

# CARDIOVASCULAR SYSTEM

## Points to be covered in this topic

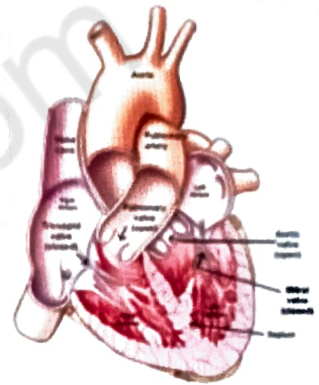
1. INTRODUCTION

2. BRIEF INTRODUCTION ABOUT HEART

(a) Structure of heart

(b) Chamber of heart

(c) Valve of heart

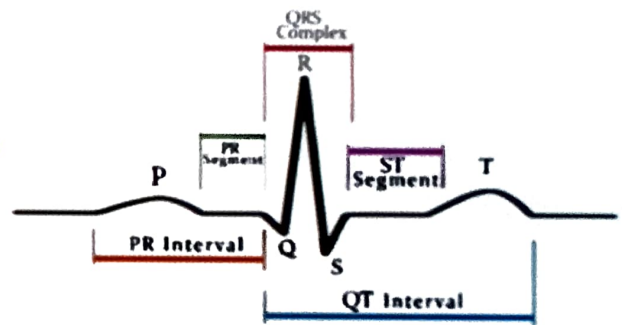


3. BLOOD CIRCULATION

4. CONDUCTION SYSTEM OF HEART RATE AND HEART BEAT

5. CARDIAC OUTPUT

6. CARDIAC CYCLE



7. REGULATION OF AUTONOMIC NERVOUS SYSTEM

8. BLOOD PRESSURE

9. ELECTROCARDIOGRAM

10. DISORDERS OF CARDIOVASCULAR SYSTEM

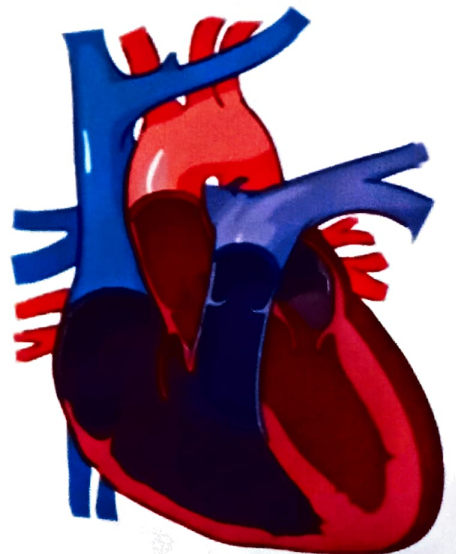
## ❑ INTRODUCTION

- The cardiovascular system **consists** of **heart** and **blood vessels**.
- Its main function is to **supply oxygenated blood** to the **tissues**.
- It transports **respiratory gases, nutrients** and **excretory products** to various parts of the body.
- **Blood** is the medium through which these substances are **transported**.
- It consists of the following organs and tissues.
- **The heart:** A muscular pump that forces blood around the body.
- **A closed system of blood vessels:** These vessels include:
  - ✓ **Arteries:** Vessels that **carry blood** away from the heart.
  - ✓ **Veins:** Vessels that bring **blood back** to the heart.
  - ✓ **Capillaries:** Tiny vessels that branch off from arteries to **deliver blood** to all **body tissues**



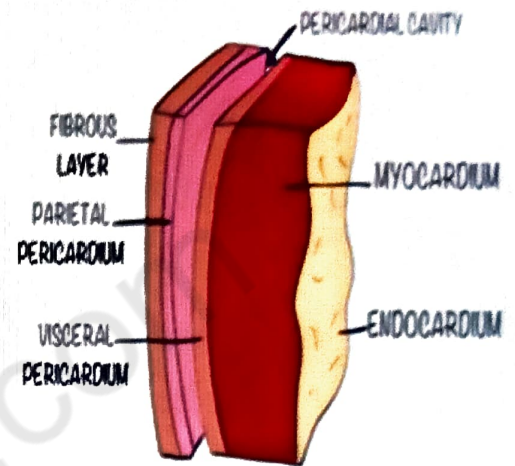
### ➤ Heart

- Heart is a **conical, hollow, musculotendinous organ**.
- It lies in the thorax between the **lungs** and behind the **sternum**.
- Located in the **front** of your **chest**.
- The base of the heart is **above** and **apex** is below.
- It is about **10 cm long** and weighs about **300 gms**.
- It sits slightly behind and to the **left** of your **sternum** (breastbone).



