

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname *StemUp Model Solution*

Forename(s)

Candidate signature

I declare this is my own work.

INTERNATIONAL AS BIOLOGY (9610)

Unit 2 Biological Systems and Disease

Wednesday 10 January 2024 07:00 GMT Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

For Examiner's Use	
Question	Mark
1	
2	
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TOTAL	



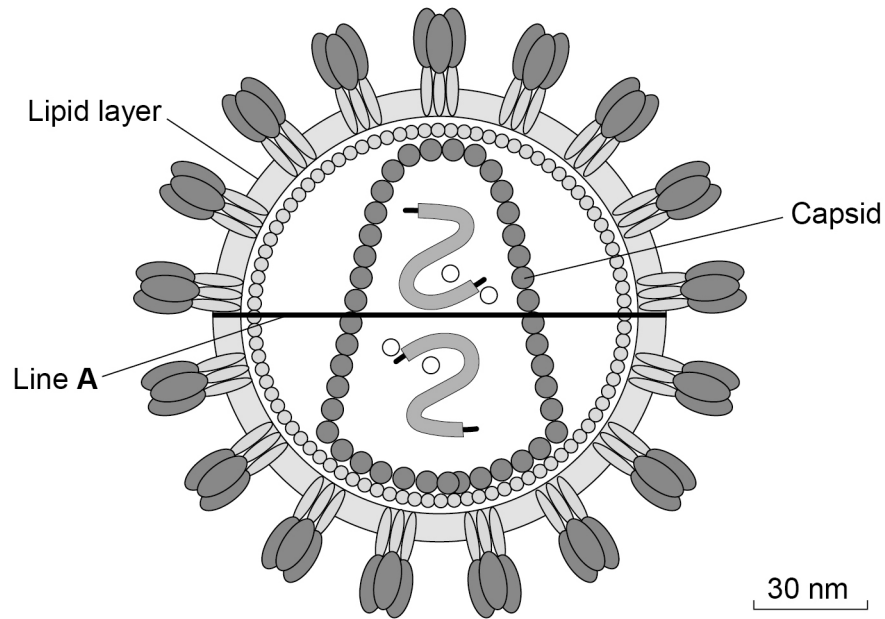
Answer **all** questions in the spaces provided.

0 1

Human immunodeficiency virus (HIV) causes acquired immune deficiency syndrome (AIDS).

Figure 1 shows the structure of HIV.

Figure 1



0 1 . 1

Name the type of nucleic acid and an enzyme found inside the capsid.

[2 marks]

Type of nucleic acid RNA

Name of enzyme Reverse transcriptase



0 1 . 2

HIV binds to receptors on helper T cells. The mean diameter of helper T cells is $8\text{ }\mu\text{m}$ and is many times larger than the HIV shown in **Figure 1**.

Calculate how many times larger.

Use the line labelled **A** to measure the diameter of the HIV.

Give your answer to 2 significant figures.

[2 marks]

Line A = 60 mm; scale bar 30 nm = 15 mm

Diameter of HIV = $60 \div 15 \times 30 = 120\text{ nm}$

$8\text{ }\mu\text{m} = 8000\text{ nm}$, so $8000 \div 120 = 66.7$

Answer = 67 times larger

0 1 . 3

Describe how viral proteins are produced inside an infected helper T cell.

[4 marks]

Viral RNA is used as a template to make (c)DNA using reverse transcriptase.

The viral DNA is inserted into the helper T cell DNA (by integrase) and the viral DNA is transcribed to form viral mRNA.

The viral mRNA is translated into viral proteins.

Translation takes place at the ribosomes of the host cell.

Viral protease is used to modify (cut) the viral proteins into functional proteins.

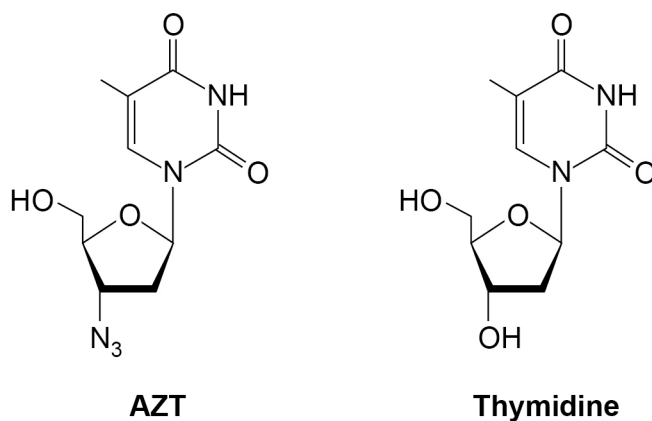
Question 1 continues on the next page



Azidothymidine (AZT) is a drug used for treating infection with HIV.

