The Cardiovascular System
The Heart

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INTRODUCTION

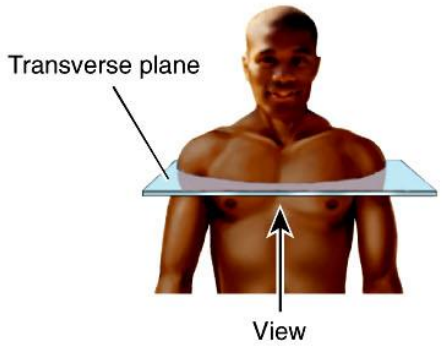
The cardiovascular system
consists of the heart, blood vessels. And Blood.

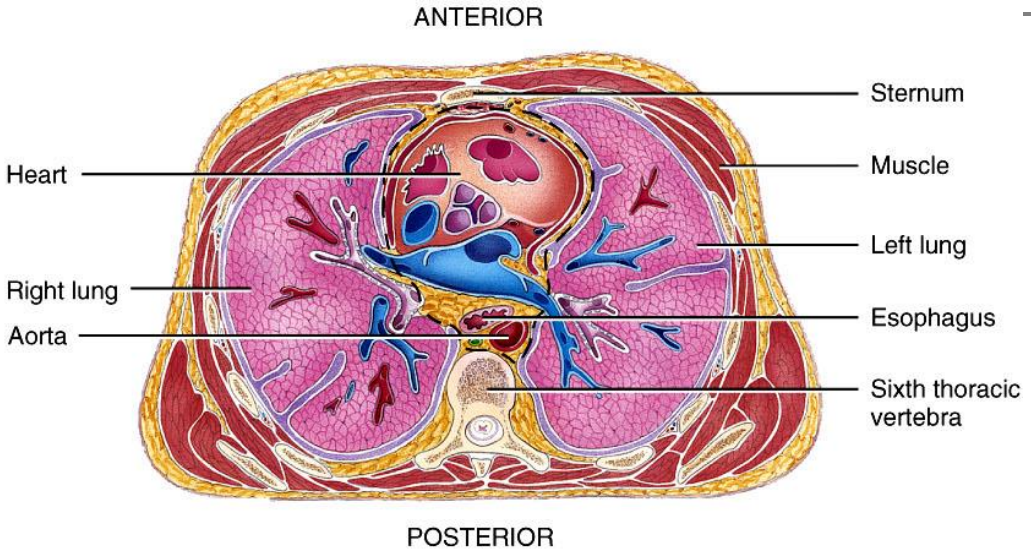
The heart is the pump that
circulates the blood through
blood vessels.

Cardiology: is the study of the normal heart and diseases associated with it .

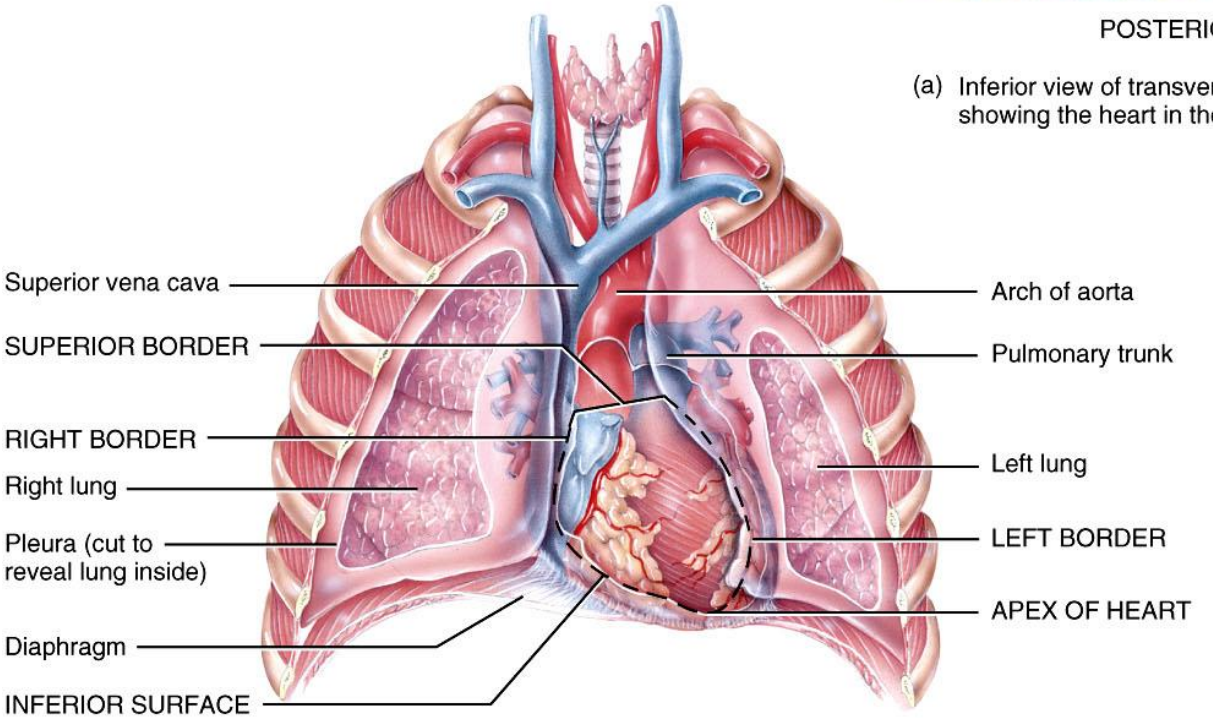
Location of the Heart

- Located in the mediastinum between lungs
- about two-thirds of its mass to the left of the midline.
- Mediastinum is an anatomical region extending from the sternum to the vertebral column, the first rib and between the lungs
- Anterior surface deep to sternum and ribs
- Inferior surface between apex and right border
- Right border faces right lung
- Left border (pulmonary border) faces left lung



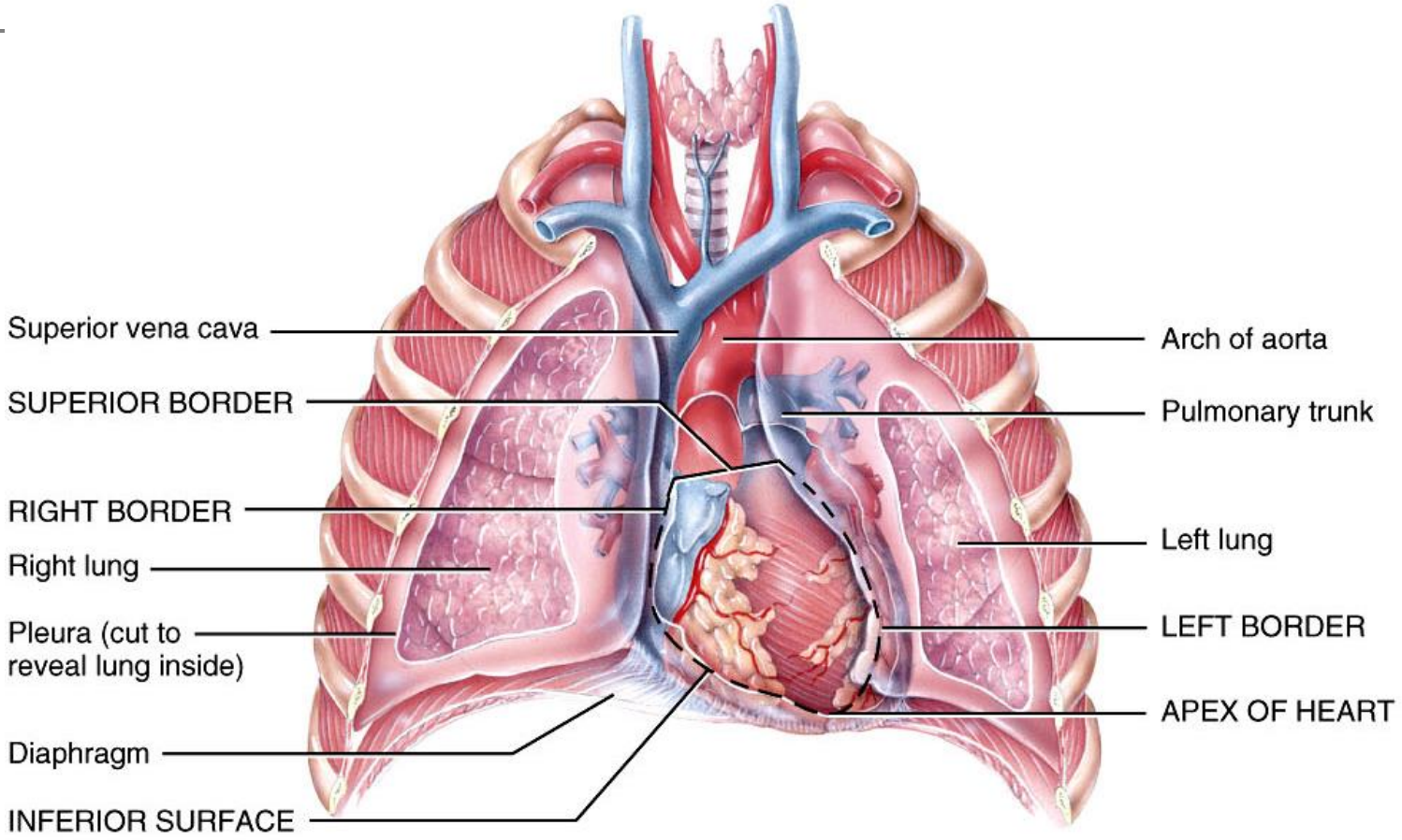


(a) Inferior view of transverse section of thoracic cavity showing the heart in the mediastinum



