The Heart

- A muscular double pump
  - Pulmonary circuit – takes blood to and from the lungs
  - Systemic circuit – vessels transport blood to and from body tissues
    - Atria – receive blood from the pulmonary and systemic circuits
    - Ventricles – the pumping chambers of the heart

The Pulmonary and Systemic Circuits

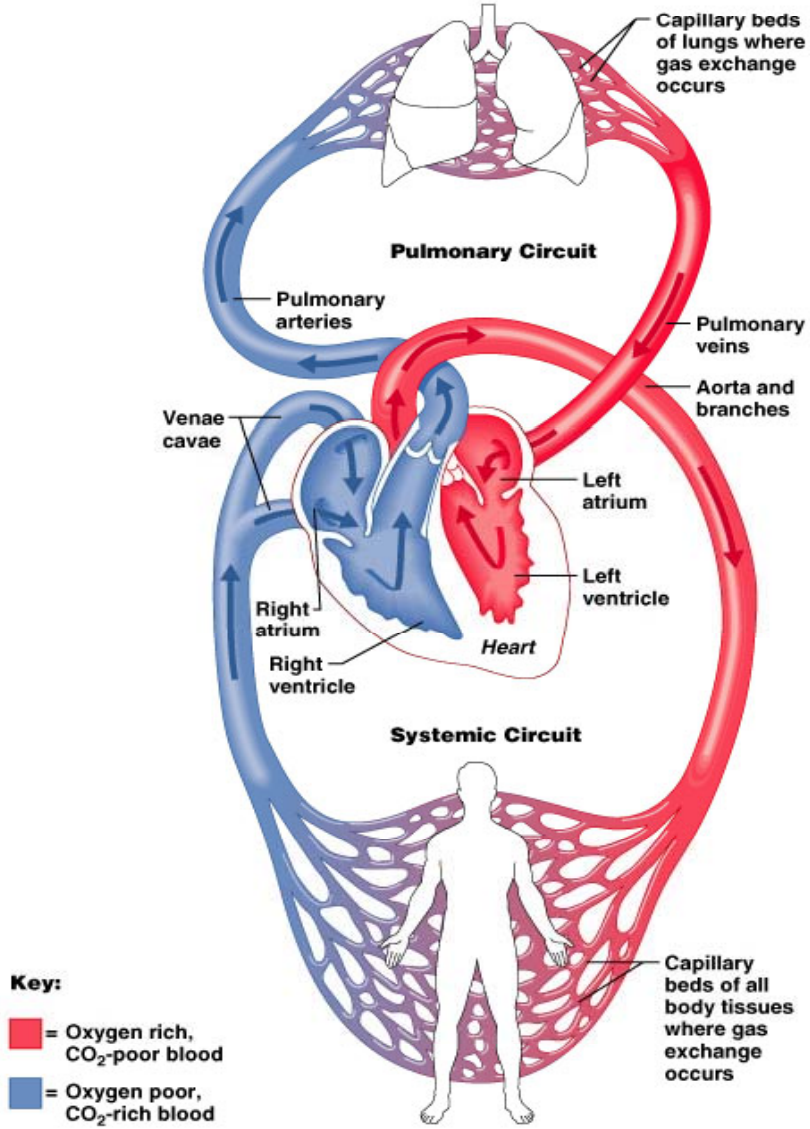


Figure 18.1

Location and Orientation within the Thorax

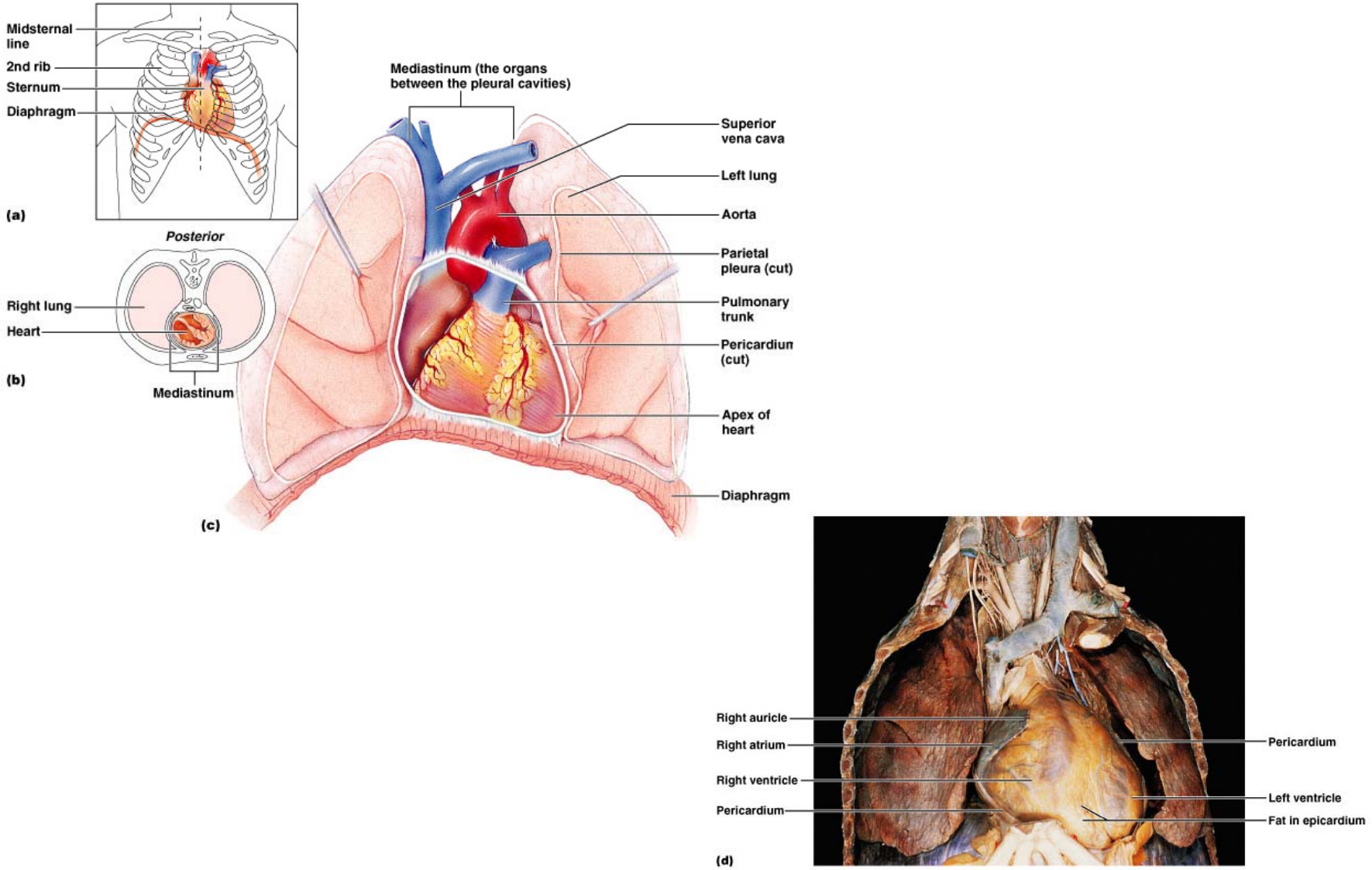


Figure 18.2

Structure of the Heart – Coverings

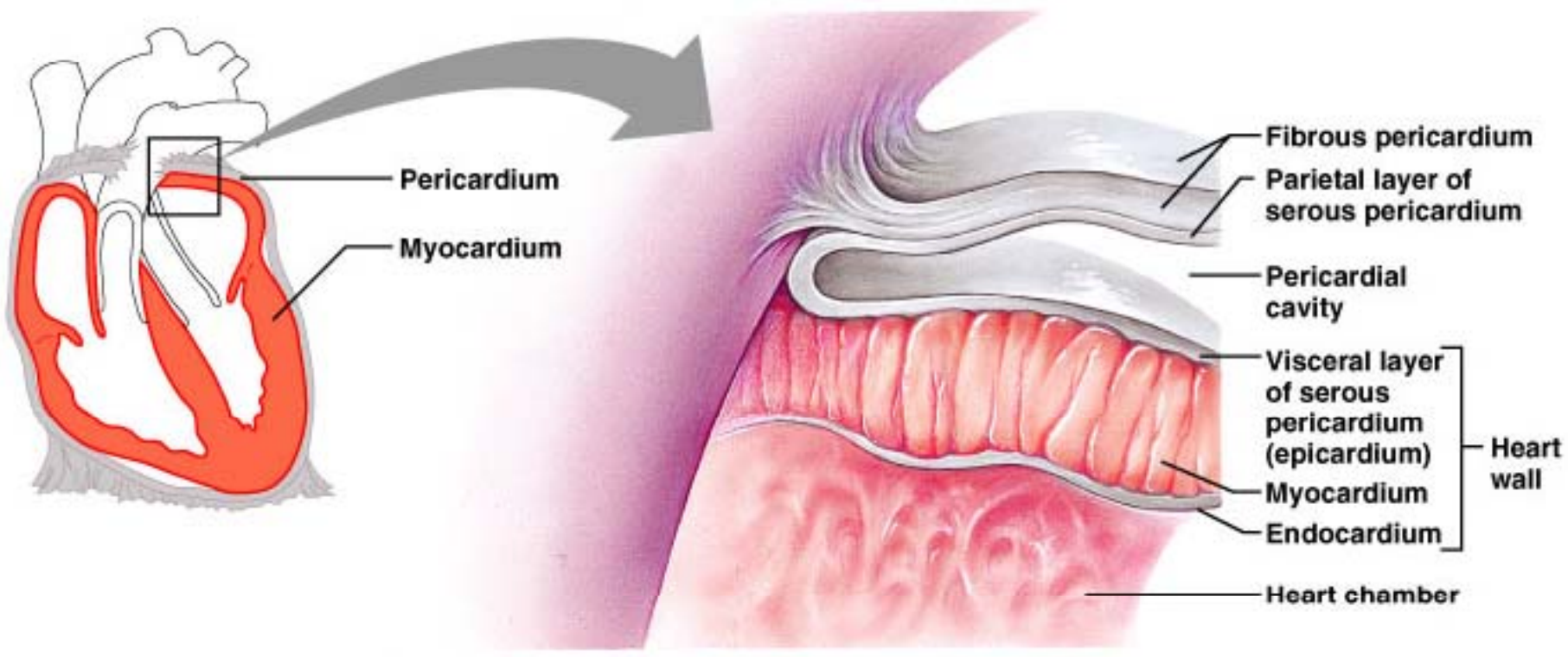


Figure 18.3

Structure of the Heart – Layers of the Heart Wall

- **Epicardium** – visceral layer of the serous pericardium
- **Myocardium** – consists of cardiac muscle
  - Muscle arranged in circular and spiral patterns
- **Endocardium** – endothelium resting on a layer of connective tissue
  - Lines the internal walls of the heart

