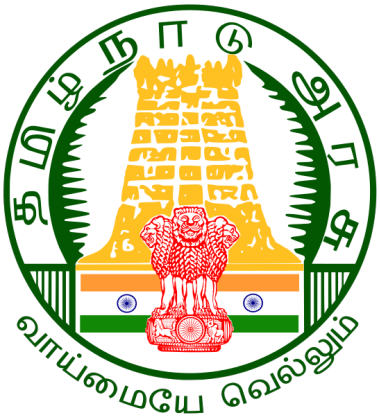

GOVERNMENT OF TAMILNADU

Department of Employment and Training

Course : TNPSC Group-II Mains Material

Subject : Biology

Topic : Blood and Blood Circulation System

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BLOOD AND BLOOD CIRCULATION SYSTEM

BLOOD

- Study of Blood–**Haematology**. Blood is a fluid connective tissue/Mobile tissue.
- Blood is slightly Alkaline in nature (pH 7.35 to 7.45). 3.5 to 5.5 times thicker than Water. Average Volume in human body: Male 5 to6 L, Female 4 to 5 L. Fibres are absent.

Function of Blood

- Transport of respiratory gases (Oxygen and Carbon Dioxide).
- Transport of digested food materials to the different body cells.
- Transport of hormones. E.g., Insulin.
- Transport of nitrogenous excretory products like ammonia, urea and uric acid. It is involved in protection of the body and defence against diseases.
- It acts as buffer and also helps in regulation of pH and body temperature. It maintains proper water balance in the body.

Plasma

- Alkaline in nature and it is straw coloured.
- Plasma mainly consists of water (80–92%) in which the plasma proteins, inorganic constituents (0.9%), organic constituents (0.1%).
- Inorganic constituents include chlorides, carbonates, phosphates of potassium, sodium, calcium and magnesium. The composition of plasma is not always constant.
- Immediately after a meal, the blood in the hepatic portal vein has a very high concentration of glucose as it is transporting glucose from the intestine to the liver where it is stored.
- The concentration of the glucose in the blood gradually falls after sometime as most of the glucose is absorbed.

- If too much of protein is consumed, the body cannot store the excess amino acids formed from the digestion of proteins. The liver breaks down the excess amino acids and produces urea.

Components of Plasma

1. Water (92%)
2. Proteins: i) Albumin, ii) Globulin,iii) Fibrinogen & Prothrombin.

- Blood in the hepatic vein has a high concentration of urea than the blood in other vessels namely, hepatic portal vein and hepatic artery.
- Haemocytometer–Counting of blood cells.
- Diluting fluid for RBC Counting–Hayem's solution.
- Diluting fluid for WBC Counting–Turk's solution or Toisson solution.

Serum

- Plasma without fibrinogen. It does not take part in blood clotting.
- Serum do not have blood cells.
- Serology: Study of Antibodies in Serum.

Blood Cells (Formed Elements)

Red Blood Cells

- Jan Swammerdam: He was (1658) the First person to observe red blood cells under the microscope. and Rbc Shape Circular biconclave & non nucleated cells.
- Mammalian RBC lack nucleus and makes the cells biconcave and increase surface area for oxygen binding. Cell organelle mitochondria absent in RBC.
- Loss of mitochondria allows the RBC to transport all the oxygen to tissues and Endoplasmic reticulum absent in RBC.
- Loss of endoplasmic reticulum allows more flexibility for RBC to move through the narrow capillaries. Cell division does not occur in RBC.
- Contains four atoms of iron, each of which can combine with a molecule of oxygen. Haemoglobin molecular weight is 68,000 dalton. Haemoglobin–4 Fe + Globin (Protein).
- Oxyhaemoglobin: When O_2 mixeswith Hb, Carbamino haemoglobin: CO_2 carring Hb.
- Its Life span: 120 days and Synthesis of RBC from Red Bone Marrow.
- Anton Van Leeuwanhoek: He was widely credited as the discoverer of red blood cells, his observation were more detailed and numerous than swammerdam. RBC's are destroyed in Spleen. When RBCs are destroyed the Iron components in Hb returns to bone marrow for reuse.
- Remaining proteins excreted by Liver as Bilirubin & Biliverdin (Bile Pigments).
- Sahli Hemoglobinometer used to determine the quantity of hemoglobin in the blood.
- In practice the hemoglobinometer proposed in 1902 by the Swiss scientist H. Sahli is used.