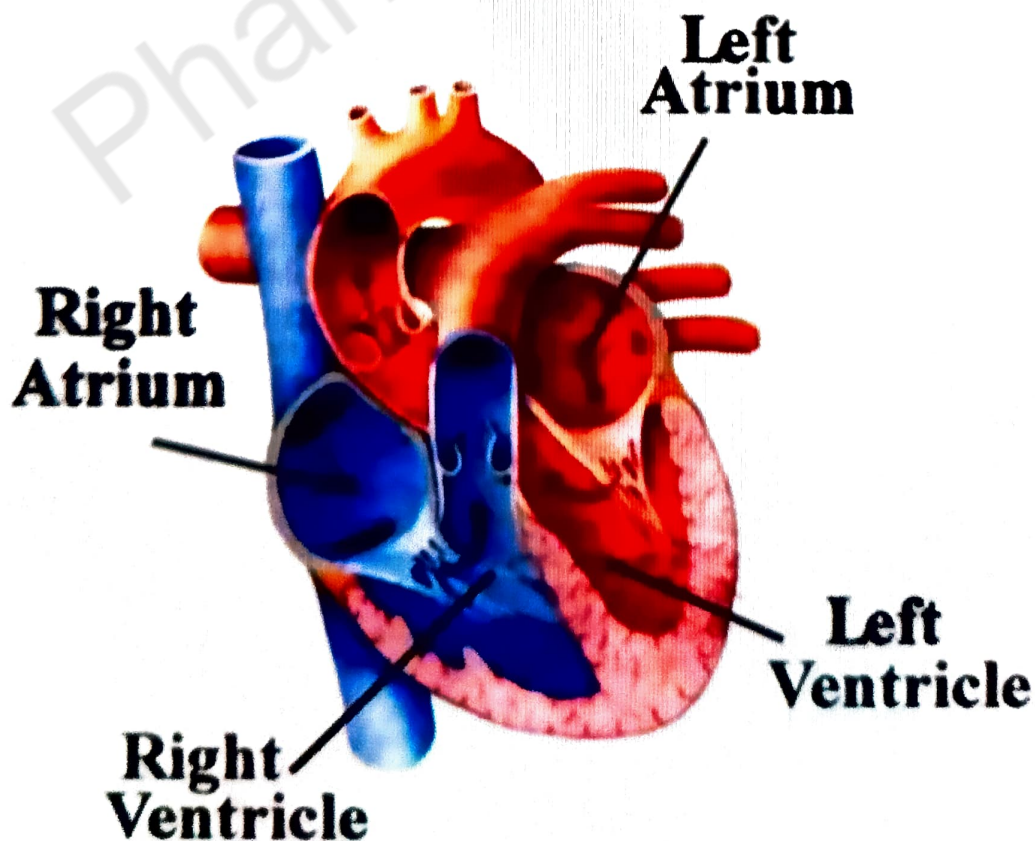
## ❖ Structure of the heart

- Heart is surrounded by an outer covering **Pericardium**.
- It contains two layers called **visceral pericardium** and **Parietal pericardium**.
- Pericardial fluid is present between these **two layers**.
- The **middle layer** is made of heart muscle fibres.
- It is called as **Myocardium**.
- The **inner lining** is called **Endocardium**.



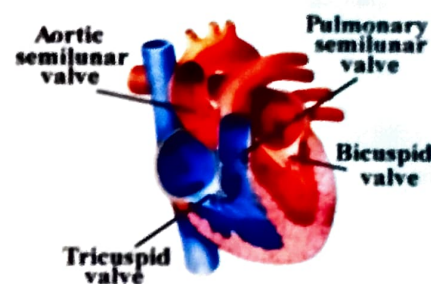
## ❖ Chambers of the heart

- Heart is made of **four chambers**.
- The **two chambers** on the **right side** are known as **Right atrium** and **Right ventricle**.
- The chambers on the **left side** are known as **Left atrium** and **Left ventricle**.



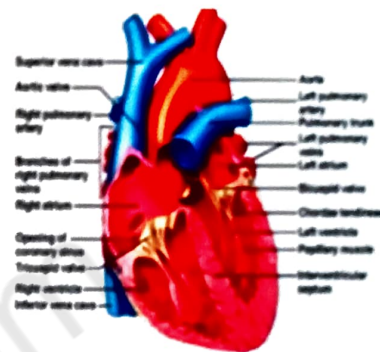
## ❖ Valves of the heart

- The opening between **right atrium** and **right ventricle** is guarded by **Tricuspid valve**.
- The opening between **left atrium** and **left ventricle** is guarded by **Mitral valve** (Bicuspid valve).



## ❖ Blood vessels attached to heart

1. The **right atrium** receives **Superior vena cava** and **Inferior vena cava**. They carry venous **blood** to **heart**.
2. From the right ventricle arises the on. **Pulmonary artery**. It carries venous **blood** to **lungs** for oxygenation.
3. The **left atrium** receives four **Pulmonary veins**. They carry **oxygenated blood** to **heart**.
4. From the **left ventricle** arises the **Aorta**. It carries **oxygenated blood** to all parts of the **body**.



## ❖ Blood supply to the heart

- Blood is supplied to heart by **right** and **left coronary arteries**.
- They arise from **aorta**.
- Venous blood of the heart is drained by **Coronary sinus**.
- It opens up directly in the **right atrium**.

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## ❖ Nerve Supply

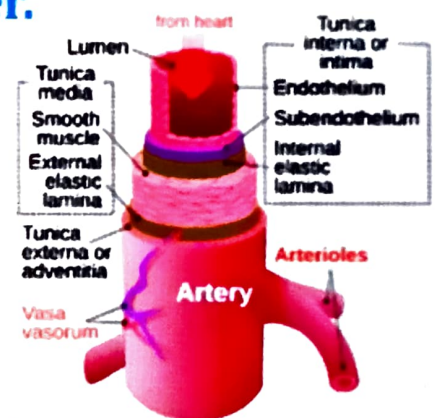
- Heart is supplied by **sympathetic** and **vagus nerves**.
- Branches from these nerves pass to the **sinoauricular node**.

## ❖ Arterial and venous system

- The heart pumps **blood** into **arteries**.
- The arteries **divide** and **subdivide** and finally **end in capillaries**.
- The **capillaries** later unite to form **veins**.
- The veins return **blood** to the **heart**.
- So arteries carry pure (**oxygenated**) blood away from the **heart**.
- Veins carry impure (**deoxygenated**) blood to the **heart**.
- Histologically, arteries and veins are made of the following **three layers**.
  1. **Tunica adventitia**- outer fibrous layer.
  2. **Tunica media** -middle muscle layer.
  3. **Tunica intima**-inner serous layer

## ❑ ARTERIES

- **Aorta** is the main artery in the body.
- It arises from the **left ventricle**.
- The opening of aorta is guarded by **semilunar valve**.
- Aorta consists of **three parts** :
  - 1) **Ascending aorta**
  - 2) **Arch of aorta**
  - 3) **Descending aorta**.
- 1. **Ascending aorta**: It gives off only **two branches**. They are
  - a) **right coronary artery**
  - b) **left coronary artery**.



