Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

BIOLOGY **9700/21**

Paper 2 AS Level Structured Questions **October/November 2023**

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 **20** pages. Any blank pages are indicated.

1 Scientists measured the concentration of sodium ions and potassium ions in the red blood cells and in the blood plasma of a group of people. The results are shown in Table 1.1.

Table 1.1

	mean concentration of sodium ions / mmol dm^{-3}	**mean concentration of potassium ions / mmol dm^{-3}**
red blood cells	10	100
blood plasma	100	4

(a) (i) Use the information in Table 1.1 to identify **and** describe the process by which potassium ions enter red blood cells from the blood plasma.

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..... [3]

(ii) Sodium ions and oxygen molecules enter red blood cells.

State **one** similarity and **one** difference between the processes used by sodium ions and oxygen molecules to enter red blood cells.

similarity .....

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difference .....

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[2]

(iii) Chloride ions move across the membrane of human red blood cells in a process called the chloride shift.

Explain why the chloride shift is important in the transport of carbon dioxide from respiring tissues.

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..... [2]

(b) Scientists studied the uptake of a substance, **F**, by human red blood cells.

The red blood cells were immersed in a solution of substance **F** for 30 minutes. After this time the scientists recorded two observations:

- the cell surface membrane of the red blood cells showed infoldings (invaginations)
- an increase in the number of vesicles in the cytoplasm.

Identify the process by which substance **F** entered the red blood cells.

..... [1]

[Total: 8]

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2 Fig. 2.1 is a transmission electron micrograph showing a section of a specialised epithelial cell found in the lining of the stomach. This cell produces extracellular proteins that are released into the bloodstream.

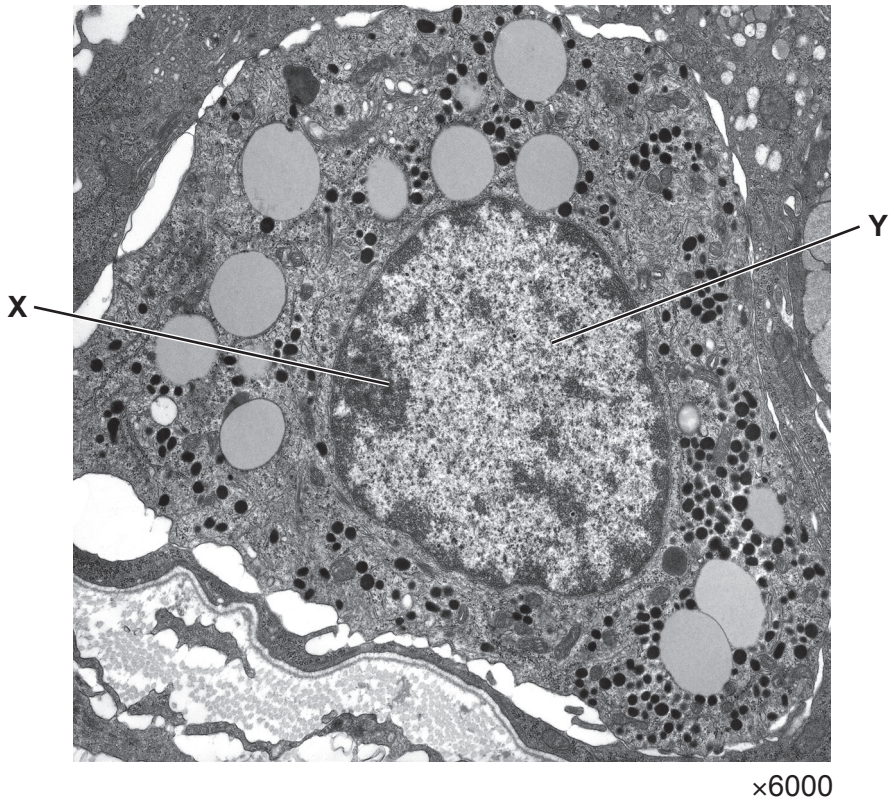

Fig. 2.1

(a) Outline the role of structure **X** and structure **Y**, as shown in Fig. 2.1, in the production of extracellular proteins.

structure **X** .....

