

## Chapter 14

### The Cardiovascular System: The Heart



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## The Heart: Introduction

- The heart beats about 100,000 times a day or 35 million beats a year
- Propels blood through approximately 100,000 km (60,000 mi) of vessels
- Pumps about 5 liters of blood per minute
- Cardiology - the study of the heart and its diseases

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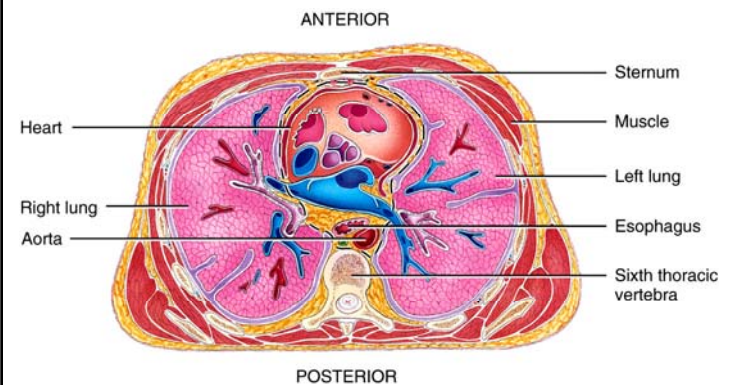
## Location and Surface Projection

- The heart is hollow, cone-shaped, about the size of a closed fist (Fig. 14.1a,b,c)
- Lies in the *mediastinum* between the lungs and rests upon the diaphragm
- Two-thirds of its mass lies to the left of the midline
- **Apex** - lower, pointed end
- **Base** - broader, superior portion

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Fig. 14.1a



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

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## Structure and Function of the Heart

- **Pericardium** - membrane (sac) that surrounds and protects the heart, it has two layers:
- **(a) Fibrous pericardium** - superficial layer, tough, inelastic, prevents overstretching, provides protection, and anchors the heart in place
- **(b) Serous pericardium** - deeper layer, thin;
  - (i) *parietal layer* - fused to the fibrous pericardium, and (ii) *visceral layer* (or *epicardium*) adheres to the heart itself
- **Pericardial cavity** (between the two layers) is filled with pericardial fluid which reduces friction (Fig 14.2)

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## Layers of the Heart Wall (3)

- **Epicardium** - external layer, composed of mesothelium and connective tissue (Fig 14.2)
- **Myocardium** - middle layer, muscular pumping layer, 95% of the heart wall
- **Endocardium** - inner layer, consists of a layer of endothelium covering connective tissue, continuous with the endothelium of the blood vessels connected to the heart
- **Endocarditis** - inflammation of the endocardium

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Fig. 14.2a

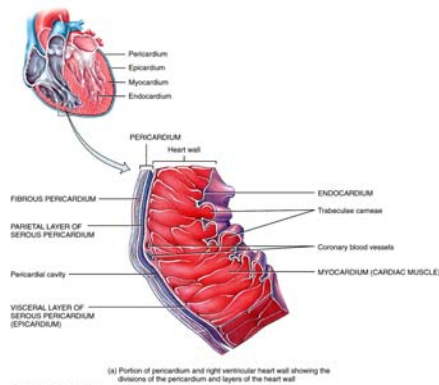


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Layers of the Heart Wall Fig. 14.2b

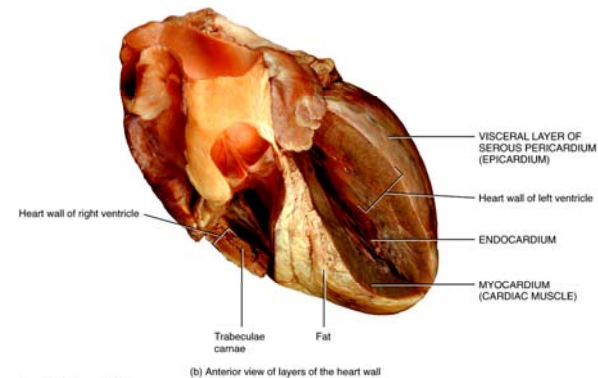
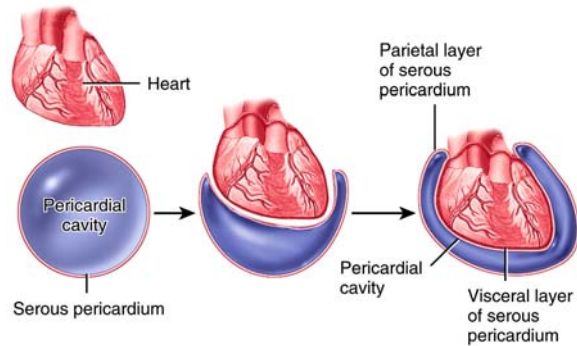


