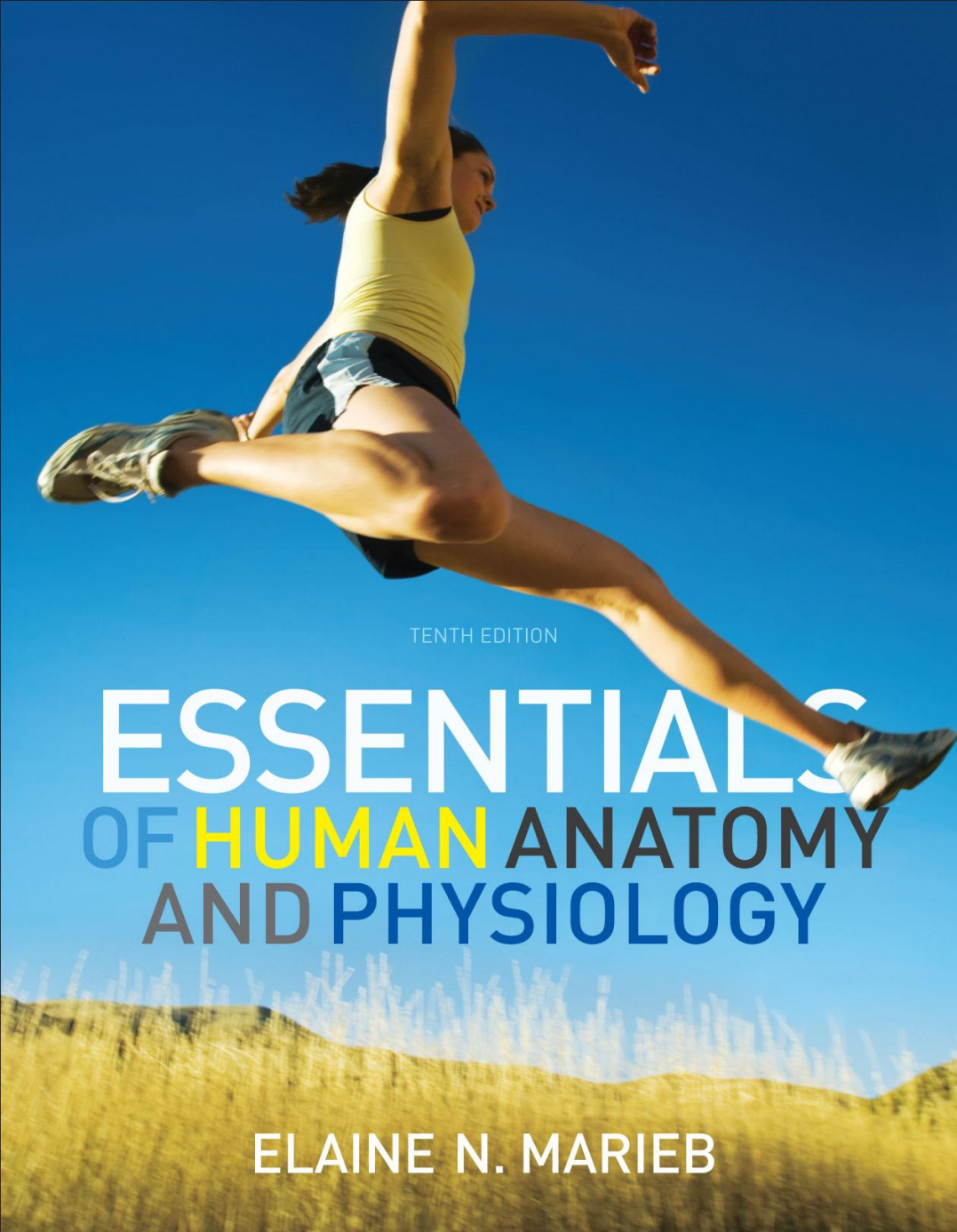


PowerPoint® Lecture Slides

Prepared by Patty Bostwick-Taylor,
Florence-Darlington Technical College

CHAPTER 11

The Cardiovascular System



TENTH EDITION

ESSENTIALS OF HUMAN ANATOMY AND PHYSIOLOGY

ELAINE N. MARIEB

The Cardiovascular System

- A **closed system** of the heart and blood vessels
- The heart pumps blood
- Blood vessels allow blood to circulate to all parts of the body

The Cardiovascular System

- The functions of the cardiovascular system
 - To **deliver oxygen and nutrients** to cells and tissues
 - To **remove carbon dioxide and other waste** products from cells and tissues

The Heart

- Location
 - Thorax between the lungs in the inferior **mediastinum**
- Orientation
 - Pointed apex directed toward left hip
 - Base points toward right shoulder
- About the size of your fist

Midsternal line

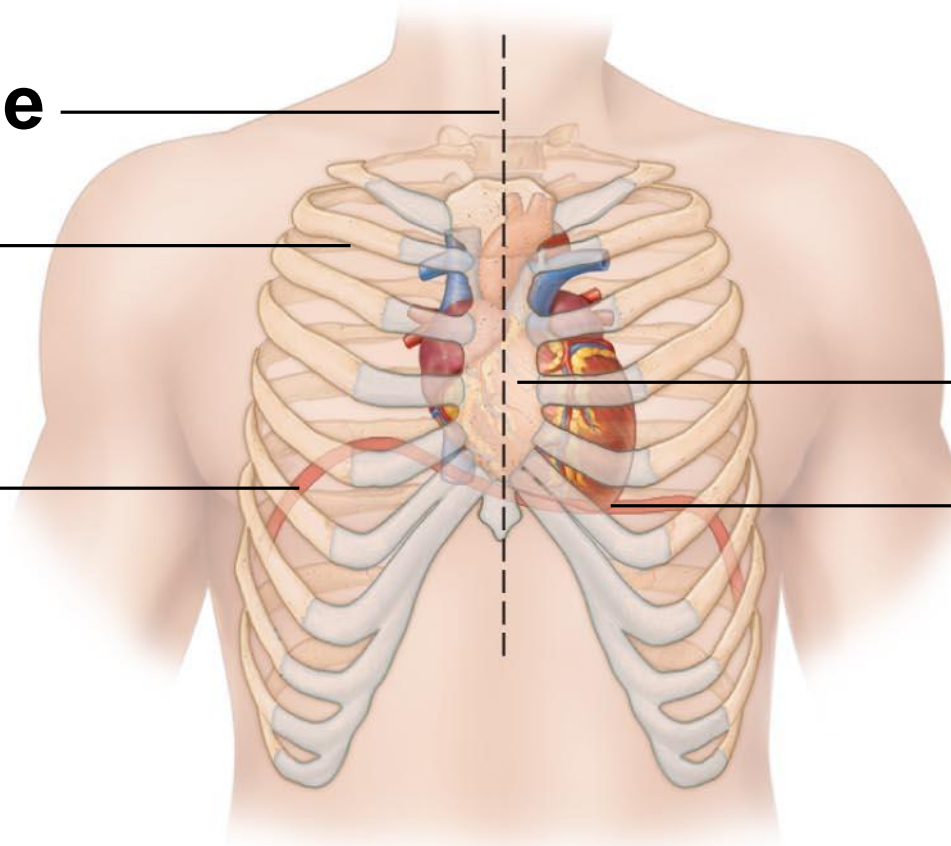
2nd rib

Diaphragm

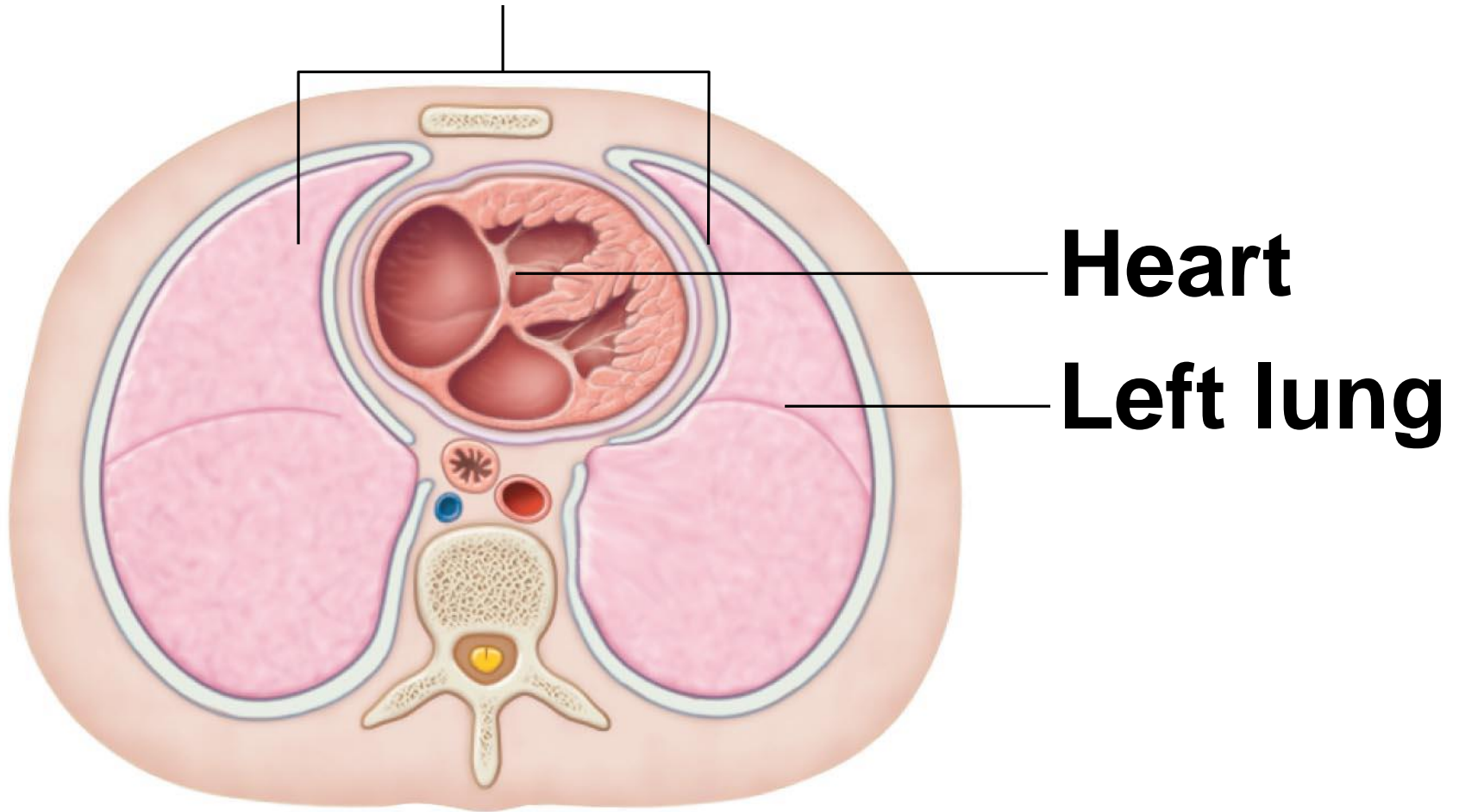
Sternum

**Point of
maximal
intensity
(PMI)**

(a)



