Edexcel

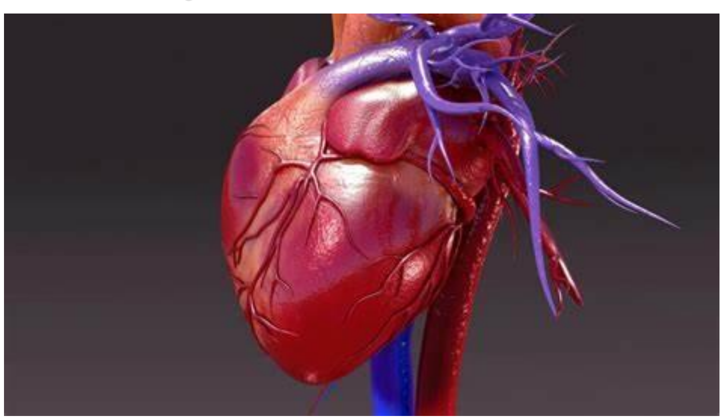
AS level

Biology

CODE: (4BI1)

Topic 1B

Mammalian transport system



1B.1- The principle of circulation

THE NEED FOR TRANSPORT

Within any organism, substances need to be moved from one place to another. One of the main ways substances move into and out of cells is by diffusion. **Diffusion** is the free movement of particles in a liquid or a gas down a concentration **gradient**.

TRANSPORT IN SMALL ORGANISMS

For a single-celled organism like an amoeba and for very small multicellular organisms including many marine larvae, the nutrients and oxygen that they need can diffuse directly into the cells from the external environment and waste substances can diffuse directly out. This works well for the following reasons.

- The diffusion distances from the outside to the innermost areas of the cells are very small.
- The surface area in contact with the outside environment is very large when compared to the volume of the inside of the organism. Its **surface area to volume ratio** (sa: vol) is large, so there is a relatively big surface area over which substances can diffuse into or out of the organism (see figs A and B).
- The metabolic demands are low-the organisms do not regulate their own temperature and the cells do not use much oxygen and food or produce much carbon dioxide.

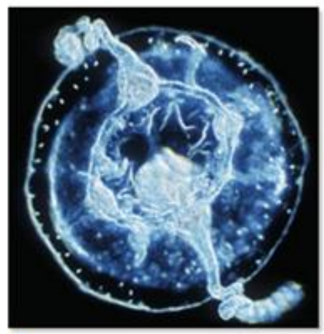


fig A The surface area : volume ratio of this tiny jellyfish larva is relatively large so simple diffusion can supply all its needs.

MODELLING SURFACE AREA: VOLUME RATIOS

The surface area to volume ratio of an organism determines the speed at which substances can enter and exit cells. Calculating this ratio is challenging for organisms like elephants, people, and palm trees. Scientists use models like cubes to illustrate the real-world situation. As organisms grow, the ratio decreases, causing slower diffusion and potential insufficient cell supply.

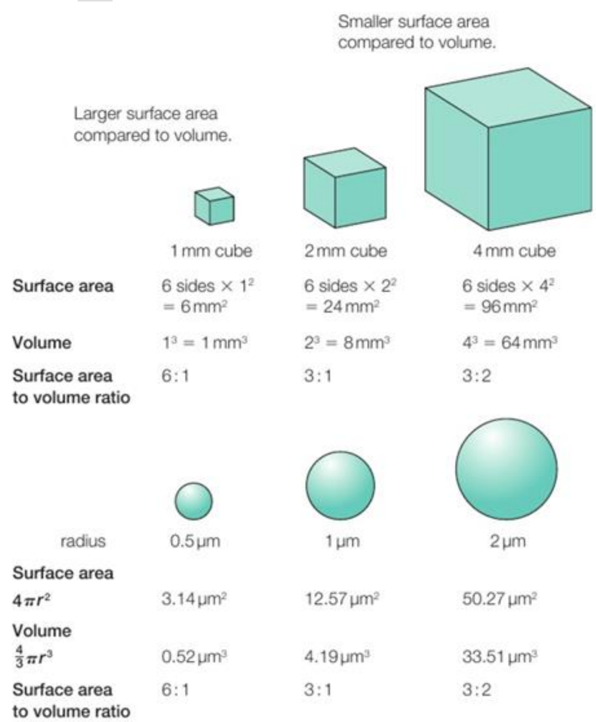


fig B In this diagram, the cubes and spheres represent models of organisms.

THE NEED FOR TRANSPORT IN MULTICELLULAR ANIMALS

Large multicellular organisms require chemical reactions within microscopic cells for respiration and energy production. These cells require substances like glucose and oxygen, which must be transported from outside the organism. Internal transport systems in large multicellular organisms deliver oxygen, nutrients, and remove waste. In large complex animals like humans, internal substances need to be moved around the body. Mass transport systems, such as the heart and circulatory system, transport substances in fluid flow, overcoming diffusion limits. Substances are delivered to individual cells through processes like diffusion, osmosis, and active transport.

FEATURES OF MASS TRANSPORT SYSTEMS

Mass transport systems are very effective for moving substances around the body. Most mass transport systems have certain features which are the same. They have:

- Exchange surfaces to get materials into and out of the transport system
- A system of vessels that carry substances - these are usually tubes, sometimes following a very specific route, sometimes widespread and branching
- A way of making sure that substances are moved in the right direction (e.g. nutrients in and waste out)
- A way of moving materials fast enough to supply the needs of the organism - this may involve mechanical methods
- A suitable transport medium (e.g. fluid)
- In many cases, a way of adapting the rate of transport to the needs of the organism.

CIRCULATION SYSTEMS

Many animals have a circulatory system in which a heart pumps blood around the body. Insects have an open circulatory system with the blood circulating in large open spaces. However, most larger animals, including mammals, have a closed circulatory system with the blood contained within tubes.

Animals such as fish have a **single circulation system** (see fig C).

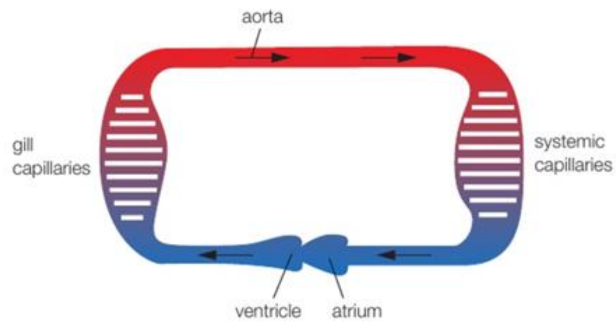


fig C The single circulation of a fish

Birds and mammals have evolved the most complex type of transport system, known as a **double circulation**, because it involves two separate **circulation systems**. The systemic circulation carries **oxygenated blood (**oxygen-rich blood) from the heart to the cells of the body where the oxygen is used. It also carries the **deoxygenated blood** (blood that has given up its oxygen to the body cells) back to the heart. The **pulmonary circulation** carries deoxygenated blood from the heart to the lungs to be oxygenated and then carries the oxygenated blood back to the heart (see fig D).

