



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2023

Centre Number

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Candidate Number

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Biology

StemUp Model Solution

Assessment Unit AS 1

assessing

Molecules and Cells



[SBY11]

SBY11

FRIDAY 12 MAY, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all eight** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 75.

Section A carries 60 marks. Section B carries 15 marks.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

You are reminded of the need for good English and clear presentation in your answers.

Use accurate scientific terminology in all answers.

You should spend approximately **20 minutes** on Section B.

You are expected to answer Section B in continuous prose.

Quality of written communication will be assessed in Section B.

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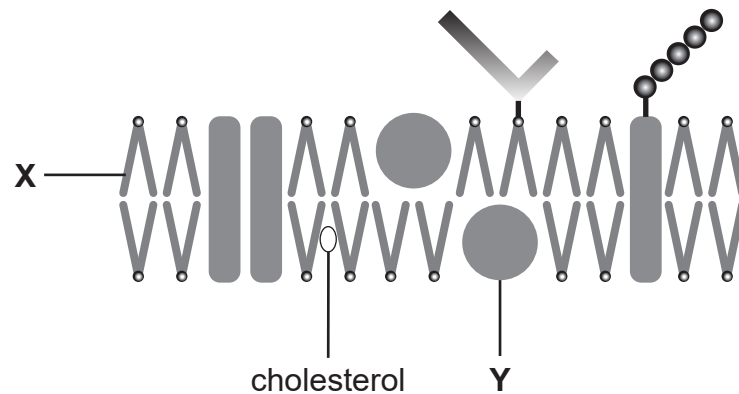
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Section A

- 1 The diagram below represents part of a plasma membrane.



Source: © Biology for
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- (a) Identify molecules **X** and **Y**.

X Phospholipid (fatty acid tails)

Y Intrinsic (transmembrane) protein

[2]

- (b) State the function of cholesterol in plasma membranes.

Cholesterol regulates fluidity and gives the membrane stability.

[1]

- (c) Describe and explain how large, water-soluble substances cross plasma membranes.

They cross by facilitated diffusion through channel proteins, which create

a hydrophilic channel through the hydrophobic core of the phospholipid

bilayer,

or via carrier proteins, which bind the substance and change shape to

carry it across the membrane.

[2]

[Turn over]



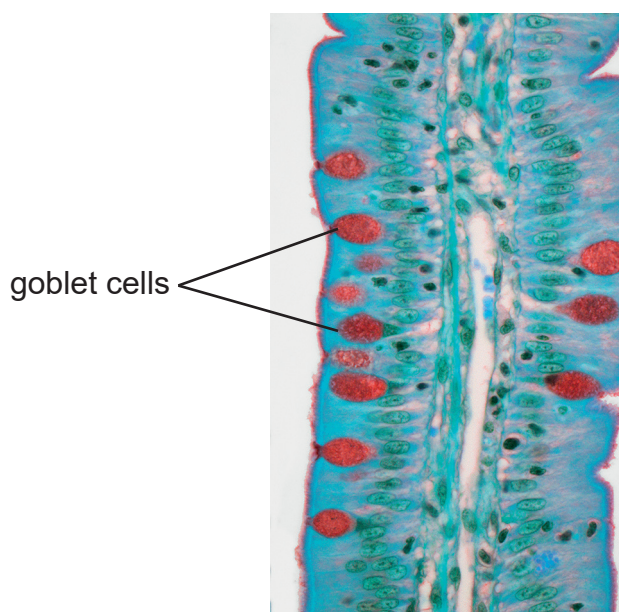
2 Many human tissues and organs are specialised for a particular function.

(a) Define the term 'tissue'.

A group of similar cells that work together to perform a specific function.

[1]

(b) The photomicrograph below shows a section through part of a human villus. Goblet cells are labelled.



Source: © Steve Gschmeissner / Science Photo Library

(i) State the role of goblet cells.

Goblet cells secrete mucus, which lubricates and protects the epithelium.

[1]

(ii) Name the layer of the ileum in which villi are located.