2. **Arch of aorta:** It supplies **blood to head, neck and upper limbs.**

• It gives off the following branches:

**i) The inominate artery**

• It divides into :

a) **Right common carotid artery**

b) **Right subclavian artery**

**ii) Left common carotid artery**

• Its divides in to :

a) **Internal carotid artery**

b) **External carotid artery**

**iii) Left subclavian artery**

• Branches of internal carotid artery are:

a) **Anterior cerebral artery** - Supplying the brain

b) **Middle cerebral artery** - Supplying the brain

c) **Ophthalmic artery** - Supplying the eye

• Branches of external carotid artery are: supplying the face

i) **Facial artery** - Supplying the face

ii) **Maxillary artery** - Supplying the jaws

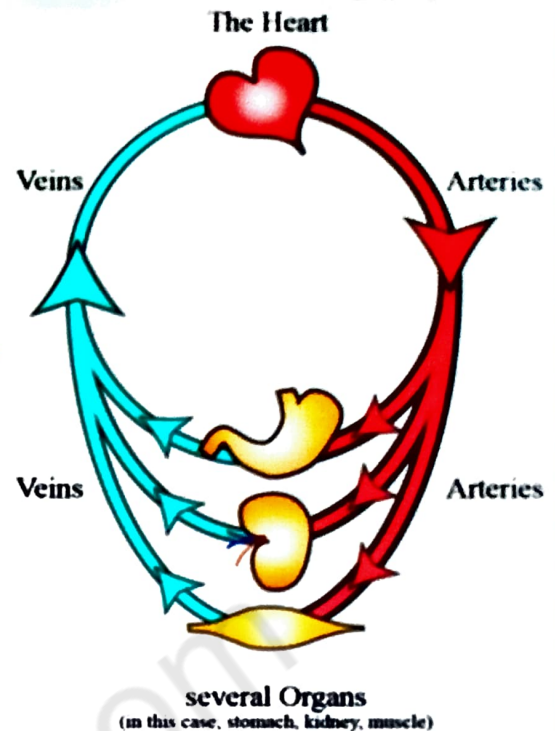
iii) **Temporal artery** - Supplying temporal parts of skull

iv) **Occipital artery** - Supplying occipital parts of skull

3. **Descending aorta :** It is further classified into:

**i. Thoracic aorta** - it supplies blood to the wall of chest cavity and its viscera

**ii. Abdominal aorta** - it supplies body wall of abdominal cavity and its viscera



## ❖ Branches of Abdominal aorta:

1. Coeliac plexus which divides into **three branches**
  - a) **Hepatic artery** - supplying the **liver**
  - b) **Gastric artery** supplying the **stomach**
  - c) **Splenic artery** - supplying the **spleen**
2. **Superior** and **inferior** mesentric arteries-supplying the **intestine**.
3. **Renal arteries** -supplying the **kidney**.
4. **Final branches** which are :
  - i) **right common iliac artery**
  - ii) **left common iliac artery**

These common iliac arteries divide into

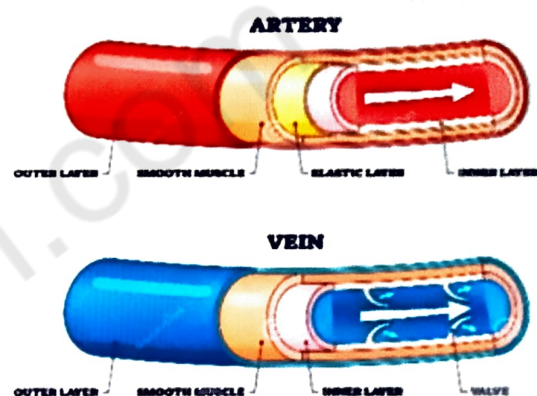
- i) **internal iliac artery**
- ii) **external iliac artery**

## ☐ Veins

- Veins are **blood vessels** in humans, and most other animals that **carry blood** towards the heart.
- Most veins carry **deoxygenated blood** from the **tissues** back to the **heart** exceptions are the **pulmonary** and **umbilical veins**, both of which carry **oxygenated blood** to the heart .

## ❖ Main veins of the body

- ✓ **Veins of the upper limb:** The veins of forearm are **Radial vein** and **Ulnar vein**.
- ✓ **Veins of the lower limb:** The Anterior and posterior tibial veins of the leg unite to form **Popliteal vein**.
- ✓ **Veins of head and neck:** The venous blood from **head** and **neck** is drained through **Internal jugular vein** and **External jugular vein**.



## Venous sinuses:

- These sinuses lie between the two layers of **Duramater**
- They receive blood from **brain** and **interior** of the **skull**.
- This **venous blood** is drained into **Internal jugular vein** .
- These **sinuses** are:
  1. **Superior sagittal sinus**: It runs in the **median plane** from the **frontal** to **occipital region**.
  2. **Inferior sagittal sinus**: It runs in the **lower edge** of **falx cerebri**.
  3. **Straight sinus**: It runs between **falx cerebri** and **tentorium cerebelli**.
  4. **Transverse sinuses**: They receive blood from **other sinuses**.
  5. **Cavernous sinuses**: They drain blood from **orbit**, **nose** and **cheek**

## □ **Capillaries**

- Capillaries are **tiny blood vessels** that **transport blood**, **nutrients** and **oxygen** to cells in your **organs** and **body systems**.
- Capillaries are the **smallest blood vessels** in your **vascular system**.