Figure 2 shows the structure of AZT and thymidine. Thymidine is part of a DNA nucleotide and consists of thymine joined to deoxyribose.

Figure 2



0 1 . 4

Suggest how AZT could prevent the onset of AIDS.

[3 marks]

AZT has a similar structure to thymidine, so it competes with the nucleotide containing thymine and is used as a nucleotide by reverse transcriptase.

AZT does not have the hydroxyl (OH) group needed to join with another nucleotide, so the sugar-phosphate backbone cannot form and formation of the viral DNA strand (reverse transcription) is stopped.

So viral replication is prevented, preventing an increase in the number of HIV in the blood.



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02.1

Human heart rate varies depending on the needs of the body.

Some students plan to investigate the effect of exercise on heart rate.

Describe an investigation the students could do in school.

In your answer, include **one** safety precaution.

[4 marks]

Each student sits quietly for 5 minutes, then records their resting pulse rate by counting beats at the wrist (radial pulse) for 60 seconds.

They then do step-ups on a 30 cm step at a set rate of 20 per minute (using a metronome) for 3 minutes, and record the pulse rate immediately after the exercise.

Control variables: same step height, rate and time for all. Repeat three times, letting the pulse return to resting each time, and calculate a mean.

Safety: students with asthma or a heart condition do not take part.

02.2

Draw a suitable table for the results of the investigation you described in your answer to Question 02.1.

[2 marks]

Condition	Heart rate / beats min^{-1}			
	Repeat 1	Repeat 2	Repeat 3	Mean
At rest				
After 3 min of exercise				



A statistical test can be used to determine if the effect of exercise on the heart rate is significant.

0 2 . 3

State a suitable statistical test, the reason for choosing this test and the result you would expect if the effect of exercise on heart rate was significant.

[3 marks]

Name of statistical test (Paired) t-test

Reason for choosing this test To look at the difference between the means of two sets of data (heart rate at rest and after exercise).

Result of test if exercise has a significant effect Calculated value greater than the critical value at the 0.05 significance level ($P < 0.05$), so reject the null hypothesis.

0 2 . 4

Give **two** factors, other than exercise, that may affect the heart rate of the students.

[2 marks]

1 Stress or fear (release of hormones, e.g. adrenaline)

2 Caffeine (e.g. coffee or energy drinks)

11

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0 3

Scientists investigate the effects of a fungal pathogen and aphids on the growth of a crop plant.

This is the method the scientists use:

1. Grow 20 plants from seeds that are infected with the fungal pathogen and 20 plants from seeds that are not infected.
2. Set up 4 groups of plants as follows:
 - **A** – infected plants with aphids added
 - **B** – non-infected plants with aphids added
 - **C** – infected plants with no aphids added
 - **D** – non-infected plants with no aphids added.
3. Grow the plants for 4 weeks in a light-controlled and temperature-controlled room.
4. Remove the aphids from the plants in groups **A** and **B**.
5. Put all the plants from each group in an oven at 90 °C to evaporate water from the plant tissue.
6. Calculate the mean dry mass per plant for each group.

0 3 . 1

During the investigation, the scientists control light and temperature.

Give **two** other variables the scientists should control.

[2 marks]

- 1 *Same number and species of aphids added to plants in A and B*
- 2 *Same volume of water given to each plant (same type of soil)*

0 3 . 2

Suggest how the scientists can make sure that all the water in the plant samples has evaporated at step 5.

[2 marks]

Weigh the plants in each group at intervals (e.g. every hour) during the heating.

Repeat until a constant mass is achieved (no further decrease in mass).



Table 1 shows the scientists' results.

Table 1

Treatment	Mean dry mass of plants / g ($\pm$ SD)
A	1.09 $\pm$ 0.12
B	2.21 $\pm$ 0.14
C	1.43 $\pm$ 0.24
D	4.34 $\pm$ 0.56

0 3 . 3

Describe what the results in **Table 1** show about the effects of the fungal pathogen and the aphids on the growth of the crop plant.

