exchange of O_2 and CO_2 between the oxygenated blood and tissues and utilisation of O_2 by the cells (cellular respiration) are the other steps involved. Inspiration and expiration are carried out by creating pressure gradients between the atmosphere and the alveoli with the help of specialised muscles – intercostals and diaphragm. Volumes of air involved in these activities can be estimated with the help of spirometer and are of clinical significance. Exchange of O_2 and CO_2 at the alveoli and tissues occur by diffusion. Rate of diffusion is dependent on the partial pressure gradients of O_2 (pO_2) and CO_2 (pCO_2), their solubility as well as the thickness of the diffusion surface. These factors in our body facilitate diffusion of O_2 from the alveoli to the deoxygenated blood as well as from the oxygenated blood to the tissues. The factors are favourable for the diffusion of CO_2 in the opposite direction, i.e., from tissues to alveoli. Oxygen is transported mainly as oxyhaemoglobin. In the alveoli where pO_2 is higher, O_2 gets bound to haemoglobin which is easily dissociated at the tissues where pO_2 is low and pCO_2 and H^+ concentration are high. Nearly 70 per cent of carbon dioxide is transported as bicarbonate (HCO_3^-) with the help of the enzyme carbonic anhydrase. 20-25 per cent of carbon dioxide is carried by haemoglobin as carbamino-haemoglobin. In the tissues where pCO_2 is high, it gets bound to blood whereas in the alveoli where pCO_2 is low and pO_2 is high, it gets removed from the blood. Respiratory rhythm is maintained by the respiratory centre in the medulla region of brain. A pneumotaxic centre in the pons region of the brain and a chemosensitive area in the medulla can alter respiratory mechanism

CHAPTER – 15

BODY FLUIDS AND CIRCULATION

EXERCISES

2 Mark Questions

Q1:Sino-atrial node is called the pacemaker of our heart. Why?

Answer: Sino-atrial node (SAN) is a mass of neuromuscular tissue which lies in the wall of right atrium. It is responsible for initiating and maintaining the rhythmic contractile activity of the heart. Therefore, it is called the pacemaker.

Q2:Why do we call our heart myogenic?

Answer: The heart of molluscs and vertebrates including humans is myogenic. It means heart beat is initiated in heart itself by a patch of modified heart muscle called Sino-atrial node or pacemaker which lies in the wall of the right atrium near the opening of the superior vena cava.

Q1:Match Column I with Column II.

Column I	Column II
(a) Eosinophils	(i) Coagulation
(b) RBC	(ii) Universal recipient
(c) AB Group	(iii) Resist infections
(d) Platelets	(iv) Contraction of heart
(e) Systole	(v) Gas transport

Answer: (a) – (iii); (b) – (v); (c) – (ii); (d) – (i); (e) – (iv).

Q3:Why do we consider blood as a connective tissue?

Answer: A connective tissue connects different tissues or organs of the body. It consists of living cells and extracellular matrix. Blood is vascular connective tissue; it is a mobile tissue consisting of fluid matrix and free cells. Blood transports materials from one place to the other and thereby establishes connectivity between different body parts.

Q4:What is the importance of plasma proteins?

Answer: Plasma proteins constitute about 7 to 8% of plasma. These mainly include albumin, globulin, prothrombin and fibrinogen. Prothrombin and fibrinogen are needed for blood clotting. Albumins and globulins retain water in blood plasma and helps in maintaining osmotic balance.

4 Mark Questions

Q1:What is the significance of atrio-ventricular node and atrio-ventricular bundle in the functioning of heart?

Answer: atrio-ventricular node (AVN) is a mass of neuromuscular tissue, which is situated in wall of. right atrium, near the base of inter-atrial septum. AV node is the pacesetter of the heart,- as it transmits the impulses initiated by SA node to all parts of ventricles. Atrio-ventricular bundle (A-V bundle) or bundle of His is a mass of specialised fibres which originates from the AVN. Within the myocardium of the ventricles the branches of bundle of His divide into a network of fine fibres called Purkinje fibres. The bundle of His and the Purkinje fibres convey impulse of contraction from the AVN to the myocardium of the ventricles.

