**UNIT 9 Transport in Man**

**THEORY Section**

**Question 1**

Fig. 5.1 shows a 'heart-lung' machine being used during an operation on the heart.

Fig. 5.2 shows details of the internal structure of the exchanger unit.

![Diagram of heart-lung machine and exchanger unit](image)

(a) On Fig. 5.1, label structures M and N. [2]

(b) State two ways in which the air entering the machine at P differs from the air leaving it at Q. [1]

(c) Which part of the structure of the lungs is represented by the hollow fibres? [1]

(d) With reference to Fig. 5.2, suggest why the pores in the fibres must be

(i) very large in number; [1]

(ii) very small in diameter. [1]

**COMMENT on QUESTION**

"(d) ii) The key word is 'pores' in the fibres. Do not confuse this with the number or the diameter of the fibres."
(e) Fig. 5.3 shows micrographs of blood from a healthy person, A, and from a patient shortly after heart surgery, B.

(i) Which type of cell has increased in number in B?  
(ii) State and explain one possible cause of this increase after heart surgery.

Solution

(a) Structure M – right atrium  
Structure N – aorta

(b) 1. Air entering at P has about 20% of oxygen and 0.03% of carbon dioxide by volume whereas air out at Q has about less oxygen and more carbon dioxide.

2. Air entering at P is at room temperature whereas air out at Q has a slightly higher temperature.

(c) Alveoli

(d) (i) To increase the surface area available for diffusion of oxygen and carbon dioxide. More pores will ensure that more gas molecules can move across the fibres per unit time.

(ii) To ensure that only exchange of small oxygen and carbon dioxide molecules occurs and not larger molecules present in blood e.g. blood cells and blood protein.

(e) (i) White blood cells

(ii) The increase in the number of white blood cells is a natural reaction to prevent the infection of the wounds caused by the surgery until they are fully healed. The lymphocytes will produce antibodies to kill invading bacteria or clump bacteria so that they can be easily engulfed and digested by the phagocytes.
**Question 2**

Describe, with examples, the transfer of dissolved materials from the blood to the cells of the body.

**Solution**

Dissolved materials from the blood moves into the cells of the body through a network of capillaries surrounding all cells of the body. In the part of the capillary network near the arterial end, blood pressure is much higher and causes some plasma to filtered out of the capillaries under pressure into the tissue space to form tissue fluid. Tissue fluid acts as a medium of transport between the blood and the body cells.

Nutrients such as glucose, amino acids diffuse out of the blood in the capillaries into the tissue fluid and from there into the body cells.

Waste products formed by the cells such as urea and carbon dioxide diffuse out into the tissue fluid, and from there diffuse into the blood in the capillaries.

As blood moves along the narrow capillaries, the blood pressure drops continuously. At the venous end of the capillary network, most of the tissue fluid is reabsorbed back into the capillaries by osmosis.

![Diagram of capillary, tissue fluid and body cells](image)

**Question 3**

Describe the relationship between the structure and function of the different types of blood vessel.

**Solution**

There are three main types of blood vessels: arteries, veins and capillaries.

Arteries have thick, muscular and elastic walls with a small lumen; this enables them to withstand the high pressure of the oxygenated blood that is pumped into the arteries by the heart. The blood of the arteries is passed into the capillaries, which form a network of fine, one cell thick vessels around cells in tissues. Part of the blood (excluding red blood cells and lymphocytes) can diffuse out of the thin walls to form tissue fluid surrounding the cells. The rate of blood flow is slower to allow diffusion of nutrient molecules out of the blood into the surrounding cells and the diffusion of waste substances from the tissue fluid into the blood.
capillaries. The veins to which the capillaries open into, conduct deoxygenated blood back into the heart. They have thin, less muscular walls with semi-lunar valves present. The lumen is large. The deoxygenated blood flows through the veins at a slow rate under low blood pressure. The semi-lunar valves prevent the back flow of blood.

