15 Body Fluids and Circulation

Blood plays the major role in circulation of nutrients, hormones to cells, removal of waste products like carbon dioxide and most importantly it carries oxygen. Every day, blood donors assist patients of all ages, including accident and burn victims, heart surgery and organ transplant patients, and cancer patients. However, many patients continue to die or suffer unnecessarily as a result of a lack of access to safe blood transfusion.

Topic Notes

- *Circulation of Blood and Regulation of Heart*

CIRCULATION OF BLOOD AND REGULATION OF HEART

1

TOPIC 1

BLOOD

Blood is a special connective tissue which is derived from mesoderm, opaque in nature constituting 6% to 8% of total body weight and 30 to 35% of extracellular fluid. It is the most common living fluid connective tissue. In arteries, blood is bright red in colour as it contains oxygenated blood and the blood carried by veins is dark red in colour as it is deoxygenated. The pH of arterial blood is slightly alkaline, *i.e.* 7.4 pH and the pH of veins is 6.8. Blood is viscous as compared to water because it contains RBCs, serum albumin and other cells. Taste of blood is salty. Volume of blood in males is 5 litres to 6 litres and that in females is 4 litres to 5 litres, it is lower in females because of the monthly menstrual cycle. Blood is composed of plasma about 55% and blood cells about 45%.

Important

➥ *Before puberty and after menopause, blood volume of female is equal to blood volume of male.*

Plasma

Plasma is a slightly alkaline or basic non-living intercellular substance which constitutes about 55 per cent of the blood. It is usually pale yellow but sometimes transparent in colour.

Composition of Plasma

(1) Water alone forms 90 to 92 per cent of the plasma. Solid forms about 8 per cent of the plasma.

(2) Minerals like Na^{+}, Ca^{2+}, Mg^{2+}, HCO_3^{-}, Cl^{-}, etc., are present in the plasma.

(3) Glucose, amino acids, lipids, etc., are the nutrients present in the plasma.

(4) Protein composes about 6 to 8 per cent of the plasma. These are mainly includes albumin for osmotic balance, globulin for defence and fibrinogen for blood clotting.

(5) Immunoglobulins which act as antibodies are the defence compound of plasma.

(6) Excretory substances includes ammonia, urea, Aric acid, creatine, etc., are also present in the plasma.

(7) Different types of dissolved gases, anticoagulants, hormones, vitamins and enzymes are also part of the plasma.

Formed Elements (Elements of blood)

There are three types of blood cells present in blood, namely: Erythrocytes or Red blood cells, Leucocytes or White blood cells and Thrombocytes or Platelets. These cells are also called formed elements of blood.

Erythrocytes

The word *Erythros* means red and cyte means the cell, therefore erythrocytes are also known as red blood cells.

It is biconcave in shape having a diameter of 7 to 8 μm. It has a peripheral thickness of about 1 to 2 μm and a central thickness of 0.8 to 1 μm. These are enucleated and contain haemoglobin.

Since the nucleus is absent in RBCs, it is also deprived of mitochondria.

The biconcave shape of an erythrocyte is important because it provides a large surface area for gaseous exchange, accommodates more amount of haemoglobin, provides flexibility to RBCs, peripheral thickness prevents rupture of RBCs while passing through small capillaries, central thickness helps in the easy exchange of gases.

RBCs production is known as erythropoiesis. Red bone marrow, liver and spleen are the sites of erythropoiesis.

Destruction of erythrocytes takes place in the spleen (graveyard of RBCs) by macrophages and in the liver by kupffer cells. Its average life span is about 120 days.

Leucocytes

The word *Leuco* means white and cyte means the cell. Leucocytes are also known as white blood cells or WBCs. It is irregular and amoeboid in shape with a well-developed nucleus. Haemoglobin is absent in leucocytes. It shows the property of diapedesis meaning, squeezing out of capillaries. Production of WBCs takes place in red bone marrow. White blood cells are broadly classified into two types:

(1) Granulocytes

(2) Agranulocytes

Granulocytes

Granulocytes are a type of leucocyte which contains different types of granules which get stained after staining by different stains. They have granular cytoplasm and irregular lobed nucleus. These are of three types:

(i) Neutrophils

(ii) Basophils

(iii) Eosinophils

(i) Neutrophils are granulocytes which are phagocytic in nature and their granule after being stained by neutral stains gives a violet or purple colour. As compared to other granulocytes neutrophils are found more in number, about 60-65% of the total WBCs count. Nucleus of neutrophils appears beaded. It is also known as Polymorphonuclear leucocyte or PMNL.

(ii) Basophils are granulocytes whose granules after being stained by basic dye, *i.e.* methylene blue gives blue colour. These are the least (0.5-1% of total WBCs) found WBCs in blood. All the inflammatory reactions are dependent on basophils, as it secretes histamine which is responsible for vasodilation and inflammation, serotonin which is responsible for vasoconstriction and heparin which acts as an anti-coagulant. Nucleus of basophil is S-shaped, surrounded by basic granules.

(iii) Eosinophils are granulocytes, which after being stained by acidic dye, *i.e.* eosin give reddish orange colour. It has a bilobed nucleus and has anti-histamine, anti-inflammatory and anti-allergic properties. Eosinophils are about 2-3% of the total WBCs present in blood.

Important

➥ *Eosinophilia is an increase in eosinophil count commonly seen in allergic conditions.*

Agranulocytes

These granules are not found in cytoplasm of these cells. Agranulocytes are of two types:

(i) Lymphocytes

(ii) Monocytes

(i) Lymphocytes: They are smaller in size containing scant cytoplasm with large nucleus. There are two types of lymphocytes, *i.e.* B and T-lymphocytes which contribute to the immune response of the body. Lymphocytes are 20-25 % of total leucocytes. They are non-motile and non-phagocytic in nature. They produce antibodies to destroy microbes.

(ii) Monocytes: These are the largest WBCs and are phagocytic in nature. Monocytes are 6-8% of total leucocytes. They have a bilobed nucleus. Generally, they change into macrophages after entering tissue spaces.

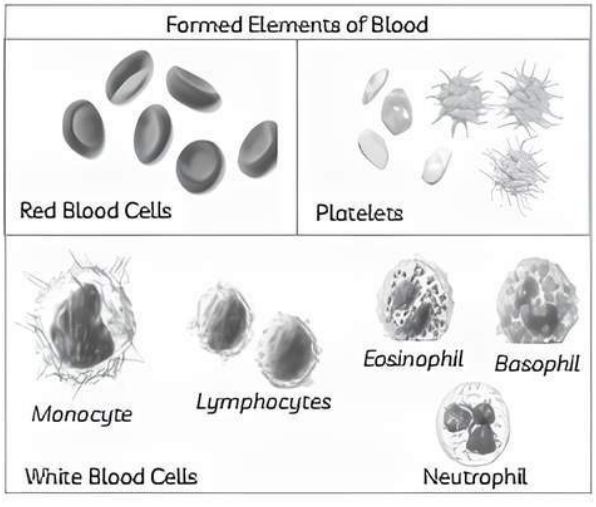
Thrombocytes

The word *thrombus* means clot, so thrombocytes or platelets are the blood cells which help in clotting of blood. Platelets are formed from fragments of megakaryocytes (very large cells of the bone marrow). Normal life span of blood platelets or thrombocytes is about a week. Shape of platelets in active form is a star or rod and in an inactive form, it is spherical in shape. Size varies from 2.5 to 5 μm. It is deprived of nucleus, *i.e.*, enucleated and does not contain haemoglobin. Platelets are produced in the red bone marrow and destruction of platelets occurs in spleen.