Mucosa

[1]



- (iii) Villi are lined with columnar epithelial cells which possess microvilli. Describe and explain how microvilli aid the ileum in carrying out its role.

Microvilli greatly increase the surface area of the epithelial cell

membrane,

so there is more surface for the increased absorption of the products of digestion (digested food) into the cells.

[2]

- (iv) Describe and explain **two** other adaptations of a villus.

1. *A lacteal in each villus for the transport (absorption) of lipids (fatty acids and glycerol) into the lymph.*

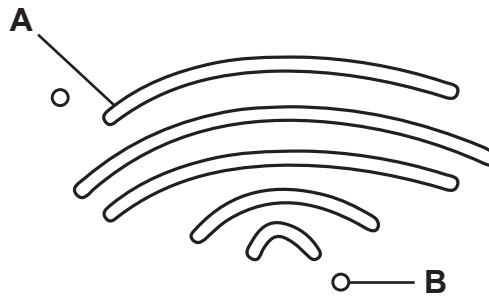
2. *A dense capillary network for the transport of absorbed amino acids and glucose away in the blood, maintaining a steep gradient.*

[4]

[Turn over



3 The diagram below represents a Golgi apparatus.



(a) Identify structures **A** and **B**.

A Cisterna

B Vesicle (Golgi vesicle)

[2]

(b) Describe **two** modifications which may be made to a protein as it moves through the Golgi apparatus from **A** to **B**.

1. Carbohydrate can be added to the protein to form a glycoprotein.

2. Two or more polypeptides can be joined together to form a protein with quaternary structure.

_____ [2]



- (c) Rough endoplasmic reticulum is another membrane system in cells. Describe how rough endoplasmic reticulum differs in **structure** from a Golgi apparatus.

Rough e.r. is encrusted with ribosomes on its outer surface, whereas a

Golgi apparatus has no ribosomes.

Rough e.r. forms a more extensive network of flattened sacs that is

continuous with the nuclear envelope, whereas the Golgi is a separate

stack of curved cisternae.

[2]



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- 4 The table below shows the number of chromosomes present in cell nuclei of females and males of some species.

Species	Number of chromosomes per nucleus	
	Female	Male
Red king crab	208	208
Walking catfish	104	104
Koala	16	16
Jack jumper ants	2	1

- (a) Cell division by meiosis produces gametes which show genetic variation.

With reference to processes in meiosis, explain how more genetic variation can be achieved in red king crab gametes, compared with koala gametes.

Red king crab have 104 pairs of homologous chromosomes compared with only 8 pairs in the koala.

During prophase I, chiasmata form and crossing over occurs between homologous chromosomes. With more chromosomes there are more chiasmata, so more opportunities for unique (new) combinations of alleles to form.

During metaphase I, independent assortment of the homologous pairs occurs, so with 104 pairs there is a far greater number of possible chromosome combinations in the gametes (2^{104} compared with 2^8).

[4]

[Turn over



- (b) The process of reproduction in jack jumper ants is unusual. A fertilised egg develops into a female, whereas an unfertilised egg develops into a male.

Cells from males in this species cannot undergo meiosis. Using the information in the table on the previous page, suggest an explanation for this.

Males develop from unfertilised eggs so they are haploid with only 1

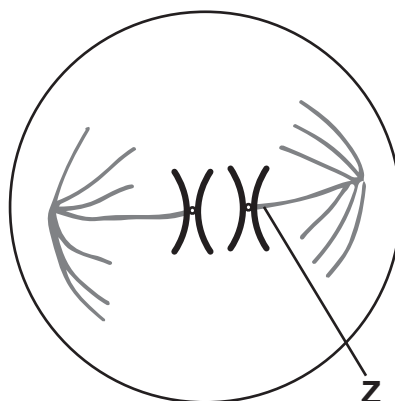
chromosome; their nucleus has no homologous (paired) chromosomes, so

they cannot undergo meiosis.

[1]

- (c) Diagram A below represents a cell of a female jack jumper ant during metaphase I of **meiosis**.

Diagram A



- (i) Identify the structure labelled Z.