## **BLOOD CIRCULATION**

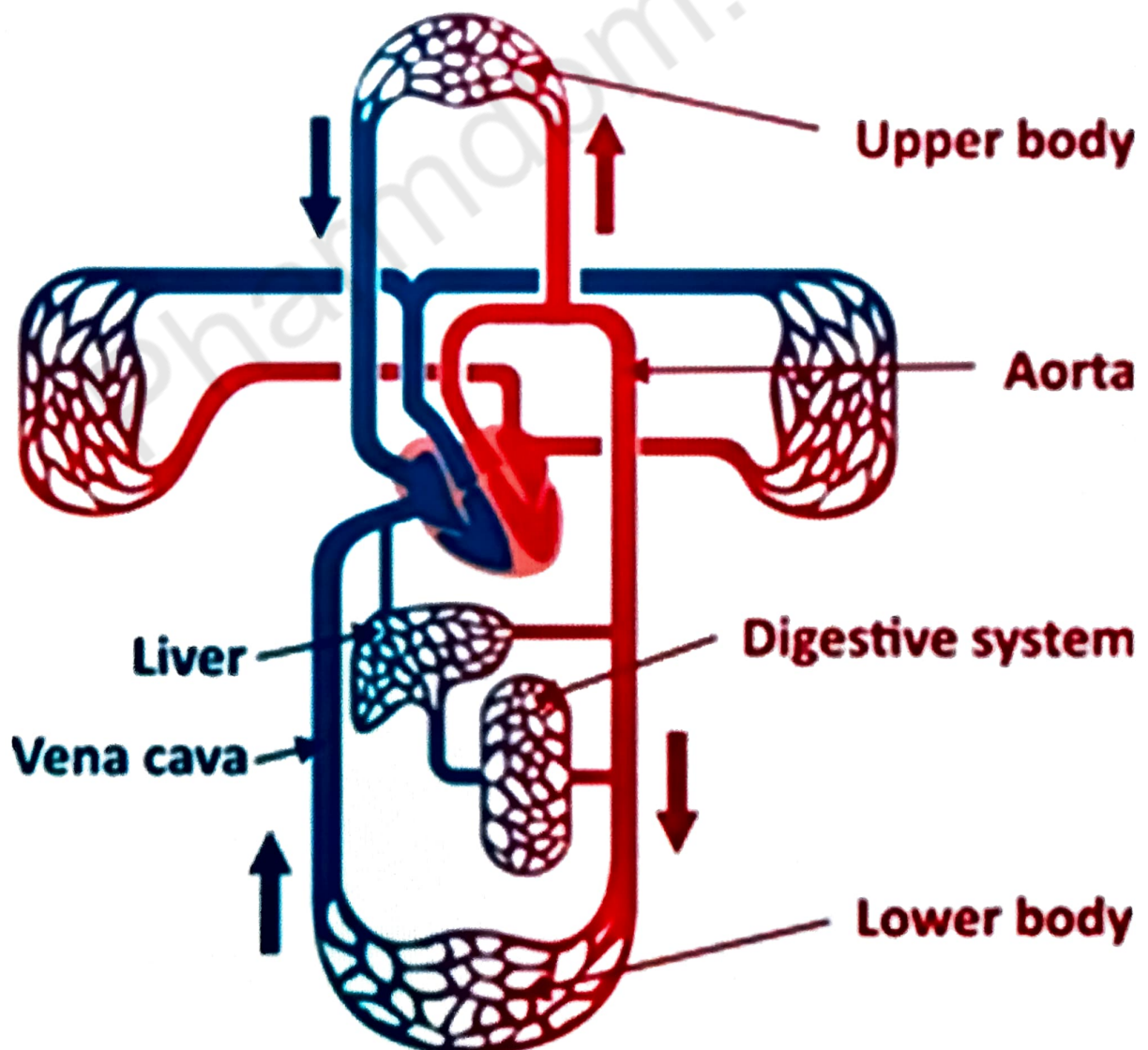
- Depending on the **course of blood** , circulation can be classified into :
  1. **Systemic circulation**
  2. **Pulmonary circulation**
  3. **Coronary circulation**
  4. **Portal circulation**
  5. **Cerebral circulation**



## 1. Systemic circulation

- It is the circulation involving **blood supply** to all **parts** of the body **excepts lungs**
- This **circulation** starts from **aorta**.
- It breaks up into **smaller arteries** and finally ends in **capillaries**.
- The **capillaries** unite to form venules which join up ultimately to form **two large venous** trunks namely the **superior vena cava** and **inferior vena cava**.
- These two trunks open in the **right atrium** of the heart.

