

# **Lect. No. 7**

## **Cardiovascular Physiology**



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# 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 general **functions** of the cardiovascular system are:
  - 1. Deliver oxygen and nutrients.**
  - 2. Remove carbon dioxide and other waste products.**

# Functions of the Cardiovascular System

## 1. Bring Materials to Cells

- Move **oxygen** from the lungs to all body cells.
- Move **nutrients** and water from the gastrointestinal system to all body cells.
- Move **stored nutrients** from liver and adipose tissue to all cells.
- **Carries immune cells, antibodies, and clotting proteins** to wherever they are needed.

## 2. Remove Waste Materials

- Move **metabolic wastes** from all body cells to kidney for excretion
- Move **heat** from cells to skin for dissipation
- Move **carbon dioxide** from body cells to lungs for elimination
- Move particular **toxic substances** from some cells to liver for processing

# The Heart

## Location

- Thorax between the lungs
- Pointed apex directed toward left hip
- About the **size** of your fist

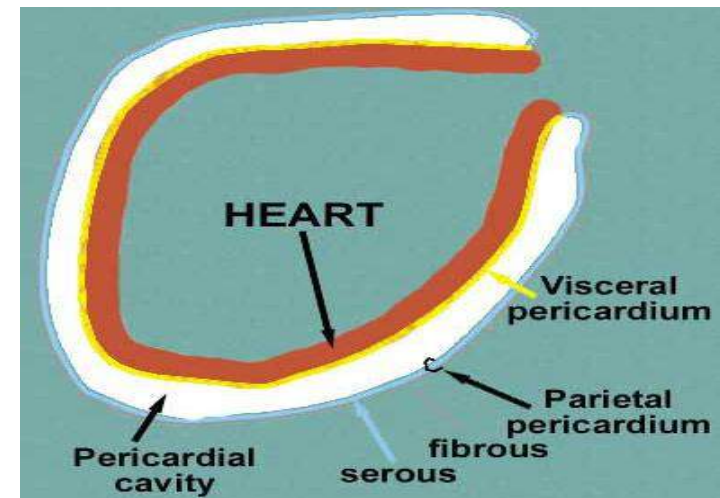
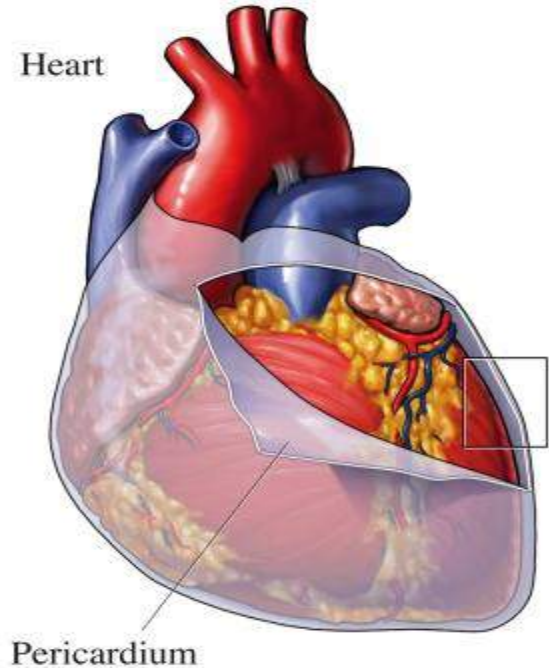
## Coverings

- **Pericardium** – a double serous membrane:
  - **Visceral** pericardium - Next to heart
  - **Parietal** pericardium - Outside layer