Heart Chambers

- Internal divisions
  - Atria and ventricles
  - Interventricular and interatrial septa
- External markings
  - Coronary sulcus
  - Anterior and posterior interventricular sulcus

Heart Chambers

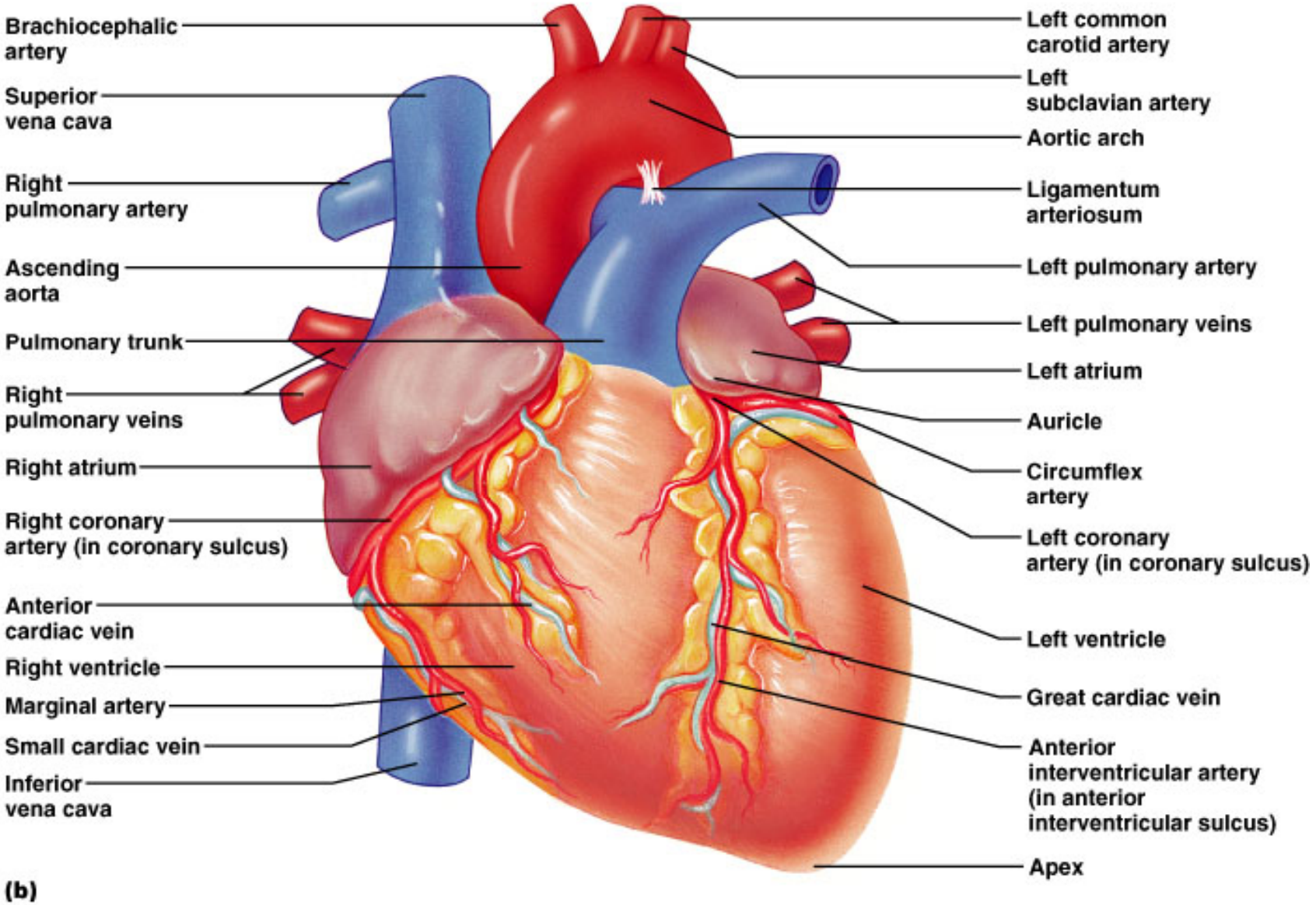


Figure 18.5b

Heart Chambers

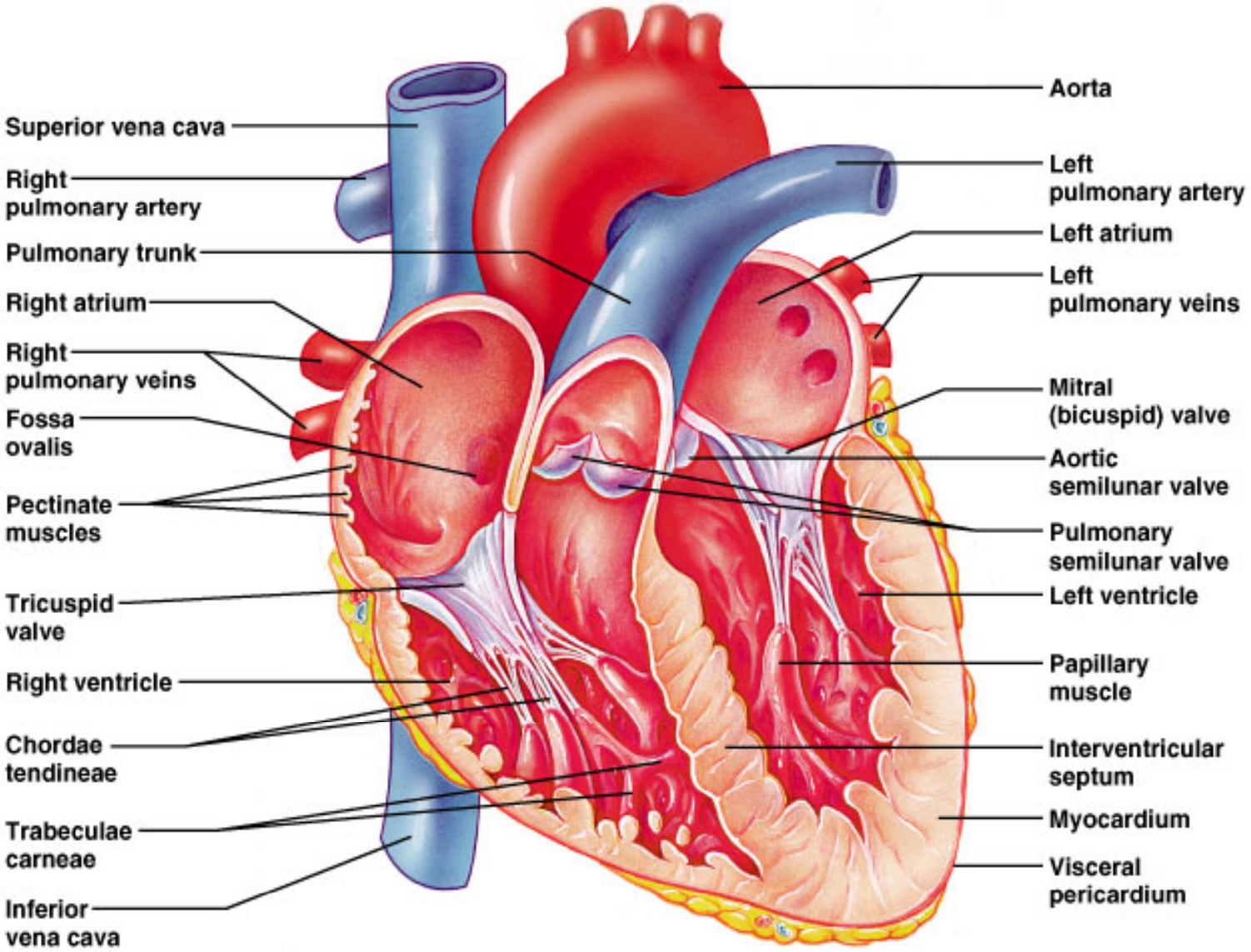


Figure 18.5e

Inferior View of the Heart

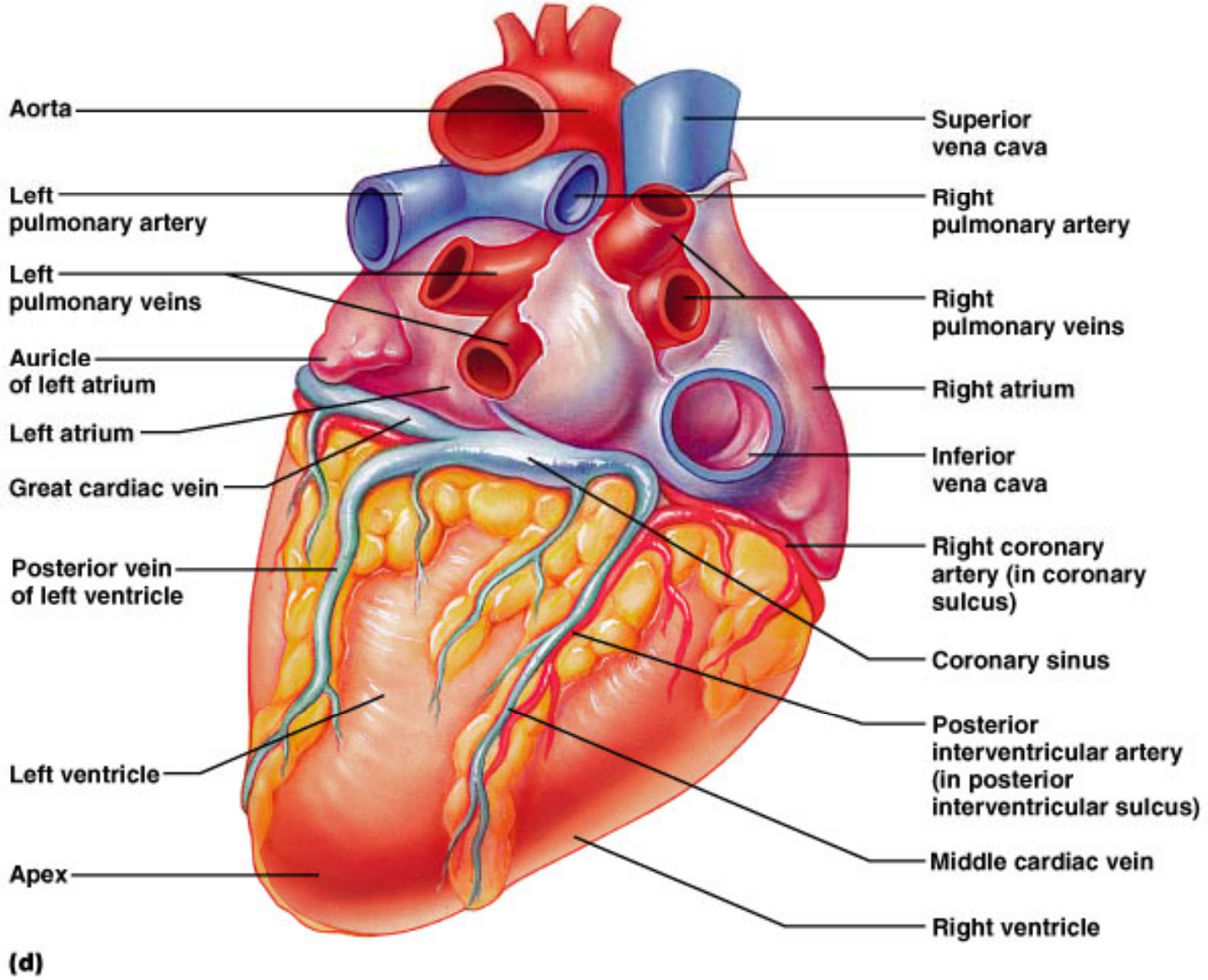
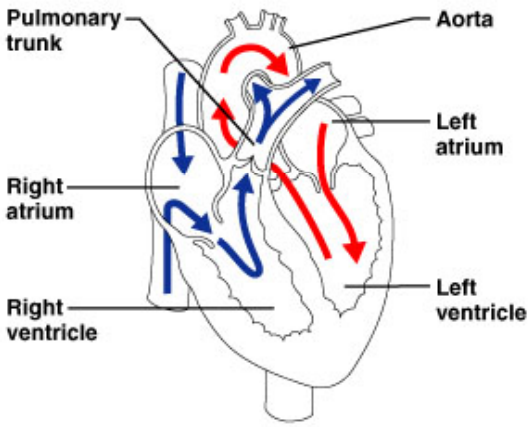


Figure 18.5d

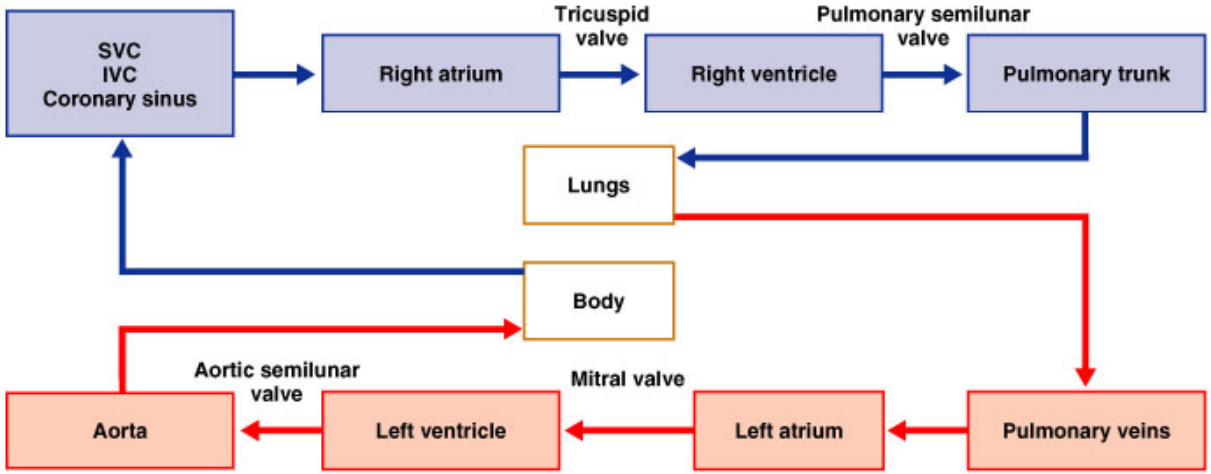
Pathway of Blood Through the Heart

- Begin oxygen-poor blood in the superior and inferior venae cavae