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

Figure 20.01 Tortora - PAP 12/e



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

Figure 20.01 Tortora - PAP 12/e

Heart has 2 surfaces: anterior and inferior, and 2 borders: right and left, has apex and base

Pericardium

- a sac surrounding and protecting the heart
- 2 main parts
  1. Fibrous pericardium – tough, inelastic, dense irregular connective tissue – prevents overstretching, protection, anchorage/ superffcial
  2. Serous pericardium – deeper, thinner, more delicate double layer membrane:
     a. parietal layer fused to fibrous pericardium
     b. visceral layer also called epicardium
  - Pericardial fluid reduces friction – secreted into pericardial cavity

Pericardial Layers of the Heart

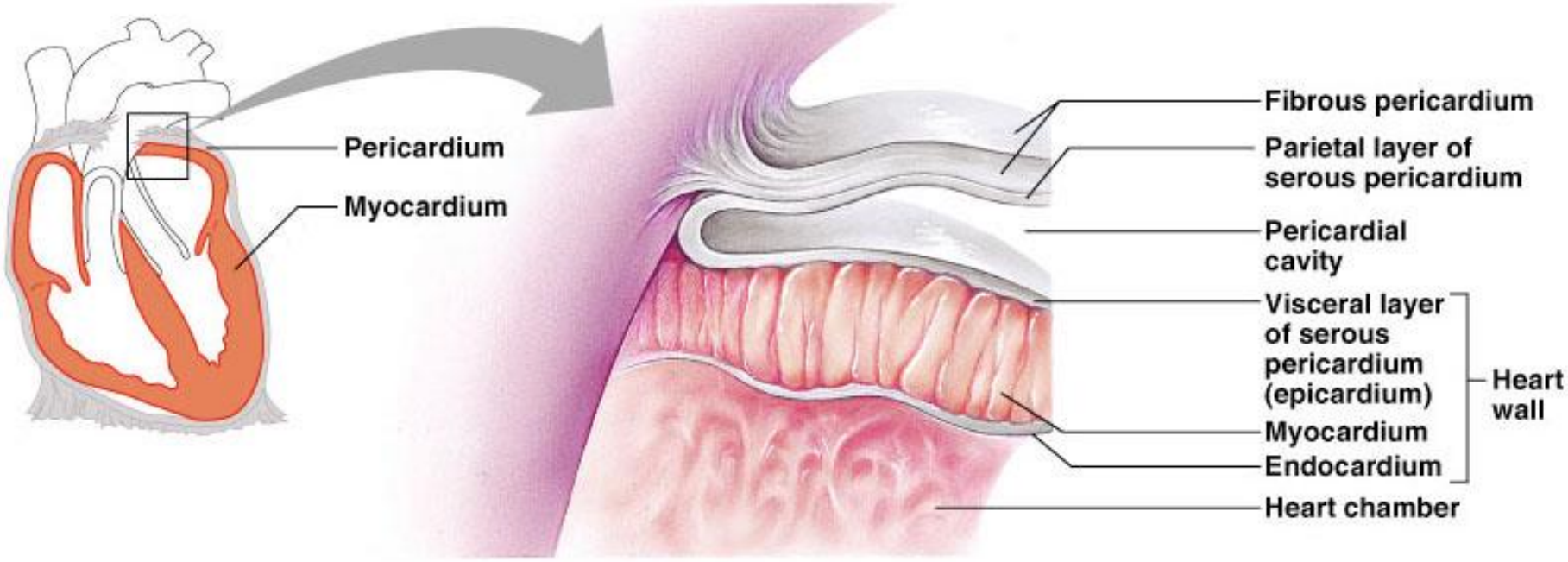
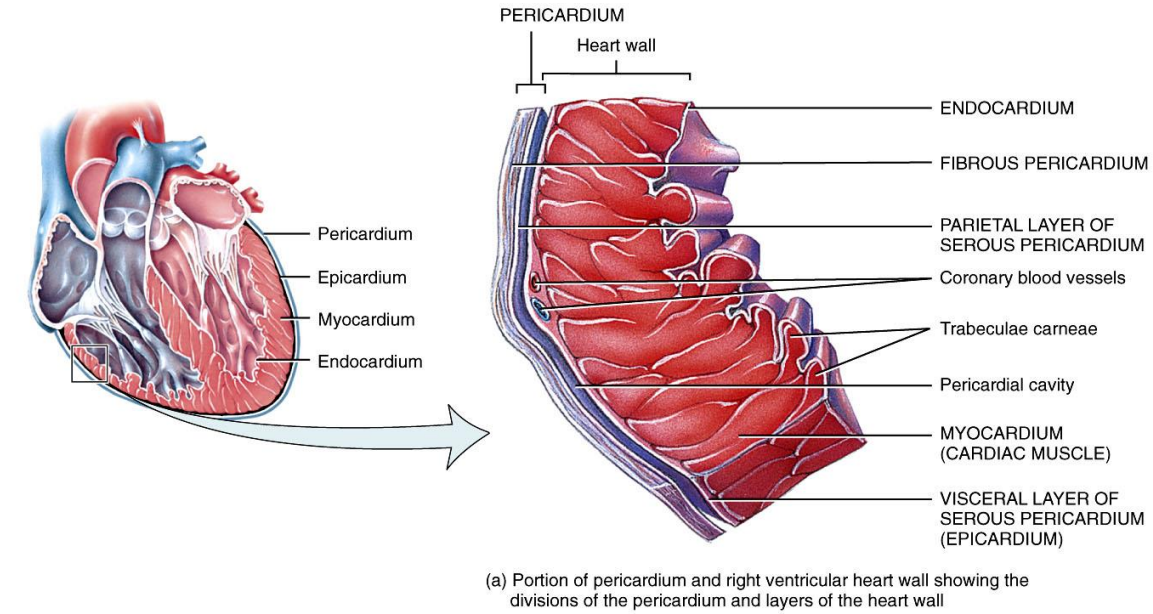


Figure 18.2

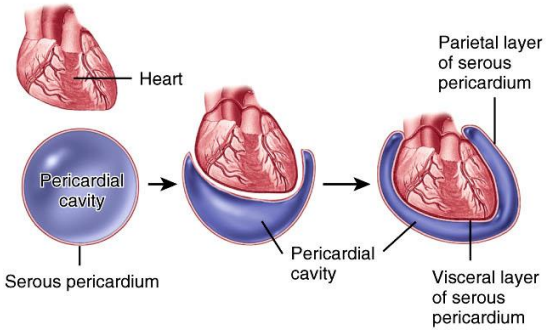
Coverings of the Heart: Physiology

- The Function of the Pericardium:
  - Protects and anchors the heart
  - Prevents overfilling of the heart with blood
  - Allows for the heart to work in a relatively friction-free environment

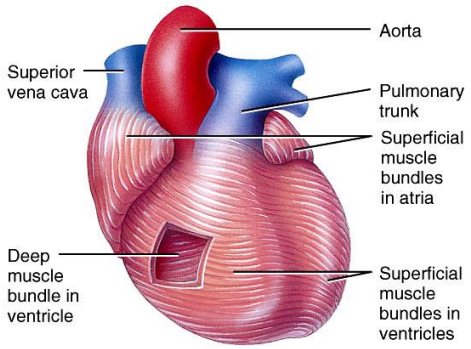
Pericardium and Heart Wall



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



(b) Simplified relationship of the serous pericardium to the heart



(c) Cardiac muscle bundles of the myocardium

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Layers of the Heart Wall

1. Epicardium (external layer)
   - Visceral layer of serous pericardium
   - Smooth, slippery texture to outermost surface
2. Myocardium
   - 95% of heart is cardiac muscle
3. Endocardium (inner layer)
   - Smooth lining for chambers of heart, valves and continuous with lining of large blood vessels