**Serous fluid** fills the space between the layers of pericardium

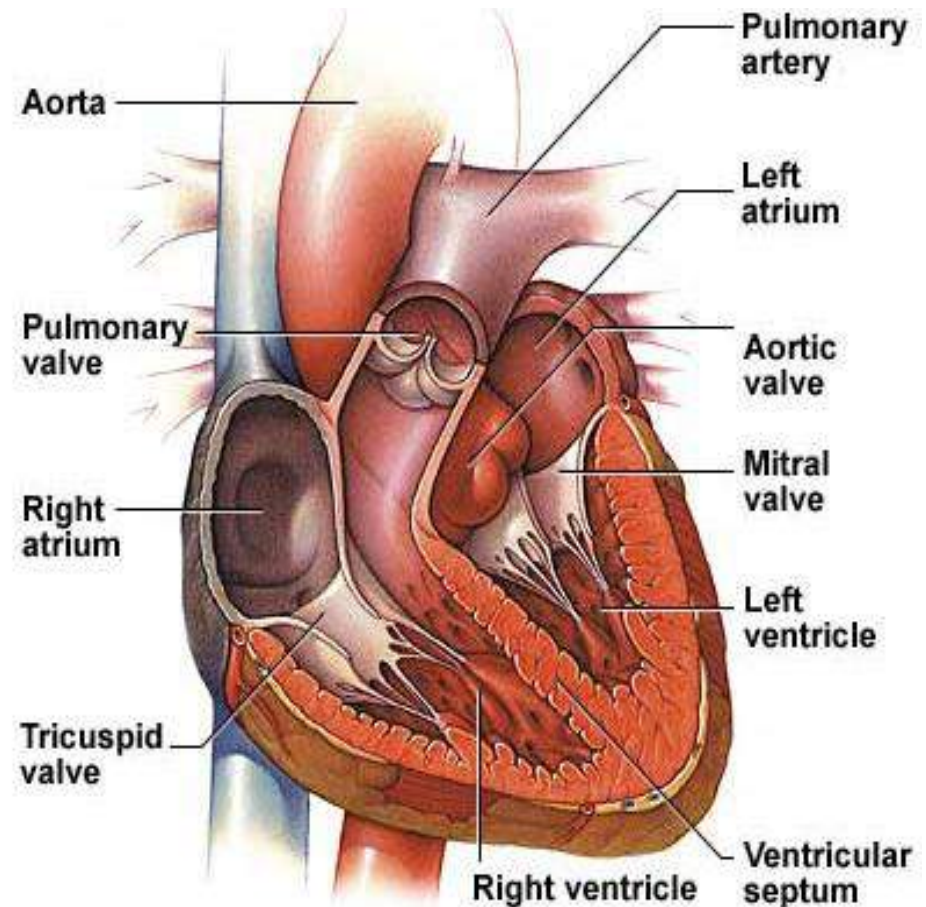
## Layers

- **Epicardium** (Outside layer)
  - This layer is the **parietal pericardium**
  - Connective tissue layer
- **Myocardium** (Middle layer)
  - Mostly **cardiac muscle**
- **Endocardium** (Inner layer)
  - **Endothelium**



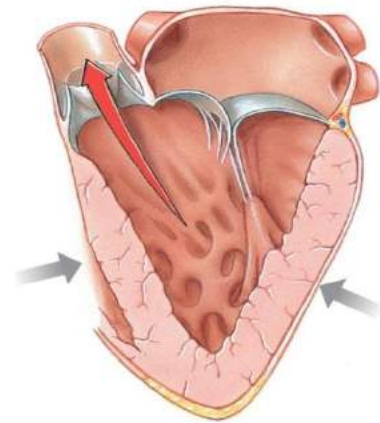
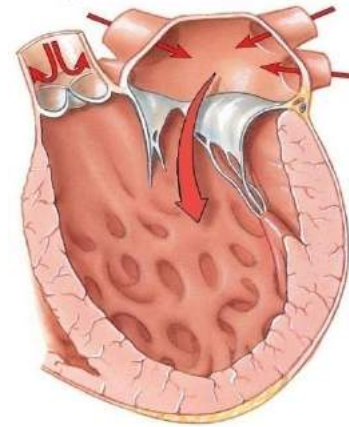
# The Heart: Chambers