Functions of Platelets: It forms platelet plugs to prevent blood loss at the site of injury. When an injury is caused, the blood platelets release a certain chemicals (thromboplastins) are called the platelet factors. The platelet factors help in blood clotting.

Example 1.1: Name the components of the formed elements in the blood and mention one major function of each of them. [NCERT]

Ans. The elements which are covered by a membrane and show proper shape are called formed elements. Nearly 45% of human body fluid, *i.e.* blood consists of formed elements. Erythrocytes, Thrombocytes, *i.e.* platelets and Leucocytes make up formed elements. The biconcave shape of an erythrocyte is important as it provides a large surface area for gaseous exchange, thrombocytes or platelets are the blood cells which help in clotting of blood, many leucocytes are phagocytic in nature and help in increasing immune system of the body.



Elements of blood

Example 1.2: Match the following:

Column I	Column II
(A) Eosinophils	(i) Coagulation
(B) RBCs	(ii) Universal recipient

Column I	Column II
(C) AB group	(iii) Resist infections
(D) Platelets	(iv) Contraction of heart
(E) Systole	(v) Gas transport

Ans. (A) – (iii). (B) – (v). (C) – (ii). (D) – (i). (E) – (iv)

Explanation:

(1) Eosinophils are WBCs which has a bilobed nucleus and have anti-histamine, anti-inflammatory and anti-allergic properties hence it resists infections.

(2) Function of RBCs is to transport gases.

(3) A human with blood group AB can accept blood from any blood group and hence act as a universal recipient.

(4) Platelets are the blood cells which help in clotting of blood. It forms platelet plugs to prevent blood loss at the site of injury.

(5) The contraction of heart muscles during the pumping of the heart is known as systole.

Blood Groups

Have you ever donated your blood? If not yet, do it in the coming blood donation camp. By doing this you cannot only donate your blood but also you are doing a noble cause by helping others in their critical situations. Isn't it magical? Yes, it is because of developed science. As we all know there are some physical tests conducted before donating blood. In these blood tests, we come to know about the blood groups and whether our blood is suitable to donate or not. What are these blood groups? What are their types? Let's see the topic below.

There are two types of blood grouping:

(1) ABO grouping

(2) Rh grouping

ABO Grouping

Blood groups A, B and O were discovered by Karl Landsteiner in 1900 and blood group AB was discovered by De Castalo and Steini. The gene present in this type of blood grouping is gene I (isoagglutinogen). On the surface of RBCs, antigen is present and their reciprocal antibodies are present in plasma. This blood grouping consists of four phenotypes A, B, AB and O and six genotypes. Antigen is made up of agglutinogen and antibodies of agglutinin.

Rh Grouping

It was discovered by Landsteiner and Wiener in the year 1940. Rh blood group was discovered in Rhesus monkeys. A protein called rhesus antigen or D-antigen is present on the surface of RBCs. Gene D/R is present in Rh grouping. Antibodies are absent in this grouping. About 80% of Humans are Rh-positive and remaining 20% are Rh-negative.

Erythroblastosis Fetalis is a rare condition between Rh-positive father and Rh-negative mother which gives birth to Rh-positive foetus. First baby of Rh-positive father and Rh-negative mother survives as there are no antibodies formed against Rh-positive antigens but the 2^{nd} baby of this couple with Rh-positive blood group dies because antibodies are formed against Rh-antigen during delivery of the 1^{st} baby. This condition is also known as Rh incompatibility or Haemolytic disease of the newborn.

Clotting Mechanism

When an injury is caused to a blood vessel, bleeding starts which is stopped by a process called blood clotting or coagulation. There are three major steps in this process:

First step: At the site of an injury, the blood platelets disintegrate and release a phospholipid, called platelet factor-3 (platelet thromboplastin). Injury or injured tissues also release a lipoprotein factor called thromboplastin. These two factors combine with Ca^{2+} and certain proteins of the blood plasma to form an enzyme called pro-thrombinase.

Second step: The prothrombinase inactivates heparin (or antiprothrombin-anticoagulant) in the presence of Ca^{2+}. Prothrombinase catalyses breakdown of prothrombin (inactive plasma protein) into an active protein called thrombin and some small peptide fragments.

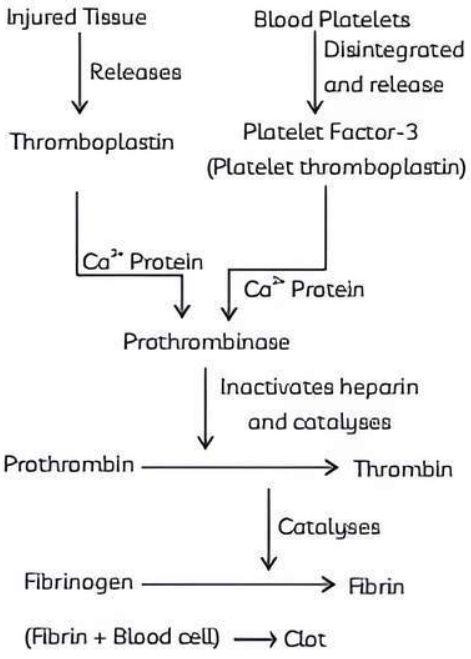
Third step: Thrombin acts as an enzyme and first brings about the depolymerisation of fibrinogen into its monomers.

Later thrombin stimulates repolymerisation of these monomers into long insoluble thread-like polymers called fibrin. The thin, long and solid fibres of fibrin form a dense network upon the wound and trap blood corpuscles to form a clot. The clot seals the wound and stops bleeding. Soon after the clot starts contracting and a pale yellow fluid, the serum, starts oozing out. This serum is blood plasma minus fibrinogen and blood corpuscles (RBC, WBC and platelets).

Vitamin K is essential for the synthesis of prothrombin in the liver.

Important

➥ *Vitamin K is essential for blood clotting because it is necessary for the synthesis of prothrombin in the liver. If vitamin K is not sufficient in the body, blood clotting becomes inefficient.*



The Process of Blood Clotting

Clotting of blood

TOPIC 2

LYMPH

Lymph is mobile connective tissue comprising lymph plasma (fluid) and lymph corpuscles (cells). It is a colourless tissue fluid composed of generally 30% of nutrients and 70% of wastes.

Lymph can be represented by a simple equation:

Lymph = Blood – [RBC + platelets + Larger proteins]

Lymph Plasma

It is similar to that of blood but has fewer blood proteins, less calcium and phosphorus and high glucose concentration. Mainly globulin proteins are present which are actually antibodies. Other components of the lymph plasma are very much like that of blood plasma, *i.e.* organic, inorganic substances, water, etc.

Lymph Corpuscles

These are floating amoeboid cells, the leucocytes (WBCs), which are mostly lymphocytes. Erythrocytes (RBCs) and platelets are absent in the lymph.