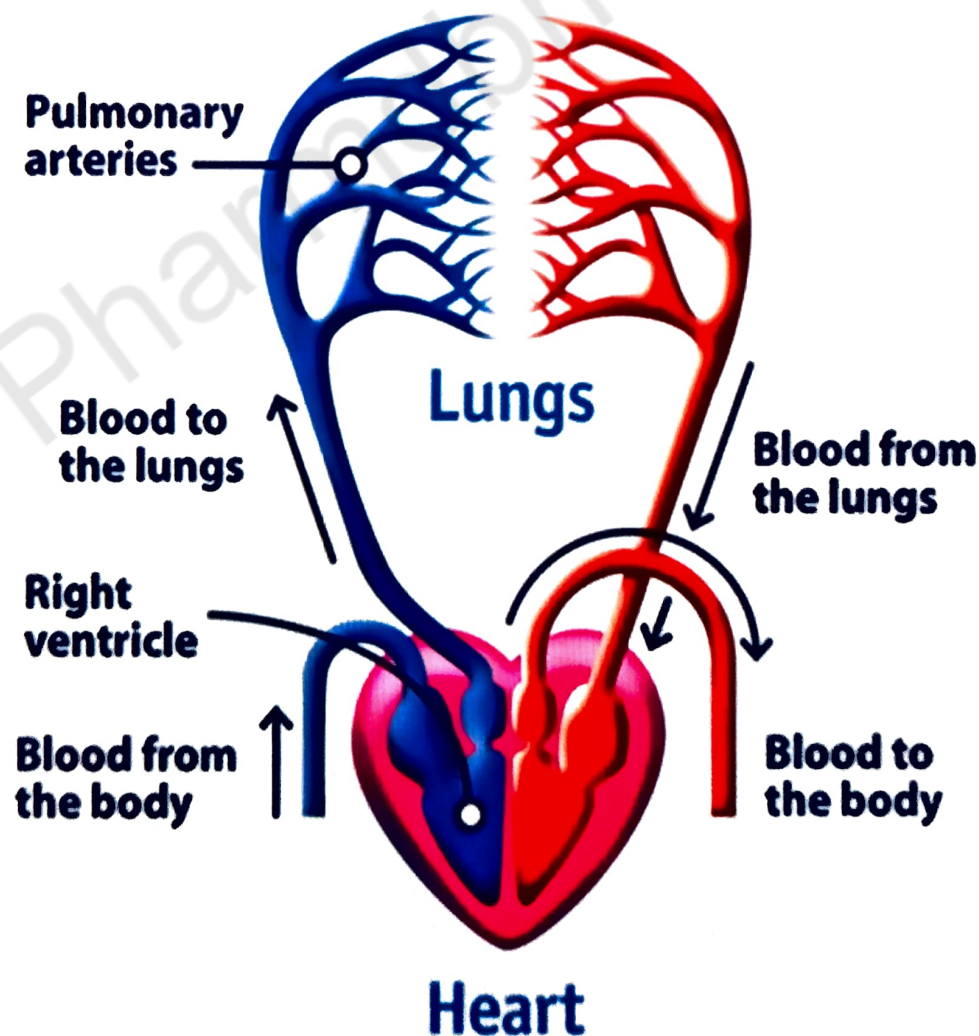
### Systemic circulation



## 2. Pulmonary circulation :-

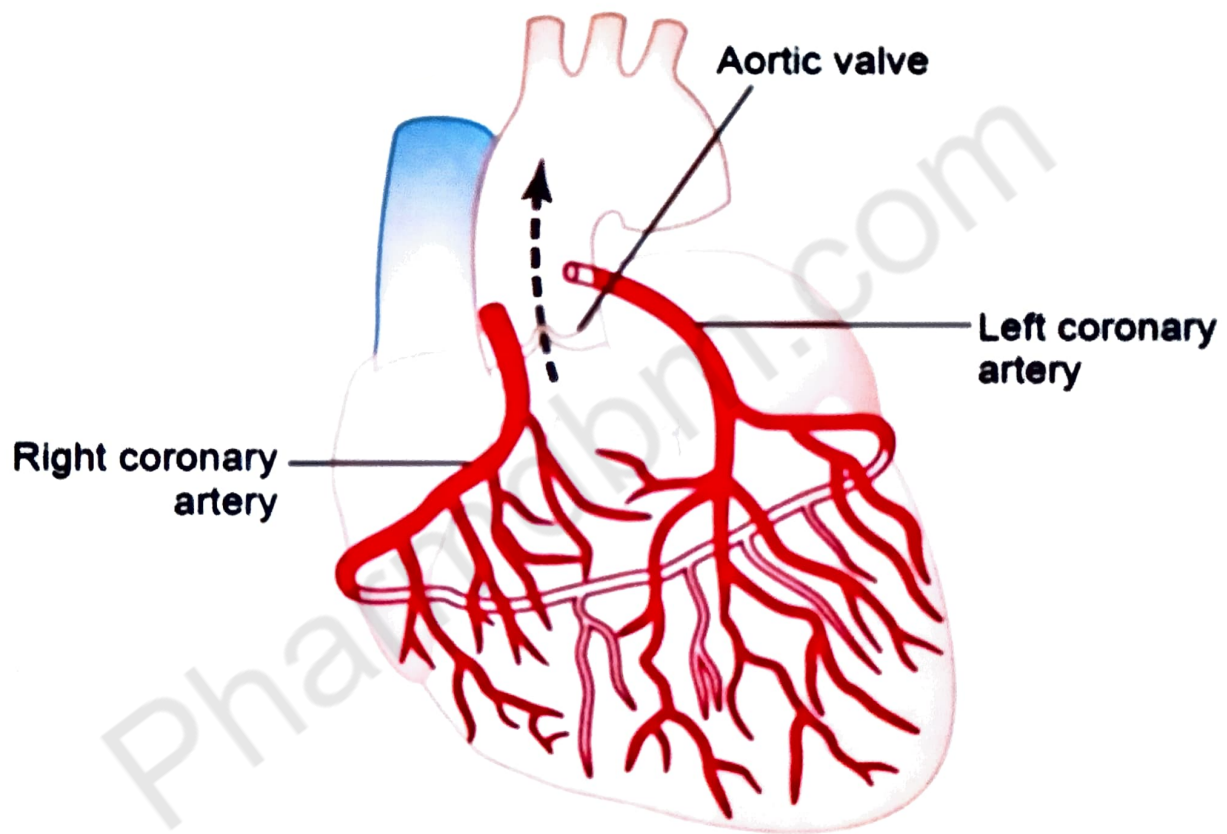
- It is the part of circulation involving the **purification** (oxygenation) of **blood** in **lungs**.
- **Impure** (deoxygenated) venous blood is pumped by the **right ventricle**.
- The **pulmonary artery carries** this blood to **lungs** where it is **oxygenated** (purified) **Four pulmonary veins** carry this purified blood from lungs to the heart.
- These veins open in the **left atrium**

