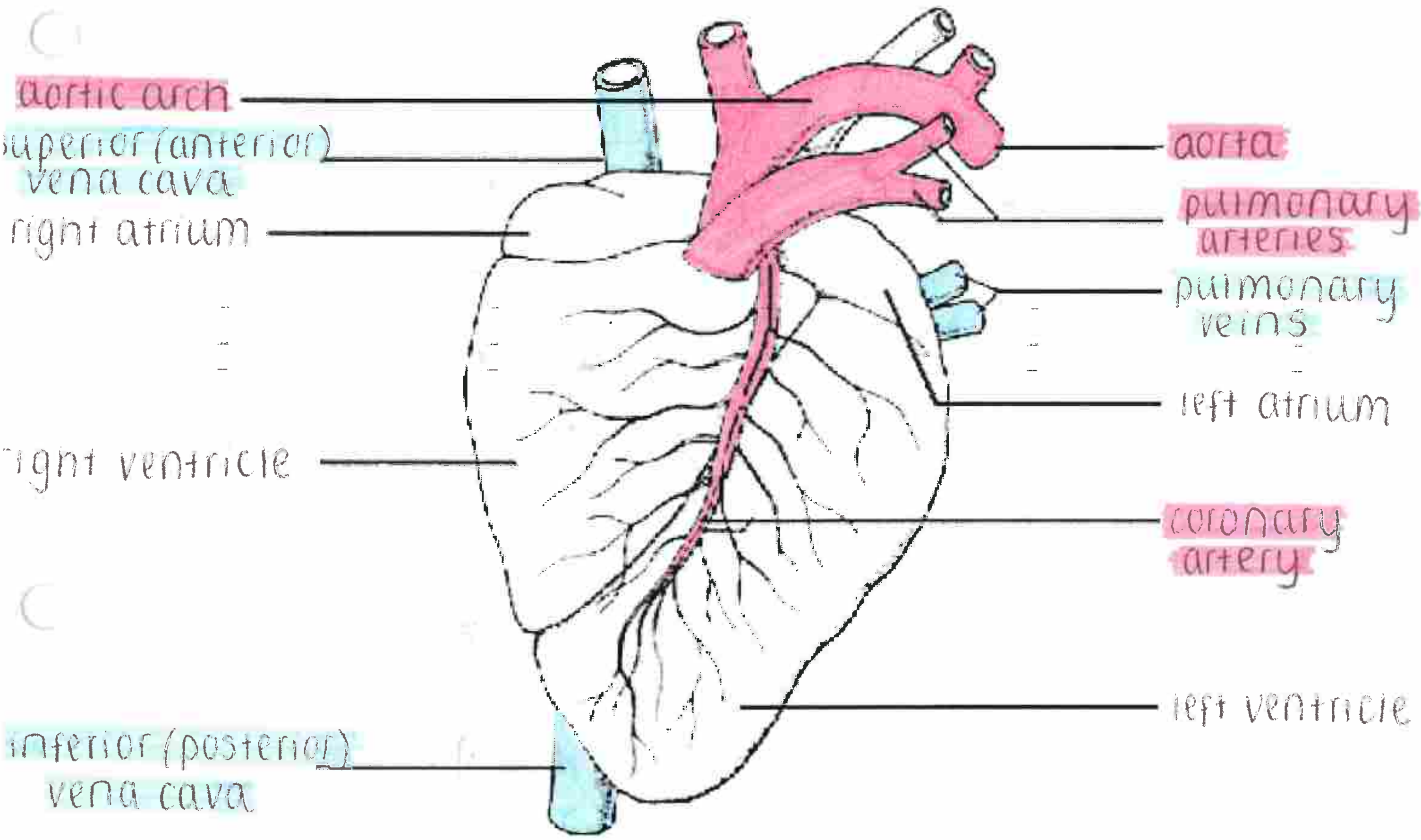
Learning outcomes:

Why do large organisms need a mass transport system?

All organisms exchange materials between themselves & the ..environment...... – ..diffusion.... is fast enough for transport over ..short... distances, so can be used in small organisms.

- However, as size increases, SA:VOL ratio ..decreases.... and specialised ..exchange surfaces are required to ..absorb.... nutrients and respiratory gases and ..remove....... excretory products.
- And a ..transport...... system is required to take materials from cells to exchange surfaces, from the exchange surfaces to cells, and between different parts of the organism.
- whether or not there is a specialised transport medium and whether or not it is circulated by a pump, depends on the SA:VOL ratio and how active the organism is.
- the smaller the SA:VOL ratio, and the more active the organism, the greater the need for a specialised transport system with a pump.

External structure of The Heart: add labels using p.171 T & Toole



circulatory systems in mammals

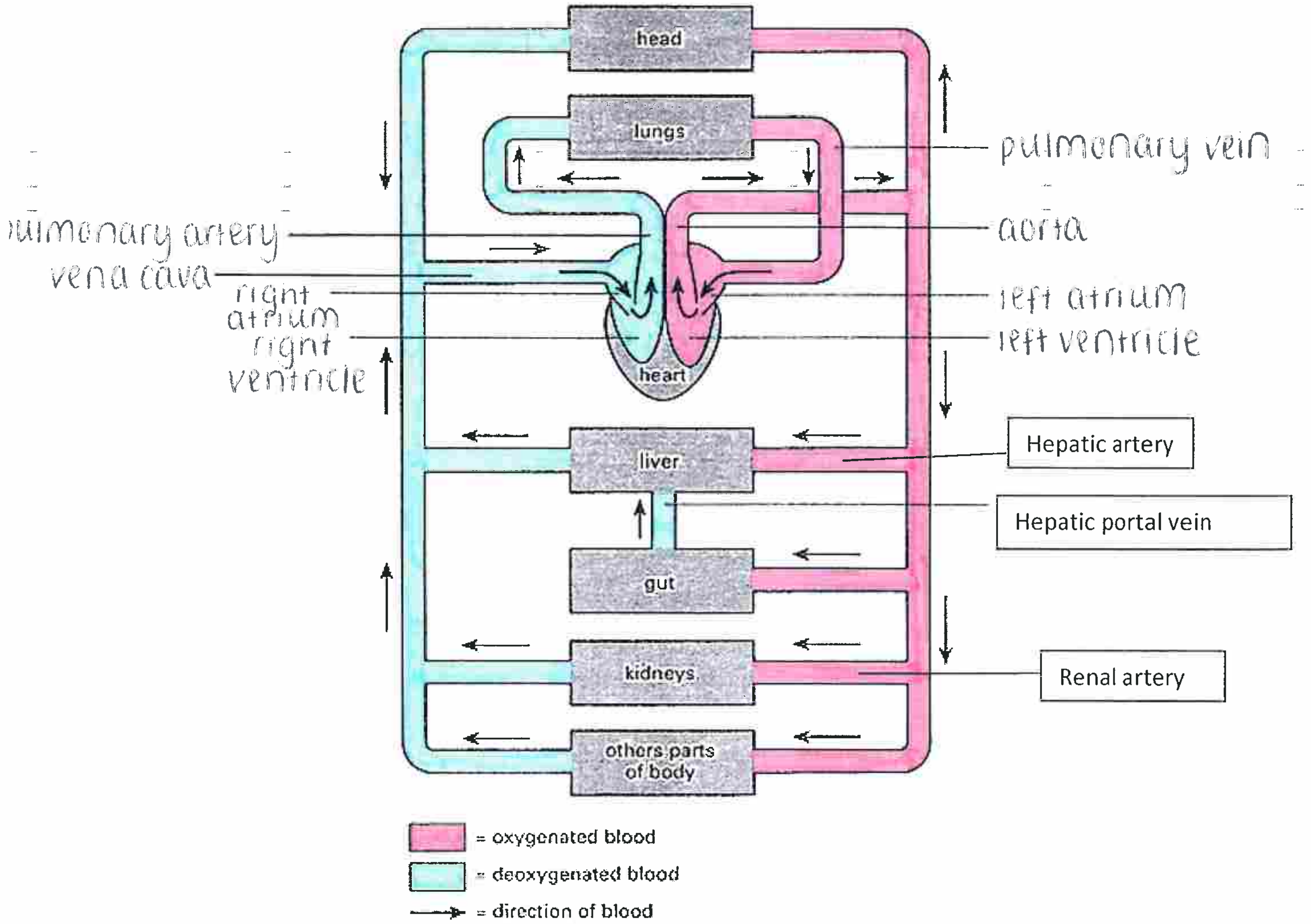
Mammals have a **closed** (blood is in vessels), **double** circulatory system (blood passes through heart twice for each circuit of the body); the 2 systems are:-

[use following words: oxygenated, deoxygenated, blood, heart, heart, increases, release, tissues in your answers]

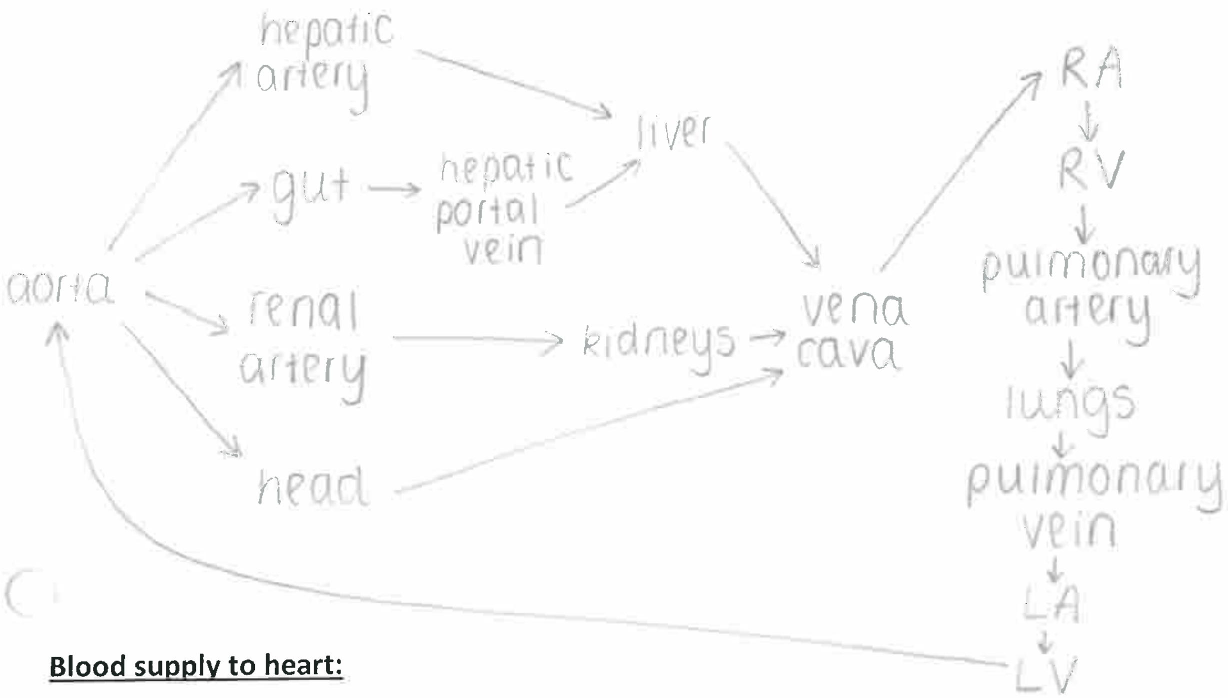
- Pulmonary circulation –
  carries deoxygenated blood to the lungs, to take up oxygen and then returned to the heart.
- Systemic circulation –
  carries oxygenated blood to the rest of the body, to release oxygen and then returned to the heart.
- The main advantage of a double circulatory system for mammals is that it increases
  blood pressure and therefore increases the rate of blood flow to the tissues

Double circulatory system

1. Label all blood vessels and heart chambers in the diagram below
2. Add colour to show oxygenated (red) and deoxygenated (blue) blood.