**Question 4**

How does the blood protect us against bacterial infection? [4]

[J00/P2/Q6b]

**Solution**

Bacteria which have entered the blood stream are destroyed by antibodies and phagocytes. The lymphocyte in the blood can produce antibodies, which can act as antitoxins to neutralise the poisonous effect of the toxins produced by bacteria. The antibodies can also cause agglutination of the bacteria so that the latter can be easily ingested by the phagocytes. Blood also contains platelets, blood clotting proteins and enzymes that forms blood clot to seal small cuts and wounds preventing bacteria from entering blood stream.

**Question 5**

Fig. 1.1 shows a section through a diseased blood vessel of a middle-aged person.

![Diagram](image)

**(a)** What type of blood vessel is shown? [1]

**(b)** On the diagram, name the parts labelled P and Q. [1]

**(c)** Describe the possible effects of P on the person's health. [4]

**(d)** Explain how the person's diet, over the previous twenty years, may have caused this blood vessel to be diseased. [2]

[J00/P2/Q1]

**Solution**

(a) Artery

(b) P: Fatty deposits

Q: Muscular wall

**COMMENT on QUESTION**

"(d) The disease is likely to be related to poor dietary habits over a long period of time."

**COMMENT on ANSWER**

"(a) An artery has a thick muscular wall and small round lumen."
(c) The fatty deposits cause the hardening of the artery, a condition called atherosclerosis. This increases the risk of blood clotting in the artery. If it was a coronary artery, a blood clot formed would result in a heart attack. It also constricts blood vessels causing an increase in blood pressure.

(d) The person had a diet rich in animal fats and cholesterol. These are saturated fats that result in high blood cholesterol level and increases the deposition of fats on the walls of blood vessels.

**Question 6**

(a) Show, by means of a table, how red and white blood cells differ in structure and function. [6]

(b) What changes are made to the blood as it flows through
   (i) the lungs;
   (ii) the kidneys? [4]

(c) Describe how the blood clots to seal a wound in the skin. [2]

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**Solution**

<table>
<thead>
<tr>
<th></th>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Red blood cell</strong></td>
<td>Biconcave disc, without nucleus</td>
<td>Contains haemoglobin to absorb oxygen and transport oxygen as oxyhaemoglobin.</td>
</tr>
<tr>
<td><strong>White blood cell</strong></td>
<td>Lymphocytes have round nucleus; phagocytes have irregular shaped nucleus.</td>
<td>Lymphocytes secrete antibodies to destroy bacteria. Phagocytes engulf and ingest foreign particles e.g bacteria.</td>
</tr>
</tbody>
</table>

(b) (i) Deoxygenated blood carried to the lungs has a high concentration of carbon dioxide.
Carbon dioxide diffuse from the blood into the air spaces in the alveoli (lower concentration of carbon dioxide) for exhalation while oxygen from the alveoli of the lungs diffuses into the blood and combines with the haemoglobin to form oxyhaemoglobin.

(ii) Blood carried to the kidneys has a high concentration of urea. The urea is removed from the blood by ultrafiltration process in the nephrons (kidney tubules) in the kidney and excreted in urine.

(c) Blood platelets and damaged tissues forms enzyme thrombokinase that converts insoluble prothrombin to thrombin. Thrombin converts fibrinogen into insoluble fibrin, which forms a mesh to trap red blood cells to form blood clot.
**Question 7**

Fig. 5.1 represents the circulatory system, the lungs and body cells.