## Pulmonary Circulation



### 3. Coronary circulation

- This circulation involves **blood supply** to the **heart itself**.
- The **right** and left coronary arteries arise from **ascending aorta**.
- They supply **blood** to the **heart**.
- The **venous blood** is collected by the **coronary sinus** which opens in the **right atrium**,

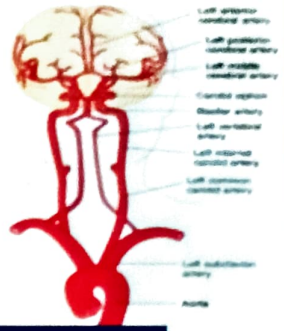


### 4. Portal circulation:

- It is the **circulation** of **blood** through the **liver**. In this circulation:
  - i. **Portal vein** carries to liver
  - ii. The portal vein **divides** into capillaries. These capillaries join with the **capillaries** of **hepatic artery**.
  - iii. The **venous blood** of **liver** is collected by **hepatic vein** which joins with **inferior vena cava**

## 5. Cerebral circulation

- It involves the **blood supply** to the cerebrum.
- **Cerebral arteries** supply **blood** to the cerebrum
- **Cerebral veins** carry the **venous blood**.



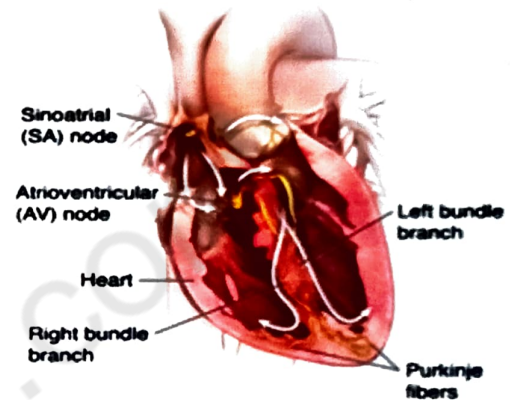
## CONDUCTION SYSTEM OF THE HEART AND HEART BEAT

- The impulses for cardiac contraction are transmitted through the conduction system of the heart

- This system is made of

1. Sinuatrial node
2. Atrioventricular node
3. Bundle of His
4. Purkinje's fibres

Electrical system of the heart



- ❖ The conduction of impulses occur in the following sequence
  1. The origin of impulses for **cardiac contraction** is at the **sinuatrial node** . It is present at the opening of **superior vena cava** into the **right atrium**. **SA node** is called as the **Pacemaker** of the heart.
  2. The **impulses** then **pass** through the **atrial muscle**.
  3. The impulses pass to **atrioventricular node**. It lies in the **upper part** of **atrio-ventricular septum**.
  4. The **impulses pass** to the **Bundle of His** . It is a **special bundle** of **nerve** and **muscle tissue**. It is also the only **muscular connection** between the **atria** and **ventricles**.
  5. The bundle of His passes through the **inter-ventricular septum**. Later it divides into branches called **Purkinje fibres**. The right and the **left branches** of this fibre supply the **two ventricles**

## ❖ Properties of cardiac muscle

- The cardiac muscle has certain characteristics. They are:
  1. **Contractility** - By **contraction** of the **cardiac muscle**, the **heart pumps blood out** of its four chambers.
  2. **Conductivity** - The impulses for **cardiac contraction** are conveyed through a specialized **conduction system**.
  3. **Rhythmicity** - Heart muscle has the **inherent** property of **rhythmic contraction**
  4. **Refractory period** - **During systole**, the heart does not respond to any other **stimuli**, however strong it may be. This is called as **Refractory period**.

## CARDIAC OUTPUT

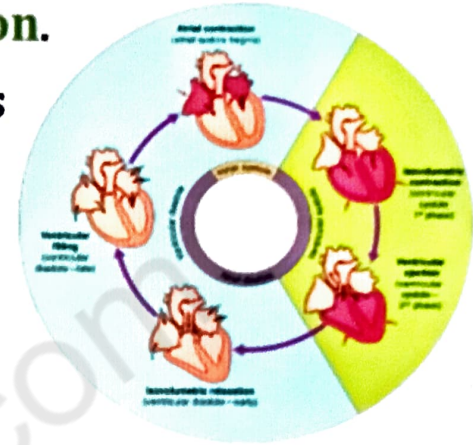
- It is the **volume of blood** ejected from the **left ventricle** in to the **aorta** each minute
- Cardiac output equals the **stroke volume**, the volume of **blood ejected** by the ventricle during each **contraction**, multiplied by the **heart rate**, the number of heart beats per minute  $CO = SV \times HR$
- In a typical **resting** adult male, **stroke volume** averages **70 ml / beat**, and heart rate is about **75beats / min**. thus, average cardiac output is

$$\begin{aligned}CO &= 70\text{ML/beat} \times 75\text{beats /min} \\ &= 5250 \text{ ml /min} \\ &= 5.25 \text{ l /min}\end{aligned}$$

- This volume is close to the total **blood volume**, which is an about **5 liters** in an **adult male**.

# CARDIAC CYCLE

- The events occurring in the heart from the **beginning of one heart beat** to the **beginning of other heart beat** is called as the **cardiac cycle**.
- The term **systole** refers to the **phase of contraction** while **diastole** refers to the **phase of relaxation**.
- A cardiac cycle is divided into four phases
  1. Phase of ventricular filling
  2. Phase of ventricular contraction
  3. Phase of ventricular ejection
  4. Phase of ventricular relaxation



## 1. Phase of Ventricular Filling

- During ventricular relaxation, a large amount of **blood collects** in the **atria**, as the **AV valves** are closed.
- This **increases** the pressure in the **atria** and **AV** valves open and **semilunar valves** are closed.
- The initial 1/3 time of **ventricular filling** is called as period of rapid **ventricular filling**.
- During the phase of **ventricular filling**, the AV valves are open and **semilunar valves are closed**.