[4 marks]

Aphids alone (B, 2.21 g) and the fungal pathogen alone (C, 1.43 g)

both decrease the mean dry mass compared with D (4.34 g).

The effect of the fungal pathogen is greater than the effect of the aphids, as the mean dry mass for C is lower than for B.

The combined effect of aphids and fungal pathogen (A, 1.09 g) gives the largest decrease in mean dry mass.

There is no overlap of the SD ranges of B, C and D, so the differences are likely to be significant, but the SD ranges of A and C overlap, so that difference is not likely to be significant.

Question 3 continues on the next page



03.4

Explain how aphids feed on crops and how this would reduce crop production.

In your answer, use the results from **Table 1** (on page 9) and your own knowledge.

[3 marks]

Aphids have long mouthparts (stylets) that are inserted into the phloem sieve tubes.

Aphids feed on the sap and remove sugars (sucrose) and amino acids from the plant.

So less sugar for respiration and less amino acids for protein synthesis, so less plant biomass is produced (B 2.21 g compared with D 4.34 g); aphids can also be vectors of plant viruses.

11



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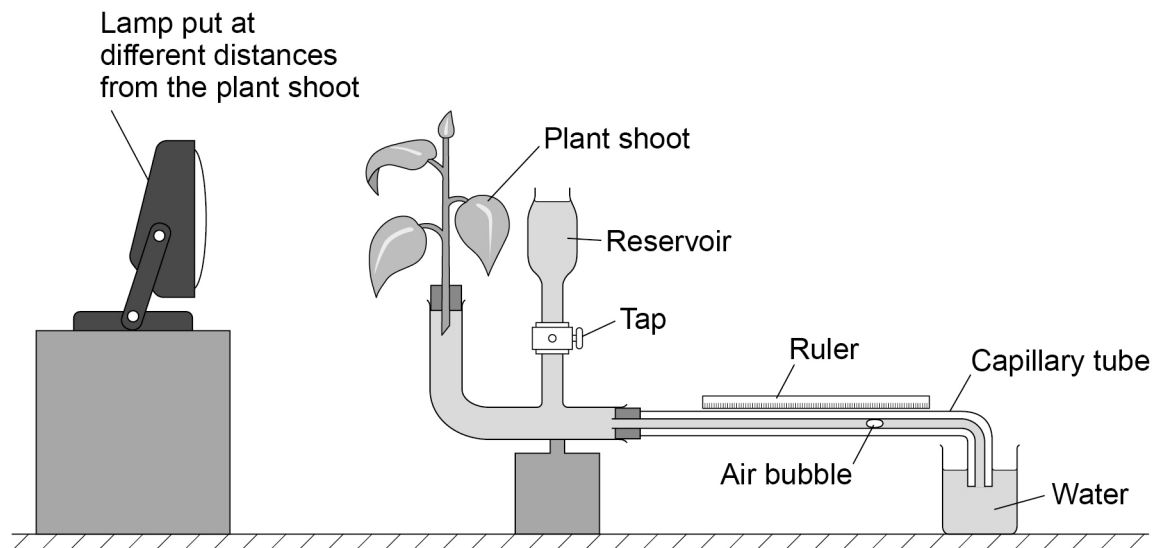
0 4

Students investigate the effect of light intensity on the rate of water uptake by a plant shoot.

The students put a lamp at different distances from a potometer to change the light intensity.

Figure 3 shows the equipment the students use.

Figure 3



0 4 . 1

Describe how the students could:

- prevent air entering the xylem of the plant shoot when setting up the equipment
- prevent leaks from the potometer
- prevent the air bubble in the capillary tube moving off the scale.

[3 marks]

Prevent air entering the xylem of the plant shoot when setting up the equipment

*Cut the shoot under water and assemble the apparatus with it
submerged in water.*

Prevent leaks from the potometer

Cover all the joints in the equipment with petroleum jelly (Vaseline).