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key:
→ = direction of blood flow
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**Fig. 5.1**

(a) On Fig. 5.1,
   (i) label blood vessels Q and R;
   (ii) identify pumps X and Y.  [2]

(b) Draw a labelled diagram of a transverse section of vessel R and a labelled diagram of a transverse section of a blood capillary.  [2]

(c) Explain how the structure of a blood capillary allows materials carried in the blood to reach a cell in the body.  [2]

(d) State one chemical, other than a respiratory gas, which passes in increased amounts
   (i) from capillaries to muscle cells at the start of a race;
   (ii) from muscle cells to capillaries after an extended period of exercise.  [2]

**Solution**

(a) blood vessel Q: pulmonary vein
   blood vessel R: vena cava
   pump X: right ventricle of heart
   pump Y: left ventricle of heart

(b) **Blood vessel R**

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large lumen
thin, less elastic wall
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**Blood Capillary**

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small lumen one-cell thick wall
```

(cross-section of a vein)
(c) Capillaries are microscopic blood vessels, which carry blood from an arteriole to a venule. They are branched repeatedly to reach all cells of the body and to provide a large surface area for rapid diffusion of food materials and oxygen from blood into the surrounding cells of all tissues. They have thin permeable walls made up of a single layer of cells called the endothelium. This ensures rapid diffusion of substances through the capillary walls.

(d) (i) Adrenaline  
(ii) lactic acid

**Question 8**

Red blood cells are an important component of blood.

(a) (i) State the function of red blood cells.  
(ii) List the other main components of blood. [2]

At an altitude of 4000 metres, the pressure which forces oxygen into the blood is reduced by approximately 33%. A person moves from sea level to live at this altitude for 24 days. Fig. 3.1 shows the effect of the reduced oxygen availability on the number of red blood cells in the person’s blood.

![Graph showing the increase in red blood cells over time.]

(b) (i) Calculate the percentage increase in the number of red blood cells during the 24 days. Show your working.  
(ii) Suggest how this change in number of red blood cells adapts the person to conditions at 4000 m. [4]

In addition to the change in number of red blood cells, the person’s total blood volume increases, as does the volume of blood pumped by the heart during each heart beat.

(c) Suggest how training at 4000 m could improve an athlete’s performance at sea level. [3]
Solution

(a) (i) Red blood cells contain the pigment haemoglobin that absorbs oxygen and transport it as oxyhaemoglobin in the bloodstream.

(ii) The other main components of blood are white blood cells and platelets and blood plasma.

(b) (i) The percentage increase in the number of red blood cells
\[ \frac{7.2 - 4.5}{4.5} \times 100 = 60\% \]

(ii) The air at a high altitude of 4000 m has a low concentration of oxygen. The increase in the number of red blood cells increases the oxygen-carrying power of the blood. This means that more oxygen can be transported to the cells and tissues at a faster rate.

(c) Training at an high altitude strengthens and conditions the heart muscles. The heart muscles are now able to contract more strongly and harder. The size of the heart also increases after a longer period of exercise. All these increase the volume of blood pumped by the heart during each heart beat, resulting in more oxygen and food substances transported to the cells.

Question 9

(a) List the structural features of a vein which distinguish it from an artery.

(b) (i) Explain what is meant by a double circulation.

(ii) Describe and explain how blood flows from the foot to the lungs.

Solution

(a) The differences in the structure of a vein and artery is summarised in the table below:

<table>
<thead>
<tr>
<th></th>
<th>Vein</th>
<th>Artery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has thin, less muscular and elastic walls</td>
<td>Has thick, muscular and elastic walls</td>
<td></td>
</tr>
<tr>
<td>Has a large lumen</td>
<td>Has a small lumen</td>
<td></td>
</tr>
<tr>
<td>Has semi-lunar valves present to prevent the back flow of blood</td>
<td>Semi-lunar valves are absent</td>
<td></td>
</tr>
</tbody>
</table>