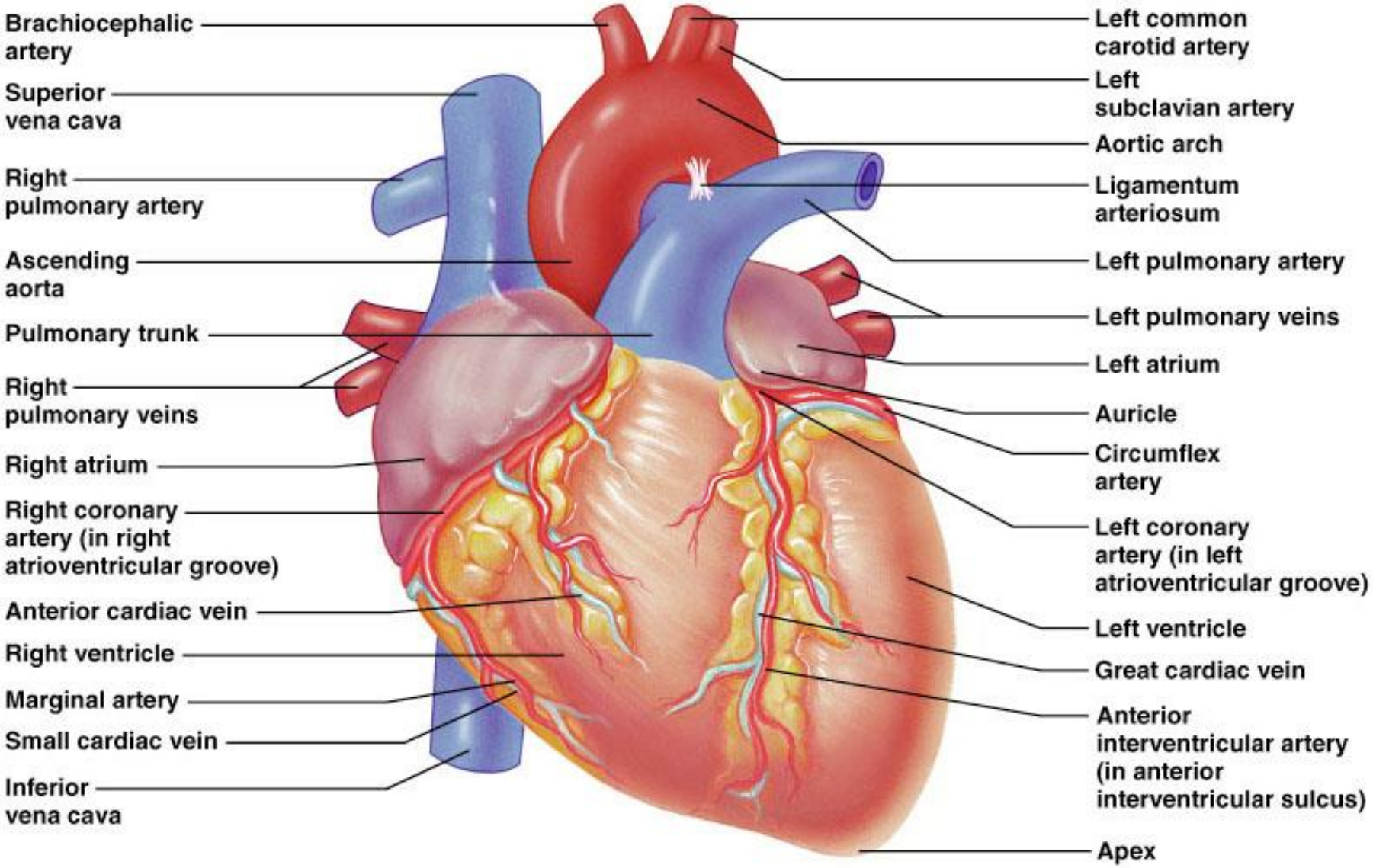
External Heart: Major Vessels of the Heart (Anterior View)

- Vessels **returning blood to the heart** include:
  1. Superior and inferior venae cavae
  2. Right and left pulmonary veins
- Vessels conveying **blood away from the heart** include:
  1. Pulmonary trunk, which splits into right and left pulmonary arteries
  2. Ascending aorta (three branches) –
     a. Brachiocephalic
     b. Left common carotid
     c. Subclavian arteries

External Heart: Vessels that Supply/Drain the Heart (Anterior View)

- **Arteries** – right and left coronary (in atrioventricular groove), marginal, circumflex, and anterior interventricular arteries
- **Veins** – small cardiac, anterior cardiac, and great cardiac veins

External Heart: Anterior View



External Heart: Major Vessels of the Heart (Posterior View)

- Vessels **returning blood to the heart** include:
  1. Right and left pulmonary veins
  2. Superior and inferior venae cavae
- Vessels **conveying blood away from the heart** include:
  1. Aorta
  2. Right and left pulmonary arteries

External Heart: Vessels that Supply/Drain the Heart (Posterior View)

- **Arteries** – right coronary artery (in atrioventricular groove) and the posterior interventricular artery (in interventricular groove)
- **Veins** – great cardiac vein, posterior vein to left ventricle, coronary sinus, and middle cardiac vein

External Heart: Posterior View

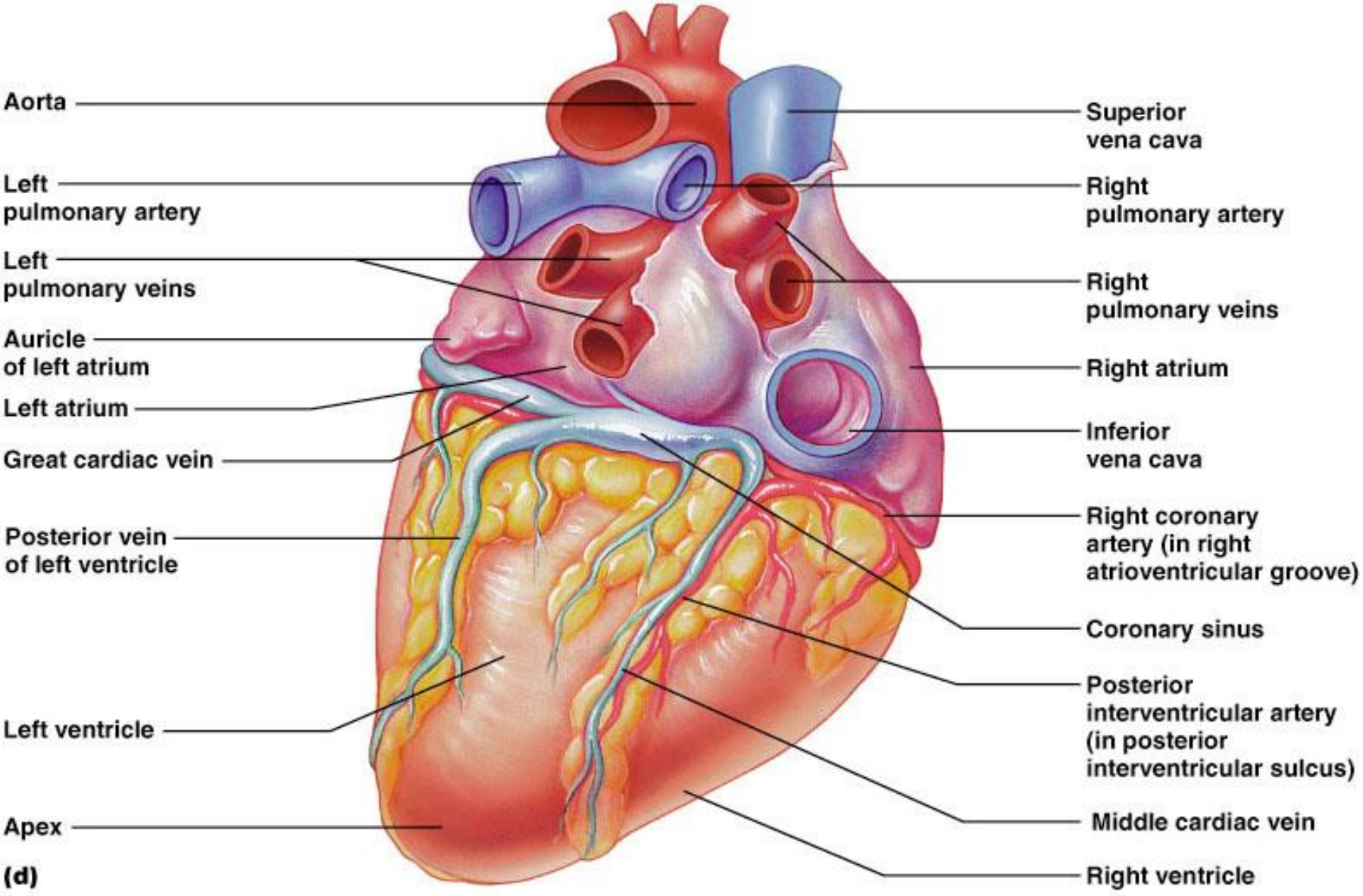


Figure 18.4d

Chambers of the Heart

- 2 atria – receiving chambers
  - Auricles increase capacity
- 2 ventricles – pumping chambers
- Sulci – grooves
  - Contain coronary blood vessels
  - Coronary sulcus
  - Anterior interventricular sulcus
  - Posterior interventricular sulcus