## 2. Phase of Ventricular Contraction

- The **QRS complex** of **ECG** represents the **depolarisation** of ventricles which begins at the apex of **ventricles**, as the **action potential** is carried from **AV node** to the **apex**.
- **ventricular filling** the pressure inside the **ventricles** rise **suddenly**.

- This rise in pressure tries to **push blood** back to the **atria** due to which the **AV valves close**.
- At this **particular junction**, the **AV valves** and **semilunar valves** are closed and the **volume inside** the **ventricles** does not change. This is called as a period of **isovolumetric contraction**

### 3. Period of Ventricular Ejection.

- As **ventricles** further start **contracting**, the pressure inside **rises sharply**.
- When the pressure **rises above** the **aortic pressure** and **pulmonary trunk pressure**, the SL. **valve opens**.
- As the **semilunar valve** opens, blood is ejected out of the **ventricles**. This period is called as **ventricular ejection**.

### 4. Phase of Ventricular Relaxation

- As the **ventricles** start **relaxing**, the pressure inside the ventricles drops suddenly. . This drop in pressure leads to **back flow** of blood from the **pulmonary trunk** and **aorta**
- This **forceful back flow** of **blood** closes the semilunar valve suddenly.
- This pressure produces a bump called as **dicrotic wave**.
- Due to this the **ventricular volume** does not change and this period is called as **isovolumetric relaxation**.

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# REGULATION OF AUTONOMIC NERVOUS SAYSTEM

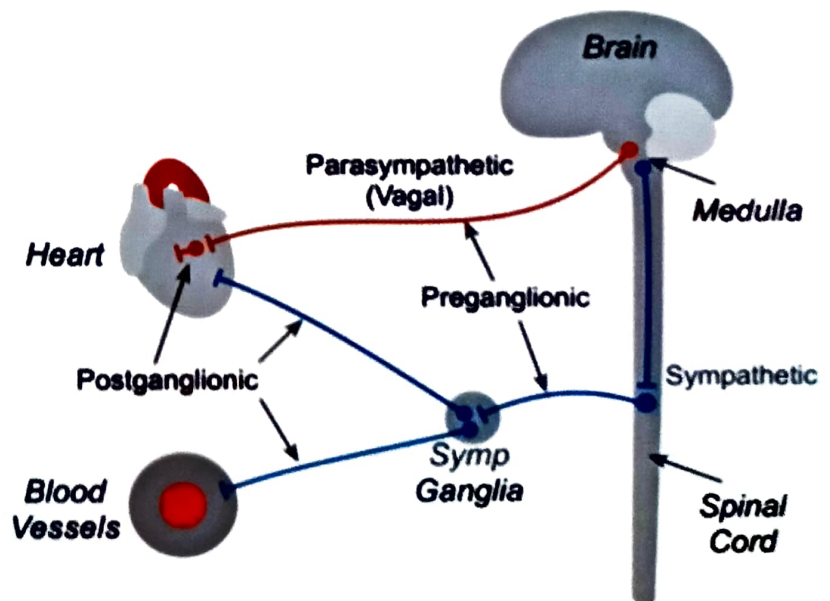
- The autonomic nervous system is a component of the **peripheral nervous** system that **regulates involuntary** physiologic processes including **heart rate, blood pressure, respiration, digestion, and sexual arousal**.
- It contains **two anatomically** distinct divisions:
  - **Sympathetic**
  - **Parasympathetic**

## ✓ Sympathetic

- Stimulation by the sympathetic nervous system causes an elevation in **intracellular ( $Ca^{2+}$ )** and thus an increase in **contraction** of both the **atria** and **ventricles**.
- **Positive dromotropic effect** :- Stimulation by the **sympathetic nervous system** also enhances the conductivity of the **electrical signal**.

## ✓ Parasympathetic

- The parasympathetic nervous system (PNS) **releases the hormone acetylcholine** to slow the **heart rate**.
- Such factors as **stress, caffeine,** and **excitement** may temporarily accelerate your **heart rate**, while meditating or taking **slow, deep breaths** may help to slow your **heart rate**.





# BLOOD PRESSURE (BP)

- It is defined as the **lateral pressure** exerted by **blood** on **blood vessels**.
- The **blood pressure** which is normally expressed is **arterial blood pressure**.
- It has two phases

## 1. Systolic blood pressure:

- It is the **maximum blood pressure**.
- This occurs during the **systole** of heart (Range-100-120 mm Hg).

## 2. Diastolic blood pressure:

- It is the **minimum blood pressure**. It occurs during the **diastole** of heart (Range-60-80 mm Hg)

Blood pressure category	Systolic mmHg (Upper number)		Diastolic mmHg (Lower number)
Normal	Less than 120	and	Less than 80
Elevated	120-120	and	Less than 80
High blood pressure (Hypertension phase 1)	130-130	or	80-80
High blood pressure (Hypertension phase 2)	140 or Higher	or	90 or higher
Hypertensive crisis (Consult your doctor immediately)	Higher than 140	and/or	Higher than 120

## ❖ Factors affecting blood pressure

1. **Blood volume**: It is the **total amount** of **circulating blood**
2. **Peripheral resistance**: It is the resistance offered by **blood vessels**, especially **arterioles** for the **blood flow**

**3. Elasticity:** Elasticity of the **arterial walls** distends the aorta when the **ventricle contracts**. The elastic recoils when the **ventricle relaxes**. This recoil pushes the blood onwards.