In a double circulation, blood passes through the heart twice. It consists of a high pressure systemic circulation and a low pressure pulmonary circulation. In the systemic circulation (main circulation), oxygenated blood is distributed to all parts of the body from the heart via the aorta and deoxygenated blood from the body is carried back to the heart by veins. In the pulmonary circulation, the deoxygenated blood is pumped to the lungs via the pulmonary arteries and oxygenated blood from the lungs is carried back to the heart through the pulmonary veins.
(ii) The deoxygenated blood from the foot passes up the veins towards the heart. The leg muscles contract and relax to help to push the blood in the veins up against gravity. Back flow of the blood is prevented by the semi-lunar valves along the length of the vein. The veins join with the larger inferior vena cava which carries the deoxygenated blood to the right atrium of the heart where it is pumped to the lungs via the pulmonary arteries when the right ventricle contracts.

**Question 10**

Figure 1.1 shows a short length of a blood vessel.

![Fig. 1.1](image)

(a) (i) What type of blood vessel is shown in Fig. 1.1?

(ii) Explain how the wall is suited to the functions of this blood vessel. [2]

Figure 1.2 shows the pressure of the blood as it completes one circulation of the body (excluding the lungs).

![Fig. 1.2](image)

(b) State which labelled section of the graph shows the pressure of the blood as it passes through arteries; veins; capillaries; the heart. [3]

(c) Suggest why the blood pressure in the pulmonary artery is not as high as that in the aorta. [1]

(d) Explain how blood pressure might be affected by eating foods rich in animal fats and cholesterol. [2]

**COMMON ERROR**

"(d) Students may overlook the 'blood pressure' and focus on coronary heart disease or heart attacks which are very closely related and more commonly tested."
Solution

(a) (i) Capillary

(ii) The wall of the capillary is thin and is only one cell thick. This allows soluble food substances and oxygen from the blood to diffuse rapidly over a short distance into the surrounding cells.

(b) arteries — B
capillaries — C
veins — D
the heart — A

(c) The pulmonary artery carries deoxygenated blood from the heart to the lungs which is very close to the heart. The aorta, on the other hand, has to pump blood over long distances as it carries oxygenated blood to the cells in all parts of the body.

(d) A diet rich in animal fats and cholesterol which are saturated fats results in high blood cholesterol level and increases the deposition of fats on the walls of the blood vessels. The fatty deposits constrict blood vessels causing an increase in blood pressure.

Question 11

Fig. 4.1 shows a photograph of a blood clot taken using an electron microscope.

(a) Identify structure X. [1]

(b) (i) What is the function of structure X?

(ii) Complete the table by stating how the listed features help structure X to carry out this function. [4]

<table>
<thead>
<tr>
<th>feature of X</th>
<th>how it helps the function of X</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. thin cell membrane</td>
<td>..................................</td>
</tr>
<tr>
<td>2. flexible cell membrane</td>
<td>..................................</td>
</tr>
<tr>
<td>3. shape</td>
<td>..................................</td>
</tr>
</tbody>
</table>

Long insoluble threads are shown in Fig. 4.1, and are formed as the blood clots over a cut in the skin. Fig. 4.2 shows how the insoluble threads are formed.
Unit 9 Transport in Man

Fig. 4.2

(c) (i) Name the soluble protein S.
(ii) Name the long insoluble thread T.
(iii) Suggest what type of chemical U is likely to be. [3]

Solution

(a) Red Blood cell
(b) (i) To absorb and transport oxygen as oxyhaemoglobin.
   (ii) 1. To facilitate rapid diffusion of oxygen into the red blood cell to combine with haemoglobin.
   2. Enables red blood cell to change their shape as they squeeze through fine capillaries and withstand the high blood pressure exerted on it in the main arteries.
   3. Biconcave disc shape to increase surface area for absorption of oxygen.

(c) (i) Fibrinogen
    (ii) Fibrin
    (iii) Enzyme

Question 12

Fig. 6 shows a ventral ('front') view of the human heart.

Fig. 6
(a) Describe and explain the flow of blood through the heart from the time that it arrives at P to the time that it leaves at Q.

(b) Explain the relationship between blood and tissue fluid.

Solution

(a) In Fig. 6, P is the superior vena cava and Q is the aorta.

Deoxygenated blood from the head, neck and arms is returned to the right atrium (upper chamber) by the superior vena cava. When the right atrium contracts, blood flows into the right ventricle via the tricuspid valve which separates the atrium from the ventricle (lower chamber) and prevents the backflow of blood from the ventricle to the atrium. Blood leaves the right ventricle when it contracts by the pulmonary arch which subsequently divides into two pulmonary arteries, one to each lung. Backflow of blood into the right ventricle is prevented by semi-lunar valves in the pulmonary arch.