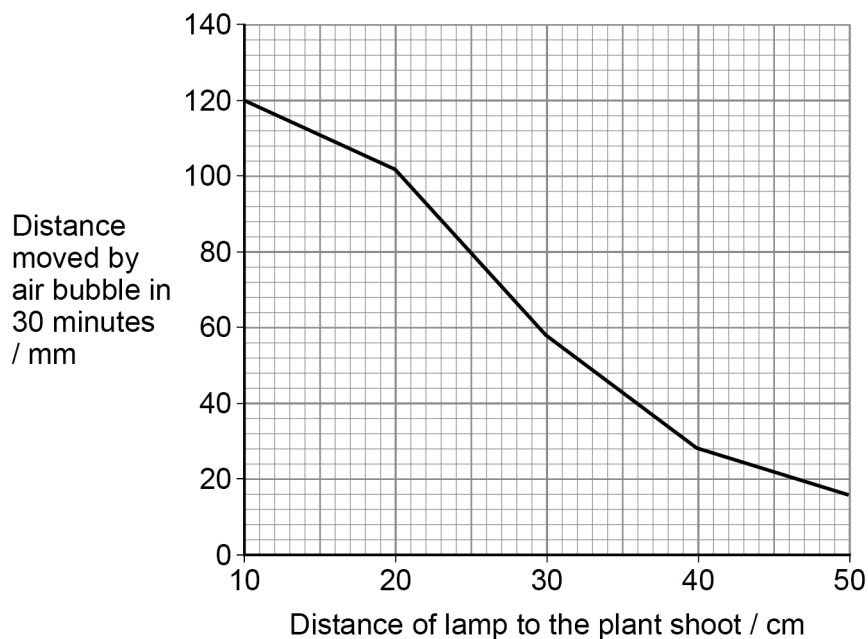
Prevent the air bubble in the capillary tube moving off the scale

*Turn the tap to allow water from the reservoir to move the air bubble
back to the start of the scale.*

Question 4 continues on the next page

Figure 4 shows the students' results from this experiment.

Figure 4



The rate of water uptake is calculated using the distance moved by the air bubble inside the capillary tube.

The internal diameter of the capillary tube shown in **Figure 3** (on page 12) is 1.0 mm

0 4 . 2

Calculate the difference in rate of water uptake when the plant shoot was 10 cm from the lamp and when it was 50 cm away from the lamp.

Give your answer in $\text{mm}^3 \text{min}^{-1}$

Use $\pi = 3.14$

[3 marks]

Distance: 10 cm = 120 mm, 50 cm = 16 mm, difference = 104 mm

Area = $\pi r^2 = 3.14 \times 0.5^2 = 0.785 \text{ mm}^2$

Volume = $104 \times 0.785 = 81.64 \text{ mm}^3$ in 30 minutes

Rate = $81.64 \div 30 = 2.72 \text{ mm}^3 \text{min}^{-1}$

Difference in rate of water uptake = 2.72 $\text{mm}^3 \text{min}^{-1}$



0 4 . 3

One student thinks that increasing light intensity causes more potassium ions to move into guard cells.

Suggest how the movement of potassium ions into guard cells would explain the results shown in **Figure 4**.

[3 marks]

Potassium ions lower the water potential of the guard cells, so water moves into the guard cells by osmosis, down a water potential gradient.

The guard cells become turgid (swell) and the stoma opens.

Higher light intensity (lamp closer) causes more stomata to open, or stomata to open wider, so there is a higher rate of transpiration and so a higher rate of water uptake.

9

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0 5

The transport systems of animals contain different types of blood vessel. **Figure 5** shows a photograph of a section through an artery and a vein.

Figure 5

**0 5 . 1**

Suggest why the artery appears circular in **Figure 5**, but the vein does not.

[1 mark]

The artery wall is thicker (more muscle and elastic tissue), so it keeps its circular shape when cut into a thin section.

Question 5 continues on the next page



Table 2 gives data for different types of blood vessel.

Table 2

Blood vessel	Mean length / cm	Mean diameter / cm	Total cross-sectional area / cm ²	Total blood volume / cm ³	Rate of blood flow (cm ³ s ⁻¹)
Aorta	40	1.0	0.8	30	28
Other large arteries	20	0.3	3	60	7.8
Arterioles	0.2	0.002	125	25	1.18
Capillaries	0.1	0.0008	600	60	0.036
Venules	0.2	0.0003	570	110	0.04
Large veins other than vena cava	20	0.6	11	220	1.9
Vena cava	40	1.3	1.2	50	1.8

0 5 . 2 Column 5 of **Table 2** shows the total blood volume for each type of blood vessel.

Give a word equation for calculating the total blood volume of a type of blood vessel.

Use information from **Table 2**.

[1 mark]

Total blood volume = mean length × total cross-sectional area

0 5 . 3 Calculate the ratio of the rate of blood flow in the aorta to the rate of blood flow in the capillaries.

