Circulatory Pathways

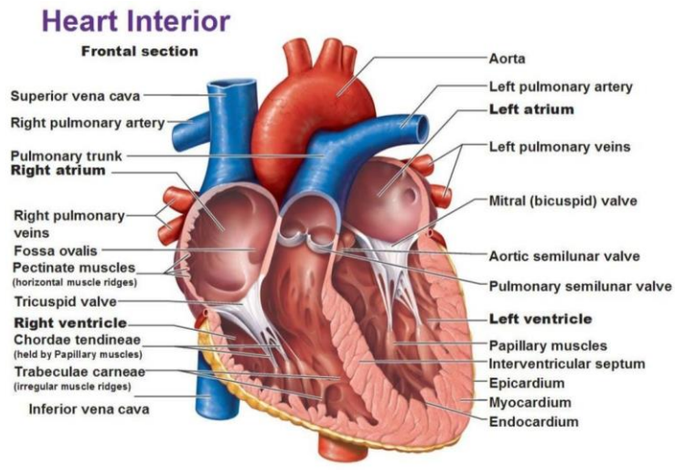
There are two types of circulatory systems:

1. **Open circulatory system:** Blood vessels are not found and blood is present in the open cavity known as sinuses, where internal organs float. Found in arthropods and molluscs.
2. **Closed circulatory system:** Blood vessels circulate the blood. Found in Annelids and Chordates.

Name	Type of Heart	Circulation
Fish	2 chambered, 1-atrium and 1-ventricle	Single circulation
Amphibian and Reptiles	3 chambered, 2-atrium and 1-ventricle	Incomplete double circulation
Crocodiles, Birds and Mammals	4 chambered, 2-atrium and 2-ventricle	Double circulation

Human Circulatory System

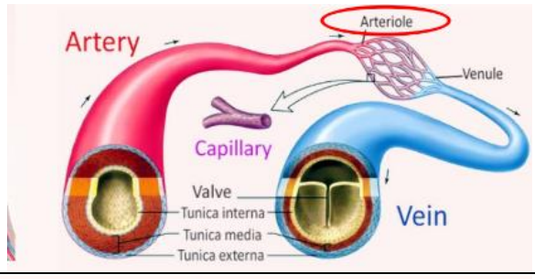
- **Heart- A** muscular organ that pumps the blood throughout the body.
- Derived from mesoderm. Located in mediastinum in thoracic cavity at level of T5-T8 vertebrae.
- Made up of cardiac muscles & Nodal Tissue
- Protected by double **pericardium** membrane filled with **pericardial fluid** (reduce friction).
- It is clenched Fist size & weights about 250-300gm.
- Human heart has 4 Chambers
  2- Auricles/Atrium (Separated by inter-atrial septum)
  2-Ventricles (Separated by inter-ventricular septum)
- **Valves**-Muscular flap like structure prevents the back flow of blood.
  Four Major Valves:
  1- **Semilunar Valve- (Left)-** Between Right Ventricle & Aorta
  2- **Semilunar Valve- (Right)-** Between Left Ventricle & Pulmonary artery
  Cuspid/Atrio-ventricular Valve
  3- **Bicuspid (mitral) valve-** Between left atrium & ventricle
  4- **Tricuspid valve** - between the right, atrium and ventricle
- Size- Left Ventricle>Right Ventricle > Left Auricles> Right Auricle
- **Foramen Ovale** -Aan opening between the two atria in the fetal heart.



- **Fossa Ovalis**- A remnant depression of foramen Ovale located in the interatrial septum of the heart.

Blood Vessels

Arteries	Veins	Capillaries
• Carry Blood away from the Heart. • Carry oxygenated Blood except pulmonary artery. • Blood flow with high pressure. • Present deep in the body. • Have thick wall & narrow lumen. • Do not contain any valve. • Divides into smaller branches called arterioles.	• Carry Blood towards the Heart. • Carry deoxygenated Blood except pulmonary vein. • Blood flow with low pressure. • Present towards surface in the body. • Have thin wall & broad lumen. • Contain valves (prevent backflow of blood). • Divides into smaller branches called venules.	• Facilitate the exchange of substances. • Carry both oxygenated and deoxygenated blood. • Blood flow with very low pressure. • Extensively distributed throughout tissues and organs. • Ver Thin walls (endothelium only) • Very Narrow lumen. • Lack valves. • Connect arterioles and venules, forming a network throughout the body.
Arteries and veins are made up of three layers 1. Inner **Tunica intima** – squamous endothelium 2. Middle **Tunica media** – elastic fibres and smooth muscles (thin in the veins) 3. Outer **Tunica externa** – fibrous connective tissue having collagen fibres		