Gross Anatomy of Heart: Frontal

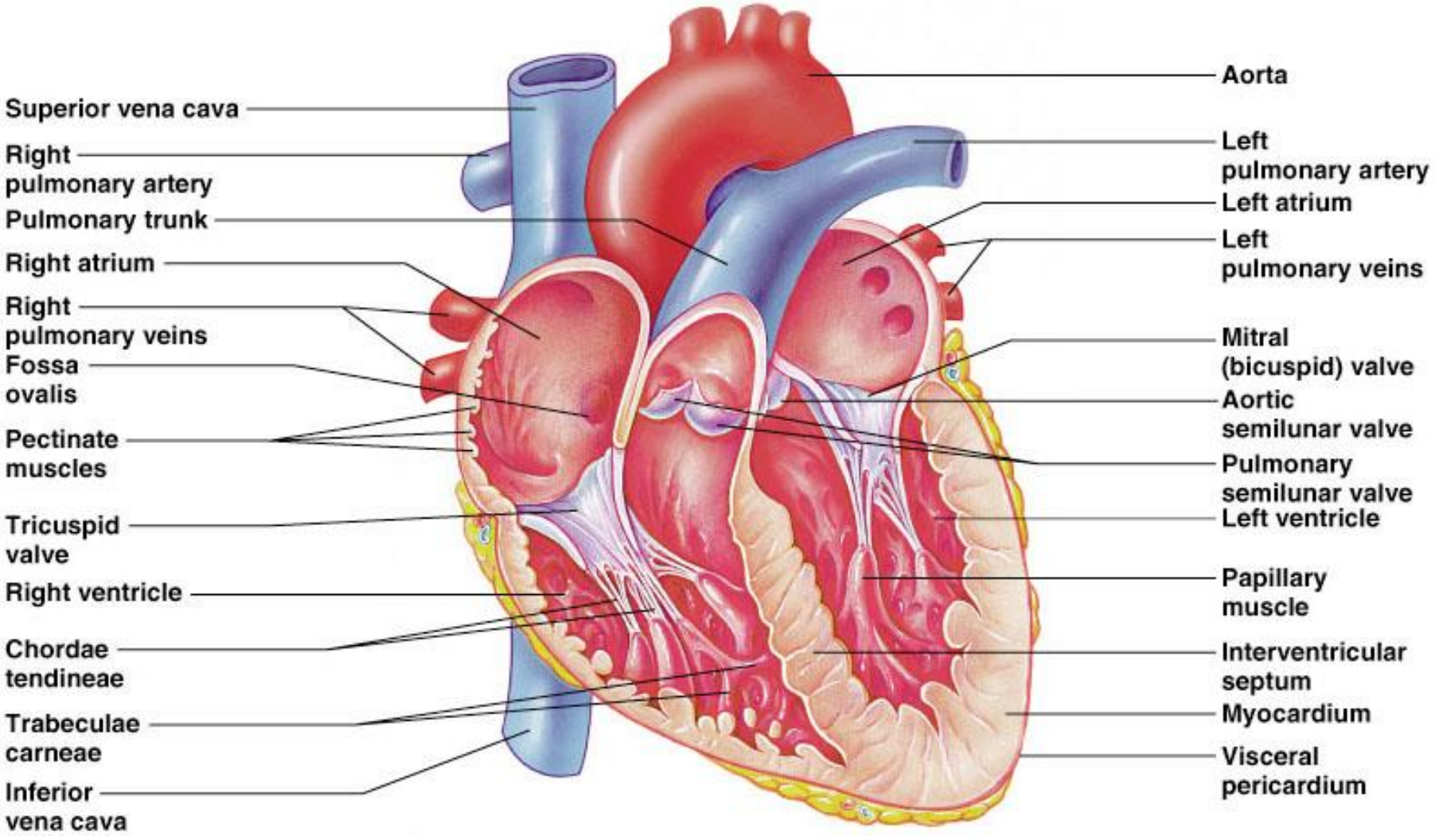


Figure 18.4e

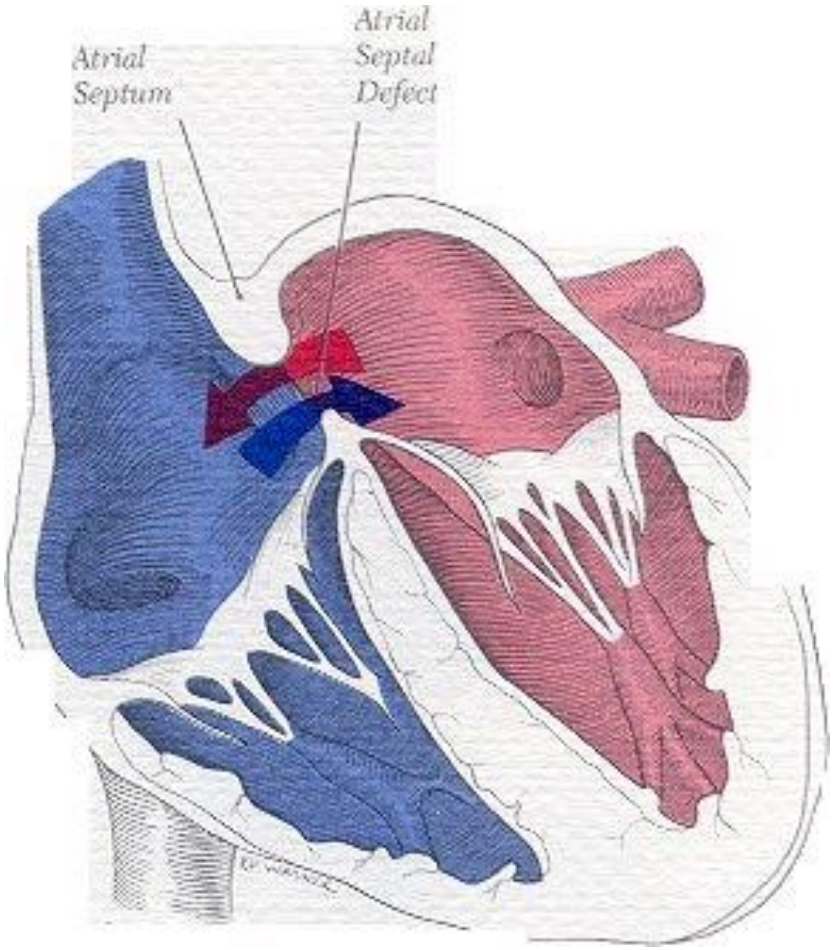
Right Atrium

- Receives blood from
  - Superior vena cava
  - Inferior vena cava
  - Coronary sinus
- Interatrial septum has fossa ovalis
  - Remnant of foramen ovale
- Blood passes through tricuspid valve (right atrioventricular valve) into right ventricle

Left Atrium

- About the same thickness as right atrium
- Receives blood from the lungs through pulmonary veins
- Passes through bicuspid/ mitral/ left atrioventricular valve into left ventricle

Atrial Septal Defect



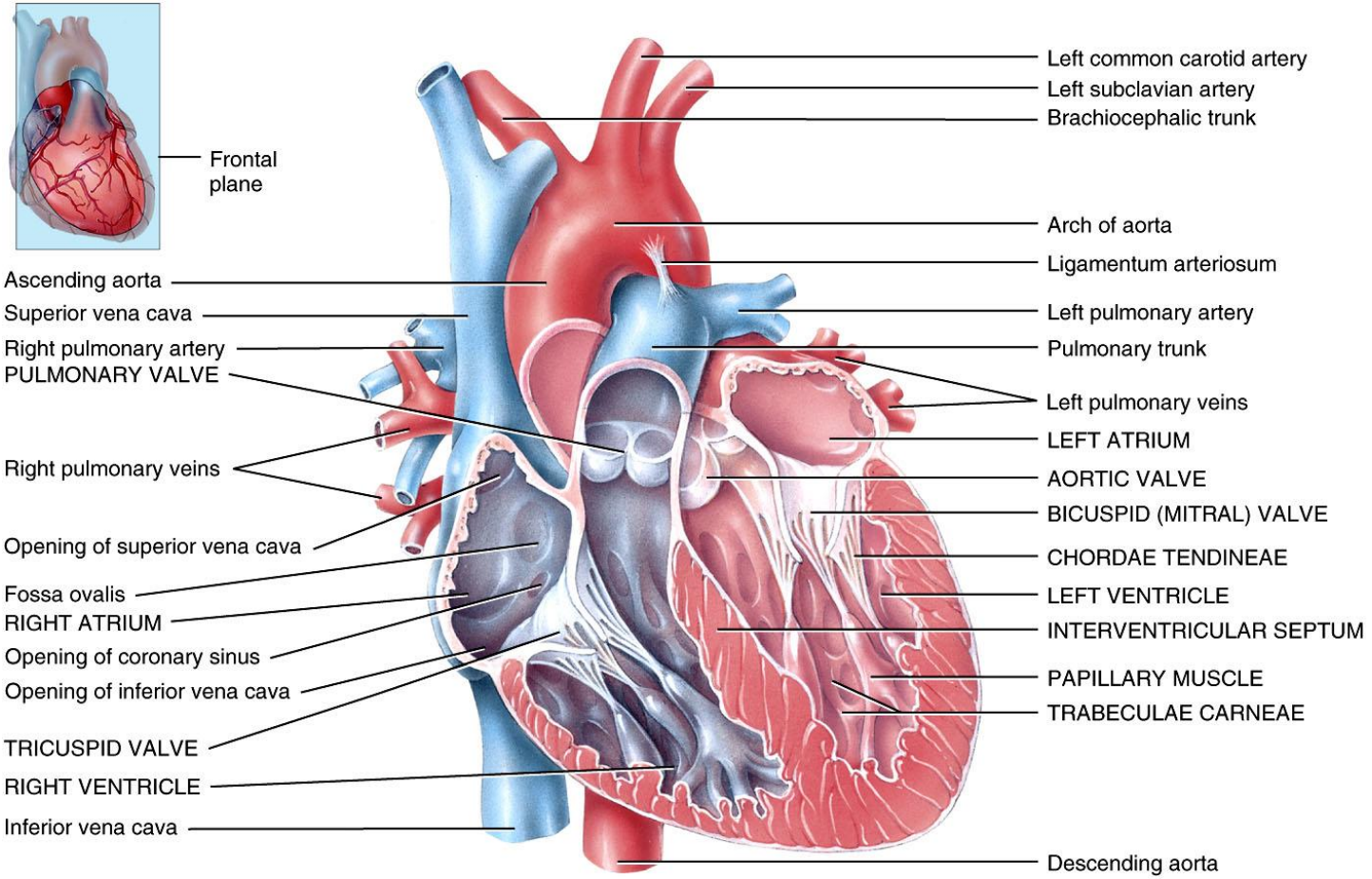
Right Ventricle

- Forms anterior surface of heart
- Trabeculae carneae – ridges formed by raised bundles of cardiac muscle fiber
  - Part of conduction system of the heart
- Tricuspid valve connected to chordae tendinae connected to papillary muscles
- Interventricular septum
- Blood leaves through pulmonary valve (pulmonary semilunar valve) into pulmonary trunk and then right and left pulmonary arteries