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structure **Y** .....

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[2]

(b) The cell in Fig. 2.1 releases ghrelin, a small protein that acts as a cell signalling molecule.

Fig. 2.2 shows the sequence of amino acids in a ghrelin molecule.

The amino acid serine (Ser) in position 3 in Fig. 2.2 has been modified by the addition of a saturated fatty acid chain.

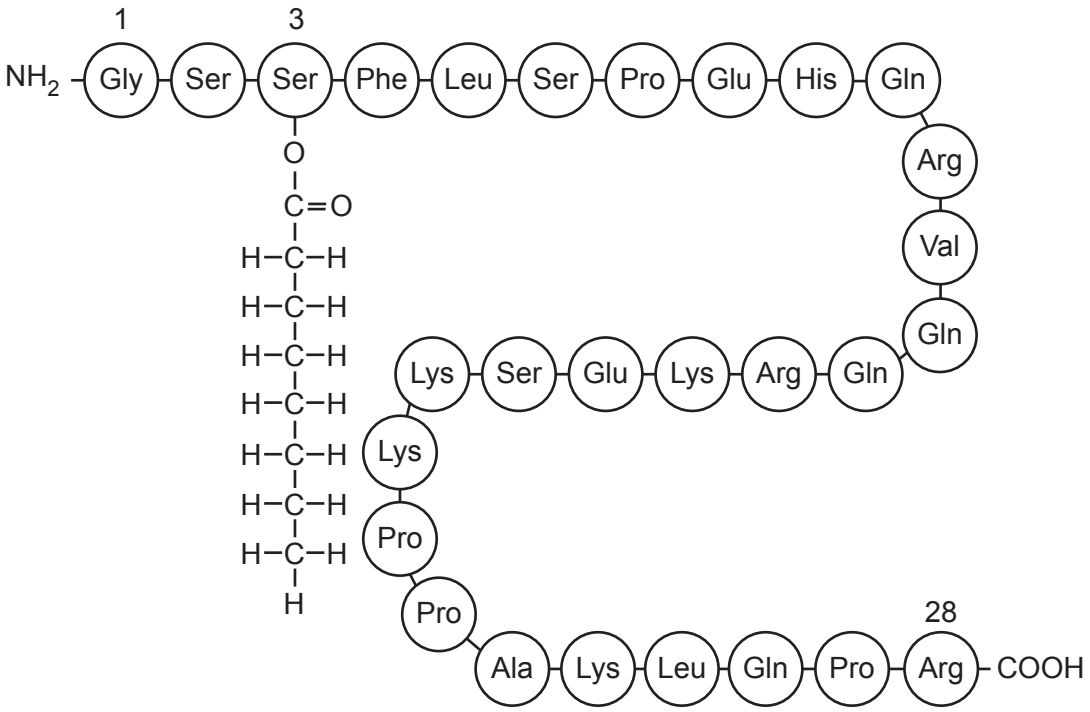

Fig. 2.2

(i) State the level of protein structure shown in Fig. 2.2.

..... [1]

(ii) State **one** similarity between the structure of a saturated fatty acid molecule and an amino acid molecule.

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..... [1]

(iii) The addition of the fatty acid chain allows ghrelin to function as a cell signalling molecule.

Suggest how the addition of this fatty acid chain allows a ghrelin molecule to act as a cell signalling molecule.

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..... [3]

(c) Scientists have discovered that the gene coding for ghrelin contains 5000 base pairs. This is a much larger number of base pairs than is needed to code for the ghrelin molecule shown in Fig. 2.2.

(i) Calculate the percentage of base pairs found in the gene that codes for the ghrelin molecule shown in Fig. 2.2.

Show your working and give your answer to one decimal place.

..... [2]

(ii) The primary transcript produced from the ghrelin gene is a longer molecule than the mRNA found in the cytoplasm.