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## Layers of the Heart Wall Fig. 14.2c



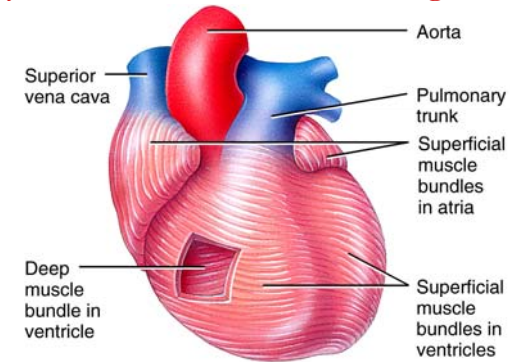
(c) Simplified relationship of the serous pericardium to the heart

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## Layers of the Heart Wall Fig. 14.2d



(d) Cardiac muscle bundles of the myocardium

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## Chambers of the Heart (4)

- Two superior chambers - right and left **atria**
- Receive blood returning to the heart via the veins, **auricles** allow increases in blood volume
- Two inferior chambers - right and left **ventricles**, powerful pumping chambers
- **Pulmonary pump** - right atrium and right ventricle, moves deoxygenated blood through the lungs
- **Systemic pump** - left atrium and left ventricle, pumps oxygenated blood to all systems of the body

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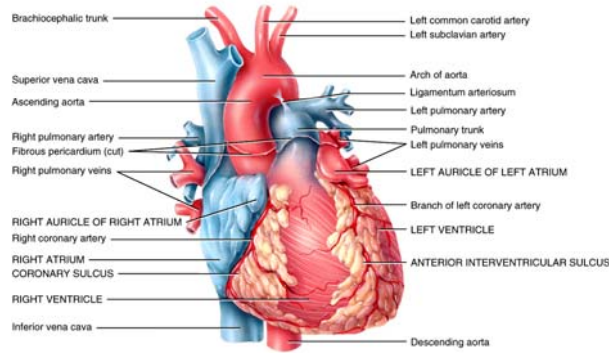
## Surface Markings - three major grooves (sulci)

- **Coronary sulcus** - encircles most of heart, demarcates the atria from the ventricles
- **Anterior interventricular sulcus** - marks the external boundary between right and left ventricles
- **Posterior interventricular sulcus** - marks the external boundary between ventricles on the posterior surface (Fig. 14.3)

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### Surface markings Fig. 14.3a



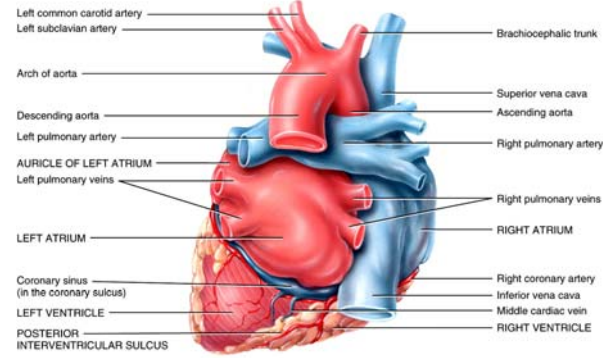
(a) Anterior external view showing surface features

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### Surface Feature of Heart Fig. 14.3c



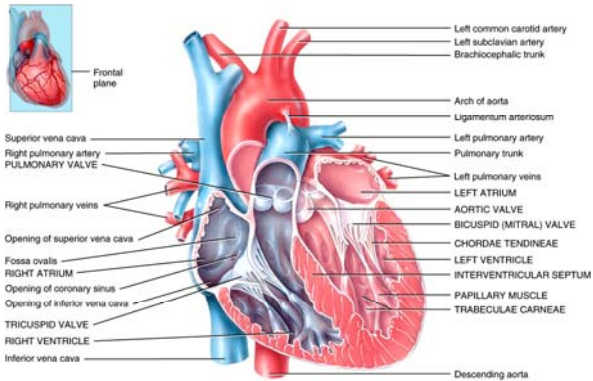
(c) Posterior external view showing surface features

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### Internal Anatomy of the Heart Fig. 14.4a



(a) Anterior view of frontal section showing internal anatomy

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### Myocardial Thickness and Function

- The atria are thin-walled as they deliver blood under less pressure
- The ventricles have thick walls since they pump blood at a higher pressure and over greater distances
- The right and left ventricles eject equal amounts of blood
- The left ventricle is thicker because it pumps under higher pressure and over a greater distance than the right ventricle (Fig. 14.4c)

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### Fig. 14.4c Transverse section of ventricles