Give your answer to the nearest whole number.

[1 mark]

$$28 \div 0.036 = 777.8$$

Answer = 778 : 1



0 5 . 4

The rate of blood flow in capillaries is slow.

Suggest why this is an advantage to an organism.

[1 mark]

Allows more time for exchange of substances (oxygen, glucose) by diffusion between the blood and the tissues.

0 5 . 5

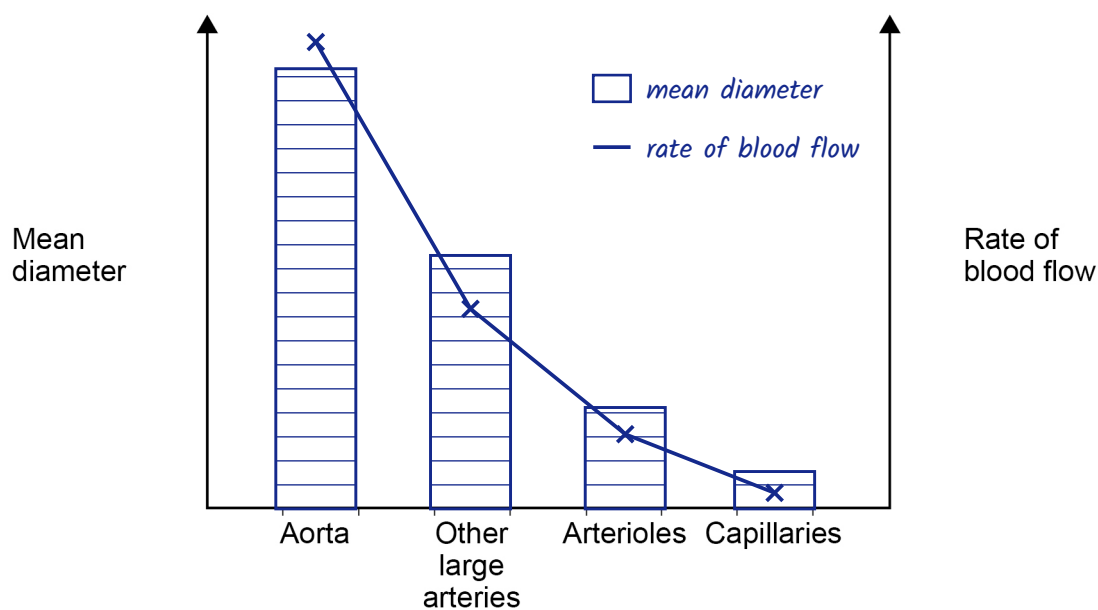
Sketch a graph to show the mean diameter and rate of blood flow for the:

- aorta
- other large arteries
- arterioles
- capillaries.

Use bars to show the mean diameters and a line to show rates of flow.

Do **not** include scales on your graph.

[2 marks]



0 5 . 6

Describe the relationship between mean diameter and rate of blood flow.

[1 mark]

As mean diameter decreases, the rate of blood flow decreases (positive correlation).



0 6

The human immune system responds to antigens by stimulating specific lymphocytes called T cells and B cells.