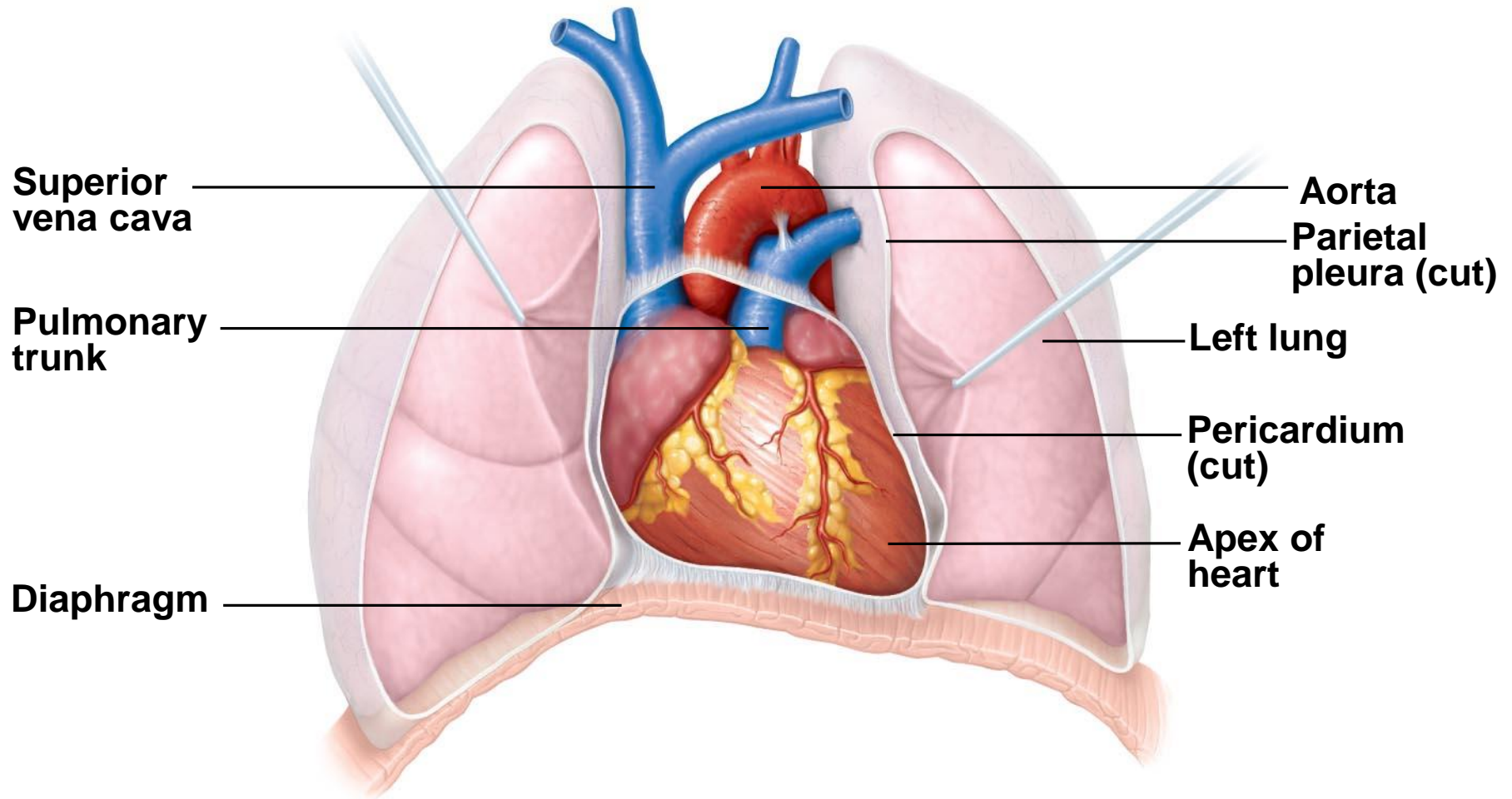
Mediastinum



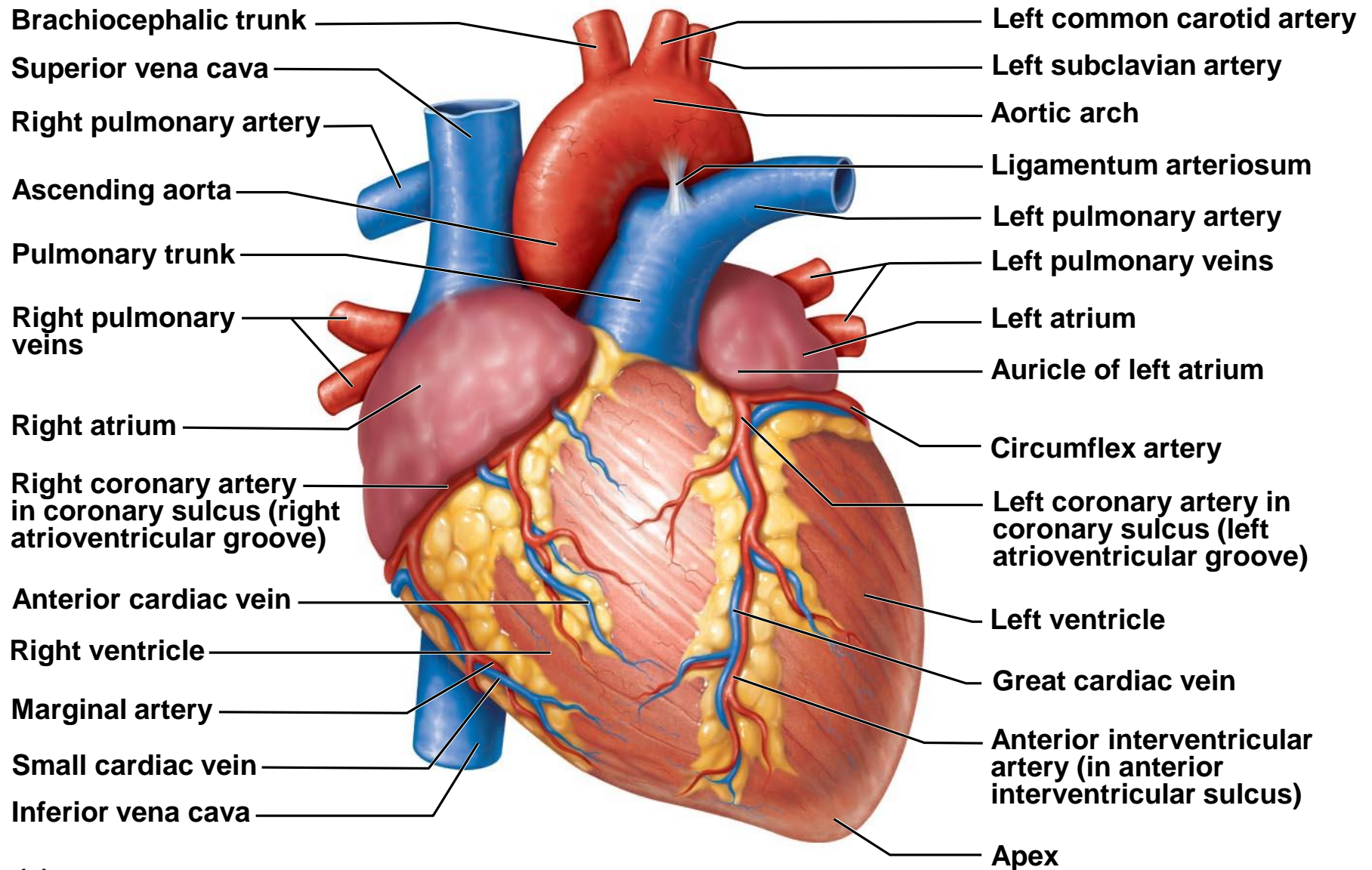
Posterior

(b)

Figure 11.1b



(c)



(a)

Figure 11.3a

The Heart: Coverings

- **Pericardium**—a double-walled sac
 - **Fibrous pericardium** is loose and superficial
 - **Serous membrane** is deep to the fibrous pericardium and composed of two layers

The Heart: Coverings

2 Layers of Serous Membrane:

- **Visceral pericardium**
 - Next to heart; also known as the **epicardium**
- **Parietal pericardium**
 - Outside layer that lines the inner surface of the fibrous pericardium
- Serous fluid fills the space between the layers of pericardium

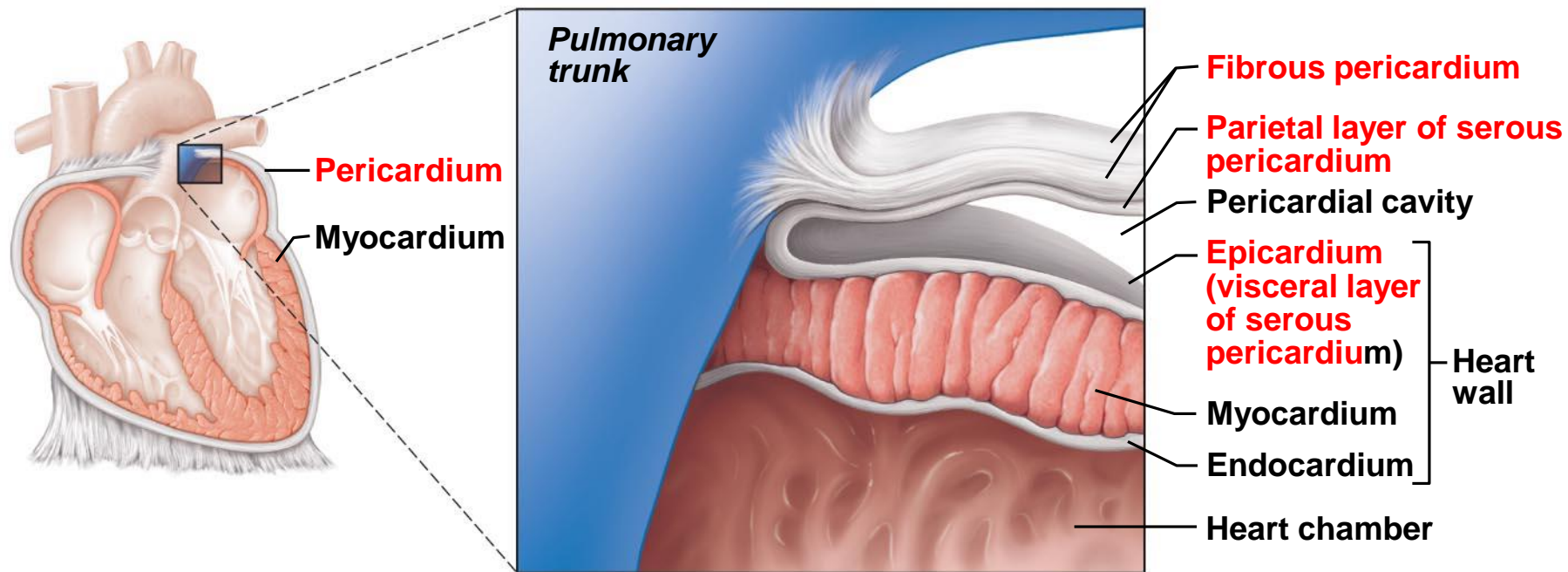


Figure 11.2

The Heart: Heart Wall

- **Epicardium**

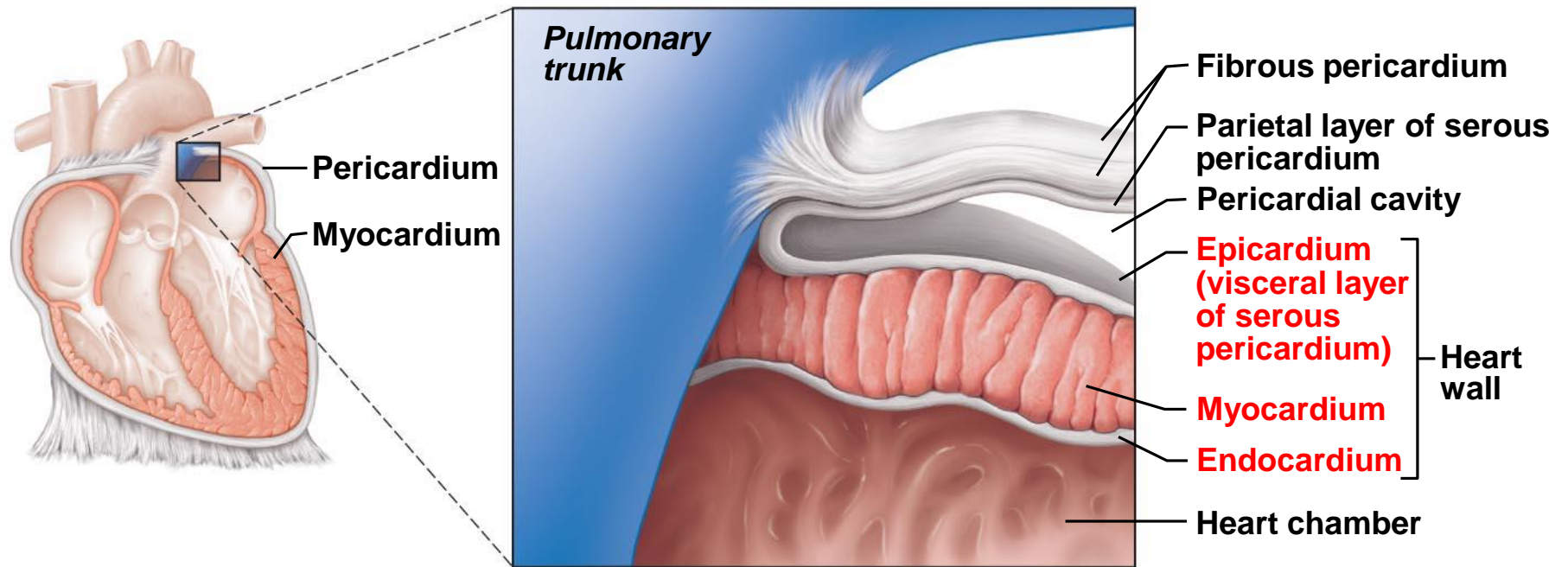
- Outside layer
- This layer is the visceral pericardium
- Connective tissue layer