Important

➥ ***Lymph organs:*** *The organs which secrete lymph are called lymphoid organs. Beside the lymph nodes, tonsils, thymus glands, spleen and Peyer's patches are the other lymphoidal organs. The spleen is the largest mass of lymphatic tissue in the body.*

➥ *Lymph help in the transport of oxygen, food materials, hormones, etc., to the body cells. It also brings CO_2 and other metabolic waste from the body cell to blood and then finally powers them into venous system. Lymph nodes produces lymphocytes.*

➥ *Lymph maintains the volume of the blood in the body. As soon as the volume of the blood reduces in the blood vascular system, the lymph rushes from the lymphatic system to the blood vascular system.*

TOPIC 3

HUMAN CIRCULATORY SYSTEM

Human Heart

Mesodermally originated human heart is located ventrally in the thorax, inside the mediastinum and slightly tilted towards the left.

Its size varies from 12×9×6 cm, *i.e.* length × width × thickness. It weighs 300 gm in male and 250 gm in females.

Structure of human heart

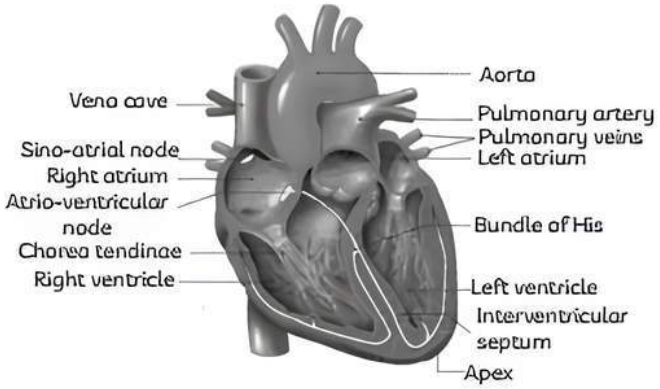
It is a hollow, fibro-muscular, pumping organ. Apex of the heart is downward and forward while the base is upward and backward.

Pericardium consists of a double-layered, peritoneum, the outermost layer of the heart. The outer wall of pericardium is fibrous, made up of collagen fibres

which gives protection by preventing over-distension and over-stretching of the heart. The inner wall of pericardium is serous, consisting of the outer parietal and inner visceral layer which is lined by squamous epithelium.

Middle layer of the heart is thick and contains cardiac muscles, it is known as myocardium.

Endocardium is the innermost layer of the heart lined by simple squamous epithelium, flat cells here, providing minimum resistance to blood flow.



Section of a human heart

Human heart consists of 2 atria (right and left) and 2 ventricles (right and left). Right atrium receives deoxygenated blood through superior vena cava, inferior vena cava and coronary sinus.

Superior vena cava, also known as precaval vein, receives deoxygenated blood from the upper part of chest, neck, head and upper limbs.

Inferior vena cava or postcaval vein receives blood from lower part of chest, abdomen and lower limbs.

Coronary sinus is a combined opening of right and left coronary veins, it is present at the posterior side of the right atrium and receives deoxygenated blood from the heart itself.

Left atrium receives oxygenated blood from pulmonary veins. Ventricles are lower, larger and distributing chambers of the human heart. Right ventricle receives deoxygenated blood from the right atrium.

Pulmonary trunk arises from the right ventricle and divides to form right and left pulmonary arteries which give deoxygenated blood to lungs.

Left ventricle is the largest and thickest chamber receiving oxygenated blood from the left atrium.

Aorta arises from the left ventricle and gives oxygenated blood to the whole body except lungs.

Smaller ridges/ gyri in the ventricle called trabeculae/ columnae carneae increase the surface area of the heart. Higher ridges/gyri in ventricles which are attached to cusp with the help of chordae tendineae are known as papillary muscles.

Chordae tendineae is a white fibrous thread like structure which connects flaps to papillary muscles. Cusps: Chordae tendineae: Papillary muscles = 1: 1: 1.

An external and incomplete partition which is transverse/horizontal between atrium and ventricle is Atrioventricular septa/Coronary sulcus.

Atrioventricular openings are guarded by Atrioventricular valves or A-V valves. Two types of AV valves are present namely right atrioventricular valve and left atrioventricular valve.

Right atrioventricular valve consists of 3 cusps and is hence known as tricuspid valve, present between right atrium and right ventricle and left atrioventricular valve consists of 2 cusps known as bicuspid or mitral valve (having two flaps), present between left atrium and left ventricle. Both the bicuspid and tricuspid valves work simultaneously.

Other than these valves, there are 4 more valves present in the heart, two of them are semilunar valves, named so because of their half-moon shape.

The valve which prevents backward flow of blood from pulmonary trunk into right ventricle is a pulmonary semilunar valve.

The valve which prevents backward flow of blood from the aorta to the left ventricle is an aortic semilunar valve.

Heart Sounds

Closure of the Atrioventricular valve makes the 1st heart sound; Lubb and closure of semilunar valve make the 2nd heart sound; Dubb. Heart murmur is an abnormal heart sound due to leakage in valves.

Important

➥ *Conducting system of heart consists of sinoatrial node, atrioventricular node, AV bundle, Purkinje fibres and inter-nodal fibres.*

Cardiac Cycle

Atrial systole of 0.1 sec, ventricular systole of 0.3 sec and joint diastole of 0.4 sec make up a cardiac cycle of 0.8 sec. In joint diastole of 0.4 sec all 4 chambers of heart relax, atrioventricular valves open and semi-lunar valves get closed causes 2nd heart sound *i.e.*, Dubb or Dub. 70% of atrial and ventricular filling is done in this stage of cardiac cycle. In an atrial systole of 0.1 sec 30% of ventricles are filled by blood and the atria get empty. In the ventricular systole of 0.3 sec ventricles get empty and the atria get filled by blood.

Important

➥ *Following are the simple equations related to cardiac cycle:*

1 cardiac cycle = *1 heart beat = 0.8 sec*
Atrial diastole = *Ventricular systole (0.3) + Joint diastole (0.4) = 0.7 sec*
Ventricular diastole = *Atrial systole (0.1) + Joint diastole (0.4) = 0.5 sec*

Electrocardiogram (ECG)

A graphical demonstration of an electrical activity of the heart is an electrocardiogram, *i.e.* ECG and Electrocardiograph is an instrument which records electrical activity of the heart.

Important

➥ *The Father of electrocardiography is William Einthoven. He got the Nobel prize in 1924 for the discovery of ECG.*

ECG consists mainly of 3 waves, *i.e.* P-wave, QRS complex and T-wave. P-wave or atrial complex is the first positive wave of ECG. Events occurring in P waves are SA node activation, spreading of impulse over atria, atrial depolarisation and atrial contraction / atrial systole. The QRS complex is also known as the Ventricular complex in which Q is the first negative wave of ECG. R is the tallest positive wave of ECG and S is the deepest negative wave of ECG. Events occurring during QRS complex are spreading of impulse over ventricles, ventricular depolarisation / ventricular contraction / ventricular systole. First heart sound is produced during this wave. T-wave is the smoothest and broad wave of ECG. Second heart sound and ventricular repolarisation take place during marking of T-wave.