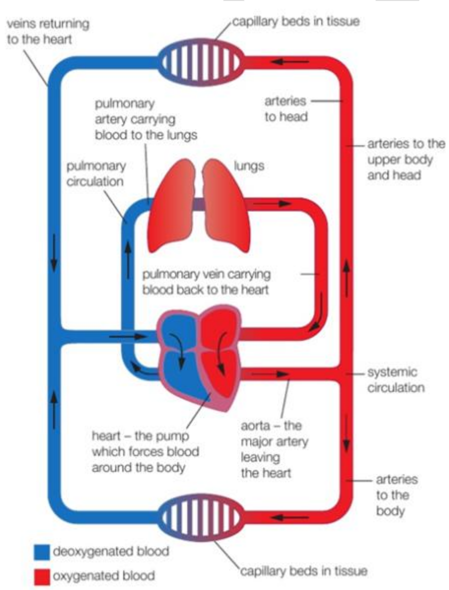


fig D A double circulation sends blood at high pressure, carrying lots of oxygen, to the active cells of the body. Take note: this is a schematic diagram. In a real double circulation, all of the blood vessels enter and leave from the top of the heart.

SUBJECT VOCABULARY

diffusion the movement of the particles in a liquid or a gas down a concentration gradient from an area where they are at a relatively high concentration to an area where they are at a relatively low concentration

concentration gradient the change in the concentration of solutes present in a solution between two regions; in biology, this typically means across a cell membrane

surface area to volume ratio (sa : vol) the relationship between the surface area of an organism and its volume

vertebrates animals with a backbone or spinal column; they include mammals, birds, reptiles, amphibians and fish

mass transport system an arrangement of structures by which substances are transported in the flow of a fluid with a mechanism for moving it around the body

single circulation system a circulation in which the heart pumps the blood to the organs of gas exchange and the blood then travels on around the body before returning to the heart

double circulation system a circulation that involves two separate circuits, one of deoxygenated blood flowing from the heart to the gas exchange organs to be oxygenated before returning to the heart, and one of oxygenated blood leaving the heart and flowing around the body, returning as deoxygenated blood to the heart

systemic circulation carries oxygenated blood from the heart to the cells of the body where the oxygen is used, and carries the deoxygenated blood back to the heart

oxygenated blood blood that is carrying oxygen

deoxygenated blood blood that has given up its oxygen to the cells in the body

pulmonary circulation carries deoxygenated blood to the lungs and oxygenated blood back to the heart

1B.2 The roles of the blood

In mammals, the mass transport system is the **cardiovascular system**. This is made up of a series of vessels with the heart as a pump to move blood through the vessels. The blood is the transport medium and its passage through the vessels is called the **circulation**. The system delivers the materials needed by the cells of the body, and carries away the waste products of their metabolism. Substances move between the plasma or red blood cells and the body cells by diffusion or by **active transport.**

THE COMPONENTS OF THE BLOOD AND THEIR MAIN FUNCTIONS

You are going to study all three parts of the cardiovascular system, starting with the transport medium - the blood. Your blood is a complex mixture carrying a wide variety of cells and substances to all areas of your body (see fig A).

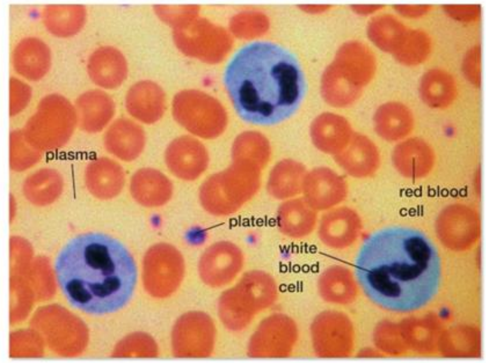


fig A This light micrograph shows red blood cells, white blood cells and platelets.

PLASMA

Your blood plasma is the fluid part of your mass transport system. Over 50% of your blood volume is plasma, and it carries all of your blood cells and everything else that needs transporting around your body.

This includes:
- Digested food products from the small intestine to the liver and then to all the parts of the body where they are needed either for immediate use or storage
- Nutrient molecules from storage areas to the cells that need them
- Excretory products (e.g. carbon dioxide and urea) from cells to the organs such as the lungs or kidneys that excrete them from the body
- Chemical messages (hormones) from where they are made to where they cause changes in the body.

The plasma helps to maintain a steady body temperature by transferring heat around the system from internal organs or very active tissues to the skin, where it can be lost to the surroundings. It also acts as a buffer to regulate pH changes.

Erythrocytes (red blood cells)

Around 5 million erythrocytes per mm3 of blood contain haemoglobin, a red pigment that carries oxygen. Made in the bone marrow, mature erythrocytes have a limited lifespan of 120 days. They transport oxygen from the lungs to cells, with a large surface area to volume ratio. Each red blood cell contains 250-300 million haemoglobin molecules, carrying around 1000 million molecules of oxygen.

LEUCOCYTES (WHITE BLOOD CELLS)

Leucocytes or white blood cells are much larger than erythrocytes, but can also squeeze through tiny blood vessels because they can change their shape. There are around 4000- 11000 per mm3 of blood and there are several different types. They are made in the bone marrow, although some mature in the thymus gland.

PLATELETS

Platelets are tiny fragments of large cells called megakaryocytes, which are found in the bone marrow. There are about 150000-400 000 platelets per mm3 of blood. They are involved in blood clotting

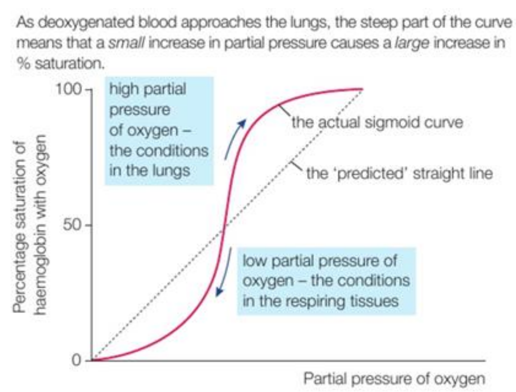


fig C Oxygen dissociation curve for human haemoglobin

TRANSPORT OF OXYGEN

The many haemoglobin molecules that are in the red blood cells transport oxygen. Each haemoglobin molecule is a large globular protein consisting of four peptide chains, each with an iron-containing prosthetic group. Each group can collect four molecules of oxygen in a reversible process to form oxyhaemoglobin:

$$\frac{Hb + 4O_2 \rightleftharpoons Hb.4O_2}{\text{haemoglobin + oxygen} \rightleftharpoons \text{oxyhaemoglobin}}$$

TRANSPORT OD CARBON DIOXIDE

About 5% of the carbon dioxide is carried in solution in the plasma. A further 10-20% combines with haemoglobin molecules to make **carbaminohaemoglobin**. Most of the carbon dioxide is transported in the cytoplasm of the red blood cells as **hydrogencarbonate** ions. The enzyme carbonic anhydrase controls the rate of the reaction between carbon dioxide and water to produce carbonic acid.

