Answers

Chapter 5 The circulatory system transports materials throughout the body

Questions 5.1

Recall knowledge

1 State the common name for:

a leucocytes

Answer: White blood cells

b thrombocytes

Answer: Platelets

c erythrocytes.

Answer: Red blood cells

2 Copy and complete the table below regarding the composition of blood.

Structure of blood	**Percentage by volume (%)**
Plasma	*Answer:* 55%
Answer: Erythrocytes	40-45
Leucocytes	*Answer:* 1%
Answer: Thrombocytes	<1

3 Name each type of white blood cell in the diagram.

Answer:

a – Lymphocyte / Monocyte

b – Monocyte

c – Eosinophils

d – Basophils

e – Neutrophil

4 Describe how monocytes are able to protect the body.

Answer:

Monocytes form other cells including macrophages, which engulf pathogens and aged or damaged cells by phagocytosis.

5 Explain how oxygen is transported from the alveoli to the body cells.

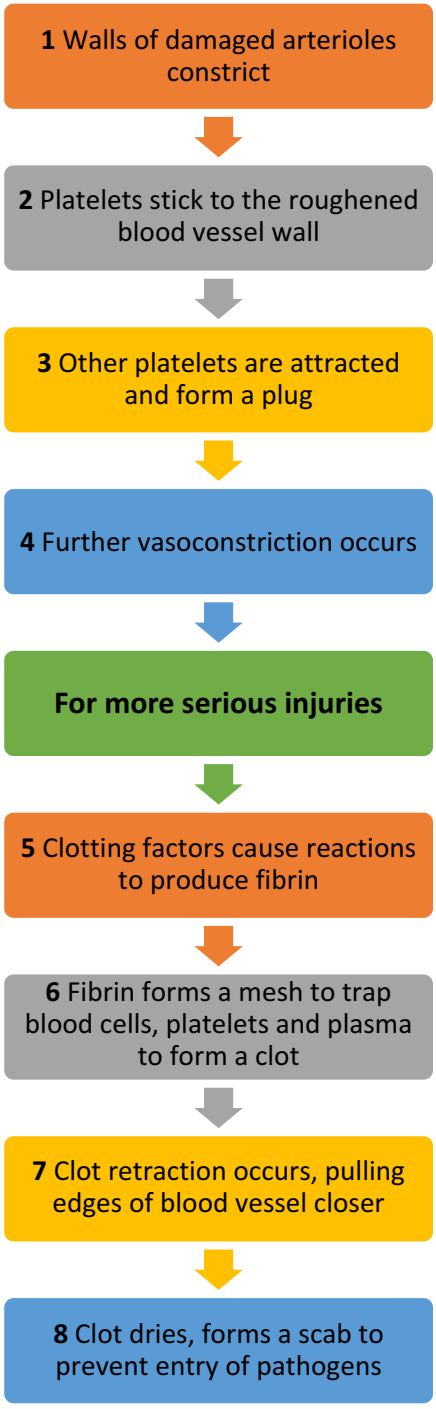
Answer:

3% is dissolved in the blood plasma

97% combines with haemoglobin to form oxyhaemoglobin and is transported on the red blood cells.

6 Draw a flow chart to show the steps involved in blood clotting.

Answer:



Apply knowledge

7 One side effect of chemotherapy is thrombocytopenia, a condition characterised by a low platelet count. Predict the symptoms that would be evident due to this condition.

Answer:

Easy bruising

Prolonged bleeding from cuts

Pinpoint sized red or purple spots on legs

Fatigue

8 Discuss the advantages and disadvantages of erythrocytes lacking a nucleus.

Answer: Advantages: The cells are more flexible, allowing them to move through small blood vessels. The biconcave shape increases the surface area for haemoglobin, enhancing their ability to carry oxygen.

Disadvantage: They have a short lifespan of 120 days on average.

Questions 5.2

Recall knowledge

1 What type of blood vessel has the thickest walls?

Answer: Arteries

2 Name the structure that stops the blood from travelling from the left ventricle to the left atrium.

Answer: The mitral valve (bicuspid valve may be used).

3 Label the parts of the heart on the diagram below.

Answer:

1 – Right atrium

2 – Right ventricle

3 – Left atrium

4 – Left ventricle

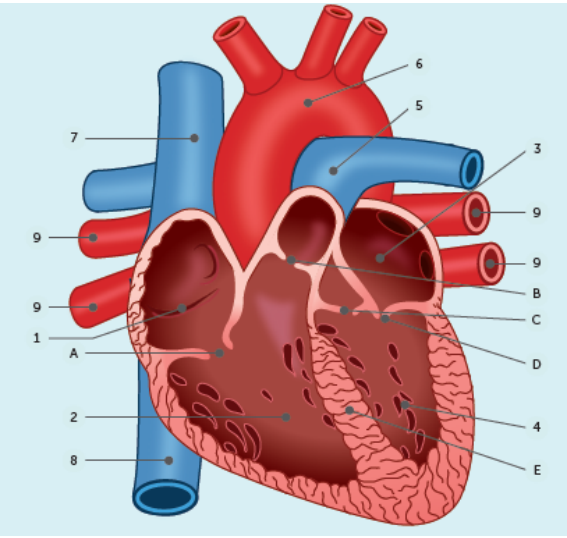
5 – Pulmonary artery

6 – Aorta

7 – Superior vena cava

8 – Inferior vena cava

9 – Pulmonary veins



A – Tricuspid valve (Right atrioventricular valve)

