Human Physiology
(Body Fluids and Circulation)

1. INTRODUCTION

System which transports materials like nutrients, gases, hormones etc. to the various parts of the body and removes waste materials from the body cells is known as circulatory system.

- Study of **blood vessels** is called **angiology**.
- Father of angiology: **William Harvey**

2. TYPES OF CIRCULATORY SYSTEM

Circulatory system is of two types:

(A) Open circulatory system– In this system circulatory fluid flows in the body cavity without any special closed tubular system. Circulatory fluid is filled in spaces. Normally irregular spaces are called **haemocoel** and circulating fluid is called **haemolymph**. In this system, cells directly come in contact with haemolymph. e.g. **Arthropoda**, all **molluscs except Cephalopods.**

(B) Closed Circulatory system- In this circulatory system fluid flows in the closed tubes. These tubes are called **blood vessels**. Cells do not remain directly in contact with the blood. Closed blood circualtion is more effiecient. e.g. **Annelids (except leeches), Chordates (except Urochordata), Cephalopods (*Sepia, Octopus*).**

3. HUMAN CIRCULATORY SYSTEM

In human beings, **circulatory system is of two types –**

(A) Blood Vascular System:– In this system, circulatory fluid is blood. This system includes blood, blood vessels, and heart. This is found in higher invertebrates and all vertebrates.

(B) Lymphatic System:– In this system, circulatory fluid is lymph. This system includes lymph, lymphoid tissue and lymph vessels. It is found in higher vertebrates.

Cardiac Circuit

- In the **fishes**, Only deoxygenated blood flows in the heart. This type of heart is called "**venous heart**". In the fishes, only two chambers (one auricle and one ventricle) are present in the heart. In the fishes **single circulation** is present.
- In the **aves** and **mammals, Double blood circulation** is found.

4. DOUBLE CIRCULATION

The movement of blood follows double circulation (systemic and pulmonary circulation) and circulation through special regions.

Double Circulation

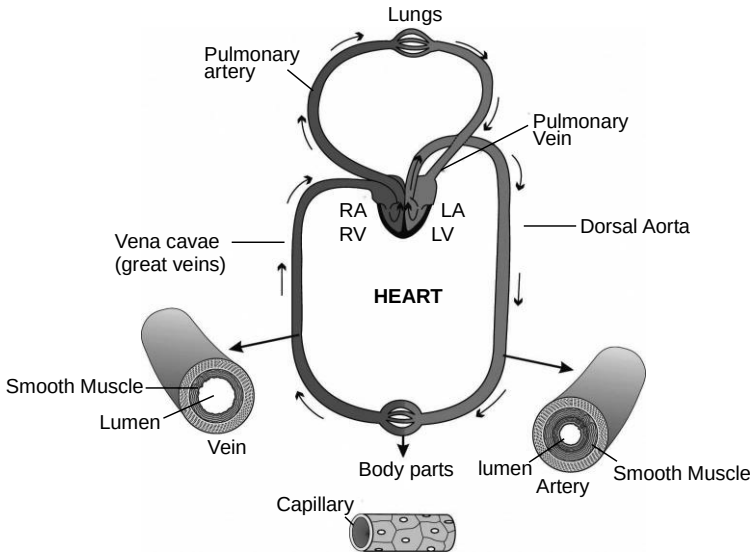
(i) Systemic Circulation – It involves the flow of oxygenated blood from the left ventricle to all parts of the body and deoxygenated blood from various body parts to the right atrium. It is also called systemic circulation.

- The systemic circulation starts from the left ventricle of the heart, passes to the aorta, to the arteries originating from it and to all their branches, then to the arterioles, capillaries, venules and the veins of the whole body and finally to the two vena cavae which enter the right atrium.

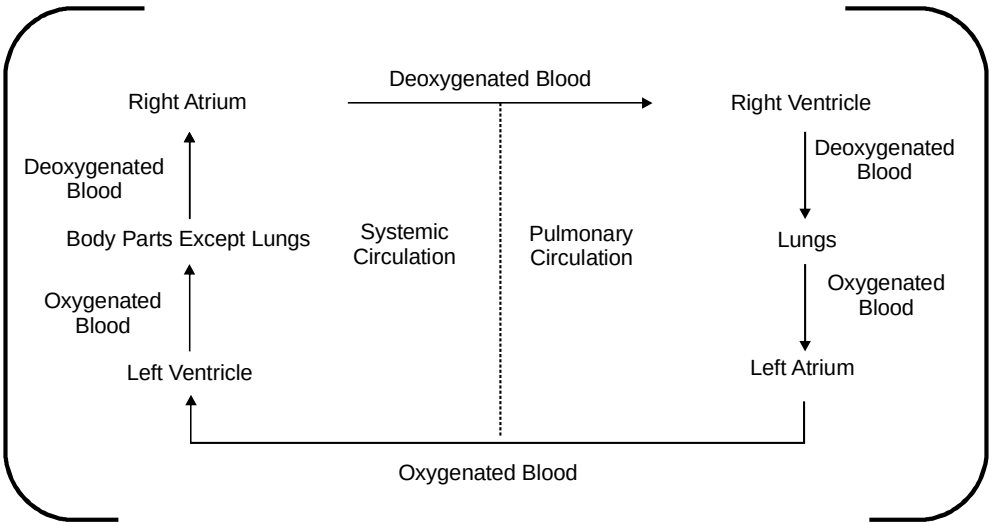
- As the systemic circulation supplies blood to most of the tissues of the body, it is also called the greater circulation or peripheral circulation. The systemic circulation carries oxygen and nutrients to body tissues and removes carbon dioxide and other wastes from the tissues.

(ii) Pulmonary Circulation – The flow of deoxygenated blood from the right ventricle to the lungs and the return of oxygenated blood from the lungs to the left atrium is called the pulmonary circulation.

- The pulmonary trunk arises from the right ventricle and then divides into the right and left pulmonary arteries which supply deoxygenated blood to the right and left lungs respectively.
- Two pulmonary veins from each lung transport the oxygenated blood to the left atrium. The systemic circulation and pulmonary circulation constitute the double circulation.
- The left side of the heart (left atrium and left ventricle) has oxygenated blood and is called **systemic heart**, and the right side of the heart (right atrium and right ventricle) has deoxygenated blood and is called **pulmonary heart**.



Schematic plan of blood circulation in human



5. BLOOD

Blood is a special connective tissue.

- About 5 litres of blood circulates in the body of an adult person.
- It is slightly alkaline fluid having pH 7.4.
- Blood consists of a watery fluid called **plasma** containing floating bodies termed **formed elements** of blood.

Plasma :

- Plasma is a straw coloured, viscous fluid constituting nearly 55 per cent of the blood. 90-92 per cent of plasma is water and proteins contribute 6-8 per cent of it.
- Factors for clotting of blood are also present in the plasma in an inactive form. Plasma without the clotting factors is called **serum**.

Plasma Proteins :

- Albumins, globulins and fibronogen are the important types of proteins present in the plasma. Most of the plasma proteins are synthesized by the hepatocytes or liver cells and include albumins, globulins and fibrinogen.
- Albumin and globulins retain water in blood plasma.
- Certain globulins called immunoglobulins (glycoproteins) act as antibodies.
- Prothrombin helps in blood clotting by changing soluble fibrinogen to insoluble fibrin.

Plasma Minerals: Plasma also contains small amount of minerals like Na^+, Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^-

Formed Elements

- The formed elements include blood corpuscles or blood cells and blood platelets or thrombocytes.
- The blood corpuscles are of two types: erythrocytes or red blood corpuscles (RBCs) and leucocytes or white blood corpuscles (WBCs).
- Nearly 45 percent volume of blood consists of formed elements.

(A) Erythrocytes (Red Blood Corpuscles or RBCs):

- They are the most abundant of all types of cells in the blood.
- Red blood corpuscles of all adult mammals are enucleated (non-nucleated), and lack cell organelles.
- They are biconcave and circular in shape. However, in **Camel and Lama,** RBCs are oval in shape.
- A healthy adult man has, on an **average 5 – 5.5 millions of RBCs /mm^3 of blood**.
- The total count of RBCs is more in man than in a woman. It is due to the fact that women undergo menstruation.
- An abnormal rise in RBC count is termed as **polycythemia**.
- Decrease in the number of RBCs is called **erythrocytopenia.**
- The decrease in RBC count causes oxygen shortage in the blood, which stimulates the release of the hormone, **erythropoietin** from the kidney cells into the blood. Erythropoietin stimulates the bone marrow to increase the production of RBCs.

- The RBCs contain a red coloured, iron containing complex protein called haemoglobin, hence the colour and name of these cells. 100 ml of blood of a normal man contains about 14-16 g of haemoglobin and of normal woman an average of 12-14 g haemoglobin.