0 6

1

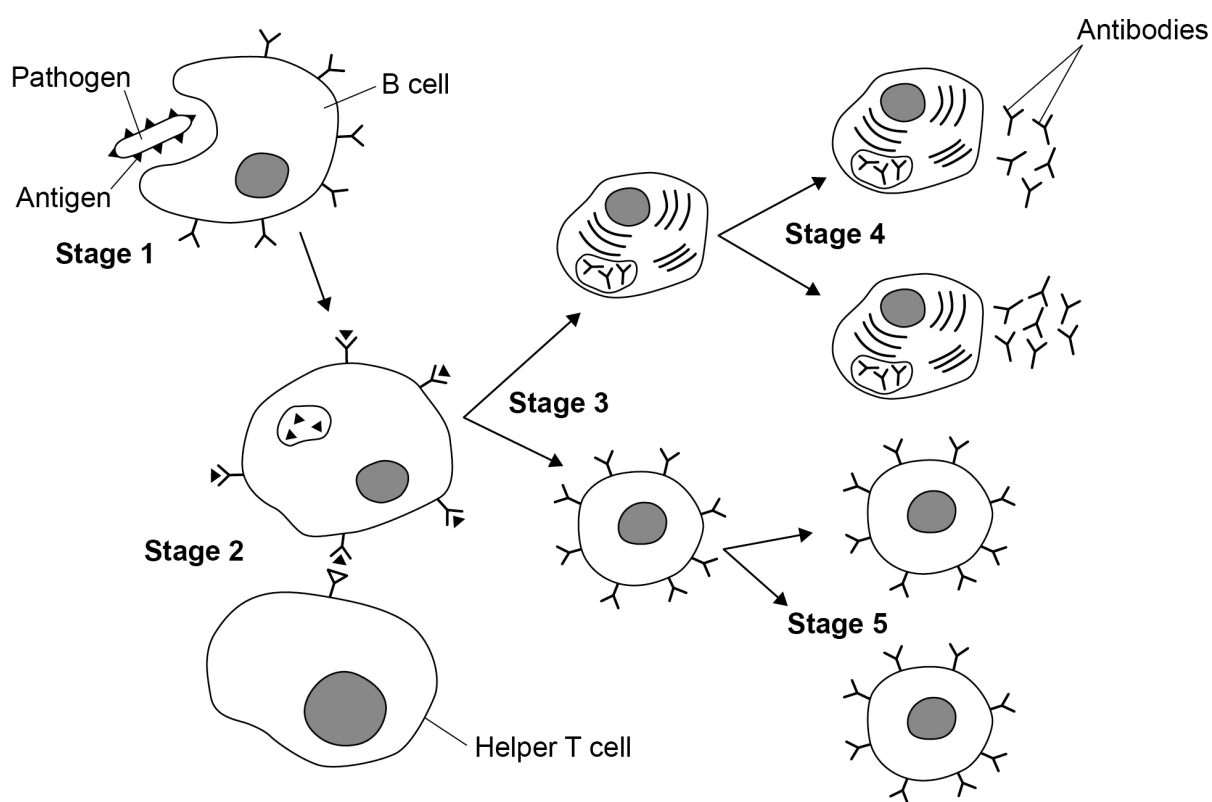
Define the term **antigen**.

[1 mark]

A foreign substance (e.g. a protein or glycoprotein) which produces an immune response.

Figure 6 shows the sequence of events during B cell activation.

Figure 6



0 6 . 2

Describe what is happening in **Stage 1** and **Stage 2**.

[3 marks]

*Stage 1: the B cell engulfs the pathogen by phagocytosis (endocytosis).**Stage 2: the B cell presents the antigens from the pathogen on its cell surface, and a helper T cell binds to the antigens on the surface of the B cell.*

0 6 . 3

An activated B cell divides into two different types of cells as shown in **Stage 3** on **Figure 6**.Plasma cells produce large quantities of antibody molecules (**Stage 4**).Name the type of cells shown in **Stage 5** and state their function.

[2 marks]

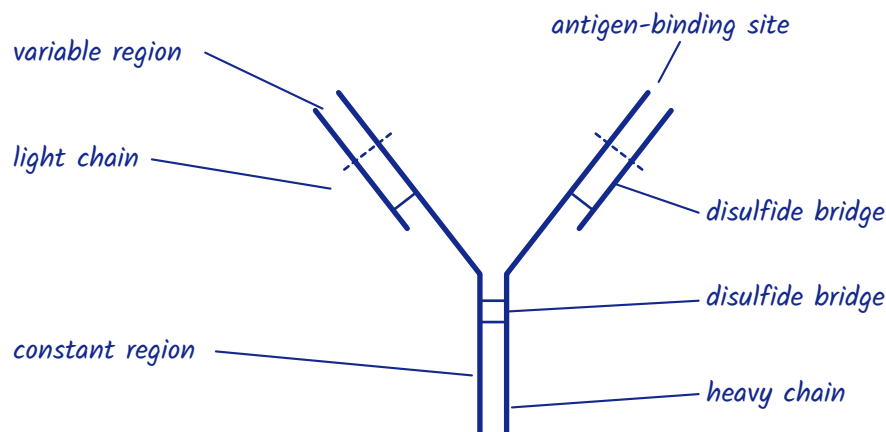
Name of cells *Memory cells*Function *Remain in the body to provide a rapid response if the same pathogen enters the body again.*

0 6 . 4

Figure 6 shows antibody molecules as 'Y' shapes.Draw a diagram to show the **detailed** structure of an antibody molecule.