Q: Describe the journey of a red blood cell around one circuit of the body, naming the main blood vessels and the chambers of the heart – start in the aorta (Answer either as a flow chart or a paragraph)



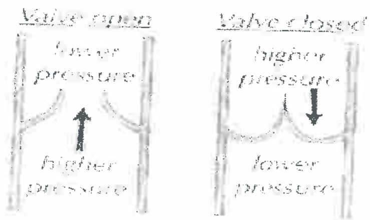
Blood supply to heart:

- ✓ Heart muscle needs its own blood supply
- ✓ Therefore arteries branch off from aorta to form the **coronary arteries** which run through heart muscle, close to outer surface.

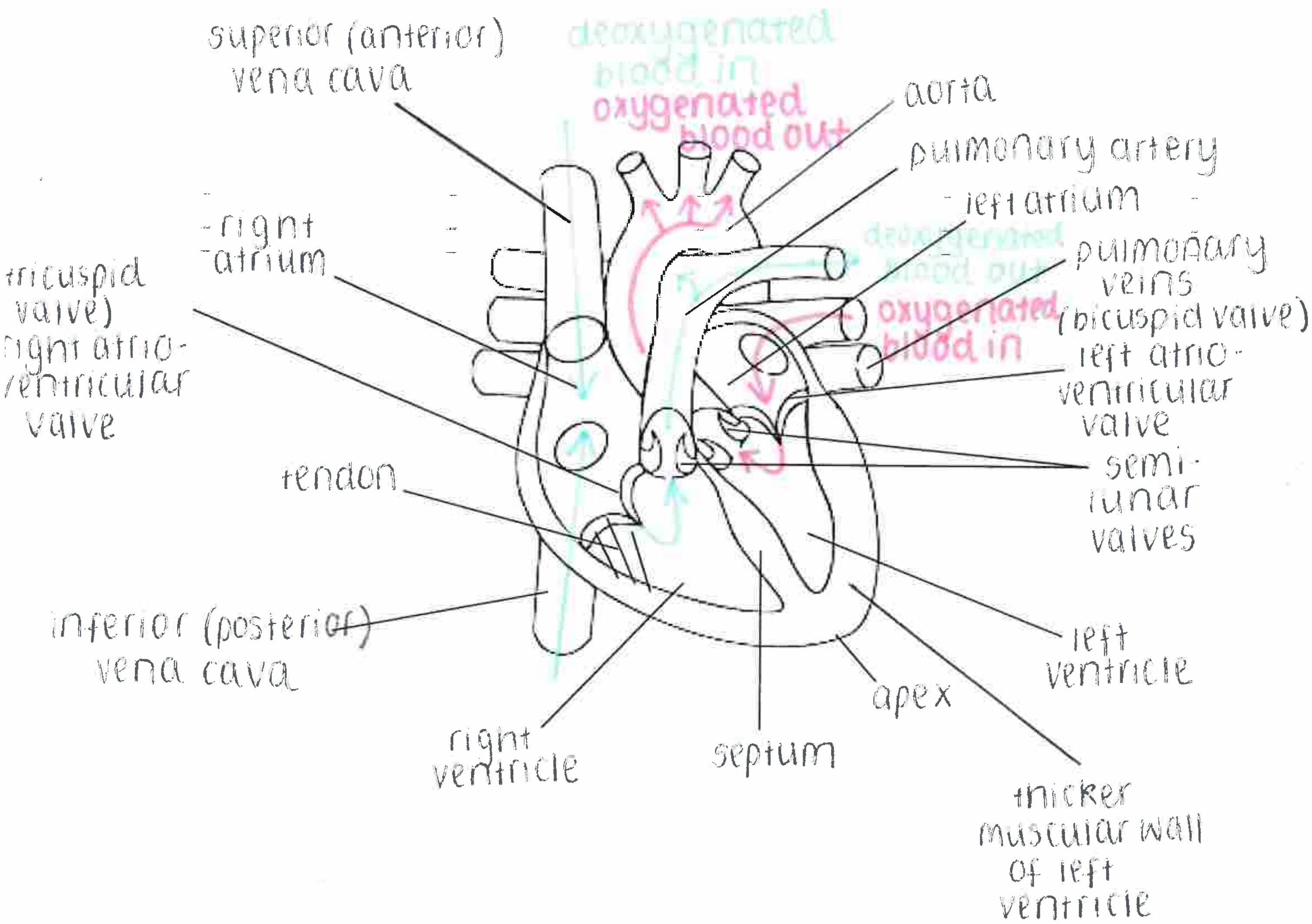
Q- Explain the role of coronary arteries, and why a blockage in one of these causes a heart attack (Myocardial infarction) (4)

Heart valves

- They only open **one way**
- If there is a higher pressure behind the valve, it is forced **open**
- If the pressure is higher in front of the valve, it is forced **closed**.
- They prevent **backflow** of blood



Internal Structure of the Heart: add labels using p.171 T & Toole



Muscle and Valves

Task: Fill in the blanks using given words, and then use the information to annotate the diagram below

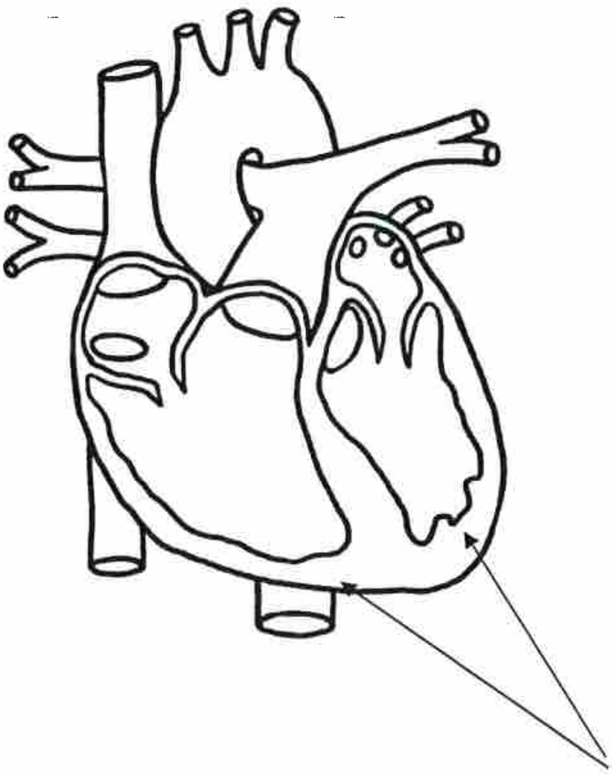
[~~direction~~, ~~pressure~~, ~~contract~~, ~~relax~~, ~~greater~~, higher, ~~A-V~~, ~~S-L~~, ~~atria~~, ~~ventricles~~, ~~ventricles~~, ~~ventricles~~, ~~ventricles~~, ~~stronger~~, ~~stronger~~]

Muscle:

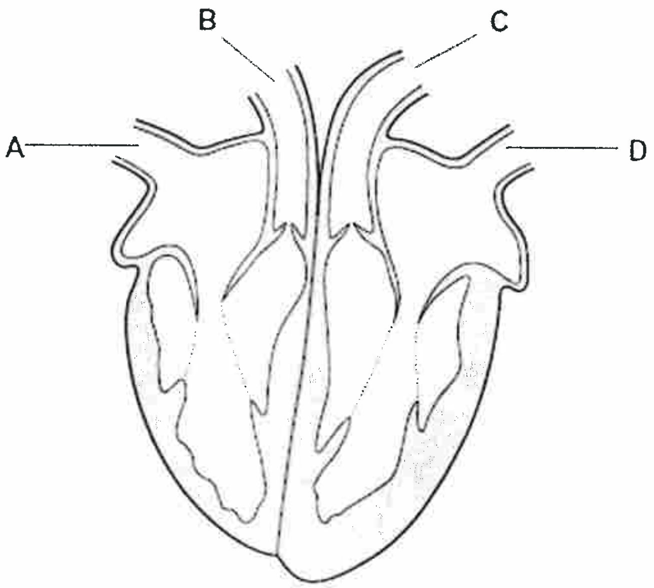
- The muscle in walls of atria & ventricles **c**.ontract............ to produce **p**.ressure..... to pump blood out
- The more muscle in a chamber wall, the s.tronger...... the contraction and the g.reater......... the pressure produced
- The ..ventricles...... have a thicker muscular wall for ....stronger..... contractions to pump blood out of the heart at .a higher...... pressure.
- The ...atria........ have a thinner muscular wall than the..ventricles because they only need to produce enough force to push blood down into .the..ventricles

Valves:

- There are **valves** between atria & ventricles, and in the ventricles, to keep blood flowing in correct d.irection.......
- The .A-V... valves link atria to ventricles, and prevent backflow to atria when ..ventricles......... contract
- The ...S-L.... valves link ventricles to aorta & pulmonary artery, and prevent backflow into heart when ventricles .....relax......



Q1. The diagram shows a section through the heart. The main blood vessels are labelled **A**, **B**, **C** and **D**.



(a) Write a letter, **A**, **B**, **C** or **D**, in the box to represent the correct blood vessel.

(i) Which blood vessel carries oxygenated blood away from the heart?