Q2:Name the components of the formed elements in the blood and mention one major function of each of them.

Answer: Blood corpuscles are the formed ele-ments in the blood, they constitute 45% of the blood. Formed elements are – (erythrocytes, RBCs or red blood corpuscles), (leucocytes, WBCs or white blood corpuscles) and throm¬bocytes or blood platelets. The major function of RBCs is to transport oxygen from lungs to body tissues and COz from body tissues to the lungs. White blood cells provide immunity to the body. Blood platelets play important role in blood clotting.

Q3:What is the difference between lymph and blood?

Answer: The differences between blood and lymph are given below:

	Blood	Lymph
(i)	It consists of plasma, erythrocytes, leucocytes and platelets.	It consists of plasma and leucocytes (lymphocytes most abundant).
(ii)	It is red in colour due to the presence of haemoglobin in erythrocytes.	It is colourless as haemoglobin is absent.
(iii)	Its plasma has more proteins, calcium and phosphorus.	Its plasma has fewer proteins and less calcium and phosphorus.
(iv)	It carries materials towards and away from the tissue, therefore, it acts as a "vehicle".	It transfers materials from the blood to the body cells and *vice-versa*, therefore, it acts as a "middle man".

Q4:Define a cardiac cycle and the cardiac output.

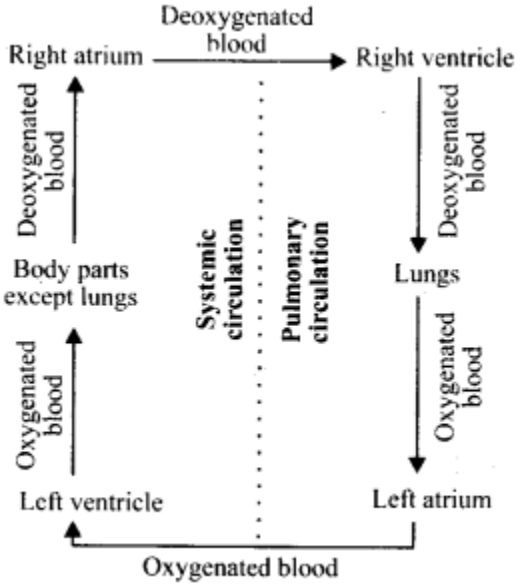
Answer: The sequential events in the heart which are repeated cyclically is called cardiac cycle and it consists of systole (contraction) and diastole (relaxation) of both the atria and ventricles. The duration of a cardiac cycle is 0.8 seconds. Periods of cardiac cycle are atrial systole (0.1 second), ventricular systole (0.3 second) and complete cardiac diastole (0.4 second).
The amount of blood pumped by heart per minute is called cardiac output. It is calculated by multiplying stroke volume (volume of blood pumped by each ventricle per minute) with heart rate (number of beats per minute). The heart of normal person beats 72 times per minute and pumps out about 70 mL of blood per beat. Therefore, cardiac output averages 5000 mL or 5 litres.

Q5:What is the significance of atrio-ventricular node and atrio-ventricular bundle in the functioning of heart?

Answer: atrio-ventricular node (AVN) is a mass of neuromuscular tissue, which is situated in wall of. right atrium, near the base of inter-atrial septum. AV node is the pacesetter of the heart,- as it transmits the impulses initiated by SA node to all parts of ventricles. Atrio-ventricular bundle (A-V bundle) or bundle of His is a mass of specialised fibres which originates from the AVN. Within the myocardium of the ventricles the branches of bundle of His divide into a network of fine fibres called Purkinje fibres. The bundle of His and the Purkinje fibres convey impulse of contraction from the AVN to the myocardium of the ventricles.

7 Mark Questions

Q1:What is meant by double circulation? What is its significance?
Answer: The type of blood circulation in which oxygenated blood and deoxygenated blood do not get mixed is termed double circulation. It includes systemic circulation and pulmonary circulation. The circulatory pathway of double circulation is given in the following flow chart.



Flow chart : Double blood circulation

Flow chart: Double blood circulation Double circulation or separation of systemic and pulmonary circulations provides a higher metabolic rate to the body and also allows the two circulations to have different blood pressures according to the need of the organs they supply.