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

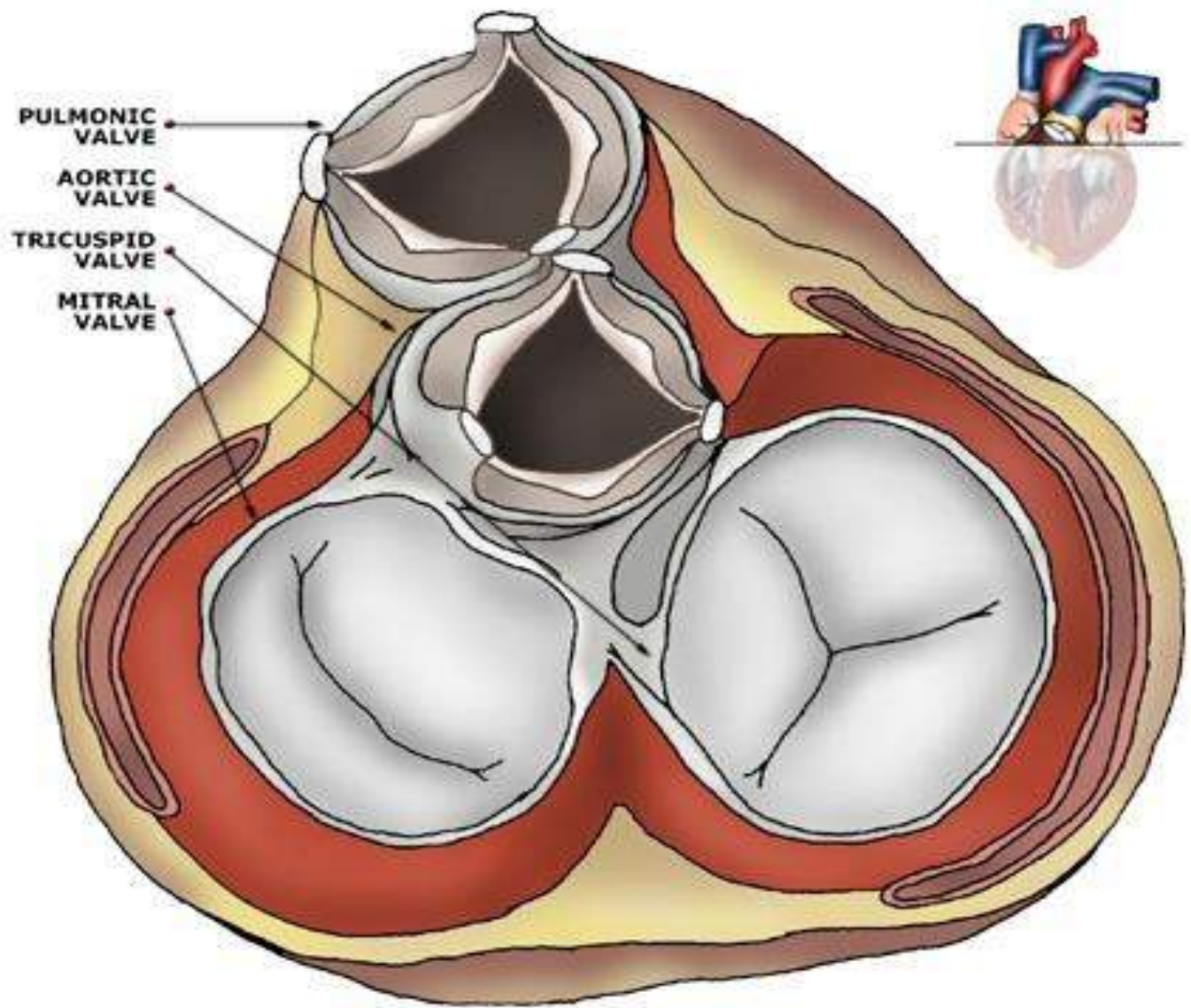


# The Heart Valves

- Allow blood to flow in only **one direction**  
Function is to **prevent backflow**
- **Four valves**
  - Atrioventricular valves –  
between atria and ventricles
    - **Bicuspid valve (left)**
    - **Tricuspid valve (right)**
  - Semilunar valves between ventricle and artery
    - **Pulmonary semilunar valve**
    - **Aortic semilunar valve**
- Valves open as blood is pumped through
- Held in place by chordae tendineae (“heart strings”)
- Close to prevent backflow



