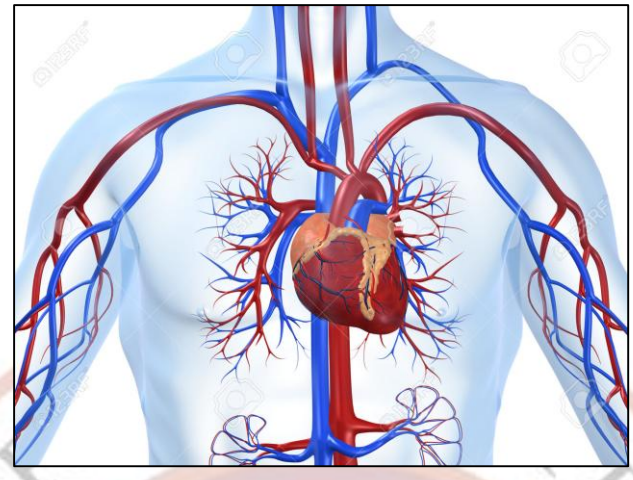
CARDIOVASCULAR SYSTEM (CVS)



- The cardiovascular system is composed of:
  - **Blood**
  - **Heart**
  - **Blood vessels**
- The heart beats approximately **100,000 times per day**
- An average adult has about **100,000 km of blood vessels**
- CVS ensures:
  - Continuous flow of blood to all body cells
  - Continuous physiological adjustments to maintain adequate blood supply

HEART GENERAL FEATURES

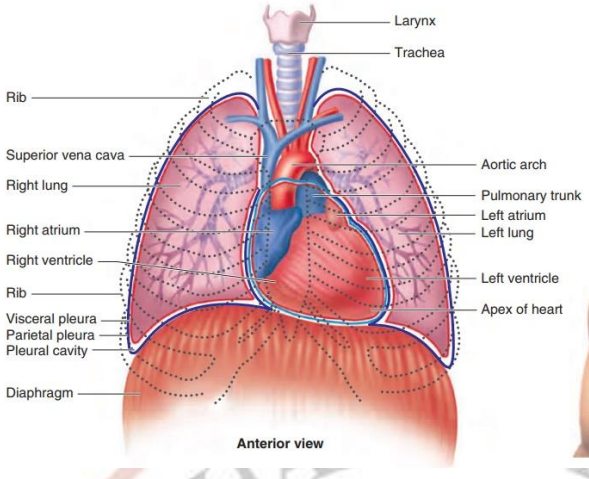
Cardiology

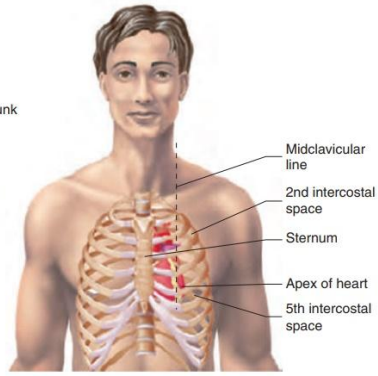
- Cardiology is the scientific study of:
  - Normal heart
  - Diseases associated with the heart

General Characteristics of Heart

- Heart is a **relatively small organ**
- Size: approximately equal to a **closed fist**
- Shape: **Cone-shaped, hollow muscular organ**
- Length: **10–12 cm**
- Weight:
  - **Women:** 225–250 g
  - **Men:** 300–310 g

PARTS OF HEART





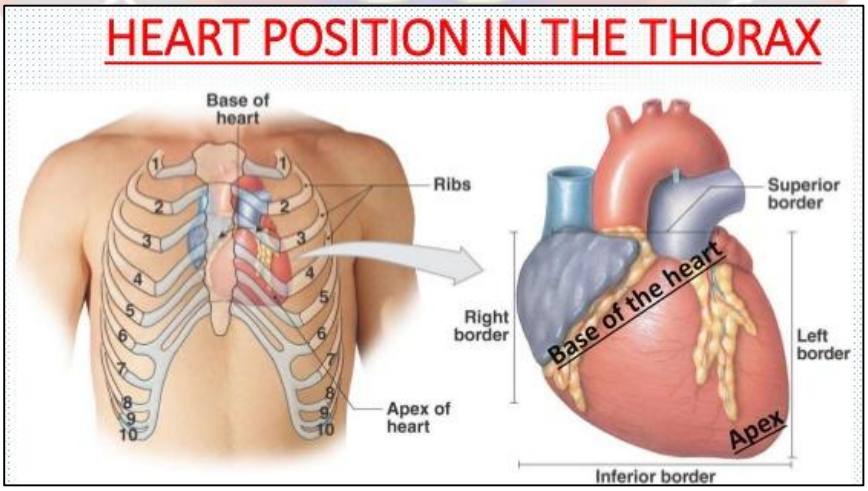
Base of the Heart

- Flat and superior surface
- Formed mainly by the **left atrium**
- Extends up to the **2nd rib**

Apex of the Heart

- Pointed end
- Directed **downwards and to the left**
- Located **9 cm left of midline**
- At the level of **5th intercostal space**
- Formed by the **tip of left ventricle**

POSITION OF HEART



- Heart lies **obliquely** in the thoracic cavity
- Located in the **mediastinum**

- Positioned slightly more towards the **left side of the chest**

Organs associated:

***Inferior* – apex rest on diaphragm**

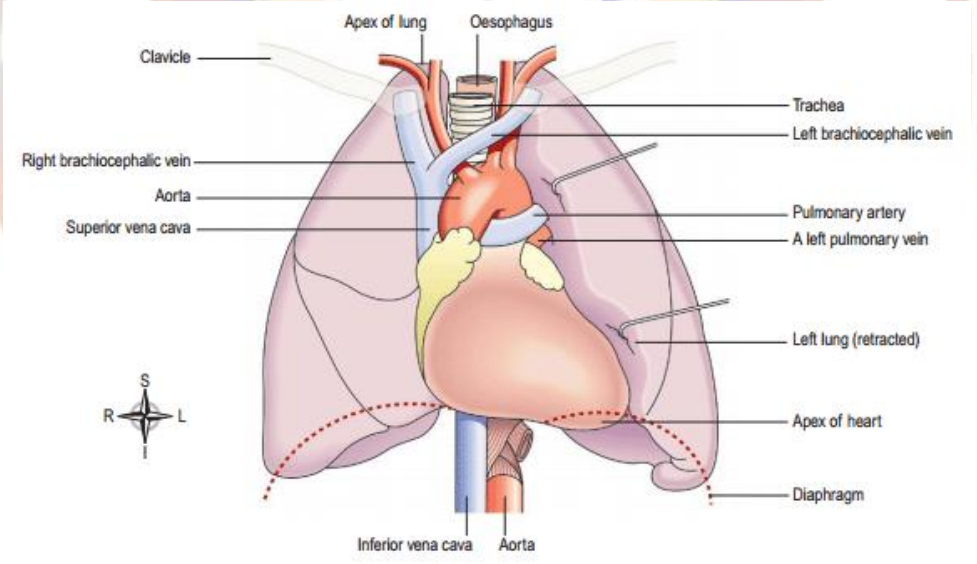
***Superior* – aorta, superior venacava, pulmonary artery, pulmonary veins**

***Posterior* – esophagus, trachea, left & right bronchus, descending aorta, inferior venacava, thoracic vertebrae**

***Lateral* – lungs; left lung overlaps left side**

***Anterior* – sternum, ribs, intercoastal muscles**

RELATIONS OF THE HEART



Inferior Relation

- Apex rests on the **diaphragm**

Superior Relations

- Aorta
- Superior vena cava

- Pulmonary artery
- Pulmonary veins

Posterior Relations

- Esophagus
- Trachea
- Left and right bronchi
- Descending aorta
- Inferior vena cava
- Thoracic vertebrae

