

# Introduction to Cardiovascular System

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## Introduction to Cardiovascular System

### Introduction

# HUMAN C

Internal Jugular Vein

External Jugular Vein

Subclavian Vein

Superior Vena Cava

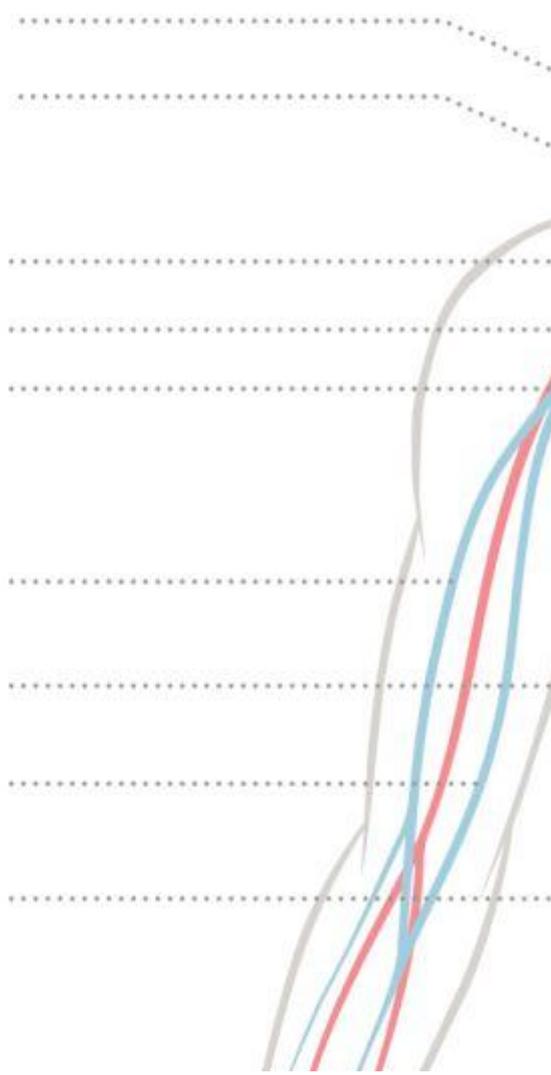
Pulmonary Artery

Cephalic Vein

Inferior Vena Cava

Basilic Vein

Renal Vein



# Circ

## PULMONARY CIRCULATION

Pulmonar  
artery

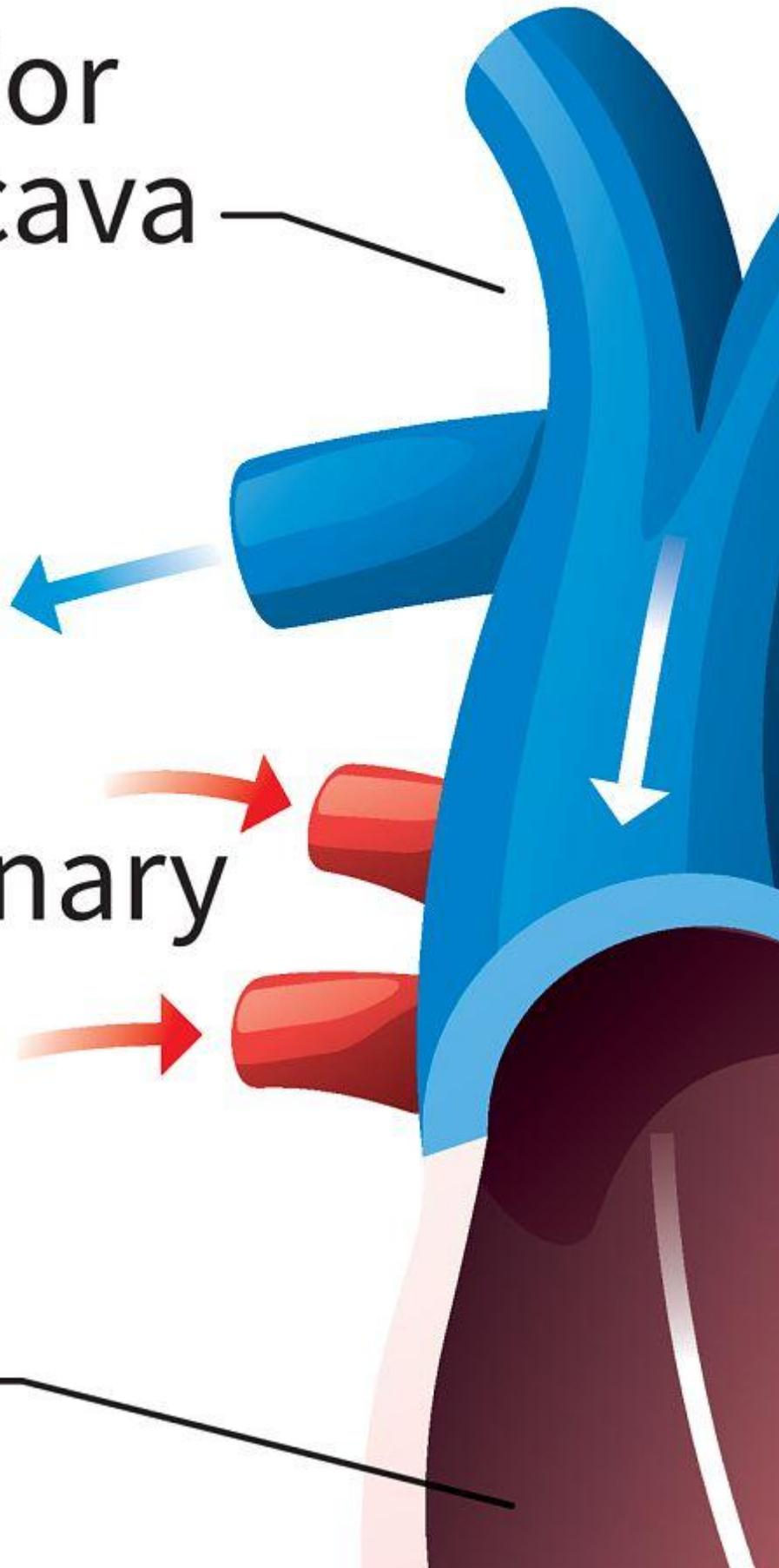
Vena

cava

superior  
vena cava

pulmonary  
vein

right  
atrium



- **Definition of cardiovascular system**

- The **cardiovascular system**, also known as the **circulatory system**, is the system responsible for **transport of blood, nutrients, gases, hormones, and metabolic waste throughout the body**.

- **Components of the system**

- **Heart**

- The **heart** is a muscular pumping organ that **maintains blood circulation by rhythmic contraction**.

- **Blood vessels**

- Blood vessels form a **network of tubes through which blood circulates**.

- These include **arteries, arterioles, capillaries, venules, and veins**.

- **Blood**

- **Blood** is the circulating fluid that transports **oxygen, nutrients, hormones, and waste products** between different tissues.

- **Functions of cardiovascular system**

- Transport of **oxygen from lungs to tissues** and **carbon dioxide from tissues to lungs**.

- Delivery of **nutrients and hormones to body cells**.

- Removal of **metabolic waste products**.

- Regulation of **body temperature, pH, and fluid balance**.

- **Pulmonary circulation**

- Pulmonary circulation refers to the **movement of blood between the heart and lungs**.

- Deoxygenated blood from the **right ventricle travels to the lungs**, where it becomes oxygenated and returns to the **left atrium**.

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- **Systemic circulation**

- Systemic circulation involves **transport of oxygenated blood from the left ventricle to all parts of the body**.

- After delivering oxygen and nutrients, deoxygenated blood returns to the **right atrium of the heart**.

- **Role in homeostasis**

- The cardiovascular system helps maintain **internal stability (homeostasis)** by regulating **blood pressure, temperature, electrolyte balance, and distribution of nutrients and oxygen**.

- **Clinical relevance**

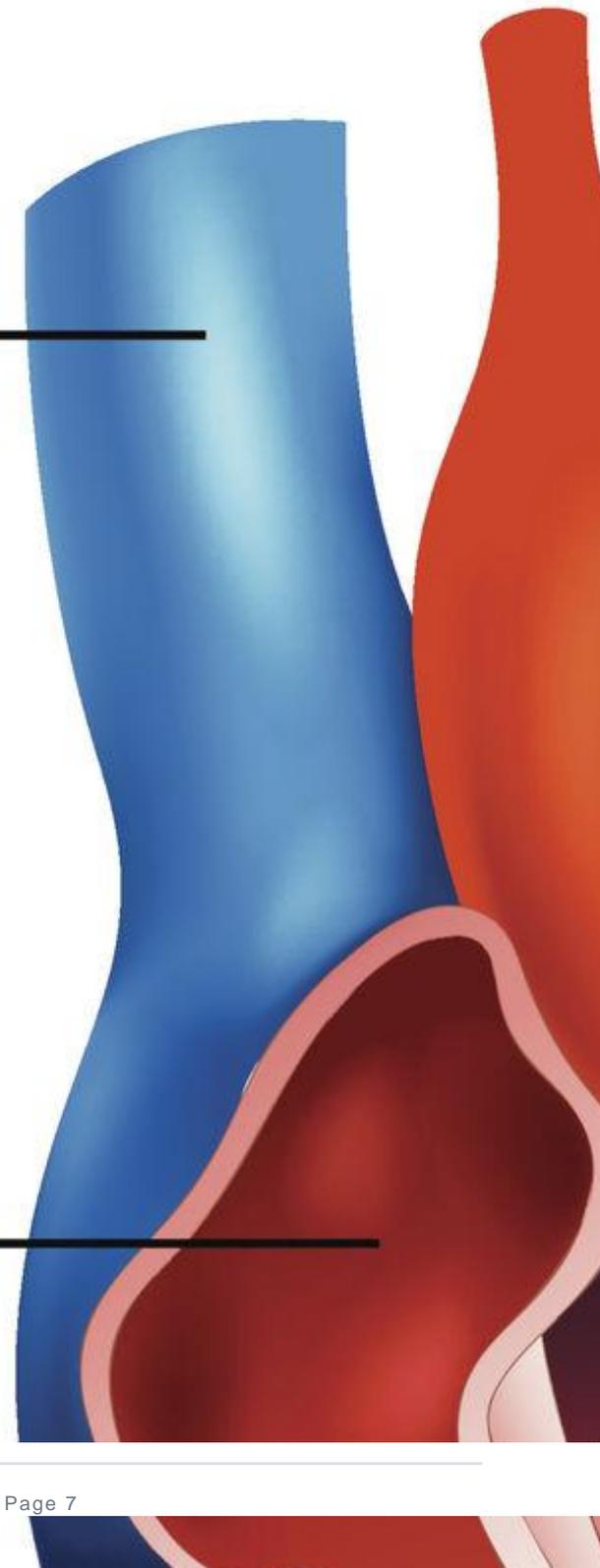
- Disorders of the cardiovascular system include **hypertension, coronary artery disease, heart failure, and stroke**, which can significantly affect body function and survival.

## Anatomical Considerations of the Heart

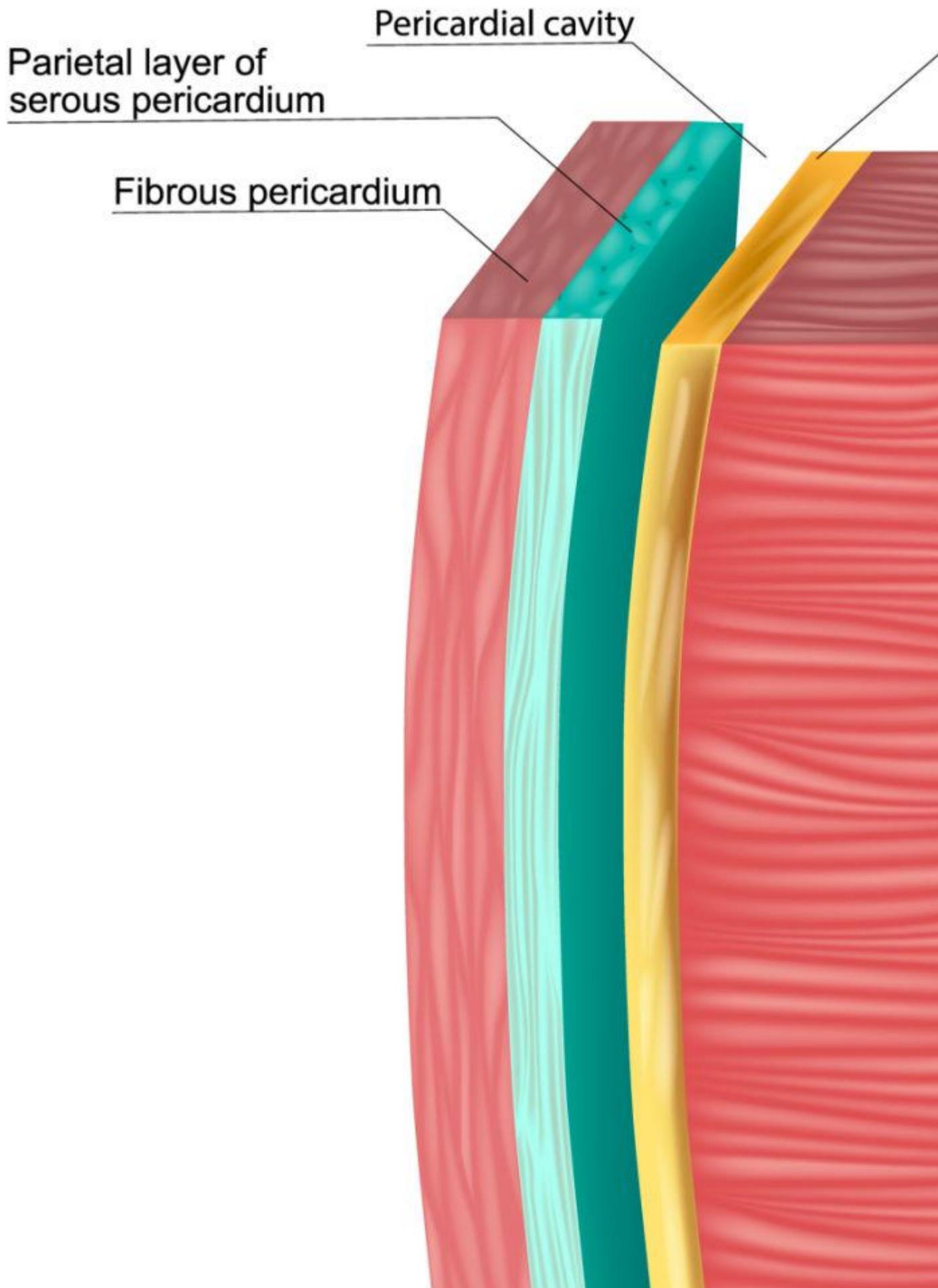
# Anatomy of

superior  
vena cava

right atrium



# Heart Po



- **Location of the heart in thoracic cavity**

- The heart is located in the **thoracic cavity between the lungs**.
- It lies behind the **sternum and above the diaphragm**.

- **Position in mediastinum**

- The heart is situated in the **middle mediastinum**, a central compartment of the thoracic cavity.
- About **two-thirds of the heart lies to the left of the midline** and one-third to the right.

- **Coverings of the heart (pericardium)**

- The heart is enclosed within a **double-walled sac called the pericardium**.
- The pericardium consists of:
  - **Fibrous pericardium** – outer tough protective layer.
  - **Serous pericardium** – inner layer with **parietal and visceral layers**.
- The **pericardial cavity between these layers contains pericardial fluid**, reducing friction during heart movements.

