The Circulatory System

Body fluids.

Every organ in our body requires the involvement of the circulating fluids.

Blood	Plasma	Light-yellow coloured, alkaline liquid (pH-7.3 to 7.45), water (90-92%), proteins (7-8%), inorganic salts (sodium chloride, sodium bicarbonate -1%) other substances (glucose, amino acids, fibrinogen, hormones, urea etc) Serum - Plasma without fibrinogen.
RBC's Erythrocytes		Red blood cells in human male are about 5 million and in females are about 4.5 million. Minute (about 7 micron in diameter) biconcave disc-like structure (provide a large surface area for absorbing oxygen), flat in the centre and thick and rounded at the periphery.

Haemoglobin - Respiratory pigment in stroma of RBC's formed of an iron-containing part (haemin) and a protein part (globin). It combines with oxygen to form oxyhaemoglobin and with carbon-dioxide forms carbaminohaemoglobin.

- Carbon monoxide poisoning: Haemoglobin has a very strong affinity for carbon monoxide (furnaces burning in closed area) forming carboxyhaemoglobin (HbCO) results in even death due to oxygen depletion in the body.
- Adults and children (after 5 years of age) produce in bone marrow (long bones like ribs, breast-bone, ilium of ilium of hip girdle). In embryo, produced in liver and spleen. On maturation, they become enucleated and average life is about 120 days.
- Destroyed in spleen, liver and bone marrow.
- Polycythaemia: Abnormally increased number of RBCs.
- Erythropenia: Abnormally decreased no. of RBCs.

WBCs.

- White blood cells are about 4000-8000 per mm^3 of blood, amoeboid and can produce pseudopodia that can squeeze through the walls of the capillaries into the tissues (diapedesis). Produced in red bone marrow, lymph node, sometime liver and spleen.
- The average life is about two weeks.

Two major categories of WBCs	five cell type (Abudance)	Appearance	Distinguishing feature	functions
(A) Granular: cytoplasm contains granules. Nucleus usually constric-Ted into lobes.	1. Neutrophils		Nucleus with 3-4 lobes. Granular cytoplasm stain with neutral dyes.	Engulf bacteria (Phagocytosis)
	2. Eosinophils (2-3 % count) increases in allergies.		Nucleus with 2 lobes. Cytoplasmic granules lar-ge and stain dark red with eosin(acid dye).	Engulf bacteria. Secrete antitonins Associated allergy.
	3. Basophils (0.4 %)		. Nucleus lar-ge indistinctly lobe. Granules stain with basic dyes (eg met-thylene blue)	Release chemical (histamine) for Inflamma-ation which dilate blood vessels.
(B) Non-Granular: cytoplasm without gra-nules. A single large nucleus.	4. Lymphocyte		Smallest of WBCs. Single large nucleus	Produce antibodies.
	5. Monocytes		Nucleus large kidney-shape. At the site of infection, th-en form into macrophages.	Ingest germs.

- Leukemia - Cancer in which WBCs count increases at the cost of RBCs.
- Leucopenia - Abnormal decrease in the number of WBCs.

Platelets (Thrombocytes)

- Minute oval or round structures, non-nucleated, floating in the blood.
- In adult, are about 200000 to 400000 per mm^3 of blood.
- Derived from megakaryocytes in the red bone marrow.
- Life span is 3-6 days and is destroyed in the spleen.
- Helps in clotting of blood (coagulation).

* Main Reactions in blood clotting.

1. Injured Tissue cells / Platelets → Thromboplastin or Thrombokinase (Presently called factor X.)
2. Prothrombin (Inactive) found in blood plasma (also called thrombinogen) → Thrombin (Active) (Ca++ ions) (Acts like enzyme)
3. Fibrinogen (soluble) → Fibrin (insoluble) Threads makes a network

+RBCs → CLOT.

Blood transfusion and blood groups.

In surgeries, blood is taken from a healthy person and injected to the patient's veins so blood should be compatible with the recipient's blood type.

Discovered by Karl Landsteiner. RBCs of human have specific proteins (antigens) on their surface and plasma has its complementary antibodi-es.