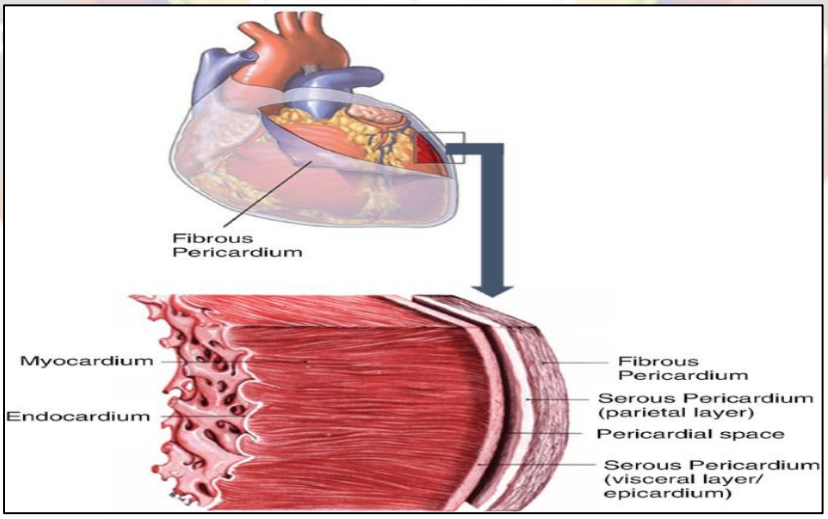
Lateral Relations

- Lungs
- Left lung overlaps the left side of heart

Anterior Relations

- Sternum
- Ribs
- Intercostal muscles

PERICARDIUM



Pericardium

- Outermost protective membrane of the heart
- Confines heart to its position in the mediastinum
- Protects the heart

Types of Pericardium

1. **Fibrous Pericardium**
2. **Serous Pericardium**

FIBROUS PERICARDIUM

- Composed of tough, inelastic fibrous connective tissue
- Dense irregular connective tissue
- Continuous with tunica adventitia of blood vessels
- Apex partly fused with diaphragm
- Functions:
    - Protects the heart
    - Prevents over-distension of heart

SEROUS PERICARDIUM

- Formed by a single layer of endothelial cells
- Forms a **double-layered sac**

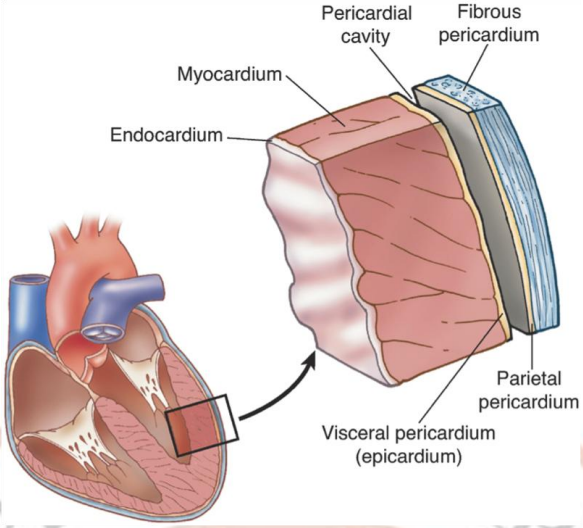
Layers

- **Parietal layer**
    - Outer layer
    - Fused with fibrous pericardium
- **Visceral layer (Epicardium)**
    - Inner layer
    - Firmly attached to myocardium

Pericardial Fluid

- About **20 ml**
- Present in pericardial cavity
- Reduces friction during heart movements

HEART WALL



The heart wall is composed of **three layers of tissue**:

1. **Epicardium** (outer layer)
2. **Myocardium** (middle layer)
3. **Endocardium** (inner layer)

Epicardium

- Outermost layer of the heart wall
- Composed of **two tissue layers**:
  - Thin, transparent visceral layer
  - Delicate **fibroelastic tissue** with adipose tissue
- Gives a **smooth and slippery texture** to the heart surface
- Contains:
  - Blood vessels
  - Lymphatics
- Supplies nutrients to the myocardium

Myocardium

- Thick middle layer
- Composed of **specialized cardiac muscle**
- Responsible for **pumping action of the heart**
- Forms about **95% of heart wall**
- Muscle is:
  - Striated
  - Involuntary
- Cardiac muscle fibers are:
  - Branched
  - Connected by **intercalated discs**
- Enables **coordinated and efficient contraction**

- Thickness:
  - Thickest at apex
  - Thinnest at base
- Specialized atrial muscle cells secrete **Atrial Natriuretic Peptide (ANP)**

Endocardium

- Lines:
  - Heart chambers
  - Heart valves
- Thin, smooth membrane
- Ensures **smooth blood flow**
- Composed of flattened epithelial cells
- Continuous with endothelial lining of large blood vessels

INTERNAL ANATOMY OF HEART

Septum

- Partition dividing the heart into right and left halves
- Made of myocardium covered by endocardium

Heart Chambers

The heart is divided into **four chambers**:

Atria

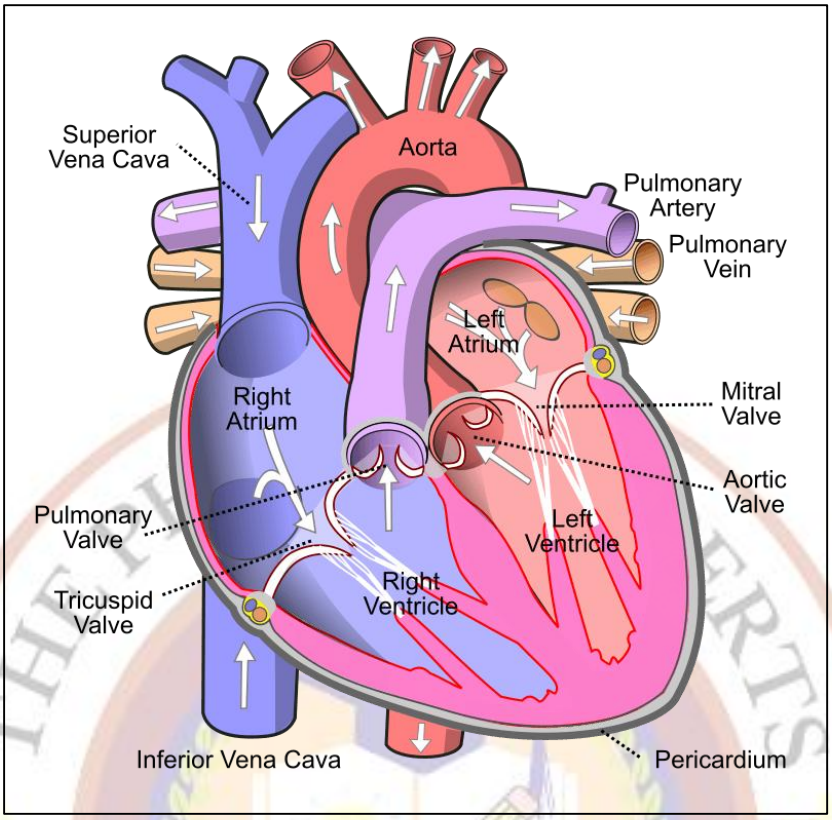
- Two superior chambers
- Receiving chambers
- Receive blood from veins

Ventricles

- Two inferior chambers
- Pumping chambers
- Eject blood into arteries

Auricles

- Wrinkled pouch-like structures on anterior surface of atria
- Increase capacity of atria to hold more blood



Sulci (Grooves)

- **Coronary sulcus**
  - Separates atria from ventricles externally
- **Interventricular sulcus**
  - Separates right and left ventricles
  - Present on anterior and posterior surfaces

RIGHT ATRIUM

Functions

- Receives deoxygenated blood from:
  1. Superior vena cava
  2. Inferior vena cava
  3. Coronary sinus

Interatrial Septum

- Thin partition between right and left atria
- Contains a depression called **fossa ovalis**
- Fossa ovalis is the remnant of **foramen ovale**

Valve

- Blood flows from right atrium to right ventricle through:
  - **Tricuspid valve**
  - Also called **right atrioventricular valve**
  - Has **three cusps**