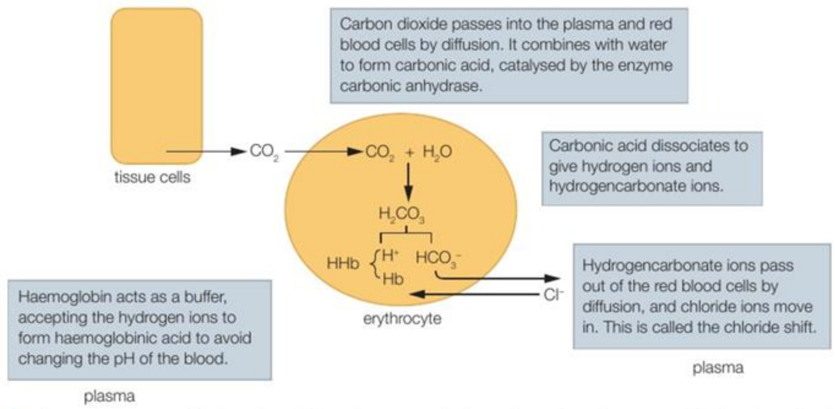


fig D The transport of carbon dioxide from the tissues to the lungs depends on the reaction of carbon dioxide with water, controlled by an enzyme in the red blood cells.

THE BHOR EFFECT

The proportion of carbon dioxide in tissues affects haemoglobin's ability to collect and release oxygen. High carbon dioxide levels reduce haemoglobin's affinity for oxygen, making it more easily released. The **Bohr effect,** resulting from changes in oxygen dissociation curves, is a key mechanism.

Fetal haemoglobin, a special form of oxygen-carrying pigment, plays a crucial role in the transfer of oxygen from maternal blood to fetal blood. Its higher affinity for oxygen allows it to remove oxygen from maternal blood, even when oxygen levels are low.

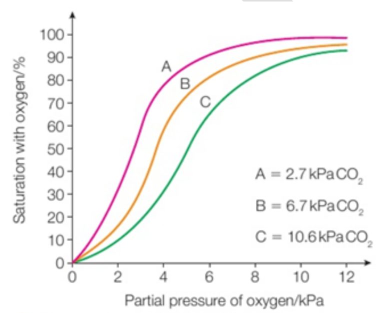


fig E As the proportion of carbon dioxide in the environment rises, the haemoglobin curve moves down and to the right, so it gives up oxygen more easily. This is known as the Bohr effect.

FETAL HAEMOGLOBIN

Fetal haemoglobin, a special form of oxygen-carrying pigment, plays a crucial role in the transfer of oxygen from maternal blood to fetal blood. Its higher affinity for oxygen allows it to remove oxygen from maternal blood, even when oxygen levels are low.

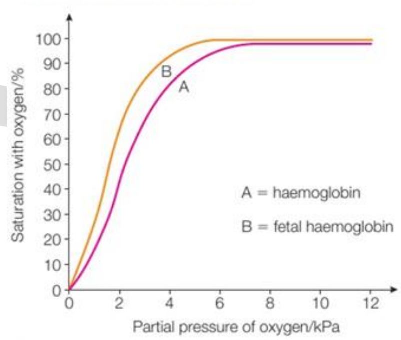


fig F Fetal haemoglobin has a higher affinity for oxygen than the adult haemoglobin of the mother, so it can take oxygen from the mother's blood and deliver it to the cells of the growing fetus.

THE CLOTTING OF THE BLOOD

You have a limited volume of blood. In theory, a minor cut could endanger life as the torn blood vessels allow blood to escape. First, your blood volume will reduce and if you lose too much blood, you will die. Second, pathogens can get into your body through an open wound. In normal circumstances, your body protects you through the clotting mechanism of the blood.

FORMING A CLOT

Plasma, blood cells and platelets flow from a cut vessel. Contact between the platelets and components of the tissue causes the platelets to break open in large numbers. They release several substances, two of which are particularly important.

- **Serotonin causes** the smooth muscle of the blood vessel to contract. This narrows the blood vessels, cutting off the blood flow to the damaged area.
- **Thromboplastin** is an enzyme that starts a sequence of chemical changes that clot the blood (see fig H).

THE BLOOD CLOTTING PROCESS

The blood clotting process is a very complex sequence of events in which there are many different clotting factors. Vitamin K is important in the production of many of the compounds needed for the blood to clot, including prothrombin. Here is a simple version of the events in the blood clotting process.

1. Thromboplastin catalyses the conversion of a large soluble protein called **prothrombin** found in the plasma into another soluble protein, the enzyme called **thrombin**. Prothrombin is biologically inactive while thrombin is biologically active - prothrombin is a **precursor** of thrombin.

2 Thrombin acts on another soluble plasma protein called **fibrinogen**, converting it to an insoluble substance called **fibrin**.

3 More platelets and red blood cells pouring from the wound get trapped in the fibrin mesh. This forms a clot.

4 Special proteins in the structure of the platelets contract, making the clot tighter and tougher to form a scab that protects the skin and vessels underneath as they heal.

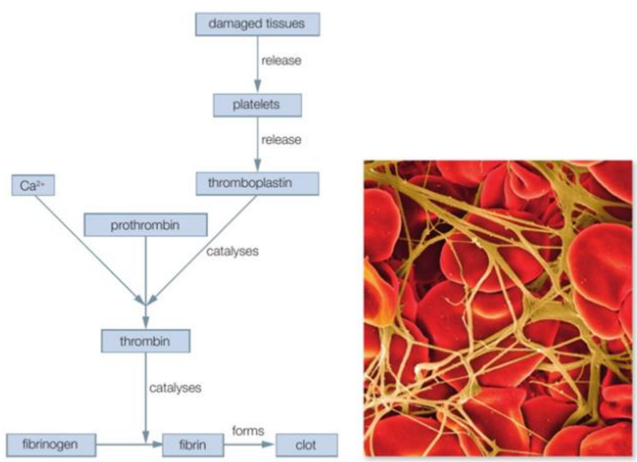


fig H The cascade of events that results in a life-saving or life-threatening clot. When you cut yourself, this is the process which seals the blood vessels and protects the delicate new tissues that form underneath.