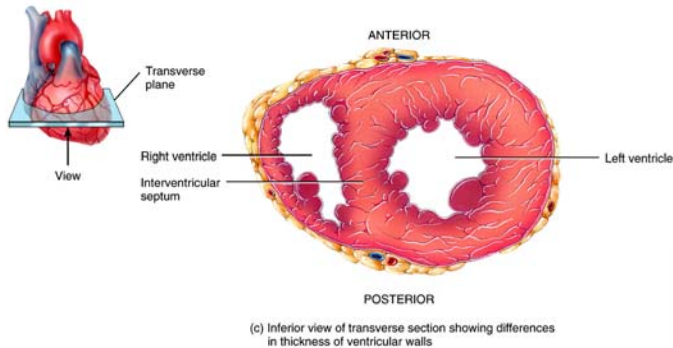


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### Fibrous Skeleton of the Heart

- Dense connective tissue embedded in the walls of the heart
- Consists primarily of four fibrous rings that surround the heart valves
- Prevents overstretching of the valves as blood passes through them
- 1. right atrioventricular fibrous ring, 2. left atrioventricular fibrous ring, 3. pulmonary fibrous ring, 4. aortic fibrous ring (Fig. 14.5)

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### Fig. 14.5 Fibrous Skeleton of the Heart

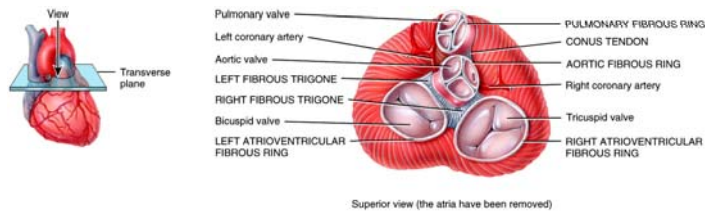


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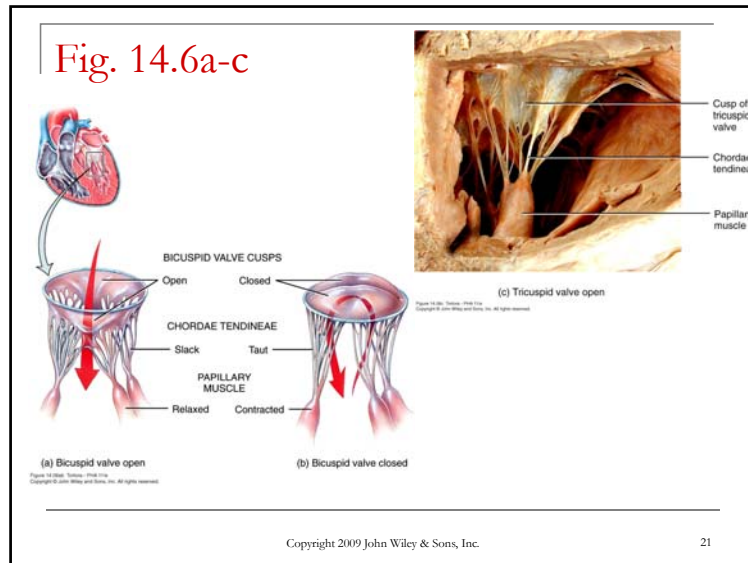
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### Heart Valves - Atrioventricular

- The four valves prevent backflow of blood in the heart after blood passes through them
- Atrioventricular (AV) valves
  - **tricuspid valve** between the right atrium and the right ventricle
  - **bicuspid (mitral) valve** - between the left atrium and the left ventricle
- Chordae tendineae and associated papillary muscles permit flow but prevent backflow (Fig. 14.6a-c)

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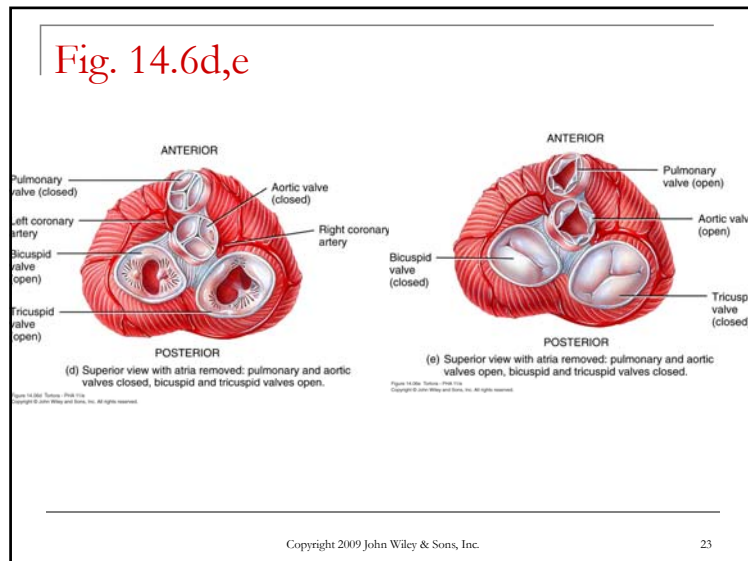
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### Heart Valves - Semilunar