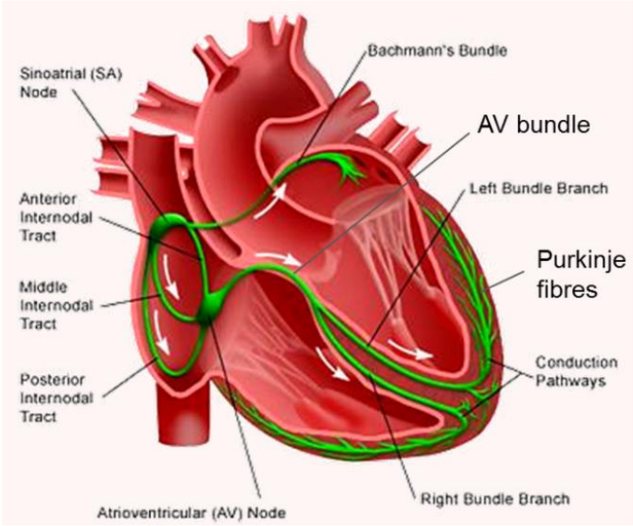
Conducting System of Heart

Nodal Tissue (musculature) is auto-excitable, i.e. it can generate action potential without any external stimuli

Sinoatrial Node (SA Node) also known as **PACE MAKER** as it initiates and maintains the heart's rhythmic activity. It is present on the upper right corner of the rightatrium that maintains contraction of heart by generating electric impulses/action potential (70-75/ min).

A**trioventricular Node (AV Node)** also know as **PACE SETTER** is present at the lower-left corner of the rightatrium receives impulse from SA Node and rapidly transmit it to all the parts of ventricles via Bundle of Hiss and Purkinje Fibres. Action Potential of AV Node I 60-65impulse/min.

- AV Node divides into right and left bundle which along with Purkinje fibres is called **Bundle of** His. It regulates heartbeat & conducts the



electrical impulses (40-45 impulse/min).

- The branches of bundle divides into minute fibres, present only in ventricle wall called **Purkinje fibres**

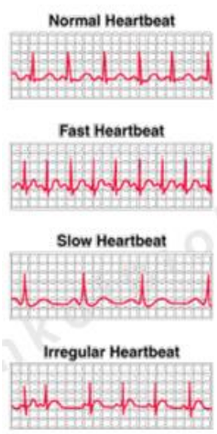
Cardiac Cycle

Total 0.8 Sec	**Atrial Sys.**	**Ventricle Systole (0.3 sec)**			**Joint Diastole (0.4 sec)**			
	0.1 Sec	0.1 Sec	0.1 Sec	0.1 Sec	0.1 Sec	0.1 Sec	0.1 Sec	0.1 Sec
Atrial	Systole	**Atrial Diastole (0.7sec)**						
Ventricle	Diastole	**Ventricle Systole (0.3 sec)**			**Ventricle Diastole (0.4sec)**			

Phase / Structure	Atrial systole	Early ventricular systole	Late ventricular systole	Early ventricular diastole	Late ventricular diastole
Atria	Contract	Relax		Relax	
Ventricles	Relax	Contract		Relax	
AV valves	Open	Closed		Open	
Semilunar valves	Closed	Open		Closed	

- **Stroke Volume** is the amount of blood each ventricle pumps in a cardiac cycle, i.e. 70 ml
- **Cardiac Output** -Total output of blood from each ventricle in a minute, i.e. no. of heart beats per minute, which is ~5 L in a healthy individual. The cardiac output varies from person to person. An athlete will have much more cardiac output compared to an ordinary person
- In each cardiac cycle, two distinct sounds are produced, ie. **'lub' and 'dub'**, which can be heard using a **Stethoscope.**
- The first sound '**lub'** is produced when bicuspid and tricuspid valves close at the time of ventricular systole
- The second sound **'dub'** is produced when semilunar valves close at the time of ventricular diastole.
- Blood pressure is the force exerted by blood against the walls of blood vessels. It's measured in millimeters of mercury (mmHg) using a device called a sphygmomanometer. Systolic blood pressure, the higher number, indicates the pressure when your heart contracts. Diastolic blood pressure, the lower number, shows the pressure when your heart relaxes.