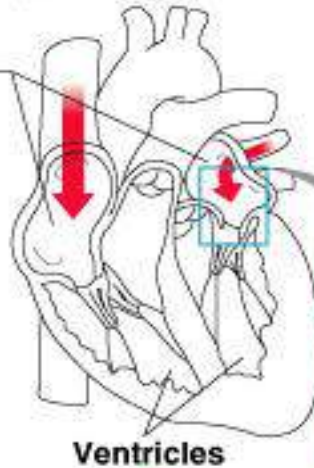




# Operation of Heart Valves

## 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

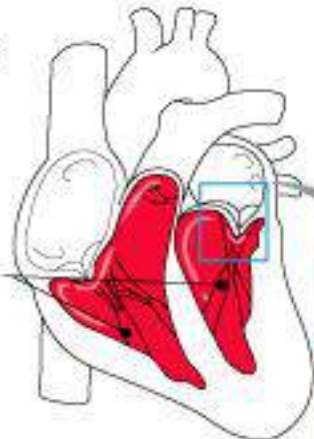


Ventricles



AV valves open

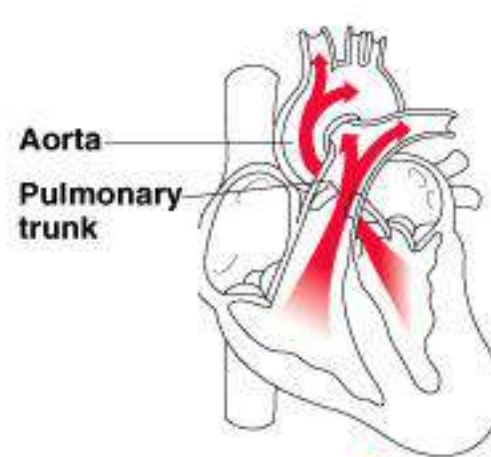
- 1 Ventricles contract, forcing blood against AV valve flaps
- 2 AV valves close
- 3 Chordae tendineae tighten, preventing valve flaps from everting into atria



AV valves closed

(a)

## Operation of the semilunar valves

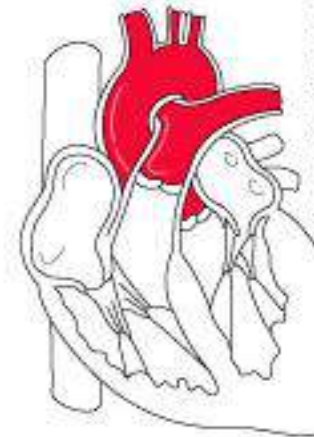


Aorta  
Pulmonary trunk

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



Semilunar valve open



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



Semilunar valve closed

(b)

Figure 11.4



# The Heart: Associated Great Vessels

1. Aorta - leaves left ventricle
  2. Pulmonary arteries - leave right ventricle
  3. Vena cava - enters right atrium
  4. Pulmonary veins (four) - enter left atrium
- Blood in the heart chambers does not nourish the myocardium

