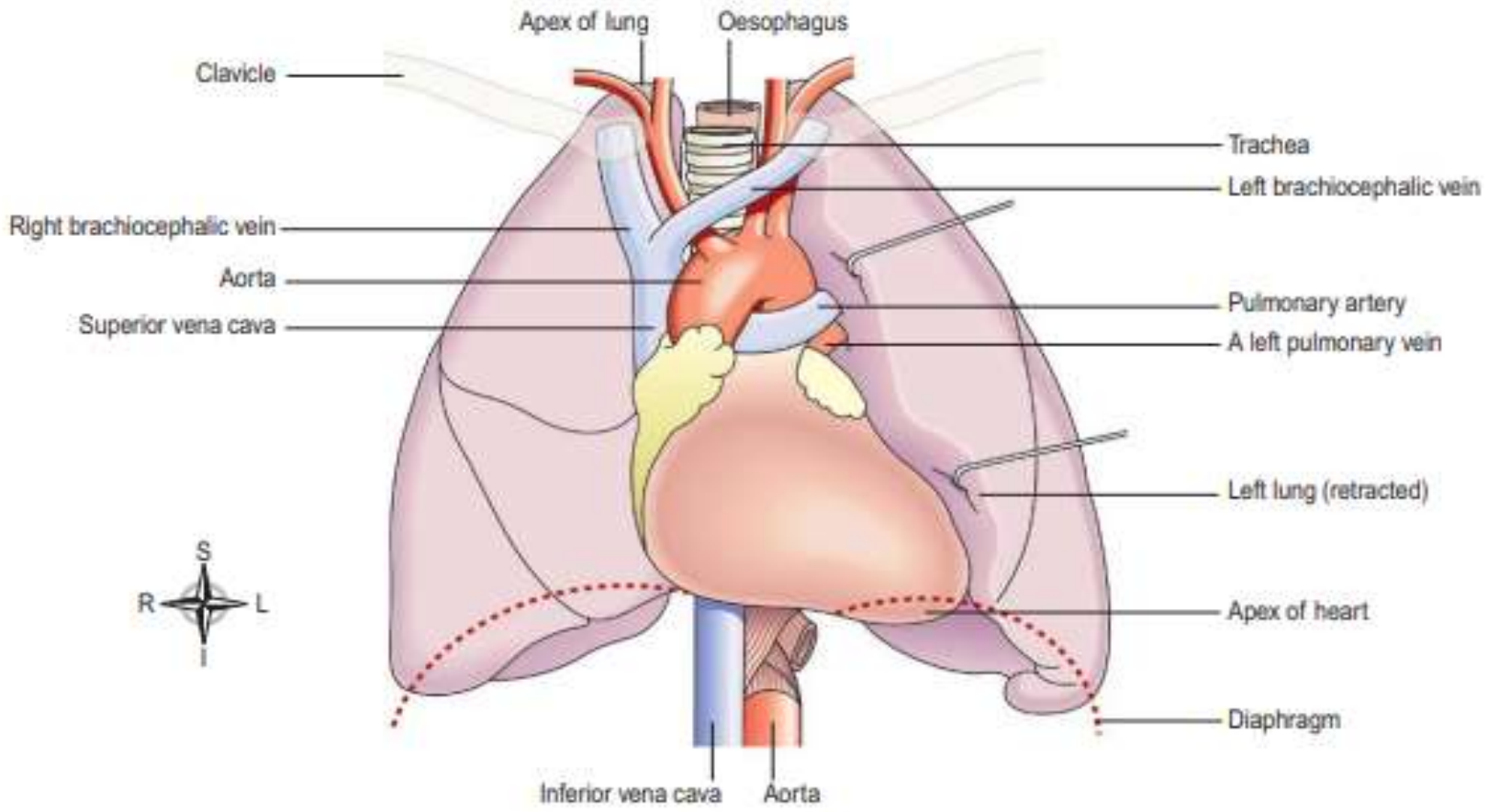
The cardiovascular system

BS Hons

AWAIS HAMZA



ıre 5.10 Organs associated with the heart.

Cardiovascular System: Introduction

- **Cardiovascular (Cardio = heart, Vascular = blood vessels)**
  The system is divided into two main parts:
- **The heart**
  → pumping action ensures constant blood circulation.
- **The blood vessels**
  → long, branching network through which blood flows.

Dual Circulatory System

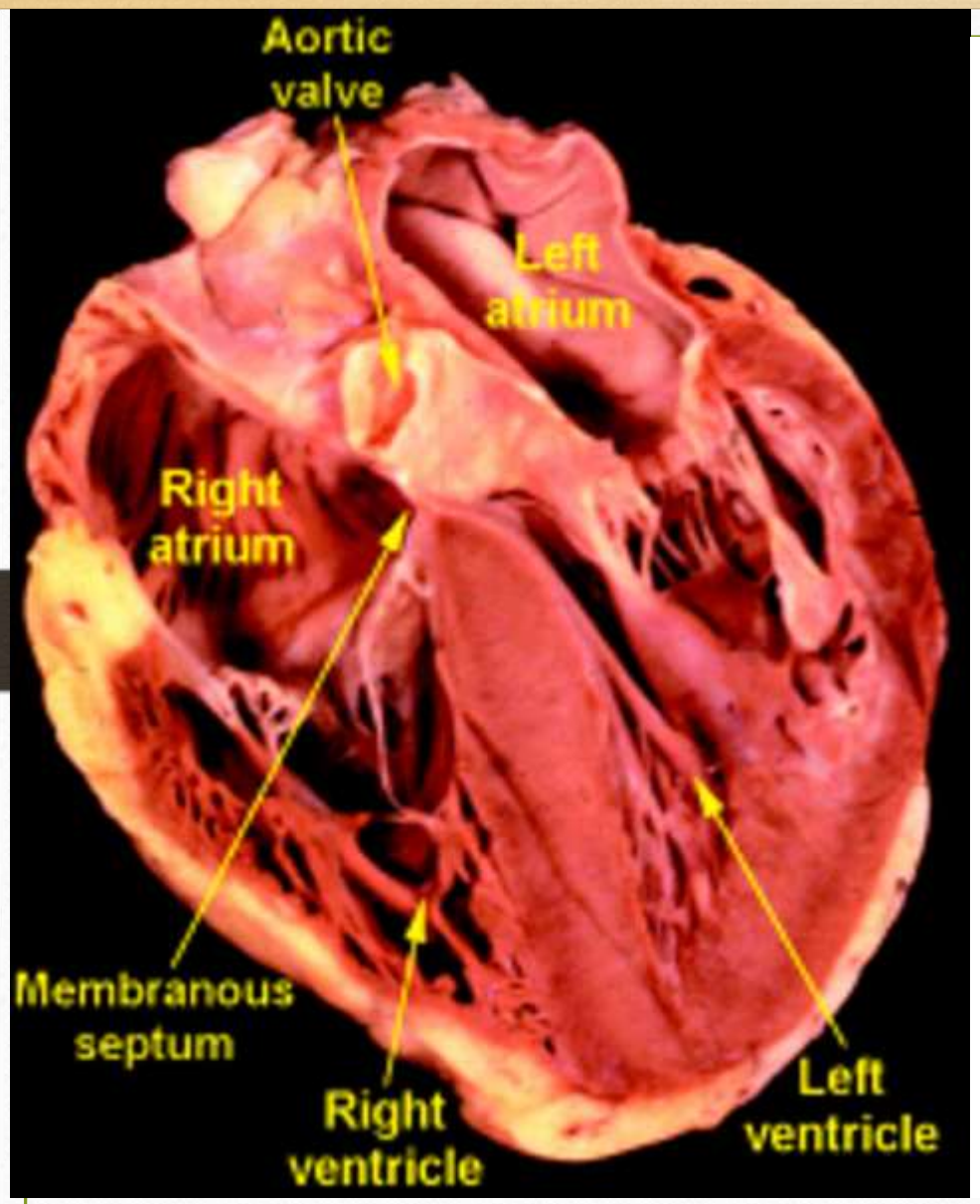
- The heart pumps blood into **two anatomically separate circulations**:
- **Pulmonary circulation**
- **Systemic circulation**