Oxygenated blood from the lungs are returned to the left atrium by the pulmonary veins. When the left atrium contracts, blood is forced into the left ventricle via the bicuspid valve which prevents the backflow of blood into the atrium. When the left ventricle contracts, the blood flows into the aorta and is then distributed to all parts of the body except the lungs. The aorta also contains semi-lunar valves to prevent the backflow of blood into the left ventricle.

(b) Blood has the following composition:

- plasma: a pale yellow liquid containing soluble proteins such as serum albumin, serum globulin, fibrinogen and prothrombin. It also contains dissolved mineral salts, dissolved food substances, excretory products and hormones;
- red blood cells;
- white blood cells;
- platelets.

Tissue fluid is plasma without proteins, but it contains white blood cells. It is formed from blood by the movement of plasma (without the plasma proteins) into the minute spaces between tissue cells. The white blood cells are able to squeeze through capillary walls into the minute spaces between tissue cells to become a component of tissue fluid.

Question 13

(i) Explain, with named examples, how essential substances carried in the blood capillaries reach the cytoplasm of the body cells.

(ii) Describe the uses of these substances in the cells.

Solution

(i) The minute spaces between tissue cells contain a colourless liquid, the tissue fluid. This tissue fluid carries substances in solution between the body cells and the blood capillaries.

Oxygen is carried in the red blood cells as oxyhaemoglobin. When blood
passes through oxygen-poor tissues, oxygen is liberated. It then diffuses out of the blood capillary wall. Dissolved food substances (e.g. glucose, amino acids and fats) also diffuse out of the thin walls of blood capillaries into the tissue fluid. From there, these substances diffuse into the cytoplasm of the cells.

(ii) In the cells, oxygen oxidizes glucose, releasing energy in tissue respiration. Amino acids which enter cells are converted into new protoplasm and are used for growth and repair of worn-out parts of the body. They are also used for the formation of enzymes and hormones. Fats are used to build protoplasm in cell membranes.

Question 14

(a) State the ways in which the human body is naturally protected against the entry of harmful bacteria. [3]

(b) (i) What measures could a person take to reduce the risk of bacterial infection and the development of bacterial disease?

(ii) Describe the processes occurring in the body after the bacteria have gained entry. [7]

(c) Why is a tissue graft from a near relative more likely to be successful than one from an unrelated donor? [2]

Solution

(a) The general body surface of the human body is covered by the skin, which protects against the entry of harmful bacteria. The presence of hair and mucous, such as those found in the nasal passages, also helps to trap bacteria in the air.

(b) (i) Risk of bacteria infection can be reduced by good health habits, sterilization of food and water, extermination of animals which carry disease germs, proper sanitary conditions and maintenance of bodily health. The development of bacterial disease can be prevented by vaccinations and inoculations.

(ii) The human blood contains phagocytes and lymphocytes. Lymphocytes produce antibodies, which can kill the bacteria, or cause agglutination of the bacteria, so that the latter can be easily ingested by the phagocytes. The antibodies also act as antitoxins, neutralizing the poisonous effects of toxins produced by harmful bacteria.

(c) Human leucocyte antigens are distributed throughout the body tissues and it is through differences in this system that cells are classified as self and non-self. In tissue graft or transplant, if the cells are recognised by the body as non-self, it will be rejected by the immune system of the host. Since this system is determined by a person's genetic makeup, it is likely to be more similar in near relatives. Hence, getting a tissue graft from a close relative reduces the risk of tissue rejection.
Question 15

Fig. 4 shows a human heart.

(a) Complete the table to show whether the blood in vessels P, Q, R and S in Fig. 4 is oxygenated or de-oxygenated, and under high or low pressure.

<table>
<thead>
<tr>
<th></th>
<th>blood oxygenated</th>