Methaemoglobin

- If the iron component of the haem moieties is in the ferric state, than the normal ferrous state in hemoglobin, it is called methaemoglobin.
- Methaemoglobin does not bind Oxygen. Normally RBC contains less than 1% methaemoglobin.
- **Smasllest RBC** (1.5 µm)–E.g., Musk deer. **Largest RBC** (80 µm)–E.g., Amphibian and Proteus.
- Nucleus present in the initial stage of RBC but when matured it looses the nucleus.
- Vitamin B9 (Folic Acid), Vitamin B12, (Cyanocobalamin), Vitamin C (Ascorbic Acid) are essential for maturation of RBC.

Erythropoietin Hormone

- It secreted by kidneys, when Oxygen level is low and it plays key role in producion of RBC.

Stages in formation of RBC

Haemocytoblast

↓

Erythroblast

(Nucleus Present)

↓

Normo Blast

↓

Reticulocyte

(Nucleus Disappear)

↓

Erythrocyte (RBC)

Haematocrit

- Ratio of RBC to total blood plasma. (Packed cell volume).

White Blood Cells (Leukocytes/Police Force of the Body)

- Colourless (lack of haemoglobin), Amoeboid nucleoid cells. Normal range of WBC is 6000 to 8000 mm^3 and Its ratio is = 600 : 1 (RBC : WBC).

Types of WBCs-Five

1. Neutrophils (Heterophils/Polymorpho Nuclear Cell)

- 60–65% of total WBCs. and Nucleus is multilobed (6–7).
- Phagocytic in nature. Appear in large number in and around the infected tissues.

2. Eosinophils (Acidophils)

- Nucleus is bilobed and 2–3% of total WBCs.
- Non-Phagocytic in nature. Increase during parasitic infections & allergic reactions.

3. Basophils

- Nucleus is large size & Tri lobed and Its Normal range is 1%. Secrete of the following substances
  1. **Heparin:** prevents blood clotting inside the capillaries.
  2. **Serotonin:** Vasso Constriction decrease blood pressure.
  3. **Histamines:** Vassodilater increase blood pressure. Involved in inflammatory reactions.

4. Lymphocytes

- Have large round nucleus and 28% of total WBCs.
- Lymphocytes-Two Types: 1. B-Lymphocytes, 2. T-Lymphocytes.

5. Monocyte (Macrophages)

- Kidney shaped nucleus. 1–3% of the total WBCs.

Different names of Monocytes

1. **Microglia –** In central nervous system.
2. **Kupffer cells –** Sinusoids of Liver.
3. **Alveolar macro phages –** Lungs.

- Functions: They destroy bacteria, dead cells and cell fragments.

Platelets (Thrombocytes)

- Platelets: Irregular shape, Nucleus & Hemoglobin absent and Its Synthesis in Megakaryocytes, Its destruction in Spleen.
- Its Normal range is 1.5 to 3 lakhs/m3
- Decrease of Platelets is Thrombocytopenia, Increase of Platelets is Thrombocytosis and Its life span is 7 to 9 days. Its functions is Involved in blood clotting.

Blood Clotting

- When blood comes out from capillaries it will lose its liquid state and it changes into jelly like structure.
- First described by Alexander Schmidt & Paul Morawitz in 1892. The reduction in Platelets numbers can lead to clotting disorder is Hemophilia.

Blood Groups

ABO Groups

- Karl Landsteiner: The concept of bloodgrouping was developed by Karl Landsteiner (1900). A, B and O blood groups.

- Landsteiner's Rule: If an antigen (Ag) is present on a red blood cells the corresponding antibody (Ab) will NOT be present in the plasma.
- AB blood group was recognized by Decastello and Steini (1902).
- Depending upon the presence/absence of Antigen (Agglutinogen) on surface of RBC blood group is divided into A, B, O, AB.
- Plasma of A, B and O have natural Antibodies (Agglutinin) in them.
- All agglutinogens (Antigens) contain Sucrose, D–galactose, N–acetyl, glucosamine & 11 terminal amino acids. The attachments of the antigens is catalysed by Glycosyl transferase.