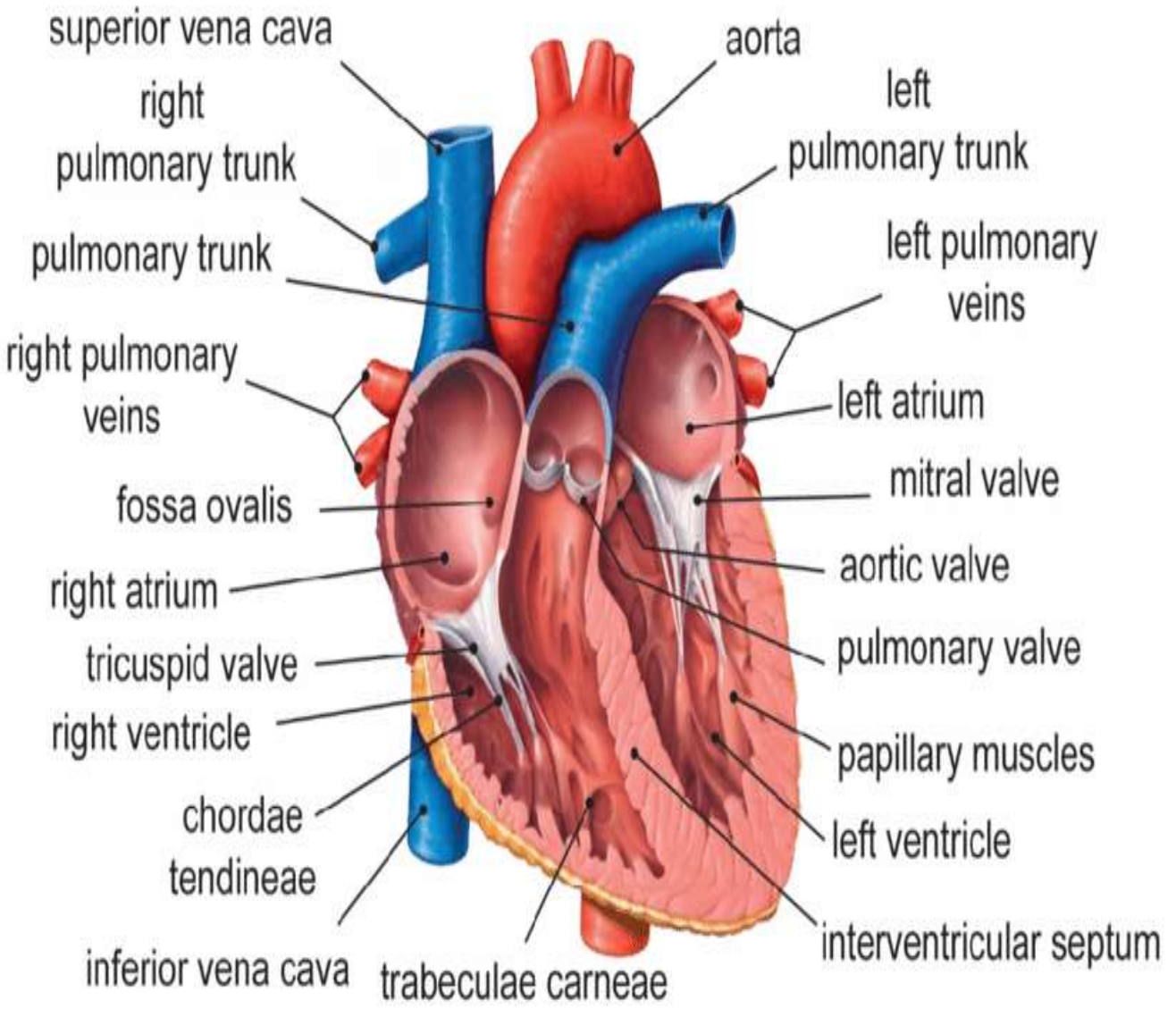
Functional Anatomy of the Cardiac System

- The cardiac system consists of:
- **Heart** → muscular pump
- **Blood vessels** → arteries, arterioles, capillaries, venules, veins
- **Pulmonary circulation** → heart ↔ lungs
- **Systemic circulation** → heart ↔ tissues

Pulmonary Circulation (Right Heart)

- **Right side of the heart → Lungs**
- Functions:
- Gas exchange
- Blood **collects oxygen** from air sacs (alveoli)
- Excess **CO_2 diffuses into alveoli** → exhaled

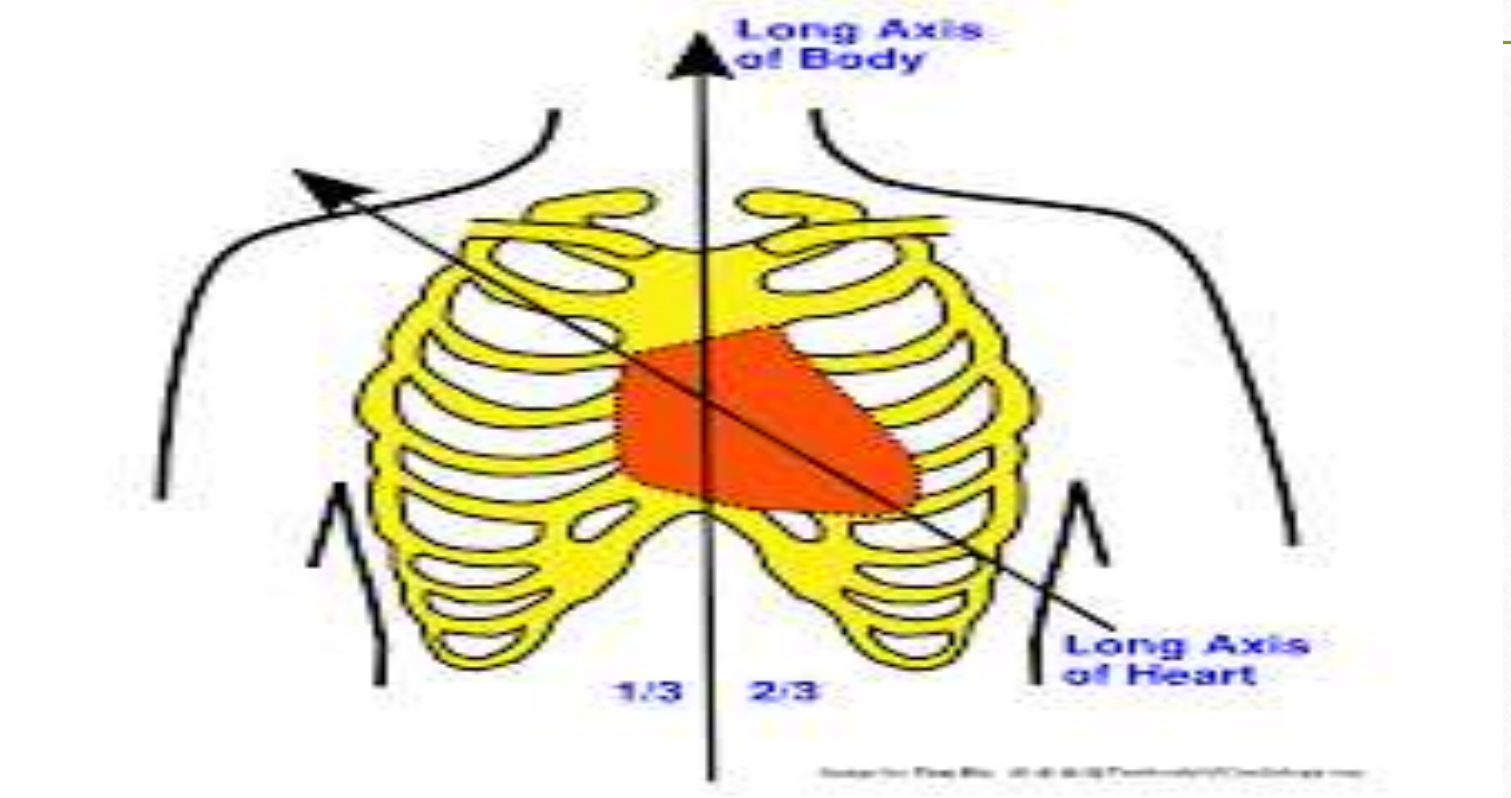

Aortic valve
Left atrium
Right atrium
Membranous septum
Right ventricle
Left ventricle