Erythropoiesis:

The process of erythrocyte formation is called **erythropoiesis.**

- In the early few weeks of embryonic life, primitive nucleated RBCs are produced in yolk sac (one of the embryonic membranes).
- In later embryonic stage, RBCs are mainly produced in the liver and spleen.
- But from birth ownwards RBCs are produced in the bone marrow by the hematocytoblasts (erythrocyte forming cells).
- Iron and proteins are necessary raw materials for the synthesis of haemoglobin.
- Vitamin B_{12} and folic acid stimulate the maturation of RBCs. Deficiency of any these nutrients can cause anaemia.
- The RBCs have an average life span of 120 days after which they are destroyed in the spleen. There fore, spleen is called the graveyard of RBCs.
- The adult haemoglobin molecule is made of 2 alpha and 2 beta chains. Each alpha chain consists of 141 amino acids while each beta chain has 146 amino acids.

(B) Leucocytes (White Blood Corpuscles or WBCs) :

- The leucocytes are the most active and motile constituents of blood as well as lymph.
- They are colourless due to the lack of haemoglobin.
- They are nucleated and rounded or irregular in shape.
- They can change their shape like Amoeba and are thus, capable of amoeboid movement. This enables them to squeeze out of blood capillaries into the tissues. This process is called **diapedesis.**
- The leucocytes are relatively lesser in number. This varies from **6000-8000/mm^3 of blood** in adult humans.
- Rise in WBC count is termed **leucocytosis**.
- Increased TLC (total leucocytic count) shows acute bacterial infection or malignancies like **leukemia** (blood cancer).
- Fall in WBC count is called **leukopenia.**

The leucocyets are of two main types : Granulocytes and **Agranulocytes**

(i) Granulocytes : They contain granules in the cytoplasm and irregularly lobed nucleus. Based on their staining property, the **granulocytes are divided into three types.**

(a) Eosinophils

- They are characterised by a bilobed nucleus.
- They contain numerous coarse granules that are stained bright red with acidic dye (e.g. eosin).
- The proportion of eosinophils is **2-3 per cent**.
- They resist infections and are also associated with **allergic reactions.**

(b) Basophils

- ❖ They have two to three lobed nucleus.
- ❖ Basophils contain fewer coarse granules, which can be stained with basic dyes, (e.g. methylene blue).
- ❖ They are the least **(0.5-1.0per cent)** among WBCs. Basophils secrete histamine, serotonin and heparin and are involved in **inflammatory reactions.**

(c) Neutrophils

- ❖ They have **two to seven** lobed nucleus.
- ❖ Neutrophils do not take colour when exposed to acidic as well as basic dyes.
- ❖ They are the most abundant **(60-65 per cent)** of the WBCs.
- ❖ Certain neutrophils in female mammals possess a small spherical lobe attached to their nucleus by a stalk. This lobe is called **drum stick (= sex chromatin) or Barr body.**
- ❖ Neutrophils are **phagocytic cells** which destroy foreign organisms entering the body.

(ii) Agranulocytes : They lack granules in their cytoplasm.

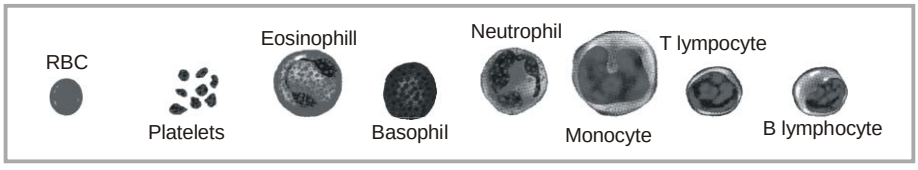
Agranulocytes are of two types.

(a) Lymphocytes:

- ❖ They are smaller in size with large rounded nucleus.
- ❖ They possess scanty pale blue cytoplasm.
- ❖ They about **20-25 per cent of the total WBCs**.
- ❖ They produce serum immunoglobulins (antibodies) to destroy microbes and their toxins, reject graft and kill tumour cells.
- ❖ **Lymphocytes occur in two major types-B lymphocytes** (B- cells) and **T-lymphocytes** (T-cells). Both are responsible for **immune responses** of the body.

(b) Monocytes:

- ❖ They are the largest of all types of WBCs and somewhat amoeboid in shape.
- ❖ They have kidney shaped nucleus.
- ❖ Monocytes constitute **6-8 per cent** of total WBCs.
- ❖ They are motile and **phagocytic** in nature and engulf bacteria and cellular debris.
- ❖ Generally they change into macrophages after entering tissue spaces.



Diagrammatic representation of formed elements in blood

Leucopoeisis:

- ❖ The process of formation of leucocytes is called.**leucopoeisis**.
- ❖ The granulocytes and monocytes are formed in bone marrow.
- ❖ Lymphocytes are produced mainly in lymph nodes, spleen, thymus, tonsils, bone marrow and Peyer's patches of small intestine.

(C) Thrombocytes (Blood Platelets) :

- ❖ They are flat and non-nucleated irregular fragments of the cells rather than the cells.

- Thrombocytes are fewer than the RBCs and more than the WBCs in number.
- There are about **1,500,00 - 3,500,00 platelets/mm^3 of the blood.**
- Platelets are formed from the megakaryocytes (special cells in the bone marrow).
- Formation of thrombocytes is called thrombopoiesis.
- The normal life span of blood platelet is about a week.
- Platelets can release a variety of substances called platelet factors (e.g., thromboplastin) most of which are involved in the **coagulation of blood.**
- A reduction in the number of platelets **(thrombocytopenia)** can lead to clotting disorders which lead to excessive loss of blood from the body.

HAEMOPOIESIS :

The process of formation of blood is called haemopoiesis and the tissues which form blood are termed haemopoietic tissues.

- In mammals, yolk sac (one of the embryonic membranes), liver, bone marrow, lymph nodes, spleen and thymus are the haemopoietic organs in the embryo.
- In adult humans, most of the blood corpuscles are formed in the **red bone marrow** of long bones.

SUMMARY OF HUMAN BLOOD CORPUSCLES

	Type and number of Corpuscle	Characters	Formation and Life span	Functions
1	Erythrocytes (RBCs) 5-5.5 million in males and 4.5–5 million in females. Number increases during exercise and at high altitudes.	Circular, biconcave, enucleated, have elastic plasma membrane and homogenous cytoplasm with haemoglobin, cell organelles absent. 7–8 µm wide, 1 – 2 µm thick	By yolk sac in the early few weeks of embryonic life, in later embryonic stage by the liver and spleen, from birth onwards by bone marrow, life span 120 days.	Transport of oxygen and some amount of carbon dioxide.
2	Leucocyets (WBCs) 6000-8000/mm3. Number in increases during infection	Colourless, rounded or irregular, nucleated 12-20 µm wide.	Bone marow, lymph nodes, spleen, thymus, tonsils and Peyer's Patches.	Act as soldiers, scavengers, some help in healing.
	(i) Granulocytes	Cytoplasm has granules, nucleus lobed.		
	(a) Eosinophils 2–3% of leucocytes	Bilobed nucleus, coarse granules in cytoplasm, take acidic stain.	Bone marrow, life 4 to 8 hours in the blood, 4 to 5 days in the tissue	Resist infections, associated with allergic reactions.
	(b) Basophils 0.5–1.0% of leucocytes.	Two to three lobed nucleus, fewer number of coarse granules, take basic stain.	Bone marrow, life 4 to 8 hours in the blood, 4 to 5 days in the tissues	Release histamine, serotonin and heparin, involved in inflammatory reactions.
	(c) Neutrophils 60–65% of leucocytes.	Two to seven lobed nucleus, fine granules, do not take acidic as well as basic stains.	Bone marrow, life 4 to 8 hours in the blood, 4 to 5 days in the tissue	Phagocytic, engulf germs and dead cells.

	(ii) Agranulocytes	Cytoplasm lacks granules, nucleus not lobed.		
	(a) Lymphocytes 20–25% of leucocytes.	Large rounded mucleus, scanty cytoplasm.	Bone marrow and Thymus, life few hours to many years.	Motile, non-phagocytic, secrete antibodies, help in healing.
	(b) Monocytes 6–8% of leucocytes	Largest of all types of leucocytes, nucleus bean shaped, enough cytoplasm.	Bone marrow life 10 to 20 hours.	Motile, phagocytic, engulf germs and cell debris, often change into macrophages.
3	Thrombocytes (Platelets) 1,500,00-3,500,00	Irregular, non-nucleated fragments of cells	Bone marrow, life about a week.	Release platelet factors, involved in blood clotting.

BLOOD GROUPS:

Human beings have more than 30 types of antigens on the surface of blood cells. They give rise to different types of blood groups.

- Two such groups blood ABO and Rh are widely used all over the world.

(A) ABO Blood Groups:

- **Karl Landsteiner** (1900) reported first time ABO blood groups in human beings. He discovered A, B and O blood groups.
- While AB blood group was reproted by ***de*** **Castello and Sturli** (1902).
- ABO grouping is based on the **presence or absence of two surface antigens** (chemicals that can induce immune response) namely A and B on the RBCs. Similarly, the plasma of different individuals contains two natural antibodies (proteins produced in response to antigens).
- The distribution of antigens and antibodies four blood groups is given below in the table.