- **Chambers of the heart**

- The heart contains **four chambers** that regulate blood flow.

- **Right atrium**

- Receives **deoxygenated blood from the body through the superior and inferior vena cava**

- **Right ventricle**

- Pumps deoxygenated blood to the **lungs through the pulmonary artery**.

- **Left atrium**

- Receives **oxygenated blood from the lungs through the pulmonary veins**

- **Left ventricle**

- Pumps oxygenated blood to the **entire body through the aorta**.

- **Septa separating chambers**

- The chambers are separated by **muscular partitions called septa**.
- **Interatrial septum** separates the atria.
- **Interventricular septum** separates the ventricles.

- **Great vessels connected to heart**

- Major blood vessels connected to the heart include:
  - **Superior vena cava**
  - **Inferior vena cava**
  - **Pulmonary artery**
  - **Pulmonary veins**
  - **Aorta**.

- **Blood flow pathway through heart**

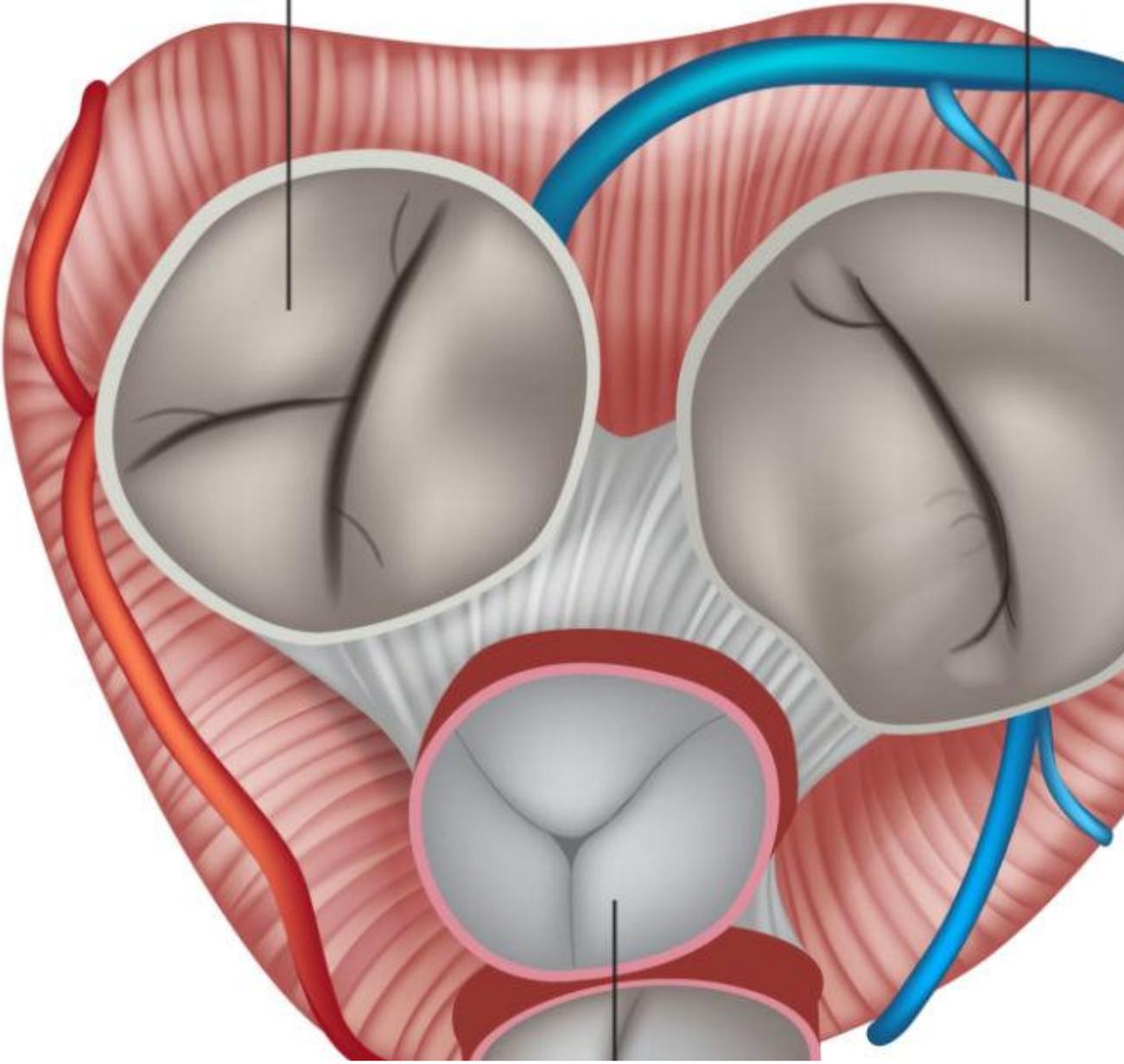
- Blood flows through the heart in the following sequence:

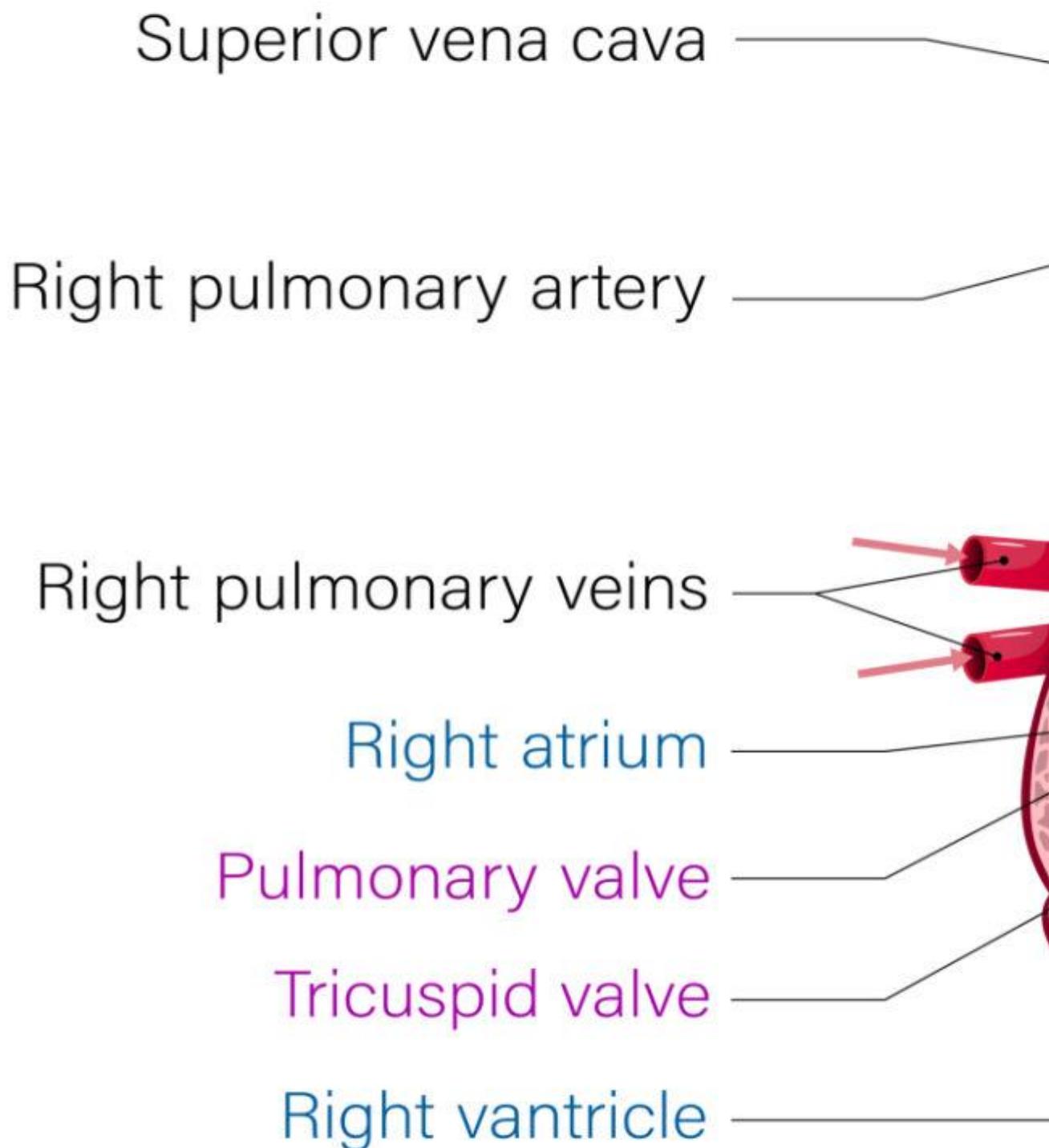
• **Body ? Right atrium ? Right ventricle ? Pulmonary artery ? Lungs ? Pulmonary veins ? Left atrium ? Left ventricle ? Aorta ? Body.**



Tricuspid valve

Mitral valve

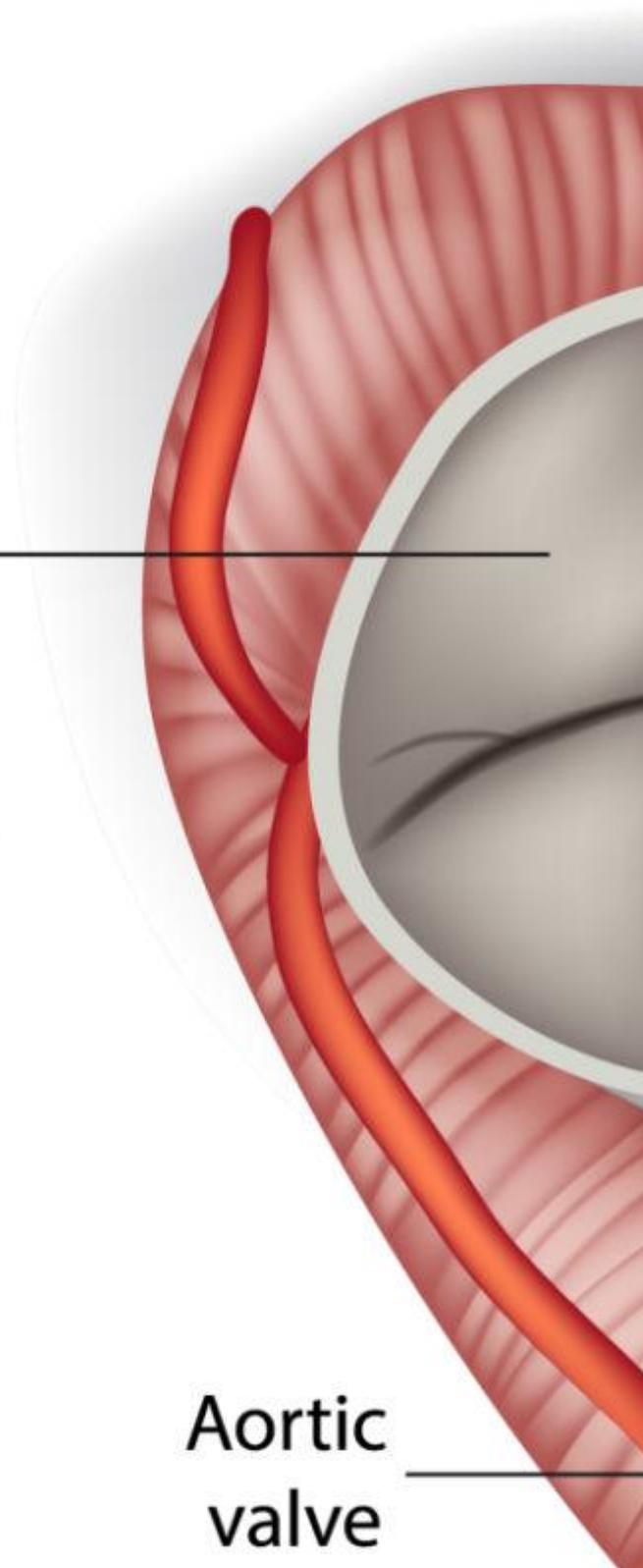




# Right side of heart

Tricuspid  
valve

Aortic  
valve



- **Function of cardiac valves**

- Cardiac valves ensure **one-way flow of blood through the heart chambers**.
- They **open and close according to pressure differences between chambers and vessels**
- Their main function is to **prevent backward flow of blood during the cardiac cycle**.

- **Atrioventricular valves**

- Atrioventricular (AV) valves are located **between the atria and ventricles**.
- They allow blood to **flow from atria to ventricles during ventricular filling**

- **Tricuspid valve**

- The **tricuspid valve** lies between the **right atrium and right ventricle**.
- It has **three cusps (leaflets)** and prevents backflow of blood into the **right atrium during ventricular contraction**.

- **Mitral (bicuspid) valve**

- The **mitral valve** is located between the **left atrium and left ventricle**.
- It has **two cusps** and prevents backflow of blood into the **left atrium during ventricular systole**.

- **Semilunar valves**

- Semilunar valves are located **at the exits of the ventricles where blood leaves the heart**

- **Pulmonary valve**

- The **pulmonary valve** is present between the **right ventricle and pulmonary artery**.
- It prevents **backflow of blood from the pulmonary artery into the right ventricle**

- **Aortic valve**

- The **aortic valve** lies between the **left ventricle and the aorta**.
- It prevents **backflow of blood from the aorta into the left ventricle**

- **Structure of valves**

- Cardiac valves are composed of **fibrous connective tissue covered by endocardium**.
- Atrioventricular valves are supported by **chordae tendineae and papillary muscles**, which prevent valve prolapse during ventricular contraction.