Rh Blood Group

- Rh factor was discovered by Landsteiner and Wiener in 1940 in Rhesus Monkey.
- Rh factor is a protein (Antigen D) present on the surface of the RBC, in majority of humans (80%). Rh Factor is named after, discovery of antigen in Rhesus monkey.
- Rh Positive → Persons carry Antigen D on surface of RBC .
- Rh Neagtive → Persons do not carry Antigen D on surface of RBC.

Determination of Blood Groups

- Berstein (1925) proposed that inheritance of A, B, AB and O Blood types of man is determinded by a series of three allelomorphic genes.
- The gene controlling blood types has been labeled as I (after the name of immune traits) or L (after the name of discoverer: Landsteiner).
- The L gene exists in three different allelic forms: L^A, L^B and L^O. The first two alleles produce characteristic antigens on the surface of red blood cells or erythrocytes. Thus L^A allele specifies A antigen, L^B allele B antigen and L^O allele specifies no antigen.

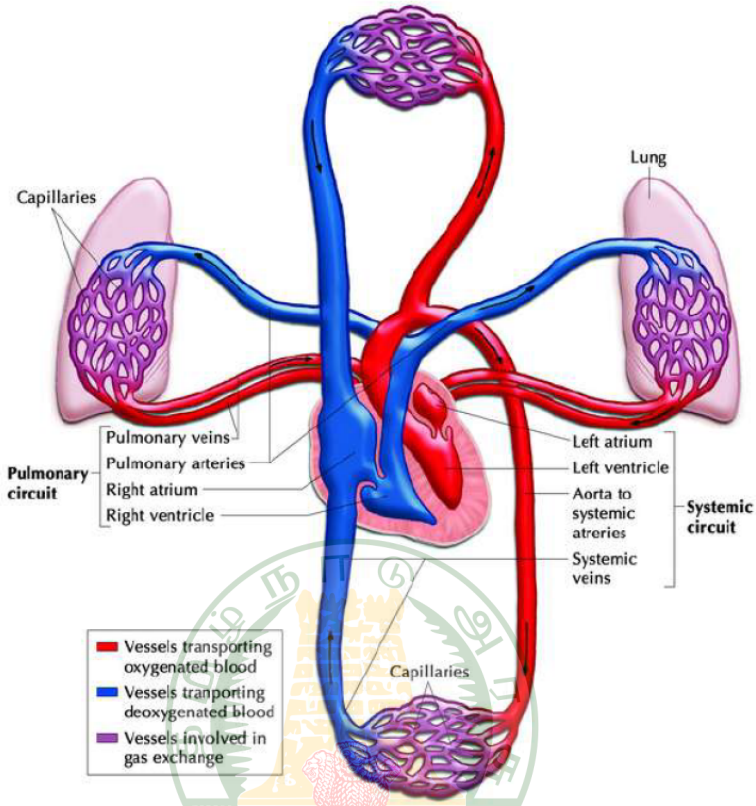
BLOOD CIRCULATION

- Circulation of blood from one part of a organ to another organ by pumping of heart. Essential components involved in blood circulation.
  1. Blood,
  2. Pumping organ (Heart),
  3. Vessels.

Circulatory System

1. Single Circulation

- The oxygenated and de-oxygenated blood are mixed and pass through the heart only once. This type of circulation is called single circulation. **E.g.,** fishes, amphibians and certain reptiles.