Spindle fibre (microtubules)

[1]

- (ii) Explain why the nuclear envelope is not visible at this stage.

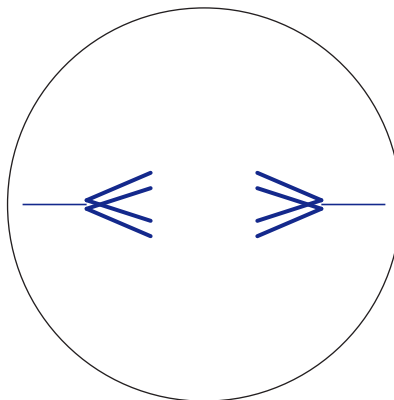
The nuclear envelope broke down during prophase I (so the spindle can attach to the chromosomes).

[1]



- (iii) In Diagram B, draw the chromosomes as they would appear in anaphase I of **meiosis** in a female of this species.

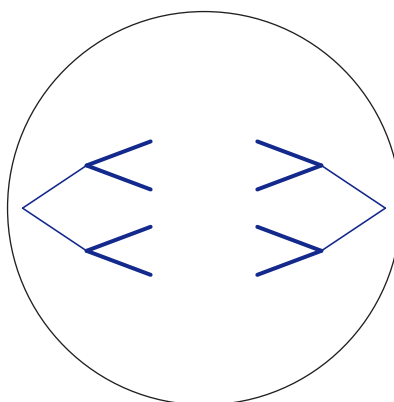
Diagram B



[1]

- (iv) In Diagram C draw the chromosomes as they would appear in anaphase of **mitosis** in a female of this species.

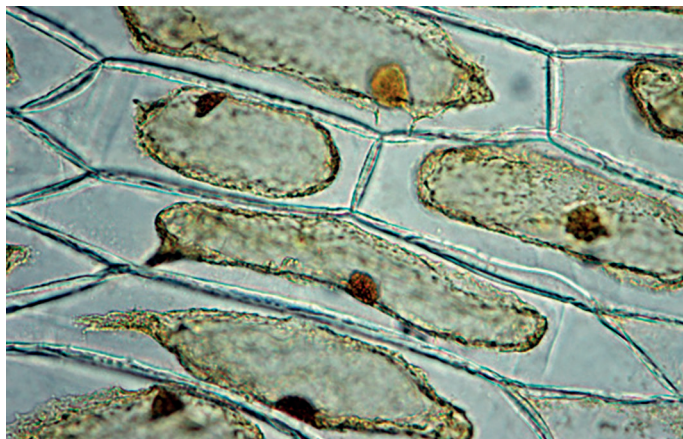
Diagram C



[1]



- 5 The photomicrograph below shows onion cells which had been placed in a concentrated sugar solution for one hour.



Source: © Getty Images

- (a) Describe and explain the appearance of the onion cells.

The cells are plasmolysed: the protoplast (cell membrane and cytoplasm) has shrunk and pulled away from the cell wall.

This is because water has moved out of the vacuole and cell by osmosis, into the sugar solution, which has a more negative (lower) water potential than the cell sap.

[3]



- (b) The absorption of water by cells in a seed is an important part of the first stage of plant growth, called germination.

An investigation was carried out into the effect of fertiliser concentration on the germination of some seeds. The table below shows the results of this investigation.

Concentration of fertiliser / arbitrary units	Percentage of seeds which germinated		
	Aubergine	Tomato	Chilli
0	65	67	71
5	78	81	86
10	82	92	98
15	90	94	99
20	81	90	94
25	69	85	88
30	58	64	70
35	44	60	65

- (i) Describe the trends shown in the table.

For all three vegetables, the percentage of seeds germinating increases as fertiliser concentration increases up to 15 au, and then decreases at higher concentrations.

Aubergine shows the greatest decrease and is affected the most at higher fertiliser concentrations (falling to 44% at 35 au).

Chilli has the highest percentage germination at all fertiliser concentrations.

[3]

[Turn over



- (ii) Using your knowledge and understanding of osmosis, suggest an explanation for the effect of higher concentrations of fertiliser on germination of seeds.

