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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER				

* 5 2 1 5 4 3 4 0 8 3 *

BIOLOGY **9700/22**

Paper 2 AS Level Structured Questions **May/June 2024**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages. Any blank pages are indicated.

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1 Smooth muscle is a tissue composed of smooth muscle cells. The cells contain cytoplasm packed with proteins that are involved in contraction and relaxation.

(a) Smooth muscle is present in the airways of the gas exchange system.

Explain how smooth muscle cells in the walls of the **bronchioles** contribute to the function of these airways.

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(b) When viewed in longitudinal section (LS), smooth muscle cells are elongated and taper at both ends. This is known as a fusiform shape. Each cell has a central nucleus, which also appears elongated.

Fig. 1.1 is a diagram of a smooth muscle cell to show the fusiform shape.

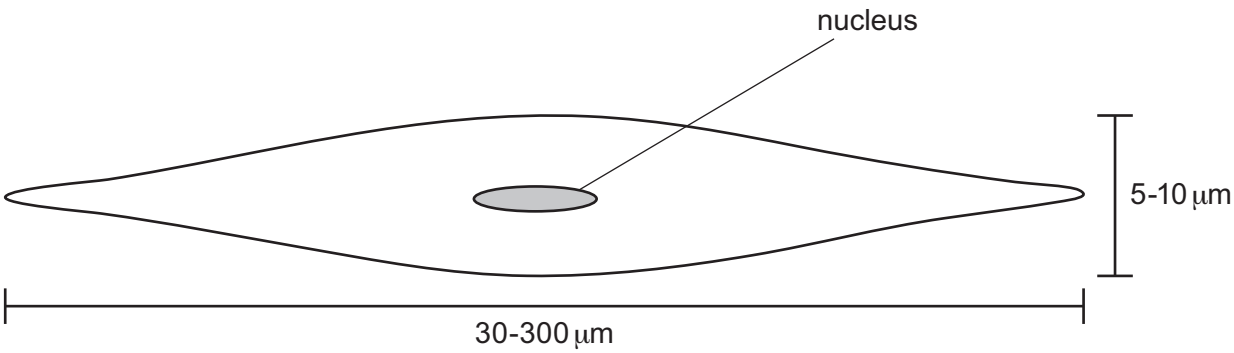

Fig. 1.1

A student used a microscope fitted with a calibrated eyepiece graticule to estimate that the length of one smooth muscle cell was 250 micrometres (μm).

(i) Name the type of microscope slide that the student used to calibrate the eyepiece graticule.

..... [1]

(ii) The smallest object the student can see without the use of a microscope is 0.2 mm in length.

Explain whether the student would be able to see a cell of length 250 μm without the use of a microscope.

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(c) Fig. 1.2 is a photomicrograph of smooth muscle tissue in the wall of the intestines. A capillary is visible in addition to smooth muscle cells.

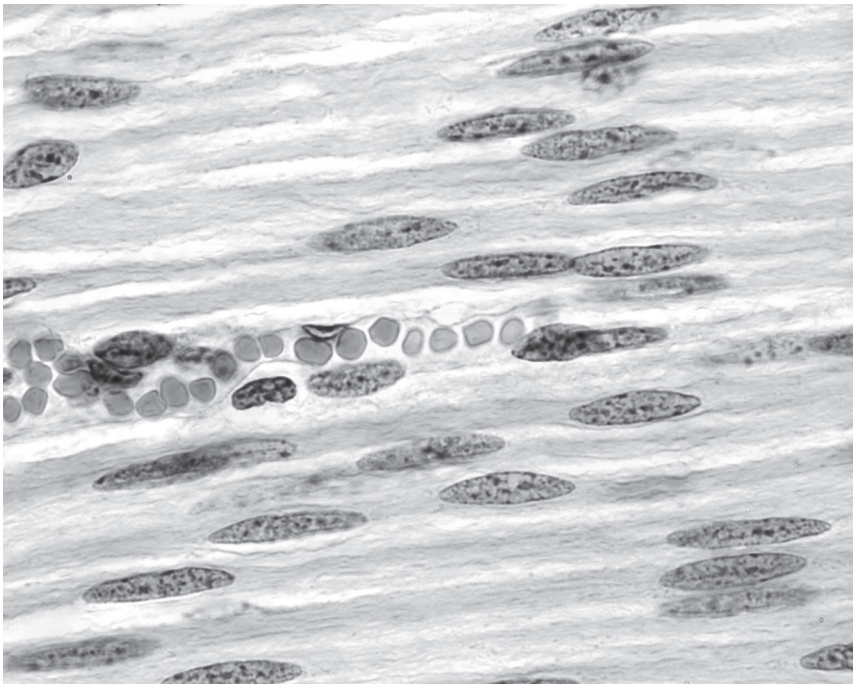

Fig. 1.2

(i) Outline the features that help to identify the blood vessel in Fig. 1.2 as a capillary.