ABO system - There are four blood groups A, B, AB and O. O type blood (universal donor) can be given to persons of all types of blood i.e O, A, B and AB. AB type blood (universal recipient) can receive blood from all types i.e AB, A, B and O.

Rh System - Blood of most people contains Rh factor, Rh stands for Rhesus, discovered in our common ancestor 'Monkey'.

An Rh-ve women may become sensitive if she carries an Rh+ve child in her uterus (Husband is Rh+ve). The first Rh+ve child will be normal but if it sensitizes the mother, the second positive child if conceived soon can leads to foetus death and abortion.

Tissue fluid: As the blood flows in the capillaries of the tissues, the plasma and the leucocytes "leak out" through their walls is known as intercellular or extracellular fluid.

This tissue fluid helps the cells to absorb oxygen and other substances in turn give out carbon dioxide and other wastes back to it.

Lymph and lymphatic system.

Most tissue fluid entering into lymph vessels is known as lymph.

Lymph drains into lymph nodes and fresh lymph channels arises and lymph pour into the major anterior veins close

to their entry into right auricle and again in circulation.

- Composition: Cellular - leukocytes (mainly lymphocytes), Non-cellular - water (94%), solids (6% - proteins, fats etc.)
- Functions: Supplies nutrition and oxygen to those parts where blood cannot reach and drain excess tissue fluid and metabolites. Lymphocytes and monocytes helps in the defense mechanism of the body.

Spleen: It is a large lymphatic organ, about the size of a clenched fist, reddish brown in colour and situated in the abdomen behind the stomach and above the left kidney.

- Functions:

(1) It acts like a blood reservoir in an emergency (haemorrhage, carbon-monoxide poisoning etc).

(2) It produces lymphocytes.

(3) It destroys worn-out red blood cells (with the liver).

(4) In an embryo, it produces RBCs.

Blood circulatory system.

It consists of heart, arteries, veins and capillaries.

The blood vessels: Arteries, capillaries and veins.

Arteries

- Blood vessels which carry blood away from the heart and into an organ.
- Progressively branched, decreasing in size.
- The smallest artery breaks into arterioles.
- It have thick and more muscular walls.
- Walls are elastic.
- Have narrower lumen.
- Have no valves in their inner linings.
- Can constrict or dilate to control blood flow.
- Usually deeper placed.
- Do not collapse when empty.
- carry fully oxygenated blood (except pulmonary artery).
- Blood flows with jerks and under great pressure.

Veins.

- Blood vessels which carry blood away from an organ and towards the heart. Except hepatic portal vein.
- Progressively unite, increase in size.
- The smallest vein arises from venules.
- Have thin and less muscular walls.
- Walls are non-elastic.
- Have wider lumen.
- Have valves in their lining to prevent backward flow of blood. Cannot constrict.
- Usually more superficial (nearer the skin).
- Collapse when empty.
- Carry partially deoxygenated CO_2 laden blood (except pulmonary vein).
- Blood flows continously and under very little pressure.

Capillary: Very narrow tube (8 micrometers in diameter)
The wall consists of a single layer of squamous epithelial cells and has no muscles. **Venules**:- Smallest united common branch of capillaries.
Functions: Allows outward diffusion of oxygen and inward diffusion of carbon-dioxide with power of vasodilation and vasoconstriction that affect the blood supply to the body parts. Allow inward and outward diffusion of substances like glucose, amino acids, urea etc. Allow leucocytes to squeeze out through capillary walls.

The heart:

Right in the centre between two lungs and above diaphragm.
The narrow end of the roughly triangular heart is pointed to the left side.

Covering and chambers: About the size of closed fist; protected by a double walled membranous covering called pericardium.

- Pericardial fluid reduces friction during heartbeat and protect from mechanical injuries.
- Upper two atria have thinner walls because major function is to receive blood from the body and pump it into the very next ventricles.
- Lower two ventricles have thick walls because they have to pump blood to long distances like up to the toes or up to the brain against gravity.

Blood vessels

- Anterior vena cava (superior vena cava) brings deoxygenated blood from the anterior or upper region of the body including head, chest and arms.