Higher fertiliser concentrations give the soil water a more negative (lower) solute potential, and so a lower water potential than in the seed.

Therefore not enough water enters the seeds by osmosis (or water leaves the seeds), preventing germination.

[2]

- (c) (i) Define the term 'pressure potential'.

The pressure exerted on the cell wall by the cell membrane and contents (or the pressure exerted on the cell contents by the cell wall).

[1]

- (ii) Explain why pressure potential does not affect an animal cell.

An animal cell has no cell wall, so no wall pressure can be exerted.

[1]



6 Collagen is a fibrous protein with quaternary structure.

- (a) Define 'quaternary structure' of a protein and describe the quaternary structure of collagen.

Quaternary structure is where two or more polypeptide chains combine to make up the protein.

Collagen consists of three polypeptide chains wound (intertwined) around each other like a rope, held together by hydrogen bonds.

[2]

Collagen is a major component of a substance called cartilage, which is found in joints such as the hip. Cartilage helps joints to move smoothly.

Rheumatoid arthritis is a disease in which the collagen in cartilage breaks down, causing pain and stiffness in the joints.

A group of protease enzymes called MMPs can act as biomarkers for rheumatoid arthritis.

- (b) (i) Define 'biomarker'.

A molecule (e.g. an enzyme) in blood or body fluids that indicates health or disease and can be used to diagnose or monitor disease.

[1]

- (ii) Suggest how protease enzymes such as MMPs may contribute to rheumatoid arthritis.

MMPs are proteases that hydrolyse (break down) the collagen in the cartilage of the joints.

[1]

[Turn over]



- (iii) A patient suffering from rheumatoid arthritis had their MMP levels monitored, and it was noted that MMP levels were increasing steadily. Suggest what the consequences of this may be for the patient.

The rheumatoid arthritis will become more severe; more collagen is broken down, causing increasing pain and stiffness in the joints.

[1]

- (c) A non-competitive inhibitor of MMPs has been developed as a drug for rheumatoid arthritis.

- (i) Describe and explain how a non-competitive inhibitor slows the rate of an enzyme-controlled reaction.

The inhibitor attaches to a site on the enzyme which is not the active site (an allosteric site), changing the shape of the enzyme.

The active site is no longer complementary to the substrate, so the substrate can no longer bind and fewer enzyme-substrate complexes form.

[2]

- (ii) Suggest how this drug could slow down the progress of rheumatoid arthritis but is not likely to relieve symptoms completely.

MMP activity is reduced, so less collagen is broken down, slowing the progression of the disease.

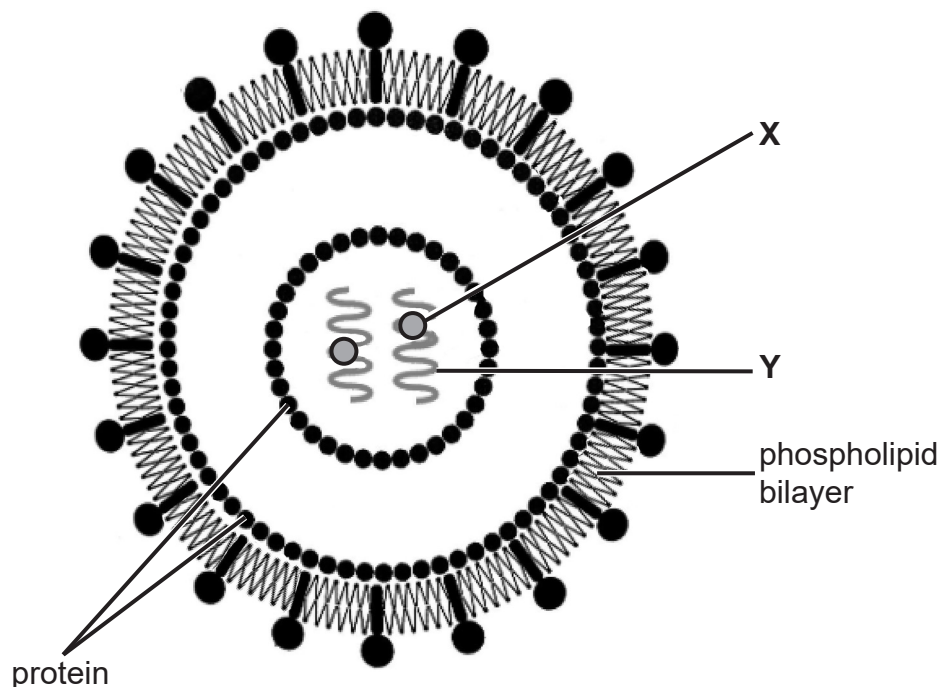
However, cartilage that is already damaged cannot be repaired, so the pain and stiffness are not fully relieved.