Q2:Write the differences between:
(a) Blood and lymph
(b) Open and closed system of circulation
(c) Systole and diastole

(d) P-wave and T-wave

Answer: (a) Refer answer 5.

(b) The differences between open and closed circulatory system are given below:

	Open circulatory system	Closed circulatory system
(i)	Blood flows through open tissue spaces, the sinuses.	Blood flows in closed tubes, the blood vessels, with definite walls.
(ii)	Blood is in direct contact with the tissue cells.	Blood does not come in direct contact with the tissue cells.
(iii)	Exchange of materials occurs directly between blood and tissue cells.	Exchange of materials between tissue cells and blood occurs *via* tissue fluid.
(iv)	Blood flow is very slow.	Blood flow is quite rapid.
(v)	Respiratory pigment, if present, is dissolved in the plasma, no red corpuscles are present.	Respiratory pigment is present, and may be dissolved in the plasma but is usually held in red blood corpuscles.
(vi)	Occurs in arthropods and most molluscs.	Occurs in annelids and vertebrates.

(c) Systole is contraction of heart chambers in order to pump out blood while diastole is relaxation of heart chambers to receive blood. The contraction of a chamber or systole decreases its volume and forces the blood out of it, whereas its relaxation or diastole brings it back to its original size to receive more blood.

(d) P wave is a small upward wave of electrocardiograph that indicates the atrial depolarisation (contraction of atria). It is caused by the activation of SA node. T-

wave is a dome shaped wave of electro-cardiograph which represents ventricular repolarisation (ventricular relaxation).

Q3:Describe the evolutionary change in the pattern of heart among the vertebrates.

Answer: Vertebrates have a single heart. It is a hollow, muscular organ composed of cardiac muscle fibres. Two types of chambers in heart are atria and ventricles. The heart of lower vertebrates have additional chambers, namely sinus venosus and conus arteriosus or bulbus arteriosus or truncus arteriosus. During the course of development, in higher vertebrates, the persistent portions viz, auricles and ventricles are retained. However, these get complicated by incorporating several valves inside them and becoming compartmentali sed.

In fishes, heart is two chambered (1 auricle and 1 ventricle). Both the accessory chambers, sinus venosus and conus arteriosus are present. The heart pumps out deoxygenated blood which is oxygenated by the gills and sent to the body parts from where deoxygenated blood is carried to the heart. It is called single circulation and heart is called venous heart. Lung fish, amphibians and reptiles have three chambered heart, (2 auricles and 1 ventricle). The left atrium gets oxygenated blood from the gills/lungs/skin/buccopharyngeal cavity and the right atrium receives the deoxygenated blood from other body parts. But both oxygenated and deoxygenated blood get mixed up in single ventricle which pumps out mixed blood. This is called incomplete double circulation.

Crocodiles, birds and mammals have a complete four chambered heart (right and left auricles; right and left ventricles). Oxygenated and deoxygenated blood never get mixed. Right parts of the heart receive deoxygenated blood from all other body parts and send it to lungs for oxygenation whereas left parts of heart receive oxygenated blood from lungs and send it to other body parts. This mode of circulation is termed as complete double circulation which includes systemic and pulmonary circulation. There are no accessory chambers in heart of birds and mammals.

Q4:Draw a standard ECG and explain the different segments in it.

Answer: ECG is graphic record of the electric current produced by the excitation of the cardiac muscles. The instrument used to record the changes is an electrocardiograph. A normal electrogram (ECG) is composed of a P wave, a QRS wave (complex) and a T wave. The P Wave is a small upward wave that represents electrical excitation or the atrial depolarisation which leads to contraction of both the atria (atrial contraction). It is caused by the activation of SA node. The impulses of contraction start from the SAnode and spread throughout the artia.

The QRS Wave (complex) represents ventricular depolarisation (ventricular contraction). It is caused by the impulses of the contraction from AV node through the bundle of His and Purkinje fibres and the contraction of the ventricular muscles. Thus this wave is due to the spread of electrical impulse through the ventricles.
The T Wave represents ventricular repolarisation (ventricular relaxation). The potential generated by the recovery of the ventricle from the depolarisation state is called the repolarisation wave. The end of the T-wave marks the end of systole.
ECG gives accurate information about the heart. Therefore, ECG is of great diagnostic value in cardiac diseases.