Blood Groups and Donor Compatibility				
Blood Group	**Antigen on RBCs**	**Antibodies in Plasma**	**Donor's Group (Can get blood from)**	**Recipient's Group (can give blood to)**
A	A	anti-B	A, O	A, AB
B	B	anti-A	B, O	B, AB
AB	A, B	None	A, B, AB, O	AB
O	None	anti A, B	O	A, B, AB, O

- During blood transfusion, any blood can not be used. The blood of a donor has to be carefully matched with the blood of a recipient before blood transfusion, to avoid severe problems of clumping (destruction of RBC).
- The group O blood can be donated to persons with any other blood group. Therefore, the individuals with blood group O are called **'universal donors'.**
- Persons with AB group can accept blood from persons with any group of blood. Therefore, such persons are called **'universal recipients'.**

(B) Rh (Rhesus) blood groups :

- **Landsteiner and Weiner** (1940) discovered another antigen on the surface of red blood corpuscles of rhesus monkey and many human beings. They called it as Rh factor or Rh-antigen.
- Depending on the race, 80 to 99 percent of humans possess this factor and are Rh positive (Rh+). Others who do not have this factor are known as Rh negative (Rh^-).
- The formation of Rh protein is controlled by a dominant gene, which may be designated as R. Thus, RR (homozygous dominant) and Rr (heterozygous) individuals are Rh positive, and rr (homozygous recessive) individuals are Rh negative.
- Phenotypically, Rh positive and Rh negative individuals are normal. The problem arises when an Rh -ve person, is exposed to Rh + ve blood during blood transfusion or pregnancy.

  (i) Incompatibility during blood transfusion: The first transfusion of Rh^+ blood into the person with Rh^- blood causes no harm. However, the recipient starts preparing antibodies (anti Rh factor) against Rh antigen in his/her blood. If the recipient person receives Rh^+ blood second time, the anti Rh factor present in his/her blood attacks and destroy red blood corpuscles of the received blood.

  (ii) Incompatibility during pregnancy

- A special case of Rh incompatibility (mismatching) has been observed between the **Rh^- blood of a pregnant mother and Rh+ blood of the foetus.** The Rh antigens of the foetus do not get exposed to the Rh- blood of the mother in the first pregnancy as the two bloods are well separated by the placenta. However, during the delivery of the first child, there is a possibility of exposure of the maternal blood to the Rh^+ blood from the foetus.
- In such cases, the mother starts preparing antibodies (anti-Rh factor) against Rh antigen in her blood. In case of her subsequent pregnancies, the Rh antibodies from the maternal (Rh^-) blood can leak into the blood of foetus (Rh^+) and destroy the foetal RBCs.
- This could be fatal to the foetus or could cause severe anaemia and jaundice in the baby, i.e., the haemolytic disease of the new born (HDN). This condition is called **erythroblastosis foetalis** (destruction of the erythrocytes of foetus). This can be avoided by administering **anti-Rh antibodies** to the mother immediately after the delivery of the first child.

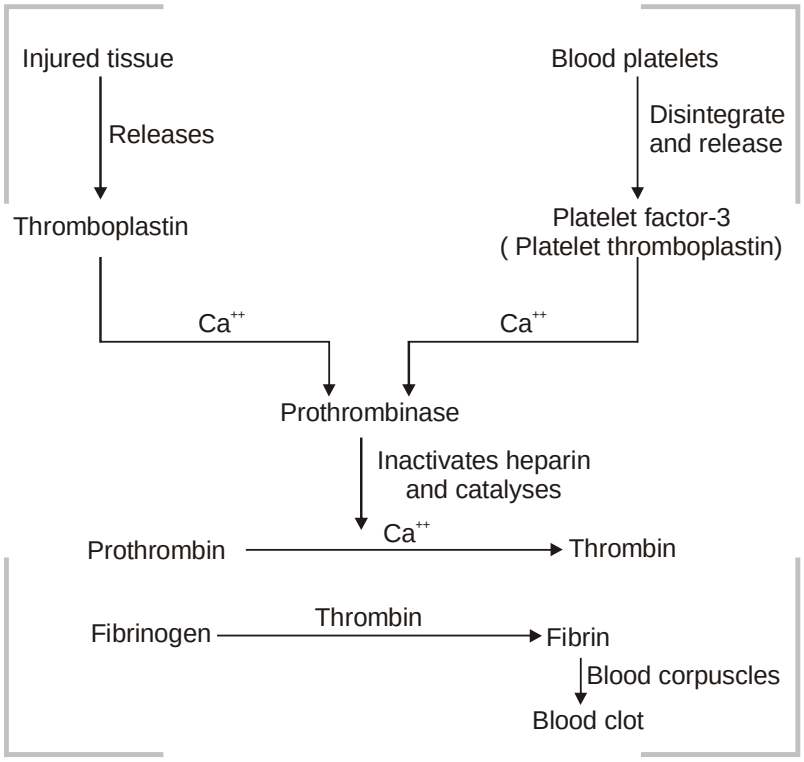
BLOOD COAGULATION, BLOOD CLOTTING OR HAEMOSTASIS

- When an injury is caused, the wound does not continue to bleed for a long time. Usually the blood stops flowing outside after sometime due to blood coagulation or blood clotting. This is a mechanism to prevent excessive loss of blood from the body.
- Inside an intact blood vessel, blood does not coagulate due to the presence of active anticoagulants, heparin and antithrombins. Procoagulants also occur in the blood but are in an inactive state.
- As soon as a blood vessel is ruptured, the injured area initiates the formation of a clot. Procoagulants become active, overcome anticoagulants and cause blood coagulation.
- The process of coagulation can be described in three major steps.

  (i) At the site of an injury, the blood platelets disintegrate and release a phospholipid, called platelet factor-3(platelet thromboplastin). Injured tissue also release a lipoprotein factor called thromboplastin. These two factors combine with calcium ions (Ca^{2+}) and certain proteins of blood plasma to form an enzyme called prothrombinase.

(ii) In presence of Ca^{2+}, the prothrombinase inactivates heparin (or antiprothrombin-anticoagulant). Prothrombinase also catalyses the conversion of prothrombin (an inactive plasma proetin) into an active protein called thrombin and some small peptide fragments.

(iii) Thrombin acts as an enzyme and first causes depolymerization of fibrinogen (a soluble plasma protein) into its monomers. Later thrombin stimulates repolymerization of these monomers into long insoluble fibre like polymers called **fibrin.** The thin long and solid fibres of fibrin form a dense network upon the wound and trap blood corpuscles and platelets to form a clot. The clot seals the wound and checks the bleeding. A clot is formed at the wound in about 2-8 minutes after injury. Soon after, the clot starts contracting (clot retraction) and a pale yellow fluid called serum, starts oozing out from it. This serum is blood minus the corpuscles and blood coagulation factors (e.g. fibrinogens).



Role of Vitamin K in blood clotting. Vitamin K is necessary for the synthesis of prothrombin in the liver. When vitamin K is not sufficient in the body, blood clotting becomes inefficient.

Cascade Theory of blood clotting. This theory of blood coagulation was putforth by **Macferlane**. According to this theory, 13 factors are required for blood clotting. The factors operate in a **cascade** manner in which the activated form of a factor catalyses the activation of the next factor.

Clotting factors present in human blood and their synonyms			
Clootting Factor	**Synonyms**	**Source**	**Pathways of Activation**
I	Fibrinogen	Liver	Common

II	Prothrombin	Liver	Common
III	Thromboplastin	Damaged tissue and activated platelets	Extrinsic
IV	Calcium	Diet, bones, and platelets	All
V	Proaccelerin, Labile factor, Accelerator globin (Ac-globin)	Liver and platlets	Extrinsic and intrinsic
VI	Proconvertin (Serum Prothrombin Conversion Accelerator or SPCA)	Liver	Extrinsic
VII	Antihaemophilic factor (AHF).	Liver	Intrinsic
VIII	Plasma thromboplastin component (PTC), Christmas factor, Antihaemophilic factor B	Liver	Intrinsic
IX	Stuart Power factor, thrombokinase	Liver	Extrinsic and intrinsic
X	Plasma thromboplastin antecedent (PTA), Antihaemophilic factor C.	Liver	Intrinsic
XI	Hagemen factor, Glass factor	Liver	Intrinsic
XII	Fibrin stabilizing factor (FSF), Loki Lorand factor.	Liver and platlets	Common

Functions of blood : Blood serves following functions in the body

(i) It transports O_2 from the respiratory organs to the tissues and CO_2 from the tissues to the respiratory organs.

(ii) It transports the digested food from the alimentary canal to the different body tissue cells.

(iii) Hormones are carried by blood from the endocrine glands to the target organ.

(iv) It transports excretory matter to the kidneys or other excretory organs.

(v) It allows the transfer of heat from the deeper tissues to surface of the bodywhere it can be lost.

(vi) Some leucocytes are phagocytic in nature, and certain leucocytes produce antitoxins to neutralize the toxins released by the foreign germs.

(vii) It maintains the body temperature to a constant level after distributing heat within the body.