[2]



- 7 HIV (human immunodeficiency virus) damages some cells of the immune system and weakens the ability to fight infections and disease.

The diagram below represents the structure of HIV.



Source: © Biology for CCEA
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Colourpoint Creative Ltd

- (a) (i) Identify the genetic material (Y) found in HIV.

RNA

[1]

- (ii) Identify enzyme X and explain its role in HIV.

Enzyme X Reverse transcriptase

Role Catalyses the synthesis of DNA from the viral RNA, so viral

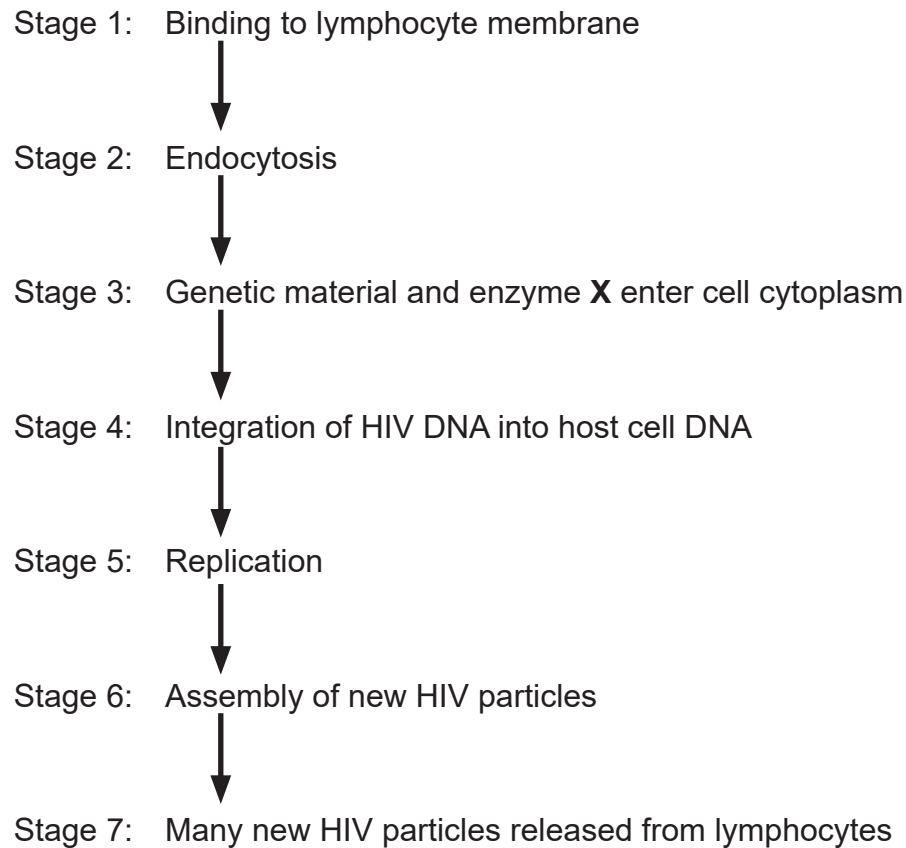
DNA can be made and new viruses produced.

[2]

[Turn over]



- (b) HIV infects a type of lymphocyte (white blood cell). The infection process is summarised in the diagram below.