Explain how the primary transcript is modified before translation.

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..... [2]

[Total: 11]

3 Plants have specialised cells for the efficient transport of assimilates.

(a) Table 3.1 shows some of the features of two different types of cell found in plant tissue, which are adapted for the efficient transport of assimilates.

Table 3.1

feature of cell	cell type A	cell type B
cytoplasm	✓	✓
nucleus	✗	✓
mitochondria	few	many
cellulose in the cell wall	✓	✓
ribosomes	✗	✓

Key
✓ present
✗ absent

Many plasmodesmata connect type **A** cells with type **B** cells.

Identify cell type **A and** explain why the plasmodesmata are important.

cell type **A** .....

explanation .....

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[3]

(b) The polysaccharide callose is found in the cell walls of cells close to plasmodesmata.

Fig. 3.1 is a simplified diagram showing the structure of callose. Not all hydrogen atoms are shown.

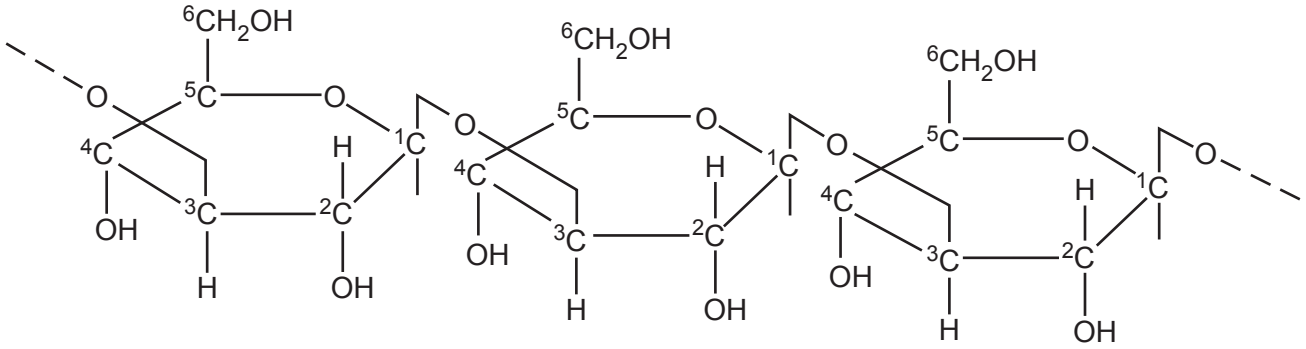

Fig. 3.1

Complete Table 3.2 to compare the structure of a callose molecule with a cellulose molecule.

Table 3.2

feature of polysaccharide	callose molecule	cellulose molecule
monosaccharide used to synthesise the polysaccharide	β-glucose	
bond connecting the monomers		1,4 glycosidic bond
shape of molecule	helix	
orientation of monosaccharides in the molecule		alternate glucose molecules are rotated by 180 °

[4]

(c) Hydrogen bonding is important for movement of water through xylem vessels in a plant.

Describe the roles of hydrogen bonding in the movement of water through xylem vessels.

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..... [3]

(d) Water that has travelled through xylem vessels reaches the leaves. Cooling of the leaf occurs as a result of the evaporation of water during transpiration.

Water has a high latent heat of vaporisation because water molecules form hydrogen bonds.

With reference to hydrogen bonding, suggest why cooling of the leaf occurs as a result of evaporation of water during transpiration.

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..... [2]

[Total: 12]

Question 4 starts on page 12

4 Some people who are infected with HIV develop HIV/AIDS.

(a) Fig. 4.1 shows the number of people that have been newly infected with HIV (new infections) in 2018 across the world and the percentage changes in the number of new infections since 2010.