B – Pulmonary valve (Semilunar valve)

C – Aortic valve (Semilunar valve)

D – Mitral valve (Bicuspid valve / Left atrioventricular valve)

4 List the following structures in the order of blood flow through the body, starting from the lungs:

Lungs, right atrium, left atrium, pulmonary vein, mitral valve, left ventricle, pulmonary valve, tricuspid valve, aorta, vena cava, pulmonary artery, aortic valve, right ventricle

Answer:

Lungs → pulmonary vein → left atrium → mitral valve → left ventricle → aortic valve → aorta → vena cava → right atrium → tricuspid valve → right ventricle → pulmonary valve → pulmonary artery → lungs

5 Describe the function of capillaries.

Answer: They are the microscopic blood vessels that form a network to carry blood close to nearly every cell in the body. They allow for the exchange of materials between the cells and the blood.

6 Define 'cardiac output'.

Answer: The amount of blood leaving one of the ventricles every minute.

7 Name the stage of the cardiac cycle when the atrium contracts.

Answer: Atrial systole

Apply knowledge

8 Compare and contrast vasodilation and vasoconstriction.

Answer: Compare: Both are referencing the change in the size of the lumen of arteries. Both require smooth muscle in the walls of the arteries.

Contrast: Vasoconstriction narrows the lumen of the arteries/arterioles by contracting the muscles in the artery wall and reduces blood flow to an organ.

Vasodilation widens the lumen of the arteries by relaxing the muscles in the artery wall and increasing blood flow to an organ.

9 Explain the importance of the papillary muscles.

Answer: Papillary muscles attach to the chordae tendineae which hold in place the atrioventricular valves. When the ventricles contract the atrioventricular valves billow shut, preventing backflow of

blood in the heart. Without the papillary muscles, the tendons would not have anything to attach to, meaning that with every ventricular contraction blood would flow back into the atria, rather than to the arteries.

10 Explain why the pulmonary artery carries deoxygenated blood, while other arteries carry oxygenated blood.

Answer: Arteries carry blood away from the heart. The pulmonary artery is carrying the deoxygenated blood away from the right ventricle of the heart toward to lungs for gas exchange to occur. The other arteries are also carrying blood away from the heart, but from the left ventricle, and as such carry oxygenated blood.

11 Mitral valve regurgitation is a condition resulting from a damaged mitral valve. Two of the symptoms of mitral valve regurgitation are an enlarged left atrium and shortness of breath during exercise. Explain why these symptoms occur.

Answer: An enlarged left atrium occurs due the backflow of blood from the ventricles back into the atrium. Blood is unable to leave the heart correctly. Shortness of breath will occur as there is insufficient oxygen reaching your body cells, as oxygenated blood is unable to fully leave your heart. A build-up of carbon dioxide in the blood plasma will also occur, leading to shortness of breath.

12 CPR is taught during first-aid training to allow blood to continue to move through the body when the heart stops working. During this process, the lower sternum is pushed to a third of the depth of the chest. Explain how this manoeuvre is able to push blood through the body.

Answer: CPR is manually squeezing the heart between the bones of the sternum and the spinal cord. The compression will force the blood from the ventricles into the arteries and when compression is released, the heart will fill again, allowing the heart to be compressed have the blood squeezed out again. By completing regular compressions, the blood flow and the blood pressure through the arteries are maintained, ensuring that the cells of the body still receive oxygen and have their waste products removed.

13 Discuss the importance of the septum in the heart.

Answer: The septum separates the left and right side of the heart. Its presence ensures that oxygenated and deoxygenated blood do not mix in the heart.

14 Calculate the cardiac output if the heart rate is 58 beats per minute and 70 mL of blood is expelled with each beat.

Answer: Cardiac output (mL/minute) = stroke volume (mL) x heart rate (beats/minute)

CO = 70 x 58

Cardiac output = 4060 mL/minute

15 Explain the difference between systole and diastole.

Answer: Systole is the pumping phase of the cardiac cycle, when the heart muscle contracts. It pushes the blood from the atria to the ventricles, and from the ventricles into the arteries. Diastole is the filling phase of the cardiac cycle when the heart muscle relaxes. It allows for the atria to fill, while the ventricles contract, and the ventricles to fill while the atria contract.

Questions 5.3

Recall knowledge

1 List four reasons that someone would require a blood transfusion.

Answer:

- If they have suffered extreme blood loss (accident, surgery, pregnancy)
- If they have leukaemia
- If they have certain types of anaemia
- If they have haemophilia

2 List the antibodies that would be present or produced from someone with B-positive blood.

Answer: Antibody Anti-A.