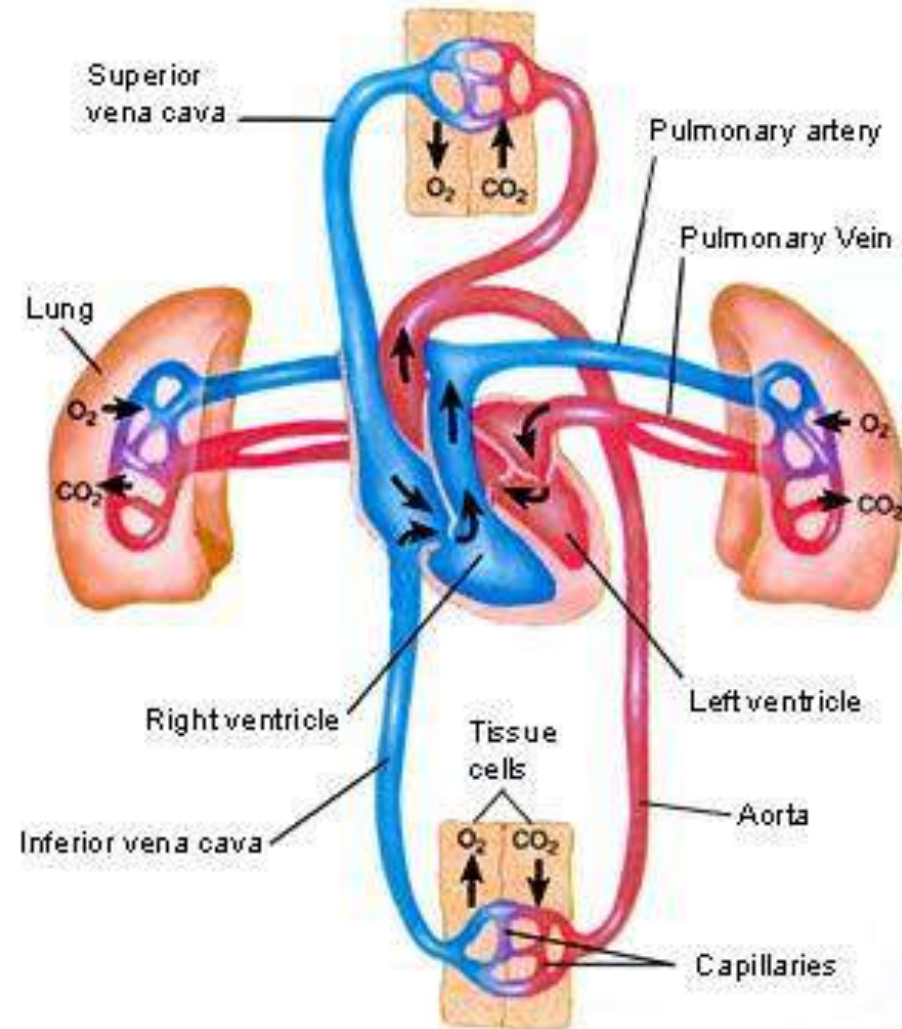
- **Coronary Circulation**

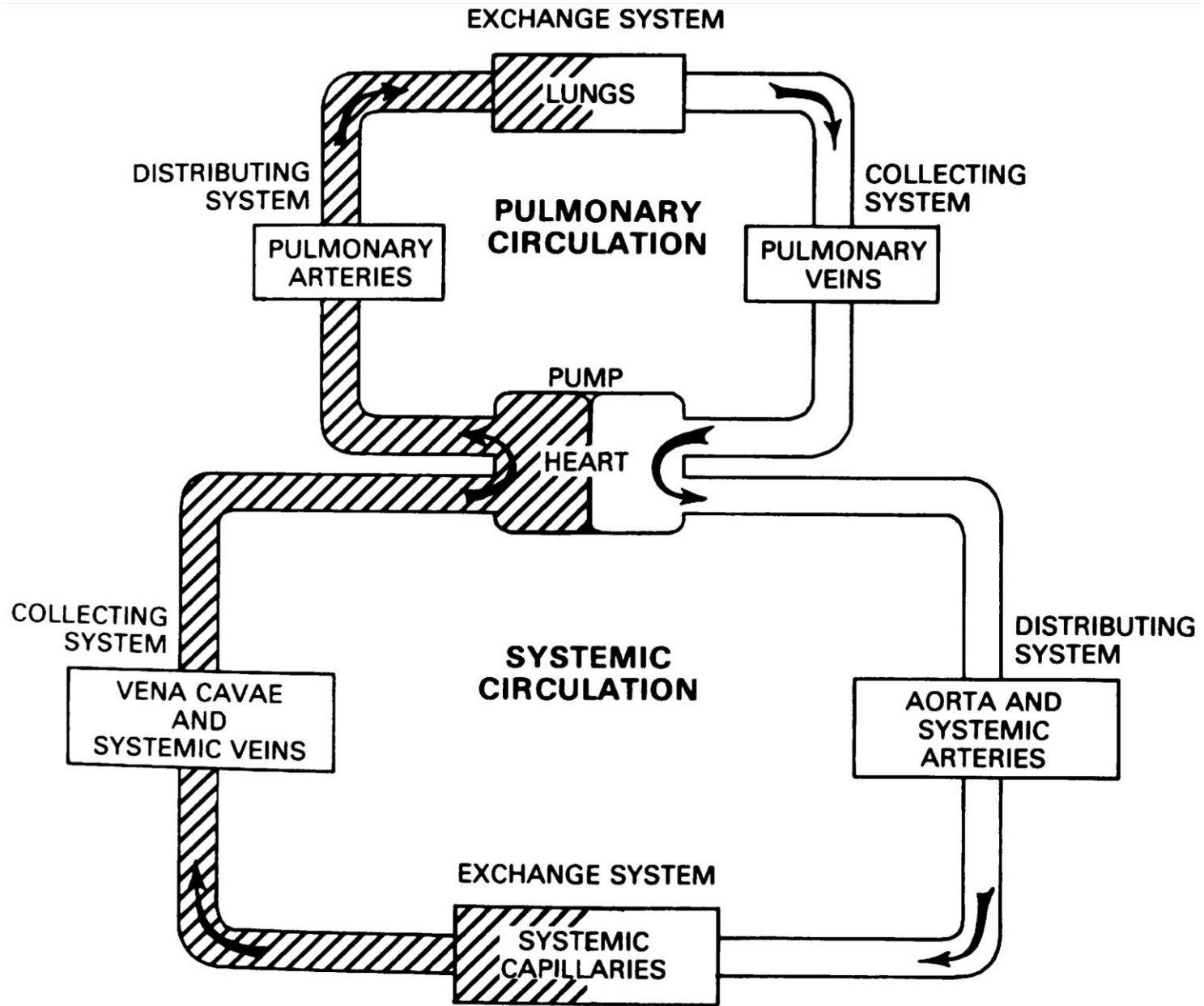
The heart has its own nourishing circulatory system