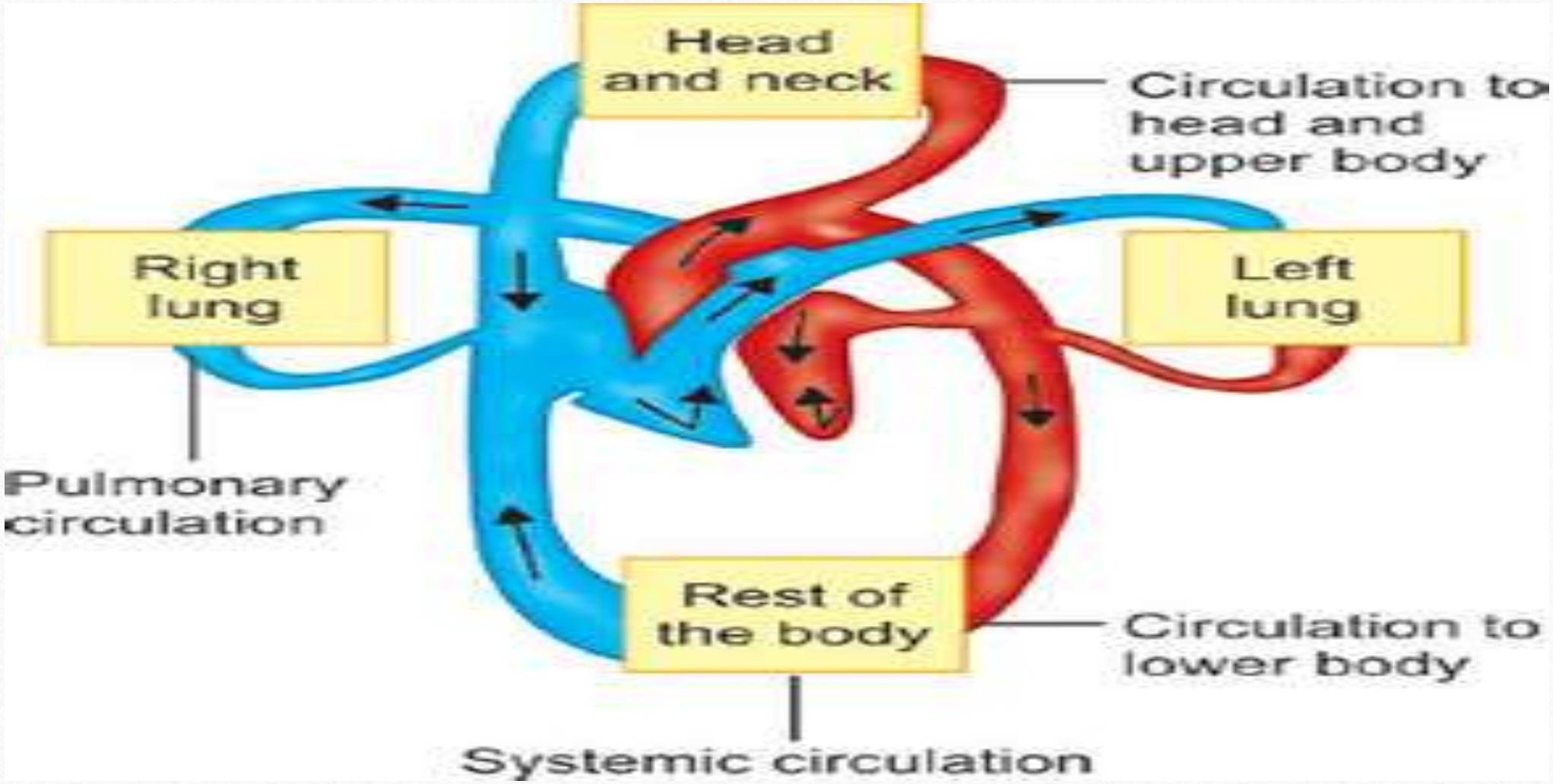

superior vena cava
right pulmonary trunk
pulmonary trunk
right pulmonary veins
fossa ovalis
right atrium
tricuspid valve
right ventricle
chordae tendineae
inferior vena cava
aorta
left pulmonary trunk
left pulmonary veins
left atrium
mitral valve
aortic valve
pulmonary valve
papillary muscles
left ventricle
interventricular septum
trabeculae carneae

The Heart: Location & Orientation

- Located in **mediastinum**, between lungs
- 2/3 lies left of midline
- Apex → left 5th intercostal space, mid-clavicular line
- Base → superior, toward right shoulder