<th>blood under high pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) (i) State two substances in food that are believed to cause heart disease.

(ii) State two other factors that are possible causes of heart disease.

When artery P becomes blocked (see Fig. 4), it is sometimes replaced, during an operation, with a vein taken from another part of the patient's body.

(c) (i) When the vein is sewn into place, why must great care be taken to ensure that it is the correct way round?

(ii) Suggest one advantage and one disadvantage of using the patient's own vein rather than an artery transplanted from another person.

Solution

(a)

<table>
<thead>
<tr>
<th></th>
<th>blood oxygenated</th>
<th>blood under high pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Q</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>R</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>S</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

(b) (i) 1. Saturated animal fat.

2. Cholesterol.
(ii) Smoking.

High blood pressure.

(c) (i) Veins have internal valves along their length to prevent backflow of blood. If the vein is sewn the wrong way round, a backflow of blood into the heart can occur.

(ii) Advantage: Using the patient's own vein prevents the risk of tissue rejection.

Disadvantage: A vein has a thinner, less elastic wall than an artery. The blood passing through P is normally under great pressure. The vein may be unable to withstand the pressure.

**Question 16**

(a) What is meant by a double (dual) circulation? [2]

(b) How do the two parts of a double circulation differ from one another? [4]

(c) Describe how the circulatory system

   (i) helps to stop bacteria entering a cut in the skin, and

   (ii) deals with bacteria which may have entered the cut. [6]

(ID93/P2/Q7]

**Solution**

(a) In double circulation, blood passes through the heart twice: from the main circulation of the body to the heart, then to the lungs and back to the heart again before the blood is pumped into the main circulation.

(b) The pulmonary circulation links the lungs to the heart. Pulmonary arteries carry the blood to the lungs; oxygenated blood is returned to the heart by the pulmonary veins.

Systemic circulation is the main circulation. Oxygenated blood is distributed to all parts of the body, and veins carry the blood from all parts of the body back to the heart.

(c) (i) When there is a cut in the skin and blood vessels are damaged, an enzyme known as thrombokinase is released. Thrombokinase converts the protein prothrombin to thrombin in the presence of calcium. Thrombin then catalyses the conversion of the soluble protein fibrinogen to a meshwork of insoluble threads of fibrin. These fibrin threads entangle the blood corpuscles and the whole mass forms a clot. Vitamin K is essential for this process. The clotting of blood seals the cut, preventing bacteria from entering the blood stream.

(ii) Bacteria which have entered the blood stream are destroyed by antibodies and phagocytes. Antibodies can act as antitoxins, neutralizing the poisonous effect of toxins produced by bacteria. The antibodies also kill the bacteria. Antibodies can also cause agglutination of bacteria, making the ingestion by phagocytes easier.
**Question 17**

(a) Explain how structure is related to function in the following parts of the circulatory system:

(i) arteries,  
(ii) veins.  

(b) Explain how a diet high in animal fat may cause coronary heart disease.  

**Solution**

a) (i) thick elastic fibres  
thick outer wall  
small lumen  

Arterial walls are thick, muscular and elastic with relatively small lumen. Arteries transport blood away from the heart. They carry blood at high pressure, hence there is no need for the presence of valves in the arterial walls. The walls are not permeable as no diffusion occurs in these areas.

(ii) thin walls  
thin outer wall  
large lumen  

Veins transport blood towards the heart. They carry blood at low pressure, and the blood flow is slow. To prevent backflow of blood, there are valves in the walls. As in arteries, the venal walls are also not permeable. However, the walls are thinner, inelastic and much less muscular than the arterial walls.

(b) A diet rich in high animal fat contains loads of cholesterol and saturated fats. This results in the person having a high level of cholesterol in his blood. This cholesterol (fatty deposits) may build up in the coronary artery walls, resulting in the narrowing and hardening of the arterial walls, a condition called atherosclerosis. This blockage in the artery may lead to a heart attack.
Question 18