3 Describe the process of agglutination.

Answer: It is the clumping of erythrocytes when incompatible blood types are mixed. The receiver will produce antibodies against the antigens on the donor/foreign red cells, causing them to clump together and disintegrate.

4 What is the most commonly transfused part of blood?

Answer: Red cell concentrates

Apply knowledge

5 Explain the importance of matching blood groups between the donor and recipients of a blood transfusion.

Answer: If the blood types are incompatible, then the receiver will produce antibodies that attack the antigens found on the donor red cells. This will cause the cells to clump together and disintegrate (agglutination).

6 Blood group O is known as the universal donor. Explain why this is valid.

Answer: Blood group O does not have antigen A or antigen B on the surface of the red blood cells. This means that blood group O can be given to anyone, without causing agglutination. It also contains anti-A and anti-B antibodies in the plasma, which will not react with any recipient.

7 Compare and contrast the ABO blood groups and the Rh blood groups.

Answer: Compare: Both are blood groups, they are inherited traits and both are based on the presence of antigens on the surface of red blood cells.
Contrast: The ABO blood group produces sugar antigens; the Rh antigens are proteins.

8 Explain why patients with severe bleeding receive plasma transfusions.

Answer: Plasma contains cryoprecipitates which contain many of the chemicals required for blood clotting.

Questions 5.4

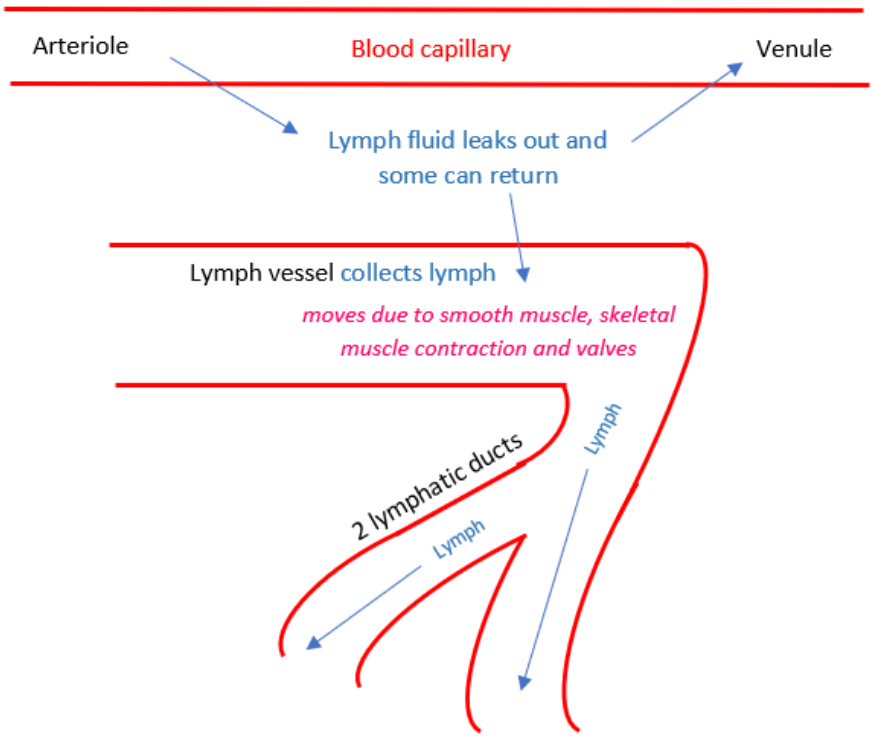
Recall knowledge

1 Define 'lymph'.

Answer: The colourless liquid that circulates through the lymphatic vessels to be returned to the blood.

2 Use a flow chart to show the movement of lymph from the blood capillaries to the veins in the upper chest.

Answer:



3 List the functions of the lymphatic system.

Answer: The main function of the lymphatic system is to collect some of the escaped fluid from the blood capillaries and return it to the circulatory system. It also filters the lymph to aid in the body's internal defence against pathogens.

4 Describe the role of lymph nodes in protecting the body against foreign bodies.

Answer: Lymph nodes contain lymphoid tissue made up of macrophages, lymphocytes and plasma cells. There is also a crisscross network of fibres. When lymph enters these nodes, large particles will become trapped in the mesh and are then consumed by macrophages by phagocytosis. Lymphocytes and plasma cells will detect any pathogenic organism and produce chemicals to destroy the pathogen. (Unit 3 content)

Apply knowledge

5 Discuss the importance of valves in lymph vessels.

Answer: Valves are important in lymph vessels because there is no central pump to drive the direction of the flow of the lymph. Valves prevent the backflow of lymph when the pressure drops.

6 Doctors will check the size of lymph nodes in sick patients. Explain why this is an important part of the physical examination.

Answer: If a patient has an infection, the pathogen will be filtered out of the lymph at the lymph nodes. The presence of the pathogen activates the macrophages, lymphocytes and plasma cells to

divide and increase in activity to remove the pathogen from the patient's body. This increase in number and activity will cause the lymph nodes to swell, which can be detected by a doctor in a physical examination.