- **Prevention of backflow**

- During ventricular contraction, the valves **close tightly to prevent regurgitation of blood**.
- This mechanism maintains **efficient forward flow of blood through the circulatory system**

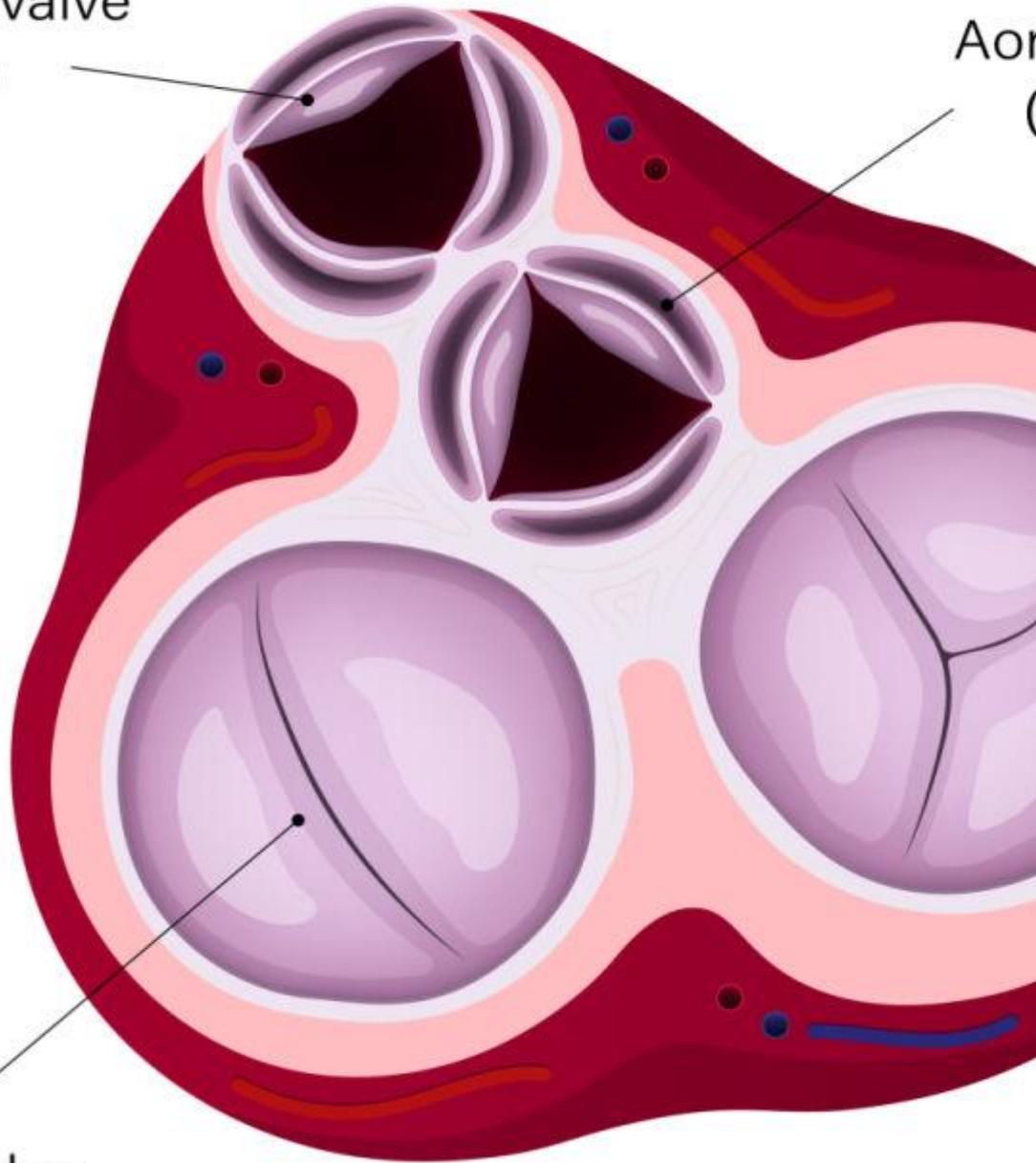
## Action of the Valves

# Systole

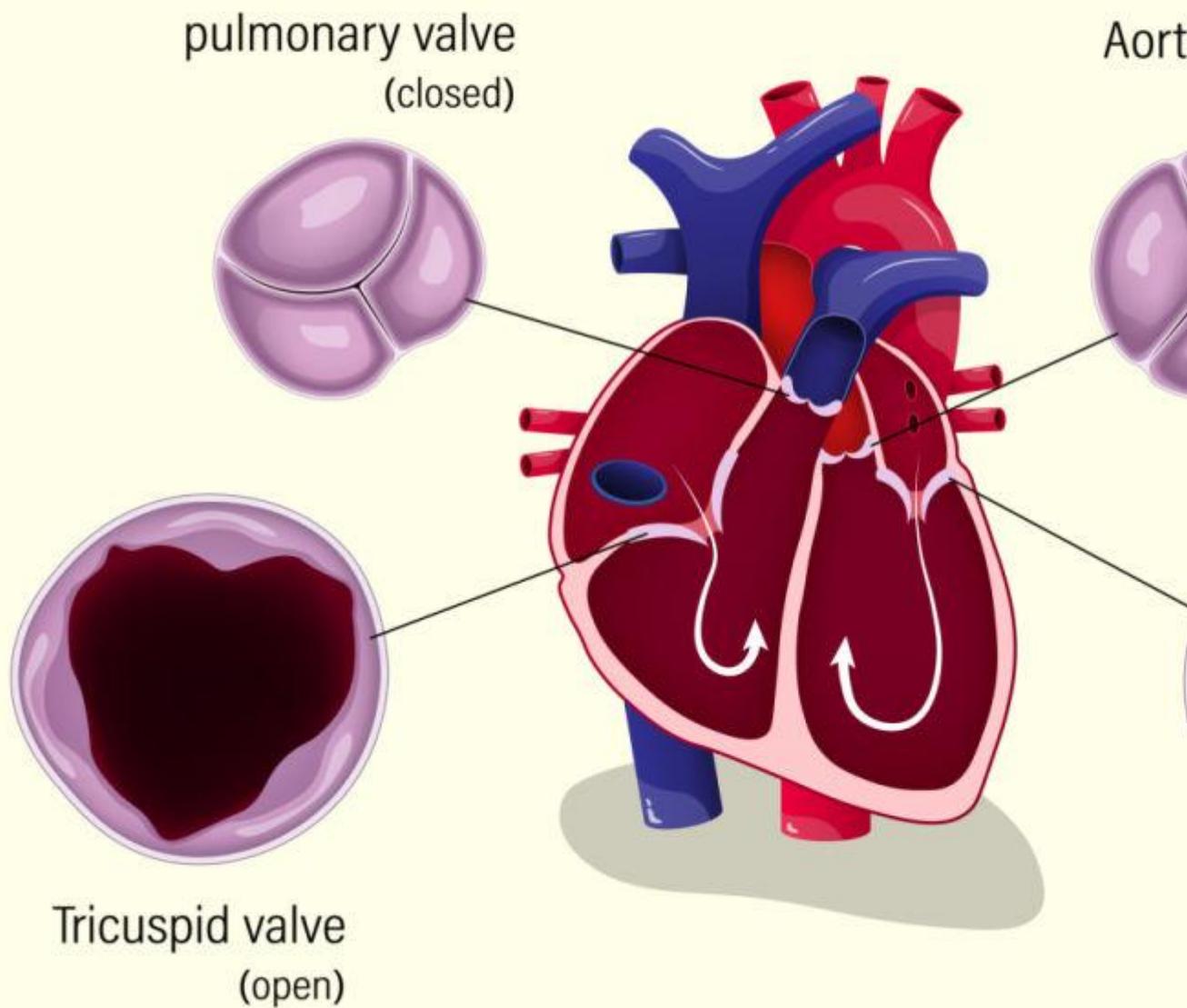
Pulmonary valve  
(open)

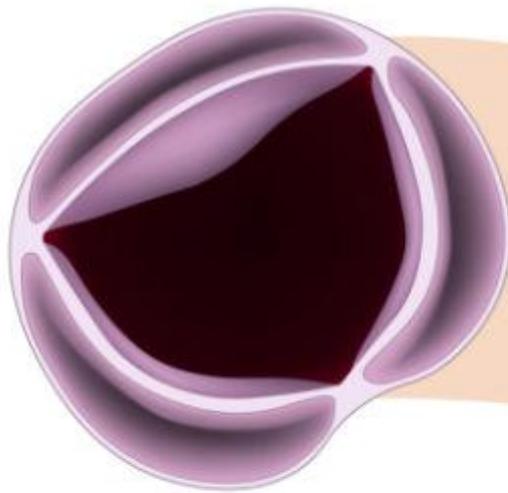
Aorta  
(closed)

Mitral valve  
(closed)

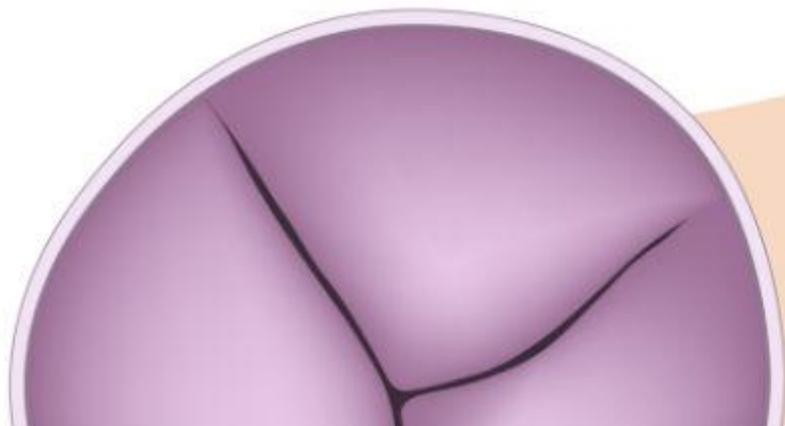


# Ventricular diastole



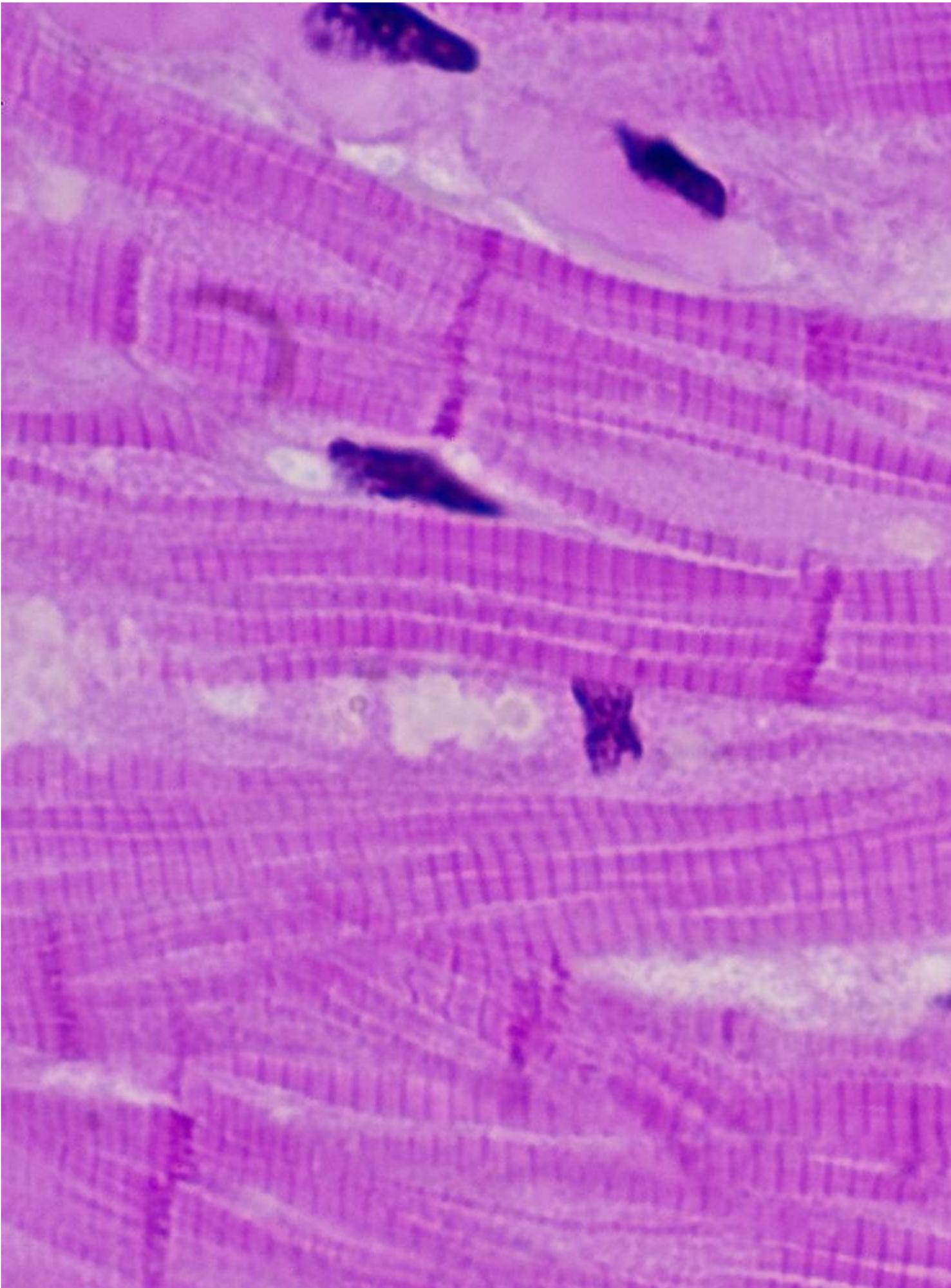


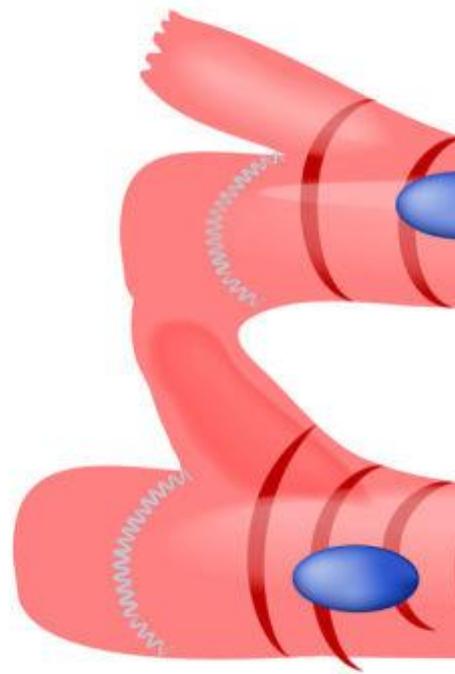
# Pulmonary valve (Open)



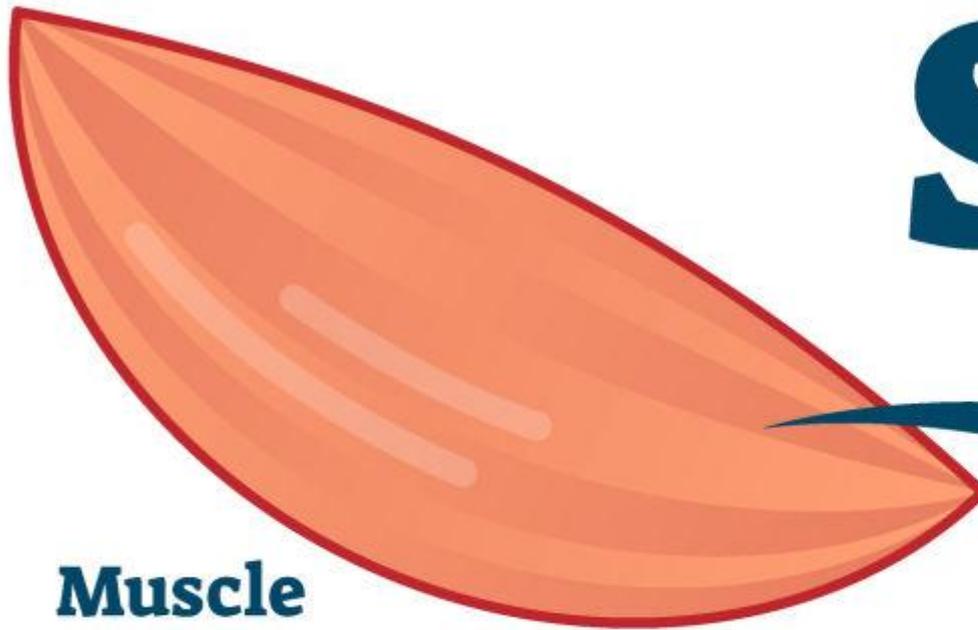
- **Opening and closing during cardiac cycle**
- Cardiac valves **open and close rhythmically during the cardiac cycle**
- Their movement ensures that **blood flows in the correct direction through the heart chambers and great vessels**
  
- **Pressure differences controlling valve movement**
- The opening and closing of valves are controlled by **pressure differences between adjacent chambers and vessels**
- When **pressure behind a valve exceeds the pressure ahead**, the valve **opens**.
- When the **pressure ahead becomes greater**, the valve **closes**.
  
- **Valve closure producing heart sounds**
- Closure of the valves produces the **normal heart sounds heard during auscultation**.
- **First heart sound (S1)** occurs due to **closure of atrioventricular valves (mitral and tricuspid)**.
- **Second heart sound (S2)** occurs due to **closure of semilunar valves (aortic and pulmonary)**.
  