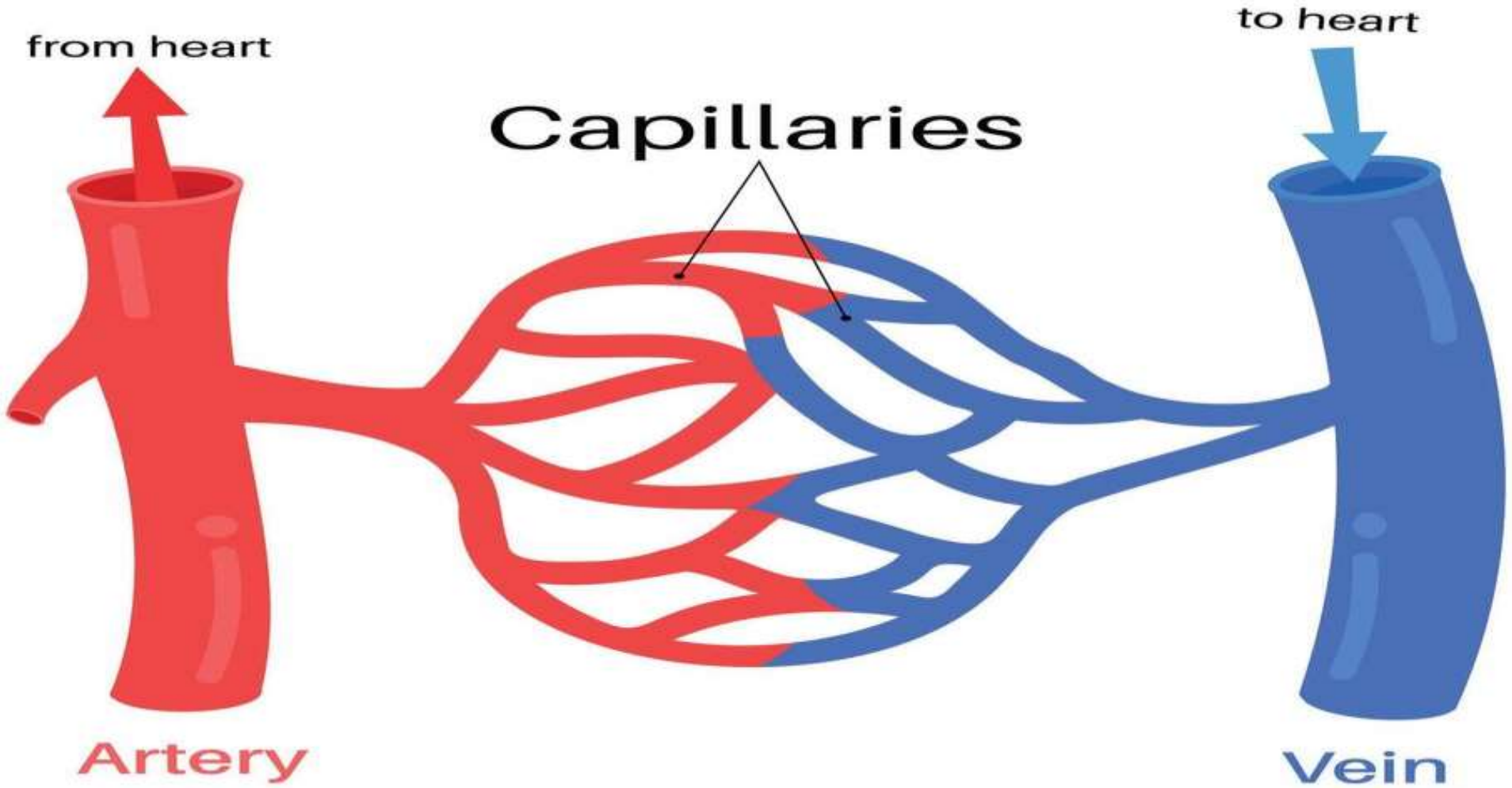
Position

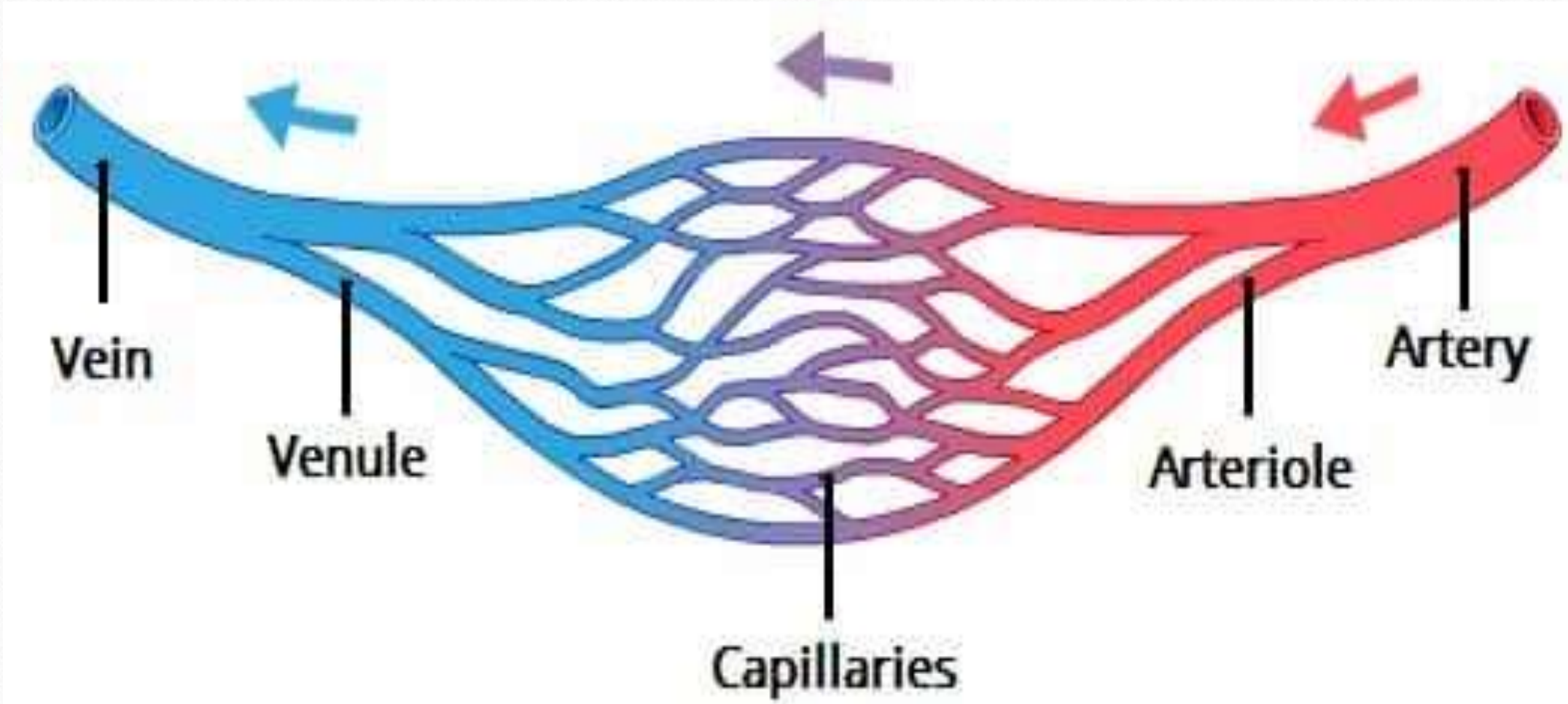


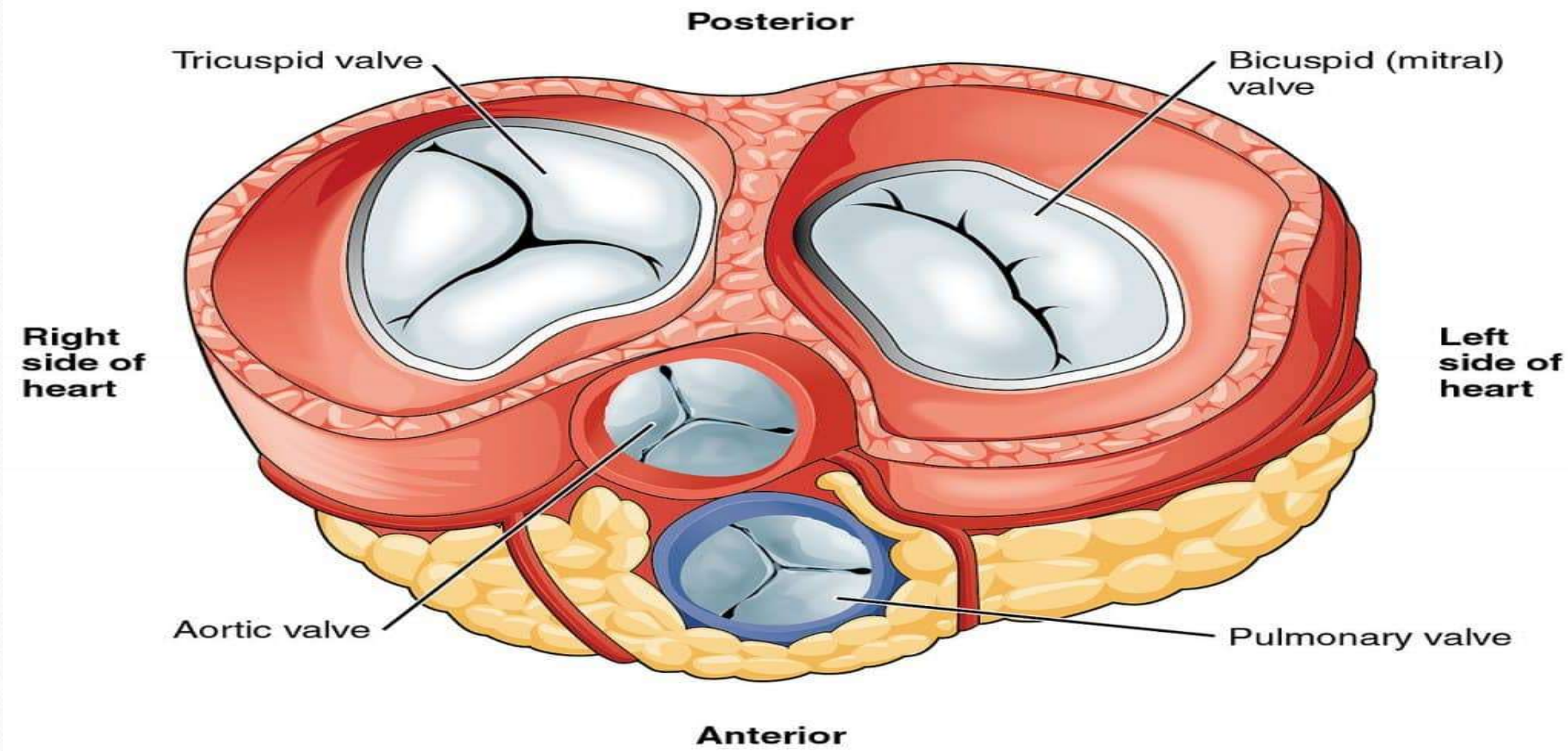

Head and neck
Circulation to head and upper body
Right lung
Left lung
Pulmonary circulation
Rest of the body
Circulation to lower body
Systemic circulation

Systemic Circulation (Left Heart)

- **Left side of the heart → Whole body**
- Functions:
- Supplies all tissues with **oxygen & nutrients**
- Collects tissue wastes for excretion
- Cells extract glucose, amino acids, ions, oxygen from blood


from heart
to heart
Capillaries
Artery
Vein


Vein
Venule
Capillaries
Arteriole
Artery


Posterior
Tricuspid valve
Bicuspid (mitral) valve
Right side of heart
Left side of heart
Aortic valve
Pulmonary valve
Anterior