(viii) The clotting factors present in the blood plasma prevent loss of blood from the site of injury due to the formation of clot.

Test your Resonance with concept

1. Mammals are said to have a "double circulatory system". This means
(1) That the blood vessels are paired
(2) That there are two types of blood vessels attached to every organ– an artery and a vein
(3) That there are two systems– one from the heart to the lungs and back to the heart and the other from the heart to the tissues and back to the heart
(4) That the blood circulates with double the normal speed

2. An open circulatory system occurs in
(1) Man (2) Reptiles (3) Earthworm (4) Insects

3. If blood cells and platlets are eliminated from the blood, the fluid matrix left is
(1) Serum (2) Plasma (3) Lymph (4) Synovial fluid

4. Which of these has a closed type of circulatory system?
(1) Cockroach (2) Fish (3) Molluscs (4) Scorpion

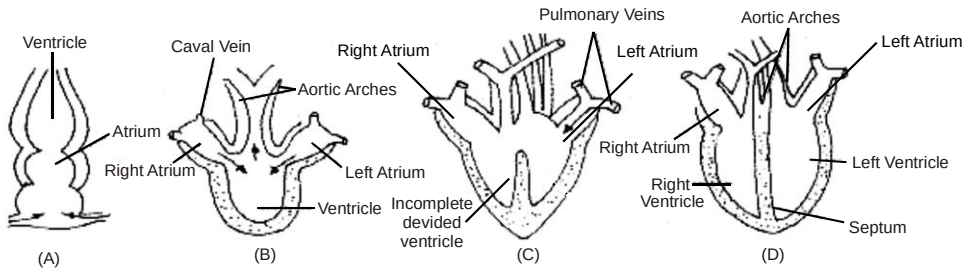
5. Single circuit heart occurs in
(1) Fishes (2) Frogs (3) Reptiles (4) Man

Answers

1. (3) **2.** (4) **3.** (2) **4.** (2) **5.** (1)

6. HEART

- Study of Heart **Cardiology**. (Karadia– heart, logos– study)
- Heart is a thick, muscular, contractile, autonomic **pumping organ** of blood vascular system.
- Vetebrates have a **single heart**. It is hollow, muscular organ composed of cardiac muscle fibres.
- Heart is divided into inter communiating cambers. The number of chambers is different in different groups of vertebrates.



Hearts of different vertebrates A – Fish; B – Amphibian; C – Reptilian; D – Mammalian

Group	No. of chambers in the heart	Name of chambers in the heart
Fishes	2	1 auricles + 1 ventricle
Amphibians	3	2 auricles + 1 ventricle
Reptiles	3 or incomplete 4 chambers	2 auricles + 2 incompletely devided ventricles
Aves	4	2 auricles + 2 ventricles
Human & Mammals	4	2 atrium + 2 ventricles

- Largest heart in *Balaenoptera musculus* (Blue Whale).

HUMAN HEART

Positon : Heart is present in **mediastinum** of thoracic cavity. The space betwen two lungs is called mediastinum.

Colour : Reddish brown.

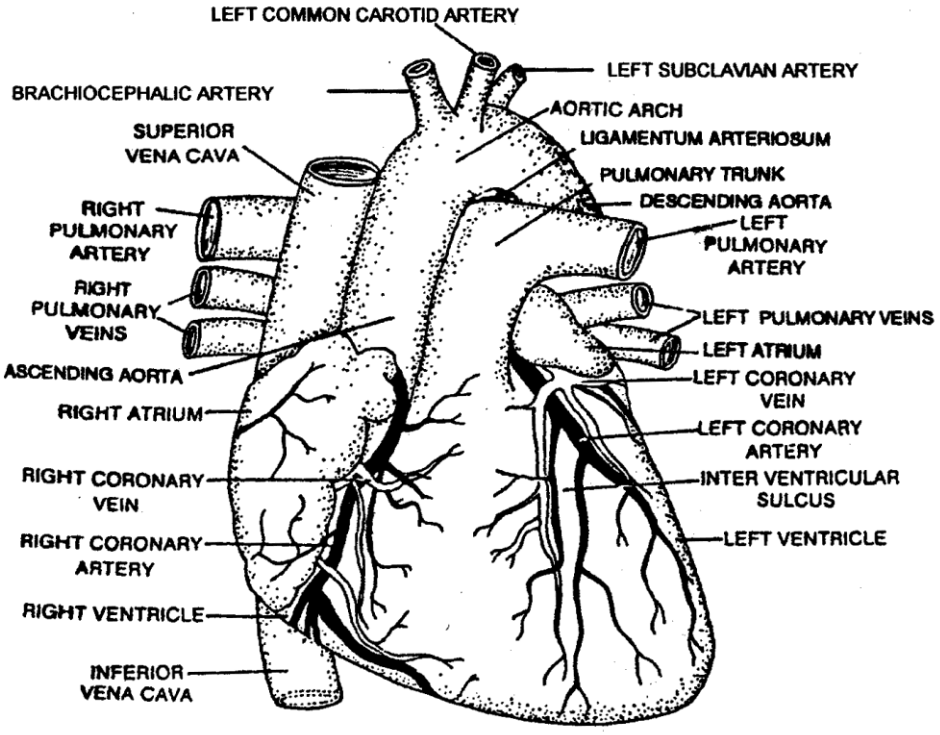
Weight : In males 300 gm (0.45% of body weight). In females 230-280 gm (0.40% of body weight)

Size : It's about 12 cm long and 9 cm broad. It's upper part is broad called base and lower part is narrow & pointed called apex.

Covering : Heart is covered by **pericardium**

EXTERNAL STRUCTURE OF HEART

- A narrow cavity present between visceral & perietal pericardium is called **pericardial sac**. A fluid present in this cavity is called **pericardial fluid**.
- Heart has **four chambers : two atria and two ventricles**.
- The upper part of heart is called Artrial part, lower part is called Ventricular part.
- Between atria and ventricles a clear groove called **coronary sulcus** is present**.** This groove is more towards atria, so the **atria are smaller than ventricles**.
- Between two atria, **inter atrial septum** is present. Simillary a **inter ventricular septum is** present between two ventricles. It is oblique and more towards right ventricle, **so right ventricle is smaller than left ventricle**.
- In the **right atrium,** impure blood is present. Superior vena cava, inferior vena cava and coronary sinus take impure blood from the body into right atrium to the heart.
- The **superior vena cava** carries blood from the upper region of body.
- The **inferior vena cava** is larger than the superior vena cava and carries blood from the lower region of body.
- The **coronary sinus** carries impure blood from the wall of heart.
- In the **left atrium** pure blood is present. Four **pulmonary veins** carry pure blood from the lungs to left atrium.
- From right ventricle, **pulmonary trunk** arises which carries impure blood from the heart to the lungs.
- From the left ventricle **carotico systemic arch** arises which carries pure blood to the different parts of the body.

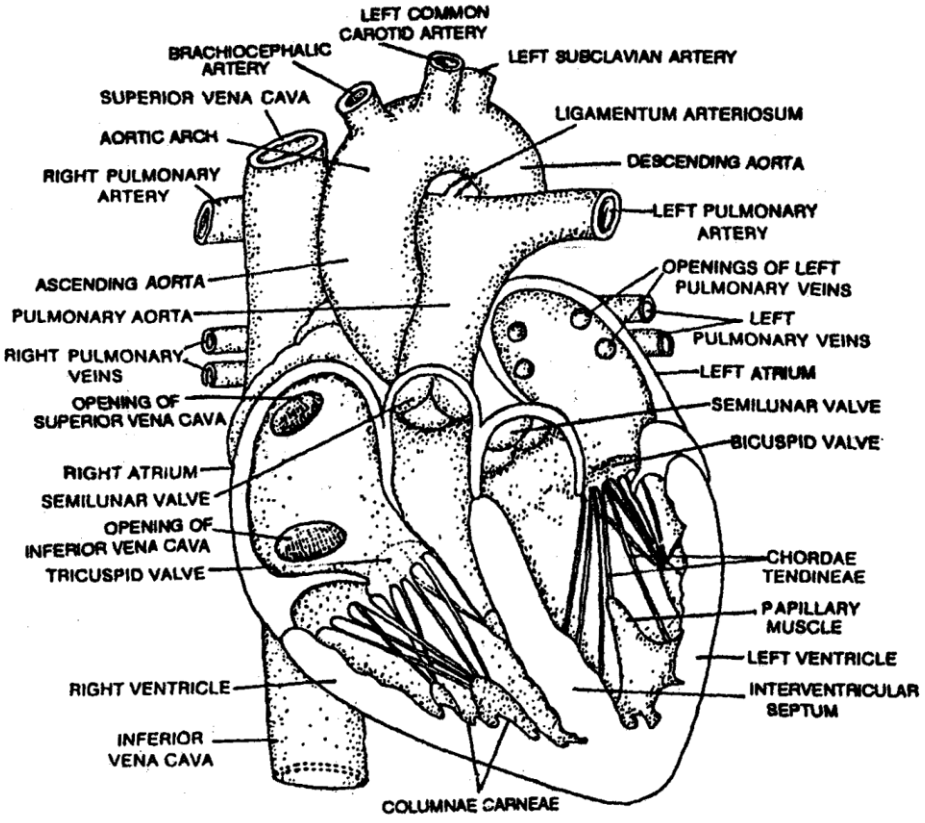


Human heart in front view.