RIGHT VENTRICLE

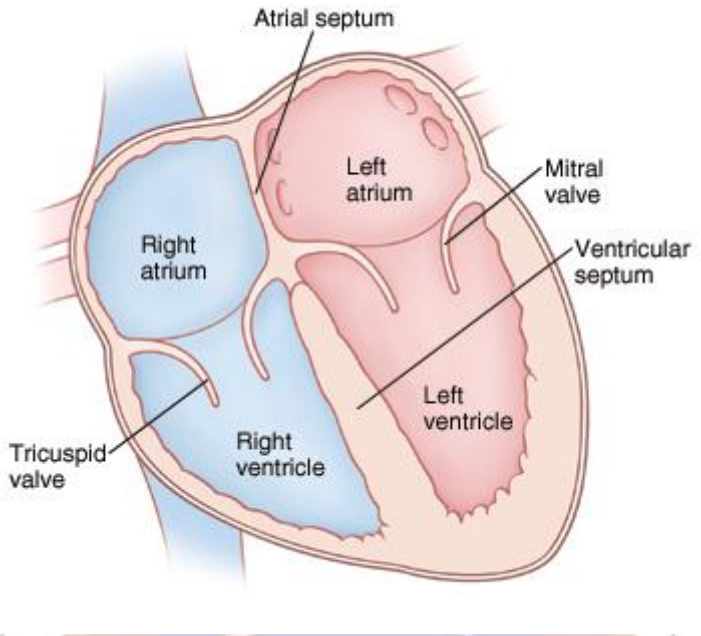
- Interior surface has muscular ridges called **trabeculae carneae**
- Cusps of tricuspid valve are attached to:
  - **Chordae tendineae**
  - These attach to **papillary muscles**
- Right ventricle separated from left ventricle by **interventricular septum**
- Blood flows from right ventricle into:
  - **Pulmonary trunk** through **pulmonary valve**
- Pulmonary trunk divides into:
  - Right pulmonary artery
  - Left pulmonary artery
- Carries blood to lungs

LEFT ATRIUM

- Forms most of the **base of the heart**
- Receives oxygenated blood from lungs via:
  - **Four pulmonary veins**
- Blood passes into left ventricle through:
  - **Bicuspid valve**
  - Also called **mitral valve**
  - Left atrioventricular valve

LEFT VENTRICLE

- Thickest chamber of the heart
- Forms the **apex of the heart**
- Contains:
  - Trabeculae carneae
  - Chordae tendineae
  - Papillary muscles
- Blood exits left ventricle through:
  - **Aortic valve**
  - Into ascending aorta
- Aorta gives rise to:
  - Coronary arteries
  - Arch of aorta
  - Descending aorta



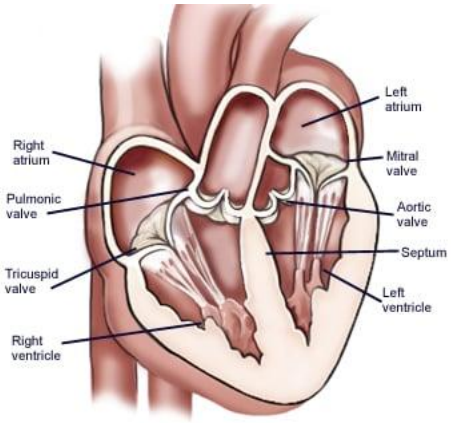
VENTRICULAR WALL THICKNESS

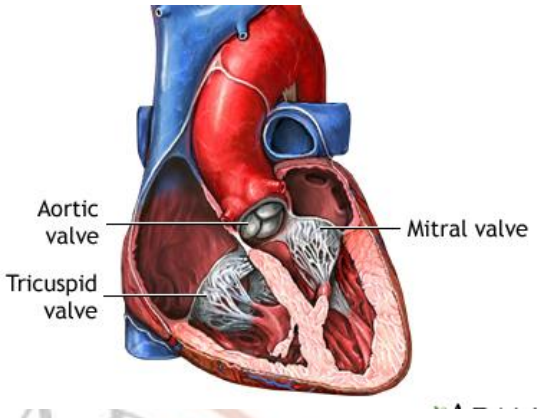
- Ventricular walls thicker than atrial walls
- Right ventricle:
  - Pumps blood to lungs
  - Short distance
  - Low pressure
- Left ventricle:
  - Pumps blood to entire body
  - Long distance
  - High pressure
  - Works harder than right ventricle

FIBROUS SKELETON OF HEART

- Network of dense connective tissue
- Surrounds heart valves
- Valves fuse with fibrous skeleton
- Functions:
  - Prevents overstretching of valves
  - Acts as electrical insulator between atria and ventricles