Left Ventricle

- Thickest chamber of the heart
- Forms apex
- Chordae tendinae attached to papillary muscles
- Blood passes through aortic valve (aortic semilunar valve) into ascending aorta
- Some blood flows into coronary arteries, remainder to body
- During fetal life ductus arteriosus shunts blood from pulmonary trunk to aorta (lung bypass) closes after birth with remnant called ligamentum arteriosum

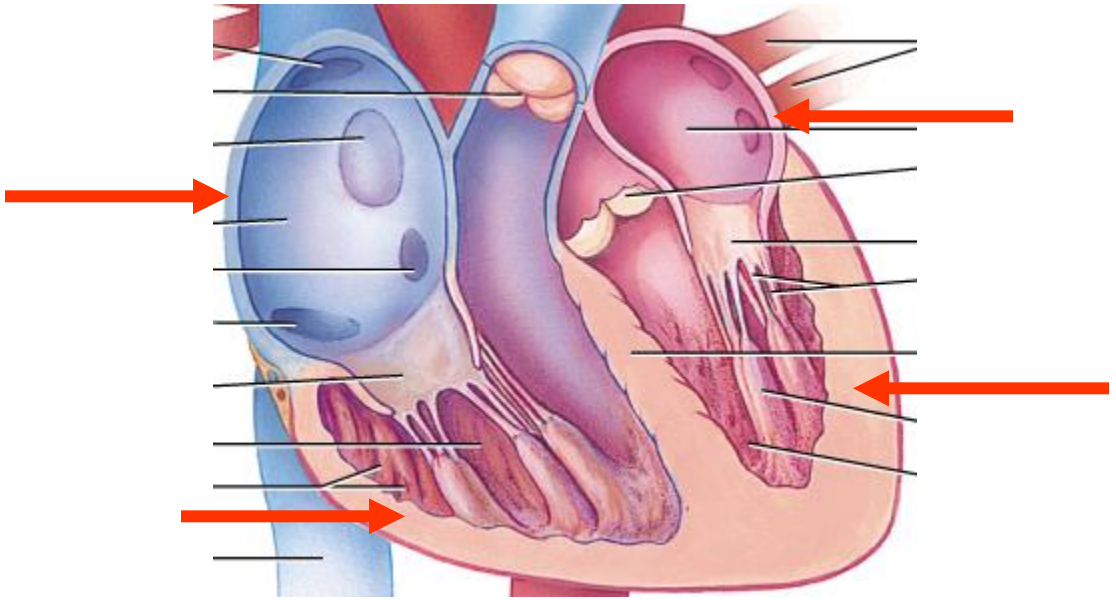
Internal Anatomy of the Heart



(a) Anterior view of frontal section showing internal anatomy

Figure 20.04a Tortora - PAP 12/e

Myocardial Thickness and Function



Thickness of myocardium varies according to the function of the chamber

Atria are thin walled, deliver blood to adjacent ventricles

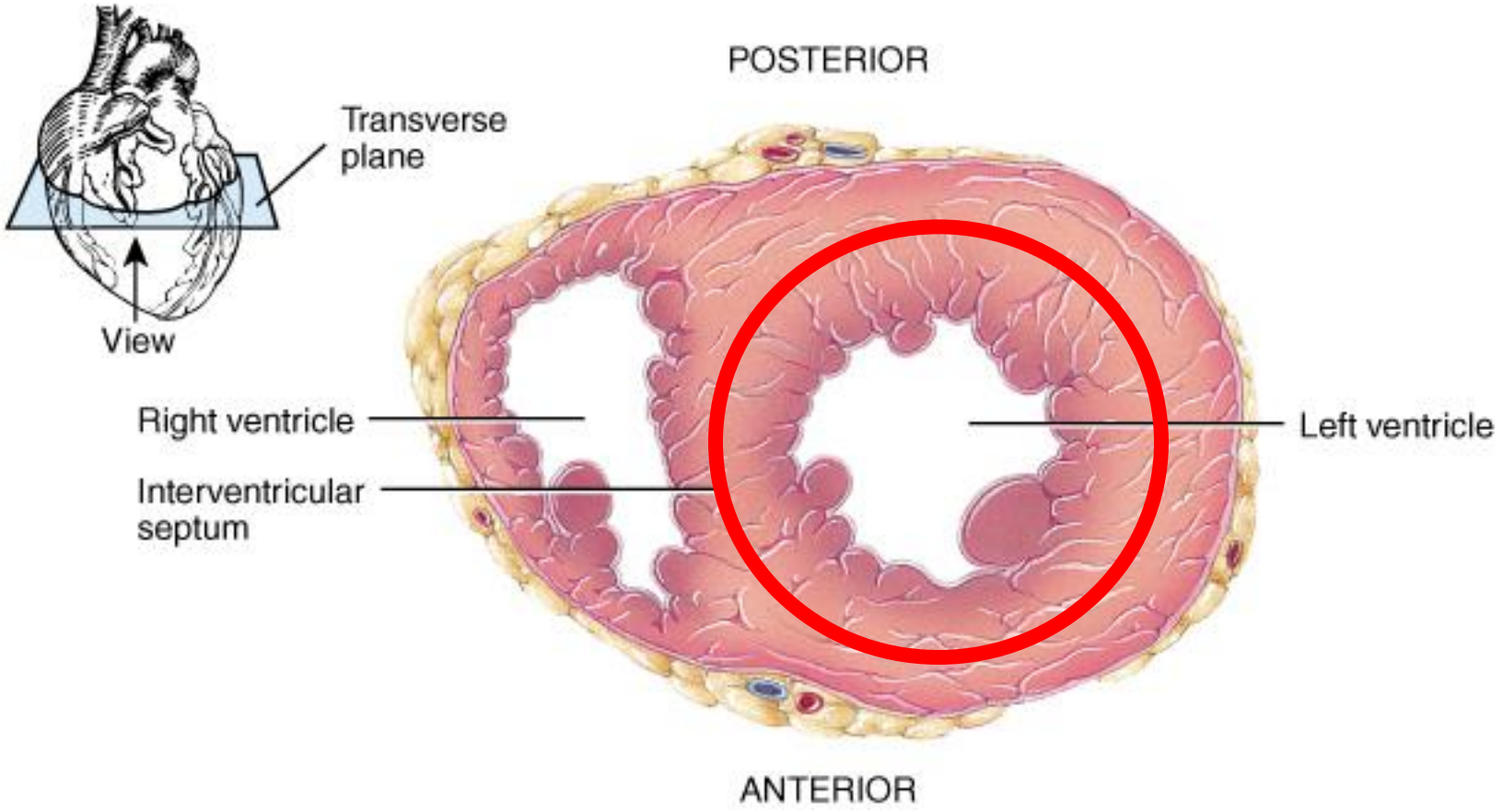
Ventricle walls are much thicker and stronger

- right ventricle supplies blood to the lungs (little flow resistance)
- left ventricle wall is the thickest to supply systemic circulation

Myocardial thickness

- Thin-walled atria deliver blood under less pressure to ventricles
- Right ventricle pumps blood to lungs
  - Shorter distance, lower pressure, less resistance
- Left ventricle pumps blood to body
  - Longer distance, higher pressure, more resistance
- Left ventricle works harder to maintain same rate of blood flow as right ventricle

Thickness of Cardiac Walls



Myocardium of left ventricle is much thicker than the right.

Fibrous skeleton

- Dense connective tissue that forms a structural foundation, point of insertion for muscle bundles, and electrical insulator between atria and ventricles