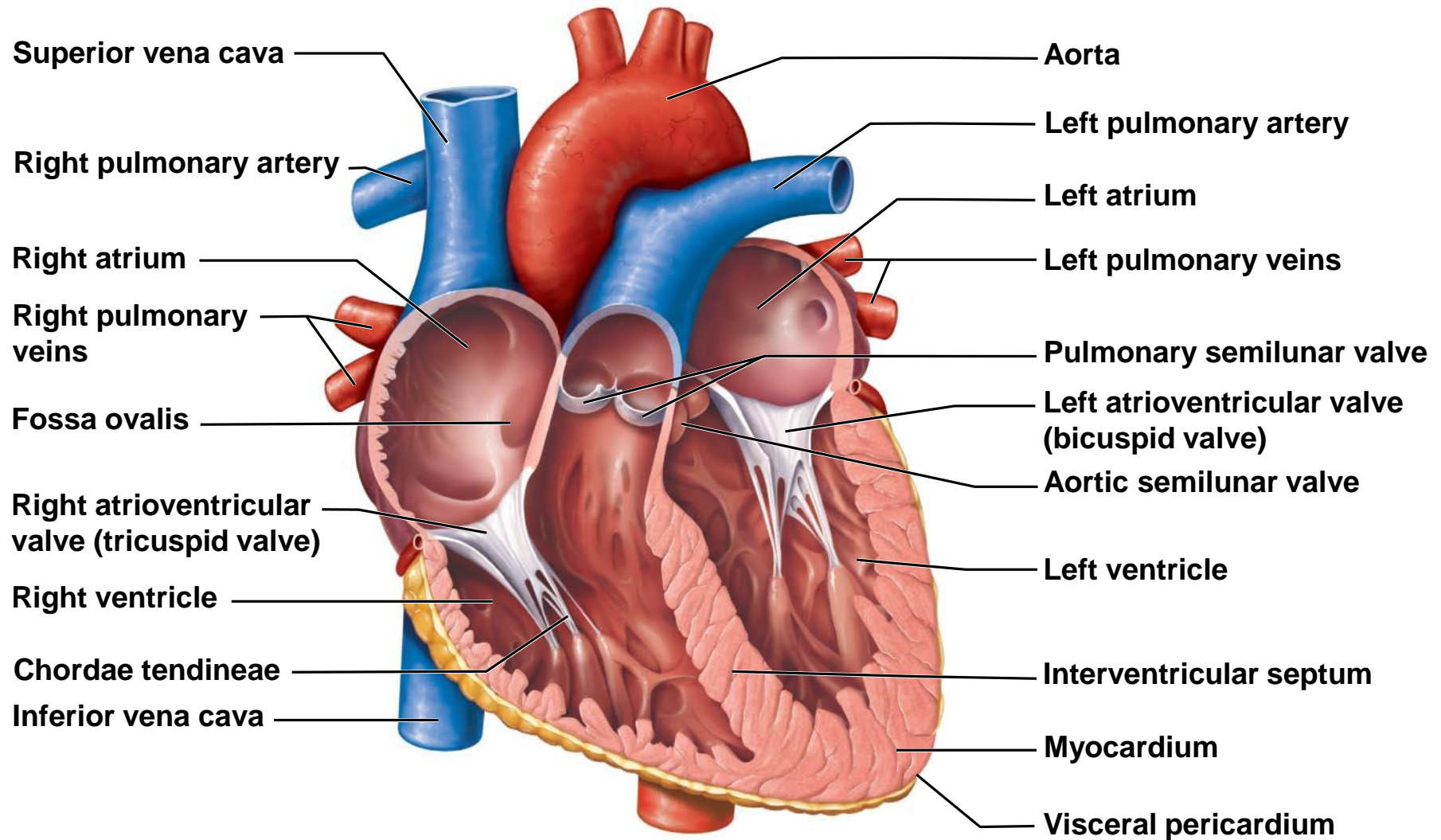
- **Myocardium**

- Middle layer
- Mostly cardiac muscle

- **Endocardium**

- Inner layer
- Endothelium

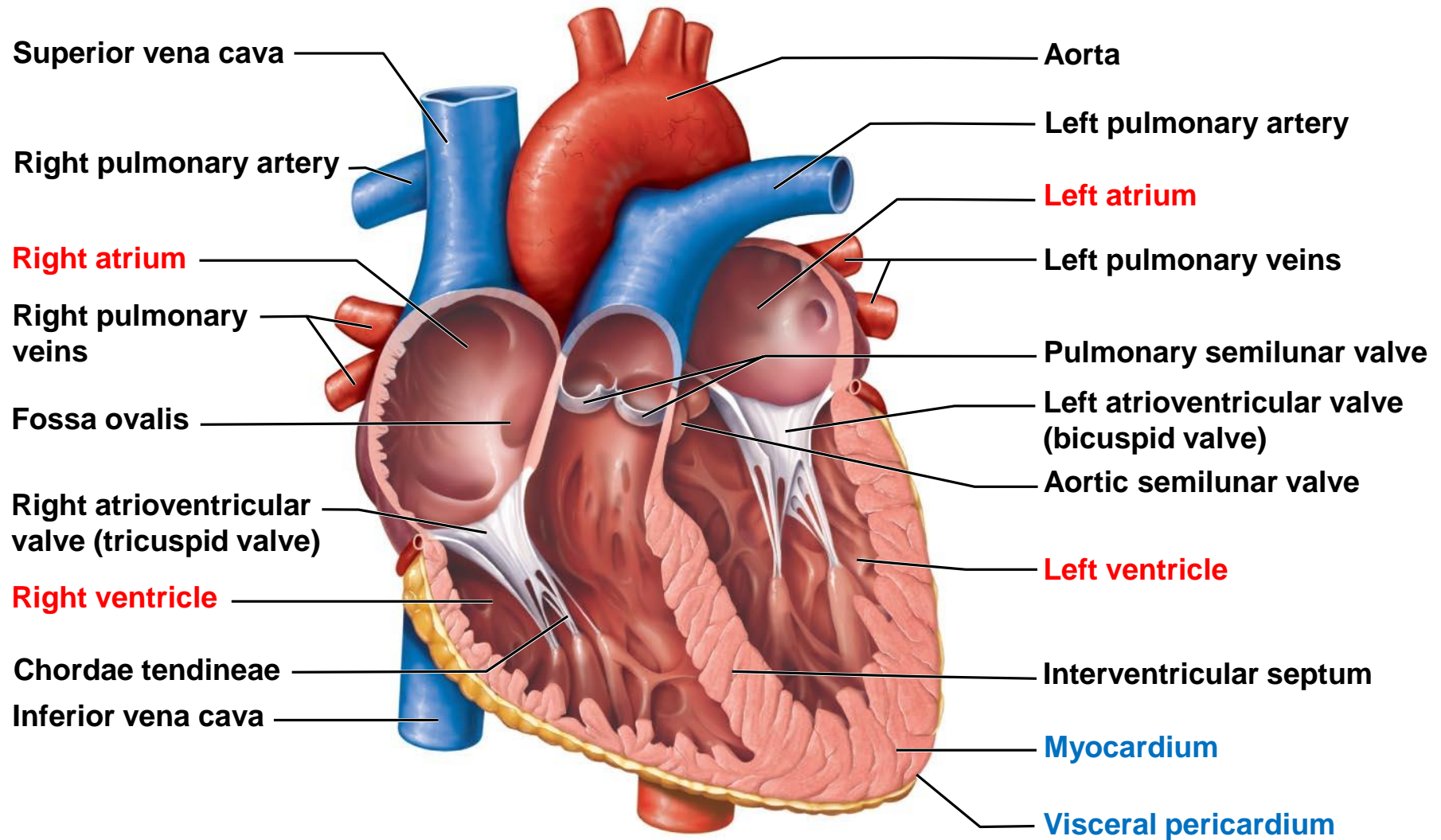




(b) Frontal section showing interior chambers and valves.

The Heart: Chambers

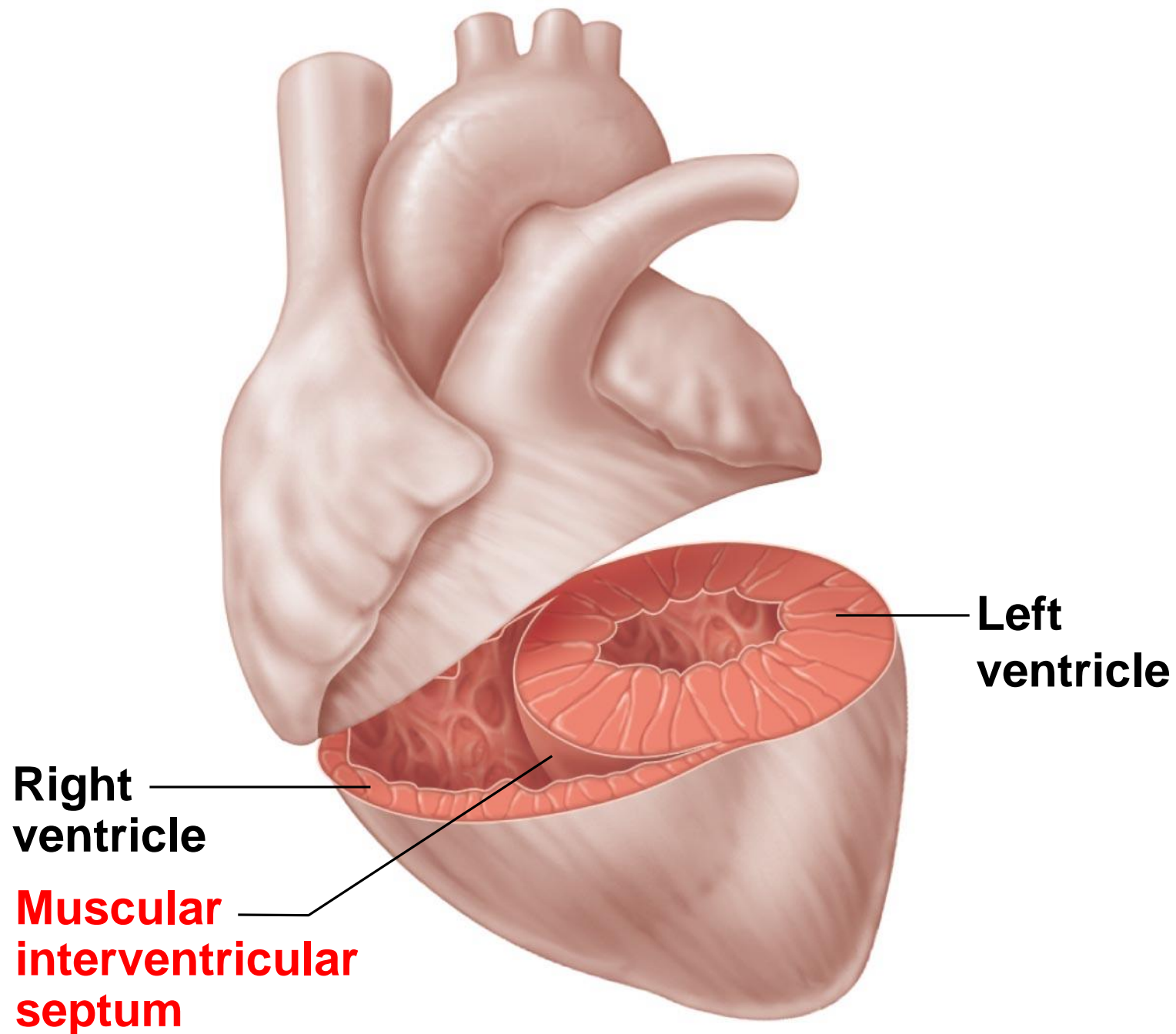
- Right and left side act as separate pumps
- Four chambers
 - **Atria**
 - **Receiving chambers**
 - Right atrium
 - Left atrium
 - **Ventricles**
 - **Discharging chambers**
 - Right ventricle
 - Left ventricle

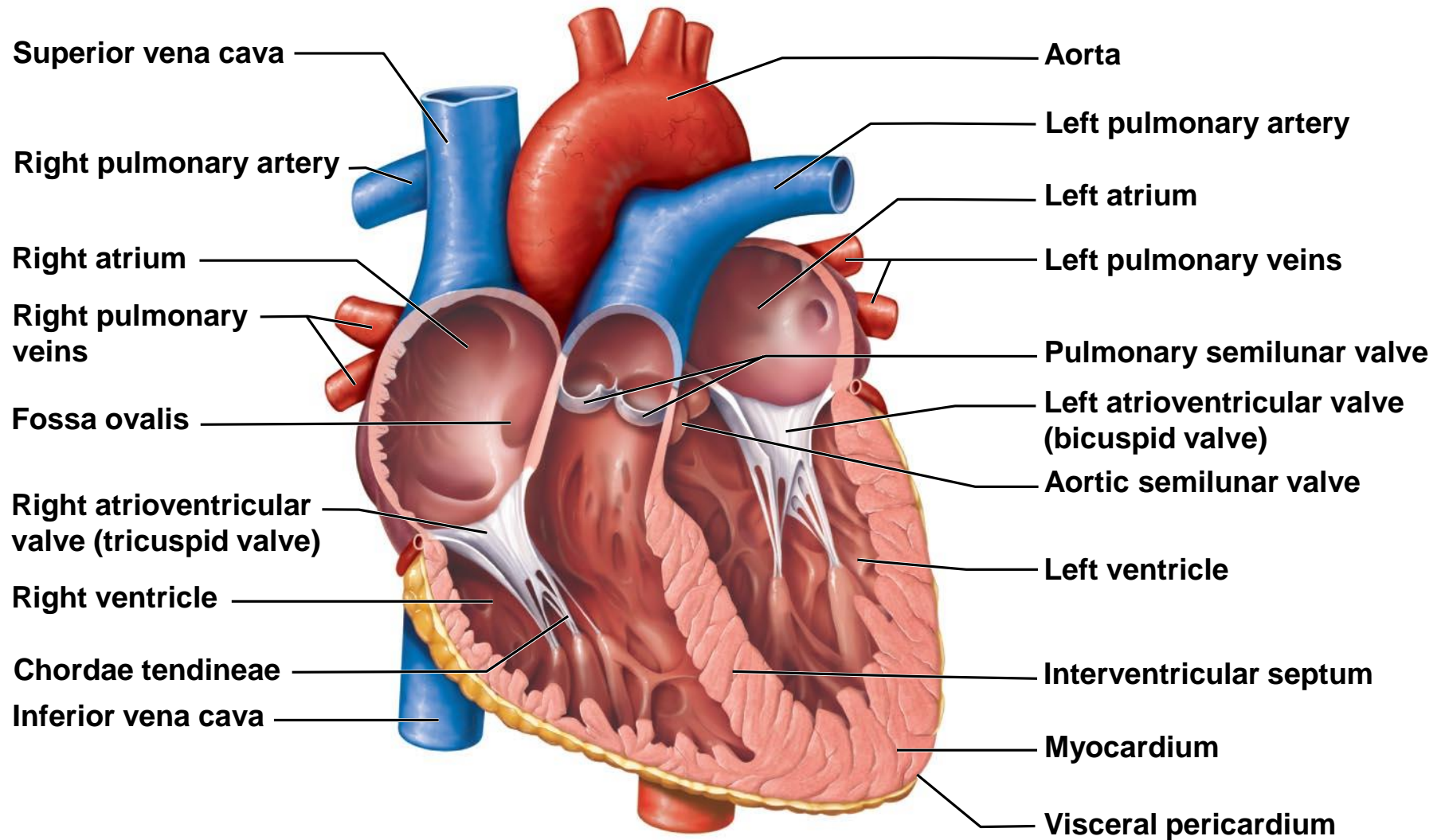


(b) Frontal section showing interior chambers and valves.