SUBJECT VOCABULARY

cardiovascular system the mass transport system of the body made up of a series of vessels with a pump (the heart) to move blood through the vessels
circulation the passage of blood through the blood vessels
active transport the movement of substances into or out of the cell using ATP produced during cellular respiration
buffer a solution which resists changes in pH
leucocytes white blood cells; there are several different types which play important roles in defending the body against the entry of pathogens and in the immune system
platelets cell fragments involved in the clotting mechanism of the blood
megakaryocytes large cells that are found in the bone marrow and produce platelets
oxyhaemoglobin the molecule formed when oxygen binds to haemoglobin
carbaminohaemoglobin the molecule formed when carbon dioxide combines with haemoglobin
carbonic anhydrase the enzyme that controls the rate of the reaction between carbon dioxide and water to produce carbonic acid
Bohr effect the name given to changes in the oxygen dissociation curve of haemoglobin that occur due to a rise in carbon dioxide levels and a reduction of the affinity of haemoglobin for oxygen
fetal haemoglobin a form of haemoglobin found only in the developing fetus with a higher affinity for oxygen than adult haemoglobin
serotonin a chemical that causes the smooth muscle of the blood vessels to contract, narrowing them and cutting off the blood flow to the damaged area
thromboplastin an enzyme that sets in progress a cascade of events that leads to the formation of a blood clot
prothrombin a large, soluble protein found in the plasma that is the precursor to an enzyme called thrombin
thrombin an enzyme that acts on fibrinogen, converting it to fibrin during clot formation
precursor a biologically inactive molecule which can be converted into a closely related biologically active molecule when needed
fibrinogen a soluble plasma protein which is the precursor of the insoluble protein fibrin
fibrin an insoluble protein formed from fibrinogen by the action of thrombin that forms a mesh of fibres that trap erythrocytes and platelets to form a blood clot

1B.3 Circulation in the blood vessels

THE BLOOD VESSELS

The blood vessels that make up the circulatory system can be thought of as the biological equivalent of a road transport system. The **arteries** and **veins** are like the large roads carrying heavy traffic while the narrow town streets and tracks are represented by the vast area of branching and spreading **capillaries** called the **capillary network.**

ARTERIES

Arteries carry blood away from your heart towards the cells of your body. The structure of an artery is shown in fig A. Almost all arteries carry oxygenated blood. The exceptions are:

- The pulmonary artery - carrying deoxygenated blood from the heart to the lungs
- The umbilical artery - during pregnancy, this carries deoxygenated blood from the fetus to the placenta.

The arteries leaving the heart branch off in every direction, and the diameter of the **lumen,** the central space inside the blood vessel, gets smaller the further away it is from the heart. The very smallest branches of the **arterial system,** furthest from the heart, are the **arterioles.**

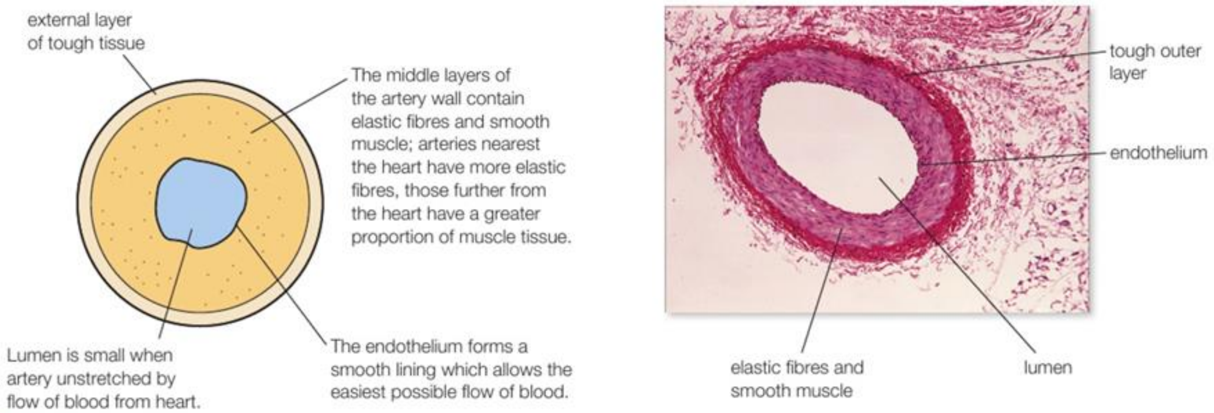


fig A The structure of an artery means it is adapted to cope with the surging of the blood as the heart pumps.

Blood flows out of the heart 70 times a minute, with high-pressure blood entering arteries. Major arteries near the heart have elastic fibers to withstand pressure surges. Blood pressure in all arteries is relatively high, except for **peripheral arteries**, which have lower pressure.

CAPILLARIES

Arterioles lead into networks of capillaries. These are very small vessels that spread throughout the tissues of the body. The capillary network links the arterioles and the **venules.**

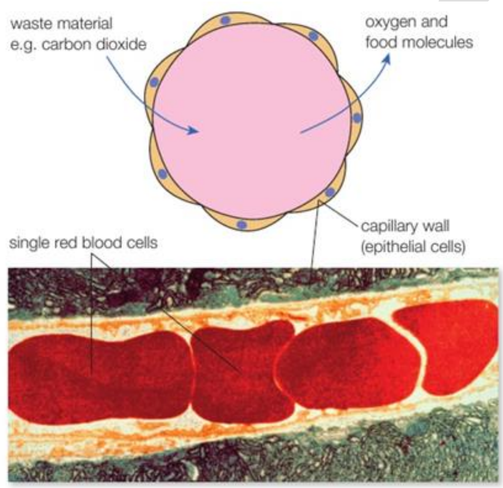


fig C The very thin walls of capillaries allow rapid diffusion of oxygen, carbon dioxide and digested food molecules. The lumen is just wide enough for red blood cells to pass through.