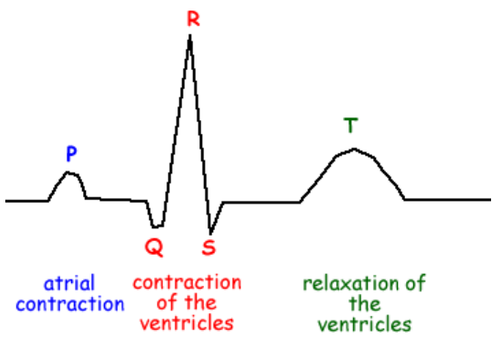
ECG



The electrical activity of the cardiac cycle can be recorded in a graphical form by electrocardiogram or ECG.
Various phases of each cardiac cycle are represented by a letter from P to T.

- **P wave** → excitation or depolarisation of atria
- **QRS complex** → depolarisation of ventricles
- **T wave** → repolarisation of ventricles (excited to normal)

The no. of QRS complex recorded in a time period tells the heart rate of the patient. Any abnormality or disease can bediagnosed by ECG if the graph shows any deviation from a regular pattern.



Deviation in ECG indicates abnormality or disease.

Double Circulation

The circulation in which blood flows through the heart twice for completing its circuit.

Pulmonary Circulation: The pulmonary artery receives deoxygenated blood and transports it to the lungs.

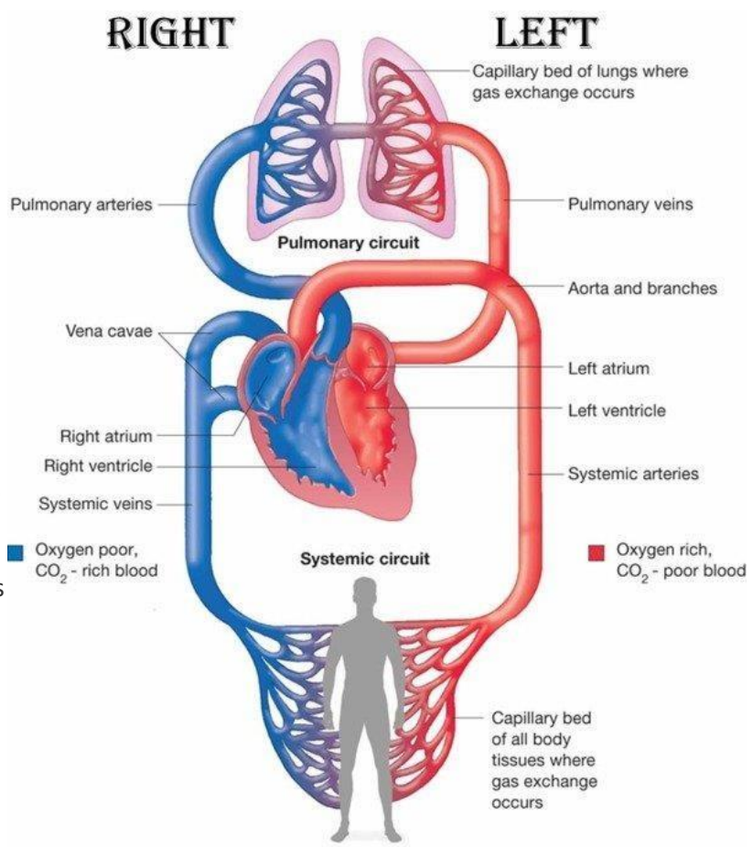
From the lungs, oxygenated blood is transported to the left atrium via the pulmonary vein.

Pulmonary artery – deoxygenated blood, Pulmonary vein – oxygenated blood.

Systemic Circulation: The oxygenated blood goes to the aorta from the left ventricle & gets transported to various tissues by arteries, arterioles and capillaries.

The deoxygenated blood from various parts of the body comes to the right atrium by the network of venules, veins andvena cava.