The Heart: Septa

- **Interventricular septum**
 - Separates the two ventricles
- **Interatrial septum**
 - Separates the two atria





(b) Frontal section showing interior chambers and valves.

The Heart's Role in Blood Circulation

- **Systemic circulation**

- Blood flows **from the left** side of the heart through the body tissues and back **to the right** side of the heart

- **Pulmonary circulation**

- Blood flows **from the right** side of the heart to the lungs and back **to the left side** of the heart

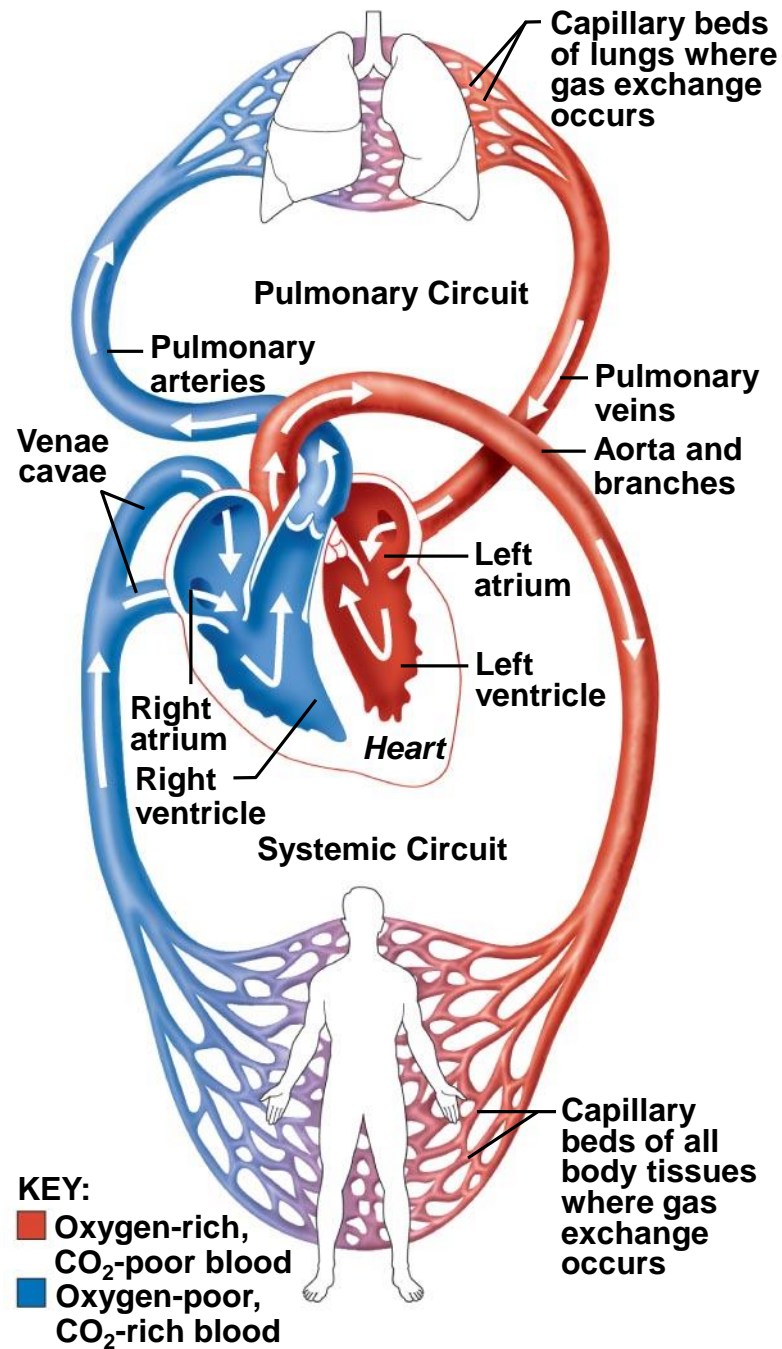


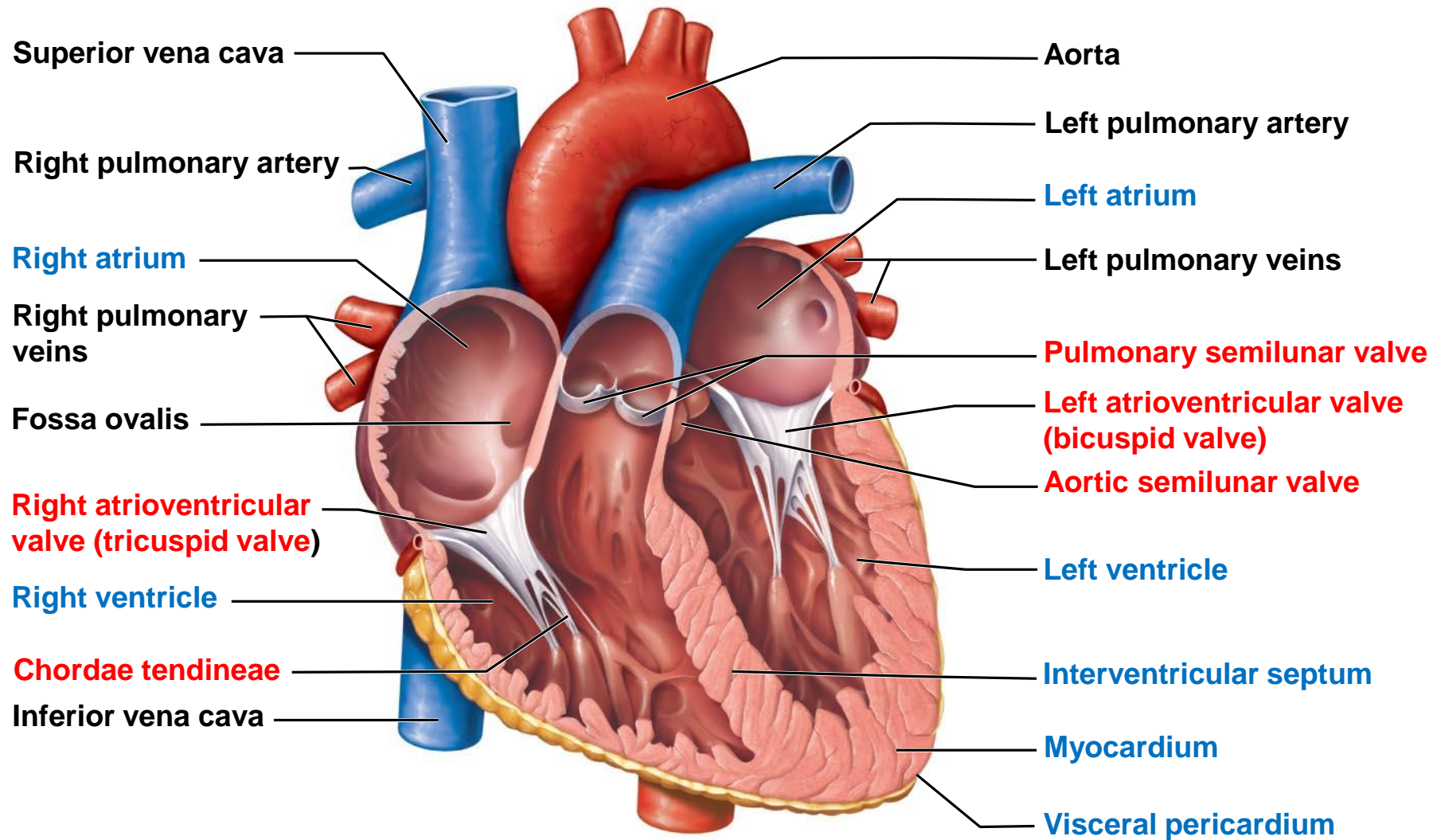
Figure 11.4

The Heart: Valves

- Allow blood to flow in only **one direction to prevent backflow**
- **Atrioventricular (AV) valves**—between atria and ventricles
 - **Bicuspid (mitral) valve** (**left** side of heart)
 - **Tricuspid valve** (**right** side of heart)
- AV valves
 - Anchored in place by **chordae tendineae** (“heart strings”)
 - **Open** during heart relaxation and **closed** during ventricular contraction

The Heart: Valves

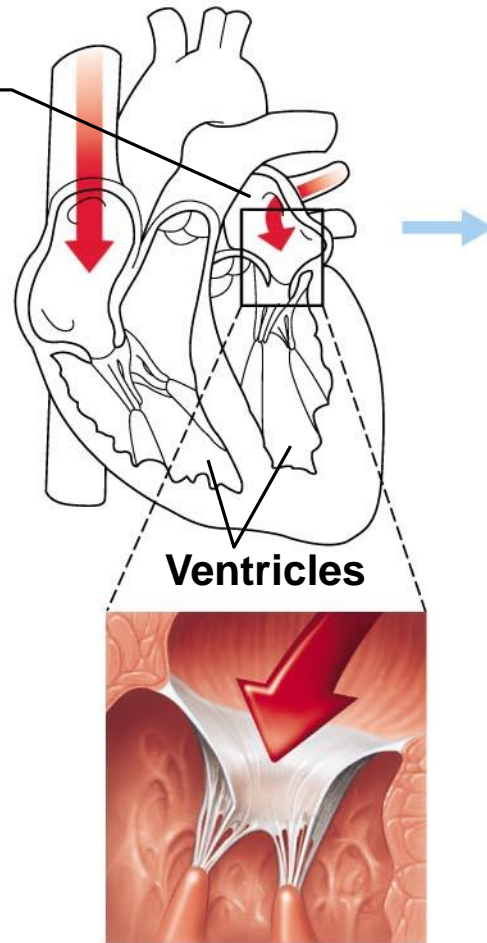
- **Semilunar valves**—between ventricle and artery
 - **Pulmonary semilunar valve**
 - **Aortic semilunar valve**
- Semilunar valves
 - **Closed** during heart relaxation but **open** during ventricular contraction
- Notice these valves operate opposite of one another to force a one-way path of blood through the heart



(b) Frontal section showing interior chambers and valves.

(a) Operation of the AV valves

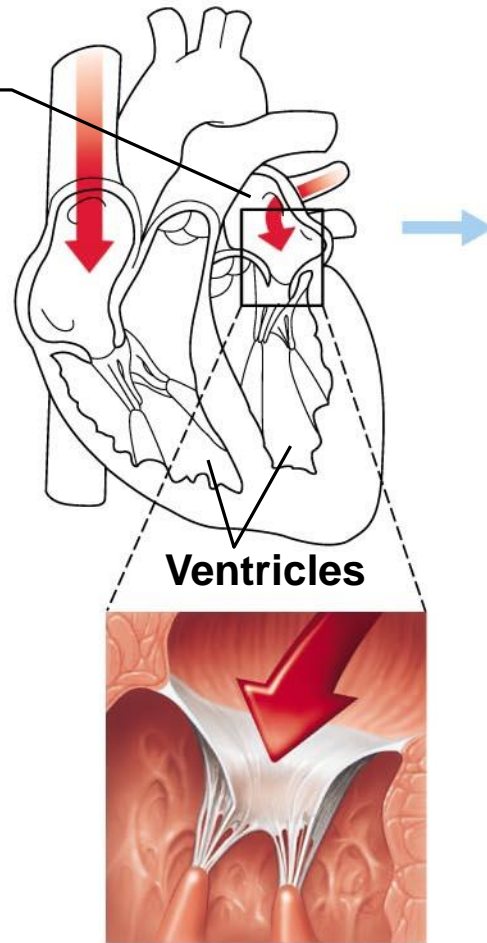
① Blood returning to the atria puts pressure against AV valves; the AV valves are forced open.



