts to flow back towards ventricles // back flow of blood fill cusps which cause them to close
- valves closed when afterload greater than ventricle pressure // valves open when pressure in ventricle is greater than pressure above valves.