INTERNAL STRUCTURE

- The internal structure of the heart can be better studied by dissecting it from the ventral side.
- **The wall of heart is made up of three layers** -
  (i) Outer layer– **Epicardium -** Originated from Mesoderm.
  (ii) Middle layer– **Myocardium -** Originated from Mesoderm.
  (iii) Inner layer– **Endocardium -** Originated from Endoderm.
- Myocardium is a muscular layer made up of special cardiac muscles. These muscles are involountry and striated. The thickining of the wall of the heart depends on myocardium. The **wall of ventricles is thicker than that of atria**.
- Posterior part of atria overlaps the ventricles. This overlapping part is called **atrial appendage**.
- Inner surface of the ventricles is raised and on this two types of ridges are present–
  (i) Columnae carneae. (papillary muscles). - Thick muscular columnae.
  (ii) Chordae tendineae – strong thread like tendons.
- Atrio-ventricular valves are present in between the atria and ventricles
- **Bicuspid** or **Mitral valve** is present in between left atrium and left ventricle. It is made up of two muscular flaps.
- **Tricuspid valve** is present between right atrium and right ventricle. It is made up of three muscular flaps.
- Atrioventricular valve are attached to the papillary muscles of ventricles by thin cord like **chordae tendenae**.
- At the base of pulmonary trunk and carotico systemic arch, three **semilunar valves** are present.

- A membranous fold called **eustachian valve,** extends between fossa ovalis and opening of inferior vena cava. The opening of the coronary sinus has **coronary or Thebasian valve**. Superior venacava has no valve.
- In the right atrium, upon posterior part of the inter atrial septum, an oval depression, the **fossa ovalis** is present. In the embryo at this place an aperture called **foramen ovalis** is present. Some times this pore remains open. Thus the blood of right atrium enters into the left atrium, this condition is called **atrial septal defect (ASD)**.
- Between two ventricles inter ventricular septum is present. Some times in congenital septum a small hole called **ventricular septal defect (VSD)**. It is most common heart defect.
- Pulmonary arch and systemic arch cross each other, at this place a ligament is present called **ligamentum arteriosum**. In the embryonic stage, a duct is present at this place called **Ductus arteriosus** or **Ductus botalis**.



Internal structure of human heart.

Test your Resonance with concept

1. In the mammalian heart, the bicuspid valve is situated between

(1) Left atrium and left ventricle (2) Post caval and right caval

(3) Right atrium and left auricle (4) Right ventricle and pulmonary aorta

2. Which valve is present between the left atrium and the ventricle?

(1) Tricuspid (2) Mitral (3) Aortic (4) Pulmonary

3. Purkinje's fibres are special types of
(1) Muscle fibres located in the heart
(2) Nerve fibres located in the cerebrum
(3) Connective tissue fibres joining one bone to another bone
(4) Sensory fibres, extending from retina to the optic nerve

4. For reaching left side of heart, blood must pass through
(1) Liver (2) Kidneys (3) Lungs (4) Brain

5. Which one of the following statements is correct with reference to the circulation of blood in a mammal?
(1) Left auricle receives oxygenated blood from the lungs
(2) Pulmonary artery returns oxygenated blood from the lungs to the left auricle
(3) Pulmonary vein carries venous blood from right auricle to lungs
(4) Venous blood is returned to the left auricle

Answers

1. (1) **2.** (2) **3.** (1) **4.** (3) **5.** (1)

7. HEART BEAT

- The wall of heart is made up of cardiac muscles which have the property of excitability and conductivity.
- The heart collects blood through both the atria and then distributes it through the ventricles. The action of **systole** and its relaxation is called a **diastole**.
- Rhythmic contraction and relaxation of heart is called **heart beat**. One heart beat includes one systole and one diastole.
- In systole, heart pumps blood into lungs and various parts of body through arteries. In diastole, heart receives blood from lungs and various parts of body through veins.
- Number of heart beats per minute is called **rate of heart beat** .

Human : 70-75/min.(Average **72/min.**)
Foetus : 140-160/min.
New born : 120-140/min.
Child : 100/min.
Rabbit : 210/min.
Shrew : 600-800/min.(Maximum)
Blue whale : < 25/min.(Minimum)
Elephant : 28/min.
Frog : 64/min
Rat : 300/min.

- Less number of heart beats than normal is called **bradycardia**.
- More rate of heart beat than normal is called **tachycardia**.

- **Rate of heart beat increases**
  - (i) After taking food
  - (ii) Exercise
  - (iii) Decreased blood pH
  - (iv) Increased acidity and CO_2 concentration
  - (v) Increased temperature
  - (vi) Tension/shock
  - (vii) In high B.P.

- **On the basis of origin of heart beat, there are two types of heart**

(i) Neurogenic heart : In this heart beat is initiated by a **nerve impulse** coming from a nerve ganglion situated near the heart. So in this wave of contraction is generated outside the heart in the ganglion. If nerve supply is cut off then heart beat stops. e.g. **Invertebrates (some annelids , most arthropods)**

(ii) Myogenic heart : In this heart, beat is originated by a **group of muscle** fibres which is situated in the wall of the heart. So in this wave of contraction is generated inside the heart. e.g. **Vertebrates (e. g. humans), molluscs.**

Special conducting system of heart

- The human heart is myogenic (myo: muscle, genic: orginating from). In this heart beat originates from a neuromuscular tissue which is called **SA node** (Sinu atrial node). It is also called **pace maker/heart of heart**. SA node lies in the wall of the right atrium near the opening of the superior vena cava. From the SA node muscle fibres arise which are situated in the wall of atria.
- In the heart another neuromuscular tissue called **atrio-ventricular node** (AV node) is present. It is present in the right atrium at the base of inter atrial septum.
- From the AV node, a group of muscle fibres called **Bundle of His** arises and it is situated in the interventricular septum.
- Bundle of His is divided into left and right branches. Each branch is divided into many small fibres which are present in the wall of ventricles. These fibres are called **Purkinje fibres.**
- Direction of impulse is SA node ⟶ AV node ⟶ Bundle of His ⟶ Purkinje fibres.

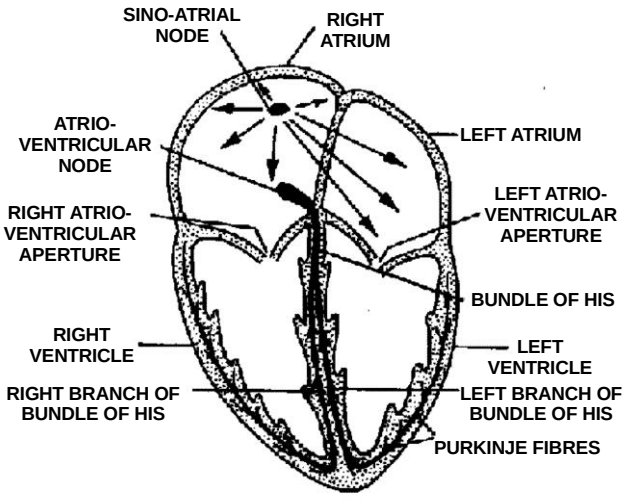


Diagram of the conducting system in human heart

Control of heart beat

The **rate of heart beat** is regulated by two mechanisms.

(i) Nervous regulation: Heart beat is controlled by a **cardiac centre.** This centre is situated in medulla oblongata of the brain. This centre has two parts:

(a) Cardio inhibitor centre: From this centre vagus nerve arises and attaches with the SA node. This nerve has parasympathetic nerve fibres. This nerve secretes acetylcholine. Due to this heart beat rate decreases.

(b) Cardio accelatory centre: From this centre sympathetic nerve arises which secretes adrenaline or noradrenalin. Due to this heart beat rate increases.

(ii) Hormonal regulation: Adrenalin (epinephrine) and noradrenalin (norepinephrine) hormones are secreted by the medulla of the adrenal glands. Noradrenalin accelerates the heart beat under normal conditions while adrenalin does this function at the time of emergency. These hormones directly influence the SA node.

Thyroxine hormone secreted by thyroid gland increases oxidative metabolism of the body cells. This requires more oxygen and thus indirectly increases heart beat.

8. CARDIAC CYCLE

- The series changes of which take place in the heart during a heart beat is called a cardiac cycle.
- It is a sequence of changes which occurs from the beginning of one heart beat to the beginning of next heart beat (completion of one heart beat).
- During cardiac cylce blood flows through the heart chambers in a specific direction.
- The phase of contraction is called **systole** and phase of relaxation is called **diastole**.
- In man cardiac cycle time duration = $\frac{60}{75}$ = 0.8 sec.