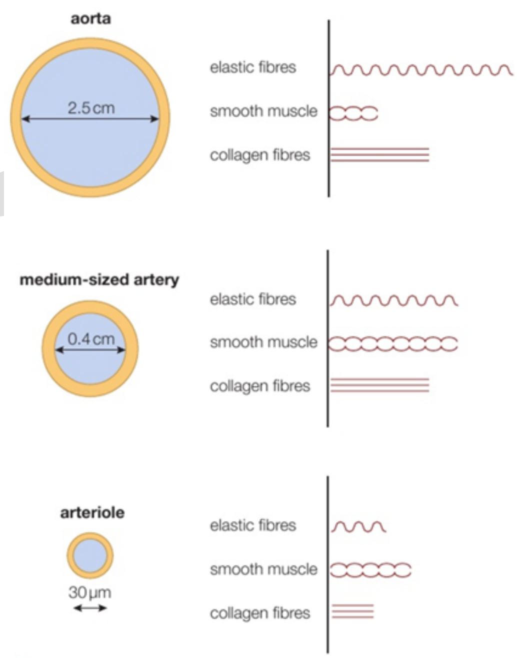


fig B The relative proportions of different tissues in different arteries. Collagen gives general strength and flexibility to both arteries and veins.

VEINS

Veins carry blood back towards the heart. Most veins carry deoxygenated blood. The exceptions are:

- The pulmonary vein - carrying oxygen-rich blood from the lungs back to the heart for circulation around the body
- The umbilical vein - during pregnancy, it carries oxygenated blood from the placenta into the fetus.

Eventually only two veins (sometimes called the great veins) carry the blood from the body tissues back to the heart - the **inferior vena cava** from the lower parts of the body and the **superior vena cava** from the upper parts of the body.

The blood is not pumped back to the heart, it returns to the heart by means of muscle pressure and one-way valves.

- Many of the larger veins are situated between the large muscle blocks of the body, particularly in the arms and legs. When the muscles contract during physical activity they squeeze these veins.
- There are one-way valves at frequent intervals throughout the **venous system.** These are called **semilunar valves** because of their half-moon shape. They develop from infoldings of the inner wall of the vein. Blood can pass through towards the heart, but if it starts to flow backwards the valves close, preventing any backflow (see fig E).

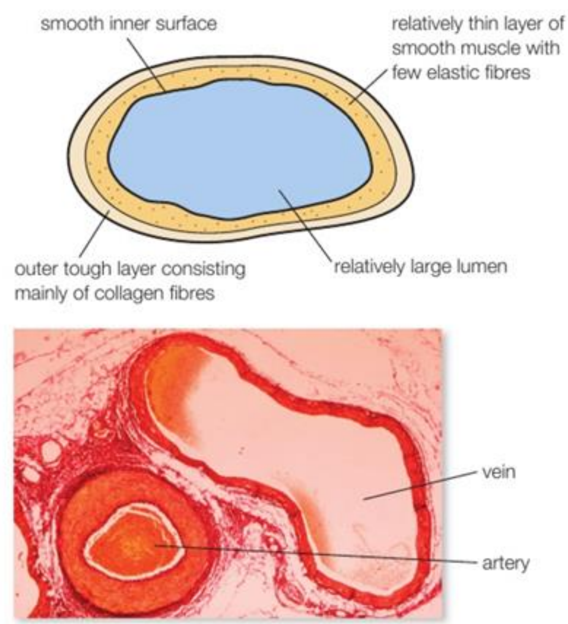


fig D The arrangement of tissues in a vein reflects the pressure of blood in the vessel.

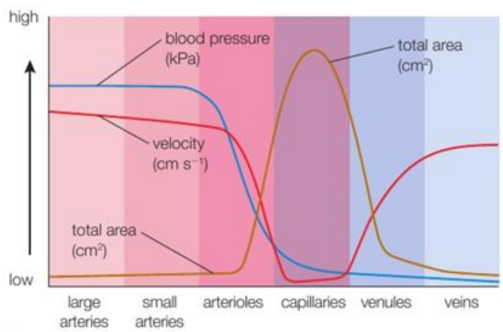


fig F Graph to show the surface area of each major type of blood vessel in your body, along with the velocity and pressure of the blood travelling in them.

SUBJECT VOCABULARY

arteries vessels that carry blood away from the heart
veins vessels that carry blood towards the heart
capillaries tiny vessels that spread throughout the tissues of the body
lumen the central space inside the blood vessel
arterial system the system of arteries in the body
arterioles the very smallest branches of the arterial system, furthest from the heart
peripheral arteries arteries further away from the heart but before the arterioles
venules the very smallest branches of the venous system, furthest from the heart
inferior vena cava the large vein that carries the returning blood from the lower parts of the body to the heart
superior vena cava the large vein that carries the returning blood from the upper parts of the body to the heart
venous system the system of veins in the body
semilunar valves half-moon shaped, one-way valves found at frequent intervals in veins to prevent the backflow of blood

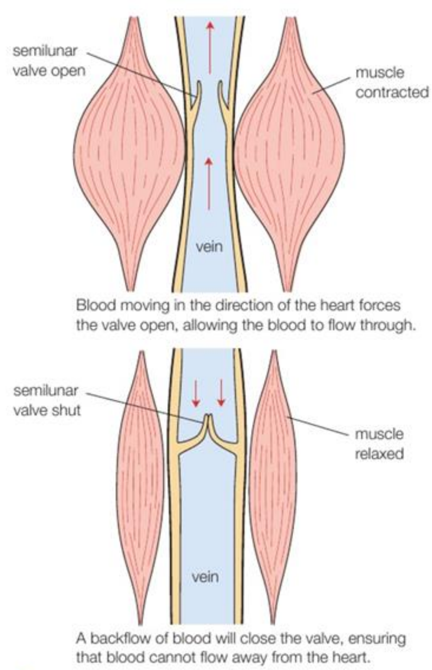


fig E Valves in the veins make sure blood only flows in one direction – towards the heart. The contraction of large muscles encourages blood flow through the veins.

1B-4 The mammalian heart

THE STRUCTURE OF THE HEART

The blood in each side of the heart does not mix with the blood from the other side. The two sides are separated by a thick, muscular **septum**. The heart is made of a unique type of muscle. known as **cardiac muscle**, which has special properties - it can carry on contracting regularly without resting or getting fatigued. You will study this in more detail in Book 2 Topic 7. Cardiac muscle has a good blood supply - the coronary arteries bring oxygenated blood to the tissue (see fig B). It also contains lots of **myoglobin,** a respiratory pigment which has a stronger affinity for oxygen than haemoglobin.

THE ACTION OF THE HEART

1 The inferior vena cava collects deoxygenated blood from the lower parts of the body, while the superior vena cava receives deoxygenated blood from the head, neck, arms and chest. Deoxygenated blood is delivered to the **right atrium.**

2 The right atrium receives the blood from the great veins. As it fills with blood, the pressure builds up and opens the tricuspid valve, so the **right ventricle** starts to fill with blood too.