(a) Operation of the AV valves

① Blood returning to the atria puts pressure against AV valves; the AV valves are forced open.

② As the ventricles fill, AV valve flaps hang limply into ventricles.



(a) Operation of the AV valves

① Blood returning to the atria puts pressure against AV valves; the AV valves are forced open.

② As the ventricles fill, AV valve flaps hang limply into ventricles.

③ Atria contract, forcing additional blood into ventricles.

AV valves open; atrial pressure greater than ventricular pressure

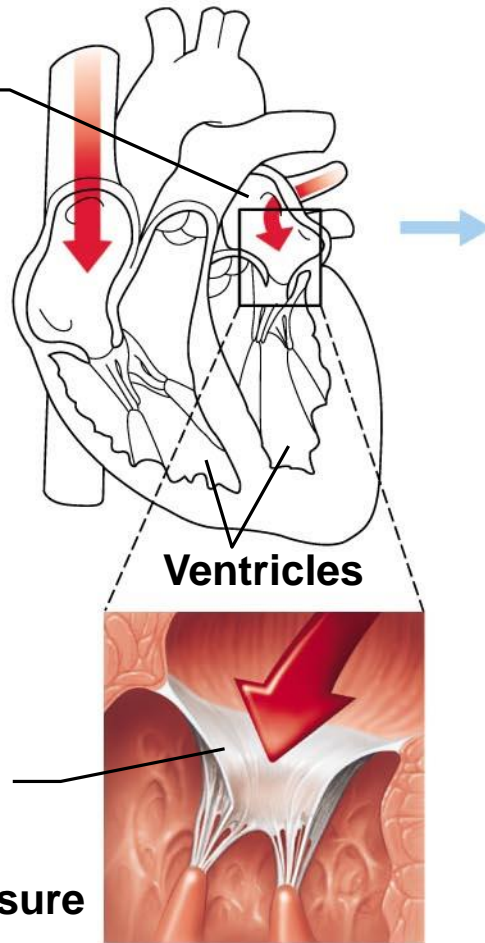


Figure 11.6a, step 3

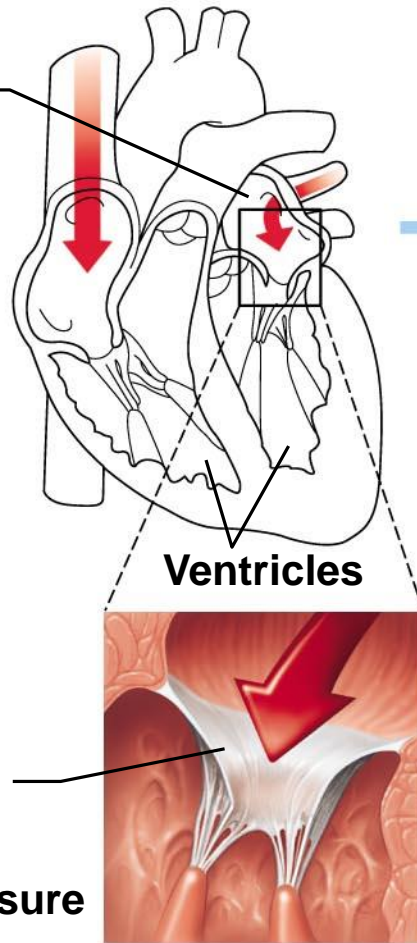
(a) Operation of the AV valves

① Blood returning to the atria puts pressure against AV valves; the AV valves are forced open.

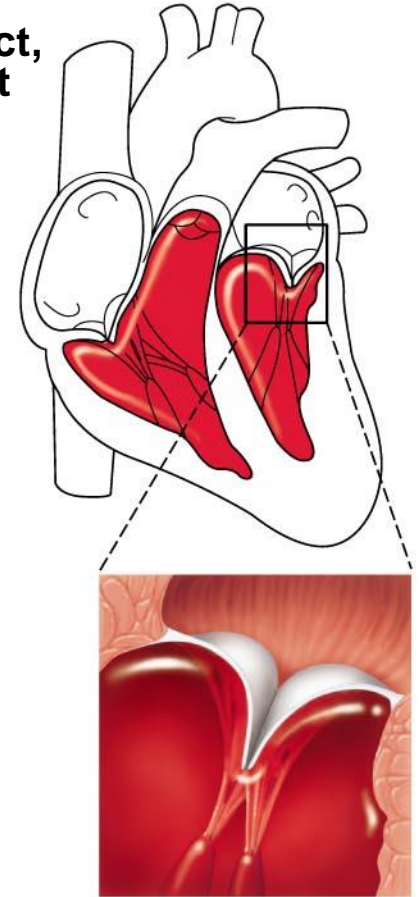
② As the ventricles fill, AV valve flaps hang limply into ventricles.

③ Atria contract, forcing additional blood into ventricles.

AV valves open; atrial pressure greater than ventricular pressure



④ Ventricles contract, forcing blood against AV valve flaps.



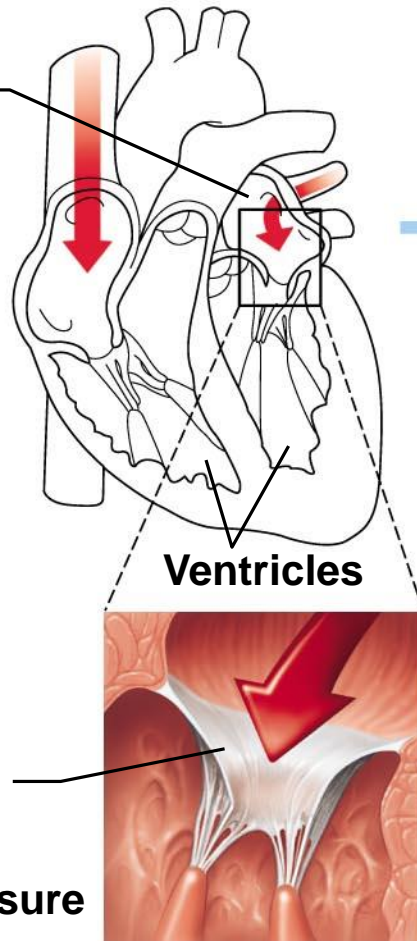
(a) Operation of the AV valves

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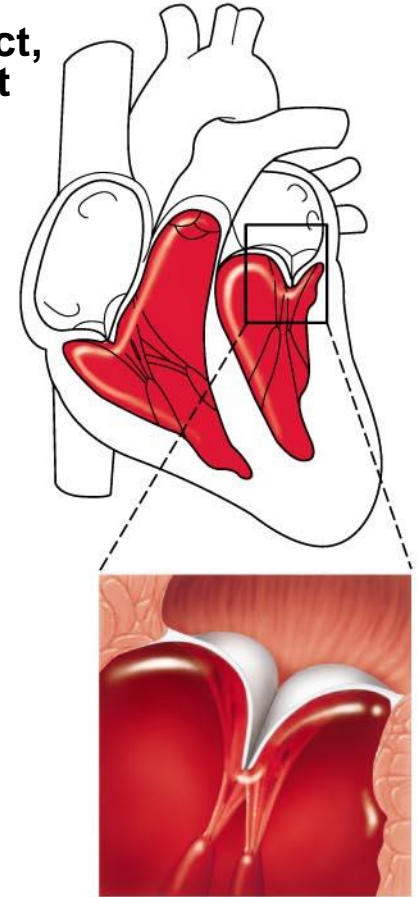
③ Atria contract, forcing additional blood into ventricles.

AV valves open; atrial pressure greater than ventricular pressure



④ Ventricles contract, forcing blood against AV valve flaps.

⑤ AV valves close.



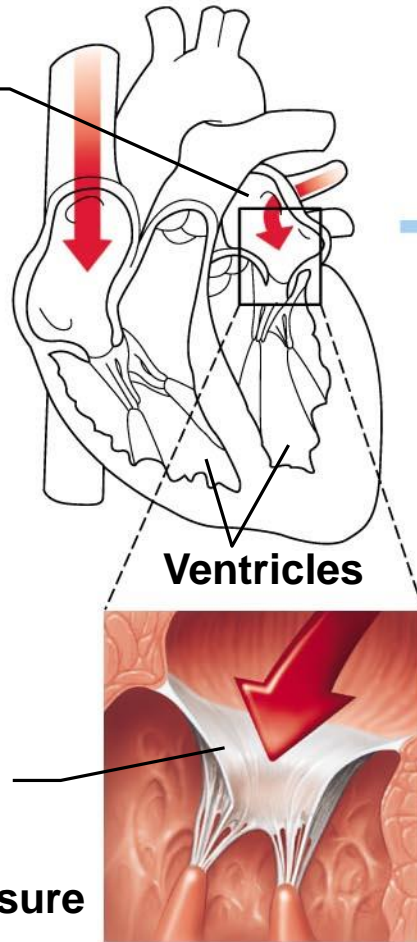
(a) Operation of the AV valves

① Blood returning to the atria puts pressure against AV valves; the AV valves are forced open.

② As the ventricles fill, AV valve flaps hang limply into ventricles.

③ Atria contract, forcing additional blood into ventricles.

AV valves open; atrial pressure greater than ventricular pressure

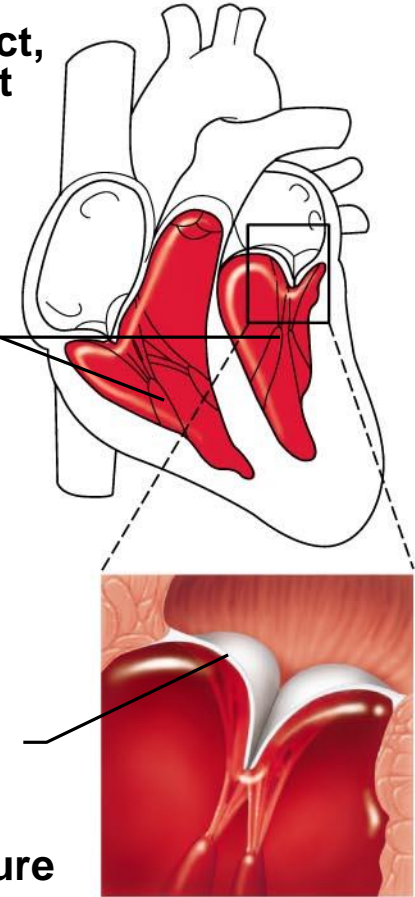


④ Ventricles contract, forcing blood against AV valve flaps.

⑤ AV valves close.

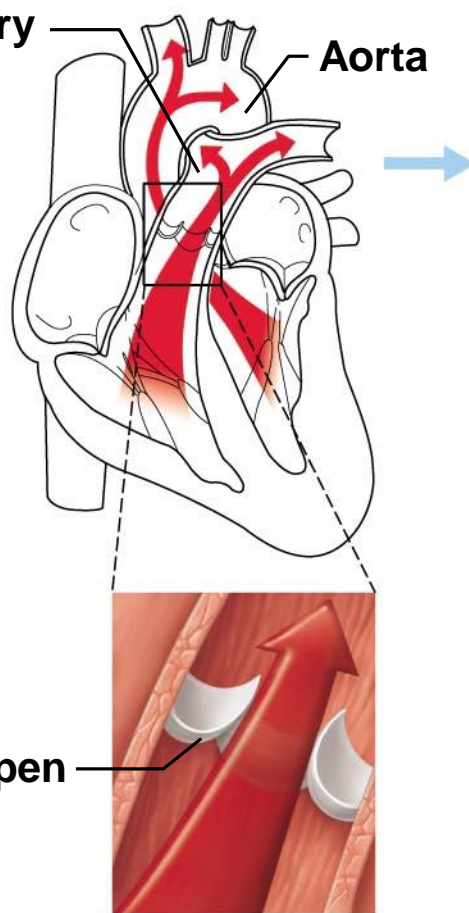
⑥ Chordae tendineae tighten, preventing valve flaps from everting into atria.

AV valves closed; atrial pressure less than ventricular pressure



(b) Operation of the semilunar valves

① As ventricles contract and intraventricular pressure rises, blood is pushed up against semilunar valves, forcing them open.



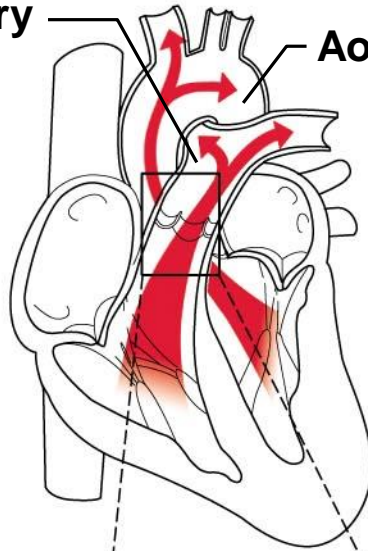
Semilunar valves open

Figure 11.6b, step 1

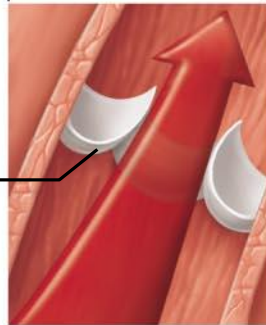
(b) Operation of the semilunar valves

① As ventricles contract and intraventricular pressure rises, blood is pushed up against semilunar valves, forcing them open.