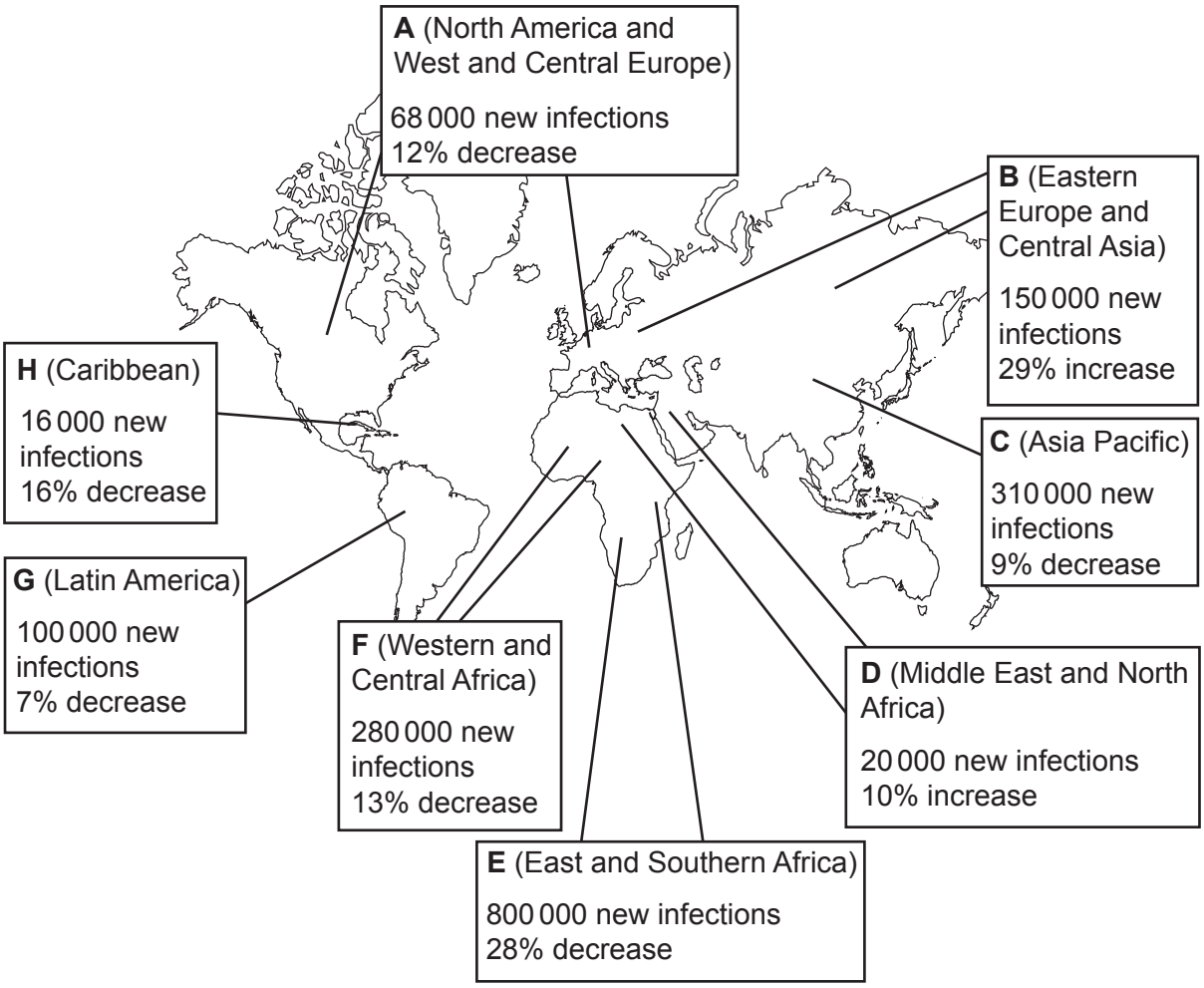

Fig. 4.1

(i) State the full name of the pathogen HIV.

..... [1]

(ii) Using **only** the data in Fig. 4.1, state what can be concluded about the change in number of new HIV infections across the world between 2010 and 2018.

You may use the letters in Fig. 4.1 to identify the regions of the world.