TOPIC 4

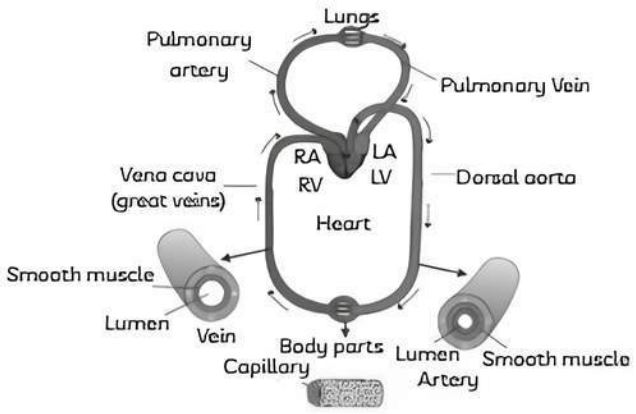
DOUBLE CIRCULATION

Double circulation is a process during which blood passes twice through the heart during one complete cycle. This type of circulation is found in amphibians, reptiles, birds, and mammals. However, it is more accurately prominent in birds and mammals as their heart is completely divided into four chambers— the right atrium, the right ventricle, the left atrium, and the left ventricle.

The movement of blood in an organism is divided into two parts:

(1) Pulmonary circulation

(2) Systemic circulation



Schematic plan of blood circulation in human

Pulmonary Circulation

It is the movement of blood from heart to the lungs and back. Deoxygenated blood of the body enters the right atrium, and passes into the right ventricle which pumps it into the pulmonary arch. With the help of two separate pulmonary arteries, the blood passes into the lungs.

Systemic Circulation

It is the circulation of blood between heart and different parts of the body except lungs. Oxygenated blood received by the left atrium passes into the left ventricle. The left ventricle pumps it into the aorta for supply to different body parts including walls of the heart with the help of arteries.

Double circulation is an improvement over single circulation as the heart pumps both the types of blood (oxygenated and deoxygenated) forcefully through the body. In amphibians and reptiles, the double circulation is incomplete due to mixing of the blood. Complete double circulation is found only in birds and mammals.

Example 1.3: Case Based:

Sheela, a 70-year-old woman, is interested in learning whether fish oil supplementation could help lower her cholesterol. She reports no significant medical history but says she is interested in doing things that can keep her healthy. Sheela eats well, exercises regularly, and takes several supplements that, she has read, can promote her health. A friend introduced her to fish oil, saying it might improve her heart health and lower her cholesterol, but Sheela would like more information from her pharmacist before deciding whether there are real benefits. At Sheela's last medical evaluation, her physician indicated that she had borderline high cholesterol and that he would give her a trial of dietary modification for 3 months to determine whether this alone might address her issue.

(A) Oxygenated blood from heart is supplied to stomach *via*:
- **(a) Hepatic artery**
- **(b) Gastric artery**
- **(c) Mesenteric artery**
- **(d) None of the above**

(B) Deoxygenated blood from heart is transported to lungs *via*:
- **(a) Pulmonary artery**
- **(b) Pulmonary vein**
- **(c) Aorta**
- **(d) Gastric vein**

(C) Name the two types of circulation present in human beings.

(D) What is pulmonary circulation?

(E) Assertion (A): Mesenteric artery supplies oxygenated blood to intestine.

Reason (R): Vena cava supplies oxygenated blood to all body parts.

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true and R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false but R is true.

Ans. **(A)** *(b) Gastric artery*

Explanation: Oxygenated blood from right atrium is collected by aorta and passed to gastric artery which supplies blood to stomach.

(B) *(a) Pulmonary artery*

Explanation: Deoxygenated blood from the heart is carried by Pulmonary artery to lungs. Pulmonary vein transports pure and oxygenated blood to heart from lungs. Aorta carries oxygenated blood from the left ventricle and passes it to all body parts.

⚠ Caution

➥ *Students must remember that except the pulmonary arteries all other arteries carry oxygenated blood and except pulmonary vein all other veins carry deoxygenated blood.*

(C) Two types of circulation present in human beings are as follows:

(1) Pulmonary circulation

(2) Systemic circulation

(D) The circulation which occurs between heart and lungs is pulmonary circulation. The flow of blood in this circulation is from right ventricle to pulmonary arteries to lungs to pulmonary veins to left atrium.

(E) *(c) A is true but R is false.*

Explanation: Mesenteric arteries supply oxygenated blood to the intestine. Vena cava carries deoxygenated blood from body parts to heart.

TOPIC 5

REGULATION OF CARDIAC ACTIVITY AND DISORDERS OF CIRCULATORY SYSTEM

Neural and Hormonal Regulation

Heart is an auto-excitable organ which is myogenic in nature. But the heartbeat is also regulated by the nerves. Cardiac centre is located in the medulla oblongata of the brain. Adrenaline, a neurotransmitter from the sympathetic nervous system part of the autonomic nervous system increases heart rate. Acetylcholine, another neurotransmitter from the parasympathetic nervous system, a part of the autonomic nervous system decreases heart rate. Adrenal medullary hormones increase heart rate, increase strength of contraction and increase cardiac output.

Disorders of Circulatory System

Hypertension (High blood pressure)

It is the most common disease affecting the heart and blood vessels. It is a disorder in which systolic blood pressure is above 140 mm Hg and diastolic pressure is about 90 mm Hg. The reasons for increases in blood pressure are severe vasoconstriction, obesity, stress, tension, anxiety, smoking, etc.

Blood pressure above 220/120 mmHg causes cerebral haemorrhage in which carotid artery bursts, it also causes blindness as retinal artery bursts.

Atherosclerosis / Coronary Artery Disease (CAD)

The word atheroma means cholesterol plaque and sclerosis means hardening. It is a disorder, in which an atheromatous plaque is formed which decreases the diameter of blood vessels and makes them narrow. Sometimes plaques may block the artery completely.

Arteriosclerosis

In this disorder, calcium ions cause hardening of elastic membrane of artery and sodium ions causes dryness of elastic membrane, both harden the blood vessels.

Heart attack / Myocardial Infarction

The word infarction means necrosis *i.e.*, death of cells and myocardial refers to myocardium. Death of cardiac cells due to inadequate supply of blood.

Angina Pectoris / Angina

The word angina means pain and pectoral means muscles *i.e.*, muscles of chest. It is the condition of chest pain due to inadequate blood supply.

Heart failure

It is the condition of the heart when it does not pump blood effectively enough to meet the needs of the body. Weakening of heart muscles due to the inadequate blood supply. Congestion in lungs leads to congestive heart failure.

Heart block / Cardiac arrest

In this disorder, heart stops beating, due to failure of conducting system.

Example 1.4: Case Based:

Mrs Peter is a 52-year-old bank manager who presents tonight in the bank following an episode of "chest pain" that she went through earlier in the day during lunch break. Although the pain was reduced and severity of pain was normalised after some time, her husband still advised her to take consultation with a physician because she had similar episodes of chest pain over the past five months.