7 Compare and contrast lymph vessels and blood vessels.

Answer: Compare: Both transport fluid, lymph vessels and veins both contain valves to prevent backflow. Contrast: Lymph vessels originate as blind-ended tubes; they are slightly wider in lumen diameter than capillaries, they are more permeable than capillaries.

Chapter 5 activities

Activity 5.1 Comparing blood cells

Studying your observations

1 Describe the appearance of a red blood cell. What does the appearance tell you about the structure of the cell?

Answer: The red blood cells are round and are a deeper colour around the edge than in the centre. The colour distribution indicates that the cells are thicker towards the edges than in the centre; that is, they are biconcave.

2 Draw a diagram showing a red blood cell and each of the types of white blood cells that you can see.

Answer: See Figures 5.3 and 5.4 on pages 104–5 of the student book for diagrams of the different types of blood cell.

3 What is the approximate difference in size between red blood cells and white blood cells?

Answer: Many of the white blood cells are about twice the diameter of the red blood cells.

4 What is the approximate ratio of numbers of red blood cells to white cells?

Answer: There are approximately 600 times as many red cells as white cells.

5 Were you able to see any platelets? Suggest why platelets are difficult to see with a school microscope.

Answer: Platelets could not be seen because they are too small and, because they are cell fragments, they are not stained by most of the stains used to view blood cells.

Activity 5.2 Investigating blood flow during exercise

Your task

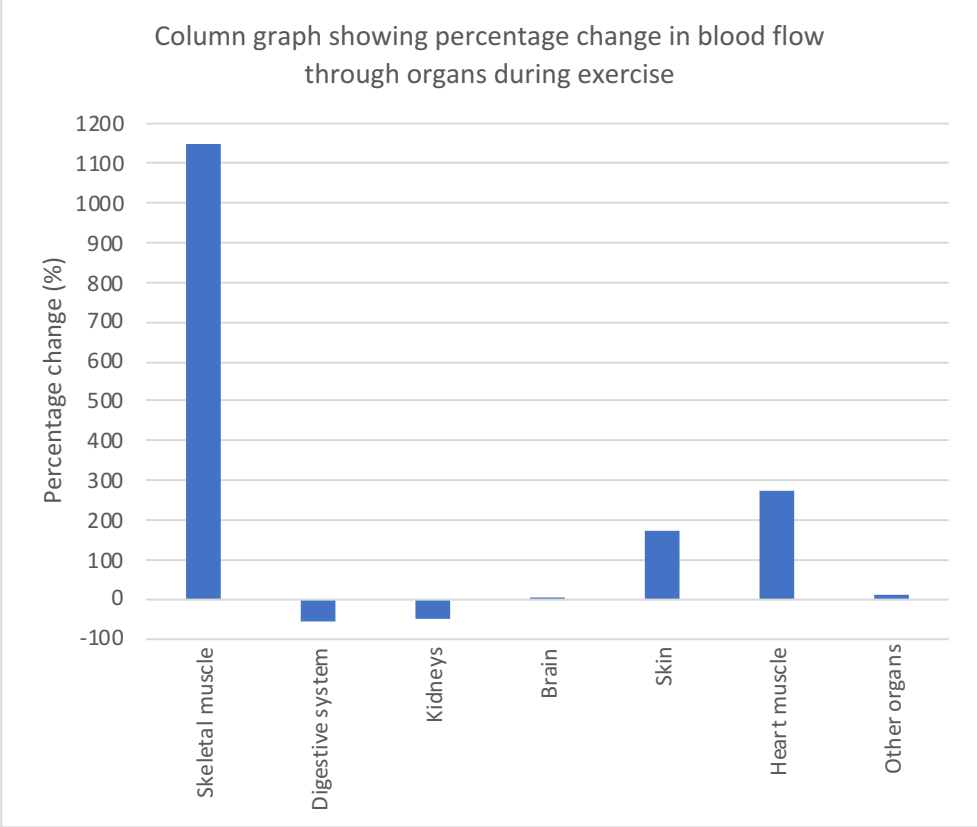
1 Calculate the percentage increase in blood flow through each organ during exercise.

Answer:

$$percentage\ change = \frac{new\ value - old\ value}{old\ value} \times 100$$

Part of the body	Rate of blood flow (mL/min)		Percentage change
	Resting	Exercising	
Skeletal muscle	1000	12 500	1150% increase
Digestive system	1350	600	55.5% decrease
Kidneys	1100	600	45.5% decrease
Brain	700	750	7% increase
Skin	300	1900	171% increase
Heart muscle	200	750	275% increase
Other organs	350	400	14% increase

2 Construct a graph to show the percentage increase in blood flow for each organ.



Discussion

1 Calculate the person's cardiac output when at rest.

Answer: Cardiac output at rest = 5 L/min

2 Calculate the person's cardiac output while exercising.

Answer: Cardiac output when exercising = 17.5 L/min

3 What are the two ways in which cardiac output can be increased?

Answer: Increase in heart rate and increase in stroke volume

4 For each part of the body listed in the table, explain the reasons for any changes in blood flow that occur during exercise.