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(ii) Explain how the structure of a capillary is related to its function in smooth muscle.

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(d) Caldesmon is a large protein with a number of binding sites to attach to other proteins.

Caldesmon exists in two different forms, H-caldesmon and L-caldesmon.

H-caldesmon helps to regulate contraction and relaxation in smooth muscle cells.

L-caldesmon is found in some non-muscle cells, where it also acts as a regulatory protein.

- Caldesmon is coded for by a gene known as *CALD1*.
- *CALD1* has 17 exons.
- The primary structure of H-caldesmon has a repeating sequence in the middle of the amino acid chain that is **not** present in L-caldesmon.

(i) Researchers have discovered that a gene mutation is **not** the cause of the two different forms of caldesmon.

Explain what is meant by a gene mutation.

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..... [2]

(ii) Researchers now know that the two different forms of caldesmon are the result of events occurring **directly after** transcription of DNA. Changes occur to the primary transcript that is formed by DNA transcription.

Suggest how the smooth muscle cells and non-muscle cells can produce different forms of caldesmon from the same primary transcript.

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(iii) Suggest how the two different forms of caldesmon can still have similar functions, even though they have a different primary structure.

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[Total: 14]

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2 Alveolar macrophages are cells of the immune system that remain in the alveolar region of the gas exchange system. The macrophages protect against infection caused by pathogens that have been inhaled.

(a) Alveolar macrophages have the same cell structures as typical animal cells.

(i) Complete Table 2.1 to **name** the cell structures that match the functions stated.

Do **not** use abbreviations.

Table 2.1

cell structure	function
.....	manufactures ribosomal subunits from proteins and ribosomal RNA
.....	synthesises triglycerides and other lipids
pair of	organise microtubules of the cell cytoskeleton

[3]

(ii) Fig. 2.1 is a diagram of an alveolar macrophage showing:

- some of the cell structures that would be visible using an electron microscope
- a newly formed phagocytic vacuole (phagosome) containing two cells of *Mycobacterium tuberculosis*.

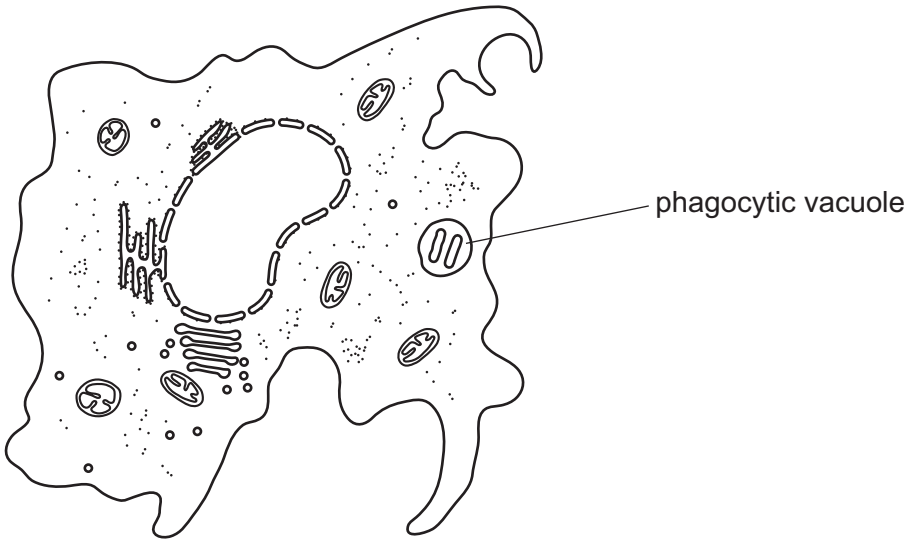

Fig. 2.1

The cell structures with the functions described in Table 2.1 are **not** shown in Fig. 2.1.