Heart Sound :

- In a normal person two sounds are produced per heart beat.
  - **(i) First sound :** This sound is due to closure of **bicuspid** and **tricuspid valves**. This shows contraction phase. The first sound is **lubb**. It is weak sound and for longer duration.
  - **(ii) Second sound :** This sound is due to closure of **semilunar valves**. This shows relaxation phase in the ventricle. So it is a diastolic sound. The second sound is "**dup**". It is louder, sharper and shorter in duration.
- In the heart, an other sound **heart murmur** is also produced due to leakage of the valves.
- These heart sounds can be heard by an instrument called **stethoscope**. It was invented by Laennec.
- The study of heart sound by making them draw on a graph is called **phono cardiograph**.

AIIMS AND OLYMPIAD CORNER

Events of cardiac cycle

(1) Ventricular cycle (0.8 sec)

(a) ventricle systole	:	0.3 sec
(b) ventricle diastole	:	0.5 sec

(2) Atrial cycle (0.8 sec)

(a) Atrial systole	:	0.1 sec
(b) Atrial diastole	:	0.7 sec
So,		
Total duration of systole of heart	:	0.4 sec
Total duration of **joint diastole**	:	0.8 – 0.4 = 0.4 sec

(1) Ventricular systole

It is an important process because by the contraction in ventricles blood flows in arches.

There are four stages in ventricular systole.

(a) Isometric contraction: By the contraction in wall of ventricles, pressure increases in ventricles, so cuspid valves of atrioventricular valves become closed.

At this moment first heart sound is heard in the form of **lubb**.

(b) Period of ejection: Due to increased pressure in ventricles, cuspid valves become close and semilunar valves of arches open up. So blood flows in arches.

(c) Protodiastole: Due to ejection of blood, pressure decreases in ventricles, so flow of blood from ventricles to arches also decreases called protodiastole.

Note: During ventricular systole, atria receive blood from veins and get filled with blood.

(2) Ventricular diastole: Two stages

(a) Isometric relaxation: Due to ejection of blood from ventricles to arches, pressure decreases in ventricles and pressure increases in arches. When it becomes more than ventricles semilunar valve of arches become close. At this moment second heart sound is heard in form of **dup**.

(b) Rapid inflow: Due to ejection of blood, pressure decreases in ventricles and atria filled with blood so pressure become more in atria. So cuspid valve of A.V. foramen open up and blood rapidly enter into ventricle called rapid inflow.

(c) Diastasis: After rapid inflow, flow of blood from atria to ventricle decrease. Now atria transfer blood to ventricle at the same rate at which they receive blood from veins called diastasis.

(d) Second rapid inflow: During atrial systole

(3) Atrial systole

At the end of ventricular diastole, atria contract and transfer more blood in ventricles, This decreases pressure in atria.

(4) Atrial diastole

Due to ventricular systole, pressure increase in ventricle and it exceeds atrial pressure.Therefore cuspid valve of AV foramen closed and then atria start relaxation called atrial diastole.

Test your Resonance with concept

1. The first heart sound is
(1) 'Lubb' at the end of systole (2) Dup' at the end of systole
(3) 'Lubb' at the beginning of systole (4) 'Dup' at the beginning of systole

2. The heart of a healthy man, normally beats, per minute
(1) 60-70 times (2) 70-75 times (3) 80-90 times (4) 85-95 times

3. Heart beat can be initiated by
(1) Sinoatrial node (2) Atrio-ventricular node
(3) Sodium ion (4) Purkinje's fibres

4. The typical lubb-dup sounds, heard in the heart beat of a healthy person, are due to the
(1) Closure of the tricuspid and bicuspid valve
(2) Closure of aortic and pulmonary valves
(3) Closure of the atrioventricular and semilunar valves
(4) Closure of the semilunar valves

5. The duration of cardiac cycle is
(1) 0.8 sec (2) 0.8 μ sec (3) 0.08 sec (4) 0.008 sec

Answers

1. (3) **2.** (2) **3.** (1) **4.** (3) **5.** (1)

9. BLOOD PRESSURE

- The pressure exerted by the flow of blood on the elastic walls of the arteries is called blood pressure.
- First B.P. is measured by ***Stephen Hales*** in the horse.
- Normal healthy person B.P. is = **120/80 mm of Hg**.
- The instrument used to measure B.P. is **sphygmomanometer**.
- B.P. is usaually taken in **left brachial artery**.
- **It has two stages.**
  - **(a) Systolic pressure:** It is the higher limit of B.P. It shows the state of heart systole. Its value is 120 mm of Hg.
  - **(b) Diastolic pressure:** It is lower limit of B.P. It shows state of relaxation in heart. It's value is 80 mm of Hg.
  - The difference betwen systolic and diastolic pressure is called **pulse pressure**. It's value is 40 mm of Hg.
  - Pulsation in the arteries is called **pulse rate**. It can measure in the artery which is situated at the surface of body. Like - **radial artery** of wrist, carotid artery of neck, temporal artery near the neck, brachial artery. The instrument used to measures pulse rate is **sphygmomenometer**.
  - The pressure varies with age. It is also influenced by the rate of heart beat.

10. ELECTROCARDIOGRAM (ECG)

- Electrical changes take place in a cardiac cycle in heart. The recording of electrical potential generated by the spread of cardiac impulse, is called ECG. It is a graphic record of the electric current produded by excitation of the cardiac muscles. The instrument used for this is called "**electrocardiograph**".
- **Father of ECG : William Einthoven**

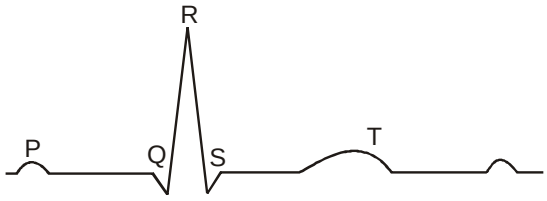
A normal ECG has three parts - P wave, QRS complex, T wave.

(i) The P wave is a small upward wave that indicates the depolarisation of atria. It means spread of impulse from SA node throughtout atria.

(ii) QRS complex has three separate Q, R and S waves. This complex indicates depolarisation of ventricles.

(iii) T - wave indicates the repolarisation of ventricles. It represents the potential generated by the recovery of ventricles from depolarisation state.

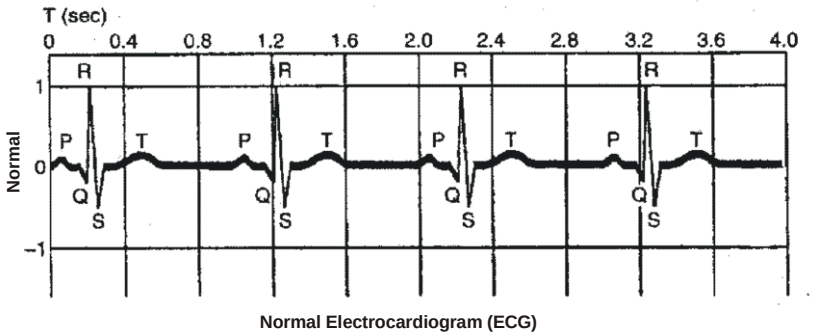
- P-Q interval is the time taken by impulse to travel through atria, AV node and the rest of the conducting tissues.
- The ST interval is representation of time between the end of the spread of impulse through ventricles and its repolarisation.



Diagrammatic Presentation of a Standard ECG

Significance of ECG : It is used for knowledge of some cardiac disorders.

(i) Cardiac arrest
(ii) Coronary Ischemia
(iii) Valvular disease
(iv) Pericarditis
(v) Cardiomegaly
(vi) Myocardial infarction



Normal Electrocardiogram (ECG)

Test your Resonance with concept

1. In a standard ECG, which one of the following waves correctly represents the activity of the human heart?
(1) R - repolarisation of ventricles (2) S - start of systole
(3) T - end of atrial diastole (4) P - depolarization of the atria

2. Sphygmomanometer measures
(1) Rate of Nerve conduction (2) Heart beat
(3) Blood pressure (4) Pulse rate

3. ECG records
(1) Electric activity of the body (2) Potential differences
(3) Pulse rate (4) Quantity of blood pumped per minute

4. QRS complex represents
(1) Ventricular contraction or depolarization (2) Atrial contraction
(3) Atrial relaxation (4) Cardiac cycle

5. In an ECG, the depolarization of atria is indicated by
(1) P wave (2) Q wave (3) R wave (4) S wave

Answers

1. (4) **2.** (3) **3.** (2) **4.** (1) **5.** (1)

11. BLOOD VESSELS

- In humans **close circulatory** system is present. In this system, blood flows in the close tubes which are called blood vessels.
- **Three types of blood vessels are**
  (A) Arteries **(B) Veins** **(C) Capillaries**
- **The wall of blood vessels is made up of three layers**
  (i) Tunica externa : It is outer most layer. It is made up of white fibrous connective tissue.
  (ii) Tunica media : It is thickest, middle layer. It is made up of circular unstriped muscles and elastic fibres.
  (iii) Tunica interna : It is inner layer made up of simple squamous epithelium.