- **Coordination with ventricular contraction**
- During **ventricular systole**, the **atrioventricular valves close** and the **semilunar valves open**, allowing blood to be ejected from the ventricles.
- During **ventricular diastole**, the **semilunar valves close** and the **atrioventricular valves open**, allowing blood to fill the ventricles.
  
- **Importance in maintaining unidirectional blood flow**
- Proper functioning of the valves ensures **unidirectional flow of blood through the heart and circulation**
- Valve dysfunction can lead to **regurgitation or stenosis**, impairing efficient cardiac function.



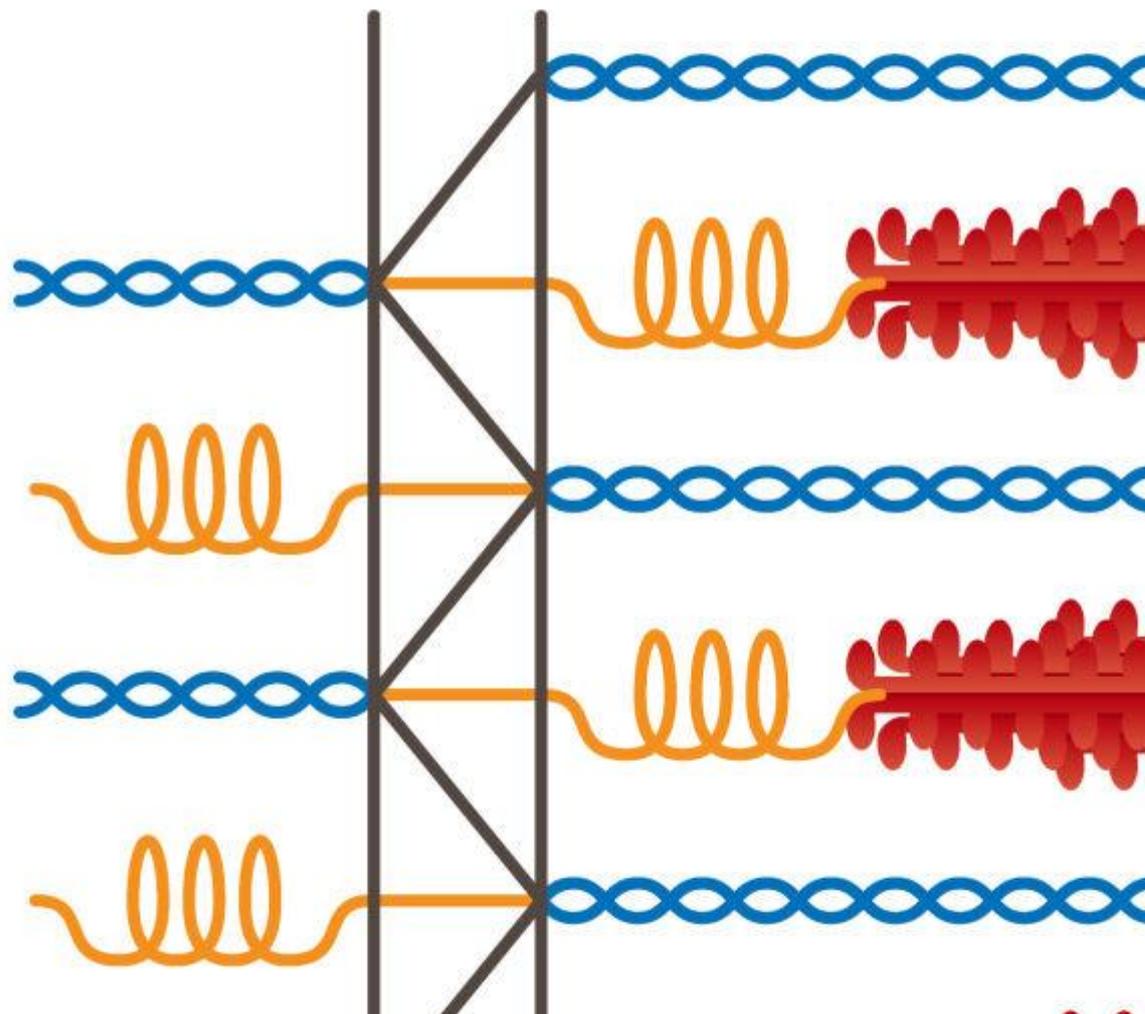




# SAR



**Muscle**



- **Cardiac muscle fibre structure**

- Cardiac muscle fibres are **short, cylindrical cells that branch and interconnect with neighboring fibres**
- These interconnected cells form a **network within the myocardium**.

- **Striated appearance**

- Cardiac muscle shows **alternating dark and light bands (striations)** due to the **regular arrangement of actin and myosin filaments within sarcomeres**.

- **Branching fibres**

- Unlike skeletal muscle, cardiac muscle fibres **branch and join with adjacent cells**, allowing efficient spread of electrical impulses.

- **Single central nucleus**

- Each cardiac muscle cell usually contains **one centrally located nucleus**, though occasionally two nuclei may be present.

- **Intercalated discs**

- Adjacent cardiac muscle cells are connected by **intercalated discs**, which contain **desmosomes, fascia adherens, and gap junctions**.
- These structures provide **mechanical strength and rapid electrical conduction between cells**

- **Abundant mitochondria**

- Cardiac muscle fibres contain **large numbers of mitochondria**, supplying the ATP required for **continuous rhythmic contraction of the heart**.

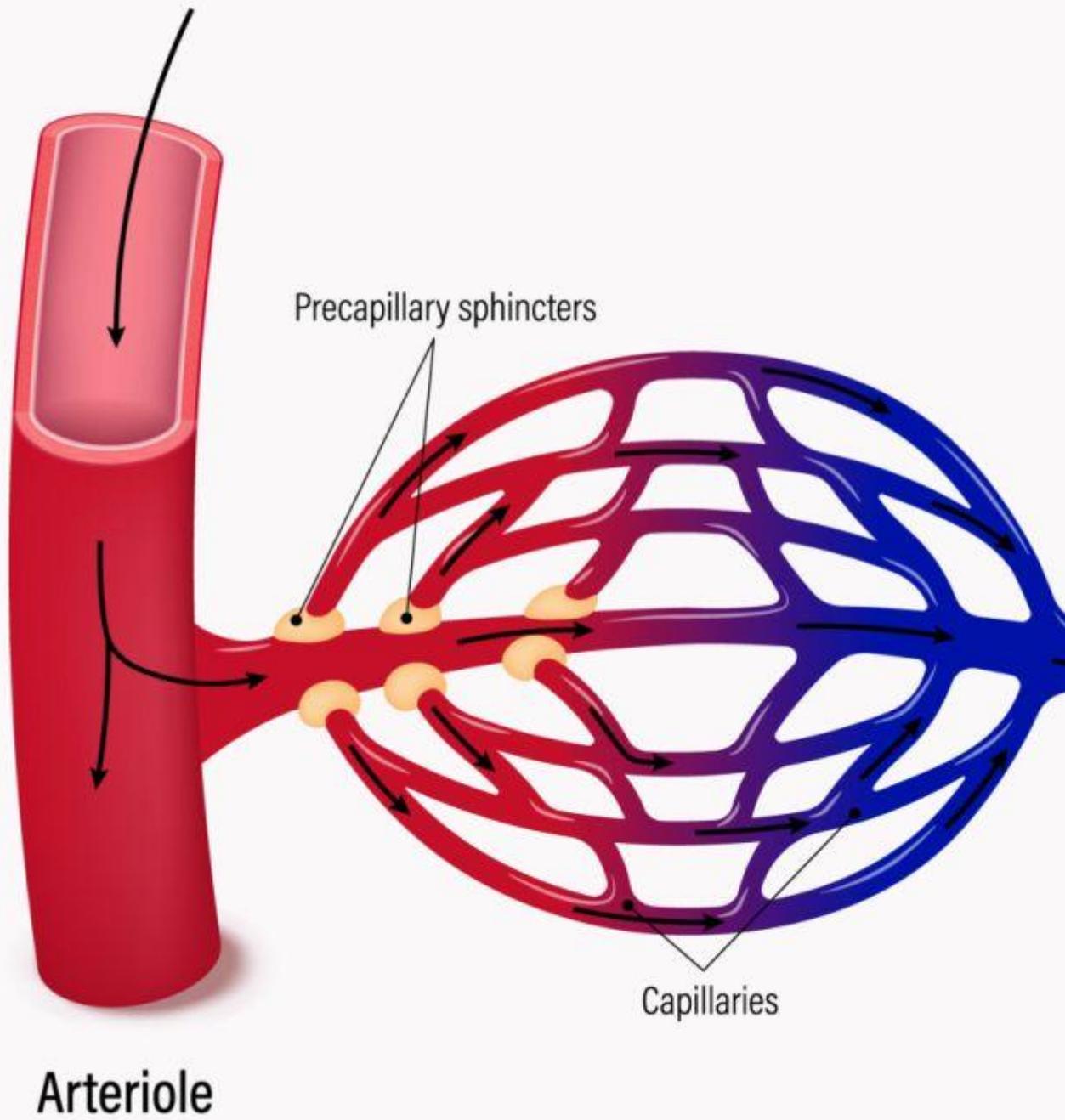
- **Sarcomere organization**

- Myofibrils in cardiac muscle are arranged in **sarcomeres**, which act as the **functional units responsible for contraction**.
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## Sphincters relaxed



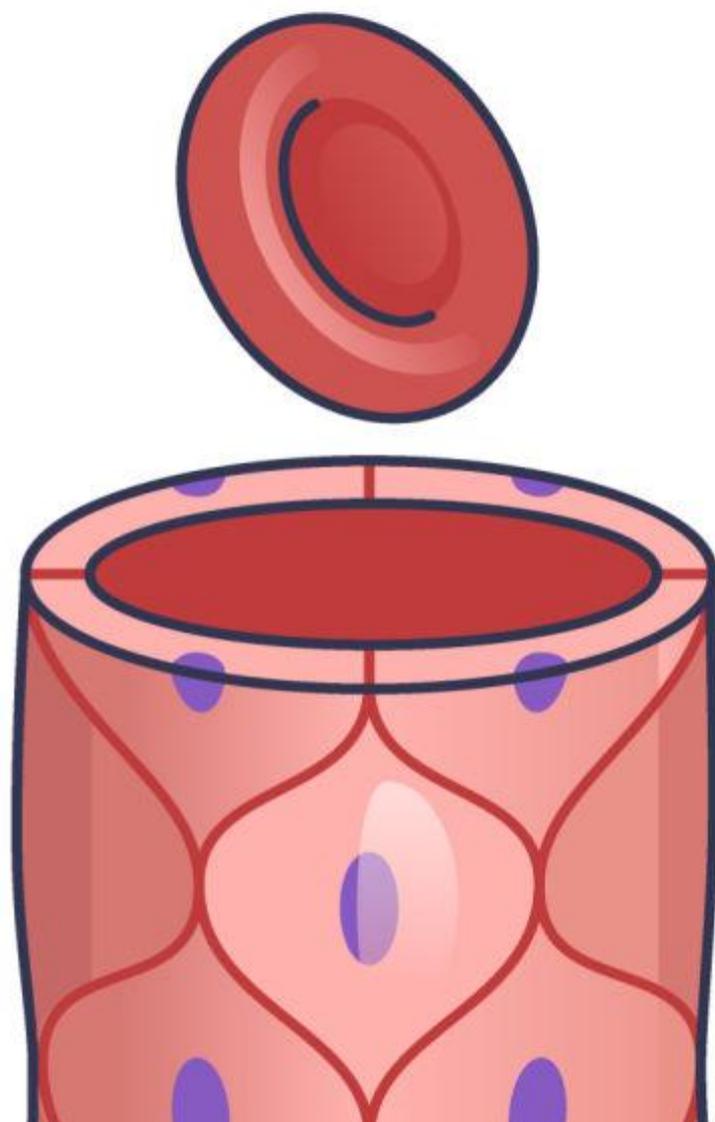


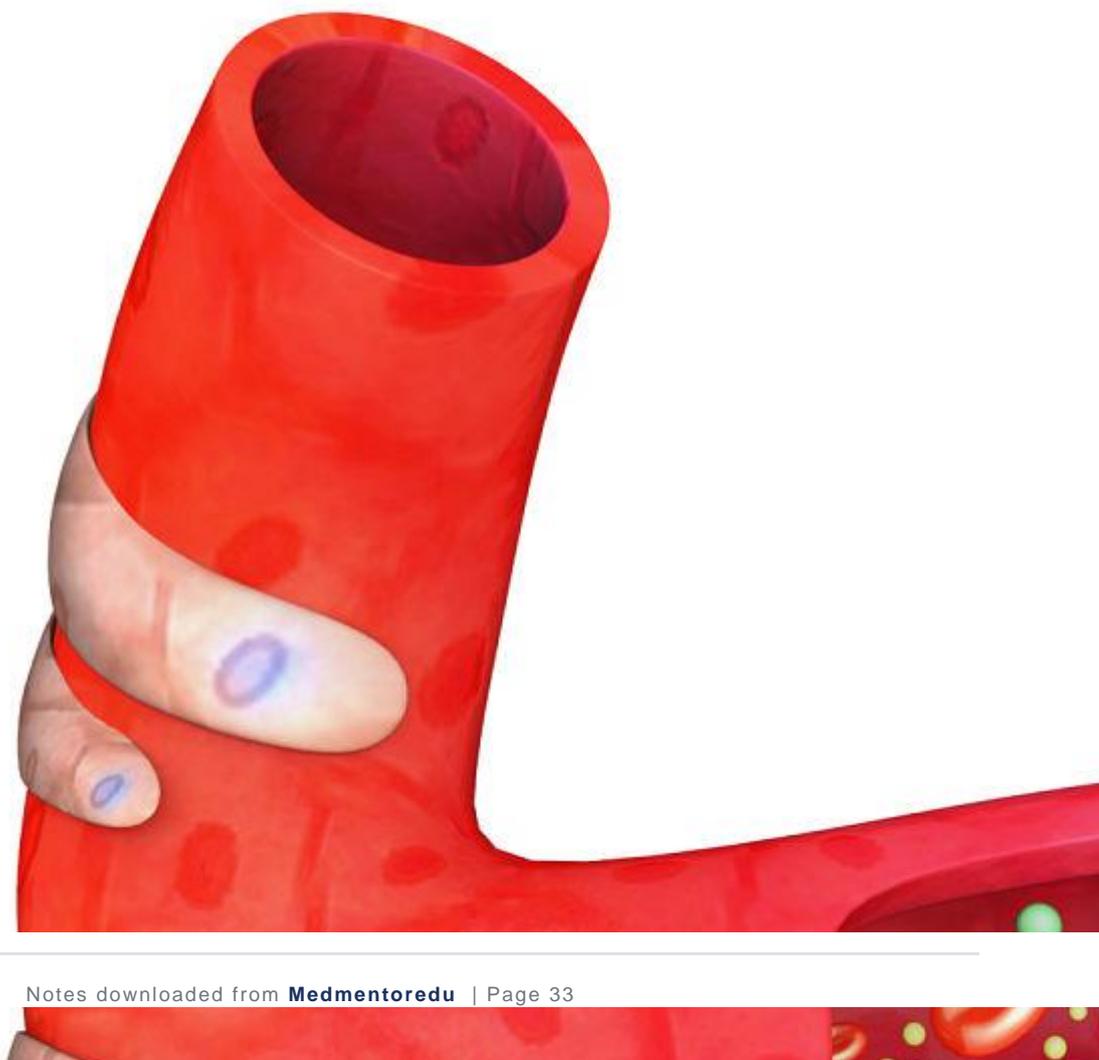
- **Small branches of arteries**
- **Arterioles** are the **small branches of arteries that lead to capillary networks**.
- **Thick smooth muscle layer**
- The walls of arterioles contain a **relatively thick layer of smooth muscle in the tunica media**.
- This muscular layer allows **active regulation of vessel diameter**.
- **Major resistance vessels**
- Arterioles are known as the **major resistance vessels of the circulatory system**.
- Changes in their diameter significantly influence **peripheral resistance to blood flow**.
- **Regulation of blood flow to tissues**
- By **constricting or dilating**, arterioles regulate the **amount of blood reaching different tissues according to metabolic needs**.
- **Role in blood pressure regulation**
- Because they control **peripheral vascular resistance**, arterioles play a major role in **maintaining and regulating systemic blood pressure**.