Posterior vena cava (inferior vena cava) brings the deoxygenated blood from the posterior or lower region of the body including abdomen and legs.

four pulmonary veins (two from each lung) bring oxygenated blood to the left atrium.

Blood vessels leaving the heart.

Pulmonary artery arises from the right ventricle and carries deoxygenated blood to the lungs.

Aorta arises from the left ventricle and carries oxygenated blood to supply it to all parts of the body.

Two coronary arteries (right and left) arise from the base of the aorta and supply the heart muscles.

Myocardial infarction/Heart attack - Dead of the corresponding area of heart due to blockage of any coronary arteries or their branches.

- Angina pectoris: Chest pain due to insufficient supply of blood to the heart muscle.

Valves:

- Right atrio-ventricular/tricuspid valve - Between the right auricle and the right ventricle.
- Chordae tendinea arises from the papillary muscle of the ventricular wall and helps the flaps in handling pressure.
- Left atrio ventricular/bicuspid/mitral valve - Between the left auricle and the left ventricle.
- Pulmonary semilunar values (three) - At the opening of the right ventricle into pulmonary artery.
- Aortic semilunar valves (three) - At the point of origin of aorta from the left ventricle.

circulation of blood in the heart.

Contraction of two atria starts and ventricles are dilating and empty so blood passes from the atria into the ventricles → Ventricles contract and atria relax, cuspid valve protect the return of blood → The ventricular blood enters - the pulmonary artery and the aorta respectively. → Semilunar value face away from the ventricles so these become flat and get a clear passage in between → Ventricle dilates, the blood from pulmonary artery and aorta tends to return, blood fills the pockets of values and the closes.

Put in box

Heart-beat-

Each full beat of the human heart lasts for about 0.85 seconds
The sequence of events in the heart-beat are called cardiac cycles.

Heart-Sound

LUBB sound when atrio-ventricular valves get closed sharply at the start of ventricular systole.
DUP sound when semilunar values get closed at the begining of ventricular diastole.

The pulse: The alternate expansion and elastic recoil of the wall of artery during ventricular systole. Counting of the pulse is indirectly the counting of the heartbeat. Eg Pulse rate in radial artery (wrist).

Blood Pressure

- The pressure which the blood flowing through the arteries exerts on their walls.

Systolic Pressure - Upper limit, the pressure when fresh blood is pushing through the artery in ventricular contraction of the heart.

Diastolic Pressure: Lower limit, the pressure when the wave has passed over.

Normal blood pressure: 100-140 mm (systolic) and 60-80 mm (diastolic)

Hypertension - Rise in blood pressure above 140/90 mmHg.

Pacemaker

- Sino-atrial node (SAN) - Located in the walls of right auricle. Impulse is relayed to the ventricles by special conducting fibres.
- Atrio-ventricular node (AVN) - Located near the interauricul-

Septum near the tricuspid value.

Bundle of HIS: It begins from AVN and extends to the Interventricular septum. It consists of Purkinje fibres together. all these forms a system which creates an impulse and conducts it to every part of the heart. If any trouble happens in the heart, the artificial pacemaker may fixed it.

Double circulations - Pulmonary and Systemic

Blood flows twice in the heart before it completes one full round.

Pulmonary circulation → It start from the right ventricle and splits into two branches, each entering a lung. In the lungs, blood gets oxygenated. The pulmonary veins then collect this oxygenated blood and carry it back to the left atrium of heart.

Systemic circulation : It begins with aorta which arises from the left ventricle. The aorta branches into multiple arteries that supply oxygen-rich blood to various body parts and tissues. Deoxygenated blood is then collected by veins and returned to the heart through the vena cava, emptying into right atrium.

Hepatic Portal System

- The veins originating from the stomach and intestines first merge into hepatic portal vein, which carries nutrient-rich blood to the liver. Unlike typical veins, the hepatic portal vein branches into a network of capillaries within the liver. These capillaries then reunite to form the hepatic vein, which drains into posterior vena cava, returning blood to the heart.
- The liver acts as a regulatory organ, controlling the quantity of nutrients entering the general bloodstream. For example, excess glucose is stored as glycogen for later use