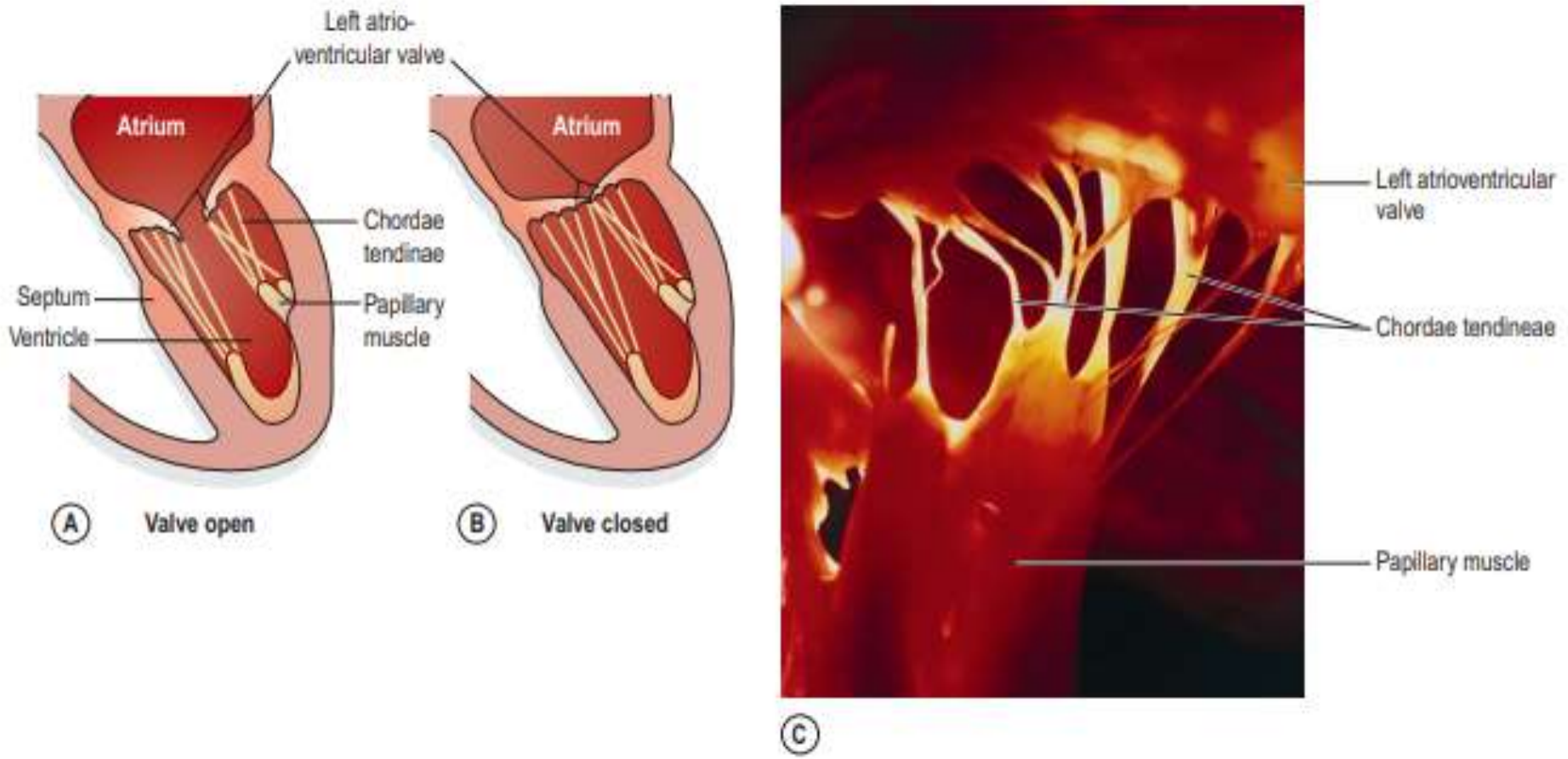


Figure 5.13 The left atrioventricular (mitral) valve. A. Valve open. **B.** Valve closed. **C.** Photograph of the chordae tendinae.

Cardiovascular Adaptation

- Cardiovascular function undergoes **constant physiological adjustments** to meet body demands.
- Examples:
- Exercise → ↑ cardiac output
- Stress → ↑ HR & BP
- Rest → ↓ HR
- Posture change → baroreceptor reflex maintains BP

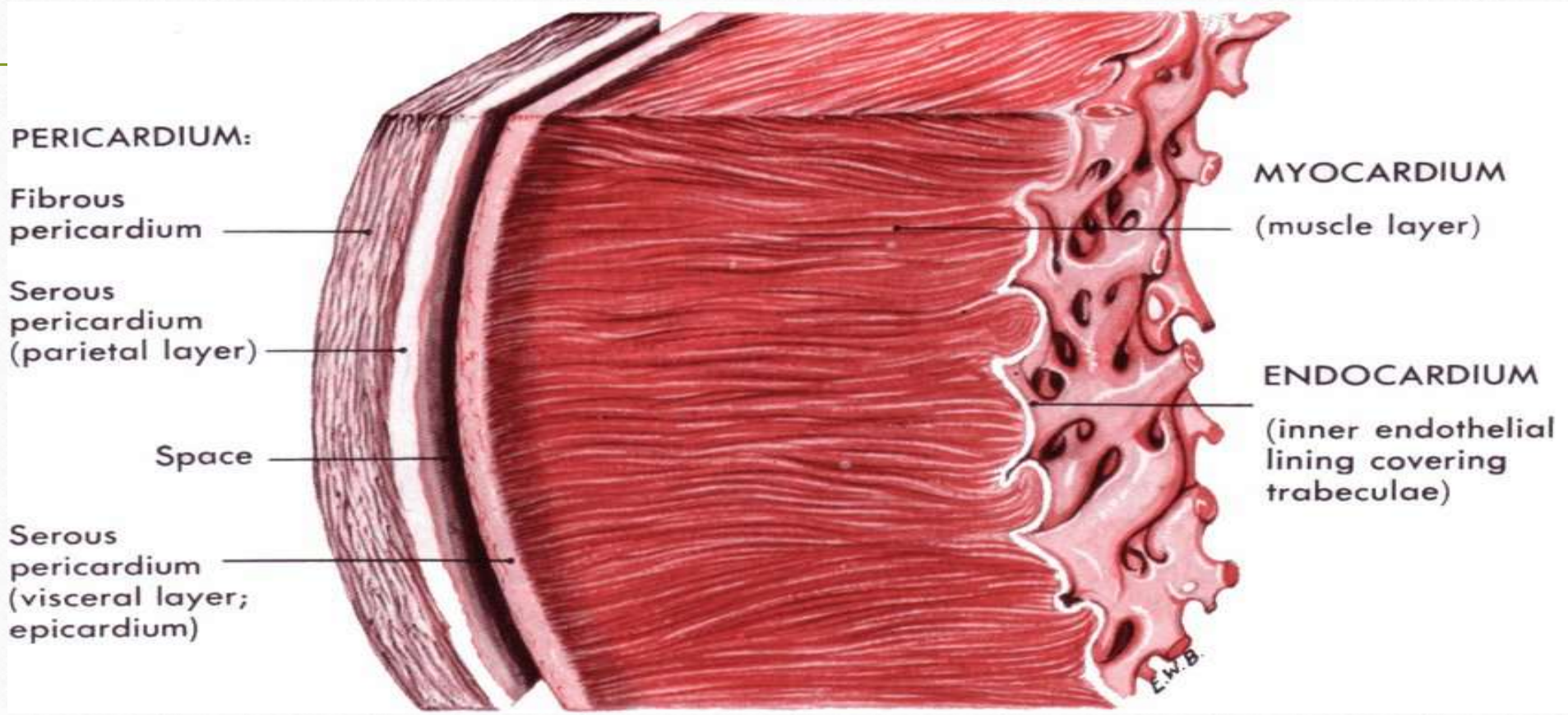
Age-Related Changes

- Cardiovascular function **declines with age**
- Effects include:
- Reduced elasticity of blood vessels
- Increased BP
- Slower heart responses
- Higher risk of arrhythmias & valve defects