- Two **semilunar (SL)** valves each having three semilunar cusps
- Allow ejection of blood from the ventricles into the pulmonary trunk and aorta
- Prevent backflow of blood into the heart
- **Pulmonary valve** - between the pulmonary trunk and the right ventricle
- **Aortic valve** - between the aorta and the left ventricle (Fig. 14.6d-g)

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### Circulation of Blood

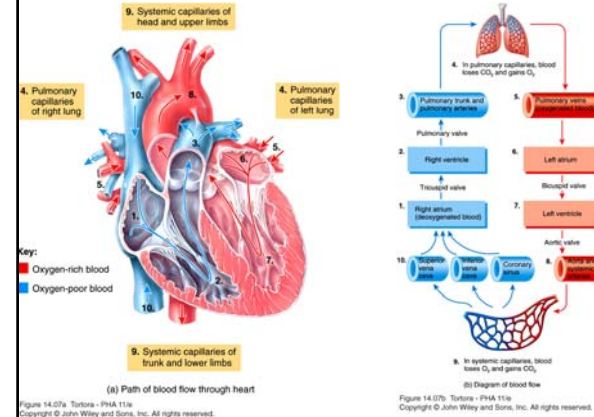
- The heart pumps blood into two circuits arranged in series (connected end to end)
- **Systemic circulation** - left side of heart receives oxygenated blood from the lungs
- Pumps this blood into the **aorta** which branches into **systemic arteries** that carry blood to all organs except alveoli of the lungs
- Arteries branch into **arterioles** and eventually into **systemic capillaries** where nutrients, gases, wastes, etc. are exchanged with the surrounding cells; **venules** and subsequently **systemic veins** return the deoxygenated blood to the right atrium

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## Circulation of Blood

- **Pulmonary circulation** - the right ventricle pumps blood into the **pulmonary trunk** which branches into the **pulmonary arteries**
- This blood goes to the **pulmonary capillaries** where the blood becomes oxygenated
- **Pulmonary veins** carry the oxygenated blood to the left atrium (Fig. 14.7a,b)

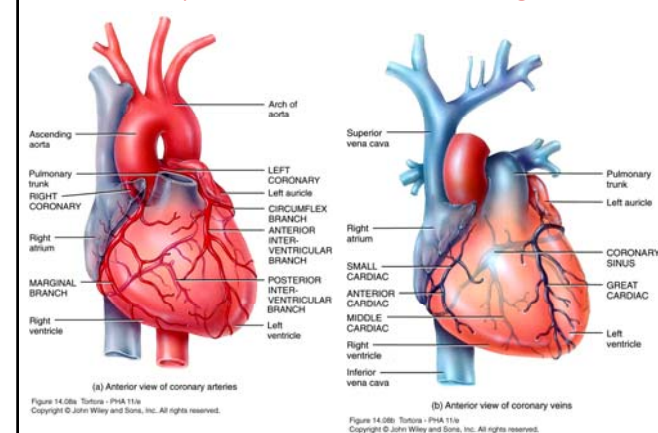
## Circulation of Blood Fig. 14.7a,b



## Coronary (Cardiac) Circulation

- Two coronary arteries, the **left** and **right coronary arteries** branching from the ascending aorta supply the myocardium
- Left coronary artery divides into the **anterior interventricular branch (or left anterior descending artery)** and the **circumflex branch**
- Right coronary artery divides into the **posterior interventricular branch** and **marginal branch** (Fig. 14.8a,b)

## Coronary Arteries and Veins Fig. 14.8a,b



## Coronary Circulation

- There are many **anastomoses** or collateral circuits for blood to reach heart tissue
- Blood drains from the myocardium into the **coronary sinus** by way of tributaries called the great cardiac vein, middle cardiac vein, small cardiac vein, and the anterior cardiac veins (Fig. 14.8c,d)

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## Cardiac Conduction System

- During embryonic development about 1% of the cardiac muscle fibers become **autorhythmic cells**
- Act as a **pacemaker** setting the contraction rhythm of the heart
- Form the **conduction system** of the heart that conduct action potentials throughout the myocardium

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## Cardiac Conduction System

- **Sinoatrial (SA) node** - the heart's natural pacemaker, initiates each heartbeat
- Other components of of the conduction system include: **Atrioventricular (AV) node**, **Atrioventricular bundle** or **bundle of His**, **right and left bundle branches**, **Purkinje fibers**
- The nervous system and certain hormones can alter the pace of contractions but the nervous system does not initiate contractions
- **Electrocardiogram** (ECG or EKG) is a recording of the heart's electrical activity (Fig. 14.9a,b)

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