Answer:

- Skeletal muscle: Blood flow is greatly increased to supply working muscles with oxygen and glucose and to carry away CO_2 and other wastes.
- Digestive system and kidneys: Blood flow is reduced because these organs are not active during exercise.
- Brain: Activity is changed very little by exercise.
- Skin: Blood flow is increased to allow radiation of the heat produced by muscular activity.
- Heart muscle: The heart is contracting more rapidly and more forcefully, so blood flows to the heart
- muscle is increased to supply more oxygen and glucose and to remove wastes.
- Other organs: Activity is changed very little by exercise.

5 Which body organ experiences the greatest increase in blood flow during exercise? Explain the reason for this.

Answer: Skeletal muscles had the greatest increase in blood flow during exercise. This is due to the increased demand of the skeletal muscle cells to be supplied with glucose and oxygen for cellular respiration to occur so ATP can be produced which is needed for muscle contraction. The cells will also be producing more waste products (carbon dioxide, water, heat and lactic acid) which need to be removed from the cells. Greater blood flow allows for the requirements to be delivered and the waste products to be removed.

Activity 5.3 Observing heart structure

Studying your observations

1 Arrange the heart as you would see it if you were looking at it in a person's chest. Take a photo or draw the heart and label all the external features.

Answer: The labelled features of the drawn heart should include:

- left and right atria

- left and right ventricles
- aorta
- pulmonary artery/trunk
- venae cavae.

The right side of the heart should be on the left side of the drawing.

2 Measure the thickness of the wall of each of the four heart chambers. List the chambers in order from that with the thinnest wall to that with the thickest wall.

Answer:

a Thinnest – left and right atria – both about the same thickness

b Right ventricle

c Thickest – left ventricle

3 In your own words, describe the appearance of the atrioventricular valves. Are there any differences between the left and right atrioventricular valves?

Answer: The valves are flaps of thin, semi-transparent tissue attached at one end to the join between atria and ventricles. The outside edge of the flaps has tendons that look like cotton threads. The tendons are attached to the inside wall of the ventricles.

The left atrioventricular valve has two flaps (it may be called the bicuspid valve).

The right atrioventricular valve has three flaps (it may be called the tricuspid valve).

4 Describe the appearance of the semilunar valves. Are there any differences between the semilunar valves of the aorta and those of the pulmonary artery?

Answer: The semilunar valves are made of thin, semi-transparent tissue that forms three half-cups attached to the artery wall where the vessels leave the heart. There is no apparent difference between the left and right semilunar valves.

5 Describe any differences that you observed between the veins and the arteries.

Answer: The arteries have much thicker walls than the veins. The major arteries are connected to the ventricles; the major veins are connected to the atria.

6 Why does the heart have two types of chamber – atria and ventricles?

Answer: The atria are thin-walled receiving chambers that receive the blood coming to the heart. The ventricles are pumping chambers with thicker walls to pump blood to the lungs and the body.

7 Why does the heart have two of each chamber – two atria and two ventricles?

Answer: The heart is really two pumps side by side. The right side pumps blood to the lungs. While going through the capillaries of the lungs, the blood loses most of its pressure so it is taken back to the left side of the heart to be pumped to the body.

Activity 5.4 Observing capillaries

2 Describe what you observe.

Answer: You should have been able to see blood cells flowing through the very small blood vessels in the fish's tail.

3 How does the diameter of a blood cell compare with the diameter of the smallest capillary?

Answer: The blood cells would be smaller than, or about the same diameter as, the smallest capillary.

Activity 5.5 Investigating blood pressure

Discussion

1 Describe how blood pressure is measured by the technique you used and the sphygmomanometer.

Answer: As air is pumped into the cuff of the sphygmomanometer that is wrapped around the upper arm (brachial artery), the vessel is squeezed closed and its blood flow is stopped. As air is slowly released from the cuff and the cuff pressure is approximately equal to the systolic blood pressure, the artery opens enough for a small amount of blood to spurt through. To get the systolic blood pressure reading, you record the pressure level at which this blood movement can be detected via sound or electronically. As the cuff pressure continues to drop, the diastolic pressure is also released and is measured in the same manner. These two numbers produce the blood pressure reading, 120/80 (SP/DP).

2 In this procedure, you were asked to listen to the systolic pressure. Describe what you were able to hear and how this corresponds with what systolic pressure is.

Answer: As the ventricles contract to squeeze the blood inside their chambers, the pressure in the arteries rises sharply. Systolic pressure is the maximum pressure achieved during ventricular contraction. This can be heard as faint rhythmic thumping sounds as the blood returns to the arm.

3 You were also asked to listen to the sounds of the diastolic pressure. Describe what you were able to hear and how this corresponds with what systolic pressure is.