Complete Fig. 2.1 by drawing **and** labelling the cell structures described in Table 2.1. [2]

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(b) Tuberculosis (TB) can be prevented if the bacterial cells that have reached the alveoli are rapidly destroyed. Alveolar macrophages can detect the presence of *M. tuberculosis* in the alveolar space and can carry out phagocytosis to form phagocytic vacuoles, such as the one shown in Fig. 2.1.

(i) Outline the sequence of events that leads to the formation of a phagocytic vacuole after detection of the bacterial cells by an alveolar macrophage.

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(ii) Name the cell structures that fuse with the phagocytic vacuole and release hydrolytic enzymes to destroy the bacterial cells.

..... [1]

(c) Research has shown that vaccination programmes are cost effective and are very helpful in the prevention and control of TB. The programmes may be aimed at particular groups of people that are at a high risk of getting the disease, or they may be aimed at an entire population because the country has a high number of cases of TB.

The Bacillus Calmette-Guérin (BCG) vaccine is freeze-dried and contains live, weakened (attenuated) *Mycobacterium bovis*.

Apart from being cost effective, suggest **and** explain the advantages of using the BCG vaccine for the prevention and control of TB.

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[Total: 12]

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3 Lysozyme is an antibacterial enzyme that was discovered in 1921 by Alexander Fleming, the scientist who discovered penicillin.

Lysozyme catalyses the hydrolysis of glycosidic bonds present in peptidoglycan molecules to form smaller products, NAG (N-acetylglucosamine) and NAM (N-acetylmuramic acid).

(a) Before the induced fit hypothesis was proposed in 1958, scientists believed that the lock and key hypothesis explained how lysozyme catalyses the hydrolysis of peptidoglycan to its products.

Draw labelled **and** annotated diagrams in the space provided to show how the **lock and key hypothesis** was used to explain the mechanism of action of lysozyme on peptidoglycan.

[3]

(b) Lysozyme and penicillin can be described as antibacterial agents.

Compare lysozyme **and** penicillin to show the similarities **and** differences between these two antibacterial agents.

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[Total: 6]

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4 In the mesophyll tissue of leaves, products of photosynthesis can be used to synthesise organic compounds, such as the polysaccharide cellulose and some amino acids.

A source of nitrogen for amino acid synthesis can be provided by nitrate ions that have been taken up in the roots and transported to the leaves.

(a) Describe the structure of a cellulose molecule.

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(b) Studies of nitrate uptake and nitrate metabolism help to provide information to scientists who are investigating ways to increase the yield of crop plants.

The first step of nitrate metabolism in leaf cells is the reduction of nitrate to nitrite, catalysed by the enzyme nitrate reductase. The activity of the enzyme can be studied by detecting the presence of nitrite formed.

(i) Researchers have found that adding nitrate to leaf tissue results in an increase in messenger RNA (mRNA) molecules of the gene *NR*, which codes for nitrate reductase.

State **one** benefit to leaf cells of an increase in mRNA molecules of gene *NR* after the addition of nitrate.

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(ii) One method used to detect the presence of nitrite formed from the reduction of nitrate in leaf tissue involves:

- using an inhibitor to prevent nitrite from taking part in further reactions in the leaf tissue
- immersing the leaf tissue in a solution containing a colourless test reagent.

The nitrite from the leaf tissue enters the surrounding solution, changing the colour of the solution to magenta (red-purple).

Suggest why using a colorimeter can improve this method to detect the presence of nitrite.

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..... [2]

(c) In the leaf, transport of amino acids from mesophyll cells to companion cells involves using a number of different membrane transport proteins called amino acid transporters.

There is evidence that amino acids can move from the apoplast into the cytoplasm of a companion cell using the same transport mechanism that is used for sucrose transport.

(i) Outline **and** explain the sequence of events that occurs, which allows amino acids to be transported from the apoplast into the cytoplasm of a companion cell.

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(ii) Suggest why amino acid transporters are **not** needed to move amino acids from the companion cell into a phloem sieve tube element.

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To investigate nitrate uptake, roots can be cut and removed (excised) and placed in a buffered solution containing nitrate ions. The root tissue can be analysed to determine the quantity of nitrate taken up over a set time period.

(d) Excised roots of the crop plant maize, *Zea mays*, were placed in three different concentrations of nitrate solution: 0.2 mmol dm^{-3}, 1.0 mmol dm^{-3} and 5.0 mmol dm^{-3}.

The solutions were maintained at 30 °C and were aerated to provide a continuous supply of oxygen to the root tissue.

Nitrate (NO_3^-) uptake by the root tissue was determined each hour for five hours.