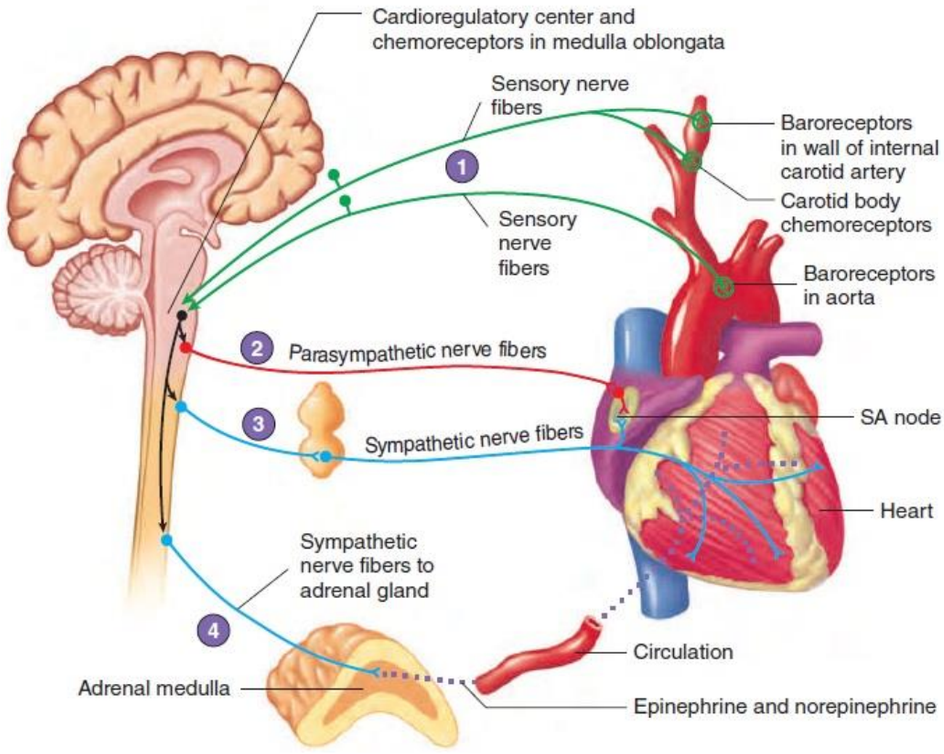
Hepatic Portal System: The vascular connection between the liver and digestive tract. The hepatic portal vein collectsintestinal blood and transports to the liver and then it goes to the systemic circulation.



Regulation of Cardiac Activity

The heart is **myogenic,** as its activity is regulated by nodal tissues.
The heart's function is moderated through **ANS (autonomic nervous system)** by a neural centre in the medulla oblongata.

1- **Baroreceptors** present in aortic arch and carotid artery sends the signal through sensory neuron to chemoreceptors in Medulla Oblongata (Cardio regulatory centre)
2- **Parasympathetic neural signals** – via Vagus Nerve carry signal to SA Node and release neuro transmitter Acetyl choline that decrease heart beat rate.
3- **Sympathetic neural signals** – via Acceleratory nerve carry signals to SA Node and release neurotransmitter Epinephrine & norepinephrine that increase heart beat rate and cardiac output.



Hormone Regulation

- Thyroxin released from thyroid gland increase Heart Beat rate.
- In emergency condition **Adrenalin & Nor-Adrenalin** released from Adrenal medulla increases Heart Beat Rate.

Disorders of the Circulatory System

1. **High Blood Pressure:** When blood pressure is more than normal blood pressure of a human being is 120/80 mm Hg
2. **Hypertension:**. High bp > 140/90 mm Hg for a longer duration. It may lead to various heart diseases and may also adversely affect the brain and kidneys.
3. **Coronary Artery Disease (CAD):** It is also referred to as atherosclerosis. It affects the supply of blood to the heart. The lumen of the arteries become narrower due to deposition of cholesterol, fat, calcium or fibrous tissues.
4. **Angina Pectoris:** The severe chest pain due to the scarcity of oxygen reaching the heart muscles, when there is interrupted blood flow.
5. **Heart Failure:** When the heart fails to pump enough blood to meet the requirement of the body. Lungs congestion is one of the symptoms of the disease.
6. **Heart attack:** When the heart muscle is suddenly damaged by an inadequate blood supply occurs, when a blood clot blocks one of the coronary arteries this can damage the heart muscle if not treated promptly. This can cause severe chest pain, shortness of breath, and other symptoms.
7. **Cardiac Arrest:** A condition where heart abruptly stops beating due to sudden electrical malfunction, leading to unconsciousness.
8. **Coronary Thrombosis:** It is a condition when there is a clot formation in the coronary artery. It happens frequently in theleft anterior descending coronary artery.

This occurs when a blood clot blocks The normal blood pressure of a human being is 120/80 mm Hg. 120 is the systolic pressure and 80 is the diastolic pressure one of the coronary arteries.