Systemic and Pulmonary circulation

2. Double Circulation

- When the blood circulates twice through the heart in one complete cycle it is called double circulation. In double circulation, the oxygenated blood do not mix with the de-oxygenated blood.

i. Systemic Circulation

- Circulation of oxygenated blood from the left ventricle of the heart to various organs of the body and return of de-oxygenated blood to the right atrium. Aorta carries oxygenated blood to all the organs of the body.

ii. Pulmonary Circulation

- The path of pulmonary circulation starts in the right ventricle. Pulmonary artery arises from the right ventricle and reaches the lungs with de-oxygenated blood.
- Pulmonary veins collect the oxygenated blood from the lungs and supplies it to the left atrium of the heart.

iii. Coronary Circulation

- The supply of blood to the heart muscles (cardiac muscles) is called as coronary circulation. Cardiac muscles receive oxygenated blood from coronary arteries that originate from the aortic arch. De-oxygenated blood from the cardiac muscles drains into the right atrium by the coronary sinuses.

iv. Open Blood Circulation

- The blood is pumped by heart into blood vessels that open into blood spaces called as sinuses. These sinuses are the body cavities which are called haemocoel. Capillary system is absent. E.E.g., Arthropods, Molluscs and Ascidian

v. Closed Blood Circulation

- The blood flows in a complete circuit around the body through specific blood vessels. The blood flows from arteries to veins through small blood vessels called capillaries. E.g., Vertebrates (Human, Birds).
- William Harvey: Father of angiology–'William Harvey' (1628) discovered closed blood circulation.

vi. Incomplete Double Circulation

- Crocodiles have two auricles and one ventricle and an incomplete inter ventricular septum. Thus, mixing of oxygenated and de-oxygenated blood takes place in the ventricles. This type of circulation is called incomplete double circulation.

vii. Hepatic Portal Circulation

- Blood enters the liver from two sources. The hepatic artery supplies oxygenated blood from the abdominal aorta and the hepatic portal vein carries de-oxygenated blood from the digestive organs (Stomach, Spleen & Intestine).
- The flow of de-oxygenated blood from the digestive organs to the liver before returning to the heart is called hepatic portal circulation.

viii. Hypophyseal Portal Circulation

- This minor portal system consists of two hypophysial portal veins which carry blood from the hypothalamus of the brain to the anterior lobe of the pituitary gland (hypophysis). This portal system enables the hormones of hypothalamus reach the anterior lobe of the pituitary gland.

Blood Vessels

- Blood vessels are a network of branched tubes that transport blood. There are three types of blood vessels namely arteries, veins and capillaries.

Arteries

- They are thick and elastic vessels that carry blood away from the heart to various organs of the body. All arteries carry oxygenated blood except the pulmonary artery which carry de-oxygenated blood to the lungs.
- As blood enters an arteriole it may have a pressure of 85 mm Hg (11.3 kPa) but as it leaves and flows into the capillary, the pressure drops to 35 mm Hg (4.7 kPa). (Note 1 mm Hg = 0.13 kPa. SI unit of mm Hg is kilo Pascal (kPa).
- Arterioles are small, narrow and thin walled which are connected to the capillaries. A small sphincter lies at the junction between the arterioles and capillaries to regulate the blood supply.
- Arteries do not always branch into arterioles; they can also form anastomoses. These are connections of one blood vessel (arteries) with another blood vessel. They provide alternate route of blood flow if the original blood vessel is blocked. For E.g., Arteries in the joints contain numerous anastomoses.
- This allows blood to flow freely even if one of the arteries closes during bending of the joints. Largest artery is Aorta.

Veins

- Veins are thin and non-elastic vessels that transport blood to the heart from the different organs. All veins carry de-oxygenated blood except the pulmonary vein which carry oxygenated blood from the lungs to the heart. **Largest vein is inferior vena cava.**