- (i) HIV can enter lymphocytes via endocytosis. Describe the process of endocytosis.

The cell (plasma) membrane invaginates (infolds) and forms around the virus,

then a vesicle containing the virus pinches off and is released on the inside of the cell.

[2]



- (ii) Suggest how intervention at stage 1 or stage 7 could help prevent the spread of HIV throughout the body.

Stage 1 – binding to lymphocyte membrane

Stopping binding would prevent the virus entering lymphocytes, so all subsequent stages of infection would be prevented.

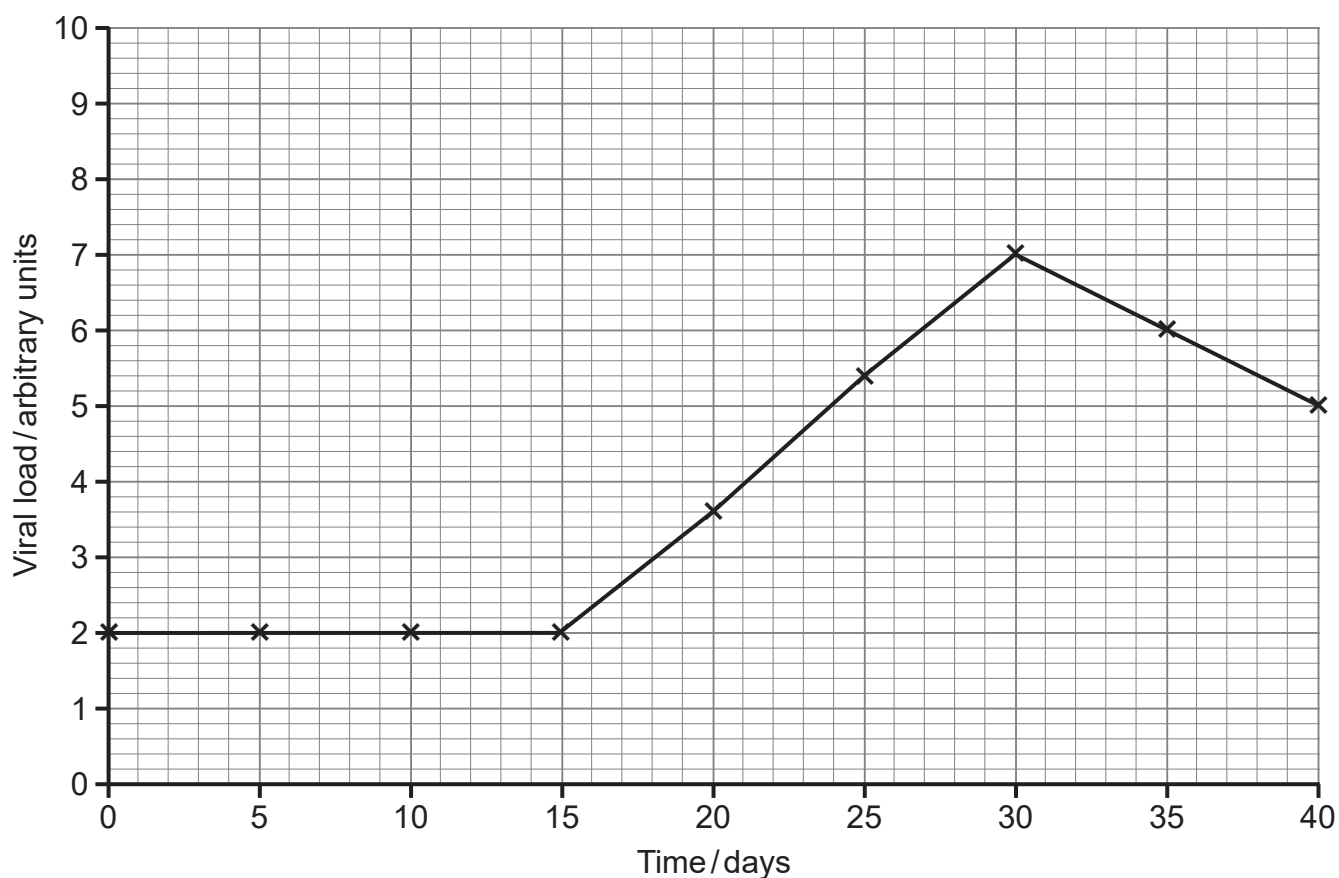
Stage 7 – release of the virus

The new viruses would not be able to leave the lymphocyte, so they could not infect other cells.