**4. Diameter of the lumen of blood vessels:** It can be altered. Narrowing of the **lumen increases** the resistance to **blood flow**.

**5. Viscosity:** Viscosity of the blood is its **stickiness** and its dense nature.

## **REGULATION OF BLOOD PRESSURE**

### ❖ **Baroreceptor reflex**

- The baroreceptor **reflex** is a neutrally-mediated reflex that **regulates blood** pressure in the **short-term**.
- This reflex is crucial for the maintenance of blood pressure throughout the day and in its absence, even a slight **change in posture** could lead to significant **changes in blood pressure**.

### ❖ **Renin-angiotensin-Aldosterone**

- **Stimuli** that initiate the **renin - angiotensin - aldosterone** pathway include **dehydration**, **Na<sup>+</sup> deficiency**, or **hemorrhage**.

- Decreased **blood volume** leads to **decrease blood pressure**

### ❖ **Epinephrine and Nor-epinephrine**

- In response to **sympathetic stimulation**, the **adrenal medulla** releases **epinephrine** and **nor-epinephrine**.
- These changes **increases cardiac output** by increase in the **heart rate** and **force of contraction**

### ❖ **Antidiuretic hormone (ADH)**

- It is produced by the **hypothalamus** and released from the **posterior pituitary** in response to **dehydration** or **decrease in blood volume**.
- ADH causes **vasoconstriction** which increases blood pressure. Hence, it is also called as **vasopressin**.

### ❖ **Atrial natriuretic peptide (ANP)**

- It is released by the cells in the **atria** of the heart **ANP** lowers blood pressure by causing **vasodilation** and by promoting the **loss of salt and water** in the **urine** which **reduces blood volume**.

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### ❑ **Pulse**

- A strong **regular beating** or **throbbing** the **rhythmic pulse** of the **music**.
- The beat resulting from the **regular widening** of an artery in the body as blood flows through it feel your **wrist** for a **pulse**.

## **ELECTROCARDIOGRAM (ECG)**

- Conduction of **action potential** through **heart** **generates** electrical currents that can be **detected** at the **surface** of the body.
- A recording of the **electrical changes** that accompany each cardiac cycle is called as **electrocardiogram**.
- The instrument used to record the change is called as an **electrocardiograph**.
- It consists of three waves
  - ✓ **P wave**
  - ✓ **QRS wave**
  - ✓ **Twave**

## ✓ P Wave

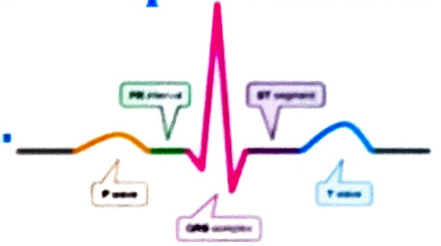
- It represents **atrial depolarisation** which spreads from **SA node** throughout both on **atria**

## ✓ QRS Wave

- The QRS complex represents the **ventricular depolarization**

## ✓ T Wave

- It represents **ventricular repolarisation.**



## ✓ PQ or PR Interval

- It is interval between beginning of **contraction of atria** and beginning of **contraction of ventricles.**

## ✓ QT Interval

- During reading of an **ECG** , the **size** and **timing** of the waves is carefully noted.
- Following conclusions can be made with the altered **ECG notes.**

✓ **Larger P wave:** It indicates **enlargement** of the **atrium.**

✓ **Enlarged Q wave:** It indicates **myocardial infarction.**

✓ **Enlarged R wave:** It indicates **enlargement** of the **ventricles**

✓ **Flatter T wave:** It indicates **insufficient oxygen** supply to **myocardium**

✓ **Larger PQ interval:** It indicates formation of scar tissue in heart due to **coronary artery** disease or **rheumatic fever.**

✓ **Larger ST segment.** It indicates **acute myocardial infarction** when elevated above the baseline and **insufficient oxygen** supply to heart muscle when depressed below the **baseline.**

## DISORDERS OF DISORDERS OF CARDIOVASCULAR SYSTEM

1. **Tachycardia:** Increase in heart rate.
2. **Bradycardia:** Decrease in heart rate
3. **Cardiac failure:** It is a condition in which the **myocardium** of ventricle is **unable to maintain** sufficient **circulation of blood** to meet the needs of the body.
4. **Stenosis of valves:** It is the **narrowing** of the valves of the heart. In this condition, the edges of the **cusps** (of the valves) become rough. So they stick together and narrow the **valvular opening**.
5. **Incompetance of valves**
  - It is a functional defect caused by the **failure** of the valve to close completely.
  - This allows blood to flow **back** in to the **ventricle** when it **relaxes**.
6. **Ischaemic heart disease (IHD)**
  - It occurs due to **narrowing or occlusion** of one or more branches of **coronary arteries**.
  - It may lead to **angina pectoris**.
7. **Angina pectoris:**
  - It is the **pain occurring** due to **myocardial ischaemia**.
  - The pain is retrosternal in origin and is radiating generally to the **left arm**.
  - It occurs due to **narrowing of coronary arteries**.
  - Because of this, physical effort causes severe **ischaemic pain**. This is called **Angina of effort**

## 8. Myocardial infarction

- It is the **death** of an area of **cardiac tissue** due to lack of **coronary blood** supply to that segment of the **myocardium**.
- It occurs due to **occlusion** of **coronary** artery by a thrombus or **deposition of fat**.

## 9. Cardiac arrhythmia

- It is a disorder in **cardiac rate** and **rhythm**.
- It occurs due to **defective impulse** formation and **defective impulse** conduction in the heart.