HEART VALVES





Functions

- Open and close due to pressure changes
- Ensure **one-way flow of blood**

Types

1. **Atrioventricular (AV) valves**
2. **Semilunar valves**

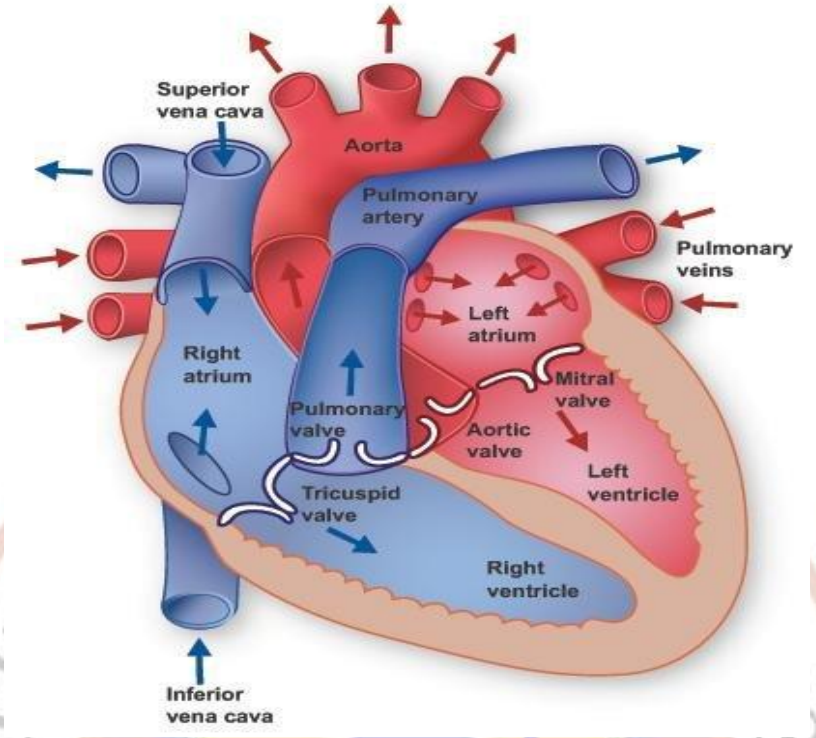
Atrioventricular Valves

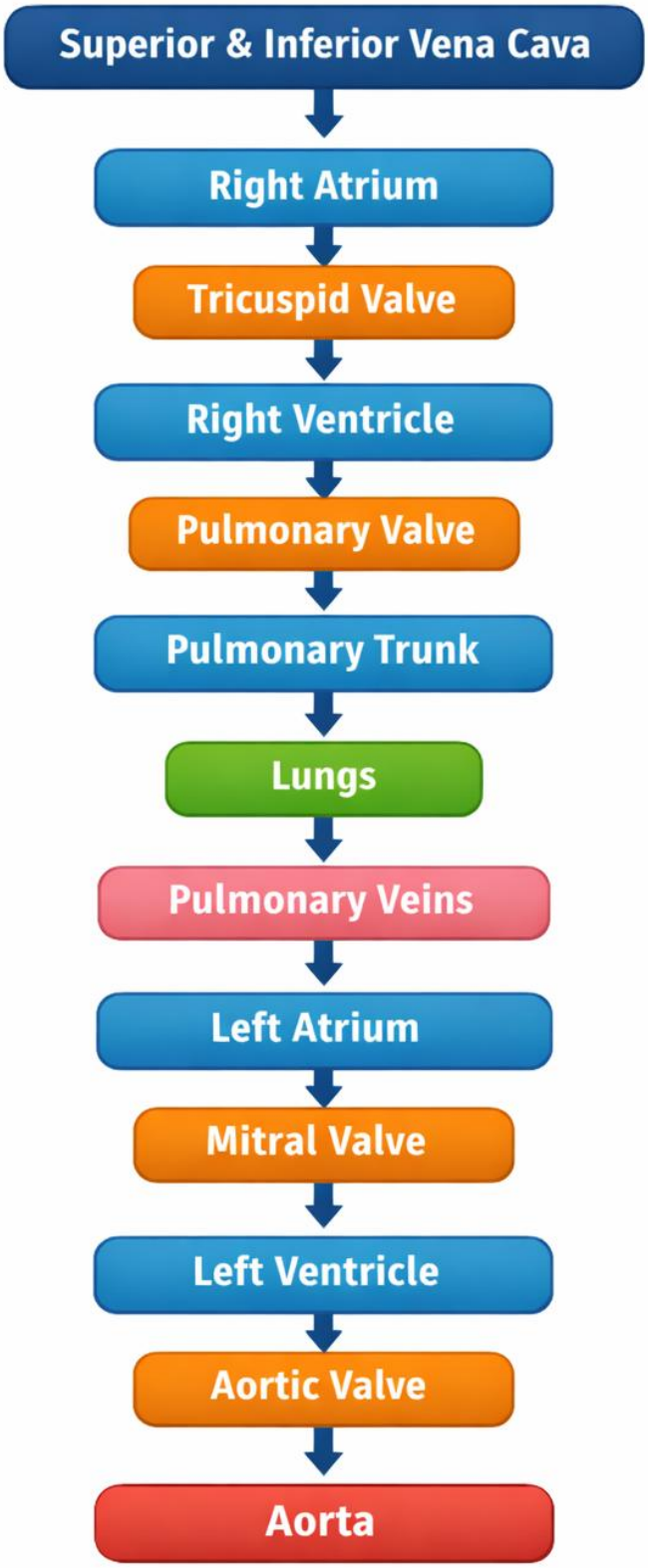
- Tricuspid valve (right)
- Bicuspid / Mitral valve (left)
- When ventricles are relaxed:
  - AV valves open
  - Blood flows from atria to ventricles
- When ventricles contract:
  - Papillary muscles contract
  - AV valves close

Semilunar Valves

- Half-moon shaped
- Types:
  - Aortic valve
  - Pulmonary valve
- Open when ventricular pressure > arterial pressure
- Close during ventricular relaxation to prevent backflow

BLOOD FLOW THROUGH HEART (START)

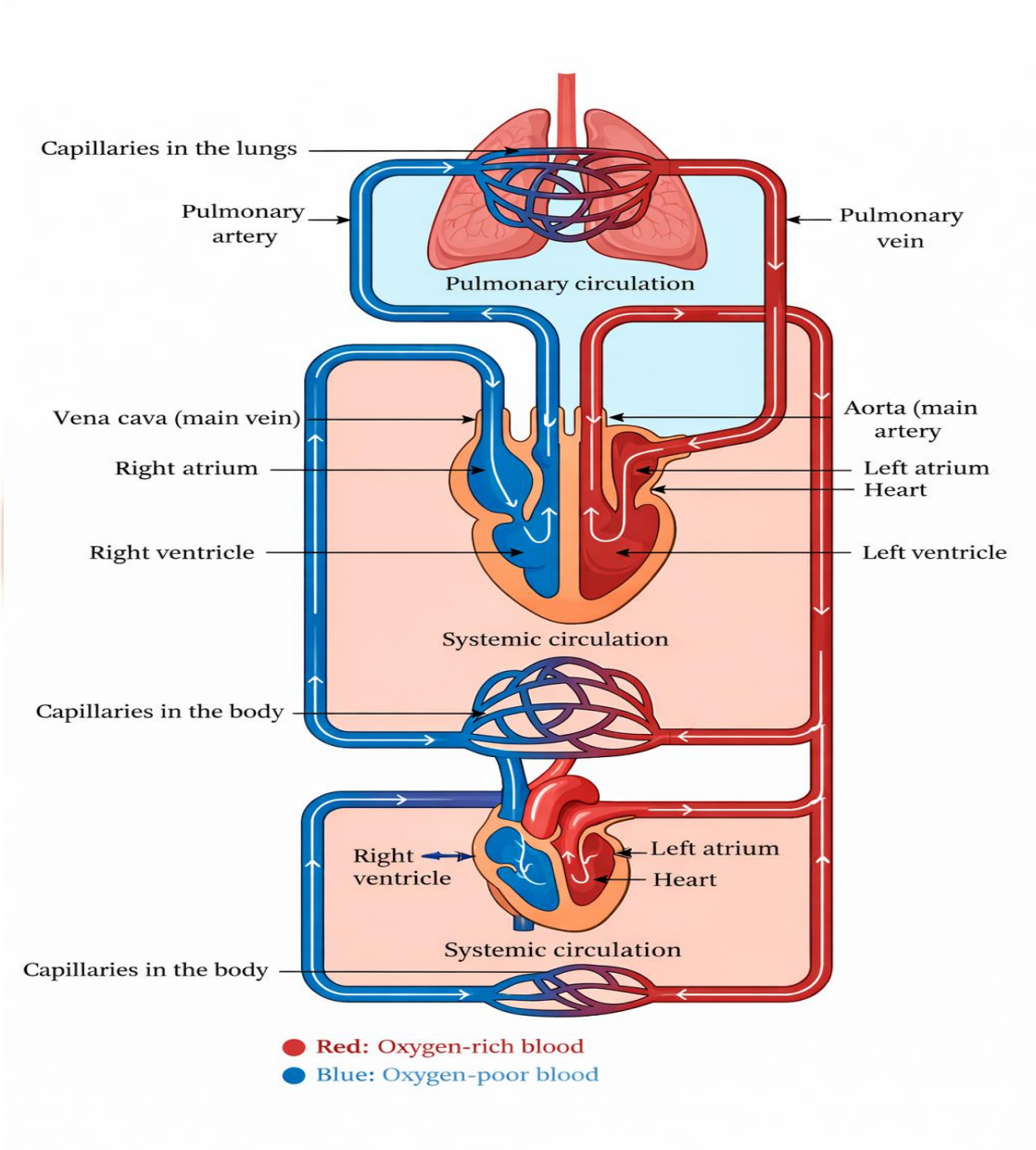

Superior vena cava
Aorta
Pulmonary artery
Pulmonary veins
Left atrium
Right atrium
Mitral valve
Pulmonary valve
Aortic valve
Left ventricle
Tricuspid valve
Right ventricle
Inferior vena cava


Superior & Inferior Vena Cava
Right Atrium
Tricuspid Valve
Right Ventricle
Pulmonary Valve
Pulmonary Trunk
Lungs
Pulmonary Veins
Left Atrium
Mitral Valve
Left Ventricle
Aortic Valve
Aorta

CIRCULATORY SYSTEMS

Two Closed Circuits

1. **Systemic circulation**
2. **Pulmonary circulation**



Systemic Circulation

- Pump: Left side of heart
- Oxygenated blood from lungs → left atrium
- Left ventricle ejects blood into aorta
- Supplies all body organs except lungs
- Deoxygenated blood returns to right atrium

Pulmonary Circulation

- Pump: Right side of heart
- Receives deoxygenated blood
- Right ventricle → pulmonary trunk → lungs
- CO_2 released, O_2 absorbed
- Oxygenated blood returns to left atrium

Coronary Circulation

- Supplies myocardium
- Coronary arteries arise from ascending aorta
- Receive ~5% of cardiac output
- Coronary veins → coronary sinus → right atrium

CONDUCTION SYSTEM OF THE HEART

Autorhythmicity

- The heart has an intrinsic property called **autorhythmicity**
- It can generate its **own electrical impulses**
- Heart can beat independently of nervous or hormonal control
- **Autorhythmic fibers** are self-excitable
- Even when removed from the body, the heart can continue beating for some time