[2]



- (c) The results of research carried out on HIV infection in a small number of people are summarised in the graph below. Viral load is a measure of the number of virus particles present in the body and was recorded over the first 40 days of infection.



- (i) Describe the results of the research.

Between day 0 and day 15 there is no increase in viral load, which stays constant at 2 au.

Between day 15 and day 30 there is a steady, large increase in viral load, to a peak of 7 au at day 30.

After day 30 there is a steady, slower decrease, falling to 5 au by day 40.

[3]

- (ii) Calculate the percentage increase in viral load from day 5 to day 25.

(Show your working.)

$$\text{Day 5} = 2 \text{ au} \quad \text{Day 25} = 5.4 \text{ au}$$

$$\text{Increase} = 5.4 - 2 = 3.4 \text{ au}$$

$$\% \text{ increase} = (3.4 / 2) \times 100 = 170$$

170 % [2]

[Turn over]



Section B

Quality of written communication will be assessed in this section.

- 8 (a) DNA and RNA are nucleic acids. Describe the structure of nucleic acids and describe the functions of DNA and RNA. [9]
- (b) Describe the process of semi-conservative replication of DNA. [6]

- (a) DNA and RNA are nucleic acids. Describe the structure of nucleic acids and describe the functions of DNA and RNA.

Nucleic acids such as DNA and RNA are polymers made up of many nucleotide monomers.

Each nucleotide consists of a pentose sugar, a phosphate group and a nitrogenous (organic) base. The pentose sugar is ribose in RNA and deoxyribose in DNA.

Nucleotides are joined together by condensation reactions, which form phosphodiester bonds between the pentose sugar of one nucleotide and the phosphate group of the next, producing a sugar-phosphate backbone.

DNA is double stranded, with the two polynucleotide strands running anti-parallel to each other and held together by hydrogen bonds between complementary bases, forming a double helix. RNA is single stranded.

DNA has four different bases: adenine, thymine, cytosine and guanine (A pairs with T, C pairs with G). RNA has uracil instead of thymine.

DNA provides the genetic code of living organisms and is passed on to new cells. It controls protein synthesis, because the base sequence codes for the sequence of amino acids in a polypeptide.



Only one of the DNA strands, the template strand, is used, and its bases are read as triplets, with each triplet coding for one amino acid.

Messenger RNA (mRNA) is transcribed from the DNA template and carries the code from the DNA in the nucleus out through the nuclear pores to a ribosome in the cytoplasm or on the rough endoplasmic reticulum.

Transfer RNA (tRNA) carries specific amino acids to the ribosome, where its anticodon pairs with the complementary codon on the mRNA, so the amino acids are lined up in the correct order.

Ribosomal RNA (rRNA), together with protein, forms ribosomes, which are the site of protein synthesis where peptide bonds form between the amino acids.

[Turn over



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(b) Describe the process of semi-conservative replication of DNA.

DNA replication takes place in interphase. First, the enzyme DNA helicase breaks the hydrogen bonds between the complementary bases, so the double helix unwinds and the two strands separate.

Each of the original strands then acts as a template.

Free (activated) DNA nucleotides in the nucleus are attracted to their complementary exposed bases on the template strands, following the base pairing rules: adenine with thymine and cytosine with guanine, and hydrogen bonds form between them.

Adjacent nucleotides are then joined together by the enzyme DNA polymerase, which catalyses condensation reactions forming phosphodiester



bonds, producing the new sugar-phosphate backbone.

As a result, each new DNA molecule consists of one original (conserved) strand and one newly synthesised strand, which is why the process is called semi-conservative. The two molecules are identical to each other and to the original DNA.



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