1. Coronary arteries
  2. Cardiac veins
- Blood empties into the right atrium via the coronary sinus

# SYSTEMIC AND PULMONARY CIRCULATION

- LEFT SIDE IS A PUMP TO THE SYSTEMIC CIRCULATION.
- RIGHT SIDE IS A PUMP TO THE PULMONARY CIRCULATION.





# Flow

- Flow (Q) is the volume flow rate of blood, and is expressed as volume per time (e.g., ml/min).
- Note that in terms of the tissues, flow is the most important physical parameter, as it dictates the delivery of materials such as oxygen and glucose.
- **Physics of Circulation: Ohm's Law**
- **(  $Q = \Delta P/R$  ) or (  $\Delta P = Q * R$  ) or (  $R = \Delta P/Q$  )**
- In these equations,  $\Delta P$  indicates the change in pressure on two ends of a vessel , and not the pressure within the vessel itself.
- Note that Ohm's law indicates that flow through a vessel will be **INVERSELY** proportional to its resistance (R).



# The Heart: Conduction System

## Intrinsic conduction system (nodal system)

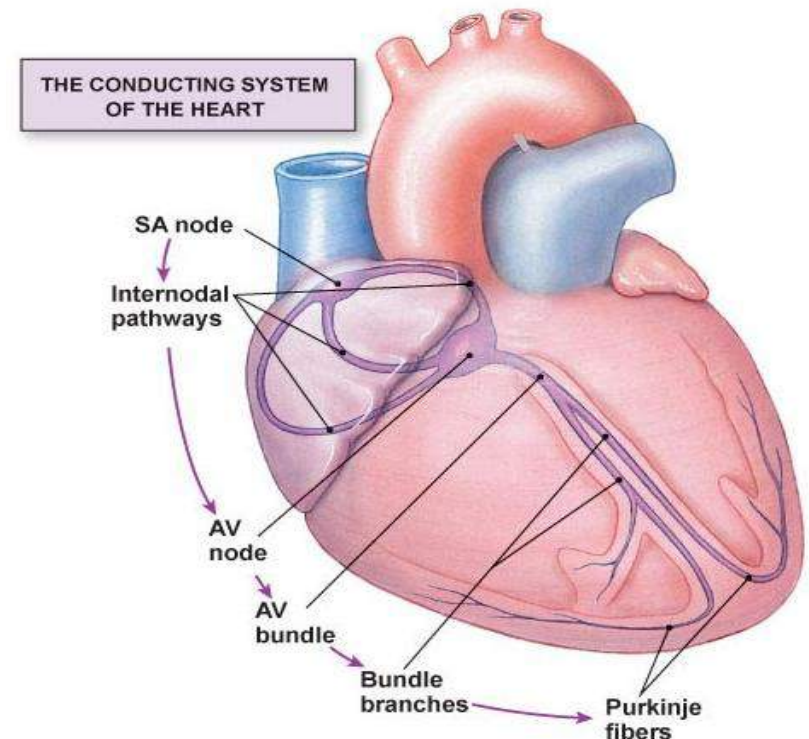
- Heart muscle cells contract, without nerve impulses, in a regular, continuous way