  - Go through pulmonary and systemic circuits

Blood Flow Through the Heart



(a)



(b)

Figure 18.6

Pathway of Blood Through the Heart

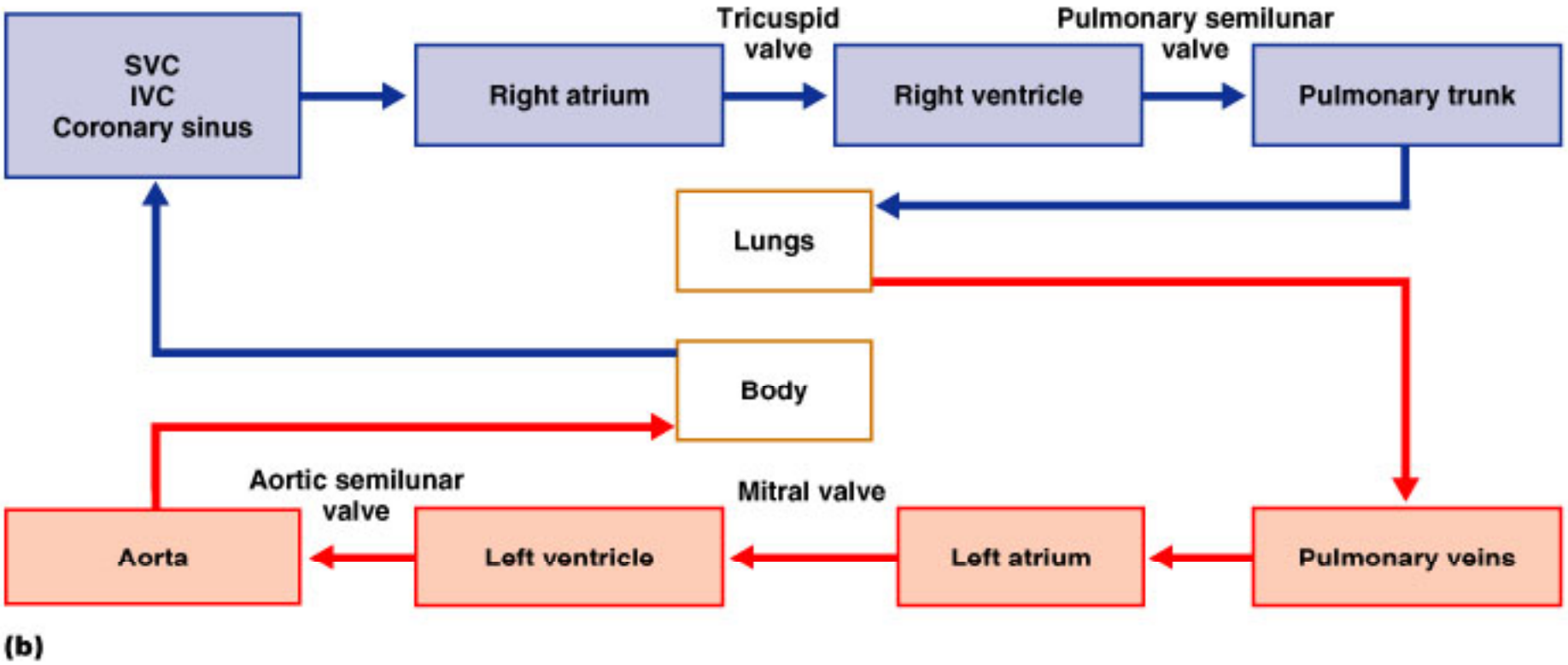


Figure 18.6b

Heartbeat

- 70–80 beats/minute at rest
- Systole – contraction
- Diastole – expansion
- Systole and diastole also refer to:
  - Stage of heartbeat when ventricles contract and expand

Structure of Heart Wall

- Walls differ in thickness
  - Atria – thin walls
  - Ventricles – thick walls

Structure of Heart Wall

- Left ventricle – three times thicker than right
  - Exerts more pumping force
  - Flattens right ventricle into a crescent shape