## Capillaries

<https://www.researchgate.net/publication/344437228/figure/fig4/AS%3A941675811700738%401601524417435/capillary-structure-and-ex>

# CAP





- **Smallest blood vessels**

- Capillaries are the **smallest blood vessels in the circulatory system**.
- They connect **arterioles to venules**, forming an extensive capillary network within tissues.

- **Single endothelial cell layer**

- The wall of a capillary consists of **a single layer of endothelial cells resting on a basement membrane**.
- This thin structure facilitates **efficient exchange of substances between blood and tissues**.

- **Site of exchange between blood and tissues**

- Capillaries are the **primary sites where exchange of oxygen, nutrients, carbon dioxide, and metabolic waste occurs** between blood and body tissues.

- **Types of capillaries**

- **Continuous capillaries**

- These capillaries have a **continuous endothelial lining with small intercellular clefts**.
- They are found in **muscles, skin, lungs, and the central nervous system**.

- **Fenestrated capillaries**

- Fenestrated capillaries contain **small pores (fenestrations) in the endothelial cells**.
- These pores allow **rapid exchange of fluids and small molecules**.
- They are commonly found in **kidneys, endocrine glands, and intestines**.

- **Sinusoidal capillaries**

- Sinusoidal capillaries have **large openings and discontinuous endothelial lining** allowing passage of larger molecules and cells.

- **Diffusion and filtration functions**

- Exchange across capillaries occurs mainly through **diffusion, filtration, and osmosis**.
- These processes maintain **nutrient supply and waste removal in tissues**.

## Sinusoids

<https://www.researchgate.net/publication/375774441/figure/fig6/AS%3A11431281224633089%401708354953571/Schematic-of-the-bone->

<https://www.researchgate.net/publication/346826821/figure/fig6/AS%3A11431281255819937%401719439815333/Structure-of-liver-sinusoids>

<https://www.researchgate.net/publication/333645988/figure/fig1/AS%3A856343405670404%401581179586732/Schematic-of-the-hepatic-sinusoids>

- **Specialized capillaries**

- **Sinusoids** are a specialized type of **capillary with unique structural features that allow extensive exchange between blood and surrounding tissues**.

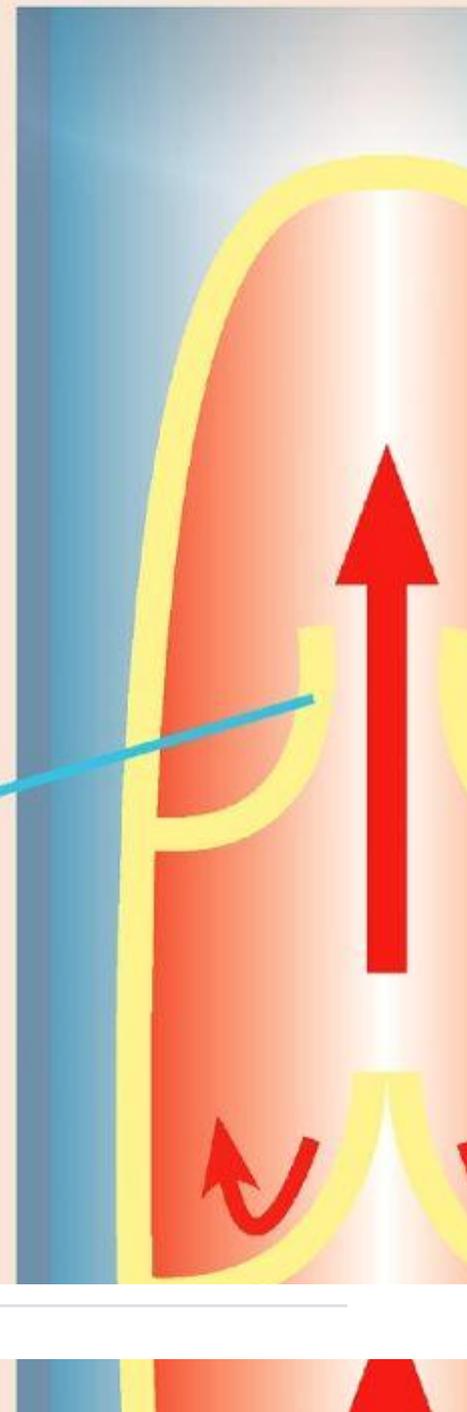
- **Larger lumen and discontinuous endothelium**
- They possess a **large irregular lumen** and **discontinuous endothelial lining with wide gaps**.
- The basement membrane may also be **incomplete or absent**.
  
- **Slower blood flow**
- Blood flow through sinusoids is **slower compared to normal capillaries**, allowing **greater time for exchange of substances**.
  
- **Found in liver, spleen, bone marrow**
- Sinusoids are commonly present in **organs involved in filtration and blood cell production**, such as the **liver, spleen, and bone marrow**.
  
- **Facilitate exchange of large molecules**
- Due to their large openings, sinusoids permit **passage of large plasma proteins, cells, and other macromolecules between blood and tissues**.
- This property is essential for **functions like detoxification in the liver and blood cell formation in bone marrow**.

## Valves of the Veins

# STR NORMAL

Normal  
open valve

Normal





4

- **Structure of venous valves**
  - Venous valves are **thin flap-like structures present inside many veins**.
  - They project into the lumen and usually occur as **paired cusps**.
  
  - **Formed by folds of endothelium**
  - These valves are formed by **folds of the tunica intima (endothelial lining of the vein)** reinforced by connective tissue.
  
  - **Prevent backflow of blood**
  - Venous valves allow **blood to flow only toward the heart**.
  - When blood tends to flow backward, the **valve cusps close and prevent regurgitation**.
  
  - **Important in venous return**
  - Valves assist the **return of blood to the heart**, especially against gravity.
  - They work together with **skeletal muscle contraction (muscle pump)** to facilitate venous return.
  
  - **More prominent in lower limb veins**
  - Venous valves are particularly **well developed in veins of the lower limbs**, where blood must travel upward toward the heart against gravity.
- 

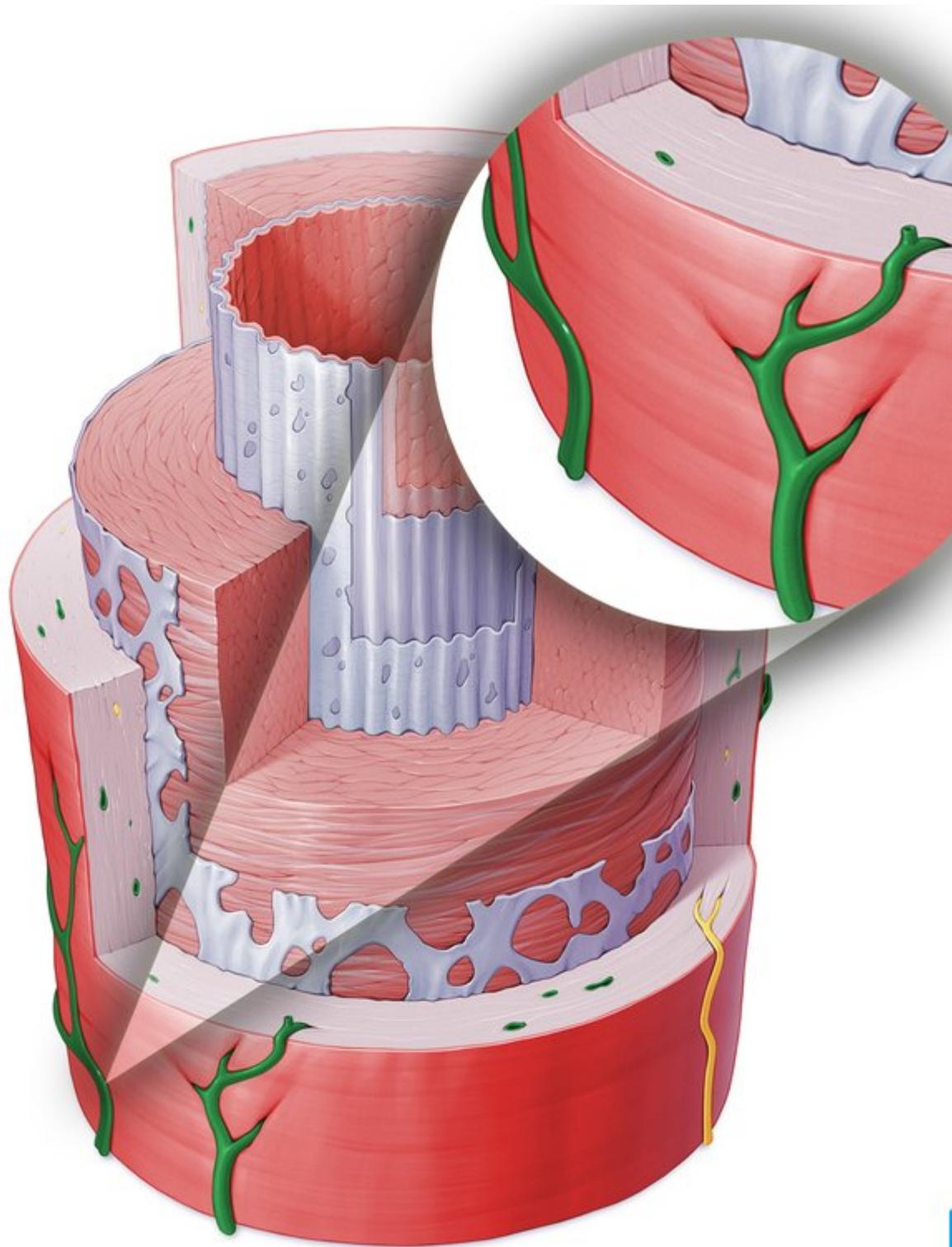
## Blood Vessels (Vasa Vasorum)

# **Tunica intima**

Endothelium

Subendothelial layer

Internal elastic lamina



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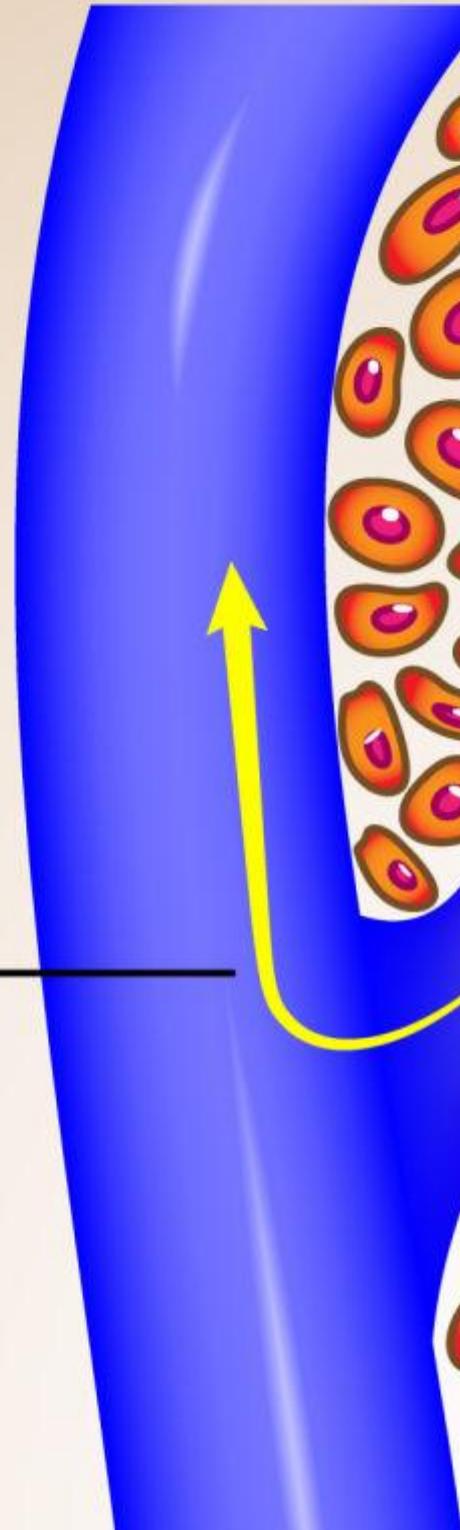
- **Definition**
- **Vasa vasorum** are small blood vessels that **supply the walls of large arteries and veins.**

- **Small vessels supplying large arteries and veins**
- Large blood vessels have **thick walls that cannot receive sufficient nutrients directly from the blood flowing through the lumen.**
- Therefore, the **vasa vasorum provide an additional blood supply to the vessel wall**
  
- **Provide nutrients to vessel walls**
- These vessels deliver **oxygen and nutrients to the outer layers of the blood vessel wall** and help remove metabolic waste.
  
- **Located in outer layers of vessel**
- Vasa vasorum are mainly located in the **tunica adventitia and outer part of the tunica media** of large arteries and veins.
  