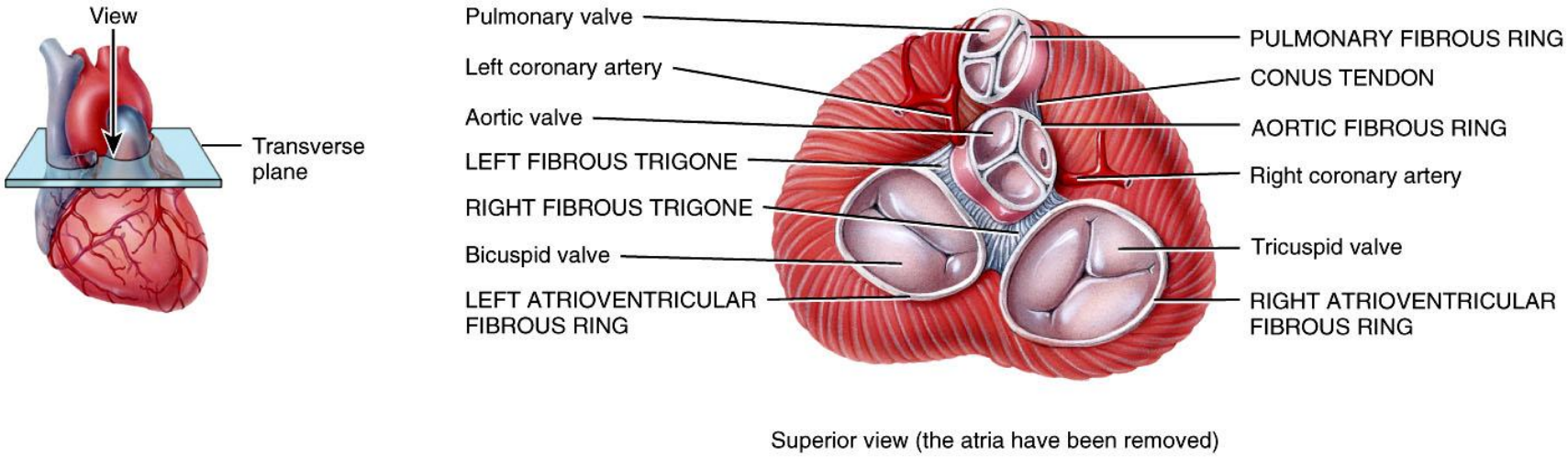
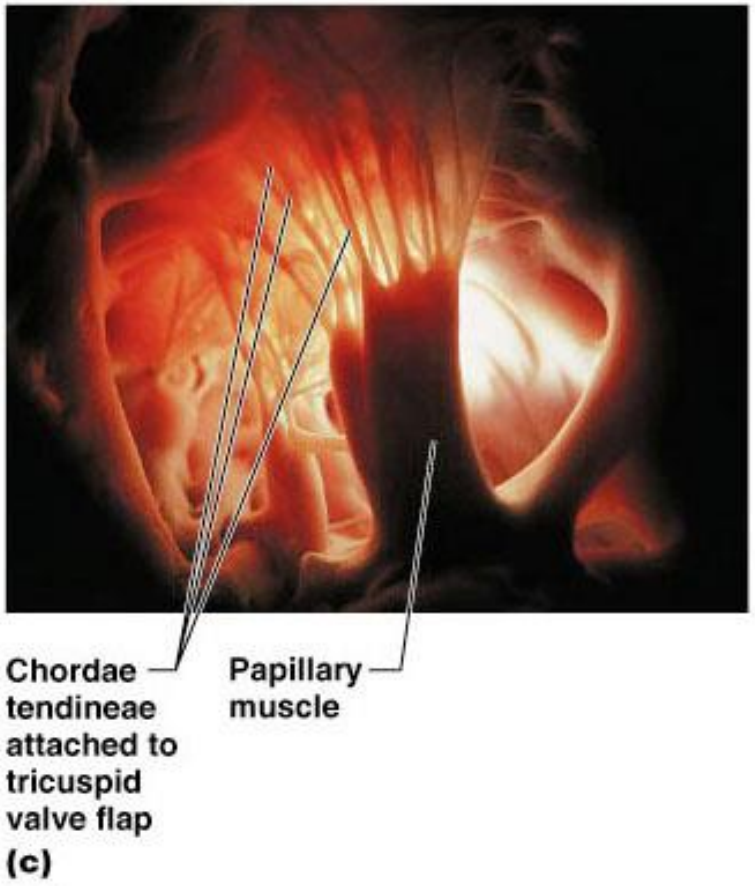


Figure 20.05 Tortora - PAP 12/e

Heart Valves and Circulation of Blood

- Atrioventricular valves
  - Tricuspid and bicuspid valves
  - Atria contracts/ ventricle relaxed
    - AV valve opens, cusps project into ventricle
    - In ventricle, papillary muscles are relaxed and chordae tendinae slack
  - Atria relaxed/ ventricle contracts
    - Pressure drives cusps upward until edges meet and close opening
    - Papillary muscles contract tightening chordae tendinae
      - Prevents regurgitation

Heart Valves



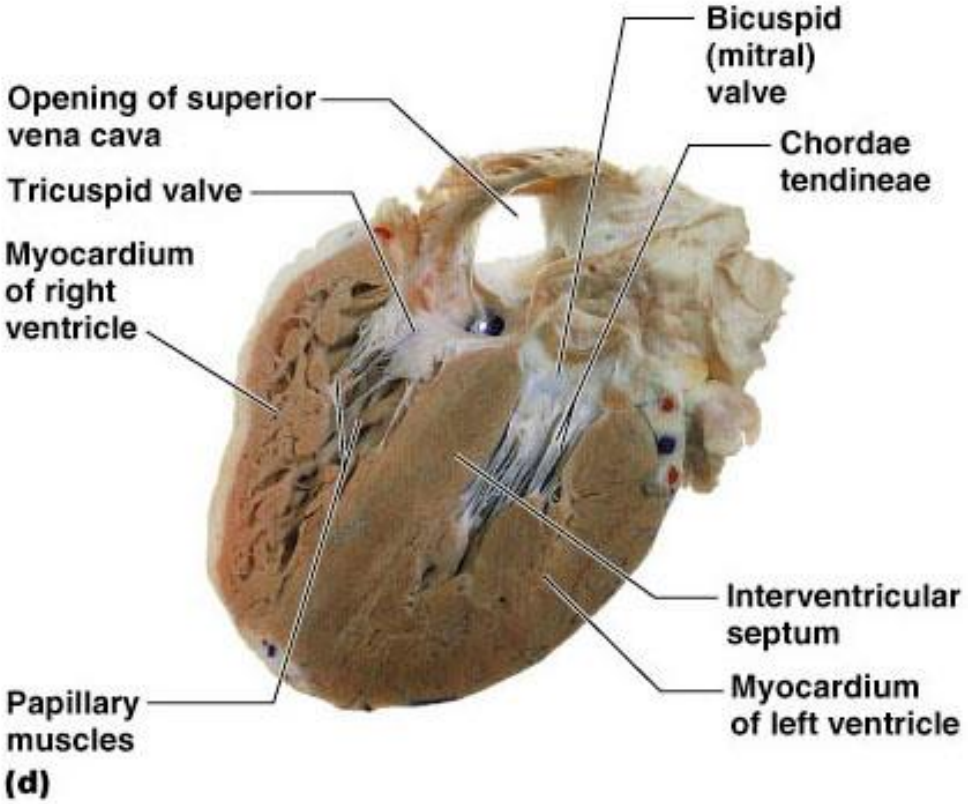


Figure 18.8c, d

Pathway of Blood Through the Heart and Lungs

- Right atrium → tricuspid valve → right ventricle
- Right ventricle → pulmonary semilunar valve → pulmonary arteries → lungs
- Lungs → pulmonary veins → left atrium
- Left atrium → bicuspid valve → left ventricle
- Left ventricle → aortic semilunar valve → aorta
- Aorta → systemic circulation

Pathway of Blood Through the Heart and Lungs

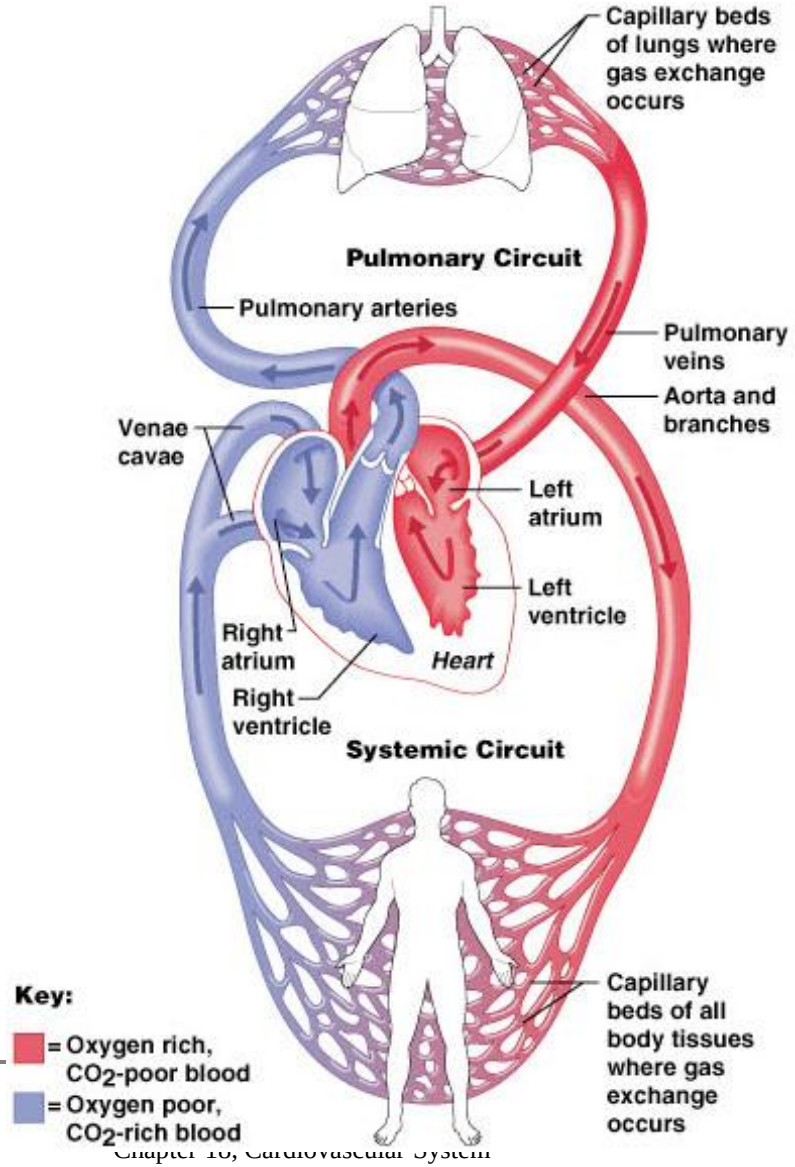
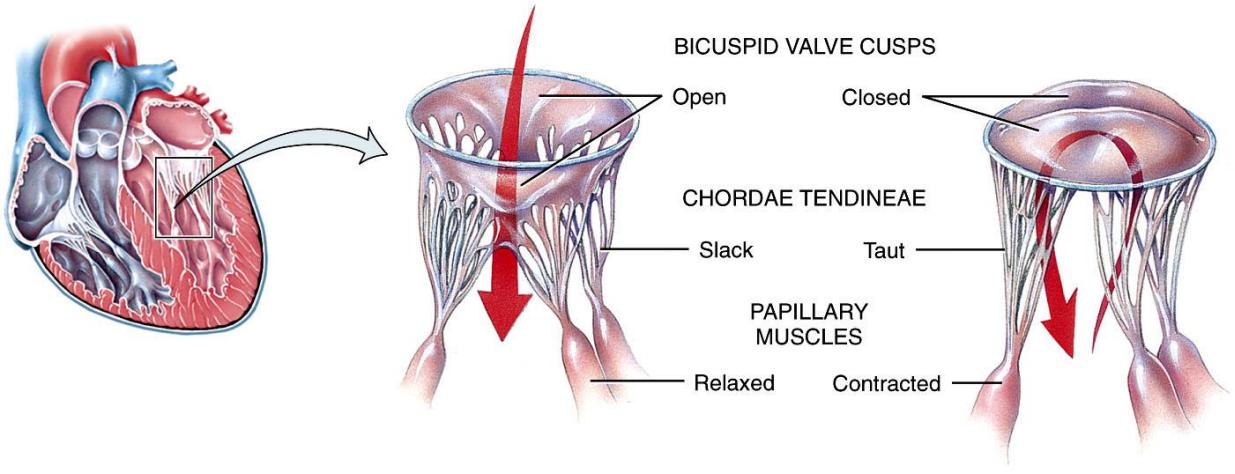