Capillaries

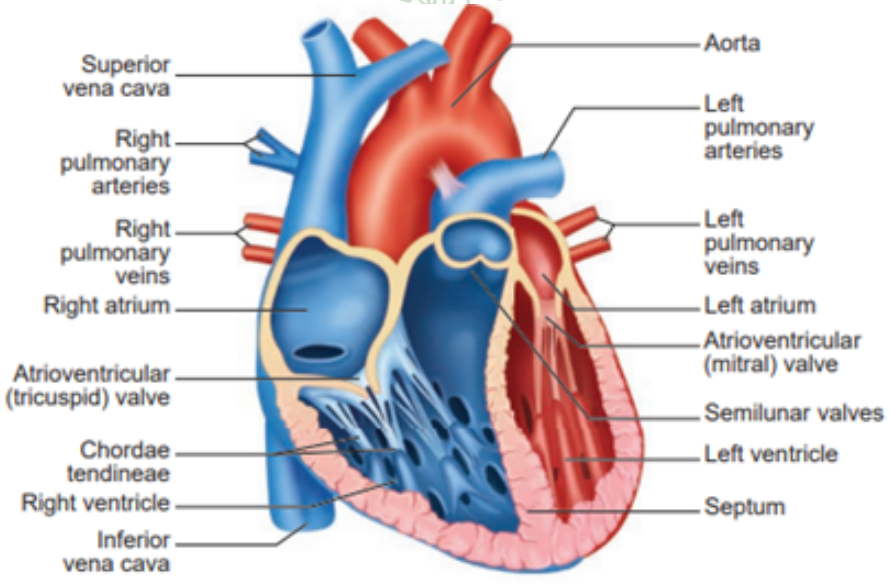
- Capillaries are narrow tubes formed by branching of arterioles which then unite to form the venules and veins. They are about 8 µm in diameter.
- Capillaries are formed of single layer of endothelial cells, and it have only tunica interna (tunica intima) layer. Capillaries are discovered by Marcello Malpighi. Smallest blood vessels

Structure of Blood Vessels

- The vessels carrying the blood are of three types; they are the arteries, veins and capillaries. These vessels are hollow structures and have complex walls surrounding the lumen.
- The blood vessels in humans are composed of three layers, tunica intima, tunica media and tunica externa.
- **Tunica Intima or Tunica Interna:** The inner layer, supports the vascular endothelium.
- **Tunica Media**: The middle layer, is composed of smooth muscles and an extra cellular matrix which contains a protein, elastin. The contraction and relaxation of the smooth muscles results in vasoconstriction and vasodilation. **Tunica externa or Tunica Adventitia**: The outer layer, is composed of collagen fibres.

Heart and their Structure

- Myogenic Heart, **its size**: 12 cm in length & 9 cm in breadth. **Its shape**: Conical or Pyramidal form.
- **Heart Weight**: 300 g (Male) & 250 g (Female). Heart is a muscular pumping organ that pumps out the blood into the blood vessels.
- Human heart is situated between the lungs, slightly tilted toward the left and above the diaphragm in the thoracic cavity. The heart is made of specialized type of muscle called the cardiac muscle.
- The heart is enclosed in a double walled sac called pericardium. It contains lubricating pericardial fluid which reduces friction during heart beat and protects it from mechanical injuries.
- The human heart is four chambered. The two upper thin walled chambers of the heart are called auricle or atria (sing: atrium) and two lower thick-walled chambers are called ventricles. The chambers are separated by partition called **septum.**
- The septum between auricles and ventricles prevents the mixing of oxygenated and de-oxygenated blood. The two auricles are separated from each other by interatrial septum. The left atrium is smaller than the right atrium. The right atrium receives de-oxygenated blood from different parts of the body through the main veins superior vena cava, inferior vena cava and coronary sinus.
- Pulmonary veins bring oxygenated blood to the left atrium from the lungs. The right and left auricles pump blood into the right and left ventricles respectively. The ventricles form the lower part of the heart.



Internal structure of human heart

- The two ventricles are separated from each other by an interventricular septum. The left and right ventricles have thick walls because the ventricles have to pump out blood with force away from the heart. From the right ventricle form right and left pulmonary arteries.
- The left ventricle is longer and narrower than the right ventricle. The walls are about three times thicker than the right ventricle.
- The left ventricle gives rise to aorta. The oxygenated blood is supplied by the aorta to various organs of the body. The coronary arteries supply blood to the heart.

Types of Heart

1. Neurogenic Heart

- Neurogenic heart beat is initiated by a nerve impulse caused from a nerve ganglion situated near the heart. E.g., Annelids, most arthropods.

2. Myogenic Heart

- Myogenic heart beat is initiated by a specialized group of modified heart muscle fibres. E.g., Mollusca and Vertebrates.