(a) Describe the path taken by a molecule of oxygen as it passes from air in the lungs to a muscle cell in the body. [6]

(b) Sometimes babies are born with a hole between the left and right sides of the heart, through which blood can pass. Explain the effect this has on the double circulation system of the baby's body. [4]

Solution

(a) The oxygen molecule from the air in the lungs dissolves in the thin film of moisture on the cells lining the alveolus. The oxygen molecule then diffuses across the thin alveolus wall and through the wall of the capillary into the blood plasma. The oxygen molecule diffuses into the red blood cells and combines with haemoglobin to form oxyhaemoglobin. The capillaries join to form the pulmonary vein which enters the left atrium of the heart when the atrium relaxes and gets pumped to the left ventricle when the left atrium contracts. The oxygen molecule is carried in the oxygenated blood which is finally pumped out of the heart via the aorta when the left ventricle contracts. The oxygenated blood is sent to the muscles in the upper arm where the oxygen molecule is released and absorbed by a muscle cell.

(b) The human body has two circulations: systemic circulation and pulmonary (lung) circulation. The left ventricle of the heart pumps oxygenated blood from the lungs into the systemic circulation. The right ventricle pumps venous blood returning from the body into the arteries of the lungs. The pressures in the pulmonary arteries are normally significantly lower than the pressures in the systemic circulation.

If the hole is big, a significant amount of oxygen-rich blood from the left side of the heart flows into the right side and is then pumped back to the lungs. The blood pressure in the pulmonary arteries and right side of heart is drastically increased. This causes an extra load on the heart and lungs. In this situation the heart may become over-worked and enlarged. If untreated the extra work causes the heart muscle to tire. Overtime, the baby can develop heart failure and slow growth.

Question 19

(a) Explain how the heart functions as a pump and keeps blood flowing in only one direction. [7]

(b) Explain how the difference in the pressure of the blood in the pulmonary artery and in the aorta is related to (i) the structure of the ventricles and (ii) where the blood is going. [3]

Solution

(a) The heart is a four-chambered, muscular organ which serves as a pump to circulate blood round the body. The strong rhythmic contractions of the heart generate a sufficiently high pressure to pump blood to the lungs and throughout the whole body. The right and the left sides of the heart function as two pumps. The right atrium receives deoxygenated blood and the right ventricle contracts to pump blood to the lungs (pulmonary circulation). The
left atrium receives the oxygenated blood from the lungs and the left ventricle contracts to pump blood to the rest of the body (systemic circulation). There are valves between the atria and ventricle, which prevent the back flow of blood into the atria when the ventricles contract. The bicuspid valve prevents backflow of blood into the left atrium while the tricuspid valve prevents backflow of deoxygenated blood into the right atrium during ventricular systole. The semilunar valves in the pulmonary artery and aorta also prevent the backflow of blood into the ventricles during diastole. This ensures a continuous unidirectional flow of blood through the heart.

(b) The blood pressure in the pulmonary artery is very low blood pressure compared to the blood pressure in the aorta.

Of the four chambers of the heart, the left ventricle has the thickest muscular wall. The wall of the left ventricle is very much thicker than that of the right ventricle. Contraction of the left ventricle generates the highest pressure, which is required to pump blood, over a longer distance via the aorta, to the rest of the body. A lower pressure is required to pump deoxygenated blood from the right ventricle via the pulmonary artery to the lungs which is near to the heart.

In a double circulation, blood passes through the heart twice. It consists of a high pressure systemic circulation and a low pressure pulmonary circulation. In the pulmonary circulation, deoxygenated blood from the right side of the heart is pumped to the lungs via the pulmonary arteries and oxygenated blood from the lungs is carried back to the left side of the heart through the pulmonary veins.

The systemic circulation (main circulation) is a high pressure circulation of oxygenated blood from the left side of the heart to all other parts of the body via the aorta and then back to the heart through the vena cava as deoxygenated blood.