C ✓

(1)

(i) Which blood vessel carries deoxygenated blood to the heart?

A ✓

(1)

(b) Explain how the highest blood pressure is produced in the left ventricle.

The left ventricle has the most muscular walls ✓ which allow it to contract ✓ strongly, which creates a high blood pressure ✓

greatest force

(1)

(c) Some babies are born with a hole between the right and the left ventricles.

These babies are unable to get enough oxygen to their tissues.
Suggest why.

(left side) (right side)
The oxygenated and deoxygenated blood would mix so some deoxygenated blood ✓ would be sent around the body to the respiring tissues, but the haemoglobin would not be saturated with enough oxygen so the tissues would not have enough oxygen.

less oxygen in blood

(2) **(Total 5 marks)**

Q2.

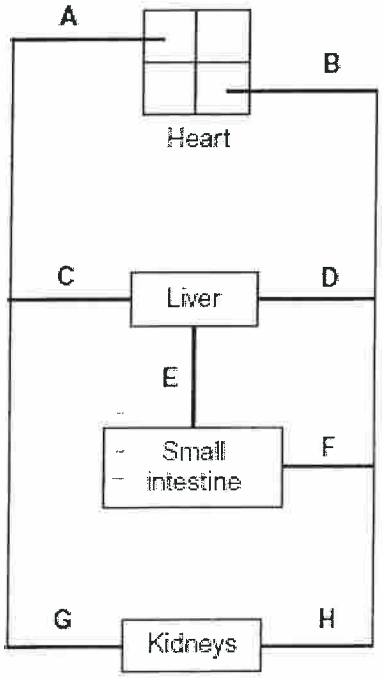
(a) What is the function of the coronary arteries?

The coronary arteries supply the tissues in the heart ✓ and glucose (aerobic respiration)
with enough oxygen ✓ in order for the muscles to contract which allows the heart to function properly.

1 **(2)**

(b) **Figure 1** shows some of the large blood vessels in a mammal.

Figure 1



(i) Which of the blood vessels **A** to **H** is the vena cava?

A ✓

(1)

(ii) Which of the blood vessels **A** to **H** is the renal artery?

H ✓

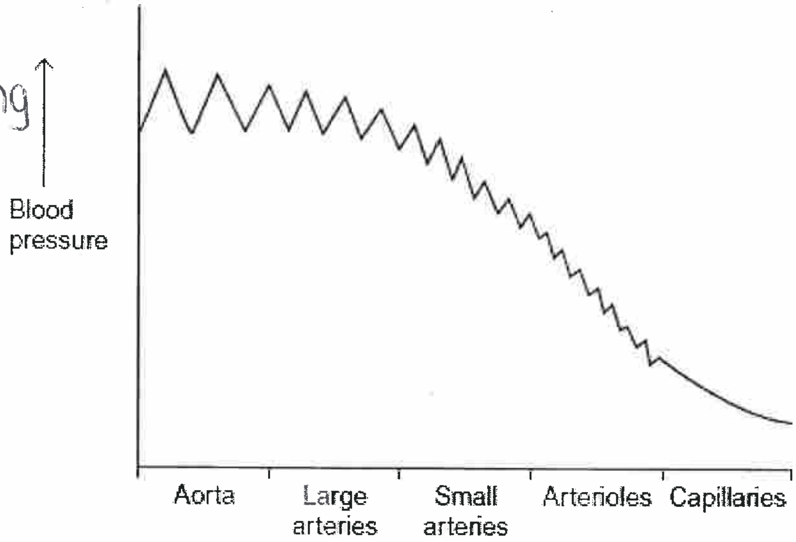
(1)

(c) **Figure 2** shows how the blood pressure changes as blood travels from the aorta to the capillaries.

Figure 2

rise in pressure = ventricles contracting

fall in pressure = ventricles relaxing



The rise and fall in blood pressure in the aorta is greater than in the small arteries.Suggest why.

ventricular systole causes blood pressure to rise

The aorta is larger than the small arteries and more muscular. so when the muscles in the aorta contract, there is a larger force produced than when the muscles in the small arteries contract. This means there is a higher pressure in the aorta. when the muscles relax, there is a larger space for the blood, so the pressure is lower.

the aorta is closer to the ventricles than the small arteries so the rise and fall in blood pressure is larger in the aorta

(3) **(Total 7 marks)**

3

Cardiac Cycle

- The cardiac cycle is the ongoing sequence of **contraction** & relaxation of the atria and ventricles
- The 2 phases are contraction **(SYSTOLE)** and relaxation **(DIASTOLE).**
- Contraction occurs separately in the atria & ventricles
- ✓ Note the **pressure and volume** changes throughout the cycle

(Use these prompts: **Muscle, Pressure, Valve, Direction – My P**arents are **V**ery **D**elightful)

1. DIASTOLE

- Muscle is ...relaxed...............
- Pressure ....increases............. in atria
- Valves: bicuspid and tricuspid valves ...open.... slightly
- Direction: blood starts to enter ...ventricles..........

atrial systole → ventricular systole → diastole → atrial systole

2. ATRIAL SYSTOLE

- Muscles in atrial walls ..contract.......
- Pressure in atria ...decreases...............
- Valves: A-V valves are forced ......open.................. when the pressure in atria is ...more........... than in ventricles
- Direction: blood flows into ..ventricles................

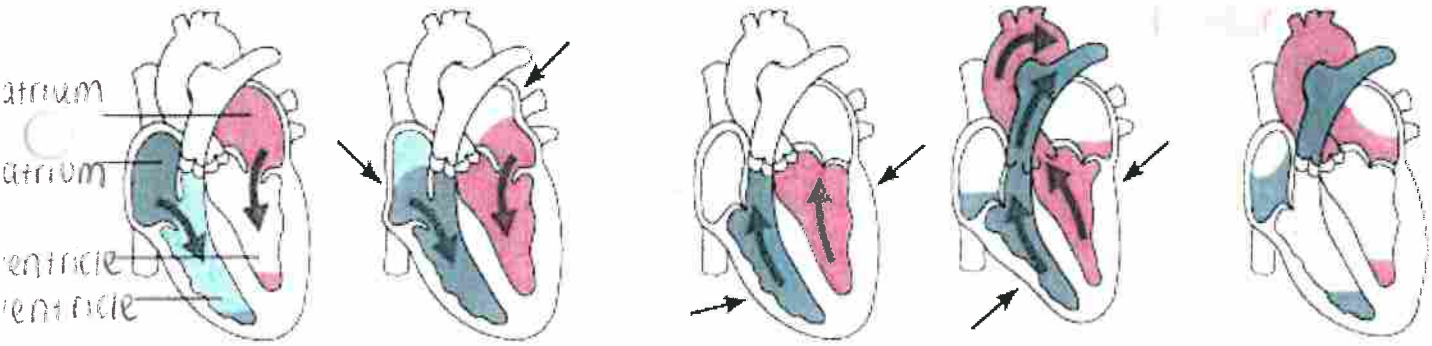
3. VENTRICULAR SYSTOLE

- Muscles in ventricle walls ....contract..........
- Pressure in ventricles....increases....................
- Valves: A-V valves are forced ..shut....... when the pressure in ventricles is .....more................ than in atria,
- Direction: valves prevent blood flowing back into ...atria.................
- Pressure in ventricles is also greater than in ...arteries........,
- Valves: S-L valves are therefore forced ....open......................
- Direction: blood flows out of ...ventricles....

4. DIASTOLE

- Muscle ...relaxes....................
- Pressure in all chambers ...decreases.............
- Pressure in arteries is now greater than in ..ventricles
- Valves: S-L valves are therefore forced .....shut..........,
- Direction valves prevent blood flowing back into ..ventricles from the arteries
- Direction: Blood enters L & R atria from ...veins......

Use red and blue to show oxy and deoxy blood, label first heart, fill in each box with name of the phase



diastole	atrial systole	ventricular systole	diastole

Calculations:

✓ **Heart rate** = the number of beats per minute (bpm)

$$HR = \frac{60}{\text{time taken for one heart beat}} \text{ (s)}$$

(1 cardiac cycle = 1 heart beat)

Q: If your cardiac cycle is 0.9 seconds long, what is your heart rate?

60 ÷ 0.9 = 67bpm

✓ **Stroke volume = cardiac output ÷ heart rate**
✓ **Cardiac output =** stroke volume x heart rate

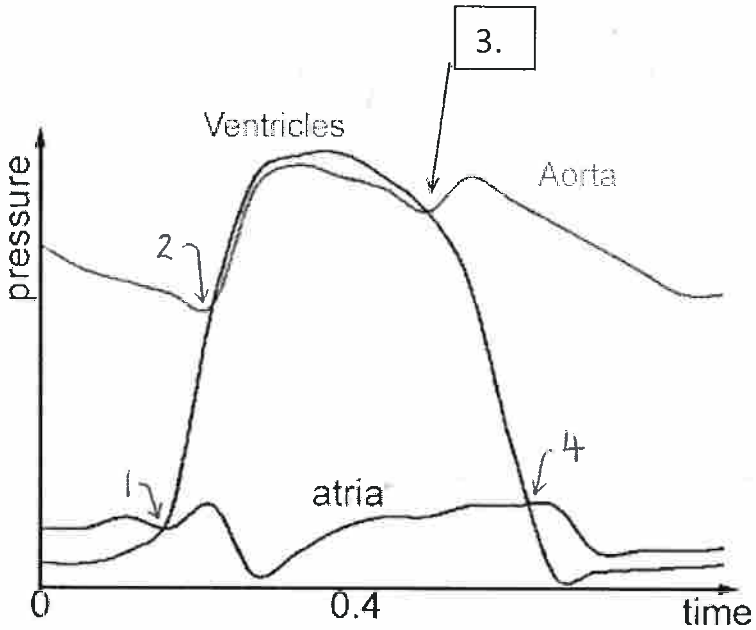
Mark scheme answer: Why does training lower the resting heart rate of an athlete?