Mrs Peter described the pain as being more discomforting and heavy. She said it is localised to "my breast bone" and does not radiate. Today, after taking a good rest, the pain was reduced and she returned to her bank. Previous incidents of chest pain and heavy feelings tended to occur following heavy and large meals and on one occasion while dancing at a party. None of the incidents lasted more than "several minutes."

Although Mrs Peter did not undergo nausea or vomiting today, she experienced many incidents in the past of feeling a burning sensation in her chest. She described the feeling as being "like acid behind my breast bone." This feeling occurs most often late at night when she lies down.

(A) The case described in above paragraph depicts which disorder of heart?

(a) Angina Pectoris (b) Heart failure
(c) Atherosclerosis (d) Hypertension

(B) The episode of chest pain in given case lasted for:

(a) Several hours (b) Several seconds
(c) Several minutes (d) Nanoseconds

(C) What characteristics define angina pectoris?

(D) What is the most common age of Angina Pectoris to occur?

(E) Assertion (A): Angina Pectoris is a disorder of the heart.
Reason (R): It occurs when a low amount of carbon dioxide is supplied to the muscles of the lung.

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true and R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

Ans. (A) (a) *Angina Pectoris*

Explanation: A symptom of acute chest pain appears when not enough O_2 is reaching the heart muscle.

Angina can occur in males and females of any age but is most common in middle-aged or elderly individuals.

(B) *(c) Several minutes*

Explanation: Each incident that occurred with a patient in a given case lasted for several minutes.

(C) Angina Pectoris is characterised by several episodes of severe chest pain and burning sensation in the chest.

(D) Angina Pectoris, a heart disorder usually can happen in any age group but it is commonly found in men and women of middle and old age.

(E) *(c) A is true but R is false.*

Explanation: Angina Pectoris is a heart disorder, in which there is severe pain in chest and is also characterised by a burning sensation in the chest due to a low supply of oxygen to muscles of heart through blood.

OBJECTIVE Type Questions

[1 mark]

Multiple Choice Questions

1. What is not the property of high blood pressure?

(a) 140 mm Hg is systolic pressure.
(b) 80 mm Hg is diastolic pressure.
(c) Leads to heart disease.
(d) Affect vital organs like brain and kidney.

[Diksha]

Ans. *(b) 80 mm Hg is diastolic pressure.*

2. Which of the following is not a formed element of blood?

(a) Erythrocytes (b) Leucocytes
(c) Plasma (d) Thrombocytes

[NCERT Exemplar]

Ans. *(c) Plasma*

Explanation: The elements which are covered by a membrane and show proper shape are called as formed elements. Nearly 45% of human blood consists of formed elements. Erythrocytes, thrombocytes *i.e.*, platelets and leucocytes make up formed elements. Plasma is in two forms, that is, liquid and solid. 90% to 92% of plasma is in liquid form, *i.e.* water and remaining 8% to 10% are in solid form which consists of inorganic substances like ions of sodium, potassium, calcium and magnesium about 1% and organic substances of about 7% to 9% like serum albumins and serum globulins.

3. Most abundant cell found in blood is:

(a) Red blood cells **(b) Erythrocytes**

(c) Leucocytes **(d) Both (a) and (b)**

Ans. *(d) Both (a) and (b)*

Explanation: Most abundant formed element found in human blood is erythrocytes also known as red blood cells. Leucocytes are white blood cells functioning in the immune response of the body, many leucocytes are phagocytic in nature.

4. Choose the correct option regarding Leucocytes.

(a) They are long-lived, about 120 days.

(b) They are deprived of nucleus, *i.e.* enucleated.

(c) Basophils resist infections.

(d) Normal count is 6000-8000 cells per cubic mm of blood.

Ans. *(d) Normal count is 6000-8000 cells per cubic mm of blood.*

Explanation: Leucocytes have a very short life span of about 3 to 4 days. They consist of prominent nuclei of different shapes in different types of white blood cells. Eosinophil is the WBCs which combat infections and is related to allergic reactions. Normal count of leucocytes is 6000 to 8000 cells per cubic mm of blood.

5. Which of the following lymphocytes are responsible for immune responses of the body?

(a) B and T-lymphocytes

(b) Eosinophils

(c) Basophils

(d) Thrombocytes **[Diksha]**

Ans. *(a) B and T-lymphocytes*

Explanation: Both B and T-lymphocytes are responsible for immune responses of the body.

Related Theory

Eosinophils have anti-histamine, anti-inflammatory and anti-allergic properties. All the inflammatory reactions are dependent on basophils, as it secretes histamine which is responsible for vasodilation and inflammation, serotonin which is responsible for vasoconstriction and heparin which acts as anti-coagulant.

6. Myogenic muscles are the:

(a) Specialised muscles in the mammalian gut.

(b) Specialised muscles in the mammalian heart.

(c) Specialised muscles in the mammalian pancreas.

(d) Specialised muscles in the mammalian kidney.

Ans. *(b) Specialised muscles in the mammalian heart.*

Explanation: Muscles of the mammalian heart are independent of any other impulse from the brain, as the nodal tissue itself generates an impulse in the heart and hence their heart is myogenic in nature.

7. Blood clotting disorders may be caused by:

(a) Reduction in WBCs count.

(b) Reduction in RBCs count.

(c) Reduction in platelets.

(d) Reduction in T-lymphocytes.

Ans. *(c) Reduction in platelets.*

Explanation: Low count of platelets causes clotting disorders. Reduction in RBCs count is seen in disorders like anaemia. Reduction in WBCs count is commonly seen in fever or chills and cough.

8. Choose the correct option regarding ABO blood group system:

(a) Antigens are present in WBCs and antibodies are present in plasma.

(b) Antigens are present in RBCs and antibodies are present in plasma.

(c) Antigens are present in plasma and antibodies are present in RBCs.

(d) Antigens and antibodies both are present in RBCs.

Ans. *(b) Antigens are present in RBCs and antibodies are present in plasma.*

Explanation: In ABO blood group system, antigens are present in RBCs and antibodies are present in plasma.

9. Which of the following has closed blood circulatory system?

(a) Arthropods

(b) Molluscs

(c) Porifera

(d) Annelids and chordates

Ans. *(d) Annelids and chordates*

Explanation: The blood vascular system consisting of closed blood vessels and capillaries is called a closed type of blood vascular system. This type of blood vascular system is found in annelids and chordates. Arthropods and Molluscs have an open type of blood vascular system. Their organs are directly bathed in blood. Phylum Porifera exchange body fluids by simple diffusion.

10. Statement A: Red blood cells are biconcave in shape and nucleated.

Statement B: Biconcave shape provides a smaller surface area for the binding of oxyhaemoglobin.

(a) Both A and B are correct.
(b) Both A and B are incorrect.
(c) Only A is correct.
(d) Only B is correct.

Ans. *(b) Both A and B are incorrect.*

Explanation: The disc-shaped body and concave core of RBC are distinctive features. They lack most organelles, the nucleus, and nuclear DNA.

RBCs are biconcave, which increases the surface area of the cell and enables the storage of more haemoglobin. Therefore, more Hb can transport more oxygen when it binds with more of it. More oxygen and carbon dioxide are exchanged because RBCs have a bigger surface area.