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..... [4]

(b) People who develop HIV/AIDS have fewer T-helper cells as the pathogen destroys these cells. This makes them more susceptible to tuberculosis (TB).

Explain why people with HIV/AIDS are more likely to develop TB.

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..... [4]

(c) A person infected with HIV may develop a heart condition called cardiac tamponade.

The pericardium is a thin sac surrounding the heart, as shown in the healthy heart in Fig. 4.2. When a person develops cardiac tamponade, the pericardium starts to fill with blood. This prevents the ventricles functioning efficiently.

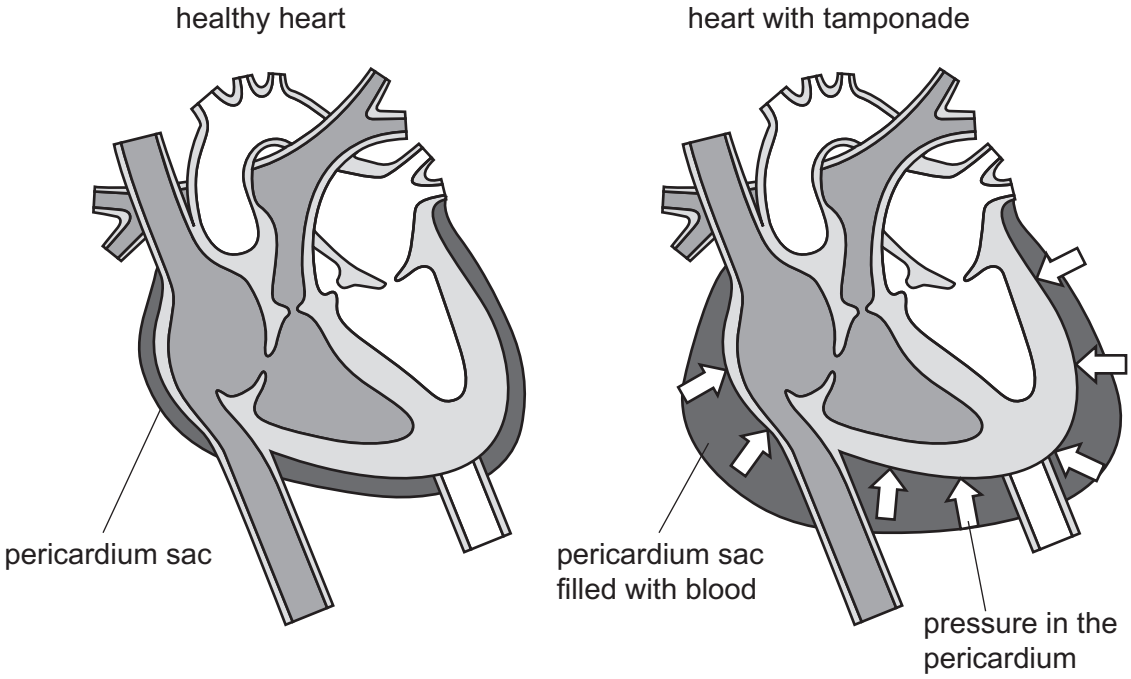

Fig. 4.2

People with cardiac tamponade experience a variety of symptoms including low blood pressure and an increased breathing rate.

Suggest why a person with cardiac tamponade would experience symptoms of low blood pressure and an increased breathing rate.

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..... [4]

[Total: 13]