Answer: As the ventricles relax, the arterial pressure drops. Diastolic pressure is the lowest pressure that remains in the arteries before the next ventricular contraction. Compared to the initial sharp tapping sounds of systolic pressure, diastolic pressure can be heard after as softer blowing or swishing sounds.

4 Describe what blood pressure is and how it occurs.

Answer: Blood pressure is the force created by the blood against the inner walls of the blood vessels. The term blood pressure is typically used to refer to pressure in the arteries, despite this force occurring throughout the vascular system. Blood pressure rises and falls as the ventricles of the heart contract and relax.

5 What are the potential consequences of prolonged high blood pressure?

Answer: Prolonged and uncontrolled hypertension can ultimately result in an enlarged and weakened heart. Continued elevated arterial pressure increases an individual's risk of having a stroke, heart attack, kidney failure and ruptured blood vessels.

6 How can hypertension (high blood pressure) be prevented?

Answer: Possible treatments and preventative measures for hypertension include stress reduction, exercise, low-sodium diet, body weight control and increased potassium consumption. Diuretics and inhibitors of sympathetic nerve activity medications may also be used.

Activity 5.6 Investigating blood typing

Investigations

1 How did the test results indicate that the blood at the crime scene did not come from this individual?

Answer: The suspect's blood must have agglutinated in the presence of anti-A serum, indicating that this blood is A-type, and therefore not the same as the blood left at the scene.

2 Imagine another suspect was tested with anti-A or anti-B and their blood did not agglutinate, but when tested with anti-Rh it does. Does this information mean the suspect may have committed the crime? Explain your answer.

Answer: This suspect has O-type blood, but the anti-Rh serum results show that it is O+, and therefore not the guilty person.

3 Jeff and Kim are first time donors taking part in a Red Cross blood drive. Before they can donate, their blood needs to be typed. Jeff is A+. Kim is AB+.

a Identify which ABO antibody/ies are present in Jeff's blood.

Answer: Jeff has anti-B antibodies

b Identify which ABO antigen/s are present in Kim's blood.

Answer: Kim has A, B and Rh antigens.

4 Both Jeff and Kim's donated blood is sent to be processed and in both samples the blood cells are separated from the plasma. The separated cells and plasmas are then to be used in blood transfusions. But a blood researcher wishes to extract the antigen A in Jeff's blood. Should the researcher attempt to extract the antigen A from his blood cells or his plasma?

Answer: The antigen A is part of the membrane of blood cells, so the researcher should use the red blood cells.

Chapter 5 review questions

Recall

1 Describe the external appearance of the heart.

Answer: The heart is roughly the size of a closed human fist, muscular and contained in a membrane called the pericardium.

2 Draw a simple diagram of the human heart and show the direction of blood flow.

Answer: Good student diagrams should include labels for the inferior vena cava, superior vena cava, pulmonary arteries, pulmonary veins, right atrium, right ventricle, left atrium, left ventricle, septum, tricuspid valve, pulmonary valve, bicuspid valve and aortic valve. Direction of deoxygenated and oxygenated blood flow should be shown using colour-coded arrows.
Refer to Figure 5.20 on page 117 of the student book.

3 State the function of valves in the circulatory system.

Answer: Valves prevent backflow of blood. In the heart they help direct blood flow from each chamber and into the arteries. In veins they prevent backflow of blood and help ensure venous return.

4 List the functions of blood and explain the importance of each function.

Answer:

• Function: Transport of oxygen and nutrients to all cells of the body

Importance: For respiration; releases energy for synthesis of new substances, for growth, movement

• Function: Transport of carbon dioxide and other waste products away from cells

Importance: To maintain homeostasis, otherwise cells would not be able to maintain the required rate of cellular respiration if there was a build-up of waste products

• Function: Transport of chemical messengers, called hormones, to cells

Importance: Cells are stimulated to carry out particular functions as required and so maintain homeostasis; the coordination of activities of organs involves hormones

• Function: Maintaining the pH of body fluids

Importance: To maintain cells at the optimum pH for normal functions, especially the functioning of the cell's enzymes

• Function: Distributing heat and maintaining body temperature

Importance: To maintain temperature so that enzymes can function at optimum efficiency; keeps all organs at optimum temperature

• Function: Maintaining water content and ion concentration of the body fluids

Importance: To maintain water concentrations so that cells do not shrivel or burst due to changes in osmotic pressure

• Function: Protection against pathogens

Importance: Prevents infections causing disruption to homeostasis

5 a Describe the ways in which oxygen is carried in the blood.

Answer: Approximately 3% of oxygen is carried in solution in the blood plasma. The other 97% is carried in combination with haemoglobin molecules, which are found only in the red blood cells.

b Describe the ways in which carbon dioxide is carried in the blood.

Answer: Approximately 7% or 8% of the carbon dioxide dissolves in the plasma. Approximately 22% combines with haemoglobin to form carbaminohaemoglobin. However, the remaining 70% reacts with water to form carbonic acid (H_2CO_3). Carbonic acid then dissociates into hydrogen ions and bicarbonate ions. Thus, approximately 70% of carbon dioxide is carried in the plasma as bicarbonate ions.