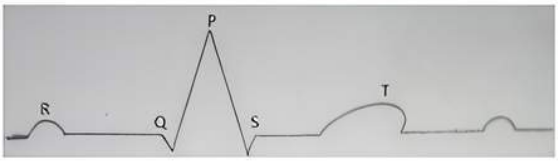
11. **Statement A: Neutrophils secrete histamine, serotonin and heparin.**
Statement B: They are involved in inflammatory reactions.

(a) Both A and B are correct.
(b) Both A and B are incorrect.
(c) Only A is correct.
(d) Only B is correct.

Ans. *(d) Only B is correct.*

Explanation: Heparin, histamine and serotonin are released by mast cells, a kind of granular basophil cell found in connective tissue, during inflammatory and allergic reactions.

12. **Which of the following letters is marked incorrectly in the given diagram?**



(a) P and R (b) Q and T
(c) T and S (d) T-wave

Ans. *(a) P and R*

13. **By counting the number of which of the following waves, the heartbeat of a person can be determined?**

(a) P-wave (b) QRS complex
(c) ST-segment (d) PQ interval

Ans. *(b) QRS complex*

Explanation: By counting the number of QRS complexes that occur in a given period, one can determine the heartbeat rate of an individual. Any deviation from the shapes of the curve indicates a possible abnormality or a disease. Hence, it is of great clinical significance.

Assertion-Reason (A-R)

Given below are two statements labelled as Assertion (A) and Reason (R). Select the most appropriate answer from the options given below:

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true and R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

14. **Assertion (A): Human heart is called myogenic.**
Reason (R): Normal activities of the heart are regulated intrinsically, *i.e.* auto-regulated by specialised muscles. [NCERT Exemplar]

Ans. *(a) Both A and R are true and R is the correct explanation of A.*

Explanation: Muscles of the human heart are independent of any other impulse from the brain, as the nodal tissue itself in the heart generates impulse which regulates the rate of the heartbeat and hence the heart is myogenic in nature.

15. **Assertion (A): Blood pumped by the right ventricle enters the pulmonary artery.**
Reason (R): Right atrium pumps blood into the aorta.

Ans. *(c) A is true but R is false.*

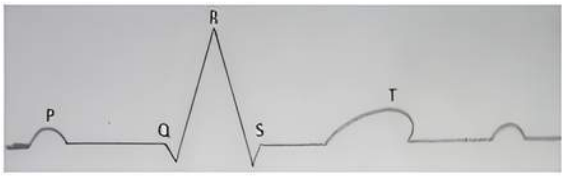
Explanation: Blood flow of the human heart is carried out by arteries and vessels. Oxygenated blood is collected from lungs by Pulmonary veins and it is passed into the left atrium, left atrium then pumps blood to left ventricle, and from left ventricle blood is passed to the aorta so that it can be supplied to all the body parts along with heart.

Related Theory

Deoxygenated blood from the upper and lower part of the body is collected by superior and inferior vena cava, respectively and passed into the right atrium. Deoxygenated blood also comes into this chamber from the heart wall through the coronary sinus. Right atrium then pumps blood into the right ventricle, and Pulmonary artery then receives deoxygenated blood from the right ventricle and transports it to the lungs for purification (Oxygenation).

16. **The representation of standard ECG corresponds to a specific electrical activity of heart.**

Each peak in the ECG is identified with a letter from P to T that corresponds to a specific electrical activity of the heart.



Assertion (A): **ECG is a great clinical significance.**

Reason (R): **ECGs obtained from different individuals have roughly the same shape for a given lead configuration, any deviation from this shape indicates a possible abnormality or disease.**

Ans. *(a) Both A and R are true and R is the correct explanation of A.*

Explanation: ECG provides detailed conditions of the human heart, and it becomes easy for doctors to diagnose any disease related to the heart without any complicated procedure. The interval between two successive QRS complexes can be used to measure the heart rate when the cardiac rhythm is regular. Any deviation in ideal ECG indicates irregular activity in the heart.

17. **Assertion (A): Heart is mesodermal in origin.**

Reason (R): The opening between the right atrium and the right ventricle is guarded by a bicuspid valve.

Ans. *(c) A is true but R is false.*

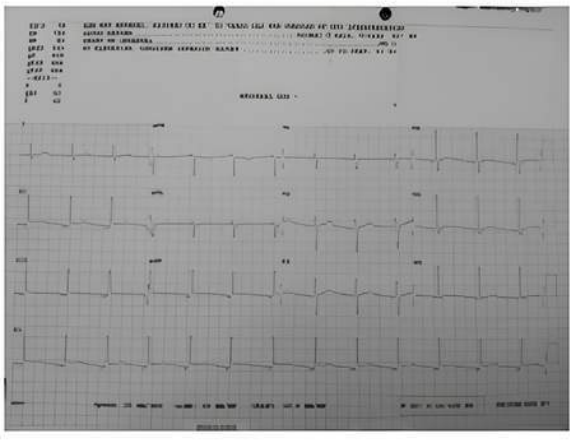
Explanation: Human heart is derived from mesoderm. Mesoderm is a primary germ layer of the embryo lying between the other two germ layers namely ectoderm and endoderm. From it, all connective tissues arise. The lateral plate of the mesodermal layer gives rise to the heart, to the blood cells and the blood vessels of the circulatory system. Tricuspid valve is present between the opening of the right atrium and right ventricle, it prevents backflow of blood from right ventricle to right atrium.

CASE BASED Questions (CBQs)

[**4** & **5** marks]

Read the following passages and answer the questions that follow:

18. *This ECG shows atrial to ventricular conduction via an accessory pathway (note the inverted P waves and very short PR interval with 'delta' waves). This ECG finding is highly suggestive of Wolf Parkinson White Syndrome (WPW), a relatively common condition affecting about 1 in 500 people. In WPW an accessory bundle ("bundle of kent") can allow for conduction from atria to ventricle bypassing the normal AV node pathway. The resting ECG shows a short PR interval (<0.12 seconds), delta wave (i.e. slurred upstroke into the QRS complex) as well as broadening of the QRS complex. There are two main subtypes of WPW: Type A (+ve delta wave in V1) and Type B -(ve delta wave in V1).*



(A) Which of the following correctly explains a phase/event in cardiac cycle in a standard electrocardiogram?

(a) QRS complex indicates atrial contraction.

(b) QRS complex indicates ventricular contraction.

(c) Time between S and T represents atrial systole.

(d) P-wave indicates beginning of ventricular contraction.

(B) The end of T-wave marks the end of:

(a) Systole (b) Diastole

(c) Joint diastole (d) None of these

(C) P-wave in standard ECG indicates:

(a) Excitation of atria

(b) Excitation of ventricle

(c) Depolarisation of atria

(d) Both (a) and (c)

(D) How can one determine the heartbeat rate of an individual?

(a) By counting the number of T-wave.

(b) By counting the number of P-wave.

(c) By counting the number of QRS complexes.

(d) By counting the number of S-waves.

(E) Position of electrical leads to obtain a standard ECG is:

(a) One to each wrist and one to the left ankle.

(b) One to each ankle and one to the left wrist.

(c) One to each wrist and one to the right ankle.

(d) One to each ankle and one to the right wrist.