- Size of the heart / ventricles ... increases
- Muscle size in the walls... increases
- Strength of contraction... increases
- Stroke volume... increases
- Cardiac output... remains the same
- increases the force
- increases the pressure
- lower heart rate

Stroke volume = volume of blood pumped by the left ventricle each time it contracts (dm^3)

Cardiac output = volume of blood pumped by the left ventricle in 1 minute ($dm^3 min^{-1}$)

Pressure changes in left side of the heart during the cardiac cycle



1. Ventricular systole → increase in pressure in ***ventricle*** so it is higher than the pressure in ***atrium*** which pushes the ***A-V valve*** shut

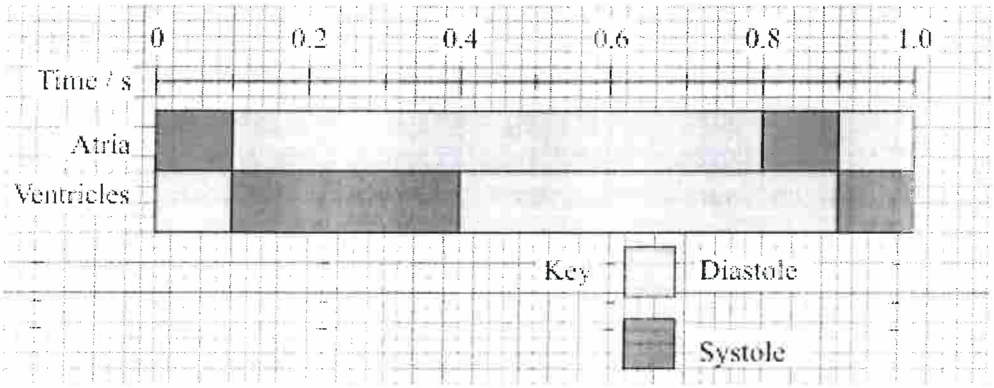
2. Ventricular systole → increase in pressure in ...ventricle...... so it is higher than in ....aorta........., which pushes the ...S-L..... valves open

3. Ventricular diastole → decrease in pressure in ...ventricle........, so it is lower than in the ....aorta.........., which pushes the .....S-L...... valves shut

4. Ventricular diastole → decrease in pressure in ...ventricle........, so it is lower than in the ...atria...., which pushes the ..A-V... valves open

- You do not need to learn this because once you **understand** why valves open and close, you can then just work it out ☺

Q. Relaxation of heart muscle is called diastole. Contraction is called systole. The diagram shows the periods of diastole and systole when the heart is beating.



(a) At what time is the volume of blood in the ventricle at a maximum?

0.1 **(1)**

(b) Calculate the heart rate in beats per minute. Show your working.

0 → 0.8 is a complete cycle

$\frac{60}{0.8} = 75$

Heart rate = 75 beats per minute **(2)**

(c) The valves between the atria and the ventricles are closed between 0.1 s and 0.4 s. A-V valves

(i) Explain how pressure causes these valves to be shut.

A higher pressure in front of the valve causes it to be shut to prevent backflow X

pressure in ventricle is higher than the pressure in atria

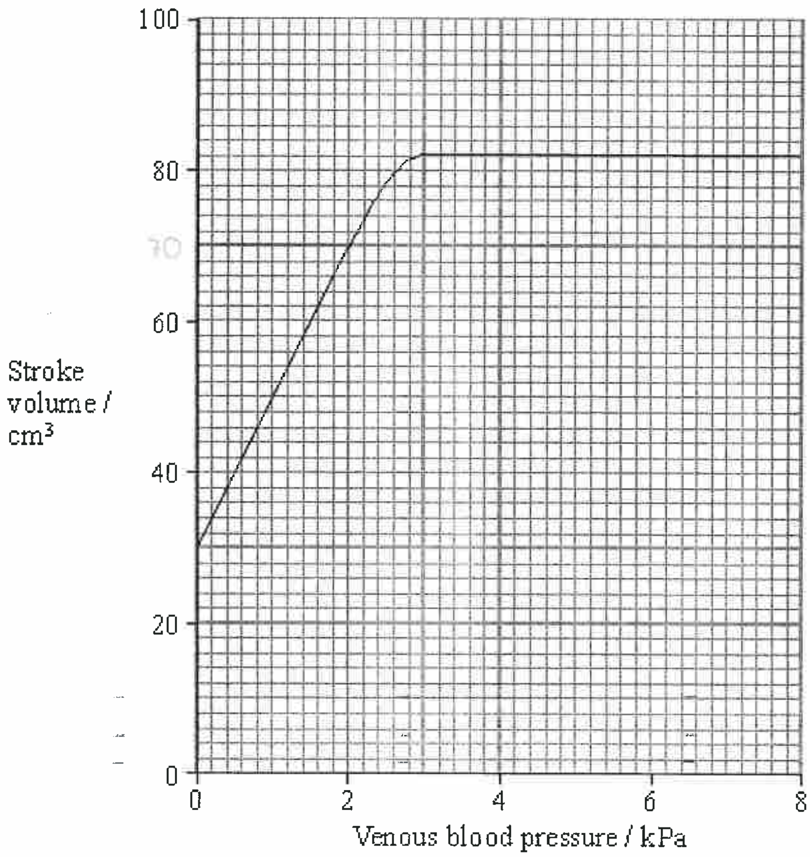
(1)

(ii) Explain how closure of these valves is essential to the functioning of the heart.

It prevents backflow ~~[illegible]~~ of blood ✓

(1)

The graph shows the effect of the pressure of blood in the veins on the stroke volume of the heart.



(d) Describe how venous blood pressure affects stroke volume.

An increase in venous blood pressure causes the stroke volume to increase. ✓

remains constant / plateau's after 3kPa.

(2) 1

(e) At a venous pressure of 2 kPa, the cardiac output is 5600 cm^3 per minute. Calculate the number of times the ventricle contracts in one minute. Show your working.

Stroke volume = $70 cm^3$

$\frac{5600}{70} = 80$

Answer 80 ✓ (2)

(f) Explain how blood in a vein in the leg is returned to the heart.

2 prevent backflow

The blood in the vein is ~~[illegible]~~ moved by the opening and closing of valves. When the pressure behind the valve is higher, then the valve will open allowing the blood to pass through. However, when the pressure behind the valve is lower, the valve closes to prevent backflow. The pressure generated by the left ventricle lessens as the blood travels around the body due to friction which causes the hydrostatic pressure to decrease. However, there is still a small amount of hydrostatic pressure and the valves to keep the blood flowing in the one right direction. The veins have large lumens and ✓6 = little resistance relatively thin walls which allows the blood to move with less friction from rubbing against the walls of the blood vessels

3 contraction of heart pumps blood through arteries into veins

4+5 recoil of heart muscle after contraction causes blood to be drawn from veins into atria

1 muscles surrounding veins contract and press on walls of the vein and squeezes blood along veins

(6)
(Total 15 marks)
7

Blood vessels

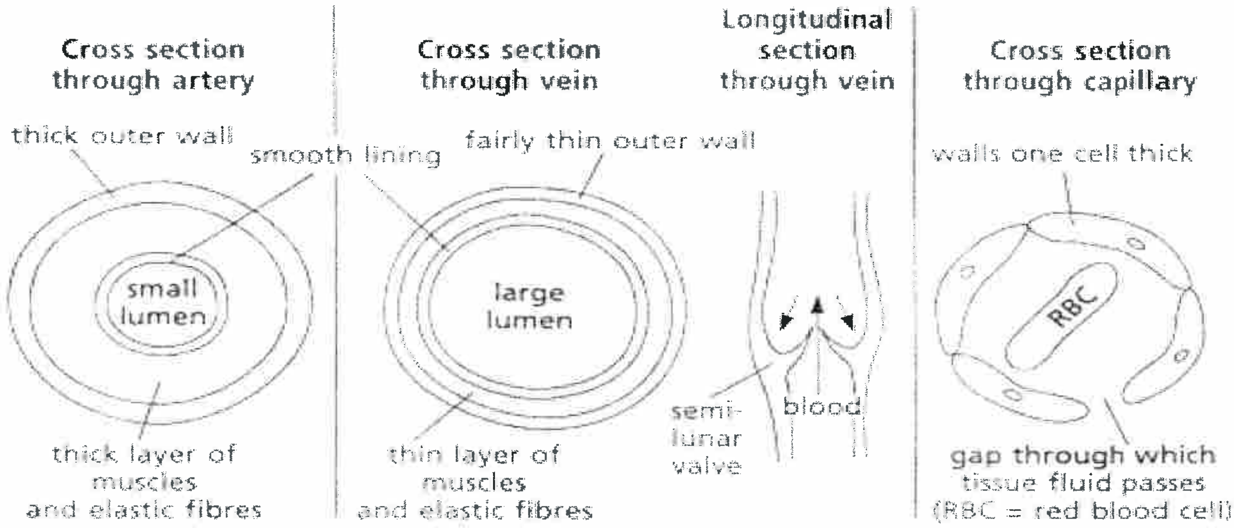
Match up the blood vessel with role

Blood Vessel	Role
Arteries	tiny vessels that link arterioles to veins; **site of exchange between blood and cells**
Arterioles	carry blood away from heart, at high pressure, and into arterioles; blood travels in pulses
Capillaries	carry blood, at low pressure, from capillaries back to heart.
Veins	smaller arteries that control blood flow from arteries to capillaries

They all have:-

- **Lumen** = central cavity
- **Endothelium** = thin, smooth inner lining
- **Wall** = made of muscle, elastic tissue and collagen
- **BUT…** the **relative proportions** of each layer differ, and links to their different functions.

Diagram of the different vessels: colour in muscle, elastic layer:-



retch and challenge:
lculate ratio of lumen to
tal diameter for artery
d vein

collagen - structural protein found on the outside of all blood vessels except for capillaries

endothelial cells - squamous endothelial cells

Artery:

- T.hicker........ muscular layer
- T.hicker........ elastic tissue layer
- Wall t.hicker........... overall
- Lumen is relatively ~~small~~........ narrower

Vein:

- T.hinner........... muscular layer
- T...hinner......... elastic tissue layer
- Wall t...hinner........overall
- Lumen is relatively ~~larger~~....... wider

Capillary:

- Very t.hin..... wall, only 1 cell thick
- Made of flattened squamous endothelial cells
- Spaces between the endothelial cells allow WBC to escape to get to site of tissue infection

arterioles - thick muscular layer

The Aorta: Mark Scheme answer

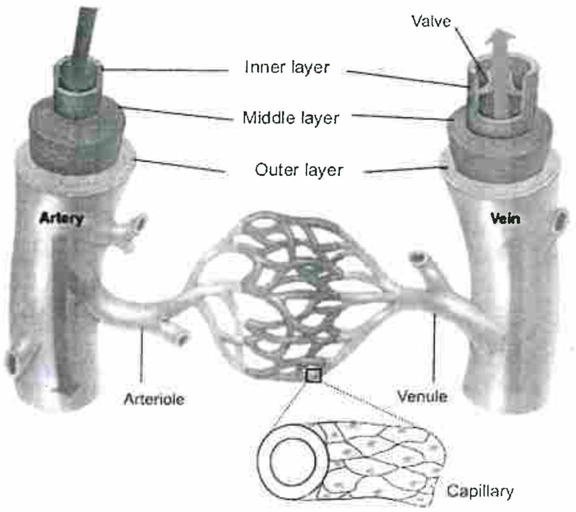
- ✓ In the aorta, elastic fibres stretch when ventricle contracts
- ✓ and recoil when ventricle relaxes
- ✓ This helps to maintain the blood pressure, smoothing it out
- ✓ and also causes the thickness of the aorta to vary during the cardiac cycle

arteries - no valves, blood pressure is sufficient

veins - valves, blood pressure is not high enough

Blood Vessel Summary

Task: a) place labels and information about the different types of vessels in the correct places below



Tissue Fluid

What is it?