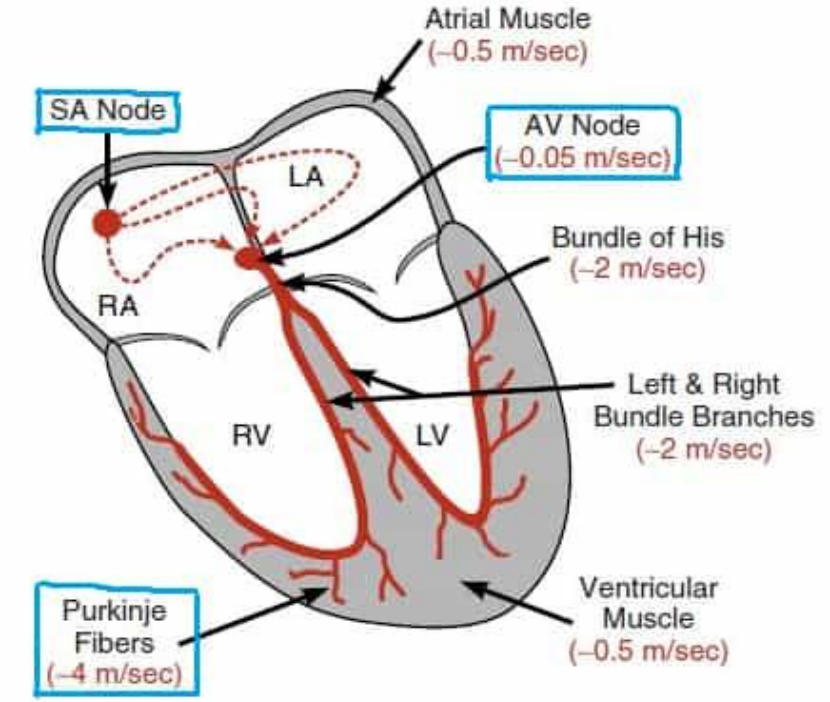
Neural and Hormonal Influence

- Heart is supplied by:
  - Sympathetic nerves (increase heart rate)
  - Parasympathetic nerves (decrease heart rate)
- Hormones affecting heart:
  - Adrenaline
  - Noradrenaline
  - Thyroxine

Function of Conduction System

- Ensures chambers contract in a **coordinated and synchronized manner**
- Makes the heart an **effective pump**
- Consists of specialized neuromuscular cells in myocardium

COMPONENTS OF CONDUCTION SYSTEM



1. Sinoatrial (SA) Node

- Small mass of specialized cells
- Located in the wall of **right atrium**
- Near opening of **superior vena cava**
- Generates impulses regularly:
  - **60–90 times/min**
- Shows spontaneous depolarization
- Acts as **pacemaker of the heart**
- Impulse spreads through both atria → atrial contraction

2. Atrioventricular (AV) Node

- Located in the **interatrial septum**
- Near atrioventricular valves
- Receives impulse from SA node after **0.1 sec delay**
- Delay allows atria to complete contraction
- Has **secondary pacemaker function**

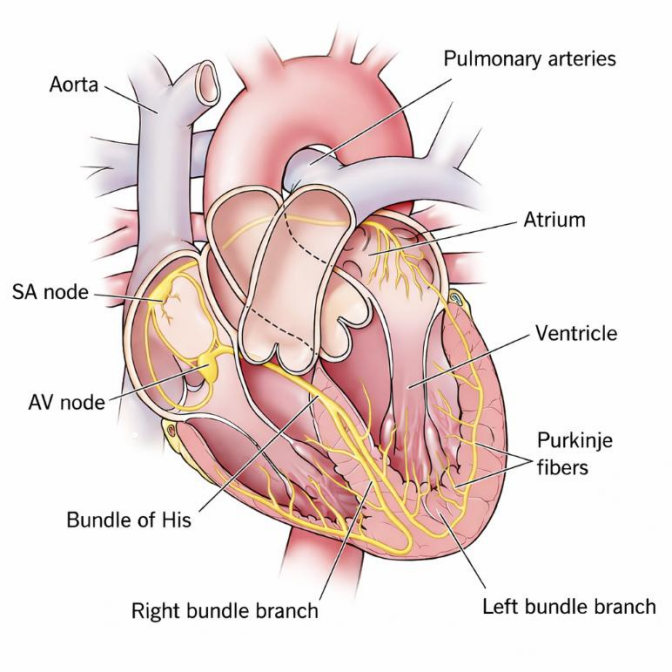
3. AV Bundle (Bundle of His)

- Originates from AV node

- Located at upper part of interventricular septum
- Divides into:
    - Right bundle branch
    - Left bundle branch

4. Purkinje Fibers

- Fine conducting fibers
- Spread throughout ventricular myocardium
- Conduct impulses from apex upwards
- Cause ventricular contraction
- Blood ejected through:
    - Pulmonary trunk
    - Aorta



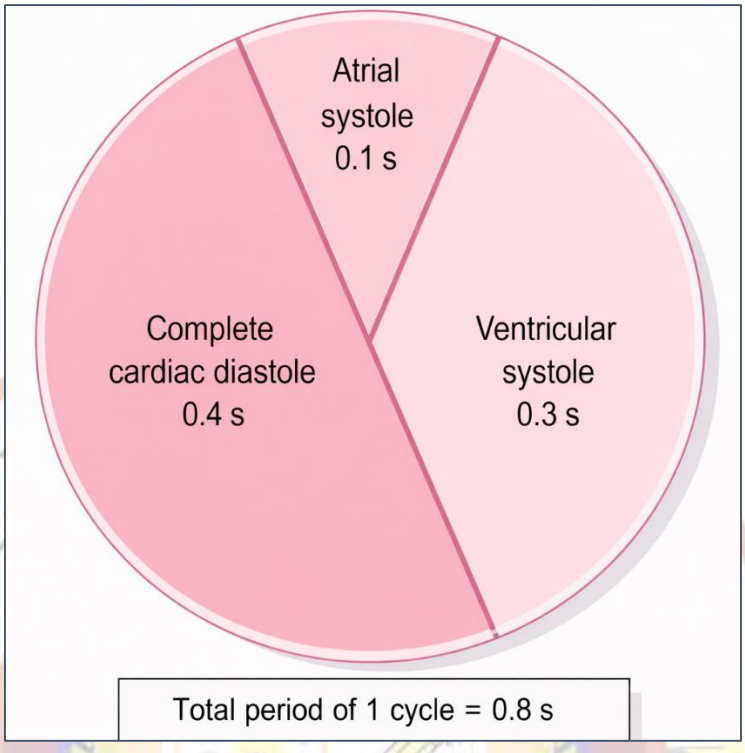
CARDIAC CYCLE

Definition

- Cardiac cycle includes all events occurring during one heartbeat

Duration

- At heart rate of 75 beats/min
- One cardiac cycle lasts **0.8 seconds**



Phases

1. Atrial systole
2. Ventricular systole
3. Complete cardiac diastole

Atrial Systole

- Duration: **0.1 sec**
- Atria contract, ventricles relaxed
- Pressure in atria increases
- AV valves open
- About **70% of ventricular filling** occurs
- ECG: **P wave**

Ventricular Systole

- Duration: **0.3 sec**
- Ventricles contract, atria relaxed
- Ventricular pressure increases
- AV valves close

- Semilunar valves open
- Blood ejected into:
  - Pulmonary trunk
  - Aorta
- ECG: **QRS complex**

Complete Cardiac Diastole

- Duration: **0.4 sec**
- Atria and ventricles relaxed
- Ventricular pressure decreases
- Semilunar valves close
- Ventricles refill
- ECG: **T wave**

HEART SOUNDS

Auscultation

- Listening to heart sounds using a **stethoscope**

Heart Sounds

- Four sounds are produced in one cardiac cycle
- Normally, only **first two sounds** are audible

First Heart Sound (S1 – "LUBB")

- Loud and long
- Caused by closure of **AV valves**
- Occurs at beginning of ventricular systole

Second Heart Sound (S2 – "DUPP")

- Short and sharp
- Caused by closure of **semilunar valves**
- Occurs at beginning of ventricular diastole