5 Fig. 5.1 is a photomicrograph of a transverse section of a bronchus in the lungs.

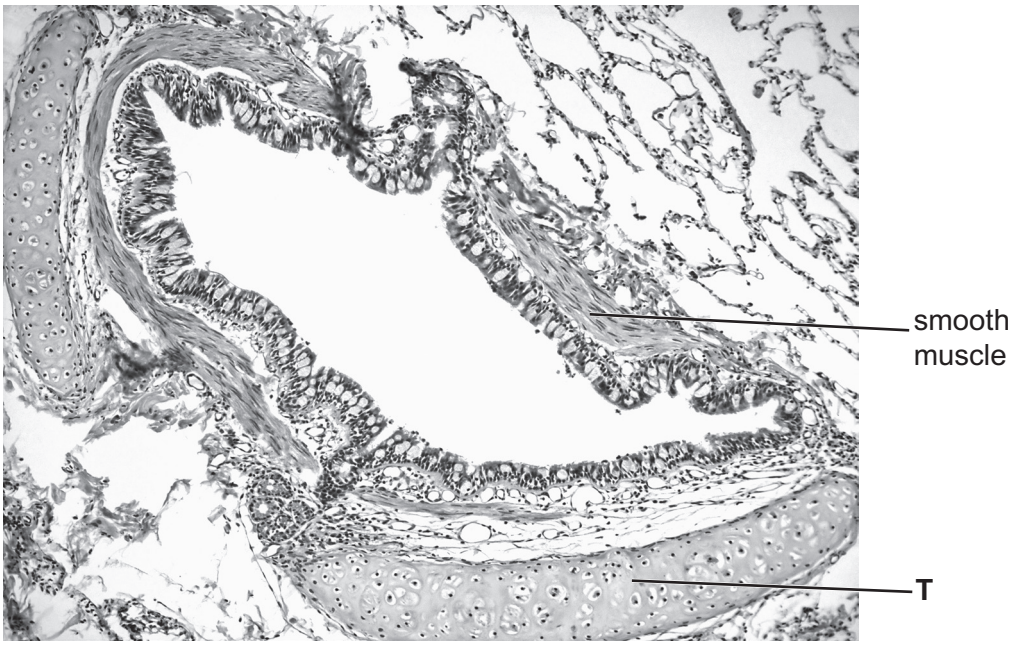

Fig. 5.1

(a) (i) Identify the tissue labelled **T** in Fig. 5.1.

..... [1]

(ii) Describe the function of smooth muscle in the bronchus.

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..... [2]

(b) The walls of alveoli contain some specialised epithelial cells called type II epithelial cells. These cells secrete surfactant. Surfactant helps to prevent the alveoli collapsing during breathing.

Surfactant contains phospholipid, cholesterol and protein.

The components of surfactant are synthesised in the rough endoplasmic reticulum and smooth endoplasmic reticulum and then passed to the Golgi body.

The surfactant that is produced is stored in secretory organelles called lamellar bodies.

The surfactant in the lamellar bodies is released onto the surface of the alveolar epithelium by exocytosis, as shown in Fig. 5.2.