- ✓ It is the environment of the cells
- ✓ Substances move out of the capillaries to form tissue fluid
- ✓ It bathes the body cells in the tissues, **supplying** all required substances
- ✓ Tissue fluid then **receives** carbon dioxide and other waste materials
- ✓ And is returned to the circulatory system
- ✓ Tissue fluid is how **exchange of gases & nutrients between blood and cells occurs**

Stretch and Challenge: **Transport of oxygen, carbon dioxide, glucose, amino acids, urea & proteins**

Tissue	**From Capillaries to tissue**	**To capillaries from tissue**
Alveoli	carbon dioxide	oxygen
Intestinal villi	oxygen	carbon dioxide, glucose amino acids
Brain	oxygen, glucose, amino acids	carbon dioxide
Leg muscles	oxygen, glucose, amino acids	carbon dioxide
Liver	oxygen, glucose, amino acids	carbon dioxide, urea (and glucose when in low conc. in blood)

Arteriole end

nigh hydrostatic pressure in capillaries

lower hydrostatic pressure outside the capillaries (in tissue fluid)

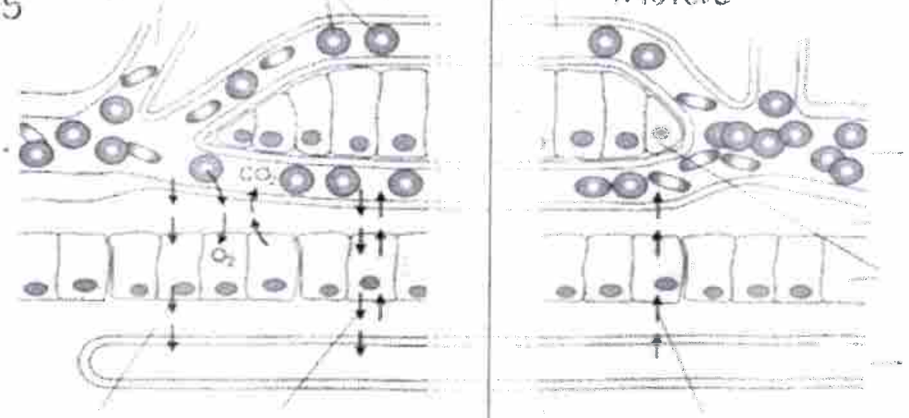
vater moves ut of the apillaries nto spaces round cells, orming ssue fluid

Venule end

loss of water from capillaries reduces hydrostatic pressure inside

hydrostatic pressure in capillaries is lower than in tissue fluid outside

Ψ is lower in capillaries than outside in tissue fluid



small nolecules re forced out = ultrafiltration

cells + plasma proteins are too large to cross through the membrane

water re-enters capillaries from tissue fluid by osmosis down Ψ gradient = oncotic pressure

Annotate the diagram with **all** the notes below

At arteriole end:	At venule end:
• There is a **high hydrostatic pressure (HP)** in the capillaries created by contraction of the ventricles. • This is greater than the HP of tissue fluid outside the capillaries • Therefore water to move OUT of capillaries and into the spaces around cells, forming the tissue fluid (TF) • Small molecules are also forced out • Cells and the larger plasma proteins, are too large to cross the membrane = **ultrafiltration.**	• The loss of water from the capillaries reduces the HP inside • So the HP is now lower than thetissue fluid outside • The **water potential is lower inside the capillary than outside in the TF** due to the water loss and the larger proteins still in the capillary • Therefore water re-enters the capillaries from the tissue fluid by osmosis down a water potential gradient.

Lymphatic System

- Not all 100% of the tissue fluid can return to the capillaries.
- The remaining fluid (10%) enters the **lymphatic system**, into a lymph vessel, and is now called **lymph**
- Eventually the vessels drain back into the bloodstream

Exam Q and Mark Scheme Answers:

1. **Describe the formation of tissue fluid**
- In the capillary there is a ...high..... hydrostatic pressure
- Which forces water ..out of the capillary
- But ....large plasma proteins remain in the capillary

2. **How does the tissue fluid return to circulation**
- There is a low water potential in ...capillaries / blood
- Due to ..large plasma proteins
- Therefore WATER ...enters....... capillary
- By ..osmosis..............
- And some water returns to circulation via ..lymphatic..... system

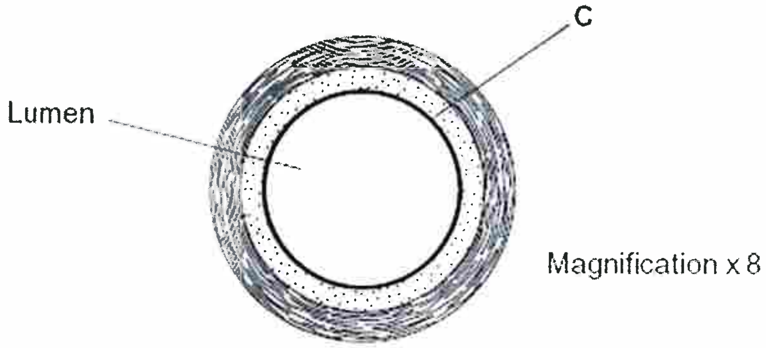
3. **Why does a high BP lead to accumulation of tissue fluid?**
- A high blood pressure will cause a high ..hydrostatic...... pressure
- Which increases the outward pressure from the ....arteriole............... end of the capillary
- Therefore ...more....... tissue fluid is formed

4. **Why does a lack of protein in the blood cause a build-up of tissue fluid (Kwashiokor)?**
- The water potential in the capillary is now not as ...low..........
- Therefore ....less....... water is returned to the capillary by .osmosis......

Comparison of Blood, Plasma & Tissue Fluid

	Blood	Plasma	Tissue Fluid	Lymph
Red blood cells	yes	no	no	no
White blood cells	yes	no	A very few	Many
Proteins	yes	yes	Yes – fewer & smaller	Yes – fewer & smaller
Fats	yes	yes	yes	Yes – more than blood
Glucose	yes	yes	Yes - less	Yes - less
Amino acids	yes	yes	Yes - less	Yes - less
Oxygen	yes	yes	Yes - less	Yes - less
Carbon dioxide	yes	yes	Yes - more	Yes - more
Location	In blood vessels	In blood vessels	Surrounding cells	In lymph vessels

Q:! The diagram shows a cross-section of a blood vessel.



(a) Name layer **C**.

smooth lining X epithelium (1)

(b) Calculate the actual diameter of the lumen of this blood vessel in millimetres. Show your working.

$A = \frac{I}{M} = \frac{26}{8} = 3.25$

Answer 3.25 ✓ mm (2)

(c) The aorta has many elastic fibres in its wall. An arteriole has many muscle fibres in its wall.

(i) Explain the importance of elastic fibres in the wall of the aorta.

The aorta needs elastic fibres in the wall as a lot of contractions take place so the aorta walls need to be able to snap back from being contracted to being relaxed. ✓ maintains blood pressure (2)

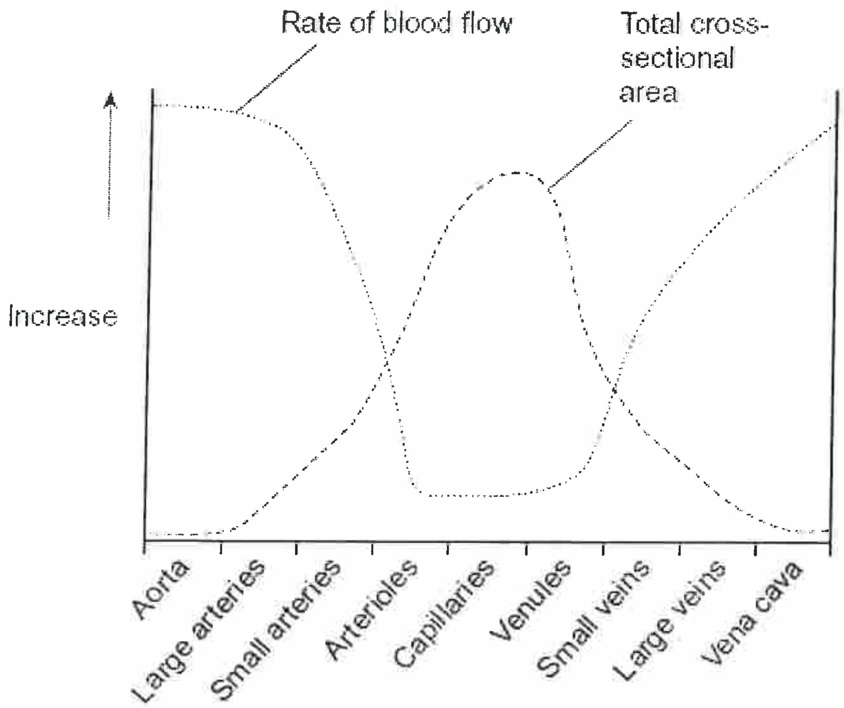
(ii) Explain the importance of muscle fibres in the wall of an arteriole.

The muscle fibres are needed to generate enough pressure to keep the blood flowing so that oxygen can be delivered to the tissues around the body. X (2)

muscle contracts

arteriole constricts

(d) The graph shows the rate of blood flow in different blood vessels. It also shows the total cross-sectional area of these blood vessels.



(i) The rate of blood flow decreases from the aorta to the capillaries. Use information from the graph to explain why.

The total cross-sectional area of the vessels increases ✓ so pressure is lost and rate of blood flow decreases.

(1)

(ii) Efficient exchange of substances in the capillaries is linked to the rate of blood flow. Explain how.

The oxygen has more time ✓ to diffuse for exchange of substances when the rate of blood flow is lower.