Ans. (A) *(b) QRS complex indicates ventricular contraction.*

Explanation: QRS complex is also known as ventricular complex in which Q is the first negative wave of ECG. R is the tallest positive wave of ECG and S is the deepest negative wave of ECG. Events occurring during QRS complex are spreading of impulse over ventricles, ventricular depolarisation/ventricular contraction/ ventricular systole. First heart sound is produced during this wave.

(B) *(a) Systole*

Explanation: There is an end of systole when marking of T-wave ends.

(C) *(d) Both (a) and (c)*

Explanation: Electrical excitation of atria causes contraction of atria which leads to depolarisation of atria, all these electrical activities take place at P-wave in standard ECG.

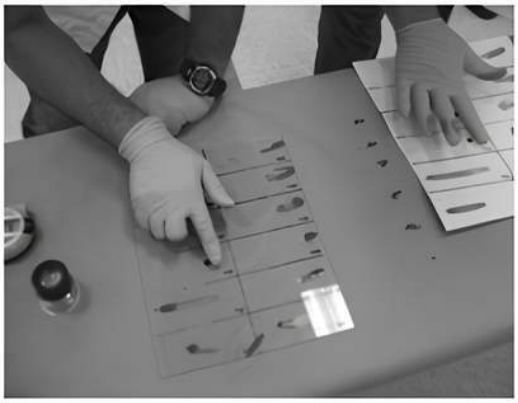
(D) *(c) By counting the number of QRS complexes.*

Explanation: The interval between two successive QRS complexes can be used to measure the heart rate when the cardiac rhythm is regular.

(E) *(a) One to each wrist and one to the left ankle.*

Explanation: To obtain an ECG, the machine is connected to the patient with three electrical leads (one on each wrist and one on the left ankle) that continually monitor the cardiac activity. Multiple leads are placed in the chest area for a detailed study of the heart's function.

19. *The use of blood in forensic analysis is a method for identifying individuals suspected of committing some kind of crime. Paul Uhlenhuth and Karl Landsteiner, two scientists working separately in Germany in the early twentieth century, showed that there are differences in blood between individuals. Uhlenhuth developed a technique to identify the existence of antibodies, and Landsteiner and his students showed that humans had distinctly different blood types called A, B, AB, and O. Once doctors differentiated blood into distinct types, they could use that information to safely perform blood transfusions. Furthermore, forensic scientists can use that information to exculpate people suspected of some types of crimes, and they can use it to help determine the paternity of children. When scientists identify blood types, they rely on slight differences in the antigens or protein markers on the surfaces of red blood cells in a blood sample. In a body, those antigens are recognized and attached to by antibodies.*



(A) Name the four blood groups found in humans.

(B) Name the blood groups that act as a universal donors.

(C) Which blood group is a universal acceptor? Where are antigens present?

Ans. (A) A, B, AB and O are the four blood groups found in humans.

(B) O negative blood group act as universal donor, this blood group has no antigens, but both antibodies A and B are present in the plasma.

(C) AB positive is a universal acceptor, it can accept blood from any other blood groups as it has both antigens A and B but no antibodies are present in the plasma. Antigens are present on the surface of erythrocytes (red blood corpuscles).

VERY SHORT ANSWER Type Questions (VSA)

[1 mark]

20. Describe about the tissue fluids of the human body.

Ans. The fluid which is present in the spaces between the tissue cells through which oxygen, carbon dioxide and dissolved substances are passed to and from the cells is called as tissue fluid.

21. Which vitamin is responsible for the synthesis of prothrombin in the liver?

[NCERT Exemplar]

Ans. Vitamin K is responsible for the synthesis of prothrombin in liver. This vitamin helps in blood clotting mechanism.

22. What is the normal platelet count in blood?

Ans. 1,500,00 to 3,500,00 thrombocytes per cubic mm of blood.

23. Name the ions that play an important role in clotting of blood.

Ans. Calcium ions are also called as clotting factor IV. This ion plays an important role in clotting of blood.

24. A cardiologist observed an enlarged QRS wave in the ECG of a patient. What does it indicate? [Delhi Gov. QB 2022]

Ans. QRS waves denote ventricular contraction of the heart which may be normal or abnormal.

SHORT ANSWER Type-I Questions (SA-I)

[**2** marks]

25. If due to some injury, the chordae tendineae of the tricuspid valve of the human heart is partially non-functional, what will be the immediate effect?

Ans. Chordae tendineae are cords that prevent the valve from collapsing back into the right atrium during powerful contraction of the right ventricle. When the right ventricle contraction forces the blood into the pulmonary artery, then the tricuspid valve closes the aperture to the right atrium thereby preventing any backflow of blood. Thus, if chordae tendineae of the tricuspid valve becomes partially non-functional, then the flow of blood into the pulmonary artery will be reduced and it happens due to the backflow of blood into the right atrium.

26. (A) What is serum?

(B) How many chambered hearts are present in birds and mammals?

Ans. (A) Serum is a body fluid (plasma) which does not contain clotting factors. It can be denoted by the equation:

Plasma – Clotting factors = Serum

There are a total of 13 clotting factors present in blood, prothrombin and fibrinogen are two of them.

(B) Heart present in birds and mammals is of four chambers. Two atria and two ventricles form four chambers. Right atrium and right ventricle contain the deoxygenated blood and the left atrium and left ventricle contain oxygenated blood.

Related Theory

➥ *Though the heart present in amphibians is 3-chambered, crocodiles have 4-chambered hearts just like humans.*

27. (A) What are the two types of blood grouping used widely in the world?

(B) Define Leucocytosis.

Ans. (A) Following are the two types of blood grouping used widely in the world:

(1) Rh blood grouping

(2) ABO blood grouping

(B) Leucocytosis is a clinical disorder in which the physiological count of WBCs in blood is increased.

Related Theory

➥ *Leucocytosis: Physiological increase of Leucocyte count (upto 20,000 per cubic mm of blood).*

28. Shikha's father went to a heart specialist. The doctor told him about various problems of heart such as heart failure and heart block. Differentiate between these two.

Ans.

S. No.	Heart failure	Heart block/ Cardiac arrest
(1)	Heart failure is due to the weakening of heart muscles because of inadequate blood supply to heart.	In heart block or cardiac arrest, heart stops beating.
(2)	It is due to congestion in lungs which leads to congestive heart failure.	It is due to a failure of the conducting system.

Caution

➥ *Students should know that in heart failure, heart continues to beat irregularly or rapidly at a heart rate of more than 120 to 150 beats per minute but in heart block, heart stops beating.*

29. Write the names of tissue layers of arteries and veins.

Ans. Following are the three tissue layers of arteries and veins:

(1) Tunica interna

(2) Tunica media

(3) Tunica externa

SHORT ANSWER Type-II Questions (SA-II)

[3 marks]

30. Sheela's father is having a problem of hypertension. Write the factors that affect hypertension.

Ans. Factors affecting hypertension are as follows:

(1) Elasticity of vessels

(2) Age

(3) Blood volume

(4) Venous return

(5) Obesity

(6) Sleep

As the elasticity of vessels increases, hypertension decreases, *i.e.* elasticity of vessels is inversely proportional to hypertension. As age increases, blood pressure also increases but heart rate decreases, age is directly proportional to hypertension but inversely proportional to heart rate. Blood pressure increases with an increase in blood volume, venous return and body weight. As sleeping hours are increased, hypertension decreases, *i.e.* sleep is inversely proportional to blood pressure.