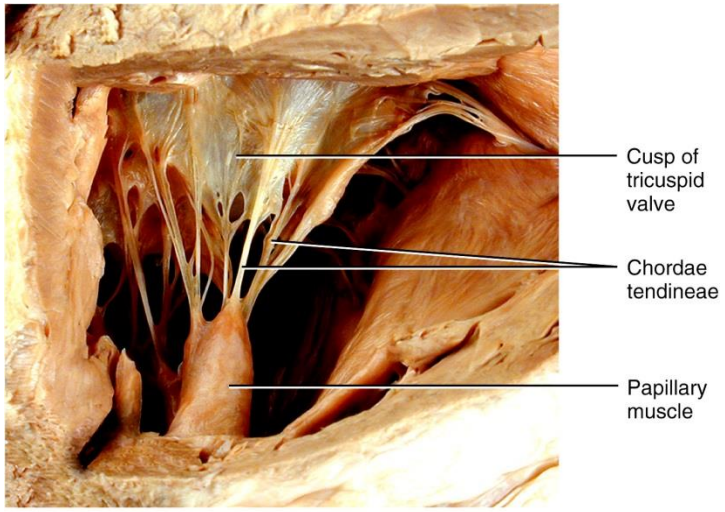
Figure 18.5



(a) Bicuspid valve open

(b) Bicuspid valve closed

Figure 20.06ab Tortora - PAP 12/e



(c) Tricuspid valve open

Figure 20.06c Tortora - PAP 12/e

Semilunar valves

- Aortic and pulmonary valves
- Valves open when pressure in ventricle exceeds pressure in arteries
- As ventricles relax, some backflow permitted but blood fills valve cusps closing them tightly

- No valves guarding entrance to atria
  - As atria contracts, compresses and closes opening

Systemic and pulmonary circulation - 2 circuits in series

- Systemic circuit
  - Left side of heart
  - Receives blood from lungs
  - Ejects blood into aorta
  - Systemic arteries, arterioles
  - Gas and nutrient exchange in systemic capillaries
  - Systemic venules and veins lead back to right atrium
- Pulmonary circuit
  - Right side of heart
  - Receives blood from systemic circulation
  - Ejects blood into pulmonary trunk then pulmonary arteries
  - Gas exchange in pulmonary capillaries
  - Pulmonary veins takes blood to left atrium

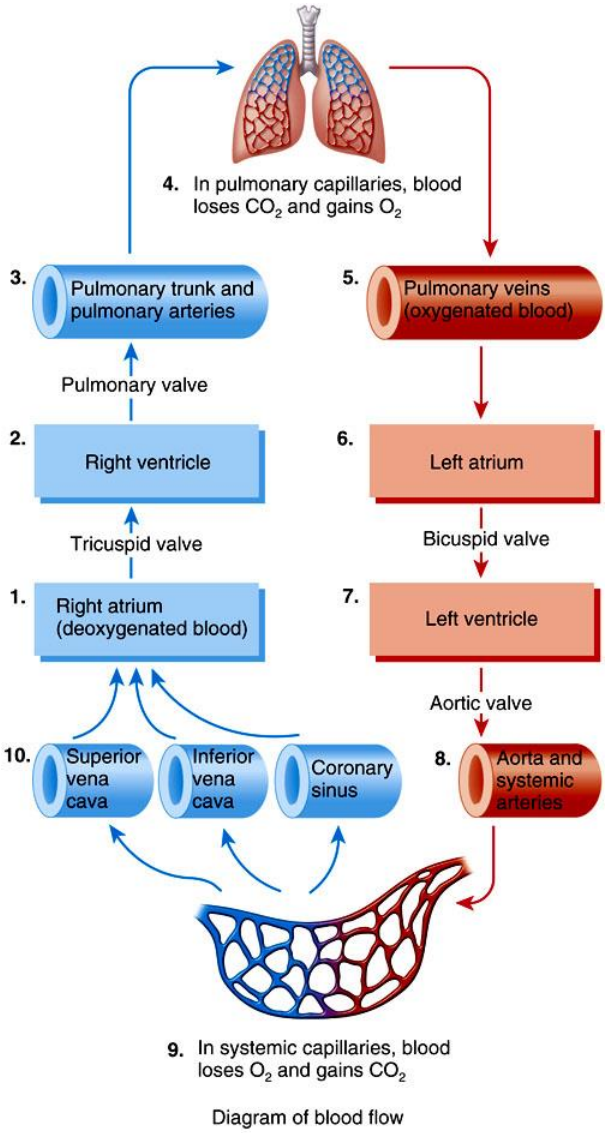


Figure 20.07 Tortora - PAP 12/e

Coronary circulation

- Myocardium has its own network of blood vessels
- Coronary arteries branch from ascending aorta
  - Anastomoses provide alternate routes or collateral circuits
  - Allows heart muscle to receive sufficient oxygen even if an artery is partially blocked
- Coronary capillaries
- Coronary veins
  - Collects in coronary sinus
  - Empties into right atrium

Coronary Circulation

- **Coronary circulation** is the functional blood supply to the heart muscle itself
- **Collateral routes** ensure blood delivery to heart even if major vessels are occluded