(1)

(Total 9 marks)

4

Q. 14 (a) (i) An arteriole is described as an organ. Explain why.

It has multiple different tissues ✓ working toward one function (transporting blood around the body).

(1)

(ii) An arteriole contains muscle fibres. Explain how these muscle fibres reduce blood flow to capillaries.

when the muscle contracts the lumen is made much narrower so blood flow is reduced.

(2)

(b) (i) A capillary has a thin wall. This leads to rapid exchange of substances between the blood and tissue fluid. Explain why.

There is a short diffusion pathway

(1)

(ii) Blood flow in capillaries is slow. Give the advantage of this.

There is more time for exchange of substances

(1)

(c) Kwashiorkor is a disease caused by a lack of protein in the blood. This leads to a swollen abdomen due to a build up of tissue fluid.

Explain why a lack of protein in the blood causes a build up of tissue fluid.

A lack of protein means that the water potential inside the capillaries is much higher. This means more fluid leaves the capillaries down a water potential gradient which causes a build up of tissue fluid, causing swelling.

2
little to no water returns to the capillary by osmosis
3

(Extra space)

1
(3)

(Total 8 marks)

6

Oxygen Transport in Mammals

Blood

Blood Consists of a liquid called plasma, containing RBC (oxygen transport), WBC (immune system), and platelets (blood clotting).

red blood cells — white blood cells

contains haemoglobin

Haemoglobin (located in the RBC)

A) Structure

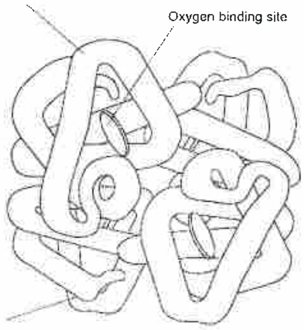
It is Globular and Soluble with a quaternary structure – recap your protein structure knowledge and fill in the blanks below:-

multiple polypeptides

It has a :-

- ▲ Primary structure = the sequence of ..amino acids.... in 4 polypeptide chains
- ▲ Secondary structure = each ...polypeptide....... chain is coiled into a helix
- ▲ Tertiary structure = each polypeptide chain is folded into a .specific... shape – important for its ability to carry oxygen 3D (precise)
- ▲ Quaternary structure = all 4 ..polypeptides....... are linked together to form a spherical molecule.
- ▲ Each polypeptide is associated with a ...haem... group, which contains and $Fe2^{+}$ ion.
- ▲ Each haem group combines temporarily with 1 ...oxygen........ molecule (2 atoms), therefore four .oxygen... molecules are carried by a single haemoglobin molecule in humans.

The diagram shows a molecule of haemoglobin



Exam Q: What is the evidence from diagram that haemoglobin has a quaternary structure?

there are multiple polypeptide chains and multiple haem groups.

B) Role

1. To LOAD oxygen in a high O_2 concentration, where it has a **high affinity** for oxygen, to form oxyhaemoglobin - association
2. This occurs **in lungs**
3. UNLOAD oxygen in a low pO_2 conditions and high pCO_2, where it has a **low affinity** for oxygen
4. This occurs in the **respiring cells / tissues**
5. These 2 different roles are possible because haemoglobin **changes its affinity** for oxygen under different conditions.

dissociation

Use this information to complete the table

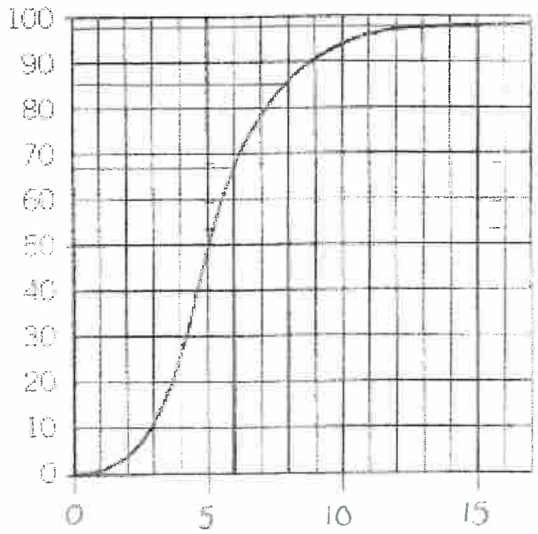
Affinity of haemoglobin for oxygen under different conditions

Region of Body	Oxygen concentration (high/low)	Carbon dioxide concentration (high/low)	Affinity of haemoglobin for oxygen (high/low)	Result (oxygen is associated/dissociated)
Gas exchange surface	high	low	high	associated
Respiring tissues	low	high	low	dissociated

Oxygen Dissociation Curves

When haemoglobin is exposed to different partial pressures (concentrations) of oxygen **(pO_2),** it does not bind oxygen evenly, giving a **sigmoid shape** to the curve.

When every molecule of Hb is combined with 8 atoms of oxygen, then it is 100% saturated, etc.



The graph shows the relationship between the saturation of haemoglobin with oxygen and the partial pressure of oxygen **(pO_2)**, and is called the OXYGEN DISSOCIATION CURVE

What is % saturation of Hb with O_2 at:

- 6 kPa ...67%...
- 8 kPa...85%...
- 15 kPa...97%...

Why is the curve sigmoid ? .... starting from the bottom

1. *As pO_2 increases from 0 to 2 kPa,*
- % saturation increases gradually and curve is shallow
  REASON: The shape of the Hb molecule makes it difficult for 1st oxygen molecule to bind
  Therefore, at low pO_2 not much oxygen binds to Hb

2. *As pO_2 increases more*
- % saturation increases more, causing a steeper gradient.
  REASON: Binding of the first oxygen changes the quaternary structure shape of Hb molecule which makes it much easier for other oxygen molecules to bind.
  Therefore it takes a **smaller** increase in pO_2 to bind 2nd and 3rd oxygen molecules

3. *As pO_2 increases to above 10 kPa,*
- *% saturation flattens out*

  REASON: Binding of 4th is harder because it is less likely that a single oxygen molecule will find an empty binding site

In reverse – loss of one oxygen makes it easier for the next one to be lost, and so on

What is the Relevance?

1. In the lungs
   √ Blood leaving the **lungs** is almost always completely saturated with oxygen.
   √ Even if pO_2 in lungs drops a bit below normal, Hb can still pick up a lot of oxygen

2. In the **body tissues**, respiration in the cells is using up the oxygen
   √ A slight decrease in pO_2 of tissues produces a large increase in oxygen release from Hb.
   √ O_2 is very effectively delivered to the tissues that need it

The BOHR SHIFT

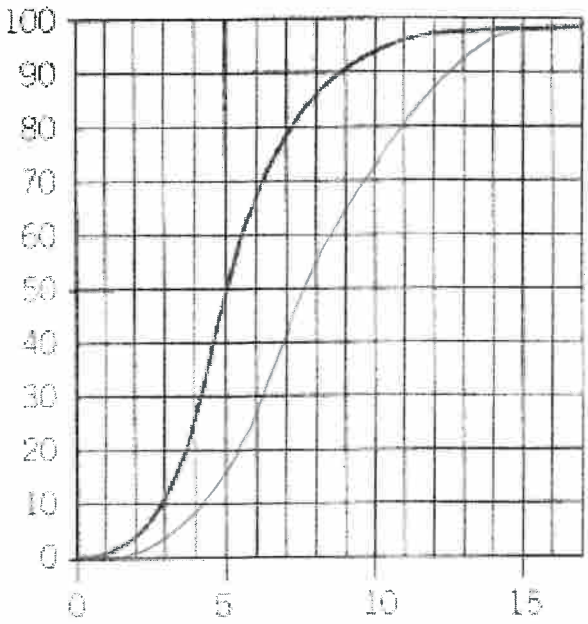
Effect of Carbon Dioxide concentration on Oxygen Transport:

- pCO_2 is the concentration of carbon dioxide.
- In respiring body tissues CO_2 is produced
- When we exercise, **more CO_2 is produced**; therefore the pCO_2 in the tissues **increases**

Write out equation for respiration:

Glucose + Oxygen → Carbon dioxide + Water + Energy

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP$



- The higher the pCO_2, the more readily the oxygen is unloaded from Hb
- So more oxygen is released for cells during activity.
- So, the dissociation curve shifts to the RIGHT
- Hb has a LOWER AFFINITY for O_2
- = the BOHR SHIFT

Draw the curve for the Bohr Shift, and label "high pCO_2"

Exam tip: When you are asked to draw a curve :-

- make sure it begins and ends at the SAME point as the one given
- Then draw to the left or right, as appropriate

What causes the Bohr Shift?

- In the tissues, CO_2 is ...produced......... by respiring cells
- It combines with water to release H ions in presence of carbonic anhydrase in RBC
- CO_2 therefore ..decreases.... pH of blood in tissues
- This changes shape of Hb so now has a ..lower....... affinity for oxygen – curve shift to right
- Therefore ...more....... O_2 is released into respiring tissues.
- The more active a tissues is, the ....more....... oxygen is unloaded.

Different Species

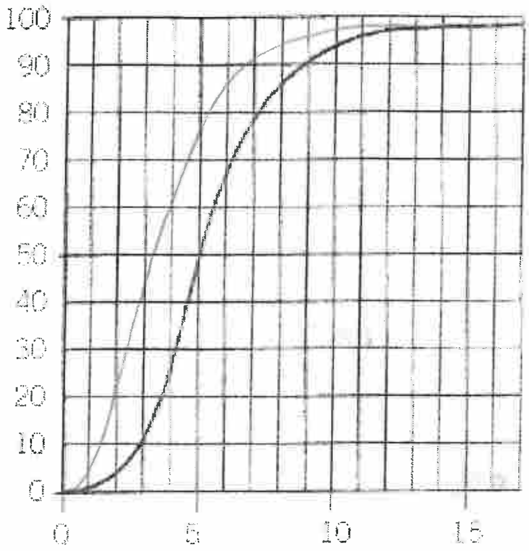
Why are there different haemoglobins?

[use these words: affinities, High, Low, Numbers, Oxygen, Quaternary, Shapes, Sequence, Tertiary]

- The haemoglobin in different organisms have different ...affinities.... for oxygen.
- Due to different ....shapes........ of the haemoglobin molecule
- Due to amino acid ..sequences....... being slightly different
- Resulting in slightly different ...tertiary........ and ...quaternary..... structures, i.e. different ....numbers........... of polypeptide chains
- Resulting in different ....oxygen............ binding properties
- Therefore affinity of different haemoglobin molecules ranges from .....low....... to ...high....... affinity for oxygen.