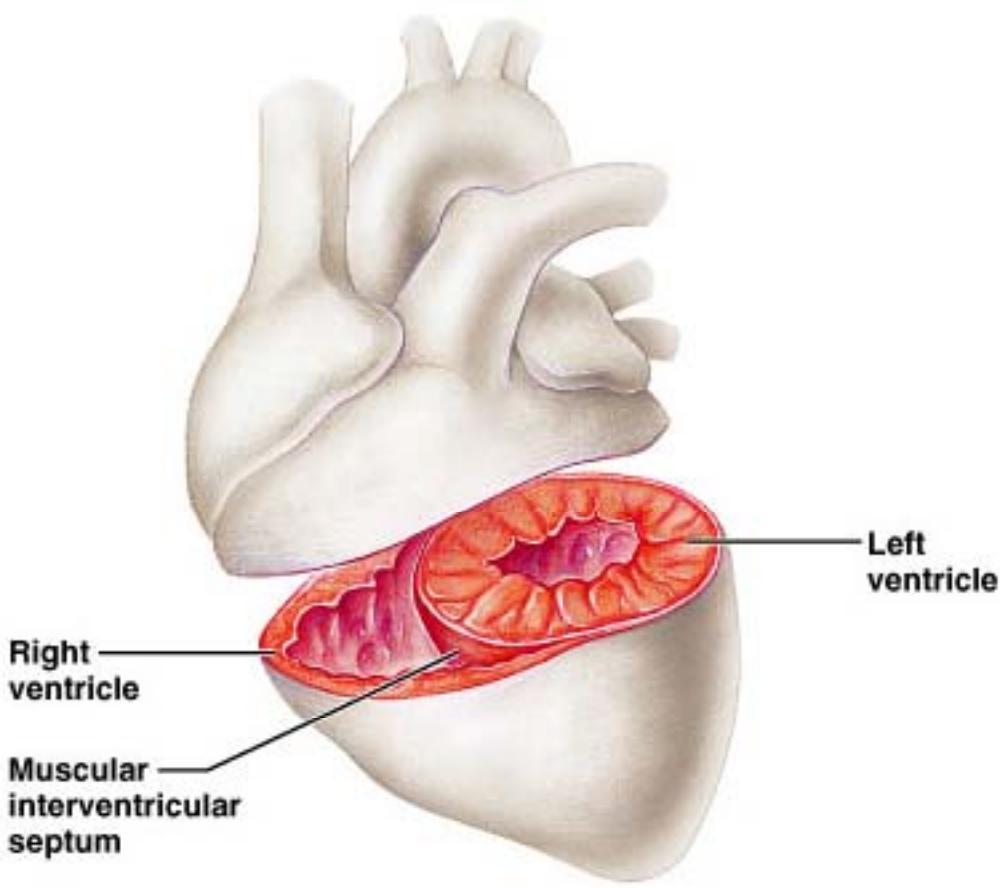


Figure 18.7

Heart Valves – Valve Structure

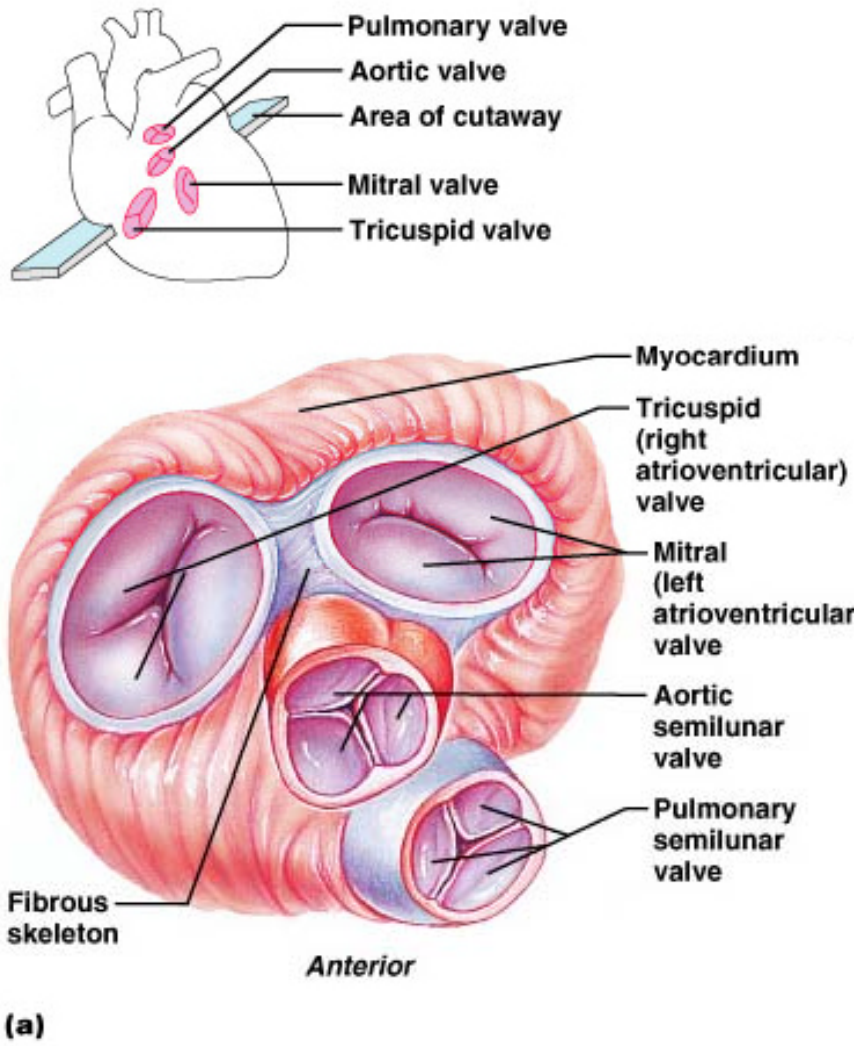


Figure 18.8a

Function of the Atrioventricular Valves

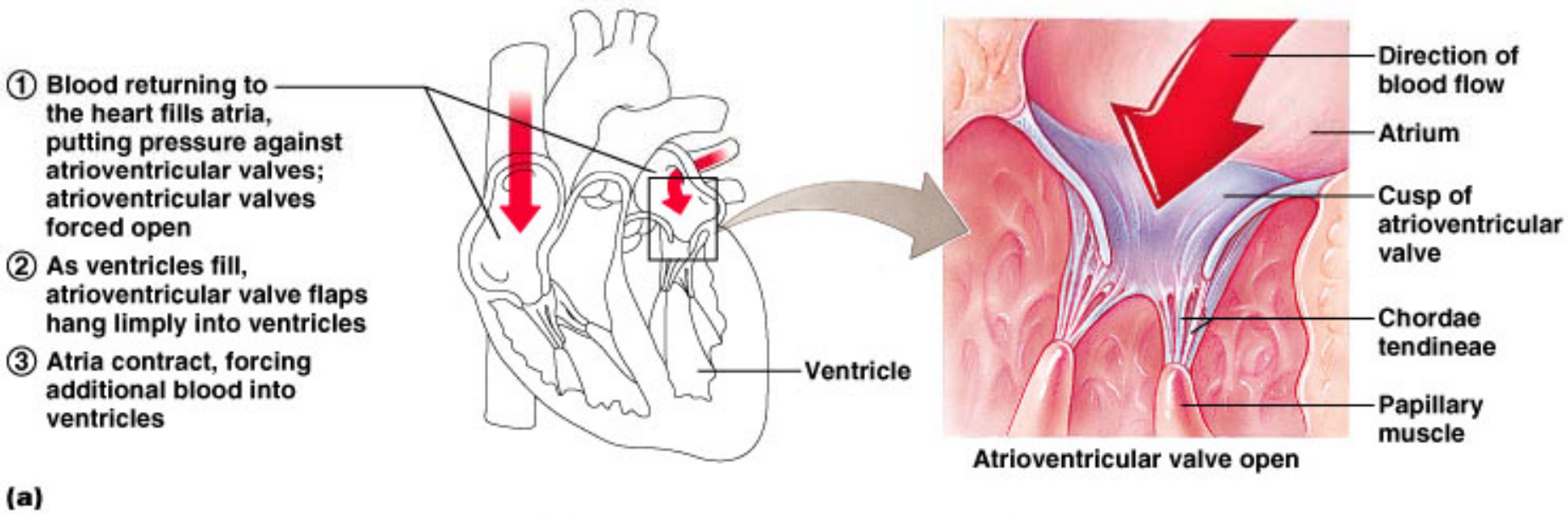


Figure 18.9a

Function of the Atrioventricular Valves

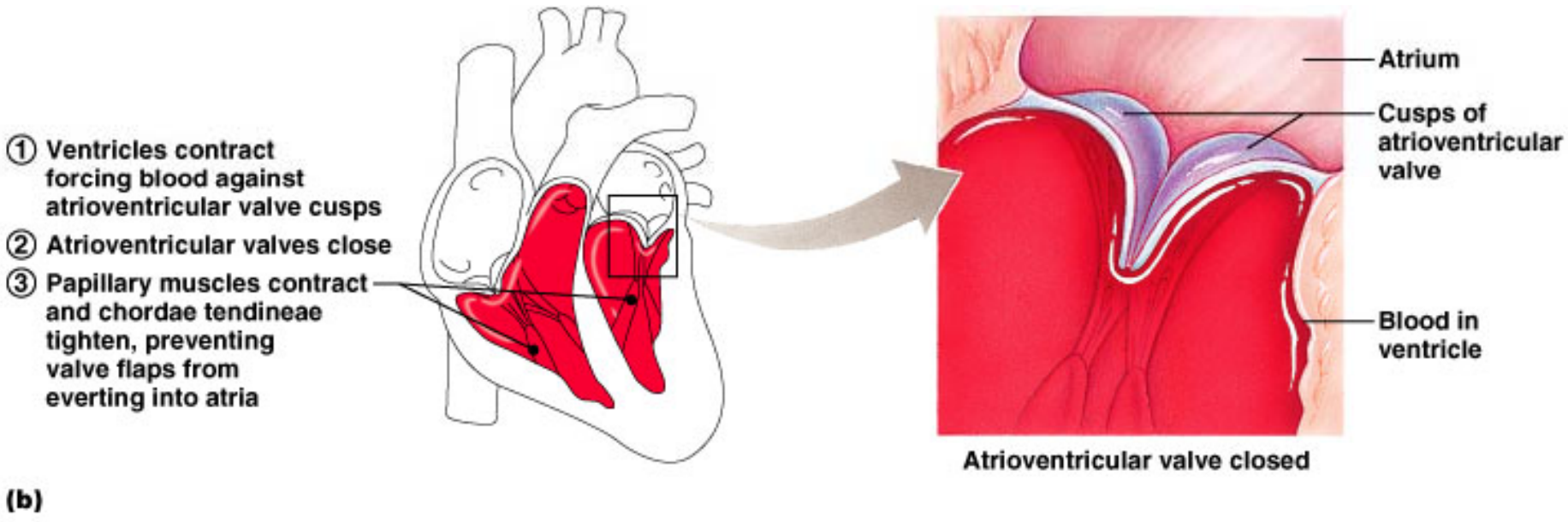


Figure 18.9b

Function of the Semilunar Valves

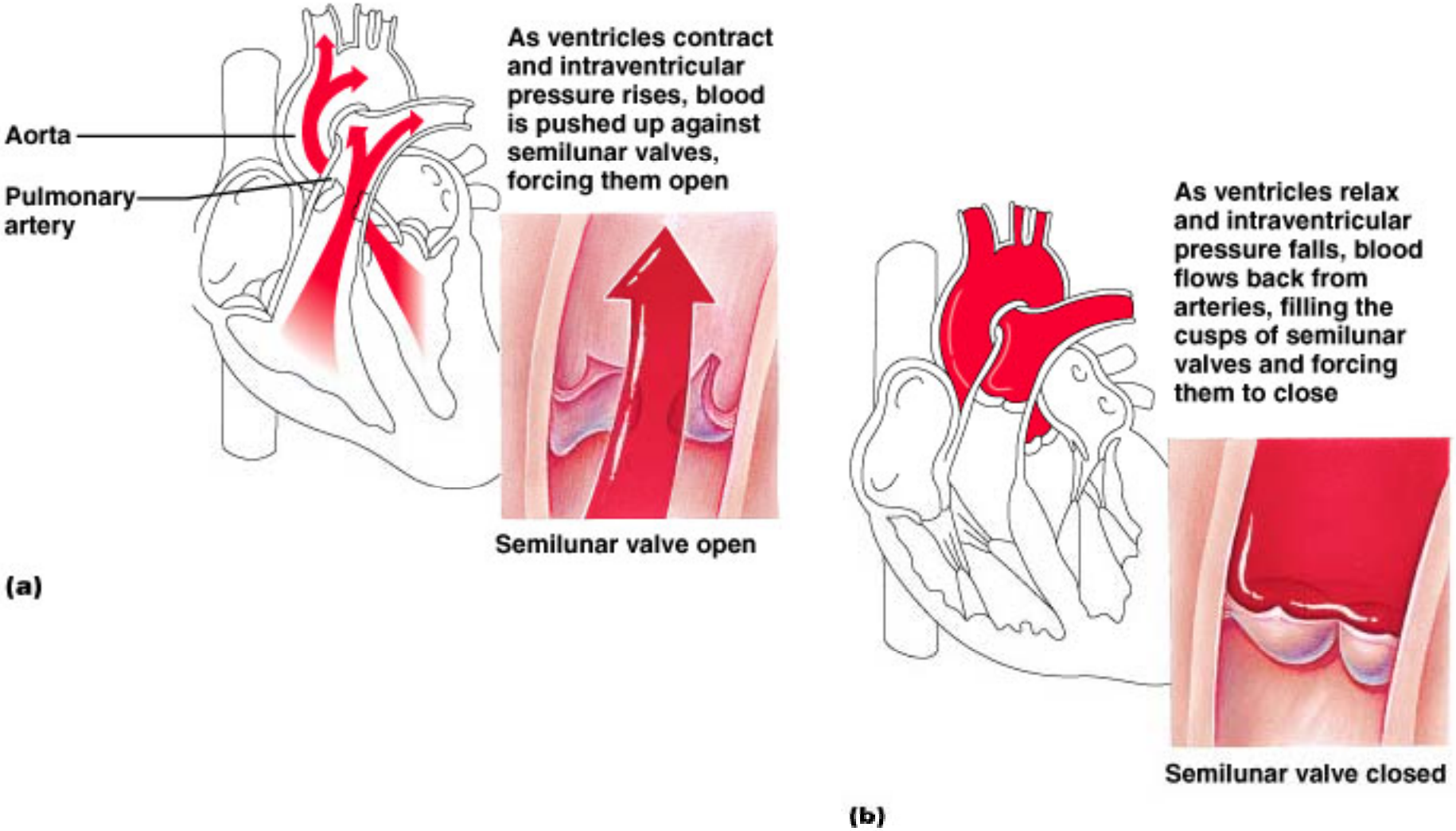


Figure 18.10a, b

Heart Sounds