- **Important in large vessel physiology**
- They play an important role in **maintaining the health and function of large blood vessels.**
- Damage or dysfunction of the vasa vasorum may contribute to **vascular diseases such as atherosclerosis.**



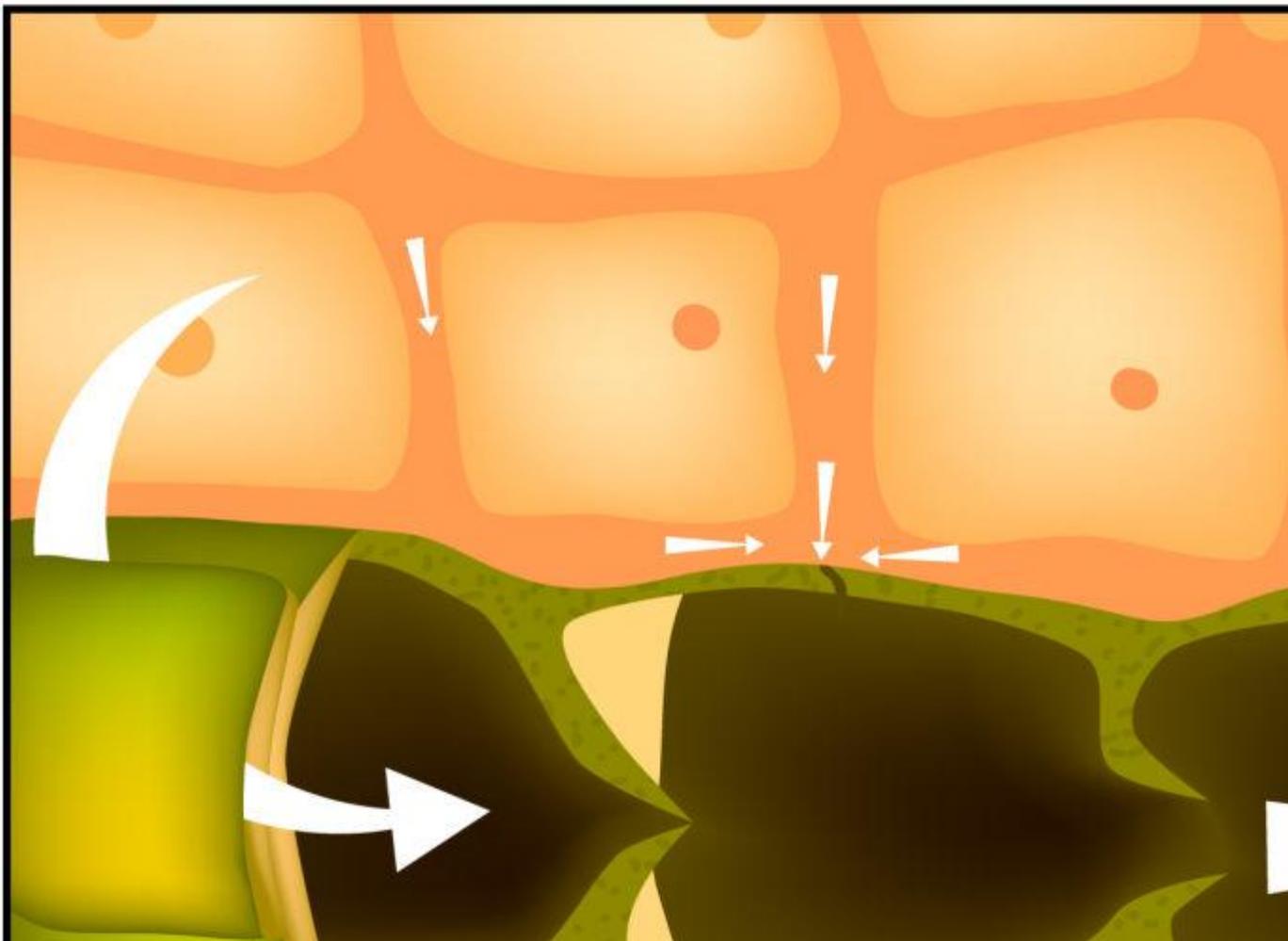
Tiss

Venule



# The Lymphatic System

## Lymphatic vessel





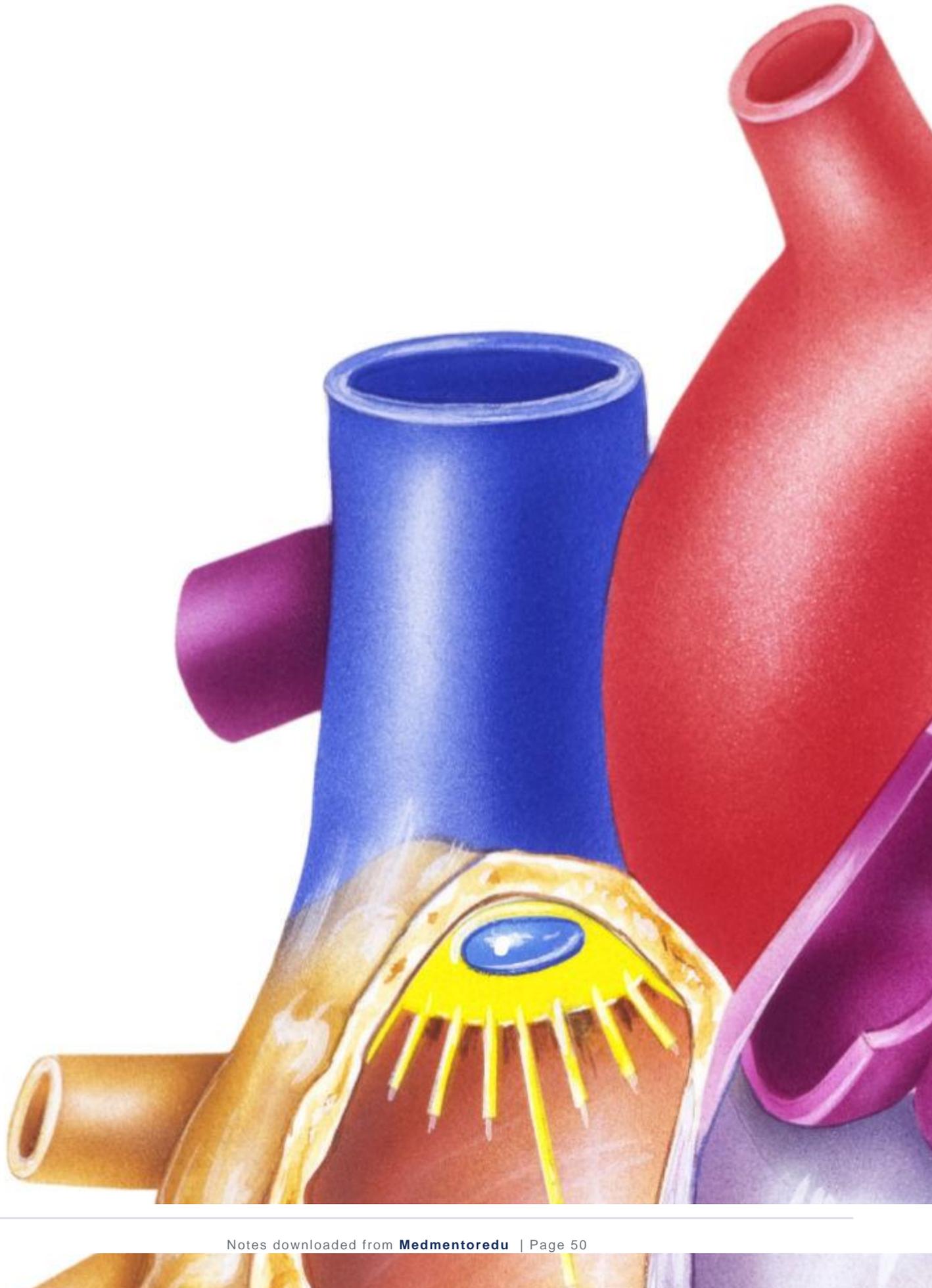
- **Presence of lymphatic vessels in vessel walls**
- Small **lymphatic vessels are present in the outer layers of large blood vessels**, particularly in the **tunica adventitia**.
- These lymphatics accompany the **vasa vasorum and connective tissue surrounding the vessels**
  
- **Drainage of excess fluid from vessel tissues**
- Lymphatic vessels help **remove excess interstitial fluid from the tissues of the vessel wall**
- This prevents **fluid accumulation and maintains proper tissue environment**
  
- **Role in immune defense**
- Lymphatics transport **immune cells such as lymphocytes and macrophages**.
- They also carry **antigens and foreign particles to lymph nodes**, contributing to the **body's immune response**.
  
- **Maintenance of tissue fluid balance**
- By draining excess interstitial fluid and returning it to the circulation, lymphatic vessels help **maintain tissue fluid balance and normal vascular function**.

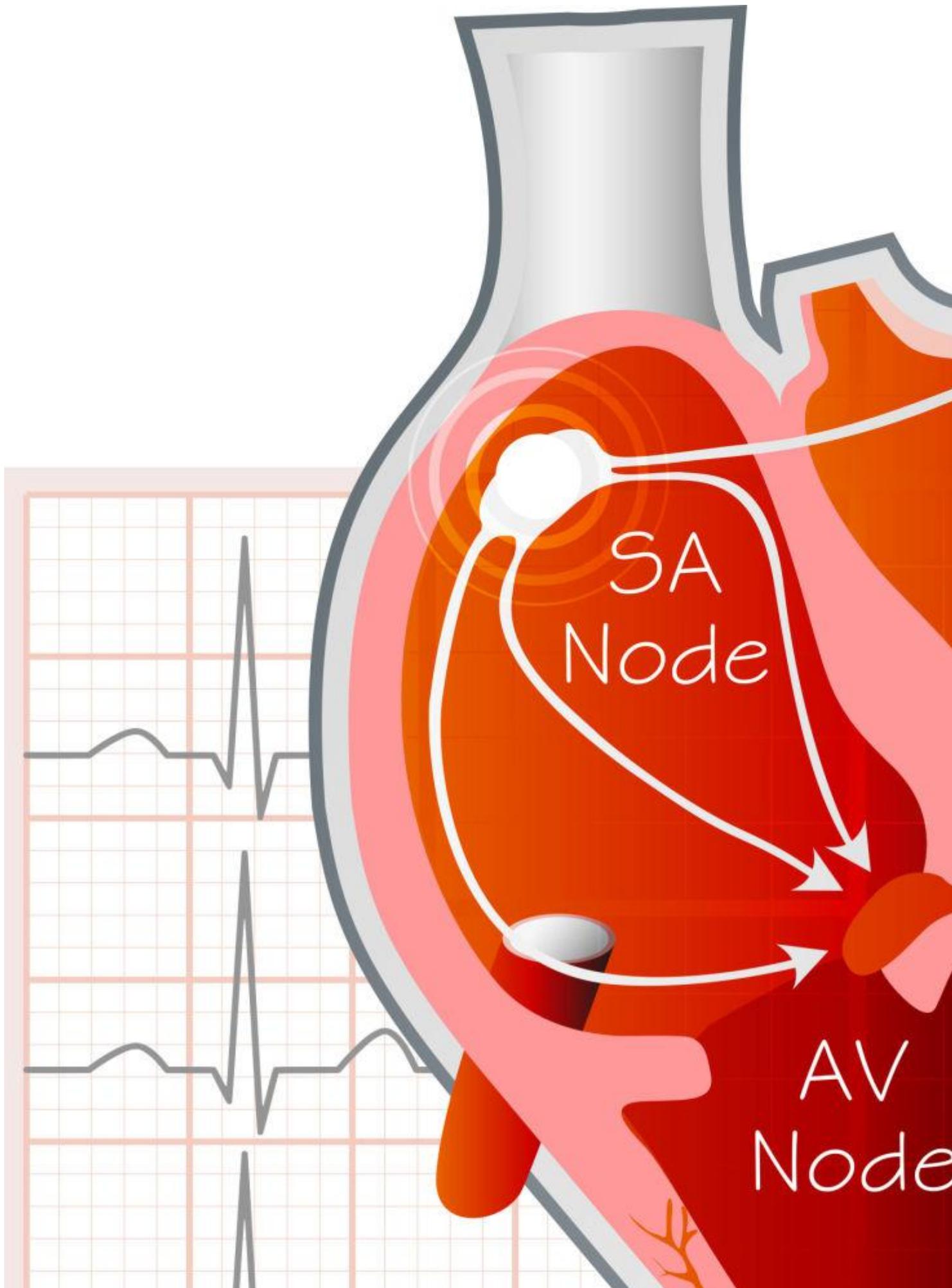


Sinoatrial Node

Atrioventricular Node







- **Specialized cardiac conduction system**

- The heart contains a **specialized system of modified cardiac muscle fibres known as junctional or conduction tissues**
- These tissues are responsible for **generation and conduction of electrical impulses throughout the heart**

- **Responsible for generation and conduction of impulses**

- The conduction system produces **spontaneous electrical impulses** and transmits them rapidly through the myocardium.

- **Coordinates rhythmic contraction of heart**

- This system ensures **coordinated contraction of atria and ventricles**, allowing efficient pumping of blood.

- **Components of conduction system**

- The cardiac conduction system includes:

- **Sinoatrial (SA) node**

- **Atrioventricular (AV) node**

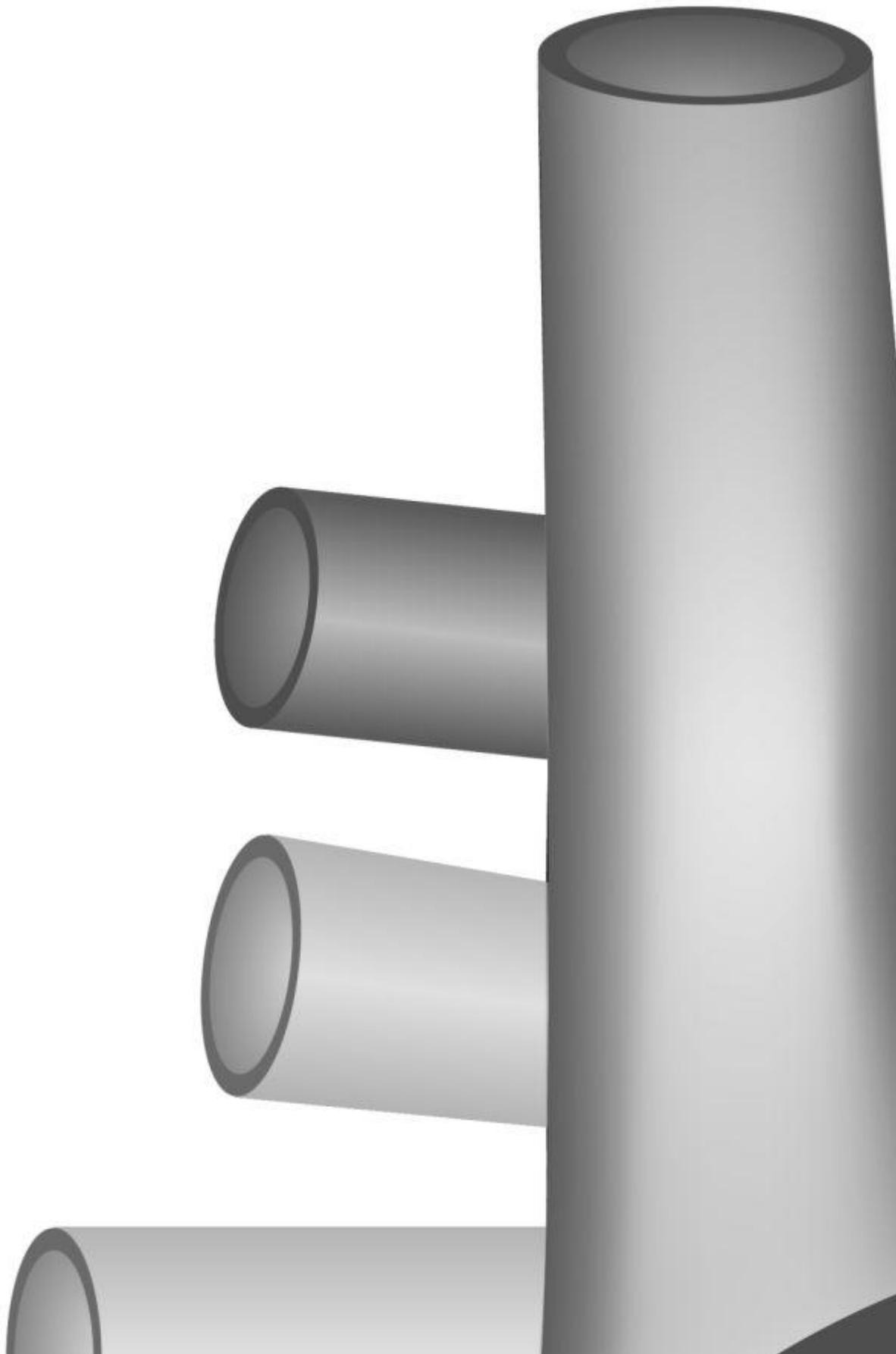
- **Bundle of His**

- **Right and left bundle branches**

- **Purkinje fibres.**

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## Sino-atrial (SA) Node





Frontal plane  
through heart

Sinoatrial  
(SA) node

Anterior internodal

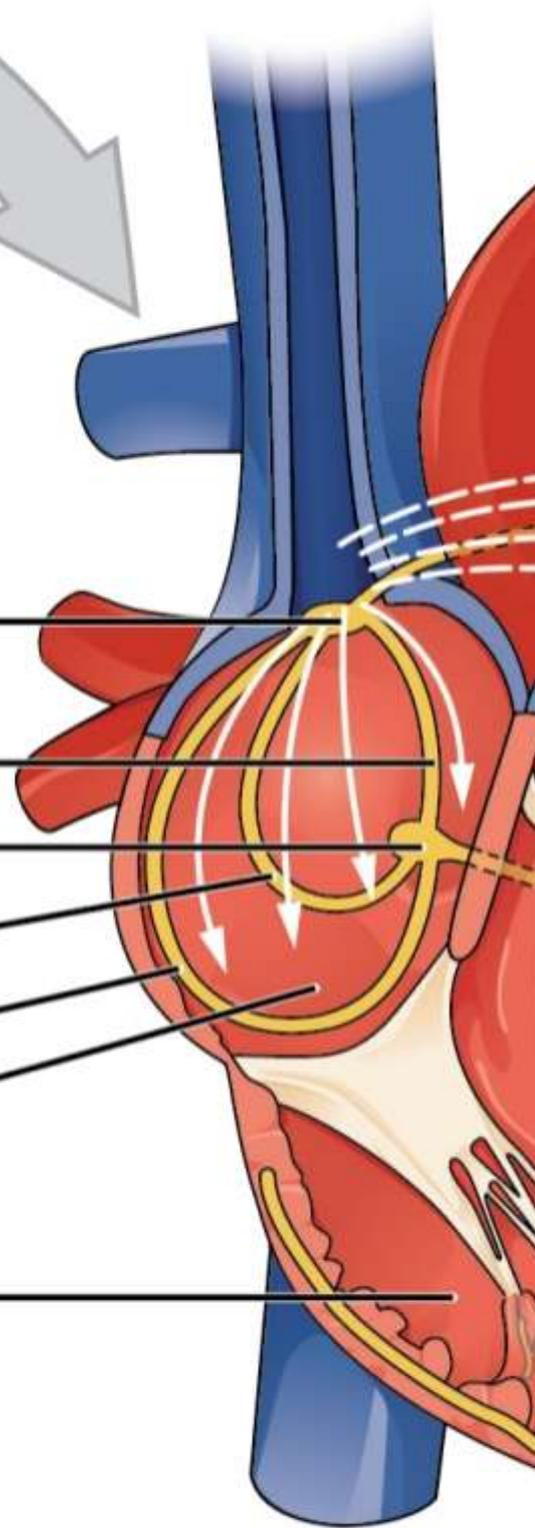
Atrioventricular  
(AV) node

Middle internodal

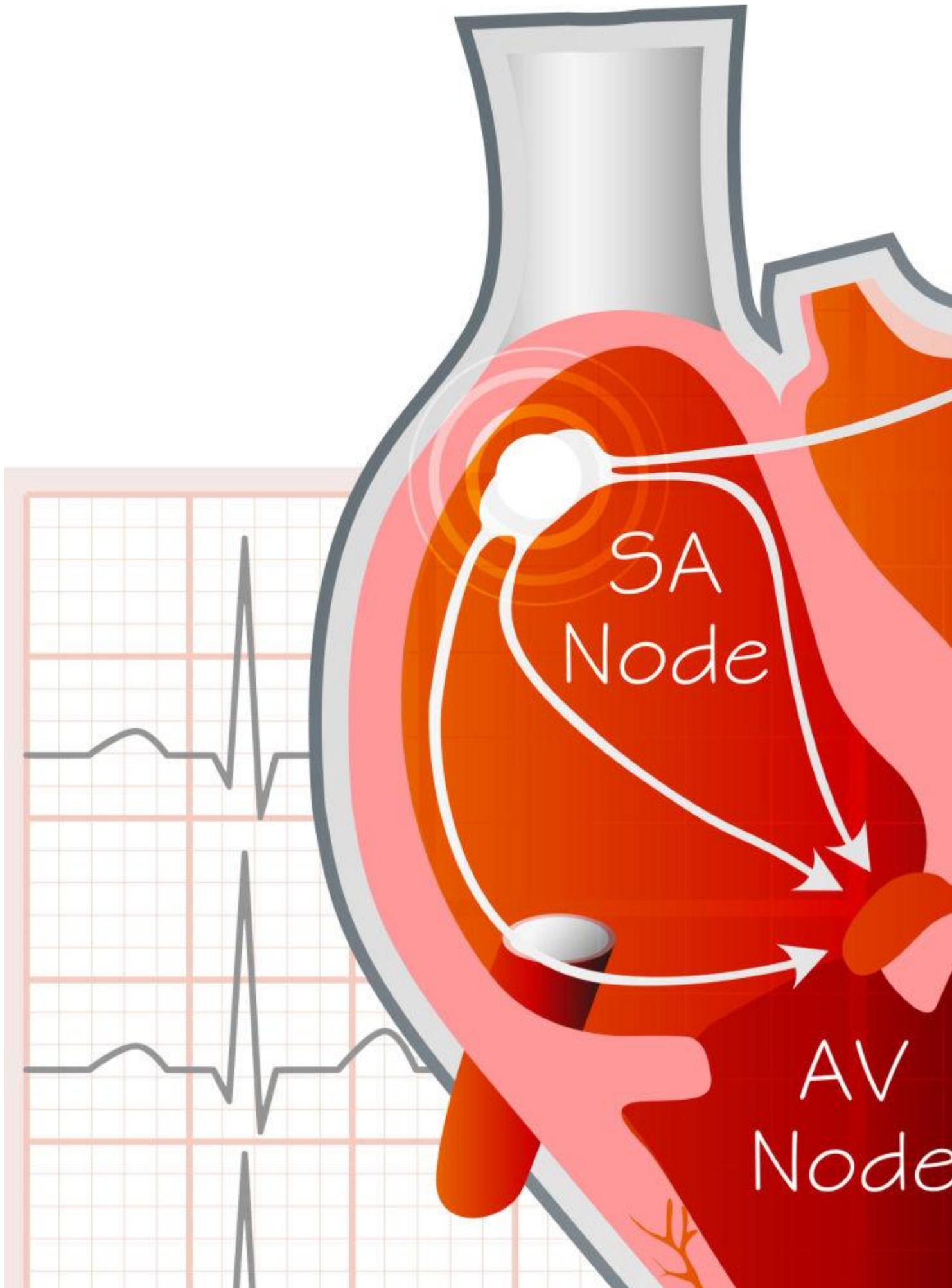
Posterior internodal

Right atrium

Right ventricle



Anterio



- **Location in right atrium**

- The **SA node** is located in the **wall of the right atrium near the opening of the superior vena cava**

- **Natural pacemaker of the heart**

- The SA node is known as the **natural pacemaker** because it **initiates electrical impulses that determine the heart rhythm**

- **Generates spontaneous electrical impulses**

- Cells of the SA node have the ability to **generate impulses automatically without external stimulation**

- **Sets heart rate**

- The rate at which the SA node generates impulses **determines the heart rate under normal conditions**

- **Initiates cardiac cycle**

- The electrical impulse produced by the SA node **spreads through the atrial myocardium**, initiating **atrial contraction and the beginning of the cardiac cycle**.

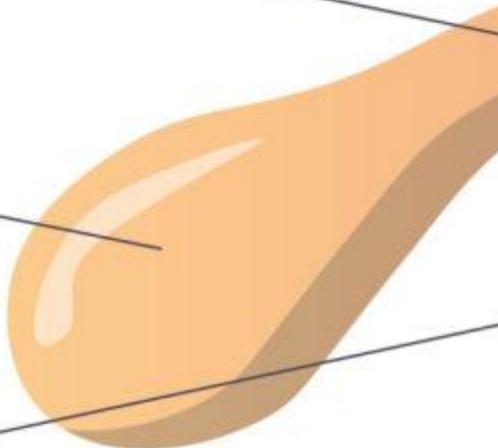
## Atrioventricular (AV) Node

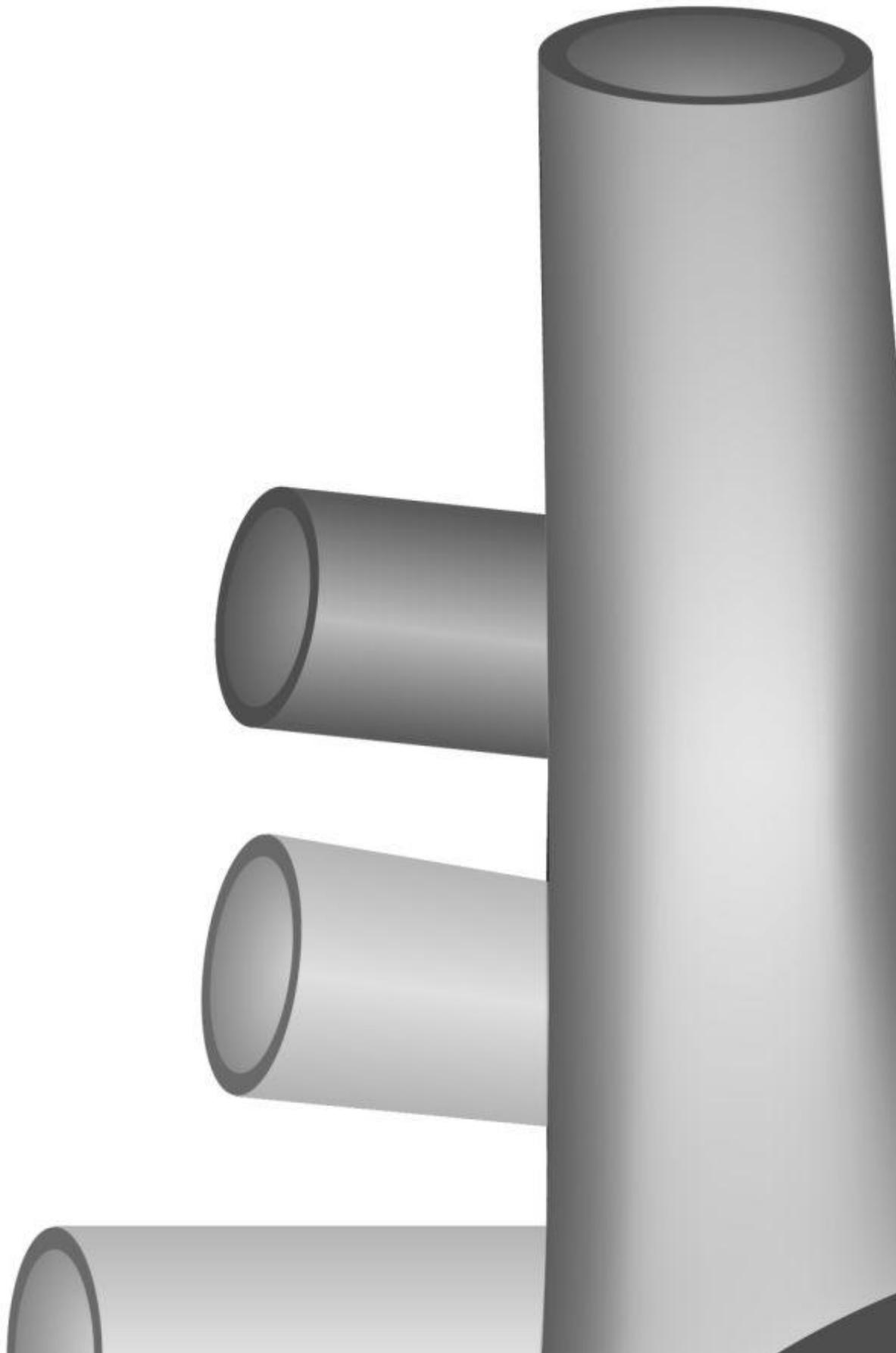
bundle of His

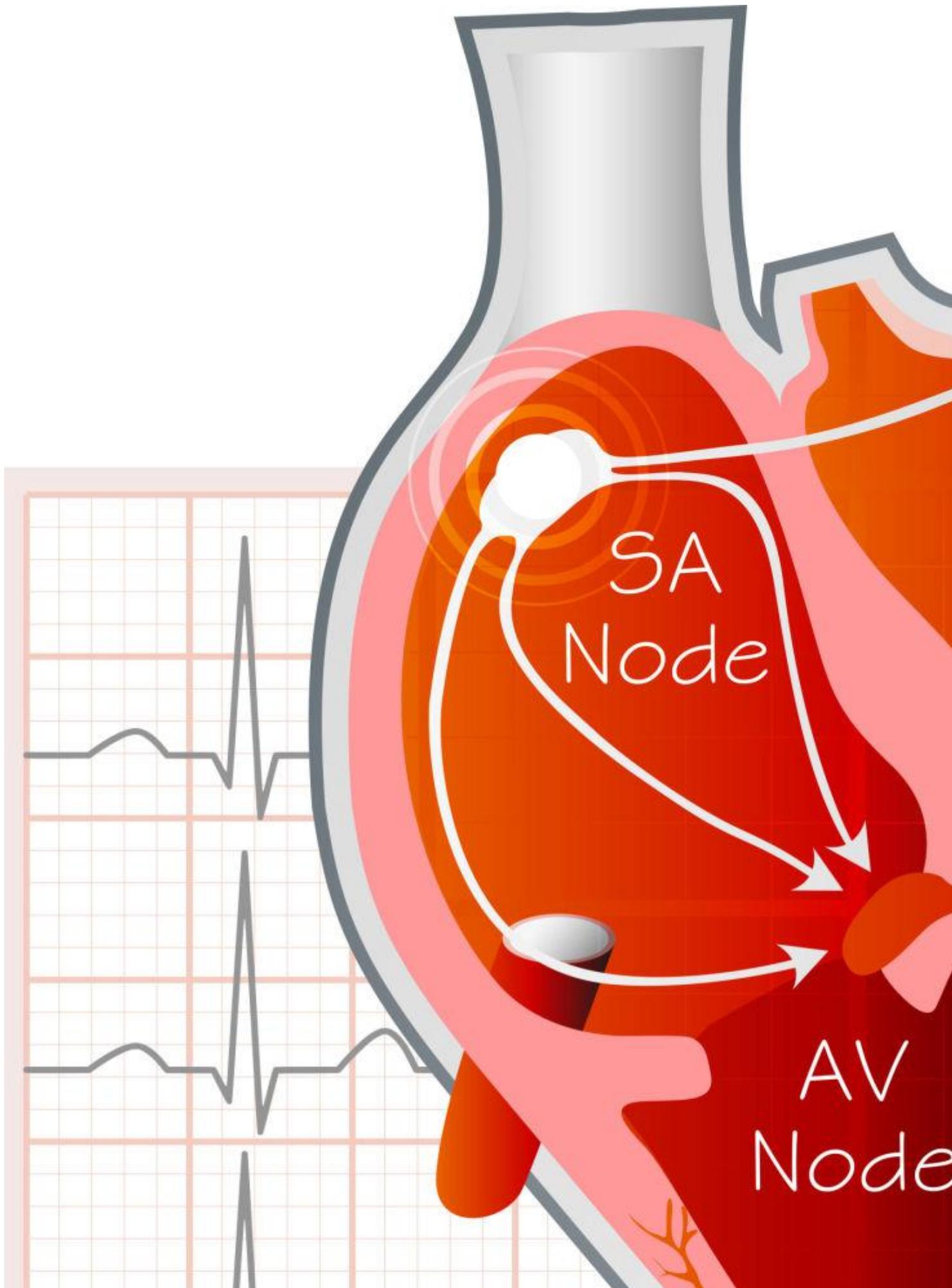
atrioventricular node

left bundle brunch

left anterior fascicle







- **Located in interatrial septum near AV junction**
  - The **atrioventricular (AV) node** is located in the **lower part of the interatrial septum near the atrioventricular junction**, close to the opening of the **coronary sinus**.
  - **Receives impulses from SA node**
  - Electrical impulses generated by the **sinoatrial (SA) node travel through the atrial myocardium** and reach the AV node.
  - **Delays conduction before ventricular activation**
  - The AV node introduces a **short delay in impulse conduction** before transmitting the signal to the ventricles.
  - This delay allows **sufficient time for the atria to contract and push blood into the ventricles**
  - **Ensures proper atrial contraction before ventricular contraction**
  - Because of this delay, **atrial systole occurs before ventricular systole**, ensuring **efficient filling of the ventricles**.
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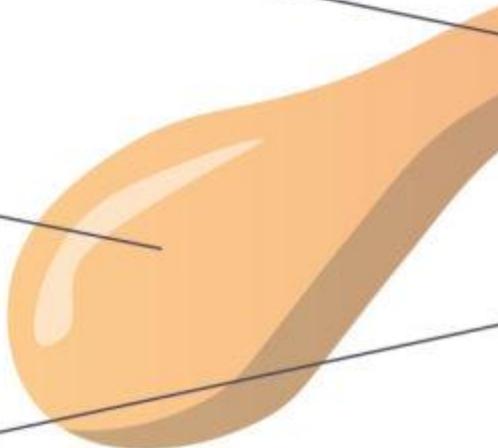