Third Heart Sound (S3)

- Due to rapid ventricular filling

Fourth Heart Sound (S4)

- Due to atrial systole

CARDIAC OUTPUT

Definition

- Volume of blood ejected by each ventricle per minute

Formula

Cardiac Output (CO) = Stroke Volume (SV) × Heart Rate (HR)

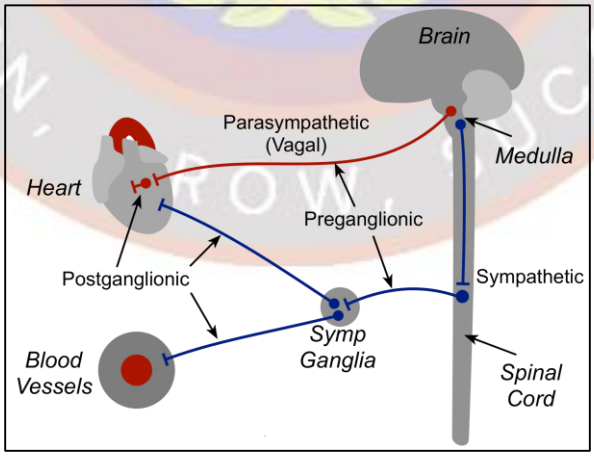
Normal Values

- SV = 70 ml/beat
- HR = 75 beats/min
- CO = 70 × 75 = **5250 ml/min**
- ≈ **5.25 L/min**
- Entire blood volume circulates every minute

REGULATION OF HEART RATE

Major Regulatory Mechanisms

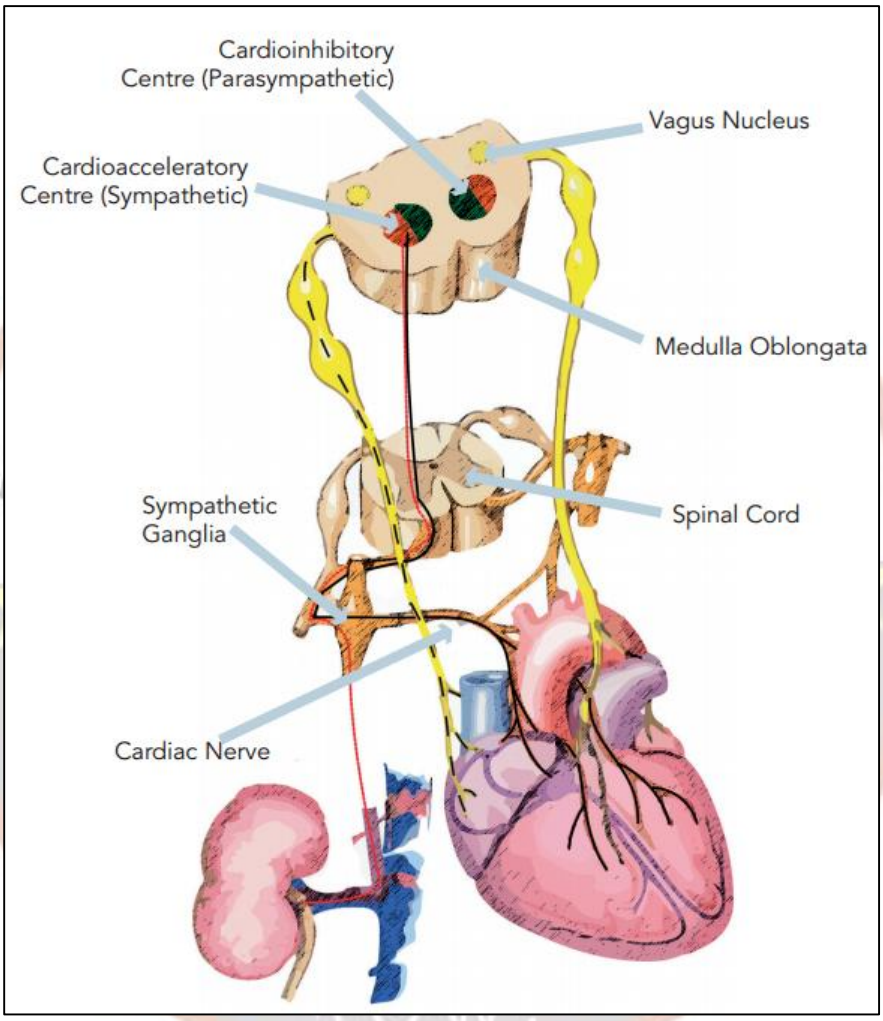
1. Autonomic nervous system
2. Hormonal regulation



Autonomic Regulation

- Controlled by cardiovascular center in **medulla oblongata**

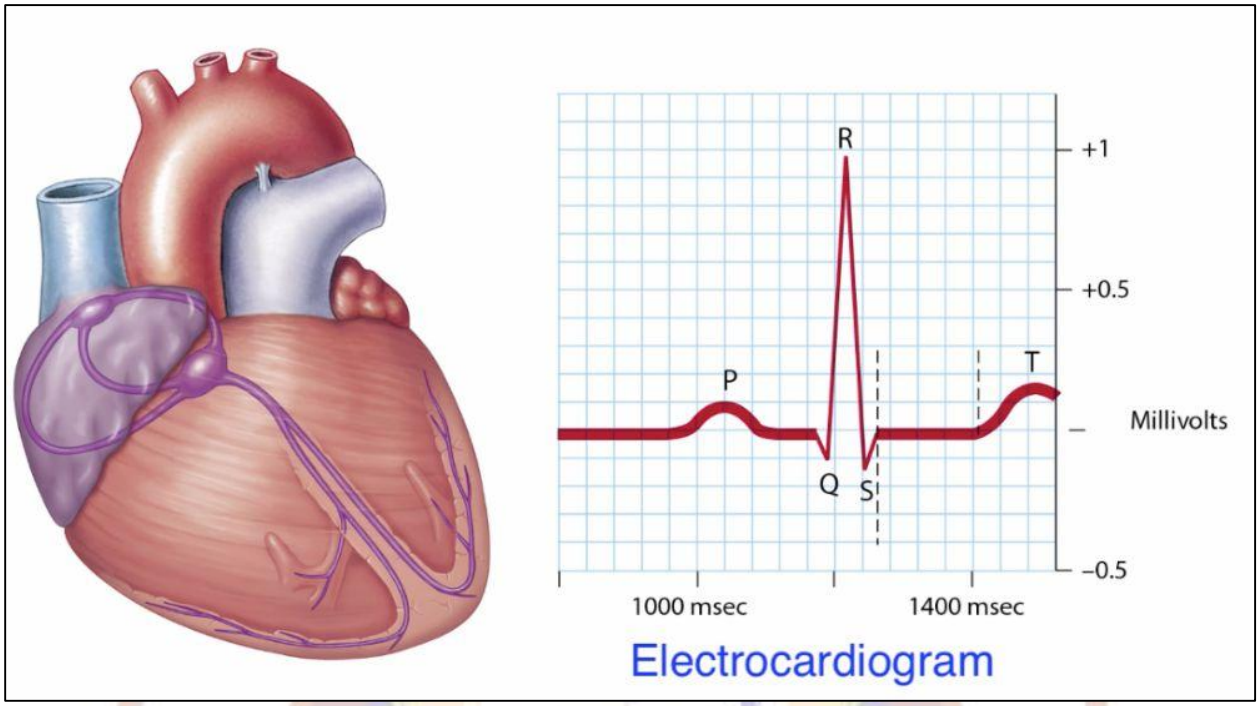
- Parasympathetic (Vagus nerve):
  - Decreases SA node firing
  - Decreases HR and force
- Sympathetic nerves:
  - Increase HR
  - Increase force of contraction