The results are shown in Fig. 4.1.

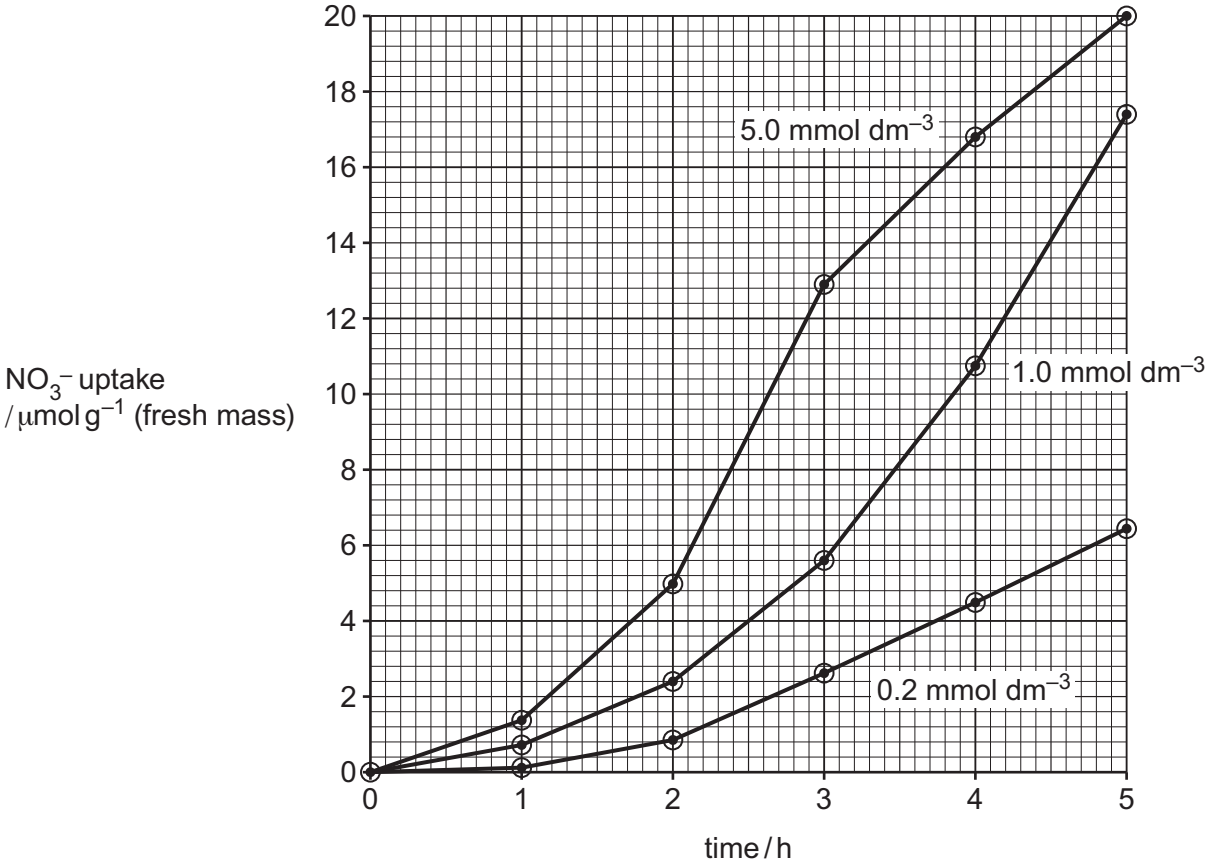

Fig. 4.1

Fig. 4.1 shows that the rate of nitrate uptake is very low initially and then increases for all three concentrations of nitrate solution tested.

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Describe the **differences** in the **rates** of nitrate uptake for 5.0 mmol dm^{-3} nitrate solution compared with 0.2 mmol dm^{-3} nitrate solution, between 2h and 5h

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(e) The nitrate uptake of excised maize roots was investigated under different conditions.

Table 4.1 shows details and results for a control experiment and four modified experiments, **1**, **2**, **3** and **4**. The same concentration of nitrate solution was used throughout for all the experiments. All the results were taken after a set time period.

Table 4.1

experiment	temperature / °C	aeration	additional substances present in nitrate solution	nitrate uptake / μmol g^{-1} (fresh mass)
1	30	no	nitrogen gas bubbled through instead of oxygen	0.4
2	3	yes	none	0.6
3	30	yes	protein synthesis inhibitor	1.4
4	30	yes	antibacterial compound	10.0
control	30	yes	none	10.9

The results for experiments **1**, **2**, **3** and **4** in Table 4.1 can be compared to the results for the control experiment.