bundle of His

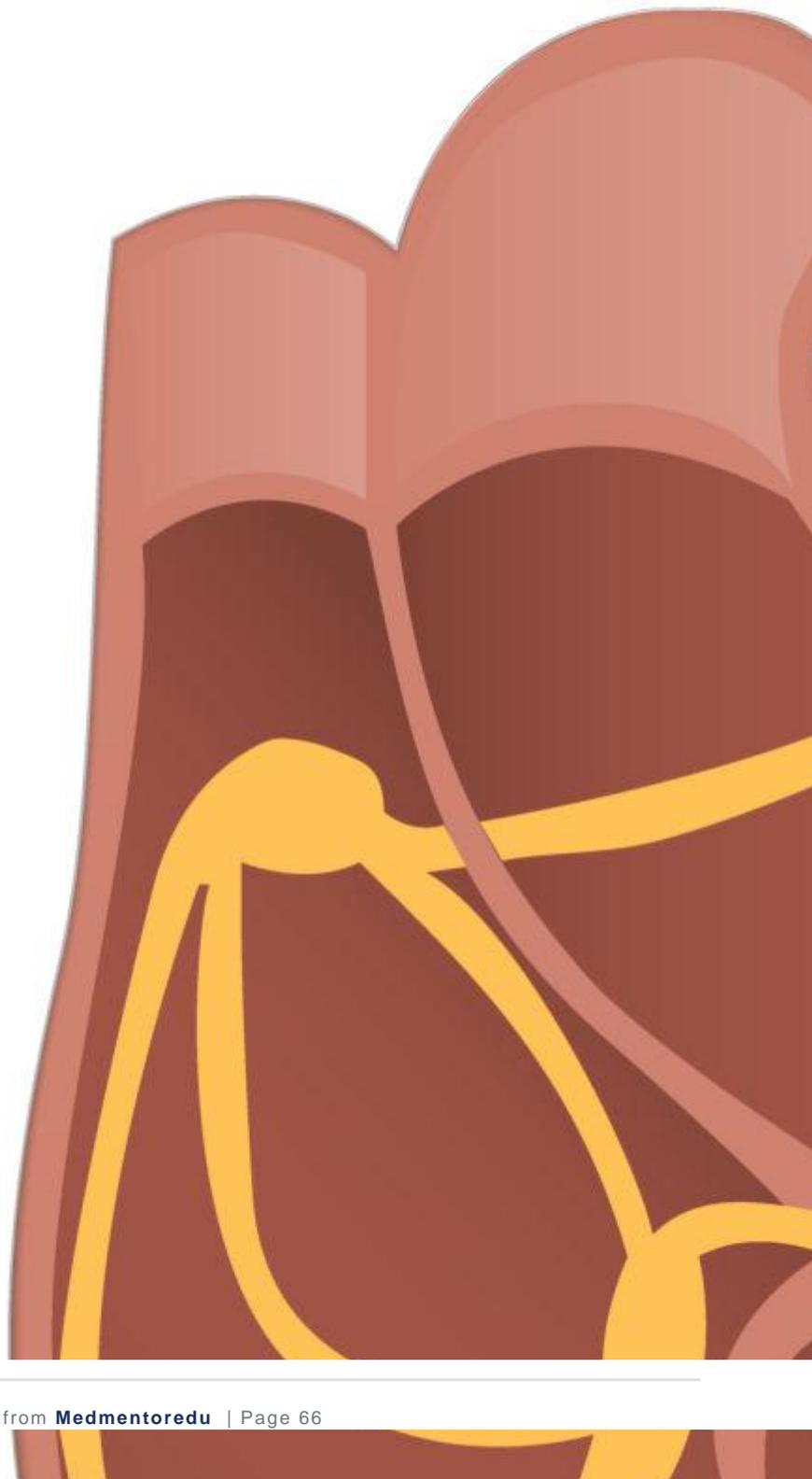
atrioventricular node

left bundle brunch

left anterior fascicle







- **Conducting pathway from AV node to ventricles**

- The **bundle of His**, also called the **atrioventricular bundle**, is the pathway that **conducts impulses from the AV node to the ventricles**.

- **Located in interventricular septum**

- It passes from the AV node into the **upper part of the interventricular septum**.

- **Divides into right and left bundle branches**

- The bundle of His divides into **right and left bundle branches**, which run along the **interventricular septum toward the apex of the heart**.

- **Transmits impulses rapidly to ventricular muscle**

- These bundle branches conduct impulses to **Purkinje fibres**, which distribute the electrical signal throughout the **ventricular myocardium**, producing **coordinated ventricular contraction**.

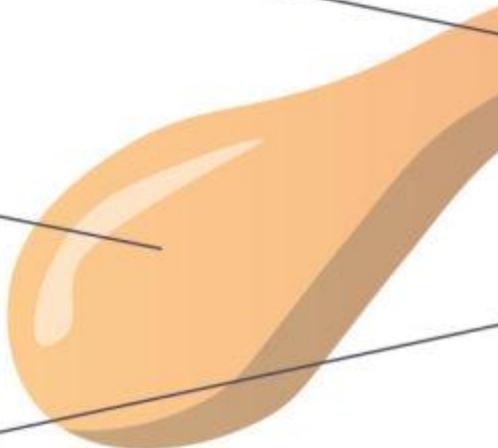
## Purkinje Fibres

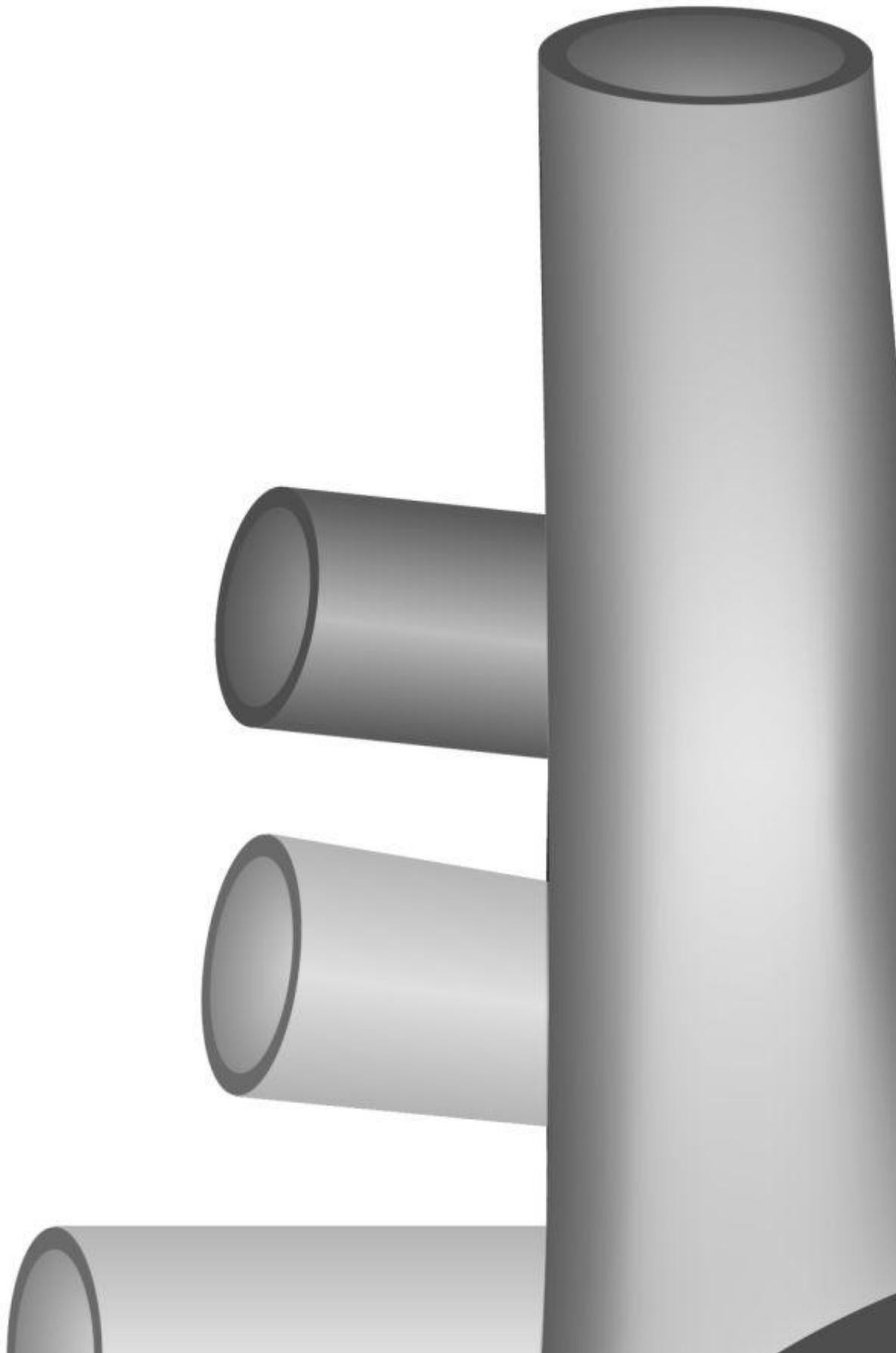
bundle of His

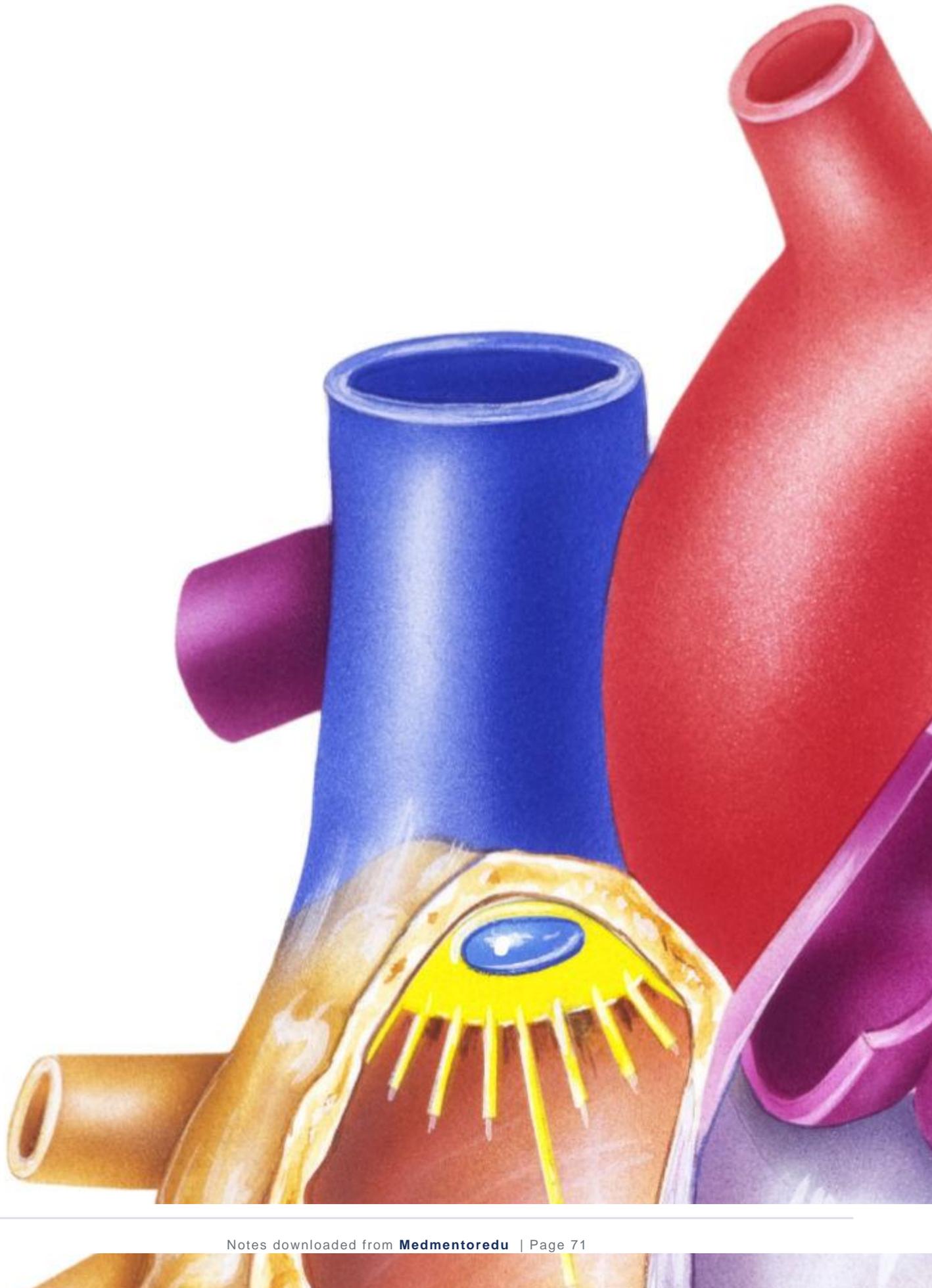
atrioventricular node

left bundle brunch

left anterior fascicle







- **Terminal branches of cardiac conduction system**
- **Purkinje fibres are the terminal branches of the cardiac conduction system**
- They arise from the **right and left bundle branches of the bundle of His**.
  
- **Spread impulses through ventricular myocardium**
- These fibres extend throughout the **ventricular walls and distribute electrical impulses to the ventricular muscle cells**
  
- **Rapid conduction velocity**
- Purkinje fibres conduct impulses **very rapidly due to their large diameter and specialized structure**
- This allows the electrical signal to **reach all parts of the ventricles almost simultaneously**.
  
- **Ensures coordinated ventricular contraction**
- Because of rapid impulse transmission, **both ventricles contract in a coordinated manner**, enabling **efficient ejection of blood into the pulmonary artery and aorta**.