6 Define 'circulation'.

Answer: The movement of blood through the heart and blood vessels.

7 Describe the two ways in which blood flow to an organ can be increased.

Answer: Blood flow to an organ can be increased by:

- increasing output from the heart (increasing heart rate or stroke volume)
- increasing the diameter of the arteries and arterioles that supply the organ.

8 Briefly describe the structure of a lymph node.

Answer: Each lymph node is surrounded by a capsule of connective tissue. The connective tissue extends into the node, forming a framework on which there are masses of lymphoid tissue. There is a network of fibres in the spaces between cells of the lymphoid tissue. Lymph filters through the spaces.

9 Describe the sequence of events that occurs in blood clotting.

Answer: The following events occur when blood clots at the site of an injury.

- Small arteries that have been damaged constrict (to reduce blood flow).
- Platelets stick to the injured surfaces of the blood vessels.
- Platelets release vasoconstrictors.
- Vasoconstrictors enhance the constriction of damaged blood vessels.
- Clotting factors in the blood promote the formation of fibrin, an insoluble protein in the form of fine threads.
- Fibrin threads stick to damaged blood vessels and trap blood cells, platelets and plasma. (The mass of threads with the trapped material is the clot.)
- Fibrin threads contract pulling the injured blood vessels together and squeezing out fluid.
- Retracted clot dries to form a scab over the wound.

10 List the antigens and antibodies involved in the ABO blood group system.

Answer: The antigens involved in the ABO blood group system are antigen A and antigen B, while the antibodies involved are anti-A and anti-B. Anti-A reacts against antigen A, and anti-B reacts against antigen B.

Explain

11 After passing through the capillaries of the body, the blood returns to the heart to be pumped again before going through the lungs. Explain why the blood must be pumped twice for each complete circulation through the body and lungs.

Answer: Blood capillaries have a very narrow diameter, which provides a lot of resistance to blood flow and reduces the blood pressure. After passing through the capillaries of the lungs the blood

pressure is so low that the blood must go back to the heart to be pumped again before passing through the capillaries of the rest of the body.

12 a Why are valves necessary in the heart?

Answer: Valves are necessary to ensure that the blood flows in only one direction.

b Explain how the atrioventricular valves work.

Answer: The atrioventricular valves are flaps in the ventricles. When blood from the atria flows into the ventricles the flaps are pressed flat against the ventricle wall. When the ventricles contract blood catches behind the flaps and they billow out, sealing off the junction between the atria and ventricles so that blood cannot flow back into the atria. The flaps are prevented from turning inside out by tendons attached to their edges.

c Explain how the semilunar valves work.

Answer: Each semilunar valve consists of three cusps. When blood is flowing into the arteries the cusps are pressed flat against the artery wall. When blood tries to flow back into the ventricle, the blood catches in the cusps, and the cusps fill out and seal off the artery. This prevents backflow.

13 Explain the changes in blood flow that occur during exercise.

Answer:

- Increased cardiac output caused by higher heart rate and stroke volume
- Increased flow to skeletal muscles
- Decreased flow to some internal organs, such as the stomach and intestines
- Increased flow through the skin to dissipate heat

Also see the table on page 127 of the student book.

14 For each of the following, explain how its structure is related to its function.

a Red blood cell

Answer: The function of red blood cells is to transport oxygen. The cells contain haemoglobin, which is able to combine with oxygen for efficient transport. Red blood cells are biconcave discs, a shape that gives maximum surface area for oxygen to diffuse in and out but also allows plenty of space for haemoglobin. They have no nucleus, which allows more room for haemoglobin. The shape also allows them to be distorted as they squeeze through narrow capillaries.

b Artery

Answer: Arteries carry blood away from the heart. The walls of an artery contain smooth muscle and elastic fibres, so that when the ventricles contract and push blood into the arteries, the walls of the arteries stretch to accommodate the higher blood pressure. When the ventricles relax, the elastic artery walls recoil. This elastic recoil keeps the blood moving and maintains the pressure. The muscle in the artery wall can contract to reduce the diameter of the artery and thus reduce blood flow to an organ; or, the muscle may relax to increase blood flow to an organ. In this way, blood flow may be changed from one organ to another to allow for the changing needs of the body.

c Heart

Answer: The following features of the heart show how its structure is related to its function:

- the heart is made of cardiac muscle, which can contract to reduce the volume of the heart chambers
- it has four chambers: two for receiving blood and two for pumping blood
- the pumping chambers have much thicker muscle than the receiving chambers because they have to pump the blood more forcibly
- the left ventricle has a thicker wall than the right because it pumps blood to the body rather than just to the lungs.

15 Explain how the lymphatic system achieves its function.

Answer: Fluid leaks out of the arterial end of blood capillaries, excess fluid is returned to the blood by the lymphatic system. Lymph vessels originate as blind ended tubes in the spaces between most cells, lymph enters the lymph capillaries and is moved through the vessels as a result of skeletal muscle contraction and valves. Lymph is filtered at the lymph nodes before being returned to the circulatory system through two lymphatic ducts in the upper chest.