- “Lub-dup” – sound of valves closing
- First sound “lub” – the AV valves closing
- Second sound “dup” – the semilunar valves closing

Heart Sounds

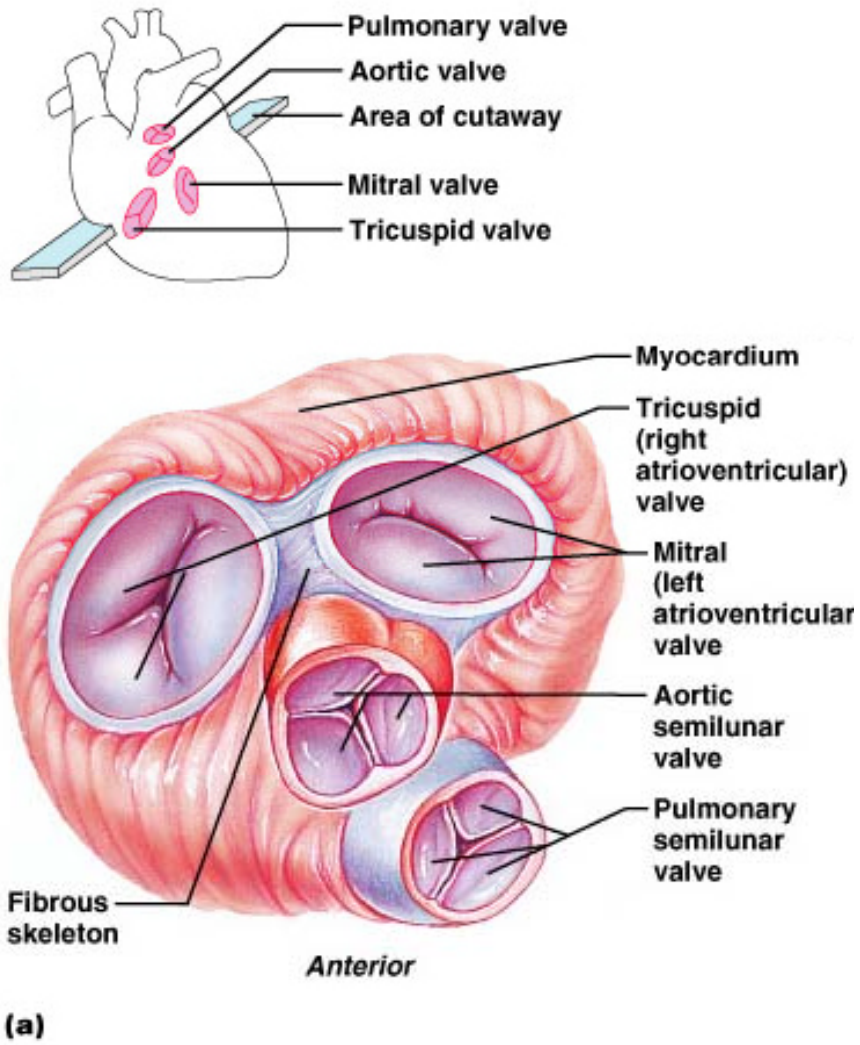


Figure 18.8a

Heart Sounds

- Each valve sound – best heard near a different heart corner
  - Pulmonary valve – superior left corner
  - Aortic valve – superior right corner
  - Mitral (bicuspid) valve– at the apex
  - Tricuspid valve – inferior right corner