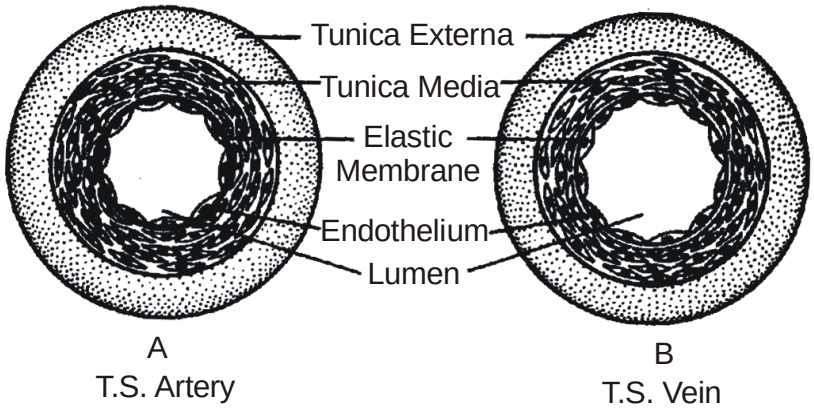
(A) Arteries : These carry blood from the heart to the different body parts. The walls of arteries are thick, muscular, elastic and non collapsible. Two elastic membranes are also present–
(i) External elastic lamina – between tunica externa and tunica media
(ii) Internal elastic lamina – between tunica media and tunica interna

- After death arteries become empty but blood is present in the veins.

(B) Veins : They bring blood from the different parts of the body to the heart. The wall of veins is thin, less muscular and non-elastic.

(C) Capillaries: The wall of capillary is made up of **only endothelium.** It's cells are flat and squamous. Blood capillaries were discovered by **Marcello Malpighi**.

VESSELS OF VESSELS: For supplying the essential materials to the cells of the wall of large blood vessels, a network of thin blood vessels is also found which is called "**Vasa Vasorum/vessels of vessels**".



Differences between arteries and veins

	Arteries		Veins
1	Arteries distribute blood from the heart to the different parts of the body.	1	Veins collect blood from different parts of of the body and pour it into the heart.
2	They are usually deep situated.	2	They are usually superficially situated.
3	The walls of the arteries are thick and muscular.	3	The walls of the veins are thin and non muscular.
4	Arteries have no valves. (except arches/trunks)	4	Veins have valves which prevent backward flow of blood.
5	They have smaller lumen.	5	The lumen of the veins is larger.
6	In arteries blood flows with jerks.	6	In veins blood flows smoothly.
7	Arteries become empty after the death.	7	Veins contain blood even after the death .
8	Arteries carry oxygenated blood except the pulmonary arteries.	8	Veins carry deoxygenated blood Except pulmonary veins.

Test your Resonance with concept

1. Serotonin in the blood

(1) Relaxes blood vessels (2) Prevents clotting of blood

(3) Helps in clotting of blood (4) Constricts blood vessels

2. The artery can be distinguished from the vein in having

(1) Thicker walls (2) More blood cells

(3) More plasma (4) Larger lumen

3. The pulse rate is measured by feeling a/an
(1) Artery (2) Capillary (3) Vein (4) Lymph vessel

4. Blood vessel carrying blood from lung to the heart is
(1) Pulmonary artery (2) Pulmonary vein (3) Azygous vein (4) Coronary artery

5. Which of the following has no muscular wall?
(1) Artery (2) Vein (3) Arteriole (4) Capillary

Answers

1. (4) **2.** (1) **3.** (1) **4.** (2) **5.** (4)

12. DISORDERS OF CIRCULATORY SYSTEM

(A) High blood pressure (Hypertension)

- The increase in the blood pressure beyond 140mm Hg (systolic) and 90 mm Hg (diastolic), is referred to as high blood pressure. A continuous or sustained rise in the arterial blood pressure is known as **hypertension** High blood pressure is a silent killer. It can damage vital organs like heart, brain, kidneys and eyes.
- Fall in blood pressure is termed as low blood pressure (hypotension).

(B) Atherosclerosis

- It is caused due to the deposition of lipids (specially cholesterol) on the wall lining the lumen of large and medium sized arteries. Such a deposition is called atheromatous or atherosclerotic plaque.
- Its formation starts with the deposition of minute cholesterol crystals in the tunica intima and smooth muscles. Gradually, these plaques grow due to the proliferation of the fibres and small muscles around them. This results into the reduction of the luminal size of the artery and consequently, the flow of blood is also reduced.
- In extreme circumstances, these plaques may completely block the artery. Such plaques, if formed in the coronary artery, reduce the blood supply to the heart or may even stop the supply to the heart. This may result in heart attack or stroke.
- High concentration of cholesterol in the form of low density lipoproteins (LDL) in the blood plasma is responsible for atherosclerosis.

(C) Angina – It is also called the 'angina pectoris. It appears when no enough oxygen is reaching the heart muscle. As a result, symptom of acute chest pain appears. Angina can occur in men and women of any age but it is more common among the middle aged and elderly persons. It occurs due to the conditions that adversely affect the blood flow.

(D) Heart failure – It is the state of heart when it is not pumping blood effectively enough to meet the needs of the body. It is sometimes called 'congestive heart failure' because congestion of the lungs is one of the main symptoms of this disease.

(E) Heart attack – It is the condition, when a part of heart muscles is suddenly damaged by an inadequate blood supply. It is also called **myocardial infarction.**

(F) Cardiac arrest – It is a condition of complete stoppage of the heart beat i.e., sudden and complete loss of cardiac function.

13. LYMPH (TISSUE FLUID)

LYMPHATIC SYSTEM

- The study of lymphatic system is called **Lymphatology** (lymph = spring water, logos = study).
- The lymphatic system consist of **lymph**, **lymph vessels, lymphoid tissues like lymph nodes, spleen and thymus.**

Lymph

- The fluid which circulates in the lymphatic system is called **lymph**.
- It is a part of tissue fluid.
- It is devoid of RBCs, platelets and some plasma proteins.
- It is colourless liquid.
- It contains large amount of metabolic wastes, CO_2, insoluble proteins.
- It contains less amount of O_2, nutrients and soluble proteins.
- Clotting capacity is present in lymph but its clotting takes more time as compared to that of the blood.

Differences between blood and lymph

	Blood		Lymph
1	It is red tissue fluid	1	It is colourless fluid.
2	RBC and platelets are present	2	Absent
3	O_2 & nutrients are in more quantities	3	Less quantities
4	CO_2 and waste materials are in less quantities	4	More quantities
5	Soluble proteins are in large amount	5	Less amount
6	It flows rapidly	6	It flows slowly
7	Its plasma has more proteins, calcium and phosphorus	7	Its plasma has less proteins, calcium and phosphorus
8	Clotting time is less i.e. it clots rapidly	8	Clotting time is more i.e. its clots slowly
9	It transports materials between different organs	9	It transports materials from tissue cells to the blood and vice versa

Lymph capillaries

- These are blind at one end.
- These are very soft and thin walled tubes.
- They are wider than blood capillaries and their diameter is not uniform.
- These are present in all the parts of body except hairs, cornea, spinal cord, cartilages, epidermis, brain, spleen and bone marrow.
- Closed system of capillaries starts from inter cellular spaces. Lymph enters in these capillaries.
- Capillaries pass lymph to lymph vessels.

Lymph vessels :

- The lymph capillaries join to form lymph vessels.

- structurally these are similar to the veins, but are thin walled and have more valves.
- All lymph vessels open into two big thoracic lymph duct.

These are

(i) Right thoracic lymph duct : It is a small duct. It receives lymph from the right side of the head, neck, thorax and right upper limb. It opens into the right **subclavian vein**.

(ii) Left thoracic lymph duct : It is a long duct. It receives lymph from the left side of the head, neck, throax, left arm, both lower limbs and alimentary canal. It opens into the **left subclavian vein**.

- In the abdominal cavity, below the diaphgram a bag like structure attached to the left thoracic lymph duct called **cisterna chyli**. It is also called **second heart** of the body.

Lymph nodes

- These are made up of lymphoid tissue.
- The lymphatic nodes occur at intervals in the course of the lymphatic vessels.
- They contain lymphocytes, plasma cells and fixed macrophages.
- The lymph filters through the lymphatic nodes.
- The macrophages remove microorganism, cellular debris and foreign particles from the lymph. Lymphatic nodes can detect and destroy cancer cells also.
- The lymphatic nodes also add lymphocytes and antibodies to the lymph.
- The lymphatic nodes are specially abundant in specific regions such as the groins, arm pits and neck.

Spleen

- The spleen is a large (7-10 cm in diameter), bean-shaped, vascular, dark-red organ located in the abdomen just below the diaphragm at the tail of the pancreas behind the stomach.
- It is the **largest lymph node**.
- It is also called **blood bank of the body**.
- It is the **graveyard of RBC**.
- It is **mesodermal** in origin.
- Spleen is covered by splenic capsule composed of elastic fibrous connective tissue.
- From the capsule many longitudinal septa arise called **trabeculae**. These septa divide splenic tissue into several incomplete lobules.
- In the spleen a special tissue called **spleen pulp** or **reticulo endothelial tissue** is present. Splenic pulp has two parts

  (i) Red pulp - It forms maximum part of splenic pulp. It is rich in RBC.