16 Discuss the differences between the lymphatic and circulatory systems.

Answer: The lymphatic system is a one-way system, carrying fluid away from the tissues and returning the fluid into the veins in the upper chest. Lymph is a clear fluid containing no blood cells. The circulatory system transports blood using a double circulatory pathway, to the lungs and to the body. It contains blood cells. Both have a role in defence against disease.

17 Explain why early attempts at blood transfusion were sometimes successful but, more often, led to the death of the patient. What would have caused those patients to die?

Answer: When transfusions were successful it would have been because, by chance, the blood group of the donor's blood matched that of the recipient. When there was a mismatch of blood groups, the transfusion would have been unsuccessful because antibodies in the patient's blood would have caused cells of the donor's blood to clump together. The patient would die because the clumps of cells would block the patient's blood capillaries so that blood could not circulate normally.

Apply

18 Why is blood red?

Answer: Approximately 40% of blood volume is made up of red blood cells. These cells give the blood its colour. They are red because they contain a red pigment – haemoglobin. When haemoglobin is combined with oxygen it forms oxyhaemoglobin, which is a bright red colour. Blood in arteries that carry blood to the body is therefore bright red. Haemoglobin is dark red or purplish, so blood in the veins from the body is dark red.

19 Explain why someone with an infected toe may experience a lump in their groin.

Answer: There are large numbers of lymph nodes in the groin. Lymph from the infected toe would contain the micro-organisms causing the infection. As the lymph passed through the lymph nodes in the groin, lymphocytes would actively remove the microorganisms and the nodes would swell and become sore.

20 If the heart contracts 70 times per minute, how many times does it contract in a day (24 hours), and how many times in a week?

Answer:

Contractions per day = 70 × 60 (minutes/hour) × 24 (hours/day) = 100 800

Contractions per week = 100 800 × 7 = 705 600

21 When blood plasma is given in a transfusion, would the donor of the plasma have to be the same ABO blood group as the receiver? Explain your answer.

Answer: No, because the antigens that determine ABO blood group and antibody response are found on the surface of the red blood cells. The plasma does not contain red cells, and therefore does not contain antigen A or antigen B.

Extend

22 People living near sea level have about 5 million erythrocytes in 1 mm^3 of blood. Those living at an altitude of 5500 m above sea level have about 7.5 million erythrocytes per 1 mm^3 of blood. Suggest an explanation for this difference.

Answer: The air at higher altitudes is less dense than at sea level, and thus contains less oxygen. People who live at high altitudes have adapted to the decreased availability of oxygen by increasing the number of red blood cells they have. This maximises the amount of oxygen their blood can take up from the air and carry around the body. The more haemoglobin they have available to them, the greater the tendency for oxygen to bind with it for transportation, thus allowing normal functioning of cells.

23 At one time, it was believed that disease was caused by 'bad blood'. Taking large amounts of blood from a patient by bleeding (blood-letting) was widely practised as a cure for disease. Louis XIII of France had blood taken 47 times in six months; Louis XV was bled 38 times, and Charles II of England had blood taken numerous times, even just before his death. Describe some of the effects that the removal of large quantities of blood would have on a patient.

Answer:

- Dehydration, because less fluid would be circulating
- The immune system would be compromised because white blood cells would be reduced
- Reduced oxygen supply to the cells because fewer red blood cells would be circulating
- Fatigue, because there is less oxygen for cellular respiration
- Accumulation of wastes in tissues because less blood is available to remove them.

24 Which do you think is more important to the body – the heart or the capillaries? Explain your answer.

Answer: They are both of vital importance. The circulation of the blood depends on both, so it is not possible to say that one is more important than the other.

25 If you remain sitting for a long time, such as on a long flight, you may experience swelling of the feet and ankles. Suggest why this occurs.

Answer: When you are sitting for long periods, the muscles in the legs are not contracting and relaxing and are therefore not squeezing the veins and helping to push blood back to the heart. The blood tends to accumulate around the feet and fluid leaks out of the blood vessels, causing swelling.

26 a Why would first babies rarely be affected by this condition?

Answer: After the first exposure to the Rh-positive blood, antibodies are produced very slowly and they have little effect on the first child.

b Why would the condition be more likely to occur if a mother had previously received a transfusion of Rh-positive blood?

Answer: If an Rh-negative mother had already received a transfusion of Rh-positive blood she would have become sensitised. Antibodies against any Rh-positive blood from a developing foetus would be produced very rapidly and in large quantities.

27 The table below shows the result of testing blood samples from three different individuals with group A plasma and group B plasma. What is the blood group of each of the individuals D, E and F?

TESTED WITH	INDIVIDUAL		
	D	E	F
Group A serum	Clumping	No clumping	Clumping
Group B serum	No clumping	No clumping	Clumping

Answer:

- Individual D: blood group B
- Individual E: blood group O
- Individual F: blood group AB