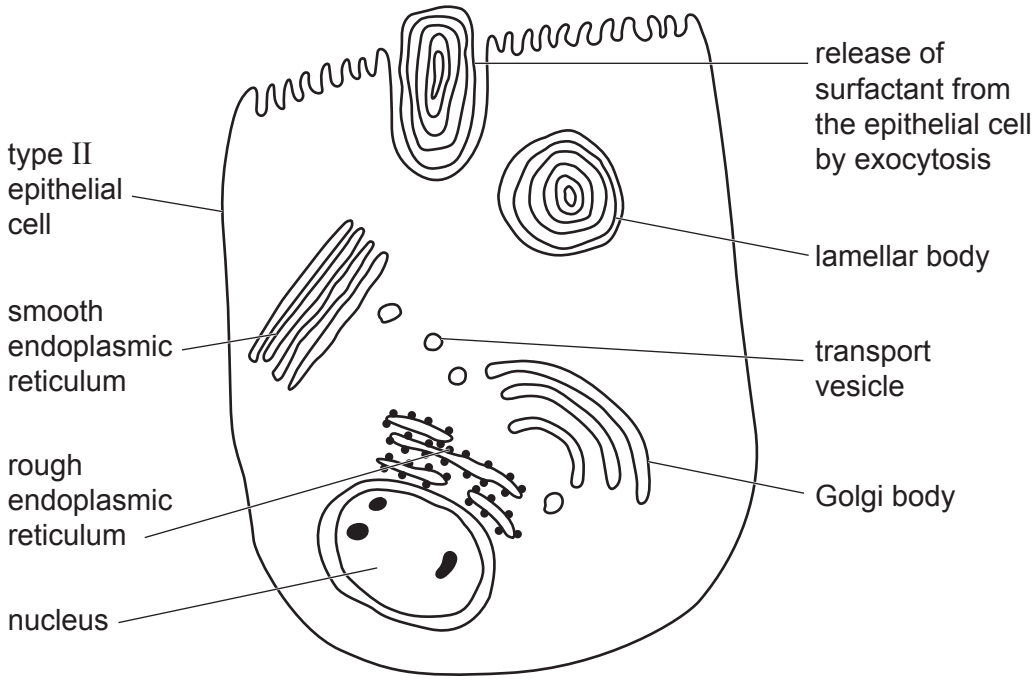

Fig. 5.2

(i) Each lamellar body is surrounded by a single membrane.

Draw a diagram to show the arrangement of phospholipid molecules in the membrane surrounding the lamellar body.

[2]

(ii) Scientists studying the production and secretion of lung surfactant have discovered that a reduction in cholesterol in the cell surface membrane of type II epithelial cells reduces the secretion of surfactant.

Suggest why secretion of surfactant is affected by a reduction in cholesterol in the cell surface membranes of type II epithelial cells.

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..... [2]

(iii) Lung surfactant is engulfed by macrophages that are in close contact with the type II epithelial cells.

Suggest why macrophages engulf surfactant.

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..... [1]

[Total: 8]

6 (a) (i) State the name of the phase of the mitotic cell cycle during which DNA replication occurs.

..... [1]

(ii) During research, scientists can use modified nucleotides to prevent elongation of a polynucleotide chain during DNA replication.

Fig. 6.1 shows the structure of a DNA nucleotide found in the nucleus of a cell.

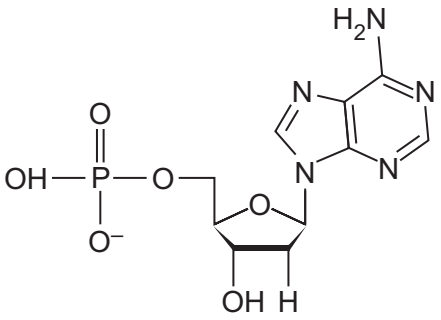

Fig. 6.1

Fig. 6.2 shows the structure of a modified nucleotide.

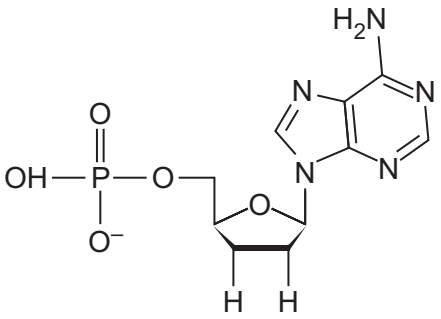

Fig. 6.2

Suggest how the structure of the modified nucleotide prevents DNA polymerase joining it to another nucleotide.

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..... [2]

(b) RNA aptamers are short, single-stranded RNA molecules that can be used to study some infectious diseases.

Scientists studying an infectious disease in animals investigated the effect of RNA aptamers on the activity of RNA polymerase that is produced by the pathogen.

The aptamers bind to a specific region of the RNA polymerase.

Table 6.1 shows the effect of two aptamers, F47 and F52, on the activity of RNA polymerase produced by the pathogen.

Table 6.1

aptamer present	V_{max} of RNA polymerase / arbitrary units	K_m of RNA polymerase / arbitrary units
none	1664	346
F47	1072	508
F52	1467	523

(i) With reference to Table 6.1, compare the effect of the aptamers on the affinity of RNA polymerase for its substrate.

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..... [2]

(ii) With reference to Table 6.1, suggest explanations for the effect of the presence of an aptamer on the rate of transcription catalysed by the RNA polymerase.

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..... [3]

[Total: 8]

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