Related Theory

Normal range of systolic blood pressure/diastolic blood pressure varies in ranges in different age groups. The normal values are as given below:

(1) In infants/newborns: 100/60 mm Hg

(2) In children: 110/70 mm Hg

(3) In adult: 120/80 mm Hg

(4) In old age: 140/90 mm Hg.

31. Elaborate atrioventricular valves present in human heart.

Ans. There are two types of atrioventricular valves present in human heart which are as follows:

(1) Tricuspid valve

(2) Bicuspid valve

Tricuspid valve is present between the right atrium and right ventricle and is made up of three muscular flaps or cusps; it guards the opening between the right atrium and right ventricle. Bicuspid valve is present between left atrium and left ventricle and is made up of two muscular flaps or cusps, it guards the opening between left atrium and left ventricle.

32. What are the major proteins found in plasma? Write their functions.

[NCERT Exemplar]

Ans. Major proteins found in plasma are as follows:

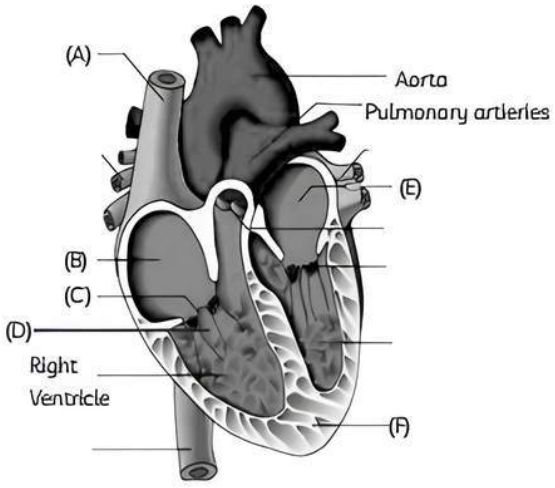
(1) Globulins

(2) Albumins

(3) Fibrinogen

Globulin functions in the defence mechanism of the body, albumin functions in maintaining osmotic balance and fibrinogen are used in blood clotting.

33. In the following diagram of a section of a human heart, identify the labelled part A, B, C, D, E and F.



[Delhi Gov. QB 2022]

Ans. (A) Superior vena cave

(B) Right atrium

(C) Tricuspid valve-3 cusps

(D) Right ventricle

(E) Left atrium

(F) Septum

34. A person suffering from fever is advised to take a blood test. What may happen to his WBC count and why? [Delhi Gov. QB 2022]

Ans. The WBC count of this person may show an increase from the normal range. As pathogens may be present in his body, so the body is producing more WBCs to fight against those pathogens. WBC count is a good tool to assess the presence of infection in a sick person.

LONG ANSWER Type Questions (LA)

[4 & 5 marks]

35. Arteries and veins are two different types of blood. Justify by giving a few points of differences.

Ans.

S.No.	Arteries	Veins
(1)	Arteries carry oxygenated blood, except Pulmonary artery.	Veins carry deoxygenated blood except Pulmonary vein.
(2)	Arteries are thick and more elastic.	Veins are thin and less elastic.
(3)	Arteries carry blood away from the heart.	Veins carry blood towards the heart.
(4)	Blood pressure is more in arteries.	Blood pressure is less in veins.
(5)	It has a narrow lumen.	Lumen present in veins is wide.
(6)	Arteries lack valves	Valves are present in veins
(7)	Arteries are deeply situated.	Veins are superficially situated.
(8)	pH of blood in arteries is 7.4.	pH of blood in veins is 6.8.
(9)	Arteries are non-collapsible.	Veins are collapsible.
(10)	Colour of artery is bright red.	Veins are bluish in colour.

(*Any five*)

36. Rahul recently read about a disease known as Erythroblastosis Fetalis in a weekly magazine. He wants to know more about it. Help him by giving a description of the disease.

Ans. It is a condition in which Rh-ve blood of a pregnant woman and the Rh+ve blood of the foetus has been found to be compatible during first delivery. The foetal Rh antigens are not exposed to the mother's Rh-ve blood during the first pregnancy, as the two types of blood are separated by the placenta. During the initial delivery, however, there is a chance that the maternal blood will be exposed to the foetus. During delivery, some blood of the foetus gets mixed with mother's blood. Due to which the mother's immune system activates and produces an anti-Rh antibody. In the event that Rh antibodies from the mother were found in her subsequent pregnancies (Rh-ve) can enter the foetal blood stream (Rh+ve) and kill the foetal RBCs. The foetus could die, or the newborn could develop severe anaemia and jaundice.

37. Explain the electrocardiogram in detail.
[NCERT Exemplar]

Ans. A graphical demonstration of electrical activity of heart is an electrocardiogram, *i.e.* ECG and Electrocardiograph is an instrument which records electrical activity of the heart. ECG consists mainly of three waves— PQRS and T. P-wave or atrial complex is the first positive wave of ECG. Events occurring in P-waves are SA node activation, spreading of impulse over atria, atrial depolarisation, atrial contraction / atrial systole. QRS complex is also known as the Ventricular complex in which Q is the first negative wave of ECG. R is the tallest positive wave of ECG and S is the deepest negative wave of ECG. Events occurring during QRS complex are spreading of impulse over ventricles, ventricular depolarisation / ventricular contraction / ventricular systole. First heart sound is produced during this wave. T-wave is the smoothest and broad wave of ECG. second heart sound and ventricular repolarisation take place during the marking of T-wave.

38. Neena has blood group A-ve while her husband's blood group is O+ve.

Their first child is having a blood group A+ve. Her second child was born with severe anaemia and jaundice. What could be the reason? How could this situation have been avoided? [Delhi Gov. QB 2022]

Ans. During her first pregnancy after exposure with blood of her first Rh +ve as a child, her body prepared antibodies against Rh antigen in her blood. In the second pregnancy, these Rh antibodies from the mother leaked into the blood of the foetus (Rh +ve) and destroyed the foetus, RBCs. It could cause severe anaemia and Jaundice, and could be fatal to the foetus. This situation could have been avoided if she had got herself administered anti-Rh antibodies

immediately after first delivery to kill Rh antibodies entered in the mother's blood from the foetus.

39. With reference to human heart, answer the following:

(A) What are SA and AV nodes? Where are they located?

(B) How heart sounds are produced? Name the two heart sounds. [Diksha]

Ans. (A) **SA node (Sino-atrial node):**

A specialised cardiac musculature called nodal tissue is distributed in the heart. A patch of this tissue is called SA node. SA node is located in the right upper corner of the right atrium.

AV node (Atrio-ventricular node):

Another mass of nodal tissue located in the lower left corner of the right atrium close to the atrio-ventricular septum is called AV node (atrio-ventricular node).

(B) **Heart sounds:**

First heart sound (lub) is associated with the closure of the tricuspid and bicuspid valves. Whereas the second heart sound (dub) is associated with the closure of semilunar valves.

The two heart sounds are 'lub' and 'dub'.