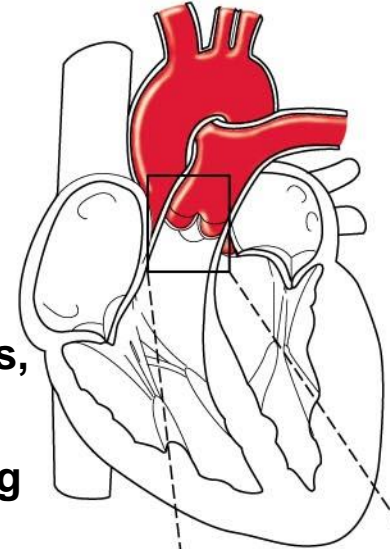
Pulmonary trunk Aorta



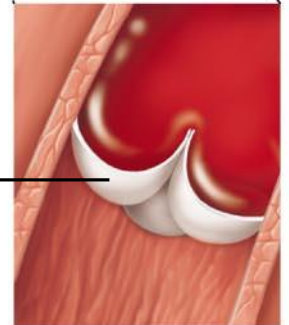
Semilunar valves open



② As ventricles relax and intraventricular pressure falls, blood flows back from arteries, filling the leaflets of semilunar valves and forcing them to close.

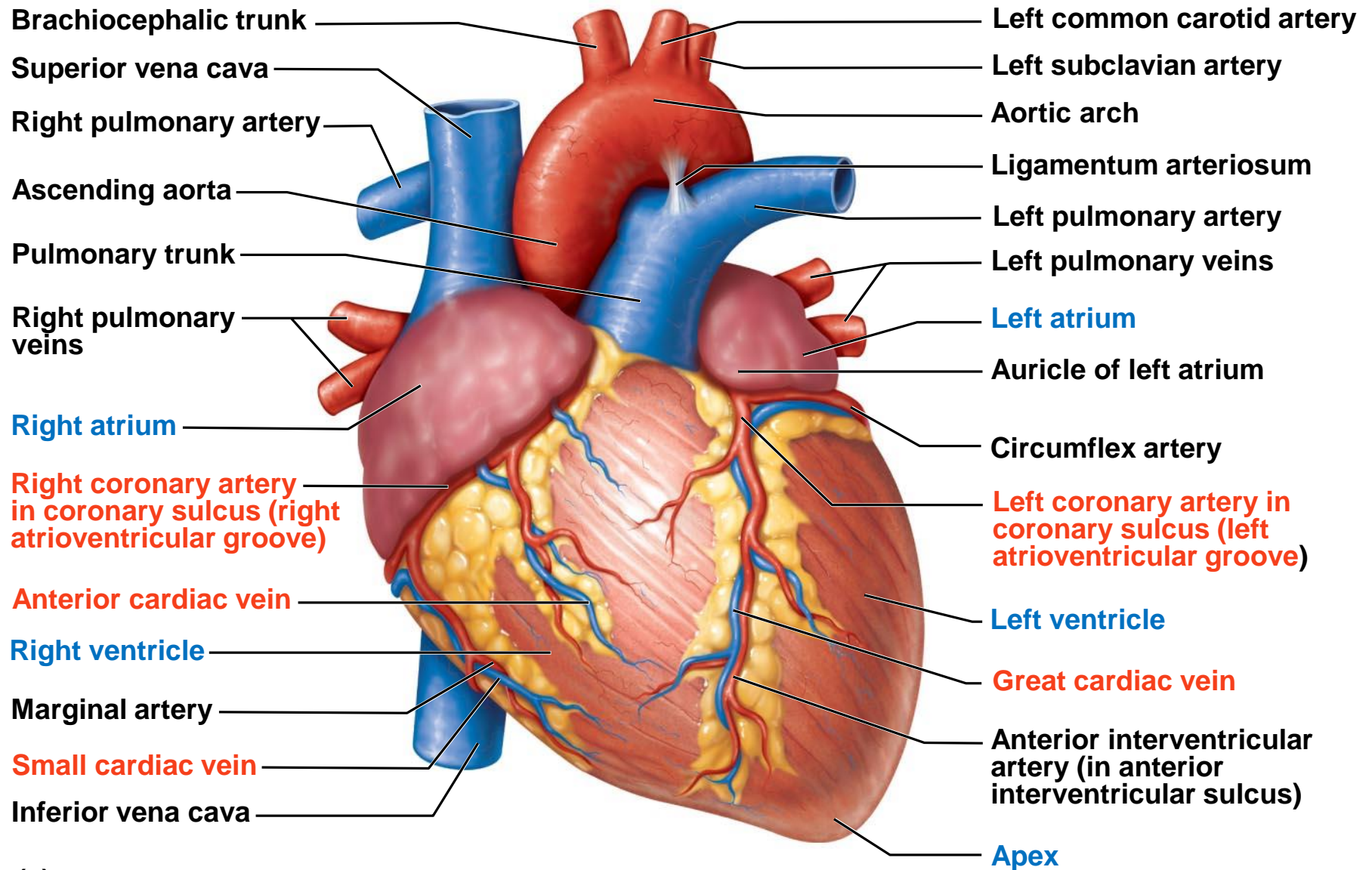


Semilunar valves closed



Cardiac Circulation

- Blood in the heart chambers does not nourish the myocardium
- The heart has its own nourishing circulatory system consisting of
 - **Coronary arteries**—branch from the aorta to supply the heart muscle with oxygenated blood
 - **Cardiac veins**—drain the myocardium of blood
 - **Coronary sinus**—a large vein on the posterior of the heart, receives blood from cardiac veins
- Blood empties into the right atrium via the coronary sinus



(a)

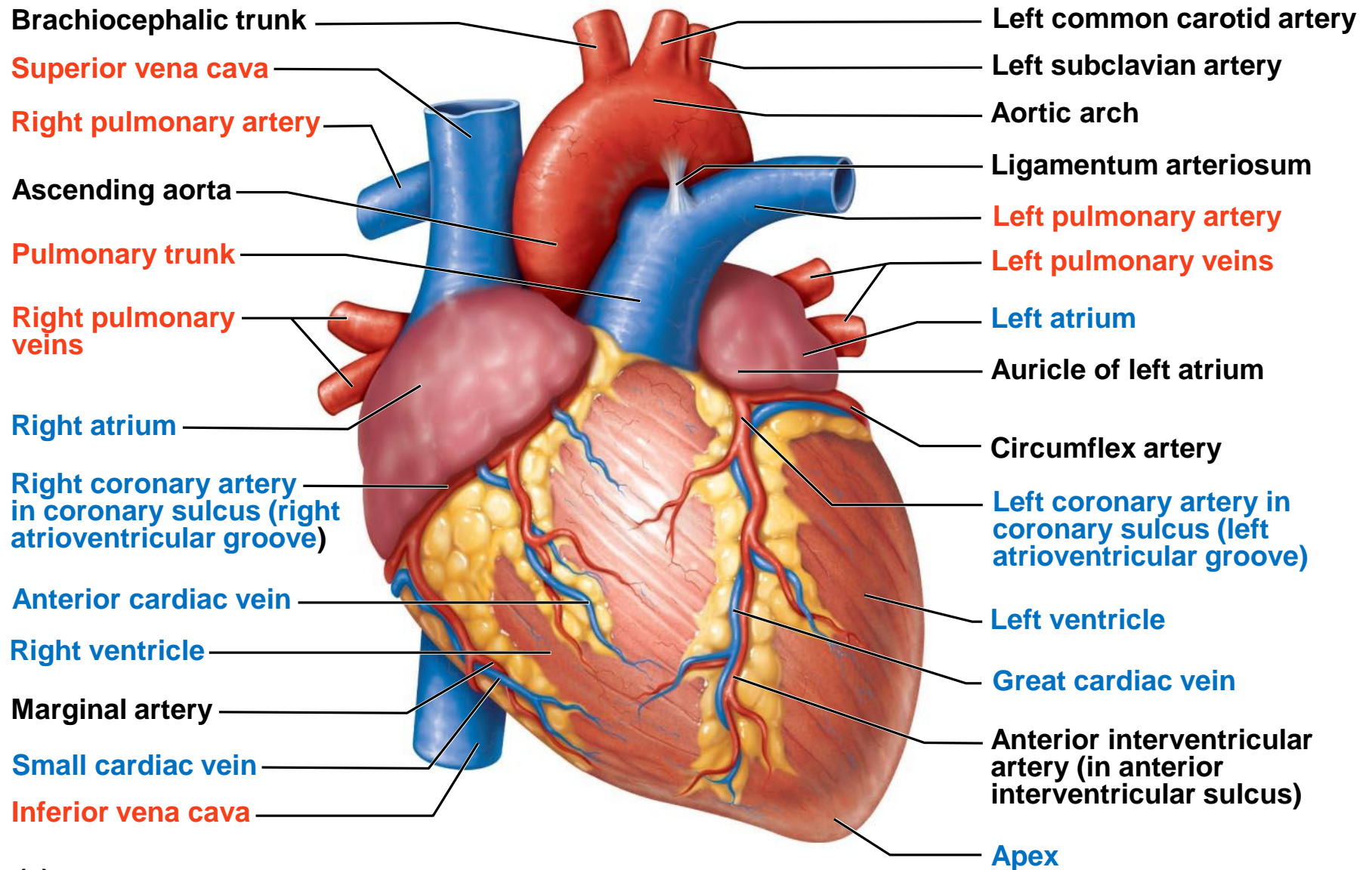
Figure 11.3a

The Heart: Associated Great Vessels

- Arteries
 - **Aorta**
 - Leaves left ventricle
 - **Pulmonary arteries**
 - Leave right ventricle

The Heart: Associated Great Vessels

- Veins
 - **Superior and inferior venae cavae**
 - Enter right atrium
 - **Pulmonary veins (four)**
 - Enter left atrium



(a)

Figure 11.3a

Blood Flow Through the Heart

- **Superior and inferior venae cavae dump blood into the right atrium**
- **From right atrium, through the tricuspid valve, blood travels to the right ventricle**
- **From the right ventricle, blood leaves the heart as it passes through the pulmonary semilunar valve into the pulmonary trunk**
- **Pulmonary trunk splits into right and left pulmonary arteries that carry blood to the lungs**

Blood Flow Through the Heart

- **Oxygen is picked up and carbon dioxide is dropped off by blood in the lungs**
- **Oxygen-rich blood returns to the heart through the four pulmonary veins**
- **Blood enters the left atrium and travels through the bicuspid valve into the left ventricle**
- **From the left ventricle, blood leaves the heart via the aortic semilunar valve and aorta**