- **Different species** have different types of Hb, with different dissociation curves
- Due to adaptions to the different environments they live in.

- Examples- You will have to describe the differences in their curves and explain why that allows them to function correctly.



1. Low oxygen environments, low pO_2

- the pO_2 is lower where they live
- so the Hb has a **higher affinity**
- so it can load **more** of the available oxygen, and
- be **saturated at a lower pO_2.**
- and the dissociation curve is **shifted to the LEFT**

a) **foetus**

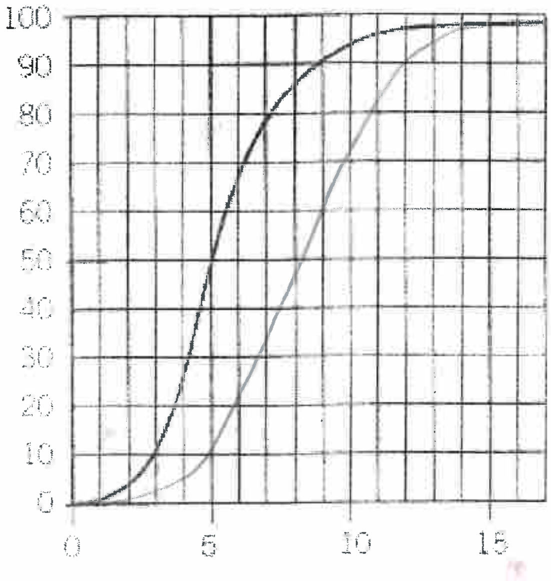
- in uterus, low pO2
- so needs to be able to load more O_2 than mother
- at same pO_2.
- Which enables oxygen to move from mother to foetus.

b) **lugworms**

- live in burrows beneath the sand - low pO_2.
- So need to load as much oxygen as possible

c) **llama**

- lives at high altitudes, low atmospheric pO_2
- so has to be able to load with more oxygen



2. Different Activity levels & Size

- Organisms that are very active and small, have a high O_2 demand
- They need their Hb to unload oxygen **more** easily
- To supply **more** oxygen to tissues
- For a faster respiration
- Therefore have a Hb with a **lower affinity**
- In all these cases, the dissociation curve is **shifted to the RIGHT**

Examples:

a) Hawk

- very high respiratory rate
- and lives where there is plenty of oxygen

Relationship between the size of mammals and their oxygen dissociation curves

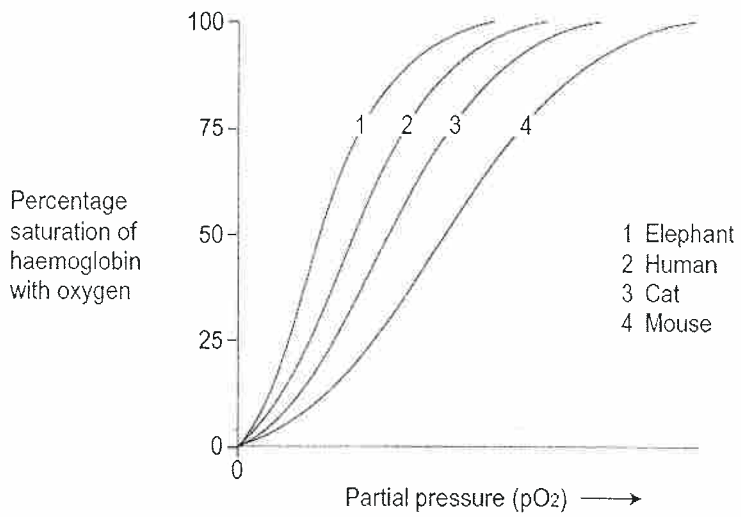
Small mammals

- have a higher SA:VOL ratio
- therefore lose heat more quickly,
- so have a higher metabolic rate to keep warm.
- Therefore have a higher oxygen demand
- So need the Hb to unload oxygen more easily.

Mark Scheme answer:

The larger the animal:-

- The more to the ..left.... the curve is
- The ..steeper........... the curve is
- The higher. the affinity for oxygen

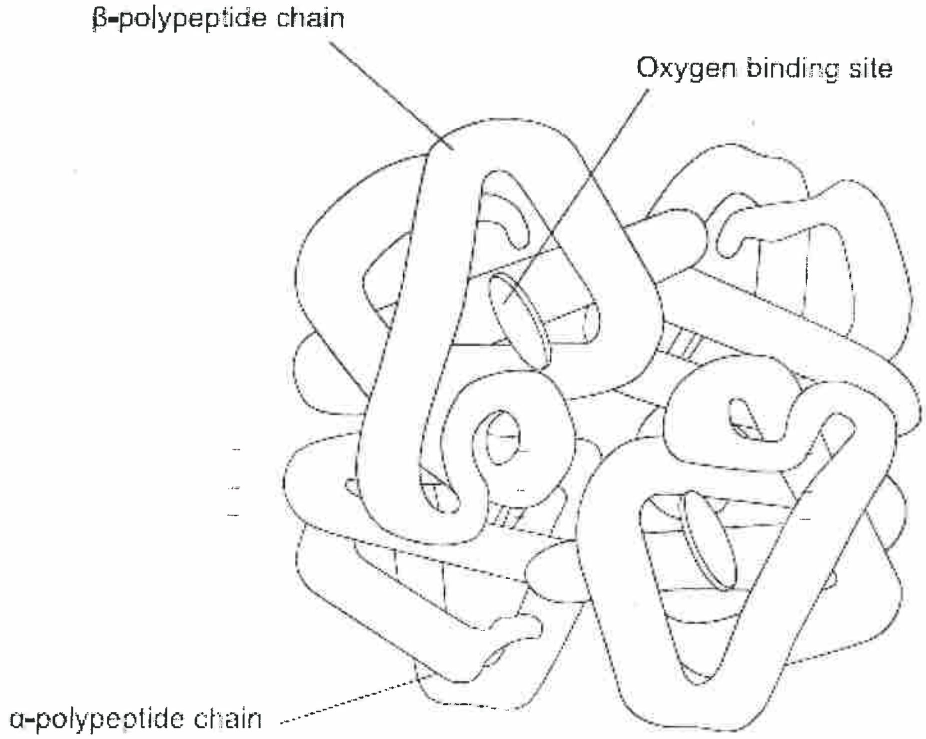


Q: Why does the Hb of smaller mammals have a lower affinity for oxygen?

Mark scheme answer:

- SA:VOL ratio is ..higher..........................
- Heat loss is ..increased.......
- Rate of respiration ..is greater...................... (if SA:Vol is greater)
- Requirement of O2 for respiration ..oxygen required for respiration, Hb releases O_2 more readily
- Haemoglobin has a .... lower............... affinity for oxygen / it releases O2 (lower affinity)
  ......more............... readily

Q15 The diagram shows a molecule of haemoglobin.



(a) What is the evidence from the diagram that haemoglobin has a quaternary structure?

There are multiple haem groups and multiple polypeptide chains (more than 2 ends of chains)

x ignore

(1)

(b) (i) A gene codes for the α-polypeptide chain. There are 423 bases in this gene that code for amino acids. How many amino acids are there in the α-polypeptide chain?

$\boxed{141}$

(1)

(ii) The total number of bases in the DNA of the α-polypeptide gene is more than 423.

Give **two** reasons why there are more than 423 bases.

1. some bases will not code for an amino acid ✓ that

th the same point

2. there could be junk DNA ✓ ← this better answer than

stop / start sequences

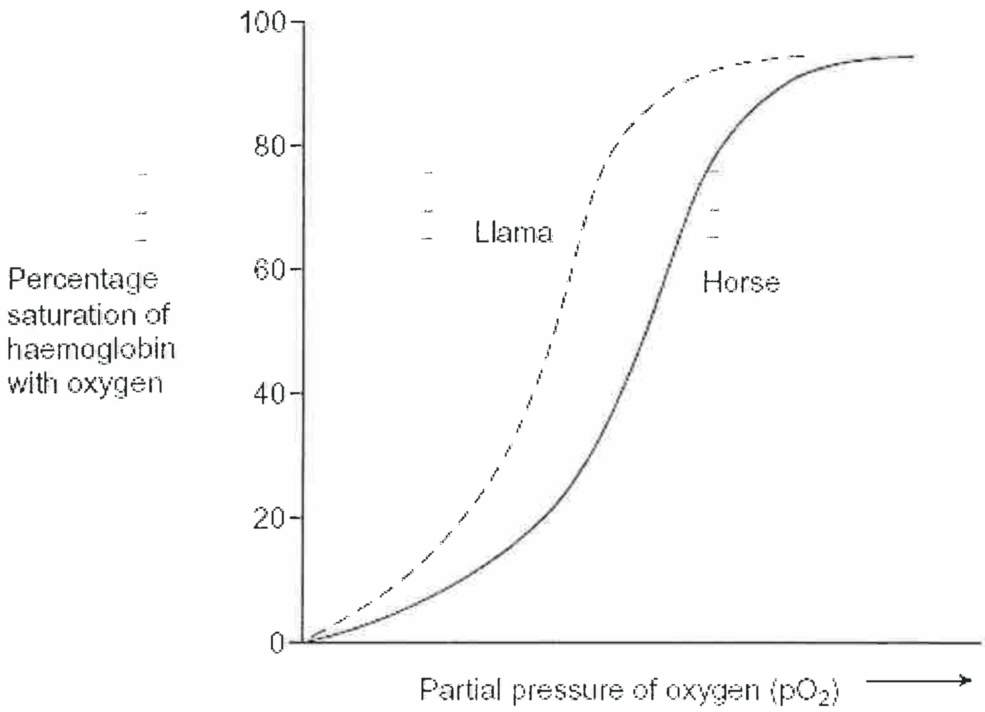
(2)

(c) The haemoglobin in one organism may have a different chemical structure from the haemoglobin in another organism. Describe how.

they will have a different sequence of amino acids ✓

(1)

(d) The graph shows oxygen dissociation curves for horse haemoglobin and for llama haemoglobin. Horses are adapted to live at sea level and llamas are adapted to live in high mountains.



Use the graph to explain why llamas are better adapted to live in high mountains than horses.

The llama haemoglobin does not need as high a concentration of oxygen in order to bind and form oxyhaemoglobin which means at high altitudes where the partial pressure of oxygen in the lungs is lower, the saturation of haemoglobin haemoglobin can load more oxygen with oxygen will be enough to survive.