Discuss how comparing each of the results with the control provides information about:

- how nitrate ions are taken up by the root cells
- the factors affecting the uptake of nitrate ions.

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[Total: 17]

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5 During interphase of the cell cycle, individual chromosomes cannot be seen within the nucleus. The genetic material is termed chromatin during this stage.

(a) Changes occur to chromatin during mitosis so that chromosomes become visible.

State what happens to chromatin so that individual chromosomes can be seen during mitosis.

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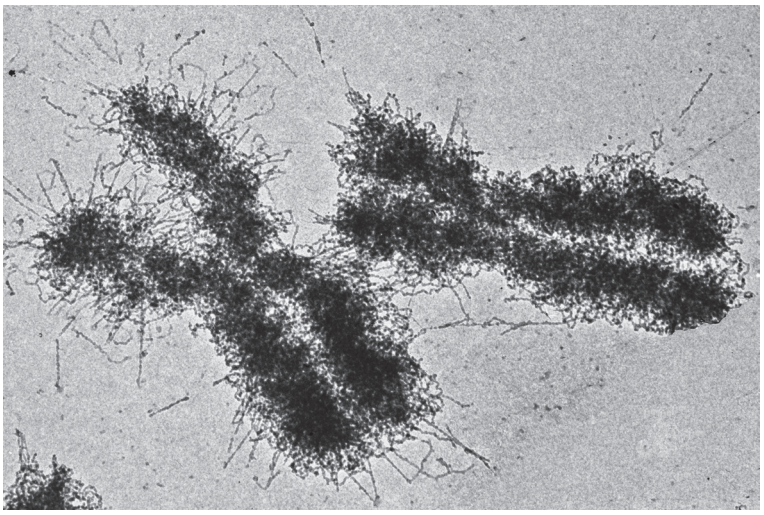
(b) Fig. 5.1 is a transmission electron micrograph of two human chromosomes at metaphase of mitosis.



magnification = ×14 000

Fig. 5.1

Describe the structure of chromosomes at metaphase, such as the two chromosomes shown in Fig. 5.1.

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[Total: 5]

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6 Some people who are infected with HIV have HIV/AIDS.

(a) State the full term for HIV.

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(b) Following transmission of HIV, early diagnosis of infection and treatment with anti-retroviral therapy (ART) helps to control the spread of the pathogen and prevent HIV/AIDS.

Suggest why treating people who have developed HIV/AIDS with ART may help to reduce the number of overall deaths from infectious diseases, such as cholera, TB and malaria.

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(c) Studies suggest that people who are infected with HIV may be at a higher risk of heart disease. One cause of heart disease is the narrowing of the lumen of one or both of the main coronary arteries.

A coronary artery bypass graft (bypass graft) is a surgical operation that uses healthy blood vessels to divert blood around diseased sections of coronary arteries. The main choice of blood vessel to use for a bypass graft is known as the internal thoracic artery.

Fig. 6.1 is a diagram of an external view of the heart to show a **double** bypass graft.

The blood vessels used in the bypass graft shown in Fig. 6.1 are the great saphenous vein from the leg and the internal thoracic artery.

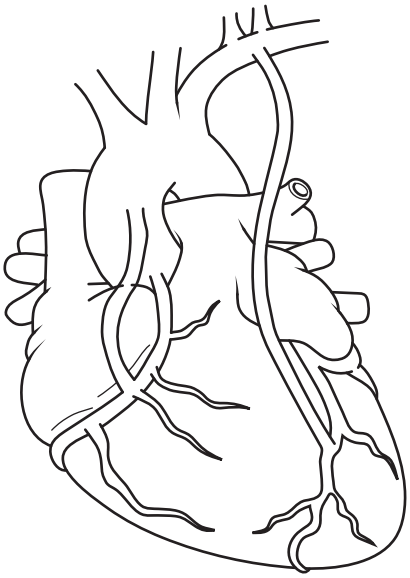

Fig. 6.1

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(i) Draw a cross (**X**) on Fig. 6.1 to show an area of the **right** coronary artery that has been bypassed. [1]

(ii) After surgery, the wall of the great saphenous vein becomes thicker.

Suggest **and** explain why it is important for the wall of the vein to become thicker after surgery.

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[Total: 6]

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