Label your diagram.

[4 marks]



Question 6 continues on the next page



A plasma cell can produce 2000 antibody molecules every second.

0 6 . 5

Calculate the number of antibody molecules **one** plasma cell could produce in 48 hours.

Give your answer in standard form to 2 significant figures.

[2 marks]

$$48 \text{ hours} = 48 \times 60 \times 60 = 172\,800 \text{ s}$$

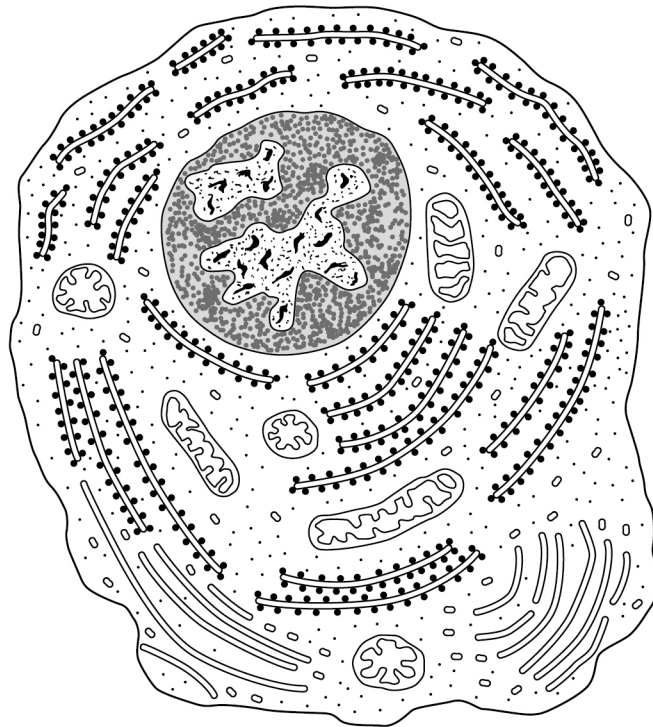
$$2000 \times 172\,800 = 345\,600\,000$$

Number of antibody molecules = 3.5×10^8



Figure 7 shows a plasma cell viewed with an electron microscope.

Figure 7



0 6 . 6

Identify **two** features shown in **Figure 7** that allow plasma cells to produce antibody molecules.

Explain how each feature allows plasma cells to produce very large numbers of antibody molecules very quickly.

[4 marks]

Feature 1 Many mitochondria

Explanation To release energy (produce ATP) by aerobic respiration, needed for protein (antibody) synthesis and for exocytosis of the antibodies.

Feature 2 Lots of rough endoplasmic reticulum (many ribosomes)

Explanation Ribosomes are the site of protein (antibody) synthesis; the RER transports the antibodies to the many Golgi bodies, which modify them for export (exocytosis).



0	7
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Fats are digested in the human digestive system by lipases.

0	7	.	1
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Describe how the products of fat digestion are absorbed.

[5 marks]

Lipase hydrolyses fats (triglycerides) into monoglycerides and fatty acids.

Bile salts associate with the monoglycerides and fatty acids to form micelles.

The micelles carry the monoglycerides and fatty acids to the membrane of the epithelial cells of the ileum.

The monoglycerides and fatty acids are lipid-soluble, so they diffuse across the membrane into the epithelial cells.

In the endoplasmic reticulum the monoglycerides and fatty acids recombine to form triglycerides.

At the Golgi apparatus the triglycerides combine with cholesterol and (lipo)proteins to form chylomicrons.

Chylomicrons leave the epithelial cells by exocytosis and enter the lacteals (lymph vessels).



07.2

A diet with a high fat content may increase the risk of developing coronary heart disease.

Describe how.

[5 marks]

A diet high in saturated fat increases LDL in the blood, and high LDL increases the cholesterol level in the blood.

White blood cells take up the LDLs (cholesterol), and lipid-containing material accumulates within the wall of a coronary artery.

This leads to formation of an atheroma, which narrows the lumen of the coronary artery.

So there is reduced blood flow to the heart muscle cells, so a reduced supply of oxygen and glucose, so less respiration and less ATP (causing angina or a heart attack).

The atheroma can lead to a blood clot (thrombus) which blocks the coronary artery, causing a myocardial infarction.

The weakened artery wall can also lead to an aneurysm.

10

END OF QUESTIONS



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