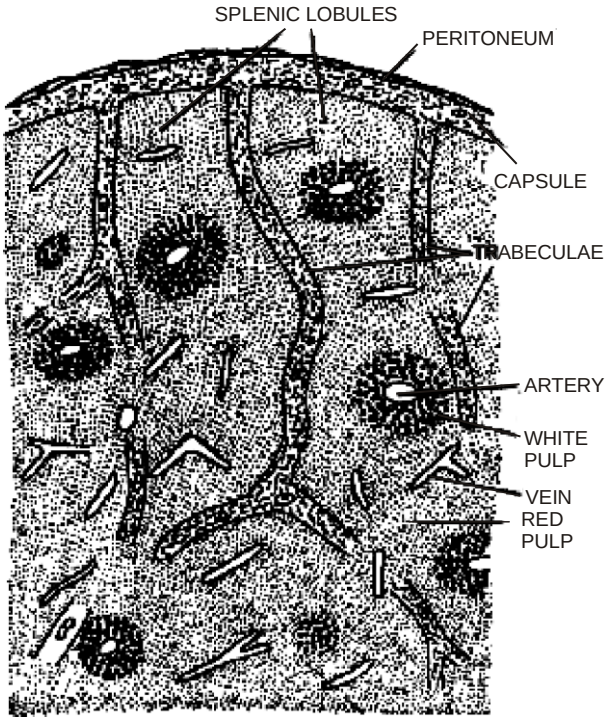
  (ii) White pulp - It forms minimum part of splenic pulp. These are small patches.

Functions of spleen

- **Destruction** of wornout RBCs.
- **Reservoir** for RBCs.
- Formation of **agranulocytes**.
- Production of **antibodies**.
- **Storage** of Iron.
- **Disposal** of foreign elements.
- In the embryo, spleen acts as **haemopoeitic organ of body**.

Thymus : It is a lymphatic organ. It lies in the upper chest near the neck. It is prominent in children but begins to degenerate in early childhood.

Tonsils : Tonsils too are lymphatic tissues. They are located in the throat. They do not filter lymph. They are thought to protect against infection.



Test your Resonance with concept

1. The lymphocytes protect us from
(1) Pathogens (2) Lymph (3) Leucocytes (4) Erythrocytes

2. The organ considered as "Graveyard of RBCs" is
(1) Red bone marrow (2) Spleen (3) Kidney (4) Intestine

3. The old worn out RBCs are filtered out by
(1) Kidney (2) Liver (3) Spleen (4) Heart

4. An antibody is a
(1) Molecule that specifically inactivates an antigen
(2) WBC which invades bacteria
(3) Secretion of mammalian RBC
(4) Component of blood

5. The antibodies are formed inside
(1) Bone marrow (2) Spleen (3) Calcium (4) Liver

Answers

1. (1) **2.** (2) **3.** (3) **4.** (1) **5.** (2)

AIIMS AND OLYMPIAD CORNER

(A) PORTAL SYSTEM

- In this system, the vein starts from capillaries and ends in capillaries
- A portal vein collects venous blood from some part of body by a set of capillaries and distributes it to some other organ by another set of capillaries.
- A portal system consists of a portal vein and second set of blood capillaries and it is named after the name of the organ containing the second set of blood capillaries.

Types of portal system

(i) Renal portal system

- In this system vein which collects blood from posterior parts of body and legs, enters into the **kidney**. This vein is called renal portal vein. Now this vein divides into capillaries and forms renal portal system. This system is found in **lower vertebrates like amphibians, fishes.**
- This system is absent in **man and rabbit.**

(ii) Heptaic portal system

It is found in all vertebrates. In this system, vein which collects blood from digestive and absorptive parts of alimentary canal, enters into the **liver**; this is called heptaic portal vein. Now in liver it divides into cappillaries and forms hepatic portal system.

This vein collects blood from four veins

(a) Lienogastric vein $\rightarrow$ collects blood from stomach and spleen

(b) Duodenal vein $\rightarrow$ carries blood from pancrease and duodenum

(c) Anterior mesentric vein $\rightarrow$ collects blood from ileum, caecum and colon

(d) Posterior mesentric vein $\rightarrow$ collects blood from rectum and anus.

(iii) Hypothalamo hypophyseal portal system

This system occurs in mammalian brain. This is present between **hypothalamus** and anterior lobe of the **pituitary gland**. Hypophyseal portal vein carries blood from the hypothalamus of the brain to the anterior lobe of the pituitary gland. This portal system enables the hormones of hypothalamus to reach the anterior lobe of the pituitary gland.

(B) SOME IMPORTANT DISEASES OF CIRCULATORY SYSTEM :

1. **Rheumatic Heart Disease (RHD).** It is caused due to repeated attack of rheumatic fever. The fever is caused by *Streptococcus aureus.* The patient may suffer from acute rheumatic fever and infection of throat. Rheumatic fever may cause permanent damage to one or more valves (mitral or aortic semilunar valves), pericarditis and myocarditis. Damage to the heart valves is detectable by a abnormal sound called a murmur. Poor sanitation, bad housing and over crowding promote rheumatic heart disease.

2. **Heart block.** It is a condition in which the component of the impulse conduction system is disrupted, causing irregularity in the heart rhythm. The two common types of heart blocks are,
   (i) AV block : The impulse from SA node does not reach the AV node.
   (ii) Bundle branch block : Failure of the atrial impulse to reach the ventricles**.**
   Such types of patients are provided with an artificial electronic device, which regularly sends electrical charge for maintaining the rhythmicity of the heart. This device is known as artificial pacemaker. It is implanted subcutaneously in the upper thoracic region and is connected to the heart.

(C) ADDITIONAL INFORMATION

1. **Blue baby :** A baby with a blue tinge to the skin due to insufficient oxygenation of the blood.
2. **Balloon Angioplasty:** It is a technique meant for unblocking coronary arteries having thrombi.
3. **Coronary artery bypass grafting surgery (CABG):** In this surgical procedure, a blood vessel from another part of the body is used to bypass the blocked region of a coronary artery. The

saphenous vein (from the leg) and the internal mammary artery (from the chest) are mostly used as graft.

4. **Defibrillator:** It is an electrical device used to treat abnormal and asynchronous contraction of the heart muscle (called fibrillation).

5. **An artificial pacemaker** is placed subcutaneously in patients with irregularity of heart rhythm. An artifcial pacemaker is a small mechanical device that is operated by a lithium battery. This device uses electrical impulses to keep the heart beating at a regular rate. The pacemaker wires are threaded through a large vein to the heart, Most commonly, the generator is placed below the subcutaneous fat of the chest wall, above the muscles and bones of the chest. The outer case of pacemakers is so designed that it will rarely be rejected by the body's immune system . It is usually made up of inert titanium.

6. Most common cause of myocardial infraction is thrombosis in left anterior descending **(LAD)** artery which is branch of left coronary artery.

7. Example of **anticoagulants** (substances preventing blood coagulation)
   (i) Natural - Heparin
   (ii) Artificial - EDTA (Ethylene Diamine Tetra Acetic acid), Sodium and pottasium salts of oxalates and citrates.

8. **Thrombus:** Blood clot formed in blood vessels, blocking the flow of blood
9. **SA node** is also called as **'heart of heart'.**
10. **Methaemoglobin : "blue baby syndrome"** can also be caused by methemoglobinemia. It is believed to be caused by high nitrate contamination in ground water resulting in **decreased oxygen carrying capacity of hemoglobin** in babies leading to death. The ground water is thought to be contaminated by leaching of nitrate generated from fertilizers used in agricultural lands and waste dumps

11. **Echocardiography:** It is a technique for detection of functional status of heart and measurment of parameters like EF (Ejection Fraction), EDV (End Diastolic Volume), ESV (End Systolic Volume) etc.

12. **Fresh frozen plasma (FFP)** contains all coagulation factors in normal concentrations. Plasma is free of red blood cells, leucocytes and platelets. One unit is approximately 250mL and must be ABO compatible. Rh factor needs not be considered. Since there are no viable leukocytes, plasma does not carry a risk of CMV (CytoMegaloVirus) transmission or Graft Vs. Host Disease (GVHD).

- **Ischaemia:** Inadequate flow of blood to a part of the heart caused by obstruction to its blood supply.
- **Dextrocardia:** Heart gets displaced right side to the chest.
- **World's first heart transplant :** World's first heart transplant was done by a team of doctors headed by Prof. Christian Bernard on 3rd Dec. 1967.
- **India's first heart transplant :** India's first heart transplant was done by a team of doctors led by **Dr. P.Venugopal** on 3rd August, 1994.
- **LDL (Low Density Lipoprotein):** It is harmful for our body. Its high concentration in blood causes heart disease and thus termed as bad lipoprotein.
- **HDL (High Density Lipoprotein):** Its higher concentration reduces the risk of heart disease thus termed as good lipoprotein.
- **Blood donation day -** October 1