(3) (Total 8 marks)

↳ higher affinity for oxygen.

c 4

Causes and Consequences of Cardiovascular disease (CVD)

Cardiovascular disease = a term that covers a range of different problems that can develop in the blood vessels and the heart, usually when the vessels become blocked

Research activity:

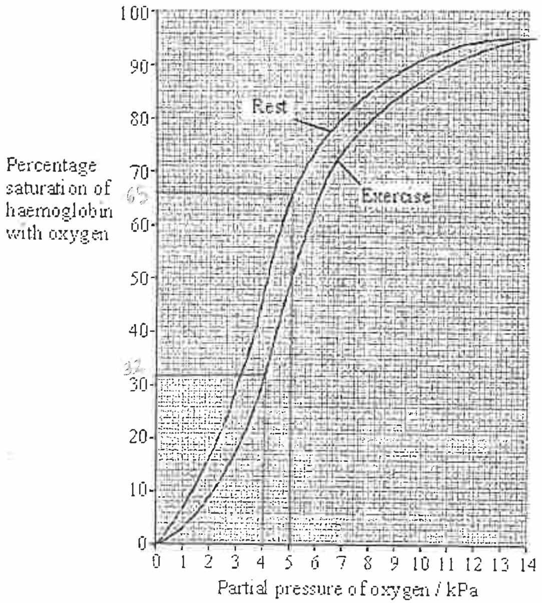
In pairs, choose one cardiovascular disease e.g. stroke, heart disease, research the causes, risk factors and consequences, then prepare a short presentation to be given to the class.

Plan your presentation below;

6

Q. The graph shows dissociation curves for human oxyhaemoglobin at rest and during exercise.

Table 1 gives information about conditions in the body at rest and during exercise.



	Rest	Exercise
Plasma pH	7.4	7.2
Blood temperature / °C	37.0	39.0
Alveolar partial pressure of oxygen / kPa	13.3	13.3
Tissue partial pressure of oxygen / kPa	5.0	4.0

Table 1

(a) What is meant by the term *partial pressure*?

the concentration of oxygen ✓

measure of the concentration of a gas

(1)

(b) Use **Table 1** and the graph to calculate the difference in the percentage saturation of haemoglobin in the tissues between rest and exercise.

65 - 32 = 33

37 - 33

Answer 33 ✗ %

(1)

(c) Explain the differences between the figures shown in **Table 1** for rest and exercise.

The alveolar oxygen concentration remains constant as the alveloar saturate the haemoglobin molecules with oxygen. the tissue oxygen concentration decreases from rest to exercise because the oxygen is being used for aerobic respiration. ✓ The blood temperature increases as heat is produced by friction during exercise as the muscles contract.

increased heat released = inc. temp increased CO_2 consumption lowering tissue pO_2.

more muscle contract causes inc respiration inc. CO_2 causes lower pH

(4) 2

(d) Explain the advantage of the difference in position of the dissociation curve during exercise.

There is a lower affinity for oxygen, ✓ so less binds to haemoglobin so there is more oxygen for respiration. ✓

(2)

Table 2 shows how the oxygen concentration in the blood going to and from a muscle changes from rest to heavy exercise.

		Oxygen concentration / cm^3 per 100 cm^3 blood	
		Blood in arteries	Blood in veins
At rest	In solution	0.3	0.2
	As oxyhaemoglobin	19.5	15.0
	Total oxygen	19.8	15.2
During heavy exercise	In solution	0.3	0.1
	As oxyhaemoglobin	20.9	5.3
	Total oxygen	21.2	5.4

Table 2

(e) By how many times is the volume of oxygen removed from the blood by the muscle in **Table 2** during heavy exercise greater than the volume removed at rest?

Show your working.

during heavy exercise = 21.2 - 5.4 = 15.8

at rest = 19.8 - 15.2 = 4.6

$\frac{15.8}{4.6} : \frac{4.6}{4.6}$

3.43 : 1

Answer 3.43 ✓ times

(2)

(f) Does enriching inspired air with oxygen have any effect on the amount of oxygen reaching the tissues? Support your answer with evidence from the graph and **Table 2**.

early if O_2 is inspired ↑ Hb

It will make the haemoglobin fully saturated, however, once all of the haemoglobin molecules are fully saturated, the amount of oxygen reaching the tissue will remain constant.

as it is only 95% saturated with oxygen at the alveoli. ✓ will raise this to 100%

(3)

(g) The change to the dissociation curve is one of a number of ways in which the total oxygen supplied to muscles is increased during exercise. Give **two** other ways in which the total oxygen supplied to muscles during exercise is increased.

1. there is a higher demand for oxygen so the concentration gradient is steeper ✗

2. increased stroke volume

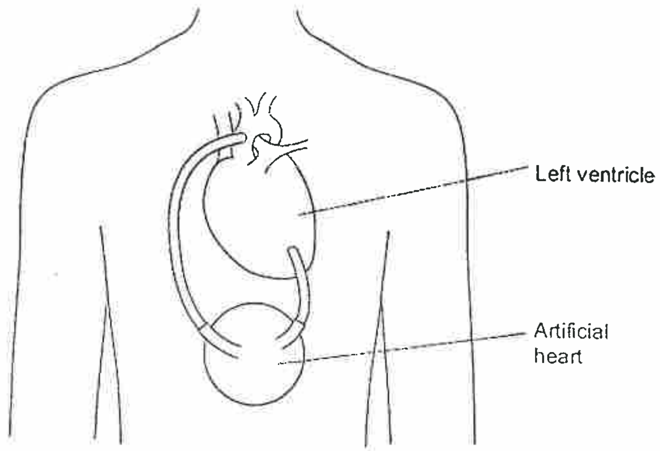
vasodilation

(2)

(Total 15 marks)

Q7. Some people have a form of *heart failure* where their heart is not pumping blood as well as it used to. Some people with heart failure are given an artificial heart to improve circulation of blood from the left ventricle. **Figure 1** shows where this type of artificial heart is connected.

Figure 1



(a) Name the blood vessel to which the artificial heart is connected.

aorta ✓

(1)

(b) In these patients, the right ventricle still produces sufficient blood flow to keep the patient alive.

Suggest why the left ventricle requires the help of the artificial heart but the right ventricle does not.

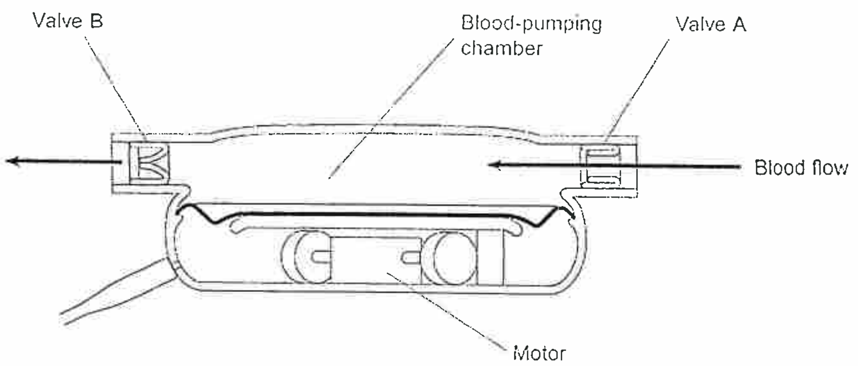
The left ventricle needs to contract with enough force to pump blood around the entire body ✓ wheras the right ventricle only needs enough force to pump blood to the lungs.

LV produces a greater force

(1) (2)

(c) **Figure 2** shows the internal structure of this type of artificial heart.

Figure 2



Valves A and B have the same functions as heart valves involved in the cardiac cycle. Name the heart valve that has the same function as:

valve A atrio-ventricular valve ✓

valve B semi-lunar valve ✓

(2)

(d) There are different designs of artificial heart. Doctors compared results for patients who received two different types of artificial heart, X and Y.

They recorded information 2 years after the artificial hearts were implanted. Their results are shown in **Figure 3**.

Figure 3

Type of artificial heart	Information recorded 2 years after artificial heart implanted		
	Number of patients surviving without replacement of artificial heart	Number of patients surviving but who required repair or replacement of artificial heart	Number of patients who died
X (119 patients)	62 52%	13 11%	44 37%
Y (58 patients)	7 12%	24 41%	27 47%

Which type of artificial heart was the more successful? Use calculations to support your answer.

Artificial heart X was more successful ✓ because 37% of patients died compared to 47% of patients with artificial heart Y. Also, only 11% of patients with artificial heart X needed repairs compared to 41% ✓ of patients with artificial heart Y.

(3)
(Total 8 marks)

7

5

Q. (a) Describe and explain **four** ways in which the structure of a capillary adapts it for the exchange of substances between blood and the surrounding tissue.

capillaries are narrow ✓ which causes the rate of blood flow to lower and allows more time for more substances to exchange ✓ over the membrane into the tissues. Also, capillaries have one cell thick walls ✓ which allows for a short diffusion pathway.

flattened cells / permeable membrane

(4) 3/4

(b) Explain how tissue fluid is formed and how it may be returned to the circulatory system.

Tissue fluid forms when ~~you~~ water, mineral ions and other components from the blood plasma diffuse out of the capillaries and into the tissues ✓. Tissue fluid builds up around the cells and ~~is supposed~~ later, most of it returns to the capillaries at the venule end. However, some tissue fluid is left and is taken up by the lymphatic system. Lymph is then took from the tissues to the circulatory system as a result of various muscle contractions ✓

1 hydrostatic pressure is high at arterial end.

3 large molecules remain

4 lowers water potential

5 water moves back into venous end of capillary by osmosis

2

(6) **(Total 10 marks)**

5

Atherosclerosis

caused by a build-up of fatty deposits on inner lining of arteries.
Build-up is called an atheroma and can occur in any blood vessel.
usual sites are aorta, cerebral arteries in brain, coronary arteries in heart muscle.
Atheroma restricts blood flow and increases chance of blood clots forming

Coronary heart disease = when an atheroma forms in coronary arteries; this restricts blood flow/oxygen to an area of cardiac muscle, causing angina.

Myocardial infarction = if a blood clot blocks a coronary artery completely = no blood supply = area may die leading to a heart attack.

Risk Factors

High fat diet - especially if this includes many saturated fats

High levels of LDL cholesterol in the blood

obesity, smoking, diabetes

High-salt diet, leading to high blood pressure

Age (and menopause in women)

The genes a person has

heart rate = number of beats per minute (bpm)
= 60 ÷ time taken for one heart beat / cardiac cycle (s)

stroke volume = volume of blood forced out of the heart in each beat
= cardiac output ÷ heart rate

cardiac output = stroke volume x heart rate