3 The **tricuspid valve** consists of three flaps and is also known as an **atrioventricular valve** because it separates an atrium from a ventricle. The valve allows blood to pass from the atrium to the ventricle, but not in the other direction. The tough tendinous cords, also known as valve tendons or heartstrings, make sure the valves are not turned inside out by the pressure exerted when the ventricles contract.

4 The right ventricle is filled with blood under some pressure when the right atrium contracts, then the ventricle contracts. Its muscular walls produce the pressure needed to force blood out of the heart into the **pulmonary arteries.**

5 The blood returns from the lungs to the left side of the heart in the **pulmonary veins.** The blood is at relatively low pressure after passing through the extensive capillaries of the lungs. The blood returns to the **left atrium**, another thin-walled chamber that performs the same function as the **right atrium.** It contracts to force blood into the left ventricle. Backflow is prevented by another atrioventricular valve known as the **bicuspid valve,** which has only two flaps.

6 As the left atrium contracts, the bicuspid valve opens and the left ventricle is filled with blood under pressure. As the left ventricle starts to contract the bicuspid valve closes to prevent backflow of blood to the left atrium. The left ventricle pumps the blood out of the heart and into the **aorta**, the major artery of the body.

HOW YOUR HEART WORKS

Heartbeats are produced by the closing of heart valves, resulting in two sounds: lub and dub. The rate of heartbeat indicates the frequency of contraction, as the first sound occurs when ventricles contract and the second when they relax.

THE CARDIAC CYCLE

Your heart is continuously contracting then relaxing. The contraction of the heart is called **systole**. Systole can be divided into **atrial systole**, when the atria contract together forcing blood into the ventricles, and **ventricular systole**, when the ventricles contract. Between contractions the heart relaxes and fills with blood. This relaxation stage is called **diastole.** One cycle of systole and diastole makes up a single heartbeat, which lasts about 0.8 seconds in humans. This is known as the **cardiac cycle** (see fig D).

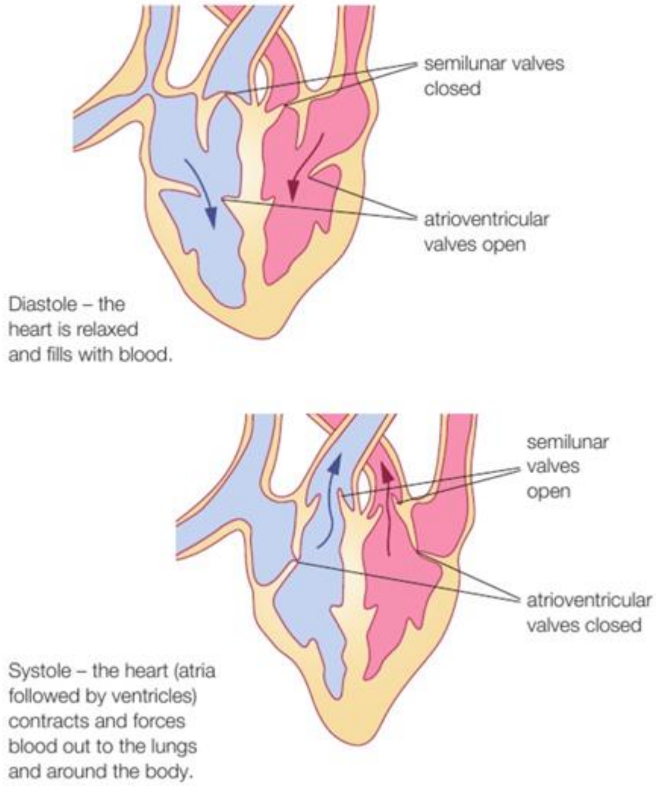


fig D The cardiac cycle

SUBJECT VOCABULARY

septum the thick muscular dividing wall through the centre of the heart that prevents oxygenated and deoxygenated blood from mixing
cardiac muscle the special muscle tissue of the heart, which has an intrinsic rhythm and does not fatigue
myoglobin a respiratory pigment with a stronger affinity for oxygen than haemoglobin.
right atrium the upper right-hand chamber of the heart that receives deoxygenated blood from the body
right ventricle the lower chamber that receives deoxygenated blood from the right atrium and pumps it to the lungs
tricuspid valve (atrioventricular valve) the valve between the right atrium and the right ventricle that prevents backflow of blood from the ventricle to the atrium when the ventricle contracts
tendinous cords (valve tendons, heartstrings) cord-like tendons that make sure the valves are not turned inside out by the large pressure exerted when the ventricles contract
pulmonary arteries the blood vessels that carry deoxygenated blood from the heart to the lungs
pulmonary veins the blood vessels that carry oxygenated blood back from the lungs to the heart
left atrium the upper left-hand chamber of the heart that receives oxygenated blood from the lungs
left ventricle the chamber that receives oxygenated blood from the left atrium and pumps it around the body
bicuspid valve (atrioventricular valve) the valve between the left atrium and the left ventricle that prevents backflow of blood into the atrium when the ventricle contracts
aorta the main artery of the body; it leaves the left ventricle of the heart carrying oxygenated blood under high pressure
systole the contraction of the heart
atrial systole when the atria of the heart contract
ventricular systole when the ventricles of the heart contract
diastole when the heart relaxes and fills with blood
cardiac cycle the cycle of contraction (systole) and relaxation (diastole) in the heart

1B.5 - Atherosclerosis

CARDIOVASCULAR DISEASES

Problems with the cardiovascular system have serious consequences. Globally, almost 18 million people die from cardiovascular diseases each year. World Health Organization (WHO) data from 2017 show that **cardiovascular diseases** were responsible for 31% of all global deaths - it is the single biggest cause of death and disability (see fig A).

Many cardiovascular diseases are linked to a condition called **atherosclerosis**.

ATHEROSCLEROSIS

Atherosclerosis, a hardening of the arteries, is a disease in which **plaques** (made of a yellowish fatty substance) build up on the inside of arteries. It can begin in late childhood and continues throughout life. Plaques are most likely to form in the arteries of the heart (coronary arteries) and neck (carotid arteries). The typical development of a plaque is summarised in fig B.