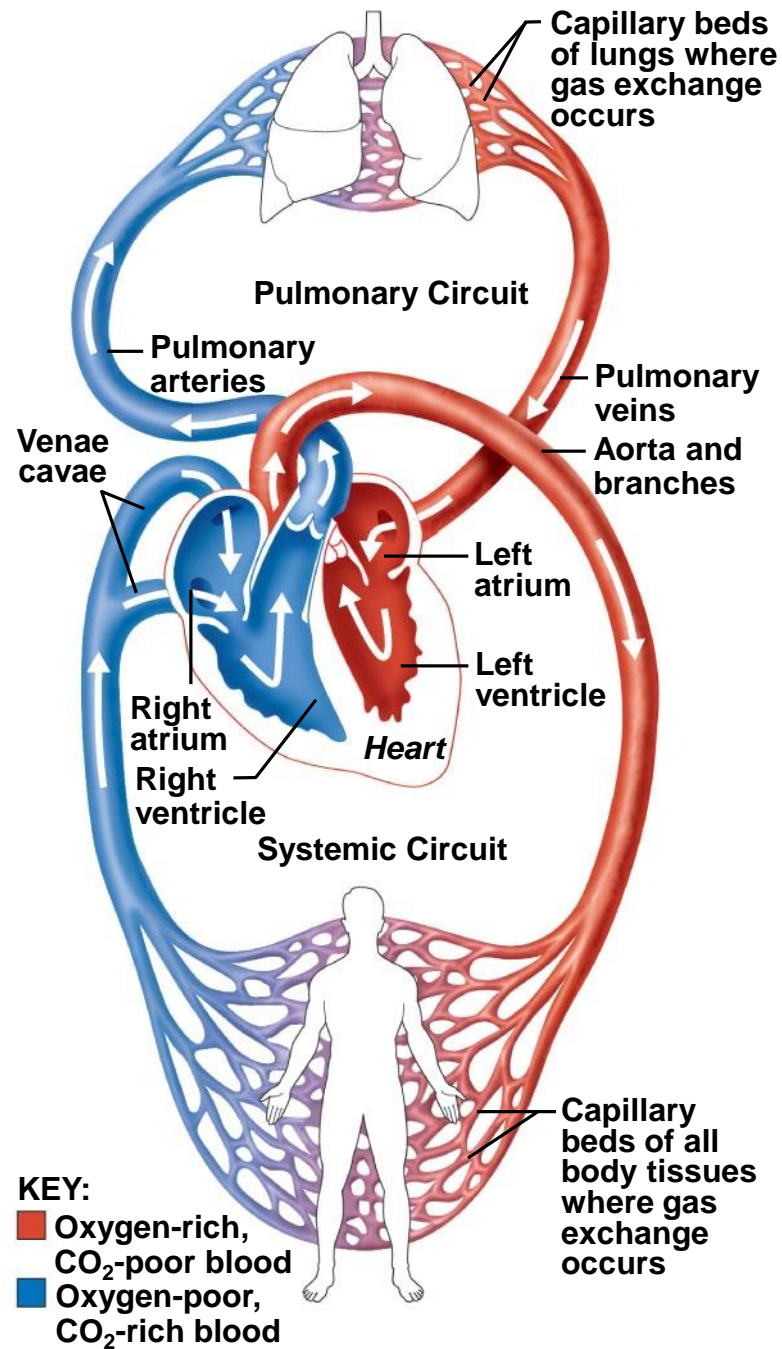


Figure 11.4

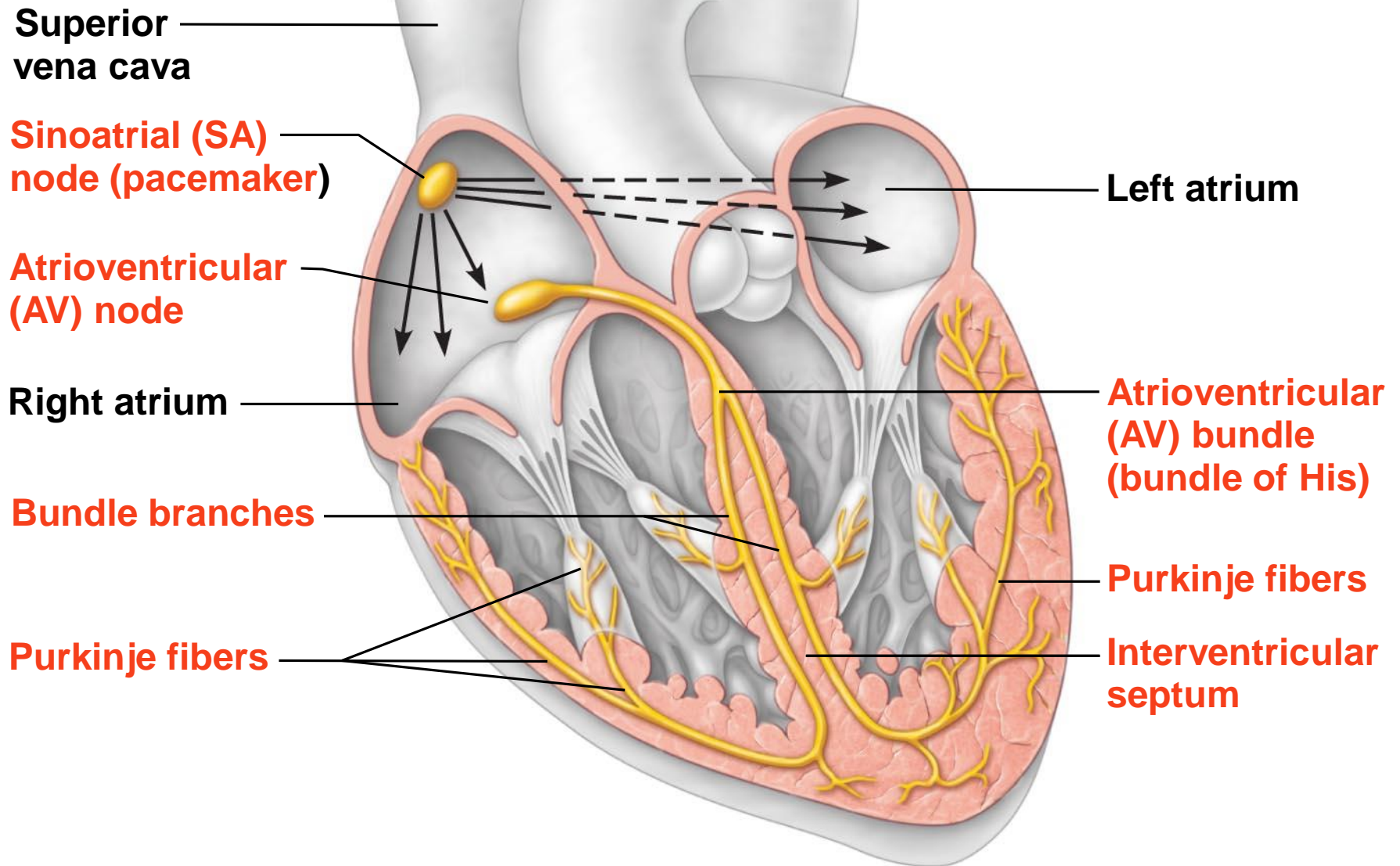
- Blood Flow Song
- Better heart video

The Heart: Conduction System

- **Intrinsic conduction system (nodal system)**
 - Heart muscle cells contract, **without nerve impulses**, in a regular, continuous way

The Heart: Conduction System

- Special tissue sets the pace
 - **Sinoatrial node** = SA node (“pacemaker”), is in the right atrium
 - **Atrioventricular node** = AV node, is at the junction of the atria and ventricles
 - **Atrioventricular bundle** = AV bundle (bundle of His), is in the interventricular septum
 - **Bundle branches** are in the **interventricular septum**
 - **Purkinje fibers** spread within the ventricle wall muscles

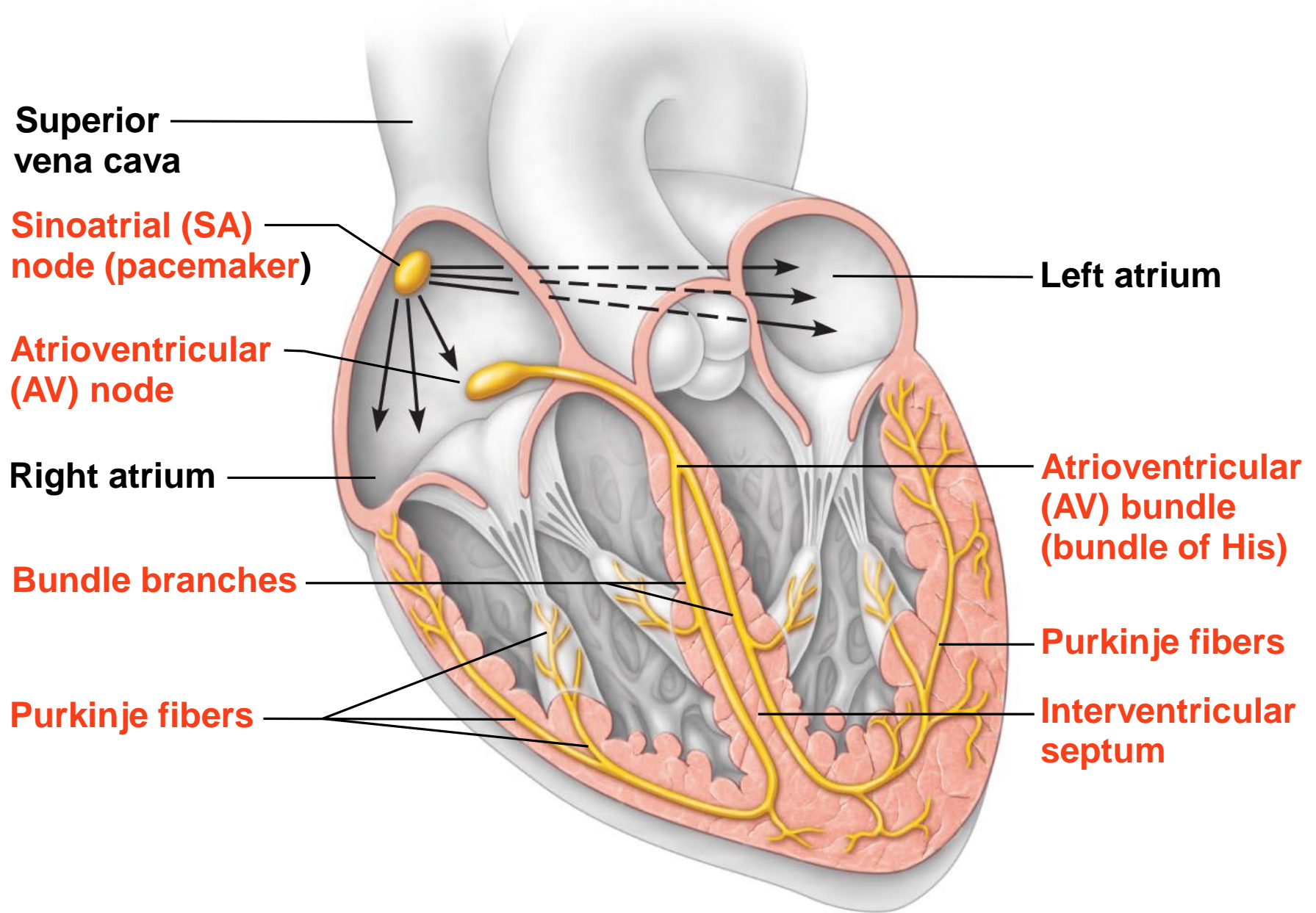


Heart Contractions

- Contraction is initiated by the **sinoatrial node** (SA node)
- Sequential stimulation occurs at other autorhythmic cells
- Force cardiac muscle depolarization in one direction—from atria to ventricles

Heart Contractions

- Once SA node starts the heartbeat
 - Impulse spreads to the AV node
 - Then the atria contract
- At the AV node, the impulse passes through the AV bundle, bundle branches, and Purkinje fibers
- Blood is ejected from the ventricles to the aorta and pulmonary trunk as the ventricles contract



Heart Contractions

- Homeostatic imbalance
 - **Heart block**—damaged AV node releases them from control of the SA node; result is in a slower heart rate as ventricles contract at their own rate
 - **Ischemia**—lack of adequate oxygen supply to heart muscle
 - **Fibrillation**—a rapid, uncoordinated shuddering of the heart muscle

Heart Contractions

- Homeostatic imbalance (continued)
 - **Tachycardia**—rapid heart rate over 100 beats per minute
 - **Bradycardia**—slow heart rate less than 60 beats per minutes

The Heart: Cardiac Cycle & Heart Sounds

- Atria contract simultaneously
- Atria relax, then ventricles contract
- **Systole** = contraction
- **Diastole** = relaxation

The Heart: Cardiac Cycle & Heart Sounds

- **Cardiac cycle**—events of one complete heart beat
 - **Mid-to-late diastole**
 - Pressure in heart is low
 - Blood flows from passively into the atria and into ventricles
 - Semilunar valves are closed
 - Atrioventricular valves are open
 - Atria contract and force blood into ventricles

The Heart: Cardiac Cycle & Heart Sounds

- Cardiac cycle—events of one complete heart beat
 - **Ventricular systole**
 - Blood pressure builds before ventricle contracts
 - Atrioventricular valves close causes first heart sound, “lub”
 - Semilunar valves open as blood pushes against them
 - Blood travels out of the ventricles through pulmonary trunk and aorta
 - Atria are relaxed

The Heart: Cardiac Cycle & Heart Sounds

- Cardiac cycle—events of one complete heart beat
 - **Early diastole**
 - At the end of systole, all four valves are briefly closed at the same time
 - Second heart sound is heard as semilunar valves close, causing “dup” sound
 - Atria finish refilling as pressure in the heart drops
 - Ventricular pressure is low
 - Atrioventricular valves open

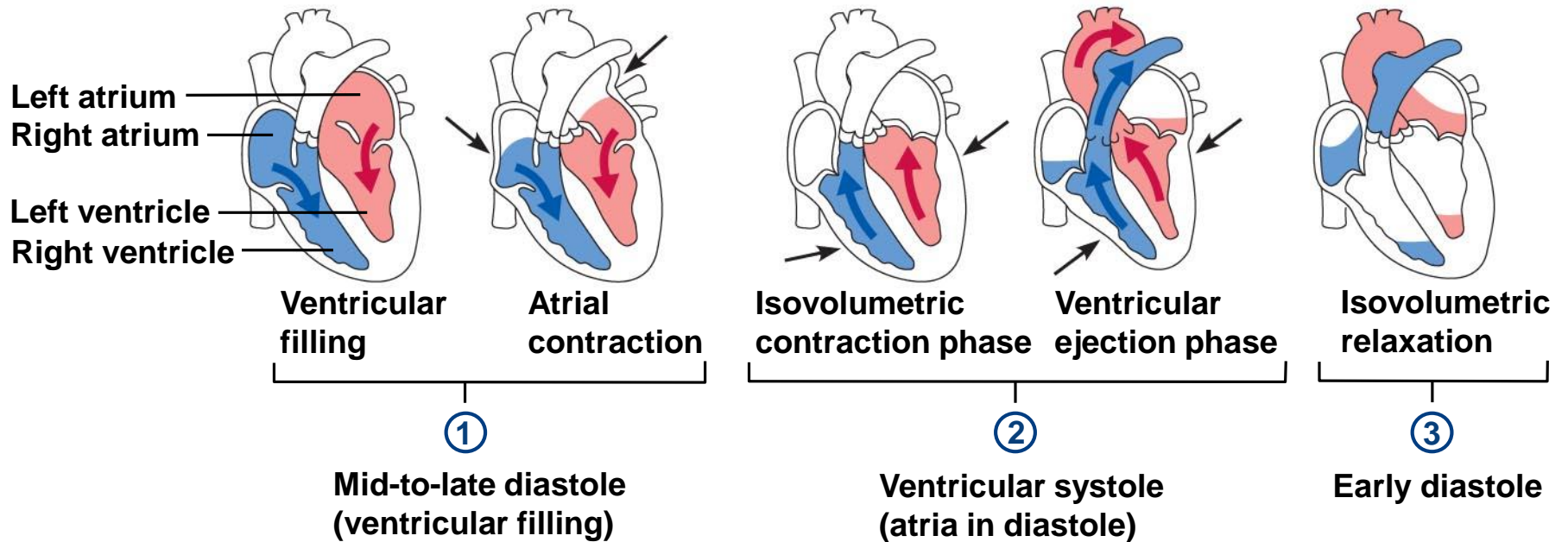
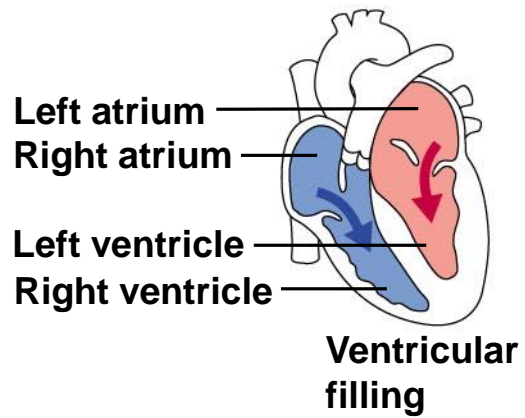