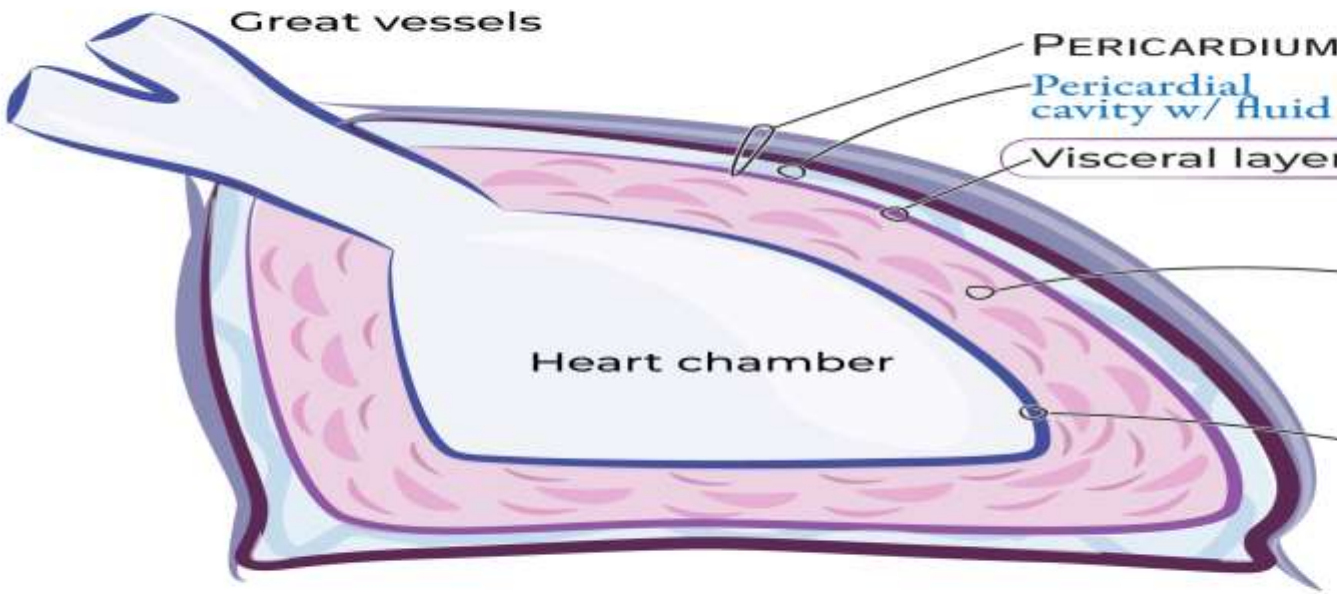
Layers of the Heart Wall

- **Pericardium**
- Fibrous pericardium,Serous pericardium: parietal + visceral (epicardium)
- Pericardial cavity with fluid → reduces friction
- **Myocardium**
- Thick cardiac muscle layer, Contains contractile fibers + conduction system
- **Endocardium**
- Smooth endothelial layer, Lines chambers & valves

Layers of the Heart Wall



Heart Wall



PERICARDIUM
Pericardial cavity w/ fluid
Visceral layer

HEART WALL:

Epicardium
Simple squamous epithelium

Myocardium
Muscle cells
Myoendocrine cells
Nodal cardiocytes

Endocardium
Endothelia
Lines chambers, valves

Chambers of the Heart

- **Right Atrium**
- Receives ** deoxygenated blood**: SVC, IVC, coronary sinus
- Contains SA node
- **Right Ventricle**
- Pumps blood → pulmonary trunk
- Thin-walled (low pressure)

Chambers of the Heart

- **Left Atrium**
- Receives **oxygenated blood** from 4 pulmonary veins
- **Left Ventricle**
- Thickest wall
- Pumps blood to whole body via aorta
- Highest pressure chamber

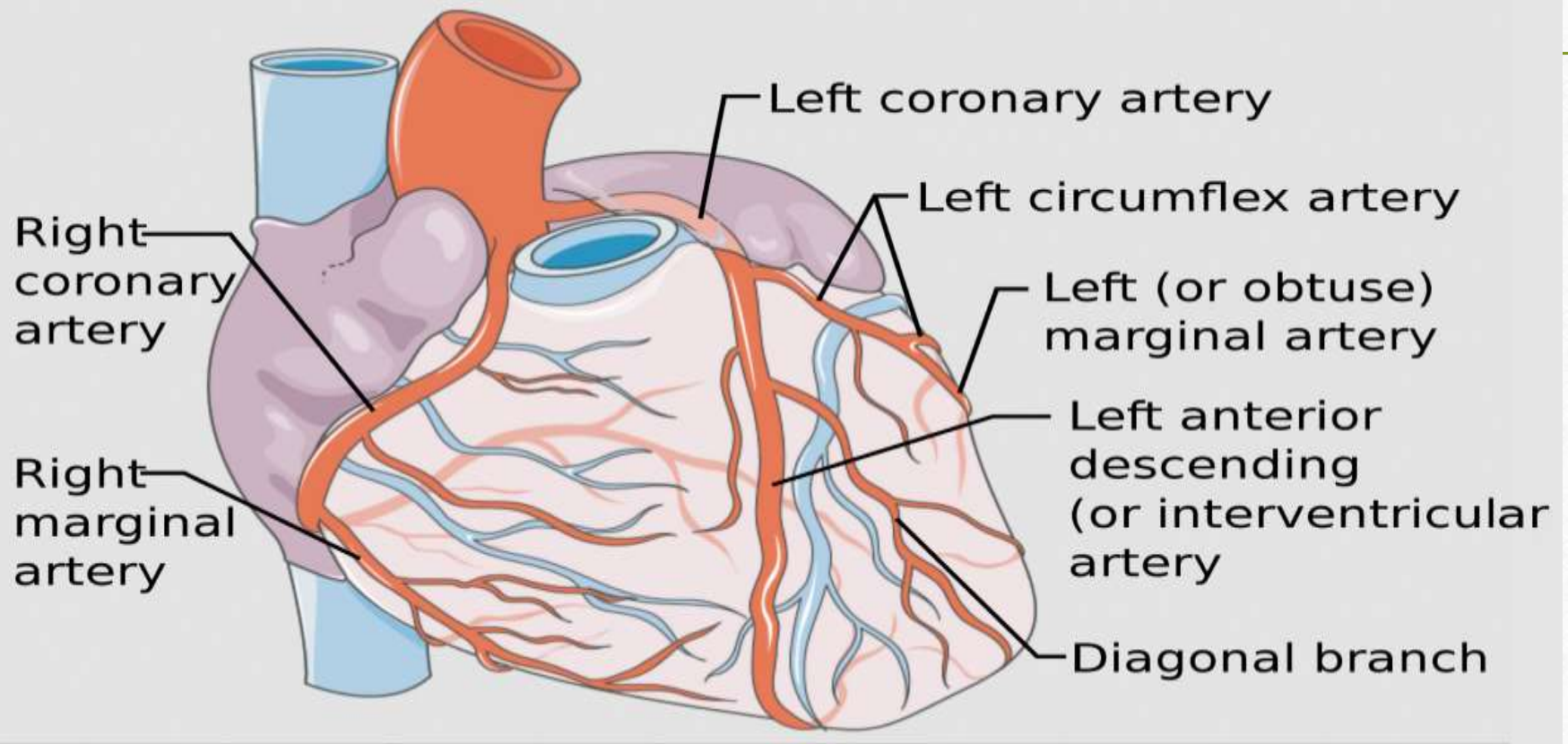
Heart Valves (Functional Anatomy)

- **Atrioventricular (AV) valves**
- **Tricuspid (right)**
- **Mitral/Bicuspid (left** Function: Prevent backflow from ventricles → atria
- **Chordae tendineae + papillary muscles:** Prevent valve prolapse during ventricular systole
- **Semilunar valves**
- **Pulmonary valve**
- **Aortic valve**

Coronary Circulation

- Heart muscle receives blood via:
- Right & left coronary arteries (from aortic root)
- Branch into: LAD, circumflex, marginal, PDA, etc.
- Coronary veins → coronary sinus → right atrium
- **High-yield physiology**
- Maximal coronary perfusion during **diastole**
- LV hypertrophy ↓ coronary flow (increased wall thickness)