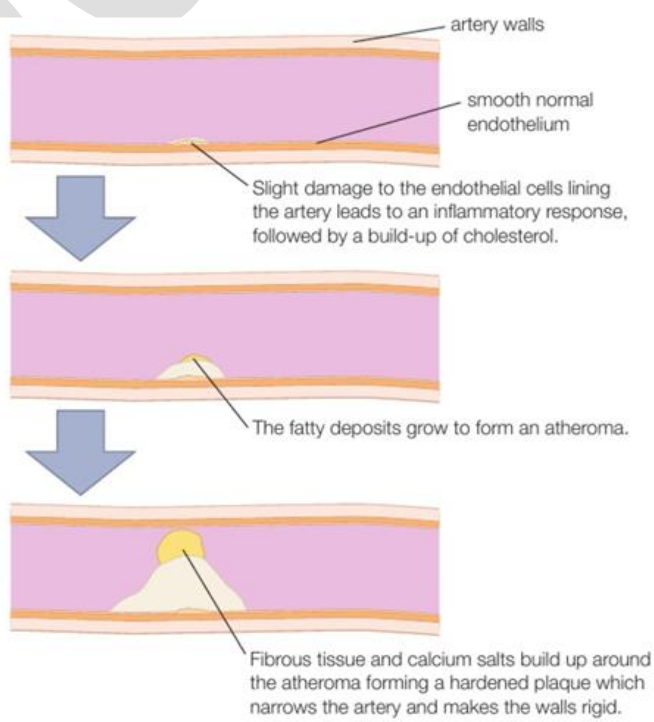


fig B The development of atherosclerosis

EFFECT OF ATHEROSCLEROSIS ON HEALTH

Atherosclerosis can have many serious effects on the health of an individual. The development
of atherosclerosis can be summarised as: damage to the endothelium of the arteries → inflammatory response → accumulation of cholesterol → atheroma → fibrous tissue/calcium salts → plaque →→ narrowing/loss of elasticity of the artery.

ANEURYSMS

If an area of an artery is narrowed by plaque, blood tends to collect behind the blockage. The artery bulges and the wall is put under more pressure than usual, so it becomes weakened. This is known as an **aneurysm**.

RAISED BLOOD PRESSURE

The arteries narrowed due to plaques on the walls cause raised blood pressure. This can lead to severe damage in a number of organs, including the kidneys, the eyes and the brain. The high pressure damages the tiny blood vessels where your kidney filters out urea and other substances from the blood. If the vessels feeding the kidney tubules become narrowed, the pressure inside them gets even higher and proteins may be forced out through their walls. If you have high blood pressure, your doctors can test for protein in your urine as a sign of kidney damage.

SUBJECT VOCABULARY

cardiovascular diseases diseases of the heart and circulatory system, many of which are linked to atherosclerosis
atherosclerosis a condition in which yellow fatty deposits build up (increase in amount) on the lining of the arteries, causing them to be narrowed and resulting in many different health problems
plaques yellowish fatty deposits that form on the inside of arteries in atherosclerosis
atheroma another term for a plaque formed on the arterial lining
aneurysm a weakened, bulging area of artery wall that results from blood collecting behind a blockage caused by plaques
angina a condition in which plaques are deposited on the endothelium of the arteries and reduce the blood flow to the cardiac muscle through the coronary artery; it results in pain during exercise
myocardial infarction (heart attack) the events which take place when atherosclerosis leads to the formation of a clot that blocks the coronary artery entirely and deprives the heart muscle of oxygen, so it dies; it can stop the heart functioning
anaerobic respiration cellular respiration that takes place in the absence of oxygen
stent a metal or plastic mesh tube that is inserted into an artery affected by atherosclerosis to hold it open and allow blood to pass through freely
thrombosis a clot that forms in a blood vessel
stroke an event caused by an interruption to the normal blood supply to an area of the brain which may be due to bleeding from damaged capillaries or a blockage cutting off the blood supply to the brain, usually caused by a blood clot

HEART DISEASE

There are many kinds of heart disease, but the two most common ones are **angina** and **myocardial infarction** (**heart attack**); both are closely linked to atherosclerosis (see figs B and D).

Often symptoms are first noticed during exercise, when the cardiac muscle is working harder and needs more oxygen. The narrowed coronary arteries cannot supply enough oxygenated blood and the heart muscle resorts to **anaerobic respiration.**

A clot that forms in a blood vessel is known as a **thrombosis**. The clot can rapidly block the whole blood vessel, particularly if it is already narrowed by a plaque. A clot that gets stuck in a coronary artery is known as a coronary thrombosis. The clot can block the artery, starving the heart muscle beyond that point of oxygen and nutrients, and this often leads to a heart attack (see fig E).

STROKES

Strokes occur when blood supply to the brain is interrupted due to bleeding or blockages, often caused by blood clots or atheromas. The damage can be severe, leading to death, while smaller arterioles may have less severe effects. Symptoms include dizziness, confusion, slurred speech, blurred vision, numbness, and paralysis. More severe strokes may result in paralysis on one side of the body.

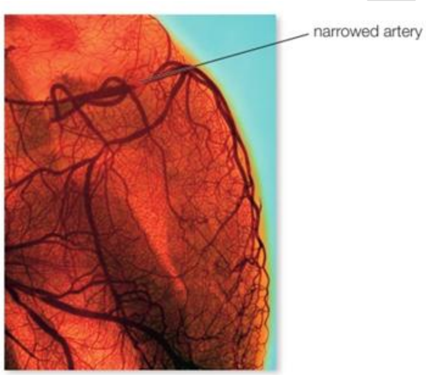


fig D Injecting the blood vessels with special dye allows doctors to see where the coronary arteries are narrowing due to atherosclerosis so they can treat the problem.

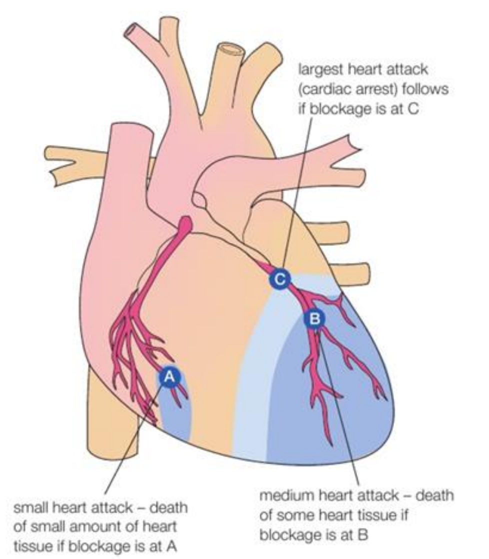
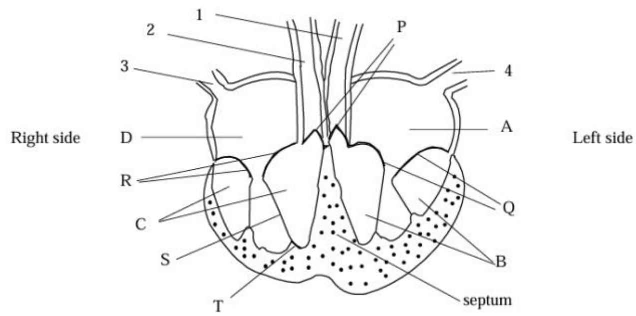


fig E The size and severity of a heart attack is closely related to the position of the blockage in the coronary artery.