Heart Sounds

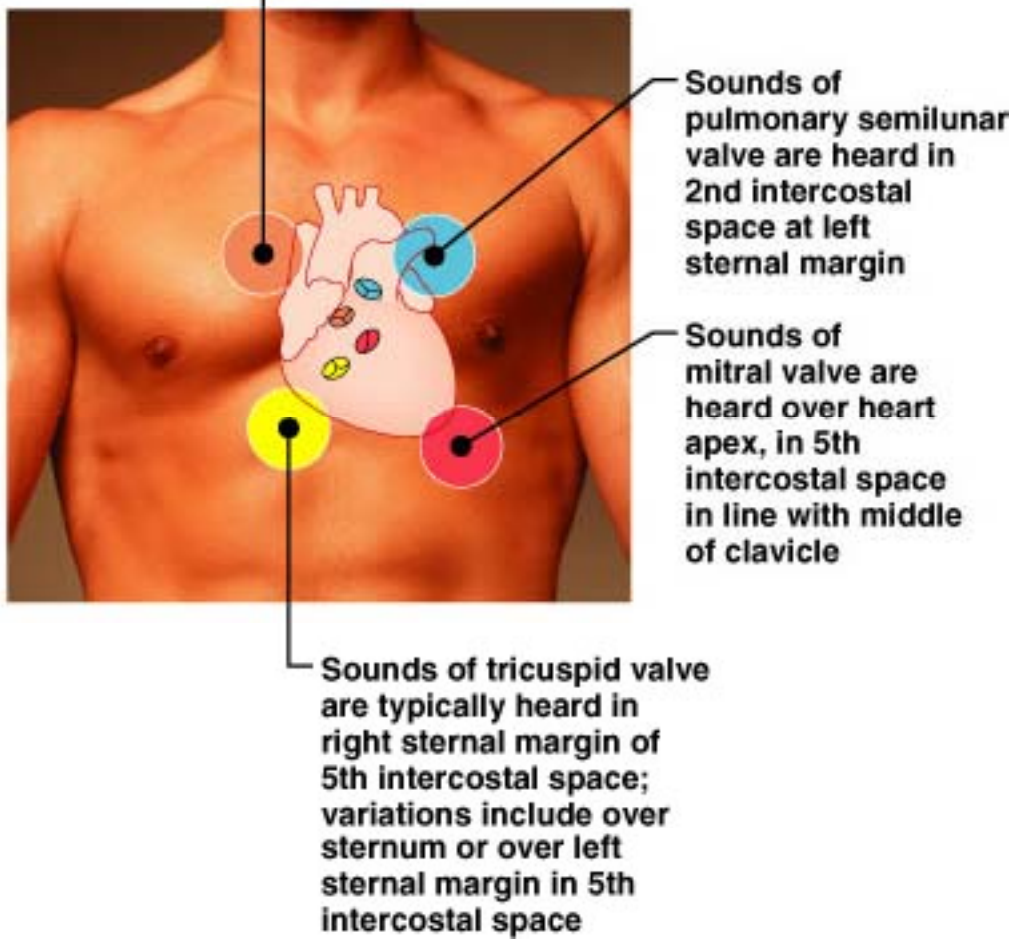


Figure 18.11

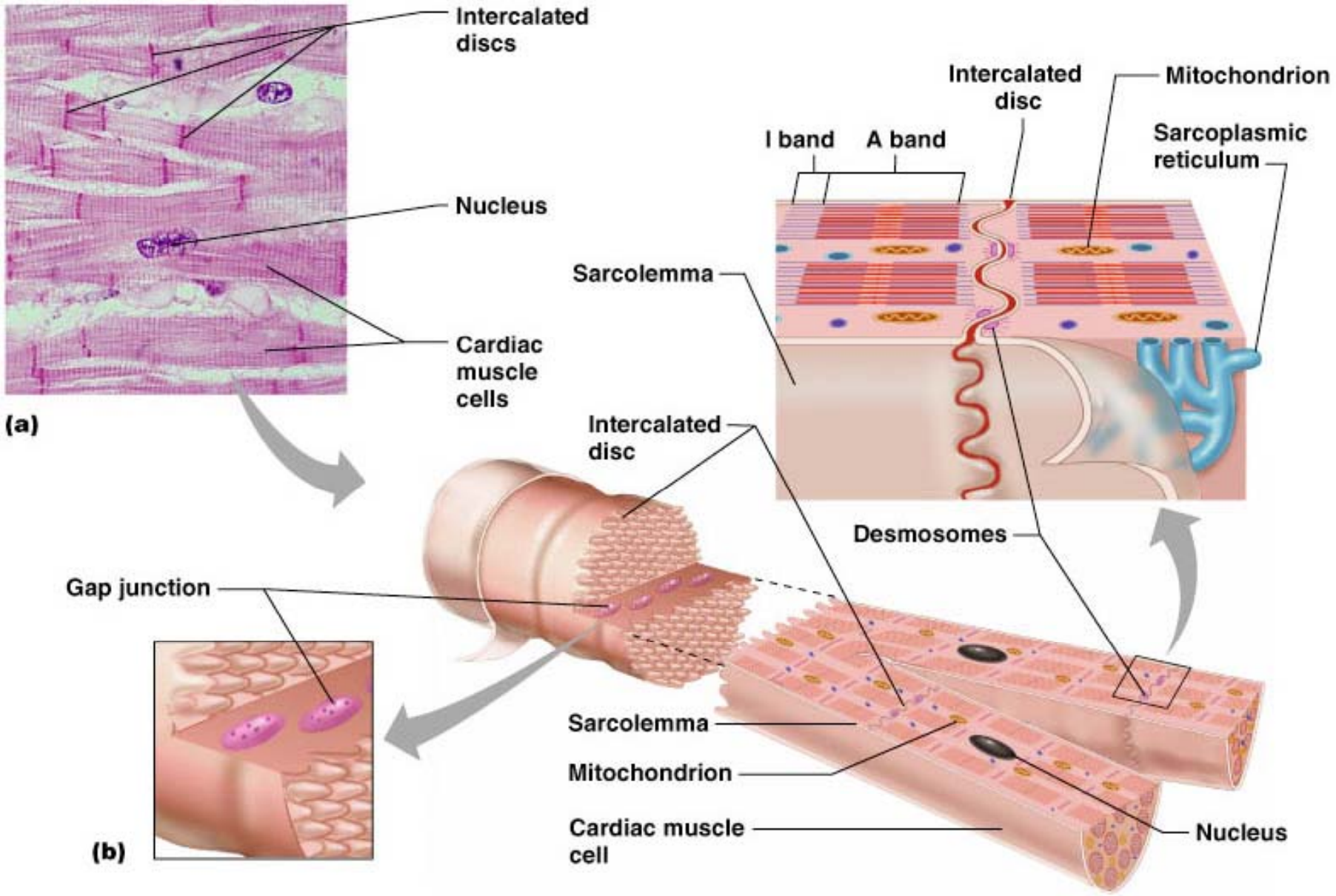
Fibrous Skeleton

- Surrounds all four valves
  - Composed of dense connective tissue
- Functions
  - Anchors valve cusps
  - Prevents overdilation of valve openings
  - Main point of insertion for cardiac muscle
  - Blocks direct spread of electrical impulses

Conducting System

- Cardiac muscle tissue has intrinsic ability to:
  - Generate and conduct impulses
  - Signal these cells to contract rhythmically
- Conducting system
  - A series of specialized cardiac muscle cells
  - Sinoatrial (SA) node sets the inherent rate of contraction

Microscopic Anatomy of Heart Muscle



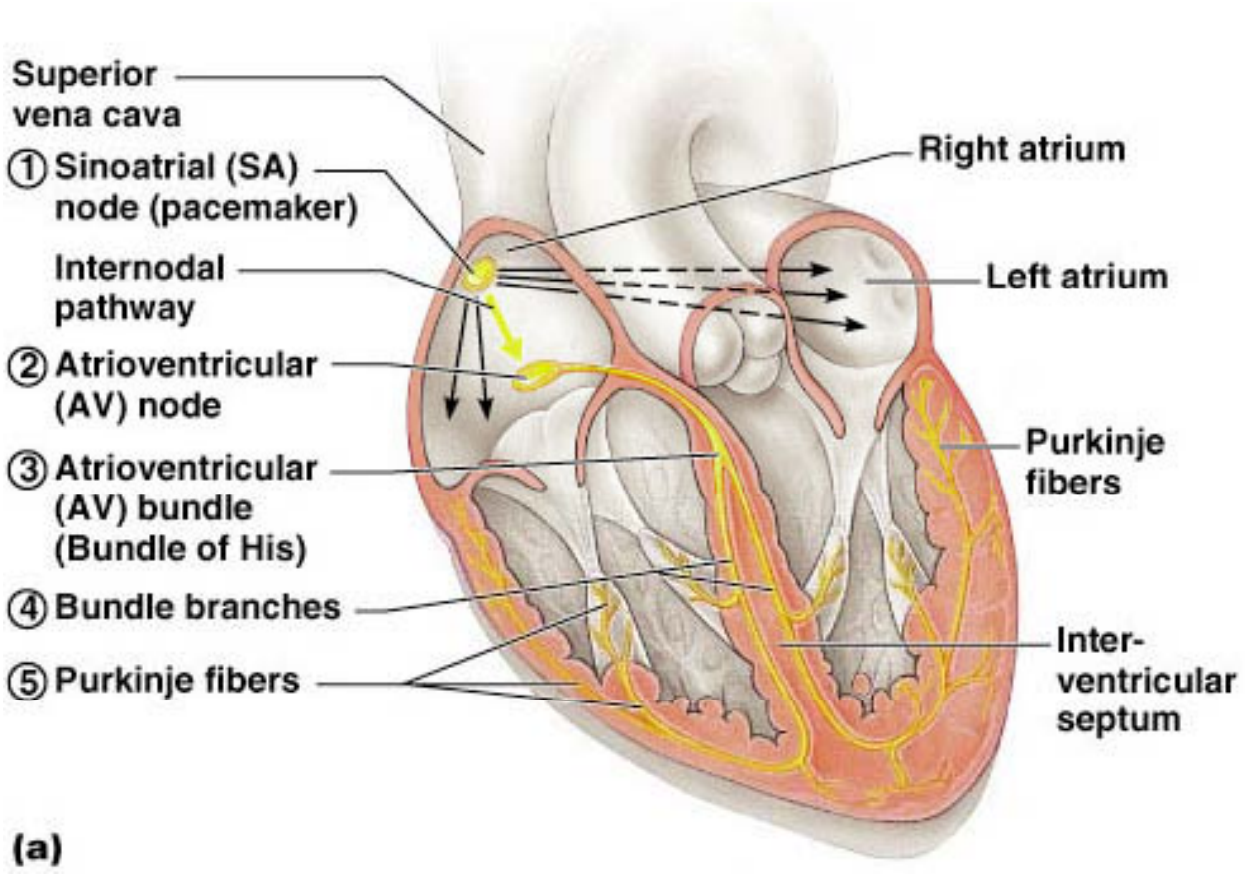
Cardiac Muscle Contraction

- Heart muscle:
  - Is stimulated by nerves and is self-excitable (automaticity)
  - Contracts as a unit
  - Has a long (250 ms) absolute refractory period
- Cardiac muscle contraction is similar to skeletal muscle contraction