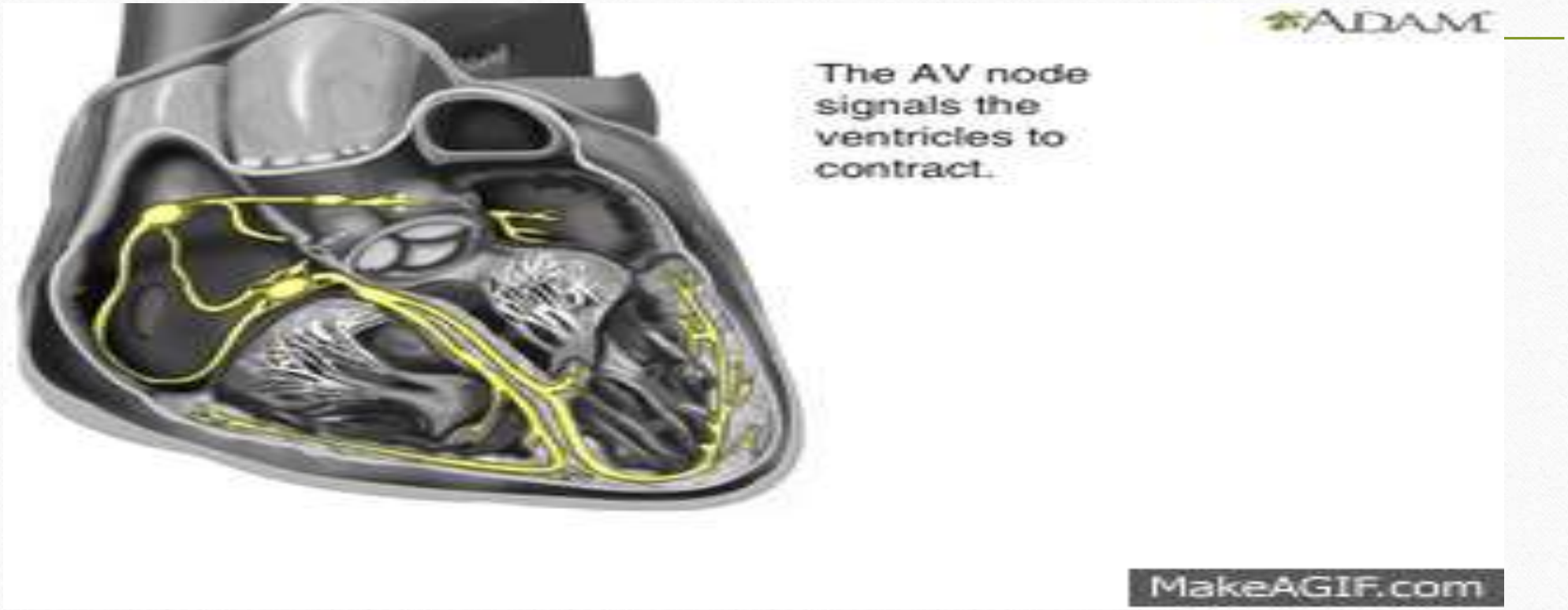
Coronary Circulation



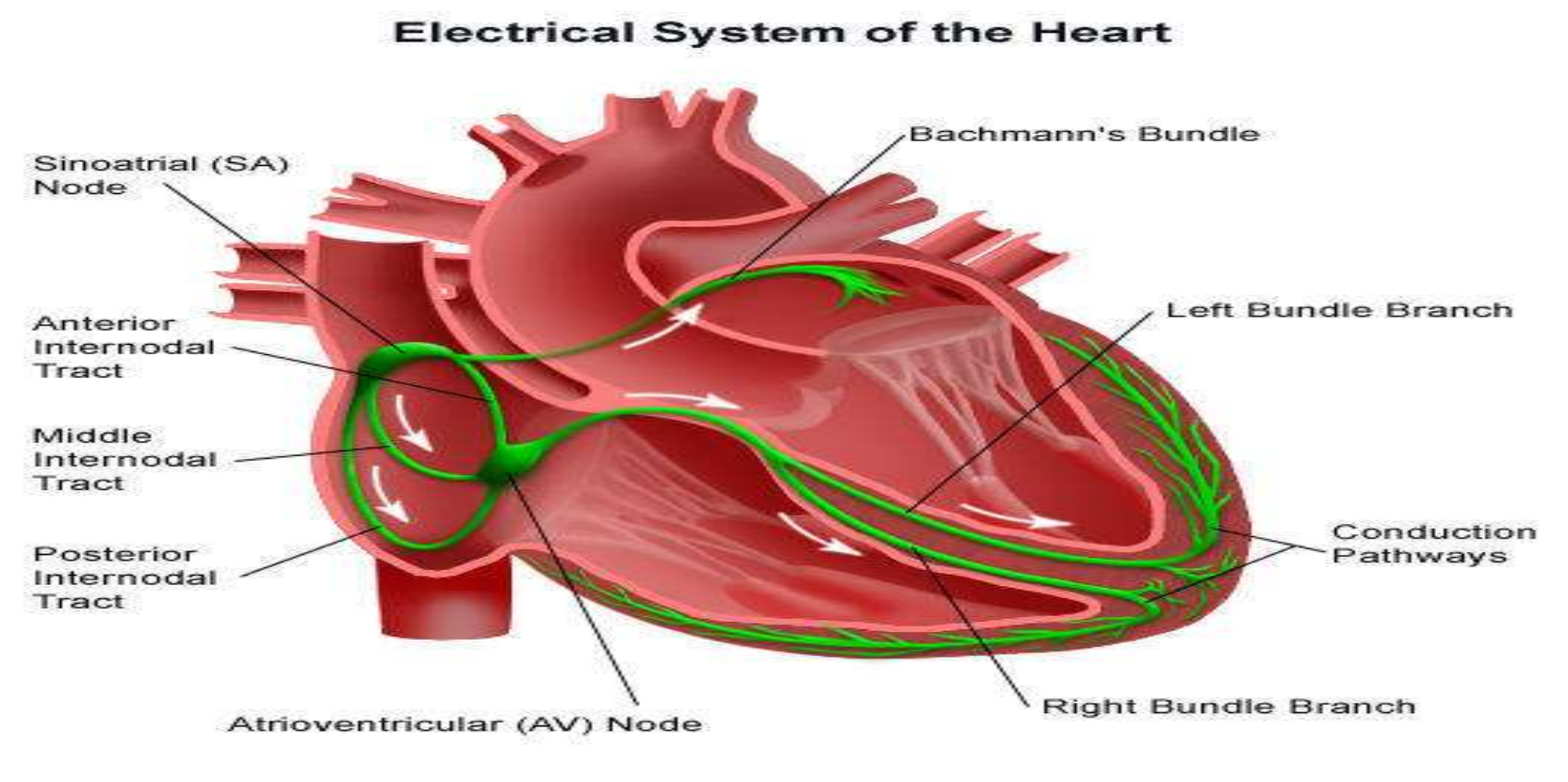
Cardiac Conduction System Components

- **SA Node** → primary pacemaker
- **AV Node** → slows conduction (AV delay)
- **Bundle of His** → only bridge atria–ventricles
- **Right & left bundle branches**
- **Purkinje fibers** → rapid conduction → coordinated contraction

Cardiac Conduction System



Cardiac Conduction System



Blood Supply to Conduction System

- SA node → RCA (60%) or LCA (40%)
- AV node → RCA (85–90%)
- Bundle branches → LAD
- Purkinje network → LAD + RCA branches
- Damage → arrhythmias or heart block

Cardiac Muscle Functional Anatomy

- Characteristics:
- **Striated, branched cells**
- **Intercalated discs**
- **Gap junctions** → electrical syncytium
- **Desmosomes** → mechanical strength
- **High mitochondrial density** → fatigue resistant

Functional Anatomy of the Pulmonary Circulation

- Right ventricle → pulmonary trunk → pulmonary arteries → lungs → pulmonary veins → left atrium
- Features:
- Low pressure (15–25 mmHg)
- Thin-walled RV
- Gas exchange in alveoli