Coronary Circulation: Arterial Supply

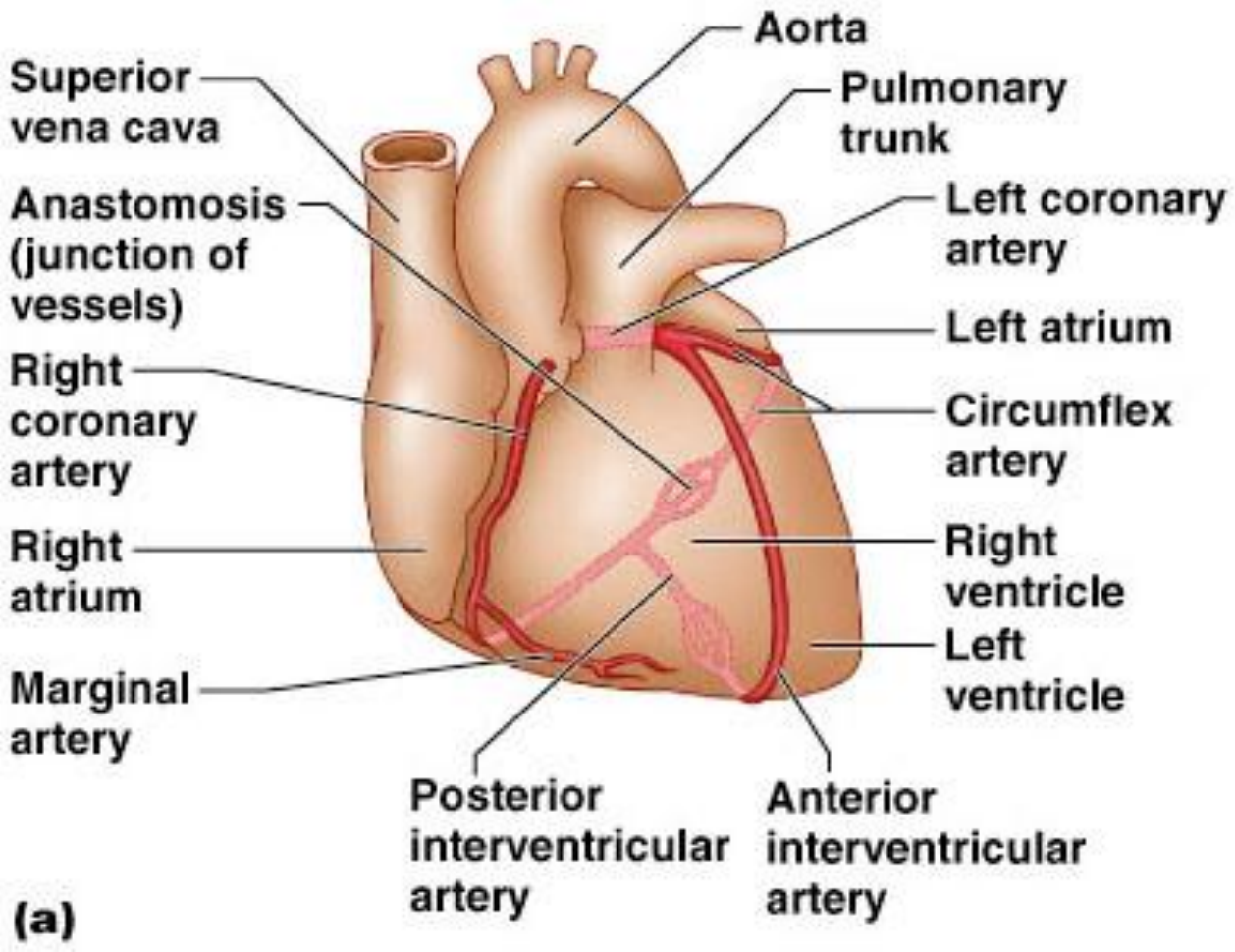


Figure 18.7a

Coronary Circulation: Venous Supply

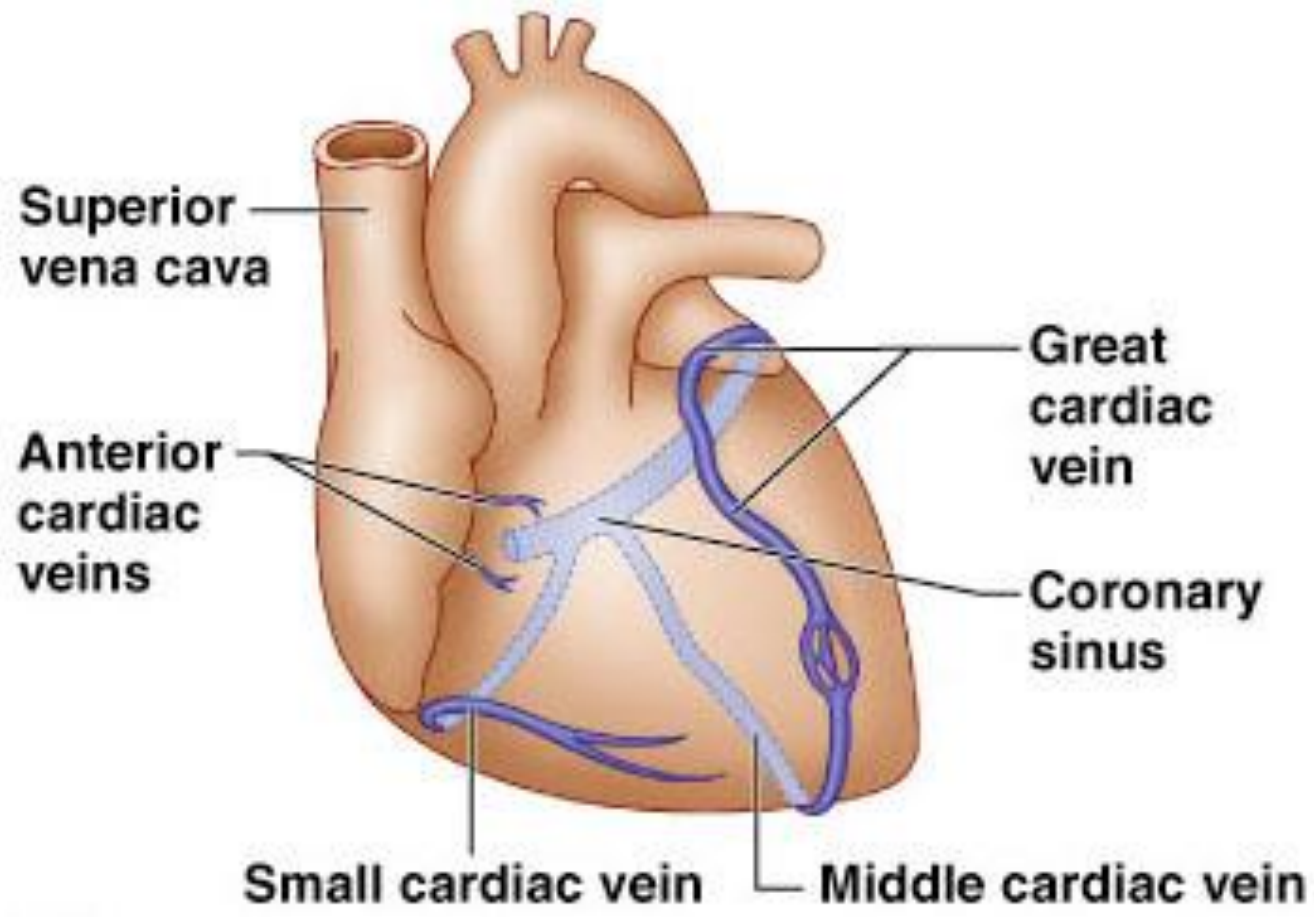


Figure 18.7b

Coronary Circulation

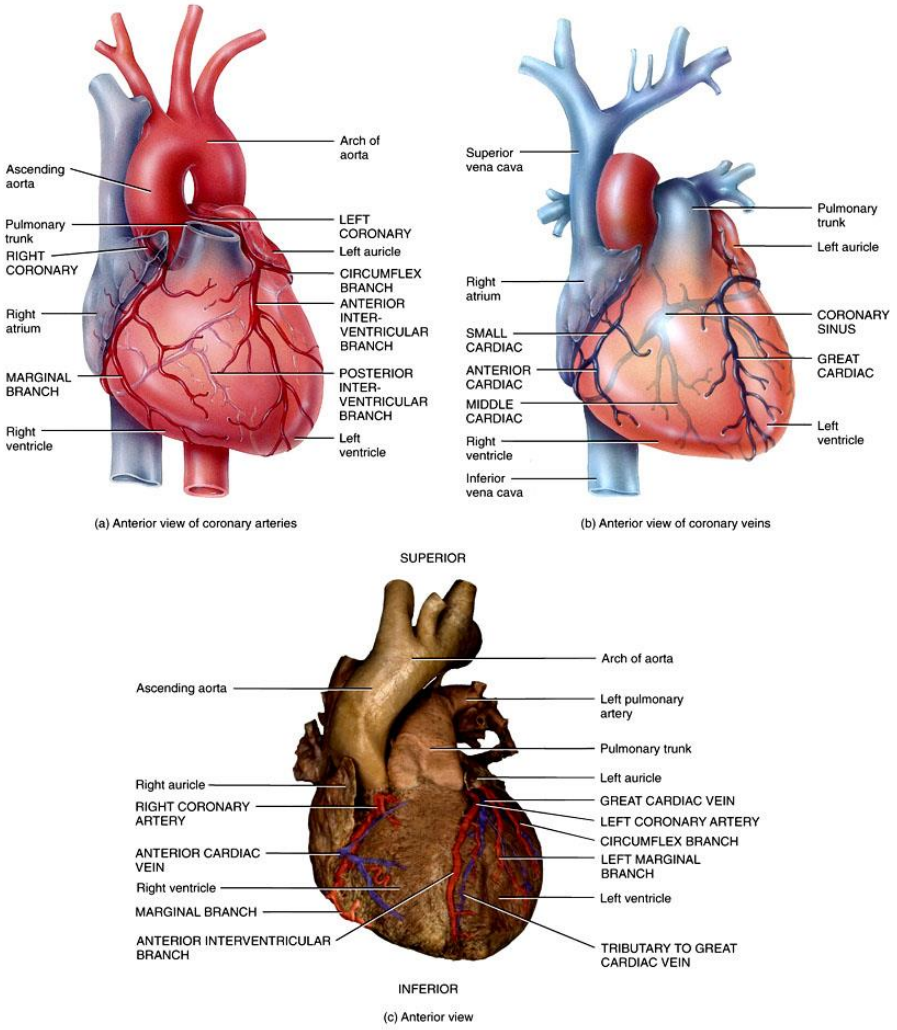


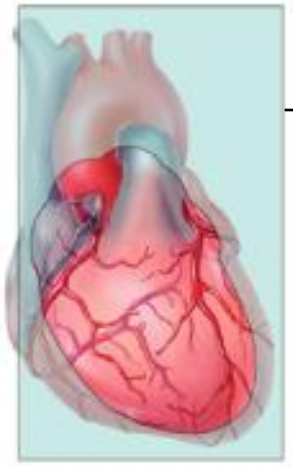
Figure 20.08abc Tortora - PAP 12/e

Autorhythmic Fibers

- Specialized cardiac muscle fibers
- Self-excitable
- Repeatedly generate action potentials that trigger heart contractions
- 2 important functions
  1. Act as pacemaker
  2. Form conduction system

Conduction system

1. Begins in sinoatrial (SA) node in right atrial wall
   - Propagates through atria via gap junctions
   - Atria contact
2. Reaches atrioventricular (AV) node in interatrial septum
3. Enters atrioventricular (AV) bundle (Bundle of His)
   - Only site where action potentials can conduct from atria to ventricles due to fibrous skeleton
4. Enters right and left bundle branches which extends through interventricular septum toward apex
5. Finally, large diameter Purkinje fibers conduct action potential to remainder of ventricular myocardium
   - Ventricles contract



Frontal plane

Left atrium

Right atrium

1 SINOATRIAL (SA) NODE

2 ATRIOVENTRICULAR (AV) NODE

3 ATRIOVENTRICULAR (AV) BUNDLE (BUNDLE OF HIS)

4 RIGHT AND LEFT BUNDLE BRANCHES

Left ventricle

Right ventricle

5 PURKINJE FIBERS

Anterior view of frontal section