Heart Physiology: Intrinsic Conduction System

- Autorhythmic cells:
  - Initiate action potentials
  - Have unstable resting potentials called pacemaker potentials

Heart Physiology: Sequence of Excitation



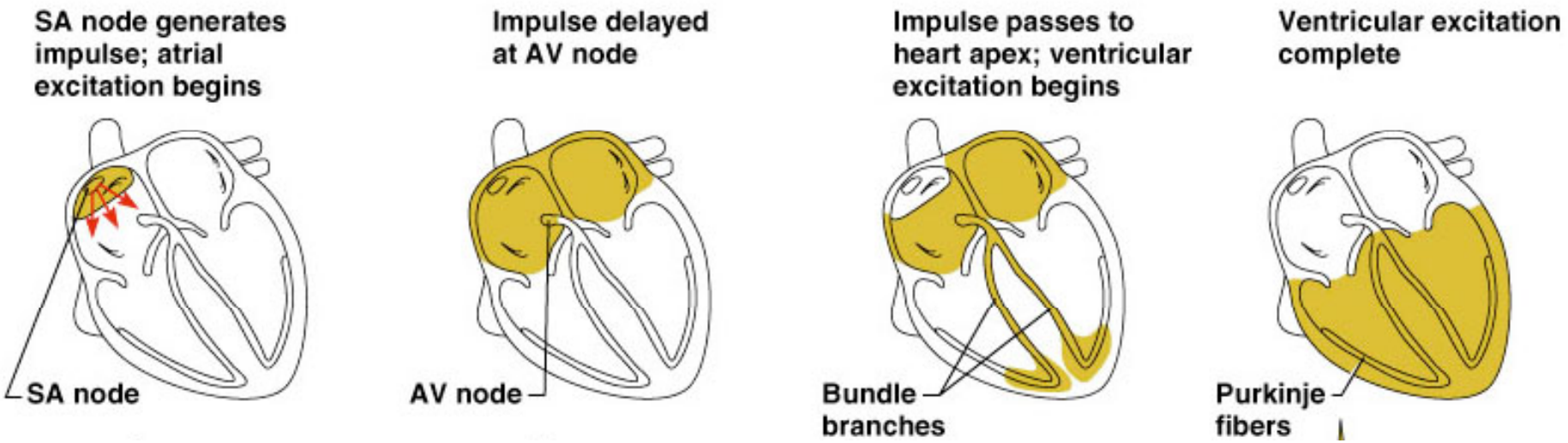
Heart Physiology: Sequence of Excitation

- Sinoatrial (SA) node generates impulses about 75 times/minute
- Atrioventricular (AV) node delays the impulse approximately 0.1 second
- Impulse passes from atria to ventricles via the atrioventricular bundle (bundle of His)

Heart Physiology: Sequence of Excitation

- AV bundle splits into two pathways in the interventricular septum (bundle branches)
  - Bundle branches carry the impulse toward the apex of the heart
  - Purkinje fibers carry the impulse to the heart apex and ventricular walls

Heart Excitation



Innervation

- Heart rate is altered by external controls
- Nerves to the heart include:
  - Visceral sensory fibers
  - Parasympathetic branches of the vagus nerve
  - Sympathetic fibers – from cervical and upper thoracic chain ganglia

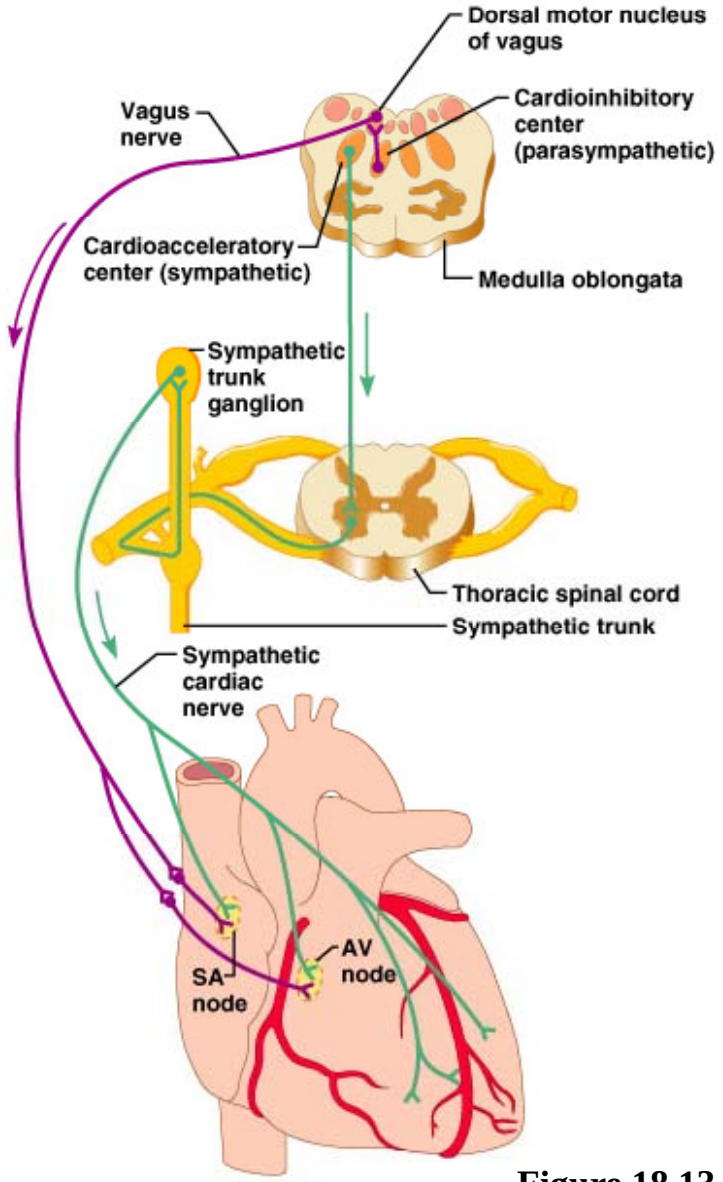


Figure 18.13

Blood Supply to the Heart

- Functional blood supply
  - Coronary arteries
- Arise from the aorta
  - Located in the coronary sulcus
  - Main branches
    - Left and right coronary arteries

Blood Supply to the Heart

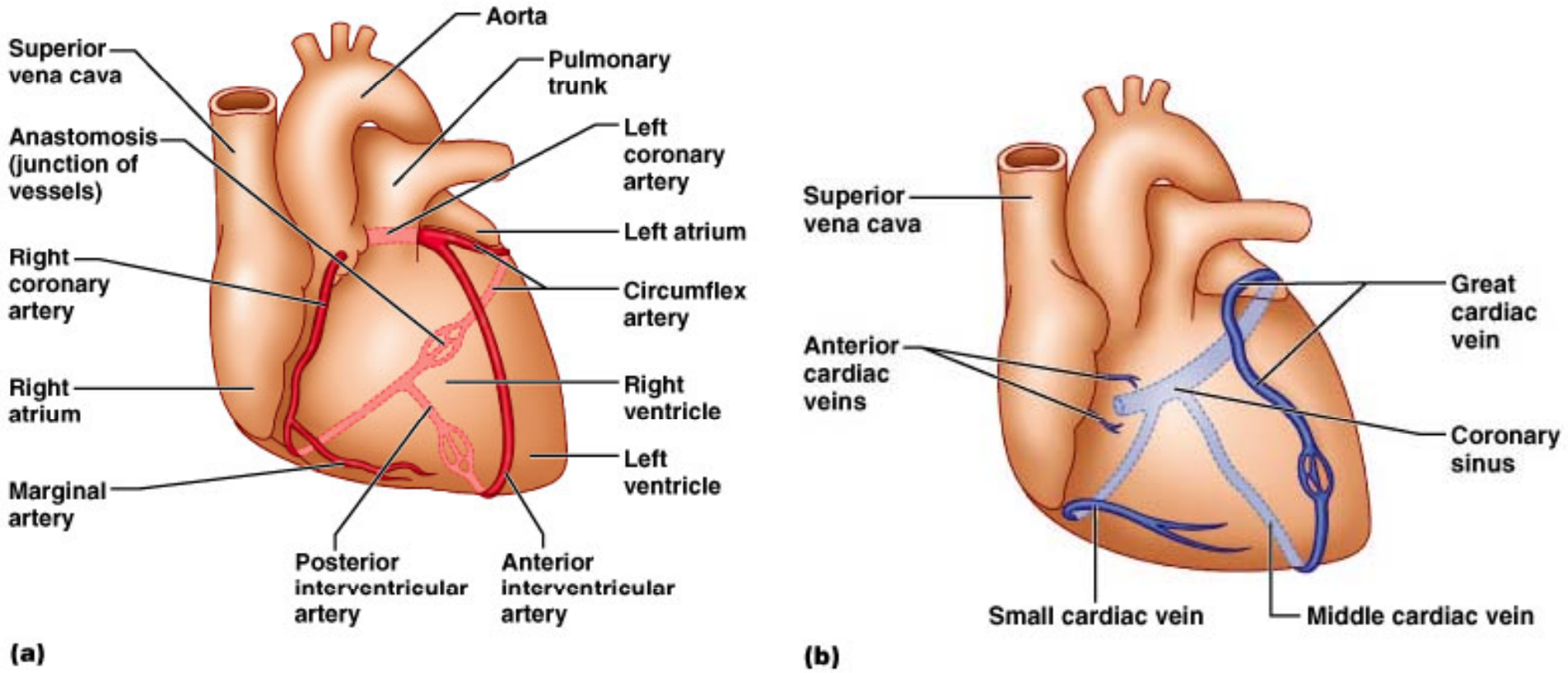


Figure 18.14

Disorders of the Heart

- Coronary artery disease
  - Atherosclerosis – fatty deposits
  - Angina pectoris – chest pain
  - Myocardial infarction – blocked coronary artery
  - Silent ischemia – no pain or warning