Functional Anatomy of the Systemic Circulation

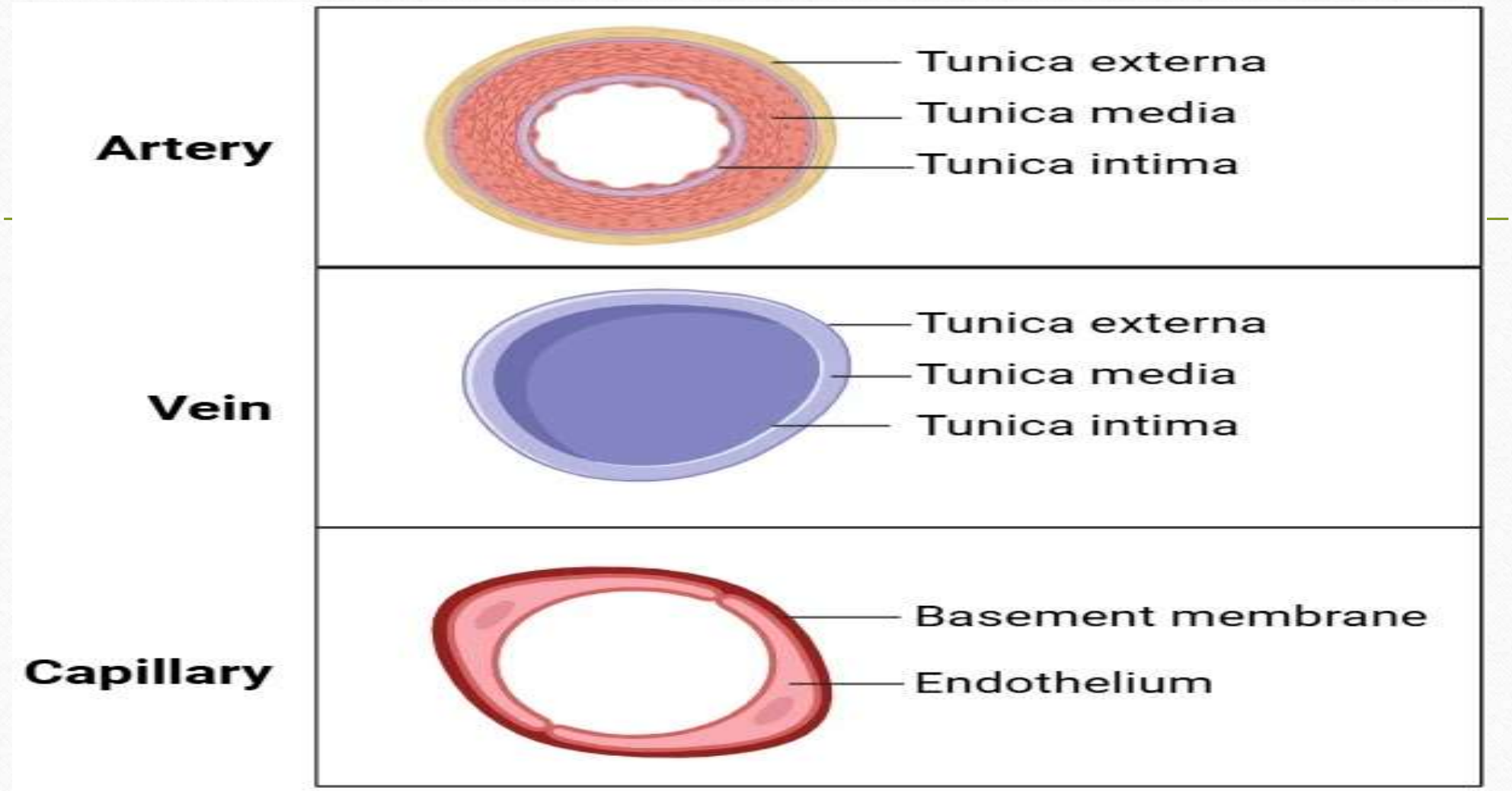
- Left ventricle → aorta → arteries → arterioles → capillaries → venules → veins → right atrium
- Features:
- High pressure system
- Arterioles are **primary resistance vessels**
- Capillaries → exchange of nutrients/gases
- Veins → act as **blood reservoirs (70%)**

Lymphatic System

- Drains excess interstitial fluid
- Returns proteins & lymph to bloodstream
- Filters pathogens
- Works closely with CV system to maintain fluid balance

Arteries & Arterioles

- **Function:**
  These vessels transport blood **away from the heart**.
- **Structure:**
  All arteries and arterioles have **three wall layers**
- **Tunica adventitia** Outer fibrous tissue layer
- **Tunica media** Middle layer of **smooth muscle + elastic tissue**
- **Tunica intima** Inner lining of **squamous epithelium (endothelium)**


Artery
Tunica externa
Tunica media
Tunica intima
Vein
Tunica externa
Tunica media
Tunica intima
Capillary
Basement membrane
Endothelium

Differences in Arterial Structure

- **Elastic Arteries (Aorta & Major Arteries)**
- Tunica media → **more elastic fibers**, fewer smooth muscle cells
  - Stretch during systole, Absorb high-pressure wave from the heart
  - Recoil in diastole (Windkessel effect)
- **Muscular Arteries → Arterioles**
- As arteries branch and become smaller:
  - Tunica media becomes **mostly smooth muscle**, Elastic fibers decrease

Arterioles: Resistance Vessels

- **Arterioles = smallest arteries**
- Tunica media almost entirely **smooth muscle**
- Their diameter is **precisely regulated**
- **Systemic blood pressure** is mainly determined by:
  - The **resistance** they offer to blood flow
    → Hence called **resistance vessels**

Structural Difference: Arteries vs Veins

- **Arteries have thicker walls than veins**
  Reason:
- Must withstand **higher pressure** of arterial blood
- Have more smooth muscle & elastic tissue

Anastomoses

- **Definition:**
  Arteries that **connect** to form a link between main arteries supplying the same area.
- **Examples:**
- Palms of hands
- Soles of feet
- Brain
- Joints
- Limited presence in heart muscle

End-Arteries

- **Definition:**
  Artery that is the **sole supply** of blood to a tissue.
- **Examples:**
- Branches of the Circle of Willis
- Central artery of the retina
- **Clinical Significance:**
  → **Occlusion → complete tissue death**
  → No collateral supply

Capillaries

- **Capillary Wall Structure:**
- **Single layer** of endothelial cells
- Thin **basement membrane**
- Allows passage of:
  - Water, Electrolytes, Small molecules
- Does **not** allow:
  - Large molecules (proteins),Blood cells

Capillary Network & Function

- Capillaries link **smallest arterioles** to **smallest venules**
- Diameter ≈ **7 μm** (same as RBC)
- Site of **exchange**:
- O_2
- CO_2
- Nutrients
- Wastes

Precapillary Sphincters

- Entry to capillary beds is controlled by **rings of smooth muscle**
- Called **precapillary sphincters**
- **Regulated by:**
- Hypoxia → sphincters dilate
- Accumulation of tissue waste
- High metabolic activity

Sinusoids (Special Capillaries)

- **Locations:**
- Liver
- Bone marrow
- Spleen (not mentioned but relevant)
- **Characteristics:**
- **Wider, irregular lumen**
- **Leaky** walls (incomplete endothelial lining)
- Blood flows **slowly** and at **low pressure**

Capillary Refill Time

- **Test:**
- Press skin → turns pale
- Time to become pink again = capillary refill time
- **Normal:**
  → < 2 seconds
- **Prolonged refill suggests:**
- Poor perfusion, Shock, Dehydration
- Low cardiac output

Veins & Venules

- **Function:**
- Veins return blood **at low pressure** to the heart.
- **Wall Structure:**
  Same three layers as arteries
- **Tunica adventitia**
- **Tunica media**
- **Tunica intima**

Structural & Functional Comparison

- **When cut:**
- **Veins collapse** (thin walls, low pressure)
- **Arteries remain open** (thicker walls)
- **Blood flow:**
- **Artery cut** → spurting, high-pressure jets
- **Vein cut** → slow, steady flow

Venous Valves

- **Structure:**
- Formed by **folds of tunica intima**
- Reinforced with connective tissue
- Semilunar cusps with concavity **toward the heart**
- **Location:**
- **Abundant in limb veins**, especially lower limbs
- **Absent** in:
  - Very small veins, Very large veins, Thorax & abdominal veins

Venules

- **Definition:**
- The **smallest veins**, formed by the union of capillaries.
- **Functions:**
- Begin venous return pathway
- Participate in **exchange** (especially post-capillary venules)
- Important in:
  - Inflammation
  - White cell migration