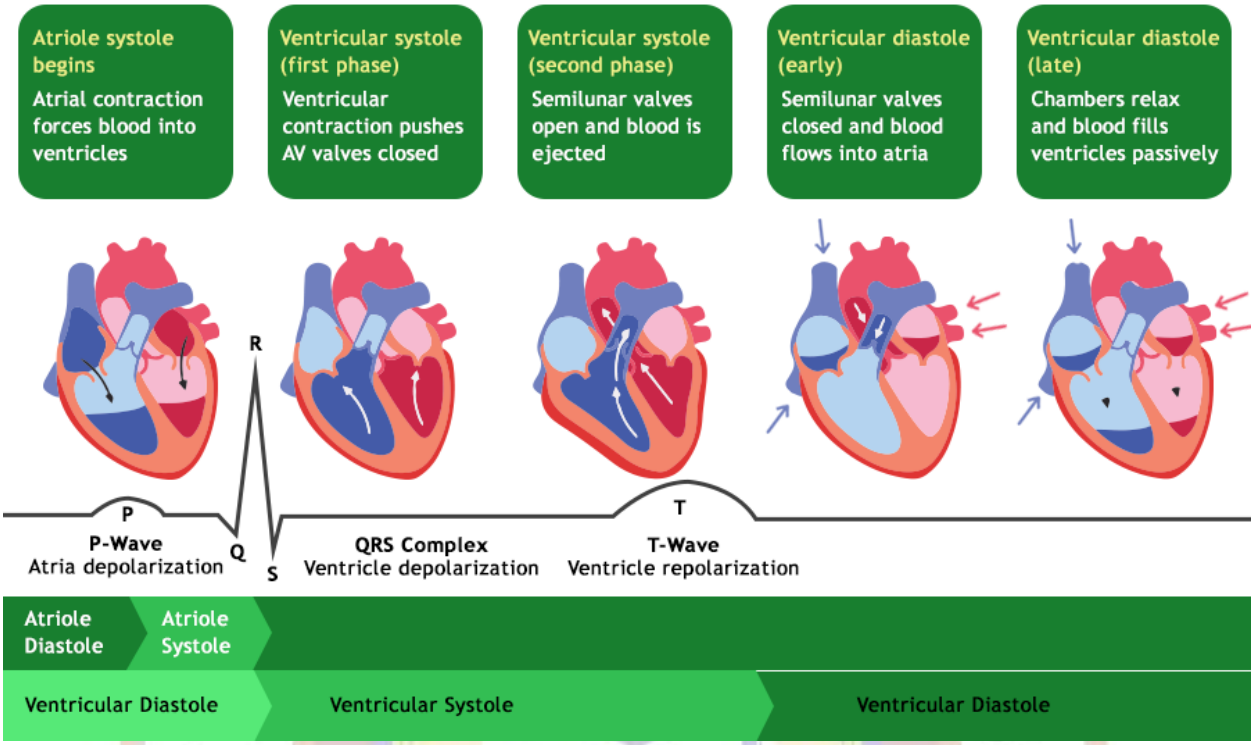
Factors Affecting Heart Rate

- Autonomic activity
- Circulating hormones
- Exercise
- Gender
- Age
- Temperature
- Baroreceptor reflex
- Emotional state

ELECTRICAL ACTIVITY OF HEART (ECG)



Electrocardiogram (ECG)



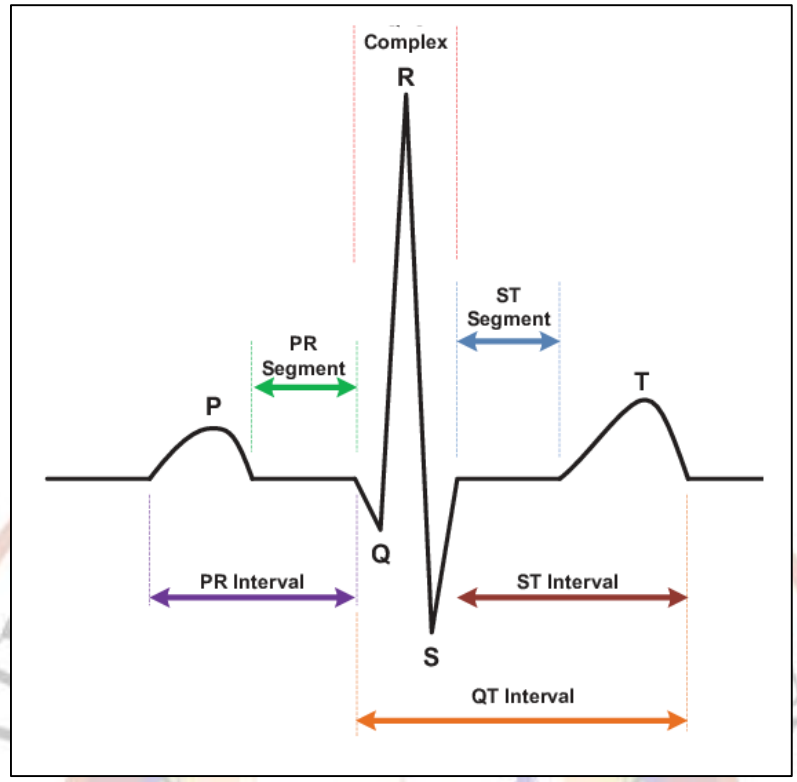
- Recording of electrical activity of heart
- Instrument used: **Electrocardiograph**
- Normal rhythm: **Sinus rhythm**
- Normal HR: 60–90 bpm
    - 100 bpm – Tachycardia
    - <60 bpm – Bradycardia

ECG Waves

1. **P wave** – atrial depolarization
2. **QRS complex** – ventricular depolarization
3. **T wave** – ventricular repolarization

ECG Intervals and Segments

- **PQ interval** – atrial to ventricular conduction time
- **ST segment** – ventricular depolarization plateau
- **QT interval** – ventricular depolarization + repolarization



Clinical Significance of ECG

- Detects:
  - Conduction abnormalities
  - Heart enlargement
  - Myocardial infarction
  - Cause of chest pain

BLOOD VESSELS

Blood vessels are tubular structures that transport blood throughout the body.

Types

1. Arteries
2. Arterioles
3. Capillaries
4. Venules
5. Veins

STRUCTURE OF BLOOD VESSELS

Tunica Interna

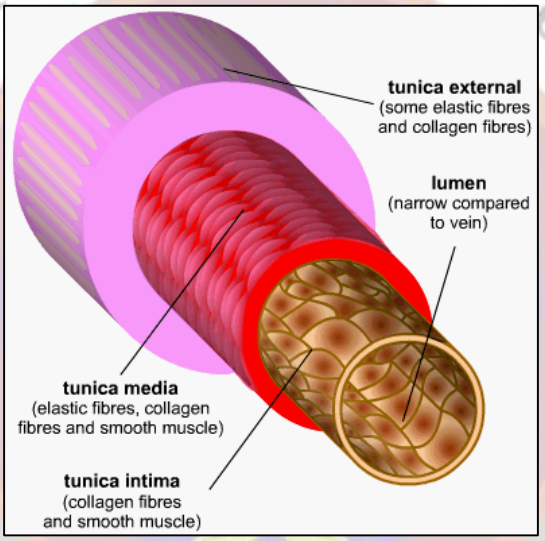
- Endothelium
- Basement membrane
- Internal elastic lamina

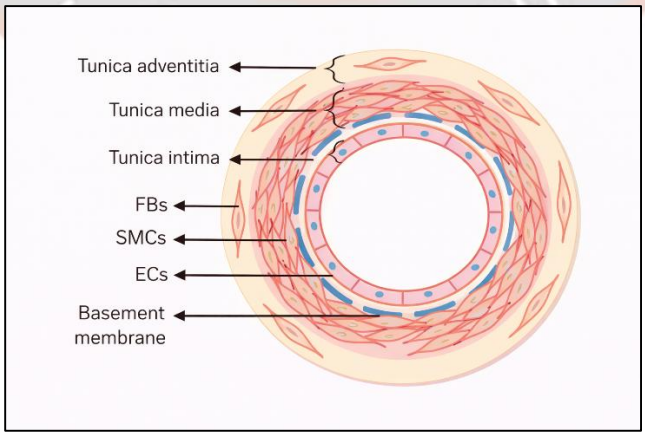
Tunica Media

- Smooth muscle
- Elastic fibers
- Regulates vessel diameter

Tunica Externa

- Collagen and elastic fibers
- Vasa vasorum present





ARTERIES

Elastic Arteries

- Large conducting arteries
- Example: Aorta
- Rich in elastic fibers
- Maintain continuous blood flow