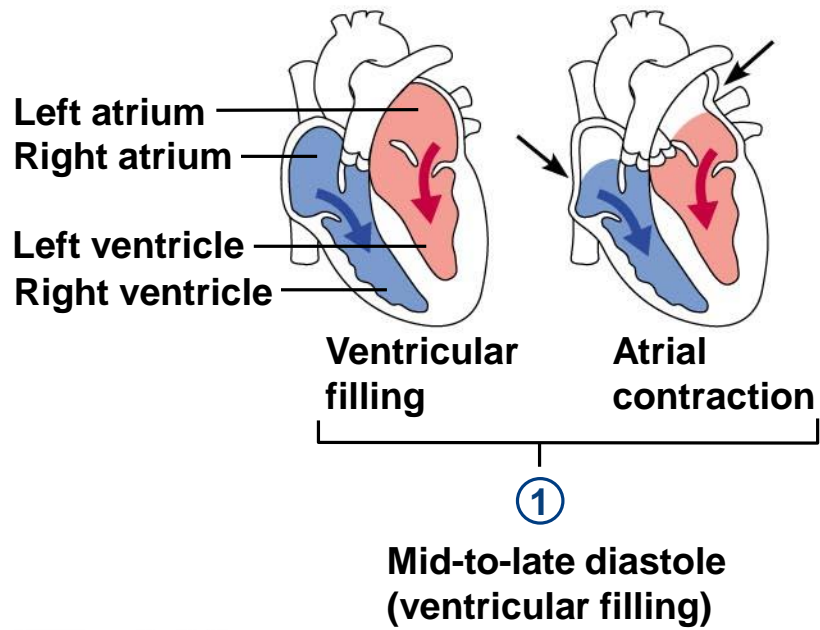
Figure 11.8



①

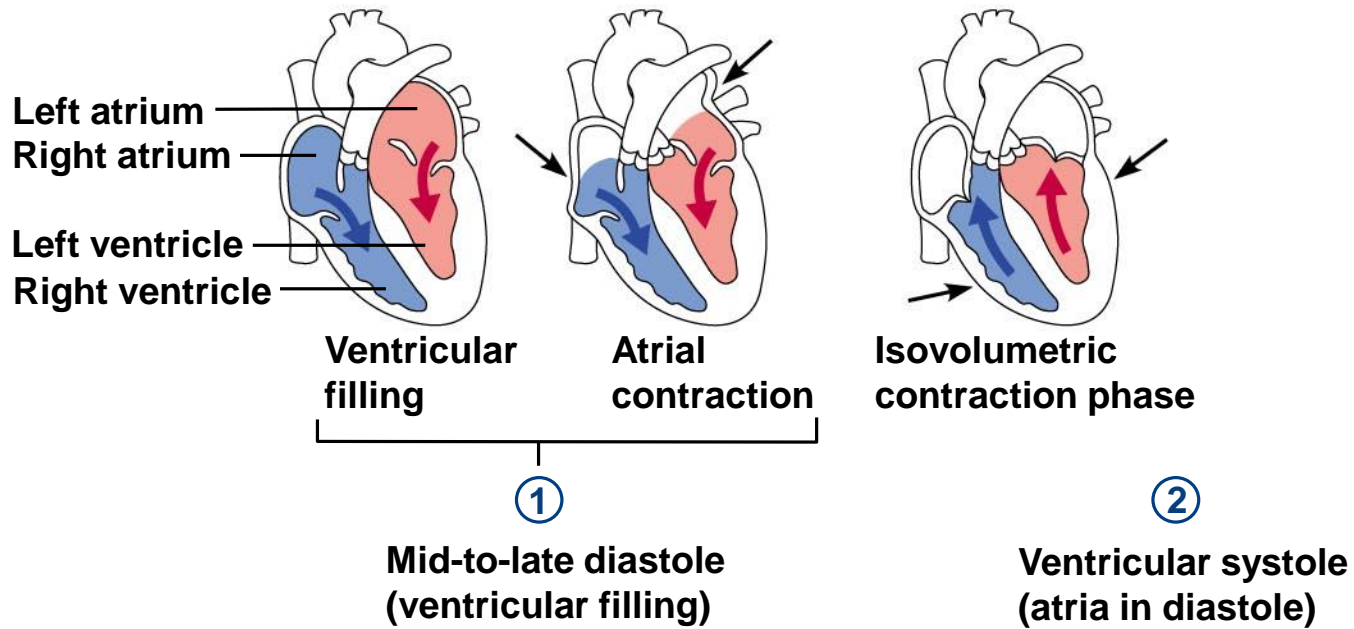
Mid-to-late diastole
(ventricular filling)

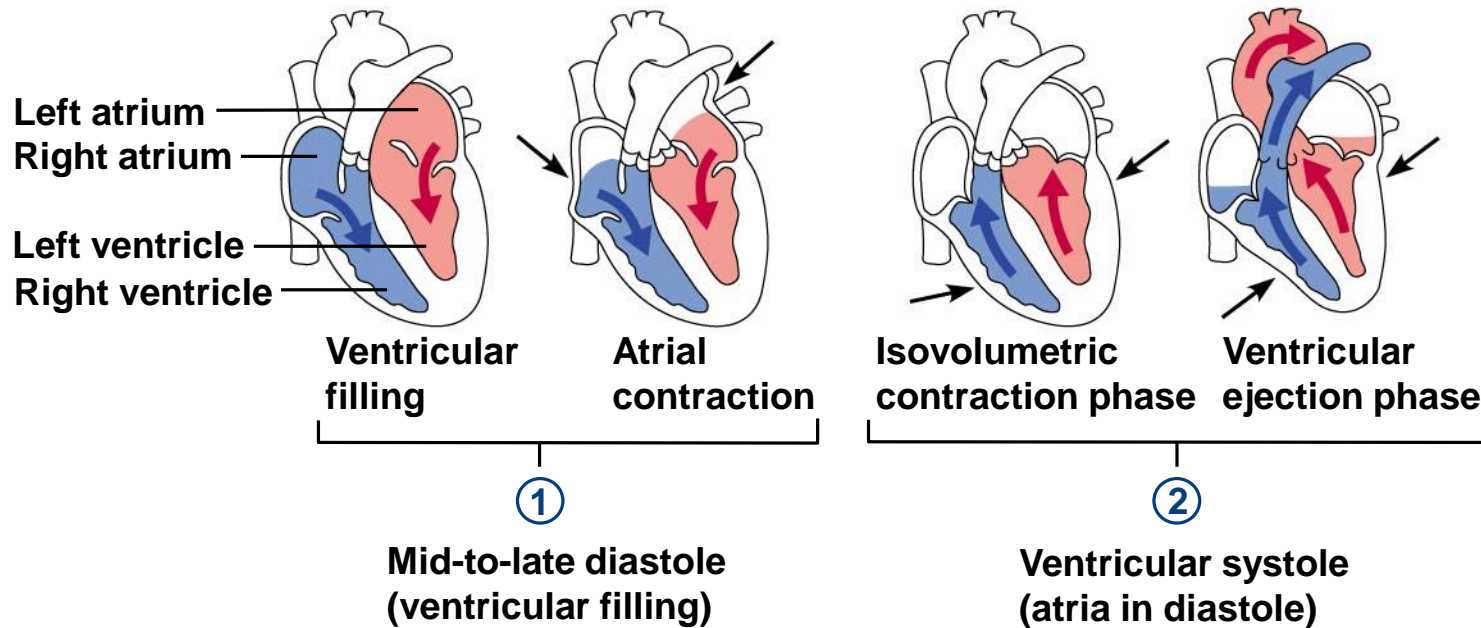
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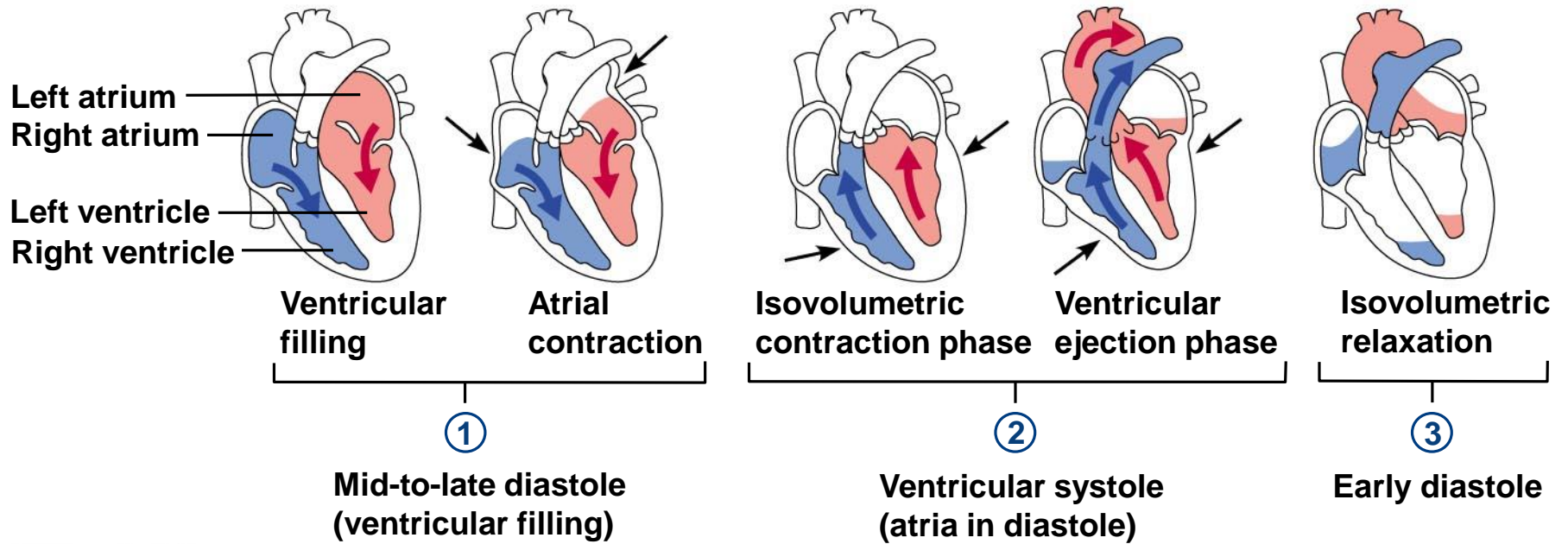


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Figure 11.8, step 1b







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Figure 11.8, step 3

The Heart: Cardiac Output

- **Cardiac output (CO)**
 - Amount of blood pumped by each side (ventricle) of the heart in one minute
- **Stroke volume (SV)**
 - Volume of blood pumped by each ventricle in one contraction (each heartbeat)
 - Usually remains relatively constant
 - About 70 mL of blood is pumped out of the left ventricle with each heartbeat
- **Heart rate (HR)**
 - Typically 75 beats per minute

The Heart: Cardiac Output

- $CO = HR \times SV$
- $CO = HR (75 \text{ beats/min}) \times SV (70 \text{ mL/beat})$
- $CO = 5250 \text{ mL/min}$
- **Starling's law of the heart**—the more the cardiac muscle is stretched, the stronger the contraction
- Changing heart rate is the most common way to change cardiac output

The Heart: Regulation of Heart Rate

- Increased heart rate
 - Sympathetic nervous system
 - Crisis
 - Low blood pressure
 - Hormones
 - Epinephrine
 - Thyroxine
 - Exercise
 - Decreased blood volume

The Heart: Regulation of Heart Rate

- Decreased heart rate
 - Parasympathetic nervous system
 - High blood pressure or blood volume
 - Decreased venous return