Revision questions

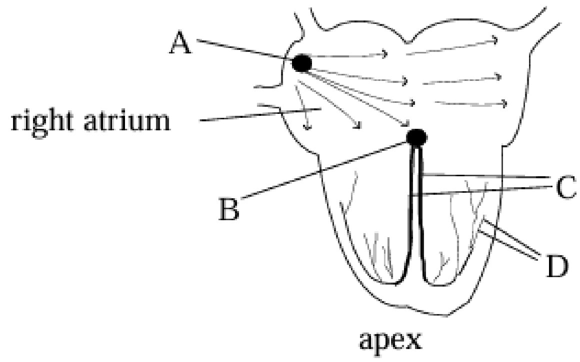
(1) The diagram below shows a human heart in ventral view, in a simplified form.



(b)Name vessels 1 to 4 and state whether each one is carrying blood to or from the heart.

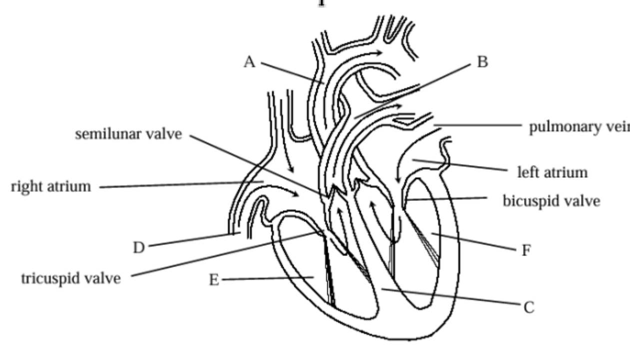
(c)(i) State the functions of valves R and Q.
(ii) State the functions of valves P.
(iii)What do S and T do?

(2) The diagram below shows the conducting system of the heart in a simplified form.

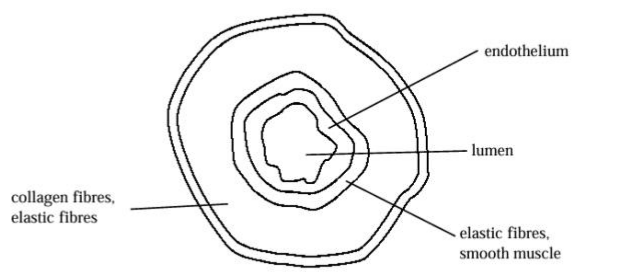


(a)(i) The heart muscle is said to be 'myogenic'. What does this mean?
(ii) Name components A to D of the conducting system.
(b)With reference to the parts of the conducting system of the heart, explain why:
(i) the right atrium contracts before the left atrium.
(ii) the ventricles contract after the atria.
(iii) the ventricles contract from the apex upwards.
(c)How is the frequency and force of the heartbeat modified to meet the body's needs

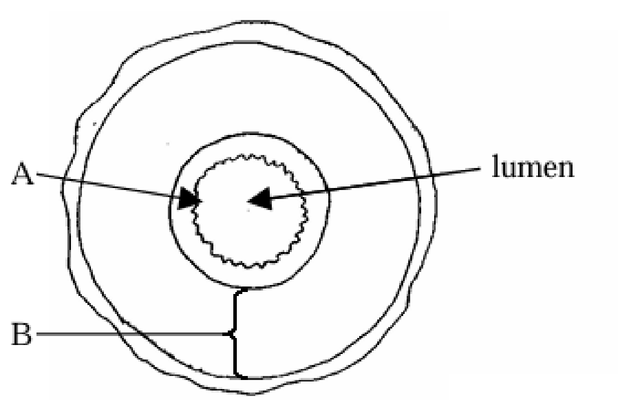
(3) The diagram shows a vertical section through a human heart.
(a)Identify features A – F
(b)Starting with the heart full of blood outline the stages of the cardiac cycle.



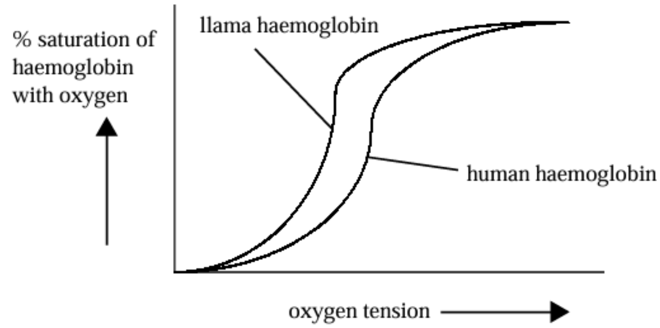
(4) The diagram shows a transverse section through an artery.
(a)Using the information in the diagram explain how arteries are adapted for their function.
(b)Distinguish between each of the following:
(i) blood and tissue fluid.
(ii) maternal and fetal haemoglobin.



(5) The drawing below shows the structure of an artery as seen in transverse section.
(a)(i) Identify tissues present in layers A and B.
(ii) Describe how the structure of an artery is suited to its functions.
(b)(i) How does the structure of a vein differ from that of an artery?
(ii) Suggest why veins differ in structure to arteries
(c) Describe the structure of a capillary.



(6) The graph below shows the haemoglobin oxygen dissociation curves of a human and a llama (a relative of the camel native to mountainous regions of South America).



(a)Suggest why the llama haemoglobin oxygen dissociation curve lies to the left of the human curve
(b) Red cell production is regulated by an enzyme, renal erythropoietic factor, which is secreted by the kidneys especially when they are deficient in oxygen. The enzyme acts on a plasma protein to convert it to the hormone erythropoietin. This hormone increases the rate of mitosis of the erythrocyte stem cells in the red bone marrow.

Use this information, and your own knowledge to explain why:

(i) athletes who are going to race in a high altitude region go and stay there a few weeks before the event
(ii) renal dialysis patients are often severely anaemic.
(iii) patients with liver disease may also be anaemic.

(7) The table below shows the results of a survey of red cell counts in similar human populations living at different altitudes above sea level. 100 individuals were included in each sample.
(a)(i) Suggest why higher red cell counts occurred as altitude increased.
(ii) State and explain three precautions which would be necessary when choosing the samples of 100 people

Altitude above sea level/meters	Mean red cell count/cells dm^{-3} blood
0	5.0×10^{12}
1000	5.3×10^{12}
2000	5.5×10^{12}
3000	5.7×10^{12}