Muscular Arteries

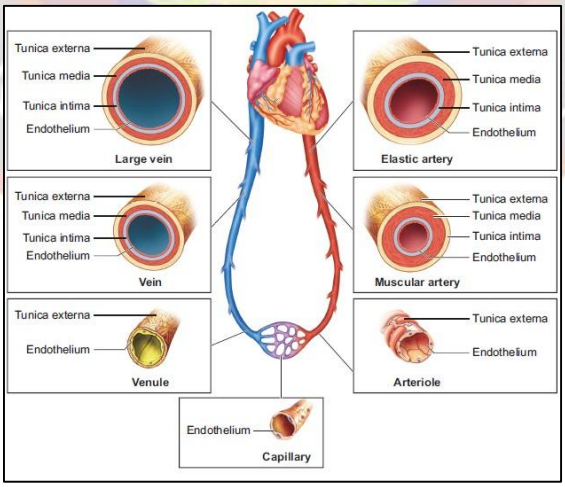
- Medium sized
- Rich in smooth muscle
- Control blood distribution
- Show vascular tone

ARTERIOLES

- Resistance vessels
- Regulate blood flow to capillaries
- Vasoconstriction → ↑ BP
- Vasodilation → ↓ BP

CAPILLARIES

- Smallest vessels (5–10 μm)
- Single endothelial layer
- Site of exchange



Types

1. Continuous
2. Fenestrated
3. Sinusoids

VEINS & VENULES

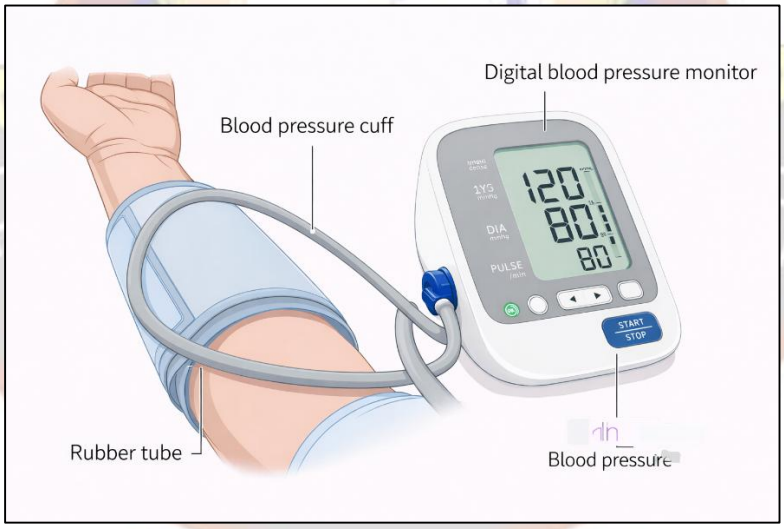
Venules

- Postcapillary venules
- Muscular venules

Veins

- Thin walls
- Large lumen
- Low pressure
- Valves present
- Capacitance vessels

BLOOD PRESSURE

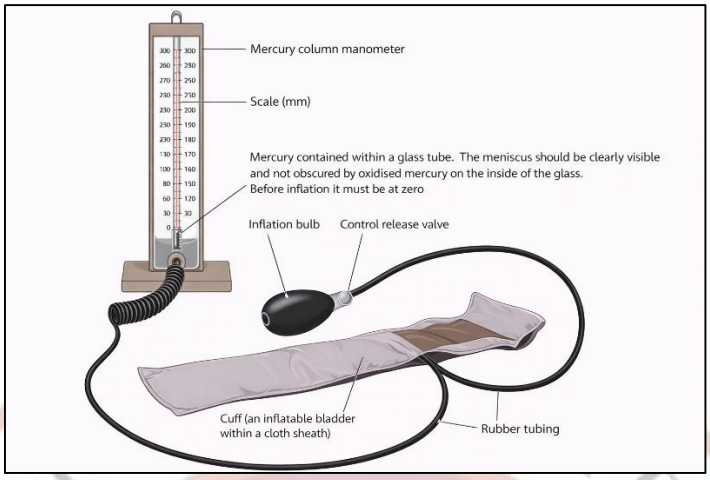


- Force exerted by blood on vessel walls
- Normal: **120/80 mmHg**

Determinants

- Cardiac output
- Blood volume
- Peripheral resistance

MEASUREMENT OF BP



- Instrument: **Sphygmomanometer**
- Sounds: **Korotkoff sounds**
- First sound – systolic BP
- Disappearance – diastolic BP

CONTROL OF BLOOD PRESSURE

Short-Term

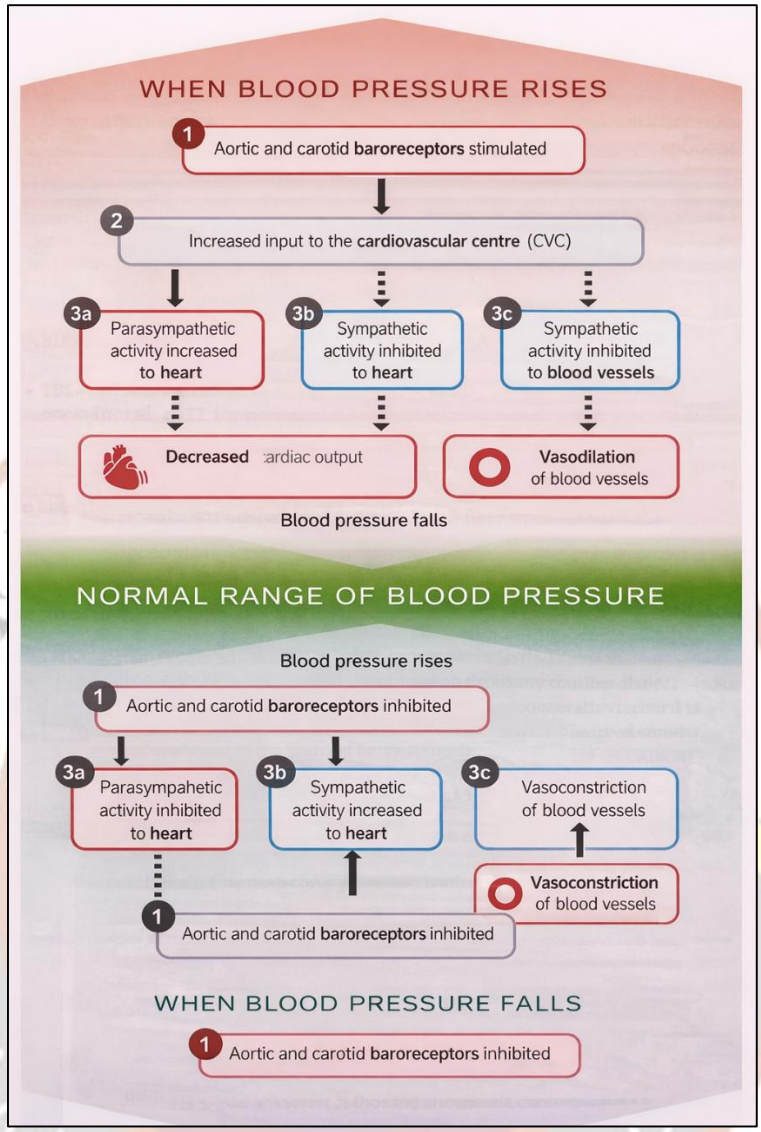
- Baroreceptors
- Chemoreceptors
- Cardiovascular center

Long-Term

- Kidneys
- RAAS
- ADH
- ANP

PULSE

- Pressure wave due to ventricular systole
- Normal: **60–80 bpm**



Pulse Points

- Radial
- Carotid
- Brachial
- Femoral
- Dorsalis pedis

Clinical Importance

- Indicates HR
- Rhythm

- Strength
- Tension