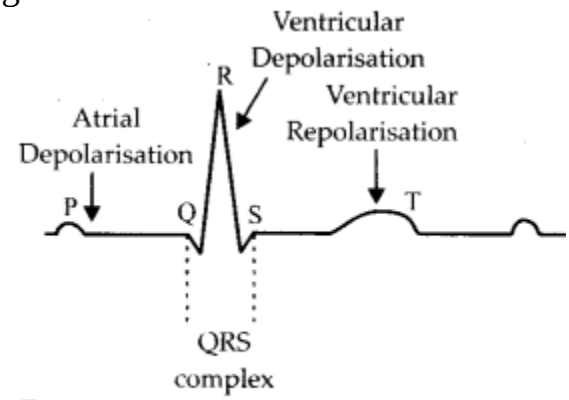


Fig.: Diagrammatic representation of a standard ECG.

Multiple Choice Questions

1.**Respiration in mature mammalian erythrocytes are _____**

1. Linear
2. Absent
3. Anaerobic
4. Aerobic

Answer: Anaerobic

2. _____ is not a characteristic feature of the respiratory surface

1.Dry

2.Thin

3.Permeable

4.Moist

Answer: Dry

3.Human skin cannot function as a respiratory organ because

1.It is not permeable to O2 and CO2

2.It is rather thick

3.It is dry

4.All of the above

Answer: All of the above

4.In cockroaches, inspirati on occurs with _____

1.Relaxation of tergo-sternal muscles

2.Relaxation of abdominal muscles

3.Neither (1) nor (2)

4.Both (1) and (2)

Answer: Both (1) and (2)

5.Pick out the statement that is wrong with respect to insects

1.Abdominal muscles do not take part in respiration

2.When abdominal muscles relax, the air is drawn in through spiracles and tracheoles

3.Contracting abdominal muscles drive the air out through the spiracles

4.Both (2) and (3)

Answer: Abdominal muscles do not take part in respiration

6.Where does the exchange of gases occur in birds?