Disorders of the Heart

- Heart failure
  - Progressive weakening of the heart
  - Cannot meet the body's demands for oxygenated blood
- Congestive heart failure – heart enlarges
  - Pumping efficiency declines
- Cor pulmonale
  - Enlargement and potential failure of the right ventricle

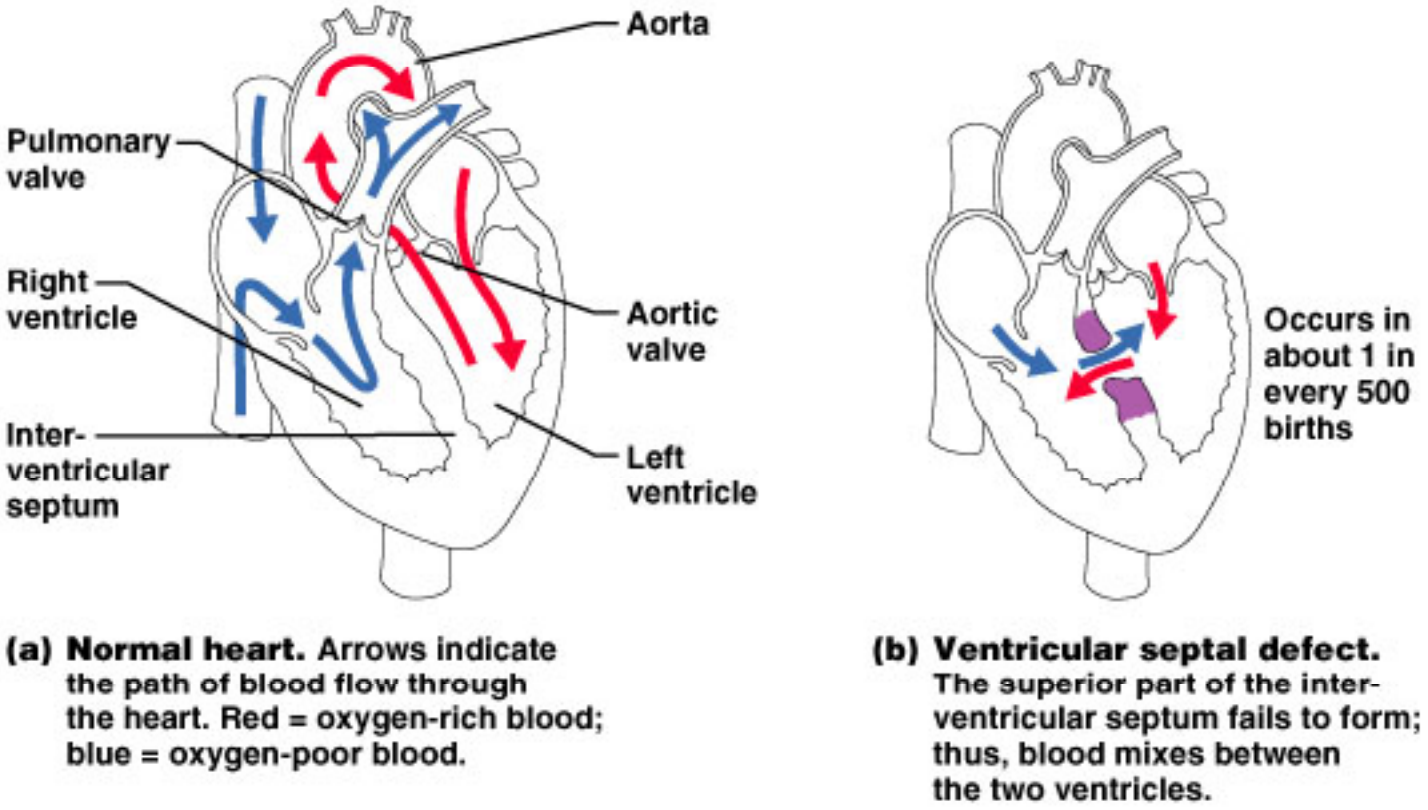
Disorders of Conduction

- Ventricular fibrillation
  - Rapid, random firing of electrical impulses in the ventricles
- Atrial fibrillation
  - Multiple waves of impulses randomly signal the AV node
  - Signals ventricles to contract quickly and irregularly

The Heart Throughout Life

- Blood vessels
  - Begin as condensations of mesodermal mesenchyme
- Embryonic heart
  - Pair of tubes fuse at day 21
  - Heart starts pumping at day 22
  - Bulges develop along heart tube

Congenital Heart Defects

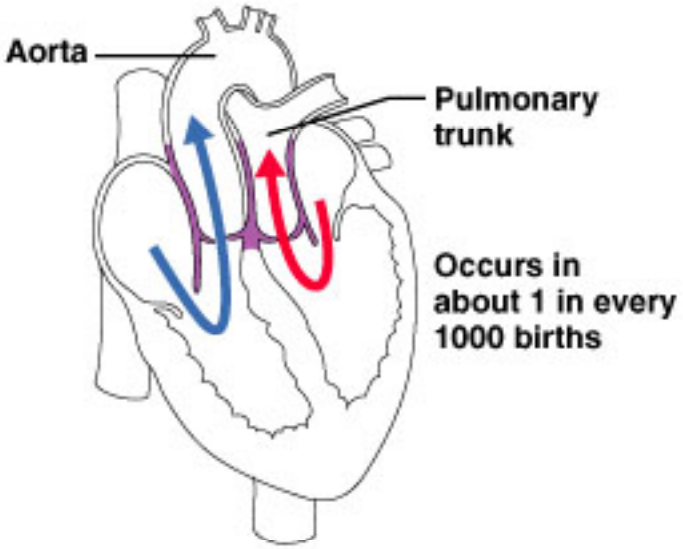


(a) Normal heart. Arrows indicate the path of blood flow through the heart. Red = oxygen-rich blood; blue = oxygen-poor blood.

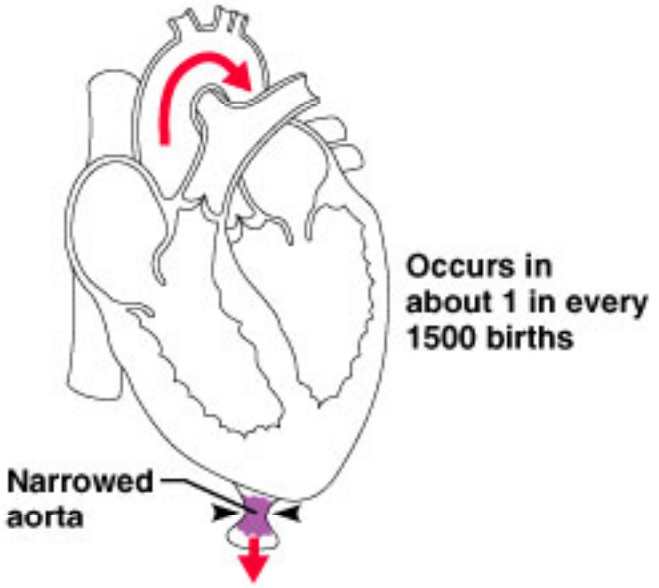
(b) Ventricular septal defect. The superior part of the inter-ventricular septum fails to form; thus, blood mixes between the two ventricles.

Figure 18.17a, b

Congenital Heart Defects



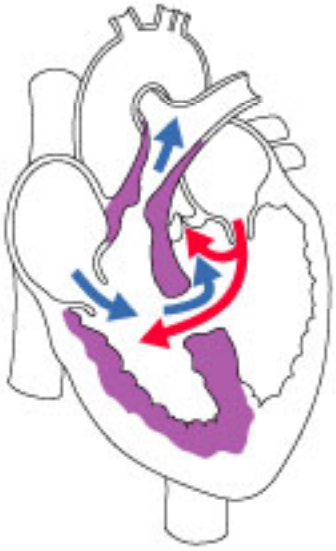
(c) Transposition of the great vessels. Aorta comes from right ventricle, pulmonary trunk from left. Results when the bulbus cordis does not divide properly. Unoxygenated blood passes repeatedly around systemic circuit, while oxygenated blood recycles around the pulmonary circuit.



(d) Coarctation of the aorta. A part of the aorta is narrowed, increasing the work load on the left ventricle.

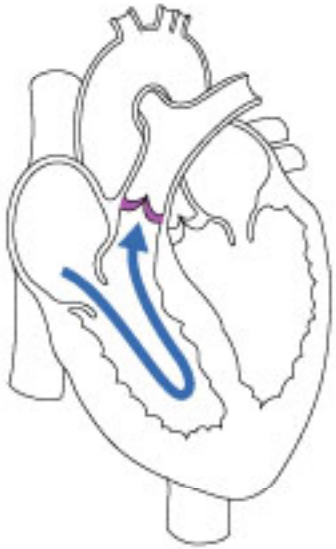
Figure 18.17c, d

Congenital Heart Defects



Occurs in about 1 in every 2000 births

(e) Tetralogy of Fallot. Multiple defects (tetra=four): Pulmonary trunk too narrow and pulmonary valve stenosed; ventricular septal defect; aorta opens from both ventricles; wall of right ventricle thickened from overwork.



Occurs in about 1 in every 2800 births

(f) Pulmonary stenosis. The pulmonary semilunar valve is narrowed, lessening the flow of blood to the lungs.

Figure 18.17e, f

The Heart in Adulthood and Old Age

- Age-related changes
  - Hardening and thickening of valve cusps
  - Decline in cardiac reserve
    - Sympathetic control over heart is less efficient
    - Less severe in the physically active
  - Fibrosis of cardiac muscle tissue
    - Lowers the amount of blood the heart can pump