## Special tissue sets the pacemakers

1. Sinoatrial node (SA) – Pacemaker
2. Atrioventricular node (AV)
3. Atrioventricular bundle
4. Bundle branches
5. Purkinje fibers

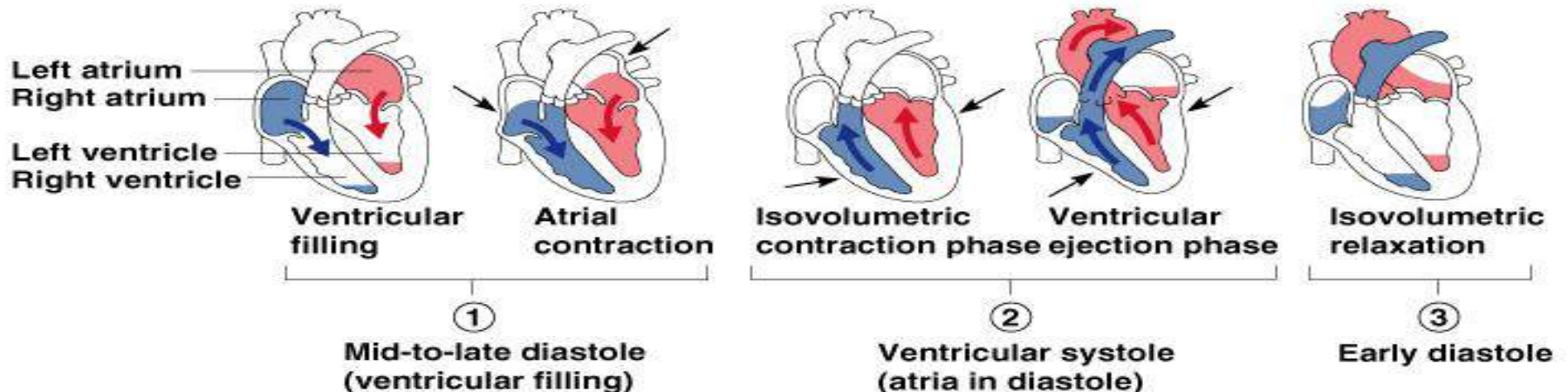
## Characteristics of Pacemaker Cells

- Smaller than contractile cells
- Don't contain many myofibrils
- No organized sarcomere structure
- do not contribute to the contractile force of the heart



# The Heart's Cardiac Cycle

- **Cardiac cycle** is the sequence of events as blood enters the atria, leaves the ventricles and then starts over.
- Synchronizing this is the **Intrinsic Electrical Conduction System**.
- Influencing the rate is done by the **sympathetic and parasympathetic** divisions of the ANS.
- Atria contract simultaneously - Atria relax, then ventricles contract.
- **Cardiac cycle events** of one complete heart beat:
  1. Mid-to-late diastole – blood flows into ventricles
  2. Ventricular systole – blood pressure builds before ventricle contracts, pushing out blood
  3. Early diastole – atria finish re-filling, ventricular pressure is low



# Cardiac Cycle

## Coordinating the activity

- The electrical system gives rise to electrical changes (depolarization/repolarization) that is transmitted through isotonic body fluids and is recordable
  - **The ECG** (Electrocardiograph)
    - A recording of electrical activity
    - Can be mapped to the cardiac cycle