1.Air sacs only

2.Air sacs and Lungs

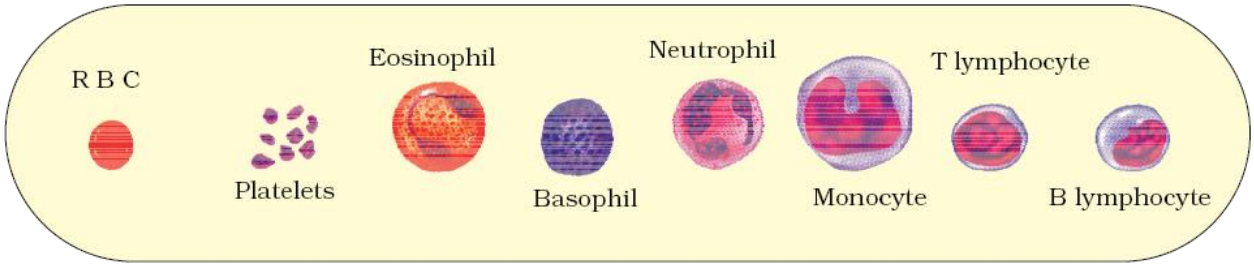
3.Lungs only

4.First in air sacs and then in the lungs

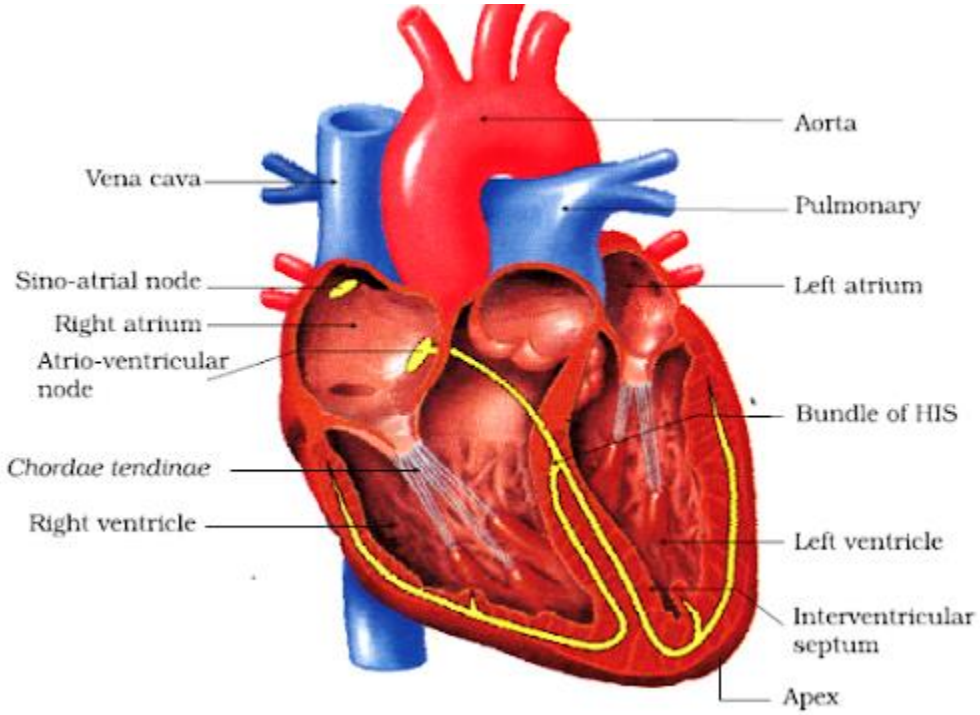
Answer: Lungs only

DIAGRAMS

Diagrammatic representation of formed elements in blood



Section of a human heart



SUMMARY

Vertebrates circulate blood, a fluid connective tissue, in their body, to transport essential substances to the cells and to carry waste substances from there. Another fluid, lymph (tissue fluid) is also used for the transport of certain substances. Blood comprises of a fluid matrix, plasma and formed elements. Red blood cells (RBCs, erythrocytes), white blood cells (WBCs, leucocytes) and platelets (thrombocytes) constitute the formed elements. Blood of humans are grouped into A, B, AB and O systems based on the presence or absence of two surface antigens, A, B on the RBCs. Another blood grouping is also done based on the presence or absence of another antigen called Rhesus factor (Rh) on the surface of RBCs. The spaces between cells in the tissues contain a fluid derived from blood called tissue fluid. This fluid called lymph is almost similar to blood except for the protein content and the formed elements. All vertebrates and a few invertebrates have a closed

circulatory system. Our circulatory system consists of a muscular pumping organ, heart, a network of vessels and a fluid, blood. Heart has two atria and two ventricles. Cardiac musculature is auto-excitable. Sino-atrial node (SAN) generates the maximum number of action protentials per minute (70-75/min) and therefore, it sets the pace of the activities of the heart. Hence it is called the Pacemaker. The action potential causes the atria and then the ventricles to undergo contraction (systole) followed by their relaxation (diastole). The systole forces the blood to move from the atria to the ventricles and to the pulmonary artery and the aorta. The cardiac cycle is formed by sequential events in the heart which is cyclically repeated and is called the cardiac cycle. A healthy person shows 72 such cycles per minute. About 70 mL of blood is pumped out by each ventricle during a cardiac cycle and it is called the stroke or beat volume. Volume of blood pumped out by each ventricle of heart per minute is called the cardiac output and it is equal to the product of stroke volume and heart rate (approx 5 litres). The electrical activity of the heart can be recorded from the body surface by using electrocardiograph and the recording is called electrocardiogram (ECG) which is of clinical importance.

We have a complete double circulation, i.e., two circulatory pathways, namely, pulmonary and systemic are present. The pulmonary circulation starts by the pumping of deoxygenated blood by the right ventricle which is carried to the lungs where it is oxygenated and returned to the left atrium. The systemic circulation starts with the pumping of oxygenated blood by the left ventricle to the aorta which is carried to all the body tissues and the deoxygenated blood from there is collected by the veins and returned to the right atrium. Though the heart is autoexcitable, its functions can be moderated by neural and hormonal mechanisms.