Chordae Tendineae

- The myocardium of the ventricle is thrown into irregular muscular ridges called trabeculae corneae. The trabeculae corneae are modified into chordae tendinae. The opening and closing of the semilunar valves are achieved by the **chordae tendinae**.
- The chordae tendinae are attached to the lower end of the heart by **papillary muscles. Cardiac Cycle (0.8 seconds).** The events that occur at the beginning of heart beat and lasts until the beginning of next beat is called cardiac cycle.

The Series of Cardiac Cycle

Phase-1

- **Ventricular diastole:** The pressure in the auricles increases than that of the ventricular pressure. AV valves are open while the semi lunar valves are closed.

Phase-2

- **Atrial systole (0.1 s):** The atria contracts while the ventricles are still relaxed. The contraction of the auricles pushes maximum volume of blood to the ventricles until they reach the end diastolic volume (EDV).
- EDV is related to the length of the cardiac muscle fibre. More the muscle is stretched, higher the EDV and the stroke volume.

Phase-3

- **Ventricular systole (0.3 s) (isovolumetric contraction):** The ventricular contraction forces the AV valves to close and increases the pressure inside the ventricles.
- The blood is then pumped from the ventricles into the aorta without change in the size of the muscle fibre length and ventricular chamber volume (isovolumetric contraction).

Phase-4

- **Ventricular systole (ventricular ejection):** Increased ventricular pressure forces the semilunar valves to open and blood is ejected out of the ventricles without backflow of blood. This point is the end of systolic volume (ESV).

Phase-5

- **Ventricular diastole (0.4 s):** The ventricles begin to relax, pressure in the arteries exceeds ventricular pressure, resulting in the closure of the semilunar valves.
- Systole and Diastole are generally equal duration is 0.4 s.

Sick Sinus Syndrome (SSS)

- SSS is characterized by dysfunction of the sinoatrial (SA) node. Treatment of SSS is directed at symptoms and typically involves the implantation of an artificial pacemaker.

Heart Sound

- The rhythmic closure and opening of the valves cause the sound of the heart. Heart sounds may be heard by **Stethoscope**.
- **Phonocardiogram** is an instrument for amplifying and recording of heart sounds. The first sound LUBB is of longer duration and is produced by the closure of the tricuspid and bicuspid valves after the beginning of ventricular systole.
- The second sound DUPP is of a shorter duration and produced by the closure of semilunar valves at the end of ventricular systole.

Electro Cardio Graph (ECG)

- **Waller (1887)** first recorded the electrocardiogram but **Einthoven (1903) (Father of ECG)** studied ECG in details. He got the Nobel prize in 1924 for the discovery of ECG.

P-Wave (Atrial Depolarisation)

- The time taken for the excitation to spread through atria from SA node. Contraction of both atria lasts for around 0.8–1.0 s.

PQ Interval (AV Node Delay)

- The time taken for the impulse to travel from the atria to the ventricles (0.12–0.21 s).
- QRS Complex (ventricular depolarisation). The normal QRS complex lasts for 0.06–0.09 s.

ST Segment

- It lies between the QRS complex and T wave. The ST segment lasts for 0.09 s.
- T wave-ventricular depolarisation.

Heart Diseases

- **Bradycardia:** Heart Rate is too low.
- **Tachycardia**: Heart beat is too high.
- **Angina pectoris**: Pain in the heart muscles.
- **Ischemia**: Reduced blood flow in heart.
- **Embolism**: The obstruction of the blood vessel by abnormal mass of materials such as fragment of the blood clot, bone fragment or an air bubble.
- **Aneurysm**: The weakened regions of the wall of the artery or veins bulges to form a balloon like sac.
- **Heart block**: The impulses from SA node do not reach the AV node.
- **Rheumatoid Heart Disease**: Rheumatic fever is an autoimmune disease which occurs 2–4 weeks after throat infection is caused by Streptococcus Pyogenes.
- **Coronary Thrombosis**: Plaque grows within the artery and tends to form blood clots, forming coronary thrombus. Thrombus in a coronary artery results in heart attack.
- **Ebstein's Disease**: It is a congenital downward displacement of the tricuspid valve into the right ventricles.